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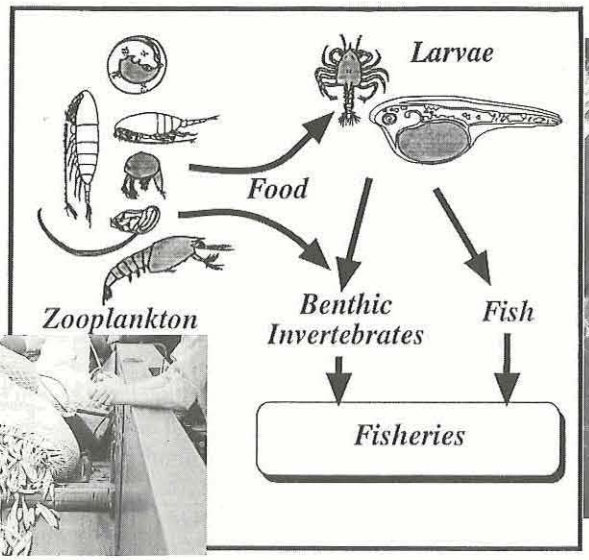
OF THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

Global Ocean Ecosystem Dynamics

by Roger Harris



R. Harris

The linking between zooplankton and fisheries through interactions in the plankton is a primary interest of GLOBEC.

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The Global Ocean Ecosystem Dynamics (GLOBEC) project was adopted by IGBP in 1995 with joint co-sponsorship from the Scientific Committee for Oceanic Research (SCOR) and the International Oceanographic Commission (IOC). It has just held its first SSC meeting, and will shortly publish its Science Plan.

The background to GLOBEC

Currently, an integrated and coherent understanding of natural forcing and its interactions with human populations is limited by shortfalls in our information on global ocean ecosystem dynamics. Equally constraining is our present inability to differentiate anthropogenic from naturally occurring effects in marine ecosystems. There are three major gaps in our knowledge of marine ecosystem dynamics, which GLOBEC is addressing:

- the dynamics of zooplankton populations relative to phytoplankton and to the major predators of these organisms;
- the influence of physical forcing on these dynamics, particularly at the mesoscale; and,
- the estimation of biological and physical parameters associated with the dynamics of zooplankton relative to phytoplankton.

An example can be used to illustrate the pressing need to improve our understanding of the dynamics of ocean ecosystems. A dramatic multidecadal decline in plankton biomass has been revealed in the North Sea and in the eastern North Atlantic by extensive continuous plankton recorder (CPR) sampling (Figure 1). Various explanations have been offered for this decline, and refining these explanations is a challenge for the field of ocean ecosystem dynamics. Such changes are also of interest from a biogeochemical viewpoint (JGOFS), because they may relate to changes in the surface fluxes of CO_2.

Natural variability, over a variety of time scales, is a characteristic feature of complex marine ecosystems, regardless of fishing or other environmental pressure. We are only now beginning to compile documentation related to such variability. Our knowledge concerning its causes remains at the level of hypotheses. Understanding of the functioning of marine ecosystems is essential if we are to effectively manage global marine living resources such as fisheries during a period of tremendously increased human impact, and concurrent dependence, on these resources.

In particular we need to improve documentation and understanding of the causal relationships between physical forcing and biological variability. The scientific understanding of these relationships obtained by GLOBEC will provide the basis for related policies in response to global change. The need is likely to become critical as anthropogenic pressures on marine ecosystems increase, particularly if the predicted changes associated with global warming materialise. For example, as one scenario, if storm activity were to increase as a result of climate change, upper ocean turbulence would be expected to increase and mixed layers would deepen. Increased mixing might bring more nutrients into the upper ocean, but the greater depth of their distribution might mean a decrease in the average rate of photosynthesis, GLOBEC will consider such scenarios and their significance for upper trophic levels and feedbacks.

These changes are occurring, and we can detect them, but with our present scientific approach to the ocean ecosystem we cannot model or even understand them. This suggests that a new and innovative approach to the study of global ocean ecosystem dynamics is necessary for improving our understanding.

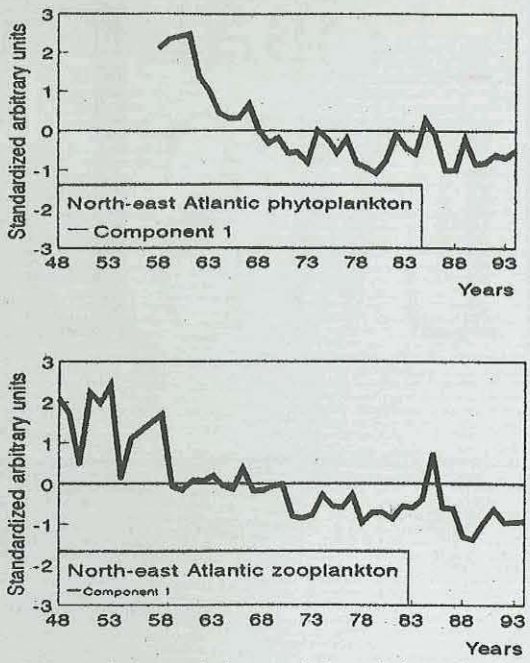

Figure 1: Long-term trends in zooplankton and phytoplankton abundance in the north-east Atlantic recorded by the Continuous Plankton Recorder (CPR) survey (Sir Alister Hardy Foundation for Ocean Science)

THE GLOBEC GOAL

To advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.

GLOBEC research directly complements that of other IGBP Programme Elements; in particular JGOFS (with its focus on primary production as it pertains to the oceanic carbon budget), by examining the role of higher trophic levels (zooplankton and fish) in the control of ecosystem structure, and their responses to physical forcing factors; GLOBEC is also complementary to LOICZ (which deals with external forcing on coastal zone fluxes, such as sedimentary and nutrient inputs) in its focus on zooplankton and fish population dynamics in key coastal environments.

The GLOBEC approach

An initial GLOBEC planning workshop noted the need *"to understand how changes in the global environment will affect the abundance, diversity and production of animal populations comprising a major component of ocean ecosystems"*. It also recognised the importance of zooplankton in *"shaping ecosystem structure (...) because grazing by zooplankton is thought to influence or regulate primary production and (...) variations in zooplankton dynamics may affect biomass of many fish and shellfish stocks"*. This regulatory control function by zooplankton in marine systems is more common in the ocean than are similar controls on land. In the long term, zooplankton exercise a regulatory control over marine systems by the balance between nutrient input from deep water and down-

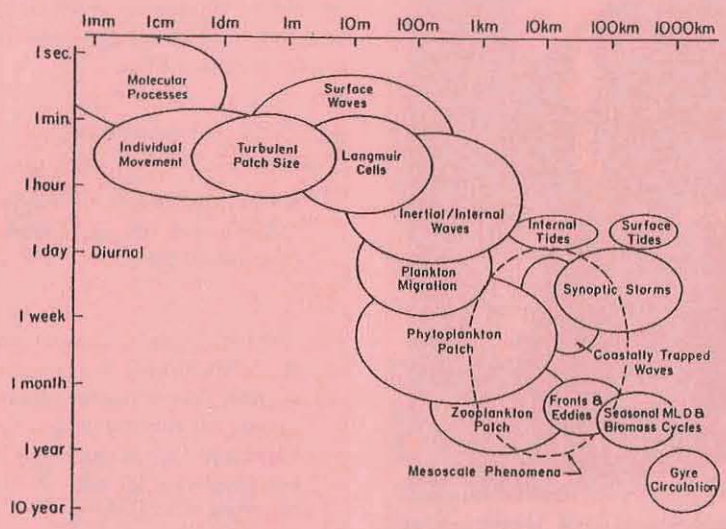

Figure 2: A schematic diagram illustrating the relevant time and space scales of several physical and biological processes of importance to GLOBEC (after Dickey, 1991) (GLOBEC Report No. 3, 1993)

ward transfer through the larger herbivores.

Hence, GLOBEC focuses on herbivores and primary carnivores - those trophic levels where primary production is processed to provide energy and nutrients for longer-lived species (Figure on page 1). The organisms in these groups include a great diversity of species and exhibit many adaptive strategies. For a specific purpose, such as studies of carbon cycling, treatment of this group as a single subset of variables may be possible. However, given the great number of different pathways by which energy and nutrients may be transferred to higher trophic levels and then fed back into nutrients, GLOBEC will require a more complex approach. One of the challenges for GLOBEC is to discover where generalisations may be made and where, conversely, attention to detail is essential. In order to meet this challenge, GLOBEC will focus on specific processes and appropriate sites. These sites will be selected to best test and improve upon the generalisations that relate structure to dynamics. They must, at the same time, represent important subsystems of the global ocean ecosystem.

Space Time Considerations

Animals living in the ocean are affected by physical processes ranging from centimetre scales of turbulence through kilometre mesoscales, where eddy motions dominate, up to the ocean basin scales of the major current systems (Figure 2). All of these scales are ecologically interesting and scientifically important. However, the focus of the GLOBEC programme must be narrowed to those spatial scales on which the physical processes have the most impact on biological variability. It is at these critical scales that the answers sought by GLOBEC will be found.

GLOBEC aims to understand the forces driving changes in marine ecosystems on decadal to century time scales. Signals at these scales appear in fluctuations of many of the major world fisheries. The shorter, decadal fluctuations have physical counterparts in changes in circulation and hydrographic properties of ocean basins. Processes at space and time scales of years and thousands of kilometres link local or regional patterns and processes in the global ocean system, and thus provide a focus for the planning of field and modelling programmes in GLOBEC.

Despite the large scales of the fluctuations noted above, the processes that drive the interactions between, for example, fish and zooplankton are generally at smaller scales. In particular, these interactions occur at the dynamically energetic oceanic mesoscales (Figure 2), which have dimensions of kilometres to tens of kilometres. The coupling of small scales, mesoscales, and macroscales is a central problem to GLOBEC and is comparable to the integration of landscape with regional processes on land.

Terrestrial *vs* Marine Systems

Marine production is dependent, at the most basic level, upon ocean mixing and circulation that control primary productivity by influencing phytoplankton exposure to nutrients and light. These physical processes are determined, in turn, by climatic factors such as variability in storm wind frequency, cloudiness, rainfall and other parameters that exert dominant physical influence over the biologically active upper ocean.

Trees and perennial grasses are the longest lived components of terrestrial food webs. Ocean plants are, conversely, among the shortest lived components of their respective food webs. Marine plants reproduce far more rapidly, however, than terrestrial plants. For phytoplankton, the generation time is on the order of a few days. Aside from marine mammals and reptiles, fish are among the longer lived marine organisms. However, their individual life cycles are generally less than a decade, or one to two orders of magnitude less than those that are typical of terrestrial

GLOBEC Reports

The GLOBEC Report Series provides detailed scientific background to the development of the Science Plan:

1. Towards the Development of the GLOBEC Core Programme: A report of the First International GLOBEC Planning Meeting. GLOBEC Report No. 1.
2. Population Dynamics and Physical Variability: Report of the First meeting of an International GLOBEC Working Group. GLOBEC Report No. 2.
3. Sampling and Observational Systems: Report of the First Meeting of an International GLOBEC Working Group. GLOBEC Report No. 3.
4. Cod and Climate Change: Report of the First Meeting of an ICES/International GLOBEC Working Group. GLOBEC Report No. 4.
5. Development of an International GLOBEC Southern Ocean Programme. Report of the first meeting of the International GLOBEC working group. GLOBEC Report No. 5.
6. Numerical Modelling. Report of the first meeting of the International GLOBEC working group. GLOBEC Report No. 6.
7. Southern Ocean Implementation Plan. GLOBEC Report No. 7.
8. Small Pelagic Fishes and Climate Change Programme. Report of the first planning meeting. GLOBEC Report No. 8.

Members of the GLOBEC SSC and representatives of national and regional GLOBEC programmes at their recent meeting at the Johns Hopkins University, Baltimore, USA, 11-13 November 1996.

systems. This overall difference in life cycle time scales makes marine systems more responsive than terrestrial systems to decadal scale changes.

Time scales of change in marine systems can be very short, in the order of a few years, as illustrated by the crash of the Peruvian anchovetta fishery. The effects of global change on marine ecosystems are perceived by society only when these effects become evident at the upper end of the trophic system. Such effects include alterations in the abundance, distribution and diversity of fish and marine mammals.

Despite these differences, marine and terrestrial systems all exhibit close linkages between energy flow, chemical cycling and food web structure. Major perturbations in the energetics or the biochemistry generally lead, in either system, to dramatic changes in species composition. Variations in abundance at higher trophic levels typically reflect changes in physical or chemical processes that are mediated, in many instances, through the lower trophic levels. Hence, knowledge of the responses of dominant species at several levels in the trophic structure offers insights into subtle changes in the physical/chemical system. Correspondingly, with respect to the population dynamics of dominant species, knowledge of the ecosystem energy and nutrient budgets is essential. GLOBEC will aim to establish close links with appropriate IGBP Programme Elements on common issues such as ecosystem structure and functioning.

Developments so far

The adoption of GLOBEC as an IGBP Core Project is a significant land-mark in the development of the international programme. The GLOBEC Science Plan will shortly be published and this provides a strong foundation for moving to implementation. This is one of the critical issues facing the members of the new GLOBEC SSC (see above) who will develop a detailed Implementation Plan for presentation to the sponsoring organisations and the larger scientific community.

Consideration of how best to achieve the GLOBEC Goal has lead directly to the development of four primary GLOBEC objectives, which are amplified in the Science Plan.

Objective 1

To better understand how multiscale physical environmental processes force large-scale changes in marine ecosystems.

Objective 2

To determine the relationships between structure and dynamics in a variety of oceanic systems which typify significant components of the global ocean ecosystem, with emphasis on trophodynamic pathways, their variability and the role of nutrition quality in the food web.

Objective 3

To determine the impacts of global change on stock dynamics using coupled physical, biological and chemical models linked to appropriate observation systems and to develop the capability to predict future impacts.

Objective 4

To determine how changing marine ecosystems will affect the global earth system by identifying and quantifying feedback mechanisms.

These four objectives then lead to a specific set of research foci, which form the basis for current development of the GLOBEC Implementation Plan.

Focus 1

Build a foundation for future global ecosystem models through re-examination of historical data bases.

Focus 2

Conduct process studies organised around the themes of (1) research and modelling of ecosystems and trophodynamics, (2) identification and understanding of meso-scale physical-biological interactions and (3) research on forced responses in ecosystems.

Focus 3

Develop predictive and modelling capabilities with interdisciplinary, coupled modelling-observational systems.

Focus 4

Co-operate with other ocean, atmosphere, terrestrial and social global change research efforts to estimate feedbacks from changes in marine ecosystem structure to the global earth system.

GLOBEC is planning an Open Science meeting for the first quarter of 1998 at which the Implementation Plan will be presented to the wider scientific community, and feed-back sought.

The Major Components of GLOBEC

The Project consists of a series of activities, planned under the aegis of the GLOBEC SSC. Much of the foundation has been laid at a series of planning meetings, in particular the 1993 GLOBEC Working Group on Population Dynamics and Physical Variability (GLOBEC Report No. 2); other working groups are directing GLOBEC efforts in, for example Numerical Modelling (GLOBEC Report No. 6) and Sampling and Observation Systems (GLOBEC Report No. 3).

