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

Forward to the past - an update on PAGES

by Frank Oldfield

M. Vuille

Ice coring expedition in the Huascaran Ice Dome in the Andes (Sajama, Bolivia) in June and July 97.

CONTENTS

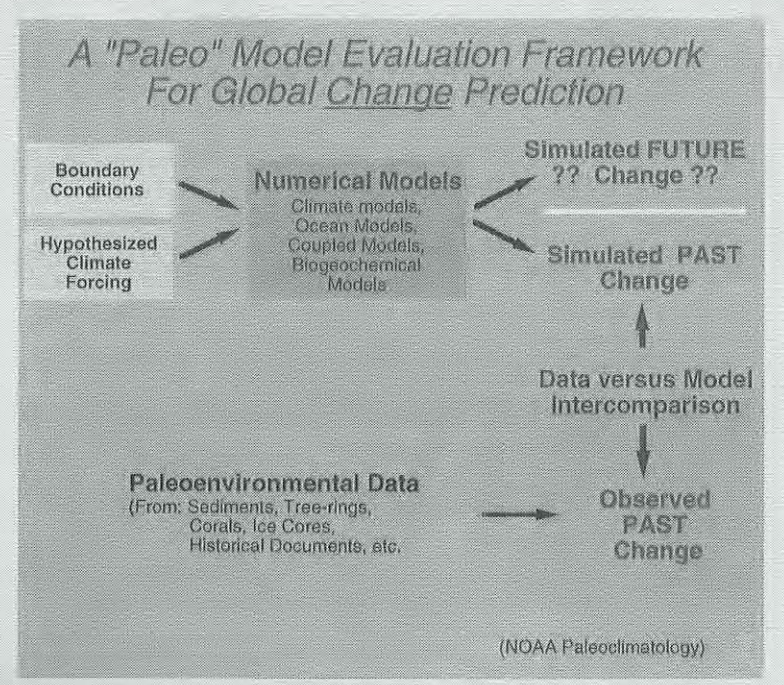
From Agenda Setting to Implementation

The Past Global Changes (PAGES) project has now reached a crucial stage of transition from an early emphasis on agenda setting to a progressively stronger orientation towards implementation. This is reflected in the completion of the PAGES Implementation Plan, a substantial document that outlines the shape of the PAGES Project over the next 5 years. To integrate the various Foci and Activities and the wide range of objectives they span, and to strengthen a sense of shared goals, it is planned to bring together, for the first time, the main PAGES Focus and Activity leaders at a meeting in Hilterfingen, Switzerland, in November of this year. During this meeting discussion will focus on finalizing the shape and content of the PAGES Open Science Meeting, synergisms between activities, sharing of information and defining a future policy for the dissemination of PAGES science. Themes will include East-West links between the Pole-Equator-Pole (PEP) Transects, as well as PEP-Polar linkages; marine-continental linkages; annual resolution record in a range of paleo-archives; data model interactions; and, future PAGES Symposia.

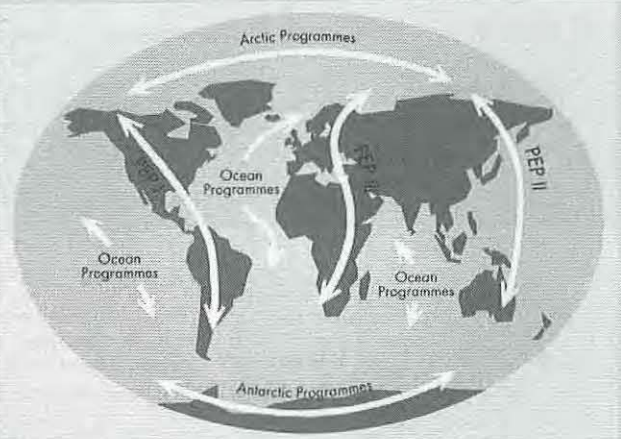
Understanding the past for a better view of the future

Whatever the anthropogenic impact on future climate may be, it will interact with natural variability as revealed in the records from the past. Even if our future climate is less modified by human activity than is currently anticipated, it will not remain constant. Natural climate variation has occurred and will continue to occur on all timescales. This variation affects people and their livelihoods in ways that are still hard to predict and plan for. These observations reinforce the need to document and understand the course of past climate variation, its causes, regional expression and consequences. The focused research agenda of PAGES Science provides essential evidence to underpin the information and advice needed by present day decision makers. Key PAGES activities in this regard include:

- *reconstructing the history of natural climate forcing mechanisms and their effects.* Links between forcing mechanisms such as solar variation and volcanic activity and the responses they generate in the earth's climate must be established through studies of past events, as well as modelled and explained in theoretical terms. These natural forcing processes will interact with any anthropogenic effects. We need to know much more about how natural forcing mechanisms have affected past climate before we can assess their future significance.
- *documenting the internal dynamics and feedbacks that modulate climate changes on the timescales of seasons to centuries.* These too will interact with and modify any human-induced changes that may occur. They often involve complex leads and lags that can only be explored in the evidence from sources such as tree rings, corals, ice cores and sediments that allow us to reach beyond the short time span of instrumental records. They affect the way in which we interpret present day trends and they will strongly affect the course of future changes. To predict their future impacts, we need to greatly improve our knowledge of their patterns and amplitudes in the past.
- *providing data for developing, testing and validating climate models.* Model simulations of the earth's climate system often highlight particular areas and processes of key importance for improving their validity and predictive power. This in turn requires that evidence from the past be refined in order to test the models against reconstructed past conditions. Models form one of the major links between science and decision making. To be fully effective in simulating future climates, models need testing using climate conditions and boundary conditions unlike those of the present. Unless models can achieve an adequate level of realism in simulating past climate conditions, their performance in predicting future conditions will remain less certain than decision makers would like. Working with the modelling community is one of the key roles of PAGES. Many past climate changes are global in their effects and can be traced as simultaneous responses in both hemispheres and from the equator to the poles; but the way these changes are expressed varies greatly from place to place. The challenge for PAGES is to understand the global mechanisms and document the regional effects. Both are vital for model development and validation, hence



The inferential framework for using paleodata to test models used for predicting future global changes



A map showing the different Pole-Equator-Pole Transects

for reducing uncertainties in future prediction.

♦ *refining our knowledge of the past role of greenhouse gases during rapid warming episodes.* The parallel trends in past global temperature, atmospheric carbon dioxide and methane concentrations, as revealed in ice core records, provide one of the most dramatic arguments in favour of future greenhouse gas warming, but the precise phasing of and the processes responsible for the parallel changes in temperature and gas concentrations need to be more fully understood before the future implications can be confidently established. Only the historical record contains the evidence needed to resolve these crucial issues.

♦ *estimating the probability of major instabilities in the earth system under warm climate conditions.* It is now clear that the earth's coupled ocean-atmosphere system has been highly unstable in the recent geological past, with massive swings of ocean circulation and associated dramatic changes in climate taking place over the space of a few decades at most. Even though such dramatic 'switches' are more typical of cool, glacial times, there is growing evidence that they cannot be excluded from the range of future possibilities in a warming world. Many lines of evidence from sources as diverse as tree rings and sediments show that even during the warm period since the last glaciation - the period we live in now - climate varied over a much greater range than instrumental records would lead us to believe. There is also growing evidence for sudden, major changes in climate during the warm period before the last glaciation, the Eemian Interglacial. All these warm climate fluctuations need much fuller investigation, since they may hold part of the key to estimating the likelihood of similarly dramatic changes in the near future, changes that would have human consequences well beyond the range of recent experience.

♦ *documenting the impact of past environmental changes on human resources and activities.* The record of the past is rich in illustrations of the ways in which climate change and human activity have been closely interwoven. It is not a simple story, for the impact of climate variation through extreme events for example, is often in part a function of the pattern of human resource use at the time. Human activities create the canvas upon which climate variation expresses its consequences for people, their welfare and their very survival. One of the responsibilities of PAGES is to improve our understanding of these interactions so that future resource management and environmental policy can learn from the lessons of the past.

New Newsletters and a new Web-site

The first PAGES Newsletter of 1997 marked a new departure. The format has expanded in size from six to sixteen pages and now includes a much greater emphasis on reporting PAGES science. The first new-style Newsletter profiled the PEP I and PEP II Transects; the second one highlights PEP III and the IMAGES (International Marine Past Global Change Study) programme.

The global change community may access PAGES information, including Newsletters, all future (and a gradually increasing number of past) Workshop Reports and updates on the PAGES Open Science Meeting via the newly developed Home Page, now maintained by the IPO in Bern: http://www.pages.unibe.ch/pages.html

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The First PAGES Open Science Meeting

We see this as a major landmark in the development of PAGES science and a demonstration of its role within the spectrum of Global Change research. The meeting will take place at Royal Holloway University of London, April 19 - 23, 1998. The theme of the meeting will, be :

'*Past Global Changes and their Significance for the Future*'

The Meeting will highlight major advances through a series of invited overview papers in Plenary sessions to be presented by some thirty leaders in the field.

The themes to be covered will include:

1. The full range of climate system variability
2. Climatic forcing
3. Climate system processes
4. Modelling the climate system
5. Biotic responses to climate change
6. Human consequences of climate change

Poster sessions will be an important component of the Meeting with the emphasis on interaction and discussion. They will be organized largely along the lines of the main projects coordinated by PAGES. Both the invited review papers and papers based on the posters will be published.

The final afternoon is designed to include a Panel Discussion addressing both the policy implications of the results of PAGES research and the priorities for future research by PAGES scientists in the light of the needs of present-day decision makers.

Academic co-sponsors of the meeting are The Environmental Change Research Centre, University College London and the Centre for Quaternary Research, Royal Holloway University of London. Royal Holloway will host the Meeting and the Environmental Change Research Centre in UCL will fund up to 5 outstanding young scholars from developing countries to attend the meeting.

Further information and updates on plans for the Meeting are available from the IGBP PAGES International Project Office, Bärenplatz 2, CH 3011, Bern, Switzerland. Phone:- + 41 31 312 3133; Fax:- + 41 31 312 3168; E-mail: pages@ubeclu.unibe.ch

Inner Mongolia Semi-Arid Grassland Soil Vegetation-Atmosphere Interaction (IMGRASS)

by Daren Lu

The Inner Mongolia Grassland-Atmosphere Surface Study (IMGRASS) is designed to advance our understanding of soil-vegetation-atmosphere interaction in temperate semi-arid grassland. In addition it will address the hydrological cycle in a mesoscale modelling framework, provide surface flux measurements over various scales for development and validation of satellite remote sensing algorithms. It attempts to understand the grassland-climate interaction under the human activity stress with the target for sustainable development in this area. Thus this project is mainly a BAHC-GEWEX type experiment but with emphasis on IGBP's biogeochemistry purpose and IHDP related tasks, in particular, Land Use and Land Cover Change. The choice of the semi-arid Mongolian grassland ecosystem for conducting such a study stems from the basic duality involving man and climate which is imposed on the modelling of land surface-atmosphere interactions. The Mongolia grasslands represent an immense natural resource containing a mixture of virtually pristine areas, which respond mostly to natural climatic perturbations and heavily used grazing crop areas, which respond to both climatic and human impacts. Because of their temperate latitudes and pervasive water-stressed ecology, they are destined as a sensitive climatic zone in which primary productivity undergoes huge swings according to prevailing surface temperature and precipitation patterns.

