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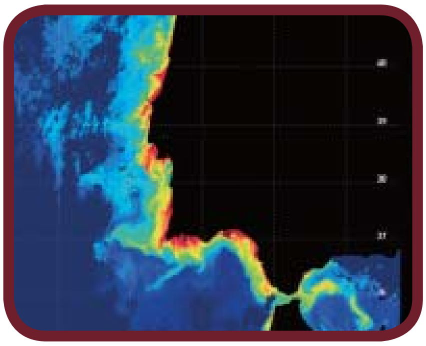
Human role in Earth System changes

Each of the science features presented in this edition of the Global Change NewsLetter address the role that humans play in the changes that are currently occurring in the Earth System, whether it be the hydrosphere, the biosphere, or in the modelling of these complex interactions. In our first article, Arjen Hoekstra introduces the novel concept of 'virtual water trade' and discusses how world trade of water-intensive products contributes to changes in regional water systems. The article by James Reynolds et al. addresses the complexities of desertification, whether or not humans necessarily play a significant role in that process, and how they may or may not be adversely affected by land degredation. The third science feature, by Costanza et al. presents the GUMBO model, a complex model that incorporates human systems into integrated models of the Earth System.

from page 2

National Committees play an integral role in IGBP Science

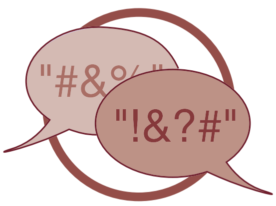


In this series, we introduce a new subsection under Science Features: National Committee Science.

page 13

Discussion Forum

The effect of the Mt. Pinatubo eruption on global net ecosystem productivity—what caused the slowed growth of atmospheric CO_2 concentration?



page 22

Contents

Virtual water trade between nations: a global mechanism affecting regional water systems

by A.Y. Hoekstra

How can people in Japan affect the hydrological system in the United States? And how do people in the Netherlands affect regional water systems in Brazil? The obvious answer is: through contributing to changes in the global climate system. We know that local emissions of greenhouse gasses contribute to the predicted change of the global climate, thus affecting temperature, evaporation and precipitation patterns elsewhere. There is however a second mechanism through which countries affect water systems in other parts of the world. There is a direct link between the demand for water-intensive products (notably crops) in countries such as Japan and the Netherlands and the water used for production of export goods in countries such as the United States and Brazil. The water used for producing export goods for the global market significantly contributes to the change of regional water systems.

Japanese consumers put pressure on water resources in the US, contributing to the mining of aquifers, emptying of rivers and increased evaporation in North America. We know the examples of the mined Ogallala Aquifer and emptied Colorado River. Dutch consumers contribute, to a highly significant degree, to the water demand in Brazil. The question put here is: how significant are these tele connections in the global water system via the mechanism of global trade? Recent research [1,2] shows that the impact of global trade on regional water systems is at least as important as the impact of climate change on regional water systems. Although a large part of the impacts of climate change are yet to come, the impacts of global trade on water systems are visible and already occurring today.

Producing goods and services generally requires water. The water used in the production process of an agricultural or industrial product is called the 'virtual water' contained in the product. About ten years ago, Tony Allan, from the University of London, introduced this concept. For example, in order to produce 1 kg of grain we need 1-2 m^3 of water. Producing 1 kg of cheese requires 5 m^3 of water and for 1 kg of beef we need 16 m^3 of water on average. If one country exports a water-intensive product to another country, it exports water in virtual form. In this way some countries support other countries in their water needs. Trade of real water between water-rich and water-

Virtual Water Pilot Project

The new Global Water System Project (www.gwsp.org) analyses the impacts of human activities on the Global Water System, emphasising the interactions and feedback between the global and the regional scale. Virtual water provides a teleconnection in the Global Water System, linking through global trade water resources in different regions. Virtual water trade also illustrates the interactions in the coupled human-environment system, a key aspect of the Earth System Science Partnership. It has biophysical dimensions, such as climate induced water scarcity as a driver or water savings through production in more humid regions, but also socio-economic dimensions, such as allocations of water at different scales, opportunity costs of water used in export agriculture etc. The GWSP has initiated a Virtual Water Pilot Project, synthesising information on current virtual water fluxes and outlining relevant research questions as a fast track activity. It may address questions of environmental or socio-economic impacts of virtual water trade, or the usefulness of virtual water trade as a tool in an integrated water resources management context, or the potential for compensation mechanisms for the water footprint that countries leave in other regions.

poor regions is generally impossible due to the large distances and associated costs, but trade in water-intensive products (virtual water trade) is realistic.

In order to assess the virtual water flows between nations, the basic approach has been to multiply international trade volumes (ton / yr) by their associated virtual water content (m^3 / ton). Trade data have been taken from the United Nations Statistics Division in New York. The virtual water content of crops has been estimated per crop and per country on the basis of various FAO databases (CropWat, ClimWat, FAOSTAT). The virtual water content of livestock products has been calculated along

Potatoes	160
Maize	450
Milk	900
Wheat	1200
Soybean	2300
Rice	2700
Poultry	2800
Eggs	4700
Cheese	5300
Pork	5900
Beef	16000

Table 1. Virtual water content of a few selected products in m^3/ton. Source: [3,4].

the lines of 'production trees' that show different product levels [3]. The virtual water content of meat for instance depends on the virtual water content of the animal carcass, which in turn depends on the virtual water content of the live animal. If the carcass of the live animal provides skin for leather as well, the virtual water content of the live animal is divided over carcass and skin according to the economic value ratio. The virtual water content of a live animal largely depends on the virtual water content of the feed consumed during the lifetime of the animal. Added to that is the drinking water required during the lifetime of the animal and if relevant other water requirements such as for cleaning stalls.

Table 1 gives the estimated virtual water content for a number of products. The given figures represent global averages. There are very significant differences between countries, mainly relating to differences in climate conditions, but in the case of livestock products also relating to differences in animal diets in different countries.

The global virtual water trade is estimated to be $1+10^{12}$ m^3 / yr in the period 1995-1999, of which 67% relates to international trade of crops, 23% to trade of livestock and livestock products and 10% to trade of industrial products [1,3,4]. Other global studies of global virtual water trade show estimates in the same order of magnitude [5,6]. For comparison: the global water withdrawal for agriculture (water use for irrigation) in the same period was about 2500 Gm^3 / yr. Taking into account the use of rainwater by crops as well, the total water use by crops in the world has been estimated at 5400 Gm3 / yr. The total water use in the world for domestic and industrial purposes has been estimated at 1200 Gm3 / yr. This means that about 15% of the water used in the world for human purposes is not used for domestic consumption but for export (in virtual form).

The world's nations do not have comparable shares in global virtual water trade. Dominant virtual water exporters are the USA, Canada, Australia, Argentina and Thailand. Countries with a large net import of virtual water are Japan, Sri Lanka, Italy, South Korea and the Netherlands.

Based on the estimated global virtual water trade flows, we can draft national virtual water trade balances. The balance is calculated by adding all virtual water

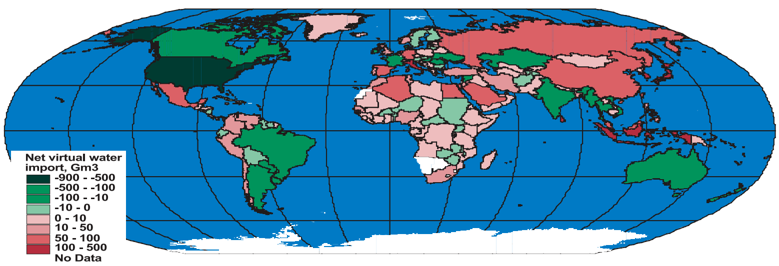


Figure 1. National virtual water trade balances over the period 1995-1999. Red represents net import, green net export.

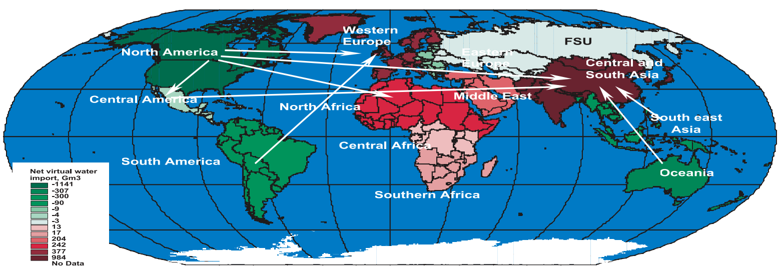


Figure 2. Virtual water trade balances of thirteen world regions over the period 1995-1999. The arrows show the largest net virtual water flows – the most important tele-connections – between regions (virtual water flows>100 Gm^3).

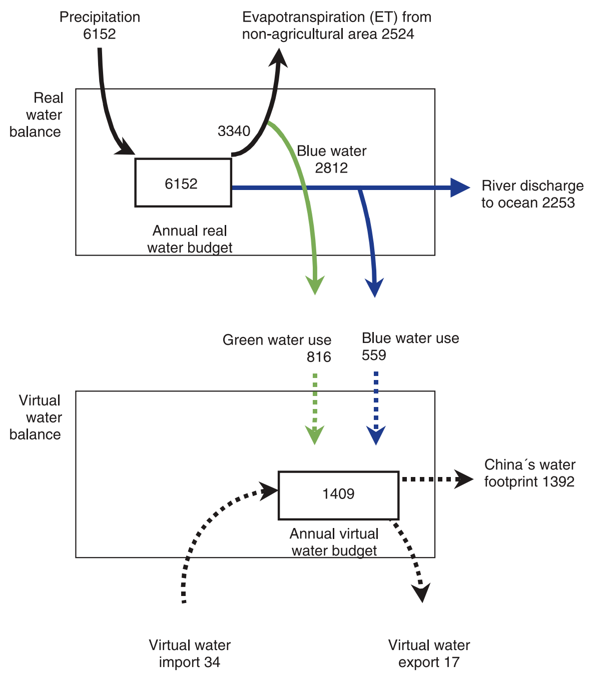


Figure 3. The real and the virtual water balance of China in 1999 (data in Gm^3/yr).

imports and subtracting all virtual water exports. The national virtual water trade balances over the period 1995-1999 are shown in Figure 1. Countries with net virtual water export (a negative balance) are shown in green colour and countries with net virtual water import (a positive balance) in red colour. Figure 2 shows the virtual water trade balances for thirteen world regions and also shows the largest virtual water trade flows between these regions.

The virtual water concept offers the possibility to analyse the impacts of consumption patterns on water use. Per country, we have calculated the cumulative virtual water content of all goods and services consumed by the individuals of the country [1]. In this way we have calculated what we call the 'water footprint' of a nation, a term chosen in analogy of the ecological footprint [7]. The water footprint of a nation is equal to the use of domestic water resources, minus the virtual water export flows, plus the virtual water import flows. Generally, the water footprint of a nation partly weighs upon their own domestic water resources and partly on foreign water resources (i.e. the water resources of the countries from which water-intensive products are imported). Import of virtual water can thus be seen as an alternative source of water, relieving pressure on the resources of importing countries.

As an example of how the real water balance and the virtual water balance of a country link to each other, Figure 3 shows both balances for China in the year 1999. The total use of domestic water resources in China is 1375 billion m^3/yr (59% 'green' water, 41% 'blue' water), of which 1.2% is used for export. The water footprint in China is 1392 billion m^3/yr, pressing on domestic resources for 97.6% and on foreign water resources for the remaining 2.4%. This is not so much, but is likely to increase in the future. China is just one example in the whole spectrum of cases. Some countries, such as the United States, Canada, Australia, Argentina and Thailand, have net export of virtual water, so they do not depend on foreign water resources. However, an extreme example at the other end of the spectrum is Jordan, which depending on the year considered, relies on foreign water resources to satisfy 60 to 90% of its domestic water need.

The overall picture is that 15% of the world water use is not for meeting domestic demands, but for meeting foreign demands, often located on other continents. In other words, roughly speaking, 15% of the disturbances of regional water systems that have been widely reported are linked to demands for water-intensive products in other parts of the world. Given the ongoing process of globalisation, these tele connections are likely to become increasingly important.

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ARIDnet: seeking novel approaches to desertification and land degradation

by J F. Reynolds, D M. Stafford Smith, and E. Lambin

"Drought and desertification threaten the livelihood of over 1 billion people in more than 110 countries around the world."

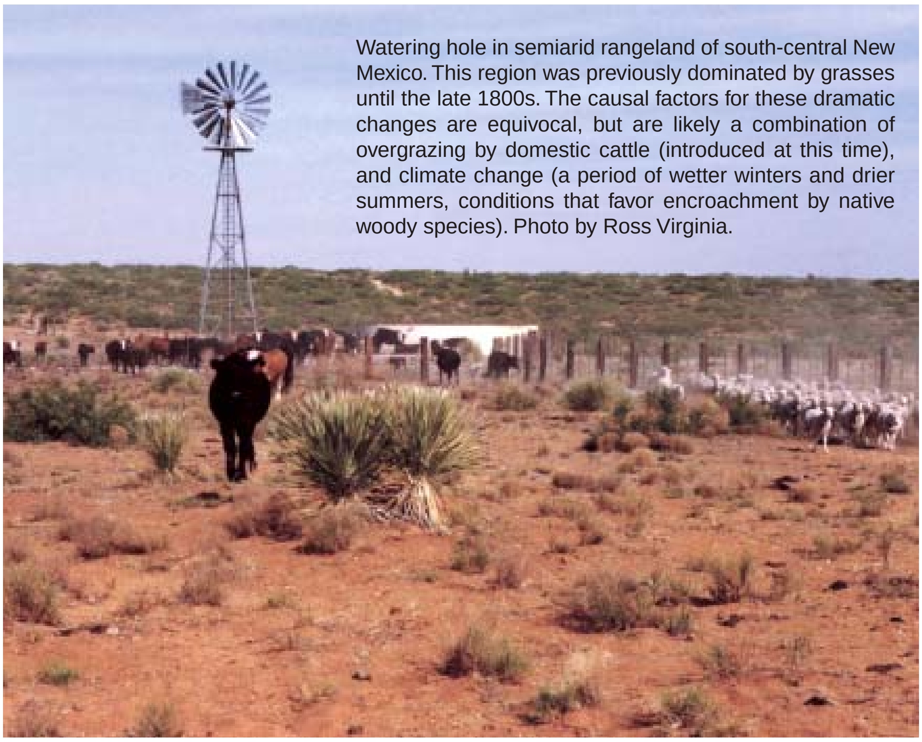
Kofi Annan (as quoted in the UN Convention to Combat Desertification)

Desertification is viewed by many as one of the most critically important global environmental change issues [1-3]. Long associated with land degradation in drylands, desertification is equated to (among many other things) a reduction in the biological and, hence, economic potential of the land to support human populations, livestock, and wild herbivores. Potentially, it affects about a fifth of the world's human population and is intimately linked to global environmental change through climate, biodiversity loss, human dimensions of change, and land cover change. In response, the United Nations established the Convention to Combat Desertification (CCD), whose aim is to "target poverty, drought and food insecurity in dryland countries experiencing desertification, particularly those in Africa" [4]. The CCD establishes the role of national governments in enacting policies to combat land degradation with support from the large infrastructure that has evolved to mobilize resources for implementation, including the CCD Secretariat in Bonn and the Global Mechanism, housed at the International Fund for Agricultural Development (IFAD) in Rome.

