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The 1995 Nobel Prize in Chemistry

A first for atmospheric chemistry and global change studies

Boo Jonsson

The three laureates of the 1995 Nobel Prize in Chemistry give a press conference at the Royal Swedish Academy of Sciences in Stockholm, on 8 December, 1995. From left to right: F. Sherwood Rowland, Mario Molina, and Paul Crutzen

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Global Change Studies Recognised by Nobel Prize

Ronald G. Prinn
MIT, 6 December 1995

It was with great pleasure that I learned during the WMO-IGAC Scientific Conference in Beijing this past October that three valued colleagues were awarded the 1995 Nobel Prize in Chemistry. Paul J. Crutzen, Mario J. Molina, and F. Sherwood (Sherry) Rowland received the award "for their work in atmospheric chemistry particularly concerning the formation and decomposition of ozone". This is the first Nobel Prize in atmospheric chemistry and the first in the broader areas of environmental and global change science. These are the areas now addressed by IGAC and IGBP.

It is particularly noteworthy that Paul Crutzen played significant roles in the formation of both IGAC and IGBP and is serving currently as the vice-chair of the IGAC Scientific Steering Committee. Sherry Rowland is also active in IGAC, measuring hydrocarbons and other species using aircraft over the globe, and Mario Molina is doing fundamental work in the laboratory on heterogeneous atmospheric chemical reactions very relevant to IGAC.

While we think of ozone depletion as a contemporary issue, the story really began more than two billion years ago when blue-green algae evolved on Earth. Their photosynthesis lead to an oxygen-rich atmosphere. Oxygen, pumped with the sun's ultraviolet radiation, produced the first ozone layer. Perhaps around this same time, there also evolved bacteria with the capability to convert nitrogen compounds in soils and water into molecular nitrogen and nitrous oxide. The nitrogen would come to dominate our atmosphere, and with the nitrous oxide emissions came an important process limiting the thickness of the ozone layer.

The contemporary ozone depletion issues effectively began in the 1930s with the invention of an extremely useful class of nearly inert chemicals called chlorofluorocarbons (CFCs), and in the 1970s with proposals for a global fleet of supersonic commercial aircraft which would fly in and exhaust gases into the lower stratosphere.

Pressens Bild /Jack Mikrut

Paul J. Crutzen receives the 1995 Nobel Prize in Chemistry from His Majesty Carl XVI Gustaf, King of Sweden. Prof. Crutzen, Vice-Chair of the International Global Atmospheric Chemistry Project (IGAC), was a member of the first Special Committee for the IGBP appointed by ICSU in January 1987. This Committee initiated, compiled and edited the IGBP Science Plan, published in 1990.

Crutzen, Molina, and Rowland played leading roles in elucidating the way in which these natural and artificial emissions affect the ozone layer which protects the global biosphere from harmful ultraviolet radiation. Their initial proposals instigated a large international research program on the ozone layer and also proved to be a catalyst for a much wider-ranging study of the complex chemical and biological connections which exist on Earth.

The first connections began to be made when Paul Crutzen published two papers in 1970 and 1971 proposing that catalytic reactions involving nitric oxide and nitrogen dioxide (let me call them the "Crutzen" reactions) are a major ozone destruction mechanism. In the natural stratosphere the major source of these nitrogen oxides is the reaction of electronically excited oxygen atoms (themselves produced from ozone) with nitrous oxide. As pointed out by Harold Johnston, supersonic aircraft currently deposit these catalytic nitrogen oxides directly into the stratosphere. The second connection was made when in two papers in 1974 and 1975, Mario Molina and F. Sherwood Rowland proposed that the nearly inert chlorofluorocarbons and chlorocarbons (CCs) were dissociated by ultraviolet light in the stratosphere to produce chlorine atoms and chlorine monoxide. Only a short time before that, it had been recognized that these chlorine species catalytically destroy ozone through the so-called "Stolarski-Cicerone" reactions which I name here after their discoverers. The CFCs were widely used in the 1970s for refrigeration, air conditioning, aerosol can propellants, solvents, plastic foam puffing agents, and a myriad of other applications. The major CC was trichloroethane (methyl chloroform) which was widely used as a cleaning agent in the electronics and automobile industries. Measurement of the CFCs and CCs in air began in the early 1970s with the invention of the electron capture detector by James Lovelock.

These early proposals of ozone depletion led to a rapid expansion of research in stratospheric chemistry. For a variety of reasons, including potential ozone depletion by the Crutzen reactions, plans for large supersonic aircraft fleets were shelved in the mid-1970s. There was also enough early confidence in the Molina-Rowland theory that several countries in the mid-1970s phased out the use of CFCs in certain trivial uses, particularly aerosol cans. Nevertheless, even as evidence for the Crutzen, Molina, and Rowland theories mounted, the observational evidence for actual depletion of ozone was equivocal. Due to changing wind patterns, the thickness of the stratospheric ozone layer is highly variable in space and time and therefore changes in its thickness are very difficult to detect. A series of international assessments were begun in order to periodically examine the validity of these ozone-depletion hypotheses. It was a watch-and-wait phase.

The situation changed dramatically with the publication of the discovery of the Antarctic Ozone Hole by Joseph Farman and colleagues in 1985. A remarkable thinning of the ozone layer was occurring every spring over Antarctica and the thinning was increasing with time. However, this very evident ozone depletion was not explained by the then-current ozone-depletion theories. These theories did not include the chemistry instigated by reactions involving the stratospheric ice clouds prevalent over Antarctica in winter due to the extremely cold temperatures occurring there. The scientific assessments accelerated and the first significant CFC regulatory policy negotiations began with the 1985 Vienna Convention leading to the 1987 Montreal Protocol. Simultaneously, several researchers, including Jim Anderson, were gathering evidence for unexpected chlorine, bromine, and nitrogen chemistry in the Antarctic spring atmosphere.

Theoretical and laboratory studies involving Susan Solomon, Molina, Crutzen, and others were establishing the fact that reactions on ice particles can lead to release of chlorine monoxide. A new catalytic cycle was discovered by Molina and colleagues involving the dimer of chlorine monoxide which operates efficiently in the Ozone Hole. The pieces of the scientific puzzle were beginning to come together and the chemical industry was at the same time gearing up to identify and manufacture suitable CFC and CC alternatives. I am glad to say that global observations of CFCs and CCs carried out in the Advanced Global Atmospheric Gases Experiment (AGAGE) and Climate Monitoring and Diagnostics Laboratory (CMDL) networks now show that the Montreal Protocol is indeed working. My AGAGE colleagues and I were able to report earlier this year that the major CC trichloroethane is the first ozone-depleting gas to actually show a dramatic decrease in the atmosphere. Carbon tetrachloride and CFC-11 are now also slowly decreasing.

The ozone depletion story is not ending, however, with the Nobel Awards and successful implementation of the Montreal Protocol. Removal of long-lived CFCs from the atmosphere will still take many decades, so we will be living with a perturbed ozone layer well into the next century. Also, AGAGE and other measurements show nitrous oxide levels are continuing to rise slowly and we have still not established why. That is one of many problems that IGAC, with help from other IGBP projects, can hopefully soon solve.

Ozone is also a chemically and radiatively important species in the troposphere and the work by Paul Crutzen on tropospheric ozone over the past twenty years has been an important contribution to our current knowledge in this area. Paul, I, and many others are however frustrated at the lack of observations of tropospheric ozone necessary to define the global distribution and trends for this critically important gas. Hopefully, the International Tropospheric Ozone Year (ITOY) proposed as a major initiative under the IGAC GLONET Activity, will receive special impetus with the Nobel Committee's recognition of ozone research.

There is still much work remaining. Nevertheless, the remarkable contributions by three members of our community are a great pleasure to acknowledge. Congratulations Paul, Mario, and Sherry for a job well done!

Professor Ronald Prinn, who has contributed this congratulatory article, is the Chair of the Scientific Steering Committee for the International Global Atmospheric Chemistry Project (IGAC). Ron Prinn is a colleague of Professor Mario Molina at the Department of Earth, Atmospheric and Planetary Sciences at MIT, and a longtime associate of both Paul Crutzen (Vice-Chair of IGAC), and Sherwood Rowland.

Professor Paul Crutzen is a Dutch citizen. He received his doctor's degree in meteorology from Stockholm University in 1973. He is a member of the Royal Swedish Academy of Sciences, the Royal Swedish Academy of Engineering Sciences and the Academia Europea. He is at the Max-Planck-Institute for Chemistry in Mainz, Germany.

Professor Mario Molina was born in Mexico City. He received his PhD in physical chemistry from the University of California, Berkeley. He is a member of the US National Academy of Sciences. He is at the Department of Earth, Atmospheric and Planetary Sciences at the Massachusetts Institute of Technology, Cambridge, USA.

Professor F. Sherwood Rowland was born in Delaware, Ohio, USA. He received his PhD in chemistry from the University of Chicago in 1952. He is a member of the American Academy of Arts and Sciences, and the US National Academy of Sciences, where he is currently Foreign Secretary. He is at the Department of Chemistry of the University of California at Irvine, California, USA.

The IGBP 'gets real'

by Peter Liss

Some thoughts on SAC IV: Beijing, 23-27 October 1995

The fourth IGBP Scientific Advisory Council was perceptibly different in emphasis from previous SACs. In particular, the IGBP began to face the realities of a more questioning attitude to global change research in many countries, requiring evidence of its relevance and benefits. Further, new concerns to society are beginning to strongly impinge on the research agenda, for example global change and human health, as well as the whole question of the availability and quality of water for human use and its consumption both now and in the future.

As an example of the changing political and economic climate for global change research, Jean-Pierre Contzen (Joint Research Centre, European Commission) argued that dialogue between scientists and policy makers was the only way to ensure continued support. In his thought-provoking address to the ICSU Forum on Earth System Research, held on the day prior to the SAC meeting, he said that the days of the ivory tower scientist are over, at least in the global change area. In order to address the large and inherently uncertain issues in IGBP, a continuing process of public education and political dialogue is vital. This may or may not succeed, and the outcome will vary from country to country.

However, a very reassuring sign from the SAC meeting was the high level of interest in global change science in the host nation, China, and in many other developing countries. This augurs well for the future. As a sign of such interest and commitment, the SAC meeting included the opening ceremony for the START Regional Research Centre for East Asia, located in Beijing. Further, on the occasion of the SAC meeting, the Chinese IGBP Committee published a book describing their national programme (China Contribution to Global Change Studies", edited by Ye Duzheng, Lin Hai, *et al.*).

The scientific symposium which occupied the first half of the SAC meeting provided further grounds for optimism regarding the future success of the region in spearheading global change research. The symposium, *Natural and Anthropogenic Changes: Impacts on Global Biogeochemical Cycles* was subtitled *Asian Change in the Context of Global Change*. It consisted of both oral and poster presentations, and clearly demonstrated the wealth of environmental material, records and intellectual talent available in the Asian region. The symposium organisers (Jim Galloway and Jerry Melillo and their committee) are to be congratulated on putting together a programme which showed not only how regional changes in Asia both affect and are affected by more global changes, but also covered the whole gamut of research domains included in the IGBP.

The subject of water was a continuing theme throughout the SAC meeting. For example, Galloway in his opening remarks at the symposium used the phrase "Food is first", but amended this to "Hunger is first", in view of the difficulties of getting food surpluses in one area to the places where they are desperately needed. However, by the end of the week the aphorism had changed to "Thirst is first", in recognition of the importance of water to so many aspects of society, and of the current problems of freshwater quality and quantity, and their future exacerbation due to population and global change pressures.

The IGBP is already addressing some of the research issues involved, but there is increasing need to confront the problem more directly. We cannot do this alone. The issue involves not only biogeochemistry but also the physical and social sciences. The present trend of greater co-working and convergence between the three global change programmes (IGBP, WCRP and HDP) is set to accelerate in the next few years as we tackle large issues which are facing mankind, such as global change and water.

Many individuals helped to ensure the success of SAC IV. However, special thanks must go to Ye Duzheng and our Chinese hosts, in particular Chen Panqin and Ge Quansheng, and the staff of the Stockholm Secretariat, especially to Suzanne Nash. Evidence of their success is shown by the fact that, by the end of the meeting, we had received seven offers from countries wanting to host the next SAC!

Peter Liss, *Chair, Scientific Committee for the IGBP, University of East Anglia, Norwich, UK*

At the opening ceremony of SAC IV. From left to right:
Peter Liss
(Chair of the IGBP)
Ye Duzehng
(Chair of the Chinese IGBP)
Zhu Guanya
(Chair, China Association for Science and Technology)
James Dooge
(President of ICSU)
Lu Yongxiang
(Vice-President of the Chinese Academy of Sciences)
Chris Rapley
(Executive Director, IGBP)

Natural and Anthropogenic Changes: Impacts on Global Biogeochemical Cycles

Asian Change in the Context of Global Change
SAC IV Scientific Symposium

To understand global change, a study of where regional change is happening the fastest can give significant insights. If we look for a region where there is high-speed development, a rich and long-standing intellectual tradition of examining the environment, and an extensive research network and data information system on global change, we have Asia.

Africa, Central and South America and Asia are all projected to develop rapidly and to increase the mobilisation of carbon, phosphorous, nitrogen and sulphur. But the major part of the changes are projected to occur in Asia where the economy is growing the most vigorously, and where over half of the world's population lives today. People require energy. People require food.

Our natural systems cannot supply enough nutrients to grow the food for our needs; we must use fertilisers. In 1990, Asia used about 45% of the nitrogenous fertiliser supplied on a global basis. In the year 2020, it is projected to be 65%. These projections, fortunately, are not cast in stone. For just as human activities can cause increases in the mobilisation of critical nutrients, human activities can also reduce or constrain these increases by intelligent action. However, before it is possible to act, we must first understand. Hence this symposium's focus on biogeochemical cycle alterations, specifically with respect to Asia, and their relationship to global change, and the impacts of alterations to these cycles.

The symposium in Beijing had two titles: *Natural and Anthropogenic Changes: Impacts on Global Biogeochemical Cycles*, and, *Asian Change in the Context of Global Change*. The main title is at the core of the work of the International Geosphere Biosphere Programme. The objective 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. The research programme studies biogeochemical cycles in many ways.

The sub-title can be appreciated in the context of IGBP history. When the first Scientific Advisory Council for the IGBP met in 1988, the IGBP was tasked to prove that its broad scientific directions satisfied the international scientific community. Two years later, at SAC II, a published science plan was introduced to a receptive public. At SAC III in 1993, a scientific symposium on reducing uncertainties presented the state of the art in global change research to an enthusiastic scientific community. "Our dreams of the 80s are the realities of the 90s", said John Perry of the US National Research Council. A recommendation of SAC III was that greater consideration be given to the regional aspects of global change, and that SAC IV have a scientific symposium associated with it that should acknowledge that fact.

At the fourth SAC, the IGBP focused on Asia to present the latest results of its scientific programme, with the collaboration of Asian scientists researching global change, and western scientists whose work has concerned Asia.

Topics at the SAC-IV Science Symposium included many aspects of IGBP and include processes that mobilise, transform, transport and sequester Carbon, Oxygen, Nitrogen, Phosphorus, and Sulphur (CONPS) as well as environmental processes that are affected by the increased concentrations of active CONPS species. In addition the sessions covered the current role of Asia in relation to global cycles, and 80 poster presentations addressed both past records of global change and future scenarios of CONPS cycling.

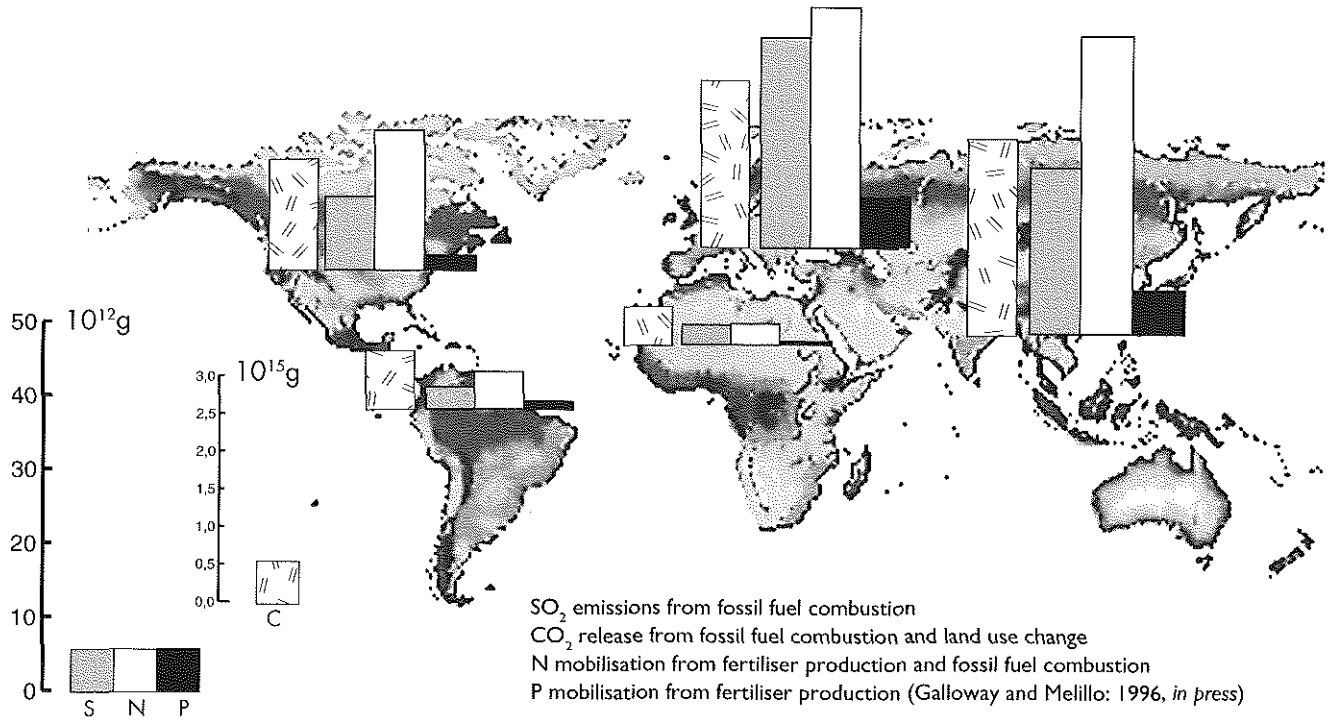
The Earth's biogeochemical cycles of Carbon, Oxygen, Nitrogen, Phosphorus, and Sulphur (CONPS) exhibit significant natural variability. Furthermore, these cycles are being increasingly affected by the activities of mankind, including combustion, agriculture, and industry. These activities have accelerated the mobilisation of CONPS from inert (e.g., gaseous nitrogen) 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.

Most human-induced changes in the natural cycles of CONPS have occurred in the 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 global impact. In addition, trends and projections indicate high growth in Asian energy use, agriculture and industry over the next few decades, leading to further changes in natural cycles.

