GLOBAL CHANGE NEWSLETTER

No. 29 — March 1997

The International Geosphere–Biosphere Programme: A Study of Global Change (IGBP) of the International Council of Scientific Unions

Climate Variability, Prediction and Agriculture in Bogor, Indonesia

Four participants of the START/WCRP/GCTE Asian Monsoon Regional Workshop in Bogor, Indonesia, taking a break in the botanical gardens. From left to right:: Chris Rapley, Executive Director IGBP, Anne Phelan, International START Secretariat, Atiek Widayati , BIOTROP-GCTE Southeast Asian Impacts Centre, and Peter Tyson, Chair of START.

CONTENTS

Implications of Global Change for Natural and Managed Ecosystems:
A Synthesis of GCTE and Related Research

by Will Steffen

During the second half of 1996, GCTE undertook a synthesis of the major results of its work so far. The synthesis project aimed to pull together what has been learned in GCTE and related research over the past six years, and to highlight gaps in understanding and future challenges.

The project drew on the work of over 750 scientists and technicians in 42 countries around the world who contribute to GCTE's networks and consortia. This global research effort was integrated by the team of GCTE Focus, Activity and Task Leaders, who met for two workshops, in Berlin, Germany, and Santa Barbara, CA, USA. The synthesis project was supported by the German National IGBP Programme and by the USA National Center for Ecological Analysis and Synthesis. This summary presents the major findings of the synthesis.

The Functioning of Ecosystems

Global change is affecting the functioning of terrestrial ecosystems in complex ways. Given the certainty of continuing atmospheric CO_2 increase and its importance for the growth and functioning of vegetation, much of GCTE's initial work on ecosystem physiology has focused on the effects of elevated CO_2 and its interaction with other factors.

Effects of elevated CO_2 The major findings are:

- Within the experimental time frame (< 10 years), all ecosystems respond to elevated CO_2 (increased net CO_2 uptake) to some extent, the cold systems being less responsive (*e.g.*, tundra).
- The prediction that C^4 species will respond less to elevated CO_2 than C^3 species is generally not realised in natural systems. [1]
- An increased concentration of carbon relative to nitrogen (protein) is observed in live leaves grown under elevated CO_2. However, this effect appears not to be reflected in the chemical composition of the litter, as was hypothesised at the time of GCTE's inception. If this holds true in the long term, decomposition rates of litter, and therefore rates of nutrient cycling in ecosystems, will not be slowed, as was initially thought.

Water and energy cycles The first whole-ecosystem elevated CO_2 experiments were conducted on crops, grasslands and tree seedlings. This work showed consistent stomatal closure under elevated CO_2, and consequent reduction in loss of water through transpiration. Thus, more carbon is assimilated under elevated CO_2 than at ambient concentrations for a given amount of water loss. But data from studies on mature trees, for which technically feasible CO_2 elevation methodologies have only recently become available, suggest that the stomatal closure, and therefore reduced loss of water, under high CO_2 that is found in herbaceous systems and in tree seedlings may not occur in mature forests. This has significant implications for the feedback effect of the biosphere on atmospheric processes, and on water cycles and the pattern of water availability in ecosystems in general.

Changes to the Structure and Composition of Ecosystems

Six years ago most studies of ecosystem structural change were either global-scale simulations of simple biome shifts based on equilibrium vegetation models or local studies of the response of a single species or small groups of species. Since then some of the more difficult problems - such as lag effects and migration rates, disturbances and other landscape processes, interaction between land use and climate, biome reorganisation as well as shifts - have begun to be addressed. Some important advances are:

- *Disturbances/migration* An initial analysis of the ability of plant species to move across landscapes in response to a changing climate, based on both paleo-environmental and modelling studies, suggest that migration rates are sufficiently large to cope with projected climatic change if the plants can move through a continuous natural ecosystem. However, given the current level of fragmentation of ecosystems due to land-use and the likelihood that fragmentation will increase over the coming decades, many species will have trouble in "tracking" a rapidly changing climate.
- *DGVM (Dynamic Global Vegetation Model) development* The first generation of Dynamic Global Vegetation Models (DGVM's) have emerged from equilibrium models following a number of developments: (i) the coupling between, and then the integration of, global biogeochemical and biome distribution models; (ii) the use of plant functional types rather than biome types as the fundamental unit of structure, thus allowing simulation of changing composition within a particular biome; (iii) initial attempts at coupling vegetation models and climate models in an interactive way; (iv) the incorporation of decadal scale ecosystem dynamics, such as lag effects and disturbances; (v) testing of DGVM simulations against records of past climate and vegetation change.

Agriculture, Forestry and Soils

The human population is expanding by one billion per decade, with much of this increase in developing countries in the equatorial regions of the world. To meet the associated food demand, crop yields will need to increase, consistently, by over 2% every year, putting enormous stress on terrestrial production systems.

This need to increase food production is expected to lead to intensification of agriculture in areas which are already cropped, and, despite increases in crop yields, to conversion of forests and grasslands into cropping systems. Much of the latter will occur in semi-arid regions and on lands which are less suitable for cultivation, which will likely lead to soil erosion, accelerated water use, and further land degradation.

Work over the past six years on terrestrial production systems has produced the following major results.

- *Crop production* Crop production will be affected very differently in different parts of the world (as already highlighted by other recent assessments). There is a mismatch between, on the one hand, beneficial projected climatic effects and low population growth, and, on the other hand, negative climatic effects and high population growth. A major concern is rice production in low latitudes, especially Southeast Asia, where yields are likely to reduce by 5% for each degree C rise.

- *CO_2 effects* The effects of increasing atmospheric CO_2 on crop yields will be much smaller than the 30% increase assumed a few years ago. In the mid-latitudes CO_2 induced yield increases in wheat are unlikely to exceed 10% under ideal conditions, and only 5-7% under field conditions.
- *Crop losses* Weeds, pests and diseases will likely become an increasingly serious problem. Associated losses reduce harvestable yields by around 50%. Increases in temperature are likely to increase insect impacts (especially) in temperate regions, both through incursions of tropical pests and diseases and through increased frequencies and intensities of temperate pest species.
- *Livestock* Rangelands livestock production will be dominated by changes in the ratio of potential evapotranspiration to precipitation. However, in both rangelands and pastures a $2xCO_2$ increase is predicted to increase aboveground production by 0 to 20% (but with a maximum increase of 7% in developing countries). In cultivated pastures, limited sensitivity analysis suggests that a 5% increase in pasture growth will lead to about a 3% increase in liveweight gain, mainly through reducing inter-annual variability in primary productivity.

Biodiversity

A recent analysis of future biodiversity trends identified the main cause of biodiversity loss in the coming decades as land-use change, mainly loss of habitat and landscape fragmentation. The next most important factor identified was invasion of alien species. Although trends are less certain here, the general conclusion is that alien species will be an increasing problem, given (i) the globalisation of economies, and hence the movement of people and materials, and (ii) the susceptibility of disturbed ecosystems to invasions. Climate change is regarded as a longer term factor, increasing in relative importance over time.

Research on the consequences of these changes to biodiversity for the functioning of terrestrial ecosystems is in its infancy. The consequences are almost entirely unknown, although it is likely that they will not be benign.

Overall Synthesis Across GCTE

In addition to these Focus-level syntheses, work is nearly complete on a GCTE-wide synthesis, drawing on insights and improved understanding from two or more Foci. Major themes are:

- A prospective analysis of the terrestrial carbon cycle, taking into account (i) the carbon dynamics of land-use/cover change; (ii) long-term changes in ecosystem structure, especially effects of disturbances; (iii) CO_2 fertilisation; and (iv) physiological "saturation" at long time scales.
- Integration of ecosystem physiological and structural responses to global change.
- A systems-level approach towards terrestrial production systems, drawing on elevated CO_2 research, analyses of biological invasions, and a "time zero" synthesis of global change and ecological complexity.

[1] *The processing pathways for photosynthesis are different for C^3 and C^4 species.*

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Editorial

Breaking new ground is a hallmark of the IGBP. Examples include the unprecedented disciplinary diversity of the research networks it has established, the rich variety of cross-linkages and collaborations between its component parts, and its growing efforts through START (jointly with WCRP and IHDP) to link both global and regional research, and basic science with policy.

Now, after six years of work, the Global Change Terrestrial Ecosystem (GCTE) Core Project is carrying out a major synthesis exercise. The aim is to provide the science community, policy makers and public alike with a clear view of recent progress in its field, to describe the limits of current knowledge and understanding , and to identify future challenges. This pioneering initiative within the IGBP is being monitored closely with a view to its possible adoption throughout the programme. The preliminary results described in the lead article of this issue of the *Global Change Newsletter* demonstrate both the impressive progress made within GCTE and the value of simple language to summarise results and to explain their context and importance. A more comprehensive statement and a major press release will follow in due course.

Also covered in this issue are reports on one of the major experiments within IGAC, on developments within the Miombo transect, and on work in progress to link IGBP research with that of the Scientific Committee on Antarctic Research (SCAR).

In addition descriptions are given of the GLOBE educational project, aimed in part at mobilising the world's schoolchildren to provide data for global change research, and of the potential of global change to impact human health. The latter is a rising concern.

Will IGBP find ways to interact beneficially with these developing initiatives? Since GCTE and LUCC are already exploring collaborations with health scientists, and there is an increasing interest in communicating IGBP's new knowledge widely, the answer is an almost certain "yes". IGBP's innovative tradition continues.

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Global Environmental Change and Human Population Health

by Anthony McMichael and Sari Kovats

The large-scale disturbance of natural biophysical systems necessarily poses risks to human population health. The sustained health of populations depends on reasonable stability of climate, protection from solar ultraviolet radiation, adequate supplies of food and fresh water, and maintenance of biodiversity (as a source of genetic and phenotypic materials, and as a stabiliser of ecological systems).

Until now, human societies have generally been able to take these supportive environmental "services" for granted — or else have dealt with localised food and water shortages by migrating, importing or otherwise improvising. Because, in the past, we have had rather little need to consider the systemic, ecological, basis to human health, we tend to perceive health as reflecting heredity, luck, and various day-to-day tangibles (for example, occupational and environmental regulation, personal consumer choices and behaviour, and access to health-care). However, the potential health impacts of global environmental changes do not refer to such local, day-to-day, health experiences, but to changes in our *global* "life support systems". To argue, as some do, that things must actually be getting better since life expectancies are increasing is to misunderstand the essential "newness" of this hazard. Gains in life expectancy, in nature, tend to happen in circumstances conducive to rapid population growth — that is, when the *immediate* carrying capacity (supply) of the environment exceeds the number of dependent individuals (demand). These generalised gains in human life expectancy indicate that, currently and recently, the life-supporting capacity of the human-modulated environment has been increasing. But we must ask: At what cost — or at what future risk?

How can we assess the long-term health impacts of global change? At one extreme are those changes which transcend their points of origin, and which entail change in truly global "commons". This category includes climate change and stratospheric ozone depletion. A different type of "global change" comprises the worldwide mosaics of multiple local change, which tend in aggregate to span much of the world. This category includes: deforestation, land degradation, the depletion of fresh water, loss of biodiversity, and depletion or displacement of ocean fisheries. Traditional environmental health concerns relate to localised pollution in the water, soil and air, for example, lead, polychlorinated biphenyls, mercury exposures. Although increasingly widespread, such problems are not usually regarded as part of *global* environmental change.

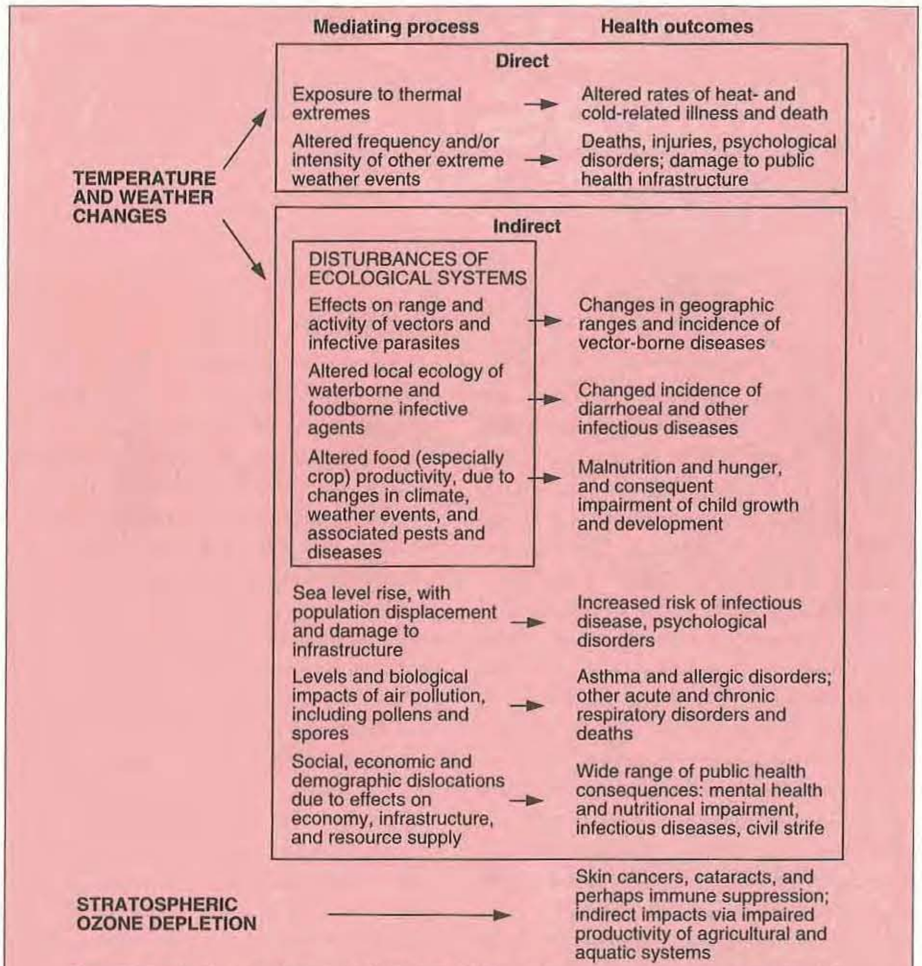
Most global change research focuses on processes and impacts within biogeophysical systems. We have been slow to appreciate that an important final common pathway for such changes is the impact on human health; it is a crucial *integrated* outcome measure. Health impacts research is now expanding, particularly in the fields of climate change and stratospheric ozone depletion. The IPCC's Second Assessment Report included for the first time a chapter on health, and in 1996 a Task Group from the World Health Organization, the World Meteorological Organization, and UNEP produced a comprehensive book on the health impacts of climate change. UNEP and WHO have both conducted assessments of the health impacts of stratospheric ozone depletion.