In addition the GLOBEC Core Project has a major field study component. Two of the largest field research programmes are briefly described below.

GLOBEC Southern Ocean Programme (SO-GLOBEC) The SO-GLOBEC programme is focused on understanding how physical forces influence population dynamics and predator-prey interactions between key species. Special efforts will be made to study the little-known overwintering strategies of zooplankton and top predators in the Southern Ocean. The knowledge gained will significantly advance under-

standing of Southern Ocean marine ecosystems and will enable us to adequately monitor and predict the impact of climate change.

Planning for a Southern Ocean GLOBEC programme has been developed at a number of meetings and working groups (GLOBEC Reports Nos. 5 and 7), and issues of implementation are now being considered as a matter of urgency by the new SSC and a newly constituted Southern Ocean working group.

Small Pelagic Fishes and Climate Change (SPACC) SPACC aims to identify linkages between the physical forces that control growth of small pelagic fish populations (sardines, anchovies, scads, herrings, mackerels, sprat, menhadens and others). The long-range goal is to forecast how changes in the patterns and intensity of these forces, caused by elevated greenhouse gases and global warming, will alter the productivity of small pelagic fish populations, particularly in coastal ecosystems.

SPACC planning has already involved major workshops in Mexico (GLOBEC Report No. 8) and Namibia, and further consideration of implementation was made at a meeting in Mexico City in August 1996.

Developing National and Regional Programmes

A major priority of the GLOBEC SSC is to work closely with National GLOBEC committees and emerging regional programmes to ensure effective co-ordination and integration, and to realise the full research potential of these regional initiatives. Many such GLOBEC activities are well established and ongoing. At the SSC meeting there were presentations on the active national programmes of Canada, China, Japan, Norway, the United States and United Kingdom, as well as North Atlantic regional co-ordination. It is a strength for GLOBEC that there is already so much research momentum within the scientific community. Two of the major regional programmes in the Northern hemisphere are described briefly below:

The membership of the GLOBEC SSC is:

Dag Aksnes	(Dept. of Fisheries and Marine Biology, Univ. Bergen, Norway)
Jürgen Alheit	(Baltic Sea Research Institute, University of Rostock, Germany)
Tommy Dickey	(University of California, Santa Barbara, USA)
Roger Harris	(Plymouth Marine Laboratory, UK) Chairman
Eileen Hofmann	(Old Dominion University, USA)
Tsutomu Ikeda	(Faculty of Fisheries, Hokkaido University, Japan)
Ian Perry	(Pacific Biological Station, DFO, Nanaimo, Canada)
Brian Rothschild	(University of Massachusetts, Dartmouth, USA)
Jarl-Ove Stromberg	(Kristineberg Marine Research Station, Sweden)
Svein Sundby	(Institute for Marine Research, Bergen, Norway)
Qisheng Tang	(Yellow Sea Fisheries Research Institute, Qingdao, China)

ICES-GLOBEC Cod and Climate Change Programme (CCC or "3Cs") The International Council for the Exploration of the Sea (ICES) and GLOBEC have joined together to develop an innovative programme to advance the understanding and prediction of variability in fish stock recruitment, both in the short term (annual forecasts) and in the long term ("climate effects"). Cod was chosen because its biology is well-known and supported by ample data bases. It has a pan-Atlantic distribution, and its abundance and distribution have been shown to be sensitive to specific past examples of climate variability. These considerations provide the possibility of developing new capabilities in predicting fish recruitment through better understanding of interactions between physical processes and population dynamics. Planning for CCC is described in GLOBEC Report No. 4.

PICES-GLOBEC Climate Change and Carrying Capacity (CCCC or "4Cs") The North Pacific Marine Sciences Organization (PICES) and GLOBEC are jointly organising a programme on Climate Change and Carrying Capacity (CCCC) in the temperate and subarctic regions of the North Pacific. The CCCC Programme has a strong focus on coupling between atmospheric and oceanographic processes, their impact on the production of major marine living resources and how they respond to climate change on time scales of decades to centuries. Particular emphasis is being placed on regime shifts, and on the biology of salmonid stocks.

TransAtlantic Study of *Calanus finmarchicus* (TASC) A further good example of GLOBEC regional development is provided by the TASC project. This focuses on a single copepod, *C. finmarchicus*, as a key biological component of the North Atlantic rim ecosystems. TASC is investigating the population ecology and dynamics of this species in a comparative way in all the major ecosystems around the North Atlantic (Figure 3). It links GLOBEC research on George's Bank and on the Eastern coast of Canada with a major European Union funded TASC project involving groups in Norway, Iceland, Denmark, Germany, United Kingdom and France. The EU TASC project is co-ordinated at the University of Tromsø. TASC was first discussed at a workshop organised in Oslo in April 1994, the proceedings of which have recently been published in *Ophelia* (1996, vol 44, 1-205). The group has designated 1997 as "*The Year of Calanus*" and a major TASC meeting to plan and co-ordinate TransAtlantic integration is being planned for January 1997 in Copenhagen.

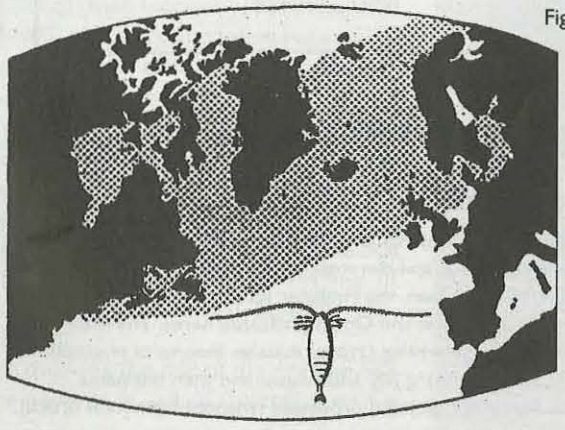

Figure 3: Schematic distribution of the copepod, *Calanus finmarchicus*, in the North Atlantic: the focus of the TASC Project.

Roger Harris, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK.

GLOBEC is currently in the process of establishing a Core Project Office. For further information on GLOBEC, including copies of GLOBEC Reports, please contact:
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JGOFS Process Studies in the Arabian Sea

by Peter Burkill and Roger Hanson

The Arabian Sea, situated in the north-west Indian Ocean, is the main site for current IGBP-SCOR Joint Global Ocean Flux Study (JGOFS) research. When fieldwork ends in 1997, more than 50 research cruises will have been carried out over a 6 year period by Germany, India, Netherlands, Pakistan, UK and USA. As well as scientists from these countries, many scientists from other countries have also been involved, often as guests on these shipboard studies. A number of training programmes aimed particularly at younger scientists in the region, have also been carried out. The large number of cruises and associated activities reflects the high level of interest in the Arabian Sea. Why is this? What do we do in our research? What have we found out? The rest of this article addresses these questions.

Why has there been so much interest in the Arabian Sea?

The Arabian Sea is a small ocean basin with a large number of unusual features. Although tropical, it is intensely seasonal and exhibits the greatest range of variability found in any ocean basin. It is, for instance, the only ocean basin that fully reverses its surface circulation pattern on a semi-annual basis. Although small on the global scale, the Arabian Sea encompasses a wide range of oceanographic conditions. While some surface waters are almost devoid of nutrients, others are nutrient rich and extremely productive. Oceanographic conditions also vary considerably with depth within the Arabian Sea. Whereas surface and deep waters are well oxygenated, waters that lie between depths of 100 and 1,200 metres are almost devoid of oxygen. The wide range of conditions in the Arabian Sea makes it a natural experimental system and allows us to study biogeochemical processes over a wide range of climate and oceanographic conditions.

What happens during the monsoons?

The unusual features outlined above can be traced to a common origin: the monsoons. The impact of the south Asian monsoon climate on the Arabian Sea is vigorous and dramatic. The Arabian Sea experiences two monsoons each year; the more vigorous, south-west (SW) monsoon, blows from June to September while the weaker north-east (NE) monsoon blows from December to February. In the intervening inter-monsoon periods, the winds wane in strength and slowly reverse their direction.

The SW monsoon has a marked impact upon biogeochemical cycling and much of this is due to upwelling. As the winds gather strength in June, they form a localised atmospheric jet (Findlater Jet) with winds that can reach in excess of 50 knots in late July as they blow along the Somali and southern Oman coastline. The winds cause surface waters to be moved offshore by Ekman transport[1]. However, the proximity of the coast causes deep water to be dragged to the surface to replace offshore moving waters. Upwelled waters which are nutrient-rich, fertilise the well-lit, warm surface waters allowing massive blooms of phytoplankton to develop. The waters literally turn green over an area that extends roughly 400 km offshore along about 1,000 km of the Oman coast and to a smaller extent, off the Somali coast. This is a much wider area than would be expected from coastal upwelling alone and the cause of this is open to debate. The classical explanation is due to open ocean upwelling caused by the localised effect of the Findlater Jet which blows most strongly far offshore (Figure 1). While winds are strong-

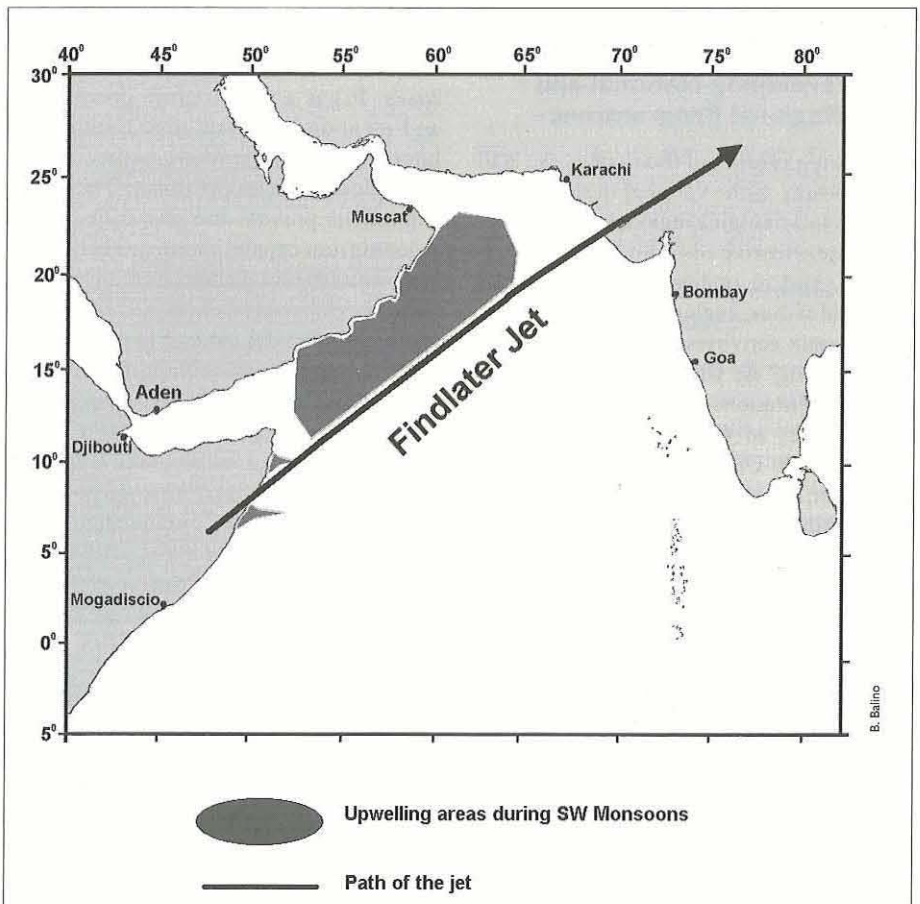

Figure 1 Arabian Sea biogeochemistry is driven by two monsoons, the stronger SW Monsoon between June and September and the weaker NE Monsoon from December to February. During the SW Monsoon, the Findlater Jet forms causing extensive upwelling along the coasts of Somalia and Oman (indicated here). The main axis of the Jet is depicted here. The upwelling creates massive blooms of phytoplankton over an area >400,000 km² during July and August and then dissipates through a variety of biological and physical processes (adapted from John Brock).

est along the central axis of the Jet, their strength falls off progressively with distance, to either side of the Jet axis. This wind pattern causes a local gradient in wind stress that results in divergence of surface waters to the left and convergence of waters to the right of the Jet. The divergence causes upwelling to the Jet's left while convergence results in downwelling to the Jet's right. The spatial and temporal extent of the upwelling is spectacular as we have learned from remote sensing data derived from the Coastal Zone Color Scanner. This can be viewed on the Internet at http://seawifs.gsfc.nasa.gov/SEAWIFS/CZCS_DATA/indian_ocean.html. However JGOFS studies suggest that there is considerable mesoscale variability in the upwelling region and that filaments of upwelled coastal water are dragged far offshore thereby adding to open ocean upwelling. While the SW Monsoon gives way to the calm of the autumn Intermonsoon, biological production decreases rapidly as it is dissipated by biological and physical removal processes.

The NE monsoon also influences biogeochemical cycling in the Arabian Sea. Although the winds are sufficiently strong to reverse the basin's circulation pattern and biological production is elevated compared to the inter-monsoon periods, their impact is not as strikingly dramatic as that of the SW Monsoon. The driving force of production in the winter months seems to be based once again upon winds. In winter, these cool the warm surface waters which sink and set in motion convective replacement by deeper nutrient rich waters. These fertilise surface waters causing "entrainment blooms" of phytoplankton with levels of productivity that are higher than those found during either of the intermonsoon periods.

What are the challenges in our research?

The JGOFS Indian Ocean Planning Group (IOPG: Figure 2), chaired by Bernt Zeitzschel (Kiel, Germany) between 1990 and 1995, identified the following as goals to a better understanding of biogeochemical cycling in the Arabian Sea:

- to investigate the seasonally-varying biogeochemical responses to intense and regularly oscillating physical forcing in the Arabian Sea;
- to quantify the role of the Arabian Sea in global biogeochemical cycling of carbon and associated biogenic elements;
- to quantify the role of the Arabian Sea as a source or sink of atmospheric CO_2 and other gases relevant to climate change;
- to quantify primary production, transformation and fate of phytogenic carbon in the Arabian Sea;
- to quantify the role of the O_2 minimum in biogeochemical cycling;
- to quantify Quaternary monsoonal variability in relation to fluctuations in ocean paleo-circulation.

These aims are being met through international integration of research that involves using ships, deploying moorings, accessing remote sensing data and modelling. Such research has been co-ordinated by IOPG using Scientific Committee on Oceanic Research (SCOR) funding, and has focused on two main areas of upwelling: the Somali upwelling region and the northern Arabian Sea. Cruises serve two purposes: surveying the basin with measurements of key variables so that we can understand spatial and seasonal distributions. This is reflected in the extensive coverage particularly of the northern Arabian Sea shown in Figure 3 (on page 8). Equally important are measurements of key fluxes made on cruises at selected sites in the basin. Many of these measurements are both conceptually and practically challenging. For instance, to address whether the Arabian Sea is a source or a sink for atmospheric CO_2 involves measuring the upward flux of CO_2 from deep waters to the atmosphere by upwelling and comparing this against the converse process of atmospheric CO_2 drawdown by phytoplankton production. Because the magnitude of each of these processes is large, we end up needing to resolve small differences between two large, and often variable, numbers. For much of the work, we use ships as floating laboratories, collecting organisms from the surrounding waters and measuring their rates of growth and grazing and quantifying their transformation of biogeochemically important components.

