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The Global Change Open Science Conference – Amsterdam, July 2001

This edition of the Global Change Newsletter focuses on outcomes of the recent Open Science Conference, *Challenges of a Changing Earth*. The Newsletter begins with an introduction to the event and feedback from conference participants.

Four influential global change scientists, Bert Bolin, Robert Watson, Bob Scholes and Ian Noble, reach a consensus over the role of terrestrial carbon sinks in reducing greenhouse gas emissions (page 4). This important statement was hammered out over lunch during the conference in response to confusion amongst journalists and others regarding the importance of terrestrial sinks.

From page 5, we have a series of 9 articles based on presentations in the abundant parallel sessions and the centrefold presents four of the eight winners of the Student Poster Awards. On page 16, we provide a preliminary analysis of media coverage resulting from the conference.

Peter Haugan takes a serious look at the future of the IGBP post Amsterdam on page 36 and Executive Director, Will Steffen, offers a response (page 37). Also in the correspondence section, Gamini Seneviratne looks for new ways to enhance terrestrial carbon sinks.

Many people have asked about the plenary papers from the conference. These are currently being collated for publication by Springer and will hopefully be available early next year. We'll keep you posted.

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The Global Change Open Science Conference, Challenges of a Changing Earth, in Amsterdam was a landmark event in many respects. It was the first time that the three Global Environmental Change Programmes, IGBP, IHDP (International Human Dimensions Programme on Global Environmental Change) and WCRP (World Climate Research Programme) held a combined conference on such a large scale. It was undoubtedly a turning point in the process of forging a three-way partnership that will significantly enhance Earth System Science at the international level.

Facing the Challenge

The conference was also unique in bringing together so many global change scientists from all over the world. More than 400 scientists (just under a third of the total participation) attended from 62 developing countries. Overall, the conference brought together around 1400 scientists representing 105 countries, making it a truly global event.

Challenges of a Changing Earth also attracted more than 50 journalists with many more reporting from a distance. The conference was covered by BBC World Service, Reuters, Associated Press, French, Dutch and German press agencies, New Scientist, Nature, Science, The Los Angeles Times and many more (see page 16 for a preliminary analysis of media coverage).

Many have commented on the high quality and breadth of the presentations, with one common complaint being insufficient time for questions and discussion. Here we present more feedback from participants who attended the conference. We welcome your feedback, either in the form of "Letters to the Editor" or comments for internal use, rather than for publication. Please send your comments to sec@igbp.kva.se

"I've attended more meetings than I care to count in my 30-odd years in this area. This one was by far the best in every dimension. Most people nowadays have a vague notion about human-induced changes in the global environment - ozone depletion, climate change, biodiversity, etc. However, hardly anyone save the people represented in Amsterdam truly comprehends the enormity and gravity of these changes - and the desperate urgency of doing something to constrain them. Scientists in general are far too cautious, far too civilized, far too concerned for abstract notions of process and credibility. All these considerations are laudable when developing fundamental knowledge over the course of generations. However, they are grossly inappropriate when faced with the impending global holocaust that is one possible scenario arising from the results presented in Amsterdam."

John Perry, Consultant to START (synthesis), USA

"The conference has successfully reviewed advances on influence of human and natural processes on the global environmental changes. I think that if relevant research achievements regarding interaction between human and nature processes as well as how they jointly exert their influence on the environment could be showed more, it would contribute to understand better the challenges of a changing Earth we face. I suggest that it is better to hold one such conference every around three years if possible."

Yetang Hong, State Key Laboratory of Environmental Geochemistry, Chinese Academy of Sciences

"The most impressive aspect of the conference was to see the large number of scientists and scientific presentations relating to so many different aspects of global change almost all, without exception, driving home the same message that there is a problem i.e. that change is occurring at a pace which demands very swift action from all countries. The participation of developing country scientists was essential because the meeting contextualised their research very forcefully especially for those whose research was not initially motivated by global change concerns. Unfortunately, the seminar on reinforcing capacity in developing countries was too short to propose concrete ways of achieving this aim in the area of global change but many of the difficulties facing all scientists in these countries were highlighted.

Richard A Hall, International Foundation for Science, Sweden

"[The conference was] unique because of the large representation from developing countries - thanks to IGBP for support - and because of including a social/policy perspective in the plenary and poster sessions. Causes of poor participation in global research by developing countries are well known. The meeting should have provided tangible/proactive action plans with specific targets set as well as an evaluation framework for the plans. A lot still remains to be done if we in the developing countries are to make any impact in global change research, and we shall continue relying on the developed world more."

Evans Kituyi, African Centre for Technology Studies, Kenya

"The conference for the first time presented convincing evidence of major change to the global system, largely based on paleological studies using ground-based data - demonstrating the central importance of preserving and extending ground-based monitoring of atmospheric and other earth system variables."

Dr Michael Hutchinson, Centre for Resource and Environmental Studies, Australia

"The multi-disciplinary global congregation on climate change made the Conference a very thought-provoking event. However identification of collaborating themes for research on impact and adaptation in the developing countries, could have made the conference much more meaningful."

Amit Garg, Indian Institute of Management, India

"This year's "Global Change" Open Science Conference in Amsterdam was a highlight in international scientific and environmental exchange. I was particularly interested in the expertise and creativity of suggested solutions to environmental issues from and within developing countries. Many of the sensitive balances of nature may only be understood from within a local ecosystem. "Western" solutions might not always meet the requirements. It is my hope that this conference has stimulated and enabled broader information exchange between the developed and less developed countries as well as between disciplines and scientific approaches. Modern technologies like Remote Sensing are highly valuable tools for interdisciplinary research."

Ulrike Granoegger, Academy For Future Science, Germany

"I was generally impressed with the quality of the presentations and the high level of co-operation among the programmes. It would have been nice to get a bit more discussion though - a few questions at least (but I suppose time was the major constraint). I was pleased to discover that the work we are doing on national assessments for adaptation to climate change resonates with other researchers, even though we are coming at the same problem from different angles for the purpose of both policy and applied science."

Bo Lim, National Communications Support Programme, UNDP-GEF, USA

At the Open Science Conference there was much discussion, and some confusion, about the contribution of terrestrial sinks to reducing the impact of anthropogenic greenhouse gas emissions. Are these sinks reliable? Can and should we depend on them? What does the future hold? Four prominent global carbon experts joined forces during the conference to nut out some answers to a few of the more perplexing questions. The following statement was sent to journalists covering the ongoing Kyoto negotiations in July.

The Kyoto Protocol and Land-Use, Land-Use Change and Forestry

By Bert Bolin, Ian Noble, Bob Scholes and Robert Watson

The Kyoto Protocol recognises the potential contribution of sinks (above and below ground biomass and soil carbon) to reducing net greenhouse gas emissions into the atmosphere through a range of land-use, land-use change and forestry (LULUCF) activities. However, there is a range of scientific issues associated with LULUCF activities that need clarification. These must be differentiated from political issues.

Scientific issues that need clarification include:

Does planting trees (afforestation and reforestation, A and R) result in the short-term and long-term sequestration of carbon? The simple answer is yes. Carbon will be removed from the atmosphere for decades to centuries and even where growth slows, carbon can remain sequestered in above and below ground biomass and soils. Monitoring systems are essential to record the uptakes and releases through forest uses or disturbances.

Is it possible that some of the sequestered carbon in the above and below-ground biomass and soils could be released back into the atmosphere if there were significant changes in climate? Yes, some of the sequestered carbon could be released under certain circumstances, particularly in areas with significant increases in temperature coupled with decreased precipitation - however, this situation is unlikely to occur for many decades. Even then there would still be more carbon in all three pools than if the A and R activities had not taken place.

Are there any situations where afforestation and reforestation activities can have adverse effect on climate? Yes, but they are of limited extent. For example, A and R activities can affect the Earth's albedo, especially at high latitudes, hence a careful analysis is needed to evaluate the climate implications of sequestering carbon vs decreased albedo.

Do A and R activities have other beneficial or adverse environmental and social effects? A and R activities can either benefit or adversely affect the environment, hence opportunities need to be sought that yield multiple environmental and social benefits, while ensuring that adverse consequences are avoided.

Does slowing deforestation help protect the climate system? Yes, it reduces the emissions of carbon into the atmosphere and simultaneously benefits biodiversity, water resources and other ecological goods and services.

Do other LULUCF activities, e.g., improved forest, cropland and range-land management and agroforestry result in the short-term and long-term sequestration of carbon? Yes and the potential magnitudes are larger, and the cautionary issues are the same as those addressed previously for ARD activities.

Can carbon be adequately measured in above- and below-ground biomass and soils? Yes, but few countries have an existing appropriate operational monitoring system in place.

Does the use of LULUCF activities buy time to transform energy systems to lower greenhouse gas emitting systems? Yes, but it will allow more fossil fuel carbon to be used thus transferring more carbon from the very long-lived fossil carbon pools into the more labile biological pools.

From the point of view of the carbon cycle, avoiding a tonne of fossil emissions is always better than creating a tonne of sinks. But recognising the difficulties of achieving reductions in fossil emissions, sinks can play an important transitional role.

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Bridging scientific and traditional knowledge of climate change in the Canadian Arctic

by J. Castleden

At the recent Global Change Open Science Conference in Amsterdam, it was apparent that the level of interest in diverse knowledge systems, and the synergies between knowledge systems, is growing. From discussions of sustainability science [1], - with one of its driving forces being the integration of knowledge and action; scholars and practitioners - to calls for the expansion of social participation and perspectives [2], the opportunity is ripe for reflection on how communities and local people may inform the growing field of global change research.

A recent project entitled *Inuit Observations on Climate Change* sought to bring together two knowledge systems – Traditional Inuit Knowledge [3] and Western Scientific Knowledge [4] – to better understand climate-related changes on an Arctic island in Canada. The following overview of the project methodology and results may serve as a model for global change researchers wishing to expand their knowledge of place-based vulnerabilities, impacts, and associated coping/adaptation strategies.

Project Overview

Sachs Harbour, NWT (72°, 125°), is located on Banks Island in Canada's western arctic. People from this tiny community have observed climate-related changes including the earlier break up and later freeze up of sea-ice, making it more difficult and dangerous to hunt and trap. New species of insects, fish and mammals are appearing for the first time. Permafrost, the permanent layer of frozen ground, is melting, causing town buildings to shift, and increasing the rate of slumping on the coastline and along the shores of inland lakes. The melting has already caused one inland lake to drain into the ocean, killing the freshwater fish.

Given the dramatic changes that local people have observed, the International Institute for Sustainable Development (IISD) and the Hunters and Trappers Committee of Sachs Harbour collaborated on a year-long project to document the evidence of Arctic climate change and communicate it to Canadian and international audiences. The *Inuit Observations on Climate Change* project set out to achieve two goals. The first goal was related to public awareness on climate change. This goal was met through the production of a video that demonstrated to decision-makers, interest-groups, civil society and the media that climate change is making an

impact on the traditional lifestyle and livelihood system of people from Sachs Harbour. The second goal was related to the relationship between traditional knowledge and scientific research on climate change. This second goal tested a methodology for understanding the traditional knowledge of Inuit people regarding

climate change and explored how traditional knowledge, local observations and adaptive strategies may complement scientific research on climate change in the Arctic.

Methodology

During the two year initiative (June 1999 – June 2001), the project team worked in partnership with specialists from five organizations [5] to develop an innovative method [6] for recording and sharing local observations on climate change. The approach combined participatory workshops, semi-structured interviews, community meetings and fieldwork to better understand the extent of local knowledge of climate change.

An initial planning session was held in Sachs Harbour in June 1999 to provide an opportunity for local people to describe their livelihood system, discuss the climate change phenomena they are experiencing and help the project team plan further trips to the community. Based on the outcome of the planning workshop, the team made three further visits to the community. The trips were scheduled on a seasonal basis so that total impact of climate change in an annual cycle could be understood and documented. These visits focused on sea and lake ice related changes during the fall fishing and sealing season (August 1999), impacts on wildlife during the winter hunting season (February 2000), and permafrost melting during the spring goose hunt (May 2000) respectively. The science team included a lead scientist, a traditional knowledge advisor, a graduate student and a rotating "guest" scientist with expertise relevant to season specific issues.

The science team members followed an informal semi-directed interview approach, asking local people to elaborate on the observations that they had identified during the initial planning workshop. The questions asked by the science team in relation to sea ice, weather, species health and distribution, and permafrost changes were open ended and meant to stimulate discussion that would draw out the linkages between different observations. The interviews were also intended to differentiate between normal and unusual climate induced events. Additionally, the interviews gave the science group insight into the process and techniques needed to interview elders, hunters and community members about traditional knowledge of climate-related change. Topographic maps of the island were used to geographically place the observations. Photos were used when available to ensure that the science team and the participant were clear on the details of the topic in question. Site visits were conducted in several cases to allow the science team to see certain changes (such as permafrost related erosion) for themselves.

Results

Seven journal articles on the findings from this project have been produced and published, with two further scientific articles being prepared for publication in 2002. The project team met its objectives to: devise a process and techniques needed to interview elders, hunters and community members about traditional knowledge of climate-related change; determine the extent of traditional knowledge in the community; and determine the relevance of that knowledge to scientific research on climate change.

Extent and Relevance of Traditional Knowledge

The project visits subsequent to the first planning mission to Sachs Harbour were particularly important, as the project team expanded on observations of climate change from the community workshops held during the first trip in June. The science group was able to get a better understanding of the extent and relevance of traditional knowledge in the community. Key results obtained from these interviews:

- climate-related observations from non-climate-related observations could be separated with further interviews by the project team;
- observations could be placed temporally and spatially;

- the context of the observations was identified;
- observations could be stratified;
- community members who were Elders or active harvesters were most knowledgeable about climate-related change and traditional activities; and
- community members have their own indicators of change, which is relevant to understanding climate change.

Science Team

The following are several conclusions [7] that have been drawn by the science group from the interviews conducted in August (1999), February (2000) and May (2000).

1. There is an abundance of knowledge in the community related to historical and current sea ice conditions, weather patterns, erosion/permafrost melt and wildlife populations, as well as the linkages and relationships between these phenomena;
2. Understanding some aspects of climate-related change, such as those related to wildlife, are complicated by other factors such as harvesting patterns or species interaction;
3. Traditional knowledge clearly contributes to current western science-based knowledge of climate change; in many cases it is spatially and temporally extensive and can help "piece together" historical information;
4. While the specific impacts of climate change may be difficult to assess, it is clear that changes will have an impact on the community and the way in which people traditionally harvest animals.
5. knowledge of permafrost-related changes is closely tied to community activities, including travel, hunting and fishing;
6. community members interviewed can differentiate between natural and abnormal climate and erosion processes;
7. discussions of permafrost-related changes do not occur in isolation from other variables such as wind, precipitation, temperature, human activity and seasonal change; and
8. changes associated with melting permafrost, while very visible, have had less of an impact on community activities than the rapid spring melt and the delayed winter freeze-up.

Coping Strategies

The focus of the project from the beginning was on observations of climate change, rather than on adaptation strategies. It became evident during the research, however, that coping strategies are being used to deal with the climate-related changes and increased unpredictability of the environment. At present, while climate change is having a direct impact on the community, community members are able to cope. This is primarily done by adjusting harvesting activities in response to the increased unpredictability of weather, and land and sea ice changes. However, Riedlinger [8] cautions that the coping strategies currently developed to alter subsistence activities in relation to this unpredictability are recent, and that they should not be interpreted as a general indicator of the ability of the community to make adaptations in the future.

Relevance to the Global Change Community

As the global change research community is grappling with the questions of vulnerability and resilience issues within the nature-society system, and seeking methods for integrating research planning, monitoring, assessment, and decision-making, the lessons learned in the *Inuit Observations on Climate Change* project may serve as one model for further inquiry.

Success of the *Inuit Observations on Climate Change* project can be attributed to several factors. Full and active community participation was sought and attained throughout all stages of the project. The dual objectives of science and public awareness were mutually reinforcing. The video documentary showed the human dimension of climate change to decision-making, media and civil society audiences. The science

papers added rigor and analysis that enhanced the credibility of the project to academia. As well, traditional knowledge and scientific research complemented each other to give a more complete understanding of climate change. Traditional knowledge provided a convincing narrative through detailed and historical observations. It helped to establish linkages between multiple climate change related impacts and it was drawn from continual observation throughout the seasons. Adopting a seasonal approach to the project itself contributed to better science team research.

Crossing Knowledge Boundaries

Cooperation between social and physical scientists in the area of climate change impact assessment has broadened our understanding of this field much more than what each could have accomplished separately [9]. The Inuit project provides an example of how crossing knowledge boundaries - in this case local and scientific expertise – increased our understanding of climate change impacts and observations on Banks Island.

Traditional knowledge, by offering a different "way of knowing" can increase the possibilities of research questions and hypotheses. In Riedlinger and Berkes (2000) [10], five areas are identified as climate change research interests which may be informed by traditional knowledge. These five areas of knowledge are:

- local scale expertise;
- a source for climate history and baseline data;
- developing research questions and hypotheses;
- insight into impacts and adaptation in communities; and
- in long-term community-based monitoring.

By including local people from the beginning in the design and practice of research, opportunities exist for expanding our understanding of complex environmental trends such as global change.

Acknowledgements

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For more information the final report, summary version of the video, photos, and individual trip reports may be accessed at the following web site: http://www.iisd.org/casl/projects/inuitobs.htm

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2. Julia Carabias, *Challenges and Road Blocks for Local and Global Sustainability.* Plenary presentation, Global Change Open Science Conference, Amsterdam, The Netherlands, July 2001.

3. Traditional knowledge, also referred to as indigenous knowledge, is local knowledge, adapted to the culture and the ecology of each population, and matured over a period of time encompassing thousands of years. (From Our Responsibility to the Seventh Generation, IISD)

4. Western Science is a term used in this document to describe the prevailing paradigm of science today.

5. The Inuvialuit Joint Secretariat; the Natural Resources Institute, University of Manitoba; the Department of Fisheries and Oceans; the Government of the Northwest Territories; and the Geological Survey of Canada.

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Secondary production in the oceans and the response to climate change.

