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The Earth's Changing Land

GCTE-LUCC Open Science Conference on Global Change
Barcelona (Spain), March 14-18, 1998

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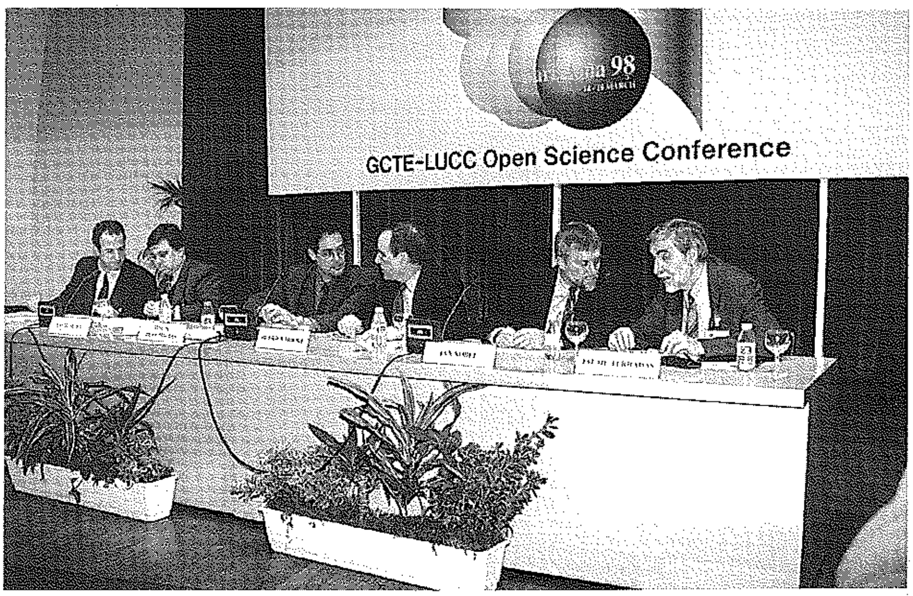

At the GCTE-LUCC Open Science Conference. From left to right: Xavier Baulies, David Skole, Pere Macias, Berrien Moore III, Ian Noble, Jaume Terradas. [Photo courtesy of F. Lloret and O. Ortiz]

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Earth's Changing Land

GCTE-LUCC Open Science Conference

The Global Change and Terrestrial Ecosystem (GCTE) and Land Use/Land Cover Change (LUCC) Core Projects of IGBP and IHDP held an Open Science Conference on March 14-18, 1998 in the Palau de Congressos of Barcelona (Spain).The event attracted 800 specialists from 51 countries who presented 120 talks and 480 posters.

The Conference brought together scientists from those research fields critical to understanding the multi-driver nature of global changes affecting the terrestrial biosphere. State-of-the-art science was presented during the conference on the following topics:

- Impacts of climate and atmospheric composition changes on ecosystem functioning, and the implications for the Earth system;
- Driving forces of land-use change and its ecological consequences;
- Vegetation and land cover changes at local, landscape, and global scales;
- Global change impacts on agricultural production, forestry, biodiversity, and other issues of importance for human well-being; and,
- Regional approach to global change research with sessions on Europe, Asia, Africa, and the Americas.

The Conference was a unique opportunity for the scientific community to take a look at the large picture of global change and the terrestrial biosphere beyond individual specialties, and also, an excellent chance for networking with colleagues from all around the world. The Conference provided a suitable framework to learn more about the objectives, challenges, and achievements of the GCTE and LUCC communities, as well as the 'cultural' distances between them in terms of concepts, methodologies, priorities, and the problems and limitations of their respective research agendas.

Several common areas of interest were identified in the fields of global integrated models, land fragmentation, environmental vulnerability, and biodiversity, in which future collaborations are likely to be very productive.

The conference also clearly showed the complementary role of both projects, which is fundamental to meet future challenges. During the last several years GCTE has produced important new knowledge about changes in structure and functioning of terrestrial ecosystems and in agriculture in response to climate and atmospheric changes, particularly increasing atmospheric carbon dioxide. Also the effects of these drivers on biodiversity have been incorporated in the agenda. This knowledge has been achieved by contributions from more than 40 projects involving a very active community of about 700 scientists. At present there is a need in GCTE to improve understanding of these interactions with land-use changes, which have been recognized as a central driver of global change.

LUCC, younger than GCTE, is starting its first implementation phase aimed at improved understanding of the nature of mechanisms of land use/cover change and their projections both at global and regional scales. Pioneer LUCC projects have revealed fundamental patterns and processes of land use and cover change and significant interannual variability. There is a need in LUCC for biophysical response models to integrate dynamics in ecosystems and agriculture as feedbacks in the land use/cover models. This complementary profile of both projects, GCTE as 'impacts of change' science and LUCC as 'driving force of change' science, has to be emphasized to guarantee fruitful work.

The conference demonstrated the need for a coordinated strategy to advance land surface interface studies. Collaboration among the ecological, remote sensing/GIS, social and economic science communities, together with the terrestrial climatology community, will be a key determinant of the quality and relevance of the scientific achievements. The coupling of these different disciplines is a huge challenge that can be approached by the creation of an integrated framework. In spite of the diversity of methodologies and languages, a set of common parameters is required in order to allow comparability, integration and modelling. This multidisciplinary community will be more and more pressured by society to deliver knowledge on the threats of environmental change to human life. Responses based on an integrated understanding will be most valuable. Activities like "The Earth's Changing Land" represent some of the first attempts to develop this new, dynamic approach.

The Conference was sponsored by the Goverment of Catalonia, City Council of Barcelona, Catalan Foundation for Research, Spanish Interministerial Commission for Science and Technology, DG XII of the European Commission, NASA, EPRI, US Department of Energy, US Forest Service, Natural Science Foundation, START, IGBP, IHDP, the Banco Bilbao Vizcaya Foundation, LUCC, and GCTE.

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GLOBEC holds first Open Science Meeting

Over 200 scientists from 35 countries met in Paris from 17-20 March for the first GLOBEC Open Science Meeting. The meeting, which was held at the UNESCO headquarters, with beautiful views overlooking the Ecole Militaire, Champs de Mars, and the Eiffel tower, was organized by the interim GLOBEC office at the Plymouth Marine Laboratory. The opening keynote address by John Steele, Woods Hole Oceanographic Institution, on "*From food webs to regime shifts*" set the high standard for presentations throughout the meeting. We were also fortunate that the incoming Executive Secretary of the Intergovernmental Oceanographic Commission of UNESCO, Patricio Bernal, agreed to give a talk on, "*The natural limits to the use of renewable resources: GLOBEC as a contribution to national and regional management goals* ".

Over the past year the Scientific Steering Committee of GLOBEC, in collaboration with interested scientists, has been developing an Implementation Plan for GLOBEC. A major aim of the Open Science Meeting was to provide a forum to present a draft of the GLOBEC Implementation Plan to the widest international science community and provide an opportunity for its discussion, and for feedback.

To achieve this, the Open Science Meeting featured invited plenary key note presentations on GLOBEC, its major subprojects and their implementation, in addition to contributed papers and posters on the current scientific activities of GLOBEC. The overall structure of the meeting reflected the four GLOBEC research Foci:

- Focus 1 Retrospective analysis in the context of global change.
- Focus 2 Process studies.
- Focus 3 Predictive and modelling capabilities.
- Focus 4 Feedbacks from changes in marine ecosystem structure.

An impressive range of contributed scientific papers and posters demonstrated the wide range of GLOBEC research already addressing these themes.

In addition there were sessions on the four major GLOBEC Regional Programmes: The GLOBEC Southern Ocean Programme (SO-GLOBEC), Small Pelagic Fishes and Climate Change (SPACC), the ICES-GLOBEC Cod and Climate Change Programme (CCC) in the North Atlantic and the PICES-GLOBEC Climate Change and Carrying Capacity Programme (CCCC) in the North Pacific.

A special session of talks provided the opportunity to review the plans and achievements of a wide range of active National GLOBEC programmes, highlighting US-GLOBEC, GLOBEC Canada, France GLOBEC-PNDR, China-GLOBEC, the BENEFIT programme of SW Africa, New Zealand and GLOBEC, GLOBEC-Chile, and Brazil GLOBEC.

Participation in the Open Science Meeting was supported by travel funds provided by grants to the Scientific Committee for Oceanic Research (SCOR) from the US National Science Foundation, the International Council of Scientific Unions, and UNESCO. Scientists from Argentina, Cameroon, Chile, China, India, Mexico, Pakistan, Peru, Russia, Ukraine and South Africa made important contributions to the meeting through this means.

Discussion of, and contribution to, the further development of the Implementation Plan was encouraged in a series of workshop discussions which reported to the final summary plenary session. In addition, an individual questionnaire on the Implementation Plan was circulated to all participants and a large number of valuable comments were received, and are being incorporated in a revised version of the Plan.

The Open Science Meeting was organized by a small committee of the GLOBEC Scientific Steering Committee: Jürgen Alheit, Chairman (Baltic Sea Research Institute, Germany); Roger Harris (Plymouth Marine Laboratory, United Kingdom); Tom Ikeda (Hokkaido University, Japan); Ian Perry (Pacific Biological Station, Canada); and Qisheng Tang (Yellow Sea Fisheries Research Institute, China). Very efficient local support during the meeting was provided by a local organizing team of Wesley Ross (Office of SCOR); Delphine Bonnet, Bob Head, Xabier Irigoien, and Bettina Meyer-Harms (all from Plymouth Marine Laboratory).

Papers from the Open Science Meeting will be published in a special GLOBEC double issue of the journal *Fisheries Oceanography*, to be published in October this year. The peer review process for this project is already well advanced.

This first Open Science Meeting of GLOBEC was a significant contribution in the development of the international programme. The level of contribution, discussion, and participation at the meeting suggest that GLOBEC will have an extremely active and productive future.

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Report on PAGES Open Science Meeting

The first IGBP PAGES Open Science Meeting *'Past Global Changes and their Signicance for the Future'*, jointly organized by PAGES and the Environmental Changes Research Centre (ECRC), University College London, was held in the University of London Senate House, April 20 - 23, 1998. The meeting attracted over 400 participants from some 35 countries. The meeting was opened by Angela Eagle, Junior Minister at the Department of Environment and Transport. The oral presentations that followed took the form of overviews by distinguished invited speakers whose remit was to present the state-of-the-art in all the main aspects of past global change research within the context of IGBP. In addition, over 200 posters were displayed. The published output from the meeting includes a 140 page volume of abstracts (containing over 350 items) available from the PAGES Project Office and also via the PAGES web site (http://www.pages.unibe.ch/). A double special issue of the *Journal of Quaternary Science* containing review papers by each of the invited speakers will be published in 1999 and will also be available in book form. It is hoped that a CD-ROM will be distributed of the PAGES Database along with this volume.

The PAGES Open Science Meeting was the first of its kind and marks a major landmark in our attempt to understand present and future environmental changes by placing them in the perspective of the past.

The meeting culminated in a panel discussion chaired by Chris Rapley, Director of the British Antarctic Survey and former Executive Director of the IGBP. Members of the panel were Sir John Houghton, co-chairman of the Science Assessment Working Group of the Intergovernmental Panel on Climate Change (IPCC), Hartmut Grassl, Director of the Joint Planning Staff of the World Climate Research programme (WCRP), Bill Hare, Climate Policy Director of Greenpeace International, Ray Bradley, Professor of Climatology at the University of Massachusetts and Chair of the PAGES Scientific Steering Committee (SSC), and Jonathan Overpeck, Head of the US NOAA Paleoclimatology Program, Director of the World Data Center-A for Paleoclimatology and member of the PAGES SSC.

The key aims of the panel discussion were to link the research agenda of PAGES, as outlined in the presentations, and its recently published 'Status Report and Implementation Plan' as effectively as possible to the concerns of all those dealing with the prediction and management of future global changes and their impacts on human society. The panel members from outside PAGES made introductory statements to open the discussion.