The Mongolian grassland plateau differs from most of the world's remaining grasslands in its vastness, the extent of the remnants which have not been disturbed and still retain their pastoral character; and the fact that its biomass productivity is so much higher than other grassland ecosystems in light of its low annual rainfall and the shortness of its growing season. The latter is presumably due to the distribution of annual rainfall of which approximately 70% occurs between June and August during peaksummer heating. It is also unique in that, unlike the C4 grasslands of North America and Russia, it is primarily a C3 grass ecosystem, although it is not clear why (C4 grasses exhibit higher water use efficiency and are more heat resistant, whereas C3 grasses show a greater increase in photosynthesis for higher CO_2 concentrations). Recent research shows that the Mongolian grasslands may sequester far more carbon than other grassland zones. Measurements in the vicinity of the Inner Mongolia Grassland Ecological Research Station where IMGRASS will take place, show underground biomass quantities exceeding above ground biomass quantities by factors of 7-10, a ratio some 3-5 times greater than warmer grassland zones. This carbon sink feature of the Mongolian grasslands has important implications on global climate as changing temperature and soil moisture patterns modulate the flux of CO_2 into the atmosphere through soil respiration. In addition, there is documented evidence that overgrazing practices and spring wheat planting in some parts of the grasslands have led to increases in surface albedo, increased wintertime and springtime aerosol concentrations and sandstorm frequency, and significant declines in primary productivity. Since 1991, a group of Chinese and American scientists inspected the proposed Inner Mongolia field experiment area, Chinese Academy of Sciences and found it will be an ideal region for conducting a mesoscale field experiment for its typical steppe and biodiversity, mild-complex terrain, and long-term ecological research background by IMGERS scientists. After a preliminary proposal to THE NSFC of China and the National Science Foundation (NSF) of USA, two workshops were held in Boulder, USA 1992 and Beijing, China 1993, respectively. Finally, NSFC approved THE IMGRASS project in the end of 1996.

The scientific objectives of IMGRASS are multiple, but concentrated in the surface fluxes modelling and long-term ecosystem-climate interaction. All objectives are based on the comprehensive mesoscale field experiment, long-term monitoring of ecology-climate parameters and their respective model development. These are:

1. Develop and validate SVAT model(s) with comprehensive soil, vegetation, atmospheric measurements at core stations with the strategy of microvariability representativeness.

2. Develop and validate a comprehensive limited area model for simulating the water cycle in the Inner Mongolian grassland area to determine the impact of evaporative recycling on mesoscale circulations under a changing landscape and representative parameterization scheme for mesoscale (GCM grid point scale) average into GCM with comprehensive mesoscale field experiment.
3. Develop satellite retrieval techniques for the principal surface variables (vegetation cover, albedo, temperature, soil moisture), along with cloud radiation, and aerosol parameters for use in both initializing and validating the process model components of the limited area model. Such algorithms will provide the capability of extending the model simulations beyond the study-area boundaries.
4. Produce a comprehensive dataset, continuous in time and typical for semi-arid grassland classes of natural preserved and anthropogenic influences, to understand the response of grassland ecosystem to climate variability and human activity, (in particular, overgrazing and agricultural farming and its feedback).
5. Quantifying and modelling the function of the steppe in carbon and nitrogen biogeochemical cycle as well as the source/sink effect to global greenhouse gases budget.

Field experiment. The mesoscale field experiment will be conducted in Xilingol District in the growing season (early May to September) 1998. The scale of experiment area is about 100-150 km. Four core stations with geographical and ecological representativeness are selected to have composite instrumented observation, including soil, vegetation, atmospheric boundary layer parameters and surface fluxes of radiation, heat, humidity, trace gases. Microvariability of surface fluxes is considered in the observation design. Also quality control and intercalibration of instruments will be routinely made in addition to core stations. Several minor stations will be selected for various purposes, such as area coverage for mesoscale model, satellite validation, ecological type, etc. Multi-satellite data, such as AVHRR, GMS, TM, SPOT, and ADEOS/POLDER will be collected for retrieving and validating regional distribution of above-mentioned parameters. Four dimensional data assimilation (4DDA) scheme will be studied. In the summer of 1997, a pilot study will be conducted mainly in the IMGERS station. Long-term monitoring will be made at one or two stations after the 1998 experiment. Along with existing research results and observation data of IMGERS since 1979, study of grassland ecology-climate interaction will be based on a qualified long-term data base.

Participants of IMGRASS in China are those scientists with an atmospheric, ecological and remote sensing background from the Institute of Atmospheric Physics (IAP), the Institute of Botany (IB), the Lanzhou Institute of Plateau Atmospheric Physics (LIPAP), the Institute of Geography (IG) (all belonging to the Chinese Academy of Science (CAS, Peking University, Inner Mongolia University). A number of US scientists e.g. Drs. K.N.Liou, E.A.Smith, W.Brutseart, J.Businger, are actively involved in the preparation of the IMGRASS project in both China and USA. Dutch scientists, e.g. Drs.P.Kabat, R.W.A.Hutjes also expressed interest in participating in the experiment. Although we have made the experimental plan, participation in the IMGRASS field experiment and modelling study from the international scientific community is anticipated.

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Report of the Chinese BAHC Workshop held in Beijing, 10-12 November 1996

by Changming Liu and Dajun Shen

From 10 to 12 November the Chinese National Committee of the IGBP and the Biospheric Aspects of the Hydrological Cycle (BAHC) Core Project Office organized a Chinese BAHC Workshop, which was attended by more than 35 Chinese scientists and 6 international scientists. The aim of the workshop was to synthesize BAHC relevant studies in China and to begin planning for a research programme around the North-East China Transect (NECT). Several issues were discussed during the workshop, such as the current state of knowledge, data collection related to climate induced land cover change impacts, agricultural sustainable development, and water resources management for agriculture. Lectures alternated presentations and a panel discussion was held.

A keynote lecture was held by W. Bastiaanse discussing the regionalization of surface fluxes in Heihe River Field Experiment (HEIFE), Echival Field Experiment in a Desertification Area (EFEDA) and Hydrological-Atmospheric Field Experiment (HAPEX Sahel led by GEWEX/WCRP) with the Surface Vegetation Index Algorithm for Land (SEBAL). The demand for regional water with energy balance, climate and water resources management studies cannot be satisfied by conducting field measurements alone. There is a need for new procedures to be defined to extrapolate *in situ* fluxes to the regional scale. Examples were given of the HEIFE, EFEDA and HAPEX-SAHEL field experiments, in which surface fluxes were estimated directly from remote sensing measurements of surface hemispherical reflectance by using SEBAL. A comparison between ground-based tower fluxes and pixelwise SEBALfluxes was achieved by integrating the fluxes of pixels located upwind of the measurement tower. In 85% of the cases comparing the field scale surface fluxes with the SEBAL surface fluxes, the deviation was within the range of instrumental accuracy.

One of the key issues of BAHC Focus 4, the Weather Generator, is the problem of downscaling. Jun Xia presented a downscaling approach by coupling a greysystem differential model with the Finite Domain Mesoscale Atmospheric Model (FDMAM) as a tool for predicting daily precipitation in high resolution. By coupling the two approaches it is possible to obtain more precise predictions than the FDMAM alone. It has been verified by daily precipitations observed in 77 rain gauging stations and 96 flood events in Hubei province, China. In addition he explained how information of atmospheric circulation patterns can improve estimating the local daily precipitation.

One of the topics of the workshop was human induced climate change impact assessment, on which Jinjun Ji discussed the results of simulating surface fluxes over natural and managed vegetations with an Atmosphere-Vegetation Interaction Model (AVIM). During the project the surface fluxes of energy, water and carbon dioxide were simulated over grassland and cropland during the growing period. The AVIM model consists of two interactive components: a Land Surface Physical process model (LPM) and a plant physiological model, and provides an efficient approach to link the biogeochemical and physical processes at the surface. Simulated results of winter wheat showed that it was highly sensitive to precipitation in growing seasons in the Yucheng station, North China Plain, and coincided with the measurements in Inner Mongolia. Sensitivity testing of steppe production to changes in climate and grazing indicates that severe drought and overgrazing will lead to desertification in a semi-arid zone.

Changming Liu outlined the current status and prospects of the Chinese BAHC study. The present study focuses on four topics: a one-dimensional soil-vegetation-atmosphere transfer (SVAT) model, regional scale studies of land-surface properties and fluxes, diversity of bio-hydrosphere interaction, and the weather generator project.

One-dimensional SVAT model

One of the critical issues in global change research is the atmosphere-ecosystem interaction that includes not only physical, but also biogeochemical processes. By coupling physical processes with biogeochemical processes between the atmosphere, vegetation and soil at land surface, a climate-ecosystem mechanical model is constructed, a so-called Atmosphere-Vegetation Interaction Model (AVIM).

Regional studies

The largest land-surface experiment in China is the Heihe River Basin Field

Experiments (HEIFE) on the atmosphere-land surface in Northwestern China, ranking only third worldwide in international experiments, after FIFE in the USA and HAPEX-MOBILHY (Modelisation du Bilan Hydrique) in France. Currently two other regional scale land-surface experiments are being planned and implemented: the Inner Mongolia Grassland-Atmosphere Surface Study (IMGRASS) — of which a detailed report can be found on pages 13 to 14 of this issue — and the Huaihe River Experiment of Energy and Water Cycle (HUBEX). In addition, the Ecohydrological Research on the Application of Watersaving Agriculture to the North China Plan is a major project of the National Natural Science Foundation. The interdisciplinary project combines the perspective of geography, biology and engineering to describe the relevant processes, mechanisms and interrelations for increasing the efficiency of crop-water utilization, which have produced fruitful results to BAHC.

Diversity of bio-hydrosphere interaction

The Mechanisms of Response of Chinese Complex Agro-ecosystems and Response Strategies to Global Change project uses interdisciplinary research to identify and quantify the mechanism of the effects of changes in climate, atmospheric composition and land use on China's complex agro-ecosystem and how these effects lead to feedback to global change. It is intended to improve the general ability for key agronomic species, forests and rangelands and to help national programmes to make near and medium term plans. The ecological transect is considered to be an efficient approach for studying global change. The North-East China Transect (NECT) will contribute to BAHC, to study the biotic control of water and energy exchanges between land surface and the atmosphere.

The Weather Generator

The Research of Water Resources in the Arid Areas of Northwest China under Global Change is developing a drainage hydrological model to account for the spatial distribution of glaciers, snow cover, soil, precipitation and runoff at different scales. This high-resolution hydrological model will be developed as a coupled climate-hydrology model. A similar initiative is started in the Coupling a Weather Generator to a SPAC Model in the North China Plain. BAHC Focus 4 is devoting a major effort to coordinate the development of methods to simulate atmospheric inputs to ecological and hydrological models in both current and projected future climate.

During the workshop research results were presented on topics of impact assessment of global change and climatic change; data set building and analysis; BAHC related scientific modelling; and, agriculture water resources use research.

