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The Global Change NewsLetter is the quarterly newsletter of the International Geosphere-Biosphere Programme (IGBP).

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Changes in the Earth System

In the Discussion Forum, Margot Wallström (European Commissioner for the Environment) teams up with Bert Bolin (founding chair of the IPCC), Paul Crutzen (winner of the 1995 Nobel Prize in Chemistry) and Will Steffen (Executive Director of IGBP) to consider if "The Earth's life support system is in peril". This article originally appeared as an opinion piece in the International Herald Tribune in January this year.

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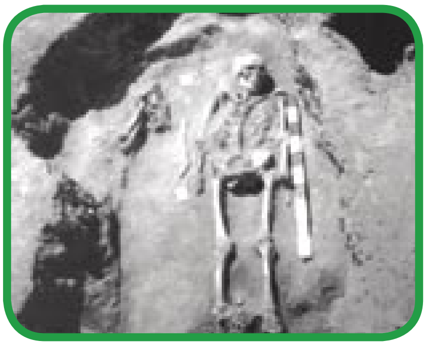
High and Dry



In contrast to the last NewsLetter's focus on the oceans, here we return to dry land with a look at the drivers of "Forest cover change", the "Changing face of the Alpine World", and palaeo-science from the Russian Federation including climate-reconstructions based on oxygen isotope analyses of human bones.

From page 3

Guest Editorial

In this issue we introduce the Guest Editorial – a place for invited perspectives on global environmental change – reflective, provocative, or visionary. The inaugural editorial is from Will Steffen, Executive Director of IGBP who will complete his term at the end of June 2004.

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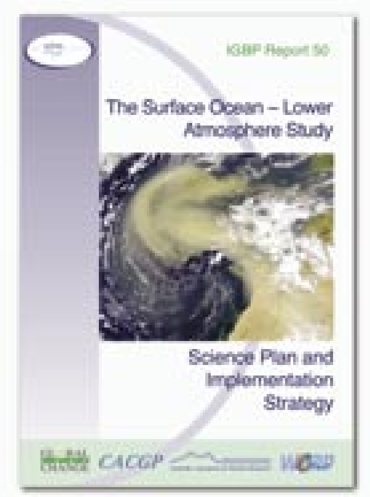
Science Plan



The IGBP Secretariat has recently published the SOLAS Science Plan and Implementation Strategy, which presents the current state of the science, outlines the goals of the project and provides a starting point for implementing the research needed. Here we provide a brief description of the science of SOLAS, drawn from the text of the Science Plan.

Centrefold

Pin Board

In this issue of the Global Change Newsletter we introduce The Pin Board – a place for short announcements and letters to the Editor.

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Guest Editorial

From Synthesis to Integration

Meeting the Challenge

Reflecting on my 6+ years as Executive Director of IGBP, the highlight has clearly been the programme's transition from a suite of projects studying aspects of global change to a integrated, unified programme studying the dynamics of the Earth System.

The first tentative steps towards a more integrated IGBP occurred in May 1999 at the 2nd IGBP Congress in Shonan Village, Japan. Two incidents were pointers to the challenge ahead. First, a prominant project scientist (who shall remain nameless) stormed out near the end of the meeting, saying the push for integration would destroy IGBP and that he/she would have no more to do with the programme. The second was John Schellnhuber's plenary presentation, in which he clearly differentiated synthesis from integration. These two words are commonly used in IGBP, and their definitions from the Concise Oxford Dictionary of Current English highlight their similarities as well as a subtle but important difference:

synthesis – the process, or result of building up separate elements, especially ideas, into a connected whole, especially into a theory or system;

integration – the act of combining (parts) into a whole; to complete (an imperfect thing) by the addition of parts.

John emphasised the fundamental difference: that synthesis can be built on disparate elements and in a post hoc fashion (as was done for the 1999-2003 IGBP synthesis project), while integration can only be built from pieces that actually fit together. Integration must thus be planned from the beginning.

The attempt to build a more integrated IGBP for the next decade has followed this definition, but it has been a difficult and at times controversial process. Several important lessons have been learnt. Firstly, integration is only successful when built around well-posed scientific questions. A good example is the so-called "Vostok challenge". Understanding Earth System dynamics as revealed in the Vostok record will require inputs from across the atmospheric, terrestrial, marine and palaeo sciences. Such wide-ranging inputs can only be productively integrated if targetted on specific questions, such as: (i) what processes effect the approximately 80-100 ppm change in atmospheric CO_2 concentration between glacial and interglacial states? (ii) what controls the set points of temperature and trace gas concentration?

Secondly, the creative tension between sub-system, disciplinary science, and integrative, system-level science is a necessary feature of the process. It is not a case of either-or, but rather of both-and. The disgruntled scientist at Shonan stormed out because he/she believed an increasing emphasis on integration meant abandoment of more disciplinary science in IGBP. However, both types of science are required. Disciplinary science alone will never answer the most challenging and relevant Earth System questions, and attempts at integration will quickly fizzle unless supported by vigorous, creative, disciplinary research. A mature IGBP must explicitly recognise the need for both types of science.

Finally, care must be taken in implementing integrative science. The most important principle is that integrative science must be developed by all relevant groups collaborating from the beginning, including in the framing of the guiding questions. The work must be undertaken on a common platform/structure – built and owned by all. It seldom works when a single – typically strong – group designs the project and subsequently invites others to participate.

And lastly, a comment and warning: IGBP's success derives from its emphasis on science above all else; the programme thus attracts many of the world's best global change scientists. Structure and process are important, but only to a point. The pursuit of the most challenging and intriguing Earth System questions must remain at the forefront of IGBP if the programme is to thrive for another decade.

In this inaugural Guest Editorial, Will Steffen (will@igbp.kva.se) - Executive Director of IGBP since March 1998 - reflects back on the highlights of the last six years of IGBP. Readers may wish to refer back to the vision Will expressed six years ago for IGBP in NewsLetter 31 (www.igbp.kva.se//uploads/nl_31.pdf); synthesis, integration, and partnerships have all flourished under Will's leadership.

Contents

The TransCom 3 Experiment:

Towards robust regional estimates of carbon sources and sinks using atmospheric transport models

K.R. Gurney, A.S. Denning, R.M. Law and P.J. Rayner

A fundamental requirement of reliable CO_2 projections is an understanding of the exchanges of atmospheric CO_2 with the oceans and the terrestrial biosphere. However, the complex mechanisms driving these exchanges and their space-time distribution remain poorly understood. Atmospheric CO_2 sources and sinks can be inferred from measurements of the spatiotemporal patterns of atmospheric CO_2 and estimates of atmospheric transport, since the atmospheric CO_2 concentration at a given point is the linear sum of its sources and sinks convolved with atmospheric transport. The importance of this atmospheric CO_2 inversion approach has increased over the last 15 years [1] as the network of CO_2 measuring stations has grown, and is expected to increase further with the advent of space-based CO_2 measurements in the next few years [2,3].

By the end of the 1990s several CO_2 inversions had been undertaken characterising carbon exchange from the sub-continental scale upwards [e.g.4,5,6]. Surprisingly however, many of these studies reached different conclusions about the location of the so-called northern hemisphere "missing sink". Some placed the sink entirely in North America, others in Eurasia or evenly spread across land regions in the extra-tropical north. The diversity of Chemical Tracer Models (CTMs), CO_2 observations, and inversion set-ups across these studies made it difficult to determine which differences were responsible for the spread in results, and provided the prime motivation for the TransCom 3 Atmospheric CO_2 Inversion Inter-comparison.

This collaborative experiment involved inverse modellers from around the world with the aims of gaining a deeper understanding of the factors that give rise to different regional carbon flux estimates, and improving inverse modelling methods. The experiment was also seen to have the potential to provide more robust estimates of carbon sources and sinks. Nearly 20 models/modelling groups took part in the TransCom 3 experiment. Each group was provided with input data and an experimental protocol [7], and returned simulation results for use in several central inversion experiments. All model output, inversion code, observational data, and supporting information were made available to participating groups to allow sensitivity and quality checks.

Results for annual mean inversions are presented as mean flux estimates for 1992-1996 averaged across all the models with two measures of uncertainty (Figure 1, [8]) – the "within-model" uncertainty (the mean of the individual model flux uncertainties), and the "between-model" uncertainty (the standard deviation of the flux estimates over the ensemble of models). For any region the within-model uncertainty must be smaller than the prior flux uncertainty (outer bounds of the boxes on Figure 1), and the extent of the uncertainty reduction indicates the degree to which the final flux estimate is constrained by measurements. For example, flux estimates for the northern land regions and Australia are more tightly constrained than those for other land regions (Figure 1). The Southern Ocean flux estimate is well constrained – in part because the Southern Ocean is treated as a single large region, whereas flux estimates for the Atlantic regions are constrained by low prior flux uncertainties – a result of good measurement coverage. The between-model uncertainty indicates the degree that differences between models contribute to the range in flux estimates. Large between-model uncertainties are found for northern Africa, tropical America, temperate Asia and boreal Asia (all > 0.5 Gt C yr^{-1}, Figure 1).

For most regions, the between-model uncertainties are of similar or smaller magnitude to the within-model uncertainties, suggesting that the choice

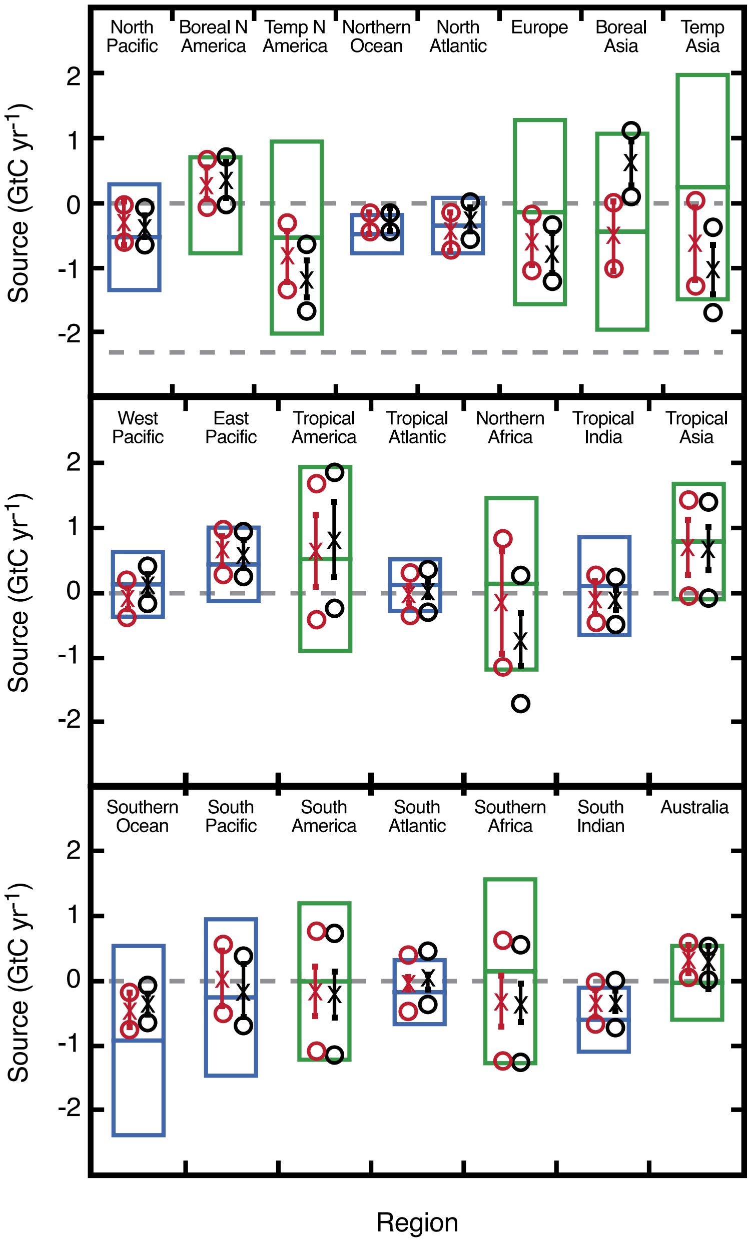

Figure 1. Inversion experiment estimates of mean annual sources and uncertainties for the period 1992-1996. Left hand symbols in each box are for the control inversion, right hand symbols are for an inversion without the background seasonal biosphere flux. Mean estimated fluxes are shown by the 'X' and include all background fluxes except fossil fuel. Positive values indicate a source to the atmosphere. The prior flux estimates and their uncertainties are indicated by the boxes (green for land, blue for ocean); the central horizontal bar indicates the prior flux estimate and the top and bottom of the box give the prior flux uncertainty range. The mean estimated uncertainty across all models (the "within-model" uncertainty) is indicated by the circles. The standard deviation of the models' estimated fluxes (the "between-model" uncertainty) is indicated by the "error bars". Regions are shown in their approximate north-south and east-west relationship.

of model is not the critical determinant of the inferred fluxes. Comparing uncertainties between regions indicates where the inversion would benefit most from new observations, and where model improvements are most needed. This inversion would benefit most from new measurements over tropical continents and in the South American and South Atlantic regions, and from a resolution of transport differences in the northern and tropical land regions.

Two results deserve attention. Firstly, the ocean fluxes estimated by the inversion are consistent with those based on a global pCO_2 database [9], except for the Southern Ocean where the modelled carbon uptake is about half the pCO_2 database estimate. Recently this discrepancy has been substantially reduced by revised pCO_2-observation-based fluxes [10]. This shift in uptake from south to north is required to simultaneously match large-scale concentration gradients and growth rates. Secondly, carbon uptake over the Northern Hemisphere continents is relatively evenly distributed with sinks in temperate North America (–0.8 ± 0.5 Gt C yr^{-1}), Europe (-0.6 ± 0.4 Gt C yr^{-1}) and Asia (-1.1 ± 0.5 Gt C yr^{-1}), and only a small source in boreal North America (0.3 ± 0.4 Gt C yr^{-1}). Estimated uncertainties are moderate (0.4-0.7 Gt C yr^{-1}) indicating that regional partitioning remains difficult, but the flux differences between this study and a widely cited study [4] lie at the edge of, or outside, the uncertainty ranges.

