Close to three hundred participants from 51 countries attended SAC III. To honour such international participation, the Director of the Centre de Convenciones, Señor José Luis Fernández Bandini, arranged for the flag of each participating nation to be flown.

Special issue of the Global Change NewsLetter on SAC III
Edited by Suzanne Nash and Phillip Williamson

photo acknowledgements:
Servicios Fotograficos, Ensenada; CICESE
John Marks, Phillip Williamson and Elise Wännman

NewsLetter requests and change of address information
should be sent to the IGBP Secretariat,
The Royal Swedish Academy of Sciences,
Box 50005, S-104 05 Stockholm, Sweden
Tel: (+46-8) 16 64 48 Fax: (+46-8) 16 64 05

ISSN 0284-5865

GLOBAL CHANGE
NEWSLETTER

No. 13 MARCH 1993

THE INTERNATIONAL GEOSPHERE–BIOSPHERE PROGRAMME: A STUDY OF GLOBAL CHANGE (IGBP)
OF THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

Integrating Earth System Science

"Our dreams of the 80s are becoming the realities of the 90s"

Third Scientific Advisory Council for the IGBP
24 – 29 Jan 1993; Ensenada, Mexico

"Never have I had such a widespread sense that any one meeting was for so many participants the best organized they had ever attended" said James McCarthy (Chair, IGBP Scientific Committee) in praise of the facilities at the Centro Convenciones Riviera, Ensenada and the local support provided by the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE).

There was 'something in the air' at Ensenada. It is unusual for a meeting to convey adequately the excitement of science – the enthusiasm generated by new knowledge that is both personal and shared – yet that was the heady atmosphere at the 3rd Scientific Advisory Council of IGBP (SAC III). Perhaps because it was really a multitude of meetings, at many different levels: in addition to the sessions of representatives of IGBP National Committees and ICSU bodies (SAC III *sensu strictu*), there were workshops on new IGBP developments and a Scientific Symposium that was truly transdisciplinary – and these were preceded by an ICSU Forum on Earth System Research, and followed by a meeting of the IGBP Scientific Committee.

Within the week there were also at least nine other formal side meetings, and maybe ninety other gatherings – in restaurants, bars and at taco stands – where scientific ideas were presented and challenged, by sub-groups of the 300 SAC III participants from 51 different countries and at least as many research backgrounds.

Two major themes emerged. First, it was clearly demonstrated that IGBP is now in action: the research agendas of many of the Core Projects, planned for so long, are now being carried out. Planning continues, but now at a different level: there are results, to confirm or refute hypotheses, and guide the further development of a programme that is now up and running.

Second, the holistic concept of Earth System science is no longer something in the mind. We have begun to fulfil the

CONTENTS

Special issue on SAC III

earlier vision of "a new kind of science, genuinely innovative, interdisciplinary and international, courageously comprehensive, resolutely integrated, and sharply focused on the scientific issues vital to meeting humanity's needs" (as described by John Perry, of the US National Research Council).

The integrations within IGBP, and IGBP's partnerships with other programmes, are proving that the whole can be more than the sum of its component parts. We are now finding out more and more about more and more – not less and less – as global-scale datasets are collected and analyzed, and the dynamics of key processes are quantified. Such endeavours will reduce the uncertainties surrounding many aspects of global change, but may also increase uncertainty in others. Their overall success must therefore be assessed according to how well we can describe and simulate the real world (that includes biologically-driven processes and human behaviour), rather than in terms of confidence limits for 'predictions' based on assumptions that may be badly flawed.

SAC III greatly strengthened the existing links between IGBP and the World Climate Research Programme (WCRP), particularly in model development and land surface interactions. In addition, a framework was created for working partnerships with the social science community, through the Human Dimensions of Global Environmental Change Programme (HDP). "Two years ago a chasm separated natural and social scientists working on global change" said Roberta Miller (President, CIESIN and member of the HDP Standing Committee), "now there is only a slight divide. We are no longer discussing the need for collaboration, but have begun to partition the research problems, with much more realistic expectations of what the two communities can achieve".

The abstract of Miller's presentation, together with the 21 others given in the Scientific Symposium can be found in pp 17-23 of this Newsletter. Other highlights from those papers included analyses of 1000 yr model runs for coupled ocean-atmosphere GCMs; insights into the behaviour of terrestrial carbon sinks; global maps of how land vegetation might respond to rising CO_2 and changing climate; new data from ice cores and lake sediments, showing precedents for rapid climate change; and detailed consideration of the origins and impacts of El Niño-Southern Oscillation phenomena.

With such a diversity of topics, any selection of the most exciting ideas and developments is arbitrary. However, the heading of a recent *Science* Research News article (19 March 1993; 259, 1694-6) on SAC III provides a convenient summary of the meeting: "Ecologists put some life into models of a changing world".

ICSU and Global Change

An important function of meetings of the IGBP Scientific Advisory Council is to focus attention on IGBP relations with other closely-related research activities, particularly those supported by the International Council of Scientific Unions (ICSU). To promote such discussions, ICSU held a one-day Forum on Earth System Research at Ensenada preceding the SAC III meeting.

Introductory presentations were given by Maurits la Rivière (Secretary General, ICSU) and James Dooge (President Elect, ICSU), the latter reviewing the follow-up to the ASCEND 21 Conference held in preparation for the Rio UNCED meeting. Topics covered by other speakers included post-UNCED developments; ecological economics; research on biodiversity; the developing suite of global observing systems; the potential for reducing the impact of natural disasters; solar variability and its climatic implications; the role of Antarctica in global change; and information networks for Earth System research.

Prof. M G K Menon (on right), President of the International Council of Scientific Unions, chaired SAC III. Here he attends the scientific symposium on "Reducing Uncertainties in Global Change", next to Dr. A. P. Mitra (on left), Chair of the Indian National Committee for the IGBP and one of the discussion leaders for the National Committee Meeting.

Those who made SAC III possible

The 3rd IGBP Scientific Advisory Council, and associated meetings, were hosted by the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) and the Mexican National IGBP Committee. Full international participation was made possible by sponsorship from the Consejo Nacional de Ciencia y Tecnología, México (CONACYT); the Universidad Nacional Autónoma de México (UNAM); the Commission of the European Communities (CEC); the Inter-American Institute for Global Change Research (IAI), the United Nations Development Programme (UNDP) through START; the United Nations Environment Programme (UNEP); and the Commonwealth Science Council. IGBP gratefully acknowledges the generous support of all these organisations.

SAC III: Recommendations

The Third Scientific Council (SAC III) of the International Geosphere-Biosphere Programme commends the Scientific Committee of the IGBP on the excellent progress made in developing the programme since SAC II, and expresses its particular satisfaction with the greater coherence of the programme; the increasing involvement of developing countries; the efforts made to develop links with non-IGBP bodies; and the success of the scientific symposium held as part of the present meeting.

SAC III recommends that the Scientific Committee takes note of the outcome of the plenary and working group discussions at the SAC III meeting, with specific consideration given to the following recommendations:

1. General

1.1 That the rapid development of well-defined links with the Human Dimensions of Global Environment Change Programme (HDP) should be encouraged, particularly with regard to LOICZ, GCTE, IGAC, BAHC, and the joint IGBP/HDP Land Use-Land Cover proposed project.

1.2 That a close working relationship with WCRP should be maintained; in particular with regard to the Stratospheric Processes and their Role in Climate (SPARC) project, noting that SPARC provides an important link to other ICSU research on relevant solar-terrestrial phenomena.

1.3 That further effort should be made to develop cooperative relations with other ICSU bodies and programmes that have interest relevant to ongoing and future IGBP activities; for example, by arranging meetings for discussion of IGBP results in coordination with the General Assemblies of ICSU Scientific Unions.

1.4 That the development of the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS) and the Global Ocean Observing System (GOOS) should be welcomed, and the Core Projects and IGBP-DIS should be encouraged to provide input to their definition and priority-setting. It is further recommended that the climate-relevant components of GOOS and GTOS be the oceanic and terrestrial components of GCOS.

1.5 That all Core Projects give increased emphasis within their research agendas to complex, non-linear interactions.

1.6 That greater consideration be given to the regional aspects of global change at the next Scientific Advisory Council meeting (SAC IV), and that this be reflected in the presentations at an associated scientific symposium.

1.7 That the active participation of National Committees in formulating and implementing Core Projects should be encouraged through Open Meetings. Regional Meetings and other consultation mechanisms should also be used to promote the involvement of the wider scientific community in IGBP.

1.8 That National Committees should keep the IGBP Secretariat and the Core Project Offices fully informed of their activities, to assist in promoting good communications within the programme.

1.9 That Core Project Offices should be encouraged to facilitate contact between researchers, noting the effectiveness of the GCTE CPO in this regard.

1.10 That Core Projects should coordinate their field activities as much as possible, particularly with regard to transect studies and other large-scale experiments.

2. Project Specific

2.1 That a detailed Implementation Plan should be prepared for LOICZ, in liaison with other organizations and groups involved in coastal zone research and management. SAC III notes with satisfaction the offer of the Netherlands to host the LOICZ Core Project Office, and recommends that the CPO should be established as soon as possible.

2.2 That the joint IGBP/HDP proposed project on Land Use-Land Cover Change should develop its Science Plan as soon as possible, coordinating its research plans with those of established Core Projects and other ongoing activities.

2.3 That GCTE should continue to develop its Focus 4, on ecological complexity, in close liaison with other relevant initiatives.

2.4 That a GOEZS Working Group should be re-formed, with SCOR and WCRP, to address the role of the upper ocean in *global* change and with the aim of starting on modelling work and technological developments well before its field phase, the latter provisionally scheduled for 1998.

2.5 That greater effort be given to detecting and analyzing the impact of human activity in past records, through cooperation between PAGES and other Core Projects, in order to improve our understanding of global change at the regional scale.

2.6 That IGBP-DIS should continue to expand its work in facilitating access to relevant global datasets (for example, data from defence satellites) and improving network capabilities, in collaboration with START. Special attention should be given to an examination of scaling problems in the matching of HDP and IGBP data sets.

2.7 That START should continue to develop its important role in enhancing the harmonization of governmental and non-governmental initiatives in global change research, particularly with regard to network development at the regional and global level. In addition, SAC III encourages the START Secretariat to assist scientists and National Committees in promoting the IGBP research agenda within the framework of relevant regional initiatives, such as the Inter-American Institute for Global Change Research (IAI).

3. Finance

SAC III approved:

3.1 The Draft Budget for the central scientific coordination activities of the IGBP for 1993.

3.2 The use of the IGBP scale derived from UN and GNP scales for the distribution of the individual national contributions.

3.3 A commitment to attempt to secure the contribution level indicated in the Draft Budget.

3.4 The plan to organize the central IGBP activities into a five year project and arranging a donor meeting process.

Furthermore SAC III recommended:

3.5 That National Committees consider the implications of their governments' approval of AGENDA 21 within the UNCED process in relation to their support of IGBP activities.

Future Directions of IGBP

Plenary sessions and discussion groups of SAC III considered components of the IGBP research agenda that are still being developed or are undergoing rapid evolution. The reports below provide an account of the discussions on Global Change and Ecological Complexity (now Focus 4 of GCTE); freshwater ecology; Land-use/Land-cover change; Land-Ocean Interactions in the Coastal Zone (LOICZ); Global Ocean Euphotic Zone Study (GOEZS); the IGBP Data and Information System (IGBP-DIS) and its links to global observing systems; and the Global Change System for Research, Analysis and Training (START). Recommendations 2.1 – 2.7 (p 3) provide the summary advice of SAC III regarding the future direction of these projects and framework activities.

Global Change and Ecological Complexity

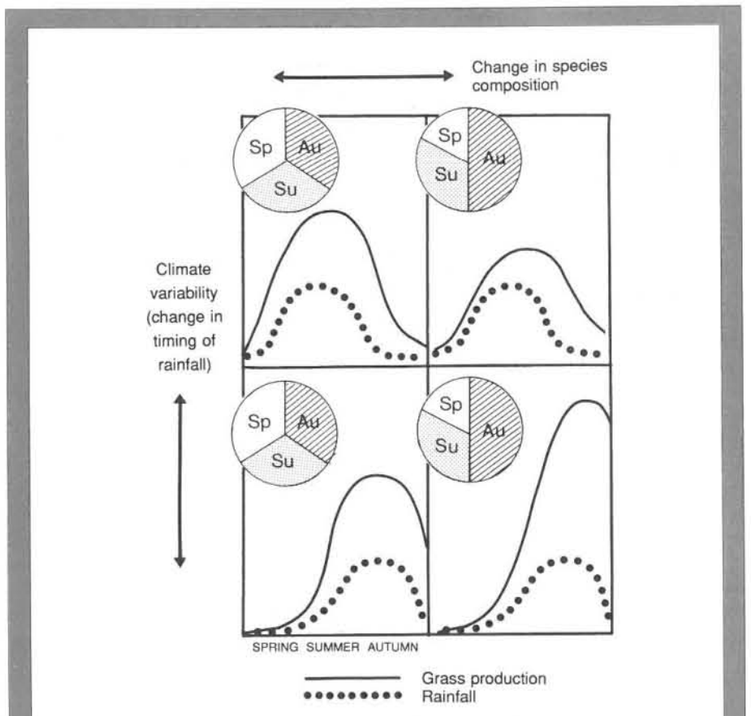
IGBP Report 12 (1990) identified Global Change and Ecological Complexity as a potential Core Project of IGBP. This topic is now being developed within GCTE, as Focus 4 of that project, although details of its scientific structure were not included in the GCTE Operational Plan (IGBP Report 21, 1992). 'Ecological complexity' is closely related to 'biological diversity'; however, the former term directs attention to the general principles underlying the interactions between community composition and ecosystem function, whereas the latter is more conservation-oriented, with greater concern for the fate of individual species.

Current rates of global species extinction are several orders of magnitude faster than at any time in geological history, including periods of 'mass extinction'. Driving forces include rising human populations, pollution, habitat degradation and destruction, and uncontrolled hunting and poaching. At the same time, deliberate and accidental introduction of organisms, including human commensals, pests and weeds, are increasing the alien species component of all continents and homogenising species composition across previously distinct fauna and floral regions.

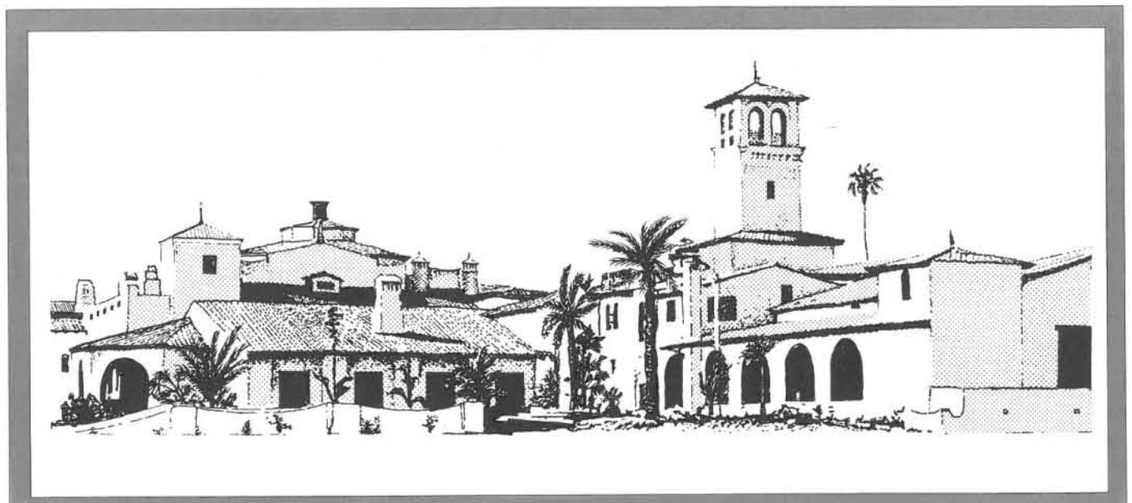
Species loss and taxonomic homogenisation are being accompanied by fragmentation of natural landscapes and consequent massive disruption of species interactions. Future global change, including changing patterns of land use driven by human pressures, will exacerbate all these problems and accelerate species extinctions, the simplification and fragmentation of natural and semi-natural ecosystems, and further disrupt species' interactions.

This global and accelerating loss of species has prompted much concern and action in the international scientific community. There are a number of ongoing initiatives related to biodiversity research, and it is important that GCTE Focus 4 should be linked to these efforts. In particular, close relations are being developed with the *Diversitas* project, jointly sponsored by UNESCO (through the Man and the Biosphere programme, MAB) and ICSU (through the Special Committee on Problems of the Environment, SCOPE; and the International Union of Biological Sciences, IUBS). *Diversitas* includes marine and microorganism diversity, and addresses three major themes: ecosystem function of biodiversity; origins, maintenance and loss of biodiversity; and assessing and monitoring biodiversity.

GCTE's role is to complement these other activities by undertaking focused research on how the suite of species interactions within an ecosystem, and ecosystem function, are affected by global change, and *vice-versa*. Here, ecological complexity includes the diversity of gene complexes and of species, and their connectivity and spatial diversity (patchiness). Connectivity, unlike species diversity, is considered to change with scale because it incorporates such effects as variations in landscape structure and migration. GCTE Focus 4 is therefore designed to understand and to determine the importance of species diversity and ecosystem on the dynamic responses of ecosystem function to global environmental change.



Conceptual model showing importance of ecological complexity in determining the response of a grassland ecosystem to climate variability. Thus the seasonal pattern, and annual total, of primary production is a function both of the timing of annual rainfall and of the relative abundance of grasses with different growth patterns (Sp, Su and Au: species with main growth in spring, summer and autumn respectively). At the left, high phenological diversity results in much the same annual production, regardless of when the rain falls; at the right, loss or reduction of one functional group increases the sensitivity of the system to climate variability (B H Walker, based on Aust. Rangel. J., 10, 69-75; 1988)



The Convention Centre where SAC III met is a registered historical monument. Inaugurated in October 1930, it was built as a hotel casino, the most elegant of the Pacific coast.