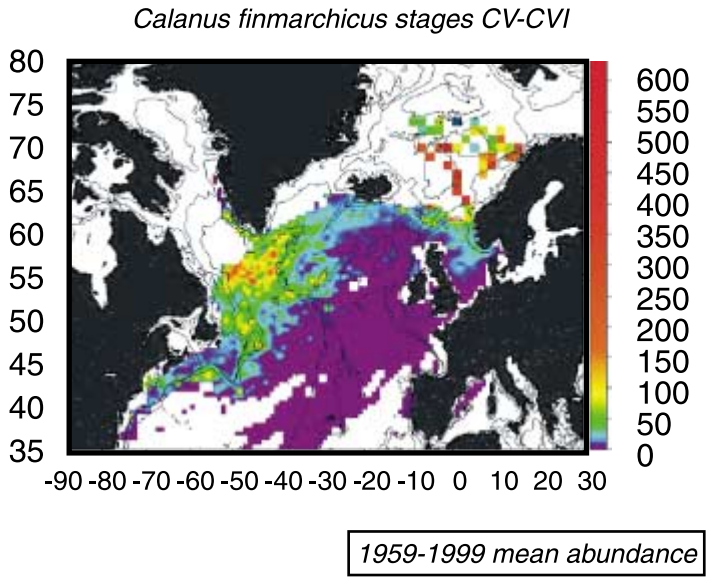
by M. Heath, F. Carlotti, B. de Young, O. Fiksen and C. Werner

Trends over the past 50 years in the ocean climate of the North Atlantic (convective depth, poleward heat transport, overflow from the Nordic Seas) are now well documented. Some of these are correlated with the North Atlantic Oscillation Index. What is the impact of these large scale, low frequency climatic changes on the living resources of the North Atlantic?

Economically important stocks of many fish species in shelf seas all around the North Atlantic have suffered major declines in abundance over the past half-century. Prime examples are cod in the northwestern Atlantic and in the North Sea. Without doubt, fishing pressure has played the major role in these declines, but some aspects of the changes indicate that concurrent environmental changes are also involved. In the northwestern Atlantic, the cod stock has failed to recover despite a moratorium on fishing, suggesting that historic productivity characteristics no longer apply. Is this because of some climate-related change in the underlying productivity of the food web as a whole, or some ecological response to the collapse of cod? Northern cod had an historical biomass on the Newfoundland and Labrador shelves of more than 2 million tonnes. The North Atlantic GLOBEC programme aims to discover how the secondary productivity of North Atlantic shelf seas is linked to basin-scale, long-term properties of the ocean circulation and climate system.

> "In the northwestern Atlantic, the cod stock has failed to recover despite a moratorium on fishing, suggesting that historic productivity characteristics no longer apply"

It is obvious that, at least at a gross level, there must be some relationship between the amount of primary production in the sea and the amount of fish available for harvesting. However, the details of this relationship are very much less clear. This is partly because the turn-over rates of carbon (roughly the reciprocal of the life-cycle duration) are very much lower at the top of the web compared to the lowest trophic levels. Hence, the production by fish reflects some long-term integral of the primary production. In addition, the connection between primary production by algae and the growth and recruitment of fish involves many predator-prey steps or trophic levels, with varying degrees of energy loss at each stage. Variations in the species composition of each



Calanus abundance map compiled from data supplied by SAHFOS to NERC Marine Productivity project GR2/2749 and data from the EU-TASC project

Figure 1. Long-term (1950-1999) mean abundance of adult and late development stages of *Calanus finmarchicus* in the upper 10m of the North Atlantic Ocean. Composite image derived from data supplied by the Continuous Plankton Recorder Survey operated by the Sir Alister Hardy Foundation for Ocean Science, UK, and from the EU-TASC project. The image shows the two main centres of abundance, one in the Irminger/Labrador Sea south of Greenland, and the other in the Norwegian Sea.

Calanus finmarchicus in the northern North Sea. Abundance, and as a proportion of all omnivorous zooplankton biomass

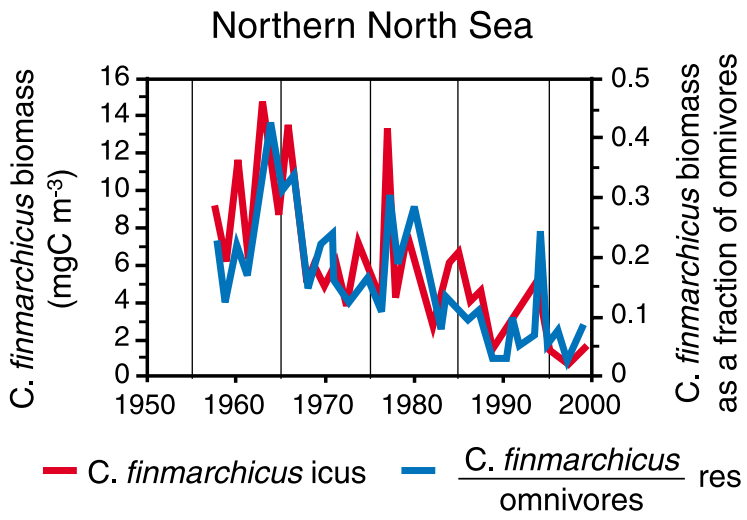


Figure 2. Trends in the abundance of *Calanus finmarchicus* copepodite stages in the northern North Sea derived from Continuous Plankton Recorder Survey data. Annual mean biomass (mg C m^{-3}) in the upper 10m, and as a proportion of the biomass of an assemblage of species representing all omnivorous zooplankton. Data supplied by the Sir Alister Hardy Foundation for Ocean Science, UK.

intervening trophic level further weaken the connection between production at the top and bottom of the food web.

At first sight the complexity of the food web makes the task of assessing the sensitivity of secondary production to climate changes seem intractable. However, it turns out that certain key species in the food web, particularly amongst the omnivorous zooplankton (the plankton animals which graze directly on the algae and are in turn eaten by pelagic fish and juvenile demersal fish), exert a particularly strong influence on the proportion of primary production which is passed up the food web towards the fish, or is deposited on the seabed to support the benthos and shellfish. By studying these, we can gain a better understanding of the flux of material to the higher trophic levels.

> "...observations indicate dramatic changes over the last 40-50 years in the structure of the food web supporting the North Sea fisheries. The rate at which they have occurred indicates that slow climatic processes are involved"

In the sub-polar North Atlantic and many of the fringing shelf seas, one of the most important of the key species is the copepod *Calanus finmarchicus*. Data from the UK Continuous Plankton Recorder Surveys (Figure 1) show that the contribution of *C. finmarchicus* to the annual average proportion of omnivorous zooplankton biomass in, for example, the northern North Sea has progressively declined from a peak of around 40% in the mid-1960's to around 5% today (Figure 2). At the same time, there has been around a four-fold increase in the abundance of larvae of benthic species, suggesting an increase in the amount of primary production reaching the seabed to feed benthic fauna. These observations indicate dramatic changes over the last 40-50 years in the structure of the food web supporting the North Sea fisheries. The rate at which they have occurred indicates that slow climatic processes are involved.

Analysis of the Continuous Plankton Recorder data set shows that the well documented decline in *C finmarchicus* in the North Sea, has occurred concurrently over a large part of the northeastern Atlantic Ocean, indicating that the events in the North Sea are probably part of a large scale phenomenon and not a local scale event. Similarly, changes in abundance are correlated over a large part of the northwestern Atlantic, but in this case the abundance has increased since the 1960's. The implication is that whilst year-to-year variability in the shelf seas may be more driven by local conditions, the low-frequency, longer term changes which are important for higher trophic level productivity, are primarily driven by the ocean basin scale dynamics. Over the past 8 years we have gained much insight into interaction between large-scale processes and *C. finmarchicus* population dynamics, from the EU funded ICOS and TASC projects, the US-GLOBEC programme, and various nationally funded projects. The details involve particular life-history characteristics of the species, and their

interaction with the 3-dimensional basin-scale circulation of the North Atlantic.

The growth and reproduction of *C. finmarchicus* occurs in the upper layers of the ocean (<100m). Under normal circumstances, at surface ocean temperatures, the species has a life cycle of 30-50 days involving a succession of naupliar (larval) and copepodite (juvenile) moult stages. However, the critical life-history trait which couples the species to the ocean circulation is its overwintering strategy. Late pre-adults have the ability to enter a resting state, equivalent to the diapause in some insects, enabling them to survive without feeding for periods of up to 6-8 months. Typically, late development stages will enter diapause in mid summer, sink out of the surface layer to the seabed or neutral buoyancy depths, forming dense aggregations. The resting copepods remain in this condition until the following spring. We do not know exactly what cues cause emergence from diapause, but in spring the surviving copepods swim back to the surface to mature, mate and spawn a new generation. At the northern extreme of the range, in the Greenland Sea and Davis Strait, the population may only produce a single generation per year, whilst at the southern extreme off the eastern coast of the USA, south of Iceland and in the waters west of the UK, at least two generation per year are more usual.

> "…the events in the North Sea are probably part of a large scale phenomenon and not a local scale event"

The conditions defining suitable overwintering habitats for *C. finmarchicus* seem to be accessibility from the loci of summer production in the surface layers, dispersal rate, temperature, and predator abundance. Low temperature is highly advantageous because it further slows down the metabolic rate and increases the endurance of the diapause state.

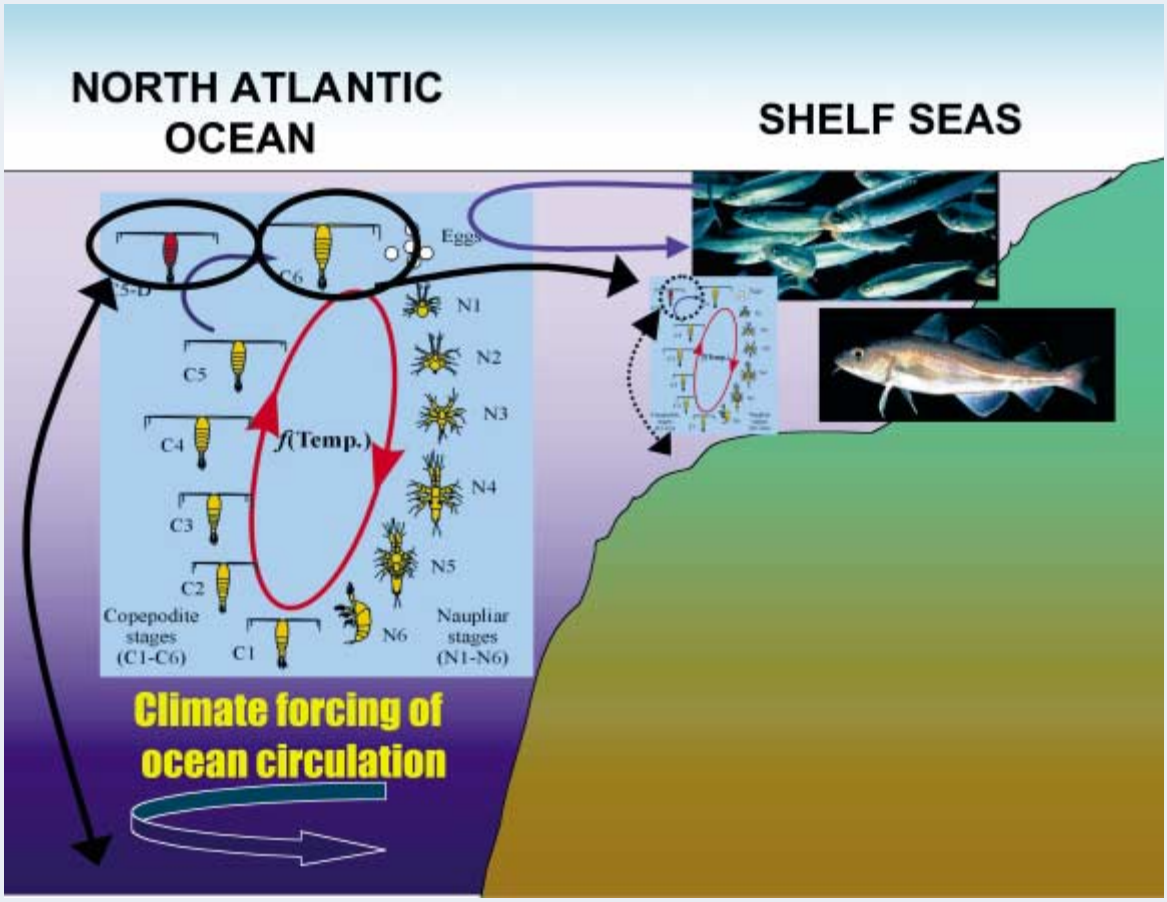


Figure 3. Schematic representation of the role of oceanic population dynamics of *Calanus finmarchicus* in the long-term trends of abundance on the continental shelf. The oceanic circulation system supports a self-sustaining life cycle, with diapause stages surviving through the winter at depth. Late development stages are exported annually to the continental shelves where there is limited scope for year-to-year maintenance of the life cycle. Population production on the shelf supports the fisheries food web.

In addition, visual predators are generally less abundant in extremes of low temperature. The appropriate combination of conditions is rarely found in shelf sea waters, and the majority of the overwintering stock resides at depths of 600-2000m in the open ocean, especially in the Norwegian Sea and, it is assumed, in the Labrador/ Irminger Sea in the northwest Atlantic. In the Norwegian Sea, these depths correspond to temperatures less than 1°C. Modelling and field observations have shown that most of the productive populations in shelf seas are sustained by annual recolonisation from these oceanic overwintering stocks. This explains why the long-term trends in abundance in, for example, the North Sea appear to be driven by the changes occurring over the wider northeast Atlantic (Figure 3).

So, the issue resolves to what is driving the basin scale changes in *C. finmarchicus* abundance in the ocean? One theory is that changes in the deep circulation of the North Atlantic and the availability of overwintering habitat in deep water masses are playing a large role. Data from the Faroe-Shetland Channel, which lies between the Faroe Islands and the Shetland Islands off northern Scotland, show that between October and March, dense concentrations of overwintering *C. finmarchicus* are found in the deep (>600m) cold overflow of Norwegian Sea Deep Water into the Atlantic. This overflow is part of the thermohaline circulation system which ventilates the global oceans. Norwegian Sea Deep Water is generated by deep convection in the Greenland Sea, and as this process has slowed down in concert with the rise in the NAO since the 1960s, so the volume of Deep Water in the Faroe-Shetland Channel has decreased. In consequence, the abundance of overwintering stock available to colonise the North Sea each spring has also declined, thus providing a possible explanation for the Continuous Plankton recorder observation in the North Sea. Are similar relationships responsible for the long-term dynamics in the North Atlantic as a whole? A detailed modelling and observation programme in the North Atlantic basin scale will be getting underway in late 2001 to address this question. The work will be a collaboration between the UK-GLOBEC programme and GLOBEC research programmes in Canada, Iceland, Norway and USA.

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Effects of increasing atmospheric CO_2 on phytoplankton communities and the biological carbon pump

by U. Riebesell, I. Zondervan, B. Rost, and R.E. Zeebe

In global assessments of potential anthropogenic CO_2 sources and sinks, the oceanic biosphere has commonly been considered to remain constant over time scales relevant to 'global change'. The 'constant oceanic biosphere' concept is based on the assumption that anthropogenic perturbations of environmental conditions determining ocean productivity are insignificant on a global scale. However, large-scale changes in surface ocean chemical equilibria and elemental cycling have occurred in the framework of 'global change' and are expected to continue and intensify in the future. One of the most prominent anthropogenic perturbations, the progressive increase in atmospheric CO_2, affects the marine biota in various ways: indirectly through rising mean global temperatures causing increased surface ocean stratification, and directly through changes in surface ocean carbonate chemistry.

A climate-induced increase in surface ocean stratification has two opposing effects on phytoplankton productivity: it reduces nutrient supply from deeper layers and increases light availability due to shoaling of the upper mixed layer. These changes are likely to cause an overall decrease and – due to a longer growing season at high latitudes – a poleward shift in oceanic primary production. Recent model calculations in fact indicate large regional differences in the effects of climate change on the marine biota, predicting a 20% decrease in export production in low latitudes and a 30% increase in high latitudes for a 2 x CO_2 scenario [3]. Changes in the amount and distribution of primary production will affect higher trophic

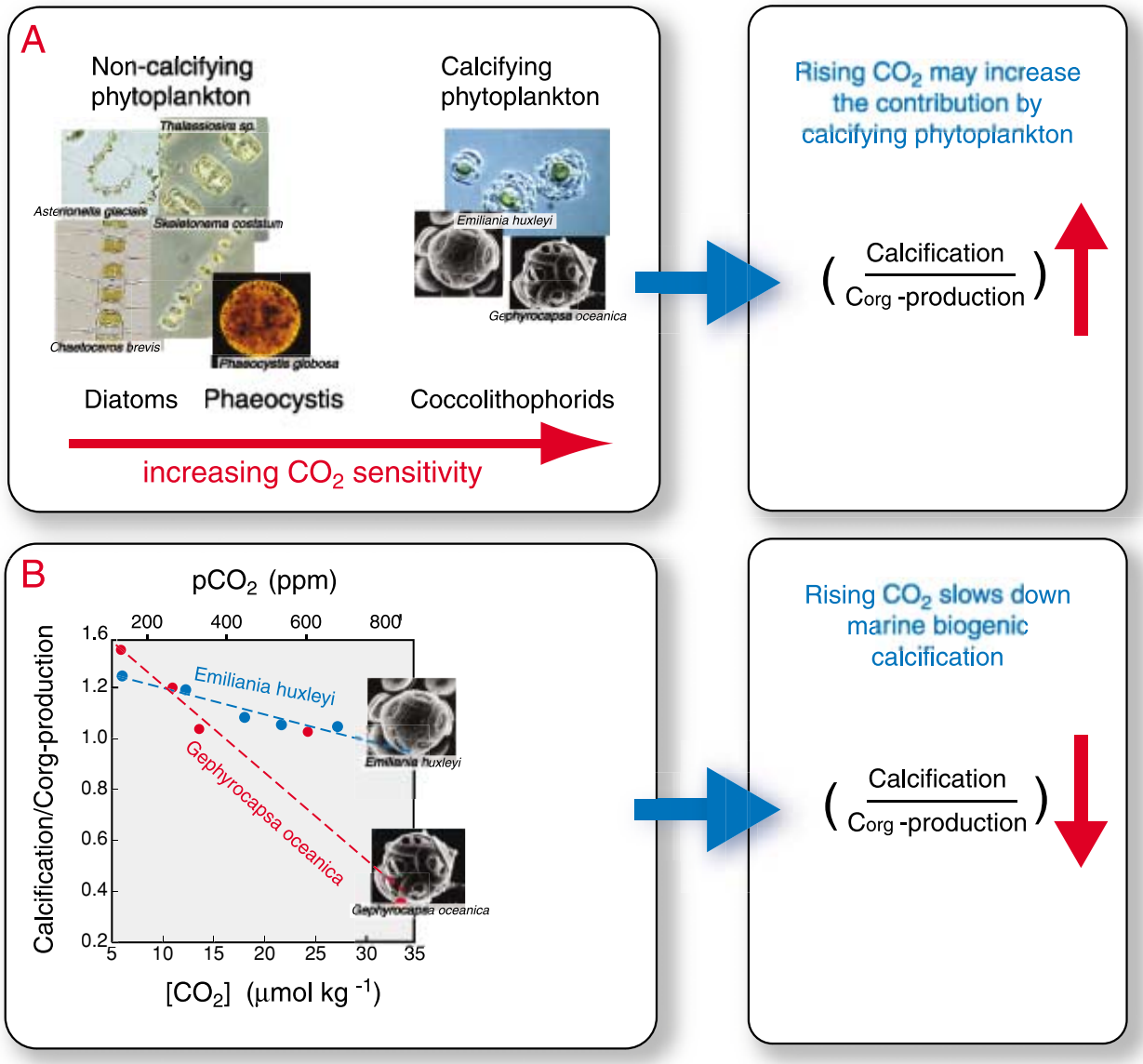

Figure 1. Potential effects of rising CO_2 on phytoplankton: A. Due to differences in CO_2 sensitivity between phytoplankton taxonomic groups, rising CO_2 is likely to influence phytoplankton composition and succession. One possible consequence could be shift in the contribution of calcifying phytoplank on to total primary production. B. Rising CO_2 decreases the ratio of calcification to organic carbon production in two coccolithophore species (Riebesell et al 2000: Nature 2000).