Sir John Houghton stressed the essential role of PAGES science in:

- validating climate and other Earth system models;
- increasing the quantitative understanding of climate sensitivity to different forcings;
- improving parameterization of key Earth system processes involved in climate change, for example biosphere feedbacks;
- characterizing climate regimes in time and space and documenting their role in the pattern of variability at the regional level;
- highlighting the importance of rapid change and of the feedbacks and nonlinear processes involved;
- detailing the impacts of climate variability on other environmental systems and especially on human activities by presenting a palaeoperspective on human adaptibility and on the problems involved in planning for sustainability in a future dominated by change.

Hartmut Grassl stressed the links between PAGES and WCRP through the CLIVAR (Climate Variability and Predictability) Programme. Inputs to CLIVAR from the PAGES research community should lead to an extension of the instrumental record to the whole of the last millennium through use of quantitatively calibrated proxies that achieve precise and accurate age control, annual resolution, and global significance. Tree rings, varved (annually laminated) sediments, ice cores, corals, and speleothems all provide this potential, as do documentary records. Grassl stressed the need for collaborative work between modellers and data researchers on the development of realistic and well validated transient models of non-linear climate change. He also emphasized the crucial role of isotope studies in global change research, stressing the need to strengthen the Global Network for Isotopes in Precipitation (GNIP) and to promote both the PAGES 'Isotope Mapping' (ISOMAP) programme and the newly established 'Isotopes in the Hydrological Cycle' (ISOHYC) initiative as complementary developments of great potential.

Bill Hare emphasized the role palaeoresearch must play by using the information at its disposal to identify critical environmental thresholds for rapid non-linear change and to establish the ways in which these may be influenced by different rates of forcing. In the policy-related domain, he stressed the need to understand better past natural variabi-lity and, in particular, the incidence and impacts of extreme events – a matter of major concern in risk assessment. By improving our understanding of the role of the terrestrial biosphere in past climate change, PAGES should also contribute to evaluating the potential for policy makers meeting their obligations within the Climate Convention by increasing biomass rather than reducing carbon emissions. Hare also pointed to the urgent need to use palaeo-records more effectively in documenting the interlinked past variations in global ice-volume, sea-level, and coastal change, so that future changes can be more effectively predicted and accommodated in policy development.

The leading points made by the panel members and the ensuing discussion provided ample justification for regarding PAGES research as a vital contribution to understanding future environmental change and its human implications, as well as many pointers to the ways in which the existing research agenda can be shaped in order to increase its impact and relevance. Our central task is to use the record from the past to shed light on what predicted future changes will actually mean for a still rapidly growing world population for which the goals of sustainable development and the realities of environmental change will be intimately linked.

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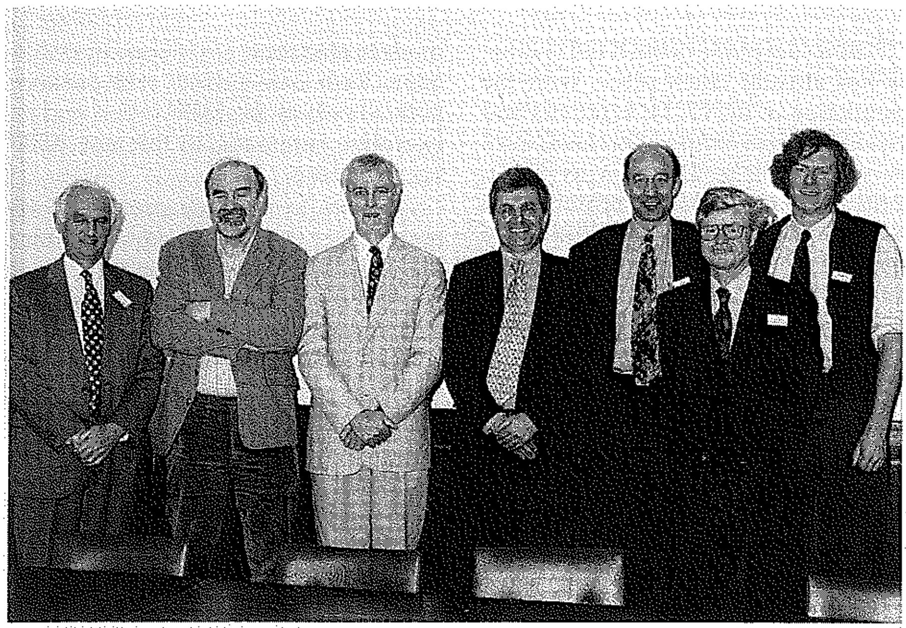
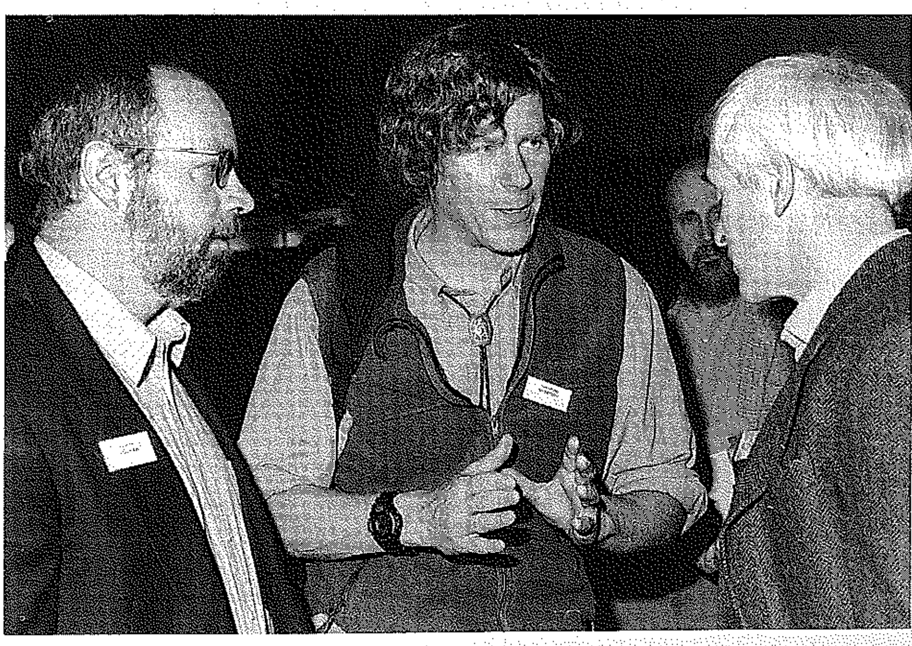


Members of the discussion panel at the PAGES Open Science Meeting, from left to right: Sir John Houghton, Rick Battarbee (local host and organizer), Ray Bradley, Chris Rapley, Bill Hare, Hartmut Grassl, and Jonathan Overpeck. [Photo courtesy of the Environmental Change Research Centre, University College London]



Discussing PAGES issues: Steve Colman, Jonathan Overpeck, Colin Prentice, and Jean Jonzel. [Photo courtesy of Environmental Change Research Centre, University College London]

How well do we understand the nature of Earth?

The challenge of the IGBP Synthesis

As global change gathers pace and humanity increasingly realizes that its activities are impacting on the functioning of Earth as a whole in complex ways, there is a growing challenge to the scientific community to provide a much better understanding of the nature of Earth. Is it fragile and vulnerable, with environmental disaster looming ahead? Or is it robust and adaptive, able to absorb humanity's activities with relatively little damage to its fundamental functioning?

Questions such as these are challenging IGBP to undertake a major synthesis of its research effort over the past decade, and to document the contributions that it has made to our understanding of the Earth system.

Just what is a synthesis?

It is important to recognize that a synthesis is NOT a review; there are critical differences. The dictionary definitions of the two words are instructive:

Synthesis: *(Webster:) -action of putting together. The combining of often varied and diverse ideas, forces or factors into one coherent or consistent complex. (Concise Oxford:) -the process or result of building up separate elements, especially ideas, into a connected whole, especially into a theory or system.*

Review: *(Webster:) 1) a looking over or examination with a view to amendment or improvement, 2) to go over with critical examination in order to discover excellences or defects. (Concise Oxford:) a general survey or assessment of a subject or thing.*

A synthesis is a combining of diverse ideas into one coherent theory or system. Reviews and summaries are important building blocks in the synthesis process, but the key concept in a synthesis is that it aims to achieve new insights and reach a higher level of understanding through integrating research results on various facets of an overall theme. Analysis and interpretation play key roles in a synthesis.

The initial phase of the IGBP synthesis has already taken place, with the completion of the GCTE synthesis and its publication as both an executive summary, available as IGBP Science No. 1, and a supporting book, to be published in September this year as Volume 4 of the IGBP Book Series (Cambridge University Press).

The GCTE effort highlighted an important characteristic of a synthesis compared to a review; the former can be somewhat speculative and forward-looking, while the latter is normally confined to an examination of what has already been published and to consensus conclusions that can be drawn directly from that material.

The treatment of the terrestrial carbon cycle in the GCTE synthesis gives an excellent example of the way in which a synthesis can both integrate research on a broad thematic area and ask provocative questions about big issues. Coupling the latest research on the effects of elevated atmospheric CO_2 on whole ecosystems, the projected effects of 'biome reorganization' with a changing climate, and the implications of the need to feed a rapidly expanding human population, GCTE questioned the long-term reliability of the current terrestrial sink for atmospheric CO_2 and suggested that the terrestrial biosphere may become a net source of carbon sometime in the next century. This projection, along with the Kyoto Protocol and associated political considerations, is triggering an accelerated research effort on the nature of the terrestrial carbon sink, particularly its size and its reliability into the future.

Building on the GCTE experience, four other 'mature' core projects - BAHC, JGOFS, IGAC, and PAGES - will undertake project-level syntheses over the next two years. The workplans call for two or three dedicated synthesis workshops, at which much review, discussion, debate, and writing will take place. In between workshops, these activities will continue at a vigorous pace through use of modern electronic communication systems. Each core project will produce both a book, in the IGBP series, and an executive summary, in the new IGBP Science series.

Parallel to the core project efforts and lagging them by about six months, an IGBP-wide synthesis will address broader global change questions, such as biogeochemical cycling and Earth system functioning in general. GAIM will play a central role in the planning and implementation of the programme-wide synthesis; a meeting of the newly reconstituted GAIM Task Force in late 1998 will finalize the workplan and begin the implementation phase.

The IGBP-wide synthesis will be organized around a number of key questions or common themes. A combination of 'top-down' and 'bottom-up' approaches will be used, with the GAIM Task Force developing a set of overarching questions, and the core projects, working with the IGBP Secretariat, developing a series of common themes. Integrating the two approaches should provide some innovative and perhaps even provocative ways of viewing the Earth system and the role of human activities in it.

From the outset IGBP has been organized around key questions, and the synthesis must address IGBP's performance in answering them. The overall objective which has guided IGBP at the programme level is:

"To describe and understand the interactive physical, chemical and biological processes that regulate the 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 of the core projects has been organized around six questions:

- How is the chemistry of the global atmosphere regulated, and what is the role of biological processes in producing and consuming trace gases?

- How will global changes affect terrestrial ecosystems?
- How does vegetation interact with the physical processes of the hydrological cycle?
- How will changes in land-use, sea-level rise and climate alter coastal ecosystems and what are the wider consequences?
- How do ocean biogeochemical processes influence and respond to climate change?
- What significant climatic and environmental changes occurred in the past, and what were their causes?

The draft GAIM "Four Fundamental Questions" attack the synthesis from the perspective of global biogeochemical cycling and the physical climate system, thus facilitating linkages to the World Climate Research Programme (WCRP). The current version, set out below, is being debated throughout the IGBP community and will be revised in the lead-up to the GAIM Task Force meeting later in the year.

