AsiaFlux Workshop 2014

Bridging Atmospheric Flux Monitoring to National and International Climate Change Initiatives

18-23 August 2014
International Rice Research Institute
Los Baños, Philippines

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AsiaFlux Workshop 2014

"Bridging Atmospheric Flux Monitoring to National and International Climate Change Initiatives"

August 18-23, 2014

International Rice Research Institute (IRRI),

Los Baños, Philippines

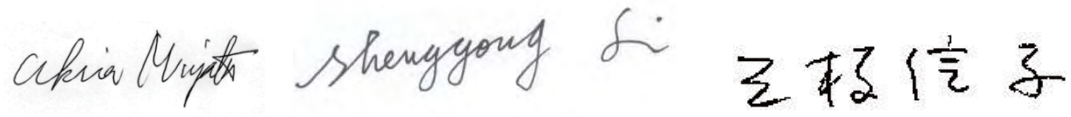
AsiaFlux Workshop 2014

Bridging Atmospheric Flux Monitoring to National and International Climate Change Initiatives

Welcome to the AsiaFlux Workshop 2014 in Los Baños, the Philippines. We are delighted to hold our 12th international workshop in the International Rice Research Institute (IRRI).

AsiaFlux has three significant reasons to hold its regular workshop in IRRI. Firstly, it is located in tropical Asia, which attracts increasing attention of our community. AsiaFlux has been focusing on tropical ecosystems in monsoon Asia since the workshop in Johor Bahru, Malaysia in 2011. The AsiaFlux Workshop 2014 in the Philippines will help us to intensify our activities in Southeast and South Asian countries. Secondly, IRRI is one of the focal points for research of crop science in the world. We expect the workshop here will provide us with the best opportunity to discuss how to promote flux studies in Asian agricultural ecosystems, which to date has drawn less attention in our community than forest ecosystems. Finally, IRRI has a long history of methane flux studies. Owing to recent improvement of gas analyzers, the technique for continuous measurements of methane flux has come to fruition. The number of eddy-covariance flux tower sites with methane eddy flux measurements has been increasing worldwide. It is timely for us to have the workshop here to discuss our progress in methane flux studies with attendance of scientists well-versed in methane studies in rice fields.

For the last 15 years, the AsiaFlux community has been working hard together to bring key ecosystems under observation to ensure sustainability and quality of life in Asia. The terms such as 'monitoring' and 'under observation' go beyond just measurements and include synthesizing the observations to potential narratives and providing feedbacks, which serve as the source of the community learning toward sustainability. In Asia, we are barely any closer to a more sustainable community and there is an urgent need to improve the awareness and effectiveness of our efforts as scientists towards sustainability. We eagerly expect and hope that the theme of the workshop – "Bridging Atmospheric Flux Monitoring to National and International Climate Change Initiatives" will guide us to the ways toward improving our service towards sustainable future.



Akira Miyata, Shenggong Li, Nobuko Saigusa

Chair and Vice-Chairs of AsiaFlux

Organizers

- AsiaFlux
- International Rice Research Institute (IRRI)

Local Organizing Committee

- Reiner Wassmann (International Rice Research Institute: IRRI, Philippines)
- Ma. Carmelita Alberto (International Rice Research Institute: IRRI, Philippines)
- Akira Miyata (National Institute for Agro-Environmental Sciences, Japan)
- Nobuko Saigusa (National Institute of Environmental Studies, Japan)
- Sawako Tanaka (National Institute of Environmental Studies, Japan)

Supported by

- APN (Asia-Pacific Network for Global Change Research)
- Campbell Scientific
- National Institute for Agro-Environmental Science (NIAES), Japan
- National Institute for Environmental Studies (NIES), Japan

Venue

International Rice Research Institute (IRRI), College, 4030 Los Baños, Laguna, Philippines

Program at a glance

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<tr><td>10:00</td><td rowspan="4">Special Session</td></tr>
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<tr><td>13:30</td><td rowspan="5">Session1</td><td rowspan="4">Session 3</td><td rowspan="5">Session 6</td></tr>
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<tr><td>18:00～</td><td></td><td>*Banquet</td><td>**SSC and YSM</td><td>***Farewell Dinner</td><td></td></tr>
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*Banquet will be at IRRI guest house

** SSC and YSM will be at BP international.

*** Farewell Dinner will be at Bonitos or Kamayan


Annex 3
IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE
Workshop Venue
Training course venue
IRRI Gate

Oral Session

Wednesday, 20 August			
08:00-09:00	Registration		
09:00-09:30	Opening and Welcome Addresses		
	Dr. Robert S. Zeigler (Director General, IRRI, Philippines)		
	Akira Miyata (Chair of AsiaFlux, NIAES, Japan)		
	Reiner Wassmann (Chair of AsiaFlux Workshop 2014 LOC, IRRI, Philippines)		
09:30-10:00	Group Photo and Break		
Special Session: Linking Mitigation Efforts to Natural Resource Management: IRRI's activities on determining GHG fluxes from rice-based ecosystems (Chair: Reiner Wassmann and Maricar Alberto)			
10:00-10:15	SP1	Bjoern Ole Sander	Chamber-based GHG flux measurements in the Philippines and Vietnam: lessons learnt and way forward
10:15-10:30	SP2	Julie Ann Basconcillo	Accelerating AWD adoption through participatory action research
10:30-10:45	SP3	Agnes Padre	Assessing the site-specific feasibility of AWD as a mitigation option for greenhouse gas emissions from rice systems in Asia
10:45-11:00	SP4	Ryan Romasanta	Methane and nitrous oxide emissions from rice straw burning: determining the effect of moisture content through laboratory measurements
11:00-11:15	SP5	James Quilty	The ecological intensification platform at the international rice research institute
11:15-11:45	SP6	Jagdish Ladha	Eco-efficient rice-based cropping systems with high grain energy output and reduced global warming potential
11:45-12:00	Discussion		
12:00-13:30	Lunch		
1. Up-to-date techniques and understanding for trace gas and methane fluxes (Chair: Yoshiyuki Takahashi and Masahito Ueyama)			
13:30-14:00	1-1	Dennis Baldocchi (invited)	Role of weather, land use and management on greenhouse gas fluxes in the Sacramento delta
14:00-14:15	1-2	James Kathilankal	Real time landfill methane flux monitoring using a microprocessor controlled on-site eddy covariance data processing system
14:15-14:30	1-3	Upendra Singh	Mitigating greenhouse gas emissions from rice fields in Bangladesh
14:30-14:45	1-4	Masahito Ueyama	Micrometeorological and chamber measurements of methane flux over two forests in Japan
14:45-15:00	1-5	Wong Guan Xhuan	Quantifying the magnitude and environmental influences on methane flux from a tropical peat swamp forest in Sarawak, Malaysia
15:00-15:15	1-6	Ryuichi Wada	Observation of vertical profiles of NO_x, O_3, VOC and inverse modeling estimates of their fluxes at vertical levels in Japanese larch and red pine forests
15:15-15:30	1-7	Akira Tani	Soil moisture conditions may affect terpenoid fluxes measured above a larch forest
15:30-15:45	Discussion		
15:45-16:30	Break and **Poster Session**		

Networking: reports and discussion (Chair: Shenggong Li)	
16:30-18:00	AsiaFlux, FLUXNET, etc.
18:00	Banquet

Thursday, 21 August

2. Carbon and water cycles in tropical and subtropical Asian ecosystems in changing environment (Chair: Nobuko Saigusa and Amnat Chidthaisong)			
09:00-09:30	2-1	Tomo'omi Kumagai (invited)	Carbon and water cycling researches in southeast Asian tropical forests
09:30-09:45	2-2	Thumaty Rakesh Kiran Chand	Studies on mass and energy fluxes in Sundarban mangroves, India, using eddy covariance flux tower data
09:45-10:00	2-3	Jate Sathornkich	Carbon and water flux measurements of young rubber ecosystem in north-eastern region of Thailand
10:00-10:15	2-4	Juliya Kurbatova	Soil and ecosystem CO_2 fluxes in seasonal tropical forest of southern Vietnam
10:15-10:30	Break		
10:30-10:45	2-5	ChandraShekhar Deshmukh	Net GHG footprint of a newly impounded subtropical hydroelectric reservoir: case Nam Theun 2 Reservoir (Lao PDR)
10:45-11:00	2-6	Fiolenta Marpaung	Environmental effects on diffuse radiation in tropical peat land
11:00-11:15	Discussion		
11:15-12:00	**Poster Session**		
12:00-13:30	Lunch		
3. Impacts of extreme climate and disturbances on carbon, water and material cycles in terrestrial ecosystems under monsoon climate (Chair: Ryuichi Hirata and Kentaro Takagi)			
13:30-14:00	3-1	Tamotsu Sato (invited)	EA-FDPN: Plots network for forest and carbon dynamics from Siberia to tropical zone
14:00-14:15	3-2	Maricar Aguilos	Dynamics of ecosystem carbon balance recovering from clearcutting in a cool-temperate forest
14:15-14:30	3-3	Munemasa Teramoto	Carbon balance of a forest in northern Japan after typhoon disturbance
14:30-14:45	3-4	Ryuichi Hirata	The impacts of disturbance on terrestrial carbon budget of Hokkaido, Japan
14:45-15:00	3-5	Liukang Xu	Response of soil CO_2 flux to rain events
15:00-15:15	3-6	Kristell Hergoualc'h	An extreme fire event: haze and greenhouse gas emissions from Sumatra, Indonesia, during 2013 a non El Niño year
15:15-15:30	Discussion		
15:30-16:00	Break		
4. Model-data integrative analysis towards better understanding of terrestrial carbon budget in Asia (Chair: Masayuki Kondo and Lulie Melling)			
16:00-16:30	4-1	Akihiko Ito	Comparison of model simulation results at different deciduous broad-leaved forests
16:30-16:45	4-2	Young-Hee Lee	Simulation of energy fluxes and NEE over rice paddy field using CLM4CN with prognostic crop

16:45-17:00	4-4	Msayuki Kondo	Spatial variation in global scale estimates of carbon-use efficiency: ecosystem model, remote sensing, and empirical upscaling
17:00-17:15	4-5	Shin Nagai	Multidisciplinary in situ and satellite observations for accurate monitoring terrestrial ecosystem structure and functioning: knowledge gained from Phonological Eyes Network (PEN)
17:15-17:30	Discussion		
18:00	Science Steering Committee meeting and Young Scientist meeting		

Friday, 22 August

5. Linking flux monitoring to climate change initiatives in agro-ecosystem (Chair: Keisuke Ono and Wonsik Kim)			
09:00-09:30	5-1	Xuhui Lee (Invited)	Land use changes, energy fluxes and surface climate
09:30-09:45	5-2	Yohana Indrawati	The characteristic and the implication of ecosystem level water use efficiency at heterogeneous farmland in south Korea
09:45-10:00	5-3	Bhone Nay-Htoon	Seasonal and spatial variations of water use efficiency of rice (*oryza sativa*): from the leaf to the ecosystem
10:00-10:30	Break		
10:30-10:45	5-4	Amit Kumar	Seasonal variation in net carbon dioxide exchange in rice fields of northern India
10:45-11:00	5-5	Wei Xue	Mesophyll diffusion conductance and growth age dependent photosynthesis: study from paddy rice under different nutrient availability
11:00-11:15	5-6	Motoko Inatomi	Application of terrestrial ecosystem model visit to paddy fields for planning better mitigation
11:15-11:30	5-7	Kazunori Minamikawa	Introducing current progress in MIRSA-2 project
11:30-11:45	5-8	Hironori Arai	The MRV (monitoring, reporting, verification) system of greenhouse gaseous emission in the world high-carbon reservoirs
11:45-12:00	Discussion		
12:00-13:30	Lunch		
6. Soil-plant-atmosphere interactions: mechanisms, responses and approaches for understanding the Asian terrestrial carbon cycle (Chair: Naishen Liang and Jin-Sheng He)			
13:30-14:00	6-1	Jin-Sheng He (Invited)	Carbon and methane fluxes from alpine grassland and wetland on the Tibetan plateau: effect of climate warming and water table decreasing
14:00-14:15	6-2	Mingyuan Du	Long term CO_2 exchange in an alpine wetland in the central part of the Tibetan plateau
14:15-14:30	6-3	Derrick Lai	Greenhouse gas emissions from a surface flow constructed wetland in Hong Kong
14:30-14:45	6-4	Rosnaeni Sakata	Nitrous oxide and carbon dioxide emissions in oil palm plantations as affected by soil types and nitrogen fertilizer
14:45-15:00	6-5	Sunghyun Min	Comparison between chamber and eddy covariance techniques for measuring CO_2 fluxes from rice-barley double cropping paddy field

15:00-15:15	6-6	Yongsheng Wang	Simulated nitrogen deposition reduces CH_4 uptake and increases N_2O emission by changing the ammonia-oxidizer in subtropical forest of southern China
15:15-15:30	6-7	Minseok Kang	New approach to select a nighttime correction method for eddy covariance flux data based on information closure
15:30-15:45	Discussion		
15:45-16:00	Wrap-up and Closing		
16:00-18:00	IRRI field tour after Break		
18:00	Farewell Dinner		

Poster session
Wednesday, 20 August 15:45-16:30
Thursday, 21 August 11:15-12:00

PSP-1	Mrinmoy Neogi	Effect of seedbed solarization on plant growth and yield
P1-1	Takafumi Miyama	Characteristics of BVOC emission under drought condition in the temperate forest
P1-2	Ayaka Sakabe	A year continuous variations of soil CH_4 fluxes in Japanese cypress forest: response to Asian monsoon rainfall
P1-3	Seiichiro Yonemura	Complete oxidation of CH_4 by easily-prepared Ni catalyst
P2-1	Watcharapong Boonruang	Energy fluxes in dry dipterocarp forest, Thailand
P2-2	Frankie Kiew	Carbon dioxide exchange of a secondary tropical peat swamp forest in Sarawak, Malaysia
P2-3	Olga Kuricheva	Heat and water exchange of seasonal tropical forest of southern Vietnam
P2-4	Motonori Okumura	Measurements of CO_2/H_2O fluxes during rainfall by an enclosed path eddy-covariance system in a tropical dipterocarp forest in Malaysia
P2-5	Pimsiri Suannapat	Introduction to new Thaiflux site: dry dipterocarp forest flux Phayao site (DPT)
P3-1	Takahisa Maeda	Year-to-year variation of canopy leaf phenology at Takayama (TKY) flux tower, Japan, analyzed using the long-term record of daily fixed view photographs
P4-1	Kojiro Hirayama	Estimation of GPP by using vegetation index in a young larch plantation, northern Japan
P4-2	Kodai Nakaya	The estimation of CO_2 exchange at paddy field using satellite data
P4-3	Kentaro Takagi	Relationship between ecosystem photosynthetic parameters derived from flux observation and MODIS vegetation indices of east Asian forests
P5-1	Abhishek Danodia	Diurnal and seasonal patterns of water vapor and sensible heat fluxes from irrigated agroecoystsem by large aperture scintillometry
P5-2	Wonsik Kim	FLUXPRO as a real time monitoring and surveilling system for eddy covariance flux measurement
P5-3	Shujiro Komiya	Methane and carbon dioxide dynamics over a rice-cropping season in Japan
P5-4	Daisuke Komori	Validation of the fractional uncertainty analysis as data quality control for eddy covariance flux
P5-5	Keisuke Ono	Canopy-scale water-use efficiency of irrigated rice under different climates and management practices
P5-6	Kyomoon Shim	Inter- and intra-annual variations of carbon dioxide fluxes in rice-barley double cropping system in Gimje, Korea
P6-1	Juqi Duan	Dynamics of decadal changes in the distribution of rice cultivation in China

P6-2	Jaesok Lee	Variation of soil respiration in rice paddy-field in Gimje, Korea
P6-3	Jaesok Lee	Biomass allocation pattern and soil respiration in temperate grassland ecosystem
P6-4	Jaesok Lee	Effect of soil moisture contents on soil respiration in temperate deciduous forest, Korea
P6-5	Shuhan Hossain	Less weed, low seed rate and more yield ensured by machine seeder in rice –mustard –rice cropping system
P6-6	Hasimah Mos	Measuring CO_2 emissions from bare peat swamp area in Sarawak using closed chamber technique
P6-7	Hibiki Noda	Ecophysiological remote sensing of canopy phenology in a cool-temperate deciduous forest in Japan
P6-8	Kazuya Okada	Carbon decomposition process of the residual biomass in the paddy soil of a single-crop rice field
P6-9	Maasa Takahashi	Effect of bacterial material on straw decomposition and greenhouse gas emission from paddy soil
P6-10	Kenta Yagi	The variations of oxidation-reduction potential in paddy soil and effects on the methane emission from a periodically irrigated paddy field
P6-11	Ryo Yoshida	Effect of nitrogen fertilization on emission of greenhouse gas from soil in oil palm plantation
P6-12	Naoki Wakikuromaru	Characteristics of methane emission from a periodically irrigated paddy field in Japan

Oral Session

[SP1]

CHAMBER-BASED GHG FLUX MEASUREMENTS IN THE PHILIPPINES AND VIETNAM: LESSONS LEARNT AND WAY FORWARD

BO Sander[1], R Wassmann[1], R Romasanta[1]

[1] *International Rice Research Institute, Los Baños, Philippines*

The closed chamber method remains the most common technique to measure greenhouse gas (GHG) emissions from cropland. The International Rice Research Institute (IRRI) operates manual chambers as well as an automated system and assesses the GHG emissions of different rice production systems in order to develop sustainable low carbon production systems. Especially different ways of water management exhibit great potential to reduce methane emissions. The alternate wetting and drying (AWD) technology in particular has proven its large mitigation potential. Under the AWD practice a rice field is not continuously flooded but encompasses a series of dry spells. These dry periods allow oxygenation of the soil and thus inhibit anaerobic decomposition hence reducing methane emission.

In 2013 and 2014 a series of experiments in farmers' fields in the Philippines have been conducted comparing the traditional practice of continuous flooding with AWD. Across different irrigation systems, methane emissions were greatly reduced under the altered flooding method. Similar studies have been conducted in central Vietnam where these experiments produced the first GHG emission data from rice cultivation.

Although dozens of studies have shown that AWD is not only an effective GHG mitigation strategy but also saves irrigation water, the uptake of this technology in Southeast Asian countries has been rather slow. However, with new policies and innovative strategies this might change in the future. This presentation summarizes IRRI-led GHG emission studies of the past years and elaborates paths to support and accelerate the dissemination of AWD.

[SP2]

ACCELERATING AWD ADOPTION THROUGH PARTICIPATORY ACTION RESEARCH

JA Basconcillo[1], R Wassmann[1], BO Sander[1]

[1] *International Rice Research Institute, Los Baños, Philippines*

Alternate wetting and drying (AWD) as water saving technology was introduced in the Angat-Maasim Rivers Irrigation System (AMRIS) in 2006 through a technical project funded by the Japan International Cooperation Agency. Thereafter, it was outscaled in several rice-growing areas in AMRIS. Despite this, estimates show that adoption has moved at a snail's pace covering 1,852 ha or only 7% of the service area as of 2013. Many farmers have been reported to revert to continuous flooding, especially those who obtain irrigation water through gravity rather than a pump. Nonetheless, AMRIS-serviced areas have great potential for AWD being widely adopted because of (i) water shortage during the dry season (having no guarantee of obtaining enough water to maintain a continuously flooded crop) and (ii) AWD's innovativeness, as it has not been widely practiced in the area before.

IRRI-led experiments in the farmers' fields in DS 2013 and DS 2014 show that pump-driven systems are much keener than gravity systems to practice AWD due to cost savings from reduced power consumption. However, the process, rate, and extent of AWD adoption do not depend wholly on the biophysical environment but more so, on the collective action among farmers. In DS 2014, the farmers have decided to outscale the practice of AWD from one to all turnout service area groups that comprise the irrigators' association. Through participatory action research (PAR) which involves a cycle of planning, implementing, monitoring, observing, and reflecting, the farmers have gained understanding on how they could optimize the net benefits from AWD adoption. This has also allowed them to decide freely and flexibly the frequency of irrigation and depth of drainage that they find suitable for their fields. By this, they themselves become responsible for the yield effects of the chosen practice (from single to mid-season to multiple drainage). Farmers' perceptions and attitude toward AWD among many other questions are solicited using Knowledge, Attitudes, and Practices (KAP) survey. Preliminary findings show that many have had poor awareness and functional knowledge of AWD. Hence, debriefing workshops and training are organized to bridge the knowledge gap and provide them with necessary information on best farming practices on nutrients, pests, water, and weeds. While women are not directly involved in AWD implementation, their roles in intra-household resource allocation could potentially impact natural resource management. Subject to data availability, an adoption propensity index measuring the likelihood of farming households to adopt AWD will be developed.

[SP3]

ASSESSING THE SITE-SPECIFIC FEASIBILITY OF AWD AS A MITIGATION OPTION FOR GREENHOUSE GAS EMISSIONS FROM RICE SYSTEMS IN ASIA

A.T.Padre[1] and S.Weller[2]

[1]International Rice Research Institute, Los Baños, Philippines
[2] Karlsuhe Institute of Technology, Karlsruhe, Germany

Water-saving management strategies such as alternate wetting and drying (AWD) reduce the periods of flooding and CH_4 emissions. Although this may increase N_2O emissions, proper crop management still allows a net benefit in terms of global warming potential (GWP). In view of future mitigation projects, it is imperative to have more reliable criteria on the site-specific feasibility of AWD as well as clear protocols on measurement, reporting, and verification (MRV) of greenhouse gas (GHG) emissions. The difficulties in MRV and the high variability commonly associated with GHG flux measurements are considered the major obstacles for mitigation projects in the land use sector.

A project entitled "Greenhouse Gas Mitigation in Irrigated Rice Systems through Water Management: Feasibility Assessment and Measurement Guidelines (MIRSA)" was established to develop GHG flux measurement guidelines in irrigated rice production expected to become the global standard in future mitigation programs, with specific reference to mitigation through water-saving techniques. The first phase of the project focused on the investigation of diurnal patterns of GHG emissions from rice fields and the development of a method for extrapolating single measurements taken at a given daytime to full 24-h cycles. Diurnal CH_4 flux measurements were conducted during the dry (Jan – April) and wet (July – Sept) seasons using automatic and manual chambers respectively. Diurnal variations in CH_4 flux, expressed as the ratio of the CH_4 flux at time T to the daily average CH_4 flux (daily mean ratio), were significant during both seasons. Similar trends were observed during the 2 seasons with the highest mean ratio obtained between 1200 and 1400 hours. Diurnal variation from the average daily flux (daily mean ratio=1) ranged from -5 to 9% and -7 to 13% during the wet and dry seasons respectively. The daily mean ratio could be used as a factor to estimate the daily average flux from a single measurement made within the day. Further, high correlations between diurnal variations and solar radiation/air temperature were found using data from chambers that had expressed diurnal variations.

As a means to ease future MRV requirements, a protocol for online gas sampling and recording of GHG fluxes from closed chambers using a photo-acoustic gas analyzer (PAS) was developed and tested at the IRRI field in comparison with the manual gas sampling and analyses by gas chromatography (GC). A highly significant correlation was obtained between the GC and PAS-measured CH_4 and N_2O fluxes.

The second phase of MIRSA aims to develop reliable criteria on the site-specific feasibility of AWD as a mitigation option for greenhouse gas emissions from rice systems in Asia. The goal is to create implementation guidelines for measurement, reporting, and verification of GHG emission reductions from irrigated paddy fields with the adoption of AWD and set up an information infrastructure to share the findings of participating members. Simultaneous field trials are being conducted in Vietnam, Thailand, Indonesia and the Philippines in collaboration with the HUE University of Agriculture and Forestry in Vietnam, Prachinburi Rice Research Center in Thailand, Indonesian Agricultural Environments Research Institute in Indonesia and PhilRice in the Philippines, to assess the site-specific feasibility of AWD as a mitigation option for GHG emissions. A standard protocol for a) the measurement of greenhouse gas emissions by manual gas sampling from static chambers , b) data processing, c) analyses and d) reporting, have been established and are being used in all sites to ensure the accuracy and comparability of research findings. The capacity of NARES (National Agricultural Research and Extension System) partners for GHG analyses have also been enhanced through hands-on trainings on the use of the gas chromatograph and more advanced measurement systems such as the PAS and the eddy covariance system.

The National Institute for Agro-Environmental Sciences, Japan and the International Rice Research Institute are in charge of the execution of the MIRSA project with support from the Ministry of Agriculture Forestry and Fisheries, Japan.