The Historical Perspective

The palaeomonsoon archives recorded by Chinese historical documents, the cores, tree-rings, deserts, lakes, and vegetation patterns, clearly indicate a history of alternating predominance of winter and summer monsoon periods in the past. China has had a crucial role in global events. One is the palaeoclimate teleconnection between South America and inland Asia, which may relate to the interaction of Asian Monsoon circulation and the El Niño-Southern Oscillation (ENSO) in the past. Chinese deserts and Tibetan arid areas are major sources for mineral dust, whose long-range input must play an important role in planetary radiation balance and biogeochemical cycles of trace substances in the Northern Hemisphere. *(An Zhisheng)*

Land-use changes in Asia are striking. Land-use history, with emphasis on biogeochemical changes, showed that a total land area under forests and wetlands had declined by 47.7% between 1880 and 1980. Human actions in southern Asia (India, Bangladesh, Sri Lanka, Myanmar, Thailand, Cambodia, Laos, Vietmam, Malaysia, Singapore, Brunei, Indonesia and the Philippines) have converted high biomass land cover to low biomass land categories in 100 years. The changes in land-use resulted in an estimated contribution of 29 x 10^6 T of carbon to the atmosphere during this century. *(John Richards)*



SO_2 emissions from fossil fuel combustion
CO_2 release from fossil fuel combustion and land use change
N mobilisation from fertiliser production and fossil fuel combustion
P mobilisation from fertiliser production (Galloway and Melillo: 1996, *in press*)

Land-use change and mobilisation rates of Carbon, Oxygen, Nitrogen, Phosphorus and Sulphur

Land-use and land-use change determines the fluxes of greenhouse gas emissions between the biosphere and the atmosphere. Since land-use and land-use change happen mostly on local and regional scales, they only have global significance through their cumulative effects. The overall impact of land-use change in China is significant, but the diversity of small-scale land uses and their dynamics create a complex problem of incorporating land-use change adequately in global assessments of climate change. *(Rik Leemans)*

Fire in vegetation, a cross-cutting issue with land use, land cover, and mobilisation rates, has recently received growing attention in the framework of global change studies. Biomass burning in the Earth's ecosystems has a strong impact on atmospheric chemistry and aerosols, and could play a significant role in processes leading to global warming. Satellite observations have been instrumental in demonstrating graphically the global nature of biomass burning; institutional arrangements now begun in Asia and throughout the world could significantly improve our understanding of biomass burning patterns and trends around the world. *(Jean-Pierre Malingreau)*

Updated, complete global cycles of the elements carbon, nitrogen, phosphorus and sulphur, emphasise comparisons between natural and human-derived fluxes, changing reservoir compositions and the potential results of the human disturbance of the cycles. A recently developed global Earth System Model that describes the behaviour of the coupled biogeochemical cycles of C, N, P and S in the land-coastal margin system, when scaled to the region of Asia, concludes that processes such as nitrogen and carbon dioxide fertilisation of the land biota, application of nitrogen and phosphorus fertilisers to the land surface and their subsequent leaching and transport to aquatic systems, and acid deposition, could indirectly affect the Asian coastal zone on a relatively short time scale. *(Fred Mackenzie)*

Moving inland and to the factors controlling nutrient cycling in various forest and grassland ecosystems in Asia, human activities have played a major role in determining the structure and function of ecosystems in Asia for thousands of years. Development of cropping systems, domestication of plants and animals, construction of large-scale agricultural facilities, such as irrigation systems, have made major changes to the ecological landscape in Asia, and elsewhere. Extensive use of forests, wetlands, and rangelands for human use have also modified biogeochemicals of carbon, nitrogen and phosphorus in a number of regions. *(Zhang Xinshi)*

Effects of changes on biogeochemical cycles

The changes in land-use and mobilisation rates have, naturally, effected changes on biogeochemical cycles, but there are gaps in the picture. Discrepancies appear between net primary productivity and the capacity of different biomass for assimilation when comparing global photosynthesis and NPP. Secular events, such as fire, introduce significant uncertainty into current conclusions about global carbon storage. *(Detlef Schulze)*

In the terrestrial carbon budget, increases in the atmospheric concentration of carbon dioxide, are attributed to two primary forcing agents: (a) combustion of fossil fuels, and (b) land cover conversion. The former is a product of industrial activities, while the latter is primarily due to the clearing of tropical forests. Although the former is well known, the latter is not. When estimates of sources and sinks are combined in global carbon models and compared with observed increases in the atmosphere, a global budget cannot be reconciled. To do this it will be necessary to develop coupled models which take into account changes in ecosystem metabolism as a result of climate and land cover changes. *(David Skole)*

Methane is an important greenhouse gas, and particularly significant in Asia where methane produced in rice paddies is released to the atmosphere through ebullition and rice plant mediated diffusion. The expansion of irrigation and increased production of wetland rice has increased methane fluxes to the atmosphere from rice fields. Present knowledge of processes controlling methane fluxes provides a promising foundation to develop mitigation technologies that are in accord with sustainable and increasing rice production and productivity. *(Heinz-Ulrich Neue)*

However, the situation with sediment/nutrient transport to the coastal zone shows areas of serious concern with few mitigation plans in view. It has become one of the major concerns of mankind from the viewpoint of global change. The situation in Asian rivers has been getting more serious

through the rapid development of economy and technology. About 13% of global fluvial discharge is presently dammed in the world. It is estimated that in the next century about 66% of the world's total stream flow to the ocean margins will be controlled by dams. The Nile River had been completely dammed and is a typical example of the effects of human activity. There are still a number of rivers in the world that will share the same fate as the Nile. Dams violate the 'natural' pattern of downstream transfers and the 'river continuum'. The discharge, sediment/organic transport, and the water quality then are governed by the releases from the reservoirs, which act as major sediment traps. Deforestation and farming are mobilising nutrients. These human activities interfere significantly with coastal marine systems and resources in the coastal zone. *(Dunxin Hu)*

The hydrology and water chemistry of Chinese drainage basins have been transformed dramatically during the past 30 years, and this is likely to continue well into the next century. We find, however, countervailing trends when appropriate management practices are instituted. The understanding of this facet of global change is one we now have the ability to coherently monitor and improve. *(Charles Vörösmarty)*

Asian marginal seas in the Northwest Pacific Ocean are case studies for reviewing what is known about the distribution of carbon and associated biogenic elements (nitrogen, phosphorus and silicon) in the oceans. Marginal seas serve as an important link in the global carbon cycle, with regard to the penetration of anthropogenic carbon dioxide in the oceans, but eutrophication-derived carbon deposits on the continental margins cannot account for all of the missing carbon dioxide. High latitude marginal seas may act as a conveyer belt in exporting excess carbon dioxide into the North Pacific, and the upward migration of calcite and aragonite saturation horizons may also make the shelf deposits on the Bering and Okhotsk Seas more susceptible to dissolution, thus neutralising excess carbon dioxide. *(Chen-tung Arthur Chen)*

Impacts of global change on Asia

Environmental changes in Asia that are part of global change are seen by examining both historical data and global change model simulations, showing the sensitivity of integrated Asia monsoon systems. These GCMs include the physical monsoon climate system and the monsoon-driven ecosystem, and model the response to global warming in particular. On this huge agricultural continent, the models show that the growing seasons of some crops might become longer due to warming, but accompanied by a harmful decrease of moisture. Changes of inter-annual variability, as well as the longer-term trend of water resources in Asia, are significant under global forcing. Seen from both historical records and model simulations, there is a general aridity trend in Northern China and Central Asia, but a wet trend in part of South Asia. Special attention in impact assessments has been given to the vulnerable areas which are located mostly in the transitional zones of climate and ecosystems, such as the coastal zones and the semi-arid zones. These areas are characterised by the strong gradients of environmental elements and instability, and therefore probably more sensitive in response to both natural and anthropogenic perturbations. Unfortunately, most GCMs fail so far to simulate the significant regional structures of Asian monsoon, mainly due to poorly incorporating the climate-ecosystem interaction in the hydrological processes and biogeochemical processes. *(Fu Congbin)*

Yuan Gao, from Rutgers University, winner of the first prize at the poster session, for her research on characterisation of atmsopheric aerosols over East Asia.

However, modelling of global terrestrial primary production has made great advances. Geographically referenced net primary productivity (NPP) and gross primary productivity (GPP) and their corresponding seasonal variation are key components in the terrestrial carbon cycle. They are needed to understand both the function of living ecosystems and their effects on the environment. Productivity is also the key variable for the sustainability of human use of the biosphere by providing food and fibre. Recently, it has become possible to investigate the magnitude and geographical distribution of this productivity on a global scale by a combination of ecosystem process modelling, and monitoring by remote sensing.

A coordinated strategy has been developed to improve estimates of terrestrial net and gross primary productivity through measurement and modelling. Several independent models now exist, other are in various stages of development. A variety of approaches are being used to describe primary production at regional and global scales.

A recent activity led by the IGBP Task Force on Global Analysis, Interpretation and Modelling (GAIM) has focused on a set of 'Standard Experiments' in which there was a standard data base for temperature, precipitation, solar irradiance and soil texture, a weather generator, and normalised difference vegetation index. Differences in the standard experiments still exist in vegetation cover, leaf area index, and the parameterisation of the models for processes such as decomposition, nutrient cycling, and evapotranspiration. The results of this inter-comparison can be highlighted for different regions, giving a particularly interesting perception of change in China. *(Berrien Moore)*

The papers of the Symposium will be published in by Cambridge University Press in the IGBP Book Series. Members of the Symposium Organising Committee were Hajime Akimoto (Japan), Chen Panqin (China-CAST), Kasem Chunkao (Thailand), B. L. Deekshatulu (India), James Galloway, Chair (USA), Hu Dunxin (China-CAST), Jerry Melillo, Co-Chair (USA), Dennis Ojima, Chair, Poster Session (USA), Riga Suprapto (Indonesia).

In summary, the Science Symposium provided a forum and a focus for an assessment of Asian change in the context of global change. In so doing, it not only gave the attendees an opportunity to learn what was known, but also to design programmes to reduce critical areas of uncertainty on the interactions between Asian and global systems. It is encouraging to note that the Science Symposium associated with SAC-V will also have a regional focus. Based on the success of the SAC-IV Science Symposium, such a strategy will certainly not only increase the involvement of the global community in global change issues, but will also advance our understanding of the regional interactions with global systems.

B. L. Deekshatulu, S. Nash, *and members of the Organising Committee.*

The nations in IGBP implementation

National Committee Panel at SAC IV

The IGBP cannot function without the National Committees. These provide the backbone of the programme, ensuring both the research and the funding. The national committees met at SAC IV, together with the SC-IGBP, the ICSU union delegates, and IGBP scientists, to discuss their most urgent issues.

A panel of five national committee chairs presented resumés of five different issues addressed in a questionnaire circulated prior to SAC IV. Fifty-seven (out of 73) national committees replied - a proportion that marketing research would envy. This survey asked for suggestions on improving the role of the National IGBP Committees in five key areas: linking scientists in the nation, making the IGBP known, funding, national vs. international priorities, and participation of developing countries.

How can the National Committees provide an effective means of linking the communities of research scientists within the nations of the IGBP?

National Committees of the IGBP vary widely in terms their structure/composition, modes of operation, capabilities, funding and even the level of activities. The national committees of the rich industrialized countries of the North differ considerably from their counterparts in the developing nations of the South. Clearly, each entity is not homogeneous and within each bloc, countries differ importantly in terms of awareness of global change issues, leadership capability, relationships with the government and the private sector, etc. Additionally, while most countries of the South may be poor economically, a few like India, China, Brazil, Egypt are richly endowed in human resources with a huge amount of highly skilled personnel.

In essence, the role of national committees will be highly dependent on the country's economic, social, cultural and political situations.

A picture emerges of different ways in which national committees are organized and operate in different countries. While a preponderant number of the national committees have been established under the aegis of a National Academy of sciences, a few seem to be *ad hoc* in nature or are established in relation to specific initiatives or programmes. While most of the national committees are composed purely of research scientists, a few include representatives from the government.

The central question is "what is or should be the role of the National Committees vis-à-vis the IGBP?". As the Botswana response puts it, "a national committee has a dual role. It is the mouthpiece of the country vis-à-vis the international IGBP community of scientists, and at the same time represents the IGBP within the country it operates". The intermediary role can be effectively enacted if a national committee first establishes a community of researchers interested in research on global change and carefully nurtures the group. As the community takes shape, the national IGBP committee should come in close liaison with various institutions at the international level.

Ireland recognizes two types of linkages between global change researchers. First are the horizontal linkages in the same discipline that are well-established in the developed countries but very little in lesser developed countries. This type of linkage has been encouraged by transnational funding agencies, e.g., the various European Union research programmes, which have forged large international specialists teams and have led to a situation where awareness of what is being done in particular fields is now probably better known to international researchers in both the North and the South than ever before. However, advances in technology have produced increasing contrast between the scale of research efforts and the level of international cooperation between the developed and developing nations.

The second is a vertical linkage which remains poorly developed in both industrialized and developing nations. Disciplines often have poor awareness of what allied research communities are doing, even within industrial institutions at a national level. This is where a national IGBP committee can act in a coordinating role.

Report by Ademola Salau, Nigeria

What role might the National Committees play in making the IGBP known to national decision making and policy sectors?

In most nations the National Committees have been established recently. In the smaller countries, it is easier for the National Committees to rapidly spread awareness and understanding of IGBP issues. But whether large or small, the National Committees must have an excellent scientific reputation to be effective. There are tasks that every national committee should perform:

Inform

Using a bottom-up approach, inform the public and involve the policy sectors in discussions of national interest at every opportunity via media and gatherings regarding the role of the IGBP in global change issues, illustrating the IGBP research objectives, and disseminating its scientific progress and relevant results.

Demonstrate

The national committee must demonstrate the usefulness and benefits of national involvement in IGBP research, and that there are benefits and returns from funding both national and international IGBP structures. The committees should stress the importance of national to regional collaborative research, the links of global to local scale studies, and the need for scientific knowledge for setting policies to preserve the environment.

Assess

The national committees should assess what is happening in the country in relation to global change: what are the relevant issues attractive to national decision makers, and what are the national indicators of global change.

Promote

The national committees can promote interactions, possibly via top-down action with private contacts: these can be IPCC/IGBP integrated views, harmonisation of government programmes from different departments, links between national scientific committees, interdisciplinary research relevant to the IGBP. An *ad hoc* structural organisation (a national secretariat) would enhance efficiency.

Report by Roberto Frassetto, Italy

How might the National Committees play a greater role in obtaining funding support for the IGBP?

The IGBP committees are not in the same position in terms of capabilities. Additionally, their functions are limited by the lack of a formal set of defined functions, the most frequent and important one being the lack of a funding/management role. To gain the support of the research community, National Committees should have a more defined role in the funding processes.

Annual contributions

Despite significant differences, there are many common problems encountered in obtaining funds for the annual national dues to the central operations of the IGBP. National agencies will fund IGBP activities only if a benefit is clear, a benefit that must be recognized at the national or regional level where the funds are being sought.

Research funding

The National Committees should identify which Core Projects are in line with the country's priorities, and then discuss with funding agencies the support for research projects on those priority areas. It is only natural that governments fund such items that are firstly of interest to their own scientists, secondly, of importance to those regions to which they preferably allocate research funds, and thirdly, in accordance with the government's research priorities. It is easier to gain the interest of sponsors for a few well-defined and integrated large-scale activities (JGOFS, for example) rather than for contributions to specific "tasks".

Developing countries

Many small countries do not have any nationally funded global change programme, and require seed funding to start one. To assist in obtaining the funding support, the programme must address issues related to their most urgent concerns. These include principally erosion of coastal areas, threat of sea-level rise, freshwater and food scarcity, desertification, and socio-economic changes.

Proposals, when submitted, are accepted on the basis of scientific excellence. Developing countries would need the IGBP to direct some effort to help in the preparation of top quality projects.

Proposals

Committees can enlarge their role in obtaining funding by:

- Establishing close links with representatives from the government and funding organisations
- Stimulating the organisation of national and international scientific workshops and conferences where scientific results of the IGBP are presented
- Incorporating the IGBP-relevant research into the national programme priorities
- Improving the scientific quality of the research projects related to the IGBP
- Promote the value that global change research brings to the formation of informed policy decisions.

Report by Vladimir Kotlyakov, Russia

What are the experiences of National Committees in reconciling the priority interests of nations and those of the IGBP in global change research?

Most national committees show a reasonable degree of reconciling national and IGBP priorities: global issues are used to defend funding of research and problem solving of local problems, and national priorities find a place in the IGBP science plan.

Global issues and national priorities were found to coincide where the human dimension is emphasised. Global change research has in fact enhanced communication and personal contacts, raising funds and identifying gaps of information, which are all of national interest.

However, the IGBP is linked in decision-makers' minds with global warming and its consequence, which are of secondary importance for some developing countries who are struggling to provide basic human needs for their populations.

Examples of priority matching

Energy conservation was enhanced when a greenhouse gas emissions inventory indicated sources of leakage. Control measures were found to have negative incremental cost.

A vulnerability and adaptation analysis identified vulnerable resources and needs for their conservation. In addition, it identified gaps of data and needs for planning and information.

Involvement and close relationships amongst members of IGBP Core Projects have proved to be useful for the development and identification of national problems.

The active and highly constructive participation of key IGBP/WCRP personnel in a recent review of the US Global Change Research Program helped significantly in highlighting the value and benefits of international collaboration in global climate change to national needs.

Problems

- Lack of communication among scientists and policy makers and among IGBP committee members in developing countries has made it difficult to exchange views of national reconciliation.
- Only national research priorities are considered for funding.
- How a country can find funding to host a Core Project office.

Suggestions

Several national committees have expressed need for orientation of IGBP research towards the vulnerability of water resources to better reconcile IGBP research with national interests.

Some countries have expressed interest and hope that the development of START (Global Change System for Analysis, Research and Training) programmes for regional research centres and sites may solve some of their difficulties.

Report by Mohamed El Raey, Egypt

How might the well-established National Committees encourage and assist the increased participation of developing nations within the programme? Would a form of twinning between committees be useful?

Several mechanisms could increase the participation of developing nations in the IGBP. These could be the involvement of scientists in international/regional programmes, the exchange of scientists, visiting and/or secondment of global change research scientists, visits of Core Project coordinators to developing countries, support for workshops, meetings and training courses, promoting START regional groups, and joint implementation of projects.

Twinning between well-established national committees, and new ones, or those with less support in their own country, could help in a variety of ways. These should address projects of common concern, aiming at joint research programmes, where each shares its particular resources: equipment, logistic support, laboratory facilities, and database sharing and assistance.

Bilateral arrangements between developed and developing nations on common issues in similar social and cultural settings are effective. In larger regional groups, the working groups of scientists take the lead with regional working groups from a variety of developing nations. These can be most effective with national committees working in a regional/START framework.

Report by Lawrence Koe, Singapore

Resolutions and Recommendations

of the Fourth Scientific Advisory Council for the IGBP (SAC IV)

Resolutions

The Fourth Scientific Council of the International Geosphere-Biosphere Programme (SAC IV) resolved:

1. That formal appreciation be recorded of the excellent support and facilities arranged by the Local Organizing Committee and the Chinese National Committee for the IGBP, and the opportunities provided by the meeting for establishing contacts with Chinese scientists and on a wider basis, through the Regional Research Centre for East Asia.