Environmental health risk assessment is typically studied in a population by looking at past events and deriving dose-response relationships which are then extrapolated to a wider population. In the future-orientated global change arena, this is useful for looking at "direct" environment/health factors, such as the relationship between UV-B exposure and skin cancer, or heatwaves and mortality, for which dose-response relationships have already been estimated. For other types of anticipated health impact, extrapolation from local climate-related changes in health may be useful to forecast future health impacts. For example, recent localised climate changes in Rwanda and Ethiopia have been associated with, respectively, an increased incidence or altitudinal range of malaria. Similarly, climate analogue scenarios may be used to compare the impacts of a particularly warm period. Studies of the health impacts of El Niño events have begun to illustrate that broad regional climate signals can have quantitative and predictable impacts on health — particularly with respect to epidemics of vector-borne diseases.

The complexity of the task of predicting future health impacts also requires the development of integrated mathematical models. Much is now being done in this area. For example, MIASMA (Modelling framework of the health Impact ASsessment of Man-induced Atmospheric changes) has been developed by Martens and colleagues at the University of Maastricht in collaboration with the Dutch National Institute of Public Health and Environment (RIVM). MIASMA is a component of the widely-used TARGETS (Tool to Assess Regional and Global Environmental and health Targets for Sustainability), an integrated assessment model also developed at RIVM.

Current research progress is well illustrated by the assessment of future climate-related changes in the potential incidence of vector-borne diseases — one of the major health problems in tropical and subtropical countries. Malaria currently affects around 350 million people per year, causing two million deaths, mostly in children. Thus, even small changes in its distribution are likely to have major health impacts. Changes in temperature primarily determine vector and parasite survival and, therefore, the limits of their distribution. Precipitation directly influences the abundance of breeding sites and vector-density — epidemics of mosquito-borne diseases often follow heavy rains. Disease incidence is also dependent upon other local factors: such as host susceptibility and public health interventions.

A global malaria model, a component of MIASMA, has estimated changes in the *potential* geographic range for malaria transmission in response to GCM climate change scenarios. The potential for malaria transmission currently includes approximately 45% of the world population and, if (a rather big "if"!) other factors remain constant, this would increase, very approximately, to 60% in the latter half of next century. This model is now being validated against historical datasets. Nevertheless, such a global aggregated model is not



Possible major types of impact of climate change and stratospheric ozone depletion on human health

able to take into account local ecosystem changes. For example, changes in forest cover or irrigation will affect mosquito breeding sites and densities.

Changes in socio-economic conditions are an important further consideration for health impacts assessment. For example, the model estimates that a 3°C warming by 2100 would increase the transmission *potential* for malaria in temperate countries a 100-fold. But this is unlikely to be realised in actual malaria cases because the richer countries would be able to undertake effective local public health surveillance. *Actual* increases in malaria in response to climate change are likely to occur in those vulnerable populations currently at the margins of established endemic areas, particularly in the tropical and subtropical regions. Recent studies in eastern Africa — including studies in Zimbabwe, Rwanda and Ethiopia — indicate that malaria would move to higher altitudes in the highland regions, thereby affecting populations that currently experience periodic outbreaks or are malaria-free.

A recent illustration of integrated mathematical modelling refers to the impact of stratospheric ozone depletion upon skin cancer incidence in fairskinned populations. The study, by Slaper and colleagues in the Netherlands (RIVM), modelled the excess skin cancer rates in Europe and the USA during the coming century in response to three contrasting ozone depletion scenarios: (i) a business-as-usual emissions scenario, (ii) the emission restrictions as for the original Montreal Protocol, and (iii) the Protocol as amended at Copenhagen (1992). The study used an integrative model that combined metamodels of the causal chain components: *i.e.*, atmospheric emissions, ozone changes, changes in UV irradiance, and dose-effect (UV-cancer) models. The uncertainties in each component were included in the model. Using a multiple-run Monte Carlo technique to allow for variable combinations of these uncertainties, the model yielded estimates of future trajectories of skin cancer incidence rates. The central estimate was that, with the Copenhagen amendments to the Montreal Protocol, excess skin cancer would peak with an increment of 10% around 2050.

Agricultural production is a major determinant of nutritional status and health in poor countries and is affected by multiple and interacting environmental stresses: climate change, level of ultraviolet irradiation, land degradation, pesticide-induced imbalances in predator-prey relationships, and aquifer depletion. Today, as we continue on the treadmill of having to extract greater food yields to feed ever-more people, almost one-tenth of the world population is malnourished in ways that impair health. The *absolute* numbers of malnourished persons, especially children, are still growing.

The worldwide loss of biodiversity will have implications for human health. The loss of various key species would weaken whole ecosystems, with consequences that would often be adverse to human interests. Those consequences would include disturbances of the ecology of vector-borne infections and reduced yield from food-producing systems. We would also lose a rich repertoire of genetic and phenotypic material. To maintain the environmental resilience of our major food species, a diversity of wild plants needs to be preserved as a source of genetic additives. Similarly, a high proportion of modern medicinal drugs in western medicine has natural origins, and many defy synthesis in the laboratory.

We are beset with a range of serious and intransigent *existing* public health problems. It is therefore difficult to mobilise interest in future and uncertain public health problems. This poses a challenge to public health scientists. New ways of dealing with complex systems and irreducible uncertainties are needed, as are new modes of transdisciplinary research. We also require enhanced surveillance and monitoring — for example, for changes in patterns of vector-borne diseases at the margins of their distributions. Global monitoring initiatives should include sensitive indices of potential health impacts.

We have long overlooked the fundamental infrastructure importance to human health of the biosphere's natural systems. Yet these are the "life-support" systems upon which the sustained health of populations depends. We therefore must extend our health risk assessment concepts and methods to accommodate scenario-based forecasting of health impacts, using new and better modelling and predictive techniques. These research methods, and the communication of research results to public and policy-maker, must accommodate an unusual mix of complexity, uncertainty and futurism.

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The Miombo Network: Causes and Consequences of Land-Use and Land-Cover Changes in the Miombo of South Central Africa

by Peter Frost and Paul Desanker

The Miombo Network was formed at an IGBP/START workshop in Zomba, Malawi in December 1995 following earlier meetings in southern Africa aimed at developing regional initiatives on global change issues. The Network aims to develop a better understanding of how changes in land use in miombo are affecting land cover and associated ecosystem processes; what contribution these changes are making to global change; and how global change in turn might affect land use dynamics and ecosystem structure and function. The Network is also aimed at mobilising and enhancing regional scientific capacity in START's Southern, Central and East African (SAF) region.

There is particular uncertainty about the precise nature, extent and rates of land-use and land-cover change in tropical Africa, their causes, and their environmental and social consequences. The focus to date has been mainly on changes occurring in or adjacent to humid tropical forests, studying impacts on biodiversity, the net release of carbon to the atmosphere, hydrology and other ecological processes that accompany deforestation. But even more extensive changes are apparent in the dry deciduous forests and woodlands of the seasonal tropics, ecosystems that support a large and rapidly growing human population. Large areas of woodland can more easily be converted to agricultural land because of the somewhat lower woody plant biomass than in tropical forests, though the social and environmental consequences are probably as profound. An area of particular concern in this regard is the miombo region of southern Central Africa. To understand how ecological and social processes change as land use is intensified, an IGBP Terrestrial Transect study has been started in the region along a gradient of increasing land-use intensity. This study, the Miombo Network, also forms one of the initiating activities of the IGBP/IHDP Land-Use and Land-Cover Change (LUCC) core project/research programme.

What is miombo? Miombo is a vernacular term used by African ecologists to refer to those ecosystems in the seasonal tropics dominated by trees of the closely related genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (subfamily *Caesalpinioideae*, family *Fabaceae* - the legumes). Interspersed with the woodlands are seasonally wet, elongate, grassy depressions, called locally dambos or mbugas. Miombo extends across almost 3 million km^2 of the Central African plateau from Tanzania and Zaire in the north, through Zambia, Malawi and eastern Angola, to Zimbabwe and Mozambique in the south. Functionally similar ecosystems with *Isoberlinia* often dominant, but lacking *Brachystegia* and *Julbernardia*, occur in the Guinea savannas of West Africa. The Central African miombo constitutes the largest more-or-less contiguous block of deciduous tropical woodlands and dry forest in the world.

The climate of the region is subhumid and rainfall is strongly seasonal: more than 90 % of the annual total falls in a single 5-7 month summer season. The soils are usually deeply weathered, well drained, and acid, with low cation exchange capacities and little total nitrogen, extractable phosphorus and organic matter. The nutritional quality of the natural vegetation is poor and limits both wildlife and livestock production. Dry season fires are frequent and affect vegetation structure, composition, and biogeochemical cycling. About 39 million rural people derive their livelihoods from miombo, while a further 15 million people in towns and cities in the region supplement their food, fibre, fuelwood and charcoal requirements with its products.

People use miombo in many different ways. The main traditional forms of land use are various forms of sedentary and shifting cultivation of maize, cassava, small grains and pulses, supplemented by the extraction of fuelwood, charcoal, timber, thatching grass, fruits, honey, mushrooms, and fodder for livestock. Apart from the drier areas of Zimbabwe and Tanzania, livestock numbers are low due to poor forage quality and widespread animal diseases, most notably trypanosomiasis spread by tsetse fly, *Glossina* species. The farmers have considerable indigenous technical knowledge of the soils and their potential, and use the land in a fine-grained manner. Except for fertile alluvium alongside rivers, few of the soils can be can be cultivated for long without a marked decline in fertility. Leaf litter, manure, termitarium soil, ash from burnt brush piles and, where available and affordable, inorganic fertilisers, are used as soil amendments. Shifting cultivation is carried out where there is enough land, though it is gradually being replaced by more permanent agriculture as human population pressures increase.

Other major forms of land use are commercial farming, mainly of maize and tobacco; forestry, based on the use and management of both indigenous and introduced species; and land set aside for tourism and conservation. At a national scale, land use in most of the countries is strongly influenced by the legacy of land division and allocation during the colonial era, particularly in countries such as Zimbabwe which had relatively large settler populations. Much of the better agricultural land was appropriated for commercial agricultural purposes. At a sub-national scale, the pattern of land use reflects adaptations by people to the constraints and opportunities of climate, landscapes, soils, vegetation, animals, pests and disease. Many of the adaptations are becoming ever more difficult to sustain as human populations expand and the demand for agricultural land increases. Although some of the population increase is being absorbed by urbanisation, creating its own problems, the pressures on the land and its resources continue to grow, inducing changes in both the kind and intensity of land use. Population growth, however, is not the only source of pressure on miombo. A range of political, economic, social and technological factors are also influencing the patterns of land use, productivity and environmental dynamics.

Human activities are therefore central to the dynamics of miombo. Large areas of woodland have been and continue to be modified or transformed by people. The observable changes include reductions in tree density due to frequent harvesting; declines in woodland cover due to frequent burning; and conversion to perma-

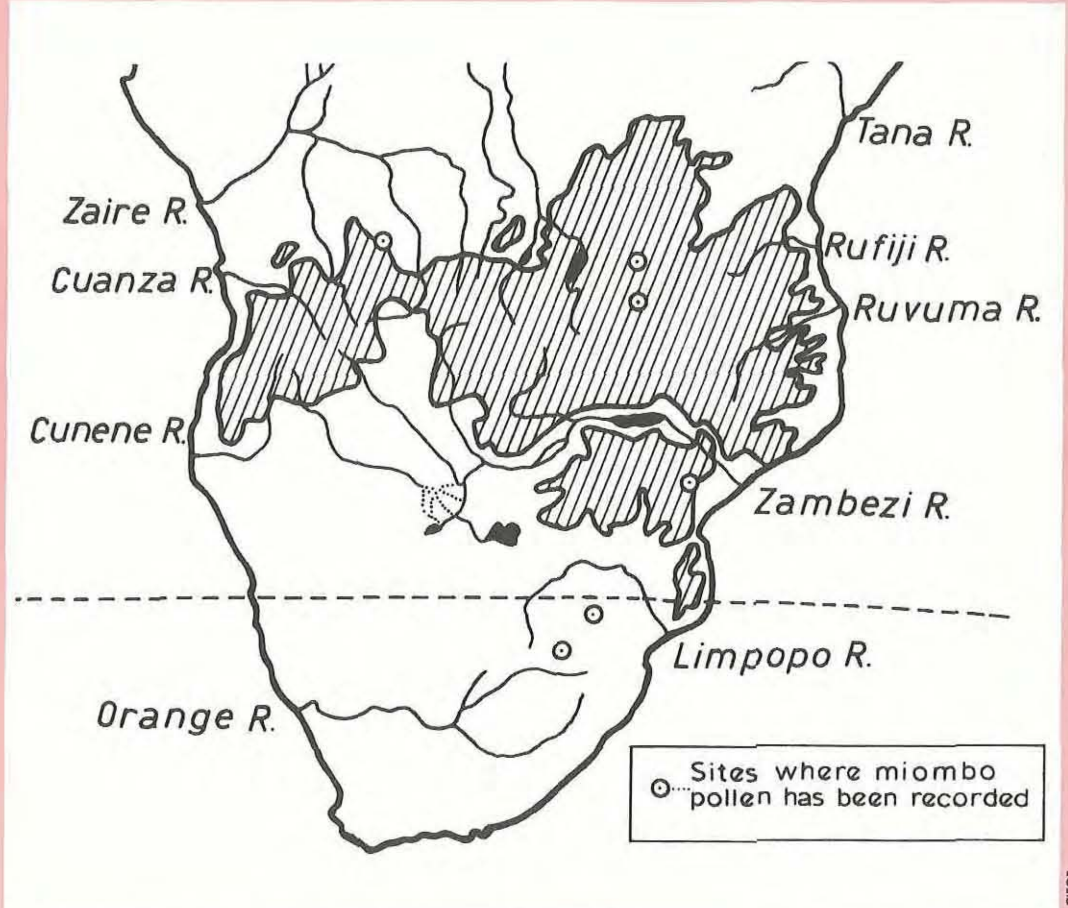

Figure 1 Distribution of miombo woodland. Sites where pollen of miombo woodland has been recorded are shown (Map reprinted from Campbell, B. (ed.) 1987. The Miombo in Transition: Woodlands and Welfare in Africa, CIFOR, Bogor, Indonesia, with kind permission of the editor and publisher)

nently cultivated land. Such changes will potentially have long-term socio-economic and environmental consequences. These include declines in the availability of natural resources in the woodlands; fewer inputs to sustain the fertility of increasing areas of arable land; reductions in grazing land; and a range of environmental impacts affecting ecological functioning, carbon storage, trace gas emissions, hydrology and regional climate. The region is a major source of carbon monoxide and tropospheric ozone derived from biomass burning, as well as being an important source of nitric oxide from biogenic processes in the soil.

