Global Change NewsLetter

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GLOBAL IGBP CHANGE

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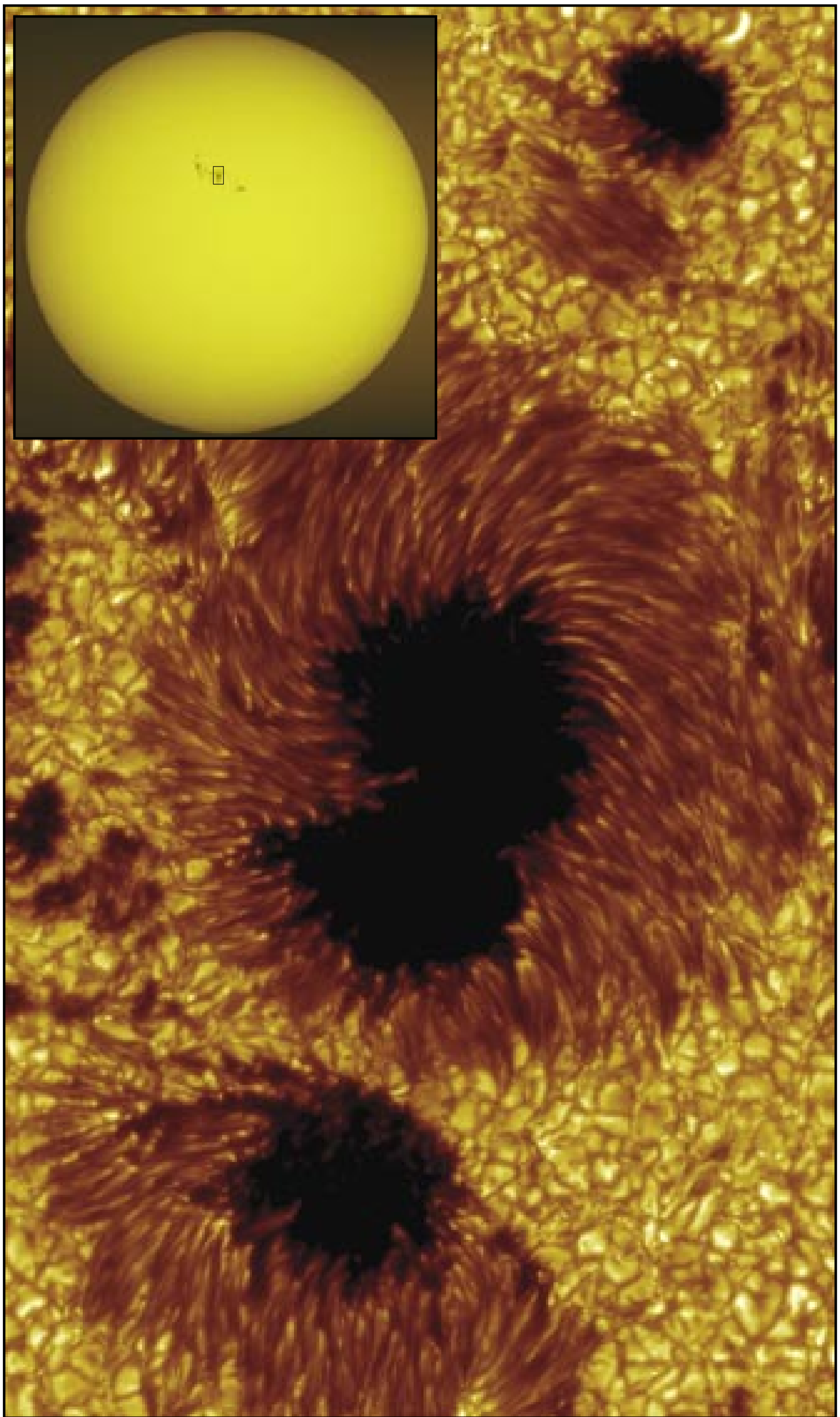

"Everybody agrees that the Sun drives the Earth's climate system", says Juerg Beer, but "until recently, almost no-one believed that the Sun had anything to do with climate change." In this NewsLetter Juerg beer discusses *Solar Variability and Climate Change* while Ulrike Lohmann and Martin Wild discuss the issue of *Solar Dimming* – the reduction of solar radiation at the Earth's surface due to increasing emissions of aerosols from human activity. A related Science Feature reports on aspects of ACE-Asia, focussing particularly on the impacts of soot and considering whether mitigating soot emissions can help mitigate global warming.

The cover image (coloured for aesthetic effect) shows sunspots on 15 July 2002, during a period of high sunspot activity. As Juerg Beer points out, solar activity (as indicated by sunspot activity) is one driver of climate variations. The image is from the 1 metre solar telescope of the Institute for Solar Physics of the Royal Swedish Academy of Sciences. This telescope (on the Canary Island of La Palma) has provided the most detailed images ever obtained of the Sun and has revealed previously unknown sunspot phenomenae. The inset shows the sunspot group on an image of the entire Sun recorded by the Institute for Solar Physics' finder telescope. The diameter of the sun is around 100 times that of the Earth.

Also in this issue of the Global Change NewsLetter we farewell LUCC – the Land-Use and Cover Change project of IGBP and IHDP. We provide a report from a recent LUCC workshop, a summary of the key findings of LUCC and a vote of thanks. In the centrefold we highlight the Science Plan of the new IGBP-IHDP Global Land Project that will subsume the ongoing research of LUCC into its research framework based on the paradigm of the coupled human-environment land system.

Contents

Guest Editorials

Four Years as IGBP Chair

At the end of 2005 I will complete my term as IGBP Chair. First of all, I would like to stress that this four-year experience has been unique: the completion of a fascinating synthesis exercise summarising ten years of intensive research, followed by the definition of new objectives for the ten years ahead has been perhaps the most interesting challenge of my scientific career. Working with visionary scientists from different parts of the world who promote new research goals and address new intellectual challenges has been an exceptional experience.

What is amazing for a programme like IGBP, is that beyond national boundaries and political systems, it has created a network of perhaps 20,000 scientists, who over the years have defined and developed the concept of Earth System science. As a result we see new research institutes emerging, or more established centres transforming themselves and tackling more integrative questions. We see funding agencies reorganising towards new challenges and education institutions offering interdisciplinary curriculae. A new generation of students is emerging – one interested in the relationships between the physical and social aspects of Earth System science. We see political groups increasingly interested in the long-term fate of the planet and debating global change issues.

Despite progress in the last decades, many challenging problems remain that have to be addressed. Firstly, it is increasingly certain that we will witness in coming decades the first substantial effects of climatic change, with changes to the hydrologic cycle including more frequent extreme and high-impact weather events. Secondly, we are not too far from when oil will be a rare and expensive product, and we have probably less than fifty years to develop an alternative, more efficient energy system. Thirdly, globalisation of economies and increasing access to information technology will profoundly modify our social system, our cultures and our environment. Making sound decisions will require, more than ever before, objective information from intensive scientific research.

Environmental questions will need to be addressed in a broader context than in the past, because it has become increasingly apparent that these are closely related to development issues. We know that population will continue to grow, and grow unevenly between regions with a shifting population balance between poor and rich nations. We know that despite progress in agricultural practices, hunger persists in many parts of the world and the water required for food production is scare. We know that in spite of industrial development and economic growth, more than one billion people earn less than US$1 per day and have limited access to health services.

Solutions to these pressing questions require, of course, political commitments at the international level, but the scientific community can help. IGBP has provided, and will continue to provide, some of the knowledge needed by decision makers to address the complex issues of the 21st century. IGBP will help to further elucidate how human activities will affect the goods and services provided by the global environment, specifically provision of food, water, clean air and health services.

Let me add a few personal considerations. Despite the recent successes of IGBP it has become increasingly clear that none of the four global change programmes in their present configuration will be able to provide the comprehensive and integrated information required by decision makers. Therefore, as the current programmes consolidate and mobilise their respective research communities, for example, through the Earth System Science Partnership (ESSP), it is time to think further ahead and develop the programmatic tools that will be needed in the next decade to address the broader Earth System questions posed by society. What is the optimal organisation that will support global change research in the future? How can we successfully implement interdisciplinary approaches and create partnerships between different scientific communities? How can we create real partnerships between scientists of the developed world and their colleagues from emerging and developing countries? How can we better take into consideration regional and cultural differences? These questions must be answered in the coming years, indeed perhaps even during upcoming ESSP Open Science Conference (Beijing, November, 2006).

Finally, I take this opportunity to thank the SC-IGBP, the Secretariat in Stockholm and the IGBP Projects for their support. It was a pleasure to work with two consecutive Executive Directors – Will Steffen and Kevin Noone – both of whom have and are playing key roles in the progress of IGBP. I am particularly pleased that Carlos Nobre (INPE/CPTEC, Brazil) has accepted to chair the SC-IGBP for the years to come. I welcome him and wish the programme much success under his leadership.

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A Reflection on IGBP Communications

Over the past five years there has been a fundamental shift in the way IGBP communicates what is known about the planet and how it is changing. In 2000 IGBP was known amongst scientists interested in global change and a few related international organisations such as other ICSU bodies, UNEP and IPCC. IGBP products consisted of a newsletter, a brochure, some rather dry scientific reports and a basic website. The assumed audience was interested scientists, and IGBP products and projects had no clear or connecting visual identity.

IGBP now has a colourful Science Series for policy and education, the IGBP Book Series published by Springer, a vastly improved newsletter and report series, a regular email bulletin, an extranet service and a professional website. All of these are visually connected by an increasingly well defined visual profile that is beginning to incorporate a recently commissioned professional illustration of the Earth System.

Most of these advances have been the collective work of the IGBP Secretariat, the IPOs and scientists in the network. However, the impetus for the shift in thinking on IGBP communications began in 1999 when people including Will Steffen, Berrien Moore and Chris Crossland realised that IGBP could not remain an organisation only for scientists. Earth System discoveries and the sheer pace of system changes made the work of IGBP of immediate and obvious importance to society. This coincided with the realisation that biogeochemistry could never provide complete Earth System understanding; this also requires understanding the role of the climate system and human activities in the Earth System. This was the genesis of the Earth System Science Partnership (ESSP).

The ESSP Amsterdam conference in 2001 helped launch IGBP into its second phase, and a series of associated high-profile media events produced a more public face for all ESSP partners. IGBP has maintained a strong media presence since, including an article in the International Herald Tribune co-authored by several SC-IGBP members and the EU Environment Commissioner, as well as items in BBC World News, the Financial Times, Reuters News Agency, the Los Angeles Times and others.

These are all very positive developments. However, as

I leave IGBP after five very rewarding years at the IGBP Secretariat, I am struck by how far there still is to go. Most of the media and public debate is still far behind the science, and rarely gets beyond climate change. Most are blissfully unaware of the broader and more worrying issue of global change. When talking to friends about global change the response is amazement and the inevitable and accusing question, "why haven't I heard about this?"

Despite major efforts, journalists have not been persuaded to take on the issue of the cumulative Earth System changes resulting from human activities. While in many countries people still argue about the extent of human influence on the climate system, other changes that are indisputably anthropogenic (such as land use change) and have dramatic global impacts, scarcely warrant a mention in the mainstream media. Initially, I thought it was only a matter of time: once people understood climate change then the broader issue of global change would follow. But perhaps people will only take notice when changes occur that are so dramatic and widespread, that adequate policy and societal responses will be extremely difficult.

The issue of global change must be made more accessible, and I believe that ESSP holds at least part of the answer. Food security, human health, carbon and energy and water resources – the foci of the ESSP projects – are issues journalists and the public understand. But there is little point in ensuring that the science of ESSP projects is policy-relevant, if the necessary time and effort is not invested to develop strategies to effectively convey this science to policy makers and the public. The ESSP projects are certainly undertaking outreach work, but they do not have the resources to comprehensively tackle the issue alone.

ESSP cannot rely on the few, over-worked communicators employed by the partner programmes; it needs a team of professional science communicators devoted to promoting the knowledge generated by ESSP activities. This team must understand the science, be both politically and media savvy and develop a comprehensive ESSP communications plan that considers both internal and external communication. If funding bodies desire practical outcomes from ESSP that inform policy and society, they need to channel more resources into science communication, and not just into the science itself. And from the ESSP side, scientists need to lobby to make this happen.

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Properties of Soot and Dust Aerosol in East Asia and Implications for Climate Forcing

P. Chuang and J. Schauer

East Asia is a significant contributor to the global budget of both elemental carbon (EC, here synonymous with soot) and aeolian dust. Here, we summarise observations of these important aerosol types downwind of continental East Asia, including periods when particles with dust and soot mixed together were common; this summary is based primarily on [1]. The efficiency with which soot absorbs light is found to increase as the amount of soot decreases, which is consistent with theoretical work. Although more research is needed to confirm this observation, if it is a general relationship, then the idea that reducing EC emissions in order to mitigate future global warming may be less effective than simple scaling would suggest. Results from modelling mixed soot and dust particles suggest that while these particles absorb significantly more light than dust alone, the overall change in absorption is a decrease of 10–40% compared to separate dust and soot particles.

Introduction

One of the important atmospheric phenomena resulting from the presence of EC in atmospheric aerosols, emitted from biomass and fossil fuel combustion, is the absorption of light in visible wavelengths. This absorption and the subsequent atmospheric heating have been estimated to lead to top of atmosphere radiative forcings in the range of 0–0.5 W m^{-2} [2], although more recent estimates give an upper bound of 0.8 W m^{-2} [3,4]. It has been estimated that sources in China account for about a quarter of the global anthropogenic EC emissions [5]. Therefore insight into the effects of EC in the plume downwind of East Asia represents a significant step towards understanding both the global budget of shortwave absorption and the climate in the western Pacific region.

Episodic dust storms cause further uncertainty in global radiative forcing. Dust is generally a much weaker absorber of visible light than EC, and the sign of the globally averaged net radiative forcing due to dust is unclear, with estimates in the range of –0.7–0.5 W m^{-2} [2]. In East Asia, the Kosa or Yellow Sand episodes are most common in late winter and spring, and their effects can extend as far as North America. Yellow Sand episodes are wind-blown sands from inland desert areas (such as the Gobi and Takla Makan) on the Asian continent, transported by strong westerly winds. Here, we report observations of dust storms that have mixed with pollution (resulting in particles containing both dust and EC) and examine the implications for both aerosol optical properties and direct radiative climate forcing.

