Asia-Pacific Network for Global Change Research

Standardization and systematization of carbon-budget observation in Asian terrestrial ecosystem based on AsiaFlux network

Final report for APN project: ARCP2006-01CMY

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Standardization and systematization of carbon-budget observation in Asian terrestrial ecosystem based on AsiaFlux network

Project Reference Number: ARCP2006-01CMY

Final Report submitted to APN

Overview of project work and outcomes

Non-technical summary

The estimation of carbon budget in terrestrial ecosystem is one of urgent research subjects in terms of climate change study and the implementation of Kyoto Protocol. The micrometeorological approach has been the most common method in this study field, however, the technique has not yet been standardized nor fully diffused into Asian countries.
We have conducted AsiaFlux Workshops in 2005 and 2006 with foremost experts as well as young scientists from both inside and outside of Asia to provide opportunities to discuss and understand the current situation and problems of each Asian country. The newly reported information was very valuable for further promotion of AsiaFlux Activities.
We have also compiled technical manual in terms of summarizing the result of data reanalysis and standardization of observation method. This manual can be used by young scientists aiming for their initial capacity building in flux observation and analysis.

Objectives

The main objectives of the project were: 1) to promote information exchange and to improve methodology in flux observation and data analysis among participating countries in order to provide much more reliable carbon budget data in Asian monsoon terrestrial ecosystems, 2) to promote the systematic carbon budget observation in Asia and to encourage activities of observation in Asian countries with the development of AsiaFlux network.

Amount received and number years supported

2005/06: USD 25,000.

2006/07: USD 20,000.

Activity undertaken

We have conducted two international workshops on the carbon flux observation in Asian terrestrial ecosystems. 1) AsiaFlux Workshop 2005 was held in August 2005 in Fujiyoshida, Japan, titled “International Workshop on Advanced Flux Network and Flux Evaluation”. 2) AsiaFlux Workshop 2006 was held in November to December 2006 in Chiang Mai, Thailand, titled “International Workshop on Flux Estimation over Diverse Terrestrial Ecosystems in Asia”. More than 130 and 140 participants, respectively, have attended both from inside and outside Asia. Active discussions have made it possible to exchange and share valuable information on flux measurement and analysis methodologies. Furthermore, we have come to understand the current situation and challenges of each Asian country and their reported information would be very helpful for further promotion of AsiaFlux Activities.

Results

We have published two proceedings of AsiaFlux Workshop 2005 and 2006 on advanced flux network and flux evaluation. About 100 reports are included in both and they discussed the latest information such as current situation of flux measurement in Asian countries, the carbon dioxide flux evaluation on complex terrains and flux estimation over diverse ecosystems from tropical to sub-arctic climates in Asia. The information is going to be utilized for the rebuilding of the Asian flux network. Significant amount of valuable information on flux measurement and analysis methodologies was exchanged and shared through active discussion at AsiaFlux Workshop 2005 and 2006.
A Technical manual was prepared and used as textbook in AsiaFlux Training Course on micrometeorology in 2006. Some of our reports about the new activities of AsiaFlux

have been introduced in some academic journals.
We have carried out inter-comparison of measurement by using annual data from different type of observation method (open- and closed-path system). The results show a significant difference in CO_2 flux values between the different observation methods. CO_2 flux value from closed-path system tends to increase as sensible heat flux increases, whereas open-path system shows larger reading when wind speed increases. These results shall be valuable evaluating index for previously obtained data.

Relevance to APN's Science Agenda and objectives

Our objectives have been related to three topics of APN research frameworks: 1) Changes in Terrestrial Ecosystems, 2) Human Dimensions of Global Change, and 3) Changes in Atmospheric Composition. Asia is a unique area where terrestrial ecosystems are continuously distributed from arctic to tropical zone, and the monsoon causes intense rain fall in the growing season of plants. There is a large amount of human activities such as land-use change by plantation and forest managements. These changes will lead to the carbon budget change in the terrestrial ecosystems, and will affect the atmospheric composition. Furthermore, this unique ecosystem in Asia has attracted the attention as a carbon sink against the global warming and carbon dioxide fertilization.
We have contributed to the APN's science objectives by the following two aspects; one is to organize the information exchange among the carbon flux observation network in Asia, and another is to promote capacity building among the Asian researchers.

Self evaluation

We have become able to picture the current situation of the carbon budget observation in Asian countries. The obtained information will help us to re-build AsiaFlux framework to enhance the general technical level of flux observation.

Potential for further work

Our activities have urged to build up new sub-regional flux observation networks in Asia, such as in Thailand, Philippines and India. The emphasized AsiaFlux network through the APN program is going to start a new scientific program on the terrestrial carbon budget among China, Korea and Japan. It will be a successive program after the APN project also to promote AsiaFlux activities.

Publications

1) Proc. AsiaFlux Workshop 2005 "International Workshop on Advanced Flux Network and Flux Evaluation", Ed. AsiaFlux Workshop Organizing Committee, 96pp., 2005
2) Proc. AsiaFlux Workshop 2006 "International Workshop on Flux Estimation over Diverse Terrestrial Ecosystem in Asia", Ed. S. Lakanavichian, 113pp., 2006
3) Practice of Flux Observations in Terrestrial Ecosystems, Ed. Asia Flux Steering Committee, 2006

References

None

Acknowledgments

AsiaFlux Activities are also financially supported by Ministry of Education, Culture, Sports, Science and Technology (MEXT) as well as APN. We have committed most of the available APN funds for subsidizing inviting leading experts to workshops and preparation of the technical manual for the AsiaFlux Training Course.

Technical Report

Preface

The estimation of carbon budget in terrestrial ecosystem is one of the urgent research subjects from the views of climate change research and the implementation of Kyoto Protocol. The objective of our study is to promote information exchange and to improve methodology in flux observation and data analysis among Asian countries in order to provide much more reliable carbon budget data in Asian monsoon terrestrial ecosystems. The systematic and standardized carbon-budget observation in Asia will be encouraged together with the development of AsiaFlux network.

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1.0 Introduction

The estimation of carbon budget in terrestrial ecosystem is one of the urgent research subjects from the views of climate change research and the implementation of Kyoto Protocol. The technology widely used in recent years to evaluate the ecosystem carbon budget is the eddy covariance method called tower flux measurement, which determines instantaneous flux from covariance of the CO_2 concentration and the vertical wind velocity. Net carbon budget for a period is computed by integrating the instantaneous fluxes over the period. Although the principle of the measurement is simple, instrumentation, data acquisition and data analysis are very complicated because these aspects are highly sensitive on local topography, vegetation and regional climatic conditions. In addition, the eddy covariance observation can be easily disturbed by heavy rain and the result is poorly reliable under calm conditions. We need to remove those data uncertainty, but its strategy and procedure are not standardized, yet. These are factors of discrepancy among observation sites.

27 flux measurements, when this project began, were under operation (10 in Japan, 8 in China, 2 in Korea, 2 in Thailand, 2 in Indonesia, 2 in Malaysia and 1 in Russia) in different implementation structure and instrumentation. Most of them have been organized in AsiaFlux network and others were in preparation for joining to it. To evaluate the regional and global carbon uptake by terrestrial ecosystem using the high quality data, the observation should be managed under the organized measurement network and operated by standardized methodology. This project aimed to promote information exchange and to improve methodology in flux observation and data analysis among participating countries in order to provide much more reliable carbon budget data in Asian monsoon terrestrial ecosystems. The activities of carbon-budget observation in Asian countries would be encouraged and the systematic observation would be established in Asia, together with the development of AsiaFlux network. For those purposes, we focus on the following two major activities. One was to hold the AsiaFlux Workshop holding annually to exchange the latest scientific information on the flux measurement and analysis. Another was to hold annual program, “AsiaFlux Training Course” to provide opportunity to study microclimatologic background, flux measurement and data analysis mainly for the younger scientists in Asia. The course itself is conducted by other project framework, but we prepare a text book used in the course in this APN project.

2.0 Methodology

The objective to open workshops were to promote information exchange and to improve methodology in flux observation and data analysis among participating countries in order to provide much more reliable carbon budget data in Asian monsoon terrestrial ecosystems. For those purposes, we have conducted two AsiaFlux Workshops in 2005 and 2006 with foremost experts as well as young scientists from both inside and outside of Asia to provide opportunities to discuss and understand the current situation and problems of each Asian country.

We have also compiled technical manual in terms of summarizing the result of data reanalysis and standardization of observation method. This manual has been used by young scientists aiming for their initial capacity building in flux observation and analysis. A flux observation manual was already published (AsiaFlux Steering Committee, 2003) by Japanese scientists in AsiaFlux community, but it was specialized to Japanese climate and land-use type and was written in Japanese. The manual has been updated and translated into English, and some descriptions on the applicable scope into Asian region have been taken into account.

AsiaFlux Activities are also supported by MEXT* project as well as APN. We have committed most of the available APN funds for subsidizing inviting leading experts to workshops and preparation of technical manual. This manual has been utilized for the AsiaFlux Training Course conducted in the MEXT project framework.

*MEXT project: AsiaFlux Activities are also financially supported by the project from Ministry of Education, Culture, Sports, Science and Technology (MEXT), titled "Initiation of the next-generation AsiaFlux". Both financial budget from APN and MEXT have been concurrently supported our activities.

2.1 AsiaFlux Workshop2005

AsiaFlux Workshop 2005 was held in August 2005 in Fujiyoshida, Japan. Active discussions have made it possible to exchange and share valuable information on flux measurement and analysis methodologies. Furthermore, we have come to understand the current situation and challenges of each Asian country and their reported information would be very helpful for further promotion of AsiaFlux Activities. More than 130 participants have attended from various research institutions and universities all over Asia including Bangladesh, China, India, Japan, Korea, Malaysia, Philippines, and Thailand. We also invited some experts from technically developed countries such as Australia, Canada and USA for keynote speeches.

2.2 AsiaFlux Workshop2006

The workshop in 2nd year was held in November 2006, in Chiang Mai, Thailand. Discussions were focusing especially on the standardized methodology and inter comparison of data obtained in various conditions. Several participants have reported about their newly established, or planned to be established, flux observation sites. We saw the progeny of our activities on capacity building technology transfer. Over 140 researchers participated from 13 countries and regions, including Australia, Bangladesh, China, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, UK and USA.

2.3 Data reanalysis

We have carried out inter-comparison of measurement by using annual data from different type of observation method (open- and closed-path system). We have installed both systems on the same observation towers which are located in the different vegetation and climate zone, such as paddy filed (Tsukuba, warm-temperate zone) and larch forest (Tomakomai, cool-temperate zone). We summarized the result of this data reanalysis and pursued incorporation of information into the technical manual.

2.4 Publication of technical manual on flux measurements

A survey was carried out to find out the distribution of observation sites in Asia, and a standard method of flux observation and data analysis was also established. To summarize the new standard method and to promote it in Asian countries, we have compiled a concrete technical manual on flux measurements which was suitable for Asian typical ecosystem and climate conditions. Detailed data analysis methodology is described in it, including the methods of unreliable data detection and the fulfillments of observation gaps. Using this manual as a textbook, the very first AsiaFlux Training Course 2006 was carried out in late August 2006 in Tsukuba, Japan which was also one of the main focuses in the MEXT project framework. 20 participants from nine countries (Bangladesh, China, India, Indonesia, Malaysia, Philippines, Taiwan, Thailand and Viet Nam) came together to learn about basis of observation theory, observation techniques and data analysis in 10 days.

3.0 Results & Discussion

3.1 AsiaFlux Workshop2005

The AsiaFlux Workshop 2005 (International Workshop on Advanced Flux Network and Flux Evaluation) was held successfully in 24-26 August 2005, in Fujiyoshida, on the foothills of Mt. Fuji, Japan. This is the 4th workshop of the AsiaFlux network and the purpose is to provide an opportunity to improve the understanding on cycles of carbon

dioxide, water vapor, and heat energy in terrestrial ecosystems. Topics included tower flux measurement, carbon cycle process models, remote sensing, general flux research, and others in related to terrestrial material cycle, especially carbon. Special session, "Flux measurements on complex topography" was also held in this workshop. More than 130 participants attended this meeting, including scientists and students from research institutions and universities in Australia, Bangladesh, Canada, China, Hungary, India, Japan, Korea, Malaysia, Philippines, Thailand, and USA. A small trip to Biodiversity Center of Japan , Yamanashi Institute of Environmental Sciences, Mt. Fuji, and a flux site in a Japanese red pine forest operated by FFPRI, was made on the last clear day of the workshop, after the Typhoon passed.

3.1.1 New Programs of AsiaFlux and reports from Asian countries

Two funds by MEXT and APN have been accepted in July 2005 for AsiaFlux activities. At the beginning of the workshop, Y. Ohtani (FFPRI), new chair of the AsiaFlux, proposed new strategies of AsiaFlux activities in the coming few years based on these funds, following the introduction of the AsiaFlux history from 1999. Please refer the previous article in this issue.

Recent progress in KoFlux (Korea) and ChinaFLUX (China) was introduced by J. Kim (Yonsei University) and G. Yu (Chinese Academy of Science; CAS) respectively. During the Phase I (2001-2004) of the KoFlux Program, the KoFlux team developed a global network (www.koflux.org), ensuring that KoFlux data could be collected and shared anywhere. Three of the KoFlux sites have been registered as reference sites for the GEWEX's inter project, Coordinated Enhanced Observing Period (CEOP), and the data have been submitted to the international community. During the Phase II (2004-2007), the initial 8 KoFlux sites have been reduced to 4 sites (one forest, two agricultural fields, and one prairie site in Tibet, China). Most forest and agricultural ecosystems in Korea are heterogeneous, and the application of conventional eddy covariance technique has been a difficult challenge for data collection, processing and analysis. The second phase ("Carbo/HydroKorea") focuses on linking flux footprint, eco-hydrological models and satellite image to bridge the gaps between different scales of carbon/water exchange processes in a complex landscape. For this purpose, they re-defined a forested watershed site (Gwangneung flux site) as the super site.

The Chinese progress in establishing the flux network is remarkable. 10 ChinaFLUX sites are operated for two years, and 6 sites are in construction enhanced by CAS. Most of these sites are designated as sites of the Chinese Ecosystem Research Network (CERN). In addition, Chinese Academy of Meteorological Sciences (CMA) has started the flux observation program at some of the meteorological station, already working as a routinely meteorological station. The flux measurement and data processing are operated by several institutes of CMA placed at all over China. They planed to establish 9 flux sites by the end of this year (2005). Furthermore, other flux sites are planned by Department of Science and Technology State Forestry Administration, China in some of the Chinese Forest Ecosystem Research Network (CFERN) sites. Although most of the ChinaFLUX sites were established 2 years ago, the network fulfills its function led by CAS. The quality control and assurance of the flux data are operated systematically, and database construction is in progress. As KoFlux strategy, ChinaFLUX intend to integrate the data from many flux sites, some of those are in a terrestrial transect of GCTE/IGBP, and to link the flux footprint, eco-hydrological models and satellite image to discuss the large scale materials (carbon, water, nitrogen, and phosphorus) dynamics.

Reports from other 4 countries in Asia were presented, and future research plan and the possible connection with AsiaFlux were discussed. E. Phillip (Forest Research

Institute Malaysia) reported the research and development activities on climate change in Malaysia. E.P. presented the C-sequestration capacity of several ecosystems (Peat swamp, Mangrove, Plantation, Inland forest, and others), based on the data of the C-sequestration inventory in Malaysian forest or the carbon budget study in Pasoh and Lambir Forest Reserves, and discussed the impact of climate change on these ecosystems based on the ecological data. C. Senthong (Chiang Mai University) introduced the 6 flux sites in Thailand, which were constructed by members of the AsiaFlux, and their recent research works on micrometeorology. In addition, C.S. introduced a new program "The Royal Golden Jubilee Ph. D. program" granted by Thailand Research Fund to train young scientists of micrometeorology. M. A. Baten (Bangladesh Agricultural University) introduced the natural, agricultural, ecological, and scientific aspects of Bangladesh, and a plan to monitor the CO_2 and H_2O fluxes at a rice ecosystem with help of National Institute for Agro-Environmental Sciences, Japan (NIAES). N. Hooda (Ministry of Environment and Forests, India) presented recent researches on the assessment of major carbon pools and fluxes in India's forest and their change caused by the change in the land use, based on the taught data sets of forest and soil carbon inventories of all over India and land use change data obtained by satellite mapping. Additionally, N.H. showed a prediction of the change in the NPP due to the climate change, using the BIOME-3 model. In order to improve its precision, she pointed out the necessity of the intensive research on the carbon dynamics by tower flux measurement at some of the typical forest ecosystems in India.

3.1.2 Special Session "Complex Topography"

There are many problems in the flux measurement on complex terrain. This session was held to recognize the problems and find solutions for them. Topics presented here were focused on nocturnal processes of CO_2 flux that is not well understood. L. Mahrt (Oregon State University) reviewed difficulties with eddy-correlation measurements in complex terrain, showing examples from field experiments in central Oregon, USA. L.M. stressed that the contribution of the advection with drainage flows to NEE is important. The horizontal transport can be directly estimated only with a dense measurement network, and the vertical motion is predictable by the divergence method based on the mass continuity equation. L.M. also proposed a technique that varies averaging length of flux calculation according to the stability and the measurement height (Vickers and Mahrt, 2003). This technique can provide superior fluxes without substantial contributions of mesoscale motions, which lead to a large unnecessary scatter when we estimate fluxes under the condition with weak turbulence. H. Kondo (National Institute of Advanced Industrial Science and Technology, Japan) reported the long-term CO_2 flux measurement at Takayama site in Japan. In this site, NEP estimated from the eddy covariance method was lager than that from biometric methods. This might be caused by the difficulties in CO_2 flux measurements at night. As a result of the examining details of the micrometeorology, irregular features on the time series of the CO_2 concentration and flux were found. H.K. suggested that these features arose from the differences of fetch and wind direction and the influence of the advection. X. Wen (CAS) reported about the estimation of ecosystem respiration over a hilly region. He showed results that the quality of eddy-flux data degrades as terrain complexity increases, and indicated the strategy of u_* correction for nocturnal CO_2 fluxes in ChinaFLUX. To estimate ecosystem respiration range, X.W. recommended combining different u_* threshold values and ecosystem respiration models. In his report, the ratio of Gross primary production to Ecosystem respiration was used to evaluate the relative contribution of these exchange processes to the total annual exchange, and the ratio could be used for determining ecological rationality of ecosystem respiration. Y. Kominami (FFPRI) tried to estimate NEE of a deciduous forest in a complex terrain with various methods: eddy-covariance, chamber and biometric methods. Compared with the biometric and

chamber measurements, u_* threshold for nighttime respiration was determined. Y.K. also pointed out that the interpolation function varied with seasons and the seasonal change was occurred by the change in the growth respiration rate in spring and the decrease in soil respiration in summer. S. Okubo (Kyoto University) validated nighttime CO_2 flux data in a mountainous site by comparing with chamber measurements of leaf, trunk and soil respirations. S.O. verified that nighttime NEE estimated from the tower-based measurement nearly equaled to the ecosystem respiration estimated from the chamber measurements at high u_* conditions. These results provided a positive prospect of the u_* correction in a complex terrain. M. Y. Leclerc (The University of Georgia) addressed the problems of nighttime flux measurements and their interpretation. M.L. showed the impact of nighttime atmospheric phenomena (waves, low-level jet and so on) on fluxes. The interactions between these phenomena at night suggested that tower flux measurements include not only the influence of the underlying surface, but also the influence of the structure of the atmosphere above. M.L. cautioned about the selection of nighttime calculations of NEE: Not all periods exhibiting turbulent mixing with arbitrary above-threshold velocities qualify to represent surface-atmosphere exchange of a target area.

The following two studies are presented in other session but are strongly related to this issue. R. Leuning (CSIRO, Australia) introduced novel mass-balance approach to measure the mass balance of a 50x50x6m control volume installed in a tall Eucalyptus forest in south east Australia. Net fluxes of CO_2 from the soil and vegetation were estimated from the vector sums of fluxes through the sidewalls and upper surface of the control volume. The novelty of the measurement system was the use of windspeed-weighted sampling of air from six airlines per sidewall combined with eddy flux instrumentation at 6 m. The results showed that all terms in mass balance equation (change in storage, eddy flux across lid, and horizontal advection) were the same scale and important at night. In addition, 10-day mean mass balance flux agreed with the biological measurements, however the dynamics was different. Y. Kosugi (Kyoto University) validated evapotranspiration rate obtained by eddy flux observation at a hilly watershed using the watershed water balance evaluation. Y.K. suggested that the correction to close the energy budget improved the water budget in the watershed.

3.1.3 Other sessions (Long-term Flux Observation, Earth Observation and AsiaFlux, Biochemical Cycles in Terrestrial Ecosystem, Modeling and Remote Sensing of Terrestrial Ecosystem, and Poster session)

In “Long-term Flux Observation” session, continuous flux observation studies in several ecosystem types in Asia (e.g. peat swamp forests, boreal forests, Japanese cypress forest, Tibetan plateau, croplands, Inner Mongolia steppe, coniferous plantation, and tidal zone) were introduced. In “Biochemical Cycles in Terrestrial Ecosystem” session, emission of carbons (e.g. CO_2, CH_4, and Isoprene) from each component (e.g. soil, stem, leaf, root) in several ecosystems were discussed. Some researchers had developed automatic chamber systems to evaluate the continuous flux. Additionally, many studies used stable isotopes to evaluate the water stress of forest trees, to partition NEE into photosynthesis and respiration factors, or to detect the origin of the respired CO_2. In addition, some studies discussed how land use change caused the change in the carbon dynamics, based on forest and soil carbon inventories. In “Modeling and Remote Sensing of Terrestrial Ecosystem” session, both localized process simulations and globalization using MODIS, TsuBiMo, and Sim-Cycle were discussed. Some researches used a neural network for the gap-filling of CO_2 flux data sets. As issues and problems of this session, the followings are offered and discussed. 1. Validation of global ecosystem models, 2. How to incorporate small-scale processes into global models (scaling problem), 3. There are too many empirical equations (processes) that cannot be globalized (Respiration is a very important

component – Q10 parameterization is grossly inadequate), 4. First principle approach? - Unification of concepts ("GCMs" of ecosystem models). In "Earth Observation and AsiaFlux" session, G. Inoue (NIES) presented possible contribution of AsiaFlux to an international operational observation "Integrated Global Carbon Observation (IGCO)" in Integrated Global Observing Strategy (IGOS; http://www.eohandbook.com/igosp/) proposed by WMO and UNEP, and the relation of IGCO to the research planning "Global Carbon Project (GCP; http://www.globalcarbonproject.org)" (Global Carbon Project, 2003) and the assessment "Intergovernmental Panel on Climate Change (IPCC)". In addition, G.I. introduced the Greenhouse gasses observing satellite (GOSAT) that will be launched in 2008. GOSAT is developed by the Ministry of Environment, Japan and Japan Aerospace Exploration Agency and can estimate column-integrated atmospheric CO_2 and CH_4. H. Sawada (FFPRI) introduced the application of satellite data to monitor forest ecosystems. More than 50 studies, concerning on the above-mentioned issues, were presented in the Poster session. (Takagi, K. and Yasuda, Y., 2005)

3.2 AsiaFlux Workshop2006

The AsiaFlux Workshop 2006 was held successfully with more than 140 participants from 13 countries and regions from 29 November to 1 December 2006 in Chiang Mai, Thailand. This workshop was titled "International Workshop on Flux Estimation over Diverse Terrestrial Ecosystems in Asia" and organized by AsiaFlux Steering Committee and Chiang Mai University (CMU, Thailand) with the funding supports from Asia-Pacific Network for Global Change Research (APN) and Ministry of Education, Culture, Sports, Sciences and Technology (MEXT, Japan). In addition, two Japanese research institutions, Forestry and Forest Products Research Institute (FFPRI, Japan) and National Institute for Environmental Studies (NIES, Japan), also supported this workshop. Participants came from various countries inside and outside of Asia, including Australia, Bangladesh, China, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, UK and USA.

This 5th meeting was the very first AsiaFlux workshop in tropical region therefore the special session was titled "Tropical Ecosystem" and we discussed much about the material cycle in the tropical region. Other topics included tower flux measurement and inter-comparison, biochemical processes, modeling, remote sensing and others in relation to terrestrial material cycle.

The numbers of presentations were 38 and 86 in oral and poster sessions, respectively; this AsiaFlux Workshop 2006 was the largest of all AsiaFlux Workshops ever held since the establishment of AsiaFlux.

3.2.1 Overview of AsiaFlux and FLUXNET Activities

The workshop opened with the welcome address and report by P. Angkasith (President of CMU, Thailand) and opening speech by P. Ayudhaya (Permanent Secretary, Ministry of Natural Resources and Environment, Thailand). Y. Ohtani (FFPRI) and each AsiaFlux sub-workgroups had reported the recent activities of AsiaFlux in the oral and poster sessions. The new AsiaFlux webpage would be available shortly and it would provide the latest information in the member's area. AsiaFlux database was constructed to promote synthesized analysis and interdisciplinary studies, and it would be accessible from the AsiaFlux webpage within the next few months. M. Falk (University of California, Davis, USA), G. Matteucci (Institute for Mediterranean Agriculture and Forest System, Italy) and R. Leuning (CSIRO, Australia) presented recent

situations in global and regional networks in flux measurement. FLUXNET highlighted the importance of synthesizing analysis and announced that they were going to hold FLUXNET data synthesis workshop in February 2007.

3.2.2 Establishment of New Sub-Regional Networks in Asia

Some of noteworthy presentations at this workshop were about new national/regional networks in flux observation in Asia. N. Tangtham (Kasetsart University, Thailand) reported about flux observations during past four decades in Thailand and the attempt of establishing a network "ThaiFlux" which consists of existing flux sites in Thailand. He also mentioned that the first colloquium was held on 31 October 2006 to promote an information exchange and strengthen the collaboration among researchers in Bangkok, it is hopeful that this activity will be strengthened and spread throughout Thailand based on this workshop. Y. Hsia (National Dong Hwa University, Taiwan) mentioned about Taiwan flux network, and several new approaches for flux measurements were reported by other Taiwanese researchers. The establishment plan of Philippine flux network was also introduced by a M. Aguilos (Department of Environment and Natural Resources, Philippines). We would like to point out that many of broachers for those new network establishments (or the plans) were participants in AsiaFlux Training Course 2006, which is the most fruitful AsiaFlux activities in 2006. This course seemed to have a positive effect on the capacity building in Asia.

3.2.3 Field Trip to the Huay Kog Ma Watershed

A day's field trip was made on the last day of the workshop. N. Tangtham and M. Suzuki (The University of Tokyo, Japan) kindly presented the flux site at the Huay Kog Ma Watershed Research Station, which has been jointly operated by Kasetsart University and The University of Tokyo. Royal Flora Expo "Ratchapruek 2006" was also visited. (Inukai, K. and Lakanavichian, S., 2006)

3.3 Data reanalysis

We have carried out inter-comparison of measurement by using annual data from different type of observation method (open- and closed-path system). We have installed both systems on the same observation towers which are located in the different vegetation and climate zone, such as paddy filed (Tsukuba, warm-temperate zone) and larch forest (Tomakomai, cool-temperate zone).

The results show a significant difference in CO_2 flux values between the different observation methods. For 30-minutes averaged value, closed-path system shows 0.04-0.64 micro-mole/m2/s bigger than the one from open-path system in both sites. This difference corresponds to 15-242 $gC/m^2/yr$. This result denotes the same tendency both in day and night, which means this difference in values is purely due to the difference in the observation method. CO_2 flux value from closed-path system tends to increase as sensible heat flux increases, whereas open-path system shows larger reading when wind speed increases. These results shall be valuable evaluating index for previously obtained data.

3.4 Publication of technical manual on flux measurements

We have compiled a concrete technical manual on flux measurements to summarize the new standard method and to promote it in Asian countries. We have used the manual as a text book in AsiaFlux Training Course 2006. The capacity building activities both in hardware (instrumentation) and in software (method of data analysis) are ready to practice when requests arise.

4.0 Conclusions

The aims of the project were:

1) To promote information exchange and to improve methodology in flux observation and data analysis among participating countries in order to provide much more reliable carbon budget data in Asian monsoon terrestrial ecosystems,

2) To promote the systematic carbon budget observation in Asia and to encourage activities of observation in Asian countries with the development of AsiaFlux network.

The followings are the findings and results:

1) More than 130 participants have attended to two AsiaFlux workshops each time from both inside and outside Asia. About 100 reports are published in the proceedings in both workshops. (Appendix A1 and A2)

2) Our training program has motivated Asian young researchers to start establishing new regional network in their country and begin flux observation by their own exertions. (section 3.2.2)

5.0 Future Directions

We realized there are a lot of attentions in Asia for this observation study. There are also strong potentials to establish the research foundations and begin observation is we can provide little support (both technical and financial) to them. We consider AsiaFlux Training Course to be one of the keys, to encourage these potential flux researchers. In March 2007, we had a meeting in Seoul South Korea with AsiaFlux members to discuss our future policy of training activity. We also decided to hold another training program (AsiaFlux Training Course 2007) in July 2007 in Seoul.

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Appendix

A1. Workshop I: AsiaFlux Workshop 2005

Title: International Workshop on Advanced Flux Network and Flux Evaluation.
Date: 24-26 August, 2005
Venue: Highland Resort, Fujiyoshida, Japan
Program:
- Opening Session: Activities of Local Network in Asia
- Oral Session 1: Long-Term Flux Observation (I)
- Earth Observation and AsiaFlux
- Special Session: Complex Topography
- Organization and National Report
- Oral Session 2: Biochemical Cycles in Terrestrial Ecosystem
- Oral Session 3: Long-Term Flux Observation (II)
- Oral Session 4: Modeling and Remote Sensing of Terrestrial Ecosystem
- Poster Session

Number of Presenting Authors:
- 111

(Details are indicated in the attached proceeding pdf file.)

A2. Workshop II: AsiaFlux Workshop 2006

Title: International Workshop on Flux Estimation over Diverse Terrestrial Ecosystems in Asia.
Date: 29 November - 1 December, 2006
Venue: Suan Bua Resort and Spa, Chiang Mai, Thailand
Organized by
- AsiaFlux Steering Committee

Co-Organized by
- Chiang Mai University, Thailand

Sponsored by
- Ministry of Education, Culture, Sports, Science and Technology, Japan
- Asia-Pacific Network for Global Change Research
- Forestry and Forest Products Research Institute, Japan
- National Institute for Environmental Studies, Japan

Program:
- Opening Session: Activities of Flux Network
- Oral Session I: Flux Intercomparison
- Special Session: Tropical Ecosystem
- Oral Session II: Flux estimation and New Approach
- Oral Session III: Biochiemical Processes
- Oral Session IV: Modeling and Remote Sensing
- Poster Session

Number of Presenting Authors:
- 113

(Details are indicated in the attached proceeding pdf file.)

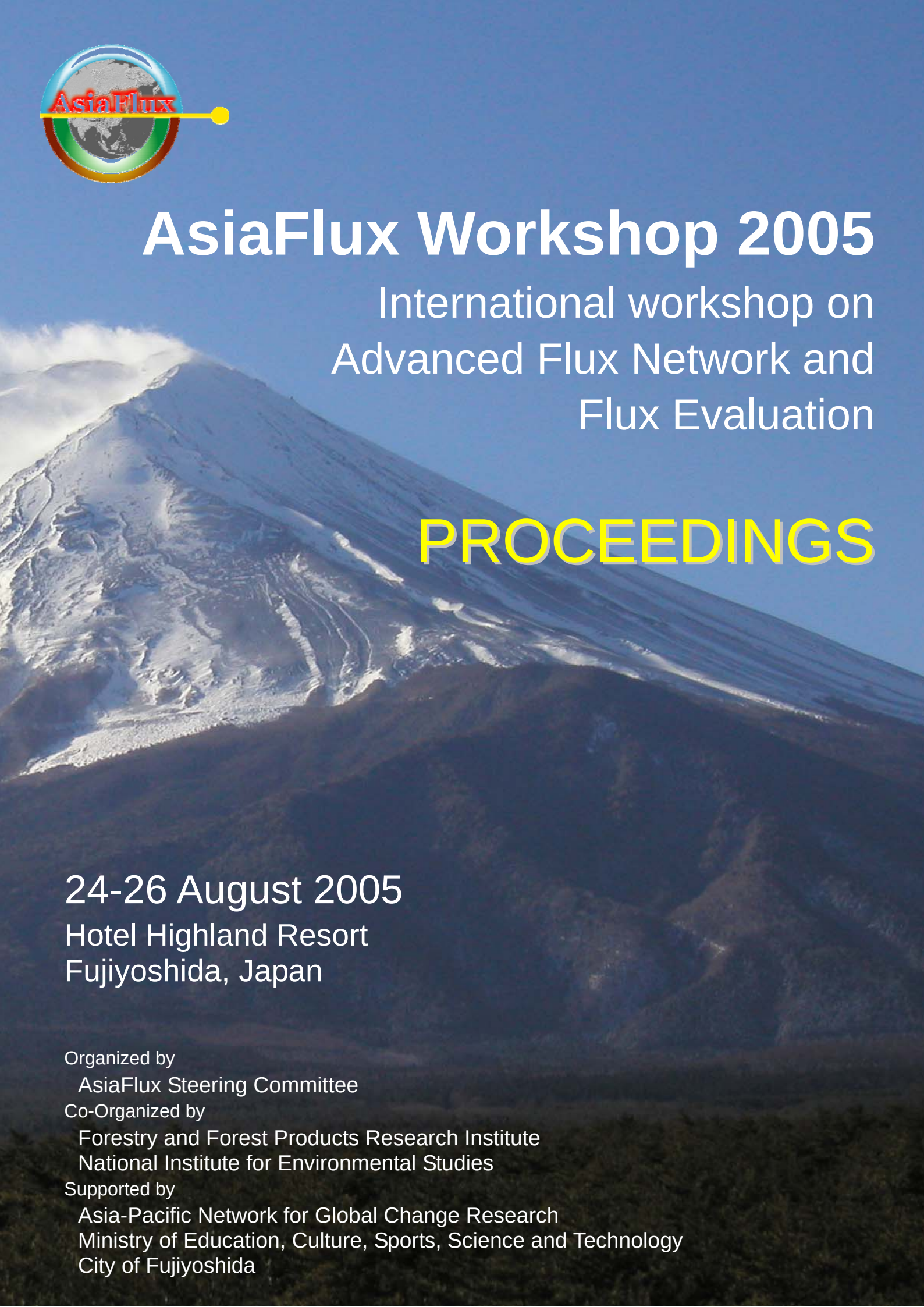
<u>Funding sources outside the APN</u>

Ministry of Education, Culture, Sports, Science and Technology (MEXT)

"Initiation of the next-generation AsiaFlux"
21,000,000JPY, FY2005; 30,963,000JPY, FY2006

Glossary of Terms

AIST: National Research Institute for Advanced Industrial Science and Technology, Japan
APN: Asia-Pacific Network for Global Change Research
CAS: Chinese Academy of Science
CERN: Chinese Ecosystem Research Network
CGER: Center for Global Change Research, NIES, Japan
ChinaFLUX: A flux observation network in China by CERN
CMA: Chinese Academy of Meteorological Sciences
CSIRO: Australian Commonwealth Scientific and Research Organization
EUROFLUX: A regional flux observation network in Europe
FFPRI: Forestry and Forest Products Research Institute, Japan
FLUXNET: A global flux observation network
GCP: Global Carbon Project
GCTE: Global Change and Terrestrial Ecosystems
GEWEX: Global Energy and Water cycle Experiment
GOSAT: Green Hause Gases Observing Sattelite
GPP: Gloss primary productivity (production)
IGBP: International Geosphere-Biosphere Programme
IGOS: Integrated Global Observing Strategy
IGCO: Integrated Global Carbon Observation
IPCC: Intergovernmental Panel on Climate Change
KoFlux: A flux observation network in Korea
MEXT: Ministry of Education, Culture, Sports, Science and Technology
NEE: Net ecosystem carbon dioxide exchange
NEP: Net ecosystem productivity (production) (= -NEE)
NIAES: National Institute for Agro-Environmental Sciences, Japan
NIES: National Institute for Environmental Studies, Japan



AsiaFlux Workshop 2005

International workshop on Advanced Flux Network and Flux Evaluation

PROCEEDINGS

24-26 August 2005

Hotel Highland Resort
Fujiyoshida, Japan

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S01

PRESENT SITUATION AND CHALLENGES OF ASIAFLUX - IMPLEMENTATION OF NEW PROGRAMS -

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Since the establishment of AsiaFlux in 2000, we have hosted three international workshops for the advancement of a flux measurement network in Asia. We have also published a booklet on flux observations and analyses as well as 14 volumes of the AsiaFlux Newsletter to promote the exchange of information on terrestrial carbon balance studies mainly in East and South-East Asia. AsiaFlux is now in the process of developing new programs with financial support from two distinct projects: "Initiation of the next-generation AsiaFlux" by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) and "Standardization and Systematization of Carbon-Budget Observation in Asian Terrestrial Ecosystems Based on AsiaFlux Framework" by the Asia-Pacific Network for Global Change Research (APN).

There are three main objectives for the MEXT project: 1) to offer training courses for flux measurements and analyses to scientists in Asia, 2) to develop a standardized portable flux observation system and flux analysis techniques for inter-comparing flux measurements among the AsiaFlux sites, and 3) to establish a structure for sharing and exchanging data within and outside the Asiaflux community. The aim of the training courses is to help scientists maintain their local flux observational sites and effectively analyze data. Use of the portable flux observational system and development of standardized analysis techniques will improve data accuracy. Collaborative flux observations will also be made in one or two terrestrial ecosystems in Asia within the MEXT project framework. The financial support from the APN project will be spent to host workshops and to prepare manuals for the training courses offered with the funding from the MEXT project.

Improved organization of AsiaFlux is considered important to effectively implement the above-mentioned programs. For this purpose, we are planning to establish workgroups within the AsiaFlux organization. With the support from the steering and executive committees, each workgroup takes an active part for implementing these new programs. We believe the efforts made through the MEXT and APN projects will enhance research collaboration among Asian nations and reinforce the existing framework for research cooperation among AsiaFlux, KoFlux and the Chinese flux community, with the collaboration from OzFlux.

Revision of the AsiaFlux Organization (tentative)

AsiaFlux Steering Committee
AsiaFlux Executive Committee
AsiaFlux Secretariat
AsiaFlux Workgroups (WG) and Sub-Workgroups (SWG) (New)
- AsiaFlux General WG
  - AsiaFlux Network Management SWG (e.g. Updating AsiaFlux directory and web page)
  - AsiaFlux Editorial SWG (e.g. AsiaFlux Newsletter)
  - Workshop Management SWG (e.g. AsiaFlux Workshop)
- Measurement and Data Policy WG
  - Measurement Support and Standardization SWG (e.g. Flux measurement and analysis methodology, site planning, and inter-site comparison)
  - Database and Data Policy SWG (e.g. AsiaFlux data policy and database arrangement)
  - Short Training Courses SWG (e.g. AsiaFlux training courses for flux measurement and analysis)

S02

KOFLUX PROGRESS REPORT

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The KoFlux Program is dedicated to understanding the fluxes of energy and matter, net ecosystem production, and water resource management in key ecosystems of Monsoon Asia. KoFlux was launched in 2001 by networking individual research sites and the limited available resources in Korea to support AsiaFlux, which builds upon the scientific initiatives of regional networks such as JapanNet, ChinaFlux, KoFlux to provide a mechanism to consolidate and leverage their scientific activities. In this way, the value of data from each site is greatly augmented and new scientific questions are further explored and answered.

During Phase I (from 2001 to 2004), the KoFlux team developed a global network (www.koflux.org), providing that KoFlux data could be collected and shared anywhere. Three of the eight flux sites have been registered as reference sites for the GEWEX's inter project, Coordinated Enhanced Observing Period (CEOP,) and the data have been submitted to the international community. During the Phase II (2004-2007), the initial eight sites have been reduced to four sites (one forest and two agricultural sites in Korean Peninsula, one prairie site in Tibet, China) due to the limited funding and human resources. Most forest and agricultural ecosystems in Korea are heterogeneous, and the application of conventional eddy covariance technique has been a difficult challenge for data collection, processing and analysis. The second phase of KoFlux ("Carbo/HydroKorea") focuses on linking flux footprint, ecohydrological models and satellite images to bridge the gaps between different scales of carbon/water exchange processes in a complex landscape.

A major difference between 1st phase of KoFlux research and its successor is the establishment of the supersite where inter-disciplinary, coordinated research efforts are conducted. The Gwangneung flux site, where a flux tower has been operated since the beginning of KoFlux and ecological and hydrological information have been monitored for more than 10 years, is selected as a representative landscape of the country and becomes the center of the inter-disciplinary researches. For this, the Gwangneung supersite is re-defined as a 7 x 7 km (MODIS) unit that includes two flux towers. Within this MODIS unit, a 3 x 3 km intensive monitoring unit is designated. The unit is further subdivided into nine 1 x 1 km basic units, comparable to the scale of MODIS grid, that become the basic component of intensive field monitoring, modeling and image analysis studies. In this progress report, we present the current status of the ongoing flux sites including some preliminary results.

Acknowledgments: KoFlux is supported by the Eco-Technopia 21 Project (Ministry of Environment) and by a grant (code:1-8-2) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program (Ministries of Science and Technology & Construction and Transportation of Korea).

O11

CO_2 EXCHANGE OF A TROPICAL PEAT SWAMP FOREST IN CENTRAL KALIMANTAN

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Peatland existing in the tropics has accumulated a large amount of carbon as organic matter. Indonesia contains the largest area of tropical petland, and the petaland usually coexists with tropical peat swamp forests. Recently, however, deforestation and drainage are in progress on a large scale owing to a growing demand for timber and farmlands. In addition, the ENSO drought and its consequent large-scale fires are accelerating the devastation of the peatland. The devastation enhances the decomposition of organic matter stored in peatland, and consequently increases carbon release to the atmosphere as CO_2. This suggests that tropical peatland will be a major CO_2 source in the near future. To evaluate the CO_2 balance of tropical peatland, we have measured CO_2 flux above a tropical peat swamp forest remaining in Area B of the Mega Rice Project near Palangkaraya, Central Kalimantan, Indonesia since November 2001.

The forest is located on flat peatland between a river and channel. Water table in the forest was zonally reduced near the channel. A tower of 50 m height was constructed about 300 m inside from the northeast corner of the forest (2º 20' 41.6" S, 114º 2' 11.3" E). Dominant tree species of the forest are *Combretocarpus rotundatus*, *Cratoxylum arborescens*, *Buchanania sessifolia* and *Tetrameristra glabra* and rich shrubs grow in the trunk space. The height of the forest canopy is about 26 m. Predominant wind direction was the south (SE-SW). Fetch was longer than 1 km for the southern wind. During the dry season of 2002, between mid-August and late October, peatland fires occurred in large areas around Palangkaraya because of the ENSO drought, whereas the forest did not burn. CO_2 and energy fluxes have been measured at 41.7 m by the eddy covariance technique with a sonic anemometer-thermometer (CSAT3, CSI) and an open-path CO_2 analyzer (LI7500, Licor) facing the south. Sensor signals were recorded with a data logger (8421, HIOKI) at 10 Hz. In addition, CO_2 concentrations have been measured at six heights below the flux measuring height with a closed-path CO_2 analyzer (LI820, Licor) to calculate CO_2 storage flux (F_s). Hourly mean fluxes were calculated from the data according to the following procedures: 1) removal of noise spikes, 2) planar fit rotation, 3) covariance calculation using block average, 4) WPL correction. From CO_2 flux (F_c) and F_s, net ecosystem CO_2 exchange (NEE) was calculated (NEE = F_c + F_s). Data quality was checked by wind direction and steady state tests. In addition, a friction velocity (u^*) threshold of 0.08 m s^{-1} was applied for nighttime. Gaps of missing data were filled using empirical models; ecosystem respiration (RE) or nighttime NEE was estimated from soil moisture, and gross primary production (GPP) was estimated form photosynthetic photon flux density (PPFD).

In this area, the dry season began in May and lasted until October, judging from monthly precipitation of 100 mm. CO_2 fluxes showed seasonal variations. Typically GPP continued to become more negative from the mid rainy season until the mid dry season, and rapidly became more positive in the late dry season. On the other hand, RE continued to increase through the dry season. As a result, NEE was smallest in the mid dry season at around zero and largest in the late dry season. In total, GPP and RE were significantly more negative and positive, respectively, in the dry season than the rainy season. However, NEE showed no significant difference between two seasons. These seasonal variations of CO_2 fluxes were caused by those of PPFD, vapor pressure deficit (VPD) and water table. During the dry season, high PPFD enhanced GPP until July or August, whereas high VPD depressed it in September and October. Low water table, which reflected on low soil moisture, enhanced RE through peat decomposition because the aerobic layer of peat increased; the negative relationship between RE and soil moisture is a distinctive feature at peatland.

The annual sums of NEE, RE and GPP were 721, 3580 and -2859 in 2002, 527, 3686 and -3159 in 2003, and 356, 3583 and -3227 gC m^{-2} y^{-1} in 2004, respectively. This forest worked as a net source of CO_2 at an intensity of 535±183 gC m^{-2} y^{-1} for the atmosphere from 2002 through 2004. The source intensity was largest in 2002, an ENSO year; this was probably caused by drought and low PPFD, which was caused by dense smoke emitted through large-scale fires.

O12

A COMPARATIVE STUDY OF CARBON DIOXIDE EXCHANGE BETWEEN A MATURE AND A REGROWTH JACK PINE FORESTS AT BERMS (BOREAL ECOSYSTEM RESEARCH AND MONITORING SITES, CANADA)

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The relationship between soil moisture and ecosystem-level carbon budget was investigated for BERMS (Boreal Ecosystem Research and Monitoring Sites, http://berms.ccrp.ec.gc.ca/) sites in Saskatchewan, Canada, using eddy covariance flux measurements obtained during 2001, 2002 and 2003. The study sites were located in a mature jack pine forest (*Pinus banksiana Lamb*.) with tree age of approximately 80 years, and in a young jack pine stand characterized by a sparse low canopy. Jack pine is an evergreen coniferous species that is found on well-drained and nutrient-poor soils. It is a pioneer species that grows quickly after a natural disturbance (e.g. fire or harvesting) and thus plays an important role in ecosystem regeneration after such disturbances.

The mature jack pine forest site (referred to as the old jack pine "OJP" site, location 53^{o} 55'N, 104^{o} 41'W) was established in 1993 in the southern portion of the Canadian boreal forest as part of the Boreal Ecosystem-Atmosphere Study (BOREAS) program. Under the BERMS program, carbon dioxide, water vapor, and sensible heat flux measurements have continued since 1999, using three-dimensional sonic anemometer-thermometer and a closed-path infrared gas analyzer on a scaffold tower at 28 m above ground.

The adjacent young jack pine site (referred to as harvested jack pine site, "HJP94", 53^{o} 54'N, 104^{o} 39'W) was established in 2001 at approximately 2 km southeast of the OJP site. A mature jack pine forest was harvested (clear-cut) in 1994 over an area of approximately 30 ha, and young trees from the ages of one year to ten years have been regenerating naturally. Fluxes were measured on a tower at 5 m above the ground, using a three-dimensional sonic anemometer-thermometer and a closed-path infrared gas analyzer.

The present study focuses on the relationship of the carbon budget components with soil moisture and various other environmental factors at the OJP and HJP94 sites. Focuses are also on the effect of seasonal and inter-annual variations in climate on carbon and water budgets at the sites with different age distributions, to increase our understanding of a transition of carbon cycling with ecosystem regeneration.

Net ecosystem CO_2 exchange (NEE), total ecosystem respiration (RE) and gross primary production (GPP) were estimated from 2001 to 2003 at the OJP and HJP94 sites. We conclude that the nighttime NEE at both sites had a positive correlation with soil volumetric water content (VWC), as well as with soil temperature, in warm growing seasons but was almost independent of VWC in cold dormant seasons. The positive correlation with VWC was more apparent at HJP94 than at OJP.

The high sensitivity of GPP and RE to VWC variations was more obvious at HJP94, probably related to the severe water stress on the photosynthetic and respiratory activities caused by poor water holding capacity of the sandy soil layer and the shallow root system of the young trees, many of which were less than ten years old. At HJP94, the relatively large RE, which sometimes exceeded GPP, was caused by high respiration rate and low LAI. The decomposition of remaining dead plant mass, either buried or on the ground surface, likely contributed to the large RE at the site. Since VWC displayed a strong seasonal variation in a shallow surface soil layer, it could be an important seasonal environmental factor governing photosynthetic and respiratory activities at sparse young forest stands like HJP94.

O13

EDDY COVARIANCE SENSIBLE AND LATENT HEAT FLUXES FOR THREE YEARS ABOVE A JAPANESE CYPRESS FOREST WITH COMPLEX TOPOGRAPHY

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Typical plantation forests in the mountains of Japan are evergreen coniferous forests. Evapotranspiration from these forests greatly influences hydrological and micrometeorological processes and also the environmental functions of the forests. Annual evapotranspiration is a component of the water cycle and can be estimated using the water balance method to elucidate the relationship with annual precipitation. However, an approach using annual hydrological data cannot rule out controlling factors or their influences on the characteristics of evapotranspiration. As a result, differences based on forest type cannot be studied in depth. In contrast, evaluation of evapotranspiration using eddy covariance heat fluxes coupled with micrometeorological data allows analysis of the factors that control evapotranspiration. Analysis of dry-canopy transpiration measured with the eddy covariance method will yield information on stomatal behavior and influence on heat, water vapor, and carbon dioxide fluxes. Understanding how dry canopy transpiration interacts with photosynthesis and is influenced by stomatal regulation is critical for understanding gas-exchange processes. Diurnal, seasonal, and inter-annual fluctuations in evapotranspiration and bulk parameters, which include surface conductance (Monteith, 1973) and decoupling factor (McNaughton and Jarvis, 1983), can and should be evaluated for various vegetation types using long term flux datasets.

There is a possibility that surface conductance is underestimated in the eddy covariance method because of an energy closure problem (the imbalance problem), i.e., sensible and latent heat fluxes are underestimated. Accurately measuring energy fluxes for the eddy covariance method may be difficult, especially for forest sites with complex topography. The imbalance problem has been noted in many sites. Whether eddy covariance data provide accurate information so that heat fluxes and evapotranspiration can be evaluated is a question that must be answered for individual sites.

In this study, we analyzed sensible and latent heat fluxes for 3 years (2001 to 2003) over a Japanese cypress forest with complex topography in central Japan. The observation site (Kiryu Experimental Watershed) was established in 1967 to study hydrological water circulation and to evaluate the roles of trees and soil in the forest. It represents one of the longest continuous research programs in Japan and has 33 years' reliable hydrological datasets from 1972. We also compared the evapotranspiration estimated with eddy covariance method with those estimated with long-term and short-term water budget methods for the validation.

A detailed assessment of the energy budget closure was performed to reveal the diagnosis of energy imbalance. The assessment of the energy budget closure coupling with the comparison between eddy covariance and water budget methods revealed that eddy covariance method underestimated the evapotranspiration even after careful data quality check. The underestimation during and after rain with closed path method was especially critical. Our suggestion for the practical solution is to apply the correction to the eddy covariance sensible and latent heat fluxes to close the energy budget. Comparison of eddy covariance method with long-term and short-term water budget methods also suggested the necessity of some corrections.

The observations described the magnitude and seasonal and inter-annual variations in sensible and latent heat fluxes, evapotranspiration and the parameters describing bulk canopy characteristics. This forest was characterized by relatively small values of surface conductance and decoupling factor compared to other forests. However, several other coniferous forests in the literatures showed smaller values. Surface conductance, and thus stomatal regulation, is important in controlling dry-canopy transpiration in this forest. Both amplitude and characteristics of seasonal fluctuation of evapotranspiration and surface conductance showed no significant inter-annual differences in spite of considerable fluctuation in precipitation and thus soil moisture condition.

O14

A novel mass-balance technique for measuring CO2 fluxes in nocturnal drainage flows beneath a forest canopy

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Eddy covariance measurements often underestimate net ecosystem CO_2 exchange under stable atmospheric conditions at night when compared to biological measurements of plant and soil respiration. One hypothesis is that errors arise because eddy covariance instruments placed above the canopy cannot measure the horizontal flux divergences associated with lateral drainage of stably stratified air in the layer below the instruments. Measuring horizontal flux divergences is difficult because the flow of stably stratified air close to the ground is determined by the topography and the degree of stability, and measurements must thus be made in three dimensions. We present details of a novel mass-balance approach to measure the mass balance of a 50 x 50 x 6 m control volume installed in a tall *Eucalyptus* forest in south east Australia. Net fluxes of carbon dioxide from the soil and vegetation are estimated from the vector sums of fluxes through the side walls and upper surface of the control volume. The novelty of the measurement system arises from the use of windspeed-weighted sampling of air from six air lines per side wall combined with eddy flux instrumentation at 6 m.

The mass balance for a square with sides of length L and area $A = L^2$ is:

$$F_0 = F_h + \frac{1}{A}\int_0^L \int_0^h \Delta(uc)dzdy + \frac{1}{A}\int_0^L \int_0^h \Delta(vc)dzdx\,, \qquad (1)$$

where F_0 is the flux at the lower boundary, F_h is the flux through the upper surface at height h, and $\Delta(uc)$ and $\Delta(vc)$ are the change in horizontal fluxes across the y-z and x-z planes, respectively. If we assume that the profiles of u and v have a constant shape and that the wind direction is constant across the control volume during a given averaging period, then the windspeed at any height can be written as

$$u(z) = u_h S(z),\ v(z) = v_h S(z)\,, \qquad (2)$$

and thus Equation (1) becomes

$$F_0 = F_h + \frac{u_h}{L}\left[\int_0^h S(z)c_{yz}(z)dz\Big|_d - \int_0^h S(z)c_{yz}(z)dz\Big|_u\right] + \frac{v_h}{L}\left[\int_0^h S(z)c_{xz}(z)dz\Big|_d - \int_0^h S(z)c_{xz}(z)dz\Big|_u\right] \qquad (3)$$

where the subscripts *yz* and *xz* represent the y-z and x-z planes, and *d* and *u* stand for the downstream and upstream faces of the control volume. Note that $S(z)$ can be considered a weighting factor for the concentration at each height, and provided the profile $S(z)$ is constant, it can be used as a scaling factor to sample the air at each height.

Details of a practical implementation of Equation (3) scheme will be presented, along with results of a two-week field campaign in March 2005 which compares the mass-balance measurements for CO_2 with independent estimates of respiration from the soil and understorey.

O15

Introduction to CMA Flux Network

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Background: The secular increase occurring in carbon dioxide concentration may help stimulation of photosynthesis, crop growth and water use efficiency. However, its potential adverse effects include global warming, perturbations of regional precipitation and soil moisture patterns. China Meteorology Administration (hereinafter, referred to as CMA) needs to investigate the global carbon and water cycle with an emphasis on assessments of surface fluxes within China landscape for better understanding how surface fluxes respond to the change in climate and in ecology. Knowledge about the surface flux is also critical for CMA to develop societal policies on future energy use. In a word, CMA was aware that establishing of flux network would significantly improve our operational work, and therefore is our responsibility too. To quantify the seasonal variations of carbon dioxide and water vapor fluxes, the Fluxnet (AsiaFlux, AmeriFlux, EuroFlux and other) has been operating since 1990s. CMA would like to deeply involve into this network for sharing the benefit within the Fluxnet and for contributing our energy.

What is being done? Recognizing a need for long term measurements, we installed three flux towers in April of 2004. They were equipped with same instruments (CSAT3, and LiCor 7500) for the fast response measurements and have been operating well since beginning. The synchronous slow response measurements (i.e., gradient air temperature, humidity, and wind speed; soil temperature and liquid water content) have been also conducting. The surface types mainly are croplands. The time series of data are ready for analysis. Meanwhile, two dust-storm towers were installed in the suburb of Beijing in north China for monitoring dust-storm, where the fluctuating wind speed and fluctuating air temperature have been collecting since the February 2005. The surfaces are sparse grasslands. In addition, four flux towers are under construction for capturing heat and water fluxes over urban and desert surfaces respectively. In a work, the CMA flux network is growing well now and will be developed further.

What is CMA Flux Data Policy? We are designing a website for releasing data to colleagues within Fluxnet. This website will provide us a bridge of our cooperation.

What are Future Plans? We plan to convene a workshop on 'Strategies for Long Term Studies of CO_2 Heat and Water Vapor Fluxes over Terrestrial Ecosystem' at the end of 2005 in Beijing. Similar to that held during March, 1995 in LaThuile, Italy, the explicit goals of the workshop is to assess the state-of-art of making long term flux measurements and to obtain advice and consensus on the direction of future long-term flux research.

How Can Get More Information? The CMA Flux program is led by Prof. Bian Lingen at Chinese Academy of Meteorological Sciences, CMA. Information about CMA Flux may be obtained via the upcoming website or via emailing Prof. Gao Zhiqiu at zgao@cams.cma.gov.cn.

S11

SEASONAL CHANGE MONITORING OF FOREST ECOSYSTEM BY REMOTE SENSING

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Main characteristics of natural disturbances and human-induced stressors affecting on forest ecosystems are considered as: frequency (number of occurrences per unit time), extent (area over which the event occurs), intensity (degree of effect), and duration (length of stressor event). These four aspects are summarized in "spatial" and "temporal" resolutions in remote sensing parameters. Therefore, these two aspects are essential for appropriate monitoring designs. Although remote sensing data give us various information of forest ecosystem, appropriate "indicators" are also required for monitoring forest ecosystem.

Because natural and human-induced stressors affect forest area for a long time, "prediction" models based on previous monitoring data are important for evaluating the apparent phenomena. However, "appropriateness" of monitoring system using remote sensing is not yet clear and the conceptual structure on monitoring design is required worldwide.

Therefore, monitoring and modeling of seasonal change is an essential task for environmental studies in forested area and appropriate monitoring design should be adopted. Remote sensing technology is considered one of the useful and important tools for monitoring various forests in the world. Especially, remote sensing data with high frequent observation capability play important role for monitoring and modeling of seasonal changes.

This presentation shows some examples of monitoring designs and the products of “indicators”, which were created from seasonal change models applied to satellite remote sensing data, such as NOAA-AVHRR, SPOT-VGT, and MODIS.

S12

CONTRIBUTIONS OF ASIAFLUX TO INTEGRTED GLOBAL CARBON OBSERVATION

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The ten-year implementation plan of the Global Earth Observation System of Systems (GEOSS) endorsed by Earth Observation Summit proposes to develop a plan to ensure comprehensive and sustained earth observations. The carbon observation system is one of the most important components of GEOSS. The carbon group of Integrated Global Observation System (IGOS) has proposed a strategy to realize a coordinated system of Integrated Global Carbon Cycle Observations (IGCO). The two main objectives described in it are;

(1) To provide the long-term observations required to improve understanding of the present state and future behavior of the global carbon cycle, particularly the factors that control the global atmospheric CO_2 level.

(2) To monitor and assess the effectiveness of carbon sequestration and/or emission reduction activities on global atmospheric CO_2 levels, including attribution of sources and sinks by region and sector.

The requirements to implement the above observations are;

(a) Consolidating data requirements, designing network configurations, and developing advanced algorithms for assimilating carbon observations, which will be the core of a future, sustained operational system by 2015,

(b) Developing cost-effective, low maintenance, *in situ* sensors for atmospheric CO_2, ocean dissolved pCO_2, and terrestrial ecosystem fluxes,

(c) Developing and implementing technologies for remote sensing of CO_2 from space,

(d) Improving estimates of biomass based on national inventories and/or remote sensing observations,

(e) Developing, operational carbon cycle models, validated through rigorous tests and driven by systematic observations that can deliver routine diagnostics of the state of the carbon cycle, and

(f) Enhancing data harmonization and intercomparability, archiving, and distribution to support model development and implementation

AsiaFlux will play an important role to understand the present state of carbon cycle in terrestrial ecosystems (c,d) in Asia, and the long-term and systematic flux observation will provide us the better prediction of future carbon cycle in different climate from now.

There are several on going or under planning activities in Asia related to carbon. The *in situ* atmospheric CO_2 observation is limited to Japan, China and Korea, but the observation on the passenger aircrafts of Japan Airline is starting very soon, and the South-east Asia area is expected to be covered. A project of *in situ* observation on cargo-ships in South-east Asia is stating from 2006. These projects just fit to the proposal of (b) in the sense of cost-effective and low maintenance. The satellite observation project, Greenhouse gases Observing SATellite (GOSAT) is under progress targeting to be launched in 2008 (c). The Asia Integrated Model (AIM) group is improving the national inventory of anthropogenic emissionmainly, but it will be extended to cover terrestrial ecosystems (d).

These activities are desirable to be integrated and a complimentary observation system will be established in Asia.

S21

MEASURING FLUXES IN COMPLEX TERRAIN

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Difficulties with eddy-correlation measurements in complex terrain are surveyed with examples from field sites in central Oregon, USA. The strategy for using fluxes to estimate the Net Ecosystem Exchange is briefly reviewed. In complex terrain, estimation of fluxes and NEE is complicated by height-dependence of the wind and flux fields within the canopy due to drainage and upslope flows and advection by such flows. Location bias and systematic errors in quantification of horizontal advection is also discussed. Estimation of vertical advection by such flows is problematic due to apparent inability of sonic anemometers to measure mean vertical motion. Mean vertical motions estimated from measured horizontal divergence and mass continuity yield vertical motions that are more systematic and in better agreement with physical expectations compared to those estimated from sonic anemometers.

Traditional averaging lengths for computing fluxes are found to be inappropriate in very stable conditions, leading to large random flux errors. These problems are most important in low-lying areas with weak nocturnal airflow. Biases in existing approaches for estimating carbon dioxide fluxes are summarized.

S22

LONG-TERM CO_2 FLUX MEASUREMENT AT TAKAYAMA SITE

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Takayama site is located at 36 ° 08'N, 137 25' E. The highest Elevation is1420m, the vegetation type is cool temperate deciduous broadleaf forest, the dominant species are *Birch and oak forest,* the canopy height is 15~20m, and Age is 30~40 years. A 25m tower was built up in 1993, and CO_2 flux measurement continues since then; before 1998 by aerodynamic method, and after 1998 by eddy covariance method. The location of the tower is at the top of a small peak. Figure 1 shows the topography around the tower. The west side of the tower is very steep slope, but vegetation covers the all the direction. Figure 2 shows the relation between the ratio of vertical wind velocity (w) to horizontal wind velocity (u) and wind direction. These are 30 min. average during 1 to 4, Aug., 1995. The figure indicates that the prevailing winds are NE and WSW, and vertical wind velocity is much affected by local topography. Diurnal variation of the wind is westerly in the daytime (valley to mountain) and opposite direction at night, and this local wind variation affected on the daily variation of CO_2 concentration (Kondo et al., 2001).

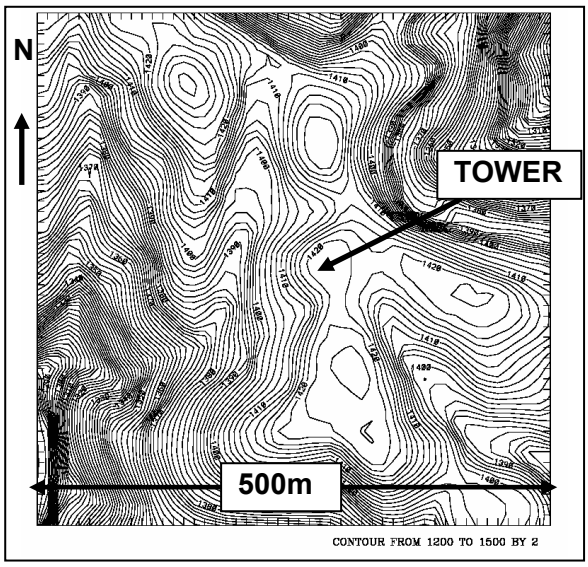

Fig.1 Topopgraphy around Takayama site. The counter lines are drawn at 2m interval.

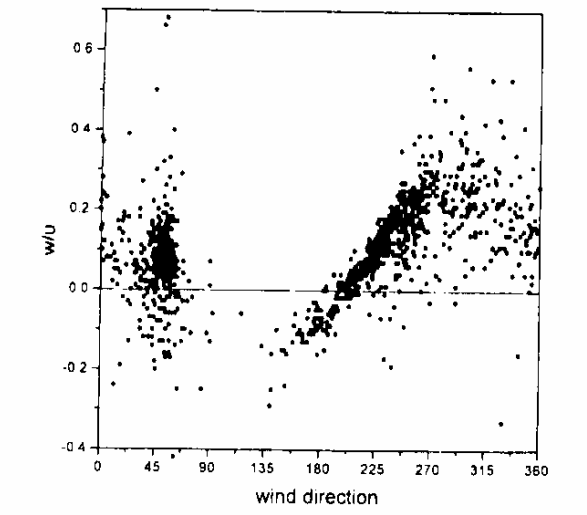

Fig.2 The relation between w/u and wind direction at the tower top.

At present, what we recognized as the problems due to complex terrain are as follows;

1) The appearance of $u_*^2 > 0$ is higher than that observed at the site on the relatively flat terrain, such as Tomakomai.

2) Separation of the flow between at the tower top and near the slope surface often occurs under the stable condition at night, which causes to underestimation of CO_2 eflux due to respiration.

The attempt to overcome these problems will be introduced.

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S23

ESTIMATION OF ECOSYSTEM RESPIRATION OF A SUBTROPICAL *PINUS* PLANTATION OVER HILLY REGION IN SOUTHEASTERN CHINA

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Long-term measurements of the exchange of CO_2 between natural and planted vegetation and the atmosphere have the potential to markedly improve understanding the role of terrestrial ecosystems play in the global carbon cycle. Eddy covariance (EC) is a micrometeorological technique that allows a non-invasive measurement of the exchange of CO_2 between the atmosphere and a several hectare area of forest, shrubland, or grassland. Expanding the scope of the FLUXNET database, ChinaFLUX offers new opportunities to quantify and compare the magnitudes and dynamics of annual ecosystem carbon and water balance and to explore the biotic and abiotic effects on ecosystem processes of carbon dioxide and water vapour exchange that are unique to ecosystems in China.

However, reliable flux measurements at nighttime or at sites subject to advective flows remains a serious obstacle to routine 24 hour operation. At night, flux corrections based on u_* thresholds are widely applied to replace aerodynamic estimates when turbulence is weak and the sum of eddy fluxes and storage terms fails to give convincing measures of CO_2 respiration. Similarly, rapid flushing of the canopy CO_2 at dawn or during intermittent turbulent events in stable conditions is usually spatially localized and may lead to systematic bias in estimates of regional exchange from a single tower. Many sites, chosen for reasons other than micrometeorological convenience such as Qianyanzhou flux site in ChinaFLUX, a subtropical *Pinus* plantation on the red earth hilly region of southeastern China, suffer from systematic advection in some or all wind directions. Operational approaches to correct for advection are not yet available.

Accuracy estimation of ecosystem respiration over tall vegetation in difficult condition was one of the major issues within the FLUXNET network, so did ChinaFLUX. To be able to compare the results of flux data of different flux measurements, the quality of the flux data must be assessed and controlled. Motivated in larger part by the need to address this question in ChinaFLUX, we analyzed the turbulence flux measurements using the EC technique at two and three canopy heights of Qianyanzhou subtropical *Pinus* plantation on the red earth hilly region of southeastern China in 2003 and 2004. The objectives of this paper focus on 1) how to assess the nocturnal flux underestimation, and 2) how to estimate the daytime ecosystem respiration to determine gross primary production, and 3) how to determine the seasonal pattern of ecosystem respiration.

The turbulent flux measurements made at two heights were within the surface layer. However, stationary test and integral turbulence test indicated that nocturnal CO_2 flux measurement was still under debate. A way to correct for flux underestimation during stable nighttimes is to replace the measured fluxes below the threshold of 0.2~0.3 m s^{-1} by the simulated efflux by a temperature and moisture function derived during well-mixed conditions at Qianyanzhou flux site.

The use of the annual respiration values derived from nighttime EC data may not be suitable for studies where heterogeneity and fetch limitation exist. Given the potential problems associated with nighttime EC measurement, such as inadequate turbulent mixing, advection, extended flux footprints, and so on, the potential difference in physiological behavior between daytime and nighttime, and the consistency of annual ecosystem respiration, which was derived from daytime light-response analyses and nighttime EC estimates, suggest that our study site was not significantly affected by heterogeneity or fetch problems.

Although ecosystem respiration showed a decline trend during the severe drought during the summer of 2003, net carbon uptake of this planted forest still declined obviously and even become a small carbon source. In essential, net ecosystem CO_2 exchange and ecosystem respiration at daily and monthly scales were determined by the gross ecosystem CO_2 exchange. Small differences in these large biospheric fluxes account for day-to-day difference in carbon storage by terrestrial ecosystem.

S24

DIVERSIFIED EVALUATION OF NEE ESTIMATED BY EDDY-COVARIANCE, CHAMBER AND BIOMETRIC METHODS ABOVE TEMPERATE DECIDUOUS FOREST IN CENTRAL JAPAN

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INTRODUCTION

In a temperate deciduous forest in Japan situated complex terrain, net ecosystem CO_2 exchange (NEE) was estimated using micro-meteorological method, measures of fluxes using chamber and biometric methods. U* threshold for interpolation of nighttime flux and seasonal change of function to estimate nighttime flux was evaluated using respective results.

SITE AND METHODS

Measurements were conducted at the Yamashiro Experimental Forest (YEF) in Kyoto, Japan. The plot area is 1.7ha. Forest type is a secondary deciduous broad-leaved forest and *Quercus serrata* and *Irex pedunculosa* are dominated. Stand density is 3209 ha^{-1}, mean crown height is about 12m and living biomass (DBH≥3cm) is 44.5tC ha^{-1} (Goto *et al*., 2003). Eddy covariance CO_2 flux measurements were conducted using a closed-path method at 26.5m height and vertical profiles of CO_2 concentration from air samples taken at 8 different heights using gas analyzer (LI-6262). In this study, we used eddy covariance flux data obtained from 1 January 1999 to 31 December 2003. Above and below ground net primary production were estimated based on allometric relationships and DBH census (Goto, 2003, Dannoura, 2002). Allometric relationships between size parameters and dry weight of stems, branches, leaves and roots were established using 46 and 16 trees for above and below ground biomass respectively. And DBH census was conducted for all trees (1cm=<DBH) in 1994 and 1999. CO_2 flux from foliage was estimated using 4 automated chambers and LAI measurements (Miyama, 2005a). CO_2 flux from soil (Fs) was estimated by 2 automated and 16 manual chambers (Tamai, 2005). Estimation function for Fs was established using the data of soil temperature (Ts) and soil water content (θ). CO_2 flux from CWD was estimated by 2 automated and 192 manual chambers measurements and CWD census in 2003 (Jomura, 2005). CO_2 flux from stem was estimated by 2 chambers measurements and the data of stem surface area estimated by allometric relation between stem surface area and DBH (Miyama, 2005b). By integrating each CO_2 flux, CO_2 flux from forest was estimated by chamber method.

RESULTS AND DISCUSSIONS

Averaged net uptake of CO_2 measured by eddy covariance method from 1999 to 2003 was 3.4 tC yr^{-1} ha^{-1} without compensation of nighttime underreports. Estimated NEP(=NEE) using biometric measurements from 1994 to 1999 was 1.56 tC yr^{-1} ha^{-1}. U* threshold based on biometric NEP were 0.28 m sec^{-1} and regression function which relate nighttime CO_2 flux and soil temperature at 5cm depth (Ts) was

$$Fco_2=0.02443EXP(0.0912\ Ts)$$

Annual averaged regression function obtained by chamber measurements showed good agreement with the function by eddy covariance method using the u* threshold as 0.35 m s^{-1}. Assuming the u* threshold as 0.32 which was mean value of two evaluations, annual NEP obtained by eddy covariance method varied from 1.29 to 1.68 tC yr^{-1} ha^{-1} from 1999 to 2003.

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S25

EVALUATION OF NOCTURNAL CO_2 EXCHANGE BASED ON DETAILED MEASUREMENTS OF CO_2 BALANCE IN A JAPANESE CYPRESS FOREST

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Introduction

Underestimation of nocturnal CO_2 respiration with the eddy covariance method under calm conditions remains an unsolved problem at many forest flux stations. In this study, to evaluate nocturnal CO_2 exchange in a Japanese cypress forest with complex topography, we observed CO_2 flux above the canopy (F_c), changes in CO_2 storage in the canopy (S_t) and soil, trunk and leaf respirations (F_s, F_t and F_l). In addition to these measurements, we observed the wind speed on the forest floor and checked whether there was a drainage flow, which is considered as one of the causes of underestimation.

Site and Methods

Our observation site is located at the Kiryu Experimental Watershed (34° 58' N, 136° 00' E) in Shiga Prefecture, Japan. The site is mainly covered by *Chamaecyparis obtusa* Sieb. et Zucc. (Japanese cypress, an evergreen conifer). This area has a mild northward inclination of approximately 9.2°. The canopy height is approximately 18 m and the total leaf area index (LAI) ranges from 4.5 to 5.5. The annual mean air temperature from 2003-2004 was 13.3℃ and annual mean precipitation from 2003-2004 was 1884 mm.

We measured wind speed and CO_2 concentration at 10 Hz with a three-dimensional sonic anemo-thermometer and an open-path IRGA at 28.5m and calculated F_c by the eddy covariance method. The reference frame of the co-variances was rotated for every 30 min flux measurement to align the flux perpendicular to the mean streamline. WPL correction for the effect of air density fluctuations was applied. The data that does not meet the stationarity was rejected. We also calculated S_t from the vertical CO_2 distribution measuring 5 (or 6) heights density. NEE was estimated every 30 min from F_c and S_t.

Each component of ecosystem respirations (F_s, F_t and F_l) was observed by the chamber method. Five automated closed dynamic chambers for soil (3), trunk (1) and foliage (1) were installed for the continuous observation. Soil respiration rate observed with the automated chambers at the three positions was compared with that observed with a closed chamber air circulation method using home-made chambers and an IRGA at 100 positions located over the watershed, to validate the spatial and temporal representativeness of the data obtained with the three automated chambers. Trunk respiration rate observed with an automated trunk chamber was assumed to be a representative value of this site and scaled to the values per unit ground area (F_t) using census data around the flux tower. Several methods for the scale up were compared to evaluate the uncertainty caused by the difference of the scale up method. The foliage respiration per unit ground area (F_l) was scaled from an automated foliage chamber data. The coefficient for the scaling was derived from the budget with F_c, S_t, F_s, and F_t, with the assumption that F_c was measured precisely at high friction velocity (u_*) in the daytime. The validity of this method was checked comparing with LAI and leaf respiration rate per unit leaf area measured at several heights in the canopy. The underestimation of nocturnal CO_2 respiration by the eddy covariance method was evaluated comparing F_c+S_t to $F_s+F_t+F_l$. In addition to these observations, three-dimensional wind speed was measured at 2 m-height on the forest floor and compared with that of above the canopy to investigate the existence of drainage flow.

Results and Discussion

Comparison of nighttime F_c+S_t to $F_s+F_t+F_l$ verified that F_c+S_t underestimated ecosystem respiration ($F_s+F_t+F_l$) at low u_*. The frequency of south wind (downward along the slope) was dominant below the canopy regardless of the wind direction above the canopy at low u_*. This suggested the drainage flow at this site under calm condition. Nighttime ecosystem respiration estimated with chamber method nearly equaled to F_c+S_t at high u_*. This result in our site provides a positive prospect for the correction of the nocturnal CO_2 flux replacing the data with low u_* by the temperature response functions from the data with high u_*, although the spatial and temporal heterogeneity in ecosystem respirations should be evaluated more precisely at each site.

S26

Interpretation of fluxes in non-ideal conditions

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Abstract

This paper reports on the impact of surface patchiness on CO_2 fluxes. Using a combination of surface-atmosphere exchange models, tracer and CO_2 fluxes and turbulence measurements, this paper demonstrates how adjoining lands of contrasting surface properties upwind, though located hundreds of meters away or more, impact tower CO_2 fluxes. The influence of the size of upwind surface patches on fluxes is also discussed.

This paper draws examples obtained from several flux research sites. It discusses important flux enhancements imparted by surface inhomogeneities upwind in daytime conditions and identifies several physical mechanisms significantly altering CO_2 fluxes in nocturnal conditions. Results from this work shed a new light on the interpretation of surface-atmosphere exchange of CO_2 in non-ideal terrain.

S32

Climate Change Activities in Forestry Sector : Current and Future R&D in Malaysia

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Abstract

Malaysia signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and ratified it in 1994 and has since doubled its efforts to fulfill its obligations. A National Climate Change Committee was established to help meet its obligations under the Convention. In addition, an Initial National Communication was submitted to UNFCCC in 2000. Malaysia is in the midst of preparing its second National Communication.

Efforts into improving the scientific knowledge base on the potential of Malaysian rainforest as CO_2 sink or source is being intensified. Research activities identifying the key carbon pools of each key forest types are on-going. Along these lines, research programmes to address how land-use affects the changes in stocks and estimate the effects of land-use and land-use changes on the emissions and removals of CO_2 is being done. In addition, the impacts of projected climate change on key forest species are also being investigated. This paper will highlight the current and future research activities related to climate change and carbon inventories in forestry sector in Malaysia.

S33

Agricultural and Forest Meteorology Research Work in Thailand

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ABSTRACT

Thailand has 6 Tower Flux Sites, which constructed by the AsiaFlux for conducting the research work in agricultural and forest meteorology. Maeklong and Sakaerat flux sites belongs to Asia Flux network were operated by Dr. Minoru Gamo et al., (2001-present), which have the objective of the research as to evaluate CO_2, water vapor and heat exchange in tropical seasonal deciduous forest. To Daeng To Daeng, and Bacho Bacho flux sites in Narathiwat province (Southern part) was investigated by Dr. Tomoyasu Ishida et al., (1994-present), which have an objective to grasp and renovate the actual conditions of destroyed environment, and to develop local appropriate technology of sustainable biological production of tropical forest. One flux site in Phangnga province (Southern part) was operated by Dr. Nobutaka Monji et al., (1996-1998), has the objective to study for CO_2 exchange and heat flow in mangrove forest. The Tak flux measurement (TFM) site, one of the sites of Korean Flux Network (KoFlux) which is an infrastructure of AsiaFlux, is constructed at a Northwest of Thailand and operated by Dr. Wonsik Kim et al., which have an objective to construct a KoFlux prototype of data information system (KoFlux-DIS), which is an infrastructure for a seal time monitoring and simulation system incorporating comprehensive data management of tower flux measurements.

