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An Earth System Illustration

Centrefold

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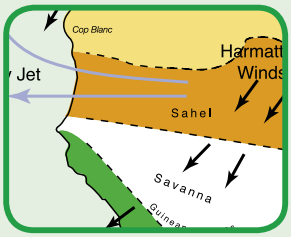

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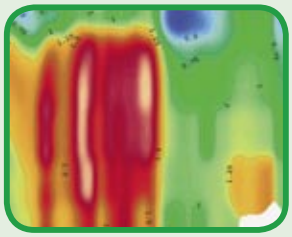

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Global Change NewsLetter Turns 60

The 60th issue of the Global Change NewsLetter marks over 15 years of continuous publication beginning in May 1989. Initially published three times each year and distributed to a few hundred people, the NewsLetter is now a quarterly publication with a distribution of more than 12,000. The focus of the NewsLetter has changed from primarily spreading news of projects, meetings and workshops across the IGBP network, to communicating a spectrum of recent IGBP and related global change and Earth System science to an audience spanning science, policy and education. It continues to evolve to meet the needs of the IGBP network, and in response to reader feedback.

IGBP has recently completed the synthesis and publication of most of its first decade of research, and is currently completing the science planning for its next decade of research. IGBP projects are documenting this planning process in Science Plans and Implementation Strategies, which will be highlighted in the NewsLetter (for example, see the SOLAS centrefold in Issue 57). Complementing the new IGBP science and structure will be a new 'visual profile'. A centrepiece of this profile will be the Earth System illustration commissioned from artist Glynn Gorick. The first incarnation of this illustration is featured on the front cover of this issue, and is described and discussed in a centrefold article.

Captured in this illustration are both the presence and environmental influence of humans in the Earth System. Increasingly it is recognised that not only are humans now a dominant force in global environmental change, but that understanding the role of humans in the Earth System requires research in both the social and the natural sciences. To meet the challenge this presents, IGBP is collaborating in various ways with the International Human Dimensions Programme (IHDP) on Global Environmental Change in various ways, including through an Earth System Science Partnership (ESSP). The focus of the ESSP is to determine the implications of global change for global sustainability. In the Guest Editorial in this issue, Gisbert Glaser considers the degree to which the global change programmes are providing the science necessary to guide global sustainable development, and whether the ESSP is an adequate way to meet the challenge. Responses and feedback on Guest Editorials, other articles and the NewsLetter in general, are welcomed by the editorial team.

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Guest Editorial

Earth System Science and Science for Sustainable Development

The global change research programmes have been highly successful in developing Earth System science. They have shown that human activities have reached a level where they significantly influence the Earth System, and not only in terms of greenhouse gas emissions and climate change. In my view, the body of knowledge already generated by IGBP and the other global change programmes represents a major contribution to science for sustainable development.

Sustainable development is a moving target. It represents the continuous effort to balance and integrate the three 'pillars' of social well-being, economic prosperity and environmental protection for the benefit of the present and future generations. The scientific knowledge needed to underpin sustainable development policies and action must derive from a broad scope of both disciplinary and interdisciplinary science, across the natural, social, economic, engineering and health science domains, from long-term observations, modelling and scenario building.

How can science improve its contribution to sustainable development? In my work with the UN Commission on Sustainable Development (CSD) for ICSU, and before in my years with UNESCO, I have repeatedly heard decision makers at all levels call for policy-relevant research that provides 'applicable' results. While scientists should never be 'policy-prescriptive', neither in their research nor in advisory capacities, the scientific community must accept responsibility for providing policy-relevant scientific information. To enhance the policy-relevance of new knowledge on the interaction between social, economic and environmental processes and conditions, it is now widely agreed that research agendas must be defined through broad-based, participatory approaches involving those in need of scientific information and advice. Those in need can range from local level actors such as farmers, through business/industry and national legislators and ministries, to regional and global organizations and bodies, such as the CSD.

Despite some progress, one of the most serious gaps in knowledge for sustainable development is a better understanding of the functioning of coupled socio-economic and biophysical systems at different time and space scales, of their resilience and vulnerability, and other aspects of system dynamics. As we know, in studying such coupled systems, research that is restricted by the traditional barriers between natural and social sciences is inadequate. What are needed are cooperative interdisciplinary research projects in which the natural and social/economic sciences are equal partners. Such integrated research, as it is often called, is essential for improved understanding of the interrelationships of the social, economic and environmental pillars of sustainable development, and for crafting the integrated approaches required for moving towards more sustainable development paths.

While global, regional and national sustainable development policies are extremely important, it seems obvious that most sustainable development actions (and the unsustainable ones) take place at the local level. However, much of our knowledge is not sufficiently site-specific (or 'place-based' as it is now often called) to be directly applicable at the local level. The place-based scientific information that is available, is in most instances, limited to a patchwork of unrelated discipline-specific knowledge. What is needed is more local systems knowledge for the large number of local social-ecological systems across the major bioclimatic zones and socio-cultural/economic regions of the world. To fill this major gap in knowledge, science for sustainable development, whilst being embedded in research on global processes, should enhance place-based studies that are explicitly geared towards the priorities and needs of locally focused development efforts. A specific initiative aimed at advancing this type of place-based research should be implemented during the next decade. Of course, place-based research must be complemented by studies on linkages across spatial scales, as well as studies on 'teleconnections' between different parts of the world.

In recent years the global change research programmes have increasingly worked together and have already made significant progress towards these new paradigms. The joint LUCC project of IGBP and IHDP showed the way, and this approach will be strengthened and extended by the new Global Land Project. The research agendas for the coming decade of the projects on water, food, carbon and health of the Earth System Science Partnership (ESSP) represent excellent examples of science for sustainable development. These new integrated research projects relate most directly to the integration of the three pillars. Moreover, they will follow a multi-scale approach.

Will this be sufficient in terms of the much needed effort to advance integrated place-based research? I do not think so. Is it the task of the global change research programmes, individually and collectively, to promote such an effort? To a degree, but I believe it would be useful to also consider other mechanisms for this purpose. Whatever mechanisms are proposed, we must ensure that they will help and not hinder IGBP and the other global change programmes, individually and collectively as ESSP, to thrive at least for another decade.

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Fossil Pollen in Marine Sediments: an African Key for Distribution Patterns

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Continental fossil pollen records have long been used as proxies for environmental change. Prior to the rapid expansion of marine sediment studies since the 1960s, terrestrial palynologists had reconstructed the series of Pleistocene ice-ages from a network of boreholes and sections. Subsequently, support for the pollen-based general chronostratigraphy of the Pleistocene that had been assembled like a jigsaw puzzle, came from hundreds of long and often continuous marine core records. It is remarkable that during this period palaeoceanographic use of fossil pollen did not develop, with marine proxies attracting all attention. Perhaps the potentially low pollen concentration in marine sediments, and the poor understanding of the mechanisms of pollen transport to the ocean floor, distracted researchers from studying fossil pollen. Marine palynology needs information about regionally relevant transporting mechanisms (horizontally by river transport, ocean currents, and winds, but also vertically in the water column) to interpret the pollen variations in a core in terms of changing environments.

A significant fraction of the world's marine sediments receive a very low input of fossil pollen because of their great distance from the source of pollen grains, i.e. terrestrial vegetation. Even when marine cores are collected close to a continent, effective mechanisms are still required to transport pollen grains to the ocean floor. In this respect, several areas studied since the 1960s had unfavourable conditions which led to premature conclusions. For example, in their classic 'Text book of pollen analysis' Faegri and Iversen [1] wrote "*Marine sediments are, on the whole, rather disappointing from the point of view of pollen analysis*". However, in this article I demonstrate the potential of pollen analysis for marine sediments, focussing on the close to ideal setting of the eastern Atlantic Ocean off northwest Africa. Pollen records are used herein to reconstruct latitudinal migrations of main vegetation belts and changes in the strength of the trade winds [2].

Northwest Africa is characterised by a strong climatic gradient between the Mediterranean and the Gulf of Guinea. As a consequence, distinct vegetation belts can be recognised, each characterised by a specific floral composition (Figure 1). This part of Africa is very dry with few rivers suitable for significant pollen transport draining into the Atlantic Ocean. However, northwest Africa is notorious for its dust plumes, driven by the trade winds and the African Easterly Jet (AEJ). The trade winds mainly blow from Morocco towards the equator at altitudes below 1000 m, and the AEJ mainly blows between June and August at latitudes close to 21°N and at about 3000 m elevation. Offshore, the Canary Current transports pollen grains in the water column to the south. However, counter currents at greater depth cause pollen grains to reach the ocean floor relatively close to where they enter the ocean. As a consequence, distribution patterns of wind-borne pollen are replicated to a significant degree in the surface sediments on the ocean floor [3].

Modern relationships between pollen source, pollen transport and pollen deposition were studied in 110 samples of surface sediments, obtained offshore between Portugal and the Gulf of Guinea [4]. This relationship is illustrated in the following four examples (Figure 2).

1. *Pinus* occurs in the Mediterranean vegetation and isolines of pollen representation show a distribution pattern in which trade wind transport can be easily recognised. Pollen percentages decrease with increasing distance from the source area. Remarkably, air masses passing over the Canary Islands are

re-loaded by the pine forests on these islands; to the south of the Canary Islands percentages decrease clearly with distance again.

2. *Artemisia* is a steppe plant dominant at the northern fringe of the Sahara. Isolines show precisely where the trade winds leave the continent in southern Morocco. There is a direct relationship between pollen source area, trade wind transport and the pattern of pollen deposition.

3. In northern Africa, plants belonging to the family of the *Chenopodiaceae-Amaranthaceae* (ChAm) occur in saline vegetation in Morocco, with a flowering season from November to April. In the northern section, isolines of ChAm clearly reflect the flow pattern of the trade winds, transporting ChAm pollen from Morocco to the south. ChAm also occurs in Saharan Africa; there the flowering season is June to September, the season during which the AEJ reaches maximum strength. The AEJ therefore transports much of the ChAm pollen, which explains the area with maximum ChAm percentages offshore at 21°N. South of 21°N, isolines show decreasing percentages. South of 10°N ChAm pollen becomes rare in the marine surface sediments; the frequent rains related to the average position of the Intertropical Convergence Zone rapidly remove pollen from the atmosphere.

4. *Alchornea* is a tree of the rainforest belt. Its highest pollen percentages in marine sediments are found offshore of the rainforest vegetation belt, and reflect pollen transport by the trade winds. The northernmost limit of *Archornea* pollen in modern marine sediments reflects precisely the northernmost distribution of rainforest on the adjacent continent.