Observations of EC

Measurements were made at the Gosan site on Jeju (or Cheju) Island, South Korea during the

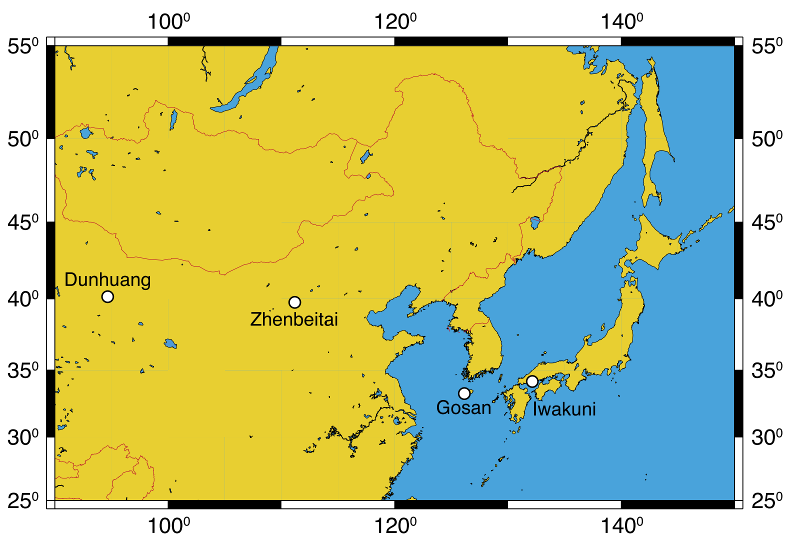

Figure 1. Map of the ACE-Asia region

ACE-Asia [6] campaign (Figure 1). Winds from the westerly quarter (NW to SW) bring aged continental air masses from East Asia to this site. However, the winds are not always from this quarter, and air masses that have most recently encountered land at Jeju Island, the Korean peninsula and Japan are not uncommon.

One interesting observation is that on some of the days that are strongly influenced by long-range dust transport, a significant fraction of EC is observed in the coarse (> 1 μm diameter) particle samples. During six of the eight Kosa events sampled, the average ratio of coarse particle EC to total EC for these six days is 40%. Because EC is emitted from combustion sources as particles typically smaller than 0.1 μm, finding a large fraction of the EC associated with coarse particles was unexpected. The likely physical explanation is that the same meteorological conditions that lead to the lofting of dust result in the lofting of pollution aerosols in the industrialised area of China farther east, and the coagulation of EC from the pollution plume with the previously lofted dust leads to dust particles coated with EC (and other pollutants).

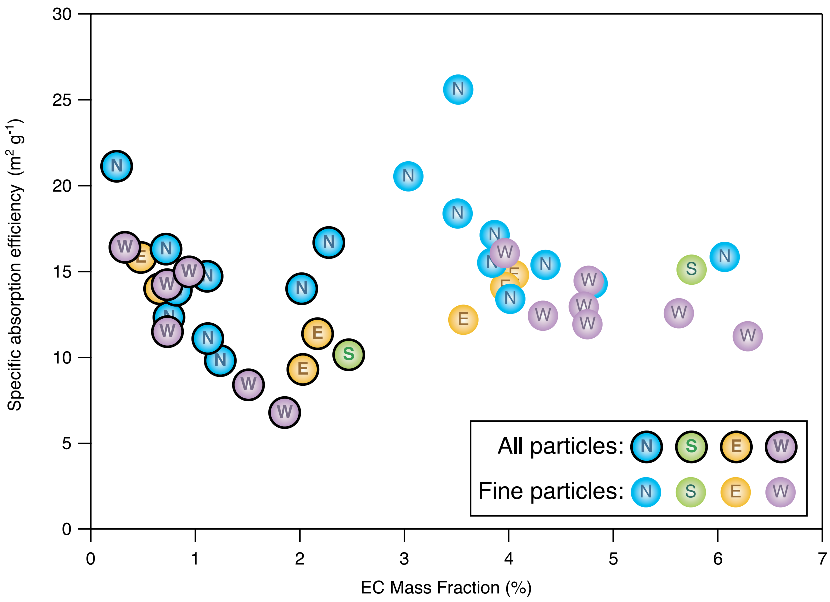

Figure 2. Specific mass absorption efficiency as a function of EC mass fraction "fine particles" and "all particles". The letter within the symbols indicate wind directions. N includes N and NE directions; W includes NW, W, and SW; E includes E and SE. Only one day was classified as S.

Does Controlling EC Mitigate Global Warming?

Because EC is the most important absorber of visible light, and because East Asia is estimated to represent about a quarter of the global EC budget [5], it is interesting to examine the efficiency with which EC absorbs light. The *absorption efficiency* (α_a) of EC has units of m^2 g^{-1} and can be physically interpreted as the amount of light that a collection of particles can absorb per gram of EC; typical values are 4–15 m^2 g^{-1}.

Models as well as laboratory studies have predicted that there is an inverse relationship between α_a and the mass fraction of EC (mass of particulate EC / total particle mass) [7]. That is, as EC becomes more dilute, its absorption efficiency increases. Our observations (Figure 2) do not show a perfect correlation, but this general trend is certainly observed for total particles, and seems to be present for fine particles (< 1 μm diameter) as well. Since α_a depends on a number of variables, it is unreasonable to expect EC mass fraction to perfectly explain the observed variations, but it does appear to play a role as predicted. One possible interpretation is that as EC mass fraction increases, the additional EC shields the pre-existing EC from light, leading to a smaller fraction of the EC that can effectively absorb light. When the data in Figure 2 are grouped by wind direction no bias is observed, suggesting that the result is not a consequence of aerosol aging, since air masses from the west have a longer transit time to Gosan than those from the north and east.

If this is a consistent feature of absorption by atmospheric aerosols, then it could be important for understanding the future impact of light absorption on climate. It has been suggested [4,8] that control of EC emissions may be an effective strategy for mitigation of climate change. The possible concomitant increase in the average EC absorption efficiency would lead to a net benefit smaller than that assuming a linear response of absorption with changing EC mass concentration. In fact, the data in Figure 2 suggest that it is plausible that a 50% decrease in EC concentration (with everything else held constant) could increase α_a by a factor of about 2, which would completely negate the intended decrease in shortwave absorption. This quantification is of course hypothetical and simply for the purposes of discussion, and furthermore, is an extension of a preliminary result based on observations over a short period of time at a single location. The observations suggest that the issue of controlling EC for the purposes of mitigating global warming requires more research.

Model Predictions of Mixed Dust and Soot Aerosol

We seek to more carefully explore the implications for light absorption of the presence of EC on dust particles. Our observations are limited by large uncertainties, which leads us to use model simulations. The discrete dipole approximation (DDA) technique has been used for simulating the radiative properties of dust and soot aerosols [9,10]. The advantage of this model (versus Mie theory, for example) is that it can simulate irregular particles of mixed composition, which is necessary for our studies here. A number of different dust and EC shapes and dust optical properties were used, and the results are summarised below.

The addition of soot to dust particles led to a mixed particle that absorbs 2–4% of the incident light (on top of the light – if any – that is already being absorbed by the dust); a result which could be important for understanding the optical properties of aeolian dust in this region, and could therefore have important implications for remote sensing measurements in addition to radiative forcing.

This result however, does not take into account the fact that soot particles absorb light even if they do not combine with dust particles. The combining of these two particle types actually leads to an overall decrease in absorption. Depending on the assumptions used, the predicted reduction in overall absorption is 10–40%. This occurs because the soot is more effective at absorbing light on its own than when combined with dust, possibly because the dust shields some of the soot from incident light. These model predictions are consistent with observations, giving more credibility to the results.

Other Effects

Along with their radiative impacts, it is possible that the association of EC on dust particles during Yellow Sand events may have other important climate implications in the western Pacific region. The lifetime of aerosols is generally governed by removal by cloud and precipitation processes. EC that is attached to dust could be removed at a very different rate, which would thereby significantly alter its lifetime in the atmosphere, but in which direction is still unclear.

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A 1437-year Precipitation History for the Northeastern Qinghai-Tibetan Plateau

X. Shao, E. Liang, L. Huang and L. Wang

Figure 1. Example of a Qilian juniper tree. Photograph Xuemei Shao.

High-resolution proxy records of climate spanning multiple millennia are needed for understanding natural climate variability of the past. The Qilian juniper (*Sabina przewalskii,* Figure 1) growing in the mountains of the arid and semi-arid area in the northeastern Qinghai-Tibetan Plateau offers great potential for climate reconstructions. Based on well-replicated and cross-dated specimens from living trees from 11 sites (Figure 2) at Delingha, Wulan and Tianjun, Qinghai province, a 1,600-year regional composite ring-width chronology was developed.

This chronology was compared with the Dulan chronology [1], which was obtained approximately 65–150 km south of the sites used in this study. Two more rings were found in the chronology of this study than in the Dulan chronology in the common interval 404–2000. One ring occurred at either 874 or 875 and another at 711, rather than one at 682 as indicated by previous work [2,3]. In addition to the climate reconstructions reported herein, this multi-site chronology will serve as the master chronology to cross-date archaeological specimens excavated from tombs of the Tubo kingdom in Delingha County, a potential that has been demonstrated [3].

In developing the regional chronology samples with more than 1,050 rings and good correlation with the mean series from each site were selected. Negative exponential or linear regression models with negative coefficients were used to fit and remove the growth trend. The sample depth of the regional chronology is six cores from

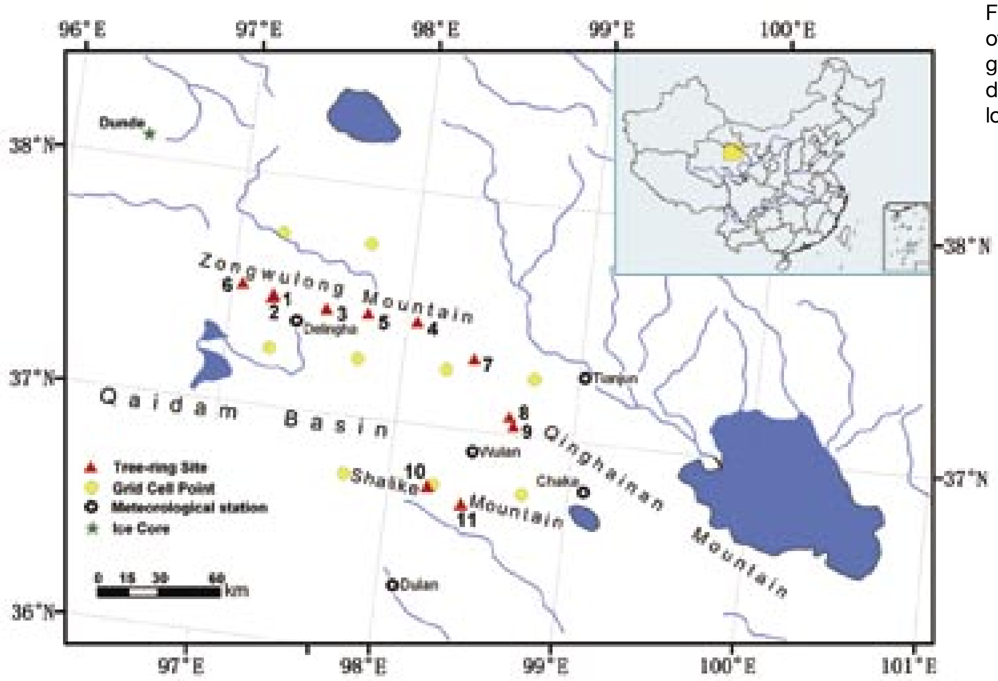

Figure 2. Locations of tree-ring sites, grids of precipitation data, and meteorological stations.

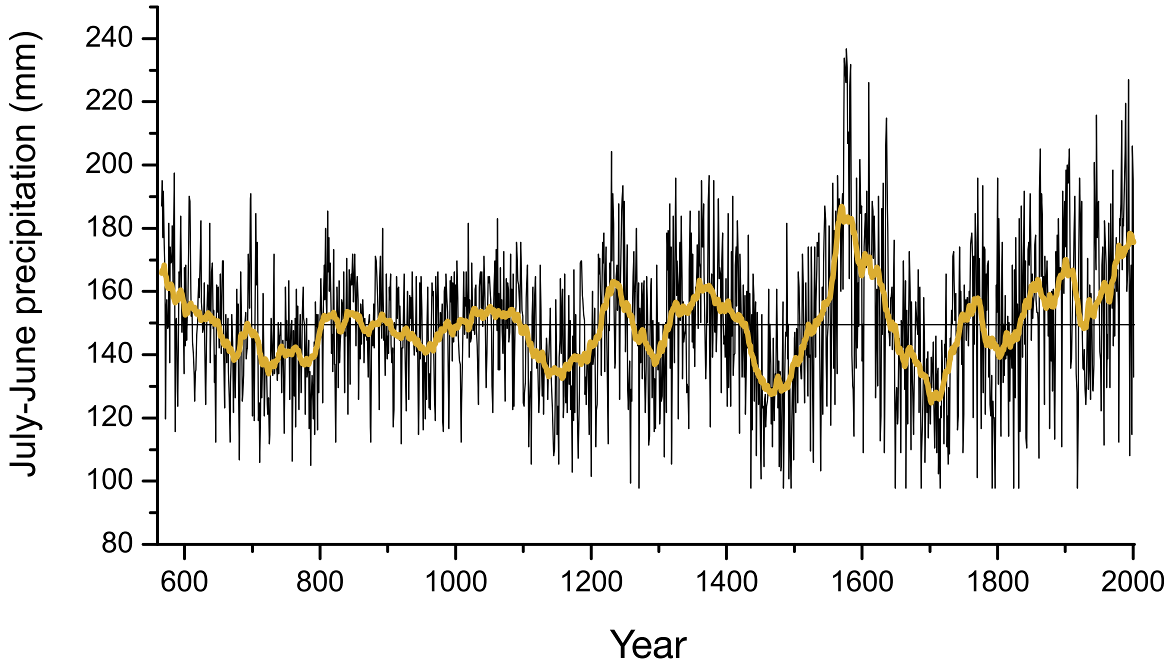

Figure 3. Precipitation reconstructions. The 31-year running means (yellow) and long-term mean (horizontal line) are also shown.

five trees in 566, nine cores from seven trees in 700, 22 cores from 16 trees in 800 and more than 50 cores from 36 trees in 900. Based on the sub-sample signal strength of 0.85, the chronology was truncated at 566 for the climate reconstruction. The average length of cores is 803 years, indicating that the chronology should capture decadal up to centennial scale variability.