The three other Foci of GCTE provide a sound basis of experimental studies and modelling expertise on which to build Focus 4. The effort to understand ecosystem function and the interactions between function and global change (GCTE Focus 1) is an essential precursor to understanding the complexity/function relationship. The elevated CO_2 research facilities and the biogeochemical transects will provide the infrastructure and background knowledge on which to base key Focus 4 experiments. The modelling programme of GCTE Focus 2 will underpin efforts to model the interaction between composition and function. In Focus 2, however, taxonomic problems are avoided by developing a global key of functional types, whereas Focus 4 will address the question of the functional role of biological diversity and the issue of species redundancy within a functional type. The construction of models of complex agro-ecosystems from crop, pest and disease, and soil models (GCTE Focus 3) will also provide insights into the stability and resilience of simple systems as they become more complex.

In addition, Focus 4 will address two specific issues. First, the relationship between loss of diversity and ecosystem functions that involve feedbacks to further global change (e.g., decomposition/carbon fluxes). Second, the vulnerability of diversity in reserves to environmental change. Reserves for species conservation are typically isolated landscape units: these will be vulnerable to global change impacts because of disrupted networks for migration.

The key questions are: does biodiversity matter in system processes such as nutrient cycling and retention, and atmospheric feedbacks over short and long-term spans? if so, can models be developed to show how the functioning of an ecosystem is affected by loss of species, or changes in their relative abundance? The human dimensions of this change are not part of GCTE; however, they are relevant to the proposed IGBP/HDP project on Land-use/Land-cover.

Discussion Group Chair and Rapporteur: Brian Walker (GCTE SSC Chair; CSIRO, Australia)

Proposed structure of GCTE Focus 4, Global Change and Ecological Complexity, as developed at SAC III

[subject to further development and refinement]

Activity 4.1 Relationships between ecological complexity and ecosystem function under global change

Component Tasks:
- 4.1.1 Experimental and observational studies on complexity/function under global change
- 4.1.2 Modelling impacts of global change on complexity/function
- 4.1.3 Complexity/function under global change: feedbacks to further change

Activity 4.2 Consequences of global change for the viability of isolated populations

Component Tasks:
- 4.2.1 Habitat fragmentation, land-use/cover change and population viability
- 4.2.2 Interactive effects of habitat fragmentation and climate change
- 4.2.3 Implications of changes in highly mobile and migrating species for ecosystem functions [requires justification and further development]
- 4.2.4 The implications of global change for speciation [requires justification and further development]

Activity 4.3 Complexity, function and global change: regional and global synthesis

Component Tasks:
- 4.3.1 Identification of areas of functional sensitivity
- 4.3.2 Effects of changing diversity in agricultural systems for ecological complexity

Freshwater ecosystems

Oscar Vanderborght (Chair, Belgian National IGBP Committee) drew the attention of SAC III participants to a potentially critical gap within IGBP's research agenda. Processes occurring in freshwater systems are highly relevant to BAHC, GCTE and LOICZ, yet are not given major emphasis in any one. In addition, the drainage of wetlands is an important land-use/land-cover change, with significance to IGAC, and water quality and availability are becoming increasingly important issues for human well-being.

The meeting noted that the IGBP Scientific Committee had recently given preliminary consideration to this matter. Further action would depend on the outcome of two initiatives now being taken. First, GCTE has asked an independent expert to prepare a position paper on the global implications of changes to freshwater ecosystems, with emphasis on importance of dissolved elements in global biogeochemical cycles; the importance of water supplies and quality to human society; biodiversity; and interactions with land-use and land-cover change.

Second, an International Symposium on Freshwater Ecosystems is being planned (Brussels, 6-7 April 1994) that will provide the opportunity for wider discussion of these issues. IGBP researchers interested in this meeting are invited to contact Dr. Vanderborght (Academy House, Hertogstraat 1, B-1000 Brussels, Belgium; tel (+32-2) 511 2629, fax (+32-2) 511 01430).

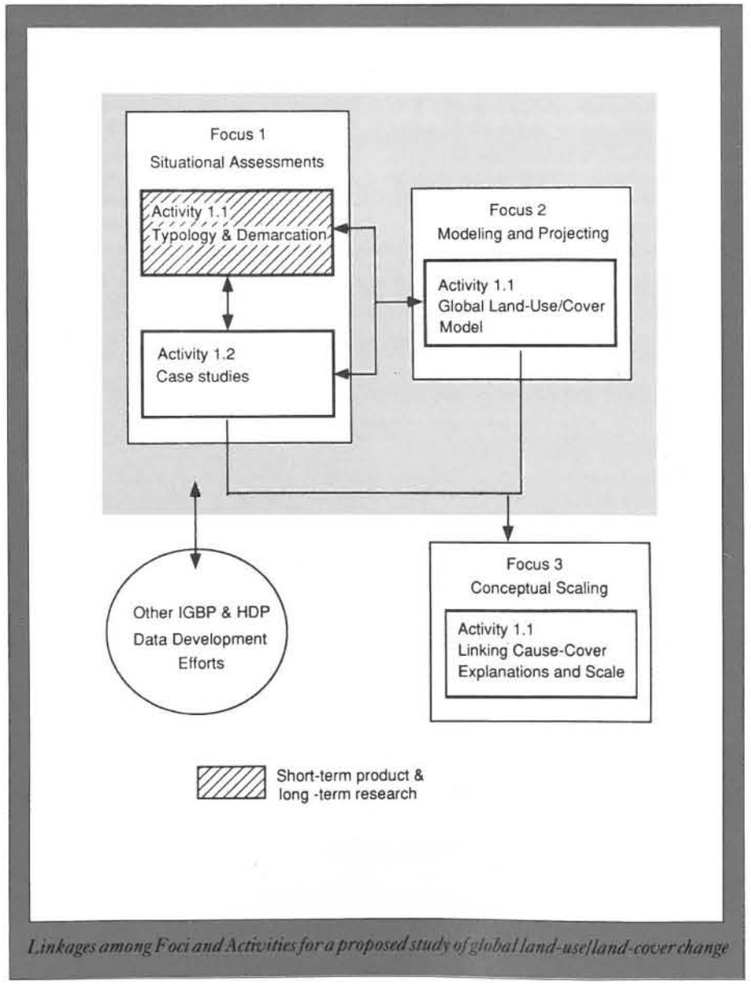
Land-use/Land-cover Change

It was agreed at SAC II (Paris, September 1990) that IGBP and the Human Dimensions of Global Environmental Change Programme (HDP) should jointly support a Working Group to consider the global implications of land-use and land-cover change. The report of this group, chaired by Billie L Turner II, has now been published (IGBP Report No. 24; HDP Report No. 5), and an overview of its findings was presented at the SAC III Scientific Symposium (see abstracts, page 20). The Working Group report identified three foci for further research: (1) the situational assessment (the identification of common 'situaions' of land covers, land uses, and human factors which motivate or 'drive' those land uses); (2) modelling and projecting global land-use and land-cover change (development of land-use/cover change models that link to other global models); and (3) conceptual scaling (identification of relationships among driving forces at scales from the local to the global and development of principles to govern the nesting of different levels of analysis). It also recommended the creation of a joint IGBP/HDP Core Project Planning Committee (CPPC) on Land-use/Land-cover Change. This action was approved by the two programmes, and the CPPC is now being established.

The advice of SAC III was sought regarding the further development of this project, and the issues to be considered in drafting its science plan. The following suggestions were made:

- The location of case studies should, where possible, match the field studies of other Core Projects.
- Land-use categories and typologies should, where possible, be based on those already existing or under development (e.g. by the UN Food and Agricultural Organization).
- Priorities for use/cover studies should take account of the needs of other Core Projects; for example, studies of irrigated rice production, and fertilization patterns in agriculture, are of special interest to GCTE and IGAC.
- The design of the science plan should allow lower-priority uses and covers to be added to the project as it develops beyond its initial phase.
- National committees should be invited to identify on-going work and past work regarding land-use/cover studies that might be useful, from the present back to the historical past.
- Consideration should be given to adding a 4th Focus on past use/cover changes over a longer time period than 300 yr (to be discussed further with PAGES).

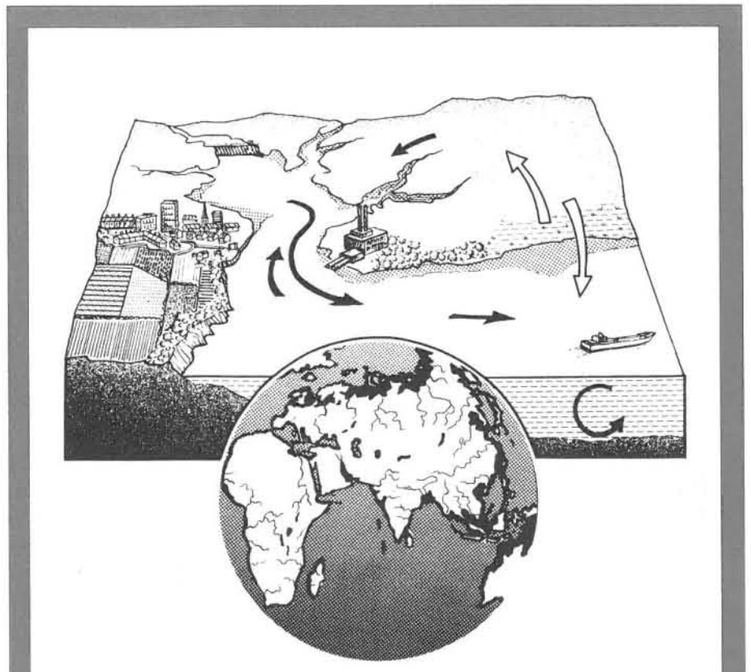
Discussion Group Chair and Rapporteur: Billie L Turner II (Chair of Land-use/Land-cover CPPC; Clark University, Worcester, MA, USA)



Linkages among Foci and Activities for a proposed study of global land-use/land-cover change

Land-Ocean Interactions in the Coastal Zone

SAC III noted that LOICZ was now an established IGBP Core Project; its science plan was ready for publication (IGBP Report No. 25); and that the LOICZ Scientific Steering Committee was being appointed (see Box). The main research foci of LOICZ are: (1) the effects of global change (land and freshwater use, climate) on fluxes of materials in the coastal zone; (2) coastal biogeomorphology and sea-level rise; (3) carbon fluxes and trace gas emissions in the coastal zone; and (4) the economic and social impacts of global change on coastal systems.



Since LOICZ addresses processes at the interface of land, ocean and atmosphere, strong links with other Core Projects are especially important. Collaboration and coordination with the social science community are also required, to address the interface between natural science and the economic, social and institutional implications of changes to coastal systems. It was agreed at SAC III that there should be full involvement of HDP in developing implementation plans for LOICZ Focus 4, and that a small *ad hoc* group should be formed for that purpose.

The further planning of LOICZ should take account of the need to standardize methodologies and classification techniques; the importance of comparative studies; the need to strengthen links between marine and freshwater research groups; the significance of episodic events, especially at the decadal time scale; and the need for strong guidance to be given to participating countries by the LOICZ SSC, because of the diversity within the project. Sea-level rise was a topic where it was particularly important to establish close working relations with other studies, planned or on-going, to ensure complementarity of the LOICZ research effort.

The LOICZ Core Project meeting (Raleigh, USA; 18-21 May 1993) provides the opportunity to discuss these issues with the wider scientific community. National Committees have been invited to send representatives with expertise in coastal research to that meeting, to consider how existing and proposed national and regional programmes could contribute to the implementation of LOICZ.

Henk Postma (Chair, Netherlands National IGBP Committee) informed SAC III of the offer by the Royal Netherlands Academy of Sciences, with government support, to establish the LOICZ Core Project Office at the Netherlands Institute of Oceanographic Research (NIOZ), Texel. This generous proposal was welcomed by James McCarthy, on behalf of IGBP, and was subsequently accepted by the IGBP Scientific Committee.

Discussion Group Chair and Rapporteur: Patrick Holligan (Chair, LOICZ SSC; Plymouth Marine Laboratory, UK)

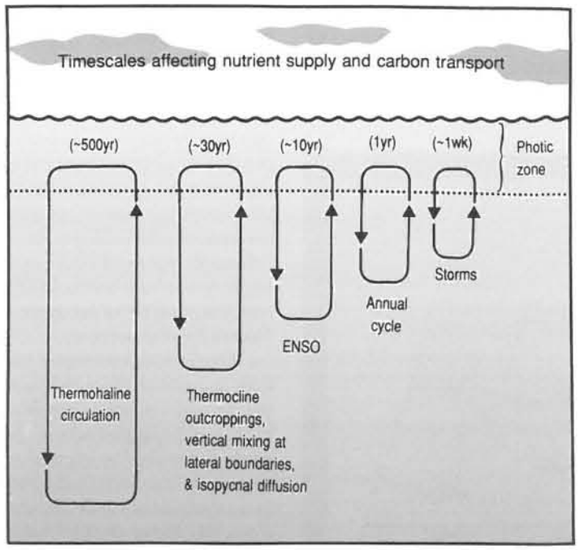
Membership of the LOICZ Scientific Steering Committee

The following individuals have agreed to serve on the Scientific Steering Committee for the IGBP Core Project on Land-Ocean Interactions in the Coastal Zone. Additional appointments are under consideration, to extend the scientific and geographical representation of the Committee.

Patrick M Holligan (Chair)	Plymouth Marine Laboratory, UK
Edgardo D Gomez	University of the Philippines, Quezon City, Philippines
Viattcheslav V Gordeev	Russian Academy of Sciences, Moscow, Russia
Donald C Gordon	Bedford Institute of Oceanography, Dartmouth NS, Canada
Stephan Kempe	University of Hamburg, Germany
John D Milliman	Woods Hole Oceanographic Institution, USA (after 1 May: College of William and Mary, Virginia, USA)
Henk Postma	Netherlands Institute for Sea Research, Texel, The Netherlands
Jeffrey E Richey	University of Washington, Seattle, USA
Liu Ruiyu	Chinese Academy of Sciences, Qingdao, China
Andrew Solow	Woods Hole Oceanographic Institution, USA
Colin Woodroffe	University of Wollongong, NSW, Australia
Tetsuo Yanagi	Ehime University, Matsuyama, Japan

Global Ocean Euphotic Zone Study

The upper ocean is the reactive buffer between the atmosphere and the ocean interior, regulating and modifying the exchange of energy and materials between the atmosphere and the deep ocean. It is



How can physical and biological interactions best be integrated over the very wide range of relevant temporal (and spatial) scales occurring in the oceans? That problem will be a major issue for the proposed GOEZS project. (Figure after K. L. Denman, in press)

clear that the ocean affects climate but the interactions between the chemical, biological and physical processes near the sea-air interface are poorly understood. These, in turn, are strongly influenced or determined by processes in the upper ocean where plant production takes place, and which respond to the atmosphere on a diurnal, weekly and seasonal basis.

Satellites and other new technologies have demonstrated the intensity, complexity, variability, and connected nature of the physical, chemical and biological processes taking place in the upper ocean. While the anticipated climate change caused by the increased concentrations of radiatively-active gases act in the decade-to-century timescale, modern observations give us information only on a seasonal or interannual scale. We do not yet have the theory (especially in respect to the biota) to extrapolate from observable season change or interannual variability to the larger time scale. We lack predictive capability even with respect to interannual variability.

In the upper ocean, we do not understand either the relation between the event-scale variance ('weather') of ecosystem properties and their larger scale means ('climate'), or how the organisms might modify climate through their production or consumption or modification of radiatively-active gases and atmospheric aerosols. Thus, at the present time, we recognize for the upper oceanic layer both priority and deficiency of scientific understanding.

Although some of these issues are currently being addressed by JGOFS and other on-going projects, there is a long-term challenge in realistic scaling-up from small scale observations of biogeochemical and physical processes to global estimates. A joint IGBP/SCOR Working Group was set up in 1992 to examine these issues, and the need for a new project in this area: a Global Ocean Euphotic Zone Study (GOEZS). Copies of the Working Group report were distributed to SAC III participants.

The SAC III discussions endorsed the general approach proposed by the GOEZS Working Group: a coordinated research project should be developed with its focus on ocean-atmosphere interactions, and explicitly bringing together biogeochemistry and physics. However, the context of global change needs to be emphasised, with particular attention given to the exchanges of substances important to climate (CO_2, DMS, N_2O etc).

Although the field phase of the project would not be until 1998-2007 (possibly nested within the pilot phase of the Global Ocean Observing System, GOOS), there was an urgent need to initiate detailed planning activities. Planning effort should be directed at establishing a sound theoretical basis for sampling strategy; modelling, using datasets of JGOFS, the World Ocean Circulation Experiment (WOCE), and the Tropical Ocean Global Atmosphere project (TOGA); and the accelerated development of instrumentation and technologies identified as relevant but at present only existing as prototypes.

The GOEZS Working Group should therefore be re-formed, with SCOR, and with an invitation for formal participation by the World Climate Research Programme (WCRP). An early task should be a careful examination of relevant ongoing and planned programmes that would include JGOFS, WOCE, IGAC, Global Ocean Ecosystems Dynamics (GLOBEC), Global Energy and Water Cycle Experiment (GEWEX) and the proposed WCRP study of Climate Variability and Predictability (CLIVAR), to determine key gaps in research addressing the interactions of the upper ocean and atmospheric boundary layer.

Discussion Group Chair and Rapporteur: Ken L. Denman (Chair, GOEZS Working Group; Institute of Oceanographic Sciences, Sidney BC, Canada)

IGBP Data and Information System and its links to Global Observing Systems

IGBP-DIS has two main responsibilities: to develop effective data management within the IGBP as a whole, and to facilitate access to global data sets collected by other research groups and agencies, particularly those obtained through remote sensing.

IGBP-DIS is not directly responsible for observational activities or for the administration of data archives. Nevertheless, IGBP-DIS has an important role as a catalyst, promoting the flow of data, and their careful management and application. To obtain maximum benefit from the actions of data collection and data storage, it is necessary for the needs of the IGBP scientific community to be taken into account by global monitoring programmes (see below) and activities of the Committee on Earth Observation Satellites.

The SAC III discussion group addressed issues related to the availability of datasets, where recent IGBP-DIS effort has been focused. The growth of CD-ROM production and use is one of the major developments in data management in recent years. Compact disks, holding around one gigabyte of information, enable global change data to be distributed easily and cheaply; they have made SPOT and Landsat data available to IGBP researchers at low cost.