[SP4]

METHANE AND NITROUS OXIDE EMISSIONS FROM RICE STRAW BURNING: DETERMINING THE EFFECT OF MOISTURE CONTENT THROUGH LABORATORY MEASUREMENTS

R. Romasanta[1], R. Wassmann[1], B.O. Sander[1], Y. Gaihre[2]

[1]Crop and Environmental Sciences Division, International Rice Research Institute, Los Baños, Laguna, Philippines
[2]International Fertilizer Development Center, Dhaka, Bangladesh

Rice straw burning is one of the common methods of rice straw management in rice producing countries especially in Asia. This practice emits greenhouse gas (GHG) (Cheewaphongphan et al. 2011) that produce adverse effects to climate change. Methane (CH_4) and nitrous oxide (N_2O) emissions occur due to incomplete burning and it is suspected that these emissions are dependent on the moisture content levels of the rice straw. However, this subject is not yet well-studied and mostly, default factors are being used to estimate the amount of emission (Gadde et al. 2009). Thus, direct measurement is necessary to quantify the emissions generated by this practice.

This study aims to determine the effect of moisture content levels on methane and nitrous oxide emissions from rice straw burning, calculate the emission factors as well as the total carbon and nitrogen lost during burning. A smoke collection set-up designed and fabricated by the IRRI Physical Plant Service was used for burning and gas sampling activity. Rice straw samples with different moisture content levels were prepared varying from 10 - 40%. Methane and nitrous oxide were analysed using SRI 8610C gas chromatograph. The ash and residues were collected and submitted to the IRRI Analytical Services Laboratory for the analysis of total carbon and nitrogen content

Through these findings, we can establish guidelines to properly mitigate greenhouse gas emissions for this type of straw management.

References:

Cheewaphongphan, P., Garivait, S., Pongpullponsak, A., & Patumsawad, S. (2011). Influencing of Rice Residue Management Method on GHG Emission from Rice Cultivation, 58–65.

Gadde, B., Menke, C., & Wassmann, R. (2009). Rice straw as a renewable energy source in India, Thailand, and the Philippines: Overall potential and limitations for energy contribution and greenhouse gas mitigation. *Biomass and Bioenergy*, *33*(11), 1532–1546. doi:10.1016/j.biombioe.2009.07.018

[SP5]

THE ECOLOGICAL INTENSIFICATION PLATFORM AT THE INTERNATIONAL RICE RESEARCH INSTITUTE

J.R. Quilty, R.J. Buresh, Ma. C. Alberto, T.Q. Correa, J. Sandro

[1] *IRRI, Los Baños, Philippines*

For more than 50 years the International Rice Research Institute (IRRI) has been developing innovative strategies, technologies, and genetic resources to reduce hunger and poverty in rice farming communities around the world. In addition to the development of high-yielding, short-duration rice varieties that spearheaded the Green Revolution in Asia, IRRI established, and has implemented for 52 years, a long-term continuous cropping experiment, which continues to provide invaluable insights into the sustainable productivity of intensive lowland rice production with modern high-yielding varieties, efficient use of fertilizer, and ample irrigation water. High yields and soil health have been sustained in this intensive production system with three rice crops per year, but like traditional rice production in Asia it requires considerable labor and irrigation water, including water for wet tillage (puddling) of soil before each rice crop. However, water and labor resources for rice production are becoming scarce in some areas of Asia. The sustained productivity of irrigated rice in such cases will increasingly require more efficient use of water and labor while meeting standards of environmental quality.

In an effort to develop innovative agronomic solutions to anticipated needs for production of more rice on less land with more efficient use of labor, water, and other inputs, IRRI established the Ecological Intensification (EI) platform in 2011. A major goal of this research platform is to develop scientifically sound principles that guide agronomic decisions to achieve productivity gains through the intensification of cropping systems while meeting acceptable environmental standards. Futuristic intensive production systems were established to contrast a benchmark system with mechanized crop establishment conducted on puddled soil for each rice crop. In the contrasting futuristic systems water-saving alternatives were implemented with mechanized establishment of rice on non-puddled soil. In the non-puddled systems, two rice crops per year are rotated with either maize or mungbean. Each of these systems were implemented on three 4-ha areas sufficiently large for use of eddy covariance (EC) systems.

To aid in the development of the principles of EI a range of environmental parameters are being closely monitored in these cropping systems. The energy, water, and carbon balances of the systems, as well as the global warming potential, productivity, agronomic input use efficiency, and changes in the soil environment, are being quantified. Eddy covariance systems were installed at the center of each of the three EI fields. These EC systems play an integral role in efforts to quantify the global warming potential, photosynthetic efficiency, and the net biome productivity of each cropping system. Additionally the daily evapotranspiration is quantified with the EC systems in each field, and is used inform irrigation scheduling to optimize water productivity and to determine the total ET demands of the contrasting systems.

Intensification of rice-based cropping systems and optimization of resource use can help to achieve productivity increases and provide environmental benefits. Ecological intensification of rice-based cropping systems will play an important role in sustaining food security in the future.

[SP6]

ECO-EFFICIENT RICE-BASED CROPPING SYSTEMS WITH HIGH GRAIN ENERGY OUTPUT AND REDUCED GLOBAL WARMING POTENTIAL

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To feed everyone adequately, world food production must double within the next 30 years. Projections indicate that production of rice, wheat, and maize will have to increase by about 1.1%, 1.7%, and 2.9% per annum, respectively, over the next four decades to ensure food security in South Asia. Widespread inefficiency of resource use, depletion or degradation of soil and water resources, rising production costs, and increasing environmental pollution are major concerns associated with crop production in South Asia in addition to negative impact of climate change. South Asia is one of the two regions of the world that, without sufficient adaptation measures, will likely suffer negative impacts of climate change on several crops that are important to large (30% of the world) food-insecure human populations. Improving agriculture adaptation and reducing agriculture's global warming contribution are the key factors that will shape the future severity of climate change impacts on food production.

Under Cereal System Initiative for South Asia (CSISA), at four distinctly different agro-ecological conditions in South Asia, the concept of "ecological intensification" was tested and the performance of four scenarios with existing (business as usual—farmers' practices) as well as proposed future cereal-based systems following the principles of conservation agriculture (CA) were evaluated for balancing productivity, profitability, sustainability, and environmental protection

Two years results show large potentials for enhancing systems productivity and efficiency. The annual grain energy outputs of conventional farmers practices increased by 32 to 72 GJ/ha/yr with best management and CA practices in intensive and diversified cropping systems (CAS), when mean across the locations and years was considered. Higher mean annual grain energy output (35 to 110 GJ/ha/yr) was in milieu of traditional rice-wheat systems (RWS) than 19 to 35 GJ/ha/yr in rice-rice system (RRS). As a result, there was a gain in mean net economic returns of farmers by 675 to 801 US$/ha over the existing farmers' practices. Mean net income gain was also higher in RWS (US $886 to 1467/ha/yr) than in RRS (US $132 to 717/ha/yr). Zero tillage and direct seeding (DSR) proved to be viable alternative to puddled transplanting to overcome constraints of labor, water and energy and reduce cost of cultivation.

The tested cropping systems have reduced mean global warming potential (GWP) by 15% in RWS locations and by 8% in RRS. The mean system GWP intensity (GWP i) was reduced by 44% in CAS with higher reduction in RWS (65%) than in RRS (26%). Observations on greenhouse gas (GHG) monitoring from the present and futuristic cropping systems show that N_2O emissions in maize were significantly higher than that in wheat, which should be related to the low temperature during the wheat season. Inclusion of maize in rice-rice cropping system during the summer season with reduced tillage can lead to significant GHG mitigation.

In addition, marked resource saving was recorded which varied significantly across the sites. Overall systems mean reductions in the usages of irrigation water ranged from 19 to 63%, with much greater savings in RRS (28 to 73%) than in RWS (14 to 59%) locations. Maize-wheat-mungbean in RWS locations and rice-maize+potato-cowpea in RRS locations were promising crop rotations and viable alternative to conventional RRS and RWS. Opting for these new cropping systems has a potential to increase the net income of farmers by a mean19% in RRS and by 113% in RWS locations.

Our results clearly show that interventions of best management including CA practices in tested cereal based cropping systems have large potential to improve crop productivity with high input use efficiencies, lower warming potential and positive economic returns on a system level.

[1-1]

ROLE OF WEATHER, LAND USE AND MANAGEMENT ON GREENHOUSE GAS FLUXES IN THE SACRAMENTO DELTA

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Draining Delta land for agricultural purposes over the last 150 years has resulted in the oxidation of peat soils, causing subsidence of Delta islands and the emission of stored carbon primarily in the form of carbon dioxide (CO_2). Changing land use from current agricultural practices to the production of rice (a crop grown under submerged conditions) and/or restoring wetland habitats provides a potential solution that could arrest or reverse subsidence by limiting oxidization and accumulating carbon. Interest in implementing these land uses widely across the Delta is increasing. Questions remain, however, about the effects of different land uses on carbon emission rates: Is carbon stored and/or emitted at different rates? Do the type (CO_2, methane [CH_4], etc.) and quantity of greenhouse gas emissions change?

Since 2007, CO_2 and CH_4 fluxes, greenhouse gases of varying global warming potentials, have been measured over managed and restored lands (pasture, rice, corn, alfalfa, restored wetlands) in the Delta by the Berkeley Biometeorology Lab, with the goal of understanding the processes that control carbon sequestration and loss. This presentation will discuss the role of different land uses on site carbon balance and explore potential tradeoffs associated with land use change in the Delta.

[1-2]

REAL TIME LANDFILL METHANE FLUX MONITORING USING A MICROPROCESSOR CONTROLLED ON-SITE EDDY COVARIANCE DATA PROCESSING SYSTEM

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The Eddy covariance technique allows in situ measurement of trace gas exchange between the surface and the atmosphere on a continuous basis. Eddy covariance data processing involves numerous correction procedures and adjustments after the initial data collection; which are numerically intensive. Normally this is done after the data collection using specialized software in a suitable computing environment. This post-field processing is time-consuming and hinders researchers from getting fully corrected flux results in real-time. A low power micro-processor based system was developed and commercialized at LI-COR Biosciences to facilitate on site data processing. This system has a small form factor which facilitates easy integration with already existing systems and has a GPS receiver which provides precise time and location information. The system incorporates EddyPro™; a data processing software developed by LI-COR, which can be run in express or advanced modes. The processed results are available as daily summary files. A server-based data management software application, which allows real time monitoring of processed data along with automated email messages for system diagnostics was also developed.

This system was incorporated into a methane measurement system installed in a landfill at Lincoln, Nebraska USA. The system allows real time monitoring of the landfill and provides a snapshot on the diurnal/seasonal trends of emissions for stake holders. This new innovation will help researchers and policy holders save both time and reduce cost by providing access to fully corrected fluxes on a real time basis.

[1-3]

MITIGATING GREENHOUSE GAS EMISSIONS FROM RICE FIELDS IN BANGLADESH

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More than 80 % of Bangladesh's agricultural land is covered with rice. Since rice is a major source of both methane (CH_4) and nitrous oxide (N_2O) emissions, Bangladesh is considered one of the major agricultural contributors to total greenhouse gas (GHG) emissions. However, research on GHG emissions measurement and mitigation are very limited. Emissions of both CH_4 and N_2O are mainly controlled by water and nitrogen management. Nitrogen fertilizer consumption in Bangladesh is about 1.37 Tg (1.37 million tons) per year, based on IPCC estimates N_2O emissions from N fertilizers is 1370 tons per year. Water saving irrigation such as alternate wetting and drying (AWD) is reported to reduce global warming potential of rice farming mainly due to reducing methane emissions. However, its impacts on N_2O emissions are not year clear. N_2O emission could be reduced by efficient N fertilization. Urea deep placement (UDP) is a promising technology that reduces N loss up to 35 percent and increase rice yield up to 20 percent. To find the mitigation potential of GHG emissions from water and nitrogen management, IFDC has started long term monitoring of N_2O and nitric oxide (NO) emissions using automated continuous measurement system. The experiments are being conducted in close collaboration with Bangladesh Agricultural University (BAU), and Bangladesh Rice Research Institute (BRRI). Monitoring of N_2O and NO emissions is being done since 2013. The objectives of this research are to determine the effects of urea broadcast compared with deep placement of urea and NPK briquettes (7-10 cm) on greenhouse gas emissions (N_2O and NO), ammonia volatilization, and rice grain yield under both continuously flooded and alternate wetting and drying conditions.

Prilled urea was broadcasted in 2-3 splits, while the urea and NPK briquettes were deep placed (7-10 cm) between 4 hills of rice at the alternate rows after 7-10 days of rice transplanting as a single application. N_2O and NO fluxes were measured continuously (24 h) throughout the rice growing and fallow seasons using an automated closed chamber technique. NH_4-N concentration of floodwater was measured for a week after each application of fertilizer. A set of unreplicated treatments were used to quantify the effect of AWD and the above N treatments on N_2O and NO emissions and grain yield.

Preliminary results showed that N_2O emissions were sporadic and event specific. The fertilizer-induced peak emissions were observed in broadcast prilled urea treatments after 4-7 days of application. But emission peaks were not observed in UDP treatments. Magnitude and emissions rate were varied between two locations. In addition to fertilizer induced peak (under urea broadcast), significant emissions were observed when field was alternately wet and dry. Broadcast application of prilled urea resulted in higher concentration of NH_4-N in floodwater which could be lost via ammonia volatilization while it was negligible under UDP. Rice yield was significantly higher from UDP compared with broadcast application. UDP with 30 percent less nitrogen resulted statistically similar yield compared with broadcast prilled urea. Moreover, rice yield was relatively higher from AWD plots compared with continuously flooded fields suggesting the potential of AWD and UDP adoption in Bangladesh.

These results suggest that N loss as N_2O emissions and ammonia volatilization could be minimized with deep placement of nitrogen along with increasing rice yield. There could be potential to reduce both N_2O and CH_4 using different modalities of AWD along with UDP. The current methodological approach, possible partnership in research and future perspective of the research in Bangladesh will also be discussed during the presentation.

[1-4]

MICROMETEOROLOGICAL AND CHAMBER MEASUREMENTS OF METHANE FLUX OVER TWO FORESTS IN JAPAN

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Forest ecosystems are thought to be a methane sink, because methanotrophs consumes methane on upland aerobic soils. However, quantifying their spatio-temporally integrated budget is difficult due to considerable spatial heterogeneity and temporal variability. Measuring methane flux using micrometeorological techniques is challenging in forest ecosystems, because magnitudes of the fluxes are close to the precision of currently available systems. To overcome this difficulty, we have developed a measurement system that integrates the micrometeorological hyperbolic relaxed eddy accumulation (HREA) method (Ueyama et al., 2013), automated dynamic closed chambers, and vertical concentration profiler with a laser-based analyzer (FGGA-24r-EP, Los Gatos Research Inc., USA). Using the measurement system, we are preparing a network for measuring methane flux at forest ecosystems. In this study, we present methane fluxes at two forests from our network.

Measurements were conducted at Fujihokuroku Flux Research Site (FHK) in northern foothill of mount Fuji, and Teshio Experimental Forest (TSE; Takagi et al., 2009) in Hokkaido island, Japan. FHK is a larch plantation (age was approximately 50 to 55) on a volcanic ash soil, and TSE is a young larch planted at 2003 on a Gleyic Cambisol with dense understory *Sasa* bamboos. Measurements started at August 2011 at FHK and September 2013 at TSE.

More than two-year continuous HREA measurements indicated that FHK was the methane sink (600-890 mg CH_4 m^{-2} yr^{-1} in 2012 and 670-970 mg CH_4 m^{-2} yr^{-1} in 2013). Measured methane fluxes were consistent among the HREA and chamber methods (Fig. 1). These results indicate that the forest soil was the major contributor to the observed sink. This was also consistent with the profile measurement showing that methane concentration near the forest floor was mostly lowest. The methane fluxes showed a clear seasonal variation, where methane sink was greater in summer months than winter months. The methane uptake was greater in higher soil temperature, whereas the uptake was lower in higher soil water content, especially just after rainfalls.

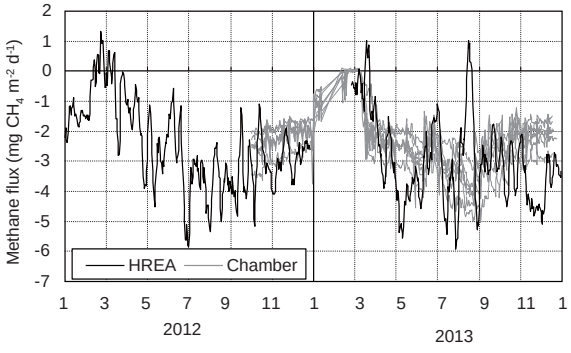

Fig. 1 Seasonal variation of methane flux at FHK.

The successful measurements at FHK indicate that our system could quantify methane flux at forest ecosystems, and could be robust under field conditions. Based on this experience, we have a plan to spread the measurement system into various forests in order to monitor methane fluxes and understand their spatio-temporal variations. TSE is an example of our network to clarify methane flux at the young plantation. We will further expand our measurement system into several forest sites in next few years by collaborating researchers in existing tower sites.

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[1-5]

QUANTIFYING THE MAGNITUDE AND ENVIRONMENTAL INFLUENCES ON METHANE FLUX FROM A TROPICAL PEAT SWAMP FOREST IN SARAWAK, MALAYSIA

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Tropical peat swamp forests are one of the world's most important terrestrial ecosystems in terms of impact on the greenhouse gas composition. Owing to the presence of water logged and anaerobic conditions, tropical peatland is likely to contribute considerable amount of CH_4, the third most important greenhouse gas after water vapour and CO_2. To date, no studies were found from all over the world regarding continuous measurement of CH_4 flux in tropical peatland. Thus, the present paper reports the major finding from our research effort to quantify the magnitude of CH_4 flux using eddy covariance method in tropical peat swamp forest. The eddy covariance method is ideally suited for quantifying the CH4 flux continuously and it integrates the CH4 flux over a larger area, giving a more representative measurement for the ecosystem. In addition, we aim to assess the influence of environmental variables, such as soil temperatures at different depths and water table depth on CH_4 flux. This study has been carried out in a logged over tropical peat swamp forest in Sarawak, Malaysia with an elevation of about 8 m above mean sea level. To measure CH_4 flux, a newly developed LI 7700 open-path CH_4 analyzer was installed at 40 m above the forest floor on eddy covariance flux tower. The LI 7700 is a fast, high precision, light weight, low power consumption and low maintenance operation sensor that provides continuous and long term observations of CH_4 flux. Due to the frequent rainfall in tropical peatland, monthly maintenance was required for CH_4 analyzer in order to ensure the instrument operate at optimum scale.

Generally, water table level and soil temperature have been reported as important regulators for CH_4 flux. Our results show that the daily CH_4 flux values were ranged from -0.1 to 0.127 μmol m^{-2} s^{-1} with an average of 0.018 μmol m^{-2} s^{-1}. No clear pattern was observed in daily variation of CH_4 flux. A positive correlation was exists between CH_4 flux and water table level; higher water table level would enhance anaerobic decomposition of organic matter and limit oxidation of CH_4. In contrast, soil temperature at 5 cm and 10 cm were negatively correlated with CH_4 flux.

[1-6]

OBSERVATION OF VERTICAL PROFILES OF NO_X, O_3, VOC AND INVERSE MODELING ESTIMATES OF THEIR FLUXES AT VERTICAL LEVELS IN JAPANESE LARCH AND RED PINE FORESTS

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The emission and absorption of trace gases at the biosphere affects to atmospheric chemistry, and thus it makes influence with potential indirect effects on carbon cycle and climate (Ollinger *et al.*, 2002). We measured concentration profiles of O_3 NO_x and volatile organic compounds (VOC) at meteorological towers in larch and red pine forests in the summer of 2012. The height of the observation tower is around 30 m. O_3 and NO_x were measured by an ultraviolet absorption O_3 analyzer and a chemiluminescencence NO_x analyzer, respectively. The air for O_3 and NO_x was sampled every 220 seconds from four vertical height locations, above the forest canopy (28 m/27 m), in the forest canopy (16 m/17 m), trunk space (10 m/9 m), and above the ground (2 m). The total interval time was 15 minutes and hourly average data were obtained. VOC were sampled by gas sampling tubes every 3 hours from 6:00 to 18:00 at the height of 27 m, 22 m, 16 m, 10 m, and 2 m. Micrometeorological data, wind speed, wind direction, radiation, precipitation, and temperature, were also observed.

Observed vertical profiles of trace gases in the larch forest are shown in Fig. 1. O_3 showed a minimum at 2 m above the ground. It increased with height, and showed a maximum at 28 m. NO showed a maximum at 28 m, and a minimum at 10 m. NO_2 did not show an obvious vertical distribution. Monoterpene was a maximum at 2 m above the ground. It decreased with height, and showed a minimum at 28 m. Methylvinylketone showed a maximum at 28 m and had a local maximum at 10 m during 9:00-12:00 and 15:00-18:00. Theses vertical profiles showed distinctive futures.

We estimated sink/source distributions of the trace gases from the observed vertical profiles using the inverse Lagrangian model (Raupach, 1989). The inverse model estimated that O_3 was absorbed at the lowest layer near the forest floor and the canopy layer. The model also estimated that NO was absorbed at all three layers. The amount of absorption of NO at the trunk space (i.e. near the trunk of trees) was estimated as 0.0068 ± 0.0030 ppb m s^{-1}. One of possible explanations of NO absorption in the trunk space is chemical reactions with O_3 in the atmosphere. The inverse model showed a large amount of monoterpene was emitted in the lowest layer, suggesting emissions from the forest floor. Methylvinylketone was estimated to be small emission in the trunk space. There was a possibility of production of methylvinylketone by oxidation of isoprene in the trunk space.

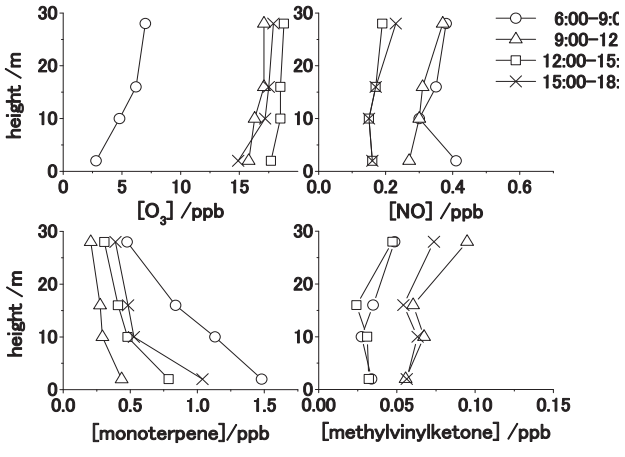

Fig. 1 Vertical profiles of trace gases in the larch forest

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Raupach, M.R., 1989, *Agricultural and Forest Meteorology* **47**, 85-108.

[1-7]

SOIL MOISTURE CONDITIONS MAY AFFECT TERPENOID FLUXES MEASURED ABOVE A LARCH FOREST

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Terpenoids emitted from forests contribute to the formation of secondary organic aerosols and affect the carbon budgets of forest ecosystems. To investigate seasonal variation in terpenoid flux involved in the aerosol formation and carbon budget, we measured the terpenoid flux of a *Larix kaempferi* forest between May 2011 and May 2012 by using a relaxed eddy accumulation method. Isoprene was emitted from a fern plant species *Dryopteris crassirhizoma* on the forest floor and monoterpenes from the *L. kaempferi*. α-Pinene was the dominant compound, but seasonal variation of the monoterpene composition was observed. High isoprene and monoterpene fluxes were observed in July and August. The total monoterpene flux was dependent on temperature, but several unusual high positive fluxes were observed after rain fall events. We found a good correlation between total monoterpene flux and volumetric soil water content ($r = 0.88$), and used this correlation to estimate monoterpene flux after rain events and calculate annual terpenoid emissions. Annual carbon emission in the form of total monoterpenes plus isoprene was determined to be 0.93% of the net ecosystem exchange. If we do not consider the effect of rain fall, carbon emissions may be underestimated by about 50%. Our results suggest that moisture conditions in the forest soil is a key factor controlling the monoterpene emissions from the forest ecosystem.

[2-1]

CARBON AND WATER CYCLING RESEARCHES IN SOUTHEAST ASIAN TROPICAL FORESTS

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Basics of vegetation productivity is photosynthesis, which occurs through CO_2 exchange between atmosphere and cavity of stomata. Stomatal behavior is influenced by atmospheric evaporative demand and ecosystem water resources such as soil moisture status. Thus, for appropriate consideration of photosynthetic process and projection of the productivity, we must take into account environmental control of stomatal behavior and fundamentally, the ecosystem water cycle process. With this background philosophy, we are conducting several cooperative works about ecosystem water and carbon cycling with Thai, Cambodian and Malaysian colleagues at tropical moist and seasonal, and natural and artificial forest sites. There, we are measuring energy, H_2O and CO_2 exchanges between atmosphere and the forest canopy, basic meteorological variables, individual/leaf –scale plant physiology, and are building models that can simulate detailed these exchanges and individual tree growth, competition, mortality, and furthermore, plantation production such as latex at a rubber plantation site. At this workshop, I am giving a presentation about some results and ongoing subjects.

