# REPORTS OF SYNTHESIS SESSIONS

Second IGBP Congress
Shonan Village, Japan
7-13 May 1999

# Synthesis Session Reports
# 10 May

## CT1 Causes and consequences of land use in the tropics

Design and approach of this synthesis session somewhat different from others: present an IGBP overview synthesis framework, to see if it works and to get comments and advice

Emphasis on two aspects:

- LU: recognized as a major GEC
- Tropical forest biome: several IGBP-relevant characteristics, including biogeochemical attributes and biodiversity importance

Objective: session NOT directed to provide complete review and synthesis of what we know or of IGBP work; rather, provide examples of the variety of ways LU influences other regional/global changes, hoping this would promote discussion among projects, that contributes to synthesis and integration of IGBP.

How? The framework

Five selected talks (examples)

*The determinants of land-use change – Billie Turner*

- Understanding determinants requires regional analysis and large structural changes (political and economic) are most important in driving major shifts in land cover/use

*Effects on biodiversity and ecological systems – Rodolfo Dirzo*

- Loss of biological diversity is an irreversible global change

*Effects on biogeochemical cycles and trace gas exchange – Pamela Matson*

- In terms of C sinks and trace gas sources, fate and management following land clearing matters most... and temperate zone 'truisms' may not hold in the tropics.

*Effects on hydrological cycles and climate – Carlos Nobre*

- Local and regional (and maybe global) climates are affected by land-use change ... and models must account for the spatially heterogeneous nature of change and for vegetation-surface-climate interactions.

*Biomass burning and effects on the atmosphere – Guy Brasseur*

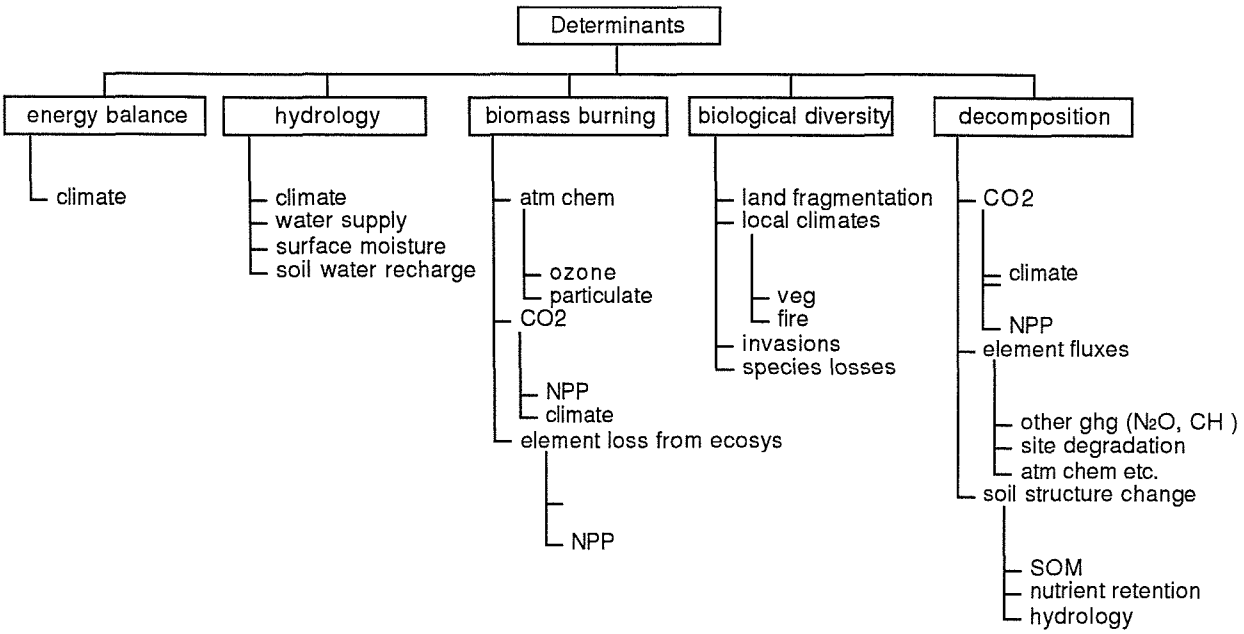
- Convection patterns in the tropics increase potential for burning to influence global system, including upper troposphere and lateral circulation.

### Conclusions

- Natural variability matters (no such thing as 'the tropical forest') ... and heterogeneity and fragmentation in land-use change also matter
- Landscape interactions are crucial and many important effects are felt at great distance from the site of change. (e.g. land-use change – coastal systems, coral reefs, ocean productivity)
- Tropics, due to biological diversity, biophysical properties (convective conditions, NPP, soils, etc.), and current rate of change, are critical areas to focus research on global change.

And ...

- The approach tested in this session provides a mechanism for discussion among Core Projects, for synthesis, and for looking towards future integration.




## Participants

Pamela Matson, Billie Turner III, A. Takahashi, Rodolfo Dirzo, Paul Falkowski, Isao Koike, Inder Pal Abrol, Qinxue Wang, João Morais, Günther Fischer, Eric Lambin, M. Tsuruta, Arvin Mosier, Isamu Kayane, Ian Noble, Masashi Nakano, Tom Pedersen, Roger François, Graham Shimmield, Hiroshi Koigumi, Volkmar Wolters, Osvaldo Sala, Vera Markgraf, Platt Bradbury, Ron Rindfuss, Stephen V. Smith, Han Lindeboom, Dan Jaffe, Paul Harrison, Ryuji Tada, Pavel Kabat, Wolfgang Cramer, Philip Newton, Roland Schulze, Andy Pitman, Roger Pielke Sr., Bert Bolin, David Goodrich, Patricia Matrai, Yasuyuki Oshima, Nobuhiko Handa, Kazuo Mabuchi, Yoshikazu Fukushima, Ryosuke Shibasaki, Pep Canadell, Matti Saarnisto, François Carlotti, Serge Poulet, Bill Aalbersberg, Lekan Oyebande, Hartwig Kremer, T.K. Fernando, E. Konohira, Takahito Yoshioka, Congbin Fu, Meine van Noodrwijk, H-U. Neue, Jotaro Urabe, Chae-Shik Rho, Patrick Buat-Ménard, Julian Priddle, Paul Tréguer, Tek Bahadur Gurung, Anne Larigauderie, Roger Hanson, William Batista, Rob Jackson, John Dearing, Terry Chapin, Jahara Yahaya, Peter Gregory, John Ingram, Bill Burnett, Akihiko Ito, Hideaki Shibata.

# B5 Global change in mountain regions

- The session was chaired by Harald Bugmann and John Tenhunen (as a substitute for Alfred Becker); after introductory remarks (Tenhunen), a series of presentations followed, dealing with research challenges in mountain regions in the 21st century (Messerli), an introduction to the contents of the Mountain Initiative (Bugmann) and contributions with respect to specific aspects of the Initiative (Sanchez, Körner, Grabherr). The remainder of the session (one hour) was devoted to an open discussion.
- The participants expressed their awareness that the Mountain Initiative in its current form reaches beyond IGBP, and its full implementation would have to involve partner programmes like IHDP, GTOS/GCOS, and others.
- At the same time, it was agreed that a considerable body of research on mountain issues is going on within IGBP, which thus is relevant for the Mountain Initiative.
- Due to the fact that mountain regions are not geographically coherent (in contrast to, e.g., the Arctic) and that the relative importance of global change drivers varies from one mountain region to the other (e.g. land use change vs. N deposition), improved communication and coordination of global change research across the different mountain regions is a high priority, both within and beyond IGBP.

- The participants agreed upon using the "International Year of Mountains" (2002) as a medium-term milestone for a synthesis of IGBP research in mountains. This time frame of 2-3 years also allows us to start a limited number of research projects to complement ongoing IGBP research.
- It was recognized that these activities need to have a clear focus, and the session participants agreed that they should be based on a small number of case study regions (3-5). Global comprehensiveness is not desired and not possible at this stage.
- Structurally, the Mountain Initiative is anchored in the Implementation Plans of GCTE and BAHC. Over the past year, PAGES was becoming increasingly involved in the development of the Initiative. At the session, LUCC also expressed interest in being a partner in the network, and LUCC projects such as those in the Hindu-kush-Himalaya should be included in the case study regions.
- The session participants supported the idea that within IGBP, the Mountain Initiative should be considered as an inter-core project collaboration by BAHC, GCTE, PAGES, and LUCC.
- Therefore we are asking the SSCs of the four participating Core Projects to endorse the Mountain Initiative in their meetings on the last day of the 2nd IGBP Congress, as follows:
  - The Core Project-related activities as formulated in the Mountain Initiative are in agreement with the science agenda of the Core Project and therefore constitute a part of the Core Project's implementation plan.
  - Additional scientific value will be added to the research through this inter-Core Project collaboration
  - Each Core Project nominates a contact person for the Mountain Initiative (in the case of BAHC and GCTE, this has already been done by the nomination of Task and Key Theme Leaders, respectively).
  - The Core Projects support publication of the document describing the Mountain Initiative, preferably in the IGBP Report series.

## Contact person for follow-ups

Harald Bugmann, Fax +1-303-497-1695, e-mail harald@colorado.edu.

## Participants

Sabine Lütkemeier, Coleen Vogel, Frank Oldfield, José Boninsegna, Jeff McDonnell, Masatoshi Yoshino, Harald Bugmann, Yoshihiro Fukushima, James F. Reynolds, Ray Bradley, James Syvitski, Takeshi Ohta, Charles Vörösmarty, Christian Körner, Sune Linder, Yoshitaka Kakubari, Takashige Sugimoto, Atsuko Sugimoto, Kanehiro Kitayama, Brad Wilcox, Georg Grabherr, Yugo Ono, Claude Lorius, Yukihiro Chiba, Bob Wasson, Arturo Sanchez, Emilio Moran, Jill Jäger, Bruno Messerli, John Tenhunen.

*Distribution list for these minutes:*
- Will Steffen
- Pavel Kabat, Holger Hoff (BAHC)
- Ian Noble, Pep Canadell (GCTE)
- Tom Pedersen, Frank Oldfield (PAGES)
- Eric Lambin, Emilio Moran (LUCC)

# GM3 Earth Observing Network: $CO_2$ and other trace gases

This group discussed the feasibility of a global system for measuring several trace gases relevant to the Kyoto Protocol such as $CO_2$, $CH_4$, $N_2O$, isotopes and also other species such as aerosols and ozone to augment existing networks.

Much of the discussion in this session centred on the purpose and objectives of such a network. Recognition was given to the impetus that the Kyoto agreement might provide for augmenting existing long term programmes such as FLUXNET and the World Meteorological Organization (WMO) Global Atmospheric Watch (GAW). It was recognized that the stations in these two programmes may not be in the best location for constraining the models.

Various approaches to better quantifying the terrestrial and oceanic source-sinks terms were discussed including bottom-up ecosystem modelling approach and top-down atmospheric inversion modelling.

Although satellites provide the spatial coverage needed, sensors are just starting now to obtaining vertical profiles and tropospheric concentrations. But, satellite measurements will always be indirect proxy of measured concentrations.

The role of ocean sources or sinks should be addressed within this network in an integrated fashion with the terrestrial ecosystems.

Vertical profiles of concentrations and isotopes are important and would be an important addition to existing surface measurements.

It is necessary to have a significant input from modellers in the design of the network.

A comprehensive EOS must include terrestrial, atmospheric and oceanic systems.

Basic question: what controls the changes in sources and sinks and distribution of trace gases in the atmosphere?

## Objectives

| | |
|---|---|
| Sources: | emissions, biomes, etc. |
| Sinks: | atmospheric reactive chemistry, ocean, biomes, etc. |
| Transport: | vertical profiles (boundary layer, day-night, etc.) |
| | horizontal (inverse models, meteorology) |

## What to measure?

Basically $CO_2$, $NH_4$, $N_2O$, aerosols, $O_3$, isotopes, plus additional measurements

## What should IGBP do about it?

In order to prepare a position paper or science plan for the 2001 IGBP Open Science Conference, IGBP should convene a workshop of selected experts to address specifically the question of what is really needed to constrain the global and regional carbon cycle models and what there needs to be addressed by improvements/additions to existing global observing stations (GAW) and regional/local stations (FLUXNET) and others. Where and what additional measurements might be needed to better constrain the atmosphere, ocean and terrestrial models. This would lead to the foundation for establishing an IBY (International Biosphere Year, see below)

## International Biosphere Year

It was agreed that we should have an IBY focus on a comprehensive efforts aiming at improving the understanding geographical distribution of sources and sinks of key trace gases. This idea follows the International Geophysical Years, where an organized and coherent global measurement programme is put in place. It should be a comprehensive effort on global observations. It is necessary to organize a science meeting to bring up a science plan to be discussed in IGBP 2001 Open Science Conference.

## Contact person for follow-ups

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## Participants

Dork Sahagian, Vyacheslav Khattatov, Danesh C. Parashar, Paulo Artaxo, Neil Trivett, Han Dolman, Kathy Hibbard, Shyam Lal, Patrick Monfray, Elliot Atlas, Jim Ehleringer, G. Alexandrov, Bob Scholes, Thelma Krug, Rik Leemans, Nadia Pinardi, Tsutomu Nakamura, Tetsuya Hiyama, Barry Huebert, Paul Crutzen, Kathy Law, Alex Pszenny.

# D1 Data management

## 1. Introduction

Thirty-six participants representing all Core Projects attended the session. Gérard Szejwach (IGBP-DIS IPO) introduced the meeting objectives and highlighted the main points to be addressed during the session. Neil Hamilton (START) agreed to be the rapporteur.

The introduction was followed by a short presentation from Philippe Martin. He presented the BAHC needs from IGBP-DIS: users should drive the data production process from end to end, a distributed approach should be followed (including for data centres, e.g. the EC JRC), IGBP-DIS should strive to involve European and other space agencies and should establish links with other programmes such as WCRP, IGBP-DIS should also produce gridded, global, multiple-resolution data products.

