

# GLOBAL CHANGE Newsletter

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## Year of Mountains

2002 is the International Year of Mountains and it is fitting that we start the Science Features section with an article on mountains and global change by Mel Reasoner and co-authors.

Another product of the OSC, the article provides a good overview of the parallel session on mountain regions.

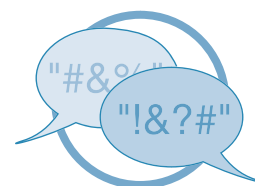


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## Discussion Forum

With this final edition of Global Change for 2001 we have introduced a new section called "Discussion Forum" to promote dialogue about global change issues.

In this edition we kick off with an article by Joao Morais on the continuing need to ensure good participation of developing country scientists in the IGBP network. Participation was strong at the Open Science Conference in Amsterdam but many ask "where to from here?" We hope that "Discussion Forum" will become a lively space for new ideas and perspectives and welcome your contributions and feedback.



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## More Science Features

From the OSC, Sandra Lavorel et al give a global perspective on fire and on page 11 Viktor Gorshkov and others challenge some of the fundamental assumptions in global change science. Michael

Raupach and colleagues share their latest work on the effect of climate gradients and land use changes on water, carbon and nutrient cycles in Australia (page 15) and Isabelle Larocque presents the fascinating work of PAGES Focus 5 on past ecosystem processes and human interactions (page 23). Finally, Robert Charlson emphasises the need for satellite measurements of atmospheric aerosols to be fully integrated with *in situ* measurements and modelling - the key to making effective use of satellite data in the future.

The centrefold shows off the work of the final 4 winners of the student poster prize awarded at the OSC in July.



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# Science Features

## Global Change and Mountain Regions: The need for an integrated approach

by M. Reasoner, A. Becker, H. Bugmann, L. Graumlich,  
W. Haeberli, S. Lütke-meier and B. Messerli

Mountain regions occupy about one-fourth of the Earth's surface, they are home to approximately one tenth of the world's population and provide goods and services such as water, forest products, refugia for biodiversity, storage of carbon and soil nutrients, and unspoiled recreation areas to more than half of humanity. Accordingly, they received particular attention in "Agenda 21" (Chapter 13, Managing Fragile Ecosystems), a programme for sustainable development into the 21st century adopted by the United Nations Conference on Environment and Development (UNCED) in June 1992 in Rio de Janeiro, and more recently by the UN declaration for the year 2002 as the "International Year of Mountains". In recognition of the sensitivity of mountain environments, and the consequences that changes in these environments might have for humanity, the scientific community has responded in recent years with a more focussed interest in global change research in mountain regions. Regional, national, and even global research initiatives are now concentrating their attention on mountain areas and are, in many cases, initiating cooperative efforts.

### Mountains at the OSC in Amsterdam

The recent intensification of interest in global change research in mountain regions was highlighted by a special mountain session during the Global Change Open Science Conference (OSC) "Challenges of a Changing Earth" of IGBP, the International Human Dimensions Programme on Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP) in Amsterdam on July 12, 2001. The mountain session included an evening discussion forum that clearly revealed the breadth of interest in mountain research, which spans various disciplines

from the natural and the human sciences, and highlighted the potential for interdisciplinary cooperation, for the development of synergies between different disciplines and for the spatial and temporal coordination of individual research projects. The OSC mountain session provided an overview of research across different mountain ranges of the Earth and specific information for stakeholders on possible development paths over the next few decades, taking into account globalisation processes and related cumulative and systemic environmental changes which may significantly

threaten the future ability of mountain regions to provide goods and services we now take for granted. This session also hosted the scientific debut for the Mountain Research Initiative (MRI), a multidisciplinary scientific initiative aimed at addressing global change issues in mountain regions and their consequences for the development of sustainable land, water and resource management in mountain regions around the globe (Box 1).

### Scientific rationale for a focus on mountains

From a scientific point of view, the strong altitudinal gradients in mountain regions often provide the best and sometimes even unique opportunities to detect and analyse global change processes and phenomena, because

- 1) meteorological, hydrological, cryospheric and ecological conditions change strongly over relatively

**"We are rapidly approaching important crossroads that require significant choices to be made. Business as usual is no longer an option for much of the world's environments, and mountain regions are not an exception."**

short distances. Accordingly, biodiversity tends to be high, and characteristic sequences of ecosystems and cryospheric systems are found along mountain



Figure 1. Photograph of the Morteratsch Glacier in the region of Bernina (Grisons, Eastern Swiss Alps) showing the retreat of the snout over the last 150 years. The '1850' trimline is clearly visible on the right-hand side of the glacier. Since ca. 1850 this glacier has lost approximately 15 percent of its area and 25 percent of its former length. The yearly measurements of the length changes started in 1878. The overall retreat from 1878 to 1998 - interrupted only by 4 years with minor readvances - accounts for a total of 2 km with a mean annual retreat rate of approximately 17 m/y. This long-term average was markedly surpassed in recent years. The glacier receded by 38.9 m and 29.6 m in 1999 and 2000 respectively. Photo by Max Maisch.

slopes. The boundaries between these systems (e.g. ecotones, snowline, glacier boundaries, etc.) are often climatically sensitive and may experience rapid shifts due to environmental change and thus can be used as indicators;

- 2) the higher parts of many mountain ranges are not affected by direct human activities and may serve as locations where the environmental impacts of climate change alone, including changes in atmospheric chemistry, can be studied;
- 3) mountain regions are distributed all over the globe, from the equator almost to the poles and from oceanic to highly continental climates. This global distribution provides unique opportunities to carry out comparative regional studies from widely separated parts of the globe and to

analyse the regional differentiation of environmental change processes.

Related to the changing environmental conditions along mountain slopes, changes also occur in socio-economic conditions, land-use and land-management practices, resource exploitation and the appeal of mountain regions for tourism. Unsustainable management practices may lead to the deterioration of the living conditions to the point where migration processes are intensified; some mountain areas become depopulated, whereas others become overpopulated. Such processes have a number of strong and mostly negative side effects.

## State and trajectories of mountain regions

Ten years ago, Chapter 13 of the Agenda 21 document acknowledged the important role of global change issues in mountain regions by pointing out

that mountain environments are essential to the survival of the global ecosystem and that many of them are experiencing degradation in terms of accelerated soil erosion, landslides, and rapid loss of habitat and genetic diversity. The seriousness and magnitude of these environmental problems in mountain regions have not abated over the last decade, and in many cases, they have been exacerbated by compounding issues. Consequently, the statements made at the 1992 United Nations Earth Summit in Rio are, unfortunately, just as valid today as they were a decade ago. The traditional perception that mountains represent pristine systems completely isolated from human impact and only marginally connected to economic, political and cultural centers of influence is rapidly becoming outdated. For example, the massive and widespread retreat of alpine glaciers highlights the impact of global climate change at high elevations and the consequences for lowland agriculture, hydroelectric power, mitigation of natural hazards and ecotourism (Figure 1). Similarly, greater physical, administrative and market integration of mountain and upland agriculture with mainstream systems has fundamentally altered local resource management strategies leading to resource use intensification and overexploitation. Threatened by the increasingly global scale of both systemic (impact environments at global scale) and cumulative (operate at local scale but are becoming globally pervasive) human impacts, many mountain systems are moving along a trajectory that fits clearly within the rubric of critical regions. Critical regions are places where high rates of environmental change are manifest in fragile ecosystems coupled with economies strongly depen-





## Research needs

Considering the fragility of mountain environments, the complex network of factors, both physical and socio-economic, that may impact these environments, and the substantial direct and indirect consequences that changes in mountain regions may have on humanity, it is clear that an integrated approach to addressing these issues is urgently required. For example, human-water interactions are global change issues that will very likely become critical in coming decades. Some mountains in arid and semiarid regions provide more than 80 – 90% of the water resources to the surrounding lowlands for irrigation, drinking water, industry and domestic use (Figure 2). Bearing in mind that approximately 60 – 70% of current freshwater resources is currently used for food production, and that the complex issue of food security is very likely to become quite important in the 21st century, effective water management strategies will need to consider a broad range of issues and consequences, will require a focus on mountain regions, and will require input from both physical and social sciences.

An integrative approach for global change research in mountain regions should consist of a series of coordinated experimental, observational, and modelling studies, with the aims of detecting and articulating the consequences of global environmental change and informing policy processes at local to global scales. A number of global change research programmes are ongoing in mountain regions and many of these are intensifying and exploring avenues for collaboration and integration. Such

Figure 2. Mt. Parinacota and Laguna Chungará in the Chilean Andes. Through the process of orographic uplift, mountains effectively extract moisture from the atmosphere thereby providing the primary source of water for many arid and semiarid regions. The transfer of water from mountains to surrounding lowland areas may be either direct via surface runoff of rainfall, or delayed by a) accumulation as snow/ice and subsequent glacial flow into the ablation zone where it is released as meltwater, and b) through groundwater flowpaths. Photo by Martin Grosjean.

dent on local environmental resources and limited response capability.

An additional source of change in mountain environments is related to the process of globalisation, i.e. the growing global integration of social, political and economic relationships. Globalisation as it affects mountain environments is reflected in demographic changes, the incorporation of mountain economies into extra-regional economies, the increasing influence of urban processes and perspectives, increases in consumption, and changes in

the location of decision-making and institutional arrangements. For the next few decades, globalisation processes are likely to be at least as important as environmental changes as factors promoting change in mountain regions. At the same time, however, the cumulative and systemic environmental changes may significantly threaten the ability of mountain regions to provide the critical goods and services described above, both to mountain inhabitants and to supply the extra-regional demands of other communities.

## Box 1. Global Change and Mountain Regions: The Mountain Research Initiative

In order to address the consequences of global change in mountain regions, an initiative for collaborative research on global change and mountain regions - the Mountain Research Initiative (MRI) - was developed and officially launched in July, 2001 with the opening of the Coordination Office in Bern. The MRI has been formally endorsed by the International Human Dimensions Programme on Global Environmental Change (IHDP), the Global Terrestrial Observing System (GTOS) and four core projects of IGBP, i.e. GCTE, BAHC, PAGES, and LUCC. The ultimate objectives of the Initiative are: a) to develop a strategy for detecting signals of global environmental change in mountain environments; b) to define the consequences of global environmental change for mountain regions as well as lowland systems dependent on mountain resources; and c) to make proposals towards sustainable land, water and resource management for mountain regions at local to regional scales. To achieve the above objectives, the research under the MRI is structured around four Activities, each of which is divided into a small number of specific tasks.

### Activity 1: Long-term monitoring and analysis of indicators of environmental change in mountain regions

This element of the Initiative will focus on mountain-specific indicators of environmental change which are sensitive to changes in climate, atmospheric chemistry, radiation, and land use/land cover. A set of four mountain-specific indicator groups is considered: 1.1) Cryospheric indicators related to snow conditions, glaciers, permafrost and solifluction processes; 1.2) Terrestrial ecosystems, particularly mountain plant communities and soils; 1.3) Freshwater ecosystems, in particular high mountain streams and lakes; and 1.4) Watershed hydrology, i.e. water balance components of high mountain watersheds/headwater basins.

### Activity 2: Integrated model-based studies of environmental change in different mountain regions

To achieve the overall goals of the Initiative, it is necessary to develop a framework that permits the analysis and prediction of hydrological and ecological characteristics and their linkages with land use and climate at various spatial and temporal scales. Accordingly, this Activity is organized around the following: 2.1) Development of coupled ecological, hydrological and land use models for the simulation of land cover and land surface processes in complex mountain landscapes; 2.2) Development of regional scale atmospheric models for mountain regions; 2.3) Integrated analysis of environmental change in mountain regions by means of fully coupled land-atmosphere models or by qualitative assessments; and 2.4) Regional scale mountain land experiment to support the development, application and validation of the above models.

### Activity 3: Process studies along altitudinal gradients and in associated headwater basins

Ecological and hydrological field studies and experiments along altitudinal gradients and at sensitive sites can provide invaluable data on potential responses of mountain ecosystems to anthropogenically induced environmental change. Research themes to be addressed within this Activity include: 3.1) Development of indicators of mountain ecosystem response to environmental forcing factors to facilitate process-related interpretation of historical and paleorecords; 3.2) Assessment of runoff generation and flowpath dynamics on steep hillslopes and in

headwater catchments; and 3.3) The relationship between diversity and ecosystem function, taking advantage of the strong changes of diversity along altitudinal gradients.

### Activity 4: Sustainable land use and natural resources management

The overall objective of this Initiative is to evaluate and enhance sustainable land, water, and resource management strategies for mountain regions. Three priority areas are suggested for assessment: 4.1) Changes in forest resources, with potential implications for agriculture, rates of erosion and magnitude of floods, and biodiversity; 4.2) Intensification and/or extensification of agriculture (including grazing), with potential implications for food security, rates of erosion and magnitude of floods, and biodiversity; and 4.3) Changes in water resources due to factors such as changing agricultural practices, increasing temporary or permanent population, and/or increasing energy generation, with implications for downstream water supply, energy availability, flooding, and sediment transfer.

The MRI implementation Plan has been published as number 49 in the Global Change Report Series and can be ordered free of charge either from the IGBP secretariat in Stockholm or the MRI Coordination Office in Bern or downloaded from <http://www.igbp.kva.se/cgi-bin/php/frameset.php>

### Web links

Mountain Research Initiative (MRI): [www.mri.unibe.ch](http://www.mri.unibe.ch)

Biospheric Aspects of the Hydrological Cycle (BAHC): [www.pik-potsdam.de/~bahc/](http://www.pik-potsdam.de/~bahc/)

Global Change and Terrestrial Ecosystems (GCTE): [www.gcte.org](http://www.gcte.org)

The Global Observation Research Initiative in Alpine Environments (GLORIA): [www.gloria.ac.at/res/gloria\\_home/](http://www.gloria.ac.at/res/gloria_home/)

Global Mountain Biodiversity Assessment (GMBA): [www.unibas.ch/gmba/](http://www.unibas.ch/gmba/)

Global Terrestrial Observing System (GTOS): [www.fao.org/GTOS/](http://www.fao.org/GTOS/)

International Human Dimensions Programme on Global Environmental Change (IHDP): [www.uni-bonn.de/ihdp/](http://www.uni-bonn.de/ihdp/)

Land-Use and Land-Cover Change (LUCC): [www.geo.ucl.ac.be/LUCC/lucc.html](http://www.geo.ucl.ac.be/LUCC/lucc.html)

Past Global Changes (PAGES): [www.pages.unibe.ch/](http://www.pages.unibe.ch/)

Terrestrial Ecosystem Monitoring Sites (TEMS): [www.wsl.ch/relics/rauminf/riv/datenbank/tems/database\\_tem.html](http://www.wsl.ch/relics/rauminf/riv/datenbank/tems/database_tem.html)

initiatives include the Global Mountain Biodiversity Assessment (GMBA), the Global Observation Research Initiative in Alpine Environments (GLORIA), the Mountain Module of the Terrestrial Ecosystem Monitoring System (TEMS) of the Global Terrestrial Observing System (GTOS), and the Mountain Research Initiative (MRI), a joint effort of IGBP, IHDP, and GTOS.

A central objective of the MRI is to facilitate the development of a synthesis of scientific information that will be of benefit to those addressing sustainability issues in mountain regions (Box 1). An example of how the various disciplines may interact is demonstrated by considering the requirements of the next generation of regional environmental models. The potential for the development of fully coupled mesoscale land-atmosphere models for mountain regions is particularly exciting as such models could prove to be very useful for predicting the effects of both land use/land cover and climate changes on spatial scales appropriate for the investigation of global change in mountain regions and thereby provide a valuable tool for addressing sustainability issues in mountain areas. The predictions of these models, however, will only be robust if they are validated with information from sensitive terrestrial sites, and mountain regions provide excellent opportunities for the acquisition of such data. Consequently, it is imperative that researchers in the modeling community are able to dovetail their efforts with those involved in reconstructing mountain palaeoenvironments on a variety of

timescales (e.g. PAGES), process studies along altitudinal gradients (e.g. BAHC, GCTE), and monitoring studies from mountain regions (e.g. TEMS Mountain Module, LUCC, GLORIA, GMBA). This will require building new linkages and reinforcing existing networks of collaboration between the various core projects within IGBP and between IGBP, IHDP and GTOS. Detailed information of this nature, acquired from a variety of research activities, will be necessary for testing the capabilities of models to represent features including: a) the interplay between atmospheric variability and changes in glaciers, water cycles, vegetation, soils and the intensity of exploitation by human populations;

“...the massive and widespread retreat of alpine glaciers highlights the impact of global climate change at high elevations and the consequences for low-land agriculture, hydroelectric power, mitigation of natural hazards and ecotourism”

b) the implications of processes operating on time scales ranging from seasonal to multicentennial; c) non-linear system responses and thresholds within the complex interactions under study; and d) changes in magnitude-frequency relationships and their consequences in terms of resource depletion and of hazard to human populations.

## Conclusions

Mountain regions provide unique and valuable settings in which to study the specific facets of environmental changes, their regional consequences, and resource management strategies

to adapt to and mitigate these consequences. This conclusion is not newsworthy in and of itself, as the value of mountain regions as sites of scientific inquiry has long been recognized. However, the vast majority of work to date has not been structured to facilitate a synthetic understanding of the interactions between climate, land surface processes, and human activities, taking into account the specific conditions in mountain environments. At present, the relevant tools and observations often suffer from mismatches in scale and gaps in coverage. The rationale for an initiative on “Global Change and Mountain Regions” thus rests on the potentially large payoff of a strategy that links mountain regions of the

world as sites for monitoring and understanding the processes of change as well as places where a predictive understanding of the consequences of change is critical for sustaining land and water resources. The proposed activities of the Mountain Research Initiative will contribute not only to the scientific understanding of the ongoing processes of change, but ultimately to suggestions for actions directed at preserving the ability of mountain regions to sustainably provide the goods and services on which humanity has come to depend. As such, the initiative is well suited to complement the contributions of IGBP and its partner programmes to the “International Year of Mountains”.

As humanity and the planet Earth enter the 21st century, it is clear that the relationship between the two must change. We are rapidly approaching important crossroads that require significant choices to be made. Business as usual is no



longer an option for many of the world's environments, and mountain regions are not an exception. As we approach these crossroads, it is clear that global change research in mountain regions will become increasingly important in the coming decades. The Amsterdam Declaration signed by more than 800 scientists at the IGBP OSC meeting in July, 2001 states that the accelerating human transformation of the Earth's environment is not sustainable and that a new system of global environmental science is required that will integrate across disciplines, environment and development issues and the natural and social sci-

ences. This is particularly true for global change research in mountain regions given the sensitive and complex nature of the relationship between mountain environments and the people who inhabit and are dependent upon them.