On the other side of the coin, desertification is also a very contentious topic, evoking much disagreement and controversy [5,6]. Although some sources routinely report that up to 70% of all drylands, which cover about 40% of the land surface of the globe, are 'desertified', other authors suggest the figure is no more than 17% (see review in [7])! While the reasons underlying the uncertainty and confusion are numerous (replete with countless angles, pitfalls, and interpretations), the bottom line is that desertification is a complex topic, not amenable to simple solutions or answers. We strongly believe that these issues can only be resolved via a simultaneous consideration of the roles of the (i) meteorological; (ii) ecological; and (iii) human dimensions of the problem and its interactions, which play out in varying and complex ways for different locations, time periods, and scales of concern, e.g., household vs. national policy. The failure to recognise and include these interdependencies in decision-making has slowed progress in developing the necessary synthetic framework for tackling the enormous problem of dryland degradation.

"Although some sources routinely report that up to 70% of all drylands, which cover about 40% of the land surface of the globe, are 'desertified', other authors suggest the figure is no more than 17%."

Desertification is presumed to be the outcome of land degradation in drylands. However,



Watering hole in semiarid rangeland of south-central New Mexico. This region was previously dominated by grasses until the late 1800s. The causal factors for these dramatic changes are equivocal, but are likely a combination of overgrazing by domestic cattle (introduced at this time), and climate change (a period of wetter winters and drier summers, conditions that favor encroachment by native woody species). Photo by Ross Virginia.

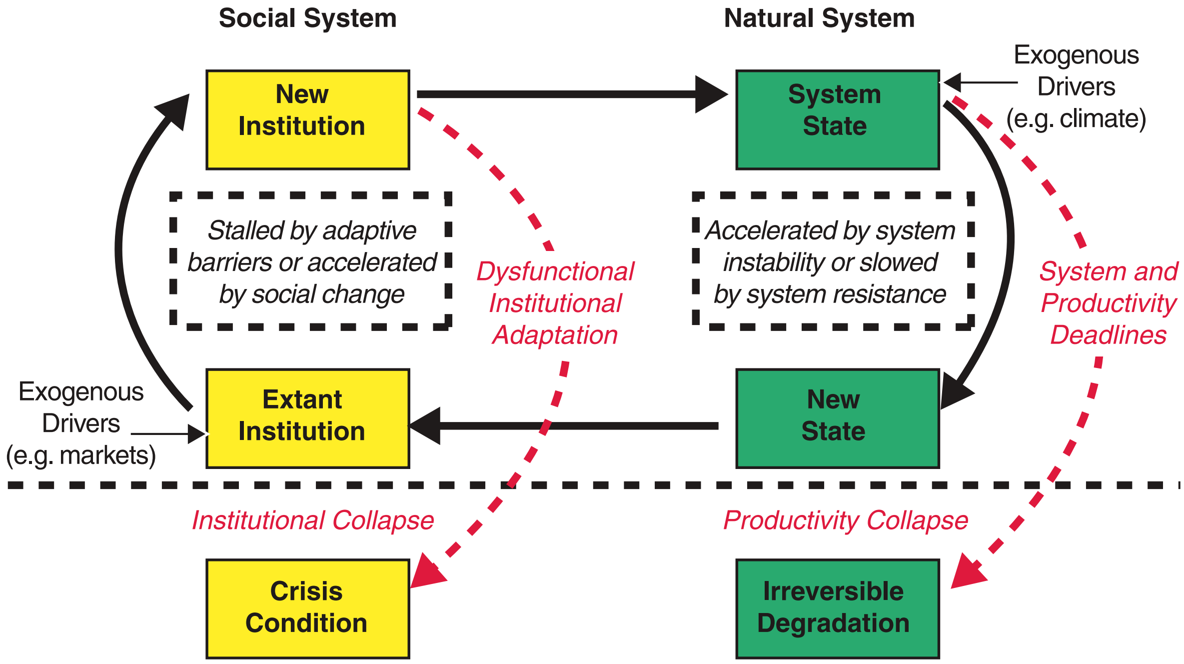


Figure 1. Sustaining a balance between change in natural and social systems is key to understanding land degradation in drylands. The systems are not static and, even under conditions of dramatic change and uncertainty, sustainable land use is possible when the rate of change and spatial overlap in the human and environmental systems are matched (illustrated by the cycle above the dashed line). Accelerated environmental change and decelerated or uncoordinated community adaptation can lead to social crises and irreversible environmental degradation (red dotted lines and *italic* text) (see [9]).

issues surrounding the causes of, consequences of, and political responses to land degradation and its importance, the extent to which land changes are 'natural' (e.g., climate-driven) vs. anthropogenic (e.g., overgrazing), whether or not it is reversible, how to determine the amount of land affected or at risk, and the role of abatement efforts aimed at social and institutional vs. scientific and technological issues, remain largely unresolved. As noted above, the problem is complex but at least threefold: first, there is no standardised meaning for land 'degradation' that fits all situations; second, land degradation is often triggered or exacerbated by climate variability, mainly drought, so that the causes are not necessarily anthropogenic; and third, not all 'changes' have a direct, immediate affect on human welfare. Yet farmers are generally only prepared to accept that they may need to change their management practices if land degradation is a direct consequence of their activities and / or it directly impacts them (or other members of society) (see Box).

Hence, in any elaboration of what constitutes land degradation, it is essential to make it clear that whilst biophysical components of ecosystems and their properties are involved (e.g., soil erosion and the loss of vegetation), the interpretation of change as 'loss' is dependent upon the integration of these components within the context of the socio-economic activities of human beings (often via a generic use of the term 'productivity'). We further propose a model for understanding and predicting conditions of arid land degradation in the context of the balance between natural and social systems (as summarised in Figure 1).

This study site in semiarid rangeland in south-central New Mexico was established in 1912 by the U.S. Department of Agriculture to measure aboveground biomass production by native black grama grass (*Bouteloua eriopoda*). Today, the site is dominated by woody shrubs (*Larrea tridentata*) and bare soil (likely due to a combination of overgrazing by domestic cattle and climate change).

Photo by Jim Reynolds.

New Directions

In an effort to address the challenge underlying desertification, the GCTE (Global Change and Terrestrial Ecosystems) and LUCC (Land-Use and Cover Change) programmes of the International Geosphere-Biosphere Programme (IGBP) joined forces on a new initiative on desertification. The intent was to bring together researchers representing various global change programs on natural and human-influenced systems to stimulate new approaches to this 'old' problem. One of the first activities was a Dahlem Conference (http://www.fu-berlin.de/dahlem/) entitled "The Meteorological, Ecological, and Human Dimensions of Global Desertification"; the key product of this meeting was the development of a new synthetic framework for global desertification, which we call the Dahlem Desertification Paradigm (DDP). As is the case for many paradigms, the constituent ideas themselves are generally not new, but bringing them together reveals a fresh view of an 'old' problem, providing a new depth of insight. The DDP focuses on the interrelationships within coupled human-environment systems that cause desertification, drawing heavily from the chapters of our Dahlem book [8], and considers non-linear processes, resilience, vulnerability, traditional range ecology, human perceptions, panarchy theory, social structures, and economic factors. The main points of the DDP are that:

- socio-ecological systems in drylands of the world are not static;
- while change is inevitable, there does exist a constrained set of ways in which these socio-ecological systems function at different, interlinked scales, thereby allowing us to understand and manage them;
- an integrated approach, which simultaneously considers both biophysical and socio-economic attributes in these systems, is absolutely essential to understand land degradation;
- the biophysical and socio-economic attributes that govern or cause land degradation in any particular region are invariably 'slow' (e.g., soil nutrients) relative to those that are of immediate concern to human welfare (e.g., crop yields, the 'fast' variables). It is necessary to distinguish these in order to identify the causes of land degradation from its effects; and
- restoring degraded socio-ecological systems to a sustainable state requires outside intervention.

An elaboration of these main points is provided in the form of nine assertions that embrace a hierarchical view of land degradation and highlight key

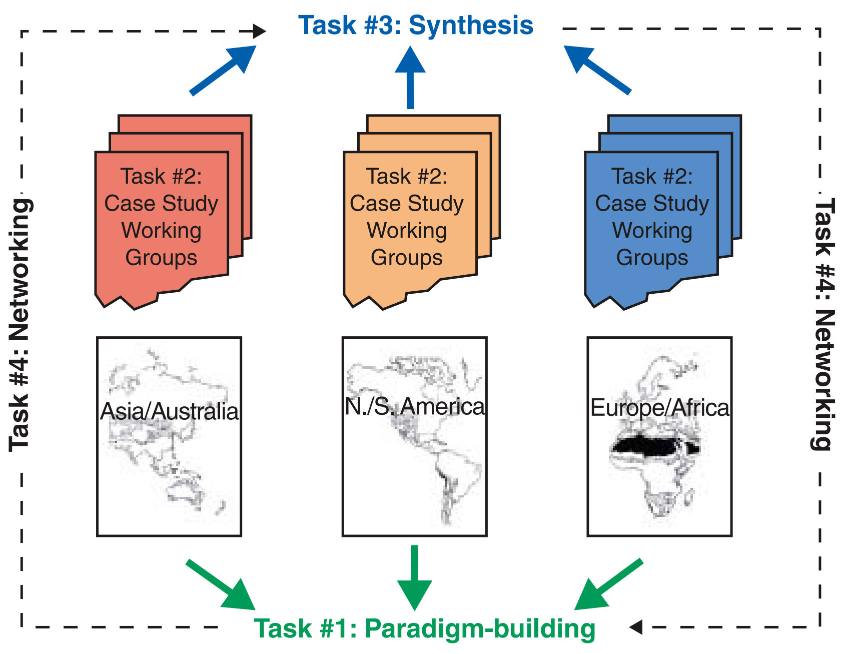
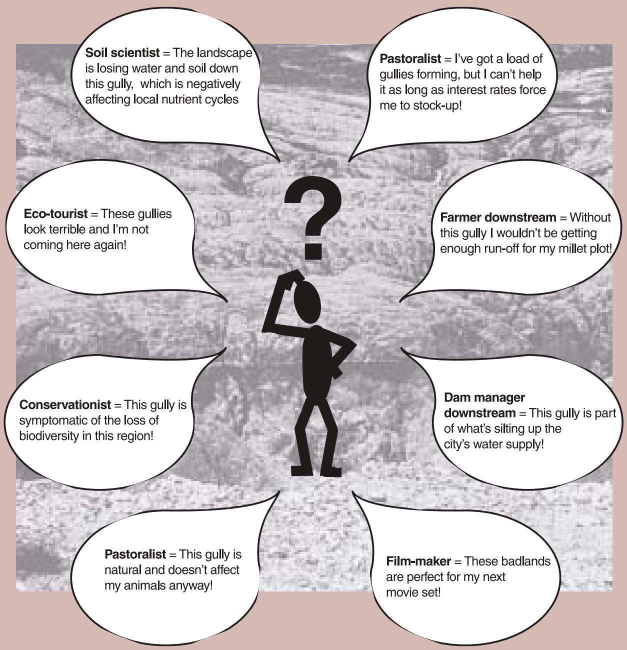


Figure 2. ARIDnet is coordinated by an international steering committee, but functionally organized into three geographic nodes, each with a leader and independent funding (JFR: America; MSS: Asia/Australia; EFL: Europe/Africa). ARIDnet has five tasks: (Task #1) Paradigm-building– the DDP will be presented to the international community of desertification researchers, stakeholders, and policy-makers for a round of critical feedback, evaluation and refinement. (Task #2) Case studies– Working Groups will develop case studies throughout the world in order to test the DDP in a well-stratified, international, and comparative manner, with a specific focus on linking natural and social system function. These case studies will be based on existing data and specific stakeholders, and will represent a range of biophysical/socio-economic types from around the world. (Task #3) Synthesis– following the results of Tasks #1-2, a quantitative assessment of findings will be done in terms of what matters in desertification, when and where it matters, and why. (Task #4) Network building– one key goal is to recruit into, and foster the participation of a diversity of researchers in the activities of ARIDnet. (Task #5) Communication-- the development and maintenance of the ARIDnet website is currently underway (http://www.biology.duke.edu/aridnet/) to support Tasks #1-4.