The areal extent and substantial woody biomass in relatively undisturbed stands means that the miombo region has the potential to be either a source or a sink for carbon in the global carbon cycle, depending on the type of land management. Converting the woodlands to short-duration crop agriculture releases a substantial amount of carbon to the atmosphere. Conversely, managing the existing woodlands for sustainable use could secure the current storage of carbon, while substantial amounts of carbon could be sequestered in the biomass, soils and wood-based products of regrowth woodlands.

By affecting atmospheric chemistry and land surface properties, the impacts of land-use and land-cover change are likely to influence global and regional climate processes, which, in turn, could feedback to affect the patterns of productivity, resource availability, and land use. The details, however, have still to be fully revealed and understood. The detailed site-, time-, and circumstance-specific findings of socio-economic and fine-scale ecological studies need to be linked to the broader regional assessments of land-use and land-cover change. To predict the consequences of current changes, the focus of research must shift from descriptions of pattern to studies of processes. These issues lie at the heart of the Miombo Network.

The Miombo Network research agenda is underpinned by a number of key questions.

- What are the current directions and rates of change in land use and land cover?
- What are the consequences of land-use and land-cover change for natural resource availability, hydrology, carbon storage, trace-gas emissions, and regional climate?
- What controls the distribution of miombo species and ecosystems?
- What controls primary production in miombo ecosystems?

The proposed research activities of the Network are grouped into six core experiments and a set of integrating activities (Box 1, page 8). One of the proposed integrating activities, to build and disseminate regional databases, is intended to provide scientists and decision-makers with regional-scale data on physical features (topography, climate, soils, vegetation, geology, hydrology), biological characteristics (vegetation maps, NDVI statistics, livestock and wildlife numbers, animal diseases), and socio-economic attributes (demography, agricultural and economic indicators, land tenure regimes, land use and other measures of natural resource use) in an easily accessible format. The main proposed medium for dissemination is CD-ROM, allowing large amounts of data to be stored relatively cheaply, and made available for little more than the cost of a reasonable computer and a CD-ROM drive. The IGBP-DIS Miombo CD-ROM is a pilot project of this activity. The CD-ROM will ensure that all participants have access to standardised data. Access to, and discussion about, common data sets could also stimulate new questions, encourage collaboration, and enhance the rigour of analyses. The compiled data sets, with appropriate caveats, could serve to test and, where necessary, refine both the data and the procedures by which they are collected.

The aim of the joint modelling activity is to produce an integrated model with which to assess the likely impacts of changes in land use and land cover on local and regional climate, natural resources, hydrological processes, and carbon and trace gas emissions. The types of models needed included process based vegetation dynamics models; soil-vegetation-atmosphere transfer (SVAT) and net primary production (NPP) models; basin-wide hydrological models; models of trace gas emissions; macroeconomic diagnostic models; and household-level micro-economic models.

Finally, the Miombo Network affords an opportunity to transfer technical skills and knowledge from international collaborators to researchers in the region. Equally importantly, it also provides a chance to promote the recognition of regional scientists, with their knowledge and understanding of ecological and social processes in miombo, by encouraging their participation in global change research. The Network aims to support existing relevant initiatives being undertaken by mid-career regional scientists, as well as to create new opportunities for early-career and post-graduate scientists from the region. Joint research will involve developing collaborative projects among individuals and groups with different and complementary skills. A major commitment on the part of the Miombo Network is obviously to obtain the resources needed to facilitate this activity.

These studies will be undertaken by a consortium of participating institutions and individuals at a network of sites across the miombo region. A scientific steering committee for the Miombo Network, consisting of regional and international representatives of participating IGBP and IHDP core projects and framework activities, will be responsible for guiding the scientific content and implementation of the projects. The activities of the network are being promoted and facilitated by a Network Coordinator, currently Peter Frost. The initial phase of the programme will run for five years (1997-2001), building strongly on existing activities.

As a regionally-based initiative, the Miombo Network inevitably intersects a number of other local, regional and international initiatives on miombo. These include various national forestry research and development programmes, research being undertaken by non-governmental organisations, regional initiatives being launched by Southern African Development Community (SADC), and the activities being undertaken by international organisations such as the Centre for International Forestry Research (CIFOR), the Alternatives to Slash-and-Burn Project coordinated by the International Centre for Research on Agroforestry, the International Livestock Research Institute (ILRI), and the World Conservation Union (IUCN). These initiatives have their own agendas and priorities which the Miombo Network respects. Where mutually acceptable, the Network will seek to complement the activities of others, both to avoid duplication and to obtain a multiplier-effect, where possible, in our understanding of the causes and consequences of land use and land-cover change in miombo. In collaborating with these other initiatives, the Miombo Network would bring data, models, techniques and insights obtained through its own and other IGBP/IHDP activities at larger scales that could enhance the value of national and regional initiatives. In these ways, the Miombo Network aims to catalyse research and contribute to understanding the regional and global implications of the changes occurring in miombo.

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Miombo Network: Core Experiments and Activities

Core Experiment 1: Macroscale Land Use Diagnostic Modelling

Activity 1.	Historical land-use patterns
Activity 2.	Dynamics of land use over last 20 years
Activity 3.	Predictive modelling

Core Experiment 2: Biogeography of Miombo

Activity 1.	Biophysical definition of miombo and biogeographical modelling
Activity 2.	Paleo-distribution of miombo

Core Experiment 3: Ecosystem Dynamics Along Moisture and Disturbance Gradients

Activity 1.	Land-cover dynamics and effects on landscape patterns and processes
Activity 2.	Remote sensing of the timing, distribution and areal extent of fires in miombo
Activity 3.	Tree growth and regeneration at the patch scale
Activity 4.	Modelling effects of deforestation on landscape ecosystem patterns and processes

Core Experiment 4: Nutrient Limitation in Miombo

Activity 1.	N & P in Miombo
Activity 2.	Effects of disturbance and fire

Core Experiment 5: Integrated Miombo Landscape Experiment

Activity 1.	Regional primary production modelling
Activity 2.	Soil-vegetation-atmosphere interactions under different land-uses

Core Experiment 6: Sustainable Natural Resource Management

Activity 1.	Natural resource use at the household level
Activity 2.	Development of rule-based models for natural resource management
Activity 3.	Decision support for options to reduce trace-gas emissions and mini mise forest-cover conversion

Integrating Activities

Activity 1.	Development and dissemination of regional databases
Activity 2.	Analysis of sustainable management options for miombo
Activity 3.	Integrated modelling of effects of land-use and land-cover changes
Activity 4.	Global integration of results with other dry forest transect studies
Activity 5.	Individual and institutional capacity-building

The Atmosphere/Ocean Chemistry Experiment: AEROCE

by J.M. Prospero and S.G. Jennings

Introduction

AEROCE is a comprehensive multi-disciplinary and multi-institutional research programme that focuses on a number of aspects of the atmospheric chemistry over the North Atlantic Ocean. AEROCE is a major contributor to IGAC's North Atlantic Regional Experiment (NARE) Activity. A major objective of AEROCE research is to gauge the impact of anthropogenic sources on the chemical and physical properties of the atmosphere, to assess the consequences of the perturbations on natural processes including climate, and, through the use of models, to predict the longer term effects. AEROCE Phase I began in September 1987; AEROCE is now in Phase III which will extend through 1998. AEROCE research is focused in two theme areas:

- Theme 1: Ozone and Oxidants: To understand the role of anthropogenic emissions and natural processes in the ozone budget and oxidising capacity of the troposphere over the Atlantic.
- Theme 2: Aerosols and Climate: To characterise the chemical and physical properties of aerosols that are important to the radiative properties of the atmosphere and to climate; to study the processes that affect these properties; and to assess the relative importance of natural *vs.* human sources.

The AEROCE strategy is to develop a chemical climatology of the atmosphere over the Atlantic. This is accomplished with a coordinated protocol of continuous measurements of aerosol chemical and physical properties in a network of stations: Barbados, West Indies; Bermuda; Izaña, Tenerife, Canary Islands; and Mace Head, Ireland. The Izaña site, a meteorological observatory operated by the Spanish government, is located at an elevation of 2,360 m which at night is in the free troposphere. Izaña is designated as a WMO Global Atmosphere Watch (GAW) site. The AEROCE operations at Izaña are carried out in close cooperation with the Spanish Meteorological Service and by various other investigators. The Mace Head site, located on the west coast of Ireland, about 60km WNW of Galway, is operated by University College Galway; Mace Head is also a WMO GAW site.

A subset of AEROCE protocol measurements is carried out at several other locations. Routine sampling is carried out at a coastal site at Miami, Florida. A station on Heimaey, an island off the south coast of Iceland, is operated in cooperation with the Iceland Meteorological Service. As a part of the ACE-2 program, a station was established at the top of a 40m light house at Punta del Hidalgo on the north coast of Tenerife. Recently, AEROCE activities were initiated on Sal Island (Cape Verde Islands) in cooperation with a group at the University of Paris (L. Gomes and G. Bergametti).

The integrated activities across this network have provided an unprecedented picture of the temporal and spatial variability of a number of important gas, aerosol, and precipitation constituents across the entire North Atlantic. This report focuses solely on the Aerosols and Climate theme.

AEROCE Strategy for Assessing Aerosol Impacts on Climate

The AEROCE programme follows two sampling strategies:

1) a continuous sampling programme that develops a climatological data set on

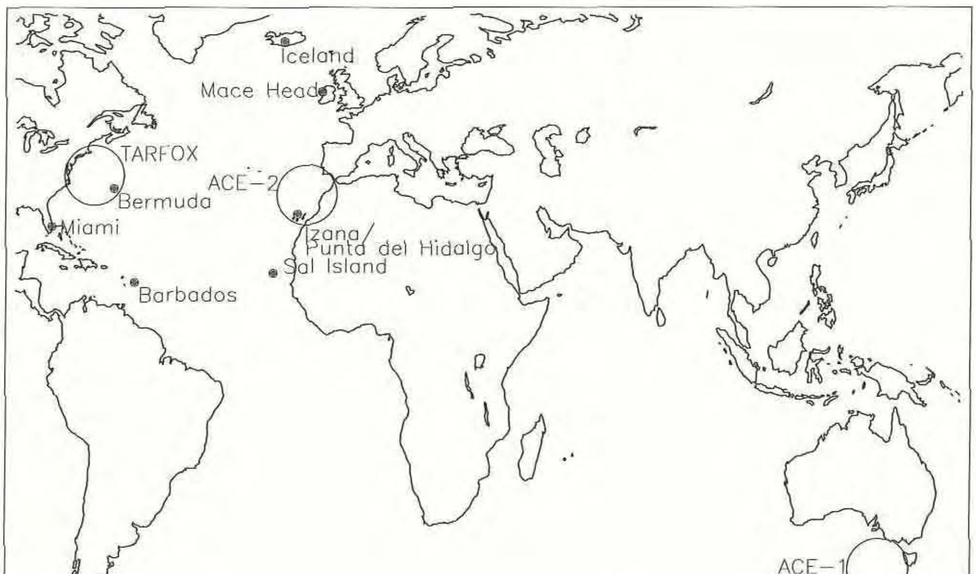

Figure 1. Locations of the ACE-1, TARFOX and ACE-2 experimental areas and the AEROCE measurement stations

Table 1. Concentrations of major aerosol constituents measured at AEROCE sites in the North Atlantic based on multi-year continuous sampling.

Station	Lat. °N	Long. °W	Al ng/m³	Dust⁺ µg/m³	NO³⁻ µg/m³	nss-SO⁴⁼ µg/m³	NH⁴⁺ µg/m³
Mace Head	53.32	9.85	38	0.47	1.49	2.03	0.91
Bermuda	32.27	64.87	447	5.6	1.06	2.19	0.31
Izaña	28.30	16.50	1783	22.3	0.77	0.92	0.33
Miami			NA	5.6*	1.87	2.34	0.61
Barbados	13.17	59.43	1164	14.6	0.53	0.78	0.11

\+ *Dust concentration computed from Al based on a crustal abundance of 8% except for Miami data which is based on weights of filter samples ashed at 500°C after extracting with water.*

* *Ash weight, 96 months of data.*

the chemical, physical, and radiative characteristics of aerosols;

2) intensive field programmes that incorporate a much more detailed measurement protocol with a strong emphasis on aerosol size distribution measurements and radiative properties.