2. That warmest congratulations be offered to Paul Crutzen, Sherwood Rowland and Mario Molina on their success in being awarded the 1995 Nobel Prize for Chemistry, for their work on atmospheric reactions causing stratospheric ozone depletion.

Recommendations

SAC IV recommended:

1 Funding & Communications

1.1 That IGBP should discuss with the International Group of Funding Agencies for Global Change Research (IGFA) concerns regarding the Programme's involvement in IGFA resource assessment exercises.

1.2 That the Scientific Committee for the IGBP (SC-IGBP) should consider establishing a Financial Advisory Committee to provide advice on all relevant financial matters, working closely with IGFA, and engaging other communities such as commerce, industry and the public at large.

1.3 That the SC-IGBP should consider establishing a Communications Committee to provide advice on policies and strategies which will improve awareness of the Programme, its goals and achievements among decision-makers, the business and commercial community, academe and the community at large.

1.4 That IGBP investigate the potential opportunities which may exist under the structure of the Megascience Forum of the Organisation for Economic Cooperation and Development (OECD).

2 Application of IGBP results

2.1 That the SC-IGBP develop a strategy for the transfer of IGBP research results to the public and decision makers, showing the policy relevance of its work.

2.2 That IGBP gives greater attention to providing the scientific underpinning for strategies to mitigate the undesirable effects of global change, and assessing their effectiveness.

3 Linkages

3.1 That IGBP develop its relationships with the World Bank and other members of the international development community, emphasising the importance of global change research for sustainable economic growth in developing countries.

3.2 That IGBP strengthen its ties with relevant ICSU Unions and Scientific Committees, for example by their closer involvement in SAC meetings.

3.3 That IGBP strongly support the development of HDP, with further joint initiatives on specific issues where appropriate.

3.4 That IGBP continue its efforts to develop close working relationships with the Asia Pacific Network (APN), the Inter-American Institute for Global Change Research (IAI), and the European Network for Research in Global Change (ENRICH).

3.5 That IGBP investigate the opportunities for productive working links with relevant research programmes within the UN system; for example, with the International Geological Correlation Programme (of UNESCO-IUGS).

3.6 That high priority continue to be given to inter core-project activities within IGBP. In particular, active interaction between LUCC and PAGES should be encouraged, taking account of the very long history of human-induced land cover changes.

4 Future Directions

4.1 That any further enlargement of the Programme should be considered with great care by the SC-IGBP, and that the mechanisms for terminating a project should be clarified.

4.2 That the SC-IGBP assess the importance of the following topics for the further evolution of the programme:

i) food security, in collaboration with other organisations already active in this field;

ii) large-scale changes in freshwater resources and freshwater ecology;

iii) the interaction of the hydrological cycle and biological processes in mobilising elements from soil and rocks, and subsequent effects on water quality;

iv) the influence of geological processes on biogeochemical cycles, in particular geo-sources of CO_2, and its uptake by rock-weathering processes.

4.3 That IGBP Core Projects consider the usefulness of developing 'sustainability indicators' for ecosystems (in cooperation with similar initiatives by SCOPE and others), identifying sensitive components that strongly influence their overall stability.

5 Regional Issues

5.1 That IGBP Core Projects highlight the importance of their research for the solution of regional problems of global concern. Future work should be planned in close coordination with efforts at national and regional levels.

5.2 That START should improve its effectiveness in promoting two way communication between the Global Change Programmes (IGBP, World Climate Research Programme and Human Dimensions Programme) and the regions.

6 Structure of IGBP

6.1 That the National IGBP Committees and relevant ICSU bodies assist in widening geographical representation on the IGBP Scientific Committee, and on the Scientific Steering Committees and Standing Committees of the programme elements, by submitting membership proposals of suitably qualified scientists.

6.2 That National IGBP Committees should consider rotating their memberships, with the inclusion of scientists with interests in WCRP and HDP. Interactions with national funding agencies are also strongly encouraged.

7 SAC Meetings

7.1 That the SAC agenda should in future include the opportunity for the discussion of actions arising from inter-SAC meetings of Chairs of National IGBP Committees

7.2 That options for the structuring of future SACs should be carefully considered; for example, allowing greater opportunity for discussion of the scientific contents and results of individual IGBP Core Projects and Framework Activities

Those who made SAC IV possible

The 4th IGBP Scientific Advisory Council and associated meetings were hosted by the Chinese Committee for the IGBP, the Chinese Academy of Sciences, the China State Commission for Science and Technology, and the Chinese National Science Foundation.

The generosity of the European Network for Research in Global Change (ENRICH) programme of the European Commission provided for publications at the meeting and those to come, and for participants from Africa and Europe. The Inter-American Institute for Global Change Research, the Canadian International Development Agency, and the Commonwealth Science Council provided travel grants to the international participants. IGBP gratefully acknowledges their support. Scientific Advisory Council meetings are funded additionally by the central IGBP budget.

Professor Ye Duzheng

Evaluation of the IGBP

When the International Geosphere-Biosphere Programme moved into the fifth year of its implementation phase, in 1994, three organisations launched a plan to evaluate its track record: the International Council of Scientific Unions (ICSU, the founding body of the IGBP), the International Group of Funding Agencies, and IGBP itself.

ICSU appointed an Evaluation Committee, chaired by Prof. Hubert Curien, former French Minister of Research, and consisting of respected individuals in research and science policy. The Committee met twice in Paris, a group visited Stockholm, members attended Programme Element meetings and visited the Core Project Offices, and a report was compiled that was presented at SAC IV in Beijing.

In its conclusion the Evaluation Committee wrote:

> "The Evaluation Committee wishes to stress that it considers the IGBP to be a well-conducted and outstanding programme. The IGBP should continue to receive support in order to carry out its primary function as a scientific programme, whose direct beneficiaries are specifically science and scientists, and more generally, society at large.
>
> "The Evaluation Committee recommends that the funding agencies continue to support the core activities of the IGBP, including providing support for the regular functioning of the Core Project Offices, the Core Project Framework Activity Scientific Steering Committees, which are essential IGBP components.
>
> "The Evaluation Committee concludes that IGBP provides added value to the sum of national/regional activities, and justifies the continued, if not increased, support by funding agencies for its central operations."

The report identified four main areas of general comments or recommendations.

Nature and Future of the IGBP

(i) The principal originality and strength of the IGBP is to be an independent, basic research programme, designed and steered by the relevant scientific communities. The IGBP should not transform itself into a more formal organisation

(ii) The life-span of IGBP projects, and the evolution of the programme itself, is being addressed by the IGBP and should continue to be a priority.

(iii) The capacity building component of IGBP should be further developed, involving the scientific community from all parts of the world.

Internal organisation and specific roles of the Framework Activities

(i) The scientific advisory role of the IGBP is assured by the Scientific Committee for the IGBP. The Scientific Advisory Council (SAC) should be renamed to reflect its primary role as a forum for wider visibility of IGBP and to strengthen the links between the Programme and the ICSU family and its partners.

(ii) Framework activities include the data functions (IGBP-DIS), analysis and modelling (GAIM), the regional research and training initiatives (START). These programme elements are central to the work of the IGBP, and clear distinctions in the division of tasks between them, the thematic research projects (Core Projects), and the IGBP as a whole, should be pursued.

Links with related programmes

(i) A formal joint forum with the WCRP (World Climate Research Programme), which has the best-developed relations with the IGBP at present, was recommended.

(ii) The IGBP should become more involved in biodiversity, through increased cooperation with DIVERSITAS at the programme level (the UNESCO biodiversity programme).

(iii) The Evaluation Committee noted with satisfaction that topics related to the HDP (Human Dimensions of Environmental Change Programme) are now addressed, in cooperation with social scientists, in the Land Use/Cover Change Core Project. It recommends that links with social scientists should occur on a case by case basis, built around specific scientific questions.

External Relations

(i) The IGBP should develop a strategy for interactions with outside partners in order to secure the required financial support.

(ii) IGBP should take into account the intergovernmental background involving the various Conventions related to the environment, and strengthen its contacts with their scientific and technical subsidiary bodies.

(iii) The IGBP should continue to publish scientific results, encourage publications from its workshops, and ensure that scientific results of IGBP research are acknowledged in literature.

(iv) IGBP should strive to gain more recognition for interdisciplinary science through the organisation of synthesis workshops and reviews, award schemes or visiting professorships.

The final version of the evaluation report will be produced by the sponsors early in 1996 following feedback from ICSU, IGFA and IGBP.

Future Directions of the IGBP

Global Ocean Ecosystem Dynamics

A new Core Project has joined the IGBP. It adds an important dimension to the overall global change science plan: a focus on marine ecosystems.

The ocean comprises seventy per cent of the Earth's surface, and the structure and functioning of its ecosystems are an important component in the biogeochemical cycling of the Earth system.

We have an increasing awareness of multiscale temporal and spatial variability in the ocean's physical structure. This variability is exemplified in such basin-scale events as the Great Salinity Anomaly of the North Atlantic, the meandering and ring structures of the Kuroshio-Oyashio interface, and the 'three dimensional' small-scale turbulent flow that exists in varying degrees in much of the upper ocean.

We have developed an improved understanding of significant multi-decadal changes, on at least sub-basin scales, of the standing stocks and probable production rates of plankton, and of the fish, birds and mammals that feed on either fish or plankton. The Continuous Plankton Recorder time-series data have demonstrated a multi-decadal decrease in plankton stocks during the 1970s over much of the northeast Atlantic. The zooplankton stock in the North Pacific doubled in the decade of the 1970s. The Peruvian anchovetta, the largest fishery in the world, collapsed during the El Niño of 1972. This collapse was correlated with a similar dramatic decrease in zooplankton populations off the coast of Peru.

One major scientific question is how these changes in the physical system relate to 'global change', how the changes in the multiscale flow field drive the structure and functioning of the marine ecosystems, and, in turn, how a changing ocean ecosystem contribute to altering the carbon dioxide uptake of the ocean.

Another current question of considerable scientific importance concerns how a changing ocean ecosystem affects the 80 million tons of fish that are taken annually from the world oceans. Will an altered ecosystem reduce in a significant way the fishery resources of some countries and enhance those of others?

Another concern is the production of anthropogenic substances, and how these substances might affect the structure and functioning of marine ecosystems.

In is necessary to take a new approach to address questions concerning the marine ecosystem's role in global change. This involves both the concept of how the ocean's ecosystems are driven by external forcing, and how such changes can be measured in a cost-effective and statistically representative manner.

The new approach is the Global Ocean Ecosystem Dynamics programme, established by SCOR and IOC in 1992, and recently adopted as a new Core Project of the IGBP. The GLOBEC goal is:

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

GLOBEC has four objectives:

(i) To understand better how multiscale physical environmental processes force large-scale marine ecosystem changes

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

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

(iv) To determine how changing marine ecosystems will affect the global Earth system by determining, identifying and quantifying feedback mechanisms, and how changing marine ecosystems will affect the Earth system.

The goal and the accompanying objectives will be achieved by concentrating research in four foci:

1. Build a foundation for future global ecosystem models through re-examination of historical data bases, synthesis and integration including the following activities:
- Identify existing data sources that contribute to GLOBEC model development (e.g., fish scales, plankton records, fish abundance, oceanographic and meteorological records)
- Synthesize understanding of small-, meso- and large-scale physical and ecosystem process interactions.

2. Conduct process studies organised around the themes of (a) research and modelling of ecosystems and trophodynamics, (b) identification and understanding of mesoscale physical-biological interactions, and (c) research on forced responses in ecosystems, with emphasis on the following activities:
- Zooplankton feeding strategies, e.g., the role of copepods as omnivores and grazers requires understanding the nutritional aspects of omnivory
- Understanding and quantifying the role of micro-zooplankton in food webs. Micro-zooplankton may be major grazers of phytoplankton, while large zooplankton are major grazers of the micro-zooplankton
- Zooplankton-fish interactions: the abundance of zooplankton is thought to critically affect fish recruitment because early zooplankton developmental stages are important food for larval fish. Simultaneously, grazing by adult and juvenile fish stocks on all plankton will influence planktonic production.
- Fine-scale stratification, turbulent flow and zooplankton, inasmuch as turbulence modifies predator-prey encounter rates
- Estimation of mortality, growth and reproduction rates

3. Develop predictive and modelling capabilities with interdisciplinary, coupled modelling-observational systems including the following activities:
- Develop multiscale biological-physi-

cal dynamical models taking account of (i) spatial and temporal nesting, (ii) formulation and parameterisation of biological processes, (iii) structured and unstructured individual-based and population models, and (iv) consistency and correspondence between data models
- Develop procedures for acquiring and assimilating data into the dynamical models that are adapted to specific experimental sites such as upwelling, coastal or polar systems via observation system simulation experiments
- Incorporate modelling an data assimilation procedures into Advanced Modelling and Observation Systems
- Develop innovative ways of archiving, storing and analysing existing and new data
- Integrate dynamical models of autotroph-heterotroph interactions in a physical setting
- Synthesise understanding of how mesoscale physics modulates the interactions among small and large-scale ecosystem processes

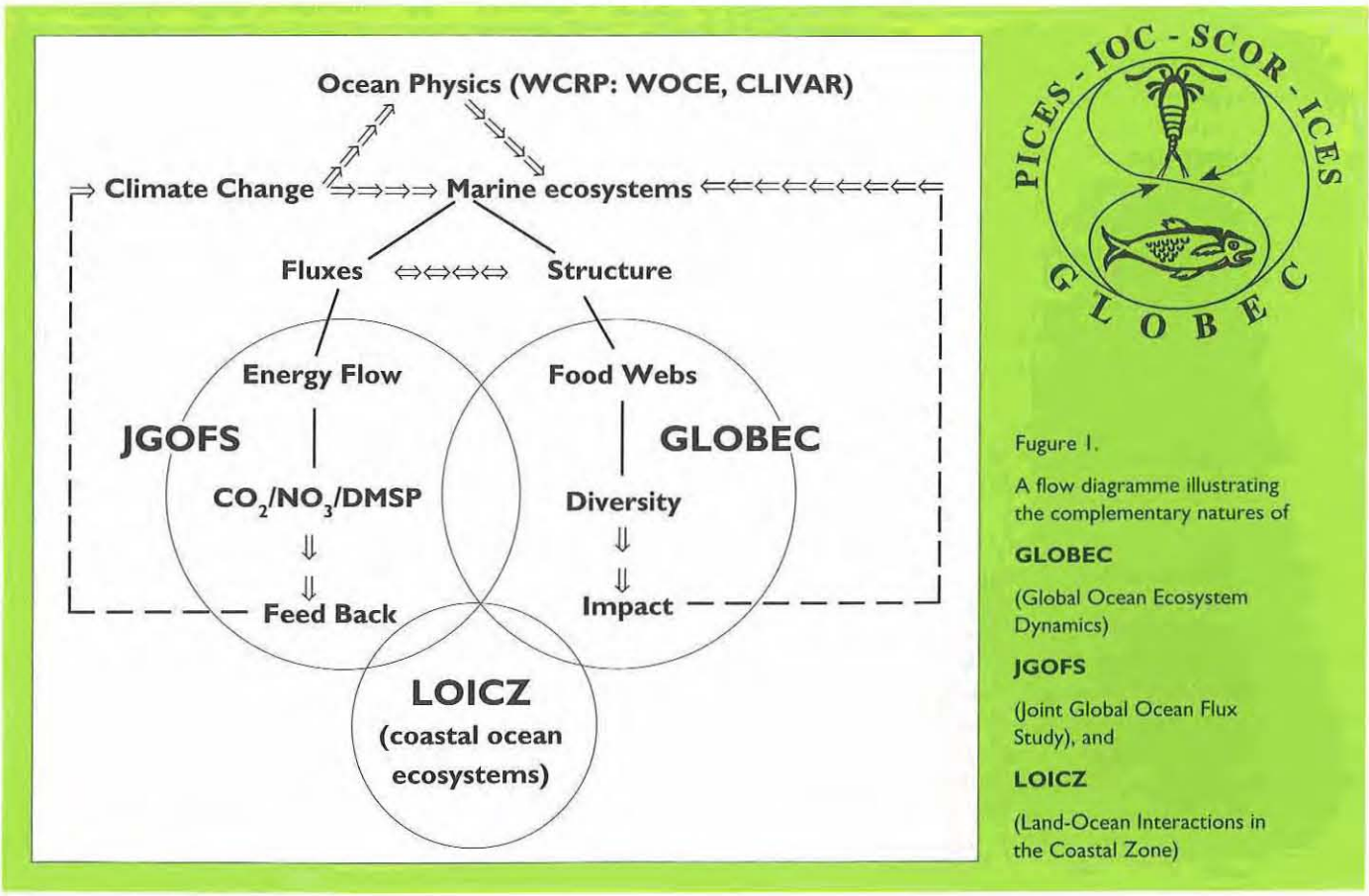
4. Cooperate with other ocean, atmosphere, terrestrial and social global change research efforts to estimate feedbacks from changes in marine ecosystem structure to the global Earth system
- Select appropriate topics for interaction, for example, carbon fluxes, in consultation with other programmes
- Predict scenarios of altered marine ecosystems and their impact on important stocks
- Draw on the results of other international programmes involved in modelling of climate change and its impacts.

Some scientific intersections between GLOBEC and other IGBP marine Core Projects are illustrated in Figure 1. In addition, there will be close ties to projects of the World Climate Research Programme (WCRP), especially the World Ocean Circulation Experiment (WOCE) and Climate Variability (CLIVAR).

The GLOBEC Core Project consists of a series of activities which are being planned under the aegis of the GLOBEC Scientific Steering Committee. Among its major field components are Southern Ocean GLOBEC, a study of Small Pelagic Fish and Climate Change, and regional programmes involving the International Council for the Exploration of the Sea /GLOBEC Cod and Climate Change which is a study of the ecosystem dynamics of the North Atlantic shelf seas and the North Pacific Marine Science Organisation/GLOBEC Carrying Capacity and Climate Change programme in the sub-Arctic Pacific Ocean. In addition to these regional programmes and several important national programmes, GLOBEC with its model-driven emphasis, maintains a strong working group on numerical modelling and on sampling and observation systems.

The advent of new concepts and the linking of dynamic models with data assimilation places GLOBEC in a position to contribute to a more coherent analysis of the biogeochemical functioning of the Earth system, along with other IGBP programmes: Global Change and Terrestrial Ecosystems (GCTE), the Joint Global Ocean Flux Study (JGOFS) and the cross-cutting Land-Ocean Interactions in the Coastal Zone (LOICZ). It not only allows for predictive capability of the fates and effects of anthropogenic substances, specifically with regard to fisheries, but new and exciting research in oceanography is enabled by linking together the grazer-phytoplankton interactions with ocean physics, multidisciplinary multiscale dynamic models, and state-of-the-art sensors and data archiving systems.

Brian Rothschild, *Chair, GLOBEC Core Project Planning Committee, Massachusetts University at Dartmouth, USA.*



Fugure 1.