Through a collaborative project with China, and the ICSU Panel on World Data Centres, IGBP-DIS has identified important multidisciplinary datasets for central and east Asia. These are being put together on CD-ROM, and will soon be made available.

Important new soils datasets have also been gathered through IGBP-DIS initiatives, in collaboration with the soil science research community.

To assist in locating data, a variety of data directory systems are being developed (see Global Change Newsletter No 12). Electronic networking provides the best means for data access and exchange, but the system is not yet global. The role of START in developing such networks, on both a regional and global basis, is of great importance.

For socio-economic data, there are considerable problems with geo-referencing and scaling, with an urgent need to establish compatibility and comparability of datasets between IGBP and HDP. Ideally, all existing tabular and analogue records should be put into digital form; unfortunately the cost is prohibitive, and effort must be directed at high-priority datasets.

Discussions emphasised the need for close links (primarily via IGBP-DIS) between IGBP Core Projects and international initiatives that were currently being developed to monitor global change; in particular, the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS) and the Global Ocean Observing System (GOOS). It was important for IGBP that, in planning these observing systems:

- the choice of variables to be monitored should be based on up-to-date theories of ecosystem dynamics and biogeochemical cycles
- account should be taken of existing monitoring systems, and there should be strong coupling between satellite- and surface-based studies
- plans for data management, analysis and archiving should, as far as possible, match those being developed in IGBP
- data processing should be designed so that the quality of observations (and derived information) will meet research as well as operational needs.

Furthermore, it was considered highly desirable that the climate-relevant parts of GOOS and GTOS should be the oceanic and terrestrial components of GCOS.

Discussion Group Chair: S Ichtiaque Rasool (Chair, IGBP-DIS Standing Committee; NASA/IGBP-DIS, Paris, France); Rapporteur: Mike Chinnery (Boulder Data Center, Colorado, USA)

Structure of the IGBP

Advisory
SAC Scientific Advisory Council

Scientific Direction
SC-IGBP Scientific Committee

Established Core Projects
BAHC Biospheric Aspects of the Hydrological Cycle
GCTE Global Change and Terrestrial Ecosystems
IGAC International Global Atmospheric Chemistry
JGOFS Joint Global Ocean Flux Study
LOICZ Land-Ocean Interactions in the Coastal Zone
PAGES Past Global Changes

Proposed Core Project
Land-use/Land-cover Change

Potential Core Project
GOEZS Global Ocean Euphotic Zone Study

Framework Activities
GAIM Global Analysis, Interpretation and Modelling
IGBP-DIS Data and Information System
START System for Analysis, Research and Training

START: Global Change System for Analysis, Research and Training

START represents the response of international science programmes (IGBP, WCRP and HDP) to the clear need for strengthening the regional basis of global change research. Its strategy is to develop networks of regional research centres and sites, enhancing the effectiveness of national research on the regional origins and impacts of global environmental change, and capacity-building through training and fellowship schemes.

Within START, thirteen biogeographic regions have been identified, covering the global land surface and coastal oceans. Priority has been given to establishing START networks in Equatorial South America , Northern Africa and the Tropical Asian Monsoon region.

Very great progress has been made since SAC II. The intellectual framework was developed in late 1990 (at Bellagio, Italy; IGBP Report No. 15); the International START Secretariat was opened in Washington DC in 1992; and funding has been obtained via UNDP and the Global Environment Facility (GEF) to initiate the regional development of global change research in the priority regions. Support for Equatorial South America is included in UNDP/GEF support to the Inter-Amer-

Informal discussions continued in the patio. Working on START are, from left to right: Hassan Virji, Jean Labrousse, Thomas Rosswall, and Jean-Louis Fellous

ican Institute for Global Change Research (IAI).

There are now regional START committees for Southeast Asia (SARCS) and Northern Africa (NAPCS), and Southern, Central and Eastern Africa (SAFCOM); the former two have established their own secretariats. Networking in other areas is progressing with collaborative initiatives. Thus the French MEDIAS programme is designed to support activities covering the Mediterranean and sub-Sahara; the Commission of the European Communities (CEC) is establishing a European network and intends to support regional networks for Africa and Eastern Europe; the IAI plans networks for the Americas; China has proposed to help initiate development of networking in Temperate East Asia; and discussions are in progress with the Mongolian Academy of Sciences and the Siberian branch of the Russian Academy of Sciences regarding work in Central Arid Asia.

START is therefore on the right track, but it is a very long one. A successful beginning should not lead to unrealistic expectations, ignoring the constraints. Training, sharply defined and linked with the global change research agenda of the IGBP, WCRP and HDP, should be emphasized in all START network activities. Within the overall concept, there must be flexibility to reflect inter- and intra-regional differences in the networks.

Although START is not a funding body, it should facilitate funding through links with the relevant agencies, and assist in the preparation of coherent and concerted global change research and training programmes. There is also an important role for START in communicating results of global change research to decision-makers, to show governments, particularly in developing countries, the practical benefits of such work.

To achieve those objectives, there must be close liaison with both governmental and non-governmental agencies, with a two-way flow of scientific information. Strong links between START and the National IGBP Committees are particularly important in defining the scientific agenda (and for identifying appropriate research groups and laboratories) in regions and countries where global change science is not yet well-developed.

Discussion Group Chair: Thomas Rosswall (Director, International START Secretariat, Washington DC, USA); Rapporteur: Ogunlade Davidson (Member of NAPCS, Sierra Leone)

SAC III Discussions on the Role of National IGBP Committees

National Committees provide an important structural link between the global-scale objectives of IGBP science and the means to achieve those aims – through the effort of individual scientists, working in many different research groups and laboratories, and mostly funded at the national level. The number of National Committees has grown to nearly 60 in only a few years – and their responsibilities are also increasing, as the science plans of the IGBP Core Projects become operational.

But there are other components to the IGBP organizational structure: the Scientific Steering Committees (SSCs) of the Core Projects; the regional networks being developed through START; and the links to governmental bodies, particularly through the International Group of Funding Agencies for Global Change Research (IGFA). The National Committee session of SAC III discussed the interactions between these levels of science management: the coherence between the different mechanisms for putting plans into action, and how the National Committees might interface with other parts of IGBP more effectively, to the mutual benefit of all concerned.

Discussions were focused on five major questions addressing these interactive issues:

- What are the national priorities for participation in IGBP Core Projects and regional initiatives?
- How well do the IGBP science plans match national research activities?
- How useful is the IGBP 3-tier classification of research in setting national priorities?
- How can communications be improved between Core Project SSCs and National Committees?
- What is the influence and involvement of National Committees in national research funding?

Written reports were requested from the National Committees, to answer these questions in terms of their policy, action, and general opinion. Thirty seven reports were received for consideration at Ensenada – a response rate of nearly 70% from the 55 National Committees then established. In addition, representatives from several other countries who had only recently formed National Committees (and therefore did not yet have an on-going programme of global change research) attended the meeting and participated in the discussions. The reports were analyzed in advance of SAC III by five Discussion Leaders, who presented their findings at a meeting session chaired by Mario Martinez García (Chair, Mexican National IGBP Committee).

National priorities for participation in IGBP Core Projects and regional initiatives

Spread of research – and gaps in effort

IGBP research is underway in a large number of countries. Where that is not the case, it is usually due either to the time it takes for organization and scientific preparation, or to a lack of resources. Participation is becoming increasingly more global. Nevertheless, the responses by National Committees indicated that the involvement of developing countries is still low.

There are four main regions where sizable research efforts have still to be developed: most of Africa, the Middle East, Latin America, and Southeast Asia. This is not because of lack of interest: instead it reflects problems such as a lack of experienced personnel, an inadequate research infrastructure, and insufficient skills and hardware for complex data management, analysis and modelling.

Specific requirements cited in the reports include a need for expertise in trace-gas flux measurements in many South American countries (to enable participation in IGAC studies), and for more research vessels and trained marine scientists in Southeast Asian countries (to increase their involvement in LOICZ and JGOFS activities proposed for that region).

Core Projects

Analysis of the survey returns showed that all the National Committees that replied had ongoing activities relating to at least two IGBP Core Projects, and often three or more. In general, those involved in the greatest number of projects also have the greatest number of joint studies with other countries, often North-South collaboration.

The Core Project SSCs were not questioned about the countries they worked with, and it was possible that some National Committee replies had not covered all the Core Projects that a country was involved in. From the Core Project viewpoint, there may also be participation from countries which have not yet formed National Committees.

Regional initiatives and links to START

Whilst there is some experience of regional programmes of environmental research within Europe, and of multinational studies in oceanography and atmospheric sciences, collaborations must now be developed elsewhere and in other fields, and extended across regional boundaries. To achieve that, IGBP (through START) has held a number of regional meetings, to promote the development of international, collaborative research in global change.

Considerable success has been achieved within countries in the START Tropical Asian Monsoon region. A Southeast Asian Regional Committee for START has been established, that will give special emphasis to improving estimates of greenhouse gas fluxes (especially CO_2 and methane) in relation to changes in land-use and land-cover, and the impacts of human activities and sea-level increase on terrestrial and marine resources in the coastal zone.

Areas of concern

In many cases, IGBP Core Projects require that similar measurements or analyses have to be carried out at a large number of sites. Information on standard protocols must be made widely available and, where necessary, training assistance provided – to ensure that all such measurements are calibrated and comparable (following the model of the International Geophysical Year), and to encourage scientists from developing countries to take part in IGBP field experiments. The Core Projects of the IGBP should be encouraged to take appropriate steps to this effect.

In the framework of the Intergovernmental Panel on Climate Change (IPCC) and the follow-up to the UN Conference on Environment and Development (UNCED), many countries are involved in producing national reports on IGBP-related issues, such as greenhouse gas emissions and sea-level rise. It is important that bodies responsible for preparing such reports are aware of IGBP activities.

To ensure the funding of IGBP research in developing countries, it is important that their national and regional involvement in IGBP Core Projects is explicitly included in funding proposals to such bodies as the World Bank or the Asian Development Bank.

Overall, there remains considerable scope for improving liaison within, and between, countries, as well as further action to increase the awareness of IGBP by international funding agencies and organizations.

Based on report by Discussion Leader, A. P. Mitra (Chair, Indian National IGBP Committee)

Matching between the science plans of IGBP Core Projects and national research activities

In assessing the agreement of national and international science within IGBP, the status and structure of the National Committees must be considered. Their constitutional position relative to national funding and policy-making mechanisms is of particular importance. Bodies responsible for the initial establishment, and subsequent support, of the committee can be divided into four main groups: (i) an "independent" National Academy or Royal Society (usually the national ICSU member); (ii) the National Research Council, or other governmental organization responsible for research funding; (iii) a government department, such as the Department of Environmental Affairs, or of Meteorology; and (iv) a loose, *ad-hoc* group, such as a committee formed to develop national science policy or a university-based group of scientists.

National participation in IGBP covers a wide spectrum of effort. At the most active level, there is full involvement in carrying out Core Project research, organizing relevant scientific meetings, developing collaborations at the national and international level, and possibly hosting an IGBP Core Project Office. At an intermediate level, there is strong interest in IGBP and planning for pilot projects. There are also cases where there is no evidence of action following the formal establishment of the National Committee. More information is needed to assess the effectiveness of National Committees in a systematic way, but it is already clear that their impact and influence differ markedly from country to country.

It is unusual to find direct matching between the science plans of IGBP Core Projects and national research programmes, since the latter have usually been developed independently from the IGBP science agenda. However, strong connections can occur, particularly when the IGBP Committee and a relevant government Ministry work closely together. In the Philippines, the action programmes of the Philippine Council for Sustainable Development are directly related to IGBP Core Projects, as a follow-up to recommendations of the UN Conference on Environment and Development (UNCED). Other countries have begun to re-examine their global change research as a result of UNCED, which could lead to closer links with IGBP science.

Where there has been a strong impetus from meteorological departments, the emphasis is likely to be on "climate change" rather than the wider scientific issues of "global change". Nevertheless, climate change programmes, set up to meet national priorities, may have many elements that correspond closely to IGBP Core Projects. For example, the new German national climate programme has three major areas that contribute to IGBP: past climate variability (PAGES), cycles of substances (IGAC, JGOFS, LOICZ, and GCTE), and the water cycle (BAHC). A similar pattern (although with different combinations of topics) is followed in several other countries with well-advanced programmes in global change research.

A crucial problem remains: encouraging the development of National Committees where there are none. Since IGBP is sponsored by ICSU, the normal procedure is to form the committee through the ICSU national membership. But many developing countries (e.g. in Africa) and small nations are not ICSU members; for these, alternative approaches are necessary to ensure that national links are made, and that IGBP science can be carried out on a truly worldwide basis.

Based on report by Discussion Leader, Masatoshi Yoshino (Chair, Japanese IGBP Committee)

Usefulness of the IGBP categories of research in setting national research priorities

The classification of IGBP-related research into three kinds – Core, Regional/National and Relevant Research – was initially formulated by GCTE. It has subsequently been adopted for general application within IGBP, with the practical arrangements currently being developed. The purpose

of categories is not only to define what can properly be described as "IGBP research", but also to focus attention on the key research issues that must be addressed for IGBP to succeed. In addition, formal recognition that a project is part of IGBP may assist in obtaining funding for such work.

It was evident from the National Committee reports that there is uncertainty regarding the definition and interpretation of the categories. Whilst the criteria for the classification are still evolving, six features are of particular importance: the overall aims of the research; the methodologies used; the data management and data access policies adopted; how the research is initiated; the bodies that have responsibility for its approval and coordination; and the extent of national and international collaboration.

All three categories are scientifically important – and all are needed for IGBP implementation. However, most 'Relevant Research' would probably be carried out whether or not IGBP existed. Whilst such projects may be included in national listings of global change research, it is not expected that they are considered as IGBP research.

The effort of the Scientific Steering Committees (SSCs) of the Core Projects will necessarily be directed at planning and coordinating 'Core Research', and strongly encouraging 'Regional and National Research'. Securing funds for research in all categories is the responsibility of the participating research groups; however, for Core Research, the IGBP Core Project Offices will assist (as far as possible) in presenting the case for support to national and international funding agencies.

Exact classification of national programmes and their component projects may not always be possible: the "category allocation" of a particular research activity may change according to its own development and to the evolving priorities of the IGBP Core Projects.

Most National Committees reported that they found the three categories were useful, but there were some exceptions. The most positive responses came from Committees that were directly involved in science funding: they found the categories gave very helpful guidance. But in cases where the Committees are only loosely related to funding activities, they regarded the categories as largely irrelevant.

In discussion, the Chairs and other representatives of National Committees agreed that some system of recognition and validation was necessary, to provide the framework for IGBP implementation. From the national and governmental point of view, the question is asked why one project should be funded rather than another: acceptance of an activity within an international programme (at either the Core or Regional/National level) then strengthens its justification. Formal recognition by the Core Project SSCs that a proposed research topic addresses one or more of IGBP's priority science objectives can therefore help researchers to obtain funding.

Based on report by Discussion Leader, Osvaldo Sala (Co-Chair, Argentinean National IGBP Committee)

Improving communications between Core Project SSCs and National Committees

Underlying this question is the problem that affects all international scientific programmes: how to transmit information effectively. Comments from the National Committees show the need for transmission to be in both directions. There are then two other problems: how to keep the information flow in manageable bounds (information overload can occur very quickly); and how to ensure that both sides take part in the exercise.

Role of National Committees as seen by Core Project SSCs

There is undoubtedly a difference between the perception by Scientific Steering Committees (SSCs) of the role of National Committees, and that which the National Committees have in practice. Most National Committees – because of either their constitution or composition – do not function as "national research coordinators", but instead act primarily in an advisory capacity.

The SSCs need to take this reality into account if they are to interact more effectively with National Committees. Some requests from the SSCs (and even from the Stockholm Secretariat) may be quite irrelevant or incapable of implementation: they will therefore be ignored, or – equally disconcerting for the SSC – will produce apparently irrelevant responses.

Interaction with Core Project SSCs

There is concern, expressed in various ways and with a range of suggested solutions, that National Committees are not well-informed or consulted about the direction of the Core Projects. Because of the variations in the way in which National Committees function, there may be no single procedure which will resolve this difficulty. Nevertheless, if the Core Projects are to be successful it is important that National Committees feel that their views are welcome, and that their inputs will be considered.

Core Project SSCs should not bypass National Committees in their contacts with researchers in participating countries. In many countries, the main role of the National Committee is to coordinate information on research in progress or proposed, and this function may be weakened if direct approaches are made to individual scientists without the National Committee at least being kept informed.

Membership of the Core Project SSCs is an issue considered to be important by a number of countries, who feel that the SSCs should be "more representative". But what are the principles by which such representation should be established? The developing countries note the dominant representation of developed nations on the Committees, and consider that this is not in the best interests of either the Core Projects or themselves. Representation on the SSC improves communications, and strengthens the authority and influence of a National Committee.

Presentations in the old casino.

Resolving this matter raises problems of efficiency, fairness and finance. Since large committees tend to lose their effectiveness, it is not sensible to have representatives of all interested National Committees on the SSCs. Even if it were, there is a question of costs – IGBP would not then be able to meet the expenses of all SSC members.

One way of addressing this problem (adopted by JGOFS) is to have SSC meetings "open", in that the leaders of national programmes are invited to attend as observers (but with the opportunity, where appropriate, to report on the progress of their national activities). Such representatives must usually meet their own costs, but some assistance may be available for the participation of developing countries in the region where the meeting is held. For this arrangement to work well, SSC meetings should be linked to associated Conferences or Workshops, and held at a variety of geographical venues. Such visits by SSCs to different countries, and discussions with their scientists and National Committees, also help to develop personal contacts and collaborative studies.

(For further discussion of representation on SSCs, see under "General Discussion" below).

Logistics and practicalities of communication

While all National Committees are interested in the general development of IGBP, very few are actively involved in more than two or three Core Projects, or regard more than three or four to be directly relevant to their interests. Thus National Committees may not require multiple copies of all IGBP Reports to be sent from Stockholm – offering scope for savings in postage costs, provided that National Committees make their interests clearly known.