In a preliminary study [4] Qilan juniper growth in the study area was mainly limited by moisture conditions in May and June, and a significant positive correlation was found between the regional chronology and the preceding annual July–June precipitation. The annual July–June precipitation was therefore reconstructed using climate data from CRU TS 2.1 (from www.cru.uea.ac.uk), with monthly precipitation data from nine 0.5° x 0.5° grid points (Figure 2) averaged to provide a regional data set.

Since the effect of low precipitation on tree growth is more profound than that of high precipitation in the arid area, the precipitation series was transformed into a logarithmic scale. The calibration model explained 65% of the variance in the calibration period 1955–2002, and the correlation coefficient was 0.79 for the cross-validation. The reduction of error, product means test and sign test statistics also support the validity of the model. Since the correlation coefficient of July–June precipitation with January–December precipitation could even reach 0.95 after the five-year running mean was performed for both series, it is clear that low frequency variability in the reconstructed precipitation series can represent the variations of the instrumental record very well.

> "The most pronounced wet intervals were centred in the late 16th century..."

The resulting 1,437-year precipitation reconstruction (Figure 3) shows:

- The climate in the calibration period was relatively moist in the context of the past 1,437 years. Only during 1563–1590 was annual precipitation higher than present;

- Dramatic oscillations in precipitation occurred during the Little Ice Age. Before 1400 the magnitude of variation in annual precipitation was about 15 mm, but was as high as 30 mm during 1400–1750. After 1750, the magnitude of variation decreased. The most pronounced wet intervals were centred in the late 16th century, and the most severe and prolonged dry periods occurred in the late 15th century and earlier 18th century. These two dry periods both correspond to periods of sunspot minima;

- Compared with the Little Ice Age, variations in the low frequency domain of precipitation during the Medieval Warm Period were less dramatic, and the variance in the high frequency domain was also low during 800–1200. A decreasing trend was observed in the period 566-800; and

- Spectral analysis indicated that the reconstructed precipitation contained significant low frequency (150–250 year) cycles. The 200-year period was indicated clearly in the Little Ice Age by wavelet analysis and singular spectrum analysis.

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Editors Note

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From LTER to LTSER: The Socio-economic Dimension of Long-term Socio-ecological Research

H. Haberl

Long-term ecological research (LTER) currently faces the challenge of engaging in the production of the knowledge necessary for addressing pressing sustainability problems. For this, it is essential to include socio-economic dimensions, thus transforming LTER into long-term socio-ecological research (LTSER).

While classical LTER focuses on monitoring and on analysing changes in patterns and processes in ecosystems over long periods of time, LTSER deals with socio-ecological systems. Socio-ecological systems are those which emerge through continuous interaction between society and nature. LTSER not only investigates changes in the state of the environment, but also societal pressures on ecosystems, their underlying driving forces, impacts of environmental change on society and the economy, as well as preventive or adaptive measures. Just like LTER, LTSER must include monitoring and analysis. LTSER can in addition, use historical sources to reconstruct past socio-ecological systems using methods from environmental history. A summary of the key features of LTER and LTSER is provided in Table 1, and the degree to which they consider socio-economic systems is shown in Figure 1.

Recently, a workshop organised by the IGBP-IHDP LUCC project and the IHDP Industrial Transformation (IT) project assembled 20 highly motivated scientists from various natural and social sciences and humanities to progress conceptualisations of society-nature interactions in LTSER. The main issues considered were: (i) how to bridge the gap between natural and social sciences; (ii) how to integrate patterns and processes across spatial scales from both natural and social science perspectives; and (iii) how to integrate results from biophysical measurements with statistical social data, cadastral surveys, and "soft knowledge" from the humanities.

The workshop concluded that there are at least four central themes for LTSER: socio-ecological metabolism, land use and landscapes, communication, and governance and decision making. Socio-ecological metabolism is important because the analysis of material and energy flows in ecosystems and the economy is an important integrative concept that can be used to link human and ecological systems in a consistent way. Land use is important, because

	LTER	LTSER
Studies:	Ecosystems.	Socio-ecological systems.
Considers people as:	Populations which are treated like populations of other species, causing disturbances in ecosystems.	Human societies/cultures engaged in an interactive process with their natural environment.
Methods and approaches used:	Natural sciences approach: observation/analysis/ explanation; intervention occurs only in controlled experiments.	Inter- and transdisciplinary approach: gets involved and is aware that the research may change the systems under investigation.
Products:	Expertise, measurement data, models, understanding of system dynamics.	As for LTER, as well as socio-economic and statistical data. Actively uses research results as a basis for participation in decision making.
Basic epistemological assumptions:	Natural scientific values: aims at objectivity and reproducibility, may sometimes have the illusion of being independent of social values and norms.	Self-reflexivity: is aware that research is a social process inextricably entangled in (historically contingent) social values and norms.

Table 1. A comparison of key features of LTER and LTSER.

we need to understand the ways in which humans use the land, thereby creating cultural landscapes and altering patterns and processes in ecosystems, including resilience, biodiversity, material and energy flows. This requires integrative, interdisciplinary approaches. Communication is important because human societies are integrated by flows of information. The way in which societal use of natural resources and the significance of the environment and its dynamics are represented in communication, why and how these representations changes over time, and how they relate to changes in the biophysical arena, are thus key questions to be tackled. Governance is also important, and LTSER should help societies to make better-informed decisions in a sustainability context, the analysis of institutions and decision-making processes relevant to society-nature interaction is of high importance.

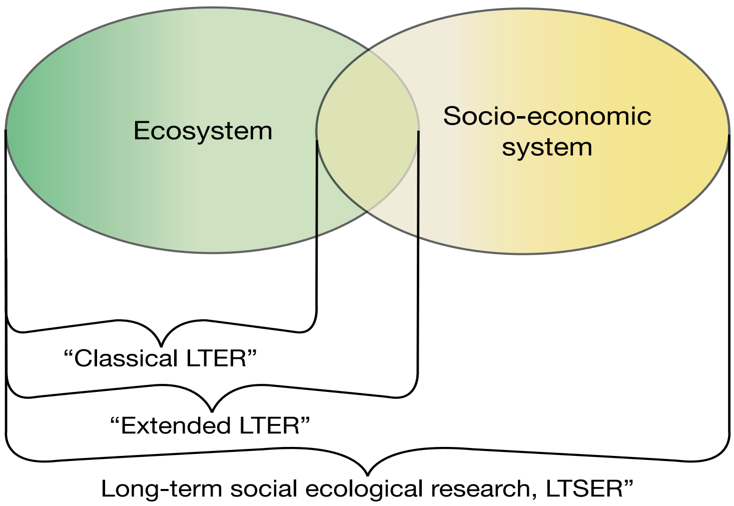

Figure 1. The ecosystem and socio-economic system domains of LTER and LTSER.

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Key Findings of LUCC on its Research Questions

Question 1: How has land cover been changed by human use over the last 300 years?

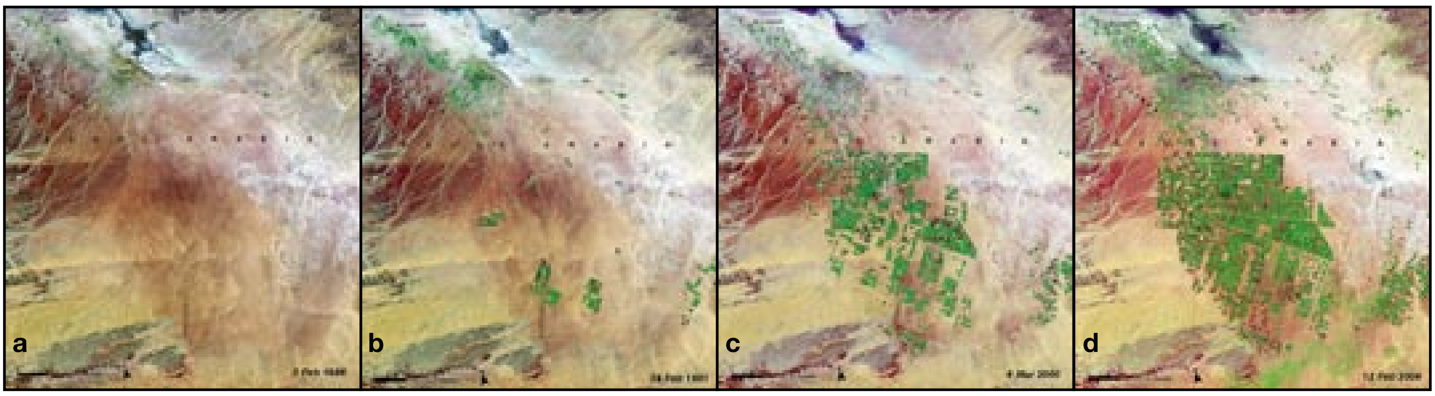
Human activities have transformed our planet's landscapes for a long time. The pace and intensity of land cover change increased rapidly over the last three centuries, and accelerated over the last three decades. Since the 1960s and the Green Revolution, an intensification in land use practices has been observed. The rapid land cover changes that have been observed (mostly in humid forests) are not randomly or uniformly distributed, but clustered in particular locations; for example, on forest edges and along transportation networks. Spatially diffuse land-cover changes, especially in drylands, are more difficult to observe.

Different processes of land cover change have taken place in different parts of the world in the last two decades (for example, decreases in cropland in temperate regions and increases in the tropics), and have had different impacts. Land cover modifications (subtle changes that affect the character of the land cover without changing its overall classification) are as important as land cover conversions (the replacement of one cover type by another). Reliable data at a global scale is lacking on changes in (sub)tropical dry forests (e.g. Miombo and Chaco forests); forest cover changes caused by selective logging, fires and insect damage; drainage or other alterations of wetlands; soil degradation in croplands; changes in extent and productive capacity of pastoral lands; dryland degradation; changes related to urban infrastructure; and lifestyle-driven changes. Moreover, many parts of the world are inadequately represented in existing land cover change data sets.

Question 2: What are the major human causes of land cover change in different geographical and historical contexts?

Land use change is always caused by multiple interacting factors originating from different levels of organisation of coupled human-environment systems. The mix of driving forces of land use change varies in time and space, according to specific human-environment conditions.

At decadal time scales, land use changes mostly result from individual and social responses to changing economic conditions, which are mediated by institutional factors. Opportunities and constraints for new land uses are created by markets and policies and are increasingly influenced by global factors. New technologies can lead to rapid shifts in land use practices. Institutions (political, legal, economic and traditional) at various scales, and their interactions with individual attitudes, values and knowledge systems, have a major impact on land use change. Globalisation can either amplify or attenuate the effect of driving forces of land use change. Migration is the most important demographic factor causing land use change at the timescale of a few decades. At a centennial timescale, both increases and decreases of a given population have a large impact on land use. Demographic change is also associated with the development of households and features of their life cycle.



Development of irrigation greening the desert region of Al Isawiyah, Saudi Arabia, showing (a) the desert landscape of 1986, (b) the beginnings of irrigation in 1991, (c) expansion by 2000, and (d) the transformation by 2004. Images from "One Planet, Many People: Atlas of Our Changing Environment", UNEP.

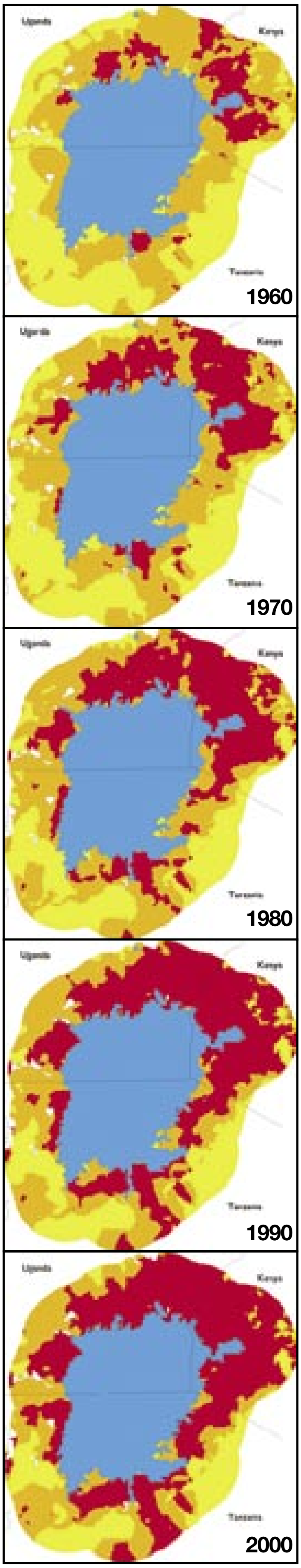
A restricted set of dominant pathways of land use change can be identified, as certain human-environment conditions repeatedly appear in case studies. For example, development of the forest frontiers by weak state economies, for geopolitical reasons or to promote interest groups; loss of entitlements to land resources (e.g. expropriation for large-scale agriculture, dams, or wildlife conservation) that lead to ecological marginalisation of the poor; induced innovation and intensification, especially in peri-urban and market-accessible areas of developing regions; urbanisation followed by changes in consumption patterns and income distribution with differential rural impacts.

Question 3: How will changes in land use affect land cover in the next 50–100 years?

Improved understanding of the complex dynamic processes underlying land use change has led to more reliable projections and more realistic scenarios of future change. A wide range of land use change models, for different scales and research questions and based on a variety of approaches, is now available. Different models of land use change address different questions, for example, location of change versus quantity of change. No model is able to answer all questions. Some models consider an area of land as the unit of analysis, while others are centred on individuals as decision making agents.

Only a few models of land use change can generate long-term projections of future land use/cover changes at the global scale, and so a regional approach is usually adopted. Crucial to projections of future land use is understanding the factors that control positive and negative feedback in land use change. Model reconstructions of past land use patterns are now better than random patterns or "no-change" assumptions.

Scenarios of land use change help to explore possible futures under a set of simple conditions by summing up current knowledge in the form of consistent, conditional statements about the future. Scenario building can involve



Population growth in the 100 km zone around Lake Vict oria in East Africa. These population growth rates are the highest for the entire continent. Images from "One Planet, Many People: Atlas of Our Changing Environment", UNEP.

policy makers and stakeholders to define and negotiate relevant scenarios. Existing land use change scenarios indicate the possibility of long-term and large-scale changes in land use and land cover with implications for many aspects of the Earth System. They indicate that long-term trends may be reversed after some decades. Urbanisation and associated changes in lifestyles are likely to become the dominant factor in land use change in the decades to come.