A flow diagramme illustrating the complementary natures of

GLOBEC

(Global Ocean Ecosystem Dynamics)

JGOFS

(Joint Global Ocean Flux Study), and

LOICZ

(Land-Ocean Interactions in the Coastal Zone)

Marine Biogeochemistry

After JGOFS, SOLAS?

Future research to determine the integrated ocean response to climate change

The importance of marine biogeochemical processes in the Earth's climate system is now firmly established. JGOFS, the Joint Global Ocean Flux Study, can claim much credit for that conceptual shift, by directing attention to the critical role of the ocean in the global carbon cycle. As a result of JGOFS work, we already have a much more reliable estimate for the current ocean uptake of fossil fuel carbon dioxide, and improved understanding of carbon exchanges within the ocean interior, and across the sea floor and continental boundaries.

JGOFS is due to finish its field phase by 1999. By then much more will be learnt about the current (and past) functioning of the ocean carbon system. Yet many key issues will remain unresolved. In particular, the linkages between carbon and other elements will need to be addressed, and climate models will require regional and global information on biogeochemical responses to future changes in ocean mixing and circulation patterns, that now seem increasingly likely to occur.

Since major oceanographic studies involve high-cost facilities, they require a long planning phase – and a strong rationale – to put into place. It is therefore necessary for IGBP to look beyond the 'JGOFS decade', by defining the objectives for ocean biosphere-geosphere research early next century. A start has already been made. In partnership with SCOR (Scientific Committee on Oceanic Research, the co-sponsors of JGOFS), a Working Group was set up in 1992 to look at long-term research priorities in this area.

The emphasis was on the upper ocean, following the earlier identification by IGBP of the Global Ocean Euphotic Zone Study (GOEZS) as a potential project that might either complement or follow JGOFS. At SAC III, the latter time schedule was adopted; it was then also agreed that WCRP (World Climate Research Programme) should join IGBP and SCOR in the exploratory planning phase.

The joint Working Group, led by Ken Denman of Canada, has since recommended that detailed planning for a new project should begin in 1996, with initial attention given to relevant aspects of the second IPCC Scientific Assessment (1995/96). The Working Group also recommended that GOEZS should be reformulated, refocussed and renamed, not only building on JGOFS, but also IGAC (International Global Atmospheric Chemistry project, IGBP) and WOCE (the World Ocean Circulation Experiment, WCRP), and closely linking to GLOBEC (Global Ocean Ecosystems Dynamics, SCOR/IGBP/IOC) and CLIVAR (Climate Variability Prediction and Research, WCRP). With regard to the project name, Denman proposed SOLAS, the Surface Ocean-Lower Atmosphere Study; this suggestion has generally been well-received within IGBP.

A key issue for investigation in the proposed SOLAS project is likely to be the role of atmospheric inputs of nutrients to the ocean. Such work would link anthropogenic changes to the carbon and nitrogen cycles, and would examine the hypotheses that dust inputs (containing iron) were largely responsible for ice-age variability in atmospheric carbon dioxide. New experimental techniques, developed in JGOFS, are now available to address such problems.
(Photo credit: IRONEX II Sue Turner)

The focus for SOLAS is envisioned to be marine biogeochemistry as it affects, and is affected by, the climate. In addition, to addressing future carbon fluxes on a 50-100 year time frame, the marine sources and sinks of other radiatively active gases (such as nitrous oxide and dimethylsulphide) would also be central to the project. There have not only been considerable scientific advances in these areas during the past decade, but also a host of new and even more challenging questions.

It was originally planned that GOEZS would be 'model driven', that is, the dynamo of the project would be questions generated from models. Whilst this is a fine idea in theory, our understanding of many biogeochemical processes is not yet sufficiently sophisticated to rely wholly on this approach. To provide a strong theoretical framework for SOLAS, it would seem better to cast it in terms of hypotheses. For carbon flux studies, examples of such hypotheses (that may be disproved) could be: (i) that changes in the uptake of anthropogenic carbon dioxide by the oceans will be initially dominated by physico-chemical processes, or (ii) that iron supply to the surface ocean is the main natural factor modulating carbon dioxide uptake, through its effect on plankton productivity and high nutrient, low chlorophyll waters.

By concentrating on biogeochemical issues, SOLAS would fill a critical gap in the plans of IGBP and WCRP. Thus GLOBEC is aimed primarily at ecosystem studies and secondary production processes, whilst CLIVAR is targeted mainly at the physical processes (atmospheric and marine) responsible for climate variability. Neither project integrates the feedback effects of whole system interactions in ocean biology, chemistry and physics in the context of future climate change scenarios. However, both GLOBEC and CLIVAR would clearly gain by SOLAS addressing such issues, and close collaboration is expected.

It is planned to develop these ideas over the next year, leading to the formulation of a fuller scientific plan in 1997.

Andrew Watson, *Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK. Fax: (+44-1752) 633 101*

Rapid Progress in IGBP Transects

The IGBP Terrestrial Transects (see IGBP Report No. 36) are rapidly becoming a reality, with many of the initial set already operational, most others in advanced planning phases, and the first series of inter-transect comparative studies underway.

The transects are one of the most exciting developments within IGBP, as they are proving to be an effective mechanism for promoting and enhancing collaboration among the core projects. They are also an ideal tool for extrapolating the understanding gained from fine-scale process studies to the regional and global levels, one of the major challenges of global change research. In addition, by enabling researchers from a number of institutions and countries to work at the same sites, often with shared equipment, the transects are a resource-efficient and scientifically effective facility for obtaining maximum benefit from the limited funding available for global change research.

The IGBP Terrestrial Transects are based on a set of integrated global change studies, usually consisting of distributed observational studies and manipulative experiments coupled with modelling and synthesis activities. The work is organized along existing gradients of underlying global change parameters, such as temperature, precipitation and land use. They are of an order 1000 km in length and are wide enough to encompass the dimensions of remote sensing images.

The transects can be visualized most easily where they represent a simple gradient of a single controlling factor that varies in space - for example, the gradient in precipitation from moist tropical forest to dry savanna. In addition to relatively straightforward transects in which a single environmental factor varies continuously in space, a set of IGBP Terrestrial Transects has been identified in which the underlying gradient is one of land use. These gradients are more spatially complex than the quasi-linear transects. Ecosystems experiencing differing intensities of land use are rarely distributed in such a way that distance along the transect corresponds directly to intensity of land use. Nevertheless, it is useful to place study sites along a conceptual gradient based on land use intensity.

The initial set of IGBP Terrestrial Transects are located in four key regions, with three or four existing, planned or proposed transects contributing to the set in each region. The locations are shown in the figure, and their underlying environmental gradients and present status is shown in the table.

Some of the transects, such as Savannas in the Long Term (SALT) in West Africa, have been operational for a number of years and are producing significant new results of benefit to several core projects. Others, such as the Kalahari transect in southern Africa and the North East China Transect (NECT), have been formed more recently and are beginning their experimental and observational work. Some transect studies, such as the Northern Eurasia Study and the Southeast Asia Land-Use Change Project, have been initiated directly by IGBP and are in various stages of planning. Most transects also serve national and regional development and resource management needs, as well as contributing to global change research.

A key feature of the transects is interdisciplinary process-oriented research carried out at study sites along the transects. To date much of this work has involved the BAHC (Biospheric Aspects of the Hydrological Cycle), IGAC (International Global Atmospheric Chemistry Project) and GCTE (Global Change and Terrestrial Ecosystems) Core Projects, and has focussed on questions such as the linkage of the carbon and hydrological cycles, the role of soil processes in controlling the rates and types of trace gas emissions, and the influence of longer term changes in ecosystem composition and structure on biogeochemical cycles. In the future, contributions from PAGES (Past Global Changes) will provide a valuable longer-term perspective in change along the transects, while LOICZ (Land-Ocean Interactions in the Coastal Zone) research will study the effects of land-use change in the humid tropical transects on the delivery of sediments and nutrients to the coastal zone.

Remote sensing will play a central role in several aspects of research on the transects. For example, measurements of Normalised Difference Vegetation Index

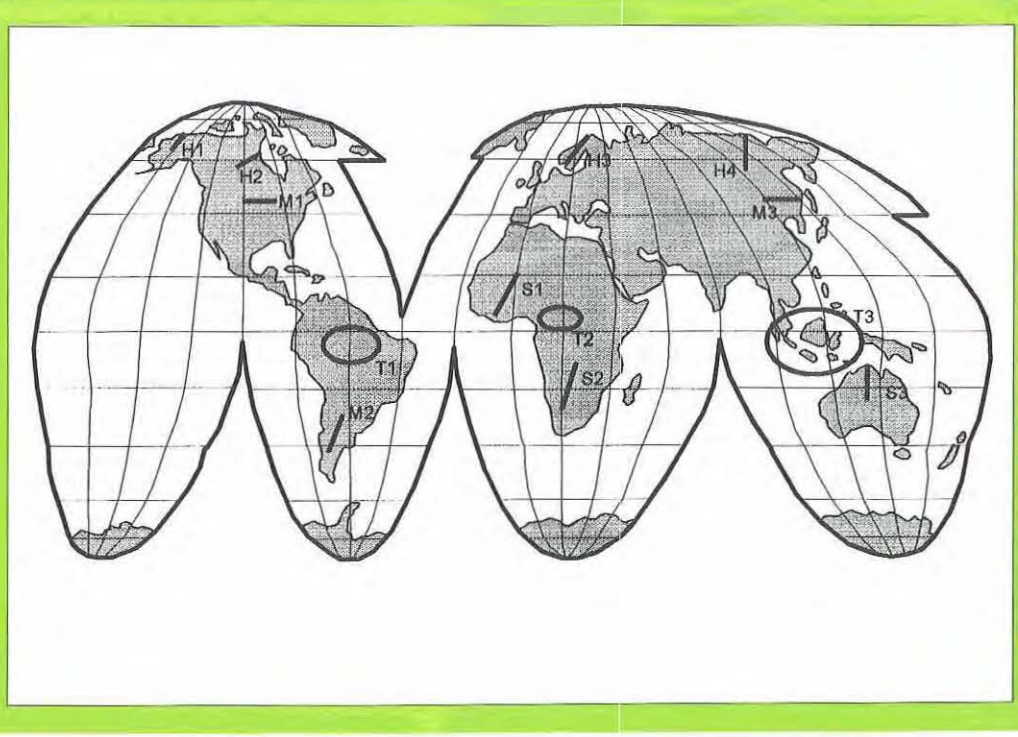


Figure 1

Humid Tropical Forests
- T1 Amazon Basin
- T2 Central Africa
- T3 South East Asia

High Latitude
- H1 Alaska
- H2 Boreal Forest Transect Case Study
- H3 Scandinavia
- H4 Siberia

Mid Latitude
- M1 Great Plains
- M2 Argentina
- M3 North East China Transect

Semi-arid Tropics
- S1 Savannas in the Long Term
- S2 Kalahari
- S3 Northern Australia Tropical Transect

IGBP Transects

Region	Land cover	Global change gradient	Contributing transects	Status
Tropical forests	Tropical forest (humid and dry) and its agricultural derivatives	Land use intensity	Amazon Basin (humid) Mexico (dry) Southeast Asia (humid) Thailand (dry) Central Africa (humid) Miombo (dry)	Advanced planning Conceptual Initial Planning Conceptual Conceptual Initial planning
Semi-arid tropics	Forest-woodland-shrubland (savannas)	Precipitation	Savannas in the Long Term (West Africa) Kalahari (Southern Africa) Northern Australia Tropical Transect	Operational Advanced planning Operational
Mid-latitude semi-arid	Forest-grassland-shrubland	Precipitation	USA Great Plains Argentina China/Mongolia	Advanced planning Operational Operational
High-latitude	Boreal forest-tundra	Temperature	Arctic Flux Study (Alaska) Boreal Forest Transect Core Study (Canada) Scandinavia Siberia	Operational Operational Conceptual Initial planning

Figure 2

by the US National Oceanic and Atmospheric Administration Advanced Very High Resolution Radiometer instrument are being used to document vegetation performance along the transects over long periods of time, and to test ecosystem models from landscape through global scales. Higher resolution images from Landsat and SPOT (satellite for Earth observation) are being employed in the Land Use/Cover Change Core Project to provide valuable information on the rates and trajectories of land-cover change, which form the core of the studies in the humid tropics. High resolution data are also being used in the scaling of results from the process studies carried out at individual study sites to the entire transect. Radar data have been used in several transects to produce high resolution digital terrain maps, essential for modelling the flow of water and nutrients across landscapes.

Several transects have been operational long enough for the first inter-transect comparisons to be undertaken. For example, a series of workshops will synthesize results from the Arctic Flux Study in Alaska and the Boreal Forest Transect Case Study in Canada, which includes the Boreal Ecosystems Atmosphere Study land-surface experiment. Such work will provide valuable input into the planning of companion high latitude transect studies in Scandinavia and Siberia. A symposium to be held in Beijing, China, in May 1996 will focus on the mid-latitude transects, and will highlight their value for biodiversity-related global change research. Planning is beginning for a cross-comparison of results from the semi-arid tropical transects, tentatively scheduled for northern Australia in late 1996 or early 1997.

One of the most innovative projects based on the transects is the testing of global vegetation models on the individual transects. The work, being carried out by the CSIRO Division of Wildlife and Ecology in Australia, features comparisons of key terrestrial ecosystem parameters, such as leaf-area index (LAI) and net primary productivity (NPP), calculated by the global models to the same parameters calculated by finer scale models developed for the individual transects, and the validation of both model outputs by measurements from sites along the transects.

The initial results from the mid-latitude Northeast China transect are encouraging. The simulation of net primary productivity by the DOLY (Dynamic Global Phytogeography Model) of the University of Sheffield, UK, agrees well with that predicted by the more detailed, finer scale regional ecosystem model designed specifically for the transect (and validated by measurements of NPP along the Northeast China transect). Comparison of the simulations suggest that the global model is not only faithfully reproducing the broad-scale change in NPP based on the underlying gradient of moisture availability, but is also predicting some of the variation in NPP caused by finer regional variations in climate.

The project is being extended to additional global vegetation models and to other transects in the IGBP set as they become operational. Such large-scale research scaling up work on sets of transects to the globe will provide an essential experimental and observational underpinning to the global models being developed in the IGBP Task Force on Global Analysis, Interpretation and Modelling.

With the rapid increase in activity associated with the transects, overall coordination of the set to achieve maximum benefit from truly collaborative and comparative research is becoming an urgent priority. Early coordination has been provided by an interaction task team consisting of Scientific Steering Committee members and officers of BAHC, IGAC and GCTE. To achieve the level of coordination now required, however, necessitates the appointment of a full-time transects scientist, attached to the IGBP Secretariat or to the core projects.

Will Steffen, *Core Project Officer, GCTE Core Project Office, CSIRO Division of Wildlife and Ecology, PO Box 84, Lyneham ACT 1602, Australia.*

For a full presentaion of the transects, write to the IGBP Secretariat for a copy of Report 36: The IGBP Terrestrial Transects: Science Plan (1995). Edited by G. W. Koch, R. J. Scholes, W. L. Steffen, P. M. Vitousek and B. H. Walker. 61. pp

Global Observing Systems and how they relate to the IGBP

Why we should be spending so much effort to produce global data sets, which is the prime objective of global observing systems? The underlying reason is that our data sets are insufficiently consistent in time and space to support the scientific goals of the IGBP.

Moreover, environmental research increasingly requires very long-term consistent data sets; science has in effect become an operational user of environmental data sets. These data sets are generated not merely for the scientific community, but also for policy makers many of whom are capable of responding and interpreting observations and information.

Generating consistent data sets could appear to be quite modest objective, but we have to recognise that there are tremendous inherent difficulties in achieving it. In part this relates to the enormous variety of ways in which data are collected. It also relates to the fact that environmental data are usually not collected with the long-term view as the first prority. The most obvious examples are probably meteorological observations, which are collected primarily for short term forecasting and though essential for climate studies have major deficiencies when generating a long term record. Satellite derived data often have major limitations unless special efforts are made. The change from one sensor to another in a series can seriously damage the consistency of a record. Finally, one of the biggest difficulties we all face is the decay of the in-situ networks. These networks designed for the collection of data at specific locations are in many cases decaying rapidly, and we are in the process of losing crucial underpinning records on which we base our science.

Currently there are a series of global observing systems which are in various processes of development. Usually we think of the three G's, namely GCOS, GOOS and GTOS - the Global Climate Observing System, the Global Ocean Observing System and the Global Terrestrial Observing System. In fact it is better to think of five observing systems the two additional ones being the World Weather Watch and Global Atmospheric Watch, which are already operational. These two systems together form the atmospheric equivalent to GTOS and GOOS. GCOS is quite different conceptually to the latter in that it considers all the observational needs of the atmosphere land and oceans which are relevant to climate.

It is not the global atmospheric observing system, it is the climate observing system. Both the global ocean observing system and the global terrestrial observing system have more difficult tasks to carry out because they have so many different objectives to deal with. Reconciling these are going to provide major challenges.

Within GCOS we have identified three major objectives

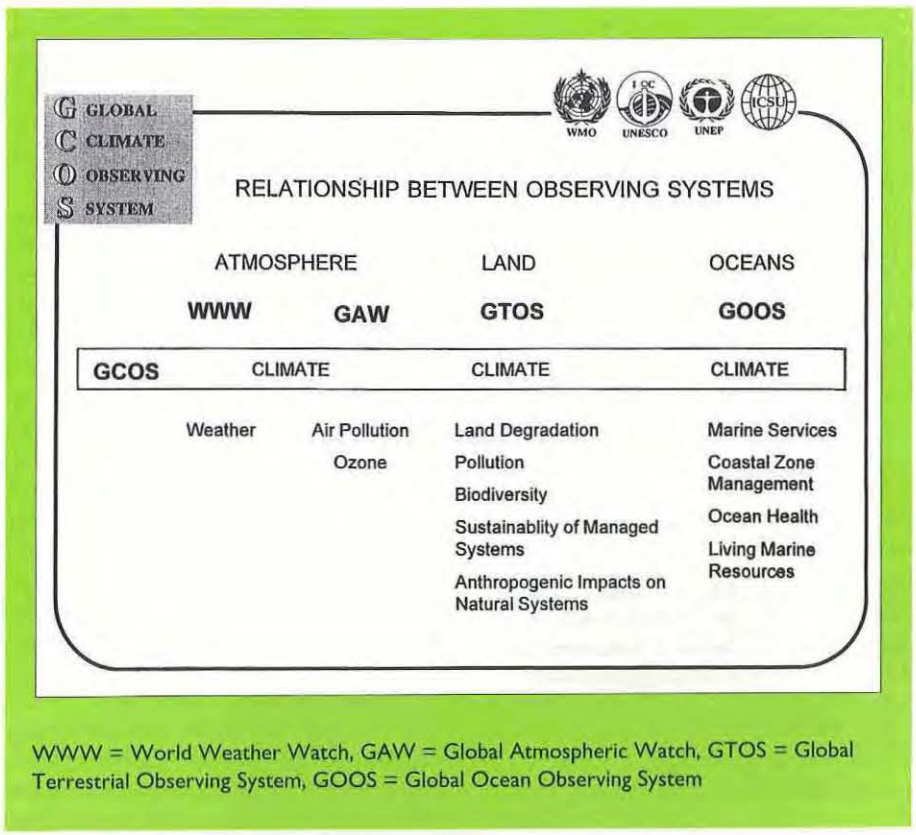
- to design an effective operational, climate observing system.
- to establish and coordinate and manage an initial observing system, by taking parts of existing systems and enhance them to a modest degree to create an initial observing system.
- recognising that this initial observing system still will be imperfect, to develop new components to provide a comprehensive and responsive system to meet future needs.