Box. ‘Land Degradation’ is (partly) in the eye of the beholder



Is this gully “desertification”? One stakeholder group may emphatically conclude that the answer is ‘yes!’, while another may conclude (and with equal conviction) that the answer is obviously ‘no!’ We argue that the answer to this question depends on its context, specifically: the type of land involved (soil types, vegetation, soil fertility, etc.); its use history; a consideration of the views of the various stakeholders involved; and the spatial and temporal scales of concern. To illustrate, we present an example loosely based on studies by Shi and Shao in the Loess Plateau in northern China, which because of its long history (over 5000 years) of human activity– combined with its unique soil (deep loess) and climate– there has been intensive soil erosion. This has resulted in profound impacts on the ecological, social and economic structures in the region and not surprisingly “solutions” have been entrenched within these structures. In some areas, visitors will immediately observe the large number of erosion gullies amongst grazing cattle and naturally conclude that they must be caused by overgrazing. In some instances this will be correct. Yet, a variety of alternative and equally plausible explanations exist: (i) natural phenomena (wind and water) produce erosion gullies; (ii) gullies, regardless of their cause, may have (in some cases) absolutely no effect on those things that concern human values, e.g., meat or milk production by cattle; (iii) even if the gullies are the direct result of overgrazing, the root causes are often complex (and vary with location), involving local government incentives, economic drivers, natural drought, etc.; and (iv) in those instances where erosion gullies are not a local concern, they may well be creating problems elsewhere (e.g., siltation and hence production losses downstream). In sum, what superficially appears straightforward may in fact be multifaceted, eschewing overly simplistic answers!

Shi H, and Shao M. (2000) Soil and water loss from the Loess Plateau in China. Journal of Arid Environments 45:9-20.

linkages between socio-economic and biophysical systems at different scales (see [10] and summary at http://www.biology.duke.edu/aridnet/).

The intent is that the DDP, while general, is specific enough to yield testable hypotheses that will help to move the debate on causal mechanisms of desertification forward. We expect that progress will stem out of attempts to apply this framework to particular systems that are different from the ones most familiar to us. To accomplish the latter, we have established ARIDnet (Assessment, Research, and Integration of Desertification research network). ARIDnet (Figure 2) is an initiative on global desertification that emphasises the interdependencies of natural and human systems as mechanisms of desertification. It evolved out of our belief that there is a pressing need for new and creative interdisciplinary approaches for addressing the global problem of desertification, as well as for new thinking that transcends regional and disciplinary concerns. ARIDnet is a consortium of researchers from various global change projects on natural and human-influenced systems, including: the Center for the Integrated Study of the Human Dimensions of Global Change (CIS-HDGC, Carnegie Mellon University); the International Human Dimensions Programme on Global Environmental Change (IHDP); and the GCTE and LUCC projects of IGBP. The general objectives of ARIDnet are: to foster international cooperation and exchange of ideas about desertification as summarized in the DDP; to open communication channels to foster more practical, field-level interactions with stakeholders in sustainable land management; and to use the concepts, experiences, and applications developed by participants to support on-going international discussions on the principles, criteria, and policies related to global desertification, and especially the CCD.

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A new approach to global, dynamic modeling of integrated human in natural systems

by R. Costanza, R. Boumans and D. Sahagian

The role of human societies in the Earth system is becoming increasingly important. As a result, it is critical to incorporate human systems into integrated models of the Earth system. One such model is the Global Unified Metamodel of the BiOsphere (GUMBO), which was developed to simulate the integrated earth system and assess the dynamics and values of ecosystem services [1]. It is a “metamodel” in that it represents a synthesis and a simplification of several existing dynamic global models in both the natural and social sciences at an intermediate level of complexity. The current version of the model contains 234 state variables, 930 variables total, and 1715 parameters.

GUMBO addresses the following key objectives:

1) To model the complex, dynamic interlinkages between social, economic and biophysical systems on a global scale, focusing on ecosystem goods and services and their contribution to sustaining human welfare.

2) To create a computational framework and database that is simple enough to be distributed and run on a desktop PC by a broad range of users. GUMBO was constructed in STELLA, a popular icon-based dynamic simulation modeling language (http://www.hps-inc.com), and the full model can be downloaded (http://www.uvm.edu/giee/GUMBO) and run using the free run-time only version of STELLA.

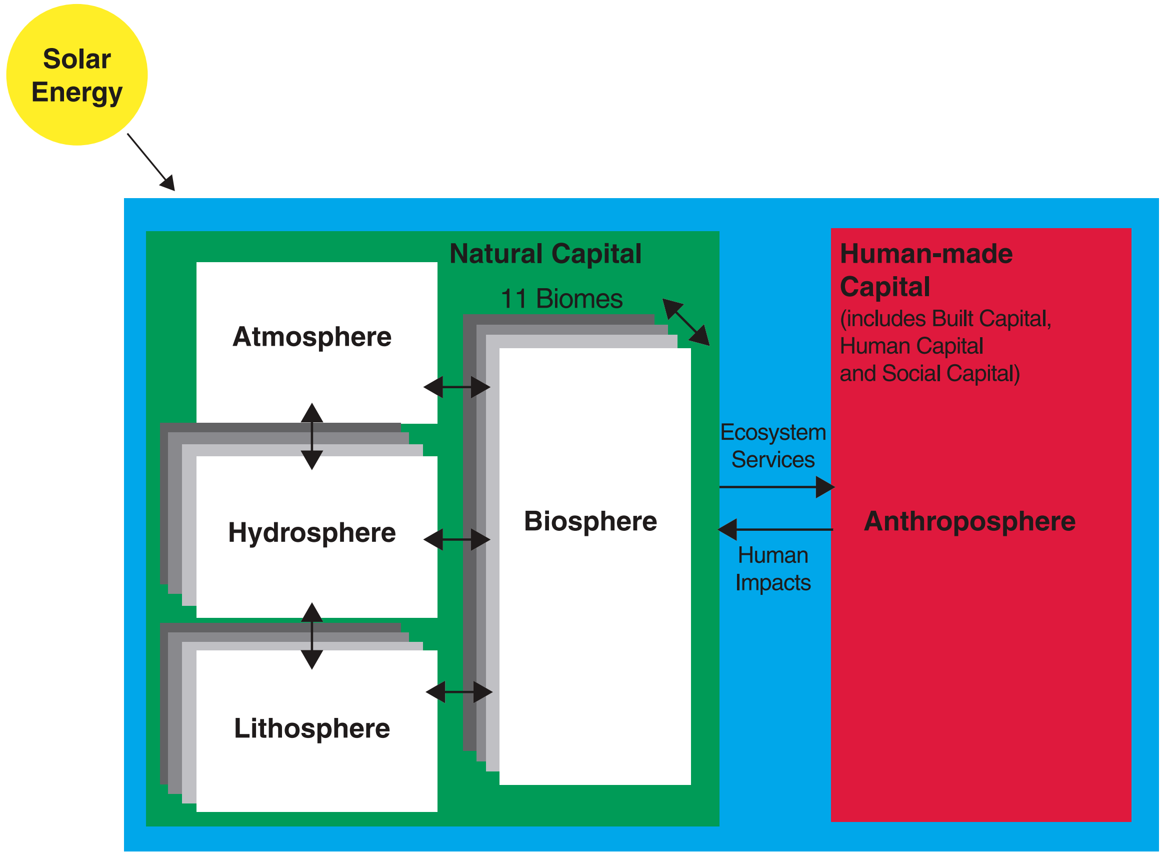

Figure 1. GUMBO; The Global Unified Model of the BiOsphere

GUMBO was designed to provide a flexible computational platform for the simulation of alternative global pasts and futures envisioned by diverse end-users. GUMBO limits historical parameter values to those that produce historical behaviour consistent with historical data. It then allows one to make explicit assumptions about future parameter or policy changes, or to determine what assumptions are required to achieve a specific future. It is then possible to assess how plausible those assumptions are, and to consider policy options that might make the assumptions required for a desired future more likely to occur. It is useful to allow the user to change specified parameters within GUMBO and generate alternative images of the future in order to both stimulate dialogue about global change and generate a more complete understanding of the complex interrelationships among social and economic factors, ecosystem services, and the biophysical Earth System. This dialogue is needed in order to achieve sustainable development on a global scale.

In GUMBO, three issues are considered that may provide new insights into the Earth System:

1. Ecosystem services explicitly affect both economic production and social welfare. This allows the model to calculate dynamically changing physical quantities and values for ecosystem services based on their marginal contributions relative to other inputs into the production and welfare functions.

2. Both ecological and socio-economic changes are endogenous, so we emphasise interactions and feedbacks between the two, rather than limiting either ecological or socioeconomic change to exogenously determined scenarios (c.f, [2-4]).

3. We include natural capital, human capital, social capital and built capital as state variables and factors of production, and distinguish between material factors and factors of transformation (material cause and efficient cause, in Aristotelian terms). This allows limited substitution between factors of production at the margin, but also imposes strong sustainability constraints on the system as a whole.

We consider five distinct modules or “spheres” in GUMBO: the Atmosphere, Lithosphere, Hydrosphere, Biosphere, and Anthroposphere (Figure 1). The Earth’s surface is further divided into eleven biomes or ecosystem types which encompass the entire surface area of the planet: Open Ocean, Coastal Ocean, Forests, Grasslands, Wetlands, Lakes / Rivers, Deserts, Tundra, Ice / rock, Croplands, and Urban (Figure 1). These eleven biomes represent an aggregation of the sixteen biomes used in Costanza et al [5]. Their relative areas change in response to urban and rural population growth, Gross World Product (GWP), and changes in global temperature. Among the spheres and biomes, there are exchanges of energy, carbon, nutrients, water and mineral matter. In GUMBO, ecosystem services are aggregated to 7 major types, while ecosystem goods are aggregated into 4 major types. Ecosystem services, in contrast to ecosystem goods, cannot accumulate or be used at a specified rate of depletion. Ecosystem services include: soil formation, gas regulation, climate regulation, nutrient cycling, disturbance regulation, recreation and culture, and waste assimilation. Ecosystem goods include: water, harvested organic matter, mined ores, and extracted fossil fuel. These 11 goods and services represent the output from natural capital, which combines with built capital, human capital and social capital to produce economic goods and services and social welfare. The model calculates the marginal product of ecosystem services in both the production and welfare functions as estimates of the prices of each service.

Historical calibrations from 1900 to 2000 for 14 key variables for which quantitative time series data was available produced an average R2 of 0.922. A range of future scenarios to the year 2100 representing different assumptions about future technological change, investment strategies and other factors have been simulated (Figure 2 is a sample plot of a few of the output variables). The scenarios include a base case (using the “best fit” values of the model parameters over the historical period) and four alternative scenarios. These four alternatives are the result of two variations (a technologically optimistic and skeptical set) concerning assumptions about key parameters in the model, arrayed against two variations (a technologically optimistic and skeptical set) of policy settings concerning the rates of investment in the four types of capital (natural, social, human, and built). They correspond to the four scenarios laid out in Costanza [6].

While we are still in the early stages of development of this integrated approach to modelling humans in natural systems, some preliminary results have already been obtained through GUMBO:

- A high level of dynamic integration between the biophysical Earth System and the human socioeconomic system is important if we are to develop integrated models with predictive capabilities.

- Preliminary calibration results across a broad range of variables show very good agreement with historical data. This builds confidence in the GUMBO model and also constrains future scenarios. We produced a range of scenarios that represent what we thought were reasonable rates of change of key parameters and investment policies, and these bracketed a range of future possibilities that can serve as a basis for further discussions, assessments, and improvements. Any user can change these parameters further and observe the results.

- Assessing global sustainability can only be done using a dynamic integrated model. However, one is still left with decisions about what to sustain (i.e. GWP, welfare, welfare per capita, etc.). GUMBO allows these decisions to be made explicitly and in the context of the complex world system. It allows both desirable and sustainable futures to be examined.

- Ecosystem services are an important link between the biophysical functioning of the Earth System and the provision of sustainable human welfare. We have found that their physical and value dynamics are quite complex.

- The overall value of ecosystem services, in terms of their relative contribution to both the production and welfare functions, is shown to be significantly higher than GWP (4.5 times in this preliminary version of the model).

- “Technologically skeptical” investment policies are shown to have the best chance (given uncertainty about key parameters) of achieving high and sustainable welfare per capita. This means increased relative rates of investment in knowledge, social capital, and natural capital, and reduced relative rates of consumption and investment in built capital.

With these preliminary results, we can continue to move forward in the development of GUMBO in order to further improve its capacity to model humans in natural systems.