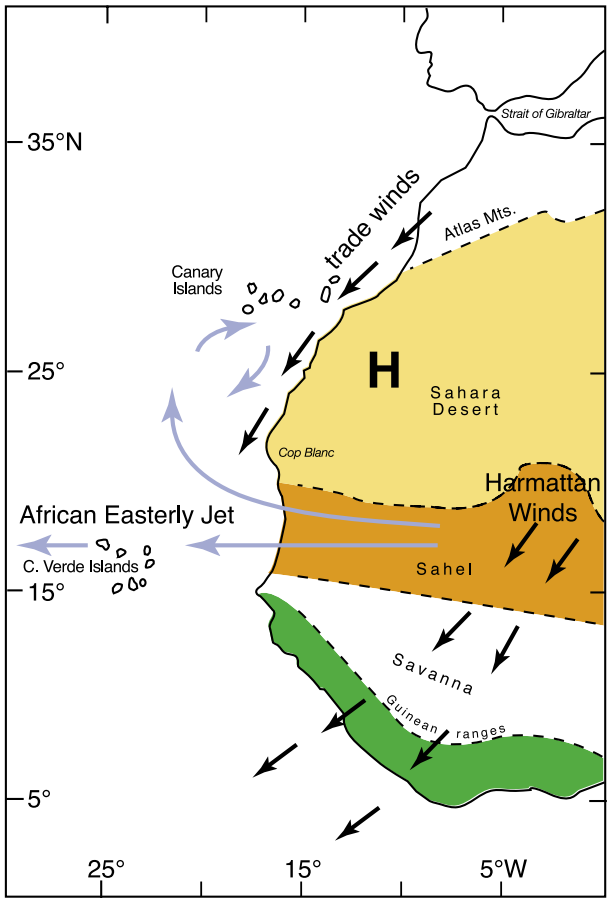

Figure 1. Main vegetation belts, river systems, wind systems and ocean currents in northwest Africa.

Under present-day conditions, all these four examples show a direct relationship between source area, transporting system and vegetation distribution. In other words, the pollen distribution is indicative of the geographical position of the vegetation belt concerned. This relationship may then be reasonably applied to earlier periods, so that the distribution patterns inferred from a grid of marine cores can be taken as indicative of past vegetation patterns. However, this is only the case where transport systems have not changed. Results show this was indeed the case (Figure 3). Data taken from well-dated intervals in 14 Eastern Atlantic cores located along a transect from 9° to 37°N, reveal distribution patterns for 9,000 ^{14}C yr BP and 18,000 ^{14}C yr BP. The ChAm pollen maxima for these two ages both occur at 21°N, suggesting that the AEJ has been latitudinally stable over this period.

The history of the trade winds has been recorded by the group of plants that have never occurred south of the Sahara (*Pinus*, *Artemisia*, *Ephedra* and other *Asteraceae*). Differences of the latitudinal position of

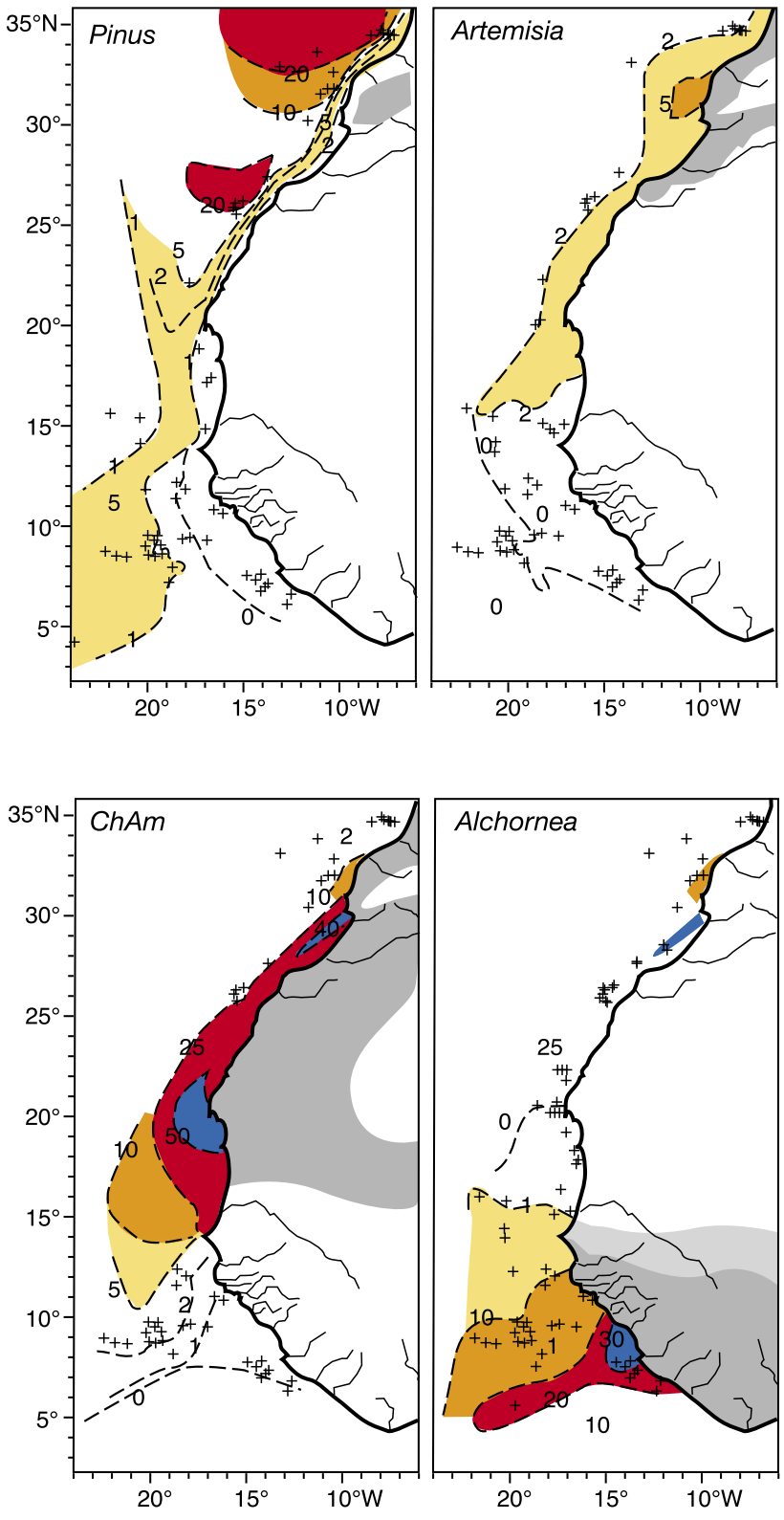

Figure 2. Percentage representation of fossil pollen grains in marine surface sediments (110 sites indicated by crosses) at the ocean floor off northwest Africa. Dotted areas on the continent reflect the main source area; areas with small dots reflect areas of minor importance. Isopercentage lines coincide with main flow patterns of wind transport. *Pinus* reflects a Mediterranean element while *Artemisia* reflects a steppe element. ChAm mainly reflects salt vegetation in coastal Morocco (pollen are mainly produced from November to April when trade winds are active) and desert vegetation in the Sahara (pollen are mainly produced from July to September when the AEJ is active). *Alchornea* reflects tropical rainforest.

isolines are indicative of changes in the efficiency of southward pollen grain transport by the trade winds [3]. The 20% isoline of the Last Glacial Maximum (LGM) lay 9° farther to the south than that of the Holocene, indicating stronger trade winds during the earlier period. In northwest Africa the position of the trade wind belt has been stable since the LGM, but wind intensities have varied, being low during interglacials and interstadials, and high during glacials and stadials.

The stable position of the AEJ transport belt provides an excellent opportunity to trace the migration of the southern Sahara border, which coincides with a sharp transition from *Poaceae*-dominated vegetation to ChAm-dominated vegetation [5]. The vegetation at 21°N determines the pollen spectrum in the AEJ-driven dust clouds propagating from the present-day southern Sahara to the Atlantic Ocean. This spectrum is mainly ChAm pollen-dominated for a large Sahara expanded far to the south (e.g. the present day and LGM situation), while is mainly *Poaceae* pollen-dominated for a constricted Sahara with the savanna belt expanded far to the north (e.g. the setting of c. 9000 ^{14}C yr BP, also called the Green Sahara period). The ratio of *Poaceae* to ChAm pollen was applied to marine core ODP 658, located at 21°N [6] (Figure 4). Down-core changes of this ratio showed that during the last 600 kyr the southern border of the Sahara migrated over 9° of latitude. Migrations of the northern Sahara border were also reconstructed and appeared more restricted, maximally moving 4° of latitude during the last 600 kyr [7]. Pollen diagrams from terrestrial

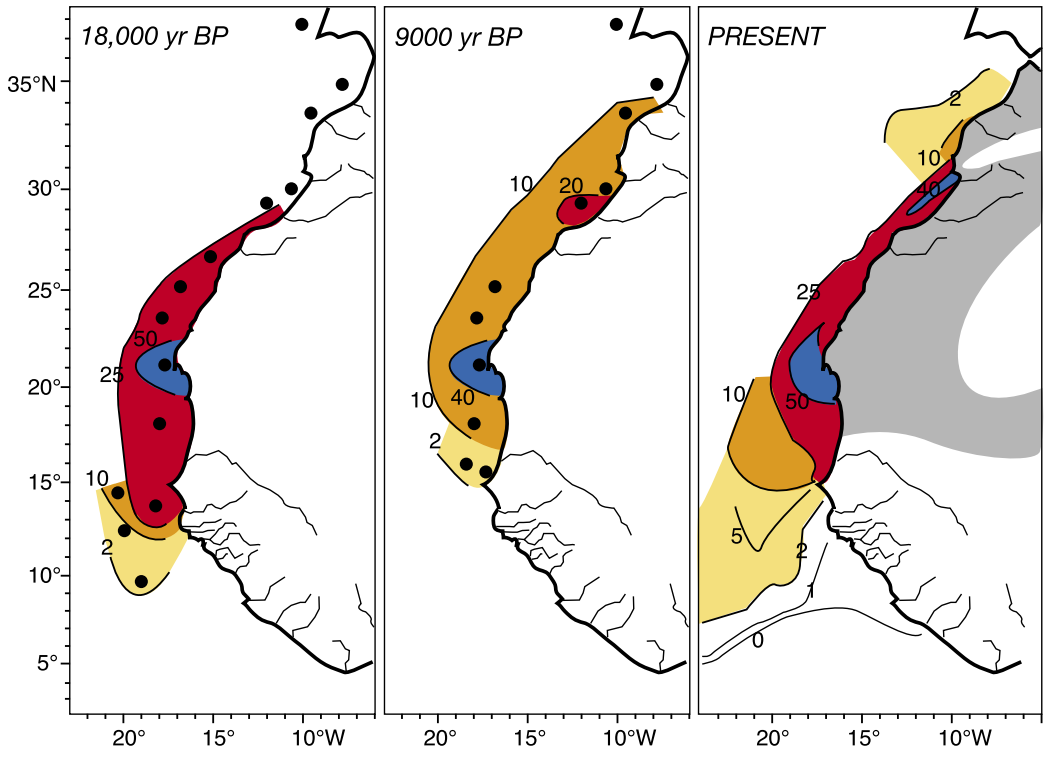

Figure 3. ChAm pollen distributions (ChAm pollen as a percentage of the total) for 18,000 ^{14}C yr BP (LGM), 9000 ^{14}C yr BP and the present-day. The left and centre panels are based on 14 marine cores (black dots). The right hand panel is based on 110 surface sediment samples; the shaded area on the continent reflects the main area where this pollen type is produced. The pollen distributions indicate that position of maximum pollen supply to the Atlantic sediments has been stable at approximately 21°N, indicating that the AEJ belt has not migrated latitudinally since the LGM.