Taking that idea further, two levels of communication can be defined: summary information (e.g. as provided by the Global Change NewsLetter); and detailed information, available on request or by arrangement to National Committees with interests in specific projects.

There are a range of ways of sending the more detailed information to (and from) National Committees, including electronic bulletin boards and Newsletters. Several IGBP National Committees already have their own Newsletters; in addition, GCTE has an international Newsletter, and those for IGAC, BAHC and PAGES are planned, and JGOFS has separate Newsletters for national activities in the US, UK and France.

Some countries have suggested that communications should primarily be through the individual scientists involved in specific Core Projects. Such an arrangement may work where there is a well-defined community at the national level for a particular Core Project, strongly linked to the National Committee, but may not be generally applicable. It does, however, raise again the issue of the structure of the National Committee, and the need for its membership to include active researchers (as well as those well-connected to funding agencies).

Within developed countries, there are many ways to achieve rapid and efficient communication, at an informal level, between IGBP scientists: by telephone, telefax, electronic mail, fast postal services, and frequent personal contact at scientific meetings. In developing countries, these facilities are often lacking or inefficient. As a result, there is greater reliance on formal channels of communication – via government institutions, and the structures provided by international organizations.

Based on report by Discussion Leader, Jane Soons (Chair, New Zealand National IGBP Committee)

Involvement of National Committees in national research funding

The role of National Committees with regard to research funding varies widely. Their level of involvement can be divided into four groups:

(i) Minimal or no influence. Many National Committees are in this category, with research funding beyond their mandate.

(ii) Small influence. For several Committees their direct influence is limited, but they may have an important role in identifying priorities and hence encouraging specific areas of science.

(iii) Advises funding. Several National Committees provide advice to funding agencies. Thus reports may be provided to funding councils as guidance; the National Committee may be represented in decision-making bodies; or representatives of funding agencies may be members of the National Committee.

(iv) Provides funding. No National Committee has exclusive control over a major research budget. However, in China (Beijing) the National Committee includes leaders of related ministries, and most of their proposals have subsequently been adopted by these ministries – and included in the 5-year plans of their research institutions. In Thailand, the National Committee has authority to review research proposals relating to global change, and some research funds are allocated to IGBP-related work by the National Research Council.

It was accepted in the SAC III discussions that National Committees inevitably function differently in different countries. Nevertheless, the consensus view was that National Committees should, in general, seek a stronger role: even if they are not involved in funding, they should actively promote global change research that matches the IGBP Core Projects, and ensure that both the science community and funding agencies are kept fully informed of the intellectual excitement of IGBP science. They should also be aware of what projects are being supported within the country, at what resource level, and offer guidance to research leaders on how closer links with IGBP activities elsewhere might be developed.

Based on report by Chen-Tung Arthur Chen (Chair, IGBP Committee located in Taipei, China)

General discussion

Representation on Scientific Steering Committees

As noted above, several National Committees suggested that much greater attention should be given to regional representation in the membership of Core Project SSCs. James McCarthy (Chair, IGBP Scientific Committee) explained how the present composition of the SSCs had been decided. Thus SSC members had been appointed by the IGBP Scientific Committee, with input from ICSU bodies with related interests, to meet the need both for scientific expertise in all critical research areas and for regional representation by the nations most closely involved. A membership of around 15 was regarded as optimal, for efficient decision-making and for financial reasons. Since membership is for 3 year terms, the Core Projects established in 1990-91 were now entering their first cycle of membership rotation. National Committees are encouraged to assist in that process by submitting nominations for SSC membership (accompanied by brief details of expertise and research interests) to either the IGBP Secretariat or to the present Chair of the appropriate SSC.

M. G. K. Menon (President, ICSU) endorsed the need for the SSCs to comprise the highest calibre of scientists active in IGBP research. The main initial task for the SSCs had been the development of detailed science plans, and implementation plans, for the Core Projects. Now that had mostly been accomplished, the SSCs

IGBP NEWSLETTER 13

were responsible for ensuring the success of the operational phase of IGBP.

Top-down or bottom-up?

It was apparent from the SAC III discussions that, to some, IGBP seems to be a hierarchical, top-down organization. That impression may arise from the structure of the programme – comprising a suite of Core Projects, within which research is defined in terms of Foci, Activities and Tasks. But it was emphasised that these were developed by the broad international scientific community, rather than by small committees in isolation, and involved a long period of consultations and iterative evolution.

For example, the GCTE Operational Plan (IGBP Report No 21) was prepared over a 3 year period, and involved over 300 scientists at workshops and discussion meetings. In May, the LOICZ Science Plan (IGBP Report No 25) will be discussed at a meeting to which representatives from all National Committees are invited. The actual research for both these projects – and all the others – is being carried out by an even larger community, which has the opportunity to influence the detailed direction of the science, by its own work, and in discussion with colleagues, at conferences and in the scientific literature.

Constitutionally, the IGBP Scientific Advisory Council (comprising representatives of National Committees and ICSU scientific adherents) has responsibility for reviewing and advising on the scientific directions of IGBP. However, that process is not limited to biennial SAC meetings: it is ongoing, and all IGBP activities benefit from wide and open discussion of their development, with the National Committees providing a key role in such communications.

Core Project Offices

Brian Walker (Chair, GCTE SSC) outlined the role of Core Project Offices, from his experience with the development of the GCTE CPO. That CPO is in direct contact with a great many research workers, but there is no intention to bypass National Committees. Instead the situation often arises that the scientist initially makes contact with the CPO, and is then informed of the existence of the National Committee – and encouraged to collaborate with other national activities, or put in touch with researchers carrying out similar work in other countries.

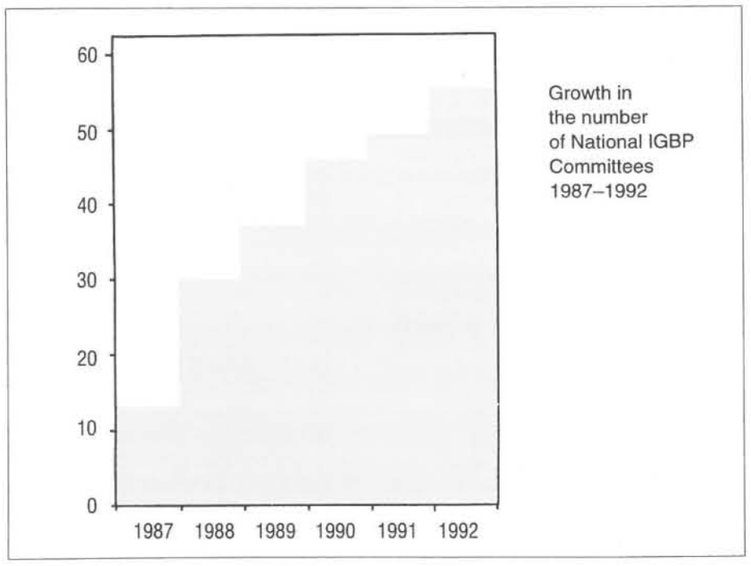
Research compendia

The GCTE Core Project Office is currently preparing a summary description of projects recognised as Core Research within GCTE, following the first round of assessment of proposals submitted for review by the GCTE SSC. A further GCTE compendium is planned, detailing the Regional/National Research approved by National Committees. Joseph Tigyi (Chair, Hungarian National IGBP Committee) informed SAC III of his country's offer to prepare a worldwide directory of all IGBP research. Whilst this was welcomed by the meeting, it was agreed that the practicalities of the exercise required further consideration, and the viability of preparing a Europe-wide directory should first be investigated.

Alfred Becker, Core Project Officer for Biospheric Aspects of the Hydrological Cycle (BAHC), talking to Zhang Xinshi, Institute of Botany, Chinese Academy of Sciences in Beijing, with Ademola T. Salau, University of Port Harcourt, Nigeria on the right.

Next National Committee meeting

Hans-Jürgen Bolle (Chair, German National IGBP Committee) invited the Chairs and other representatives of National Committees to a meeting in Bonn, Germany, on 14-16 March, 1994. The proposed theme of the meeting is "How are we putting to use the information gathered in IGBP?". Whilst focusing on problems of global synthesis (as addressed by GAIM and IGBP-DIS), the meeting will also include other issues that the National Committees may wish to discuss.



SAC III: IGBP Finances

Peter Liss (Treasurer, IGBP Scientific Committee) chaired the session of the meeting of National Committees that considered financial issues. Information on the 1992 and 1993 budgets for central scientific activities of IGBP, and proposed procedures for funding such activities from 1994 onwards, were presented by John Marks (Acting Executive Director, IGBP).

The meeting noted that income (and expenditure) in 1992 was around US $1.2 million – considerably less than the amount considered necessary when revised rates of national contributions were set at the 1991 meeting of National Committees. These contributions provide the main source of income for the scientific coordination of IGBP. Unfortunately, 29 of the 53 established National Committees had not yet paid their 1992 contributions; 9 others paid less, 4 paid more and 11 the amount requested. The shortfall in income has resulted in important meetings being cancelled or postponed, a reduced level of inter-Project coordination, and a lower expenditure on publications than was considered desirable.

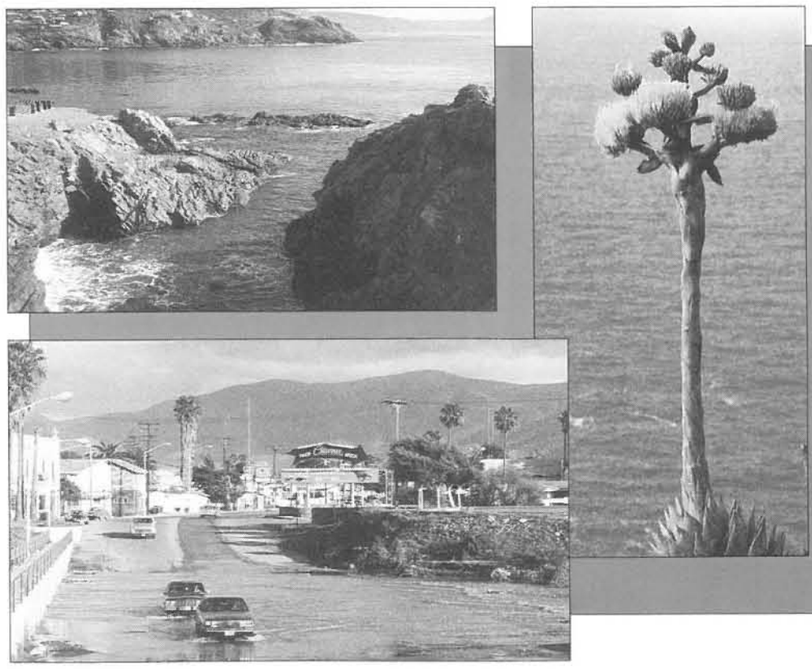
The proposed Draft Budget for 1993 was set at US $2.1 million – assuming that all countries would pay according to the scale previously agreed, and also assuming other income of US $0.5 million. This proposed level of expenditure was based on an assessment of the minimum needs for adequate fulfilment of tasks, according to priorities set by the IGBP Scientific Committee (as detailed in papers made available to SAC III participants). In the event of a shortfall in income re-occurring in 1993, several measures were proposed – but all with detrimental consequences, affecting either the implementation of the Core Projects, the overall coherence of the Programme, the involvement of developing countries, the schedule for publications, or other key aspects of central scientific coordination.

Proposals for the financing of IGBP central activities from 1994 onwards are being developed in close liaison with the International Group of Funding Agencies for Global Change Research (IGFA). Specifically, a 5 year work programme for central scientific coordination within IGBP will be prepared, and a donor meeting process initiated, in order to secure a more long-term commitment by the agencies and authorities that are financially responsible for national contributions.

In the subsequent discussion of IGBP finances, Grant Gross (US National Science Foundation) suggested that financial information could be better packaged, to emphasise the scientific nature of the central activities. Bruce Thom (Chair, Australian National IGBP Committee) urged National Committees to link their participation in IGBP with governmental commitments made within the UNCED process (specifically, to AGENDA 21) when seeking funds for national contributions from central sources.

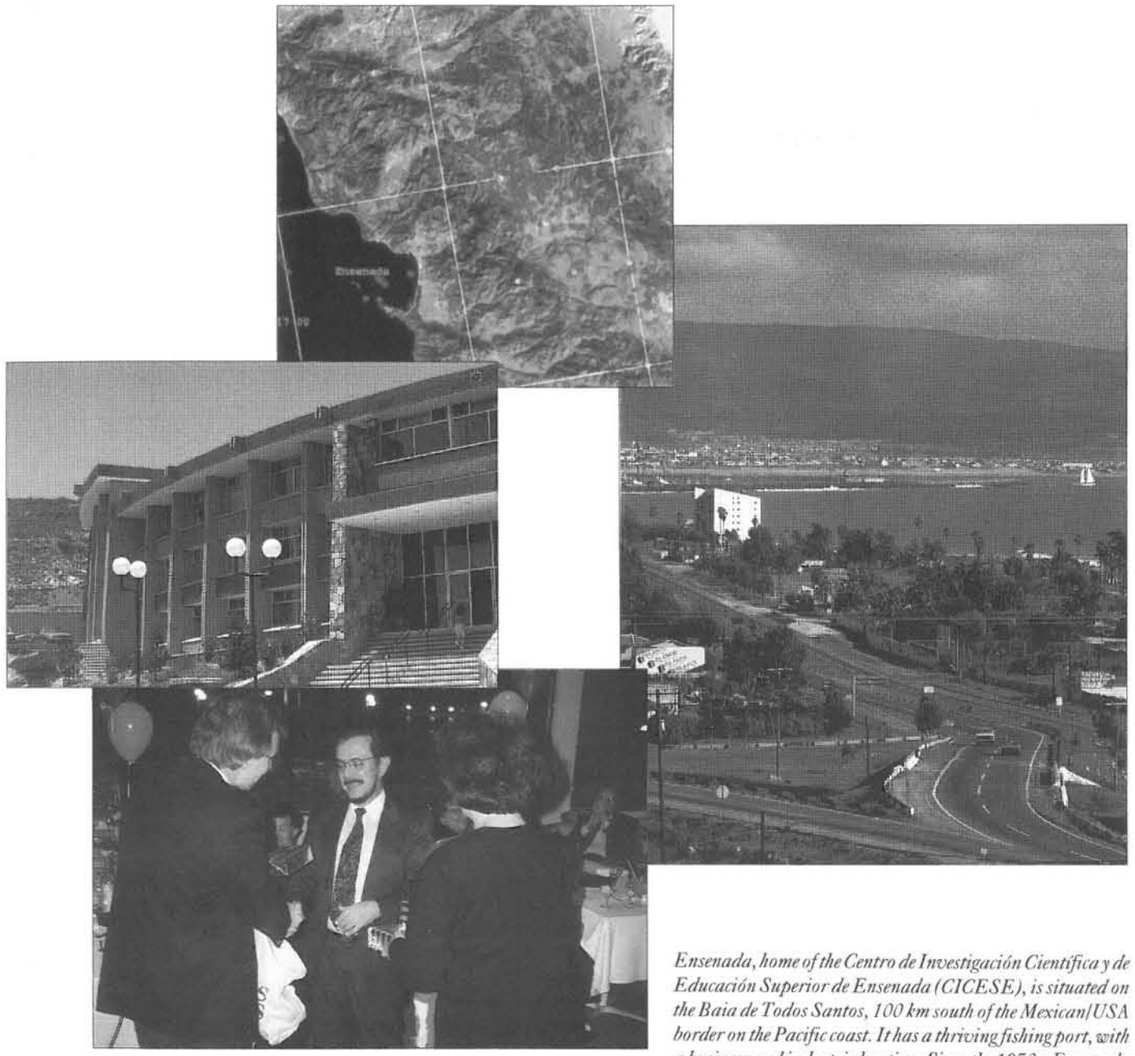
Advice was sought from the meeting on what action should be taken to encourage payment of national contributions. The consensus was that a positive approach would be most effective; if sanctions were applied, the commitment to IGBP research in such countries would be reduced, and IGBP might no longer be able to draw on the best scientific expertise, regardless of nationality, in project and programme planning and implementation.

After further discussion, SAC III agreed that the proposed level of expenditure was necessary for the scientific coordination of IGBP, and re-affirmed approval of the scale used for setting national contributions (also see Recommendations 3.1 – 3.5, p 3).



The river-bed that runs through town in Ensenada had not seen water in years. Unusually heavy rain storms, beginning in early January, had filled it, and flooded the Tijuana river in the border town to the north, causing mud slides. Access was difficult from San Diego, and 200 km south of Ensenada roads were entirely cut off. A few days before the conference the weather was back to Baja California sunshine. Clock-wise from the top:

- *view of the Baia de Todos Santos.*
- *a local plant used for making string*
- *driving through the normally dry river-bed*



Ensenada, home of the Centro de Investigación Cientifica y de Educación Superior de Ensenada (CICESE), is situated on the Baia de Todos Santos, 100 km south of the Mexican/USA border on the Pacific coast. It has a thriving fishing port, with a business and industrial section. Since the 1950s, Ensenada has grown from small town to a major city of 260,000 people.

CICESE was founded in 1973 as part of a plan by the Mexican Government to decentralize the scientific activities in the country. It is a major research institution whose mission is to develop basic and applied science and new technologies, and to promote their assimilation and dissemination.

From the top:

- *satellite view of the west coast of northern Baja California*
- *Entrance to CICESE*
- *view of the port of Ensenada from CICESE*
- *Mario Martínez García, Director CICESE, Chair of the Mexican National Committee for the IGBP, and host of SAC III. Here he receives hearty thanks from John Marks, Acting Executive Director of the IGBP*
- *The staff who made things work for SAC III From top left: Elena Enriquez, Gilda Elorriaga, Norma Fuentes, Cristina Elorriaga, Lupita Martínez (CICESE) From lower left: Suzanne Nash (IGBP), Esther Cortez, Ana Maria Hirales (CICESE)*

IGBP NEWSLETTER 13

SYMPOSIUM ABSTRACTS

Abstracts of presentations at the Scientific Symposium "Reducing Uncertainties in Global Change" are given here, in the order of their delivery. Full, illustrated versions of these papers will be published in a special issue of the environmental journal *Ambio*, in February 1994 (Vol 23, no. 1).