While transport uncertainties do not overwhelm the flux estimates, the "rectifier" produced by the covariance between the seasonal biospheric background flux and atmospheric transport [11,12] appears to be responsible for a significant fraction of the model spread. The impact of the rectifier is seen in the results from the inversion without the background biospheric fluxes (Figure 1, right symbols within each box). The between-model uncertainty is reduced for almost all regions and in some regions there are substantial changes to the flux estimates. An increase of 1.1 Gt C yr^{-1} in boreal Asia changes it from a moder-

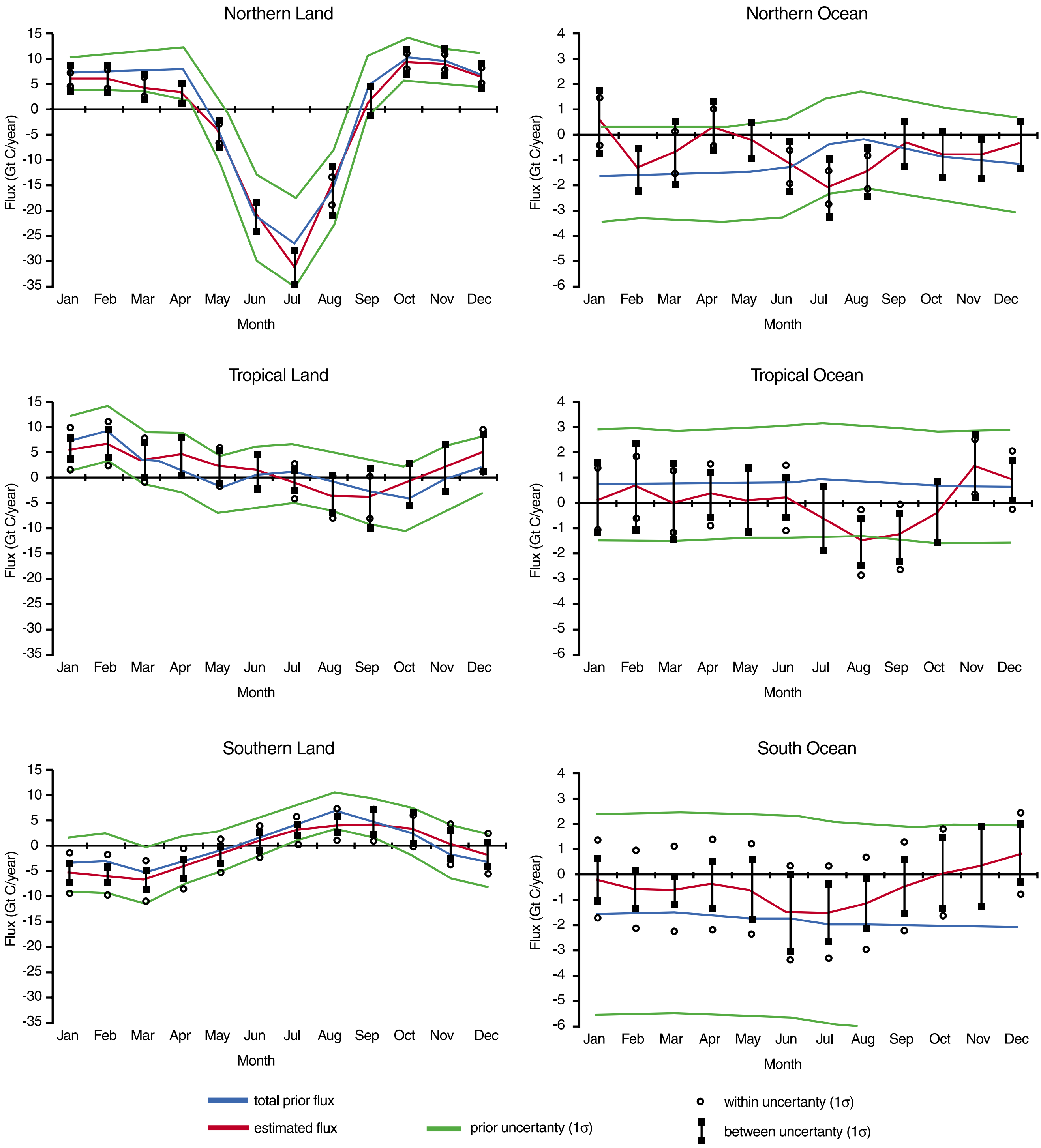

Figure 2. Model mean estimated flux, prior flux, prior uncertainties, and posterior uncertainties for aggregated land and ocean regions. Flux estimates do not include fossil fuel emissions. Different scales are used for the land and ocean regions.

ate sink to a moderate source, because rectification produces the highest mean concentrations downwind of this region in many of the models. Sink strengths increase by 0.35-0.55 Gt C yr^{-1} for temperate North America, temperate Asia and northern Africa, to maintain the required global source. The influence of the rectifier not only alters how individual models distribute carbon exchange in the extra-tropical northern land, but also indirectly influences exchange in the tropical land regions. The results indicate that models which strongly rectify generate large northern land sinks, and require relatively large tropical land sources in order to meet the prescribed global mass constraint. This emphasises the fact that new CO_2 observations in the tropics could not only constrain modelled tropical fluxes, but

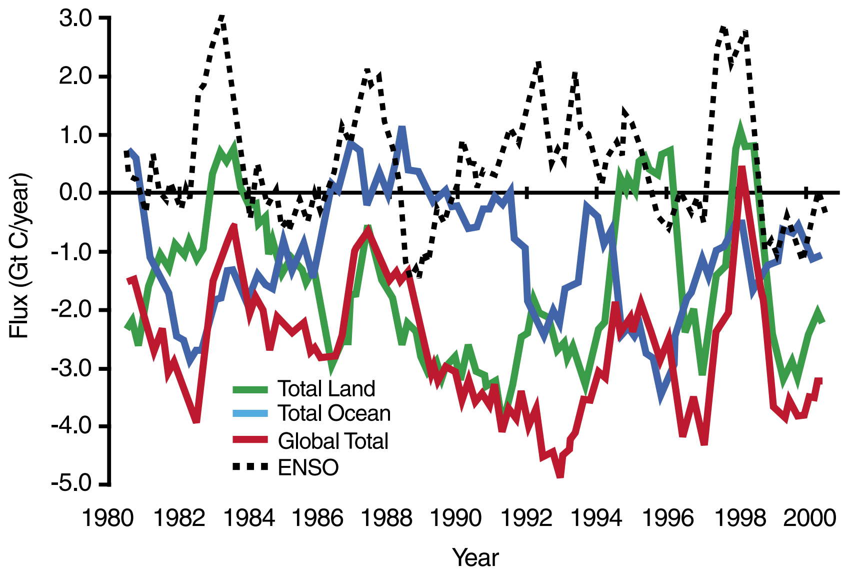

Figure 3. Regionally aggregated, de-seasonalised carbon flux estimates from an inter-annual inversion. This inversion utilises a CO_2 observing network comprised of 23 stations. Flux estimates do not include fossil fuel emissions.

could also influence modelled estimates outside of tropical regions.

Results for a seasonal inversion are presented as mean monthly fluxes and uncertainties for 1992-1996 over land and ocean regions grouped into broad latitudinal bands (Figure 2, [13]). These reveal that as for annual mean inversion results, the greatest uncertainty reductions are for the northern extra-tropical lands and the southern extra-tropical oceans owing to the greater number of observations in these regions and their generally lower uncertainty. In the northern land regions, the between-model uncertainty is greatest at the peak of the growing season when carbon uptake is largest.

The mean monthly flux estimates show that the northern extra-tropical land sink is driven by both greater uptake at the peak of the growing season, and lessened carbon emission in early spring months. Results for individual land regions (not shown) indicate that this is particularly true for the Europe, boreal Asia and temperate North America land regions. The difference between the pCO_2 observation-derived estimates for the Southern Ocean and modelled estimates are seen in the seasonal inversion as a discrepancy at particular times of the year (not shown). Good agreement occurs during the austral summer when pCO_2 measurements are taken, however, agreement is poor during the austral winter leading to the differences in the annual means.

"...land carbon exchange tends to lag behind the peak of the ENSO index..."

The time domain of the inverse approach can be extended in order to examine inter-annual variations in carbon exchange. Preliminary results (Figure 3) show the time-dependent carbon exchange for the globe, total land, total ocean, in comparison to a multivariate El Nino-Southern Oscillation (ENSO) index [14]. The land carbon exchange tends to lag behind the peak of the ENSO index and responds by turning from sink to source or a lessened sink. Furthermore, the influence of the June 1991 Pinatubo eruption can be seen as a gradual strengthening of the global sink in the early 1990s, confounding the ENSO event of the early 1990s. Global variations generally appear to be forced by carbon exchange on land, which in turn is primarily driven by the aggregated tropical land region. Similarly, global ocean variations are largely driven by the aggregated tropical ocean region.

At the regional level, inter-annual variations are much more consistent across models than the long-term mean, and so can be interpreted with greater confidence. They suggest mechanisms that may be driving inter-annual flux anomalies. For example, significant correlations between lagged regional flux estimates and the ENSO index suggest climate forcing, with positive flux anomalies first occurring in the tropical land regions and later spreading to extra-tropical land regions.

Extensive sensitivity tests have been performed on the TransCom 3 results [15,16]. Different station networks, the uncertainties assigned to CO_2 observations, prior fluxes, and prior flux uncertainties have all been systematically varied. While individual flux estimates are sensitive to variations in these key aspects of the inversion, the mean flux estimates are surprisingly robust, thus increasing the confidence in the flux estimates and their interpretation. However, flux estimates in the tropical regions remain more uncertain because of the poor observational constraint, and it is possible that bias exists in the problem formulation [17,18]. For example, if all models contain a similar transport bias, this would be reflected in the estimated mean fluxes.

Extensive analysis of the model-to-model differences (not shown) has also been performed and has helped explain which transport features give rise to particular regional inverse flux patterns. Many of these transport differences appear to stem from variations in sub-grid vertical transport and planetary boundary layer formulation.

The inverse approach to estimating global carbon exchange has made considerable progress in the last decade. The TransCom 3 experiment has contributed greatly to this progress and helped elucidate those aspects of the approach that contribute to the spread of results seen in many recent studies. Most importantly, TransCom 3 has shown that the mean flux estimate from all transport models is more robust than the estimate from any single model, and hence may provide an opportunity for improved interpretations of the biogeochemical drivers of carbon exchange.

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http://transcom.colostate.edu/Announcements/L2.author.list,

http://transcom.colostate.edu/Announcements/L1.author.list.

References

1. Enting I. (2002) Inverse Problems in Atmospheric Constituent Transport. Cambridge University Press: Cambridge, U.K.
2. Rayner PJ and O'Brien DM. (2001) The utility of remotely sensed CO_2 concentration data in surface source inversions. Geophysical Research Letters, 28(1):175-178.
3. Houweling S, Breon F-M, Aben I, Rödenbeck C, Gloor M, Heimann M and Ciais P. (2003) Inverse modelling of CO_2 sources and sinks using satellite data: a synthetic inter-comparison of measurement techniques and their performance as a function of space and time. Atmospheric Chemistry and Physics Discussions, 3:5237-5274.
4. Fan S, Gloor M, Mahlman J, Pacala S, Sarmiento J and co-authors. (1998) A large terrestrial carbon sink in North America implied by atmospheric and oceanic CO_2 data and models. Science, 282:442-446.
5. Rayner PJ, Enting IG, Francey RJ and Langenfelds RL. (1999) Reconstructing the recent carbon cycle from atmospheric CO_2, $\delta^{13}C$ and O_2/N_2 observations. Tellus, 51B: 213-232.
6. Bousquet P, Ciais P, Peylin P, Ramonet M and Monfray P. (1999) Inverse modelling of annual atmospheric CO_2 sources and sinks 1. Method and control inversion. Journal of Geophysical Research, 104(D21),161-26,178.
7. Gurney K, Law R, Rayner P and Denning AS. (2000) TransCom3 Experimental Protocol. Department of Atmospheric Science, Colorado State University, USA, Paper No.707, http://transcom.colostate.edu/TransCom_3/transcom_3.html
8. Gurney KR, Law RM, Denning AS, Rayner PJ, Baker D, Bousquet P, Bruhwiler L, Chen YH, Ciais P, Fan S, Fung IY, Gloor M, Heimann M, Higuchi K, John J, Maki T, Maksyutov S, Peylin P, Prather M, Pak BC, Sarmiento J, Taguchi S, Takahashi T, Yuen CW. (2002) Towards robust regional estimates of CO_2 sources and sinks using atmospheric transport models. Nature, 415:626-630.
9. Takahashi T, Wanninkhof RH, Feely RA, Weiss RF, Chipman DW, Bates N, Olafsson J, Sabine C, and Sutherland SC. (1999) Net sea-air CO_2 flux over the global oceans: an improved estimate based on the sea-air pCO_2 difference. Proceedings of the 2nd CO_2 in Oceans Symposium, Tsukuba, Japan.
10. www.ldeo.columbia.edu/res/pi/CO2/carbondioxide/text/10m_wind.prn
11. Keeling CD, Piper SC and Heimann M. (1989) A three-dimensional model of atmospheric CO_2 transport based on observed winds: 4. Mean annual gradients and inter-annual variations. In Peterson DH (ed.) Aspects of Climate Variability in the Pacific and the Western Americas, Geophysical Monograph 55, 305-363. AGU, Washington, USA.
12. Denning AS, Fung IY and Randall DA. (1995) Latitudinal gradient of atmospheric CO_2 due to seasonal exchange with land biota. Nature, 376:240-243.
13. Gurney KR, Law RM, Denning AS, Rayner PJ, Pak B and the TransCom 3 L2 modellers. (2004) Transcom 3 inversion inter-comparison: model mean results for the estimation of seasonal carbon sources and sinks. Global Biogeochemical Cycles, 18, GB1010, doi:10.1029/2003GB002111.
14. Wolter K and Timlin, MS. (1998) Measuring the strength of ENSO - how does 1997/98 rank? Weather, 53:315-324.
15. Law R, Chen YH, Gurney KR, Rayner P, Denning AS and TransCom 3 modellers. (2003) TransCom3 CO_2 inversion inter-comparison. 2. Sensitivity of annual mean results to data choices. Tellus, 55B(2):512-521.
16. Gurney KR, Law RM, Denning AS, Rayner PJ, Baker D, Bousquet P, Bruhwiler L, Chen YH, Ciais P, Fan S, Fung IY, Gloor M, Heimann M, Higuchi K, John J, Kowalczyk T, Maki E, Maksyutov S, Masarie K, Peylin P, Prather M, Pak BC, Randerson J, Sarmiento J, Taguchi S, Takahashi T and Yuen CW. (2003) TransCom 3 CO_2 inversion inter-comparison. 1. Annual mean control results and sensitivity to transport and prior flux information. Tellus, 55B:555-579.
17. Kaminski T, Rayner PJ, Heimann M and Enting IG. (2001) On aggregation errors in atmospheric transport inversion. Journal of Geophysical Research, 106:4703-4715.
18. Engelen RJ, Denning AS, Gurney KR and TransCom3 modellers. (2002) On error estimation in atmospheric CO_2 inversions. Journal of Geophysical Research, 107(D22):4635.