[2-2]

STUDIES ON MASS AND ENERGY FLUXES IN SUNDARBAN MANGROVES, INDIA, USING EDDY COVARIANCE FLUX TOWER DATA

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In the present study we report analysis of mass (carbon dioxide-CO_2 and methane-CH_4) and energy (sensible heat, latent heat and soil heat) fluxes, measured by eddy flux tower over mangrove forests of Sundarban Biosphere Reserve (SBR), West Bengal, India during April, 2012 – March, 2014. The tower is equipped to measure fast response measurements of CO_2, H_2O, CH_4 fluxes and orthogonal wind components (u, v, w) at a frequency of 10Hz (averaged to half hourly fluxes) along with meteorological and soil parameters at a frequency of 10 sec (averaged to 10 min). Continuous measurements of CO_2 and CH_4 were carried out using open path IRGAs - LI-7500A and LI-7700 (LI-COR Inc., USA) respectively. A three-dimensional sonic anemometer, CSAT-3 (Campbell Scientific Inc., Canada) was used to measure high frequency wind velocity components and sonic temperature. Eddypro post processing software (version 4.1, LI-COR, USA) was used to compute half hour fluxes for the study period. The half hour flux data sets were processed for removal of spikes and erroneous data and subsequent gap filling was carried out using Marginal Data Sampling (MDS) and Mean Diurnal Variation (MDV) methods. Seasonal variability of mass and energy fluxes over the study area was analyzed to understand the soil-vegetation-atmosphere fluxes and relevant contributing factors.

Results suggested that the study area is a sink of CO_2 with maximum carbon sequestered during winter months (maximum monthly mean daytime NEE CO_2 of -9 μmol m^{-2} s^{-1} during October to December 2012). Preliminary analysis of CH_4 suggested that the study area is a source of CH_4 (daily average flux of ~ 150.22 ± 248.87 mg m^{-2} day^{-1} during April-May 2012). The sensible heat flux (H) and latent heat flux (LE) showed a linear relationship with net radiation with values peaking during mid-day throughout the study period. More energy was observed to have partitioned into sensible heat flux during summer (maximum monthly mean daytime flux of 230 Wm^{-2} during April) while inversely, latent heat flux dominated during winter (maximum monthly mean daytime flux of 250 Wm^{-2} during October). Further, detailed seasonal and inter-annual analysis on the mass and energy fluxes of the SBR is presented.

The study is carried out as part of the National Carbon Project, an Indian Space Research Organisation's (ISRO) initiative and is funded by ISRO's Geosphere Biosphere Programme (ISRO-GBP).

[2-3]

CARBON AND WATER FLUX MEASUREMENTS OF YOUNG RUBBER ECOSYSTEM IN NORTH-EASTERN REGION OF THAILAND

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Rubber tree (*Hevea brasiliensis* Müll. Arg.) is the source of natural rubber which is mainly planted Southern Thailand. For many years, rubber plantation has been extended to North and North East region of Thailand. This area has extreme climatic condition for rubber including long period of cold and dry season. The objectives of this study are to understand an ecosystem of rubber plantation response to environmental perturbation and also to understand the impact of extreme drought on carbon and water balances of young rubber plantation. The CO_2 and H_2O fluxes will be used to validate model of carbon and water balance of young rubber plantation ecosystem. Fifteen meters-height eddy covariance tower was established in 4 year old rubber plantation which, located in Pak Khat district, Buengkan Province (18° 13' N, 103° 18' E) since October 2012. The eddy flux measurement was setup at 12 m above ground (4 meters above rubber tree canopy). The system continuously measures net ecosystem exchange (NEE) of carbon and water vapor, net ecosystem production (NEP), gross primary production (GPP), and total ecosystem respiration (TER) along with additional air and soil meteorological measurements. Since January 2013, soil respiration measurement has been setup. Measurements have been performed once a month to study the carbon flux emission from the soil. Due to the open canopy of young rubber tree, some species of weeds and grasses was found over the plantation area. Since February 2014, weed canopy carbon exchange measurement has been performed. This measurement will be performed during different season of the year to explain the role of weed and grass carbon emission and absorption within net ecosystem exchange of young rubber plantation. The preliminary results of the study have been shown in this report.

[2-4]

SOIL AND ECOSYSTEM CO_2 FLUXES IN SEASONAL TROPICAL FOREST OF SOUTHERN VIETNAM

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Soil and ecosystem CO_2 fluxes were studied in tropical monsoon forest located in southern Vietnam from 2011 to present time. Site under investigation is located in Cat Tien National Park in southern Vietnam. The study area is described as a tropical monsoon valley tall-stand forest at altitude about 156 m above sea level. Canopy height is ~ 37 m. Forest has 3-5 canopy sub-stages and rich biodiversity (80 tree species), predominant spp. on drained plots are Lagerstroemia calyculata (Lythraceae), Haldina cordifolia (Rubiaceae), Tetrameles nudiflora (Datiscaceae), Afzelia xylocarpa (Caesalpiniaceae), Sterculia cf. cochinchinensis (Sterculiaceae). Soils are medium-rich ultisols over basalt rock. Climate is tropical monsoon with 2 seasons: dry winter (each month from December to March has less than 100 mm of rain) with temperature of +24...+28 and rainy summer with +26 on average. Total year precipitation is 2518 mm (Dong Xoai meteorological station, 1981-2010).

Soil fluxes were measured by chamber method every 10-15 days at 7 plots with differ soils and forest types, mostly in Lagerstroemia - or Dipterocarpus-dominated tree stands. CO_2 concentration was defined with LI-820 gas. Ecosystem CO_2 fluxes were investigated under canopy of forest at the height 50m. Eddy covariance system consisted of LI-7500A open-path gas analyzer and CSAT3 sonic anemometer. All the standard EC procedures were applied to the raw 10-Hz data including time-lag compensation, block average, WPL-correction, planar fit, low- and high-frequency corrections etc. in EddyPro software (LI-COR Inc., USA).

Our studies have shown significant temporal and spatial variability of soil respiration in tropical rainforest. Namely in 2012-2013, highest annual CO_2 efflux rates were calculated for cambisols under lagerstroemia-dominated tree stand and for light sandy fluvisols under dipterocarpus-dominated tree stand (1694.3±546.0 and 1628.1±442.7 $gC \cdot m^{-2} \cdot y^{-1}$ respectively). Noteworthy is that the content of organic carbon in these soils varies utterly. Lowest annual CO_2 efflux rate was calculated for clay-slate leptosols under dipterocarpus-dominated tree stand (972.7±716.5 $gC \cdot m^{-2} \cdot y^{-1}$). We also observed a significant impact of termites activity on site-scale spatial variability of soil respiration. Seasonal patterns of soil respiration rates were conformed for all plots except one on sandy soils. The beginning of rainy season in April did not result in higher soil respiration rates, but rates did rise in August – October, at the end of rainy season. Apparently this pattern is related to the accumulation of decomposed organic matter in soil and to the deficient aeration caused by high water table at the peak of wet season. On sandy fluvisols CO2 efflux rates were high throughout the whole length of rainy season.

In 2012 the seasonal tropical forest of southern Vietnam was strong sink for CO_2: estimations based on different despiking algorithms, u*-threshold shift and gap-filling strategies gave from -296 to -612 gC•m-2•y-1 (minus means sink of carbon). We suggest -400 gC•m-2•y-1 as realistic estimation of net ecosystem exchange (NEE) in 2012. Using flux-partitioning of NEE to gross primary production (GPP) and total ecosystem respiration (Reco) (Reichstein et al., 2005), we got GPP of 3498 gC•m-2•y-1 and Reco of 3162 gC•m-2•y-1 for 2012. So, the rate of soil respiration in outcoming ecosystem CO_2 flux was about 50 %. NEE showed significant seasonal course which origins from different reactions of GPP and Reco to changing environmental conditions. GPP was limited by solar radiation in wet season and soil moisture in dry season. Reco was driven mainly by soil moisture changes: too dry soil as well as too wet caused decrease in respiration. Overall, in 2 driest months GPP reduced by 44 % and Reco reduced by 37 % in comparison with 2 wettest months, drawing forest to carbon-neutral one in conditions of drought.

[2-5]

NET GHG FOOTPRINT OF A NEWLY IMPOUNDED SUBTROPICAL HYDROELECTRIC RESERVOIR: CASE NAM THEUN 2 RESERVOIR (LAO PDR)

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Rising concern over the contribution of hydroelectric reservoirs to increased atmospheric concentration of greenhouse gases (GHGs) led to quantify the net GHG footprint of a hydroelectric reservoir. We present here the first comprehensive assessment of GHGs footprint associated with the creation of a hydroelectric reservoir Nam Theun 2 (NT2) in subtropical region of the Lao People's Democratic Republic. This is the results of a large scale study that have been conducted over 4 year (2008-to date). The major GHG sources and sinks of the terrestrial and aquatic components of the pre-impoundment landscape where quantified. Similar estimate of these various emission pathways were made at the reservoir scale since the May 2009.

Ecosystems existing on the reservoir footprint before flooding were a sink of carbon dioxide (-73 ± 225 $GgCO_{2eq}.year^{-1}$), roughly neutral in terms of methane (7 ± 11 $GgCO_{2eq}.year^{-1}$), and a source of nitrous oxide (345 ± 158 $GgCO_{2eq}.year^{-1}$). Post-impoundment GHG budget reveal that the same footprint has become a more significant source of CO_2 and CH_4, and a much smaller source of N_2O. For the year 2010, with 1307 ± 244 $GgCO_{2eq}.year^{-1}$ and 768 ± 206 $GgCO_{2eq}.year^{-1}$ respectively, CH_4 and CO_2 have contributed around 60% and 35%) to the total GHG budget. With 93 ± 163 $GgCO_{2eq}.year^{-1}$, N_2O accounts for less than 5% of the total emission. While CH_4 emissions declined a bit the second year of study (473 ± 91 $GgCO_{2eq}.year^{-1}$ in the year 2011), CO_2 emissions increased (1551 ± 197 $GgCO_{2eq}.year^{-1}$) in the same time, while N2O emissions remained constant. Our results indicate that upstream GHG emissions (emissions from the reservoir water surface and drawdown area) contributed around 87% and 92% of total GHG emissions for the years 2010 and 2011, respectively. Remaining total GHG emissions were contributed from downstream emissions (degassing and diffusive emissions from the downstream), a percentage lower than reported for tropical reservoirs.

With a total gross emissions of 2168 ± 358 and 2133 ± 276 $GgCO_{2eq}.year^{-1}$ for the years 2010 and 2011, gross NT2 emissions are about an order of magnitude higher than pre-impoundment emissions (276 ± 343 $GgCO_{2eq}.year^{-1}$). With a net GHG emissions of 1889 ± 496 (2010) and 1854 ± 440 (2011) $GgCO_{2eq}.year^{-1}$, and an annual power generation of about 6 TWh, GHG emission factor equal to 0.31 (2010) and 0.30 (2011) $MgCO_{2eq}.MWh^{-1}$ for the NT2 Reservoir. This is lower than a typical thermal coal based power plant emission factor of 0.96 Mg of $CO_{2eq}.MWh^{-1}$. GHG emission factor for the year 2010 corresponds to the initial years after impoundment for NT2, and as such, can be considered as the maximum value that would be reached for this reservoir. Work is in progress to predict the trends of GHG emissions over the projected life span (e.g. 100 years) of the reservoir yields integrated long-term net GHG emissions per energy generation. It will allow comparing with alternate energy sources over the projected life span (100 years) of the reservoir.

[2-6]

ENVIRONMENTAL EFFECTS ON DIFFUSE RADIATION IN TROPICAL PEATLAND

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1. Introduction

Global solar radiation (R_g) is a major driver for ecosystem gas exchange of photosynthesis and is divided into two components: direct (R_b) and diffuse radiations (R_d). Under the haze atmosphere (e.g. large-scale fires), R_d increases, although R_g decreases. Aerosol, air mass and water vapor alter the proportion of R_d to R_g (R_d/R_g). A high diffuse fraction (R_d/R_g) produces more uniform irradiance within plant canopy and enhances ecosystem photosynthesis (GPP) with a small fraction of light saturation. Thus, to investigate the effects of large-scale fires on GPP, it is crucial to quantify R_d as well as R_g. We analyzed the seasonal and interannual variations of R_d/R_g in tropical peatland, where large-scale fires frequently occur, using long-term field data.

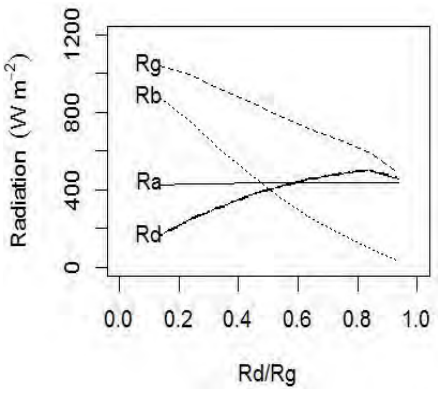

Fig. 1. Change in half-hourly solar radiation (R_g, R_b, R_d, atmospheric radiation (R_a)) with R_d/R_g in rainless conditions around midday (1000-1400 h) at DB site.

2. Materials and methods

The R_g and R_d were measured using a sunshine sensor (BF3, Delta-T Device) at drained burnt swamp forest (DB: 2°20′26″S, 114°2′16″E) in Central Kalimantan, Indonesia from 2010 to 2013. Also, R_g (CNR-1, Kipp & Zonen) and some meteorological factors were measured along with groundwater level (GWL) at drained swamp forest (DF), which was about 600 m apart from the DB site, for 12 years from 2001 to 2013. To estimate the fraction of R_d for a long period, we applied a widely-used approach (e.g. Roderick, 1999) using a ratio of R_g and the extra-terrestrial solar radiation (R_0), which can be calculated based on solar latitude (Spitters *et.al*., 1986).

3. Results and Discussion

For half-hourly data around midday (1000-1400 h), increasing R_d/R_g leads to a sharp decrease in R_b and R_g, and an initial increase in R_d (Fig. 1). Due to absorption and reflection process, R_g (the sum of R_b and R_d) decreased with R_d at R_d/R_g over 0.8. The high R_d/R_g in rainless hours suggested as a result of dense aerosol loading to the atmosphere. Using daily data, we found a significant negative linear correlation between R_d/R_g and R_g/R_0, when R_g/R_0 is larger than 0.26 (r = 0.88, p < 0.001). The R_d/R_g was constant at 0.96, when R_g/R_0 was below 0.26. The RMSE of the model was 0.0089. Using the model, a long-term variation in R_d/R_g was estimated at the DF site. In 2009, an El Niño year, GWL significantly decreased during the dry season from July to mid-November (Fig. 2), which produced a series of peat fires in this area. Because of smoke emitted through burning, R_d/R_g increased in August and September regardless of fewer clouds. On the other hand, in 2010, a La Niña year, GWL never lowered underground without any fires even in the dry season because of continual precipitation. As a result, a relatively high level of R_d/R_g, which was due to more clouds, continued during the period.

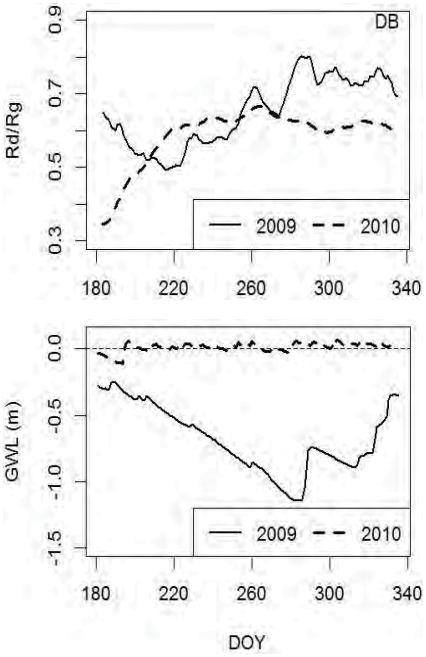

Fig. 2. Temporal variations in R_d/R_g and GWL for 5 months from July to November in 2009 (El-Niño year) and 2010 (La Niña year) at DB site.

[3-1]

EA-FDPN: PLOTS NETWORK FOR FOREST AND CARBON DYNAMICS FROM SIBERIA TO TROPICAL ZONE

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In 2009, Japan's Forestry and Forest Products Research Institute (FFPRI) created the EA-FDPN (the East Asia Forest Dynamics Plots Network), which covers forests from Siberia to the Equator. The EA-FDPN comprises seven long-term monitoring plots, in which continuous tree censuses have been conducted, across four forest types: boreal forests (Tura [Russia]), tropical dry forest (Mae Klong [Thailand]), tropical rain forests (Semangkok [Malaysia], Pasoh [Malaysia], and Bukit Soeharto [Indonesia]), and tropical swamp forests (Lam Se Buy and Ranong [Thailand]).

The carbon stock values from the five carbon pools varied across the monitoring plots and showed a general tendency of decrease toward high latitudes. High carbon stocks, which were more than 300 Mg-C ha^{-1}, were estimated in Semangkok and Pasoh. Both plots were similar in composition in carbon pools: more than 60% of carbon stocks retain within aboveground biomass. In Semangkok, large size class trees of *Shorea curtisii*, dominated especially on the ridge, contributed to high aboveground biomass. In Mae Klong, the soil carbon pool contained about 37% of the total carbon stock. Dead wood stocks showed small values (i.e. 3% of total carbon pools) due to low tree biomass and frequent fire disturbances. On the other hand, the impact of severe fires and subsequent drought caused relatively high dead wood stock and low aboveground biomass in Bukit Soeharto.

The ANPP (aboveground net primary production) values also varied across the monitoring plots and showed a general tendency of decrease toward high latitudes. Disturbance agents would also play an important role in ANPP fluctuations. In Ranong, mangrove forests, the impact of the tsunami caused by the 2004 earthquake and subsequent recovery caused large fluctuations in the ANPP. The data from across the East Asian forests will allow us to comprehensively compare the climate change responses of different forest types. Further studies and information sharing will provide great opportunities for broad-scale comparisons that could not be accomplished by studying any individual plot.

[3-2]

DYNAMICS OF ECOSYSTEM CARBON BALANCE RECOVERING FROM CLEARCUTTING IN A COOL-TEMPERATE FOREST

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A mixed forest in northern Japan, which had been a weak carbon sink (net ecosystem CO_2 exchange [NEE] = –0.44 ± 0.5 Mg C ha^{-1} yr^{-1}), was disturbed by clear-cutting in 2003 and was replaced with a hybrid larch (*Larix gmelinii* × *L. kaempferi*) plantation in the same year. To evaluate the impact of the disturbance on the ecosystem's carbon budget, we used 10.5 years (2001–2011) of eddy covariance measurements of CO_2 fluxes and the biomass observation for each ecosystem component. After clear-cutting in 2003, the ecosystem abruptly became a large carbon source. The total CO_2 emission during the first 3 years after the disturbance (2003–2005) was 12.2 ± (0.9–1.5; possible min–max range of the error) Mg C ha^{-1}, yet gradually decreased to 2.5 ± (1–2) Mg C ha^{-1} during the next 4 years. By 2010, the ecosystem had regained its status as a carbon sink (NEE = –0.49 ± 0.5 Mg C ha^{-1} yr^{-1}). Total gross primary production, ecosystem respiration, and NEE during the 7 years after the disturbance (2003–2009) were 64.5 ± (2.6–7), 79.2 ± (2.6–7), and 14.7 ± (1.3–3.5) Mg C ha^{-1}, respectively. From 2003 to 2009, the understory *Sasa* biomass increased by 16.3 ± (4.8) Mg C ha^{-1}, whereas the newly planted larch only gained 0.92 ± (0.32) Mg C ha^{-1}. Ecosystem carbon budget evaluation suggested that the litter including harvest residues became a large carbon emitter (~31.9 Mg C ha^{-1}) during the same period. Based on the cumulative NEE during the period when the forest was a net carbon source, we estimate that the ecosystem will require another 8 to 34 years to fully recover all of the CO_2 that was emitted after the disturbance, if off-site carbon storage in forest products is not considered.

[3-3]

CARBON BALANCE OF A FOREST IN NORTHERN JAPAN AFTER TYPHOON DISTURBANCE

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Soil respiration (*R*s) is the second largest carbon flux in terrestrial ecosystem, and involved remarkably to the global carbon balance. Global *R*s was estimated to be 98 Gt C yr^{-1}, and said to have been increasing 0.1 Gt C yr^{-1} (Bond-Lamberty and Thomson, 2010). To understand and predict the global carbon balance in the future, it is vital to know factors that influence *R*s.

Natural disturbance is one of the important factors changing the carbon balance. In particular, typhoon disturbances occur frequently in East Asian region under the influence of Asian monsoon. In the case of forests, if the canopy structure was totally destroyed, the carbon balance of the disturbed forest (which means NEP, GPP and RE) will be changed dramatically. The IPCC 4th report implied the occurrence of stronger typhoon in the near future because of climate change. Therefore, detailed analysis of the influence of typhoon disturbance on *R*s and whole carbon balance in the disturbed region is an important topic. However, observed data in typhoon disturbed ecosystem is very limited.

In 2004 September, typhoon Songda attacked Northern region of Japan, Hokkaido. Due to the attack, most of larch trees (45-years old) fell down in Tomakomai flux site. In 2001, multi-channel automated chamber system was installed on this site, and data collection started. After the disturbance, we restarted the continuous measurement to investigate the influence of typhoon disturbance on the carbon balance of this flux site.

The measurement period of 2013 was from 25th April to 25th November. The average value of *R*s and heterotrophic respiration (*R*h) were 2.43 μmol CO_2 m^{-2} s^{-1} and 2.42 μmol CO_2 m^{-2} s^{-1}, respectively (fig 1). The low contribution of root respiration to *R*s was thought to be caused by the low density of living root due to typhoon disturbance. *R*s was estimated to be 5.4 tC ha^{-1} during the measurement period. On the other hand, net ecosystem CO_2 exchange (NEE, measured with larger chamber which include vegetation inside) was 0.38 μmol CO_2 m^{-2} s^{-1}, and this flux site was estimated to be 0.86 tC ha^{-1} of carbon source during the measurement period. It means that even though vegetation recovery was on the process, this flux site did not function as stable carbon sink yet.

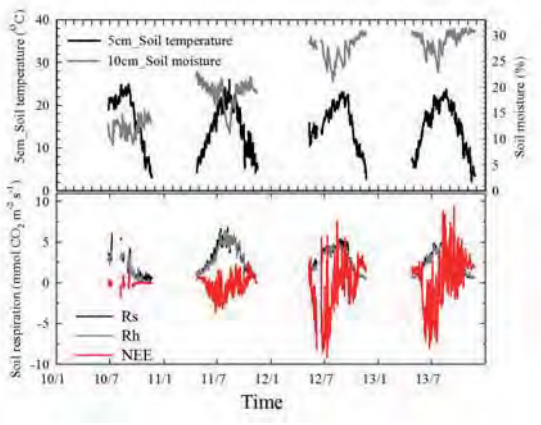

Fig. 1 Seasonal changes in soil temperature and soil moisture (upper), and soil respiration rates and NEE (net ecosystem exchange) in a Tomakomai flux site from 2010 through 2013.

Bond-Lamberty B, Thomson A. 2010. Temperature-associated increases in the global soil respiration record. Nature 464(7288):579-U132.

IPCC2007. 2007. Climate Change: The Physical Science Basis. Cambridge Univ Press.

[3-4]

THE IMPACTS OF DISTURBANCE ON TERRESTRIAL CARBON BUDGET OF HOKKAIDO, JAPAN

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We evaluated spatial and temporal variations in carbon balance of forest ecosystems using a process-based ecosystem model taking a forest age map into account. Carbon balances in forest ecosystems change by disturbances and recovery-processes, because forest ecosystem structure and functions are abruptly changed. Forests whose age are less than 60 years old occupy more than 70% in Japan because forest stands were directly replaced by disturbances such as thinning, harvest, plantation, fire, typhoon and insects. However, few studies have attempted to quantify how much disturbances affect spatial and temporal variations in carbon balances. In this study, we focus on how disturbance and following regrowth affect spatial and temporal variations in carbon balance.

We used Vegetation Integrative SImulator for Trace Gases (VISIT) model in order to simulate carbon balance in Hokkaido, which is northern island of Japan. Simulations of the carbon balance were conducted for the period 1948–2010 following 1000 years of spinning-up at a spatial resolution of 1km × 1km. We conducted two cases of simulations concerning the carbon balance: one taking account of spatial distribution of disturbance-induced forest age derived from forest inventory data and another ignoring the disturbance impact (i.e., no disturbance, even-aged case).

Firstly, we focus on the difference of spatial distribution of net ecosystem production (NEP) in 2000s between disturbance and non-disturbance cases.