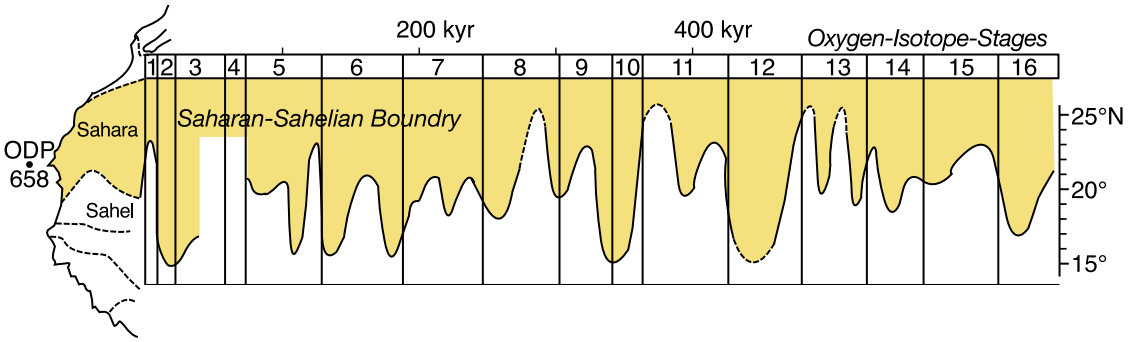

Figure 4. Record of migrations of the southern Sahara border (currently close to 19°N) during the last c. 600 kyr; i.e. from oxygen isotope stage 16 to oxygen isotope stage 1 (Holocene). The position of the present day border is shown at the left. Changes of the ratio between *Poaceae* pollen (reflecting Sahelian vegetation) and ChAm pollen (reflecting desert vegetation) in core ODP Site 658 document shifts of the Saharan-Sahelian border from 14°N (maximally expanded Sahara) to 23°N (maximally squeezed Sahara).

sites confirm the vegetation dynamics inferred from the marine pollen record.

Understanding mechanisms at work in the north-west African setting helps evaluate whether newly designed palaeoceanographic studies might benefit from pollen analysis of marine sediments in other areas of the world.

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Census of Marine Zooplankton: A New Global Survey of Marine Biodiversity

A. Bucklin, S. Nishida, and S. Schiel

The Census of Marine Life (CoML) is surveying marine biodiversity to gain an accurate understanding of the diversity, geographic distribution, and abundance of marine species – from pole to pole, coastal estuaries to open ocean, and surface to the abyss. By 2010, CoML field projects will integrate and synthesise their discoveries and conclusions, and thereby produce a new global view of the diversity of life in the ocean. This comprehensive information – the answers to the "who, where, and how many" questions about marine life – is critical for observing, measuring, and understanding the impacts of global change.

The Census of Marine Zooplankton (CMarZ) is a new CoML field project designed to work towards a taxonomically comprehensive assessment of biodiversity of animal plankton throughout the world ocean. The project goal is to produce accurate and complete information on zooplankton species diversity, biomass, biogeographical distribution, genetic diversity and community structure by 2010. The taxonomic focus is the animals that drift with ocean currents throughout their lives (i.e. the holozooplankton). This assemblage currently includes about 6,800 described species in fifteen phyla, however, it is expected that several new species will be discovered as a result of CMarZ.

CMarZ will result in more complete knowledge of biodiversity hotspots and unexplored ocean regions, new understanding of the functional role of biodiversity in ocean ecosystems, and better characterisation of global-scale patterns of marine zooplankton biodiversity. CMarZ will contribute to the fundamental understanding of biogeochemical transport, fluxes and sinks; productivity of living marine resources; and structure and function of marine ecosystems.

At present, we do not know how differences in the diversity of marine communities impact flows of energy and matter through marine food webs. The new IGBP project – IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) – will seek to unravel this interrelationship, and will require accurate and comprehensive descriptions of biodiversity. Describing and understanding species-level biodiversity are important aspects of IMBER's scientific goals and objectives, which include understanding how species diversity impacts, determines, and/or drives global elemental cycles, food web structure and ecosystem stability, transfer of organic matter from the photic zone to deep waters, and biogeochemical feedback processes that control the carbon cycle.

The scientific rationale for CMarZ includes topics that are fundamental for IMBER and other IGBP projects, including:

- *Functional consequences for marine ecosystems.* Shifts in the relative abundances of important species can be propagated through the food web. Short-term shifts in zooplankton species composition and biomass have been associated with El Niño or La Niña [1], and zooplankton species have shown persistent shifts in abundance in the northeast Pacific [2]. In the northeast Atlantic, distributions of copepod species (Figure 1) [3] and planktonic food web dynamics [4] have been shown to shift with decadal climate variability. Altered copepod species composition can dramatically alter the biological pump – i.e. the export of carbon from surface waters into the ocean's interior [5]. In the Antarctic, polar warming and a decrease in sea-ice cover have been associated with changes in the relative importance of Antarctic krill and salps [6], species that play central roles in the Southern Ocean food web.

- *Global elemental cycles.* Marine zooplankton are significant mediators of fluxes of carbon, nitrogen and other important elements in ocean biogeochemical cycles [7]. It has been recognised for many years that changes in the species composition of zooplankton assemblages have strong impacts on rates of recycling and vertical export [8]. Long-term changes in fluxes into the deep sea [9] may be related to zooplankton species composition in overlying waters [10].

Figure 1. The copepod, *Calanus hyperboreus*. (Photograph: R.R. Hopcroft, University of Alaska, USA).

- *Marine bio-invasions*. Species invasions are occurring with ever-increasing frequency, particularly in coastal waters [11]. Non-indigenous gelatinous species have negatively affected ecosystems throughout the world. A spectacular example of this phenomenon is the inadvertent introduction of the ctenophore *Mnemiopsis leidyi* into the Black Sea – and now the Caspian Sea – presumably by transport in ballast water. The resultant perturbation of the food web included devastation of Black Sea and Caspian Sea fisheries [12]. In the Bering Sea, an enormous increase in jellyfish biomass, dominated by the scyphozoan *Chrysaora melanaster*, is likely to have consequences for groundfish fisheries [13]. Gelatinous zooplankton species (see Figure 2) have been reported to form blooms with deleterious effects on ecosystems and fisheries in Japanese waters, the eastern Mediteranean Sea, the North Sea, estuaries in Argentina, and elsewhere.

- *Food web stability.* The majority of pelagic species may be consistently rare [14]. It cannot be assumed that these species play a negligible role in community dynamics, although theories from terrestrial studies argue for this view. In recent years, theoretical ecologists have found that food webs containing many species with weak trophic interactions exhibit greater ecological stability than those having few species with strong interactions [15]. This result and ongoing research suggest that rare species may play an important role in stabilising communities over time. Species dominance patterns may also change through time: previously rare species may become predominant, and *vice versa*. The ecology of rare species needs to be better understood, in order to work toward genuine understanding of community and ecosystem dynamics, especially the effect of rare species on foodweb stability.

- *Baseline biodiversity assessment.* There is an urgent need for a global baseline assessment of marine zooplankton biodiversity. Changes in the ocean environment and the availability of new methods to observe, analyse, and monitor zooplankton species make such a global census both feasible and necessary. A baseline assessment will provide a contemporary benchmark against which future changes can be measured.

CMarZ will begin by coordinating with ongoing, planned, and proposed oceanographic field programs. Such coordination will provide opportunities for sampling zooplankton taxa in many ocean regions during the first years of the project. Sampling design will be optimised using theoretical and numerical models, in collaboration with the FMAP (Future of Marine Animal Populations) project of CoML. Sampling systems will include traditional nets and trawls, remote detection, optical sensors, and integrated sensor systems deployed on towed, remotely-operated, or autonomous vehicles and submersibles. New sampling methodologies will be required to collect and study rare and fragile organisms which are less well known. CMarZ will also make use of existing data and archived zooplankton collections. CMarZ will benefit from molecular approaches, including DNA sequences for target regions to be used for species identification (i.e. DNA "barcodes"; see www.barcodinglife.com). DNA micro-arrays and gene expression analysis. Molecular protocols can be used to identify key species and/or functional groups, and to increase our knowledge of the structure and function of marine food webs.

A primary product of CMarZ will be a distributed database of species names, collection information, voucher and specimen locations, DNA sequences, images and other information. The CMarZ database will be fully integrated with, and searchable from, the Ocean Biogeographical Information System (OBIS) portal (see www.iobis.org). CMarZ will train graduate students and professionals, who will enhance capacity for taxonomic identification of species of zooplankton groups. CMarZ will build public appreciation for the value of marine biodiversity with dissemination of information via web pages, presentations, and printed materials for students, research-

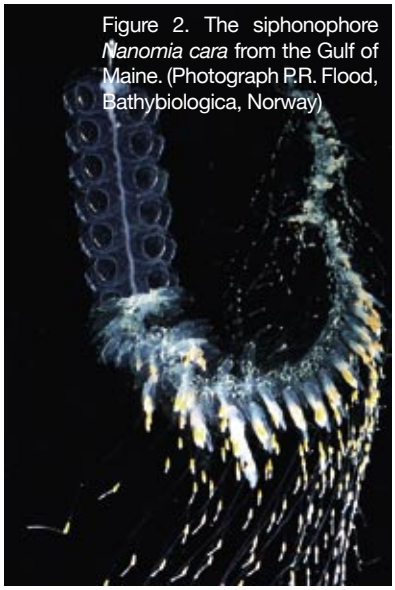

Figure 2. The siphonophore *Nanomia cara* from the Gulf of Maine. (Photograph P.R. Flood, Bathybiologica, Norway)

ers, and general audiences, as well as peer-reviewed scientific publications.

CMarZ will require international collaboration and coordination, through a distributed network of program centres, field project participants, students and laboratory technical staff and taxonomic specialists. CMarZ will establish project offices in North America, Europe and Asia to provide scientific leadership, planning and implementation of field activities, and coordination of proposals and fund raising activities. For more information, the CMarZ Science Plan can be downloaded from the CoML portal (www.coml.org) or the CMarZ project website (plankton.unh.edu).

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GEOTRACES Gathers Speed

R.F. Anderson and G.M. Henderson

Since the late 1990s there has been a growing impetus for a comprehensive global study of the marine biogeochemical cycles of trace elements and their isotopes (TEIs). This has led to the development of a research programme known as GEOTRACES.

GEOTRACES is motivated by the fact that TEIs play critical roles in many aspects of oceanography, and by the incompleteness of our understanding of their marine biogeochemical cycles. Better knowledge of the distribution and behaviour of TEIs in seawater will provide insights into a wide range of oceanic processes. It will provide, for example, understanding of the role that micronutrients play in regulating ecosystem structure and productivity, and will elucidate the mechanisms that control the fate of pollutants in the oceans. Some TEIs, particularly radionuclides, constrain rates

of key processes regulating the carbon cycle. Other TEIs can be used to study mixing processes in the ocean. TEI distributions in marine sediments provide many of the proxies used to reconstruct past environmental conditions (e.g. productivity, circulation, ecosystem structure, weathering, hydrothermal activity, anoxia).