Question 4: How do human and biophysical dynamics affect the coupled human-environment system?

Human-environmental systems are complex adaptive systems in which properties, such as land use, emerge from the interactions amongst the various components of the entire system. These properties themselves feed back to influence the subsequent development of those interactions. Land use changes have multiple impacts on ecosystem goods and services at a variety of spatial and temporal scales. There are trade-offs between immediate human needs satisfied by land use, and maintaining the capacity of the biosphere to provide goods and services in the long term. Adopting a long-term view of land use change history in a given region is essential to understanding current changes and to predicting future ones as legacies of past land use changes. Institutional and technological innovations may lead to negative feedback loops that decrease the rate of land use change. There are several historical and contemporary examples of land use transitions associated with other societal and biophysical changes.

Question 5: How might changes in climate (variability) and biogeochemistry affect both land use and land cover, and vice versa?

Slow and localised land cover conversion takes place against a background of high temporal frequency regional-scale fluctuations in land cover conditions caused by climatic variability, and it is often linked through positive feedbacks with land cover modifications. Abrupt, short-term changes, often caused by the interaction of climatic and land use factors, have important impacts on ecosystem processes.

Towards a Theory of Land Use Change

The complexity of causes, processes and impacts of land change has so far impeded the development of an integrated theory of land use change. Much progress has been made in understanding under what conditions different theoretical orientations, borrowed from a variety of disciplines, prove useful. However, the need to address land change from the perspective of a coupled human-environment system (or societal-ecological system) is now widely recognised, with the hope that one or more overarching theories of land change may emerge. Such theories must address the behaviour of people and society (agency and structure) and the uses to which land units are put, as well as feedbacks from one to the other. Theories must be multi-level with respect to both people and land units, recognising that they can combine in ways that affect their collective and individual behaviours. They must incorporate the extent to which people and pixels are connected to the broader world in which they exist, and must incorporate both history and the future.

Policy Implications

The use of land is a highly political activity. Misguided or uncoordinated sectoral policies are one of the major causes of land degradation. Lifestyle choices and consumption patterns affect land use choices, and universal policies for controlling land use change will not be effective when implemented. Rather, a detailed understanding of the complex set of causes affecting land use change in a given location is required prior to any policy intervention. Policy intervention should address the underlying causes as much as the proximate causes of land use change. To design effective response strategies in the face of rapid land use change, one needs to understand: (i) environmental perception, information processing and transfer by agents; (ii) determinants of decision making and individual behaviour with respect to land management; and (iii) portfolios of available and feasible responses to land use change for the different categories of agents. Good and efficient communication of the location of adverse impacts of land-use change to policy makers can allow them to react in a timely manner.

LUCC Scientific Steering Committee
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Conclusion of LUCC

At the end of October 2005 the Land Use and Cover Change (LUCC) core project co-sponsored by IGBP and IDHP will conclude its work; this is an occasion both for reflection and celebration.

When LUCC was formulated in the early 1990s, there was much debate in the global change community about whether land use and land cover had any role to play in Earth System dynamics. Now, a decade later, one the most important overall findings of IGBP research, highlighted in the 2001 Amsterdam Declaration, is that “Global change is more than climate change. It is real, it is happening now and in many ways is accelerating”. More than any other IGBP project, the research of LUCC gave rise to that conclusion, and led the way in integrating human and environmental interactions, and ultimately the growing synergism between IGBP and IHDP.

The past decade of LUCC has been one of superb science, excitement and surprise, and has raised new questions and challenges that have caused us to reflect on the nature of IGBP itself and its ability to rise to these new challenges. As a result IGBP has restructured in recent years, with the outstanding success of LUCC providing a critical bridge to the new structure. Significant parts of LUCC and the Global Change in Terrestrial Ecosystems (GCTE) communities are spearheading the Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) and the Global Land Project (GLP). The latter has recently been officially launched in Bonn at the IDHP Open Science Conference, and its project Science Plan and Implementation Strategy has been published (see Centrefold this issue).

Others from the LUCC community are playing significant roles in the development of the ESSP joint project on Global Environmental Change and Food Systems (GECAFS), which has a much strong emphasis on food system typologies, food vulnerability, scenario-building and decision support systems. Additionally, LUCC has contributed to the reformulation of AIMES and PAGES, and to the emergence of an integrated Earth System perspective in IGBP. The forthcoming LUCC synthesis book in the IGBP Series will provide a through and comprehensive account of the project’s achievements.

IGBP thanks all those who contributed to LUCC over the years (especially those who served on the Scientific Steering Committee or staffed the Project Office), and welcomes and encourages their continued involvement in the activities of the restructured IGBP.

In September 2005, around 80 scientists and science managers (primarily from Africa) met for three days in Nairobi, Kenya, to discuss the need for, and nature of, a formal regional network to coordinate and promote Earth System and global change research in Africa.

African Global Change Research Network – Progressing the Concept

The workshop also sought to (i) identify the foundations, based on past initiatives, for further developing scientific networking among African scientists and with the international community at large; (ii) recommend structures and modalities and help identify future funding strategies for an African global change research network, and begin the process of seeking long-term international support from potential partners and sponsors, and (iii) help to build high-quality, truly global, Earth System science capacity, sharing scientific agendas, concerns and resources.

A series of plenary talks provided important background for the participants, including a summary by Bob Scholes of the pertinent report he and colleagues have recently prepared–*Global Change and the New Partnership for African Development (NEPAD)*. However, the majority of the three days was spent in four parallel workshop sessions: (i) governance and structural organisation, (ii) funding and partnerships, (iii) key thematic global change research issues, and (iv) the policy-science-practice interface.

The workshop concluded with strong agreement that a formal regional network is needed for African global change research. A formal network would: provide a new significant, independent funding opportunity; facilitate access to funding; facilitate knowledge transfer; provide Africa-wide research prioritisation and advocacy; help coordination and convergence of research agendas; and provide a unified voice to policy.

The mooted network would most likely have two interrelated components; firstly, a formal governance structure that might include a general assembly, advisory board and secretariat, and secondly, a less formal forum for dialogue amongst science, policy and society. It was clear that a network would require both internal (e.g. African research organisations and national research councils) and external (e.g. EU and UN agencies) funding.

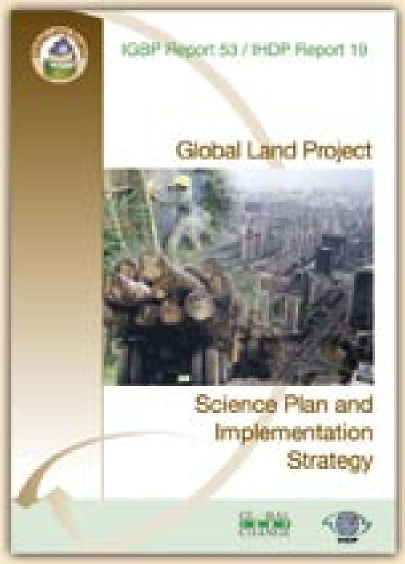
It was concluded that of the many global change research issues, the network should focus efforts on the issues of greatest relevance to sustainable development within Africa, these being: (i) water and climate modelling, (ii) desertification, (iii) land degradation, biodiversity, and food security, (iv) health and pollution, and (v) aquatic ecosystems.

An organising committee with broad regional representation was identified at the meeting to progress the network. Over the coming 6–9 months a more formal body (secretariat) will be established with the necessary funding to develop the network and arrange a first Dialogue Forum Meeting.

The Nairobi workshop was organised by the Earth System Science Partnership and the International Council for Science (African Office, Pretoria) with support from the US National Science Foundation, the New Partnership for African Development and the National Research Foundation of South Africa. For further information contact Eric Odada, Pan-African START Secretariat (eodada@uonbi.ac.ke) or Robert Kriger, ICSU African Regional Office (r.kriger@icsu-africa.org).

Photograph: Sospeter Muhongo (Director, Regional Office for Africa, International Council for Science) speaking during the plenary session of the workshop.

Global Land Project – Science Plan & Implementation Strategy



The Global Land Project (GLP) is a new IGBP-IHDP project to improve the understanding of the coupled human-terrestrial environment system in the context of Earth System functioning. GLP will build on the extensive heritage of IGBP and IHDP networks of scientists, data and largely disciplinary understanding, particularly from the IGBP project on Global Change and Terrestrial Ecosystems (GCTE) and from the joint IGBP-IHDP project on Land Use and Cover Change (LUCC). The GLP Science Plan and Implementation Strategy can be downloaded from www.glp.colostate.edu. Here, an overview of the scope of the GLP science agenda is provided.

Human transformations of ecosystems and landscapes are the largest source of change on Earth, affecting the ability of the biosphere to sustain life. Humans have become ever more adept at appropriating and altering the Earth's resources for their needs. Intensification and diversification of land use and advances in technology have led to rapid changes in biogeochemical cycles, hydrologic processes and landscape dynamics. Changes in land use and management affect the states, properties and functions of ecosystems, which affect ecosystem service provision and hence human well-being.

Links between decision-making, ecosystem services and global environmental change define important pathways of feedback from coupled human-environment activities at the local and regional scale, and to and from the global scale. However, there is a need for greatly improved understanding of how human actions affect natural processes of the terrestrial biosphere, and an even greater need to evaluate the consequences of these changes. The goal of GLP is therefore: to measure, model and understand the coupled human-environmental system.

Every point on Earth can be defined along a continuum of states (from wilderness to mega-cities) resulting from the interactions between societal and natural dynamics (Figure 1). The dynamic of this continuum generally, but not always, moves towards increasing human occupation and impact. Abandoned farmland may return to forest, and clear-felled forests may re-grow; however, once an area carries human structures it seldom reverts to open land. The time scales of movement along this continuum vary. Human development may occur in years, even months as economic and social opportunities arise, but return to a wilderness landscape may take centuries. GLP aims to define this continuum more explicitly, to quantify the rates of landscape change, and to explain the underlying causalities and decisions involved.

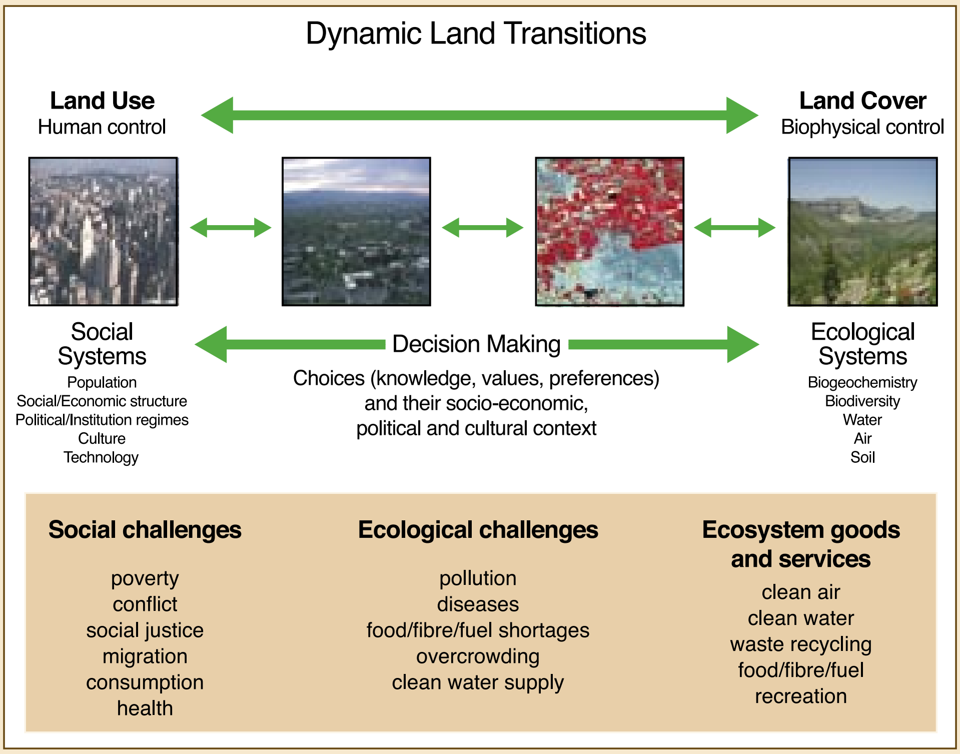


Figure 1. The continuum of states resulting from the interactions between societal and natural dynamics.

GLP has three objectives that determine the research framework (Figure 2):

(i) to identify the agents, structures and nature of change in coupled human-environment systems on land, and to quantify their effects on the coupled system;

(ii) to assess how the provision of ecosystem services is affected by the changes in (i) above; and

(iii) to identify the character and dynamics of vulnerable and sustainable coupled human-environment systems to interacting perturbations, including climate change.