Special ocean moorings were deployed at the onset of fieldwork to provide continuous records of variables such as wind speed, air temperature and light as well as current speed and direction at selected depths in the ocean. A major question in Arabian Sea biogeochemistry concerns the mechanisms by which the low oxygen waters are maintained. Part of the answer lies in the rate with which particles sink from surface waters into the midwater where they fuel oxygen-requiring processes in mid-water. To address particle sinking fluxes, sediment traps are deployed at different depths, to generate data on the vertical profiles of particle sedimentation. Such an approach has been very illuminating and has demonstrated that particle flux within the ocean's interior show a clear, and almost immediate, response to the monsoons.

A first-look at the data at JGOFS workshops held recently in the Netherlands, UK and USA, suggests that the pattern of carbon cycling in the Arabian Sea differs from that in other oceans. While the same fundamental pathways operate, it is the relative importance of these pathways that provide the biogeochemical signature of

Figure 2 JGOFS Indian Ocean Planning Group members and advisers (front row: Martien Baars, Sharon Smith, Viktor Melnikov, John Brock; back row: Peter Burkill, Micheni Ntiba, Bernt Zeitzschel (then chairman), Thabit Al-Abdessalaam, Shahid Amjad) taking a break from their meeting in May 1992 aboard RV TYRO during its outward voyage to start the Netherlands Indian Ocean Programme

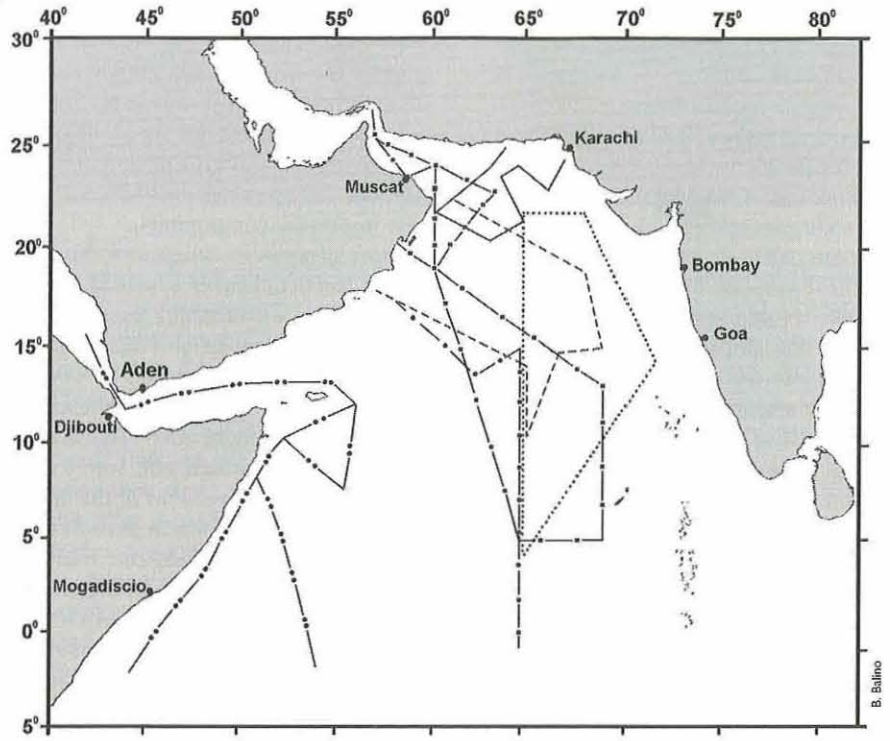

Figure 3 JGOFS cruises mounted by Germany, India, Pakistan, UK and USA focused upon good coverage of the northern Arabian Sea during 1992/97 while Netherlands JGOFS cruises tackled the Somali system during 1992/93. The full list of cruises is given on the Internet at: http://ads.smr.uib.no/jgofs/inventory/Indian/Indindex.htm

each ocean. JGOFS studies in the Equatorial Pacific in 1992 showed the tropical region of that ocean to be efficient at recycling carbon in the upper ocean. There was little export from surface waters to the deep ocean in the equatorial Pacific, suggesting that carbon exchange between the atmosphere, surface waters and deep ocean is balanced. Studies in the North Atlantic in 1989/90, on the other hand, demonstrated that biological activity in spring allowed considerable drawdown of atmospheric CO_2 to surface waters at temperate latitudes. This was accompanied by export of particulate carbon from surface waters to the deep ocean. In the Arabian Sea, a considerable quantity of the phytoplankton carbon bloom is exported during the SW Monsoon. Unlike the temperate Atlantic where protozoans dominate grazing, it is larger zooplankton that seem to act as gatekeepers to the export process. In the Arabian Sea, copepod species time their reproduction to coincide with the phytoplankton bloom. Large zooplankton faecal pellets with high sedimentation rates and vertical migration of the animals themselves provide a mechanism for the active export of phytogenic carbon into the ocean's interior. This export is thought to occur over a wide area and is the mechanism that fuels depletion of oxygen in the midwater zone. The pattern that is emerging is that seasonality, whether in the tropics or temperate latitudes, provides a mechanism by which particulate carbon can be exported from the surface waters to the deep ocean. The export of particulate carbon is, however, only one aspect of the vertical flux of carbon. The dissolved carbon component is also important. In the Arabian Sea where upwelling fuels surface production so prodigiously, the balance between particulate export of carbon from surface waters on one hand and its remineralisation at depth and return as CO_2 through upwelling on the other, still remains to be addressed.

What next?

In July 1997, the current round of JGOFS fieldwork in the Arabian Sea will end and with it one phase of our research. The next phase will focus upon data assimilation, synthesis and modelling. The first step in this next phase involves assembling and archiving all JGOFS Arabian Sea data-bases. Some of these activities have already been set up at national level, and agreements remain to be drawn up on international access, exchange and integration. This is an important step towards modelling biogeochemical cycling in the Arabian Sea - an activity that will be carried out at several levels. A good understanding of physical oceanography and atmospheric forcing will be required to underpin biogeochemical cycling. This will require collaboration with the WOCE community who are also studying the Arabian Sea. Modelling the carbon cycle will involve analysing individual biogeochemical processes in detail within restricted space and time scales. Once these processes have been resolved, they will have to be simplified to allow biogeochemistry to be embedded within general circulation models with adequate space and time resolution. This is an exciting prospect and will keep the JGOFS Arabian Sea modelling community busy well towards the JGOFS sunset in 2004.

Peter Burkill (Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH, UK.. e-mail: p.burkill@pml.ac.uk) has recently taken over from Bernt Zeitzschel (FRG) as JGOFS IOPG Chairman. Other IOPG Committee members who have ensured the success of the JGOFS Arabian Sea Programme are Thabit Al-Abdessalaam (Oman), Shahid Amjad (Pakistan), Martien Baars (NL), Otis Brown (US), Hugh Ducklow (US), R R Nair (India), Ezekiel Okemwa (Kenya), Trevor Platt (Can), Alan Poisson (Fr) and Sharon Smith (USA). IOPG Meetings were held in Goa and Bermuda (1991), aboard RV Tyro (1992) (see Figure 2), Mombasa (1993) and Muscat (1994). **Roger Hanson** (JGOFS CPO, Center for Studies of Environment and Resources, High Technology Centre, University of Bergen, N-5020 Bergen, Norway, e-mail: roger.hanson@jgofs.uib.no) is JGOFS Executive Officer. We thank Beatriz Balino for preparing Figures 1 and 3.

[1] *Ekman transport is the net flow of water to the right of the wind in the Northern Hemisphere and to the left in the Southern Hemisphere, the deflection being a consequence of the Coriolis effect.*

Closing the atmospheric CO_2 budget:
inferences from new measurements of $^{13}C/^{12}C$ and O_2/N_2 ratios

by Martin Heimann

The regional and global quantification of sources and sinks of major biogeochemical elements such as carbon constitutes one of the ultimate goals of many IGBP endeavours. The degree to which this quantification results in a closed global budget provides a critical test of our understanding of the relevant source and sink processes, while the estimated uncertainties assigned to individual budget components highlight directions of future research. Clearly, a mere quantification *per se* only highlights our present state of knowledge; even more important is our understanding of how the budget changes with time as a function of natural and anthropogenic perturbations. This, in turn, requires long-term observations, detailed process studies and modelling. This article aims at providing a summary of recent developments regarding the relative partitioning of CO_2 uptake between land and sea based on old and new techniques.

The IPCC94 budget revisited.

The recent assessment by the IPCC 1994 of the different budget terms and their uncertainties (all uncertainties in this article are expressed as estimated 90% confidence intervals) is given in Table 1 (page 10). The listed numbers are representative of the decadal average 1980-1989. Table 1 has been reorganised such that all terms related to land biotic sources and sinks are listed at the end. Accordingly, emissions from fossil fuel use and cement production amount to 5.5±0.5 $GtCyr^{-1}$. The atmospheric increase of 3.2±0.2 $GtCyr^{-1}$, as determined from the background CO_2 monitoring stations, represents the best known term in the budget. The ocean uptake of 2.0±0.8 $GtCyr^{-1}$ is based on detailed calculations with ocean models. These include global 3-dimensional ocean general circulation models, but also simpler box model representations of the ocean. These models are either calibrated or validated by means of observations of transient tracers, such as radiocarbon, tritium and CFCs, which are to some extent analogue to the anthropogenic CO_2.

The fossil emissions, together with the increases in atmospheric and oceanic CO_2 storage imply that the terrestrial carbon pools, as a whole, must have been a very small net sink (0.3±1.0 $GtCyr^{-1}$) or effectively almost in balance during 1980-89. If so, any terrestrial CO_2 emissions due to land use changes (1.6±1.0 $GtCyr^{-1}$) must have been balanced by other terrestrial sinks *e.g.* regrowing forests in temperate latitudes (0.5±0.5 $GtCyr^{-1}$) or other processes such as fertilisation effects due to the increasing CO_2 concentration and from increased nitrogen deposition. The identification of these latter processes (often referred to as the "missing" or "unidentified sink") and their quantification on a regional and global scale represents a formidable challenge.

It is important to note, that global net fluxes between the atmosphere, ocean, and the terrestrial biosphere, are not only induced by the direct anthropogenic perturbation, *i.e.* by the rise in atmospheric CO_2. The global carbon cycle is also subject to interannual and longer term climate fluctuations which induce temporary imbalances in the natural exchange fluxes of carbon between the different. Depending on the approach and the time scale under consideration, climate driven fluxes may contribute considerably to a budget compilation such as given in Table 1.

New Approaches

How solid are the inferences on the net balance of terrestrial biospheric carbon? Clearly the logic represented in the lines (1)-(4) of Table 1 hinges crucially on the ocean uptake term. Two new approaches allow an independent check on this term.

A significant advance in the last few years has been the development of measurement techniques to determine changes in atmospheric oxygen content with very high-precision. Technically, the ratio of O_2/N_2 in air is measured, either by interferometric techniques or by mass-spectroscopy. Since the atmospheric content of nitrogen can be assumed to remain constant on timescales of decades to thousands of years, the O_2/N_2 ratio essentially reflects the oxygen content of the atmosphere. These measurements provide a new possibility to discriminate the contributions of oceanic and biospheric sources and sinks of CO_2. This follows from the fact that O_2 is produced during photosynthesis and consumed during any oxidation

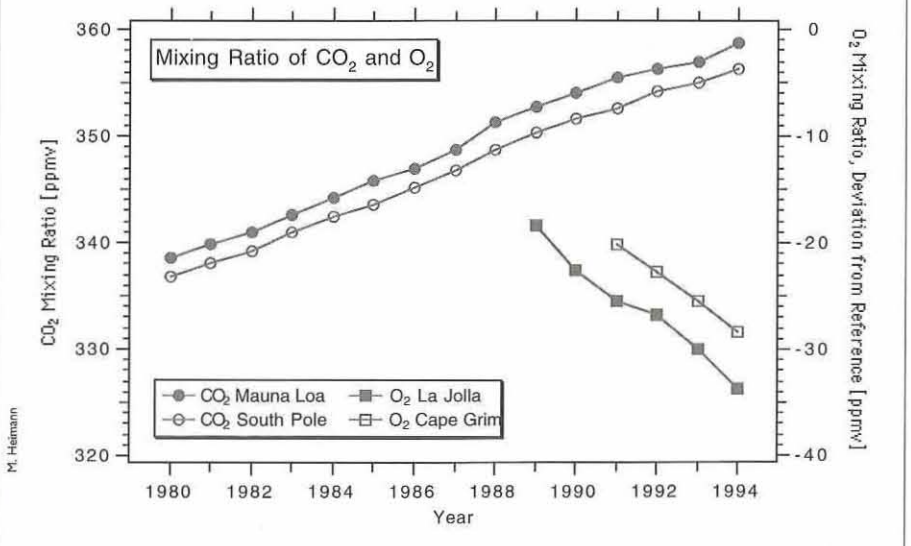

Figure 1: Observations of the annually averaged mixing ratio of CO_2 (left axis, circle symbols) and of oxygen (right axis, square symbols) in the northern hemisphere (solid symbols) and in the southern hemisphere (open symbols). Oxygen mixing ratios are shown as deviations from a reference value which is approximately 209,500 ppmv

Table 1: Atmospheric CO_2 Budget 1980-89 (IPCC 1994)		
(1) Fossil fuel and cement production		5.5±0.5
(2) Atmospheric increase (observed)		3.2±0.2
(3) Ocean uptake (model calculated)		2.0±0.8
based on observed O_2/N_2 ratio trend (1989-1994)	1.9±0.8	
based on observations of $^{13}C/^{12}C$ ratio	2.1±1.5	
(4) Net balance of terrestrial biosphere = (1) - (2) - (3)		0.3±1.0
(5) Land use change emissions (primarily tropics)		1.6±1.0
(6) Regrowth of temperate latitutde forests (based on forest statistics)		0.5±0.5
(7) CO_2 uptake by other terrestrial processes (a.o. CO_2 fertilisation effect, N-fertilisation, climate effects) = (4) + (5) - (6)		1.4±1.5
Fluxes expressed in GtCyr^{-1}, uncertainty ranges represent estimated 90% confidence intervals		

process in clearly defined stoichiometric ratios relative to CO_2. However, the oxygen gas is only very weakly soluble in oceanic waters, in contrast to CO_2 which is strongly chemically buffered in the oceanic carbonate system. Hence any oceanic uptake of CO_2 is not mirrored by a corresponding oxygen absorption or release from the ocean. As a consequence, the dynamical behaviour of the two gases is different and measurements of their behaviour are not redundant.