Despite these important roles and uses of TEIs, our knowledge of their cycles is limited. For example, the distributions, sources and sinks of micronutrients are so poorly known that their sensitivity to global change and the resulting changes in marine ecosystems and the carbon cycle cannot be meaningfully predicted. Similarly, although it was established decades ago that many TEIs are removed from seawater by sedimentation, we still lack quantitative rate and process understanding. It is also clear that sediment TEI distributions relate to climate variability, but our ability to use TEIs as reliable proxies is limited by incomplete characterisation of their current biogeochemistry. This in turn, limits our ability to test ocean models against past conditions, and therefore limits our ability to forecast future changes.

Marine geochemists are poised to make significant progress in TEI biogeochemistry. Advances in clean sampling protocols and analytical techniques provide unprecedented capability for measurement of a wide range of TEIs. The potential afforded by these advances has not however, been realised, largely because of a lack of coordinated research since the GEOSECS programme of the 1970s. New analytical methods that allow high density sampling, and new modelling strategies (as applied successfully during WOCE and JGOFS), make this the right time to mount a major international research programme to study the global marine biogeochemical cycles of TEIs.

The GEOTRACES mission can be expressed in two principal goals (i) to determine global oceanic distributions of selected TEIs, and (ii) to evaluate the

The value of studying multiple TEIs, and the general value of high-resolution TEI data on ocean sections, is illustrated by recent results from the North Atlantic Ocean. Distributions of dissolved iron and aluminium measured at 1° resolution (Figure 1) reveal first-order features of the sources and internal cycling of these trace elements. High surface concentrations of aluminium between the equator and 20°N define the location of dust deposition in the months prior to sampling. Dissolved iron concentrations are low in surface waters, but increase in the thermocline under the region with high surface aluminium concentrations. Dust deposition supplied both iron and aluminium to surface waters, but whilst iron was removed from surface waters in sinking biogenic detritus, and regenerated subsequently in the thermocline, aluminium has a longer residence time and remains at the surface as a tracer of the dust deposition. Examining the two elements together tells us more about their biogeochemical cycles than could be inferred from one element alone. The sharp boundaries of the high–iron region in the thermocline also informs us that the regeneration of iron is sufficiently rapid to prevent substantial dispersion by lateral mixing.

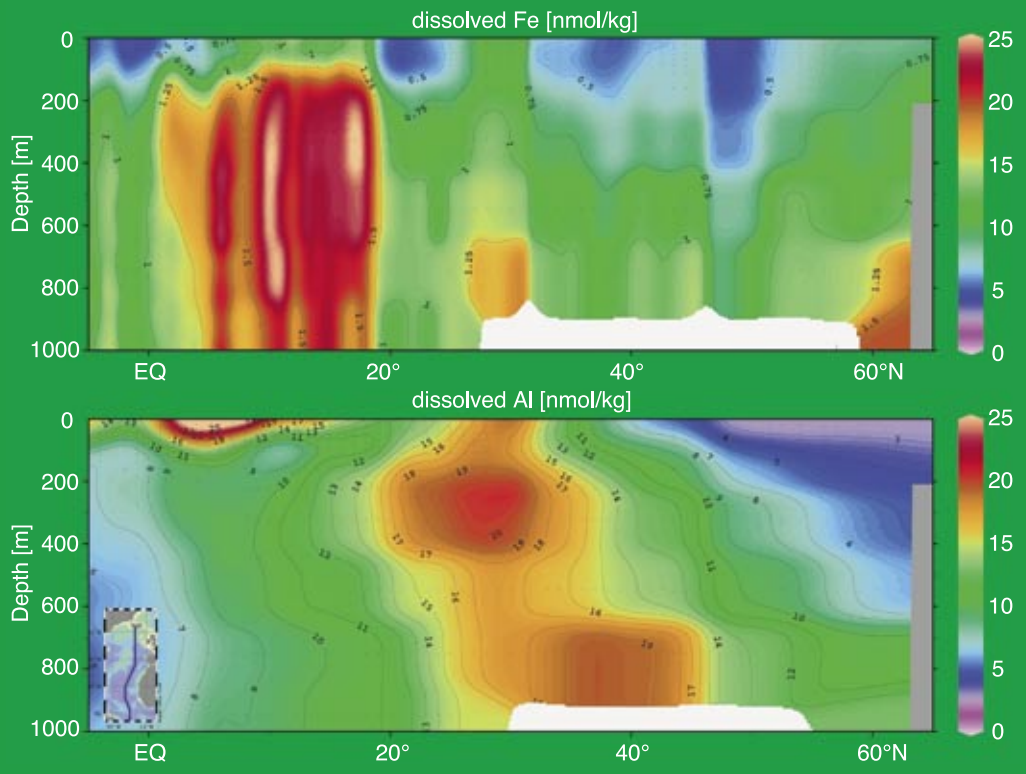

Figure 1. Distributions of dissolved iron (upper panel) and aluminium (lower panel) in the upper 1000 m along the CLIVAR A16 cruise track May 19 to August 11, 2003 (see inset for location). Courtesy of Chris Measures (University of Hawaii) and Bill Landing (Florida State University).

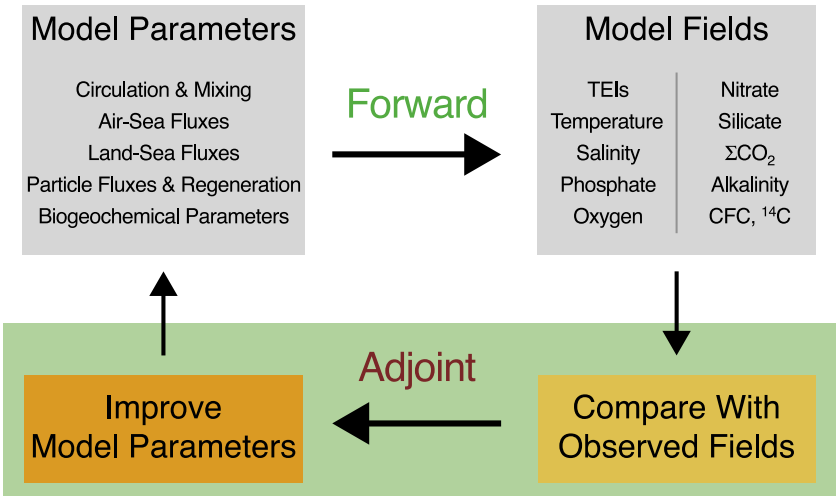

Figure 2. Schematic illustration of the strategy by which TEIs fluxes across ocean interfaces, and their rates of transport within the ocean, can be derived from measured ocean distributions using an inverse modelling approach. This approach proved highly successful in programmes such as WOCE and JGOFS over the last decade. Courtesy of Reiner Schlitzer (Alfred Wegener Institute).

sources, sinks, and internal cycling of these TEIs, and thereby characterise the physical, chemical and biological processes regulating their distributions. Research in pursuit of these goals will be organised under two themes. The first theme will examine the modern cycling of TEIs by quantifying fluxes at the principal ocean interfaces (e.g. atmosphere, continental margins, mid-ocean ridges), and by determining the rates of internal cycling of TEIs within the ocean (e.g. biological uptake, chemical scavenging, physical transport). The second theme will focus on TEIs that serve as palaeoceanographic proxies, to understand the factors controlling proxy distributions in the water column and sediments. A natural outcome of this work will be to build a community of marine scientists who understand the processes regulating TEIs sufficiently well to exploit them reliably in interdisciplinary studies. Another outcome will be the ability to incorporate TEI cycles into models to predict responses to future global change.

GEOTRACES will be global in scope, consisting of ocean sections complemented by regional process studies. Sections and process studies will combine fieldwork, laboratory experiments and modelling. Sections will cross regions that provide most information about sources, sinks and internal cycling of TEIs. Although commitments have not yet been made to particular sections, priority will be given to regions of prominent TEI sources or sinks, such as dust plumes, major rivers, hydrothermal plumes and continental margins. Sections will also sample the principal end-member water masses, as well as the major biogeographic provinces.

A fundamental principle underlying GEOTRACES is that measurement of multiple TEIs with varying behaviour will provide insights into processes not attainable from study of a single TEI (see box). GEOTRACES will also go beyond qualitative descriptions of sources, sinks and internal cycling of TEIs. Numerical models will be used to evaluate the relative importance of physical and biogeochemical processes, and to calculate TEI fluxes from measured distributions. GEOTRACES will apply a hierarchy of model resolutions and complexity. Examples include coupled physical/biogeochemical general circulation models, box models, chemical speciation models and inverse models. Recent advances in data assimilation and inverse modelling, for example, now allow direct data utilisation methods not yet applied for determination of TEI fluxes. Inverse models promise to be an important element of ongoing and future studies of ocean circulation (e.g. CLIVAR). Expanding those activities to the assimilation of TEI distributions offers a strategy to quantify TEI flux terms in marine biogeochemical cycles, including the vertical fluxes associated with TEI uptake and regeneration by sinking particles (Figure 2). GEOTRACES will allow intercalibration and standardisation of the analytically-challenging TEI measurement methods, and provide for technology transfer and capacity building in nations that presently lack TEI measurement capability.

The resources needed for this research require international cooperation. Formal planning of GEOTRACES was launched with an international workshop in April 2003 involving 85 scientists from 15 nations. This workshop was followed by regional/national planning workshops in Europe, North America and Japan. Plans are advancing for additional workshops in Canada, China, and elsewhere. In 2003, the SCOR agreed to provide oversight for GEOTRACES, and a SCOR-sponsored planning group that first met in June 2004 was tasked with preparing a science plan. A draft science plan

will be released for comment early in 2005, leading to revisions by the planning group during their May 2005 meeting.

On completion of the Science Plan, the planning group will be replaced by a Science Steering Committee (SSC) to oversee implementation of the programme. Early tasks for the SSC, in preparation for the main field programme, will include the creation of a data submission and management strategy, the development and distribution of standard reference materials, and the initiation of inter-calibration exercises. These activities will be organised under the direction of an International Programme Office, overseen by SCOR. GEOTRACES will collaborate closely with other ocean research initiatives, including CLIVAR, IMBER, SOLAS, LOICZ, GLOBEC, IMAGES/PAGES, INTERRIDGE, MARGINS, and various modelling programmes, to ensure synergy between the different programmes and to avoid unnecessary duplication of effort.

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Land Use/Cover Change on the Indo-Gangetic Plains: Implications for the Terrestrial Carbon Cycle

A. Chhabra

The Indo-Gangetic Plains – one of the most extensive fluvial plains of the world, consists of rich fertile alluvium from the Indus and the Ganges river systems. Agriculture probably began over 7000 years ago on the Plains in the form of settled cultivation. It has been suggested that that the first human intervention in the Indo-Gangetic Plains Region (IGPR) occurred when agro-pastoralist Aryans colonised the middle Gangetic Plains [1]. The Vedic Aryans are believed to have always been a settled agrarian people, reliant on the tending of domestic animals as well as cultivation [2]. However, the oldest written account – preserved in the Rigveda (Hindu scriptures dated to 1200-1500 BP), tells of ancient agrarian practices by Indo-Aryans. The IGPR cuts across Pakistan, India, Nepal and Bangladesh, and is a globally important agricultural area, often referred to as the 'food bowl of the Indian sub-continent'.