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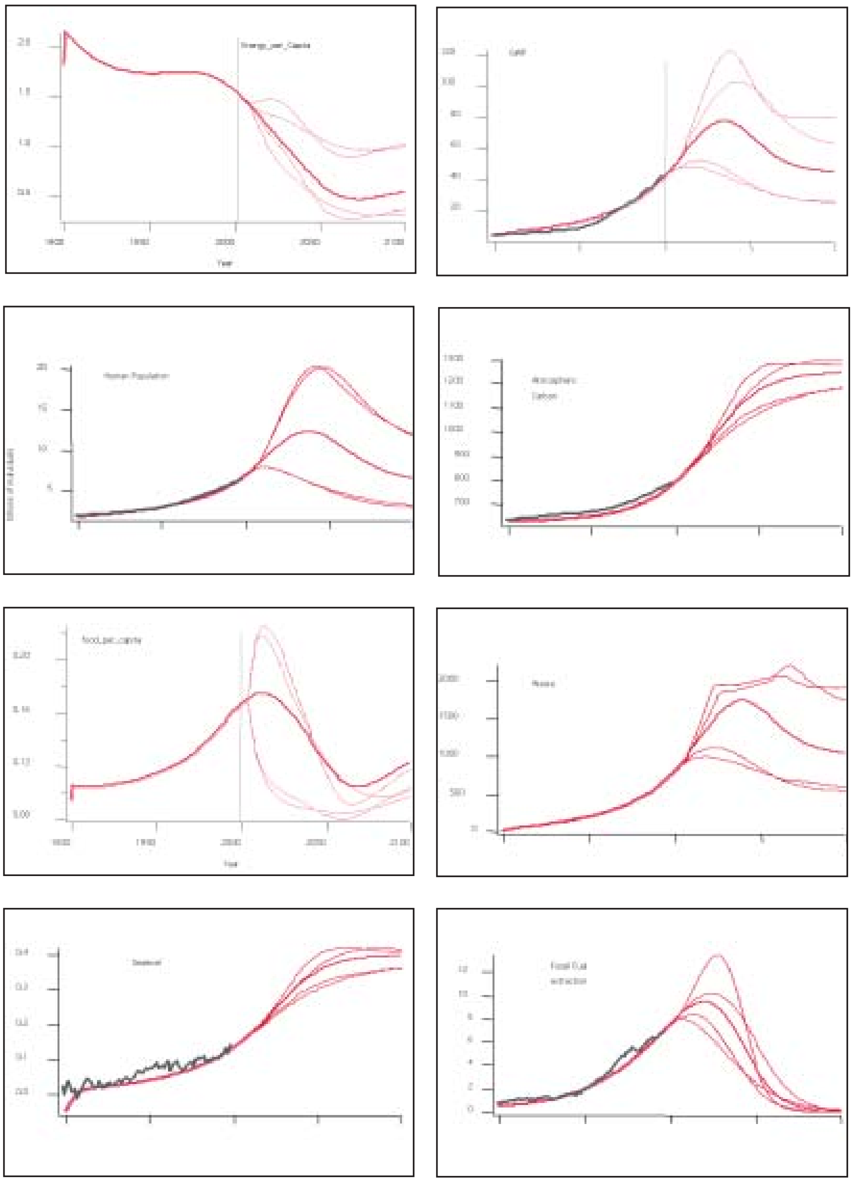

Figure 2. Depending on assumptions regarding technological change, resource utilization strategies, and other factors, there are a number of scenarios that can be used in the model to generate specific predictions regarding a number of parameters. A few of these parameters are indicated here. “Star Trek” is a scenario of technologically optimistic policies in a world that in fact produces new alternative energy sources and solutions to technologic and environmental problems, “Mad Max” involves technologic optimism that is not supported by new energy sources or solutions, “Big Government” is technologically pessimistic but with new alternative energy sources and solutions, and “Ecotopia” involves little technologic change, with no new sources of energy or other novel approaches to current and future environmental issues. Note that in all scenarios, present trends generally continue for some time, and then reverse for various reasons.

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These articles are the first in our new regular feature on National Committee Science. National Committees (NC) play an integral role in IGBP science, and as such, the recent research conducted by members of IGBP sponsored National Committees will be presented here in order for the IGBP international community to learn more about the science at the national level.

In this edition, we present two features from the Portuguese National Committee, focusing on the contribution they make to GLOBEC-oriented science and research. The first introduces the role that GLOBEC plays at the national level and how it has influenced the national research agenda. The following article further supports this assertion by presenting recent research results on ocean dynamics specific to the coast of Western Iberia and how they affect small pelagic fish populations. These articles are excerpts from the Portuguese NC Newsletter. For further information, see their website at: http://www.isa.utl.pt/igbp-pc/.

The importance of GLOBEC within the Portuguese scientific community

by I. Ambar

GLOBEC (Global Ocean Ecosystem Dynamics) aims to understand the way global climate changes can affect the abundance, diversity and productivity of marine ecosystems. GLOBEC focuses primarily on zooplankton, including not only the herbivorous species but also the primary carnivores, since both are of vital importance for larvae and juvenile fish feeding. The dynamics of zooplankton populations is especially relevant to aspects connected with carbon transport through marine ecosystems (from the primary producers through to the higher trophic levels of the food web) and with the recruitment and stocks of fish species.

Plankton are very sensitive to the effect of oceanic currents, turbulent motions, temperature fluctuations and solar radiation penetration. As a result, aspects connecting the variability of the physical processes to the variability of the biological processes are important issues from the point of view of GLOBEC. It is necessary to know better the structure and the functioning of the global ocean ecosystem and its response to the physical forcing agents in order to evaluate and predict the behaviour of the marine ecosystem subject to global climate changes. Here we outline some aspects of the relationship between physical and biological processes that take place off the Portuguese coast and how the GLOBEC national community can strongly contribute to GLOBEC's research agenda.

The basic components of the Portugal Current System include: (i) the Portugal Current, a permanent southward surface circulation off the Portuguese continental margin that constitutes the eastern branch of the North Atlantic large scale subtropical gyre; (ii) the Portugal Coastal Current, which exists during the summer as a southward surface current in the vicinity of the continental shelf edge associated with the upwelling regime; (iii) the Portugal Coastal Countercurrent that forms during autumn-winter, as a northward surface current along the upper slope; and (iv) a Mediterranean Undercurrent that flows at intermediate depths along the continental slope, and transports warm and salty water northward from the Mediterranean.

The Portugal Coastal Current and the coastal upwelling phenomenon are associated with the coastal divergence generated by northerly winds that predominate during the summer months off the Portuguese western coast [1,2]. These winds induce an offshore mass transport in the upper layer (first 100 to 200 meters) of the coastal ocean. By continuity, the colder subsurface waters ascend to the surface, substituting the top layer, and leading to the cooling of the sea surface near the coast. The upwelling phenomenon, besides its cooling effect, increases the concentration of nutrients (nitrates, phosphates and silicates) in the surface waters. This is due to the fact that the subsurface layers that are carried to the surface are richer in nutrients. There are also large concentrations of nutrients in layers where the solar radiation can penetrate, creating ideal conditions of food and light for the phytoplankton growth. The consequent increase in primary production (first level of the trophic chain) generates the development of the whole food chain, from zooplankton to fish and other marine species that feed from plankton or other fishes [3].

On the other hand, during autumn and winter months, the circulation regime reverses, giving way to the Portugal Coastal Countercurrent, which is partially induced by the coastal convergence associated with southerly winds, which are dominant during this season [4]. This Countercurrent carries northward warm and salty water of subtropical origin, and is associated with the transport of subtropical marine species to higher latitudes. These are two good examples of the interaction between physics and biology, the study of which requires the development of numerical models that simulate the physical and biological processes associated with in situ and remote sensing observations.

From the point of view of research at the national level, the North Atlantic Oscillation (NAO) is also an extremely relevant aspect of climate fluctuations and their consequences for marine ecosystems. The NAO corresponds to a large-scale atmospheric phenomenon, involving an alternation in the intensity of the subtropical atmospheric high-pressure center over the Azores and the subpolar low-pressure center over Iceland. The NAO has a strong influence on interannual climate variability and affects the intensity and direction of the westerlies blowing in the North Atlantic. As a result, it has consequences on the ocean circulation and physical processes. On the other hand, the fluctuations of the sea surface temperature and upper ocean stratification that might directly or indirectly result from this oscillation, seem to be connected with fluctuations in the abundance of some zooplankton species. Presently, this is an important issue that the Portuguese scientific community should invest in, especially considering that they benefit from the privileged geographic location for the development of this research.

In summary, what is suggested here is that the efforts of the national scientific community should proceed in developing the knowledge of the dominant physical processes (coastal currents and countercurrents, frontal zones and ascending movements associated with coastal upwelling, etc.) and associated biological processes, in order to be able to understand the mechanisms forcing the fluctuations in marine ecosystems and build capacity for predicting future impacts.

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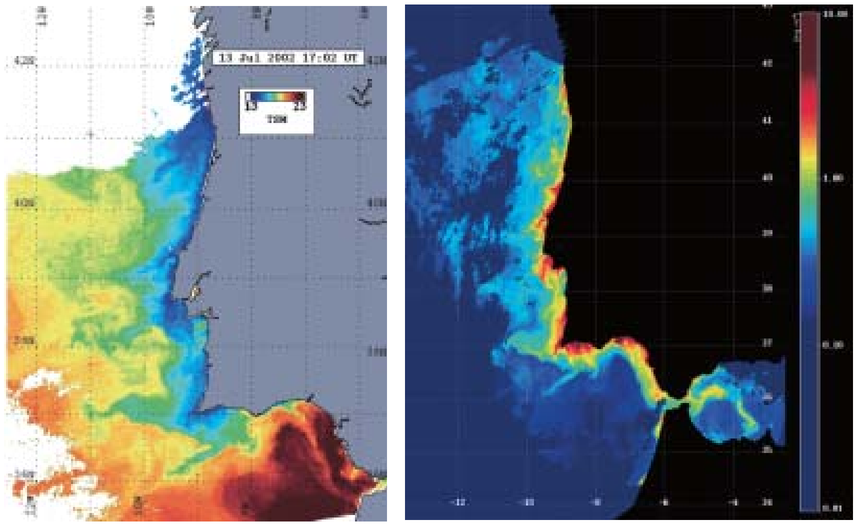

Figure 1. Satellite remote sensing images in the domain of (a) infrared (sea surface temperature) and (b) visible (concentration of chlorophyll pigments), in July 2002. The lower temperatures near the Portugal western coast and the large chlorophyll concentrations are evidence of coastal upwelling in this region.

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Dynamics of marine ecosystems off the Western Iberian Peninsula: local contributions to GLOBEC

by A. Miguel Santos and Á. Peliz

Populations of small Pelagic Fish (SPF), such as sardines, show significant natural fluctuations in their abundance. These fluctuations appear to be related to, among other factors, variations in environmental conditions.

Over the last decades, researchers have observed a decline in sardine recruitment, particularly off the coasts of northeast Portugal. This decline accompanies a change in the typical wind patterns of the region. An increasing frequency of northerly winds favourable to upwelling along the Western Iberian coast (typical of the summer regime) has been observed during winter months. Given that the reproduction of SPF (e.g., sardine and mackerel) in this region occurs during winter, these atypical wind events may have a negative impact on the survival of the early life stages of these pelagic fish. Results of the PO-SPACC Project (a Portuguese contribution to the SPACC programme) revealed a statistical relationship between this environmental factor and recruitment variability, with consequences for the dynamics of SPF populations [1,2].

There is evidence that these wind fluctuations may be related to larger or basin scale processes. The North Atlantic Oscillation (NAO; e.g. [3]) is one of these large-scale processes. Positive values of the NAO index leads to an increase in wind events favourable to upwelling off the coast of Western Portugal during winter months. The NAO index has been predominately positive since the beginning of the 1970s, with especially high values in the beginning of the 1990s when the maximum values were observed. This indicates an important shift in the climatic regime between the periods 1940-1960 and 1970-1990 that coincides with the fluctuations in sardine catches; a cycle of high catches before the 1970s followed by a period of low catches in the following years [2].

From an oceanographic point of view, the basis for this hypothetical relationship is simple: in the presence of coastal upwelling dynamics, the SPF eggs and larvae are flushed offshore to zones unfavourable for their development / growth, both in terms of the hydrodynamics and the availability of food. In this way, the increase in frequency of winter wind events favourable for upwelling off Westen Iberia has a negative impact on the reproduction of SPF, with a consequent decline in their recruitment.

With the objective of investigating these hypotheses, several projects have been conducted by the IPIMAR, forming national contributions (funded by the Portuguese Science Foundation) to GLOBEC international (e.g., SURVIAVAL, PO-SPACC, [4]). Results from Project SURVIVAL show that wind driven transport alone does not explain the complex circulation observed over the slope and shelf, and the associated patterns of egg and larvae dispersal that were observed during the oceanographic cruise SURVIVAL 2000 [5]. It was evident that shelf / slope circulation and the distribution of ichthyoplankton were also affected by other factors: (i) the structure and circulation of the Western Iberia Buoyant Plume (WIBP) [6]; and (ii) the slope circulation and mesoscale structures associated with the 'Iberian Poleward Current-IPC' [7].

The WIBP is a low salinity lens (< 35.8 psu) fed by river runoff at several points off the coast of north western Iberia and it intensifies in winter. In typical winter conditions (i.e., without coastal upwelling) the WIBP is trapped in the inner shelf north of the Mondego River [6,7]. In situations when coastal upwelling is developing, like those observed during SURVIVAL 2000 (February 2000), the WIBP can extend beyond the shelf break as a thin surface layer, usually

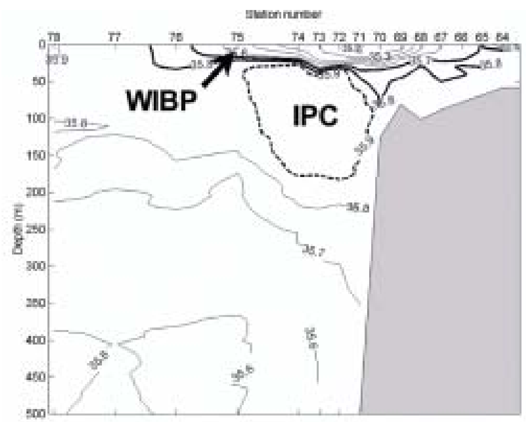

Figure 1. Vertical section of salinity obtained during the SURVIVAL 2000 cruise. The purpose of the section is to illustrate the Iberian Poleward Current flowing along the upper slope (note the high salinity core with dashed lines) and the surface low salinity water of the WIBP defined as having salinity values under 35.8 (thick solid line).