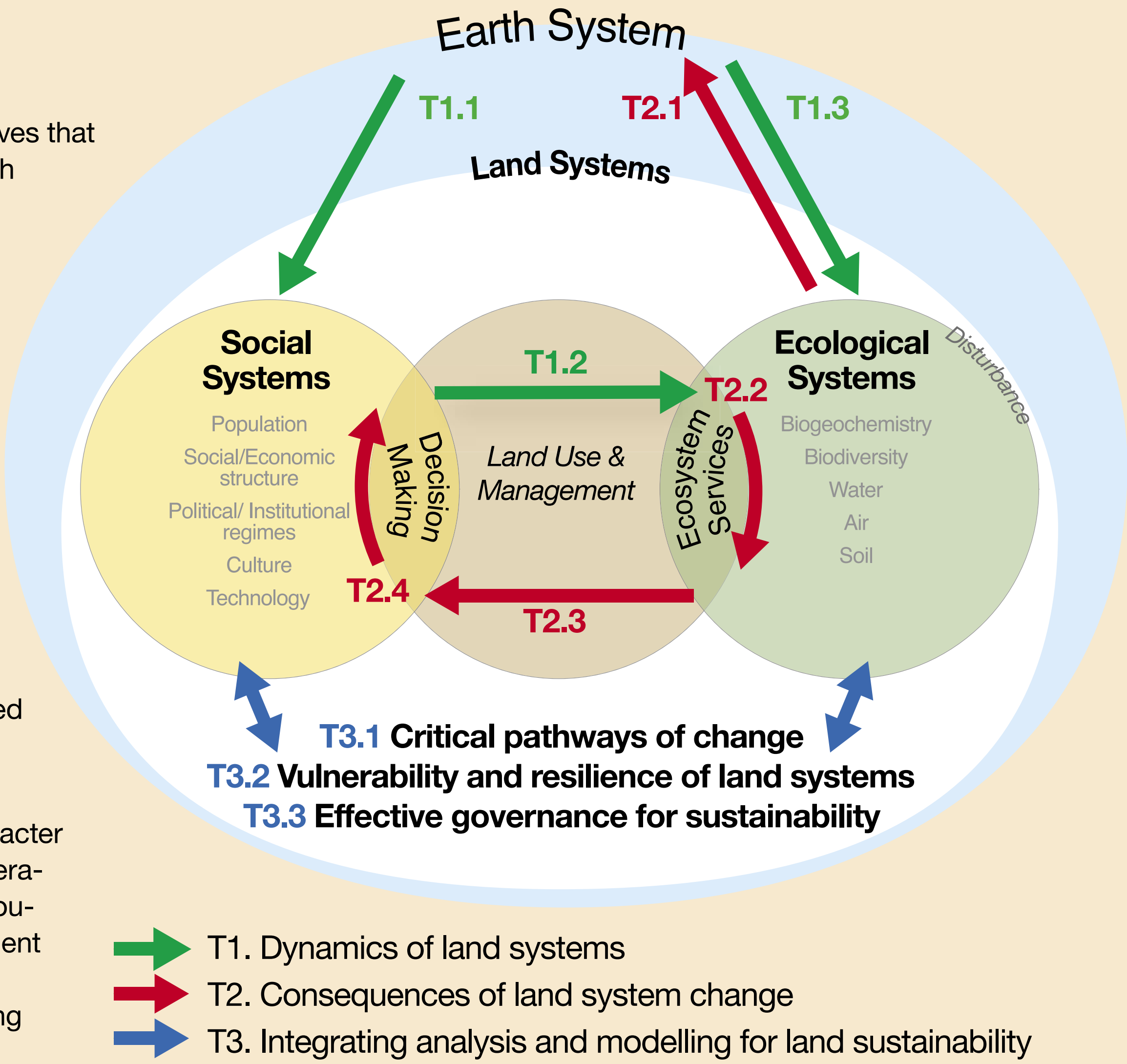


Figure 2. The GLP analytical structure.

Three thematic areas emerge from these objectives: (i) the dynamics of land systems; (ii) the consequences of land system change; and (iii) integrating analysis and modelling for land sustainability.

Theme 1: Dynamics of Land Systems

Issue 1.1: How do globalisation and population change affect regional and local land use decisions and practices?

Issue 1.2: How do changes in land management decisions and practices affect biogeochemistry, biodiversity, biophysical properties and disturbance regimes of terrestrial and freshwater ecosystems?

Issue 1.3: How do the atmospheric, biogeochemical and biophysical dimensions of global change affect ecosystem structure and function?

Theme 2: Consequences of Land System Change

Issue 2.1: What are the critical feedbacks to the coupled Earth System from ecosystem changes?

Issue 2.2: How do changes in ecosystem structure and functioning affect the delivery of ecosystem services?

Issue 2.3: How are ecosystem services linked to human well-being?

Issue 2.4: How do people respond at various scales and in different contexts to changes in the provision of ecosystem services?

Theme 3: Integrating Analyses and Modelling For Land Sustainability

Issue 3.1: What are the critical pathways of change in land systems?

Issue 3.2: How do the vulnerability and resilience of land systems to hazards and disturbances vary in response to changes in human-environment interactions?

Issue 3.3: Which institutions enhance decision making and governance for the sustainability of land systems?

Discussion Forum

Everybody agrees that the Sun drives the Earth's climate system. Every second, the Sun loses around four million tons of weight which are irradiated into space mainly in the form of visible light. One billionth of this power (1,017 W) arrives at the top of the Earth's atmosphere – an amount which corresponds to about 10,000 times humankind's present global consumption. This solar power arriving at the top of the atmosphere is known as the "solar constant" (1,365 W m^{-2}).

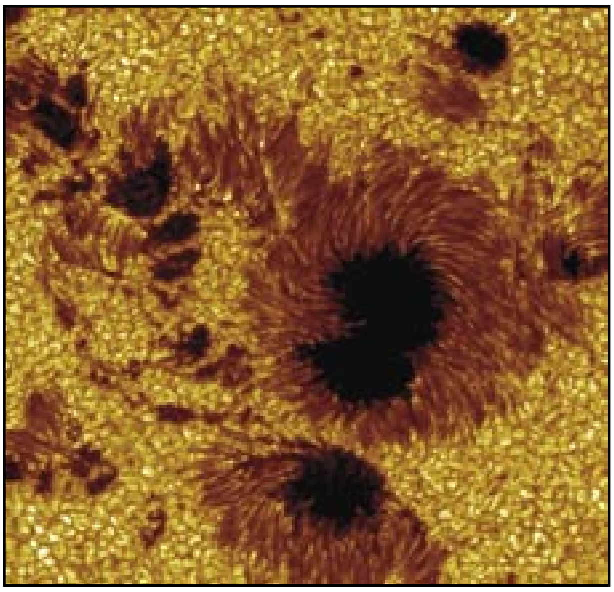
Solar Variability and Climate Change

Until recently, almost no-one believed that the Sun had anything to do with climate change. A small number of scientists had tried to test whether the solar constant really is constant. As they were only able to observe the Sun from the surface of the Earth they failed, because absorption of the sunlight crossing the atmosphere fluctuates. It was only in the satellite era that it became possible to continuously monitor the solar constant from outside the Earth's atmosphere. A compilation of several instrumental records clearly shows that the solar constant is indeed not constant [1], but varies with solar activity as indicated by the number of sunspots (Figure 1). However, over an eleven-year cycle the observed change is quite small – only about 0.1%. From these results many people conclude that solar forcing of the climate does occur, but is negligible.

However, in addition to these direct measurements of the solar constant (more appropriately called total solar irradiance – TSI), there are several pieces of indirect evidence proving that the Sun is a variable star and that these variations may well influence climate change. Herein, some aspects of the different mechanisms and amplitude of solar variability are described, together with descriptions of the corresponding sensitivity of the climate system.

In contrast to TSI, changes in the ultra-violet part of the solar spectrum are large, and affect the ozone content in the stratosphere. Model calculations show that these changes can ultimately affect the circulation of the lower atmosphere [2]. While these changes in total and spectral irradiance are caused by processes on the solar surface, models describing the lifetime of the Sun (approximately 10 billion years) show that 4.5 billion years ago when the solar system was created, TSI was lower by about 30%. Since then it has steadily increased, and will continue to do so for about another 4 billion years. A very interesting question is how the Earth System managed to avoid becoming an "ice house"; this is known as the "faint young Sun paradox".

For much shorter – but still quite long – time scales, there is some unique information. The amount of solar radiation arriving at the top of the atmosphere is not only related to the emission from the Sun, but also to the position of the Earth relative to the Sun. As a consequence of the gravitational forces of other planets in our solar system (mainly Jupiter and Saturn), the orbital parameters of the Earth change with periodicities ranging from 100,000–400,000 years (eccentricity), through approximately 40,000 years (tilt angle) to periodicities of around 20,000 years (precession of the Earth's axis). The theory of orbital forcing which was developed to a



Sunspots July 2002. Image from Institute of Solar Physics, Royal Swedish Academy of Sciences. See cover for more details.

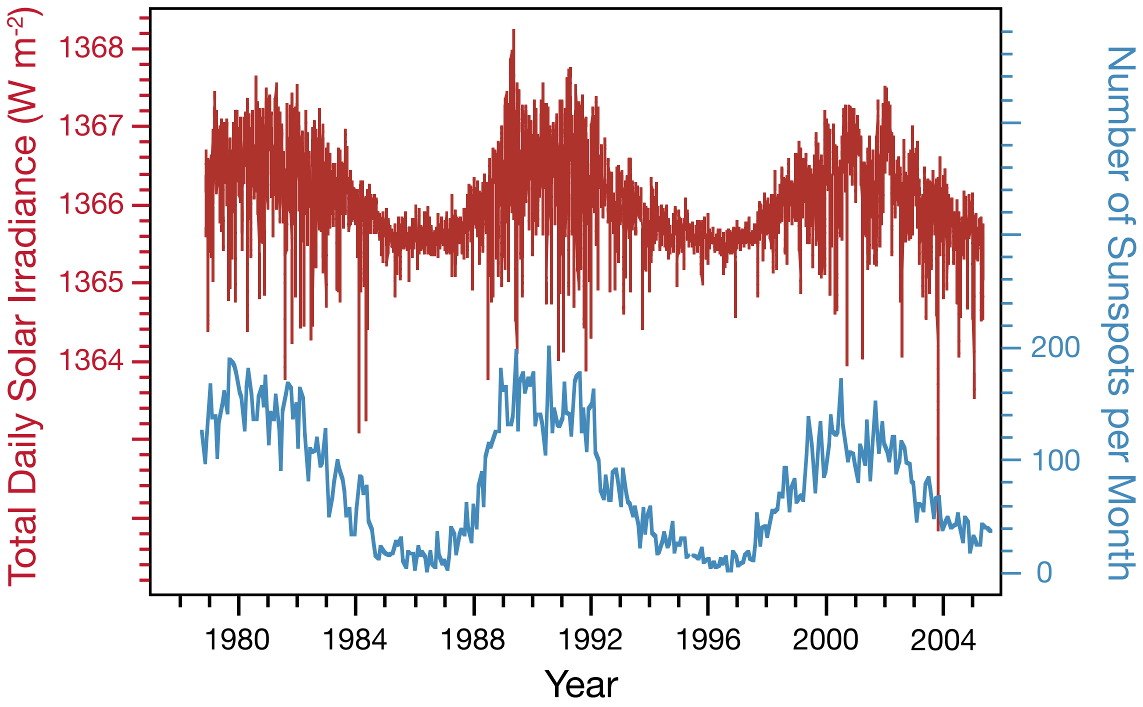


Figure 1. Total solar irradiance (TSI) measured from satellite-based radiometers (daily values) compared with the corresponding number of sunspots per month. TSI data from www.pmodwrc.ch/, sunspots data from sidc.oma.be/index.php3.

large extent by Milutin Milancovic, is unique in the sense that it is the only forcing which can be calculated precisely, not only for the past several million years, but also for the future [3]. The measured $\delta^{18}O$ record of the GRIP ice core (Greenland) indicates the temperature changes during the past 100,000 years, and is plotted here together with the calculated solar insolation (solar radiation reaching the Earth's surface) at 72° N (latitude of the GRIP ice core) during the months July and August (Figure 2). Although the $\delta^{18}O$ record is mainly characterised by the abrupt changes of the so-called Dansgaard-Oeschger events due to changes in the deep-water formation of the North Atlantic, the general long-term trend agrees quite well with insolation changes, except in the past 10,000 years.

The biggest effect of the orbital forcing is the cyclic change between glacial periods and inter-glacial periods over the past 700,000 years, with a periodicity of 100,000 years. This is surprising because the corresponding mean annual change in forcing is very small (~0.2 W m^{-2}). This raises questions regarding the sensitivity of the climate system which are discussed below.

A fundamental problem in assessing the effect of any change in forcing, is the fact that the climate system consists of many components which interact in non-linear ways on very different spatial and temporal scales. Due to positive feedback mechanisms, even very weak but persistent forcing signals can be amplified and lead to strong effects. The sensitivity of the climate system is investigated by means of climate models which are designed to simulate reality [4]. Unfortunately, the closer the climate models approach the complexity of the climate system, the less they are able to simulate orbital forcing effects on time scales of 20,000–100,000 years.

The final issue is the question whether in view of the uncertainty in the forcing and the sensitivity to it, there is any evidence for solar forcing in palaeoclimate records. Clearly on multi-millennial time scales solar forcing is active (Figure 2), and Figure 1 suggests a weak relationship between TSI and solar activity. If true, this offers the possibility to estimate solar irradiance in the past. The sunspot record, which goes back to 1610 when the telescope was invented, clearly shows that the satellite era is characterised by comparatively high solar activity. Periods like the Maunder Minimum (1645–1715) were quite different, with almost no sunspots. This suggests a TSI considerably lower than during the past 30 years. However, we do not yet know how much lower; anything between 0.1% and 1% is possible. But what did the Sun do before 1600?

Using cosmogenic radionuclides such as ^{14}C, ^{10}Be and ^{36}Cl which are produced by the interaction of cosmic rays with the atmosphere, it is possible to reconstruct the solar activity over the past 10,000 years. This gives a first order estimate of solar forcing based on the suggested relationship between

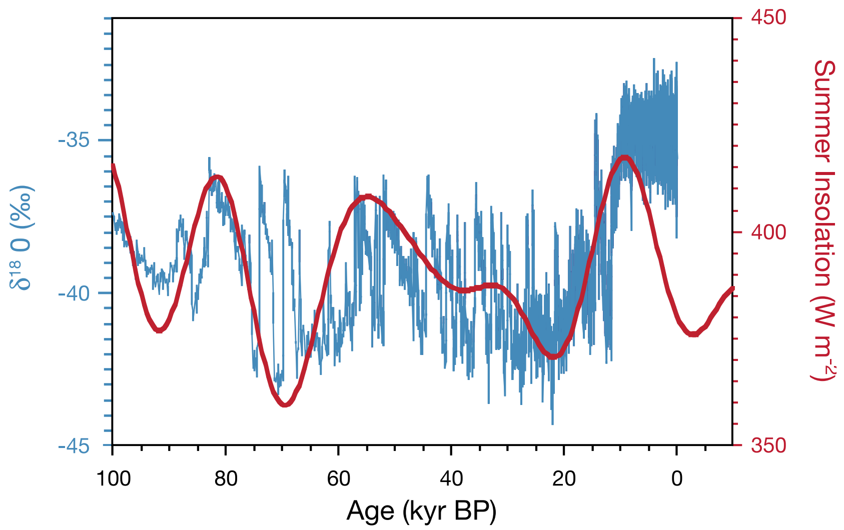


Figure 2. Comparison of the $\delta^{18}O$ record from the GRIP ice core (Greenland) indicating climate change over the last 100,000 years ago and the corresponding summer insolation at this site. $\delta^{18}O$ data from www.ncdc.noaa.gov/paleo/icecore/greenland/summit/document/gripisot.htm and insolation values calculated with AnalySeries www.ncdc.noaa.gov/paleo/softlib/softlib.html.