The Indian portion of the IGPR extends over an area 1600 km by 320 km, reaching from the Indus delta in the west, to the Ganges delta in the East, and comprising around 21% of the total area of the country (Figure 1). It broadly includes the states of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal, and is home to 40% of India's population. More than 70% of most districts of the Indian IGPR are under agriculture. The dominant rice-wheat cropping system in this sub-region has been a major contributor to the 'Green Revolution' in India, providing close to half the Indian food grain production. Average rainfall and humidity increase from west to east; dryness typifies the northwest, whereas places in the east record very high rainfall. The soils developed in the IGPR alluvium under arid, semi-arid and sub-humid environments are therefore very important for India's agricultural production (Figure 2).

The major historical land cover changes in the IGPR include conversion of fallow and scrub to agriculture, agriculture and wasteland to settlements or urban areas, and both creation and loss of wetlands. The major landuse intensifications relate to cropland, and include: (i) an increase in irrigated cropland, (ii) an increase in the area under high yielding variety cultivars, (iii) an increase in cropping intensity, (iv) an increase in fertiliser application, (v) changes in cropping patterns and dominance of wheat-rice rotation and marginalisation of kharif and rabi coarse cereals and pulses, (vi) increased mechanisation, involving tractors, planters and combine harvesters, and (vii) crop residue/biomass use for fodder and fuel, and recently, *in situ* burning of crop residues. Many of these changes are interlinked and have been driven by a number of technological, policy, socio-economic and biophysical factors [3]. Prior studies include a description of the major agricultural developments between 1757 and 1947 [4], a description of agricultural expansion in India since independence [5] and a summary of the major landuse changes from 1880 to 1980 in IGPR states [6] based on data from [7] and [8].

Agriculture is the dominant

Continued on page 16…

IGBP has commissioned UK artist Glynn Gorick to construct an illustration of the Earth Sys
across IGBP products and more effectively communicate IGBP science. The first version o
of this edition of the Newsletter. The illustration aims to depict both the complexity and the i
the pervasive presence of humans.

An Earth System Illu

The Earth System illustration is constructed using differing spatial scales: from the molecular scale at the outside of the main circle to the planetary scale at the centre of the circle. This allows more picture space for the representation of the small-scale physical and chemical processes which drive the Earth System. The complexity of the Earth System of course precludes comprehensive representation in an illustration, but the selected features attempt to cover the majority of important domains and disciplines in Earth System science. Some of the details contained in the illustration are described below. Note that the illustration is still a work in progress.

The ocean, atmosphere and land compartments of the Earth System are all represented, as are many of the important interface (ocean-atmosphere, land-ocean, land-atmosphere) processes. Evidence of human activities is apparent in all Earth System compartments. The coastal plain is unfinished, and will reflect the human "footprint" with a considerable fraction developed, but some pristine. The sphere in the centre represents the global-scale spatial predictions from computer models, validated against measurements.

Each corner of the picture represents a different aspect of the Earth System. The top left represents the energy supply to the Earth System – solar radiation shown as a spectrum from infrared to ultraviolet. In this part of the illustration I depicted well understood aspects including warming gases, ozone formation, and a range of the reactive gases in the troposphere. The top right represents the importance of water in the Earth System, and one of its special properties – the hydrogen bonding between water molecules. The lower left represents granite rock amongst clay particles – a part of the vital soil ecosystem. The lower right corner (as yet incomplete) will contain micro-organisms with DNA detail, emphasising that much of the Earth System is orchestrated by the living biota operated by the same organic chemistry designed by natural selection, and interacting with physical systems. The unseen microbes are the largest biomass on Earth and are intrinsic to the majority of the chemical cycles.

The centre right hand side of the picture depicts two plankton species of current research interest: *Emiliania huxleyi* cells releasing dimethylsulphide (DMS), and *Calanus finmarchicus* locating microzooplankton and being eaten by young cod fish. Two of the many outcomes of this local system as illustrated

IGBP Visual Identity

The idea for incorporating visually striking artwork into the IGBP programme and project visual profiles emerged from the success of the illustration Glynn produced for the GLOBEC project. We are encouraging IGBP projects to work with Glynn to develop project illustrations that link visually with the overall Earth System illustration. Glynn is currently working on illustrations for iLEAPS, SOLAS, IGAC and LOICZ. The project-specific images will provide more scientific detail while helping to develop a unique thread of "visual identity" for each project.

The overview illustration has been constructed at high resolution and fits comfortably on a large poster. A staggering amount of information is contained in the illustration, and magnification of any part yields another level of detail of various biogeochemical processes.

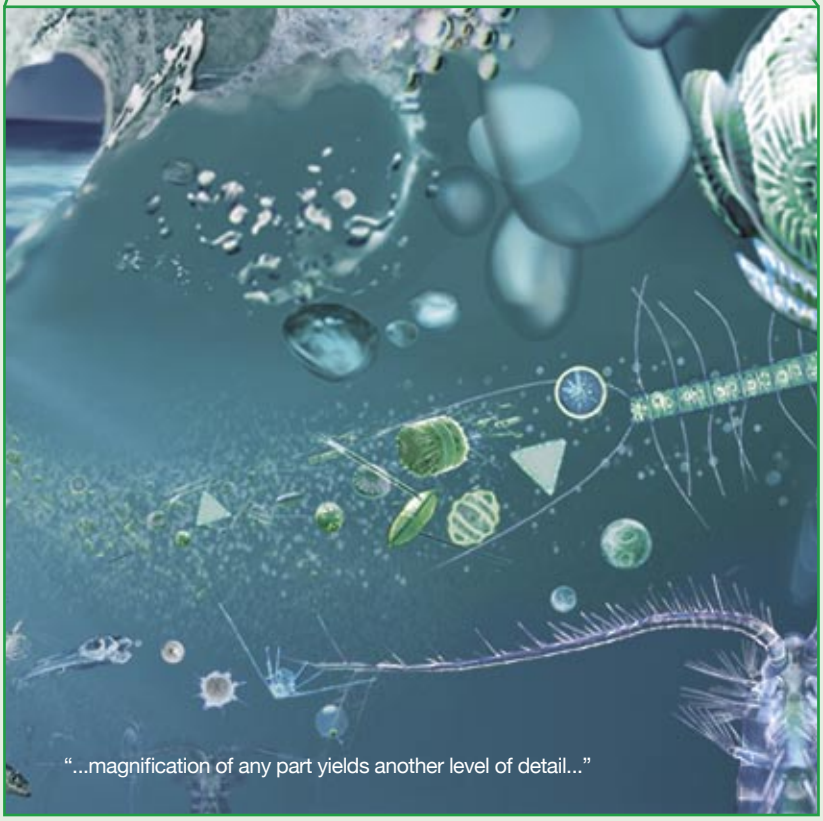
Together with a complimentary set of IGBP design elements (colour schemes, use of the "IGBP curve", font types etc), we expect to use the illustration – or parts of it – in a range of communications products. Already it has provided the basis for a series of posters for the AGU Fall Meeting in San Francisco and a new IGBP brochure (see inset).

stem to both strengthen visual integration
f this illustration is shown in full on the cover
nterconnectedness of the Earth System, and

stration

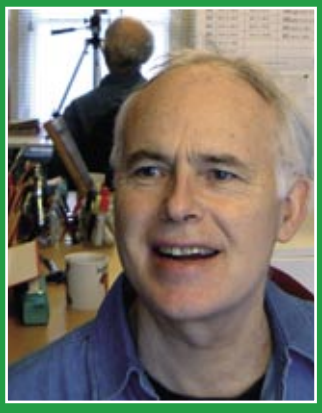
are the DMS pathway to cloud condensation nuclei causing possible shade cooling of the ocean, and the formation of marine snow taking carbon to the ocean sediments. Within the sediments there are good indicators of past climate conditions such as foraminifera shells. Other sea bed layers contain all-important fossil carbon sinks from past high carbon dioxide atmospheres, the hydrocarbon mixtures of crude oil represented here seeping upwards, trapped, and now extracted to drive the industrialised world, but contributing to climate change.

The carbon cycle is central to the carbon-based biosphere, and so I have made carbon atoms a distinctive red colour (the hydrocarbons not yet altered), with oxygen in blue, hydrogen in grey, and nitrogen in purple. CO_2 can be clearly seen against the dark background on the left hand side, where as a greenhouse gas, the molecule bends in and out as it absorbs and releases 15 micron wavelength photons. CO_2 has also been drawn near leaf stomata to indicate the transfer of carbon into plants. Carbon can be held in plants for extended periods, or be released surprisingly quickly under warmer or dryer soil conditions, when the soil community as shown is busy respiring and recycling plant-derived carbon.



"...magnification of any part yields another level of detail..."

The Artist – Glynn Gorick



Born near Manchester, England, I studied marine biology at Bangor in North Wales where I met my wife. We later worked together in Zambia and Papua New Guinea where, while teaching high school science, I became involved in agricultural studies as a way of linking biology and nutrition studies in the classroom with small school farms.

Since returning to England, I have concentrated on paintings and illustrations. My painting evolved from drawings of the material world, then living systems, and now combining these with aspects of human society. Between 1994 and 2004 I was invited to show my pictures at the four Gaia science meetings, and the wide range of talks on Earth System science opened my eyes to a great field of new knowledge packed with ideas for me to try and interpret graphically. I have also developed pictures for UNESCO for an online encyclopaedia and a booklet about life support systems.

When time permits I move from digital tools back to the paintbrushes. Later this year I will be painting a portrait of James Lovelock, the second author of the CLAW hypothesis, referred to on the right side of the IGBP overview picture.

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…continued from page 13.

Figure 1. Administrative map of north India indicating the Indus and Gangetic basins. The state of Uttar Pradesh shown here includes the new Uttaranchal state. Adapted from [6].

landuse, with total cultivated area in IGPR states having increased by 6 Mha from 1880 to 1980, while total forest area decreased by 4.4 Mha [6]. Agricultural and forest phytomass carbon pools in Southeast Asia are estimated to have decreased by about 463 Tg between 1880 and 1980, mainly due to conversion of various land cover to agriculture in five major Indian IGPR states [8]. The contribution of agricultural phytomass increased from 162 Tg of carbon in 1880 to 219.2 Tg of carbon in 1990. The total standing forest biomass in Indian IGPR states for the year 1992-93 has been estimated at 869 Tg carbon, based on field inventory-based growing stock volume, and using biomass expansion factors as a function of growing stock volume density [9]. The district-level spatial distribution of forest phytomass carbon pool in Indian IGPR states has been studied using remote sensing-based forest area, and field inventories of growing stock volume [10]. Total forest litter fall flux in Indian IGPR states has been estimated to be 19.2 Tg of carbon, compared to 194.5 Tg of carbon for all of India [11]. A recent account of the total carbon stock in Indian soils indicate that the high calcareous IGPR soils under hot humid and sub-humid climates are deficient in soil organic carbon due to a history of intensive agriculture. Using soil organic carbon data from 36 soil series the soil organic carbon pools for the Great Plains physiographic region of India (an area of 72.4 Mha) have been estimated to be 3.2 and 10.5 Pg of carbon for the upper 30 and 150 cm of soil respectively [12]. The total forest soil organic carbon pool in the upper 100 cm of soil in Indian IGPR states (total forest area of 7 Mha) is estimated to be only 0.63 Pg of carbon, based on estimated soil organic carbon densities and remotely sensed forest area [13].