- What controls the partitioning of the major biogeochemical elements in the Earth system? What are the patterns and processes by which C, N, P, S, Fe, and other biologically important elements are partitioned among the major active reservoirs (vegetation and soils, atmosphere, continental water, coastal zone, open ocean)?
- How do changes in ecosystems interact with the physical climate system? What processes determine how climate change affects marine and terrestrial ecosystems, and what are the potential climate feedbacks due to these processes?
- How do changes in the radiatively and chemically active gas composition of the atmosphere interact with the physical climate system? What controls the sources and sinks of CO_2, CH_4, N_2O, NO_x, NMHC, and CO in the biosphere and how are changes in climate likely to impact on the atmospheric concentrations of these gases?
- Given our understanding of the couplings among physical and biogeochemical aspects of the Earth system, what will be the nature of its future interactions with human activities?

An alternative set of overarching questions was used for a final integrating session at the recent GCTE-LUCC Open Science Conference in Barcelona, and could be adapted for use in the IGBP synthesis. These questions highlight the central, critical role that human societies play in the Earth system, and point the way towards the rapidly growing links between IGBP and the International Human Dimensions Programme (IHDP).

- What is the nature of Earth's fundamental element cycles: robust and highly buffered, able to withstand major perturbations, or fragile and prone to major changes in functioning when perturbed?
- What is the nature of Earth's biosphere: fragile or robust? How does the biosphere interact with (i) direct perturbations from human activities, and (ii) a changing abiotic environment?
- What is the spatial nature of processes, patterns and interactions of a changing Earth: local, regional, or global?

These various sets of questions are not mutually exclusive, and, in fact, are complementary in that they approach IGBP's overarching goal at different levels of generality and specificity and from different perspectives. Together, they provide a powerful framework for a fascinating and challenging scientific endeavour.

The culmination of the synthesis will be an IGBP Open Science Conference, to be held in late 2000 or early 2001. This meeting will be an excellent opportunity for the international global change community to present the rich variety of research around the world which contributes to IGBP, and will provide an ideal platform on which to present, discuss and debate the results of the synthesis.

What is the nature of Earth? The challenge for IGBP over the next three years is to make a significant contribution towards answering this question.

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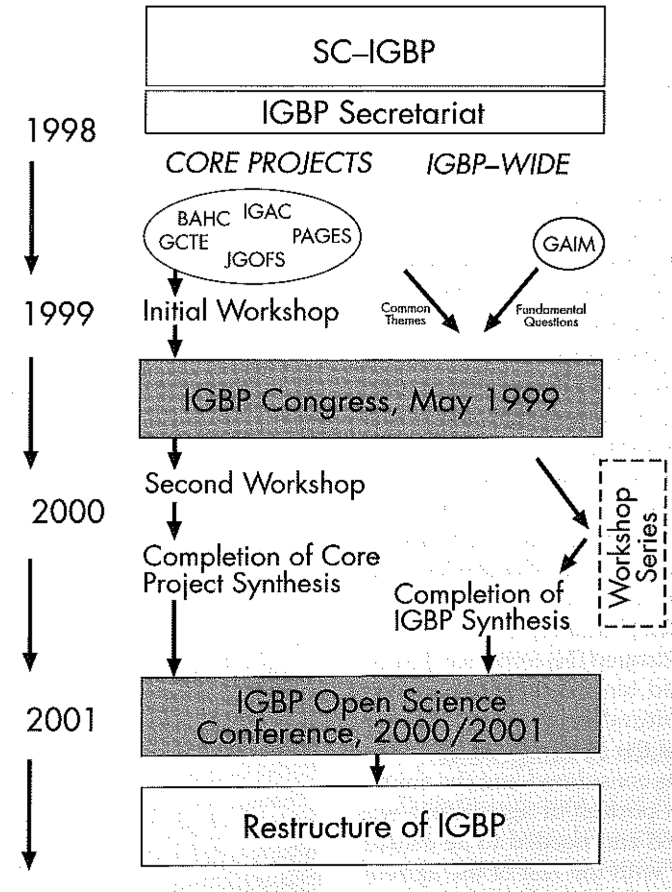

Figure 1. Schematic representation of the workplan for the synthesis

A new approach to estimate emissions of nitrous oxide from agriculture and its implications for the global N_2O budget

As part of the IGAC Trace Gas Exchange: Mid-Latitude Terrestrial Ecosystems and Atmosphere (TRAGEX) Activity, the U.S. Trace Gas Networking Activity (TRAGNET) has been assembling a trace gas data base. Information from trace gas workshops conducted under IGAC auspices is being used in assembling this database. Some of these data were used in the development of the biosphere N_2O emissions inventory methodology discussed in the following article. The basis for the article was presented during an IGAC-sanctioned International Workshop on Dissipation of N from the Human N-Cycle, and its Role in Present and Future N_2O Emissions to the Atmosphere, held in Oslo, Norway, in May of 1997.

Introduction

During the past decade attempts to define budgets for global atmospheric N_2O suggested that the strength of known N_2O sources is underestimated or that unidentified sinks exist (1, 2, 3). In these budgeting efforts anthropogenic N_2O emissions due to agricultural activities were considered to be relatively small (Table 1). These assessments were based upon a few reviews and interpretations that needed further examination (2, 7, 8). Questions to these interpretations were beginning to be raised during the development of national inventory methodologies for N_2O in agriculture (4, 9, 10, 11) and within IGAC trace gas Activities. Before that time N_2O emissions from agricultural systems were only considered from the aspect of direct N_2O emissions from agricultural fields (12) that had been fertilized with synthetic nitrogen (N) fertilizer. The estimates used tended to underestimate total agricultural emissions (7, 8) since only part of the N input into crop production was considered and the animal production portion of agriculture was not included and needed to be considered along with the rest of the agricultural N cycle. A number of data sets that have been collected as a part of IGAC trace gas Activities are now being used to evaluate and improve the procedures described below.

In this paper, we summarize the background of the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (5) for N_2O from agriculture and its implications for the global N_2O budget as described in Mosier *et al.* (13). The United Nations Framework Convention on Climate Change requires that all parties periodically update and publish national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies. In response to this mandate the IPCC, through the Office of Economic Cooperation and Development (OECD) and the International Energy Agency (IEA), has been coordinating the development and updating of national inventory methodologies for various greenhouse gases. The first phase of methodology development was published in the 1995 IPCC Guidelines for National Greenhouse Gas Inventories (14). In Phase II a working group of 32 persons from 18 countries

Table 1. Global N_2O budgets: IPCC (2), IPCC (4) and from the N_2O methodology presented in this paper for N_2O from cultivated soils (5)

	IPCC, 1992 (2)	IPCC, 1995a (4)	IPCC, 1997 (5)
	$Tg\,N\,y^{-1}$		
Sources			
Natural[*]			
ocean	1.4-2.6	3(1-5)	3.0(1-5)
tropical soils			
wet forest	2.2-3.7	3(2.2-3.7)	3.0(2.2-3.7)
dry savannas	0.5-2.0	1(0.5-2.0)	1.0(0.5-2.0)
temperate soils			
forests	0.5-2.0	1(0.1-2.0)	1.0(0.1-2.0)
grasslands	?	1(0.5-2.0)	1.0(0.5-2.0)
Subtotal	4.6-8.3	9(4.3-14.7)	9.0(4.3-14.7)
Anthropogenic			
agricultural soils	0.03-3.0	3.5(1.8-5.3)	3.3[#] (0.6-14.8)
biomass burning	0.2-2.1	0.5(0.2-1.0)	0.5 (0.2-1.0)
industrial sources	0.8-1.8	1.3(0.7-1.8)	1.3 (0.7-1.8)
cattle and feedlots	?	0.4(0.2-0.5)	2.1 (0.6-3.1)
Subtotal	1.0-6.9	5.7(3.7-7.7)	7.2 (2.1-19.7)
Total Sources	5.6-15.2	14.7(8-22.4)	16.2(6.4-34.4)
Sinks			
Atmospheric Increase	3-4.5	3.9(3.1-4.7)	3.9 (3.1-4.7)
Soils	?	?	?
Stratospheric Sink	7-13	12.3(9-16)	12.3(9-16)

[*] For IPCC (5) estimates of natural N_2O sources we use the "likely" values from (4). The values in parentheses in this column represent the range of estimates for each category.

[#] The 3.3 shown here is 0.8 lower than the total in Table 2, because we assume that part of the natural soil and ocean emissions estimates include part of the indirect N_2O that we calculate from emissions of NH_3 and NO_x from fertilization of agricultural soils and from nitrate leaching and runoff from these soils (6).

was assembled in December, 1995 at the request of OECD/IPCC/IEA to revise the IPCC Guidelines for National Greenhouse Gas Inventories for N_2O from Agricultural Soils (5).

The IPCC 1995 Guidelines (14) included only N_2O emissions occurring directly from agricultural fields. The N sources in this calculation were expanded to include synthetic fertilizers, organic N from animal excreta and crop residue, and the amount of biological N fixation. This basic formula equating direct N_2O emissions from agricultural soils to the N input multiplied by a conversion factor of 1.25 ± 1.0 % was used in the Cole *et al.* (15) Climate Change 1995 assessment of mitigation options for N_2O emissions from agriculture. Values from these estimates were included in the Climate Change 1994 (4) report. Cole *et al.* (15) included an additional factor of 0.75% of N applications to provide some accounting for indirect N_2O emissions that eventually evolved back to the atmosphere from N leaching or runoff from agricultural fields as well as NO_x and NH_3 volatilization (15) (Table 1).

The IPCC 1995 Guidelines still lacked mechanisms for estimating N-fixation and crop residue input and a quantifiable method for calculating N_2O productions following N leaching and runoff. N applied to agricultural soils may be lost from the fields through surface erosion or leaching (10). This leached N continues recycling in the soil-water-air system and eventually is denitrified and converted to N_2O and N_2 and released back to the atmosphere (Figure 1), or buried in sediments. All of these pathways and factors needed to be included in the anthropogenic agricultural soil N_2O source. Additionally, in the IPCC 1995 Guidelines animal production systems were not included in the agricultural anthropogenic N_2O production guidelines. As a start in overcoming these deficiencies in national emission inventories, we developed a revised method for estimating country scale anthropogenic N_2O emissions from agricultural soils which is described in detail in the 1996 IPCC National Inventory Methodology Guidelines (5) and in Mosier *et al.* (13). The result of using the new calculations suggests that an underestimation of total anthropogenic N_2O emissions from agricultural systems is likely responsible for the previous imbalanced global N_2O budgets (Table 1).

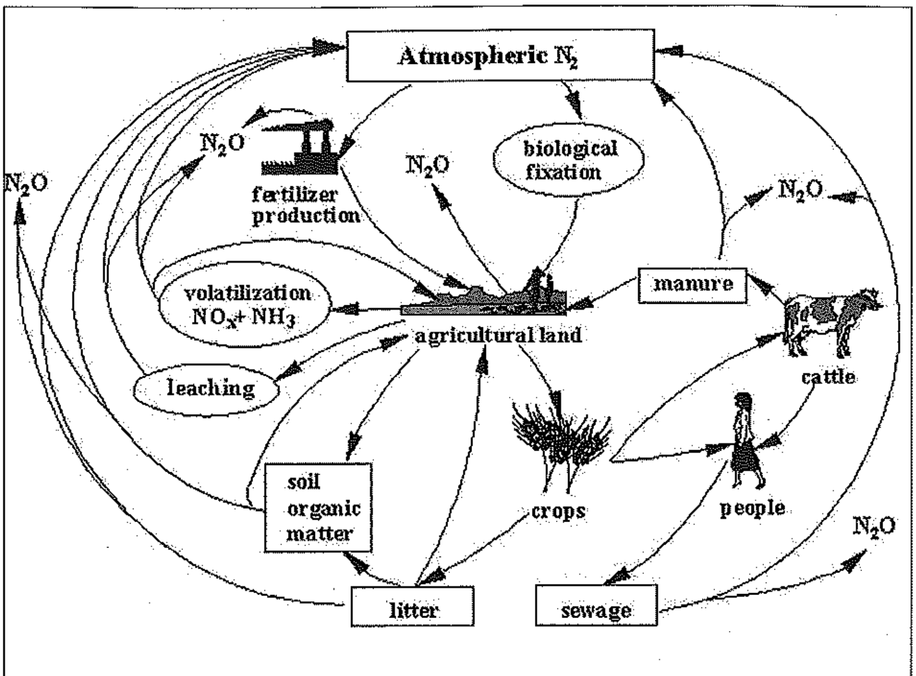

Figure 1. Diagram of agricultural soil N cycle and N_2O production (concept from 16 and 13 by permission of John Wiley & Sons)

Sources of N_2O directly related to N input into agricultural soils

In most agricultural soils biogenic formation of N_2O is enhanced by an increase in available mineral N which, in turn, increases nitrification and denitrification rates. Addition of fertilizer N, therefore, directly results in extra N_2O formation (Figure 1). In addition, these inputs may lead to indirect formation of N_2O after N leaching or runoff, or following gaseous losses and consecutive deposition of NO_x and NH_3. We term a variety of sources of N in agricultural systems as anthropogenic; including synthetic fertilizers, animal manures (urine and feces), N derived from enhanced biological N-fixation through N_2-fixing crops, crop residue returned to the field after harvest and human sewage sludge application. Some part of the animal manure N, crop residue, and sewage may have come from previous application of synthetic fertilizer. However, the re-entry of this N back into the soil systems renders it again susceptible to microbial processes which produce N_2O.