The first session of the Symposium emphasised the need for a quantitative understanding of the role of the biosphere in global change, followed by an overview of research on physical aspects of the global climate system. Session Chair: M G K Menon, President of ICSU.

Global change models : a biogeochemical perspective

Berrien Moore III

Institute for the Study of Earth, Oceans & Space, University of New Hampshire, USA

Human activity has significantly altered biogeochemical cycling at the planetary scale. The magnitude of that disturbance may now be approaching a critical level: the values of key components of many global cycles are moving into a range unprecedented during the past million years. For example, as a result of fossil fuel burning, forest clearance and other activities, the atmospheric concentrations of carbon dioxide (CO_2) and methane (CH_4) have increased by more than 25% and 100% respectively over the past 200 years, with current annual increases of around 0.4% for CO_2 and slightly less than 1% for CH_4. From ice core records we know that the concentrations of these gaseous fractions of the global carbon cycle were relatively constant between the beginning of the present interglacial era (c 10,000 years ago) and the onset of increases in the 18th century.

The nitrogen cycle has also been affected by human activities. Atmospheric nitrous oxide (N_2O) is increasing by 0.2-0.3% per year, due to biomass burning, the application of nitrogen fertilizer and the discharge of sewage. Much of the nitrogen in fertilizer and sewage reaches aquatic systems (groundwater, wetlands, rivers, estuaries and the coastal ocean), and it is estimated that N_2O releases resulting from this eutrophication have increased by 50% over the past 50 years.

There has also been an anthropogenic increase of around 50% in the global flux of sulphur to the atmosphere, primarily due to emissions of gaseous sulphur from fossil fuel combustion. Over continental regions, industrial activities now account for up to 70% of the total sulphur released to the atmosphere, mostly as sulphur dioxide (SO_2). Sulphur dioxide is rapidly hydrolysed to sulphuric acid which is then deposited back to terrestrial and aquatic ecosystems in the form of acid rain. Another possible consequence of changing sulphur emissions is an environmentally-significant change in the concentration of cloud concentration nuclei, with potential impacts on cloud optical properties – with feedback to the physical climate system.

This paper highlights the current state of knowledge about these cycles and their interaction. It then focuses upon the global carbon cycle, applying some simple carbon models to an important policy issue: the lifetime of CO_2. The classical notion of atmospheric lifetime is discussed, and difficulties noted in applying this construct to CO_2. An alternative definition is suggested, by defining the single half-life ($T_{0.5}$) for a Global Carbon Cycle Model as the time it takes for the concentration of CO_2 in the atmosphere to relax from its present value to one half of its equilibrium pCO_2 value. Using three simple ocean carbon cycle models and a model of global terrestrial carbon cycling, $T_{0.5}$ is calculated for a number of scenarios. We find significant differences due to the inclusion of the terrestrial model and to the nature of assumptions made about the possible existence of a terrestrial fertilization flux.

Global change models: a physical perspective

Gordon A McBean

Department of Oceanography, University of British Columbia, Vancouver, Canada

The World Climate Research Programme (WCRP) has the dual objectives of determining the extent of climate predictability and the influence of human activities on climate. To meet these objectives, the WCRP has instituted a set of research projects focusing on specific aspects of the physical climate system. Global climate models are at the core of the programme. Models provide a structural framework around which to organize research: they are used to identify knowledge gaps, to assimilate data, and for prediction and simulation. Time scales of interest stretch from those of numerical weather prediction, through interannual variability to decadal climate change. As the time scale of interest expands we must include more and more components of the climate system.

Physically-based global climate models will also be the framework upon which to build full global change models. Modelling and other research activities coordinated by the WCRP have provided the basis for the assessment of global warming by the Intergovernmental Panel on Climate Change (IPCC) and the proposed international centre for climate prediction research. A major thrust of the WCRP is to reduce the uncertainties in simulations of climatic response to increasing concentrations of greenhouse gases. There is a need for a continuous interaction between the modelling community and those scientists studying the processes and data. Through international coordination and national contributions considerable progress has been made over the past decade and we anticipate similar success in the future.

The second session addressed atmospheric and oceanic processes relevant to climate. In particular, the importance of chemical reactions in the atmosphere; the development of coupled ocean-atmosphere General Circulation Models; prediction of El Niño/Southern Oscillation events; and recent results from the JGOFS Equatorial Pacific study. Session Chair: J J McCarthy, Chair of the IGBP Scientific Committee.

The interactive atmosphere: global atmospheric-biospheric chemistry

Ronald G Prinn

Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

The global atmosphere is a chemically complex system with significant chemical interactions both internally and with the oceans, land, and living organisms. Its composition is known to be changing today, and there is evidence from ice-cores for major changes over the last 160,000 years. Most of the key processes occur in either the troposphere or the stratosphere: events there influence the global environment through their control of the ozone layer, and through their effects on the levels of radiatively active gases and particles.

Methane, a very important greenhouse gas, has major natural biological and anthropogenic sources and is destroyed largely by reaction with the hydroxyl radical in the troposphere. Both the sources and sinks of methane are strongly influenced by human activity. Nitrous oxide has a similar range of sources. Through its decomposition it plays a controlling function in the ozone layer and it is also a significant greenhouse gas.

The chlorofluorocarbons (CFCs) are purely anthropogenic, and there is now wide awareness of their effects on ozone. However, the potency of both nitrous oxide and the CFCs as greenhouse gases is offset partially by the ozone they destroy.

Ozone, a key chemical and protective ultraviolet shield, has a complex chemistry influenced by many other trace species and is also an important greenhouse gas. Nitric oxide, nitrogen dioxide, hydrocarbons heavier than methane, and carbon monoxide are not very important directly as greenhouse gases, but have a key influence on the concentrations of ozone, the hydroxyl radical, and methane. Gaseous sulphur compounds, both natural and anthropogenic, are efficiently oxidized to particulate sulphates which can be very important contributors to the albedo, offsetting somewhat the influence of the greenhouse gases.

It is important to recognize the many complex interactions among the atmospheric, oceanic, terrestrial, and biological processes controlling atmospheric chemistry. As a result of these interactions, changes in industrial activity, climate, and land use are linked to changes in atmospheric composition in ways that are not realistically described by single numbers such as 'potentials' for ozone depletion or global warming. The International Global Atmospheric Chemistry (IGAC) Project, now underway, is dedicated to understanding this complex system through a combination of observations, theory, and laboratory and modelling studies.

The role of oceans in global warming and interdecadal variability of climate

Syukuro Manabe and R J Stouffer
NOAA Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey, USA

This study investigates the response of a climate model to a gradual increase of atmospheric carbon dioxide. The model is a general circulation model of the coupled ocean-atmosphere-land surface system with a global computational domain, smoothed geography, and seasonal variation of insolation. It is found that the simulated increase of sea surface temperature is very slow over the northern North Atlantic and the circumpolar ocean of the Southern Hemisphere, where the vertical mixing of water penetrates very deeply and the rate of deep water formation is relatively fast.

With the exception of these two regions, the distribution of the change in surface temperature of the model is qualitatively similar to the equilibrium response of an atmospheric-mixed layer ocean model, which has been the subject of many previous studies. In most of the Northern Hemisphere, the seasonal dependence of surface air temperature change is also similar to the equilibrium response. For example, the temperature increase is at a maximum over the Arctic Ocean and its surroundings in late autumn and winter, whereas it is at a minimum in summer. However, the increase of surface air temperature and its seasonal variation is very small in the Southern Ocean and the northern North Atlantic.

The CO_2-induced change of the coupled ocean-atmosphere model described above is compared with the natural variability of climate obtained from the 1,000-year integration of the model in which atmospheric carbon dioxide remains unchanged. It was found that, in the high latitude region of deep oceanic mixing identified above, sea surface temperature anomaly is very persistent and its spectrum tends to be very red. The relevance of the present result for the detection of global warming is discussed.

The presentation concludes with the discussion of the strategy for the validation of the coupled ocean-atmosphere model. It involves the monitoring of the combined atmosphere-ocean-land surface system, by both *in situ* measurements and remote sensing; the prediction of future climate change by a state-of-the-art model; and in-depth comparison of the predicted and observed climate change.

Prediction and understanding of El Niño/Southern Oscillation phenomena: results from the TOGA programme

Antonio D Moura
NOAA Office of Global Programs, Silver Spring, Maryland, USA, and Institute for Space Research (INPE), São dos Campos, São Paulo, Brazil

The international scientific community has made remarkable progress in understanding the El Niño/Southern Oscillation (ENSO) phenomenon. We are now on the verge of a major breakthrough – moving to routine prediction of ENSO and its climatic impacts, mainly over the tropics. This development is due to the success of the decade-long (1985-1984) WCRP research programme Tropical Oceans and Global Atmosphere (TOGA), under the auspices of the WMO and ICSU, and in collaboration with the IOC.

The advances in our predictive abilities have been tremendous: our understanding has evolved from relatively simplified coupled ocean-atmosphere models (such as that developed by Cane and Zebiak, at the Lamont-Doherty Geological Observatory), to global models (such as the one under development by Leetmaa, at the National Meteorological Center, NWS/NOAA).

The prediction efforts depend critically on oceanic and atmospheric data for the initialization of operational models and also for their validation. Thus solving the prediction problem not only requires good models, but also an adequate operational observing system: models and observations have to go hand-in-hand. In the tropical Pacific, the establishment of the TOGA Tropical Atmosphere Ocean (TAO) array of upper ocean and surface wind measurements is now nearly complete, but its long-term operational mode is not yet guaranteed. It is expected that the implementation of the Global Climate Observing System (GCOS) and the climate module of the Global Ocean Observing System (GOOS) will supply adequate data for operational ENSO prediction beyond the TOGA programme. It is also expected that results from the TOGA Coupled Ocean-Atmosphere Response Experiment (COARE), now underway in the Pacific warm pool, will help develop the theory of seasonal and interannual behaviour of the interacting ocean-atmosphere system, and clarify many aspects of ENSO not yet fully understood.

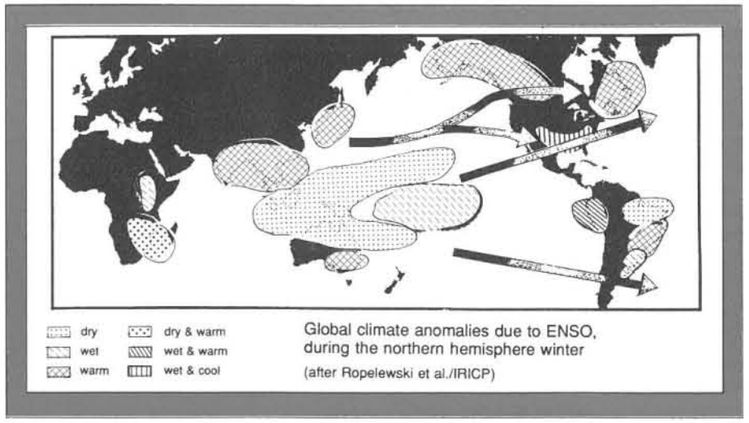
In 1995, TOGA will be succeeded by a new WCRP project: a Study of Climate Variability and Predictability (CLIVAR). This will include retrospective analysis of atmospheric, oceanic and palaeoclimate data; modelling the climate system; experimental seasonal-to-interannual climate prediction; and analysis of upper and deep ocean observations. In the context of seasonal to interannual prediction, it has been proposed that an International Research Institute for Climate Prediction (IRICP) should be established, with emphasis on ENSO prediction.

Biogeochemical interactions in the equatorial Pacific*

Richard T Barber
Duke University Marine Laboratory, Beaufort, North Carolina, USA

During 1992, the IGBP/SCOR Joint Global Ocean Flux Study (JGOFS) carried out a major fieldwork programme in the Equatorial Pacific. This ocean region is of interest because it is an important source of CO_2 to the atmosphere; nutrient levels are high, yet plankton productivity is low; and little was known about how interannual variability in the physical environment (ENSO events) affected air-sea carbon fluxes and biological processes within the water column. Fortuitously, research cruises in February and March coincided with strong El Niño conditions (with +4°C sea surface temperature anomalies), whereas those in August and September were able to investigate a cooler "overshoot" phase of the cycle. Good physical data were provided by the TOGA moored buoy arrays.

Preliminary results indicate that the unusual physical conditions enhanced primary production during both cruise periods, with a corresponding reduction in near-surface nutrients. Yet, surprisingly, chlorophyll values were lower than usual – suggesting either a marked change in species composition, or intense grazing activity. High rainfall in March may have provided trace nutrients (e.g. Fe, from Asian dust) that helped to stimulate phytoplankton growth. Marked latitudinal and seasonal changes were observed in upper ocean pCO_2; however, these seemed to be more strongly controlled by the physical, rather than biological, properties of near-surface waters.



Global climate anomalies due to ENSO, during the northern hemisphere winter
(after Ropelewski et al./IRICP)

The third session considered the role of water vapour and cloud characteristics in radiative forcing; the responses of terrestrial ecosystems to global change; the significance of social factors in determining land use and thus land cover; and whether factors affecting climatic variability on a regional basis, particularly the occurrence of drought, can be predicted. Session Chair: J M Melillo, Marine Biological Laboratory, Woods Hole, USA.

How critical are clouds and water vapour to climate change?

Thomas H Vonder Haar
Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, Colorado, USA.

Atmospheric water in all its phases (vapour, liquid and ice) provides a complex, central interaction mechanism with the global climate system. Atmospheric and oceanic energy cycles and the global water cycle are heavily influenced by physical processes, whereby solar and infrared radiant power is modulated by variable atmospheric water vapour and clouds. As the horizontal, vertical and temporal magnitude of these forcing processes vary, the resulting impact on the dynamics of the atmosphere and oceans is modified accordingly.

Biological processes at the air/land and air/ocean interfaces exert both direct and indirect effects on atmospheric water substance. In turn, the biosphere responds to variations in the overlying water (including clouds) and to the interlinked dynamic circulations. This paper develops the concept of atmospheric water as a central interaction mechanism in the climate system. New observational data are used to illustrate current research on the topic, and suggestions for future lines of research are presented for discussion.

The impact of rising CO_2 concentrations on the terrestrial biosphere

Harold A Mooney & George W Koch
Department of Biological Sciences, Stanford University, Stanford, California, USA

Current research is making large advances in linking terrestrial biospheric and atmospheric processes in real time. Further, we can now model the potential response of the Earth's primary productivity to changes in climate, and to changes in atmospheric CO_2.

We still have limited information, however, on the total responses of ecosystems to enhanced CO_2 because of the complex web of possible interactions. What is needed are experiments on whole ecosystems under enhanced CO_2 in which all of the potential interactions and feedbacks can be monitored, including plant-microbe, plant-herbivore, and plant-atmosphere interactions. The information we have to date on natural and crop systems indicates, at least in relationship to biomass accumulation, that enhanced CO_2 will increase allocation of carbon below-ground more than above-ground, perhaps at ratios of 4 to 1.

A global network of experiments in the major biomes of the world is being developed by the IGBP Global Change and Terrestrial Ecosystems (GCTE) project, in order to resolve questions related to the implications of a changed pattern of biomass distribution in the biosphere. The proportionality of the shifts between allocation of carbon to above and below- ground tissue may well depend on the natural abundance of soil nutrients and water. These factors determine the normal carbon allocation patterns of plants, and differ considerably among biomes. In addition, we need to understand the implications of below-ground carbon allocation for longterm carbon storage: does enhanced carbon transfer to roots simply increase below ground respiration, or is carbon accumulation in woody roots and soil organic matter also stimulated? A second pressing need concerns the water balance of ecosystems under elevated CO_2. How will the effect of CO_2 on stomatal aperture be balanced against changes in leaf area production in determining whole-system transpiration and energy flux? This is a critical question for understanding the coupling of the biosphere and atmosphere responses to enhanced CO_2.

Landscape to regional scale responses of terrestrial ecosystems to global change

Brian H Walker
CSIRO Division of Wildlife and Ecology, Lyneham, ACT, Australia

The twin objectives of the IGBP Global Change and Terrestrial Ecosystems (GCTE) project are to predict the feedback effects of changes in terrestrial ecosystems on the atmosphere and climate, and, at a finer scale, the effects of global changes on the structure and function of natural and agro-ecosystems. In terms of feedback, the main effects are via exchange of energy, water and momentum, and changes in biogeochemistry. The question is, how significant is ecosystem composition in these processes: does biology matter? A brief review, using a number of examples, indicates that it certainly is important in influencing evapotranspiration, albedo, surface roughness and biogeochemistry. An important conclusion is the need for describing vegetation in terms of its functional characteristics and for this there is, in turn, an urgent need for a generally applicable and acceptable classification of plant functional types (PFTs).

Global scale predictions of induced changes in ecosystem composition have proceeded via top-down models, starting with non-dynamic, correlative models based on the Holdridge Life-Zone classification. This has progressed to mechanistic, ecophysiological models that predict PFTs (and either leaf area index or biomass) using plant responses to minimum temperature, water balance, and other factors. The BIOME model of the International Institute for Applied Systems Analysis (IIASA) is also of this type. Two such models are now being incorporated into General Circulation Models (GCMs) as first attempts at coupled atmosphere-biosphere models. A parallel development is global scale process modelling which uses fixed vegetation types to predict net primary production and nitrogen cycling (e.g., the Total Ecosystem Model). The next step is for the integration of these two types of models.

A bottom-up approach to modelling begins with detailed, mechanistic patch-scale models, extending to spatially variable versions involving landscape processes and gradually incorporating simplifying routines to allow for large data sets. This again requires the use of PFTs. The large, international modelling effort will be greatly facilitated by the establishment of a Longterm Ecological Modelling Activity (LEMA) within the GCTE project.

The myriad implications for agriculture are illustrated by just two examples – effects on cereal crops, and pest and diseases. Analyses of crop effects using current GCM scenarios suggest declining yields in centres of continents and shifts to higher latitudes (of the order of 200-300 km per °C). These predictions, however, are as yet unreliable and we require experimental data on the interactive effects of changes in CO_2, water and temperature before the models are acceptable. The GCTE crop modelling and experimental networks aim to achieve this; one for wheat is now established. Pest effects are illustrated by the seasonal dynamics of the brown plant-hopper, showing how the incidence of this important rice-pest in Japan and Korea depends on the timing, location, and direction of winds in the vicinity of the Tibetan Plateau.