There are already several Flux sites in Thailand but it need to find an ecosystem that has been overlooked or left out by the current Thai network especially in the upper North. In the northern part of Thailand the rate of forest loss by deforestation have been relatively modest in the last two decades, with a reduction in forest cover from 52 percent in 1982 to 44 percent in 1995 and even of an increasing more in recent years. There are several activities that involve biomass burning which is the principle source of air pollution; for example slash and burn agriculture especially in the upland and highland areas, and the establishment of permanent farms and cattle ranches, the clearing for which also involves the burning of large amounts of forest materials. Cruzen (2003) estimated $1.8\text{-}4.7\times10^{15}$ gC of biomass are burned each year in the tropics, compared to the amounts of 5.5×10^{15} gC/year of fossil burning. No research work has been done on the biomass burning as a pollution source and limiting in the studies of soil-vegetation-atmosphere interaction in the upland and highland agricultural system.

One of the serious causes for the social and economic weakness of Thailand is the severe shortage of highly qualified human resources especially in the field of science and technology. Agricultural meteorology and micrometeorology is the one of the most severe shortage area. There have some scientists from the Royal Forest Department working with the Asia Flux network, and have some course work in agricultural

meteorology offered for the undergraduate students in some universities. No Ph. D. graduated in agricultural meteorology has been produced by the Thai University. Previous attempts to solve this problem, the Thailand Research Fund, a state research funding agency was initiated a Royal Golden Jubilee (RGJ) Ph. D. program by giving scholarships for the talented student to gain about 6-12 months international research experience.

With a shortage of a well-trained personnel in micrometeorology, it would be good for Thailand in terms of to developing the course in agricultural meteorology and micrometeorology. This course would be beneficial immediately to all scientists throughout Thailand, Laos. Cambodia, Malaysia, Vietnam and South of China. The course would be particularly helpful if it can set up a flux site near Chiang Mai University, and should prepare graduate students, post docs, and professors as well as government scientific personnel in the basic principles of micrometeorology / agricultural meteorology. This may be of interest to scientists who work in agriculture, in forestry (ecophysiology), agricultural and civil engineering, environmental sciences, atmospheric sciences, botany, and biology. To tackle these severe shortages we need the collaboration and support from AsiaFlux. With so much photochemical activity in the tropics, it is very unfortunate that we know very little about the atmospheric chemistry in these regions. Thus, an important goal for the future research is to gain a better understanding about chemical processes in these areas. The tropics and subtropics, especially Asia, contain an increasing proportion of the world's population, which is under rapid development. The large change in atmospheric chemistry and climate forcing during the coming decades will therefore largely come from these region. CO_2 has a concentration of approximately 370 per million air molecule, together with water vapor and sunlight, it builds the organic molecules of living matter. As a so-called greenhouse gas, CO_2 is also significant for the Earth's climate. However, despite these important aspects, it plays no role in atmospheric chemistry. O_3 and water vapor are the most important drivers of the photochemistry of the atmosphere. Without O_3, the chemistry and chemical composition of the atmosphere would be totally different.

There was an interaction found in between CO_2, O_3 and UV-B as the stress factors. An increase of UV-B in the troposphere will promote ozone formation. Ozone and UV-B are known to reduce bio-productivity and therefore less carbon is sequestered in biomass. This response of plants will contribute to the increase of CO_2 in the atmosphere. Higher temperatures (greenhouse effect) and CO_2 seem to reduce the sensitivity of some plants to ozone and UV-B. This synergism is not understood at all, but due to the high cost of "crucial" experiments to gain reliable results, they are not performed frequently.

This paper was prepared for the AsiaFlux workshop 2005, which will be held in Fujiyoshida, Japan, August 24-26, 2005.

S34

MICROMETEOROLOGICAL RESEARCH AND FLUX STUDIES IN BANGLADESH – CURRENT STATUS AND FUTURE PROSPECT

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Geologically, Bangladesh is a part of the Bengal Basin, one of the largest geosynclinals in the world. Physiographically, the country can be divided into hills, uplifted land blocks, and the majority alluvial plains with very mean elevation above sea level. Climatologically, it is characterized by high temperature, excessive humidity, and fairly marked seasonal variations of precipitation. Bangladesh experiences abundant rainfall during the monsoon (July-October) followed by a cool winter period (November-February), and then a hot dry summer (March-June).

Bangladesh is highly suitable for crop production. The total land area of Bangladesh is approximately 35 million acres (14 million hectares) of which around 20 million (8 million hectares) or 55.5% of the total area is under cultivation. This is one of the highest percentages in Asia. Seventy percent of the population depends on agriculture. Agriculture is the life nerve of Bangladesh. It contributes 34% to the Gross Domestic Product (GDP). Most of the cultivable land covers with rice based cropping pattern as Rice-Fallow-Rice or Rice-Rice-Rice. And also different types of cereal crops, pulse crops, vegetables, fiber crops, oil crops are cultivated in agricultural sector. Biomass (wood, crop residues, dung) fuel constitutes 73% of total energy consumption and per capita supply is declining gradually which is the principal source of air pollution.

Ecologically, Bangladesh plays a major role with the contribution of terrestrial and aquatic ecosystem. Terrestrial ecosystem includes Dipterocarp forest, Savannas, Bamboo forests, swamp forest, natural inland Sal forest, littoral Mangrove Forest and aquatic ecosystem includes freshwater and coastal wetland. The total land under forest in Bangladesh is about 2.56 million hectare. In Cox's Bazar, natural forest cover dropped from 31,300 ha in 1985 to about 24,300 ha in 1992. In Sundarbans, 78% of the forest had canopy closure of 75% or more in 1961, which was reduced to 65% in 1984. As of 1989 only about 17% of the total legitimate Sal forest area remained across central and northwest of Bangladesh (FMP, 1995). The total area of the wetlands in the country has been variously estimated at seven to eight million hectares, or about 50% of the total land surface. No research work on micrometeorology/ flux measurement has been conducted on any ecosystem in our country in the past.

In Bangladesh, there are 36 meteorological stations among 64 districts (under Govt. supervision). They record traditional meteorological parameters with their age-old instruments and process their data manually. Space Research and Remote Sensing Organization (SPARRSO), SAARC Meteorological Research Centre (SMRC), EGIS work with collected meteorological data through Remote Sensing, Satellite Image and Geographical Information System.

International Union for Conservation of Nature and Natural Resource (IUCN) and United Nations Development Programme (UNDP) have several countries programmed to conserve biodiversity in different ecosystems. Food and Agricultural Organization (FAO), CARE and Bangladesh Agricultural Research Council (BARC) work with vulnerability, climate change and adaptation. Department of Environment (DoE) under the Ministry of Environment and Forest (MOEF) and hundreds of NGOs involved in different categories of environmental programme like air pollution, water pollution, soil degradation, waste management *etc*. But their works are limited in survey based data and awareness building rather than technological development.

There was no course on micrometeorology for students in any University of Bangladesh till 2002, though micrometeorological research started in 1998 after coming back of Dr. Baten from Chiba University, Japan, with a very limited scope at Bangladesh Agricultural University (BAU) with few portable sensors. By adding a few more sensors with a datalogger provided by National Institute for Agro-Environmental Sciences (NIAES), Japan in September 2002, Dr. Baten is now offering courses to MS students of the Department of Environmental Science of BAU on micrometeorology and has started research on it. Some MS students are working on crop micrometeorology for their dissertations on energy balance, heat storage and radiation use

efficiency over different ecosystems. We wish to start measurement of micrometeorology in details with water vapor and CO_2 fluxes soon over rice ecosystem with collaboration of NIAES. Since Bangladesh is a rice-based country, flux measurement should be continued for 5-7 years. In addition our evergreen “sal forest” should be included for flux observation.

Identified obstacles for our research works are social and economic weakness, severe shortage of highly trained human resource, lack of scientific research centre and scientist and lack of sophisticated instruments. We have already several potential ecosystems for flux study, but we don’t have any facility to conduct such research. We would like to start collaborative research with Japan and thus we want cordial co-operation from AsiaFlux and FLUXNET for financial support, sophisticated instruments and trained manpower. This kind of collaboration will help to provide data to AsiaFlux from a densely populated rice based country for the development of future strategy to combat global warming.

S35

Status of forest carbon budget studies in India

At present, India being a party to the UNFCCC has initiated its first National Communication and emission inventory in various sectors, this was conveyed successfully to the UNFCCC in June 2004. As part of the NATCOM process, the emissions inventory from the forestry sector was assessed. The data source for this was mainly secondary in nature. The institutions that took part in this process were, Forest Survey of India, Forest Research Institute and Indian Institute of Science. The emissions from the forestry sector make up only one percent of the total national emissions.

The forest carbon budgeting efforts have been made to a very limited extent by Indian Institute of Remote Sensing. Besides, the mitigation potentials have been worked out by Indian Institute of Science through forestry mitigation projects using the current productivity rates and land availability. There is a dire need for generating primary information for CO_2 and other GHGs in forest ecosystems. No systematic or collaborative programme has been initiated so far. A preliminary attempt has been made by IIRS to establish a flux net tower in Nainital district of Uttaranchal, the modalities for which are in the process of finalization.

The Indian Council of Forestry Research and Education as a premier national research organization and custodian of forestry research for the last hundred years and would be interested in a collaborative effort to promote carbon budget studies in India. The organization has eight regional institutes at strategic locations all over the country, adequate strength of scientist and researchers to undertake this work and also coordinate the establishment of a flux network with State Forest Departments. Further, the scientific staff in ICFRE is adept and with the research on nutrient cycles, ecological sciences and forests and conversant with the climate change issues in forests. Here, I would like to highlight that the major clients for forestry research carried out by ICFRE are the State Forest Departments. The SFDs are also the custodians of forest resources and hence ICFRE could liaise very well to enable such a networking and locate ideal sites in representative forest types. The area in which ICFRE would like strengthening and support through the medium of AsiaFlux would be in expertise in handling the flux net tower operations and modeling for carbon budgets.

O21

A AUTOMATIC CHAMBER SYSTEM FOR MEASURING CONTINUOUS SOIL RESPIRATION BASED ON AN OPEN-FLOW DYNAMIC METHOD

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We developed an automatic opening and closing chamber system (AOCC) based on an open-flow dynamic method (open-flow AOCC). The AOCC can be used during all four seasons, even at the surface of relatively deep snow. We compared the open-flow AOCC with two closed dynamic methods (the AOCC configured as a closed dynamic system (closed dynamic-AOCC) and the LI-6400 system) under field conditions. The closed dynamic-AOCC and LI-6400 measurements were about 15.5% and 5.2% lower, respectively, than the values obtained with the open-flow AOCC. There was significant difference in soil respiration rate between the open-flow AOCC and the closed dynamic AOCC system. In contrast, no significant difference in soil respiration rate was detected between the open-flow AOCC and the LI-6400 system. In the field, the open-flow AOCC permitted long-term measurements under a range of temperature conditions and did a good job of reflecting the marked daily and seasonal variations in soil respiration as a function of soil temperature.

O22

Soil respiration in tropical seasonal rain forest and rubber plantation in Xishuangbanna, Yunnan, SW China*

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Abstract: Xishuangbanna is the most northerly situated tropical rain forest in the world and, as a result, has remarkable seasonal climate variations, which is different from tropical rain forests in other regions. In Xishuangbanna, the canopy of rubber plantations, *Hevea brasiliensis*, often form a single layer structure that is different from the multi-layer canopy of tropical seasonal rain forests.

Measurements of soil respiration rates were carried out for one year in a tropical seasonal rain forest in a Nature Reserve (21°57'N, 101°12'E) and a rubber plantation (21°56'N, 101°15'E). The two sites are about 5 km away near the Xishuangbanna Tropical Botanical Garden in Xishuangbanna, Yunnan.

The results showed that there was remarkable seasonal changes in the soil respiration rates in both the tropical seasonal rain forest and rubber plantation with changes in soil temperature at 5 cm depth, air temperature and soil water content. Soil respiration rates of the tropical seasonal rain forest and rubber plantation were greatest in October (9.24 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$ and 11.06 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$, respectively), and lowest in February (4.71 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$ and 5.13 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$, respectively). Soil respiration rates in May, June, July, August, September and October were higher than those in November, December, January, February, March and April. Soil respiration rates in the rubber plantation were significantly higher than that of the tropical seasonal rain forest (P ‹0.01). There was a significant correlation between soil respiration rates and soil temperature at 5 cm depth, air temperature, and the correlation between soil respiration rate and soil temperature (r^2= 0.87 and r^2= 0.82, respectively) was higher than that between soil respiration rate and air temperature (r^2= 0.80 and r^2= 0.72, respectively) (P ‹ 0.01) for the forest and plantation. There was a significant (P ‹ 0.01) correlation between soil respiration rates and soil water content in the forest and plantation (r^2= 0.73 and r^2= 0.63, respectively). The annual CO_2 efflux from the tropical seasonal rain forest and rubber plantation was 2.64 kg $CO_2 \cdot m^{-2} \cdot a^{-1}$ and 2.80 kg $CO_2 \cdot m^{-2} \cdot a^{-1}$, respectively. The Q_{10} values of the tropical seasonal rain forest and rubber plantation were 2.16 and 2.18, respectively. The Q_{10} value of the tropical seasonal rain forest measured by the alkaline absorption method in our study was slightly higher than the values measured using the static opaque chamber and gas chromatography techniques. The Q_{10} values of the seasonal tropical rain forest and rubber plantation in Xishuangbanna are higher than those reported in other tropical regions.

Key words: Tropical seasonal rain forest; Rubber plantation; Soil respiration; Q_{10}; Xishuangbanna

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O23

ISOPRENE EMISSION OF *QUERCUS SPP.* AND ITS CONTRIBUTION TO THE LEAF CARBON BUDGET

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Isoprene is a major volatile organic compound emitted from higher plant. Annual isoprene emission is estimated to be 220 TgC which is higher than the annual emission of non-methane hydrocarbons resulting from fossil fuel (IPCC 2001). One of isoprene emitters is *Quercus spp.*, but there is no available database for the tree species grown in Japan showing which *Quercus* species emits isoprene and which does not.

Isoprene quickly reacts with some kinds of reactive species such as OH, O3 and NO3 in the atmosphere. The life time of isoprene in the atmosphere is less than several min. It is finally converted to CO2 and this carbon emission is sometimes not negligible in considering carbon budget of leaf, whole plant and forest. We reported in a previous paper that carbon emission as isoprene from *Edgeworthia chrysantha* corresponds to 7% of carbon fixed by photosynthesis. In the present study, we collected volatiles from 12 *Quercus spp.*to identify the compounds emitted. Here we report the effects of leaf temperature and light intensity on isoprene emission of some *Quercus spp.*

Plants used here were *Q. serrata*, *Q. mongolica* var. *grosseserrata, Q. aliena, Q. dentate, Q. acutissima, Q. variabilis, Q. acuta, Q. glauca, Q. phillyraeoides, Q. salicina, Q myrsinaefolia and Q. sessilifolia.* A portable photosynthetic meter was used to measure photosynthetic rate and stomatal conductance. The leaf temperature and PPF in the cuvette were controlled. The flow rate entering the cuvette was set to be 500 umol/s. The volatiles in the cuvette was collected into adsorbent tube containing Tenax TA and Carbotrap. The volatiles were thermally desorbed and then analyzed with a gas chromatograph mass spectrometer. The isoprene concentration was often measured with a proton transfer reaction mass spectrometer (PTR-MS), allowing a real time monitoring of plant response to environment.

Among twelve species only deciduous trees *Q. serrata*, *Q. mongolica* var. *grosseserrata, Q. aliena,* and *Q. dentate* were identified as isoprene emitters. Isoprene emission from these plant species increased with an increase in leaf temperature up to 40 °C. Isoprene emission rate of these plant species at a leaf temperature of 40 °C ranged from 0.1 to 0.3 μmol(C) $m^{-2}s^{-1}$, which is corresponding to 5 ~ 20 % of carbon fixed photosynthetically. Their isoprene emission also raised with an increase in PPF and reached a plateau around 500 ~ 1000μmol $m^{-2}s^{-1}$, showing the change was similar to that of photosynthetic rate.

O24

Using ^{13}C to partition NEE into photosynthesis and respiration of broad-leaved Korean pine forest

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Terrestrial ecosystems played an important role in the global carbon balance and mitigating of global climate warming with the increase of CO_2 concentration. Net ecosystem exchange of CO_2 (NEE), water and energy are widely measured using the eddy covariance (EC) technique. Under-estimate of ecosystem respiration is one of great uncertainty during EC observation in the evaluation of forest ecosystem carbon sequestration function. Another challenge is attributed the abiotic and biotic factors to influences on the mechanism of ecosystem carbon metabolism which results in the annual NEE fluctuation. In order to overcome the weakness of eddy covariance technique and improve our understanding of the ecosystem ecophysiological behavior, stable carbon isotope technique is used to partition the NEE into photosynthesis and respiration components of broad-leaved Korean pine forest, which is the typical forest type in the northeastern of China.

Along with open path eddy covariance and meteorology measurements, on the 3-4 and 6-7 August of 2004, ambient air at 3 heights (0.5m, 24m and 32m) within the forest were sampled every two hours for determination of ^{13}C ratio of CO_2 using flask with custom-made sampling system. The measured CO_2 concentration and ^{13}C ratio are applied to determine the ^{13}C flux (isoflux of ^{13}C) and isotopic characteristics of ecosystem photosynthesis and respiration using Keeling plot technique etc. during the week pre and post sampling. Combined with EC and isotopic measurements, the NEE are successfully partitioned into photosynthesis and respiration components. The respiration flux derived from isotopic technique consists of about 40% of the total gross primary production (GPP) and 50% percent of NEE. In comparison with respiration flux derived from the NEE vs PPFD using nonlinear regression and extrapolation from the exponential dependence of nighttime NEE on air temperature with year round data, the isotopic derived is much higher with apparent diurnal trend. The PPFD technique derived respiration is the lowest and the air temperature derived one is the median with less diurnal change.

It is concluded that the stable carbon isotope technique combined with eddy covariance can be successfully used to partition NEE into photosynthesis and respiration components, and obtain more accurate estimate of ecosystem respiration to study ecophysiological dynamic response to environmental change.

Keywords Net ecosystem exchange, eddy covariance, Keeling plot, carbon flux

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O25

Carbon Isotope Composition of *Quercus serrata* (Japanese Oak) and *Caprinus laxiflora* (White Birch) Leaves grown in Gwangneung Forest

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Gwangneung site in Korea has been a center of intensive ecological, meteorological and hydrological researches during last ~10 years to understand forest-atmosphere exchanges of energy, carbon and water in a typical landscape of the country. We report carbon isotope data of *Quercus serrata* (Japanese Oak) and *Caprinus laxiflora* (White Birch) leaves collected in 2003 and 2004 from Gwangneung forest for an effort to characterize forest response to changing environmental conditions. Carbon isotope ratios of leaves exhibit remarkable temporal and inter-/intra-specimen variability. For both years, *Q. serrata* leaves are more enriched in ^{13}C than *C. laxiflora* leaves. For *Q. serrata*, leaves grown at higher level of canopy are more enriched in ^{13}C, which mainly correlates with vertical gradients in temperature and vapor pressure within canopy. Leaves of both species grown in 2004 are consistently depleted in ^{13}C compared to those grown in 2003. Carbon isotope fractionation during photosynthesis is mainly determined by the ratios between intercellular and ambient CO_2 concentration that is related to the stomatal conductance and photosynthesis rate. Precipitation and soil water content were higher in 2003 than in 2004, while temperature and radiation were lower in 2003. Presumably greater VPD favors low canopy conductance and high WUE in 2004 but higher radiation may result in a condition suitable for low WUE due to high stomatal conductance of the same year. In terms of carbon isotope data, greater Δ values in 2004 indicate a lower WUE of the year. A more complicated interpretation is derived if normalized nitrogen concentration in leaves is considered. The lower concentration of leaf nitrogen in 2004 likely indicates that Gwangneung forest (or at least two species studied) in 2004 had low 'Maximum Photosynthesis Ability' than in 2003. Without supplementary data, it is difficult to interpret how and why Gwangneung forest in 2003 and 2004 had different WUE and photosynthesis rate. However, the results discussed here clearly indicate that the carbon isotope composition of leaves can be a useful measure of forest dynamics under changing environmental conditions. This study is supported by "The Eco-Technopia 21 Project" from the Ministry of Environment, Korea.

O26

Contributions from belowground respiratory fluxes in an irrigated rice paddy determined by carbon isotopic compositions of ecosystem respiration

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CO_2 efflux from waterlogged soil surface has been often neglected, because the floodwater and water-filled pores form a strong diffusion barrier to release of belowground CO_2. Furthermore, it has been often assumed that belowground (root and soil microbial) respirations are negligible (or negligibly small compared to those under drained conditions) and thus do not contribute to the carbon balance of the ecosystem under flooded conditions. However, other compelling experimental evidences exist that anaerobic decomposition of organic matter (e.g., plant debris and photosynthates released by roots) and production of CO_2 and methane as the end products are the very active processes governing the carbon cycle in the paddy ecosystem. To investigate the contribution from belowground respiratory flux at the ecosystem scale, we periodically measured the carbon isotopic composition of ecosystem respiration (δ_R) by means of Keeling plot in an irrigated Japanese rice paddy, in conjugation with continuous aerodynamic flux measurements of CO_2 and methane (by eddy covariance and flux-gradient methods, respectively).

The observed δ_R increased from –26.3‰ to –23.2‰ over the growing season in 2003 and was strongly correlated with the variations in carbon isotopic composition of bulk leaf and CO_2 entrapped in soil (δ_P and δ_S, respectively). δ_S was gradually enriched in ^{13}C as influenced by the CO_2-dependent methane production pathway ($CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$). Upon floodwater drainage, δ_R increased remarkably by 1.1‰ to 3.1‰ accompanied with large emissions of methane and with increased nighttime NEE (net ecosystem exchange). The results strongly support a significant role of belowground CO_2 flux on the ecosystem carbon exchange, regardless of flooding conditions.

We attempted to quantify the contribution from belowground respiratory flux to the total ecosystem respiration by partitioning ecosystem respiration into plant (above-ground) and soil (belowground) respirations based on δ_R and the carbon isotope ratios of each respiratory component (δ_P and δ_S, respectively). The estimated proportion of soil respiration under flooded conditions was, on average, 32% of the ecosystem respiration and showed a weak seasonal variation. In the early growing season when the rice canopy was still small (LAI = 0.1), soil respiration accounted for about 50% of the ecosystem respiration. In the later flooded periods ($2 \leq LAI \leq 5$), the proportion of soil respiration ranged between 20% and 33%. Under drained conditions, the proportion of soil respiration was estimated to be about 40% of the ecosystem respiration, regardless of the duration of drainage. A simple calculation showed that emission rate of belowground CO_2 increased by 2 to 3 times by the drainage practices. To illustrate the importance of belowground CO_2 processes in the paddy ecosystem, we estimated the temporal variation in NPP (net primary production) from the measured NEP (net ecosystem production), the approximated total ecosystem respirations from air temperatures, the inferred proportions of soil respiration, and the above- and below-ground biomass distributions. The cumulative NEP over the growing season was about 200 g C m^{-2} smaller than the measured biomass carbon increase. There was a good correspondence between the time courses of the estimated NPP and the measured biomass carbon.

O27

CO_2 SINK ASSESSMENTS FOR LONG-TERM MONITERING IN A COOL-TEMPERATE DECIDUOUS FOREST IN KOREA

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Long-term monitoring and accurate measuring the net ecosystem production (NEP) in forest ecosystems are very important to understand the carbon balance under current and future global warming environments.

Our study on carbon sink assessments was based on the forest ecological method in a *Quercus mongolica* forest at Daegwallyeong Flux Measurement Site (DFMS), which is the typical cool-temperate deciduous forest in Korea. We carried out the measurements of biomass, net primary productivity (NPP), soil CO_2 efflux and estimated the net ecosystem productivity (NEP) from August 2003 to August 2005. The biomass and NPP were calculated from results of tree census in each year. The soil CO_2 efflux and heterotrophic respiration were measured with a multichannel automatic chamber system through the whole year.

The biomass was estimated to be 144.5 and 154.1 ton ha^{-1} in 2003 and 2004, respectively. NPP was 4.8 tC ha^{-1} in 2004. Annual total soil respiration and heterotrophic respiration in 2004 was 5.3 and 2.4 C tC ha^{-1}, respectively. NEP of this forest was 2.4 tC ha^{-1} in 2004.

O28

THE ROLE OF CARBON-TO-NITROGEN RATIOS FOR QUANTIFYING CARBON SEQUESTRATION IN CHINA'S SOILS

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Soils may help decrease the threat of global warming by removing greenhouse gases from the atmosphere and using the carbon in those gasses to build soil organic matter. This process is called carbon sequestration. We found that the ratio of carbon to nitrogen in soil organic matter can be used as an index to determine whether soil organic matter is increasing or decreasing. Net accumulation of soil organic carbon in soil is constrained by the amount of soil organic matter and its maximum C:N ratio. Our objectives were to estimate the potential for China's soils to continue sequestration carbon within the soil organic pool. We calculated total soil organic carbon and organic nitrogen in the top meter of 5439 representative soil profiles from the China national second soil survey database. Nitrogen in these mainly forest soils was assumed to be at steady state. The maximum carbon storage capacity was estimated by calculating the amount of carbon stored under assumed maximum soil C:N ratios of either 20,15 or 13. We will discuss the spatial differences of soil carbon sequestration in arid and humid regions in China. The research will benefit land managers who need information on how well their management systems are working and may serve as a tool to help action agencies and policy makers measure the amount of carbon being sequestered in soil organic matter.

***Keywords*:** Soil carbon storage; C:N ratio; Soil nitrogen storage; Carbon sequestration

O29

THE EFFECTS OF SOIL EROSION ON DYNAMICS OF SOIL ORGANIC CARBON AND CO_2 RELEASE

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Soil erosion and deposition influences the accumulation and loss of soil organic carbon (SOC), yet it has not been concerned in the study of soil carbon cycle. In this paper, A typical rolling farmland in Black Soil region of Northeast China was taken as a case to analyze the impact of soil erosion and deposition on the diurnal and seasonal CO_2 flux and the variation of different labile carbon fractions based on measurement of CO_2 flux, water soluble organic carbon (WSOC), microbial biomass carbon (MBC), particulate organic carbon (POC) and macro-aggregate organic carbon (MOC).The results showed that the CO_2 evolved from the soil surface varied significantly among seasons ranging from 0 gC m^{-2} d^{-1} in the winter to about 13.6 gC m^{-2} d^{-1} during the summer. There was no obvious difference for the release of CO_2 between erosion and deposition sites except for shoulder-slope although depositional areas had higher labile fraction content than eroded slope positions. Soil C flux exhibited diurnal variations with high values differing from lows by as much as 0.067 g C m^{-2} h^{-1}. Peak flux rates as high as 0.106 g Cm^{-2} h^{-1} occurred during the mid afternoon during the spring, summer, and autumn seasons. Soil C flux was significantly correlated with soil temperature and air temperature but not with soil moisture content. In addition, soil erosion significantly decreased the content of WSOC, MBC, POC and MOC at eroded geomorphic positions, those of depositional sites such as foot-slope accumulated except for WSOC. The significant positive correlation between each labile carbon fraction and TOC was found. Above preliminary conclusions demonstrated that eroded carbon trapped in deposition positions increased the activity of microorganism and was apt to be mineralized other than be sequestrated in oxidizing environment.

Keywords: Soil erosion and deposition; CO_2 flux; labile organic carbon; black soil

O30

SEVERAL CONSIDERATIONS ON STUDYING CARBON BALANCE OF GLOBAL TERRESTRIAL ECOSYSTEMS.

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To address “missing carbon sink” in global scale is a big challenge for the global change scientists. Although the reported value of missing carbon sink is different in various documented materials, it is usually about 2 Pg C. If the value can be found only in some concentrated areas, for example, as reported in middle latitude areas, the carbon sink in these regions will be unimaginable great and would be easily found and have been well documented. More probable situation may be that the missing carbon sink is more averagely distributed in terrestrial ecosystems and inland water bodies, although there may be some relative high sink areas. If this hypothesis is rational, the carbon sink in normal regions will be less than 0.5 ton$\cdot$ ha$^{-1}\cdot$ yr^{-1}. Under this consideration, precise, long-term and large area of measurement is absolutely necessary, and carbon flux by eddy covariance must be tested by the complexity of other multiple ways due to its unstability of recording and rigorous requirement on flat topography. Furthermore, some processes in which carbon content is low can not be omitted, such as the organic carbon in forest hydrological processes, it may be the best way to show the accumulation of organic carbon in soil, especially in deep soil. When studying carbon balance of global terrestrial ecosystems, another important aspect that we should pay more attention to is comprehensively considering the turnover time and storage change of various carbon pools in terrestrial ecosystems. The organic carbon in the pools has turnover times ranging from months to millennia, with much of it around several years to a few decades.

Key words: Carbon missing sink, Tentative distribution pattern, Measurement ways, Hydrological processes, Turnover time

O31

Carbon dioxide flux of three ecosystems on the Tibetan Plateau.

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Abstract: Grassland ecosystem provides a wide range of environment service function and plays an integral part in the life supporting-system. Tibet plateau is a unique geogranfic unit with a vast territory, high attitude, cold air temperature, strong sonar radiation, and typical alpine ecosystems. Alpine meadow，alpine shrub and alpine swamp ecosystems are widely distributed on the plateau and they are characterized by short growing period, high soil carbon content and sensitive to global warming. Alpine meadow dominated by *Kobresia humilis* and various grasses and forbs (depending on grazing density) are distributed in this region along the valley floor. The shrub, *Potentilla fruticosa* are joined by shrubby *Salix* species are locating on the north hill. The region swamp vegetation consists primarily of *Kobresia tibetica* and *Pedicularis longiflora.* Sheep and yaks, the major herbivorous animals in the region, live on herbage, which varies greatly with seasons. The eddy covariance method was employed to measure the CO_2 exchange between the atmosphere and alpine meadow, alpine shrub land and alpine swamp ecosystems in northeastern Tibetan plateau from November 2002 to October 2003. Results from the first year indicated that net CO_2 fluxes were carbon sink for alpine meadow, shrubland but weakly sources for swamp ecosystem on Northeastern Tibetan Plateau. Corresponding daily CO_2 fluxes were 2.36, 1.67, and 2.07 g CO_2 sink of growing season from May to October, and 1.35, 1.18, 2.19 g CO_2 sources of non-growing season from November to April of next year for meadow, shrubland and swamp ecosystems respectively. The temperature sensitivity of ecosystem CO_2 emission (Q_{10}), was estimated to be 2.73, 5.06 and 15.15 for the alpine meadow, shrubland and swamp ecosystems, respectively. The high Q_{10} for the swamp ecosystem seems due to the high organic matter and large proportion of belowground biomass as well. The results indicate that the swamp would have larger potential of ecosystem CO_2 emission than the other two alpine ecosystems. The high Q_{10} for the swamp ecosystem seems due to the high organic matter and large proportion of belowground biomass as well. The current study suggests that the Qinghai-Tibetan Plateau could be a significant CO_2 source during the no-growing season and it has significantly contribution on annual CO_2 flux.

O32

Seasonal Variations in Energy and CO2 Fluxes over a Cropland Surface in north China

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The direct and indirect effects of increasing atmospheric CO_2 may have profound implications for the structure and function of plant communities. Vegetation, in turn, plays a crucial role in the global carbon balance. Climate simulations are especially sensitive to the surface partitioning of available energy into sensible and latent heat fluxes. Agricultural ecosystem is one of the most widespread vegetation types in the world and therefore is a significant component of the earth's climate system. Field studies designed to characterize land surface processes in agricultural ecosystem are thus needed. We report results obtained from one year of an ongoing measurement campaign that quantifies the land surface-atmosphere exchanges of carbon dioxide, water, and energy over a cropland surface in the agricultural ecosystem in north China. Eddy covariance flux measurements have been making at the height of 16 m in a regular meteorological station (39.22N, 115.72W) since May, 2004. Ancillary measurements include radiation budget, meteorology, and soil moisture and temperature. The site is typical of plains in north China. Within the experimental period, the dominant temporal variation in fluxes of carbon, water, and energy are caused by variations of crop (winter wheat and corn) growth. Based on footprint analysis, we expect >90% of the measured flux to occur within the nearest 10 km of upwind area. We examine seasonal and diurnal variations in the components of the surface energy balance and in CO_2 flux. Results show that significant variation occurred in surface energy partition and CO_2 during the experiments. Daytime absorption of CO_2 flux by the crop canopy increases when latent heat flux increases. We examined the energy budget closure and found it ranges from 0.6 to 0.9.

O33

The carbon dioxide exchange over a typical steppe in Inner Mongolia, China

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Introduction

Typical steppe ecosystems developed under semi-arid continental temperate climate condition cover approximately 4.1×10^7 hm^2 that is about 10.5% of the national grassland area. Recent study shown the climate change in this region has been getting warmer trendy accompanied with obvious increasing air temperature in winter and serious drought in spring. Therefore, there is a virtual need for long-term field measurements to quantify carbon dynamics under climatic changes condition and management practices.

The experimental site is at Inner Mongolia Grassland Ecosystem Research Station located at Xilin River Water- shed of Inner Mongolia Autonomous Region (43 ° 32 ′N , 116 ° 40 ′E, 1200m a.s.l.). The site has been fenced for 24 years since 1979, being distant from settlements and water holes, the center of the research of Global Change and NECT. The climate is described as semi-arid continental temperate steppe with a dry spring and moist summer. Annual temperature averages - 0. 4 ℃ with a plant growth season of 150 - 180 d. The annual precipitation range is 320 - 400 mm, but is mainly concentrated in June to August. There are many litter falls on the ground.

Methods

Wind speed, temperature, CO_2, and air temperature were measured at 2 m over ground level. Vertical wind speed and temperature fluctuations were measured at 10 Hz using a three-dimensional sonic anemometer-thermometer aligned into the mean wind. Carbon dioxide and H_2O vapor fluctuations were measured at 10 Hz with a fast response open-path infrared gas analyzer.

Results

1. Diurnal course of CO_2 flux

During the study period in two years, the diurnal CO_2 flux pattern was divided into two situations. One had dual uptake peaks that after sunrise (at 6:00 am, Beijing Standard Time), grassland began to take up CO_2 (F_{CO2} was negative) and F_{CO2} reached the daily maximum magnitude at 8:00; then gradually decreased as PAR increased until became positive (i.e. emission) at 11:00. F_{CO2} became negative at 16:30 again. After sunset at 19:00, the grassland kept the emission of CO_2 and became a net source of CO_2.

Another diurnal course of CO_2 flux was only single peak of uptake. In 2003, the grassland started to take up CO_2 around 6:00~6:30. After reaching the maximum uptake about 8:00, F_{CO2} gradually decrease until became a net source of CO_2 around 19:00~20:00. In contrast, in 2004 the ecosystem began to take up CO_2 around 8:00 and reached its maximum magnitude around 10:00 as PAR increased. Subsequently the uptake gradually decreased with the progress of PAR, and the grassland began to become the net source of CO_2 around 20:00 (i.e. F_{co2} was positive).

In addition, in order to investigate the relationship between PAR and F_{CO2}, we plotted the F_{CO2} against PAR. After sun rising the magnitude of F_{CO2} increased as PAR increased every month and reached the maximum value around 600~800 μ mol $m^{-2}s^{-1}$and 1000 μ mol $m^{-2}s^{-1}$ respectively in 2003 and 2004. At the same level of PAR, the afternoon F_{CO2} magnitudes were smaller than those in the forenoon. In particularly in 2004, the difference between afternoon and forenoon magnitudes was bigger than that in 2003.

2. Seasonal variation of CO_2 flux

The daytime fluxes of CO_2 ranged from an uptake of -3.5 g $m^{-2}d^{-1}$ for the month of July to an emission about 2.8 g $m^{-2}d^{-1}$ in May during this study period in 2003. The maximum uptake and release was -6.6 g $m^{-2}d^{-1}$ in August and 3.1 g $m^{-2}d^{-1}$ in May respectively in 2004. By mid May in 2003, the grassland began to uptake CO_2 the peak value time was in Mid-June through Mid-July. Until late September, the signal fell into positive that indicated grassland began to release CO_2. In 2004, grassland began to uptake CO_2 at early June, the peak value appeared in August, and released CO_2 until late September. Through integrating half-hour night F_{CO2} magnitude, we found that the grassland released more CO_2 comparable at night during this study period. In 2003, the magnitude of night CO_2 flux (Re) reached the maximum value 4.4 g m^{-2} d^{-1} in July. In contrast, in 2004, the value 4.5 g $m^{-2}d^{-1}$ t was observed in August.

Calculating the sum of diurnal and nighttime F_{CO2}, and then integrated the daily sum to one month. The variation in monthly CO_2 fluxes was considerable distinction from May to September between 2003 and 2004. In 2003, the magnitude of maximum monthly CO_2 uptake -135.36 g $m^{-2}mon^{-1}$ was observed in June. However, the maximum emission 95.2g m^{-2} mon^{-1} exhibited in July. In contrast, there was a maximum uptake -244.26 g m^{-2} mon^{-1} and emission 121.37 g m^{-2} mon^{-1} in August of 2004. Grassland started to become a net sink of carbon dioxide in June and reached the maximum value during growing season in 2003. However, in 2004, the date of conversing is in July, delayed near one month than 2003's.

3. Depression of net ecosystem CO_2 exchange

This study found that there was an evident decrease at midday (F_{CO2} is positive) during the study period of two growing seasons. This phenomenon cannot simply attribute to midday photosynthesis depression although the photosynthesis decrease can cause the ability of fixing CO_2 decline at midday. We entitle "Ecosystem Midday Decrease" for this phenomenon. When the ecosystem respiration over the vegetation photosynthesis also causes the positive F_{CO2} Besides this situation, we found also that during this study period CO_2 flux did not increase with PAR increased and its maximum value was not consistent with the maximum PAR. However, at midday F_{CO2} still maintain negative

Conclusions

Comparably, the characteristics of carbon dioxide exchange at our sit are totally difference with other grasslands in the world. Except the magnitude and tend variability of CO_2 uptake, the most distinct difference is that the grassland displayed double peaks of CO_2 uptake, i.e. there was an "Ecosystem midday decrease" phenomenon at midday.

O34

RESPONSES OF TRANSPIRATION AND CANOPY CONDUCTANCE OF YOUNG CONIDFEROUS PLANTATION TO SEVERE DROUGHT IN SOUTH CHINA

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A two-year measurement (2003-2004) of evapotranspiration (LE) and its components were made in a coniferous plantation in south China. This ecosystem was experienced a prolonged dry spell and above-normal temperatures during July 2003. During this episode, total precipitation was less than 5 mm, and the temperature was higher 3 ℃ than the average level. LE was measured continuously with eddy-correlation systems from a 42.5 m tower, and transpiration (Tr) was measured by thermal-dissipation sapflow technique in six different trees. Canopy conductance (Gc) was estimated from the sap flux measurement using the inversed Penman-Monteith equation. The results showed that for this young coniferous plantation, the difference of the canopy conductance value was significant in different water conditions. The canopy conductance linearly increased with drought index. Moreover the long-term no-rain weather caused the peak value of daytime Gc to occur earlier in the morning. The weight of transpiration and understory evaporation (Es) to the total evapotranspriation varied with the climate condition, and the ration of Es to Tr increased decreased with drought index. There was sensitive response of Gc to environmental factors under no water stress and ample water conditions, but it was relative conservative under severe drought condition.

Keywords: Drought; Canopy conductance; Transpiration; Evapotranspiration; Coniferous forest

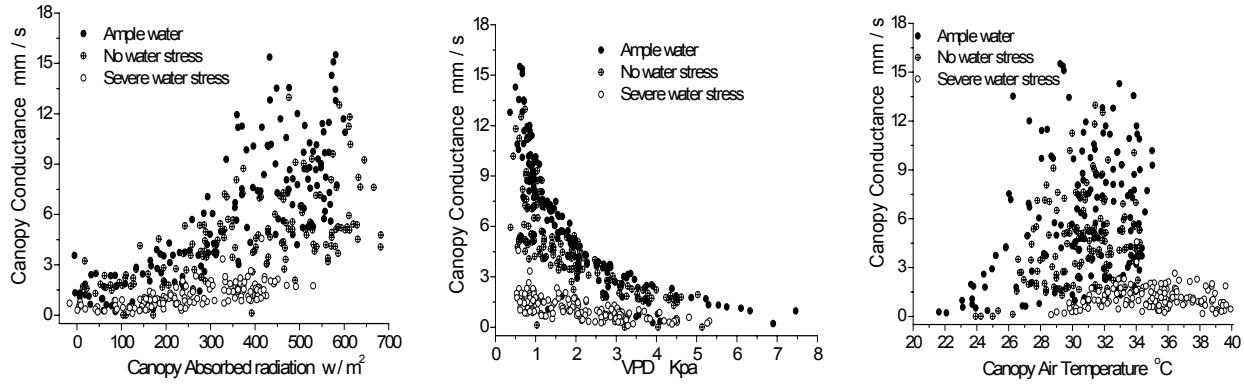

Fig. Response of Gc to environmental factors under different water conditions

O35

SURFACE ENERGY FLUXES OF THE TIDAL ZONE OVER THE ARIAKE SEA

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The Ariake Sea is a closed bay on the west of Kyushu Island, Japan, with a dynamic tidal range over 5 m in the closed-off section of bay in the spring tide. The Ariake Sea also has a vast tidal flat: the exposed area becomes wider than 200 km^2 in the spring tide, occupying about 40 % of the total exposed area in Japan.

The energy budget on the tidal flat surface has been thought to play an important role in controlling the thermodynamic properties of seawater and the biophysical chemical processes of the tidal bottom surface. However, the land sea surface-atmosphere interaction on the tidal flat is complicated because of including not only the diurnal cycle mainly driven by solar radiation but also the tidal cycle controlling the seawater coverage in the tidal bottom surface. Therefore, the objective of this study is to observe the surface energy fluxes on the tidal flat using the direct method of turbulent eddy correlation.

The observation system was constructed on the inter-tidal zone near the Kumamoto Port (32º46´5" N, 130º35´40" E). The turbulent flux observation system of the AWS is composed of the sonic anemo-thermometer (81000, YONG) and the infrared H_2O/CO_2 gas analyzer (LI-7500, Li-COR). The data are sampled at 10 Hz and stored on the data logger (CR-5000, Campbell). The surface around the system exposes offward about 1.5 km at lowest water level. Around site, the bottom surface exposes as long as 3.5 hours in a half-day tidal cycle in the spring tide. In the neap tide, however, the bottom surface is always submerged.

While the bottom surface was submerged in the daytime, the sensible heat flux and latent heat flux was as low as 100 Wm^{-2}, although the net radiation flux became higher than 700 Wm^{-2}. As soon as the bottom surface was exposed, both the sensible heat flux and the latent heat flux increased because the bottom soil surface was heated directly by the net radiation. Under the exposed condition, the bottom soil was still wet and the latent heat flux was dominant. During several hours from sunset, the latent heat flux became higher than 150 Wm^{-2}. The diurnal variation of the water temperature, skin surface temperature, and atmospheric temperature showed that the atmospheric stratification was still unstable during the night with the bottom surface covered by seawater, which released the heat energy both into atmosphere and into the bottom soil.

A scale analysis of seawater temperature equation showed that vertically integrated advection term became an order of 100~500 Wm^{-2}, by substituting the typical value in the Ariake Sea. This value was comparable to other components of the surface energy fluxes.

O36

APPLICATIONS OF GENETIC NEURAL NETWORK MODELS FOR GAP-FILLING OF CO_2 FLUX DATA SETS

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In continuous measurements of flux, about a quarter to almost a half of data is commonly missed. Many gap-filling methods have been proposed; lookup-table and mean diurnal variation methods, multiple imputation method, empirical equations parameterized by the non-linear regression (NR) and artificial neural network (ANN) method.

At first, we proposed two new gap-filling methods; an ANN designed by genetic algorithm (GA) - **GNN** (genetic neural network) method, and a multiple GNN model, in which data are classified by a self-organized map (SOM; Kohonen, 1995: *Self-Organizing Maps*, Springer-Verlag, pp. 362) - **SOM-GNN** method. When an ANN model is applied for NEE gap-filling, there are some difficulties in selection and determination of the input elements and model parameters. In the GNN method, GA, which is one of optimization methods, selects effective input elements from the data sets and determines parameters automatically (Fig. 1a). However, calculation time of GNN methods is not short, therefore we tried to reduce the calculation cost by SOM-classifying input data and preparing a specialized GNN model for each data class (Fig. 1b). It is different from conventional classification (e.g. cluster analysis) that SOM is a non-linear method and has a topological conservation of input vector data. In this study, these classes may imply differences in phenology and meteorological conditions. In the SOM-GNN method, a GNN model used only one data class, so that it can save calculation time by preventing over-fitting of the model to other data classes. Additionally, for rapid calculation, ANN-design (chromosome) in each a chromosome pool in a GNN are exchanged among the pools in adjacent GNN models whose classes were topologically near in the SOM, according to probability and varieties of chromosome in the pools.

Secondly, we evaluated the performance of the NR, ANN, GNN and SOM-GNN methods for the gap-filling of NEE data sets measured at a Japanese larch plantation (Tomakomai, Hokkaido: Site T), a Japanese red pine forest (Miki, Hyogo: Site M) and a Siberian larch forest (Neleger, Yakutsk: Site N). For site T (May to September 2002). Determination coefficients (r^2) of the ANN models between observed and estimated values of NEE were almost same as that of the NR method (r^2=0.86). Performance of the GNN and SOM-GNN was somewhat higher. For sites M (September 2004 to July 2005), the GNN and SOM-GNN methods also indicated favorable performance compared to the NR method.

From these results, it was suggested that the proposed neural network methods are powerful tools for gap-filing and have high availability because they do not require special knowledge about the mechanisms of target systems. In addition, this study demonstrated a data-oriented modeling supported by adaptive computation, which is consistent with a change in the paradigm of developing biospheric models more constrained from with observational data.

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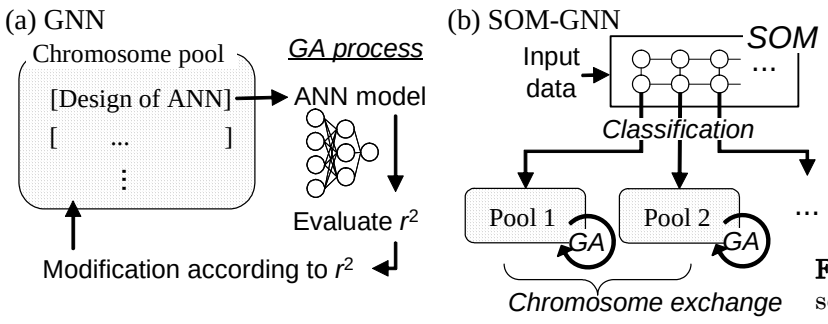

Fig. 1 Diagrams of the GNN method and self-organized map (SOM)-GNN method

Table 1 Example of determination coefficients (r^2) at site T and M

	NR	ANN	GNN	SOM-GNN
T	0.86	0.85	0.88	0.87
M	0.79	0.67	0.81	0.80

O41

RECTIFIER EFFECT IN AN ATMOSPHERIC MODEL WITH DAILY BIOSPHERIC FLUXES

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Inversion studies (e.g. Gurney et al. 2002) showed that an important uncertainty in the flux estimates is the interaction between the atmosphere and the biospheric fluxes or the 'rectifier effect'. Recent studies have shown that supplementing the baseline flask CO_2 data with continuous CO_2 measurements at baseline and continental sites could yield inversion results with greater spatial/temporal resolutions. However, continuous CO_2 measurements at continental sites show strong interaction between the atmospheric mixing and the biospheric fluxes on many time scales including diurnal, synoptic and seasonal time scales. The synoptic scale interaction is the subject of this study.

This study investigates the atmosphere-biosphere interaction on the synoptic time scale using the Biome-BGC (Thornton et al., 2002) and NIES (National Institute of Environmental studies) transport models (Maksyutov and Inoue, 2000) We used two global biospheric source distributions from Biome-BGC. One represents the daily fluxes with Biome-BGC driven by NCEP (National Centers of Environmental Prediction) daily averaged data from 1990 to 1999 (the fluxes for each year were adjusted to yield a neutral biosphere), and the second source distribution is the mean monthly fluxes averaged from year 1990 to 1999 (used as the reference in this study). These biospheric fluxes were then transported in the NIES transport model with NCEP wind data from year 1990 to 1999. Thus the biospheric flux and transport are consistent as they both used the NCEP meteorological data. The difference in the atmospheric CO_2 concentration produced by these two source distributions represents the effect of coupling between the atmosphere and biosphere with daily variations in the biospheric fluxes.

We have found that the magnitude of the difference in CO_2 simulated by the model by these two sources is approximately 10 ppm near the surface. These variations are comparable to the mean seasonal cycle. The anomalies are typically centred over landmasses and have length scale of ~500-1000 km with little continuity over different months. The smaller scale features have shorter lifetime (~ 1 month). The annually averaged CO_2 difference is about one order of magnitude smaller while still showing large interannual variations and similar spatial features.

These results show that the synoptic scale rectifier effect on the CO_2 concentration is significant on the monthly timescale and has some effect on the annual time scale. Thus the synoptic scale rectifier effect may contribute to the errors and uncertainties of CO_2 inversion estimates by models without the synoptic scale interaction of the atmosphere and biosphere.

O42

Eco-hydrological modeling and remote sensing for monitoring carbon and water fluxes in topographically complex forested landscapes

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MODIS (Moderate Resolution Image Spectrometer) is a core satellite sensor boarded on Terra and Aqua satellite of NASA Earth Observing System since 1999 and 2001, respectively. MODIS vegetation products (e.g. LAI, GPP, and ET) provide useful tools for monitoring seasonal variations of terrestrial carbon and water fluxes. For the reliable application of MODIS products, extensive validation efforts need to be addressed for diverse ecosystem regimes. We evaluated uncertainties in MODIS FPAR, LAI, and GPP products with respects to cloud contamination, input meteorology, and parameterization in Korea. The cloud-originated errors were 8.5%, 13.1%, and 8.4% for FPAR, LAI, and GPP, respectively. Summertime errors from June to September explained by 78% of the annual accumulative errors in GPP, which indicates that cloud-originated errors should be mitigated for practical use of MODIS vegetation products to monitor seasonal and annual changes in plant phenology and vegetation production in Korea. MODIS GPP algorithm adopts Data Assimilation Office (DAO) meteorological data to calculate daily GPP. By evaluating the reliability of DAO data with respect to surface weather station data, we examined the effect of errors from DAO data on MODIS GPP estimation in Korea. DAO data resulted in overestimation of GPP by 25% for most of biome types but up to 40% for forest biomes that is major biome types in Korea. MODIS GPP was more sensitive to errors in shortwave radiation and VPD than air temperatures. Our results indicate that more reliable gridded meteorological data than DAO data are necessary to better estimate MODIS GPP in Korea. Finally, we applied eco-hydrological models (BIGFOOT and RHHESSys) to evaluate uncertainty in MODIS GPP parameterization. The models were validated by using NPP data which was estimated from dendrochronological data and then, applied to calculate maximum light use efficiency(ε_{max}), a core biophysical parameter in MODIS GPP algorithm, which showed 30% underestimation of the MODIS GPP default parameter. Overall, our research indicates that considerable uncertainties were imbedded in MODIS vegetation products and hence, special concerns to mitigate the uncertainties are required for regional application of MODIS vegetation products.

O43

AN EVALUATION OF CO_2 FLUX AND LATENT HEAT FLUX IN OPEN CANOPIES WITH A MODIFIED SOIL-PLANT-ATMOSPHERE MODEL

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This study evaluates the prediction of diurnal variation of moisture and carbon dioxide flux from a modified soil-plant-atmosphere model with eddy correlation data collected above a pine forest located in a semiarid environment in central Oregon.

The model is based on the canopy model (soil plant atmosphere (SPA) model) of Williams et al., (1996), coupled to a multi-layer soil model with snow and frozen soil physics (Koren et al., 1999). In the canopy model, plants are assumed to open their stomata until either (1) further opening does not constitute an effective use of stored water in terms of carbon gain per unit water loss, or (2) further opening causes a drop in leaf water potential below the limit that causes xylem cavitation (Williams et al., 1996). In modified SPA model, we reduced vegetation layers from 10 layers to 2 layers for use in large-scale model and included stem effect in leaf energy balance. And also subcanopy eddy diffusivity was incorporated to calculate air temperature and mixing ratio in the subcanopy. Estimates of NEE were calculated as the sum of GPP from model simulation and estimates of respiration of ecosystem (R_e) determined from empirical temperature response equations.

Simulations were carried out for June and July during growing season in 2003. In June, soil water stress was relatively low and vapor pressure deficiency was moderate while in July both soil water stress and vapor pressure deficiency were high. The model showed an overall good performance in simulating the variability of half hourly latent heat flux and NEE, explaining 78% and 87 % of the variance, respectively. Two cases were selected to examine the impact of soil moisture deficit on diurnal variation of carbon dioxide and water vapor fluxes. The first case contained data for the period between days 152 and 181 when soil moisture was ample. The second case contained data between days 197 and 212. At this time, both soil moisture deficit and air temperatures were high. The model reproduced mean diurnal variation of latent and sensible heat flux and net ecosystem exchange when soil moisture was ample. In case 2, the model predicted reasonably the diurnal course of latent heat flux and CO_2 flux but it overestimated the turbulent fluxes in the morning and showed an earlier peak of carbon uptake compared to the measured CO_2 flux. Compared to case 1, case 2 had many calm nights and mornings with weak turbulence. The overestimation of the turbulent fluxes was related to the large energy imbalance in observations mainly due to weak turbulent intensity. The earlier peak of carbon uptake was due to neglected CO_2 storage term in model. However, the CO_2 storage did not explain the overestimation of respiration throughout the night, suggesting that other process such as drainage flow could play a role in carbon budget during calm night at this site.

O44

A COMPARISON BETWEEN MODELED AND MEASURED CO_2 AND WATER VAPOR FLUX IN A SUB-TROPICAL CONIFEROUS FOREST

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Abstract: Using data from eddy covariance measurements in a subtropical coniferous forest, we tested and evaluated the model of **C**arbon **E**xchange in the **V**egetation-**S**oil-**A**tmosphere (CEVSA) that simulates energy transfers and water, carbon and nitrogen cycles based on eco-physiological processes. In the present study, we improved the model in calculating LAI, carbon allocation among plant organs, litterfall, decomposition and evapotranspiration, and tested and validated the model. The modeled seasonal variations in carbon and water vapor flux were consistent with the measurements. The model explained 79% and 86% of the measured variations in evapotranspiration and soil water content. However, the modeled evapotranspiration and soil water content were lower than the measured systematically, because the model assumed that water was lost as runoff if it was beyond the soil saturation water content, but the soil at the flux site with abundant rainfall is often above water saturated. The model reproduced 79% and 88% of the measured variations in gross primary production (*GPP)* and ecosystem respiration (R_e), but only 31% of the variations in measured net ecosystem exchange (*NEP*) although the model annual NEP was close to the measured. The modeled *NEP* was generally lower in winter and higher in summer than the measured. The modeled responses of photosynthesis and respiration to water vapor deficit at high temperatures were different from measured, and the model underestimated ecosystem photosynthesis and respiration in extremely condition. The present study shows that CEVSA can simulate the seasonal pattern and magnitude of CO_2 and water vapor fluxes, but it requires improvement in simulating photosynthesis and respiration at extreme temperatures and water vapor deficit.

***Key words*:** Ecosystem CO_2 and water vapor flux, CEVSA, eddy covariance, subtropical coniferous forest.

O45

Simulation of CO2 flux in three different ecosystem in ChinaFLUX based on artificial neural networks

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The non-linearity of the relationship between CO2 flux and other micrometeorological variables flux parameters limits the applicability of carbon flux models to accurately estimate the flux dynamics . but the need for Carbon dioxide(CO2) estimations covering larger areas and the limitations of the point eddy covariance technique to address this requirement necessitates the modeling of CO2 flux from other micrometeorological variables. Artificial neural network (ANN) are used because of their power to fit highly non-linear relations between input and output-variables without to explain the nature of the phenomena. In this paper ,we applied a multilayer perceptron ANN technique with error back propagation algorithm to simulate CO2 flux on three different ecosystems (forest, grassland and maize) in ChinaFLUX . Energy flux(net radiation, latent heat, sensible heat and soil heat flux) and temperature (air and soil) and soil moisture were used to train the ANN and predict the CO2 flux . Diurnal half-hourly fluxes data from June to August of observations in 2003 were divided into training , validating and testing. Results of the CO2 flux simulation show that the technique can successfully predict the observed values with R2 value between 0.75 and 0.866. The results also showed the soil moisture couldn't improve the simulative accuracy without limitations of soil moisture. The analysis of the contribution of input variables in ANN show the ANN is not a black box model, it can tell us about the controlling parameters of NEE in different ecosystem and micrometeorological environment. The results indicate the ANN is not only the reliable ,efficient technique to estimate regional or global CO2 flux from point measurements and understand the spatiotemporal budget of the CO2 fluxes ,but also can discovery the relations between the CO2 flux and micrometeorological variables.

***Keywords*:** Artificial neural network;CO2;ChinaFLUX; Energy flux; variables contribution.

O46

ANALYSIS AND INTERPRETATION OF ASIAFLUX DATA IN CONNECTION TO GLOBAL CARBON CYCLE MODELING

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A regional carbon sink is a sum of carbon fluxes provided by regional ecosystems. The combinations of ecosystems, environmental and climate conditions form a variety that developing network for carbon flux monitoring cannot cover, and so the regional and global assessments are presumed to be based on models extrapolating and interpolating measured fluxes.

Getting robust estimate of regional carbon sink is a challenge. Not every model that fit fluxes measured at a site may serve the purpose. If accuracy achieved by model specialization, that is, by taking into account specific features of the site, the model is hardly applicable at regional scale, across the ecosystem diversity.

TsuBiMo (a process-based carbon cycle model) was developed for applying at the regional and global scale, and therefore it employs only those biophysical concepts that are commonly applicable. One of them is optimal temperature of photosynthesis. The temperature dependence of light-saturated photosynthesis is commonly drawn as a bell-shaped curve that peaks somewhere between 20 and 30°C. The width and height of the "bell" as well as the position of its center depends on plant species and conditions at which plant was grown. The problem is to find values at which corresponding parameters should be set in a global scale model.

With this in mind we consider the AsiaFlux data as indirect measurements of light-saturated photosynthesis, derive its rate by inverting the model of productivity (see [1-2] for details of the method), and plot against temperature. Thus interpreted data provide valuable information about temperature dependence of light-saturated photosynthesis that currently presents a "bottleneck" in modeling climate feedbacks from terrestrial ecosystems. The position of optimal temperature dictates when and where carbon sinks switch to sources under given global warming scenario, and thus current uncertainty in positioning the optimal temperature is a cause of discrepancies in carbon sink assessments [3].

Here we present the results of analysis and interpretation of the data from Takayama [4] and Tomakomai [5] sites of AsiaFlux network and discuss some peculiarities in the obtained curves of temperature response that cannot be readily interpreted within the framework of chemical thermodynamics.

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Poster Session

P01

Leaf phenology model based on seasonal carbon allocation for a forest ecosystems model.

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Abstract

We proposed a new phenological model in which we utilize the amount of carbon stored during the previous late-growth season as the determinate index of the leaf amount built in the following spring, together with several phenological events that have been considered in previous researches of phenology models; i.e., the timings of budburst and leaf-fall, the time series of the increment leaf amount during the growing season and of the decrement until completion of the entire leaf-fall of the stand. Further, our phenological model was coupled with a forest ecosystems model to describe the dynamics of a forest stand. The combined model was applied to a deciduous *Larix kaempferi* forest stand, and the validity of the representation of the dynamics in the stand over seven years was examined. As the outcome of the adjustment of the model parameters along with inventory data obtained at the study site, simulated annual variations of the size-structure and total canopy biomass, canopy averaged diameter and tree height of *L. kaempferi* were quite consistent with outputs derived from observed data (Fig.1). In addition, a simulated annual estimation of NPP (net primary production) agreed well with that by an alternative approach based on field data (Kurachi *et al*., 1993)(Fig.2). Thus, the simulation showed the importance of determining the annual variation of total leaf amount for applying the forest ecosystems model to forest stands with deciduous plant species, by considering the seasonal carbon utilization of trees.

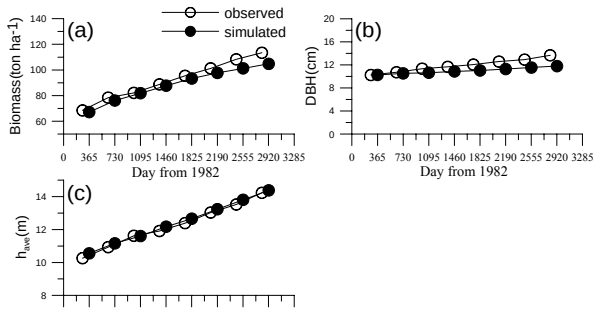

Fig. 1 Observed and simulated annual variations of (a) the entire forest biomass(ton ha^{-1}), (b) stem diameter at breast height (D_{BH})(cm) and (c) averaged tree height (h_{ave}) (m).

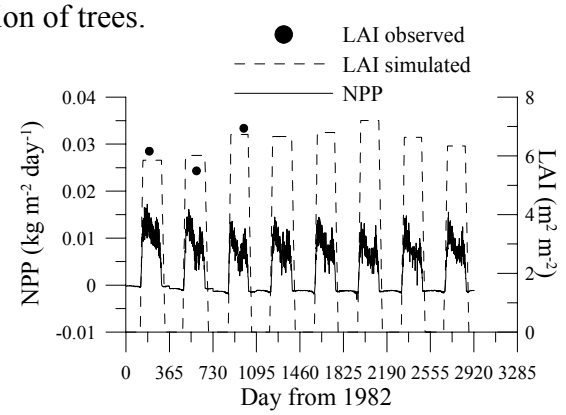

Fig. 2 Seasonal and annual variations of net primary production (NPP) and LAI. The 3-year LAI measured from 1982 to 1984 is plotted.

P02

SEASONAL VARIATION IN LEAF PROPERTIES AND ECOSYSTEM CARBON BUDGET IN A COOL-TEMPERATE DECIDUOUS BROAD-LEAF FOREST: SIMULATION ANALYSIS AT TAKAYAMA SITE, JAPAN

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Temporal variations in the net ecosystem exchange (NEE) of CO_2 over terrestrial ecosystem are regulated by various factors such as environmental conditions and plant phenology. Process-based models, which simulate photosynthetic uptake and respiratory release explicitly, are effective for analyzing the mechanisms of the temporal NEE variations. We have developed an ecophysiological process-based model, which is applicable to flux measurement site, and in this study applied it to assess the effect of another factor, *i.e.* temporal change in leaf properties or leaf aging from emergence to senescence. The carbon cycle model is composed of 12 compartments for four sectors: canopy trees, understory plants, dead biomass (litter), and mineral soil. Net ecosystem production (NEP, = –NEE) is obtained as the difference between gross primary production (GPP) and ecosystem respiration (ER). To simulate carbon budget from diurnal to decadal time scales, the model consists of two modules, one for the 1-day-step ecosystem carbon dynamics and another for the 30-min-step canopy net CO_2 exchange. Leaf phenology is simulated in the 1-day module, using cumulative temperatures to determine leaf emergence and shedding times. The 30-min-step module adopts a sun/shade canopy radiation transfer and photosynthetic scheme developed by de Pury and Farquhar (1997). A series of model simulations were performed at a cool-temperate deciduous broad-leaved forest in Takayama, central Japan, where long-term continuous measurements of NEE with the eddy-covariance method and ecological surveys have been carried out by the National Institute of Advanced Industrial Science and Gifu University. Observational data of leaf area and gas exchange were used to parameterize the temporal change in leaf properties of canopy species, *Betula* and *Quercus*: leaf mass per area (LMA), maximum carboxylation rate (V_{cmax}), electron transport rate (J_{max}), and dark respiration rate (R_d). We conducted a sensitivity analysis by comparing with simulations using constant parameter values (i.e., no leaf aging effect). At first, we examined model reliability with observational data in terms of the carbon cycle such as biomass, soil carbon stock, and annual GPP, ER, and NEP. The estimated NEP was well correlated with the observed NEE (r^2 = 0.85) in 1999 and 2000, suggesting validity of the model. The model reasonably simulated the seasonal NEE change from 3 g C m^{-2} day^{-1} net source in late winter to 5 g C m^{-2} day^{-1} net sink in early to mid-summer (Fig. 1). The sensitivity experiments, in which leaf phenology and/or leaf aging were neglected, showed that sole environmental variation was not sufficient to account for the evident NEP seasonality, and that the leaf aging effect was one of the important factors. For example, neglecting the leaf aging effect, the model overestimated annual GPP by 6% and annual NEP by 38%. Detailed analyses indicated that the temporal change in V_{cmax} was firstly and those in LMA and R_d were secondarily important.

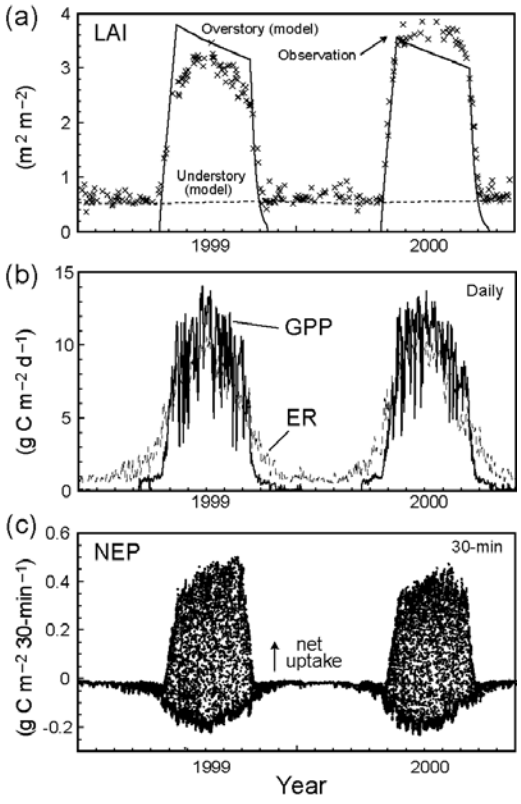

Fig. 1. Seasonal changes in the carbon cycle of Takayama site estimated with a process-based model including the leaf aging effect. (a) Leaf area index (LAI), compared with observation, (b) daily gross primary production (GPP) and ecosystem respiration (ER), and (c) net ecosystem production at 30-min time step.

P03

ESTIMATION OF PLANT AREA INDEX BY DOWN-LOOKING HELIBORNE LIDAR IN JAPANESE LARCH FOREST

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The distribution of leaf area and wood area in forest play an important role in estimation of CO_2 fixation of forest and interpretation of spectral reflectance on remote sensing data. As the indices that express the distribution, a plant area index (PAI), which is the total one-sided leaf area and wood surface area per unit ground surface area, and an average plant inclination angle (APIA), which is the angle between the normal of leaf and wood surface and the vertical, are widely used. Among the many techniques to measure PAI and APIA, gap fraction theory is applied to various applications, because it can measure PAI and APIA without destruction of forest and time-consuming. We developed the techniques to measure gap fraction from the probability of penetration of laser beams through the canopy by the laser range finder (Takeda, 2005). The advantages of using the laser range finder are that, 1) the three-dimensional distribution of PAI and APIA can be measured, 2) the measurement at night time become possible, and 3) the measurement not only at the forest floor but also above the canopy become possible. In relation to 3), we succeeded in the measurement of PAI and APIA in large scale by using side-looking LIDAR mounted on helicopter. However, the commonly used airborne or heliborne LIDAR can not shot the laser beam in the direction of the angle needed to invert PAI and APIA from gap fraction. So, as one attempt to estimate PAI by commonly used heliborne LIDAR, we discussed that the technique to estimate PAI by down-looking heliborne LIDAR, under the assumption that APIA was already known.

The measurement was conducted at the Tomakomai Flux Research Site (hereafter refer to TFRS) in the national forest located in Tomakomai, Hokkaido, Japan (42° 44′ N、141° 31′ E). In TFRS, 45-year-old Japanese larch (*Larix kaempferi* Sarg.) with the tree height of 13.8m (range from 7.0m to 20.0m) was planted and the population was about 1087 plants/ha^{-1}. In order to estimate PAI, dividing the area scanned by down-looking heliborne LIDAR into 63 plots with the area of 100m × 100m, and the measurement of gap fraction in each plot was conducted. To verify accuracy, the measurement of PAI and APIA by side-looking heliborne LIDAR was also conducted in same plots. The measurement of side-looking heliborne LIDAR was conducted in September 8, 2003 and down-looking heliborne LIDAR was conducted in September 9, in 2003.

In a case that APIA assumed 57.3 degree, which is the APIA of spherical distribution, the relation of PAI measured by side-looking heliborne LIADR and down-looking heliborne LIDAR shows that RMSE is 2.21 and the slope of regression line is 1.11. On the other hand, in a case that APIA assumed 45.5 degree, which is the averaged APIA in all plots measured by side-looking heliborne LIDAR, the relation of PAI measured by side-looking heliborne LIADR and down-looking heliborne LIDAR shows that RMSE is 1.84 and the slope of regression line is 0.94. A difference was few seen in RMSE between both PAIs. But, from the result that RMSE was about 2, it was suggested that the error included in PAI could not be neglected in some plots.

Reference

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P04

DEVELOPMENT OF MEASUREMENT SYSTEM FOR EVALUATING FOREST ECOSYSTEMS: MEASUREMENT METHOD OF NPP BY USING AIRBORNE LASER SURVEY

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In order to develop a monitoring system for evaluating forest ecosystems, a method of forest stand measurement using airborne laser survey was examined. The study area was a *Larix leptolepis* forest (100m×100m) in the Tomakomai Flux Research Site, Hokkaido, Japan (42°44'N, 141°31'E). Canopy height was approximately 15-16m and tree age was about 45 years old.

The laser survey data were taken in the year 1999, 2001 and 2003. A canopy DSM (Digital Surface Model) was constructed from first pulse of the laser survey data, and the DTM (Digital Terrain Model) was constructed from the last pulse of it. The DCHM (Digital Canopy Height Model) was made by the difference of the canopy DSM and DTM. The crowns of trees were extracted from the canopy DSM by the Watershed method. Tree height was measured by the difference of maximum altitude of laser point and DTM altitude within the extracted crown. The stem volume of trees was calculated by using the relationship between tree height and the stem volume. The tree height measured by the laser survey tends to be underestimated because of penetration in the foliage and missing tree tops. Therefore, tree heights are corrected by the relationship of the true height and measured height when the pulse density is thinned as a simulation. And, since the crowns of under-storey tree could not be detected in the laser survey, the MNY method (Hozumi, 1971) was used for the prediction of under-storey trees. The stand volume was calculated as the sum of stem volumes. The carbon weight of the stand was calculated by using the relationship between the wood volume and the wood dry-weight, and by multiplying the expansion factor, and the carbon content factor. NPP using laser survey was calculated as the sum of the annual carbon weight growth and the annual carbon weight of leaf fall. And, for the comparison, *NPP* by using micrometeorological method was calculated as

$$NPP = NEP + R_h - w_f \quad (1)$$

where *NEP* was the estimated NEP by the eddy covariance technique (Open- and closed-pass system) , R_h was the heterotrophic respiration and w_f was the carbon weight of forest floor plants.

The results that the growth of the forest stand height was 0.23~0.25cmyr^{-1}, and that the growth of the forest stand volume was 11m^{3}yr^{-1}, both were near to the data obtained by the complete enumeration. NPP calculated from the laser survey method and from the complete enumeration method were 298 gCm^{-2}yr^{-1} and 311 gCm^{-2}yr^{-1} , respectively. *NEP* by the Open- and closed-pass system was 566 gCm^{-2}yr^{-1} and 232 gCm^{-2}yr^{-1} (Hirata *et al.*, submitted) , R_h was 545 gCm^{-2}yr^{-1} (Liang *et al.*, 2004) and w_f was 355 gCm^{-2}yr^{-1}, then *NPP* became 756 and 422 gCm^{-2}yr^{-1}. This value was larger than the NPP by laser survey. This bias of NPP is thought that the formula (1) lacks the production of the rootlet. But, NPP calculated from the laser survey method and from the complete enumeration method were close value. Therefore, this method has a precision for the measurement of NPP.

P05

RELATIONSHIP BETWEEN THE REMOTE SENSED VEGETATION INDICES AND PHOTOSYNTHETIC LIGHT USE EFFICIENCY OF JAPANESE LARCH NEEDLES

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To clarify the utility of remote sensed vegetation index for evaluation of photosynthetic light use efficiency (LUE) of Japanese larch (*Larix kaempferi*), three types of spectral vegetation indices and daytime gas exchange rates of larch needles were investigated on different satellite overpass time.

In six clear days from early June to late October in 2003, the 4-band spectral reflectance (531, 570, 671 and 782 nm), net photosynthetic rate (*Pn*) and photosynthetically photon flux density (PPFD) were investigated at the canopy top of mature Japanese larch forest in Tomakomai, Japan (42° 44'N, 141° 31'E). The measurements were carried out two times per day, on near overpass time of Terra/MODIS (10:40 JST) and Aqua/MODIS (13:40 JST). Spectral reflectance of larch needles was measured using a portable spectral imager (MSI-4, Photron Co.), and the photochemical reflectance index (PRI)[1)], normalized vegetation index (NDVI)[2)] and difference of reciprocal reflectance ($1/R_{RED}$-$1/R_{NIR}$)[3)] were calculated from spectral reflectance as follows (R_λ denotes the reflectance at λ nm):

$$\mathrm{PRI} = (R_{531} - R_{570}) / (R_{531} + R_{570}) \quad (1)$$

$$\mathrm{NDVI} = (R_{782} - R_{671}) / (R_{782} + R_{671}) \quad (2)$$

$$1/R_{RED}\text{-}1/R_{NIR} = 1/R_{671} - 1/R_{782} \quad (3)$$

The *Pn* of the larch needles and the incident PPFD were determined using a portable photosynthesis system (Li-6400, Li-Cor, USA), and the LUE was calculated as *Pn* divided by the incident PPFD.

At the monitoring site, expansion of short-shoot needles was started from mid-May, and yellow color change of the needles was observed in late October. As well as phenology of needle growth, both *Pn* and LUE increased during summer, with peaks in August, and reduced in October. The *Pn* from June to July was significantly higher in the morning overpass time than that in afternoon overpass time due to higher irradiation in the morning period. However, no significant difference was found on the LUE between the overpass times.

The feature of seasonal variation differed among the analyzed vegetation indices. The NDVI and $1/R_{RED}$-$1/R_{NIR}$ stabilized from late June to September, and then reduced in October. On the other hand, the PRI increased from June to August, and reduced in October together with needle senescence. There was no significant effect of satellite overpass time on these vegetation indices.

Consequently, strong correlation was detected between the LUE and PRI of larch needles in both satellite overpass time ($r = 0.955$ in AM, $r = 0.954$ in PM). Although the significant correlations were found between the *Pn* and the analyzed vegetation indices, their correlations (coefficient correlation and regression line) were affected by observation time. Although further study is needed to develop the LUE estimation model for the large scale targets (ex. tree canopy and forest ecosystems), these results obtained in this study suggest that PRI is one of the useful indices for estimating the seasonal change in LUE of CO_2 flux in Japanese larch forest even by using snapshot data.

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P06

ANALYSES OF PHENOLOGY AT THE TAKAYAMA SITE USING A TIME SERIES OF FIXED VIEW CAMERA IMAGES

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A simple numerical method for analyzing phenology in a cool-temperate deciduous forest using seasonal variation of fixed view images was investigated. The images were taken in daytime everyday by a fixed camera, 'Gamo's Eye System', looking down the forest canopy located in the Takayama observation site, Japan. After digitizing each photo into RGB image data, normalized values (*r*, *g*, *b*) of the average intensities for each channel (red, green, blue) over the image were calculated. The seasonal variation of the normalized average intensities (Fig. 1) was compared with the observation of the images. As a result, it was found that discontinuities in the seasonal variation, i.e. days when maximum or minimum, change of increasing or decreasing rate of any of *r*, *g* or *b* appeared, were coherent with and utilizable to detect events such as snow melting, leaf opening, changing from new green leaves to mature leaves, autumn leaves, leaf shedding and so on. Also, discontinuities appeared in the time series of simultaneously observed parameters related to photosynthesis such as fPAR (Fraction of Absorbed Photosynthetic Active Radiation), PAI (Plant Area Index) were consistent with any of that appeared in the time series of *r*, *g* or *b*. These results suggest the possibility of application to a simple method to estimate photosynthetic parameters using fixed view images taken by handy imaging devices like digital still / video cameras or PC cameras.

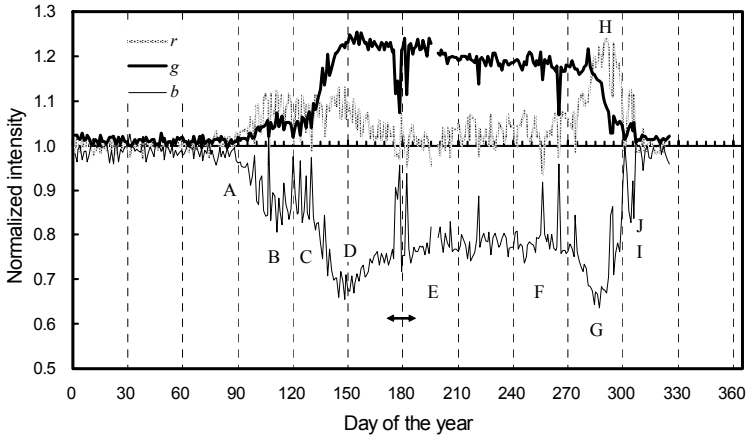

Fig.1 Seasonal variations of normalized average intensities r, g, b and y obtained from the fixed view images at Takayama site in 2002.

Letters plotted in the figure denote the days A: beginning of snow melting, B: end of snow melting, C: beginning of leaf opening, D: end of leaf opening, E: alteration from new green leaves to mature leaves, F: beginning of autumn leaves, G: peak of yellow leaves, H: peak of red leaves, I: end of leaf shedding, J: snowfall, respectively.

