GLOBAL CHANGE
NEWSLETTER

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

What is Global Change?

The term 'global change' has evolved since it became popular in the 1970s. From first referring to change in international social, economic and political systems, it has come to mean global environmental change, covering systemic and cumulative changes. What part does mankind play in these changes? The Manager of the Core Project on Land-Ocean Interactions in the Coastal Zone, Dr. John Pernetta, analyses the IGBP approach.

During the 1970s the social sciences community adopted the term 'global change' to refer to changes in international social, economic and political systems, particularly with regard to concerns about international security and decreases in the quality of life. The first use of the term was essentially therefore anthropocentric.

During the 1980s a geocentric use was adopted by the natural scientists to encompass **global environmental changes** - changes in the Earth's atmospheric, biological, geological and hydrological systems. This geocentric view of global change appears to involve two separate but related usages:

Systemic changes are seen as those which occur throughout a global compartment of the Earth system, with the often quoted examples of rising CO_2 in the atmosphere and global warming; global mean sea-level rise; and depletion of stratospheric ozone.

Cumulative changes are those which take place at discrete locations around the globe, but when combined have 'global' importance; often quoted examples are acid rain, deforestation, desertification and other processes leading to changes in the biosphere which alter its capacity to store CO_2. A coastal example of such change would be eutrophication leading to changes in carbon flow and sequestration with consequences for the global carbon cycle.

As its name suggests, the International Geosphere-Biosphere Programme (IGBP) takes a primarily geocentric and systemic view of global change, although Land-Ocean Interactions in the Coastal Zone represents *par excellence* a Core Project addressing cumulative changes in a defined spatial domain. IGBP measures the 'global importance' of cumulative changes in deciding whether or not a topic deserves inclusion in the core projects by assessing the feedback between the actual change and the global system. The observable decline in marine, bony fish biomass, or increasing contamination of coastal waters with heavy metals, Polychlorinated Biphenols (PCB's), and pesticides, whilst they have undoubted local impacts are anthropogenically driven changes which cannot presently be demonstrated to have a feedback on the Earth system. They are therefore not topics included within the IGBP research agenda.

The separation of so-called systemic changes from cumulative changes is merely one of temporal and in some instances spatial distance which separate cause and effect. Feedback from the geocentric perspective is measured on temporally limited and spatially defined scales. Ozone depletion is actually a cumulative change, in that it results from release of ChloroFluroCarbons (CFC's) at discrete locations around the globe, but its impact on

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the Earth system is observed in a single environmental compartment - the stratosphere - within a short period of time - years - hence it is for the purposes of these definitions, systemic.

The short time-lapse between cause and effect in this example reflects the comparatively rapid mixing and diffusion processes in the atmosphere, and its comparative uniformity and homogeneity. This contrasts with the oceans which are highly stratified, physically divided into compartments of different scales (ocean basins, semi-enclosed seas, abyssal depths, and continental shelves, amongst others), and in which the mixing and diffusion processes are much slower, decades to centuries. Demonstrating cause and effect when the two are separated by long time periods is clearly more difficult than in the case of short term reactions of the Earth system to anthropogenic forcing. Nevertheless, the importance of such longer-term interaction cannot be ignored, as recognised by the climate modelling community, in its current endeavours to build coupled ocean-atmospheric Global Circulation Models.

The overall aim of the IGBP is:

> "To describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions."

Central to the theme of the IGBP therefore is the interaction between chemical, physical and biological processes. Most biological subsystems are relatively complex in that they contain numerous individuals, species and populations each with their characteristic metabolic rates, life styles and life expectancies. Changes in one species effect changes in other species in the same community to varying degrees, depending on the relationships between the species concerned. Changes in the abiotic environment affect different species differently, hence altering the balance between the different species in the biotic community as a whole, and from the geocentric view of global change, altering the role of the biological subsystem in biogeochemical cycles. The buffering capacity of biological systems in terms of the slowness of their response to chronic or low levels of external forcing, causes delay, or may even mask, the overall system response. Non-linear responses are often characteristic of biological subsystems. The difficulties of modelling in the oceanic realm are also compounded by the truly three-dimensional universe which marine biota exploit compared with the more two-dimensional universe of terrestrial organisms.

Our capacity to model the processes in biological systems is extremely limited, hence our capacity to predict how changes in physical or chemical limiting factors will affect the biological compartment directly and alter its role in global cycles is correspondingly limited, as is our ability to predict the impact of changes in one biological compartment due to human use of that compartment. We cannot say definitively therefore that the present decline in teleost biomass in the world's coastal oceans does not feedback on global biogeochemical cycles and hence the earth system as a whole. Equally, we cannot prove that it does. The Scientific Committee of the IGBP has placed lower priority on resolving this uncertainty than on addressing other more pressing issues.

Given that the anthropogenic inputs of nutrients, particularly nitrogen and phosphorus to the oceans, are now equivalent to and in some areas exceed the natural rates of transfer from land to ocean, and given also that the main limiting factors for primary production in the marine environment are generally nitrogen and phosphorus, changes to the rate of carbon fixation in coastal waters and hence temporary and perhaps permanent sequestration of carbon must be occurring - or are they? The question cannot be definitively answered at present simply because data concerning the role of coastal oceans in the undisturbed carbon cycle are inadequate to provide a baseline against which to measure change in the coastal carbon cycle. Hence 'global change' due to these changes in the role of the coastal subsystem in the global carbon cycle cannot be quantified. We do not know whether the world's coastal oceans are being changed from systems with predominantly internal cycles of production and consumption (the presumed pre-industrial condition) to systems which are based more on external inputs of organic carbon. This is one of the process issues which is to be addressed by LOICZ and hence has been given priority by IGBP.

The geocentric view of global change views humans as a driving force of change. Hence, for example, CO_2 emissions are calculated in relation to human population numbers and fossil fuel consumption, thus providing input data to the models of the anthropogenically disturbed carbon cycle. The anthropocentric view of global change considers environmental or Earth system changes as one of many drivers of social and economic change, for example, deforestation or desertification are measured in terms of changes in land quality and productivity and hence as driving forces of social and economic change and migration.

But the two views (the natural and social science perspectives) as exemplified by the IGBP and the Human Dimensions of Global Environmental Change (HDP) are merely the two halves of a feedback loop which cannot be considered, analysed, or understood independently of one another. IGBP and HDP are jointly trying to address this issue of mutual feedback, through the development of a co-sponsored Core Project on land-use and cover change, LUCC. This Core Project aims to address both sides of this relationship, while recognising the importance of humans as drivers of change since this

Anthropogenic change in the coastal areas is intense since:

- That is where the majority of people presently reside, resulting in comparatively high existing population densities
- Rates of growth in coastal populations are usually greater than rates of growth in land areas due to migration of permanent residents
- Most international tourism is coastal
- 90% of land-based pollution including sewage, nutrients and toxic materials remains in the coastal ocean
- Much of the fertile agricultural land in tropical countries is coastal, hence land-use and cover change are most intense in coastal margins
- Earlier this century anthropogenically driven flux of sediment from land to ocean exceeded natural rates of flux
- On continental scales the rates of sediment flux is now considerably reduced, due to dam construction and large scale irrigation schemes (a reversal of previous trends)
- The anthropogenic flux of dissolved nutrients from land to coastal ocean is now equal to and in some areas greatly in excess of the natural flux

direction of forcing is dominant at this point in human history. The impact of changes in vegetation cover, as a consequence of anthropogenic changes in land-use, on the Earth system, is apparently a 'given' since it is assumed that these changes alter the biospheric storage of carbon. The systemic basis for inclusion of LUCC in IGBP is therefore obvious.

Economic and social impacts of global change on coastal systems (Focus 4 of the LOICZ science plan) represent another area in which the interplay: between the natural and social sciences; between HDP and IGBP; between the anthropocentric and the geocentric; and between systemic and cumulative views of how global change is occurring. The logic for the inclusion in an IGBP project of what is, in the view of many natural scientists, essentially a social sciences focus is based on the importance of coastal zones both to human populations and to global biogeochemical cycling.

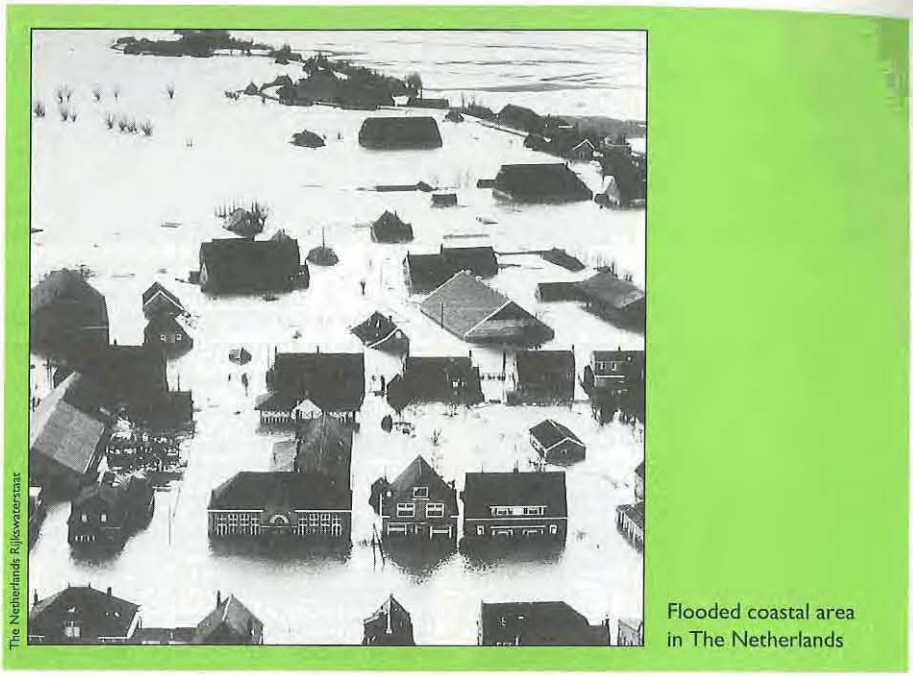
The LOICZ science plan (IGBP, 1993) defines for the purposes of this Core Project, the coastal zone as:

> "extending from the coastal plains to the outer edge of the continental shelves, approximately matching the region that has been alternately flooded and exposed during the sea level fluctuations of the late Quaternary period".