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## Fires in the Earth System: The need for integrated research

by S. Lavorel, E. F. Lambin, M. Flannigan and M. Scholes

Fire is the most important disturbance worldwide in terms of area and variety of biomes affected. Every year, fire affects extensive areas of savannas (200-400 Mha annually), circumboreal forest (5-15 Mha annually) and many other ecosystems like woodlands and shrublands of mediterranean climate regions. Fire, and its use by humans as a management tool, have now and in the past caused dramatic changes in the structure and functioning of ecosystems, and are now shown to significantly affect atmospheric composition. Fire regimes and their effects on terrestrial ecosystems are highly sensitive to all global change factors, in particular to climate change and land-use change. For all these reasons, the study of fire and how it did, does, and will respond to global environmental change has attracted an impressive amount of research activity within IGBP and elsewhere.

By physical nature fire ignition and propagation are strongly linked to climate. Changing climate, and especially increased summer maximum temperatures, lead to increased fire risk in fire-prone ecosystems. Landscape simulations have shown dramatic effects of changing

climate on fire regimes, e.g. in the boreal forest (Figure 1). These simulations uncovered unexpected changes in the distribution of very large fires due to complex interactions between climate, vegetation, and fire: the warmer and wetter scenario experienced many more large-

scale fire events compared to the warmer and drier scenario. Indeed in the warmer and drier climate scenario frequent medium-sized fires prevented fuels from building up across the landscape and limited the number of large-scale fire events. In contrast, in the warmer and wetter climate scenario frequent small-sized fires allowed buildup of highly flammable late-successional fuels across the landscape that were highly susceptible to burning when climate conditions allowed [10].

In many regions of the world, including tropical areas, natural ignition only accounts for a small fraction of the number of fires and area burned. In these regions, while the timing of rainfall and rates of vegetation senescence define the predisposing conditions for fires, land use influences the amount and exact timing of burning within the window of opportunity provided by natural conditions. For many farmers, fire is indeed an essential management tool. In dense humid forests fires are used for land-cover conversion

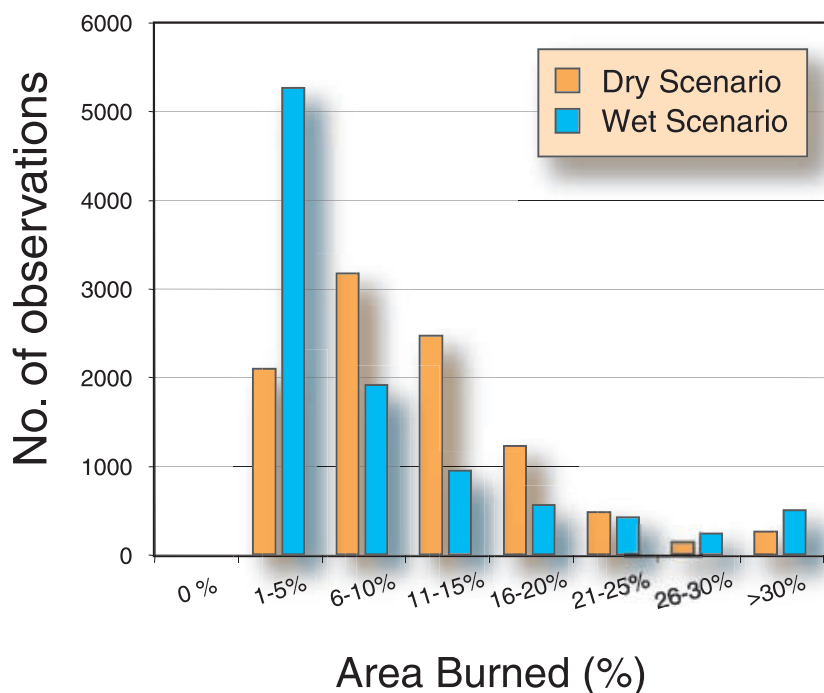


Figure 1. Simulation of the potential consequences of different precipitation regimes in the northeast interior region of Alaska, using the model ALFRESCO. The experiment implemented an instantaneous 2 degree C growing-season temperature increase with 2 different precipitation regimes (a 20% increase and 20% decrease from current). (from Turner et al. 2001)

or for agricultural rotations. In savannas, the main purpose of burning is to prevent the replacement of the herbaceous strata by woody biomass and to enhance, in the short-term,

therefore modify opportunities for fire ignitions. In the recent decades, exceptional fire events in tropical rainforests have increased in frequency and magnitude in relation to El Niño climatic events [6,8]. During

“normal” years, the patterns of burning have changed in most regions.

Land-use changes also control biomass burning indirectly through their effects on fuel availability and spatial arrangement. Human alterations of landscapes have a profound influence

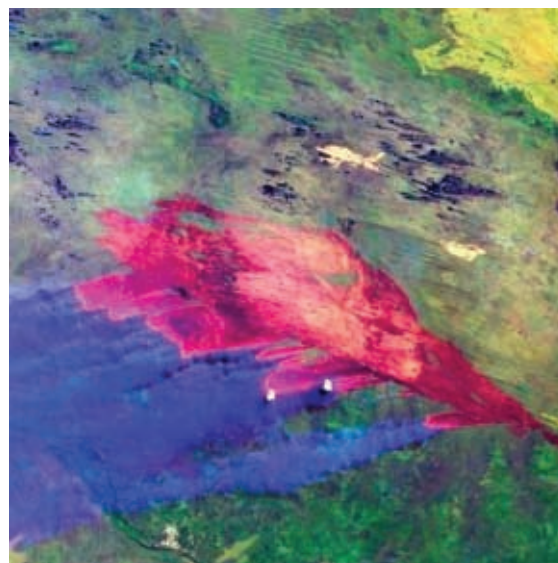
on the amount of biomass that can be burned. For example, agricultural expansion

reduces the amount of natural fuels, although intensification may lead to a higher temporal frequency of fire, due for instance to the burning of crop residues. Conversely, uncommonly large fire regimes have been observed in Mediterranean Europe as a result of the conjunction of unusually dry and hot summers and fuel accumulation after the extensification or cessation of agro-pastoral activities. Landscape fragmentation by land use can also cause a reduction in the spontaneous propagation of fires. However forest fragmentation caused by selective logging may be an exception since it may result in an increase in the number and areas burned by fires. Indeed the increased occurrence of fire entering into the moist forests once selective logging has been undertaken creates a positive feedback, where

fire-affected forest becomes more prone to subsequent fires and degradation [3]. Increased connectivity between forest clearings and pastures (with easily flammable vegetation) increases fire spread as well as it

“...simulations uncovered unexpected changes in the distribution of very large fires. ...warmer and wetter scenario experienced many more large-scale fire events compared to the warmer and drier scenario”

the production of some grass species for grazing by domestic and wild animals. In combination with increasing climatic risk, changing land use can



A landsat image showing active savanna fires in northern Australia, recently changing direction due to a wind shift. The hot-pink is active fire, and the blue is smoke. Source: Grant Allen, Northern Territory Bush Fires Council, Darwin.





A savanna fire in Northern Australia. Source: Barbie McKaige, CSIRO, Darwin.

and enhances overall fire susceptibility [4].

The global importance of fire relates to direct feedbacks from fire events and fire-induced vegetation changes to the atmosphere, biogeochemical cycles and land use, via several ecosystem goods and services. Fire impacts, and their modifications by land use change, are thereby of acute relevance to human societies and global change.

Because of its global extent fire is indeed the disturbance of most significance for the net carbon balance of terrestrial ecosystems. The annual C flux to the atmosphere from global savanna and forest fires is estimated to be in the range of 1.7 to 4.1 Pg. Though at large spatial scales the magnitude of the carbon flux associated with landscape disturbances is typically not large in comparison to ecosystem photosynthesis and respiration, the magnitude of the disturbance can be a critical factor in determining whether an ecosystem or region is a carbon sink or source. For example, the net carbon balance of Canadian forests has changed from a strong carbon sink during the first part of the 20th century to a weak source over the last few decades due to increased landscape disturbances [7]. Preliminary modelling results show great interannual variability in

carbon emissions, but during active fire years the amount of carbon released by forest fires in Canada is comparable to the amount released by burning fossil fuels (Figure 2).

Smoke and excess tropospheric ozone, both by-products of biomass burning, have long been observed over large regions of the tropics. For instance savannas are thought to be responsible for approximately 36% of the global total emissions from biomass burning [1]. The highest smoke aerosol and tropospheric ozone amounts occur over southern Africa and the adjacent Atlantic, where a strong ozone, biomass-burning link has been

confirmed by airborne and ship-based measurements. Globally the extent of biomass burning produces some 40% of the world's annual production of CO<sub>2</sub>, and also significantly accounts for the production of other greenhouse gases such as CO (32%), methane (10%), tropospheric ozone (38%) and over

**“Because of its global extent fire is indeed the disturbance of most significance for the net carbon balance of terrestrial ecosystems. The annual C flux to the atmosphere from global savanna and forest fires is estimated to be in the range of 1.7 to 4.1 Pg.”**

86% of black soot [5]. Increases in biomass burning resulting from changing climate and land use therefore have the potential

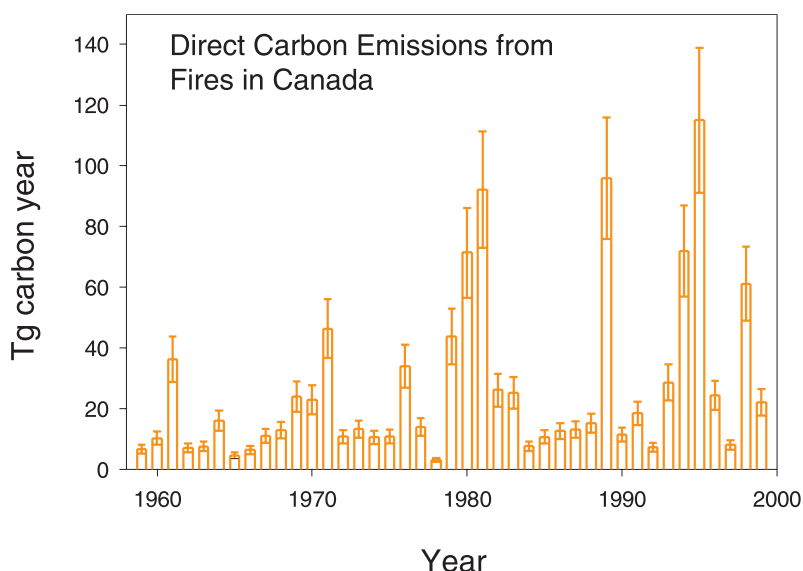


Figure 2. Direct carbon emissions from large fires(>200 ha) for Canada, 1959 to 1999. Carbon released was determined from the fuel consumption as calculated by using the Canadian Fire Behavior Prediction System. During extreme fire seasons like 1995 (direct emissions from fire exceeded 115 Tg C per year) the carbon released approaches the carbon emissions from fossil fuels for Canada (150 Tg C per year). Error bars are estimated bounds of uncertainty. (from Amiro et al. 2001)

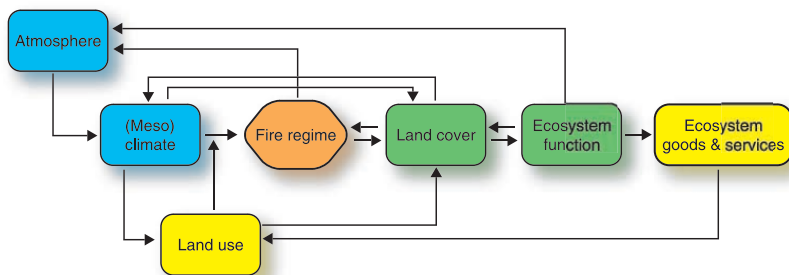


Figure 3. A conceptual framework for the development of integrated fire research within IGBP II

to lead to powerful positive feedbacks through the effects of these emissions on climate.

As pointed out in the examples above fire regimes and their effects on ecosystems, the atmosphere, and human societies involve most of the time multi-scale phenomena, complex interactions and feedback loops, which require multi-disciplinary approaches. However most fire research to date has focused on single aspects such as the effects of climate on fire risks, the effects of land use on fire regimes, the effects of fires on land cover or the quantification of emissions from burned areas to the atmosphere. What is still lacking in order to be able to provide policy makers and land managers with an assessment of the potential consequences of alternative courses of action is an integrated view including the combination of causes, effects and feedbacks relating fire and global change, and how these will affect societies through the alteration of ecosystem goods and services. A group of scientists from GCTE, LUCC and IGAC are developing a conceptual framework for the integration of fire research within the future IGBP II (Figure 3). The objective of such a framework is to organise research that emphasises causal and effect relationships, feedbacks and nonlinearities within but

also across compartments of the Earth System (terrestrial ecosystems, humans, climate and atmosphere). Place-based syntheses will form the initial core of this new approach, focussing on regions selected for data availability and global importance, such as the LBA [9], or African savannas [11]. Later

developments should lead to regional and global syntheses, including the assessment of relative vulnerabilities across regions to integrated global change scenarios that couple climate and land use.

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# Biological theory and global change science

by V. Gorshkov, A. Makarieva, B. Mackey and V. Gorshkov

Today the anthropogenic transformation of the biosphere is growing exponentially. This is accompanied by an equally rapid deterioration of environmental conditions favourable for humans on both local and global scales. The now well-established coupling of local and global processes raises issues associated with the role of ecological systems undisturbed by modern technological society in maintaining a life-compatible environment on Earth. As a consequence, the biological/ecological component of global change science is conspicuously expanding. It is therefore reasonable to expose to close scrutiny those theoretical biological principles that are employed in global change science, bearing in mind the potential large-scale practical implications of global change studies. The purpose of this brief article is to introduce the reader to such a critical re-examination of two biological principles, for the purpose of stimulating ongoing scientific dialogue on this issue.

There are two related theoretical principles that have been borrowed by global change science from biology and are now used to integrate biological factors into global change studies. These are the principles of “limitation” and “adaptation”. According to the limitation principle, productivity of biological systems is limited by the least available nutrients. For example, the productivity of agricultural systems can be elevated by introducing fertilisers that contain some particular chemical elements.

The adaptation principle refers to the proposition that biological species adapt genetically to changing environmental conditions. Any population is composed of individuals with different genetic composition (different genotypes). The genotypes allowing their carriers to produce the maximum number of offspring are by def-

inition the most fitted to the corresponding environment and enjoy the highest frequency in the population. When the environmental conditions change, different genotypes may appear to be most fitted and will dom-

“It is easy to see that if the biotic regulation of the environment is in action, the “adaptation” and “limitation” principles cannot be valid for describing the natural biota.”

inate the population. If there are no genotypes fitted to a new environment, the population becomes extinct.

As well as the limitation principle, the adaptation principle has been verified in artificial, human-supported systems. During artificial selection, populations of natural

biological species are placed under human-created conditions where organisms with properties satisfying the corresponding human needs can be selected, while the wild-type organisms are artificially eliminated from the population. The possibility of artificial creation of new sorts of plants and breeds of animals is interpreted as empirical evidence proving the existence of genetic adaptation.

The two principles are extensively employed in various aspects of the global change research. For example, the “adaptation” principle underpins a fundamental strategy of conservation programs aimed at preserving the biological diversity of Earth under conditions of global change. Significant resources and scientific efforts are allocated to studying and preserving the genetic variability of the endangered species because this variability is assumed to be indispensable in giving the species the capacity to adapt to and survive in the continuously changing environment. The limitation principle is widely used in

the analysis of the global carbon budget – a central topic in global change studies. It is assumed that the oceanic biota does not react to the human-induced increase in concentrations of atmospheric and, consequently, dissolved carbon because its functioning is limited by nutrients other than carbon (nitrogen, phosphorus, iron etc.). As a result, the oceanic dissolved organic carbon pool is excluded from considerations of the global carbon cycle changes. On the contrary, the terrestrial biota, which is believed to be fertilised by the excessive carbon (limiting nutrient), is considered to be



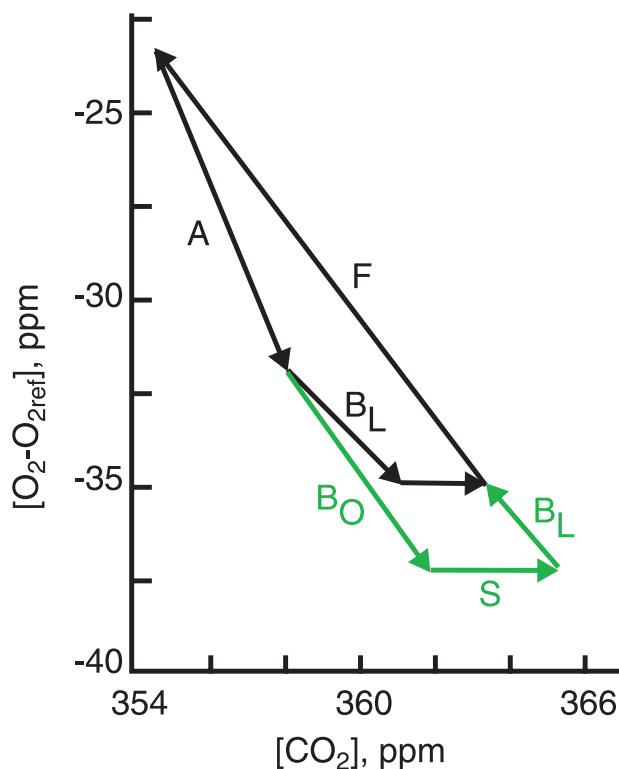


Figure 1. Possible different views on the global carbon cycle as dictated by acceptance/rejection of the limitation principle.

Vectors indicate the three-year (1991-1994) changes in carbon and oxygen content in the major global reservoirs: A — atmosphere, F — fossil fuel, BL — land biota, S — dissolved inorganic carbon of the ocean, BO — oceanic biota (dissolved organic carbon). Vector slopes are determined from the stoichiometric ratios  $a \int O_2/CO_2$  for the land biota ( $a = 1.10 \pm 0.05$ ), oceanic biota ( $a = 1.30 \pm 0.03$ , Redfield ratio) and fossil fuel ( $a = 1.38 \pm 0.04$ ), and by direct measurements for the atmosphere ( $a = 2.2 \pm 0.2$ , Keeling et al. 1996).