P07

RESEARCH PLAN AND STRATEGY OF THE FOREST OBSERVATION METHOD USING REMOTE SENSING IN THE FUJI-HOKUROKU SITE

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Remote sensing techniques are expected to play an important role in establishing the carbon sink assessment system for the Kyoto Protocol and the study of the carbon cycle on both the regional and global scale. So far, the technique for monitoring photosynthetic activity and phenological change of larch trees by passive remote sensing and the aboveground biomass measurement techniques by laser remote sensing were developed and verified at the Tomakomai Flux Research Site. We are going to develop remote sensing research of two themes like Tomakomai also at the new site in Fuji-hokuroku. The outline of two themes is described below.

1)Assessment of aboveground biomass

The airborne laser-profiler is a remote sensing technology that promises to increase the accuracy of wide-area biomass measurements. It can measure to an accuracy of about 15 cm in the vertical direction and 3cm in the horizontal direction. We are planning to observe 200ha around new Fuji flux research site with airborne laser-profiler, and high spatial resolution digital camera in this August or September. The laser-profiler provides us with the canopy height, the digital surface model (DSM), and the digital terrain model (DTM). The airborne digital camera acquires multispectral image with a resolution of 5cm from the altitude of 500m and is expected generating the three dimension model of 15cm resolution. By analyzing these data, the aboveground biomass of the larch forest is calculated and making it into the fiducial data of the year which began to measure CO_2 flux is expected.

2)Evaluation of forest ecosystems using hyper spectral reflectance

The hyper spectral reflectance over the forest is expected to obtain the information, related to the health condition, leaf biochemical contents ratio and photosynthetic activity. Hemispherical spectro radiometer system which covers the wavelength range from approximately 350nm to 1100nm with a spectral resolution of 7nm was developed in order to take the hyper-spectral reflectance of the forest canopy in the daytime automatically by cooperation with Phenological Eyes Network (PEN).

Two spectroscopes are mounted in the highest floor of the flux tower and observe hyper reflectance spectra of the canopy at intervals of 2 minutes. The goal of this research is comparing various vegetation indexes such as NDVI, PRI, WI with CO_2 flux using this data.

References

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P08

SPATIAL RESOLUTION EFFECT ON AREAL EVAPOTRANSPIRATION SIMULATION IN HAIBEI, TIBET PLATEAU, CHINA

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Quantification of areal evapotranspiration from remote sensing data requires the determination of surface energy balance components with support of field observations. Much attention should be given to spatial resolution sensitivity to the physics of surface heterogeneity. Using the Priestley–Taylor model, we generated evapotranspiration maps at several spatial resolutions for a heterogeneous area at Haibei, and validated the evapotranspiration maps with the flux tower data. The results suggested that the mean values for all evapotranspiration maps were quite similar but their standard deviations decreased with the coarsening of spatial resolution. When the resolution transcended about 480 m, the standard deviations drastically decreased, indicating a loss of spatial structure information of the original resolution evapotranspiration map. The absolute values of relative errors of the points for evapotranspiration map showed a fluctuant trend as spatial resolution of input parameter data layers coarsening, and the absolute value of relative errors reached minimum when pixel size of map matched up to measuring scale of eddy covariance system (was shown in Fig.1). Finally, based on the analyses of the semi-variogram of the orignal resolution evapotranspiration map and the shapes of spatial autocorrelation indices of Moran and Geary for evapotranspiration maps at different resolutions, the optimum resolution for the areal evapotranspiration simulation at this study area was determined.

Keywords: evapotranspiration; optimum resolution; spatial variation; eddy covariance; TM.

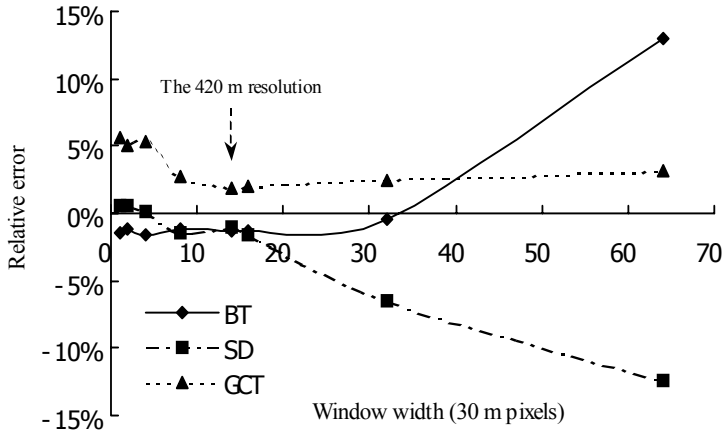

Fig.1 Different response of evapotranspiration simulation to the resolution coarsening at three ecosystems, BT: Meadow ecosystem, SD: Swamp ecosystem and GCT: Shrub ecosystem.

P09

RESPONSE CHARACTERISTICS OF PORTABLE CO_2 SENSORS

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Portable infrared CO_2 sensors are often used for soil CO_2 efflux measurements; however, such inexpensive small sensors are often relatively inaccurate and exhibit a slow response. The output signals are delayed both from diffusion processes in the sample cell and from internal averaging calculations for stable data output. Therefore, for accurate estimations of the CO_2 efflux, we need to know the actual increase in the CO_2 concentration in a chamber without these composite delays.

First, we conducted laboratory experiments to check the accuracy of each sensor, namely, GMD20, GMT222, GMM222, GMP343 (Vaisala), and Li820 (LiCor). The outputs of GMD20, GMT222, and GMM222 were monitored when the standard gas concentrations were 0, 353.3, 420.5, and 950 ppm. The errors ranged from 5 ppm to 140 ppm. After calibration, the maximum error reduced to 20 ppm or less. The error of GMP343 was below 1% after calibration. GMP343 had the highest accuracy among the Vaisala sensors. The error of Li820 was below 0.1%. Hence, the accuracy of Li820 was higher than that of GMP343.

Next, we conducted response experiments to parameterize composite delays under diffusion and flow-through conditions. Since Li820 has a quicker response in comparison with the other sensors, it was excluded from these experiments. The response time of a sensor when installed with a dust filter was longer than that without a dust filter. Furthermore, the response time of a sensor under the diffusion condition was longer than that under the flow-through condition. We developed a backward estimation method (BCDC: Backward calculation for delay compensation) for estimating the actual increase in the CO_2 concentration by using delayed sensor outputs. The actual CO_2 concentration is given by the following equation in BCDC:

$$C_t' = C_0 + (C_{t+b} + C_0)/(1 - \exp(-aT))$$

where a and b are the constants of each sensor; C_t', the expected CO_2 concentration in the chamber if the output of the sensor is not delayed; C_0, the initial CO_2 concentration in the chamber; C_{t+b}, the CO_2 concentration in the chamber at $t + b$ (s); and T, temperature (°C). The constants a and b of GMP343 diffusion type with a dust filter under diffusion condition were 0.0076 and 0 s, respectively, while those without the dust filter were 0.0133 and 0 s, respectively. Further, the constants a and b of GMP343 flow-through type under the flow-through condition were 0.2210 and 0s, respectively, and those of GMM222 probe type C with a dust filter were 0.0421 and 21 s, respectively.

We calculated the soil CO_2 efflux with the sensor outputs and modified CO_2 concentration by BCDC, using a nonlinear regression under diffusion model. The soil CO_2 effluxes calculated with the sensor outputs (F_{cal}) were always smaller than those calculated with the actual CO_2 concentration (F_{model}). The difference between F_{cal} and F_{model} decreased when the sampling interval was long. A long sampling interval may reduce errors; however, it is inefficient and sometimes has a negative effect because the closure of the chamber for a long period leads to changes in the chamber environment. This suggests that a short sampling interval leads to a large underestimate of the soil CO_2 efflux when the efflux is calculated with non-corrected data using the nonlinear regression. Thus, the correction of the sensor response with the backward estimation method provides an effective solution for archiving an accurate estimation of the soil CO_2 efflux using the sensors that are slow to respond.

P10

RELATIVE CONTRIBUTION OF ROOTS ON SOIL RESPIRATION IN A COOL-TEMPERATE DECIDUOUS FOREST IN KOREA

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The soil CO_2 efflux is a major source of CO_2 in terrestrial ecosystems and a key component of the carbon balance. The soil CO_2 efflux is resulted from the combinations of biological and physiological processes with high spatial and temporal variations. The objectives of this study were (1) to qualify the relationship between soil CO_2 efflux and environmental factors, such as soil temperature, and (2) to estimate the relative contribution of root respiration in soil CO_2 efflux. The study was carried out in a *Quercus mongolica* forest at Daegwallyeong Flux Measurement Site (DFMS), which is the typical cool-temperate deciduous forest in Korea. The measurements were carried out from August 2003 to August 2005. The soil CO_2 efflux and het erotrophic respiration were measured continuously with a multichannel automatic chamber system through the whole year.

The soil CO_2 efflux was increased exponentially with increase in soil temperature. We found a significant relationship between soil temperature and soil CO_2 efflux, root respiration and heterotrophic respiration, respectively. Annual soil CO_2 efflux and heterotrophic respiration in 2004 was 5.3 and 2.4 tC ha^{-1}, respectively. Annual root respiration in 2004 was estimated to be 2.9 tC ha^{-1} that accounted for about 55% of soil CO_2 efflux.

P11

SEASONAL CHANGE IN THE CONTRIBUTION OF ROOT RESPIRATION TO SOIL RESPIRATION IN A TEMPERATURE FOREST IN JAPAN

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INTRODUCTION

CO_2 flux from root, considered a part of soil respiration (*Rs*), plays an important role in the carbon cycle of forest. Hanson *et al*. (2000) concluded in their review that the contribution of root respiration (*Rr*) to *Rs* might converge at approximately 48.5% in the forest ecosystem. However, it is difficult to build the technique to separate accurately *Rr* from *Rs*. We had measured root respiration according to root thickness and it was shown that fine root had an important role in root respiration (Dannoura *et al*., 2003). In this study, we developed a new method for temporal *Rr* of fine root and evaluated the contribution of *Rr* to *Rs*.

SITE DESCRIPTION

Measurements were conducted at Yamashiro Experimental Forest (YEF) in Kyoto, which is a mixed forest of deciduous and evergreen broad-leaved trees including some conifers. The soil is immature and originated from granite. DBH (Diameter at breast high) of all trees (DBH > 1.0 cm) were measured in this research site in 1999 (Goto *et al.*, 2003).

METHODS

We developed an automatic chamber system for measuring CO_2 flux from fine root. It consisted of an IRGA (Li-820), a pump, and 5 chambers that were alternately operated. To measure only *Rr*, forest soil of A layer including organic matter was removed, and only living root was remained. Instead of removed soil, the space was stuffed with decomposed granite soil. Acrylic board was put between A and B layer to elude the influence of CO_2 flux from below B layer (mineral soil). At the same time, *Rs* and CO_2 flux from B layer were measured. We set up 3 chambers for *Rr*, 1 chamber for *Rs*, and the last one for CO_2 flux from B layer. At each chamber, CO_2 flux was measured at 35-min intervals, soil temperature and water content were measured continuously from April 2004 to May 2005.

RESULT AND DISCUSSION

From annual measurement of CO_2 flux using automatic chamber system, *Rr* of fine root responded exponentially to soil temperature. High soil moisture during and just after rainfall became limiting factor in *Rr*. *Rs* responded exponentially to soil temperature, too. There was positive relationship between soil water content and *Rs*. CO_2 flux from B layer did not make response to soil temperature and soil water content. From annual measurement, relationship between *Rr* and soil temperature did not change seasonally and *Rr* reached its peak at summer same as soil temperature. On the other hand, *Rs* showed clearly hysteresis to soil temperature. Therefor, yearly peak of *Rs* reached earlier than that of soil temperature. The ratio of *Rr* to *Rs* changed from about 20% to 70% through a year. The decomposition rate might be accelerated by high temperature and high soil water content in rainy season (June and July), so most litter was decomposed by summer. We suspected that the change in *Rr*/*Rs* ratio was caused by seasonal change of the amount of decomposed litter. These results suggested the importance of analysis of long-term measurement for discussion about the role of *Rr* in forest ecosystem.

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P12

CONTINUOUS MEASUREMENT OF CO_2 EVOLUTION FROM A JAPANESE CEDAR FOREST FLOOR USING A CHAMBER SYSTEM WITH AUTOMATIC OPEN AND CLOSING BASED ON AN OPEN-FLOW METHOD

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The carbon stock of Japanese cedar (*Cryptomeria japonica* D. Don) forests represents 24% (308 to 364 $\times 10^6$ Mg C) of the total Japan forests, with an area-weighted mean of 77 Mg C ha^{-1} (Fukuda *et al*., 2003; Fang *et al*., 2005). However, there are only a few studies concerning soil respiration in Japanese cedar forests (Simono *et al*., 1989; Ohashi *et al*., 1999; Shutou and Nakane 2004). The static CO_2 absorption method (Shutou and Nakane, 2004) and manual open-flow method (Simono *et al*., 1989; Ohashi *et al*., 1999) have been used to measure soil respiration for once a month on a just fine day. Some reports, however, demonstrated that the static CO_2 absorption method might be inadequate for field measurements (Edwards and Sollins, 1973; Nakadai *et al*., 1993). It has been also confirmed that CO_2 concentration in the chamber (Hanson *et al*., 1993; Nakadai *et al*., 1993) and rainfall (Lee *et al*., 2002) significantly affect soil respiration rate. Moreover, the measurement at night or on rainy days is strongly limited with these methods because human intervention is required. Thus, it is important to consider both short-term and long-term measurements that account for changes in various environmental factors. To accomplish these subjects, we established a chamber system with automatic open and closing for measuring continuous soil respiration based on an open-flow method (AOCC) described in the previous study (Suh *et al*., *in press*). In the present study, our object is to examine seasonal changes in soil respiration of a Japanese cedar forest using the new chamber system. We also evaluated the relationship between soil respiration rates and environmental factors, such as soil temperature and soil moisture.

The study area was a Japanese cedar plantation located in Takayama city, central Japan (36º 08' N, 137º 22' E). The plantation was approximately 50 years old. This region refer to a cool temperate zone, Asia monsoon climate. The annual mean of air temperature and precipitation for 44 years (1961–2004) were 11ºC and 1745 mm, respectively (data from Japan Meteorological Agency). The ecological-process research plot was established on the middle of a slope (30 m×50 m) in November 2004. The altitude of plot ranged from 800 to 850 m. The slope inclination ranged from 10º to 20º. The slope direction is south-east. The site had 1153 trees ha^{-1} with ca. 20-25 m in height. The study site was rice terrace before conducted Japanese cedar plantation.

The AOCC system is composed of three main parts: a chamber system, plus pumping and timer systems. Each chamber system consisted of three parts: chamber, cell, and soil collar. The chamber systems have an elongated octagonal shape (20×30×8 cm, L×W×H) to avoid the stagnation of circulation in any zones. A top frame encloses the upper part of the chamber and supports a fixed, 12V DC motor and two limit switches. An acrylic lid (0.5 cm thick) is supported on both short sides of the top frame. Further descriptions on the system are given by Suh *et al*. (*in press*). We installed the six chambers at locations with east-facing slope (n = 3, subplot: 15 m×10 m) and north-facing slope (n = 3, subplot: 10 m×10 m) on 25 April 2005. To establish each chamber, we inserted the collars at the depth of 6 to 8 cm below the top of the litter layer, cutting through the surface litter and roots. We operated the AOCC over a period of about 4 months, from May to August in 2005. Each chamber measurements during 30-min and then one measurement cycle of 3 hours were repeated. Analysis data were used when the CO_2 concentration at the air outlet reached a steady state. The raw CO_2 signals from the IRGAs (LI-820) were sampled every 10s and averaged every 1-min. We measured air temperature at the height of 30 cm near the chambers and soil temperatures at depth of 5 cm in the chambers. Continuous measurements of soil temperature and water content by TDR were carried out near the chambers at a soil depth of 5 and 10 cm below the top of the litter layer at 30-min intervals over the entire study period.

In this study site, no marked diurnal trends in the soil respiration rates were observed on days without rainfall. In contrast, significant changes in soil respiration rates were detected on days with rainfall events. The exponential relationship between soil temperature and soil respiration rates accounted for approximately 50 % of the soil respiration rate variability. Also, soil respiration rates in east-facing slope tended to be higher than those in north-facing slope. Our results indicated that soil respiration rates are strongly related to not only soil temperature but also soil water content and/or precipitations.

P13

LONG-TERM MEASUREMENTS OF SOIL RESPIRATION IN AN AGRO FOREST ECOSYSTEM IN KOREA

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The soil CO_2 efflux is a major source of CO_2 in agroforest ecosystems and a key component of the carbon balance. The soil CO_2 efflux is resulted from the combinations of biological and physiological processes with high spatial and temporal variations. The objective of this study was to determine the relationships between soil CO_2 efflux and environmental factors, such as soil temperature, soil moisture, air temperature and depth of soil A_1 layer in spatial variation. This study was carried out at the flux measurement site in an apple agroforest ecosystem (AFMS), in Euiseong, Korea. The measurements were carried out from August 2004 to August 2005.

The soil CO_2 efflux was measured with a multichannel automatic chamber system through the whole year. We found that the soil CO_2 efflux was increased exponentially with increase in soil temperature. Soil CO_2 efflux Q_{10}, derived from all measurements, was 3.5 during the measurement period.

P14

SOIL CO_2 EFFLUX IN A TEMPERATE FOREST ECOSYSTEM UNDER MONSOON CLIMATE IN NOTRHEAST ASIA

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Soil CO_2 efflux is the primary component (≈70%) of ecosystem respiration in forests. Quantitative and qualitative understanding of soil carbon emission is therefore critical for identifying carbon sink/source strength of forest ecosystems in the context of climate change protocols. Although soil temperature is the major controlling factor in the annual soil carbon emission, a realistic long-term estimation under monsoon climate must take the effect of precipitation into account. The objectives are to estimate annual carbon emission from deciduous broad-leaved forest floors and to investigate the influence of monsoon climate on interannual variability of soil CO_2 efflux. The annual soil carbon emission from site for three years averaged about 871 g C m^{-2} with an annual variability of the order of 10%. Such variation, however, could not be explained by the annual variations of soil temperature, suggesting the potential influence of other controlling factors such as soil water content. However, no clear relationship was apparent between soil CO_2 efflux and soil water content due to the confounding effect of both positive and negative correlations. The variability of soil carbon emission was then related to changes in magnitude, duration, and frequency of precipitation particularly during *Changma*, the rainy spell in summer. Contrary to our expectation with moderate and persistent rainfalls, an excess of soil water rather restrained CO_2 efflux. These results clearly indicate that the changes in intensity and frequency of precipitation can significantly alter the carbon sink/source strength of forest ecosystems in monsoon. This study is supported by “The Eco-Technopia 21 Project” from the Ministry of Environment, Korea.

P15

INFLUENCE OF SOIL TEMPERATURE AND MOISTURE ON SPATIAL VARIATION OF CO_2 EFFLUX ON FOREST FLOOR IN SMALL CATCHMENT -IN CASE OF YAMASHIRO EXPERIMENTAL FOREST, MAY 2004-APRIL 2005-

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1. Site Description and Methodology

The CO_2 efflux on the forest floor (F_c: mg CO_2 m^{-2} s^{-1}) was observed at the plots settled on a ridge and in a valley in the Yamashiro Experimental Forest, located at 34° 47' N, 135° 50' E, in southern Kyoto Prefecture, Japan. The distance between the two plots was 70 m horizontally and 35 m vertically. The region is covered by a deciduous broad-leaved secondary forest dominated by oak. In 1999, the total basal area and aboveground biomass of stems with a diameter at breast height (DBH) greater than 3 cm were 20.7 m^2 ha^{-1} and 105.05 t ha^{-1}, respectively. The same authors recorded the average litterfall, mean temperature, warmth index, and annual precipitation for 1999-2002 as 5.16 t ha^{-1} $year^{-1}$, 5.5°C, 125.6°C $month^{-1}$, and 1449.1 mm, respectively. The forest soil originates from granite, and has an immature structure. The forest floor at the experimental forest was consistent with this regolith, and the organic carbon content was less than 2.75%.

The CO_2 efflux was measured using an automated chamber with an enclosed infra-red gas analyzer (IRGA; Tamai *et al*., 2005a), which is classified as a closed static method. Soil temperature (T_s: ºC) and soil moisture (θ: m^3 m^{-3}) at 5-cm depth were also measured near the automated chamber. The data for May 2004 to April 2005 was analyzed in this study.

2. Results and Discussion

The average rate and standard deviation of "F_{cv} - F_{cr}" was calculated for every 5-6 days, where F_{cv} and F_{cr} are the CO_2 efflux in the valley and on the ridge, respectively. A clear difference between F_{cv} and F_{cr} was defined as the range of standard deviation that did not include "F_{cv} - F_{cr} = 0 mg CO_2 m^{-2} s^{-1}". F_{cv} was up to 0.04 mg CO_2 m^{-2} s^{-1} larger than F_{cr} from July to September 2004, while F_{cr} was slightly larger than F_{cv} (less than 0.01 mg CO_2 m^{-2} s^{-1}) from November 2004 to March 2005.

Tamai *et al*. (2005b) reported Eq. (1) based on observations at five plots in Yamashiro Experimental Forest, including the two plots observed in this study.

$$F_c = 0.0566 \exp(0.0717 T_s) \frac{\theta}{\theta + 0.1089} \qquad (1)$$

"F_{Ts} - F_{rcal}" and "F_{θ} - F_{rcal}" were calculated when F_{cr} and F_{cv} clearly differed. F_{Ts}, T_{θ} and F_{rcal} were calculated by substituting the respective values of T_s in the valley and θ at the ridge, T_s at the ridge and θ in the valley, and T_s and θ at the ridge, respectively into Eq. (1). "F_{Ts} - F_{rcal}" and "F_{θ} - F_{rcal}" are thought to indicate the effects of soil temperature and soil moisture on "F_{cv} - F_{cr}", respectively.

The calculated results show that "F_{Ts} - F_{rcal}" and "F_{θ} - F_{rcal}" had marked effects on "F_{cv} - F_{cr}" from November 2004 to March 2005 and from July to September 2004, respectively. This means that the cause of the difference between F_{cv} and F_{cr} was the spatial difference in soil temperature and soil moisture during the respective periods.

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P16

EXPORT OF DISSOLVED ORGANIC CARBON FROM KOREAN NATURAL FOREST CATCHMENT DURING STORM EVENTS

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The carbon exchange between terrestrial ecosystems and the atmosphere has been quantified in various biomes and climate regions. The movement of water also exports dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and particulate organic carbon (POC) from the soil. These materials contribute significantly to the carbon cycle, because the transport of soil-derived organic matter by rivers and its subsequent burial in coastal sea sediments is an important sink for carbon. The presented data have shown that these carbon fluxes through rivers are an important component in the global carbon cycle. Therefore, we intensively measured DOC, anions and cations in soil water, groundwater and streamwater during storm events, especially in Monsoon.

This study was conducted in the Gwangneung deciduous forest catchment (22ha), located in the Gyeonggi-do near Seoul metropolitan (elevation: 280 ~ 470m; 37° 44' N, 127° 09' E). The mean annual air temperature was 11.5℃, and average annual precipitation was 1436 mm between 1970 and 2002. Much of precipitation concentrates in summer Monsoon. The Gwangneung deciduous forest catchment was prohibited forest management such as thinning, and preserved naturally. The Gwangneung deciduous forest catchment is covered with weathered gneiss over the whole area. Hillsides with slopes 10~20° account for 80% of the total area, while maximum slope was 51°. The soil texture is sandy loam.

We found high concentration of DOC in shallow soil water during pre-events, and it ranged from 20 to 80 $mg \cdot L^{-1}$. However, DOC concentrations in groundwater decreased with increasing well depth. It seems to be that decreasing of DOC concentrations with well depth due to adsorption and decomposition process in soil layer. It showed decreasing of DOC concentration in shallow soil water during storm events. Although DOC concentrations in streamwater were showed below 1 $mg \cdot L^{-1}$ during base flow, they were drastically increased to 6 $mg \cdot L^{-1}$ with increasing runoff discharge during storm events. The maximum carbon efflux through DOC was investigated 0.6 $kg \cdot 10min.^{-1}$ with runoff discharge 1.05 $mm \cdot 10min.^{-1}$. Furthermore, DOC concentration in spring water increased about 10 times after storm events. These results suggest that DOC discharge through lateral flow significantly contributes carbon efflux during storm events. Our result also suggests that Monsoon is important component to evaluate the carbon flux in Korean natural forest.

P17

Fluxes of CH_4 and N_2O from soil under tropical seasonal rain forest in Xishuangbanna, Yunnan, SW China*

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Abstract: CH_4 and N_2O fluxes from soil under tropical seasonal rain forest in Xishuangbanna, SW China, were measured for 1 year by using the closed static chamber technique and gas chromatography method. Three treatments were set in the studied field: (A) litter free, (B) with litter, (C) with litter and seedling. The results show that the soil in our study was a sink of atmospheric CH_4 and a source of atmospheric N_2O. The observed mean CH_4 fluxes from treatments A, B, and C were –57.5 ± 6.9, –35.9 ± 2.8, –31.6 ± 2.8 μg CH_4–C m^{-2} h^{-1} (Mean ± SE), respectively, and calculated annual fluxes in 2003 were –5.19, –3.15, and –1.44 kg C ha^{-1}, respectively. The observed mean N_2O fluxes from treatments A, B, and C were 30.9 ± 3.1, 28.2 ± 3.5, 51.9 ± 4.1 μg N_2O–N m^{-2} h^{-1}, respectively, and calculated annual fluxes in 2003 were 2.92, 2.64, and 4.36 kg N ha^{-1}, respectively. Seasonal variations in CH_4 flux were significant in all three treatments and seasonal variations in N_2O fluxes only existed in treatment C. Litter decreased CH_4 uptake, which were mainly observed in the wet season. Seedlings increased N_2O emission, which occurred in the dry season. A strong positive relationship existed between CH_4 fluxes and soil moisture for all three treatments, and between CH_4 fluxes and soil temperature for treatment A and treatment C. N_2O fluxes correlated with soil temperature for all three treatments.

Key words: Greenhouse gases; Seasonal variability; Tropical seasonal rain forest; Xishuangbanna

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P18

HETEROGENEOUS NATURE OF SOIL ORGANIC MATTER AS INDICATED BY RADIOCARBON SIGNATURES

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Recent debate over the importance of soil organic matter (SOM) in the global carbon budget has emphasized a lack of fundamental knowledge of soil carbon dynamics and a difficulty in predicting the magnitude and timing of the response of soil carbon reservoir to changes in climate. This is mainly due to the lack of understanding of heterogeneous nature of SOM. In this study, SOM is separated by a chemical fractionation method into organic matter fractions with different chemical stabilities, and then radiocarbon (^{14}C) abundances of the fractions are determined by an accelerator mass spectrometry (AMS) to characterize the heterogeneous nature of SOM.

Soil sampling was made in a temperate-zone forest in Aichi prefecture, Japan. The mineral soil layer was covered with 4 cm forest litter layer, which was composed of a leaf litter layer of 3 cm thickness and a well-decomposed leaf debris layer of 1 cm thickness. Samples of mineral soil were collected at 1 cm, 2 cm and 5 cm intervals for 0-10 cm, 10-20 cm and 20-40 cm depth layers, respectively. The soil samples were dried to constant weight, sieved with a 106 μm mesh in distilled water and re-dried. The soil was then fractionated chemically with a method described in Fig.1. The bulk soil was hydrolyzed with 1.2 N HCl at 130 ^{o}C repeatedly. After the hydrolysis, organic matter left in the residual solid was defined as "non-hydrolysable fraction". The residual solid was further treated repeatedly with 1.2 N NaOH at 130 ^{o}C, and hydrolyzed several times with 1.2 N HCl at 130 ^{o}C. The organic matter remaining in the solid obtained here was defined as "humin fraction". Radiocarbon abundances in the fractions were measured with AMS at Tono Geoscience Center, Japan Nuclear Cycle Development Institute. In this study, ^{14}C data are presented as $\Delta^{14}C$, the permil (‰) deviation from $^{14}C/^{12}C$ ratio of a standard selected so that $\Delta^{14}C$ is zero for atmospheric CO_2 in 1950.

Radiocarbon signatures of SOM fractions are given in Fig.2. The highest $\Delta^{14}C$ values were observed in the bottom of forest litter layer in bulk and non-hydrolysable fractions, indicating the considerable amount of carbon fixed over the past four decades is still preserved in this layer where the microbial decomposition of SOM is highly active. The depth profiles also suggest leaching of a part of the ^{14}C-enriched SOM from surface to the deeper layer (8 cm). The ^{14}C signatures of the non-hydrolysable fraction were rather lower than those of the bulk fraction. This means that carbon in hydrolysable fraction have higher $\Delta^{14}C$ values, implying that this fraction (approximately 70% of total carbon) become the most important pool for carbon exchange on annual to decadal timescales. On the other hand, significant radioactive decay was observed for carbon in humin fraction of mineral soil layers, demonstrating that the chemically recalcitrant SOM, accounting for 4-10% of total carbon in this soil, plays a role as a long-term sink in the carbon cycle.

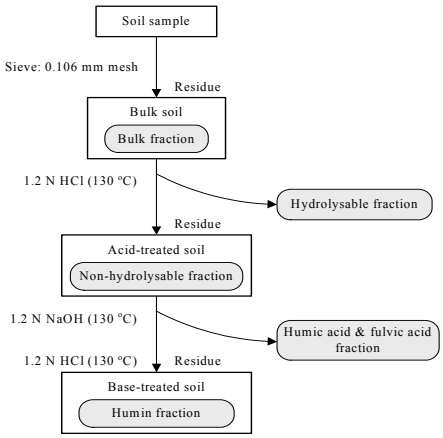

Fig.1. A chemical fractionation method.

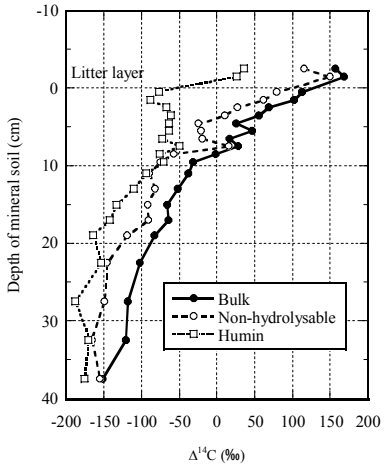

Fig.2. Radiocarbon signatures in SOM fractions.

P19

IS CARBON STABLE ISOTOPE RATIO OF HETEROTROPHIC RESPIRATION INVARIANT? ~WHAT WE LEARNED FROM OBSERVATIONAL FACTS~

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To investigate potential variability in $^{13}C/^{12}C$ ratio of heterotrophic respiration, we measured $^{13}C/^{12}C$ ratio of CO_2 respired from soil at plots with and without "root-exclusion" in a deciduous needle leaf forest in Japan for 3 years. High-precision measurement coupled with a sampling system optimized for soil respiration made it possible to detect spatiotemporal variability intrinsic to heterotrophic respiration. Even in the absence of root respiration, the $^{13}C/^{12}C$ ratio of soil-respired CO_2 had significant seasonal variation with range greater than previous model estimate. The $^{13}C/^{12}C$ ratio of soil-respired CO_2 at the root-excluded plot generally showed minimum in early summer but its temperature relationship was not monotonous like that in the CO_2 efflux. Those observational facts would have implications for future validation of model predictions. Our results also showed that the $^{13}C/^{12}C$ ratio of soil-respired CO_2 had significant short-term variability related to temperature change and large spatial variation even without influence of root-respiration. Under the limitations of chamber-based measurement, the spatial variations would give sampling bias that made it difficult to estimate flux-weighted mean value of the d13C in canopy-or-larger spatial scales. While much remains to be learned about the natural variations in the $^{13}C/^{12}C$ ratio of soil-respired CO_2, the variations in the $^{13}C/^{12}C$ ratio of soil-respired CO_2 observed in this study likely captured some characteristics intrinsic to heterotrophic respiration.

P20

LEAF ECOPHYSIOLOGICAL PROCESSES FOR THE PHOTOSYNTHETIC PRODUCTIVITY IN A COOL-TEMPERATE DECIDUOUS FOREST ECOSYSTEM AT TAKAYAMA SITE.

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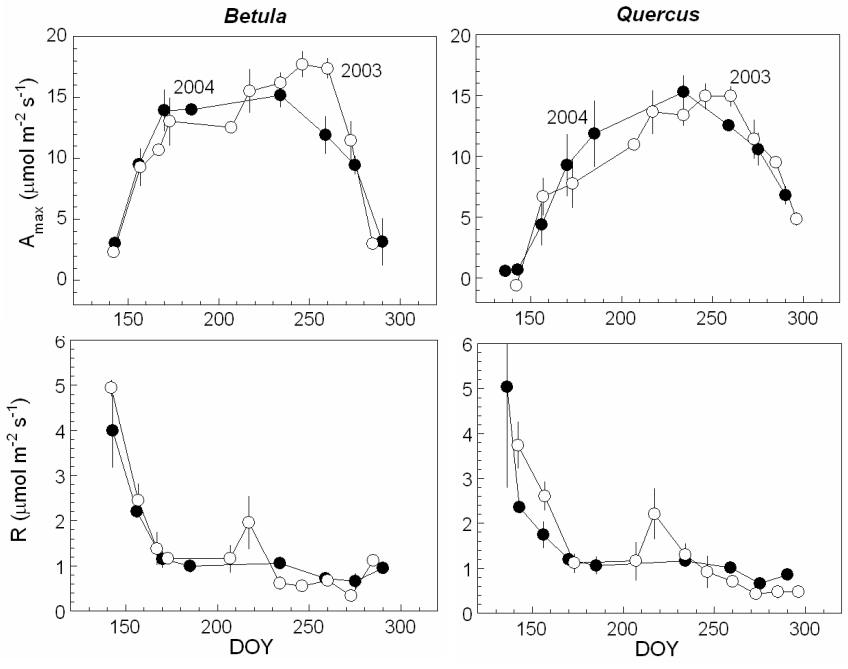
Plant ecophysiological properties including photosynthetic responses to environmental conditions, canopy geometrical consequences with photosynthetic carbon gain and their seasonality have considerable responsibility to the forest ecosystem carbon fixation. This paper overviews these traits for canopy tree species in a cool–temperate deciduous broadleaved forest of Takayama AsiaFlux site located at central Japan.

Two–year measurements of leaf CO_2 gas exchange characteristics for full growing season on canopy tree species, *Betula ermanii* and *Quercus crispula*, revealed that their photosynthetic capacities increase with leaf expansion from late spring (mid May) to early summer (June) in 2004 or mid summer (August) in 2003 and decrease in autumn (October). In contrast, seasonal change of dark respiration was similar between the two years in both tree species; the maximum was observed at the start of leaf expansion and decreased by June when the leaf area matured. Leaf and shoot (branch) level photosynthetic and geometrical consequences to canopy carbon gain were examined with a 3–D structural–functional model, Y–plant. Simulations with shoots at the canopy top of *Betula* and *Quercus* revealed that the steeper leaf angle and higher stomatal conductance of *Betula* contribute to maintaining high photosynthetic activity by reducing high light stresses such as heat load and photoinhibition. Comparison of sunlit (canopy top) and shaded (inner canopy) shoots of *Quercus* revealed that the leaf display with small self–shading of shade shoots is effective in receiving light incidence in the light–limited environment, but prolonged sunfleck limits photosynthesis of the shade leaves by increasing temperature and stomatal closure.

These ecophysiological considerations of plant photosynthesis and structure would provide us deeper insight into the mechanistic understanding of the forest ecosystem carbon gain in changing environments.



Seasonal changes of photosynthetic capacity (A_{max}) and dark respiration (R) of the leaves of *Betula* and *Quercus* in 2003 and 2004. Symbols and error bars reprent mean ± SD of 3 – 7 leaves.

P21

SEASONAL VARIATION IN THE NOCTURNAL WOODY-TISSUE RESPIRATION OF A MIXED BROAD LEAVED FOREST

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1. INTRODUCTION

To understand how deciduous and evergreen trees control nocturnal CO_2 flux in Yamashiro Experimental Forest (YEF), we measured the seasonal variation in the nocturnal woody-tissue respiration of the deciduous and evergreen trees using a static automated chamber method. In this study, we estimated the ratio of growth respiration to total annual nocturnal respiration.

2. SITE DESCRIPTION AND METHODS

The YEF is located in a valley in Yamashiro-cho (34°47'N, 135°51'E), Soraku-gun, Kyoto, in a hilly, mountainous region of central Japan and at an elevation of about 220 m asl. The forest consists of deciduous broadleaved species (mainly *Q. serrata*) and evergreen broadleaved species (mainly *I. pedunculosa*). We measured the leaf area index (LAI) of the forest once per week with an LAI-2000 (Li-Cor).Based on the seasonal variation in the LAI, and the measured foliar respiration, we were able to estimate total foliar respiration for the forest (Miyama et al., 2005). We also measured the diameter at breast height (DBH) of all trees in the YEF every 5 years (*Goto et al*., 2003). In this study, we measured seasonal variations in nocturnal stem respiration using static, automated stem chambers in the YEF. The chamber automatically measured nocturnal stem respiration at 30-min intervals. We measured the relationship between DBH and the surface area of woody tissue in the trees, estimated total surface area in the YEF, and scaled up stem respiration to the whole forest level to estimate respiration by woody tissue. We attached the stem chambers to stems of *Q. serrata* and *I. pedunculosa* (DBH, 20.7 and 17.9 cm, respectively) at breast height. The air temperature within the stem chamber was measured with a copper-constantan thermocouple. Nocturnal respiration of woody tissue per unit surface area of *I. pedunculosa* and *Q. serrata* (F_{wI} and F_{wQ}, respectively) were calculated from the difference in CO_2 concentrations between 30 and 210 sec (3 min) in chambers. We collected data continuously from 1 May to 31 December 2003. We measured the relationship between DBH and the surface area of woody tissue on the sample trees. We defined surface areas of trees from the sum of twig surface areas, and measured twig surface areas using slide gauges directly. We used F_{wE} and F_{wD}, respectively, to represent the whole-tree respiration of woody tissue for evergreen and deciduous trees.

3. RESULTS AND DISCUSSION

The relationship between DBH(cm) and stand-level surface area of woody tissue (SA, cm^2) was expressed by the following allometric equation ($SA = 247\ DBH^{2.24}$, $R^2 = 0.949$). We confirmed the linearity of the relationship between surface area and the respiration rate of woody tissue using destructive stem samples. The ambient air temperature was strongly correlated with respiration by woody tissue, except during the growing season, when there was relatively high growth respiration. The growing season for stems of *Q. serrata* was 1 month longer than that for *I. pedunculosa*. The proportions of F_{wE}, and F_{wD} to nocturnal whole-tree aboveground respiration (F_{tree}) were estimated to be 8 and 16%, respectively. The rate of growth component of F_{wE}, and F_{wD} in F_{tree} were estimated as 1 and 2%, respectively. These results suggest the importance of exact estimation of woody tissue respiration in similar forests.

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P22

ESTIMATING THE CO_2 FLUX FROM COARSE WOODY DEBRIS IN A TEMPERATE DECIDUOUS BROAD-LEAVED FOREST IN JAPAN

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INTRODUCTION

CO_2 sequestration in forest ecosystems plays a key role in the global carbon cycle. Forest uptake CO_2 via photosynthesis and release CO_2 via autotrophic and heterotrophic respiration (R_a and R_h respectively). NEP is the small difference between the two large fluxes, so an understanding the biological and physical characteristics of all of the processes in a forest is necessary to estimate how the carbon cycle will respond to environmental change. R_a can be considered in a quantification of NPP, while R_h has to be treated as an independent compartment, because R_h relies on the amount of dead plant tissues. Coarse woody debris (CWD) releases CO_2 that affects the carbon cycle of a forest for 10 to 100 years after death, because it decomposes slowly. However, the CO_2 flux from CWD (R_{CWD}) is hardly included in measurements of soil respiration, and few studies have treated CWD as a CO_2 source. Therefore, this study focused on CWD and estimated the annual R_{CWD} in a forest to evaluate the contribution to R_h and NEP.

SITE & METHODS

R_{CWD} was measured in the Yamashiro Experimental Forest (YEF), in Kyoto, Japan. The forest is a secondary deciduous broad-leaved forest dominated by *Qercus serrata* and *Irex pedunculosa*. The stand density (DBH≥3cm) is 3,209 ha^{-1}, the mean crown height is about 12m, and the living biomass is 44.54tC·ha^{-1}. The soil is generally thin, immature, and sandy. To examine the temporal changes in R_{CWD} due to the environmental factors, automated chamber were installed on two CWD samples and measured R_{CWD} 72 times a day from 2002 and 2003. For modeling of R_{CWD} to environmental factors and CWD characteristics, R_{CWD} of 192 CWD samples, which were cut from snags and logs in the forest, were measured. CWD census in 2003 and CWD input census from 1999 to 2994 were made from the field surveys. For the evaluation of CWD carbon cycle, the annual R_{CWD} was scaled to the ecosystem after considering environmental factors associated with the position (snag or log) of CWD and CWD characteristics.

RESULTS

Long-term continuous measurements of the R_{CWD} of two samples showed daily and seasonal patterns with changes in T. Precipitation events caused notable changes in the R_{CWD} of both samples. Manual measurements of R_{CWD} of 192 samples showed that R_{CWD} was correlated with temperature (T), water content(θ), wood density(ρ), and diameter (D) of CWD; ($R_{CWD} = 78.5\exp(0.0494T)(\theta+0.0591)(0.871-\theta)0.581\ D^{-0.682}\ \rho^{-0.790}$) and the function explained 53% of the variance in R_{CWD}. Measurements of environmental factors of snags and logs showed that the θ of snags was 20% of that of logs. A field survey conducted in 2003 estimated the CWD mass as 9.30 tC·ha^{-1}. Seventy percent of the CWD had been created before 1999. Snags constituted 60% of the total CWD mass. The annual R_{CWD} estimated in 2003 in YEF was 0.50tC·ha^{-1}·yr^{-1}, amounting to 13-19% of R_h. The mean annual CWD input from 2000 to 2004 was 0.61tC·ha^{-1}·y^{-1}, and 60% of this occurred as snags. Snags fell to the ground during sporadic events, such as typhoons. The forest sequestered 0.11tC·ha^{-1}·y^{-1} as CWD, which was 7% of the NEP (1.56tC·ha^{-1}·y^{-1}) estimated from tower and biometric measurements.

DISCUSSION

R_{CWD} was controlled by both environmental factors and CWD characteristics. In YEF, snags constituted 60% of the total CWD mass. The water content of snags was markedly lower than that of logs. Therefore, the difference in water content due to CWD position (snag or log) affects the annual R_{CWD} in YEF. Most CWD initially occurs as snags, which then fall to the ground during sporadic events and subsequently decompose more rapidly. Therefore, the transformation of snags into logs is an important event in the CWD carbon cycle. Since CWD forms accidentally during disturbances and decomposes more slowly, it is difficult to assume that CWD input and decomposition are balanced. Therefore, in order to quantify the carbon cycle in forest, it may be important to consider the CWD balance in a forest, especially when CWD is abundant in the forest or the forest conditions have recently changed.

P23

BIOMETRIC BASED ESTIMATES OF NET ECOSYSTEM PRODUCTION IN A COOL-TEMPERATE DECIDUOUS FOREST BENEATH A FLUX TOWER

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The eddy-covariance based estimates of NEE clearly demonstrated that temperate forests have significant contribution to the global uptake of CO_2 (Wofsy et al. 1993). An alternative approach to measuring carbon sequestration is biometric based estimates of net ecosystem production (NEP), which is described as the balance between net primary production (NPP) and heterotrophic respiration (Rh). Inter-comparison of NEP and NEE in a flux site is important not only to cross-validation of both independent methods but also to qualify the contribution of various biological processes to NEE. We conducted that biometric based NEP in a temperate deciduous broad-leaved forest beneath a flux tower. Our objectives are 1) to help accurate estimates of forest carbon storage, and 2) to show how and where the forest is storing C.

The study site is located in Takayama Forest Research Station, River Basin Research Center, Gifu University. The site is a part of Asia Flux Network that is presently measuring CO_2 and energy exchange between forest canopy and the atmosphere from 1993 (Yamamoto et al. 1999). A permanent plot of 1 ha was set on a west-facing slope. The flux tower is included in the plot. Forest compartment model was applied to construct for stand-level mass balance of carbon budget. Biometric NEP is conceptually equivalent to the sum of the change in carbon pools ($\triangle$C), i.e., plant biomass (B), coarse woody debris (CWD), and soil organic carbon (SOC). Annual $\triangle$C in each carbon pool was based on process-level flux measurements. Annual growth of tree dbh was measured in each winter to estimate annual biomass increment ($\triangle$B) from 1999. Annual detritus production was estimated from 14 litter traps (1 m^2 area). Diurnal and seasonal change in soil surface CO_2 efflux were measured continuously for 24-48 h once or twice a month with the open-flow (OF) IRGA method using four chambers beneath the flux tower from 1999. Heterotrophic respiration was separated from root respiration based on comparisons of CO_2 efflux between untrenched and trenched areas in the permanent quadrat (Lee et al. 2003).

The mean annual tree growth of above-ground and large roots amounted to 1.3±0.47 t C ha^{-1}. However, $\triangle$B in the site was rather small (0.3 t C ha^{-1}) because of annual tree mortality amounted to 1.0 t C ha^{-1}. Annual coarse litter production (branches) varied year-to-year ranged from 0.19 to 0.70 t C ha^{-1} compared to less variable fine litter (foliage) production (1.8±0.14 t C ha^{-1}). The soil surface CO_2 efflux was determined as the average across a 5-year record (8.4±0.52 t C ha^{-1}). The contribution of the root respiration of the total soil respiration was 45.3%, thus, Rh was 3.9±0.24 t C ha^{-1} with topographical correction. The mean total C uptake ($\triangle$C) of the Takayama site is 2.6 t C ha^{-1} yr^{-1} during 1999 to 2003, which agree well with eddy-covariance based NEE (Saigusa et al. 2005, 237±92 g C m^{-2} yr^{-1} from 1994 to 2002) within 10% mean value. However, validation of $\triangle$SOC is still limited by an insufficient data of the below-ground detritus production (fine root of trees and rhizomes of dwarf bamboo). These limitations make it difficult to estimates accurate $\triangle$C by process-level flux measurements.

P24

INTER-ANNUAL VARIABILITY OF NET PRIMARY PRODUCTION AND SOIL CO_2 EFFLUX IN A COOL TEMPERATE RED PINE FOREST AT NORTHERN FOOT OF MT. FUJI

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The carbon flux between the terrestrial and the atmosphere, which has been decided by balance that CO_2 emission from the land use change and the substantial CO_2 absorption by plant was clarified by the third report of IPCC in 2001. It is important to know the carbon budget of the terrestrial ecosystem because CO_2 has largest contribution to global warming. Therefore the tower flux observation in forest ecosystems was spread rapidly in 1990's to comprehend the substantial CO_2 absorption in the terrestrial ecosystem. Ecological measurement of carbon budget beneath the flux tower is needed for accurate estimate of carbon budget. In this study, we aimed to consider that inter-annual variability of net primary production and soil CO_2 efflux and how dose they contribute to net ecosystem production in a forest ecosystem, and to show where and how the forest is storing carbon.

The study site is located in northern foot of Mt. Fuji (35°27′N, 138° 4 6′E, 1030m a.s.l.). Secondary forest of red pine (*Pinus densiflora*) was established on the Kenmarubi lava flow, which was formed in 937. This site is a part of the Asia Flux Network that is presently measuring CO_2 flux from 1999.

The permanent quadrat of 0.64 ha (80m×80m) was set on 2000 near the flux tower. NPP was estimated by the harvest method as expressed by the sum of ⊿B (annual biomass increment) + L (annual litter production). Annual biomass increment was estimated by measuring the dbh of all living stems greater than 5cm in December after growing season from 2000. 20 point of litter traps ($1m^2$) and 9 point of big branches traps ($100m^2$) were used to estimate the litter production. These samples were collected at monthly intervals from 2000 to 2004, and dried and weighed. Soil CO_2 efflux was measured by three methods (2000-2002: Automated closed chamber method, 2003: Closed chamber method, 2004: LI-6200).

Annual tree growth was fluctuated 2.18 ton C ha^{-1} to 2.91 ton C ha^{-1} in five years. Annual biomass increment was fluctuated 1.81 ton C ha^{-1} to 2.50 ton C ha^{-1}, and annual tree mortality was 0.35 ton C ha^{-1} to 0.76 ton C ha^{-1} in four years. Mean annual litter production (including big branches) was 3.50 ton C ha^{-1} in five years. NPP was fluctuated 5.68 ton C ha^{-1} to 6.41 ton C ha^{-1} in five years, soil CO_2 efflux was almost constant excluding 2004 (3.22 ton C ha^{-1} to 4.08 ton C ha^{-1}). We assumed that heterotrophic respiration is 83% of soil respiration (Sakata personal communication). Therefore, NEP that is estimated by subtracting heterotrophic respiration from NPP was fluctuated 2.84 ton C ha^{-1} to 3.73 ton C ha^{-1}. Moreover, the mean annual carbon storage in the forest ecosystem in five years was 2.20 ton C ha^{-1} in plant biomass, 0.33 ton C ha^{-1} in soil organic carbon, 0.71 ton C ha^{-1} in coarse woody debris.

P25

CARBON BALANCE OF LARCH FOREST ECOSYSTEMS

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Forests worldwide contain about 45% of the global stock of carbon, the large part of which is found in forest soils. They impact upon the natural cycle of carbon, nitrogen and water, and they influence the radiation balance of the planet. Larch forests widely distribute throughout the North Hemisphere, e.g. occupying >40% of Russian forests, thus is global important of forested biome. However, the carbon budget of larch ecosystems has received little attention. We routinely measure net ecosystem exchange (NEE) with eddy covariance at larch forests in northern Japan, northeastern China and central Siberia. In addition, we partitioned the components of the CO_2 flux with the chamber methods, in terms of canopy photosynthesis, aboveground woody tissue respiration, understory vegetation gas exchange, total soil-CO_2 efflux, heterotrophic and root respirations. Our objectives were: (1) to quantify the contributions of CO_2 flux components to GPP; and (2) evaluate the influence of environmental conditions on CO_2 flux components.

For a 50-year-old larch plantation at Tomakomai Flux Site in Hokkaido, northern Japan, we scaled up the flux components based on the chamber measurements. In 2003, annual soil-CO_2 efflux was averaged to 9.59 tC ha^{-1}, heterotrophic respiration was about 5.47 tC ha^{-1} that accounted about 57% of the soil-CO_2 efflux, net annual CO_2 exchange of understory vegetation was about -0.39 tC ha^{-1}, annual aboveground woody tissue respiration was bout 0.75 tC ha^{-1}, and annual photosynthesis and respiration of the canopy was about -12.75 and 1.15 tC ha^{-1}, respectively. Annual GPP, NPP, NEP and ecosystem respiration for this forest was estimated to be about 13.49, 7.16, 2.04 and 11.45 tC ha^{-1}, respectively. The contribution of canopy respiration, aboveground woody respiration, root respiration and heterotrophic respiration to GPP was about 8.1%, 5.6%, 30.6% and 40.5%, respectively.

P26

LEAF PHOTOSYNTHESIS AND RESPIRATION OF A DECIDUOUS TREE (KONARA OAK) IN THE LEAFING STAGE

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Seasonal trends in leaf photosynthesis and respiration are important factors in determining the seasonality and magnitude of ecosystem CO_2 fluxes. In deciduous broad-leaf trees, photosynthetic and respiration rates change drastically in the leafing stage, so that the better understanding of those rates is required in order to study net ecosystem CO_2 exchange of deciduous forests. In this report, we present results of gas exchange measurements of leaf photosynthesis and respiration in the leafing stage.

Single-leaf gas exchange measurements were made with a portable photosynthesis system (LI-6400, LI-COR) at Fujiyoshida, Japan, from May to August 2005. From the measurements, we estimated maximum rate of carboxylation at 25℃ (V_{cmax25}) and dark respiration rate per unit area (R_d) of a deciduous tree (*Quercus serrata* Thunb., called "Konara" in Japanese), where V_{cmax25} means a measure of photosynthetic capacity at 25℃. Four branches (16, 13, 11 and 8 m high) were selected for the measurements. The LI-6400 was equipped with a LED light source and a CO_2 injector to control photosynthetically active photon flux density (PPFD) and CO_2 concentration in the chamber. In the experiments, we made light response curves of net photosynthetic rate. V_{cmax25} was estimated from saturated photosynthetic rates using Farquhar's model and R_d was assumed CO_2 exchange rate at PPFD = 0 μ mol m^{-2} s^{-1}. The CO_2 concentration and relative humidity in the chamber were kept at 360 μ mol mol^{-1} and about 60 %.

There were apparent seasonal trends in V_{cmax25} and R_d in the leafing stage. The V_{cmax25} values rapidly increased with leaf expansion. When the sharp expansion of the leaves was finished, the seasonal variation in V_{cmax25} became gradual. Although V_{cmax25} of lower branch increased faster than that of higher branch in the early period of the leafing stage, averaged V_{cmax25} of higher branch was larger than that of lower branch after the stage.

Respiration rate per unit area decreased over time in the leafing stage. Measured R_d just after leafing was higher than photosynthetic rate. After that, R_d steadily decreased for a month, even though the leaf temperature rose. Leaf respiration at 25℃ (R_{d25}) was estimated with the assumption of Q_{10} = 2.0 at each measurement, where Q_{10} is the coefficient of temperature dependency for leaf respiration rate. R_{d25} rapidly decreased with leaf expansion, which was opposite to the trend of V_{max25}. The relationship between R_{d25} and the leaf temperature clearly showed a attenuation function that indicated R_{d25} was reduced by 20 % with a 10℃ rise in temperature. Leaf respiration per unit leaf was also analysed. The trend of R_{d25} per unit leaf ($R_{d25leaf}$) showed the peak one month later from the beginning of the leafing. The time of the peak corresponded with the end of the leaf expansion period.

We found the photosynthetic and respiration rates of the deciduous tree were changed with the leaf expansion during the leafing stage. At the beginning of the growing season, leaf area could be an important parameter to determine the characteristics of leaf photosynthesis and respiration.

Keywords: Deciduous tree, Leafing stage, Photosynthetic capacity, Respiration, Single-leaf gas exchange

P27

Instrumentation and data quality assessment at Daegwallyeong CO_2 flux measurement site (DFMS) in Korea

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There is presented the instrumentation of eddy covariance technique at the Daegwallyeong CO_2 flux measurement site (DFMS) in Korea, and the initial results of applying a data quality assessment to measurements which are acquired during two experiment periods of each summer and winter season. For the data quality assessment, 1) instationarity, 2) correlation coefficient, and 3) integral turbulence characteristics (ITC) test are carried out, and then the measurements are classified to the two groups (accept or worst) according to final quality flags suggested by Foken and Wichura (1996). The acceptable group of which flag of data quality leveled from 1 to 4 is 85.4% for summer experiment and 68.1% for winter experiment, respectively. This result represents not only stationarity but also good agreement of the turbulent characteristic within similarity theory during experimental periods without the temporal difference according to diurnal or nocturnal time. The measured minimum and maximum CO_2 fluxes during the experimental periods are -27.3 μmol CO_2 m^{-2} day^{-1} (uptake) and 4.5 μmol CO_2 m^{-2} day^{-1}, (release) respectively. In theses results, the DFMS is one of the best sites for CO_2 flux measurement in order to make the information of CO_2 absorption for *Quercus mongolica* community in Korea.

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QUALITY CHECK OF FLUX DATA USING A MULTILAYERED CANOPY MODEL

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To obtain accurate estimates of ecosystem CO_2 uptake based on the eddy covariance measurements, the quality control of the flux data is highly important. A widely used method of the quality control is a screening of raw instantaneous data. This procedure flags questionable data, according to prescribed acceptance criteria for the level of spiky noise, absolute values of data, the range of higher-order momentum, the level of discontinuity found in a data record, and so forth. The fluxes are then calculated using data that were not flagged by this procedure. By means of these steps, observers are able to select flux data unaffected by instrumental or data recording problems. Nevertheless, there is no warranty that these selected flux data surely represent the actual ecosystem exchange. Some factors (*e.g.*, advections) may disconnect the fluxes measured at a height above the canopy from the actual exchange fluxes; or the data may be affected by some system problems that cannot be detected by the above-mentioned data screening procedure. It is, therefore, necessary to crosscheck the flux data using other independent estimates of the ecosystem exchange.

One possible method of the crosscheck is comparing the summation of flux and the net growth of ecosystem. However, this method is only applicable for a long period of time (*i.e.*, one year or longer), and the uncertainty inherent in the net growth estimates may degrade the reliability of crosscheck. Obviously, we need to have a more reliable means that can be applied for a short period of time.

We have been developing a stand microclimate model named Multilayered Implementation for Natural Canopy-Environment Relations (MINCER) as a tool for compiling individual leaf-scale measurements into a comprehensive representation of canopy-scale fluxes. This model includes all essential processes that affect the fluxes above a plant canopy, that is, biophysical, hydrological and physiological processes functioning differently at various levels inside the canopy. If the leaf-scale fluxes, the soil surface fluxes and the canopy structure are given to the model, it predicts the canopy-scale fluxes using meteorological conditions measured above the canopy. Although the output fluxes are not purely 'measurements', the comparison between the predicted and measured fluxes provides some information on the consistency of measured above-canopy fluxes with individual small-scale fluxes.

We applied MINCER to a FFPRI FluxNet site (Hitsujigaoka) established in a broadleaf forest in Sapporo, Japan. This forest is a mixture of various broadleaf species dominated by *Betula platyphylla*, *Quercus mongolica*, and *Kalopanax pictus*. In this site, measurements of canopy architecture, leaf-scale physiological measurements and the soil CO_2 flux are available as well as the eddy covariance fluxes and micorometeorological variables. The vertical profile of leaf area density was measured once for each major species, and the seasonal variation in total leaf area was monitored by the photographical technique and by measurements of PAR attenuation across the canopy. To monitor seasonal variations in the photosynthetic capacity of the dominant species, light-saturated net photosynthetic rates at two different CO_2 concentrations (360 and 1500 ppm) were measured about once per month for several leaves at each of four different heights in the canopy. From these data, seasonal variations in the vertical profile of maximum catalytic activity of Rubisco (V_{cmax}) were evaluated. The soil respiration rates were measured once per month by the closed chamber method, and the relationship between the respiration rate and the soil temperature has been established.

Using these measurements or relationships as input to the model, temporal variations in 30-min average fluxes of energy and CO_2 were simulated for three years from 2000 to 2002. For most part of the simulation period, the modeled fluxes showed good correspondence with the measured flux at least for the daytime. This agreement indicates both the model's good performance and the consistency of the eddy covariance fluxes with individual leaf-scale and soil surface fluxes. However, there were some cases when the model could not simulate the diurnal flux variations. One example is that the time trace of measured CO_2 flux was unstable and deviated from the simulated time course during and after rainfall events. We do not mean to claim that the modeled results are always true, but if we closely look at the data when inconsistency is found between modeled and measured fluxes, we can find some problems in measurements or something new that really happens.

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EXAMINATION OF THE HIGH FREQUENCY CORRECTION THEORIES TO THE CLOSED-PATH CO_2 FLUX MEASURED OVER A CONIFEROUS FOREST IN KYUSHU ISLAND, JAPAN

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1. Introduction

The method of high frequency correction has been one of the issues about the eddy covariance technique. Estimation of the high frequency attenuation were initially summarized by Moore (1986, Boundary-Layer Met., **37**) with simple functions, and Massman (2000, Agric. For. Met., **104**) developed it to be applicable to the closed-path system. In spite of the merit of the theoretical approach, which enables to respond to the change of wind speed, wind direction and the tube flow rate, almost all the researchers have applied an empirical frequency correction method on the basis of the discrepancy between the theoretical function and the ratio of (co-)spectra obtained from their observation system. However, in the recent study of Massman (2004, "Handbook of Micro meteorology", Kluwer academic publishers), the signal processing algorithm of an infra-red gas analyser (IRGA) was precisely described, and the volume averaging effect of the IRGA chamber was newly proposed. These factors have not been taken into account in previous studies, thus this study re-tests the theoretical approach by comparison with the field observation data obtained in the various flow rates.

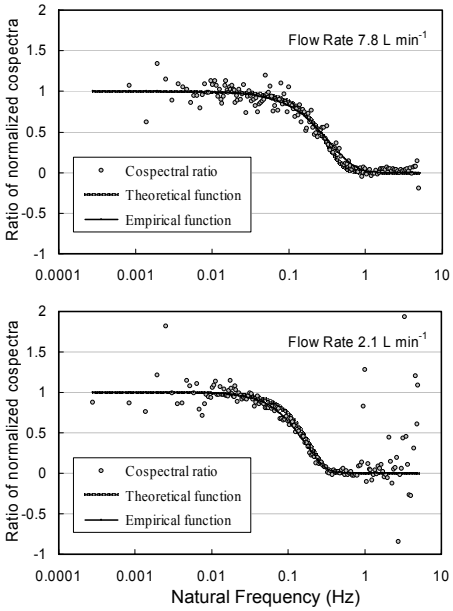
2. Site and Method

The observation site named "Kahoku Experimental Watershed (KEWS)" is a planted coniferous forest located in Kyushu Island, southeastern part of Japan (N 33°08', E 130°43'). The distribution pattern of plant species is Japanese cypress on the ridge area, and Japanese cedar (maximum 32 m height) from the valley to the hillside.

CO_2 flux measurement has been conducted by using a sonic anemo-thermometer (DAT-600, KAIJO, Japan) and an IRGA (LI-6262, LI-COR, USA). The sonic and a gas intake were installed at 50 m height, and the mutual separation was 0.5 m. The main sample tube was 57 m length and 6 mm i.d., and the sub-sample tube was 4 m length and 4 mm i.d. within which the flow rate was controlled to 2 L min^{-1}. 30 minutes block average was applied to calculate turbulence fluxes, and the tube flow delay was determined to maximize the correlation of scalars. A given 30-min data was screened by the criteria of friction velocity (0.3 ms^{-1}) and of the number of spikes (1%), before it was accepted for further analysis. Two of 1-month data sets were used for the comparison with the theoretical transfer function, and the flow rate was reduced by condensation when one of the data sets was acquired.

3. Result

Figures 1 show the ratios of normalized co-spectra of CO_2 flux to those of sensible heat flux and the theoretical functions for normal and reduced flow rates (7.8 L min^{-1} and 2.1 L min^{-1}). The exponential functions fitted to the plotted points are also represented as experimental functions. The differences of the CO_2 flux corrected by the theoretical function are on average within 0.5 % from those corrected by the empirical functions. These relatively small errors indicate that the theoretical function can be applied to the high frequency correction for the closed-path CO_2 flux, at least measured at KEWS, even when the flow rate is decreased by condensation. However, despite the two factors proposed by Massman (2004), the underestimation of the correcting factor caused by the theoretical function is proved to remain in some previous studies (e.g. Aubinet et al., 2001, Agirc. For. Met., **108**). This fact indicates that the applicability of the theoretical transfer function is somewhat limited.



Figures 1. Comparison of the ratio of normalized co-spectra with the theoretical functions for various flow rates.

P30

EFFECT OF LOCAL TEMPERATURE FLUXES IN THE VICINITY OF AN OPEN-PATH GAS ANALYZER ON THE WPL CORRECTION

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The authors often observed unrealistic downward CO_2 fluxes over a non-vegetated rice paddy in the suburb of Tsukuba, Japan (36.05°N, 140.03°E) in follow periods only when we employed an open-path eddy covariance system. We conducted a measurement campaign from March to April 2003, and found that the unrealistic downward CO_2 fluxes did not represent true transport of CO_2 and might be caused by inappropriate application of the WPL correction (Webb et al., 1980). The WPL correction postulates that all the variables involved in the correction are measured at a same point or represent the same area-averaged properties of turbulence. In the strict sense, however, the assumption is rarely satisfied in practical field measurements because the covariances in the WPL correction are measured with two different instruments, a sonic anemometer-thermometer and an open-path gas analyzer. If the open-path gas analyzer itself was a heat source, temperature fluxes measured with the sonic anemometer would differ from those at the optical path of the analyzer. This might lead to under- or over-estimate of the WPL correction term. Over the follow paddy field where only small CO_2 efflux was expected, underestimate of the WPL correction term could leave the corrected CO_2 fluxes in the daytime still downward . In order to confirm this idea by measuring local temperature fluxes in the vicinity of the open-path eddy covariance system, we conducted another experiment at the same paddy from 14 March 2005 to 7 April 2005.

We employed a sonic anemometer-thermometer (DA-600, Kaijo), two open-path gas analyzers (LI-7500, Li-Cor) and a closed-path gas analyzer (LI-7000, Li-Cor). The instrumentation and configuration were almost the same as those in the 2003 campaign. We wrapped one of the probes of the two open-path gas analyzers in a black tape made of chloroethene while keeping its optical path open in order to increase the absorptance of the probe againt short- and long-wave radiation. The taped and not taped probes are hereafter denoted by black and white probes, respectively. We measured fluctuations in air temperature at the acoustic path of the sonic anemometer and at the optical path of the black and while probes with T-type fine thermocouples (0.025 mm in diameter). Surface temperature of the probes of the gas analyzers was also monitored. These signals were sampled at 10Hz and recorded using a high-speed logger (CR5000, Campbell Scientific Inc.) All the statistics were calculated every half hour. The results obtained on March 31 are described below.

In the daytime of March 31, the mean surface temperature of the black probe was higher than that of the white one. The differences in the surface temperature between the two probes reached 1.4 °C at maximum, but they were smaller than the temperature difference between the top and the bottom parts of the white probe, which was 3.7 °C at maximum. The intra-probe differences in the white probe were also found in the nighttime with similar tendency and magnitude. This implied heat transfer from the internal infrared source to the surface at the bottom part of the probes. The standard deviation of air temperature measured at the optical path of the black probe was larger by 43% than that measured at the acoustic path of the sonic probe, and also 2.5 times as much as that measured at the optical path of the white probe However, the temperature fluxes calculated from the fluctuations in air temperature measured with the thermocouples and the vertical wind velocity (w) showed different results. The temperature fluxes calculated from temperature at the acoustic path were the largest among the three because of short separation from the path measuring w. To avoid the contamination by the different sensor separation, we introduced an equivalent temperature flux, in which the correlation coefficient between w and air temperature measured at respective paths were replaced by the correlation coefficient between w and air temperature measured at the acoustic path. The calculated equivalent temperature fluxes suggested that the local temperature fluxes as much as 50 W m^{-2} were generated at the black probe at 1100 hours on 31 March, but they were not obvious at the white probe. The temperature flux of 50 W m^{-2} is equivalent to about 2 μmol m^{-2} s^{-1} in the WPL correction and worth taking into account when we discuss the downward flux observed over the fallow paddy field.

P31

COMPARISON OF EDDY CO_2 FLUXES MEASURED WITH OPEN-PATH AND CLOSED-PATH SYSTEMS

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Long-term measurements of CO_2 flux by the eddy covariance technique using an open- or closed-path system on a tower have been performed for elucidating the carbon cycle of terrestrial ecosystems. Evaluation of the difference between annual net CO_2 ecosystem exchanges (NEE) from the open- and the closed-path data is important for site intercomparison studies. However, long-term measurements of NEE using both systems have been limited. We report the comparison of eddy CO_2 fluxes measured with open- and closed path systems for three years from 2001 through 2003.

The study site is a Japanese larch plantation in Hokkaido, Japan (42°44'N, 141°31'E). Canopy height was approximately 15-16 m and tree age was about 45 years old. Canopy LAI reached the maximum at 5.5 m^2 m^{-2} in July. Wind speed and virtual temperature were measured with a 3D sonic anemometer-thermometer (DA600, Kaijo). CO_2 and water vapor densities were measured with an open-path CO_2/H_2O analyzer (LI7500, Licor) and a closed-path CO_2/H_2O analyzer (LI6262, Licor) at height of 27 m. Data were sampled at 10Hz, and 30-min averages of fluxes were calculated. NEE was calculated as the sum of CO_2 flux and CO_2 storage change. Gross primary production (GPP) and ecosystem respiration (RE) were estimated from photosynthesis photon flux density and soil temperature using non-linear regression.

Daytime 30-min NEE tended to be more negative by about 10% for open-path than for closed-path. In contrast, nighttime 30-min NEE tended to be about 10% less positive for open-path than for closed-path.

The annual GPP estimated from closed-path data was 8–10% less negative than that from the open-path data, whereas the annual RE was 11–16% more positive for closed-path data. Consequently, the annual NEE from the closed-path data was less negative by 301–333 gC m^{-2} y^{-1}.

The bias of NEE between two systems is large and an extremely important issue. Ecophysiological approaches are needed to validate the eddy covariance technique.

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DATA GAP FILLING FOR ANNUAL AND MONTHLY NET ECOSYSTEM CARBON DIOXIDE EXCHANGE USING GENETIC ALGORITHM

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Selection and performance of the data gap filling method are important for the accurate and reliable estimation of annual net ecosystem carbon dioxide exchange (NEE) from long-term observations of the eddy covariance flux. The biological response models that base on well-studied environmental responses of ecosystem respiration to temperature and gross assimilation to radiation are, therefore, more reliable than the empirical techniques, and comparable among different sites. The model parameters are often determined by the non-linear regression technique, however, the technique is unable to determine all parameters for the respiration and assimilation during daytime simultaneously, and assumes an extrapolated respiration from the nocturnal observation or a constant respiration within narrow temperature ranges.

Genetic algorithm is a simple and universal optimization technique that simulates the evolution and natural selection of a organism community, and is available even for analytically insoluble problems. The simple genetic algorithm (SGA) was employed to determine the biological response model of NEE. Quality controlled datasets of carbon dioxide eddy flux, air temperature, photosynthetic photon flux density (PPFD) observed in a Japanese red pine forest and in a Siberian larch forest were used for the evaluation of this technique. Four model parameters to be determined *i.e.* ecosystem respiration at the air temperature of 0 °C (R_0), the temperature coefficient of ecosystem respiration (Q_{10}), maximum gross assimilation (A_{gmax}) and initial light use efficiency (α), were encoded into chromosomes of 16-bit long for each. The objective function of SGA to be optimized was defined as the third power of the product of correlation coefficient and inverted relative error between observed and modeled fluxes, where each statistic was scaled between 0 and 1. The SGA originally does not preserve the best-fitted individual in a generation that occasionally does not survive in the next generation. To prevent this loss, the best-fitted individual was immigrated unconditionally into the new generation. Initial population, crossover rate and mutation rate were set to 1000, 0.5 and 0.2, respectively, and each trial computed up to 100 generations. The model was evaluated monthly and 20 trials were performed for a monthly dataset.

The best-fitted estimations of the NEE model parameters among 20 trials for each month were used for the evaluation. In the Japanese red pine forest, the standard error in NEE was 0.6 μmol m^{-2} s^{-1} in average and ranged between 0.4 (October 2004) and 1.2 μmol m^{-2} s^{-1} (June 2005), and the determination coefficient (r^2) was 0.76 in average and ranged between 0.65 and 0.88. Estimated Q_{10} and A_{gmax} showed obvious seasonal change, which was corresponded with monthly mean air temperature. The large Q_{10} in a hot season suggests large errors in the ecosystem respiration and, consequently, in the gross assimilation if it was estimated using only nocturnal observations. Solutions by the SGA generally vary more or less for the trials and are not deterministically unique. However, the estimates of NEE parameters did not change so much among the 20 trials for each month, and the solutions by this technique was supposed to be sufficiently optimized.

The modeled NEE for the Siberian larch forest also showed a good accuracy. This forest stand often catches a severe drought in summer, and the significant depressions both in photosynthesis and ecosystem respiration have been observed. Linear trends of the Q_{10} and A_{gmax} to the vapor pressure deficit were modeled and encoded in additional three chromosomes in the SGA. This new model well described the drought effect on NEE in mid summer, and the accuracy was slightly improved.

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P33

DIURNAL AND SEASONAL VARIATIONS IN CO_2 EXCHANGE OVER A *GMELIN* LARCH FOREST ON CONTINUOUS PERMAFROST OF THE CENTRAL SIBERIA

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The magnitude of ecosystem CO_2 exchange between the boreal forests and atmosphere is of particular interest because of the wide coverage of the forests. The boreal forests are comprised primarily not only of evergreen conifer but also of deciduous conifer, Larch. Larch forests distribute widely over central to eastern Eurasia. The larch species form forests even over continuous permafrost in North-West Eurasia. Now, the measurement network on carbon balance over the larch ecosystems is very sparse, and the representative magnitude of CO_2 exchange was not quantified. The above background, ecological investigations have been continued and micro-meteorological measurements initiated at some larch forests in Russia, China, and Japan.

Recently, we are able to carry out long-term micro-meteorological measurements at remote sites because of technology developments in micro-computer, data-loggers, solar power-generators, high-quality batteries and sensors for surface meteorology. Based on this technological background, half-hourly CO_2 exchange between a *Gmelin*-larch forest ecosystem and atmosphere, was measured during a whole growing period of the tree at Central Siberia, using the eddy covariance method. The whole measurement integration system could be stably operated.

Diurnal patterns with daytime uptake in CO_2 exchange were observed in early June when the soil was almost frozen. The maximum half-hourly net CO_2 uptake rate appeared mainly between late of June and the end of July. In early September, the net CO_2 exchange was positive (release from the surface) and it's diurnal variation was not clear.

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P34

Author: Larry Lopez

Transpiration, water potential and stomatal conductance of *Larix cajanderi* under non-limiting soil moisture, Central Yakutia, Eastern Siberia.

Two plots were set in a larch (*Larix cajanderi*) forest one under non-limiting soil water conditions (irrigation regime applied) and the other under natural precipitation regime in Central Yakutia, Eastern Siberia. Sap flow rate values were scaled up to stand transpiration and utilized for calculations of canopy conductance. The calculated values provided the basis to estimate Potential transpiration using maximal canopy conductance as a function of vapour pressure deficit. For non limiting water conditions canopy conductance was 2.57 and about 3.11 mm s^{-1} for natural conditions. Predawn water potential was not followed by variations of stomatal conductance or leaf transpiration. Tree transpiration response to irrigation was immediate whereas at leaf level the effects were observed after 3 to 4 days. This lag suggests that extra water in the soil is first used in replenishing tree compartments rather than giving it all to transpiration. The percentage of increased transpiration ranged between 20 to 50 % following the days after irrigation. The upper 10 cm of soil layer played an important role in the control of transpiration. When soil moisture at this layer is not a limiting factor canopy conductance and consequently transpiration can be estimated as a function of VPD. The total transpiration during the growing season 2004 was merely 70 mm. Despite irrigation, the total amount of transpiration at both plots was not significantly different.

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ECOSYSTEM CO_2 FLUX OVER TWO YEARS FOR A 200-YEAR-OLD CHINESE BROAD-LEAVED KOREAN PINE MIXED FOREST

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Long-term measurement of carbon metabolism of old-growth forests is critical to predict their behaviors and to reduce the uncertainties of carbon accounting under changing climate. Eddy covariance technology was applied to investigate the long-term carbon exchange over a 200 year-old Chinese broad-leaved Korean pine mixed forest of Forest Ecosystem Open Research Station of Changbai Mountains (128° 28'E and 42° 24' N, Jilin Province, P. R. China), Chinese Academy of Sciences, since August 2002. This paper reports the result on (1) Regulation of environmental factors on phase and amplitude of ecosystem CO_2 uptake and release; (2) sink/source status on the data obtained with open-path eddy covariance system and CO_2 profile measurement system from Jan. 2003 to Dec. 2004. Corrections due to storage and friction velocity were applied to the eddy carbon flux.

The most significant difference between 2003 and 2004 were precipitation and temperature. The precipitation of 2004 was 707.3 mm and very close to 693.9 mm, the averaged value between 1982 and 2004, while the precipitation of 2003 was 538.4 mm. Atmospheric and soil temperature at 5 cm depth of 2004 were 0.7 and 0.5 C higher than that of 2003 separately. The forest was a net sink of atmospheric CO_2 and sequestered - 449 gC m^{-2} during the study period, and -278 and -171 gC m^{-2} for 2003 and 2004 separately. F_{GPP} and F_{RE} over 2003 and 2004 were -1332, -1294 gC $m^{-2.}$ and 1054, 1124 gC m^{-2} separately. The seasonal trends of gross primary productivity (F_{GPP}) and respiration (R_E) followed closely with the change in LAI and temperature. The summer is the most significant season as far as ecosystem carbon balance is concerned. The 90 days of summer contributed 66.9, 68.9% of F_{GPP}, 60.4 and 62.1% of R_E of whole year. This study shows that old-growth forest can be strong net carbon sink of atmospheric CO_2.

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CO_2 EXCHANGE OF A LARCH FOREST ECOSYSTEM IN NORTHEAST CHINA

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Larch forest is believed to take an important role on the global ecosystem carbon budget due to its vast distribution area. It is a dominant forest type in Siberia, covering an area of 277.5×10^6 ha. Northeast China is the southern distribution edge of Dahurian larch (*Larix gmelinii*), which is covering as large as 15.6×10^6 ha in area as a critical natural forest ecosystem in this region. The aim of this study is to evaluate the carbon budget of larch forest ecosystem and also the possible influence of environmental variables during the period from October 2003 to September 2004.

This study was carried out in an artificial larch (*Larix gmelinii*) forest, planted in 1969, at Laoshan site (LS, 45°20' N, 127°34'E) in northeast China in May 2002. Dahurian larch is the dominant canopy species and comprises 88% in basal area and 81.3% in individual number. The mean canopy height of the forest is about 17 m. The elevation of the tower site is about 370 m above sea level. Closed path eddy covariance technology was used for CO_2, water vapor and energy fluxes measurement. The measurement height was 29 m above ground and about 12 m high above the canopy layer. Wind velocity and virtual temperature were measured using a three-dimensional ultrasonic anemometer. Variation of CO_2 and H_2O concentrations were measured with a closed path CO_2/H_2O infrared gas analyzer. The raw data was sampled at a rate of 10 Hz and CO_2 flux (Fc) was calculated half-hourly based on a series of quality control rules. The carbon storage (Fs) under the canopy was estimated from the temporal difference in CO_2 concentration measured at the flux plane. The net ecosystem CO_2 exchange (NEE) is calculated as the sum of Fc and Fs.