Long-term observations allow us to statistically characterise these properties and their temporal and spatial variability. Measurements taken during intensive field campaigns focus on specific processes in the context of case studies. In both modes, long-term and intensive, we test the completeness of our knowledge of aerosol properties by comparing the measured radiative parameters with those computed with aerosol radiative models. A major strength of AEROCE is that the sites are exposed to a wide variety of atmospheric conditions with winds that can carry aerosols from sources in North America, Europe and Africa; consequently, aerosol characteristics vary over wide ranges. These factors enable us to more readily associate changes in radiative properties to changes in chemical and physical properties of aerosols. Meteorological studies carried out in AEROCE enable us to associate these changes with specific source regions and source types.

Continuous Protocol

Aerosol Chemical Measurements We collect, daily, high volume bulk aerosol samples under selected meteorological conditions (to minimise the possible impact of local sources). These samples are analysed for various soluble species derived from natural and anthropogenic sources, *e.g.*, nss-$SO_4^=$ (non-sea-salt sulfate), NO_3^-, NH_4^+, sea-water species. Various trace elements serve as indicators of source type and/or region. Aluminium is used to estimate mineral aerosol concentration; other elements (*e.g.*, Sb, Zn, Rb, Se) can serve as tracers for various anthropogenic sources and biomass burning. Finally, two radionuclides, ^{7}Be and ^{210}Pb, are used as tracers for upper troposphere/stratosphere air and continental boundary layer air, respectively.

Aerosol Physical Properties We make continuous measurements of: (1) aerosol light scatter using integrating nephelometers. The air stream is heated (to reduce the RH to under 50%) and drawn through a 10 µm impactor; an automatically switchable 1 µm impactor is periodically inserted into the line so as to obtain data that are specific to the large-particle and sub-micron size ranges. (2) Aerosol composition in two size ranges: 1-10 µm diameter and the fraction below 1 µm (*i.e.*, the same size fractions viewed by the nephelometer); (3) total aerosol number concentration; and (4) total aerosol light absorption coefficient. The concentration of organic components and black carbon is estimated using a stepwise oxidation procedure and using non-dispersive IR measurement of the evolved CO_2.

Radiation measurements The sites at Barbados, Bermuda, Miami, Tenerife, and Sal Island currently make continuous radiation measurements with two types of instruments: rotating shadowband radiometers (RSR) and automatic solar-sky scanning

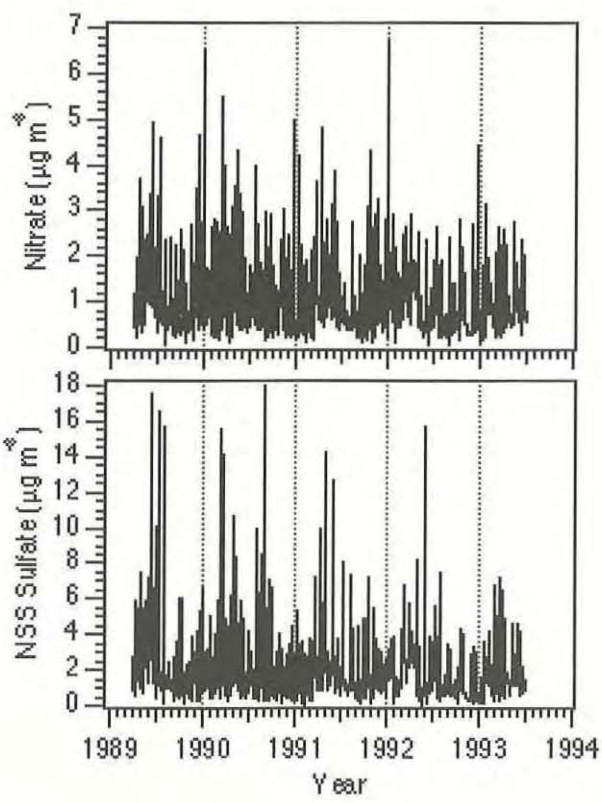

Figure 2. Aerosol concentrations on Bermuda, 1989-1993. Data are based on daily samples collected during on-shore winds. AEROCE maintains two sampling sites on Bermuda, one on the west end at Tudor Hill and one on the east end at David's Head. Thus, we can collect samples under all wind conditions. The data in the figure are composited from the samples collected at both sites. (Data courtesy of D. Savoie, University of Miami).

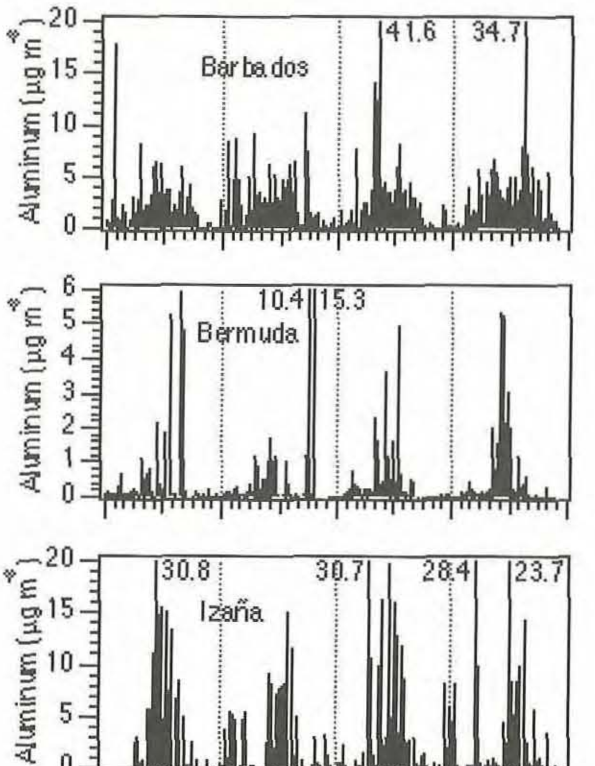

Figure 3. Daily aluminum concentrations in aerosols collected at Barbados, West Indies, Bermuda and Izaña Observatory. Samples are only collected at night-time during downslope wind conditions. The mineral dust concentration can be estimated by multiplying the Al values by 12.5, assuming an average Al concentration of 8% in soils. (Data courtesy of R. Arimoto, University of Rhode Island).

radiometers (ASSR). The RSR measures radiation in 5 passbands and an open channel (for total downwelling irradiance), yielding diffuse, direct and total solar irradiance. This instrument is used extensively in the U.S. Department of Energy/Atmospheric Radiation Measurement (DOE/ARM) programme. The RSR's at the AEROCE sites are deployed by investigators from several different institutions. The ASSR (CIMEL) instruments automatically make direct sun measurements every 15 minutes at 340, 440, 670, 870, 940 and 1020 nm; sky radiance and polarisation measurements are made hourly. The ASSR's are deployed by various groups but they are all integrated into the Aerosol Robotic Network (AERONET) under B. Holben (NASA, Goddard) who maintains an on-line central data base for all instruments. Routine products are spectral aerosol optical depth, size distribution, phase function, asymmetry factor and precipitable water.

Other Measurements A variety of other measurements are made at AEROCE sites. These include continuous measurements of O_3 and CO. These data assist greatly in the interpretation of the aerosol data. In addition, meteorological data are obtained and meteorological support is provided (in the form of isentropic trajectories and other meteorological products) as a routine component of the AEROCE protocol.

Intensive Protocol

The aerosol intensives employ more sensitive aerosol aerosol/radiation instrumentation than that used in the continuous programme. Emphasis is placed on measuring aerosol size distributions using state-of-the art instrumentation. Because many of these instruments have averaging times on the order of minutes, we obtain much higher temporal resolution which allows us to interpret changes in aerosol properties in terms of rapidly changing meteorological conditions. Consequently, specific aerosol properties can be more definitively associated with specific transport conditions.

Aerosol Physical Properties We continue to make the measurements listed in the continuous programme (as listed above). In addition we measure: (1) aerosol total integrated light scattering and back scattering using a high-sensitivity integrating nephelometer (three spectral bands) that incorporates a back-scatter shutter (TSI Model 3563); and (2) aerosol size distributions with several instruments that cover the size range from 3nm to 15 µm diameter.

Aerosol Chemical Measurements In addition to the measurements that we make under the continuous protocol, we measure: (1) size distributions using a variety of impactors; (2) continuous total aerosol mass using tapered element oscillating microbalance; (3) annular diffusion denuders and filter packs.

During the past several years intensive field campaigns have been carried out at Bermuda, Barbados and Tenerife. In preparation for the ACE-2 campaign, we have participated in intensive field studies in cooperation with the Ispra group during the summers of 1994 through 1996.

Some Examples of AEROCE Results

The measurements made over the past few years clearly show that the atmosphere over the North Atlantic is highly impacted by materials transported from continental sources. Table 1 presents the mean concentrations of some major aerosol species, based on at least several years of data. The concentrations of species such as non-sea-salt sulfate (nss-SO_4^-) and nitrate (NO_3^-) are substantially higher than concentrations in remote ocean regions (*e.g.*, the southern oceans).

The effect of transport from North America is clearly evident at Bermuda (Figure 2) as reflected in the large day-to-day variability in the concentrations of NO_3^- and nss-SO_4^-. A seasonal pattern is also evident, with maximum concentrations in the winter and spring, when the region is often dominated by westerly flow. In contrast, during the summer, southerly winds are prevalent and the concentrations of NO_3^- and nss-SO_4^- are substantially lower.

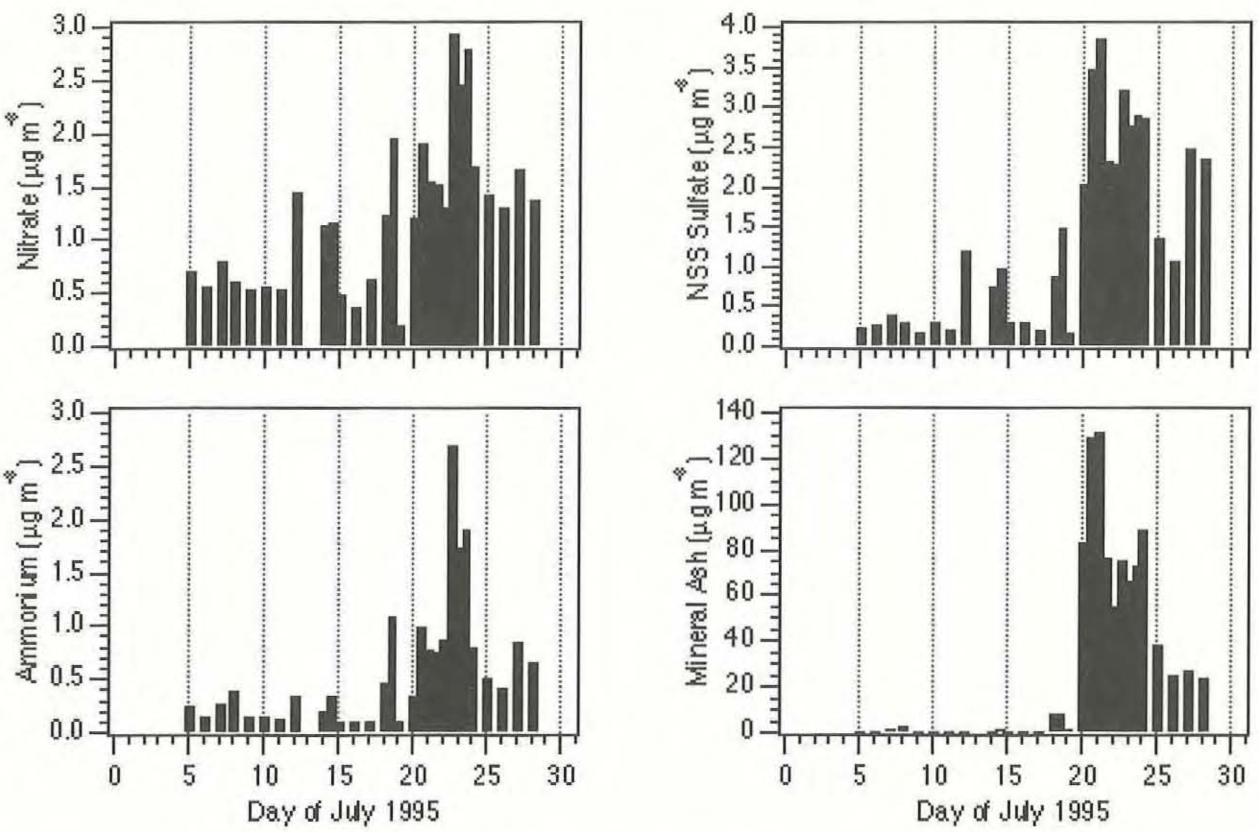

Figure 4. Daily aerosol concentrations at Izana Observatory, July 1995. Samples are normally collected only at nighttime during downslope wind conditions. During July, some daytime upslope sampling was done as well; these are also shown in the figure. The upslope wind concentrations do not appear to be substantially different from the nighttime samples, especially during dusty periods. (Data courtesy of D. Savoie, University of Miami).

One of the most striking features of the aerosol records at many AEROCE sites is the frequent presence of high concentrations of North African dust. As can be seen in Table 1, the concentrations of dust are quite high at Izaña and Barbados, but they are also substantial at Bermuda and Miami. There is a very clear seasonal cycle in dust transport (Figure 3, page 11), with maximum concentrations occurring in the summer at all sites. Note that the dust concentrations at Barbados are comparable to those measured at Izaña; although peak concentrations tend to be higher at Tenerife, the dust transport to Barbados occurs over a longer period during the year. Because of the more northerly location of Tenerife relative to Barbados, dust transport does not become persistent until mid-summer, generally in July. This feature has implications regarding the activities in ACE-2 which begins in mid-June and extends through July. According to the dust climatology of Tenerife, the ACE-2 region should be relatively dust-free in the early weeks and then dust levels should increase sharply.