Regarding changes in the coastal zone that are driven by changes to the Earth system, theory suggests that global warming will result in a rise in global mean sea level, hence coastal areas will be impacted by potential changes not only to the climate system but to sea level. The potential impacts of environmental changes on humanity may therefore be greater in this compartment of the geosphere-biosphere system than in many other areas of the surface of the globe, since the range of geocentric drivers of change includes not only climate change in the broadest sense of changes in temperature, rain fall and wind regimes, but also includes changes in ocean climate, storminess, and flooding.

At the same time, anthropogenically driven change is arguably more intense in coastal areas than elsewhere on the surface of the globe (Box 1).

We must conclude therefore that the primary driving forces for immediate change (years to decades) in the coastal domain are direct anthropogenic influences, but that longer term changes (decades to centuries) may be driven by environmental system changes (climate and sea level). Furthermore, we cannot quantify at regional or global scales, the impacts of anthropogenically driven change in coastal systems, and hence cannot describe the scale and in some instances the actual direction of changes to the Earth system which result from anthropogenically driven cumulative changes in biosphere-geosphere elements of the coastal domain. Hence the obvious need for LOICZ to be involved in the scientific investigation of anthropogenically driven coastal changes and their implications for global Earth system functioning.



The Netherlands Rijkswaterstaat

Flooded coastal area in The Netherlands

It is in this area of LOICZ research in general, and in economic and social impacts of global change on coastal systems in particular, that some confusion exists concerning the more specific objectives of LOICZ. This confusion arises from the fact that the **science of anthropogenically driven change** is often confused with **the management of the immediate consequences of these changes.** LOICZ research is concerned with the science of anthropogenically driven change in coastal systems.

The argument is often advanced that research on the anthropogenic driving forces of change belongs to the domain of the social sciences rather than as a component of the LOICZ Project, which is primarily concerned with biogeochemical processes and the role of coastal systems in these processes. The corollary of this argument is that LOICZ should merely take the outputs of the LOICZ natural sciences research on geocentric change and use this as input for data for their models of social change.

Whilst these arguments are superficially attractive in that they simplify the lines of responsibility and place defined limits on the research domain of each community, they are in reality specious, since the temporal scales over which the two driving forces of coastal change operate are different, the spatial scales are different, and the whole is almost certainly greater than the sum of the parts. In reality, the way in which natural and social science data are collected and models constructed independently of one another, precludes their easy integration or assimilation by each research community. There is therefore a need to engage both research communities simultaneously if the spatial and temporal domains of both datasets are to be congruent, and if coupled natural and social sciences models are to be developed.

A real intellectual challenge exists therefore in developing coupled interdisciplinary models which fully integrate both types of data in describing and ultimately predicting the nature of change in coastal systems. The entire feedback loop must be examined, analysed and described if we are to understand the role of coastal system in the Earth system as a whole (the IGBP and LOICZ natural sciences objective), or to understand the way in which environmental change affects society (the HDP and LOICZ social sciences objective), or to manage human activities in the coastal zone with a view to halting or slowing the present rates of change, and avoiding or mitigating the adverse consequences of global changes (the IPCC and management objective).

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Deposition of Biogeochemically Important Trace Species (DEBITS)

An activity of the International Global Atmospheric Chemistry Project (IGAC)

The long-term aim of IGAC is to develop models that integrate relevant biospheric and atmospheric processes for a wide suite of atmospheric species, contributing to a predictive capability for the atmospheric and Earth system as a whole, under conditions of global change. This is a formidable task that requires an integrated and interdisciplinary approach and a cooperative effort involving many scientists from different countries.

IGAC is presently structured as five regional Foci (Marine, Tropical, Polar, Boreal, Mid-latitude), a Global Focus, and a Fundamental Focus. Each Focus consists of a number of Activities which comprise achievable endeavours addressing the major IGAC goals and objectives.

Focus 2 of IGAC addresses Natural Variability and Anthropogenic Perturbations of Tropical Atmospheric Chemistry, a topic that acknowledges the importance of tropical regions to global atmospheric chemistry and global change. DEBITS is one of the four activities in this vitally important area.

The reasons for a focus on the atmospheric composition and chemistry of tropical regions have been well articulated in recent years, and apply equally to many important atmospheric constituents. They were given, for example, in Global Change NewsLetter No. 19, September 1994, in the pull-out section on ITOY (International Tropospheric Ozone Years), and may be paraphrased as follows:

1. Urban, industrial and agricultural growth are increasing rapidly in the tropics, bringing with this growth strong increases in emissions of anthropogenically-derived, reactive, atmospheric pollutants.
2. The large fluxes of solar UV radiation, high temperatures and high water vapour content of the tropical atmosphere promote intense photochemistry all year round in this part of the lower atmosphere. Anthropogenic perturbations to this very active chemical system have the potential to increasingly affect human and plant health, atmospheric acidity, the levels of important greenhouse species and other climatically active atmospheric constituents (e.g., aerosols and clouds) as emissions grow.
3. Deep convection common to tropical regions can provide a rapid vertical transport path that causes surface emissions to be lofted efficiently into the upper troposphere, so that atmospheric chemical effects of emissions are not simply limited to the lower atmosphere but have a more widespread influence.

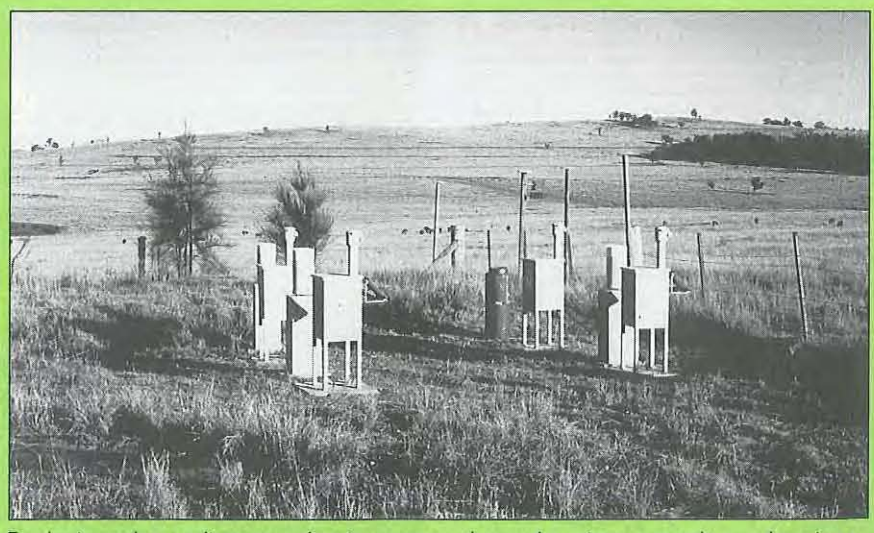
The initial focus of DEBITS has been on the atmospheric sulphur and reactive nitrogen cycles, which have been highly perturbed globally by anthropogenic emissions from the power, transport, agricultural and other industries. It makes an interesting contrast to note that in the last two centuries human activities have increased the global atmospheric carbon cycle only a few percent, but have increased the global atmospheric sulphur cycle by 300%; the global reactive nitrogen cycle has been perturbed in similar fashion.

It is now widely recognised that consequences of these increases to the atmospheric throughput of reactive S and N include elevated levels of acidic deposition, atmospheric haze and photochemical smog, including increased levels of tropospheric ozone. The initial implementation of the DEBITS Activity could not address all these issues, but building on earlier work undertaken in the SCOPE Project 36, Acidification in Tropical Countries, concentrated its first efforts on acid deposition in tropical Asia, the part of the tropics in which economic growth was most rapid, and where the doubling time for S and N emissions was as little as 15 years according to some projections. It is now generally acknowledged that by the turn of the century the Asian region overall will clearly dominate over Europe and North America as the largest source region globally for S and N emissions.

The Asian Initiative

DEBITS launched the Composition and Acidity of Asian Precipitation (CAAP) experiment via a planning workshop held in Singapore in 1991, followed by a progress meeting held in Bombay in 1993. In tropical Asia where data coverage has been especially sparse (as in the tropics generally) and local scientific resources have not been large, the initial emphasis has been on rainwater composition measurements and determination of gaseous SO_2 and NO_2 concentrations, the latter using inexpensive passive sampling devices of Swedish origin ('Ferm' samplers). Rainwater samples for chemical analysis are collected using 'wet-only' samplers that exclude dry deposition during dry periods.

DEBITS has not been predicated on short-term process studies, but on the basis of a need for high quality, multi-year



Emphasis on data quality: wet-only rainwater samplers and passive gas samplers undergoing a performance comparison prior to installation at separate field measurement sites

data records that will provide a continuing record of the 'dose' of atmospheric S and N species delivered to the earth's surface, as well as a record of temporal changes that may be interpreted with chemistry/transport models to define the atmospheric effects of ongoing secular changes in emissions. Accordingly the DEBITS approach has been, where possible, to seek collaboration with existing measurement programs and relevant agencies in countries covering the region of interest, so that long-term measurement support may be assured. A consequence of this approach, that must always attend the coupling together of disparate contributions to a larger network, is a strong need to emphasise data quality, and quality assurance procedures, to ensure compatibility of the different datasets.

Collaboration with other relevant international activities is also of considerable importance, both as a means of avoiding duplication, and as a means of ensuring the wider relevance of DEBITS. A particularly important connection is that with the Global Atmospheric Watch (GAW) of the World Meteorological Organisation. Many of the people involved in DEBITS/CAAP are also involved in GAW.

The CAAP aim of providing a number of representative data sets from sites spread broadly across Asia/SE Asia has been difficult to implement in many countries because local resources for atmospheric sciences are often severely limited. In a few cases seed funding has been obtained (mostly from Swedish and Australian sources) by DEBITS participants to enable the setting up of specific DEBITS/CAAP measurement sites. The result is that CAAP currently is connected, either operationally or as a recipient of data records, with wet deposition and/or passive gas sampling sites stretching from tropical Australia, through to Papua New Guinea, Fiji, Indonesia, Malaysia, India, Thailand and Hong Kong.