Figure 1 (page 9) shows the annually averaged records of the O_2 and CO_2 mixing ratio from representative background monitoring stations in the northern (La Jolla and Mauna Loa) and southern hemisphere (South Pole and Cape Grim) [Keeling *et al.*, 1996]. The oxygen measurements (scale on the right) are expressed as ppmv deviations from a standard which corresponds to approximately 209,500 ppmv. It is seen that the oxygen concentration is diminishing at a slightly faster rate than the increase of the CO_2 concentration. This reflects on one hand the stoichiometric relation between O_2 and CO_2 in burning of fossil fuels of about -1.4:1 and approximately -1.1:1 with respect to photosynthesis and respiration of organic carbon. More importantly it reflects also the fact that oxygen is not buffered by the ocean. The observations of the global trends in CO_2 and O_2 provide two budget equations, which permit the determination of the oceanic and biospheric contributions in the global CO_2 balance.

The quantitative analysis using the longer O_2 record from La Jolla yields an average oceanic CO_2 uptake of 1.9±0.8 GtCyr^{-1} (the error is the estimated 90% confidence interval) over the time period 1989-1994. With an increasing length of the record and provided that there are no problems with long-term stability of the standards, the uncertainty of the oxygen based ocean uptake rate is expected to decrease further. The oxygen analysis yields also an estimate of the global net terrestrial balance over the 1989-1994 time period amounting to 1.8±1.1 GtCyr^{-1}. This is much larger than the base period adopted by the IPCC as given in Table 1. The reason is that during the early 1990's the atmospheric CO_2 growth rate was much smaller than during the 1980's.

Observations of the isotopic composition of oceanic carbon, either of the temporal changes in the vertical ^{13}C or of the surface $^{13}C/^{12}C$ distribution also allow an independent determination of the oceanic uptake of excess CO_2. Because of the presently insufficient database of oceanic ^{13}C measurements, together with uncertainties in some of the other isotopic budget terms, the current estimates based on the ^{13}C technique are subject to considerable uncertainties, yielding 2.0±1.5 GtCyr^{-1}over the time period 1970-1990 [Heimann and Maier-Reimer, 1996].

It is reassuring that both the oxygen and the ^{13}C based approaches confirm the model based ocean CO_2 uptake rates, albeit with considerable uncertainties. It is also important to note, though, that both the $^{13}C/^{12}C$ and O_2/N_2 based estimates of the oceanic CO_2 uptake refer to different timeperiods than the IPCC 1994 budget.

Spatial constraints

Figure 1 also demonstrates the gradient in the CO_2 and the oxygen mixing ratio which exists on annual average between the northern and the southern hemisphere. The primary cause of this gradient are the emissions of CO_2 and the corresponding losses of oxygen from the burning of fossil fuels taking place predominantly in the northern hemisphere.

A quantitative assessment of these interhemispheric mixing ratio differences and of the more detailed spatio-temporal structures as revealed in the CO_2 records from the global monitoring station networks since the late 1970's requires models that accurately describe the mixing of air in the global troposphere. The most conspicuous result from atmospheric modelling studies was the inference of a strong, presumably natural, CO_2 sink in the northern hemisphere, offsetting about 40% of the gradient induced from the fossil fuel source. Whilst this finding is thought to be rather robust, there remain substantial uncertainties related to modelling of the atmospheric transport as witnessed by a recent model intercomparison. Furthermore, seasonal terrestrial biosphere exchanges also impact the mean annual mixing ratio gradient between the hemispheres. A continuation of the atmospheric transport model intercomparison and validation by means of observations of long-lived atmospheric tracers such as sulphur hexafluoride (SF_6) is currently conducted within the TRANSCOM project of IGBP-GAIM.

The nature of the northern hemisphere sink, whether of oceanic or terrestrial origin has been controversial. Again, analyses based on measurements of O_2/N_2 and of $^{13}C/^{12}C$ provide new insights. The oxygen observations allow a separation between oceanic and biospheric components in the north-south gradient. Assuming that the southern hemisphere biosphere plays a negligible role, the gradient information together with the global budget allows the determination of the net terrestrial biospheric contributions from the tropics and from the northern temperate and high latitudes. The analysis of the data for the time period 1991-1994 yields a biospheric sink of about 1.9±1.5 GtCyr^{-1}in the extratropical northern northern hemisphere. This value, together with the global net biospheric balance of 2.0 GtCyr^{-1}for the same time period, implies that the terrestrial equatorial regions must have been almost in balance during 1991-1994. If so, any net CO_2 releases from these regions due e.g. to deforestation must have been balanced by corresponding CO_2 uptake at other locations in the tropics. The picture provided by the oxygen measurements for the early 1990's is grossly in accordance with a recent analysis of the interhemispheric gradient in the atmospheric $^{13}C/^{12}C$ ratio, which, however, refers to a shorter time period.

The interhemispheric CO_2 mixing ratio gradient in the 1980's (at least 1980-87) was similar in magnitude as during the

early 1990's (Figure 1), despite the fact that the atmospheric increase was substantially smaller in the later period. Unfortunately there exist no observations of the O_2/N_2 interhemispheric gradient for the 1980's. If one assumes, in accordance with ocean model calculations, that the oceanic contributions to the meridional gradient were similar in the 1980's than in the early 1990's, then one can postulate a large scale scenario of land-sea partitioning of the surface sources and sinks also for the 1980's. Accordingly, the tropical terrestrial regions must have been a net source of almost 1 $GtCyr^{-1}$ in the 1980's which subsequently decreased to the balanced conditions during the 1991-1994 period. It remains to be seen, whether shifting patterns of land-use or other factors, such as climate driven fluctuations are responsible for this trend.

Reference:

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Keeling , R.F., S.C. Piper and M. Heimann, 1996. Global and hemispheric CO_2 sinks deduced from changes in atmospheric O_2 concentration. *Nature*, 381, 218-221.

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In Search of a Language that Connects

John Stone, Richard Rockwell, and Chris Rapley

There is a need to connect the efforts of the research community working to understand our changing planet with the day-to-day concerns of the public and policy makers worldwide. In spite of substantial public interest in environmental issues, and significant media attention, there is a widespread lack of appreciation of the significance of the changes under way.

It is not just that scientists often find it difficult to explain themselves in plain language, but they have a tendency to assume that the relevance of research is self evident, when it is not.

How can we improve our effectiveness at getting the message across?

The following question and answer session, based on what we believe are deep human concerns, offers one approach:

Are we being poisoned?

Poisons involve more than eating or drinking things that make us ill or kill us. We are adding poisons to the air that we breathe. The sources include emissions from vehicles, from industry and from agriculture. Although some emissions are being controlled in some nations, the overall levels continue to increase because of growing populations and expanding economies. The problem is global. Even remote areas over the tropical ocean are found to be polluted by the products of agricultural burning on distant continents.

We can also be harmed by radiation. The Earth's outer ozone layer protects us and our crops from damage by ultraviolet radiation. The ozone layer has been thinning for several decades due to the emissions of certain man-made chemicals. In spite of international agreements which seek to eliminate the problem, ultraviolet radiation levels are not expected to decline significantly for some years yet.

Are we damaging our life support system?

The Earth's ecosystems provide a variety of services essential to our well-being - services for which we do not pay and which we take for granted. These include the purification of water and air, the recycling of nutrients, the generation and preservation of soils, the pollination of crops, and even the regulation of the atmosphere's oxygen content.

Ecosystems are being damaged by human activities. We know about the effects of acid rain on forests and lakes, of toxic chemicals on fish and wildlife, of increases in ultraviolet radiation on all forms of life, and of the major impacts of changes in land use. In the longer term, shifts in rainfall and temperature patterns, resulting from climate change, will also become important.

The Earth's ecosystems are being strained to the point where their capacity to provide services upon which we rely may be seriously impaired.

Is there a future for my children?

There is a tradition amongst some societies to "tread lightly on the Earth" - that we are only here as caretakers for our children, and that our actions must take into account the interests of future generations.

In practice the uncertainties are so great that we cannot predict the kind of future that our children will face. However, it is likely that they will experience profound changes in ecosystems, in the climate system, in the availability of water and food, and in the distribution of diseases.

When we reduce species diversity, we know that we are depriving our children of future resources. And yet we do not know enough at the moment to choose which resources to save and which to let go.

What can science contribute?

Nations, communities and individuals with the greatest understanding of global change and its consequences will be in a stronger position to take advantage of new opportunities and to adapt to the problems. Scientific research provides the best means of obtaining such understanding. Given the vast size and complexity of the Earth system, we cannot rely on the traditional methods of science. An unprecedented degree of interdisciplinary and international co-operation is necessary. To succeed will be science's greatest challenge, but progress will depend on a wide acceptance of the importance of the goal.

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LOICZ in Southeast Asia: working towards the integration of socio-economic and natural sciences

by Paul R. Boudreau and Robert W. Buddemeier

A key premise of the LOICZ Core Project is that enhanced understanding of biogeochemical processes in coastal systems must be combined with an understanding of the socio-economic factors that drive change in the coastal zone. Thus far two LOICZ "guidelines" publications have been developed with the joint support of the South East Asian Centre for START (SARCS), the Netherlands Foundation for the Advancement of Tropical Research (WOTRO):

- Coastal Zone Resources Assessment Guidelines (Turner and Adger, 1996), and
- LOICZ Biogeochemical Modelling Guidelines (Gordon *et al.*, 1996).

These two documents are useful by themselves as guides in the collection of relevant data, modelling, and the analysis of the data. The widespread application of these guidelines will provide the LOICZ Core Project with the necessary information base to eventually carry out the global modelling activities described in the LOICZ Implementation Plan.

However, the ultimate challenge for the participating organisations is the integration of these methodologies into a framework for carrying out integrated modelling of coastal systems that incorporates both socio-economic and natural science aspects of global change. This integration is being pursued through empirical studies using as a "test bed" four Core Research Sites in Southeast Asia that are supported jointly by SARCS, WOTRO and LOICZ.

The projects, with locations shown on the map and descriptions below, all address SARCS Immediate Objective 2: to integrate natural - social science assessment of changes in coastal zones. All involve the modelling and synthesis of both biogeochemical and socio-economic data that will be useful not only in characterising the coastal zone processes in the region, but also as test cases for the necessary conceptual and operational development for scaling up to global analysis.

1. Integrated Coastal Zone Management in Banten Bay

The Banten Bay project in Indonesia ("Sustainable Coastal Zone Management in Banten Bay: a process oriented study of environmental degradation") has been approved by LOICZ as a Core Project, and is embedded in the SE Asian framework of co-operation in global change research (SARCS). Banten Bay is located in the north western part of West Java, about 175 km west of Jakarta. It features several coral islands and river estuaries, and coastal and marine fisheries support some seventy thousand people around the bay. The coral forms the base and stability of the different coral islands; composition, distribution and functioning are affected by different patterns of sedimentation, abrasive forces, eutrophication and overfishing. Seagrasses play a critical role with respect to fisheries, and are affected by changes in runoff of sediment and nutrient loads. Finally, the bay harbours the important Pulau Dua Nature Reserve (since 1937), which is under severe pressure from tourism and general degradation of the environment. The area is located along the main connection between Jakarta, Java and Sumatra and is at the heart of the economic development plans of Indonesia. Economic activities in the area have steadily increased over the last decades, and in the near future a significant increase is foreseen. The Bay of Banten is a typical example of an area where human use of both land and marine resources complement each other, yet impact the fragile coastal ecosystems on which both depend. Aims of the research programme are to develop a better understanding of the processes and determining factors in the sustainable use of the coastal ecosystem and to contribute to a supporting framework for the formulation and evaluation of policies and strategies for human activities in, and exploitation of, the coastal ecosystem.

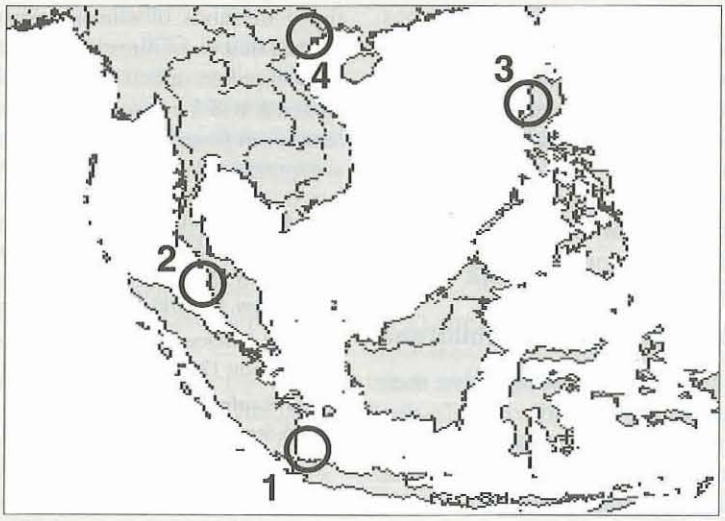


Figure 1. Location of SARCS/WOTRO/LOICZ Core Research Sites in Southeast Asia.

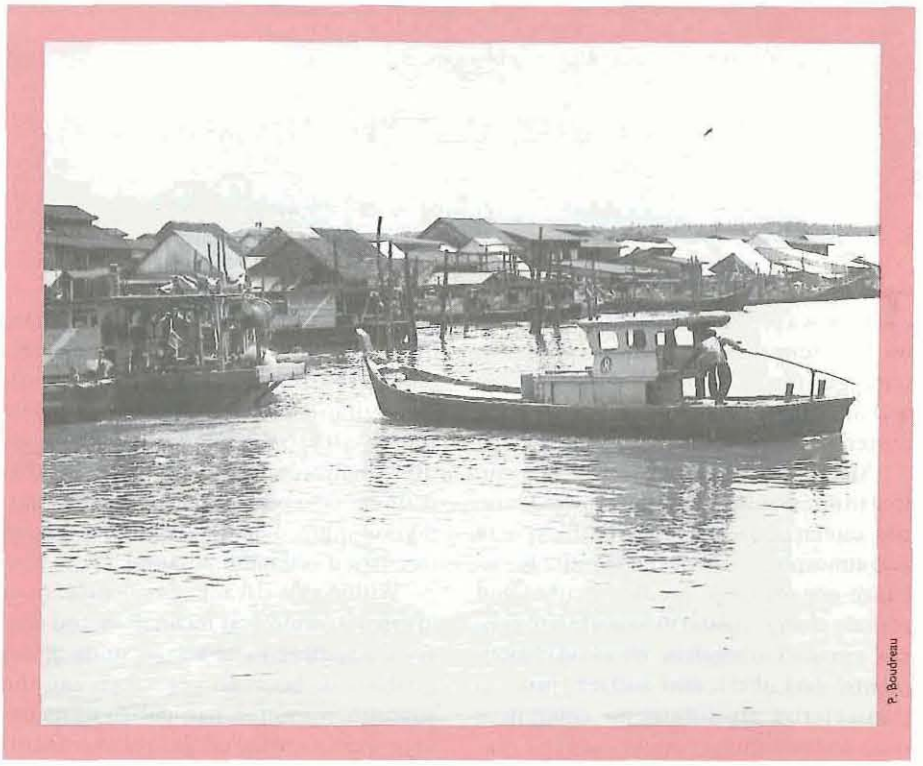
2. Carbon and Nutrient Fluxes and Socio-Economic Studies of the Merbok Mangrove Ecosystem

The study site for the Malaysian Core Research Site is the Sungai Merbok Mangroves in the State of Kedah in the northwestern part of Peninsular Malaysia. The Merbok Mangroves cover an area of about 40 km^2 including about 10 km^2 of waterways at low tide. Universiti Sains Malaysia started work on the system in the late 60's doing an ecological baseline study for a massive prawn pond aquaculture project. This led to the question of how much mangrove could be put to alternative use, *i.e.* aquaculture, without adversely affecting the estuary and adjacent capture fisheries. The multi-disciplinary team of re-

searchers associated with the Universiti Sains Malaysia's Mangrove Ecosystems Research Group has been working to answer several important questions concerning this ecosystem dealing with the possible socio-economic and environmental impacts of changes to the mangroves: What percentage of mangroves can be converted for other uses and what is the rationale for arriving at the number? What are the socio-economic effects of conversion of mangrove land for other uses? Will the capture fisherfolk be adversely affected? What are the effects of industrialisation on the mangrove ecosystem? The SARCS/WOTRO/LOICZ project will allow the continuation and hopefully successful completion of the flux studies. The work of socio-economists will be incorporated into the study.