The larch ecosystem released 0.3 ~ 3 gC m^{-2} d^{-1} CO_2 during the leafless season from mid October 2003 to mid April 2004. While in growing season, the ecosystem strongly assimilated CO_2 from the ambient atmosphere. The maximum carbon uptake rate was about 8.0 gC m^{-2} d^{-1} for daily average value, but exceeded 30 μmol m^{-2} s^{-1} for the half-hourly mean value. The ecosystem respiration mainly determined by temperature, but seemed less affected by soil water content. The ecosystem photosynthesis activity mainly controlled by the absorbed photosynthetic active radiation (APAR), but it was also greatly influenced by vapor pressure deficit (VPD). The carbon sequestration ability of the larch plantation peaked in June, and totally absorbed 110 gC m^{-2} mon^{-1} (with friction velocity (u*) > 0.2 m s^{-1}) or 140 gC m^{-2} mon^{-1} (with u* >0 m s^{-1}). During this study period, the larch ecosystem acted as a carbon sink and sequestered 120 gC m^{-2} yr^{-1} (u* > 0.2 m s^{-1}) to 190 gC m^{-2} yr^{-1} (u* > 0 m s^{-1}). This result is comparable with that observed in a Japanese larch forest at Tomakomai flux site in northern Japan, where the larch ecosystem sequestered 141 to 240 gC m^{-2} yr^{-1} (Wang et al, 2004), but it is much higher than that in Siberia and Mongolia regions, where the larch forest ecosystems absorbed 90~85 gC m^{-2} yr^{-1} (Hollinger et al., 1998; Li et al., 2005).

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SEASONAL VARIATION IN CO_2 AND H_2O FLUXES IN A YOUNG LARCH PLANTATION IN NORTHERN JAPAN

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In order to evaluate the change in the watershed scale carbon and water cycles according to the tree growth, 2-year old hybrid larch (*Larix gmelinii*×*L. kaempferi*) was planted in an area of 13.7 ha in October 2003, 8 month after the clear-cutting of trees in the area, and flux observation by eddy covariance technique and watershed-scale water balance evaluation using an observation weir were conducted. The study site was located on a flat terrace in the Teshio Experimental Forest, Hokkaido University (45°03'N, 142°06'E, 66 m asl). During January to March 2003, trees in the area were clear-cut, and in October 2003, *Sasa* bamboos (the above ground biomass is 6–12 tC ha^{-1}) were strip-cut into 4 m rows (a half of the clear cut area) and ca. 30000 saplings (ca. 0.04 tC ha^{-1}) of hybrid larch were planted.

Closed-path eddy covariance technique was applied to evaluate the carbon and water fluxes at 4.6m height. A sonic anemometer and CO_2/H_2O fluctuation meter were used for the evaluation. Meteorological measurements included air temperature and relative humidity, net radiation, photosynthetically active radiation, and precipitation. Underground, soil temperature and water content profiles, and soil heat flux were measured at five points. Water table of the stream in the watershed (8 ha) was monitored and the discharge rate was evaluated using a water table-discharge rate relationship.

The clear-cutting of trees decreased the sequestration capacity of this ecosystem. *Sasa* bamboos still have large biomass and the half-hourly NEE often indicates negative values (carbon sequestration) in the daytime from July to September (-5 μmol m^{-2} s^{-1} at its maximum). However, because of the large NEE in the nighttime, the daily NEE kept positive values even in that situation (ca. 0.2 mol m^{-2} day^{-1}). The daily emission rate of the young larch plantation in the growing period of 2004 was almost the same level with that of the *Sasa* dominated ecosystem after the tree cutting in 2003, in spite of the strip cutting of *Sasa* bamboos and planting of the larch saplings. On the other hand, evapotranspiration rate in 2004 (ca. 250 mm $year^{-1}$) recovered to the same level with that in the mixed forest in 2002 and ca. 3 times larger than that in 2003. Watershed scale water balance observation also revealed the increase in the evapotranspiration rate and the decrease in the run off rate of the stream in 2004. We attributed the increase in the evapotranspiration rate partly to the acclimation in the transpiration capacity of *Sasa* bamboos. In conclusion, the young larch plantation is still net source of the carbon, however, the distinct decrease in the evapotranspiration rate caused by the tree cutting recovered to the same level with that in the mixed forest in the next year after larch plantation.

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SEASONAL AND INTER-ANNUAL CHANGES IN CARBON BALANCE FOR A BROADLEAVED DECIDUOUS FOREST IN SAPPORO, NORTHERN JAPAN

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A long-term observation of CO_2 exchange was conducted above a broadleaved deciduous forest in Sapporo, northern Japan. In this study, we report seasonal and inter-annual changes in carbon balance based on the eddy covariance flux measurements.

The observation has been conducted in the Sapporo observation site, located in the Hitsujigaoka Experimental Forest (42°59'N, 141°23'E, 180 m a.s.l.) of Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI, Japan). The experimental forest is a secondary forest after a forest fire occurred about 100 years ago. Dominant species of the forest canopy are Japanese white birch and Mizunara oak. The average canopy height is about 20 m. This site is a part of the FFPRI-FluxNet (CO_2 flux monitoring network). Fluxes above the forest were measured by the eddy covariance method using a 3-D sonic anemothermometer (DAT-600, KAIJO) and a closed-path infrared gas analyzer (IRGA, Li-Cor Li-6262) at the height of 28.5 m. The CO_2 storage change below the eddy-flux level (*Fs*) was measured using an IRGA, and meteorological elements were also measured. In the process of eddy flux calculation, we applied quality control procedures (Ohtani et al. 2005) to check raw eddy fluctuation data.

To estimate net ecosystem production (*NEP*), ecosystem respiration (*RE*) and gross primary production (*GPP*) of the forest, a simple empirical model was applied. The model is as follows.

$$RE = a \cdot \exp (b \cdot Ts5) \quad (1)$$

$$GPP = Agmax \cdot PAR / ((Agmax/c) + PAR) \quad (2)$$

$$NEP = GPP - RE \quad (3)$$

(*a, b*, *Agmax* and *c*, coefficients; *Ts5*, soil temperature (°C) in the depth of 5 cm; *PAR*, photosynthetically active radiation)

The coefficients, *a* and *b* were determined by curve fitting of eq. *(1)* between observed nighttime *NEE* (net ecosystem exchange, determined as the sum of CO_2 flux and *Fs*) and soil temperature on condition that the friction velocity (*U**) is greater than 0.4 m s^{-1}.

Annual *GPP*, *RE* and *NEP* estimated by the model and the temperature sensitivity of *RE* (*Q10*) are indicated in Table 1. Averages of annual *GPP* and *RE* were about 1300 and 950 g C m^{-2} $year^{-1}$ respectively, and annual *NEP* ranged from 237 to 431 g C m^{-2} $year^{-1}$. The *Q10* was largely different in each year. We don't think that the *Q10*, which influences estimation of *RE*, widely changes every year, so further consideration is necessary for *RE* estimation.

Table 1. Annual *GPP*, *RE*, *NEP* (g C m^{-2} $year^{-1}$) and *Q10* value (temperature sensitivity of respiration)

Year	*GPP*	*RE*	*NEP*	*Q10*
2000	1231	994	237	1.86
2001	1289	970	319	1.79
2002	1313	882	431	2.88
2003	1357	951	406	2.19

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A YEARLONG OBSERVATION OF ECOSYSTEM CARBON CYCLE IN JAPANESE RED PINE FOREST

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Recently, carbon cycle in the typical ecosystems is studied worldwide. Most of red pine forests (*Pinus densiflora*) in Southwest Japan are formed as the secondary forests in which broadleaf trees are mixed, and are different from those in the continental cool temperate zone. In this study, we are observing ecosystem carbon cycle including various carbon compartments in a Japanese red pine secondary forest.

The observation site is located in Mikiyama forest park, Hyogo, Japan. The average height of trees was 8m, and tree species in the stands consisted of Japanese red pine (*Pinus densiflora*) and broadleaf trees; *Clethra barbinervis*, *Quercus serrata* and so on. CO_2 flux above the forest was measured continuously with the eddy covariance method using a sonic anemometer and an open-path IRGA installed on a tower of 13 m tall since September 2004. Air temperature and photosynthetic photon flux density (PPFD) were also measured. In the flux calculation, linear trend removal for the CO_2 concentration and WPL correction were applied and the less reliable values were removed by the stationarity and standard deviation tests, and the flux footprint test. Ecosystem respiration (R_e) and gross photosynthesis (A_g) were estimated as the functions of air temperature and PPFD, and the data gap of NEE was interpolated by the estimates. Soil temperature at 5 cm deep and soil respiration (R_s) were measured using automatic ventilation closed-chambers. Litter fall was measured every month using ten traps. Above ground tree biomass and soil organic carbon content was measured in December 2003 and 2004

Monthly total NEE of the red pine forest was negative in all month showing the absorption of CO_2 during measurement period. Monthly total R_e and A_g estimated by the interpolation functions changed largely with the season, and both maximum R_e and A_g appeared in September, and minimum in February. Seasonal variation of R_e correlated to air temperature. A_g decreased from September through December and increased from February through April, which is similar to the seasonal course of PPFD, however, A_g reached the minimum in February regardless of marginally increasing PPFD from December to February. Estimated maximum gross photosynthesis (A_{gmax}) depended on air temperature strongly and it reached the minimum value in the January and February when monthly mean temperature was the lowest. A sudden decrease of A_g in October 2004 was probably because of severe leave fall by a strong typhoon attacked the site. Therefore, the seasonal variation of NEE from autumn to spring is not simple because its components A_g and R_e individually depend on the different environmental elements and disturbances.

Seasonal variation of R_s was closely related to the variation of soil temperature. R_s increased also with soil moisture, and monthly R_s was very high in September and October 2004 when monthly precipitation was large. In October, the fraction of R_s to R_e was the maximum during the measurement period. Carbon stock in aboveground biomass was estimated 53.4 and 63.0 tC ha^{-1} in December 2003 and 2004, respectively, and annual growth of aboveground biomass was estimated 35.0 mol m^{-2}. Litter fall was the most from September to November 2004 consisting of the leaves and fruits of trees and shrubs, and was the second most in January 2005 consisting of the bark and twig of red pine.

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LONG-TERM OBSERVATION OF MICROMETEOROLOGICAL NEP IN FUJIYOSHIDA SITE

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A long-term monitoring of net ecosystem production (NEP) has been conducted in Fujiyoshida forest research site (FFPRI FluxNet). The site is located on a gentle lava slope of Mt. Fuji covered with 90 year old Japanese red pine forest. Above canopy CO_2 flux (*Fc*) was measured by eddy covariance method with a sonic anemometer (DA-600/KAIJO) and a closed-path infrared CO_2 analyzer (LI-6262/LI-COR). Raw fluctuation data were recorded at 5Hz by a data logger with a magneto-optical disk (DRM3/TEAC). CO_2 Storage change within the canopy (*Sc*) was measured with another CO_2 analyzer (LI-6262/LI-COR). Then the net ecosystem exchange of CO_2 (NEE) was obtained by NEE = *Fc* + *Sc* at every 30 minutes. After the data quality control, the semi-empirical parameterization of the nighttime ecosystem respiration and the gross primary production was applied; finally continuous data of the net ecosystem production (NEP; NEP = - NEE) were obtained.

The CO_2 release from the forest ranged from 1 to 2gCO_2m^{-2}d^{-1} continued through the mid winter, though the daily NEP showed almost absorption in the remaining period. This suggested that the dormant period of the coniferous forest was shorter than that of the deciduous forest. Although the magnitude of the daytime NEP increased from late spring to summer, the daily sum of NEP decreased, because the ecosystem respiration also increased in the course. Among the years from 2000 to 2003, the inter-annual variation in NEP was large, i.e. the maximum was about 30% lager than the minimum. The difference of the annual NEP induced by the balance of the ecosystem respiration and the assimilation was mainly affected by the inter-annual variation of the seasonal radiation and the temperature.

From 2000 to 2002, the solar radiation had large year-to-year variation in almost all months. The monthly air temperature also showed year-to-year variation, but was relatively low from May to October. The monthly gross ecosystem assimilation also had large inter-annual variation throughout the year. Even in winter, the assimilation occurred if air temperature became positive. But the ecosystem respiration was relatively more consistent than the assimilation, because the air temperature behaved similarly among years in summer, and the forest was snow covered in winter when the inter-annual variation of the air temperature became large.

In 2003, the monthly solar radiation and the air temperature were extremely low in July in Fujiyoshida because of the distinct Asian monsoon. In this year, the sunshine duration in summer season observed in 10 meteorological stations in Eastern Japan updated the lowest record. At which time in the Fujiyoshida site, more than 100 gCm^{-2}month^{-1} of the gross ecosystem assimilation was reduced, alternately about 80 gCm^{-2}month^{-1} decrease of the ecosystem respiration made up the deficit.

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Annual variation in carbon flux and relationships between carbon flux and impact factors in a tropical seasonal rain forest

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Abstract: Two years eddy covariance measurements of above- and below-canopy carbon fluxes and the static opaque chamber and gas chromatography technique measurements of soil respiration for three treatments (bare soil, soil+litterfall, soil+litterfall+seedling) were carried out in a tropical seasonal rain forest. In addition, data of photosynthesis of dominated tree species and shrubs, leaf area index, litter production and its decomposing speed, precipitation, soil moisture, soil temperature and photosynthetic photon flux density within the forest were all measured at the same time. Data from January 2003 to December 2004 are used to present annual variability of carbon flux and relationship between carbon flux and impact factors. The results showed that, carbon flux of this forest was smaller and annual variability was not great, however, it presented special tendency of annual variation, which exhibited above-canopy carbon fluxes were negative in dry season (November-April) and forest is a carbon sink; while above-canopy carbon fluxes were mainly positive in rainy season (May-October), and forest is a weak carbon source; carbon flux of this forest presented an opposite annual dynamic tendency composed to other forest ecosystems. Carbon flux has obviously diurnal variations in this tropical seasonal rain forest. Above-canopy carbon fluxes were negative in the daytime and absolute values were bigger, which presented carbon sink effect; while in the nighttime, carbon fluxes were mainly positive and it presented effects of carbon source; moreover, carbon fluxes were greater in the fore-midnight of the fog-cool and dry-hot season. Below-canopy carbon fluxes were almost positive in every season and they were greater in the daytime, which showed that CO_2 was transferred upwards in the forest, and it presented more significant in the rain season than that in the dry season. Dominated tree species have greater photosynthesis capability, which have a great effect on above-canopy carbon flux. There existed the significant correlation relationship between above-canopy carbon flux and rate of photosynthesis of tree species. There also exhibited the significant correlation relationship between above-canopy carbon flux and rate of photosynthesis of shrub; however, it only did in the dry-hot season that the significant correlation relationship between the ground carbon flux and rate of photosynthesis of shrub was in existence. Soil respiration of three treatments possessed markedly seasonal dynamic; in addition, above- and below-canopy carbon fluxes all have good correlation relationship with soil respiration, also did with litterfall production, litterfall decomposing rate, precipitation, and soil moisture and temperature. This research showed that carbon flux was impacted by many factors in this forest. Unique climate, soil environment, and mutual actions between these two factors and plant physiological actives are all the factors to impact annual variation of carbon flux in tropical seasonal rain forest. A primary statistical result of this study showed that above-canopy carbon flux in this forest presented carbon source or sink effects in different seasons, and it is a carbon sink at the scale of a year.

Keyword: Carbon flux, annual variation, impact factors, tropical seasonal rain forest, Xishuangbanna

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Carbon flux observation in the tropical seasonal forests and tropical rain forest

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Our knowledge of the sources and sinks of CO_2 is not sufficient in the tropical area where sequestration of CO_2 by forests seems to be large. Generally, there are two types of forests in the tropical humid areas, rain forests and seasonal forests. Sakaerat site belongs to Dry Evergreen Forest (seasonal forest). Maeklong site belongs to Mixed Deciduous Forest (seasonal forest). Bukit Soeharto site belongs to secondary tropical rain forest.

Sakaerat tower is located in the comparatively flat top whose inclination is 6m/100m of the table-like hill. Maeklong tower is located in the complicated terrain. Bukit Soeharto tower is located in the secondary forest where young *Macaranga* species grow rapidly after fire caused by drought related with ENSO event.

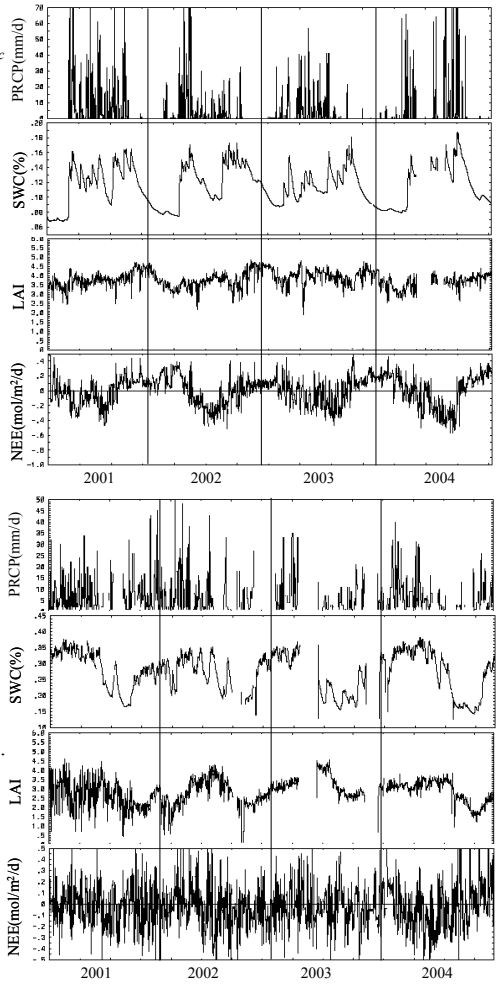
The data gap filling was made by parameterization. We applied the characteristics of photosynthetic light curve at individual leaf level to the canopy level, since we considered photosynthetic light curve of canopy as an analogy of that of individual leaf. Gross primary production GPP was parameterized by the following non-rectangular hyperbola,

$$GPP = (\phi\, APAR + GPP_{\max} - ((\phi\, APAR + GPP_{\max})^2 - 4\phi\, APAR\, \theta\, GPP_{\max})^{0.5}) / 2\theta - R_{ec}$$

Here, ϕ is the quantum yield, GPP_{max} the maximum rate of gross primary production, θ the efficiency of absorption, APAR the absorbed photosynthetic active radiation, R_{ec} the ecosystem respiration. It seems that parameterization by generally used rectangular hyperbola leads to overestimation for ϕ and GPP_{max}.

Figure (top) shows the daily trends of precipitation PRCP, soil water content SWC, Leaf area index LAI, and Net ecosystem exchange NEE at Sakaerat for the four years. In spite of the evergreen forest, there is a seasonal change in LAI. The annual NEE was -13.5, -12.7, -14.9, and -13.0 t C ha^{-1} in 2001, 2002, 2003, and 2004, respectively. Tree census data (Kanzaki et al, 1995) showed this site was a mature forest. One of the reasons caused large negative NEE for this forest is probably due to the ecosystem respiration (R_{ec}) which is the sum of plant and non-plant respiration outflows from this community. The relationship between NEE and friction velocity u_* during the nights showed NEE increased with u_*, and did not maintain at a constant value at large u_*. We estimated R_{ec} in the case when yearly accumulated NEE for each year becomes zero (NEE in Figure for Sakaerat). In that case, R_{ec} (μmol m^{-2} s^{-1}) was 9.6, 10.2, 11.3, and 9.9 in 2001, 2002, 2003, and 2004, respectively.). There was the dependency of GPP_{max} on soil moisture (SWC) at Sakaerat and Maeklong.

Figure (down) shows the daily trend of parameters at Bukit Soeharto. In spite of the rain forest climate, there were dry season from July to October for every year. It seems that NEE had large negative value in the beginning of dry season, and absorption of CO_2 became small in the latter stage of dry season.



P45

Effects of disturbances and the ENSO drought on the micrometeorology and radiation characteristics of a tropical peat swamp forest

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Tropical peat swamp forests are widely distributed in low plains in Southeast Asia, where a large amount of organic carbon has accumulated as peat. Recently, land-use changes following deforestation and drainage have disturbed their environment, and drought due to the El Nino Southern Oscillation (ENSO) leads to large-scale peatland fires. Such disturbance and consequent fires bring a large amount of CO_2 emission into the atmosphere and a change in the energy balance of land surface, whereas we have little information on the micrometeorology of tropical peat swamp forests. Therefore, to investigate the effects of disturbance and the ENSO drought on the micrometeorology, we have continuously measured micrometeorology at a forest (F-site) since July 2001 and a deforested area burnt in 2002, an ENSO year, (B-site) since April 2004; both sites are located on a tropical peatland in Central Kalimantan, Indonesia. Moreover, we compared the radiation characteristics of the land surface of the sites. At F-site, micrometeorology was measured at a height of 41−42 m above forest canopy on a tower. On the other hand, the measurement was made at 1.5−3 m at B-site. Using radiation measurements, we calculated broad-band NDVI (Huemmrich et al., 1999) as an index of radiation characteristics.

Precipitation data showed that the dry season began in May and lasted for about 6 months until October on average, judging from a threshold of monthly precipitation of 100 mm. In 2002, the dry season had less precipitation than those of 2003 and 2004 because of the ENSO drought. During the dry season in 2002, low PPFD was also measured in spite of fewer clouds. This unexpected low PPFD was caused by smoke emitted from widespread peatland fires. In September, monthly mean CO_2 concentration increased to 401.6 ppmv in 2002, which was considerably higher than 387.5 ppmv in 2003.

Figure 1 shows a seasonal variation in NDVI at F-site from 2001 through 2004. NDVI of the forest decreased during the dry season except in 2003. In 2002, the decrease was largest and continued until the end of October. The difference in the seasonal pattern of NDVI would be related to the water status of trees and/or LAI. Figure 2 shows seasonal variations in water table and NDVI at B-site from April 2004 through March 2005.Water table went under the ground at mid-June and reached the minimum of -0.82 m at the end of October. Contrastively, NDVI continued to increase during the dry season; its monthly mean value increased from 0.47 in July to 0.60 in November. This increasing NDVI reflected the re-growth of grass vegetation. Scattering NDVI before June and after December was caused by open water on the ground.

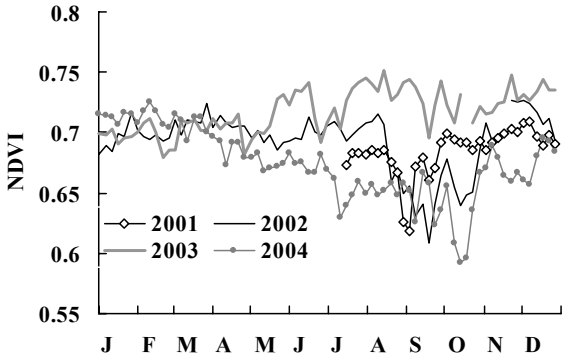

Fig.1 Seasonal variation in NDVI at F-site from 2001 to 2004 (5-day means)

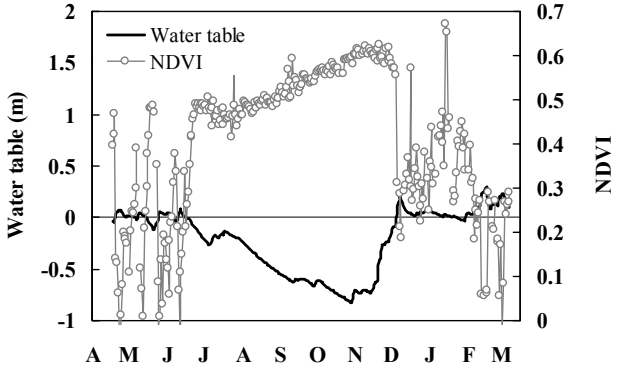

Fig.2 Seasonal variations in water table and NDVI at B-site from April 2004 to March 2005

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CARBON DIOXIDE EXCHANGE MONITORING AND RESEARCH PROGRAMS AT THE HUNGARIAN TALL TOWER SITE

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The mixing ratio and the surface-atmosphere exchange of carbon dioxide have been monitored at different elevations on a tall tower in West Hungary (Hegyhátsál, 46°57'N, 16°39'E, 248 m asl) since 1994 and 1997, respectively. The vertical mixing ratio profile measurements along the 115 m tall tower has been completed with occasional aircraft measurements up to 3000 m above the ground. The poster presents the Hungarian tall tower site and the temporal variation of carbon dioxide observed here. The research activities that are related to the measurement site are also presented together with the linkages with the core measurements. We discuss the region of influence determining the mixing ratio variability, the so-called concentration footprint, as well as that of the flux measurements. The environmental factors governing the net ecosystem exchange (NEE) of the vegetation are analyzed by means of a process oriented ecosystem simulation model. It might be used to estimate the future behavior of the region as the climate is changing. On the basis of the measurements at Hegyhátsál a boundary layer model has been developed which can give rough surface-atmosphere carbon dioxide flux estimate for sites where only surface mixing ratio monitoring is available.

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FLUXES OF CARBON DIOXIDE, WATER VAPOR AND ENERGY OVER A TEMPERATE GRASSLAND IN CENTRAL JAPAN FROM AUTUMN TO EARLY SUMMER

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To investigate the influence of manure application on greenhouse gas budget of managed grasslands, we started an experiment at four grassland sites in Japan. At each site, two plots were provided for the experiment, one for manure application (M plot) and the other for chemical fertilizer application (F plot), and fluxes of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are measured at each plot. In this paper, we focus on CO_2, and report results of eddy covariance measurements of CO_2, water vapor and energy fluxes at one of the four sites in central Japan. The measurements were conducted from September 2004 to July 2005 at a grassland in National Institute of Livestock and Grassland Science, Nasushiobara, Japan (36°55'N, 139°58'E). The annual temperature and precipitation of this site is about 12.0°C and 1600 mm, respectively. The vegetation is dominated by orchard grass (*Dactylis glomerata* L.) and Italian ryegrass (*Lolium multiflorum* Lam.). Manure was applied on M plot after the last harvest of 2004 (mid-November). The eddy covariance system, which consisted of a sonic anemometer (CSAT3, Campbell Scientific) and an open-path infrared gas analyzer (LI-7500, LI-COR), was installed at each plot with instruments to measure other meteorological variables.

Seasonal changes in fluxes of latent heat (*LE*), sensible heat (*H*) and CO_2 over the grassland of the two plots were quite similar even after the manure application. From the last harvest of 2004 to mid-March 2005, daily *LE* was kept constant at a value of around 1.9 MJ m^{-2} d^{-1} (equivalent to 0.8 mm d^{-1} in evapotranspiration rate (*ET*)). On the other hand, daily *H*, which was almost zero until late-January, took positive value from February to mid-March, and the Bowen ratio for midday increased from 0.6 to 1.4. CO_2 flux temporally changed from negative to slightly positive after the last harvest of 2004. CO_2 uptake was thereafter kept almost at a constant level, 0.6 g C m^{-2} d^{-1} on average, during this period. Even in mid-winter, diurnal variation of CO_2 flux was observed, and daytime CO_2 flux responded to changes in incident photosynthetically active photon flux density. From mid-March to the first harvest of 2005 (mid-May), daily *LE* and CO_2 uptake increased markedly up to 13.0 MJ m^{-2} d^{-1} (5.3 mm d^{-1} in *ET*) and 9.7 g C m^{-2} d^{-1}, respectively. In contrast, daily *H* decreased gradually to a constant level of 0.5 MJ m^{-2} d^{-1}. After the first harvest of 2005, temporal release of CO_2 to the atmosphere was observed, but with growth of aftermath CO_2 uptake recovered rapidly to the pre-harvest level just 2 weeks later. Fluxes showed similar trends to the previous period: daily *LE* and CO_2 uptake increased up to 13.1 MJ m^{-2} d^{-1} (5.4 mm d^{-1} in *ET*) and 10.7 g C m^{-2} d^{-1}, respectively, and daily *H* decreased to a constant level of 0.6 MJ m^{-2} d^{-1}.

In summary, this study showed seasonality of CO_2, water vapor and energy fluxes over the temperate grassland in central Japan, and that the influence of different treatment on CO_2 flux was insignificant. Furthermore, although the available data were limited, the results suggest that the grassland in central Japan may act as a CO_2 sink throughout the year.

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EXCHANGE OF CARBON DIOXIDE AND WATER VAPOR BETWEEN GRASSLANDS AND THE ATMOSPHERE AT FOUR HAY MEADOW SITES IN JAPAN FROM AUTUMN TO SPRING

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In order to investigate how stable manure application affects greenhouse gas emission from Japanese managed grasslands, we started an experiment at four hay meadow sites (Fig. 1) from 2004. At each site, two adjoining plots were provided for the experiment: one for stable manure application, and the other for chemical fertilizer application. Nitrous oxide and methane flux densities are measured on selected days by the static chamber method, while flux density of carbon dioxide (CO_2) is monitored continuously from September 2004 by the eddy covariance method. From the results of the first year, we present seasonal variations of CO_2 and water vapor fluxes from autumn to early spring when plant activity is relatively low. Because the main objective of this paper is to describe seasonal trends of CO_2 and water vapor fluxes at each site and their inter-site differences rather than to assess the effect of stable manure application on CO_2 exchange, we selected one of the two experimental plots from each site to show the results.

Net ecosystem CO_2 exchange (NEE) and evapotranspiration rate (ET) at the four sites exhibited high-degree of seasonality and inter-site variabilities. At Kobayashi (KBY) site in southwestern Japan, daily CO_2 uptake of 4-5 g C m^{-2} d^{-1} and ET of 1.4 mm d^{-1} were observed in mid-winter. With growth of grasses from mid-March to harvest in late April, daily CO_2 uptake and ET showed marked increases, which were followed by temporary post-harvest CO_2 release in late April. At Nasushiobara (NSS) site in central Japan, ET of 0.8 mm d^{-1} on average was observed throughout the winter. Daily NEE at NSS site in mid-winter was –0.2 g C m^{-2} d^{-1}, indicating that daytime photosynthetic CO_2 uptake was almost balanced by ecosystem respiration. Both CO_2 uptake and ET increased with growth of grasses from mid-March to harvest in mid-May. At Shizunai (SZN) site in central Hokkaido, the grassland was generally dormant in CO_2 and water vapor exchange during the snow cover period. Daily latent heat flux started an increase prior to snowmelt in late March, while daily NEE was kept around zero until late April. Similar seasonal trends in energy and CO_2 exchange were observed at Nakashibetsu (NKS) site in eastern Hokkaido, but unexpected CO_2 emission of 0.6 g C m^{-2} d^{-1} on average was observed from snow-covered grassland throughout the winter. The total NEE and ET from October 2004 to April 2005 exhibited climatic gradients that the total CO_2 uptake and ET increased with the mean temperature.

Fig. 1. Location of four study sites

This study was conducted as a part of "Establishment of Good Practices to Mitigate Greenhouse Gas Emissions from Japanese Grasslands (GHGG-Japan)", which was organized by Japan Grassland Agriculture and Forage Seed Association and funded by Racing and Livestock Association.

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MEASUREMENT AND SIMULATION ON CARBON AND WATER FLUX OF THE CROPLAND ECOSYSTEM IN NORTH CHINA PLAIN

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North China Plain is one of the most important areas of food production in China. Measurement and simulation on its carbon and water flux can help us understand the formation mechanism of crop yield, and evaluate the role of farmland in climate change.

In this study, the experiment was performed at Yucheng Comprehensive Experiment Station (36° 57′ N,116 ° 36′ E, 20m a.s.l.) in the North China Plain characterized by a semi-humid and monsoon climate. Mean annual precipitation, temperature and global solar radiation at the station over the past 30 years are 528mm, 13.1℃, and 5225 MJm^{-2} respectively. The soil of the area is mainly the moisture soil and the salinized moisture soil. The vegetation is a winter wheat and summer maize rotation field. Winter wheat is sown in early October and harvested in mid June while summer maize is sown with the residues of the winter wheat in mid June and harvested in late September. The terrain surrounding it is vegetated with large, flat areas of crop field, upwind fetch of the site extends more than 5 km for winds from all directions.

Continuous fluxes and meteorological measurements with the eddy covariance (EC) technique began on October 20, 2002. The EC system, mainly composed of a 3D sonic anemometer (model CSAT3, Campbell Sci., Logan, UT) and an open path, CO_2/H_2O analyzer (IRGA, Li-7500, Li-Cor Inc., Lincoln, Nebrasks, USA), could measure virtual fluctuations and averages of wind velocity, temperature, water and CO_2 concentrations. Two soil heat flux plates (model HFT-3, Campbell Scientific Inc.) were embedded in between-rows and between-plants to determine fluxes. A data logger (model CR5000, Campbell Sci., Logan, UT) connected with the system operated at 10 Hz and the fluxes were averaged for 30 min periods. Along with the fluxes measurements, standard meteorological data were collected including air pressure, photosynthetic active radiation, net radiation, precipitation, soil temperature, soil moisture etc. Routine irrigation and fertilization were employed to achieve a non-limiting condition throughout the growing season.

We obtained the temporal variation characteristics of CO_2 and H_2O flux of the farmland ecosystem with the observed data. On the other hand, according to the Synthetic Model of Photosynthesis-Transpiration based on Stomatal Behavior (SMPTSB) at leaf level developed by Yu et al. (2004), we scaled it up to ecosystem level by introducing soil respiration and aerodynamic resistance. The NEP, ET, and WUE of the cropland ecosystem in North China Plain were estimated with the model. With the measured data obtained by EC system, the simulation results were verified. The comparison showed that the simulated NEP, ET, and WUE were in good agreement with the measured values with relative high R^2 values. Therefore, we deduced that the model not only provide a tool for simulating carbon and water flux at ecosystem level but also for partitioning the ET measured by EC system into evaporation and transpiration.

P50

CO_2 FLUX OBSERVED OVER A RICE PADDY FIELD BY THE EDDY COVARIANCE METHOD AND ITS QUALITY CHECK

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Rice paddy field is one of the most popular cultivation patterns in East Asia under a monsoon climate. And it takes a great important role in carbon budget. Therefore, we have been observed CO_2 flux above rice paddy field using eddy covariance method since 1999 in Okayama, Japan. The objectives of this observation are evaluating Net Ecosystem Exchange of CO_2 (NEE) between atmosphere and rice paddy, and investigating between its seasonal variation or inter-annual variation and environmental factors.

To evaluate reliable NEE at rice paddy, we have to check the data quality and to exclude the inappropriate data for eddy covariance method. In recent years, many kind of quality control were proposed; for example, criterion of atmospheric turbulence condition using u_*, inspection of skewness and kurtosis which are higher moment terms using its threshold for testing of instationarity. But thresholds of these methods are depending on site or observation system, so they are not universal. Then, we can not apply automatically the threshold which is determined for certain condition to other condition. In this study, we determine the appropriate threshold for rice paddy field, and conduct quality control for the data in 2003 and 2004. Then we calculate the cumulative NEE using selected data with complement of the deficit data.

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BOWEN RATIO MEASUREMENTS OF ENERGY BUDGET COMPONENTS OVER VARIOUS ECOSYSTEMS IN MYMENSINGH, BANGLADESH

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Micrometeorological studies on exchange of energy and water vapor between soil/vegetation and the atmosphere is a new research filed in Bangladesh. Partitioning of net radiation (*Rn*) into latent heat flux (*lE*), sensible heat flux (*H*) and ground heat flux (*G*) over any ecosystem was not reported so far in Bangladesh. We therefore designed experiments to provide preliminary information on *lE*, *H* and *G* over various ecosystems. Such information might be helpful for the AsiaFlux community to design gas flux measurements in Bangladesh in future. To fulfill our aim, experiments were carried out over various ecosystems *viz*. irrigated rice field, harvested rice field, grassland and bare land at Bangladesh Agricultural University Farm, Mymensingh from October to December 2004 using Bowen Ratio Energy Balance (BREB) technique.

Subtropical climate prevails in the experimental area. It is characterized by heavy rainfall from April to September and by a little shower from October to March. Late precipitation in September or even in October helped to store sufficient soil moisture during the experimental period. Soil moisture content, except for the irrigated rice filed, ranged from 39 to 45%. During the experiment, plant height of rice was 92-95 cm and its leaf area index was 2.8-3.0, while the harvested rice field had only rice straw with 10-15 cm in height. The grassland was covered with 34 species of grasses having 5-10 cm height, and the bare land site was a cultivated open land having no plants. A pair of temperature-humidity sensors equipped with homemade aspirators as well as a naturally ventilated net radiometer and heat flux plates were used to measure energy budget components. The experimental period at each site included 3 to 8 clear days in a row. The data in those periods were used for the following analysis.

At all of the four sites, diurnal trends of *Rn*, *lE* and *G* followed the diurnal course of global radiation. However, *H* showed slightly positive values, 5-15 W m^{-2}, only around midday and was almost zero in other hours in the daytime. In the total energy balance of the daytime (from 0600 to 1800 hours), *lE* was dominant at all of the four sites, while *H* was minor. *lE/Rn* was 0.92 on average at the irrigated rice field, 0.82 at the harvested rice field, 0.84 at the grassland and 0.79 at the bare land. *H/Rn* was the largest at the bare land (0.04 on average) and even smaller in other three sites. *G/Rn* was greater than *H/Rn*, and ranged from 0.07 at the irrigated rice field to 0.15 at the bare land. In summary, surface energy balance in the study period was characterized by dominant *lE* and negligibly small *H* under sufficient soil moisture conditions, with small modification by vegetation.

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SENSIBLE HEAT, LATENT HEAT, AND CO_2 FLUXES ON THE LOESS PLATEAU IN CHINA DURING THE SEASON FROM SPRING TO SUMMER IN 2005

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The Loess plateau is located in the middle region of the Yellow river basin, China, and occupies 380,000 km^2, which corresponds to about 3.9 % of total area of China. In May 2004, an observation system for measuring the atmospheric boundary layer (ABL) was installed in the southern part of the plateau in order to measure seasonal and inter-annual variations of ABL as well as to investigate the water cycles in the Yellow river basin. This observation was carried out as a part of the project of Yellow River Study, which has been promoted by Research Institute for Humanity and Nature, Japan, with cooperation by Chinese Academy of Sciences (CAS), China.

Flux Radiation Observation System (FROS) was established at the field of Changwu Agro-Ecological Experimental Station on the Loess Plateau (35°2'N, 107°8'E), Institute of Soil and Water Conservation, CAS. The elevation of the site is 1206.5 m. The average annual precipitation is 578 mm and the annual average air temperature is 9.2°C. The main species of crops in this region are wheat, corns, and apples, and much area of this region is randomly occupied by these agricultural fields. Meteorological instruments of FROS were installed on the 30 m-height observation tower and on the 2 m-height pole. Ultrasonic anemometers (Gill, UK) and open-path CO_2/H_2O gas analyzers (LI-7500, Li-COR, USA) were installed at heights of 30, 10, and 2 m. Wheat was seeded around the tower in early spring in 2005. Its height reached about 70 cm in May. The field of apple trees was situated in the north to northeast region. In the east, about 50 m apart from the tower, there are some residential buildings. Some narrow streets distribute around the observation site and residential houses stand alongside of the streets. Also, the main street lies at several hundreds meters apart from the observation site.

This study shows sensible heat, latent heat, and CO_2 fluxes observed by FROS during the season from spring to summer in 2005. The period of the analyzed data is from 11th May to 12th July. The main results are as follows. 1) In May, each flux had almost constant profile in the vertical direction, respectively. This indicates that the biological activities of plants were closely similar among the different footprint areas for each flux measured at different heights, in spite of presence of several species of plants around the observation site. 2) An apparent influence of water vapor deficit was observed, i.e. the extent of aperture of stomata might be significantly regulated by water vapor deficit. 3) In June, as the color of wheat turned to yellow gradually indicating its biological activity decreased, the amplitudes of latent heat and CO_2 fluxes measured at a height of 2 m became smaller than those measured at the other heights, 30 and 10 m. This may indicate that phenological degradation of wheat around the tower could be detected by the sensor at a height of 2 m. 3) In evening, efflux of CO_2 was observed frequently caused by that respiration overcame photosynthesis. However, the efflux did not continue any longer than several hours, which might be caused by that respiration decreased with temperature decreased. On the other hand, when evaporation occurred due to downward (negative) sensible heat flux in windy condition during nighttime, respiration was maintained throughout the night.

P53

CO_2 FLUX MEASUREMENT OVER WINTER BARLEY AND SOYBEAN FIELDS GROWING ON THE RICE BASED DOUBLE CROPPING PADDIES IN NORTHERN KYUSHU, JAPAN

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We conducted the CO_2 flux measurement for the agricultural field in northern Kyushu, Japan. In this area the rice based double cropping paddies are used to culture the winter barley from winter to next spring. The double cropping field has two chances to absorb the atmospheric carbons in a year. Additionally, occasional soybean culture on the converted upland from paddies has been widely introduced in summer seasons. The increase in soybean harvest yields on such fields is assumed to be lead by nitrogen cycle, suitable supply of nitrate to plant from decomposing stubbles in soil, accompanied characteristics in carbon cycle also is expected. However after barley remains are burned before the conversion to the rice paddy customary, it should be possible to reduce the greenhouse gasses from agriculture land. This observation aim to provide the characteristics of CO_2 fluxes under rice based double-cropping paddies as the basal study.

The study area is extensive reclaimed farmland (33o9'18"N, 130o18'30"E, 2 m ASL); mainly cropping rice paddies in summer and converted to grow malt barley in winter, occasionally used for soybean in summer. The observation was conducted from January 30 to May 19 for barley, from July 24 to November 12 in 2004 for soybean, March 9 to May 1 in 2005 for barley. At the top of the 3 m high observation mast, built at the center of the study area, the sonic anemometer (Model 81000, Young) and IRGA (Li-7500, Licor) were installed. The flux measurements of CO_2, sensible and latent heats, and momentum performed by eddy correlation method are automatically calculated by data logger (CR23X, Campbell) and recorded every 30 min.

The lack data caused by the uncertainty of the measurement are filled with the estimation from air temperature and solar radiations observed simultaneously. Seasonal variation of CO_2 flux (NEE) over the barley gradually increased with plant growth and approached to around –2.0 $mgCO_2/m^2/s$ in 120 days after seeding, and decrease to –0.5 $mgCO_2/m^2/s$ before harvest. During the growing, and they changes with LAI (leaf area index). The accumulated NEE was 437 $g\text{-}C/m^2$ in Apr. 23. The carbons taken out of the field as harvest yields was 121 $g\text{-}C/m^2$, and the stubbles and plant remains are plowed into the soil. The following soybean grow, variation of CO_2 flux approached to around –1.2 $mgCO_2/m^2/s$ (maximum in the daytime) in 35 days after seeding, and dropped to almost -0.0 $mgCO_2/m^2/s$ before harvest. The accumulated NEE in soybean was 251 $g\text{-}C/m^2$ in Nov. 12, and taken out carbon weight was around 68 $g\text{-}C/m^2$ estimated from harvest yields, which is quite smaller than normal. Considering the emission during uncultured period, the total NEE in this field (barley - soybean) was estimated around 150 - 200 $g\text{-}C/m^2/yr$ except compost application.

P54

Air Temperature Measurement Errors in a Naturally Ventilated Multi-Plate Radiation Shield

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In observational networks of air temperature, mechanically aspirated radiation shields are often replaced by naturally ventilated radiation shields because of the operational costs and power requirements. The radiatively-induced errors (radiative errors hereafter) need to be assessed for correctly interpreting air temperature data collected in a naturally ventilated shield. If sensor-shield systems within a network of air temperature measurements experience different radiative forcing, e.g. due to variable cloudiness or exposure differences, the horizontal temperature gradient may be incorrectly estimated. In addition, when air temperature measurements are used to evaluate the sensible heat flux from the surface with the bulk-transfer method, the radiative error could cause significant errors in the predicted sensible heat flux and even the wrong sign (Anderson and Baumgartner, 1998). As a multi-plate shield relies on the ambient wind for ventilation, radiative errors tend to occur when radiative forcing on the radiation shield is large and the ambient wind speed is low. Radiative errors need to be considered in correctly interpreting air temperature data collected in a multi-plate shield.

A series of field experiments are conducted to investigate the sources of the radiative errors of a commonly-used system consisting of the HOBO Pro Data Logger external thermistor (Model H08-031-08, Manufacturer: Onset Computer Corporation; Whiteman et al., 2000) enclosed in the Davis Instruments multi-plate shield (a.k.a. Onset Computer RS1). The amount of solar radiation reaching inside the shield is positively correlated with the ground surface albedo. The deviation of the shield surface temperature from the ambient air temperature generally becomes positive during the daytime and negative at nighttime. The magnitude of the systematic radiative error within the thermistor-shield system is assessed by comparing it with a RTD sensor in a mechanically aspirated shield. Empirical models are developed for correcting temperature errors using information on wind speed and net or solar radiation. The same empirical models may be applicable for systems consisting of different sensors and multi-plate shields by empirically determining new coefficients in the models.

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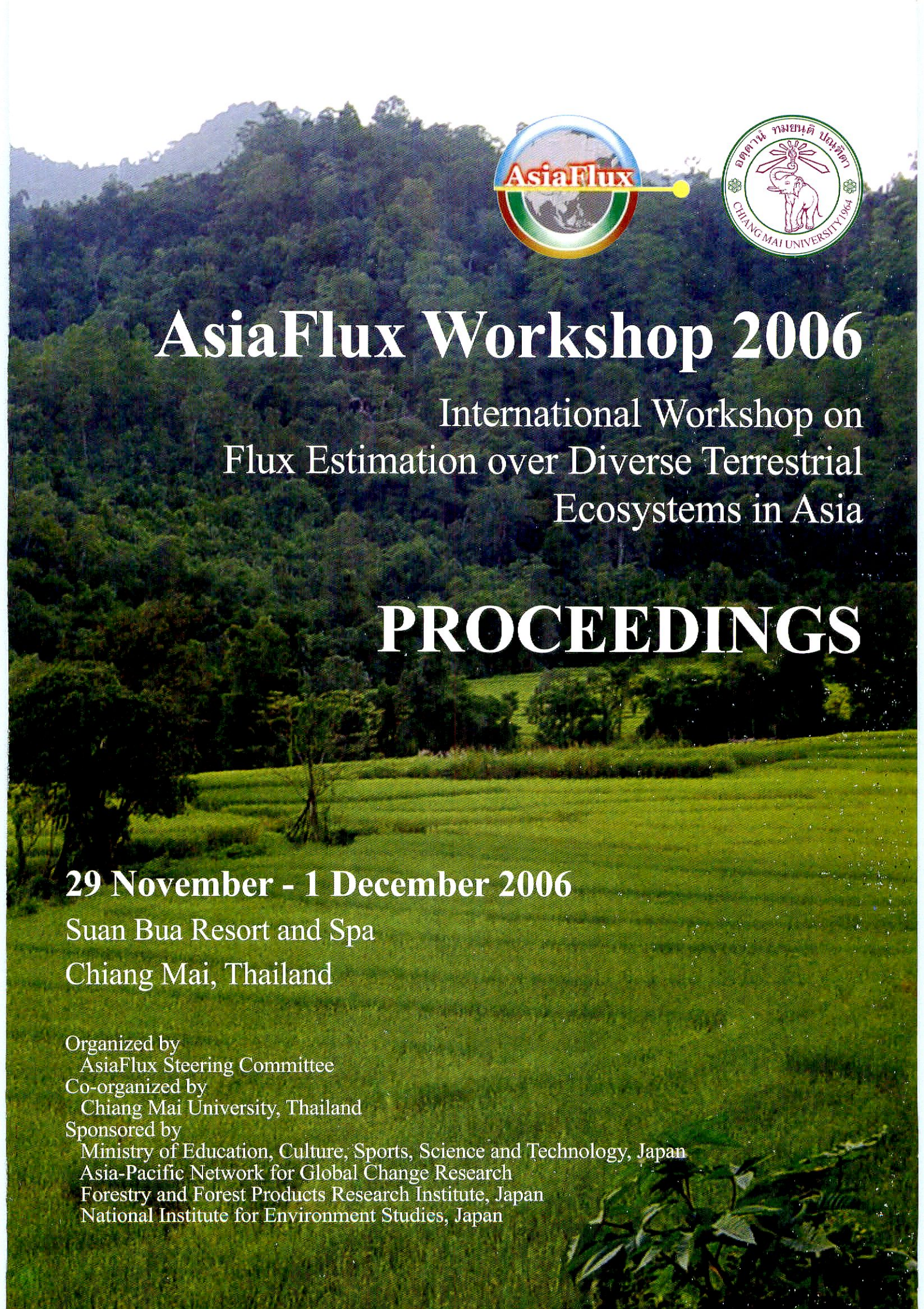

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S01

PRESENT SITUATION AND CHALLENGES OF ASIAFLUX - FROM ACTIVITIES OF WORKGROUPS IN 2006 -

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We have introduced last year, at the 4th AsiaFlux Workshop held in Fujiyoshida, Japan, about our plan on building the Asian regional flux network along the frame work of projects "Initiation of the next-generation AsiaFlux (MEXT)" and "Standardization and Systematization of Carbon-Budget Observation in Asian Terrestrial Ecosystems Based on AsiaFlux Framework (APN)". After the Workshop, we have situated two workgroups with three sub-workgroups under each workgroup, in the AsiaFlux organization (Ohtani, 2005). We are steadily carrying out our activities, and these AsiaFlux workgroups play important roles in its implementation.

One of the most topical and fruitful activities in this year was the very first AsiaFlux Training Course on Micrometeorology, organized by *Short Training Course Sub-workgroup*. The training course aimed for diffusing basic theory and observation techniques to Asian flux researchers. More than twenty participants who were about to start carbon dioxide flux measurement joined from ten different countries (Saigusa *et al.*, 2006). We believe this training course has contributed to extend the carbon dioxide flux observation in Asia, and to improve data quality and fostering leading researchers. Above all, cooperative relations among Asian research institutions we developed through the course is a great hoard to AsiaFlux community.

AsiaFlux Editorial Sub-workgroup has issued five volumes of AsiaFlux Newsletter in the updated editorial line. In these issues, five editors from Korea and Japan compiled 21 articles from Korean, Chinese and Japanese authors. Contributions from wider district in Asia are expected, along with the further intensification of our activities.

In parallel with these on-going activities, we are discussing AsiaFlux policy and membership to be taken in context. We have not updated those descriptions in our web site since the establishment of AsiaFlux in 1999. The AsiaFlux executive and steering committees are conducting comprehensive deliberations on these matters, suggested by *Network Management Sub-workgroup*. One important issue is to situate AsiaFlux to be an umbrella organization which covers Asian communities who carry out observations on carbon dioxide, energy and water vapor flux or terrestrial carbon.

Moreover, *Database and Data Policy Sub-workgroup* has begun to discuss the AsiaFlux database policy and updating site information. *Measurement Support and Standardization Sub-workgroup* has also started the development of standardized flux measurement systems. Some workgroup members have suggested us that we have to reconsider the current linkage among each subgroup activities. We intend to improve AsiaFlux to be more accessible and attractive with a cooperation of participants who join to AsiaFlux.

Acknowledgements: *We would like to thank all the collaborators in AsiaFlux sub-workgroups for promoting our activities. The AsiaFlux activities were financially supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) and by the Asia-Pacific Network for Global Change Research (APN).*

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Saigusa, N., Takagi, K., Yuta, S. and Hirata, R. 2006. Report on the AsiaFlux Training Course 2006, AsiaFlux Newsletter 19, 1-2.

S02

FLUXNET AFTER 10 YEARS: SYNTHESIZING CO_2 AND WATER VAPOR FLUXES FROM ACROSS A GLOBAL NETWORK

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FLUXNET is a global network of micrometeorological flux measurement sites (Fig. 1) that measure the exchanges of carbon dioxide, water vapor, and energy between the biosphere and atmosphere. Over the past ten years, the FLUXNET project has grown from a handful of sites that are continuously measuring carbon dioxide and energy fluxes to over 400 sites worldwide (Fig. 2). With an extended dataset overlapping the duration of the TERRA and AQUA satellites, the FLUXNET project is poised to address the next generation of carbon cycle questions. The overarching goal of FLUXNET is to quantify spatial/temporal variations of terrestrial carbon dioxide exchange, as assessed with a global network of eddy covariance flux measurement towers, and relate this information to carbon fluxes being deduced from remote sensors on satellites and towers.

Fig 1. Distribution of flux tower sites (October 2006)

Specifically, the FLUXNET project has collected a large amount of data from a spectrum of canopy roughness conditions, functional types and climate spaces provided by regional networks and investigators. FLUXNET can be seen as a model for data sharing in the scientific community. FLUXNET has sponsored collaboration and synthesis through workshops, hosting visitors and has helped in building a collaborative, cooperative, multi-disciplinary and international community of researchers.

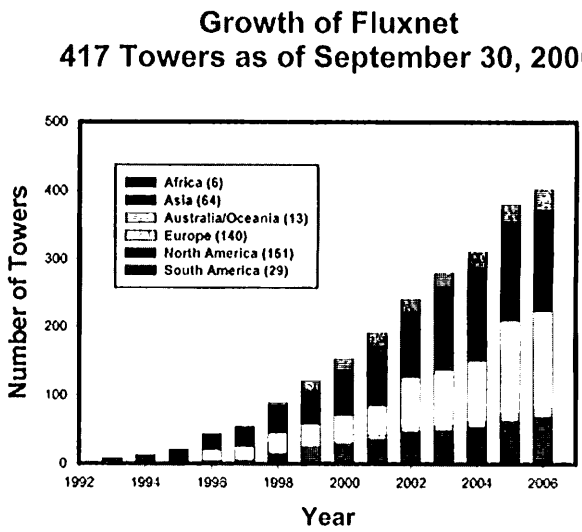

Fig 2. Number of flux tower sites

The FLUXNET project produces gap-filled, value-added databases of carbon flux measurements. These data provide the experimental foundation for improving and testing algorithms that assess gross primary productivity (*GPP*) and net primary productivity (*NPP*) using remote sensing data and normalized vegetation indices (Fig. 3) and validating and improving SVAT models used for weather, climate, biogeochemistry and ecosystem dynamics.

The intrinsic value of flux networks on regional and global scales lies in their ability to produce large and long-time data sets, reduce sampling error, create robust datasets for model development, capture pulses and lags of ecosystem processes, study the gradient of climates, structure and function, and provide for better integrated research studies.

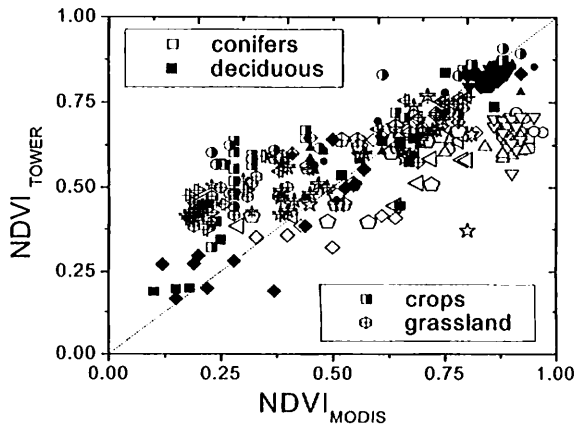

Fig 3. A broadband tower NDVI plotted against MODIS NDVI for 14 FLUXNET sites

O11

NEW DEVELOPMENT IN CANOPY-ATMOSPHERE EXCHANGE

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This paper introduces the concept of a Carbon Flux Super Site, the next-generation of flux sites aimed at characterizing carbon exchange between terrestrial ecosystems and the atmosphere. The Carbon Flux Super Site harnesses cutting-edge technologies to generate insights leading to highly relevant biological and physical process information about the carbon cycle. It does so in a concentrated, integrated effort, so that comprehensive novel measurements related to carbon exchange in non-ideal conditions result in more scientifically credible data.

Using recent methods to characterize the impact of frequent and poorly documented atmospheric phenomena on carbon fluxes, this Carbon Flux Super Site aims at producing revised, more robust regional-scale carbon fluxes. This data is obtained using both stationary and airborne flux platforms combined with onsite tall tower CO_2 mixing ratio measurements. The data will be used as input into regional models to simulate more accurate climate change scenarios that result from increased atmospheric CO_2 concentrations.

The second portion of this talk reports on the latest developments surrounding canopy-atmosphere exchange. A recent Lagrangian diffusion method is used to examine the canopy-atmosphere gaseous exchange for sources vertically distributed within the canopy layer. We examine the validity of the Lagrangian diffusion method and discuss the behavior of the diffusing scalar as a function of distance from the in-canopy sources/sinks, both for the near-field and for the far-field. It mimics the diffusion of CO_2 respired from the soil surface, and the diffusion of gases exchanged separately from the main canopy layer and from the understory. The influence of buoyancy forcing on the results is discussed. These results spark new understandings on gaseous transport inside forest canopies and its exchange of gases between the canopy layer and the atmosphere.

O12

SYNTHETIC ANALYSIS OF THE LONG-TERM CARBON BUDGETS ESTIMATED FROM TOWER-FLUX MEASUREMENTS AT VARIOUS FORESTS IN EAST ASIA

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The elucidation of the carbon budgets at various ecosystems has become an important subject of the global warming issue. Especially, forests have a key role in the global carbon cycle, sequestering large amounts of atmospheric CO_2. However, the ability of carbon sequestration depends on the type of forests and climate conditions. The environmental conditions in East Asia under a monsoon climate differ from North America and Europe. The precipitation in East Asia is larger than that in these continents, in particular, the much precipitation in the mid-latitude. Due to the specific features of climate and forest type, the carbon budgets in East Asia should be different from those of North America and Europe.

From this point of view, in this lecture, the preliminary results of long-term carbon budgets at forest sites in East Asia are explained and discussed about following points: (1) Annual-integrated values of carbon budget and their relation with meteorological conditions, (2) Comparison of the results of Net Ecosystem Production (NEP) with each other in East Asia and with NEP values in American and European forests and (3) Quantitative evaluation of NEP by the eddy covariance method through comparison with biometric estimation of NEP.

Table 1: Annual-integrated values of NEP, RE, GPP (gC/m^2/year), NEP/GPP, Mean Air Temperature (degC), PPFD(mol/m^2/year) and Precipitation(mm/year) (from data-base of S1 project, *: without u*-correction)

Site (degN, degE)	Years	NEP	RE	GPP	NEP/GPP	Air Temp.	PPFD	Precip.
Takayama, Japan (36.1,137.4) (deciduous broad-leaf forest)	2000-04	337	882	1219	0.28	7.3	9900	2400
Fujiyoshida, Japan (35.5,138.8) (evergreen needle-leaf forest)	2000-04	489	1059	1548	0.32	9.5	10466	1506
Kiryu, Japan (35.0,136.0) (evergreen needle-leaf forest)	2001-04	554	1471	2025	0.27	15.1	9146	1500
Tomakomai, Japan (42.7,141.5) (deciduous needle-leaf forest)	2001-03	177	1502	1679	0.11	7.7	8529	1247
Laoshan, China (45.3,127.6) (deciduous needle-leaf forest)	2004	121	1227	1348	0.09	2.8	---	724
Pasoh, Malaysia (3.0,102.3) (tropical rain forest)	2003-05	854*	---	---	---	26.3	12967	1733
Sakaerat, Thailand (14.5, 101.9) (tropical seasonal forest)	2003	1283*	1543*	2826*	0.46*	24.3	14570	1750

Acknowledgements: *This study was supported by Japan Ministry of Environment (S1 project: Integrated study for terrestrial carbon management of Asia in the 21st century based on scientific advancements). The authors would like to thank all the project investigators, their co-workers, and students for providing data.*

O13

TEMPORAL AND SPATIAL VARIATIONS IN THE SEASONAL PATTERNS OF CO_2 FLUX IN BOREAL, TEMPERATE, AND TROPICAL FORESTS IN ASIA

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Measurements of the net ecosystem production (NEP) over forest stands were conducted from flux towers in boreal, temperate, and tropical regions in East Asia from 2000 to 2005. The sites are distributed over a wide latitude ranging from 3 to 64 °N and include boreal and temperate needle-leaf deciduous forests (larch) (central Siberia, Mongolia, China, and northern Japan), temperate broadleaf deciduous and needle-leaf evergreen forests (central Japan), and tropical rain forest and seasonal forest (Malaysia and Thailand).

The boreal larch forests had short growing periods of 3-4 months. The temperate deciduous sites showed the greatest positive NEP in early summer, after leaf expansion. The temperate evergreen sites showed earlier positive NEP in spring than the deciduous sites and had long growing periods (> 10 months). The tropical rain forest showed a small flux throughout the year without a clear seasonal change.

In 2002 and 2003, several significant weather anomalies were observed, such as positive temperature in the temperate sites in the 2002 spring, negative precipitation in the tropics in 2002, and negative solar radiation in the temperate sites in the 2003 summer. The seasonal patterns of NEP were sensitive to the anomalies, and the variations were caused by (1) high spring-air temperature, which induced an early start of the growing period in the temperate sites, (2) summer solar radiation, which controlled the annual gross primary productivity; (3) and a long dry season, which affected the leaf area index and NEP in the tropical seasonal forest.

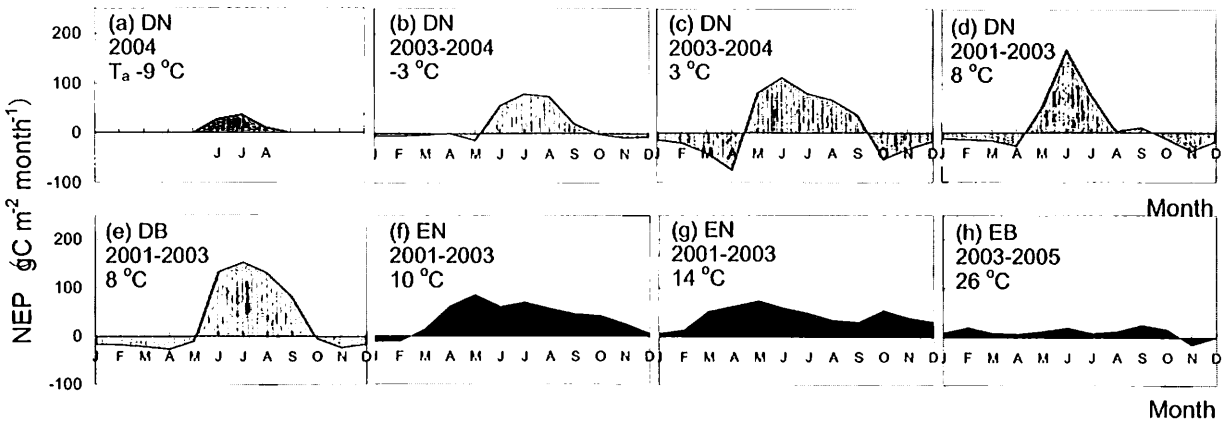

Fig. 1. Monthly NEP observed in (a) boreal larch forest in central Siberia; (b) boreal larch forest in Mongolia; (c) temperate larch forest in northeastern China; (d) temperate larch forest in northern Japan; (e) temperate birch-oak forest in central Japan; (f) temperate red-pine forest in central Japan; (g) temperate cypress forest in central Japan; and (h) tropical rain forest in Malaysia. The symbols DN, DB, EN, and EB indicate deciduous needle-leaf, deciduous broadleaf, evergreen needle-leaf, and evergreen broadleaf, respectively. The year(s) of NEP evaluation and annual air temperature (T_a) are indicated in each figure.

Acknowledgements: *This study was supported by the Japan Ministry of the Environment (Integrated study for the terrestrial carbon management of Asia in the 21st Century on the basis of scientific advancements). The authors would like to thank all the project investigators, their co-workers, and students for providing data.*

O14

THE SPATIAL AND TEMPORAL DISTRIBUTIONS OF THE ENERGY PARTITION ABOVE FORESTS IN MID- AND HIGH-LATITUDE REGIONS

–Analyses using the AmeriFlux, EuroFlux, and E. Eurasia-Japan datasets–

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Introduction

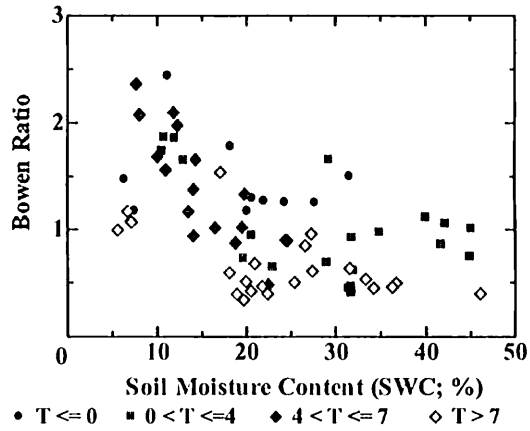
Water, energy, and carbon dioxide exchanges have been examined intensively at many sites on the globe in the last decade, and site-specific characteristics are revealed using these datasets. Nevertheless, the quantitative characteristics of the spatial and temporal distributions of these exchanges remain obscure. The exchanges are strongly controlled by environmental conditions, such as radiation, temperature, humidity, wind speed, and soil moisture. Which factors control the spatial distribution and which factors limit the temporal distribution? This study investigated the spatial and temporal distributions of water and energy exchanges using datasets obtained in North America, Europe, Eastern Eurasia, and Japan.

Materials and Method

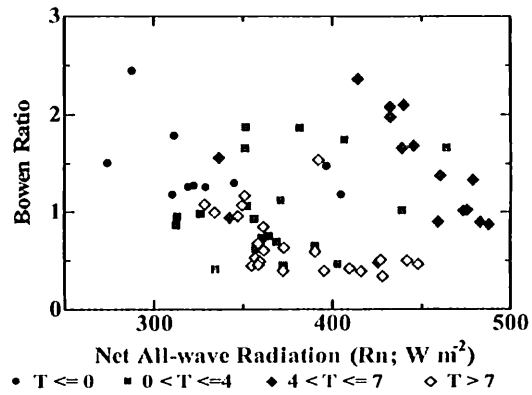
The data analyzed in this study come from nine AmeriFlux, sites, ten EuroFlux sites, and eight sites in Eastern Eurasia and Japan. They are located from 33°N to 64°N and from 142°E to 122°W. In addition to the dataset for the turbulent fluxes and meteorological elements, soil moisture content (SWC) was also used. Data that were more than two standard deviations outside the relationship between TF and net all-wave radiation were excluded from the following analysis. The period analyzed is 90 days of growing season, *i.e.*, day of year (DOY)=151 – 240, at each site, in every year. The characteristics in the 73 growing seasons are totally analyzed in this study.

Results and Discussion

Figure 1 shows the relationships between the Bowen ratio (BR) and SWC and net all-wave radiation (Rn). The BR dropped rapidly as the SWC increased from 0 to 20% and then remained constant at an SWC above 20% (see the upper figure) regardless of forest type or tree species. The lower the annual mean temperature obtained from the IIASA global climate dataset is, the larger the values of the BR for wet SWC exceeding 20%. There was no significant relationship between BR and Rn (see the bottom figure). By contrast, the opposite was true on a half-hourly basis. The BR increased with the Rn, while there was no clear relationship versus SWC at each site. These results show that spatial and long-term temporal, *i.e.*, year to year, variation in the characteristics of water and energy exchanges is strongly limited by the SWC, whereas short-term temporal distributions are controlled mainly by radiation conditions.



(a) Relationship between BR and SWC



(b) Relationships between BR and Rn

Figure 1. The spatial distributions of the water and energy exchanges above 27 forests between 33–64° N in the Northern Hemisphere

O15

SEASONAL VARIATION OF NET ECOSYSTEM PRODUCTIVITY IN JAPANESE TEMPERATE FORESTS

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Micrometeorological observations of the net ecosystem productivity (NEP) were conducted in different types of temperate forests, such as deciduous broadleaf, deciduous coniferous, evergreen coniferous and mixed forests, distributed in Japanese main islands from Hokkaido to Kyushu. The measured NEP modified by data selection and empirical gap-filling procedures, obtained from 2000 to 2003, were used in this report.

The maximum NEP was largest in deciduous coniferous forest, followed by deciduous broadleaf forests. These groups had remarkably higher maximum NEP than evergreen coniferous forests, with large inter-annual variability in the growing season. In evergreen coniferous forests, the NEP's intetr-annual variability was appreciable throughout the year, but its magnitude was smaller than that of the deciduous forests. The period of positive NEP lasted for 140 to 200 days in deciduous broadleaf forests, and more than 290 days in evergreen coniferous forests. These varieties in NEP might be caused by the different forest response to the regional and inter-annual climatic variations. The response of the NEP, as the difference between gross primary productivity and ecosystem respiration, to the climatic variations will be discussed in the presentation.

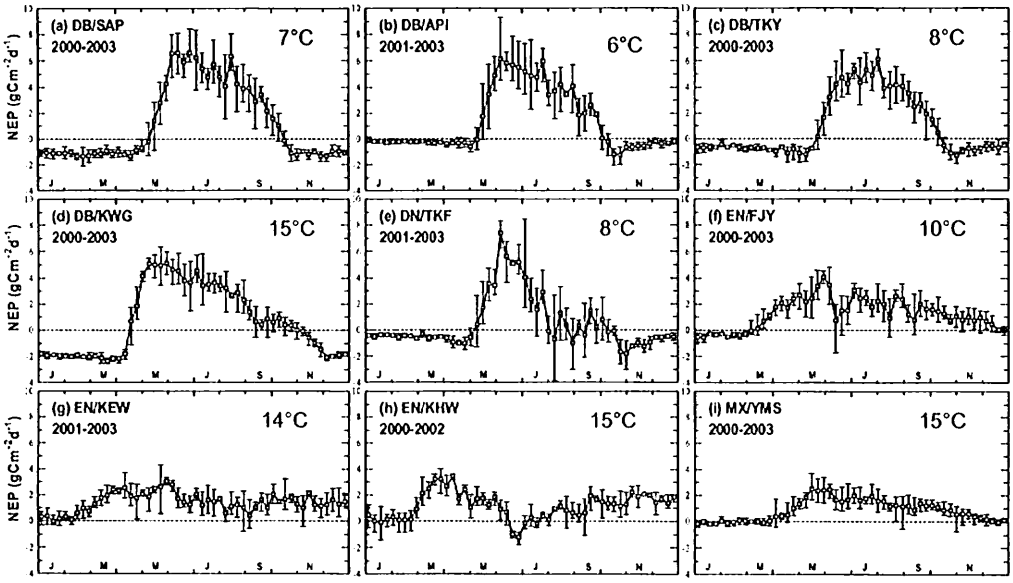

Fig. 1 Seasonal changes of NEP observed in [DB] deciduous broadleaf forests in (a) Sapporo, (b) Appi, (c) Takayama and (d) Kawagoe; [DN] deciduous coniferous forest in (e) Tomakomai; [EN] evergreen coniferous forests in (f) Fujiyoshida, (g) Kiryu and (h) Kahoku; and [MX] mixed forest in (i) Yamashiro. Square symbol tied with solid line shows weekly mean NEP ($gCm^{-2}d^{-1}$) averaged over the observation period, and the annual mean air temperature is also indicated in each panel. Vertical bar shows the maximum and the minimum NEP in weekly mean NEP among the years.

Acknowledgements: *The authors would like to thank all the project investigators, their co-workers and students for providing data. This study was supported by the following grants: 1) the Japan Ministry of the Environment (Integrated study for the terrestrial carbon management of Asia in the 21st Century on the basis of scientific advancements), and 2) the Forestry and Forest Products Research Institute (#199903, #200303: Long-Term CO_2 Flux Observation Project).*

S11

THE CARBON DYNAMICS OF TROPICAL RAIN FORESTS: LESSONS FROM FLUX STUDIES AND BIOMETRIC MEASUREMENTS IN AMAZONIA

Y. Malhi
Oxford University Centre for the Environment

In this talk I review the progress that as been made in our understanding of the carbon and water dynamics of tropical rain forests, through the application of eddy covariance and biometric techniques in Amazonian forests.

Eddy covariance studies have been able to quantify the seasonal and interannual variability of carbon fluxes in Amazonian forests. They have demonstrated that rainforests can demonstrate seasonal variability, but the pattern of this variability can vary from site to site. In forests where the water supply can be maintained in the dry season, there is often an increase of carbon uptake in the dry season as photosynthesis increases but soil respiration declines. In forests where the dry season is more severe, carbon uptake declines in the dry season. Many rainforests demonstrate seasonal phenology, but there is increasing evidence that these seasonal shifts are not triggered directly by water supplies but by internal rhythms in the ecosystem.

The issue of determining the net carbon balance of tropical forests using flux techniques has proved more challenging. The problem centres around the accurate determination of night-time CO_2 fluxes. This problem is particularly acute in many tropical forest regions because (i) night-time wind speeds can be particularly low; (ii) the tall dense canopies discourage within-canopy turbulence; (iii) the photosynthetic and respiratory fluxes are so large that small errors in respiration can lead to large errors in the net carbon balance. At some sites the application of a friction velocity filter appears to remedy this issue; at other sites the friction velocity filter is not adequate.

Flux measurements are much more valuable when couples with biometric measurements, of woody growth, litterfall, root dynamics etc. They also help to place the study site in regional context. In Amazonia, the RAINFOR network of biometric measurements has demonstrated that (i) there is large regional variability in forest carbon dynamics that is not adequately captured by the flux tower network; (ii) the regional patterns seem more driven by soil properties than by climate; (iii) there appears to be a net increase of biomass in Amazonian forests over time; (iv) tropical forests may lose up to 70% of their acquired carbon through plant respiration. I explore the consequences of these findings for how tropical forests may be responding to global atmospheric change.

S12

LAND-ATMOSPHERE INTERACTION IN CLIMATE MODEL: INDOCHINA DEFORESTATION, GLACE, AND WHAT'S NEXT

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This presentation describes some previous studies on land-atmosphere interaction with the utilization of numerical climate models, and discusses on potential future studies that may be interesting. Firstly, a numerical simulation study on the impact of deforestation on precipitation-decrease over Thailand is introduced based on Kanae et al. (2001) in *J. Hydrometeorology*. Next, results of GLACE, a model inter-comparison study under GEWEX for land-atmosphere coupling, are briefly described. Finally, we will try to discuss on future issues.

The extent of deforested area in Thailand and Indochina is large, as you might already know, after the deforestation through past decades. The evaluation of the impact of deforestation on hydrology and climate is a topic of general concern in this region. On the other hand, although most of previous numerical simulation studies (mostly for Amazon) showed decreases in precipitation occur as a result of deforestation, they did not show observational evidence. Thus, both from the viewpoint of social concern and scientific concern, the impact of deforestation on precipitation-change was an important target. In our study, statistical analyses were applied to precipitation data through 1951-1994 for each month at each meteorological station in Thailand. Significant decreases in precipitation over Thailand were detected only in the time series of monthly precipitation in September. Then, numerical experiments with a regional climate model with a simple land surface scheme were carried out for the Indochina Peninsula. In these experiments, the type of vegetation in the northeastern part of Thailand was specified as either short vegetation (the current vegetation type) or forest (the former vegetation type). The experiments were carried out using the conditions of August and September. As a consequence of these numerical experiments, a decrease in precipitation over the deforested area was obtained for September, but not for August. The climatic mechanism was speculated as follows. Precipitation in the wet season over the Indochina Peninsula basically occurs under the influence of the Southeast Asian summer monsoon system. The strong summer monsoon westerlies bring abundant moisture to the Indochina Peninsula as a source of precipitation. The monsoon westerlies are the predominant external force influencing the regional climate. However, the strong westerlies over the Indochina Peninsula disappear in September, although it is typically the month of maximum precipitation. Accordingly, it is inferred that the impact of local deforestation appears significantly only in September because of the absence of this strong external force. A simulation study with stable isotope of water also showed a positive result (Yoshimura et al., 2004, *J. Meteor. Soc. Japan*).

Although both observational evidence and numerical simulation qualitatively showed the impact of land-surface change on precipitation for the case of Thailand, a better representation of the land-impact in climate model is preferable. So, we join GLACE. GLACE (Global Land-Atmosphere Coupling Experiment) is a multi-model inter-comparison experiment focusing on the ability of land surface state to affect rainfall generation and other atmospheric processes. The experiment aims to quantify the strength of land-atmosphere coupling in the different global atmospheric models used for weather and climate studies. The hope was that the development of a "table" of coupling strengths would aid in the interpretation of the many land-atmosphere interaction studies now appearing in the literature. The representative result already appeared on Koster et al. (2004) in *Science*. The main result showed that the land-atmosphere coupling is strong enough only over semi-arid regions of the world. Although the result of GLACE is excellent as a state-of-the art modeling study, the result is not so positive in order to quantify the impact of land-surface change/variability over Asia. In addition, the inter-model difference in the degree of land-atmosphere coupling indicates difficulty in quantifying the impact of land change by using a climate model.

Finally, based on the experiences above, we want to discuss future ways to go. In terms of land-surface modeling, the utilization of stable isotope is a big challenge. We want to introduce some recent results. More investigation on modeling of boundary layer should be a big challenge as well, but we are not familiar. From atmospheric modeling point of view, modeling with very fine resolution – cloud resolving model – should be a big challenge for land-atmosphere coupling studies.

S13

CO_2 AND WATER VAPOUR FLUXES MEASUREMENT OVER A STEEP SLOPE FOREST USING TWO FLUX TOWERS

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Institute of Natural Resources, National Dong Hwa University, Hualien, Taiwan

Fluxes of CO2, H2O, and sensible heat have been measured by eddy covariance technique at carefully selected sites with flat terrain, homogeneous surface. Fluxes measurement over patchy forest at steep slope poses difficult problems since it might violate some basic assumptions underly the theory of eddy covariance technique. Among these problems, the requirement of sufficient fetch is a primary limitation on the flux measurement in mountain area of Taiwan. The possibility of using two point measurements along the prevailing wind direction to represent the fluxes of a forest stand is tested at the Chilan flux tower site, Ilan, Taiwan. The experimental site is located at a 310 ha partially managed natural regenerated conifer forest (*Chamaecyparis obtusa* var. *formosana*) and the average tree height is about 9.8 m. The stand extends down slope of a relatively uniform mountain slope with a slope of 14° facing southeast direction. Pronounced diurnal mountain-valley wind pattern was observed year round. Accompany with the valley wind, uplifted moist air brings heavy fog at the study site. With steeper slope and heterogeneous forest canopy sounded the study stand, source areas of flux measurements sometimes fall outside of the closed and relatively uniform forest stand. Based on preliminary footprint analysis, two flux towers (23.4 m and 28.6 m tall, respectively) separated by a distance of 220 meters mere established. Open path CO_2/H_2O-analyzers (LI-COR 7500 and OP-2 ADC) and 3D sonic anemometers (Young 81000 and Gill R3) were mounted on top of both towers and signals were recorded with sampling rates ranged from 10 to 20 Hz. 30-minute averaged fluxes were then calculated.