The workshop was concluded by a panel session chaired by Mike Fosberg, Executive Officer of the BAHC Core Project Office. The discussion centred on how land use and water influence agriculture sustainability along the North-East China Transect; what effect changes in land use and water will have on the agriculture; and the BAHC project itself.

The workshop was very successful and filled gaps in knowledge on biospheric aspects of the hydrological cycle as part of a global synthesis. It also enhanced the incorporation of Chinese BAHC activities with international BAHC activities. The authors gratefully acknowledge the National Natural Sciences Foundation of China, the Chinese Academy of Sciences and the BAHC Core Project Office, for their generous support in organizing the workshop.

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Will Steffen, An Introduction

Executive Director of the IGBP from 1st March 1998

The ICSU Executive Board has appointed Dr Will Steffen to the post of Executive Director of the International Geosphere-Biosphere Programme for a period of three years, to replace Professor Chris Rapley, who is returning to the UK to his post at University College London.

Dr Steffen is an Australian citizen with a BSc. in chemical engineering from the University of Missouri (USA) and an MSc. and PhD. in chemistry from the University of Florida (USA). He is currently the Executive Officer for the Global Change and Terrestrial Ecosystems (GCTE) Core Project of the IGBP and is a Visiting Fellow at the Research School of Biological Sciences, The Australian National University. His early research career was in structural inorganic chemistry, with an emphasis on the use of x-ray crystallography to elucidate the structure of transition metal complexes. More recently he has been involved as a collaborator in projects associated with GCTE, including the recent synthesis and integration of GCTE's research effort over the past six years. Earlier he worked as a science manager and scientific editor and information officer in the Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Environmental Mechanics, whose research focuses on environmental physics.

"For many of you I probably don't need an introduction. I have been very active in the international global change research arena since 1990, when I joined GCTE as the Core Project Officer. The early days were chaotic, as Rowena Foster (who was hired before I was and is the real boss of the GCTE Core Project Office) and I struggled to turn a tiny office with a pad of paper, a few pens, a discarded PC, and two champagne-stained pages of notes from Brian Walker, scribbled on paper from a Qantas lounge, into a functioning international research programme. Somehow we managed over the years, with quite remarkable leadership from Brian, a considerable amount of help and support from the other GCTE officers and tremendous volunteer input from a very large number of top-class scientists (the real strength of IGBP!), to get a few runs on the board.

During that time I have also interacted with a large number of colleagues from other programme elements, from the IGBP Secretariat, from the START Secretariat and their regional networks, and from the broader global change community. This work at the "coalface" of global change research has been a fascinating experience, and has exposed me to the mind-boggling spectrum of people, programmes, themes, cul-

tures, nationalities, disciplines, activities, meetings, discussions, arguments, fights, laboratories, research stations, and expeditions that make up the global change research effort.

One of the most remarkable achievements of IGBP has been to meld this enormous pot of ideas, people and structures into a coherent international research programme. It hasn't been easy, and there have been many false steps and frustrations along the way. But the excitement and enthusiasm displayed at the IGBP Congress is proof of the emerging sense of common purpose and of the new level of maturity of the programme.

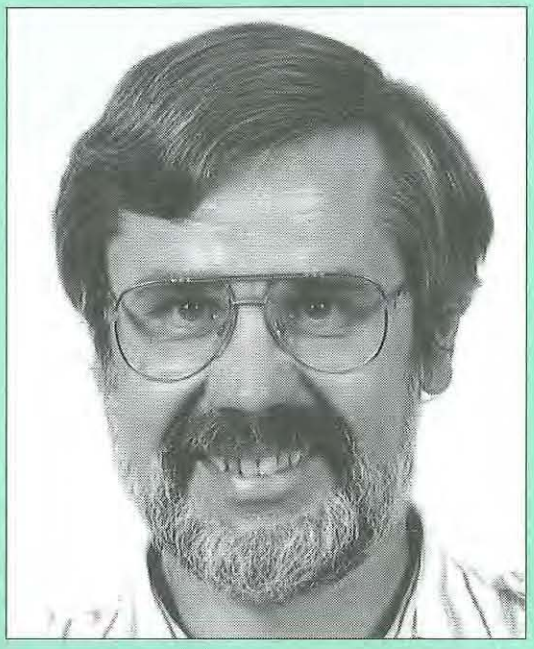
Now, however, is not a time for IGBP to rest on our laurels. We are facing a big challenge. As the planning phase of the programme turned towards implementation in the late 1980s, we set ourselves six fundamental questions (see IGBP Report No. 12). Through the 1990s a few more questions have been added, but the list still remains short and focused. It is time to revisit that list, and to evaluate how well IGBP has answered those questions. During the next three years, a synthesis of the programme's research to date - what we have learned about the functioning of the Earth system, the critical gaps in our understanding, the emerging issues that we must tackle in the future - would be an ideal way to define the value we have added to the broad global change research effort over the last decade and to provide a scientifically-sound springboard for the next phase of IGBP. The issue of a programme-wide synthesis needs to be discussed not only by the Scientific Committee, but also (and very importantly) at the programme element level and throughout the IGBP community of scientists. To produce a high quality state-of-the science synthesis will require the active support of the entire community.

Whatever the emerging scientific issues and the future directions of IGBP, one thing is certain: we must become more effective at working together with other groups interested in global change to solve common problems. Some of these important partnerships include:

- Enhanced scientific collaboration with our colleagues in the climate sciences and in the social sciences. This process has accelerated rapidly over the past year or two through the efforts of Chris Rapley and Peter Liss, the current IGBP Executive Director and Chairman, respectively, and their counterparts in the World Climate Research Programme and the International Human Dimensions Programme.
- Further strengthening of an already strong and productive relationship with START to build an effective two-way cooperation with regional research: regional research building up a global picture, and global understanding providing policy and management support at the regional level.
- Closer interaction with the International Group of Funding Agencies to ensure that, in this era of resource constraints for research, the goals, science plans and implementation strategies of national and regional global change programmes and those of IGBP and the other international programmes are developed and implemented as harmoniously and efficiently as possible.
- A better working relationship with the Intergovernmental Panel on Climate Change, which provides governments with advice on the climate component of global change.
- Closer cooperation with those United Nations agencies which have a remit for the global environment or on whose focal areas global change has a significant impact.

We now sit at an interesting point in the history of global environmental research. There is a confluence of fundamental science and important societal needs. We need the absolutely best science, across a large number of disciplines, to address questions of very high importance for the future of the Earth's life support systems and thus for humanity. The questions appear on a wide range of space and time scales, from immediate local and regional management problems to longer-term policy decisions which have implications for the future evolution of the Earth system. If we can develop the effective partnerships suggested above (which will require good will from all parties to overcome some traditional tensions and barriers), IGBP and our sister international global change programmes can enhance our leadership role in global change science and improve our delivery of policy and management advice.

Finally, I acknowledge the tremendous efforts and achievements of my predecessors in the post of Executive Director. My own beginnings in the IGBP came in the period of inspirational leadership from Thomas Rosswall, who kindled my enthusiasm for global change research and kept me focused on the bigger picture as I worked with my GCTE colleagues to get that core project off the ground. Thomas, John Marks and Chris Rapley have all brought energy, enthusiasm and considerable skills to the post, and together have led IGBP to its current solid position of eminence in global change research. I hope that I can carry on in the same tradition."



Will Steffen

Surface Ocean-Lower Atmosphere Study (SOLAS)

by Andrew Watson

In order to begin outlining plans for a potential new IGBP Programme Element in the area of marine biogeochemistry and climate, the following group met in London at the Ciba Foundation in January 1997: Andrew Watson (UK, Chair), Wallace S. Broecker (USA), Robert A. Duce (USA) Patrick M. Holligan (UK) M. Dileep Kumar (India), Michael Witfield (UK), Phillip Williamson (UK). The chairman of the group submitted the following report.

Summary

The group proposed a new project with a new approach to cover the area of marine biogeochemistry and its interaction with the atmosphere. The following goal is proposed for the "Surface Ocean-Lower Atmosphere Study" (SOLAS):

To address key interactions among the marine biogeochemical system, the atmosphere and climate, and how this system affects and is affected by past and future climate and environmental changes.

This goal will be attained by:

- formulating and testing hypotheses about these key interactions,
- quantifying cause and effect in these interactions, and
- incorporating this new understanding into models

SOLAS should proceed by use of perturbation experiments to examine key interactions, and by detecting the responses to ongoing variations in the system. Perturbation experiments should include both *in vitro* and *in situ*, enclosed and unenclosed studies. Detection of responses of global system should include both anthropogenic change and studies of the effects of natural variation (dust deposition, El Niños, monsoons, volcanic eruptions etc.). These studies should make full use of the anticipated great increase in the availability of remote sensing data, and both existing and new observational time series in the ocean and atmo-sphere.

Five important hypotheses in need of testing are:

- marine sulphur emissions have a substantial effect on climate by influencing cloud albedo
- atmospherically derived iron stimulates diatom and other phytoplankton growth in "high-nitrate-low-chloro-