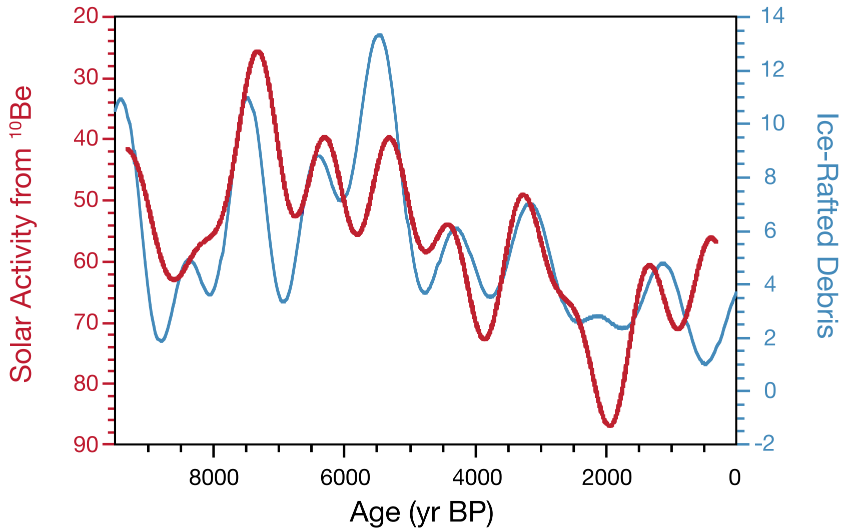


Figure 3. Comparison of ice-rafted debris in North Atlantic sediments (Bond, personal communication) with solar activity derived from ^{10}Be (arbitrary units) (Vonmoos, personal communication). Both records are low-pass filtered with a cut-off frequency of 900 yr^{-1}.

solar activity and solar irradiance [5]. A growing number of high resolution and well-constrained reconstructions of the palaeoclimate during the Holocene, reveal considerable climate changes which point to external forcing. Prior to the industrial era the anthropogenic influence on the climate was probably negligible, so we are basically left with solar and volcanic forcing. The fact that many of the palaeorecords show a relatively high correlation with the reconstructed solar activity, indicates that solar forcing does indeed play an important role.

An example of such correlations is the comparison of ice-rafted debris in the North Atlantic with the solar activity record derived from ^{10}Be in the GRIP ice core (Greenland) [6] (Figure 3). Ice-rafted debris consist of characteristic particles which are picked up by the glaciers moving towards the sea where they break up into icebergs. The origin of some particles is well known: hematite stained grains can be traced back to an area in Greenland, and glass particles originate from volcanic eruptions in Iceland. As the icebergs drift southwards, they slowly melt and release the particles which finally find their way into the sediments. If the climate is generally cold, the icebergs drift further south than during warm periods – as the Titanic experienced in 1912. On longer time scales cold periods with large numbers of ice-rafted debris coincide quite well with periods of low solar activity (high ^{10}Be concentration; Figure 3), as suggested by the direct measurements of total and spectral solar irradiance. Differences arise due to uncertainties in the time scales of the sediment and the ice core, other forcing factors and the non-linear response of the climate system.

Solar forcing is of course just one forcing factor, and understanding climate change requires considering all the different forcing factors. A better knowledge of the natural forcing factors during the industrial era will lead to a better quantification of the anthropogenic forcing, and ultimately to better predictions of the future climate change.

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Emissions from human activities have substantially increased the amount of particulate matter (aerosol particles) in the atmosphere since pre-industrial times. These aerosol particles consist of a variety of chemical species: the major anthropogenic species being sulphates and particles containing carbon, such as soot and organic matter.

Solar Dimming

Aerosol particles affect the climate system via three physical mechanisms. Firstly, they scatter, and can absorb, radiation from the Sun. Secondly, they can scatter, absorb and emit long-wave radiation. These two mechanisms are referred to as aerosol direct effects and cause a net negative forcing at the top of the atmosphere. Thirdly, aerosol particles act as nuclei onto which cloud droplets and ice crystals can form. For a given amount of cloud condensate, an increase in cloud condensation nuclei leads to a higher surface area, and hence more reflection of solar radiation – the so-called "cloud albedo effect". At the same time, these more numerous but smaller cloud droplets retard precipitation formation, because smaller droplets are less likely to collide and to grow to precipitation size drops. This increases the lifetime of polluted water clouds and is referred to as the "cloud life-time effect". On the other hand, aerosols that can absorb solar radiation, such as black carbon (also known as soot) or to a lesser degree mineral dust, can lead to a warming of the surrounding air. This warming can prevent cloud formation because the atmosphere becomes more stable, or can even lead to an evaporation of cloud droplets. This "semi-direct effect" thus counteracts some of the negative aerosol forcings at the top of the atmosphere [e.g. 1].

At the Earth surface scattering and absorbing aerosols both work to reduce the amount of solar radiation reaching the surface. Since pre-industrial times, increasing emissions of aerosols and aerosol precursors from human activity have caused a reduction of solar radiation at the surface ("solar dimming") by increasing aerosol and cloud optical depth. Such a reduction has been observed in many regions worldwide, including remote sites like Mauna Loa and Arctic and Antarctic stations, as well as in industrial regions [2–5].

The decline of solar radiation from 1961 to 1990 amounts to 1.3% per decade over the global land surface. While the strongest declines (3.3% per decade) have occurred over the United States, surface solar radiation has also declined over Europe and the former Soviet Union [3]. It has been estimated that during the dry winter monsoon season over the Indian Ocean region, anthropogenic aerosols – especially the highly absorbing aerosols, can decrease the average solar radiation absorbed by the surface by 15–35 W m^{-2} [6].

Despite this decrease in surface solar radiation, land surface temperatures have increased by 0.4 K between 1961 to 1990 [7], indicating that the increase in the downward long-wave radiation has not been sufficient to outweigh decreased insolation [5]. Surface evaporation must therefore have decreased, suggesting that the observed intensification of the hydrological cycle over extratropical land is more likely due to increased moisture advection from the oceans than due to increased local moisture release through evaporation.

Likewise, both equilibrium [8] and transient [9] simulations using a global climate model coupled to a mixed-layer ocean model with increasing aerosols and greenhouse gases due to human activity from pre-industrial times to the present, showed that solar radiation decreases at the surface resulting from increases in optical depth due to direct and indirect anthropogenic aerosol effects, are more important for controlling the surface energy budget than the greenhouse gas induced increase in surface temperature. The conductive flux from below the surface is negligible in the long-term mean surface energy budget. The other components of the surface energy budget (thermal radiative flux, sensible and latent heat fluxes)

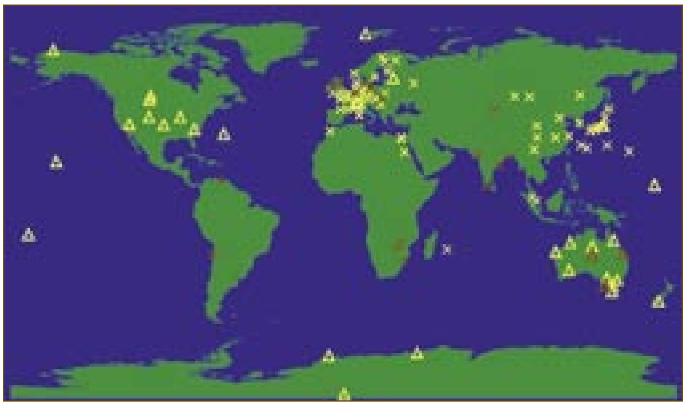

Figure 1. Changes (yellow=increase, red=decrease) in solar radiation after 1990 at surface observation sites from the updated Global Energy Balance Archive used in this study. Triangles indicate high-quality Baseline Surface Radiation Network sites. Information from 300 sites over Europe and 45 sites over Japan are displayed as aggregated regional means. From [10].

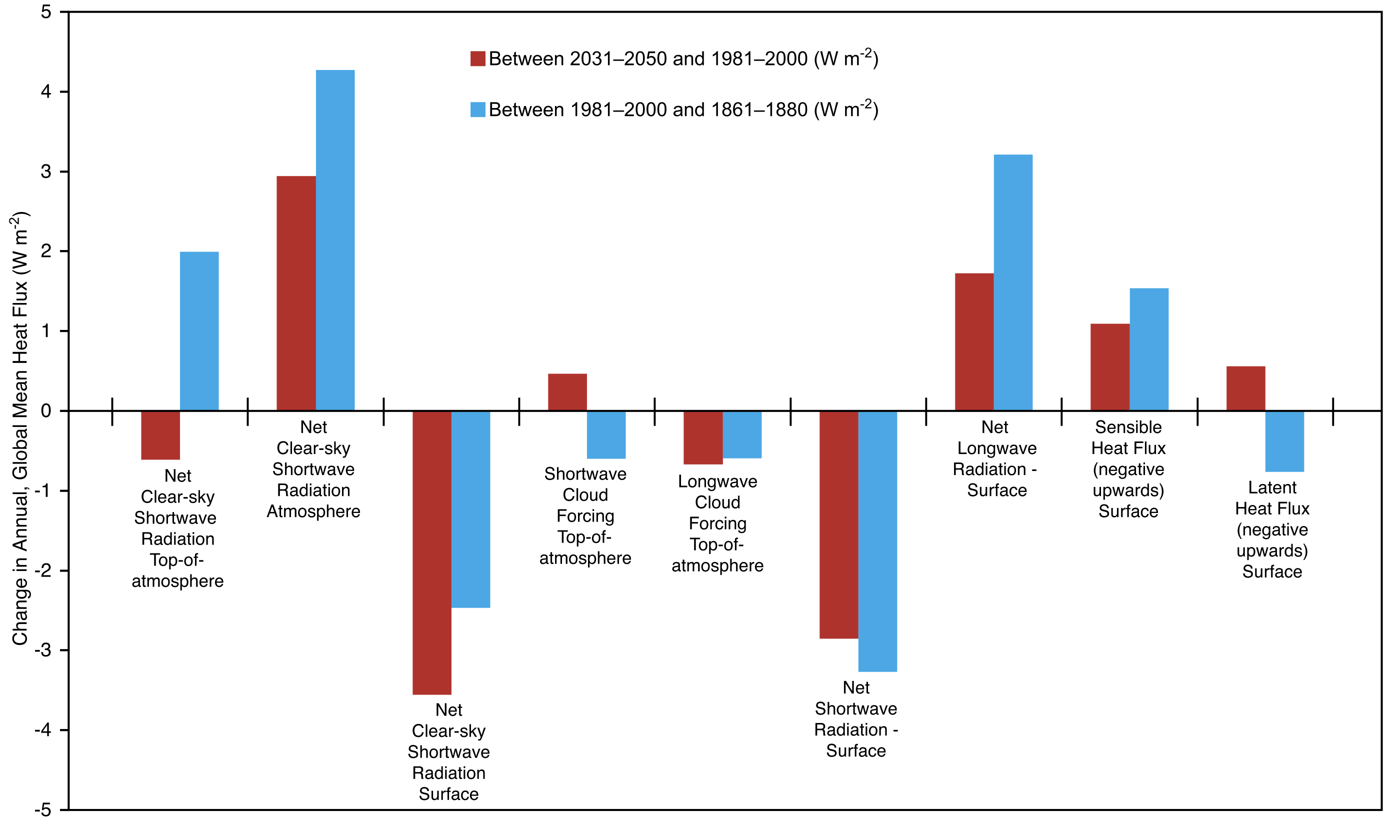

Figure 2a. Changes in annual, global mean heat fluxes.

decreased in response to the reduced input of solar radiation. This mechanism could explain the observations of decreased pan evaporation over the last 50 years [see 10] and the historic surface temperature [5]. As evaporation must equal precipitation on the global scale in equilibrium climate simulations, a reduced latent heat flux led reduced precipitation.

Recent surface observations show that the long-term decline in solar radiation at the land surface reversed during the 1980s [11] (Figure 1), in agreement with recent emission trends in the "old" industrial regions of the northern hemisphere [12], long-term black carbon trends in the Canadian Arctic [13] and post-1978 sulphate deposition declines over Europe and North America (E. Holland, *pers. comm.*). In addition, there is some evidence for a decline in cloud amount and planetary albedo during the 1990s which would increase surface solar radiation [14,15]. Satellite data have been used to show an overall increase in surface solar radiation between 1983 and 2001 of 0.16 W m^{-2} yr^{-1} (0.10% yr^{-1}) [16]. This change is a combination of a decrease until around 1990, followed by a sustained increase. Thus, the increasing greenhouse effect may no longer be masked by an aerosol-induced decline in solar radiation, resulting in the enhanced warming observed since the 1990s [11].

Climate model simulations suggest that the decrease in global mean precipitation from pre-industrial times (1861–1880) to the present-day, may reverse into an increase in global mean precipitation of about 1% for 2031–2050 compared to 1981–2000. This is because increased warming due to greenhouse gases will outweigh sulphate cooling in the mid-21st century [17] (Figure 2). In South Asia, absorbing aerosols in atmospheric brown clouds may have played a major role in the observed South Asian climate and hydrological cycle changes, and may have masked as much as 50% of the surface warming due to the global increase in greenhouse gases [18]. Simulations suggest that if current trends in emissions continue, it is possible that the South Asian subcontinent may experience a doubling of the drought frequency in future decades [19].

The overall picture is one of an end to the trend of solar dimming in major industrialised regions, but a continuation of surface solar radiation decline over India and Southern Africa (Figure 1).