Forest Cover Change – Tales of the Unexpected

W.J. McConnell

In a world that is experiencing unprecedented degrees of global environmental change and degradation, there are many cases of local and regional ecological restoration. Understanding why some forests are fragmented, degraded, and losing species, while others are in good condition or even expanding, is a puzzle to any thoughtful observer of the environment. The Center for the Study of Institutions, Population, and Environmental Change (CIPEC) at Indiana University is dedicated to understanding these processes and sharing new knowledge with the scientific community and the public. The research at CIPEC forms part of the Land Use/Cover Change project of IGBP and is supported by the US National Science Foundation.

The forest dynamics literature tells us to expect (i) population growth and market demand to be strong underlying factors associated with deforestation, and (ii) topographic controls and the provision of infrastructure to influence the location and rates of forest cover change. Meanwhile, the biodiversity conservation literature tells us to expect protection to generally achieve the stabilisation of forest cover, while the privatisation of previously communal lands is considered necessary to encourage long-term investments in establishing and maintaining forest-based enterprises. When large numbers of people move into forested regions, either as a result of government-sponsored settlement schemes or violent conflict, we expect to see dramatic deforestation.

CIPEC research has often concurred with the literature, but has also frequently found evidence to the contrary. There are several major reasons for the contradictions including issues of defining dependent and independent variables, spatial and temporal scalar dynamics, and conjunctural causation [1]. These reasons are discussed below following a discussion of the sometimes contradictory findings, under the themes of *biophysical factors*, *population growth*, *markets*, *disturbances* and *institutions*.

Biophysical factors are in many ways fundamental to explaining forest cover patterns. CIPEC intentionally chooses research sites (Figure 1) where environmental conditions permit forest growth, and hence finds, unsurprisingly, that spatial patterns of forest cover can be largely explained by simple topographic controls – the steepest areas and those furthest from human settlement are generally the last to be cleared and the first to regrow. This has been found consistently across CIPEC sites in the Americas, Africa and Asia. In fact, a fruitful approach to investigating forest dynamics has been based on the search for "anomalies" – forests in locations favouring conversion to other uses, or regrowth in conditions favouring other uses. By controlling for the effects of biophysical factors, the role of social dynamics can be explored. Social factors, discussed below, are less amenable to scientific "control" because their expression differs between locations, and there is considerable interaction amongst factors; for example, demographic growth and market demand.

Population growth has been positive over the last few centuries – at least down to the national scale. Over the same period forest cover has generally declined – thus the *prima facie* case for a strong correlation, that is largely confirmed by CIPEC research at this level

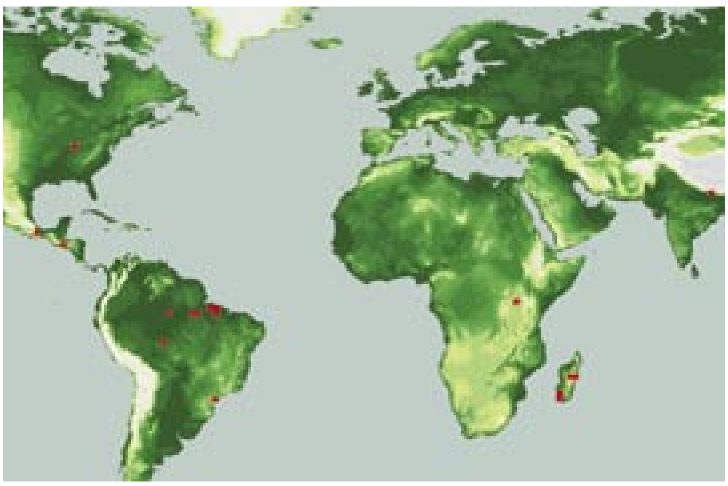

Figure 1. Locations of CIPEC research sites.

of generalisation. However, as the analytical focus narrows to specific sites over specific periods, the relationship becomes much less clear. For example, stable forest cover has been documented in "gazetted" government forests that surround the capital of Uganda (Figure 2) during periods of both rural population growth and rapid urban population growth, in the latter case due to the consequential urban demand for commercial fuelwood and food crops [2]. In contrast, following a major depopulation of the agricultural landscape of Indiana in the early 20th century, the population increased while forests reclaimed abandoned farmland. Reforestation of the agricultural landscape continued (Figure 3) until urban expansion triggered a new wave of forest removal for residential, commercial, and industrial land uses. Such land is often subsequently reforested as part of urban and suburban landscaping [3]. Similar trends to this have been observed in the eastern USA and in Europe.

Markets create a demand for timber and other forest products such as charcoal – an obvious proximate cause of deforestation, and a process that CIPEC studies have seen in Mexico, Madagascar, Uganda and Nepal. Likewise, the demand for crops has led to forest clearing for farmland at several CIPEC sites. For example, recent deforestation in Brazil and southern Madagascar have been largely driven by the growing export markets for soy and feed corn respectively [4]. In contrast, afforestation has occurred in eastern Madagascar and Uganda where woodlots have been established and maintained to meet the urban demand for fuel and lumber. If one considers coffee groves to be forest, then market demand can be viewed to have resulted in further afforestation in eastern Madagascar. In Honduras, coffee expansion enhanced afforestation because farmers abandoned marginal fields in areas poorly suited for coffee. However, when coffee prices fell, many of these abandoned fields were returned to subsistence agriculture [5,6]. The Amazon Estuary is an intermediate case where market demand for the *açai* fruit led to a significant change in the floristic composition of the forests of Marajó Island, although with little change to the canopy [7].

Disturbances, both natural and social, can cause dramatic changes in forest cover, the consequences of which have been observed at many CIPEC sites. For example, periods of land clearing in southern Madagascar were associated with migration induced by ENSO-related drought in the early 1990s, and similarly, rapid deforestation in Oaxaca, Mexico was associated with the 1997-1998 ENSO event. Social unrest in Madagascar's capital, Anatananarivo, during a period of political instability in the 1970s led to a near total destruction of one forest on the outskirts of the city, unlike the forest reserves in Mpigi, Uganda, that survived some of the greatest political instability of the late 20th century.

"...forest reserves in Mpigi, Uganda ... survived some of the greatest political instability of the late 20th century."

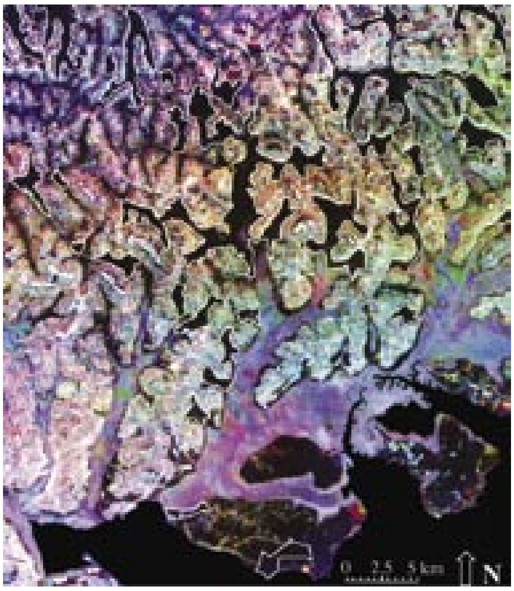

Figure 2. Government forest reserves (outlined in white) within the traditional boundaries of the Buganda Kingdom in central Uganda. The waters of Lake Victoria appear in the lower portion of the figure. The multi-temporal colour composite is produced from Landsat images from 1986, 1995, and 2002: band 3 from 1986 and 1995 Thematic Mapper (TM) scenes, and band 3 from a 2002 Enhanced Thematic Mapper Plus (ETM+) scene. From [9].

Institutions are systems of formal and informal rules at local to global scales that play key roles in mediating human interactions with the environment [8,9]. Our understanding of the role of local, national, and international institutions in mediating the forest dynamics described above has grown enormously over the past decade. In close collaboration with the IHDP core project on the Institutional Dimensions of Global Environmental Change, CIPEC has sought to identify the role of governance systems at multiple scales [10]. Institutions that provide formal protection of forests for conservation purposes are of particular importance. Several CIPEC sites include protected areas, allowing investigation of the human, institutional, and environmental factors that are most important in land-cover

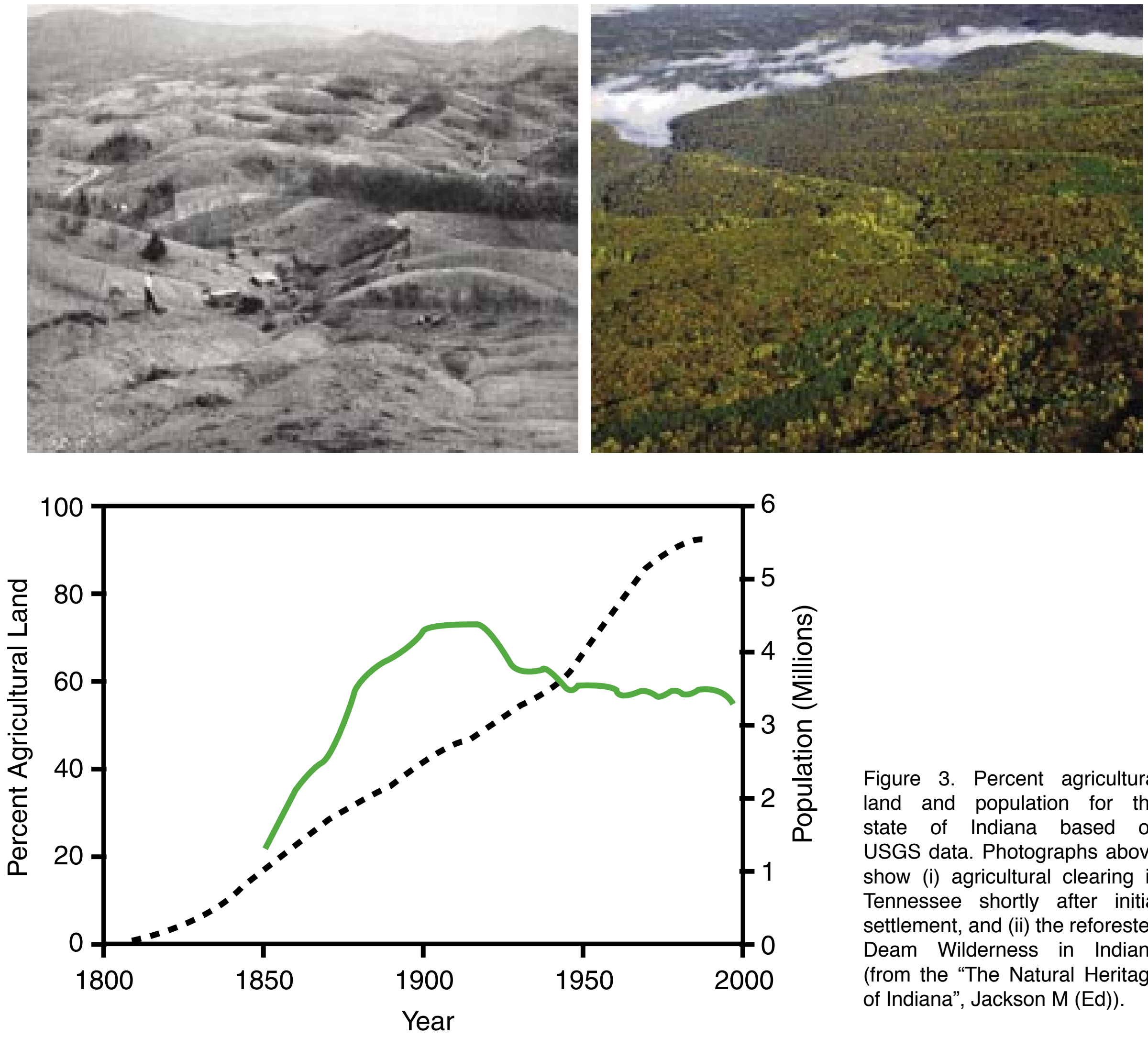

Figure 3. Percent agricultural land and population for the state of Indiana based on USGS data. Photographs above show (i) agricultural clearing in Tennessee shortly after initial settlement, and (ii) the reforested Deam Wilderness in Indiana (from the "The Natural Heritage of Indiana", Jackson M (Ed)).

change processes in and around parks. In Rondônia (Brazil), Nepal, Uganda, and eastern and southern Madagascar, CIPEC research has shown the ability of conservation reserves to protect forests [2,4,11,12,13]. Research in the Maya Biosphere Reserve in Guatemala, however, has shown that declaring an area as national park is insufficient to guarantee forest stability. If insufficient resources are committed to the protection effort, demographic and market forces can easily overwhelm the "paper park". The active involvement of local groups in rule design and enforcement may be crucial for forest protection, whether or not a forest is legally protected [14]. This builds on recent work [9] that argues that panaceas do not exist for effective natural resource management, but that institutions must fit the local context and involve interested parties.

Progress and Challenges

The above examples illustrate the importance of considering the interaction of multiple factors – or "conjunctural causation" [15] – in explaining forest dynamics at an individual site, and the importance of considering the temporal dynamics of causal forces – the location of a region within an historical trajectory of landscape transformation [16]. CIPEC research in Uganda highlights the former: biophysical factors play a strong, but not overwhelming role, strong institutional arrangements protect forests despite rapid population growth and political instability, and market forces can

> "...declaring an area as national park is insufficient to guarantee forest stability."

lead to either deforestation or afforestation. CIPEC research in Indiana demonstrates the importance of considering the temporal dimensions of causal forces: here a phase of almost complete deforestation due to European settlement was followed by a period of forest regrowth due to rural depopulation during industrialisation, and subsequent forest removal and replacement as a result of urban sprawl.