## 2. Discussion

The following main themes were addressed during the session:

- Data sets, metadata, data quality
- Data generation process
- Data/information access, exchange, availability
- Data legacy and long-term archival of IGBP data

### *2.1 Data sets, metadata, data quality*

It was agreed that both global and regional data should be part of the new IGBP-DIS mandate (the current mandate is restricted to global datasets). IGBP-DIS should review what relevant data sets exist (within IGBP and from other sources such as WCRP or the GxOS) in order to avoid duplication of efforts. IGBP-DIS should address datasets relevant to several Core Projects or crosscutting issues. When deriving a product, there should be flexibility on scale and coverage since requirements may be different depending on specific usage. Data sub-setting was an essential requirement for regions. It was also proposed to include relevant processing software (in particular for scaling purpose) in the data package. Participants confirmed that information on data (metadata) was essential, and should include information on data quality. A number of participants insisted on the fact that knowledge about the original source of data (e.g. point data) was essential.

Concerning existing global IGBP-DIS data sets, it was proposed that a task force composed of scientists and data producers evaluate the possibility of adapting already produced data sets to better suit the science needs (e.g. reformatting, partitioning into suitable subsets, or re-analyzing the data)

### *2.2 Data generation process*

User management at all stages of the processing was considered essential. Participants stressed the fact that the whole process should be user driven and should address inter-project needs. The proposed task team approach was welcomed as long as scientists led it. It was recognized that the role of IGBP-DIS is mainly to "facilitate" and coordinate rather than performing the processing. The concept of "thematic" data bundle (for global and regional data) was endorsed as long as the definition of the contents was made and agreed by scientists (demand driven approach). The theme approach for global data bundle was endorsed as a contribution to the synthesis but the point was made that there were time constraints and that data bundles could be usefully applied as a research tool. Data bundle could consist of a collection of parameters or derived data, models, model outputs and associated software. Data bundles represent a product of IGBP research, a tool to facilitate interdisciplinary research, and a support, to back-up results, of IGBP science.

### *2.3 Data access, exchange, availability*

A major problem within IGBP (as well as in the rest of the scientific community) concerns the willingness of researchers to make their data available. This was considered as a major issue as it had large negative implications on the data exchange process. It was recognized that the issues of intellectual property and acknowledgement were not to be addressed by IGBP-DIS. The Secretariat, or SC-IGBP (acting as a moral authority) could possibly produce general guidelines for IGBP scientists, and adopt a consistent way of reacting when problems arise. Regarding remote sensed data, IGBP-DIS has a role in

ensuring optimum access though Space Agencies. The IGBP research tool was also seen as a first step in the facilitation of data and information access and exchange.

### *2.4 Data legacy and long-term archival of IGBP data*

It was proposed that IGBP data should be maintained and archived on a long-term basis in Institutes with an archiving mandate such as those associated with the WDC system, in order to ensure that important databases are kept. This is consistent with the outcome of the joint IGBP-WDC workshop held in Boulder in 1997. Scientists should be encouraged to make use of that system.

## Participants

Michael Hutchinson, Géraldine Verrière, Harriet Barker, Jean-Pierre Lacaux, Lelys Guenni, Upik Rosalina, Beatriz Baliño, Holger Hoff, Gerardo Perillo, Tony Hunt, Bob Groman, Kiyoshi Tuschiya, Hiorya Yamano, Toshiro Saino, Neil Hamilton, Byong-Lyol Lee, Eric Odada, John Gash, Roland Fuchs, Jonathan Overpeck, Yasushi Asai, Keith Alverson, Lou Pitelka, Bob Sutherst, Hassan Virji, Laurent Labeyrie, Philippe Martin, Reinder Feddes, Will Steffen, Neil Swanberg, Xavier Baulies, Chris Crossland, Gérard Szejwach, Celia Marrase, Sergei Piontkovski, G.B. Pant.

# Synthesis Session Reports
# 11 May

## CT2/J2 Carbon Synthesis

### Themes

1. WHAT do we know about the Carbon cycle?
    a. 2nd Carbon meeting at Scripps in February, 2000 to debate the issues and to look beyond the fast-track (a broader perspective). The Scripps meeting to be in the same vein as the SCOPE books.
    b. What we know, or think we know:
3. Fossil fuel combustion is the primary cause for (b)
4. Rise in atmospheric $CO_2$
5. Palaeo

Primary cause for the rise in atmospheric $CO_2$ is fossil fuel combustion, secondarily from land-use changes. Evidence of our understanding is from the Suess effect, the Mauna Loa increases.

We think we know pretty well (6 Gt/Y → within +-10%) fossil fuel emissions, palaeo record shows that variations in $CO_2$ not abrupt like the methane record.

Can we improve upon the Schimel (1995) numbers?

### Our uncertainties revolve around:

1. Global budget

    b. Specific geographic distributions of atmospheric $CO_2$ ‡e.g. east vs. west partitioning ‡we can't really identify this with any certainty.
    c. Uncertainties in the tropical land fluxes. The atmospheric signal is more mixed in low latitudes.
    d. The net land term is unclear
    e. Oceans
    f. Of the total atmospheric emissions, 42% is in the airborne fraction and we know that there is a sink. The strongest evidence supports a terrestrial sink. The ocean net uptake is fairly well constrained by $^{14}C$. The observations (emissions in the north) across the meridional gradient also supports a sink in the Northern Hemisphere.
    g. Major debate to date: what is controlling the terrestrial sink and where is it?

Phase II: what are the land/ocean dynamics:

1. Introduction
2. Ocean (net) fluxes
    2.1 introduction and diagram
    2.2 perturbation mechanisms
    2.3 spatial and temporal patterns
3. Land fluxes
    3.1 Introduction and diagram
    3.2 Perturbation mechanisms
    3.3 Spatial and temporal patterns
    3.4 Carbon transport from land and oceans

**OCMIP Summary**- Phase I – 4 models - models agree **+- 2 Gt C/y as a consensus number ~19% of total uptake for the 1980s,** however they differed substantially geographically – particularly in the southern ocean. All models at least agreed that 30-50% of the uptake IS in the southern Oceans. Phase II with 13

models. Net transport across meridional gradient had a net flux ~0. Oceanic transport of riverine carbon augments the estimate by ~ 0.5 Gt C/y. Chemical weathering and erosion also leak C (DIC/DOC) to the oceans. There **was** a southward movement of C across meridional gradient in pre-industrial times. The models are poorly constrained in the Southern Ocean and this is where they disagree the MOST. CFC's are the best tracer to highlight these new understandings. All of the models now have a common biology model.

Phase III in discussion: objectives to look at interannual variability to $CO_2$. Without riverine carbon there is no transfer of carbon across the northern/southern hemispheres.

**When ocean and 3D inversions are done with the riverine transfers, the sink in the northern hemisphere is smaller and moves some of the sink into the tropics. Because the atmospheric transport models are so variable, these results don't necessarily remove concern for a northern hemispheric sink.** Jim's results with riverine transport were conducted with Martin's TM2 model. The riverine estimates are from: Ludwig et al. (1996) and Amiotte-Suchet et al. (1995). Air-sea fluxes from Aumont (1998). These results Aumont et al. Nature, en relecture.

The breakdown between solubility and biologic pump shows the Southern Oceans as a sink, not a source.

Maybe phase III to resolve the ocean/terrestrial with observations? What about a fully-coupled vegetation/ocean model?

Patrick warned to be careful in interpreting 'sinks'. Are they natural or transient?

This leads into Phase III of the carbon synthesis: what ARE the big issues?

1. Introduction
2. Quantification of land cover/land use change: historically and into the future
3. Dynamics of the terrestrial sink over the next 200 years - b comment that it would be problematic for the terrestrial sink to increase dramatically in the future
4. Oceanic physical and biological feedback
   4.1 implications of terrestrial oceanic sinks
5. Decadal to century datasets
6. Where, geographically and ecologically, are the balancing sources and sinks, and why?

What kind of a strategy could we develop to determine the **location** of a Northern Hemispheric sink??? **and**, what are the processes that control the sink(s)??

Based on atmospheric calculations, how could we identify the location of a Northern Hemispheric sink? First cut would be observations. Neil's comment that the primary input datasets for the inversion models are maritime. Growth rates for continental vs. maritime are out of phase because the vegetation has a lagged response. To improve the inversion models need to include better inputs from the vegetation. Paul's response that the unconscious assumption by OCMIP (common biological pumps) that biology in the oceans are static are misleading as the ocean's biology is more than likely NOT in steady state, but are dynamic.

How do you resolve the scaling problem from flux towers to the globe?? Use a good global, or many good global models. Mesoscale models will be the KEY to these questions. Also, the disturbance dynamics are necessary (fires, pests, grazing, deforestation, fire suppression).

Steve Smith: What actually are some numbers for riverine transport ~20X mismatch between erosion and sediment transport in the U.S.. the idea of temporary storage in reservoirs, etc. by sedimentation rates. Essentially, oxidizing material is moved into wet areas, primarily associated with human activities and ending in artificial reservoirs.

Besides looking at the fluxes, must include more detailed measurements of the pools. Back to Bob's need for a better soils map, etc. For instance, Detlef replotted the Euroflux data and it appears that gross PSN uptake is largely controlled by ecosystem respiration. There was a very narrow band of PSN vs. respiration. This points out that Rs is a driver in NEE.

These carbon documents are the step we are taking vs. the step we SHOULD take which is to take some action.

In addition, we need to ask ourselves **why** are we doing this? **Perhaps we should reiterate that the 'sink' that we are looking for is ~10% of the budget. The expectations are rather unimportant relative to the entire budgets.**

**We (the IGBP) needs to propose a strategy to identify: how to get the data.**

Perhaps the IGBP can form a 'team' to develop and establish such a strategy‡ this would be the follow-on to Will's Framework Document

**Summary of Numbers for Boreal Forests:**
NPP: 223 gC m2/y ( global: 60 GtC/y)
NEP: 56 gC m2/y ( global: 10 GtC/y)
NBP 15 gC m2/y ( global: 1-2 GtC/y)

Canadell et al. in prep summary of NEE estimates for several globally distributed forests. His numbers from the tower data differ from the boreal numbers (above) by 10X. they look more like the NPP numbers (Mean Average about 12 GtC/y and NOT 1-2Gt/C). These are 'pristine' forests and will be torn apart for IPCC.

*Paul Falkowski leads the discussion:*

Previous discussions revolved around oceans, atmosphere, and biosphere as separate entities. The largest reservoir of carbon is primarily oceans. Annual NPP from oceans and terrestrial comparative. Table below From :

Field et al. 1998. Science

A. Morel. 1991. Proc. Oceanogr.

M Beherenfleld and Falkowski 1997. Limnol. Oceanogr.

| | **Oceans** | **Terrestrial** |
|---|---|---|
| **Annual NPP** | 4.1 | $4.7 * 10^{15}$ |
| **Par** | $4.5\ 10^{18}$ | 2.0 |
| **Quantum Yield** | 1,1101 | 425 moles photons/carbon |
| **APAR** | 7% | 33% |
| **Qy for APAR** | 78 | 140 moles photons/carbon |
| **Global Biomass** | 0.3-0.75 | 800-100 Pg C |
| **Turnover times** | 2-6 days | 14-19 years |

The sink in the oceans as a result of the biological pump, or the 'breathing' of the ocean between the glacial and interglacial periods is the sink we need to explore.

1. Is the oceanic NPP and export production in steady state on timescales of decades to centuries?

2. What can cause a deviation from steady state
   a. change in utilization efficiency in the LNHC regions – primarily affected by Fe fert which is controlled by land use. These fluxes are a function of the hydrologic and thermal gradients on the global scale. These feedbacks are currently not accounted in any of the global carbon or ocean models.
   b. addition/removal of limiting nutrients (e.g. N). biological constituents in the oceans have highly variable Redfield ratios between plankton, seawater, etc. are stable. The N:P ratios below ~1500m are always less than 16:1. We **do not** have an analogue to the Redfield ratios in terrrestrial systems. The ratios are significantly lower in surface waters. These are Fe-limited systems. There is very little N-fixation in surface waters....they are very nutrient poor systems. If the N-fix/denit processes were to change, these ratios would increase c absorption by 50%. There is a very natural 'stack' within oceans that has developed over thousands of years and we are deviating from that 'stack'.
   c. changes in elemental ratio of C/N/P (Redfield ratio). If this were to occur (relatively long geologic timescales). We don't really have a good explanation for WHY redfield ratios occur.
   d. changes in the rain ratio of organic/inorganic C

3. how do physical processes (e.g. stratification, pH, deep water formation) affect #2 a-d?

What are the processes that would affect the probability of a weakening of the oceans biological pump?

changes in stratification
if the export of C changes, then the sink strength changes.
Increased Fe, nutrient dynamics can also alter sink strength of the oceans.

The atmosphere has less carbon in it and the land has less carbon on it, therefore, the oceans have stored a significant amount of carbon.

Other processes: if you lower sea level, you increase salinity and this has a stronger impact than temperature changes.

There is something that is causing the change of the oceans 'breathing' , or, there is something that is causing the changes in climate.....

We DO know that the delivery of dust, and aeolian transport of iron is MUCH larger during glacial periods than the interglacial.

**Late 1970s saw a doubling of chlorophyll in the oceans. This is another example of an ecological non-linearity.**

Changes in the ocean's stratification: Patrick Monfray:
The geochemical perturbation (due to an increase in $CO_2$) primarily impacts the solubility pump.

Increase in SST leads to increased $CO_2$
WRT stratification:
DIC from the bottom up to the surface leads to decreased $CO_2$ uptake
Decreased N, P export from the bottom to the surface increases $CO_2$ uptake and
Anthropogenic $CO_2$ invasion decreases $CO_2$ uptake

Climate change without increased $CO_2$, the geochemical and climate effects decrease, and saturation occurs at a much lower level relative to a geochemical effect only (HAMOCC3).

Climate change impact on ocean $CO_2$ uptake:
2x $CO_2$ decreases by 10-15 percent
4x decreases by 50 %

Over 2x $CO_2$ need there is a strong need for coupled carbon–climate models driven by $CO_2$ emissions

What might be the changes in an ocean-ecological structure, and their impacts on the C-balance of the oceans? ~95% of the ocean's phytoplankton are cyanobacteria and VERY small (~600-1000nm). They are neutrally buoyant. Most of the fluxes are generate by diatoms (we think). Diatoms require silicate. During interglacial transitions, there are changes in the Si concentrations. The flux rates of Si and nitrate are basically linear with a slope greater than 4, and the intercept around 1. Si generation is not biological, it is either by weathering or by transport from lower depths. Export flux could be markedly reduced if the surface waters weren't recharged with Silicates. What drives the distribution of the 'functional' or keystone groups 250M years ago was the origin for today's organisms. (dinosaurs are starting to walk).