Footprint analysis showed that the source areas of flux measured at the upper slope tower were well situated within the homogeneous stand when the upslope valley dominated. As the wind shifted from upslope wind to the downslope mountain wind, source areas also shifted direction but most of them fell outside of the homogeneous stand. With an additional tower located downslope, fluxes represented the forest stand can then be estimated confidently in terms of the fetch requirement. However, as the downslope mountain wind also bring in strong sinking advection air, turbulence is suppressed as indicated by the low friction velocity, u* and downward momentum fluxes, questions on the eddy flux estimation remained unsolved especially during the nighttimes. In addition to the above-mentioned problems, Daily foggy hours estimated with a visibility meter ranges from 4.7 hours in summer to 11 hours in winter. Heavy fog occurrence at the study site causes instrument malfunction for both the open path CO2/H2O-analyzer and the sonic anemometers and thus introduces many data gaps in our fluxes estimation. However, as the cloud mountain forest consists of a large portion of forest in Taiwan, flux measurement at such a non-ideal hilly site is important and poses a challenge task for forest micrometeorological research in Taiwan.

S14

MEASUREMENTS OF CO_2 FLUXES IN A TROPICAL CITY (SINGAPORE)

C. Jansson and M. Roth
National University of Singapore, Singapore

Although small in terms of land area, the urban environment is estimated to be the source from which up to 85 % of the anthropogenic emission of CO_2 originates. Urban areas are therefore significant sources for CO_2 and the influence of these emissions reaches hundreds, and for large cities even thousands of kilometers downstream the border of the source itself. However, direct measurements of urban CO_2 budges are not that extensive and have mainly been conducted in mid-latitude cities. To the authors knowledge only one such study has been reported from a tropical city (Mexico). Hence, in the context of urban development in the tropics being among the fastest growing in world, there is an increasing interest to investigate the CO_2 budgets for these environments.

Here we will present results from ongoing research in Singapore which aims to quantify urban CO_2 concentrations and fluxes as well as the urban energy balance in a long-term perspective (at least one year). The measurement site is located east of central Singapore in a residential area characterized by 10 m high buildings (Fig 1). The measurement equipment consists of a CSAT3 sonic anemometer, a Licor 7500 open path vapor and CO_2 analyzer and a CNR1 radiation sensor. The sensors have been mounted onto a tower (Fig 2) and the data are sampled at 10Hz. For the flux measurements to represent the area average characteristics of its heterogeneous surroundings the equipment has to be sited at such height that the contributions from the individual surface patches cannot be distinguished. As a rule-of-thumb this height starts at about two times the mean building height. The sensors have therefore been mounted at 20 m which should be above this co-called blending height.

The presentation will give a preliminary estimate of this city as a source (or sink) of CO_2 in general and examine the diurnal and seasonal flux patterns. In addition we will try to associate CO_2 flux variations to various emission sources, in particular those from transport.

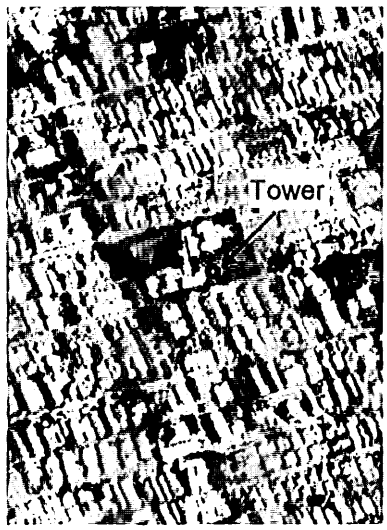

Fig 1. Aerial photo of tower surroundings

Fig 2. Measurement tower

S15

TOWARD FOUR DECADES OF FLUX OBSERVATION IN THAILAND

N. Tangtham
Faculty of Forestry, Kasetsart University, Bangkok, Thailand

Starting in 1968, preliminary of energy flux observation to study evapotranspiration of Dry Evergreen forest at Sakaerat Experiment Station (SER) in Nakorn Ratchasima province, Northeast Thailand was initiated and inconsistently observed for gases and energy fluxes until the present. Almost 20 years later, the aforementioned fluxes observation have been investigated at the Mae Klong Watershed Research Station in Mixed Deciduous forest (in 1996), and at Kog-Ma Watershed Experiment Station, Chaing Mai province in Hill Evergreen forest (in 1997- to present). Besides these 3 observation stations, energy flux has been observed in teak Plantation in Lampang province, rain-fed paddy field in Sukhothai province and cassava field in Nakorn Ratchasima under cooperatively work of TUAT and KUFF. Recently, the energy and carbon fluxes have been comparatively studied in the rubber plantation in Chachoengsao province by KU, UMR Ecologies Microbience des Sols (CNRS-University Lyon) and Department of Agriculture and Cooperatives. The soil CO_2 emission in different forest and agricultural soils and CH_4 flux from rice field have also been investigated continuously during the past decade by KMUT.

In the coming year, ThaiFlux in forms of research, development and technology transfer would be established and more publication could be contributed to those who are interested and all stakeholders related to this field.

S16

THE POTENCY OF INDONESIAN BIOSPHERE RESERVES IN ABSORBING CO_2

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Indonesia has six biosphere reserves (BR), they are: **Gunung Leuser** (in Sumatera with core zone 792,675 ha, 0-3466 m.a.s.l., major ecosystem tropical rainforest)), **Siberut Island** (in Sumatera with core zone 46,533 ha, 0-384 m.a.s.l., major ecosystem lowland dipterocarp rain forest), **Cibodas** (in Jawa with core zone 15,196 ha, 700-3015 m.a.s.l., major ecosystem mountainous rain forests); **Tanjung Puting** (in Kalimantan with core zone 415,040 ha, 0-10 m.a.s.l., major ecosystem tropical humid forest), **Lore Lindu** (in Sulawesi with core zone 217,982 ha, 200-2,610, major ecosystem montane forest;) and Komodo Island (in Flores with core zone 31,258 ha, 0-735 m.a.s.l., major ecosystem mangrove and lowland forest. Each biosphere reserve is designed to fulfill three functions: Conservation, Sustainable development, and logistic (to provide support for research, monitoring, education, and information exchange related to local, regional, national and global issues of conservation and sustainable development).

Besides the above functions there is a growing needs for the 'global wellbeing' in keeping the core area of the biosphere reserves as an important stock and sink of carbon. Therefore, we need estimation of how much carbon absorbed and stays in these forests and how to easily monitoring it.

NPP (Net Primary Production) is one of the most important variable characterizing the performance of an ecosystem. It is the difference between the total carbon uptake from the air through photosynthesis (Gross photosynthesis, GPP) and the carbon loss due to respiration (growth and maintenance) by living plants. By combining remote sensing and GIS technology with simple modeling, we can estimate GPP and NPP of a large ecosystem easier.

This paper presents the estimation of CO_2 absorption by six biosphere reserves in Indonesia through the estimation of NPP values using radiation use efficiency and estimated absorbed PAR (Photosynthetically Active Radiation). Absorbed PAR is derived from LANDSAT TM imagery. It is found that these areas are quite a significant carbon sink.

Keywords: Carbon absorption, Biosphere Reserves, Indonesia

S17

CARBON DIOXIDE EXCHANGE AT DOUBLE CROPPING RICE PADDY FIELD IN BANGLADESH

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Rice is a major crop in Bangladesh. It is practiced at least twice in the same land in a year (rice-fallow-rice pattern) and hence, it is thought that rice field plays an important role in annual carbon budget in agricultural ecosystem in Bangladesh. We have been conducting a long-term observation of carbon dioxide (CO_2) flux using the eddy covariance technique since February 2006 in Bangladesh low land rice-fallow-rice ecosystem to investigate seasonal variation of net ecosystem CO_2 exchange (NEE) between rice paddy and the atmosphere and to estimate annual carbon budget of the ecosystem. Some other related parameters were also observed. The observation site was located in the extensive farmland (24.75°N, 90.5°E, 18 m above sea level) of Bangladesh Agricultural University. A part of the farmland is occasionally used for green manuring crop in summer season. The mean annual rainfall is 2,175 mm, with 70% falling from May to August. A sonic anemometer (HS, Gill) and an open-path infrared gas analyzer (LI-7500, LI-COR) have been installed at the top of a 3-m high observation mast. Output signals from the eddy covariance sensors were sampled at 10 Hz using a data logger (CR1000, Campbell) and recorded. Half-hourly variances and covariances were calculated on line to detect instrumental failure as early as possible. The 10 Hz data were post-processed to calculate half-hourly fluxes of momentum, sensible heat, latent heat and CO_2, and also used for quality control tests. The storage term in NEE was estimated from the mean CO_2 density measured at the flux measurement height. Missing half-hourly fluxes caused by failure in power supply or those rejected by the quality control tests were filled with fluxes estimated by a parametric method (non-linear regression) from air temperature and incident photosynthetically active radiation flux density.

During the dry season of 2006 (from DOY 30 to 140), daily NEE showed a seasonal variation with a maximum net uptake rate of 9 g C m^{-2} d^{-1} at the maximum growth stage of rice (60 days after transplanting with a LAI of about 5), while the net uptake was small in early and late growth stage due to decreased photosynthetic fixation. The rice field turned a net source of CO_2 for several days immediately after the harvesting, but afterwards, it acted again as a net sink of CO_2 due to new plant sprouting (ratoon/re-growth) from the base of harvested plants and with appearance of different kinds of weedy plant. The ratio of gross primary production (GPP) to ecosystem respiration (RE) was 1.8 for the rice growing period (from DOY 34 to 140) and 1.1 for the former half of the fallow period (from DOY 141 to 185). Continuously watered conditions after the harvest with only a few drained days (from DOY 203 to 205 and DOY 212 to DOY 218) resulted in reduced soil respiration under high temperature conditions, and thereby affecting NEE in the fallow period. The observed CO_2 exchange in the fallow period differs from results in previous studies that were conducted in single cropping rice paddy fields in north-east Asia, where fields are drained during the fallow period. The difference in field management and resultant difference in CO_2 exchange in the fallow period as well as difference in cropping pattern have probable influence on the annual carbon exchange in paddy ecosystem.

S18

IN PURSUIT TOWARDS ESTABLISHING A CO_2 FLUX MONITORING STATION IN THE PHILIPPINES

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The Kyoto Protocol in the Philippines was enforced in February 2005. With it came an urgent need to evaluate the carbon sequestration in forest ecosystems. In view of the participation of the Philippine Government to this international agreement, there is a need to assess the gas exchange capacity of its major forests. Especially, since that the Philippines is an archipelagic country (*surrounded by Pacific Ocean on the east, the South China Sea on the west and north, and the Celebes Sea on the south*) with a tropical climate; is likely to be highly vulnerable to long-term climate change.

But unlike most of the countries worldwide, the Philippines is still behind in terms of CO_2 flux measurement efforts. It is sad to note that until now, the Philippines is still using the conventional way of measuring CO_2 done at the expense of cutting down trees by way of destructive sampling.

It is on this premise that we would like to embark on establishing our own flux tower station. This will be situated at the Mt. Makiling Forest Reserve in Los Baños, Laguna managed by the University of the Philippines at Los Baños.. It is a 4,244-hectare natural and secondary forest vegetated with mostly dipterocarp species. It has a rugged topography, reach up to 1,100 m asl. It has two pronounced season: wet and dry. The average annual rainfall is 2,397mm and mean annual temperature ranges from 25.5°C to 27.5°C. Ecologically, it is an important watershed area, a wildlife sanctuary, a genepool for genetic diversity, a recreational site and an educational and scientific laboratory for instruction and research. The Philippines is often struck by typhoon, and Mt. Makiling sits across the typhoon belt making it a very challenging task for the researchers to tackle. Not to mention the frequent occurrence of El Niño phenomenon that adds pressure to this forest. The influences of these disturbances on the carbon cycle can be of interest to research.

Nevertheless, with this proposed tower, we will try to monitor long-term CO_2 and energy balance (flux) between forest ecosystems and the atmosphere in order to determine whether the country is a major 'source' or 'sink' of carbon; investigate the biological responses of vegetation to the changing climatic condition; examine the effects of extreme cases like typhoon and ENSO event to the seasonal and diurnal fluxes; investigate the functions of soil ecosystems; and examine the influence of anthropogenic disturbances to the amount of emissions in a given ecosystem. The database that we will get from the flux tower can be used as baseline information to validate other researches in climate change (e.g. modeling, etc.)

But due to economic crisis, financially, we are seeking funding institutions to help us build the tower. With that, we would like to collaborate highly developed countries like Japan through the support of Asiaflux Network.

There are so many factors that ensure the success of this endeavor. Given all the endless possibilities of the uses of this flux tower...with the Philippine government to joining hands with other countries in combating global climate change...; with the people having the will to keep up-to-date with the latest technologies in atmospheric gas monitoring...; the presence of a trained researcher on CO_2 flux measurements; and the strong support from experienced local and foreign collaborators..., we are positive it will not take long before, we will be installing the most-awaited state-of-the-art CO_2 flux tower in the Pearl of the Orient Seas – the Philippines.

O21

NOCTURAL CARBON EFFLUX: RECONCILIATION OF EDDY COVARIANCE AND CHAMBER MEASUREMENTS USING AN ALTERNATIVE TO THE U*-THRESHOLD FILTERING TECHNIQUE

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Eddy covariance measurements often underestimate net ecosystem CO_2 exchange under stable atmospheric conditions at night when compared to biological measurements of plant and soil respiration. One hypothesis is that errors arise because eddy covariance instruments placed above the canopy cannot measure the horizontal flux divergences associated with lateral drainage of stably stratified air in the layer below the instruments. Measuring horizontal flux divergences is difficult because the flow of stably stratified air close to the ground is determined by the topography and the degree of stability, and measurements must thus be made in three dimensions. We present details of a novel mass-balance approach to measure the mass balance of a 50 x 50 x 6 m control volume installed in a tall *Eucalyptus* forest in south east Australia. Net fluxes of carbon dioxide from the soil and vegetation are estimated from the vector sums of fluxes through the side walls and upper surface of the control volume. The novelty of the measurement system arises from the use of windspeed-weighted sampling of air from six air lines per side wall combined with eddy flux instrumentation at 6 m.

The mass balance for a square with sides of length L and area $A = L^2$ is:

$$\begin{aligned}\overline{F_0} = {} & \frac{1}{hL^2}\int_0^L\int_0^L\int_0^h \overline{c_d}\,\overline{\frac{\partial \chi_c}{\partial t}}\,dxdydz \\ & + \frac{1}{L^2}\int_0^L\int_0^L\int_0^h \left[\overline{uc_d}\,\overline{\frac{\partial \chi_c}{\partial x}} + \overline{vc_d}\,\overline{\frac{\partial \chi_c}{\partial y}} + \overline{wc_d}\,\overline{\frac{\partial \chi_c}{\partial z}}\right] dxdydz\,, \qquad (1) \\ & + \frac{1}{L^2}\int_0^L\int_0^L\int_0^h \left[\frac{\partial \overline{c_d}\,\overline{u'\chi_c'}}{\partial x} + \frac{\partial \overline{c_d}\,\overline{v'\chi_c'}}{\partial y} + \frac{\partial \overline{c_d}\,\overline{w'\chi_c'}}{\partial z}\right] dxdydz\end{aligned}$$

where u, v, w are the wind vector components in the orthogonal x, y, z directions, t is time, c_d is the concentration of dry air, χ_c is the mixing ratio of the trace gas relative to dry air, and the overbar represents a time-average. Standard Reynold's notation is used to express the instantaneous value of a quantity as the sum of the mean and fluctuations about the mean. The term $\overline{F_0}$ represents the time and space average flux density of the trace gas at the lower boundary of the control volume. If we assume that the profiles of u and v have a constant shape and that the wind direction is constant across the control volume during a given averaging period, then the windspeed at any height can be written as

$$u(z) = u_h S(z),\; v(z) = v_h S(z)\,, \qquad (2)$$

With the further assumption that terms such as $\overline{uc_d}$ can be approximated by $\overline{u}\,\overline{c_d}$, Equation (1) can be written as

$$\begin{aligned}\overline{F_0} = &\frac{\overline{c_d}}{\Delta t}\left[\int_0^h \chi_c dz\Big|_{t=\Delta t} - \int_0^h \chi_c dz\Big|_{t=0}\right] \\ &+\frac{\overline{c_d}\,\overline{u_h}}{L}\left[\int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{x=L} - \int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{x=0}\right] \\ &+\frac{\overline{c_d}\,\overline{v_h}}{L}\left[\int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{y=L} - \int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{y=0}\right] \\ &+\overline{c_d}\left[\overline{w'\chi_c'} + \int_0^h\left(\overline{w}\frac{\partial\overline{\chi_c}}{\partial z}\right)dz\right]\end{aligned} \tag{3}$$

Note that $S(z)$ can be considered a weighting factor for the concentration at each height. The paper discusses in detail how the shape factor is used to calculate the vertical velocity and advection terms paper using the continuity equation for total mass flow for the control volume. Details of a practical implementation of Equation (3) scheme will be presented, along with results of a two-week field campaign in March 2005 which compares the mass-balance measurements for CO_2 with independent estimates of respiration from the soil and understorey. The relative importance of the eddy flux, change in storage, horizontal advection and vertical advection terms in the mass balance equation will be shown.

O22

FLUX-TRANSPORTING EDDIES REVEALED BY LARGE EDDY SIMULATIONS

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Most of tower flux measurements are made essentially in the roughness sublayer, which is strongly affected by coherent large-scale eddies developed near the top of plant canopy. The existence of coherent eddies causes some practical difficulties in measuring or modeling fluxes transported to/from canopies. The Monin-Obukhov similarity (MOS) does not predict the enhancement of turbulent transfer across the roughness sublayer, which leads to underestimation of fluxes when they are measured or modeled using the flux-profile relationship. Nevertheless, because of their spatial scale much larger than the canopy depth, the presence of coherent eddies more or less ensures the similarity between scalar quantities irrespective of difference in source/sink distributions. We can expect well-behaved similarity between scalar quantities when the above-mentioned coherent eddies are the dominant agent in the flux transportation. In such situations, we can use the Bowen-ratio method for measuring the heat and water vapor fluxes, while the profile shape itself is different from the MOS prediction.

The eddy covariance method is a technique to count all contributions of individual coherent-eddies that passed through a flux tower. Indeed, the signature of their passage can be recognized as the so-called "ramp patterns" in measured time traces of scalar densities. By taking averages over a long period of time, we can obtain in principle a reasonable estimate of the actual flux by this method. In reality, however, we have been facing problems of the lack of energy balance closure and the dissimilarity between temperature and water vapor fluctuations especially in low-frequency components. From the above discussions, it is clear that these problems do not arise when the coherent eddies are dominant in the turbulence spectrum. Since these problems were observed even at the most homogeneous sites, advection due to the surface heterogeneity is not the only reason. There must be a common mechanism that causes additional flux or fluctuations, independent of the surface condition.

In this study, several runs of small-scale and large-scale large eddy simulations (LES) were conducted. The small-scale LES was used to investigate the 3D structure of coherent eddies in the roughness sublayer over a homogeneous plant canopy. The revealed structure was a combination of streamwise elongated regions of high-speed and low-speed streamwise velocities, co-located with a downdraft and an updraft, respectively. The length scale of each elongated region was on average 3 to 4 times the canopy height. These properties are consistent with previous field observations showing that the sweep and ejection motions are dominant in the flux transportation across the canopy-top and that the peak wavelength of the streamwise-velocity spectrum is about 7 times the canopy height. Since this type of eddies are normally the most dominant carrier and are sampled quite well during the averaging period of eddy-covariance measurements, a large part of the actual fluxes can be captured. A problem, however, may arise if long-term (large-scale) transportation mechanisms exit in the background of these active eddies.

The large-scale LES was then applied to model the turbulent transfer in the entire boundary layer under the convective conditions, when most of the problematic cases have been observed. Simulated scalar transport in this spatial scale was not similar. The spatial perturbation of temperature (active scalar) was well correlated with the vertical motions and organized in the form of convection cells. However, the correlation between water vapor (passive scalar) and the vertical velocity was less obvious near the surface, and the spatial scale of water vapor perturbations was much larger than temperature. These differences are caused by different contributions of the entrainment to the vertical transfer of each scalar quantity. The entrained dry air, which are transferred downward by large-scale eddies, contaminates the spatial distribution of water vapor near the surface, thereby producing large-scale perturbations. Using these simulation results, some discussions will be presented with respect to possible explanations of the non-closed energy balance and the dissimilarity between temperature and water vapor fluctuations.

O23

APPORTIONMENT OF OBSERVED HEAT FLUXES TO HETEROGENEOUS SURFACES

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Heat flux data collected from the Baiyangdian (38°55'N, 115°58'E) field experiment were analyzed using footprint analyses. As a sensitive site in response to climate and environmental changes, Baiyangdian, the largest lake/wetland in Northern China Plain, is suffering from degradation or drying out in recent decades. Heat, vapor and energy fluxes and their balance in this area are of special concern, as well the CO2 flux in the related bio-system. However, difficulties exist in observation of turbulent fluxes over such a location characterized by highly heterogeneous landscape. Footprint method is used for interpretation of the observed results.

Data from two observation sites in September, 2005 were used. One site (Wangjiazhai) located in the central area of the Baiyangdian lake/wetland, was surrounded with highly heterogeneous surfaces. Another site (Xiongxian) is on land as a reference, with more uniform land cover. High resolution (25m) Landsat5 satellite imaginery was used to determine land cover in this area and four types of surfaces, i.e., farmland, water, wetland and village are assigned to each mesh of the model domain. An improved Eulerian analytical flux footprint model is applied to analyze the 'source area' of heat fluxes during this experiment and to select the turbulent flux data from the raw collection, i.e. a mixed landscape composed information from different surface types. Results show that, in general, the wetland and water surface contribute most to heat fluxes in Wangjiazhai site while the farm field contributes most to the Xiongxian site. Using the footprint distribution and the assessment of a major influence type for the observation data, heat fluxes were apportioned for water surface, wetland and farmland, respectively. Mean results show that heat fluxes of wetland and farmland are comparable. While heat flux from water surface is obviously lower during daytime (about 50 w m^{-2} and 100 w m^{-2} lower than their wetland or farmland counterparts, respectively for sensible and latent heat fluxes).

Keywords: flux footprint, Eulerian analytical model, heat flux, heterogeneous surface

O24

.USING OPEN-PATH LASERS TO MEASURE AMMONIA EMISSIONS FROM SMALL FIELDS

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Ammonia (NH_3) is an indirect greenhouse gas. When emitted to the atmosphere, it affects the earth's radiation balance and the greenhouse effect through aerosol formation and cloud-forming processes. Agriculture is a strong source of atmospheric NH_3. The gas is generated from animal wastes and from the breakdown and volatilization of nitrogenous fertilizers and organic manures. NH_3 emissions are often responsible for low efficiencies of N fertilizers in agriculture. However, quantifying emissions is difficult. Not only is there a sampling problem because NH_3 is a sticky gas, but also, most of the standard techniques for measuring atmospheric NH_3 concentrations are indirect (involving wet chemistry), labour intensive and often require mains power. Recent years have seen the development of open-path sensors for measuring atmospheric NH_3 concentrations and new theoretical treatments of atmospheric dispersion, which, between them, make it possible to measure emissions of NH_3 from small, well-defined sources, such as a farmer's field. Here we describe the application of this technology to measuring emissions of NH_3 from a maize field after application of urea fertilizer. Line-averaged concentrations of NH_3 over paths of 50 to 100m were measured upwind and downwind of the field using an open-path laser mounted at 3.4m above the ground and the emission rate was calculated by application of a backward Lagrangian stochastic (bLs) dispersion model. Inputs to the model are the enrichment in NH_3 concentration as the wind blows over the field, the height and location of the measurement, the exact geometry of the field and its surface roughness, and atmospheric information including wind speed and direction, atmospheric stability and turbulence as measured by a 3 D sonic anemometer. The combination of open path laser and bLs model is sensitive enough to measure fluxes of less than 1 kg N ha^{-1} day^{-1}.

Fig.1. Half-hourly NH_3 emissions from a fertilized maize field at Yongji, Shanxi Province, China.

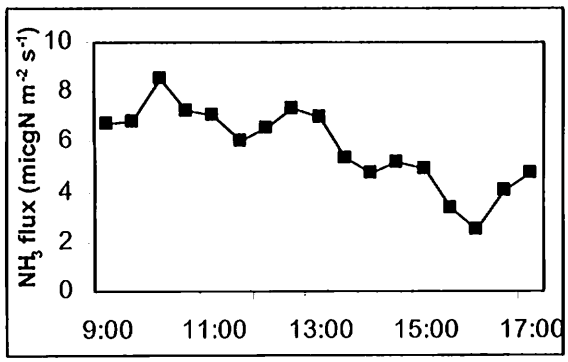

Fig.2 Aligning an NH_3 laser on its reflector. The unit is portable, battery powered, and provides continuous, instantaneous measurements. The resolution is in the ppb range.

O25

EDDY COVARIANCE MEASUREMENTS OF ISOTOPIC CO2 FLUXES WITH TUNABLE DIODE LASER SPECTROSCOPY

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Surface fluxes of CO2, 13CO2, and C18OO were measured over soybean (*Glycine mays*) for several weeks during the summer of 2006 using the eddy covariance (EC) technique. The analyzer (Model TGA100A, Campbell Scientific, Inc) uses a tunable diode laser (TDL) capable of scanning adjacent absorption lines of the three isotopomers, in the mid-infrared spectrum (~ 2300 cm^{-1}). The analyzer can be deployed in the field but requires frequent measurement of calibration gases to achieve high accuracy in the isotopic ratios. A specialized sampling system is required to obtain proper eddy covariance sampling and accurate automated measurements of the calibration gases, while minimizing the consumption of the gases. During the field study, 34 seconds out of every five minutes were used to measure three calibration gases with accurately known isotopic composition, and fluxes are computed over a 30-minute averaging period. The discussion includes description of the TDL analyzer and EC/calibration sampling system, the effects of the periodic calibration on the 30-minute flux estimate (disjoint EC), flux processing methodology, noise analysis of the measured isotopic ratios, measured fluxes and isotopic flux ratios.

026

OBSERVATION AND SIMULATION OF NET ECOSYSTEM CARBON EXCHANGE IN CHINA

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Terrestrial ecosystems play a critical role in modulating the global carbon cycle. Human activities are disrupting terrestrial ecosystems that directly affect ecosystem function. Previous studies have suggested that tropical Asia is an important source of carbon to the atmosphere, ranging from 25% to 31% of the global carbon emissions released from land since the middle of the eighteenth century. Recent estimates have indicated that tropical deforestation in South and Southeast Asia released from one third since the 1980s to more than half of the total carbon lost derived from land-use changes across the globe. However, more recent analyses based on atmospheric transport models and CO_2 observations suggested that the northern portion of monsoon Asia has acted as a carbon sink. The uncertainty in the magnitude of the carbon source or sink strength in monsoon Asia is clearly a key to balancing the global carbon budget. To reduce the uncertainty of the carbon budget in monsoon Asia and to improve our understanding of the carbon cycle at various spatial and temporal scales, the integration of multiple, complementary and independent methods used by the different research communities should be required.

This report will present the main research results related to terrestrial ecosystem carbon budget and trend in China during recent years from the following aspects: (1) Terrestrial ecosystem carbon databases, including long-term ecosystem research observation data, IGBP-terrestrial transect research data of International Geosphere - Biosphere Program (IGBP), long-term national forest inventory data (FID) and carbon flux data from eddy covariance (EC) towers. (2) Carbon budget simulation models of terrestrial ecosystems, including FID-based NPP model and process-based models. Here, we present a framework for the requisite next step in biosphere model development: a dynamic terrestrial ecosystem model coupled biological, physical and chemical processes. Especially, it includes the effects of soil carbon and nitrogen on leaf photosynthesis and an environment-based carbon allocation model. It consists of land surface processes, leaf nitrogen uptake, canopy physiology, carbon allocation, vegetation phenology, terrestrial carbon balance, and vegetation dynamics. It could simulate the dynamics of grassland ecosystem much better than IBIS model does, based on a 14-year observation of aboveground net primary productivity and 2-year flux observation by eddy covariance tower in typical steppe ecosystem in Inner Mongolia. (3) Carbon budget evaluation and prediction of Chinese terrestrial ecosystems in terms of carbon flux observation, FID data and process-based models from typical terrestrial ecosystems, vegetation types and regional level. The uncertainty of evaluating terrestrial ecosystem carbon budget and trend in China was discussed from the carbon flux observation network, long-term terrestrial ecosystem monitoring as well as model development, and some key scientific tasks related to carbon budget evaluation were suggested.

Key words: Carbon budget, Eddy flux, NECT, Transect Approach, NEE, Model

O27

COMPARISON OF ECOPHYSIOLOGICAL TECHNIQUE WITH EDDY COVARIANCE METHOD AND BIOMETRIC APPROACH FOR ESTIMATING CARBON BALANCE OF FOREST ECOSYSTEMS

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In terrestrial ecosystems, plants are the interfaces between soil and atmosphere and as well as transducers that provide the energy for microbial metabolism through the turnover of foliages and roots. On the other hand, soil CO_2 efflux is a combination of plant and microbial processes that respond to climatic drivers at a variety of temporal and spatial scales. Therefore, deconvolving the CO_2 flux signal into several components over similar time scales may help us critical understand the controls on ecosystem carbon balance, and it is one of the major goals of the AsiaFlux network. We used automated chamber systems to continuous partitioning the net ecosystem production (NEP) among gross primary production (GPP), autotrophic respiration (foliage respiration, aboveground woody tissue respiration, and root respiration), and heterotrophic respiration at three representative tower sites – Tomakomai, Teshio and Pasoh – within the AsiaFlux. The methodology and progress will be presented. At both Tomakomai (50-year-old larch forest) and Teshio (clear-cut and reforested) sites, NEP integrated by the chamber technique matched the result observed via eddy covariance method (EC). At Tomakomai site, interannual variability in NEP was closely linked with interannual change in heterotrophic respiration, whereas at Teshio site, interannual NEP was strongly driven by the combination between regeneration of vegetation (increasing in photosynthesis) and interannual soil CO_2 efflux. At Pasoh (tropical primary rainforest) site, EC obviously overestimated NEP, probably due to EC significant underestimated ecosystem respiration (Re) under poor mixing conditions such as the calm nights. However, the corrected NEP (synthesized Re with the chamber technique) consisted with NEP that estimated by the biometric approach.

O28

THE CORRECTED METHOD OF FLUX USING GYRO AT NON-STATIC PLATFORM

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There are lots of factors needed to be overcome when measuring "accurate" flux at sea, including wave stress reduced by sea-spray, flow distortion cause of the movable ship, and other marine environmental factors.

This study is trying to simulate mobile platform at sea which using Gyro that could measure angle vectors (pitch, roll, yaw) along three axis and installed two eddy covariance systems on experimental farm for soybean in Wu-Feng Agricultural Institute, in Central Taiwan (24° 01′ N, 120° 41′ E) as Fig 1. There are three different experimental designs to measure covariance flux of atmosphere (still *vs* shaking_still, still *vs* shaking_5rpm and still *vs* 10 rpm) between 27 December 2005 and 17 January 2006, between 18 January and 20 January 2006 and between 20 January and 24 January 2006. The mechanical shaking equipment simulates mobile platform shows as Fig 2. Furthermore, we use statistics methods of OLS, average of difference and standard deviation to compare three different correction methods of two-axis rotation correction, three-axis rotation correction and sea correction method which published by Edson (1998). The results showing that the sea correction method is the most appropriate method, secondly is two-axis rotation correction. Although three-axis rotation correction is relatively unsatisfactory, it is still better than uncorrected data. Therefore, the raw data is needed to be corrected certainly.

KeywordsGyro, eddy covariance system, coordinate rotation, mobile platform, flux correction

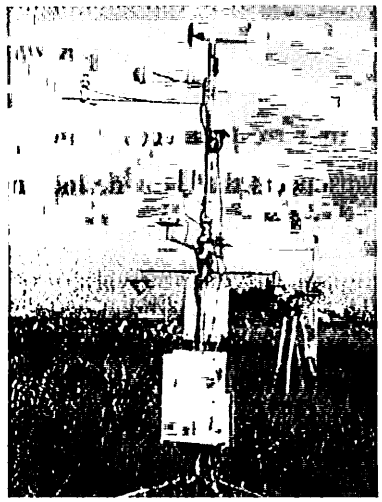

Fig 1. Two eddy covariance systems set on experimental farm.

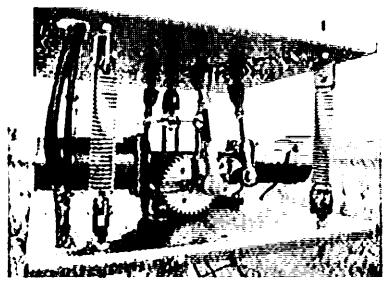

Fig 2. Mechanical shaking equipment simulates mobile platform.

O29

INTRODUCTION TO ASIAFLUX DATABASE

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AsiaFlux now stands in the entrance to the next research phase of integrative and/or inter-comparative studies. Compared with CARBOEUROPE/AmeriFlux, AsiaFlux activities are performed under diverse countries, languages and cultures. AsiaFlux will try to combine data from such activities. In this report, we introduce AsiaFlux Data Base (AsiaFlux DB), which is now constructed. Coordinated database system is sure to facilitate the multidirectional studies in flux researching communities. Development of an easy-to-use open database system, "AsiaFlux Database", is one of the key activities of AsiaFlux. An effective use of the AsiaFlux database will provide a number of benefits including:

- Distinguishing (extract) essential characteristics of material exchanges between individual sites (ecosystems) and atmosphere,
- Advances in understanding of material circulation in Asian region,
- Contribution to Asian environmental management strategy by extending cooperation with the modeling and remote sensing communities, and
- Efficient upgrading of observation techniques and analysis processes.

All data sets to be registered in AsiaFlux DB will be provided by Principal Investigators (PIs) at observation sites in AsiaFlux network. Each data should be acquired and analyzed by PIs, and contents in the data set are copyrighted to the individual PIs unless stated otherwise.

All data sets are to be downloaded by anyone at will as long as they agree and abide by AsiaFlux DB Fair-Use Policy and register as AsiaFlux DB user. We hope this DB will greatly influence this study field and encourage further education for young researchers.

We consider that the most important thing is data provider's copyright. In order to protect it and avoid their concern, we have compiled the rules for DB as fair-use policy as follows.

1) Any distribution of downloaded data to the third person for any use whatsoever is strictly prohibited.
2) If you wish to distribute the downloaded data to the third person, after post-processing and reanalyzing, you must inform the data provider and obtain his/her/their approval.
3) If your research directly conflicts to data provider's analysis, you must give clear priorities to the data provider. He/She/They may ask you to postpone the usage of the data.
4) For any publication using data from AisaFlux DB, the data provider must be informed and his/her/their approval obtained prior to publishing. The data provider may request co-authorship. A proper acknowledgement to the data provider and AsiaFlux is required.
5) All data users are required to provide reprints of paper/article using data from AisaFlux DB to data provider and AsiaFlux immediately after the publication.

The data user is required to register using Registration Form to obtain user ID and password, before any data can be downloaded.

We would like data provider to prepare document files about their data on specified format. Document files describe site information, instrument for flux/meteorological measurement, calculation method and revision number. We realized that flux data are sometimes recalculated, so we can confirm it from the document. The document files should ensure the data traceability. Document files are packed with data files.

AsiaFlux committee members wish "AsiaFlux database" becomes the entrance for new studies and produces new encounters.

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O31

EFFECT OF ORGANIC MATTER VARIATION ON DECOMPOSITION PROCESS IN FOREST ECOSYSTEM -EVALUATION USING MODIFIED ROTH-C MODEL-

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The structure and function of carbon budget in soil should be understood for the estimation of long-term forest carbon sequestration. Annual carbon accumulation in soil is considerably small, so it is much difficult to measure the accumulation rate directly and estimate as a difference between organic matter input and decomposition carbon loss. Soil organic matter (SOM) turn over models are effective at simulating temporal changes in SOM. These models have conceptual organic matter pools and can calculate flows and storages of carbon as a function of environmental factors and decay rate of each component. Numerous SOM turnover models have been developed for grassland and crop fields (e.g. Parton et al. 1987; Jenkinson, 1996). Forest litter is characterized as a great amount of wood litter, such as branch, stem, and root litter. So to evaluate carbon budget in forest soil, the model should contain their mortality and decomposition processes. Decomposition rate of wood litter is slower than that of leaf litter. Wood decomposition process is affected by chemical and physical characteristics of wood material (Harmon et al. 1986). Our objective of this study is to modify a SOM turnover model to give a better fit to carbon budget in forest soil. Primarily, we check existing and new setting parameters for leaf and wood decomposition in the model.

Materials and methods

We modified a SOM turnover model of Rothamsted Carbon Model (RothC, Coleman and Jenkinson, 1996). Roth-C model is a model of the turnover of organic carbon in non-waterlogged soils that allow for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It needs few inputs and those it needs are easily obtainable. Soil organic matter is split into four active compartments and a small amount of inert organic matter. Incoming plant carbon is split between decomposable plant material (DPM) and resistant plant material (RPM) depending on the DPM/RPM ratio of incoming plant material. Shirato and Yokozawa (2006) indicated that the ratio can be obtained from an experimental measurement and reported the ratio of both leaf and wood litter. Thus, we checked primarily the validity of the ratio of wood litter. Moreover, we examined the effect of wood size that is one of the important factors affecting wood decomposition rate (e.g. Harmon et al. 1986) on wood decomposition process in the model. Investigation of model parameters was conducted by comparing between model outputs and measurement values of decay rate and CO_2 efflux of leaf and wood litter.

Results and Discussion

The DPM/RPM ratio of leaf litter is provided 0.2 for tree leaf litter in the Roth-C model. Shirato and Yokozawa (2006) reported that this value was consistent to the value obtained from experimental measurement. In our site, leaf litter decay rate simulated by the model is almost consistent to the observed value. On the other hand, DPM/RPM ratio of woody material (0.13 provided by Shirato and Yokozawa, 2006) gives a faster decay rate than the observed. Therefore, incorporation of wood decomposition process into the model needs other parameters that express the physical and chemical properties of wood materials.

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O32

CARBON ACCUMULATIONS IN FOREST SOILS OF NORTHERN THAILAND AS CARBON POOLS IN THE GLOBAL ECOSYSTEMS

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Fifty-one soil pits sampled from different locations in various forest types and subtypes of northern Thailand are interpreted, synthesized and reviewed to explain about organic carbon accumulations as a carbon pool in the forest ecosystem. The forests include 5 types (1) dry dipterocarp forest (DDF), (2) mixed deciduous forest (MDF), (3) dry evergreen forest (DEF) (4) pine forest of two subtypes, pine-dry dipterocarp forest (P-DDF) and pine-lower montane forest (P-LMF), and (5) montane forest (MF) consisted of 3 subtypes; lower montane forest (LMF), middle montane forest (MMF), and upper montane forest (UMF).

Soil types in these forests are classified into 4 Orders; Entisols, Inceptisols, Ultisols and Alfisols. The Entisols represent very shallow rocky soil profiles, less than 50 cm. Order Inceptisols are developing soil profiles deeper than that of Entisols (50-100 cm), and have poor clay accumulation in subsoils. The Ultisols are well developed soils, depth of 100 cm or more, high clay accumulation in subsoils, and base saturation <35%. The Alfisols are similar to Ultisols that contain high clay contents in the profiles. These soils usually develop on limestone area with the depth of 100 cm or more, base saturation > 35%.

Soils under DDF vary from Entisols to Inceptisols and Ultisols (Suborder Ustults). Carbon storages in one-meter depth are normally varied between 12.11-93.66 t/ha. It is exceptional for a high carbon amount as 106.68 t/ha for soil in limestone area. MDF soils are usually Inceptisols and Ultisols (Suborder Ustults), and contain 94.8-197.29 t/ha of carbon. The DEF are Inceptisols or Ultisols (Suborder Humults), with carbon of 56.51-93.41 t/ha. Most soils under montane forest are Ultisols (Suborder Humults). The LMF soils are Ultisols with carbon storages of 96.72-201.66 t/ha. The MMF soils are Order Ultisolss, 173.12 t/ha of carbon. The UMF soils are Order Inceptisols or Ultisols, and contain the higher carbon accumulation, 237.49-371.04 t/ha.

Differences in soil types, forest types and conditions, parent rocks, altitude, forest fire and topographic conditions are important factors affecting amounts of carbon accumulations in forest soils of northern Thailand.

033

EXPLORING THE VARIATION OF ABOVE-GROUND WOOD PRODUCTIVITY AND ROOT PRODUCTION ACROSS 50-HA PASOH FOREST PLOTS AND THEIR RELATIONSHIP TO SOIL DETERMINING FACTORS

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The net primary productivity (NPP) of an ecosystem is the net amount of carbon that is fixed from the atmosphere into new organic matter per unit time. Understanding the relative magnitude and spatial and temporal variation of these terms is a subject of considerable interest, for testing our understanding of the functioning of ecosystems, the role of the biosphere in global biogeochemical cycles, and the response of ecosystems to local and global perturbations. However, below or above-ground NPP are still poorly quantified and their relationship to environmental factors not well understood, particularly in tropical forests and savannas. This study attempts to assess some components of forest productivity by using the censuses or forest inventory of Pasoh Forest Reserve, Peninsular Malaysia and conduct measurement on litterfall and root production to acquire more comprehensive estimates of productivity and allocation. Here we define above-ground wood productivity as the rate of carbon fixed and produced in woody biomass such as coarse stems and branches. The magnitude and variation of coarse wood productivity can be directly determined from the long term forest census data, using the approach and corrections. The assessed spatial variation of above-ground productivity and root production will be explored over the forest plot. The study aims to evaluate the questions as follow:

1. Is there a significant relationship between productivity and soil properties with the 50 ha plot?
2. What are the main soils or landscape factors contributing to the productivity variations?
3. How do the patterns observed at Pasoh compare with the productivity-soil trends observed in the Neotropics? Do Palcotropical forests fall into the same explanatory framework, or are they fundamentally different?

O34

MOISTURE AND TEMPERATURE EFFECTS ON RESPIRATION OF AGRICULTURE AND FOREST SOILS IN THAILAND

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We investigated soil respiration both in the field and laboratory incubation to understand the relationship between soil respiration, and soil temperature and moisture in tropical upland soils. Diurnal variations of *in situ* CO_2 efflux was studied in May 2004 and February 2005 at an agricultural site (maize) and a dry evergreen forest. In the laboratory, we measured soil respiration in a short-term incubation under various moisture contents (air-dry, 25, 50, 75 and 100%WHC) and various constant temperatures (10°C to 45°C). The soil CO_2 flux showed significant diurnal changes and these patterns were highly correlated with both air and soil temperatures. CO_2 efflux from both study sites increased to the maximum values during the late afternoon, usually 2-4 hours after a peak in air temperature. The total soil CO_2 effluxes integrated over one day period were 1354 and 3082 mg CO_2 m^{-2} at agricultural site and 1467 and 12851 mg CO_2 m^{-2} at forest site in May 2004 and February 2005, respectively. The Q_{10} values for agricultural site estimated from relationship between soil temperature at 5 cm and CO_2 efflux was 3.37 (available only in May 2004). For forest site, the Q_{10} was 2.04 (available only in February 2005). Results from laboratory study indicate that the topsoil layer (the top 20 cm) contributed mainly to the overall respiration. Soil respiration was highest at moisture between 20% and 75% WHC. The Q_{10} values of agricultural soil were higher than of forest soil in laboratory incubation, confirming the field measurement results. Laboratory results also indicate that subsoil was more sensitive to temperature and moisture changes than topsoil.

O35

PARTITIONING OF WATER FLUX IN RUBBER PLANTATIONS: ESTIMATION OF TREE TRANSPIRATION BY SAP FLOW MEASUREMENT

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In Thailand, rubber is the major tree crop covering more than 2 millions hectares. Its impact on environment, and particularly water use, is a major issue. In order to assess water balance of tree plantations at plot scale, it is necessary to partition total water flux measured by eddy-covariance between soil and understorey evaporation (E), tree transpiration (T). Therefore, accurate dynamic measurement of tree transpiration is required.

Sapflow was measured in a 12 years old rubber plantation (RRIM 600) in eastern Thailand, by heat dissipation method (Granier 1985, 1987) using home-made 20 mm-long radial probes, continuously heated (0.2 W), and connected to a data logger. The calibration of the home-made probes was checked in the laboratory with reference to the gravimetric method.

We adjusted the experimental devices to rubber field conditions and evaluated the different sources of variability to design the appropriate monitoring process. Natural thermal gradient was not significant. Vertical variation along the trunk below canopy was low. Conversely a significant azimuthal variation was recorded, though without specific trend. Accordingly 2 probes (one on the North face, one on the South face), located above the tapping panel were used for monitoring.

Radial distribution of sapflow was recorded, using a long probe, and our results showed significant variations of sapflow along the radius. A function was derived from these radial variations to estimate total tree sapflow from measurements within the outer 2 cm of sapwood. Finally to evaluate stand transpiration (mm h^{-1}), trees were sampled according to trunk diameter. Transpiration data will be processed together with flux data obtained from eddy-covariance.

Keywords: Sapflow, transpiration, field monitoring.

036

STRAW MANAGEMENT AS KEY FACTOR FOR DETERMINING PRESENT AND FUTURE GREENHOUSE GAS EMISSIONS FROM RICE ECOSYSTEMS

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Wetland rice fields are a source of the greenhouse gas (GHG) CH_4 and – to a lesser extent – N_2O. CH_4 emissions are generally enhanced by organic inputs into the soil and thus, are correlated to straw recycling. The actual impact of straw amendments, however, depends on a variety of management factors. This study summarizes various field studies as well as incubation experiments conducted in the Philippines. The common practice of incorporating rice straw during field preparation resulted in seasonal averages of 30 to 250 mg CH_4 m^{-2} d^{-1}. Early residue incorporation (i.e. app. 30 d before field preparation) reduced emissions by 81 %, 18 % and 54 % in the different seasons studied. Emissions could also be reduced when the straw was either composted or mulched on the soil under zero-tillage.

However, GHG emissions triggered by straw in flooded soils have to be seen against GHG emissions from straw burning which is the prevailing practice in rice farming systems. Agricultural crop residue burning is increasingly posing local health hazards and adds significantly to global warming by emitting large amounts of N_2O. Therefore, this presentation also assesses alternative uses of rice straw with the potential to mitigate overall (i.e. on-farm and off-farm) emissions. There are several technological options to utilize rice straw for energy (and thus, offsetting CO_2 emissions from fuel) or carbon sequestration. While none of these options has yet achieved wide acceptance, they will become more attractive under high prices of fossil fuel and may gradually change the practices of straw management in the near future.

037

ASSESSMENT OF THE CARBON BALANCE IN A FORESTED WATERSHED OF TAKAYAMA BY ECOLOGICAL PROCESS-BASED APPROACH

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Is the forest ecosystem a source or a sink of carbon, and how will global climate change affect the forest carbon balance? This critical question remains difficulty to answer, in part because of spatial heterogeneity such as in mountainous region, Japan. The carbon net balance is sum of two large terms: photosynthetic carbon uptake and respiratory carbon release. The ecological process-based method provides a detailed assessment of belowground compartment as one of the major compartment of carbon balance. This method is determined by the balance between net primary production (NPP) of vegetation and heterotrophic respiration (HR) of soil. The carbon balance of forest ecosystems was estimated in Daihachigakawa watershed, Takayama, Japan since 2004. To estimate the NPP, we applied a biometric method involving tree allometric analysis and litter traps for biomass measurements. Moreover, to estimate the annual soil carbon emission (SR), we used a chamber system with automatic open and closing for measuring continuous soil CO_2 efflux based on an open-flow method, a portable system for measuring soil respiration (LI-6400) and a closed chamber method by soil air samples. Our object is to evaluate (1) the ecosystem carbon balance in second-growth deciduous forests, plantations of Japanese cedar and a larch forest at the Daihachigakawa watershed, (2) the relationships between ecosystem carbon pools and fluxes and (3) temporal changes in soil CO_2 effluxes of the above forest types. The overall goal of this study is to investigate carbon cycling on a regional scale using ecological process, remote sensing, and climatic observation and modeling analysis as a part of the COE program "Satellite Ecology". The study region refers to a cool temperate zone, Asia monsoon climate. The study area was located in Takayama city, central Japan (Fig. 1, 36° 08' N, 137° 22' E). The annual mean of air temperature and precipitation for the sites were 7.2~11°C and 1745~2079 mm, respectively. The Q50, Q20 and Q7 stands composed mainly by *Quercus* are secondary deciduous forests of 50, 20 and 7 year old, respectively. C50 and C3 sites composed by Japanese cedar (*Crytomeria japonica*) are 50 and 3 year old plantations. L50 stand composed by larch forest (*Larix kaempferi*) is 50 year old. Biomass of C50 stand was larger than other stands (C50>L50>Q50>Q20>Q7>C3). The aboveground NPP (ANPP) of Q7 stand was largest (Q7>C50>C3>Q20>Q50>L50). There were significant exponential relationship between soil CO_2 efflux and soil temperature in all stands. There was higher ANPP and SR in Q7 stand than those of other stands. We found a significant correlation between ANPP and SR (Fig. 2). The results suggest that linkage between the remote sensing method using the satellite data and ecological process- based method provides a key approach to evaluate carbon balance and dynamics in a mountainous region.

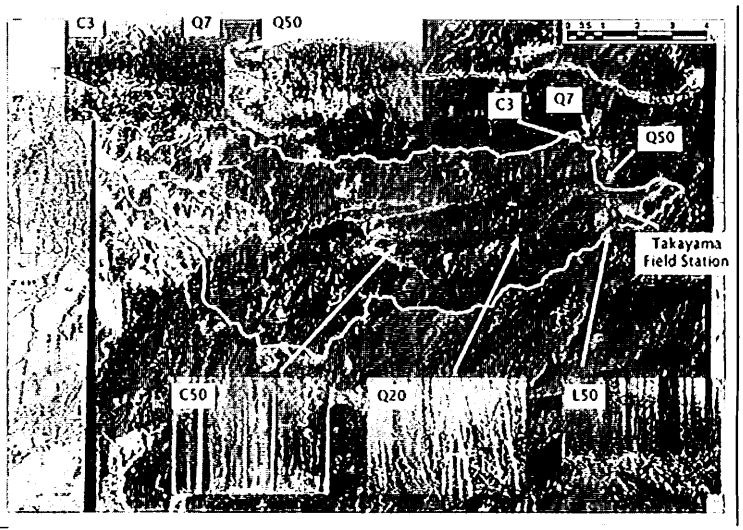

Fig. 1. Map of the principal study stands in the Daihachigakawa watershed, Takayama.

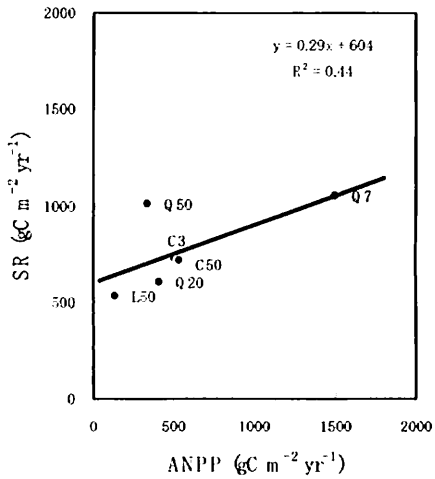

Fig. 2. Relationship between ANPP and SR for six forest stands.

041

MOVING TO THE REGIONAL-SCALE: ATMOSPHERIC BOUNDARY LAYER CONCENTRATIONS AND SURFACE FLUXES

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Precise measurements of the concentration of trace gases and isotopic ratios have been made for up to 50 years at a number of locations around the world. These measurements have been widely used to track changes in the total atmospheric burden of CO_2 and to estimate the geographical location of sources and sinks for carbon. Measurements of other trace gases and isotopic species have been used to infer the respective roles of the oceans, terrestrial biosphere and human activities in the carbon cycle. Adding such measurements at flux sites around the world would greatly increase the sampling of trace gases in the atmospheric boundary layer over the continents. My talk will review some technologies for making such measurements; what level of precision is needed for such measurements to be useful, and some approaches for using these measurements for model validation and to infer surface fluxes at regional scales.

042

CARBON SINKS AND SOURCES IN CHINA'S FORESTS DURING 1901-2001

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This paper reports annual carbon (C) balance of China's forests during 1901-2001 estimated using the Integrated Terrestrial Ecosystem C-budget model (InTEC). Annual carbon source and sink distributions are simulated for the same period using various spatial datasets including land cover and leaf area index obtained from remote sensing, soil texture, climate, forest age, and nitrogen deposition. During 1901-1949, China's forests were a source of 21.0±7.8 Tg C yr^{-1} due to disturbances (human activities). Its size increased to 122.3±25.3 Tg C yr^{-1} during 1950-1987 due to intensified human activities in late 1950s, early 1960s, 1970s and early 1980s. The forests became large sinks of 176.7±44.8 Tg C yr^{-1} during 1988-2001, owing to large-scale plantation and forest regrowth in previously disturbed areas as well as growth stimulation by nondisturbance factors such as climatic warming, atmospheric CO_2 fertilization, and N deposition. From 1901 to 2001, China's forests were a small carbon source by 3.32 Pg C, about 32.9±22.3 Tg C yr^{-1}. The overall C balance in biomass from InTEC generally agrees with previous results derived from forest inventories of China's forests. InTEC results also include C stock variation in soils and are therefore more comprehensive than previous results. The uncertainty in InTEC results is still large, but it can be reduced if a detailed forest age map becomes available.

Key words: Carbon sink, Carbon source, Forest, Carbon cycle, China

043

SATELLITE AND TOWER FLUX COMPARISONS OF SEASONAL VEGETATION DYNAMICS IN MONSOON ASIA

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The metabolism and phenology of the world's rainforests significantly influence global dynamics of the Earth system through their role in biogeochemical cycling and climate, and as major reservoirs of the planet's biological diversity. Despite their enormous importance, the impact of environmental and human factors on tropical forest functioning and phenology remain poorly understood. Recent neotropical rainforest studies with in-situ tower flux measurements of gross primary productivity (GPP) and regional satellite observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) have shown dry season increases in vegetation photosynthesis resulting from greater seasonal availability of sunlight. These studies yield consistent depictions of forest seasonality but contradicted ecosystem models that predict dry season declines in photosynthesis due to water limitations. Intact rainforests appear to avoid dry season water stress through root access to deep soil waters and hydraulic redistribution. However, a reversal in the seasonal patterns of ecosystem fluxes and satellite phenology was found in disturbed forests and with forest conversion. In this study we assessed the extent to which the tropical rainforests in Southeast Asia respond similarly as the neotropics to sunlight, moisture, and human controls on seasonal ecosystem functioning. Tropical forest degradation induced by land use pressures is more prominent in Monsoon Asia and deforestation rates are the highest on the planet with important consequences to tropical forest sustainability, fire susceptibility, carbon emissions, and resilience to land-use pressures.

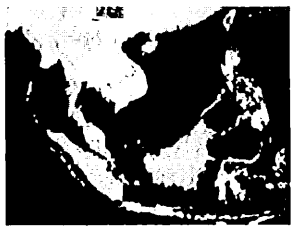

Figure 1. Southeast Asia EVI annual average

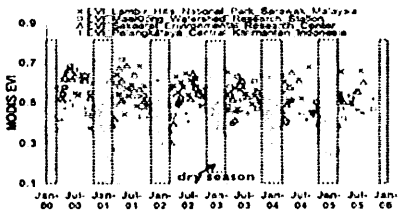

Figure 2. MODIS EVI time series of 4 sites.

We analyzed the phenology of Monsoon Asia at multiple scales with 6 years of MODIS satellite measures of 'greenness', using the Enhanced Vegetation Index (EVI, an index of canopy photosynthetic capacity). More intense analyses were conducted at local field study sites and with seasonal canopy photosynthesis measured from eddy flux towers at the MaeKlong Watershed Research Station (mixed deciduous tropical forest, 14° 34.57'N; 98° 50.62'E) and the Sakaerat Environmental Research Center (dry evergreen broadleaf tropical forest, 14°29.6'N;101°55.32'E), both in Thailand. Satellite EVI data was well correlated with seasonal and interannual tower GPP measurements at both Thailand sites.

However, satellite measured greenness and tower flux GPP measurements from these sites, at 14^0 latitude, were positively correlated with precipitation seasonality, such that photosynthesis was more tightly coupled with water availability, as found in the drier and transitional, southern Amazon rainforests.

The more moist rainforest sites, closer to the equator, such as Lambir Hills National Park in Sarawak, Malaysia (4.1865^0 N;114.017^0 E) and Palangkaraya in Central Kalimantan, Indonesia (2° 20.7' S; 114° 2.183' E) displayed satellite greenness phenologies that were less well coupled with rainfall and showed slightly higher photosynthesis in the dry season when light availability was stronger. As there were no tower flux data available over these wetter areas, our results are not entirely conclusive as to whether neotropical and Monsoon Asia tropical ecosystems respond similarly to light and rainfall controls. Throughout the region, however, land disturbances resulted in satellite phenology profiles that strongly followed precipitation seasonality.

044

COMPARISON OF SATELLITE GREENNESS DATA WITH FLUX TOWER MEASUREMENTS IN AMAZON

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[2] *Instituto Nacional de Pesquisas Espaciais – INPE, Brazil*

Recently, a better understanding of vegetation phenological responses to environmental factors, e.g. climate is necessary to develop reliable biosphere-atmosphere and climate models for predictions of mass and energy exchanges between the land surface and atmosphere. The Amazon, the largest extent of tropical rainforest on the Earth with extensive tropical savannah (cerrado) and ecotone, is under great pressure of landuse/ landcover changes from anthropogenic impacts. For more than two decades, the Amazon region has been transformed into pasture and agricultural uses with significant consequences on biodiversity, biogeochemistry, carbon and water budgets, and productivity in regional and global scales. The controlling mechanisms and factors on tropical forest phenology and productivity are not well understood, yet the Amazon basin continues to undergo rapid rates of human-induced disturbances.

Therefore, the objectives of this study were to investigate the interactions of moisture and light controls and vegetation physiognomy on vegetation phenology across various eco-climatic transects traversing rainforest, transitional, and cerrado biome types with intact and converted forest areas. Then, we evaluated the satellite-derived greenness seasonal variations with flux tower photosynthesis data to examine the consistency of the MODIS EVI with local flux measurements.

We utilized 5-years Moderate Resolution Imaging Spectroradiometer (MODIS) Enhanced Vegetation Index (EVI, "greenness" or canopy photosynthetic activity measurement) satellite time series data to analyze seasonal and spatial patterns of biological vegetation activity over the Amazon basin. We found MODIS EVI depicted significant trends in landscape phenology observed across the rainforest, cerrado and ecotone forests with strong seasonal shifts resulting from differences in vegetation physiognomic responses to rainfall and sunlight. In the cerrado region, strong seasonality with greening and browning was tightly coupled to rainfall. The dense and open tropical rainforest phenologies were more controlled by seasonal variations in sunlight with greening in the sunnier dry season coincident with periods of maximum solar radiation. This suggested the rainforest ecosystems were light-limited. Significant changes in phenology were observed in both converted- ecotone and open rainforest with greening synchronized with rainfall and browning coinciding with the dry season, resulting in a forest conversion seasonality similar to the cerrado. In contrast, transition ecotone forest seasonal dynamics were unique and complex, as neither sunlight nor rainfall had a direct influence on the forest metabolism and phenology.

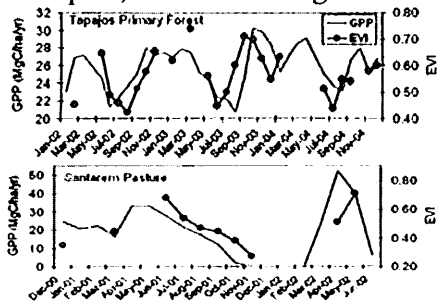

Fig. 2 Comparison between satellite-based EVI and GPP at Tapajos dense rainforest and Santarem pasture sites.

We compared the EVI seasonal profiles with the eddy flux tower measures of canopy photosynthesis or gross primary productivity (GPP). Overall, the EVI seasonal profiles at the tropical rainforests and conversion sites behaved similarly to GPP profiles confirming the MODIS EVI greenness patterns. This suggests that satellite-based greenness measures with EVI, in intact and converted rainforests can be confidently related with their photosynthetic activity.

Therefore, MODIS satellite greenness measures are potentially useful for quantitative and consistent regional estimates of carbon dynamics and for monitoring human-induced landcover changes.

045

THE SIMULATION OF WATER VAPOR AND CARBON DIOXIDE FLUXES OVER IRRIGATED FARMLAND BY MODIFIED SOIL-PALNT-ATMOSPHERE MODEL (mSPA)

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The exchange of CO_2 and water vapor in the farmland was examined with a two-layer canopy model (mSPA model). The study site is located in a southwestern end of Korean peninsular (34.55°N, 126.57°E) which is part of the Koflux sites (Haenam). The turbulent fluxes of energy and CO_2 were measured from October of 2002 to September of 2003 by eddy covariance method. The landcover was the mixture of rice paddies and various agricultural crops such as beans and sweet potatoes etc. Four cases were selected for detailed examination among southeasterly wind cases during growing seasons (June to September in 2003). The footprint area consists of mostly rice paddy field. Case 1 is characterized by low LAI, small root biomass and high vapor pressure deficit while Case 2 is characterized by near maximum LAI, large root biomass and moderate vapor pressure deficit. Cases 3 and 4 are characterized by ripening period and maturity period, respectively. The simulated diurnal variation of turbulent fluxes agrees well with observation in Cases 1 and 2. However, the model fails to simulate both latent heat flux and CO_2 flux during late growing season (Cases 3 and 4). The observed assimilation–stomata (A-g_s) relationship shows a different slope between mid-growing season and late growing season while modeled one shows same slope in both seasons.

Sensitivity test was performed to investigate the influence of uncertainties of prescribed model parameters on simulated cumulative GPP and evaporation during growing season. During this period, vapor pressure deficit was moderately low and soil moisture was ample due to irrigation and rainfall. The cumulative evaporation showed little sensitivity to both LAI and V_{cmax} due to compensating effect of soil evaporation. The cumulative GPP showed a larger sensitivity to LAI than V_{cmax} , which emphasizes the importance of good estimates of LAI for reasonable long-term GPP estimate. For hydraulic parameters such as stem hydraulic conductivity and root resistivity, model showed little sensitivity. It is due to low water stress during the growing season.

Keywords: Farmland, Net ecosystem exchange, mSPA model, Eddy covariance fluxes

046

MODELING SEASONAL VARIATION OF CO_2 FLUX IN A SUBTROPICAL CONIFERIOUS FOREST USING THE EALCO MODEL

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EALCO (Ecological Assimilation of Land and Climate Observations) model is a process-based model used to simulate the carbon, water and energy exchange between the atmosphere and land surface. It has been succeeded in modeling the deciduous ecosystem in boreal forest and contributing to the study of ecosystem processes. Seasonal drought frequently happens in the southern subtropical region of china, which was commonly combined with high temperature. Flux measurements using eddy covariance technology at Qianyanzhou site (QYZ) (26°44'N, 115°03'E, 110.8m) of ChinaFLUX have been made since October of 2002 in order to investigate the carbon flux characteristics and the impact of seasonal drought on terrestrial ecosystem processes. QYZ is located in southern China, influenced by subtropical monsoon climate. The vegetation is man-panted coniferous forest. It's a relatively dry year in 2003 (precipitation=855 mm), with 35% less precipitation than the historical average. The year 2004 has a close to normal precipitation of 1325mm. The contrasting climate conditions over these two years enables us to test the sensitivity of carbon exchanges to seasonal drought (combination of increasing temperature and declining precipitation) with EALCO model, which is one of the possible trends in the future climate projections.

In this study, EALCO model is parameterized to simulate ecosystem carbon exchange process in the man-planted evergreen forest. Simulation results have been validated using the half-hourly carbon fluxes and daily and annual GPP (gross primary production), NEP (Net ecosystem production) and TER (Total Ecosystem Respiration) estimated from eddy covariance measurements. The influences of seasonal drought on ecosystem photosynthesis and net ecosystem carbon budget have also been discussed.

In general, the model can considerably simulate the two years' carbon fluxes among soil –plant –atmosphere on hourly, daily and annually scale. Both the simulations and observations showed strong impact of drought on GPP in 2003. Compared with 2004, the annual GPP in 2003 decreased 12.9% according to observations (1610 vs. 1865 g C m^{-2}) and 11.2% according to model results (1637 vs. 1844 g C m^{-2}). The diurnal variations of NEP from both observations and simulations during the period of soil water deficit show asymmetric format, that is, the peak value of carbon exchange accrued on a certain time in the morning then decreasing with time. Modeling results indicate that water stress have more influence on TER than photosynthesis, which lead to the decrease of NEP. Further analysis suggests that deep soil water content controls the canopy photosynthesis dramatically in sunny day before noon time during soil water stress. While after noon time both high temperature and deep soil water content eliminate the GPP and their elimination percents are equal. In cloudy days, radiation and deep soil water content primarily determine the photosynthesis and temperature becomes a minor controlling factor generally.

Poster Session

P01

CARBON SEQUESTRATION IN EAST ASIA: A MINI-REVIEW OF EDDY FLUX MEASUREMENT STUDIES

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The terrestrial ecosystem and the physical climate system are strongly coupled through carbon exchange. However, major uncertainties in the magnitude of these feedbacks to climate change are still remaining. To solve these problems, many research activities has built up the eddy flux tower monitoring the carbon dioxide exchange over the canopy of natural ecosystems and attempt to clarify the carbon dynamics between the atmosphere and the terrestrial ecosystems in East Asia. Most of them have published their measured results in the international and domestic scientific journals in these years. There is, however, no summarized discussion with regard to their relationship of carbon dioxide exchanges against environmental gradients on the sub-continental spatial scale. To understand the present situation of carbon sequestration capacities over whole of East Asia and to recognize the inherent problems in terms of tower installation location and coverage rates of each ecosystem types in East Asia, the summarizing report of the already-stored data about annual carbon uptake values is to be shown as quickly as possible.

We review the published results of the eddy covariance flux measurements, which have been conducted in more than twenty field points within East Asia (70 °N – 10 °S, 90 °E – 150 °E) in these ten years (Fig. 1), and investigate the relationships between carbon dioxide budgets and environmental factors in East Asia. Annual net ecosystem exchanges (Ann. NEE) of carbon dioxide is higher in the dipterocarp forest in tropical region and lower in alpine grassland on Tibetan Plateau and larch forest in high-latitudinal region. The relationship between Ann. NEE and latitude is linear-like but not so clear (Fig. 2). Against to annual mean air temperature, Ann. NEE indicated relatively clear positive relationship without reference to ecosystem types. Ann. NEE and annual gross primary production (Ann. GPP) show a negative and strong positive correlation to maximum leaf area index and annual ecosystem respiration (Ann. Re) also increases with annual mean air temperature increasing. These indicate that annual ecosystem carbon fluxes have apparent correlation with environmental factors rather than geographical location. On the other hand, it is found that further research is needed in higher and lower latitudinal regions, in which there is smaller number of evidence.

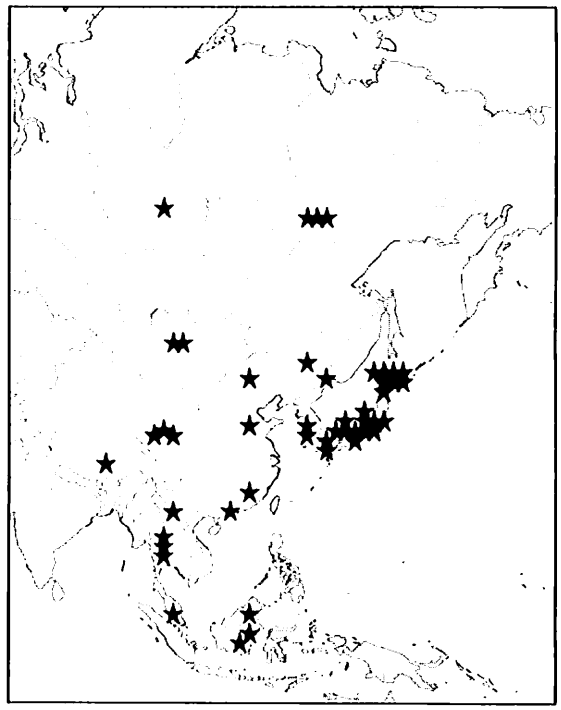

Fig. 1. Location of eddy flux measurements in East Asia.

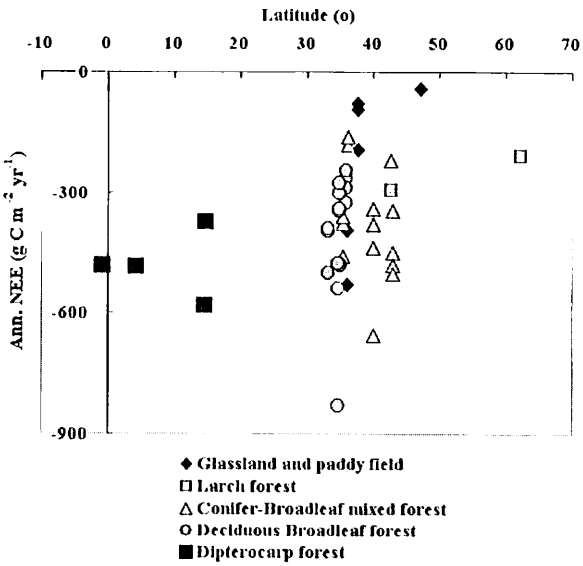

Fig. 2. Annual net ecosystem exchange along latitudinal trend.

P02

FLUX OBSERVATION AND EVAPOTRANSPIRATION OF THREE LAND USE TYPES IN THAILAND

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An intensive flux observation were carried out in various types of land use, Thailand. In order to find out the heat budget and evapotranspiration (ET) in difference types of land use, which are paddy field, teak plantation and cassava field in Sukhothai, Lampang and Nakhonratchasima Provinces. Each land use type was installed the automatic weather station (AWS) in different height of tower. The measurement of energy balance using Bowen ratio technique and collecting data between January – December 2005.

The results showed that an average daily solar radiation (R_s) of the whole year in paddy field was 19.3 MJ m^{-2} and an average daily net radiation (R_n) was 13.2 MJ m^{-2}, while in teak plantation and cassava field, the average daily R_s was 19.0 and 18.6 MJ m^{-2}, and an average daily net radiation (R_n) was 14.8 and 14.3 MJ m^{-2} respectively. The average daily ET of paddy field was 4.1 mm. while the average daily ET of teak plantation and cassava field were 3.9 and 4.7 mm. respectively.

Comparison of latent heat flux, sensible heat and soil and water heat flux among land use type found that in paddy field almost 72.3 percent of R_n was used for latent heat of vaporization (LE), while in teak plantation and cassava field were only 71.6 and 68.7 percent of R_n. On the other hand sensible heat (H) in cassava field was 27.5 percent of R_n while in paddy field and teak plantation were only 22.9 and 23 percent of R_n respectively. Heat storage in soil and water (G_s, G_w) in paddy field were 3.1 and 1.7 percent of R_n while G_s in teak plantation and cassava field were 5.4 and 3.8 percent of R_n respectively.

P03

EFFECT OF ENVIRONMENTAL FACTORS ON CARBON DIOXIDE EXCHANGE OF FOREST ECOSYSTEMS IN EAST ASIA

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Understanding of global carbon cycles demands evaluation of the interaction between various terrestrial ecosystems and the atmosphere. Long-term observation of net ecosystem CO_2 exchange (NEE) has been performed by eddy covariance technique over various terrestrial ecosystems. Comparative studies of NEE have been advanced in America or Europe. However, reports that address the NEE for Asian ecosystems, which are affected by Asia monsoon, are few. In this study, we analyze the response of forest ecosystems to environment factors. The study sites are two larch forests (Laoshan (LSH), China and Tomakomai (TMK), northern Japan), two evergreen needle-leaf forests (Fujiyoshida (FJY), Kiryu (KEW), central Japan), deciduous needle-leaf forest (Takayama (TKY), central Japan) and tropical rain forest (Pasoh (PSO), Malaysia) and tropical seasonal forest (Sakaerat (SKR), Thailand).

Figure 1 shows relationships between half-hourly mean daytime NEE and PPFD for four months (June to September). Curves were fitted by the non-rectangular hyperbola equation, and maximum gross primary production at light saturation (P_{max}) (μmol m^{-2} s^{-1}), the initial slope (ϕ) (mol mol^{-1}), the convexity of the light-response curve (θ) and daytime respiration (RE_{day}) were obtained. The curves of the equation show the large difference between two tropical forests at low-latitude (PSO, SKR). It should be caused by the difference of vegetation, tree age, climate, and soil type. In contrast, for three mid-latitude forests in central Japan (TKY, FJY, KEW), their fitting curves almost overlapped in spite of different vegetation and environment. Although two curves for larch forests (LSH, TMK) show large difference because of different environment, both forests have common characteristics that P_{max} and RE_{day} were larger than other forests except for SKR.

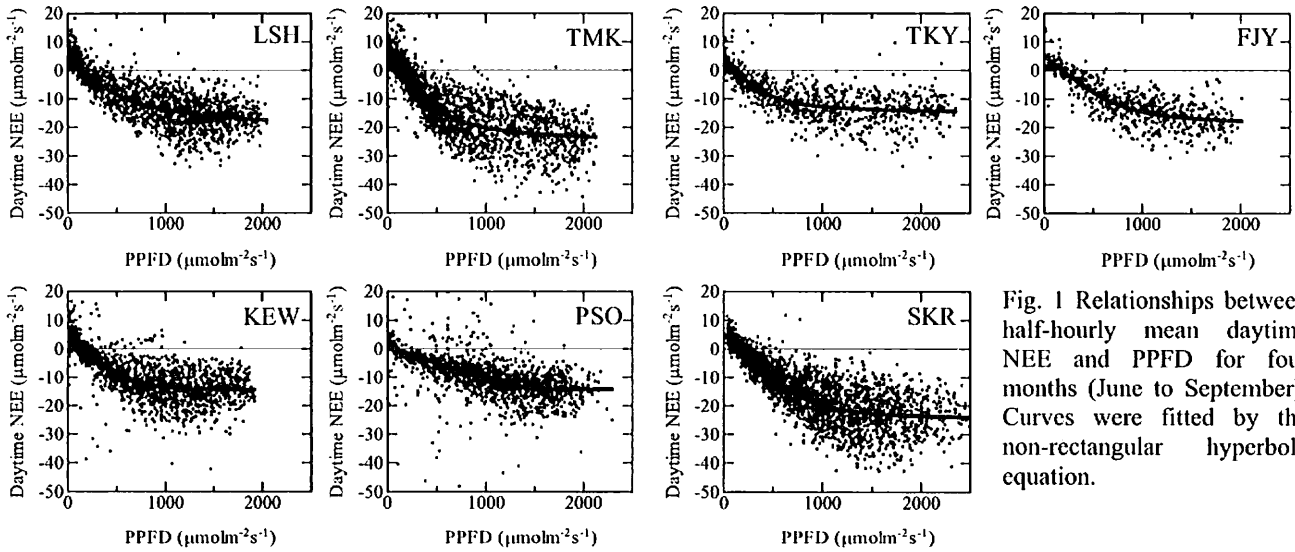

Fig. 1 Relationships between half-hourly mean daytime NEE and PPFD for four months (June to September). Curves were fitted by the non-rectangular hyperbola equation.

Acknowledgements: *This study was supported by Japan Ministry of Environment (Integrated study for terrestrial carbon management of Asia in the 21st century based on scientific advancements). The authors would like to thank all the project investigators, their co-workers, and students for providing data.*

P04

ANNUAL CARBON BUDGET OF A SINGLE-RICE CROPPING PADDY FIELD BASED ON LONG-TERM FLUX MEASUREMENT

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Rice paddy fields are agricultural ecosystem covering the largest land area in monsoon Asia. Although there are a variety of cropping patterns in rice paddy fields, single rice-cropping paddy fields widespread in northeast Asia are characterized by continuously flooded crop-growing season followed by a contrasting drained fallow period. Ecological conditions of paddy fields are basically controlled by human activities and exhibit drastic changes within each year. Carbon exchange between paddy fields and the atmosphere is also influenced by cultivation practices and field management. In this paper, annual carbon exchange at a customarily cultivated single rice-cropping paddy field in central Japan is presented based on results of measurement of carbon dioxide (CO_2) and methane (CH_4) fluxes combined with ecological measurement.

The present study was conducted at Mase paddy flux site (36° 03'N, 140° 02'E, 15 m asl). Rice is transplanted to the irrigated field at the beginning of May and harvested in mid-September. The field was flooded to a depth of 3 to 5 cm from late April to mid-August with temporary interruption by mid-season drainage. Harvest residue (rice straw and stubbles) was ploughed into soil. CO_2 flux density was measured by the standard eddy covariance method with an open-path infrared gas analyzer, while CH_4 flux density was determined by the modified aerodynamic method from the vertical gradient of CH_4 concentration.

CO_2 flux exhibited a distinct seasonal variation: uptake during the growing season and release during the fallow period. CO_2 flux showed a maximum uptake of 9 g C m^{-2} d^{-1} around heading period of rice. The field became a net source of CO_2 prior to the harvest due to declined photosynthetic fixation and increased soil respiration under drained field conditions. With a peak emission immediately after the harvest, release of CO_2 as small as 1 g C m^{-2} d^{-1} continued until the field was irrigated again in April. The annual net ecosystem CO_2 exchange (NEE) from 2002 to 2005 ranged between –130 and –290 g C m^{-2} y^{-1}. The interannual variability in NEE was caused by 1) changes in Gross Primary Production (GPP) influenced by the amount of incident solar radiation, 2) changes in soil respiration influenced by duration of drainage, and 3) changes in soil respiration during the fallow period influenced by temperature and length of the fallow period. CH_4 flux exhibited a commonly observed seasonal pattern. It showed a gradual increase from about 40 days after flooding, a temporary decrease during the mid-season drainage, and a flush of CH_4 stored in soil at the final drainage. Timing and magnitude of the flushes varied year by year depending on water management of the field and precipitation during the drained periods. The total amount of CH_4 released from the field in the growing season of 2003 to 2005 was 19.9, 19.1 and 11.4 g C m^{-2} $season^{-1}$, respectively. A long mid-season drainage in 2005 resulted in smaller amount of CH_4 emission than those in previous two years.