Considerable progress has been made in the explanation of forest cover dynamics at many research sites, yet the articulation of a concise set of universal, uni-directional "drivers" of change has proved elusive. The above discussion of the main causal factors highlights issues of conjunctural causation – "drivers" are not independent, as well as the limited ability of "natural experiments" to isolate individual effects. Two related issues also hamper the explanatory undertaking: spatial and temporal scalar dynamics, and the consistent definition of dependent and independent variables. Progress on consistent definition of land cover has been made by the UN Food and Agricultural Organisation, which developed the Land Cover Classification System (LCCS) [17]. LCCS, and its software implementation, defines a fundamental set of diagnostic criteria typically invoked in defining land cover, and provides a hierarchical, internally consistent way of recording these characteristics at any spatial scale. CIPEC and other LUCC activities, along with most of the world's major land cover mapping organisations, are using LCCS to harmonise their land cover information and are participating in the development of a parallel, or expanded, system to logically code information on land *use* – the proximate cause of land cover change [18]. As more researchers employ standardised approaches, larger comparative analyses can be undertaken, and stronger analytical conclusions drawn.

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References

1. McConnell W. (2001) Why and how people and institutions matter beyond economy. Global Change Newsletter, 47:20-22.
2. Vogt N. (2003) Understanding the long-term stability of West Mengo (Mpigi) Forest Reserve boundaries. CIPEC Working Paper CWP-03-02. Bloomington: Center for the Study of Institutions, Population, and Environmental Change, Indiana University.
3. Evans TP, Green GM, and Carlson LA. (2001) Multi-scale analysis of landcover composition and landscape management of public and private lands in Indiana. In: Millington AC, Walsh SJ and Osborne PE (Eds), GIS and Remote Sensing Applications in Biogeography and Ecology. Kluwer Publications, Boston.
4. Sussman RW, Green GM, Porton I, Andrianasolondraibe OL and Ratsirarson J. (2003) A survey of the habitat of Lemur catta in southwestern and southern Madagascar. Primate Conservation, 19:32–57.
5. Southworth J and Tucker CM. (2001) The roles of accessibility, local institutions and socioeconomic factors influencing forest cover change in the mountains of western Honduras. Mountain Research and Development, 21(3):276–283.
6. Castellanos EC, Conde HE and Tucker C. (2003) Adapting to market shocks and climatic variability in mesoamerica: the coffee crisis in Mexico, Guatemala and Honduras. Final Report to the Inter-American Institute for Global Change Research. São Paulo, Brazil.
7. Brondizio ES, Moran EF, Mausel P and Wu Y. (1996) Land cover in the Amazon Estuary: linking of the Thematic Mapper with botanical and historical data. Photogrammetric Engineering and Remote Sensing, 62(8):921-929.
8. National Science Foundation (NSF) and the Advisory Committee for Environmental Research and Education (AC-ERE). 2003. Complex environmental systems: synthesis for Earth, life and society in the 21st century. National Science Foundation, Washington, DC.
9. Dietz T, Ostrom E and Stern P. (2003) The struggle to govern the commons. Science, 302:1907-1912.
10. Gunderson LH and Holling CS (Eds). (2002) Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, Washington, DC.
11. Batistella M, Robeson S and Moran E. (2003) Settlement design, forest fragmentation, and landscape change in Rodonia, Amazonia. Photogrammetiric Engineering and Remote Sensing, 69(7): 805-812.
12. Nagendra H. (2002) Tenure and forest conditions: community forestry in the Nepal Terai. Environmental Conservation, 29(4): 530–539.
13. McConnell W, Sweeney S and Mulley B. (2003) Topography, demography and enforcement; explaining agricultural expansion in Madagascar. Agriculture, Ecosystems and Environment, 101(2-3):171-184.
14. Supplement to [9] available at: www.sciencemag.org/cgi/content/full/302/5652/1907/DC1
15. Ragin CC. (1987) The Comparative Method: Moving beyond Qualitative and Quantitative Strategies. University of California Press, Berkeley.
16. Mertens B and Lambin EF. (2000) Land-cover-change trajectories in southern Cameroon. Annals of the Association of American Geographers, 90(3):467-494.
17. Gregorio A and Jansen L. (2000) Land Cover Classification System (LCCS): Classification Concepts and User Manual. FAO, Rome.
18. McConnell W and Moran E (Eds). (2001) Meeting in the middle: the challenge of meso-level integration. LUCC Project Report Series No.5. Indiana University, Bloomington.

The Changing Face of the Alpine World

L. Kullman

Accelerated global warming has now reached a level where substantial biological effects can easily be detected in cold-marginal ecosystems around the world [1,2,3]. Data from a unique network for high elevation vegetation monitoring in the Swedish Scandes reveal continuing responses to a new and anomalous climate [4,5] – summer temperatures are currently about 1°C higher than 100 years ago [5]. Consequential glacier recession and reduced summer snow cover have induced drying of alpine grounds and a longer growing period. This has altered the ecological preconditions in alpine and sub-alpine environments leading to rapid vegetation adjustments.

The rate and magnitude of climate change over the last 100 years in Scandinavia conforms to a hemispheric or even global pattern [6]. These changes have led to the recent exposure of 7,000-9,000 year old sub-fossil wood remnants of mountain birch at the margin of retreating Swedish mountain glaciers, 500-600 m above the current tree-line [5,7] (Figure 1). These sub-fossil birches have probably not been exposed since death, and hence can be considered as a botanical analogue to the Ice Man (Ötzi) discovered in the Alps in the early-1990s as a consequence of extreme glacier wastage [8]. Similar, although less spectacular discoveries have been made at the fringe of shrinking glaciers in North America [9].

Figure 1. Rapid recent frontal recession of the glacier Ekorrglaciären in the Sylarna massif (southern Swedish Scandes) has exposed sub-fossil remnants of an originally tree-sized mountain birch, 460 m above the modern tree-line. Radiocarbon date: 7920±80 ^{14}C years BP [5].

The current climatic anomaly is also reflected in tree-line rises of up to 150-165 m, which closely match the 1°C summer warming assuming a cooling of 0.6°C per 100 m vertical rise [4]. Tree-line advance in the Swedish Scandes implies a patchy reduction of the areal extent of the alpine tundra to a level unsurpassed for at least the last 4,000 years [10,11,12].

Substantial advances of the tree-line into alpine tundra during the warm phase of the late 20th century have not been restricted to Scandinavia, but have been observed at locations across both hemispheres [13,14,15]. However, because tree-lines in different topo-climatic settings vary in their sensitivity to altered climate [4], some local studies have failed to detect tree-line advances [16].

There is little to suggest that the shrinkage of the alpine world, which was at its post-glacial areal maximum about a century ago [10], has come to an end. On the contrary, there is ample evidence from the monitoring network [17,18] and from case studies elsewhere in Scandinavia [19,20] and in the Alps [21,22], of rising altitudinal limits of alpine and sub-alpine plant species. An intensive study of a set of 29 vascular plants in the Sylarna massif (Swedish Scandes) showed rises in the altitudinal limits of nearly all species by an average of 165 ± 20 m over the past 50 years [5]. Hence the discovery of large herbs such as *Epilobium angustifolium* and *Solidago virgaurea* growing on still ice-cored moraines close to receding glacier fronts (Figure 2) was highly unexpected. The lack of similar reports from around the world however, is most likely due to a lack of historical records rather than a lack of change. The global relevance of the current ecological development is supported by similar progressive plant cover responses in antarctic and sub-antarctic environments [23,24].

> "...saplings of mountain birch, spruce and pine have recently become established 500-700 m above their current tree-limits .."

Within the Swedish Scandes monitoring network young saplings of mountain birch, spruce and pine have recently become established 500-700 m above their current tree-limits (Figure 3), suggesting the potential for further encroachment into the alpine tundra. Similar

Figure 2. *Epilobium angustifolium* growing on an ice-cored moraine at the front of the glacier Ekorrglaciären in the Sylarna massif, at an elevation 110 m higher than the mid-1950s altitudinal limit of this species [5].

observations of young saplings at surprisingly high altitudes have also been made in alpine Alaska [25]. Records of historical distribution together with tree ring age determinations of alpine recruits indicate that this is a new phenomenon at least in Scandinavia. In fact, establishment now takes place where these trees have been absent for the past 9,000-10,000 years [5]. Furthermore, warmth-demanding, broadleaved tree species (*Ulmus glabra, Alnus incana, Acer platanoides, Betula pendula*) have recently emerged as saplings in the sub-alpine birch forest belt, where members of this group have been absent for several millennia [5,18]. Likewise, as a consequence of milder winters in recent decades, advances of species that require warm environments are occurring in the foothills of the Alps [26], and the oak (*Quercus robur*) is currently invading boreal forests in the Scottish Highlands [27] and in North Sweden [5]. The presence of young specimens of different species at much higher altitudes than at any time in the recent past may of course be a transient phenomenon, however, it indicates that the current climate is highly unusual, and demonstrates the ability of many species to spread rapidly upslope over considerable distances.

Line intercept studies of the areal frequency distribution of different alpine plant communities within the Swedish Scandes monitoring network disclose major changes in the general plant cover structure [5]. At relatively high elevations, large areas that were previously almost unvegetated due to perennial snow or extremely late snowmelt are now rapidly becoming colonised by moss carpets, for example of *Polytrichastrum sexangulare*. Closer to the tree-limit, snowbed communities are ubiquitously transformed into alpine grasslands lending an uncharacteristic steppe-like character to the Nordic mountain landscape. This phenomenon is not unique to Scandinavia, but has also been observed in Central European high mountain areas, where certain rare plant species seem to be on the brink of local extinction due to increasing competition from even denser alpine grasslands [28]. This "grassification" process has been a much discussed scenario for the future alpine world in case of sustained warming [29].

Another aspect of vanishing late-summer snowpacks in the Scandes is dried-up stream furrows, which are currently being filled with ferns (e.g. *Athyrium distentifolium*) and deciduous dwarf-shurbs, especially *Vaccinium myrtillus*. The latter species expands on a broad front by sending colonists into topographic depressions, where late-lying snow previously excluded the growth of anything but snow-bed species of mosses and a few tiny herbs. The reduced areal extent of snowbed plant communities and other changes in alpine plant community composition appear to have become ubiquitous manifestations of climate warming in many European mountain regions [22,30].

Markedly increased seed viability, for example by tree species, signals a shift in ecosystem function to a stronger reliance on sexual reproduction [5,17]. This is a prerequisite for rapid spread and for the maintenance of a tight equilibrium between distributional limits and climate change and variability.

Theoretical predictions of alien plant species invasions associated with climate change are now being confirmed by establishment of exotic tree species such as *Pinus contorta*, *Pinus cembra* and *Larix sibirica* in sub-alpine and alpine environments [5,12]. In general, it appears that alpine vegetation and distributional limits of its component species are less resilient to climate change than often believed. These experi-

Figure 3. A young and fast-growing pine sapling 700 m above the current pine tree-limit in the Sylarna massif [5].

ences, gained by monitoring of natural "experiments", provide the foundation for the development of realistic projective models of alpine plant cover evolution in a possibly warmer future.

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Editorial Note

This work may become a new contribution to the Global Observation Research Initiative in Alpine Environments (GLORIA) that contributes to the Mountain Research Initiative (MRI) of IGBP, IHDP, GTOS (Global Terrestrial Monitoring System), and UNESCO MAB (United Nations Educational, Scientific and Cultural Organization's Man and the Biosphere Programme. The MRI strives to achieve an integrated approach for observing, modelling and investigating global change phenomena and processes in mountain regions, including their impacts on ecosystems and socio-economic systems.

References

1. Hughes L. (2000) Biological consequences of global warming: is the signal already apparent? Trends in Ecology and Evolution, 15: 56-61.
2. McCarthy JP. (2001) Ecological consequences of recent climate change. Conservation Biology, 15:320-331.
3. Parmesan C and Yohe G. (2003) A globally coherent fingerprint of climate change impacts across natural systems. Nature, 421: 37-42.
4. Kullman L. (2001) 20th century climate warming and tree-limit rise in the southern Scandes of Sweden. Ambio, 30:72-80.
5. Kullman L. (in review) A face of global warming – "Ice Birches" and a changing alpine plant cover. Ambio.
6. Bradley RS, Briffa KR, Cole J, Hughes MK and Osborn TJ. (2003) The climate of the last millennium. Alverson KD, Bradley RS, and Pedersen TF (Eds): Paleoclimate, Global Change and the Future. Springer, Berlin, pp105-141.
7. Kullman L. (in press) Early Holocene appearance of mountain birch (Betula pubescens ssp. tortuosa) at unprecedented high elevations in the Swedish Scandes. Megafossil evidence exposed by recent snow and ice recession. Arctic, Antarctic, and Alpine Research, 36.
8. Haeberli W and Beniston M. (1998) Climate change and its impacts on glaciers and permafrost in the Alps. Ambio, 27:258-269.
9. Luckman BH. (1998) Landscape and climate change in the Central Canadian Rockies during the 20th century. The Canadian Geographer, 42:319-336.
10. Kullman L and Kjällgren L. (2000) A coherent postglacial tree-limit chronology (Pinus sylvestris L.) for the Swedish Scandes: aspects of paleoclimate and "recent warming", based on megafossil evidence. Arctic, Antarctic, and Alpine Research, 32:419-428.
11. Kullman L. (2003) Recent reversal of Neoglacial climate cooling trend in the Swedish Scandes as evidenced by mountain birch tree-limit rise. Global and Planetary Change, 36:77-88.
12. Kullman L. (in press) Tree-limit landscape evolution at the southern fringe of the Swedish Scandes (Dalarna province) – Holocene and 20th century perspectives. Fennia.
13. Meshinev T, Apostolova I and Koleva E. (2000) Influence of warming on timberline rising. A case study on *Pinus peuce* Griseb. in Bulgaria. Phytocoenologia, 30:431-438.
14. Sturm M, Racine C, and Tape K. (2001) Increasing shrub abundance in the Arctic. Nature, 411:546-547.
15. Kremenetski C, Vaschalova T and Sulerzhitsky L. (1999) The Holocene vegetation history of the Khibiny Mountains: implications for the post-glacial expansion of spruce and alder on the Kola Peninsula, northwestern Russia. Journal of Quaternary Science, 14:29-43.
16. Dirnböck T, Dullinger S, and Grabherr G. (2003) A regional impact assessment of climate and land-use change on alpine vegetation. Journal of Biogeography, 30:401-417.
17. Kullman L. (2002) Rapid recent range-margin rise of tree and shrub species in the Swedish Scandes. Journal of Ecology, 90: 68-77.
18. Kullman L. (2003) Changes in alpine plant cover – effects of climate warming. Svensk Botanisk Tidskrift, 97:210-221.
19. Klanderud K and Birks HJB. (2003) Recent increases in species richness and shifts in altitudinal distributions of Norwegian mountain plants. The Holocene, 13:1-6.
20. Virtanen R, Eskelinen, A, and Gaare E. (2003) Long-term changes in alpine plant communities in Norway and Finland. Nagy L, Grabherr G, Körner C and Thompson DBA. (Eds): Alpine Biodiversity in Europe. Springer, Berlin, pp. 411-422.
21. Grabherr G, Gottfried M and Pauli H. (1994) Climate effects on mountain plants. Nature, 369:448.
22. Bahn M and Körner C. (2003) Recent increases in summit flora caused by warming in the Alps. Nagy L, Grabherr G, Körner C and Thompson DBA. (Eds): Alpine Biodiversity in Europe. Springer, Berlin, pp. 337-441.
23. Kennedy AD. (1995) Antarctic terrestrial ecosystem response to global environmental change. Annual Review of Ecology and Systematics, 26: 683-704.
24. Pockely P. (2001) Climate change transforms island ecosystems. Nature, 410: 616.
25. Cooper DJ. (1986) White spruce above and beyond treeline in the Arrigetch Peaks Region, Brooks Range, Alaska. Arctic, 39: 247-252.
26. Walther GR, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin JM, Hoegh-Guldberg O and Bairlein F. (2002) Ecological responses to recent climate change. Nature, 416: 389-395.
27. Crawford RMM. (2001) Plant community responses to Scotland´s changing environment. Botanical Journal of Scotland, 53:77-105.
28. Crawford RMM. (1997) Consequences of climate warming for plants of the northern and polar regions of Europe. Flora Colonia, 5/6:65-78.
29. Rupp TS, Chapin FS and Starfield AM. (2000) Response of subarctic vegetation to transient climatic change on the Seward Peninsula in northwest Alaska. Global Change Biology, 6:541-555.
30. Keller F, Kienast F and Beniston M. (2000) Evidence of response of vegetation to environmental change on high-elevation sites in the Swiss Alps. Regional Environmental Change, 1:70-77.