Human forcing of land cover change

Billie L Turner II
Graduate School of Geography, Clark University, Worcester, Massachusetts, USA

Human actions are altering the terrestrial environment at unprecedented rates, magnitudes, and spatial scales. Land-cover change stemming from human land uses represents a major element in global environmental change. Not only are the global-level data on land-use/cover change relatively poor, but we need a much better understanding than we currently possess of its human sources, or driving forces. Many forces have been proposed as significant, but single-factor explanations of land transformation have not proven to be adequate.

How the human causes interact and under what circumstances each is important are questions needing systematic research. An international and interdisciplinary agenda is being developed, proposing several closely connected foci of study. A division of the world according to common "situations" of environment, human driving forces, and land-cover dynamics will be followed by detailed study of the processes at work within each situation. The results will form the basis for regionally sensitive global modelling and projection of patterns of land transformation.

Predictability of regional climate variations

Jagadish Shukla
Center for Ocean-Land-Atmosphere Interactions, University of Maryland, College Park, Maryland, USA

Factors affecting climate variability on a regional basis are briefly reviewed. It is suggested that almost all of the major interannual regional climate fluctuations observed during the past 100 years can be explained either by atmosphere-ocean or atmosphere-ocean-land interactions. In particular, based on a large number of observational and modelling studies, it is concluded that the occurrence of large scale droughts and floods in tropical and subtropical regions is a manifestation of spatial and/or temporal shifts of the mean climatological circulation and rainfall. The primary mechanism for these shifts in tropical and subtropical regions is found to be associated with anomalous boundary conditions of sea surface temperature and land surface conditions.

Some speculative remarks are also presented on the predictability of regional climate variations in the enhanced CO_2 climate regime, and during the transition from the current climate to the enhanced CO_2 equilibrium.

The fourth session considered how the effects of plant physiology and biochemistry on water and energy fluxes can best be investigated and quantified, for their inclusion in Earth System models. It also asked (and partly answered) what relevant lessons can be learnt from studies of past climate changes, with presentations of new results showing rapid regional and global environmental changes. Session Chair: H-J Bolle, Chair of the IGBP Biospheric Aspects of the Hydrological Cycle (BAHC) project.

Representation of terrestrial vegetation in global models

Steven W Running
School of Forestry, University of Montana, Missoula, Montana, USA

Accurate representation of the terrestrial biosphere in Earth System models is a continuing challenge. A major problem is the incredible diversity of terrestrial vegetation: this is usually classified by biologists according to certain biome type characteristics; and, by physical scientists, according to more functional biophysical parameters. Neither approach is adequate for the next generation of Earth System models.

Global modelling requires that the complexity of terrestrial vegetation is described in relatively simple terms. Global climate models require only rather abstract biophysical definitions of the vegetation characteristics that control energy and water fluxes at the Earth's surface; typically albedo, leaf area index, surface resistance and roughness length. But more comprehensive models of global biogeochemistry (needed for future dynamic Earth System models) require more sophisticated definition of plant physiology and biochemistry. Variables needed include C3 vs C4 photosynthetic pathway, leaf longevity and turnover rate, specific leaf area, canopy nutrition, respiring biomass, and soil carbon and nutrient pools. However, these sophisticated vegetation definitions must be measurable for all global vegetation, implying heavy reliance on advanced remote sensing techniques. Additionally, it is critical that global vegetation variables be mapped with geographic accuracy and repeatability for regional interpretation and change detection.

This paper provides a background of the basic biophysical principles incorporated in Soil-Vegetation-Atmosphere Transfer (SVAT) models, a primary tool for theoretical analyses of problems describing vegetation in a global context. Next, it explores efforts to derive a critical list of essential vegetation variables for global modelling, by sensitivity analysis of a SVAT model. Finally, it discusses new remote sensing based methodology for the global measuring and mapping of these advanced vegetation variables.

Much of the rationale presented is incorporated in the Operational Plan for the IGBP Biospheric Aspects of the Hydrological Cycle (BAHC) project, and is also part of the US Global Change Research Program Science Agenda for the 1990s.

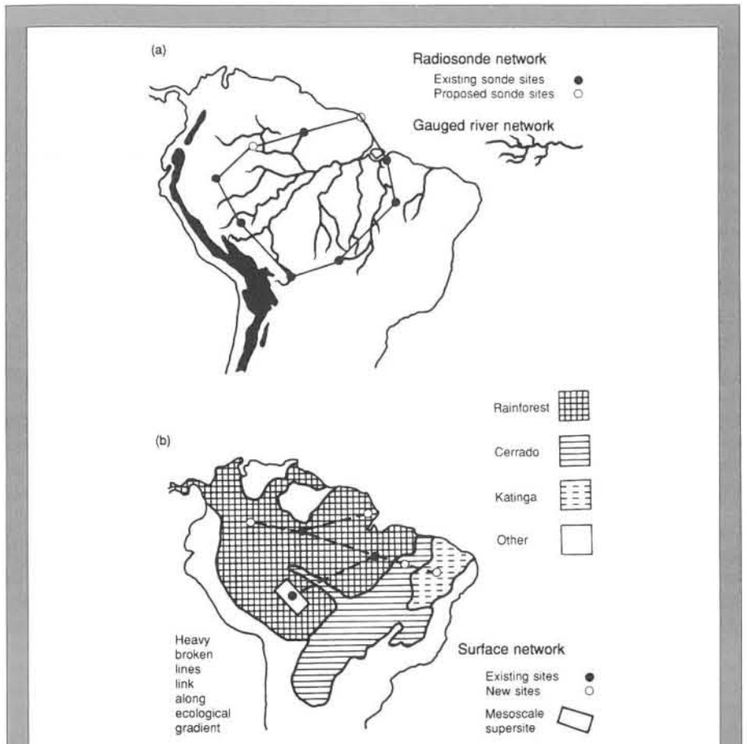
Large-scale experimental and modelling studies of hydrological processes

W James Shuttleworth
Department of Hydrology and Water Resources, University of Arizona, Tuscon, Arizona, USA

Better understanding of the terrestrial hydrological cycle is critical to our joint need to maintain human development, and to understand the consequences of such development on global processes. This is because the terrestrial hydrological cycle not only sustains life through the provision of water, food and industrial resources, but is simultaneously integral to the climate system – and in large measure causal in biogeochemical cycles and in determining land cover. In consequence of its uniquely important role, research into global hydrology is fostered under several international programmes – notably the IGBP Biospheric Aspects of the Hydrological Cycle (BAHC) project, the WCRP Global Energy and Water Cycle Experiment (GEWEX), and the UNESCO International Hydrological Programme – and supported by the routine observational frameworks of the World Meteorological Organisation and other bodies. Each of these programmes has necessary and complementary roles.

The terrestrial hydrological cycle is scientifically important because it is the mechanism for recycling water, energy and key biogeochemical elements over land surfaces, and because this recycling is sensitive to the control exerted by the soil-vegetation-atmosphere interface at the ground. One of the primary objectives of large-scale experiments (and associated modelling studies) is to represent this interaction at a range of spatial scales, including the global scale, which are realistic and which take account of the inherently heterogeneous nature of continental surfaces. A series of large-scale observational studies are ongoing to address this need, under the sponsorship of the above international programmes. This paper selectively overviews such experiments, with emphasis on progress towards better definition of area-average representations of land-atmosphere interactions (from the studies carried out in France, Spain and Niger); and with reference to advances in the indirect calibration of the parameters within land surface models, using remote sensing data.

Future experiments will extend the areal extent of such large-scale observations. The aim is not only to improve the calibration (and hence predictions) of global models, but also to provide better validation of such models in present day conditions, and hence better interpretations of the hydrological consequences of their predictions. Further, the extended interdisciplinarity of the participation in proposed and upcoming experimental studies of the boreal forest regions of the northern hemisphere, and in the tropical biomes of Amazonia, will broaden the range of understanding – by investigating not only the hydrometeorlogical interactions, but by simultaneously studying associated biogeochemical cycles, and other ecological processes, along climatological and land-use gradients.



Planning is currently underway for a major land-surface experiment in the Amazon basin, as a joint study of the IGBP (BAHC) and WCRP (GEWEX)

Fig. credit: W J Shuttleworth

Palaeo-perspectives: overview and the ice-core record

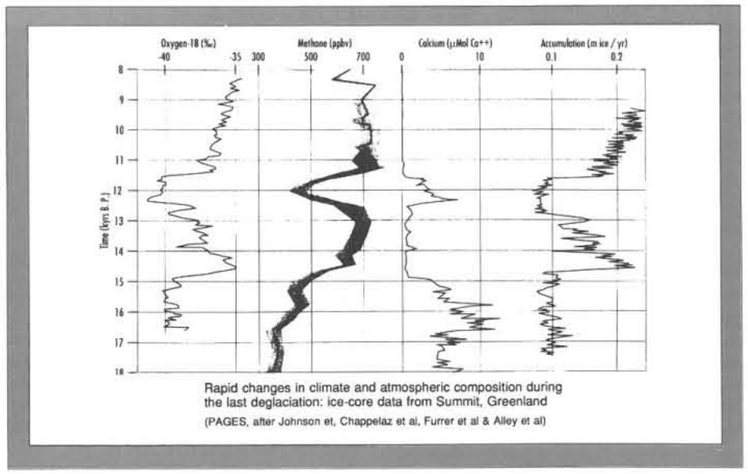
Claude Lorius
CNRS Laboratoire de Glaciologie, St Martin d'Hères, France

The IGBP Past Global Changes (PAGES) project is designed to characterize the significant climatic and environmental changes which occurred in the past, and strives to understand their causes. These studies have been largely responsible for our present awareness of the coupled nature of global environmental systems, and for our understanding of the natural variability of the Earth's climate; they also provide information on the condition of the Earth system prior to human impact. Information gained from the study of natural archives provides constraints in predicting future environmental changes on societal time scales.

A more complete assessment of aerosol and greenhouse gas concentration in the atmosphere over the last few centuries is currently underway. The results, obtained primarily from ice core research, will address the key issue of disentangling natural from anthropogenic climatic variability, as well as providing initial data on solar forcing of the climate system.

Important new data on glacial-interglacial changes over the last climatic cycle have been obtained from marine, continental and ice-core sources. These confirm the close association of climate, atmospheric composition and aerosols, and the importance of external forcing. Progress has been made in the correlation of marine and ice-core records for the analysis of climate sensitivity, feedback systems, and lead and lag relationships.

There is a growing body of evidence suggesting very abrupt natural changes in the climate system. These occurrences are particularly well documented over the last deglaciation when abrupt changes appear to be global in extent. They are also present during the ice ages and may reflect ice sheet instability and rapid changes in atmosphere-ocean circulation.



Rapid changes in climate and atmospheric composition during the last deglaciation: ice-core data from Summit, Greenland

(PAGES, after Johnson et, Chappelaz et al, Furrer et al & Alley et al)

Palaeo-perspectives: changes in terrestrial ecosystems

Alayne Street-Perrott
Environmental Change Unit, University of Oxford, Oxford, UK

Evidence from tropical regions demonstrate that rapid climatic changes are linked to changes in monsoon behaviour. Such rapid large-scale phenomena increase the uncertainties in predicting future climate change.

Current research into the effects of long-term natural CO_2 variation demonstrate large shifts in the distribution patterns of vegetation. The ecology of tropical rain forests and mountains is particularly sensitive to changes in atmospheric composition. These results are obtained primarily from the study of carbon isotopes in lake sediments which are also used to demonstrate societal impact on the environment. In Mexico, the effects of deforestation in pre-Columbian times resulted in accelerated rates of soil erosion.

Convincing validation of physical and ecological simulations require a high resolution database which characterize the naturally-occurring climate regimes and environmental changes of the past. One of the central objectives of the PAGES Project is the establishment of an accurate global environmental history required for the validation of predictive models of environmental and ecological changes.

The fifth session focussed on global change research in Central and South America. Presentations covered the development of the Inter-American Institute for Global Change Research; a case study on recent climatic changes in Costa Rica; terrestrial ecology research in Mexico; and the application of satellite imagery to in-

vestigate primary production off the Pacific coast of Mexico. Session Chair: D Piñero, of the Center of Ecology, Universidad Nacional Autónoma de México.

The Inter-American Institute for Global Change Research

Federico García Brum
Iniciativa del Conto Sur, Montevideo, Uruguay

At the White House conference of April 1990, on Science and Economic Research related to Global Change, the USA proposed the creation of three institutes for global change research: the Americas, Europe and Africa, and the Far East and southwest Pacific. To develop the idea of the American programme, a workshop was held in Puerto Rico in July 1991: this initiated the development of the "Inter-American Institute for Global Change Research" (IAI). Subsequently, in May 1992, an Intergovernmental Agreement establishing the IAI was signed in Montevideo by representatives of 11 countries of the Americas. The signatories were Argentina, Bolivia, Brazil, Chile, Costa Rica, Dominican Republic, Mexico, Panama, Peru, the USA and Uruguay. Later Paraguay was added to the list of member countries.

The Agreement, which is open for signature to all other sovereign States of the Americas, will come into force 60 days after its ratification by at least six of the Parties. To assist the development of the IAI framework, the Parties also signed the Declaration of Montevideo. This document includes the decision to create an Implementation Committee, to ensure that the IAI can start its activities as soon as the Agreement comes into force and the first meeting of the Conference of the Parties – the main organ of the IAI – takes place. The other bodies of the IAI will be the Executive Council, the Scientific Advisory Committee, and a Directorate with administrative functions.

The main goals of the IAI are to conduct and promote research on global change processes and their interactions with human activities, and to serve as an effective interface between science and the policy process, in order to contribute to the preservation of our planet and improve the welfare of mankind. The basic structure of the IAI, which is seen as a system 'without walls', will consist of a network of Research Centres and Affiliated Research Institutions linked to the Associate members which may be countries outside the region, intergovernmental bodies, or other organizations interested in supporting its activities.

The IAI's scientific agenda, which will be basically interdisciplinary, will initially focus on the following research topics: tropical ecosystems and biogeochemical cycles; the study of impacts of climate change on biodiversity; El Niño-Southern Oscillation and interannual climate variability; ocean-land-atmosphere studies of oceanic, coastal and estuarine processes in temperate zones; comparative studies of temperate terrestrial ecosystems; and high latitude processes. IAI research activities will be coordinated with existing programmes such as IGBP, WCRP and HDP, and special effort will be given to promoting training and interaction among scientists throughout the region.

General circulation changes and their influence on precipitation in Central America. A specific case: Costa Rica

Alvaro Brenes
Institute Meteorológico Nacional, San José, Costa Rica

A trend analysis of 81 series of precipitation data from the last 30 years (1960-90) is presented. These series are from different meteorological stations distributed throughout Costa Rica on the leeward and windward sides, both of which are affected by the trade wind regime.

An analysis of these series shows that precipitation has decreased over 75% of Costa Rican territory during this 30 yr period. Most of the areas affected by this trend are located along the leeward side of the mountain range which divides the country from northwest to southeast. The territory along the windward side, however, exhibits a positive trend in precipitation. This suggests that the country is affected by the trade wind regime more than before, and that the mean speed of the trade winds may have increased in this 30 yr period.

An analysis of data on Atlantic hurricane trajectories since 1900 shows that, even though the total number of hurricanes in the Atlantic has increased, there has been a reduction in the number of hurricanes along the Caribbean Basin.

The movement of tropical cyclones in the Caribbean Basin accounts for approximately 70% of total precipitation in the Pacific region of Central America. These countries' economies are highly dependent on agriculture and water resources for energy generation. Therefore any change in hurricane patterns and associated rainfall could have a negative impact on the economies of Central American countries.

Terrestrial ecosystems as targets and causes of global change

José Sarukhán and Daniel Piñero
Universidad Nacional Autónoma de México, México City, México

There are two central questions when terrestrial ecosystems are considered with respect to global change. First, the role of terrestial ecosystems in the fluxes of carbon dioxide and other greenhouse gases. Second, the impact that global change could have on the distribution of biodiversity and ecosystem processes. Until now, only the first question has been addressed in some Latin American countries and in Mexico in particular. With respect to the second question, we are aware of some research programmes that have been proposed, but we lack critical data on this matter.

It is estimated that there are 51.5 million ha of closed forests in Mexico. These are typically divided into four different types: tropical evergreen forests, tropical deciduous forest, temperate coniferous forest, and temperate broadleaf forest. These forests have different ecological properties, and therefore their contribution to greenhouse gas emissions should be studied separately. Previous estimates of deforestation rates show large differences, ranging from 329,000 ha to 1.5 million ha per year. Mexico also has reforestation projects, and although small, these must be taken into account when determining net deforestation. The causes for deforestation differ among different kinds of forests. Using available estimates for current national carbon emissions from energy sources (74 million tons C per yr), and for current carbon emissions from deforestation (27.5 million tons C), we conclude that around 27% of the carbon emissions in Mexico comes from deforestation.

It is estimated that nitrous oxide (N_2O) accounts for only around 5% of the total emissions of greenhouse gases in Mexico. Published data indicate that, during the wet season, tropical dry forests produce N_2O at rates similar to moist or wet tropical forests; however, they inactive during the dry season.

For most Latin American countries (that harbour a large number of species) it is very important to develop a research programme to advance our knowledge on relationships or biodiversity and global change. A workshop, to be held in Mexico, is planned to develop this topic, and to advance the research agenda of the Inter-American Institute for Global Change Research. Since the IGBP is also developing research in this area (as Focus 4 of GCTE), it is important that there should be close collaboration with all the organizations with interest in this topic. All these are aspects that we considered to be important when considering terrestrial ecosystems in the context of global change in Latin America. Developing local, regional and global projects on these matters is the best way to develop mitigation strategies and policy decisions related to global change.