Black vectors: Global carbon cycle as predicted by the limitation principle (from Keeling et al. 1996): the oceanic biota vector BO is missing, the land biota BL becomes a large net sink of carbon.

Green vectors: Global carbon cycle if one accounts for possible reaction of the oceanic biota (from Gorshkov and Makarieva, 1998): the oceanic biota ensures a considerable sink of carbon, the land biota represents a net source of carbon to the atmosphere in accordance with direct measurements of carbon flows from cultivated lands. (The inorganic carbon sink S was determined from  $^{13}C/^{12}C$  data under the assumption that the rate of inorganic carbon uptake by the ocean grows proportionally to the relative increment of atmospheric  $CO_2$ .)

the critical carbon sink in terms of the contemporary greenhouse problem, see Figure 1.

As already noted, the validity of these two principles in accounting for biological systems has been tested on examples of organisms artificially extracted from their natural ecological niches. Moreover, they were tested using time periods not exceeding the average human life-span. For example, the limiting principle predicts a short-term increase in productivity of a fertilised plant, but says nothing about the processes of soil erosion and the general instability of cultivated biological systems where such fertilisation is widely used. These negative effects take a longer time to become apparent and are caused by complex interactions among various organisms rather than by processes in the fertilised plant

itself. Similarly, global change processes are impacted by ecological communities rather than by individual organisms and until very recently have been

“Given the extent to which the “adaptation” and “limitation” principles influence global change science, issues associated with whether or not they are scientifically valid is of more than academic interest.”

characterised by a longer time scale (e.g. the anthropogenic perturbation of the atmospheric composition is more than hundred years old). Nevertheless, following recognition in the scientific community of the need to incorporate biology into global change studies, we suggest that

the two principles noted above have been uncritically adopted without any detailed analysis of their applicability to describing the long-term behaviour of natural ecological communities.

In the meantime, the independent development of both empirical and theoretical global change research has outlined the possibility of a different approach to the problem of biota-environment interactions, where the natural biota is largely responsible for formation and maintenance of a life-compatible environment on the planet.

Functioning of natural ecological communities compensates all external environmental disturbances, stabilising the environment in a certain optimum state. (Information needed for such regulation should be then coded in the genomes of biological species that form the ecological community.) It fol-

lows that anthropogenic transformation of natural genetic programs of species in the course of artificial selection, as well as direct anthropogenic disturbance of natural ecological communities, disable the proposed mechanism of biotic regulation.

It is easy to see that if the biotic regulation of the environment is in action, the “adaptation” and “limitation” principles cannot be valid for describing the natural biota.

First, if the biota forms and maintains its environment, there cannot be any nutrients that would limit its functioning. The very notion of limitation becomes meaningless. Second, species cannot adapt genetically to environmental changes, because if the biotic regulation of the environment exists, their reaction to environmental change should be compensatory (not adaptive). In other words, the species do not change themselves, but return the environment to its (pre-perturbation) initial state.

If species changed genetically and became adapted to a new environment, there would be no need for them to return the environment to its previous state. Similarly, if there existed nutrients limiting functioning of the biota, this would mean that biotic regulation of the environment is impossible. This is because the “limitation” principle implies an absence of biotic reaction to changes in non-limiting nutrients (as per the above example with the oceanic biota).

On the other hand, within the biotic regulation approach it is possible to offer a different interpretation of evidence that is commonly interpreted to sup-

port the “adaptation” and “limitation” principles. When an additional amount of a certain nutrient is introduced into an ecosystem, it leads to increased productivity of the corresponding ecological community, which is considered as an experimental proof of the limitation principle. However, an alternative explanation is possible, namely, that the increased productivity represents the biota’s stabilising response to the disturbance of the optimum nutrient concentration. By increasing

“The scientific community must foster the fearless re-examination of cherished modes of thinking should prove inadequate in meeting the environmental challenges we currently face.”

its productivity, the biota is able to return the nutrient concentration in the environment to the optimum in the shortest possible time, storing the excessive nutrient amounts in the form of additionally synthesised inactive compounds. Which of the two explanations is true can be discerned by a long-term continuation of the experiment. If it is indeed limitation of primary productivity by the respective nutrient, then the community will keep the increased productivity for a long time, given that the corresponding nutrient is continuously supplied. No environmental degradation is to be expected. If, on the contrary, it is a stabilising reaction of the community, then, if the perturbation is artificially supported for a long time despite the community’s efforts, the stabilising potential of the community may be exhausted and the commu-

nity may degrade together with its environment. An analogy of such a long-term experiment can be found in agriculture. Primary productivity in modern agricultural systems is currently sustained by continuous increase in supply of fertilisers and is accompanied by continuous degradation of environmental conditions, e.g. soil erosion, which is in agreement with the second explanation of the observed phenomena.

Empirical evidence interpreted in favour of the “adaptation” principle can be summarised as follows: changes in environmental conditions bring about changes in the genetic and morphological properties of individuals. However, appearance of new genetic variants in an altered environment may be a consequence of erosion (i.e. decay) of the normal genetic program of the species rather than acquisition of some new properties. Under natural environmental conditions such erosion is prevented by natural selection, which effectively “monitors” a great variety of morphological properties in individuals. In artificial or significantly distorted environments only a few basic morphological properties of individuals are “monitored”, namely those directly related to viability and artificially selected qualities. Thus, genetic defects may accumulate up to the lethal threshold. Such a process will be manifested as changes in the genetic composition of the population but will have nothing to do with a stable state of adaptation to a new environment. In accordance with this view, the majority of artificially selected plants and animals are characterised by lower fitness (e.g.

lower resistance to infections) than their wild-type progenitors.

Given the extent to which the "adaptation" and "limitation" principles influence global change science, issues associated with whether or not they are scientifically valid is of more than academic interest. As noted above, the extension of the limitation principle to the whole oceanic biota became the sole ground for the exclusion of the latter from the global carbon budget. If one accepts that the oceanic biotic response may be more diverse and complicated than predicted by the limitation principle, it is possible to obtain quite a different picture of the modern global carbon cycle, see Figure 1. For example, the stabilising reaction of the oceanic biota to the anthropogenic disturbance of the atmospheric composition may take the form of changed proportions in production of long-lived and short-lived biomatter, the overall productivity remaining unchanged. If more long-lived biomatter is produced, one may expect to find a significant organic carbon sink in the ocean. Its magnitude can be deduced from the available data on atmospheric  $O_2/N_2$  ratio change and the known stoichiometric C/O

ratios in the biotas of land and ocean as well as in the fossil fuel. As one can see from Fig. 1, such a consideration makes it possible to account for the modern global carbon budget without assuming the existence of a substantial carbon sink on land. Such a sink can hardly be assigned to the terrestrial biota. The latter is significantly transformed by humans, while it is well-known that the exploited lands add carbon to the atmosphere, mostly due to deforestation and soil erosion.

During the course of human history the biological sciences have been predominantly applied to solving the tasks of feeding humans and their medical treatment, while their application to global environmental problems is a more recent phenomenon. We think that the issues raised here are sufficient to suggest that the various scientific paradigms and theories upon which the multidisciplinary endeavour of global change science is based need to be critically evaluated and tested – even if for no other reason than they are being applied in a novel context. The scientific community must foster the fearless re-examination of cherished modes of

thinking should they prove inadequate in meeting the environmental challenges we currently face.

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More discussion at:  
[www.biotic-regulation.pl.ru](http://www.biotic-regulation.pl.ru)

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# Water, carbon and nutrient cycles on the Australian continent

by M. Raupach, D. Barrett, P. Briggs and M. Kirby

The terrestrial cycles of energy, carbon, water and nutrients are fundamentally connected with climate processes, the global carbon cycle and ecosystem function. Through these connections, the management of ecosystems to provide food, fibre and timber has impacts at both global and local scales. Local changes are often manifested as shortages (where excess harvesting of a resource in one place or time creates a deficit elsewhere) or as leakages (where water or nutrients leak into a region where they cause harm, as in dryland salinity due to rising water tables or the contamination of surface or underground water by nutrients). For these reasons, resource managers are becoming increasingly concerned about ecosystem function as determined by the terrestrial cycles of carbon, water and nutrients, and increasingly interested in the behaviour of these cycles at both small and large scales.

In Australia, a major program (the National Land and Water

Resources Audit) has focussed for the last four years on deter-

mining the current state and trend of the land and water resources on the Australian continent. Within that program, one activity (the subject of this article) has been to characterise the coupled cycles of water, C, and key nutrients (N and P) on Australian landscapes. The aims were (1) to determine the spatial patterns of the major stores and fluxes in the cycles of water, C, N and P; (2) identify key climate processes controlling these spatial patterns; and (3) assess the ways that the water, C, N and P cycles have changed in response to large-scale changes in land use, especially the introduction of cropping and grazing (both dryland and irrigated) since the settlement of Australia by Europeans from 1788 onwards.

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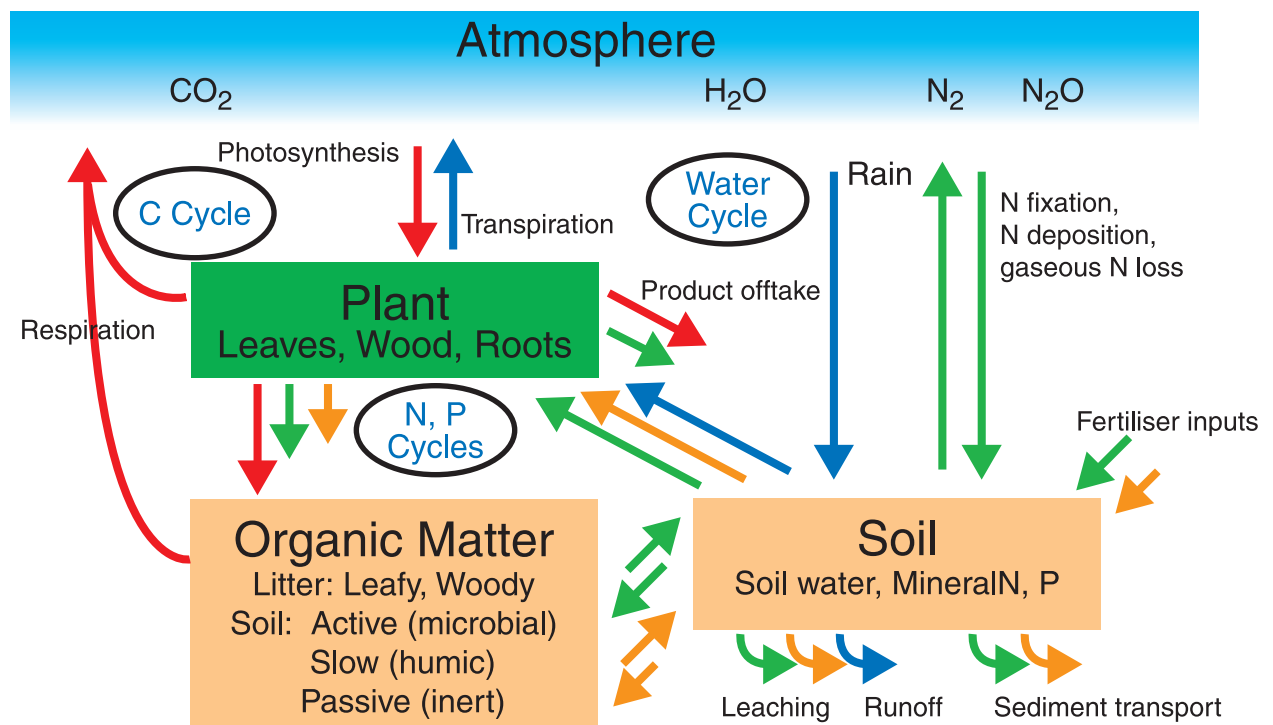


Figure 1. Major pools and fluxes in the linked terrestrial cycles of water, C, N and P through the atmosphere, plants and soil. NPP is the sum of photosynthesis and plant (not litter and soil) respiration.

Water flow  
 C flow  
 N flow  
 P flow

# Effects of Climate Change and Nitrogen Deposition on Soil Organic Matter Decomposition

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## Introduction

Since the industrial revolution, atmospheric CO<sub>2</sub> concentrations have increased from 270 ppmv to 360 ppmv today and could reach 970 ppmv through the 21<sup>st</sup> century. This increase in carbon dioxide concentrations, a powerful greenhouse gas, is mainly due to human activities. This greenhouse effect increases the mean annual temperature and could be accompanied by a modification of precipitation.

In terrestrial ecosystems, soil is the major stock of carbon compared to vegetation. Soil organic matter is an important component of the global carbon cycle. Moreover, it is a nutrient reservoir regulating the growth of ecosystems. In the response of the forested ecosystems to climate change, it is also important to consider nitrogen deposition mainly caused by human activities. Especially NH<sub>4</sub><sup>+</sup>-N deposition may enhance nitrification in soils and lead to soil acidification, cations leaching and Al<sup>3+</sup> mobilisation.

## Material and Method

Organic and hemiorganic horizons of an acid brown soil planted with *Picea abies* were sampled from the experimental site "La Robinette" in the Hergogenwald (East Belgium). Soil columns with and without *Picea abies* seedlings (two years old) were incubated in chambers under defined experimental conditions (see below). They were watered weekly and leachates were sampled and analysed every two weeks.



## Experimental design

Factors are studied according to a complete factorial design at 2x3x3 levels with three replicates for soil columns with and without *Picea abies* seedlings (108 columns).

CO <sub>2</sub> , T° ppmv/°C	Rainfall mm/yr	NH <sub>4</sub> <sup>+</sup> -N kg/ha.yr	CO <sub>2</sub> , T° ppmv/°C	Rainfall mm/yr	NH <sub>4</sub> <sup>+</sup> -N kg/ha.yr
800/15	1062	50	400/12	1062	50
	792	25		792	25
	522	0		522	0
800/15	1062	50	400/12	1062	50
	792	25		792	25
	522	0		522	0

## Results

After five months of incubation regression analysis (equation 1) showed a significant effect of rainfall (RAIN) and interaction between [CO<sub>2</sub>] combined with temperature (COT) and N deposition (N) on NO<sub>3</sub><sup>-</sup>-N concentrations in the solution of soil columns, as shown in graphs (Figure 1 and 2).

$$NO_3^-N = 59.648044 + 0.015 \cdot COT - 0.183665 \cdot RAIN + 0.000176 \cdot N + 0.000158 \cdot COT \cdot RAIN \quad (1)$$

The regression model explained NO<sub>3</sub><sup>-</sup>-N concentrations at 49%. In solution of soil columns with *Picea abies*, there is no clear evidence of statistical effects of treatments.

Both in soil solution of columns with and without *Picea abies*, NO<sub>3</sub><sup>-</sup>-N concentrations are correlated with the sum of K and Mg (r<sup>2</sup>=0.54 and 0.71 respectively) and sum of Al and Ca (r<sup>2</sup>=0.88 and 0.79 respectively) which put in light that NO<sub>3</sub><sup>-</sup>-N is a cation carrier (Figure 3 and 4).

Fig 1 NO<sub>3</sub><sup>-</sup>-N in soil solution of soil columns

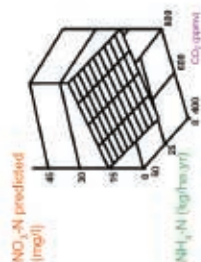


Fig 2 NO<sub>3</sub><sup>-</sup>-N in soil solution of soil columns

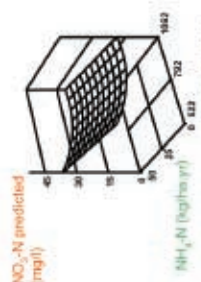


Fig 3 NO<sub>3</sub><sup>-</sup>-N vs Al + Ca in solution of soil columns

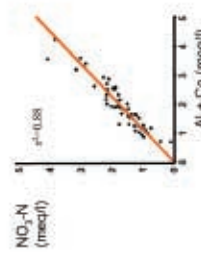
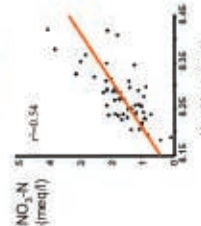


Fig 4 NO<sub>3</sub><sup>-</sup>-N vs K + Mg in solution of soil columns



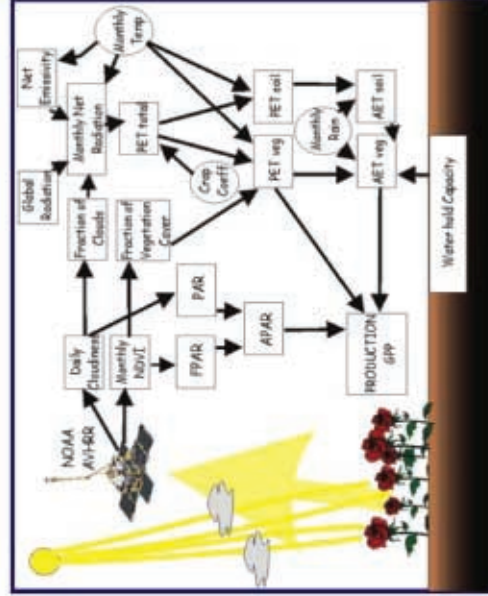
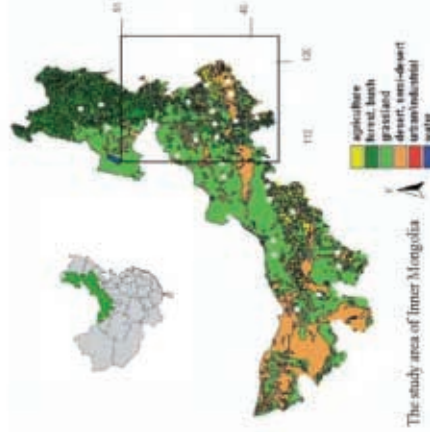
## Conclusions

These preliminary results demonstrate significant effects of CO<sub>2</sub> concentration combined with temperature, N deposition and rainfall on the quality of soil solution after only five months of treatment. Higher NO<sub>3</sub><sup>-</sup>-N leaching appeared to lead to leaching of cations with potential consequences for pollution of groundwater. These results must be confirmed by continuing the observations in the next months.