Note that the decrease in this ratio is caused by both reduced calcification and enhanced C_{org}-prduction. A and B have opposing effects on the ratio of calcification to organic matter production.

levels, with likely consequences for key economic fisheries.

Aside from its indirect effect on climate, the present rise in atmospheric CO_2 concentration directly impacts the marine biota by changing the surface ocean carbonate chemistry. By the end of the next century, the expected increase in atmospheric CO_2 will give rise to an almost three-fold increase in surface water CO_2 concentrations relative to pre-industrial values (assuming IPCC's 'business as usual' scenario IS 92a). This will cause CO_3^{2-} concentrations and seawater pH to drop by ca. 50% and 0.35 units, respectively. These changes in seawater carbonate chemistry are likely to affect phytoplankton taxonomic groups differently. For instance, large differences between major phytoplankton groups exist with respect to the CO_2 specificity of the predominant carboxylating enzyme ribulose bisphosphate carboxylase/oxygenase (Rubisco). Rubisco specificity - the enzyme's affinity to CO_2 relative to its affinity to O_2 – decreases with increasing evolutionary age of the phytoplankton [9]. Highest Rubisco specificities are found in the most recently evolved group of phytoplankton,

the diatoms. Progressively lower values occur in coccolithophorids, green algae, dinoflagellates, and the most ancient phytoplankton, the cyanobacteria.

Recent studies further indicate that dominant phytoplankton species differ in their CO_2 requirement. Whereas some species preferably use CO_2 as a carbon source, others mainly draw their inorganic carbon from the large pool of HCO_3^- (e.g. [6]). Also, group-specific differences in CO_2 sensitivity exist with respect to carbon metabolism. Most notably, the photosynthetic carbon fixation rates of all diatom species tested thus far, as well as of the prymnesiophyte *Phaeocystis globosa*, are at or close to CO_2-saturation at present day CO_2 levels [4, 5; Rost et al. unpubl.]. In contrast, the coccolithophorids *Emiliania huxleyi* and *Gephyrocapsa oceanica* are well below saturation at these levels [Rost et al. unpubl.; 8]. These findings suggest large differences in CO_2-sensitivity between major phytoplankton taxonomic groups. CO_2-sensitive taxa, such as the calcifying coccolithophorids, would be expected to benefit more from the present increase in atmospheric CO_2 compared to the non-calcifying diatoms and *Phaeocystis*. Rising CO_2 levels might therefore increase the contribution of the calcifying phytoplankton to overall primary production, which would consequently increase the ratio of calcification to organic carbon production in the ocean (Fig. 1A). Since coccolithophorid blooms predominantly occur in well-stratified waters, projected climate-induced changes in the marine environment may prove even more advantageous for this group of phytoplankton.

> "It is now becoming increasingly clear … that the assumption of a constant oceanic biosphere in assessments of future global change is no longer viable"

A shift in phytoplankton species composition and succession is likely to impact both ecosystem regulation and biogeochemical cycling. Diatoms, *Phaeocystis*, and coccolithophorids each serve a specific role in the marine ecosystem and have distinct effects on elemental cycling. This is reflected in the 'functional groups concept', in which phytoplankton taxa are grouped according to their role in ecological and biogeochemical processes. One of the most prominent examples of this is the impact calcifying and non-calcifying phytoplankton have on CO_2 air-sea exchange. While the latter drive the organic carbon pump, which causes a draw-down of CO_2 in the surface ocean, the former also contribute to the calcium carbonate pump, which releases CO_2 into the environment (Fig. 2). An increase in the ratio of calcium carbonate to organic carbon in the vertical flux of biogenic material (the so-called 'rain ratio'), as could result from an increased contribution of coccolithophorids to total primary production, would enhance the relative strength of the carbonate pump. This would in turn lower biologically-mediated CO_2 uptake from the atmosphere. A basin-wide shift in the composition of sedimenting particles - seen in a decrease of the opal:carbonate ratio – has in fact been observed across the entire North Atlantic and is suggested to be related to large-scale changes in climatic forcing [1].

Rising atmospheric CO_2 may impact the marine biota in yet another form. CO_2-related changes in seawater carbonate chemistry were recently shown to affect marine biogenic calcification. A doubling in present-day atmospheric CO_2 concentrations is predicted to cause a 20-40% reduction in biogenic calcification of the pre

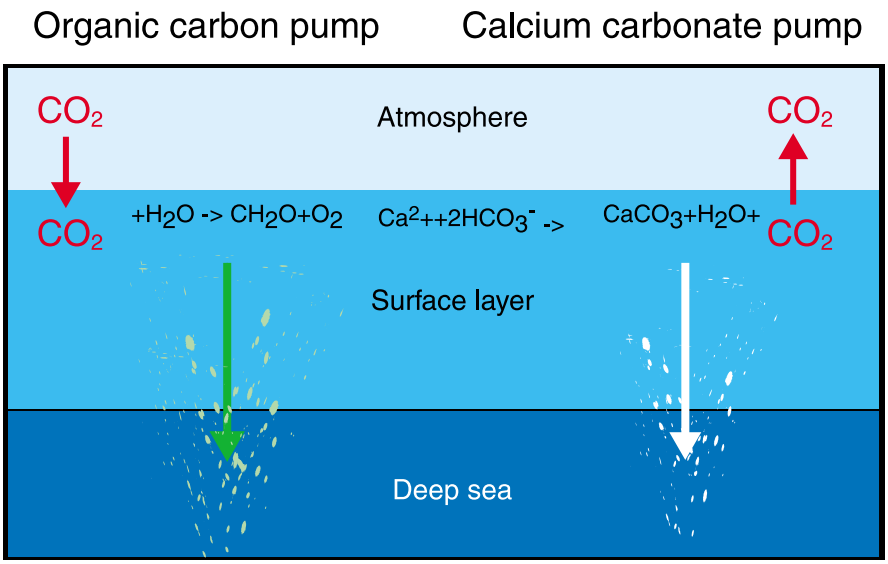

Figure 2. The biological carbon pumps: Photosynthetic carbon fixation in the surface layer of the flux of organic matter to depth, termed organic carbon pump, generates a CO_2 sink in the ocean. In contrast, calcium carbonate production and its transport to depth, referred to as the calcium carbonate pump, releases CO_2 in the surface layer. The relative strengths of these two processes largely determine the biologically-mediated ocean atmosphere CO_2 exchange.

dominant calcifying organisms - the corals, foraminifera, and coccolithophorids [2, 7, 8]. A CO_2-related reduction in calcification decreases the ratio of calcification to organic matter production (Fig. 1B). With ca. 80% of global $CaCO_3$ production contributed by planktonic organisms, reduced calcification decreases the strength of the calcium carbonate pump and thereby increases the biologically-driven uptake of CO_2 into the surface ocean [10].

As illustrated above, a climate-induced increase in the contribution of coccolithophorids to total primary production, hypothetical at present, and a CO_2-related decrease in biogenic calcification would have opposing effects on the marine carbon cycle. Their net effect on carbon cycling will depend on their relative importance and sensitivity to global change. Changes in marine production and phytoplankton species composition and succession will also impact other biogeochemical cycles, such as the nitrogen, opal, and sulfur cycles, which in turn is bound to feedback on the climate. Despite the potential importance of global change-induced biogeochemical feedback, our understanding of these processes is still in its infancy. It is now becoming increasingly clear, however, that the assumption of a constant oceanic biosphere in assessments of future global change is no longer viable.

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Conference Newsletter

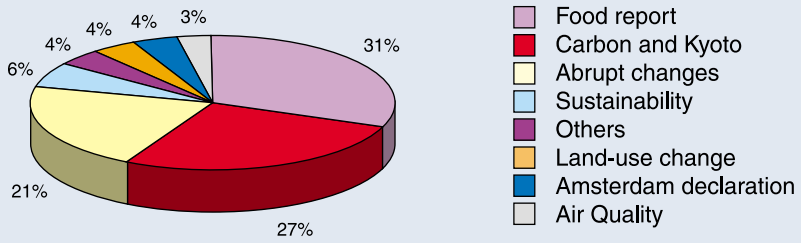
Highlights from the Challenge of a Changing Earth Open Science Conference were made available each day in a daily Newsletter. These 4 to 6 page Newsletters written by global change students can be downloaded in PDF format from the conference web site.

www.sciconf.igbp.kva.se

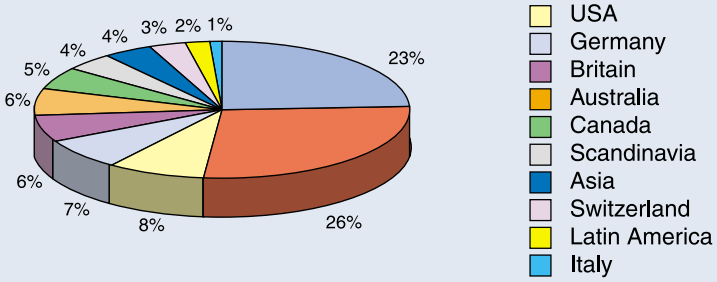
Media at the Open Science Conference

The Open Science Conference attracted significant media attention, with 55 reporters attending the conference and many others reporting from a distance, resulting in at least 120 media "hits". Although most reporters who attended were local journalists or foreign correspondents, a comprehensive web-based "Media Room" enabled journalists from all over the world to cover the conference regardless of their location. Reporters from News Agencies such as Reuters, Associated Press and Dutch, German and French Press Agencies also ensured global coverage. A preliminary analysis of coverage by topic and country is presented in the charts below. A more detailed analysis is underway and will be presented in the December issue of the Newsletter.

Media coverage by topic



Media coverage by country



Feedback from the media

"I felt it was an extremely useful and well-organised conference, which provoked considerable interest from BBC radio news programmes both in the UK and in the World Service. The press briefings were all very informative and gave excellent access to leading figures in the field. To some extent the coincidence of its timing just before the Bonn Climate Change Conference helped to raise the profile of the event, but the stories which did emerge in Amsterdam would have been of interest in their own right. Much of the detailed science was beyond the reach of mainstream news programmes but I have no criticism of that. My only slight gripe would be that the working space for journalists was rather cramped — more room next time please!"

Tim Hirsch, Environment Correspondent, BBC News

"If I have any suggestion to make, it would be to have a larger pressroom, and a closed-circuit TV to relay speeches and details of meetings. …I much appreciate the way you and your colleagues helped me so enthusiastically with other, smaller hitches."

Richard Ingham, Science and Environment Reporter, Agence France-Presse (AFP)

"I just want to say that, as a reporter, I find that your website [OSC 'Media Room'] is very well organized! Bravo."

Chantal Srivastava, Reporter, Radio-Canada

Land cover change over the last three centuries due to human activities

by N. Ramankutty, K. K. Goldewijk, R. Leemans, J. Foley and F. Oldfield[c]

The recognition of global human impact on the environment is not a recent idea. As early as 1864, Marsh [1] recognized the deleterious consequences of human activity on the Earth's landscape. More recently, Thomas [2] lent further credence to the notion that one of the most obvious global changes in the last three centuries has been the direct human modification and conversion of land cover. Turner et al. [3] made an excellent documentation of some of these historical changes.

Recently, efforts have been made to quantify the nature and extent of these changes at a global scale. Richards [4] estimated that over the last 3 centuries, the total global area of forests and woodlands diminished by 12 million km² (19%), grasslands and pastures declined by 5.6 million km² (8%, but many grasslands have been converted to pastures), and croplands increased by 12 million km² (466%). Such large changes in land cover can have important consequences such as significant changes in regional and global climate (e.g., [5-7]), modification of the global cycles of carbon, nitrogen, and water [8-10] and increased rates of extinction and biological invasion [10].

Despite the recognition of the magnitude and impact of global scale changes in land use and land cover, there have been relatively few comprehensive studies of these changes. Several continental-to-regional scale land use data sets have been compiled. For example, Houghton [11] presents land use data for nine continental-scale regions of the world. Richards and Flint [12] have compiled a very comprehensive land use database for South and Southeast Asia. Unfortunately, these databases are not very useful for spatially-explicit modeling. The modeling community especially needs global land use data sets in a geographically-explicit format, with regular time slices.

Two separate efforts have recently emerged in the reconstruction of historical land use databases, one based at the National Institute of Public Health and the Environment (RIVM) in the Netherlands, and the other at the University of Wisconsin-Madison in the U.S.A. [13-16]. These two efforts used historical statistical inventories on agricultural land (e.g. census data, tax records, land surveys, historical geography estimates, etc) and applied different spatial analysis techniques to reconstruct land cover change due to land use for the last 300 years (e.g., Figure 1). In particular, the data sets focused on reconstructing the historical expansion of cropland and pasture areas. The data sets indicate that cropland areas expanded from 3-4 million km² in 1700 to 15–18 million km² in 1990 (mostly at the expense of forests), while pasture area expanded from 4-5 million km² in 1700 to 31-33 million km² in 1990 (mostly at the expense of grasslands). A data set of global potential natural vegetation has also been created. By overlaying the agricultural land data sets over the potential vegetation data set, the change in extent of natural vegetation types has also been estimated. Major differences in the two data sets can be explained by the use of different land use classifications, calibration techniques, and inventory datasets.

Simultaneous with the development of these land use data sets, the demand for global land use databases also emerged in the IGBP community. IGBP/IHDP-LUCC and IGBP-PAGES came together to take up the challenge of providing the global change community with historical land use data sets. PAGES, having participated in the BIOME 6000 project, has experience with historical reconstructions for 6000 years before present. A new joint PAGES-LUCC initiative, labeled BIOME 300, was created to reconstruct historical land use/land cover data sets for the last 300 years (1700 to 2000), with coarse time slices in the past (50-100 years) and finer time slices in the later periods (10-25 years). A

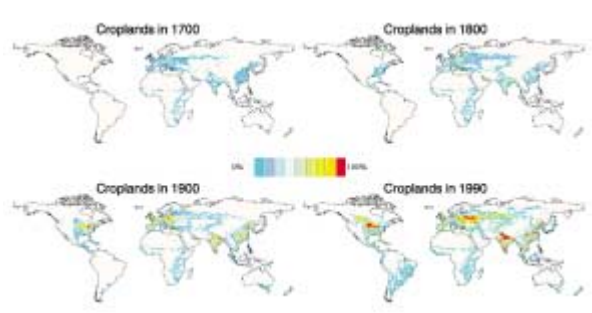


Figure 1. An example of the historical land use data set included in the CD-ROM. This figure shows snapshots of global cropland areas from 1700 to 1090. The general pattern of crop cover change reflects the history of human civilisations as well as the patterns of economic development and European development.

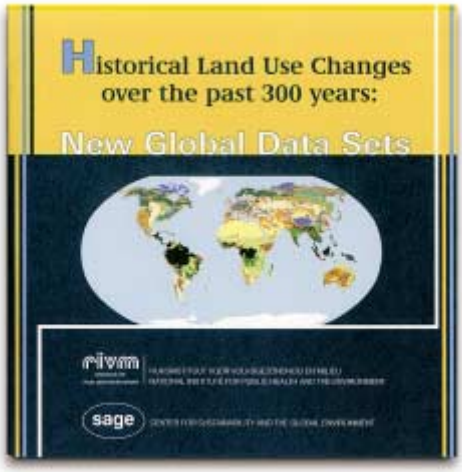


Figure 2. Data set released on a CD.ROM

group of roughly 40 researchers, covering different disciplines and approaches, came together in Bern in March 2000 at the first BIOME 300 workshop [17]. Preliminary RIVM and SAGE land use datasets were presented at this workshop and discussed. Several limitations were identified in these products, and recommendations were made to fix them. This led to the idea of creating a "fast-track" land use data product, with the effort to be led by Klein Goldewijk and Ramankutty. This fast-track product would give the global change community a preliminary product to use in their current studies.

Over the next several months, Klein Goldewijk and Ramankutty revised their land use databases based on the recommendations from the Bern meeting. Rather than create a unified data product, the researchers decided to maintain two separate efforts, and offer the community two different products. At this stage, the SAGE product offers a continuous fractional data set of land use (i.e., the fraction of each grid cell in cultivation is described), while the RIVM data set offers a Boolean version (each grid cell is entirely in a single land cover type). These different versions are appropriate for different modeling applications depending on the model's ability to handle subgrid scale landscape heterogeneity. At the American Geophysical Union meeting in San Francisco in December 2000, preliminary versions of the fast-track land use product were reviewed and plans were made to release the final product at the IGBP Open Science Conference in Amsterdam in July 2001.

At the IGBP Conference in Amsterdam, in a parallel session chaired by Rik Leemans titled "Understanding Land-Use Changes to reconstruct, describe or predict changes in land cover", Klein Goldewijk and Ramankutty presented their fast-track land use products. They discussed the background for their data set development, the different approaches used, and invited participation from the larger global change community in their continued efforts. The data set was also released on a CD-ROM (Fig. 2). The data sets are available at a spatial resolution of 0.5 degree in latitude and longitude, and at an annual resolution (SAGE database) or decadal/multi-decadal resolution (RIVM database), from 1700-1992.