Photosynthesis in the ocean and the role of the CZCS and the SeaWiFS colour scanner*

Ruben Lara Lara
Centro de Investigacíon Científica y de Educacíon Superior de Ensenada, Ensenada, México

Ocean colour data from the Coastal Zone Color Scanner (CZCS) satellite sensor for 1978-1986 have been compared with *in situ* data (from 1955 onwards) for primary production and chlorophyll *a* in Mexican coastal waters. Although the *in situ* observations cover a longer period, their seasonal coverage is poor, with most fieldwork carried out in June and July. A month-by-month analysis of CZCS data for 1981/82 showed many novel features, including high inshore values of phytoplankton biomass in the Gulf of California between November and February. Tidal mixing is believed to be responsible for the strong N-S gradient in pigment concentrations in this semi-enclosed ocean region.

The CICESE research group is currently involved in calibration studies in preparation for the late 1993 launch of the Sea-viewing Wide Field of View Sensor (SeaWiFS). This sensor has more bands than the CZCS satellite, and should provide much better discrimination beteen photosynthetic pigments, other organic matter and suspended sediment.

The sixth, and final, session of the Symposium explored the links between research on the human dimensions of global environmental change and studies on physical and biogeochemical aspects. It also addressed the issues of policy making at the governmental and intergovernmental level, in the context of the IPCC experience. In the concluding discussions, the progress, direction and expectations of global change programmes were reviewed. Session Chair: F Bretherton, of the University of Wisconsin.

Interactions and collaboration across the social and natural sciences

Roberta Balstad Miller
National Science Foundation, Washington DC, USA (now at the Consortium for International Earth Science Information Network, University Centre, Michigan, USA)

In its second decade, the study of global change will require increased research on the interactions of physical, biological, and anthropogenic processes. The absence of prior substantive collaboration across the natural and the social sciences has resulted in the delineation of a well-articulated global change research agenda that calls for, but does not yet encompass significant interdisciplinary collaboration.

There are few models of the kind of successful collaboration that is needed, and little concrete evidence of how it should be attempted. This paper makes a distinction between cooperative but partitioned multidisciplinary research, and collaborative interdisciplinary research. The latter will only be possible if scientists from collaborating fields begin to alter the way they think about global data, and prepare to take the time needed to work through the problems.

Science and policy making

Bert Bolin
Department of Meteorology, University of Stockholm, Stockholm, Sweden

A policy for a particular area of society provides a framework for action based on factual information and value judgements. The knowledge base derived from scientific understanding, is one important component in this context. It is essential for scientists to recognize and also communicate clearly, and as objectively as possible, the limitations of the information that is provided. By being able in this way to represent truly a broad spectrum of scientists in the field a mutual and respectful relation between scientists and decision makers can develop.

The scientist serving in the position of a science advisor must acquire good insight into other aspects of the problem under consideration in order to be able to provide the most essential information for the decision maker. He or she must recognize (although, as a private individual, not necessarily accept) political or other constraints under which a decision maker is acting. Further, at the international level it is necessary to understand the different value systems that prevail in different cultures and which markedly influence the views that are being held. Some examples are given based on the experiences from the Intergovernmental Panel on Climate Change (IPCC).

Perspectives on policy

Francis Bretherton
Space Science and Engineering Center, University of Wisconsin, Madison, USA

The interface between IGBP and discussions of policy alternatives for global environmental change has not yet been clearly articulated. As a possible framework for this needed debate, a natural scientist's view is presented of the different perspectives that appear to underlie conflicting agendas for mitigation, adaptation and response strategies. Based upon different ways individual humans respond to uncertainties in everyday life, these agendas have distinct but specific needs for scientific and technical information. IGBP can best serve decision makers by consciously catering to the highest priority requirements of each agenda, without attempting to pass judgement between them.

The dialogue with social scientists and members of action groups necessary to clarify these information needs and expectations has barely begun. It must be anticipated that as this dialogue develops it will have a far reaching influence on the present formulation of the IGBP.

** Abstract prepared by the IGBP Secretariat, based on the oral presentation. Some of the other abstracts have been slightly shortened here, for space considerations and to achieve greater consistency in the level of detail presented.*

IGBP Meetings

1993

12-15 April, Pack Forest, Washington, USA
GCTE Focus 3 Workshop: Global Change and Forested Ecosystems. Mr. John Ingram, GCTE Focus 3 Office, Oxford University, Oxford, UK.

15-21 April, Canberra, Australia
PAGES Workshop on Palaeoclimates of the Northern and Southern Hemisphere and High Resolution Sequences. Dr. Robert Wasson, Division of Water Resources, CSIRO, GPO Box 1666, Canberra, ACT 1601, Australia. Tel: (+61-6) 246 5778; Fax: (+61-6) 246 5800

17-18 April, Eilat, Israel
IGAC Council (Scientific Steering Committee and Activity Conveners)

18-22 April, Eilat, Israel
Global Atmospheric-Biospheric Chemistry: First IGAC Scientific Conference and 37th OHOLO conference. IGAC Core Project Office, Bldg. 24-409, MIT, Cambridge, MA 02139, USA. Tel: (+1-617)253 9887, Telex: 921473 mitcam; Fax: (+1-617) 253 9886.

19-20 April, Texel, Netherlands
LOICZ Workshop: Interface Between Natural Science and the Economic, Social and Institutional Implications of Change in the Coastal Zone.

19-21 April, Vienna, Austria
PAGES Workshop: Monitoring Climate Change by Isotope Measurements in the Hydrological Cycle. Dr. Hans Oeschger, PAGES Core Project Office, Bärenplatz 2, CH-3011 Bern, Switzerland. Tel: (+41-31) 21 31 33; Fax: (+41-31) 21 21 68

21-22 April, Taipei, Taiwan
PAGES Workshop on High Resolution Records of Past Climate from Monsoon Asia: the last 2,000 years and beyond. Dr. David D. Sheu, Institute of Marine Geology, National Sun Yat-Sen University, Kaohsiung, Taiwan. Tel: (+886-7) 532 1407, Fax: (+886-7) 561 4455.

21-24 April, Madras, India
First National Symposium on IGBP. Prof. R. R. Daniel, COSTED, 24 Gandhi Mandap Road, Madras, India. Fax: (+91-44) 94 4444

22-23 April, Washington, DC, USA
6th START Standing Committee

26-27 April, Wageningen, Netherlands
IGBP-DIS Soil Data Base Working Group

27-29 April, Warnemünde, Germany
JGOFS North Atlantic Planning Group Workshop. Dr. Richard Lampitt, Institute of Oceanographic Sciences, Wormley, Godalming, Surrey GU8 5UB, UK. Fax: (+44-428) 683 066

29-30 April, Cambridge, Massachusetts, USA
GAIM Task Force Meeting

3-7 May, Wiesbaden, Germany
BAHC Symposia on: Atmospheric and hydrological process and models at the soil-vegetation-atmosphere interface; Effective parameter estimation for flow and transport in the subsurvace; Data sampling and parameter estimation for spacially distributed hydrological systems. XVIII General Assembly of the European Geophysical Society, Max-Plank-Str. 1, 3441 Katlenburg-Lindau, Germany. Tel: (+49) 5556 1440; Fax: (+49) 5556 4709

4-5 May, Bidston, UK
JGOFS Data Management Task Team. British Oceanographic Data Centre

10-12 May, Beijing, China
IGBP Officers Meeting

10-12 May, Accra, Ghana
Northern Africa Planning Committee for START Meeting

13-15 May, Barcelona, Spain
Core Project Planning Committee on Land Use/Cover Change

15-16 May, Edmonton, Alberta, Canada
Canadian BAHC Steering Committee.

17-20 May, Raleigh, North Carolina, USA
Open Meeting on the IGBP Core Project Land-Ocean Interactions in the Coastal Zone (LOICZ). Dr. P. M. Holligan, Plymouth Marine Laboratory, West Hoe, Plymouth PL1 3DH, UK. Tel: (+44-752) 222 772, Fax: (+44-752) 670 637

17-21 May, Manilla, Philippines
Third Meeting of the Southeast Asian Regional Committee for START (SARCS), First Scientific Advisory Panel Meeting (SAP)

24-25 May, Washington, DC, USA
IGBP Core Project Managers

1 June, Victoria Falls, Zimbabwe
Second Meeting of the *ad hoc* START Regional Committee for Southern, Central and Eastern Africa

2-5 June, Victoria Falls, Zimbabwe
African Savannas, Land Use, and Global Change: Interactions of Climate, Productivity and Emissions – a joint IGBP-START/GCTE/DIS/GAIM Meeting

7-8 June, New York City, USA
Land Use/Land Cover Change Project Modelling Working Group

7-8 June, Amsterdam, Netherlands
START in Europe: A regional Initiative for the Development of a European Network for Global Change Research. Prof. Dr. H. Postma, Netherlands MAB/SCOPE/IGBP Committee, The Royal Netherlands Academy of Sciences, Het Trippenhuis, Kloveniersburgwal 29, NL-1000 GC Amsterdam. Fax: (+31-20) 620 4941

10-11 June, Bremerhaven, Germany
German PAGES Marine Planning Meeting. Prof. Dr. D. Fütterer, Alfred-Wegener-Institut, Pf. 12 01 61, D-1850 Bremerhaven 12. Fax: (+49-471) 483 1149

14-16 June, Plymouth, UK
JGOFS – Intergovernmental Oceanographic Commission CO_2 Advisory Panel. Art Alexiou, IOC Secretariat,

17-19 June, Southampton, UK
Global Ocean Euphotic Zone Study (GOEZS) Working Group Meeting, IGBP/SCOR/WCRP

21-25 June, Rhode Island, USA
JGOFS-LOICZ Continental Margins Task Team. Elizabeth Gross, SCOR Secretariat, Department of Earth and Planetary Sciences, John Hopkins University, Baltimore, MD 21218, USA.

24 June, Solstrand-Bergen, Norway
PAGES Project Planning Meeting on Nansen Arctic Drilling, in conjunction with the Nansen Centennial Symposium, Nansen Environmental and Remote Sensing Centre. Dr. Tore Vorren, Dept. of Geology, University of Tromso, PO Box 3085, N-9001 Tromso, Norway.

28 June-2 July, Ispra, Varese, Italy
Scientific Committee for the IGBP

7-11 July, São José dos Campos, Brazil
Joint WCRP/IGBP Working Group on Land-Surface Experiments (BAHC Focus 2 – Amazon Experiment)

11-23 July, Yokohama, Japan
International Association of Hydrological Sciences (IAHS) and the International Association of Meteorology and Atmospheric Physics (IAMAP). BAHC Symposium on exchange processes at the land surface for a range of space and time scales; WCRP Symposium on Stratospheric Processes and Their Role in the Climate. Dr. Takeo Kinosita, National Research Institute for Earth Science, Tennodai-3, Tsukuba, Ibaraki, 305 Japan

13 August, Glasgow, UK
PAGES Workshop on comparison of chrolonlogies, in connection with the Radiocarbon Conference. Dr. Willem Mook, Centre for Isotope Research, University of Groningen, Wesstersingel 34, NL-9718 GM Groninge, The Netherlands. Tel: (+31) 2220 693 66; Fax: (+31) 2220 19 674

16-20 August, San Francisco, USA
GCTE/BAHC Workshop on Developing GCTE Transects and Study Areas for Biogeochemcial Research and Ecosystem Dynamics Modelling, and BAHC Focus 3 meeting. Dr. George Koch, Department of Biological Sciences, Stanford University, Stanford, CA 94305, USA. Tel: (+1-415) 723 1179, Fax: (+1-414) 723 9253, E-mail: gwksu@leland.stanford.edu

21-26 August, Oppdal, Norway
Global Change and Arctic Terrestrial Ecosystems: an International Conference. Jarle I. Holten, Coordinator, GCTE Tundra Boreal Office, Norwegian Institute for Nature Research, Tungasletta 2, N-7005 Trondheim, Norway. Tel: (+47-7) 58 05 00, Fax: (+47-7) 91 54 33

23-25 August, Bern, Switzerland
PAGES Workshop on Data Coordination for Palaeoclimatology. Dr. J. Overpeck, NDGC/NOAA, 325 Broadway, E/EC, Boulder, CO 80303, USA. Tel: (+1-303) 497 6172; (+1-303) 492 6388

3-6 September, Kyoto, Japan
GCTE Symposium: Global Change Impacts on Terrestrial Ecosystems in Monsoon Asia. In conjunction with the XV International Botanical Congress, 28 August-3 September. Dr. Tadaki Hirose, Biological Institute, Faculty of Science, Tohoku University, Aoba-yama, Sendai 980. Tel: (+81-22) 222 1800, ext. 3480, Fax: (+81-22) 263 9206

6-8 September, Kyoto, Japan
GCTE Scientfiic Steering Committee.

8-11 September, Carqueiranne, France
JGOFS Scientific Steering Committee

16-18 September, Bratislava, Slovakia
Weather Generator Project, BAHC Focus 4

20-25 September, Bratislava, Slovakia
Symposium on Precipitation and Evaporation WMO, IAHS, IAMAP, UNESCO, FAO, IGBP/BAHC. Dr. Milan Lapin, Slovak Hydrometeorological Institute, Jeseniova 17, 833 15 Bratislava, Slovakia. Tel: (+42-7) 371 392; Fax: (+42-7) 372 459; 372 034

30 Sept-2 Oct, Panama City, Panama
PAGES Workshop on Late Quaternary Palaeoclimates in the Americas, Pole-Equator-Pole. Dr. Vera Markgraf, INSTAAR, University of Colorado, Boulder CO 80309, USA. Tel: (+1-303) 492 5117; Fax: (+1-303) 492 6388

13-15 October, Washington, DC, USA
Open Meeting of the PAGES Core Project Scientific Steering Committee. Dr. Herman Zimmerman, NSF/ATM, Washington, DC 20550, USA. Tel: (+1-202) 357 9892; Fax: (+1-202) 357 3945.

October, Berlin, Germany
5th IGBP-DIS Standing Committee

25-27 October, India
7th START Standing Committee

8-11 November, Kyoto, Japan
International Sysmposium on the Sino-Japanese Cooperative Programme on Atmosphere-Land Surface Processes in the Heihe River Basin (HEIFE)/BAHC

Focus 2 on Land-Surface Experiments. Prof. Yasushi Mitsuta, Dister Prevention Research Institute, Kyoto Unversity, Gokasho Uji, Kyoto 611, Japan. Tel: (+81) 774 32 3111, ext. 3200; Fax: (+81) 774 33 0026

17-19 November, Oxford, UK
Land Use/Land Cover Change Project Modelling Working Group

30 Nov-3 Dec, Taipei, Taiwan
APARE/IGAC International Conference on Regional Environment and Climate Changes in East Asia. Dr. Chung Ming Liu, Dept. of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan. Tel: (+886-2) 362 3112, Fax: (+886-2) 363 3642

1-3 December, Tuscon, Arizona, USA
PAGES Workshop: Extracting Climatic and Other Environmental Signals from Millenial-Aged Tree-Ring Chronologies. Dr. D. Graybill, University of Arizona, Tucson, Arizona 85721, USA. Tel: (+1-602) 621 6469; Fax: (+1-602) 621 8229

14-17 December, Texel, Netherlands
JGOFS Indian Ocean Planning Group. Dr. Bernt Zeitzschel, Institut für Meereskunde, Universität Kiel, Düsternbrooker Weg 20, Kiel, Germany. Tel: (+49-431) 597 3860; Fax: (+49-431) 565 876

1994

17-21 January, Lilongwe, Malawi
First Regional South African Workshop for START (see announcement)

14-16 March, Bonn, Germany
Fourth Meeting of the IGBP National Committees. Dr. Sabine Lütkemeier, IGBP-Sekretariat, Institut für Meteorologie, Freie Universität Berlin, Dietrich Schäfer-Weg 6-10, D-1000 Berlin 41, Germany. Tel: (+49-30) 838 71117, Fax: (+49-30) 838 71160, E mail: H.Bolle.IGBP (Omnet)

6-7 April, Belgium
International Open Symposium on Freshwater Ecosystems. Dr. Oscar Vanderborght, Royal Belgian Academies of Sciences, Palais des Académies, 1, rue Ducale, B-1000 Bruxelles. Tel: (+32-2) 511 2629; Fax: (+32-2) 511 01430, or at the University of Antwerp, Department of Biology: Fax: (+32-3) 328 0497.

23-27 May, Woods Hole, Massachusetts, USA
First GCTE Science Conference. Dr. Will Steffen, GCTE Core Project Officer, CSIRO, Division of Wildlife & Ecology, PO Box 84, Lyneham ACT 2602, Australia. Tel: (+61-6) 242 1748; Fax: (+61-6) 241 2362; E-Mail: wls@cbr.dwe.csiro.au

5-9 September, Fuji-Yoshida, Japan
International Symposium on Global Atmospheric Chemistry : Human Impact on the Global Troposphere. 2nd Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC) and 8th Symposium of the IAMAP Commission on Atmospheric Chemistry and Global Pollution. Toshihiro Ogawa, CACGP/IGAC Symposium, Dept. of Earth and Planetary Physics, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan, or IGAC Core Project Office, MIT, Room 24-409, Cambridge, MA 02139, USA. Tel: (+1-617) 253 9887, Telex: 921473 mitcam; Fax: (+1-617) 253 9886.