# A Satellite driven parametric Model of Primary Production implemented over the Inner Mongolian Rangeland, Northern China

Micael Runnström, Sara Brogaard & Jonathan Seaquist



Decreasing productivity and vegetation cover is considered a serious environmental threat to China's arid regions. The post 1979-economic reforms are believed to have aggravated the situation due to growing livestock numbers and reclamation of land in marginal grasslands. Severe sandstorms in northern China in the spring of 2000 and the winter of 2001 have increased the awareness for the need to monitor productivity development in the arid to sub-humid steppe regions in the northern part of China.

This work aims to estimate regional, end-of-growing season Gross Primary Production (GPP) for the 1982-1999 period for the rangelands of Inner Mongolia based on NOAA/AVHRR data and climate data.

## METHODOLOGY

The model uses a basic parametric approach grounded on simple plant physiological principles. The method includes computing the growing season sum of canopy Absorbed Photosynthetically Active Radiation (APAR) from the Normalized Difference Vegetation Index (NDVI) and an estimate of incoming Photosynthetically Active Radiation (PAR). Soil moisture is assumed to limit plant growth and is computed with a model that treats separately bare soil evaporation and plant transpiration (Richie, 1972; Wight and Hanks, 1981).

Monteith (1972) noted the strong correlation between dry matter yield of vegetation and APAR. A conversion factor necessary to transform APAR into dry matter yield (growth efficiency) is assumed to be reduced from its potential value in semi-arid environments by water stress, defined here as the ratio of actual to potential transpiration, expressing the water actually used by plants (Hanks and Wight, 1981):

$$GPP_{\text{veg}} = \sum_{i=1}^n \left( \frac{T_a}{T_p} \right) \cdot PAR_i \cdot \text{COP}$$

$$GPP_{\text{veg}} = \text{potential growth efficiency (gm}^{-1}\text{M}^{-2}\text{)} \cdot T_a = \text{actual transpiration (mm)}$$

$$NDVI = \frac{PAR_{\text{veg}} - PAR_{\text{soil}}}{PAR_{\text{veg}} + PAR_{\text{soil}}}$$

$$PAR = \text{Photosynthetically Active Radiation (MJm}^{-2}\text{)}$$

The satellite-based method is best suited to quantify GPP rather than NPP (by virtue of the Functional Convergence hypothesis: Goetz and Prince, 1999).

Data input: Monthly NDVI (data (PAL NOAA 8 km data))

Monthly climatic data: temperature and precipitation for 3° stations of Inner Mongolia

Soil Moisture Capacity Map, SMA, computed from top soil texture and soil depth from the FAO soil map of the world

PAR was calculated by a model (Seaquist and Olsson 1999) that generates spatially comprehensive PAR values at a monthly time scale. Equations describing the spatial and temporal variations of global radiation receipt at the top of the atmosphere are calculated and multiplied by calculated site-specific Angstrom coefficients based on 108° ground measurement from two stations. The fraction of sunshine hours per day are based on daily NOAA CLAVR values grouped into overcast, mixed and clear days. Aggregation from daily to monthly values then gives a decent estimate of incoming PAR. The PAR Global Radiation ratio is taken as 0.48.

## HYDROLOGY COMPONENT

The underlying assumption for computing the gross production of dry matter yield is (Wight and Hanks, 1981, Srivastava et al., 1997):

$$\frac{GPP_{\text{veg}}}{GPP_{\text{veg}}} = \frac{T_a}{T_p}$$

$$GPP_{\text{veg}} = \text{gross primary production (gm}^{-1}\text{M}^{-2}\text{)}$$

$$GPP_{\text{veg}} = \text{potential gross primary production (gm}^{-1}\text{M}^{-2}\text{)}$$

$$T_a = \text{actual transpiration (mm)}$$

$$T_p = \text{potential transpiration (mm)}$$

$$T_p = \text{time step (day)}$$

$$SM = \text{soil moisture (mm)}$$

$$R_{\text{veg}} = \text{rainfall (mm)}$$

$$AE = \text{actual evaporation (mm) from the soil evaporation model}$$

$$Runoff = \text{water lost from the cell over the surface (mm)}$$

$$Drainage = \text{water lost from the cell by drainage (mm)}$$

$$T_a = SM - AE - Runoff - Drainage$$

Bare soil evaporation and transpiration are treated separately, the partitioning facilitated by converting the NDVI into fractional vegetation cover (Carlson and Ripley, 1997; Choudhury and DaGudano, 1998). The model of Ritchie (1972) is used to compute actual evaporation from the bare soil component, after disaggregating monthly rainfall into daily rainfall. This model assumes evaporation from a two-stage process, where the first stage is limited by soil hydraulic properties as a function of time. Finally, transpiration is computed with a running bucket model where the result may be used to formulate a water stress factor pertaining to vegetation only:

$$T_a = SM - AE - Runoff - Drainage$$

$$T_a = \text{actual transpiration (mm)}$$

$$T_p = \text{potential transpiration (mm)}$$

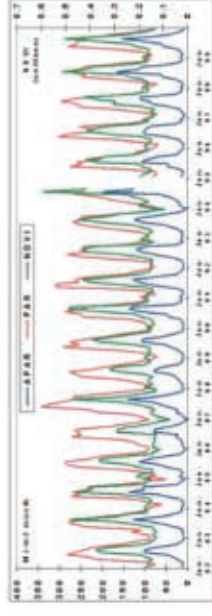
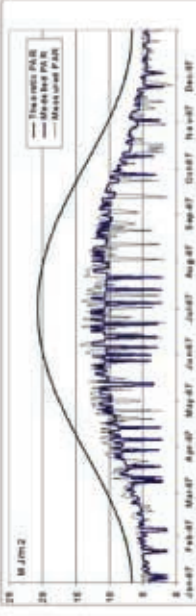
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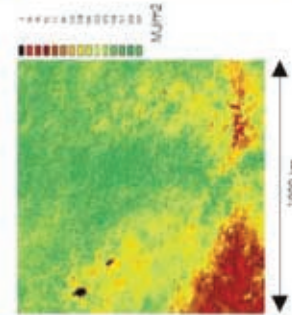


## RESULTS

The top graph shows theoretical PAR received at the top of the atmosphere as well as modelled and measured daily PAR at the land surface.

The next graph illustrates monthly dynamics of NDVI and modelled PAR and APAR between 1982-1999.

The image to the left shows an example of distributed monthly aggregated APAR in MJ/m², here for August 1999.



## CONCLUSION AND FURTHER WORK

The result presented here is a 'step' towards achieving a good estimate of primary production over large areas based on existing climate and remotely sensed data for regions where limited ground measurements are available. The merits of the approach are as follows:

NDVI is not always a reliable indicator of primary production due to the decoupling between photosynthesis and APAR. Complementing the NDVI with other information yield more realistic assessments of primary production.

NDVI is a quantitative index but can only be used to assess relative vegetation amounts. This method can quantify vegetation in absolute terms.

The method considers transpiration (the water actually used by plants) in isolation from bare soil evaporation, as transpiration is directly related to plant growth.

The environmental situation of the grass steppes of northern China is in a critical situation where operational and reliable methods for production monitoring are essential.



# Late Quaternary vegetation and climate change in the Panama Basin: palynological evidence from marine cores ODP 677B and TR 163-38

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## Introduction

When studying global climate changes in the tropics, the Panama Basin is a strategic area. This is due to its unique oceanographic and climatic features, especially those related to salinity and moisture transference through the Panama Isthmus, the ENSO phenomenon, and the equatorial current system dominated by the Peru Current. The great number of continental studies in the vicinity, makes the Panama Basin even more attractive to establish ocean-continent correlations and to contribute to an accurate reconstruction of tropical paleoclimates. The interdisciplinary project Quaternary paleoceanography in the Panama Basin, Colombian Pacific: Implications in the Global Climate Change (Martínez, 1999), intends to reconstruct the main oceanographic variables with emphasis on the Last Glacial Maximum. The project also includes palynological analyses from two marine cores that provide: (1) a general reconstruction of vegetation changes, and (2) marine data for ocean-continent correlations.

## Methods and Study site

Sites ODP 677B (83°44'2200" W, 1°12'1440" N, 3473 m water depth) and TR 163-38 (81°583' W, -1°337' N, 2200 m water depth) are located in the Panama Basin. Samples were taken every 10 cm for the uppermost 185 cm in core ODP677B, and 103 cm for core TR163-38, that represent ~37,900 yr BP, and ~17,330 yr BP, respectively.

Chronostratigraphic control is provided by oxygen isotopes on planktonic foraminifera and AMS14C analyses. A pollen sum of 200 grains was reached and only in case of very low pollen densities <200 grains were counted. Spores and marine microfossils were also counted but not included in the pollen sum.

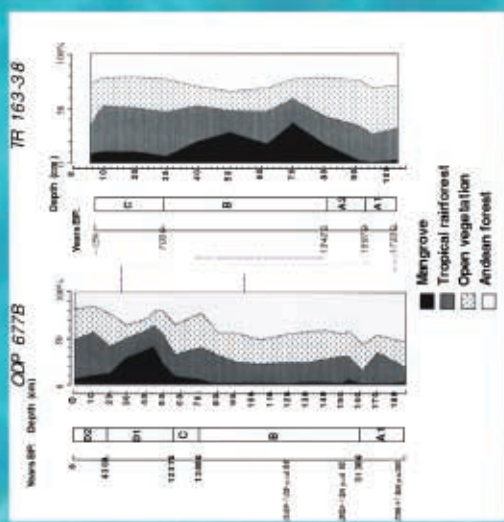


Mangrove: *Rhizophora*

Lowland tropical forest: *Alseodendron*, *Anacardium*, *Avicennia*, *Bignoniaceae*, *Bombacaceae*, *Bursera*, *Cecropia*, *Celtis*, *Euphorbiaceae*, *Leguminosae*, *Meliaceae*, *Moraceae*, *Myricaceae*, *Myrsineae*, *Piper*, *Salicaceae*, *Sapotaceae*

Open vegetation: *Poaceae*, *Cyperaceae*, *Compositae*, *Amaranthaceae*-*Chenopodiaceae*, *Alternanthera*

Andean forest: *Alnus*, *Caryophyllaceae*, *Cedrela*, *Myrica*, *Podocarpaceae*, *Quercus*, *Rapanea*, *Symplocos*, *Wikstroemia*, *Valonia*, *Cyathaceae*



## Conclusions

Pollen records from marine cores ODP 677B and TR 163-38 reconstruct vegetation changes during the last 37,900 years based on established ecological groups. We assume that fluvial input is the main mechanism of transport of pollen grains from the continent to the ocean.

Based on transport assumptions, results can be interpreted as a reconstruction of vegetation and climate changes occurred on the western slope of Colombian and Ecuadorian Andes during the last glacial/interglacial cycle.

Four periods were identified (see Table) and correspond chronologically to Middle Pleistocene, Late Pleistocene, Tardiglacial and Holocene.

Andean forest existed during the whole period with maximum extension between 31,300 and 13,800 yr BP. Mangroves reached their maximum during early Holocene (11,500-7,000 yr BP). Open vegetation increases during middle and late Holocene (7,000 yr BP - Present).

We confirm that pollen analysis in marine sediments is a useful tool in the reconstruction of regional changes.

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## An approach to exploring the dynamics between

# Globalization and Climate Change Policy

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## Overview

Our study seeks to discern the influence of globalization on selected national climate change policies. We hypothesize that globalization—the world's emerging socioeconomic paradigm—can significantly impact policy in ways that are not readily apparent. Through a thorough analysis of literature and interviews, we map the social, political, economic, natural and ideological terrain in which selected policies must function (Phase 1). Next we match that map with our own definition of globalization developed from interviews and a separate analysis of literature (Phase II). The results should allow us to assess the likelihood of a policy to succeed and provide informed suggestions for improvement.

## Research Tools

### Content Analysis

We have begun compiling articles, science reports and books relevant to the study. They are sorted into categories for analysis. Some examples follow:



### Contextual Mapping

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

*While much consideration has been given separately to climate change and globalization, relatively little attention has been focused on the interaction between these two phenomena. This study outlines an approach to examining the impact of globalization on selected countries' efforts to comply with carbon standards outlined in the Kyoto Protocol. The resulting insights could be used to help anticipate responses to certain international protocols and devise more effective climate change mitigation strategies, in addition to providing a means to distinguish between IPCC future scenarios.*

## Methods

## PHASE I

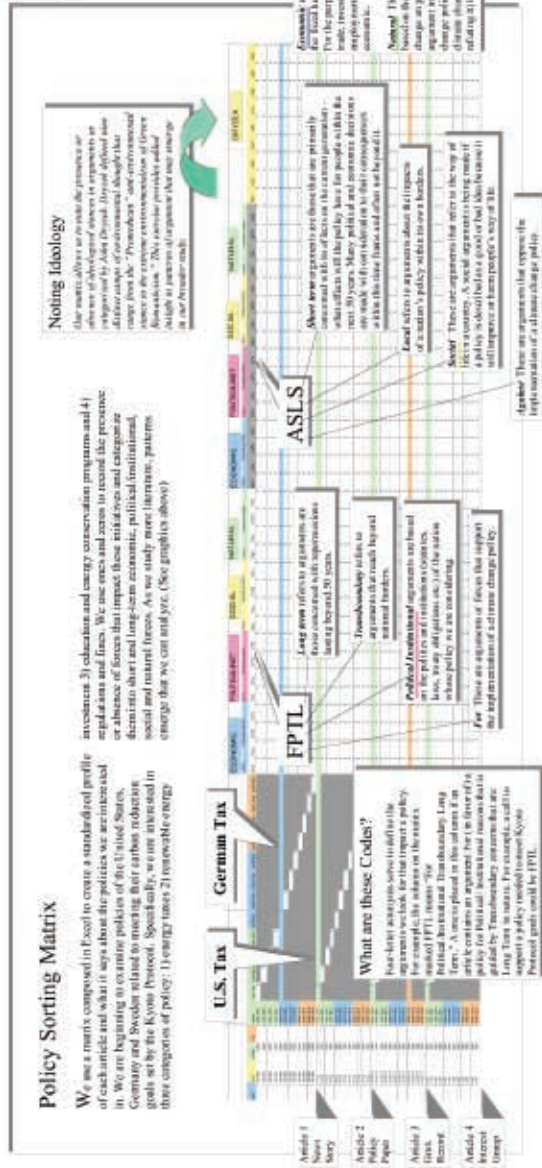
Collect literature and conduct interviews with scientists, policy analysts and policy makers about national climate change policies intended to reduce carbon emissions.

- Energy taxes
- Renewable energy investment
- Education and conservation programs
- Pollution regulations and fines

Identify forces – from individuals to governments, social norms to natural limits – that buffet these policies and sort them into four general areas:

### Policy Sorting Matrix

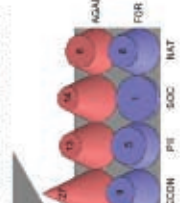
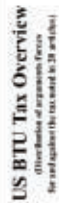
We use a matrix composed in Excel to create a standardized profile of each article and what it says about the policies we are interested in. We are beginning to examine policies of the United States, Germany and Sweden related to meeting their carbon reduction goals set by the Kyoto Protocol. Specifically, we are interested in three categories of policy: 1) energy taxes 2) renewable energy



## Demonstration of Methods

Assessment of selected articles on US BTU Tax

These charts are derived from a study of 20 articles about the ill-fated US BTU flux, using our matrix. Each number represents a certain type of argument.



Forces and arguments FOR the BTU tax were based mostly on short-term domestic economic and environmental concerns. Proponents cited the tax's use to reduce the national deficit and improve air quality. They also noted the benefits of using it to help meet international climate goals.

Determine whether these forces are driven by domestic or international concerns and whether they are based on short or long-term agendas. They could be affected by all of the above.

## PHASE II

Develop a working definition of Globalization based on a separate analysis of the literature on globalization, ecological economics and global systems theory.

We will return to the data on each policy and determine to what degree they reflect our definition of globalization. We seek to answer the question: "How and where does globalization affect this climate change policy?" From there, we can make some educated judgements about the policy's efficacy and its future prospects.

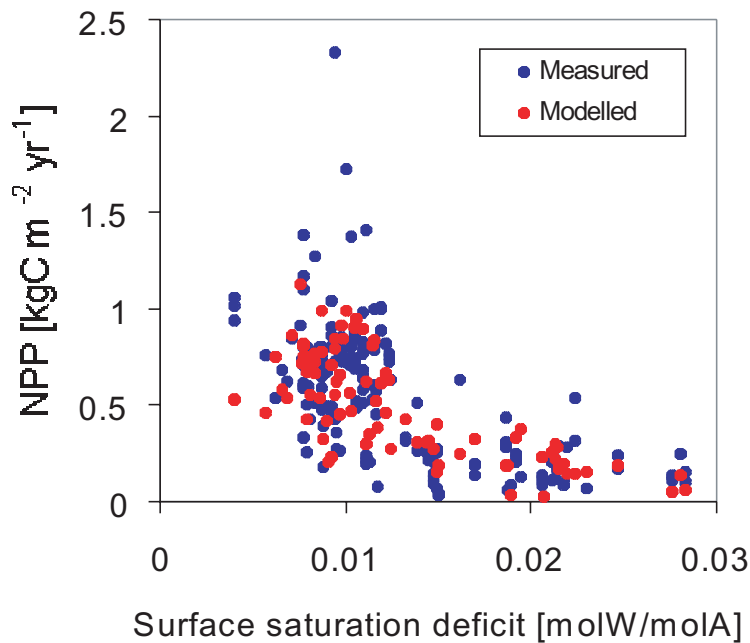


Figure 2. Comparison of NPP measured at 183 sites across Australia (Barrett 2001) with modelled NPP at the same sites, showing the strong response of both measured and modelled NPP to the saturation deficit of the air near the surface.

## Approach

A model of the coupled cycles of water, C, N and P is required; this was developed using three guiding principles. The first was a rigorous formulation [1] of the model as a dynamical system involving two kinds of unknowns: stores (X) of water, C, N and P within a set of defined control volumes, and the fluxes (F) of material entering or leaving these control volumes. These are linked by two kinds of equation: conservation equations of the general form  $dX/dt = \text{sum}(F)$ , which specify the time rates of change of the stores, and phenomenological equations of the general form  $F = \text{function}(X, M, P)$ , where M are the external

forcing variables specifying weather, climate and land use, and P are the process parameters in the model. The phenomenological equations contain the process information in the

“...environmental costs (such as nutrient leakages) increase sharply with increasing nutrient inputs. The implication is that a reduction in nutrient inputs will have more benefit through lower leakage than cost through decreased net production.”

model and are scale-dependent. We used equations tailored to landscape scale, in which all variables (X, F, M and P) are averaged both horizontally and in time. The horizontal averaging

is to a grid resolution of 0.05 degrees or about 5 km, and the time averaging is over interannual climate variability, but with retention of a mean annual climate cycle. Hence, the averaged equations describe a steady, annually cycling climate. To derive phenomenological equations with this degree of spatial and temporal averaging it is necessary to aggregate process information available from smaller-scale process models of the form  $f = \text{function}(x, m, p)$ , where the lower-case letters denote variables averaged over smaller space and time scales. We devoted considerable attention [1] to the problem of determining the large-scale function and parameters P from statistical information about the small-scale function and parameters p. This is a formalisation of the “upscaling” or “aggregation” problem.