At another parallel session in the IGBP Conference on the "Global Carbon Cycle", chaired by Martin Heimann and Mike Raupach, Ramankutty illustrated the use of the global land use data in biogeochemical cycle modeling. In particular, he presented results from four terrestrial ecosystem model simulations over the last century of the net carbon emissions due to the establishment and abandonment of cultivated land [18]. Over the 1920-1992 period, the models simulated net emissions of 56-91 Gt-C due to cropland change.

Klein Goldewijk and Ramankutty plan to continue improving their historic land use data sets. They request and welcome the participation of the global change community in this effort as scientists in different parts of the world might have access to data and information that they might be willing to share. In particular, they request the following kinds of information: 1) census data on land use and land cover; 2) historical maps of land use and land cover; 3) participation of agricultural geographers and historians who might be able to critically evaluate the land use data products; 4) significant events information (e.g. timing of European settlement, expansion of cultivation into the New Lands region of the Former Soviet Union initiated by Khrushchev in 1954, etc.).

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To order the BIOME 300 fast-track land use data CD-ROM, please contact Kees Klein Goldewijk or Navin Ramankutty. The following variables can be found on the CD-ROM:

Data on the CD-ROM

RIVM

1. Human Population density
2. Land use (croplands, pastures, other natural vegetation types)

SAGE

1. Historical Croplands
2. Potential vegetation

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How and why people and institutions matter beyond economy: People and trees in Madagascar

W. McConnell

Land use and cover change is one of the most important aspects of human impact on the earth, playing key roles in carbon cycling through the emission of greenhouse gasses, and affecting hydrological processes and other earth system processes. The importance of understanding these impacts was recognized by the International Geosphere-Biosphere Programme and the International Human Dimensions Programme on Global Environmental Change in the creation of a joint core project on Land Use and Cover Change (LUCC) [1]. While closely related, the terms land *use* and land *cover* refer to quite distinct things: while *land cover* refers to the biophysical attributes of the earth's surface, *land use* refers to the activities undertaken in a place including the motivation for, and mediating factors shaping, those actions.

The scalar dynamics of land use and cover change in Madagascar

Madagascar is a global biodiversity "hotspot", prompting international biodiversity conservation efforts based upon the "population pressure-on-resources" thesis, which holds that rapid demographic growth has caused widespread environmental degradation. Alternative views have emerged, however, which either ascribe degradation to forces other than population growth, or find the country's forests expanding rapidly near major population centers. Population growth can be seen to lead to deforestation in one case, while in another it leads to afforestation. This may be a product of the *scalar dynamics* of the relationship in question. The term *scalar dynamics* was coined to denote the ways that phenomena appear differently when observed at different scales of analysis.

This case study illustrates the issues encountered in tracing the relationship between population "pressure" and land use dynamics, and to the ways that institutional factors mediate this relationship at different spatial and temporal levels. The term *institutions* is used here to refer to the laws, regulations, rules and norms that shape social behavior, with particular emphasis on access to land and the rights to use land-based resources.

Madagascar's privileged biodiversity "hotspot" status stems from two facts: its long separation from the African mainland (about one hundred million years) leading to high biological endemism; and the short duration of human occupation (less than two millennia). Through most of the 20th Century, observers largely took for granted a causal linkage between population "pressure" and deforestation: while the human population grew to over ten million, what was presumed to be the near complete forest cover of the island was reduced to meager vestiges along the steep eastern escarpment, leaving the central plateau and most of the western portions of the island covered in poor grasslands.

This thesis was bolstered by a very influential spatially-explicit study published in *Science* in 1990 [2]. The study compared forest cover change measured through the analysis of satellite imagery with population density, concluding that deforestation had been most rapid in areas of high population density. This analysis formed the cornerstone of biodiversity conservation efforts based unequivocally upon the fundamental understanding that:

more people => less trees.

Two aerial photographs illustrate a dramatic increase in woody biomass in the last half of the 20th century in Alaska, on Madagascar's central plateau. In the earlier photograph, from 1957, the hills around the village rice paddies are covered in grass, with only small patches of trees.

By 19991, much of the landscape is covered in trees, especially hilltops and the steep slopes of the rivers cut bank. (The photographs show an area about 2 km x 2 km)

The eucalyptus forest extending to the east of Madagascar's capital, Antananarivo, has been estimated at over 100.00ha, and is said to supply the city with over half of its fuel wood needs.

As the two main variables are disaggregated, however, the relationship becomes less clear. In the temporal domain, it has been shown that factors other than simple demographic growth share much of the responsibility for deforestation during certain periods, including the exodus of highland populations into the forest during the consolidation of the Merina Monarchy around 1800 [3], and the felling of huge numbers of trees under French colonial rule a hundred years later, when population growth may have been quite low, or even negative [4]. Similarly, disaggregating the population density classes used in the *Science* study also weakens the relationship – differentiating the very dense population centers of the highlands (containing about a third of the island's population) shows deforestation to have occurred in the moderately-populated regions along the forest's edge. In carrying out regional analyses, taking into account the afforestation that has taken place around the capital, Antananarivo, and other major urban centers, the opposite relationship is much more plausible:

more people => more trees.

Taking the disaggregation a step further to analyze the relationship at the level of individual landscapes can reverse the relationship once again. Comparing land cover dynamics in the vicinity of villages along the upper (western) edge of the escarpment forest, for example, shows forest cover conversion to be directly proportional to village population, a relationship made even stronger when the relative "pressure" of neighboring villages is accounted for [5]:

more people => less trees.

Aforestation of hilltops has become quite widespread in the highlands, largely with exotic pine species, providing for local fuel wood and construction needs.

Shifting the lens to focus on rural highland landscapes which have been cultivated for centuries, however, recent studies suggest that population growth has led to the propagation of woody species, both for fuel and construction needs, as well as for fruits and other non-timber forest products [6]:

more people => more trees.

Meanwhile, along the country's two rail lines dramatic impacts of colonial infrastructure on forest cover dynamics, including the influx of population related to the supply of (involuntary) labor, the removal and later replacement of forest cover along the rail lines, and subsequent diffusion and adaptation of afforestation germplasm and techniques, were visible. At such fine levels of analysis, it is possible to see how local institutions shape the land use patterns. For example, in most parts of the country, burial tombs are used, and often the adjacent lands are protected by covenants that stipulate the conditions under which these "ancestral domains" may be farmed. These and other aspects of local tenure systems, such as the borrowing of land, affect the spatial and temporal dynamics of land use at the local level.

Scalar Dynamics and Institutions

At the coarsest level of analysis, deforestation in Madagascar is clearly linked to the growth of the population from the initial settlers to well over 10 million. At regional levels of analysis, however, the relation between forest cover and population is quite sensitive to temporal and spatial aggregation – differentiating particular periods or retaining detailed population density classes makes the relationship appear very different. Distinct period effects appear to account for much of the temporal and spatial patterns of forest cover change, especially attempts to control land use practices on the part of the Merina Monarchy, the French colonial authorities,

Every year, part of Madagascar's rainforest is felled to make way for crops. Hillsides are planted in rain fed rice and other crops, while bottomlands are developed into rice paddies.

and the independent Malagasy Republics. The flight of highland populations into the forests of the upper escarpment and the construction of the railroad are key examples of institutional factors that shape spatial and temporal forest cover dynamics. The relationship is also sensitive to another spatial effect – the delineation of the area of interest. The inclusion or exclusion of major population centers has a dramatic effect on the observed relationship between population density and forest cover dynamics. At local levels of analysis, simple demographic growth appears to explain much of the dynamics observed, though social institutions at the village level have profound effects on the spatial patterns produced.

Thus, there is no way to understand the relation between people and trees without close attention to institutions, and accounting for these factors requires an expansion of socio-economic analysis beyond the traditional framework of neo-classical economics. The dislocation of large numbers of people into forested landscapes is poorly explained as a response to "market signals", whether they are fleeing Merina or French hegemony; both events involved the use of overwhelming force to achieve political aims.

Is it all just too complex?

The simple conclusion from such analysis is that land use dynamics are just very complex. But such a reaction is not warranted. While we are unlikely to arrive at a general theory of land use dynamics that accurately predicts land cover outcomes in specific cases, we have learned quite a bit about the key factors that explain most cases. Meta-analysis of case studies is yielding insights into regional trends that provide typologies and testable hypotheses of landscape trajectories [7]. Meanwhile, social science theory concerning institutional dynamics has made major strides in recent years – for example, in the realm of land tenure, the simple dichotomy between private and common property has evolved to a more nuanced understanding of the key dimensions of tenure, such as the degree to which the resources in question are subtractable (one person's use diminishes the resource) and excludable (users can be excluded) [8]. We know that the "tragedy of the commons" [9] is not inevitable - rather, there are examples of local, regional and national institutional arrangements that successfully accomplish land management goals, including protected areas, afforestation programs, and traditional ancestral domains.

Furthermore, we have learned that factors do NOT aggregate across levels in any simple way - one cannot understand the regional dynamics by simply summing up effects of traditional land management institutions, any more than one can simply disaggregate the regional political-economic forces by assuming that they play out equally across space. Perhaps the greatest mistake is to take prima facie evidence for the culpability of simple demographic growth at the broadest and finest levels and stop at that, having discovered the proximate and ultimate causes to be one and the same. Rather, the search must be for solutions that bear replication. Fortunately in Madagascar, as elsewhere, development project managers are becoming more aware of these scalar dynamics, and more attuned to the institutional dimensions of land use dynamics.

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Student Poster Awards

There were 8 winners in the student poster awards at the Open Science Conference. Winning posters were selected for the quality of their overall design, illustrations, scientific context and accessibility to a broad audience. Here we present 4 of the 8 winning posters, the remaining 4 to be featured in the December edition of the Newsletter.

LOCAL CLIMATE CHANGE DUE TO LANDSCAPE MODIFICATIONS: IMPACTS ON THE WATER CYCLE (CASE STUDY IN SOUTHEASTER

Natalia Hasler[1], Ion Iorgulescu[1], Alberto Martilli[2], Glen Liston[3], Rodolphe Schlaepfer[1]

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[2]Laboratory of Air and Soil Pollution, Swiss Federal Institute of Technology, Lausanne, Switzerland
[3]Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado, USA

The **aim of this research** is to assess, from a model-sensitivity analysis, the impacts of landscape structure, considering both the effects of landscape composition (type and extent of ecosystems) and landscape configuration (spatial arrangement of ecosystems) on local climate and the water cycle in a semiarid region like Castilla-La Mancha, southeastern Spain.

MATERIAL AND METHOD

Numerical experiments using ClimRAMS:
364 x 280 km^2 domain, centered (39.1N;2.8W)
14 km and 3.5 km cell size, 2-way nested grids
April - September 1997 runs
4-daily NCEP reanalysis data as boundary conditions
FAO soil classification database
USGS numerical elevation model
Landscape changes done on 2nd grid (84x112km^2) on composition: for example 100% forest configuration: see figure 1

Fig. 1 different configuration scenario of a 50% shrub 50% semi-desert landscape

RESULTS

Evapotranspiration

Considered scenarios are 50% forest and 50% semi-desert landscapes in vertical and horizontal strips, 2 blocks in four directions and chessboard configurations

Fig. 2 Monthly evapotranspiration rates over forested areas in landscapes with different configurations

- Evapotranspiration is 8% lower over forested areas in 2 blocks scenarios than in a chessboard configuration
- Horizontal and vertical strips have similar values than chessboard configuration
- Not shown here, forest evapotranspirates up to 3 times more than semi-desert

Precipitation

Considered scenarios are different configurations of a 50% shrub and 50% semi-desert landscape

Fig. 3 Absolute differences to chessboard scenario of precipitation amounts between cells with the same landcover in both scenarios

- Absolute differences on cells with same landcover in precipitation between two scenarios may be as large as 28% of the precipitation amount
- Even on domain average, changes may be as large as 8% of total monthly precipitation between two configuration scenarios (not shown here)

In **conclusion**, the differences obtained with these scenarios demonstrate that both configuration and composition have substantial influence on climate and water resources. These preliminary results show that land-use planning, especially in semiarid regions, need to consider vegetation-climate feedbacks.

This study also suggests that there is a need to further investigate the influence of configuration parameters like landscape patches' size or patches' neighborhood on climate and water resources.

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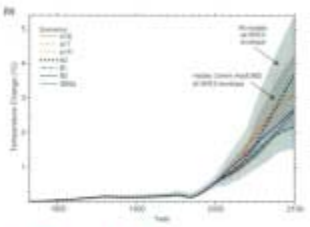
Representing Climate Change Futures: Developing the Use of Images for Visual Communication

Sophie Nicholson-Cole – School of Environmental Sciences, UEA, Norwich, UK. s.nicholson-cole@uea.ac.uk.

Climate change: The most recent IPCC report published new projections of future emissions linked to a range of possible future climate change scenarios (see fig.1).

What will make the difference between any scenario and what actually becomes our climate change future, will be for society to determine.

Future Global Warming Rates [Source: Sarah Raper]



Tyndall°Centre for Climate Change Research

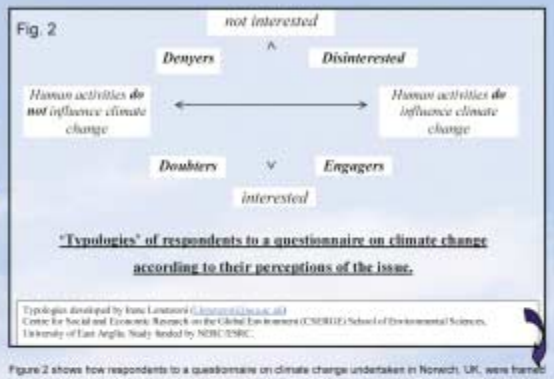
Fig. 1

For many people, climate change is remote from their everyday lives.

Research undertaken at UEA suggests that psychological barriers and the demands of day to day living can shape people's perception of their role in determining future climates.

Unless people have a clear idea about how future climate change is dependent on their own role and outlooks, it will be very difficult for them to become engaged with the problem and feel that they have a part in influencing climate change in the future.

Fig. 2



'Typologies' of respondents to a questionnaire on climate change according to their perceptions of the issue.

Typologies developed by Irene Lorenzoni (i.lorenzoni@uea.ac.uk)
Centre for Social and Economic Research on the Global Environment (CSERGE) School of Environmental Sciences, University of East Anglia. Study funded by NERC/ESRC.

Figure 2 shows how respondents to a questionnaire on climate change undertaken in Norwich, UK, were framed in terms of their belief in human actions affecting the climate. This was based on a factor analysis of some of their answers.

Deniers: Do not think humans have an impact on climate change, the issue is not important

Doubters: Do not feel humans have an impact on the climate but this is an important issue.

Disinterested: Believe that humans affect the climate, but it is not important.

Engagers: Very concerned about human impacts and climate change.

By exploring if similar 'typologies' can be defined elsewhere in Italy, it is hoped that these studies will shed light on how policies and campaigns can be geared towards different types of interest within the population to awaken an active interest in the adoption of measures to combat climate change

There are a variety of orientations within society towards climate change, human and natural causes and consequences, trust in government, dependency on sources of knowledge and information etc.

The challenge is to develop effective and accessible ways of visually portraying climate change to a cross section of society, so that people can see their responsibility for choosing and shaping climate futures. The principal aim of this research comes in three parts;

- to draw together the research into attitudes and perceptions of climate change and that of visual communication and climate science;
- to investigate whether climate change can be visually represented in ways that are fair and scientifically plausible, as well as being attainable for the layperson;
- to do this in ways that will constructively engage people with the issue of climate change.

Learning to Change Climate Change...

Researchers at UEA have begun to develop images of future landscapes under various climate change conditions (see fig.3).

Such visualisations have the potential to communicate the science of climate change, to educate and to encourage participation in decision-making processes. But what kinds of images are suited to each of these purposes and which ones convey a meaningful message?

Fig. 3 Dockerty, T. et al. (2001) Climate Change Impacts on Landscape: New Approaches to Visualising Rural Landscape Change. Working Paper No. 9. Jackson Environment Institute, UEA, UK.

- It is essential to understand the attitudes of people affected by climate change in both positive and negative ways. Also, what motivates those who feel engaged with the science and the politics, and those who feel disengaged.
- We also need to know how people feel when faced with many future climates and their potential consequences.
- In an effort to help people comprehend climate change futures, visualisations of what the nature of society and the economy will look like in relation to projections of the climate in these futures need to be developed.
- Learning tools to do this should also be methods of engaging people and giving them the opportunity to think about what changes in society could help to turn climate change around.

In order to find out which kinds of images that are meaningful to people, a qualitative approach has been adopted. This will lead to a knowledge base developed through the exploration of how visual imagery is, and could be used for communicating the science of climate change and its implications for the future.

The results will guide us towards the kinds of images that are most useful in helping people engage with climate change, and to conceptualise the kind of worlds and societal choices that might lead to different climate futures; images which communicate the science and make climate change an accessible concept.

The end point of this research is to deliver a basis for a learning tool which will offer a particular way in which climate change can be communicated.

It is hoped that this research will assist policy networks to share with stakeholders the most acceptable mix of adaptation and mitigation for the coming climate change transition.

July 2001

Environmental information to strengthen the decentralised EIA process in the Indonesian coastal zone

Dwi Abad Tiwi (IHE/BPPT, tiw@ihe.nl), W.J.A.M Douven (IHE) and F.R. Rijsberman (IWMI)

Background

Environmental Impact Assessment (EIA) is considered as an important tool of ICZM. Recently, Indonesia has approved several laws on the decentralisation of the EIA process to local governments. A pre-analysis showed that:

- environmental information and stakeholder participation are lacking; and
- the expertise of local government is not enough.

Objective

- to assess the quality of EIAs in the Banten Bay area, in particular with respect to the use of environmental information.

Based on this, suggestions can be given how the EIA process in the coastal zone can be improved, and thus ICZM.

Methodology

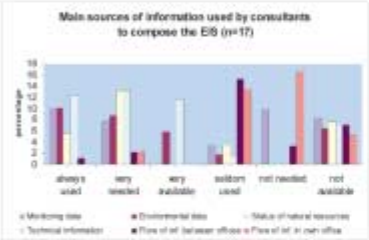
Analysis of quality of environmental information as stated in the Indonesian guidelines and used in the EIA practice.

EIA guidelines
- The Indonesian general guideline
- The Sea Communication guideline
- The Industry guideline

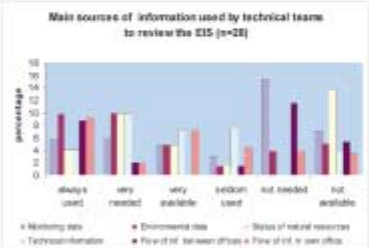
EIA practice
- Review of 10 EIS reports
- Interview of 56 respondents on the use of sources of information to compose and to review the EIS
- Observation of 4 EIS-review meetings
- Interview of 2 local operators on environmental monitoring.