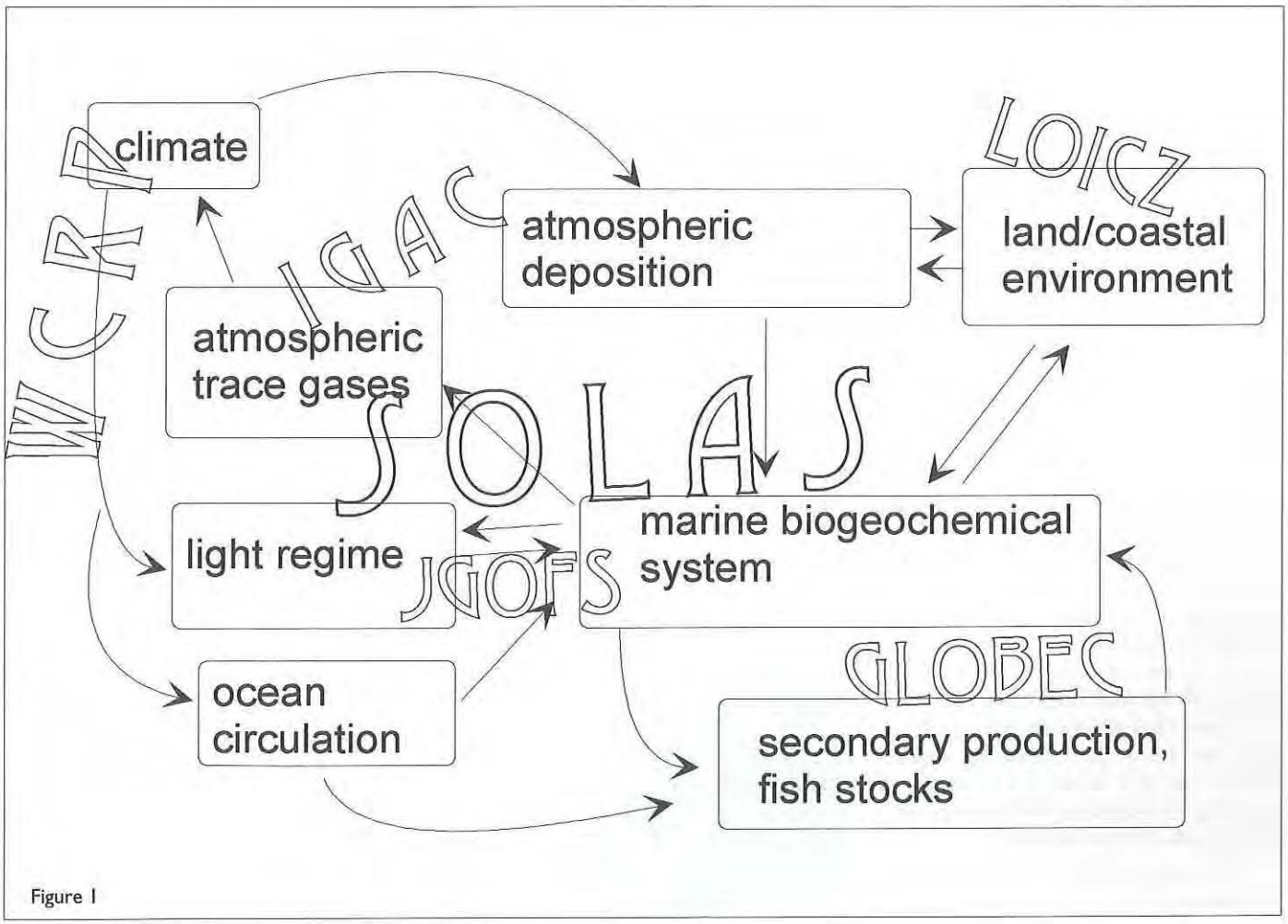


Figure 1

phyll" regions of the ocean, and this may exert significant feedback effects on climate

- changing patterns of atmospheric nitrogen deposition consequent on increasing industrialization will significantly influence the marine biota in some parts of the ocean
- the influence of changes in marine biogeochemistry on ocean uptake of anthropogenic CO_2 in the next century will be small
- the principal effect on the marine production in a warmer world would be a decrease in global productivity, consequent on a slowing of the thermohaline circulation.

The development and prioritization of principal hypotheses will however be part of the planning of the programme — we do not intend these to be set in stone at this stage.

Though by reason of its membership, the focus of the working group's discussions was on biogeochemistry, physical interactions between atmosphere and ocean should not be neglected in SOLAS and future development of the programme will, it is hoped, include participation by scientists with an expertise in this area also.

Introduction

SOLAS would investigate the marine biogeochemical system as it affects, and is affected by, the atmosphere and climate. The diagram on page 9 (Figure 1) illustrates some of the interactions of processes within the marine and atmospheric environment and the major projects being undertaken to investigate them. While a few studies within JGOFS, IGAC and LOICZ presently fulfil parts of the role envisaged for SOLAS, there has been relatively little emphasis on detailed study of such interactions. In addition, JGOFS and IGAC are due to finish by the early years of the next century.

The progress made by IGAC, JGOFS and their sister programmes was considered by the working group. Much has been learned, but many crucial questions regarding the interaction of the marine system with the atmosphere and climate have not been answered, and in some cases not even addressed. For example, while JGOFS has contributed in a major way to understanding of the role of the biota in the marine carbon cycle, its contribution to understanding the mechanics of global change has been much more modest.

The domain of SOLAS may be divided into effects of marine biogeochemistry on the atmosphere, and the effects of climate and atmospheric processes on the marine biogeochemistry. Regarding the effect of the marine biogeochemistry on atmospheric conditions and hence climate, the following describes present understanding and its limitations.

CO_2: On a 50-100 year timescale, the degree to which the marine biota can increase or decrease the sink for CO_2 is small. An upper limit can be derived from a scenario in which the entire Southern Ocean is assumed to utilize all the available phosphate and nitrate nutrients (due to iron fertilization or changes in circulation for example). Then a shift in atmospheric CO_2 on the order of 60 ppm is possible, rather modest by comparison to projected increases of 300-700 ppm above the pre-industrial concentration by the end of the next century. The likely actual effect would be much lower than this extreme case. Major changes in for example, globally integrated carbon-to-nutrient "Redfield" ratios could also cause changes in the size of the ocean CO_2 sink, but since large shifts in these ratios are not currently seen between different marine ecosystems, it seems unlikely that these would occur. By contrast, in the glacial-interglacial context, 60ppm is a very significant shift in atmospheric CO_2. On longer timescales therefore, and in particular with regard to understanding the past history of CO_2 in the atmosphere, the study and understanding of marine biogeochemical controls on CO_2 remains a very important topic. SOLAS should include study of these controls, but should be careful not to overstate their relevance to short-term changes in climate.

Dimethylsulphide, (DMS): the hypothesis that cloud albedo may be substantially influenced by marine sulphur emissions through the formation of sulphate aerosol particles and cloud condensation nuclei has been in the literature since 1987. Potentially, this is a powerful climate-influence mechanism, even on the short 50-100 year timescale. It has been studied to only a very limited extent by IGAC and JGOFS, and to date its importance remains largely unresolved. We do not know the degree to which the underlying assumption, that more DMS makes more cloud condensation nuclei in remote areas is correct or not.

Other gases: the ocean is a relatively minor source of the radiatively active gases CH_4 and N_2O, so changes here are unlikely to greatly influence global change on timescales of less than 100 years. Once again, on longer timescales, however, there may

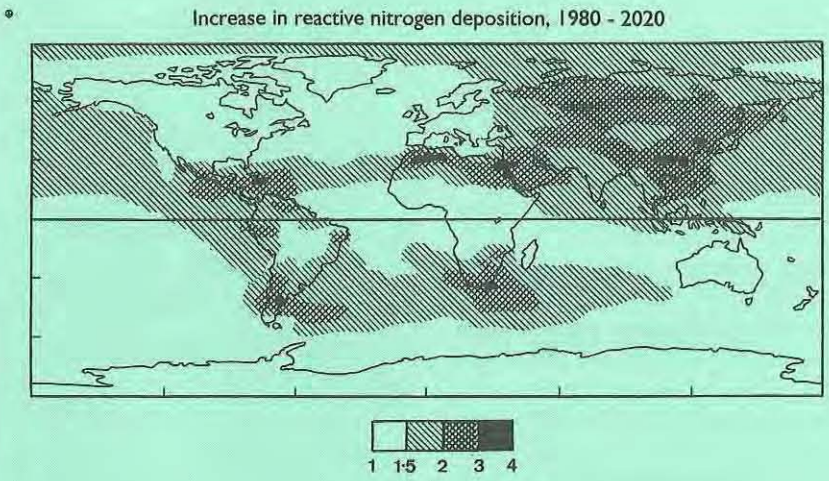


Figure 2 Ratio of estimated deposition of oxidized nitrogen to the ocean (and land) surface in 2020 relative to 1980 (From Galloway, Levy and Kasibhatia; *Ambio* 23, 120-123; 1994).

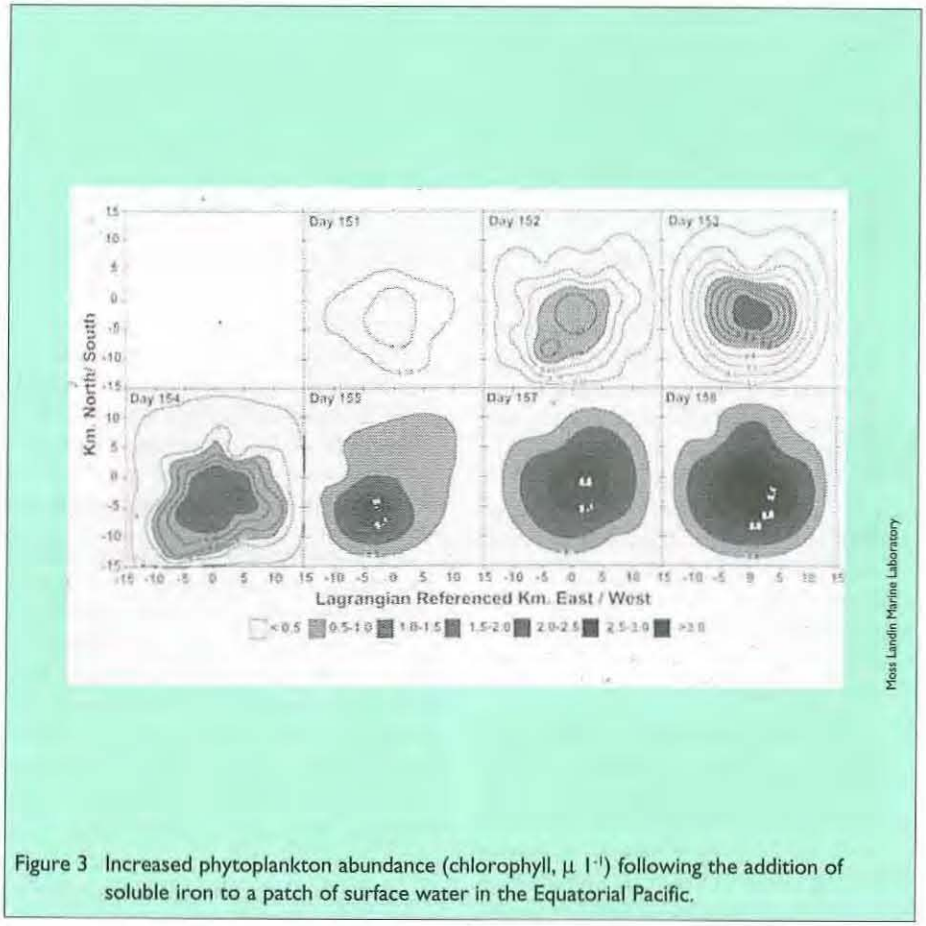


Figure 3 Increased phytoplankton abundance (chlorophyll, μ l^{-1}) following the addition of soluble iron to a patch of surface water in the Equatorial Pacific.

be important effects. N_2 production and fixation do not influence climate directly, but because the balance between them controls the nitrate concentration in the oceans on timescales of 1000 years, this will be important in maintaining the marine biota. The chemistry of the atmosphere is influenced by many trace gases of marine origin: non-methane hydrocarbons, CO, organohalogens, and ammonia for example. Factors influencing the sources and sinks of these gases have not so far been subject to detailed study.

With regard to the influence of the atmosphere and climate on marine biogeochemistry, the situation is less clear. One approach to this problem seeks first to characterize the marine biota in terms of biogeographic regimes, where the boundaries between the zones and the biology within them are strongly influenced by external factors set by the atmosphere and climate, such as ocean circulation patterns, light and supply of nutrients. The biota in these regimes may in turn have distinct biogeochemical attributes, for example, one can distinguish between the diatom dominated systems, common in upwelling and seasonal bloom regions (high organic carbon and silica deposition and low carbonate production rates) and low f-ratio systems found in the permanently stratified gyres, having broadly the opposite properties.

Attempts have begun to describe and model the response of these subsystems to changes in the external factors, but confidence in the model results is generally low. Progress in this area has been hampered by (1) a lack of hard information on the impact of changing conditions and resource availability on marine ecosystems, and (2) the lack of good data on remote sensing of ocean colour in recent years. The following are important global change hypotheses in this area.