What will be the tools we can use in the future to monitor the changes in ocean biogeochemistry / ecology?

How will the schizms between ocean and terrestrial communities be crossed?

A multiple field / modelling / community pronged approach is needed.

Fe-fertilization during glacial periods may have been the natural mechanism to maintain the 200ppm carbon metabolism in the past.

Paul proposed: Let's put some biological processes of the ocean in some intermediate model such as Martin's....we can bring the nutrients in the southern ocean down to very low numbers by the addition of Fe.

Are there some datasets that would be useful? Is there a sedimentary record? A qualitative proposal of this type was proposed by Paul in Nature. There aren't any strong datasets for oceans.

Berrien charged the group to write up 2-3 key strategies they would like to see: experiments, datasets, etc. that could be used as a springboard to central elements in an IGBP carbon strategy.

There do seem to be a set of 4-5 critical questions: palaeo, contemporary
Freshwater trapping of sediments
Ocean palaeo sediment histories
Nutrient (Fe, N, P) limitations / experiments for oceans AND terrestrial systems

# J3/G4 Influence of structure and biodiversity on the functioning and dynamics of terrestrial and marine ecosystems

Chairs: Osvaldo Sala, Paul Harrison

This session explored:

- Key similarities and differences between terrestrial and marine environments in terms of:
  - The influences of structure and biodiversity on ecosystem dynamics and functioning
  - The main factors regulating ecosystem functioning and dynamics
- Mutual influences between terrestrial and aquatic ecosystems
- Possible relation between these interactions and global change patterns

## Main points that emerged from the session

- The same phenomena are readily observable in either marine or terrestrial ecosystems. As a consequence, comparison between the two types of systems fosters better understanding.
- Ecosystem processes tend to occur at larger spatial scales and smaller temporal scales in marine than in terrestrial habitats.
- Primary producers tend to be smaller and grow faster in marine than in terrestrial ecosystems.
- Terrestrial ecosystem responses to biodiversity loss depend on the magnitude of the loss, but they also depend on the functional group of the lost genotypes.
- Marine ecosystem responses to organism removal varies with the functional group eliminated.
- Marine ecosystem productivity and N uptake are sensitive to the deposition of Fe-rich dust transported from the continents, possibly as a result of land degradation.
- Variability in biomass and productivity of phytoplankton and bacteria appear to be equal. This suggests that variability does not attenuate as one goes up the food chain. How general is this observation?
- Transfers of energy and materials between marine and terrestrial ecosystems is dominated by different agents depending on the direction of the movement. Terrestrial-to-marine transfers occurs mainly through water runoff, whereas marine-to-terrestrial transfer is largely mediated by animal activity. The atmosphere can bridge the two types of ecosystems in both directions.
- Interactions between marine and terrestrial ecosystems that are mediated by climate have a regional component associated with heat and water transfer to the atmosphere, and a global component associated with $CO_2$ and $CH_4$ emissions.
- In marine ecosystems, the main human impact directly affects the upper trophic levels, whereas in terrestrial ecosystems, human action can directly affect all trophic levels.
- Marine pelagic ecosystem structures may be more resilient to fishing than to climate change.

## Contact person for follow-ups

William Batista, GCTE Focus 4 officer, batista@ifeva.edu.ar

## Participants

Eileen Hofmann, Brad Wilcox, Michio J. Kishi, François Carlotti, Tim Baumgartner, Yoshihiro Fukushima, Peter Tyson, Nadia Pinardi, Julie Hall, Proespichaya Kanatharana, Narin Boontanon, Ralf Conrad, James F. Reynolds, Vladimir Kasyanov, Bob Buddemeier, Tek Bahadur Gurung, Roger Pielke Sr., Paul Harrison, Rodolfo Dirzo, Serge Poulet, Ian Perry, John Field, Jarl Ove Strömberg, Robert Le Borgne, Michael Landry, Julian Priddle, Roger Harris, Neil Swanberg, Takayoshi Koike, Huasheng Hong, Isao Koike, Alex Bychkov, Chris Crossland, G.B. Pant, Jotaro Urabe, Tohru Nakashizuka, Volkmar Wolters, William Batista, Hugh Ducklow, Roni Avissar, Tommy Dickey, Pat Livingston, Paul Crutzen, Harald Bugmann, Jokoshige Sugimoto, Rik Leemans, Terry Chapin, Takayoshi Koike.

# J6 The palaeo-$CO_2$ record in the ocean

The aim of this session was to explore ways in which the knowledge of the processes in the modern ocean ecosystem can be extended to longer time scales. A very good insight into the factors controlling primary production and export has been gained by JGOFS on a regional scale by the process studies, and on a global scale by the global surveys and remote sensing. However, this basically represents a "snapshot" of the marine system and does not address the climate driven variability of the system. PAGES research has identified rapid changes occurring in the marine system obviously coupled to alterations of ocean circulation, however, it is difficult to connect these changes to biogeochemical processes relating to community structure. An effort to link these two fields of research may, therefore, be an important step in order to understand climatically driven variations in the ocean. The session focused on selected topics which were introduced in six short talks.

The effects of monsoonal forcing on export production in the Arabian Sea (Peter Burkill)

Evidence of past changes in the monsoonal forcing in the Arabian Sea (Graham Shimmield)

Atmospheric $CO_2$ during the Holocene, Younger Dryas and major Heinrich events as reconstructed from ice cores (Thomas Stocker)

Changes in plankton composition: the role of large grazers on the export production and the fluxes of biogenic matter to the sea floor (Paul Tréguer)

Fe fertilization and phytoplankton responses (Paul Harrison)

The iron fertilization experiment in the Southern Ocean (Julie Hall)

Peter Burkill presented data on long-term sediment trap records of the effect of monsoons on vertical flux in the Arabian Sea. A ten-year record of sedimentation is now available from the western Arabian Sea and gives evidence on interannual variation of export production. One surprising result is that exceptionally strong SW monsoons seem to clearly reduce export production. The mechanisms of this effect are not yet understood. Changes of the intensity of the monsoon are well documented from sediment records on me scales of 100ka and 23ka caused by variation in external orbital (insolation) forcing of the southwest monsoon as shown by Graham Shimmield. He also presented high resolution data from coral records, which record the temperature variations caused by upwelling on short time scales and indicated some cyclicity in upwelling strength and nutrient supply. These presentations showed the sensitivity of this regional productivity regime to wind forcing and evidence of short-term variations.

Thomas Stocker presented data from Arctic and Antarctic ice cores. During the rapid temperature changes of the Dansgaard-Oeschger cycles (2°C) atmospheric $CO_2$ concentrations varied by 20 ppm. In the Younger Dryas, a cooling of the northern hemisphere was observed, but not in Antarctic ice cores where no decrease in atmospheric $CO_2$ was found. A drop in $CO_2$ concentrations and concurrent changes in $\delta^{13}C$ during the Holocene (11ka-8ka) indicate that a large part of this carbon was taken up by land vegetation. Subsequent rises in $CO_2$ by 20ppm can be accounted for by a rise in sea surface temperature of 2°C and emission of $CO_2$ from terrestrial vegetation respiration. These data cannot identify regional changes or the underlying processes. Thus model simulations are used to investigate the mechanisms causing the changes. They indicate that in the Younger Dryas changes of $CO_2$ are controlled by interhemispheric solubility and that the carbon cycle has not been in steady state for the last 10ka.

In his talk Paul Tréguer concentrated on the major role of diatoms for the export pathway of the biological pump. In order to be able to model present ocean processes and to reconstruct past productivity from sediment records it is of major importance to consider the coupling/decoupling between the cycles of carbon, nitrogen and silica. Data from satellite imagery (primary production) and sediments (carbon and silica concentrations) from the Southern Ocean indicated a decoupling between carbon and silica fluxes. Hence, silica can not be used as a quantitative proxy of palaeo-productivity without knowing the physical and chemical conditions that prevailed during diatom growth. Paul Harrison showed evidence for iron limitation at station P in the North Pacific. Experimental addition of iron resulted in increased growth of large diatoms which was not controlled by grazing. Fe limitation of diatoms increased their sinking speed. At station P, pulsed input of iron occurs via dust transported by storms from the Gobi desert. An observed long-term trend in reducing the depth of the thermocline may also cause a gradual increase in Fe concentration sin surface waters potentially associated with changes in primary production and export flux. Julie Hall presented results of the iron enrichment experiment in the Southern Ocean (SOIREE) which gave clear evidence of increased primary production, a rise in

firstly small and then larger phytoplankton cells, drawdown of $CO_2$ and stimulation of DMS production. These examples of phytoplankton physiology and growth demonstrated the major impact of ocean geochemistry, in particular iron fertilization, on productivity and the potential effects of change in land cover on the oceanic carbon cycle.

The general discussion stressed the importance to understand the processes in the modern upper ocean and their sensitivity to changes in the chemical and physical environment. This is a basic condition for the interpretation of the historical record as reconstructed from sediment and ice cores or corals. This can not be restricted to time scales of 200 years but has to be considered on time scales of ocean mixing and deep water formation. A second issue of importance touched upon were the biogeochemical processes in the deep ocean. As major progress of this session a joint task team between JGOFS and PAGES is suggested for approval by the SSCs of both CorePprojects and first members are nominated as a nucleus to develop this task team. A first step is to organize a joint workshop.

## Participants

Karin Lochte, Graham Shimmield, Bob Buddemeier, Paul Tréguer, Laurent Labeyrie, Tom Pedersen, Thomas Stocker, Keith Alverson, Bill Burnett, Ryuji Tada, Peter Liss, Platt Bradbury, Patrick Buat-Ménard, Roger François, Takao Iguchi, Shu Gao, Paul Harrison, Julie Hall, Dominique Raynaud, Mitsuo Uematsu.

# P3 PAGES Focus 3

The session was organized around the following sequence of themes and questions

1. How may we best define the essential goals and priorities of PAGES Focus 3?
2. To what extent is it a 'stand-alone' PAGES theme and to what degree should it be responsive to the requirements of other IGBP Projects?
3. Is the currently emerging structure of Focus 3 the most appropriate?
4. Are there new and additional tasks that should be identified and endorsed?
5. Can we identify an overarching Steering Group to ensure coordination within Focus 3 as a whole?
6. How should we best progress with the (hitherto problematic and delayed) theme of 'Human Impact on Terrestrial Ecosystems' (HITE)?.
7. What are the next steps / milestones / goals for Focus 3?
8. What is the role of PAGES Focus 3 in Synthesis?
9. Might PAGES Focus 3 have a potential role in envisioning the future orientation of the PAGES project and of IGBP as a whole?

Some of the key outcomes were as follows:

- Focus 3 was concerned with the history of the combined and interacting effects of human activity and climate variability on ecological, hydrological and regional atmospheric processes and systems. This was not simply a question of descriptive, palaeo-reconstruction, but included the need to understand the interactions, to disentangle their effects where and when possible and appropriate and also to characterize the synergies between anthropogenic and natural drivers of recent environmental change.
- The leaders of Focus 3 should endeavour to create a programme that gave priority and full expression to high quality PAGES research, but at the same time every effort should be made to optimize links with LUCC, GCTE, BAHC, the inter-project Water Initiative, GAIM, LOICZ and GLOBEC.
- LUCIFS, LIMPACS and HITE were endorsed as the three strands of PAGES Focus 3, dealing respectively with fluvial, aquatic and terrestrial systems. The theme of non-linear changes and systems interactions was seen as germane to each and not as a separate activity; the possibility of adding separate and distinctive PAGES Focus 3 activities linked to marine and mountain initiatives was considered but not endorsed at this stage, though the role of PAGES Focus 3 research in each was recognized and encouraged.

- Battarbee, Dearing, Messerli, Oldfield and Wasson were designated as members of the Focus 3 Steering Group. Additional names were suggested to complement their expertise, especially in the area of terrestrial ecosystem change. The need to reap maximum benefit from linkages between the three strands of Focus 3 at a regional/individual catchment level was emphasized.
- Consideration of the special problems and challenges within HITE led to endorsement of a PAGES contribution to a 'BIOME 200/300' initiative with LUCC, as well as an involvement in more detailed case studies. The need to link such initiatives to ongoing work in the PEP Transects etc was strongly emphasized.
- In outlining and discussing the sequence of workshops proposed in order to ensure maintenance of momentum in Focus 3 initiatives, it became apparent that great benefit would derive from soliciting an input to Focus 3 from the full range of existing PAGES programs and from the whole range of paleo-archives in which signals of anthropogenic impact can be detected.
- The remit of the Focus 3 coordinating group would include drafting a potential contribution to the synthesis exercise as well as exploring the extent to which the emerging research agenda might provide a stimulus to new initiatives during the course of planning the next phase of IGBP.

## Participants

Frank Oldfield, Bruno Messerli, José Boninsegna, Jonathan Overpeck, John Dearing, Bob Wasson, Rick Battarbee, Ray Bradley, Vera Markgraf, Claude Lorius, Yugo Ono, Niklaus Schranz.

# G5 Food and fibre supply in terrestrial and marine ecosystems

## Summary of the major points

1. In addition to the classic drivers of global change (climate, atmosphere and land use changes) several new issues are emerging that will have major effects on food and fibre production. These include:
    - fresh water supplies
    - soil fertility, fertilizer use and off-site environmental impact
    - climate variability
    - application of biotechnology and breeding to adapt to environmental change
    - trade regulation and market reforms
2. Several IGBP projects are conducting research of relevance to food supply and security including:
    - GLOBEC - several countries (e.g. Bangladesh and Pacific islands) are dependent on marine sources for the majority of their dietary protein. Harvesting of fish contrasts with the harvesting of terrestrial food in that fish are towards the top end of the marine food chain and the factors influencing the productivity of the basic food sources (phytoplankton) are poorly understood. The strengths of the current programmes lies in nutrient budgeting and in their interdisciplinary nature. The links between climate, ocean currents, food sources and fish production are beginning to emerge for some major fish stocks but this is new (and exciting) science.
    - BAHC - many elements of the hydrological cycle interact with agricultural production practices but the scientific links between BAHC and production are indirect. Most attention has been paid to the vertical flux of water, but there is considerable scope for increasing work in rainfed environments to increase the efficiency of water use for crop production, and in irrigation issues. Examples of the relations between water use and food production in Sub-Saharan Africa demonstrated the scope for future research efforts. This needs to be developed as part of the IGBP Water Initiative, in close collaboration with other IGBP Core Projects and partner programmes.