National Committee Science

Palaeo-Science in the Russian Federation

The Russian National Committee of IGBP has renewed the publishing of its Bulletin in both Russian and English (Figure 1). In his forward to issue No.2, 2003, the Chairman of the National Committee – Vladimir Kasyanov – pointed out that the vast expanse of Russia and the value of Russian science mean it is important for the global scientific community to be aware of the research being conducted within the Russian Federation. The Bulletin has two goals: (i) to inform Russian global environmental change scientists about relevant international projects, conferences and activities, and (ii) to inform global environmental change scientists in other countries about relevant projects, conferences and activities occurring in Russia.

Following the interactions with the Russian National Committee in connection with this year's meeting of the IGBP Scientific Committee in Moscow, we take this opportunity to assist the Russian National Committee by highlighting some of the palaeo-science occurring in Russia that was reported in the latest issue of their *Bulletin*.

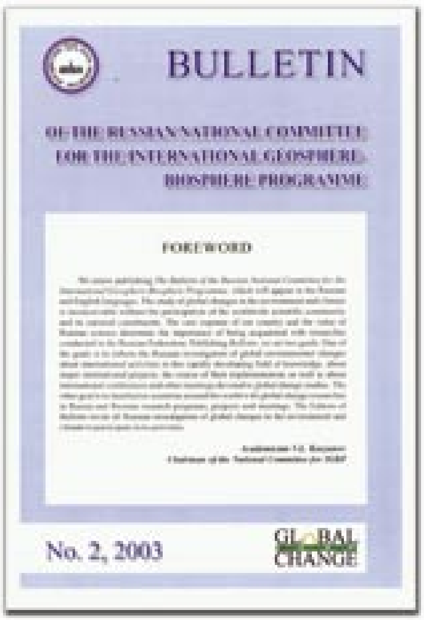

Figure 1. The Bulletin – No.2, of the Russian National Committee for IGBP.

Isotope Studies of Late Pleistocene and Holocene Russia

Oygen isotope analyses of mammal bone and tooth phosphate are being used to infer climate conditions in the Pleistocene and Holocene in northern Russia and northern Eurasia. This requires isotope equations from modern mammal specimens calibrated against the mean oxygen isotope composition of local meteoric water. To extend this method back in time as far as possible, it is important to calibrate as many isotope equations as possible. Isotope equations for terrestrial mammals have been calibrated on humans, pigs, deer, mice, cattle, sheep, elephants, horses, roebuck deer, goats and foxes.

In the late Pleistocene arctic and boreal mammoth assemblages were usual in the great territories of northern Eurasia. Reindeer (*Rangifer tarandus*) (Figure 2) were one of most common mammals in these assemblages, and hence a reindeer isotope equation would greatly help palaeo-climate studies of these regions. Recently, more than 60 samples of modern reindeer skeletal material from 14 locations between Spitzbergen and Polar Yakutia in northern Eurasia have been used to provide an initial isotope equation for palaeo-climate studies.

Other stable isotope studies on human and animal skeletal remains and on palaeosols from archaeological sites in Russia are providing new clues to Holocene human and animal migrations, allowing inference of the Holocene climate of the region. Stable isotope signatures from remains of various ages support the hypothesis of nomadic sheep migration from areas with only C_3 grasses (e.g. the piedmont of the Caucasus, Middle Volga river valley) to areas with mixed C_3 and C_4 plants (the Caspian maritime steppe, Kuma-Manych depression) and vice-versa. The oxygen isotope composition of bone phosphate from kurgan burials from the interfluve of the Don and the Volga rivers (Figure 3) suggests that the steppe populations may have moved alternatively from east to west and west to east, with changing climatic conditions. Similar data from kurgan burials from the left bank of the Ilek River (Pre-Ural) show anomalously low values, suggesting that the bones belonged to new-comers – possibly migrants from the southern section of Western Siberia).

Expressions of Recent Climate Change in Montane Regions

Significant spatio-temporal changes have been taking place

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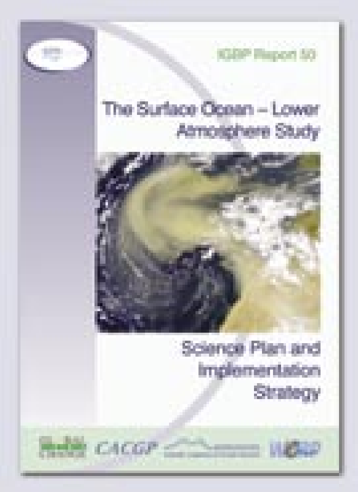
The Surface Ocean – Lower Atmosphere Study

Science Plan and Implementation Strategy



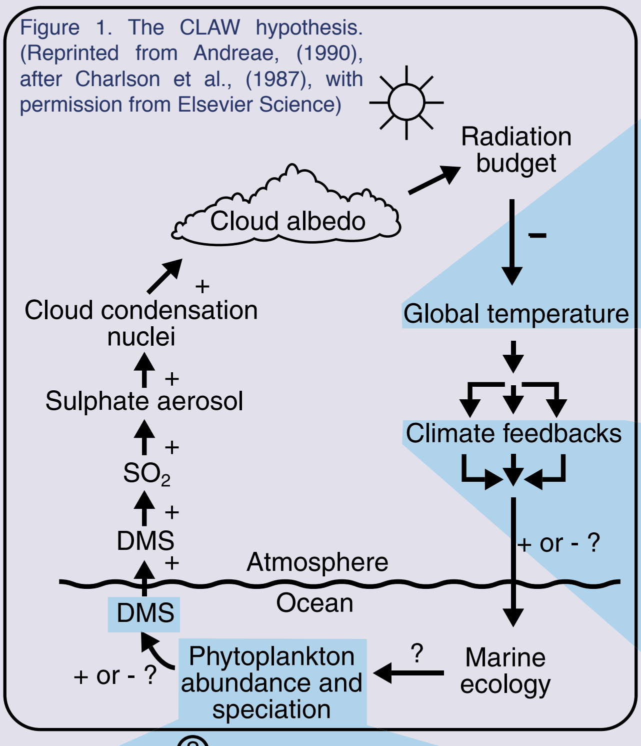
SOLAS (Surface Ocean - Lower Atmosphere Study) is a new international research initiative co-sponsored by IGBP, SCOR, WCRP and CACGP. It aims to improve quantitative understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere, and quantify how this coupled system affects and is affected by climate and environmental change. The SOLAS Science Plan and Implementation Strategy – the first of the revised IGBP Report Series – can now be ordered or downloaded at www.solas-int.org. Here we provide a few examples of the science of SOLAS.

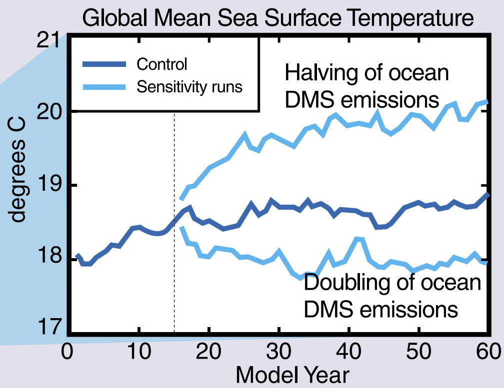
FOCUS 1: Biogeochemical Interactions and Feedbacks Between Ocean and Atmosphere

Focus 1 aims to quantify feedback mechanisms involving biogeochemical couplings across the air-sea interface. These couplings include emissions of trace gases and particles and their reactions of importance for atmospheric chemistry and climate, deposition of nutrients that control marine biological activity, ocean carbon uptake, and trace gas emissions.

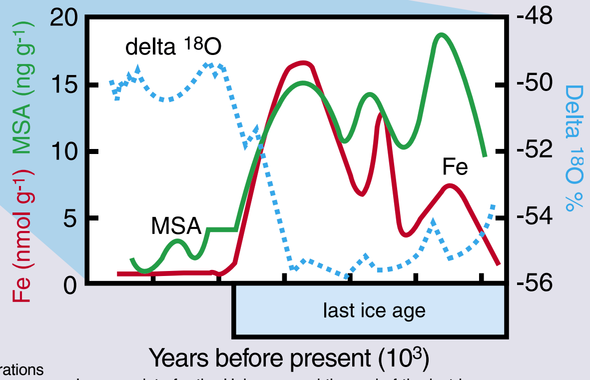
Trace gas emissions from the ocean can have a profound effect on atmospheric properties, and may play a key role in regulating the Earth System. An example is the postulated feedback loop called the "CLAW" hypothesis (after its authors Charlson, Lovelock, Andreae and Warren) whereby an increase in phytoplankton leads to an increase in dimethylsulphide (DMS) emissions to the atmosphere, raising atmospheric DMS concentrations, and thus potentially increasing the rate of sulphate aerosol formation. If this also increases the number concentration of cloud condensation nuclei, it

Figure 1. The CLAW hypothesis. (Reprinted from Andreae, (1990), after Charlson et al., (1987), with permission from Elsevier Science)

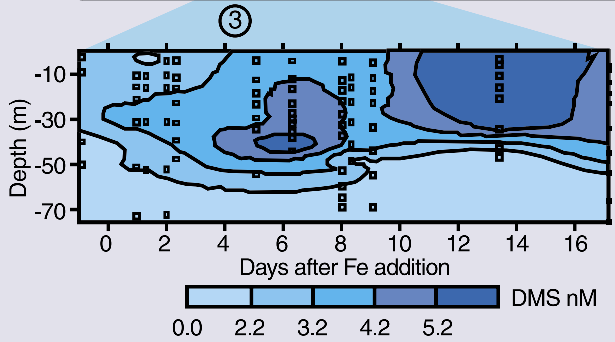




Global mean sea surface temperature simulated in the Hadley Centre atmosphere/ocean coupled model (HadCM3). The simulation includes a representation of the effect of ocean DMS emissions on cloud properties. Sensitivity experiments show a strong climate response to changes in ocean DMS emissions. From: Met Office (2001). Science and Technical Review 2000/1.



Ice core data for the Holocene and the end of the last ice age. MSA (green) is a proxy for atmospheric DMS concentrations and ∂¹⁸O (blue) is a proxy for temperature (data from an ice core at Dome C, east Antarctica). Estimated Fe concentrations are shown in red (data from Vostok, Antarctica). After: Turner et al. (1996) Nature 383:513, reprinted with permission from Macmillan magazines.



DMS concentrations during an Fe addition experiment in the tropical Pacific (Iron Ex II). DMS concentrations increased by a factor of 3.5 during the experiment. (Image: S.Turner, data from Turner et al. (1996) Nature 383: 513.

would lead to whiter clouds, thus reflecting more sunlight back to space and cooling the Earth (Figure 1).

Coupled ocean-atmosphere modeling studies (Figure 1,) show that even a relatively small change in marine DMS emissions may have a significant impact on global temperatures. Evidence from ice cores (Figure 1,) and Fe fertilisation experiments (Figure 1,) show that changes in DMS release at least as large as this have occurred in the past and may occur in the future.

FOCUS 2: Exchange Processes at the Air-Sea Interface and the Role of Transport and Transformation in the Atmospheric and Oceanic Boundary Layers

Gas exchange across the air-sea boundary is normally viewed as being dependant on the concentration difference across the interface and a transfer velocity term, k. The transfer velocity is typically parameterised in terms of wind speed, however, field data and laboratory experiments have shown that k is dependant on additional factors, among which the effects of bubbles and surfactants are thought to be of considerable importance. Rain may also play a role in driving air-sea exchange, especially at low wind speeds, as shown by the change in heat flux (Figure 2) which is an analogue for gas transfer.

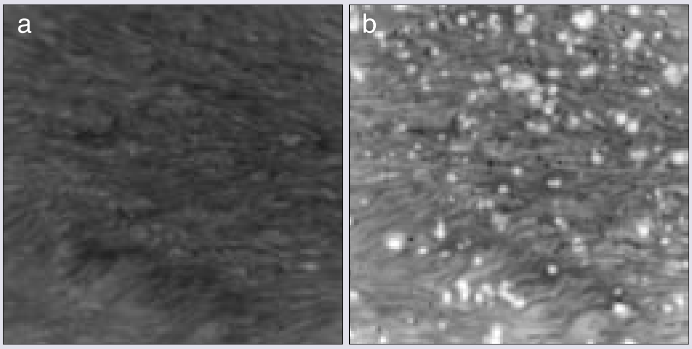


Figure 2. Infrared imagery during rain over the model 'ocean' in Biosphere II. The temperature variation in the image is approximately 1 °C. Warmer regions are light and cooler regions are dark. a) Before onset of rain. b) Onset of rain (black dots) produces localised mixing of the surface layer to produce warm patches. From: Ho et al. (In press) J.Geophys.Res.