- Overall, a warming world might be expected to reduce the strength of the global thermohaline circulation, leading to lower marine production.
- In specific regions, the marine biota may be expected to respond to input of nutrients from the atmosphere, in particular iron from dust in iron-poor regions, and nitrogen inputs in nitrogen-limited regions. Changes are likely in these inputs in the next century due to anthropogenic effects. Of particular concern are inputs of nitrogen from the developing economies in Asia, affecting the western Pacific and North Indian Oceans, and industrial development in currently pristine regions of the Southern Hemisphere (see figure 2 on page 10).
- Regional winds may increase in intensity. This would be expected to increase the prevalence of nutrient-rich ecosystems at the expense of steady-state ecosystems, for example by increasing the rates of coastal upwelling and open-ocean mixing.
- Many of the changes in source and sink strengths will occur especially in the coastal oceans. These are the site of a large proportion of marine productivity and will be subject to increasing nutrient input due to river eutrophication and waste disposal.

Philosophy of a new programme

A coordinated programme should have a guiding philosophy concerning the interaction of measurement with theory, if it is not to risk that these two elements become uncoupled from each other, resulting in observations made "for their own sake", and models which are not amenable to testing. An earlier suggestion for the Global Ocean Euphotic Zone Study (GOEZS, the precursor to SOLAS) was that it should be "model driven". This philosophy works best with models which are predictively robust. In most instances, such models do not exist in this subject area.

It was suggested that in SOLAS, theory and observation should be coupled by means of hypotheses. These should be formulated such that, if they are quantitatively established or refuted this will result in substantive increases in our knowledge. Five examples of such hypotheses are given at the beginning of this article.

SOLAS goal

We propose the following goal for SOLAS:

To address the key interactions among the marine biogeochemical system, the atmosphere and climate, and how this system affects and is affected by past and future climate and environmental changes.

This goal will be attained by:

- formulating and testing hypotheses about these key interactions,
- quantifying cause and effect in those interactions, and
- incorporating this new understanding into models.

It was felt that past climate change should not be sidelined, since a full understanding of the system will involve explaining observed past changes as well as predicting future ones. While a study of past changes is mostly the domain of IGBP-PAGES, investigations of specific biogeochemical mechanisms are appropriate to SOLAS.

Tools and technologies

Hypotheses such as those suggested above must be amenable to test. The following technologies and techniques would enable progress in this regard.

1. Perturbation experiments: the behaviour of marine ecosystems with regard to perturbations of nutrients and other parameters can be studied by enrichment experiments, be these *in vitro, in situ*, enclosed, partially enclosed or unenclosed. A recent example of the power of this technique has been the Ironex experiments in the equatorial Pacific; which proved beyond reasonable doubt that iron is an important factor limiting primary production there (see Figure 3 on page 11). Though these experiments were convincing because they were unenclosed similar results had previously been obtained by the simpler technique of bottle incubations. The lesson is that when carefully performed, *in vitro* techniques do have the capability to mimic some aspects of the response of the real system.

   A programme of perturbation experiments could advance our knowledge in many ways. For example, examination of the effect of adding increased phosphorus and nitrogen, separately or together, could be undertaken by careful *in vitro* experiments leading to unenclosed fertilization experiments. Attempts have been made to do *in vitro* experiments before, often with inconclusive results. However, the introduction of ultra-clean handling techniques means the approach can, and should, be revisited. Such a programme could quantify for example, whether the increased nitrogen input by atmospheric deposition into the subtropical gyres would materially affect the ecosystems there. The larger scale perturbation experiments also offer an unrivalled opportunity to study the internal dynamics of the marine ecosystem, and the effect of perturbation on regularly measured proxies such as isotope ratios.

   In the atmosphere, the DMS-cloud albedo link is also amenable to study by perturbation. The potency of this mechanism remains uncertain, but there is good reason to suppose that in regions remote from land and human influence (such as most of the Southern Hemisphere) DMS emission may affect cloud albedo substantially. To test this hypothesis would require first, observations of existing sulphur emissions there (for example, effect of ships' emissions) and then probably, controlled releases of SO_2 and/or DMS, followed by studies of the consequent effects on the concentrations of sulphate aerosol and CCNs. Observations would also need to be designed to quantify the marine emission of DMS and the factors influencing it.

2. Coordinated atmosphere-ocean observation and experiment campaigns: there have been relatively few campaigns strong in both atmospheric and oceanic components in the past, but the potential for advancing knowledge by such experiments is large. The DMS study described above is one example, but atmospheric deposition of nutrients, fluxes of reactive gases from sea to air, and the influence of weather patterns on the marine biota are all areas where such an approach could pay dividends.

3. Detecting change and response to natural perturbation: Detection and early warning of global change are of course important to any programme concerned with the impacts of human activities on the planet. However, detection of response to natural perturbations can also serve as an important test of our understanding of the system. Thus, for example, the response to global natural perturbations such as El Niños, monsoons and large volcanic eruptions (which inject iron and sulphur in large quantities into the environment) will be useful to study in addition to changes due to increasing industrial and agricultural activities.

Several very promising new techniques are now becoming available for detecting such responses, and SOLAS should take full advantage of them. They include:

a) Monitoring of atmospheric oxygen/nitrogen and argon/nitrogen ratios at very high accuracy. The former ratio gives direct insight into changes in the net productivity of the global oceans, while the latter may enable direct monitoring of the temperature response of the global ocean. SOLAS should encourage the setting up of a network of stations at which such ratios could be monitored, and technology transfer to enable more groups around the world to make these very exacting measurements.

b) Remote sensing of ocean properties. Sensors for ocean colour, at much improved spectral and spatial resolution, are now becoming available after more than a decade in which no instruments were flying.

c) Establishment of ocean time series. This was one of the important activities of JGOFS. It should be continued and the number of such stations increased, for example by fostering their establishment by a wider variety of nations. Such stations give data which may be difficult to interpret in isolation, because of the heterogeneity of the ocean. However, in conjunction with the new remote sensing and atmospheric data, separation of global from local trends in such time series is much more likely to be possible.

What should happen next

First, to stimulate discussion a publication of the conclusions of the working group should be made widely available to scientists in the international community. If enthusiasm for the approach is evident, we suggest a small group should organize an international workshop on the hypothesis testing approach. At the workshop steps would be taken to form a steering group to work up a science plan. The group should include one or two members of the task force which produced this document. The planning group would be responsible for ensuring adequate links with other projects (both within IGBP and relevant WCRP activities). A reasonable timescale would be for the workshop to be held in late-1998, followed by production of a science plan in mid-1999.

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Measurement and Modelling of Methane Fluxes from Landfills

by Keith Smith and Jean Bogner

Methane is an important and relatively long-lived greenhouse gas. Its atmospheric concentration has grown from about 700 ppbv in pre-industrial times to over 1700 ppbv today. It is the only long-lived gas that shows chemical feedback effects – increases in atmospheric CH_4 reduce the concentration of the hydroxyl radical, OH, and thus increase the CH_4 lifetime, and also result in increases in tropospheric ozone.

The global annual input of CH_4 to the atmosphere is estimated to be 535±125 Tg (IPCC, 1995a), of which about half is considered to be both anthropogenic and originating from biospheric processes, particularly anaerobic bacterial fermentation. Decomposition of refuse in municipal landfills is believed to be one of the major components of this biogenic CH_4, but past estimates of the emissions from this source have varied greatly, from 9 to 70 Tg yr^{-1}. More reliable estimates are clearly needed, but it appears that landfills are the largest anthropogenic source of atmospheric CH_4 in the United States and European countries. This source has been targeted in many countries as one which is capable of control by recovery of the CH_4 and using it as a fuel, thus potentially providing a way of reducing current greenhouse gas emissions.

In contrast, in developing countries, urban refuse disposal is often in open dumps, which do not result in much CH_4 emission even though they create a range of other environmental problems. However, as these dumps are replaced in the future by covered landfills it is likely that CH_4 production will increase, and in most cases this will not be recovered for use as fuel or flared, but released to the atmosphere.

Landfills characteristically have two contrasting microbial ecosystems, often with sharp gradients between them: anaerobic methanogenic zones in the refuse, and methanotrophic zones in aerated cover soils. Rates for both CH_4 production and oxidation can exceed observed rates for other terrestrial ecosystems by large factors. Field flux measurements (net emissions) vary over 7 orders of magnitude, from less than 0.0004 to about 4,000 g m^{-2} d^{-1} (Bogner et al., 1997). These net emissions, of course, are the result of CH_4 production, oxidation, and gaseous transport processes in the cover soil. The various pathways into which landfill methane is partitioned are shown in Figure 1, which illustrates that both methanotrophic oxidation and engineered control systems (pumped gas recovery) may reduce emissions.

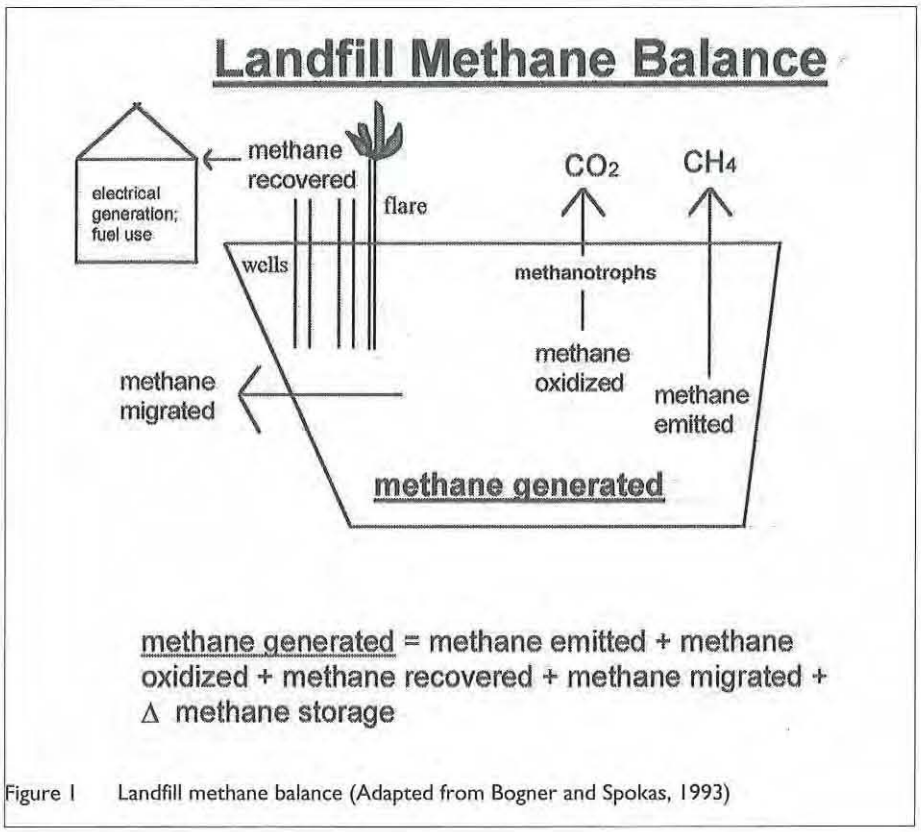

Figure 1 Landfill methane balance (Adapted from Bogner and Spokas, 1993)

Compared with more well-studied sources, mechanistic understanding of how specific physical and biochemical controls affect net CH_4 emissions from landfills is poor. Hence, it is difficult to predict emission rates at sites with various cover types, climatic regimes, and management practices. CH_4 oxidation in cover soils requires further study to determine its impact on net emissions. Oxidation rates in these soils range up to over 100 g m^{-2} day^{-1}, among the highest for any biological system, and in some cases, the landfill can be a net sink for atmospheric CH_4 oxidation. Emissions of other greenhouse gases, such as nitrous oxide, and aromatic and chlorinated compounds of environmental concern, also occur, but not much is known about flux rates.