The large variability of aerosol concentrations and properties at Izaña is illustrated in Figure 4 which shows data from July 1995. The air was extremely clean until mid July when there was a sudden influx of African dust. Note that the concentrations of all species increased sharply with the dust. Previous studies have shown that the nss-$SO_4^{=}$, NO_3^- and NH_4^+ associated with the dust was most likely derived from sources in Europe.

Summary

The AEROCE studies show that aerosols over the North Atlantic are greatly affected by transport from continental sources. The temporal and spatial variability of aerosols over this region is quite complex because of the abundance of sources, natural and anthropogenic, that border the North Atlantic and because of the complex meteorology. Although we have developed some appreciation of the factors affecting aerosol concentrations over the Atlantic, we are far from a quantitative understanding of these processes. Our knowledge about the vertical distributions of aerosols is especially limited. Focused intensive field programs such as TARFOX and ACE-IGAC-2 coupled with longer-term programs such as AEROCE will do much to improve our knowledge about these processes and the role that aerosols play in climate processes.

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Global Change and the Antarctic - an Overview of the SCAR GLOCHANT Programme

by Ian D. Goodwin

Antarctic Systems

The Antarctic and Southern Ocean region is a powerhouse for climate, sea-level and ecosystem dynamics. Variability in these systems has a global impact. Decadal scale changes in the size of large ice free areas in the circum-Antarctic sea-ice belt, known as polynyas, have a profound impact on air-sea interchange and Antarctic bottom water production. The polynyas are regions of intense heat loss from the ocean to the atmosphere, and of rapid and copious ice growth: they may be significant as "ice factories" for the total sea ice zone, and in water mass modification through the process of salt rejection during ice growth. Antarctic bottom water is also produced by the cooling and transformation of shelf water under the large floating ice shelves, such as the Filchner-Ronne and the Ross Ice Shelves. Variability in the production of bottom water may be linked to oscillations in the surface windfield. On the Antarctic ice sheet itself the glaciological characteristics can change significantly, even dramatically on the timescale of a few decades. Major decadal changes in the ice dynamics and morphology have occurred along the Siple Coast of West Antarctica, where the ice sheet drains into the Ross Ice Shelf. The Antarctic Peninsula ice shelves have displayed a dramatic response to atmospheric warming over the last few decades. The occurrence of these ice shelves is linked to an abrupt thermal limit, and in recent decades the isotherm associated with this limit has been driven south by atmospheric warming. These changes have important effects on the regional climatology of the ice sheet, and on the coupled ice-ocean processes, particularly the bottom water production. Large decadal changes of up to 20-30% have also occurred in the rate of snow accumulation across some regions of East Antarctica and the Antarctic Peninsula. Interannual variability in snow accumulation rates in the Pacific Ocean sector of West Antarctic have been shown to be correlated with the El Niño-Southern Oscillation (ENSO) phenomenon.

Regional patterns of seasonal to interannual climate variability have been identified in the Antarctic Peninsula, and circum-Antarctic. The west coast of the Antarctic Peninsula has been identified as a region of extreme climatic variability:

1) a significant warming, strongest in mid-winter (5.5 °C) but also in fall and summer (4.1 °C and 1.5 °C, respectively) over the 1941-1991 record;
2) a significant anti-correlation between surface-air temperatures and sea-ice extent; and
3) long-term persistence in surface-air temperature and sea-ice anomalies, where two to four low-temperature/high-ice years are followed by one to three high-temperature/low-ice years, a pattern coherent with the Southern Oscillation Index (SOI), indicating that there may be an ENSO teleconnection between the western Antarctic Peninsula region and lower latitudes. Interannual variations in surface atmospheric pressure, sea-ice extent, sea surface temperature and wind stress in the Southern Ocean have been identified. Known as the Antarctic Circumpolar Wave, these anomalies propagate eastward with the circumpolar flow, with a period of 4-5 years and taking 8 years to encircle the pole.

The physical changes in the Antarctic climate and oceans have had a profound effect on ecosystem dynamics in the Southern Ocean, which in turn impact the Southern Hemisphere oceans. ENSO related variability in Southern Ocean ecosystem dynamics has been identified in recent years in the South Georgia and South Orkney regions and along the Antarctic Peninsula coastline. Krill biomass shows major interannual fluctuations which have been attributed to the influence of the physical system in transporting krill, rather than local changes in population size. These fluctuations in krill availability have had a strong influence on the food chain and the dynamics of higher trophic level species. Not surprisingly the demographic variables of a number of seal species show some correlation with ENSO.

Development of GLOCHANT

During the late 1980's the Scientific Committee on Antarctic Research (SCAR) recognised the need for the coordination and development of global change related research in Antarctica, and established the Group of Specialists on Global Change and the Antarctic (GLOCHANT). A number of areas have been identified where GLOCHANT has been encouraged to develop scientific contributions to the IGBP and WCRP global programmes. These areas and the corresponding programmes are:

- Antarctic sea-ice processes, climate variability and ecosystem/biochemical interactions within the pack ice zone of the Southern Ocean (ASPECT programme with WCRP CLIVAR/ACSYS, IGBP JGOFS, and SCOR);
- Determination of the recent Antarctic ice sheet mass balance and its contribution to global sea-level (ISMASS programme, a contribution to the global programme on Glaciers, Ice Sheets and Sea-Level GISSL);

Table 1 Composition of the SCAR Global Change Programme

Antarctic sea ice processes and climate	ASPECT
Paleoenvironments from ice cores	PICE
International Trans-Antarctic scientific expedition	ITASE
Late Quaternary sedimentary record of the Antarctic ice margin evolution	ANTIME
Ice sheet mass balance and sea-level contributions	ISMASS
Ecology of the Antarctic sea ice zone	EASIZ
Biological investigations of terrestrial Antarctic ecosystems	BIOTAS

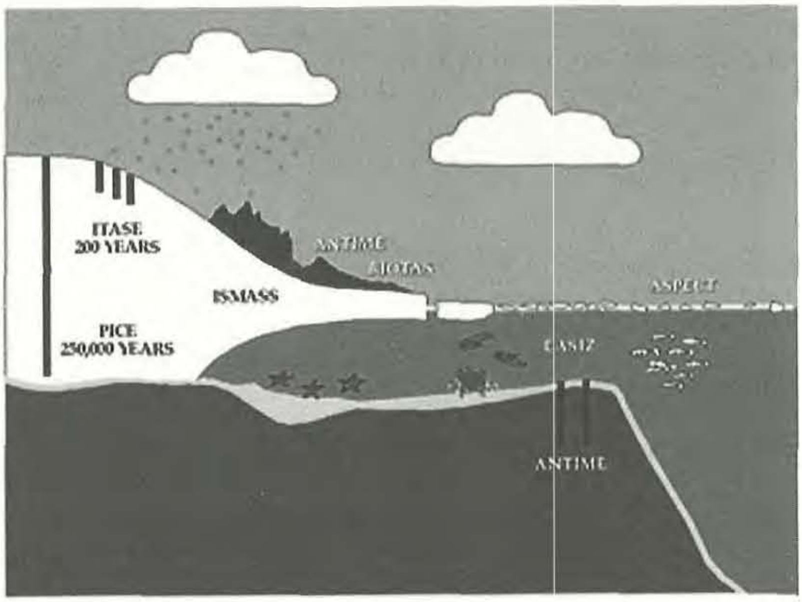


Diagram showing the geographic association of the component scientific programmes within GLOCHANT.

- Late Quaternary and Holocene paleoenvironmental records from deep ice cores retrieved from East and West Antarctica (PICE programme with IGBP PAGES);
- High resolution Antarctic paleoenvironmental and paleoclimatic records covering the last 200 years, from ice cores collected across the ice sheet (ITASE programme with IGBP PAGES);
- Paleoenvironmental and paleoclimatic records covering the last 200,000 years, from circum-Antarctic onshore and offshore sediments (ANTIME programme with IGBP PAGES);
- Ecology of the Antarctic sea ice zone (EASIZ programme);
- Impact of physical and biological changes on Antarctic terrestrial ecosystems (BIOTAS), and;
- Training and coordination of research programmes through the establishment of the START Regional Research Committee for the Antarctic.

To coordinate these programmes SCAR established the SCAR Global Change Programme Office at the Antarctic CRC, in Hobart, Tasmania Australia, in 1995. The chairman of GLOCHANT is Professor Charles Bentley, from the University of Wisconsin, Madison, Wisconsin, USA, and the Programme Coordinator is Dr Ian Goodwin.

START Regional Research Committee for the Antarctic

In 1994, at the 23rd SCAR meeting in Rome, Italy, it was agreed that a formal interaction with START (System for Analysis, Research and Training) and the IGBP, WCRP, and IHDP should be undertaken through the development of a SCAR-sponsored Regional Research Network (RRN) (Recommendation XXIII-10 (1)).

After discussion with the START Secretariat is was agreed that the interaction should be dealt with at two levels: (1) at the institutional level, between SCAR, START, and its parent programmes (IGBP, WCRP and IHDP) and (2) at the core programme level, between the core projects of IGBP and WCRP and related programmes within SCAR. It was also recognised that there would be benefits in adopting a bi-polar approach to the interaction with START and its parent programmes. Accordingly, a round-table meeting was held between members of SCAR, START, WCRP, and IASC in Hanover, New Hampshire, December 6, 1995 to look at these issues. The outcome of this meeting was the agreement that the institutional-level linkage between SCAR and IGBP/WCRP should be developed through the START RRN concept, whilst the inter-programme linkage should be formed through the SCAR Global Change Programme Office.

The institutional-level linkage is being facilitated by a memorandum of understanding (MoU) between SCAR and START. GoS GLOCHANT has taken on the role of a START Regional Committee for the Antarctic to promote the principal programmes of IGBP and WCRP in the Antarctic. Whilst it is recognised that SCAR has a wider portfolio of interests than those of START, there is a close congruence of major interests between the two organisations, which indicates the value of joint planning and implementation for the good of global science. The MoU has been approved by the SCAR Executive and the START Scientific Steering Committee.

Future Role of the GLOCHANT Group of Specialists

Since the establishment of the GLOCHANT Group of Specialists four years ago the role of the GoS has changed substantially. Its principal purpose in the future will be to serve as the focus for internal and external coordination for all aspects of SCAR research related to global change, including the incorporation of a viable mechanism for serving as the START Regional Research Committee for the Antarctic.

The revised composition of GoS/GLOCHANT is as follows:

- An independent chair;
- The Chief Officer of each of the SCAR programmes; BIOTAS, EASIZ, ISMASS, and PICE, ITASE, ASPECT and ANTIME;
- Scientific representatives from other key international programmes; in particular, SO-JGOFS and SO-GLOBEC (SCOR/IGBP), and ACSYS/CLIVAR DEC-CEN (WCRP);
- A small number of scientific experts chosen from important global-change research areas not otherwise covered; for example, Arctic research, atmospheric science, numerical modelling, higher-trophic-level biology, data matters, and policy or management fields such as the Antarctic Treaty.

The final membership of GLOCHANT is awaiting approval of the SCAR Executive and the START Scientific Steering Committee.

Further information on GLOCHANT can be obtained by contacting:

Ian Goodwin, SCAR Global Change Programme Coordinator, Antarctic CRC, GPO Box 252-80, Hobart, Tasmania 7001, Australia. Phone (+61-3) 6226 7544, Fax (+61-3) 6226 7650, or by email: Ian.Goodwin@antcrc.utas.edu.au, World Wide Web site: http://www.antcrc.utas.edu.au/scar/.

The GLOBE Program: A Source of Datasets for Use in Global Change Studies

by Barrett N. Rock and James G. Lawless

The GLOBE (Global Learning and Observations to Benefit the Environment) Program is an international student scientist partnership that involves primary and secondary school (*i.e.* pre-college) students in the collection of environmental measurements that will be of use to global change researchers. GLOBE has enlisted the assistance of scientists from around the world to develop and monitor scientific measurement activities focused on selected atmospheric, hydrologic, geologic, and biologic parameters, following detailed protocols developed by the participating scientists (see Table 1). They in turn intend to use these student-collected datasets in their own research, as well as make student-generated datasets available to other researchers interested in making use of them in their own research activities.

At present, GLOBE teachers from over 4,000 schools in the United States and 45 other countries have been trained to make measurements of important environmental parameters and these teachers are in turn training their students to provide data of use in conducting global change research (see Table 2 for a list of participating countries, page 16). Once collected, these data are sent via the World Wide Web to the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC), in Boulder, Colorado, USA, where they are processed and archived. Selected student datasets such as temperature, precipitation and cloud cover are displayed daily on the Web GLOBE Homepage (www.globe.gov) in the form of GLOBE Visualizations, developed at the NASA Goddard Space Flight Center, in Greenbelt, Maryland, USA.

The science component of GLOBE is designed to meet two objectives: first, to introduce students to hands-on methods of scientific measurement and analysis, and second, to provide the research community with access to a source of accurate and meaningful data. Participating GLOBE scientists are actively involved in the program in several ways: they design detailed measurement protocols and definition of equipment requirements for student use, they analysis and validate student-collected data, and they utilise these data in their own research. Student datasets provide measurements of basic climatic and environmental parameters, which may be from data-sparse areas that are unavailable from other sources, and many of the datasets are of potential use in the study of broad environmental issues, and thus may be of interest to the IGBP research community.

Table 1. Scientific measurements to be made by GLOBE students and the equipment to be used.