Results

1. In all three EIA guidelines marine information was lacking, and no executing institutions were stated for monitoring.
2. The sources of information used to compose EIS are insufficient as reported by consultants.



4. The sources of information used to review EIS are insufficient as reported by technical teams.



3. All EIS reports showed weakness in all areas of assessments except in area of general description (see no 1 in the table).

Review areas	Number of reports per rating (n=10)						Average score
	A	B	C	D	E	F	
Overall assessment		2	3	3	2		D
1. General description area	2	1	2	4	1		C
2. Evaluation of key impacts		1	4	3	1	1	D
3. Impact mitigation and monitoring		3	2	3	2		D
4. Communication of results		2	3	3	2		D

Quality above the acceptance level Quality below the acceptance level

5. The biology component received limited attention in the discussion of the EIS-review meetings observed.
6. Most of the parameters are seldom monitored by local operators, with constraints related to human resources, data recording, and analysis.

Conclusions

Quality of environmental information in particular biology component in the guidelines and in the EIA practice is insufficient, priority of information sources to compose and to review the EIS are lacking, information sharing is limited, and monitoring activity is lacking.

Recommendations

Integrate existing information and information needs, improve guidelines, develop and improve local capacity for coastal monitoring.

IHE DELFT — International Institute for Infrastructural, Hydraulic and Environmental Engineering (www.ihe.nl)

WOTRO — Netherlands Foundation for the advancement of tropical research (www.nwo.nl)

BPPT — Indonesian Agency for the Assessment and Application of Technology / BPPT (www.bppt.go.id)

Exchange of Volatile Organic Compounds from Tropical Savanna Grasses

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Summary

Even though grasslands and pastures cover about one quarter of the Earth s surface, very few studies have been made to characterise the volatile organic compound (VOCs) emissions from grasses (i. e. Fukui and Doskey, 1998; Kirstine et al. 1998) . In this study, VOC emission rates from different graminea grasses, were measured under ambient conditions using a dynamic plant enclosure technique. Two measurement campaigns were made, one during the wet season of 1999, and a second during the dry season of 2000, at the Estaci n Biol gica de Los Llanos, located nearby Calabozo in the central part of Venezuela. The site is a productive woodland savanna, minimally affected by urban or industrial pollution sources.

The Proton Transfer Reaction-Mass Spectrometer (PTR-MS) instrument was used to measure the VOC emissions (Hansel et al. 1995; Lindinger et al. 1998). This technique enables simultaneous measurement of a multitude of compounds with high time resolution. CO_2, water vapour, and meteorological parameters were also monitored.

The emission rate of methanol (0.2 — 11 µg g(dw)$^{-1}$ h^{-1}) was found to be the highest among the detected VOCs, in both seasons, and for all the measured grass species. Methanol emissions correlate very well with radiation and temperature. Other protonated masses measured using PTR-MS, the postulated compounds and the average daytime exchange rate (for green *trachypogon* grasses during wet and dry season, respectively): mass 45 acetaldehyde (0.1 and 0.3 µg g(dw)$^{-1}$ h^{-1}); mass 59 acetone (0.1 and 0.6 µg g(dw)$^{-1}$ h^{-1}); mass 61 acetic acid (-0.02 and -0.8 µg g (dw)$^{-1}$ h^{-1}). Another very important emission was detected at mass 57. The signal is probably caused by more than one compound, since butanol (fragment), acrolein, butene and a hexanal fragment are detected at this mass. Minor emissions were i.e. mass 73 methylethyl ketone, mass 83 hexanal, hexenol. No emission of isoprene and monoterpenes were detected.

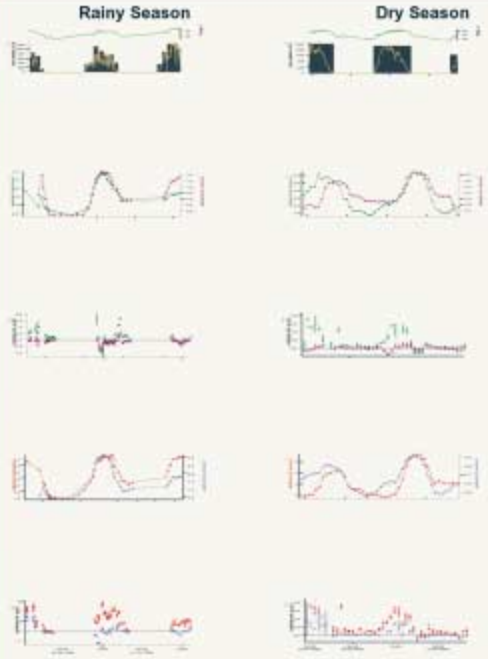

Fig. 2: Diurnal and seasonal variation of ambient mixing ratios and exchange rates of selected VOCs

This figure shows the exchange rate of green *Trachypogon* grasses and ambient mixing ratios of mass 33 (protonated mass of METHANOL), mass 45 (protonated mass of ACETALDEHYDE), mass 59 (protonated mass of ACETONE) and mass 61 (protonated mass of ACETIC ACID) during 48 hours in the wet and dry season.

The observed mixing ratios show significant diurnal variations. During the wet season the maximum is observed at noon and early afternoon, whereas in the dry season higher levels are found at night, probably due to biomass burning emissions trapped in the nocturnal layer. The maximum peak observed at night, correlates very well with acetonitrile and CO (not shown) clearly indicating a biomass burning source in the dry season.

Methanol is the major emission from all the measured grass species in both seasons, followed by acetone and acetaldehyde. Acetic acid was mainly deposited.

No significant seasonal difference was found between the methanol emission of Trachypogon grasses, but there are differences between individuals of the same species. An example can be seen during the wet season: the measurements on October 1 were performed on a different grass bundle. The average mixing ratio of methanol during daytime were almost the same during both seasons (4.6 and 5.3 ppbv for wet and dry season respectively).

The acetaldehyde emission is slightly higher during the dry season. It is interesting to notice that higher ambient mixing ratios were observed during the wet season (daytime average 2.7 ppbv wet season and 0.9 ppbv dry season) which can not be explained by the direct emission from the vegetation.

The acetone exchange behaviour was variable, showing both emission and uptake. Higher emissions were observed during the dry season. Ambient average concentration was 4.2 and 2.9 ppbv for wet and dry season respectively.

Acetic acid was mainly taken up (or deposited) especially during the wet season, when also the ambient mixing ratio was higher (2.7 ppbv).

Methods and Site

Continuous measurements were made at the Biological Station of Plains, located nearby Calabozo (8°53'N; 67°19'W), during the wet season September 24 to October 17, 1999, and the dry season from March 18 to April 9, 2000. The site is located in the central part of Venezuela and is minimally influenced by urban or industrial pollution sources. The surrounding woodland savanna is covered with graminea grasses (mainly *Trachypogon sp, Hyparrhenia rufa and Axonopus canescens*) interrupted by trees and scrubs (*Curatella americana, Bowdichia virgilioides*, and *Byrsonima crassifolia*).

Determination of VOCs: The volatile organic compounds were measured using a Proton Transfer Reaction Mass Spectrometer, PTR-MS. It is based on proton-transfer processes involving H_3O^+ ions, which do not react with the major atmospheric constituents N_2, O_2, Ar and CO_2, but react with most VOCs in nondissociative proton-transfer reactions. With the exception of alkanes smaller than C_5 almost all VOCs can be measured as their proton affinities are higher than that of water.

Plant enclosure system: The exchange rate of the grasses were measured using dynamic chambers (cuvettes) that were continuously flushed with ambient air. The system consisted on 2 to 4 cuvettes. One or more sample cuvettes were placed directly on the soil enclosing a whole grass bundle. A reference cuvette was placed on bare soil as control. During the experiment radiation, temperature, humidity, assimilation and transpiration were continuously monitored.

Fig. 1 Measurement site with mobile laboratory and grass enclosure chambers

Table 1: Summary of exchange rates of major VOCs

	m 33	m 45	m 59	Total	Total ng(C) g^{-1} h^{-1}
Trachypogon 1	812	195	134	1141	441
Trachypogon 2	453	n.e.	-40	414	146
Trachypogon 3	675	160	187	1022	1202
Trachypogon 4	476	126	126	728	325
Hyparrhenia 1	284	84	125	493	206
Hyparrhenia 2	88	111	209	408	260
Axonopus 1	884	289	297	1470	673
Axonopus 2	917	394	404	1715	809

three grass types during the rainy season, 1999. Data given on a dry weight basis (ng g^{-1} h^{-1}). Daytime averages calculated between 11 am - 4 pm.n.e.: no exchange

Conclusions

Methanol is the major volatile organic compound emitted by grasses. It exhibits a strong diurnal pattern, and correlates well with light and temperature. Daytime emissions ranged between 0.2 and 1.1 µg g(dw)$^{-1}$ h^{-1} in both wet and dry season.

No significant seasonal difference was observed for the VOCs exchange of green grasses.

The total emission rate of the most abundant VOC from grasses (m 33, m 45 and m 59) ranged between 0.4 and 1.7 µg g(dw)$^{-1}$ h^{-1}. This three species together accounted for 64-75% of the total.

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Agents and their Environment Syndromes of land-use change in developing countries

by G. Petschel-Held

Human induced changes in the Earth System are starting to enclose all scales, from the global to the local, yet the local *actor* plays a key role, both in terms of proximate causes and consequences. The analysis of the social and natural situations, options, and possible futures of people in their respective environment is hindered by the huge variety of localities throughout the world. This variety is extensively documented in numerous case studies. There are recent efforts to scrutinize case studies in order to attain better insights into the nature of environmental changes, e.g. the recent Land Use and Cover Change International Project Office (LUCC-IPO) analysis of tropical deforestation.

Within the work presented here, it is suggested that the interactions between civilization and nature can be clustered into typical patterns. This implies that case studies can be grouped into ensembles of similar processes, embedded into similar (dynamic) constraints of larger-scale, even global, earth-system properties (see Figure 1).

The appealing of patterns of civilization-nature interaction raises some intriguing questions: How can patterns be specified or "discovered"? How to model them? What to learn from this kind of analysis? The example presented here is dealing with aspects of land-use changes in developing countries and has to be considered as work in progress. It will demonstrate a qualitative modeling technique which operationalizes the idea of functional similarity by utilizing sets of ordinary differential equations. These sets are defined by monotonicity properties, e.g. two functions are considered to belong to the same set if in both functions the dependent variable increases if the independent variable is increasing. The QSIM-algorithm, developed by Ben Kuipers from the University of Texas, Austin,

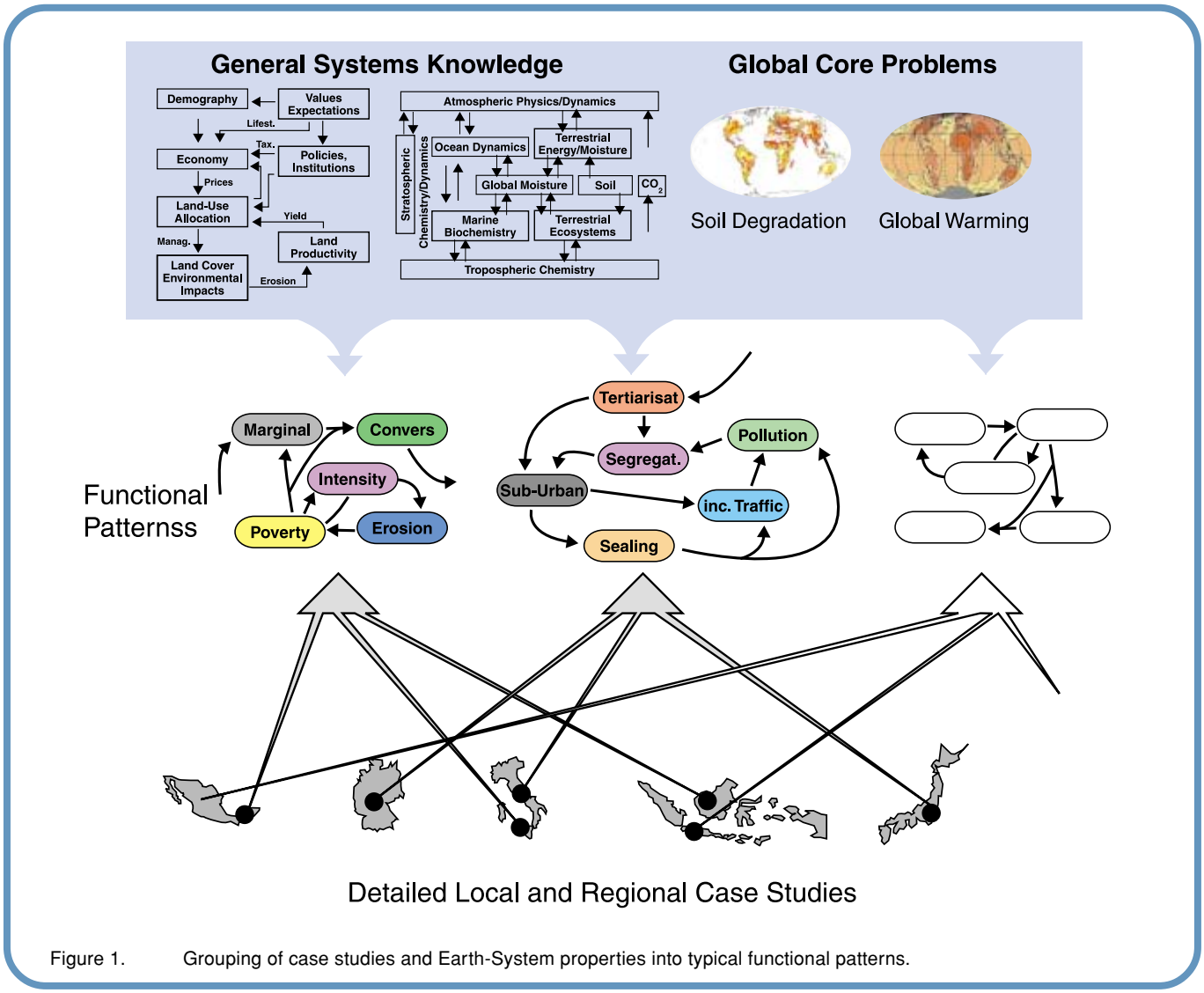

Figure 1. Grouping of case studies and Earth-System properties into typical functional patterns.

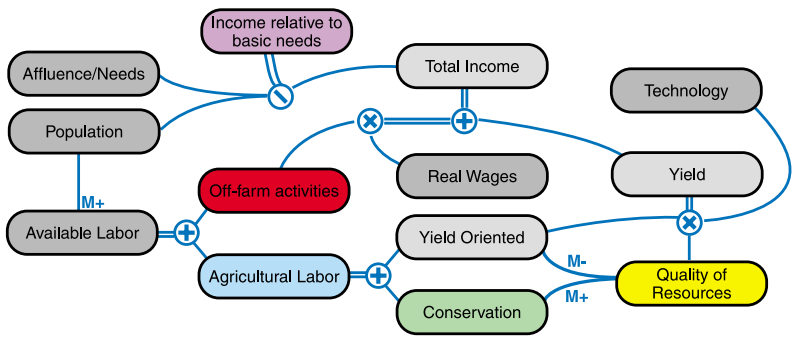

Figure 2. "Wiring diagram" of the qualitative model of smallholder agriculture.

uses these relations as constraints. It allows all dynamic behaviors in which the directions of change share these properties. Taking the example of a monotonously increasing relation, this produces, e.g., behaviors in which both variables are increasing, then simultaneously reach an extremum and decrease or increase again afterwards. The "or" indicates that the modeling technique produces a set of dynamic behaviors instead of a single solution as conventional modeling does. This set of possible behaviors again corresponds to a cluster of case studies: Different stories from different case studies can be generated by a single qualitative model [3].

The "wiring diagram" of the exemplary qualitative model of smallholder agriculture in fragile ecosystems in developing countries is presented in Figure 2. The *Available Labor* is a monotonously increasing function (M+) of the population, which is increasing within the experiments described in the following. Labor can be allocated into *Off-farm Activities* and *Agricultural Labor,* which in turn can be divided into *Yield Oriented* or *Conservation* oriented labor. Each allocation is constrained by a qualitative addition ⊕ which allows changes in signs of the variables as in the usual addition, e.g. if both "independent" variables increase, their sum is increasing as well, etc. *Yield Oriented* labor constitutes one factor of the agricultural production function and has negative impact on the change (dotted area) of the *Quality of Resources*, i.e. it induces an environmental degradation. In contrast, the second type of agricultural labor is assumed to have solely a positive impact on the change of resource quality, but no direct yield effect.

It is obvious that this scheme of impact of human activities is by no means applicable to *all* situations of smallholder land-use, but the qualitative character of the relations implies also that it should be applicable to more than one situation. The intermediate generality of the cause-effect scheme thus represents the first level of pattern formalization. The global and regional context, both in terms of natural as well as social conditions, e.g. climate, societal and economic stratification, etc., determines the actual regions where it should be valid. The analysis of the potential regions for a particular pattern is based on data and model results and yields, what we call, the *disposition* [2, 4].

The graph of the remaining parts of the model is self-explaining, if we take the symbols ø and ⊗ to mean qualitative division and multiplication, respectively. We underline that agricultural *technology* is taken as a further production factor and is assumed to be increasing. This relates to Boserup's argument of an increasing technological effectivity induced by population growth. In contrast, the fact that population growth itself affects the *Income relative to basic needs* allows the Malthusian type of outcome, i.e. a limited carrying capacity inevitably deteriorates living conditions.

Within the framework of the model, local agricultural decision making (ADM) comprises the two aspects of labor allocation. There is a long ongoing debate about rationalities and objectives of ADM, which consider, for example, economic rationality, i.e. the smallholder family optimizes its utility, or risk averting strategies by diversification. As long as only the summation rules depicted in Figure 2 are taken into account, no decision-making rationale is implemented. This openness would allow a vastness of behaviors, which makes the identification of patterns difficult and hardly helpful. We therefore have implemented simple allocation rules: off-farm labor is increased if it is more productive than agriculture, corresponding to a bias towards agriculture. Secondly, conservation oriented labor is not increased if either the resource quality is enhancing anyway or if the income per capita falls below a certain level. In qualitative terms, it is sufficient to assume a "certain level" to exist. It is not necessary to know its actual level in terms of numbers, which would be different in different contexts.