Up to now, "top-down" approaches have been used to estimate CH_4 fluxes from landfills. The quantities and types of decomposable refuse deposited have been calculated, and multiplied by assumed rates of CH_4 generation. However, such estimates have not taken account of many factors which affect net emissions, and there is a need to be able to quantify these emissions by field measurements, to validate the top-down approach. As a contribution to this objective, IGAC's *Trace Gas Exchange: Mid-Latitude Ecosystems and Atmosphere* (TRAGEX) Activity organized a

joint North American-European Workshop at the Argonne National Laboratory, USA, on October 21-24, 1996, to establish the state of the art in field measurement and modelling of emissions, and to identify major research and scaling issues that have to be tackled to improve global estimates for input to climate models. The workshop involved participants from nine countries, and was sponsored by the European IGAC Project Office, NASA, Argonne National Laboratory, and the US Environmental Protection Agency Landfill CH_4 Outreach Program.

At the workshop, an overview of current work was given through invited presentations and a poster session. The presentations dealt with current global estimates, measurement methods, particularly chamber methods and micrometeorological techniques, oxidation studies, and isotopic techniques for characterizing microbial CH_4 processes. The remainder of the workshop consisted of three working sessions focusing on measurement strategies; on ancillary soil studies; and on modelling, scaling, and inventory issues. The principal conclusions are summarized below. A full report of the workshop has recently been published (Smith and Bogner, 1997 and is available on request from the IGAC Core Project Office.

Emission data can be obtained by chamber, inert tracer, and micrometeorological methods. All these methods have inherent advantages and disadvantages, but are not uniformly applicable to all landfill types, and preferably different methods should be used in combination. To date, most measurements have been by static chamber methods, which have also been used to determine net uptake of atmospheric CH_4 (Whalen and Reeburgh, 1990), and occasionally to measure emissions of nitrous oxide and non-CH_4 hydrocarbons from landfill surfaces.

Tracer methods involve the release of an inert tracer gas, most commonly sulphur hexafluoride (SF_6), from points along the upwind edge of the emitting surface, to simulate gas emission. If the released tracer is well mixed in a source "plume" and if the CH_4 concentration in the plume differs sufficiently from background atmospheric CH_4, then the emission rate can be obtained directly, using a ratio method (Figure 2).

Tracer methods circumvent the problem of spatial heterogeneity by integrating the whole area flux and are therefore a favoured method for estimating emissions for whole landfills. However, their high cost, dependence on meteorological conditions, and potential for interference from other sources of CH_4 limit their applicability. Only two micrometeorological methods — eddy correlation and flux gradient — have been applied so far. These methods can be used to evaluate whole-landfill CH_4 emissions, and because they are more automated, they are especially useful for the study of diurnal and seasonal flux variations. However, they require complex instrumentation and calculations, and also have surface constraints (relatively level terrain) that may limit their application.

New methods have been proposed (e.g., Fourier transform infrared methods with dispersion modelling), but have not yet been applied to landfill studies. Because previous investigations have shown significant spatial variability at a given site, major research needs include effective screening tools – simple portable gas analyzers — to aid experimental designs; a systematic comparison of various methods under both controlled conditions and full-scale field conditions; and basic studies on the variables controlling gaseous emissions.

Considerable attention was given to the effect of methanotrophic CH_4 on net emission vs. gross production, and possible isotopic approaches to quantify this relationship. Important variables include soil texture, gas-filled and total porosity, tortuosity, dynamic water content and moisture-holding capacity, clay mineralogy, and nutrient and organic matter content. For example, in landfill soils containing organic matter with a low C/N ratio, CH_4 oxidation can be suppressed because of increased nitrogen turnover. Soil cover design and management practices are also important.

Isotopic methods (both ^{13}C and deuterium (D)) are especially attractive for quantification of CH_4 oxidation in landfills. As CH_4 is oxidized, the lighter isotopes are used preferentially, leaving residual CH_4 enriched in both ^{13}C and D. The $d^{13}C$ for CH_4 in the anaerobic zone is about -50 to -60 ‰ and the dD about -285 to -325‰ (Bergamaschi and Harris, 1995). The isotopic shift is proportional to the fraction of CH_4 that is oxidized and the degree of preference of the microbes for the lighter isotope. Measurements of the shift have been used with success to estimate the fraction of CH_4 oxidized in wetlands, and have an obvious application in analogous landfill studies. Identifying the depth of maximum CH_4 oxidation would assist with determination of a minimum cover thickness and other properties needed for optimum oxidation.

The workshop also addressed issues associated with modelling landfill CH_4 emissions at various scales, including the development of improved global inventories for input to climate models. In particular, the problem of scaling up from specific site studies was discussed with reference to suggested protocols for future site classification and inventory purposes. Three methods are currently being used: (1) a US EPA system using current estimates of per capita refuse generation and landfill disposal in a first-order kinetic model for CH_4 generation, without CH_4 oxidation (Doorn and Barlaz, 1995); (2) the UK approach (Aitchison et al., 1996), also based on a

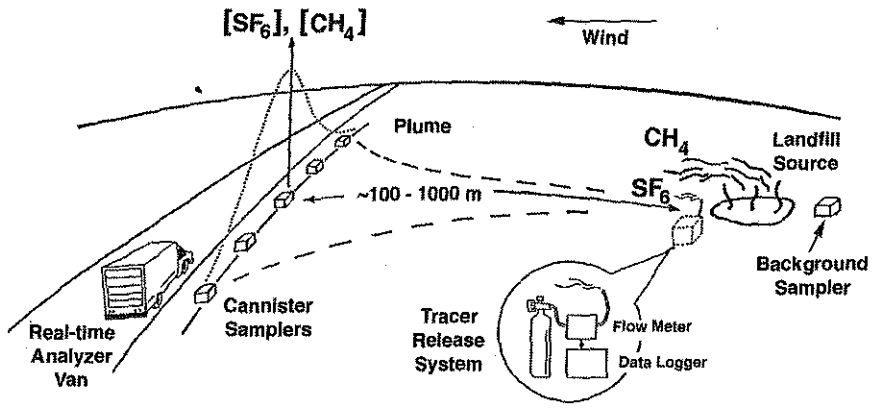

Figure 2 Use of tracer (SF_6) for field measurement of landfill methane emissions (Czepiel and Mosher, unpublished)

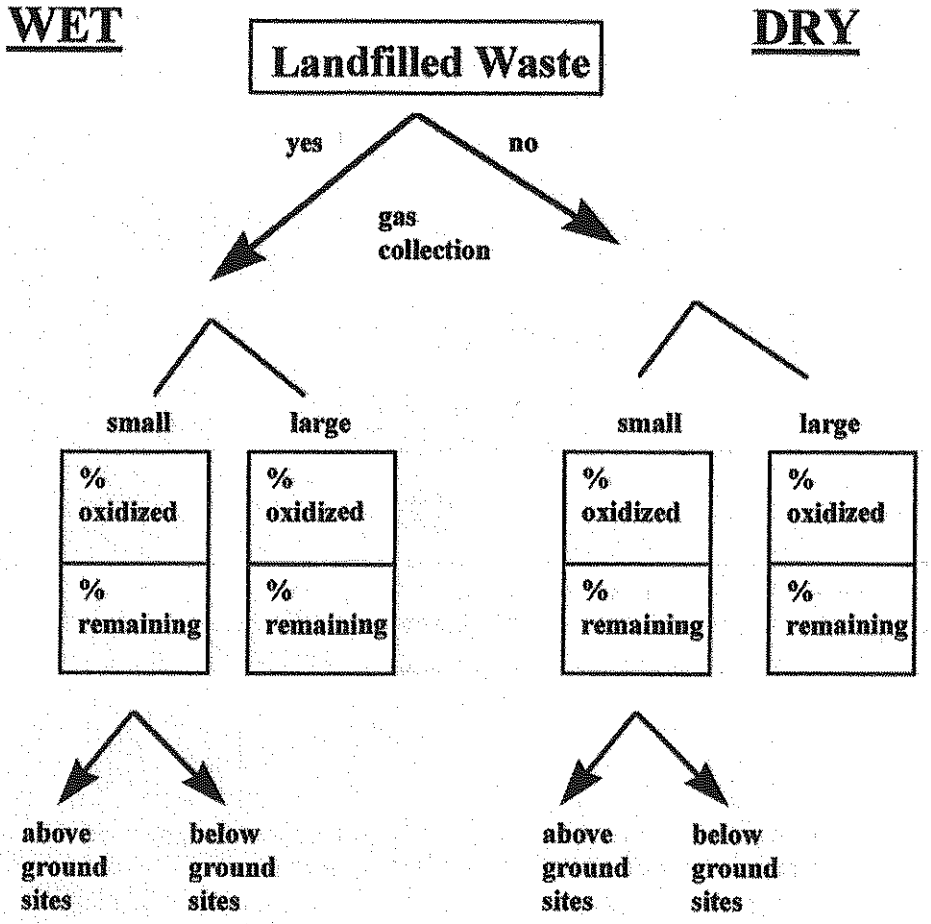

Figure 3 A conceptual model for improved quantification of country-based landfill-methane emissions. This model is for developed countries with available solid wastes and landfill management statistics. The primary criterion is wet vs. dry sites (based on the moisture content of the bulk landfilled waste), the second tier criterion is the presence or absence of pumped gas recovery, the third criterion is size (small vs. large), the fourth criterion is fractional methane oxidation, and the fifth criterion relates to site construction (above-ground vs. below-ground at small sites).

first-order model, which considers numerous factors shown to be important for CH_4 emissions over time (pumped gas recovery; refuse composition; CH_4 oxidation); and (3) the current IPCC approach (IPCC, 1995b), which assumes steady-state CH_4 generation on the basis of the degradable organic carbon content of landfilled refuse.

The improvement of models to estimate global emissions depends on the development of more refined methods, as well as improved inventories for waste generation rates, waste composition, organic carbon conversion, and CH_4 recovery. The extrapolation of results from small-scale studies to estimates of national or global emissions is difficult. The current models used for global estimates have not been validated by field measurements for either net CH_4 flux or CH_4 oxidation rates. Recommendations for scaling up include the direct use of available CH_4 flux or oxidation data where available. For many locations, national estimates could be improved through development of algorithms inclusive of specific management practices (above-ground or below-ground sites; gas recovery or no gas recovery), landfill size (gross size and surface-to-volume ratio), and realistic rates for CH_4 oxidation. An improved methodology was suggested (Figure 3) that incorporates these factors for countries where solid waste statistics are available. As such approaches are adopted and field measurement programmes are completed, there is reason for optimism that "top-down" and "bottom-up" approaches may be reconciled.