A detailed study of long-term historical landuse/cover changes and their impacts on the agroecosystem carbon cycle in Indian IGPR states, estimated an increase of 435.6 Mt in crop biomass for the period 1901-1991 [6]. The close relationship between estimated crop net primary production (NPP) for Indian IGPR states is shown in Figure 3. The crop NPP varied between 0.8 t ha^{-1} in Bihar to 16.8 t ha^{-1} in Punjab. High cycling of the produced biomass through livestock as fodder and use as domestic fuel sustains the high population density in this region. The intensification of agriculture with modern technology based on mechanisation, high fertiliser and energy inputs, have also led to an increased agricultural contribution to carbon emissions. Using IPCC methodology, the estimated total 1990 CO_2 emissions from energy, industrial, agriculture, waste and land use change and forestry sectors are 585 Tg for Indian IGPR states, compared to 76.1 and 39.9 Tg for Pakistan and Bangladesh respectively [14]. A district-level analysis of five major Indian IGPR states estimated the total CO_2, CH_4 and N_2O emissions (year 1995) as 211.3, 5.8 and

Figure 2. Wheat farming in Uttar Pradesh on the Indo-Gangetic Plains.
(Photograph: Warren Apel, the Confluence Project, http://www.confluence.org).

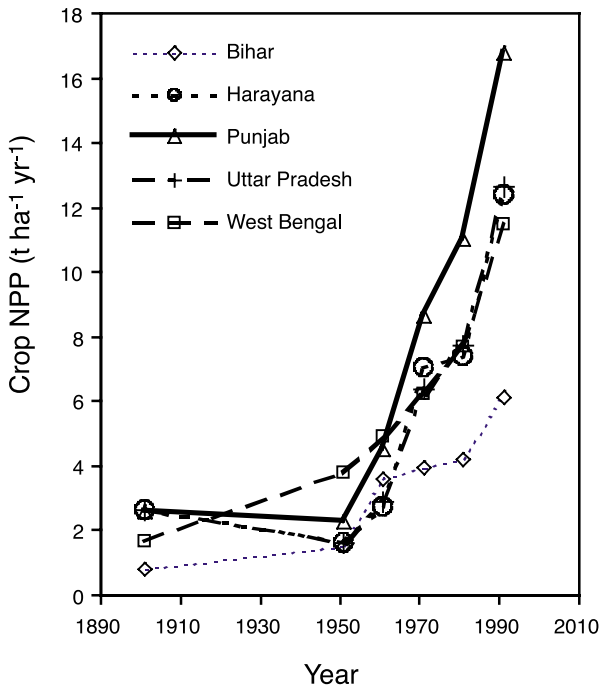

Figure 3. Secular changes in state level crop NPP for Indian IGPR states (1901-1990).

84.8 Gg respectively [15]. NO_x emissions have been estimated as 3.4 Tg [16]. The world's three dominant food-producing regions (including the IGPR) are vulnerable to ground level ozone pollution resulting in yield reduction, unless NO_x emissions are abated [17].

Large-scale historical landuse/cover changes in the IGPR resulting in increased carbon flux to the atmosphere have drawn the interest of the international scientific community. It has become necessary to understand the fundamental patterns and processes of land use/land cover changes taking into account the biophysical, socio-economic and demographic factors that drive them in this agriculturally-dominant and rapidly changing region. The soils of the IGPR of the Indian-subcontinent require immediate attention for better carbon management. Carbon sequestration in these soils is possible through green manuring and application of farmyard manures in view of conducive soil and climatic conditions, and using agroforestry and silviculture practices [18]. Regional level efforts are required to develop empirical, diagnostic and integrated predictive models for assessments of land use sustainability (particularly managed agriculture) and biogeochemistry and climate on [19]. Different policy options need to be evaluated using appropriate models, in terms of future landcover, agricultural landuse, the carbon source/sink balance and opportunities of enhancing carbon sinks.

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Editors Note: This article is based on an article published in the final newsletter of the LUCC (Land-Use and Cover Change) project of IGBP and IHDP. See www.geo.ucl.ac.be/LUCC/.

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Potential Climate Change Impacts on Water Resources in Romania

V.Cuculeanu and D.Balteanu

It is now well established that increases in atmospheric concentrations of greenhouse gases may lead to irreversible climate changes [1]. Sufficient evidence indicates that climate change could have significant impacts on agriculture, forests and water resources, particularly in regions with high present-day vulnerability and little potential for adaptation [2].

The UN Framework Convention on Climate Change calls upon countries to assess the sectoral impacts of climate change, so that vulnerable areas and adaptation options can be identified. The results presented here are part of a wider study [2] that was undertaken within the framework of the Romania Country Study on Climate Change, established under the US Country Studies Program [3]. The study considered the outputs from four equilibrium General Circulation Models (GCM) and one transient GCM for a double carbon dioxide atmospheric concentration scenario to assess potential climate changes in Romania up to 2075. The results for this climate scenario from the best performing GCM were then used to assess water resource impacts using the Guidance for Vulnerability and Adaptation Assessment methodology [4].

Climate Change Scenarios

The equilibrium models used were *GISS* [5], *GFDL R-30* [6], *UK* [6], *CCCM* [5], and the transient model used was *GFDL* [7]. The climate scenarios considered were (i) the current atmospheric concentration of carbon dioxide ($1xCO_2$) and (ii) a doubling of atmospheric carbon dioxide concentration ($2xCO_2$). The model outputs used for impact assessment were long-term monthly mean temperature and precipitation values, and the 10-year statistics for each month from transient model runs.
The GCM that best depicted the Romanian climate was determined by comparing the $1xCO_2$ output with the baseline climate. The baseline climate was defined as the 1961-1990 monthly averages of precipitation and surface air temperature from 100 meteorological stations uniformly distributed across Romania.

CCCM and *GISS* reproduced temperatures most accurately, however, the spatial resolution of *GISS* is too low to adequately assess regional impacts. UK and *GFDL R-30* generally simulated a much colder climate than the baseline, except for some warm months, in which *GFDL R-30* simulated an even warmer climate. The simulated annual temperature variations were generally similar to the baseline, except for GFDL R-30, which simulated higher temperatures in August than in July, and *UK*, which simulated lower temperatures in February than in January. Overall, all models simulated a more continental climate than observed.

Model performance for precipitation simulation varied considerably between months. *UK* produced the largest over-predictions, and *GFDL R-30* the largest under-predictions. The annual precipitation pattern was poorly simulated by all models, and generally, precipitation was over-predicted for the cold months and under-predicted for warm months. Overall *CCCM* gave the lowest differences between observed and simulated precipitation, and was thus judged the best performing model overall.

Under $2xCO_2$ *CCCM* predicted mean monthly temperature increases between 2.8 and 4.9 °C, an average precipitation increase of 20% during the cold season and an average precipitation decrease of 20% during the warm season. New climate scenarios were constructed by adjusting the baseline data by the differences (for temperature) and by the ratio (for precipitation) between the $2xCO_2$ and $1xCO_2$ scenarios.

Impacts on Water Resources

To simulate the water resource impacts of potential climate change and corresponding adaptation measures, the *VIDRA* rainfall-runoff model [8] was used. As *VIDRA* is a lumped-parameter model, input meteorological data and model parameters should be considered as spatial averages. This is a reasonable modelling approach for sufficiently small

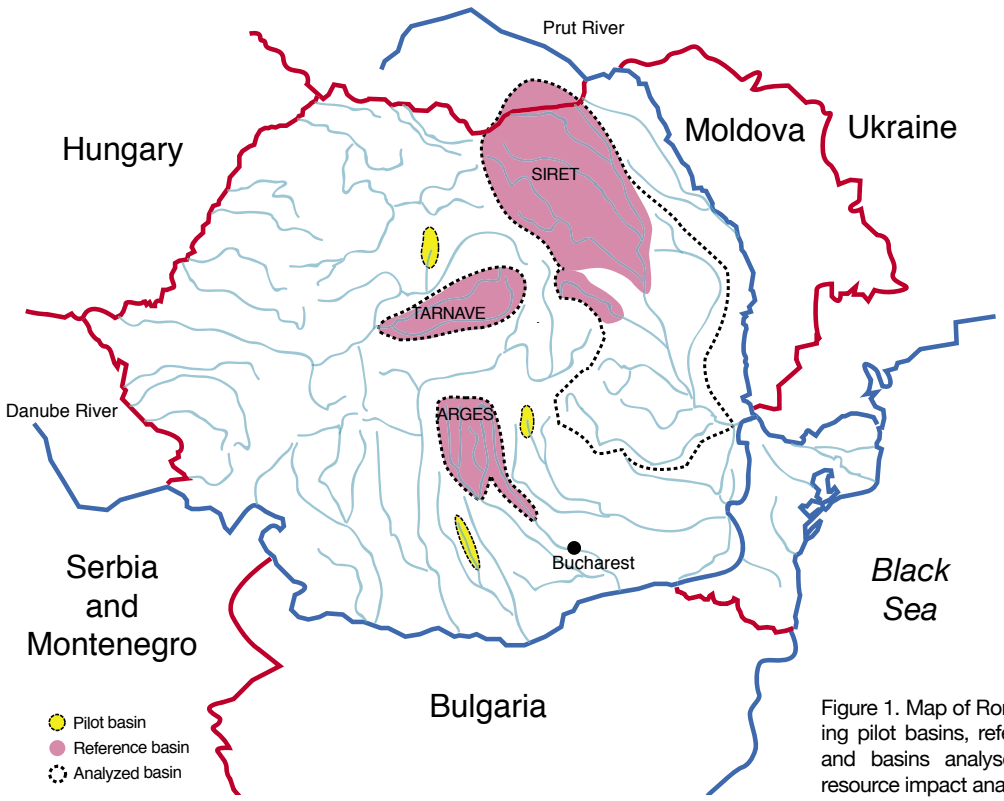

Figure 1. Map of Romania indicating pilot basins, reference basins and basins analysed for water resource impact analysis.

basins (a few hundred square kilometres), and so three small 'pilot' basins (200-350 km^2) were selected representing mountain (Poiana Tapului), hill (Band) and plain (Vârtoapele) regions. The simulated monthly flow series from the pilot basins have been transferred to three runoff forming basins (reference basins - Siret, Arges, Tãrnave, Figure 1). Both the Siret and Arges basins actually encompass two zones with different hydrological behaviour: (i) a hilly or mountainous *contributing zone,* which, generates most of the catchment runoff, and (ii) a *routing zone,* of significant extent but which generates minimal runoff. In the Tarnave Basin runoff generation is relatively uniform.

Two sets of model inputs were used: firstly, inputs to characterise the current climate, and secondly, inputs representing the *CCCM* 2xCO_2 scenario. The model was calibrated using daily flows (1971-1988) observed at the basin outlets. For water resource impact assessments the simulated pilot basin outflows were then transferred to several river sections in "reference" basins using an up-scaling procedure. The up-scaling procedure uses the relief configuration of the reference basin, which usually shows a quasi-gradual variation with altitude. For basins with complex topography, the mean altitude is a morphometric variable which integrates the climatic and physiographic influences on runoff formation. The river and the basin slopes, the hydrographic network density, soil permeability, vegetation, as well as the main climate factors (temperature and precipitation) show obvious changes with altitude. Thus, the multi-annual specific runoff (the ratio of multi-annual discharge to basin area) correlates well with mean basin altitude. There is also a clear correlation between mean altitude and long-term monthly mean specific discharge. By coupling the hypsometric curves with these statistical relationships, the monthly mean specific runoff for each relief zone of each reference basin was obtained, and these were then integrated to obtain total reference basin runoff.