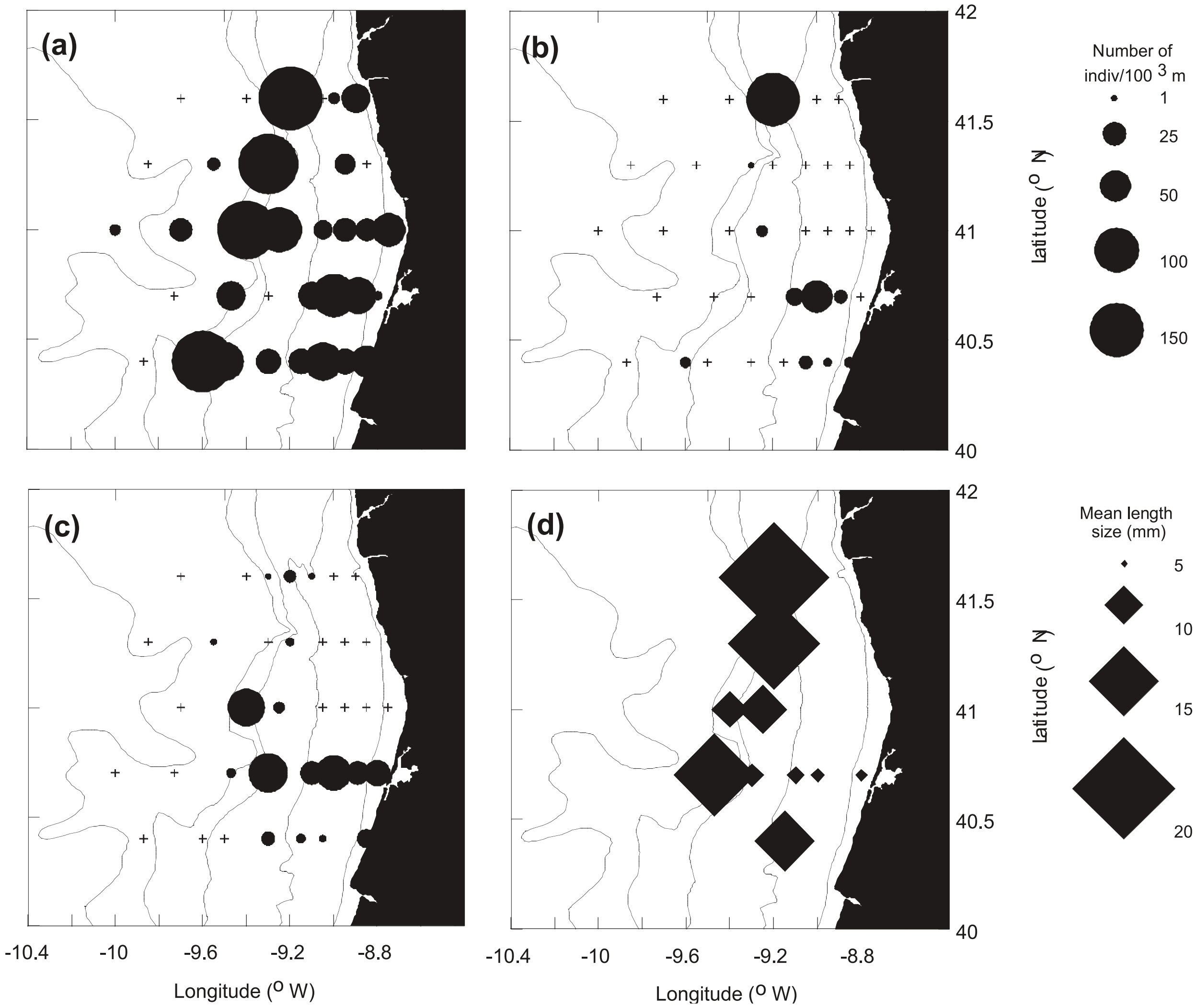

Figure 2. Distribution and abundance of ichthyoplankton during cruise SURVIVAL 2000: (a) Number of fish eggs/100 m^3; (b) number of sardine eggs/100 m^3; (c) number of sardine larvae/100 m^3 and (d) mean sardine larvae length (mm). The thin lines represent bathymetric contours: 30, 100, 200, 1000, 3000 m.

less than 25 m deep, capping the poleward flow that transports warmer and saltier waters northward parallel to the shelf slope (Figure 1). The IPC originates in the interaction of zonally aligned fronts usually present during winter off the coast of Western Iberia (e.g., Western Iberia Winter Front -WIWiF, [7]) with the shelf / slope system. The WIWiF, the IPC and its associated mesoscale features can be observed in Figure 3a. Complementary to the wind-driven transport, the slope current plays a very important role in the definition of larvae advection patterns (e.g.,[5]). The IPC: (i) induces zones of convergence along the shelf-break; (ii) modulates the along-shore transport; and (iii) enables means of exchange between the shelf, slope and deep ocean through its mesoscale structure.

The biological consequences of these two important structures are evident from the results of the SURVIVAL Project (e.g., [5,8,9])(Figure 2). Mechanisms of retention / aggregation of biogenic material were proposed by Santos et al. [5] for ichthyoplankton and by Ribeiro et al. [9] for phytoplankton. Contrary to expectations, in a situation with coastal upwelling occurring as it did during the SURVIVAL 2000 cruise (offshore transport and high larvae mortality as the initial working hypothesis of SURVIVAL) almost all the larvae captured during the cruise were in good nutritional condition and only 0.64% were classified as in starving state [8]. These results were explained by high food availability at the time of the cruise, estimated by the calculation of the zooplankton biomass daily copepod egg production.

Ribeiro et al. [9] give additional information for the understanding of this winter upwelling event and of the high food availability. Using phytoplankton

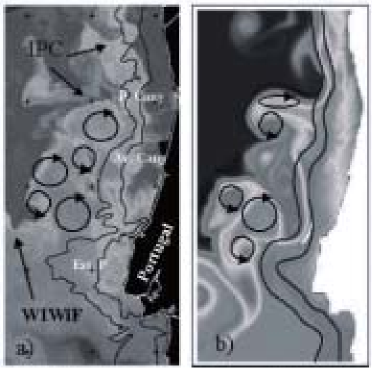

Figure 3.

The Western Iberia Coastal Transition Zone and the generation of the IPC: (a) NOAA/AVHRR 25 Feb 1998 sea surface temperature (SST); and (b) Model output (SST) of the Regional Ocean Modeling System (ROMS). Darker colours represent colder waters. Isobaths 200 and 100 m are shown and the circles represent the zones of intense eddy activity associated with the IPC.

biomass distributions obtained using combined data from satellite (SeaWiFS) and in situ (Fluorometric), the authors verified that during the SURVIVAL sampling period the biological response to coastal upwelling was different from what was expected in relatively deep (100-150 m) low nutrient mixed layers. The presence of the WIBP enabled the necessary amounts of nutrients and degree of stratification for phytoplankton growth to commence.

Santos et al. [5] showed that the transport of sardine larvae in this region is largely constrained by the local structures (IPC and WIBP), and can not be simulated with oversimplified Ekman layer transport models. The retention of ichthyoplankton in general and sardine larvae in particular along convergence zones generated by these two circulation features was a decisive factor for the survival of larvae despite the ''unfavourable" wind conditions. The phytoplankton biomass growth observed inside the WIBP provided larvae with good nutritional conditions even in an adverse situation.

In conclusion, these studies demonstrate that atmospheric variables (e.g., wind), despite their importance in these studies once they are observed operationally, are not sufficient for the estimation of transport patterns in complex circulation scenarios such as in the northern part of Western Iberia. The results indicate the need for further study of local oceanographic processes in order to gain better understanding of the overall marine ecosystem. For example, a single biological component might have different responses to a wind event in different zones depending on the local oceanographic features. Considerable effort is presently being dedicated at IPIMAR to modelling these oceanographic processes. Preliminary model results indicate that the structures resulting from the interaction of the IPC with the shelf/slope (eddy-topography interaction) may influence cross-shelf larvae transport, comparable to the wind-driven currents if not higher. In Figure 3b one of the model results is presented, where it is possible to compare the type and scales of the structures associated with the IPC.

The IPIMAR team continues to investigate these areas and seeks national and international cooperation in the GLOBEC related fields, namely in the influence of oceanographic processes and their climatic fluctuations on marine ecosystems.

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News on The Land Project

For the past two years, a group of scientists representing IGBP and IHDP programme elements has been working, with the collaboration of many others in the community, on developing a Science and Implementation Plan for the new Land Project (Figure 1). Co-chairs of this effort are Dennis Ojima, Sandra Lavorel, Emilio Moran, and Lisa Graumlich. Major changes were recently undertaken in the Science Plan at Banff, where scientists came to agreement on the broad outline of an exciting Science Plan.

The Land Project has one overall objective: understanding the terrestrial coupled human-environment system in order to reduce the vulnerability of the human-environment system to global environmental change and enhance sustainability of land systems.

Land Change Science

During IGBP I we learned that our understanding of global change is dependent not only on our understanding of how the physical world works, but on our ability to better understand the role that human activities play. Human use of land resources alters biogeochemical cycles, the provisioning of goods and services, and the structure and function of ecosystems, i.e. the Earth System. These changes, in turn, result in shifts in how people make decisions about land resources and even how people organise and govern themselves. Research in the coming decade needs to address these interactions in new ways by examining the causes and consequences of these interactions in order to achieve an integrative understanding of the ways that human and biophysical feedbacks may reduce vulnerability. This research will also contribute to understanding the conditions under which these feedbacks can move us towards sustainability in human and biophysical parts of ecosystems. To do so we need a new paradigm which we will call Land Change Science.

The challenge of Land Change Science for the scientific community is how to effectively link, or couple, human and biophysical components of the Land System. This coupling is necessary to adequately understand the impacts that humans have on the physical world, the consequences of those impacts on the structure and function of ecosystems and their capacity to provide goods and services (such as food and fiber), and to develop effective ways to reduce vulnerability and enhance sustainability. This effort requires new scientific approaches in which social, agricultural, biological, and physical scientists work together to achieve a new level of synthesis heretofore rarely if ever tried.

To undertake this challenge, two core communities have come together to collaborate in making this daunting task a reality: the Land Use and Land Cover Change Project (LUCC) and the Global Change in Terrestrial Ecosystems Project (GCTE). Figure 2 illustrates the key components, themes and interactions of the Land Project. Many other programmes further support this work and collaboration, among them: IHDP elements such as IDGEC, GECHS, and IT; DIVERSITAS; IGBP elements such as ILEAPS, PAGES, LOICZ, GAIM; and others in the ESSP network (e.g. GCP, GECAFS, Water and Health). This document outlines the framework for research and the initial steps towards Implementation. Previous work carried out by the LUCC and GCTE projects has focused on the pathways of change and on the major impacts of environmental and societal changes on land use and terrestrial ecological systems, respectively. The aim of the Land Project is to build on this knowledge in order to consolidate and broaden our understanding of specific drivers and processes, and to comprehend the inter-linked dynamics of humans and environmental systems (Figure 2).

Land Change Science Themes

The goal of the Land Project is to develop a comprehensive and integrative understanding of how human and natural systems interact so that policy-relevant models can be developed that will support pathways towards sustainability of human and natural systems, and the reduction of their vulnerability under conditions of global change. Three themes serve to organise the research to be undertaken: (1) causes and nature of Land System change; (2) consequences of Land System change; and (3) integrative analysis and modeling.

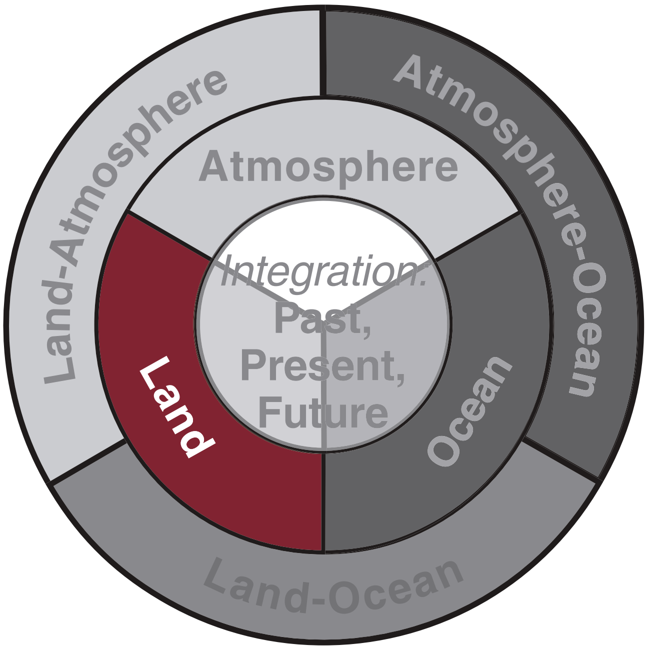

Figure 1. The organisational srtucture of IGBP.

Land Change Science will use place-based studies, long-term observations and experiments, process models, meta-analyses, decision-making models, and integrative modelling to carry out its research tasks. It will give new emphasis to integrative regional studies to complement process studies and lead to integrative modelling. Three foci give order to the implementation of the Science Themes:

Focus 1: Causes and Nature of Land System Change

Research activities will address the impacts on ecosystems of human activities, and in particular, land uses: how people make decisions under uncertainty; how climate and other Earth System processes affect the decisions heterogeneous agents make; how agents organise into different social and governance systems to manage land resources; and how the Earth System impacts land-based ecosystems. These will be addressed by studying multiple and interacting stresses. The following questions will guide research conducted within focus 1: How do the human dimensions of global change affect regional and local human societies and their land use practices? How does land use affect ecosystems? How do climatic and atmospheric factors individually and interactively affect the biophysical sub-system? What are the combined impacts of human and biophysical change on ecosystems?

Focus 2: Consequences of Land System Changes

Research activities will address the consequences of changes in ecosystems for a variety of land uses experiencing different magnitudes of disturbance and management, including those that may be extreme enough or frequent enough to bring about changes in the structure and function of ecosystems. It will also address the ways that the provisioning of ecosystem goods and services may be affected by changes in land uses, biogeochemical cycles, soil fertility and water availability, and shifts in net primary production resulting from changes in both human and Earth System dynamics. Of particular interest are the feedbacks from changes in the biophysical sub-system to the Earth System, and the ways human sub-systems at local to regional scales feed back to larger scale processes. Focus 2 will be guided by the following questions: What are the consequences of changes in ecosystems services for human welfare? How do ecosystem functions translate into ecosystem services? What are the feedbacks from changes in ecosystems to the coupled Earth System? How do global institutions receive information about ecosystem changes and how do they respond? How is land use shaped by changes in ecosystem services and the human dimensions of global change?