Synthetic fertilizers and animal excreta N used as fertilizer

Although synthetic fertilizers and animal manures are important sources of N_2O, their soil input is required to provide the N needed to meet global food production demands. The amount of synthetic fertilizer N applied to agricultural fields world-wide is well documented in the FAO data base (FAO Annual Yearbooks [17, 18]; or WWW: http://www.fao.org/waicent/Agricul.htm). Although the amount of N used as fertilizer from animal excreta is more uncertain, estimates are made, based on animal population and agricultural practices (5, 13). To account for the loss of N fertilizer from NH_3 volatilization and emission of nitric oxide (NO) through nitrification after fertilizer is applied to fields, an NH_3 volatilization and NO emission factor is needed. Even though climate, soil, fertilizer placement and type, and other factors influence NH_3 volatilization and NO_x emission, a fixed, default emission factor of 0.1 (kg NH_3-N + NO_x-N emitted/kg N execreted) is used for synthetic fertilizers and 0.2 (kg NH_3-N + NO_x-N emitted/kg N applied) for animal waste fertilizer. The amount of N from these sources available for conversion to N_2O is therefore equal to 90% of the synthetic fertilizer N applied and 80% of the animal waste N applied (19).

Biological N fixation

Both the amount of N fixed by biological N fixation in agricultural systems and the N_2O conversion coefficient are uncertain. Biological nitrogen fixation (BNF) supplies globally some 90 to 140 Tg N y^{-1} to agricultural systems (20). Although more verification on these figures is necessary, most indications are that BNF contributes more N for plant growth than the total amount of synthetic N fertilizers applied to crops each year (21). The Phase I IPCC Guidelines (14) mention about equal rates. On average, BNF supplies 50-60% of the N harvested in grain legumes, 55-60% of the N in nitrogen fixing trees and 70-80% of the N accumulated by pasture legumes (21). Cultivation of grain legumes, however, often results in net soil N depletion.

Because of the uncertainty in knowing the amount of N_2 fixed during N-fixation (20) and the lack of country data on N-fixing crops, it is difficult to assign a conversion factor to N_2O emission that is related to the amount of N fixed by a crop. Total N input is estimated by assuming that total crop biomass is about twice the mass of edible crop (FAO), and a certain N content of N fixing crop. This crop production is defined in FAO crop data bases as pulses and soybeans. The N-fixation contribution does not include N_2O produced in legume pastures. This N_2O production is at least partially accounted for in emissions from pastures that are being grazed. Australia and New Zealand, for example, contain large areas of pasture land that includes legumes as part of the pastoral system.

Crop residue

There is only limited information concerning reutilization of N from crop residues applied to agricultural lands. Although the amount of N that recycles into agricultural fields through residues may add 25-100 Tg of N y^{-1} of additional N into agricultural soils (mainly from crop residues) the amount converted to N_2O is not known. To account for the N_2O in the inventory budget at this time the emission factor for fertilizers is used as default and the amount of N re-entering cropped fields through crop residues is calculated from the FAO data concerning crop production.

Nitrous oxide emissions associated with crop residue decomposition are calculated here by estimating the amount of N entering soils as crop residue. The amount of nitrogen entering the crop residue pool is calculated from crop production data. Since FAO data only represent the edible portion of the crop, these must be roughly doubled to estimate total crop biomass. We assume a nitrogen percentage to convert from kg dry biomass y^{-1} to kg N y^{-1} in crops. We distinguish between N-fixing crops (pulses and soybeans) and non-N-fixing crops. Some of the crop residues is removed from the field as crop (approximately 45%), and some may be burned (approximately 25% of the remaining residue in developing countries), or fed to animals. The amount of N in crop residue actually returned to a field is uncertain, as is the amount of time required for the N to mineralize. We assume here that input and impact on N_2O production occur annually. Neither the amount of root biomass remaining in the soil nor the amount of plant residue fed to animals is accounted for in this crop residue estimate.

Revised IPCC guidelines for estimating N_2O emissions from agriculture

This new approach to estimating N_2O emissions from agricultural systems includes: (i) direct emissions of N_2O from agricultural fields; (ii) direct emissions of N_2O in animal production systems and, (iii) some of the indirect emissions of N_2O that are derived from N that originated from agricultural systems. Elements (ii) and (iii) were not previously included in the IPCC Guidelines for National Greenhouse Gas Inventories (5). These guidelines provide default emission factors that can be applied to readily available databases; thus the method is applicable to any world country.

Direct emissions of N_2O from agricultural soils

Formation of N_2O in agricultural soils is a biogenic process and primarily results from nitrification and denitrification. Simply defined, nitrification is the aerobic microbial oxidation of ammonium to nitrate and denitrification is the anaerobic microbial reduction of nitrate to dinitrogen gas. Nitrous oxide is an intermediate in the reaction sequences of both processes which leaks from microbial cells into the soil atmosphere (22).

The revised IPCC Guidelines estimate direct emissions of N_2O from agricultural soils as a fixed percentage, 1.25 (0.25 - 2.25)% of the additional N inputs, recognizing that in most agricultural soils biogenic formation of N_2O is enhanced by an increase in available mineral N which, in turn, increases nitrification and denitrification rates (13). Addition of fertilizer N, therefore, directly results in extra N_2O formation.

The IPCC Guidelines also provide an estimate of enhanced background emissions (2-5 kg N_2O-N ha^{-1} y^{-1}) from cultivated organic soils. Many studies on N_2O emissions from agricultural soils investigate the difference in N_2O production between fertilized and unferti-

Table 2. Global N_2O emissions from agricultural soils calculated with the IPCC (5) methodology (Tg N y^{-1}) for 1990.

Direct soil emissions	
- synthetic fertilizer	0.87 (0.18-1.6)[1]
- animal waste	0.63 (0.12-1.1)
- biological N_2 fixation	0.12 (0.02-0.2)
- crop residue	0.37 (0.07-0.7)
- cultivated Histosols	0.1 (0.02-0.2)
- subtotal	2.1 (0.4-3.8)
Animal production[2]	
- animal waste management systems	2.1 (0.6-3.1)
Indirect emissions	
- atmospheric deposition	0.36 (0.07-0.7)
- nitrogen leaching and runoff	1.4 (0.11-6.7)
- human sewage	0.22 (0.04-2.6)
- subtotal	1.98 (0.22-10.0)
Total	6.2 (1.2-16.9)

[1]Values in parentheses indicate estimated range which is derived from emission factor range.
[2]Animal production includes grazing animals.

lized fields. Emissions from unfertilized fields are considered background emissions. However, actual background emissions from agricultural soils may be higher than historic natural emissions as a result of enhanced mineralization of soil organic matter due to previous agricultural activities. This is particularly observed in organic soils (23,24). Background emissions may also be lower than historic emissions due to depletion of soil organic matter (25).

N_2O emissions in animal production systems

The IPCC 1995 Guidelines, as most earlier estimates of N_2O emissions from agriculture and other sources (1, 2), did not include N_2O emission from animal production. Recent studies (e.g. 8, 26, 27) indicate that emissions from animal wastes can be significant. Therefore, the revised IPCC Guidelines include two potential sources of N_2O in animal production: (i) wastes from confined animals and (ii) dung and urine deposited on the soil by grazing animals. Emissions induced by use of manure N as fertilizer applied to agricultural fields are considered direct N_2O emissions from agricultural fields. The revised method assumes that N_2O emissions can be calculated as a function of the N excretion and the type of animal waste management system (AWMS) (13). Therefore, default N excretion factors were defined (in kg N per animal) for several animal types in different world regions. In addition, N_2O emission factors (as a fraction of the amount of manure-N) are given for different AWMS. Thus, the calculation estimates N_2O produced from animal production systems (AWMS) separately from the N from animal wastes that is used as fertilizer.

Indirect N_2O emissions from N used in agriculture

The revised methodology includes indirect N_2O formation induced by (i) emissions and consecutive deposition of NO_x and NH_3, (ii) nitrogen leaching and runoff, and (iii) sewage (13). Thus the method recognizes that annual N input into agricultural systems for crop production is only partly utilized by crops. Generally, less than 70% of N applied, and frequently as little as 20%, is taken up by the crop (28). The added fertilizer N that is not utilized by the crop is either stored in the soil profile of the field or is lost from the system through leaching of nitrate to groundwaters, runoff of soil or nitrate to surface waters, or volatilized through ammonia volatilization or nitrification/denitrification as NO_x, N_2O or N_2. The N that leaves the agricultural system is, over the long term, either denitrified to N_2 with a small fraction of N_2O produced (5), or stored in sediments of aquatic systems.

To summarize the aspects of indirect N_2O emissions, the major pathways for synthetic fertilizer and manure nitrogen input that give rise to indirect emissions are:

A. Volatilization and subsequent atmospheric deposition of NH_3 and NO_x;
B. Nitrogen leaching and runoff; and,
C. Human consumption of crops followed by municipal sewage treatment.

The IPCC Guidelines provide default factors to estimate the N_2O emissions related to these fluxes on a national scale. In short, the method assumes that 1 (0.2 - 2)% of the NO_x and NH_3 emitted from agricultural fields is converted to N_2O elsewhere. Indirect emissions following N leaching and runoff are estimated as 2.5 (0.2 -12)% of the amount of N lost from the fields. And an estimated 1 (0.2 - 12)% of N in sewage is estimated to be lost as N_2O. Thus these N_2O-N emissions are calculated from a country's NO_x and NH_3 emissions and N transported in leaching and runoff, so that all N_2O formed as a result of NO_x and NH_3 emissions and leaching and runoff in country Z are assigned to country Z, even if the actual N_2O formation takes place in another country (13).

Global emissions of N_2O from agriculture 1960 - 1994

Following the IPCC (5) methodology the total global emissions of N_2O from agricultural sources in 1990 were 6.2 (1.2 - 16.9) Tg N_2O-N y^{-1}. The estimated direct emissions from agricultural soils totaled 2.1 Tg N, direct emissions from animal production totaled 2.1 Tg N and indirect emissions resulting from agricultural N input into the atmosphere and aquatic systems totaled 2.0 Tg N_2O-N (Table 2). These estimates show that each of the three components of agriculture considered contribute about the same amount of N_2O to the global atmospheric budget. Moreover, the estimates indicate that the N_2O input to the atmosphere from agricultural production as a whole has apparently been previously underestimated (Table 1 on page 8).