- LUCC - Site studies are being aggregated to produce regional studies that link behavioural aspects of land use to food production practices. The interaction of social and biophysical constraints and the adaptation of families and societies to their changing environment could provide a major focus for LUCC/GCTE research in future.
- GCTE - A synthesis of GCTE and related work has recently been published and key points were summarized.

3. IHDP is setting up a series of projects that will examine the social and economic constraints to improved livelihoods in several developing countries. There will be scope for joint working with IGBP projects especially in relation to agricultural practices.
4. START is launching CLIMAG under the auspices of IGBP, WCRP and IHDP to explore the interactions between climate variability and crop production and to determine how the improving reliability of 6 - 9 month climate forecasts might be used to the benefit of farmers.
5. In relation to the IGBP synthesis, it was concluded that:
   - Insufficient results currently exist to allow a proper synthesis unique to IGBP but there are some areas of work that might usefully be tabulated or referenced to a database.
   - Revision of the FAO figures on land degradation and desertification might usefully be undertaken as a joint activity by LUCC and GCTE. The current values are unreliable.
   - Landscape approaches to food-biophysical interactions could be explored as an introduction to future research approaches.
   - The natural resources of soil and water and their role in food production on a sustainable basis should be stressed.
   - Although results are scarce at present, there is scope to explore in conceptual terms the effects of changing land use on inputs to rivers in terms of flow rates, pollution and transport to estuaries, and how food supply problems can be upscaled from site to region to nation.
   - Case studies of a monoculture, a very complex agro-ecosystem and an agroforestry or intercropped system could be used to explore the effects of perturbations and likely research advances on the ability of these systems to adapt and be sustainable in a 20 year timescale.
6. Forward Look: Attention was drawn to the distinction between ***food supply*** and ***food security***, and IGBP's role was defined as within the former area. An organizational plan to address the Global Change aspects of food security was proposed as a joint programme of IGBP, IHDP and WCRP.

## Participants

John Ingram, Keith Brander, Lee Byong-Lyol, Günther Fischer, Pam Matson, Mary Scholes, Bill Aalbersberg, Changming Liu, Meine van Noordwijk, Reinder Feddes, Tony Hunt, Bob Sutherst, Elizabeth Gross, Roland Fuchs, Arvin Mosier, H-U. Neue, John Gash, Inder Pal Abrol, Emilio Moran, Lelys Guenni, João Morais, Roland Schulze, Lekan Oyebande, Ramiro Sanchez, Michel Meybeck, Holger Hoff, John Hunter, Jill Jäger, Coleen Vogel, Eric Lambin, Billie Turner II, Masatoshi Yoshino, Peter Gregory.

# S1 Regional syntheses

- START role in IGBP Synthesis is to coordinate regional syntheses
- Approach will be to build on the strengths of the individuals and science which has already been undertaken in each region, by START scientists, the Core Projects, IHDP, and other important research initiatives outside IGBP
- Four regional synthesis studies are currently underway – Southern Africa, Temperate East Asia, Southeast Asia, and South Asia. Southern Africa already presented at earlier session.

## **Temperate East Asia** – Congbin Fu

- Fundamental questions to be addressed – degree of change, drivers of change, societal adaptation to change, and role of East Asia in Earth system dynamics.
- Perspective will use atmospheric chemistry as uniting concept, and monsoon as case study for development of a conceptual model which will include human and socio-economic components of change.
- Recognition of global significance of East Asia in terms of climate, ecosystems, and atmospheric chemistry, and importance of our ability to predict future impacts.
- Prediction requires development of conceptual and mathematical models which capture driving forces of environmental change, feedbacks, and variability.

## **South East Asia** – Daniel Murdiyarso

- Southeast Asia is a hotspot of global change and sustainable development issues.
- Synthesis is a key mechanism of presenting global change science to policy community.
- Synthesis includes analysis of human driving forces, regional environmental change, response of biophysical systems, and sustainable development issues.
- Key Point: humans are part of the natural system, not simply external drivers of it.
- Cross-regional issues unite an otherwise diverse region – haze can be a global, climate change, C cycle, and also a biodiversity conservation issue.
- We have the capacity to draw conclusions from limited data and knowledge, to get synthetic results *now*.

## **South Asia** – A.P. Mitra

- South Asia is diverse, but united by monsoon circulation.
- Atmospheric chemistry is a central uniting theme for synthesis in the region.
- Numerous campaigns have been completed – ALGAS, MAC98, INDOEX examples.
- Human driving forces are critical – GHG emissions are currently 12% of world total, will be much larger proportion in 2020, energy and industry sector of economy generates largest C fluxes.
- Major mathematical modelling efforts have revealed the importance of ozone and aerosols in forcing regional climate and agriculture.
- Biomass burning is of global significance.

## **Conclusion**

- Four case studies from regions covering wide geographic area, a wide range of biomes, nations, and cultures, will assist in understanding how global change impacts are felt at the regional level, and may help suggest how region-specific policy responses may be developed.
- Challenge: to understand how to engage the policy community as well as the scientific communities of the regions.

# I2/G3 Terrestrial Trace Gases

## Synthesis

Accomplishments are outlined in a GCTE Working Document No. 16, 8 December 1994; Summary papers of IGAC activities of the 12th SCC, 1997 and in a review and synthesis of IGAC findings on terrestrial trace gas is being prepared for the IGAC project synthesis and the outline for the "biosphere-atmosphere interactions" and are available on request.

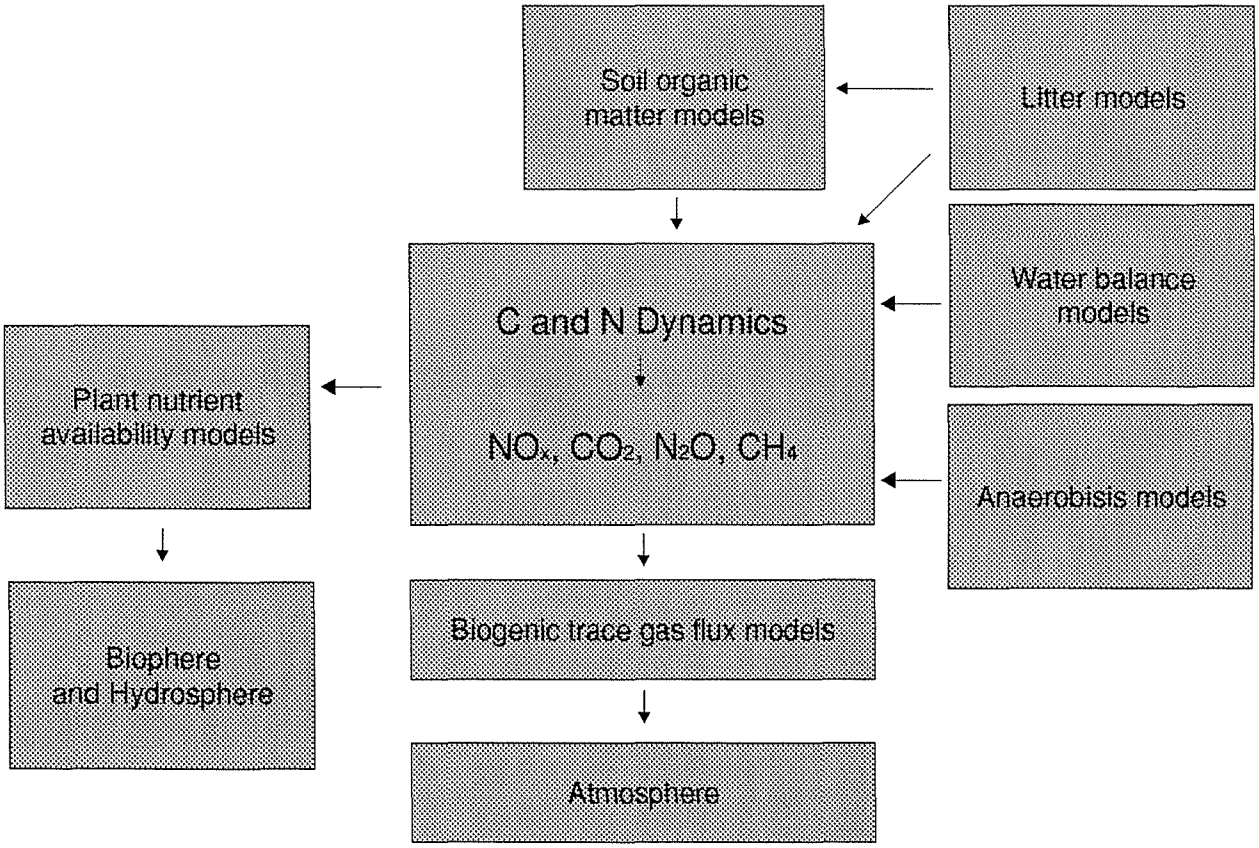
The major output of the I2/G3 session was to outline the main components of an integrated synthesis on the carbon and nitrogen cycles (see figure below) which involves a number of IGBP Core Projects (i.e. GCTE, IGAC, PAGES, BAHC, LUCC). The figure highlights achievements and future programme directions needed to perform this integrated synthesis. The integration involves: the identification of common processes and their underlying controls; recognition of the common basis that should guide the development of models; and the accumulation of databases and the design of field observations and experiments. The programme is applicable to all of the main biomes or climate regions of the globe which includes the major issues in polar, boreal, temperate and tropical environments.

Within the areas related to soil organic matter, soil biology and terrestrial trace gases, to improve emission inventories and to clarify the constraints on carbon and nutrient cycling for plant availability the following are needed:

Definition of current understanding of the processes of organic matter decomposition and nutrient dynamics (especially nitrogen) in relation to trace gas fluxes and impacts on atmospheric composition and processes. These trace gas analyses should include appropriate isotopic analyses to assist in further interpretations.

Compilation of essential minimum data on soil chemical and physical properties, litter quality, organic matter decay rates, nutrient pools and dynamics, water dynamics, and trace gas fluxes for environmental conditions covering the climate matrix cool-dry to warm-wet, and for major soil types and management.

Development and integration of existing models of litter and soil organic matter decomposition, nitrification-denitrification dynamics, water balance and anaerobiosis, in order to predict nutrient dynamics, trace gas exchange and their interrelationships (see figure).



These objectives are closely linked and, although concentrated on the integration of existing data and understanding, will be strengthened by developing field observations and experiments on specific long-term sites.

Useful models exist of the relationships between accumulation/decomposition of soil organic matter and various environmental, pedological and land-use factors. Further integrative work is needed (i) to combine these models into a more holistic description of the complex dynamic system relating C and N transformations and gaseous fluxes, and (ii) to relate these processes to environmental and landscape factors which will improve extrapolation from point or patch scales to regions. Intercomparisons of models for each level of integration are an essential element of the integration.

## Contact persons for follow-ups

Uli Neue (IGAC), Arvin Mosier (IGAC), and John Ingram (GCTE)

## Participants

H. Tsuruta, Ralf Conrad, Paul Crutzen, Derek Cunnold, Peter Gregory, John Ingram, Vyacheslav Khattatov, E. Konohira, Elliot Atlas, Kathy Law, Robert J. Delmas, Atsuko Sugimoto, Jean-Pierre Lacaux, Shyam lal, Ming-xing Wang, Barry Huebert, Tony Hunt, Pam Matson, Neil Trivett, Dominique Raynaud, Narin Boontanon, Proespichaya Kanatharana, Anne Larigauderie, Patricia Matrai, Alex Pszenny, Harriet Barker, Paulo Artaxo, Jim Ehleringer, Mary Scholes, Stan Cieslik, Thelma Krug.

# LU1 Socializing the pixel

The session began with an introduction that explained that there would be four short presentations providing examples of how LUCC scientists read advancing methods that permit giving social content to remotely sensed data, as part of the effort to link biophysical to social processes.

The first speaker, Emilio Moran, summarized the approaches used in LUCC generally, and his series of studies in Amazonia on issues of deforestation. He pointed out the growing number of LUCC projects across the world are now mapped on the Focus 1 web site (www.indiana.edu/act/focus1) in order to encourage colleagues to consider partnering with LUCC to advance knowledge of earth-*cum*-human systems. He showed that by engaging land managers in the interpretation of the satellite image for their land it has been possible to add considerable detail to spectral information and to achieve much finer separation of vegetation and land cover classes than otherwise might be possible: for example, distinguishing between three structural classes of secondary forest with an average accuracy of 92%. It has been possible to link the behaviour of households to the Landsat imagery by overlaying the property grid for the study area, and asking household level questions from 500 households to infer the behaviour of the 3,400 households on the landscape. Studies of biomass burning have measured biomass before and after the burn to find that the efficiency of burns is higher than the literature had estimated (46 to 57%) in secondary forests – and that up to 60% of burnt areas burned unintentionally.

The second speaker, Ronald Rindfuss, summarized his study in Nan Rong District in Thailand. This is a longitudinal study going back to 1984 encompassing 51 village, where all residents were included. The unit of observation is the village since households are settled in villages and it is very difficult to make a direct linkage of households to plots of land since they own an average of three non-contiguous plots. Evidence was presented for the growth in the number of villages, the growth in population, the growth of the are in rice cultivation, and in cassava cultivation. The study found a strong association between the amount of forest available to the village and their ability to hold on to their young males, and of population increase and deforestation.

The third speaker, Billie Turner, summarized his project in Yucatán, Mexico. Like the previous speaker, the unit of analysis is the village and includes a narrative of the history for the area, characterized by deforestation by the Maya, followed by a collapse of the Maya civilization, the return of forests, which remain relatively unaffected until after World War II. After that, especially after 1967, a road is built that begins to bring change to the area. The study examines household economics with a focus on resource demand, and uses regional satellite imagery to examine the impact of infrastructure, biophysical variables, and geographic location on land use. The study finds major change in the area, and high rates of

deforestation, like to be exacerbated by further infrastructure development for Maya ecological tourism.