Our fundamental scientific priorities have been identified with the advice of our sponsors, WMO, UNESCO, UNEP and ICSU. These are seasonal and inter-annual prediction, the earliest possible detection of climate trends, and reduction of major uncertainties in longer- term prediction.

We have tried to carry our task in a systematic fashion, and the resultant plans are now available throught the GCOS Secretariat (see address below). Not only have we made detailed plans of the space and in situ systems but we are already moving into implementation.

When we talk about global observing systems, it may appear as though we are limiting ourselves to the collection the observations themselves. It is quite clear that that is not enough. What we have to think about are the products we create for users. Much of the work of GCOS and the other global observing systems is concerned with the creation of products and not only observations as such. But you can only create products if you make sure that your observations are not simply collections of data but that there are appropriate systems for communication, assimilation and distribution.

As an example of a major attempt to develop such an operational system we can with value consider the work of CERN (The Chinese Ecosystem Research Network) and its Information System. In the context of information systems people often talk about the transfer of understanding from the North to the South, but from what I have seen of the system being developed, CERNIS is providing leadership for the world in terms of how people should take responsibility for their data, and how they should bring their data together to create useful products from the observations which are being collected *in situ*.



WWW = World Weather Watch, GAW = Global Atmospheric Watch, GTOS = Global Terrestrial Observing System, GOOS = Global Ocean Observing System

A key role for the IGBP in relationship to this issue of products and observations, is networking the global IGBP community of scientists. This summer IGBP-DIS played a role in initiating this through a joint activity with START at a workshop in which 25 global change scientists from the START regions came together. Initially this was with the idea of defining the techniques to communicate electronically, but we also created an embryonic information system for the START regions to assist communication within the regions and between the them.

It is, however, ironic that the scientific community of the South which can benefit most from Internet and from the communication of data sets and ideas is the one that has the least capacity telecommunication capacity at the moment. The Internet and the Web, are of potentially even greater importance for the South than for the North, because what we need are not only observing systems and global data management systems, but also better global knowledge systems. Only through improved global networking can we achieve these goals.

Scientific enquiry clearly generates the need for new data sets and scientists play key roles in specifying new observational strategies. But they also need to play important roles in the validation and management of these data sets. As it matures IGBP is becoming a supplier as well as a user of new data sets. With this comes new responsibilities. The openness we demand of others in supplying us with data must now be shown by us. We have to ensure that our data sets, the ones we create, are also freely and readily available.

These responsibilities mean that scientists have to become part of the process of global environmental data management process, a concept close to anathema for some scientists. But we have to take on these responsibilities if we are to pass on the legacy of our data sets to support not only the science of today and tomorrow but also the science that will happen long after IGBP has finished its work.

John Townshend, *Department of Geography, Room 1113, Lefrak Hall, University of Maryland, College Park, MD 20742, USA. Tel. (301) 405 4050, Fax (301) 314 9299*

For a list of GCOS publications please contact the Joint Planning Office for GCOS c/o WMO C.P. No.2300 CH-1211, Geneva 2, Switzerland; Fax +41 22 740 1439; e-mail jpo@gcos.wmo.ch

Regional Research Initiatives

Covering the World

In April 1990 President George Bush launched an appeal from the White House to countries of the world to join the United States in developing three regional research institutes that would link the interests and capabilities of the developed and the developing world. These institutes would be regional partnerships involving countries and their scientific communities that focus on broadening global change research in the developing world, providing support for truly multi-disciplinary research and education and encouraging the development of sound scientific underpinning that supports national, regional and international policy making needs.

In the same year, the IGBP initiated the most all-encompassing project: the Global Change System for Analysis, Research and Training (START).

START

A workshop on "Global Change Regional Research Centres: From Concepts to Reality" was organised by the IGBP at the Rockefeller Foundation in Bellagio (Italy) in December of 1990, creating the groundwork for a visionary programme. The World Climate Research Programme (WCRP) and the Human Dimensions of Global Environmental Change Programme (HDP) have since both become co-sponsors of START.

A regional approach was seen as necessary for two reasons: (i) First, regional differences in such characteristics as biogeography and climate would have to be incorporated into a truly global perspective. (ii) Second, the goal of a "practical predictive capacity" for global environmental change required that such a capacity be developed at regional, i.e., subcontinental, levels where global change prediction would also be of the greatest value to decision makers.

The Bellagio workshop proposed some 14 subcontinental regions, sufficiently large to embrace areas that are generally homogenous and representative in terms of vegetation and climate, but which would also include biogeographical diversity adequate to permit various transect or gradient studies as are called for by several IGBP Core Projects.

Regional Research Networks

The fundamental purpose of these networks was "to mobilise manpower and resources to address the scientific questions concerned with global change" and to provide a framework to support the regional syntheses and scientific assessments of relevance to policy development.

Such regional research networks are a means of promoting regional cooperation in global change research, developing coherence and greater efficiency among regional and national research agendas, enhancing exchange of data and communication of research results, and providing scientific knowledge more rapidly to the public.

Finally, a major common objective of the regions was capacity building - the improvement of regional scientific and technical capabilities and research infrastructures, including human resources.

Each Regional Research Network has a Regional Research Centre, and a number of Regional Research Sites. The centre serves as the information and coordination focal point for the regional network and in addition is expected to perform the region-wide tasks of training; data management, synthesis, assessment and modelling; and communication of scientific results to the public and to decision-makers.

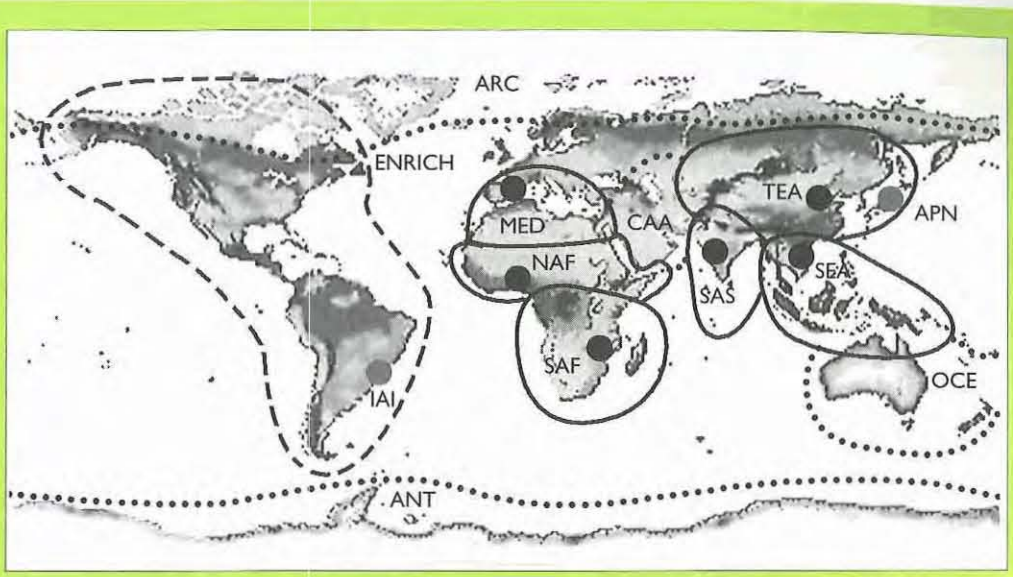
Regional sites are existing institutions within the region that would conduct research on some specific aspect of global change research and maintain a close relationship, not only with the regional centre, but with the programme elements of the IGBP, WCRP and HDP.

START has already formed six regional research networks, largely covering developing countries, which have been assigned highest priority: (see map): Northern Africa, Mediterranean, Southeast Asia, Southern, Central and Eastern Africa, South Asia, and Temperate East Asia.

Organisational efforts are also underway to develop START networks for Oceania, Central Arid Asia, the Arctic and Antarctica.

The various START regional networks are in different stages of development, reflecting their date of initiation, existing

START Regional Networks, including the location of the Secretariat Offices (dots), and the inter-governmental networks: the Inter-American Institute for Global Change Research (IAI) and its regional office, the European Network for Research in Global Change (ENRICH) and the Asia-Pacific Network for Global Change Research (APN).
ARC = Arctic; ANT = Antarctic; CAA = Central Arid Asia; MED = Mediterranean; NAF = Northern Africa; OCE = Oceania; SAF = Southern Africa; SEA = Southeast Asia; SAS = Southern Asia; TEA = Temperate East Asia



regional capacity, resource availability, etc. Regional centres have now been designated for Southeast Asia (Chulalongkorn University, Bangkok), South Asia (National Physical laboratory, New Delhi), and North Africa (University of Ghana, Accra-Legon). The official opening of the Regional Research Centre for Temperate East Asia held at SAC IV, where memorandum of understanding was signed with the Chinese Academy of Sciences, which will host the new centre at the Institute of Atmospheric Physics in Beijing.

Roland Fuchs, *International START Secretariat, Suite 200, AGU Building, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Tel: (+1-202) 462 2213, Fax: (+1-202) 457 5859, E-mail: start@dis.start.org*

European Network for Research In Global Change (ENRICH)

The ENRICH programme was established by the European Commission, the Executive body of the European Union, in the work plan of the Directorate General for Science, Research and Development and the Joint Research Centre (JSC).
The major objectives of ENRICH are:
(i) Promotion of a pan-European contribution to the international global change research programmes
(ii) Fostering of collaboration between the European Union/European Free Trade Association, the Countries of Eastern Europe/Commonwealth of Independent States (Russia), Africa, and other developing countries.
(iii) Promotion of the establishment of networks, with regional and thematic foci
(iv) improvement of access by the scientific community to European Union mechanisms for global change research.

Global change research under the fourth framework programme of the European Commission (1995-1998) addresses four themes:

1. Natural environment, environmental quality and global change
2. Environmental technologies
3. Space technologies applied to environmental monitoring and research
4. Human dimensions of environmental change

A broad array of projects are part of the work plan. Projects under Environment and Climate Programmes, including human dimensions of environmental change, amount to 225 million Ecu.

The research areas of the JRC cover the ocean and coastal zones, deforestation, desertification, air chemistry, ocean dynamics. The EU International Cooperation with Third World Countries and International Organisations also supports ENRICH.

A look at the ENRICH actions show a constant concern for helping the IGBP meet its science goals. Many IGBP Programme Elements are beneficiaries. The natural collaborator in regional research being START, its action is often supported, but human dimensions too are given a high priority. To mention only a few activities carried out with ENRICH planning and support in 1994 and 1995:

START: the South African Committee for START meeting in Botswana, the START Standing Committee meeting in Brussels, the Africa and Global Change International School in Nairobi, the START/ENRICH session at the first GAIM science conference, and, planned for 1996 is an international conference on global change in the Mediterranean.

HDP: Integration of the Human Dimensions Programme into the IGBP, through the support to the IGBP Secretariat for the Social Science Programme Officer, a study on HDP capacity building and networking in ENRICH regions, support to the third Scientific Symposium of the HDP, and planned for 1996, the Land Use/Cover Change open science meeting in Amsterdam in January.

In the framework of science planning for studies of climate and environmental change, the ENRICH sponsored the Pole-Equator-Pole III workshop in Tunisia of the IGBP Core Project on Past Global Changes, and the IGAC/Deposition of Biogeochemically Important Trace Species workshop in Yamoussoukro, Ivory Coast.

The Scientific Symposium at SAC IV (including its future publication), and the broad participation of IGBP national committees from ENRICH regions (eastern Europe and Africa) at the meetings in Beijing, have come about through ENRICH.

But the principal aim of ENRICH is to facilitate science planning, and carry out its own projects. Two of these projects recently launched are terrestrial (TERI) and coastal zone (ELOISE). ENRICH has convened workshops on mechanisms to address environmental concerns in central and eastern Europe and in the newly independent states of the former USSR.
ENRICH:

- focuses on research
- responds to the research agendas of international global change programmes
- is an enabling mechanism to foster and promote research cooperation and collaboration
- acts as a clearing house of information within and between the European Commission and in the ENRICH regions
- relies on close interactions with the scientific community and relevant governmental initiatives

- facilitates access to different European Commission funding mechanisms
- aims to channel the research results to the policy makers at the European level
- remains open to suggestions for support in planning cooperation and networking.

For further information, the ENRICH programme has a Web site: http://www.enrich.hi.is/

Anver Ghazi, *ENRICH Office, European Commission, DG XII/JRC, Rue de la Loi 200, B-1049 Brussels, Belgium. Fax: (+32-2) 295 0146*

InterAmerican Institute for Global Change Research

The concept of the IAI emerged from a workshop in Puerto Rico (July 16-17) Twenty-six American States proposed the establishment of an institute for global change research, a regional network of research centres dedicated to the study of global change and its impact on human society.

There are now 16 signatories to the Montevideo Agreement for the IAI, covering practically all the territory of the Americas. Each State has provided high-level support from their respective governments. In order to assure that the initiative is an effective partnership with a tangible environmental return, the IAI has worked to develop a sense of regional ownership of the Institute, and to promote the development of a programme which enhances the scientific capacity of the region.

The IAI Science Agenda

The IAI currently has seven scientific research themes. Discussions held during a set of scientific development workshops expanded thee themes from the core of the IAI science agenda.

1. Tropical ecosystems and biogeochemical cycles
2. Impacts of climate change on biodiversity
3. El Niño-Southern Oscillaltion and interannual climate variability
4. Ocean/atmosphere/land interactions in the inter-tropical Americas
5. Comparative studies of ocean, coastal, and estuarine processes in temperate zones
6. Comparative studies of temperate terrestrial ecosystems, and
7. High latitude processes.

The IAI has also identified cross-cutting themes: human dimensions of global environmental change; networks; networks: training and education; modelling, and others such as agriculture and industrial metabolism. The IAI has published a newsletter since 1992.

Funding

The IAI member states' contributions represent the majority of the contributed funds. These may be new monies, contributions to programmes, or in-kind contributions. The IAI budget is divided into three main areas: the Core Budget that covers central activities; the Project Budget supports short-term activities from several months to five years; and the Programme Budget that supports long-term (3-15 years) objectives and commitments.

The contributions pledged from member states to the Core Budget amount to USD 570,000 per year. The other source of funds for the projects and programmes amount to 6.6 million for 1996. The IAI provides a stable framework within which to build the region's capacity to conduct research to promote sustainable development and provide input to the fulfilment of global policies and conventions.

Armando Rabuffetti, *Executive Director of the IAI, Instituto Nactional de Pesquisas Espaciais, Avenida Astronautos, 1758, São José dos Campos, São Paulo, Brasil.*

Asia-Pacific Network for Global Change Research (APN)

The APN is the newest actor to the Intergovernmental Global Change research initiatives. It was originally an initiative of the government of Japan, launched in December 1992, and is rapidly catching up to its only slightly older colleagues.

The objectives of the APN are

- to promote global change research in each country
- to establish the cooperative network at the governmental level.

Principles

The general principles of the APN are:

1. Promotion of regional cooperation
2. Standardisation, collection, analysis and exchange of scientific data
3. Improvement of scientific and technical capabilities and research infrastructure of nations in the region
5. Provision of scientific knowledge for public awareness and as an input to policy-making by the governments of the region
6. Development of appropriate mechanisms for transfer of technology and technical know-how in recognition of the recommendations of AGENDA 21 (of the United Nations Conference on Environment and Development).

Research fields and topics

Climate system change and variability

- Asian monsoon
- Ocean processes
- El-Niño Southern Oscillation (ENSO)
- Greenhouse gases and atmospheric composition change

Coastal processes and impacts

- Coastal processes and ecosystems
- Sea level change

Terrestrial ecosystem change and impacts

- Managed and unmanaged ecosystems, including agriculture and forestry
- Biodiversity
- Land use and land cover change, land degradation and desertification
- Water resources

Crosscutting and others

- Human dimensions
- Policy and programme responses to research outcomes
- Human health

The major tasks of the APN are right now to develop a scientific programme for 1996/1997, and to investigate how to fund the topics selected by the APN. A first issue of the APN newsletter has just been published.

Keiko Segawa, *Programme Manager, APN Interim Secretariat, 1-9-7 Azabadai, Minato-ku, Tokyo 106, Japan. Fax: (+81-3) 5561 9737*

Global Change Science in China

At the occasion SAC IV, the Chinese National IGBP Committee held a symposium on Global Change Study in China. It covered those areas where Chinese studies are so remarkable: the detailed recording of changes of the past, from palaeorecords to land-use change in the past five thousand years, and terrestrial ecosystem studies. The Chinese Ecosystem Research Network (CERN), and its information system (CERNIS), are important focal points in the international study of global change.

For a free subscription to CERN News, write to Ms. Wan Qunli, Secretariat of SC-CERN, Commission for Integrated Survey of Natural Resources, Chinese Academy of Sciences, Andingmen Wai, Chaoyang district, PO Box 9717, Beijing 100101, China.

An impressive publication on Chinese global change research, *China Contribution to Global Change Studies*, second in the series of the Chinese IGBP Committee reports, was presented at the occasion of SAC IV. Write to: Chen Panqin, Bureau of Coordinataive Development, Chinese Academy of Sciences, 52 Sanlihe Road, Beijing 100864, China. Tel: (+86-10) 859 7531, Fax: (+86-10) 851 1095, E-mail: chenpq@sun.ihep.ac.cn

The Megascience Forum of the OECD

The Organisation for Economic Cooperation and Development (OECD) is a permanent intergovernmental conference to promote economic development, improve efficiency of exchanges, and foster contacts among different public systems. Its 25 members, principally the free-trade, industrialised countries, discuss their policies, including science policy, at the level of senior government officials, who return home informed, and sometimes influenced, by the common discussion. In no way is the OECD a funding body.

In 1992, governments created the Megascience forum, a committee aimed at achieving improved performance in the handling of large scientific facilities and large scale programmes (such as global change research and the human genome). Keywords were: international cooperation from early phases of joint projects, sharing of intellectual and financial resources, avoiding unnecessary duplications in building facilities. The Forum is both a committee within the OECD, and a programme within the OECD Directorate for Science, Technology, and Industry. The initial mandate of the forum was three years, ending on 1 October 1995. A large majority of OECD countries participated, although the megascience forum is an optional programme within OECD, and observer countries joined: Russia, Poland, Hungary, the Czech and Slovak Republics. Results of the Forum's work are published by the OECD.