In the case of non-disturbance, NEP was gradually and spatially changed ranging from 0 to 1 t C/ha/y depending on meteorological conditions such as temperature or solar radiation. On the other hand, in the case of disturbance, large NEP ranging from 3 to 5 t C/ha/y were distributed patchwise like hotspots, because forest age of these spots ranging from 20 to 100 years old and then younger than those of the non-disturbance case. In the 1970s, wood harvest and tree planting were intensively conducted in Hokkaido. In the disturbance case during this period, there were many hotspots which show negative NEP.

Next, we focused on the difference in temporal variations of spatially averaged NEP in Hokkaido between the disturbance and non-disturbance cases. Until 1970, the difference of average NEP between the two cases was less than 0.01 t C/ha/y. After 1970, the difference became large and reached about 0.5 t C/ha/y. It means that regional NEP of the disturbance case increased 2-5 times of the non-disturbance case.

Our results showed the importance of considering forest age when simulating carbon balance. Carbon balance maps taking forest age into account are useful for carbon managements and prediction of ecosystem feedbacks to climate change.

[3-5]

RESPONSE OF SOIL CO_2 FLUX TO RAIN EVENTS

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The rain event during a drought can have a large impact on soil carbon dynamic of an ecosystem. Earlier studies have shown that soil microbes can start utilizing carbon substrate immediately when environmental conditions become favorable, such as when it rains. This is so-called Birch Effect. So often in the literature we see reports which show an enhancement of soil CO_2 respiration (total CO_2 produced inside the soil profile) after rain events, especially for studies from ecosystems when the soil surface is dry. The same cannot be said for soil CO_2 flux (CO_2 transport across the soil surface). Based on our soil CO_2 flux studies over a California oak-grass savanna ecosystem and a crop (corn/soybean) field at Mead Nebraska, we found that the response of soil CO_2 flux to rain events depended on soil texture and the amount of plant residues on the soil surface. For the California oak-grass savanna ecosystem where the soil was silt loam (30% sand, 57% silt, and 13% clay), rain events during summer drought always stimulated large pulses in soil CO_2 flux. Peak flux pulses were on the order of 60–80 times pre-rain values. For the crop field at Mead Nebraska where the soil was silt clay (10% sand, 50% silt and 40% clay), the response of soil CO_2 flux to rain pulse seems not as strong as the California oak-grass savanna, however. Measurements of soil CO_2 flux with a 16-chamber multiplexer at Mead crop field revealed that for a location where there was no plant residue on the soil surface, soil CO_2 flux could be decreased after rain events because liquid water reduced the soil conductance for gas transport. While for a location where there was a large amount of residue, soil CO_2 flux was always enhanced after rain events. Our study demonstrates that although the rain pulse during dry season can stimulated soil respiration, the soil CO_2 flux could be either enhanced or suppressed depending on the soil text and plant residues accumulated at the soil surface. From our data, one can see that it is imperative to have continuous measurement of soil CO_2 flux in order to understand the total soil respiration of an ecosystem. Neglecting the pulse effect as stimulated by rain events in modeling study, one would definitely underestimate the soil respiration, especially for arid and semiarid ecosystems.

[3-6]

AN EXTREME FIRE EVENT: HAZE AND GREENHOUSE GAS EMISSIONS FROM SUMATRA, INDONESIA, DURING 2013 A NON El NIÑO YEAR

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Previously, trans-boundary haze in Southeast Asia has always been associated with forest fires triggered by protracted droughts induced by El Niño conditions. Here, we show that the region's worst haze event to date occurred in 2013: a "wet" non El Niño year. Singapore's Pollutants Standards Index reached a record high (three consecutive days > 236; rated "very unhealthy") in June 2013. Using satellite and aerial imagery, rainfall records and greenhouse gas (GHG) emission factors, we determine that the fires that caused the 2013 haze event were limited to a localized area in Central Sumatra (1.6% of Indonesia) and follow a short drought (≤ 2 months) in an otherwise rainy year. The fires burned an estimated 163,336 ha, including 137,044 ha on peat. They were short-lived (one week of burning), and largely confined to deforested lands (82%; 133,216 ha). The GHG emissions from this brief localised event were considerable (171 ± 59.13 Tg CO_2-eq), representing 5-10% of Indonesia's mean annual GHG emissions for 2000-2005. While the 2013 event appear anomalous, we conclude that major haze events will recur during non El-Niño years due to ongoing peat land development.

[4-1]

COMPARISON OF MODEL SIMULATION RESULTS AT DIFFERENT DECIDUOUS BROAD-LEAVED FORESTS

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Terrestrial ecosystem models are widely used to simulate biogeochemical cycles and atmosphere-ecosystem exchange of trace gases. These models allow us to integrate observational data and to conduct extrapolation in both spatial and temporal dimensions. Nevertheless, there remain large uncertainties in the present modeling studies, because of insufficiencies in model-constraining data and our understanding on key processes and parameters.

In continental-scale simulations, model parameters (e.g., albedo, threshold thermal requirement, productive capacity, metabolic activity, mean lifetime) are often determined on the basis of biome or plant functional types (lookup-table approach). In other words, terrestrial ecosystems at different locations are assumed to have mostly same ecophysiological and biogeochemical properties if they have same biome type. Such assumption is practical, because it is difficult to directly measure ecosystem parameters at broad scales, but probably resulting in estimation errors by neglecting site specificity. Therefore, in this study, I applied a terrestrial ecosystem model to different locations with same biome type (dominant plant functional types), and made comparison to clarify key parameter and processes determining the intra-biome variability.

A terrestrial ecosystem model, VISIT (Vegetation Integrative SImulator for Trace gases), was used in this study. The model consists of water, carbon, and nitrogen cycling schemes and is applicable to point to continental scales. Different biomes are characterized by parameters such as leaf morphology and longevity, photosynthetic capacity, environmental responsiveness, photosynthate partitioning, and respiratory activity. A simulation is driven by meteorological data of radiation, temperature, humidity, precipitation, and wind.

The model was applied to 12 deciduous broad-leaved forests in different regions: 4 in Europe, 4 in North America, and 4 in Asia. In latitude, these sites span from 36 to 55 degree-north, and in altitude, from 40 m to 1560 m above sea level. First, at each site, the model was driven using the same generic parameter set (preliminarily calibrated at a cool-temperate deciduous broad-leaved forest in Asia) and compared each other and with flux measurement data. This comparison shows the potential width of intra-biome variability. It was examined whether a single representative parameter set is generally applicable to different sites and how much biases could be introduced by using the parameter set. Second, at each site, the model parameters were calibrated (or optimized, if possible) on the basis of flux measurement data. This clarifies which parameter and processes are critical to characterize atmosphere-ecosystem exchange of the biome type (deciduous broad-leaved forest) at different locations. Based on these results, I discuss what kind of modeling and observational studies are required to reduce estimation uncertainties.

[4-2]

SIMULATION OF ENERGY FLUXES AND NEE OVER RICE PADDY FIELD USING CLM4CN WITH PROGNOSTIC CROP

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Rice paddy fields are widespread in monsoon Asia. Like other agricultural crop, ecological conditions in the rice paddy fields are basically controlled by human activity. CLM4CN employs prognostic crop phenology which sets several parameters related to human activity such as planting date and harvest. Current prognostic crops in the model are corn, spring and winter temperate cereals and soybean. In order to simulate NEE over rice paddy field, we set several parameters used in prognostic crop for rice and modified the crop phenology. Major changes are as follows. In prognostic crop phenology, leaf area index (LAI) remains constant during growing season and becomes zero after harvest. Harvest is performed for one time step (30 min). However, observed LAI of rice decreases after flowering. To consider it, instead of harvest date we set flowering date after which LAI decreases to zero for 45 days. We set planting dates and maximum LAI for rice at study site in Korea. In original prognostic crop, there is no nitrogen limitation, which results in too much production of biomass leading to large respiration right after harvest. We considered nitrogen limitation for rice. In order to get the initial soil carbon pool, we run the model with no nitrogen limitation for 600 years. Model results have been compared with flux observations over the rice paddy field in Korea. The study site (35°.49 ´ N, 128° 27 ´ E) is located near Nakdong river in southeast of Korean peninsula. Flux measurements were made using the eddy covariance technique. Model captures seasonal variation of energy fluxes and NEE. Some overestimations of energy fluxes are noted depending on season. Comparison of mean diurnal variation of NEE between model and observation during growing season showss that the magnitude of nighttime respiration is well simulated but carbon uptake is slightly overestimated during daytime. Other issues related to simulation of energy fluxes and NEE over rice paddy field have been discussed.

Key words: CLM4CN, Eddy covariance fluxes, rice paddy field, prognostic crop

[4-3]

SPATIAL VARIATION IN GLOBAL SCALE ESTIMATES OF CARBON-USE EFFICIENCY: ECOSYSTEM MODEL, REMOTE SENSING, AND EMPIRICAL UPSCALING

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Carbon use efficiency (CUE), defined as the ratio of net primary production (NPP) and gross primary production (GPP), represents the ability of plants to acquire carbon from the atmosphere for biomass production. Not only indicating an efficiency of for biomass production, the CUE is also a useful index for extracting information about plant respiration (as 1−CUE is the ratio of plant respiration to GPP). The CUE was considered uniform across forest types when the concept was first introduced to the research community, but this notion was revised as a meta-analysis identified a large variation of the CUE across forest types from 0.2 to 0.8. Until today, potential global distributions of the CUE have been estimated with various methodologies such as ecosystem modelling, remote sensing, and empirical upscaling. Although many studies addressed result such that estimated global CUE was close to the universal value of 0.5, spatial variability pattern of the CUE were not rigorously discussed or compared. In this study, we evaluated spatial variability patterns of mean annual global CUE from 2000 to 2010 estimated by 7 ecosystem models, the MODIS-based products (MOD17), and an empirical upscaling method. In conjunction with mean annual global GPP, and NPP, we discuss how global distributions of the CUE varies among estimates of different methodologies and addresses potential causes for variations.

[4-4]

MULTIDISCIPLINARY IN SITU AND SATELLITE OBSERVATIONS FOR ACCURATE MONITORING TERRESTRIAL ECOSYSTEM STRUCTURE AND FUNCTIONING: KNOWLEDGE GAINED FROM PHENOLOGICAL EYES NETWORK (PEN)

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To accurately evaluate the spatio-temporal variability of ecosystem structure (e.g., foliage density and leaf area) and functioning (e.g., photosynthesis and evapotranspiration) due to meteorological and anthropogenic environmental changes, general, global, long-term, and comprehensive phenological observations are required. Towards this aim, accurate integration of *in situ* and satellite observations is very important but challenging task. However, from the *in situ* ecological research viewpoint, this integrated approach has not been sufficiently tested and validated by the ground-truthing. We have conducted the Phenological Eyes Network ("PEN": http://www.pheno-eye.org), which consists of digital camera, spectro-radiometer, and sun photometer, in various ecosystems (e.g., boreal, temperate, tropical rain forests and rice paddy) since 2003. For instance, we found (1) the seasonal patterns of digital numbers of red, green, and blue extracted from daily canopy surface images can detect the different characteristics of phenology (e.g., flowering, leaf-expansion, -colouring, and -fall) among tree species and ecosystems and those of forest structure [Nagai et al. 2011, Plant Ecol Diver; 2013 Polar Sci]. (2) The seasonal patterns of camera-based and spectro-radiometer-observed vegetation indices correlate with those of potential photosynthetic activity (gross primarily productivity on sunny days) in deciduous broad-leaved and evergreen coniferous forests [Nagai et al. 2012, Int J Remote Sens; Saitoh et al. 2013, Ecol Infor]. (3) The effect of spatial heterogeneity on the timing and patterns of leaf-fall on vegetation indices in a high biodiversity deciduous broad-leaved forest can be reduced by observing only the seasonal variation in colour on the canopy surface by using Green-Red Vegetation Index (GRVI), which consists of visible green and red reflectance bands, rather than that of both leaf area and colour of the canopy surface by using Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI), which consist of visible red and blue and near-infrared reflectance bands [Nagai et al. 2014, Int J Remote Sens]. Our long-term continuous observations and scientific efforts suggest that further sensor collaborations (e.g., PEN and AsiaFlux) are required to develop the ecosystem monitoring by integrating *in situ* and satellite observations from plot to global scales.

[5-1]

LAND USE CHANGES, ENERGY FLUXES AND SURFACE CLIMATE

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Urbanization and deforestation, two most important forms of land use changes, have been occurring rapidly in recent decades and will continue into the foreseeable future. These changes alter the flows of energy, water and momentum in the soil-vegetation-atmosphere continuum. One consequence is changes in the surface temperature, in magnitudes comparable or even larger than those caused by the anthropogenic greenhouse effect. However, these land use changes occur at local scales that are often too small to be resolvable by typical climate models. To improve our predictive understanding of the land use impacts on the surface climate, in this paper I present an analytical framework for partitioning the surface temperature changes into signals associated with various biophysical factors, including surface albedo, surface roughness, Bowen ratio, and heat storage. Results are validated against FLUXNET data, MODIS satellite observations and subgrid-scale calculations of a climate model. In the case of deforestation, the resulting surface temperature change is dependent on latitude, with cooling in the boreal zone and warming in the tropical zone. However, a latitudinal asymmetry exists such that the boreal cooling is greater in magnitude than the tropical warming. In the case of urbanization, the surface temperature change, also known as the urban heat island (UHI), is strongly dependent on local precipitation. Contrary to the conventional belief that evaporation reduction is the major contributor to UHI, the partitioning results reveal that it is changes in the convection efficiency between urban and nonurban land that drive spatial variations in the UHI intensity across cities in North America.

[5-2]

THE CHARACTERISTIC AND THE IMPLICATION OF ECOSYSTEM LEVEL WATER USE EFFICIENCY AT HETEROGENEOUS FARMLAND IN SOUTH KOREA

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For many years, researches related to water use efficiency are actively conducted and published which cover leaf to ecosystem scale for different types of climate and vegetation. Method to calculate water use efficiency also developed to capture vegetation response toward the environmental change. However, what should be learned from this continuous effort is how this can be applied to give some contribution to solve the real world water problem. In order to do so, this paper is trying to describe the ecological system of water use by documenting the relationship between ecosystem water and carbon cycles with the focus on agricultural ecosystem.

Agriculture is the major user of water, accounting for about 70% of the world's freshwater withdrawals (OECD 2010). Due to climate change, greater attention in agriculture to water saving while maintaining its productivity is aroused. Inherent Water use efficiency (W_{ei}) can be utilized as a tool to analyze the relationship between ecosystem water and carbon cycles using direct measurement of carbon and water exchange. In this study, multiyear flux tower measurement data are utilized to quantify W_{ei} in the Koflux heterogeneous farmland (HFK). W_{ei} is quantified to observe its change in response to changes in ecosystem-level photosynthesis and evapotranspiration in a typical farmland ecosystem in South Korea. The objectives of this research are understanding the changes in W_{ei}, recognizing its complexity and resilience, and filling up information deficiencies of water use to better guide agricultural water resource management in South Korea.

W_{ei} as a proxy of intrinsic water use efficiency at ecosystem level is formulated as: $W_{ei} = \frac{GPP}{ET}.VPD.$ Vapor pressure deficit (VPD) is included in calculation to account for the effects of atmospheric evaporative demand (Keenan et al. 2013). Data from rainy day and two days following rain events were excluded and VPD was averaged from daytime only. The result of annual means of GPP, ET, VPD and W_{ei} at HFK in dry condition for 8 years are 568 ± 88 g C m^{-2} y^{-1}, 307 ± 32 kg H2O m^{-2} y^{-1}, 2 ± 0.3 g C kg $H2O^{-1}$, 6.8 hPa and 16.4 ± 3.6 g C kg $H2O^{-1}$ hPa, respectively. Seasonal W_{ei} is highest in summer season (22.7 ± 2.9 g C kg $H2O^{-1}$ hPa). There were two distinctive period of W_{ei}, the first period is years with high annual W_{ei} and GPP and low-high ET and VPD, and the second is years with low W_{ei} and GPP and low-high ET and VPD which shows decreasing pattern in GPP and W_{ei}. The two distinctive patterns could be resulted from land surface representation, productivities and environmental condition. HFK W_{ei} also shows lower magnitude than those of cropland and forest sites, suggesting that Haenam agricultural ecosystem is inefficient in using water resource.

[5-3]

SEASONAL AND SPATIAL VARIATIONS OF WATER USE EFFICIENCY OF RICE (*Oryza Sativa*): FROM THE LEAF TO THE ECOSYSTEM

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Rice (Oryza Sativa), the second largest cereal crop in the world, plays an important role in global water cycling process due to its high water demand and evapotranspiration. As climate change scenarios predict altered precipitation patterns with the likelihood of more frequent and severe droughts, there are intense research efforts to better understand and predict carbon and water fluxes, crop productivity and water use efficiency of rice under extreme climate conditions. We studied the process of carbon and water coupling at leaf, canopy and ecosystem scale by comparing different growth stages of rice (seedling, active tillering, panicle initiation and maturity) under two water availability (rainfed and flooded) and three nitrogen application (180, 115 and 50 Kg/ha). We tested i) the role of environmental changes on the carbon and water cycling process of rice at leaf, canopy and ecosystem and different time scales (hourly, daily and season) ii) the role of nutrient and water availability on crop water use efficiency at different spatial scale iii) the relationship between different water use efficiency calculations namely: intrinsic water use efficiency (WUE_i = *A/gs*), transpiration efficiency (*TE=A/E*), ecosystem water use efficiency (WUE_e = *GPP/ET*), inherent ecosystem water use efficiency ($_iWUE_e$= *GPP.VPD/ET*) iv) the advent of "precision agriculture technology" by the use of unmanned aerial vehicle (UAV) equipped with remote sensors which will help facilitate the crop water management of irrigation scheduling.

The preliminary results show that carbon and water fluxes of both flooded and rainfed rice and environmental variables were well correlated at hourly time scale with PAR ($P \leq 0.001$), VPD ($P \leq 0.05$) and Tair ($P \leq 0.05$). Ecosystem respiration plays an important role in seasonal variation of carbon fluxes. That of rainfed rice was mainly governed by soil moisture changes, leaf area development and available nitrogen while that of paddy rice was governed by leaf area development. Higher N application (115 and 180 Kg/ha) did not significantly effect on carbon and water fluxes but affected significantly on biomass development and water use efficiencies. Preliminary results show that canopy development and crop growth could be monitored efficiently by UAV remote sensing.

[5-4]

SEASONAL VARIATION IN NET CARBON DIOXIDE EXCHANGE IN RICE FIELDS OF NORTHERN INDIA

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Based on the eddy covariance flux measurement in rice fields of northern India, net ecosystem exchange of carbon dioxide (NEE) was estimated in the kharif season (rainy season) of 2013. The daily NEE showed a seasonal variation and the carbon dioxide (CO_2) flux fluctuated with in ±0.05 g C m^{-2} d^{-1} during the early vegetative stage. Thereafter there was net consumption of CO_2 from late July until end of September. It was observed to be maximum with an uptake rate of -6.54 g C m^{-2} d^{-1} during booting reproductive stage. The rice fields acted as a CO_2 source during early October when daily NEE turned positive around maturity stage, a few days before rice harvest because of declining photosynthetic activity and enhanced ecosystem respiration from almost dried soil. The mean and cumulative NEE over the rice growth period was -2.97 and -316.6 g C m^{-2} d^{-1} respectively. The daily ecosystem respiration (Re) varied from 0.62 to 7.30 g C m^{-2} d^{-1} depending upon the crop growth stage. The mean Re and gross primary productivity (GPP) over the growing period was 4.00 and 7.23 g C m^{-2} d^{-1} respectively. Further investigations are needed to clarify seasonal and inter-annual variations in NEE in rice based cropping systems.

[5-5]

MESOPHYLL DIFFUSION CONDUCTANCE AND GROWTH AGE DEPENDENT PHOTOSYNTHESIS: STUDY FROM PADDY RICE UNDER DIFFERENT NUTRIENT AVAILABILITY

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Develop process-based photosynthesis models thereafter understand effects of leaf nitrogen and CO_2 diffusion conductance on photosynthetic performance over growth season were evaluated in paddy rice grown under high, intermediate and control nitrogen supplies (180, 115 and 0 kg N/ha). Leaf nitrogen per mass (N_m) and photosynthetic capacity (A_{max}) decreased gradually with growth age. Higher values were perceived by plants of ample nitrogen groups at tillering stage but not milk-filling stage. Enhanced total leaf area by fertilization after tillering stage mainly rested on leaf number per bundle less on leaf area per mass, and related to leaf *N*-facilitated photosynthesis occurring initially due to higher electron transport capacity and mesophyll conductance (g_m). Temperature coefficient of g_m (Q_{10}) occurring at saturating irradiance and current atmosphere conditions were lower in tillering plants compare to milk-filling plants. Absolute g_m and Q_{10} negatively related to increasing CO_2 concentration. Limitations of photosynthesis by g_m (l_{gm}) and stomatal conductance g_{sc} (l_{gsc}) were more severe at milk-filling stage. Irrespective of nutrient supply and growth age, l_{gm} responding to temperature was steeper but lower than l_{gsc}. Stomatal coefficients (g_{fac}) of leaves of upper canopy were analogous among groups over growth season. Model simulations indicated that traditional A/C_i curve and conversion from A/C_i to A/C_c with constant g_m can not always well predict photosynthesis. Include g_m and environmental responses to modelling and the developed algorithm to estimate g_m occurring under saturating irradiance were discussed.

[5-6]

APPLICATION OF TERRESTRIAL ECOSYSTEM MODEL VISIT TO PADDY FIELDS FOR PLANNING BETTER MITIGATION

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Terrestrial carbon-nitrogen cycle model VISIT (Vegetation Integrative SImulator for Trace gases) aims at evaluating the budget of greenhouse gases (CO_2, CH_4, N_2O) between the atmosphere and terrestrial and operates at site to global scales. However, the present model has not been fully applied to agricultural ecosystems that were suffering from anthropogenic land-use change and management. CH_4 production by rice crop accounts for 15–20 % of the total emission (IPCC 2013). To evaluate the greenhouse gas budget for a long-term period, it needs to include the effect of land use change.

In this study, a CH_4 production scheme by Walter and Heimann (2000) was introduced to site-scale VISIT model. We aim at validating the model by comparing with observational data at Mase, Japan (36° 03'N, 140° 02'E), which is a paddy field and one of the AsiaFlux sites. The model performance was examined for CO_2 and CH_4 fluxes and also we performed a sensitivity analysis in terms of photosynthetic parameters and management practices (water management, amount and timing of fertilizer input, and so on). On the basis of analyses using the model, we are discussing how to take better mitigation measures against global warming.

[5-7]

INTRODUCING CURRENT PROGRESS IN MIRSA-2 PROJECT

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Rice paddies emit 33-40 Tg CH_4 yr^{-1} and 90% of these emissions come from tropical Asia (IPCC-AR5, 2013). An accurate measurement of the CH_4 emissions, as well as its reporting and verification, is becoming increasingly important to implement carbon trading schemes, such as the Clean Development Mechanism (CDM) and the Bilateral Offset Credit Mechanism (BOCM). One of the most promising mitigation strategies is water management in irrigated rice paddies, especially for Alternate Wetting and Drying (AWD) that developed and promoted by IRRI to Asian countries.

The MIRSA-2, a 5-year international research project since 2013 among Indonesia, Japan, the Philippines, Thailand and Vietnam funded by the Ministry of Agriculture, Forestry and Fisheries of Japan aims to develop improved water management based on AWD that can always reduce soil-derived CO_2-eq emission (CH_4 + N_2O) during rice growing season from irrigated rice paddies in Asian countries by 30% compared to the conventional practice. This project is regarded as a spin-off activity of the Paddy Rice Research Group of the Global Research Alliance on Agricultural Greenhouse Gases. Two research subjects are (1) field demonstration and integrated analysis of AWD effect on reducing GHG emissions and (2) development of the guidelines for implementing Measurement, Reporting and Verification (MRV). This presentation focuses on the latter subject because the former subject is going to be introduced by Dr. Agnes T. Padre in other session of this workshop.

The latter subject consists of (a) writing the MRV guidelines based on latest scientific knowledge and (b) auxiliary social (area) study of rice cultivation at multiple spatial scales in the five countries. The measurement guidelines targeted for a static closed chamber method are now in preparation and the first version will be completed by the end of March 2015. This chamber method has the merit of being easy to compare the effect of experimental factors such as AWD on the CH_4 emissions. However, the method has not always been consolidated among countries due to the limitations of scientific knowledge and instrument. The proposed chapters of the guidelines are as follows:

I. Preface
II. Recommendations
III. Experimental design
IV. Gas sampling
V. Gas concentration analysis
VI. Auxiliary measurements.

Our social study aims to elucidate what are the limiting factors for promoting AWD technique at each spatial scale. Those seem to be divided into social ones (e.g., cost and irrigation rights) and natural ones (e.g., soil type and weather pattern). The detailed progress in the two subjects will be introduced in our presentation.

MIRSA logo mark designed in the motif of AWD water management.