The second principle was to make maximum use of known constraints provided by the coupling between the water, C, N and P cycles (for example, [1, 4, 6]). As indicated by the schematic in Figure 1, this

coupling constrains the ratios between fluxes of water, C, N and P along shared pathways in the interacting cycles, and places limits on the ratios between C, N and P stores in various pools. Examples of such constraints are the link between carbon assimilation and transpiration through joint stomatal control; links between carbon and

nutrient turnover in the decomposition of litter and soil organic matter; and links between carbon, water and nutrient uptake by plants as they grow.



The final principle was to tailor the model to make maximum use of available high-quality information. We were fortunate to have available excellent gridded data sets on climate, soils, vegetation, land cover and land use, including irrigation. Of great importance was a data set [5] on the agricultural nutrient inputs of nitrogen and phosphorus, resolved regionally in space (and subsequently further disaggregated to 0.05 degree cells) and annually in time.

Using these principles, we developed a set of phenomenological equations describing all necessary water, C, N and P fluxes, at a spatial scale of kilometres and a time scale appropriate for determining steady-state balances directly (so that the condition  $dX/dt = 0$  could be used). A key example is the prediction of Net Primary Production (NPP) of biomass carbon, which was obtained with a single-parameter model which combines light-use and water-use efficiencies in a way consistent with process information. This model predicts, among other things, a significant response of NPP to saturation deficit. Figure 2 shows a comparison with nearly 200 data points derived from the ecological literature [2, 3], indicating that the model successfully captures this feature and confirming that it is indeed significant.

## Results

**NPP and carbon stores:** Figure 3 shows the steady-state NPP under present conditions (that is, with agricultural nutrient inputs and irrigation). On the Australian continent the spatial distribution of NPP broadly follows rainfall, but with addi-

tional influences from saturation deficit or air dryness (through its effect on water use efficiency) and light (only in Tasmania, because light is not a limiting resource elsewhere). The influence of saturation deficit implies that there is less NPP per unit rainfall in the north of the continent (dominated by tropical wet-dry savannah woodlands in which the average saturation deficit is large) than in the south (dominated by temperate forest and agricultural land in which average temperatures are cooler

and saturation deficits lower). This is a basic physiological constraint (Figure 2).

The C stores in biomass, litter and soil are strongly controlled by NPP (hence rainfall and saturation deficit), so these C store distributions strongly resemble the NPP distribution. However, the C stores are also modulated by temperature: for a given NPP, there is less C storage in the tropics than in temperate regions because tropical C stores decay faster than temperate stores.

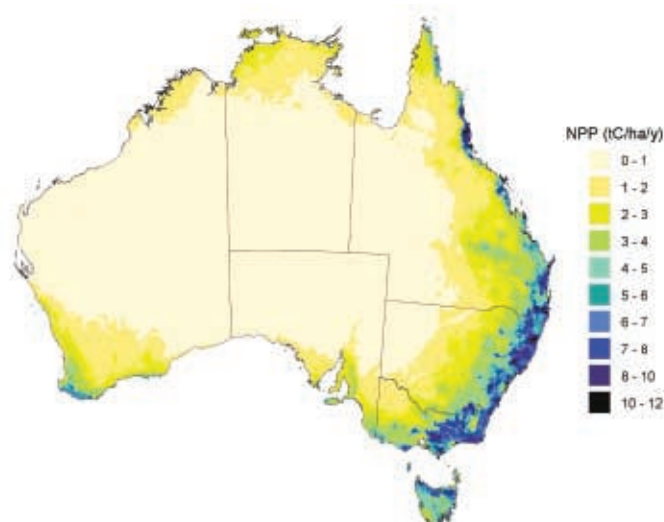


Figure 3. Mean annual Net Primary Productivity over the Australian continent, with present agricultural inputs of water and nutrients.

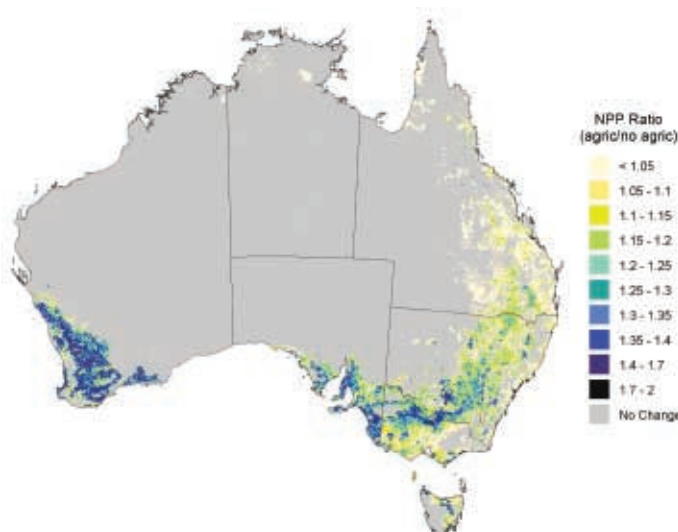


Figure 4. Ratio of mean NPP with current agricultural inputs (irrigation, N and P inputs and offtakes) to mean NPP without agricultural inputs.

### *Effects of agriculture on NPP and the landscape stores of C, N and P:*

As shown in Figure 4, agricultural inputs (including water from irrigation, N and P from fertilisation and N from sown legumes) have led to regional-scale increases (relative to pre-agricultural conditions) of up to a factor of 2 for NPP. Similar maps for other quantities show increases of up to a factor of 2 for the stores of C, organic N and organic P, and up to a factor of 5 for plant-available mineral N and P, and the N and P concentrations in soil water. These increases are concentrated in the southern agricultural regions. The influence of irrigation on NPP and the stores of nitrogen and phosphorus is locally large (especially in economic terms because of the prevalence of high-value commodities in irrigated areas) but its effect on continental aggregate stores and fluxes is relatively small because the irrigated area of the continent is small.

**N Balance:** Before the advent of European-style agriculture, the N balance was dominated by input of N from natural fixation, with a small contribution from atmospheric N deposition. The balancing losses of N occurred through a mixture of gaseous loss, leaching and disturbance (herbivory and fire). The spatial distributions of all these N fluxes were closely connected with the NPP distribution. With the advent of European-style agriculture, the N budget changed substantially: the largest term remains fixation, greatly enhanced in agricultural areas by sown legumes. Losses occur through disturbance (primarily herbivory by stock), leaching and gaseous loss. The contribution of agricultural offtakes is

negligible continentally but can be significant locally.

### *Continental-aggregate stores and fluxes of C, N and P:*

We estimate that the mean continental NPP is 0.96 GtC/year. This is about 30% of the NPP that would be observed if Australia had the average NPP of terrestrial land surfaces; an expected situation given that Australia is mostly a semi-arid continent.

Agricultural nutrient inputs have increased the continental NPP by around 5%, and the plant-available mineral N and P stores by around 13% and 8%, respectively. Hence, the increases in mineral N and P stores substantially exceed the NPP increase. This may suggest that at large scales, agricultural nutrient inputs to landscapes exceed those required to achieve optimum production levels and are approaching diminishing returns. However, environmental costs (such as nutrient leakages) increase sharply with increasing nutrient inputs. The

implication is that a reduction in nutrient inputs will have more benefit through lower leakage than cost through decreased net production.

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# Past ecosystem processes and human-environment interactions

by I. Larocque

In the new structure of PAGES, a new Focus 5 has been created with the goal of using the palaeorecord to inform about, understand and better manage ecosystems. All projects included in this Focus are concerned with interactions between human activities and natural processes, including climate variability.

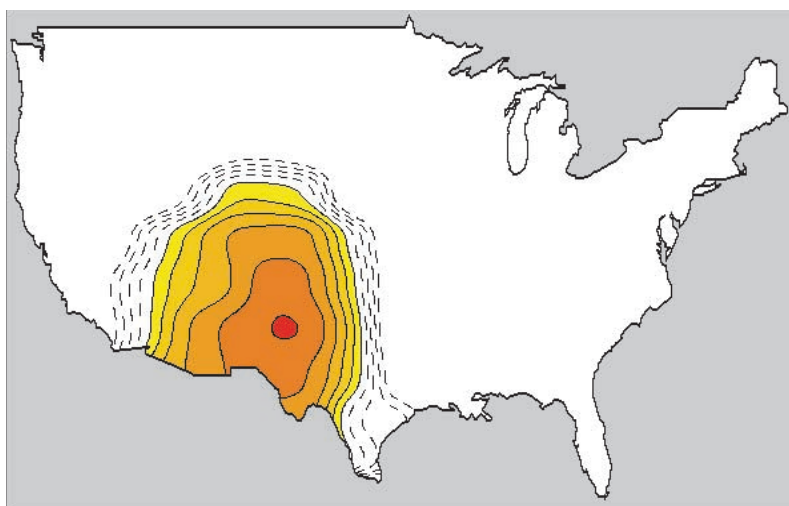
Current ecosystem management practices are based on existing instrumental data, which are not long enough to determine the natural variability of the system. Thus Focus 5 projects are based on the need to integrate long-term studies in order to better manage ecosystems. An example is the drought severity in the U.S. (Figure 1). Dendrochronology has shown evidence of past megadroughts of unusual severity and duration in the palaeoclimatic record that appear to exceed the biggest drought recorded in the 1930s [1]. Instrumental data over the U.S. are inadequate for capturing the full range of droughts, particularly the incidence of naturally occurring megadroughts. Why megadroughts occur has still to be answered – and there are questions still to be solved and systems to be modeled. What should be realized is that management of these ecosystems has been based on these “non-representative” years and a return to the previous cycle could potentially be disastrous [2].

Although long-term studies provide the natural variability needed to better assess future climate, they often lack information about contemporary processes and the human

dimension perspective necessary for predicting the effect of climate change on ecosystems used for various human activ-

ities. Linking and interacting with researchers studying contemporary processes through observation and experiment is a key goal to the development and the testing of models to better predict future changes - and is a key goal for PAGES Focus 5. There is also the need for a better understanding of how proxy records are interpreted in terms of climate and human activities, and their interaction. For example, climate reconstructions using chironomids (non-biting midges) in the Swiss Alps has shown that at one site the temperature reconstructed is

## A. Extended Southwest Drought Factor



## B. Drought Factor Scores – 1200-1994

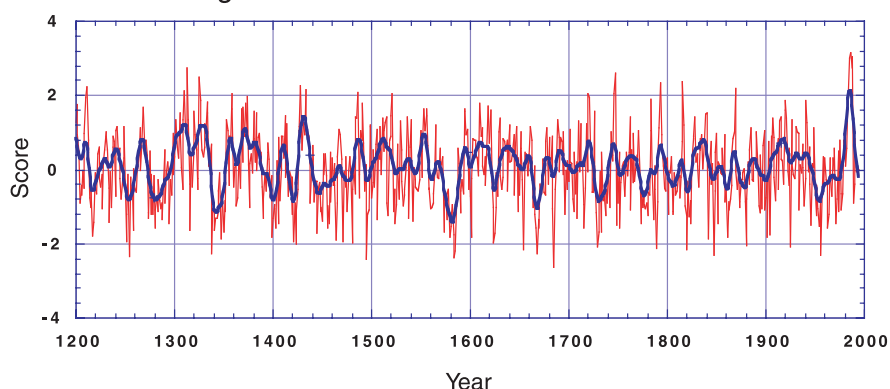


Figure 1. A. Palmer Drought Severity Index emphasizing the western US has the highest risk region.

B. Time series of drought as recorded in tree rings. Their correlation with instrumental data is 0.77. The correlation between the smoothed data (blue line) and the instrumental data is 0.86. Cook et al. 1999.



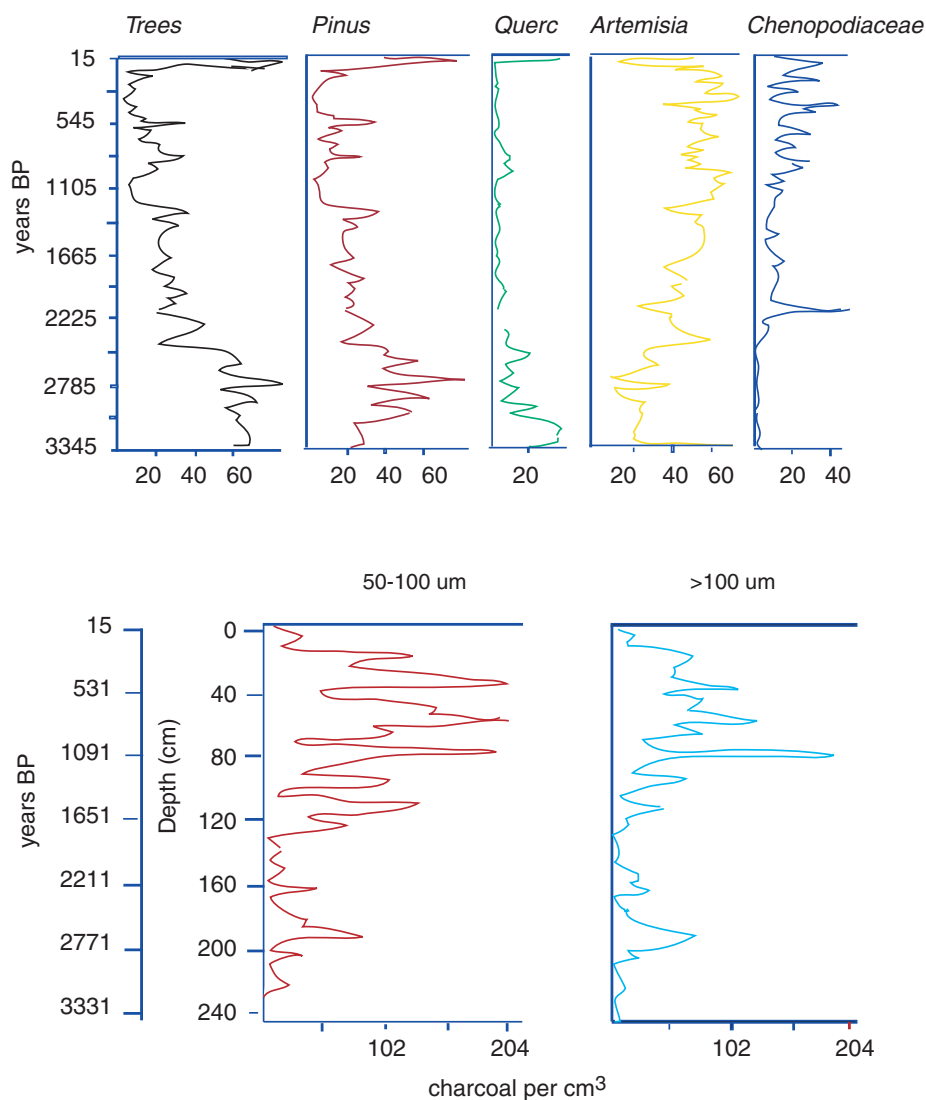


Figure 2. First panel: Pollen stratigraphy of a site in Mongolia Second panel: Charcoal stratigraphy of the same site (Ren, 1999).

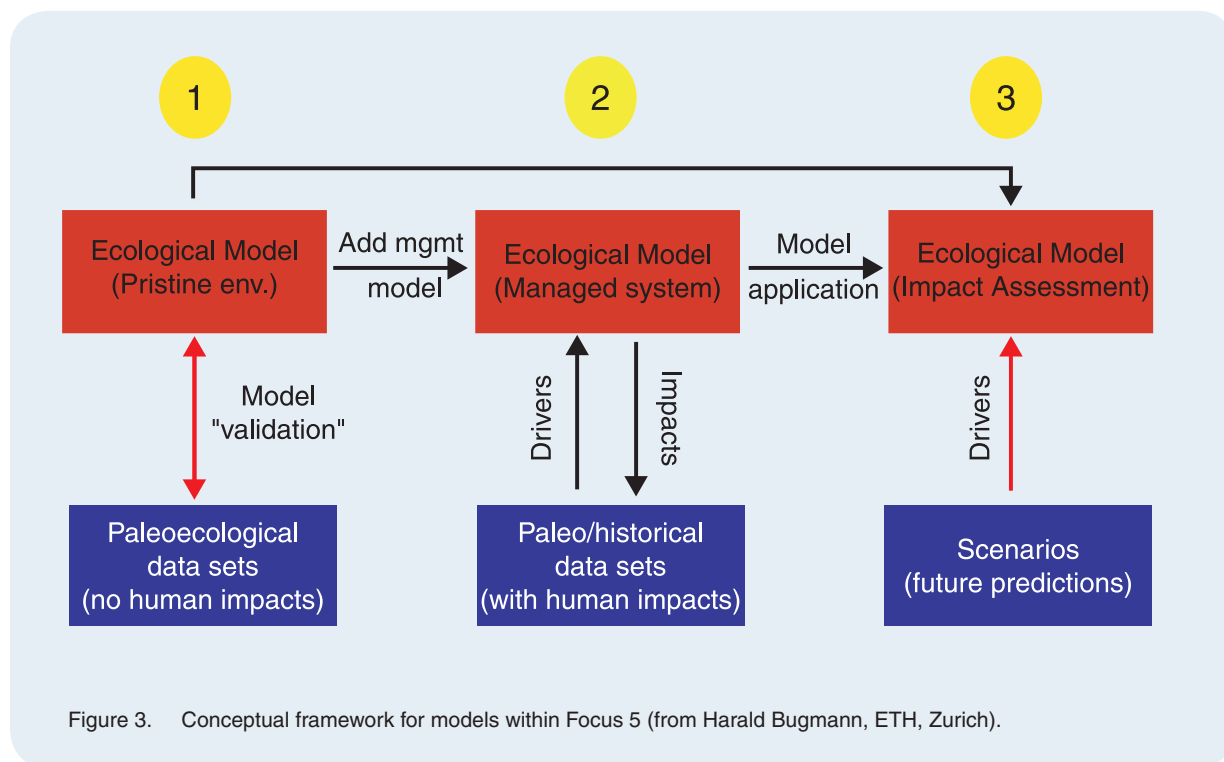
not comparable to other proxy reconstructions probably due to human impact at this site [4]. Only contemporary studies on the ecology of chironomids can bring more rigorous insights about the effect of anthropogenic factors on chironomids and their behavior. Historical ecology is also a much-needed discipline in such projects. While historians were sometimes reluctant to admit that climate changes affected human societies in the past, palaeoecologists have sometimes neglected to consider the impacts of human

behavior on vegetation and climate. Historical ecology can offer an integrated theoretical framework, drawn on diverse studies of social and environmental change [3], which are often lacking in palaeoresearch and contemporary ecology.