After three years, at a meeting of ministers in charge of research held at OECD (26-27 September 1995) the need for an intergovernmental consultation mechanism was reaffirmed, and the ministers re-established the Megascience Forum. They agreed to slightly extend the Forum's mandate: the Committee will be complemented by Working Groups of limited duration, created at the request of at least three governments, when the need exists (i.e., in a given field or a given region), with the goal of discussing new projects, comparing priorities and plans, and achieving specific actions, such as preparing a negotiation among interested governments. These groups will be open to OECD non-member countries on a case by case basis.

For any big science project (large facility or large-scale programme), three categories of actors are involved: the scientists, the funding agencies, the governments. To all three it is advantageous to use the new mechanism just created, in order to accelerate the process of either the study of new projects to be conducted in broad cooperation (regional or global) or the solution of any stumbling block problem on the road to cooperation. Since science will no longer (during five to ten years?) easily find money just for its beauty, more cooperation in big science might be a way to better share limited resources. It is therefore time that scientists and agencies use the tools set up by governments to their advantage, and the leaders of IGBP and WCRP are certainly invited to carefully consider this new situation.

Françoise Praderie, *Observatoire de Paris, 61, av. de l'Observatoire, 75014 Paris, France. Fax: (+33-1) 40 51 20 02*

Funding: are the fountains dry?

The major concern during the discussions related to financing research. The large organisations are, so far, adding an important impulse to supporting global change.

Paul Gray, of the European Union's DGXII/D (Environment and Climate), stated "In the current long-term programme on Environment and Climate, half the resources for research are devoted directly to Global Change. Together with the chapter on space and the related parts of the marine science and technology programme, the levels available to shared cost research are on the order of $US 500 million. Researchers obtain a 50% grant from the EU making the total funds for cost-shared research with the relevant EU programmes for 1995-1998 reach one billion US dollars. This excludes budgets allocated for shared cost work on human dimensions, support for Earth observation instruments, the Centre for Earth Observation and direct support for global change research in the European Union's own Joint Research Centre [in Ispra, Italy]."

The need is greater than ever for nations to invest their resources wisely. Said Françoise Praderie "in a recent survey of science spending throughout all the countries of the OECD, only two nations showed an increase: New Zealand, and Korea. Global Change Programmes must transmit a clear and coherent message: what has been achieved, what new countries are involved, and what value has been added".

Hugh Morris, Chair of the Canadian Global Change Program, commented on the concern arising from the attempts and failures of the scientific communities to communicate with the broad group of 'decision makers', and secondly the plea to keep some level of funding.

"The issue", said Morris "is really a communication challenge. One can only ask why communications specialists are not systematically included in the outreach carried out by our international and national secretariats and programmes. We would not hesitate to reach out for an expert scientist in a speciality which we could not cover.

"A similar comment can be made regarding the finance and funding area . . . This does not mean that governments and industry will not fund worthwhile projects, but it does mean that the science must be carefully and effectively explained - marketed, if you like, and it must be presented in terms that are readily understood, and the value and potential future significance of the work must be equally well explained.

"I suggest that it should be carefully considered how our international and national organisations can best approach these tasks in a systematic and planned manner . . . If we are genuinely and sincerely concerned about the long-term importance of our scientific work, then we should be equally concerned about finding the right procedures, and organisations, to get the result of our work to the places where it will do the most good.

"I believe there is far less opposition in these 'other worlds' than we may sometime think. Rather, it is because we have not achieved the effective and compelling communication which enables others such as the decision makers to understand and share our points of view."

Jean-Pierre Contzen, Director General of the Joint Research Centre, European Commission, takes the floor

The Longer-term Future of the IGBP

adopted by the Scientific Committee for the IGBP in Beijing, October, 1995

All good things come to an end, as the saying goes, but when is never specified. What will be the medium term (5-10 years) to long-term (>10 years) future of the IGBP?

International global environmental change research programmes are subdivided into a number of programme elements (currently ten in the case of the IGBP, including core research projects and framework activities). IGBP has set the objective to integrate its own programme elements, so attempting to make the whole greater than the sum of its parts. This integration of the different elements is a novel feature of the IGBP, and distinguishes it from the other programmes; it also has significant bearing on the longevity of the programme and its elements.

The Programme Elements (the IGBP Core Projects devoted to specific research and the Framework Activities on data, modelling, and regional programmes which support them) provided a short paper to the Scientific Committee for the IGBP on how they saw their future development and ultimate demise (or transformation). We now draw some of these views together, and assess the longer-term prospectus for the Programme Elements and for the IGBP as a whole.

At opposite ends of the spectrum of possibilities, one could propose either that IGBP should continue in perpetuity, or that it have a definite termination date, say ten years after commencement. The first option would be unacceptable to scientists and funders, because it minimises the possibilities for evaluation, criticism or change. The second suggestion is similarly flawed, since it is arbitrary and unrelated to achievement of objectives, which should be a major criterion for continuation/termination of any programme. The optimum approach requires a solution somewhere in between these two extremes.

Each of IGBP's Core Projects already has a defined time-line for its existence, generally given in the science or implementation plan at the outset of the project. Typically, a Core Project is envisaged to last for about a decade, although the Global Change and Terrestrial Ecosystem project (GCTE) argues that for ecological studies a 15 year time horizon is appropriate. IGBP's longest-standing project, JGOFS (Joint Global Ocean Flux Study), published its science plan in 1990 and is on track to complete its field phase in 2000. However, due to lack of funding in some countries and technical problems with the launch of vital satellites (e.g., Sea WiFS) the full decade is needed for data gathering at sea, leaving insufficient time for data archiving, modelling and global synthesis. JGOFS has proposed that the project should continue for an additional five years. It seems likely that many of the younger projects will follow a path similar to JGOFS. The International Global Atmospheric chemistry Project (IGAC) makes the point strongly that funding shortfalls will certainly lead to extension of the timetable, if their objectives are to be achieved.

With regard to Core Project lifetimes, two further points are pertinent:

(i) within existing Core Projects, particular activities will last for shorter periods than the 10-15 years of the project as a whole, and new ones will be incorporated, so that the research profile continually develops as the project proceeds;

(ii) even when a project has been terminated, some aspects will carry on, for example, long-term monitoring activities and some transect studies.

At the end of its 10-15 year lifetime, a Core Project can either:

(a) terminate, leaving in place any long-term activities which necessarily outlive the project itself

(b) be granted a second phase (although unlikely in most cases)

(c) transform itself into a new entity.

The likely reasons for such a transformation are clear - although the original objectives will have been met, a new set of scientific questions will have arisen, partly out of the results generated by the Core Project itself, but also from new discoveries and approaches from elsewhere. Thus, any new Core Projects will almost certainly have very different approaches from those they replace. Indeed "replacement" is too weak a word to describe something which will look very different from what went before. In particular, new projects will almost certainly be more interdisciplinary than the present ones, and may start at the existing interfaces (both environmental and intellectual).

Further, they are likely to be technology aided if not driven. In addition, the growing trend of IGBP Programme Elements being more strongly linked than previously to the other global change research programmes (WCRP and HDP) will continue.

This discussion leads naturally to the value and longevity of the IGBP programme as an entity. The chief programme-wide activities are Global Analysis, Interpretation and Modelling (GAIM), the IGBP Data and Information System (IGBP-DIS) and START (the Global Change System for Analysis, Research and Training). A fourth element is the growing acknowledgment of the importance of environmental transects for studying and monitoring global change, which, since it applies to a majority of core research projects, can be regarded as an output of the programme as a whole.

The function of IGBP-DIS is to assist the other programme elements in relation to their data and information needs, and to ensure the long-term conservation of information products even after the completion of the programme. Its existence is closely linked to those of the other programme elements, and IGBP-DIS as an entity will not outlive them. However, as long as there is an IGBP, there will be a DIS whose shape and function will be determined by the future configuration of the programme, and by the evolution of related international activities such as the Global Observing Systems.

START has an ambitious agenda, both in terms of research and capacity building, which will not be completed within the present lifetime of the existing Core Projects.

Since its inception, GAIM has been thought of as the vehicle by which the IGBP will achieve its programme-integrating role. It has the task of producing the Earth System model, and the Core Projects have the vital task of feeding modules into it. But by its nature, the development of GAIM will be dependent on progress within the Core Projects on which it rests; it would be logical for GAIM to turn the lights out on the IGBP!

At present, IGBP scientists feed knowledge into policy-related activities such as the Intergovernmental Panel on Climate Change (IPCC) and in the future will provide scientific input to the implementation of international conventions such as those on global biodiversity and desertification. This will continue as an important part of our activities.

The question has been asked as to how the role of the IGBP might alter when it is widely accepted that climate and potentially harmful global changes are actually taking place. Unbiased scientific understanding of the Earth system will become even more vital at that time, so that IGBP research will need to be pursued with much greater urgency. Some changes in emphasis will be appropriate in those circumstances, for example, greater effort on research into the environmental impacts of such changes.

Finally, the IGBP must be able to respond rapidly to new scientific and technological opportunities. The programme and its future plans should be carefully reviewed and critically assessed every five years to determine whether it should continue. To sum up:

- Core Projects will have a lifetime of 10-15 years
- The importance of framework Activities will increase with time and they will provide input to global observing systems and operational climate models
- New Programme Elements will generally link across existing interfaces within and among other global change programmes
- There will be an increasing input to assessment and policy-related activities
- The programme should be critically assessed every five years.

Peter Liss, *Chair, Scientific Committee for the IGBP, University of East Anglia, Norwich, UK.*

Why the International Global Change Research Programmes Need the Human Dimensions of Global Environmental Change Programme

João Morais, Chris Rapley and Hartmut Grassl

The General Committee of ICSU has decided to become a co-sponsor of the Human Dimensions of Global Environmental Change Programme (HDP), in partnership with the International Social Science Council (ISSC). Thus, ICSU now sponsors all three international global environmental change programmes: the IGBP, the World Climate Research Programme, and the HDP.

Recently, the third HDP Symposium (Geneva, August 1995), IGBP's Fourth Scientific Advisory Council (Beijing, October 1995), and the workshop to launch an International Research Institute for El Niño Predictions (Washington DC, November 1995), all made clear the crucial role of social science research in the international research programmes studying the physical and biogeochemical aspects of the Earth system.

This awareness draws from the fact that humans are bound to their physical and biological environments in terms of shelter, territory, food and water. At the same time, human practices of resource utilisation impact on natural processes, with significant consequences for the carrying capacity of the environment, and its long-term sustainability.

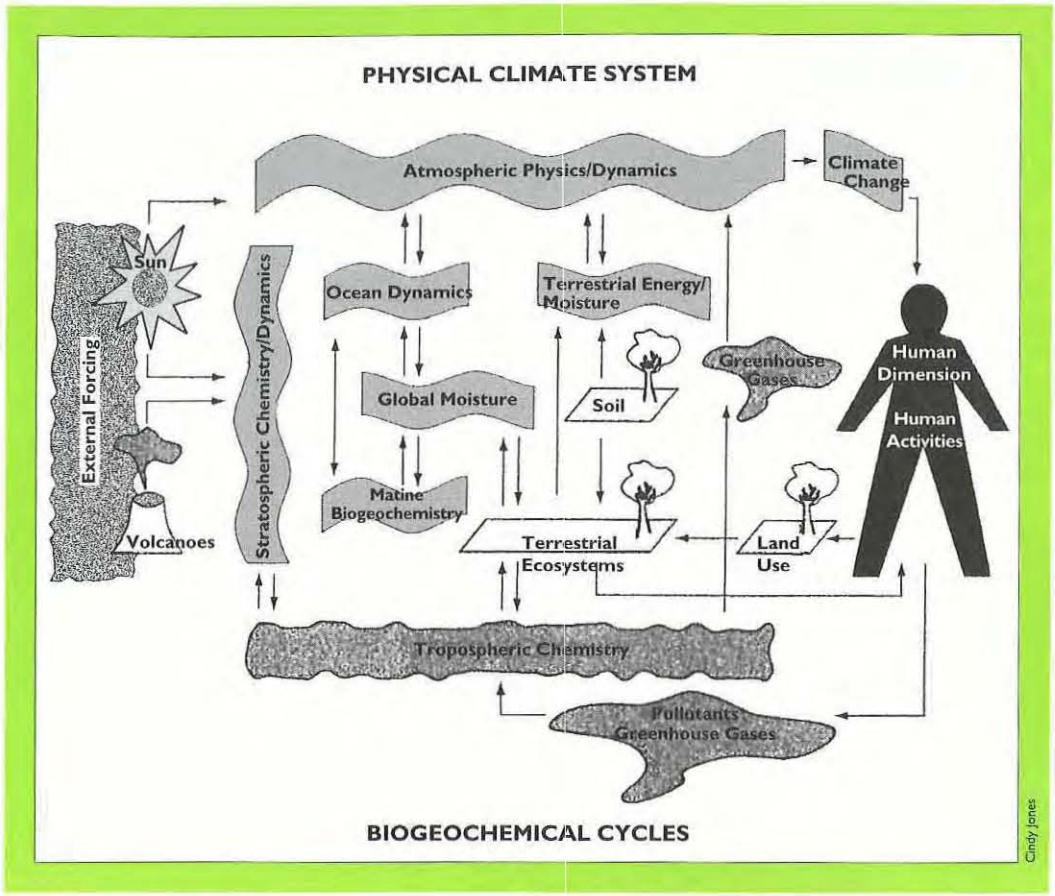
The fundamental nature of the interactions between humans and the Earth system is not different from the past. However, the spatial and temporal scales of current impacts are unprecedented. Humans have been engaged since the dawn of time in finding *creative* solutions to such problems. This process has cut across biological, spatial and cultural differences, as well as methodological ones. It has been based on "trial and error" in which a few new responses slowly arise from a considerable number of "experiments". Science offers a better chance of success provided it builds upon *systemic* and *diversified* networks which link the natural and the social sciences, and addresses comprehensively both basic and applied approaches, and both quantitative and qualitative analyses. In general, this will require a shift of existing attitudes to ensure that knowledge is articulated between the science community, institutions and the public at large, creatively participating in determining better policies and focused choices. These will derive from a more effective use of information, improved educational resources, and well focused research and development. Additionally, the science itself will benefit from the plurality of knowledge emerging within a variety of different, and original viewpoints, thereby avoiding the dangers of a monolithic approach.

It is crucial that global change processes are addressed globally. Local, regional and international organisations have to interact and collaborate fully, and research projects have to be designed to address pressing solutions to socio-economic and cultural problems occurring world-wide. Public opinion increasingly requires that science should be useful, and its benefits more tangible. Communities are pressing for improved living standards and security. Policy making calls for rapid solutions, requiring a quick return on the investment in science research. However, scientists cannot promise the desired results either to a schedule or even with guaranteed certainty. Nevertheless, there is a growing acceptance amongst scientists of the need to make scientific results clearer and to provide inputs to the policy process.

Complementarity, the only way forward

Bridging the regional, the national and the global can only be achieved at the international level of Global Change science through two complementary areas of activity: the operational and the methodological. The former should take into consideration the need to overcome geopolitical barriers, the latter should aim at developing better theories and at applying them.

The *operational level* should integrate national needs (strongly represented through national committees) as well as regional initiatives (e.g. European, Inter-American, or Asia-Pacific such as ENRICH, IAI and APN respectively) into the global environmental change research, making sure that efforts are not duplicated, and resources not wasted. Every opportunity must be grasped to improve the applica-



tion of research results in the regional and international context.

On which problems should we concentrate resources? There is a need to strengthen the interactions between regional and global activities as well as between the natural and social sciences. Some of these interactions are already addressed within specific themes concerning biogeochemical processes (International Geosphere-Biosphere Programme–IGBP), physical processes (World Climate Research Programme–WCRP) and socio-economic processes (Human Dimensions Programme of Global Environmental Change–HDP). They embrace both topics and *methodologies*. For example:

- Land Use

A major project recently initiated by IGBP and HDP deals with Land-Use and Land-Cover Change (LUCC). Human alterations of the landscape have had at least regional impacts over recorded history, but these are now global. They are the major causes of socio-economic reactions (e.g. soil degradation and groundwater depletion have consequences on population distribution and commodity prices) and change on the biogeochemical and energy cycles, and thus climate (e.g. carbon dioxide releases from land clearing and biomass burning). Climate change in turn alters land use. LUCC will identify a range of land use and land cover dynamics, and better ways for land managers to deal with food security and sustainability issues. A Science Plan has recently been published (*IGBP Report* 35 and *HDP Report* 7) and an Open Science Meeting will be held in Amsterdam (29-31 January 1996) to start the preparation of an implementation plan.

- Population and food production

Population growth drives socio-economic change and is intimately related to resource use, production and distribution patterns. Biological and cultural diversity as well as population dynamics are therefore intimately linked to sound policies addressing the need for sustainability aimed at approaching socio-environmental equilibria. A relevant example derived from recent research carried out by IGBP-IGAC (International Global Atmospheric Chemistry Project) has pointed out the fact that there are options to mitigate methane emissions from flooded rice fields which have a considerable impact on air chemistry and climate. A crucial reduction of global methane emissions will only require acceptance by the rice farmers of the world that it is in their interest to modify their current irrigation practices without loss of yields and increases in water and energy costs (*IGBP NewsLetter* 22:4-5). Another good example is the use of information on natural climate variability for the benefit of entire nations. The WCRP project TOGA (Tropical Oceans/Global Atmosphere) has – by giving for the first time skilful climate predictions on seasonal to interannual timescales for ENSO (El Niño/Southern Oscillation) affected areas – helped to turn a basic research result rapidly into operational use. Peru, for example, has changed farming and fishing practices based on climate predictions and thus reduced or even eliminated economic losses during El Niño years. An IGBP project strongly illustrating social and economic impacts is LOICZ, the Land-Ocean Interactions in the Coastal Zone, which has a particular focus addressing socio-economic driving forces of and responses to global change for 60% of the human population living there.

- Energy

Energy is related to population increase and the use and extraction of resources from ecosystems. People, resources and the environment have developed as a mutually interactive and co-evolving system. Large emissions of trace gases into the atmosphere have resulted from the industrial society's change of production processes and consumption patterns, based on the extensive use of fossil fuels, together with accelerated patterns of biomass burning from traditional agriculture and deforestation. To understand both the physical and the socio-economic systems, and the key interactions regulating the amount of energy used in relation to population density and consumption patterns, we need information from a broad spectrum of sources. Our sources include the past, extant, and prognostic biospheric and climatic models generated by the IGBP and WCRP, in order to synthesise the interactive natural and social mechanisms of change.

Global environmental research on energy requires transdisciplinary Earth system science of themes cutting across all fields of study from the IGBP (mainly LUCC-Land-use/Cover change with the HDP, GCTE-Terrestrial Ecosystems, IGAC-Atmospheric Chemistry, BAHC-Hydrological Cycles, PAGES- Past Global Changes, and GAIM- Analyses and Modelling) and WCRP (GEWEX-Global Energy and Water Cycle and SPARC- Stratospheric Processes and their role in Climate).

Furthermore, the studies should pro-

vide decision makers with information to evaluate equity implications of abatement mechanisms in different socio-economic contexts and scenarios, linking global energy and environmental policies to sustainable energy development.