[5-8]

THE MRV (MONITORING, REPORTING, VERIFICATION) SYSTEM OF GREENHOUSE GASEOUS EMISSION IN THE WORLD HIGH-CARBON RESERVOIRS

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l. Background and Objectives

In October, 2013, UNFCCC meeting entitled "Technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the convention" was held to clarify the necessity of greenhouse gas (GHGs) monitoring on the high-carbon reservoirs. In the meeting, it was overviewed that Monitoring, Reporting and Verification (MRV) system in the high-carbon reservoirs are under development even the ecosystems have exceptionally high carbon stocks and emit substantial amounts of CO_2. Taking it into account, we are proposing a new system to understand GHGs emission mechanism from ecosystems with high-carbon reservoirs in the viewpoint of Monitoring, Reporting and Verification (MRV) simultaneously regarding new remote sensing techniques. In this project, we aim to (1) construct climate change research network with international research organizations or facilities which are monitoring GHGs emission in representative area in each high carbon reservoir (permafrost, wetland and coastal area) and (2) integrating the results of ground GHGs monitoring and remote sensing. By conducting A) Ground monitoring, B) Inventory refinement and C) Remote sensing, we integrate and verify each working result.

2. Research methodology and techniques

We have been monitoring GHGs emission in representative field in each high carbon reservoir (permafrost, wetland and coastal area) in association with International Arctic Research Center (USA), International Rice Research Institute (Philippines), Dhaka University and Bangladesh Agricultural University (Bangladesh) (e. g. Arai *et al*. 2014, Inubushi *et al*. 2014. Mano *et al*. 2011, Saito *et al.* 2012).

Currently, we are also going to establish the MRV system in representative field in each high carbon reservoir by installing eddy covariance GHGs monitoring towers in Sundarban mangrove forest, Bangladesh and in a permafrost (Tundra), Alaska. By using the results of GHGs emission by chambers and eddy covariance techniques, and monitoring of environmental factors, we establish the model to estimate GHGs emission.

We also assess the carbon (information of vegetation diversity and/or above ground plant biomass) and water condition in each reservoir with a Japanese new remote sensing satellite called HISUI: Hyperspectral Imager Suite (going to be launched in 2016). Finally, we would integrate and verify the results of ground monitoring and remote sensing.

Since several new remote sensing satellites (e. g. GOSAT-2, GPM, SMAP…) are going to be launched lately, methodologies of integration and cross-verification of results obtained from ground observation and remote sensing techniques should be scientifically discussed.

[6-1]

CARBON AND METHANE FLUXES FROM ALPINE GRASSLAND AND WETLAND ON THE TIBETAN PLATEAU: EFFECT OF CLIMATE WARMING AND WATER TABLE DECREASING

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Climate warming is likely to have a large impact on carbon and methane fluxes in high-altitude ecosystems such as alpine grassland and wetland. This is due to the rapid rise in air temperature and the large amounts of stored soil organic carbon of these systems. During the past decade, we have conducted a series of studies on carbon balance and methane fluxes in alpine grassland and wetland on the Tibetan Plateau, using transect field investigation, eddy covariance technique of CO_2 and CH_4 fluxes measurements. In addition, we have also investigated the effects of climate warming (Infrared heater soil warming experiments) and water table decreasing (Soil monolith mesocosm experiment) on the carbon cycles and methane fluxes in alpine grassland and alpine wetland. In the current contribution, we will synthesize the results from these studies and provide evidence that the productivity of alpine grassland can buffer climate warming by the mechanism of changes in resource allocation and shifts in species composition. Our results suggest that alpine wetlands on the Tibetan plateau are, and will continue to be, a source of greenhouse gas in the future, but will not lead to a positive feedback to climate warming with decreasing of water table.

[6-2]

LONG TERM CO_2 EXCHANGE IN AN ALPINE WETLAND IN THE CENTRAL PART OF THE TIBETAN PLATEAUTITLE

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The Tibetan Plateau, the highest plateau in the world (average 4000m a.s.l.), has a total wetland area of 50,000km^2. These alpine wetlands contain a large amount of soil organic carbon, which is estimated to compose about 0.2% of the global pool of soil carbon. It is suggested that a major climatic factor limiting production of the wetland ecosystem is the low thermo-conditions on the Tibetan Plateau. An increase in temperature may therefore increase the productivity of wetlands on the Plateau. It may also accelerate carbon releasing at the same time.

Therefore, understanding how environmental variables affect the processes of carbon fluxes variations in alpine wetland on the Tibetan Plateau is extremely important. To address this issue, we have measured CO_2 flux over an alpine wetland at Damxung (30°28'N, 91°04'E, 4280m a.s.l.) in the central part of the Tibetan Plateau based on Eddy covariance (EC) technique since May, 2009. Our results showed a strong diurnal, seasonal and annual variation in CO_2 exchange in relation to environmental driving forces. As shown in Table 1, annual NEE from 2009 to 2012 were -149 to -273, -144 to 197, -215 to -220, -158 to -163.00 g C m^{-2}, respectively by different gap-filling methods, indicating this alpine wetland was a stable CO_2 sink. Our data strongly suggested that temperature played a key role in variations of NEE owing to the common significant positive effect on photosynthesis and respiration at all timescales, but Re exhibited more sensitive to temperature than GPP, thus the net CO_2 uptake decreased with increasing temperature. Meanwhile, the diurnal course of PAR had strongly effects on daytime variation in NEE during growing seasons. Seasonal variations of GPP and Re closely followed the changes of AGB. With the context of global warming, the alpine wetland meadow would have more chance to enhance CO_2 emission to atmosphere.

However, as other wetlands on the Plateau, this wetland is winter grazing field and pasture harvesting occurred every two or three years. These human activities play very important rule on the carbon balance at the wetland ecosystem on the Tibetan Plateau and long-term monitoring of the CO_2 flux is extremely important to know the change of the large carbon pool and to have a suggestion for scientifically management of the wetland ecosystems on the Tibetan Plateau.

Table 1 Annual values of NEE, GPP and Re of Damxung wetland from 2009 to 2012
Obtained by different gap-filling methods

Year	NEE (C g/m^2/year)	Re (C g/m^2/year)	GPP (C g/m^2/year)
2009*	-149 ～ -273	520 ～ 787	792 ～ 936
2010	-144 ～ -197	598 ～ 827	794 ～ 971
2011	-215 ～ -220	479 ～ 541	694 ～ 762
2012	-158 ～ -163	522 ～ 632	680 ～ 796

* 2009 data only from May.

[6-3]

GREENHOUSE GAS EMISSIONS FROM A SURFACE FLOW CONSTRUCTED WETLAND IN HONG KONG

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Constructed wetland is becoming increasingly popular as a means to purify wastewater and mitigate wetland habitat loss owing to urban development. However, little is known about the effects of constructed wetlands, especially in the Southeast Asian region, on greenhouse gas emissions and hence global climate change. This study aims to: (1) examine the influence of plant species on greenhouse gas emissions from a surface flow constructed wetland in Hong Kong, and (2) investigate the relationships between environmental parameters and greenhouse gas emissions from this wetland. We used the closed chamber technique to measure CO_2, CH_4 and N_2O emissions over a four-month period from triplicate plots that were covered by (i) *Phragmites australis*, (ii) *Typha angustifolia*, (iii) *Eleocharis acutangular*, and (iv) un-vegetated. We found significantly higher mean CO_2 effluxes from the *P. australis* and *T. angustifolia* plots, while no significant differences in mean CH_4 and N_2O emissions were observed among the four site types. Temperature is the most dominant environmental factor governing the temporal variations of greenhouse gas fluxes. Overall, CO_2 contributes to over 80% of the global warming potential arising from greenhouse gas emissions from this wetland. The results highlight the importance of considering the radiative forcing impacts of greenhouse gas fluxes when selecting plant species in wetland construction projects.

[6-4]

NITROUS OXIDE AND CARBON DIOXIDE EMISSIONS IN OIL PALM PLANTATIONS AS AFFECTED BY SOIL TYPES AND NITROGEN FERTILIZER

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Carbon dioxide (CO_2) and nitrous oxide (N_2O) account for 56% and 7% of the total greenhouse gases (GHGs) emissions, respectively, with different values of global warming potentials. Oil palm production in Indonesia and Malaysia is currently the focus of debates concerning the potential impact to the environment via greenhouse gas emissions. Oil palm plantations have been reported to release large quantities of N_2O into the atmosphere, most likely linked to nitrogen fertilizer use. However, there are still limited studies comparing the type of soil and nitrogen fertilizer, affecting N_2O and CO_2 emissions. This study was aimed to evaluate the effects of soil types and nitrogen fertilizer on N_2O and CO_2 emissions in oil palm plantations.

Field experiments were conducted in oil palm plantation areas from 2010 to 2012. Study sites were located on sandy loam soil in Tunggal, Indonesia and two other sites on sandy soil in Simunjan, and on peat soil in Tatau, Malaysia. Following treatments were established for N_2O and CO_2 flux measurement: no nitrogen fertilizer and no tillage (B), coated fertilizer (M), conventional fertilizer (C), and no fertilizer with tillage only (B2). The rates of application for the coated fertilizer were about half rate of the conventional fertilizers. N_2O and CO_2 fluxes were determined by placing a 20.8 cm diameter and 14.2 cm high PVC pipe chamber to soil depth of 5 cm. Gas samples were taken after it had been sealed for approximately 5 minutes, by connecting a 30 ml gas syringe with tubes to the chamber. Gas samples were collected at 0-, 10-, and 20-minute intervals and were injected into a glass vial that had been evacuated and closed tightly with butyl rubber seals. The filled vials were transported to the laboratory, and the gas fluxes were measured by gas chromatograph. Undisturbed soil core and composite soil samples were collected at 0 –10 cm depth from each site study, and physicochemical properties of soil were analyzed in laboratory.

Results of this study showed that cumulative N_2O fluxes ranged from 0.59 to 4.09, 0.11 to 0.42, and 11.1 to 42.7 kg N ha^{-1} $period^{-1}$, in Tunggal sandy loam soil, Simujan sandy soil, and Tatau peat soil, respectively. Cumulative CO_2 fluxes ranged from 5302 to 7971, 7638 to 11431, and 8797 to 16949 kg C ha^{-1} $period^{-1}$, in Tunggal sandy loam soil, Simunjan sandy soil, and Tatau peat soil, respectively. The effect of soil types on N_2O and CO_2 fluxes in the studied tropical oil palm plantation were highly significant, but no consistent tendency was observed across nitrogen fertilizer. Applications of fertilizer have to consider with suitability of soil type to mitigate the gas emission to the atmosphere.

[6-5]

COMPARISON BETWEEN CHAMBER AND EDDY COVARIANCE TECHNIQUES FOR MEASURING CO_2 FLUXES FROM RICE-BARLEY DOUBLE CROPPING PADDY FIELD

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The carbon dioxide (CO_2) fluxes from rice-barley double cropping paddy field at the Gimje site in the southwestern coast of Korea were measured during the 2012-2013 growing season using a chamber system with the automatic open/close chamber (AOCC) and an open system with the eddy covariance (EC) technique. The aims were to compare the CO_2 fluxes obtained from both techniques, assess the uncertainties in the fluxes, and evaluate the carbon budget during the rice and winter barley growing season. The daily total CO_2 fluxes for winter barley ranged from -11.7 to 5.7 g C m^{-2} d^{-1} by AOCC, and from -9.6 to 4.6 g C m^{-2} d^{-1} by EC, respectively. During the rice growing season, they varied between -10.1 and 6.6 g C m^{-2} d^{-1} by AOCC, and between -10.1 and 3.5 g C m^{-2} d^{-1} by EC, respectively. The cumulative net ecosystem exchange (NEE) of CO_2 during the winter barley season was estimated at -195.7 g C m^{-2} d^{-1} by AOCC and -100.6 g C m^{-2} d^{-1} by EC, while NEE was estimated at -332.5 g C m^{-2} d^{-1} by AOCC and -351.1 g C m^{-2} d^{-1} by EC during the rice season. So, AOCC technique was evaluated to measure more CO_2 uptake than EC by 49% during the winter barley season, but less than the EC by 6% during the rice season. The difference in the based on the two measurement techniques may vary greatly with changing environmental conditions and management practices. Further comparisons are still needed to elucidate this issue.

[6-6]

SIMULATED NITROGEN DEPOSITION REDUCES CH_4 UPTAKE AND INCREASES N_2O EMISSION BY CHANGING THE AMMONIA-OXIDIZER IN SUBTROPICAL FOREST OF SOUTHERN CHINA

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To date, the underlying microbial mechanisms of how nitrogen (N) deposition alters methane (CH_4) uptake and nitrous oxide (N_2O) emission are largely unknown. In this study, we examine the effects of two contrasting N irons (ammonium and nitrate) and three N levels (0, 40 and 120 kg N ha^{-1} yr^{-1}) on soil CH_4 and N_2O fluxes, and the abundance and community structure of ammonia oxidizing archaea (AOA) and bacteria (AOB) based on a field N addition trial in subtropical plantation forest. Our goal was to examine how *amoA* genes mediating CH_4 uptake and N_2O emission in soil ammonia-oxidizer have responded to N deposition using the combined approaches of quantitative PCR, terminal-restriction fragment length polymorphism (T-RFLP). N addition tended to inhibit soil CH_4 uptake, but significantly promoted soil N_2O emission. Furthermore, ammonium-N fertilizer application had a stronger inhibition to soil CH_4 uptake and a stronger promotion to soil N_2O emission than nitrate-N application. NH_4Cl rather than $NaNO_3$ additions significantly increase AOA abundance and decrease AOB abundance. AOB was not amplified in the plantation forest soil. The T-RFLP analysis of AOA shows that low level N addition significantly decreases the relative abundance of 329bp. Regression analysis suggest that N addition reduce CH_4 uptake and increase N_2O emission by increasing AOA abundance and decreasing AOB abundance. Soil CH_4 uptake was related to (terminal restriction fragments) AOA T-RFs of 370bp, while N_2O emission was related to AOA T-RFs 421bp and 443bp.

Keyword: Atmospheric N deposition; Soil CH_4 uptake; Soil N_2O emission; Ammonia-oxidizer; Soil pH

[6-7]

NEW APPROACH TO SELECT A NIGHTTIME CORRECTION METHOD FOR EDDY COVARIANCE FLUX DATA BASED ON INFORMATION CLOSURE

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Nighttime correction for eddy covariance flux data is still an important issue for quantifying an accurate carbon budget because 1) there is no standardized method which can be applied to any site, 2) the result highly depends on the selected correction method (especially hilly and complex terrain site), and 3) the flux partitioning (i.e., net ecosystem exchange (NEE) into gross primary production (GPP) and ecosystem respiration (RE)) is also determined by nighttime correction. Without any additional independent measurement, it is difficult to judge which method is appropriate for the site. In this study, we propose the methodology based on information theoretic statistics for validating the results of nighttime correction under the two hypotheses: 1) the method which obtains more information budget closure of mass conservation equation (i.e., corrected NEE = Storage term + Eddy flux + Advective flux), and 2) the method which makes the NEE consume more information (i.e., the NEE becomes a stronger information consumer) based on MaxEnt principle. Details will be reported at the workshop.

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Poster Session

[PSP-1]

EFFECT OF SEEDBED SOLARIZATION ON PLANT GROWTH AND YIELD

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An experiment was carried out at RDRS Farm in Rangpur, Bangladesh during the 2010 transplanted aman rice season to determine the impact of seedbed solarization on plant growth and yield of rice varieties, BR11 and BRRI dhan33. Soil solarization is a method for controlling soil borne pest and diseases, which involves in-situ solar pasteurization of soil using transparent polythene sheet and solar heat. Solarization as a pre-treatment for pest and disease-free healthy crops was originally described by Katan et al. (1976). It is an alternative and inexpensive technique as compared to chemical soil disinfection methods. It is an eco-friendly management option to control soil borne pathogens and pests, since no pesticides are required. Soil solarization also has been found to suppress weeds, insect pests, to release some plant nutrients and to have a sustained effect of up to 2 years (Katan 1981; Horiuchi 1984; Elmore, 1991; Gerson et al., 1991; S.P. Banu, personal communication). Solarization was achieved by covering the seedbeds with transparent polythene sheet for four weeks prior to sowing. Seedlings of both varieties were raised on solarized and non-solarized seedbeds and later transplanted into the main field for comparison of growth and yield. Emergence, seedling height and weight, root length and weight were higher with seedlings raised on solarized seedbeds compared to seedlings from non-solarized seedbeds. Also root knot nematode galls decreased significantly on seedlings from solarized seedbeds compared to those from non-solarized seedbeds for both the varieties tested. The increase in height and weight of solarized seedlings enabled easy access for uprooting and transplanting seedlings in the main field within the recommended 20-25 days after sowing. When transplanted in untreated main fields, plants grown from the solarized seedlings of both the rice varieties had significantly less infestation of stem borer as compared to non-solarized plants. Grain yields obtained from solarized seedlings were 7% higher for BR11 and 9% higher for BRRI dhan33 relative to normal seedlings.

In Bangladesh, transplanted rice is a common practice under irrigated and lowland conditions. Although the recommendation for short duration rice varieties is to transplant young seedlings of 20-25 days in age, farmers face problems in uprooting rice seedlings of short duration varieties within the recommended time due to their small size. To overcome the difficulty of uprooting small seedlings especially for short duration rice varieties (where the recommended age for transplanting is 20-25 days), farmers can adopt the solarization technology to obtain healthy and larger seedlings within the recommended period. Rice seedlings produced from solarized nurseries also have the potential to increase rice yields compared to using normal seedlings. Previous studies on solarization, (Baksh et al., 2004; Banu et al., 2005; Culman et al., 2006) indicate that rice seedlings from solarized seedbeds are larger and taller than normal seedlings of the same age. Thus farmers will be encouraged and feel comfort in uprooting seedlings of the recommended age from solarized seedbeds, because of adequate height, weight and vigour of the seedlings. The level of pesticides Bangladeshi farmers uses year after year to increase rice production and to control diseases and insects is quite high. The production cost is increasing although production is not increasing according the farmers' expectations. The solarization technology has scope to reduce chemical pesticides and input costs.

[P1-1]

CHARACTERISTICS OF BVOC EMISSION UNDER DROUGHT CONDITION IN THE TEMPERATE FOREST

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Isoprene (2-methyl-1,3-butadiene, C_5H_8) is the most common biogenic volatile organic compound (BVOC) emitted from vegetation worldwide: emissions are estimated to be >500 Tg per year (Guenther et al., 2006). Woody plants—mainly deciduous broadleaf trees—emit 75% of this quantity (Schnitzler et al., 2010). Isoprene has significant impacts on atmospheric chemistry, including the formation of tropospheric ozone and secondary aerosols, levels of carbon monoxide and hydroxyl radicals, and the half-life of methane (Trainer et al., 1987; Chameides et al., 1988; Jacob and Wofsy, 1988; Novakov and Penner, 1993). For this reason, models that predict the emissions of isoprene from woody plants need to be improved.

The emission of isoprene from trees is regulated mainly by light and leaf temperature. For this reason, the most common model is the simple G93 algorithm proposed by Guenther et al. (1993), which uses light and leaf temperature as inputs. As light is an essential control factor, nighttime emission in the model is 0. However, there are reports of non-negligible nocturnal emissions of isoprene by pine (*Pinus sylvestris*; Shao, 2002) and deciduous oak (*Quercus serrata*; Miyama et al., 2013). Isoprene synthesis had earlier been believed to use only newly fixed carbon, but ^{13}C labeling has shown that plants also use stored unlabeled (^{12}C) carbon under conditions of low photosynthesis (Brilli et al., 2007). Thus, if plants can use alternative sources for isoprene synthesis and the pool size is large enough, it is necessary to reevaluate the capacity for nighttime isoprene emissions by plants. Here, we measured nocturnal rates of isoprene emission from three deciduous *Quercus* species in the field.

Measurements were collected in an experimental field of the Kansai branch office of the Forestry and Forest Products Research Institute, Kyoto city, central Japan (34°56′N, 135°46′E). The annual mean temperature for three years at the Kansai office is 15.5 °C, and the hourly maximum (August) and minimum (February) temperatures are 37.9 °C and –3.4 °C. The mean annual precipitation is 1240 mm. The rainy season runs from late June through early July, and typhoons occur during the summer and fall.

We used an automated chamber system and a proton-transfer-reaction mass spectrometer to detect nocturnal emissions of isoprene from three *Quercus* species (*Q. serrata Murray*, *Q. crispula Blume*, and *Q. dentata Thunb*.). The rate of emission was greatest after sunset and decreased till dawn. It showed a linear relationship with temperature. It was higher in the upper canopy than in the lower canopy, and was higher under drought. These results suggest that heat and drought stress increase nocturnal isoprene emission. Such characteristics of emissions are lacking in current emission models. As global warming could increase nocturnal isoprene emissions worldwide, this study identifies the need for further study of emissions under drought and heat stress.

[P1-2]

A YEAR CONTINUOUS VARIATIONS OF SOIL CH_4 FLUXES IN JAPANESE CYPRESS FOREST: RESPONSE TO ASIAN MONSOON RAINFALL

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Upland soils, especially those in forests, are thought to be the most efficient sinks for atmospheric methane (CH_4). However, CH_4 absorption in forests under Asian monsoon climate would be greatly restricted by intensive summer rainfall. To clarify variations of soil CH_4 fluxes at high time resolution including response to rainfall, we conducted a year continuous soil CH_4 flux measurements in Japanese cypress forest using automated chamber. The aim of this study is to reveal i) the ranges and annual budgets of CH_4 fluxes, ii) the seasonal variations of CH_4 fluxes and the effects of environmental factors (temperature and soil water content) on their seasonality, and iii) detail 30-minute time resolution response of CH_4 fluxes to rainfall.

The observation was made in a temperate coniferous forest in the Kiryu Experimental Watershed located in Shiga Prefecture, Japan (136°E, 35°N). The forest consists of 50-year-old Japanese cypress (*Chamaecyparis obtusa* Sieb. et Zucc.), which were planted in 1959. The entire watershed is underlain by weathered granite, with abundant amounts of albite, and the soils are predominantly cambisols. The study site has warm temperate monsoon climate. Rainfall occurs throughout the year with two peaks in summer due to the Asian monsoon; the early summer 'Baiu' front season and the late summer typhoon seasons. We selected three characteristic plots of water-unsaturated forest floor: lower part of slope with thick organic layer and high volumetric soil water content, middle part of slope with thick organic layer, and upper part of slope with thin organic layer. In each plot, a closed chamber which had automatically opening and closing lid was located. Soil CH_4 and CO_2 fluxes were measured by a CH_4 analyzer (FMA-200, Los Gatos Research) and a CO_2/H_2O gas analyzer (LI-840, Li-Cor), respectively.

CH_4 absorption was observed almost throughout a year at all plots (Figure 1). The ranges of CH_4 and CO_2 fluxes were different among three plots. Within a small catchment (0.68 ha), annual budget of CH_4 fluxes had large spatial variability ranging from –142 to -825 mg C m^{-2} yr^{-1}. We revealed that spatial variability is caused by differences of local soil characteristics, such as soil water conditions and organic matter content. As for temporal variations, CH_4 absorption was greatly weakened by summer rainfall events such as 'Baiu' from June to July, and peaked in August or September after 'Baiu'. At short time scale (30-minute), CH_4 absorption and CO_2 emission showed abrupt decrease during rainfall in plots with thick organic layer. After rainfall, CO_2 emission recovered soon, while CH_4 absorption took more time to recover. We suggested that the bidirectional response of CH_4 fluxes, CH_4 production by methanogens and CH_4 consumption by methanotrophs, caused the difference from CO_2. The balance between CH_4 absorption and emission would have changed with wetting and getting reduced condition. In plot with thin organic layer, decreased CH_4 and CO_2 fluxes recovered taking almost same time after rainfall. This suggests that CH_4 fluxes would be mainly controlled by gas diffusivity in this plot. Our measurements revealed the Asian monsoon characterized by summer heavy rainfall strongly influenced seasonal variation of CH_4 fluxes, and the pattern of responses differed depending on topographic environment.

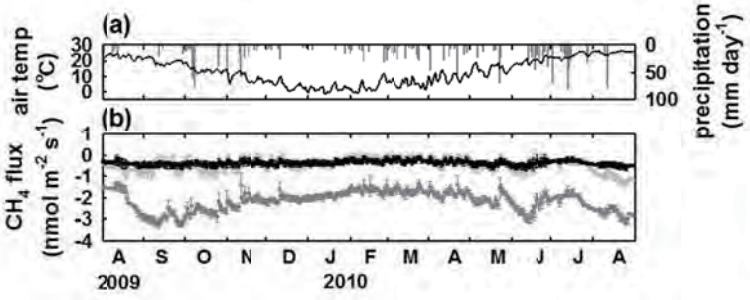

Figure 1.
Seasonal variations of daily averaged (a)air temperature and precipitation ,and (b) soil CH_4 fluxes in each plot during August 1st, 2009 to August 31st, 2010.