Until recently, the inability to directly measure gas fluxes across the air-sea interface directly has prevented construction of a process-based model of how k changes with environmental forcing. However, recent direct measurements of CO_2 and DMS fluxes offer the possibility of describing fluxes on the same time scales as for instance, variations in wind speed, rain rate and bubbling. This will allow SOLAS to develop flux estimates founded on sound physical and biogeochemical principles, reducing the uncertainty in estimates of, for example, global air-sea CO_2 fluxes (Figure 3) that currently vary by over 100% depending on the parameterisation of k.

FOCUS 3: Air-Sea Flux of CO_2 and Other Long-Lived Radiatively Active Gases

The oceans are the Earth's largest active carbon reservoir and have absorbed 25-35% of the CO_2 emitted from fossil fuel burning. The atmospheric reservoir is two orders of magnitudes smaller, and therefore the atmospheric CO_2 concentration (with all its implications for the Earths radiative balance) is highly sensitive to changes in the oceanic carbon cycle. SOLAS aims to characterise the air-sea fluxes of CO_2 and other greenhouse gases and the boundary-layer mechanisms that drive them, in order to assess their sensitivity to variations in environmental forcing.

The global climatology of CO_2 fluxes shown in Figure 3 is derived from a database of about a million measurements made over the last half century. There are however few data from coastal areas, many of which are highly productive and have large carbon fluxes, and few data from the Southern Ocean during the austral winter. The latter data paucity is unfortunate, because global carbon cycle models disagree wildly on the magnitude and even direction the air-sea flux of CO_2 in the Southern Ocean.

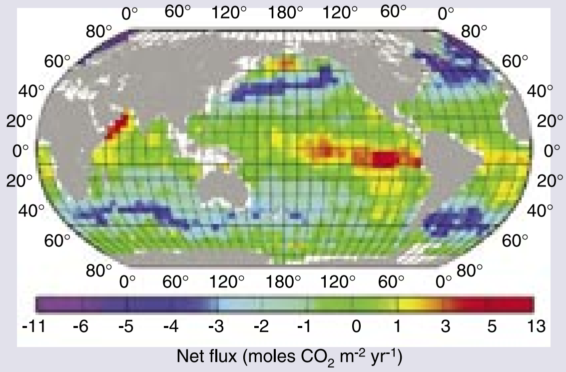


Figure 3. Global climatology of the annual net air-sea CO_2 flux based on interpolation of air-sea pCO_2 differences referenced to the year 1995. From: Takahashi et al. (2002) Deep Sea Research II 49:1601, reprinted with permission from Elsevier Science.

Although extending the database of air and sea CO_2 measurements will help constrain estimates of the present day carbon cycle, achieving a predictive capability for future air-sea CO_2 fluxes will require detailed understanding of the processes governing near-surface CO_2 concentrations and their response to global change. An example is the lowered seawater pH caused by higher atmospheric CO_2 levels that makes conditions less favourable for the production of calcium carbonate – the material from which some phytoplankton build their skeletons. This leads to malformation and other changes in coccolithophorids (Figure 4). Whether such laboratory-demonstrated feedbacks will scale to the open ocean is a question which SOLAS will pursue.

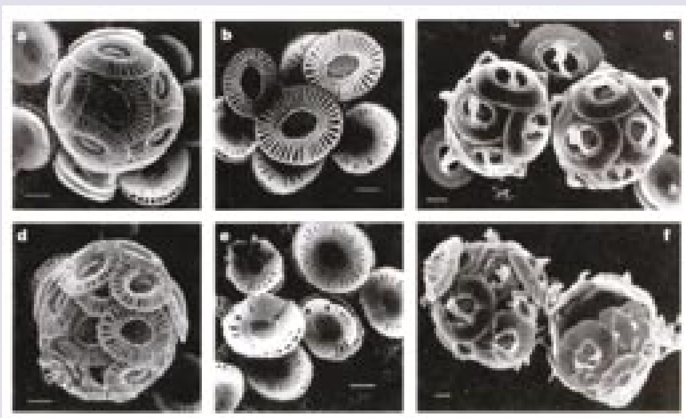


Figure 4. Scanning electron microscope pictures of coccolithophorids grown under low (300 ppmv, a-c) and high (780-850 ppmv, d-f) CO_2 conditions. Note the poorer coccolith structures and cell calcification under elevated CO_2 conditions. From: Riebesell et al. (2000) Nature 407:364, reprinted with permission from Macmillan Magazines Limited.

Compiled by Casey Ryan, and based on the SOLAS Science Plan and Implementation Strategy.

...continued from page 15

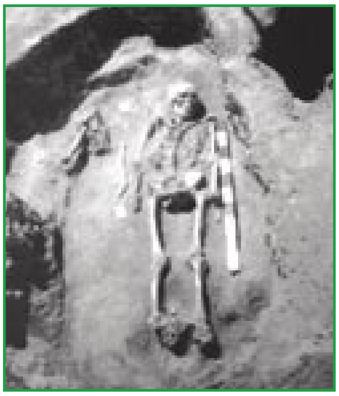


Figure 2. Kurgan burials on the interfluve of the Don and Volga rivers.

Figure 3. Reindeer (*Rangifer tarandus*) – a common mammal of northern Eurasia.

over the last millennium in the upper treeline ecotone in the Polar Ural Mountains (66-67° N, 65-66° E). This area is located within the deep valleys and foot-slopes of the forest-tundra zone, 100-350 m a.s.l., where open Siberian larch (*Larix sibirica*) forests dominate. Patches of closed larch-spruce (*Picea obovata*) forests grow in the lower altitudes of the ecotone. These forests are largely unaffected by human activities, and a great number of well preserved dead tree remains, up to 1300 years old, have been found around 60-80 m above the present treeline. These remains are preserved due to low rate of wood decomposition in the cold, dry climate. More than 1000 samples have been collected from dead trees within a 860 m x 80 m transect from tundra to closed forest on the eastern lateral moraine of Chernaya Mountain. For each sample the calendar year of the beginning of growth and of dying have been determined by dendrochronological techniques, allowing estimation of stand density in this ecotone over the last millennium. The maximum stand density occurred in the 11^{th}-13^{th} centuries and relates to the medieval climate warming period. The second highest stand density coincides with the climate warming of the 18^{th} century. Climate warming in the 20^{th} century has resulted in the highest number of young trees. Several thousand kilometres east in the Alaty Mountains of northern Eurasia, this more recent climate warming is expressed in the glacial retreat that has been ongoing since the late 19th century (Figure 4). Here, the rate of retreat is of the Western Kanas glacier is estimated to be 15-20 m per year. Since 1905 the glacier has shrunk in length by 1.5-2.0 km, and the elevation of the tongue has risen by over 100 m. In spite of the general warming of this region reflected in glacial retreat, a 3°C cooling in the last 30-40 years is indicated by reconstructions of past surface temperatures of Eurasian Artic ice caps. These reconstructions are based on inversions of measured bore hole temperature depth profiles, calibrated by measured oxygen isotopic ratios and a melt feature index.

Figure 4. The Western Kanas Glacier in 2001 (Photograph: Mikhailov and Ostanin) and inset 1905 (Photograph: Sapozhnikov).

Special Edition – Palaeo 3

The above science highlights are a mere fraction of wide range of exciting Russian palaeo-science. A collection of Russian palaeo-science is due to appear in a special issue of the journal Palaeo3, published by Elsevier. The special issue – High Latitude Eurasian Paleoenvironments (Eds: Solomina and Alverson) – is a collection of articles on the Late Pleistocene and Holocene palaeo-environmental history of northern Eurasia – from the White to the Black Sea and from Estonia to the Kurile Islands. The papers were selected from those presented at the first open PAGES conference within the vast territory of the former Soviet Union that was held in Moscow in May 2002.

Acknowledgements

This article draws on work published in the Bulletin (No.2) of the Russian National Committee of IGBP, in particular it refers to the work of V.I.Nikolaev (Institute of Geography, Russian Academy of Sciences), V.S.Mazepa and S.G.Shyatov (Institute of Plant and Animal Ecology, Russian Academy of Sciences), N.N.Mikhailov and O.V.Ostanin (Barnaul State University), and O.V.Nagarnov (Moscow Engineering Physics Institute, State University).

The Global Emissions Inventory Activity (GEIA) was created in 1990 as an activity of the International Global Atmospheric Chemistry Project (IGAC) – a core project of IGBP. Since 1990 GEIA has been developing and distributing inventories of global gas and aerosol emissions from natural and anthropogenic sources, under the guidance of activity conveners and a Coordinating Committee. The GEIA network includes over 300 people around the globe.

Where is GEIA Going?

The GEIA database includes emissions for the major atmospheric compounds, including gases important for aerosol formation and a number of trace species [1] (e.g. Figure 1). Separate inventories have been developed for different groups of chemical compounds, and these datasets are only accepted into the GEIA database after substantial peer review and agreement amongst GEIA project teams. Most datasets were developed for a 1985 base year, and all are at a 1x1 degree spatial resolution. The database thus has sufficient accuracy and spatial and temporal resolution to be widely used in global chemistry-transport models, and hence is considered as a standard for Earth science studies. The inventories provide a scientific foundation for assessments dealing with global pollution, global warming, stratospheric ozone depletion, acid precipitation and biological damage. In addition to the inventories, GEIA has summarised the state of the science for each inventory constituent. The list of species, data sets and their documentation, state of science summaries, workshop overviews, planning documents, and a list of the people involved can be obtained from www.geiacenter.org.

As a result of the fast development of chemistry-transport models and Earth System models, and the large amount of new observational data becoming available, GEIA is entering a new phase. In 2003 the IGBP Steering Committee formed a working group to define the future of GEIA as an IGBP Fast-Track Initiative, to identify scientific priorities, and to propose a new organisation for the activity. The working group (WG) first met in June 2003 in Boulder, Colorado, USA.

The WG refined the goal of GEIA to that of *"quantifying the anthropogenic emissions and natural exchanges of trace gases and aerosols that drive Earth System changes"*, and recommended that GEIA establish strong links and co-sponsored activities with the new IGAC project, with the IGBP projects of iLEAPS (land-atmosphere), SOLAS (ocean-atmosphere) and GAIM, as well as with external programs such as IPCC and ICSU. The WG proposed seven themes for GEIA (below), within which activities will be identified that are related to integrated or international projects, and/or are driven by scientific or societal issues.

1. **New Inventories:** incorporate new, quality-assured datasets, such as regional/global inventories and time-dependent inventories (e.g. historical and future), that will follow the rapid evolution and development of chemistry-transport and Earth System models used for long simulations.
2. **Inter-comparisons and Evaluations:** identify the main uncertainties and problems remaining in the inventories, so as to improve emission and deposition estimates.
3. **Prioritise Observations:** identify and prioritise the measurements needed to improve emission and deposition estimates, in collaboration with other IGBP projects.
4. **Databases of Driving Variables**: provide the evaluation and compilation of emission factors, emission algorithms and other driving variables used for emission estimation. This will improve consistency between inventories, and provide recommendations on the use of variables which could help in developing new inventories (e.g. gridded population data, fire pixels, burned scars, leaf area index).
5. **Temporal Variations:** improve predictions of short-term (i.e. diurnal, weekly, seasonal) emission variations, to allow detailed analysis at the local or regional scale, and to allow more detailed analysis of global datasets.
6. **Chemical Exchange Models:** develop stand-alone models for evaluating parameterisations of chemical-exchange processes and incorporate

a. b.

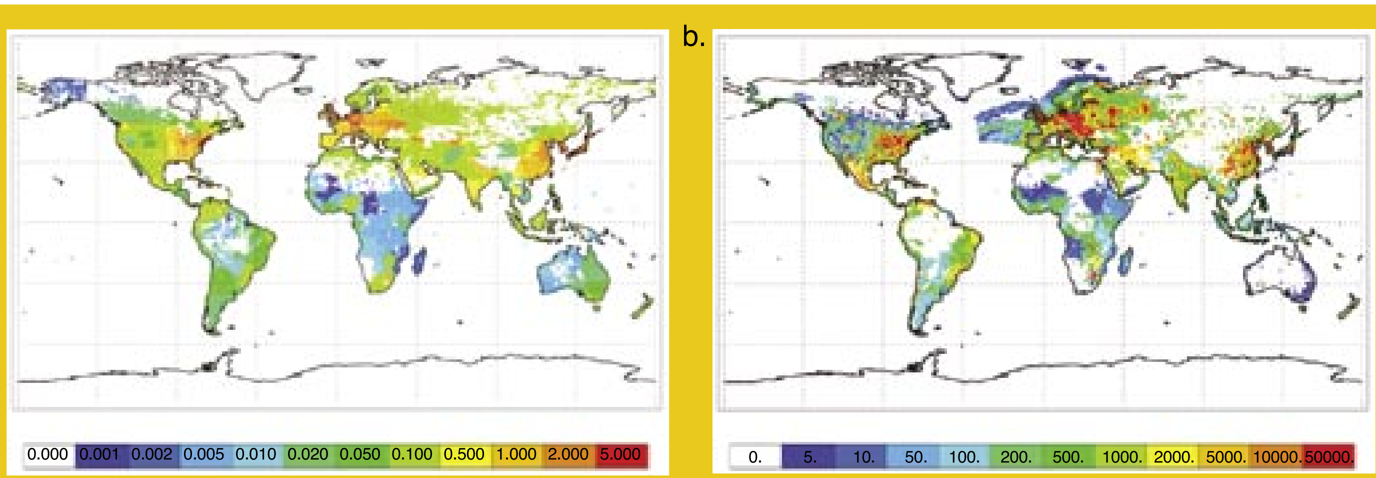


Figure 1. Example datasets from the GEIA database. a: Global carbon dioxide emissions for 1990 (10^6 tonnes). b: Global sulphur dioxide emissions for 1985 (tonnes).

these into chemistry-transport and Earth System models. This activity will (in collaboration with other IGBP projects) help couple mechanistic or comprehensive emission models.

7. **Validation Using Observations and Global/ Regional Chemistry-transport Models:** develop and apply (in collaboration with scientists performing measurements) forward and inverse modelling methods, using observations from surface networks, in-situ (aircraft or balloon) or satellite observations.

GEIA will build on focus group experiences to compile emission inventory (flux estimates, driving variables, algorithms) and model information, and to provide guidance for inventory and model evaluation and improvement. Some high priority issues that could be promoted within GEIA are:

- improvement, development and comparison of existing global anthropogenic emission inventories with regionally specific data and quantified uncertainties;
- emission estimates from mega-cities;
- improvement of global biomass burning emission estimates: comparison of emission inventories and evaluation by comparison with observations;
- compilation of gas and aerosol (including black and organic carbon) emission estimates for the past 100 years and extension of Special Report Emissions Scenarios of IPCC to detailed chemical species and regional scales.