How to validate a qualitative model or, more adequately, how to specify which cases are represented by the corresponding functional pattern? Besides the comparison of the qualitative properties of the relation between variables, the validation uses the story each case study tells. When analyzing studies on smallholder agriculture, however, one can identify a few, typical stories, which we call *stylized narratives.* Kates and Haarman [1], for example, have identified three types of poverty induced environmental degrada

tion: the well-known impoverishment -degradation spiral and cases of degradation induced either by division of land or by displacement. In another stylized narrative to be found in the literature increasing off-farm activities reduces the work available for conservation. In many of these cases this leads to significant environmental degradation, sometimes stimulating diminishing returns.

The question of validation is: Does the model tell the stylized narratives? Leaving out the technical representation of the results, we state that this is the case for the spiral and the off-farm induced degradation narratives, but not yet for the division and displacement cases.

The next question is: what to learn from this qualitative model? It turns out that the model produces "good" stories, e.g. off-farm activities are paid well enough to increase incomes and allow preservation of natural resources. Yet constellations arise which inevitably lead to deteriorating environmental conditions and diminishing incomes. We call such an unsustainable constellation a *syndrome.* Such a situation arises when no off-farm alternatives are available, the rate of technological progress is decreasing, and impoverishment occurs. It is important to note that the inevitability happens though technological efficiency increases. Yet, the increase in soil degradation might only be compensated if this efficiency grows with an increasing rate or, in other words, only in this case Boserup's argument for the non-existence of a carrying capacity might hold.

Finally, we might ask: can we identify regions of the world that are already characterized by the unsustainable constellation or at least close to it? Using data from the early 1990s the direction of change of the five relevant variables (wage labor, agricultural intensification, soil degradation, agricultural yield and rural poverty) are analyzed. Figure 3 depicts the result, where "-n" means that the direction of changes of n variables differs from the unsustainable constellation, i.e. in red one identifies regions where the syndrome is active.

It has to be stressed again that the present model represents work in progress. Yet the results indicate that this kind of syndrome analysis might be a powerful method for the identification of barriers against sustainability and thus for, what is now called, *sustainability science.*

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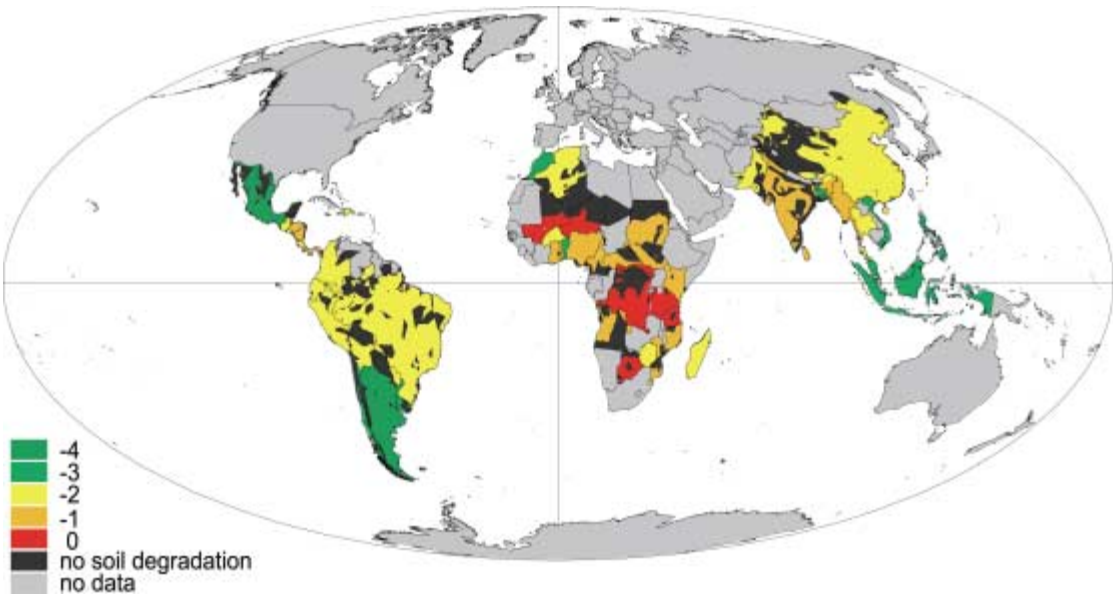

Figure 3. Geographical distribution of regions with unsustainable constellations of smallholder agriculture (see text).

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Climate change in the Tropical Pacific: Understanding and quantifying uncertainties

by M. Collins

The El Niño Southern Oscillation (ENSO) is a well know modulator of global climate on seasonal to interannual time scales. The quasi-period warming and cooling of Sea Surface Temperatures (SSTs) in the eastern Tropical Pacific, and corresponding shifts in atmospheric pressure and precipitation patterns, cause climatic variations both locally and via teleconnection patterns to remote areas. These short-term climate variations have significant impacts on ecology, society and economics. What role then does the Tropical Pacific play in the global change problem?

There are an increasing number of studies of climate and environmental change that point to the Tropical Pacific as an important modulator of the global climate system. The studies of Latif et al. [9] and Thorpe et al. [10] both examine the potential for a reduction in the strength of the North Atlantic Ocean Thermohaline Circulation (THC) as greenhouse gases increase. They find that the rate of the reduction in strength (and hence the potential for a permanent shut-down) is controlled by the advection of salty water from lower latitudes - the saltier the Tropical Atlantic ocean, the smaller the reduction in THC strength. During an El Nino event the Tropical Atlantic Ocean becomes more salty through a combination of changes in evaporation, precipitation and river run-off. In both the Latif et al. [9] and Thorpe et al. [10] studies the climate models produce a climate change towards more El Nino like mean conditions in the Tropical Pacific and this results in changes to the freshwater cycle which cause a more salty Tropical Atlantic ocean and thus limits THC slow down.

> "How ... can we resolve uncertainties in climate change in the Tropical Pacific (and indeed globally) if models are highly sensitive to small changes the parameters of their physical schemes?"

The work of Cox et al. [5] also points to an important role for the Tropical Pacific in global climate change. In their study they include representations of the terrestrial and marine carbon cycles in a global climate model and find a positive feedback in which the terrestrial biosphere can flip from being a carbon sink to a carbon source. The corresponding increase in atmospheric CO_2 amplifies the rate of global warming in the model considerably. One of the major components of the flip is a die-back of the Amazonian rain forest during the middle 21st century. A possible cause of this die-back is a reduction in precipitation over the Amazon region caused by a shift in atmospheric circulation and corresponding precipitation patterns associated with, again, a shift towards more El Nino like mean conditions in their model.

Understanding the climate of the Tropical Pacific is a complex problem because of the tight coupling of the ocean and atmosphere in the region. Coupled ocean-atmosphere global circulation models (AOGCMs), which are now the principal tools for global change studies, show large differences in their predictions for Tropical Pacific climate change [6]. We can begin by examining two models for changes in the mean climate and changes in the ENSO cycle.

Collins [2], using version 2 of the Hadley Centre Coupled Model (HadCM2), found that at four times pre-industrial levels of CO_2 ENSO events became larger in amplitude and more frequent than present day ENSO events. Thus in addition to the impacts of climate change, the impacts of ENSO events would be felt more often and with greater magnitude. Using version 3 of the Hadley Model (HadCM3) Collins [3] found that magnitude and frequency of ENSO events remained unchanged as greenhouse gases increased, contradicting the results of the earlier study and highlighting a level of uncertainty. This range of uncertainty in the future of ENSO is further widened when one examines the responses of other AOGCMs [6].

The difference in the ENSO response to global warming in HadCM2 and HadCM3 was found by Collins [3] to be due to differences in the response of the mean climate of the two models in the Tropical Pacific region. HadCM2 produced a pronounced broad maximum in SST warming on the equator while

HadCM3 had a more confined maximum and a change in the south-north SST gradient (see figure). Forcing HadCM3 with the pattern of mean SST warming from HadCM2 caused the HadCM3 ENSO cycle to amplify and to become more frequent, much like the HadCM2 ENSO response. Hence differences in the models mean pattern of SST change caused differences in the response of ENSO to climate change.

But what caused the differences in the pattern of mean climate change between HadCM2 and HadCM3? HadCM3 has a higher resolution oceanic component than does HadCM2 and does not require a "flux-adjustment" term to control climate drift [see 7 and 8 for details of the models]. It would be tempting to attribute the differences in mean climate response to these features. The reason is much more subtle than this, however. Williams et al. [12] examined changes in the physical parametrisations of cloud formation and the representation of atmospheric boundary layer processes between HadCM2 and HadCM3 and found that rather small changes to these schemes could combine in a non-linear way to produce the large differences in the patterns of cloud, precipitation and SST change in the two models (see figure). Cloud feedbacks are among the most important and most complex of feedbacks in the climate system and it appears that even small perturbations to the parameters of cloud models can cause non-linear and far-reaching differences in global climate change.

> "One fossilised coral suggests that ENSO variability may have been very much weaker (and perhaps even non-existent) around 6.5 thousand years ago, at a time when global climate was not greatly different from that of today"

Knowledge of the parameters of model physical schemes (particularly those associated with clouds) may be ultimately limited by observational errors or by uncertainties in parameters, which have no observable counterparts. How then can we resolve uncertainties in climate change in the Tropical Pacific (and indeed globally) if models are highly sensitive to small changes the parameters of their physical schemes? There are two methodologies we can adopt to understand and quantify uncertainties in global climate change: Palaeoclimate studies and mega-ensembles of AOGCMs.

Tudhope et al. [11] have collected and analysed fossilised corals from the Western Tropical Pacific. These corals provide

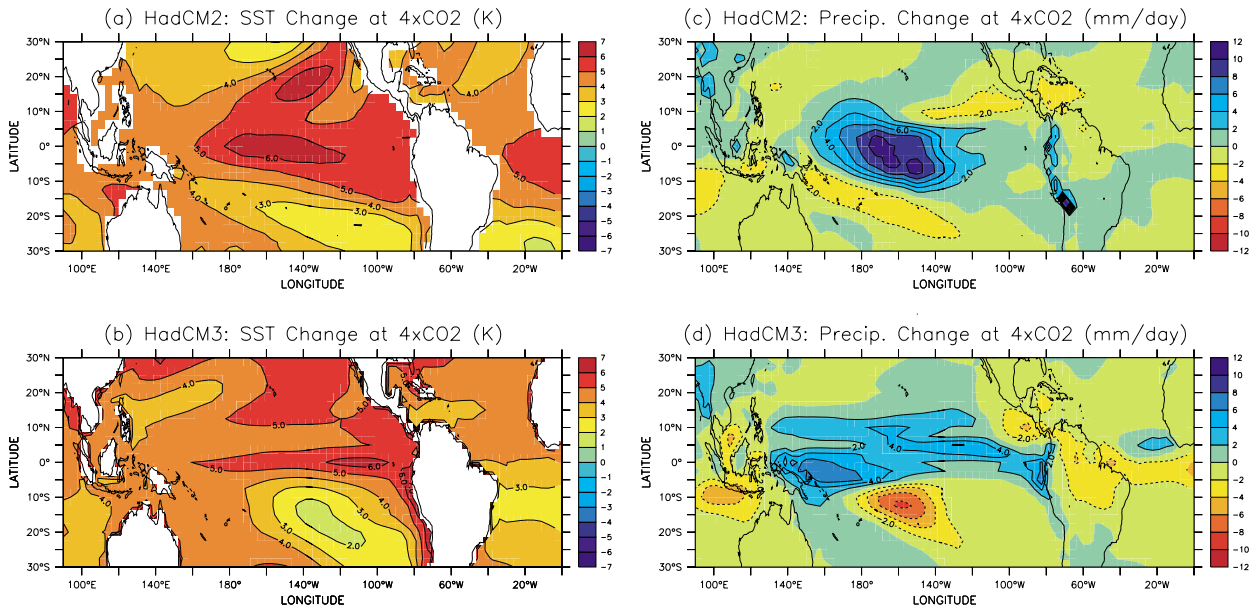

Figure1. Sea Surface Temperature (SST) and precipitation changes at $4xCO_2$ from two coupled ocean-atmosphere global circulation models. (a) SST change from version 2 of the Hadley Centre Coupled Model (HadCM2), (b) SST change from version 3 of the Hadley Centre Coupled Model (HadCM3), (c) precipitation change from HadCM2 and (d) precipitation change from HadCM3. The differences in the patterns of climate change between the two models are caused by subtle changes in the physical representations of clouds and these differences in mean climate also lead to very different behaviour of the El Niño Southern Oscillation in a globally warm world [see the text and 3 and 12 for more details].

windows of ENSO variability in periods of history back 130,000 years. One fossilised coral suggests that ENSO variability may have been very much weaker (and perhaps even non-existent) around 6.5 thousand years ago, at a time when global climate was not greatly different from that of today. AOGCMs can be forced with boundary conditions from different epochs and validated using the palaeo record. Given the sensitivities of AOGCMs, the validation process needs to be quantitative and this requires careful use of both the palaeo proxies, which are indirect measures of climate, and the model that simulates climate in large-scale grid-boxes with dimensions of several hundreds of kilometres [see e.g. 4]. One possible future development would be to include models of coral growth within the AOGCMs themselves.

> "…just as the Tropical Pacific is an important modulator of global climate on seasonal and interannual time scales, it also plays an important role in the global climate change problem"

A brute-force method of quantifying uncertainty in AOGCM estimates of climate change is to systematically explore all the parameters of the model physical schemes and map the potential climate change. This would allow the construction of the probability density function (PDF) of future climate scenarios for use by policy makers. Because of the complexity of AOGCMs and because of potential non-linear interactions between the parametrisation schemes (recall the Williams et al. [12] study) this requires many thousands and perhaps millions of AOGCM simulations. Such a study is beyond the capacity of the world's current supercomputer resource. A novel solution was suggested by Allen [1] who proposed that if the AOGCM could be run on a Personal Computer then members of the public could each produce a climate change prediction with a combination of parameter perturbations, and the PDF could be made. The climateprediction.com project is now underway - more details are available from www.climateprediction.com.

It appears that, just as the Tropical Pacific is an important modulator of global climate on seasonal and interannual time scales, it also plays an important role in the global climate change problem. The coupled AOGCMs currently show a wide range of possible changes in both the mean and the ENSO variability in the region and hence there is a large degree of uncertainty both in local and in global human-induced climate change. It is hoped that future palaeoclimate studies and mega-ensemble approaches will help in understanding and quantifying these uncertainties.

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Estimations of ENSO effects on sugarcane yields in Cuba, Mexico and Venezuela

by A. Utset*, J. López and M. Alvarez

One of the approaches for recommending crop and water management practices under variable climate conditions is the use of crop-growth simulation models linked with weather forecasts [1]. This approach has been pointed out as the soundest available during the START-WMO* supported Climate Prediction and Agriculture (CLIMAG) workshop. The approach was used to develop a methodology for predicting ENSO-caused climate-variability effects on sugar cane yields at farms in Cuba, Mexico and Venezuela; in the framework of a proposal supported by the Inter-American Institute for Global Change Research (IAI). Our starting hypothesis was that ENSO effects on rain fed sugarcane mainly due to water deficits/excess as a result of droughts/rainfall events associated with ENSO.

Local daily climatic variable series are not usually long enough for assessing ENSO effects on crop yields. Hence, we used a weather generator for obtaining an ENSO-conditioned climate series. A mechanistic model, based on the Richards equation for simulating the soil water content and crop water use, was selected. These models provide the most accurate estimates of water effects on crop yields [2].

Therefore, the tested methodology combines a weather generator, able to provide an ENSO-conditioned climate series, with a mechanistic crop model for estimating ENSO effects on sugarcane water use and yields in rain fed conditions. This paper presents our main results.

Crop model and model validations

The model SWAP [5] was used for sugarcane yield estimations. SWAP requires some particular crop function, which were experimentally determined for sugarcane by Ruiz et al. [3].

Experimental farms of several hundred hectares were selected in each country. Climate data were assumed as constant for each experimental zone. The soil hydraulic properties were calculated from pedotransfer functions, using available soil data. Average values of those properties were assigned to each sugarcane field through a GIS operation.

Simulations were performed for the 1995-1996 cropping season in the three countries. The Penman-Monteith potential evapotranspiration was calculated daily and was taken as the topsoil boundary condition. Free water flux was taken as the bottom boundary condition. Daily rainfall was considered as the only water supply.

The simulated and actual yields as well as the Root Mean Square Errors (RMSE) are depicted in Figure 1. The correlation coefficients between actual and estimated yield are 0.46, 0.36, 0.54 and 0.41 for the Cuban, Mexican, Venezuelan and overall data cases, respectively. As can be seen in Figure 1, the average estimated and actual yields are equivalent. Furthermore, we found that the model mimics not only the final yields, but also the sprouting month effects, and hence the weather influence on the yields. However, the model's predictive accuracy can be improved if local conditions are considered. Utset et al. [4] provides all the details of the model validations.

Comparison between actual and generated precipitation and evapotranspiration

A daily series of precipitation, maximum, minimum and mean temperatures, wind speed, sun radiation and relative humidity for more than 25 years was available in each country. The Japan Meteorological Agency ENSO index was used to classify ENSO years.

One hundred years of daily evapotranspiration and rainfall data were generated in each country for El Niño, La Niña and Neutral conditions. A daily-basin weather generator was used. The correlation coefficients between actual and generated data are 0.97 and 0.92 for the monthly precipitation and its standard deviation, respectively. However, the weather generator under predicts very large rainfalls and slightly over predicts the standard deviation of the monthly rainfall. The correlation coefficient between actual and generated evapotranspiration is 0.97. Still, the weather generator systematically under estimates the ETP. Conversely, it over estimates the ETP standard deviation, even though the correlation coefficient remains relatively high (0.84). Despite these inaccuracies, we consider that the weather generator is able to mimic ENSO effects on the studied variables, particularly on precipitation.