3. Economic Evaluation and Biophysical Modelling of the Marine Environment of Bolinao in Support of Management for Sustainable Use

The Philippines' Core Research Site is Bolinao, a fringing reef system located on the north-western side of Lingayen Gulf, which is an embayment along the Northwest coast of Luzon. The Marine Science Institute of the University of the Philippines has conducted marine science research in the area for almost two decades and the College of Social Work and Community Development also of the University of the Philippines has spent a decade carrying out social science research among the coastal communities of the Lingayen Gulf including the coastal town of Bolinao. This multi-disciplinary team will be studying the four major pressures on the area: over-harvesting of fish, eutrophication, deforestation and mining. It will build on an ongoing Community Based-Coastal Resources Management project in Bolinao. The proposed research will centre on the town of Bolinao and its fringing reef-seagrass ecosystem. This ecosystem is presumed to play a critical role in the maintenance of the rich demersal and pelagic fisheries of the Lingayen Gulf. This natural resource base provides for 30% of the employment in the town of 53,000 people. This dependence will most likely increase with the rapidly growing population whose options for employment in the land based activities of farming and industry are limited. The total population for the watershed of Lingayen Gulf is estimated at around 5 million people and although the population in the inland mountainous areas is low, mining activities are widespread with unrestricted tailings discharge and result in consequent environmental pressures from coastal sedimentation.



4. Economic Evaluation Studies of Mangrove Conservation and Rehabilitation in Nam Ha Province

The focal area of the Vietnam Core Research site is the region of the Red River delta, an area with diverse economic activities and settlements and a range of ecological "habitats" for comparative study. It is one of the main agricultural regions of Vietnam with rice production of over 200 kg/capita. It is served by a complex irrigation and food production system. There is increasing investment in "high-value" products such as shrimp ponds at the expense of mangrove areas. Although this provides financial supplement to the low household incomes from rice farming in marginal areas, it seriously reduces the protection of the coast from flooding and erosion afforded by the mangroves. The Mangrove Ecosystem Research Center has worked in the area for over 20 years. In conjunction with the Centre for Environmental Research, Education and Development the proposed research will contribute to the development of dynamic models that could be used in formulating scientifically grounded management strategies for the study area.

In addition to the project contacts, LOICZ Scientific Steering Committee (SSC) members actively participating in the development of the integrated guidelines include Edgardo Gomez (SSC Chair), Stephen Smith (Biogeochemical Modelling), Jahara Yahaya (Economics), and Kerry Turner (Economics). A workshop held recently in Hanoi, Vietnam, October 26-30th, 1996, brought together researchers from the core research sites and other sites in the region, LOICZ Scientific Steering Committee (SSC) members, CPO staff and resource persons to work together in developing a draft conceptual framework model for the integration of socio-economic and natural sciences.

Further development activities are scheduled to provide essential testing, validation and evolution of the draft conceptual framework, and publication of an integrated modelling guidelines document is expected in 1997. Application of these guidelines is expected to enhance the assessment and prediction of global change in the coastal zone, and also, in conjunction with LOICZ development of coastal typologies, to facilitate globalisation of coastal zone effects based on application of general principles to type locales.

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The IGBP-BAHC global flux network initiative (FLUXNET): current status and perspectives

by Riccardo Valentini, Dennis Baldocchi, Steven Running

There is a pressing need for information on how terrestrial ecosystems influence trace gas fluxes between the biosphere and atmosphere and impact the Climate System.

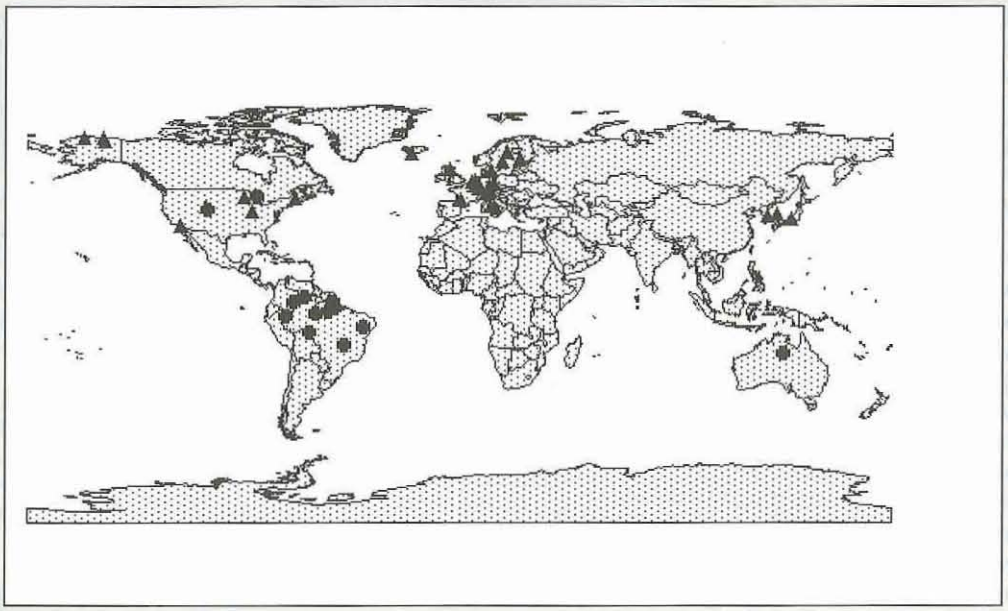
Mathematical models are a valuable tool to integrate and extend knowledge on the interactions between the biosphere and atmosphere. However, in order to enhance our ability to predict weather and climate changes using mesoscale and general circulation models, we need experimental data of relevant surface fluxes to parameterise algorithms for computing mass and energy exchanges between vegetation and atmosphere. Quantitative estimates of fluxes are also needed to develop surface aggregation schemes for the integration of fluxes from the scale of a patchwork of landscapes to the regional and, ultimately, the global domain.

With regard to CO_2 exchange, terrestrial ecosystems have a potential role for long-term CO_2 uptake from the atmosphere and carbon storage. How much and where the biosphere can store carbon are two questions that are currently receiving attention. A number of recent studies suggest a sink of carbon in the regrowing forests of the Northern Hemisphere, though the estimates are imprecise. Estimates of this term range from essentially zero to >0.7 $GtCy^{-1}$. The uncertainty of this magnitude arises from the wide disparities in the published data and assumptions employed, particularly when inventory-based estimates are used.

Within this decade, developments in micrometeorological technology and theory are starting to make the study of the interactions between vegetation and the atmosphere routine, particularly by recent improvement of the eddy covariance method which provides a direct measure of biosphere-atmosphere mass and energy fluxes. Historically, this technique has been used primarily in intensive and short-term land surface experiments, but new opportunities are arising for application at larger spatial and longer temporal scales since it is now possible to make continuous measurement of carbon dioxide and water fluxes on a seasonal basis with hourly time resolution. It is also possible to standardise the equipment and methodology, using a common software and instrumentation design in order to have a solid basis for site intercomparisons.

Last year an international workshop on strategies and future perspectives of a global network for studying fluxes of water vapour and carbon of terrestrial ecosystems was organised under the sponsorship of BAHC, GCTE, and IGAC, the US Department of Energy and NASA. In this workshop more than 25 flux measurement experiments on terrestrial ecosystems were presented. One of the insights from this workshop was that longer term studies are necessary to be useful for global climate modellers, mesoscale meteorologists, Soil Vegetation Atmosphere Transport (SVAT) developers and ecologists.

Continuous eddy covariance measurement of CO_2 fluxes over an annual basis is the only direct tool for estimating net ecosystem production (NEP), which is critical for evaluating the carbon balance of an ecosystem and vitally important for assessments of the fate of excess CO_2 from combustion of fossil fuel. Also, long-term flux measurements are needed to capture seasonal dynamics. Many of the processes driving water and carbon fluxes at the



R. Valentini

Figure 1: A preliminary registry of flux stations in the world compiled on the basis of the forms received so far. Triangles are currently operating, circles are planned operating stations

The EUROFLUX Project

EUROFLUX, is funded by the European Commission, Directorate General XII under the Environment and Climate Programme (EUROFLUX ENV4-CT950078). The project consists of a combination of flux measurements on a continuous multi-year time basis with ecological process interpretation and modelling. Long-term measurements of the fluxes of CO_2, water vapour and energy exchange are carried out at 15 representative forest sites encompassing the entire range in European climate, species distribution, and site conditions. The selected sites are representative of the regional features of the European basin (Mediterranean, Boreal, Continental, Atlantic), and form a unique integrated system for the analysis of climate related ecosystem processes, their impact on hydrological and carbon cycles, and test cases for validation of environmental policies.

In this context the EUROFLUX programme addresses the following specific objectives:

1 to characterise fluxes and energy exchange at the surface in order to provide useful parameters for global and regional climate modellers and to analyse the variables that determine energy partitioning by forests in different climatic conditions, including extreme events and stress limitations.
2 to determine the sink strength of European forests for carbon and analyse the variables that determine the gains and losses of carbon from forests of differing vegetation composition and in different climate regions.
3 to analyse the response of European forest water and carbon fluxes to climatic factors in order to aid regional scale modelling designed to predict impacts of global environmental change on forest ecosystem function.
4 to provide objective data for the validation of forest models, related to growth, partitioning of primary production, water cycling, and hydrology.
5 to provide information for the development and testing of schemes designed to elaborate forest-atmosphere interactions based on remotely sensed data.
6 to recommend management strategies for the conservation of carbon stores in forests.

The sites are distributed geographically along a North-South transect, going from about 41° to 65° North Latitude and from about 20° West to 25° East longitude.

Project co-ordinator: Riccardo Valentini, University of Tuscia, Viterbo, Italy.

Other related projects on Ocean, Biosphere and Atmosphere interactions (ESCOBA - Biosphere), Amazonian (CABARE), Sahel (Hapex - Sahel), desertification (EFEDA), impacts on high CO_2 and temperature on forests (ECOCRAFT and LTEEF) and climate change (CLIMEX) are funded by the Climate and Natural Hazards Unit of the Directorate General for Sciences, Research and Development (DGXII).

For further contact: Anver Ghazi and Panagiotis Balabanis, European Commission, Climate and Natural Hazards Unit DGII-D2.

ecosystem level are strongly dependent on seasonal changes in climate. Seasonal changes of phenology, available energy and biomass production significantly affect the rates and properties of water and carbon exchanges in the atmosphere. Extreme events (extreme temperature, high wind velocity, drought conditions) are not usually considered during short term field campaigns but they can have a strong impact on the hydrological and carbon cycles. Finally, questions concerning the biospheric responses to interannual climate variability require continuous flux measurements. For example, how do terrestrial carbon fluxes differ during ENSO (El Niño Southern Oscillation) years, rather than La Niña (the "negative" phase of an El Niño event) in regions influenced by this climatology? How do perturbations such as the eruption of Mt. Pinatubo influence biospheric carbon exchanges?

With this ability at hand and the results capitalised in the La Thuile workshop, many members of the scientific community have recommended the establishment of a network of flux measurement sites over a spectrum of ecosystems. Hence, a global flux network initiative (FLUXNET) is now proposed. It is the result of a co-ordination activity carried out under the auspices of BAHC, derived from recommendations outlined in Report No. 27 (BAHC Operational Plan 1993/1996, Focus 1, Task 1.1.2 "Implementation and co-ordination of long-term monitoring of water and carbon fluxes for terrestrial ecosystems").

A parallel concept has been developed within GCTE (GCTE - Focus 1, Activity 3 of the Operational Plan), co-operating with BAHC, where the need for long-term flux measurements and canopy functional relationships has been highlighted in order to better understand of the impact of global changes on biogeochemical cycles.

A first inventory of the flux stations, based on the registration forms received so far, is shown in Figure 1. Of particular note, the European Commission, Directorate General XII, under the programme Environment and Climate is currently funding a three year project on long-term flux measurements of carbon dioxide and water vapour on 15 different forest ecosystems of the European continent, encompassing a wide range of climates and vegetation types and structures (see box). A similar network has been established on the American continent, AMERIFLUX, with support from the US Department of Energy and other US and Canadian Agencies. Australia and New Zealand will also be covered by a flux network (OZFLUX).

In the framework of the Large Scale Biosphere Atmosphere Experiment in Amazonia (LBA), an array of flux tower measurement sites will be installed along two eco-physiological and land use intensity transects. Continuous flux measure-

ments and supporting monitoring of basic environmental characteristics will extend in LBA over several years with the intention of capturing the interannual dynamics of ecosystem behaviour. Selected flux measuring sites along these transects will be kept operational as a part of FLUXNET beyond the LBA implementation period (1997-2003).

A global organised network of multi-purpose tower measurements is now being considered by the US NASA Mission to Planet Earth as a primary source of ground validation data for the Earth Observing System (EOS) satellite series. The EOS tower requirements also include instrumentation for atmospheric haze and aerosol monitoring for both radiometric corrections of satellite data and for cloud characterisation for meteorology. A sun photometer network has been prototyped for this purpose, and can easily be added to a flux tower configuration. An additional dimension in the EOS tower plan is a "footprint analysis", a quantification of the vegetation cover, Leaf Area Index (LAI), and carbon storage for the land surface in a 1-km radius around the tower. These vegetation measurements will then allow a complete SVAT model parameterisation of a tower location, and allow the resulting flux measurements to serve as validation of SVAT models, as suggested in the original BAHC Science Plan. EOS also sponsors a data archiving center for global biogeochemical research and is a leading candidate for the central archive for a flux network.

Two integrated global observing systems sponsored by the World Climate Research Program are also considering a global tower network multi-purpose global change monitoring. The Global Climate Observing System (GCOS), and the Global Terrestrial Observing System (GTOS) both have objectives of monitoring key aspects of global change. The tower flux network being planned by IGBP fulfils many of the objectives GCOS and GTOS have for measurement of relevant terrestrial variables, global co-ordination and data quality control and continuous operation.