Collaborative activities with other IGBP projects could focus evaluation or development of models for:

- climate-driven global dust emissions;
- global terrestrial ecosystem emissions (nitrogen compounds, methane, individual volatile organic compounds) and depositions;
- global natural sulphur emissions (dimethlysulphide, sulphur dioxide, hydrogen sulphide, carbonylsulphide);
- climate-driven global lightning nitric oxide emissions.

The WG recommended that GEIA be reorganised to be led by a steering committee of high disciplinary and geographical diversity consisting of two co-chairs and about 12 members (serving one or two 3-year terms). The steering committee would approve and monitor GEIA activities and suggest new activities. The recommended reorganisation also included the establishment of a secretariat and a web portal to improve internal and external GEIA communication. Scientific meetings should be organised jointly with IGBP projects and other international projects, and specific workshops held to coordinate ongoing activities and to initiate new activities. The GEIA data center will be directed by a scientist and with computer support, using the latest data distribution and information exchange technology. Opportunities for improved integration and consistency of data storage and exchange will be discussed with other IGBP data centers.

A close collaboration will be established with the activity on emissions within the European Network of Excellence ACCENT (Atmospheric Composition Change: a European Network). The first open scientific meeting of the new GEIA will take place during the ACCENT emissions database meeting in Paris, June 23-25, 2004. This will be followed by an open meeting associated with the 8th Conference of the IGAC Project, in Christchurch, New Zealand. (See page 21).

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Reference

1. Graedel TF, Bates TS, Bouman AF, Cunnold D, Dignon J, Fung I, Jacob DJ, Lamb BK, Logan JA, Marland G, Middleton P, Pacyna JM, Placet M and Veldt C. (1993) A compilation of inventories of emissions to the atmosphere. Global Biogeochemical Cycles, 7: 1-26.

Discussion Forum

This work, co-authored by the European Commissioner for the Environment and three IGBP scientists, originally appeared in the International Herald Tribune, Tuesday, January 20.

Our planet is changing fast. In recent decades many environmental indicators have moved outside the range in which they have varied for the past half-million years. We are altering our life support system and potentially pushing the planet into a far less hospitable state.

The Earth's Life-support System is in Peril

Such large-scale and long-term changes present major policy challenges. The Kyoto Protocol is important as an international framework for combating climate change, and yet its targets can only ever be a small first step. If we cannot develop policies to cope with the uncertainty, complexity and magnitude of global change, the consequences for society may be huge.

We have made impressive progress in the last century. Major diseases have been eradicated and life expectancy and standards of living have increased for many. But the global population has tripled since 1930 to more than six billion and will continue to grow for several decades, and the global economy has increased more than 15-fold since 1950. This progress has had a wide-ranging impact on the environment. Our activities have begun to significantly affect the planet and how it functions. Atmospheric composition, land cover, marine ecosystems, coastal zones, freshwater systems and global biological diversity have all been substantially affected.

Yet it is the magnitude and rate of human-driven change that are most alarming. For example, the human-driven increase in atmospheric carbon dioxide is nearly 100 parts per million and still growing - already equal to the entire range experienced between an ice age and a warm period such as the present. And this human-driven increase has occurred at least 10 times faster than any natural increase in the last half-million years.

Evidence of our influence extends far beyond atmospheric carbon dioxide levels and the well-documented increases in global mean temperature. During the 1990s, the average area of humid tropical forest cleared each year was equivalent to nearly half the area of England, and at current extinction rates we may well be on the way to the Earth's sixth great extinction event.

The Earth is a well-connected system. Carbon dioxide emitted in one country is rapidly mixed throughout the atmosphere, and pollutants released into the ocean in one location are transported to distant parts of the planet. Local and regional emissions create global environmental problems.

The impacts of global change are equally complex, as they combine with local and regional environmental stresses in unexpected ways. Coral reefs, for example, which were already under stress from fishing, tourism and agricultural pollutants, are now under additional pressure from changing carbonate chemistry in ocean surface waters, a result of the increase in atmospheric carbon dioxide.

Similarly, the wildfires that hit southern Europe, western Canada, California and southeastern Australia last year were a result of many factors, including land management, ignition sources and extreme local weather. However, prevailing warm and dry conditions - probably linked to climate change - amplified fire intensity and extent.

Poor access to fresh water means that more than two billion people currently live under what experts call "severe water stress." With population growth and economic expansion, this figure is expected to nearly double by 2025. Climate change would further exacerbate this situation.

Biodiversity losses, currently driven by habitat destruction associated with land-cover change, will be further exacerbated by future climate change. Beyond 2050, rapid regional climate change, as would be caused by changes in ocean circulation in the North Atlantic, and irreversible changes, such as the melting of the Greenland ice sheet and the accompanying rise in sea levels

Smoke engulfed the Australian capital - Canberra - as fires destroyed vast areas of surrounding forest and penetrated into the suburbs; 18 January 2003.

of 6 m could have huge economic and societal consequences.

It is now clear that the Earth has entered the so-called Anthropocene Era - the geological era in which humans are a significant and sometimes dominating environmental force. Records from the geological past indicate that never before has the Earth experienced the current suite of simultaneous changes: we are sailing into planetary *terra incognita*.

Global environmental change challenges the political decision-making process by its uncertainty, its complexity and its magnitudes and rates of change.

Because of the uncertainties involved, decision-making will have to be based on risks that particular events will happen, or that possible scenarios will unfold. A lack of certainty does not justify inaction - the precautionary principle must be applied.

Because of its complexity, global environmental change is often gradual until critical thresholds are passed, and then far more rapid change ensues, as seen in the growth of the ozone hole. Some rapid changes – such as the potential melting of the Greenland ice sheet – would also be irreversible in any meaningful human timescale, while other changes may be unstoppable, and indeed may have already been set in motion.

Because of the magnitudes and rates of change, we are unsure of just how serious our interference with the dynamics of the Earth system will prove to be, but we do know that there are significant risks of rapid and irreversible changes to which it would be very difficult to adapt.

The first step toward meeting the challenge presented by global change is to appreciate the complex nature of the Earth system, the ways in which we are affecting the system, and the economic and societal consequences. Scientists and policy-makers must establish a dialogue to communicate current knowledge and to guide future research.

Real policy progress must address the need for large-scale change, technological advances and global cooperation. Incremental change will not prevent, or even significantly slow, climate change, water depletion, deforestation or biodiversity loss. Breakthroughs in technologies and natural resource management that will affect all economic sectors and the lifestyles of people are required.

Although action at local, regional and national levels is important, international frameworks are essential for addressing global change. We must develop new approaches that consider the diversity of national circumstances and interests, based on a shared political will for action. Never before has an effective multilateral system been more necessary.

The evidence of our impact on our own life-support system is growing rapidly. Will we accept the challenge to respond in a precautionary manner, or wait until a catastrophic, irreversible change is upon us?

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People and Events

New roles and faces

New Members of the IGBP-SC

ICSU – parent body to IGBP – has appointed three new members to the Scientific Committee of IGBP: Ulrike Lohmann, Mark Stafford Smith and Steve Running.

Ulrike is Associate Professor and Canada Research Chair at the Department of Physics and Atmospheric Science at Dalhousie University, Canada. Her research focuses on the role of clouds and aerosols in the climate system. Ulrike serves on the IGAC SSC and the Scientific Advisory Committee for SOLAS Canada. She will help in the SOLAS investigations of the possible atmospheric link between enhanced dimethylsulfide emissions from ocean phytoplankton and changes in cloud microphysics and reflectivity. Ulrike is a member of the review committee of the Radiative Forcing Effects on Climate of the US National Research Council of the US National Academy of Sciences, the International Commission of Clouds and Precipitation (ICCP), and the Commission for Atmospheric Chemistry and Global Pollution (CACGP) of the International Association for Meteorology and Atmospheric Science (IAMAS).

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Mark has lived and worked as a systems ecologist in arid areas for 25 years. He is the inaugural CEO of the Desert Knowledge Cooperative Research Centre (CRC) based in Alice Springs, Australia. The CRC, which Mark was instrumental in establishing, is a partnership between 28 organisations. Previously, Mark led CSIRO's work in ecosystem management of arid lands from their Centre for Arid Zone Research. He has made significant contributions to understanding the economic and policy implications of drought in Australian rangelands. Mark was a Co-Task Leader for rangelands and pastures with GCTE. Among other international activities and collaborations, he co-organised a Dahlem workshop on Desertification in 2001, and is now contributing to the development of ARIDNet – an international network of research relevant to desertification issues.

E-mail: Mark.StaffordSmith@csiro.au

Steve is a Professor of Ecology and Director of the Numerical Terradynamic Simulation Group at the University of Montana, Missoula. Steve was a member of BAHC where he initiated the concept of a long-term monitoring network of water and carbon fluxes for terrestrial ecosystems that eventually led to the highly successful global FLUXNET system of over 200 eddy covariance flux towers. His research focuses on global and regional ecosystem biogeochemistry, including the integration of remote sensing with climatology and terrestrial ecology in computer simulations. Steve is a member of the NASA Earth Observing System team, the Moderate Resolution Imaging Spectroradiometer (EOS/MODIS) team, and chaired the EOS Land Science Panel. He has served on numerous committees for the US National Research Council, and is on the National Carbon Cycle Science Committee, and Co-Chair of the Land Panel for the NCAR Community Climate Model. Steve has been active in the WCRP planning of the Global Terrestrial Observing System, and so can assist cooperation between IGBP and WCRP. He was elected a Fellow of the American Geophysical Union in 2002.

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The Officers of IGBP have appointed Karin Lochte as a Vice Chair of the IGBP-SC. Karin has served on the SC for the last three years, and is head of Biological Oceanography at the Institute for Marine Research at the University of Kiel, Germany. Her scientific interests focus on the role of micro-organisms in the cycling of carbon in the ocean, particularly in the deep sea, and she has wide experience in the investigation of marine microbial processes in the open ocean and coastal seas. She was involved in JGOFS including as an SSC member and is a Co-Chair of the German National Committee for Global Change Research. Karin has contributed to the development of marine science plans of the European Science Foundation, and is a member of the Senate Commission of the German Research Council for Oceanography and of the National Committee of Global Change Research.

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New Scientific Steering Committees Chairs

Three new Scientific Steering Committee (SSC) Chairs have been appointed for IGBP projects: Julie Hall, Julie Brigham-Grette and Liana McManus.

Julie Brigham-Grette is the new Chair of the SSC of PAGES; she has served on the committee for four years – most recently as Vice Chair. Julie is a Professor in the Department of Geosciences at the University of Massachusetts-Amherst. Her research focuses on the stratigraphy and chronology of lakes, rivers and oceans that record information about past climate change, in particular the climate evolution and history of the Arctic. Julie serves on review panels and steering committees for the US National Science Foundation and was recently appointed to the Office of Polar Programs Advisory Board. She is on the editorial advisory boards of Quaternary Science Reviews, Quaternary International, and Arctic, and is a US representative member of the Science Advisory Group of the International Continental Drilling Program. Currently, she is President Elect of the American Quaternary Association, and was elected a Fellow of the Geological Society of America in 2002.

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Julie Hall is the inaugural Chair of the SSC of the new IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) project, having chaired the Transition Team for the previous two years. Julie currently works for the National Institute of Water and Atmosphere (NIWA) in Hamilton, New Zealand. She is a biological oceanographer interested in microbial processes and the structure and dynamics of marine microbial food webs. She has also worked in aquatic ecotoxicology and algal ecophysiology. Julie is the past Chair of the JGOFS/LOICZ Continental Margins Task Team, and was also a member of the JGOFS SSC. She has been actively involved in the development of the Global Ocean Observing System (GOOS) as Vice Chair of its SSC and as a member of the Coastal GOOS panel. She is also the Secretary of the Scientific Committee for Oceanic Research.

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Liana is the new Chair of the SSC of LOICZ after having served for five years on the committee. Liana is an Associate Professor in the Division of Marine Affairs, Rosenstiel School of Marine and Atmospheric Science at the University of Miami, Florida, USA. Her research encompasses marine plankton productivity, coastal typology, integrated catchment modelling and coastal resource management. Liana has worked extensively on community-based participatory coastal planning in the Philippines and on plankton production in the South China Sea and adjacent Philippine waters. She coordinated a seven country initiative examining the social and economic causes of water-related problems and concerns in the region surrounding the South China Sea, leading to a Global Environment Facility project promoting sustainable management of coastal and ocean resources in the region.

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New Project Executive (and Deputy Executive) Officers

We introduce three new staff at International Project Offices (IPO):

- Anni Reisell – Executive Officer for iLEAPS (Integrated Land Ecosystem-Atmosphere Processes Study) of IGBP, at the University of Helsinki, Finland
- Martin Le Tissier – Deputy Executive Officer for the LOICZ (Land-Ocean Interactions in the Coastal Zone) project of IGBP and IHDP, at the Netherlands Institute for Sea Research, Netherlands.
- Eric Craswell – Executive Officer for the GWSP (Global Water Systems Project) of the Earth System Science Partnership, at the University of Bonn, Germany.

Anni came to iLEAPS from a research scientist position shared between the University and the Finnish Meteorological Institute. Her training is in radiochemistry and analytical chemistry – her PhD was on reaction chamber and ambient air studies of biogenic volatile organic compounds. In the late 1990s Anni worked for over three years at the Air Pollution Research Center at the University of California, Riverside. Her research interests range from experimental methods for monitoring inorganic and organic compounds in the atmosphere, to gas phase chemistry and particle formation. Recently she has been engaged with emissions and flux measurements at Hyytiälä – the Finnish forested research Station for Measuring Forest Ecosystem - Atmosphere Relations.

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Martin has been seconded from Envision Partners LLP – an environmental consultancy company. Martin has worked widely with coastal scientists, academics, governmental and non-governmental officers dealing with coastal issues across the spectrum from science to management. Martin has helped foster programmes to design and implement capacity building, work-related learning, and curricula for Government organisations, academics and NGOs in integrated coastal management. Martin's research began with investigations of the formation of skeletons by corals, and broadened to include the ecology and ecophysiology of corals. He will split his time between the IPO in the Netherlands and Newcastle, United Kingdom.

E-mail: tissier@nioz.nl

Eric comes to the GWSP with extensive research experience in tropical soil management and nutrient cycling, having worked for many international organisations including as Director General of the International Board for Soil Research and Management in Bangkok between 1996-2001. He recently co-authored a discussion paper on ecological and policy aspects of global nutrient flows in trade while based at the Centre for Development Research (ZEF) at the University of Bonn – home also to the GWSP.