We also estimated global agricultural N_2O emissions for each fifth year from 1960 through 1994, to observe temporal emission trends (Figure 2 on page 12). Considering only N_2O emitted directly from agricultural fields, these emissions increased 2.6 times over the 35-year period while total global agricultural emissions increased by about 1.8 times. The larger increase from direct emissions is due, mainly, to increased synthetic fertilizer input. Synthetic fertilizer comprised about 15% of total N input (about 64 Tg) into agriculture in 1960 compared to about 44% of total N input (about 167 Tg) in 1994 (FAO). N_2O emissions did not increase in 1994 above the 1990 value because synthetic N use was 3.6 Tg lower in 1994 than in 1990 and beef production globally has not increased while N input from other sources increased by only about 3.3 Tg; thus total N input was about 167 Tg both years. From 1980 to 1994 agricultural N_2O emissions increased by about 15%.

We found that the total global N_2O budget is reasonably in balance if we use the N_2O emission estimate for agricultural soils calculated by the IPCC (5) methodology. Incorporating the above estimate into an atmospheric model, Kroeze *et al.* (6) suggest that the increases in atmospheric N_2O that have occurred during the past century can be mainly attributed to changes in food production systems.

Future needs for methodology development

The methodology for country-based N_2O emissions described above is a rough, generalized approach which treats all agricultural systems as being the same under all climates, in all soils, in all crops and in all management systems. The ranges of conversion factors, however, provide for direct emissions calculations which cover much of the potential N_2O emissions from each country, whatever climate, soils and set of crops is involved. Some recent studies in temperate (e.g. 29) and tropical (30) systems show very high direct N_2O emissions while other studies (31, 32, 33) demonstrate that significant N_2O emissions commonly occur during thaw periods in early spring and winter or through snow-covered agricultural soils (34). Thus annual emission factors used

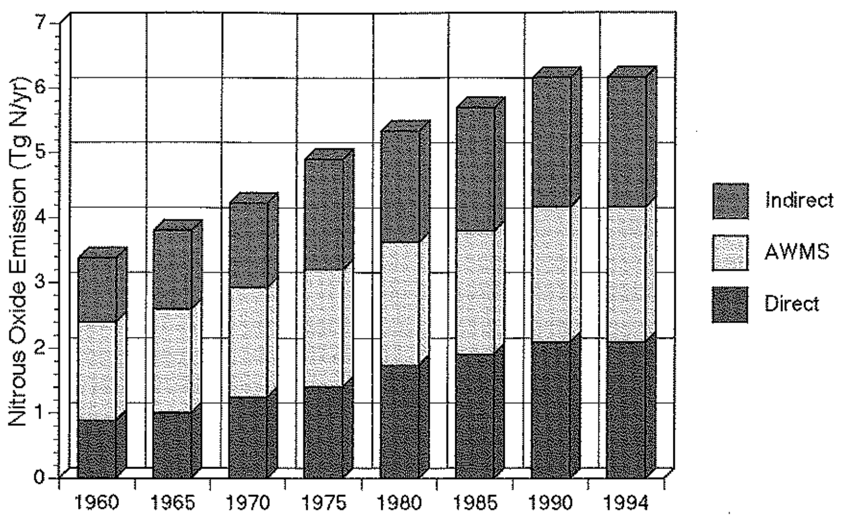

Figure 2. Estimates of N_2O emissions from agricultural systems worldwide, directly from agricultural fields (direct), from animal waste management systems (AWMS), and from indirect sources (indirect).

may underestimate direct annual N_2O emissions from agricultural fields.

To make significant improvement in inventory methodologies for N_2O, we think that the next step is to utilize process based models to produce country inventories, for direct emissions from agricultural soils (e.g. 29, 35, 36, 37); appropriate animal management models for N_2O from animal production; and simulation models which more effectively represent N transformations in aquatic systems, including riparian areas, wetlands, rivers estuaries, continental shelves and the deep ocean (e.g. 38). The soil C and N cycles are tightly integrated and we think that both C and N should be considered together so that various aspects of the C and N cycle and CO_2 and N_2O production can be more accurately defined. The accuracy of N fraction prediction is closely tied to C turnover in the soil as it controls N mineralization and immobilization. The turnover and retention of N and consumption of methane in all soils is also intimately linked with the C cycle. Conversely, retention in soils is directly tied to mineral N availability. These models must, however, include adequate flexibility to predict cold soil emissions as well as emissions under tropical conditions.

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JGOFS entering its next project phase

by Roger B. Hanson and Michael J.R. Fasham

The Joint Global Ocean Flux Study (JGOFS) project is rapidly approaching the end of its intensive field observations, but the project will not end there. A continuing effort will be essential to ensure that the observations are fully exploited to achieve JGOFS scientific goals. One of the many legacies that JGOFS bequeaths to future generations will be extensive biogeochemical and physical data sets collected during its high profile and successful 10-year field campaign that began in 1989. However, future generations will not judge JGOFS on its data sets and its interdisciplinary research alone. The real measure of success will rest entirely on its ability to synthesize its data sets in order to improve ocean carbon models and to be able to predict future ocean carbon cycling scenarios accurately.

The international JGOFS Scientific Steering Committee (SSC) began discussions in 1997 for an extensive JGOFS synthesis-modelling phase. This phase is expected to continue well past the end of the field campaign and is intended to provide researchers with the time and resources needed to complete the best possible descriptions and interpretations of JGOFS data sets. It is also intended to provide snap shots of the temporal and spatial scales of the ocean's biogeochemical regimes and boundaries. Rigorous time and space descriptions of the biogeochemical regimes and their boundaries are needed to develop present 1D models into 3D models that can describe the biogeochemical state of the global ocean as it varies in time and space.

The JGOFS Scientific Steering Committee envisions that the final synthesis phase will require five to six years to successfully complete its scientific goals and objectives by the year 2004.

Scientific Goals[1]

- To determine and understand on a global scale the processes controlling the time-varying fluxes of carbon and associated biogenic elements in the ocean, and to evaluate the related exchanges with the atmosphere, sea floor and continental boundaries, and
- To develop a capacity to predict on a global scale the response of oceanic biogeochemical processes to anthropogenic perturbation, in particular those related to climate change.

Ocean data from the JGOFS fieldwork are being released and rapidly appearing at national ocean data centres, on CD-ROMs and/or distributed data systems. Now with the shift towards data analysis and biogeochemical modelling, international JGOFS has begun to restructure its Process Study Planning Groups. The new groups will be called JGOFS Synthesis Groups for the North Atlantic, Indian Ocean, and Equatorial Pacific Ocean, and eventually for the Southern Ocean, and are responsible for the international perspective of national activities over the respective regions. Their goals are (1) to enhance national synthesis efforts, (2) to identify JGOFS biogeochemical data and related data sets in the regions, (3) to assist the development and validation of regional models of ocean biogeochemistry, and then (4) to report their efforts to JGOFS and other international concerns.

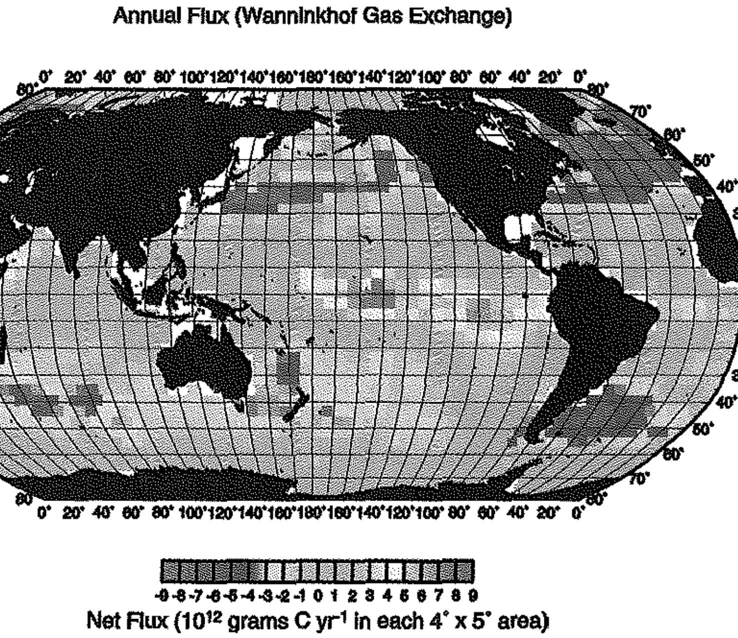

Figure 1. Mean annual net CO_2 flux over the global oceans (in 10^{12} grams of C per year for each 4° x 5° area) computed for 1990 using the gas transfer coefficient formulated by Wanninkhof (1992, J. Geophys. Res. 97: 7373-7382). The effect of full atmospheric CO_2 increase is assumed for normalizing observed delta pCO_2 values in high latitude areas to the reference year of 1990. Areas covered with ice are assumed to have zero sea-air CO_2 flux (from Takahashi *et al.*, 1997, Proc. Natl. Acad. Sci USA 94: 8292-8299) [Copyright (1997) National Academy of Sciences, USA]

[1] JGOFS Science Plan (JGOFS Report No. 5, 1990) and Implementation Plan (IGBP Report No. 23 and JGOFS Report No. 9, 1992)

In April 1998, the international JGOFS Scientific Steering Committee (SSC) in Cape Town, South Africa spent nearly a day and a half on these issues and developing its Synthesis Goal and Objectives. After considerable discussion, the SSC decided it should participate directly in the integration of JGOFS observations and agreed to accept additional tasks for coordinating the efforts of the Regional Groups. This action provides a global perspective to the regional synthesis-modelling activities and avoids the formation of an additional coordinating group and for the most part a redundancy of members that are on the SSC. Thus, global integration of the regional activities now resides with the members of the SSC.

The composition of the 1999 JGOFS SSC will be restructured towards the synthesis and modelling phase to accomplish the new tasks and overall responsibility. New members will represent critical links to analysis, interpretation, and modelling, IGBP Programme Elements, as well as with international programmes on ocean colour, and other global ocean observing systems. The following are the tasks and objectives of the synthesis effort conducted by the JGOFS SSC:

- Oversee the integration and modelling activities of the four Regional Groups and all Task Teams with similar activities, such as Data Management, CO_2 Advisory Panel, etc.;
- Liaise with IGBP Programme Elements (e.g., GLOBEC, LOICZ, and IGAC) and Framework Activities (GAIM, DIS, and START), data information systems and capacity building, as well as with international ocean programmes with extensive ocean data sets and global ocean-climate observing systems;
- Identify critical scientific gaps in our knowledge of ocean biogeochemistry that may significantly compromise carbon monitoring and modelling carbon in Earth's oceans;
- Organize synthesis, modelling, and training workshops; and,
- Publish international JGOFS book(s), brochure(s), and other data products.

With these new efforts in mind, the JGOFS SSC unanimously adopted an overarching goal and specific objectives for synthesis[2], which provides a practical guide for assessing the success of JGOFS:

Goal

To develop an integrated, quantitative view of the biogeochemical cycle of carbon in the ocean, indicating the roles of biota, physical transport, air-sea exchange and particle settling and remineralization, and including estimates of uncertainties.

This goal will be achieved through the following products, which serve as JGOFS synthesis objectives:

Objectives

- Ensure that all JGOFS observations are lodged with organizations which can guarantee long-term stewardship. Provide web-based information on the availability and access mechanisms to all JGOFS data. Encourage the development of Web-based data delivery systems.
- Create a new synthesis of ocean biogeochemical regimes from the major JGOFS Regional Process, Time Series, and Global Survey studies, with special emphasis on biogeochemical processes and ecological community structure, and including the mechanisms controlling primary production, carbon, macro- and micronutrient cycling, and carbon export from the upper ocean.
- Develop a hierarchy of coupled, biogeochemical-physical circulation models of varying ecosystem complexity, and use them to enhance understanding of natural variability and anthropogenic changes in the carbon cycle over decadal-centennial time scales.
- Building on Objective III, assess the capability of 3-dimensional ocean carbon cycle models with biogeochemistry to simulate observed global inventories, seasonal cycles and fluxes of carbon, nutrients, and functional groups, and to evaluate current rates of carbon remineralization and ocean forcing over time scales. The models will be constrained, calibrated and validated using JGOFS and other pertinent global and regional data sets (e.g., JGOFS/WOCE global survey of CO_2 and tracers, pCO_2, ocean colour, particle fluxes and deep ocean cores).
- Assess the contribution of continental margins and seas to CO_2 sequestration and the horizontal flux of carbon across the ocean-continental margin boundary.
- Utilize ocean colour observations from satellites, aircraft, moorings, and towed vehicles to provide a global picture of the seasonal cycles of phytoplankton biomass, primary and new production.
- Make recommendations on the development and implementation of future global ocean observing systems for detection of changes in the ocean carbon cycle and impacts on marine ecosystems, as one aspect of global change.