Broadly speaking the results available to date confirm expectations based on regional emissions densities : deposition of acidic S and N is low in locations such as tropical Australia and Fiji, where regional anthropogenic emissions are small; however in places such as Hong Kong and west Java in Indonesia, where regional emissions are high, acidic deposition occurs at levels comparable with those that have caused concern in Europe and north America. A singular feature emerging from these early results is the conclusion that dry deposition of acidity often exceeds wet deposition of acidity, so the often loosely used term "acid rain" is a misnomer that is not employed in DEBITS.

At this stage a number of the sites have been in operation for a relatively short time, and data quality issues remain paramount. However as time goes on the DEBITS datasets will be integrated into newly emerging regional and global observational databases against which transport/chemical models must be validated. Some modelling of this type has already commenced within the DEBITS community. However in the main DEBITS will remain fixed on providing high quality, representative observational data from tropical regions not yet well served by other programs, with a central theme related to acidic deposition. Related questions are already being addressed by other IGAC Activities, for examples the role of tropical biomass burning is addressed by BIBEX, and building of high quality regional (and global) emissions inventories is being addressed by the IGAC Global Emissions Inventory Activity (GEIA).

The African Initiative

The following stage of development for DEBITS took place in equatorial Africa at a highly successful planning workshop in December 1994 under the joint sponsorship of IGAC DEBITS and MEDIAS-FRANCE (Regional Research Network for the Mediterranean Basin and Subtropical Africa - a Toulouse-based programme of the National Centre for Space Studies). A draft plan for the African part of DEBITS was produced at this meeting (IDAF - IGAC DEBITS AFrica) to initiate for Africa a network of measurements comparable with CAAP in Asia. A subsequent focus on central and south America is highly desirable, but has not at present advanced sufficiently to warrant a planning workshop.

DEBITS has now reached the point where new, high quality data on rainwater composition, and SO_2 and NO_2 concentrations, have begun to emerge for tropical regions where to date data have been either nonexistent, or of questionable quality. Some of these new data will be presented and discussed at the "Acid Reign? 95" Conference in Gothenburg, Sweden, in June 1995. We believe these new data will provide further confirmation of the importance of human expansion in the tropics as a source of global atmospheric change, and of the need to obtain an increased quantitative understanding of the ways in which this change may impact on regional ecosystems and global atmospheric chemistry and climate.

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TRAGNET: Building a U.S. Trace Gas Network

In September, 1992 a scientific and organisational planning workshop was held at Pingree Park, Colorado to develop a programme to integrate sites across North America where fluxes of CO_2, CH_4 and N_2O and other trace gases are being made. Concomitantly, the development and implementation of quantitative flux models at several geographic scales was planned. This Trace Gas Network (TRAGNET) is designed to fulfill the U.S. contribution to the worldwide program being established under the auspices of IGBP/International Global Atmospheric Chemistry Project (IGAC). The project relates particularly to IGAC Activity 5.2 (TRAGEX), which is specifically aimed at characterizing trace gas fluxes in the mid-latitudes. TRAGNET, however, will utilize data from both more northern and more southern locations as well. In September, 1994, the U.S. National Science Foundation provided funds to permit establishment of a TRAGNET activity. Under this program, TRAGNET will establish a database and model analyses to be used in determining general relationships of trace gas exchange across broad environmental gradients in climate, atmospheric deposition of N, and soils. The Network includes, as a core, many LTER (Long-Term Ecological Research) sites and other long-term research sites where trace gases are being measured, and locations where trace gas model development is being conducted. Establishment of models and data bases with which to use the models is being initiated at the Natural Resource Ecology Laboratory at Colorado State University as a task of TRAGNET. Persons conducting trace gas measurements or modelling of trace gases are encouraged to participate in TRAGNET.

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Asia and Global Change

Global Change in Asia and the Pacific

The Scientific Symposium on Natural and Anthropogenic Changes: Impacts on Global Biogeochemical Cycles, which will be held on 23-25 October 1995, in association with the Fourth Scientific Advisory Council for the IGBP (SAC IV), is the second major international science conference on global change organised by the Chinese National Committee for the IGBP in Beijing.

The International Symposium on Global Change in Asia and the Pacific Regions was held in August 1994 at the Beijing International Convention Centre, China, where the Scientific Symposium in conjunction with SAC IV will take place. It was organised in association with the Chinese Academy of Sciences, the Chinese National Committee for the Pacific Science Association, and the Chinese National Climatic Research Committee.

Recommendations on key scientific issues that should receive more attention in the Asian and Pacific region were:

- Past Global Changes. The emphasis was on data needs: greater digitised data banks with normalised information; a 'time-slice' approach with mapping of time-slices across intervals of important changes, quality checks; comprehensive exploitation of loess/palaeosol successions as a climate record and as a sensitive climate proxy.
- Global Change Impact and Terrestrial Ecosystems needs an international exchange on biological studies; multidisciplinary cooperation on research, experiments, monitoring and modelling; and information sharing;
- Variability of the Climate System studies require development of various coupled climate models, including those key physical, chemical and biological processes; studies on multi-scale structure and interactions; and studies on predictability, theory and methods of climate and global change.
- Biogeochemical Cycles and Greenhouse Gases studies should address the trade-off between CH_4 and N_2O; modelling of paddy CH_4 emission; mitigation of CH_4 and N_2O emission; and monitoring background concentrations of O_3, CO_2, N_2O, CFC.
- Earth observations for global change in the region require strengthening the application of remote sensing to global change; and studies on theory and methods of extracting information and data from satellite images.

In addition to data and information sharing through international cooperation, participants called for establishing user-contacts in related disciplines such as anthropology, history, archaeology, geography, meteorology, and climatology.

Chinese National Programme for Global Change Studies

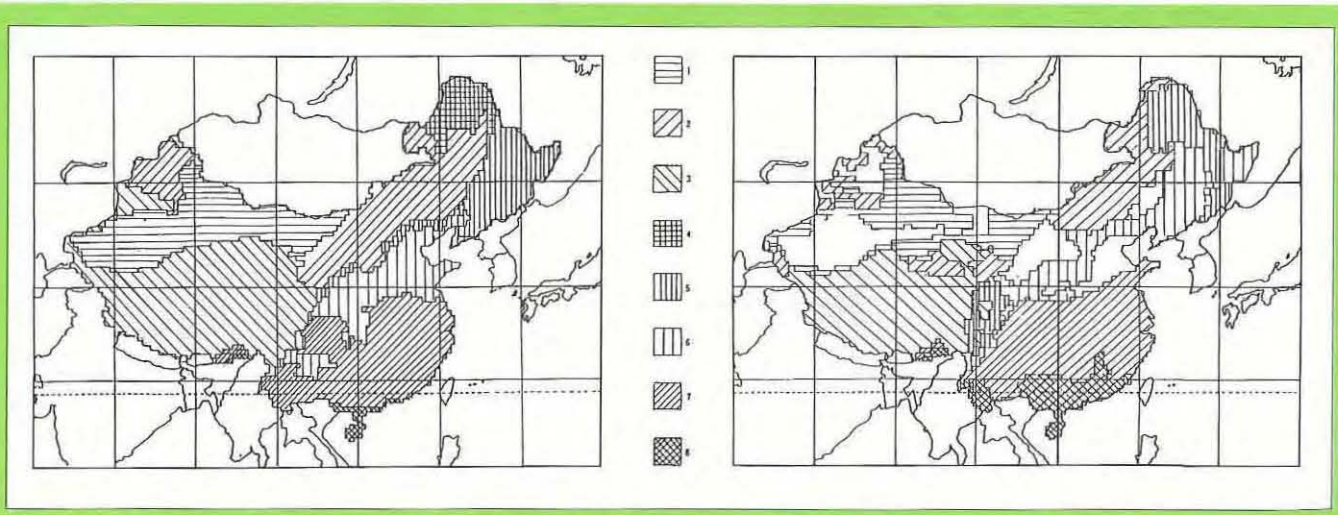
The first priority for the programme is China's environmental problems. The programme will furnish the government with research results as the scientific basis for making strategies for the management of natural resources, economic development and environmental protection.

China is a significant part of the world with about one-fifth of the world population and more than 5000 years of civilisation. She has contributed to the changing global environment in all aspects, beneficial and adverse. The programme therefore focuses on those problems which are not only important for China, but also have global significance.

The life-supporting environment in China responds to changes in external conditions and load-bearing capacity which are characterized by complexity, variability, periodicity, sensitivity, and fragility. Because of its large portion of the world's population, China's environment and the damage it has sustained due to human actions have a global impact.

The major environmental problems in China are:

- The emission of trace gases and the resulting greenhouse effect
- Drought and fresh water shortage



Distribution of characteristic vegetation paterns in China under current climate (1951-1980)

Characteristic vegetation patterns in China under projected climate change by composite GCM scenario for 2050

1, temperate desert; 2, temperate steppe; 3, Qinghai-Tibetan alpine vegetation: 4, cold-temperate coniferous forest; 5, temperate mixed coniferous broadleaf forest; 6, temperate deciduous broadleaf forest: 7, subtropical evergreen broadleaf forest: and 8, tropical rain forest

Wang and Leemans, 1992. Climate Change due to the Greenhouse Effect and its Implications for China (WWF, London)

- Vegetation damage, particularly with regard to industrialisation and urbanisation, deforestation and over-grazing
- Soil erosion and land deterioration

Based on the characteristics of the ecological environment and on the problems faced in China, the basic scientific issues that will be addressed are: sources and sinks of trace gases; global and climatic changes; the role of changing land-use patterns in global change; transitional zones of climate and ecosystems in global change; global change impact studies: and past global change records.

The first objective of the national programme is to describe and better understand the ecological environmental changes in China by studying the interactions between the components of the Earth system, the interactive physical, chemical and biological processes and the man-induced and natural global changes. The second objective is to detect in sensitive zones (those areas that are transitional zones between vegetation and biomes with different temporal and spatial scales) the early signals of significant environmental changes on a time scale of decades and centuries; and finally to furnish the research results to decision makers as the scientific basis for the management of natural resources, economic development, and environmental protection. Research results are expected:

- To evaluate where we are now in the history of environmental evolution in China and to assess the impact of human activities
- To detect the early signals and features of abrupt environmental changes
- To understand the major processes of environmental changes, with a focus on the role of biological processes in climate change and hydrological cycles
- To develop a methodology for projecting large-scale features of environmental changes in China over the next 20-50 years.