Focus 3: Integrative Analysis and Modelling

Research activities will address the characteristics of complex systems, such as their emergent and non-linear properties, seek to identify the thresholds that may reset the system at different equilibrium points, and develop suites of models capable of encompassing the spatial and temporal dimensions of complex human-natural systems. These models will be oriented towards discovering the processes and feedbacks that result in enhancing the resilience and sustainability of both the human and natural systems, while also reducing their vulnerability to a whole range of global system changes. This will include focusing not only on ecosystem feedbacks, but also on human system feedbacks, such as changing perceptions of environmental risk, new national and international governance modes to regulate use of land resources, and shifts in population growth rate and location. Research under focus 3 will examine the following questions: What are the dynamics of land systems that lead to emergent and path dependent properties and to thresholds that change the structure and function of the systems? How does the vulnerability and resilience of land systems to hazards and disturbances vary due to changes in human and environment interactions? Which institutions and policies enhance adaptation towards land sustainability? How can data and models at different scales and complexities of analysis improve understanding and enhance decision-making and governance?

In short, the research plan addresses a number of key issues. The research activities associated with these issues are developed across the set of three themes described above. These issues include:

- Human effects on, and impacts of, changing coupled biogeochemical cycles, includ-

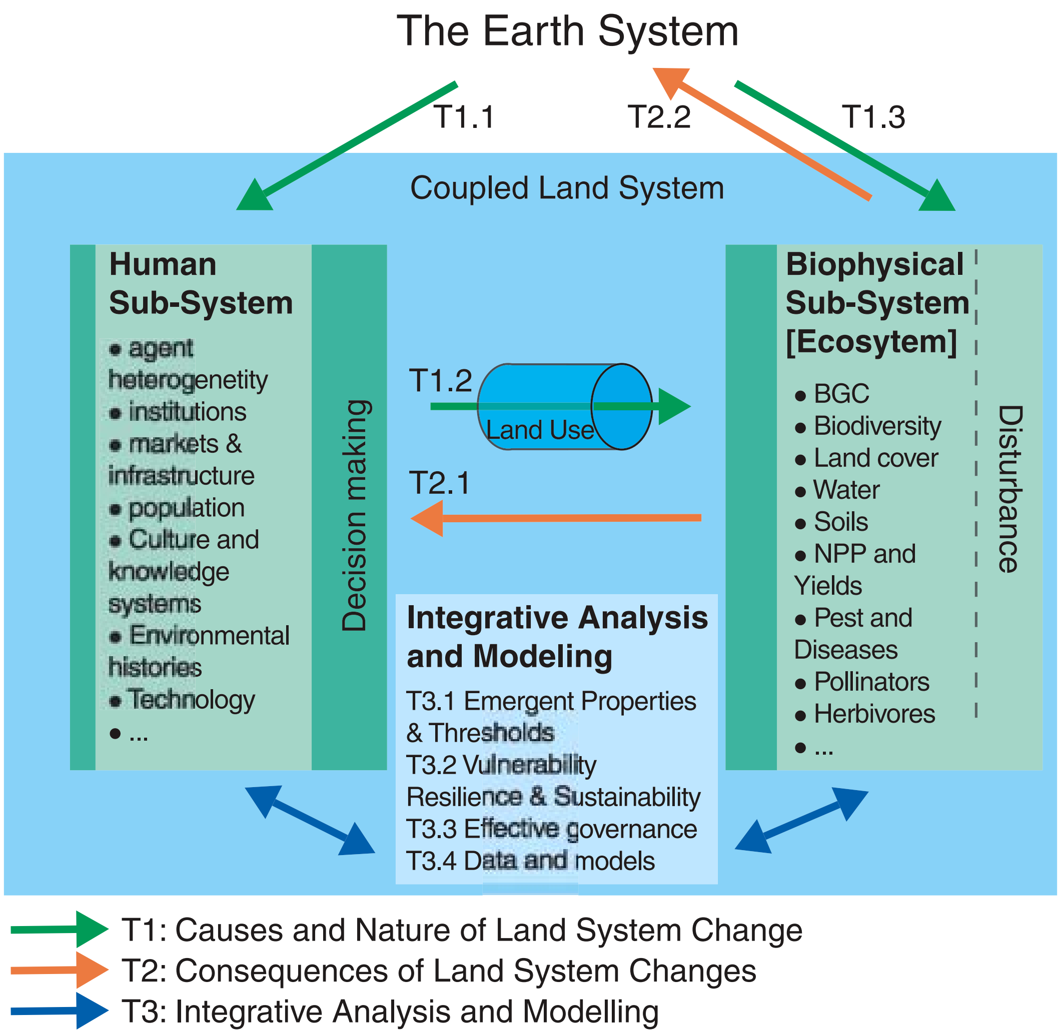

Figure 2. Conceptual framework for the Land project

ing a focus on the terrestrial-aquatic carbon cycles.

- Societal impacts of changes in disturbance and management regimes (e.g., associated with fire, pest, or diseases) on the human-environmental system and the provision of ecosystem goods and services.
- The impact of changes in biodiversity on the maintenance of ecosystem goods and services.
- The vulnerability of specific human-environmental systems (e.g., mountains, water basins, arid lands) due to multiple stresses on key social and natural resources.
- The impact of human activities in modifying the land use/cover pattern and human-environmental interactions along the urban-rural gradient.

These questions provide guidance to the many communities that contribute to this effort. We invite the social science community, the agroecological community, the ecosystem ecology community, the atmospheric and climate science community, the biodiversity community and others who study related issues to join us and contribute to answering the questions posed in the Land Project and advancing the state-of-knowledge within Land Change Science. We also invite these communities of scientists to attend the First Open Science Meeting of the Land Project that will take place in Morelia, Mexico between 1-5 December 2003. A one-day workshop will take place 1 December which will allow the GCTE, LUCC and IHDP communities as well as others, to organise and begin to specify the activities to be undertaken as the project moves forward in 2004. Details are available at the GCTE webpage via the IGBP webpage.

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After the Mt Pinatubo volcanic eruption in 1991, the rate of increase of atmospheric CO_2 was much lower than expected. The cause of this reduced rate of increase in CO_2 is the subject of much debate in the scientific community. Here we present two different viewpoints.

"Using the Lena-Potsdam-Jena (LPJ) dynamic vegetation model, Lucht et al. (2002) concluded that the increase in net ecosystem productivity following the eruption was not due to increase in CO_2 uptake by vegetation but due to a decrease in heterotrophic respiration associated with cooling."

Decreased heterotrophic respiration reduced growth in atmospheric CO_2 concentration

The interannual variability in the rate of growth of atmospheric CO_2 is governed primarily by terrestrial ecosystem processes [1]. In the two years following the eruption of Mt. Pinatubo in June 1991, the rate of increase of atmospheric CO_2 concentration (~0.72 ppm/year) was about half the average rate (~1.43 ppm/year) from 1968-2001 (e.g. see [2] (Figure 1)). The reduction in the rate of increase of atmospheric CO_2 concentration following the eruption has been attributed to an increase in net ecosystem productivity of the terrestrial biosphere. This note addresses the debate about whether this increase in global net ecosystem productivity was caused by an increase in photosynthetic CO_2 uptake by vegetation (associated with an increase in the fraction of diffuse radiation due to increased volcanic aerosol concentration in the atmosphere) or by a decrease in ecosystem respiration (associated with a decrease in mean global annual temperature). Climate records show that the eruption was followed by a 0.5 °C decrease in mean global annual temperature [3], a 33% increase in diffuse radiation and a 3% reduction in global solar radiation[4].

The interannual variability in CO_2 uptake by the terrestrial biosphere is driven primarily by changes in precipitation and temperature. Incoming solar radiation shows very little interannual variability. However, the large fraction of incoming solar radiation which is diffuse relative to direct may significantly influence the CO_2 uptake by the vegetation. Measurements in forest ecosystems have shown that canopy CO_2 exchange is sensitive to the diffused component of incoming solar radiance [5]. Researchers have also shown that gross CO_2 uptake by plants is higher under diffused radiation (e.g., see [6,7]) because the photosynthetic rate of individual leaves saturates at high irradiance. Since individual leaves in low irradiance have a higher light-use efficiency (LUE, CO_2 uptake per unit radiation) the canopy as a whole is more efficient in low irradiance.

An increase in net ecosystem productivity following the Pinatubo eruption could have been due to an increase in CO_2 uptake by the terrestrial biosphere, a reduction in respiration from vegetation and soils, or both. An increase in CO_2 uptake by the terrestrial biosphere is likely because of an increase of 33% in diffuse radiation. Equally likely is the reduction in ecosystem respiration due to a decrease in mean global annual temperature of 0.5 °C.

Based on a LUE ecosystem model, Roderick et al. [6] estimate that the Mt. Pinatubo eruption may well have resulted in the removal of an extra 2.5 Pg of carbon from the atmosphere (~1.2 ppm) due to the stimulation of the terrestrial vegetation with more diffuse radiation. Baldocchi et al. [7] also suggest that a possible increase in photosynthesis due to increased diffuse radiation may have reduced the growth rate of atmospheric CO_2.

However, recent results from a modelling study [8] and northern hemisphere (NH) normalized difference

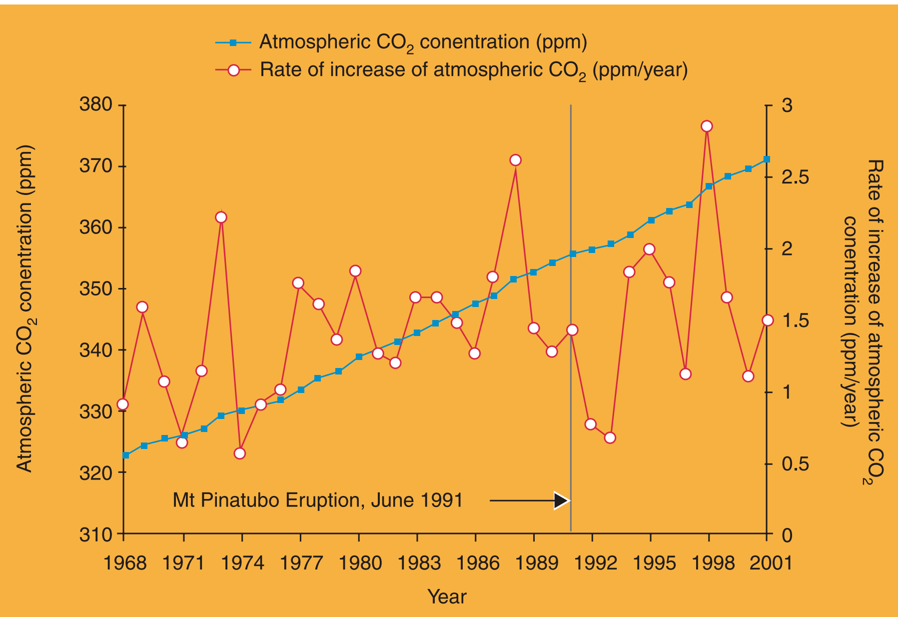

Figure 1. Atmospheric CO_2 concentration (ppm) from Mauna Loa (Keeling et al., 1995) and its rate of increase (ppm/year) for the 1968-2001 duration. The average rate of increase of atmospheric CO_2 concentration from 1968-2001 is ~1.43 ppm/year. The rate of CO_2 increase in the atmosphere dropped to ~0.72 ppm/year for two years following the Mt. Pinatubo eruption.

vegetation index (NDVI) data reported by Slayback et al. [9] suggest that CO_2 uptake by vegetation did not increase following the eruption. Using the Lena-Potsdam-Jena (LPJ) dynamic vegetation model, Lucht et al. [8] concluded that the increase in net ecosystem productivity following the eruption was not due to increase in CO_2 uptake by vegetation but due to a decrease in heterotrophic respiration associated with cooling. Lucht et al. [8] did not simulate an increase in vegetation carbon in years following the eruption, rather they simulated a decrease in NH boreal zone modelled leaf area index. The decrease in NH leaf area index simulated by Lucht et al. [8] is consistent with the clear drop in NDVI data reported by Slayback et al. [9]. The drop in observed NH NDVI data following the eruption indicates that the increase in diffuse radiation following the eruption did not help the vegetation to increase its carbon uptake. On the contrary, the carbon uptake by vegetation following the eruption most likely reduced due to cooler temperatures. Even if the diffused radiation did help the vegetation to photosynthesize more, it appears that the photosynthesis was even more constrained by cooler temperatures. Slayback et al. [9] show that the drop in NDVI is greater at higher latitudes. The boreal zone in Canada and Siberia experienced the largest drop in NDVI such that the calculated NDVI trend for these regions over the 1982-1999 duration is almost zero, despite the general NH greening trend [10].

There are caveats associated with both NDVI measurements and the LPJ modeling study. The change in observed NDVI characteristics in 1992 may be due to the incorrect aerosol correction or it may reflect actual changes in vegetation growth due to global cooling [9]. The LPJ model does not take into account the diffuse and direct fractions of incoming radiation to model photosynthetic CO_2 uptake, rather it models CO_2 uptake as a function of total incoming radiation [11].

If confidence can be placed in NDVI data, then the overall decrease in NH NDVI following the Pinatubo eruption (despite an increase in diffuse radiation) suggests that temperature plays a primary role in affecting net CO_2 uptake rates by the terrestrial biosphere. Additionally, while the Mt. Pinatubo eruption was helpful in slowing the rate of growth of atmospheric CO_2 for two years, the NDVI data appear to show that the eruption had an adverse effect on NH foliage biomass and therefore possibly photosynthetic CO_2 uptake.

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Response by Dennis Baldocchi and Lianhong Gu

“Here we concur that changes in the Earth’s carbon cycle due to a pulse of aerosols are not simple processes that can be explained by changes in a single variable. We proffer the explanation that regional differences in several climate forcings have conspired to produce a complex answer to this question. We also critique the evidence upon which Dr. Arora bases his conclusion.”