Copies of the workshop report are available from J. Bogner (Argonne National Laboratory) and from the IGAC Core Project Office.

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Jean Bogner, DOE Argonne National Laboratory, Illinois, USA

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START Fellowship/Visiting Scientist Programme

This program is designed to increase the number of developing country scientists who serve as active partners in global change research in START regional networks and in the Core Projects of IGBP, WCRP and IHDP. Through this effort, these scientists will be able to contribute to related aspects of sustainable development for their respective countries and regions.

START Fellowships are offered at the dissertation and post-dissertation levels. The fellowships allow young scientists from Africa and Asia to work under senior mentors in leading laboratories or institutions in any part of the world, where research is conducted on relevant regional aspects of global change. START fellows are able to learn and use new techniques and approaches not prevalent in their own countries. Long-term collaboration between the individuals and institution involved is one important outcome of the programme. The duration of these fellowships is ordinarily one or two semesters.

A parallel activity, the START Visiting Scientist Awards, allows more senior scientists from developing countries the opportunity to undertake short-term visits to major international laboratories to become acquainted with recent advances in research and possible policy applications. The intended outcome is the development of long-term programmatic linkages between the individuals and institutions involved.

Both the fellowship and visiting scientist award will provide economy roundtrip airfare and a modest monthly subsistence allowance.

START Guest Lectureship Programme

The objective of the START Guest Lectureship Programme is to provide scientists and institutions in the START regional networks with the opportunity to establish long-term links with leaders in global change research. During their visit, lecturers are based at START Regional Centers or research sites. There, they interact closely with the staff at the host institution and within the region by providing lectures, tutorials, and advice. The aim is to strengthen existing global change activities and also assist in establishing new lines of policy-related global change research. Priority is given to scientists willing to develop long-term links between their own and the host institution. START Visiting Lecturers must also be willing to commit to an extended relationship with the host institution. Lectureships require a minimum stay of one week.

For short-term visits of less than one month, travel (round-trip economy) and subsistence expenses are provided. For long-term visits of one month or more, an honorarium may also be awarded.

Nominations/Applications

The following information should be included in nominations/applications for the START Fellowship, Visiting Scientist or Visiting Lectureship Programmes:

1) Expected outcomes and benefits of the proposed fellowship or lectureship;
2) Indication of willingness of host institution to receive fellow or lecturer;
3) Brief resume of candidate, including relevant qualifications and experience; and
4) Proposed budget requirements (economy airfare and stipend as appropriate).

The deadline for the fifth round of awards has tentatively been set for October 1, 1997.

For further information, contact Ms. Anne Phelan, Programme Associate, at:

International START Secretariat, 2000 Florida Avenue, NW, Suite 200, Washington, DC 20009 USA. Tel: (1-202) 462-2213; Fax: (1-202) 457-5859, E-mail: aphelan@kosmos.agu.org

IGBP and Other Meetings

1997

First week September, Vladivostok, Russia
7th TEACOM Meeting.
Congbin Fu, START Regional Centre for Temperate East Asia, CAST, ICR, Institute of Atmospheric Physics, Zhongguancun Road, Beijing 100080, P.R. of China. Fax: (+86-10) 6256 2458, E-mail: fcb@ast590.tea.ac.cn

1-7 September, Krasnoyarsk, Russia
PAGES/GCTE/IGAC/BAHC Workshop on Spatial-Temporal Dimensions of High Latitude Ecosystem Changes.
Eugene A. Vaganov, Institute of Forest SB RAS, Akademogorok, Krasnoyarsk, 660036 Russia. Fax:(+7-3912) 43 36 86, E-mail: evag@ifor.krasnoyarsk.su

3-6 September, Nairobi, Kenya
WHO/START/GCTE/LUCC Workshop: Global Change Impact Assessment Approaches for Vectors and Vector-Borne Diseases.
John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

15 September, Washington DC, USA
8th START Bureau meeting.
International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859. E-mail: start@dis.start.org

15-17 September, Washington DC, USA
11th START SSC meeting.
International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859. E-mail: start@dis.start.org

22-24 September, Baltimore MD, USA
ICES International Symposium on Recruitment Dynamics of Exploited Marine Populations: Physical-Biological Interactions.
ICES Secretariat, Palagade 2^4, DK-1261 Copenhagen, Denmark. Fax: (+43-33)934 215, E-mail: ices.info@ices.dk

October, Ispra, Italy
DIS Focus 1: Fire Project Workshop.
José Miguel Pereira, D.E.F./I.S.A., Tapada Da Ajuda, 1300 Lisboa, Portugal. Fax: (+351-1) 364 5000. E-mail: jmcpereira@isa.utl.pt or Chris Justice, NASA/GSFC - Code 923, Greenbelt, MD 20771, USA. Fax: (+1-301) 286 1775, E-mail: justice@kratmos.gsfc.nasa.gov

2-5 October, Rio de Janeiro, Brazil
10th IGBP Officers Meeting
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

6-9 October, Texel, Netherlands
JGOFS/LOICZ Continental Margins Task Team Workshop.
Stephen V. Smith, University of Hawaii, Honolulu HI 96822, USA. Tel: (+1-808) 56 8693, e-mail: svsmith@soest.hawaii.edu

10-13 October, Noordwijkerhout, Netherlands
*LOICZ Open Science Meeting 1997.
LOICZ CPO, NIOZ, PO Box 59, NL-1790 AB Den Burg-Texel, Netherlands. Fax: (+31-222) 369 430, E-mail: loicz@nioz.nl

13-14 October, Noordwijkerhout, Netherlands
7th LOICZ SSC
LOICZ CPO, NIOZ, PO Box 59, NL-1790 AB Den Burg-Texel, Netherlands. Fax: (+31-222) 369 430, E-mail: loicz@nioz.nl

16 and 19 October, Pusan, Republic of Korea
2nd Meeting of the JGOFS North Pacific Task Team
Alexander Bychkov, Institute of Ocean Sciences, PO Box 6000, Sidney, B.C., Canada V8L 4B2. Fax: (+1-250) 363 6827, E-mail: bychkov@ccs.ios.bc.ca

17-18 October, Pusan, Republic of Korea
PICES/GLOBEC Workshop on Carrying Capacity and Climate Change.
Elizabeth Gross, SCOR, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

20-22 October, Giessen, Germany
GCTE Activity 4.3 Time-zero Meeting: Interactive Effects of Global Change on Ecological Complexity.
Volkmar Wolters, Department of Animal Ecology, Justus-Liebig University, Stephanstrasse 24, D-35390 Giessen, Germany. E-mail:volkmar.wolters@allzool.bio.uni-giessen.de

20-23 October, Beijing, China
TEA Regional Modelling of Monsoon System.
Congbin Fu, fax: (+86.10) 6204 5230, E-mail: fcb@ast590.tea.ac.cn

23-25 October, La Jolla CA, USA
GLOBEC SPACC Steering Committee.
John Hunter, Southwest Fisheries Science Center, Coastal Fisheries Resources Division, La Jolla, CA 92038-0271, USA. Fax: (+1-619) 546 5656, E-mail: john.hunter@noaa.gov

24 October, Anaheim CA, USA
GCTE Focus 1 Soil Warming Workshop.
Lindsey Rustad, E-mail: rustad@maine.maine.edu

26-28 October, San Diego CA, USA
GCTE Activity 2.2 Workshop on Global Change and Terrestrial Ecosystems - Landscape Scale Processes.
Sandra Lavorel, RSBS, ANU, Canberra ACT 0200, Australia. Fax: (+61-6) 249 5095, E-mail: lavorel@rsbs-central.anu.edu.au

29-31 October, Santa Barbara CA, USA
GCTE Activity 4.2 Workshop: Global Change and Landscape Complexity
Indy Burke, Colorado State University, Department of Forest Sciences, Fort Collins CO 80523, USA. E-mail: indy@artemisia.cfnr.colostate.edu

30-31 October, Williamsburg VA, USA
JGOFS Executive Meeting.
JGOFS International Project Office, Centre for Studies of Environment and Resources, University of Bergen, High Technology Centre, 5020 Bergen, Norway. Fax:(47-55) 58 96 87, E-mail: jgofs@uib.no

November, Santa Barbara CA, USA
GCTE Focus 4 - Activity 4.1 Workshop: Biodiversity and Ecosystem Functioning.
David Tilman, 100 Ecology Building, University of Minnesota, 1897 Upper Buford Circle, St. Paul, MN 55108-6097, USA. E-mail: tilman@cdr.lter.umn.edu

1-3 November, Santa Barbara CA, USA
GCTE Focus 4 Time-zero Workshop and Planning Meeting.
Elisabeth Huber-Sannwald, GCTE Focus 4 Officer, Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av San Martin 4453, Buenos Aires 1417, Argentina. Fax: (+54-1) 521 1384, E-mail: huber@ifeva.edu.ar

3-5 November, Accra, Ghana
START/NAF Workshop on Land Use/Land Cover Change in Northern Africa (tentative).
G.T. Aygepong, University of Ghana-Legon. Fax:(+233-32) 500 310., E-mail: rsau@ncs.com.gh

3-6 November, Beijing, China
Land-Use Cover Change in Temperate East Asia (LUTEA) Meeting.
Dennis Ojima, Fax: (+1-970) 491 1965, E-mail: dennis@nrel.colostate.edu

3-14 November, Sioux Falls SD, USA (tentative)
DIS Focus 1: Land Cover validation workshop.
Joseph Scepan, University of California, Santa Barbara, Department of Geography, Santa Barbara CA 93106-4060, USA. Fax: (+1-805) 893 3703, E-mail: scepan@geog.ucsb.edu

7-10 November, Hilterfingen, Switzerland
PAGES Leader Meeting
Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

8-10 November, Barcelona, Spain
LUCC SSC Meeting.
LUCC Core Project Office, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: carolinen@icc.es

11-13 November, Nagoya, Japan
*IGAC International Symposium on Atmospheric Chemistry and Future Global Environment.
Yoshizumi Kaiji, RCAST, University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153, Japan. Fax. (+81-3) 3481 4562, E-mail: kaiji@atmchem.rcast.u-tokyo.ac.jp

11-14 November, Barcelona, Spain
LUCC/IGBP-DIS Data Requirements Workshop
LUCC Core Project Office, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: carolinen@icc.es

12-14 November, Wageningen, Netherlands
GCTE Workshop on Modelling Inter-Plant Competition in Natural and Agro-Ecosystems.
John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, McLean Building, Crowmarsh Gifford, Wallingford OX10 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

15-18 November, Chungliu, China-Taipei
START(SARCS)/LUCC/IGAC Synthesis Workshop on Greenhouse Gas Emissions, Aerosols, and Land Use and Land Cover Change in Southeast Asia.
Tolentino B. Moya, Southeast Asian Regional Center for START (SARCS), Phayathai Road, Bangkok 10330, Thailand. Fax: (+66-2) 255 4967, E-mail: toti@start.or.th

16-19 November, Wageningen, Netherlands
GCTE-BAHC-LUCC Workshop: Development of Joint Projects and Coordinated Activities within and between IGBP Core Projects GCTE, BAHC, and IHDP/IGBP LUCC.
Irene Gosselink, AB-DLO, PO Box 14, 6700 AA Wageningen, Netherlands. Fax: (+31-317) 423 110, E-mail: igbp@ab.dlo.nl

17-21 November, Mar de Plata, Argentina
GLOBEC SPACC Working Group on Daily Growth, Zooplankton and Physical Forcing.