The projects included in Focus 5 are necessarily case-study based. Only case studies can capture both environmental change and human activities over decades, centuries, and even millennia at a scale where concepts of durability in long-sustained ecosystems, questions

of sensitivity and of thresholds and non-linear responses can be totally understood. These case studies include a major concern with ecosystems of high vulnerability caused by a combination of natural and human induced stresses. Three activities are included in Focus 5: LUCIFS (Land use and Climate Impacts on Fluvial Systems during the Period of Agriculture), LIMPACS (Human Impact on Lake Ecosystems) and HITE (Human Impacts on Terrestrial Ecosystems). The first two were established a few years ago, while HITE has been officially launched in June 2001. Although each activity has its own set of case studies, there will be “flag-ship” studies in which all three themes will be intimately involved. These shared studies sites will allow the exploration of system linkages (terrestrial, fluvial and lacustrine) as well as model integration. Capacity building is a key element in the strategy of the projects.

Existing projects in HITE include, for example, human impacts on vegetation in Mongolia (Figure 2). The association between pollen and charcoal records indicates that in the last hundred years, the vegetation has reverted to levels exceeding those of 2000 years ago when natural fire frequency was low. The recent decrease of fire might be due to two factors: climate and suppression of fires by human activities. To better understand the linkage between climate and anthropogenic factors, contemporary ecology and historical ecology will be added to this



project ultimately leading to a better understanding and management of this area. Other case-studies include the records of erosion and agro-environmental changes in India, human activity and climate change in Australia, rapid climate change and human populations in the UK, climate and land use in central Europe, human impact on terrestrial ecosystems in southern Scandinavia, the European sub-alpine terrestrial ecosystem in France and the temperate ecosystems in the United States. Additional case studies are invited to join the HITE project, especially from South America, Southeast Asia and Africa.

An important part of Focus 5 will be to develop models for a better management of ecosystems. Three steps should be included in such models (Figure 3). A first step is to use palaeoecological and palaeoclimate data for model construction and evaluation in the pre-human impact period. Next it is necessary to disentangle climatic and

land use effects, based on both historical and palaeodata. The last step is model application or impact assessment. While many studies to date have been based on step 1 and step 3, very few included step 2. A framework for modeling using all three steps has yet to be completed, but nonetheless seems to be the only valid way to link palaeodata to contemporary and historical data for an impact assessment of climate and human interactions.

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To learn more about Focus 5 and its activities or to integrate your project into the Focus, consult the PAGES website at: [www.pages-igbp.org](http://www.pages-igbp.org), and look under structure or contact the activity leaders, John Dearing for HITE ([J.Dearing@liv.ac.uk](mailto:J.Dearing@liv.ac.uk)), Robert Wasson for LUCIFS ([robert.wasson@anu.edu.au](mailto:robert.wasson@anu.edu.au)) and Rick Battarbee for LIMPACS ([rbattarb@geog.ucl.ac.uk](mailto:rbattarb@geog.ucl.ac.uk)). Inquiries can also be sent to Isabelle Larocque ([Larocque@pages.unibe.ch](mailto:Larocque@pages.unibe.ch)).

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# Extending atmospheric aerosol measurements to the global scale

by R.J. Charlson

Three disparate approaches have heretofore been employed to study atmospheric aerosols: 1) *in situ* observations of micro-physical and chemical properties; 2) long-path/column and remote sensing of their influence on propagation of radiation in the atmosphere (including satellite observations); and 3) modeling on all spatial/temporal scales, which depends on accurate and realistic knowledge from (1) and (2), or on assumptions. While these different approaches have been useful in the exploratory stages of research on atmospheric aerosols, applications of them to current scientific questions regarding climate forcing and other global-scale issues requires an integrative strategy that is defined by the scientific questions themselves. Simultaneous and coordinated use of all three approaches is required for generating a complete and integrated description of these complex systems, particularly for understanding and quantifying large-scale to global effects of aerosols. Accomplishing the needed integration requires consideration of the spatial/temporal variability of aerosols as well as the influences of and correlations with the thermodynamic state (particularly the relative humidity). Rationalization of the data from the three required approaches in the context of clearly stated scientific questions cannot be achieved without coordination. While a need still exists for exploratory observations, e.g., in order to discover new processes or properties, data from such experiments must be clearly labeled as not belonging to the integrated set.

## Background

Exploratory and monitoring observations of atmospheric aerosols over the last several decades have emphasized three features of those particulate systems: chemical composition and concentration, physical characterizations (primarily particle size distribution and number population), and cloud nucleating properties. Observations of optical depth or turbidity from the ground, along with lidar observations show that the non-cloud aerosol is a major factor governing the amount of sun-

light reaching the ground; however, most such observations are sporadic, for short periods of time and for only a few places on Earth. Taken together, these *in situ* and column observations show that there are large variations in both the extensive and intensive properties of the aerosols, and that these variations occur on many time and space scales, especially in the vertical direction. In spite of this high degree of variability, aerosols occur globally and have large-scale (regional to global) effects, ranging from climate forcing to acidification of precipitation and

modification of biogeochemical balances. Hence, there are substantial reasons for extending observations from the regional to global scale, primarily to provide quantification of such large-scale effects. The remainder of this paper focuses on the single scientific question of climate forcing; however, the approach would be the same for the other large-scale effects as well.

While these existing aerosol observations have resulted in enough information to allow preliminary model-based estimates of direct and indirect climatic forcing by both natural and anthropogenic aerosols, there are questions of whether the observations are representative; and there are large uncertainties (+/- a factor of two in concentration for the best-known case of anthropogenic sulfates in the PBL, and much worse for the upper troposphere or for anthropogenic organic aerosols or for indirect effects on clouds). Given the existing suite of *in situ* observational capabilities, it is clearly impossible to obtain enough data by those means alone to guarantee global representation. On the other hand, data from satellite-based radiometers have shown the great benefits of global geographical coverage but, so far, have been of limited use, also because of large uncertainties [2] and limitations imposed by satellite orbital characteristics. These uncertainties and limitations, along with a need for vertical resolution and much more accurate inferences of aerosol optical depth, became the basis for implementation of a lidar in the CALIPSO satellite, which will be orbited in formation with the EOS-PM (AQUA) system and CLOUDSAT beginning in 2004. Prior to that time,



numerous satellite-borne sensors capable of providing some aerosol information are already deployed (or soon will be), including other lidars [GLAS, 2002], high resolution spectrometers operating in the oxygen A-band (e.g., GOME), and polarization of upwelling reflected sunlight (e.g., POLDER). But, however extensive these observations may be and however promising these new technologies may seem, especially given the global extent of their observations, they cannot by themselves measure the actual chemical composition of the detected aerosol, nor provide information on key intensive aerosol parameters, and, most significantly, they cannot quantify the proportion of natural and anthropogenic components. Even the combination of satellite observations and models together cannot adequately remedy the inherent, unacceptably large uncertainties of the models such that *in situ* aerosol characterizations are still necessary. This requirement poses a series of questions of how to coordinate in time and space the *in situ* observations and how to formulate model results so that in combination with satellite observations it is possible to seek closure; that is, ask to what degree the entire set of remote and *in situ* data and model outputs (moputs) are internally consistent. To put these thoughts in a different way, the different modes of observation—satellite instruments and *in situ* devices—do not and cannot observe exactly the same aerosol properties, and models are only models such that it is necessary to develop means to connect them and test whether they agree with each other.

## Basis for integrating data from satellite-borne lidar, radiometers, models and *in situ* observations

First, it is necessary to recognize that no single mode of observations or modeling can provide a complete or adequate integrated output, viz:

- Satellite (usually polar) orbital characteristics bring the remote sensors over a given site only rarely and for sun-synchronous systems only at one time of day. Hence, models and *in situ* continuous observations are needed for temporal interpolation.
- Satellite radiometers can image large geographical areas (in the x-y horizontal dimensions only) and can cover the whole Earth daily, but cannot view the whole Earth continuously, on time scales on which aerosols and clouds vary (hours to fractions of a day).
- Satellite lidar yields vertical (z) information along the orbital ground track (x), but requires extrapolation in the cross-track direction and interpolation between repeats of visits to a given site.
- *In situ* observations at fixed sites give no information on the x, y or z axes. Ground-based lidar yields information on the z axis (not x or y), but both can be run for unlimited periods of time to provide connections between orbital visits, hence allowing interpolation during times when the satellite-borne lidar and radiometers are not present.
- *In situ* observations with aircraft can yield some information on x, y and z, but only for very short time periods. Large numbers of short flights can, in principle, yield data over lengthy periods of time but would require dedicated use of such facilities.
- Models of atmospheric aerosols can yield outputs

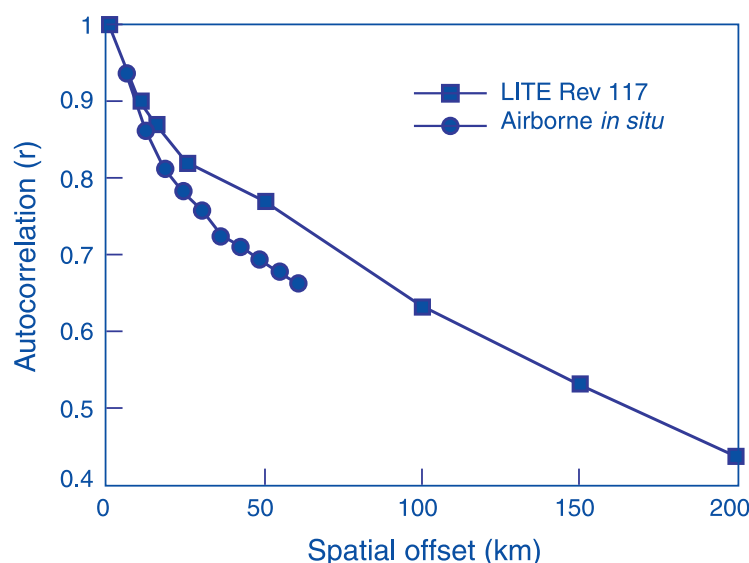


Figure 1. Autocorrelation coefficient versus log distance (km) down the orbital or flight ground track.

with short (few hour) time resolution over all three dimensions (x, y, z) over any time frame. However, the uncertainties in the models (parametric, structural and mechanistic) require continuous validation via *in situ* and remote measurements. Models also may not adequately describe such factors as sub-grid-scale correlations between aerosol parameters and the thermodynamic state of the air (esp. RH; see Charlson et al. [1]) and hence again require *in situ* measurements for confirmation.

Second, it is essential to coordinate *in situ* and satellite observations so that the resultant multivariate data sets strictly and demonstrably apply to the same exact air parcel, and so that the integrated data set includes all of the independent variables that control the column-integral properties. This includes both the relevant extensive properties (EP)—such as scattering and absorption coefficients, lidar backscatter, and species mass concentrations—and intensive properties (IP) (see Table 1) and their dependence on the thermodynamic state (TS), particularly RH. Numerous factors are involved in achieving such coordination:

- Horizontal variability of all extensive variables
- Vertical variability and stratification in the atmosphere of the extensive parameters
- Variations in time and space of the thermodynamic factors influencing column properties
- Correlations among the above.

Implementation of such coordinated observations regarding direct climate forcing thus requires some degree of knowledge of the nature of spatial and temporal variability of both the extensive and intensive aerosol parameters, and the relevant thermodynamic state variables.

### Defining the role of thermodynamic state as an dependent variable that influences column properties

Thermodynamic state (TS) is defined here as the aggregate of temperature- and vapor-pressure related quantities that influence phase changes, particle size, and refractive index in the multiphase aerosol system. The optical properties of any column or path within the atmosphere are determined by both the amounts (EP) and properties (IP) of the aerosol-particle substances and TS, and both are functions of length along the path, such that measurement of one variable alone (whether at a point or over the path) clearly cannot describe the whole path.

Relatively large amounts of water are expected to be in the particles under typical atmospheric conditions. Eighty percent RH is the average of the Earth's PBL, and at eighty percent RH, soluble particles are approximately eighty mole percent water.

### Consideration of the influences of the spatial and temporal characteristics of aerosols on sampling and measurement protocols

Two related approaches are available for observing the spatial-temporal variability of

aerosol EP, IP and TS: 1) Measurements over a spatial dimension, for example with a mobile sampling platform such as an aircraft or non-geo-stationary satellite; and 2) Measurements over time. The two are related in that the spatial dimension of the former is replaced by the time dimension of the latter along with a mean velocity. The first satellite-borne lidar data that were acquired in LITE reveal the existence of synoptic (1000 km) horizontal scale aerosol masses, with substantial variability down to 10 to 100 km scales. Lengthy time series reveal the same sort of variability, with large aerosol masses passing by on the time scale of a day and variability on time scales of an hour to a few hours. Figure 1 is an autocorrelation plot of LITE data, showing that at distances of greater than 100 km or times greater than three to four hours, the autocorrelation coefficient drops below about 0.8. This means that any attempt to obtain correlative *in situ* data for satellite observations is expected to result in less than a 0.8 correlation coefficient if the samples are acquired, or the observations made, outside the ~100 km or the three to four hour space/time window, respectively.

### Consideration of the effects of aerosol characteristics and thermodynamic state on the sampling protocols

Not all particle size classes are important to the scattering and absorption of solar radiation, with sub-micrometer particles having much larger influence per unit mass of aerosol substance. Also, it is generally observed that sub-micrometer particles have a systematically

different composition than super-micrometer ones, and sub-micrometer particles often have a significant anthropogenic component (e.g., sulfates). Sub-micrometer (so-called accumulation mode) particles are formed from the gas phase via either low or high temperature nucleation processes (gas-to-particle conversion), while coarse, super-micrometer ones are primarily from mechanical production (e.g., wind-blown dust or sea salt). Hence if it is desired to separate out and identify the optically important particles and to estimate the fraction that is anthropogenic, it is necessary to separately analyse the sub-micrometer fraction. This can be achieved by intertial separation prior to sampling, e.g., with a cyclone separator

operating at 10 and 1 mm. However, this separation cannot yield consistent samples if the RH is sufficiently high because as shown above, the particles grow at RH well below 100%. Hence, it is necessary to control the RH by slight (a few degrees) heating prior to imposing the size cut. This RH control (e.g., at RH<40%) also achieves measurement of the needed EP values (mass concentrations,  $mi$ ) at a reference low RH at which the thermodynamic state has little influence. But, it also requires that  $f(RH)$  also be measured so that the EP values at higher RH (e.g., aloft) can be accurately calculated. The actual choice of 40% RH and 1 and 10 mm is what is practiced by the U.S. aerosol monitoring performed by NOAA-CMDL. And,

once again, it is necessary to make these observations in one-and-the-same airparcel seen by the satellite instruments if meaningful correlations are to be obtained.

## Considerations of the applications of the data to scientific questions in the design of observational protocols and modeling

As is evident from Sections 2 to 5 above, every aspect of the measurement strategy is in one way or another dictated by the scientific question at hand. The key variables to be measured (Table 1) are all parameters that are needed for either modeling climate forcing or for

**Table 1. Aerosol measurements for direct forcing of climate.**

### Extensive Properties

$\sigma_{sp}(\lambda)(m^{-1})$ :	Scattering component of extinction, scattering coefficient
$\sigma_{bsp}(\lambda)(m^{-1})$ :	Hemispheric backscatter coefficient
$\sigma_{ap}(\lambda)(m^{-1})$ :	Absorption coefficient *
$m$ :	Mass concentration
$m_i$ :	Species mass concentration (chemical composition as $f(r)$ )
$\beta_{180}(m^{-1}\sigma p^{-1})$ :	Lidar backscatter coefficient

### Intensive Properties

$\ddot{a}$ :	$d \log \sigma_{sp} / d \log \lambda$	Wavelength dependence (Ångström exponent)
$f(RH)$ :	$\sigma_{sp}(RH) / \sigma_{sp}(low\ RH)$	Humidity dependence
$B$ :	$\sigma_{bsp} / \sigma_{sp}$	Backscatter ratio
$\omega$ :	$\sigma_{sp} / (\sigma_{sp} + \sigma_{ap})$	Single scatter albedo *
$\alpha_m$ :	$\partial \sigma_{sp} / \partial m (m^2 g^{-1})$	Mass scattering efficiency
$\alpha_i$ :	$\partial \sigma_{sp} / \partial m_i (mg)$	Species scattering efficiency
$S(sr)$ :	$(\sigma_{sp} + \sigma_{ap}) / \beta_{180}$	Lidar ratio
	_____	Ratios of chemical components

\* Most uncertain property



inputs into the retrieval of data from satellite-borne instruments. Other scientific questions would require a different set of variables. Most importantly, it is seldom possible to utilize data acquired for one problem (e.g., health effects) for another scientific question (e.g., relationship to satellite data for climate forcing estimates). It is necessary to keep all of the constraints on measurement in mind when developing the overall observational and modeling strategy.

### Conclusions: Suggestions for strategies of coordination

The final point of this brief tutorial is that this integrative strategy would appear to require overt coordination. "Business as usual", with individual scientists measuring one or a few parameters as they always have done cannot provide a coherent dataset for correlation with sat-

ellite data. Intensive campaigns likely will be replaced by longer term measurement programs, and models will be developed that attempt to optimize the use of the data. Given that the data are imperfect (and always will be), appropriate uncertainty analyses must be carried throughout the entire integrative activity. Just how to organize and coordinate this effort is not clear; but, what is clear is that it cannot work without coordination.

There also is a clear need for close collaboration of modelers with both the satellite and *in situ* measurers. Indeed, it will

be necessary to develop new sorts of models that actually calculate (or use) the data from satellite instruments or *in situ* observations. Data assimilation techniques appear to hold considerable promise.