Mutliple ecosystem interactions lead to overall reduced growth in atmospheric CO_2 concentration

The terrestrial biosphere is a complex system, which by definition consists of intertwining parts that are subject to multiple feedbacks. The emergence of new properties, as one transcends scales, is one particular feature of complex systems. The ability to perform an experiment on a large and complex system like the terrestrial biosphere is difficult and rare, but in 1991 a unique pulse experiment was performed on the Earth’s climate system and biosphere-- Mt Pinatubo erupted, injecting huge quantities of dust and sulphate aerosols into the atmosphere. The dust and aerosols from this volcanic eruption veiled the Earth’s surface for several years and has provided us the opportunity to examine how the terrestrial carbon cycle is responding to coincident changes in the Earth’s surface radiation budget.

One of the notable feature of this ‘pulse-experiment’ was a 0.5 ^{o}C global cooling [1]. The second notable feature was a short-term reduction in the secular trend of growing atmospheric CO_2, as measured at the Mauna Loa monitoring station [2]. Because simultaneous reductions in the anthropogenic sources and increases in oceanic sinks were not recorded, it has been deduced that the net terrestrial biosphere sink increased [3]. One school of thought has concluded that the 0.5 ^{o}C global cooling reduced global respiration and leaf area index (e.g. [4]). Another group of investigators [5-7] have proposed that the veil of dust following the Mt Pinatubo eruption may have led to an increase in photosynthesis in some regions of the world. These researchers based this proposition on theoretical and experimental evidence that canopy photosynthesis is more efficient under diffuse light than under clear skies.

Dr. Arora addresses this issue in the Discussion Forum of this newsletter and concludes that the reduction in temperature explains the temporal change in atmospheric CO_2 post Pinatubo; his arguments are derived mostly on the work of Slaybeck et al. [8] and Lucht et al. [4] and their observed and modelled changes in NDVI.

Here we concur that changes in the Earth’s carbon cycle due to a pulse of aerosols are not simple processes that can be explained by changes in a single variable. We proffer the explanation that regional differences in several climate forcings have conspired to produce a complex answer to this question. We also critique the evidence upon which Dr. Arora bases his conclusion.

In order to understand how the terrestrial carbon cycle responds to environmental perturbations, one needs to decompose the net carbon flux into its constituent components and examine the forcing upon each component. By definition, net ecosystem exchange is the difference between gross photosynthesis (GPP) and ecosystem respiration (Reco). GPP is most sensitive to changes in sunlight, temperature, leaf area index and soil moisture. Reco is most sensitive to changes in temperature, soil moisture, size of the soil and plant carbon pools and disturbance. To understand how the terrestrial carbon cycle responded to the Mt. Pinatubo eruption we must assess how the volcanic eruption changed environmental forcings of the carbon cycle (light, temperature, soil moisture) in time and space. We must also assess if the relative sensitivity of GPP and Reco changed.

With regards to the issue of global cooling and reduced respiration we present the data on the global temperature anomaly after the Mt. Pinatubo eruption (Figure 1). Upon inspection, one sees that major cooling was concentrated in the middle of North America and Siberia, little or no cooling occurred over the tropics and warming over west Europe. Since there are regional differences in cooling and warming, so there will be regions with decreased respiration (e.g. the boreal forest region) and regions with increased respiration. While global respiration might have been reduced, since global mean temperature decreased after the Mt. Pinatubo eruption, the question is: could this factor alone explain the observed large drop in the growth rate of atmospheric CO_2? Gu et al. [7] listed several lines of evidence that suggested a no to this question:

"First, long-term records of CO_2 and temperature generally show that there is a time lag between fluctuations in CO_2 and those in temperature [2]. However, the response of atmospheric CO_2 after the eruption appears to be rapid. Second, the magnitude of the global surface cooling (up to 0.5°C in mid-1992) is within the range of annual temperature swings since the 1950s [1]. Previous cooling of this magnitude did not cause a drop in the atmospheric CO_2 growth rate as large as the one observed after the eruption. Third, modelling of the effects of the eruption on atmospheric CO_2 using a coupled general circulation climate-carbon cycle model showed that the cooling stops short of fully accounting for the observed atmospheric CO_2 anomaly [3]."

In using cooling to explain the post-Pinatubo variations of atmospheric CO_2, one must also note that cooling can potentially reduce annual GPP by shortening the length of the growing season and by decreasing leaf area index. Given these considerations, we believe other mechanisms, in conjunction with the cooling scenario, are needed to account for the atmospheric carbon budget. To support this view further, we cite new evidence from a recently published global inversion modelling study of interannual variability of CO_2 exchange, by Rodenbeck et al. [9]. They state:

"…according to our estimates the distribution of anomalous carbon uptake regions across the globe is markedly uneven. The regions that are mainly responsible for enhanced carbon uptake are the Amazon basin and the East of North America. For the rest of the world, flux anomalies are small. Comparison of these flux anomalies with the climate anomalies indicates that increased carbon uptake tends to coincide with increased precipitation, although the comparison is not entirely conclusive."

The regional enhancement of photosynthesis in eastern North America, deduced by the data inversion work of Rodenbeck et al. [9], is consistent with our results deduced from direct carbon flux measurements [7].

With regards to Arora's dismissal of the diffuse radiation effects, we raise several caveats. First, his arguments were based on the interpretation of NDVI data using the Lund-Potsdam-Jena (LPJ) biogeochemical model. The LPJ model has many strengths but it does not consider diffuse light effects on photosynthesis. Secondly, temperature response functions of carbon exchange of ecosystems are not static. Respiration rates of most ecosystems will acclimate and shift with long-term changes in temperature [10]; at present most biogeochemical models do not account for this effect. Thirdly, changes in NDVI are used to infer changes in leaf area index and GPP. NDVI based models only infer GPP, they do not measure it directly like we did with the eddy covariance technique [7]. Finally, there still remains the question of imperfect aerosol corrections to NDVI after the Pinatubo eruption [8].

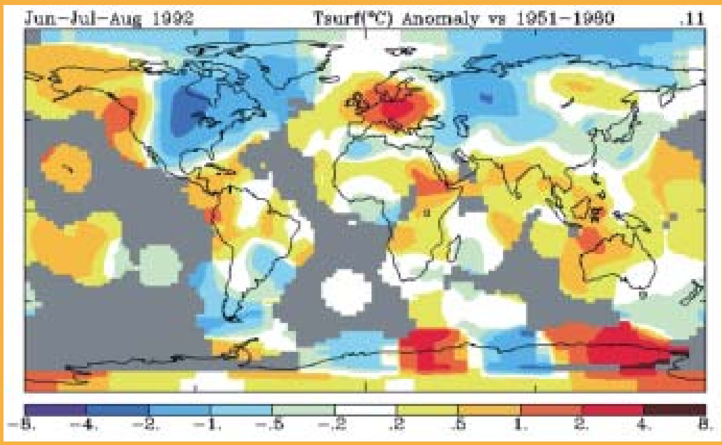

Figure 1. Global temperature anomaly after the Mt Pinatubo eruption. Data are generated from NASA GISS. http://www.giss.nasa.gov/data/update/gistemp/maps/; data source Peterson, T.C., and R.S. Vose 1997. An overview of the Global Historical Climatology Network temperature database. Bull. Amer. Meteorol. Soc. 78: 2837-2849.

In closing we note that a growing number of FLUXNET field sites are installing diffuse radiation sensors at their field sites. We now anticipate the next volcanic eruption and are ready to observe directly how carbon fluxes at points across the globe may respond to such an event.

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People and events

This edition of the NewsLetter marks a few changes within the IGBP Secretariat. Most notable, is the new Science Editor, Bill Young, who will join the IGBP Secretariat in September. Bill comes to the Secretariat from Australia, where he worked as a Principle Research Scientist within CSIRO Land and Water division. Bill received his PhD in Natural Resources Engineering from Lincoln University, New Zealand and has twelve years of professional experience in river and catchment research, modeling and management. Bill's responsibilities in the Secretariat will largely be editing IGBP products and liaising with scientists in the IGBP network. On behalf of the IGBP community, we welcome Bill to the Secretariat.

While welcoming a new member, the IGBP Secretariat will also bid farewell to two of its staff. Angelina Sanderson, the Acting Science Editor, has completed her work with the IGBP Synthesis and will return to research at Stockholm University's System Ecology Department, where she will study the socio-economics of pesticide use in rural areas of Central America. Suzanne Nash, who contributed significantly to organising National Committee partisipation in the IGBP 3rd Congress, will leave the Secretariat to enjoy the peace and relaxation of retirement. The Secretariat would like to thank Angelina and Suzanne for their invaluable help and wish them luck in their future endeavors.

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IGBP Science No. 5

Changes are occurring in the oceans, increasingly due to human impacts on the Earth System. GLOBEC Science Series 5 addresses marine ecosystems' responses to the changing oceans and how those responses affect fisheries and food supply, as well as the functioning of the planet as a whole.

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Final JGOFS Open Science Conference

JGOFS held its final science conference in Washington DC, USA, 5-8 May 2003. The organisers developed a strong, very lively and successful presentation of JGOFS over the last decade and half. The conference programme was designed to emphasise the accomplishments and the lessons learned from JGOFS, through eight sessions covering the scientific themes and strategies of JGOFS.

The morning speakers and commentators covered specific themes on ocean colour and carbon dioxide, ecosystem structure and dynamics, data assimilation and modelling. The afternoon sessions covered JGOFS' connections to other international programmes, ocean margins and benthic processes, highlights from the JGOFS era, and future programmes in ocean biogeochemistry and ecology. On each of the first three days, a dedicated poster session covered highlights from all aspects of JGOFS science, including both the synthesis work and ongoing research.

Presentations emphasised the latest synthesis works, especially regarding the process studies, time series and global survey, and the related modelling efforts on the global, regional and basin-wide scales.

On one evening during the conference at the Smithsonian Museum of Natural History, the participants were offered a challenging overview by Carol Browner about the interactions of politics and environmental science based on her personal experience as former US EPA administrator and decision maker. Browner's address was followed by a reception and a private showing of this famous institution.

The four JGOFS Chairs, who along with Mike Fasham (Chair), were unanimously acknowledged for their contribution. From left to right: John Field (ZA), Trevor Platt (CA), Bernt Zeitschel (DE) and Hugh Ducklow (USA). Not present: Michael Fasham (UK).

The epilogue of the conference was delivered by Margaret Leinen, Deputy Director of the US NSF, who recognised the importance of international large-scale programmes and the value of the science culture built by the JGOFS community. Immediately following this epilogue, participants were greeted on the Nina's Dandy for a final banquet and an award ceremony on the Potomac River.

A complete set of presentations will be made available through the conference websites of the US JGOFS PDMO (usjgofs.whoi.edu/osc2003.html) and JGOFS IPO (www.uib.no/jgofs/osc2003.html).

IGBP and Related Global Change Meetings

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

Symposium at the IUGG 2003 General Assembly: 'State of the Planet: Frontiers and Challenges'

03 July-04 July, Sapporo, Japan

Contact: IUGG 2003 Secretariat, iugg_service@jamstec.go.jp or http://www.jamstec.go.jp/jamstec-e/iugg/index.html

START, GCP: Advanced Training Institute: Urbanization, Emissions and the Carbon Cycle

04 August-24 August, Boulder, CO, USA

Contact: Amy Freise, afreise@agu.org or http://www.start.org

LUCC: Studying Land Use Effects in Coastal Zones with Remote Sensing and GIS

13 August-16 August, Kemer/Antalya, Turkey

Contact: Feliz Sunar, fsunar@ins.itu.edu.tr or http://www.ins.itu.edu.tr/rslucoast1/

PAGES: 9th International Paleolimnology Symposium

24 August-28 August, Otaniemi Espoo, Finland

Contact: Atte Korhola, Atte.Korhola@helsinki.fi or Veli-Pekka Salonen, Veli-Pekka.Salonen@helsinki.fi or Antti Ojala, antti.ojala@gsf.fi

IGBP Book Series

The aim of the Series is to present major results of IGBP research – at both the project and programme-wide level – in a single series. The volumes emphasise the key findings of the programme and each is based on an integration of a large body of work carried out around the world under the auspices of IGBP.

The IGBP Synthesis project, involving most IGBP projects, is nearing completion and is producing a set of state-of-the-science volumes on the nature of the changing environment of the Earth and the research challenges for the future.

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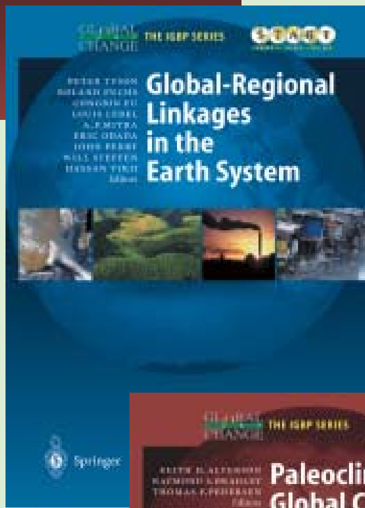
www.igbp.kva.se/bookpromotion/

Either follow the links to order online, or print and fax or post the order to the address given.

Challenges of a Changing Earth (Proceedings of the Global Change Open Science Conference, Amsterdam, the Netherlands,10-13 July 2001).

An overview of global change and its consequences for human societies.

Steffen W, Jäger J, Carson DJ, Bradshaw C (Eds.)



Global-Regional Linkages in the Earth System.

Springer Verlag, Heidelberg, Germany.

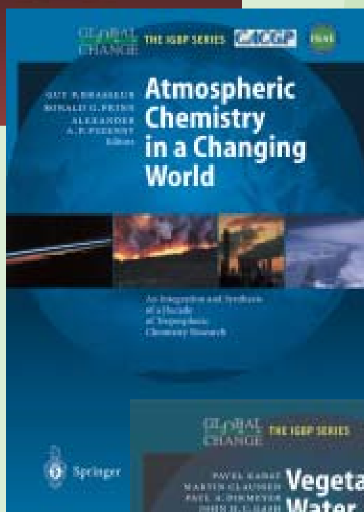
Synthesises current knowledge of regional-global linkages to demonstrate that change on a regional scale can enhance understanding of global-scale environmental changes.