Carbon removed from the field at harvest was estimated between 200 and 260 g C m^{-2} depending on yield of rice. Previous studies conducted at the study site showed that the budget of water-dissolved carbon was almost balanced in the total of the irrigated period. The annual carbon budget of the filed estimated by including all of these components ranged between +30 (gain of carbon) and –90 g C m^{-2} y^{-1} (loss of carbon). The total carbon budget of the field was close to neutral on average, but its year-to-year variations exceeded 100 g C m^{-2} y^{-1}. Seasonal CH_4 emission from the field was only 3 to 5% (on molar basis) of the magnitude of NEE in the growing season. However, CH_4 emission is important in the greenhouse gas budget of the field when the global warming potential of CH_4 is taken into account. From the viewpoint of greenhouse gas exchange, the paddy ecosystem is more important as a source of CH_4 than as a sink of CO_2.

At the study site, unexpected downward CO_2 fluxes were often observed in the latter half of the fallow periods as is reported at other flux study sites where open-path eddy covariance system is employed. It is important to solve this problem to improve the estimate of annual NEE of the paddy field as the fallow period lasts for about two-thirds of a year. In order to understand how the paddy ecosystem in Asia affects the global carbon budget in total, observation at paddy fields with various cropping patterns is needed, such as double-rice and rice-wheat cropping paddy fields that are widespread in Asia. *This study was sponsored by the GWIP by MAFF, Japan, GERF (B-3, S-1) by ME, Japan and CSSPR (H12-10) by JST.*

P05

SEASONAL VARIATION OF CARBON DIOXIDE EXCHANGE AND ANNUAL CARBON BUDGET AT FOUR MANAGED GRASSLAND SITES IN JAPAN

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Grassland occupies 40.5% of the total land area in the world, and it is an important ecosystem to support herbivorous livestock production. Grassland is also important as a reservoir of organic carbon stock because of perennial plants dominating in grassland vegetation. In Japan, where grassland accounts for 13% of the total agricultural land area, the abandonment of livestock excreta together with the insufficient manure application to crop fields due to livestock husbandry supported by enormous imported feed has resulted in the stream and groundwater pollution. To promote the use of livestock excreta as manure to grassland, it is necessary to understand how manure application affects carbon budget in grassland ecosystem, taking the influence on the total greenhouse gas exchange into account. We started a field study to clarify the impact of manure application on carbon budget at four grassland sites located from cool temperate to warm temperate region in Japan (Fig. 1). At each site, adjoining two plots were provided for the experiment: one for stable manure application, and the other for chemical fertilizer application. Flux densities of carbon dioxide (CO_2) at both plots are monitored by the eddy covariance method using the same instruments and a common data processing method. In this paper, we place the focus on the chemical fertilizer plot at the four study sites, and present seasonal trend of CO_2 exchange and annual carbon budget at each site by using the results obtained from November 2004 to October 2005.

Observed NEP exhibited high-degree of seasonality and inter-site variability that are influenced by climate conditions and field management. At Nakashibetsu (NKS) site and Shizunai (SZN) site in northern Japan, the grassland was generally dormant in CO_2 exchange from November to April. At Nasushiobara (NSS) site in central Japan, diurnal variation of CO_2 flux was observed even in mid-winter, but daily NEP was close to zero, indicating photosynthetic CO_2 fixation was almost balanced by ecosystem respiration on daily basis. In contrast with these three sites, at Kobayashi (KBY) site in southwestern Japan, daily CO_2 uptake as much as 4 to 5 g C m^{-2} d^{-1} was observed continuously on clear days in winter. CO_2 exchange at all of the study sites was activated by the beginning of the growing season of grasses. NEP during the growing season repeated a gradual increase in net CO_2 uptake with growth of grasses followed by an abrupt change to CO_2 emission immediately after harvest of grasses. The annual NEP ranged from 2.7 Mg C m^{-2} y^{-1} at NKS to 6.4 Mg C m^{-2} y^{-1} at NSS. Interestingly, Net Biome Production (NBP) estimated by subtracting harvested carbon from the annual NEP was negative at two sites in cool temperate region (NKS and SZN), while NBP was positive at the other two sites in wamer region (NSS and KBY). This indicates that at NKS and SZN the total outflow of carbon from the grassland by harvest and decomposition of harvest residue and soil organic matters exceeded Net Primary Production (NPP) of the ecosystem.

This study was financially supported by Japan Grassland Agriculture and Forage Seed Association.

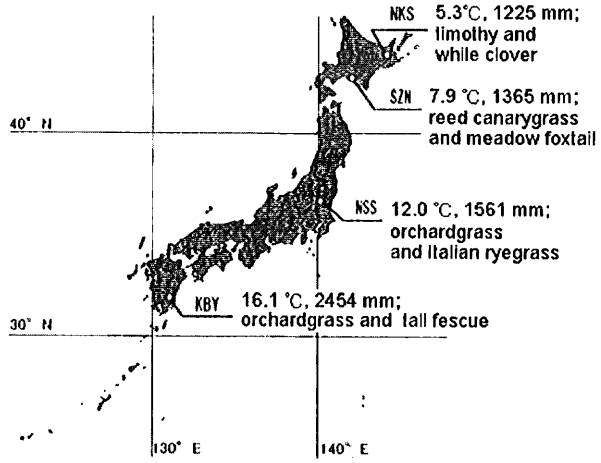

Fig. 1 Location of study sites with their annual mean air temperature, annual amount of precipitation and dominant species of grasses.

P06

SEASONAL AND INTER-ANNUAL VARIATIONS IN CARBON DIOXIDE EXCHANGE AT FIVE GRASSLAND AND CROP FIELD SITES IN EASTERN ASIA

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Carbon dioxide exchange in grassland and agricultural ecosystems in eastern Asia are discussed based on net ecosystem CO_2 exchange (NEE) and meteorological data obtained at five tower-based flux sites from 2002 to 2004. The study sites include alpine meadow on Tibetan Plateau (QHB), C3/C4 mixed grassland in central Japan (TGF), rice paddy in central (MSE) and western Japan (HCH), and a rotational forage (maize-Italian ryegrass) field in southwestern Japan (KON). We used the original datasets of half-hourly fluxes (15-minute fluxes for QHB) registered on a S-1 project database. After applying a common set of quality check to the original flux data, we applied the multiple imputation (MI) method semimonthly to fill up the gaps in the half-hourly NEE dataset, and estimated seasonal and annual sums of NEE. Half-hourly ecosystem respiration (RE) was also estimated by applying the MI method to the dataset composed of nighttime NEE, air temperature and friction velocity. Gross primary production (GPP) was calculated from the estimated NEE and RE. As an example, variations of estimated semimonthly NEE, GPP and RE at MSE are shown in Fig. 1.

At QHB, incident short-wave radiation (*Rs*) in early spring was a determining factor of the length of the growing season and the annual GPP. The soil moisture content had an obvious effect on the phase and the amplitude of GPP and RE. An extended dry period from beginning of July 2002, when the soil moisture content was lower by 0.1 m^3 m^{-3}, yielded smaller annual GPP and RE by 36% and 25%, respectively, than those in 2004. At the paddy sites (MSE, HCH), which were under the control of water management for rice cultivation, seasonal and inter-annual variations of GPP were influenced by *Rs* and timing of rice planting. Decreased *Rs* from June to July 2003 significantly influenced the annual GPP at MSE because the period of decreased *Rs* overlapped the first half of the growing season. Contrastingly, at HCH, influence of decreased *Rs* on GPP was more obvious in and after August 2004 than in June and July 2003 because the growing season of HCH was behind MSE by about 30 to 40 days. At MSE, the amplitude and the variation of RE during the growing season corresponded to the frequency and the length of mid-season drainage practices. At TGF, where observed CO_2 exchange during the growing season was quite different from the other study sites, closed vegetation (the maximum leaf area index exceeded 6.5) and dead grasses that were mown and left in the field previous year caused considerably large GPP and RE. At KON, continuous CO_2 uptake by the rotational forage field was observed almost throughout the year. At this site, a draught period accompanied by high vapor pressure deficit had decisive influence on magnitude of GPP. Although our study sites located in monsoon Asia are generally believed to be less water-stressed than European and North-American sites, the present results suggest that not only radiation but also dryness are key factors to investigate carbon dynamics on grassland and agricultural ecosystems in this region.

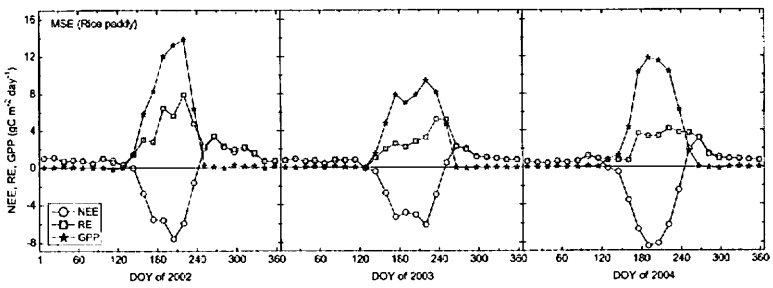

Fig. 1 An example of seasonal and inter-annual variations of semimonthly carbon budget components estimated by the MI method.

Acknowredgements
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P07

ENVIRONMENTAL CONTROLS ON CARBON BUDGETS IN TYPICAL GRASSLANDS IN CHINA

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Long-term measurements of CO_2, H_2O and heat fluxes between natural vegetation and atmosphere have facilitated the research on carbon cycle in terrestrial ecosystems and its response to global climatic changes. Based on flux measurements at five different grassland ecosystems, one semi-arid *Leymus chinensis* steppe in Inner Mongolia (NMG), an alpine meadow (BT), an alpine shrub-meadow (GCT), an alpine swamp-meadow (SD) at Haibei in Qinghai and a steppe-meadow at Dangxiong on Tibet Plateau, the dynamics of main processes of ecosystem CO_2 exchange in the five grassland ecosystems and their responses to environmental changes were investigated.

Located in different regions, there were significant differences in the climate, vegetation and soil type among the five grassland ecosystems, which result in their different response to environmental changes. The net ecosystem CO_2 exchange (NEE) in five grasslands showed large seasonal and interannual variation with the change of temperature, water availability and solar radiation. The four alpine meadows on Tibet Plateau mainly sequestrate carbon from June to September and emit carbon in other months. The NEE of NMG has biggest interannual variation due to the fluctuation in precipitation. The alpine meadow (BT), shrub-meadow (GCT) and swamp-meadow (SD) at Haibei have larger photosynthetic production (F_{GEP}) than the alpine steppe-meadow at DX and the semi-arid steppe at NMG. With abundant rainfall during growing season, the F_{GEP} of alpine ecosystems at Haibei was mainly limited by air temperature and solar radiation, while the F_{GEP} at DX showed significantly positive correlation with soil and air moisture. The frequent moisture stress has important effects on both F_{GEP} and ecosystem respiration (R_{eco}) at NMG site. The annual total ecosystem respiration of the five grassland ecosystems followed the order in BT>SD>GCT>NMG>DX. In arid and semi-arid ecosystems, soil water condition has important effects on R_{eco} and its response to temperature. Results indicated that temperature and water availability are main determinants of net ecosystem CO_2 exchange in all grassland ecosystems.

Comprehensive analysis shows that NMG, DX and SD sites were a net carbon source during the observing years, and the GCT and BT sites are net carbon sink. The global change with global warming and changes in precipitation could have profound effects on temperate and alpine grasslands in China.

Keywords: Eddy covariance, grassland ecosystem, alpine meadow, net ecosystem CO_2 exchange, ecosystem respiration

P08

STUDY ON THE RELATIONSHIP BETWEEN CO_2 FLUX AND H_2O FLUX IN PADDY FIELDS OF THILAND AND JAPAN

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There is high correlation between FCO_2 and FH_2O during all growth stages of paddy rice fields in Thailand as well as in Japan. Furthermore, FCO_2/FH_2O (CWFR) in each growth stage can be estimated by VPD, and then we could estimate CWFR by VPD in each growth stage (Pakoktom *et al*, 2004). If we can estimate the ratio of CWFR, then we can estimate CO_2 flux from H_2O flux which is relatively easy to calculate by using simple climatic data. In the present research, the further analysis was carried out using measured data sets of Japan in 2005.

Measurement

The measurements were conducted at a paddy field of Tokyo University of Agriculture and Technology, Fuchu city, in 2005. Flux densities of CO_2 and H_2O were measured during 4 stages of growth, LAI<1.5 (stage I), 1.5<LAI<4 (stage II), 4<LAI<6 (stage III) and ripening stage (stage IV) based on Bowen ratio technique. The relationship between FCO_2 and FH_2O, CWFR and climatic data were analyzed by regression analysis.

Results

The FCO_2 and FH_2O showed high correlation for all of VPD levels at all growth stages as shown in Fig. 1. Fig. 1 shows the correlation at stage III. The slope of the regression lines decreased when increasing VPD in a paddy field of Japan (fig 1A) as the same as in a paddy field of Thailand (Fig 1B).

The CWFR and VPD in a paddy field of Japan showed high correlation in all of growth stages as shown in Fig. 2. The trend of regression lines were decreased when increasing VPD at all of growth stages in a paddy field of Japan (see Fig.2) as the same as in a paddy field of Thailand.

Conclusion

A high correlation between FCO_2 and FH_2O during all growth stages and CWFR (FCO_2/FH_2O) in each growth stages had high correlation with VPD. Then it may be possible to estimate CWFR by VPD for both of paddy fields in Japan and Thailand.

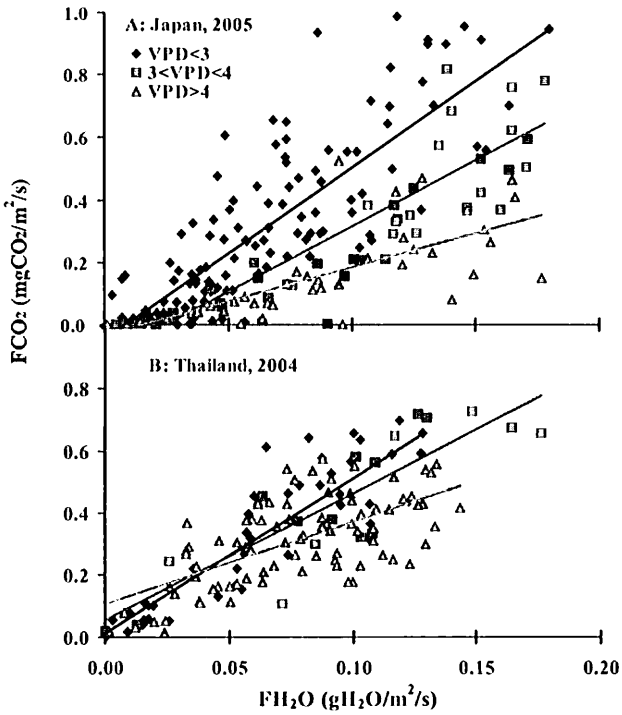

Fig. 1 Correlation between FH_2O and FCO_2 at each VPD level in a paddy field of Japan (A) and Thailand (B) for stage III

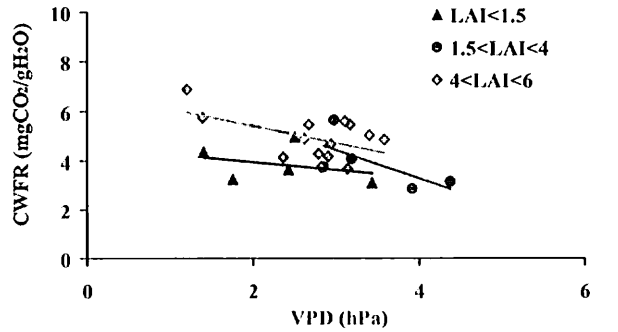

Fig. 2 Correlation between CWFR and VPD in each growth stage of Japan, 2005

P09

ANNUAL CARBON CYCLE OF *PINUS DENSIFLORA* STAND EVALUATED BY EDDY FLUX OBSERVATION AND ECOLOGICAL SURVEY

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Annual ecosystem carbon cycle of a broadleaf species mixed *Pinus densiflora* stand in Miki, Hyogo, Japan (34°47'N, 134°59'E) including flow among carbon compartments was evaluated based on the eddy flux observation and ecological survey during the period between December 2004 and December 2005. CO_2 flux above the forest was measured by means of the eddy covariance method. Meteorological conditions including photosynthetic photon flux density (PPFD), air and soil temperatures, soil water content etc. were also measured in the period. Linear trend removal for CO_2 concentration and WPL correction were applied for flux calculation and the less reliable data were removed by the stationarity, standard deviation and foot print test to produce the quality controlled half hourly datasets of CO_2 flux. The hyperbolic relationship between gross primary productivity (GPP) and PPFD, and the exponential relationship between ecosystem respiration (Re) and air temperature were determined simultaneously applying the genetic algorithm in monthly basis, and were used to fill the data gap of ecosystem CO_2 exchange and to evaluate monthly GPP and Re. Soil respiration was measured using two automatically ventilated closed chambers which were replaced biweekly. Above ground tree biomass and soil carbon content were measured in December of 2004 and 2005. Litter fall was collected in ten traps and the carbon content of litter was analyzed monthly.

Monthly mean air temperature reached its maximum in August, while monthly PPFD showed two peaks in May and August. Monthly Re and GPP showed similar seasonal courses to those of air temperature and PPFD, respectively. This difference in the seasonal courses of Re and GPP caused a unique seasonal course of net ecosystem productivity (NEP) which showed two peaks in May and October and the minimum in February. Monthly NEP was positive (CO_2 sink) throughout the observation period, and annual NEP was estimated to be 53 molC m^{-2} y^{-1}. The initial gradient of GPP to PPFD and the maximum GPP estimated by the hyperbolic model correlated to air temperature. Soil respiration rate was related to soil temperature and also moisture.

Above ground tree biomass evaluated by in situ survey was 276 and 287 molC m^{-2} in December of 2004 and 2005, respectively, and its annual growth was 9 molC m^{-2} y^{-1}. Total biomass including root was estimated by an allometric equation, and its annual growth was estimated to be 11 molC m^{-2} y^{-1} between 2004 and 2005. Annual litter fall of this period was 17 molC m^{-2} y^{-1} and the increase of soil organic matter was 5 molC m^{-2} y^{-1}. Annual heterotrophic respiration from soil evaluated as the difference between annual litter fall and annual soil organic matter rise was 12 molC m^{-2} y^{-1}. Annual net primary productivity (NPP) was calculated by summing annual tree biomass growth and litter fall, and was 28 molC m^{-2} y^{-1}. While NPP calculated by summing annual NEP from flux measurement and heterotrophic respiration was 64 molC m^{-2} y^{-1}, which was larger than NPP evaluated by the ecological survey. The estimated ratio of above and below ground tree respiration by using ecosystem, soil and heterotrophic respirations was 0.9 and was far smaller than the ratio of above and below ground biomass (4.5) in the allometric equation. These differences suggested the underestimation of Re, and/or over estimation of GPP and NEP by the flux measurement. This may be caused by the commonly reported tendency of CO_2 flux measured by the open-path eddy covariance systems. The result suggested the importance of validation employing different methods to evaluate ecosystem carbon cycle.

This study was supported by Japanese Ministry of Environment providing the grants "Strategy for the reproduction of natural and urban area in a basin."

P10

ENERGY, WATER, AND CO_2 FLUXES ABOVE GMELIN LARCH FOREST ON CONTINUOUS PERMAFROST OF CENTRAL SIBERIA

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We constructed a 20-m high tower made of wood (Fig.1) at a Gmelin larch forest, which is a principal ecosystem in continuous permafrost of Central Siberia. Heat, water vapor, and carbon dioxide fluxes were measured at the top of the tower during a growing season from June to early September, using the eddy covariance technique. Micro-meteorological variables as air temperature, humidity, wind speed and direction, radiations, soil temperature and moisture, were measured to support the eddy flux measurements.

The study site was an even-aged *Larix gemelinii* forest, near Tura in Evenki region, central Siberia (64°12'N, 100°27'E, 250 m a.s.l.). The forest trees formed open canopy structure, where canopy closure index was bellow 0.4 $m^2 m^{-2}$.

Monthly mean air temperature for the study period was higher in June but lower in July and August than the stationary 30-year averages. Monthly precipitation was half in June but was almost same in July and August of the long-term averages. Air temperature averaged 13.5°C through the measurement period (105 days) and total precipitation was 125.5 mm for the whole measurement period.

Fig.1 The meteorological tower equipped with solar panels

The sum of the eddy covariance heat and vapor fluxes occupied about 80% of net radiation on daily basis. During the growing season, mid-day mean daily shortwave and PPFD albedo values were lower compared with grass and tundra ecosystems. Values of mid-day mean daily Bowen ratio ranged approximately between 1 and 2, being relatively higher at the beginning and at the end of the growing period. Sensible heat fluxes responded to changes in incident radiation more sensitively than water vapor fluxes. Cumulative evapotranspiration slightly exceeded the total precipitation for 81 days of the growing period. Slight absorption of carbon dioxide by the ecosystem was observed during daytime even in early June when the larch trees were developing needle leaves and when the soil surface was snow-free but still frozen. The maximum half-hourly net uptake of carbon dioxide was observed between late June and early August. In early September, the ecosystem became the source of CO_2 in daily basis when the needles were still alive but began to change colors to yellow. The seasonal variation in the net uptake of CO_2 was primarily related to needle phenology of the larch trees. The magnitude of net uptake and release of CO_2 at the larch ecosystem was relatively low compared with other boreal forests and even with other larch forests on the continuous permafrost near Yakutsk.

P11

LONG-TERM VARIABILITY OF NET ECOSYSTEM PRODUCTION OF FUJIYOSIDA SITE ESTIMATED BY AMEDAS DATA - RESPONSE TO FLUCTUATING METEOROLOGICAL CONDITIONS OVER 30 YEARS -

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A tower was constructed at the northern foot of Mt. Fuji (Fujiyoshida forest meteorology site: Fig.1) and CO_2 flux monitoring started in 1999. Fujiyoshida site (35°27'N, 138°46'E, 1030m in elevation) is located on a gentle slope in a cool temperate region of central Japan. The dominant species of the site are Japanese red pine (*Pinus densiflora*) at the upper canopy and Japanese holly (*Ilex pedunculosa*) at the lower canopy. The soil is composed of volcanic lava and covered partially with litter and organic matter.

CO_2 flux has been measured by eddy covariance method using a three-dimensional sonic anemometer (SAT; DA600/KAIJO) and an infrared gas analyzer (IRGA; LI-6262/LI-COR). The SAT was set at a height of 26m on the tower, which is about 6m above the mean canopy height (Fig.2). The air is drawn at the same height by an air pump to the IRGA and the CO_2 concentration is analyzed.

The net ecosystem CO_2 exchange (NEE) was calculated every 30 minutes, taking account of CO_2 storage change within the canopy. Within this method, three-dimensional axis rotation (McMillen, 1988), corrections of the effects of lateral wind and water vapor on sonic velocity (Kaimal et al., 1968), and WPL correction (Webb et al., 1980) were employed. Then the data quality control tests (QC) were put into practice to check for inadequate data. The QC procedure followed Foken and Wichura (1996) and Vickers and Mahrt (1997).

The nighttime NEE was parameterized by air temperature. It equals ecosystem respiration (*Re*). Gross ecosystem assimilation (*Ag*) was calculated using the relationship: $Ag = -NEE+Re$. *Ag* was parameterized by absorbed photosynthetically active radiation (APAR).

The meteorological data have been measured at Kawaguchiko weather station (AMeDAS) for more than 30 years (Fig.3). The station (35°30'N, 138°46'E, 860m in elevation) is about 5km north of the Fujiyoshida site. The air temperature and APAR of the Fujiyoshida site was estimated by the meteorological data of the weather station. Then, the annual NEP (Net Ecosystem production: NEP= negative NEE) for 30 years was estimated by the above relationship using the meteorological data, assuming that the condition in the forest did not change.

This presentation shows the characteristics of the variability of the annual NEP in Fujiyosida site.

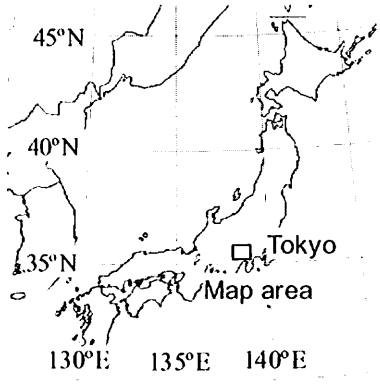

Fig.1 Location of Fujiyoshida forest meteorology site

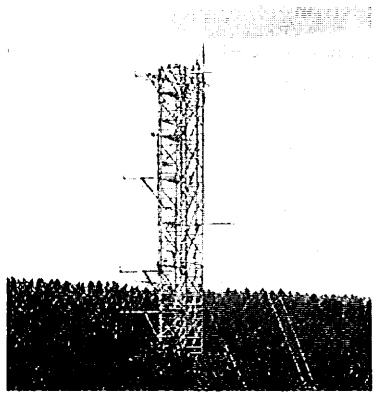

Fig.2 Tower at Fujiyoshida site

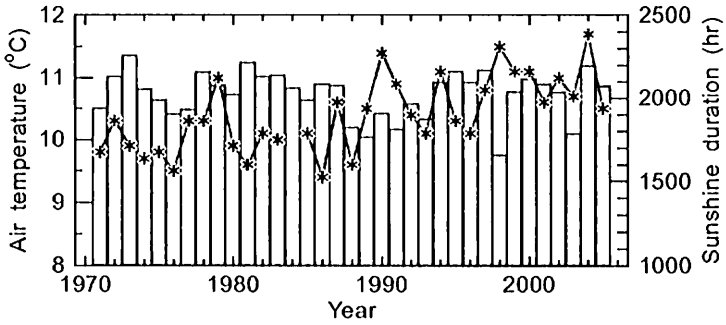

Fig.3 Annual mean air temperature and annual sunshine duration of Kawaguchiko weather station (Meteorological Agency)

P12

CO_2 AND WATER VAPOUR FLUXES AT A SUBTROPICAL MONTANE CLOUD FOREST ECOSYSTEM IN NORTH-EASTERN TAIWAN

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From 04 August through 27 September 2006, an eddy covariance setup was installed within a subtropical montane forest ecosystem to study the turbulent vertical fluxes of CO_2 and water vapour. To our knowledge, this is the unique eddy covariance site in Taiwan due to high micrometeorological requirements concerning the experimental site. The study site is part of Taiwan's Long Term Ecological Research sites which is supported by the Taiwan National Science Council in cooperation with the Taiwan Forest Research Institute. Scope of the program is to research the ecological processes with regard to hydrological and biogeochemical cycles of the ecosystem.

The experiment was carried out in a partly managed forest plantation where the tree canopy is considerably closed and uniform and the average height is 13.7 m. The meteorological tower is situated within a valley on a relatively flat section which slopes with an angle of 15° towards south east. The eddy covariance setup consisted of a Young 81000 sonic anemometer and a LI-COR 7500 combined infrared CO_2/H_2O-analyzer (12.5 Hz sample frequency) which was installed at the uppermost platform at 23.4 m.

In this study we examine the influence of fog on the vertical fluxes of CO_2 and water vapour and hence on the microclimate of the endemic cypress forest. A pronounced diurnal wind regime dominates with valley winds from S to SE during the day and downhill winds from N to NW at night. The presence of fog is strongly related to wind directions from SE and S. The occurrence of fog at the study site is very frequent with an average duration of 4.7 to 11 hours per day. During about 25 % of the experimental period, foggy conditions (visibility < 1000 m) were prevailing. Fog affects the physiological conditions of the plants (*Chamaecyparis obtusa var. formosana* and *Chamaecyparis formosensis*) by high air humidity and strong reduction of incoming shortwave solar radiation. Therefore, not only the leaf metabolism but also the development of flowers or fruits for reproduction is influenced. Moreover, a reduced mineral uptake by plants is associated with the minor rate of transpiration during foggy conditions.

The measurements took place in mountainous and rather non-ideal terrain for the eddy covariance approach. Moreover, the presence of fog causes large instrumental difficulties since the optical and sonic measurement techniques are often obstructed by water droplets on the sensing devices. Special effort was employed on quality assurance of the flux data. Only data during steady-state conditions during the 30-min averaging intervals, simultaneously exhibiting a well developed turbulence regime, were used for the calculations of turbulent fluxes. The extent of atmospheric turbulence was determined with help of the friction velocity u*, and the integral turbulence characteristic ITC. In particular during nighttimes, when atmospheric layering was stabile and the turbulence regime poorly developed, the measured fluxes were small. The examination u* lead to the hypothesis that advective downhill fluxes associated with positive momentum flux, e.g. drag from below the canopy occurred at nighttime.

A footprint analysis was applied to evaluate the fluxes and data quality regarding the changing topography and fetch properties of the study site depending on wind direction. A source weight function based on the Eulerian approach was used to identify the surface area influencing the flux measurements. The footprint calculation shows excellent fetch conditions for flux measurements for winds from south easterly direction.

The 30 min averages of CO_2 fluxes ranged between -52.5 µmol m^{-2} s^{-1} and +18.1 µmol m^{-2} s^{-1}, and the median was +2.6 µmol m^{-2} s^{-1}. The net CO_2 flux is hence assumed to be positive, e.g. directed upward. The fluxes proceeded in a pronounced diurnal cycle with negative values for the CO_2 fluxes during daytime representing CO_2 uptake by the plants. At night, CO_2 fluxes were positive, e.g. directed upward resulting from respiration. During foggy conditions, the CO_2 fluxes of both directions were considerably reduced. The water vapour fluxes showed an opposite diurnal pattern with maximum positive values at daytime and minor or even negative fluxes during night times. It ranged between -3.2 mmol m^{-2} s^{-1} and +6.7 mmol m^{-2} s^{-1} with a median flux of +0.9 mmol m^{-2} s^{-1}.

P13

CO_2 FLUX IN TROPICAL AREA IN SOUTHEAST ASIA MEASURED WITH EDDY COVARIANCE METHOD

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We have been observed CO_2 flux at 45 m tower in the Sakaerat Environmental Research Station (here after abbreviated by SKR), Nakhon Ratchasima, Thailand (14°29'29''N, 101°55'05''E, elevation 535 m.a.s.l.) and other two sites in tropical area since 2001. Gamo et al. (2005) reported that the -NEE estimated by eddy covariance method at the top of the tower at SKR in a whole year took a too big value, which cannot be explained with census data analysis. Figure 1 shows the wind rose at the tower in 2004 at SKR. Most of the wind direction is SW, and NE wind appears only in short time during dry season. The nighttime NEE does not increase as temperature rises, because there is clear correlation between temperature and vapor pressure depression (Figure 2).

Figure 3 shows an example of monthly averaged daily variation of CO^2 concentration at the four levels on the tower in June, 2003. This figure suggests there is not so big storage of CO_2 in the canopy and not small amount of CO_2 outflows from the community without being detected by eddy covariance equipments.

Since the surface around SKR is inclined by 6 %, the CO_2 may flow out as drainage flow in the understory in the canopy at night. Takayama site in central Japan is located on a hilltop, and we setup a new 20m tower in a small valley there, the inclination of the slope is approximately 40%. The profile observation at the Takayama tower showed that drainage flow in the understory is generated soon after the sunset and CO_2 rich airmass is restricted below the layer 6 m above the ground. Similar process might be worked in the tropical forests.

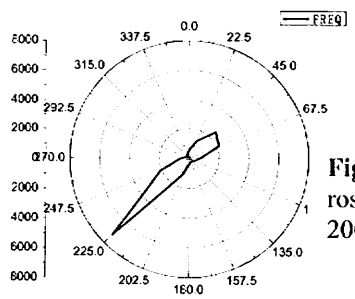

Figure 1 Wind rose at SKR in 2004.

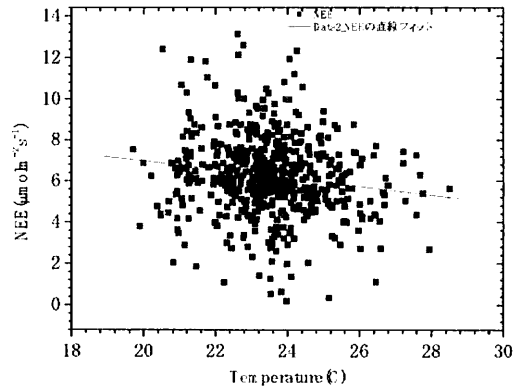

Figure 2 The relation between temperature at 5m above the ground and night time NEE at SKR, wet season in 2004 (for u* > 0.8m/s).

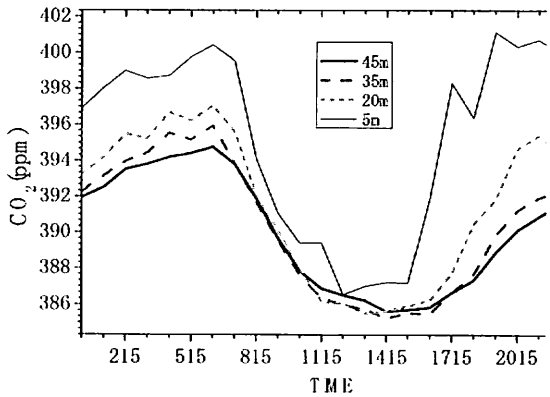

Figure 3 Monthly averaged daily course of CO_2 concentration at SKR, June 2003.

Reference

Gamo, M. et al., 2005: Proceedings of AsiaFlux Workshop 2005, Fujiyoshida, pp.86.

P14

EFFECTS OF MANURE APPLICATION ON CARBON BUDGET OVER MANAGED GRASSLAND IN CENTRAL JAPAN

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In order to investigate the effects of manure application on carbon budget over managed grassland, field experiment has been conducted. The eddy covariance measurements of carbon dioxide (CO_2) were made from September 2004 to August 2006 at grassland in National Institute of Livestock and Grassland Science (NILGS), Nasushiobara, Japan (36°55'N, 139°58'E, 320 m a.s.l.). The annual temperature and precipitation of the experimental site are 12.0°C and 1561 mm, respectively. The vegetation is dominated by orchardgrass (*Dactylis glomerata* L.) and Italian ryegrass (*Lolium multiflorum* Lam.), and the grasses are harvested four times a year.

At the grassland two contiguous plots were provided for the experiment, one for manure application (M-plot) and the other for chemical fertilizer application (F-plot). Composted cattle manure was applied on M-plot after the last harvest of each year (mid-November, 15 Mg ha^{-1} in 2004 and 32 Mg ha^{-1} in 2005). Fluxes of CO_2 were measured with the eddy covariance system, which consisted of a sonic anemometer (CSAT3, Campbell Scientific) and an open-path infrared gas analyzer (LI-7500, LI-COR). The system was installed at each plot with instruments to measure other meteorological variables.

Seasonal trends in CO_2 flux (F_c) of the two plots were similar throughout the observation period: F_c of both plots were kept almost zero during winter season, and, from mid-March, increase of CO_2 uptake with growth of grasses and temporal CO_2 release after harvest were observed. However, in summer season when the temperature was high, values of F_c between the plots were somewhat different: F_c of M-plot shifted toward CO_2 release, especially in 2006.

Each year net biome production (NBP), which represents carbon budget in terrestrial ecosystem, was calculated as a sum of carbon in the net ecosystem production (NEP), exported carbon through grass harvest (C_H) and imported carbon through manure application (C_M). In the first year, integrated value of NEP was larger than C_H in both plots. While NEP was smaller in M-plot than in F-plot, NBP of M-plot was larger than that of F-plot by 0.48 Mg C ha^{-1} due to carbon input through manure application. In the second year, NEP was smaller than C_H in both plots and, manure application taken into account, NBP of M-plot was larger than that of F-plot by 3.68 Mg C ha^{-1}.

Although manure applied on the grassland in autumn was suggested to be decomposed and more CO_2 was released from M-plot than from F-plot during summer season, this study showed that manure application can increase the amount of carbon sequestered to managed grassland in central Japan.

This study was conducted as a part of "Establishment of Good Practices to Mitigate Greenhouse Gas Emissions from Japanese Grasslands", which was organized by Japan Grassland Agriculture and Forage Seed Association and funded by Japan Racing and Livestock Promotion Foundation.

Table Annual carbon budget of the experimental plots

Year	Plot	Carbon budget (Mg C ha^{-1})			
		NEP	C_H	C_M	NBP*
2004-2005†	M-plot	5.27	4.81	1.85	2.32
	F-plot	6.36	4.53	0.00	1.84
2005-2006‡	M-plot	2.72	3.06	3.79	3.45
	F-plot	2.40	2.63	0.00	-0.23

* NBP = NEP - C_H + C_M
† Integrated value from the last harvest of 2004 to the last harvest of 2005 (373 days).
‡ Integrated value from the last harvest of 2005 to the second harvest of 2006 (241 days).

P15

EVAPORATION AND CO_2 EXCHANGE IN MAIZE FIELDS IN SHANXI PROVINCE, CHINA

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We report on collaborative studies of water use and water use efficiency by maize crops conducted in 2005 and 2006 in Shanxi Province, China. The area is semi-arid and crops are irrigated. A micrometeorological flux station has been established in the midst of farmland in Yuci County. In both years, the site has been surrounded by extensive maize fields. Instrumentation includes a 3-D sonic anemometer, an open-path CO_2/H_2O gas analyser, a net radiometer, soil heat flux plates, soil thermometers, soil moisture probes and a recording rain gauge. The instruments and data logger are powered from batteries connected to solar panels. Relevant fluxes of energy, momentum, heat, water vapour, CO_2, and supporting information are measured continuously in 30-min runs. In 2005, measurements were made from May 20 to October 6, covering the period from planting to near maturity. In 2006, measurements were made over a similar period from May 5 to September 26. Highlights have been:

- Energy closure is quite satisfactory, giving confidence in the eddy covariance system. Regressions of the sum of sensible and latent heat (uncorrected for sensor separation or low u_*) on the available energy yielded a regression coefficient of 0.88 with an r^2 value of .853 in 2005 and a coefficient of 0.94 and an r^2 of 0.832 in 2006.
- Evaporation rates were high, averaging 3.2 mm d^{-1} for the whole growing season in 2005 and 2.6 mm d^{-1} in 2006. Maximum rates exceeded 5 mm d^{-1} in both years.
- Total water use was estimated at 440mm over 144 days in 2005 and 374mm over 140 days in 2006.
- Crop CO_2 exchange rates were similarly high, with 24-h averages of -0.17 mg CO_2 m^{-2} d^{-1} for the whole of the growing season in both years. Maximum sequestration rates were near 50g m^{-2} d^{-1}.
- Equilibrium evaporation, E_{eq}(= (s/(s+γ) (R-G_0)),was a good predictor of actual evaporation. Regression analysis yielded $\lambda E = 1.09E_{eq}$, $r^2 = 0.850$ in 2005 and $\lambda E = 1.17E_{eq}$, $r^2 = 0.825$ in 2006.
- Crop CO_2 exchange was closely linked to crop evaporation. For the hours of 0700-1800, water use efficiency, F_c/E, was -3.886 μmol $mmol^{-1}$, with an r^2 value of 0.688 in 2005 and was -3.542 μmol $mmol^{-1}$, with an r^2 of 0.604 in 2006.

The project is yielding valuable basic data for a main cereal crop in the North China Plain.

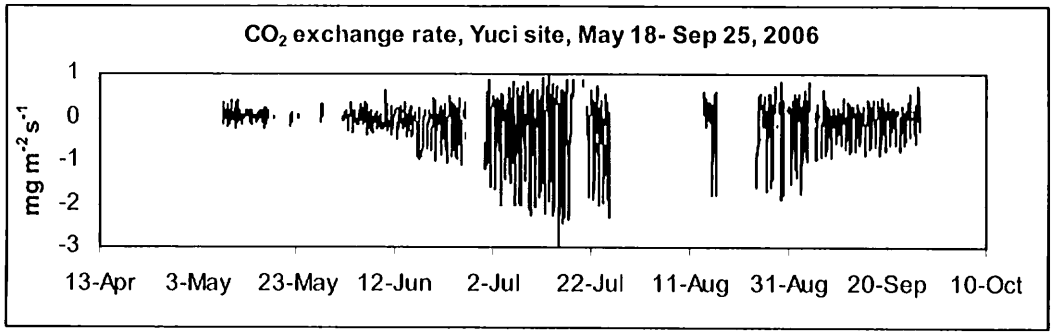

Fig 1. Example CO_2 fluxes. CO_2 exchange shifts from positive to negative as the crop grows.

P16

MICROMETEOROLOGICAL MEASUREMENTS OF GAS EXCHANGE BY SUGARCANE

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Sugarcane is a high-producing tropical crop, but although much studied, there is little documentation of gas exchanges with the atmosphere. High CO_2 assimilation rates are expected because sugarcane is a C4 plant, and high evaporation rates because the crop is grown in wet tropical and sub-tropical regions. However, the high use of nitrogen fertilisers in its production and the same environmental conditions are also conducive to the production and emission of nitrogen gases, most notably the greenhouse gas nitrous oxide, N_2O. We report first results from a project to determine the magnitudes and seasonal patterns of gas exchange from Australian sugarcane crops. Fluxes have been measured using micrometeorological and chamber techniques for the whole of the 2005/2006 growing season on a ratoon crop growing on an acid sulfate soil at Murwillumbah (latitude 28°S) on Australia's east coast. An account will be given of the measurement techniques employed and results from the first year's investigations will be presented. Some notable outcomes of the study are:

- The average CO_2 exchange rate for the growing season was 31.7 g m^{-2} s^{-1}, but soil respiration measurements indicated that net assimilation rates were much higher, approaching 50 g $m^{-2}s^{-1}$
- Over the 350 days of the study, evaporation from the cane averaged 3.1mm d^{-1} for a total evaporation of 1089 mm
- Rainfall for the period was 1879 mm
- The soil was thus frequently wet
- Emissions of N_2O from fields fertilised with 160 kgN ha^{-1} as urea have been large, totalling 41 kgN ha^{-1} over the 350 days; they were greatly stimulated by high soil moisture contents
- Emissions from the unfertilized soil have also been large, amounting to 20 kgN ha^{-1}
- Emissions from the fertilizer thus constituted 13% of the N applied
- This contrasts with the figure of 1.25% commonly used in greenhouse gas inventories
- Net sequestration of CO_2 by the crop from the atmosphere was 110 t ha^{-1}, while the emission of N_2O was equivalent to 20 t ha^{-1} of CO_2.

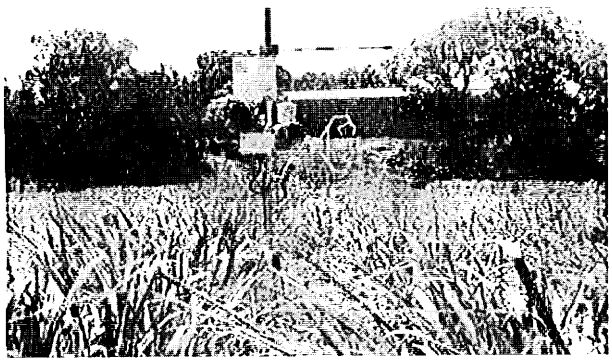

Fig.1. Eddy covariance equipment in sugarcane crop 2m high.

P17

SEASONAL AND INTERANNUAL CHARACTERISTICS AT RAIN-FED PADDY FIELD, THAILAND

D. Komori [1], M. Aoki [2], W. Kim [3], S. Miyazaki [1], J. Cho [1], S. Boonyawat [4], P. Polson [5], S. Pukngam [4], P. Tongdeenok [4], S. Kanae [6], T. Oki [1] and K. Musiake [7]

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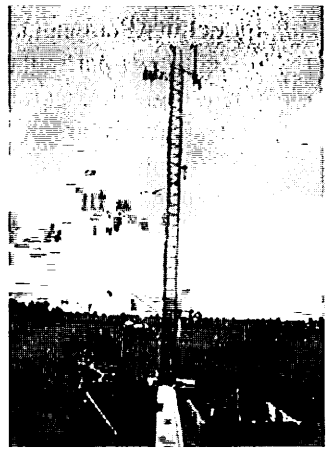

Fig.1 Flux observation site at rain-fed paddy field

To understand surface energy and water balance over paddy field which is main crop in Tropics is pivotal in investigating the interaction between vegetation and atmosphere. Rain-fed paddy field, Sukhothai (17°04′N, 99°42′E, 194 m asl, Fig.1) located at Chaophraya river basin, which is one of the measurement sites as the framework of the GEWEX Asian Monsoon Experiment-Tropics (GAME-T) was selected for measuring heat and water vapor exchanges between biosphere and atmosphere in time and in space using a micrometeorological fluxes measurement method. Sensors were installed on a 10m high tower to measure evapotranspiration (ET), sensible/latent heat flux and micrometeorological data since March 1997. The 7-year data observed continuously by GAME-T at Sukhothai rain-fed paddy field (1999-2005) were analyzed.

From data analysis using hydrologic equation,

(Precipitation) - (submerge water) - (evapotranspiration) = (infiltration) + (runoff) - (influent) *(eq.1)*

it was found the possibility that significant quantities of water may inflow to paddy field (Fig.2). For more understanding water budget, further survey is necessary to figure out the component of the surface water level at rain-fed paddy field in Thailand.

From flux observations, it was found that the submerge water have a significant impact on heat budget (Fig.3). However, it was found that measured data included imbalance which corresponds to 0-30 % of Rn. For more understanding surface energy balance, further systematic research is necessary to figure out the cause of flux imbalance.

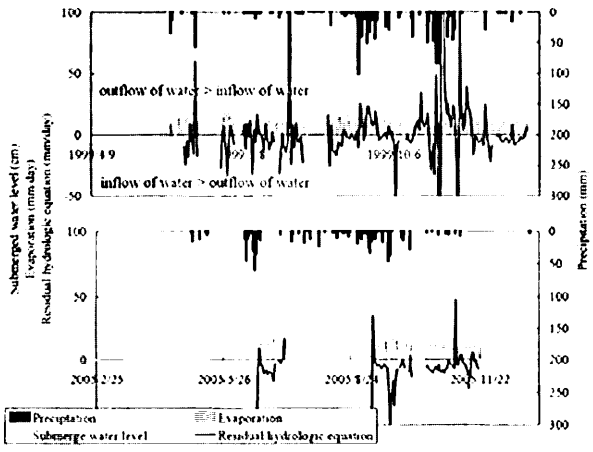

Fig.2 The transitions of the residual hydrologic equation, submerge water level and evaporation in 1999 and 2005.

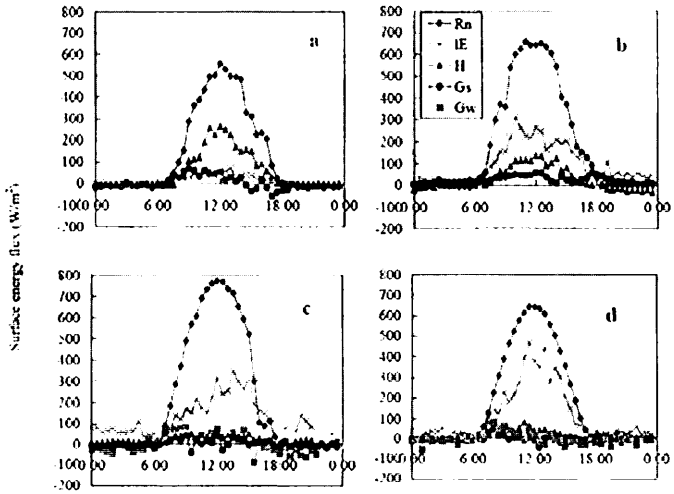

Fig.3 The diurnal change of surface energy flux
a) Feb 10, 2006 b) August 24, 2005 c) September 24,2005 d) October 22, 2005 Rn: net radiation, lE: latent heat flux, H: sensible heat, Gs: surface heat flux in soil, Gw: surface heat flux in water

P18

SEASONAL VARIATIONS IN HEAT AND CARBON EXCHANGES OVER A TEAK DECIDUOUS FOREST IN A TROPICAL MONSOON ENVIRONMENT: A COMPARISON BETWEEN FLUX DATA AND TREE PHENOLOGY

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Energy and carbon exchanges between the biosphere and atmosphere are strongly coupled both with the regional dynamics of climate and atmospheric carbon balance. Significant roles of forest vegetation within regional climate systems have been demonstrated using a regional climate model in inland areas of Indochina Peninsula. The ecological and hydro-meteorological roles of these forests are, however, poorly understood particularly with regard to seasonally dry deciduous forests in the region. Recently, phenological research in a teak deciduous forest in the region revealed that annual growing season length varies greatly among years probably due to inter-annual changes in the seasonal distribution of rainfall. This implies that energy partitioning and carbon exchange in deciduous forests in a tropical monsoon environment fluctuate between years, depending upon the rain-induced inter-annual variation in vegetative tree phenology. We established a flux tower in a teak deciduous forest in Mae Moh plantation, northern Thailand, for the purpose of understanding the seasonal and inter-annual changes in energy and carbon exchange in response to leaf phenology. With this in mind, the current study 1) reports seasonal changes in energy partitioning and carbon exchanges based on the eddy covariance approach, and 2) compares the seasonal changes with tree phenology such as changes in the leaf area index (LAI) and sap flow velocities of dominant trees. The exchanges of energy and CO2 were monitored using an ultra sonic anemometer (USA-1, METEK) and an openpass CO2/H2O analyzer (LI-7500, Li-Cor) mounted on a 40-m tower, as well as the storage flux within the canopy. Sap flow velocities of several teak trees were measured at a nearby site. Seasonal changes in LAI were estimated by transmittance of incident radiation through the canopy, which exponentially decreases with increasing LAI.

Net radiation energy was relatively constant throughout the study period (from October 2005 to July 2006). As expected, latent heat exchange above the canopy was generally high in the growing season and low in the dormant season, while sensible heat exchange was low in the growing season and high in the dormant season. The sap flow velocities declined approximately 1 month earlier than leaf-shedding of the teak trees. The decline in latent heat transfer to the atmosphere coincided more with the decrease in sap flow velocities than leaf shedding, while in contrast, activated latent heat exchange was occasionally observed from the leafless season to the beginning of the leaf-out season. This was likely caused by evaporation form the soil, which was wetted due to rainfall in the pre-monsoon season. Uptake of CO2 in the daytime was largest in the mid-growing season (June and July) and lowest in the late dormant season (February and March). Slight daytime uptake of CO2 was observed in the late dry season despite the fact that the studied forest is fully deciduous with only a few evergreen trees and shrubs. In conclusion, this study revealed distinct seasonal variation in energy and carbon exchange in response to the seasonal change in LAI in a deciduous teak forest in northern Thailand. Our results suggest that the large inter-annual variation in vegetative phenology will cause large fluctuations in the annual energy and carbon budget of deciduous forests in tropical monsoon regions.

Seasonal variation of CO_2 flux and its comparison with biomass measurement at a rice paddy field in Japan

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Rice paddy field is one of the most popular cultivation patterns in East Asia under a monsoon climate, which takes a great important role in CO_2 uptake. From this view, measurements of the Net Ecosystem Production (NEP=-NEE: Net Ecosystem Exchange) were conducted using eddy covariance method at several paddy fields. And the results were compared with Net Primary Production (NPP) estimated from biomass measurement.

In this study, measurements were conducted at the Hachihama experimental farm of Okayama University, Japan (34°32'16"N, 133°55'39"E, 2m a.s.l.) during growing season in 2005 and 2006. NEE was estimated after quality check and gap filling data obtained by eddy covariance method. Quality tests were applied in order to check the validity of the data and to eliminate erroneous data, and Gross Primary Production (GPP) and Respiration (Re) were separated by Non-Linear Regression Method. Nighttime Re (NEE in nighttime) was fitted by an exponential function of temperature and it was applied to the daytime Re, and also GPP was expressed as a rectangular hyperbolic function of incident PAR. Biomass was sampled on budding and at 2-weaks intervals until harvest in both years. Samples were clipped to above and below ground biomass from two 0.5m×0.6m plots randomly located in the field. Weights of samples were measured after dry process of 100°C at the first 2 hours and the next 48 hours by 80°C. Then, total biomass in carbon was estimated dry weight multiply by rate of carbon content. Rice paddy field, which has flat, relatively homogeneous canopy density and short canopy height, is suitable for applications with eddy covariance method, and biomass measurement in paddy fields is easier than that of forest ecosystems. Therefore, we can evaluate the integrated value of NEP in growing season through the comparison with NPP estimated from biomass measurement and heterotrophic respiration.

Using these data, we obtained the following results in 2005: (1) Rice paddy field was a source of CO_2 for the first 27 days of the growing period. NEE in 2005 was turned negative on 13 June, and decreased until maximum CO_2 uptake about 35 $gCO_2\ m^{-2}\ d^{-1}$ at 6 August as shown in Fig.1. Then, NEE was gradually increased and turned positive before harvest, (2) GPP, Re, and NEP integrated over the growing period in 2005 were 2979, 1385, and 1594 $gCO_2\ m^{-2}$, respectively and (3) Total biomass increased gradually and reached 638 gC m^{-2}, and cumulative NEP before harvest was 483 gC m^{-2} in 2005 as shown in Fig.2. In the lecture, we will explain about the results in 2006 and discuss about the differences in 2005 and 2006.

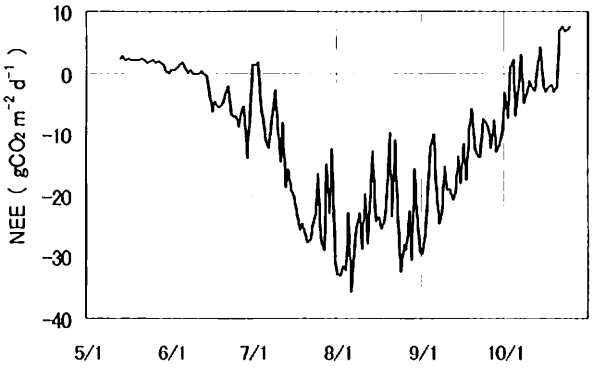

Fig.1 Temporal variation of NEE during glowing season in 2005.

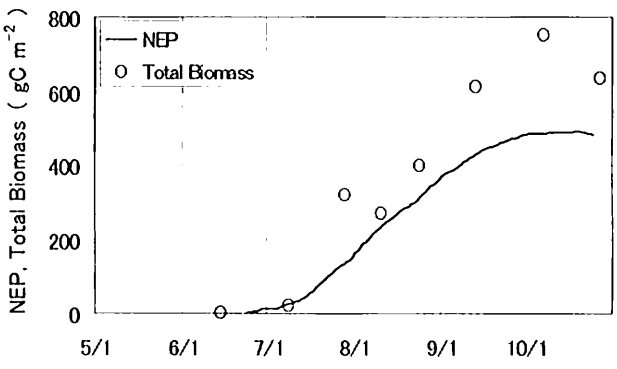

Fig.2 Comparison of integrated NEP with total biomass during glowing season in 2005.

P20

UNDERSTANDING OF WATER AND CARBON EXCHANGES IN GWANGNEUNG FOREST, KOREA IN 2003 AND 2004 BASED ON INTERDISCIPLINARY APPROACHES

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Precipitation in 2003 and 2004 showed a significant difference in magnitude and pattern and accordingly made an impact on the temporal variation of radiation and air/soil temperature in Gwangneung forest. The greater amounts of precipitation in 2003 resulted in the absence of a typical dry spell during the early and late growing seasons. We report water and carbon exchange based on interdisciplinary approach conducted by CarboKorea and HydroKorea projects. We conducted various measurements and analyses such as micrometeorological, chamber, leaf carbon isotope, leaf nitrogen content, biometric, and satellite data. Based on the measured *NEE* and *PAR*, the light use efficiency (*LUE*) was compared for the two years. Due to frequent power and instrument failures in 2004, the tower flux data were available only from 28 May to 14 June during the growing season. The α (initial slope) was similar in both years with values ranging from 0.4 ~ 0.5. However, maximum CO_2 flux (NEE_{max}) was smaller in 2004 (32 ~ 54 μ molm^{-2}s^{-1}) than in 2003 (45 ~ 61 μ molm^{-2}s^{-1}). The chamber measurements of soil CO_2 efflux indicated a significant reduction (~20%) of soil respiration in 2004 compared to that in 2003. Soil CO_2 efflux from May to October was 618 g C m^{-2} in 2003 and 477 g C m^{-2} in 2004. Seasonally averaged carbon isotope discrimination (Δ) of *Quercus serrata* (konara oak) leaves grown at the canopy top was 18.7±0.5 ‰ in 2003 and was higher (20.1±0.5 ‰) in 2004. Averaged Δ of *Q. serrata,* which were always lower than those of *Carpinus laxiflora* (red-leaved hornbeam), also were higher in 2004 (21.8±0.9 ‰) than that in 2003(20.7±0.3 ‰). WUE (Water Use Efficiency) of *Q. serrata* from carbon isotope discrimination ranged from 7 to 17mmol/mol and that of *C. laxiflora* ranged from 6 to 14mmol/mol during growing season in 2003. In 2004, it was impossible for WUE to be calculated due to loss of vapor pressure deficit. The nitrogen concentration was consistently lower in 2004. It is unlikely that there has been a significant change in nutrient supply/availability in 2003 and 2004. Diameter at breast height (DBH) measurements indicated that the growth rates of *C. laxiflora* and *C. cordata* in 2004 were consistently lower than those in 2003 ($P < 0.05$), while the growth rates of *Q. serrata* showed no significant difference. When the raw MODIS *GPP* image was utilized, the *GPP* in 2003 was 1027 g Cm^{-2} which was comparable to 1019 g Cm^{-2} in 2004. When these bad data were excluded, the mean *GPP* in 2004 was smaller than in 2003 by ~5%. Micrometeorological, chamber, biometric and isotopic measurements represent widely different temporal and spatial scales and measures but seemed to indicate a consistent ecosystem trait for Gwangneung forest during 2003 and 2004. Ecosystem processes occur at diverse temporal and spatial scales and therefore, single observation with limited scales often induces incomplete understanding. It is clear that the mutually consistent and complementary nature of interdisciplinary approaches presented above would provide greater advantages in studies for the ecosystem carbon and water exchanges in heterogeneous and complex landscapes.

This study is supported by "The Eco-Technopia 21 Project" from the Ministry of Environment, Korea and by a grant (Code: 1-8-2) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program.

P21

MEASUREMENT OF CO_2 EXCHANGES IN A PEANUT FIELD: RESPONSES TO WATER STRESS

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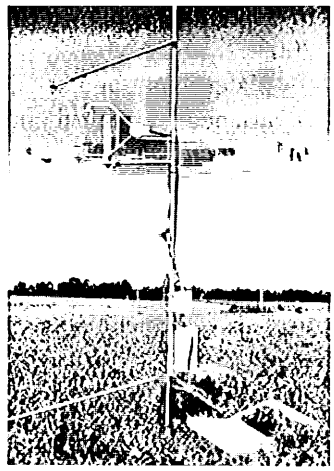
Peanut (*Arachis hypogaea* L.) is susceptible to drought stress of different duration and intensities for some period of the growing season and so plant water stress is one of the most critical abiotic factors limiting peanut yield. As climate change and land use cover change progress rapidly especially in Asia, water stress becomes a main concern of farmers even though it is grown in regions with abundant rainfall or irrigation. It is also important to decide how to distribute water to agricultural and urban areas. For meeting such demands, it is necessary to understand the peanut's response to water stress in relation to microclimates. In particular, autotrophic and heterotrophic respirations react differently to changes in environmental conditions. It is, therefore, crucial to get more insight into the response of both components of soil respiration (autotrophic and heterotrophic) to water stress. This study examines the role of ecosystem respiration rate and NEE (Net Ecosystem Exchange) and theirs relationships with environmental stress.



During crop year 2005, micrometeorological measurements were carried out over a non-irrigated peanut field near Vienna, Georgia. The fluxes of CO_2 and H_2O vapor were measured by the eddy-covariance technique. Environmental parameters such as wind direction and speed, air temperature and humidity, solar and net radiation, soil temperature, soil moisture, soil heat flux, and rain were also monitored. For separating soil respiration into autotrophic and heterotrophic respiration, we added the CO_2 gradient method and the root-exclusion method in 2006. Preliminary results show that ecosystem respiration is sensitive to air temperature. We also found that ecosystem respiration was a well-behaved function of soil moisture throughout the plant's life cycle.

P22

SEASONAL AND INTERANNUAL VARIATION IN EVAPOTRANSPIRATION AND ENERGY BALANCE OVER A LARCH FOREST

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The energy and water exchanges between terrestrial ecosystems and the atmosphere are strongly affected by vegetation on the surface. A grasp of these exchanges over a larch forest is important to understand Asian forest ecosystem, because larch is widely distributed from tundra to temperate zone in Asia.

The study site, Tomakomai Flux Research Site in Hokkaido, Japan (42°44'N, 141°31'E), was located in a larch plantation at a distance of more than 10 km from human habitation. The stands were about 45 years old and covered over 100 ha. The topography was almost flat with very little undulation. The canopy height was approximately 16m above the surface. We had measured water vapor and heat fluxes for more than three years before a disaster by a typhoon in September 2004. In this study, we analyzed flux data from 2001 to 2003.

Water vapor and sensible heat fluxes were measured using an eddy covariance system mainly consisting of a three-dimensional sonic anemometer-thermometer (DA600-3TV, Kaijo Corp.) and an open-path IRGA (LI7500, Licor Inc.).This system was installed at 27m height on the 42m-high tower. Meteorological factors were also measured on the tower and forest floor.

Figure 1 shows the closure of energy balance to check the quality of flux measurement using the eddy covariance method. Eddy energy flux, which is the sum of sensible heat flux (H) and latent heat flux (lE), accounted for 93% of available energy, which is the sum of net radiation (R_n) and ground heat flux (G). There is no remarkable difference in this tendency among three study years.

Seasonal variation in H was almost similar among three study years (Fig. 2(a)), however, lE in the growing season in 2001 was less than those in 2002 and 2003 (Fig. 2(b)) by more than 25%. Table 1 shows cumulative H, lE, R_n, G and precipitation, and mean leaf area index (LAI) from May through October. There is no significant difference in net radiation between three years, however, the other energy fluxes in 2001 differed significantly from those in 2002 and 2003. LAI in 2001 was less than those in 2002 and 2003; the small LAI probably resulted in the small lE in 2001.

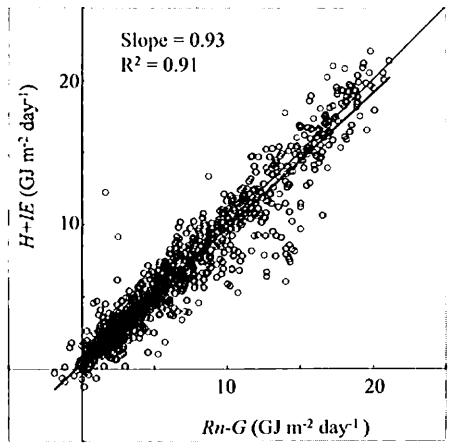

Fig. 1 The relationship between (H+lE) and (R_n -G)

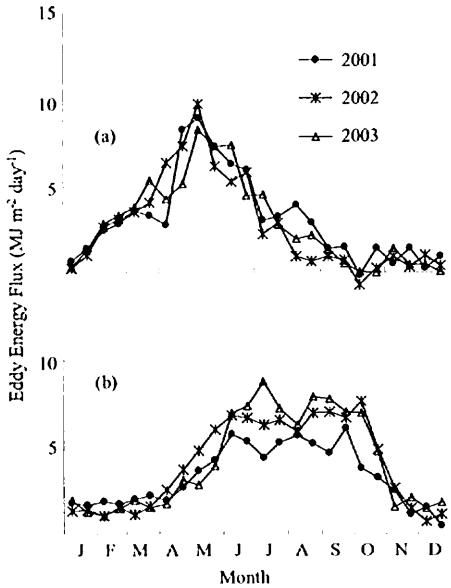

Fig. 2 Seasonal and interannual variation in H (a) and lE (b).

Table 1 Cumulative H, lE, R_n, G and precipitation, and mean LAI in the growing season from May to October.

		2001	2002	2003
Sensible Heat Flux	MJ m^{-2}	706.5	539.9	629.4
Latent Heat Flux	MJ m^{-2}	876.1	1167.1	1190.5
Net Radiation	MJ m^{-2}	1616.5	1655.5	1698.7
Ground Heat Flux	MJ m^{-2}	22.9	19.5	17.9
Precipitation	mm	929.5	729.3	773.3
LAI (mean)	m^2 m^{-2}	3.1	3.4	3.3

P23

ENERGY AND WATER FLUX OBSERVATION OF IRRIGATION PADDY FIELD IN PHITSANULOK, THAILAND

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Khon Kaen University Thailand
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The energy balance and actual evapotranspiration (water flux) of irrigation paddy field in Phitsanulok province, Thailand, was installed with the automatic weather station (AWS). The measurement of energy balance using Bowen ratio technique were collected during 2002 to 2003. The results showed that the net radiation(Rn), the latent heat flux (LE) and the sensible heat flux (H) were 411.3, 368.5 and 70.43 W/m^2. The results of evapotranspiration were found that in paddy field the average AET were 6.16 mm/day while the pan evaporation (Epan) was 4.32 mm/day respectively. In planting season the average AET were 493 and 525 mm/day, while Epan were 477 and 318 mm/day respectively.

P24

ENERGY BALANCE OF A TROPICAL PEAT SWAMP FOREST IN KALIMANTAN, INDONESIA

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Tropical peat swamp forests grow over tropical peatlands, which are widely distributed in flat lowlands in Southeast Asia. Since the 1970s, however, deforestation and drainage have progressed on an enormous scale because of growing demands for timber and farmland. In addition, El Niño and Southern Oscillation (ENSO) drought and its consequent fires are accelerating the forest devastation. The forest devastation alters energy balance and will influence regional climate. Thus, we have measured eddy energy fluxes above a tropical peat swamp forest left in a devastated peatland in Central Kalimantan, Indonesia since November 2001. Both in the rainy and dry seasons, latent heat flux (lE) considerably exceeded sensible heat flux (H). Net radiation (R_n) was mainly used by evapotranspiration (ET). An ENSO event occurred in 2002, and the consequent drought caused large-scale peatland fires in Central Kalimantan. A large amount of smoke emitted from the fires decreased R_n from mid-August through October. Bowen ratio (H / lE) decreased gradually from January through July in the range of 0.20–0.35. Although Bowen ratio decreased to a minimum of 0.15 in late September, it continued to increase during the late fire period and was high at 0.35–0.45 after the fires. ET accounted for 67 percent of precipitation (1856 mm) on an annual basis in 2002. Annual mean daily ET was 3.4 mm d^{-1}.

P25

PROFILING OF VERTICAL DISTRIBUTION OF CO_2 IN FOREST CANOPY

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The estimation of temporal variation of net ecosystem CO_2 exchange requires precise measurement of CO_2 flux. The eddy covariance (EC) method is common technique for measuring CO_2 flux above forest canopy. Recently, some measurement systems are commercially available as complete-kit forms and no special skill for installation and maintenance is needed for the EC measurements. Temporal change in CO_2 storage below the forest canopy is regarded as one of the flux components, but it cannot be observed by the EC measurements. Especially under the condition that air column is stable, measurements of the CO_2 storage is critical to evaluate ecosystem CO_2 exchange flux precisely. We developed a new measurement system for the CO_2 storage observation and installed it in the Fuji-Hokuroku Flux Observation site in Japan. Our new system measure CO_2 mixing ratio of air at 10 height levels in a sequential order with frequency of 2minites/1cycle. The flow-path and flow-rates of sample air are optimized to minimize cross contamination inside the system and to maximize the time-representativeness of each measurement. The gas analyzer was calibrated with four standard gases every 2 hours interval. The CO_2 mixing ratio of standard gases were determined to be the same scale as that used in baseline atmospheric CO_2 measurements. In this presentation, we introduce features of our newly developed system and results from measurements at the site.

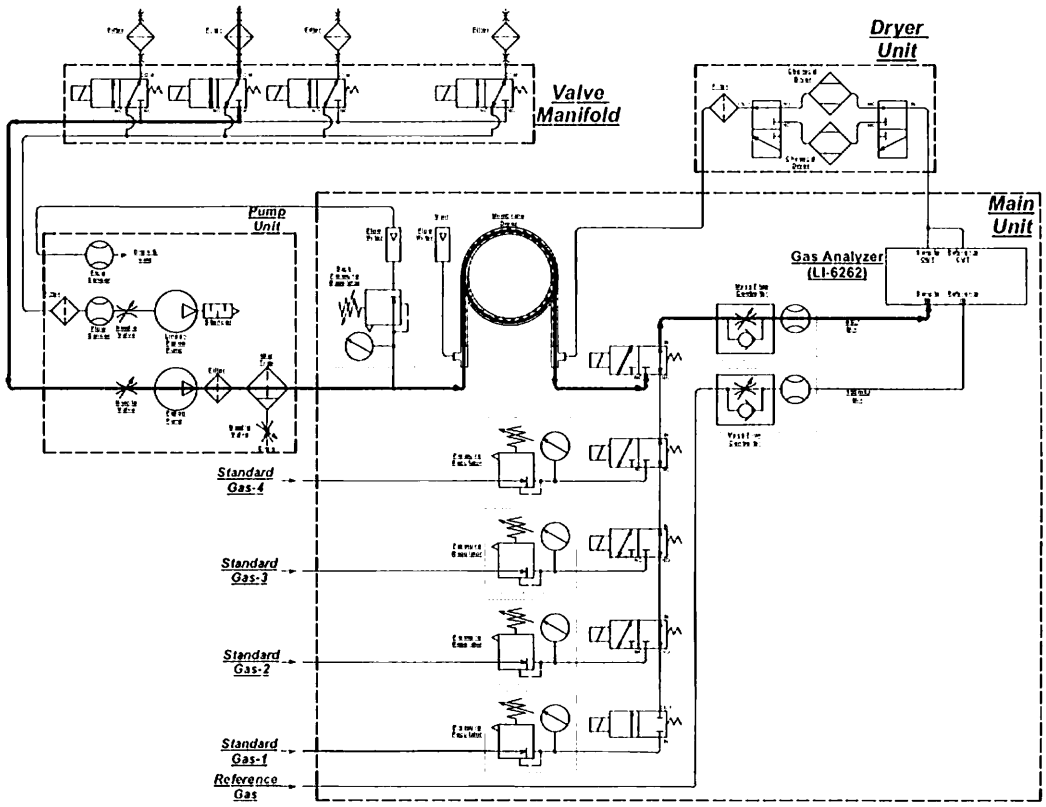

Figure 1. Schematic diagram of the CO2 profiling system installed in the Fuji-Hokuroku Flux Observation site.

P26

CO_2 CONCENTRATION PROFILE WITHIN A CANOPY OF A TROPICAL RAIN FOREST IN MALAYSIA AND A TEMPERATE CYPRESS FOREST IN JAPAN

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Globally, one of the most important interactions between terrestrial ecosystems and the atmosphere is the transfer of CO_2. Although the magnitude of the CO_2 exchange process varies from place to place, generally, CO_2 exchange between forest and the atmosphere is evaluated using the eddy covariance method. However, stored CO_2 in forest may not be negligible, especially in a tall canopy. Over a scale of 1 day or more, the change in CO_2 storage (S_c) is very small, but over a shorter timescale, S_c may be very large under certain conditions; therefore, it is necessary to measure S_c and evaluate its contribution to eddy flux (F_c). In the air space within a forest, the meteorological environment varies from the forest floor to the canopy top, and vertical profiling is critical in determining the process of CO_2 exchange. Thus, we conducted CO_2 concentration ($[CO_2]$) profile measurements continuously in a tropical rain forest and a temperate cypress forest. We then examined the daily vertical transition of $[CO_2]$ phases, the contribution of S_c to F_c, and differences between the forests.

Site and Methods

The tropical rain forest site was located at the Pasoh Forest Reserve (PFR), Negeri Sembilan, in Peninsular Malaysia (2°58' N, 102°18' E). The core area (600 ha) of the reserve was covered by a primary lowland mixed dipterocarp forest, which consisted of various species of *Shorea* and *Dipterocarpus*. The continuous canopy height was approximately 35 m, although some emergent trees exceeded 45 m. The total leaf area index (LAI) estimated from tree diameter observations was 6.52 (Niiyama, unpublished data). The annual mean air temperature was 26.6°C and the annual precipitation was 1630 mm during 2004/2005.

The temperate cypress forest site was located at the Kiryu Experimental Watershed (KEW) in Shiga Prefecture, Japan (34°58' N, 136°00' E). The site was mainly covered by *Chamaecyparis obtusa* Sieb. et Zucc., an evergreen conifer. The canopy height was approximately 18 m and the LAI ranged from 4.5 to 5.5. The annual mean air temperature was 12.9°C and the annual mean precipitation was 1639 mm from 2003 to 2005.

We measured wind speed and $[CO_2]$ at 10 Hz using a three-dimensional sonic anemo-thermometer and an open-path infrared gas analyzer (IRGA) at 54 m in the PFR and 28.5 m in the KEW and calculated F_c using the eddy covariance method. The reference frame of the covariances was rotated for every 30-min flux measurement to align the flux perpendicular to the mean streamline. The Webb–Pearman–Leuning (WPL) correction was applied for the effect of air density fluctuations. $[CO_2]$ profile measurements were conducted at several heights at both sites. Air samples for $[CO_2]$ measurements were drawn continuously from each inlet at ten levels in the PFR and five levels in the KEW to a closed-path IRGA through a polyethylene tube. The IRGA was located in an observation house on the forest floor. The IRGA was automatically calibrated daily using zero concentration gas (N_2). Switching between canopy heights was controlled by a control port module and a series of solenoid valves. The $[CO_2]$ at each height was determined every 30 min. These measurements were performed intermittently from September 2004 to November 2005 in the PFR and from March 2006 to September 2006 in the KEW.

Results and Discussion

At both sites, the daytime $[CO_2]$ was lower than that at night because of photosynthetic CO_2 uptake in the daytime and plant and soil respiratory CO_2 efflux and its accumulation at night. The soil surface $[CO_2]$ was always higher than that at any canopy level. At the KEW, S_c was largest in summer due to high soil respiration and plant assimilation. In contrast, obvious seasonality was not observed at the PFR. The diurnal fluctuation in the $[CO_2]$ at each height was larger in the PFR than in the KEW, indicating that the S_c at the PFR was larger. Indeed, the negative peaks of S_c were -12.7 μmol m^{-2} s^{-1} (78% of the negative peak of F_c, overall average) for the PFR and -2.9 μmol m^{-2} s^{-1} (16% of the negative peak of F_c, July average) for the KEW. The tall canopy and large LAI in the PFR may have caused this difference.

P27

FLUX DATA QUALITY CONTROL OF TAK FLUX MEASUREMENT STATION

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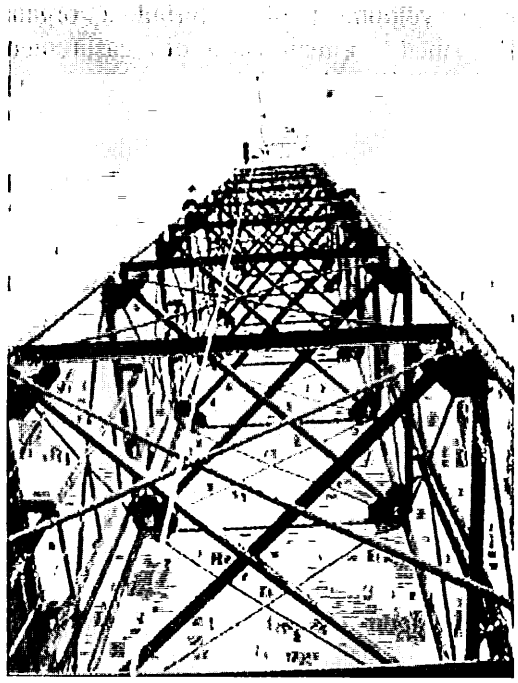
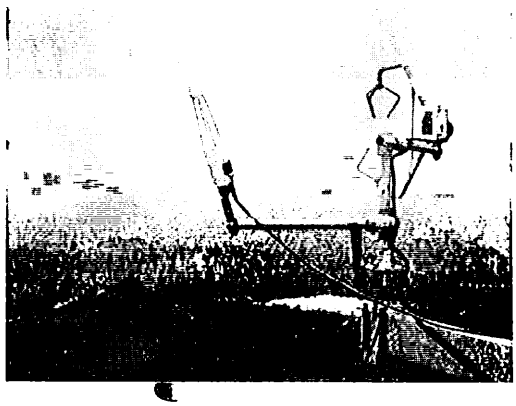
The experimental site (latitude: 16°56'N, longitude: 99°25'E), named Tak Flux Measurement Station (TFMS), is located about 20 km east of Tak and 50 km west of Sukhothai in the northwest part of Thailand. The TFMS is essentially a flat area of about 100 km^2 and 130 m higher than sea level. The fetch is more than 10 km with gently undulating hills with about 20 m differences in height. The climate of the experimental area is divided into wet and dry seasons as a part of the Southeast Asia Monsoon region. The onsets of the wet and dry seasons are in May and October, and the mean temperatures of each season are about 27°C and 31°C, respectively. The total annual precipitation is about 1200 mm.



The zonobiome of TFMS is the humido-arid tropical summer-rain region with deciduous forests by Walter classification (1994). Vegetation type is a mixed wet-deciduous forest with trees 20-25 m tall (e.g., *Tectona*, *Shorea* and *Dipterocarpus*) (Ruangpanit, 1995) and a sparse covering of grass with about 4.0 leaf area index. However a secondary forest matures on the fallow patches within about 10-20 years, due to exploitation by the population for shifting cultivation (Ogawa et al., 1971). According to our recent survey, the vegetation consists of 60% 10-15 m tall deciduous trees with 3-5 LAI, and 40% agricultural area cultivating rice, corn et. al.

The eddy covariance technique to measure the sensible and latent heat, and the carbon dioxide (CO_2) fluxes is used at the TFMS, Thailand. In applying the technique, two sets of instruments, consisting of three dimensional sonic anemometers (CSAT3, Campbell Scientific, Inc.) to measure wind velocity fluctuation and an open path CO_2 / H_2O gas analyzer (LI7500, LI-COR, Inc.) to measure vapor pressure and CO_2 fluctuation. They are mounted at the end of booms located at 30 m and 100 m levels attached to a 120 m climbing tower. The boom is able to fold for sensor maintenance and extends 2 m beyond obstacles. The length is 2 times longer than lateral dimension of tower to minimize wind flow distortion. Leveling of CSAT3 is carried out before the boom is opened and LI7500 is tilted 20 degrees to the north to prevent a radiation effect.