For further reading, refer to *Global Change Report (No. 1)*, First report of IGBP-related studies in China, edited by Ye Duzheng and Chen Panquin, published by the China Meteorological Press in 1994. This report outlines the background, planning principles and current status of global change research, providing a base for further understanding China and conducting international cooperation on global change issues

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People and Places

Pamela A. Matson, Vice-Chair of the International Global Atmospheric Chemistry Project (IGAC), has been elected member of the US National Academy of Sciences.

Pamela A. Matson

Pam Matson is professor in the Environmental Science, Policy and Management Department at the University of California. Her research has focused on the effects of natural and anthropogenic disturbances on biogeochemical cycling and trace gas exchange in topical ecosystems. She has developed an ecologically-based global budget for the greenhouse gas nitrous oxide, and has provided evidence that land-use change and agricultural intensification in the tropics may contribute significantly to the increasing atmospheric concentration of that and other gases. She is now working to examine interactions between managed and natural ecosystems, and to examine, with a multi-disciplinary team, the economic drivers and environmental consequences of land-use decisions in the developing world.

Prof. Matson is a member of the NAS Committee on Atmospheric Sciences, chaired by **William L. Chameides,** Convener of the IGAC Activity on Mid-Latitude Ecosystems and Photochemcial Oxidants.

Other members of NAS active in the IGBP are **Edward A. Frieman,** Chair of the US National IGBP Committee, and Chair of the NAS Board on Global Change, and **Thomas F. Malone,** who was instrumental in the initial creation of a Geosphere-Biosphere Programme.

BAHC has moved!

The BAHC Core Project Office moved to the Potsdam Institute for Climate Impact Research (Germany) on 1 March.

The Potsdam Institute (PIK - Potsdam-Institut für Klimafolgenforschung) was created in 1992 by the German Ministry for Science, Research and Culture of the State of Brandenburg and the Federal Ministry for Research and Technology. Its basic mission is to investigate the consequences of global climate change as a paradigm for the unfolding fundamental crisis between the ecosphere and humanity.

An 'holistic' perspective of system Earth is envisaged, based on integrated models taking into account the intensive long-range interactions between atmosphere and other natural spheres (hydrosphere, biosphere, pedosphere). This also applies to feedbacks between global change and the anthrosphere (economic, social and political reactions, such as change in land-use or provisions to reduce greenhouse gas emissions). PIK has set up its research groups as a matrix so that interactions will take place between disciplines. Climate is central to this matrix and is surrounded by groups working on Global Change and Natural Systems, Global Change and Social Systems, Integrated Systems Analysis and Data Computation.

PIK sees itself as acting as an integrator of research across disciplines and at various temporal and spatial scales. It also envisages itself as a 'virtual' centre in which national and international research cooperation in such fields as meteorology, ecosystem research, environmental technology, resource economics, and environmental sociology are welcomed.

The Vice-Chair of the BAHC Scientific Steering Committee, Dr. **Alfred Becker,** is a member of staff in PIK in the Global Change and Natural Systems group, headed by Prof. **Wolfgang Cramer** (GAIM Task Force member and GCTE activity leader). Prof. **Hans-Joachim Schellnhuber,** the Director of PIK, is a member of the Global Change Council of the Federal Government of Germany.

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Progress Report on Free-Air CO_2 Enrichment (FACE) Wheat Experiments

Bruce A. Kimball, Paul J. Pinter, Jr., Gerard W. Wall, Douglas J. Hunsaker, Richard L. Garcia, and Robert L. LaMorte
U.S. Water Conservation Laboratory, Agricultural Research Service, USA

Research that contributes to achieving IGBP scientific objectives is carried out in different projects all over the world. Results of core research - that which addresses global-scale objectives - of particular importance for wheat are given here.

Two free-air CO_2 enrichment (FACE) experiments were conducted at Maricopa, Arizona on the wheat ecosystem from December 1992 through May 1993 and again from December 1993 through May 1994 (Fig. 1). Devoid of walls, the FACE approach enabled the effects of elevated levels of CO_2 to be studied under natural field conditions. Because it is so vital to predict the effects of the increasing atmospheric CO_2 concentration on vegetation and ecosystems in general and especially on wheat, the world's most important food crop, these experiments have been designated as Core Research for the Global Change Terrestrial Ecosystems (GCTE) Core Project. They contribute to GCTE Focus 1, both Activity 1.1, "Effects of Elevated CO_2" and Activity 1.3, "Effect of Changes in Vegetation on Water and Energy Fluxes." The experiments especially contribute to GCTE Focus 3, Activity 3.1, "Effects of Global Change on Key Agronomic Species," in this case the GCTE Wheat Network.

The FACE apparatus was designed by personnel from Brookhaven National Laboratory (Hendrey, 1993; Dugas and Pinter, 1994). It consists of four toroidal plenum rings of 25 m diameter constructed from 30-cm irrigation pipe (Fig. 1). The rings had 32 2.5-m-high vertical vent pipes spaced at intervals around the periphery. Air enriched with CO_2 was blown into the rings and exited through holes at various elevations in the vertical pipes. Each vertical vent pipe had an on/off valve at its base. Wind direction, wind speed, and CO_2 concentration were measured at the center of each ring. A computer control system used wind direction information to turn on only those vertical pipes upwind of the plots, so that the CO_2-enriched air flowed across the plots, no matter which way the wind blew. The system used the wind speed and CO_2 concentration information to adjust the CO_2 flow rates to maintain 550 ppm by volume CO_2 concentration across the FACE rings. Four matching Control rings at ambient CO_2 (about 370 ppm) but with no air flow were also installed the field.

In addition to the two levels of CO_2, there were ample (Wet) and limiting (Dry) levels of water supply applied to separate halves of each ring in a split-plot design. The water was supplied through a subsurface drip irrigation system. The Wet or well-watered plots received 100% replacement of potential evapotranspiration (adjusted for rainfall), with irrigations being initiated when 30% of the available water in the rooted zone was depleted. The Dry or water-stressed plots received 50% of the amount applied to the Wet plots. With two levels of water supply and two levels of CO_2 each replicated four times, there were a total of 16 plots.

Fifty scientists from 25 different research organizations in 8 countries have participated in these experiments. We are grateful for the contributions of our many collaborators; however, there are too many to acknowledge individually in this brief report. All together, our measurements include: leaf area, plant height, above-ground biomass plus roots that remained when the plants were pulled, apical and morphological development, canopy temperature, reflectance, chlorophyll, light and water use efficiency, energy balance, evapotranspiration, soil and plant elemental analyses, soil water content, sap flow, root biomass from soil cores, photosynthesis, respiration, stomatal conductance, leaf water potential, carbohydrates, photosynthetic proteins, antioxidants, phenolics, stomatal density and anatomy, digestibility, decomposition, grain quality, soil CO_2 fluxes, and changes in soil C storage as inferred from soil and plant C isotopes. Several collaborating wheat growth modellers plan to utiliese our data for validation, along with other data obtained at other locations in the GCTE Wheat Network.

This research was supported by the Agricultural Research Service, U. S. Department of Agriculture, including the U.S. Water Conservation Laboratory, Phoenix,

Figure 1.
View of one of the free-air CO_2 enrichment rings on 19 March 1993, during the 1992-3 FACE Wheat Experiment at the University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona, USA.

Arizona; the Grassland Soil and Water Research Laboratory, Temple, Texas; and the Plant Stress and Protection Group, Gainesville, Florida. Operational support was also contributed by the Potsdam Institute for Climate Impact Research, Potsdam, Germany; by the NASA Goddard Space Flight Center, Greenbelt, Maryland; by the Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado; and by the Department of Soil Science, University of Alberta, Edmonton, Alberta, Canada. We also acknowledge the helpful cooperation of the staff at the University of Arizona, Maricopa Agricultural Center. The FACE apparatus was furnished by Brookhaven National Laboratory.

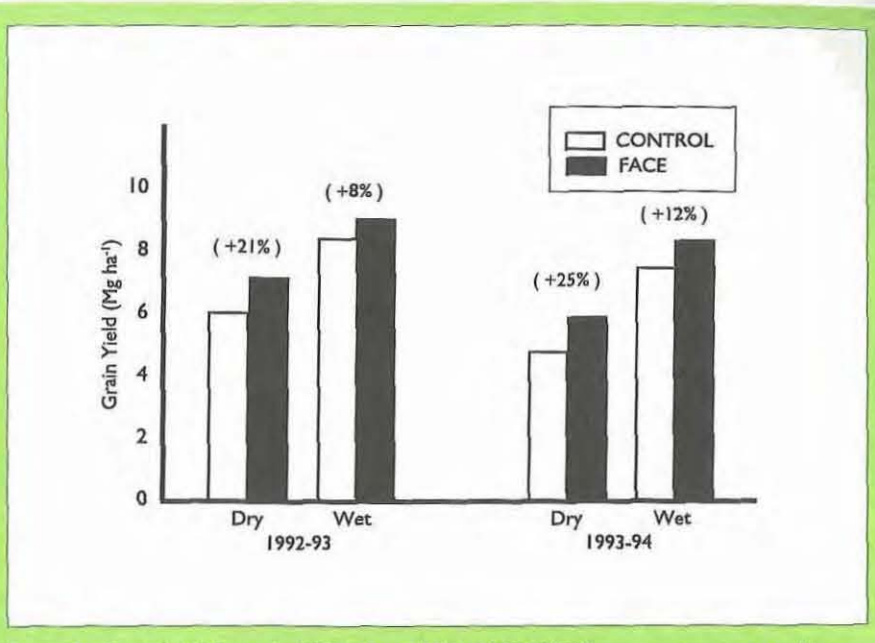

Figure 2. Grain yields from the 1992-93 and 1993-94 FACE Wheat experiments at ambiant control (about 370) and FACE (550 ppm) levels of CO_2 and at Wet (well-watered) and Dry (water-stressed) levels of irrigation. Numbers in parentheses refer to percentage stimulation by elevated CO_2.