Although many specifics of this next phase are still being planned, the work has in fact begun. JGOFS scientists already are producing data products (such as CTD, CD-ROMs) and global interpretations (Figure 1). To assist further synthesis, the SSC is planning parallel activities and conferences over the next four years. First, the Regional Groups will meet to identify all available data sets, to write chapter(s) for the book(s), and to arrange presentations for the IGBP Congress (Japan, 1999), JGOFS Science Conference (Norway, 2000) and the IGBP Open Science meeting (USA, 2000/1).

The SSC will hold two workshops (October 1998 and 2000) to coordinate the regional efforts, to prepare the overall synthesis of JGOFS research and related research, to edit and produce a brochure, and to review chapters of the book. Products of the first workshop will include a brochure (1999) and a draft of the book. In addition, programme plans will be made for the IGBP Congress and the JGOFS Science Conference. The second workshop of the SSC (early 2000) is planned to finalize the editing of review chapters for the JGOFS book. Cambridge University Press (2001) will publish this book in the IGBP series.

A second JGOFS Science Conference is being planned for Bergen, Norway (April 2000). This conference follows the successful 1995 JGOFS Science Con-

[2] The authors acknowledge the conscientious efforts of the members of the 13th Scientific Steering Committee and their guests, who contributed substantially to the scientific details of the JGOFS Synthesis Goal and Objectives.

ference in Villefrance, France, and its first five-year review. The purpose of this conference will be to review the status of the regional and global syntheses and to finalize the review chapters of the book.

Other workshops are planned to develop 3D Ocean Biogeochemistry Modelling and to analyze and interpret JGOFS data sets (1999-2004). A symposium on the Indian Ocean (Arabian Sea) along with a training course on 3D Ocean Biogeochemical Modelling in Bangalore, India (January 1999) is planned. The Southern Ocean, Continental Margin, Deep Ocean Flux, and North Pacific groups plan to start synthesis soon (2000).

The Joint Global Ocean Flux Study has been, without doubt, the most successful interdisciplinary biogeochemical ocean project yet undertaken. It transcended cultures, politics and economic boundaries to bring together oceanographic talent, research ships, and other resources from all parts of the world. With a successful completion of its synthesis, it promises to provide a unique observational data set on the status of the global ocean during 1990s. Along with the observations, significant advances in biogeochemical modelling have found important application in studies of carbon partitioning and transport on regional and global scales.

While the research elements of Regional Process Studies and Time Series Studies are perhaps the most often associated with JGOFS, the surface ocean JGOFS/WOCE CO_2 surveys and the synoptic view of ocean colour made from CZCS and SeaWiFS satellites are no less critical elements of JGOFS research strategy. The SeaWiFS data, in fact, promise to revolutionize our knowledge of ocean biological variability. When the JGOFS synthesis is complete in 2004, the legacy of JGOFS will be the successful transfer of the most valuable observational data set and theoretical understanding of global carbon cycling to date. Programmes beyond JGOFS will be challenged to deliver a comparable portrait of the Earth's ocean.

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The JGOFS IPO is supported by the Norwegian Research Council, University of Bergen and Meltzer Foundation.

The Scientific Committee on Oceanic Research

Since the late 1980s SCOR has played a major role in fostering the development of two global change programs, both of which form part of the IGBP effort. These are the Joint Global Ocean Flux Study (JGOFS) and the Global Ocean Ecosystem Dynamics (GLOBEC) Project.

Established in 1957, SCOR is the oldest of the International Council of Scientific Unions' (ICSU) interdisciplinary bodies. The recognition that the scientific problems of the oceans required a truly interdisciplinary approach was embodied in plans for the International Geophysical Year. Accordingly, SCOR's first major effort was to plan a coordinated, international attack on the least-studied ocean basin of all, the Indian Ocean. The International Indian Ocean Experiment of the early 1960s was the result.

For the next thirty years, the reputation of SCOR was largely based upon the successes of its scientific working groups. These small international groups - not more than ten members - are established in response to proposals from national committees for SCOR, other scientific organizations, or previous working groups. In general, they are designed to address fairly narrowly defined topics (often new, "hot" topics in the field) which can benefit from international attention. All Working Groups are expected to produce a final report, organize a workshop or symposium or otherwise make a significant contribution to advancing understanding of the topic at hand, within three or four years of being established.

There are fifteen current SCOR Working Groups, addressing topics which range from the ecology of sea ice to the role of wave breaking on upper ocean dynamics and from coastal modelling to the biogeochemistry of iron in seawater and the responses of coral reefs to global change.

Why is SCOR sponsoring two marine programs within IGBP? They differ substantially in their goals: the focus of JGOFS is on the role of the ocean in the global carbon cycle, while GLOBEC is concerned with the relationships between physical and biological variability in the ocean and how change might impact the structure and functioning of marine ecosystems, with particular emphasis on important fisheries.

SCOR does not and cannot run large research programmes – it simply does not have the budget or personnel to do so. Rather, it prefers to initiate and nurture the establishment of programmes, providing coordination and administrative support during the early planning stages, stepping back as the programmes gather their own momentum and find their own sources of funding. The early affiliation of these programmes with SCOR provided an efficient mechanism for international coordination and the involvement of many new countries in these programmes.

For information about SCOR or any of its activities, please contact the Executive Director, Elizabeth Gross at:

SCOR, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore MD 21218, USA.
Tel: (+1-410) 516 4070, Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

The Dahlem Conference

Integrating hydrology, ecosystem dynamics, and biogeochemistry in complex landscapes

The recent conference on climate change in Kyoto demonstrated the importance of natural ecosystems, human influenced ecosystems, and industrial development for controlling trace gas emissions to the atmosphere. Trace gas composition of the atmosphere influences global and regional climate through so-called "greenhouse effects." How strongly climate can be influenced regionally is seen in recent occurrences of flooding and drought that are related to tropical sea surface warming occurring with the phenomenon known as El Niño.

Natural and anthropogenic disturbance regimes and land management determine the patch structure of regional vegetation mosaics, which in turn establish agricultural and forest production, water availability to homes and industry, and water quality in rivers and streams. Due to the ubiquitous influence of man on land use in all parts of the globe and the complexity of response of biological systems, there is a pressing need for computer models that

1) make better estimates of trace gas contributions to the atmosphere;
2) estimate ecosystem use of natural resources; and,
3) allow us to assess the potential effects of climate change on human concerns.

It is necessary to build into such models our summary understanding of shifts in ecosystem structure and function along landscape, regional, and continental scale gradients.

Scientific research programmes related to understanding global change due to human activities must provide recommendations that ensure wise use of limited resources. At present, this is hampered by a lack of understanding of how to best quantify processes acting at landscape and regional scales, the dimensions most relevant to the everyday activities of mankind. Achieving better methodologies for process integration at such scales requires a close cooperation among hydrologists, ecologists, and atmospheric scientists. Furthermore, it requires that specific critical regions and landscapes be utilized as objects of research, that they be observed over time with respect to change, and that resource use within these regions be quantitatively defined in order to establish criteria that are related to potential degradation.

The Dahlem conference entitled "*Integrating Hydrology, Ecosystem Production, and Biogeochemistry in Complex Landscapes*" critically reviewed experimental and modelling approaches that have been used to describe Biosphere-Hydrosphere-Atmosphere interactions. Special attention was paid to feedback controls, and the focus was on determining means by which new types of system descriptions can aid in assessing the consequences of particular landscape structure and land-use patterns. The conference attempted to define how and to what extent a process-based understanding of controls on water, carbon, and nitrogen cycles at regional scales can be achieved. The potentials for compatible scaling and exchange of information between models describing ecosystem function, climate driving of energy and water exchange, and hydrological processes were evaluated and summarized.

Modelling the impact of land use and land cover on atmospheric processes and climate and vice versa requires new tools and different approaches to model simulations than have previously been achieved. Based on extensive studies of ecosystems as points in the landscape, the participants of the conference discussed strategies and possibilities for quantifying the metabolism and flows within complex landscapes. In regional considerations, a simplification of ecosystem process model representations is needed that remains phenomenologically "true" but allows efficient quantification of response and interactions at thousands of locations. The conference made important steps in conceptually formulating new approaches for building such models and for connecting them both to remote sensing and ground-based measurements at test sites.

By the means of remote sensing technologies, we are able to see the impacts of the humans on landscape and regions as never before. Furthermore, through the interpretation of remotely sensed data, the thin surface biosphere layer of the Earth can now be viewed as a breathing entity. This conference found opportunities to make a new stride in interpreting the metabolism of the land surface of the Earth. In this effort, remote sensing is the tool with which to observe, while appropriately designed simulation models provide the means for integrating the physics, chemistry, and biology of the biosphere. Some aspects of remote sensing are currently operational in terms of evaluating the pulse of the earth, but there is now greater potential for accomplishing this due to increased experience and wisdom gathered in recent years.

The world and its regional parts must be studied as a connected system, but models are required at regional scales that allow evaluation of the consequences of climate change for human dimensions. Humans through their activities are stressing the metabolism of the earth, the metabolism must be monitored and a stability must be maintained. Instability is indicative of change that is undesirable and which may be catastrophic for human populations.

Long-term changes in the structure of landscape mosaics will likely be characterized by sharp transitions from one "state" to another when a threshold is exceeded. Of these changes, direct human-driven changes to the structure of mosaics will be dominant. Do changing landscape mosaics have a larger effect on regional and global climate than the so-called greenhouse effect? There is some evidence for this, especially for regional climate. Additional evidence may be gained through new experimentation and modelling approaches that were discussed. However, due to the extreme complexity involved in integrating hydrology, ecosystem processes, and biogeochemistry, the appropriate use of current and future models must be to assess vulnerabilities rather than to make precise predictions.

Regional climate and, therefore, potential resource availability and use is highly sensitive to human land management and disturbances of natural systems. Results of the conference will aid the interdisciplinary effort focused on understanding regional hydrological cycles and water use in complex, anthropogenically-influenced landscapes. The methods which are being sought by the invited experts are extremely important for managing resources in climate regions where resources available on a per capita basis are very low.

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The Dahlem-IGBP Partnership

The recent Dahlem Conference on *"Integrating Hydrology, Ecosystem Dynamics, and Biogeochemistry in Complex Landscapes"* was an excellent example of a partnership between IGBP and an existing scientific endeavour.

The Dahlem Conference series has a well-earned reputation for scientific excellence, stimulating discussions and debates, and forward-looking outcomes that often point the way towards new directions in a scientific field. A partnership with IGBP seemed natural.

The 'Complex Landscapes' Conference, organized by John Tenhunen and Pavel Kabat of BAHC, lived up to the Dahlem standard. John's article highlights the outcomes of the meeting. From the IGBP perspective, three particular conclusions are especially important:

- The direct effects of changing landscape mosaics on regional and global climate may be as large or larger than the forcing caused by the enhanced greenhouse effect. This reinforces the importance of land-use/cover change as a component of global change, not only for its effects on terrestrial ecosystems but also for its direct impacts on climate.
- Given the extreme complexity of integrated hydrological, ecosystem process and biogeochemical models, their appropriate use is to assess sensitivities and vulnerabilities of systems rather than to make precise predictions. This has important implications for approaches to global change impact studies.
- A higher priority must be given to the use of our evolving understanding of the functioning of complex landscapes for resource management, particularly in the developing regions of the world.