In terms of data quality control, several reports are available for assessment of high quality data (Vickers and Mahrt, 1996; Foken and Wichura, 1996; Falge et al., 2001; Lee et. al., 2004). It is important that those methods are applied to data processing in order to determine heat, energy and CO_2 fluxes using the eddy covariance technique. In this presentation, the methodical characteristics and experimental results of data quality control at TFMS from 2002 to 2006 are discussed in this presentation.

P28

SPATIAL AVERAGING EFFECT ON FLUX MEASUREMENT BY A SCINTILLOMETER APPLIED ONTO A FOREST CANOPY

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Development of a turbulent organized structure (TOS) is described as a main cause of measurement error in cases where the turbulent flux above a forest canopy is measured at a single tower. It is presumed that spatially averaged flux cannot be obtained solely from the temporal averaging of the eddy-covariance term because of the development of local vertical advection is caused by the TOS. We used two sets of eddy-covariance (EC) systems during May--November 2005 at 86-m intervals in a mixed deciduous forest (dominant species is Japanese mountain birch) of 18 m height with 28-m towers. Results showed apparent spatial variation of the turbulent flux between two towers of separated by 86 m; the energy imbalance of flux measurements increased concomitant with the increase of spatial variation of turbulent flux. The above-mentioned presumption was supported experimentally.
A mobile elevated working platform was used as an additional tower to establish a double orthogonal measurement path of the displaced-beam small aperture scintillometer (DBSAS). The averaged energy imbalance of heat flux measured using the two EC changed according to the difference of averaged dissipation rates between the DBSAS and the EC. Positive correlation between the dissipation rate of temperature fluctuations and the source area was apparent from simultaneous observations of orthogonal DBSAS. Although limited to measurements of the dissipation rate of temperature fluctuations, the spatial averaging effect of DBSAS was confirmed.

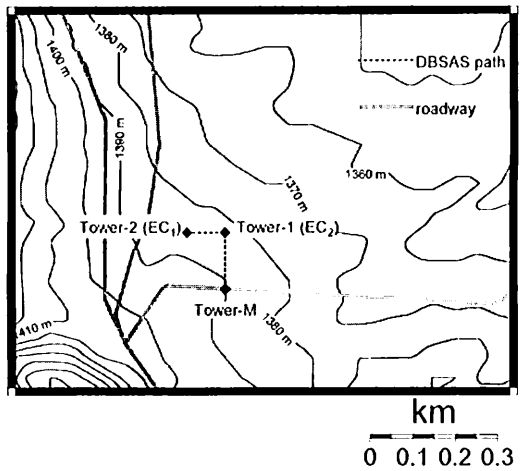

Fig 1. An overview of the experimental site and the tower arrangement for simultaneous measurements of DBSAS and EC

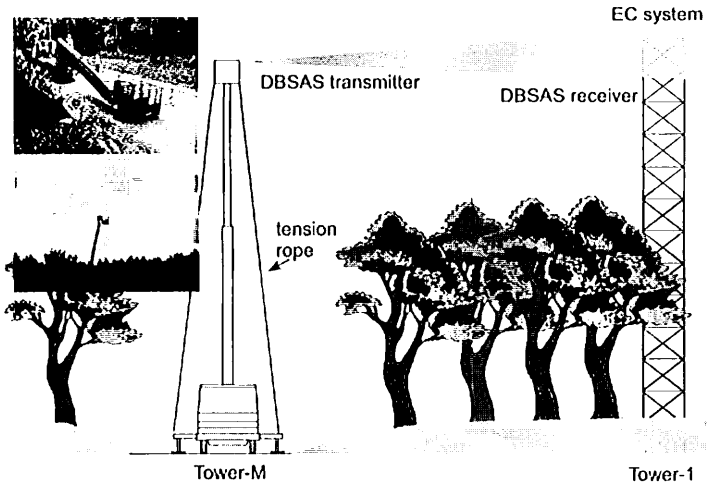

Fig 2. Mobile elevated work platform as an additional tower for the DBSAS

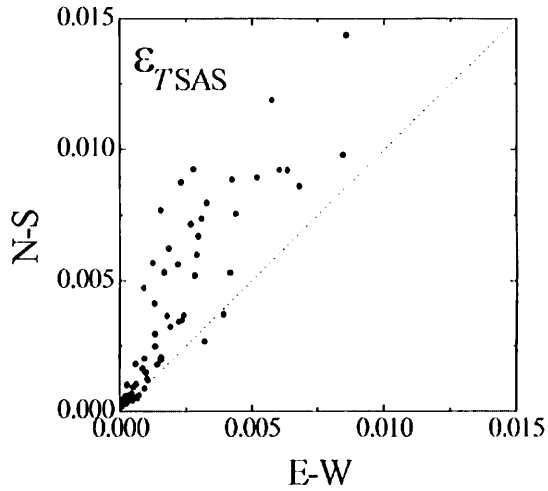

Fig 3. Comparison of the dissipation rate of temperature fluctuations between orthogonal paths of DBSAS

P29

EFFECT OF CORRECTION OF SONIC ANEMOMETER ANGLE OF ATTACK ERRORS ON EDDY FLUXES OVER BOREAL AND COOL TEMPERATE FORESTS

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From a previous study, ultrasonic anemometers have been shown to suffer errors depending on the angle of attack α (°), which is the angle between the wind vector and the horizontal (Gash and Dolman, 2003; van der Molen *et al.*, 2004). Building on the previous work of van der Molen *et al.* (2004), we propose an improved method of correcting for the angle of attack error resulting from the imperfect (co)sine response of ultrasonic anemometers which gives a closer representation of their wind tunnel calibration data for R2- and R3-type Solent ultrasonic anemometers (Gill Instruments, Lymington, UK) (Nakai *et al.*, 2006).

This correction method was applied to field data from four forests: a larch forest (YL) and a pine forest (YP) in Spasskaya Pad, near Yakutsk, Russia (boreal forests), a birch forest (MB) and a conifer-broadleaf-mixed forest (MM) in Moshiri , Hokkaido, Japan (cool-temperate forests). R3-50 Solent ultrasonic anemometers (Gill Instruments) and LI-7500 open path infra-red gas analyzers (LI-COR, Lincoln, USA) were used there.

The effect of the correction on the eddy fluxes was evaluated by linear regression through the origin using summer data (JJA) of 2004 (YL, YP) and 2005 (MB, MM). Figure 1 shows the increments in eddy fluxes (sensible heat flux, H, latent heat flux, lE and CO_2 flux, F_c) against $(z - d) / z_0$ (where z is measurement height, d is zero-plane displacement and z_0 is roughness length). The increments depend on $(z - d) / z_0$ and are larger over rough forest than over smooth forest, as would be expected from the analysis of Gash and Dolman (2003). For the MB site, however, the increments were larger than for the YL and YP site despite a larger $(z - d) / z_0$. MB site is located near a mountain ridge and has an inclination to the west (about 4°), and hence this slope might affected these relatively large increments.

Figure 2 shows the comparison of uncorrected and corrected accumulative net carbon fluxes at the MB site in 2005. Annual net carbon uptake was increased from −4.26 to −4.67 (tC ha^{-1}) due to this correction. This increment of 9.6% is larger than the increment on 30 minutes' data evaluated by the linear regression using whole data (7.9%), daytime (8.1%) and nighttime data (5.1%). It seems the smaller effect on uptake flux (nighttime) compared with that on downward flux (daytime) has a positive effect on the accumulated annual carbon flux, and hence the effect of the correction on annual flux was larger than that on 30 minutes' data.

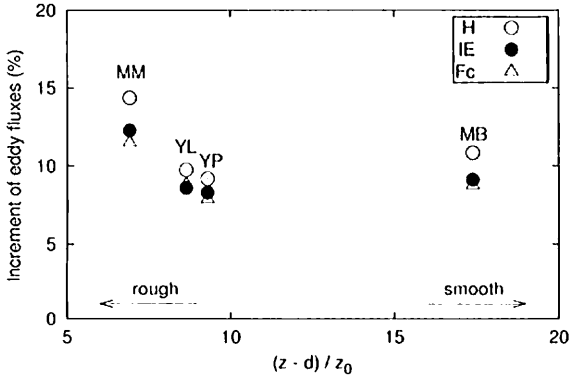

Fig 1. Plot of increments of eddy fluxes by correction against $(z - d) / z_0$.

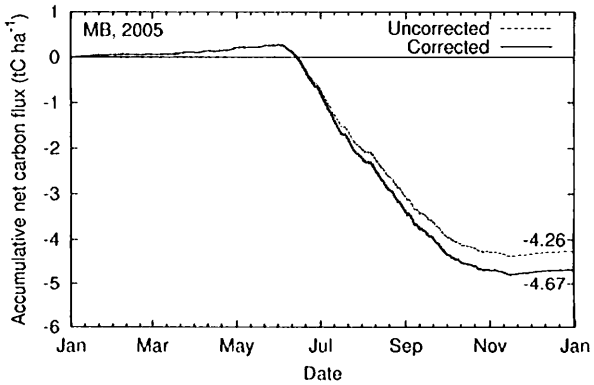

Fig 2. Comparison of uncorrected and corrected accumulative net carbon fluxes in MB (2005).

P30

LOCAL TEMPERATURE FLUCTUATIONS IN THE VICINITY OF AN OPEN-PATH GAS ANALYZER

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Introduction The WPL correction (Webb et al., 1980) postulates that all the variables involved in the correction are measured at the same point. In the strict sense, however, this is rarely satisfied in practical field measurements because the covariances in the WPL correction are usually measured with the separate two instruments, a sonic anemometer for sensible heat and an open-path gas analyzer for gas densities. Several studies recently published have discussed the prerequisite in association with unrealistic CO_2 uptake observed in dormant season with open-path eddy covariance (Burba et al., 2006; Ono et al., *submitted*). Ono et al. (*submitted*) found that unrealistic CO_2 uptake resulted from an artifact of open-path eddy covariance comparing with the closed-path eddy covariance and chamber methods, and then concluded that the WPL correction with the two instruments was not applicable to their measurements in some cases. Burba et al. (2006) indicated that the WPL correction could fail due to heat from the surface of an open-path gas analyzer and suggested a practical procedure to correct it. However, no studies have directly demonstrated that sensible heat fluxes measured with a sonic anemometer differ from those at the optical path of a colocated open-path gas analyzer when CO_2 uptake is apparent. We have challenged this since 2004 at a paddy field in Japan, and obtained substantial results from our recent experiment, which are presented in this study.

Method An ordinary instrumentation was employed for eddy covariance: a 3-D sonic anemometer-thermometer (CSAT3; Campbell Scientific, USA), an open-path infrared gas analyzer (LI-7500; LI-COR, USA), a closed-path infrared gas analyzer (LI-7000; LI-COR, USA). All digital singals from those instruments, including diagnostic data, were sampled at 20 Hz and stored in a data logger (CR5000; Campbell Scientific, USA). Fine-wire K-type thermocouples with a diameter of 0.025 mm (ANBE SMT, Japan) were placed near the center of the sonic path and at 3 different points in the optical path of the open-path gas analyzer. Signals from the thermocouples were also recorded with the logger at 20 Hz. Surface temperature of the open-path gas analyzer and other micrometeorological variables were also measured. We carried out the measurement at a paddy (36.05°N, 140.03°E) in March and April of 2006 and obtaied 18-day data. During the period there were few active plants in and around the paddy, which implied that only soil respiration could contribute to atmospheric CO_2 flux. All statistics in this study were calculated every 600 s by block averaging.

Results For the sake of the subsequent analyses we compared temperature fluxes derived from the sonic anemometer with those from the colocated fine-wire thermocouple. After the water-vapor correction, those temperature fluxes did not differ except under windy conditions. With mean horizontal wind velocity over 10 m s^{-1}, the sonic anemometer overestimated sensible heat flux by 20 W m^{-2} on average, but did not mean air temperature. The difference in sensible heat flux was equivalent to approximate 1 μmol m^{-2} s^{-1} in the WPL correction. Consequently data that were collected under windy conditions, $\geqslant$ 8 m s^{-1}, were excluded from the present analyses. Temperature fluctuations measured by the 4 fine-wire thermocouples were not different in phase and amplitude except in calm and clear sky daytime, when temperature fluctuations at the lower part of the optical path of the open-path gas analyzer were greatly increased and sometimes exceeded those at the sonic path by up to 180 W m^{-2}. Other parts such as the middle and upper spaces of the optical path, however, did not show such increased fluctuations. The local heat transports at the lower part of the optical path were also obvious in 20-Hz time series data. The data showed that updrafts often transported heat at the lower part, sometimes at the middle part too, of the optical path, but not at the sonic path. CO_2 densities as measured with the open-path gas analyzer decreased in warm updrafts. These results indicated that local temperature fluctiations in the vicinity of the optical path could influence the WPL correction. Applying the in situ measurements of temperature fluctuation did not always improved the WPL correction, but rather often led overestimation of the WPL correction.

P31

LARGE-SCALE TRANSPORT OF SENSIBLE HEAT AND WATER VAPOR TRANSPORT OVER A SHORT CANOPY

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The issue of the flux components at the largest scales has remained unresolved: indeed, the questions to what extent the transport by larger scale motions should be included in the flux calculation, and what is the relevant physical mechanism are left unanswered so far. This study examines the nature of vertical transport of sensible heat and water vapor density due to mesoscale motions and how they are observed with surface eddy covariance systems. For this purpose, turbulence data measured above a flat and irrigated rice paddy field in Tsukuba, Japan (36°05'N, 140°03'E) under unstable conditions were analyzed. It was shown that larger scale component in the measured time series represents mesoscale motions. Wavelet cospectra of the scalar fluxes revealed the presence of vertical transport at horizontal scales larger than the cospectral gap. A time series and the eddy covariance flux were decomposed into a turbulence and a mesoscale component using the identified cospectral gap. The mesoscale transport component of sensible heat and water vapor were found to be related to the wind direction, and, therefore, characteristic of the upwind surface conditions at this scale. With southeasterly wind, it was characterized by the moister air advection due to greater surface evaporation at the upwind surface conditions. With non-southeasterly wind, in contrast, it was characterized by the drier air advection associated with relatively drier urbanized area. In addition to these moist or dry air advection, the remarkable difference of surface temperatures between paddy field and external area may induce mesoscale circulations. On the other hand, the turbulence flux component exhibits universal attributes resulting from the local surface characteristics.

P32

COMPARISON OF THE TURBULENCE CHARACTERISTICS OF THE ATMOSPHERIC SURFACE LAYER OVER A RICE PADDY AS OBSERVED BY A TETHERSONDE SYSTEM AND BY AN EDDY COVARIANCE SYSTEM

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The turbulence characteristics of the atmospheric surface layer (ASL) over a rice paddy were measured using both tethersonde and eddy covariance (EC) systems. Comparisons of the friction velocities and Bowen Ratios estimated from the observations by both systems show correlation coefficients to be > 0.7. Their discrepancy can be associated with the discrepancy between their fingerprint areas. Compared to the tethersonde measurement, no significant underestimation for the total turbulent heat flux observed by the EC system can be identified. The aerodynamic roughness estimated from both tethersonde and EC data is determined to be 0.02-0.03 m for wind coming from a homogeneous rice paddy and > 0.07 m from a rice paddy interspersed with buildings. During daylight hours, the height ranges of the ASL were measured, ranging from a few meters to 25 m agl over the homogeneous rice paddy, and 14 m – 42 m over the rice paddy interspersed with buildings. However, the ratio between the zero-plane displacement height and aerodynamic roughness was observed as > 10, higher than the commonly suggested ratio. Finally, an empirical equation for determining aerodynamic roughness over heterogeneous land cover is examined.

P33

DEVELOPMENT OF A FLUX TOWER FOR LONG-TERM FLUX MEASUREMENT OF AIR POLLUTANTS IN AN URBAN AREA

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Current air quality stations only measure concentrations of air pollutants. Nonetheless, the concentrations are functions of meteorological conditions and emission rates. There is a need to measure the long-term trend of emission rates directly for evaluating air quality management strategies. This study presents our effort to build such a flux tower. The profile method is used in this study. That is, the vertical mass flux F of a pollutant (kg m^{-2} s^{-1}) is determined according to the mass transfer theory as: $F = -K_z(dc/dz)$, where Kz is vertical eddy diffusivity (m^2 s^{-1}) and $\partial C/\partial z$ is the concentration gradient.

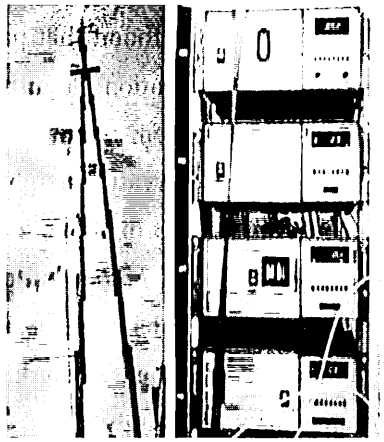

Fig 1.Urban flux town

Air pollutant concentrations are continuously observed at four heights at 32.5 m, 36.5 m, 40.5 m, and 46.5 m above ground level. They are measured on a tower (Fig 1) standing on the roof of a 7-floor building in the third largest city (Taichung City, 24°12' N, 120°67' E) in Taiwan. The vertical eddy diffusivity is determined according to the similarly theory for the atmospheric surface layer. Five pollutants including ozone, nitrogen monoxide, nitrogen dioxide, carbon monoxide and sulfur dioxide are measured at the 4 heights. In addition, eddy covariance system for measuring sensible heat flux, latent heat flux and CO2 is installed. During the test period from 25 March to 11 April 2006, it is found that the derived NO and NO2 fluxes were upward during the daytime and were almost zero during the night. This pattern can be compared with the emission inventory derived according to the traffic volume of the nearby road.

P34

SURFACE ENERGY CLOSURE OBSERVED AT VARIOUS HEIGHTS ON AN URBAN FLUX TOWER

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The energy imbalance has been observed at many flux towers. This study has found that parts of the reasons are due to the fact that the observation of turbulent heat fluxes by using the eddy covariance system is not at height within the atmospheric surface layer. Two observation heights were tested. One measured turbulent heat fluxes at 33 m above ground level on a tower (Fig 1) standing on the roof of a 7-floor building (24°12' N, 120°67' E) in the third largest city (Taichung City) in Taiwan. The other measured the fluxes at 50 m agl. According to a tethersonde ballon observation analysis, at the study site, the ASL is within 40 – 70 m agl. That is, obsevaition at 50 m agl was within the ASL, while the observation at 33 m agl was not.

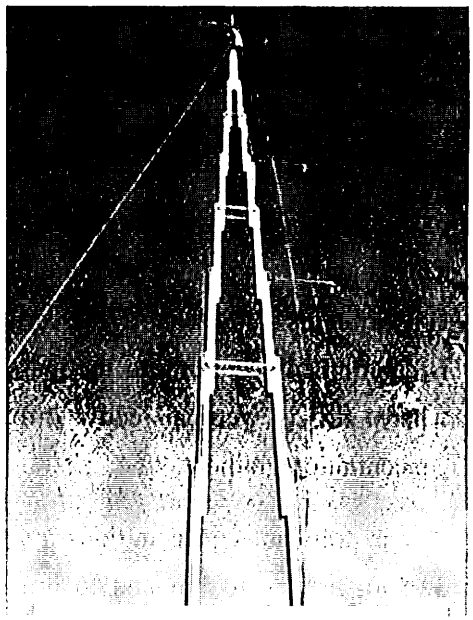

Fig 1. Flux tower

While measuring the turbulent heat fluxes at 33 m agl, it is found that the sum of the turbulent fluxes was 21 % lower than the available surface heat flux. In addition, it is found that the mean vertical velocity was about -0.06 m s^{-1} for northern wind, which was likely caused by the building wakes. On the contrary, while measuring the turbulent heat fluxes at 50 m agl., the sum of the fluxes was only 4 % lower than the available surface heat flux. In addition, the mean vertical velocity was to 0 at 0.01 m s^{-1} for northern wind. Note that corrections were made to reduce the energy gap, including coordinate system rotation, WPL correction, urban albedo correction, advected term correction, and long-wave radiational cooling term correction. The average urban albedo is determined to be 0.20 estimated within the radius of 1.4 km from the tower site (Fig 2).

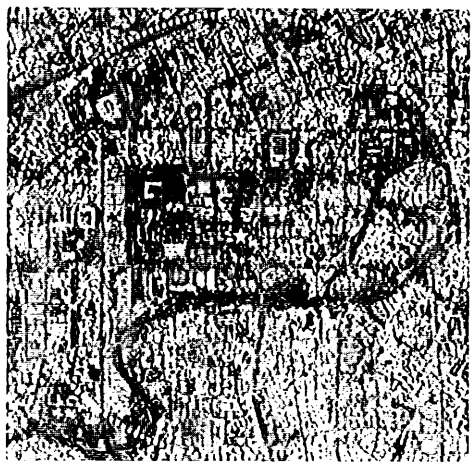

Fig 2. Landuse within the footprint area of the study site

P35

TIME SERIES ANALYSIS OF SOIL MOISTURE AT A STEEP HILLSLOPE

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Understanding the hydrological processes at a hillslope scale can be achieved through intensive in situ monitoring of an intermediate hydrologic variable, soil moisture, during rainfall events. A soil monitoring system for a hillslope with steep relief and shallow soil depth was installed to efficiently represent the spatial and temporal features of soil moisture on the conjunction of the terrain attributes. The soil moisture responses to sequential rainfall events were obtained as multiple time series. Time series analysis provides a systematic method of evaluating the stochastic characteristics of hydrologic variable. A derivation of the soil moisture transfer mechanism can be used as the physical basis of soil moisture time series analysis. After recording the soil moisture response patterns for a few consecutive rainfall events, a time series modeling procedure was applied to configure the characteristics of soil moisture.

The stochastic structures of soil moisture time series were explored in conjunction with topographic attributes such as the topographic wetness index, contributing upslope area and pathway distance from the outlet. Even though the variations in soil moisture did not have a significant linear or proportional relationship with the topographic attributes, the existence of potential threshold for formulation of time series models was found. The monitoring locations can be characterized from the final model structures of soil moisture in the context of topographic parameters. Distribution of the models on the hillside suggested that the distribution and existence of macropores can be an important component for explaining the soil moisture dynamics of a steep hillslope.

This study employed univariate models to analyze soil moisture time series. Introduction of more elaborated analysis method such as transfer function, prewhitening causality analysis can provide more comprehensive insight but will also cost more and easily suffer from the uncertainty effective rainfall input in the scale of the study area. This research was performed using soil moisture during the late autumn season. Analysis of this restricted soil moisture data may need to be further generalized. Further analysis of the extended monitoring of soil moisture and more elaborate time series techniques are future research issues for configuring complete soil moisture dynamics.

Acknowledgement : This research was supported by grants (code: 1-8-2) from Sustainable Water Resources Research Center for 21st Century Frontier Research Program, and BK21 Program of the Ministry of Education and Human Resources Development of Korea.

P36

ESTIMATE OF PRODUCTIVITY IN ECOSYSTEM OF THE BROADLEAVED-KOREAN PINE MIXED FOREST IN CHANGBAI MOUNTAIN

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Forest is an important type of natural vegetation. Forests are considered to be the terrestrial ecosystems that assimilate the largest amount of CO_2 and store it for a relatively long time. Forest accounts for about 70% of the total carbon storage in terrestrial ecosystems. Recently, the eddy-covariance technique and chamber method are used in estimation of ecosystem carbon exchange.

Methods:

Study site

The study site is located in Changbai Mountain Natural Reserve (42°24′0 9″N, 128°05′45″E) at an altitude of 738 m. The site is characterized as a mountain climate.

we used The NEE obtained by the eddy covariance method was compared with those observed with chamber measurements.

Different component and whole system CO_2 flux measurements

NEE were measured at 40 m with a tri-axial sonic anemometer (model CAST3, Campbell, USA) and a fast response open-path CO_2/H_2O infrared gas analyzer (Li7500, Li-Cor Inc., Lincoln, USA). Different component CO_2 fluxes were obtained by chamber techniques

Estimate of productivity of forest ecosystem

Net carbon exchange of ecosystem (NEE) refers to net primary production subtracts loss of carbon by heterotrophic respiration (R_h). An empirical equation was used to calculate the aboveground biomass of each tree species. Net increment of forest biomass was the sum of stem, branch, root and foliage biomass. The former year DBH value was calculated according to the growth ring data, and then calculated the former annual biomass using the empirical equation. The net increment of biomass was the difference of the two years.

Results

The amount of carbon accumulated underground in broad-leaved Korean pine mixed forest ecosystem was soil respiration subtracted falling leaves, and the value was 841.98 gC· m^{-2}· a $^{-1}$ (Table 1). Assume plant roots consumed 50% of the carbon accumulated underground during growth, then the root respiration CO_2 efflux was 424.2 gC· m^{-2}· a $^{-1}$ which contributed to 44% of soil respiration, and accounted for 31% of ecosystem CO_2 efflux.

The gross primary production (GPP) of the forest was the total sum of system photosynthesis (1612.74 gC· m^{-2}· a $^{-1}$). Trees, shrubs and herbage annual primary production accounted for 89.7%, 3.5% and 6.8% of the gross primary production of the mixed broad-leaved Korean pine forest. The sum of system autotrophic respiration (foliage respiration, branch respiration and root respiration) was 843.4 gC· m^{-2}· a $^{-1}$. The amount of annual accumulation of carbon underground accounted for 0.52 of gross primary production, and the ratio of soil respiration to gross primary production was 0.60. Annual carbon accumulation of the needle and broad-leaved Korean pine forest ecosystem was 856.2 gC· m^{-2}· a $^{-1}$and the NEE was 229.51 gC· m^{-2}· a $^{-1}$.

Table 1 Different component biomass (gC·m^{-2}), respiration gC·m^{-2}) and net primary production (NPP, gC·m^{-2}·a^{-1} in the broad-leaved Korean pine forest ecosystem

component	/gC· m^{-2}
biomass:	
foliage biomass	417
branch biomass	15696
gross biomass aboveground	16113
annual fallen leaves	122
respiration:	
annual leaf respiration	210.41
annual stem respiration	208.84
annual soil respiration	963.98
annual ecosystem respiration	1383.23
growth:	
annual leaf growth	225.99
annual aboveground growth	513.32
annual net primary production ANPP	541.31
annual underground carbon accumulation (soil respiration and fallen leaves)	841.98
annual underground carbon accumulation: GPP	0.52
annual underground carbon accumulation: soil respiration	0.87
underground NPP: NPP	0.33
NPP:GPP	0.48
NEE	229.51
NPP	769.3

P37

CARBON CYCLING IN THE TROPICAL DRY EVERGREEN AND DECIDUOUS FORESTS IN THAILAND

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A study on carbon cycling of tropical forests in Thailand was aimed at determining temporary changes in carbon balance of two contrasting terrestrial forest ecosystems. A dry evergreen forest at the Sakaerat Environmental Research Station, Nakhon Ratchasima province, and a mixed deciduous forest with bamboos at the Maeklong Watershed Research Station, Kanchanaburi province were studied during May 2003 – April 2005. For each study site, a one ha sampling plot was established to determine forest structure and carbon stored in biomass and soils as well as forest CO_2 exchange in terms of plant photosynthesis and emission through autotrophic and soil respiration.

The two studied forests indicated distinctive canopy structure and species composition. The dry evergreen forest was dominated mainly by *Hopea ferrea* with the importance value index (IVI) of 101, while the most important tree species of the mixed deciduous forest were *Ptercarpus macrocarpus*, *Xylia xylocarpa* and *Schleichera oleosa* respectively, as well as two bamboo species, *Bambusa tulda* and *Gigantochloa albaciliata*. The former also had higher tree density and basal area, thereby gaining greater biomass production and carbon stored in biomass. The result on annual carbon changes showed that, compared with the mixed deciduous forest, the dry evergreen forest gained remarkably higher net primary production (NPP) due to greater biomass increment even less litter production. Likewise, the dry evergreen forest sequestered considerably greater CO_2 through plant photosynthesis and released higher CO_2 to the atmosphere through autotrophic respiration than did the mixed deciduous forest. Expectedly, CO_2 emitted from soil surface in both studied forests accounted for almost 50% of the total CO_2 emission. Overall, the dry evergreen forest showed higher potential as carbon sinks compared to the mixed deciduous forest. Further developments of some measurement techniques of ecosystem photosynthesis and respiration are, therefore, required to provide useful insights into CO_2 dynamics in these terrestrial forest ecosystems.

Keywords carbon cycling, gross primary production, net primary production, dry evergreen forest, mixed deciduous forest

P38

OBSERVATION-BASED HYDROMETEOROLOGICAL STUDIES AT TROPICAL MONSOON FORESTS IN THAILAND

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This study summarizes forest types of tropical monsoon forests in Thailand, and reviews published hydro-meteorological studies conducted at each forest type with emphases on our new findings derived from two forest sites in the region. As a result of summarizing current status of knowledge, this paper finds that fundamental hydro-meteorological aspects, i.e. seasonal variation in energy partitioning during a year with normal climatic condition, at most of the forest types in the region has been already studied. Contrast in seasonality of evapotranspiration (ET) between the uplands and lowlands might be a noteworthy feature of hydro-meteorology in tropical monsoon forests in Thailand. As is often discussed in studies at Amazonian rain forests with defined dry period, accessibility of roots to deep soil layer is suggested to be an important factor supporting the elevated ET rate during the dry season. In addition, inter-annual variations both in rainfall and its seasonal distribution are significantly large in the region, leading to occasional severe droughts and irregular ecological rhythms of trees. Recent findings from our long-term observations imply that the variations in rainfall result in phenological and physiological responses of the two forest ecosystems. These responses may in turn affect the hydro-meteorology such as exchanges of energy, water, and carbon dioxide between the forest ecosystems and the atmosphere. Such effects of year-to-year variations in rainfall on the tropical monsoon forests have been poorly understood thus far. We, therefore, stress the necessity of further efforts to examine the ecological and hydro-meteorological responses of all tropical monsoon forests to the inter-annual variation in rainfall and its seasonality.

P39

DEFFIRENCES IN ENVIROMTENTAL RESPONSES OF CANOPY CONDUCTANCES BETWEEN UNDERSTORY VEGETATION AND MAIN CANOPY TREES IN A BOREAL FOREST

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Boreal forests have a unique feature compared with forests in other climate regions: monotonous vegetation, relatively sparse stand density of main canopy trees and thus, dense understory vegetation. Many previous papers indicated that the transpiration from the understory occupied 50% of total evapotranspiration. Therefore, we need to know how the transpiration from the understory responds to environmental conditions. We derived canopy conductance of the main canopy and the understory from water and heat fluxes observed above both of them, and revealed the differences between them.

Materials and Methods

We observed water and heat fluxes at a larch forest (60°14'18"N, 129°39'02"E) in Spasskaya Pad, Yakutsk city, Republic of Sakha, Russia. The main forest canopy is composed of larch (*Larix cajanderi*), and the forest floor was completely covered with cowberry (*Vaccinium vitisideae*). Air temperature (T_a), vapor pressure deficit (*VPD*) and photosynthetic photon flux density (*PPFD*) were measured at the top and the bottom of tower: measurements at the top ($_T$) and the bottom ($_B$) represent the conditions of the larch and the understory canopies, respectively. The latent and sensible heat fluxes at the top and the bottom were observed by the eddy covariance method. Canopy conductance (g_c) was calculated from the inverted Penman-Monteith equation. We obtained canopy conductance of the understory vegetation ($g_{c\text{-}B}$) and larch ($g_{c\text{-larch}}$): $g_{c\text{-}B}$ was calculated from actual evapotranspiration at the bottom of the tower (ET_B), and $g_{c\text{-larch}}$ was derived from the difference between ET_T and ET_B (*i.e.* $ET_{larch} = ET_T - ET_B$). Finally, to evaluate the responses of g_c to the environmental variables, a Jarvis- type g_c model was applied.

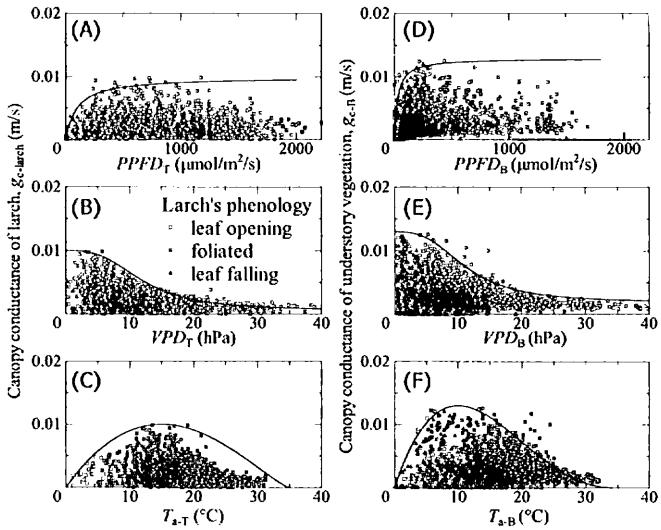

Fig. 1 Responses of canopy conductance to environmental factors.

Results and Discussion

Figure 1 shows responses of $g_{c\text{-larch}}$ and $g_{c\text{-}B}$ to environmental factors observed at each corresponding height. The maximum value of $g_{c\text{-larch}}$ was somewhat smaller than that of $g_{c\text{-}B}$. Although the response of $g_{c\text{-larch}}$ was relatively similar to that of $g_{c\text{-}B}$ (Figs. 1-B and E), their responses to *PPFD* and T_a were different (Figs. 1-A and D, C and F). Optimal temperature of $g_{c\text{-}B}$ was 10 °C, that is 5 °C smaller than that of $g_{c\text{-larch}}$ (Figs. 1-C and F), and $g_{c\text{-}B}$ increased with *PPFD* more rapidly than $g_{c\text{-larch}}$ (Figs. 1-A and D). These differences suggested that the understory vegetation photosynthesized efficiently during the relatively colder period, in which the larch's leaves defoliated and/or were budding, and were falling. However, the biomass of understory is much smaller than that of larch: the understory may consume inefficiently water than larch for photosynthesis during the foliate period? We will evaluate the water use efficiency of the larch and the understory in a future work.

P40

COMMON POTENTIAL RESPONSES OF CANOPY CONDUCTANCE TO ENVIRONMENTAL VARIABLES IN VARIOUS FORESTS IN THE FAR EAST REGION

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Canopy conductance (g_c) is important as a controlling factor for water, gas and heat exchange between vegetation and the atmosphere. We investigated g_c variations in five different forest types distributed from central to high northern latitudes in the Far East. We applied a Jarvis-type g_c model (Jarvis, 1976) to the data for the mature growing seasons of 2003, 2004 and 2005 and examined the response characteristics of g_c to environmental factors.

Materials and Methods

The research sites were five mature forests in the Far East region: two boreal larch and pine forests in eastern Siberia (sites L-YKS and P-YKS, respectively); two cool temperate birch and mixed forests in Hokkaido, Japan (B-HOK and M-HOK, respectively), and one warm temperate mixed forest in Aichi, Japan (M-AICHI). Micrometeorological observation towers were installed at each site to measure fluxes and meteorological variables. Water and energy fluxes were calculated using the eddy covariance technique. g_c was calculated using the Penman–Monteith equation (big-leaf model). The Jarvis-type g_c model (Jarvis, 1976) expresses g_c as a function of several environmental variables. We used photosynthetic photon flux density (Q), vapor pressure deficit (D), air temperature (T) and volumetric soil water content (W) as the environmental variables and evaluated the responses of g_c to these variables.

Results and Discussion

Figure 1 presents the responses of g_c to the environmental variables at each site and the lines of the functions in a model fitted for all site data. The responses of pooling g_c at all sites could be expressed as one lumped fitted line (model). It is interesting that the difference in maximum g_c among sites was well explained by the lumped fitted line of W. g_c estimated by the lumped model agreed well with the observed g_c at each site. Although it has been assumed that the behaviours of gas exchange properties in forests are site- or forest type-specific, we believe that the lumped model lines indicate the rough "potential" response curves of g_c to environments in mature forests in the northern Far East region, even if small differences exist among forests. If this concept is correct, it will be effective in spatial parameterisation of heat, water and gas exchange between vegetation and the atmosphere in the Far East region.

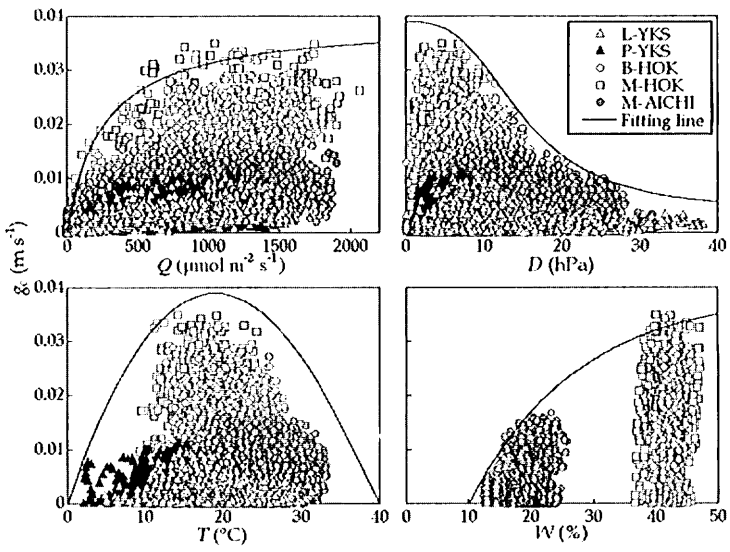

Fig. 1 Relationships between g_c and various environmental variables, and the fitted line for all data (the lumped model).

P41

CARBON AND OXYGEN ISOTOPE RATIOS OF TREE LEAVES GROWN IN DIFFERENT CLIMATES IN EAST ASIA

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Water-use efficiency and stomatal conductance are important indicators of leaf-scale control over CO_2 and H_2O exchange between trees and the atmosphere. Carbon isotope ratio ($\delta^{13}C$) of leaf organic matter is known to reflect water-use efficiency (Farquhar *et al.* 1989). Oxygen isotope ratio ($\delta^{18}O$) of leaf organic matter may also reflect leaf evaporative condition (Farquhar 1998). Therefore, $\delta^{13}C$ and $\delta^{18}O$ in tree leaves are expected as useful tools to know the response of leaf gas exchange to climate change (Barbour et al. 2000). However, the $\delta^{18}O$ model is still under development and has not been tested on various types of trees. This study presents the $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter of various trees grown in different climates in East Asia.

We collected sunlit leaves from current year shoots of dominant-trees in warm-temperate broad-leaved forest (Akou, Hyogo, Japan), warm-temperate coniferous forest (Kiryu, Shiga, Japan), cool-temperate deciduous broad-leaved forest (Tomakomai, Hokkaido, Japan), rainforest (Pasoh, Peninsular Malaysia), rainforest (Lambir, Borneo Malaysia)and desert (Mu-Us, Inner-Mongolia, China). The leaves were oven-dried at 70°C for 48 h, and finely ground. The $\delta^{13}C$ of the leaf samples was analyzed with a continuous-flow isotope-ratio mass spectrometer (Delta-S, Thermo Electron) following an elemental analyzer (EA-1500, Carlo Erba) at the Center for Ecological Research, Kyoto University. The $\delta^{18}O$ of the leaf samples were analyzed with a continuous-flow isotope-ratio mass spectrometer (Delta-plus-XP, Thermo Electron) following a pyrolysis furnace in a elemental analyzer (TCEA, Thermo Electron) at the Research Institute of Humanity and Nature.

A positive relationship was found between $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter (Fig 1). The tropical trees, which had low water-use efficiency and high stomatal conductance, tended to have lower $\delta^{13}C$ and $\delta^{18}O$. The semi-arid trees, which had high water-use efficiency and low stomatal conductance, tended to have higher $\delta^{13}C$ and $\delta^{18}O$. This suggests that $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter present the gas exchange trait and affected by water conditions.

Acknowledgment

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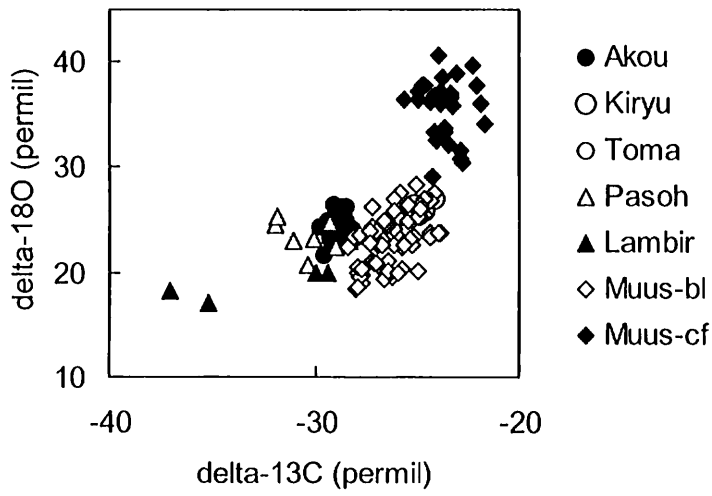

Fig 1. $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter of various trees grown in different climates.

P42

SIMULTANEOUS ISOTOPIC DETERMINATION OF CO_2 AND METHANE EXCHANGED BETWEEN THE PADDY AND THE ATMOSPHERE REVEALS MARKED DIFFERENCES IN GAS EXCHANGE PROCESSES BETWEEN FLOODED AND DRAINED CONDITIONS

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*A*t the ecosystem and global scales, the carbon isotopic compositions of CO_2 and methane exchanged between the biosphere and the atmosphere (δ_N and δ_M, respectively) have been used to partition net fluxes of CO_2 and methane into the source and sink terms. In comparison with other terrestrial ecosystems, rice paddies are unique because they provide the primary food source for over 50% of the world's population and act as major sources of global methane. In the present study, the importance of high-frequency simultaneous measurement of δ_N and δ_M was demonstrated in a Japanese rice paddy.

*W*e investigated short-term variations in δ_N and δ_M by combining stable isotopes and concentration measurements within and above the canopy, in conjugation with continuous aerodynamic flux measurements of CO_2 and methane on two representative days of flooded and drained conditions. For both CO_2 and methane, strong linear relationships were found between the measured isotopic compositions and the inverse of concentrations over the time spans of 2 hours to 1 day, which enabled us to examine diurnal variations of δ_N and δ_M solely form measured data. Both δ_N and δ_M showed large differences in magnitude and diurnal pattern from those obtained by the conventional isoflux approximation, in which δ_N or δ_M varies linearly with the period-averaged concentration measured above the canopy.

*U*nder flooded condition, δ_N varied between –25.8‰ and –20.2‰ and had lower values around noon, indicating that the assimilated CO_2 had more negative $\delta^{13}C$ values than the respired CO_2. After drainage, δ_N increased by about 2‰ on average and showed a more pronounced diurnal pattern, consistent with increased methane emissions and nighttime CO_2 fluxes. On the other hand, the diurnal pattern of δ_M under flooded conditions showed clear midday ^{13}C enrichment by about 8‰. This strong diurnal shift in δ_M is likely to be associated with a transpiration-induced bulk flow of methane and/or with an enhanced microbial oxidation of methane during the daytime. However, under drained conditions, δ_M showed the opposite diurnal pattern with lower values during the daytime and highly ^{13}C-enriched values at night. This strongly supports that floodwater drainage enhances methane oxidation but can bring about large emissions of less-oxidized methane through the soil surface in the daytime.

P43

ESTIMATING EVAPORATION FLUX IN THE HAN RIVER BASIN, KOREA, USING STABLE ISOTOPE TECHNIQUES

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Stable isotope composition of water (both liquid and vapor) is widely used to constrain water budget in various terrestrial settings. The advantage of isotope technique is in the fact that it enables a quantitative estimation of evaporation flux. In terms of $^{18}O/^{16}O$ and D/H ratios of water, evaporation imparts two different fractionation effects, i.e., equilibrium and kinetic. Both processes increase the isotopic ratios of water that was subjected to evaporation. Unlike the equilibrium fractionation effect occurring at 100% relative humidity, the kinetic effect (occurring at RH lower than 100%) arises due to the difference in diffusivity of isotopic species of water molecules and enriches water with the heavier oxygen isotopes (^{18}O) relative to the heavier hydrogen isotopes (Deuterium, ^{2}H). Rain water is a typical example of equilibrium isotope fractionation between water and vapor, which is represented by slopes of ~ 8 if the isotope data of water plotted in $\delta^{18}O - \delta D$ space (Meteoric Water Line, MWL). Kinetic fractionation effect is widely observed in most natural evaporation settings such as lakes and soils and results in isotope data of remaining water whose slopes are 4 ~ 6 in $\delta^{18}O - \delta D$ cross plot.

Based on this isotope fractionation effects, the evaporation flux from the Han River basin, Korea was estimated as a part of Carbo/HydroKorea project. The Han River basin and its tributaries are the focus of inter-disciplinary efforts to understand water and carbon exchanges in typical Korean forest catchments. The Han River basin is located in the middle part of the Korean peninsula. The drainage area (26,128 km^2) consists of temperate mixed forests and croplands. The mean annual precipitation in the Han River basin is 1301 mm (34.0 km^3) and the mean annual discharge is reported as 18.9 km^3. Approximately ~20 % of total rainfall is reported as interception in many studies for Korean forests and therefore, assuming a steady state, the mean annual evapotranspiration (ET) flux is estimated as 8.3 km^3. Evaporation from the basin has not been estimated quantitatively.

The isotope composition of river water collected monthly from the Han River and its tributaries is similar to that of monthly composite precipitation in the basin. In other words, in $\delta^{18}O - \delta D$ cross plot, the isotope ratios of river water do not show deviation from the MWL that is commonly observed in many evaporating systems. The result is intuitively interpreted as indicating an insignificant evaporation flux from the Han River basin. Evaporation is also not recognized from smaller tributary watersheds with spatial scales ranging from ~2 km^2 to ~10^3 km^2. Similar stable isotope results were reported for many watersheds in temperate regions of the world.

The results merit further discussion. First, as indicated by the isotopic composition, evaporation can be truly negligible in the forest watersheds. However, this interpretation does not support the model-based results indicating a significant evaporation flux from soils. Second, the isotope fractionation model originally developed for open-water evaporation may not properly explain the processes occurring during soil evaporation. Few studies have been conducted on stable isotope fractionation during evaporation in dry soils and in vegetated soils. Even fewer studies have been done for soils covered with litter layers. Third, the soil evaporation may largely occur during dry period after shedding leaves and due to low soil moisture content, soil water does not recharge into groundwater or discharge into stream (river). In this case, evaporation effects are only preserved in soil water and are not identified in the water discharged from watersheds. In this regard, the uncertainties of isotope techniques, isotope fractionation model for soil evaporation and relevant hydrological information are being thoroughly reviewed to verify the evaporation flux in the Han River basin.

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P44

ISOPRENE EMISSION FROM *QUERCUS SERRATA* IN THE DECIDUOUS BROAD-LEAVED FOREST

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Isoprene is a biogenic volatile organic compound (BVOC) emitted by many plant species. Isoprene emission contributes to the reactive carbon budget entering the troposphere. In Japan efforts to measure and understand the mechanism controlling BVOC emissions and to establish their emission inventories for the country have not been extensive, despite the fact that Japan has a large area of forests composed of coniferous and/or deciduous tree species (about 70% of total land area) and that forestry statistics across Japan are available (Tani et al. 2002).

Methods

The measurements were taken in the deciduous broad-leaved forest, Yamashiro, Kyoto (34°47N, 135°50'E). During June, July, August and October 2006, the isoprene emission, net assimilation rate, stomatal conductance, photo-synthetically active radiation (PAR), air and leaf temperature, relative humidity was measured on using a LI-6400 portable photosynthesis system (Li-Cor Inc., Lincoln, NE, USA)

Isoprene samples from the LI-6400 cuvette were trapped by adsorbents (Tenax 200mg and Carbotrap 100mg) packed into stainless steel tubes (Perkin Elmer) and stored at <5°C until analysis. Samples were analyzed using GC-MS system (Shimadzu QP5050A). Samples underwent two stage thermal desorption (Perkin-Elmer ATD).

Results

Fig. 1 shows the obvious effect of PAR on isoprene emissions and photosynthesis rates. Isoprene emissions reached their peak around noon, while for sun leaves the largest photosynthesis rates during morning and the subsequent decrease were observed as shown in Fig. 2.

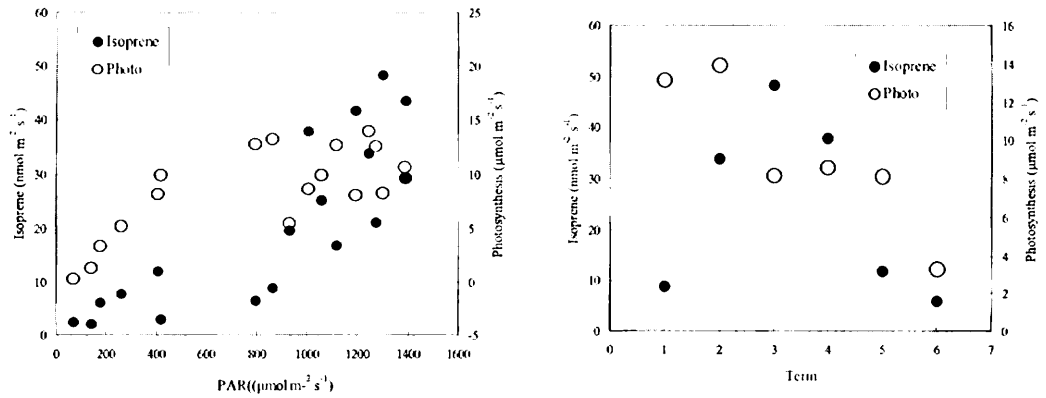

Fig. 1. Isoprene emissions and photosynthesis rates as a function of *PAR* (left)

Fig. 2. Temporal variations of isoprene emissions and photosynthesis rates for sun leaves on July 1 2006. Sampling term (1: 7:00-9:00, 2: 9:00-11:00, 3: 11:00-13:00, 4: 13:00-15:00, 5: 15:00-17:00, 6: 17:00-18:30), number of samples: 4-6 leaves. (right)

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P45

CH_4 AND N_2O EMISSION FLUXES OF MIRE SOILS IN SANJIANG PLAIN, NORTHEAST CHINA

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The fluxes of CH_4 and N_2O emission in four types of mire soil were measured, using the opaque chamber and gas chromatogram technique in Sanjiang Plain, northeast of China. For the differences of hydrological condition and vegetation type, the observation sites were selected in Carex lasiocarpa and Carex pseudocuraica (continuously inundated) mire, Deyeuxia angustifolia (seasonal inundated) mire and brushwood meadow soil.

During the observation, fluxes of the two types greenhouse gases were mainly focused on the growing season (June to August), that was the high temperature and precipitation season. However, the largest fluxes of CH_4 and N_2O appeared in different types of mire soil, respectively. The flux of CH_4 emission was mainly affected by the mineralization of organic matters, soil respiration, and the processes of heat exchange and so on. During our observation, the mean flux was larger in Carex lasiocarpa (7.67 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average) and Carex pseudocuraica (3.38 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average) mire soil (continuously inundated). However, there were no significant seasonal differences in inundated Deyeuxia angustifolia mire and brushwood meadow soil (0.28 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average). The flux of CH_4 appeared decreasing with the decrease of water level in soil. The mean fluxes of N_2O were positive in the four types mire soil, that was the source of N_2O to atmosphere during the entire observation. Brushwood meadow soil had the largest flux of N_2O (0.041 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average). Then were Deyeuxia angustifolia mire soil (0.038 mg $\cdot$ m^{-2} $\cdot$ h^{-1}), Carex pseudocuraica mire soil (0.024 mg $\cdot$ m^{-2} $\cdot$ h^{-1}), Carex lasiocarpa mire soil (0.017 mg $\cdot$ m^{-2} $\cdot$ h^{-1}). Hydrological condition and soil temperature were the main influencing factors controlling mire soil CH_4 and N_2O emission fluxes. Soil temperature was the main factor controlling soil respiration, but the CH_4 and N_2O emission fluxes intensity and their features were affected significantly by the hydrological condition.

P46

EDDY COVARIANCE MEASUREMENTS OF CH_4 FLUX IN A JAPANESE RICE PADDY FIELD

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Rice paddies are major source of atmospheric CH_4 in spite of their importance to the global food production. The accurate monitoring in CH_4 emission is essential to understand its behavior and achieve the methane mitigation. We conducted the measurement in CH_4 flux using the eddy covariance method (EC-F_{CH_4}) with the closed-pass type methane gas analyzer over Japanese rice paddies, "Mase paddy flux site", located in the middle of Japan during the growing season in 2003. Methane mixing ratio (ρ_{CH_4}) of 10 Hz frequency was measured by a frequency-modulated tunable diode laser absorption spectrometer (TDLAS), when the response of 2.4 Hz derived from gas replacement in the volume of the detector are achieved in situ.

Spectral power distribution of ρ_{CH_4} computed by using the fast Fourier transform (FFT) appeared as a representative ogive, which showed the source signals had a sufficient coverage to perform flux calculation. On the momentum-ρ_{CH_4} cospectra, we found that the major power range of methane flux contribution located in lower frequency compare to the other fluxes such as the sensible heat, the latent heat and CO_2, which means the EC-F_{CH_4} are transferred with relatively large turbulences. It may depend on a physical response of the rhizospheric soil where the methane emission and production take place in relation to the heat capacity.

EC-F_{CH_4} provides the typical diurnal variations; they followed by an increase in emission rate from 30 days after flooding in the range of 1 $\mu g\text{-}CH_4\ m^{-2}s^{-1}$ in the daytime. In the seasonal variation, they increased to 80 $mg\text{-}CH_4\ m^{-2}\ day^{-1}$ in mid-Jun (60 days after flooding) and exceeded 100 $mg\text{-}CH_4\ m^{-2}\ day^{-1}$ in mid-July. Especially in the mid-term and final drainage event, approximately 400 ~ 500 $mg\text{-}CH_4\ m^{-2}\ day^{-1}$ of causal large emission was observed. We compared EC-F_{CH_4} to the other CH_4 flux by an advanced aerodynamic method using vertical CH_4 profiles which were measured simultaneously. Although the half hourly EC-F_{CH_4} were scattered while the minuscule emission period due to the signal to noise ratio within ρ_{CH_4}, the two fluxes principally agreed under certain emission period.

We discuss the behavior of the CH_4 turbulence transfer in flux calculation. There were no dependency in non-dimensionalized variations for CH_4 (σ_{CH_4}/ CH_4*) on atmospheric stability under the neutral and stable conditions, and the gradient profile function in CH_4 (Φ_{CH_4}) shows almost similar characteristics to past studies in other scalar fluxes. We consider that the assumption which the eddy diffusivity for CH_4 behaves as in sensible heat flux, based on the Monin–Obukhov similarity, can be reasonably employed.

P47

THE EFFECT OF LOGGING ON SOIL GREEN HOUSE GAS (CO_2, CH_4, N_2O) FLUXES IN TROPICAL HUMID FOREST, PENINSULAR MALAYSIA

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Quantifying soil CO_2 flux is critical to understand the overall response of the carbon cycles to human perturbation worldwide. CO_2 accounts for most of the anthropogenically driven increase in radiative forcing. Moreover, methane (CH_4) and nitrous oxide (N_2O) are also important green house gas, whose concentrations in atmosphere have increased by human activities. The CH_4 increase accounts for 20 % of the increased green house warming potential of the atmosphere. The N_2O contributes about 6 % of the green house warming.

IPCC (2001) pointed out that the logging or land use change in tropical zone can affect the global warming strongly. Soils are an important source and sink of these green house gases (GHG: CO_2, CH_4, N_2O). Therefore, it is important to understand the effect of logging on soil GHG fluxes in tropical area. However, a little work on the these gas fluxes has been carried out in Southeast Asia, which is one of the largest tropical regions in the world and an area of significant logging during the last three decades.

The aims of the present study are to evaluate soil GHG fluxes in logged and un-logged forest in tropical Asia and to understand the effect of logging on the soil GHG fluxes.

We carried out the investigation of the soil GHG fluxes in Pasoh forest (2° 58'-59'N, 102° 16'-20'E) in Peninsular Malaysia. One compartment of Pasoh forest was logged selectively on January 2005. The logged area is about 37 ha and 1004 trees were collected from this area. Soil GHG fluxes were measured at daytime in the logged sites and the un-logged sites within the compartment area on February, May, June, July 2005 and March 2006.

The soil CO_2 emission rates in the un-logged sites did not differ from those in the logged sites significantly except for June 2005 (Fig. 1a). The soils in the un-logged sites absorbed CH_4 throughout the experimental period, while those in the logged sites absorbed or emitted CH_4, close to zero, except for February 2005 (Fig. 1b). The soil CH_4 absorption rates in the logged sites tended to be less than those in the un-logged sites. The soil N_2O emission rates in the logged sites were about 3-100 times higher than those in the un-logged sites significantly throughout the experimental period (Fig. 1c). The logging practices had increased the soil N_2O emission rates throughout the experimental period, one year after the logging.

These above results suggest that logging practices in humid tropical forest affect soil CH_4 and N_2O fluxes, which can accelerate global warming throughout one year after logging, while do not affect soil CO_2 fluxes.

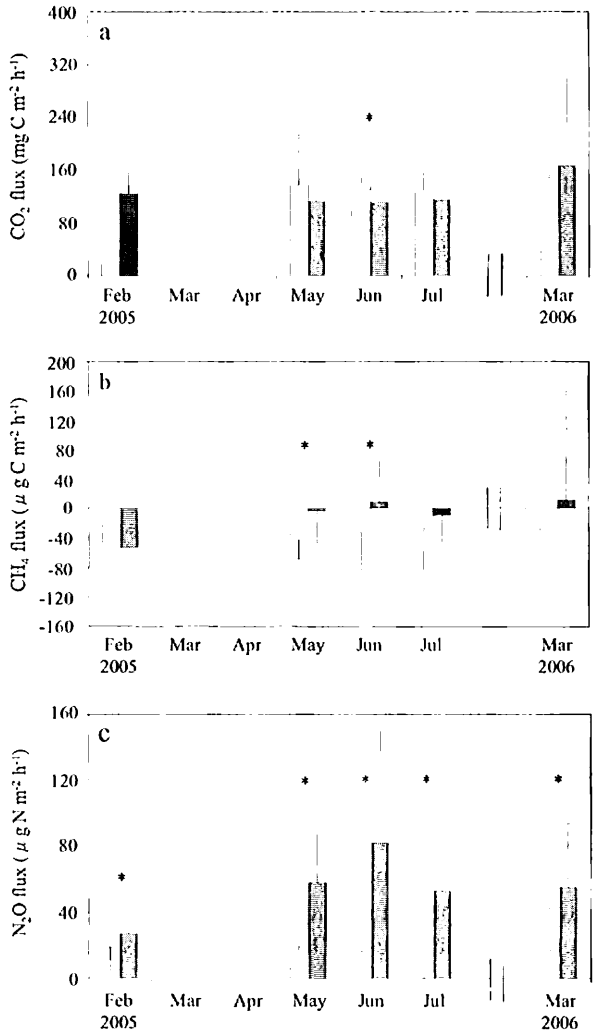

Figure 1. Mean value and standard deviation of monthly (a) CO_2, (b) CH_4 and (c) N_2O fluxes in logged and un-logged sites. □ ; Un-logged sites, ▨ ; Logged sites. An asterisk means the significantly difference between logged and un-logged sites in same month by ANOVA ($P<0.05$).

P48

Effects of typhoon damage on the vegetation properties and carbon dynamics in a larch forest

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1.Introduction

Typhoon is an important disturbance factor for forest ecosystems in East Asia, which damages them extensively and intensively. It is thought that the disturbance affects ecosystem properties including vegetation dynamics, nutrient cycling, soil organisms and micrometeorology, and consequently changes carbon cycling of forest ecosystems. In particular, the function of forest ecosystems to fix carbon after disturbance is important from the standpoint of global warming.

A plantation of Japanese larch (*Larix kaempferi* Sarg.) in Tomakomai, Hokkaido, Japan was destroyed by Typhoon Songda in September 2004. About 90% trees were blown down by strong wind. In this study, we compare vegetation properties, biomass and soil carbon content before and after the typhoon damage, and investigate the effects of the typhoon damage on carbon cycling of larch forest.

2.Methods

The study site is Tomakomai Flux Research Site in, Hokkaido, Japan (42°44'N, 141°31'E). This site was established in August 2000 by the National Institute for Environmental Studies (Fujinuma *et al.*, 2001). However, in September 2004, Typhoon Songda hit it and blew down 90% of trees. Before the typhoon damage, this forest was a 45–year-old plantation of Japanese larch with some broad-leaved trees (*Betula* spp). The canopy height was 15-16m, and the maximum leaf area index (LAI) was 5.8 m^2 m^{-2}. The forest floor was densely covered with buckler fern (*Dryopteris crassirhizoma*) and Japanese spurge (*Pachysandra terminalis* Sieb. et Zucc.). After the typhoon, all stems of larch trees were removed from the forest for commercial use.

Fig.1. Location of the stydy area

We established a 140x100 m (1.4 ha) plot in the site in 2005, about one year after the typhoon damage. To measure aboveground biomass, we established 10 rectangular plots (1x6 m); each plot was divided into 6 subplots (1x1 m). Aboveground biomass was sampled monthly from June through November in 2006 for every dominant species. Similar data of understory species in 2001 was used for comparison.

To evaluate the total amount of carbon stored in the site, tree biomass was calculated from data of diameter at breast height (DBH) using an allometric regression equation. Soil carbon content at 0-2.5 cm depth was measured in November 2005.

Fig.2. View of the stydy area (August 2006)

3.Results and Discussion

Live aboveground biomass of understory species or invaded herbaceous species was 2.7 ton ha^{-1} in 2001 before the typhoon damage and 2.7 ton ha^{-1} in 2006. There was no difference in aboveground biomass. However, plant species changed. Dominant species was pteridophyte (buckler fern and so on) in 2001 but was nettle in 2006.

The carbon of dead biomass left in the site was estimated at 30.3 tC ha^{-1}; 16.4 tC ha^{-1} for larch trees and 13.9 tC ha^{-1} for broad-leaved trees. The dead biomass has been decomposed to CO_2 and changed to soil organic matter. Soil carbon content was 15.8% (±8.5%) in 2005. It was similar with a published value of 16.0% in 2000 (Yamamoto *et al.*, 2001).

P49

SOIL RESPIRATION IN A SUBTROPICAL MONTANE CLOUD FOREST IN TAIWAN

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The measurement of soil respiration was conducted from May 2005 to April 2006 in a long-term biogeochemical study site located in the mid-altitude of a mountain range of north Taiwan. The dominant species, *Chamaecyparis obtusa* var. *formosana* is characterized by very long life (up to 3000 years) and low growth rate, which might result from the perhumid climate condition and low solar radiation caused by fogs all year round. Besides the limitation of high humidity both in the air and in the soil (annual precipitation usually higher than 3000 mm), the metabolic performance of this cypress tree species might be also constrained by the relatively low temperature (annual average 13.6 °C) compared to the environment of lowland subtropical trees. Based on these information, a low soil respiration rate was proposed for that forest ecosystem.

The major carbon pools and internal flux of the site was investigated in the previous studies. *C. obtusa* var. *formosana*, which consists 83% of the total basal area, contains 43.8 and 37.2 t C ha^{-1} for the above and belowground parts, respectively. The soil of the site is a Lithic Leptosol and contains only 27.3 t C ha^{-1} due to high stone composition. The aboveground litterfall amounts to ca. 3.0 t C ha^{-1} y^{-1}.

An automatic chamber system (LI-COR 8100 with long-term chamber) was setup on the forest floor. The place was chosen based on three one-day measurements using 10 static chambers that were randomly put on a 40 x 40 m^2 area. Soil respiration rate was measured every 30 minutes with 5-min closure of the chamber. Soil temperature and soil water content at 10 cm depth were monitored together with other meteorological parameters. Soil respiration rate increased exponentially with increasing soil temperature and decreased exponentially with increasing soil water content. The range of soil temperature during the experiment period was 4 to 18 °C, while that of soil water content was 0.25 to 0.47 cm^3 cm^{-3}. The soil respiration rate of single measurement ranges from 6 to 395 mg CO_2 m^{-2} hr^{-1}. We derived from these data an empirical model for soil respiration rate [mg CO_2 m^{-2} hr^{-1}] : Flux = 1.16*exp(0.279*ST)+4809*exp(-13.34*SW) (ST: soil temperature in [°C]; SW: soil water content in [%]; R^2=0.96). An annual soil respiration rate of 2.0 Mg C ha^{-1} y^{-1} for our study site was estimated when upscaling the point flux rate to the site that has 92.5% area of soil (the rest of the area is covered by stones and falling logs).

The contribution of fresh aboveground litter decomposition to soil respiration was investigated using manipulated plots with different amount of addition of *C. obtusa* var. *formosana* leaves. Three groups of transparent acrylic chambers (inner diameter: 29 cm, height: 20 cm) were randomly put on forest floor (each group with four replicates). The treatments of the three groups were three-fold annual litter, one-fold, and no litter. The chambers were covered with plastic net (mesh size: 1 mm). Soil respiration rates were measured by 24-hr static alkali method in 13 dates, three of which were done before the litter treatment. The result showed a significant increase in soil CO_2 efflux immediately after the artificial input of leaf litter. The difference between the treatments diminished gradually and the soil respiration rates decreased to the pre-treatment level in 6 months. The total releases of CO_2 within 6 months were estimated to be 120, 85, and 69 g C m^{-2} for the three-fold, one-fold, and no litter group, respectively. About 8% of the added carbon in the litter released in form of CO_2. Comparing the release of CO_2 between one-fold and no litter treatments, we concluded that 20% of the soil respiration comes from fresh litterfall within first 6 months of litterfall. The contribution of soil respiration in the ecosystem carbon budget will be evaluated by comparing the results of this study with the tower measurement of canopy CO_2 exchange by eddy covariance technique, which was conducted in the same time period at the site.

P50

EFFECT OF SOIL-COLLAR INSERTION ON SOIL RESPIRATION IN SECONDARY DECIDUOUS BROAD-LEAVED FOREST

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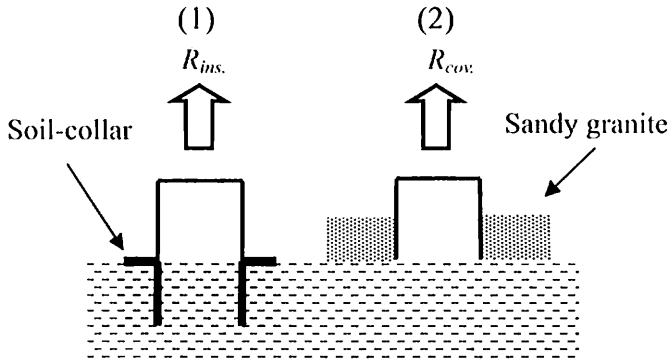
Soil respiration is one of the most important factors for estimating CO_2 dynamics in the forest ecosystem. For measuring soil respiration, soil-collar is commonly inserted to the ground to remove the influence of wind flowing through soil surface. But inserting soil-collar causes occurrences such as cutting off live roots and as interfering with approach of next live roots. However there is little information about the effect of disturbance by inserting soil-collar on soil respiration measurement. In this study, we investigate the effect of inserting soil-collar temporally and spatially.

This study was conducted in a secondary deciduous broad-leaved forest dominated by *Quercus serrata* and *Ilex pedunculosa*. The soil is poorly developed from sandy weathered granite soil with thin A layer. The depth of A layer is about 10 cm. We made chambers of two types: One was that soil-collar was inserted in the ground about 6 cm (Fig.(1)). The other was that soil-collar was covered the surroundings by sandy granite without inserting to the ground (Fig.(2)). We defined $R_{ins.}$ and $R_{cov.}$ as measured soil respiration in respective chambers. To investigate the temporal effect of soil-collar insertion, an automated closed-chamber system was used. The system was composed of IRGA (model 800, LI-cor) , two chambers and a pump. Observations were made from June to October 2006. Measurement frequency of soil respiration was once an hour in each chamber. And to investigate the spatial effect of soil-collar insertion, we established another plots in ridge and valley of the experimental forest. A manual closed-chamber system that contained a small IRGA (GMD20, Vaisala) was used there. We measured $R_{ins.}$ and $R_{cov.}$ at each 8 points in ridge and valley plot in intensive observations. In both experiments, soil temperature was monitored by thermocouple at depth of 5 cm and soil moisture was monitored by TDR (ECH2O Probe, Decagon Devices) at depth of 5 cm.



Through measurement periods, soil respiration in the inserting soil-collar treatment ($R_{ins.}$) was always smaller than soil respiration in the covering the surroundings by sandy granite ($R_{cov.}$). $R_{ins.}$ was about 6.3% - 85.4% of $R_{cov.}$ and it was about 27.8% on average. Therefore, it was suggested that soil respiration was underestimated when we used inserting soil-collar system. Particularly $R_{cov.}$ had a large temporal variation with the maximum occurring in high temperature and moisture. And $R_{ins.}$ was significantly smaller than $R_{cov.}$ in ridge plot and valley plot. ($P<0.01$, Student t-test). In ridge plot, $R_{ins.}$ was about 57.1% - 70.3% of $R_{cov.}$, and it was about 63.9% on the average. In valley plot, $R_{ins.}$ was about 48.0% - 54.7% of $R_{cov.}$, and it was about 51.48% on the average. It was suggested that if environmental factors resembled closely, $R_{ins.}$ was also spatially smaller than $R_{cov.}$ We found that soil respiration was temporally and spatially underestimated by inserting soil-collar at this study site. When we measure soil respiration, we must take a method that does not disturb soil as much as possible.

P51

ABOVE AND UNDERGROUND RESPIRATION IN A DECIDUOUS BROADLEAVED FOREST

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1. INTRODUCTION

Ecosystem respiration can be measured at night by means of the eddy covariance method, but the data may not be reliable because of low turbulence or other methodological problems. Adequate atmospheric mixing is required to obtain reliable measurements of the flux between ecosystem and atmosphere with this method; however, low wind speeds at night are common in our study area, the Yamashiro Experimental Forest (YEF). Consequently, the estimation of nocturnal respiration requires the use of a chamber method. To understand how trees control their CO_2 flux in this forest, we measured above and underground respiration in the forest using a static automated chamber method. In the present study, foliar and woody-tissue respiration was measured using automated foliage chambers, including periods when growth respiration was occurring. In this study, we estimated the above and underground respiration in YEF.

2. SITE DESCRIPTION AND METHODS

The YEF is located in a valley in Yamashiro-cho (34°47'N, 135°51'E), Soraku-gun, Kyoto, in a hilly, mountainous region of central Japan and at an elevation of about 220 m asl. The forest consists of deciduous broadleaved species (mainly *Q. serrata*) and evergreen broadleaved species (mainly *I. pedunculosa*). We measured the leaf area index (LAI) of the forest once per week with an LAI-2000 (Li-Cor). Based on the seasonal variation in the LAI, and the measured foliar respiration, we were able to estimate total foliar respiration for the forest (Miyama et al., 2005). We also measured the diameter at breast height (DBH) of all trees in the YEF every 5 years (Goto et al., 2003). In this study, we measured seasonal variations in nocturnal respiration of tree using static, automated chambers in the YEF. The chamber automatically measured nocturnal respiration at 30-min intervals. We measured the relationship between DBH and the surface area of woody tissue in the trees, estimated total surface area in the YEF, and scaled up stem respiration to the whole forest level to estimate respiration by woody tissue. We attached chambers to *Q. serrata* and *I. pedunculosa* (DBH, 20.7 and 17.9 cm, respectively) tree. The air temperature within chamber was measured with a copper-constantan thermocouple. Nocturnal respiration per unit area of *I. pedunculosa* and *Q. serrata* were calculated from the difference in CO_2 concentrations between 30 and 210 sec (3 min) in chambers.

3. RESULTS AND DISCUSSION

The contribution of underground respiration to the total ecosystem respiration rate reached its minimum (49.1%) on 12 June (DOY 163) and its maximum (82.4%) on 29 November (DOY 333). Seasonal change of growth respiration was marked, indicating that the seasonal variation of growth respiration must be evaluated carefully to estimate total ecosystem respiration. According to continuous automated chamber measurements, the seasonal change of nighttime ecosystem respiration was controlled by growth respiration in a deciduous broadleaved forest. There were two marked peaks of growth respiration, which were caused sequentially by foliar and woody-tissue respiration. These results indicate the effectiveness of averaging long-term continuous chamber measurements to evaluate the annual nighttime ecosystem respiration. Seasonal variation of nighttime ecosystem respiration should be estimated using several parameters, including phenological data. By using the automated chamber method, the total nighttime ecosystem respiration was estimated continuously, thus allowing seasonal patterns to emerge. Therefore, long-term continuous measurement using automated multi-channel chambers and averaging provides an effective means of evaluating the annual nighttime ecosystem respiration.

REFERENCE

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P52

AUTOMATIC SOIL RESPIRATION MEASURING IN THE TROICAL SEASONAL EVERYGREEN FOREST IN SAKAERAT, THAILAND

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The present study was aimed to determine soil respiration in dry evergreen forest at the Sakaerat Environmental Research Station, Nakhon Ratchasima, Thailand (14°29'29''N, 101°55'05''E, elevation 535 m.a.s.l.) during 2005-06. Soil respiration was determined by hourly automated closed chamber method, operated with a CR10 data logger (Campbell Scientific). Soil respiration was measured using closed-part CO_2 Analyzer (LI-820, Licor) and pneumatic cylinder system chamber which is 20 cm in diameter and 20 cm height. Soil moisture contents at 10 and 50 cm depths were measured using TDR (CS615, Campbell Scientific). Rainfall and soil temperature also were recorded by an automatic weather station throughout the study.

The hourly soil temperature, rainfall, soil moisture content at 10 cm depth and soil respiration data during study period are displayed in Figure 1. The results showed that there were remarkable seasonal changes in the soil respiration rate and soil moisture content at 10 cm depth. Soil respiration rates in rainy season (July-November) were found to be greater than those in dry season (December-June). The highest soil respiration rate was found to be 11.220 umol/m^2/s in November while the lowest one was 1.241 umol/m^2/s, found in February. The soil respiration rates varied significantly with soil moisture content at 10 cm depth with r = 0.76.

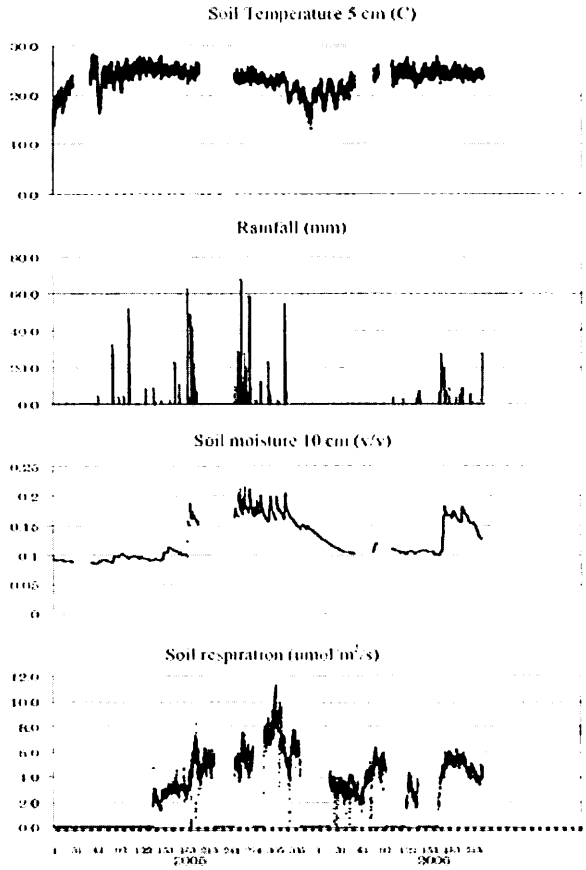

Figure 1 The hourly soil temperature, rainfall, soil moisture content at 10 cm depth and soil respiration data during study period

P53

EFFECT ESTIMATION OF ENVIRONMENTAL FACTORS AND SOIL PROPERTY ON TOPOGRAFICAL VARIATION OF SOIL RESPIRATION - THE CASE OF EXTREMELY IMMATURE AND MATURE FOREST SOIL

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The topographical variation of soil respiration (F_c:mgCO_2m^{-2}s^{-1}) and the effect by environmental factors and soil property are compared between extremely immature forest soil in Yamashiro Experimental Site (YES), Kyoto, Japan and mature forest soil in Kahoku Experimental Watershed (KHEW) in Kumamoto, Japan.

The two observation sites were settled at ridge and bottom of gully. The difference of altitude between them is around 30m. F_c was measured by automated chamber installed IRGA from July 2004 to June 2005 in YES. The four observation sites were settled at top, upper, middle and base part of south faced slope with around 70m height. Each plot had 24 colors and measured F_c by manual chamber installed IRGA at once or two times in a month from August 2005 to August 2006 in KHEW. The soil temperature (T_s: °C) and soil moisture (□: m^3 m^{-3}) at 5cm depth were also monitored at every 6 plots.

When F_c was expressed with Eq.(1) for each plot, parameters a, b and c were gained as Table 1.

$$F_c = aExp(bT_s)(\frac{\theta}{\theta + c}) \qquad (1)$$

Table 1 The parameter values in Eq.(1) at each plot

	YES			KHEW		
	Ridge	Gully	Base	Middle	Upper	Top
a	0.1111	0.0424	0.0159	0.0357	0.0464	0.0904
b	0.1000	0.0878	0.0890	0.0969	0.1049	0.0619
c	0.6752	0.1368	0.1989	0.4716	0.6935	0.4648

The difference of estimated annual F_c from the standard plot was -0.46tCO$_2$ha^{-1}year^{-1} in YES and -9.45 - $+1.27$tCO$_2$ha^{-1}year^{-1} in KHEW. The standard plots were bottom of gully and middle part of slope in YES and KHEW, respectively. The effects of T_s,□ and parameters in Eq.(1) on the difference of F_c were shown in Table-2. The large absolute values of each effect means the large effect on the difference of F_c. The result reported by Palmroth *et al.* (2005) was also shown in Table 2. They dealt with the adjacent forests on flat terrain in north-west USA.

In KHEW, the parameter effects were larger than other cases. The parameter effect is thought to indicate the effect of the soil property difference. The soil in KHEW was thought to mature individually in each topographical part by individual condition. Thus, the soil property is supposed to be different from each other at each topographic part and effect on the soil respiration individually. In the case reported by Palmroth *et al.* (2005), the forests were located on the flat terrain and soil property difference between plots is supposed to be smaller than KHEW.