It is also foreseen that the IGBP Transect Studies consider the long term flux stations as an important contribution to the integrated science programme which is going to be implemented in various regions of the world. A co-ordination meeting is being considered for Summer 1997 to attempt to unify both objectives and requirements of these different international organisations for a global tower network. It could well be that the global flux network initiated by BAHC will be the template from which a comprehensive global tower based monitoring plan can be derived.

Riccardo Valentini, Department of Forest Science and Environment, University of Tuscia, 01100 Viterbo, Italy.
Dennis C. Baldocchi, NOAA/ERL, Atmospheric Turbulence andDiffusion Division, PO Box 2456, Oak Ridge, TN 37831, USA.
Steven W. Running, School of Forestry, Montana Forest and Conservation Experiment Station, University of Montana, Missoula, MT 59812-1063, USA.

AmeriFlux Network.

The AmeriFlux network consists of more than 20 long-term carbon flux measurement sites in North and Central America. Vegetation at these sites encompasses temperate deciduous, temperate evergreen, boreal, montane, and tropical forests, pine plantations, natural grasslands, crops, and tundra.

To assist with the co-ordination of the AmeriFlux network, the US Department of Energy established a network science team (contact person: David Hollinger, E-mail: DavidH@christa.unh.edu). The science team provides information, guidance, quality assurance and control, and facilitates data exchange and archiving among the stations. The science team is also involved with developing and refining flux measurement protocols and data use strategies. As part of its quality assurance and control activities, the flux team will maintain and circulate among the network sites calibration standards for temperature, humidity, radiation, and other environmental variables.

At an initial meeting of flux network participants discussed at length methods to insure comparability of flux systems. The group decided upon a strategy of establishing a "master" flux measurement system that would be transported and set-up at each of the flux measurement sites. This system will be based upon that presently in use at the Harvard Forest. Flux network members met to discuss additional network issues including flux measurement hardware and software, nocturnal measurements, quality control protocols, data archiving, and ecological data concerns.

Getting involved with FLUXNET

A register of Flux stations around the world is established by BAHC. A flux station should be an eddy covariance station for CO_2/H_2O fluxes over terrestrial ecosystems with an existing or planned duration of 1 year at least. The advantages of being registered are multiple, such as the facilitation of data exchange, promotion of new research projects, participation in workshops, access to a common database of flux measurements, etc.

For more information and/or registration forms, please contact Riccardo Valentini at the Department of Forest Science and Environment, University of Tuscia, 01100 Viterbo, Italy. E-mail: GAIA@UNITUS.IT or by fax: (+39-761) 357 389.

The IGBP 1995 Central Budget

During 1995, the total income of the IGBP central budget was a record US$1.75m. Contributions were received from 43 Nations, from ICSU, the CEC, The Swedish Council for Planning and Co-ordination of Research (FRN), and from the Dutch Electricity Generating Board. Figure 1 is a league table of contributing nations, in order of magnitude of contribution.

Total expenditure during the same period was US$1.70m. This covered the costs of all scientific planning meetings (46%), publications (5%), the operational costs of the Secretariat (18%), and the salary costs of the Secretariat (31%). Figure 2 displays the expenditure in these broad categories as a pie chart.

We are extremely grateful to all those individuals who worked tirelessly on our behalf to ensure our central support during difficult financial times.

Chris Rapley and **Elise Wännman,** IGBP Secretariat, Box 50005, S-104 05 Stockholm, Sweden.

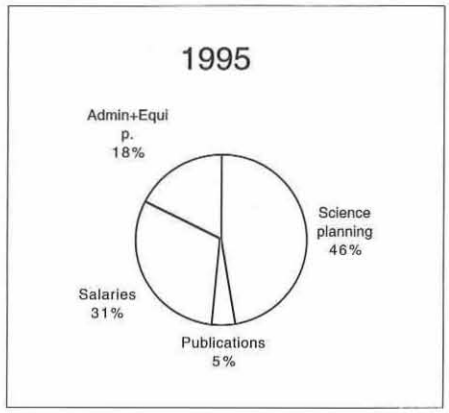


Figure 2

1	Sweden	16	China, Beijing	31	Chile
2	USA	17	Denmark	32	India
3	Germany	18	Finland	33	Philippines
4	Japan	19	Czech Republic	34	Argentina
5	United Kingdom	20	Mexico	35	Mongolia
6	Italy	21	Greece	36	New Zealand
7	Russia	22	Israel	37	Botswana
8	Netherlands	23	Poland	38	Estonia
9	Australia	24	Ireland	39	Kenya
10	Switzerland	25	South Africa	40	Romania
11	China, Taiwan	26	Slovakia	41	Togo
12	Belgium	27	Bulgaria	42	Colombia
13	Norway	28	Singapore	43	Sri Lanka
14	Canada	29	Thailand		
15	Austria	30	Tunisia		

Figure 1

Clockwise from top: John Marks, Kirsten Broch-Mathisen and Chris Rapley at the IGFA meeting in Oslo, Norway; The IGBP Officers visited the Korean Oceanography Centre (KORDI) in Korea; the IGBP Officers at their recent meeting in Seoul, Korea.

People and Events

New Chairs for Scientific Steering Committees

IGBP-DIS

Jean-Paul Malingreau is the new Chair of the Scientific Steering Committee for the IGBP Data and Information System. Dr Malingreau is employed at the Joint Research Centre of the European Commission in Ispra, Italy, where he has established a research team and facilities for the global monitoring of vegetation.

Dr Malingreau studied hydrology and ecology at the University of California, Davis. After his PhD in Ecology he started working as a specialist for the Agricultural Development Council at Gadjah Mada University in Indonesia. He has worked as a Research Fellow at the East West Center in Hawaii and at the US National Research Council. Since 1986 he has been working at the Joint Research Centre in Ispra.

He is a member of the American Geophysical Union and is Chairman of the International Users Committee SPOT-VEGETATION Instrument. His research interests are focused on the use of space observation for natural resource assessment, environmental monitoring and deforestation studies. Dr Malingreau has been a member of IGBP-DIS for the past 3 years.

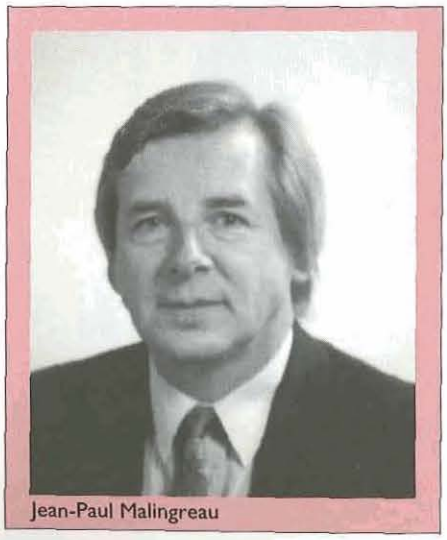
John Townshend

John Townshend is leaving the IGBP-DIS Scientific Steering Comittee after six years with IGBP-DIS - three years as vice-chair and the last three years as chair. His chairmanship has been crucial to the development of IGBP-DIS, in particular during the very difficult year that IGBP-DIS had to overcome without a Core Project Office in place. Professor Townshend is Chair of the Department of Geography of the University of Maryland. His research interests are focused on applications of remote sensing to vegetation characterisation, geographic information systems and geomorphology. Professor Townshend is chair of the Global Climate Observing System (GCOS).

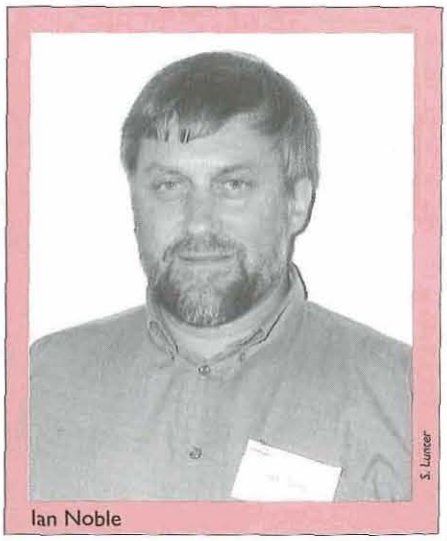
GCTE

Ian Noble is the new chair of the Scientific Steering Committee for the Global Change and Terrestrial Ecosystems Project. Professor Noble is Professor of Global Change Research for the Ecosystem Dynamics Group at the Australian National University in Canberra. He has been editor for the *Australian Journal of Ecology* and has served as President of the Ecological Society of Australia from 1991 to 1993.

Professor Noble studied botany and zoology at the University of Adelaide in Australia. After receiving his PhD in Biology he started working as a Research Fellow for the Research School of Biological Sciences at the Australian National University in Canberra. He has been one of the founders of the Ecosystem Dynamics Group and has been Group Leader of a team from 1987 onwards. He has worked with several international scientific organisations, including SCOPE, the International Union of Biological Sciences (IUBS), UNESCO Man and the Biosphere (MAB) and the Intergovernmental Panel on Climate

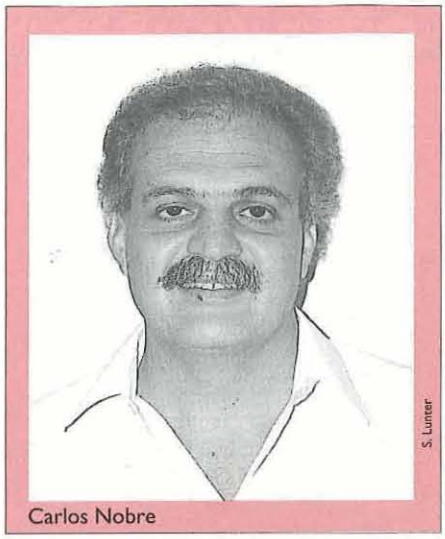

Jean-Paul Malingreau

Brian Walker

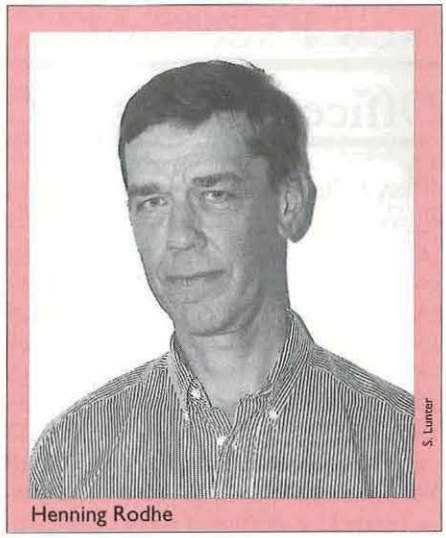


Ian Noble

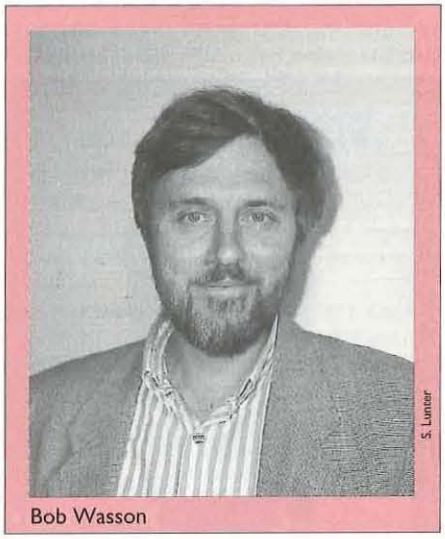

Pamela Matson



Carlos Nobre



Henning Rodhe



Bob Wasson

Change (IPCC). His scientific research interests are experimental studies and models of the dynamics of vegetation subject to disturbances such as fire, grazing or climatic change. Professor Noble has been a member of the GCTE SSC since 1991.

Brian Walker is leaving the chairmanship of the GCTE Scientific Steering Committee after six years of visionary leadership. During this time GCTE has evolved towards a synthesis stage involving more than 700 scientists throughout the world.

Dr Walker has been involved in the IGBP from the very beginning and many will remember him for his dedication in building up GCTE to its present status. Dr Walker will again be able to devote his full-time attention to his research work at the University.

New members of SC-IGBP

The following four scientists have been nominated by ICSU as members of the SC-IGBP.

Pamela Matson, of the Department of Environmental Science, Policy and Management of the University of California, Berkeley, is a professor of ecosystem science. She received a PhD in forest ecology from Oregon State University in 1983 and has worked for nine years as a research scientist at NASA/Ames Research Center. Her research has focused on the effects of natural and anthropogenic disturbances on biogeochemical cycling and trace gas exchange in tropical ecosystems. She has been active in developing interfaces between ecological and atmospheric sciences, and has been involved in numerous multi-disciplinary, multi-national planning and research activities. She was elected to the American Academy of Sciences in 1992 and has won a MacArthur Fellowship for 1995-2000. She has been a member of the IGAC-SSC from 1991 to 1996, of which the last three as vice-chair.

Carlos Nobre is head of the Center for Weather Forecasting and Climate Studies at INPE in Brazil. He received a PhD in Meteorology from the Massachussetts Institute of Technology in 1983 and has worked in different positions for INPE. His research has focused on tropical deforestation and climate impacts.He is an active member of ISLSCP and GEWEX and is a member of the GAIM Task Force. He has been a member of the BAHC-SSC from 1991 to 1996.

Henning Rodhe, of Stockholm University in Sweden, is professor of chemical meteorology as well as director of the International Meteorological Institute in Stockholm and Vice Dean of the Faculty of Sciences of Stockholm University. He received a PhD in meteorology in 1969 and has worked at the universities of Nairobi and Seattle, as well as at the National Center for Atmospheric Research in Boulder, USA and at CSIRO in Mordialloc in Australia. His research has focused on biogeochemical cycles in the atmosphere. He is president of IAMAP's Commission on Atmospheric Chemistry and Global Pollution (CACGP) and is a member of the Human Rights Committee of the Royal Swedish Academy of Sciences. He has been a member of the IGAC-SSC from 1991 to 1996.

Bob Wasson, of the School of Resource and Environmental Management at the Australian National University in Canberra, Australia, is professor of geography. He received a PhD in Geology from Macquarie University in 1975 and has worked at different universities, such as the University of Auckland, New Zealand and the Physical Resarch Laboratory in Ahmedabad in India, and recently at the CSIRO Division of Water Resources in Canberra. His research has focused on geomorphology and sedimentology of rivers and mass movements, aeolian processes and landforms, past environments and climatic change and land and water management. He has been vice-chair of the PAGES-SSC for the past six years.

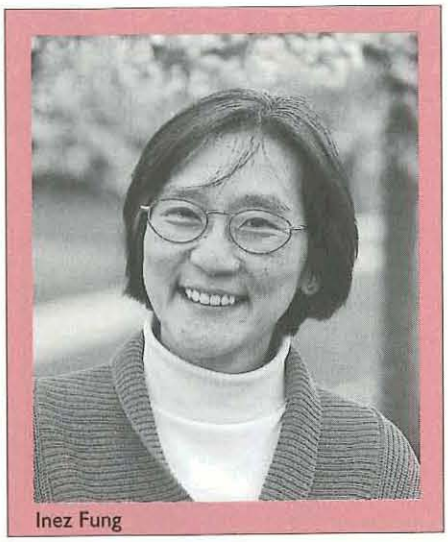
New Executive Officer for LOICZ

Roy Sidle has accepted the position of Executive Officer at the LOICZ Core Project Office, and will join the CPO staff on December 1, 1996. Dr Sidle is currently employed as Senior Research Hydrologist in the Geological Survey of Denmark and Greenland. Prior to that, he was a research scientist and Project Leader in the US Forest Service in Alaska and Utah for 15 years. He has also served in positions as Watershed Extension Specialist with Oregon State University and as research scientist with USDA Agricultural Research Service.