**R.J. Charlson**

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E-mail: charlson@chem.washington.edu

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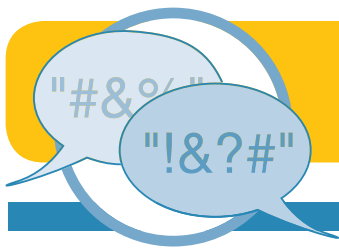
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# Discussion Forum

The first decade of IGBP research has inspired us to think about the ethics for global stewardship and the type of science we need to develop in order to better understand the Earth System [1]. In an increasingly interwoven world a major question is not *if* globalisation exists but *which* globalisation should we address in order to better harmonize human and biophysical systems.

## Building capacity for science and human progress at global scales

The Open Science Conference (Amsterdam 10-13 July 2001) set the stage for a new and challenging decade. Valuable participants' feedback in the last NewsLetter highlighted the "uniqueness of the event" in bringing such a "large representation from developing countries" and "suggested solutions to environmental issues from and within developing countries". Others stressed, more critically, that the "causes of poor participation in global research by developing countries are well known (...) and the meeting should have provided tangible/proactive action plans with specific targets". Comments like "a lot still to be done", "need to stimulate information exchange" and "western solutions might not always meet the requirements" resonate.

The immediate effort paid off in the short-term: out of a total of 1400 participants from 105 countries we attracted 681 initial registrations from developing countries, of which 320 were actually able to attend. Beyond what we had anticipated, the sponsoring programmes were able to directly support 133 participants on the basis of their poster abstracts (see table for numbers and country representation). We are grateful to other international NGOs, foundations, intergovernmental and national global change agencies for their support. Some of those institutions also provided direct funding for a handful of their own grantees to attend the Conference.

But Amsterdam also provided us with an additional challenge: to demonstrate that we both care

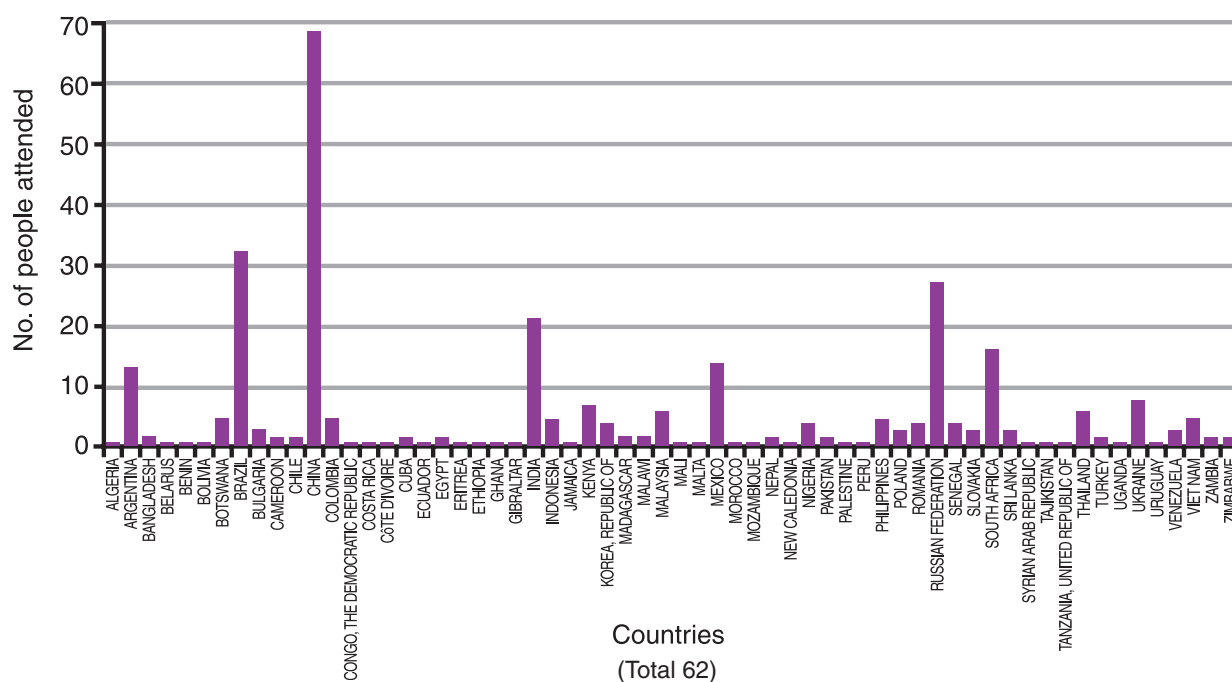
about existing research networks and must do better in support of a new and larger generation of Earth System scientists. Both to maintain and expand human capacity and scientific knowledge from local to global scales. Value adding and networking, hand-in-hand. In an increasingly integrated world only win-win and sustainable efforts make for long-lasting solutions.

### Scientific networking, education and outreach

The Global Change Programmes are presently discussing how best to address integrated regional studies as a central part of their activities, possibly out of regional co-ordination centres. Initiatives like these should potentially enhance synergism between subject-specific programme elements (i.e. core research projects) and regional projects selected for their relevance as "hot-spots" of global relevance. We anticipate that, in addition to the developing agenda for the coming decade, emerging scientific and ethical concerns will focus on issues dealing with vulnerability of nature-society systems. This should be done in parallel with the need to seek novel ways to integrate assessment with monitoring, fundamental with applied question formulation, scientific knowledge and outreach.

Truly international scientific partnership should inspire joint teams operating across geopolitical

## Number of scientists from developing countries who attended the OSC.



divides, helping to bring down the unsustainable scientific boundaries separating knowledge centers and peripheries. Only in this way may the “digital and scientific divides” and “brain-drain” syndromes be tackled. Most of the developing world lacks the means to support existing scientific infrastructure, let alone deal with the accelerating scope and rate of change and their cascading effects on life support systems and community quality of life itself. How can we best help change the course of action?

In parallel with direct funding from existing programme elements (a few ones- like PAGES- award seed funding to developing world workshop participants, others - like START- actively promote capacity building) novel ways should be explored. New agenda-setting efforts can only be truly owned if done across developed and developing nations and regions. New projects implemented in developing countries should include specific action to optimise and expand local human and material scientific infrastructure. Without much additional funding effort (c.1% of total new project budgets?) much can be done in providing support to colleagues whom otherwise cannot attend international workshops and therefore have an active role in drafting the new scientific agendas. And without involvement there is no commitment.

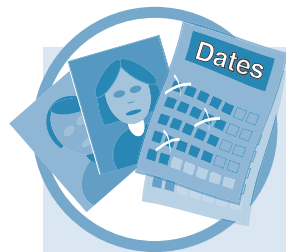
Communication and synergism with existing global change national committees (IGBP has ca.

78 of them) has been rather weak. Action goes both ways: while we should assist in the assessment of scientific information at the international level, it is also necessary for national communities to help their governments realise the potential role that Earth System science can play in providing an essential input to developmental policies. Such collaboration should namely help with curricula formulation as well as with the provision of viable options and meaning to colleagues in pursuing an academic research career in national universities and research institutes.

IGBP is also trying to improve on developing communication tools to help larger audiences to understand critical knowledge such as how the earth functions and how we can achieve global sustainability. Such tools range from a revamped website, the NewsLetter, the “IGBP Science Series” and even internet portals, film documentaries and voyages of discovery. Watch this space for developments and please keep exploring every window of opportunity and provide us with all constructive feedback!

**João Morais**  
IGBP Secretariat,  
Stockholm, Sweden  
E-mail: morais@igbp.kva.se





## People and events

### The Inaugural Chair for SOLAS



The Scientific Committee of the IGBP welcomes back Peter Liss, who has recently been appointed Chair of the Scientific Steering Committee for the new IGBP Project SOLAS (Surface Ocean - Lower Atmosphere Study). Peter has made significant contribu-

tions to IGBP over the years, serving as Treasurer and then Chair of the Scientific Committee as well as on the IGAC SSC. He was instrumental in strengthening IGBP in response to international review, and helping to develop the international recognition which has led to a successful synthesis. Peter has a truly global, multi-disciplinary vision and helped integrate IHDP into the ICSU family.

Having studied at Durham University and University of Wales, Peter was a postdoctoral fellow at Southampton University before being appointed to the

faculty of the newly established School of Environmental Sciences at the University of East Anglia in 1969. For the past 3 decades he has led a research group there, specialising in various aspects of biogeochemical interaction between the oceans and the atmosphere.

Both nationally and internationally, he has served on a wide variety of working/planning/evaluation groups, sponsored by many national and international organisations.

The full membership of the SOLAS SSC is as follows. Their first meeting was held in San Francisco in December 2001.

Peter Liss (United Kingdom), Philip Boyd (New Zealand), Elsa Cortijo (France), Ken Denman (Canada), Barry Huebert (USA), Tim Jickells (United Kingdom), Truls Johannessen (Norway), Gebrand Komen (Netherlands), M. Dileep Kumar (India), Patricia Matrai (USA), William Miller (Canada), Ulrich Platt (Germany), Katherine Richardson-Christensen (Denmark), Peter Schlosser (USA), Mitsuo Uematsu (Japan), Ilana Wainer (Brazil), Doug Wallace (Germany).

### ICSU gets a new Executive Director



In January 2002, Thomas Rosswall will take up the post of Executive Director of ICSU (International Council for Science) based in Paris. The current Director, Larry Kohler, will move back to Geneva where he will be working for the International Labour Organisation.

Thomas Rosswall is currently Director of the International Foundation for Science, a not-for profit organisation established to support developing country scientists working in developing countries on aspects of natural resource management and conservation.

Professor Rosswall was Rector (President) of the Swedish University of Agricultural Sciences 1994-2000. In 1987, he became the first Executive Director of IGBP and was also the first Director

of START. He has also served as Secretary-General of the Scientific Committee on Problems of the Environment (SCOPE) of ICSU. He is Professor in Water and Environmental Sciences, a position that he has held at three Swedish universities.

His research has focused on microbial ecology, soil nutrient dynamics and land and water management in both temperate and tropical regions. He has published some 150 papers in refereed journals and edited 12 scientific volumes. He has also been on the editorial board of many scientific journals and is a member of four learned societies including Academia Europaea and the Royal Swedish Academy of Sciences.

Kohler has a strong connection with the global change research community. From 1997 to 1999, he was the Executive Director of the International Human Dimensions Programme on Global Environmental Change (IHDP). A political scientist by training, he played a decisive role in the rapid development of the current IHDP research agenda in the late 1990s and also in building closer links to IGBP and WCRP, the first stages in the development of the Earth System Science Partnership.

## New face at the IGBP Secretariat



Dr Clare Bradshaw is a marine ecologist who has just joined the IGBP Secretariat in Stockholm. In May 2001 she moved to Sweden from Britain where she worked at the University of Liverpool's Port Erin Marine Laboratory, researching the impacts of fishing on seabed fauna. She has also

worked on several coral reef projects, having most recently been involved with monitoring coral bleach-

ing mortality in the Indian Ocean with colleagues from the Universities of Cambridge and Warwick. Her PhD (at Edinburgh University) looked at how burrowing and bioeroding crustaceans affect reef preservation. Having initially worked at the IGBP Secretariat with the Science Communication Team before and during the Open Science Conference in July, her new position will be split between coordinating a new educational expedition and film project and helping with the editing of the forthcoming IGBP synthesis book.

In March 2002, Clare will replace Susannah Elliott who goes on maternity leave until the beginning of 2003.

## A changing of the guard for IGAC



Dr Peter Czepiel is the new IGAC Executive Officer, effective 5 November 2001. Peter is an expert in the production and consumption of radiatively active trace gases. He is primarily interested in the biogeochemical cycling of carbon and nitrogen in both natural and

anthropogenic systems. While a doctoral candidate at the University of New Hampshire, he devised new techniques to assess the magnitude, variability, and environmental influences on the sources and sinks of methane, carbon dioxide, and nitrous oxide in liquid and solid waste processing systems as well as disturbed and undisturbed soils. Peter has been working at the University of New Hampshire with two long-time contributors to IGAC research, Michael Keller and Patrick Crill, investigating carbon and nitrogen trace gas exchange in tropical forests as a participant in the Large Scale Biosphere-Atmosphere Exchange in the Amazon (LBA) project.

The IGBP Secretariat would like to take this opportunity to thank outgoing Executive Officer, Dr Alex Pzenny, and Office Manager, Edmund Carlevale for their tireless efforts with IGAC and their many contributions to IGBP over the years.

Alex has been the Executive Officer of IGAC for most of the project's existence, joining in 1992 during Ron Prinn's Chairmanship and continuing until a month or two ago. During that time he has supported the project in very many ways with quiet but exceptional competence, playing a central role in the development of IGAC into a strong and effective IGBP core project. The IGAC Newsletter, always put together carefully under Alex's guidance, is well known for its solid scientific content, even to the point that publication in it is sometimes considered by journals as prior publication! The IGAC Integration and Synthesis is another project in which Alex's quiet but effective leadership has helped to build a product of very high scientific quality.

The IGAC Core Project Office itself has moved to the University of New Hampshire. New contact information is:

Dr Peter Czepiel, Executive Officer IGAC Core Project Office Institute for the Study of Earth, Oceans, and Space (EOS) University of New Hampshire, 39 College Road Durham, NH 03824-3575 USA

Tel: (+1-603)862-4520; Fax: (+1-603)862-3875;  
Email: [igac@unh.edu](mailto:igac@unh.edu); [www.igac.unh.edu](http://www.igac.unh.edu)

# IGBP and Related Meetings

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

## Planning Meeting on Future of Ocean Research within IGBP/SCOR

**2-5 December, Barcelona, Spain**

Contact: Peter Burkill, [p.burkill@pml.ac.uk](mailto:p.burkill@pml.ac.uk)

## RICAMARE: Global Change and Water Resources in the Mediterranean Region

**2-8 December, Toledo, Spain**

Contact: J.M. Moreno, [jmmoreno@vic-to.uclm.es](mailto:jmmoreno@vic-to.uclm.es) or [ricamare.info@amb-to.uclm.es](mailto:ricamare.info@amb-to.uclm.es) or <http://www.uclm.es/cursos/ricamare>

## Global Conference on Oceans and Coasts at Rio +10

**3-7 December, UNESCO, Paris, France**

Contact: Dr. Biliانا Cic-in.Sain, [bcs@ude1.edu](mailto:bcs@ude1.edu)

## International Conference on Freshwater

**3-7 December, Bonn, Germany**

Contact: [info@water-2001.de](mailto:info@water-2001.de) or <http://www.water-2001.de>

## In conjunction: Dialogue on Water and Climate

Contact: Holger Hoff, [hhoff@pik-potsdam.de](mailto:hhoff@pik-potsdam.de)

## GLOBEC: PNEC-GLOBEC Meeting

**5-7 December, Paris, France**

Contact: François Carlotti, [carlotti@biocean.u-bordeaux.fr](mailto:carlotti@biocean.u-bordeaux.fr)

## A History of Atmospheric CO<sub>2</sub> and its Effects on Plants, Animals, and Ecosystems

**6-8 December, Snowbird, Utah, USA**

Contact: <http://c3c4.utah.edu>

## 2001 Berlin Conference on the Human Dimensions of Global Environmental Change

**7-8 December, Berlin, Germany**

Contact: <http://www.environmental-policy.de>

## Regional Climate Model Intercomparison Project for Asia Workshop

**10-13 December, Kobe, Japan**

Contact: Congbin Fu, [fcu@ast590.tea.ac.cn](mailto:fcu@ast590.tea.ac.cn)

## Royal Society Meeting on Climate Change

**12-13 December, London, UK**

Contact: Marisa Goulden or Rachel Quinn, [climate@royalsoc.ac.uk](mailto:climate@royalsoc.ac.uk)

## LUCC: International Symposium on LUCC Contribution to Asian Environmental Problems

**13-14 December, Tokyo, Japan**

Contact: LUCC-J@skl.iis.u-tokyo.ac.jp, or <http://shiba.iis.u-tokyo.ac.jp/LUCC/symp/> or <http://shiba.iis.u-tokyo.ac.jp/LUCC/symp/>

## SOLAS: 1st Meeting of the SOLAS SSC

**14-17 December, San Francisco, USA**

Contact: Peter Liss, [p.liss@uea.ac.uk](mailto:p.liss@uea.ac.uk)

## American Geophysical Union (AGU) Fall Meeting

**15-19 December, San Francisco, USA**

Contact: AGU Meetings Department, [meetinginfo@agu.org](mailto:meetinginfo@agu.org) or [http://www.agu.org/meetings/fm00\\_spss.html#Hydrology](http://www.agu.org/meetings/fm00_spss.html#Hydrology)

2002

## LUCC: Linking Household and Remotely Sensed Data: Methodological and Practical Problems

**3-8 January, Honolulu, Hawaii**

Contact: Jefferson Fox, [FoxJ@EastWestCenter.org](mailto:FoxJ@EastWestCenter.org) or Vinod Mishra, [mishra@hawaii.edu](mailto:mishra@hawaii.edu) or Ronald R. Rindfuss [ron\\_rindfuss@unc.edu](mailto:ron_rindfuss@unc.edu) or Stephen J. Walsh [wash@geog.unc.edu](mailto:wash@geog.unc.edu)

## IAS/SEPM Environmental Sedimentology Workshop: Continental Shelves - Processes, Record, Utilization and Management

**7-10 January, The University of Hong Kong, Hong Kong**

Contact: Wyss Yim, [wysyim@hkucc.hku.hk](mailto:wysyim@hkucc.hku.hk)

## 3rd Workshop on Land Use/Management Change and Trace Gas Emission in East Asia

**8-10 January, IRRI, Los Baños, Philippines**

Contact: Arvin Mosier, [amosier@lamar.colostate.edu](mailto:amosier@lamar.colostate.edu)

## GECAFS: Global Environmental Change and Food Systems: Rice-Shrimp Systems Project Development Workshop

**11-13 January, Chiang Mai, Thailand**

Contact: Louis Lebel, [llebel@loxinfo.co.th](mailto:llebel@loxinfo.co.th)

## JGOFS, LOICZ: Continental Margin Task Team Workshop on Subpolar Regions

**23-25 January, Southampton, UK**

Contact: Jonathan Sharples, [j.sharples@soc.soton.ac.uk](mailto:j.sharples@soc.soton.ac.uk)

## IGBP: New IGBP Atmosphere Project: Planning Workshop

**27-30 January, Stockholm, Sweden**

Contact: Tim Bates, [bates@saga.pml.noaa.gov](mailto:bates@saga.pml.noaa.gov)