- Freshwater resources

This is probably the most pressing environmental research issue both on local and global scales. It is usually more obvious on regional or local levels where freshwater resource degradation is more conspicuous. However, there is a need to develop comparative research in terms of overall *vulnerability* to water shortage from communities to nations to continents, in order to find their differences between populations, socio-economic systems and within a variety of ecological settings. These studies can build on the continental scale hydrometeorological experiments of the Global Energy and Water Cycle Experiment (GEWEX) of WCRP and on the IGBP project Biospheric Aspects of the Hydrological Cycle (BAHC). They should suggest ways in which early warning systems can be implemented in order to improve the responses of social systems to drought. Water availability is therefore intimately linked with population, health, epidemic vulnerability and food production. The studies will further need to link with ongoing initiatives dealing with global freshwater research and modelling within UN agencies (WMO, WHO, UNEP and FAO), and research institutes such as the Stockholm Environment Institute and the International Institute for Applied System Analysis.

Ultimately, the research agenda investigates the growing impact of anthropogenic environmental change on earth system processes supporting life. The UN conventions on biodiversity and climate change have reacted to the disturbance of these processes and they need continuous scientific advice during their implementation. There is therefore a need to establish realistic priorities, to favour a problem-solving approach, and to extract policy-relevant results from which concerted strategies for mitigation and adaptation should emerge, and in which different partners are engaged, from the regional to the global spheres. An example of such an effort is the recent launching of International Research Institute for El Niño Predictions. It should forecast seasonal to interannual climate in El-Niño affected areas and involve all user groups in order to minimise climate impact on, for example, on farming and fisheries (*Nature* 378:228).

Identity, it's what binds us all together

In spite of the necessity for complementarity and pluralism in science, the search for better theories has to cultivate the right to be different, to disagree with established views, to produce new knowledge with originality. Therefore, on a methodological level, all major international research programmes have to identify and to develop their own agendas. All scientific progress is built upon previous knowledge, which is best represented in each of the individual disciplines. In this sense there is never a new start, science and individuals (who ultimately produce science) are part of a continuum of social or disciplinary tradition, language and behaviour. This should not be altered by forcing homogeneous attitudes, but existing environmental problems are in part due to a lack of discussion between the different disciplines. Complex social structures, including scientific research activities, must develop in face of the need to solve the fundamental problems of environmental change.

The increasing degree of detailed collaboration between the IGBP and WCRP is very welcome development in this respect, but the full benefits to society will only accrue through a similar degree of convergence with a strong IHDP.

João Morais *is Programme Officer for Social Sciences at the IGBP Secretariat*
Chris Rapley *is Executive Director of the IGBP*
Hartmut Grassl *is Executive Director of WCRP*

Views from SAC IV

James Galloway (USA), is warmly thanked by Ye Duzheng, Chair of the Chinese National Committee for the IGBP, and host of SAC IV, for the organisation of the scientific symposium which was done in collaboration with Jerry Melillo at the Woods Hole Marine Biological Laboratory.

James Dooge (Prisident, ICSU) and Tandong Yao (winner of a poster prize)

Participants at the Beijing Inernational Convention Center

People and Events

New Directors for IGBP Programme Elements

IGBP-DIS

Gérard Szejwach is the new Executive Director of the IGBP-Data and Information System Office, following the return of Dr. Ichtiaque Rasool to NASA. He will officially take up his duties 1 January 1996. Dr. Szejwach comes to the IGBP from EUMETSAT, the European Organisation for the Exploitation of Meteorological Satellites.

Gerard Szejwach

Dr. Szejwach began his career at the Laboratoire de Météorologie Dynamique at Ecole Normale Supéieure in Paris in 1973. His fields of research included theoretical modelling of radiative transfer in the visible and IR regions with applications in remote sensing from aircraft measurements and satellite data.

In 1976 Szejwach was appointed to the Centre National de la Recherche Scientifique and led a Research Group at Ecole Polytechnique, France, followed by a series of joint airborne campaigns in collaboration with NASA. From 1980 until 1986 he was Senior Visiting Scientist at the NASA Goddard Space Flight Center where his field of research included theoretical modelling from the visible to the microwave spectral regions, and analyses of satellite data. He has spent considerable time in management of research and satellite applications both in France and in the USA.

Dr. Szejwach joined EUMETSAT in Darmstadt, Germany, in 1986. In his capacity as Technical Director (until present), he was responsible for all technical and scientific activities of the organisation, and the development and operations of EUMETSAT's programmes. This included both the Meteosat Operational and Transition Programmes, in particular the establishment and implementation of its related Ground Segment at the EUMETSAT Headquarters; the Meteosat Second Generation Programme, and the preparatory phase of the EUMETSAT Polar System.

He was elected Vice-Chairman of the CEOS (Committee on Earth Observation Satellites) Working Group on Information Systems and Services in his new capacity as Director of IGBP-DIS. Dr. Szejwach says:

"After having spent the last nine years of my life in management of technical and programmatic activities, I am very much looking forward to being more closely associated with the resolution of scientific problems. I wish to be at the service of the scientific community and, after having worked on the side of the operational data producers in EUMETSAT, I feel in a very good position to continue and help users to get the best possible data to satisfy their scientific requirements.

"It should be noted that, following a tradition established by NASA, the European Space Agency will, through an Agreement signed by Jean Marie Luton (ESA Director General) and Chris G. Rapley (IGBP Executive Director), ensure continuity of direct support of the IGBP-DIS Office for an initial period of three years. This agreement, developed in close collaboration with Guy Duchossois and supported by his Director Lanfranco Emiliani (Directorate of Observation of the Earth and its Environment), demonstrates the interest and commitment from the Space Agencies to maintain the essential link with those who should first benefit from the state-of-the-art technologies."

The IGBP-DIS Office was located in Paris until March 1995. The new office in Toulouse is now in place with an Administrative Assistant, Chantal Le Scouarnec, and a Scientist on secondment from Meteo France, Martine Michou.

IGBP-DIS Office, 42 avenue Gustave Coriolis, F-31057 Toulouse cedex, France. Tel: (+33) 61 07 85 81, Fax: (+33) 61 07 85 89, E-mail: szejwach@cnrm.meteo.fr

Michael A. Fosberg

BAHC

Michael A. Fosberg is new Executive Director of the Biospheric Aspects of the Hydrological Cycle (BAHC) Core Project Office. Dr. Fosberg will take his position in Potsdam, Germany, on 12 January 1996.

Dr. Fosberg is currently working for the United States Department of Agriculture Forest Service as Chief Scientist for Atmospheric Sciences. He has been coordinating Forest Service research in the fields of atmospheric sciences, air quality, fire physics and chemistry, and also development of the Forest Service global change research programme.

His main research interests range from atmosphere (dynamics of air flow, air pollution transport, air quality, weather station network design) to fire (forest fire danger, fire behaviour, fire weather) and from global change to natural resource management.

Dr. Fosberg has been active in several national and international committees, such as the IPCC Working Group III (on interdisciplinary issues and socio-economic analyses), the UN Food and Agricultural Organisation panels on Climate Change and Global Forestry Inventory, the IGBP-IGAC Biomass Burning Group, the World Meteorological Organisation Commission on Agricultural Meteorology, the United States National Science and Technology Council, the Committee on Environment and Natural Resources, and many others in the USA.

BAHC Core Project Office, Potsdam Institute for Climate Impact Research, Telegrafenberg, D-14473 Potsdam, Germany. Tel: (+49-331) 288 2543, Fax: (+49-331) 288 2547, E-mail: bahc@pik-potsdam.de

Roger Hanson

JGOFS

Roger Hanson has accepted the position of Executive Officer for the JGOFS Core Project Office, which has recently been established in Norway under the auspices of IGBP and the Scientific Committee on Oceanic Research.

Dr. Hanson will begin at the University of Bergen in January 1996. The University received international recognition from IGBP and SCOR as an outstanding centre for marine academic research with the opening of the JGOFS Core Project Office. The Office will operate in the Centre for the Studies of Environment and Resources in the University of Bergen High-Technology Centre.

Dr. Hanson, a biological oceanographer, began marine studies at the University of California and received his PhD in Marine Microbiology at the University of Hawaii in 1974. He began his Post Doctoral research on microbial processes in coastal systems at the University of Georgia Marine Institute, and was at the Skidaway Institute of Oceanography from 1976 to 1995, where he became Professor of Oceanography. His research focused on the structure, function and physiology of microbial populations, in particular bacterioplankton, in coastal and oceanic systems.

The studies were conducted over the southeastern US continental shelf and adjacent Gulf Stream, with additional research in contrasting ocean systems from the northern seas between Alaska and Russia to the southern ocean waters between South America and the Antarctic Peninsula.

Since 1989, Dr. Hanson has been involved in peer-reviewed polar biology and oceanic research projects grants at the National Science Foundation in Washington, DC. He began with the management of research projects in the Office of Polar Programs. Most of these projects uncovered exciting new discoveries and advanced our present understanding of polar ecosystems.

He is presently with the National Science Foundation-US Environment Protection Agency Partnership on US Water and Watersheds, under the United States Global Change Research Program.

During the coming years, under the leadership of Dr. Hanson, the JGOFS Core Project Office will assist IGBP and SCOR in planning and management of scientific research in our global oceans. Dr. Hanson will move to Bergen to assume his post early in 1996.

Roger Hanson takes over after Hugh Ducklow who was JGOFS Core Project Scientist. Professor Duklow is Chair of US JGOFS, and member of the JGOFS SSC. The JGOFS-Büro in Kiel, which had worked hard for JGOFS since 1990, has transferred its activities to Bergen.

JGOFS Core Project Office, Centre for Studies of Environment and Resources, High Technology Centre, University of Bergen, N-5020 Bergen, Norway, Tel: (+47-55) 544 240, Fax: (+47-55) 324 801, E-mail: jgofs@smr.uib.no
URL: http://www1.whoi.edu

PAGES

Frank Oldfield, the new Executive Director of the Core Project Office for Past Global Changes, will be welcomed in Berne to fill his new position in January, 1996. Professor Oldfield, a former member of the PAGES Scientific Steering Committee, is familiar with the PAGES programme and its many achievements.

He comes to the PAGES Core Project Office from the Department of Geography at the University of Liverpool.

His current research interests focus on the use of lacustrine and near-shore marine sediments and ombrotrophoic peats for reconstructing the history of environmental change on timescales ranging from the last few decades to the last glacial cycle. Within this broad area, he presently specialises in the use of magnetic properties and short-lived radiosotopes, while continuing with his earlier specialisation in pollen analysis and palaeoecology.

Current projects at the university are divided between those primarily concerned with human impact, and those dealing with the history of climatic change, exploring contexts where the interplay between the two can be resolved in detail for the last one to two thousand years. Professor Old-

Frank Oldfield

field has recently published on coastal radioactivity, on contemporary beach sediment tracing, and on the philosophical implications of future-oriented research agendas in environmental science.

Dr. Oldfield has served on research bodies as President of the UK-based Quaternary Research Association, member of NERC working groups on the history of land-ocean interactions and quaternary dating methods, and Editor/Editorial Board member for *The Holocene*, the *Journal of Palaeolimnology*, and the *Journal of Quaternary Science*.

Herman Zimmerman, of the National Science Foundation, Washington, DC, was Co-Director (with Hans Oeschger) of the PAGES Office until the end of 1995.

Bruno Messerli, Professor of physics at the University of Berne, will be the Co-Director of the PAGES Office from January 1996, and the point of contact with the Swiss NSF (co-funding agency of the PAGES CPO). Professor Messerli is a senior researcher with expertise in terrestrial processes in mountain regions. His presence on the PAGES Scientific Steering Committee is especially welcome for the wide experience that he brings in international activities in Africa, South America, and the UN.

Professor Messerli presently serves as Vice President of the International Geographical Union, and was a member of the Swiss Delegation to UNCED.

PAGES Core Project Office, Bärenplatz 2, CH-3011 Berne, Switzerland, Tel: (+41-31) 312 31 33, Fax: (+41-31) 312 31 68, E-mail: pages@ubeclu.unibe.ch

New Chairs for Scientific Steering Committees

The year 1996 is one of great turnover for the Chairs of the Scientific Steering Committees. In 1990 the IGBP began its implementation phase, with Chairs on its SSCs who had already been responsible for the initial planning. Having now served two three-year terms, and seen the research results coming in, they return to academia with a sense of achievement. Other outstanding scientists have been elected to succeed them. Chairs of the Scientific Steering Committees are also members of the Scientific Committee for the IGBP, the directing body of the programme.

Guy Pierre Brasseur

IGAC

Guy P. Brasseur is the new Chair the Scientific Steering Committee for the International Global Atmospheric Chemistry Project. Professor Brasseur is currently both Senior Scientist and Director of the Atmospheric Chemistry Division at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, USA. NCAR is operated by the University Corporation for Atmospheric Research (UCAR) under the sponsorship of the US National Science Foundation.

In addition to his present positions, Guy Brasseur has been Editor-in-Chief of the *Journal of Geophysical Research - Atmospheres* since 1992, and is lecturer at the Free University of Brussels.

Professor Brasseur studied science at the Free University of Brussels in Belgium, successively receiving diplomas of Engineer in Applied Physics, Engineer in Telecommunications and Electronics, and a PhD in Space Aeronomy.

His career has been highly international: he first did research at the Belgian Institute for Space Aeronomy and at the Belgian Fund for Scientific Research - during which time (1977-1981) he was also a member of the Belgian House of Representatives, and of the Parliamentary Assembly of the Council of Europe in Strasbourg. During 17 years, from 1971 to 1988 he was member of the Uccles City Council - the town in Belgium where the meteorological institute is located. In 1986 he was Visitor at NCAR, where he accepted a position in 1988 as Scientist and Head of the Atmospheric Chemistry Modelling Section, and became a permanent US Resident.

His scientific research interests have also been varied, with many significant publications on the chemistry, circulation, and physics of the upper atmosphere, and, in collaboration with Susan Solomon, on the chemistry of the middle atmosphere. He is currently very active in the development of new global three-dimensional transport and chemistry models of the troposphere.

Other major responsibilities include program leader, Global Tropospheric Chemistry Program at NCAR, and member of the science team and science advisory council, climate system modelling programme at UCAR. Professor Brasseur has been a member of the IGAC SSC since 1994.

He is presently on one year leave of absence in France, at the Service d'Aéronomie of the Centre National de la Recherche Scientifique in the Paris area.

Ronald Prinn is now leaving the chairmanship of the IGAC Scientific Steering Committee after six years of leadership. During this time IGAC has become a large and comprehensive project with activities that involve hundreds of outstanding atmospheric scientists throughout the world (see Nobel awards, p. 1-3 of this issue). He and his colleagues played an important role in the understanding of the role of the atmosphere in biogeochemical cycles.

Professor Prinn's research interests and accomplishments cover a broad area involving the chemistry, dynamics and physics of the atmospheres of the Earth and other planets, and the origin and evolution of these atmospheres. His early work on the chlorine and sulphur chemistry of the Venus upper atmosphere foreshadowed the explosive growth of interest in the chlorine and sulphur chemistry of the Earth's atmosphere. By delimiting conditions for the predominance of either sulphur or sulphuric acid in the clouds of Venus, his work provided the first comprehensive explanation for the spectacular

Ron Prinn

dark markings in ultraviolet images of Venus; he and a colleague additionally proposed the now widely-accepted explanations for the distinctive colorations on Jupiter involving photochemically-produced sulphur and phosphorus compounds.

Prinn and colleagues developed the first comprehensive global three-dimensional model of the stratosphere with fully interactive chemistry, dynamics, and radiation. This model was applied specifically to elucidating the effects of proposed supersonic aircraft on the ozone layer and plays an important role in the policy discussions regarding these aircraft.

In 1978 he and his colleagues began the Atmospheric Lifetime Experiment (ALE) in which the lifetimes of the trace gases involved in ozone depletion and the greenhouse effect were determined from continuous measurements of these gases over the globe, combined with industry estimates of their emissions. ALE served to confirm the proposal by Molina and Rowland that the chloroflurocarbons are destroyed principally in the stratosphere. One of the gases measured in ALE (and its successor, the Advanced Global Atmospheric Gases Experiment) is methal chloroform. This gas has enabled Prinn and his colleagues to provide the most accurate determinations to date of the weighted global average concentrations of hydroxyl radicals, which are used for determining the removal rates or lifetimes of most of the hydrogen-containing gases involved in the ozone layer and climate.

His research team is now developing more accurate global chemistry and transport models to determine trace gas emissions and chemical removal rates at the regional level.

During Professor Prinn's tenure, IGAC held three open science meetings: in Israel in 1993, in Japan in 1994, and in collaboration with the World Meteorological Organisation, in China in October 1995.

Edgardo Gomez

LOICZ

Edgardo Gomez, Professor of marine sciences at University of the Philippines, is now Chair of the Scientific Steering Committee for the IGBP Core Project Land-Ocean Interactions in the Coastal Zone. He has been a member of the LOICZ SSC since 1993.

Ed Gomez is well-known among marine scientists in southeast Asia for his contribution to coral reef research, to coastal zone management-related activities, and to capacity building.

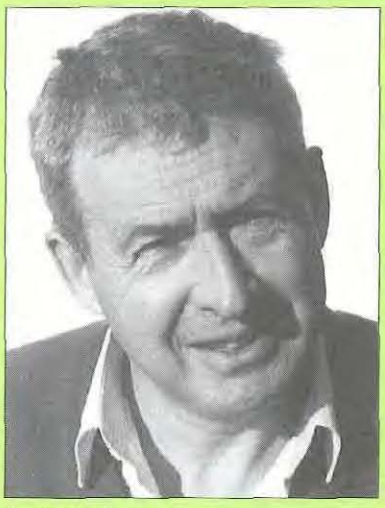
The Marine Science Institute at the university of the Philippines has risen to regional and international recognition as the leading tropical marine research institute in the developing world under his leadership. Starting with a handful of staff working on local issues, the institute now ranks as one of the largest in the region with an expanding research agenda that addresses regional concerns that are of relevance to global projects such as LOICZ.

His personal involvements are of greatest relevance to Focus 4 of LOICZ which attempts to integrate the natural and social sciences in the coastal zone. Among activities relevant to the broad programme of LOICZ, Ed Gomez has chaired the UN interagency Group of Experts on the Scientific Aspects of Marine Pollution, the Scientific Committee on Coral Reefs of the Pacific Science Association, and the Association of Southeast Asian Marine Scientists.

Patrick M Holligan, Professor of Oceanography at Southampton University, UK, was the driving force behind the Core Project on Land-Ocean Interactions in the Coastal Zone.

Much of the planning and creating for LOICZ was done during the time when Professor Holligan was senior research scientist at the Plymouth Marine Laboratory, UK. He was Chair of the LOICZ Core Project Planning Committee from 1991-1993, and Chair of the Scientific Steering Committee from 1993 to 1995. He will continue to serve on the SSC as member during 1996-1998.