It is beyond the scope of this report to review the results obtained by the numerous workers, and in many cases the analyses are not complete. Briefly however, wheat responded much differently than the cotton we had studied previously. The cotton increased its growth and yield about 40% with enrichment to 550 ppm at both ample and limited supplies of water (Mauney et al., 1994).

In contrast, the wheat had little aboveground growth response to elevated CO_2 early in the season in January when temperatures were cool. Then as temperatures warmed into spring, the FACE plants grew about 20% more than the Control plants at ambient CO_2 both above- and below-ground. In contrast to many laboratory experiments, there was little acclimation of photosynthesis. Instead, we found that elevated CO_2 increased daily net canopy photosynthesis by averages of 19 and 44% for the Wet and Dry treatments, respectively, over most of the 1992-3 season.

Then, in May a surprising thing happened. The FACE plants matured and senesced 7-10 days earlier than the Controls. The FACE plants averaged 0.6°C warmer than the Controls all season long in the well-watered plots, and we speculate that this temperature rise contributed to the earlier maturity. Because of the acceleration of senescence, there was a shortening of the duration of grain filling, and consequently, there was a narrowing of the final biomass and yield differences (Fig. 2). For both the 1992-3 and 1993-4 growing seasons, the mid-season growth advantage of FACE of about 20% shrunk to about 10% in the Wet plots, while the differences remained at about 20% in the Dry plots (Fig. 2).

Thus, the increasing atmospheric CO_2 concentration should be beneficial to future agricultural production, especially to indeterminate woody crops like cotton growing in warm climates, provided water supplies do not change significantly. Cool-season determinate herbaceous crops like wheat probably will benefit also, but not as much. Yet, a 10% increase in yield under well-watered conditions with enrichment to 550 ppm would be quite important, and furthermore, a 20% increase in wheat yields under dry conditions would go far toward compensating for any future decreases in precipitation.

In addition, the energy balance and the sap flow data showed decreases in evapotranspiration of about 10% in the Wet plots. The soil water balance measurements showed similar trends, although the differences were not statistically significant. Thus, irrigation requirements may be somewhat reduced for future wheat production, provided climate changes are minimal.

FACE wheat experiments at ample and limiting supplies of soil nitrogen will be conducted in 1995-6 and 1996-7 in the same field at the Maricopa Agricultural Center. The experiments will be funded by the U.S. Department of Energy through a grant to the University of Arizona. U.S. Water Conservation Laboratory personnel will continue to be major collaborators on the project and will help with management. To prepare for these upcoming experiments, the FACE field at Maricopa has been planted with a crop of oats which will be green chopped and removed from the field in order to withdraw as much nitrogen as possible from the soil. During the summer of 1995, new drip irrigation tubing will be installed, and the plots will be moved about 30 m south of their present locations. We plan to plant on 27 November 1995 or shortly thereafter. For more information, contact the authors above or Dr. Steve Leavitt, Tree Ring Laboratory, University of Arizona, Tucson, Arizona 85721.

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The Canadian Global Change Program

by Dave Henderson, Information Coordinator, Canadian Global Change Program

Promoting Informed Action Through Sound Advice on Global Environmental Change

Founded in 1985 under the auspices of the Royal Society of Canada, the Canadian Global Change Program (CGCP) has evolved into an interdisciplinary and multi-agency network that spans the country. The CGCP brings together scientists and other specialists from many disciplines in the sciences and humanities to plan interdisciplinary research, assess the significance of this research in a policy context and communicate the implications to its target audiences. The CGCP is characterized by its independent, non-governmental status and its combined treatment of the natural and human dimensions of global change.

The CGCP's operational framework is shown in Figure 1. The Program is governed by a Board of Directors composed of senior decision makers from government, industry and non-governmental organisations, as well as leading academics. Contributing to the Board are Research/Policy and Communications Committees concerned with Program content and activity. The Research/Policy Committee is also the Canadian National Committee (CNC) for the IGBP. Reporting to the Research/Policy Committee are a number of research panels and project teams. An Ottawa-based Secretariat of five people supports the entire framework.

The CGCP is working both alone and with partners to ensure that the best possible knowledge about global change can be transformed into options for policy decisions and is communicated effectively to all sectors of society, encouraging lifestyle changes that facilitate sustainability.

In keeping with this orientation, Panel reports have examined a variety of issues important to Canadians, including lake acidification, options for greenhouse gas emission reduction, data and information, and long term ecosystem research and monitoring. Ongoing communications of interim and final global change research results occurs through the CGCP's newsletter, DELTA, and by publishing and distributing research plans, reports, short issue bulletins and educational materials and teachers' guides.

This year the Program has undertaken a number of new initiatives. They include the integration of global change concerns into environmental assessment (a project undertaken with the Canadian Environmental Assessment Agency and the International Study on the Effectiveness of Environmental Assessment), a water issues forum with the Canadian Water Resources Association, and a study examining transportation and climate change with the Ontario Round Table on Environment and Economy.

On a broader scale, the CGCP's new strategic plan focuses the Program on the following interrelated thrusts:

Research Assessment and Policy Options
Assessing outcomes of research in high impact areas to provide policy options for decision makers; identifying knowledge gaps, filling them and developing opportunities for Canadians internationally; providing state of the art reviews of Canadian global change research.

Research Planning and Collaboration
Integrating global change research; enhancing Canada's role in international research programmes; creating mutually beneficial partnerships.

Information Management
Managing and brokering information on global change activities and expertise; developing products and services tailored to needs; maintaining a global change information resource centre.

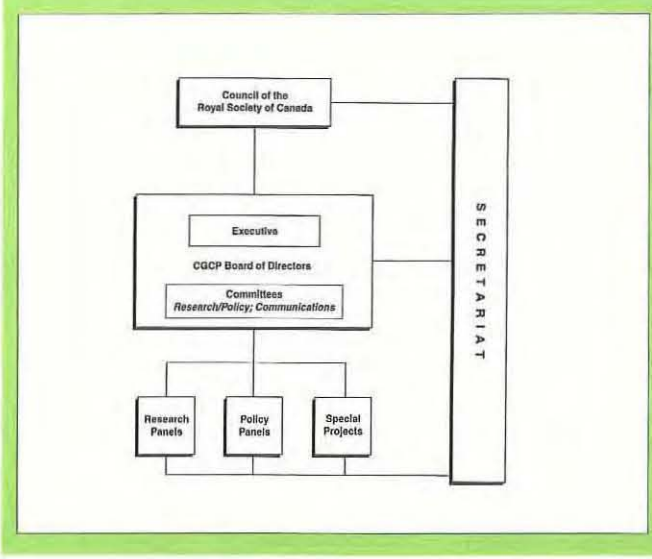


Figure 1

Operational framework of the Canadian Global Change Programme. The Research/Policy Committee of the CGCP Board acts as the Canadian National Committee for the IGBP.
The Chair of this Committee is Dr. William Leiss

IGBP & Related Activity in Canada

The CGCP does not fund global environmental research - its focus is on providing support for research planning, effective project integration and communication of results. Working closely with the Canadian Climate Program, which houses the Canadian National Committee for the World Climate Research Program (WCRP), the CGCP supports global change research planning by encouraging activities that are multi-disciplinary and multi-sectorial in composition and are of relevance to Canadians. Effective integration with other activities is accomplished by CGCP representation at the Canadian National Committee or management level of research projects.

In addition to supporting its own research panels, the CGCP works with partners to support several IGBP core activities in Canada, including the following:

IGAC

The Canadian National Committee for the International Global Atmospheric Chemistry (IGAC) project resides with the Canadian Institute for Research in Atmospheric Chemistry (CIRAC) located at York University in Toronto. CIRAC is a partnership of 50 industries, consultants, federal and provincial agencies and universities across Canada with interests in issues related to atmospheric chemistry.

JGOFS

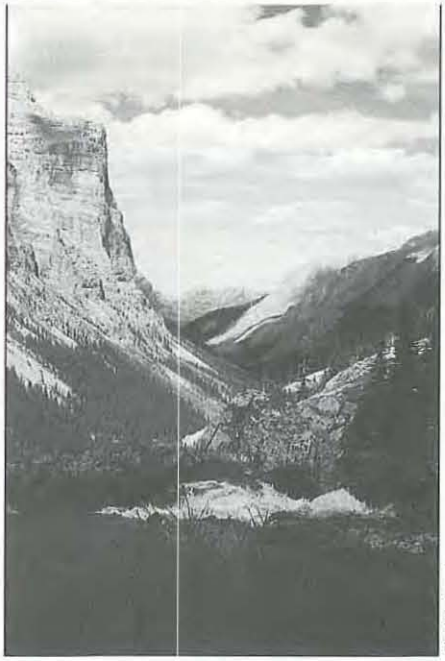
Presently in its third year of operation, the Canadian National Committee for the Joint Global Ocean Flux Study (JGOFS) oversees the major directions of this core-IGBP project. During the first three years (Phase I), the project focused on gas exchange at sea level; transformations and transport of carbon in the water column and the burial of carbon in the sea floor. Among principal accomplishments in Phase I are:

- advances in understanding the bio-optical properties of seawater that have led to improved estimates of phytoplankton production from spectral information
- extrapolation of local measurements in the North Atlantic to estimates of basin scale productivity
- extensive benthic measurements leading to a realistic diagenetic model of processes that control carbon burial in continental margin sediments
- results of *in vitro* studies showing strong enhancement of diatom production from iron enrichment in the North Pacific
- modelling of mixed layer dynamics and zooplankton grazing that provides an understanding of why the spring phytoplankton bloom is a prominent feature of the North Atlantic but not the North Pacific
- modelling of new production in the Equatorial Pacific from measurements of the surface heat flux and the deep-water nitrate-temperature relationship
- understanding contrasting trophic and carbon export characteristics at stations within the Gulf of St. Lawrence in terms of hydrodynamic conditions.