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IGBP and Related Global Change Meetings for 2004

For a more extensive meetings list please see our web site at www.igbp.kva.se

SC-DIVERSITAS Annual Meeting

14-15 April, Paris, France

Contact: diversitas@unesco.org

GLOBEC Scientific Steering Committee Meeting

16-19 April, Swakopmund, Namibia

Contact: globec@pml.ac.uk

TRACE Meeting (Tree Rings in Archaeology, Climatology and Ecology)

22-24 April, Birmensdorf, Switzerland

Contact: Ulf Buentgen, trace2004@wsl.ch

1st EGU General Assembly

25-30 April, Nice, France

Contact: http://www.copernicus.org/EGU/ga/egu04/index.html

4th World Fisheries Congress – Reconciling Fisheries with Conservation: The Challenges of Managing Aquatic Ecosystems

02-06 May, Vancouver, Canada

Contact: http://www.worldfisheries2004.org/

12th Annual Scientific Conference: International Boreal Forest Research Association

03-07 May, Fairbanks, Alaska

Contact: http://www.lter.uaf.edu/ibfra/default.cfm

START-IIASA: Advanced Institute on Vulnerability to Global Environmental Change

03-21 May, Laxenberg, Austria

Contact: http://www.start.org/links/announce_oppo/P3_Announcement.pdf

The Ocean in a High CO_2 World: An International Science Symposium

10-12 May, Paris, France

Contact: http://ioc.unesco.org/iocweb/co2panel/HighOceanCO2.htm

The Brussels Climate Change Conference

11-12 May, Brussels, Belgium

Contact: http://www.euconferences.com/fraclimate04.htm

ICES Symposium – The Influence of Climate Change on North Atlantic Fish Stocks

11-14 May, Bergen, Norway

Contact: http://www.imr.no/2004symposium/

International Workshop on the Indian Summer Monsoon and Climate Variability during the Holocene

17-18 May, Bangalore, India

Contact: http://www.pages-igbp.org/calendar/2004/bagaloreIndia1.html

Joint CGU, AGU, SEG and EEGS Assembly

17-21 May, Montreal, Canada

Contact: http://www.agu.org/meetings/sm04/index.shtml

iLEAPS: Summer Course on Aerosol Measurement Techniques

22-27 May, Hyytiälä, Finland

Contact: http://www.nilu.no/projects/ccc/aerosolcourse/index.html

16th Rencontres de Blois – Challenges in the Climate Sciences

23-28 May, Château de Blois, France

Contact: http://opserv.obspm.fr/confs/climates.html

Quadrennial Ozone Symposium

01-08 June, Kos, Greece

Contact: http://www.qos2004.gr

LOICZ Scientific Steering Committee Meeting

04-05 June, Location TBA

Contact: LOICZ IPO, loicz@nioz.nl

APN CAPaBLE Workshop
14-16 June, Islamabad, Pakistan
Contact: Amir Muhammed, amir@nu.edu.pk or
Linda Stevenson, lstevenson@apn.gr.jp

SOLAS Scientific Steering Committee Meeting
16-18 June, Bergen, Norway
Contact: casey.ryan@uea.ac.uk

1st International CLIVAR Science Conference
21-25 June, Baltimore, MD, USA
Contact: http://www.clivar2004.org/

2nd International Conference on Climate Impacts Assessment
28 June-02 July, Grainau, Germany
Contact: Philip Mote, philip@atmos.washington.edu

Joint AOGS 1st Annual Meeting and APHW 2nd Conference
5-9 July, 2004, Singapore
Contact: http://www.asiaoceania.org/

GCP Scientific Steering Committee Meeting
12-15 July, Goa, India
Contact: pep.canadell@csiro.au

PAGES Scientific Steering Committee Meeting
16-17 July, Nairobi, Kenya
Contact: pages@pages.unibe.ch

35th COSPAR Scientific Assembly and Associated Events
18-25 July, Paris, France
Contact: http://www.copernicus.org/COSPAR/COSPAR.html

PAGES-START Africa Workshop
19-20 July, Nairobi, Kenya
Contact: Daniel Olago, dolago@uonbi.ac.ke

Climate Change and Aquatic Systems, Past, Present and Future
21-23 July, Plymouth, UK
Contact: http://www.biology.plymouth.ac.uk/climate/climate.htm

SCAR Open Science Conference: Antarctica and the Southern Ocean in the Global System
25-28 July, Bremen, Germany
Contact: http://www.scar28.org

3rd Scientific Congress of the Large-Scale Biosphere-Experiment in Amazonia
26-30 July, Brasilia, Brasil
Contact: michael.keller@unh.edu

SPARC 3rd General Assembly
01-06 August, Victoria, BC, Canada
Contact: http://sparc.seos.uvic.ca

30th Congress of the International Geographical Union
15-20 August, Glasgow, Scotland, UK
Contact: http://www.meetingmakers.co.uk/igc-uk2004/

ESA Summer School – Earth System Monitoring and Modelling
16-26 August, Frascati, Italy
Contact: http://envisat.esa.int/envschool/

3rd International NCCR Climate Summer School
29 August-03 September, Ticino, Switzerland
Contact: http://www.nccr-climate.unibe.ch/suscho_04_index.html

Palaeoclimate and the Earth Climate System
30 August-02 September, Belgrade, Serbia
Contact: milankovitch-erc@sanu.ac.yu or
http://www.sanu.ac.yu/English/meetings/Milankovic.pdf

Bjerknes Centenary – Climate Change in High Latitudes
01-03 September, Bergen, Norway
Contact: http://www.bjerknes.uib.no/conference2004/

8th International Global Atmospheric Chemistry Conference
04-09 September, Christchurch, New Zealand
Contact: Trist Scott, trish@conference.co.nz
or http://www.IGAConference2004.co.nz

10th Wengen Workshop on Global Change Research
06-09 September, Wengen, Switzerland
Contact: http://www.unifr.ch/geoscience/geographie/EVENTS/Wengen/04/Wengen2004.html

Earth System Science Summer School
13-24 September, University of Reading, UK
Contact: http://www.met.reading.ac.uk/courses/ES4/

4th Annual Meeting of the European Meteorological Society
26-30 September, Nice, France
Contact: http://www.emetsoc.org/ems_4th_annual_meeting.html

SCOR General Meeting
27-30 September, Venice, Italy
Contact: Ed Urban, scor@jhu.edu

1st SOLAS Open Science Conference
13-16 October, Nova Scotia, Canada
Contact: Daniela Turk, solas@dal.ca

6th International Symposium on Plant Responses to Air Pollution and Global Changes.
19-22 October, Ibaraki, Japan
Contact: http://apgc2004.en.a.u-tokyo.ac.jp/

IHDP-IAI 2004 Global Environmental Change Institute on Globalisation and Food Systems. Scientific Workshop and Science-Policy Forum

24 October-06 November, Nicoya, Costa Rica

Contact: http://www.ihdp.org

2005

PAGES Open Science Meeting

10-12 August, Location TBA

Contact: pages@pages.unibe.ch

IHDP: Open Meeting of the Human Dimensions Research Community

10-16 October, Bonn, Germany

Contact: http://www.ihdp.org

1st DIVERSITAS International Conference on Biodiversity – Integrating Biodiversity Science for Human Well-being

09-12 November, Oaxaca, Mexico

Contact: http://www.diversitas-international.org

XXVIII SCAR
25-31 JULY 2004
BREMEN GERMANY
COMNAP XVI
SCAR OPEN SCIENCE CONFERENCE
26 - 28 July 2004 · Bremen, Germany
"Antarctica and the Southern Ocean in the Global System"
world's leading Antarctic scientists
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a SOLAS open science conference
2004
International Council for Science
Scientific Committee on Oceanic Research
GLOBAL CHANGE
IGBP
WCRP
CACGP
solas
surface ocean - lower atmosphere study
science
13-16 october 2004
halifax, nova scotia
canada
organising committee:
Barry Huebert, USA
Dileep Kumar, India
Peter Liss, UK
Patricia Matrai, USA
William Miller (chair), Canada
Ulrich Platt, Germany
Daniela Turk, Canada
Mitsuo Uematsu, Japan
Douglas Wallace, Germany
Abstract deadline June 15th 2004
email Daniela Turk: solas@dal.ca
www.solas-int.org

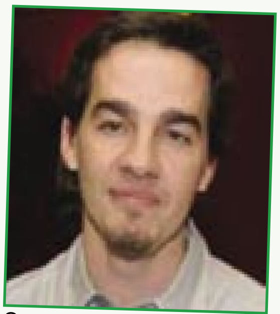
Pin Board

In this issue of the Global Change NewsLetter we introduce The Pin Board – a place for short announcements and letters to the Editor. Announcements may range from 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.

START Conference

The highly successful START Young Scientists Conference on Global Change was hosted by the Third World Academy of Sciences in Trieste, Italy in November 2003 under the Chairmanship of Professor Peter Tyson. The conference aims were to stimulate competition, encourage excellence, reward outstanding performance, encourage the development of personal and institutional networks, while indulging in high-level capacity building among young scientists from developed and developing countries. Over 1000 papers were received: 51 were selected for 15-minute oral paper presentations and 31 for 2-minute oral poster presentations.

The winner of the Crutzen Award for the Best Paper was Gervasio Piñeiro of University of Buenos Aires ('Long term grazing impact on soil carbon and nitrogen pools in South American grasslands' co-authored by JM Paruelo, EG Jobbagy, M Oesterheld and RB Jackson). The award for Best Poster went to Susanne Marquart of DLR Oberpfaffenhofen ('Future development of contrail cover, optical depth and radiative forcing: impact on increasing air traffic, alternative fuels, and climate change' coauthored by M Ponater and R Sausen).


Gervasio Piñeiro


Susanne Marquart

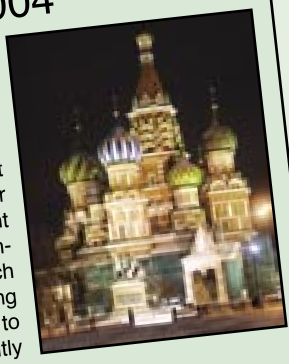
IGBP Synthesis

The IGBP synthesis book – Global Change and the Earth System: A Planet Under Pressure – was published recently by Springer and was launched in Stockholm in January. Highlights of the launch included an opinion article in the International Herald Tribune by EU Commissioner Margot Wallström, Bert Bolin, Paul Crutzen and Will Steffen (see Discssion Forum). A summary of the book launch including media coverage is available at www.igbp.kva.se/booklaunch/.

World Register of Field Centres

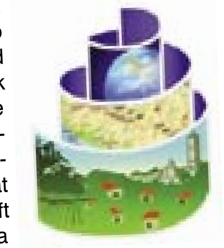
The Royal Geographical Society has developed an on-line database – the World Register of Field Centres (www.rgs.org/fieldcentres). It includes information on 348 established field centres from small independent field camps to large long-term international facilities in 80 different countries, and in environments ranging from the high arctic to the Sahara Desert. The database may be of interest to researchers, students, teachers, and conservationists. The website also provides information for potential field centre users and a forum for communication between field centres. The only criterion for inclusion in the register is that centres welcome international visitors who wish to undertake fieldwork at the centre, whether scientists, students, teachers, school pupils or others.

Moscow 2004



This month the Scientific Committee (SC) of IGBP held its annual meeting at the Russian Academy of Sciences, Moscow, at the invitation of the Academy. The nearly 30-person committee, IGBP Project Executive Officers, IGBP Secretariat staff, and invited guests gathered for four days, the last day being a profitable joint session with the Joint Scientific Committee of the World Climate Research Programme. The business of the meeting focussed on completing the transition to the second phase of IGBP. Importantly the meeting progressed the science plans of the new IGBP projects (iLEAPS, GLP, IMBER), the restructured IGBP projects (IGAC, LOICZ, PAGES) and IGBP as a whole (see www.igbp.kva.se for project information). The published science plan for the new SOLAS project was tabled. The draft plans for three joint projects of the Earth System Science Partnership were also considered, and the regional and capacity building activities of the IGBP community were reviewed.

The Developing Global Land Project



The bourgeoning Global Land Project (GLP) held an Open Science Conference in Morelia, Mexico last December, where 150 scientists gathered to further develop the GLP and add to the work of the project Transition Team to progress the Science Plan and Implementation Strategy. Presentations from the conference (and other conference and project information) can be found at www.glp.colostate.edu/meetings.htm. The draft Science Plan now presents a research agenda wherein science questions are embedded in a systemic view of the coupled human-environmental system. The draft plan was reviewed within the IGBP community in early 2004; reviewers found the plan ambitious, challenging and worthwhile, although identified the need for a more sharply focused vision. Reviews within the IHDP (International Human Dimensions Programme on Global Environmental Change) are now being completed.

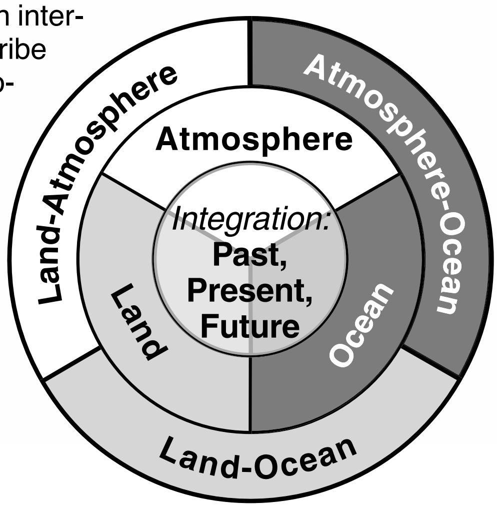
New IAI information

The Inter-American Institute for Global Change Research (IAI) has recently uploaded four new information sheets in both English and Spanish to its website (www.iai.int) under "IAI Communications – IAI Infosheets":

- No.19: general information on IAI, its science programs and capacity building.
- No.23: IAI Small Grants Program and its review process.
- No.24: revised IAI science agenda.
- No.26: IAI Data and Information System development.

The International Geosphere-Biosphere Programme

IGBP is an international scientific research programme built on interdisciplinarity, networking and integration. IGBP aims to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth System, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions. It delivers scientific knowledge to help human societies develop in harmony with Earth's environment. 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

- synthesises 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.kva.se) 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 .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.

The Global Change NewsLetter is published quarterly – March, June, September and December. The deadline for contributions is two weeks before the start of the month of publication. Contributions should be emailed to the Editor.

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