Simulated ENSO effects on sugarcane yields and possible recommendations for decision-makers

The 100 generated years of daily evapotranspiration and precipitation data for each ENSO phase and country were used in the

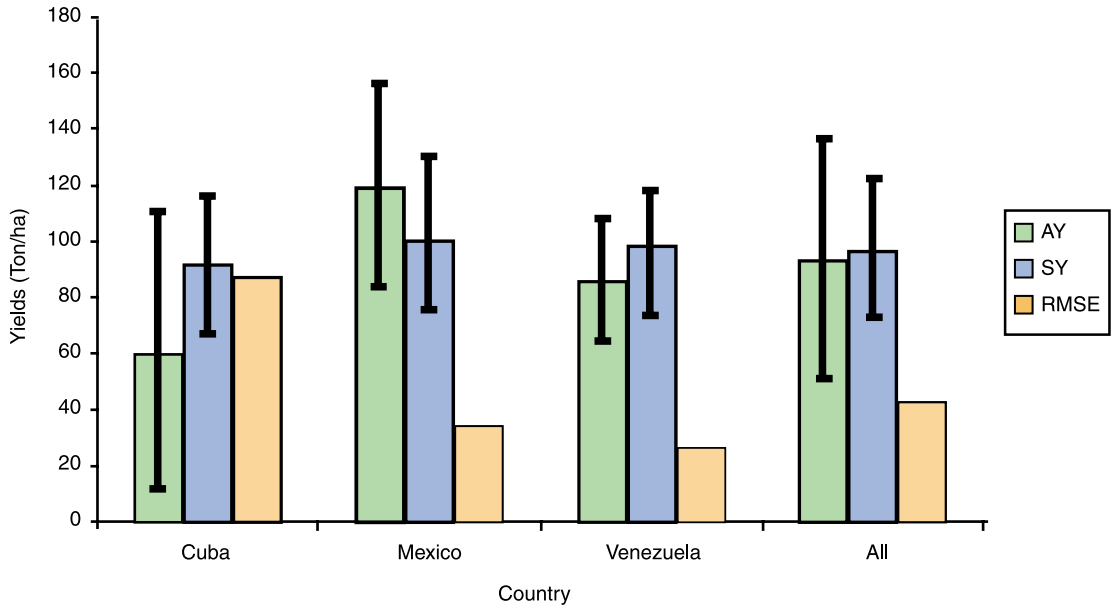

Figure 1. Mean actual and simulated yields and corresponding RMSE. The Y-bars show the standard deviations.

simulations. The considered sprouting and harvest dates in all simulations were January 1 and December 20, respectively. Rain fed conditions and perfect drainage at the bottom of the 1-m simulation layer were assumed. The "average" values of the soil hydraulic properties at each farm were calculated through the scaling procedure. Relative final yields [5] were estimated at the end of each SWAP run.

The basic statistics of the simulated relative yields for each ENSO phase and country is shown in Table I. Significantly lower yields are obtained in Cuba and significantly higher yields in Mexico during El Niño years. The yields are significantly lower in Neutral years in Venezuela. El Niño increases yield variability in the Cuban farm, whereas this variability is higher in Neutral years in Venezuela. The temporal behavior of relative yields (figures not shown) provides evidence that most of the negative effect is due to water stress in the first months, during the sugarcane intensive growing period. Accordingly, sugarcane farmers should provide irrigation in these months in El Niño years in Cuba and in Neutral years in Venezuela.

The correlations between relative yields and the simulated components of the water balance, i.e. effective rainfall, transpiration, soil evaporation and water flux at the bottom of the simulated soil layer, are shown in Table II for each ENSO phase and country. As expected, transpiration is significantly positively correlated to the yields in all the cases. Soil evaporation is significantly negatively correlated to the relative yields in Cuba in El Niño years, when the lowest yields are predicted. Hence, farmers should prevent evaporation through any management practice. However, soil evaporation increases the sugarcane relative yields in Mexico and Venezuela. Rainfall is negatively correlated and bottom flux positively correlated in the Cuban farm, which indicates that a drainage solution for the heavy clayey soils of the farm could improve the yields. Rainfall is positively correlated in the Mexican farm, since the precipitation is usually scarce at the beginning of the crop season and irrigation supply is required, as can be concluded from the low mean relative yields obtained in the Mexican farm (see Table I) under the simulated rain fed conditions. The water lost by deep drainage affects sugarcane growing in Venezuela in Neutral years, when the lowest yields are achieved. This can be concluded from the significant negative correlation coefficient between bottom flux and relative yields in this case, as shown in Table I. All of these results depend on the modeling assumptions and on the soil hydraulic properties.

Conclusions

Indeed, the combination of a physically based model and a weather generator could provide many useful recommendations to sugarcane and agricultural decision-makers regarding crop water management under ENSO conditions. The crop model mimics climate effects on the yields and the weather generator effectively reproduces climate behavior. However, the simulation outputs rely on the model

Table I. Means, standard deviations (SD), coefficients of variation (CV), medians and maximum (Max) and minimum (Min) values of the Relative yields estimated from the 100 simulations at each country and ENSO phase.

* Significantly at the 95% confidence level

Country	ENSO phase	Mean	SD	CV	Median	Max	Min
Cuba	Niño	0.58*	0.08*	13.25*	0.58*	0.83	0.38
	Niña	0.61	0.05	8.72	0.61	0.72	0.49
	Neutral	0.61	0.06	9.73	0.60	0.79	0.46
México	Niño	0.29*	0.09	30.11	0.26*	0.59	0.14
	Niña	0.21	0.08	39.27	0.17	0.47	0.11
	Neutral	0.22	0.10	44.04	0.19	0.58	0.12
Venezuela	Niño	0.90	0.09	10.20	0.94	0.98	0.51
	Niña	0.92	0.09	9.52	0.95	0.98	0.45
	Neutral	0.84*	0.12*	13.97*	0.88*	0.97	0.46

Table II. Correlation coefficients between the estimated relative yields and the components of the water balance, as obtained from the 100 simulations.

		Rainfall	Bottom Flux	Transpiration	Evaporation
Cuba	El Niño	-0.21	*0.28	*0.30	-*0.41
	La Niña	-0.20	*0.40	*0.75	0.11
	Neutral	-0.07	0.18	*0.79	0.17
Mexico	El Niño	*0.39	-0.09	*0.57	*0.77
	La Niña	0.16	0.00	*0.52	*0.63
	Neutral	*0.49	-0.21	*0.53	*0.54
Venezuela	El Niño	0.07	-0.15	*0.36	*0.54
	La Niña	-0.03	-0.25	*0.37	*0.37
	Neutral	0.13	-*0.31	*0.36	*0.55

assumptions and on the weather generator performance. Therefore, validation studies in several years are required before using the methodology for decision-making. The simulation results and the corresponding recommendations for decision-makers are highly site specific and hence particular studies should be carried out at several places of economic interest or climatic risk.

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Correspondence

Down to Earth after Amsterdam

Letter to the Editor, from Peter M. Haugan

The Global Change Open Science Conference in Amsterdam 10-13 July 2001 was an unprecedented event, a celebration and a success in many ways. Many good overview talks, detailed information in parallel and poster sessions, active communication between scientists and policy makers, and an opportunity to meet colleagues for off-line discussions about projects, activities and scientific status. As one of the many conference participants, I would like to thank the IGBP leadership and organization for their efforts in collaboration with WCRP and IHDP, and congratulate the rapid progress obtained by the IGBP programme in the relatively few years that it has existed. The future evolution of the IGBP can play a very important role for development of many branches of science. It is therefore critical to examine and discuss the path that the programme is presently taking. As an outsider to IGBP until very recently, I would like to raise some questions, which I hope to get answered or discussed.

My first question is, *how is the research agenda of the IGBP set?* During the first day of the Open Science Conference, following an appropriate, colourful and stimulating overview by the chair of the IGBP, and information on recent actions in industry, the following plenary talks discussed a number of so-called research challenges. These were all associated with legal aspects of the Kyoto protocol and how nations could comply with or circumvent various paragraphs there. The research challenges all dealt with short-term behaviour of terrestrial carbon sinks. These issues have made their way into the new proposed (or already endorsed?) IGBP/WCRP/IHDP joint project on the Carbon Cycle, where one of the three especially highlighted major goals is to explain the current patterns of sources and sinks.

In the session on sustainability science on the following day in Amsterdam, professor Bert Bolin in his very polite way, made the point that in the broad flow of information from the IGBP to policymakers, some key messages can easily get lost. One of them is that the carbon problem is primarily a problem on a centennial time scale. It is an important methodological question in earth system modelling to aggregate unnecessary details and retain important system-level features (IGBP Science #4, p. 24). Has this message made its way to IGBP planning on the carbon issue? Based on the way the Amsterdam conference was structured, it is tempting to suggest that there has been perhaps too much influence from short-term concerns of politicians and/or some terrestrial ecosystem scientists. I sincerely hope this is not the case, but it did emerge as a take-home message from the first part of the conference. It can in fact be very damaging to national and other research policies if the most important aspects of an issue get lost in a flow of less essential side tracks. In this case it does make a difference. The research that can shed light on centennial scale carbon transports may be quite different from that which illuminates interannual and geographical variations in sinks.

More generally, should it not be the role of IGBP and ICSU to come up with independent advice and highlight themes that are important, but are not necessarily high up on the short-term political agenda? In the broad new structure of the IGBP (see IGBP brochure: *A study of global change*) most other compartments and interfaces are mentioned, but I miss something on the deep ocean sea floor, and, if you wish, its interaction with the ocean above. This boundary surface covers 70 % of the planet and probably contains genetic and other resources which may be crucial in a long-term perspective. The deep ocean chemistry and the sea floor are already affected by anthropogenic carbon and trace gases. It is not currently high on the political agenda and has not made its way to IGBP priorities. It is in fact not mentioned at all. Is this another reflection of external determinants of IGBP priorities?

The IGBP is marching at a rapid pace. Motivated by the possibility for science to contribute significantly and actively to political processes linked to sustainable development, present emphasis is on synthesis, integration and cross-disciplinary activities. This has been spelled out e.g. in the recent IGBP Science Series #4. My second question is *whether framework programmes, consensus building, capacity building, and advice to policymakers should be prioritised tasks of the IGBP in the future*? It is perfectly appropriate that science coordinated by ICSU and IGBP underpins intergovernmental processes and panels, and that prominent scientists in the IGBP are also advisers to governments and political institutions. But are these activities as such suitable for a non-governmental scientific programme?

Over the past decade, an unprecedented number of scientific panels have been set up to advise governments on various environment and sustainable development issues. More than 3000 experts are currently appointed to UN-sponsored advisory processes alone (www.unep.ch/earthw/sciadv2.htm). Can too much eagerness to contribute to action-oriented programmes in the long run jeopardize the role of the IGBP as an independent scientific advisor? Policy and action pro

grammes rely on value-based judgements. Scientific consensus building and synthesis are resource-demanding and challenging tasks. Who shall champion the basic research efforts needed if even the IGBP prioritises integration and interpretation that semi-political panels are perhaps better placed to deal with? How to organize capacity building is a related aspect. It is easy to agree that capacity building is a good investment for global earth science as well as for development and alleviation of poverty. However, rather than embarking on capacity building organized by the IGBP, perhaps it would be more productive to recommend governments to strengthen capacity building programmes of existing intergovernmental organizations. When appropriate, they will certainly consult the IGBP and IGBP scientists anyway.

A third question is, *how to ensure quality of IGBP science in the future*? This may seem an improper question to ask since it is easy to convince oneself that the IGBP presently enjoys input from a large number of highly qualified scientists. However, in the long run, mechanisms may need to be institutionalised in order to secure a similar continued quality. My, possibly biased, impression is that with the presently expressed sense of urgency in global change research, there is a tendency for the IGBP to formulate research plans rapidly with limited independent review. The plans definitely tend to be very broad, effectively accepting proposals and formulations put together by many active subgroups. Are there satisfactory procedures in place to prioritise? This would imply the need to sometimes say no, and to be able to give lower priority to some issues than others. Admittedly that is very hard to do, since very much research is in some way relevant to global change. But unless it is done, the IGBP science plans can be counter-productive. If too many scientists can find a home for their pet activity in some corner of IGBP plans, one runs the risk of attracting mainly well-established and politically active subgroups. In the mean time the most important and most challenging scientific problems representing new areas of research that require top intellectual resources and efforts might not get the attention they deserve, neither from the IGBP nor from the funding agencies who could look to IGBP for advice.

Emphasis on broad reviews, synthesis, frameworks, dialogue with non-scientific groups and tight integration with policymakers does not have to, but can, reduce the possibilities for classical scientific peer review activities. We heard many excellent review presentations in Amsterdam, and e.g. recently published reviews from PAGES and JGOFS science provides testimony to the importance of such activities. There were also presentations in Amsterdam containing mistakes which would not have survived peer review, and examples of improper mix of science and non-scientific interactions with society. The format of the conference did not allow much interventions or discussion. Is there a danger that the "scientific method" as such, with formulation and possible rejection of hypotheses, discussion and critique, may get lost in the strive for usefulness and immediate policy relevance? It is more important than ever to stress that minimum scores on the "old" quality dimensions are required. How do we ensure traditional quality in interdisciplinary research? There are not many experts in "earth system science". Perhaps it is too easy to trust specialists. Those specialists who articulate well are not always those who have the deepest insight.

These may seem like primarily critical remarks. But my comments are meant to be constructive. I hope that others who care about the future of earth science as much as I do, take part not only in the individual scientific activities, but also in the discussion about the appropriate role of the IGBP, as well as ways and means to secure this role.

I am professor of physical oceanography at the University of Bergen, Norway, member of the JGOFS SSC and the IOC/SCOR Carbon Advisory Panel, president of the Norwegian Geophysical Society, and Norwegian delegate to Intergovernmental Oceanographic Commission. My research is presently funded by the Norwegian Research Council, the European Union and industry. This contribution contains viewpoints on behalf of myself only and does not necessarily represent any of the mentioned organisations or institutions.

Peter M. Haugan

Response to Peter Haugan's Letter

Peter Haugan's letter raises some critical issues concerning the ways in which IGBP determines and carries out its research agenda and indeed some fundamental questions about the place of IGBP in the broader set of activities associated with global environmental issues.

1. How is the research agenda of IGBP set?

The research questions tackled within IGBP are set by a combination of 'bottom-up' and 'top down' approaches. Thousands of scientists around the world contribute to IGBP. Through their work in IGBP-initiated activities, they generate both new understanding of critical Earth System processes and new questions that must be tackled if progress is to continue. In addition, IGBP is undertaking a more formal process to define the agenda for the

next decade of its research. This process involves (i) the addition of 'new blood' to the planning teams - scientists not currently associated with IGBP; (ii) interaction with the assessment community, most notably the Intergovernmental Panel on Climate Change (IPCC) and the Millennium Ecosystem Assessment (MA), regarding the priority questions arising from their assessments; (iii) open science meetings on proposed new projects to allow the scientific community as a whole to have appropriate and timely input into the process; and (iv) much electronic communication with a very broad range of scientists throughout the whole process.

The Scientific Committee of the IGBP provides a 'top down' approach to ensure that the overall research agenda of the programme is well focused, manageable, balanced and able to address the large system-level questions that are now arising in Earth System Science. The SC-IGBP carefully reviews all proposed new research projects and revisions to existing projects in the context of the programme as a whole. The aim is to prevent projects from becoming collections of many individual or small-group agendas and ensures the coherence of the programme as a whole. Although this bottom-up/top-down approach is long and somewhat cumbersome in terms of multiple reviews at various stages (contrary to Peter Haugan's impression), it does produce a cutting-edge, achievable, widely accepted research agenda for the programme.

In terms of the more specific issues raised in Peter Haugan's letter: (i) Long time-scale processes are indeed included in the new Carbon Joint Project and explicitly noted in the Project's prospectus, available at the Global Change Open Science Conference and from the IGBP Secretariat in Stockholm. (ii) Scientific questions in the deep ocean in an Earth System context are under consideration as new ocean research within IGBP is being developed. The planning process is still in its early stages with an IGBP-SCOR Planning Committee developing a set of draft questions for further consideration by the community.

2. Should framework programmes, consensus building, capacity building, and advice to policymakers be prioritised tasks of the IGBP in the future?

Dealing with each of the issues in turn: (i) IGBP does not directly fund individual research projects themselves but rather provides a framework within which these projects can work together towards common objectives. IGBP focuses on those questions and activities where an international approach is the only or best way to tackle the question. Building widely accepted and agreed frameworks is a key IGBP activity.

(ii) IGBP periodically carries out synthesis of its own work (syntheses are not the same as either assessments or consensus building) to attempt to answer the broad questions around which it has organised its research and to build a new level of insight and understanding that provides the foundation for the next phase of research.

(iii) IGBP cannot continue to be dominated by the wealthy countries of the North and claim to be a truly international research programme. Capacity building is crucial and central to the work of the programme. Through START, jointly sponsored by IGBP, IHDP and WCRP, the programmes are building up stronger participation of developing country scientists in their research networks. Much remains to be done, but all three programmes strongly feel that capacity building cannot be left to others. It is vitally important for the programmes themselves.

(iv) IGBP's activities are almost entirely funded by the public sector in about 50-60 countries around the world. They quite appropriately expect that IGBP's research be relevant to the global environmental issues that are affecting their countries, and furthermore that IGBP communicate the research in ways that inform (but not prescribe) policy debate.

3. How can the quality of IGBP science be ensured in future?

All of the research published as a result of IGBP activities must go through the normal peer-review process. The IGBP website (www.igbp.kva.se) contains a list of publications arising from IGBP-sponsored activities. The websites of the core projects contain even more extensive lists. All of these publications have been peer-reviewed in the normal fashion. The set of synthesis volumes now nearing completion have gone through an exhaustive review process that has added about six months to their publication schedules but has ensured the quality of the volumes.

In terms of the programme as a whole, IGBP was reviewed in 1995 by its parent organisation ICSU (International Council for Science) and by IGFA (International Group of Funding Agencies). Oversight of the programme is carried out annually by ICSU's Advisory Committee on the Environment. A major review of the programme by ICSU is due again soon.

In the final analysis, the quality of the programme's science is best ensured by attracting the highest quality scientists to the programme. In this regard, IGBP continues to be very successful, and the future for international Earth System Science within the framework of IGBP and its partner programmes IHDP, WCRP and DIVERSITAS appears exceptionally bright.

Will Steffen, Executive Director, IGBP

Manipulating terrestrial carbon sinks

Letter to the Editor, from Camini Seneviratne

It is reported that both forestry and agricultural management have the potential to increase terrestrial C sinks (IGBP Newsletter, No. 46, p. 26, June 2001). However, recent studies showed that fast turnover rates of organic C in the forest floor litter layer result in quick return of the C to the atmosphere in little over 3 years (Nature 411: 466, 2001). Additional C taken up by some forests in response to atmospheric CO_2 enrichment is partitioned preferentially to fast turnover pools (i.e. leaves and fine roots) (R. Norby et al., 86th annual meeting of ESA, 5-10 August, 2001). Production of slower turnover pools like refractory humus substances in soils, which have turnover times over 1000 years, sequesters only 0.7% of terrestrial net primary production (Nature 348: 232, 1990). This justifies that terrestrial C sinks would be short-term, one-off benefits that should not be considered as long term alternatives to cutting emissions (Nature 412: 108, 2001). The question here is how can we increase the production of the humus substances to enhance long term C storage? This can easily be done by direct inoculation of soil fauna to the litter layer. In a spruce forest in Germany, the inoculation of earthworms markedly incorporated organic matter to a depth of 20 cm (Soil Biol. Biochem. 29: 677, 1997). In a woodland flood plain in U.S., earthworms consumed all the litter deposited on the soil surface within several weeks (Am. Midl. Nat. 113: 1, 1985). Soil faunal activities increase N availability and hence C sequestration in plants (Ecology 72: 665, 1991). Therefore, soil faunal inoculation has a two-fold advantage; increased C sequestration in soils as well as in plants. Further C sequestration in forest trees may be possible by foliar application of both macro- and micronutrients to the canopy using aeroplanes.