Canadian JGOFS is in the process of applying for Phase II funding to continue the project. Phase II includes plans for both a comprehensive study of the biogeochemistry of carbon in the Northeast Pacific, and modelling of results from Phases I and II (as well as other sources) to place these in a global context. The Secretariat is located at Dalhousie University in Halifax.

LOICZ

During its founding workshop in October 1994 the Canadian National Committee for the Land-Ocean Interactions in the Coastal Zone (LOICZ) project identified the Arctic as the major focus for a Canadian contribution to the global core program. A Science Plan will be formulated over the next few months and meetings with Inuit leaders will take place in March. Climate-induced change in the timing and duration of ice and snow cover in the coastal zone is expected to have a fundamental impact on the economy and social activity of the communities located in northern coastal areas.



Claude Lefrançois

Additional CGCP activities that are closely related to the goals of the IGBP are:

BOREAS

The Boreal Ecosystem-Atmosphere Study (BOREAS) is a large multi-disciplinary study that intends to understand the interactions between the boreal forest and the atmosphere to clarify their roles in global change. The BOREAS team consists of principle investigators from the U.S., U.K., Canada, France and Scandinavia. Five major data collection programs took place in 1994 - cold snow (February: hydrology and remote sensing of snow); snow melt (April - remote sensing, hydrology and trace gas measurements) and three growing seasons (May-June, July-August and September). The calibration and testing of these data are currently under way. BOREAS is an activity sponsored by the WCRP program on Global Energy and Water Cycle Experiment's (GEWEX) International Land Surface Climatology Project (ISLSCP), as well as other organisations.

PACT

Palaeoecological Analysis of the Circumpolar Treeline (PACT) is a five-year project that has been undertaken by a multi-disciplinary team of Canadian and Russian researchers to study the Holocene history of the northern treeline. The field component of PACT involves securing lake sediments, peat, sub-fossil wood and tree ring cores from sites across northern Canada and Eurasia to document the changes in the treeline position. PACT members are also involved in synthesizing data from other studies and to this end, close linkages are emerging between PACT, the National Science Foundation's (NSF) Palaeoclimates of Arctic Lakes and Estuaries (PALE) and PAGES Programs.

In addition to their contributions to the IGBP core and related activities, Canadian researchers continue to play important roles in the evaluation of the IGBP and the development of its research agenda.

Primary funding for the CGCP comes from the Canadian government's Green Plan. Other sources support the Program on a project basis. The Richard Ivey Foundation is a generous supporter of the CGCP's environmental education program. A strategy is under way to broaden this funding base, and to move to a 'fee for service' organization.

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Global Change Television Series Receives New York Festivals Award

The NASA Langley Research Center, Old Dominion University, and the Virginia Space Grant Consortium received medallist honours for the television series 'Mission EarthBound' at the International New York Festivals Awards Competition for Non-Broadcast Media and Television Programs and Promotion.

'Mission EarthBound' is a six-part teleconference detailing scientific efforts to better understand human-induced changes in the composition and chemistry of the atmosphere and on global climate.

1. Preview of the 'Mission EarthBound' series
2. The cosmic perspective: formation of the Earth, the atmosphere, and life
3. Atmospheric ozone: what is it and what is happening to it?
4. The climate system: one of the most complex systems in the world
5. Greenhouse gases and climate change
6. Challenges and solutions to global atmospheric problems

The scientific script of 'Mission EarthBound' was written by Dr. Joel Levine at NASA Langley Research Center, who served as on-camera host for the series. The television series featured slides and video-tapes of biomass burning during the Southern African Fire-Atmosphere Research Initiative (SAFARI), conducted as part of the IGAC Biomass Burning Experiment (BIBEX).

Copies of the 'Mission EarthBound' series in VHS and the Teacher's Guide can be obtained from Mark Pine, Mission to Planet Earth Program, NASA Headquarters, Washington DC 20546-0001, USA, Fax: (+1-202) 358 2891.

The 9th Meeting of the Scientific Committee for the-IGBP Thredbo, Australia

The Scientific Committee for the IGBP is tresponsible for the development of the Programme, and meets at approximately nine-month intervals to guide its implementation. In December 1994 the Scientific Committee met for the ninth time since its establishment in 1990, and for the first time in Australia.

The ninth meeting of the Scientific Committee of the IGBP (SC-IGBP) was held in early December 1994 in the small ski resort of Thredbo, Australia. For one day prior to the meeting, the members of the SC participated in a Global Change Seminar at the Australian Academy of Sciences in Canberra, Australia. A series of talks by leading Australian scientists and IGBP Core Project Chairmen provided an excellent counterpoint between national and regional focus and global interests. After this, the SC members proceeded to Thredbo for their meeting. Situated in the Smoky mountains, about a 3-hour drive from Canberra through Australian countryside, this off-season locale (late Austral Spring) offered a pleasant, inspiring and cost-effective environment for the meeting.

This was the first SC-IGBP meeting for Chris Rapley, the new Executive Director of the IGBP. Rapley presented ideas about the difference between the planning and the implementation stages of the IGBP, noting the importance of milestones and deliverables, both in demonstrating one's progress to external interests, and also as a means of measuring one's approach towards identified goals and objectives. Whereas the success of IGBP certainly depends on the success of each Core Project or Framework Activity, its success as a whole is largely dependent on the premise that the whole will be more than the sum of the parts. That requires a high level of co-ordination between the Core Projects. The successful completion of one project's activity may be dependent on another project's output. This means that the timelines generated by the Core Projects have significance beyond the obvious desire to measure progress towards objectives. Failure in matching the outputs and inputs of the Core Projects would have profound implications for the future of IGBP. A lively discussion weighed the merits of what was considered a focused engineering approach, viewed as a mapped course through a city street, versus the basic research approach, which was viewed as a random walk through a pile of leaves.

The SC held the view that objectives are clearly necessary, and progress towards them must be monitored. Yet it was also maintained that, in many areas, IGBP is exploring unknown terrain, so sufficient flexibility must be maintained to allow the basic research component of IGBP to shine through. The SC approved the establishment of a small Task Force, to be chaired by the Executive Director, to pursue the matter further.

Towards the end of achieving greater integration between the Core Projects, the proposal was made that the IGBP hold a joint meeting of all the Core scientific committees. This meeting would provide time for each Core Project to deal with its own business, but there would also be time for planned and extemporaneous cross-project meetings as well as several scientific plenary sessions in which all would participate. The SC found this to be a challenging but extremely interesting idea and recognised the potential the meeting would offer for catalysing increased cross project interaction. Such a forum could heighten substantially the degree of identity which individual members would feel with IGBP as a whole. The SC decided to hold such a meeting in mid 1996.

Chris Rapley reported on a recent meeting in Vancouver, BC of the International Group of Funding Agents for Global Change Research (IGFA). At previous meetings, IGBP requested IGFA to explore mechanisms for increasing funding for several purposes: to bring the Secretariat up to its originally conceived strength, to support the cost of planning activities between Core Projects, to support the operating costs of the Core Project Offices, to support internal Core Project meetings, and to support the participation in IGBP planning activities by developing country scientists. Unfortunately, at the Vancouver meeting IGFA was unable to offer much counsel on how IGBP could find more money to support these needs. It was emphasised that IGFA does help IGBP considerably in indirect ways, by setting priorities within funding agencies for the cost of basic research. In connection with that, IGFA proposes that there be a new Resource Assessment, involving a categorisation of existing IGBP projects into research categories based on the IGBP three-tier classification. Lists of projects will be developed by IGFA members and passed to IGBP national committees. Information about projects perceived to contribute to core IGBP research will be passed on to the Core Project Offices for completion. These lists would then be compared by IGFA and IGBP so that an estimate can be made of how much money is being expended world-wide on global change research and what portion of it is going to IGBP. Similar exercises would be done with the World Climate Research Programme (WCRP) and the Human Dimensions of Global Environmental Change Programme (HDP). A by-product of this process would be a computerised database and directory of global change research projects world-wide.

A second element of the Resource Assessment is a review of the resource requirements. Each Core Project will be asked to estimate the costs of its Core Research and planning activities for a five year period. This would allow a judgement to be made of how close we are to the funding target for IGBP research. Generally the SC recognised the value of performing this exercise, but great concern was expressed about the time and cost involved in performing it relative to the likely benefit to come from it.

Major topics of the SC meeting included a review of issues and developments in each of the Core Projects, and presentations relating to new or potential Core Projects.

Berrien Moore, Chair of the Task Force for Global Analysis, Interpretation and Modelling, submitted a proposal to renew the Task Force for four years based on its Strategic Plan, subject to revision every two years.

Patrick Holligan, who has guided the

Land Ocean Interactions in the Coastal Zone (LOICZ) project from its earliest planning days, submitted the LOICZ Implementation Plan, along with a report of progress in science and planning during the year. The Implementation Plan was approved by the Scientific Committee, with thanks for a job well done by the Core Project Office and especially by John Pernetta, the Core Project Manager. The plan will be published by the IGBP Secretariat in Stockholm in time for the LOICZ Open Science Meeting in April at the Marine Science Institute, University of the Philippines, Quezon City.

Kenneth Denman, who leads the Working Group on the Global Ocean Euphotic Zone Study (GOEZS), presented a summary of current thinking, emphasising results from the Joint Global Ocean Flux Study (JGOFS) and a summary of work from the Intergovernmental Panel on Climate Change (IPCC) working group that he heads. Although GOEZS was not considered to have reached a stage where it should embark on a fast track to develop a science plan, it was recognised that there continues to be a strong need for a working group to plan a future oceanographic project that will build on the results from JGOFS and from the International Global Atmospheric Chemistry Project (IGAC), and that will address the physical and biological interactions over the wide range of relevant temporal (and spatial) scales in the upper oceans.

Brian Rothschild, Secretary of the Scientific Committee on Oceanic Research (SCOR), presented the Global Ocean Ecosystem Dynamics (GLOBEC) plan on behalf of SCOR. SCOR submitted a precis document for consideration by IGBP, with a view to GLOBEC - a project already implemented in some countries - being adopted as a Core Project of the IGBP. The SC-IGBP decided to establish a GLOBEC Core Project Planning Committee jointly with SCOR, after a discussion of the timing, content, relationship and relative merits of JGOFS, GOEZS and GLOBEC. The task of the planning committee will be to draft a Science Plan for consideration by the SC-IGBP at their 10th meeting in Beijing, China, in October 1995.