CORE MEASUREMENTS	EQUIPMENT USED
Atmosphere	
Air temperature (maximum/minimum and current)	Maximum/Minimum Thermometer
Precipitation (liquid and solid)	Rain Gauge
Cloud Cover	Eyes
Cloud Type	Cloud Chart
Hydrosphere	
Water Temperature	Thermometer
Dissolved Oxygen	Dissolved Oxygen Kit
Water pH	Indicator Paper/Pen/Meter (varies with student grade)
Alkalinity	Alkalinity Kit
Electrical Conductivity	Conductivity Meter
Biosphere	
Land Cover	Landsat Data, *MultiSpec* software
Tree Height/Circumference	Clinometer/Tape Measure
Canopy/Ground cover	Densiometer
Grass Biomass	Scissors, Tape Measure
Species Identification	Dichotomous Keys
Geosphere	
Soil Moisture	Sample Cans, Auger, Oven
Soil Characterisation	Color Chart, Graduated Cylinder
Global Positioning System	
Latitude/Longitude of study sites	GPS Receiver

The GLOBE Program and Earth Systems Science

Studying the Earth from orbit reminds us that our planet consists of a network of interconnected Earth systems, and that changes in one system will result in changes in other systems. From a student's standpoint, such a concept may be intimidating and global processes may seem too vast and/or complicated to be understood. To simplify the concept, the GLOBE Program has divided scientific measurements into four of the Earth Systems (Atmosphere, Hydrosphere, Biosphere and Geosphere), and into small, easily understood pieces. The various GLOBE measurements (Table 1), made over time, will allow the student to see on a local scale how the Earth's systems are interconnected in a dynamic and predictable way, producing an increased knowledge and understanding of how our planet works.

The measurement of GLOBE environmental parameters will contribute significantly to an improved understanding of both the local and global environment — because they will be measured by GLOBE schools all over the Earth. GLOBE students can be the experts regarding the details of their local environment. Because students live in these areas, they become a valuable source of accurate data for use by the research community, once they are properly trained as to what data are needed and how to objectively and accurately measure the environmental features of interest.

Table 2. Countries that have joined the GLOBE Program as of February, 1997.

Argentina	Egypt	Jordan	Romania
Australia	El Salvador	Kazakstan	Russia
Austria	Estonia	Kyrgyzstan	Senegal
Belgium	Fiji	Korea, South	Sweden
Benin	Finland	Luxembourg	Trinidad and Tobago
Bolivia	The Gambia	Marshall Islands	Tunisia
Chad	Germany	Mexico	Turkey
China	Greece	Moldova	United States
Costa Rica	Ireland	Morocco	United Kingdom
Croatia	Israel	Netherlands	Uruguay
Czech Republic	Italy	Norway	
Ecuador	Japan	Portugal	

GLOBE Student Measurements

The atmospheric measurements (maximum, minimum and current temperatures, cloud cover and type, and precipitation - both liquid and solid) are made by students daily, while the hydrology measurements (surface water temperature, pH, conductivity, alkalinity, and dissolved oxygen) and soil moisture are made monthly. The biological measurements (vegetation cover identification, biomass assessment, and land cover maps) and soil characterisation are made yearly.

Daily temperature measurements (maximum, minimum and current) are to be made by following a specific set of protocols developed by GLOBE research scientists. The daily measurement must be taken plus or minus one hour of solar noon, using thermometers housed in a specially-designed, white weather station, at a height of 1.5m above the ground. The teacher is trained to position the post-mounted weather station to be free from influence of the nearest trees, buildings, and paved or concrete surfaces. If these protocols are strictly followed, using a calibrated max/min thermometer (see below), there is a great likelihood that the data quality will be high.

Students use an adjustable max/min thermometer housed within a standard weather station box, along with a calibration thermometer. The max/min thermometer has a scale which can be adjusted to match the temperature given by the calibration thermometer. Twice per year the calibration thermometer is brought into the school laboratory and tested in an ice bath.

As shown in Figures 1 and 2, GLOBE students are able to collect very good quality data when compared with the same measurements made by the National Weather Service (NWS) Cooperative Observer Program instruments. These data are from the Jones County School District 37-3, Murdo, South Dakota (both a GLOBE School and a member of the NWS Cooperative Observer Program). The GLOBE rain gauge, an inexpensive clear plastic collector read in millimeters of precipitation, when properly placed has been shown to provide reasonably accurate data. In fact, it is very likely that the rain event recorded for May 27, 1996, (Figure 2) is more accurate than the same event recorded by the NWS instrument, since the tipping bucket type of gauge used by the NWS tends to under-report heavy rainfall events. One of

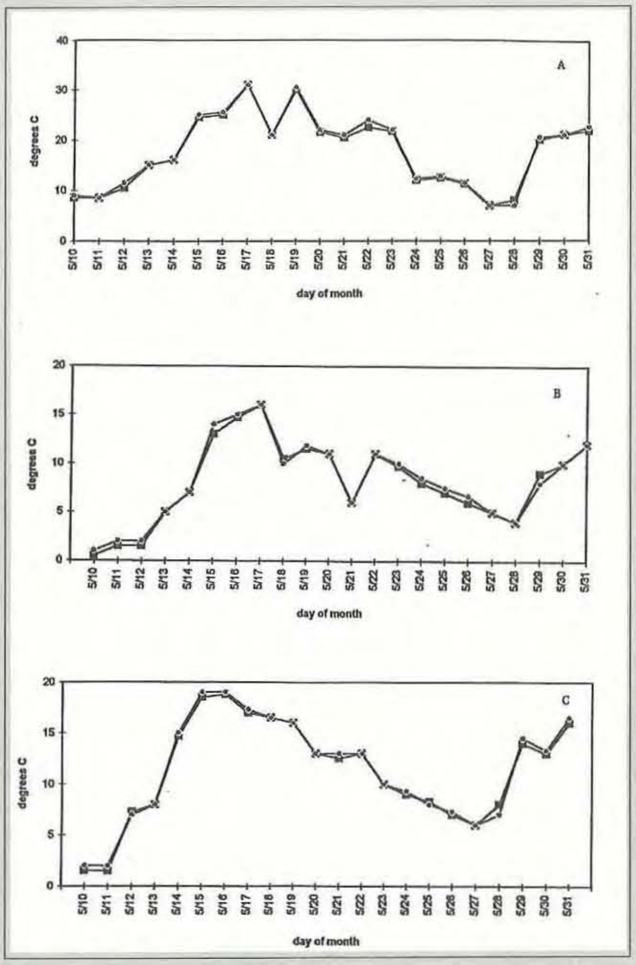


Figure 1 Instrument intercomparison of the GLOBE Thermometer to the National Weather Service (NWS-Cooperative Observer Program) professional thermometer to determine data quality for maximum (A), minimum (B), and current observed (C) temperature. Legend: -•- NWS; -*- GLOBE

the serious limitations of student-based daily measurements such as those provided by GLOBE relates to the lack of data for weekends and school vacations. A variety of alternatives to direct student measurements are currently under consideration, including the use of automated equipment (expensive and of less educational value).

Each participating GLOBE teacher has been trained to use a 512 x 512 pixel subset of Landsat Thematic Mapper (TM) data (approximately 15x15km) of the area surrounding the school, as well as free image processing software (MultiSpec, developed by David Landgrebe at Purdue University) and a training tutorial on the use of the TM data to monitor a variety of conditions within the subset area. One of the image analysis activities done by the students is the generation of a land cover map for the 15x15km area using the 30m TM data. A Modified UNESCO Classification (MUC) system for land cover types has been developed for international use, and is used by all GLOBE Participants. The student-generated MUC-Level 2 land cover maps are validated by the students using an error matrix methodology to determine their level of accuracy. Such land cover maps will represent the highest-resolution, validated maps available for many areas of the world.

Data Quality

A significant issue with student/scientist partnerships regards data quality. The most practical contribution to the scientist to come from student partnerships is the data. The data are at the heart of such a partnership, and the level of interest in access to student data by the scientific community will be determined in large part by the quality of the data. In order for student data to be of use to the researcher, a defined level of confidence in the accuracy of the data must be assigned. This implies that the quality of the data can be documented, characterised and quantified, a continuing challenge to any scientific research effort (*i.e.* not peculiar to student-generated products). "Bad" data must be recognised and removed from the analysis process before the scientist is willing to put her/his name on the results of the analysis.

The scientific protocols provided by GLOBE are designed so that, if properly followed, data will be accurate. These protocols insure that all measurements will be made in the same way, following standard methods. In addition, most of the equipment used in making the GLOBE measurements can be calibrated, another way to improve the accuracy of the measurements. Because GLOBE schools are likely to occur in clusters within an area (multiple schools in the same city) the averaging of student measurements will reduce sources of error. Electronic screening of data entered is also employed by GLOBE to limit sources of error.

Finally, the integrity of GLOBE student-generated data has been addressed by participating GLOBE scientists from each relevant discipline who developed the measurement protocols and the supporting educational materials. In this way, GLOBE scientific measurement procedures and support materials are scientifically valid, and quality control is applied throughout the acquisition, processing and analysis of GLOBE data. Scientists join with educators in GLOBE Science/Education Teams for each discipline area. Each Team oversees all relevant activities and participates in the instruction of GLOBE students.

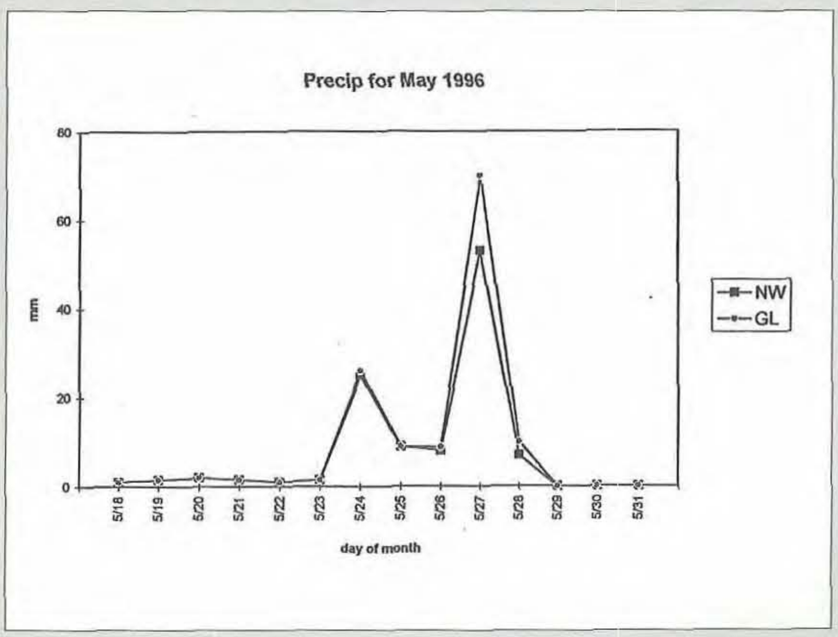


Figure 2 GLOBE precipitation gauge compared with NWS Cooperative Observer Program tipping bucket rain gauge. Legend: -•- NWS; -*- GLOBE

Access to GLOBE Data

Members of the global change research community who are interested in learning more about GLOBE student measurements as a potential source of data for their own research are encouraged to visit the GLOBE Homepage (www.globe.gov), or to call the GLOBE office in Washington, DC (+1-202-395 7600).

Barrett N. Rock, Ph.D., Associate Professor, Complex Systems Research Center, University of New Hampshire, Durham, NH, was the first Senior Scientist and Assistant Director of Science for the GLOBE Program (1994-1995).

James G. Lawless, Ph.D., Director, Environmental Applications, ERIM, Ann Arbor, MI, was the second Senior Scientist and Assistant Director of Science at GLOBE (1995-1996).

Acknowledgements: The authors thank the NWS and the Jones County School District 37-3, Murdo, South Dakota for the data used in Figures 1 and 2.

SPOT Digital Quick Look Images: Another Look At High Resolution Data

MEDIAS-FRANCE and IGBP-DIS have initiated discussions with representatives of SPOT IMAGE regarding the provision and use of Digital Quick Look Image Data (DQLI) to the scientific community.

Digital Quick-Look Image Data are sub-sampled images obtained by sampling one pixel in a 6-pixel by 6-line matrix in the multispectral mode, and by averaging 4 pixels and then sampling one pixel in the resulting 6-pixel by 6-line matrix in the panchromatic mode. This results in approximately equivalent image of 120m in sampling resolution (by opposition to foot-print size). An example is presented in Figure 1.

This type of images, or derived products, present a great potential for a number of regional or global scientific studies where the spatial resolution of AVHRR is too coarse but where the full high resolution of SPOT or LANDSAT-TM is not required. It is anticipated that Digital Quick-Look Image Data could in particular interest the following Core Projects: DIS (*e.g.* Land Cover evaluation), LUCC, GCTE (*e.g.* Transect activities), LOICZ, IGAC, and BAHC.

SPOT IMAGE is currently operating an archive containing about 1,500,000 Digital Quick Look Images acquired since 1991 by the Toulouse and Kiruna stations. Recently the SPOT IMAGE Corporation (in the US) has started to forward DQLI to SPOT IMAGE archive in Toulouse. Cooperation agreements are under discussion with Japan and Canada concerning the provision of DQLI from those countries to the Toulouse archive.

The purpose of the ongoing discussion between IGBP-DIS, MEDIAS-FRANCE and SPOT IMAGE is to promote and facilitate access (from the technical aspect and at marginal costs) to DQLI by the relevant scientists, taking into account that the interest in full high resolution images remain for a number of other, or complementary studies.

Core Projects will be approached in the near future and a pilot project will be initiated by MEDIAS-FRANCE, SPOT IMAGE and IGBP-DIS to elaborate Image Mosaics derived from DQLI (*e.g.* over Africa). Such a product will be generated over a geographical area of common interest for LUCC, IGAC, GCTE or others projects in view of evaluating its scientific value and usefulness.

G. Szejwach (IGBP-DIS), A. Podaire (MEDIAS-FRANCE) and P. Munier (SPOT IMAGE)
IGBP-DIS Core Project Office, CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse Cedex, France.

Figure 1 Deforestation patterns in the Amazonian forest - 180 km south of Belem (Brazil) - SPOT-3 Quick Look Image - August 10, 1995

The IGBP 1996 Central Budget

During 1996, the total income of the IGBP central budget was USD1.76m. Contributions were received from 42 Nations, from ICSU, the CEC, the US National Science Foundation, and the Swedish FRN. Figure 1 is a league table of contributing nations, in order of magnitude of contribution.