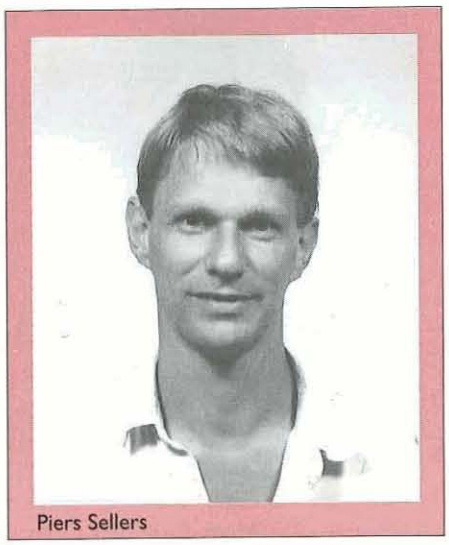
With training in hydrology, soil science, and civil engineering, Dr Sidle has BSc and MSc degrees from the University of Arizona, and a PhD from Pennsylvania State University. He has worked extensively in coastal watershed systems from both a scientific and a management standpoint, dealing with the interaction between forestry and fisheries in both terrestrial and marine environments. His background includes the development, co-ordination, and management of multidisciplinary research focused on water quality and integrated ecosystem studies. He holds appointments as Adjunct Professor in the Departments of Forest Resources, and of Civil and Environmental Engineering at Utah State University.

Dr Sidle's international experience includes receipt of a fellowship from the Science and Technology Agency of Japan to develop co-operative studies in watershed hydrology and erosion, and numerous follow-on collaborations in Japan. He has also carried out research or consulting activities in Iceland, Indonesia, Malaysia, New Zealand, Norway, Oman, PR China, Taiwan and Thailand.

Dr Sidle replaces Dr John C. Pernetta, who left the LOICZ CPO in June to accept a position with the UNEP GEF Co-ordination Unit in Nairobi, Kenya.



Inez Fung



Piers Sellers

1996 AGU Fellows elected

Thirty-two distinguished scientists were awarded as AGU Fellows in 1996. This selection was based on the individuals' attainment of acknowledged eminence in a branch of geophysics. Among the new fellows are Inez Fung, newly selected to the GAIM Task Force, and Piers Sellers, former ISLSCP member of the BAHC Scientific Steering Committee.

Inez Fung was selected for her pioneering work in ocean and climate modelling and, above all, the biogeochemical cycle of carbon, for which she has uniquely combined remote sensing and synthesis of sources with three-dimensional modelling to change our view of global carbon dioxide.

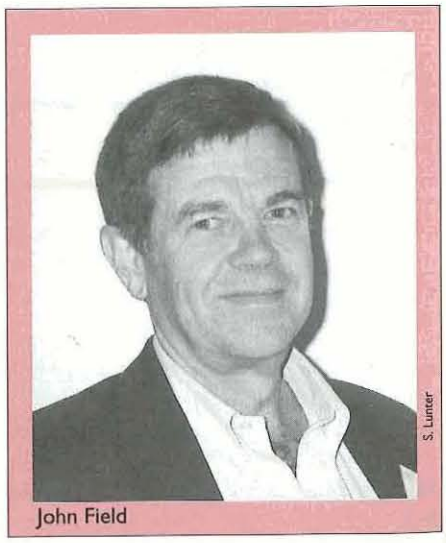
Piers Sellers was selected for his incisive and prolific research contributions and leadership in advancing our understanding of the role of vegetation in the climate.

Roy Sidle

New President for SCOR

At their recent meeting SCOR selected a new president, John Field.

Professor Field is well known in the IGBP for his chairmanship of JGOFS, which has been extended for one year.



S. Lunter

John Field

IGBP and Other Meetings

*Only meetings marked with * are open for all scientists to attend. All other meetings are by invitation only.*

1997

1997, TBA

IGBP-DIS Focus 1: Soils WG meeting.

Early 97, TBA

Land Use and Climate Impacts on Fluvial Systems Workshop.

Robert Wasson, Research School of Pacific Studies, Australian National University, Canberra, Australia. Fax: (+61-6) 249 3770, E-mail: robert.wasson@anu.edu.au

Early 97, TBA

The Use of Stable Isotopes in selected Palcoarchives Workshop.

Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

8-10 January, Reduit, Mauritius

SAIPO/SASCOM Workshop on Aerosols, Biomass Burning and Acid Rain.

A.P. Mitra, SASCOM, National Phsycial Laboratory, Hillside Road, New Delhi 110 112, India. Fax: (+91-11) 575 2678, E-mail: apmitra@doe.ernet.in

11-12 January, Reduit, Mauritius

4th SASCOM Meeting.

A.P. Mitra, SASCOM, National Phsycial Laboratory, Hillside Road, New Delhi 110 112, India. Fax: (+91-11) 575 2678, E-mail: apmitra@doe.ernet.in

11-22 January, Siwa Oasis, Egypt

INQUA-PAGES Workshop on Continental Signals of Paleomonsoon Dynamics in Africa: Interhemispheric Perspectives.

Stefan Kroepelin, INQUA-PAGES Paleomonsoons Project, Free University of Berlin, Podbielskiallee 62, 14195 Berlin, Germany. Fax: (+49-30) 841 00363, E-mail: skroe@zedat.fu-berlin.de

20-23 January 1997, New Delhi, India

START/APN/IHDP/GCTE Workshop on Human Dimensions of Global Environmental Change in Asia

A.P. Mitra, SASCOM, National Physical Laboratory, Hillside Road, New Delhi 110 112, India. Fax: (+91-11)575 2678, E-mail: apmitra@doc.ernet.in

21-23 January, Santa Barbara CA, USA

DIS Focus 1: Land Cover Working Group Meeting.

Alan Belward, Space Applications Institute, Monitoring of Tropical Vegetation, Joint Research Centre of the CEC, Building 44, I-21020 Ispra, Varese, Italy.

27-28 January, Merseyside, UK

JGOFS Data management Task Team Meeting.

Roy Lowry, DMTT Chair, British Oceanographic Data Center, Proudman Oceanographic Laboratory, Bidston Observatory, Birkenhead, L43 7RA, UK. Tel: (+44-151) 653 8633, E-mail: rkl@ua.nbi.ac.uk

30 January-1 February, Potsdam, Germany

ExCom Meeting BAHC SSC.

IGBP-BAHC Core Project Office, Institute for Climate Impact Research, PO Box 601203, D-14412 Potsdam, Germany. Fax: (+49-331) 288 2547

TBA, Japan

GCTE Rice Network: FACE and TGT (Temperature Gradient Tunnel) CO_2 Planning Workshop.

K. Kobayashi, National Institute of Agro-Environmental Science, Tsukuba, Ibaraki 305, Japan. Fax: (+81-298) 38 8211, E-mail: clasman@niaes.affrc.go.jp

10-14 February, La Jolla CA, USA

Joint GEWEX-ISLSCP/PILPS and IGBP-BAHC/GCTE Workshop.

Dawn Ehrlich, GEWEX Project Office. E-mail: gewex@cais.com

17-20 February, Nairobi, Kenya

GCTE/LUCC/WHO/FAO/LSHTM Workshop: Global Change Impact Assessment Approaches for Vectors and Vector-Borne Diseases.

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

19-22 February, Bogor, Indonesia

START/WCRP/GCTE: Climate Variability, Agricultural Productivity and Food Security in Asian Monsoon Regional Workshop.

Will Steffen , GCTE Core Project Office, CSIRO, Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

24 February - 2 March, Norwich, UK

12th SC-IGBP Meeting.

TBA, Santa Barbara CA, USA

Joint IGBP-BAHC/GCTE/DIS Workshop on Large-scale Pattern and Process in Root System Structure and Dynamics.

Bhaskar Choudhury, NASA-GSFC, Code 974, Greenbelt, MD 20771, USA. Fax: (+1-301) 286 1758 and Chris Field, Carnegie Institution of Washington, Stanford CA, USA. Fax: (+1-415) 325 6857

March, Kathmandu, Nepal

SASCOM Meeting on Dynamics of Land Use/Land Cover Change in the Hindu Kush-Himalayas (tentative).

Lisa Graumlich, Institute for the Study of Planet Earth, University of Arizona, Tucson AR 85748, USA. Fax: (+1-520) 621 5004, E-mail: graumlich@ltrr.arizona.edu

March, Tucson AZ, USA

DIS Focus 1: Soils Pedo Transfer Function meeting.

Sorrosh Sorooshian, Dept. of Hydrology and Water Resources, University of Arizona, Tucson, AZ 87521, USA. Fax: (+1-602) 621 1422

3-12 March, Mombasa, Kenya

African GAIM/START Tutorial Workshop on Terrestrial Modelling.

Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. Fax: (+1-603) 862 1915, E-mail: gaim@unh.edu

4-6 March, Barcelona, Spain

8th IGBP-DIS Scientific Steering Committee Meeting.

Gérard Szejwach, IGBP-DIS Office, 42 Avenue G. Coriolis, F-31057 Toulouse, France. Fax: (+33) 61 07 85 89, E-mail: gerard.szejwach@igbp.cnrm.meteo.fr

11-12 March, Japan (tentative)

IPCC/START Integrated Assessment Modelling Training Programme Core Group Planning Meeting.

Hassan Virji, International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859. E-mail: start@dis.start.org

16-18 March, Bogor, Indonesia

GCTE SSC Meeting

Will Steffen , GCTE Core Project Office, CSIRO, Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

18-20 March, Bogor, Indonesia

GCTE Activity 3.4 Workshop: Complex Agro-ecosystems Workshop.

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

18-20 March, Barcelona, Spain

LUCC SSC Meeting

LUCC Core Project Office, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: carolinen@icc.es

20-22 March, Montpellier, France

Terrestrial Global Productivity: Past, Present and Future.

Jacques Roy, Centre d'Ecologie Fonctionnelle et Evolutive, CNRS, BP 5051, F-34033 Montpellier Cedex 1, France. Fax: (+33-4) 67 41 21 38, E-mail: roy@srvlinux.cefe.cnrs-mop.fr

April, TBA

Southern Ocean GLOBEC Working Group

Liz Gross, SCOR Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

1-3 April, Barcelona, Spain

GAIM Task Force Meeting

Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. Fax: (+1-603) 862 1915, E-mail: gaim@unh.edu

6-13 April, Santa Barbara CA, USA

Arctic and Boreal Processes that feed back to climate: Extrapolation and Synthesis.

F. Stuart Chapin III, Department of Integrative Biology, University of California, Berkeley, CA 94720-3140, USA. Fax: (+1-510) 643 6242, E-mail: fschapin@garnet.berkeley.edu

8-11 April, Boulder CO, USA

IGBP-DIS/WDC: Data Management Requirement Workshop.

Jonathan Overpeck, Paleoclimatology Programme, National Geophysical Data Center E/GC, National Oceanic and Atmosphere Administration (NOAA), 325 Broadway, Boulder, CO 80303-3328, USA. Fax: (+1-303) 497 6513, E-mail: jto@mail.ngdc.noaa.gov

14-18 April, Utrecht, Netherlands

GCTE Soil Erosion Network Water Erosion at Catchment Scale: Model Comparison and Sensitivity Analysis Workshop.

Christian Valentin, ORSTOM, Institute Français de Recherche Scientifique pour le Développement en Coopération, BP 11416, Niamey, Niger. Fax: (+227) 722 804, E-mail: valentin@orstom.rio.net

21-25 April, Vienna, Austria

BAHC: Special Sessions at the European Geophysical Society (EGS) XXII General Assembly.

EGS Office, Max -Planck-Strasse 1, D-37191 Katlenburg-Lindau, Germany. Fax: (-49-5556) 4709, E-mail: egs@linax1.mpae.gwdg.de, http://www.mpae.gwdg.delegs/egs.html

23 April-3 May, Rabat, Morocco

IAHS 5th Scientific Assembly, Workshop W1: Scaling Issues in the Coupling of Hydrological and Atmospheric Models.

Alfred Becker, PIK, PO Box 601 203, 14412 Potsdam, Germany. Fax:(-49-331) 288 2560, E-mail:becker@pik-potsdam.de

Late April, Arizona, USA

GCTE Wheat Network Workshop.

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

May, TBA

Regional Workshop for France and Africa.

Cory Fleming, International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859. E-mail: start@dis.start.org

17-19 May, Argyll, Scotland (UK)

JGOFS Scientific Steering Committee Meeting.

Roger Hanson, JGOFS Core Project Office, Center for Studies of Environment and Resources, High Technology Centre, University of Bergen, N-5020 Bergen, Norway. Fax: (+47-55) 324 801, E-mail: jgofs@uib.no

17-19 May (tentative), Toronto, Canada

IGAC Scientific Council Meeting.

Alex Pszenny, IGAC Core Project Office, Bldg. 24-409, Massachusetts Institute of Technology, Cambridge, MA, 02139-4307, USA. Fax: (+1-617) 253-9886, E-mail: pszenny@mit.edu.

20-22 May, Toronto, Canada

IGAC/SPARC Conference on Global Measurement Systems for Atmospheric Composition

IGAC-GOMAC, Department of Physics, University of Toronto, 60 St. George St., Toronto, Ontario M5S 1A7, Canada. Fax: (+1-416) 978-8905, E-mail: gomac@atmosp.physics.utoronto.ca, WWW: http://www.atmosp.physics.utoronto.ca/gomac

20-26 May, Argyll, Scotland (UK)

JGOFS Symposium on Synthesis and Modelling.

Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca or: Graham Shimmield, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll, Scotland. Fax: (+44-1631) 65518, E-mail: g.shimmield@ed.ac.uk

28-30 May, Missoula MT, USA

BAHC SSC Meeting.

BAHC Core Project Office, Potsdam Institute for Climate Impact Research, PO Box 601 203, 14412 Potsdam, Germany. Fax:(+49-331) 288 2547, E-mail:bahc@pik-potsdam.de

June, Plymouth, UK

GLOBEC SSC Meeting

Roger Harris, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, United Kingdom. Fax:(+44-1752) 633 101

June, Potsdam, Germany

Net Primary Productivity Model Intercomparison workshop.

Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. Fax: (+1-603) 862 1915, E-mail: gaim@unh.edu

16-17 June, Laxenburg, Austria

LUCC SSC Meeting

LUCC Core Project Office, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: carolinen@icc.es

June/July, TBA

Joint NAFCOM/SAFCOM Meeting: 5th NAFCOM Meeting and 6th SAFCOM Meeting (tentative).