Billie Turner and David Skole presented the Land Use and Cover Change (LUCC) Draft Science Plan. A working group, chaired by Turner and first launched in 1990 to prepare a Core Project to be shared between HDP and IGBP, has already published a planning report on relating land use and global land-cover change (IGBP Report No. 24). The Scientific Committee agreed that LUCC was proposing science that was of substantial importance to the global change effort. Elements of LUCC exist in some of the other projects, giving it some of the character of a framework activity. The interface between social and natural scientists was viewed as being particularly important and of a fundamental nature. The Committee decided that from IGBP's perspective, LUCC should be established as a Core Project with extensive links to other IGBP and HDP projects. An interim working group will draft some minor improvements and clarifications to the science plan that will be an IGBP report published in 1995.

The Scientific Committee for the IGBP at Thredbo, Australia, December 1994

John Townshend, Chair of the IGBP-Data and Information System, described plans for networking the IGBP using the World Wide Web (see Global Change NewsLetter No. 20). There is considerable interest in presenting information about IGBP on the Internet, and DIS has started the process by constructing a Home Page, which will ultimately point to Home Pages for the Core Projects, Framework Activities and Task Forces, and the Stockholm Secretariat. All the Projects were encouraged to continue to co-operate in establishing an electronic network interface for the IGBP. At the same time, concern was expressed that considerable effort must be expended to continue to provide information of similar quality and timeliness for developing countries, which in many cases do not have Internet access well developed.

Larry Gates, Chair the World Climate Research Programme (WCRP) Joint Scientific Committee (that links the World Meteorological Organisation, the International Council of Scientific Unions and the Intergovernmental Oceanic Commission), described the current status of the programme, including the completion of the highly successful Tropical Oceans and Global Atmosphere project, which has provided the basis for reliable El Niño forecasting. A new project has just prepared its science plan: Climate Variability and Predictability (CLIVAR) which will initially focus on the monsoon, tropical/extra-tropical interactions, Thermohaline processes and large-scale ocean circulation variability. CLIVAR will integrate many of the existing WCRP research activities. Gates emphasised the need for and commitment to greater integration between the WCRP and IGBP; a Workshop with participation from CLIVAR and IGBP Past Global Changes has already met in Venice (November 1994) to discuss the dynamics of low-latitude climate change.

In closing the meeting, the Australian hosts Brian Walker (Chairman of GCTE) and Rowena Foster (from the GCTE Core Project Office) were thanked and Peter Liss paid particular respect and thanks to past Chairman James McCarthy, and to Bob Stewart for both of whom this was the last SC-IGBP meeting.

Neil Swanberg *Deputy Executive Director, IGBP, IGBP Secretariat, Stockholm, Sweden.*

GLOBAL CHANGE NEWSLETTER

Edited by Suzanne Nash
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PAGES/CLIVAR Workshop

The IGBP Core Project on Past Global Changes organized a workshop in Venice on 16-20 November, 1994, to identify research foci in which palaeoclimate data would contribute significantly to the goals of the World Climate Research Programme on Climate Variability and Predictability (WCRP-CLIVAR). The issue which joined PAGES and the WCRP in Venice was seasonal to century-scale climate dynamics.

Tropical ocean-atmosphere systems orchestrate climate variability worldwide over interannual-decadal time scales, and the tropical ocean is a primary source of energy and water vapour to the global atmosphere. Intensive observational programs such as the WCRP Tropical Oceans and Global Atmosphere-related projects have focused on improving our empirical basis for understanding and modelling the tropical ocean-atmosphere. Still, most instrumental observations of tropical climate span only the past few decades, and only a handful of instrumental records from the tropics predate the turn of the century. Thus, state-of-the-art predictive models are based only on the information available from the past several decades, at most. Palaeoclimatic reconstructions from corals, tree-rings, ice cores, sediments, and other sources can be used to extend the observational baseline of tropical variability and document the sensitivity of these systems to past changes in climate forcing. Such reconstructions offer new opportunities to gain insight on the intrinsic variability of tropical systems and validate numerical model simulations of regional and global variability.

The workshop was organized around defining state-of-the-art questions, and how to answer these questions using an integrated palaeoclimate data and modelling approach. The first focus was on the seasonal to century-scale dynamics of the ENSO and the African-Asian monsoon systems, as well as the interaction between these systems. A plan was also initiated to map out the long-term patterns and dynamics of the low- to mid-latitude teleconnections related to these systems. Regional hydrologic changes, including droughts and floods, and how these changes relate to tropical forcing, received the most attention.

Parallel discussions at the workshop focused on decade to century-scale variability of the global ocean thermohaline system. Special emphasis centred around the growing palaeoclimatic evidence that the thermohaline system, and the climate system in general, is capable of shifting abruptly between distinctly different climatic modes. Recent results from ice cores and sediments highlight these changes, and the evidence suggests that both the high- and low latitudes are susceptible to abrupt climatic change. Workshop participants defined several abrupt shifts in need of further palaeoclimatic study, and agreed that present and future generations of climate models must be evaluated in terms of how well they can simulate these observed abrupt climatic shifts.

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News from the IGBP Secretariat

Kristina Nyström

The Secretariat has the good fortune to have a new recruit on board, who comes to us from the Fulbright Commission. Kristina has accepted the newly created post of Personal Assistant to the Executive Director, assuming a line of office and managerial tasks that will enhance our efficiency.

Delivery?

During the dark days of the Nordic midwinter, the December (No. 20) issue of the NewsLetter was put together, went to layout, then to the printers, then to the distributors. Snow storms came, rain storms followed, but the shipment finally arrived in London, where our distributors, DHL, put all the copies in little plastic envelopes (I know, you may not like these, but friends in monsoon countries have asked us to use them to insure that the contents are not soaked), and handed the lot over to Royal Mail to send it by post. Now it appears that many of you did not receive a copy. If so, please let us know - should enough people reply that they never got it and want one, we will have a new print-run made.

Care to write us?

Letters to the Editor on any issue regarding the IGBP will be welcome. We will print what we can, space allowing.

Resource Assessment Seminar

Invited by the Co-ordinator of the International Group of Funding Agencies (IGFA) Working Group on Resource Assessment, Dr. Helmut Kühr, thirty representatives of funding agencies, national contact points, IGBP and the International Council of Scientific Unions, met in Germany at Schloss Birlinghoven near Bonn on 15-16 February. The group discussed practical aspects of the Resource Assessment and took part in a training course on software and Internet capabilities.

First produced for the year 1992, an updated compendium on the budget spent for global change research is in worldwide demand by research programmes, the scientific community, funding sources and policy makers. The assessment addresses the main global change research programmes of the IGBP, WCRP and HDP, augmented by research and related activities by IGFA members. (see *Global Change NewsLetter*, Sept. 1994, pp. 14-15).

The survey will be carried out by national contact points reporting to IGFA's Working Group "Resource Assessment". An iterative process was agreed upon in 1994 to collect and categorise relevant project information on a worldwide scale, starting with the compilation of lists of national projects according to the IGBP structure which categorises core research, and regional/national research.

A total of roughly 8000 project descriptions is expected to be collected in the near future by the national contact points. The capacity to handle this bulk of information will influence the outcome of the Assessment. To facilitate the work, IGFA has designed a questionnaire, and Cristoph Ritz of ProClim Switzerland and Arne Spekat of the German National IGBP Secretariat in Berlin have collaborated on a pilot study determining the practical use of the Swiss-designed system that builds upon "4th Dimension" database software on the Apple Macintosh. The data bank system is on offer to the participating countries, but each member is free to use software from other sources, as long as the data format is met for importing national data sets into the international data bank.

The IGFA Working Group is establishing this international database. Information about a selected set of projects compiled from the information collected nationally will be accessible through the World Wide Web. Initially it is planned that only IGFA and the global change triad will have access, but it is hoped that it can be opened to the research community.

Arne Spekat, *German IGBP Secretariat, Institut für Meteorologie, Freie Universität Berlin, Carl-Heinrich-Becker-Weg 6-10, D-12165 Berlin, Germany. Fax: (+49-30) 838 71217, E-mail: as@zedat.fu-berlin.de*

Publications

Joint Global Ocean Flux Study (JGOFS)
JGOFS Report No. 16
Report of the 9the Meeting of the JGOFS Scientific Steering Committee, and Report for 1993/94 on JGOFS Southern Ocean Planning.
SCOR Secretariat, The John Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhuvms.hcf.jhu.edu

JGOFS Core Measurement Protocols. Intergovernmental Oceanographic Commission Guides and Manuals, No. 29, 1995.
Chide Ibe, IOC, UNESCO, 7 Place Fontenoy, 75700 Paris, France.

US Dept. of Energy, 1994. Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water. Ver. 2, Edited by Andrew Dickson and Catherine Goyet. ORNL/CDIAC-74 (Vol. 2 of the JGOFS Core Measurement Protocols)
SCOR Secretariat, or Carbon Dioxide Information Analysis Center, Building 1000, PO Box 2008, MS 6335, Oak Ridge, TN 37831-9984, USA

Biospheric Aspects of the Hydrological Cycle (BAHC)
BAHC Report No. 3
Climate Change, Uncertainty and Decision Making, 1995. A joint publication with the Institute for Risk Research, Canada. Edited by Greg Paoli.
BAHC CPO, Potsdam Institute for Climate Impact Research, Telegrafenberg, D-14473 Potsdam, Germany.Tel: (+49-331) 288 2543, Fax: (+49-331) 288 2600, E-mail: bahc@pik-potsdam.de

On the Web

During the past months several IGBP Core Projects have set up home pages on the World Wide Web. Here are the Uniform Resource Locaters (URL) available on 1 March.

Joint Global Ocean Flux Study (JGOFS)
http://www1.whoi.edu/jgofs.html

Past Global Changes (PAGES)
http://www.ngdc.noaa.gov/paleo/pages.html

Global Analysis, Interpretation and Modelling (GAIM)
http://pyramid.unh.edu/csrc/gaim

IGBP Data and Information System (IGBP-DIS)
http://xtreme.gsfc.nasa.gov/dis/

The Global Change Master Directory (GCMD), compiled by the US National Aeronautics and Space Administration, is a data base of Earth science data holdings with more than 3000 descriptions of available data sets, giving a point of contact for each.