[P1-3]

COMPLETE OXIDATION OF CH_4 BY EASILY-PREPARED NI CATALYST

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CH_4 exchange in ecosystems is widely investigated in the AsiaFlux community. Sometimes, it is necessary to get rid of CH_4 or to oxidize CH_4. However, among atmospheric constituents, CH_4 is the most stable gas that cannot be easily oxidized. Machines to oxide CH_4 oxidizers using catalysts such as Pd are commercially available but they are high-cost and technical details in flux communities are not well-known because of patent problems. We developed a system to continuously oxidize CH_4 by easily-prepared Ni and report it. We investigated conditions to accomplish complete oxidation of CH_4 and obtained $\delta 13CO_2$ and $\delta 13CH_4$ in case of incomplete oxidation..

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[P2-1]

ENERGY FLUXES IN DRY DIPTEROCARP FOREST, THAILAND

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Study of energy exchange is important to explain various biophysical processes of forest ecosystem. Energy is a part of carbon sink mechanism, especially photosynthesis and respiration proceses. Generally, trees in dry dipterocarp forest ecosystem have to adapt to drought and high wildfire risk. Measurements of energy will help improve our understanding of how sink and sources capacity of forest ecosystem responds to such climate extremes and wildfire. In this study, eddy covariance technique was used between June and October in 2013 to study a pattern of energy exchange in dry dipterocarp forest, University of Phayao. The results revealed that most energy exchange (66%) was occurred in form of latent heat flux (LE), with the average during the measurement period (6.75 MJ/m^2/day). The rest was stored in biomass (16% or 1.73 MJ/m^2/day), exchanged through sensible heat flux (H; 14% or 1.43 MJ/m^2/day), and soil heat flux (Gs; 4% or 0.43 MJ/m^2/day). In August, average LE was highest consistent with highest rainfall (259.87 mm), which effected on the high soil moisture (20.95%VWC). On the other hand, average H was highest in September since the highest of net radiation (10.89 MJ/m^2/day). Conversely, Gs was rather low over the study time because of canopy cover. During 5 months, on the average the net ecosystem carbon change was 2.87 tonC/ha/month.

Keywords: Energy exchange, Dry dipterocarp forest, Eddy covariance techneque

Acknowledgments

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[P2-2]

CARBON DIOXIDE EXCHANGE OF a SECONDARY TROPICAL PEAT SWAMP FOREST IN SARAWAK, MALAYSIA

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1. Introduction Tropical peatland is one of the world massive reservoirs of terrestrial carbon. Therefore, the exchange of carbon dioxide (CO_2) of tropical peatlands ecosystem plays an important role in the global carbon cycle and climate change. In peatland, soil respiration would have significant contribution to ecosystem respiration (RE) owing to its high soil carbon stock. Groundwater level (GWL) in peat influences the formation of aerated zone where peat decomposition takes place. Low GWL increases the aerated zone, thus theoretically increases oxidative decomposition of peat organic carbon, and consequently increases RE. It is important to know the influence of GWL on the CO_2 exchange of tropical peatland forest ecosystems. Therefore, we have measured CO_2 flux over a secondary peat swamp forest Sarawak, Malaysia.

2. Materials and Methods The study was conducted in a secondary tropical peat swamp forest with the height of 26 m at Betong, Sarawak, Malaysia (01° 24' N, 111° 23' E). Both CO_2 and energy fluxes have been measured at the height of 41 m on a tower since January 2011 using the eddy covariance method. A sonic anemometer/thermometer (CSAT3, Campbell) and an open-path CO_2/H_2O analyzer (LI7500A, LICOR) were used to measure 3D wind velocities, air temperature, CO_2 density and water vapor density at 10Hz. Raw data were recorded with a datalogger (CR3000, Campbell). The CO_2 profile was also measured every 6 min using a closed-path CO_2 analyzer (LI-820, LICOR) at the heights of 41, 21, 11, 3, 1, and 0.5 m. Global and reflected solar radiations and long-wave radiations (upward and downward) were measured using a pyranometer (CNR4, Kipp&Zonen) at the height of 41 m. Downward and upward photosynthetic photon flux densities (PPFD) was also measured at the height of 41 m using a quantum sensor (LI-191, LICOR). Wind speed and direction were measured with a vane and 3 cup anemometer (Wind sentry, Young) at the height of 41m. Air temperature and relative humidity were measured with a temperature & relative humidity probe (CS215, Campbell) at 41 and 3 m. The GWL was measured with a water level logger (STS). Precipitation was measured with a tipping-bucket raingauge (TE525, Campbell) at 1 m in an open space. These data were averaged every 30 min and recorded using a datalogger (CR3000, Campbell).

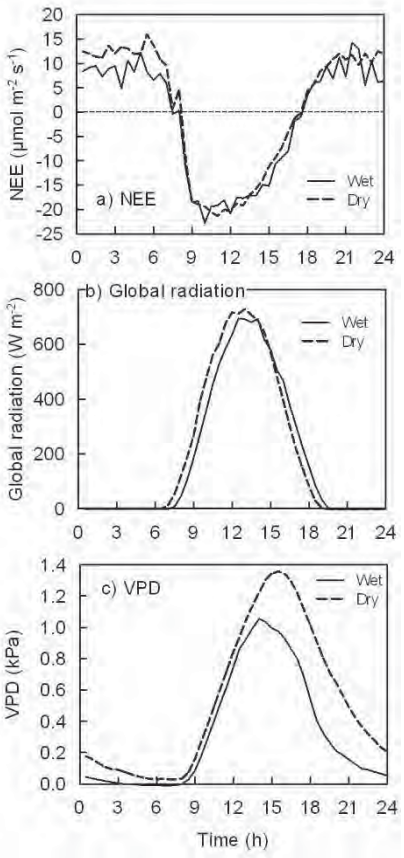

Fig. 1. Mean diurnal variations of NEE, global radiation and VPD from Jan. to Apr. (dry season) and Jun. to Sep. (wet season) in 2012.

3. Results and discussion From GWL, the periods of January to April and June to September in 2012 were identified as the wet and dry seasons, respectively; mean GWLs of the seasons were 0.05 and -0.45 m, respectively. Figure 1 shows the mean diurnal variations of net CO_2 exchange (NEE), global radiation and vapor pressure deficit (VPD). Nighttime NEE or RE in the dry season was higher than in the wet season, probably because low GWL enhanced oxidative peat decomposition in the dry season. However, daytime NEEs of the two seasons were almost the same even though VPD was much higher in the dry season. Global solar radiation was a little higher in the dry season than in the wet season mainly because of fewer clouds. Higher solar radiation may have compensated higher VPD, which would cause stomatal closure. In

addition, root hypoxia due to flooding may have caused stomatal closure in the wet season.

[P2-3]

HEAT AND WATER EXCHANGE OF SEASONAL TROPICAL FOREST OF SOUTHERN VIETNAM

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Heat and water fluxes of seasonal tropical forest in Cat Tien national park (N 11°27', E 107°24', 140 m a.s.l.) were collected for 2011-2013. Forest is primary because of rock soil which is unsuitable for agriculture, and probably low-disturbed. Canopy height is ~ 37 m. Forest has 3-5 canopy sub-stages and rich biodiversity (80 tree species), predominant spp. on drained plots are Lagerstroemia calyculata (Lythraceae), Haldina cordifolia (Rubiaceae), Tetrameles nudiflora (Datiscaceae), Afzelia xylocarpa (Caesalpiniaceae), Sterculia cf. cochinchinensis (Sterculiaceae). Soils are medium-rich ultisols over basalt rock. Climate is tropical monsoon with 2 seasons: dry winter (each month from December to March has less than 100 mm of rain) with temperature of +24...+28 and rainy summer with +26 on average. Total year precipitation is 2518 mm (Dong Xoai meteorological station, 1981-2010).

Eddy covariance system at 50-m scaffold tower consisted of LI-7500A open-path gas analyzer and CSAT3 sonic anemometer. 10-Hz raw data were processed in EddyPro software (LI-Cor Inc.) using planar fit rotation, block average, high- and low-pass filtering etc. Data were allotted to 9 quality classes; values of 6-9 flags were eliminated for calculating of totals. Visual check for spikes or odd values was used before and after gapfilling procedure in online tool of Max Planck Institute, Germany (http://www.bgc-jena.mpg.de/~MDIwork/eddyproc/method.php). Storage of heat in soil over heat plates and in air was calculated and added to the heat flux (H); as well as storage of water vapour in canopy space was added to evapotranspiration (LE). In 2012 rate of gaps in latent heat data was 44 %, or 59 % in night-time (night boundary was solar radiation less than 20 Wt m^{-2}) and 23 % in day-time. In heat flux, rate of gaps was 38 %, or 48 % at night-time and 24 % in day-time. Because night-time fluxes of heat and water are small the gaps did not play a great role. Uncertainty associated with gapfilling (estimated by using artificial gaps in look-up table method) for evapotranspiration was 98.3±0.2 Wt m^{-2} (=1285±3...8 mm) or 25.4±0.1 Wt m^{-2}. Evapotranspiration assessed without gapfilling through mean diurnal course was 1342±47 mm. The main uncertainty of estimation of heat and water exchange was connected with a problem of energy imbalance, which made up 17-18 % in Cat Tien. If we divide imbalance between H and LE according to Bowen ratio (H/LE) as usually recommended, total E for 2012 becomes 1542 mm. So, average LE flux becomes 118.0 Wt m^{-2} and average H flux becomes 30.5 Wt m^{-2}. Radiation balance at NCT site was 154.2 Wt m^{-2}. Both radiation balance and latent heat flux were high and close to tropical rain forests. We suggest high radiation is caused by evening peak of cloudiness and rain in Cat Tien, and high evapotranspiration is caused by substantial annual precipitation sum and expenditure of water storage in deep soil layers for transpiration in dry season.

[P2-4]

MEASUREMENTS OF CO_2/H_2O FLUXES DURING RAINFALL BY AN ENCLOSED PATH EDDY-COVARIANCE SYSTEM IN A TROPICAL DIPTEROCARP FOREST IN MALAYSIA

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It is important to clarify the function of tropical rainforests in carbon and water balance and the response of such rainforests to climate change. Long-term tower observation of carbon balance and evapotranspiration using the eddy covariance method is a useful method for this purpose. In a previous tower observation, despite the importance of clarify gas exchanges during precipitation for accuracy estimation of the annual NEE, there was little study focusing on the characteristics of gas exchange during precipitation based on fluxes during precipitation and immediately after precipitation. Measurements of fluxes during precipitation and immediately after precipitation are difficult with open-path gas analyzer (LI-7500, Li-Cor) due to wet sensors from the rain season squalls and high humidity. Therefore, fluxes before and after the precipitation are extrapolated from the relationship between fluxes during sunny periods and environmental factors. Although several gap-filling procedures were proposed (e.g. Kosugi et al., 2010), this leaves uncertainties in the annual NEE. Our group has been conducting a continuous observation of CO_2/H_2O fluxes using the eddy covariance method in a tropical rainforest since 2002, for 11 years (Kosugi et al., 2008, 2012). However, at Pasoh, an open-path gas analyzer has been used. Thus, in this research, we newly installed an enclosed CO_2/H_2O gas analyzer (LI-7200, Li-Cor), which makes measurement of fluxes during precipitation possible. And we examined the most appropriate method of gap-filling for CO_2/H_2O fluxes before and after precipitation among the ones proposed until now.

The study was conducted at an observation tower in the Pasoh Forest Reserve of the Forest Research Institute Malaysia (2°58′N, 102°18′E, 75-150 m a.s.l.). The core area (600 ha) of the reserve (2,450 ha) is covered with primary lowland mixed dipterocarp forest. The continuous canopy height is approximately 35 m. Mean annual rainfall at the study site totals 1,804 mm (1983-1997, Tani et al., 2003). Rainfall peaks from March to May and from October to December, and mostly occurs from late afternoon to night (Kosugi et al., 2008). Meteorological variables were monitored at a height of 52-54 m on the observation tower. Three-axis sonic anemometer (SAT-550, Kaijo) and simultaneous measurement of fluxes using LI-7500 and LI-7200 were conducted at the height of 54 m on the observation tower at our study site from January to May, 2013. The flow rate of LI-7200 was set at 10 L/min. Using a tube (DK tube Φ6 mm, Nitta) of approximately 0.7 m, the intake opening was installed at approximately 0.1 m below the measurement path of three-axis sonic anemometer. Data were sampled at 10 Hz with a data logger (CR-5000, Cambell Scientific). Fluxes of momentum CO_2/H_2O were calculated as 30-min averages. Double rotation (McMillen, 1988) was applied. For LI-7500, relationships between the time lag and wind speed and direction were established. Webb-Pearman-Leuning (WPL) correction for the effect of air density fluctuations (Webb et al., 1980) was applied to the open-path data. For the enclosed-path data, fluxes were calculated from the mixing ratio relative to dry air.

Calculated CO_2/H_2O fluxes from LI-7200 and LI-7500 during the time of no precipitation agreed well. With these results as the base, variations in the relationship between CO_2/H_2O fluxes and environmental factors during the time of no precipitation and during precipitation were investigated. The results showed that the response of CO_2/H_2O fluxes to environmental factors during precipitation was the same as in the time of no precipitation, and photosynthesis and transpiration occurred depending on the amount of solar radiation regardless of rain occurrence. In our presentation, using the relationship between obtained CO_2/H_2O fluxes before and after precipitation and the amount of solar radiation, we present the results of gap-filling for the missing period before and after precipitation in the past results from LI-7500 only.

[P2-5]

INTRODUCTION TO NEW ThaiFlux SITE: DRY DIPTEROCARP FOREST FLUX PHAYAO SITE (DPT)

Pimsiri Suwannapat[1*], Montri Sanwangsri[1], Daisuk Komori[2], Wonsik Kim[3], Amnat Chidthaisong[4], Nittaya Cha-un[4], Korakod Nusit[5], Warangluck Sonklin[5], Patipat Vongruang[1], Mana Panya[1], and Watcharapong Boonruang[1]

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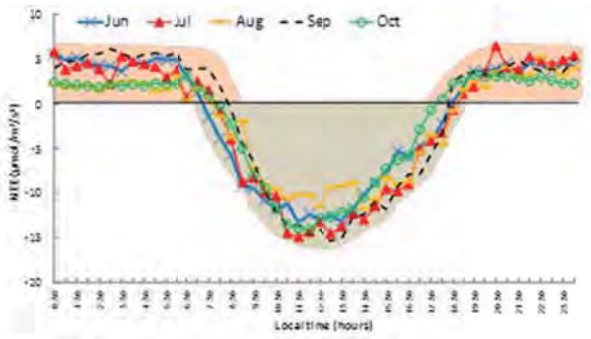
Dry Dipterocarp Forest Flux Phayao Site Thailand (DPT), is located in the University of Phayao (UP) in northern part of Thailand (coordinates: Latitude: 19º 02' 14.38" N, Longitude: 99º 54' 10.96" E at 512 m asl). The climate condition was tropical monsoon (means precipitation 1262 mm; 1998-2007) and slope terrain. The objective was set to monitor long-term exchanges of heat, water and carbon dioxide, which allow the assessments of the impact of climate and land use changes on interaction between land and atmosphere.

DPT site was established under the JST-JICA supported project on integrated study on hydro-meteorological prediction and adaptation to climate change in Thailand (IMPAC-T Project) in 2013. The 42 m-tower was installed with the followings; uses open-path CO_2/H_2O analyzer (EC150, Campbell Sci), three-dimensional sonic anemometer (CSAT3, Campbell Sci.). Preliminary results reveal that the CO_2 exchange between atmosphere and dry dipterocarp forest was about 1.27 to -2.19 µmol/ m^2/s (average 2.87 tonC/ha/month, Fig. 1a). Most of energy was used 66% (6.75 MJ/m^2/day) for evaporating water, 16% (1.73 MJ/m^2/day) for storing in biomass, 14% (1.43 MJ/m^2/day) for air burning and 4% (0.43 MJ/m^2/day) for storing in soil, respectively (Fig. 1b). The underground and modeling analyses, such as root system and plant growth including water use efficiency under drought and forest fire are currently investigated to provide more information about the various processes and adaptive mechanisms in this forest ecosystem in the future.

a



b

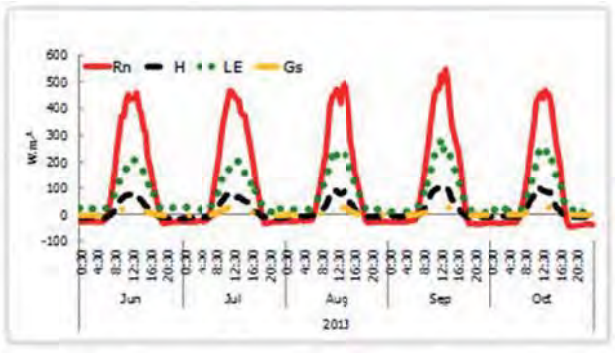


Figure1. The average diurnal patterns in net ecosystem CO_2 exchange (a) and the components of energy exchange (b) in DPT site Thailand

Keywords: Dry dipterocarp forest flux Phayao site Thialand (DPT), Eddy covariance method,

Acknowledgments

This research was supported by JST-JICA under the IMPAC-T project, and SEEN, UP, Thailand, and ThaiFlux Network.

[P3-1]

YEAR-TO-YEAR VARIATION OF CANOPY LEAF PHENOLOGY AT TAKAYAMA (TKY) FLUX TOWER, JAPAN, ANALYZED USING THE LONG-TERM RECORD OF DAILY FIXED VIEW PHOTOGRAPHS

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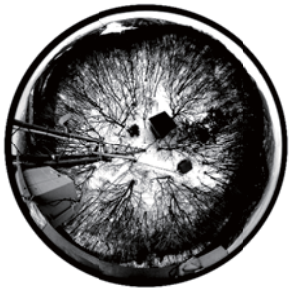
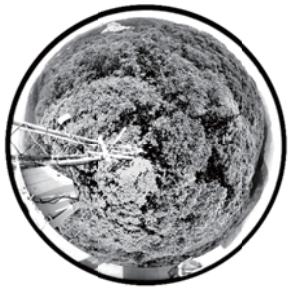
The long-term record of daily fixed view photographs of the forest canopy taken from the top of the Takayama (TKY) flux tower, Japan (36°08'46"N, 137°25'23"E, 1420m ASL) and analyses of the leaf phenology using the photographs are introduced. The operation of the automated fixed view camera by the AIST group started in the end of 1990's, by a handy video camera with a time-lapse video tape recorder and a video digitizer. In 2004, the camera was replaced with a self-made online system with automated digital fish-eye still camera and has been continuing operation. The major purpose of the camera is to record the occurrences of phenological and meteorological events, e.g. foliation and defoliation, and snow coverage around the tower as a part of the flux monitoring at the tower. Some part of the digital photo archive was employed for the development of an algorithm for numerical analysis and automatic discrimination of such phenological events in typical broadleaf deciduous forests (Maeda and Gamo, 2004, patented). The algorithm utilizes the inflection points that appear in the time series of 'normalized intensities', monochromatic intensity (brightness) of individual RGB channels normalized by panchromatic intensity calculated from daily digital images.

In the presentation, the overview of the year-to-year variation and some significant events of the leaf phenology around the TKY flux tower in the previous decade basing on the time series of the normalized intensities are discussed. The forest around the tower is cool-temperate broadleaf forest that mainly consists of *Quercus* and *Betula* trees. During winter, the ground is covered by deep snow for 5 months (Fig.1). According to the daily normalized intensities averaged over the whole field of the view during 12 years from 2001 (Fig. 2), year-to-year variation of the timing of the each phenological event was around 3-6 days in standard deviation, even though the period included El Nino, La Nina, and some years with extreme climate such as frequent typhoons. Influences of climate on the phenology of the forest in the TKY site and carbon flux are also discussed.



Winter, 070DOY, 2006



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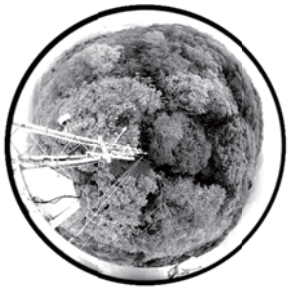

Autumn, 293DOY, 2006

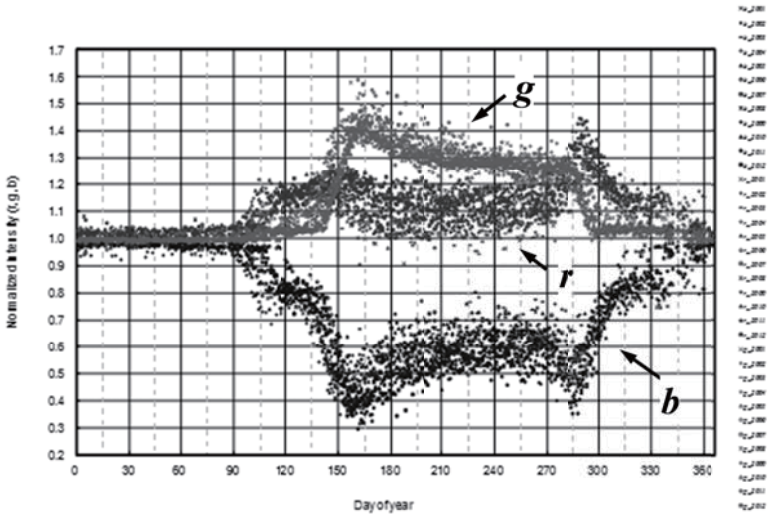

Fig. 2. Seasonal variations of RGB normalized intensities during 12 years from 2001.

[P4-1]

ESTIMATION OF GPP BY USING VEGETATION INDEX IN A YOUNG LARCH PLANTATION,NORTHERN JAPAN

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Remote sensing technique is expected to be an effective method to estimate the gross primary production (GPP) of forest ecosystem using vegetation indices evaluated from spectral reflectance of vegetation surfaces. Green ratio (GR), one of the vegetation indices, can be evaluated using only visible band reflectance, thus can be derived from the colors in photographs taken by commercially available digital camera with low cost. In addition, several previous studies have reported that the seasonal variation of GR well corresponds to that of photosynthetic characteristics of vegetation. The aim of this study is to clarify the relationship between seasonal and interannual variation of GR and those of photosynthetic characteristics in a young larch plantation in northern Hokkaido, Japan, using 6 years data obtained during the early developmental stage of the vegetation after clearcutting, and to simulate the GPP using that relationship. We focused on two main parameters of the light response curve of GPP ―A_{max} (maximum GPP at light saturation) and ϕ (initial slope of the light response curve) ―as indicators to represent the photosynthetic characteristics.

The study site was located in a young larch plantation in Teshio experimental forest in northern part of Japan. Two-year old hybrid larch saplings were planted after clearcutting in 2003. During plant growing periods from 2007 to 2012, fisheye photo was taken every day at noon by a digital camera (Nikon CoolPix 4500+Fisheye lens) and spectral reflectance of the vegetation was evaluated at 1-min interval using up- and down-ward spectral radiometers (MS700, EIKO) at the top of the 30 m tower. CO_2 flux and GPP was evaluated by using eddy covariance technique with a closed-path infrared analyzer and a 3D sonic anemometer. Daily GR was evaluated as $G_{DN} / (R_{DN} + G_{DN} + B_{DN})$ for each vegetation type such as larch, undergrowth *Sasa*, bare ground, and whole studied area by selecting the targets in the fisheye photos, where R_{DN}, $G_{DN,}$ and B_{DN} are digital numbers for each red green and blue channel in each pixel, and daily A_{max} and ϕ were evaluated using 30-min CO_2 flux and photosynthetic active radiation data.

The GR derived from digital camera clearly distinguished the seasonal variation of each vegetation phenology, larches showed steep increase in the GR in early June and gradual decrease thereafter. Seasonal variation of GR of *Sasa* or whole studied area is similar to that obtained from spectral radiometer or the seasonal variation of A_{max} and ϕ. Estimated GPP using the relationship between GR and photosynthetic parameters (A_{max} and ϕ) well simulated the seasonal variation of observed GPP, however, more improvement were needed to simulate the interannual variation.

[P4-2]

THE ESTIMATION OF CO_2 EXCHANGE AT PADDY FIELD USING SATELLITE DATA

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Paddy fields in monsoon Asia have a great important role in the global budget of GHGs. Recently long-term fluxes are continuously observed at cropland ecosystems in Asia. In this study, the exchange of CO_2 at a number of paddy fields were estimated by a satellite-based empirical model with the Terra/MODIS data, and the results were compared with the ground-based observation data.

Gross primary productivity (GPP) is estimated from normalized difference vegetation index (NDVI) and photosynthetically active radiation (PAR). Ecosystem respiration (RE) is also estimated from NDVI and land surface temperature. And net ecosystem exchange of CO_2 (NEE) was calculated the difference between GPP and RE. Some parameters used in the model were determined by the ground data measured at HCH, the single-rice site in western Japan (34N32, 133E56).