Cory Fleming, International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859. E-mail: start@dis.start.org.

June/July, Lake Tahoe NV, USA

GCTE Focus 1 Workshop: Comparative Analysis of Forest Responses to Atmospheric CO_2 Increase and Global Environmental Change.

Boyd Strain, Duke University, Botany/Phytotron Building, PO Box 90340, Durham NC 27708-0340, USA. Fax: (+1-919) 660 7425.

July, Nantes, France

Joint meeting of the GLOBEC Working Groups on Numerical Modelling and Sampling and Observation Systems.

Liz Gross, SCOR Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

July, Cotonou, Bénin

START/WCRP/SCOWAR (ICSU) Workshop on Climate Variability, Water and Agriculture in Sub-Saharan Africa: Food Security Issues (tentative).

Abel Afouda. Fax: (+229) 30 08 39

July, Birmensdorf, Switzerland

GCTE Focus 2 Workshop on Comparison of Forest Patch Models.

Dr Harald Bugmann, Potsdam Institute for Climate Impact Research, PO Box 601203, (Telegrafenberg), D-14412 Potsdam, Germany. Fax: (+49-331) 288 2600, E-mail: bugmann@pik-potsdam.de

July, Barcelona, Spain

LUCC/IGBP-DIS Data Requirements Workshop

LUCC Core Project Office, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: carolinen@icc.es

1-9 July, Melbourne, Australia

Fourth IGAC Scientific Conference,

Comprised of three Symposia of the IAMAS/IAPSO Joint Assemblies on Earth - Ocean - Atmosphere: Forces for Change. Symposium JMP3: Chemical Processes and Climate, Convener: Barry J. Huebert, University of Hawaii, USA; Fax: (+1-808) 956-9225; E-mail: huebert@soest.hawaii.edu. Symposium IM7: Tropospheric Chemistry and Related Air/Surface Exchange in Polar Regions, Convener: Gregory P. Ayers, CSIRO Division of Atmospheric Research, Australia; Fax: (+61-3) 9239 4688; E-mail: greg.ayers@dar.csiro.au. Symposium IM22: Closing the Budgets of CO_2, CH_4 and N_2O, Convener: Paul J. Fraser, CSIRO Division of Atmospheric Research, Australia; Fax: (+61-3) 9239 4444; E-mail: paul.fraser@dar.csiro.au. Further information: http://web.mit.edu/afs/athena.mit.edu/org/i/igac/www/IAMAS.html

13-19 July, Suva, Fiji

START Planning Meeting for Oceania (tentative).

August, Longyearbyen, Svalbard

JGOFS Symposium on Photosynthesis Measurement.

Egil Sakshaug, Trondheim Biological Station, Institute for Marine Biochemistry, University of Trondheim, Erling Skakkesgt. 47, N-7013 Trondheim-North, Norway. Fax: (+47) 7359 1597, E-mail: egil.sakshaug@vm.unit.no

24-30 August, Krasnoyarsk, Russia

PAGES/GCTE Workshop on Spatial-Temporal Dimensions of High Latitude Ecosystem Changes.

Eugene A. Vaganov, Institute of Forest SB RAS, Akademogorok, Krasnoyarsk, 660036 Russia. Fax:(+7-3912) 43 36 86, E-mail: evag@ifor.krasnoyarsk.su

September, Manhattan KS, USA

GCTE Soil Erosion Network Wind Erosion Model Comparison and Sensitivity Analysis Workshop.

Christian Valentin, ORSTOM, Institute Français de Recherche Scientifique pour le Développement en Coopération, BP 11416, Niamey, Niger. Fax: (+227) 722 804

14-20 September, Niamey, Niger

START/BAHC/GCTE Workshop on Vegetation and the Hydrological Cycle in the Sahel.

BAHC CPO, Potsdam- Institute for Climate Impact Research, PO Box 601 203, D-14412 Potsdam, Germany. Fax:(+49-331) 288 2547, E-mail:bahc@pik-potsdam.de

week of 15 September, TBA

11th START SSC meeting and 7th START Bureau meeting.

International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859. E-mail: start@dis.start.org

October, TBA

JGOFS Arabian Sea Synthesis Workshop.

Peter Burkill, Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH, UK. Fax: (+44-1752) 670 637, E-mail: p.burkill@pml.ac.uk

October, TBA

JGOFS/LOICZ Continental Margins Task Team Workshop.

Stephen V. Smith, University of Hawaii, Honolulu HI 96822, USA. Tel: (+1-808) 56 8693, e-mail: svsmith@soest.hawaii.edu

10-13 October, The Hague, Netherlands

*LOICZ Open Science Meeting.

LOICZ CPO, NIOZ, PO Box 59, NL-1790 AB Den Burg-Texel, Netherlands. Fax: (+31-222) 369 430, E-mail: loicz@nioz.nl

October/November, Accra, Ghana

START/NAF Workshop on Land Use/Land Cover Change in Northern Africa (tentative).

G.T. Aygepong, University of Ghana-Legon. Fax:(+233-32) 500 310., E-mail: rsau@ncs.com.gh

11-13 November, Nagoya, Japan

IGAC/IGBP Symposium.

Hajime Akimoto, 4-6-1 Komaba, Meguro-ku, Tokyo 153, Japan. Fax: (+81-3) 3481 4562, E-mail: akimoto@atmchem.rcast.uk-tokyo.ac.jp

November, TBA

SARCS/WOTRO/LOICZ Workshop.

LOICZ CPO, NIOZ, PO Box 59, NL-1790 AB Den Burg-Texel, Netherlands. Fax: (+31-222) 369 430, E-mail: loicz@nioz.nl

2-9 December, Nairobi, Kenya

*Fifth Scientific Advisory Council Meeting (SAC V).

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se

TBA

JGOFS Synthesis Meeting for the Planning Group on North Atlantic Ocean.

Mike Fasham, James Rennell Centre, Chilworth Research Centre, Gamma House, Chilworth, Southampton SO1 7NS, UK. Fax: (+44-1703) 767 507, E-mail: mjf@ub.nso.ac.uk

1998

First quarter, Paris, France

*GLOBEC Open Science Meeting

Liz Gross, SCOR Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

First quarter, TBA

JGOFS Training Course on Synthesis and Modelling.

Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca

14-18 March, Barcelona, Spain

*GCTE-LUCC Science Conference.

Will Steffen, GCTE Core Project Office, CSIRO Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

April, London, UK

*PAGES Open Science Meeting.

Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

July, Montpellier, France

*GCTE Special Session at International Soil Science Congress.

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

19-25 August, Seattle WA, USA

*Joint 5th IGAC Scientific Conference and 9th CACGP Symposium on Global Atmospheric Chemistry.

Patricia Quinn, NOAA/PMEL/OCRD, Building 3, 7600 Sand Point Way NE, Seattle, WA 98115, USA. Fax: (+1-206) 526 6744, E-mail: quinn@pmel.noaa.gov, WWW: http://saga.pmel.noaa.gov/cacgp98/

Publications

IGBP Programme Elements

IGBP-DIS

The IGBP-DIS Global 1km Land Cover Data Set "DISCover" - Proposal and Implementation Plans. - Report of the Land Cover Working Group of IGBP-DIS (1996). Edited by Alan S. Belward. IGBP-DIS Working Paper No. 13. Toulouse: IGBP-DIS,

IGBP-DIS Office, IGBP-DIS - CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse cedex, France.

GAIM

Special Issue of Global and Planetary Change on Soil Moisture Simulation. Edited by A. Henderson-Sellers. Volume 13, Nos. 1-4, June 1996. Amsterdam: Elsevier, 225 pp.

Elsevier Science B.V., Journal Department, PO Box 211, 1000 AE Amsterdam, The Netherlands.

Research GAIM (Fall 1996). NewsLetter of the GAIM Task Force.

GAIM Task Force Office, EOS, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA.

GCTE

GCTE Task 3.3.1 Soil Organic Matter Network (SOMNET): 1996 Model and Experimental Metadata (1996). Edited by P. Smith, J.U. Smith and D. Powlson. GCTE Report No. 7. Wallingford: GCTE, xii + 255 pp.

GCTE Focus 3 Rice Network: 1996 Model and Experimental Metadata (1996). GCTE Report No. 8. Wallingford: GCTE, v + 57 pp.

GCTE Activity 3.3 Effects of Global Change on Soils: Implementation Plan (1996). Edited by J.S. Ingram and P. Gregory. GCTE Report No. 12. Wallingford: GCTE, v + 56 pp.

GCTE Activity 3.4 Effects of Global Change on Multi-species Agroecosystems: Implementation Plan (1996). Edited by M.J. Swift and J.S. Ingram. GCTE Report No. 13. Wallingford: GCTE, iv + 56 pp.

GCTE Focus 3 Office, NERC Centre for Ecology and Hydrology, Maclean Building, Wallingford, Oxon OX10 8BB, UK.

IGAC

Atmospheric Aerosols: A New Focus of the International Global Atmospheric Chemistry Project (IGAC) (1996). Edited by P.V. Hobbs and B.J. Huebert. Cambridge MA: IGAC, 40 pp.

IGAC Core Project Office, MIT, Building 24-409, Cambridge, MA 02139, USA.

JGOFS/LOICZ

First Report of the JGOFS/LOICZ Continental Margins Task Team (1996). Compiled and edited by J. Hall and S.V. Smith. LOICZ Reports and Studies No. 7. Texel: LOICZ, 38 pp.

LOICZ Core Project Office, NIOZ, PO Box 59, NL-1790 AB Den Burg - Texel, The Netherlands.

LOICZ

Report of the International Symposium on Groundwater Discharge in the Coastal Zone held at the Russian Academy of Sciences, Moscow, Russia, 6-10 July 1996. LOICZ Meeting Report No.16. Texel: LOICZ, 78 pp.

LOICZ NewsLetter No. 1 (October 1996)

LOICZ Core Project Office, NIOZ, PO Box 59, NL-1790 AB Den Burg - Texel, The Netherlands.

National Research

Czech Republic

Climate Variability and Climate Change Vulnerability and Adaptation (1996). Proceedings of the Regional Workshop in Prague, Czech Republic, September 11-15, 1995. Edited by I. Nemesová. Prague: Czech Academy of Sciences, 394 pp.

Institute of Atmospheric Physics, Czech Academy of Sciences, Bocní II, 141 31 Prague 4, Czech Republic.

Germany

List of MAK and BAT Values 1996. Maximum Concentrations and Biological Tolerance Values at the Workplace (1996). Deutsche Forschungsgemeinschaft, Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Report No. 32. Weinheim: VCH Publishers, 180 pp.

Deutsche Forschungsgemeinschaft, Kennedyallee 40, D-53175 Bonn, Germany.

Italy

Ricerche italiane: Rapporto del Workshop organizzato dalla Commissione Italiana IGBP, CNR Roma 25-26 marzo 1996 (1996). Edited by R. Frassetto. Venezia: CNR-ISDGM, 355 pp.

Roberto Frassetto, CNR-ISDGM, 1364 San Polo, 30125 Venezia, Italy.

Netherlands

RIVM Annual Scientific Report '95 (1996). Bilthoven: RIVM, 235 pp.

National Institute of Public Health and the Environment, PO Box 1, 3720 BA Bilthoven, The Netherlands.

USA

Our Changing Planet: The FY 1997 U.S. Global Change Research Program (1996). A Report by the Subcommittee on Global Change Research, Committee on Environment and Natural Resources of the National Science and Technology Council. A Supplement to the President's Fiscal Year 1997 Budget. Washington: U.S. Global Research program, 162 pp.

Global Change Research Information Office, User Services, 2250 Pierce Road, University Center, MI 48710, USA

Ocean Studies Board Annual Report 1995 (1996). Washington: National Academy Press, 49 pp.

Ocean Studies Board, Commission on Geosciences, Environment and Resources, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418, USA.

Related Organisations

IHDP

Global Change, Local Challenge (1996). HDP Third Scientific Symposium, 20-22 September 1995. Proceedings (Vol. 1) and Poster Papers (Vol. 2). HDP Report No. 8. Geneva: HDP, 132 + 197 pp.

Eckart Ehlers, Department of Geography, University of Bonn, Meckenheimer Allee 166, 5 115 Bonn, Germany.

IOC

Annual Report 1995 (1996). Intergovernmental Oceanographic Commission Annual Reports Series No. 2. Paris: UNESCO, 68 pp.

IOC of UNESCO, 7 Place de Fontenoy, 75352 Paris Cedex, France.

ICSU

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GLOBAL CHANGE NEWSLETTER

Edited by Sheila M. Lunter

NewsLetter requests and change of address information should be sent to:
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The IGBP Report Series is published in annex to the Global Change Newsletter

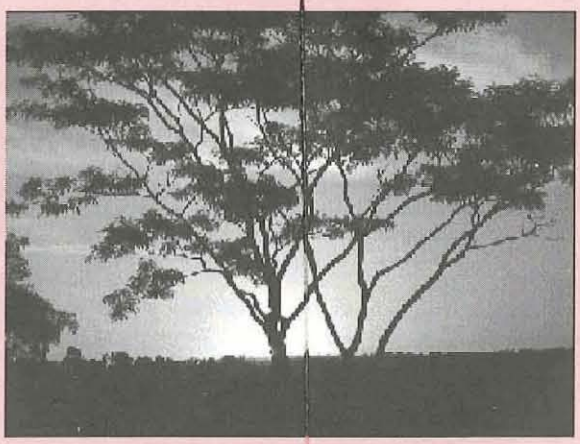
First announcement

Fifth Scientific Advisory Council Meeting (SAC V)

2-9 December 1997
UNEP Headquarters, Gigiri, Nairobi, Kenya

The Kenyan National Committee for the IGBP has graciously invited the highest body of the IGBP, the Scientific Advisory Council (SAC), to hold its fifth session in Nairobi. The Council, comprising the ICSU bodies and National IGBP Representatives, advises on the scientific content of the programme, assesses its results, and makes recommendations for its future direction and strategy. The IGBP is well established, with the majority of its Core Projects and Framework Activities now well advanced in their implementation phase, and with numerous cross-project links being actively developed. It is timely that SAC V will be held in Africa, and that the topic of the associated Scientific Symposium will be:

Living with Global Change in Africa



The two day Scientific Symposium, will be preceded by a day of presentations outlining the present status of the IGBP Programme, and will include plenary and poster sessions. The plenary session will consist of presentations by invited speakers. The poster session will have its own designated time and will consist of posters selected from submitted abstracts. Both plenary and poster presentations will focus on how global change influences daily life in Africa. The poster session is an opportunity to showcase the African perspective on global change to the IGBP community.

The organising committee for the Symposium is chaired by Eric O. Odada, Vice-Chair of the SC-IGBP, with Robert J. Scholes, as Co-Chair. The Scientific Symposium will be followed by a Policy Session, National Committee discussions and formal SAC business.

The invited papers will be published in the IGBP Report Series. The deadline for receiving abstracts for the poster presentations is 1 June 1997. Please send poster abstracts of maximum 250 words by 1 June 1997 to the IGBP Secretariat.

Registration forms and information on hotel accommodation will be obtainable from the IGBP Secretariat in Stockholm after 1 January 1997:

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