LOICZ differs from the other IGBP research projects and is more complex in that it is geographically defined, cross-cutting both terrestrial and ocean ecosystems, while at the same time including a focus on the social sciences. For these reasons, the science plan required many workshops to evolve, from the publication by Holligan of Coastal Ocean Fluxes and Resources (IGBP Report 14, 1990), to the LOICZ open science meeting in 1993, and the publication of the LOICZ implementation plan in 1995.



Patrick Holligan

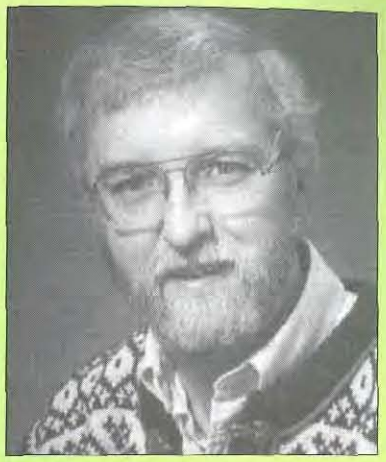
In parallel to reports and preparations for LOICZ, Holligan contributed the ecosystems impact study to the Intergovernmental Panel on Climate Change scientific assessments, the chapter on marine and coastal systems for Agenda 21, and continued research on ocean productivity, particularly in relation to studies of the optical and biogeochemical properties of coccolithophores using a combination of ships and satellites.

His main scientific interests are in phytoplankton ecology and biogeochemistry, remote sensing of the oceans, and biological feedback systems.

PAGES

Raymond S. Bradley, Professor of Climatology and Palaeoclimatology, Head of the Department of Geosciences at the University of Massachusetts, Amherst, USA, is the new Chair of the PAGES Scientific Steering Committee. He has been a member of the PAGES SSC since 1991.

After receiving his BSc degree in geography from Souhampton University, UK, in 1969, Bradley did graduate work at the Institute of Arctic and Alpine Research,



Raymond S. Bradley

University of Colorado, receiving a PhD in 1974. He joined the University of Massachusets in 1973 and was appointed Professor in 1984.

Bradley's interests are in climatic variations and global change. He has been involved for a number of years in studies of late Quaternary environmental change in the Canadian high Arctic. Most recently, this includes studies of laminated lake sediments from Ellesmere Island, and processes of sediment transport and deposition, with a view to interpreting late Holocene sedimentary records from the region.

Bradley is also studying decade to century-scale climate variability of northern hemisphere and continental regions. This work is aimed at placing the modern instrumental climate record in a longer-term perspective, to try to distinguish between 'natural' and anthropogenic, human-driven, climate change.

He has published extensively on both palaeoclimatology and climatic change in the past century.

Hans Oeschger, Professor Emeritus at the University of Berne, Switzerland, and Past Chair of PAGES, is a physicist and glaciologist who is internationally renowned for his research in extracting records of past changes from ice cores. His work has also covered nuclear energy, the history of cosmic radiation, and studies of deep-sea sediments, ground water, and lunar material, among others. His attention to carbon dioxide concentrations led to prognostics of carbon dioxide increase due to fossil fuel combustion – only a few topics on a career whose more recent focus has been on the awareness of global climatic and environmental change. Professor Oeschger was lead author for the Intergovernmental Panel on Climate Change Assessment first published in 1990.

Professor Oeschger was among the first to be invited by the International Council of Scientific Unions to join the Special Committee for the IGBP in 1987. The Swiss national committee for ICSU had been a driving force when the IGBP was founded at the ICSU General Conference at Berne in 1986.

During the planning phase, the IGBP emphasised the importance of modelling results from studies of the individual Earth system processes, which can be obtained from a wealth of information recorded in natural archives. Under his leadership, Past Global Changes was the first purely IGBP research team to create a Scientific Steering Committee, with both Hans Oeschger and Jack Eddy (NCAR, USA), as Co-Chairs.

PAGES workshop in Mainz (1991) formulated an implementation plan that was edited at NCAR, and published as IGBP report No. 19. It served as a guide for palaeostudies in global change research, and is used for designing national programmes. Highlights of PAGES accomplishments have been studies of pre-industrial conditions, natural greenhouse gas variations and their relation to climate, reaction of vegetation to past climate change, natural climate variability, sudden and unexpected events in past climates, and model-data comparisons.


Hans Oeschger

Hans Oeschger is President of "ProClim", the Swiss Forum for Climate and Global Change, located at the Swiss Academy of Sciences.

With his close association to the Swiss Academy (of which he was Vice-President 1975-1981) he was influential in setting up the Core Project Office for PAGES at the Academy, where it still functions today.

He will continue his work with the IGBP as Chair of the Swiss National Committee, and Past Chair of the PAGES SSC.


Peter Tyson

START

Peter Tyson, Director of the Climatology Research Group at the University of the Witwatersrand, South Africa, is the new Chair of the Scientific Steering Committee for the Global Change System Analysis, Research and Training (START). Professor Tyson is a distinguished scientist in the disciplines of meteorology and climatology.

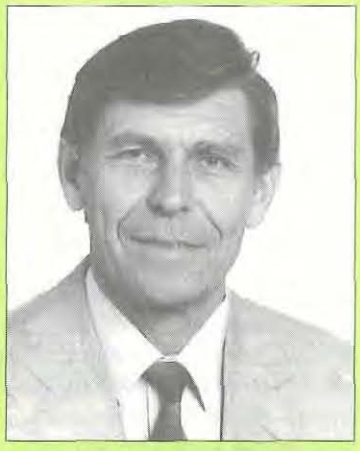
Formerly Dean of the Faculty of Science (1975-78), Deputy Vice-Chancellor (1981-84; 1986-93), and Vice-Principal (1988-92) of the University of the Witwatersrand, he obtained his PhD at the university in 1968 for his thesis 'An investigation of some topographically-induced local wind systems in Natal'. He has been recognised in the top category of scientists in South Africa by the Foundation for Research Development, is a Fellow of the Royal Society of South Africa (1989) and the South African Geographical Society (1978).

Professor Tyson has done pioneering work in climatology in Southern Africa. He was joint recipient of the Bill Venter Award for producing the best book published in the natural sciences in South Africa in the period 1983-86, 'Climatic change and Variability in Southern Africa'. Another major publication by him is 'The Atmosphere and Weather of Southern Africa.'

He has been active in several national and international scientific organisations, including the South African National Committee for the IGBP (of which he was Chair 1987-1992); Water Research Commission; Working Group on Desertification; Desert Ecological Research Unit; National Committee for Weather, Climate and Atmosphere Research; and the National Air Pollution Advisory Committee.

He has had extensive overseas experience as Visiting Lecturer at universities in Canada, the United States, the United Kingdom and New Zealand.

Professor Richard Rockwell who chaired the nominating committee noted that "Professor Tyson's own research touches on all of the global change research programmes - the IGBP, the World Climate Research Programme, and the Human Dimensions Programme. He has a great deal of experience with capacity building within his own country - all of which will benefit START enormously".


Genady Golubev

Genady Golubev, Professor of Geography at Moscow State University, was a founding member of the START Standing Committee, of which he served as chair for the five years following START's creation after a workshop in Bellagio (Italy) at the end of 1990.

His research interests began with the study of high mountains, glaciology and hydrology. He is author (in Russian) of Hydrology of Glaciers, still the only monograph on this subject. From there he began studies on the application of systems analysis to water and environmental management, which resulted in two monographs (in English) on the implications of large scale water transfers. As with many other IGBP scientists, his studies led to research interests in the global environment, and a position within the UN as Assistant Secretary General. His most recent work addresses global change science and science management with a publication (in Russian) on Russia in Environmental Crisis.

START will continue to seek his council in its work.

New Member of the Scientific Committee for the IGBP

Isao Koike, of the Ocean Research Institute, University of Tokyo, is a new member of the Scientific Committee nominated by ICSU.

Isao Koike

When Professor Koike started his scientific career at the beginning of the 1970s, his primary interest was biogeochemical cycling of nitrogen in natural environments, and the role of microorganisms within the cycling. He then expanded his research to water column studies, both open ocean and coastal waters, expanding field studies from tropical lagoon, Antarctic coastal waters and the central Pacific. His interests focused on process-oriented studies regarding the interaction between biological activities and the cycling of carbon and nitrogen in the system. He identified the importance of colloidal forms of organic materials within the carbon cycling of marine environments in 1990. Many people realised the importance of those tiny particles and named them "Koike particles".

He continues close contact with research activities, organising 1-2 month scientific cruises every 1-2 years, and participating in field programmes, such as his latest field trip for research on the tropical coastal lagoon in Fiji.

Professor Koike will bring to the Scientific Committee a rich background at an important time, when JGOFS will enter its final research phase, and other programmes join the IGBP.

Leaving the Scientific Committee is Professor Shizuo Tsunogai, of the Department of Chemistry, Hokkaido University.

Professor Tsunogai contributed to the success of the IGBP during the planning days of the programme, as a member of the panel on Marine Biosphere-Atmosphere Interactions, whose agenda was incorporated into JGOFS - a programme on which Tsunogai also collaborated. He became Vice-Chair of the IGBP in 1992.

Shizuo Tsunogai

Professor Tsunogai works with an impressive number of PhD students in atmospheric and ocean chemistry, on the hypotheses: (i) the role of the North Pacific and Antarctic intermediate waters as a sink of anthropogenic carbon, (ii) fluxes of carbon from the continental shelf, and (iii) gas transfer velocities under heavy storms in winter in high latitude oceans. He looks forward to devoting more time to them and to their research activities.

Open Science Meetings

29-31 January, 1996, Amsterdam, Netherlands
First Open Science Meeting of Land Use and Cover Change (LUCC). The Royal Dutch Academy of Sciences, Trippenhuis, Amsterdam.
Louise Fresco & Rik Leemans, Department of Agronomy, P.O. Box 341, 6700 AH Wageningen, The Netherlands, Tel: (+31) 317 483 077 Fax: (+31) 317 484 575, E-mail: lucc@sec.agro.wau.nl

4-6 March, 1996, Tsukuba, Japan
International Workshop on NOx Emission from soils and its influence on atmospheric chemistry. National Institute of Agro-Environmental Sciences, co-sponsored by IGAC.
Haruo Tsuruta, National Institute of Environmental Sciences, 3-1-1 Kan-nondai, Tsukuba, Ibaraki 305, Japan. Fax: (+81) 298 38 8199, E-mail: tsuruta@niaes.affrc.go.jp,
and Arvin Mosier, USDA/ARS, PO Box E. Fort Collins CO 80522, USA. Fax: (+1-970) 490 8213, E-mail: amosier@lamar.colostate.edu

17-21 June 1996, Washington DC, USA.
GEWEX: Second International Scientific Conference on the Global Energy and Water Cycle Experiment, at the US National Academy of Sciences. Scientific interests involve the climate feedback associated with clouds, radiation, and the hydrologic processes. **Papers invited.** *Contact: GEWEX Project Office, 409 Third Street SW, Suite 203, Washington, DC, 20024, USA. E-mail: GEWEX@cais.com*

26-30 August 1996, Helsinki, Finland
Fourteenth Interantional Conference on Nucleation and Atmospheric Aerosols. *M. Kulmala, Department of Physics, University of Helsinki, PO Box 9, FIN-00014, Helsinki, Finland. Tel: (+358-0) 191 8308, Fax: (+358-0) 191 8680, kulmala@phcu.helsinki.fi*

September/October 1996, Lagos, Nigeria
LOICZ Open Science Meeting. *Larry Awosika, National Institute of Oceanography, Lagos, Nigeria,* or *John Pernetta, LOICZ Core Project Office, Netherlands Institute for Sea Research, PO Box 59, NL-1790 AB Den Burg-Texel, The Netherlands. Tel: (+31) 2220 69404, Fax: (+31) 2220 69430, E-mail: pernetta@nioz.nl*

2-6 December 1996, Melbourne, Australia
First SPARC General Assembly (Stratospheric Processes and their Role in Climate). *David Karoly, SPARC 96, CRC for SH Meteorology, Bldg 70, Monash University, Clayton, VIC 3168, Australia.*
E-mail: sparc96@vortex.shm.monash.edu.au

Peter Liss (Chair, SC-IGBP), Patrick Buat-Ménard (Treasurer, SC-IGBP), and Chris Rapley (Executive Director, IGBP) at SAC IV in Beijing.

IGBP Publications

IGBP Report Series

IGBP Report No. 35

Land-Use and Land-Cover Change. Science/Research Plan (1995). Edited by B. L. Turner II, David Skole, Steven Sanderson, Günther Fischer, Louise Fresco and Rik Leemans. Stockholm/Geneva, IGBP/HDP. 132 pp. (IGBP Report 35/HDP Report 7).

IGBP Report No. 36

The IGBP Terrestrial Transects: Science Plan (1995). Edited by G. W. Koch, R. J. Scholes, W. L. Steffen, P. M. Vitousek and B. H. Walker. 61. pp.

IGBP Directory 1995. 181 pp.

Book of Abstracts

Natural and Anthropogenic Changes: Impacts on Global Biogeochemical Cycles (Beijing, 23-25 Oct. 1995). Plenary Session and Poster Session Abstracts. 107 pp.

IGBP Secretariat, The Royal Swedish Academy of Science, Box 50005, S-104 05 Stockholm, Sweden.

Programme Elements

GCTE

Report No. 3. Global Change Impacts on Pastures and Rangelands. Implementation Plan. (1995). 59 pp.

GCTE Annual Report 1994 (1995).

GCTE Core Project Office, CSIRO Division of Wildlife and Ecology, PO Box 84, Lyneham ACT 1602, Australia.

Focus 3 Implementation Plan (1995). [Global Change Impact on Agriculture, Forestry and Soils]. 45 pp.

GCTE Focus 3 Associate Office, Dept. of Plant Sciences, University of Oxford, South Parks Road, Oxford OX1 3RB, UK

Past Global Changes

Palaeoclimates of the Northern and Southern Hemispheres. The PANASH Project. The Pole-Equator-Pole Transects. Science and Implementation Plans: PEP I: The Americas Transect, PEP II: The Austral-Asian Transect, PEP III: The Afro-European Transect. 92 pp. (PAGES Series 95-1)

PAGES Core Project Office, Bärenplatz 2, CH-3011 Bern, Switzerland. Fax: (+41-31) 312 31 68

GAIM

Abstracts from the GAIM Science Conference are available on the World-Wide-Web GAIM home page, http://gaim.unh.edu or

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

National Research

Austria

Austrian Contributions to the IGBP. Vol. 2 (1995). Ed. by S. J. Bauer. Vienna: Austrian Academy of Sciences.

Siegfried J. Bauer, Institut für Meteorologie und Geophysik, Universität Graz, Halbärthgasse 1, A-8010 Graz, Austria

Canada

Global Change Research Themes (1995). Ottawa: CGCP. 29 pp.

Canadian Global Change Program, 225 Metcalfe, No. 308, Ottawa, Ontario, KWP 1P9, Canada.

China

China Contribution to Global change Studies, edited by Ye Duzheng, Lin Hai et al. (1995). Beijing: Science Press. 226 pp.

Chen Panqin, CNC for the IGBP, Bureau of Coordinative Development, Chinese Academy of Sciences, 52 Sanlihe Road, Beijing 100864, China.

Czech Republic

Manifestation of Climate on the Earth's Surface at the End of Holocene (1995). Ed. by E. Ruzicková & A. Zeman. PAGES Czech Contribution. 176 pp.

E. Ruzicková, Geological Institute, Rozvojová 135, Praha 6, 165 02 Czech Republic.

Finland

The Finnish Research Programme on Climate Change (1995). 12 pp.

Web site: http://www.aka.fi/silmu/silmu.htm

SILMU, Academy of Finland, PO Box 57, FIN-00551, Helsinki, Finland

Germany

IGBP Research in the Federal Republic of Germany, 1995. Ed. by S. Lütekemeier & A. Spekat. Berlin: IGBP-Sekretariat,

IGBP-Sekretariat, Institut für Meteorologie, Freie Universität Berlin, Carl-Heinrich-Becker-Weg 8-10, D-12165 Berlin, Germany. Fax: (+49-30) 838 71217, E-mail: igbp@zedat.fu-berlin.de

Japan

An Interim Report of IGBP Activities in Japan. 1990-1994. Japan National Committee for IGBP. 265 pp.

Isamu Kayane, Institute of Geoscience, University of Tsukuba, 1-1 Tennodai, Tsukuba, Ibaraki 305, Japan. Fax: (+81-298) 51 9764

Poland

Ozone – a Regional and Global Problem. Polish IGBP Committee and Institute for Ecology of Industrial Areas (1995). Ed. by S. Godzik & L. Starkel. 104 pp.

Leszek Starkel, Geomorphology and Hydrology Dept., Polish Academy of Sciences, Ul. Sw. Jana 22, PL-31-018 Kraków, Poland.

Switzerland

Global Change: Swiss Experts, Researchers and International Programs. Bern: ProClim. 60 pp.

Christoph Ritz, ProClim, Swiss Academy of Sciences, Bärenplatz 2, CH-3011 Berne, Switzerland

USA

Our Changing Planet (1995). The Fiscal Year 1996 U.S. Global Change Research Program. An Investment in Science for the Nation's Future. Washington DC: National Science and Technology Council.

Global Change Research Information Office, 1747 Pennsylvania Ave. NW, Suite 200, Washington, DC 20006, USA.

Related Organisations

APN

The Third Workshop on Asia-Pacific Network for Global Change Research. Tokyo: APN. 71 pp

APN Interim Secretariat, Global Environmental Forum, 1-9-7 Azabudai, Minato-ku, Tokyo 106, Japan.

European Commission

Global Environmental Change and Sustainable Development in Europe (1995). Ed. by Jill Jäger, Angela Liberatore, Karin Grundlach. *243 pp.*

Office for the Publication of the European Communities, 2, rue Mercier, L-2985 Luxembourg

GTOS

Global Climate Observing System Reports

The GCOS has published 22 reports to date on its action and plans. These are available in hard copy, and on the Web: ftp://www.wmo.ch/Documents/gcos/

For list and hard copyieswrite to: GCOS, World Meteorological Organisation, CP No. 2300, CH-1211 Geneva 2, Switzerland

IAHS

Man's Influence on Freshwater Ecosystems and Water Use (1995). Ed. by Geoffrey Petts. Wallingford: International Association of Hydrological Sciences. 280 pp. (IAHS Pub. No. 230)

IAHS Press, Institute of Hydrology, Wallingford, Oxfordshire OX10 8BB, UK.

IAI

Reports of Workshops to Develop the Scientific Agenda of the Inter-American Institute for Global Change Research (1995): El-Niño-Southern Oscillation and Interannual Climate Variability. 56 pp; High Latitude Processes. 59 pp.; Scientific Development. [68 pp.]

Paul Filmer, IAI Secretariat, National Science Foundation, Suite 705, 4201 Wilson Boulevard, Arlington, VA 22230, USA

ITC

The Land Use Database (1995). A knowledge based software program for structured storage and retrieval of user-defined land use data sets. 90 pp. [Manual and diskette for MS DOS]

International Institute for Aerospace Survey and Earth Sciences, 350 Bd. 1945, PO Box 6, 7500 Enschede, The Netherlands

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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

e-mail: sec@igbp.kva.Se

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