The fourth speaker, Eric Lambin, summarized his work in Cameroon showing the different spatial processes of agricultural expansion an logging expansion. He finds distinctive patterns and spatial location for these two types of land uses that permit examination of distinctive ways to use the landscape. He also finds over time important shifts in the causes of deforestation from coffee/cocoa cultivation to other crops, from agriculture to logging, and the increase in rural land occupation with economic downturns. The growth of logging industry has led to a large population of rural non-farm workers that demands food, without producing it thereby creating a market for staple food production. Logging companies have improved road infrastructure, facilitating access and deforestation.

After the break, discussion centred at first on how LUCC can provide useful information for LOICZ. On the one hand, LOICZ wishes to move to a synthesis by 2002 and does not believe it has the resources to engage the fine detail of the LUCC studies illustrated, even though it agrees that that is precisely what needs to be done to understand the human dimensions in coastal zones. Suggestions were made that a typology of land uses might help a great deal, as well as evaluating the LUCC home page for projects that deal with land uses near coastal zones. The Focus 3 of LUCC addresses issues in large countries like China and their data and experience might provide valuable data at a higher level of aggregation more consistent with the current LOICZ data sets. It was suggested that there are disaster mitigation groups and organizations in a number of countries that have excellent data on population, buildings, infrastructure, and other variables relevant to the process of evaluating the human dimensions in coastal zones.

The discussion then turned to how to build on the experience of the GCTE/LUCC Open Science meeting in Barcelona. It was agreed by the group that that was a very successful meeting and that there have been clear formal and informal outcomes. Among the formal outcomes are the fast-track historical overview of land use changes at global scale as an input into Image model; joint attention to landscape processes; and the joint attention to food security with Focus 3 of GCTE. Informally, many scientists have begun collaboration and discussion since that meeting. Six to seven projects have resulted from these informal discussions. It was agreed that we need stronger still formal projects that link GCTE, LUCC, and BAHC. The group agreed that the unit of analysis could be agreed upon (Landscape/watershed/transects). Thus, the collaboration with units from 1 hectare patches up to a watershed are units that all three groups are comfortable and consistent with their modus operandi. Whenever possible, it was agreed there would be an effort to find common sites where GCTE can work on biophysical aspects, LUCC on social aspects, and BAHC on climate/hydrology aspects. All three groups agreed to examine their portfolio of projects to see when and where such mutual collaboration can be developed to improve the quality of the information and achievement of synthesis.

There was a strong feeling that IGBP should encourage projects that are doubly or triply endorsed and that cut across core projects, and also to encourage further networks of scientists with these common interests. While LUCC is still too young in the IGBP family to be in a position to have a comprehensive synthesis, it has made considerable progress since the Science Plan cam out in 1995 in galvanizing a community that has now agreed on an Implementation Plan. The portfolio of LUCC sites is impressive both in its geographical coverage, and in the wide range of land-use types represented. Over the next two years LUCC expects to be able to contribute to the IGBP synthesis volume (particularly in taking the lead in preparing chapter 3) and to have some of the projects with substantive results and models to present to the community.

To achieve this synthesis in the next two years there are a set of priority topics that have been identified and agreed on that will require a series of workshops to achieve the synthesis of LUCC contributions. The community of LUCC is now fully organized, results from separate projects have been coming in, and LUCC is poised to advance understanding of the human dimensions. There was agreement that the community of IGBP supports such an endeavour, and even views it as high priority. Over the next two years LUCC will call together these workshops to ensure the integration of human dimension considerations into the scientific questions of IGBP.

## Summary of action items

Contribute to development of fast-track historical land cover database in time for 2001 IGBP Open Science Conference (with GAIM, GCTE, BAHC).

Contribute to understanding global change impacts on food security (with GCTE Focus 3).

Develop joint research with GCTE at sites of mutual interest using watershed/landscape units.

Encourage IGBP to promote doubly and triply endorsed projects to promote synthesis of biophysical with social processes.

Contribute to IGBP synthesis volume in general, and taking lead on Chapter 3 in particular.

Hold a series of 4 to 6 workshops, and a LUCC Open Science Meeting, in next two years to synthesize LUCC research (with PAGES, GCTE, and other core project involvement).

## Participants

Billie Turner II, Emilio Moran, Ronald Rindfuss, Kiyoshi Tsuchiya, Ryosuke Shibasaki, Yoshikazu Fukushima, João Morais, Meine van Noordwijk, Reinder Feddes, Eric Lambin, Bob Buddemeier, Arturo Sanchez, David Goodrich, Upik Rosalina, Inder Pal Abrol, Holger Hoff, K.S. Rajan, Hartwig Kremer, James Reynolds, Brad Wilcox.

# P1 PAGES and process studies

The first part of the session, chaired by Bruno Messerli, took the form of a series of brief presentations on: "The PAGES/CLIVAR intersection" *(Overpeck)*; " Linking GIS and sediment-based studies" *(Oldfield)*; "The role of palaeolimnology" *(Battarbee)*; "Human Impacts on fluvial systems" *(Wasson)*; "System dynamics of past environments" *(Dearing)* and "Towards BIOME 300" *(Oldfield)*. Full titles and the rationale for the session were set out in a widely distributed brochure and are available on the PAGES website. The presenters of the PAGES Focus 3 component of the program agreed to prepare a joint publication based on the session and this in turn may help to define the nature of part of the input from PAGES Focus 3 to Synthesis.

In the discussion that followed, there was positive input from members of other Core projects and the points raised included:

- the need to define clear goals and products, especially in the case where inter-project collaboration was involved.
- the interest for LUCC in the future development of both the ‚BIOME 200/300' initiative and the concern with non-linear system processes and interactions.
- the importance of changes in the extent of permafrost and in the extent and status of wetlands for understanding changes in trace gas exchanges between the terrestrial biosphere and the atmosphere.
- the desirability of developing a global network of lake sediment study sites.
- the value added arising from linking approaches and methodologies within the same region.
- the interest of LOICZ especially in PAGES Focus 3 research in the coastal zone.
- the scope for a strong PAGES response to LOICZ through sediment-based studies in several key regions, as well as through reconstructions of the history of tropical cyclones.

## Participants

Laurent Labeyrie, Bruno Messerli, Bob Wasson, Claude Lorius, Yugo Ono, Graham Shimmield, Keith Briffa, G.B. Pant, Han Lindeboom, Tsutomu Nakamura, John Dearing, Günther Fischer, José Boninsegna, Keith Alverson, Niklaus Schranz, Harald Bugmann, Rick Battarbee, Jonathan Overpeck, Ray Bradley, Platt Bradbury, João Morais, Vera Markgraf, Michel Meybeck.

# GM2 Earth System Models of Intermediate Complexity (EMICs)

Three presentations focused on:

1. Definition of the Earth system
2. Models of Intermediate Complexity
3. Examples of EMICs
4. Current activities in the field

1. The Earth system can be defined to encompass the natural environment, referred to as ecosphere or climate system in the following, and the anthroposphere. The ecosphere consists of the abiotic world, the geosphere, and the living world, the biosphere. Geosphere and biosphere are further divided into components such as the atmosphere, hydrosphere, ... which interact via fluxes of momentum, energy, carbon, water ... In the discussion, it was confirmed that the conventional definition of climate in terms of atmospheric variables only, still being used in many applications, should be abandoned.

Only caricatures of Earth system models exist for obvious reasons. While models of the ecosphere can be built upon the thermodynamic approach, this does not seem to be possible for many components of the anthroposphere. Earth system models are expected to be developed under the umbrella of both IGBP and IHDP. Within IGBP, Earth system models usually refer to models of the ecosphere prescribing anthropogenic effects as boundary conditions.

Earth system models have to be global models per definition, because atmospheric and oceanic transports lead to nonlocal cause-effect relations. When referring to regional-scale models, regional integrated models would be an appropriate term.

2. Because of the complexity and the wide spectrum of time scales implicit in the ecosphere, a fully coupled comprehensive model seems to be out of reach within the next decade. In the discussion, it was mentioned that such a model will not be accomplished in the foreseeable future. Instead, models which describe all components of the ecosphere and its fluxes, albeit in a reduced form, would be most valuable for IGBP. This model type is referred to as EMIC. It is proposed to define EMICs more concisely in terms of integration of ecosphere components, number of processes included, and detail with which components and processes are described.

The discussion focused on the consistency in the description of subcomponents. A presentation and discussion of biospheric models eluded to this problem.

3. Examples of EMICs and their application to climate system analysis were given by the Potsdam Institute of Climate Impact Research and the Center for Environmental Studies at the University of Bern.

In the discussion, it was emphasized to use a model hierarchy. EMICs are viewed upon as a complementary approach to comprehensive models. The latter are needed for high-resolution studies, time slice analyses, as well as intercomparison to assure that EMIC do not miss important processes. At the same time, simple, conceptual models will be useful to interpret the output of more comprehensive models and to outline new hypotheses. To which degree reduction of model complexity will influence the representation of non-linear dynamics is subject to an ongoing discussion.

4. A group of 9 European labs have informally established a European network on EMICs in February this year.

An IGBP workshop on EMICs will be held in Potsdam, June 15/16, 1999.

# GL3 Review of GLOBEC Related Study in Japan

The following talks were presented:

1. Introduction, *T. Ikeda,* **Hokkaido University, (5 min)**
2. Japan GLOBEC and Related Studies, *T. Sugimoto,* **Ocean Research Institute of Tokyo University, (10 min)**
3. Decadal change in the ecological parameters of the surface migratory *Myctophid* fishes in the Kuroshio region (ORI-GLOBEC), *K. Kawaguchi, S. Nishida and H. Watanabe,* **Ocean Research Institute of Tokyo University, (15 min)**
4. Recruitment dynamics of small pelagic fish (ORI-GLOBEC), *Y. Watanabe, I. Aoki, H. Nakata, M. Terazaki and T. Sugimoto,* **Ocean Research Institute of Tokyo University, (15 min)**
5. Long-term monitoring of subarctic Pacific ecosystems (HUBEC), *Y. Sakurai, N. Shiga, H. Ohnishi, S. Takagi and T. Ikeda,* **Hokkaido University, (15 min)**
6. Spring phytoplankton blooms and inflow of the Oyashio Water in Funka Bay, Hokkaido (HUBEC), *H. Miyake, I. Kudo, S. Ban, T. Nakatani and S. Saitoh,* **Hokkaido University, (15 min)**
7. Sampling observation systems for micronekton and juvenile fish (HUBEC, ORI-GLOBEC),. *Iida, T. Miura, K. Miyashita, Hokkaido University, T. Komatsu and T. Inagaki ,Ocean Research Institute of Tokyo University,* **(15 min)**
8. Turbulence and zooplankton behaviour, *H. Yamazaki,* **Tokyo University of Fisheries, (15 min.)**
9. Numerical models for subarctic Pacific Ecosystem, *M. J. Kishi,* **Hokkaido University, (15 min.)**
10. Variations of oceanic environment and size-structure of copepods in the Kuroshio, (VENFISH-Kuroshio), *K. Nakata, K. Sasaki, National Research Institute of Fisheries Science, and K. Okuda,* **Tohoku National Fisheries Research Institute, (15 min.)**
11. Japanese sardine recruitment project: studies on population structure and recruitment variability, *Y. Oozeki,* **National Research Institute of Fisheries Science, (15 min.)**
12. Sea ice and penguin study in the Southern Ocean, *Y. Naito, A. Kato* , **National Institute of Polar Research, and Y. Watanuki, Hokkaido Universit, (15 min)**

There followed a general discussion, which was continued at the GLOBEC SSC meeting on the Friday.

## Participants

Roger Harris, Neil Swanberg, Peter Burkill, Alex Bychkov, John Field, Eileen Hofmann, Keith Brander, Pat Livingston, Hideo Miyake, Ramiro Sanchez, Kohji Iida, Yasunori Sakurai, Naonobu Shiga, Nadia Pinardi, Hidekatsu Yamazaki, Rudi Stichler, Katsuyoki Sasaki, Kaoun Nahata, Terulisa Komatsu, Ian Perry, Tommy Dickey, Michio J Kishi, François Carlotti, M Hishida, Akira Taniguchi, Ryo Kimura, Yoshino Watanabe, Jarl Strömberg

# Synthesis Session Reports
# 12 May

## CT3 Water Initiative

The Water Initiative session has been attended by about fifty participants from most IGBP Core Projects. PAGES, BAHC and LOICZ were the conveners of the first IGBP workshop on riverine fluxes to terrestrial freshwaters and coastal ecosystems (IGBP Report□39) and are now joined by other participants as from GAIM, LUCC, START, IGBP-DIS. Two main questions have been actively debated during the sessions:

(i) What are the longer term tasks of the Water Initiative?
(ii) What are the products of the Water Initiative for the next two years?

The six main tasks that were raised at the Brussels workshop (November 1997) were not much critized and they can be considered as a guideline:

- Assessment of present-day stocks, concentrations, and flux fields of water and freshwater-borne material to the ocean
- Influence of human activities, at various time scales, on these, at regional and global scales
- Biogeochemical control of the riverine fluxes
- Sensitivity of ecosystems function and water resources to changes at the regional and global scales.
- Sensitivity of riverine fluxes (water, water-borne material) to global change and their impact on global Earth system.

A thorough review of existing knowledge on continental aquatic systems will be done in February 2000 at the IGBP/Swedish Academy of Sciences workshop on continental waters (see below). The IGBP Water Initiative will benefit from these conclusions and may read just some of these tasks.

Many participants raised the need for integrated regional studies (e.g. Subarctic rivers, monsoon Asia, dry tropics) in which the socio-economic factors linking Man and continental aquatic systems for water management, biogeochemical cycling can be more easily studied. Also the response of aquatic systems to climate change, for water resources issues, water management, biogeochemical cycling should be assessed at the regional scale since it may be quite different from one region to another. On the other hand the need for a global coverage of the Water Initiative has also be put forward particularly in regions where direct observation are still sparse or lacking and when considering the global impacts of water and sediment and the biogeochemical cycling of carbon, nitrogen, phosphorus and silica, the major focus of the Water Initiative.

Within the next 12 months the following activities will take place:

*Harmonization of the global typology of aquatic systems.*

This typology is progressing rapidly within BAHC (TYGRIS-BAHC for river systems) and within LOICZ (coastal zone typology). A first assessment of the coastal zone population and few other characteristics will be presented by BAHC and LOICZ at the LOICZ Open-Science Meeting in Argentina next November. A first presentation of the BAHC river typology will be presented at the Manaus workshop on Large-Scale river basins also in November 1999. In parallel PAGES is progressing in its analysis of watersheds source areas and input/output functions for water and sediments which will be presented in March 2000 at a LUCIFS workshop in Germany.