Camini Seneviratne, Institute of Fundamental Studies, Sri Lanka. E-mail: gaminis@ifs.ac.lk

New members of the Scientific Committee of the IGBP

Professor Karin Lochte is a biological oceanographer with a wide experience in the investigation of marine microbial processes in the open ocean and coastal seas. Her scientific interests focus on the role of microorganisms in the cycling of carbon in the ocean, particularly in the deep sea. She has been actively involved in the JGOFS research programmes since the beginning of this core project and is a member of the JGOFS scientific steering committee. After her PhD in 1985, which she obtained at the School of Oceanography in Bangor North Wales, UK, Karin worked as a scientist at the Institut of Marine Sciences at the University of Kiel, and at the Alfred-Wegener-Institut for Polar and Marine Research in Bremerhaven. Since 1995 she has taught biological oceanography, at first as a Professor at the Baltic Sea Research Institute at the University of Rostock and since 2000 at the Institut of Marine Sciences at the University of Kiel, where she is head of the Department of Biologial Oceanography. She has contributed to the development of marine science plans of the European Science Foundation. As a member of the German National Committee for Global Change Research and of the Senate Commission of the German Research Council for Oceanography she is involved in the development of global change research on a national level.

Professor An Zhisheng is well-known in the past global change and quaternary science Communities. He is a member of the Chinese Academy of Sciences and the Third World Academy of Sciences. He has been working on East-Asian Monsoon changes, dust accumalation, and the interactions of these with global change. He was invited as key-note speaker at the SAC IV meeting, Beijing in 1995 and at the 1st IGBP PAGES Open Science Meeting, London in 1998. He worked at the State Key Laboratory of Loess and Quaternary Geology as director from 1989 to 1999; he is at present the director of the Institute of Earth Environment, Chinese Academy of Sciences. In 1999 he was elected the vice president of INQUA after being the president of INQUA Loess Commission for two terms (1991-1999). His contributions to science won him Chinese Natural Scientific Awards both in 1991 and in 1999.

Third International Human Dimensions Workshop

Human Dimensions of Urbanisation and the Transition to Sustainability

IHDP (International Human Dimensions Programme on Global Environmental Change) and START (Global Change SysTem for Analysis, Research and Training) announce the third bi-annual International Human Dimensions Workshop on "Human Dimensions of Urbanisation and the Transition to Sustainability".

IHDP

START
IHDP • IGBP • WCRP

The workshop aims at providing young researchers with an intensive learning experience in the interdisciplinary field of Human Dimensions of Global Environmental Change (GEC) with a focus on different aspects of urbanisation; integrating these researchers into the international GEC network; and providing a forum for strengthening the input from developing countries, Central and Eastern European countries and nations in transition to the IHDP research agenda.

Foci and questions to be addressed at the Workshop include:

1. Urbanisation – Trends and Driving Forces
   How fast is urbanisation occurring in different parts of the world?
   What are the main driving factors?
   What causes the high consumption level of cities?
2. Urbanisation as a causal factor of GEC
   In what way do cities cause GEC?
   How could the environmental impact of cities be reduced, while economic and social development continues?
3. The vulnerability of urban systems to GEC
   What factors (social, economic, location, environmental) explain the differential vulnerability of cities to GEC?
   In what respects does GEC constitute a threat to people living in cities and the infrastructure that supports them?
4. The transition to sustainability
   What role do cities play in the transition to sustainability?
   How can the human dimensions research community engage in the transitions to sustainability of cities?
5. Human Dimensions research
   To what extent do analytical frameworks, such as ecological footprint and the urban metabolism model help in understanding and evaluating the relationships between cities and GEC?

Applicants must be 40 years of age or younger; be a national/citizen of a developing country or of Central/Eastern Europe/Russia; currently be working in the field of human dimensions of global environmental change (both social and natural scientists are encouraged to apply); have full working knowledge of the English language; and have completed their university education (with at least a Master's degree) and have been working in their field for a minimum of 3 years. We encourage applications from women, as a goal for the workshop is to enhance the participation of women in this field.

For more information on the workshop and the application procedures check www.ihdp.org (forms located under "News" section), or contact: Maarit Thiem, IHDP Secretariat, Walter-Flex-Str.3, D-53113 Bonn, Germany
Fax: +49-228-739054,
E-mail: thiem.ihdp@uni-bonn.de

June 3 – 14, 2002
Bonn, Germany

Deadline for applications:
November 10, 2001

IGBP and Related Meetings

For a more detailed meetings list please see our web site at http://www.igbp.kva.se

GLOBEC: IOC/SPACC Workshop on the Use of Environmental Indices in the Management of Pelagic Fish

3-5 September, Cape Town, South Africa

Contact: GLOBEC IPO: globec@pml.ac.uk

GLOBEC: SPACC - Spatial Approaches of the Dynamics of Coastal Pelagic Resources and their Environment in Upwelling Areas

6-8 September, Cape Town, South Africa

Contact: Pierre Freon: pfreon@sfri.wcape.gov.za or GLOBEC IPO: globec@pml.ac.uk

LOICZ: LOICZ-UNEP Polar estuarine biogeochemical budgets workshop

9-11, September, Stockholm, Sweden

Contact: LOICZ IPO, loicz@nioz.nl

International Conference on Paleoceanography VII

16-22 September, Sapporo, Japan

Contact: Hisatake Okada, icp7@cosmos.sci.hokudai.ac.jp or http://www.iijnet.or.jp/JTB-CS/icp7/

3rd International Conference on Land Degradation and the Meeting of the IUSS Sub-commission C - Soil and Water Conservation

17-21 September, Rio de Janiero, Brazil

Contact: icld3@cnps.embrapa.br or http://www.cnps.embrapa.br/icld3

Environmental Change: Implications for Population Migrations

19-21 September, Wengen, Switzerland

Contact: http://www.unifr.ch/iguf/EVENTS/Wengen/01/Wengen2001.html

GCTE: Impacts of Biotic Invasions in Terrestrial Ecosystems: Spatial Assessment, Base Rates and Consequences

19-22 September, Barcelona, Spain

Contact: Mark Lonsdale, Mark.Lonsdale@ento.csiro.au or Richard Mack, rmack@mail.wsu.edu or Montserrat Vila, vila@cc.uab.es

Tree Rings and People. An International Conference on the Future of Dendrochronology

22-26 September, Davos, Switzerland

Contact: Paolo Cherubini, paolo.cherubini@wsl.ch or http://www.wsl.ch/forest/dendro2001/

GCTE: Manipulating Insect Herbivory In Biodiversity-Ecosystem Function Experiments

22-26 September, Jena, Germany

Contact: Valarie Brown, v.k.brown@reading.ac.uk or Wolfgant Weisser, b9wewo@uni-jena.de or Winfried Voigt, b5wivo@uni-jena.de

International Symposium on Abrupt Holocene Environmental Changes in Arid Asia - History and Mechanisms (RACHAD 2001)

26-28 September (Tentative), Lanzhou, China

Contact: Dr. Chengjun ZHANG, cjzhang@lzu.edu.cn or Jianjun LI., lijianj@lzu.edu.cn

JGOFS: JGOFS/LOICZ/IOC Continental Margins Workshop on Marginal Seas, International Symposium on Biogeochemical Fluxes in Marginal Seas and Tropical Coastal Zones

28-30 September, Taipei, Taiwan, ROC.

Contact: Kon-Kee Liu, kkliu@ccms.ntu.edu.tw

First Sustainability Days

28 September-5 October, PIK Potsdam, Germany

Contact: sustdays@pik-potsdam.de or http://www.pik-potsdam.de/sustdays

FAO Conference: Responsible fisheries in the Marine Ecosystem

1-4 October, Reykjavik, Iceland

Contact: Dr. Grimur Valdimarsson: grimur.valdimarsson@fao.org or http://www.refisheries2001.org/

6th International Carbon Dioxide Conference

1-5 October, Sendai, Japan

Contact: Shuji Aoki, secre@co2.geophys.tohoku.ac.jp or http://co2.geophys.tohoku.ac.jp/

Data Management Task Team Meeting

2-3 October, Washington, DC, USA

Contact: Margarita Conkright, mconkright@nodc.noaa.gov

Scoping Workshop on Global Change Impact Assessment on Himalayan Mountain Regions

2-5 October 2001, Nagarkot, Nepal

Contact Person: Kedar Lal Shrestha, klshrestha@wlink.com.np

SCOR WG 119 'Quantitative Ecosystem for fisheries management' Meeting

5-6 October, Reykjavik, Iceland

Contact: P. Cury: curypm@uctvms.uct.ac.za or W. Christensen: v.christensen@fisheries.ubc.ca

North Pacific Synthesis Group Meeting

5-13 October, Victoria, BC, Canada

Contact: Alexander Bychkov, bychkov@ccs.ios.bc.ca

IHDP: Open Meeting of the Human Dimensions of Global Environmental Change Research Community

6-8 October, Rio de Janiero, Brazil

Contact: open.meeting@ciesin.org, http://sedac.ciesin.org/openmeeting/

Workshop on IMAGE ANALYSIS, sediments and paleoenvironments

8-10 October, Amherst, USA

Contact: francus@geo.umass.edu or http://www.geo.umass.edu/climate/imagewks.html

Chapman Conference on State-of-the-Art Hillslope Hydrology

8-12 October, Sunriver, Oregon, USA

Contact: Jeff McDonnell, jeff.mcdonnell@orst.edu or http://agu.org/meetings/cc01ecall.html

SPACC/GLOBEC Workshop on Paleoceanography

10-13 October, Munich, Germany

Contact: Dr. Juergen Alheit: juergen.alheit@io-warnemuende.de or Dr. Uli Struck: u.struck@lrz.uni-muenchen.de

START: START Scientific Steering Committee Meeting

15-18 October, Washington, D.C., USA

Contact: Ching Wang, xwang@agu.org

International Water Association World Water Congress

15-19 October, Berlin, Germany

Contact: http://www.iwa-world-water-congress.de/netscape/index.html

GCTE: GCTE Focus 1 Workshop: Tracing Carbon in Elevated CO2 Experiments

19-21 October, Durham, NC, USA

Contact: Diane Pataki, pataki@biology.utah.edu

Joint IAPSO/GLOBEC Symposium

21-28 October, Mar del Plata, Argentina

Contact: Paola Rizzoli: rizzoli@MIT.EDU or GLOBEC IPO: globec@pml.ac.uk or Hugh Ducklow, duck@vims.edu or Karin Lochte, karin.lochte@ifm.uni-kiel.de

SEARCH/APD Show Case Workshop; Past Landcover Changes; the Human Impact – An African Database and Network Symposium

22-26 October 2001, Nairobi, Kenya

Contact Person: Eric Odada, Email: eodada@uonbi.ac.ke

International Conference on Carbon Sinks and Biodiversity

24 - 26 October, Liège, Belgium

Contact: N. Baute, n.baute@mrw.wallonie.be or http://environnement.wallonie.be/presidence/en/event7/detail.htm

5th International Conference on the Cenozoic Evolution of the Asia-Pacific Environment

29 October-1 November, Hong Kong, China

Contact: Dr Wyss Yim, wwsyim@hku.hk or Prof. Jiamao Han, jmhan@public.east.cn.net

Afri Basins II Workshop on African River Catchments/Coastal Fluxes and Human Dimensions

29 October-1 November, Nairobi, Kenya

Contact: LOICZ IPO, loicz@nioz.nl

LOICZ AfriBASINS II Meeting; Workshop on African River Catchment/Coastal Zone Interaction and Human Dimensions

29 October-1 November 2001, Nairobi, Kenya

Contact: Hartwig Kremer, loicz@nioz.nl

Changes in Climate and Environment at High-Latitudes

31 October-2 November, Tromsø, Norway

Contact Kai-Rune Mortensen, kairm@ibg.uit.no or http://www.ibg.uit.no/geologi/konferanser/clienvir/index.html

VI International Symposium and Field Workshop on Paleopedology (ISFWP)

TBA, October, Mexico City

Contact: Dr. Elizabeth Solleiro-Rebolledo, solleiro@geologia.unam.mx or http://inqua.nlh.no/commpl/pedmeet2.htm

First ARTS Open Sciences Meeting

4-7 November, Nouméa, New Caledonia

Contact: Rob Dunbar (Stanford University) or Thierry Correge, Thierry.Correge@noumea.ird.nc or Brad Linsley, blinsley@csc.albany.edu or Sandy Tudhope, sandy.tudhope@ed.ac.uk or http://pangea.stanford.edu/Oceans/ARTS/ or http://pangea.stanford.edu/Oceans/ARTS/Noumea2001.html

Africagis 2001 Conference and Exhibition

5 -9 November, Nairobi, Kenya

Contact: Nasser Olwero, nasser@gathkenya.com or The World Bank/EIS Program, c/o CSIR-Environmentek, eis.program@mweb.co.za

International Conference on Agricultural Science and Technology

7-9 November, Beijing, China

Contact: ICAST, China Science and Technology Exchange Center, icast@agscience2001.org or http://www.agscience2001.org

GCTE: Trophic Interactions in a Changing World

7-11 November, TBA, The Netherlands

Contact: Peter de Ruiter, p.deruiter@frw.ruu.nl or W.H. van der Putten, putten@cto.nioo.knaw.nl or Jeff A. Harvey, harvey@cto.nioo.knaw.nl or Martin Wassen, M.Wassen@geog.uu.nl

GCTE: Workshop on IMAGES ANALYSIS

8-10 November, University of Massachussets

Contact: Pierre Francus, francus@geo.umass.edu or http://www.geo.umass.edu/climate/imagewks.html

PAGES: Abrupt Climate Change Dynamics

10-15 November, Il Ciocco, Italy

Contact: Keith Alverson, alverson@pages.unibe.ch or http://www.esf.org/euresco/01/lc01170a.htm

LOICZ: LOICZ/UNEP Global Synthesis Expert Workshop on Coastal Biogeochemistry and Scaling

11-14 November, Lawrence, Kansas, USA

Contact: LOICZ IPO, loicz@nioz.nl

ICARDA/IGBP/IDDC Workshop: Agriculture, Environment and Human Welfare in West Asia and North Africa. The Search for 'Sustainability'

12-14 November, Aleppo, Syria

Contact: Dr Adel El Beltagy, A.EL-BELTAGY@CGIAR.ORG

Global Change and Fire Effects at Landscape Scales

12-16 November, Santa Barbara, CA, USA

Contact: Mike Flannigan, mflannig@nrcan.gc.ca or Sandra Lavorel, lavorel@cefe.cnrs.mop.fr

RICAMARE Training Course on the Socio-Economic Effects of Climate Change in the Mediterranean Region

12-16 November 2001, Trieste, Italy

Contact: Gerard Begni, Begni@medias.cnes.fr

JGOFS: Paleo-JGOFS Task Team and Workshop

12-17 November, Germany or France

Contact: Karen Lochte, klochte@ifm.uni-kiel.de

1st SARCS Regional Scientific Committee Meeting

15-16 November, National Central University, Taiwan

Contact: Connie Chiang, connie@cc.ncu.edu.tw

Indicators of Sustainable Development Workshop

17-19 November 2001, National Central University, Taiwan

Contact: Connie Chiang, connie@cc.ncu.edu.tw

GAIM: GAIM Task Force Meeting

18-20 November, PIK Potsdam, Germany

Contact: Gaim@unh.edu/

IV International Symposium on Sustainable Development in the Andes: The Andean Strategy for the XXI Century, AMA-Mérida 2001

25 November-2 December, Mérida, Venezuela

Contact: http://www.forest.ula.ve/ama-merida2001

GLOBEC: 1st Symposium GLOBEC-Spain

28- 30 November, Cadiz, Spain

Contact: Fidel Echevarria, symposium.globec@uca.es or GLOBEC IPO: globec@pml.ac.uk or http://www.uca.es/symposium_globec/

Scientific Forum on Global Change Studies

28-30 November, Havana, Cuba

Contact: geprop@ceniai.inf.cu

Workshop for the DIAL Network for Supporting Global Change Research in the Asia-Pacific Region

TBA, November, Malaysia Center for Remote Sensing, Malaysia

Contact: Liping Di, lpd@rattler.gsfc.nasa.gov

African Groundwater Resources Workshop

TBA, November, Natal, South Africa

Contact: Eric Odada, eodada@uonbi.ac.ke

Global Conference on Oceans and Coasts at Rio+10

3-7 December, UNESCO, Paris

Contact: Dr. Biliana Cicin-Sain, bcs@udel.edu

International Conference on Freshwater

3-7 December, Bonn, Germany

Contact: http://www.water-2001.de

Regional Climate Model Intercomparison Project for Asia Workshop

10-13 December 2001, Kobe, Japan

Contact: Congbin Fu, fcb@ast590.tea.ac.cn

LUCC: International Symposium on LUCC Contribution to Asian Environmental Problems

13-14 December, Tokyo, Japan

Contact: http://shiba.iis.u-tokyo.ac.jp/LUCC/symp

In coming edition of the IGBP Newsletter...

More highlights from the Open Science Conference

Skin cancer and global change

Special edition on IGBP Phase II

Note to contributors

Articles should achieve a balance of (i) solid scientific content, and (ii) appeal to the broad global change research community rather than to a narrow discipline. Articles should be between 800 and 1500 words in length, and be accompanied by one to three key graphics or figures (colour or black and white).

Letters in response to an article in this Newsletter or relating to Global Change issues generally should be a maximum of 200 words in length and include author and contact details.

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Some charts, graphs and illustrations can be reconstructed at the IGBP Secretariat, however, poor quality photographic images, maps and logos can not be improved. Material "borrowed" from the Internet can not be used for publication, as it does not fit the requirements listed above.

Deadlines for 2001/2002:

December issue	Deadline for material: November 2
March 2002 issue	Deadline for material: February 8
June issue	Deadline for material: May 10
September issue	Deadline for material: August 9
December issue	Deadline for material: November 1

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