The GCMD describes global-change data held by NASA and other federal agencies, universities, and research centres, in addition to a broad array of international holdings. The descriptions provide geographic and temporal coverage, spacecraft/sensor, investigator, data contact, storage medium, parameters measured and derived, discipline, location, summary, and data quality.

http://gcmd.gsfc.nasa.gov/

To list data sets in the GCMD contact: **John N. Scialdone**, *Hughes-STX Corporation, 7701 Greenbelt Road, Suite 400, Greenbelt, MD, Fax: (+1-301) 441 9486, E-mail: scialdon@gcmd.gsfc.nasa.gov*

Open Science Meetings

3-7 April 1995, Congress Centre Hamburg, Germany
Atmospheric and Hydrological Processes and Models at the Soil-Vegetation-Atmosphere Interface. Open meeting of Biospheric Aspects of the Hydrological Cycle (BAHC). *BAHC CPO, Potsdam Institute for Climate Impact Research, Telegrafenberg, D-14473 Potsdam, Germany.Tel: (+49-331) 288 2543, Fax: (+49-331) 288 2600, E-mail: bahc@pik-potsdam.de*

24-27 April 1995, Marine Science Institute, University of the Philippines, Quezon City, The Philippines
The Dynamics of Global Change and the Coastal Zone. Open meeting of Land-Ocean Interactions in the Coastal Zone (LOICZ). Contact John Pernetta, LOICZ Core Project Manager, Netherlands Institute for *Sea Research, PO Box 59, 1790 AB Den Burg, Texel, The Netherlands. Fax: (+31) 222 69430, E-mail: pernetta@nioz.nl*

24-26 April 1995, CSIR Conference Centre, Pretoria
Regional Conference on Global Environmental Change: Implications for Southern Africa. Organised by theSouth African National Committee for the IGBP. *Louise Botten, The SA IGBP Secretariat, Foundation for Research Development, PO Box 2600, 0001 Pretoria South Africa, Fax: (+27-12) 841 3791, or E-mail: louise@frd.ac.za*

8-12 May 1995, "La Citadelle", Villefranche, France
First JGOFS Scientific Symposium. *Elizabeth Gross, Executive Director, Scientific Committee on Oceanic Research, Department of Earth and Planetary Sciences, The John Hopkins University, Baltimore, MD 21218, USA. Tel: (+1-410) 516 4070, Fax: (+1-410) 516 4019, E-mail: scor@jhuvms.hcf.jhu.edu*

9 August, Berlin Germany
Palaeomonsoon Variations and Global Change During the Late Quaternary, in conjunction with the XIV International Congress of INQUA. Stefan Kroepelin, Co-ordinator, INQUA-PAGES Palaemonsoons Project, Free *University of Berlin, GeoLaboratory, Altensteinstrasse 19, D-14195, Berlin, Germany. Fax: (+49.30) 838 6263, E-mail: skroe@zedat.fu-berlin.de or Suzanne Leroy, PAGES CPO, Bärenplatz 2, CH-3001, Bern, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch*

6-12 August, Tampere, Finland
GCTE-BAHC Session at the International Union of Forestry Research Organisations XX World Congress. *Paul Jarvis, Institute of Ecology & Resource Management, Darwin Building, The King's Buildings, Mayfield Road, Edinburgh EH9 3JU, UK Tel: (+44-316) 505 426, Fax: (+44-316) 620 478*

14-18 August, Moscow, Russia
IGU '95. Global Changes and Geography, including PAGES Multiproxy Mapping Session. *A. Velichko, Institute of Geography, Russian Academy of Sciences, Staromonetny 29, Moscow 109017, Russia. Tel: (+7 095) 238 02 9+8, Telex: (64) 411781 globe, Fax: (+7 095) 230 20 90*

25-29 September 1995, Garmisch-Partenkirhcen, Germany
First International Science Conference of Global Analysis, Interpretation and Modelling (GAIM). *German IGBP Secretariat , Institut für Meteorologie, Freie Universität Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany. Fax: (+49-30) 838 71217, E-mail: igbp@zedat.fu-berlin.de, or Dork Sahagian, Complex Systems Research Center, Institute for the Study of Earth Oceans and Space (EOS), Morse Hall, 39 College Rd., University of New Hampshire, Durham, NH 03824-3525, USA. Fax: (+1 603) 862 1915, E-mail: gaim@unh.edu*

22-23 September, Maynooth, Ireland
Global Change and the Irish Environment. *John Sweeney, Irish Committee for IGBP, The Royal Irish Academy, 19 Dawson Street, Dublin 2, Ireland. Fax: (+353-1) 676 2346, E-mail: jsweeney@vax1.may.ie*

9-13 October 1995, Beijing, China
WMO/IGAC Conference on the Measurement and Assessment of Atmospheric Composition Change. 3rd science conference of the International Global Atmospheric Chemistry Project (IGAC). *For complete information contact: John Miller, Environment Division, AREP, World Meteorological Organisation, 41 Ave. Giuseppe Motta, CH-1211 Geneva 2, Switzerland. Fax: (+41-22) 740 0984, E-mail:. john-milton.miller@itu.ch*

21-27 October 1995, Beijing, China
SAC IV; ICSU Global Change Forum *(see back page)*
IGBP Secretariat, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se.

INVITATION AND CALL FOR ABSTRACTS

The Chinese National Committee for the IGBP has graciously invited the highest body of the IGBP the Scientific Advisory Council (SAC), to hold its fourth session in Beijing. The Council, composed of National IGBP representatives and ICSU bodies, advises on the scientific contents of the programme, assesses its results, and makes recommendations. The IGBP, now at its fourth SAC, is well established, with its initial Core Projects and Framework Activities in their implementation phase, and with numerous cross-project and interdisciplinary links being actively developed. It is timely that SAC IV will be held in Asia, and that the topic of the associated Scientific Symposium on 23-25 October will be:

Natural and Anthropogenic Changes : Impacts on Global Biogeochemical Cycles

THE EARTH'S biogeochemical cycles of Carbon, Oxygen, Nitrogen, Phosphorus, and Sulphur (CONPS) exhibit significant natural variability on time scales of relevance to mankind. Furthermore, these cycles are being increasingly affected by the activities of mankind, including combustion, agriculture, and industry.

These activities have accelerated the mobilisation of CONPS from inert (e.g., N_2) and sequestered (e.g., fossil carbon) forms into chemical species that can impact critical processes of our biogeochemical environment, such as ecosystem productivity, and atmospheric energy adsorption and photochemistry. Historically, changes in the natural cycles of CONPS have occurred in the more developed countries of the western portion of the northern hemisphere. Over the past few decades however, combustion, agriculture and industry in Asia have grown to the level that mobilisation rates in some Asian countries are now among the highest in the world and are having a significant affect on natural cycles. In addition, projections are for significant growth in Asian energy use, agriculture and industry over the next few decades, leading to further changes in natural cycles.

The Symposium will include plenary and poster sessions. The plenary session will consist of presentations by 12 to 16 invited speakers. The poster session will have its own designated time and will consist of posters selected from submitted abstracts. Both plenary and poster presentations will focus on how natural and anthropogenic changes in Asia impacts on global biogeochemical cycles. The plenary presentations will be reviews and will take a broad view of the topic.

It is expected that the poster presentations will consist of larger views, and more narrow approaches. The poster session is an opportunity to showcase, to the IGBP community, the Asian perspective on work on global change and biogeochemical cycles.

Topics will include all aspects of IGBP and will include processes that mobilise, transform, transport and sequester CONPS as well as environmental processes that are affected by the increased concentrations of active CONPS species. In addition to a focus on the current impacts of Asia on global cycles, plenary and poster presentations are encouraged to examine future scenarios of CONPS cycling.

In the first session, invited speakers will discuss change in the historical perspective, using historical records of climate change, and land-use history.

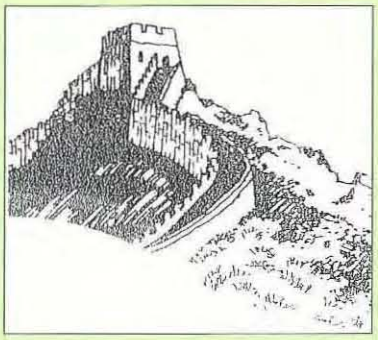
A second session will address land use and CONPS mobilisation rates, and a third session will cover a broad view of the effects of changes for biogeochemical cycles. A final overview will focus on the implications of Asian change on global systems, and, from the opposite approach, the implications of global change on Asian systems.

The Organising Committee for the Symposium is chaired by James N. Galloway, with Jerry M. Melillo, Vice-Chair of the Scientific Committee for the IGBP, as Co-Chair. The Asian scientists on the Committee are: Hu Dunxin (also a member of the SC-IGBP), Chen Panqin (Beijing), Suvit Vibularesth (Thailand), Hajime Akimoto (Japan), Paul Cheung (Singapore), B. L. Deekshatulu (India), and Riga Suprapto (Indonesia).

Poster presentations are invited. The deadline for receiving abstracts has been extended until 1 May. The invited papers will be published in a peer-reviewed collection of papers by Cambridge University Press (IGBP Book Series). Poster presentations will published in a journal such as *Global Biogeochemical Cycles*, following the standard peer-review process.

Send poster abstracts of 250 words by 1 May 1995 to: Jim Galloway, Marine Biological Laboratory, Woods Hole, MA 02543, USA, by fax at (+1-508) 457 1548 (if by fax, please send a diskette and a hard copy) e-mail: asia@lupine.mbl.edu

to register for SAC IV
contact the IGBP Secretariat in Stockholm



SAC IV and the ICSU Forum on Earth System Research
Beijing, China, 22-27 October 1995

22 October	ICSU Forum	Presentations on Earth System Research Panel on science and decision making
23-25 October	Scientific Symposium	Natural and Anthropogenic Changes: Impacts on Global Biogeochemical Cycles
26-27 October	SAC IV	Scientific Advisory Council: IGBP Evaluation

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