*Developement and publication of global data bases.*

The coastal zone database realized by LOICZ at 1° grid cell with about 30 layers of information is already available on LOICZ website and regularly updated. The first global data on river basins is now being completed by BAHC. It will combine the major basin characteristics, from hydrology to population, with river chemistry at mouth from the GEMS-GLORI register developed by UNEP/WHO. It is intended to make this data base available on CD-Rom, possibly with the help of IGBP-DIS.

*Stockholm water workshop (February 2000).*

Within the set of IGBP workshops sponsored by the Swedish Academy of Science it has been accepted by both parties to hold a specific workshop with invited participants next February in Stockholm. This meeting will bring together IGBP participants from most Core Projects having worked on water-related issues at the regional and global scale, with scientists from other fields such as water-management, socio-economy and river ecology. The main purpose of the workshop is to set up a global picture of the water scene, based on IGBP knowledge and outside, to help IGBP to redefine or focus the Water Initiative tasks (see above). The past interactions between Man and hydrosystems will be considered as well as the evolution of hydrosystems over the next 50□years.

*Global Change Newsletter.*

It was proposed that a special issue on the Water Initiative would be realized in the second half of year 2000. It will present both the specific activities of the various Core Projects in this field as well as the joint activities between Core Projects related to water issues (e.g. global typology of continental aquatic systems, mountain hydrology). The regional descriptions of water issues will be given through case studies on Artic and sub-Artic rivers, Chinese rivers, European basins, South African rivers, etc. A summary of the Stockholm workshop will also be presented.

*START meeting on Freshwater resources of Africa (Nairobi, October 1999).*

This meeting will consider all the aspects of water resources assessment, management and policy for both dry and humid regions of the African continents. It will be attended by many IGBP scientists as well as water management authorities from many African countries. A small technical meeting could be organized back-to-back as a follow-up of the IGBP-GAIM meeting held in Mombasa in 1997.

In addition to these integrated activities from BAHC, LOICZ, PAGES and START other Core Projects have presented or mentioned specific programme activities related to continental waters and related fluxes such as the regionalization of water use, in China and in South Africa (impact of land-use changes on the hydrological cycle), within LUCC and the carbon and nutrient fluxes of forested cultivated catchments to lake, within GCTE. Also worth noting is the GTCE Soil erosion network which combines both monitoring experiments and modelling and the GTCE-GAIM workshop on wetlands (IGBP report #46). Finally it must also be noted that the IGBP Mountain project led by GCTE and BAHC has also a major water component (see session B5 report).

# B3 Risk and vulnerability assessments of environmental change and climate variability with respect to water resources

## Motivation

A change in the spatial and temporal distribution of precipitation and temperature could result in a shift in river runoff in time and space, affecting decisions concerning future use of water resources.

In this session the need to have scenarios considering a wide range of conditions enclosing land-cover/use change and other human actions besides environmental change and variability was the main issue.

In the motivation given by Roger Pielke and Lelys Guenni, the need to quantify environmental variability from observed data as an important system driver for climate impact studies, was discussed. It was also explained that because of the presence of important non-linear feedback not included in global models, scenarios based only on GCM outputs with increased $CO_2$ are of limited value for impact studies. A more useful approach is to define how vulnerable is your water resource system when you reach some threshold values associated with a damaging event. The need to assess the frequency of occurrence of these damaging events and in general, the short-term occurrence of important phenomena driving the system, was also highlighted in this motivation.

Two approaches can be distinguished here:

A. Given a scenario or projection of the future climate, analyze the response of the water resource system.

B. Define a threshold or limit of tolerance of an actual water resource system to a proposed change in climate.

András Bárdossy considered the importance of assessing risk of adverse events. These events have a probability and damaging consequences. Their probability can be quantified from observed data. These unusual events can have an instantaneous effect and a cumulative effect and their impact will depend very much on the nature of their variability. For example, changes in precipitation will have a different effect on peak discharge depending on the type of change (amount and/or intensity). He also showed that from large-scale weather patterns it is possible to evaluate the behaviour of rainfall variability, as for example, probability of rainfall occurrences and rainfall extremes. Rainfall characteristics are largely controlled by large-scale information.

Mike Hutchinson stressed the importance of communication among IGBP and defined scales as a unifying and informing factor. He described the atmosphere/climate system as a coherent and dynamic system in where space and time scales of variation and interactions can be statistically calibrated. He presented evidence for a physical basis for these calibrations. He also gave an overview of the Weather Generator (previous BAHC Focus 4) as a useful tool to provide scenarios. He presented results on the spatial scale of the interaction between precipitation and topography which offer to be globally applicable.

The usefulness of an integrated vulnerability approach was presented by Coleen Vogel showing a case study for Mozambique. In this location variations from floods to droughts are common. Different measures of physical vulnerability were assessed including vulnerabilities to floods, to food availability and accessibility. The human dimension aspects (e.g., demographics, role of policy, land use change) were considered in this study jointly with land-use change implications including agriculture intensification and increasing erosion. We discussed erosion as a strong response of the system to extreme weather events and land use changes.

In conclusion, the assessment of climate variability at different time and spatial scales, especially with respect to extremes, provides added value to the required scenarios for the assessment of risk and vulnerability with respect to water resources.

## Participants

Sabine Lütkemeier, András Bárdossy, Coleen H. Vogel, Lee Byong-Lyol, Liu Changming, Roger Pielke, Michael Hutchinson, Lelys Guenni, Peter Tyson.

# B2/G1 Terrestrial carbon metabolism: contemporary (FLUXNET) and future (C sink saturation) carbon fluxes

## Part I - FLUXNET

The goal of FLUXNET is to produce global coverage of carbon fluxes at the patch scale to improve understanding of the surface controls on the carbon balance. FLUXNET strives to achieve this by maintaining and setting up flux towers over a variety of ecosystems. FLUXNET now needs to collaborate with other groups within IGBP to fully make use of the data and achieve complementarity in measurements and interpretation.

There is a need to scale the information gained at the patch level to regions or landscapes. Equally important is that studies are executed around flux sites to determine the soil and ecophysiological controls determining the ecosystem exchange. More attention needs to be directed towards a better understanding of respiration, as differences in respiration, driven by changes in growing season, appear to determine a large part of the variability in ecosystem exchange. Similarly other techniques may be used (isotope discrimination) to support interpreting the eddy correlation measurements. To be able to understand the response of forests at a longer timescale needs to be studies, by concentrating on additional chronosequences.

It may be beneficial to collocate a few sites with the flask sampling network or high towers, to achieve a consistent data set which can be used to study upscaling to larger areas. At this scale the atmospheric boundary layer (ABL) plays a crucial role as mediator between the surface fluxes and the atmosphere. There is also a need to link the upscaling efforts more closely with the disturbance regimes.

The data and quality control has progressed substantially over the last few years and data bases now exist in the US and EU storing the emerging data sets from FLUXNET. A well-focused modelling programme may now be progressing towards understanding the longer-term behaviour of ecosystems and move away from detailed process level modelling. This will also allow identification of ecosystem units.

The data on water and energy balance are also potentially very useful in for checking the performance of GCM's and NWP's. This link with WCRP (GEWEX) efforts needs to be strengthened.

There is a need to strengthen the input of terrestrial scientists, both from FLUXNET and ecosystem process studies, to the IGBP Carbon Working Group.

### Part II - Non-linear responses in the carbon cycle.

The session mainly focused on the non-linearity responses and thresholds associated with the carbon sink saturation hypothesis. The first type of non-linearities was related with metabolic responses such as $CO_2$ response saturation at high levels of atmospheric $CO_2$, and the exponential response of ecosystem respiration to warming. The second type of non-linear responses were at the landscape level mainly associated with fire regimes and its behaviour in various landscape patterns. Emphasis was given to results from the DGVM intermodel comparison which shows various models with a NEP saturation curve which flattens around the middle of next century, and declines after 2100. There is a need to better understand the reasons why each of the models performed the way they did. It was also proposed to build a box model to further test this hypothesis and also gather all evidences from elevated $CO_2$ and warming experiments that show any kind of saturation responses.

## LU3 Historical/future land use and cover

### History of fast-track project

- IGBP carbon group urgently needed a historic database to determine terrestrial sources and sinks and their dynamics (not only land cover, but also other attributes, that influence the C-cycle);
- LUCC DAPLARCH (Data plan for land-use and land-cover research) identified the need for an assessment of historical land use and land cover that builds on existing data;
- GCTE and BAHC also expressed the need for an appropriate historic land-cover database.

### Purpose of this session

- To identify and define the desired properties of the fast-track historic database (e.g. resolution, time steps, coverage);
- To define the desired land-use and land-cover attributes;
- To involve all core projects;
- To broaden acceptance and use to all IGBP (and IHDP) projects.

### Preliminary work plan

| | |
|---|---|
| November 98 | Start during the GAIM meeting |
| April 99 | End feasibility study; looking for funding |
| May 99 | Requirement workshop at IGBP Congress |
| September 99 | Start post-doc |

| | |
|---|---|
| Early 2000 | Workshop with regional experts, who have developed (regional) historical datasets |
| Spring 2001 | Validation workshop with potential users |
| July 2001 | Presentation at IGBP Open Science Conference in Amsterdam |

## Further development of the database

- LUCC will be the host of the final version of the fast-track database as part of Focus 1 and 3;
- LUCC will maintain, correct, and update the database when required and/or possible;
- LUCC will further develop the database with annotated regional case studies. These studies will be more precise, focused and useful for detailed modelling studies.

## Participants

Rodolfo Dirzo, Eric Lambin, Billie L. Turner, K.S. Rajan, Arturo Sanchez-Azofeifa, Chae-Shik Rho, Achmad Suryana, Upik Rosalina, Andy Pitman, Bob Buddemeier, Wolfgang Cramer, Kathy Hibbard, Roni Avissar, Emilio Moran, João Morais, Martin Claussen, Rik Leemans, Pamela Matson.

# P2 PAGES Synthesis

During this session the PAGES SSC and a few guests met to discuss the PAGES synthesis effort. The outcome of these discussions was to develop a new theme for the synthesis effort.

*"What is the significance of the palaeo-record for understanding the future?"*

In addition, a new outline of the book was developed, authors chosen and a schedule of writing workshops was drawn up. Finally, a budget for the overall effort was drawn up.

Two synthesis products, a book and a glossy brochure, will be produced. In addition a set of overheads will be made available, probably on the PAGES website.

The anticipated constituency for the book is the scientific global change community and high-level educators, while the brochure will be written for non-governmental and governmental organizations, public school educators, and the environmentally concerned public.

The book will be structured as follows:

**Chapter 1, Introduction**: The Human Rationale for Past Global Change Research

10,000 –15,000 words.

The "Results" section: 5 chapters, each structured around a central question and each of ~15,000 words plus figures. Each will summarize the existing information:

**Chapter 2**: What has been the history of trace gases and aerosols?

**Chapter 3**: What has been the history of atmospheric, oceanic and cryospheric dynamics?

**Chapter 4**: What has been the history of the carbon and other biogeochemical cycles?

**Chapter 5**: What have been the roles and responses of vegetation in the climate system?

**Chapter 6** (a transition chapter to the Discussion section) : How has the Earth system changed during the last 1,000 years?

**Chapter 7+**: Crosscutting synthesis/discussion section, title(s) to be determined. Topics to be considered include:

The potential for surprises

Implications for future change and sustainability of ecosystems and resources

Modelling the future – lessons from palaeoclimatic reconstructions

## PAGES Synthesis Schedule (as of Shonan, May, 1999)

*1999*

*May*. Contact invitees.

*May*. Contact PAGES task/activity leaders requesting a short list of key references and figures in response to the question, "What are your most significant findings?" Deadline for contributions: June 15.

*July*. Compendium of key references to be prepared and sent to all lead and contributing authors.

*September - November*. Preliminary small group meetings as required by lead authors of each "Results" chapter.

*2000*

*January or February*. **FIRST "RESULTS" WRITING SESSION**. To be held in Switzerland, either during the period Jan. 21-26 or in the week before PAGES SSC Meeting in Pune, India.

*March*. Distribute widely the "Results" draft (Chapters 1-6, inclusive). All "synthesis/discussion" section writers to receive a copy of the draft. Solicit/collate comments from all recipients by May 31.

*June*. **SECOND SESSION TO WRITE THE DISCUSSION/SYNTHESIS**. Location to be determined (Switzerland?).

*July*. Start preparation of Brochure/Executive Summary.

*July*. Completion of final draft of book, distribute for comment with deadline of September 30.

*October/November*. Revision of final draft to produce finished product for submission to IGBP/Publishers by Nov. 30.

*2001*

*January*. Executive summary/brochure to be completed by Jan. 31.

## Participants

Keith Briffa, Vera Markgraf, Jonathan Overpeck, Claude Lorius, Bruno Messerli, Ray Bradley, Roger François, Matti Saarnisto, Laurent Labeyrie, Thomas Stocker, Yugo Ono, Dominique Raynaud, Keith Alverson, Frank Oldfield, Tom Pedersen, Govind Pant, Niklaus Schranz, José Boninsegna

# I1 Ocean-atmosphere, atmosphere-ocean biogeochemical coupling

- Importance of iron for 'high nutrients, low carbon' oceanic systems (Southern Ocean, e.g. Pacific)
- Success of iron addition experiments
- Iron input due to aeolian fluxes. However, not everywhere is there a concomitant increase in biomass, especially cyanobacterium *Trichodesmium*. Why?
- Relevance and success of Lagrangian studies in ocean and atmosphere.
- Need for more studies for gas exchange coefficients
- Need for new, direct techniques to measure atmospheric fluxes
- Bring atmospheric and oceanic modelling communities timely together, as the difference in $CO_2$ ?? fluxes derived from $pCO_2$ field marine measurements and from atmospheric inversion models not only are of different magnitude but sometimes of opposite sign in specific regions, although the global number may be similar.
- Need inclusion of more detailed biology into ocean models, ocean-atmosphere models. Geochemistry is different from biogeochemistry.
- Importance of dissolved, organic compounds not well known.
- SOLAS = global and/or regional emphasis

- To be successful, SOLAS must have a balance between oceanic and atmospheric research. Should it also include gas transport from terrestrial environments into the coastal zone?