On the contrary, the parameter effect in YES is much smaller than other case. The forest soil in YES is extremely immature and the difference of soil property at each topographic part is thought to be small and effect on the soil respiration in similar.

Table 2 Estimated effect of environmental factors and parameters in Eq.(1)

	YES			KHEW			NF-USA(Palmroth et al 2005)	
	Ridge	Gully	Base	Middle	Upper	Top	Pine Plantation	Hard Wood
Estimated F_c (tCO$_2$ha^{-1}year^{-1})	21.56	21.10	14.42	23.87	25.13	24.79	41.80	51.66
Deifference of Fc from the standard site (tCO$_2$ha^{-1}year^{-1})	Standard site	-0.46	-9.45	Standard site	1.27	0.92	Standard site	9.86
Effect of θ (tCO$_2$ha^{-1}year^{-1})		1.66	3.89		-1.90	-4.55		2.79
Effect of T_s (tCO$_2$ha^{-1}year^{-1})		-2.10	-1.74		-0.48	-0.54		4.40
Effect of parameters (tCO$_2$ha^{-1}year^{-1})		0.20	-9.84		4.41	7.61		2.67

Reference: Palmroth *et al.* 2005. Global Change Biology. 11: 1-14.

P54

THE EVALUATION OF ROOT RESPIRATION USING SOME MATHODS IN TEMPERATE DECIDUOUS FOREST OF CENTRAL JAPAN

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When we evaluate the net ecosystem exchange of CO_2 in forest ecosystems using the eddy covariance methods, it is necessary to compare the input and output of carbon to/from compartments that forest composed of. Because measurements of each component of respiration are required to provide a complete picture of carbon exchange for a complex forest, the chamber method may offer a significant advantage over the eddy covariance method because it provides accurate, continuous, direct measurements of respiration that are largely unaffected by atmospheric conditions such as wind. Moreover, belowground processes play an important role in the carbon cycle of the biosphere. Soil respiration is the main pathway for carbon moving from the ecosystem into the atmosphere (Ryan and Law, 2005) and can strongly influence net ecosystem exchange. However, the efflux from a soil surface is an assemblage of multiple belowground processes such as decomposition respiration and root respiration. In this study, we try to evaluate each compartments of forest carbon cycle using respiration measurements and biomass measurements.

The study was conducted in a mixed forest of deciduous and evergreen broad-leaved trees including some conifers at Yamashiro Experimental Forest in Kyoto. The area consists of very thin soil layer, immature and originated from granite. Kominami et al. (2003) measured CO_2 exchange by eddy covariance methods.

We measured forest biomass in study site and litter and CWD input to forest floor. We measured *Rs* at many points and *Rr* with many samples by chamber method. We developed an automatic chamber system for measuring CO_2 flux of fine root. At the same time, *Rs* and CO_2 flux from B layer were measured. At each chamber, CO_2 flux was measured at 35-min intervals, and soil temperature and water content were measured continuously from April 2004 to May 2005. We combined some methods for estimation of *Rr* because it is difficult to build the technique to separate accurately *Rr* from *Rs*.

From annual measurement of *Rr* and *Rs*, we estimated the carbon output from forest floor. We found the differences of responsibility to environmental factor between root and soil respiration. These results suggested that it is important to analyze *Rr* separately for discussion and modeling forest carbon cycle. Moreover, we found that fine root plays an important role in belowground carbon cycle and the importance of measurement of root litter, though there is no data yet.

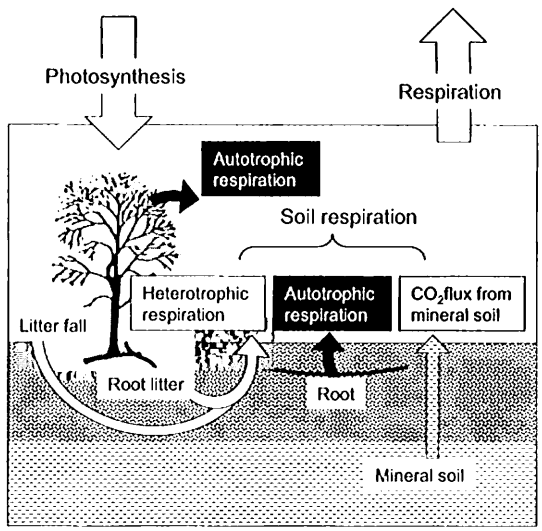

Fig 1. The illustration of carbon cycle of forest

P55

CONTRIBUTIONS OF ROOT AND MICROBIAL RESPIRATION TO SOIL RESPIRATION FOR *ABIES HOLOPHYLLA* AND *QUERCUS MONGOLICA* STANDS OF CENTRAL KOREA

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To investigate contributions of root and microbial respiration to total soil respiration, trenched plots and control plots were set up in *Abies holophylla* and *Quercus mongolica* stands at Gwangneung Experiment Forest of central Korea in October 2004. Soil respiration, soil temperature, soil water content, soil pH, and soil microbial activity were measured from June, 2005 through May, 2006. There were no differences in total annual soil respiration (t C/ha/yr) between *A. holophylla* (9.4) and *Q. mongolica* (7.9) stands. Contribution of root respiration to total annual soil respiration was 39% for *A. holophylla* and 35% for *Q. mongolica* stands. Soil temperature was not different between *A. holophylla* (13.2□) and *Q. mongolica* (14.6□) stands. Soil water content for the *A. holophylla* stand (12.8%) was lower than that (14.2%) for the *Q. mongolica* stand. Soil pH for the *A. holophylla* stand (4.8) was lower than that for the *Q. mongolica* stand (5.0). Soil microbial activity (μg hydrolyzed FDA/min/g dry soil) for the *A. holophylla* stand (8.2) was higher than that for the *Q. mongolica* stand (6.5). Soil respiration for both stands was related with soil temperature ($p<0.001$). And soil respiration for the *Q. mongolica* stand was related with soil microbial activity ($p<0.01$), however, that for the *A. holophylla* stand was not related ($p>0.05$). Contribution of root respiration to soil respiration for both stands was related with soil temperature ($p<0.05$) in the study period except winter.

Fig 1. The picture of estimating total soil respiration

P56

COMPARISON OF ECOSYSTEM RESPIRATION OF WINTER-WHEAT MEASURED WITH EDDY COVARIANCE AND STATIC CHAMBER

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Aim of the paper is to compare the measurements of ecosystem respiration of a winter-wheat cropland in North China Plain during the growing season(March to June) of 3 years(2003-2005) using eddy covariance and static/GC chamber. Most of the chamber measurement were made in darkness, either during nighttime or during daytime by covering wheat and ground. The average difference of air temperature inside and outside the chambers was 1.2℃ after data quality control for minimizing the environmental disturbance. Half-hourly nocturnal flux values were excluded when the friction velocity(u*) was <0.12 m s^{-1}, sensor variance was excessively high or extremely low, rain was falling. The available nocturnal half hourly data were 25%, 33%, 31% for analysis in growing season of 2003, 2004, 2005. The study showed that the measurements of ecosystem respiration using chamber at nighttime is 16% higher than that of eddy covariance during the growing season of 2003. Continual nocturnal half-hourly ecosystem respiration estimates of chamber were derived by extrapolating the relationship between diurnal ecosystem respiration and air temperature, LAI. Nocturnal eddy covariance measurements were good correlated to nocturnal chamber estimates in 2003(R^2=0.63) and were only 11% lower than the latter, but poorly correlated to chamber estimates of ecosystem respiration in 2004 and 2005. When the nocturnal friction velocity was 0.25-0.4 m s^{-1}, two measurements all had good agreement in the 2004 and 2005 which may suggest that the u* was an predictor of good nocturnal eddy covariance measurements. Correlations of daily nocturnal measurements by eddy covariance and chamber were good (R2=0.895, 0.515, 0.497) and chamber measurements had 10.7%, 38.5%, 2.4% higher than eddy covariance measurements during the 3 years.

P57

DIVERSIFIED EVALUATION OF CARBON BALANCE AT WARM TEMPERATE FOREST IN JAPAN

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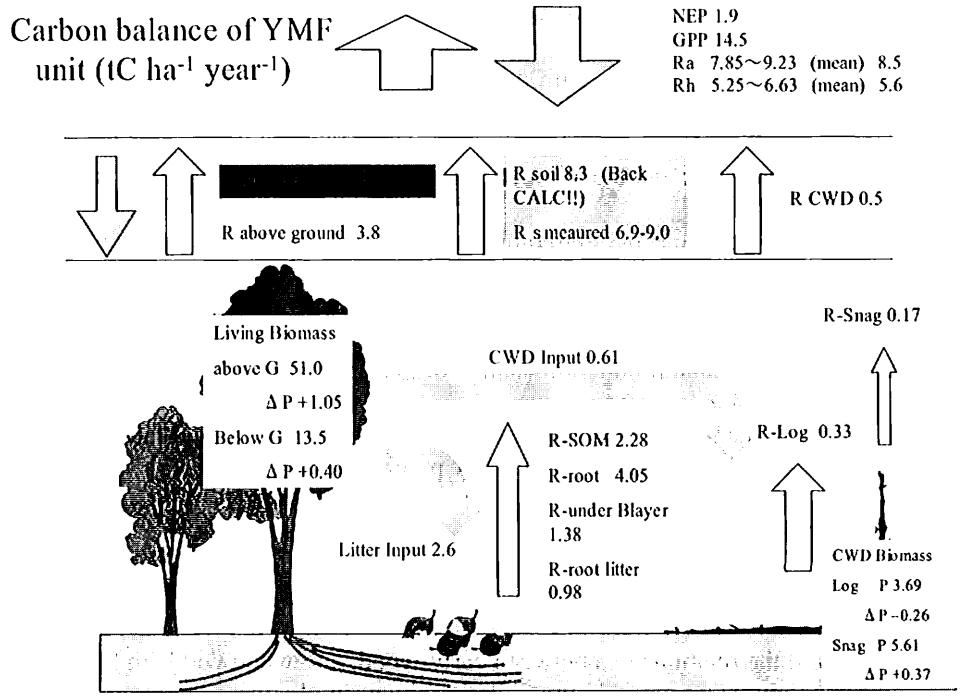
Estimation of carbon balance and structure of forest ecosystem is an important subject for long term evaluation of forest carbon dioxide exchange. In a temperate deciduous forest in Japan situated complex terrain, Total carbon balance was estimated using micro-meteorological method, chamber methods (leaves, stems, root, soil CWD) and biometric methods.

Materials and methods

The study was conducted in the Yamashiro Experimental Forest (temperate secondary broad-leaved forest in central Japan, 34°47'N, 135°50'E). *Quercus serrata* is a dominant species in the site. The area of the site is 1.7ha, annual mean air temperature was 15.5 °C and annual precipitation was 1449 mm in 2002. Tower CO_2 flux have been measured from 2000. Above and below ground net primary production were estimated based on allometric relationships and DBH census from 1994. CO_2 flux from foliages, stems and roots was estimated using automated chambers and LAI and root biomass measurements. CO_2 flux from soil (Fs) was estimated by 4 automated and 160 manual chambers. CO_2 flux from CWD was estimated by 2 automated and 192 manual chambers measurements and CWD census. Carbon balance of litter was estimated by RothC model and litter trap measurements. By integrating each CO_2 flux measurement and various censuses, carbon balance of YMF was estimated.

Results and Discussion

Comparing with daytime CO_2 uptake, nighttime respiration was relatively high in warm temperate forest caused by warm temperate environment. Therefore accurate estimation of nighttime respiration is required. Carbon accumulation in soil was considerably small caused by high decomposition rate comparing with C input in forest floor. As chamber measurements had high variations especially in soil respiration measurements, diversified evaluation using another measurements (eg. biometric) should be required in adopting chamber measurements in NEE estimation.



P58

LONG TERM ESTIMATE OF ABOVEGROUND PRODUCTION BY A TREE RING ANALYSIS IN A TEMPERATE BROAD-LEAVED SECONDARY FOREST IN JAPAN

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Influence of climate change due to increase of atmospheric CO_2 content on forest ecosystem should be evaluated. The long-term data of forest productivity is needed to evaluate the influence of climate change on net ecosystem production (Jacoby and D'Arrigo, 1997). The tree ring analysis is a useful method to calculate long-term annual aboveground production (AGP) which is important part of net ecosystem production's estimation (Graumlich et al, 1989).

The objective of our study is to determine long-term changes in AGP of a forest by a tree ring analysis. We estimated annual AGP as multiplied wood density by annual volume increment calculated from ring width. We examined annual AGP variation in relation to environmental factors such as monthly mean air temperature and monthly precipitation.

Materials and methods

The study was conducted in the Yamashiro Experimental Forest (temperate secondary broad-leaved forest in central Japan, 34°47'N, 135°50'E). *Quercus serrata* is a dominant species in the site. The area of the site is 1.7ha, annual mean air temperature was 15.5 °C and annual precipitation was 1449 mm in 2002. Tree census was conducted in 1994, 1999, and 2004. About 40 trees were harvested and allometric relationships were obtained for the biomass and production estimation in the site.

Method of this study was shown in Fig.1.

①Increment cores of *Q. serrata* (n=22) were obtained from the stem at the breast height

and each tree's ring widths were measured.

②Ring-width series of samples were cross-dated by visually, and cross-dating was verified by using COFECHA program. It was confirmed whether there was a synchronism among them by cross-dating.

③Biomass change of each sample tree was calculated using the ring-width series, wood density of each tree and the allometric relation between diameter at breast height and AGP.

④We assumed that the ecosystem biomass from 1994 to 2004 in the site was proportional to the summation of the biomass of 22 samples of *Q. serrata*, and applied the total biomass change in *Q. serrata* for current 20 years to the ecosystem biomass change in the site.

⑤We estimated annual production change of the site during this period as the annual difference of the biomass change.

⑥ We examined annual AGP variation in relation to environmental factors, such as monthly mean air temperature and monthly precipitation.

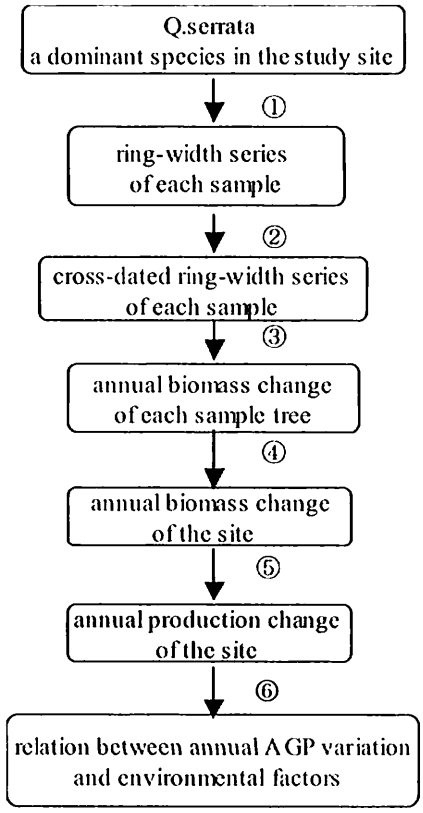

Fig.1 Method of this study

Results and Discussion

We could find the synchronism after 1980 among ring-width series of *Q.serrata*. The average annual production change was 2.3tC ha^{-1} $year^{-1}$, and it ranged from 2.6 to 1.1 tC ha^{-1} $year^{-1}$.

We analyzed the relationships between early-wood, late-wood width and environmental factors (monthly mean air temperature and monthly precipitation) by a simple linear regression analysis. As a result, late-wood width which highly contributed to annual ring width had a negative relation to summer temperature, and a positive relation to summer precipitation.

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P59

SEASONAL VARIATIONS IN LEAF AREA INDEX AT THE KOFLUX GWANGNEUNG WATERSHED IN KOREA

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Leaf area index (LAI) is one of the fundamental variables that are critical to analyze and synthesize various ecophysiological and biophysical measurements to ascertain water and energy exchanges in key terrestrial ecosystems. Information on LAI not only reflects the phenology of the site vegetation but also connects the changes in ecohydrological conditions to the observed fluxes of carbon and water at the study site. KoFlux Gwangneung forest (designated as a National Arboretum) is located in the west-central part of Korean Peninsula (37°45'25.37"N, 127°9'11.62"E, 280~470 m above m.s.l). The study site is dominated by an old natural broadleaf deciduous forest of *Quercus* sp. and *Carpinus* sp. (80-200 years old) along with scattered coniferous (e.g., *Abies holophylla*) and mixed forests, representing complex and heterogeneous landscapes of the country. We have measured LAI since 2001, using various methods at different locations at the site by different research groups. In this presentation, all the available LAI measurements made from April 2001 to September 2006 were combined and analyzed to characterize its seasonal variations at the site and to eventually compare with LAIs estimated from MODIS (Moderate Resolution Imaging Spectroradiometer) products. The information on the seasonal and spatial distributions of LAI, when combined with knowledge of other ecohydrological and biogeochemical measurements will provide a means of understanding and predicting components of energy, water and carbon cycles in this important ecosystem.

Acknowledgment: This study was supported by a grant (code: 1-8-2) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program, the Eco-Technopia 21 Project and BK21 from the Ministry of Environment, Korea. And I am very thankful to Jeongshim Kim, Jaeyoung Lee and Kyunghee Kim for collecting data.

P60

DEVELOPMENT OF OUTDOOR INSTALLATION TYPE LASER SCANNER FOR CONTINUOUS MEASUREMENT OF TREE HEIGHT AND PLANT AREA DENSITY

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In order to estimate carbon storage and fixation of a forest, usage of the laser measurement technique was rapidly spread in recent years. For example, tree height was measured by an air-borne LIDAR and canopy structure was measured by a ground-based laser scanner (Takeda *et al.* 2005). But these measurements require high cost and were influenced by weather. The aim of this study is to develop the outdoor installation type laser scanner which can be measured automatically.

The outdoor installation type laser scanner was manufactured by attaching a laser range finder (LD90-3100HS, Riegl) put in a waterproof case to a pan-tilt rotation stage (PTU-D46-70, Directed Perception, Inc.) (Fig.1). It was placed at 28.7 m height on the CO_2 flux observation tower in Fujihokuroku Flux Observation Site (35°26′N, 138°46′E) in Fujiyoshida, Yamanashi, Japan. A measurement was conducted at night in every two days, because atmosphere was stable and noise of radiation to the laser range finder was little. The tree height was estimated from DCHM (Digital Canopy Height Model), which was calculated by difference of DTM (Digital Terrain Model) and DSM (Digital Surface Model), these were calculated from three-dimensional coordinates by which the laser beams were intercepted. The profile of plant area density (PAD) was estimated from a probability which the laser beams pass through the horizontal layers in the forest.

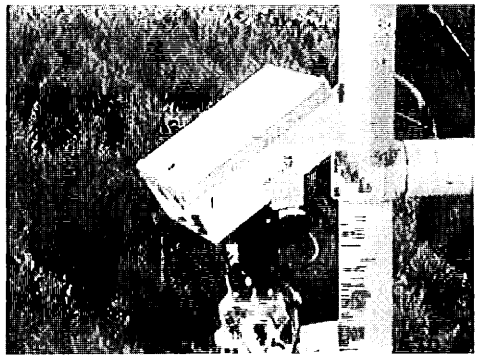

Fig. 1 Outdoor installation type laser scanner.

The laser scanner operated correctly in fine days, but it did not operate correctly in rainy days or foggy days. So, only data measured in fine days were used to calculate the tree height and the PAD. Fig.2 shows the distance image measured by the laser scanner in September 5, 2006 and fisheye photograph. In order to verify an accuracy of tree height, it was compared with a ground measurement for the total number of trees and the histogram of tree height. Although the total number of trees measured by the laser scanner was smaller than measured by the ground measurement, good coincidence was obtained by the tall trees higher than 20m which have a large number in this site. In order to verify the profile of PAD, the measurement by the plant canopy analyzer (LAI-2000, Li-Cor) was conducted on each floor of the tower. A clear distinction of canopy space and trunk space, and PAD in the layer higher than 20 m was seen in the measurement by the laser scanner, but these were not seen in the measurement by the plant canopy analyzer. These results indicated that the laser scanner was suitable for the measurement of PAD rather than the plant canopy analyzer.

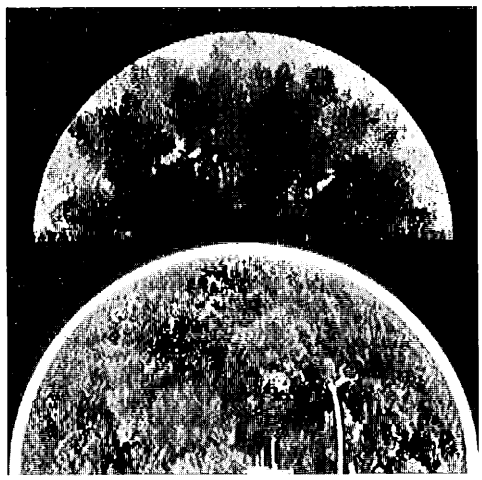

Fig. 2 Distance image measured by laser scanner (upper) and fisheye photograph (lower).

Reference

Takeda T., H. Oguma, Y. Yone and Y. Fujinuma, 2005, Comparison of leaf area density measured by laser range finder and stratified clipping method. PHYTON-ANNALES REI BOTANICAE, 45: 505-510.

P61

THE RESPONSE OF TROPICAL FOREST PHOTOSYNTHESIS TO SEASONAL VARIATIONS IN LIGHT CONDITIONS IN THE AMAZON REGION

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This study examines radiation-related factors associated with seasonal and interannual variation in model-simulated gross photosynthesis of tropical evergreen broadleaf forest in the Amazon region. An 11-year climatology is produced for photosynthetically active radiation (PAR), canopy-absorbed PAR, and model-estimated gross photosynthesis. A sun-shade model of canopy photosynthesis was employed to simulate mid-day rates of gross photosynthesis. The analysis was performed on both regional and local scales. Previous studies have demonstrated that the PAR regime influences photosynthesis directly by affecting (a) the total energy available for photosynthesis (via total PAR), (b) the spatial distribution of PAR within the canopy (via diffuse PAR), and (c) the spectral composition of diffuse PAR. Factors (b) and (c) directly influence photosynthetic rates through their effect on canopy light use efficiency. Evidence of this influence is apparent in the present analysis. The diffuse PAR fraction is a key determinant of how gross photosynthesis responds to variations in total and/or diffuse PAR. Generally, high diffuse PAR fractions indicate both sunlit and shaded leaves are light-limited, whereas low diffuse PAR fractions indicate light limitation by only shaded leaves. Among years, mid-day rates of gross photosynthesis typically exhibit positive correlations with total PAR (sum of direct and diffuse PAR). Negative correlations with total PAR and positive correlations with diffuse PAR are observed in limited regions and months. Whereas the majority of the Amazon region exhibits high diffuse PAR fractions (>0.75) throughout the year (even during dry season), the southeastern region in particular has lower values (<0.5) on a seasonal basis. Potential changes in the Amazon PAR regime associated with climate change may be expected to directly influence rates of gross photosynthesis. These results reveal the unique spatiotemporal patterns of light limitation in the Amazon and its dependence the ambient conditions of PAR scattering and extinction by clouds. Accurate modeling and monitoring of vegetation-atmosphere carbon exchange in moist tropical forest depends in part on accounting for these conditions.

P62

TRACER VALIDATION OF LAGRANGIAN ANALYTICAL SOLUTION INSIDE AND ABOVE A FOREST CANOPY

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A two-dimensional Lagrangian analytical model was recently proposed to relate source strength to concentration profiles within and above a plant canopy. This new model is able to describe passive scalar dispersion even in conditions of local advection and permits horizontal inhomogeneity of a tracer field. This new approach appears to be a significant step forward in canopy diffusion modeling, relying on gradient-diffusion relationships and horizontal homogeneity. This new model, therefore, has broad application areas such as flux and concentration footprint estimation and stable isotope modeling inside a plant canopy.

A thorough validation in real outdoor conditions is essential and the present work is an extension of preliminary validations done with wind tunnel experiments and incomplete data set in the field. The paucity of suitable experimental data in natural vegetation canopies has hindered us from improving the model and extension to other applications. In this respect, a tracer experiment can provide us with a powerful tool to evaluate the performance of the Lagrangian model. Tracer concentration profiles were measured inside and above a managed pine forest at the Florida AmeriFlux site in 2004 and 2006. During this experiment, several passive tracers were released at two different levels from a line source and tracers concentrations measured at ten levels above the surface.

This poster reports on profiles of turbulence statistics measured with three-dimensional sonic anemometers and discusses the sensitivity of the Lagrangian analytical model to the various turbulence scales used and their impact against these turbulence scales on the profiles of concentrations measured inside and above a forest canopy for a variety of environmental conditions.

Acknowledgements *This study is supported by the U.S. Dept. of Energy, Office of Biological and Environmental Research, Terrestrial Carbon Processes Program.*

P63

SURFACE FLUX PARAMETERIZATION SCHEMES FOR BARE SOIL SURFACES: PHYSICS AND SCHEME EVALUATION

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Bare soil is a major landscape in arid and semi-arid regions. Heat flux parameterization schemes for bare soil surfaces play a crucial role in modeling land-atmosphere interactions in this region and they are also a basis for developing sparse-canopy heat transfer schemes. This paper presents relationships of thermal roughness lengths (z_{0h}) with aerodynamic roughness lengths (z_{0m}) and flow state for eight aerodynamically rough bare soil surfaces in arid and semi-arid regions. These sites represent a variety of conditions of surface roughness lengths (0.5 mm ~ 10 mm) and sensible heat fluxes (–50 W m^{-2} ~ 400 W m^{-2}). It is shown that z_{0h} and parameter kB^{-1} (= $\ln(z_{0m}/z_{0h})$) exhibit clear diurnal variations for each site, with higher values in the daytime and lower values in the nighttime. Mean values of kB^{-1} for the individual sites increases with z_{0m} while z_{0h} decreases with it. As a result, C_D (momentum transfer coefficient) increases faster than C_H (heat transfer coefficient) with the surface roughness length. Parameter kB^{-1} often becomes negative at night for moderately rough surfaces (z_{0m} ~ 1 mm) and even in the daytime for relatively smooth surfaces (z_{0m} < 1 mm). This indicates that the widely accepted excess resistance for heat transfer can be negative, which cannot be explained by current theories for aerodynamically rough surfaces. Further analysis shows that the diurnal variations of z_{0h} depend on the flow state, because $\ln(z_{0h})$ is most correlated with $u_*^{1/2}|T_*|^{1/4}$, though not strongly for smooth surfaces (z_{0m} < 1 mm). Based on these results, we evaluated performances of five kB^{-1} schemes at these bare soil surfaces. We identified one scheme that has an overall better performance and is able to reliably estimate surface turbulent fluxes at all the sites, while other schemes of interest may systematically over-estimate or under-estimate heat fluxes at some sites or have a limited applicable range. The different performances result from how well a scheme can produce the major characteristics of heat transfer over bare soil surfaces.

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SCALING CARBON DIOXIDE AND WATER VAPOR EXCHANGE FROM LEAF TO CANOPY IN A LOWLAND DIPTEROCARP FOREST

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The exchange of both carbon dioxide and water vapor by terrestrial ecosystems affects global warming and plays an indirect role in the regulation of the surface temperature of the planet. Tropical rain forest, in particular, plays an important role in climate change because of their large plant volume and complexity. Since the gas-exchanges in a forest are related to various complicated physical and physiological processes and factors interactively, more precisely analyses based on an individual leaf studies linked to other processes, including light and rainfall interception, scalar and energy transfer, soil respiration process are needed. In order to understand how interactions between environmental factors and leaf-level physiological parameters might impact a canopy-level CO_2 exchange, we developed and parameterize a multi-layer forest model in a tropical lowland dipterocarp forest in Peninsular Malaysia.

Observations were conducted at the Pasoh Forest Reserve where is about 70 km southeast of Kuala Lumpur, Peninsular Malaysia (2°58' N, 102°18' E). The core area (600 ha) of the reserve is a primary lowland mixed dipterocarp forest, consisting of various species of *Shorea* and *Dipterocarpus*. The continuous canopy height is approximately 35 m, although some emergent trees exceed 45 m. In order to parameterize a leaf submodel of the forest model, we measured gas-exchange characteristics at the scale of a leaf using a leaf chamber and at the scale of a whole forest by eddy covariance method. We scale from leaf level gas exchange to a canopy using the information of a canopy structure, such as a profile of leaf area index, a distribution of leaf inclination angle, clumping index.

Leaves in the canopy of the Pasoh Forest Reserve showed patchy stomatal behavior, and the results indicated that the afternoon depression in apparent photosynthetic capacity in dipterocarp leaves was mainly caused by patchy stomatal closure. Apparent photosynthetic capacity at the scale of a single leaf was modeled and scaled with cumulative leaf area index to a canopy. The diurnal patterns of energy, H_2O and CO_2 fluxes above the canopy were investigated using the multi-layer model that considered patchy stomatal closure. Both bimodal and homogeneous stomatal opening distributions were simulated, and the results indicated that the observed negative relationship between CO_2 absorption under light-saturated conditions and vapor pressure deficit were not sufficiently explained by stomatal closure alone, for homogeneous stomatal opening distributions. For bimodal stomatal opening distributions, however, a greater depression in canopy photosynthesis was found with increased atmospheric vapor pressure deficit. The diurnal changes in CO_2 flux accumulated until each layer indicated the afternoon depression in canopy photosynthesis, which was almost completely explained by the assimilation depression of leaves above >30 m in the canopy that was caused by bimodal stomatal closure, although the assimilation of lower leaves was not limited by bimodal stomatal closure. We concluded that the diurnal change in NEE at the Pasoh Forest Reserve could be accurately explained with the modified multi-layer model by considering patchy stomatal closure. Thus, the midday depression in canopy photosynthesis was mainly caused by patchy stomatal closure.

P65

GPP DYNAMICS OF AN OLD-GROWTH CHINESE MIXED FOREST: SCALED BY VPM MODEL

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Remote sensing techniques provide ideal tools to validate and scale up flux measurements of single tower. In this paper, a satellite-based Vegetation Photosynthesis Model (VPM) was applied to simulate the annual and seasonal dynamics of GPP fluxes of a old-growth Chinese mixed forest. The VPM model uses two improved vegetation indices(Enhanced Vegetation Index (EVI), Land Surface Water Index (LSWI)). We used there years (2003-2005) images from the MODIS sensors and CO_2 fluxes data form a flux tower site in Changbai Mountain, Jilin Province,China.

Fluxes were measured using micro meteorological methods and routine correction were applied to fluxes time series. Neural network technique was used to fill gaps in the hourly fluxes time series and to predicate daytime RE.

The predicted GPP values agreed reasonably well with the GPP estimated from the measured NEE time series. This study highlighted the biophysical performance of improved vegetation indexes in relation to GPP and demonstrated the potential of the VPM model for scaling-up of GPP although some improvements are needed.

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MODEL VALIDATION OF NET ECOSYSTEM CO_2 EXCHANGE AT ASIAFLUX SITES: TOWARD CARBON BUDGET IN EAST ASIA

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Process-based carbon cycle models are an essential tool for carbon budget studies to interpret and integrate observational data and to extrapolation them for time and space. Therefore, validation of the models used in regional carbon budgeting is an important task, which determines the credibility of estimation.

We have developed a process-based terrestrial ecosystem carbon cycle model, on the basis of a simple model (Sim-CYCLE; Ito and Oikawa, 2002), for the purpose of evaluation of East Asian carbon budget, in conjunction with various observational data. The modified model consists of four sectors (Fig. 1), canopy trees, floor shrubs and grasses, dead biomass, and mineral soil, each of which is sub-divided into a couple of functionally different components. The model simulates specific carbon flows among the atmospheric CO_2 and ecosystem carbon pools: photosynthetic assimilation (gross primary production, GPP), allocation, plant autotrophic respiration (AR), litter fall, and soil microbial heterotrophic respiration (HR). The ecosystem carbon budget (net ecosystem production, NEP) is obtained as NEP = GPP – AR – HR, and the difference in environmental responsiveness of the carbon flows produces complicated spatial and temporal variations. Ecophysiological parameters used in the model were mainly obtained through calibration using observational data of the ecosystem surveys such as plant biomass, soil organic matter, litter fall, and net primary production. Additionally, the model was improved by introducing advanced canopy radiation transfer and biochemical photosynthetic schemes, which operates at 30-minute time step. For deciduous broad-leaved forest, important leaf properties such as maximum carboxylation rate and leaf mass per area were parameterized using field studies to account for leaf aging and acclimation.

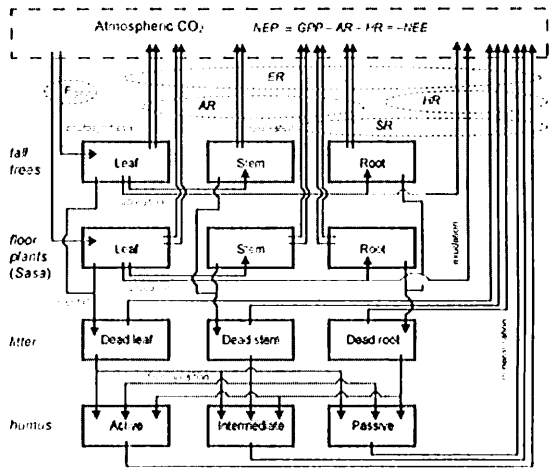

Fig 1. Model structure.

Flux measurements of net ecosystem CO_2 exchange (NEE) by the eddy covariance method provide invaluable data for validation of NEP (= –NEE) estimated by the model. For the carbon budget in East Asia, data from the tower network of AsiaFlux are available at approximately 20 sites (and about 10 sites in Southeast Asia and North America). The model was firstly applied to a cool-temperate deciduous broad-leaved forest in Takayama, central Japan, where we can use the longest record of NEE from 1998 to 2005. The model simulation was driven by daily meteorological dataset of the NCEP/NCAR reanalysis from 1948 to 2005 corrected by station data. The model simulated NEP shows, in general, a good agreement with observed NEE, implying the credibility of model simulation. Clear seasonal variation in CO_2 exchange of the temperate deciduous forest was appropriately captured. However, the model simulation differed significantly from the flux data; for example, the model simulated largely higher carbon uptake in the late growing season in 2004, probably due to unexpected defoliation by tropical cyclone (typhoon). Also, the model simulated higher ecosystem respiration in non-growing times such as winter dormancy and nighttime; this may be caused by both observational and modeling reasons of atmospheric stability and snow-pack effect.

Now, we are trying to apply the model to other AsiaFlux sites such as evergreen needle-leaf forest in Fuji-Yoshida, deciduous needle-leaf forest in Tomakomai, and alpine meadow in Qinghai-Tibetan Plateau, in order to examine model applicability to a wide variety of ecosystems. The model validation using AsiaFlux data will improve the reliability of our evaluation of East Asian carbon budget.

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DEVELOPMENT OF A PROCESS-BASED MODEL FOR ANALYZING THE LAND-ATMOSPHERE EXCHANGE OF CO_2, CH_4, AND N_2O: PLOT-SCALE STUDY IN COMPARISON BETWEEN A TEMPERATE DECIDUOUS FOREST AND A TEMPERATE CONIFEROUS FOREST IN CENTRAL JAPAN

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Land-atmosphere exchange of greenhouse gases can exert considerable feedback effects on the human-induced climatic change. However, there remain large uncertainties in our understanding and quantification of the greenhouse gas exchange, owing to complexity and heterogeneity of terrestrial ecosystems. To evaluate the global warming potential (GWP) reasonably, we should account for net budgets of major greenhouse gases, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), each of which are regulated by different biogeochemical mechanisms. We developed a process-based model of land-atmosphere exchange of the major greenhouse gases, on the basis of a carbon cycle model (Sim-CYCLE). First, methane oxidation schemes were considered for one by Potter et al. (1996) and Ridgewell et al. (1999), in which CH4 oxidation rate by soil was parameterized as functions of temperature and soil moisture. Second, schemes of nitrous oxide emission by nitrification and denitrification were considered for one by Parton et al. (1996) and Potter and Klooster (1998), in which N_2O emission rate from soil was parameterized as functions of soil inorganic nitrogen, temperature, and moisture conditions. Preliminarily, we applied the model to a cool temperate deciduous broad-leaved forest in Takayama, an AsiaFlux site in central Japan, using a time-series climate data of the NCEP/NCAR from 1948 to 2004. The land-atmosphere exchange of the greenhouse gases showed clear seasonal variations: strong net uptakes of CO_2 and CH_4 and strong N_2O emission in summer. The model estimations were compared with observations with a flux tower and soil chambers, showing fair agreements. On average during the last 10 years, the model estimated that the temperate forest net absorbed CO_2 and CH4 at rates of 804.53 g CO_2 m^{-2} yr^{-1} and 0.34 g CH_4 m^{-2} yr^{-1}, and net released N_2O at a rate of 0.02 g N_2O m^{-2} yr^{-1}, respectively. Based on the 100-year GWP of greenhouse gases in IPCC (2001), the forest was estimated to have a negative effect of GWP by 807.74 g CO_2 (equivalent) m^{-2} yr^{-1}. In our forthcoming study, after modifying the model for water and nitrogen cycles, we will apply the model to other AsiaFlux sites and estimate the Asian greenhouse gas budget. The effect of net greenhouse gas is planed to be evaluated also at a cool temperate coniferous forest in Fujiyoshida, other Asian flux sites, and to compare with Takayama site.

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MODELING TEMPORAL-SPATIAL WATER AND ENERGY BUDGETS IN NORTH-EASTERN SIBERIA BY LAND SURFACE MODEL

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Synthesis of river-monitoring data reveals that the average annual discharge of major arctic rivers showed upward trend. Some studies reported that the increasing trend in discharge relates in part to the winter warming and increased winter precipitation. In contrast, precipitation shows downward trends in summer season, strongest in August (Yang et al. 2002). However, evapotranspiration (ET) in arctic basin areas showed stable inter-annual trend, which seems to be related to both melt of ground ice and increased winter precipitation input. However, we do not have enough data about the relationship between vegetation and water budget in arctic area. Thus, we calculated water and energy budgets in north-eastern Siberia over 15 years using a one-dimensional land surface model (Yamazaki et al., 2004). The model, divided the canopy into two layers and then represented the fluxes above and within the canopy, was applied to north-eastern Siberia bounded by 30° - 72°N and 90° - 180°E, with grid spacing of 0.5° × 0.5°.

Precipitation shows a spatial distribution decreased gradually with latitude, while ET is spatial-largely scattered. Spatial distribution of the calculated ET is similar to the fashion of Serreze *et al.* (2003) who calculated ET in the arctic area with a climate model. Furthermore, to demonstrate the soundness of the calculated ET, ET in Lena watershed was calculated by water budget method based on the measurement of precipitation and runoff. Their comparison showed good agreement. In an ET-climate diagram, large ET did match regions of high air temperature and precipitation. The diagram also represented that the spatiality of ET was determined by air temperature rather than precipitation. ET was in significant increasing trend in the regions dominated by taiga forest and grassland over the 15 years, while air temperature showed decreasing trend over all area. The decrease of temperature seems to be correlated the seasonal trend decreasing since May, indicated in Lena watershed. Precipitation in Lena watershed showed a characteristic seasonal trend increasing at melting period and late summer. This seasonal pattern of precipitation could influence on the trend of ET increasing in summer season. The precipitation in late summer when ET is relatively small does probably contribute to runoff and soil storage, thus the water flowed into soil would be used for ET of the next year through the freezing period. Our calculation clearly showed that precipitation and ET were increasing in warm and wet area over the previous 15 years. We anticipate that this study could contribute to understand the change of water and energy fluxes in Asia continent following to climatic change.

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GROSS PRIMARY PRODUCTIVITY ESTIMATION OF DECIDUOUS BROADLEAF FOREST BY 3-PG MODEL COMPARING WITH MODIS IMAGE

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Gross Primary Production (GPP) is the assimilation of carbon absorption by plants. It can be indicated the carbon status on the biosphere which is to understand Global Warming, relating to Kyoto Protocol. To estimate GPP, there are several representative models. One of those models is 3-PG, namely Physiological Principles Prediction Growth (Landsberg and Waring, 1997). It is process based model which required the actual monthly meteorological or the mean monthly meteorological data as the main input data. All parameters in 3-PG model are recently used appropriately for Eucalyptus and Pine, but not for the deciduous broadleaf forest.

In this study, 3-PG model parameterization is done for Deciduous Broadleaf Forest to estimate Gross Primary Productivity (GPP). The flux tower data from Hitsujigaoka Site (FFPRI), Hokkaido since 2000-2003 is collected for analyzing in this study such as the meteorological data. First, the sensitivity analysis is examined among the meteorological data for checking GPP value how much it vary. From the result, it showed that the minimum and optimum temperatures are the most sensitive to GPP value. The parameterization is done based on the temperature data in terms of the temperature growth modifier. Figure 1 illustrated that the observed GPP and the estimated GPP have the relation likely approached to one to one line.

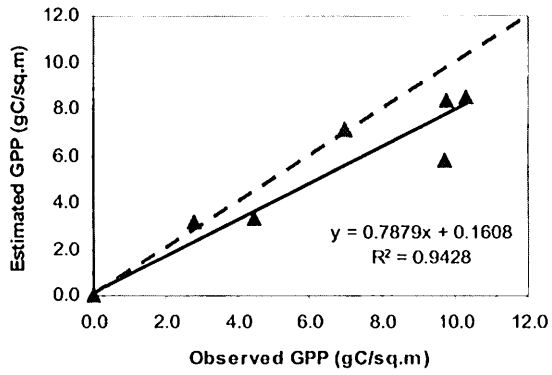

Figure 1 Comparison of observed GPP and estimated GPP, red dot line is one to one line.

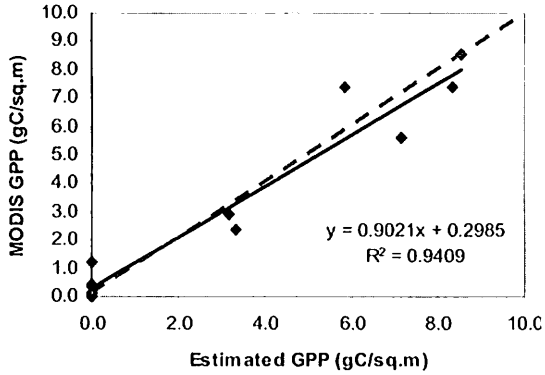

Figure 2 Comparison of estimated GPP and MODIS GPP, red dot line is one to one line.

After doing the parameterization, MODIS GPP, 8-days composite which is integrated into monthly data, is compared with the estimated GPP from 3-PG model. The comparing method is based on one pixel basis. The result is showed in the figure 2. MODIS GPP and the estimated GPP performed a very good relation which closed to one to one line. However, both estimated GPP and MODIS GPP are given the underestimated value when comparing with the observed one from the flux tower data. There is other parameters related to estimate GPP directly which is still not do the parameterization. Since the meteorological parameter is only adjusted in this study. Then, the result could be improved the accuracy appropriately.

Finally, we would like to give a special thanks to Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI) for supporting us the flux tower data as the long time monitoring meteorological data.

P70

COMPARISON OF MODIS DRIVEN NET RADIATION OVER A MOUNTANOUS TERRAIN AND A HETEROGENEOUS FARMLAND

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Moderate Resolution Imaging Spectroradiometer (MODIS) senses throughout the earth nearly twice per daytime (i.e. onboard TERRA in the morning and onboard AQUA in the afternoon), and provides a powerful tool to monitor various ecosystems periodically. The main objective of this study is to validate the fully MODIS driven net radiation for both TERRA and AQUA by comparing with flux tower measurements in a heterogeneous farmland and a rugged deciduous forest for clear sky days. We described the MODIS processing covering land and atmospheric products using IDL / ENVI environment. We also tested whether MODIS successfully captures diurnal variation of required input variables for calculating net radiation. The accuracy of MODIS driven data including air temperature, humidity, and total solar radiation were compared with field data measured in national weather stations of Korea. Evaluation against field measurement showed that net radiation were retrieved with overall root mean square errors of 45 W/m^2 and 38 W/m^2 for TERRA and AQUA in the forest site, respectively. MODIS also successfully retrieved diurnal variation of air temperature, actual vapor pressure, and solar radiation with good accuracy. We also discussed the effect of complexity and heterogeneity on the estimation of net radiation.

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APPLICATION OF FIELD OBSERVED FLUXES AND NOAA/AVHRR TO EVALUATE SEASONAL CARBON BUDGET OF BLACK SPRUCE FORESTS OVER ALASKA

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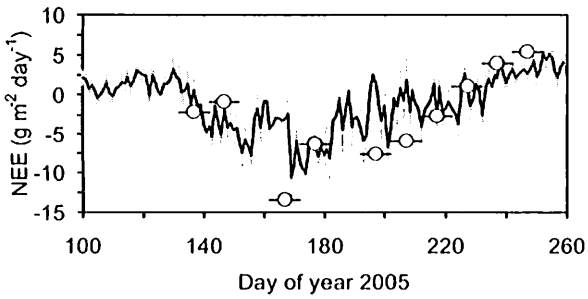
Climate change in northern high latitudes has been remarkable in the past few decades, and the affection on the mid-latitudes climate has been revealed by regional models and synoptic analyses. Since the changes in the prolonged vegetation growing period, enhanced decomposition rate of soil organic matter, and permafrost degradation are evidently detected in arctic Alaska and Siberia, to reveal the actual changing trend of ecosystem dynamics and the carbon budget change are important to understand the climate-connection between high latitudes and mid and low latitudes.

We have been observed carbon fluxes at a sub arctic black spruce forest in interior Alaska since 2002 fall, and some controlling factors to the carbon budget were parameterized. As the black spruce forest was dominant in Alaska's boreal forests, we applied the both remote sensing and field observation data to evaluate the seasonal changes of carbon budget over all Alaska. In the analysis, we made an empirical model to calculate the carbon budget by using only satellite data of normalized differential vegetation index (NDVI) and land surface temperature (LST). The NOAA/AVHRR satellite data (10-days composite) and observed fluxes at the site in 2005 were used to determine the relationship among dataset, in which outputs of carbon budget analysis tool (CBAT) for the black spruce forests were also integrated into the model to calculate gross primary productivity (GPP), ecosystem respiration (R_{eco}) and net ecosystem exchange (NEE). The CBAT is an empirical model designed to analyze observed fluxes. Model calculations were carried out for ten periods within 2005 growing season and the calculated NEE, GPP, and R_{eco} agreed well with those measured at the observation site (NEE was shown in the Figure).

The same model parameters and AVHRR data were applied to whole Alaska area to estimate carbon budget of the ecosystem, and then maps showing spatial distribution of NEE, GPP, and R_{eco} over Alaska black spruce forests were obtained. The distributions of carbon budget showed clear regional differences in the start time of the growth and the different carbon sink. Black spruce forests were high productivity at middle-east part of interior Alaska, even though the area was extremely cold region in winter.



Seasonal change of observed NEE at the black spruce forest site in interior Alaska and calculated NEE by the empirical model with AVHRR data. Gray area represents standard deviations of 10-days.

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SPATIAL HETEROGENEITY OF SATELLITE-SENSED FLUX INDICES RELATED TO EVAPOTRANSPIRATION

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Bridging the gap between scales is the challenge to the flux research community. For the MODIS grid scale (i.e., 7km x 7km) of the Gwangneung KoFlux site in central Korea, the scale of spatial heterogeneity is of the order of ~1 km. When we focus on upscaling or downscaling of eddy-covariance flux observations, smaller extent such as footprint scale of tower flux (e.g., 1km x 1km) is needed. We set the two study extents of 1km x 1km for the two flux towers in the Gwangneung forest catchment. In this presentation, representative structural functions such as semivariogram and fractal were used to quantify spatial heterogeneity and directional dependence (i.e., anisotropy) of ET-related variables obtained from LANDSAT ETM+ imageries and DEM over the montane landscape. The variables include topographically corrected-normalized difference vegetation index (NDVI), land surface temperature (LST), and topographic elements (i.e., elevation, slope angle and slope aspect). Our results show that these indices have anisotropy, various scales of statistical heterogeneity that are less than 1km and have fractal characteristics. Implications of these results for sampling strategy, grid scales of ecohydrological modeling, and satellite image analyses are discussed.

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UTILITY OF SPECTRAL VEGETATION INDEX FOR ESTIMATION OF LIGHT USE EFFICIENCY IN ARTIFICIAL FORESTS OF JAPANESE LARCH AND HINOKI CYPRESS IN JAPAN

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To clarify the utility of spectral vegetation index (VI) for estimating light use efficiency (LUE) of artificial coniferous forests, we investigated the seasonal variations of canopy spectral reflectance and CO_2 flux in young and mature Japanese larch (*Larix kaempferi*) forests and mature hinoki cypress (*Chamaecyparis obtusa*) forest. In this study, we conducted regression analysis between LUE and eight VIs (NDVI, EVI, GEMI, SAVI, PRI, CCI, CI, mND_{705}) derived from spectral reflectance.

All measurements were carried out in 3 Asia Flux monitoring sites; Kiryu (hinoki cypress), Teshio CC-LaG site (young larch) and Tomakomai (mature larch) in Japan (http://www-cger2.nies.go.jp/asiaflux/index.html). In each forest, downward and upward spectral radiance between 300 and 1100 nm was measured with hemispherical spectroradiometers mounted at the top of flux tower, and the spectral reflectance of forest canopy was derived from their ratio. We calculated mean VIs around noon (11:00-13:00 JST) based on the 1-min reflectance data recorded under clear sky (defined as relative irradiance >75% of full sunlight). The ideal maximum irradiance at the ground surface (i.e. full sunlight) was estimated from the sun position and atmospheric conditions.

LUE was calculated as gross CO_2 flux (FCO_2) divided by the absorbed PAR (APAR). FCO_2 was calculated from canopy CO_2 flux which was measured using a closed-path eddy covariance system and CO_2 storage estimated from temporal changes of CO_2 concentration. Daytime ecosystem respiration was estimated from an exponential relationship between air temperature and nighttime ecosystem respiration. Since the transmitted PAR through the canopy was not fully investigated during the experimental periods, APAR was calculated as the difference of incoming PAR and reflected PAR from canopy surface.

In the case of mature larch forest, all the calculated VIs significantly correlated with daily mean LUE ($P < 0.001$, Figure 1). Although the most relationships of LUE and VIs tended to be saturated at the high range VI, CCI and LUE showed good linear relationship with highest correlation coefficient. In this presentation, we summarize the results of regression analysis in each forest site, and discuss the effects of species type and tree age on VI usefulness.

Table 1. Listing of VIs used in this study. R_λ and D_λ indicate reflectance value and first derivative of reflectance at wavelength of λ nm, respectively.

Index	Formulation
NDVI	$(R_{857}-R_{647})/(R_{857}+R_{647})$
EVI	$((R_{857}-R_{647})/(1+R_{857}+6R_{647}-7.5R_{466}))\times 2.5$
GEMI	$eta\times(1-0.25\,eta)-(R_{647}-0.125)/(1-R_{647})$
	$eta = (2\times(R_{857}-R_{647})+1.5\,R_{857}+0.5\,R_{647})/(R_{857}+R_{647}+0.5)$
SAVI	$((R_{857}-R_{647})/(R_{857}+R_{647}+0.5))\times 1.5$
PRI	$(R_{531}-R_{570})/(R_{531}+R_{570})$
CCI	D_{720}/D_{700}
CI	$(R_{750}-R_{705})/(R_{750}+R_{705})$
mND705	$(R_{750}-R_{705})/(R_{750}+R_{705}-2R_{445})$

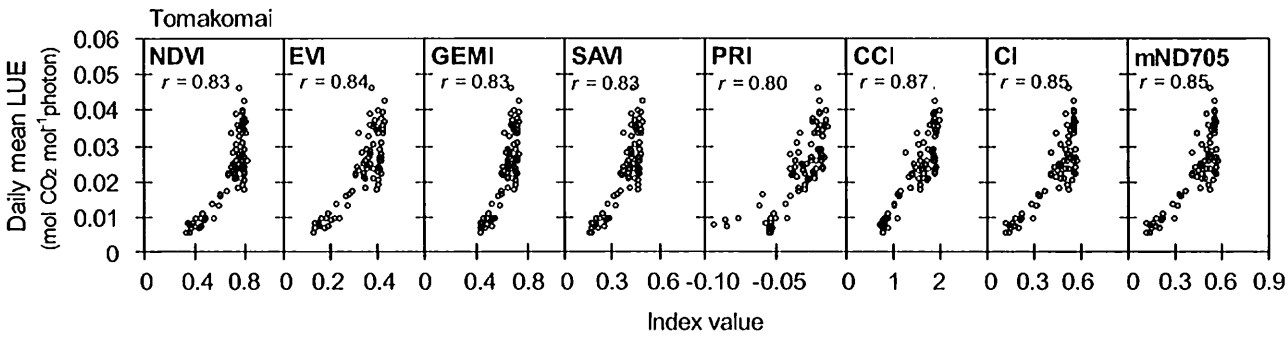

Figure 1. Relationship between VIs and daily mean LUE in Tomakomai larch forest ($n = 78$).

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ESTABLISHING A NETWORK OF EXISTING FLUX SITES IN THAILAND

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Several observation sites have been established to study flux of gas and energy in diverse ecological systems in Thailand since 1994. While the observations in a few sites, mainly in the south of Thailand, have been terminated due to various reasons, researches in many other sites continue until now. Existing flux observation sites in Thailand are located in natural forests, tree plantations and cultivated field crop plantations all over the country.

Total forest area in Thailand was estimated at approximately 12.5 million hectare which is equivalent to 25% of total land in Thailand. Several observation sites were set up to study flux in major types of forest. An observation site at Sakaerat is dedicated to study CO_2, water vapor and heat exchange in dry evergreen forest. Another observation site at Maeklong was established to study the meteorological and biological influence on CO_2 concentration and flux in the mixed deciduous forest. Researches at Kog-Ma watershed focus on hydro-meteorological studies on hill evergreen forests (lauro-fagaceous forests) which are wide spread throughout Southeast Asia in mountainous area at elevation greater than 1,000 m. In addition, two new flux sites are planned to be set up at the beginning of 2007. One will be at the third generation dry dipterocarp forest at Ratchaburi province and another will be at a climax dry dipterocarp forest in Sakol Nakon province.

There are two existing observation sites in economically important tree plantations. One is located in a teak (*Tectona grandis*) plantation in Lampang province. The initial objectives were to observe and to model the hydrologic cycle and energy fluxes. The other is located in a rubber (*Hevea brasilensis*) plantation in Chachoengsao province. The aims are to study carbon, water, and energy budget in the plantation ecosystem. Rubber plantation in Thailand now covers more than 2.5 million hectares.

Rice is the most important field crop in Thailand. Growing area exceeds 10 million hectares annually. One observation site is in rain-fed paddy field in Sukhothai province and the other site is in irrigated paddy field in Pitsanulok province. There is also an observation site in a cassava field in Nakorn Ratchasima province. Cassava planning area averages more than 1 million hectares. These sites in field crop plantations were established in the Global Energy and Water Cycle Experiment.

Most of these observation sites were established through collaborations with and/or assistances from many scientists from international institutes and agencies, mainly from Japan (National Institute of Advanced Industrial Science and Technology, Tokyo University of Information Studies, Tokyo University of Agriculture and Technology, etc.) and France (Centre de coopération internationale en recherche agronomique pour le développement and French National Institute for Agricultural Research).

With the encouragement from AsiaFlux, several principal researchers of these existing observation sites in Thailand convened on September 13, 2006 and unanimously agreed to establish a network of existing observation sites in Thailand. The initial objectives of this network will be (1) to promote collaboration among researchers (2) to promote information exchange, (3) to organize scientific meeting and workshop on flux studies, (4) to organize training courses on important scientific techniques, and (5) to attempt to find research fund. Finally, the organizing committee was set up to hold the first ThaiFlux Colloquium on October 31, 2006 at Kasetsart University.

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Lee, Young-Hee O45	Chungnam National University	Korea
Leuning, Ray O21	CSIRO Marine and Atmospheric Research	Australia
Liang, Naishen O27	CGER, National Institute for environmental Studies	Japan
Liu, Deyan P45	Northeast Institute of Geography and Agricultural Ecology, Chinese Academy of Sciences	China
Machimura, Takashi P09	Osaka University	Japan
Maeda, Takahisa P74	National Institute of Advanced Industrial Science and Technology (AIST)	Japan
Malhi, Yadvinder S11	Oxford University, Centre for the Environment	UK.
Matsumoto, Kazuho P40	Graduate School of Bioagricultural Sciences, Nagoya University	Japan
Matsuo, Naoko P41	Graduate School of Agriculture, Kyoto University	Japan
Matsuura, Shoji P14	National Institute of Livestock and Grassland Science	Japan
Mi, Na O46	Nanjing University of Information Science and Technology	China
Misawa, Noriko P58	Graduate School of Science and Technology, Kobe University	Japan
Miyama, Takafumi P51	Kansai Research center, Forestry and Forest Products research Institute	Japan
Miyata, Akira P04, P05	National Institute for Agro-Environmental Sciences	Japan
Mizoguchi, Yasuko P11	Forestry and Forest Products Research Institute	Japan
Moon, Sang P72	Global Environmental Institute, Yonsei University	Korea

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Nakai, Yuichiro P10	Forestry and Forest Products Research Institute	Japan
Nakaji, Tatsuro P73	Center for Global Environmental Research, National Institute for Environmental Studies	Japan
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Noh, Nam Jin P55	Ecosystem Ecology Lab., Div. of Environmental Engineering, Korea University	Korea
Ohkubo, Shinjiro P26	Graduate School of Agriculture, Kyoto University	Japan
Ohta, Takeshi O14	Nagoya University	Japan
Ohtani, Yoshikazu S01, O15	Forestry and Forest Products Research Institute	Japan
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Ono, Keisuke P30	University of Tsukuba	Japan
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Panuthai, Samreong P52	Watershed Research Division, National Park, Wildlife and Plant Conservation Department	Thailand
Park, Ho Taek P68	CREST, Japan Agency of Science and Technology	Japan
Park, Sung-Bin P59	Biometeorology Laboratory, Yonsei University	Korea
Pingintha, Natchaya P21	Faculty of Agriculture, Chiang Mai University, and The University of Georgia, Griffin Campus, GA 30223, USA.	Thailand
Polsan, Panya P23	Hydrology and Water Management Center for Lower Northern Region, Tha Thong, Muang, Phitsanolok 65000	Thailand
Potithep, Supannika P69	The University of Tokyo, IIS, Yasuoka Laboratory	Japan

Ratana, Piyachat O44	University of Arizona	USA.
Saigusa, Nobuko O13	National Institute of Advanced Industrial Science and Technology (AIST)	Japan
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Sano, Tomohito P48	Graduate School of Agriculture, Hokkaido University	Japan
Son, Mina P35	Pusan National University	Korea
Sun, Li	Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences	China
Takahashi, Yoshiyuki P25	National Institute for Environmental Studies	Japan
Takanashi, Satoru P64	Laboratory of Forest Hydrology, Division of Environmental Science and Technology, Graduate School of Agriculture, Kyoto University	Japan
Takeda, Tomomi P60	National Institute of environmental Studies, Tsukuba	Japan
Takimoto, Takahiro P19	Graduate School of Environmental Science, Okayama University	Japan
Tamai, Koji P53	Kyusyu research Center, Forestry and Forest Products Research Institute	Japan
Tanaka, Nobuaki P38	JST/The University of Tokyo	Japan
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Tanner, Bertrand D. O25	Campbell Scientific, Inc. Logan, UT. 84321	USA.
Thaler, Philippe O35	CIRAD, UPR Plantation Ecosystems, DORAS Center, Kasetsart University	Thailand
Tsai, Jeng-Lin P32	Department of Environmental Engineering, National Chung-Hsing University	Taiwan
Tseng, Kuohsin P33	Department of Environmental Engineering, National Chung-Hsing University	Taiwan

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Wang, Shaoqiang O42	Institute of Geographic Sciences and Natural Resources Research	China
Wassmann, Reiner O36	International Rice Research Institute	Philippines
Watanabe, Tsutomu O22	Forestry and Forest Products Research Institute	Japan
Yamamoto, Susumu O12	Graduate School of Environmental Science, Okayama University	Japan
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Yashiro, Yuichiro P47	River Basin Research Center, Gifu University	Japan
Yoshikoshi, Hisashi P46	Faculty of Agriculture, Kyushu University	Japan
Zhang, Junhui P65	Institute of Applied ecology, Chinese Academy of Sciences	China
Zheng, Zemei P56	Institute of Geographic Sciences and natural Resources, Chinese Academy of Sciences	China
Zhou, Guangsheng O26	Institute of Botany, Chinese Academy of Sciences	China

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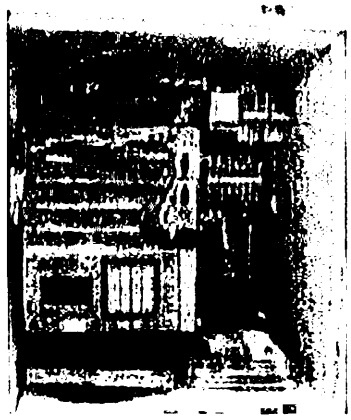
Eddy Covariance Measurement System
C-SCT-SAT/7500

SAT & CO2/H2O Analyzer



Measurement Box

Solar Power Generation Unit

Summary

This system measures the Sensible Heat, H_2O and CO_2Flux using the eddy covariance method in our data-logger. The whole system do not require the AC power. If you choose this system, you can get the Sensible Heat, H_2O and CO_2 Flux anywhere.

Measurement Method

The measurement system both Raw 10Hz data, and calculated Flux data on the data-logger memory and Memory Card(ATA/CF card) in harsh conditions. The Flux calculation is basing on real-time each variance and covariance data, air density and specific heat at constant pressure.

Measurement Items (standard)

1. 3-axis wind component(Ux, Uy, Uz), Sonic Temperature (10Hz fluctuations)
2. CO_2, H_2O 10Hz fluctuation
3. Air Temperature and Relative Humidity
4. Short-wave and Long-wave Radiation component(4 types)
5. Air Pressure

System Customize

We prepare various kind of sensors.
For Example:
Wind Speed profile, Air Temperature & Relative Humidity profiles, Soil Heat Flux, Soil Water Content and Soil Temperature and Soil Respiration.

Contact us, and you will get the best measurement system!!

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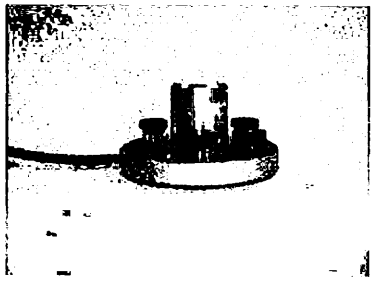
Climatec

Portable Pyrheliometer PCM-01

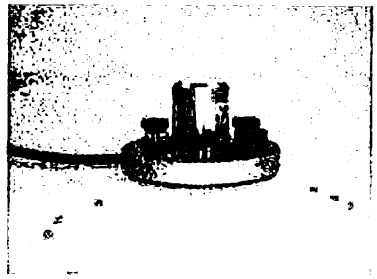


This Pyreheriometer observes solar irradiance. The sensor is thermopile.
It's used by micrometeorologic.
It's easy to use, light and no power.

Specification

Spectral range	315-2800nm
Sensitivity	7mV(kW·m^{-2})
Response time	1sec
Accuracy	±3%
Dimension	φ85×45mm
Weight	0.5kg
Cable	10m

Light Photon Senser PAR-01

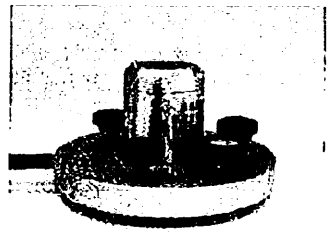


It's instrument for measuring photon's quantum of solar spectrum (400-700nm).
The sensor is Siliconphotodiode.

Specification

Spectral range	400-700nm
Sensor	Silicon Photodiode
Sensitivity	0-3,000 μ Mol·m^{-2} / 0-10mV
Dimension	φ85×45mm
Weight	0.5kg
Cable	10m
Calibration	1000W typically optical source

Portable Pyrgeometer PRI-01

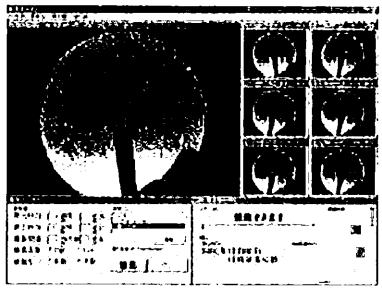


This Pyrgeometer observes infrared radiometer.
It's simplified Pyrgeometer.

Specification

Spectral range	600-1400nm
Sensitivity	5-20mV(kW·m^{-2})
Thermopile putput range	-250-+250 W/m^2
Response time	<100msec
Accuracy	±3%
Temperature sensor	Pt100Ω
Dimension	φ85×45mm
Weight	0.75kg
Cable	10m

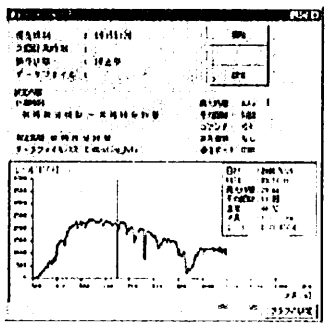
Sky View PSV-100



This instrument monitores of the sky by CCD camera and automatically saves a photo to JPEG format in PC for a fixed interval.
It's outdoor-safe.

System
It needs PC of Windows XP with two serial ports of RS232C, memory over 64MB and Hard disk space over 10GB.

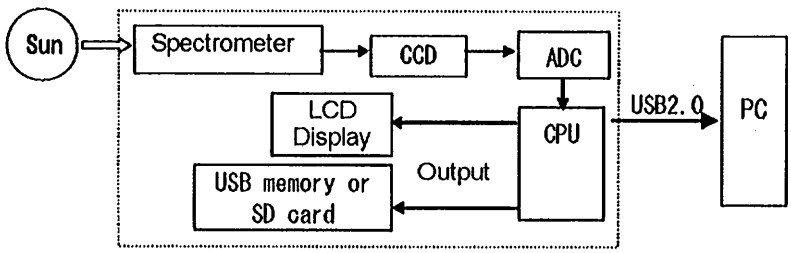
Portable Grating Sunphotometer PPGS-100



This instrument is portable grating sunphotometer.
Spectral range is 350–1050nm, wavelength resolution is 0.4nm.
It's recorded by USB memory or SD card, so it's possible to measure without PC but also use by PC.
It's able to check measurements by LC Display.
There is optional Software.

Specification

Spectrometer	Fastie-Ebert Mount
Slit width	100 μ m
Wave length resolution	0.4nm
Wave length accuracy	±0.5nm
Wave length range	350-1050nm
Optical resolution	3.6nm
Detector	SI-CCD 2048ch
Exposure time	5ms
Interface	USB2.0
Power supply	AC or AA Battery×6
Dimension	230×110×80mm 2.2kg
Record	USB memory or SD card



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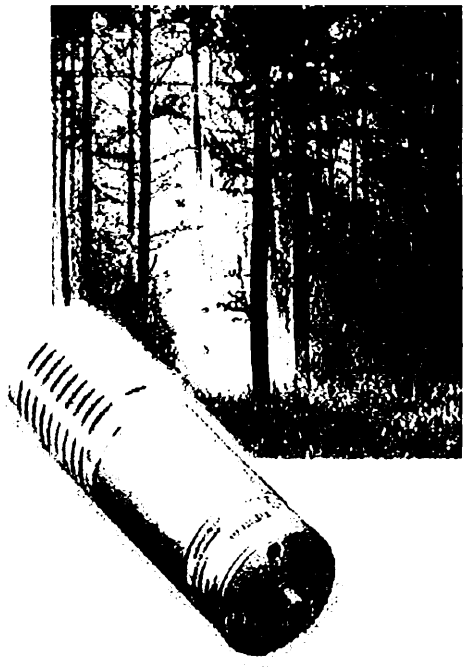
GMP343 Carbon Dioxide Probe for CO2 Soil Respiration

The CO_2 respiration from soil is a good indicator of overall biological activity of the soil, and is often used when studying the carbon cycle. The CO_2 flux can be measured on the soil surface in respiration chambers. Belowground CO_2 profile measurements can be made at variable depths in the soil.

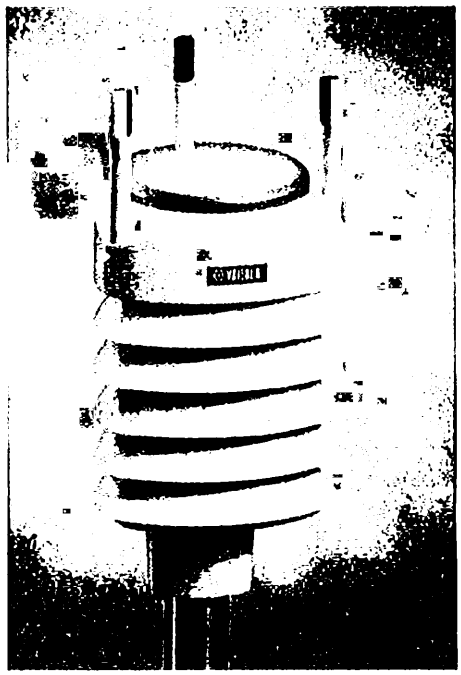


Performance

Sensor	Vaisala CARBOCAP®
Measuring principle	Single-Beam Dual-Wavelength NDIR
Measurement range options	0... 1000ppm, 0... 2000ppm, 0... 3000ppm, 0... 4000ppm, 0... 5000ppm (reduced accuracy >4000 ppm)
Accuracy	After factory calibration with 0.5 % gases ± 2.5 % of reading at the CO2 calibration points ± 1.5 % of reading
Operating environment	Temperature : -40... +60°C, Relative humidity : 0... 100%rh
Outputs	Analog outputs 4... 20mA, 0... 2.5V, 0... 5V Digital outputs RS-232, RS-485
Operating voltage	10... 36VDC
Dimensions	Length: 180 mm, Diameter: 55 mm Weight: 360g

WXT510 Weather Multi-Sensor

Integrates the six most essential weather parameters in one instrument: wind speed and direction, liquid precipitation, barometric pressure, temperature and relative humidity. Unique design with no moving parts makes it virtually maintenance free.



Technical Data

Wind Speed	Range : 0... 60 m/s
Wind Direction	Azimuth: 0... 360°
Barometric Pressure	Range : 600... 1100 hPa
Air temperature	Range : -52... 60 °C
Relative humidity	Range : 0... 100 %rh
Rainfall - quantity	Surface area measured: 60 cm2
Rainfall-duration	counting each ten second increment whenever droplet detected
Rainfall-intensity	Range : 0 to 200 mm/h
Operating Voltage	5...30 VDC
Dimensions	Height: 240 mm, Diameter: 120 mm Weight: 620 g

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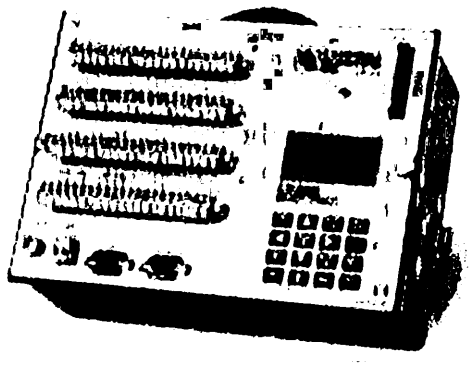

CR3000

Micrologger®

Features

- Program execution rate of up to 100 Hz
- 16-bit analog to digital conversions
- 16-bit microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- 4 Mbytes data storage memory
- Battery-backed SRAM and clock that ensure data, programs, and accurate time are maintained while the CR3000 is disconnected from its main power source
- Measures SDI-12 or serial sensors with four independent COM ports

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WHEN MEASUREMENTS MATTER

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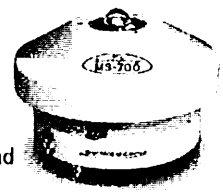
EKO INSTRUMENTS CO., LTD.

Precision instruments for accurate flux measurements

Grating Spectroradiometers

MS-710 (Visible to NIR, 350-1050 nm)
MS-712 (NIR, 800-1700 nm)
NEW MODEL

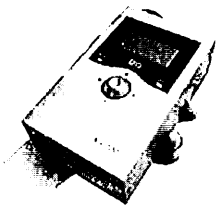
- Precision optics in a weather proof enclosure
- Continuous field measurements
- NIST traceable
- Measurement results are displayed and stored on a PC.



Hand held Grating Spectroradiometer

MS-720 (350-1050 nm)

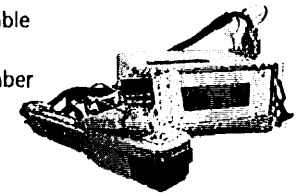
- Portable
- Selectable aperture angle
- Measurement without PC
- Stores up to 800 data
- Acquisition of spectral radiation data ($W \cdot m^{-2} \cdot \mu m^{-1}$)
- Lightweight (720g, batteries included)



Intelligent Portable Photosynthesis System

LCpro+

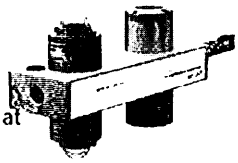
- Full and automatic programmable environmental control
- Miniaturized IRGA in leaf chamber
- Graphic display
- Powerful yet affordable



Four Component Radiometer

MR-50 (Pyranometers + Pyrgeometers)

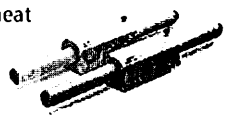
- Intension for the analysis of the radiation balance of solar and far infrared radiation.
- Measurement of Net (total) Radiation at the earth's surface



Surface Layer Scintillometer

SLS 20

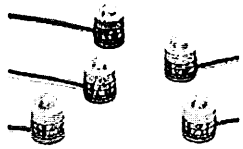
- The Ultimate sensor for turbulence, heat flux, momentum flux and crosswind
- Two parallel laser beams
- Path length : from 50 to 250m



Photon Sensor

ML-020P

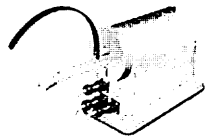
- Special designed corrector for excellent cosine response
- Measurement the photosynthetic photon flux density



Automated Shadow Band

NEW MODEL

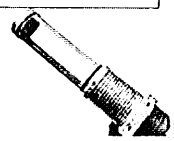
- Measurement and calculates direct, diffuse and global components of solar irradiance in each scanning



Open path CO_2/ H_2O Analyser

OP-2

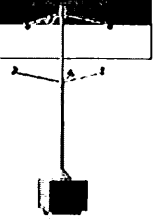
- OP-2 has longer path length (80cm) to achieve higher resolution.



3D Ultrasonic Anemometer

USA-1

- USA-1 measures accurate wind and turbulence with solid-state 3D sensor.



High Precision Pyranometer

MS-802

- ISO Secondary Standard
- WRR traceable
- Accurate measurement of global solar radiation

Heat Flow Sensor

MF-180M

- Durable designed sensor
- Suitable sensor for the direct measurement of soil heat flux

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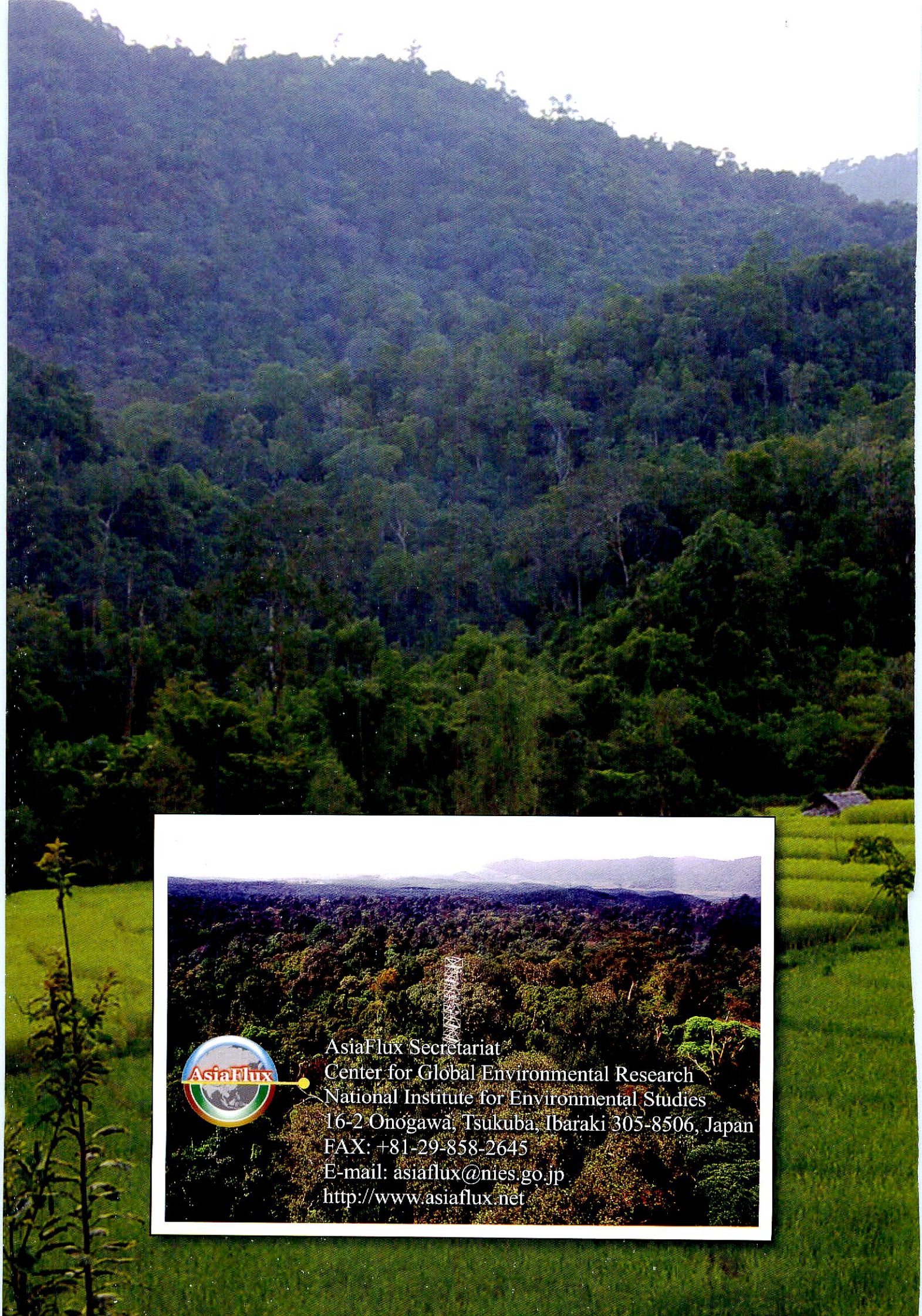

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