Note that the pilot basins were not located inside the reference basins, and so the pilot basins only represent the typical relief configurations (mountain, hill and plain) found in the reference basins. The modelled meteorological input data used in the rainfall-runoff modelling of the pilot basins, should therefore reflect the climate changes in the reference basins as well as possible. To achieve this, the baseline temperature and precipitation data for pilot basins were adjusted according to *CCCM* simulations in reference basins. The

adjustments involved averaging the *CCCM* values for various points of each relief zone.

Analysis of the modelling results for the reference basins under 2xCO_2 showed that runoff decreased in spite of a higher precipitation, due to a significant increase in evapo-transpiration caused by increased air temperatures. The distribution of monthly mean runoff changed, and the coefficients of variation of monthly discharges increased. Analysis of the monthly frequency of the above-median discharges revealed that the greatest runoff changes were in April, with a large decrease in the maximum runoff. Maximum monthly discharges shifted from the spring–summer months to the winter months, because of the predicted winter warming that caused snow cover to melt earlier than the precipitation maximum; the latter generally occurring in April-July. Minimum monthly mean discharges shifted from October-January to August-October, due to air temperature increases (causing greater evapo-transpiration and lower soil moisture) as well as marked decreases in September precipitation.

To assess water resource vulnerability under the simulated climate change, the series of mean monthly discharges at several key locations were analysed. These locations relate to water reservoirs and diversion and restitution works, where the water resource-demand budgets could be quantified. Monthly flows at these key locations were estimated using correlations with reference basin outlet stations, with correlations based on 40-50 year flow records. It was assumed that the correlations remain valid under the 2xCO_2 scenario.

A water balance 'resource-demand' model was applied considering the future water

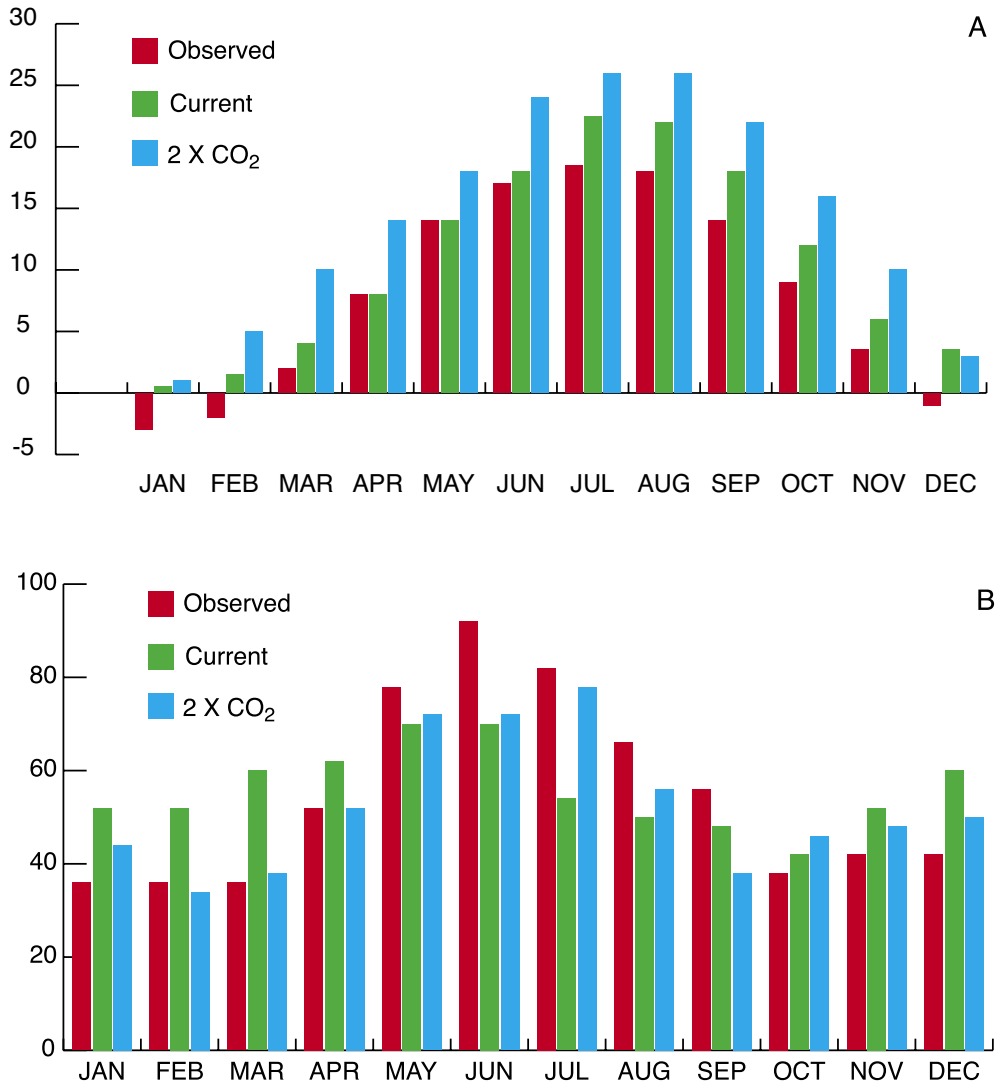

Figure 2. Observed and modelled (current and 2xCO_2) monthly mean (A) temperature and (B) precipitation averaged over the Romanian territory.

demands for agriculture, industry and town water supply. The model [9] allows simulation of reservoir exploitation according to pre-established scenarios. For each time step the model calculates the water balance for each reservoir in an upstream-to-downstream cascade. This model was used to assess water resource vulnerability in three basins (Arges, Siret and Târnava). Taking into account the existing water management, only the Arges River Basin appeared to be sensitive to climate change. However, it is one of the most important water basins in Romania from an economic, social and environmental point of view. Bucharest, the capital of Romania with around two million inhabitants, is located in the Arges River basin.

The adaptation options considered for the Arges basin include structural and non-structural measures. To assess structural measures, 15 combinations of the most economical options were analysed for a number of reservoirs and water diversion works, and economic criteria were used to select three combinations of options. Non-structural measures assessed included possible new operational rules for the strategic reservoir Vidraru, and the time evolution of water demands combined with a gradual reduction in water losses in the water supply network.

The results show that climate change could have significant water resource impacts in Romania, with, for example, water demands potentially exceeding availability in the Arges River basin. Improved estimates should be sought using the outputs of more advanced GCMs and rainfall-runoff models.

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Land-Ocean Interactions in the Coastal Zone LOICZ II

Inaugural Open Science Meeting

COASTS AND COASTAL PEOPLE - SCENARIOS OF CHANGE AND RESPONSES

Egmond aan Zee, Netherlands

27-29 June, 2005

The meeting seeks to bring together human dimension and natural scientists, decision-makers, managers and user groups.

Abstracts that address one or more of the LOICZ II Themes or cross-cutting activities are solicited.

Theme 1: Vulnerability of coastal systems and hazards to human societies.

Theme 2: Implications of global change for coastal ecosystems and sustainable development.

Theme 3: Anthropogenic influences on the river basin and coastal zone.

Theme 4: Fate and transformation of materials in coastal and shelf waters.

Theme 5: Towards coastal system sustainability by managing land-ocean interactions.

GLOBAL CHANGE IGBP

IHDP

www.loicz.org/conference

OPEN MEETING 2005

The 6th Open Meeting of the Human Dimensions of Global Environmental Change Research Community

9-13 October, 2005

University of Bonn

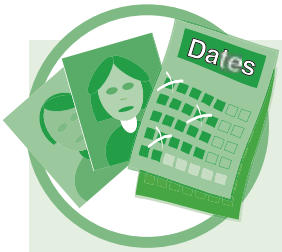
Bonn, Germany

The call for sessions is now open and will last until November 15th, 2004.

We encourage all interested session organisers to submit a session proposal through the Open Meeting website.

IHDP

http://openmeeting.homelinux.org/



New Roles and Faces

New Executive Director for PAGES

Thorsten Kiefer has been appointed as the new Executive Director of PAGES. Thorsten comes to PAGES from the Department of Earth Sciences at the University of Cambridge. His recent research has focused on rapid centennial-scale climate changes of the late Pleistocene and Holocene. His interests include the ramifications of global change on regional climates, past human-climate interactions, and the role of surface and deep-ocean circulation on modulating climate. He has developed and integrated palaeoceanographic records with ice core data, climate model simulations and archaeological evidence, and has studied a number of areas in the Indian, Pacific and North Atlantic Oceans. Thorsten has begun working part-time for PAGES from Cambridge, and will begin full-time work at the PAGES IPO in Bern in April 2005. He encourages the IGBP communitys to exchange with PAGES on questions of present and future global change and to benefit from the wealth of the palaeoenvironmental record that is unravelled by the PAGES community.

E-mail: kiefer@pages.unibe.ch

IGBP and Related Global Change Meetings

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

Avoiding Dangerous Climate Change: A scientific symposium on the stabilisation of greenhouse gases

01-03 February, Exeter, UK

Contact: Rhian Checkland, rhian.checkland@cvg.gov.uk or http://www.stabilisation2005.com

Tropical-Extratropical Climatic Teleconnections: A Long-Term Perspective (AGU)

08-11 February, Honolulu, Hawaii

Contact: http://www.agu.org/meetings/cc05ecall.html

International Conference on Integrated Assessment of Water Resources and Global Change: a North-South Analysis

23-25 February, Bonn, Germany

Contact: http://www.zef.de/watershed2005

1st International Workshop on Climate Variability over Africa

06-17 March, Alexandria, Egypt

Contact: http://agenda.ictp.trieste.it/agenda/current/fullAgenda.php?ida=a04222

PAGES/DEKLIM Conference-The climate of the next millennia in the perspective of abrupt climate change during the late pleistocene

07-10 March, Mainz, Germany

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

7th IAHS Scientific Assembly

03-09 April, Foz do Iguacu, Brazil

Contact: http://www.acquacon.com.br

CLiC 1st Open Science Conference

11-15 April, Beijing, China

Contact: http://www.clic2005.org/

16th Global Warming International Conference

19-21 April, New York, USA

Contact: gw16@globalwarming.net

European Geosciences Union General Assembly

24-29 April, Vienna, Austria

Contact: EGU Office, egu@copernicus.org or http://www.copernicus.org/EGU/ga/egu05/index.htm

Atmospheric Sciences and Air Quality Conference

27–29 April, San Francisco, CA, USA

Contact: http://www.ametsoc.org/meet/fainst/asaa.html

1st Alexander von Humboldt International Conference

16-20 May, Guayaquil, Ecuador

Contact: http://www.copernicus.org/EGU/topconf/avh1/

International GLOBEC Symposium: Climate Variability and Sub-Arctic Marine Ecosystems