Other global change meetings

1993

14-16 April, Geneva, Switzerland
The Climate Agenda. Ingervovernmental Meeting on the World Climate Programme

16-19 April, Moscow, Russia
Meeting on Industrial Transformation. Human Dimensions of Global Environmental Change Programme (HDP) Industrial Growth Working Group

22-27 April, Acquafredda di Maratea, Italy
Ocean Forecasting. John D. Woods, Natural Environment Research Council, Marine Sciences Directorate, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU, UK. Tel: (+44-793) 41 15 00 ext 1637, Fax: (+44-793) 41 15 01

3-8 May, Dakar, Senegal
Coastal Evolution in the Quaternary. International Geological Correlation Programme 274 Conference. Pr. J. Paul Barusseau et Dr. Cyr Descamps, LRSM Université, 52 av. de Villeneuve, 66860 Perpignan Cedex, France, Tel: (+33) 68 66 20 56/57; Fax: (+33) 68 66 20 19

4-7 May, Montréal, Québec, Canada
Second Last InterGlacial in the Arctic. John Matthews, Terrain Sciences, Geological Survey of Canada, 588 Booth St., Ottawa, Ontaria, K1A 0E8, Canada. (+1-613) 996 6371; Fax: (+1-613) 996 2462; e-mail: matthews@cc2smtp.emr.ca

5-8 May, Liège, Belgium
Data Assimilation: A new tool for modelling the ocean in global change perspective. (NATO AWR) Prof. J. Nihoul, University of Liège, GHER, Sart Tilman B5, B-4000 Liège, Belgium

10-12 May, Barcelona, Spain
HDP and International Social Sciences Council National Programmes on Global Change

17-21 May, Tuscon, Arizona, USA
Global Environmental Change and Land Surface Processes in Hydrology: Modelling and Measuring (NATO ARW). Prof. S. Sorooshian, University of Arizona, Dept. of Hydrology & Water Resources, Bldg. 11, Tuscon, AZ 85721, USA

20-23 May, Viterbo, Italy
Ecophysiology and Genetics of Trees and Forests in a Changing Climate. Promeeting, Via San Pellegrino, 45, I-01100 Viterbo, Italy. Tel: (+39-761) 345 960; Fax: (+39-761) 345 933

26-28 May, Winnipeg, Manitoba, Canada
Experiment Planning Workshop for the Boreal Ecosystems-Atmospheric Study (BOREAS). Dr. Josef Cihlar, Canada Centre for Remote Sensing, 588 Booth St., Ottawa, Ontario, K1A 0Y7. Tel: (+613) 947 1265; Fax: (+1-613) 947 1385

26-29 May, Beijing, China
Climate Change, Natural Disasters and Agricultural Strategies. Prof. Lu Guangming, Beijing Agricultural University, 100 094 Beijing, China, Telex: 222487 bau cn, Fax: (+86-1) 258 2332

7-10 June, Halmstad, Sweden
Nutrient Uptake and Cycling in Forest Ecosystems. Dr. L. O. Nilsson, Swedish University of Agricultural Sciences, Dept. of Ecology and Environmental Research, Box 7072, S-75007, Uppsala, Sweden. Fax: (+46-18) 673 430

12-18 June, Gainsville, Florida, USA
Stratospheric Ozone Depletion / UV-B Radiation in the Biosphere (NATO ARW). Dr. R. Biggs, Horticultural Science Dept., University of Florida, PO Box 110690, Gainsville, FL 32611-0690, USA

19-24 June, Port d'Albert, France
Modelling and Prediction of Coastal Zones. Prof. W P M de Ruijter, State University of Utrecht/IMAU, Princetonplein 5, 3584 CC Utrecht, The Netherlands.

1-3 July, Helsinki, Finland
HDP Perception and Assessment of Global Enviromental Conditions and Change Working Group

11-15 July, London, UK
The Role of Biodiversity in Ecosystem Stability, Function and Evolution. (EC/Unesco Diversitas Programme Workshop)

11-15 July, Oxford, UK
Climate Change and World Food Security (NATO ARW). Prof. Martin Parry, University of Oxford, School of Geography, Environmental Change Unit, Oxford OX1 3TB, UK.

25-30 July, Lhasa, Tibet, China
Internatnional Symposium in the Impacts of Clamatic Change on Hydrology and Water Resources in Moutainous and Cold Regions. Mr. Zhang Guoyou, Geographical Society of China, PO Box 771, Building 917, Anwai, Beijing 100 101, China. Fax: (+86-1) 491 1844; Tel (+86-1) 491 1104

26 July-2 August, Kyzul, Tuva Republic, Russia
Uvs Nuur Experiment – methodics of local, regional and global monitoring. Dr. S. Kurbatskaya, Director, Uvs Nuur International Biosphere Research Center, Box 107, 667 000, Kyzul, Tuva, Russia, Telex: 788070 grad.

2-6 August, Montevideo, Uruguay
IAI Workshop on Comparative Studies of Oceanic, Coastal and Estuarine Processes in Temperate Zones.

16–19 August, Montebello, Québec, Canada
Biodiversity, Temperate Ecosystems, and Global Change (NATO ARW). Dr. T. Boyle, Forestry Canada, Place Vincent Massey, 21st Floor, 351 St. Joseph Blvd, Hull, Québec K1A 1G5, Canada

22-25 August, Wageningen, The Netherlands
The Future of the Land: mobilizing and integrating knowledge for land use options. Congress Office, Wageningen Agricultural University, J.L. Meulenbroek, PO Box 9101, 6700 HB Wageningen

24-26 August, Sioux Falls, South Dakota, USA
Land Information from Space-based Systems. Pecora Remote Sensing Symposium. Pecora 12, EROS Data, US Geological Survey, Sioux Falls, SD 57198, Fax: (+1-605) 594 6589.

13-17 September, Carqueiranne, France
Fourth International CO_2 Conference. Mme Reveillon, INSU/CNRS, 77 Av. Denfert-Rochereau, F-75014, Paris, France. Tel: (+33-1) 40 51 20 08; Fax: (+33-1) 40 51 21 49)

17-22 September, Pelaghia, Crete, Greece
Ice-Sheet-Climate Interaction. Dr. Claude Lorius, Laboratoire de Glaciologie et de Géophysique de l'Environnement, 54, rue Molière, Domaine Universitaire, BP 96, F-38402 St. Martin d'Hères, France. Tel: (+33) 76 82 42 79; Fax: (+33) 76 82 42 01

18-20 September, Prague, Czech Republic
BIOGEOMON. Ecosystem Behaviour: Evaluation of integrated monitoring in small catchments. Tom Paces & Jiri Cerny, Czech Geological Survey, Malostranske namesti 19, 118 21 Prague 1, Tax: (+42-2) 798 0965.

20-23 September, Hemavan, Sweden
CO_2 – Chemistry Workshop. Dr. Jan Paul, KTH/Royal Institute of Technology, Physics III, Teknikringen 14, 100 44 Stockholm, Sweden. Fax: (+46-8) 24 91 31

20-24 September, New Delhi, India
Asian Workshop and Training Course on Methane Emission Studies. Dr. A. P. Mitra, National Physical Laboratory, New Delhi, India

20-24 September, Silsoe, UK
Soil Responses to Climate Change: Implications for Natural and Managed Ecosystems (NATO ARW). Dr. P. Loveland, Cranfield Institute of Technology, Soil Survey & Land Research Centre, Silsoe Campus, Silsoe MK45 4DT, UK

27 Sept 1 Oct, New Delhi, India
Global Environmental Chemistry Seminar of the Federation of Asian Scientific Academies and Societies.

Dr. A. P. Mitra, National Physical Laboratory, New Delhi, India. Fax: (+91-11) 575 2678

28 Sept-2 Oct, Kiel, Germany
International Conference on the State of the Art in Ecological Modelling.

29 September-1 October, Taipei, Taiwan
Fourth Meeting of the International Group of Funding Agencies for Global Change Research (IGFA). Dr. Ho Lin, Dept. of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan. Tel: ((+886-2) 363 6775, Fax: (+886-2) 363 3642.

4-8 October, Reykjavik, Iceland
International Symposium on the Ecological Effects of Airborne Pollution in the Arctic. Dr. Jesse Ford, Dept. Fisheries and Wildlife, Oregon State University, c/o U.W. EPA, 200 SW 35th St, Corvallis, OR 97333. Tel: (+1-503) 754 4607, Fax: (+1-503) 754 4716, e-mail: fordj@ucs.orst.edu

10-15 October, Montebello, Québec, Canada
Evaluating and Monitoring the Health of Large-Scale Ecosystems (NATO ARW). Prof. D. Rapport, University of Ottawa, Dept. of Biology, 30 Marie Curie, Ottawa, Ontario K1N 6N5, Canada

17-19 October, Beijing, China
International Symposium on East Asian Atmospheric Trace Gases. Prof. Wen-Xiang Yang, c/o Associate Professor Di-Xin Shen, Reserch Center for Eco-Environmental Sciences, PO Box 2871, Beijing 100 095, China. Fax: (+86-1) 255 5381

12-13 November, London, UK
Reconstruction of North Atlantic Climate Change Using Extinct Plant Data (NATO ARW). Prof. M. Boulter, University of East London, Palynology Research Unit, Romford Road, London E15 4LZ, UK.

22-26 November, Canberra, Australia
Water Issues in Forests Today. Australian Convention and Travel Services, GPO Box 2200, Canberra ACT 1601, Australia. Tel: (+61-6) 257 3299; Fax: (+61-6) 257 3256

29 Nov-3 Dec, Niterói, Brazil
Perspectives for Environmental Geochemistry in Tropical Countries. Dr. Julio C. Wasserman, Dr. Jorge J. Abrão, Programa de Geoquímica, UFF, Instituto de Química, Outeiro de São João Batista, Centro, CEP 24020-007, Niterói, RJ, Brazil. Tel: (+55-21) 717 1313; Fax: (+55-21) 719 7025.

6-10 December, Perth, WA, Australia
Modelling Change in Environmental and Socio-Economic Systems. International Congress on Modelling and Simulation. Michael McAleer, Department of Economics, University of Western Australia, Nedlands, WA 6009. Fax: (+61-9) 380 1016

13-15 December, Maastricht, The Netherlands
Non-CO_2 Greenhouse Gases: Why and How to Control. Dr. J. van Ham, Vereniging Lucht, Postbus 6013, 2600 JA Delft, The Netherlands. Tel: (+31-15) 696 884, Fax: (+31-15) 613 186

1994

31 Jan-2 Feb, New Orleans, Louisiana, USA
Second Thematic Conference on Remote Sensing for Marine and Coastal Environments. Robert Rogers, ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001. Tel: (+1-313) 994 1200, ext. 3234; Fax: (+1-313) 994 5123

18-22 July, Edinburgh, UK
Prospects for Carbon Sequestration in the Biosphere (NATO ARW). Prof. O. Heal, Institute of Terrestrial Ecology (North), Edinburgh Research Station, Penicuik, Midlothian EH26 0QB, UK

18–22 July, London, UK
European Conference on the Global Energy & Water Cycle Royal Meteorological Society, 104 Oxford Road, Reading Berkshire, RG1 7LJ, UK

1995

26-30 June, Gothenburg, Sweden
5th International Conference on Acidic Deposition. Peringe Grennfelt, Swedish Environmental Research Institute, PO Box 47086, S-40258 Göteborg, Sweden. Fax: (+46) 31 48 21 80

First START Meeting for Southern, Central and Eastern Africa, Lilongwe, Malawi

17–21 January, 1994

The IGBP/WCRP/HDP Global Change system for Analysis, Research and Training (START) will hold its first regional meeting for Southern, Central and Eastern Africa (the SAF region of the START programme) in Lilongwe, Malawi.

This meeting is aimed at providing a forum for SAF scientists to identify and prioritise research areas pertinent to global change in order to lay a foundation for a regional network that can strengthen and coordinate global change research in the region. The network to be established will also provide collaborative links to other networks of START as well as the three international programmes sponsoring START.

After keynote presentations on global change topics of particular importance to the region, the major part of the meeting will be devoted to discussions on how to strengthen research collaboration within the region focused on the following topics:

1. Climate variability, change and modelling
2. Land use, vegetation and global change
3. Global change impacts on river basins and water resources
4. Sea-level rise and coastal systems
5. Deforestation, biomass burning and greenhouse gases
6. Past global changes

Other issues, such as ozone depletion, will be discussed during the workshop. Suggestions for additional topics for discussion are welcomed.

Scientists interested in attending the workshop and becoming part of the emerging network should inform the organizers before 30 May 1993 to receive the final announcement and registration form. There are some possibilities of providing financial support for scientists in the region with particular interest in global change issues. To be considered for such financial support, please send a brief summary of academic qualifications and current research areas to be received before 30 May 1993 to:

Professor Z. M. Kasomekera, University of Malawi, Bunda College of Agriculture, PO Box 219, Lilongwe, Malawi, Tel: (+265) 277 222, Fax: (+265) 277 251, or (+265) 277 364.

Publications

New IGBP Reports

No. 24 Relating Land use and Global Land-Cover Change: A Proposal for an IGBP-HDP Core Project. A report from the IGBP/HDP Working Group on Land-Use/Land-Cover Change, edited by B. L. Turner, R. H. Moss, and D. L. Skole (1993). 65 pp. (Human Dimensions of Global Environmental Change Programme, HDP Report No. 5)

The report presents the main findings of the joint Working Group of the IGBP and the Human Dimensions of Global Environmental Change Programme (HDP) on Land-Use/Land-Cover Change; it describes a research framework that links case-study and modelling approaches and identifies the next steps needed to address the human causes of global land-cover change and to understand its overall importance. It calls for the development of a system to classify land-cover changes according to the socio-economic driving forces. The knowledge gained will be used to develop a global land-use and land-cover change model that can be linked to other global environmental models.

No. 25 Land-Ocean Interactions in the Coastal Zone (LOICZ) Science Plan. Edited by P.M. Holligan and H. de Boois. (1993). 50 pp.

The report describes the new IGBP Core Project, giving the scientific background and objectives, and the four research foci. These are: the effects of global change (land and freshwater use, climate) on fluxes of materials in the coastal zone; coastal biogeomorphology and sea-level rise; carbon fluxes and trace gas emissions on the coastal zone; economic and social impacts of global change on coastal systems. The LOICZ project framework includes data synthesis and modelling, and implementation plans cover research priorities and the establishment of a Core Project office in the Netherlands.

Core Projects

JGOFS: The North Atlantic Bloom Experiment (1993). H. W. Ducklow and R. P. Harris (eds). *in*: Deep-Sea Research, Part II, Topical Studies in oceanography, Vol. 40, Nos. 1/2. 642 pp. *Order from*: Anne Allen, Pergamon Press, Headington Hill Hall, Oxford OX3 0BW, UK.

Global change reports

Greenhouse-Impact on Cold-Climate Ecosystems and Landscapes (1992) M. Boer & E. Koster (eds). Cremlingen-Destedt: Catena, 151 pp. (Catena Supplement, 22).

Scientific Plan for the GEWEX Continental-scale International Project (GCIP). Washintgon, D.C: International GEWEX Project Office. 72 pp.

National activities

Austria
Austrian Contributions to the IGBP. Volume 1 (1992). Vienna: National Committee for the IGBP, Austrian Academy of Sciences. 32 pp.

Canada
Global Change and Canadians (1993). Canadian Global Change Program. 60 pp.

Les canadiens et les changements à l'échelle du globe (1993). Programme canadien des changements à l'échelle du globe. 60 pp.

Environmental Degradation, Population Displacement and Global Security: An Overview of the Issues (1992). Barbara Kavanagh and Steve Lonergan, Canadian Global Change Program Incidental Report No. IR92-1. 55 pp.

Northern Biosphere Observation and Modelling Experiment: Science Plan (1993). Canadian Global Change Program Incidental Report No. IR93-1. 61 pp.

Projet d'observation et de modélisation des écosystèmes boréaux: Plan scientifique. Programme canadien des changements à l'échelle du globe. Rapport Divers No. IR93-1. 67 pp.

Germany
IGBP Research in the Federal Republic of Germany (1993) S. Lütkemeier and H.-J. Bolle (eds). Berlin: IGBP Secretariat, Institute für Meteorologie, Freie Universität Berlin. 86 pp.

India
Greenhouse Gas Emissions in India, 1992 update. Ed. by A. P. Mitra. CISR Global Change Scientific Report, 4. New Delhi: CSIR

Norway
Past Global Changes (PAGES) (1993). Report from a Norwegian symposium at Solstrand, 9-10 November 1992. Oslo: Research Council of Norway. 80 pp.

Russia
International Geographical Union Newsletter on Global Programmes and Geography. V. M. Kotlyakov, V. V. Annenkov (eds). No. 4, December 1992

Newsletter of the IGU Commission on Historical Monitoring of Environmental Changes, V. V. Annenkov (ed.) No. 1, December 1992.

USA
National Action Plan for Global Climate Change (1992). Washington: Office of Global Change, Bureau of Oceans and International Environmental and Scientific Affairs, US Department of State. 129 pp. (Dept. of State Publication 10026)

Perry, John S. (1992) The United States Global Change Research Program. Early Achievements and Future Directions. Washington, DC: Board on Global Change, National Research Council. 2o pp.

USA-China
China and Global Change (1992). Opportunities for Collaboration. Washington: National Research Council, Panel on Global Climate Change Sciences in China. 228 pp.

UNCED

The Earth Summit's AGENDA FOR CHANGE. A plain language version of Agenda 21 and the other Rio Agreements, by Michael Keating. (1993). Geneva: Centre for our Common Future. 72 pp.

Copies may be ordered from Ellen Permato, Information Director, Centre for our Common Future, 52 rue des Pâquis, Geneva CH-1201, Switzerland. Fax: (+41-22) 738 50 46. Individual copies are US$ 10.00; for 20 or more US$ 7.50.

THE ROYAL SWEDISH ACADEMY OF SCIENCES
SECRETARIAT FOR THE INTERNATIONAL
GEOSPHERE-BIOSPHERE PROGRAMME

Deputy Executive Director IGBP

The Royal Swedish Academy of Sciences invites applications for the position of Deputy Executive Director of the International Geosphere-Biosphere Pro gramme (IGBP) from 1 September 1993. The IGBP is an internationally coordinated research effort, dealing with causes and effects of global environmental change. Current projects addressing atmospheric chemistry, the ocean carbon cycle, coastal zone interactions, terrestrial ecosystems, ecological hydrology and past global changes. Integrated modelling activities are ongoing as well, together with the development of data and monitoring, and regional research and training.

The Deputy Executive Director will be responsible for
- liaison with IGBP core projects
- support of the IGBP Scientific Committee
- liaison with the science community
- representation of the IGBP at meetings
- editing of reports
- assisting the Executive Director in guiding the work of the Secretariat

The successful candidate will
- have a PhD in a relevant scientific field
- have proven interest in global environmental change research
- be well acquainted with international scientific collaboration, including the associated organizational and policy aspects
- be fluent in written and spoken English; knowledge of other languages is an advantage

The Deputy Executive Director is based in Stockholm, Sweden. The minimum contract period will be two years, with the possibility of an extension. The salary is paid in SKR and based on that of a senior scientist in Sweden.

Letters of application describing past relevant experience, with a curriculum vitae, and the names of three referees, should be sent no later than **1 May 1993** to the IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-10405 Stockholm, Sweden; Fax: +46-8-166405, Tel: +46-8-166448.