Tyson PD, Fuchs R, Fu C, Lebel L, Mitra AP, Odada E, Perry J, Steffen W, Virji H (Eds.)

Paleoclimate, Global Change and the Future.

A synthesis of a decade of research into global changes that occurred in the Earth System in the past.

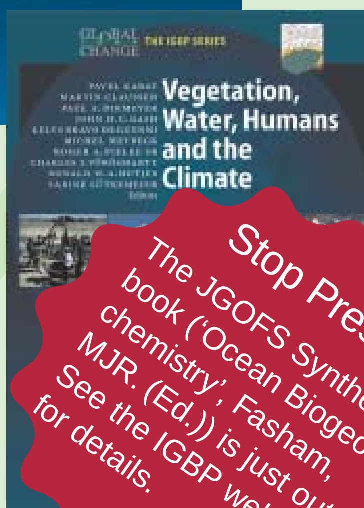
Alverson KD, Bradley RS,
Pedersen TF (Eds.)



Atmospheric Chemistry in a Changing World

Summary and integration of more than a decade of atmospheric chemistry research.

Brasseur GP, Prinn, RG, Pszenny AAP (Eds.)



Vegetation, Water, Humans and the Climate

Kabat P, Claussen M, Dirmeyer PA, Gash JHC, de Guenni LB, Meybeck M, Vörösmarty CJ, Hutjes RWA, Lütkemeier S (Eds.)

An overview of the influence of the terrestrial vegetation and soils within the Earth System (BAHC).

Stop Press!

The JGOFS Synthesis book ('Ocean Biogeochemistry', Fasham, MJR. (Ed.)) is just out. See the IGBP website for details.

Springer

GLOBAL IGBP CHANGE

GAIM, WCRP: GAIM and WGCM (WCRP) - International Conference on Earth System Modelling

15 September-19 September, Hamburg, Germany

Contact: Annette Kirk, annette.kirk@dkrz.de

GAIM: Coupled Carbon Cycle Climate Model Intercomparison Project (C4MIP) Workshop

18 September-20 September, Hamburg, Germany

Contact: Pierre Friedlingstein, pierre@lsce.saclary.cea.fr

World System History and Global Environmental Change

19 September-22 September, Lund, Sweden

Contact: Symposium Secretariat, christian.isendahl@humecol.lu.se or http://www.humecol.lu.se/woshglec/

JGOFS: JGOFS Executive Meeting

26 September-27 September, Bergen, Norway

Contact: Roger Hanson, roger.hanson@jgofs.uib.no

ILEAPS: ILEAPS Open Science Conference

29 September-03 October, Helsinki, Finland

Contact: Taina Ruuskanen, Taina.Ruuskanen@helsinki.fi or Tanja Suni, Tanja.Suni@helsinki.fi or Maarit Raivonen, Maarit.Raivonen@helsinki.fi or http://www.atm.helsinki.fi/ILEAPS/

IGBP: 16th IGBP Officers Meeting

06-09 October, Toledo, Spain

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

GWSP: Global Water System Project Open Science Conference

07 October-09 October, Portsmouth, NH, USA

Contact: Holger Hoff, hhoff@pik-potsdam.de or http://www.gwsp.org

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

16 October-18 October, Montreal, Canada

Contact: McGill School of Environment, info.mse@mcgill.ca or http://sedac.ciesin.columbia.edu/openmeeting

GAIM: GAIM Task Force Meeting

26 October – 29 October, Cambridge, UK

Contact: Dork Sahagian, dork.sahagian@unh.edu

START: START Pan-Africa Regional Committee (PACOM) Meeting

October, Capetown, South Africa (tentative)

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

Science Policy Conference on Global Change and the Vulnerability of Land and Water Resources in Africa

October, Capetown, South Africa (tentative)

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

IGFA Plenary 2003

29 October-31 October, Capetown, South Africa

Contact: IGFA Secretariat, sofia.wretblad@formas.se

WCRP: Final Conference on the WCRP ACSYS Project

11-14 November, St. Petersburg, Russia

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

START: Young Scientists 1st International Global Change Conference

16 November-19 November, Trieste, Italy

Contact: Kristy Ross, kristy@crg.bpb.wits.ac.za or http://www.start.org/Fellowships/YS_Conference.html

START: 17th START Scientific Steering Committee Meeting

19 November-22 November, Trieste, Italy

Contact: Ching Wang, xwang@agu.org

GLOBEC:SPACC Workshop on Long-term Dynamics of Small Pelagic Fish and Zooplankton in Japanese waters

TBA, Tokyo, Japan

Contact: Juergen Alheit, juergen.alheit@io-warnemuende.de or Takashige Sugimoto, sugimoto@ori.u-tokyo.ac.jp

GCTE: GCTE Final Science Symposium

01 December, Morelia, Mexico

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

Transition in Agriculture and Future Land Use Patterns. International Workshop

01 - 03 December, Wageningen, The Netherlands

Contact: Floor Brouwer, f.m.brouwer@lei.wag-ur.nl

IGBP, IHDP: LAND Open Science Meeting 'Global Change and the Terrestrial Human Environment System' (Land Core Project)

02 December-05 December, Morelia, Mexico

Contact: Dennis Ojima, dennis@nrel.colostate.edu, dennis@saccharum.nrel.colost or Victor Jaramillo, luque@ate.oikos.unam.mx or http://www.gcte.org, http://www.geo.ucl.ac.be/LUCC/lucc.html

START, LOICZ: Regional Workshop on Assessment of Nutrient, Sediment and Carbon Fluxes, to the Coastal Zone in South Asia and their Relationship to Human Activities

09 December-11 December, TBA, TBA

Contact: Janaka Ratnasiri, janakar@itmin.com

International Conference on Sustainability and Energy

16-19 December, Tokyo, Japan

Contact: nakano27@vesta.ocn.ne.jp

2004

GLOBEC: UK-GLOBEC Open Meeting

26 February, London, UK

Contact: Phil Williamson, p.williamson@uea.ac.uk or GLOBEC IPO, globec@pml.ac.uk

IGBP: 19th SC-IGBP Meeting (also 5 March, Moscow, Russia – Joint session with WCRP-JSC)

01-03 March, St. Petersburg, Russia

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

WCRP: WCRP-JSC Meeting

01-06 March, Moscow, Russia

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

IHDP: 11th SC-IHDP Meeting

22-24 March, Bonn, Germany

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

GLOBEC: IOC-SCOR-GLOBEC Symposium on 'Quantitative Ecosystem Indicators for Fisheries Management'

31 March-03 April, Paris, France

Contact: Philippe Cury, curypm@uctvms.uct.ac.za or Villy Christensen, v.christensen@fisheries.ubc.ca

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

02 May-06 May, Vancouver, Canada

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

GLOBEC: ICES-GLOBEC Symposium on 'The Influence of Climate Change on North Atlantic Fish Stocks'

11 May-14 May, Bergen, Norway

Contact: Harald Loeng, harald.loeng@imr.no or http://www.imr.no/2004symposium/

PAGES: PAGES Scientific Steering Committee Meeting

24 May-25 May, Beijing, China

Contact: PAGES IPO, pages@pages.unibe.ch

PAGES: PAGES Open Science Meeting

26 May-28 May, Beijing, China

Contact: PAGES IPO, pages@pages.unibe.ch

Quadrennial Ozone Symposium

01-08 June, Kos, Greece

Contact: Christos Zerefos ozone2004@geol.uoa.gr

CLIVAR 2004: 1st International CLIVAR Science Conference

21 June-25 June, Baltimore, MD, USA

Contact: CLIVAR, info@clivar2004.org or http://www.clivar2004.org/

IGAC: 8th Scientific Conference of the IGAC Project

04 September-09 September, Christchurch, New Zealand

Contact: Kim Gerard, kim@conference.co.nz

SOLAS: 1st SOLAS Open Science Conference

13 October-16 October, Halifax, Nova Scotia, Canada

Contact: Daniela Turk, solas@dal.ca

The 3rd International Nitrogen Conference

12 October – 16 October, Nanjing, China

Contact: n2004@issas.ac.cn

6th International Symposium on Plant Responses to Air Pollution and Global Changes: from Molecular Biology to Plant Production and Ecosystem

19 October-22 October, Ibaraki, Japan

Contact: Luit J. De Kok, l.j.de.kok@biol.run.nl or http://apgc2004.en.a.u-tokyo.ac.jp/

START/GCP: Training workshop on "South China Sea Regional Carbon Pilot Project"

16-28 November, Chungli/Kaohsiung, Taiwan

Contact: www.sarcs.org or C.T.A. Chen: ctchen@mail.nsysu.eud.tw

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

16-18 October 2003 Montreal, Canada

Taking Stock and Moving Forward

Following a decade of sustained interdisciplinary research on the human dimensions of global change, this is an appropriate time to assess our efforts. Are we achieving cumulative, progressive research findings? Are we generating useful knowledge for decision-makers?

Plenary speakers at the 5th Open Meeting will address these and other questions in the context of major areas of human dimensions research. Special “stock-taking” panels will look at land-use/land-cover change, integrated assessment, population, environmental security, industrial transformation, institutions, environmental economics, and others. Panels of special interest to the IGBP community include Global Politics of Carbon Emissions, Fragile Ecosystems (eg. Coastal Regions or Mountains), and Regional Cooperation and Climate Change.

Hosted by the McGill School of Environment, Canada and sponsored by the Center for International Earth Science Information Network (CIESIN) at Columbia University, the Inter-American Institute for Global Change Research (IAI) and the International Human Dimensions Programme on Global Environmental Change (IHDP).

More information about the Open Meeting, as well as registration details are available on the meeting website.

http://sedac.ciesin.columbia.edu/openmeeting

ILEAPS: Integrated Land Ecosystem – Atmosphere Processes Study

INTERNATIONAL OPEN SCIENCE CONFERENCE

29 September - 3 October 2003

Helsinki, Finland

Towards the development of the new land-atmosphere project in IGBP

This conference will focus on the processes of land – atmosphere exchange of energy and matter, emphasising feedbacks and interactions between these two components of the Earth System. It will address these processes at all scales, reaching from the local through the regional and continental to the global scale. The conference is designed to summarise the current scientific knowledge in this area and to discuss the research agenda for the coming years.

More specifically, the conference is a major step in the development of a science plan and implementation strategy for ILEAPS as a 10-year international research project within the framework of IGBP. Broad community input and support is required to build this new project; the ILEAPS International Open Science Conference is a key event in this process.

The conference will combine:

- Plenary presentations and discussions by leading scientists in the field
- Extensive working group discussions for direct input into ILEAPS planning
- Poster presentations by meeting participants

Further information can be found at http://www.atm.helsinki.fi/ILEAPS/

After a decade of research, the GCTE and LUCC projects are working together to develop an integrated research agenda under the new LAND project. The goal is to build on the knowledge generated by these projects in order to elucidate the ecological and social responses to changes and feedbacks in the terrestrial biosphere.

Open Science Conference on Global Change and the Terrestrial Human-Environment System

1-4 December 2003, Morelia, MEXICO

Conference Goals:

(i) To present the state-of-the art science on a number of research areas dealing with global change and the terrestrial biosphere with an emphasis on integrative projects addressing the coupled biophysical-human system.

(ii) To provide input into the development of the research agenda that will steer the new LAND project. The new project will be launched in early 2004 after feedback from the Conference has been taken into consideration.

(iii) To stimulate the scientific community to develop more integrative research on issues related to biogeochemical cycles, disturbances, and biodiversity under global change, with attention to consequences for the delivery of ecosystem services and vulnerabilities of the human-environment system.

Who should attend?

All scientists with an interest in understanding components or the totality of the terrestrial biosphere as a coupled biophysical-human system.

Further information and Contact: Information on the Conference will be posted at the websites of GCTE (http://www.gcte.org) and LUCC (http://www.geo.ucl.ac.be/LUCC/lucc.html). A second and third announcement with detailed information on the registration procedures, agenda, and venue will follow.

The Global Water System Project (GWSP) is a new activity of the Earth System Science Partnership: IGBP, WCRP, IHDP and DIVERSITAS.

Theme

The central theme of the GWSP is human-induced changes to the global water cycle, the associated biogeochemical cycles and the biological components of the global water system, as well as the social and biophysical feedbacks of these changes.

Focus

The Open Science Conference will focus on scientific planning and co-ordination with other water-related activities. We invite inputs and critical comments to the draft of the Scientific Framework (science and implementation plan) for the GWSP, which will be made available before the Conference.

GWSP

Global Water System Project

Open Science Conference 8 - 10 October 2003, Portsmouth, New Hampshire, USA

For latest updates contact Holger Hoff, e-mail: hhoff@pik-potsdam.de. or visit the GWSP website.

Earth System Science Partnership

www.gwsp.org

Note to contributors

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

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

Contributions for 'Integration' should be between 800-1200 words in length and highlight how IGBP or its core projects are integrating with other areas of Earth System Science. The article can include up to two figures.

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

Required Image Quality for IGBP Publications

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

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

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

Please note: figures of any kind must either be original and unpublished, or (if previously published) the author(s) must have obtained permission to re-use the figure from the original publishers. In the latter case, an appropriate credit must be included in the figure caption when the article is submitted.

Deadlines for 2003:

September issue	Deadline for material: Aug 15, 2003
December issue	Deadline for material: Nov 3, 2003

Send contributions by email to the Editor, Angelina Sanderson
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IGBP's mission is to deliver scientific knowledge to help human societies develop in harmony with Earth's environment. The Global Change NewsLetter serves its readers as a forum for up-to-date information on IGBP science, programmatic development, people and events. Published quarterly since 1989, the NewsLetter is available free-of-charge from the IGBP Secretariat.

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