## JGOFS: Data Management Task Team Meeting

**29-30 January, Washington, DC, USA**

Contact: Margarita Konkright, [mkonkright@nodc.noaa.gov](mailto:mkonkright@nodc.noaa.gov)

## AIACC Project Initial Meeting

**TBA January, Nairobi, Kenya**

Contact: Neil Leary, [nleary@agu.org](mailto:nleary@agu.org)

## IGBP, IHDP, WCRP: Workshop "Sustainable Development-The Role of International Science"

**4-6 February, ICSU, Paris, France**

Contact: Sylvia Karlsson, [karlsson.ihdp@uni-bonn.de](mailto:karlsson.ihdp@uni-bonn.de)



**VAMOS/CLIVAR Conference on  
South American low-level jet**

**5-7 February, Santa Cruz de la Sierra, Bolivia**

Contact: Carolina Vera, carolina@at.fcen.uba.ar or Michael Douglas, michael.douglas@nssl.noaa.gov or <http://www.clivar.org/vamos/index.htm>

**Coccolithophores: From Molecular Processes to  
Global Impact**

**10-15 February, Ascona, Switzerland**

Contact: Dr. Patrick Sean Quinn, patrick.quinn@erdw.ethz.ch or <http://www.coccoco.ethz.ch/>

**Special Session at AGU/ASLO Ocean Sciences**

**11-15 February, Honolulu, Hawaii, USA**

Contact: Ann Holbourn, ah@gpi.uni-kiel.de or Roger Francois, rfrancois@whoi.edu or <http://www.images-pages.org>

**IGBP: 17th SC-IGBP Meeting and IPO Executive  
Directors Meeting**

**19-23 February, Bangalore, India**

Contact: Clemencia Widlund, clemencia@igbp.kva.se

**GAIM: Trans Com III**

**25-28 February, Fort Collins, USA**

Contact: Kevin Gurney, keving@atmos.colostate.edu

**Synthesis Workshop on Institutional Response to  
Global Change**

**TBA, February, Chiang Mai, Thailand**

Contact: Louis Lebel, llebel@loxinfo.co.th

**GCTE: Rice-Wheat Workshop Planning Meeting**

**TBA, February, Delhi, India**

Contact: John Ingram, jsii@ceh.ac.uk

**PAGES: 2nd Swedish National PAGES Meeting**

**14-17 March, Sigtuna, Sweden**

Contact: Gunhild (Ninis) Rosqvist, ninis@natgeo.su.se or <http://www.geo.su.se/naturegeo.klimat>

**GCTE: 12th GCTE SSC Meeting**

**18-20 March, Sydney, Australia**

Contact: Rowena Foster, Rowena.Foster@csiro.au

**Stage 5 deposits in Europe in the context of global  
climate evolution**

**18-22 March, Lepizig, Germany**

Contact: Saskia Rudert, rudert@mail.uni-mainz.de or <http://www.uni-mainz.de/FB/Geo/Geologie/sedi/index.html>

**WCRP: WCRP Joint Scientific Committee Meeting**

**18-23 March, Hobart, Australia**

Contact: WCRP Secretariat, dwcrp@gateway.wmo.ch

**Special Session, 98th Annual Meeting of the Asso-  
ciation of American Geographers (AAG)**

**19-23 March, Los Angeles, USA**

Contact: <http://www.aag.org/> (Annual Meeting Link)

**IGAC: IGAC Scientific Steering Committee Meeting**

**21-23 March, Johannesburg, South Africa**

Contact: IGAC IPO, igac.cpo@unh.edu

**IHDP: IHDP-Scientific Committee Meeting**

**25-27 March, Bonn, Germany**

Contact: IHDP Secretariat, ihdp@uni-bonn.de

**GCTE: Trophic Interactions in a Changing World**

**3-7 April, 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

**LUCC: LUCC Scientific Steering Committee Meeting**

**11-13 April, Louvain-la-Neuve, Belgium**

Contact: LUCC IPO, lucc.ipo@geog.ucl.ac.be

**European Geophysical Society XXVII General  
Assembly**

**21-26 April, Nice, France**

Contact: JGOFs IPO, jgofs@uib.no or <http://www.copernicus.org/EGS/egsga/nice02/nice02.htm>

**GCTE: From Transient to Steady State Response of  
Ecosystems to CO<sub>2</sub>-Enrichment and Global Warm-  
ing**

**28 April-1 May, Durham, New Hampshire, USA**

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

**Workshop on Building Adaptive Capacity to Envi-  
ronmental Change in Southeast Asia**

**TBA, April, Chiang Mai, Thailand**

Contact: Louis Lebel, llebel@loxinfo.co.th

**GCTE: GCTE Focus 1 Workshop: Biological Controls  
on the Stable Isotope Composition of Atmospheric  
Carbon dioxide, Methane & Nitrous Oxide: Pro-  
cesses and Applications**

**12-14 May, Banff, Canada**

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

**PAGES: PAGES Scientific Steering Committee  
Meeting**

**14-15 May, Moscow, Russia**

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

**GCTE: GEGC-II/GCTE Soil Erosion Network co-  
sponsored Meeting**

**22-25 May, Chengdu, China**

Contact: Yong Li, yongli32@hotmail

**GCTE: GCTE-SEN co-sponsored Meeting. Soil Ero-  
sion and Land Use Change**

**26-31 May, Chengdu, China**

Contact: <http://www.wssc.org.cn/isco2002/index.htm>

**LOICZ: LOICZ Synthesis Futures Meeting**

**29 May-1 June, Miami, Florida, US**

Contact: LOICZ IPO, loicz@nioz.nl

**JGOFS: Joint Meeting of the Global Synthesis Working Group and JGOFS/GAIM Task Team on 3D Ocean Carbon Modelling and Analysis**

**TBA, May or June, Ispra, Italy**

Contact: Reiner Schlitzer, rschlitzer@awi-bremerhaven.de or Patrick Monfray, monfray@cea.fr

**IHDP, START: 3rd IHDP and START bi-annual Workshop on Human Dimensions of Urbanisation and the Transition to Sustainability**

**3-14 June, Bonn, Germany**

Contact: Maarit Thiem, thiem.ihdp@uni-bonn.de, or <http://www.ihdp.org>

**The 2nd International Past Grasslands Research Conference (PGR 2002)**

**13-16 June, St. Cloud, MN, USA**

Contact: Mikhail Blinnikov: mblinnikov@stcloudstate.edu or Matthew Wooller: wooller@gl.ciw.edu or <http://www.visitstcloudmn.com/pages/visitor.html>

**GCTE: GCTE Focus 1/NCEAS 2nd Working Group Meeting: Progressive Nitrogen Limitation of Plant and Ecosystem Responses to Elevated CO<sub>2</sub>**

**18-21 June, Santa Barbara, CA, USA**

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

**International Conference to Mark the International Year of Mountains (IYM 2002)**

**1-5 July, Moshi, Tanzania**

Contact: S.B. Misana, smisana@ud.co.tz

**2nd LBA Science Conference**

**7-10 July, Manaus, Brazil**

Contact: LBA Central Office, yara@cptec.inpe.br

**Quaternary Climatic Changes and Environmental Crises in the Mediterranean region**

**15-18 July, Madrid, Spain**

Contact: Ana Vadeolmillos Rodriguez, climatic.changes@uah.es or <http://www2.uah.es/qchange2002>

**ICAR5/GCTE-SEN Wind Erosion and Aeolian Processes Conference**

**22-25 July, Texas Tech. University, Texas, USA**

Contact: John Ingram, jsii@ceh.ac.uk

**J G F S**

# Joint Global Ocean Flux Study

## Final Open Science Conference

**A Sea of Change: JGOFS Accomplishments and the Future of Ocean Biogeochemistry**

**5-8 May 2003**

**National Academy of Sciences, Washington, DC, USA**

### Scientific Program Committee:

Véronique Garçon, Centre National de la Recherche Scientifique, France  
Peter Haugan, University of Bergen, Norway  
David Karl, University of Hawaii, USA  
Kon-Kee Liu, National Taiwan University, Taiwan  
Deborah Steinberg, Virginia Institute of Marine Science, USA  
Bronte Tilbrook, CSIRO Marine Research, Australia

### Local Organizing Committee:

Mark Abbott, Oregon State University  
Mardi Bowles, U.S. JGOFS Planning Office  
Ken Buesseler, U.S. JGOFS Planning Office  
Hugh Ducklow, Virginia Institute of Marine Science  
Elizabeth Gross, Scientific Committee on Oceanic Research  
Roger Hanson, JGOFS International Project Office  
Mary Zawoysky, U.S. JGOFS Planning Office

Program will be announced. Check our web sites for further information as it becomes available:

<http://usjgofs.whoi.edu> or <http://ads.smr.uib.no/jgofs/jgofs.htm>

### For more information contact:

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Fax: 508-457-2161,

E-mail: [mzawoysky@whoi.edu](mailto:mzawoysky@whoi.edu) or

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Phone: +47-55-58-4244,

Fax: 55-58-9687,

E-mail: [roger.hanson@jgofs.uib.no](mailto:roger.hanson@jgofs.uib.no)

**GLOBAL  
CHANGE**

**SCOR** INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS  
SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

**3rd International Conference on Water Resources and Environment Research (ICWRER): Water Quantity and Quality Aspects in Modelling and Management of Eco-systems**

**22-26 July, Dresden, Germany**

Contact: <http://www.tu-dresden.de/fghhihm/normal/2nd-Announc-2.htm>

**Geographical Renaissance at the Dawn of the Millennium, Regional Conference of the International Geographical Union (IGU)**

**4-7 August, Durban, South Africa**

Contact: Joan Fairhurst, [joanfair@global.co.za](mailto:joanfair@global.co.za)

**Enviromental Catastrophes and Recoveries in the Holocene**

**29 August-2 September, West London, UK**

Contact: <http://www.brunel.ac.uk/depts/geo/Catastrophe>

**World Summit on Sustainable Development**

**2-11 September, Johannesburg, South Africa**

Contact: <http://www.johannesburgsummit.org/>

**Climate Variability, Predictability and Climate Risks**

**7-14 September, Bernese Oberland, Switzerland**

Contact: [nccr-climate@giub.unibe.ch](mailto:nccr-climate@giub.unibe.ch) or  
<http://www.ncccr-climate.unibe.ch>

**Atmospheric Chemistry in the Earth System:  
From Regional Pollution to Global Climate Change**

**18-25 September, Crete, Germany**

Contact: [igac2002@chemistry.uoc.gr](mailto:igac2002@chemistry.uoc.gr) or  
<http://atlas.chemistry.uch.gr/IGAC2002/>

**Cave Climate and Paleoclimate - Best Record of the Global Change**

**24-27 September, Stara Zagora, Bulgaria**

Contact: [P.Delchev@Museum.web.bg](mailto:P.Delchev@Museum.web.bg)

**START: Global Change in Northeast Asia, and TEACOM Meeting**

**TBA September, Vladivostok, Russia**

Contact: Vladimir Kasyanov, [inmarbio@mail.primorye.ru](mailto:inmarbio@mail.primorye.ru)

**JGOFS: 17th JGOFS Scientific Steering Committee Meeting and Capacity Building / Training Course on Ocean Biogeochemistry**

**TBA, September/October, Concepción, Chile**

Contact: Roger Hanson, [Roger.Hanson@jgofs.uib.no](mailto:Roger.Hanson@jgofs.uib.no)

**BAHC: Workshop on Vulnerability of Water Resources to Environmental Change**

**TBA, September, Beijing, China, P.R.**

Contact: BAHC IPO, [bahc@pik-potsdam.de](mailto:bahc@pik-potsdam.de)

**GLOBEC: ICES ASC (ICES Centenary)**

**1-8 October, Oslo, Norway**

Contact: GLOBEC IPO, [globec@pml.ac.uk](mailto:globec@pml.ac.uk)

**GLOBEC: GLOBEC Working Group Meetings**

**13-14 October, Qingdao, China, P.R.**

Contact: GLOBEC IPO, [globec@pml.ac.uk](mailto:globec@pml.ac.uk)

**GLOBEC: GLOBEC Scientific Steering Committee Meeting**

**14 October (pm), Qingdao, China, P.R.**

Contact: GLOBEC IPO, [globec@pml.ac.uk](mailto:globec@pml.ac.uk)

**GLOBEC: OSM2 - 2nd GLOBEC Open Science Meeting**

**15-18 October, Qingdao, China, P.R.**

Contact: GLOBEC IPO, [globec@pml.ac.uk](mailto:globec@pml.ac.uk)

**GLOBEC: Joint GLOBEC Foci WG/PICES Task team Meetings**

**19 October (am), Qingdao, China, P.R.**

Contact: GLOBEC IPO, [globec@pml.ac.uk](mailto:globec@pml.ac.uk)

**START: 16th START Scientific Steering Committee**

**21-23 October, Treiste, Italy**

Contact: START IPO, [start@agu.org](mailto:start@agu.org)

**GLOBEC: PICES XI**

**21-26 October, Qingdao, China, P.R.**

Contact: GLOBEC IPO, [globec@pml.ac.uk](mailto:globec@pml.ac.uk)

**16th International Symposium on Ice**

**2-6 December, Dunedin, New Zealand**

Contact: <http://www.physics.otago.ac.nz/~nzice/> or email  
[nzice@physics.otago.ac.nz](mailto:nzice@physics.otago.ac.nz)

**North Pacific Synthesis Group meeting for the North Pacific Synthesis**

**TBA, Autumn, Nagoya, Japan**

Contact: Toshiro Saino, [tsaino@ihas.nagoya-u.ac.jp](mailto:tsaino@ihas.nagoya-u.ac.jp)

**North Pacific Synthesis Group editorial meeting for an issue of the Journal of Oceanography on JGOFS NP synthesis.**

**Autumn, Sidney, BC, Canada**

Contact: Toshiro Saino, [tsaino@ihas.nagoya-u.ac.jp](mailto:tsaino@ihas.nagoya-u.ac.jp)

**Equatorial Pacific Synthesis Meeting and Workshop**

**Summer, Orono, ME, USA**

Contact: Robert Le Borgne, [leborgne@noumea.ird.nc](mailto:leborgne@noumea.ird.nc) or Fei Chai, [fchai@maine.edu](mailto:fchai@maine.edu)

**Continental Margin Task Team Workshop for the Global Synthesis of the 5 Regional Synthesis**

**TBA, Winter, TBA**

Contact: Renato Quiñones, [rquinone@udec.cl](mailto:rquinone@udec.cl) or Larry Atkinson, [atkinson@ccpo.odu.edu](mailto:atkinson@ccpo.odu.edu)



2003

**3rd International Limnogeology Congress**

**29 March-2 April, Tucson, USA**

Contact: Noah Lopez, [noahl@u.arizona.edu](mailto:noahl@u.arizona.edu)

**JGOFS: 18th JGOFS Scientific Steering Committee Meeting**

**5-8 May, Washington DC, USA**

Contact: Roger Hanson, [Roger.Hanson@jgofs.uib.no](mailto:Roger.Hanson@jgofs.uib.no)

**JGOFS: 3rd JGOFS Open Science Conference**

**5-8 May, Washington, DC, USA**

Contact: Roger Hanson, [Roger.Hanson@jgofs.uib.no](mailto:Roger.Hanson@jgofs.uib.no) or Ken Buesseler, [kbuesseler@whoi.edu](mailto:kbuesseler@whoi.edu)

**XVIth INQUA Congress**

**23-31 July, Reno Hilton Resort & Conference Center  
Reno, Nevada USA**

Contact: [http://www.dri.edu/DEES/INQUA2003/inqua\\_home.htm](http://www.dri.edu/DEES/INQUA2003/inqua_home.htm)

**18th International Radiocarbon Conference**

**1-5 September, Wellington, New Zealand**

Contact: <http://www.14conference2003.co.nz>

## International Human Dimensions Programme



### Vacancy Announcement

#### Executive Director of the International Human Dimensions Programme

The International Council for Science (ICSU) and the International Social Science Council (ISSC) invite applications for the position of Executive Director of the International Human Dimensions Programme on Global Environmental Change (IHDP).

The Executive Director facilitates the expeditious and orderly development, implementation and evaluation of the IHDP Programme. A detailed listing of the requirements for the position of the Executive Director is available on the IHDP web-site ([www.ihdp.org](http://www.ihdp.org)).

The successful candidate will be appointed by ICSU and ISSC for a 3-year period, renewable. The IHDP Secretariat is located in Bonn, Germany. The position will be filled by 1 April 2002, or as soon as possible thereafter. The salary is competitive and will take due account of the experience and qualifications of the candidate.

**Letters of application with a curriculum vitae and the names of three referees should be received no later than 15 January 2002 by the IHDP Secretariat, Attn. Search Committee, Walter-Flex-Str. 3, D-53113 Bonn, Germany, Fax +49 228 73 9054, e-mail: [ihdp@uni-bonn.de](mailto:ihdp@uni-bonn.de).**

**Interviews for the post will be scheduled in February 2002.**

## Note to contributors

Articles for "Science Features" should achieve a balance of (i) solid scientific content, and (ii) appeal for the broad global change research and policy communities 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).

Contributions for "Discussion Forum" should be between 500 and 1000 words in length and address a broad issue in global change science. A "Discussion Forum" article can include up to 2 figures.

"Correspondence" should be no more than 200 words and be in the form of a Letter to the Editor in response to an article in a previous edition of the Newsletter or relating to a specific global change issue. Please include author and contact details.

## Required Image Quality for IGBP Publications

Photographic images should be saved in TIFF format. All other images including charts, graphs, illustrations, maps and logos should be saved in EPS format. All pixel images need to be high resolution (at least 300 pixels per inch).

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

If you have queries regarding image quality for the Global Change NewsLetter please contact John Bellamy  
E-mail: [john@igbp.kva.se](mailto:john@igbp.kva.se)

## Deadlines for 2002:

March issue (special edition on IGBP Phase II)	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

Send contributions by email to the Editor, Susannah Eliott  
E-mail: [Susannah@igbp.kva.se](mailto:Susannah@igbp.kva.se); Phone: +46 8 6739 556;  
Reception: +46 8 16 64 48; Fax: +46 8 16 64 05

## Next edition of the IGBP Newsletter...

- Special edition on IGBP Phase II



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## GLOBAL CHANGE NEWSLETTER

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

## Correction

In the "Correspondence" section of NewsLetter No. 47, the author of the letter entitled "Manipulating terrestrial carbon sinks" was misspelt. The author's correct name is Gamini Seneviratne.