## General points

- Ocean carbon uptake from models and data (ocean and atmosphere) are in general agreements (x2G+C/yr)
- Regional uptake estimate from atmospheric inversions often disagree with regional fluxes estimated from ocean data and models
- Ocean modelling indicates that most interannual variability in the air-sea carbon flux occurs in the equatorial Pacific. Atmospheric inversions usually show larger interannual variability and not just in the equatorial Pacific. The few locations in the ocean with sufficient data to detect interannual variability are the Equatorial Pacific and Northern Hemisphere sub/tropical gyres (HOTS and BATS sites).
- Coupled ocean-atmosphere carbon models suggest future $CO_2$ uptake will be reduced if climate changes (biological and physical response).
- The regional and interannual discrepancies between atmosphere and ocean derived estimates of carbon uptake need to be resolved. Is it a model or data limitation or both.
- Time series and regional ocean data are needed to improve ocean carbon uptake estimates and validate ocean carbon cycle models. The Southern Ocean is particularly important.
- Direct air-sea flux measurements and an improved gas transfer coefficient/wind speed relationship are needed to better constrain air-sea carbon fluxes calculated from ocean data.
- A strategy is needed to detect the response of the ocean carbon cycle to potential changes in circulation of the ocean due to climate change.

## Participants

Paul Falkowski, Harriet Barker, Bronte Tilbrook, Danesh Parashar, Karin Lochte, Peter Burkill, Shyam Lal, Ming-xing Wang, Proespichaya Kanatharana, Narin Boontanon, Takao Igushi, Jozef Pacyna, Roger Hanson, Michio Kishi, Toshiro Saino, Mitsuo Uematsu, Barry Huebert, Paul Crutzen, Pat Livingston, Celia Marrase, Patricia Matrai, Mary Scholes, Julian Priddle, Robert Delmas, Masataka Hishida, James Orr, Derek Cunnold, Elliot Atlas, Alex Pszenny, Kathy Law, Paul Harrison, Robert Le Borgne, Paul Tréguer, Philip Newton, Roger Harris, Elizabeth Gross, Neil Swanberg, Peter Liss, Bob Duce, John Field, Patrick Monfray, Ian Perry, Yoshimi Suzuki, Guy Brasseur.

# J7 Continental margins $CO_2$

## Aims

- Better define the role of continental margins in global carbon cycle
- Identify major gaps in current knowledge
- Identify IGBP Core Projects, which contribute to the assessment of different carbon fluxes at various margins

## Summary


- The continental margins serve as an important part of the $CO_2$ sequestration machinery in the ocean with an estimated strength of 0.5-1 Gt C/yr, representing 5-15% of the global ocean biological pump.

- In western boundary current systems, such as the Kuroshio, an efficient continental shelf pump may draw down atmospheric $CO_2$ and transport dissolved inorganic carbon and also organic carbon to the intermediate waters in the open sea. Better understanding of the processes involved in the pump is needed.
- In eastern boundary current systems, both the temporal and the spatial variability of air-sea $CO_2$ fluxes are very high (fluctuating between strong sources and weak sinks), but new observations are emerging which may shed light on the control mechanisms for the carbon fluxes.
- The recently published assessment of the global export production in the coastal ocean raised questions. A more comprehensive assessment is needed. The joint LOICZ-JGOFS Continental Margins Task Team (CMTT) will take on the responsibility to carry out the synthesis in the next 2-3 years, if it gets sufficient support.

## Short talks

1. Steve Smith indicated that estimates of the export production in the global coastal ocean in some recent publications might be too high and suggested area-weighted average for assessment. He then gave an overview about the general LOICZ budgeting procedure, which is based on linked water, salt and nutrient budgets to estimate the net organic production. Dissolved organic N and P are ignored due to lack of information in most systems, but could be important.
2. Liana Talaue-McManus and Julie Hall discussed budgets for coastal areas in the Philippines and New Zealand, respectively. These were constructed using the LOICZ budgeting procedure. In three areas (Linganyen Gulf and Manila Bay in the Philippines, and Hauraki Gulf, New Zealand), the coastal zone was heterotrophic (i.e., $CO_2$ source) and net denitrifying.
3. Arthur Chen presented carbon estimated for the North Pacific and summarized a number of carbon fluxes from other shelves. In all cases except the Gulf of California, the continental margin acted as $CO_2$ sink. In the East China Sea, upwelling and river runoff supplied nutrients to support new production, which was exported not only as particulate organic carbon (POC) but also as dissolved organic carbon (DOC). In the Okhotsk Sea and the Bering Sea, formation of the North Pacific Intermediate Water was important to the sequestration of anthropogenic $CO_2$. Chen agreed with Smith's assessment of the global coastal export production and suggested the value might be too high by a factor of 3. Shizuo Tsunogai described a mechanism he termed the continental shelf pump, which transported mostly dissolved inorganic carbon and to a lesser extent DOC and POC into the deep ocean by isopycnal mixing. If the pump worked the same way everywhere on the shelves, it would have sequestered 1 Gt C per year.
4. Tetsuo Yanagi estimated the nutrient budget of the East China Sea by numerical modelling and showed the significant contribution of the Kuroshio to the nutrient pool. Specifically, it provided 54% of the dissolved inorganic nitrogen influx and 74% of the dissolved inorganic phosphorus influx.
5. Renato Quiñones presented the heterogeneous nature of the eastern boundary Humboldt Current System, which had actively upwelling and quiescent periods over a variable timescales. In actively upwelling areas, $CO_2$ release occurred. During slack periods, the $CO_2$ flux was nearly neutral or slightly downward.
6. Shu Gao and Larry Atkinson both discussed the role of sediment transport in the global carbon cycle. Identification of depositional areas and the concurrent processes associated with the remineralization of organic matter and/or the sequestration of carbon through burial should be assessed. Gao showed that high concentration of suspended sediment at the shelf break was concurrent with high nutrient regimes, indicating remineralization.

## Discussion

1. Summary of areas reported
   Nearshore coastal waters
   - Linganyen Gulf, Philippines — $CO_2$ source
   - Manila Bay, Philippines — $CO_2$ source
   - Haurakai Gulf, New Zealand — $CO_2$ source

   Eastern boundary current system

- Humboldt Current Systems — $CO_2$ source

Western boundary current system

- East China Sea — $CO_2$ sink

Marginal Seas

- Bering Sea — $CO_2$ sink
- Sea of Okhotsk — $CO_2$ sink
- South China Sea — $CO_2$ sink

2.. A more complete assessment of net $CO_2$ flux will need:
   a. A better characterization of air-sea interaction to refine $pCO_2$ estimates;
   b. Identification of depositional areas in the shelves and slopes;
   c. Better estimates of calcium carbonate precipitation/dissolution fluxes;
   d. Vertical and horizontal fluxes of the dissolved organic phase (DOC, DON, DOP);
   e. Spatial and temporal variability of source/sink signature.

3. Strategy for future synthesis
   Julie Hall presented the joint LOICZ_JGOFS CMTT conceptual framework. The latter identified the five typology areas for continental margins: wester and eastern boundary currents, marginal seas, tropical and polar margins. CMTT hopes to synthesize the state of knowledge on fluxes and processes in each of these typology areas. To achieve this, draft outline of a synthesis book was shown.

## Participants

Larry Atkinson, Beatriz Baliño, Alex Bychkov, Arthur Chen, John Field, Shu Gao, Julie Hall, Masataka Hishida, Eileen Hofmann, Huasheng Hong, Dunxin Hu, Hajime Kayanne, Mike Landry, Kon-Kee Liu, Patrick Monfray, Renato Quiñones, Stephen Smith, Takashige Sugimoto, Liana Talaue-McManus, Shizuo Tsunogai, Tetsuo Yanagi.

# GL2/J5 Marine Ecosystem Models: Exploiting the JGOFS legacy

JGOFS is moving to its synthesis and modelling phase and there have been major achievements by JGOFS in relation to carbon flux modelling, modelling primary production, and coupling biology to GCMs. This legacy of JGOFS provides a solid foundation for GLOBEC modelling efforts at higher trophic levels, and for developing coupled physical-biological models. These are developed in Focus 3 of the GLOBEC Implementation Plan.

The aim of this discussion session will be to explore ways to evaluate how far ecosystem modelling has progressed in addressing JGOFS and GLOBEC questions, and to nourish its progress further. In addition, the session will discuss with other Core Projects how they could best share their experiences with other marine research agendas. Coupled physical and biogeochemical models in marine ecosystems constitute powerful research tools to test ecosystem functioning scenarios derived from *in situ* or satellite observation analysis. They are also the unique routes towards predicting the marine environment's response to natural and/or anthropogenic perturbations. For IGBP-wide synthesis, the following questions merit discussion:

1. Which aspects of ocean physics and dynamics are of the most direct concern for marine ecosystems?
2. Are there significant structural differences in marine ecosystems and how do such differences affect the biological pump? Do the data give us enough information to choose among the candidates' models and degree of complexity?
3. How do we evaluate the fit of models and the constraining power of data? How do we extrapolate from local studies to the global scale?
4. How "well" does the present generation of coupled biogeochemical and physical models predict the seasonal cycle of total and export production, distributions of phytoplankton chlorophyll, etc.?

The discussion was introduced by short talks of about 15 minutes each. The first talk was given by John Field on the JGOFS modeling strategy which consists of a suite of numerical models tuned to the different scientific questions. Geochemical box models were developed to answer the carbon budget problems, adapted to the biogeochemical provinces, in order to differentiate between regional primary production regimes. This approach should make it easier to go from regional to global synthesis of ocean primary production standing stock.

Finally a suite of biochemical and coupled biochemical and physical models were also developed for the different JGOFS test sites, such as Bermuda and the North Atlantic, and for regional seas and the global ocean. The most important findings are that most of ocean production is at the mesoscale and thus we need high space time resolution data to verify the models.

The discussion was centred around the minimal number of biochemical and physical state variables needed to reproduce the primary production cycles and conclusion was that it may depends on the question asked and the scale of the problem.

JGOFS modeling effort continued to be shown by Patrick Monfray who presented the global ecosystem modeling done with an intermediate resolution ocean general circulation model, coupled with two simple biochemical models which consider phosphorous as a limiting nutrient. The comparison with SeaWifs colour images is encouraging even if some regions show large discrepancies between model and observations which may be related to the biochemical model approximations. François Carlotti introduced then the general aims of GLOBEC modeling, centred around zooplankton modeling and the development of interfaces to phytoplankton dynamics. The novelty of the GLOBEC approach is that it wants to model targeted species of zooplankton with population dynamics models and understand links with lower trophic levels conditions on the one side and physical conditions on the other. The discussion introduced the concept of geo-statistical information to be coupled with targeted species zooplankton modeling to enlarge the number of species considered. Eileen Hoffmann showed how different ecosystem models can be formulated, a structured modeling approach being able to answer the question of the standing stock while the unstructured modeling considering the question of single species abundance. Data assimilation of available information was shown to be very important to detect model inadequacies and drawbacks. The Pacific JGOFS experiment data were shown to be successfully assimilated into a structured phytoplankton dynamics model. The data assimilation experiment showed the necessity for continuous monitoring or long time series of data in the upper ocean. Discussion pointed out the specific need for models which could switch between phytoplankton species dynamically depending on environmental conditions and nutrient availability.

Nadia Pinardi showed the capability of complex biomass based phytoplankton and microzooplankton models to simulate the seasonal nutrient and phytoplankton growth in a limited region of the world ocean, the Adriatic Sea. The result is that such models can be successfully coupled with high resolution regional hydrodynamic models capable of capturing frontal systems and large water mixing events such as the deep water formation events occurring in shallow depth areas.

The discussion pointed out the need for tuning of the parameters in such complex models especially at the level of benthic-pelagic coupling. Serge Poulet showed the importance of phytoplankton species on the fertility of copepod, thus pointing out the necessity for models to describe in details the coupling between zooplankton population models and phytoplankton biomass.

## Participants

Roger Harris, Serge Poulet, Julian Priddle, James Orr, Patrick Monfray, Robert Le Borgne, Celia Marrase, John Hunter, Nadia Pinardi, KK Liu, Peter Burkill, Ramiro Sanchez, Alex Bychkov, Toshiro Saino, Michio Kishi, Paul Tréguer, Mike Landry, Neil Swanberg, Wandera Ogana, Paul Harrison, Tom Ikeda, Keith Brander, François Carlotti, Pat Livingston, Eileen Hofmann, Shizuo Tsunogai, Bob Scholes, Masataka Hishida, Renato Quiñones, Tim Baumgartner.