Finally, Ian Noble, the Chair of GCTE, made the interesting observation that the IGBP-associated scientists seem to perform particularly well at this type of free-flowing, interdisciplinary encounter. Perhaps it is evidence that IGBP is helping to create a new breed of scientist, operating from a sound disciplinary base but able to think and work across disciplines as easily as in his or her own.

Will Steffen

The IGBP 1997 Central Budget

During 1997, the total income of the IGBP central budget was USD 1.74m. Contributions were received from 48 nations, and from ICSU. The table to the right of the box lists the contributing nations, in order of the magnitude of contribution.

Total expenditure during the same period was USD 1.46m, with the difference largely due to the postponement of the SAC-V meeting from December 1997 to September 1998. The expenditure covered the costs of scientific implementation activities (39%), publications (6%), the operational costs of the Secretariat (17%), and the salary costs of the Secretariat (38%). The expenditure in these broad categories is shown in Figure 1.

As always, we are most grateful to the many individuals and their organizations who have worked so hard on our behalf to maintain central support at its current level. We hope to repay this loyal support over the next two-three years with the flow of new results and understanding from the IGBP synthesis project.

Elise Wännman

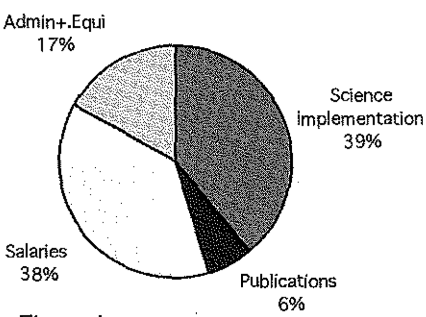


Figure 1

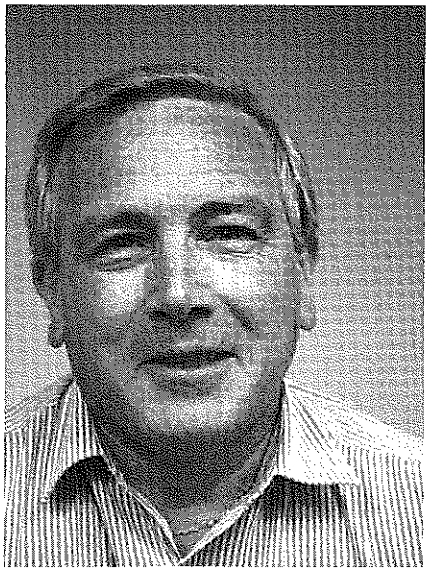
1. USA	17. Canada	33. Singapore
2. Sweden	18. China, Beijing	34. Thailand
3. Japan	19. Austria	35. Philippines
4. Germany	20. Denmark	36. Jamaica
5. United Kingdom	21. Korea, Republic of	37. Egypt
6. Italy	22. Finland	38. New Zealand
7. France	23. Czech Republic	39. Argentina
8. Spain	24. Greece	40. Tunisia
9. Russia	25. Israel	41. Romania
10. Netherlands	26. Slovakia	42. Kenya
11. Australia	27. Portugal	43. Iceland
12. Switzerland	28. Ireland	44. Estonia
13. China, Taipei	29. Poland	45. Botswana
14. Belgium	30. South Africa	46. Mongolia
15. Norway	31. India	47. Lebanon
16. Mexico	32. Malaysia	48. Colombia

People and Events

New Executive Officer appointed for LOICZ

Chris Crossland has been appointed as Executive Officer for the LOICZ IPO from May 1998. He was previously the inaugural Director of the CRC Reef Research Centre in Townsville, Australia. The Centre, established in 1993, is a successful enterprise of the Australian government's Cooperative Research Centres Program which brings together researchers and industry users of scientific information to form collaborative consortia further developing key economic sectors. Centres operate as networks of research-industry teams solving problems and delivering science outputs to meet strategic goals – a model with some similarity to LOICZ.

Born and educated in New Zealand with BSc and MSc (Hons) from Auckland University, Crossland completed a PhD in plant physiology at James Cook University, Queensland and took Australian citizenship in 1974. His research career on marine issues focused on coral productivity and calcification, extending to wider ecosystem and resource issues in tropical and subtropical coastal environments. A foundation researcher with the Australian Institute of Marine Science, he joined CSIRO Division of Fisheries in 1979 working as a researcher and with management agencies in Australia, Middle East, South East Asia, and the Caribbean.



Chris Crossland

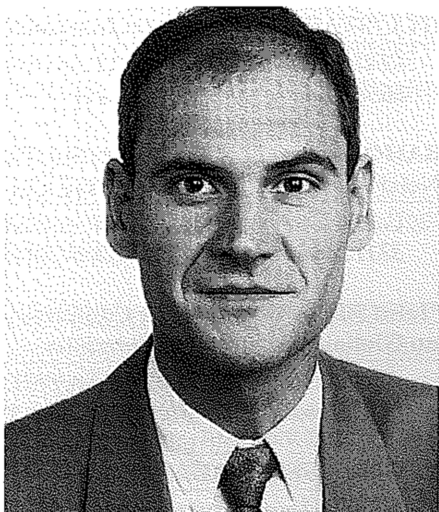
The demands in the late 80s by environmental managers and resource planners for scientific information at regional coastal scales underpinned his establishment of the CSIRO Institute of Natural Resources and Environment Project Office in 1989. This brought together interdisciplinary scientific capabilities in Australia to address major coastal zone issues for governments and agencies. The multimillion dollar Port Philip Bay Environmental Study (1992-1996) and the National Pulp Mills Research Program (1990-1995) were successfully designed and implemented in Australia and a number of international marine project designs were developed for South East Asia and in the Middle East. The Port Philip Bay Study team received the 1996 CSIRO Chairman's Award and Crossland was awarded the 1997 Australian Science Communicators Award.

The increasing recognition over the last decade by coastal zone authorities that it is people and their activities rather than the environment that is managed has added the further dimension of socio-economics to traditional research approaches to the coastal zone. Crossland has been building these capabilities into the issues-driven research on the Great Barrier Reef and the information transfer activities fundamental to the CRC Reef Research Centre.

Crossland has served on a large number of Australian state and national advisory committees dealing with planning and management, use and conservation of coastal resources and participated in delegations from Australia to international fora dealing with coastal zone and ecological sustainability of marine resources. Now resident in Texel and working out of the LOICZ IPO at NIOZ, he is looking forward to discover hidden linquistic talents and to explore Europe whenever possible.

LOICZ appoints Deputy Executive Officer

Hartwig Kremer has been appointed as Deputy Executive Officer for the LOICZ IPO. He studied Biology at the Universities of Marburg and Kiel in Germany and specialized in biological and physical oceanography at the Institute for Marine Science in Kiel focusing on fisheries, ecology, and toxicology. Work for his MA and PhD thesis in 1987 and in 1994 was done at a number of research institutions in Germany, Denmark, the Netherlands, and the UK. In his work Kremer has cooperated in an interdisciplinary fashion with marine institutes, but also with medical centres, administrative bodies, and NGOs. While spending a year at sea he gained experience in the practical aspects of fisheries, marine pathology and, most important-



Hartwig Kremer

ly, in teamwork with the people who are commercially involved in this field.

While preparing his PhD thesis, which addressed the question of heavy metal burdens and toxic relevance in bone tissues of top predators in response to the disastrous seal epizootic in the Wadden Sea 1988/89, Kremer was a full-time civil servant in the chamber of agriculture and related ministeries of the Federal and the State Government of Schleswig-Holstein, Germany. This gave him a first hand view of the process of transferring scientific knowledge into decision-making and management practice by policy and administrative performance and provided him with insight of many social and economic aspects of fisheries, aquaculture and environmental quality.

Thanks to his twofold professional experience in science and administration he was appointed to take over the programme manager position of "Environmental Protection of Coastal Waters and Food Security" in early 1995, a programme which aims at the development of human resources and institutional capacity building in coastal and marine research and management. One of of its most prominent projects was the international symposium on "Socio-Economic Benefits of Integrated Coastal Zone Management" in December 1996. It had a strong LOICZ participation and addressed the global dimension of coastal processes from the perspective of ecology and economic pressures. The overall philosophy is to ensure that people involved may benefit as much as possible from science and its application by fostering a cross-sectorial dialogue between the different coastal and marine social actors. Hartwig Kremer will start at the LOICZ IPO from the beginning of July.

IGBP Meetings

PEP II Workshop:
Variability of Southern Hemisphere Climate Systems and Linkages with Northern Hemisphere Systems on Time Scales covering the last two Glacial Cycles — **July 2-7, Perth, Australia**

Contact: John Dodson, E-mail: johnd@sunny.gis.uwa.edu.au

START Workshop on Southern African Land-Atmosphere-Biosphere Interactions (Miombo) — **13-18 July, Blydepoort, South Africa**

Contact: Robert J. Swap, University of Virginia, USA. Tel: (+1-804) 924 7714

GCTE Focus 2 Workshop on Comparison of Forest Patch Models — **TBA, Potsdam, Germany**

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

LUCC workshop on Sustainable Development of Plateau Region — **end of July, China**

Contact: Günther Fischer, IIASA, Schloßplatz 1, A-2361 Laxenburg, Austria. Fax: (+43-2236) 71313, E-mail: fisher@iiasa.ac.at

IPCC/START Workshop on Integrated Assessment Modelling — **TBA, Zimbabwe**

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

BAHC Session on Communicating Policy and Decision Makers Needs for Information on Global Change Impacts on Freshwater — **17-20 August, Espoo, Finland**

Contact: BAHC-IPO, Potsdam Institute for Climate Impact Research (PIK), PO Box 601203, 14412 Potsdam, Germany. Fax: (+49-331) 288 2547, E-mail: bahc@pik-potsdam.de

***Joint 5th IGAC Scientific Conference and 9th CACGP Symposium on Global Atmospheric Chemistry** — **19-25 August, Seattle WA, USA**

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

SCOR/PAGES IMAGES Scientific Committee Meeting — **20-21 August, Lisbon, Portugal**

Contact: Laurent Labeyrie, Centre des Faibles Radioactivités, CNRS-CEA, Domaine du CNRS, Avenue de la Terrasse, F-91198 Gif sur Yvette Cedex, France. Fax: (+33-1) 6982 3568, E-mail: laurent.labeyrie@cfr.cnrs-gif.fr

***GCTE Special Session at International Soil Science Congress** — **20-26 August, Montpellier, France**

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

13th IGAC SSC — **26-27 August, Seattle, WA, USA**

Contact: IGAC IPO, Massachusetts Institute of Technology, Building 24-409, Cambridge, MA 02139, USA. Fax: (+1-617) 253 9886, E-mail: pszenny@mit.edu

***Fifth Scientific Advisory Council Meeting (SAC V)** — **1-7 September, Nairobi, Kenya**

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

START PACOM Meeting — **September, Nairobi, Kenya**

Contact: Eric Odada, PASS Secretariat, Box 30197, Nairobi, Kenya. Fax: (+254-2) 449 539, E-mail: pagesnbo@form-net.com

LUCC/IGBP-DIS/START Data and Cover Change — **September, Bangkok, Thailand**

Contact: Caroline Nunes, LUCC IPO, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: lucc@icc.es or Jariya Boonjawat, START SEA RRC Director. Fax: 8+66-2) 251 2951, E-mail: jariya@start.or.th

JGOFS Southern Ocean Planning Group Four Provinces Workshop — **3-5 September, Bremerhaven, Germany**

Contact: Ulrich Bathmann, Alfred-Wegener-Institut, Polar und Meeresforschung, Am Handelshafen 12, D-27515 Bremerhaven, Germany. E-mail: ubathmann@awi-bremerhaven.d

IGBP-DIS Land Cover Global Validation Workshop — **7-18 September, Sioux Falls SD, USA**

Contact: Joseph Scepan, University of California, Department of Geography, Santa Barbara CA 93106-4060, USA. Fax. (+1-805) 893 3703.