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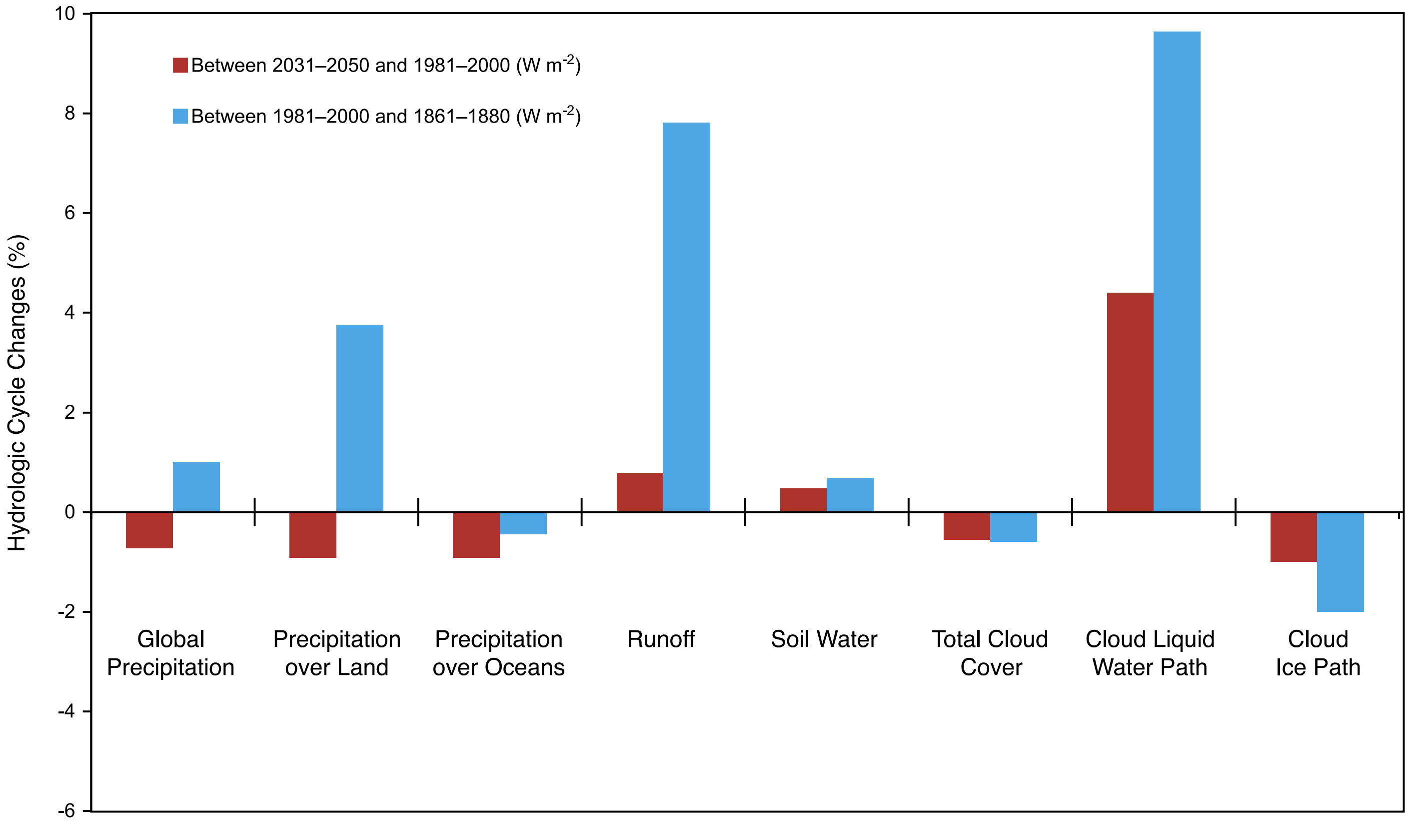

Figure 2b. Components of the hydrological cycle [adapted from 16].

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In the Profile of a Scientist section we aim to feature "early-career" scientists who are making important contributions to Earth System science and to IGBP. We will strive to achieve gender, discipline and developed/developing country balances in this section. The Editor welcomes suggestions from readers for scientists to profile in the Global Change NewsLetter.

Profile of a Scientist: Petra Tschakert

Petra Tschakert is an Assistant Professor of Geography and the Alliance for Earth Sciences, Engineering and Development in Africa at Pennsylvania State University.

"It must have been the books I read as a child that triggered my interest in desert environments and other wide-open spaces", says Petra. "I would get absolutely absorbed by the novels of Karl May, a turn-of-the-century author who used his vivid imagination and thorough inquiries to portray human-environment interactions in drylands of the Middle East and the American Southwest." During a geography field trip to Tunisia 20 years ago Petra first experienced life in marginal, semi-arid environments, an encounter that still inspires her work.

After completing her Master's degree in geography in Austria, Petra led a small-scale three-year natural resource management project in northern Senegal. "This experience certainly changed my life" Petra reflects; it being a glimpse into the complexity of land use coupled with the perpetual struggle of agricultural and pastoral land users to secure livelihoods under climatic, economic and political uncertainty and risk. "I remember this time as a truly humbling experience. It taught me to pay closer attention to dynamic processes and adaptive capacity, as well as to unpredictability and surprise, both in human systems and ecosystems. More importantly, it prompted my scientific interest in global environmental change and sustainability."

Since the 1990s Petra has been driven by the question of how to make Earth System research results more accessible and useful to decision-makers. Remarkable technological advances (primarily high-resolution remotely sensed imagery and biogeochemical modeling), have allowed us to detect, monitor, quantify and predict local to global land use and land cover changes with increasing accuracy. Researchers throughout West Africa, for instance, now use these tools to identify 'hotspots' of vegetation degradation and improvement and deduce information on biomass and carbon stock, as well as the implications for global climate change. Where our understanding is still incomplete is on what drives these changes – social, economic, institutional, and policy factors that shape livelihood strategies and land use patterns of those who own and manage the land.

Intrigued by interdisciplinary approaches in human dimensions of global environmental change, Petra began a PhD in Arid Lands Resource Sciences with a minor in Applied Anthropology at the University of Arizona. "I was originally investigating the possible use of seasonal climate forecasts for the Sahel as a means to predict and prevent food shortages and famine among vulnerable populations. But I soon got discouraged by – at the time – high uncertainties in the forecasts themselves", Petra recalls. "It would have been like adding another layer of uncertainty to the multiple stressors and risks farmers in African drylands experience in their daily lives."

Encouraged by her former advisor, Chuck Hutchinson, and by the emerging debates on synergistic linkages between soil carbon sequestration in degraded drylands and poverty reduction, Petra shifted her scientific direction and became one of the first researchers to investigate the potential of the Clean Development Mechanism at the community level. One of the key findings of her work on the potential for carbon offset programmes in Senegal was that the majority of smallholders, especially those with low resource endowments, would not have the necessary start-up capital to invest in improved land use and management practices such as long-term fallow, reforestation, agroforestry and integrative biomass management. Given the modest carbon sequestration potential in dryland farming systems, well-targeted programmes with front-loaded payments, flexible management plans and institutional strengthening would be required to reconcile poverty alleviation and long-term environmental management.

After having worked briefly with indigenous people at the tropical forest margin in Panama, Petra now collaborates with researchers in Ghana, Mali, Niger, and Burkina Faso as part of a Sahel-wide climate change mitigation and adaptation assessment. Although biogeochemical modelling of soil organic carbon constitutes the bulk of the research, Petra is increasingly interested in the linkage between farmers' adaptive capacity to multiple stressors – with climate change being one of several threats perceived and experienced – and land use and management decisions. So far, social science contributions in the field have mainly focused on people's assets as main drivers of adaptive responses to environmental and climate change, while the role of cognitive factors in decision-making processes have been largely ignored. "This is an exciting new direction in integrative global change research because it helps fine-tune the design of future management scenarios and test their viability together with actors in the field", Petra explains.

One of Petra's personal goals is to increase the visibility of her African colleagues in global environmental change research. Even more importantly, she has a strong commitment to linking science with political decision-making. "The growing scientific understanding of integrative Earth System dynamics is exhilarating. What preoccupies me is the disconnect between technical sophistication to assess and predict current and future land use on the one hand, and empowerment – or lack thereof – of land users and other stakeholders to make informed decisions on the other. IGBP can help bridging this gap. This is where all of us should be creative and innovative."

Earth System Science Partnership Open Science Conference

Global Environmental Change:

Regional Challenges

Beijing, China
9–12 November 2006

This conference will present advances in our understanding of the natural and socio-economic aspects of global environmental change since the Amsterdam Conference, and will highlight the ESSP approach to study of the Earth System.

Conference Themes

- Advances in our understanding of the physical, biogeochemical, biodiversity, and human dimensions of global environmental change.
- Science in support of global sustain ability with special sessions on global environmental change research as it relates to food, water, carbon and human health.
- Dynamics, interactions and feedbacks relating to natural and socio-economic systems at regional scales and how these interact with global-scale phenomena.
- Research concerning global environmental change in Monsoon Asia.

We invite scientists, policy makers, practitioners, scholars, private enterprise and journalists to participate in this conference and to submit abstracts. Prior to the main conference, the 2nd International Young Scientists Global Change Conference (7–8 November 2006) will provide an opportunity for selected young scientists to present and discuss their work.

Call for sessions:
Oct–Nov 2005
Registration now open

DIVERSITAS
IHDP
Earth System Science Partnership
GLOBAL IGBP CHANGE
WCRP

www.essp.org/essp/ESSP2006/

GLOBAL IGBP CHANGE

SCIENCE COMMUNICATOR

for the International Geosphere-Biosphere Programme

Applications are invited for the position of Science Communicator for the International Geosphere-Biosphere Programme (IGBP). IGBP is an international research programme that provides scientific knowledge about the Earth System in response to the challenges of global sustainability. IGBP scientists study the interactions between biological, chemical and physical processes, and human systems. IGBP collaborates with other international programmes to develop and impart the understanding necessary to respond to global change. IGBP is organised under the aegis of ICSU and its 10-person Secretariat is headquartered at the Royal Swedish Academy of Sciences in Stockholm.

The Science Communicator will direct the communications efforts of IGBP, including internal communications amongst IGBP projects and project scientists, and outward communications with the wider science community, the education sector, policy makers, the media and the public. A key function of the Science Communicator is to assist IGBP in generating and communicating impartial, policy-relevant science.

The successful candidate will:

- ✓ have demonstrated experience in effectively translating the results of scientific research into forms appropriate for a range of difference audiences including policy makers, educators, the media and the general public;
- ✓ be capable of refining and guiding the implementation of a long-term science communication strategy for a large and diverse international scientific network;
- ✓ have excellent verbal and written communication skills in English and experience in science communications or science journalism;
- ✓ have demonstrated experience in planning and implementing media campaigns;
- ✓ coordinate a portfolio of communication activities;
- ✓ be able to initiate and manage a large and complex workload to tight deadlines and be responsible for communications outcomes; and
- ✓ have highly developed interpersonal skills, and the ability to work in a multi-cultural environment; and
- ✓ be willing to undertake international travel.

The Science Communicator will be appointed initially for a 3-year period, will be an employee of the Royal Swedish Academy of Sciences, and will report to the IGBP Executive Director. The salary is negotiable, but will be based on the salary structure of the Royal Swedish Academy of Sciences (roughly equivalent to Swedish academic salary structure) and will consider the qualifications and experience of the candidate.

Applications should address all selection criteria (available on request) and include a curriculum vitae, three personal references, and brief, representative examples of previous work.

Applications must be received by the IGBP Secretariat no later than 30 November 2005. Interviews will be held 9–13 January 2006.

For further information and submission of applications contact:

Charlotte Wilson-Boss: IGBP Secretariat,
Royal Swedish Academy of Sciences,
Box 50005, SE 104 05 Stockholm, Sweden;
Tel (+46-8) 16 64 48, Fax (+46-8) 16 64 05,
email charlottew@igbp.kva.se
www.igbp.net.

IGBP and Related Global Change Meetings

A more extensive meetings list is held on the IGBP web site at www.igbp.net.

4th GKSS School of Environmental Research Environmental Crises: Science and Policy

02–11 November, Delmenhorst. Germany

Contact: coast.gkss.de/events/4thschool/

1st National Meeting of the Mexican Carbon Program

07–08 November, Mexico City. Mexico

Contact: jmartine@ine.gob.mx

1st DIVERSITAS International Conference on Biodiversity.

09–12 November, Oaxaca, Mexico

Contact: www.diversitas-osc1.org or secretariat@diversitas-international.org

ICARP II. Research Planning to Understand the Arctic System in a Changing World

10–12 November, Copenhagen, Denmark

Contact: www.icarp.dk or icarp@dpc.dk

Greenhouse 2005: Action on Climate Control

13–17 November, Melbourne, Australia

Contact: www.greenhouse2005.com

Climate Science in Support of Decision Making

14–16 November, Arlington, VA, USA

Contact: www.climatescience.gov/workshop2005/contribpres.htm

3rd International Conference on Plants and Environmental Pollution (ICPEP-3)

29 November-02 December, Lucknow, India

Contact: http://www.geocities.com/isebindia/index.html

International Organisations and Global Environmental Change: Berlin Conference on the Human Dimensions of Global Environmental Change

02–03 December, Berlin, Germany

Contact: www.fu-berlin.de/ffu/akumwelt/bc2005/

AGU Fall Meeting

05–09 December, San Francisco, USA

Contact: www.agu.org/meetings/fm05/fdfdf

1st International Conference on Water Resources in the 21st Century

26–28 December, Alexandria, Egypt

Contact: www.ewra.com

2006

Ecology in an Era of Globalisation: Challenges and Opportunities for Environmental Scientists in the Americas

08–12 January, Merida, Mexico

Contact: www.esa.org/mexico

4th Franco-British Climate Change Seminar for Young Researchers: Climate-Society Interactions – Case Studies from Africa

9-12 January, Paris, France

Contact: http://www.britishcouncil.org/france-science-inys.html

EcoMod Modelling School

16–21 January, Bangkok, Thailand

Contact: www.ecomod.nt or Theresa.leary@ecomod.net

1st iLEAPS Science Conference

21–26 January, Boulder, CO, USA

Contact: www.atm.helsinki.fi/ILEAPS/boulder or ileaps-ipo@helsinki.fi

Workshop on Flux Measurement in Difficult Conditions

26–28 January, Boulder, CO, USA

Contact: www.atm.helsinki.fi/ILEAPS/fluxworkshop2006/

ERCA 2006: European Research Course on Atmosphere

09–11 February, Grenoble, France

Contact: www-lgge.obs.ujf-grenoble.fr/enseignement/erca/home.html

AAAS Annual Meeting (with IGBP Session: Vital Organs in the Earth System: What is the Prognosis?