# LU2/B1/G2 Landscape session

## Strong points of the talks

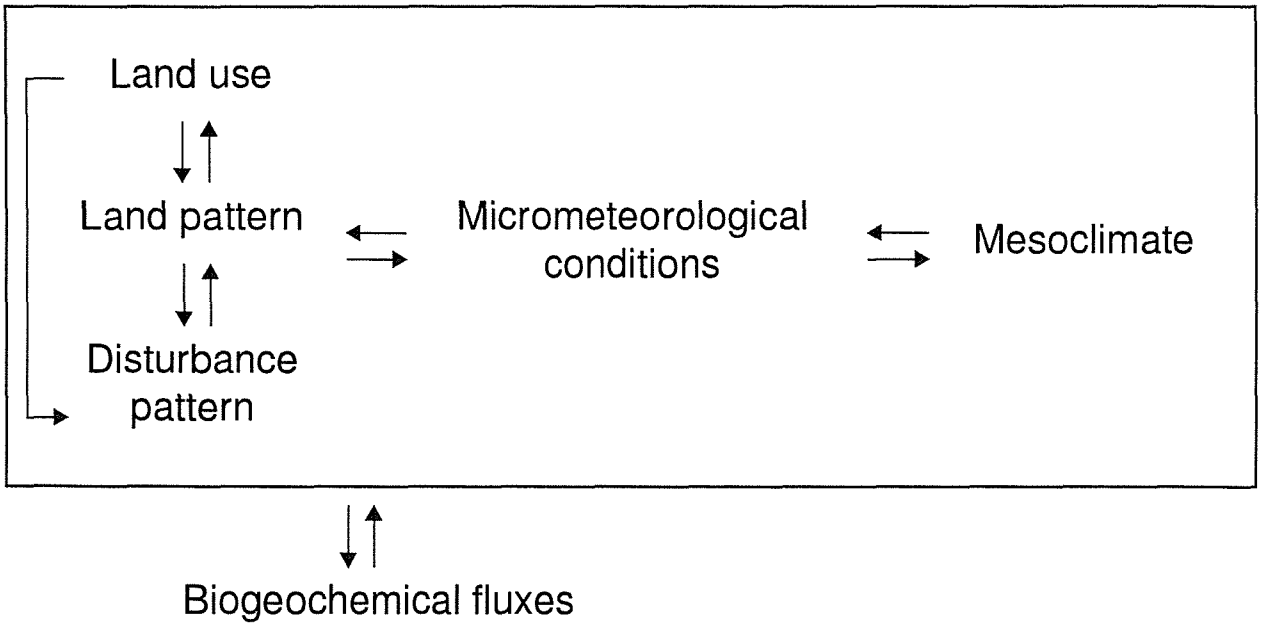
- Land-use effects on disturbance patterns need to be integrated in models of distant spread.
- Land-cover feedbacks to the meso-scale meteorology need to be coupled to
- Land-cover disturbance pattern interacts with disturbances, and need continued investigation
- Subtle changes in landscape pattern can have dramatic effects on biophysical energy fluxes

## Issues

- Temporal and spatial scales: overlaps and discrepancies between programmes, research and models (e.g., DGVMs) require more attention.
- Non-linear effects and thresholds. These are common features at the landscape scale. One of the places where awareness of them is high. E.g. disturbance spread as a feature of land cover pattern as well as a weather patterns.
- Effect of coupling several non-linear processes between land-use/land-cover vegetation dynamics and atmosphere.
- Vulnerability analysis rather than prediction as a common approached?

## Concrete Plans

- To develop a case study for land use change (and causes of fire ignition) which would be coupled into landscape disturbance models. Indonesia is a preferred region for the case study.
- To couple detailed vegetation models with detailed atmospheric/climate models.
- To estimate biogeochemical fluxes at the landscape level, with appropriate understanding of the processes involved for specific landscapes.



# B4 Rivers/coastal typologies

The typology session was not only attended by participants from BAHC, PAGES and LOICZ but also from JGOFS and GCTE.

The BAHC-TYGRIS (Typology of Global River Systems) is based on a general characterization of more than 1,000 river basins at the global scale, both for the external and internal drainage of continents, such as : relief, runoff, organization of river network and stream ordering, large reservoir, water quality (major ions, nutrients and organic carbon from the coupled GEMS-GLORI register), population, land use. Most of these characteristics have been determined for the first time in TYGRIS with a resolution of 0.5°. The first application of TYGRIS concerns the interception of water discharge and related "river aging", the sediment trapping in reservoir ("neocastorization") the effect on biogeochemical fluxes and the changes in linkages between terrestrial and ocean systems.

The LOICZ Coastal Zone typology describes the coastal ribbon between -25□m water depth to +25□m altitude (for some characteristics the ribbon may extend between -50□m and +□50□m) at grid cell with 30□variables such as air temperature, precipitation, seasonal sea-surface temperature, tides amplitudes, wave energy, continental runoff, soil texture, coastal zone colour scanner, vegetation types, socio-economic attributes, coral reef and mangroves descriptors, etc. It is the first coastal zone global data base of this kind and will be used to assess the major coastal zone processes as photosynthesis, respiration, calcification, carbonate dissolution, and their human disturbances. This typology is already used by LOICZ to set up the carbon and phosphorus budgets on more than 30 of representative sites out of 200 targeted sites.

LOICZ is also developing an integrated project on the typology of socio-economic forcing of river fluxes to the coastal zones (pressure-state-impact-response). Two projects have started at the regional level in Western Europe and South-East Asia and another one could result from LOICZ Open Science Meeting in Argentina.

PAGES presented two projects with typology elements: LUCIFS and LIMPACS. LUCIFS concern mainly the past evolution of river systems hydrology, sediment transport and particulate nutrients mostly through agricultural impact. The selected case studies will cover all evolution types from pioneer settlement to developed industrial basins in various climate and relief conditions. The system analysis will be based upon source types of fluxes, particularly for particulate material, transfers and sinks on river basins at various time scales over the last 6,000□yearsA LUCIFS workshop in March 2000 will synthetize this typology.

LIMPACS concerns the human impacts on lake ecosystems based on limnological archives from sediment core analysis. The transfert function are studied in calibrated present or recent conditions using micro organisms as plankton and/or biogeochemical markers. They are then used to infer the past history of lakes systems, a complex interaction of lake basin changes and of in-lake processes. Successfull attempts of reconstruction of past pH, nutrients status, salinity have already been achieved.

In the next twelve months several meetings will help to harmonize and integrate these various typologies: LOICZ/BAHC workshop on coastal zones: Catchment Interactions and Human Dimensions of Change in November 1999 (attached to LOICZ Open Science Meeting) and a PAGES-LUCIFS workshop in March 2000 (Germany) at which BAHC TYGRIS will be presented.

# GM1 Palaeo trace gas

## Trace gas and Aerosol Changes in the Earth System (TRACES)

1. Progress on resolving the issue of the diffusivity of the real ocean for chemical species (so we know where we are with respect to explanations of low $CO_2$ at LGM) - Tom Pedersen
2. Progress in building terrestrial models that couple trace gas sources to ecosystem processes (i.e., progress beyond empirical correlations, which are still all there is for several key species): important species would be $CH_4$, $N_2O$, $NO_x$, NMHC, CO - John Ingram, Arvin Mosier
3. Progress in modelling marine ecosystem processes, particularly as regards
   a. the abundance of siliceous versus carbonaceous plankton - Roger Harris
   b. the pathways for incorporation of Fe into the ecosystem: towards a "DGVM of the ocean" - Peter Liss

4. Holocene $CO_2$: more and more precise measurement of $^{13}C$, to help focus land versus ocean explanations for the changes; also isotopes of $CH_4$ in the ice cores to help locate sources - Dominique Raynaud (isotopes in general)
5. a. Integration of terrestrial, marine and ice core dust flux palaeodata (DIRTMAP project; already adopted by INQUA) and assimilation into models of knowledge concerning the mineralogy of dust sources – important for radiative forcing as well as for possible biogeochemical effects - Colin Prentice
   b. GHG - Colin Prentice
6. A new focus in palaeoclimate modelling, to understand abrupt and non-linear climate changes in the Holocene using both 2,5 D and 3 D models - Colin Prentice, Thomas Stocker
7. Using various aspects of the above, running atmospheric chemistry-transport models under the climatic and biological conditions for pre-industrial time, 6 ka, LGM to try to match ice core information on atmospheric composition - Colin Prentice

| Target record | Type | Validation | Model output | Data priority |
|---|---|---|---|---|
| $CO_2$ | TERRESTRIAL | biomes | ✓+ | ✓+ |
| | | lake area | ✓+ | ✓+ |
| $CH_4$ | | $d^{13}C$ - macrofossils | ✓+ | ✓+ |
| | | Dust distribution | ✓ | ✓+ |
| $N_2O$ | | Noble gases | ✓+ | ✓- |
| | | $^{18}O$ | ✓+ | ✓ |
| Dust | | wetlands | ✓- | ✓+ |
| | | river discharge | ✓+ | ✓- |
| Sulphate | | charcoal (bio. burn) | ✓ | ✓ |
| | | CCD | ✓ | ✓ (longer times) |
| MSA | MARINE | accum. rate (Ca, Si) | ✓ | ✓ |
| | | MFTs | --- | ✓+ |
| | | $^{13}C$ in forams | ✓ | ✓ (need analysis) |
| | | $^{18}O$ in carbonates | ✓+ | ✓ |
| | | proxy SST (e.g. alkenone ratios) | ✓+ | ✓+ |
| | | ventilation proxies | ✓+ | ✓+ (need interpretation) |
| | | weathering | --- | ✓+ |
| | | alkalinity | ✓+ | ✓+ |
| | | Dole effect | ✓+ | ✓+ |
| | ICE | $^{13}C$ | ✓+ | ✓+ |
| | | trace gas isotopes | --- | ✓ (need lots) |
| | | mass balance | ✓- | ✓ |
| | other bio proxies | $NH_3$ $NO_3$ | ✓- | ✓- |
| | | Formate | --- | ✓- |

## Participants

Dominique Raynaud, Ryuji Tada, Alex Pszenny, Arvin Mosier, Derek Cunnold, Roger François, Claude Lorius, Masataka Hishida, Robert Delmas, Karin Lochte, Philip Newton, Paul Crutzen, Kathy Law, Dork Sahagian.

# JP1 Food in monsoon Asia

## Participants

Peter Gregory, Masatoshi Yoshino, Satya Priya, Arthur Chen, Masataka Hishida, Günther Fischer, Heinz-Ulrich Neue, Chae-Shik Rho, Yousay hayashi, Kazuhiko Kobayashi, Suresh K. Sinha, Tony Hunt, A.P. Mitra, John Ingram, Daniel Murdiyarso, Achmad Suryana, Rita Nurmalina, T.K. Fernando, Edmond Ranatunge, Byong-Lyol Lee.

# JP2 IGBP Northern Eurasia Study

## Introduction

The background of IGBP-NES was briefly explained by conveners. In 1995 first meeting mapped out the plan of inter-cores programme among IGAC, GCTE and BAHC. In 1995 December, at Tsukua the meeting was held under the name of IGBP-NES. In 1996 at Ykutsk, action plans of transect study of semi-continental scale was discussed. At present meeting, there are three key words which characterize IGBP-NES: 1) carbon cycle, 2) disturbance (human dimensions), 3) transect study.

The main objectives of the discussion today are as follows:

What is the goal?

When will we carry out the programme and how long?

Where will we carry out the programme?

Five speakers reported the present stage of own programme, early results and future plan. Some related topics such as political and economic issues sin the area of northern Eurasia were also discussed.

## Report of speakers

Takayoshi Koike explained his group's activities in eastern Siberia as well as future plans. Four topics of the joint study between Skachev Forest Institute at Krasnoyarsk were explained as biomass (vegetation change), soil mineralization process, micro relief performance and nutriment. He also emphasized the prediction of future regeneration of taiga was important under global warming trend. In coming three years he will conduct joint research programme near Yanisei River focusing on air pollutants influence to Taiga environment. In near future flux study in northeast China will be conducted. The micro topography influence to vegetation was asked. The comment about frost mount was presented.

Yoshihiro Fukushima made his presentation about GAME/Siberia programme. First he explained the scheme and structure of the programme under the umbrella of WCRP. Along Lena River, two monitoring sites for heat-water-carbon budget were active and an additional site would be set up soon. The early results of the monitoring were presented using some figures. For example, ground temperature observation was shown indicating the active layer depth as 100cm deep at the site near Yakutsk. Seasonal variation of photosynthesis with different type of forest was also shown and comment to this result was made afterward. Hydrological cycle in watershed was another target in his programme. In 2000, IOP was planned to conduct at the site. At the end of his report, future perspectives of the programme associate with enhancement of Frontier programme. The amount of the active researchers were 30 to 40.

Masami Fukuda explained about his newly established programme "Permafrost disturbance and green house emission", which was supported by Science and Technology Agency Japan as CREAST programme. As already mentioned by Gen Inoue, human dimensions to the environment is a big issue. Increasing of taiga forest fire occurrence may reduce the carbon stock in the Taiga region. The quantitative evaluation of forest fire is one of the urgent tasks of NES. The possible artificial forest burn experiments are planned at Alaska and Siberia. Response of permafrost disturbance and forest dynamics to forest fire with atmospheric compound is enhanced in his programme. The modelling of the impact of forest fire will be also examined based on modified GCM. The scale up analysis of on-the-spot investigation

will be developed by means of remote sensing technique. He showed the early results of the fire detection capability of remote sensing over far-eastern part of Siberia in 1998 season. Based on NOAA data, the occurrence of forest fire and size of each fire were clearly detected. The long-term monitoring after fire is planned in future cooperating with another research group.

Gen Inoue reported his group's activity, which is categorized into the Yenisei Transect study and interaction between wetland and atmospheric aspects. According to aircraft monitoring of trace gases over west Siberia, the profiles of each gas shows the source and sink variation which exhibits the strong connection of seasonal variation. Two clear peaks of methane flux in wetlands were detected. The summer high flux of methane derived from biogenic sources and wither peak denoted as leakage from gas pipe line. Identification of different sources was authenticated by $^{14}C$ concentration of methane. Research need of human impact of green house gas emissions in Siberia was strongly pointed out.

Neil Hamilton proposed the IGBP regional study initiative based on the necessity of more integrated study. The main reason of the proposal is that many aspects of global change occur in not only global but also on a regional level. The facilitation of the development of integrated regional study in IGBP will be a major target in the NES activity. The policy responses to global change may be decided in the regional level. However there are some issues when we will set up the action plan.

There are some or many overlapping programmes in the topics and areas to study. More collaborations among research societies are needed to avoid the duplication of programmes and to share results. The comments on the activities relationship between IGBP and other governmental networks, like APN, was indicated.

## Discussion

The management issue in field investigation in Siberia was discussed in various aspects. Especially import tax was a major obstacle when large scale expedition is planned to import the equipment into Russia. The idea about the establishment of a platform center in Siberia was introduced. Already Japan and US developed the International Arctic Research Center (IARC) at Fairbanks and is open to international research groups for global change research. New mechanisms for assistance to Russian researchers on the base of furnishing research salary is urgently necessary.

The next IGBP-NES meeting will be held in August at Krasnoyarsk and Khabarovsk. The website of IGBP-NES will be developed by GAME/Siberia group or CREST/Permafrost Disturbance group in the near future.

## Participants

Gen Inoue, Masami Fukuda, Neil Hamilton, Kazuo Mabuchi, Susumu Yamamoto, Neil Trivett, Yasuo Sato, Keiji Higuchi, Yoshihiro Fukushima, Hans Graf, Paul Crutzen, Vyacheslav Khattatov, H. Shimizu, Takayoshi Koike, Han Dolman, Tetsuo Sueyoshi, Ryuji Tada.