19-24 November, Almeria, Spain
Joint MEDALUS-GCTE Focus 3 Workshop on Field Experimentation: Impact of Global Change on Semi-Arid Erosion Processes.

Juan Puigdefabregas, EEZA, CSIC, Calle Gen. Segura, 104001, Almeria, Spain. Fax: (+34-50) 277 100, E-mail: puigdef@eeza.cscic.es

24-28 November, Bolinao, Philippines

SARCS/WOTRO/LOICZ Workshop

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

December, Potsdam, Germany

GCTE Focus 2 Workshop on Comparison of Forest Patch Models.

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

December, Santa Barbara CA, USA

GCTE Focus 4 - Activity 4.2 Workshop: Effects of Landscape Complexity on Ecosystem Functioning.

Elisabeth Huber-Sannwald, GCTE Focus 4 Officer, Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av San martin 4453, Buenos Aires 1417, Argentina. Fax: (+54-1) 521 1384, E-mail: huber@ifeva.edu.ar

8-10 December, Salt Lake city UT, USA

GCTE Focus 1 Biosphere-Atmosphere Stable Isotope Network (BASIN) Workshop: Strategies for Linking Ecosystem Processes and Global Carbon Balance.

Jim Ehleringer, Department of Biology, University of Utah, Salt Lake City, Utah 84112, USA, Fax: 8+1-801) 581 4665, E-mail: ehleringer@bioscience.utah.edu

TBA

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

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

Late 97/Early 98, TBA

The Use of Stable Isotopes in selected Paleoarchives Workshop.

1998

17-21 February, TBA

13th SC-IGBP Meeting.

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

25-27 February, Toulouse, France

9th IGBP-DIS SSC Meeting.

Gérard Szejwach, IGBP-DIS Office, 42 Avenue G. Coriolis, F-31057 France. Fax: (+33-5) 61 07 85 89, E-mail: gerard.szejwach@igbp.cnrm.meteo.fr

14-18 March, Barcelona, Spain

*GCTE-LUCC Open Science Conference.

Pep Canadell, GCTE Focus 1 Office, Department of Biological Sciences, Stanford University, Stanford, CA 94305, USA

16-20 March, Heraklion, Crete

IGAC/GIM and GAIM Worskhop on Inverse Modelling of Global Biogeochemical Cycles.

Martin Heimann, Max-Planck-Institut für Meteorologie, Bundesstrasse 55, 20146 Hamburg, Germany. Fax: (+49-40) 41173 298, E-mail: martin.heimann@dkrz.de http://www.gatech.edu/gsc/inverse/overall.web.html

17-20 March, Paris, France

*GLOBEC Open Science Meeting

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

April, Chiang Mai, Thailand

PAGES Tree ring Workshop

Brendan Buckley, University of Tasmania

19-23 April, London, UK

*PAGES Open Science Meeting.

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

24-29 May, Halifax NS, Canada

*WOCE Conference on Ocean Circulation and Climate.

WOCE IPO Southampton Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, United Kingdom. Fax: (+44-1703) 596 204, E-mail: woceipo@soc.soton.ac.uk http://www.soc.soton.ac.uk/others/woceipo/ipo.html

June/July, Potsdam, Germany

3rd GAIM/DIS/GCTE Workshop on Comparing Global Biogeochemical Models.

Wolfgang Cramer, Potsdam Institute for Climate Impact Research, Telegrafenberg, Postfach 601203, 14412 Potsdam, Germany. Fax: (+49-331) 288 2600, E-mail: wolfgang.cramer@pik-potsdam.de

August, Montpellier, France

*GCTE Special Session at International Soil Science Congress.

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

19-25 August, Seattle WA, USA

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

Patricia Quinn, NOAA/PMEL/JOCRD, 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/

1-7 September, Nairobi, Kenya

*Fifth Scientific Advisory Council Meeting (SAC V).

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

September/October, Nova Scotia, Canada

WMO-IGAC International Cloud Chemistry Modelling Meeting.

Andrea Flossman, Université Blaise Pascal - CNRS, Laboratoire de Météorologie Physique, 24 Avenue des Landais, 63177 Aubiére Cedex, France. Fax: (+33-7) 327 1657, E-mail: flossman@opgc.univ-bpclermont.fr

followed by and linked to:

WCRP-IGAC Workshop on a Comparison of the Performance of Large Scale Models in Simulating Atmospheric Sulfate Aerosols.

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

October, TBA

11th IGBP Officers Meeting

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

1999

21-24 August, Potsdam, Germany

GCTE Focus 2/3 Workshop on Crop Models and Scaling.

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

20-23 September, Reading, UK

GCTE Focus 3 Science Conference.

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

Important

Please note that a decision has been made to postpone the convening of the Fifth Meeting of the Scientific Advisory Council and National Committee Meeting to 1-7 September 1998.

GLOBAL CHANGE NEWSLETTER

Edited by Sheila M. Lunter

Requests for reproduction of articles appearing in this distribution should be addressed to the Editor (E-mail: sheila@igbp.kva.se)

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http://www.igbp.kva.se/

The IGBP Report Series is published in annex to the Global Change NewsLetter

Ocean Circulation and Climate - The 1998 WOCE Conference Halifax N.S, Canada, 24 - 29 May 1998

The World Ocean Circulation Experiment: WOCE is a component of the World Climate Research Programme investigating the role played by the ocean circulation in the earth's climate system. Its aim is to develop improved ocean circulation models for use in climate research. The WOCE observational phase from 1990 - 1997 has used satellites and *in situ* physical and chemical measurements to produce a data set of unprecedented scope and precision. WOCE is now entering its phase of Analysis, Interpretation, Modelling and Synthesis (AIMS) which will continue until the end of WOCE in 2002. The reconciliation of model results and observations, and ultimately the assimilation of ocean data into models, presents the ocean science community with a novel set of challenges.

The Conference

The 1998 WOCE Conference "Ocean Circulation and Climate" marks the end of the observational phase and looks towards the challenges of WOCE AIMS. It will provide an opportunity for scientists who have been involved in the observational and modelling activities to display the progress made towards the programme's objectives and to highlight the intellectual challenges that remain to derive maximum benefit from the enormous investment already made in WOCE.

Scientific Organizing Committee

Gerold Siedler (Chair), Trevor McDougall, Bernard Barnier, Carl Wunsch, Nobuo Suginohara, Allyn Clarke, John Gould and Andrea Frische (WOCE IPO).

Conference Structure

In order to provide the greatest opportunity for interaction between scientists with varying interests there will be no parallel sessions. Each day will have a particular theme relating to the overall objectives of WOCE. A series of invited plenary lectures will be given in the mornings and afternoons will be dedicated to posters. Posters will, as far as possible, be related to the daily themes and will be available for viewing throughout each day. The call for poster presentations will be made in August 1997 with a submission deadline of February 1998. A book of poster abstracts will be produced prior to the meeting.

Main Announcement and Registration

The main announcement containing the registration form, details of the plenary lectures, poster submission and accommodation will be issued in August 1997. The first circular can be obtained from the WOCE IPO (woceipo@soc.soton.ac.uk) and is also available on the WOCE Conference WWW Page: http://www.soc.soton.ac.uk/OTHERS/woceipo/wconf

IGBP Homepage

The homepage has adopted a new look. Although the contents are for the major part the same, the presentation has changed. The new version uses frames to facilitate navigation of the page and pointers are included to the necessary software to view the homepage. A new feature is the possibility to view the Global Change NewsLetter in Acrobat Reader, which shows the publication as if it were printed. In future IGBP reports will be available in the same format on the homepage. Herewith we hope to increase the accessibility of our publications.
The IGBP homepage will be continuously updated and new features will be added to it. Your comments and suggestions for the homepage are highly valued and can be directed to: sheila@igbp.kva.se

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Global Change and Terrestrial Ecosystems (GCTE) Core Project of the International Geosphere-Biosphere Programme (IGBP)

CORE PROJECT EXECUTIVE OFFICER

The Global Change and Terrestrial Ecosystems (GCTE) Core Project of the International Geosphere-Biosphere Programme (IGBP) is seeking to appoint a highly motivated and independent person as its Executive Officer, based at the GCTE Core Project Office in Canberra, Australia. The successful applicant will take administrative and scientific responsibility for a small, dynamic international office coordinating GCTE's international research programme. GCTE's objectives are: (i) to predict the effects of changes in climate, atmospheric composition, and land use on terrestrial ecosystems, including agriculture, forestry, soils, and ecological complexity; and (ii) to determine how these effects lead to feedbacks to the atmosphere and the physical climate system. As of July 1997 the GCTE Core Research Programme consisted of 55 contributing projects involving over 1000 scientists and technicians from 44 countries. This research is supported by a large number of national and regional agencies; its current value on an annual basis is about $US 44.2 million. Further information on GCTE can be found on the homepage at: http://jasper.stanford.edu:80/GCTE/

Responsibilities:

- manage the GCTE Core Project Office and its staff on a day-to-day basis;
- act as the central communication node for the international GCTE community;
- assist the Chairman and the Scientific Steering Committee (SSC) in developing and coordinating the GCTE Core Research Programme;
- provide project advocacy, promotion and publicity;
- develop and maintain links with the IGBP Secretariat, other IGBP programme elements, and other international and national agencies and programmes;
- raise funds for GCTE activities;
- assist the Chairman and SSC in providing policy advice to appropriate agencies;
- organize conferences, meetings and workshops in support of GCTE.

Qualifications and Experience:

- a broad interest in the scientific fields related to GCTE;
- appropriate management, organizational and communication skills;
- a Ph.D. (or equivalent research experience) in ecology or a related discipline;
- experience in the organization of international meetings and workshops;
- a sound working knowledge of the English language;
- flexibility and willingness to undertake extensive, long-distance overseas travel.

Conditions:

The contract is for a period of 2 years, with a commencement date of April 1998. The successful applicant will be an employee of the Commonwealth Scientific and Industrial Research Organization (CSIRO). Salary will be commensurate with qualifications and experience. Applications from persons interested in accepting the appointment on a leave of absence from their home institution or university are encouraged.

Location:

CSIRO Division of Wildlife & Ecology, Canberra, Australia.

For further information, please contact the GCTE CPO, Tel: 61-6-242-1748; Fax: 61-6-241-2362; E-mail: rowena.foster@dwe.csiro.au

Interviews with selected applicants will be conducted in the English language. Applications in English, together with a curriculum vitae and names and contact information for three referees, should be directed to: Administrative Officer, GCTE Core Project Office, PO Box 84, Lyneham, ACT 2602, AUSTRALIA. The closing date for applications is 10 OCTOBER 1997.

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