16–20 February, St. Louis, Missouri, USA

Contact: www.aaas.org/meetings/Annual_Meeting/

AGU Ocean Science Meeting (with SOLAS and GLOBEC sessions)

20–24 February, Honolulu, Hawaii

Contact: www.agu.org/meetings/ or os-help@agu.org

4th World Water Forum: Local Actions for a Global Challenge

16–22 March, Mexico City, Mexico

Contact: www.worldwaterforum4.org.mx./home/home.asp

Workshop on Tropical Cyclones and Climate

27–29 March, Palisades, NY, USA

Contact: iri.columbia.edu/outreach/meeting/TropicalCyclones/index.html

PICES/GLOBEC Symposium: Climate variability and ecosystem impacts on the North Pacific – A Basin-scale Synthesis

19–21 April, Honolulu, USA

Contact: www.pices.int/meetings/international_symposia/Honolulu2006/default.aspx or secretariat@PICES.int

17th Global Warming International Conference and Expo

20–21 April, Miami, USA

Contact: gw17@globalwaming.net

8th International Conference on Southern Hemisphere Meteorology and Oceanography

24–28 April, Foz de Iguacu, Parana State, Brazil

Contact: www.cptec.inpe.br/SH_Conference/

Open LUCIFS Workshop 2006

12–14 May, Frankfurt/Geisenheim, Germany

Contact: web.uni-frankfurt.de/fb11/ipg/lucifs/2006/

AGU/GS/MB/MSA/SEG Joint Assembly

23–26 May, Baltimore Convention Center, Maryland, USA

Contact: www.agu.org/meetings/ja06/

Climate Changes and Their Impact on Boreal and Temperate Forests

05–07 June, Ekaterinburg, Russia

Contact: ecoinf.uran.ru/conference/

HOLIVAR 2006 Open Science Meeting: Natural Climate Variability and Global Warming

12–15 June, London, UK

Contact: www.holivar2006.org/

IGU 2006 Brisbane Conference: Regional Responses to Global Changes – A View from the Antipodes

03–07 July, Brisbane, Australia

Contact: www.igu2006.org

International Conference on Regional Carbon Budgets

16–18 August, Beijing, China

Contact: www.icrcb.org.cn

5th International NCCR Climate Summer School: Adaptation and Mitigation – Responses to Climate Change

27 August–01 September, Grindelwald, Switzerland

Contact: www.nccr-climate.unibe.ch

17th International Sedimentological Congress

27 August–01 September, Fukuoka, Japan

Contact: www.isc2006.com

Carbon Management at Urban and Regional Levels: Connecting Development Decisions to Global Issues

04–08 September, Mexico City, Mexico

Contact: penelope.canan@nies.go.jp

Biohydrology 2006 Conference

20–22 September, Prague, Czech Republic

Contact: www.ih.savba.sk/biohydrology2006/ or lichner@uh.savba.sk

2nd International Young Scientists' Global Change Conference

07–08 November, Beijing, China

Contact: ysc@agu.org

ESSP Open Science Conference: Global Environmental Change – Regional Challenges

09–12 November, Beijing, China

Contact: www.essp.org/essp/ESSP2006/ or catherine.michaut@ipsl.jussieu.fr

2007

SOLAS Science 2007: SOLAS Open Science Conference

06–09 March, Xiamen, China

Contact: www.uea.ac.uk/env/solas/meetings.html

17th International Union for Quaternary Research Congress

28 July–03 August, Cairns, Australia

Contact: INQUA2007@aqua.org.au

Vladimir Leonidovich Kasyanov
January 4, 1940 – October 1, 2005

Vladimir Kasyanov was an outstanding biologist, well known for his work on comparative embryology of marine organisms, his investigations and preservation of biota and his studies of biosphere evolution and climatic changes on the Earth. He formulated fundamental statements about reproductive strategies of sea invertebrates, and many of his articles and monographs were translated and published internationally. Vladimir Kasyanov founded Russia's leading research school in comparative embryology, and initiated and directed the monographic series "Biota of the Russian Waters of the Sea of Japan" published by the Institute of Marine Biology. He was Editor-in-Chief of the All-Russian journal "Biologia Morya" (Russian Journal of Marine Biology) of the Russian Academy of Sciences.

Vladimir Leonidovich was born on January 4, 1940, in the former Leningrad (St. Petersburg). He graduated from Leningrad University in 1962, completed a post-graduate course in 1965, received a candidate degree and then worked at the university until 1971. He then moved to Vladivostok where he progressed from Junior Research Scientist to Academician of the Russian Academy of Sciences and Director of the Institute of Marine Biology.

Vladimir was a clever, fascinating person who pursued rational solutions to the complicated questions of resource management and the interaction of science and society. As a result of his efforts and wisdom the Far-Eastern State Reserve achieved "biosphere reservation" status. Vladimir was a man of principle and integrity and fought for a considered ecological approach to the problems resource exploitation in Russia and the world's oceans.

As an internationally recognised scholar Vladimir Kasyanov was prominent in national and international scientific organisations. He was Chairman of the Russian National Committee for the International Geosphere-Biosphere Programme, the Joint Scientific Council on Biological Sciences (Far-Eastern Branch Russian Academy of Sciences) and the Temperate East Asia Committee of START. He was also Vice-President of Otto Kinne Foundation (Germany) and a member of the International Ecological Institute (Germany). In Vladivostok, the scientific capital of the Russian Far East, he organised seven global change meetings leading to the involvement of Russian scientists in IGBP and its partner programmes. He was leader of several Asia-Pacific Network for Global Change Research projects, and edited publications of the Temperate East Asia Regional Committee for START and the Bulletin of the Russian National Committee for IGBP.

Up until his tragic death in a car accident, Vladimir Leonidovich was full of creative ideas for the development of the Institute of Marine Biology, for new large-scale programs for the Far-Eastern Branch Russian Academy of Sciences, for major international projects and ecological programmes and regional initiatives. We have lost a wonderful colleague, teacher, friend and like-minded person. A brilliant creative life, tragically ended in the prime of creative new ideas.

Administration of the Institute of Marine Biology
(Far-Eastern Branch, Russian Academy of Sciences)

Secretariat of the Russian
National Committee for IGBP

AAAS Annual Meeting

6–20 February 2006 • St. Louis, Missouri

Symposium No. 913: Vital Organs in the Earth System: What is the Prognosis?

Growing awareness that the Earth operates as a system not unlike a human body has led to the concept of the Earth's "vital organs" – components, processes or regions that regulate the functioning of the entire planet. Examples include the West Antarctic and Greenland ice sheets, the Amazon Forest, the Sahara Desert and the Asian Monsoon system. Many are sensitive to human pressure and all have the potential to reach critical thresholds that once crossed, could lead to abrupt climate change. This symposium focuses on investigations of the Earth's vital organs. What are their main features? How are they connected? What may the consequences be if critical thresholds are crossed? Could human activities push the Earth into another mode of operation?

For further information on the meeting visit:
www.aaas.org/meetings/Annual_Meeting/
or for queries about the above session contact the organiser:
Wendy Broadgate, wendy@igbp.kva.se.

AAAS

GLOBAL IGBP CHANGE

Pin Board

The Pin Board is a place for short announcements and letters to the Editor. Announcements may range from major field campaigns, new websites, research centres, collaborative programmes, policy initiatives or political decisions of relevance to global change. Letters to the Editor should not exceed 200 words and should be accompanied by name and contact details.

Obituary
Joke Waller-Hunter

Joke Waller-Hunter, Executive Secretary of the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), passed away on 14 October 2005 at the age of 58.

As UNFCCC Executive Secretary Ms. Waller-Hunter oversaw the entry into force of the Kyoto Protocol. Under her leadership, the UNFCCC secretariat moved forward preparations for the implementation of the Protocol and advanced its support to the implementation of the Convention, in particular concerning the adaptation to climate change impacts.

A national of the Netherlands, Ms. Waller-Hunter will be remembered for her intelligent grasp of the issues for which she passionately worked and her down-to-earth, straightforward personality. She believed deeply in the importance of the principles of the UNFCCC and the Kyoto Protocol.

UN Secretary-General Kofi Annan called her a "firm believer in the principles of sustainable development" adding that she "knew that global cooperation was essential to advancing that cause." He said that she "would be mourned with deep affection and respect by her family, many colleagues, friends and allies around the world."

GCP Office in Beijing

To advance the understanding of the impacts of a large population, intensive land use, rapid economic growth and environmental changes on the carbon cycle in China and the Asian region, GCP has established an office in Beijing, China. It's roles are to support and coordinate carbon cycle research in China, and in cooperation with the offices in Australia and Japan, to help coordinate, lead and build research capacity in the Asian region. The office will organise workshops, conferences and training courses, facilitate linkages between regional observational networks and research programs, and promote multi-national research. The office is currently supported by Chinese Academy of Sciences and hosted at the affiliated Institute of Geographic Sciences and Natural Resources Research. GCP SSC member Professor Mingkui Cao directs the office. For more information contact Professor Cao at caomk@igsnrr.ac.cn.

New Faces Across ESSP

Martin Rice has been appointed as ESSP Coordinator. Martin comes to the ESSP from APN and is now based at the DIVERSITAS Secretariat in Paris, France. Martin's main responsibilities are to: (i) be a contact point and liaison for ESSP; (ii) represent ESSP at various meetings; (iii) be the main Secretariat point of contact for the upcoming ESSP Open Science Meeting and assist the international organising committee; (iv) coordinate initiation of the ESSP joint project on global environmental change and human health; (v) coordinate the annual ESSP Chairs and Directors meetings; and (vi) manage ESSP publications and communications activities.

IHDP is undergoing a changing of the guards: a new Executive Director will commence in November 2005 and a new chair of the SC-IHDP will commence in April 2006. The current Executive Director, Barbara Göbel, leaves IHDP to take the position of Director of the Ibero-American Institute (of the Prussian Herritage Foundation) in Berlin. The new Executive Director is Andreas Rechkemmer, a Policy Consultant with the United Nations University, Institute for Environment and Human Security.

Current chair of the SC-IHDP, Colleen Vogel, completes her term in March 2006. The incoming chair of the SC-IHDP from April 2006 will be Oran Young, current co-chair of the Global Carbon Project and chair of the IHDP project Institutional Dimensions of Global Environmental Change. Oran Young is based at the Bren School of Environmental Science and Management at the University of California, Santa Barbara.

WCRP is also undergoing a change of leadership with the retirement of Director David Carson on 31 October 2005. The new Director from 1 January 2006 will be Ann Henderson-Sellers, current Director of the Institute for Nuclear Geophysiology at the Australian Nuclear and Science and Technology Organisation.

ISCU Regional Office for Africa

ISCU has established in Africa the first of its new regional offices. The vision for the Regional Office for Africa is twofold. Firstly, to link excellence in science to policy making and to sustainable socio-economic development in Africa; and secondly, achieve equitable access to scientific data and information, and to establish the scientific capacity that can be used to contribute to the production of new scientific knowledge for the sustainable benefit of society. The Director for the ICSU Regional Office Africa is Professor Sospeter Muhongo. For more information visit www.icsu-africa.org.

Erratum

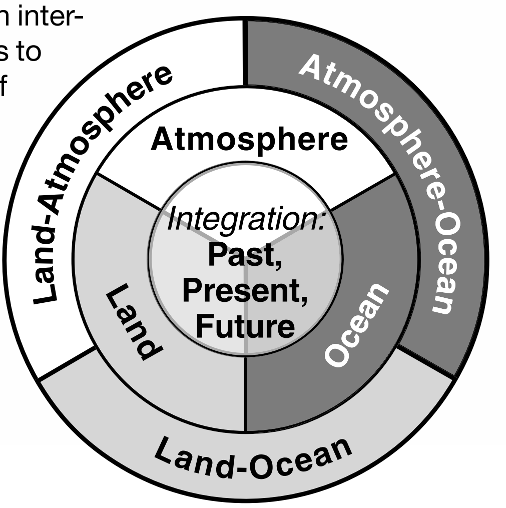
In NewsLetter No. 62, Taiwan was inadvertently omitted from the maps in Figures 3 and 4 in the article on *Ecological Capital Assessment and Land Use Adjustment*. The Editor apologises for any offence this may have caused.

Land Cover in South Central Asia

The Indian Institute of Remote Sensing has published the following two volumes which will be useful for researchers of terrestrial ecosystems in south central Asia: *"Biome Level Characterization of Indian Vegetation using IRS–WiFS Data"* and *"Land Cover Mapping Using SPOT-VEGETATION for South Central Asia"*. These are products of the Indian Space Research Organisation's Geosphere-Biosphere programme that aims to understand environmental processes on the Indian Subcontinent. The land cover mapping work contributes to the Global Land Cover 2000 project of the European Commission and the Italian Joint Research Centre.

The International Geosphere-Biosphere Programme

IGBP is an international scientific research programme built on interdisciplinarity, networking and integration. The vision of IGBP is to provide scientific knowledge to improve the sustainability of the living Earth. IGBP studies the interactions between biological, chemical and physical processes and human systems, and collaborates with other programmes to develop and impart the understanding necessary to respond to global change. IGBP research is organised around the compartments of the Earth System, the interfaces between these compartments, and integration across these compartments and through time.



IGBP helps to

- develop common international frameworks for collaborative research based on agreed agendas
- form research networks to tackle focused scientific questions and promote standard methods
- guide and facilitate construction of global databases
- undertake model inter-comparisons
- facilitate efficient resource allocation
- undertake analysis, synthesis and integration of broad Earth System themes

IGBP produces

- data, models, research tools
- refereed scientific literature, often as special journal editions, books, or overview and synthesis papers

- syntheses of new understanding on Earth System science and global sustainability
- policy-relevant information in easily accessible formats

Earth System Science

IGBP works in close collaboration with the International Human Dimensions Programme on Global Environmental Change (IHDP), the World Climate Research Programme (WCRP), and DIVERSITAS, an international programme of biodiversity science. These four international programmes have formed an Earth System Science Partnership. The International Council for Science (ICSU) is the common scientific sponsor of the four international global change programmes.

Participate

IGBP welcomes participation in its activities – especially programme or project open meetings (see meetings list on website). To find out more about IGBP and its research networks and integration activities, or to become involved, visit our website (www.igbp.net) or those of our projects, or contact an International Project Office or one of our 78 National Committees.

Contributions

The Global Change NewsLetter primarily publishes articles reporting science undertaken within the extensive IGBP network. However, articles reporting interesting and relevant science undertaken outside the network may also be published. Science Features should balance solid scientific content with appeal to a broad global change research and policy readership. Discussion Forum articles should stimulate debate and so may be more provocative. Articles should be between 800 and 1500 words in length, and be accompanied by two or three figures or photographs. Articles submitted for publication are reviewed before acceptance for publication. Items for the Pin Board may include letters to the Editor, short announcements such as new relevant web sites or collaborative ventures, and meeting or field campaign reports. Pin Board items should not exceed 250 words.

Photographs should be provided as tiff files; minimum of 300 dpi. Other images (graphs, diagrams, maps and logos) should be provided as vector-based .eps files to allow editorial improvements at the IGBP Secretariat. All figures should be original and unpublished, or be accompanied by written permission for re-use from the original publishers.

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