Total expenditure during the same period was USD1.42m. This covered the costs of all scientific planning meetings (38%), publications (5%), the operational costs of the Secretariat (15%), and the salary costs of the Secretariat (42%). Figure 2 displays the expenditure in these broad categories.

As in previous years, we wish to express our deep appreciation to the many individuals who have worked on our behalf to sustain our central support.

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

Chris Rapley and **Elise Wännman**, IGBP Secretariat, Box 50005, S-104 05 Stockholm, Sweden.

Next Slide Please

"I thought that in the eight minutes I've got I'd bring you up to date on what our group has been doing in the last year; in a sense this is a progress report and updates the paper we gave here last year; I won't go over the nomenclature again; could I have the first slide please - oh, I think you must have someone else's box - mine is the grey one with my name on the top, no, wait a minute, not my name, whose name was it now? ah yes, you've found it; there's a red spot on the top right hand side of each slide that is the side that becomes the bottom left when you project it, OK, you've got it now, let's have a look, no, that's the last slide not the first, yes, now you've got the right one but it's on its side, what about the red dot? there are two? well anyway turn it through ninety degrees, no, the other way, yes now we're there, perhaps we could have the lights off, well I'm sorry there are probably too many words on this slide, and the printing is a bit thin; can you read it at the back? you can't; well I'd better read it out; no I won't, it's all in the paper which should be published within a month or so, and anyone who wants I'll give a preprint afterwards, anyway, for those who can read it, this slide is a block diagram of the measurement scheme we used and before I go any further I should mention that there are a couple of misprints: on the third row, fourth box from the left, well, of course that's the second box from the right, if you can read it, it says mega, now that should be micro; also you can perhaps see the word ipnut, that should of course be input; now which one is this? ah, yes it's the scatter diagram, I haven't marked the quantities but we are plotting concentration against flow; if I remember rightly this has been normalised; perhaps I could have the lights for a moment to check in the text, yes, here we are, well it doesn't actually say - we could work it out but it's probably not worth the time, so if I could have the lights off, let's have a look at the plot: well I think you can see a sort of linear relationship - there's a fair bit of scatter, of course, but I think the data are at least suggestive; perhaps if I held up a pointer you could see the relationship more clearly - I expect there's a pointer around somewhere, no I won't need the lights, yes here it is, now you can see the trend and there's just the hint of another trend running subparallel to it through this other cluster of points, you may see that more clearly if I slide the pointer across to the other - no, I wasn't saying next slide, just that I would slide the pointer; anyway now the next slide is up let's keep it on the screen, now this is the sort of evidence on which the data in the last slide were based; this is a processed image - it could take just a bit of focusing - yes, that's better, it's difficult to get the whole slide in focus at once, now the scale is, well the bar is one arcminute long, hang on what am I saying? it's ten kilometers long - oh dear, the chairman is giving me the two minute warning, it's difficult to give you a clear picture of this work in only eight minutes, but let's plough on, what was I saying? ah yes, that bar is ten kilometers long, now if we turn to the next slide, please, this is the result of an analysis of the dark region that is near the centre of the image, is it possible to go back a slide? well not to worry, you can see in the analysis how dominant - sorry what was that? oh yes, the errors are plus or minus twenty per cent or so - that's the standard deviation, no it can't be, it must be the standard error of the mean - oh dear, the chairman says my time is up, can I beg half a minute - are there any more slides? really? well let's skip the next two, now this one is pretty important, it brings together several of the threads that you've probably been able to discern running through this talk, but rather than go through it in detail perhaps I should have the lights and just put up one or two key numbers on the blackboard - the chairman says there is no chalk, well since it's all in the paper I was mentioning anyway perhaps I've been able to give you a gist of what we've been doing, I guess that's all I've got time for."

People and Events

IHDP Secretariat Opens in Bonn

The offices of the International Human Dimensions Programme on Global Environmental Change (IHDP) were officially opened during an Inaugural Reception on 31 January 1997 in Bonn, Germany. The event, attended by the Secretary General of ISSC and the Executive Director of ICSU, as well as a number of senior German, European Union, University of Bonn, and city officials, reflected the wide-range of support and interest in the launching of the "new" IHDP. The IHDP Secretariat, whose core financing is provided by the German Federal Ministry for Education, Science, Research and Technology, is now established in offices provided by the University of Bonn. An important next step will be taken on 1 March 1997, when the newly appointed Executive Director, Dr Larry Kohler, officially joins the Secretariat in Bonn.

The Scientific Committee, chaired by Professor Eckart Ehlers from the University of Bonn, has already taken a number of decisive steps to develop a new and more focused scientific profile for IHDP. In addition to collaborating with IGBP, WCRP, START, LUCC and others, IHDP will focus on three project priorities: industrial transformation, institutions, and human security. Emphasis will be given to "internationalising" the role of the IHDP by serving as a "clearinghouse" and world-wide network for natural and social scientists involved in research related to the human dimension of global environmental change and by providing support for the development of national human dimension research activities. At the top of the agenda for Dr Kohler and the IHDP Secretariat will be the completion of the organisational structure of the IHDP, the development of a coherent and dynamic research/work plan, the launching of an IHDP newsletter and web page, and the identification of relevant national regional and specialised research units and projects to become part of the future IHDP network.

IHDP, Nussallee 15a, D-53115 Bonn, Germany, Tel: (+49-228) 73 90 50, Fax: (+49-228) 73 90 54, E-mail: ihdp@uni-bonn.de, WWW: http://www.uni-bonn.de/ihdp

Eckart Ehlers, Chair of IHDP, and Larry Kohler, new Executive Director for IHDP, shaking hands at the opening of the IHDP Secretariat in Bonn

Larry Kohler

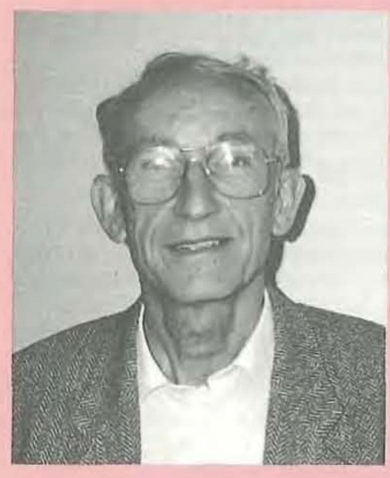
New Executive Director for IHDP

Dr Larry Kohler is the new Executive Director for the International Human Dimensions Programme. He received his BA degree from Michigan State University in Political Science (1968), an MA degree in International Affairs from Carleton University (1970) and a PhD from the School of Advanced International Studies of the Johns Hopkins University (1985).

At present he is the Focal Point for Environment and Sustainable Development at the International Labour Office (ILO) in Geneva, Switzerland. For the past ten years, Dr Kohler has been responsible for developing and implementing the ILO's programme of activities related to environment and the world of work. He has played a key role in the ILO's active participation in the preparations for the UN Conference on Environment and Development in 1992 and subsequent follow-up to Rio, including Agenda 21. In 1994-95, he also managed a special ILO Interdepartmental Project on Environment and the World of Work which promoted and supported follow-up activities related to Agenda 21 in over 30 countries.

After having spent 22 years at the ILO in a wide-range of positions dealing with the labour and social aspects of petroleum, energy, human settlements and environmental problems and policies, Dr Kohler has been granted a special leave of absence from the ILO to become the IHDP's Executive Director.

Dr Kohler describes this move as a challenging opportunity to focus his personal and professional interest and experience regarding the human dimension of global environmental change within a new, dynamic secretariat and Scientific Committee sponsored by both ISSC and ICSU. He looks forward to strengthening IHDP's role as a catalyst for integrating human and public policy dimensions within global environmental change research by promoting close collaboration with and synergy between the many existing and potential national human dimension research programmes and projects.


S. Lunter

Bruno Messerli

Bruno Messerli New President of IGU

Bruno Messerli has been elected as President of the International Geographical Union for the next three years. He obtained a PhD in geography in 1962 and has worked as Professor at the University of Berne, Switzerland. Later he became Director of the Institute of Geography and from 1986 to 1987 he was rector of the University of Berne. He has carried out research in many areas of the world. His research interests range from geomorphology and glaciology to climatology and climate change. Professor Messerli is Director of the PAGES Core Project Office and a member of the PAGES Scientific Steering Committee.

IGBP Symposium at RRL

The second IGBP National Symposium on the theme "Changes in global climate due to natural and human activities" was organised jointly by the Indian National IGBP Committee, IGBP and Regional Research Laboratory (RRL), Bhubaneswar at RRL, January 15-17, 1997. It was attended by more than 100 delegates working in ten core areas of IGBP in different Universities and research and development institutions.

The Symposium was inaugurated by Dr Mitra, Professor Rapley, and Professor Deekshatulu. Over the course of three days about 100 technical papers were presented. In addition the delegates were presented with 20 lectures by invited speakers concerning the IGBP. The symposium was concluded by a panel discussion which provided several recommendations on how to augment and improve global change research in India. Among other things the development of an inventory of resources in global change research was recommended, as well as an integrated, intercalibrated/intercompared and coordinated programme for each core area of IGBP in India, introduction of global change science at university levels, national and international exchange of scholars, and the institution of IGBP awards to encourage and recognise breakthrough achievements in the area of global change research.

C. Rapley

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C. Rapley

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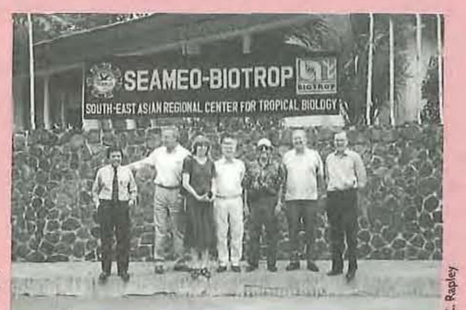

C. Rapley

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C. Rapley

4

Clockwise from top left: 1) Indian dancers at the IGBP Symposium in Bhubaneshwar; 2) R.R. Daniel receives an award for his longstanding service to global change research; 3) both START and GCTE held meetings at the SEAMEO in Bogor, Indonesia; 4) the SC-IGBP during their recent meeting in Norwich, UK; 5) Hassan Virji, Deputy Director for START, smelling tea at a plantation in Bogor, Indonesia.

IGBP and Other Meetings

*Only meetings marked with * are open for all scientists to attend. All other meetings are by invitation only.*

1997

TBA, Santa Barbara CA, USA

Joint IGBP-BAHC/GCTE/DIS Workshop on Large-scale Pattern and Process in Root System Structure and Dynamics.

Bhaskar Choudhury, NASA-GSFC, Code 974, Greenbelt, MD 20771, USA. Fax: (+1-301) 286 1758 and Chris Field, Carnegie Institution of Washington, Stanford CA, USA. Fax: (+1-415) 325 6857

March, Tucson AZ, USA

DIS Focus 1: Soils Pedo Transfer Function meeting.

Sorrosh Sorooshian, Dept. of Hydrology and Water Resources, University of Arizona, Tucson, AZ 87521, USA. Fax: (+1-602) 621 1422

March, TBA

SARCS/LUCC Synthesis Workshop.

3-12 March, Mombasa, Kenya

African GAIM Modelling Workshop.

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 1915, E-mail: gaim@unh.edu

4-6 March, Toulouse, France

8th IGBP-DIS Scientific Steering Committee Meeting.

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

9 and 13 March, Japan

IPCC/START Integrated Assessment Modelling Training Programme Core Group Planning Meeting.

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

13-17 March, Capetown/Stellenbosch, South Africa

PAGES SSC Meeting.

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

16-18 March, Bogor, Indonesia

GCTE SSC Meeting

Will Steffen, GCTE Core Project Office, CSIRO, Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

17-19 March, Norwich, UK

LOICZ Integration Guidelines Workshop

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

18-20 March, Bogor, Indonesia

GCTE Activity 3.4 Workshop: Complex Agro-ecosystems Workshop.

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

18-20 March, 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

20-22 March, Montpellier, France

Terrestrial Global Productivity: Past, Present and Future.

Jacques Roy, Centre d'Ecologie Fonctionnelle et Evolutive, CNRS, BP 5051, F-34033 Montpellier Cedex 1, France. Fax: (+33-4) 67 41 21 38, E-mail: roy@srvlinux.cefe.cnrs-mop.fr

April, New Delhi, India

SASCOM/GCTE: FACE Planning Meeting (tentative)

Professor A.P. Mitra, SASCOM, Fax: (+91-11) 575 2678, E-mail: apmitra@doc.ernet.in

1-3 April, Barcelona, Spain

GAIM Task Force Meeting

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 1915, E-mail: gaim@unh.edu

6-13 April, Santa Barbara CA, USA

Arctic and Boreal Processes that feed back to climate: Extrapolation and Synthesis.

F. Stewart Chapin III, Department of Integrative Biology, University of California, Berkeley, CA 94720-3140, USA. Fax: (+1-510) 643 6242, E-mail: fschapin@garnet.berkeley.edu

8-11 April, Boulder CO, USA

IGBP-DIS/WDC: Data Management Requirement Workshop.

Jonathan Overpeck, Paleoclimatology Programme, National Geophysical Data Center E/GC, National Oceanic and Atmosphere Administration (NOAA), 325 Broadway, Boulder, CO 80303-3328, USA. Fax: (+1-303) 497 6513, E-mail: jto@mail.ngdc.noaa.gov

14-16 April, Kuala Lumpur, Malaysia

LOICZ Integration Guidelines Workshop

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

14-18 April, Utrecht, Netherlands

GCTE Soil Erosion Network Water Erosion at Catchment Scale: Model Comparison and Sensitivity Analysis Workshop.

Christian Valentin, ORSTOM, Institute Français de Recherche Scientifique pour le Développement en Coopération, BP 11416, Niamey, Niger. Fax: (+227) 722 804, E-mail: valentin@orstom.rio.net

20-25 April, Kathmandu, Nepal

Dynamics of Land Use/Land Cover Change in the Hindu Kush-Himalayas.