CO_2 exchanges at four sites – HCH, MSE, SGA, and IRRI – were estimated. PAR and air temperature as input data were also tested by the ground data at each sites. Seasonal variations of GPP, RE, and NEE during cultivated period at four sites were compared in Fig.1. The model reasonably reproduced the seasonal variation of CO_2 exchange at three sites in Japan. However GPP by the model was overestimated at early stage of the first cropping term and through the second cropping at the Phillipine site, IRRI. Cumulative NEE by the model showed the difference by from -6.8 to 10.1% compared with the observed NEE.

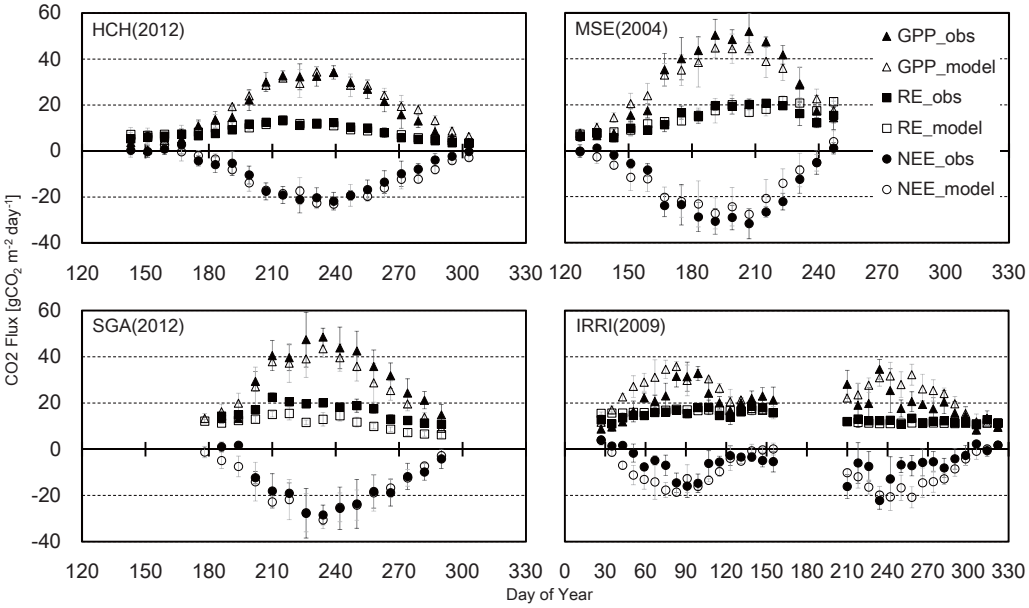

Fig.1. Seasonal variations of CO2 exchange by the model and the observation

[P4-3]

RELATIONSHIP BETWEEN ECOSYSTEM PHOTOSYNTHETIC PARAMETERS DERIVED FROM FLUX OBSERVATION AND MODIS VEGETATION INDICES OF EAST ASIAN FORESTS

Kentaro Takagi[1], Masahito Ueyama[2], Reiko Ide[3], Kazuhito Ichii[4], Keisuke Ono[5], Ryuichi Hirata[3], Nobuko Saigusa[3], Takashi Hirano[1], Hyojung Kwon[6], Jinkyu Hong[7], Leiming Zhang[8], ShengGong Li[8], Shijie Han[8], Hui-Min Wang[8], Yi-Ping Zhang[8], Jun Asanuma[9], Minoru Gamo[10], Takahisa Maeda[10], Shohei Murayama[10], Takashi Machimura[11], Yuichiro Nakai[12], Takeshi Ohta[13], Taku M. Saitoh[14], Yoshiyuki Takahashi[3]

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The aim of this study is to clarify the relationship between ecosystem photosynthetic parameters derived from eddy flux observation and remotely sensed MODIS vegetation indices for East Asian forests. For this purpose, we used CO_2 flux and micrometeorology data obtained at 21 East Asian forests to extract seasonal or inter-annual variations of the photosynthetic parameters. Target parameters were maximum gross primary productivity at light saturation (A_{max}), the initial slope of the light-response curve (ϕ) and daytime respiration rate (R_d). For each flux site, monthly MODIS NDVI, EVI, and LAI were prepared. Daily photosynthetic parameters were determined by least-squares method using daytime half-hourly net ecosystem CO_2 exchange rate within 29 days moving windows, and the monthly average was calculated to compare with monthly MODIS vegetation indices.

All photosynthetic parameters showed the seasonal variation peaked at mid-summer for temperate (deciduous, evergreen and mixed) and boreal forests; however, the variation was small for tropical forests. MODIS LAI explained not only the seasonal variation at each flux site but intersite variation of photosynthetic parameters, which implies that the ecosystem photosynthetic characteristics are substantially affected by the change in the leaf area. Monthly GPP was estimated using the relationship between seasonal variation of photosynthetic parameters and MODIS LAI, where photosynthetically active radiation was used as an environmental variable, and this estimation well simulated the observed GPP.

[P5-1]

DIURNAL AND SEASONAL PATTERNS OF WATER vAPOR AND SENSIBLE HEAT FLUXES FROM IRRIGATED AGROECOYSTSEM BY LARGE APERTURE SCINTILLOMETRY

Abhishek Danodia[1], V.K. Sehgal[1], Joydeep Mukherjee[1], N.R. Patel[2], Mamta Singh[2]

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Accurate surface energy balance assessment over a cropland is important to understand the interaction between the land surface and atmosphere including practical applications in crop yield prediction and water resources management (Hwang and Choi, 2013). Besides, the accurate partitioning of surface available energy into sensible and latent heat fluxes (i.e. evapotranspiration) over various scales has been recognized as being critical in understanding the impact of soil-vegetation–atmosphere interactions on local and regional weather and climate (Idso et al., 1975). In recent time, Large Aperture Scintillometer (LAS) along with meteorological station is increasingly being used to measure sensible and latent heat fluxes over very large footprints of 1 to 5 km. A large aperture Scintillometer (Kipp & Zonen- Mk II) has been installed in the experimental farm of Indian Agricultural Research Institute, New Delhi, over a path length of 990 km covering intensively cultivated irrigated agricultural landscape. This Scintillometer is complimented with a meteorological station having a pyranometer, net radiometer, temperature and wind speed sensors at two heights, wind direction sensor and soil heat flux plate at 10cm depth. This study describes the results of diurnal and seasonal patterns of radiation, sensible and latent heat fluxes observed during fallow – crop season. The LAS footprint was mainly dominated by maize crop. The frequency of data observation was 5 minute which resulted in computing 5 minute fluxes and these were later averaged over 1 hour period. The soil moisture in top 20 cm and crop parameters of phenology, LAI, height and ground cover were recorded at different locations in the footprint of LAS during the crop season. The diurnal pattern of fluxes at different growth stages of the crop were analyzed in relation to crop parameters and soil moisture. The partitioning of energy among sensible, latent and soil heat fluxes was compared for fallow and crop period. The detailed results and analysis of fluxes will be presented.

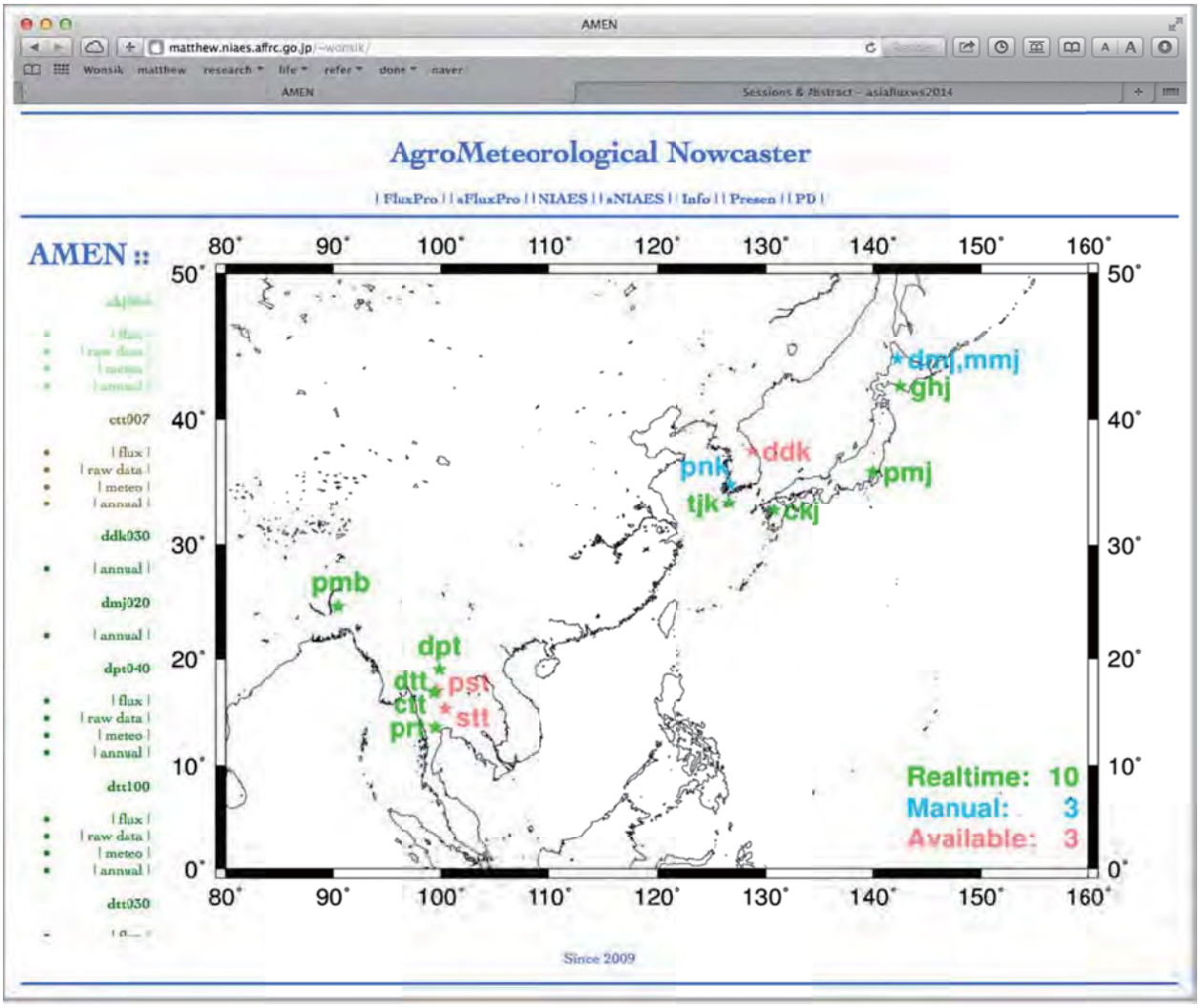
[P5-2]

FLUXPRO AS A REALTIME MONITORING AND SURVEILLING SYSTEM FOR EDDY COVARIANCE FLUX MEASUREMENT

Wonsik Kim, and FluxPro committee

National Institute for Agro-Environmental Sciences, Tsukuba, Japan

Using the eddy covariance (EC) method, the fluxes of energy, water and carbon dioxide over various vegetations have been globally measured to understand responses of terrestrial ecosystem under the global climate change. However, it is not only laborious to immediately address the flux (F) under the complexity of calculation process and quality control, but also troublesome to instantly maintain remote EC sites against instrumentation problems and administrative difficulties. To overcome these issues, namely to challenge a prompt monitoring and surveilling, FluxPro is created based on following three functional systems: 1) Gathering system to transport turbulence data from the sites to FluxPro server by every one hour; 2) Cooking system to compute F and its uncertainty together with micrometeorological parameters; and 3) Informing system to present above F using fruitful kinds of charts over various time scales in realtime base. Therefore, FluxPro could be an appropriate system in terms of multi-site management not only to automatically produce F with those uncertainty but also to continuously maintain EC site with an alert mail.



[P5-3]

METHANE AND CARBON DIOXIDE DYNAMICS OVER A RICE-CROPPING SEASON IN JAPAN

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Methane (CH_4) and carbon dioxide (CO_2) are considered as major greenhouse gases in agricultural land. In particular, a flooded rice paddy field is a major source of anthropogenic CH_4. Recently, micrometeorological techniques for measuring trace gas flux have been improved. Gas fluxes obtained with micrometeorological techniques represent spatially-integrated fluxes in a macro-scale; therefore, the techniques provide sufficient site spatial representations. The eddy-covariance technique (EC) is a popular and reliable micrometeorological technique. The EC requires a sensor whose response time must be sufficiently small to detect fluctuation of a gas concentration on the order of 10Hz to measure gas flux. The recent advances in laser spectroscopy enable researchers to measure trace gas concentrations such as CH_4 at fast sampling rates of 10Hz. The objective of this study is to investigate gas (CH_4, CO_2, H_2O) fluxes in a rice paddy field over a rice-cropping season using the EC.

Field experiments were conducted in a rice paddy field, Japan. Gas (CH_4, CO_2, H_2O) fluxes were continuously measured using the EC. Gas concentrations (CH_4, CO_2, H_2O) were analyzed with a closed-path gas analyzer (G2301-f, Picarro Inc., USA) based on wavelength-scanned cavity ring-down spectroscopy (WS-CRDS). The concentrations of CO_2 and H_2O were also analyzed with an open-path infrared gas analyser (EC150, Campbell Inc., USA). Volumetric water content at 0-10 cm deep and soil temperature at 5cm were also measured using time domain reflectometry (TDR) probe and a thermocouple, respectively. In addition, soil gas at 5cm was regularly sampled using silicon permeability tubes. The CH_4 and CO_2 concentrations in soil gas were measured using a gas chromatography equipped with a flame ionization detector.

The exchanges of CO_2 between the rice canopy and the atmosphere seemed to be regulated by the variations of photosynthesis and respiration with crop growth over a rice-cropping season (Fig. 1a). The variation of CO_2 in soil at 5cm deep over rice-cropping season agreed well with that of soil temperature at 5cm deep (Fig. 1b, d); therefore, the variation of soil respiration seemed to be regulated with that of soil temperature. The temporal change in soil CH_4 concentration might be affected by those of volumetric water content and soil temperature from 0th day as transplanting date to 76th day (Fig. 1b, c, d). In addition, CH_4 concentrations in soil were quite-high during the last stage. In order to demonstrate this mechanism, soil factors, such as total organic carbon in soil water and total carbon in soil, are being investigated. The calculation of CH_4 flux is in progress. The relationship between CH_4 dynamics and soil factors will be discussed in the conference.

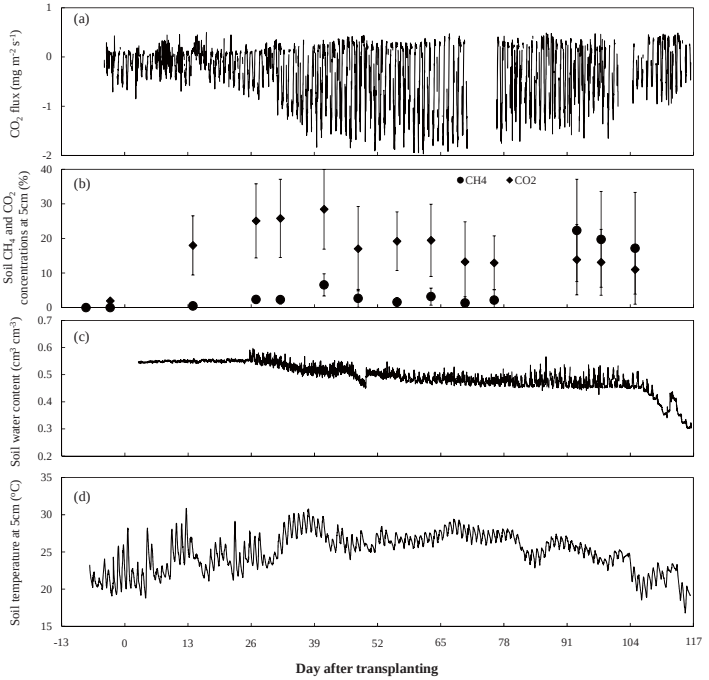

Fig. 1. Temporal changes in CO_2 fluxes with eddy covariance method (a), in soil CH_4 and CO_2 concentrations at 5cm (b), volumetric soil water content at 0 – 10 cm deep (c) and soil temperature at 5cm deep (d) over the rice-cropping season. 0 day is transplanting date on July 5th.

[P5-4]

VALIDATION OF THE FRACTIONAL UNCERTAINITY ANALYSIS AS DATA QUALITY CONTROL FOR EDDY COVARIANCE FLUX

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Various flux tower sites have applied the eddy covariance (EC) technique to measure those fluxes over various crop and forest types. However, not all measured flux data may be of sufficient quality to provide a quantitative view of the fluxes, because they do not match all the flux measurement theoretical conditions, such as homogeneous land cover, flat terrain, and proper atmospheric conditions (Baldocchi, 2003). In this study, the data quality control and assurance (QC/QA) on worldwide EC flux measurements in homogeneous and heterogeneity sites have implications for wide applications in ecosystem intercomparison, model development, and model-data synthesis. We present a quantitative assessment of QC/QA for the EC data using a fractional uncertainty analysis. The fractional uncertainty analysis captured the similar characteristics of a qualitative assessment of QC/QA using the conventional technique at homogeneous and heterogeneous surface vegetation sites in the rainy and nonrainy seasons. The quantitative assessment of QC/QA using the fractional uncertainty analysis experimentally confirmed that the estimated fractional uncertainty can be applied for QC/QA with regard to the development of turbulent conditions and flux nonstationarity. Furthermore, the fractional uncertainty is a more adequate technique to detect measurements of unacceptably developed conditions, including measurements of nighttime fluxes and surface heterogeneity, because the *T* analysis is independent of meteorological influence. Therefore, the QC/QA criteria by the fractional uncertainty serves as a standard of comparison for field EC regardless of the specific periods, sites, and flux types.

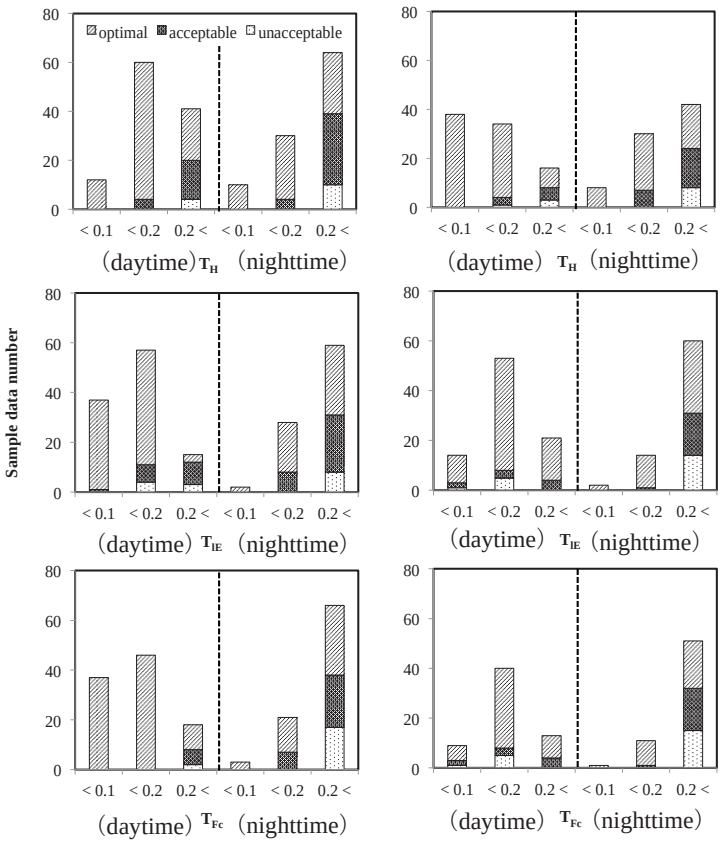

Figure 1 Comparison between uncertainty analysis and the conventional QC/QA technique at homogeneous surface vegetation in the rainy (left) and nonrainy seasons (right).

[P5-5]

CANOPY-SCALE WATER-USE EFFICIENCY OF IRRIGATED RICE UNDER DIFFERENT CLIMATES AND MANAGEMENT PRACTICES

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The agricultural sector consumes two-third of global water withdrawal, which accounts for 90% of total water consumption. Therefore, it is a critical challenge to develop cropping systems that achieve yields at higher levels of water use efficiency (WUE). There are several definitions of WUE with different target scales from plant tissues to landscapes. Canopy-scale WUE is a practical measure to evaluate how a cropping system efficiently uses water because it includes surface evaporation (non-beneficial water use) as well as transpiration (beneficial water use) and has been determined over various crop canopies. However, those measurement techniques were not well standardized and difficult to compare the values from study to study. The purpose of this study was, therefore, to compare the canopy-scale WUE of irrigated rice observed at three sites in East and South Asia by the identical measurement and analytical techniques and to examine the factors affecting their differences among the sites.

We used field measurement data obtained at three rice-paddy sites, Mase in Japan (MSE; +36.05392, +140.02692, 11 m asl, 2002–2010, single crop) for 9 years, Mymensingh in Bangladesh (MYM; +24.72528, +90.42425, 18 m asl, 2006–2008, double crop) for 3 years, and Jiangdu in China (JND; +32.59844, +119.70692, 2 m asl, 2007–2008, double crop of rice/wheat) for 2 years. Typically, the growing season was 4.5 months in May–September at MSE, 4 months in January–May for dry-season rice (Boro) and August–December for wet-season rice (Aman) at MYM, and 4 months in June–October for rice at JND. Fertilizer and pesticide were used in the conventional ways of the sites. We calculated and partitioned the eddy flux data according to the standard methods which were well documented and confirmed at other flux sites. Finally, we obtained the seasonal datasets of daily gross primary production (GPP), evapotranspiration (ET), and WUE (=GPP/ET) for each growing season. Each growing season was divided into 4 sub periods according to the developmental stages (DVS; 0 at transplanting, 1 at heading, and 2 at harvesting): 0–0.5 (the vegetative stage), 0.5–1.0 (the reproductive stage), 1.0–1.5 (the early ripening stage), and 1.5–2.0 (the late growing stage).

Seasonal variation in WUE was obvious but its pattern differed among the sites. The WUE for the whole season was 1.91±0.19, 1.93±0.16, 2.15±0.13, and 2.58±0.04 g C / kg H_2O for MSE, Boro of MYM, Aman of MYM, and JND, respectively. The higher WUE at JND resulted from the higher rate of canopy development and relatively higher humidity during the daytime. When normalized by vapor pressure deficit, the WUE did not much differ among the sites and seasons. Our results revealed that the rate of canopy development was one of the most important factors characterizing the sites and, from its point of view, the cultivation schedule at the MSE site might not be the best and therefore could be improved in terms of water use although it is a consequence of the comprises of many other aspects such as the farmer's convenience and the commercial strategy.

[P5-6]

INTER- AND INTRA-ANNUAL VARIATIONS OF CARBON DIOXIDE FLUXES IN RICE-BARLEY DOUBLE CROPPING SYSTEM IN GIMJE, KOREA

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Agriculture plays a substantial role in the balance of the most significant green house gases and quantifying CO_2 fluxes in agricultural ecosystem is critical for better understanding of global and regional carbon cycling. This study examined year-round temporal variation of CO_2 fluxes of rice-barley crop double rotations during 2 years. CO_2 flux was investigated using eddy-covariance (EC) technique and environmental parameters such as net radiation and temperature were measured as well. Whole-plant crop biomass was also collected throughout growing seasons. Fluctuations in diel CO_2 fluxes were correlated with changes in net radiation, while seasonal-long trends in CO_2 fluxes were associated with changes in leaf area index and stage of development. Data showed a positive correlation between crop biomass and cumulative Net Ecosystem Exchange of carbon dioxide (NEE) for both years of the study. Annual cumulative NEE were –312.6 g C m^{-2} for barley and –273.9 g C m^{-2} for rice in 2012, –100.6 g C m^{-2} for barley and –349.5 g C m^{-2} for rice in 2013, respectively. CO_2 fluxes differences were the result of the effect of crop biomass. The measurement of the C content of the barley biomass in 2012 (536.4 g C m^{-2}) was higher than 2013 (293.4 g C m^{-2}). On the other hand, the measurement of the C content of the rice biomass in 2012 (489.1 g C m^{-2}) was lower than 2012 (498.1 g C m^{-2}). From the present study, results suggest crop biomass have a substantial impact on dynamics of CO_2 exchange.