JGOFS Equatorial Pacific (SGM) Meeting — **10-11 September, Seattle, USA**

Contact: James Murray, School of Oceanography, University of Washington, Box 357 040, Seattle, WA 98195-7940, USA. E-mail: jmurray@ocean.washington.edu

10th START Bureau Meeting — **20 September, Washington DC, USA**

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

START SSC Meeting — **21-23 September, Washington DC, USA**

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

JGOFS Executive Meeting — **September 21-23, Bergen, Norway**

Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Fax: (+47-55) 589 687, Email: roger.hanson@jgofs.uib.no

GCTE Focus 2/3 Workshop on Crop Models and Scaling — **21-24 September, Germany**

Contact: John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, McLean Building, Crowmarsh Gifford, Wallingford OX19 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

Meeting of the JGOFS Data Management Task Team — **September 23, Bergen, Norway**

Contact: Beatriz Baliño, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Fax: (+47-55) 589 687, Email: beatriz.balino@jgofs.uib.no

JGOFS Data Management and Synthesis Workshop — **September 24-25, Bergen, Norway**

Contact: Beatriz Baliño, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Fax: (+47-55) 589 687, Email: beatriz.balino@jgofs.uib.no

9th IPO Executive Officers Meeting — **28-30 September, Durham NH, USA**

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

WMO-IGAC International Cloud Chemistry Modelling Meeting — **October, Nova Scotia, Canada**

Contact: Andrea Flossman, Université Blaise Pascal - CNRS, Laboratoire de Météorologie Physique, 24 Avenue des Landais, 63177 Aubiére Cedes, France. Fax: (033-7) 327 1657, E-mail: flossman@opgc.univ-bpclermont.fr

Oceania Workshop on Climate Impact Assessment and Coastal Zone Issues and Oceania Regional Committee Meeting — **5-10 October, Suva, Fiji**

Contact: Kanayathy Koshy, S.P.A.S, The University of the South Pacific, P. O. Box 1168, Suva, Fiji. Fax: (+679) 302 548, E-mail: Koshy_k@usp.ac.fj

WCRP-IGAC Workshop on a Comparison of the Performance of Large Scale Models in Simulating Atmospheric Sulphate Aerosols — **19-21 October, Nova Scotia, Canada**

Contact: Leonard A. Barrie, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4, Canada. Fax: (+1-401) 739 5704, E-mail: len.barrie@ec.gc.ca

PICES/JGOFS CO_2 Workshop — **October 20, Fairbanks, Alaska**

Contact: Andrew Watson, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, U.K., E-mail: a.j.watson@uea.ac.uk,

TEA Regional Modelling of Monsoon System — **October, Beijing, China**

Contact: Congbin Fu, fax: (+86.10) 6204 5230, E-mail: fcb@ast590.tea.ac.cn

11th IGBP Officers Meeting — **12-16 October, St. Petersburg, Russia**

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

START/IOC/LOICZ Workshop — **November, Cotonou, Bénin**

Contact: Larry Awosika, Nigerian Institute for Oceanography and Marine Research, PMB 12729 Victoria Island, Lagos, Nigeria. Fax: (+234-1) 619 517, E-mail: niomr@linkserve.com.ng

LUCC SSC Meeting — **14-15 November, Barcelona, Spain**

Contact: Caroline Nunes, LUCC IPO, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: lucc@icc.es

GAIM Task Force Meeting — **16-20 November, Stockholm, Sweden**

Contact: Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham NH 03824-3525, USA. Fax: (+1-603) 862 3874, E-mail: gaim@unh.edu

LUCC Data Gathering and Compilation Workshop — **18-20 November, TBA**

Contact: Caroline Nunes, LUCC IPO, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: lucc@icc.es

SARCS Meeting in conjunction with Pacific Science Association Congress — **19-20 November, Taipei**

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

1999

Biogeochemistry of the Arabian Sea: Synthesis and Modelling — **January 18-20, Bangalore, India**

Contact: Roger B. Hanson, Centre for Studies of Environment and Resources, University of Bergen, High-Technology Centre, N-5020 Bergen, Norway. Fax. (+47-55) 58 96 87, E-mail: Roger.Hanson@jgofs.uib.no

Training Course of Biogeochemical Modelling of the Ocean — **January 21-29, Bangalore, India**

Contact: Roger B. Hanson, Centre for Studies of Environment and Resources, University of Bergen, High-Technology Centre, N-5020 Bergen, Norway. Fax. (+47-55) 58 96 87, E-mail: Roger.Hanson@jgofs.uib.no

GCTE Focus 1 Workshop: Global change effects on root dynamics — **TBA, Tennessee, USA**

Contact: Richard Norby, 1.1.1 Task Leader, Oak Ridge National Laboratory, Building 1059, PO Box 2008, Oak Ridge, TN 37831-6422, USA. Fax: (+1-423) 576 9939, E-mail: rjn@ornl.gov

GCTE Focus 1 Workshop: A cross-biome synthesis of ecosystem response to global warming — **TBA, USA**

Contact: Lindsey Rustad, Department of Applied Ecology and Environmental Sciences, University of Maine, 57212 Deering Hall, Orono, Maine 04469-5722, USA. Fax: (+1-207) 688 3356, E-mail: rustad@maine.maine.edu

14th SC-IGBP Meeting — **23-26 February, Estoril, Portugal**

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

Second IGBP Congress — **6-13 May, Shonan Village, Japan**

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

GCTE Focus 3 Science Conference — **20-23 September, Reading, UK**

Contact: John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, McLean Building, Crowmarsh Gifford, Wallingford OX19 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

Publications

IGBP Report Series

No. 45

Past Global Changes (PAGES) Status Report and Implementation Plan. Edited by F. Oldfield (1998) IGBP: Stockholm, 237pp.

No. 46

Global wetland distribution and functional characterization: trace gases and the hydrologic cycle. Report from the joint GAIM/IGBP-DIS/IGAC/LUCC Workshop. Edited by D. Sahagian and J. Melack (1998). IGBP: Stockholm, 96pp.

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. E-mail: sec@igbp.kva.se

IGBP Programme Elements

GCTE

Report of EU/TERI-IGBP/GCTE-DIVERSITAS Workshop *"Effects of Global Change on Biodiversity and Ecological Complexity"*. GCTE Report No.15. GCTE: Canberra.

GCTE IPO, CSIRO - Division of Wildlife and Ecology, PO Box 84, Lyneham ACT 2602, Australia.

GCTE/LUCC

The Earth's Changing Land. Abstracts of the GCTE-LUCC Open Science Conference on Global Change. Edited by GCTE and LUCC. ICC: Barcelona, 414pp.

LUCC

Electronic Conference on Land Use and Land Cover Change in Europe. Edited by E. Lambin, G. Fischer, J. Jäger, and X. Baulies. ICC: Barcelona, 51pp.

Caroline Nunes, LUCC IPO, Generalitat de Catalunya, Institut Cartogràfic de Catalunya, E-08038 Barcelona, Spain.

Other organizations

GTOS

Global Terrestrial Observing System Annual Report 1997.

Report of the Global Observing Systems Space Panel Third Session (1997). GTOS Report No. 9.

GTOS Secretariat, c/o FAO, SDRN, Viale delle Terme di Caracalla, Rome 00100, Italy. E-mail: gtos@fao.org

National Research

Germany

German Global Change Research 1998. Edited by E. Ehlers and T. Krafft (1998). German National Committee on Global Change Research: Bonn, 128pp.

German National Committee on Global Change Research, Secretariat, Nussallee 15a, 53115 Bonn, Germany. E-mail: krafft.nkgcf@uni-bonn.de

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GLOBAL OCEAN ECOSYSTEM DYNAMICS

GLOBEC INTERNATIONAL PROJECT OFFICE EXECUTIVE OFFICER

Three years of funding for a GLOBEC International Project Office located at the CCMS Plymouth Marine Laboratory (UK) has been announced by several organizations and agencies within the UK and USA. Accordingly, the GLOBEC Scientific Steering Committee is initiating an international search for an Executive Officer to direct the activities of the Project Office. The Executive Officer will be a highly-motivated and independent individual, capable of taking administrative and scientific responsibility for the GLOBEC International Project Office coordinating the activities of the GLOBEC programme.

GLOBEC (Global Ocean Ecosystem Dynamics) is a Core Project of the International-Geosphere Biosphere Programme (IGBP), with co-sponsorship by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC). GLOBEC's 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. A series of scientific objectives and foci for the programme has been defined in the GLOBEC Science and Implementation Plans. The overall international GLOBEC effort consists of a large number of national programmes in addition to the major multi-national regional field activities which are directed by the SSC, as well as cross-cutting framework activities such as numerical modelling and the development of sampling and observation systems. Further information on GLOBEC can be found on the Home Page at http://www1.npm.ac.uk/globec/.

Responsibilities of the staff of the International Project Office:

- support the Chairman and SSC and implement the decisions of the committee;
- manage the GLOBEC International Project Office and its staff on a day-to-day basis;
- act as the central node for communication within the international GLOBEC community and with the national GLOBEC programmes;
- assist the Chairman and the Scientific Steering Committee in developing and coordinating the international GLOBEC programme;
- provide project advocacy, promotion, and publicity, including the GLOBEC Newsletter and the GLOBEC Report Series;
- develop and maintain links with the SCOR, IGBP, and IOC Secretariats, other global change research programmes and other international and national agencies and organizations;
- organize conferences, meetings, and workshops in support of GLOBEC;
- oversee the development of an international data policy for GLOBEC and the establishment and maintenance of a data and information system [it is expected that an Assistant Executive Officer will appointed who will be an expert in data systems];
- represent GLOBEC at international meetings as needed; and,
- raise funds for GLOBEC activities.

Qualifications and experience for both positions:

- a broad interest in the scientific fields related to GLOBEC;
- appropriate management, organizational and communication skills;
- a PhD in a field of marine science relevant to GLOBEC;
- mastery of spoken and written English;
- flexibility and willingness to undertake extensive international travel; and,
- experience in the organization of international meetings and workshops is desirable.

Conditions:

- The appointment terms are flexible, either as an employee of the United Kingdom's Natural Environment Research Council or on secondment terms from the Executive Officer's home institution.
- The contract will be full-time for a fixed term of three years beginning in the second half of 1998. The contract may be renewed depending on funding for the Project and the performance of the Executive Officer.
- As an employee of the NERC (applications are welcome from persons interested in accepting appointments on leave of absence from their home institutions), the salary will be commensurate with qualifications and experience, and with prevailing norms in the UK science community (£30,000 - £35,000). Other benefits inlcude: an annual, paid holiday allowance of 25 days in addition to 10 public and privilege, paid holidays per year; performance-related pay; non-contributory pension scheme; flexible working hours of 42 hours (including lunch) per week.

Applications

The Natural Environment Research Council has an equal opportunities policy and welcomes applicants from all sections of the community. People with disabilities and those from ethnic minorities are currently under-represented and their applications are particularly welcome. We operate a Guaranteed Interview Scheme for disabled candidates who hold the minimum qualifications for the post.

For further information, please contact Dr Roger Harris, CCMS Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH, UK. Tel: (+44-1752) 633 400, Fax: (+44-1752) 633 101, E-mail: r.harris@pml.ac.uk

For an application form, write to Carol Brown, Establishment Office, CCMS Plymouth Marine Laboratory, Citadel Hill, Plymouth, PL1 2PB, UK. Tel: (01 752) 633205. Fax (01 752) 633102. E-mail:enquiry@pml.ac.uk

Completed application forms (quoting ref. no. 815) and CVs should be returned to Carol Brown no later than 15 July 1998. Interviews will be held in August, with a view to the appointment commencing in October.

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