Lisa Graumlich, Institute for the Study of Planet Earth, University of Arizona, Tucson AZ 85721, USA. Fax: (+1-520) 621 5004, E-mail: graumlich@ltrr.arizona.edu

21-25 April, Vienna, Austria

BAHC Special Sessions at the European Geophysical Society (EGS) XXII General Assembly.

EGS Office, Max-Planck-Strasse 1, D-37191 Katlenburg-Lindau, Germany. Fax: (+49-5556) 4709, E-mail: egs@linax1.mpae.gwdg.de, http://www.mpae.gwdg.de/egs/egs.html

23 April-3 May, Rabat, Morocco

IAHS 5th Scientific Assembly, Workshop W1: Scaling Issues in the Coupling of Hydrological and Atmospheric Models.

Alfred Becker, PIK, PO Box 601 203, 14412 Potsdam, Germany. Fax: (-49-331) 288 2560, E-mail: becker@pik-potsdam.de

28-29 April, TBA

SASCOM/LUCC: Land Use/Cover Change in the Indo-Gangetic Plain.

A.P. Mitra, SASCOM, Fax: (+91-11) 575 2678, E-mail: apmitra@doc.ernet.in

29 April - 2 May, Arizona, USA

GCTE Wheat Network Workshop.

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

May, TBA

Kalahari Ecosystems Transect Project - Coordination Workshop (tentative).

Bob Scholes, CSIR, South Africa, Fax: (+27-12) 841 2689, E-mail: bscholes@csir.co.za

May, TBA

Regional Workshop for France and Africa.

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

10-15 May, Castelvecchio Pascoli, Italy

*European Research Conference on Palaeoclimate Modelling and Analysis.

Dr Josip Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedes, France. Fax: (+33-3) 88 36 69 87, E-mail: euresco@esf.org

17-19 May, Argyll, Scotland (UK)

JGOFS Scientific Steering Committee Meeting.

Roger Hanson, JGOFS Core Project Office, Center for Studies of Environment and Resources, High Technology Centre, University of Bergen, N-5020 Bergen, Norway. Fax: (+47-55) 324 801, E-mail: jgofs@uib.no

17-19 May, Toronto, Canada

IGAC Scientific Council Meeting.

Alex Pszenny, IGAC Core Project Office, Bldg. 24-409, Massachusetts Institute of Technology, Cambridge, MA, 02139-4307, USA. Fax: (+1-617) 253-9886, E-mail: pszenny@mit.edu.

20-22 May, Toronto, Canada

IGAC/SPARC/GAW Conference on Global Measurement Systems for Atmospheric Composition

IGAC-GOMAC, Department of Physics, University of Toronto, 60 St. George St., Toronto, Ontario M5S 1A7, Canada. Fax: (+1-416) 978-8905, E-mail: gomac@atmosp.physics.utoronto.ca, WWW: http://www.atmosp.physics.utoronto.ca/gomac

20-26 May, Argyll, Scotland (UK)

JGOFS Symposium on Synthesis and Modelling.

Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca or: Graham Shimmield, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll, Scotland. Fax: (+44-1631) 65518, E-mail: g.shimmield@ed.ac.uk

29-31 May, Missoula MT, USA

BAHC SSC Meeting.

BAHC Core Project Office, Potsdam Institute for Climate Impact Research, PO Box 601 203, 14412 Potsdam, Germany. Fax: (+49-331) 288 2547, E-mail: bahc@pik-potsdam.de

28-30 May, Ensenada, Mexico

LOICZ SSC Meeting

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

June, Potsdam, Germany

Net Primary Productivity Model Intercomparison workshop.

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 1915, E-mail: gaim@unh.edu

4-8 June, Lake Tahoe NV, USA

GCTE Focus 1 Workshop: Critical Assessment of the Response of Forest Ecosystems to Elevated Atmospheric Carbon Dioxide.

Evan DeLucia, Department of Plant Biology, University of Illinois at Champaigne-Urbana, 265 Morrill Hall, 505 S Goodwine Avenue, Urbana, IL 61801, USA. E-mail: delucia@uiuc.edu

12-14 June, Laxenburg, Austria

*1997 Open Meeting of the Human Dimensions of Global Environmental Change Research Community.

I. Teply-Baubinder, IIASA, A-2361 Laxenburg, Austria. Fax: (+43-2236) 71313, E-mail: teply@iiasa.ac.at

16-17 June, Laxenburg, Austria

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

24-26 June, Plymouth, UK

GLOBEC SSC Meeting

Roger Harris, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, United Kingdom. Fax: (+44-1752) 633 101, E-mail: rph@wpo.nerc.ac.uk

July, Nantes, France

Joint meeting of the GLOBEC Working Groups on Numerical Modelling and Sampling and Observation Systems.

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

July, Cotonou, Bénin

START/WCRP/SCOWAR (ICSU) Workshop on Climate Variability, Water and Agriculture in Sub-Saharan Africa: Food Security Issues (tentative).

Abel Afouda. Fax: (+229) 30 08 39

July, 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

July, La Jolla CA, USA

Southern Ocean GLOBEC Working Group

Eileen Hofmann, Center for Coastal Physical Oceanography, Crittenton Hall, Old Dominion University, Norfolk, VA 23529, Usa. Fax: (+1-804) 683 5550, E-mail: hofmann@ccpo.odu.edu

1-9 July, Melbourne, Australia

*4th IGAC Scientific Conference,

Comprised of three Symposia of the IAMAS/IAPSO Joint Assemblies on Earth - Ocean - Atmosphere: Forces for Change. Symposium JMP3: Chemical Processes and Climate, Convener: Barry J. Huebert, University of Hawaii, USA; Fax: (+1-808) 956-9225; E-mail: huebert@soest.hawaii.edu. Symposium IM7: Tropospheric Chemistry and Related Air/Surface Exchange in Polar Regions, Convener: Gregory P. Ayers, CSIRO Division of Atmospheric Research, Australia; Fax: (+61-3) 9239 4688; E-mail: greg.ayers@dar.csiro.au. Symposium IM22: Closing the Budgets of CO_2, CH_4 and N_2O, Convener: Paul J. Fraser, CSIRO Division of Atmospheric Research, Australia; Fax: (+61-3) 9239 4444; E-mail: paul.fraser@dar.csiro.au. Further information: http://web.mit.edu/afs/athena.mit.edu/org/i/igac/www/IAMAS.html

13-19 July, Suva, Fiji

START Planning Meeting for Oceania (tentative) in conjunction with the 13-19 July Pacific Science Inter-Congress: The Islands in the Pacific Century.

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

24-26 July, TBA

Joint NAFCOM/SAFCOM Meeting: 5th NAFCOM Meeting and 6th SAFCOM Meeting (tentative).

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

August, Longyearbyen, Svalbard

JGOFS Symposium on Photosynthesis Measurement.

Egil Sakshaug, Trondheim Biological Station, Institute for Marine Biochemistry, University of Trondheim, Erling Skakkesgt. 47, N-7013 Trondheim-North, Norway. Fax: (+47) 7359 1597, E-mail: egil.sakshaug@vm.unit.no

4-8 August, Duluth MN, USA

*IBFRA Conference on Disturbance in Boreal Forest Ecosystems: Human Impacts and Natural Processes.

E. F. Schmucker, USDA Forest Service - FFASR (IC-Aud) 201 14th St. SW, Washington DC 20250, Usa. Fax: (+1-202) 205 2497, E-mail: ibfra97@worldweb.net

20-22 August, Potsdam, Germany

IPO Executive Officers Meeting

24-30 August, 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

September, Birmensdorf, Switzerland

GCTE Focus 2 Workshop on Comparison of Forest Patch Models.

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

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 X10 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

October, TBA

JGOFS Arabian Sea Synthesis Workshop.

Peter Burkill, Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH, UK. Fax: (+44-1752) 670 637, E-mail: p.burkill@pml.ac.uk

October, TBA

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.

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

17-18 October, Pusan, 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

October/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

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

November, TBA

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

2-9 December, 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

December, Niamey, Niger

START/BAHC/GCTE Workshop on Vegetation and the Hydrological Cycle in the Sahel.

BAHC CPO, Potsdam- Institute for Climate Impact Research, PO Box 601 203, D-14412 Potsdam, Germany. Fax: (+49-331) 288 2547, E-mail: bahc@pik-potsdam.de

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

1998

First quarter, TBA

JGOFS Training Course on Synthesis and Modelling.

Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca

14-18 March, Barcelona, Spain

*GCTE-LUCC Science Conference.

Will Steffen, GCTE Core Project Office, CSIRO Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

16-20 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, 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

18-21 May , Bozeman Montana, USA

BAHC/GCTE/IGAC/IBFRA symposium on Effects of Fire on Nutrient, Biogeochemical and Hydrological Cycles, in conjunction with the 125th Anniversary of Yellowstone National Park (USA).

Mike Fosberg, BAHC CPO, PIK-Potsdam, PO Box 601203, 14412 Potsdam, Germany. Fax: (+49-331) 288 2547, E-mail: bahc@pik-potsdam.de

July, 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/OCRD, Building3, 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/

Publications

IGBP Report Series

IGBP Report No.38

Natural Disturbances and Human Land Use in Dynamic Global Vegetation Models. A report of a workshop co-convened by the GAIM, GCTE, LUCC, and IGBP-DIS Programme Elements of the IGBP (1997). Edited by F.I. Woodward and W.L. Steffen. Stockholm: IGBP, 49pp.

Directory

IGBP Directory 1997. Stockholm: IGBP, 169pp.

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

IGBP Programme Elements

IGBP-DIS

The IGBP-DIS Fire Algorithm Workshop 2 (1996). Report of the Meeting in Ispra, Italy, 17-19 October 1995. Edited by Chris Justice and Jean-Paul Malingreau. IGBP-DIS Working Paper No.14. Toulouse: IGBP-DIS, pp.66

Pedotransfer Functions for Thermal Soil Properties (1996). Edited by Loide Hubreachts and Jan Feyen. IGBP-DIS Working Paper No.15. Toulouse: IGBP-DIS, pp.55

IGBP-DIS Office, IGBP-DIS - CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse cedex, France

GCTE

GCTE Focus 3 Wheat Network: 1996 Model and Experimental Data (1996). GCTE Report No.2 *Second Edition*. Wallingford: GCTE Focus 3 Office, pp.264

GCTE Focus 3 Office, NERC Centre for Ecology and Hydrology, Maclean Building, Wallingford, Oxon OX10 8BB, UK

JGOFS/LOICZ

Report of the International Workshop on Continental Shelf Fluxes of Carbon Nitrogen and Phosphorus (1996). Edited and compiled by Julie Hall, Stephen V. Smith and Paul R. Boudreau. LOICZ Reports & Studies No.9, JGOFS Report No.22. Texel: LOICZ, pp.50

LOICZ Core Project Office, NIOZ, PO Box 59, NL-1790 AB Den Burg-Texel, Netherlands.

LOICZ

Report of the SARCS/WOTRO/LOICZ Workshop on Integrated Natural and Socio-economic Modelling (1996). LOICZ Meeting Report No.20. Texel: LOICZ, pp.46

LOICZ Core Project Office, NIOZ, PO Box 59, NL-1790 AB Den Burg-Texel, Netherlands.

PAGES

Climatic Impact of Explosive Volcanism: Recommendations for Research (1996). Edited by James E. Begét, Hiroshi Machida and David J. Lowe. PAGES Workshop Report Series 96-3. Bern: PAGES, pp.28

Continental Drilling for Paleoclimatic Record: Recommendations from an International Workshop (1996). Edited by Steven M. Colman. PAGES Workshop Report Series 96-4. Bern: PAGES, pp.104

PAGES Core Project Office, Bärenplatz 2, 3011 Bern, Switzerland.

National Research

Finland

Climate Change and Finland: Summary of the Finnish Research Programme on Climate Change (SILMU) (1996). Helsinki: The Academy of Finland, pp.16

The Academy of Finland, PO Box 99, FIN-00501 Helsinki, Finland.

Japan

Global Environment Research of Japan in 1995 (3 volumes) (1996). Tokyo: Global Environment Department, pp.982

Association of International Research Initiatives for Environmental Studies (AIRIES), 3-1-13, Shibakoen, Minato-ku, Tokyo 105, Japan.

Poland

Global Change: Polish Perspectives 3 (1996). Edited by Leszek Starkel and Malgorzata Gutry-Korycka. Geographia Polonica 67. Warszaw: Polish Academy of Sciences, pp.139

Polish Academy of Sciences, Ul.Sw. Jana 22, PL-31-018 Kraków, Poland.

Related Organisations

SCOPE

Functional Roles of Biodiversity: A Global Perspective (1996). Edited by Harold A. Mooney, J. Hall Cushman, Ernesto Medina, Osvaldo E. Sala and Ernst-Detlef Schulze. SCOPE Report No.55. Chichester: John Wiley & Sons, pp.516

Global Change: Effects on Coniferous Forests and Grasslands (1996). Edited by A.I. Breymeyer, D.O. Hall, J.M. Melillo and G.I. Ågren. SCOPE Report No.56. Chichester: John Wiley & Sons, pp.483

Nitrogen Cycling in the North Atlantic Ocean and Its Watersheds. A Report of the Internatioanl SCOPE Nitrogen Project (1996). Edited by Robert W. Howarth. Dordrecht: Kluwer Academic Publishers, pp.304

Scientific Committee on Problems of the Environment (SCOPE), 51 boulevard de Montmorency, 75016 Paris, France.

WCRP

Climate, WCRP Newsletter No.1, October 1996.

World Climate Research Programme (WCRP) c/o WMO, 41 avenue Giuseppe Motta, Ch-1211 Geneva 2, Switzerland.

GLOBAL CHANGE NEWSLETTER

Edited by Sheila M. Lunter

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

PRINTING: BERGS GRAFISKA, STOCKHOLM