[P6-1]

DYNAMICS OF DECADAL CHANGES IN THE DISTRIBUTION OF RICE CULTIVATION IN CHINA

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Paddy rice impacts on carbon budget by methane emission in agricultural ecosystem. Quantitative description of changes in the distribution of paddy rice cultivation in response to recent climate change provides a reference for rice cultivation patterns and parameter information to estimate paddy rice ecosystem carbon budget change in China. This study analyzes the dynamics of decadal changes in distribution of rice in China during 1961–2010 in relation to climate change based on the maximum entropy method. The results showed that:

As for single-cropping rice cultivation, (1) The distribution of climatic suitability showed an obvious decadal change. Climate warming and drying induced a decrease of the suitability area in China since 1980s. (2) The sensitive area to climate change included the northern part of Heilongjiang province, eastern Inner Mongolia province, central and southern Hebei province, most of Shanxi and Shaanxi province, southern Gansu province and central Sichuan province. (3) Interactive temperature and precipitation affected the northern boundary. The northern boundary in China moved southward and withdrew eastward in 1970s compare with 1960s, and only withdrew eastwards in 2000s compare with 1990s.

As for double-cropping rice cultivation, (1) The total area of climatically suitable regions was highest in the 1960s, and subsequently showed an increasing trend at first and then a decreasing trend from the 1970s to 2000s. However, the low climatic suitability area decreased, which implied that the moderate and high climatic suitability areas increased. Among the latter, the high climatic suitability area showed the highest increase in extent to 4.4 times that of the 1990s and four times that of the 1960s. (2) The areas most sensitive to climate change are mainly located in central Jiangsu, central Anhui, the eastern Sichuan Basin, southern Henan and central Guizhou. Transformation of areas between low and moderate climatic suitability was observed in northern Zhejiang, southern Anhui and Hubei, and northern Guangxi. Transformation of areas between moderate and high climatic suitability was observed in central Jiangxi and Leizhou Peninsula. (3) The northern boundary shifted southwards and contracted eastwards in the 1970s, and extended northwards in the 1980s in China. However, the northern boundary did not shift northwards in response to climate warming in the 2000s.

[P6-2]

VARIATION OF SOIL RESPIRATION IN RICE PADDY-FIELD IN GIMJE, KOREA

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Most rice paddies are intensively managed and unique agro-ecosystems; soil flooding is general performance for rice cultivation and decomposition of plant residues is shown to be the active process in carbon cycling in rice paddy. Therefore, Rice paddy has an important role in the global budget of green house gases. To improve understanding of the CO_2 exchange in rice paddy, the seasonal amounts of carbon fixed CO_2 in primary production and that respired CO_2 by the soil exchange were investigated employing the floating" automatic opening /closing chamber (AOCC) method in Gimje in the southwestern coast of Korea. Soil chamber measurements were performed in the Gimje field. The advantage of the AOCC system is that it provides measurements at a high time resolution and it also minimizes disturbances to cultivate environmental factors. During pre-tranplant period (from Oct. in 2012 to May. In 2013), daily mean soil respiration rate (Rs) was 21.1 mg CO_2 m^{-2} h^{-1}. Rs was shown very low value (< 53 mg CO_2 m^{-2} h^{-1}) from transplanting of rice to midsummer drainage. During midsummer drainage, Rs was increased with decreasing water level. After than Rs was rapidly decreased with supply of water. In a conclusion, Rs in rice paddy field was fluctuated by change of environmental factors such as temperature and soil water contents, greatly influenced by cultivation practices and field management (e.g. stable manure amendment, seeding or transplanting of rice, water management, harvest, treatment of harvest residuals and plowing).

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[P6-3]

BIOMASS ALLOCATION PATTERN AND SOIL RESPIRATION IN TEMPERATE GRASSLAND ECOSYSTEM

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We measured the *SR* in three different biomass allocation pattern communities (*Miscanthus sinensis* var. *purpurascens*, *Solidago altissima*, and *Imperata cylindrica* var. *koenigii* communities in temperate grassland in Japan). The SR was measured using the open-flow method from June 2002 through May 2003. Five plots (2×2 m^2) were established within each of three communities for *SR* measurements, and one collar was installed at each plot. SR data was rotationally collected from collar No. 1 to five for five days in each community. To calculate the contribution ratio of the soil surface litter decomposition to annual SR, aboveground plant part was harvested at representative point of the four quadrates (1x1 m^2) in the one community in Nov. 2001.. Annual productivity of aboveground of *S. altissima*, *I. cylindrica* var. *koenigii*, and *M. sinensis* var. *purpurascens* communities were 0.72, 0.83 and 3.35 kg d.w. m^{-2} yr^{-1}, respectively. The aboveground to belowground (new-bud) biomass was high value about 1.3 times in *S. altissima* community, 2.3 times in *I. cylindrica* var. *koenigii* community, and 4.0 times in *M. sinensis* var. *purpurascens* community. The SR was relatively high in lateral compared with former succession stage. The annual SR in *S. altissima*, *I. cylindrica* var. *koenigii* and *M. sinensis* var. *purpurascens* communities were 520, 430, and 2,020 g C m^{-2} yr^{-1}, respectively. The contributions of aboveground litter to annual SR were estimated about 27% for *S. altissima*, 28% for *I. cylindrica* var. *koenigii* and 31% for *M. sinensis* var. *purpurascens* community. Our results confirm our hypothesis that significant changes in SR according to the successional stages resulted from differences in biomass allocation patterns among communities. Based on the results of our study, we suggest that the changes of biomass allocation patterns according to successional stages should be considered as one of critical factors in the estimation of temperate grassland carbon budget.

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[P6-4]

EFFECT OF SOIL MOISTURE CONTENTS ON SOIL RESPIRATION IN TEMPERATE DECIDUOUS FOREST, KOREA

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Understanding of relationships between soil respiration (*SR*) and environmental factor is strongly demanded for simulating the carbon cycle dynamics of an ecosystem related to the control of the global warming. Therefore, it is very important how the soil respiration relates to ecological factors such as temperature or soil water content. We aim to find characteristics of relationship between the soil respiration and various environmental factors and change of annual value of soil respiration due to different meteorological factor in each year under the long term measurement. Soil respiration (SR) was collected by automatic opening/closing chamber system (AOCC) based on closed dynamic method composed with six chambers, and was collect 24 data per a day in each chamber. Also, we measured air (Ta) and soil (Ts, 5cm depth) temperatures, and soil water contents (SMC) at the 0~10cm and 0~30cm soil depths in near chambers. Also, precipitation was collected on forest floor in site. SR was weakly correlated to SMC (R^2=0.15), but it was shown high correlation to Ts (R^2=0.74). However, correlation coefficients between SMC and SR were shown varies values in different range of Ts showing 0.19 in range under 5 ^{o}C, 0.245^{o}C in ranging from 5^{o}C to 15^{o}C, and 0.32 in range above 15^{o}C. Also, under the high Ts condition, SR was highly correlated to SMC. On the other way, during the summer rainy season, when SMC was maintained a high level for a long time resulted from long heavy rain, SR was significantly decreased. In this study, change of *SR* was highly correlated seasonal change of SMC. However, SMC showed working with another control factor in high temperature season above about 15^{o}C. Therefore, gap filling or calculating of SR using the exponential function based on only one relationship between Ts and SR is not desirable. In conclusion, to calculate more accurate SR value, we suggest that it can be helpful to have relationship between SR and SMC at least high temperature season.

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[P6-5]

LESS WEED, LOW SEED RATE AND MORE YIELD ENSURED BY MACHINE SEEDER IN RICE –MUSTARD –RICE CROPPING SYSTEM

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Cropping system can reduce farmers risk as well as changing the climate factor. Mustard is one of the important crops in Rice –mustard –Rice cropping pattern and it is getting wide popularity in Bangladesh. Traditional broadcasting of mustard in a well-plowed land often give irregular plant stand and involves high seed cost. Mechanized seeding quickens land preparation and seeding process, and thus reduces the turnaround time as well as timely seeding which it makes possible proper winter rice cultivation. Mustard was seeded by machine seeder through 2 wheel power tiller and compared with the traditional broadcasting practice. For machine sowing spacing was maintained line to line 30 cm and broadcasting method plant spacing didn't maintain. After seeding the field was leveled by laddering and fertilizer application was same in both methods.The trials was repeated at four farmer's field in Northern region of Bangladesh. The experiment area has a subtropical climate. Seeding time was November, 2013. 2 wheel machine seeder was save 34% seed than broadcasting method. Due to plant spacing plant growth and development well in machine seeder mustard than broadcasting mustard. Highest weed biomass was found in broadcast method. Machine seeder Mustard reduced 84% weed biomass compare with traditional broadcasting fields. In broadcasting mustard field, major weed infested by common chickweed which cover 52% of total weed. The machine seeded mustard gave 32% higher grain yield compared to the broadcasting method. Due to maintain proper plant spacing and low weed infestation resulting highest grain yield of mustard. The machine seeded showed 26% more branching and 13%higher 1,000 grain weight than broadcasting method. On the other hand machine seeder method increased gross return and variable cost than broadcast method by 37% and 13%, respectively. Each village, farmers have 2 wheel power tillers. The power tiller machine is available in farm level. By adding seeder in 2 wheel power tiller that could be used multipurpose of wheat, Maize, jute and Pulse seeder. Newly invented of Seeder machine cost is 350$.The seeder machine is new opportunity to work with the farmers that earn more money as a service provider of seeder machine and disseminate the new technology in the Community level.

[P6-6]

MEASURING CO_2 EMISSIONS FROM BARE PEAT SWAMP AREA IN SARAWAK USING CLOSED CHAMBER TECHNIQUE

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Conversion of Tropical Peat Swamp into cultivation area will lead to carbon emissions once the peat is drained. A study was undertaken to measure the baseline CO_2 emissions from a newly developed logged-over peat swamp area that was purposely kept free of vegetation. A portable CO_2 analyzer (EGM-4, PP-System, UK) was used to determine the soil CO_2 emissions from bare drained peat soil area. Soil CO_2 emission was calculated by performing a linear regression on the rate of increase in CO_2 concentration within the closed soil chamber over time. The measurements were done at monthly intervals over a one-year period in 16 sub-plots (25 m x 25 m) in the one hectare study plot with three replications per sub-plot. At each measuring point, soil temperature (STP-1 Soil Temperature Probe, PP-System, UK) and soil moisture (Hydrosense CD620 & CS620, Campbell Scientific, USA) were measured at 5 to 10 cm depth below the peat surface. The soil CO_2 efflux rate measured by the portable soil survey chamber technique was about 3.32±0.10 µmol m^{-2} s^{-1} with soil temperature and volumetric soil moisture of 28.91±0.04°C and 31.85±0.12% respectively. The average water table recorded was about -43.64±0.61cm below the peat surface.

[P6-7]

ECOPHYSIOLOGICAL REMOTE SEINSING OF CANOPY PHENOLOGY IN A COOL-TEMPERATE DECIDUOUS FOREST IN JAPAN

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Leaf optical properties (spectral reflectance, absorption and transmittance of radiation) reflect leaf biochemical components, such as pigments contents and anatomical structures (Gitelson et al. 1996; Sims and Gamon 2002; Ustin et al. 2004; Asner et al. 2009). The reflectance and transmittance of radiation by the leaves in a canopy, which radiative transfer models express (Verhoef 1984), affect the diffuse light environment. Thus detailed information of the consequence between ecophysiological traits and optical properties at single leaf level realizes the remote sensing of ecophysiological function of canopies. The aim of our research is to clarify the relationships between leaf-level ecophysiology and optical properties in forest canopy trees, and then to apply those relationships to satellite imagery for landscape-level observation.

Our research site, Takayama site (36°08′N, 137°25′E, 1,420 m a.s.l.), is a cool-template deciduous broadleaf forest and is one of core research sites of AsiaFlux, JaLTER (Japan Long Tern Ecological Research network) and PEN (Phenological Eyes Network). In-situ measurement of canopy spectral reflectance, which is then used for calculating vegetation index, has been conducted by using spectroradiometer MS-700 (Eko Instrument, Japan) since 2004. In this study, to link leaf ecophysiological traits to the remote sensing of canopy phenology, leaf mass per area (*LMA*), nitrogen contents, chlorophyll contents, and photosynthetic traits (V_{cmax} and J_{max}) were measured for dominant canopy tree species *Quercus crispla* and *Betula ermanii* throughout the seasons for seven years during 2003-2010 (except 2008). In addition, the optical properties (reflectance and transmittance spectra) of single leaf were also measured in these years.

Leaf budbreak occurred in mid to late May, after two to three weeks of snowmelt, and the photosynthetic capacity increased gradually in *Q. crispula* but quickly in *B. ermanii*. Photosynthetic capacity was largely correlated with chlorophyll contents throughout the growing season. In these leaves, the reflectance at “Red Edge” (705 nm) changed by corresponding to the changes of chlorophyll contents throughout the seasons. These results suggested that photosynthetic capacity of the canopy could be detected by remote sensing by focusing on the reflectance at Red Edge. In addition, our canopy-level examination showed that canopy chlorophyll index (CCI), which was obtained by Red Edge reflectance, has linear relationship with canopy photosynthetic capacity which was estimated by a canopy photosynthesis model. Finally we apply this knowledge to the Rapid Eye satellite imagery around Takayama site.

[P6-8]

CARBON DECOMPOSITION PROCESS OF THE RESIDUAL BIOMASS IN THEPADDY SOIL OF A SINGLE-CROP RICE FIELD

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In cultivated fields, residual organic matter is plowed into soil after harvest and decaying in fallow season. Greenhouse gases such as CO_2 and CH_4 is generated by the decomposition of the substantial organic matter and released into the atmosphere. In some fields, open burning is carried out by tradition, when carbon in residual matter is released into atmosphere as CO_2. However, burning effect on carbon budget between crop lands and atmosphere is not entirely considered yet.

In this study, coarse organic matter (COM) in paddy soil of a single-crop rice field was sampled on regular intervals between January, 2011 and August, 2014 The amount of carbon release from residual matter was estimated by analyzing of the variations in carbon content of COM. Effects of soil temperature (Ts) and soil water content (SWC) at the paddy field on the rate of carbon decomposition was investigated. Though decreasing rate of COM was much smaller in winter season, it is accelerated at the warming season between April and June every year. Decomposition was resisted for next rice cultivated season despite of highest soil temperature.

In addition, the observational field was divided into two areas, and three time open burning experiments were conducted in November, 2011, 2012, and 2013. In each year, three sampling surveys, or plants before harvest and residuals before and after the burning experiment, were done. From these surveys, it is suggested that about 48±2% of carbon contents of above-ground plant was yield out as grain by harvest, and about 27±2% of carbon emitted as CO_2 by burning. Carbon content of residuals plowed into soil after the harvest was estimated 293±1 and 220±36gC/m^2 in no-burned and burned area, respectively, based on three-years average. It is estimated that 70 and 60% of the first input amount of COM was decomposed after a year in no-burned and burned area, respectively.

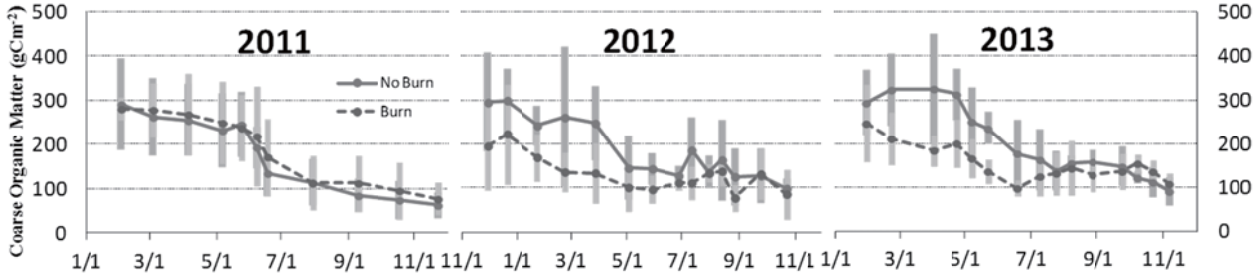

Fig.1 Seasonal variations of COM from 2011 to 2013

[P6-9]

EFFECT OF BACTERIAL MATERIAL ON STRAW DECOMPOSITION AND GREENHOUSE GAS EMISSION FROM PADDY SOIL

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Methane (CH_4) has about 25 times stronger greenhouse effect to carbon dioxide (CO_2) in mole basis. About 10% of the total emissions is emitted from paddy field. Paddy field is an important source of greenhouse gases production because it is supplied with a lot of organic matter like rice straw and microbial activity also changes in accordance with rice cultivation. As countermeasures to reduce CH_4 emission from paddy field, water management such as midseason drainage and intermittent irrigation, and organic matter management such as promoting decomposition of organic matter in the non-submerged period and composting of rice straw are proposed. To control CH_4 emission, application of bacterial material before flooding period is considered to be an effective method, because it can promote aerobic decomposition of fresh organic matter which is substrate of methanogens. In this study, we investigated the effect of bacterial material including spores of *Bacillus subtilis* and *Clostridium acetobutylicum* on the rice growth and greenhouse gas emissions including CH_4 in paddy field and pot experiment.

Experimental treatments are similar to field experiment and pot experiment. We have cultivated rice under the similar environmental condition. Three treatments were set up; 1st, Soil only (control), 2nd, Urea+Rice straw, and last, Urea+Rice straw+Bacterial material. We collected gas samples at every 2-3 days before flooding, and every 2 weeks after flooding. Gas was collected by using closed chamber method, and gas fluxes were analysed in the laboratory with gas chromatographs. Under aerobic conditions, CO_2 flux was measured. Under anaerobic conditions, CH_4 flux was measured. In addition, other soil parameters such as Eh were measured during the cultivation period.

As a result of using the microbial material, the amount of CO_2 emission was maximized under aerobic conditions and amount of CH_4 emission was minimized under anaerobic condition. It is considered to be the effect of organic matter decomposition promoted by microorganisms which is included by using the microbial material. By the promoting effect under aerobic conditions, the amount of CH_4 emissions and total CO_2eq were decreased.

[P6-10]

THE VARIATIONS OF OXIDATION-REDUCTION POTENTIAL IN PADDY SOIL AND EFFECTS ON THE METHANE EMISSION FROM A PERIODICALLY IRRIGATED PADDY FIELD

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Paddy fields are one of the most important eco-system in monsoon Asia and one of the largest source of CH4 emission. CH4 has significant contribution to the global warming next to CO2 and its greenhouse effect is about 21 times as large as same amount of CO2. CH4 is generated by decomposition of organic matter in soil under anaerobic condition. Oxidation-Reduction Potential (ORP) is the most suitable index representing soil aerobic condition. Or, CH4 is more generated under lower ORP conditions.

In this study, ORP in paddy soil was measured during rice cultivated season at a periodically irrigated paddy field, and some effects on the methane flux from the paddy soil was investigated. 3-days flood and 4-days drained condition were regularly repeated at the site from late-June to early October. ORP under flooded condition was measured during irrigated term in 2013 at two mode; regular interval measurement every 2 weeks and intensive measurements during two flooded periods. Methane flux was also measured by the aerodynamic gradient technique.

ORP showed rapid decrease when irrigation water was introduced in the paddy field, and lower ORP was shown under the longer flooded condition. From the seasonal-term point of view, lower ORP was shown in later rice season. ORP was suitably modeled as a function of irrigation time. During an irrigation period for four days, higher methane emissions were shown under lower OPR conditions as shown in Fig.1. From the seasonal-term point of view, however, no significant relationship between ORP and methane fluxes. Rapid rise of CH4 flux in early August and gradual decrease between late August and September were shown. It is suggested that seasonal change of methane flux is affected by seasonal changes of soil temperature or the growth level of rice plants.

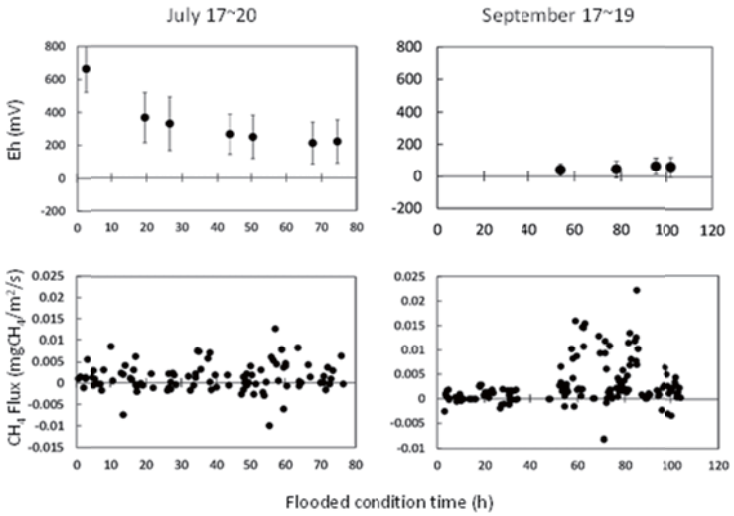

Fig.1. ORP and CH4 flux during an irrigation period for four days

[P6-11]

EFFECT OF NITROGEN FERTILIZATION ON EMISSION OF GREENHOUSE GAS FROM SOIL IN OIL PALM PLANTATION

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Large-scale land developments are going for oil palm plantation in Indonesia and Malaysia. Nitrogen fertilization on the farm is considered to induce groundwater pollution by nitrate leaching and increase of N_2O emissions to the atmosphere. We examined the effect of nitrogen fertilization (conventional fertilizer, coated fertilizer) on N_2O emissions from soil in oil palm plantations.

The field experiment was carried out in oil palm plantation near Sibu, Sarawak, Malaysia. N_2O and CO_2 fluxes were determined by placing a 20.8 cm diameter and 14.2 cm high PVC pipe chamber to soil depth of 5 cm. Gas samples were taken after it had been sealed for approximately 5 minutes, by connecting a 30 ml gas syringe with tubes to the chamber. Gas samples were collected at 0-, 10-, and 20-minute intervals and were injected into a glass vial that had been evacuated and closed tightly with butyl rubber seals. The filled vials were transported to the laboratory, and the gas fluxes were measured by gas chromatographs.

Several treatments of different form, application method and rate were set up. These treatments were; conventional fertilizer (C), MEISTER, which is coated urea, localized application (ML100), MEISTER broadcasting application (MB100), reduced rate of MEISTER localized application (ML50), reduced rate of MEISTER broadcasting application (MB50), to compare with nitrogen free (B1) and nitrogen free plus tillage (B2). ML50 and MB50 were reduced by 50 percent in nitrogen rates as compared to 100 (same as conventional).

N_2O emissions of localized application were smaller than broadcasting application. Also reducing application rate decreased N_2O emissions. There was no difference in conventional fertilizer and coated urea localized application. However, N_2O emissions of broadcasting application, MB50 and MB100, showed a larger value than conventional fertilizer. From these results, it was suggested that the effect of the physical environment such as soil moisture is heavily involved in N_2O emissions rather than the effect of the form of nitrogen fertilizer.

[P6-12]

CHARACTERISTICS OF METHANE EMISSION FROM A PERIODICALLY IRRIGATED PADDY FIELD IN JAPAN

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Methane (CH_4) is generated by organic matter decomposition in the anaerobic soil. Paddy field is one of the most important eco-system in monsoon Asia. It is said that about 10% of CH_4 sources is paddy fields (IPCC AR4, 2007). In this study, methane emission from a single-rice crop field was estimated by long-term micrometeorological measurements. Methane emission was calculated by the aerodynamic gradient technique from January 2011 to August 2014. Intermittent water management was carried out during cultivation period at the observational site, HCH, located in Okayama, Japan. 3-days flood and 4-days drained condition were regularly repeated from late-June to early October.

Seasonal variations of CH_4 flux for irrigation term from 2011 to 2013 were shown in Fig.1. Remarkably large fluxes were shown at early stage of irrigation term in 2011.It seemed to be caused by the relatively longer flooded condition that the first flooded period was 20 days. Flux in 2012 was smaller than in other year through the entire irrigation period. Rapid rise in flux for early August and gradual decrease between late August and September were shown in 2013. Fluxes under drained condition showed larger emission than under flooded condition. Cumulative CH_4 emissions during cultivated period from 2011 to 2013 were estimated 15.7, 8.6, and 12.9 gC/m^2, respectively.

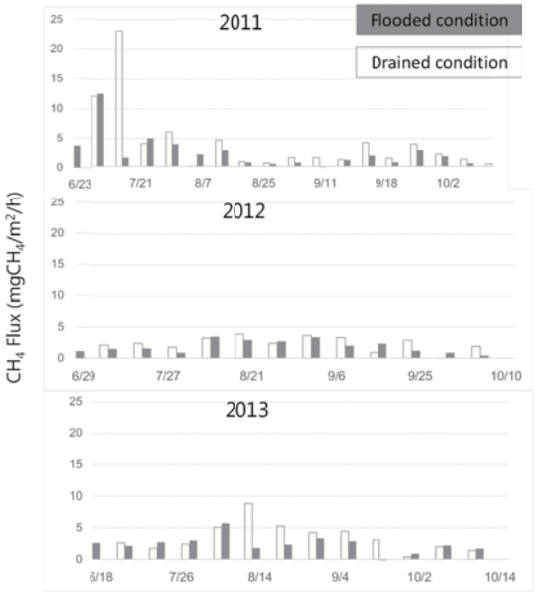

Fig.1 Seasonal variations of CH_4 flux for irrigation term from 2011 to 2013

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