16-21 May, Victoria, Canada

Contact: GLOBEC IPO, globec@pml.ac.uk
or http://www.globec.org

International Symposium on Arid Climate Change and Sustainable Development

23-25 May, Lanzhou, Gansu, P.R. China

Contact: Bi Xiaodong, Ebxd_2463@sohu.com or
Guo Hui, Guoh_lz@sina.com or Yao Hui, ISACS@gsma.gov.cn

3rd International Congress Environmental Change in Central Asia

23-27 May, Ulaanaatar, Mongolia

Contact: http://www.num.edu.mn/MOLARE/frames/international_congress_frame.html

4th Euro-GOOS Conference

06-09 June, Brest, France

Contact: Eurogoos2005@ifremer.fr or
http://www.eurogoos2005.org/

The Oceanography Society and UNESCO/IOC International Ocean Research Conference

06-10 June, Paris, France

Contact: http://www.tos.org/conference.htm

Rapid Landscape Change and Human Response in The Arctic

15-17 June, Whitehorse, Yukon, Canada

Contact: Antony Berger, bergerar@telus.net or
http://www.brunel.ac.uk/ICSU/yukon/index.html

ASLO Summer Meeting

19-24 June, Santiago de Compostela, Spain

Contact: http://aslo.org/meetings/santiago2005

5th International Scientific Conference on the Global Energy and Water Cycle Experiment (GEWEX)

20-24 June, Irvine, CA, USA

Contact: http://www.gewex.org/5thconf.htm

Asia Oceania Geosciences Society's 2nd Annual Meeting

20-24 June, Singapore

Contact: http://www.asiaoceania-conference.org/

GECHS Workshop on Human Security and Climate Change

21-23 June, Oslo, Norway

Contact: CICERO, humsec-secretariat@cicero.uio.no
or http://www.cicero.uio.no/humsec/

Land-Ocean Interactions in the Coastal Zone LOICZ II Inaugural Open Science Meeting

27-29 June, Egmond aan Zee, The Netherlands

Contact: LOICZ IPO, loicz@nioz.nl or
http://www.loicz.org/conference

Advances in Marine Ecosystem Modelling Research Symposium

27-29 June, Plymouth, UK

Contact: Administrative inquiries, admin@amemr.info or
Scientific enquiries@amemr.info

Non-CO_2 Greenhouse Gases (NCGG-4)

04-06 July, Utrecht, The Netherlands

Contact: http://www.milieukundigen.nl/pages/ncgg4/

IAMAS Symposium

02-11 August, Beijing, China

Contact: http://web.lasg.ac.cn/IAMAS2005/program.htm

2nd PAGES Open Science Meeting

10-12 August, Beijing, China

Contact: PAGES IPO, pages@pages.unibe.ch or
http://www.pages2005.org/

Dynamic Planet 2005

22 August, Cairns, Australia

Contact: info@dynamicplanet2005.com or
http://www.dynamicplanet2005.com/

SOLAS Summer School

29 August-10 September, Corsica, France

Contact: SOLAS IPO, casey.ryan@uea.ac.uk

7th International CO_2 Conference

26-30 September, Boulder, CO, USA

Contact: pep.canadell@csiro.au

Open Science Conference: Global Change in Mountain Regions

01-05 October, Perth, Scotland, UK

Contact: http://www.mountain.conf.uhi.ac.uk/

6th Open Meeting of the Human Dimensions of Global Environmental Change Research Community

09-13 October, Bonn, Germany

Contact: http://www.ihdp.org or
http://openmeeting.homelinux.org/

1st DIVERSITAS International Conference on Biodiversity. Integrating biodiversity science for human well-being

09-12 November, Oaxaca, Mexico

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

Greenhouse 2005: Action on Climate Control

13-17 November, Melbourne, Australia

Contact: http://www.greenhouse2005.com

International Conference on

Integrated Assessment of Water Resources and Global Change: A North-South Analysis

Bonn, Germany
23-25 February, 2005

Objective and themes of the conference

The main objective of the conference is to analyse the global change challenges that are encountered in the integrated assessment and management of water resources in large river basins. By bringing together scientists and managers from North and South, it is expected that international research efforts concerning water related issues will be translated into more practical methods and coherent approaches.

At the conference, the following themes will be addressed explicitly:

* **Water resources data**
* **Stakeholders perspectives**
* **Scaling**
* **Integration**
* **Water science and policy**
* **Summary of international water programs**

CGIAR Challenge Program on WATER & FOOD · IAHS AISH · GWSP · UNESCO · Bundesministerium für Bildung und Forschung · GLOWA

www.zef.de/watershed2005

DIVERSITAS:OSC1

Integrating biodiversity science for human well-being

9-12 November 2005

Hotel Mision de Los Angeles
Oaxaca, Mexico

For more information visit:
www.diversitas-osc1.org

Contact: info@diversitas-osc1.org

DIVERSITAS
an international programme of biodiversity science

Linking biological, ecological and social disciplines, the

First DIVERSITAS Open Science Conference

will address current issues in biodiversity science:

How is biodiversity changing? And why? • What are the consequences of change for ecosystems and for the delivery of ecosystem services? • What can we do to promote more sustainable use of biodiversity and improve human well-being?

Confirmed Plenary Speakers

Michel Loreau, Chair DIVERSITAS Scientific Committee
David M. Hillis, University of Texas, USA
Bob Scholes, South Africa
David Tilman, University of Minnesota, USA
Jeremy Jackson, Smithsonian Tropical Research Institute, USA
Partha Dasgupta, University of Cambridge, UK
Laurence Tubiana, IDDRI, France
José Sarukhân, CONABIO,Mexico

Parallel Sessions will focus on strengthening biodiversity science, supporting the science-policy interface, and on integrated approaches to thematic issues such as biodiversity in specific ecosystems (mountain, agricultural, marine, freshwater, urban), invasive species, and biodiversity and human health.

Abstract Submission now online!
Deadline: 31 March 2005

International Summer School
Corsica, France

29 Aug - 10 Sept 2005

Scientific Committee

Corinne Le Quéré (coordinator)
Véronique Garçon
Maurice Levasseur
Peter Liss
Wade McGillis
Ulrich Platt
Mitsuo Uematsu
Rik Wanninkhof

Aims to expose doctoral students and young scientists to recent developments and methodologies in the study of biogeochemical and physical feedbacks between the ocean and the atmosphere

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Apply now at www.uea.ac.uk/env/solas/summerschool

Application deadline: February 11 2005

Institut d'Études Scientifiques de Cargèse
http://cargese.univ-corse.fr

PAGES 2nd Open Science Meeting
10-12 August, 2005
Beijing, China

Palaeoclimate, Environmental Sustainability and Our Future

Meeting Themes
· Future Change: Historical Understanding
· Humans and their Environment: Past Perspectives on Sustainability
· Ocean-Continent-Cryosphere Interactions: Past and Present
· Climate, Humans and the Environment in Asia
· PAGES Research Foci and Initiatives within IGBPII

The OSM will consist of plenary lectures and poster sessions.
See the preliminary program at www.pages2005.org/schedule.html.

The PAGES OSM is being held alongside the 9th IAMAS Scientific Assembly (2-11 August, 2005).

Poster abstract submission deadline 31 March, 2005

Early registration before 15 May, 2005

GLOBAL CHANGE IGBP

www.pages2005.org

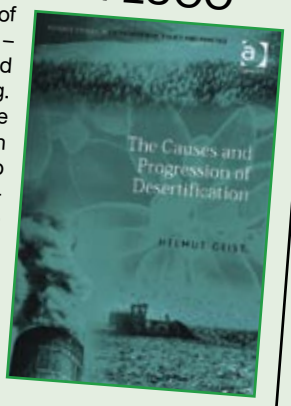
PAGES PAST GLOBAL CHANGES

Pin Board

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

Forthcoming Book from LUCC

A new book "The Causes and Progression of Desertification" authored by Helmut Geist – Executive Director of LUCC – will be released in the January 2005 by Ashgate Publishing. The book provides an examination into the causes and prospects of desertification through a systematic review of 132 sub national case studies. It uses a meta-analytical model to determine whether proximate causes and underlying driving forces fall into any patterns, to identify mediating factors, feedbacks, cross-scalar dynamics and typical pathways. It shows a limited set of recurrent core variables in varying combinations to drive desertification. Most prominent root causes are climatic factors, institutions, national policies, population growth and remote economic influences that lead to local cropland expansion, overgrazing and infrastructure extension, associated with desertification as a potential but not necessary outcome. Some factors are geographically robust; most of them are region and time specific. Order online from www.ashgate.com.



Portuguese-Spanish IGBP Seminar

In April this year the Portuguese and Spanish IGBP National Committees, chaired respectively, by João Corte-Real and Carlos Duarte, promoted and organised a seminar on Global Change and Sustainability, at the University of Évora, Portugal. The seminar adopted an Earth System approach, considering the ensemble of system components, and the complex interactions and feedbacks between them. Five seminar sessions were held: Oceans and Atmosphere, Forests and Desertification, Freshwater Ecosystems and Global Change, Coastal Zones and Sustainable Management of Ecosystems, and Climate Change and Carbon Sequestration.

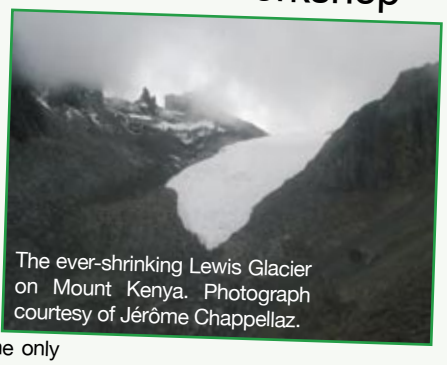
The seminar drew participants from IGBP (including a presentation from the Chair, SC-IGBP), IHDP and WCRP, as well as projects of the Earth System Science Partnership. A total of 78 people attended, including ten invited speakers and 37 students. As a result of the seminar, a Portuguese National Global Change Committee is being formed, encompassing the present IGBP and IHDP National Committees. The seminar concluded with a 'round table' discussion on Integrated Regional Studies (IRS), including the suggestion for an Iberian IRS on 'Atmospheric and Biogeochemical Cycles of Elements in the North East Atlantic'. The third Portuguese IGBP National Committee, being elected December 2004, will develop and expand these ideas and initiatives from the seminar, providing a new impetus to global change activities and the promotion of IGBP activities in the region.

Norway in International Global Change Research

How can one improve interactions between national research and the international global change programmes? This was the question addressed at a workshop in Oslo last November 4, to which the Research Council of Norway had invited the Executive Directors of IGBP, IHDP, WCRP, DIVERSITAS and IIASA. Norway has a long and strong tradition for global change research, particularly with respect to polar, oceanic and climate research. However, the links between this research and the international global change programmes is of varying quality. Mechanisms to strengthen the links between this Norwegian research and the global change programmes was the focus of group discussions at workshop. This proved very fruitful, and many ideas on how the interactions could be improved were presented. The Research Council of Norway is now preparing to implement some of these suggestions through the establishment of a Norwegian National Global Change Committee. This will improve the coordination and profile of the international programmes and IIASA in Norway.

PAGES Pan Africa Workshop

In July 2004 the PAGES workshop "African Paleo-perspectives: Linking the Past to the Present and the Future" was held in Nairobi, Kenya. Africa is rich in records of palaeoenvironmental and palaeoclimatic change, and is unique in that it is the only continent that straddles, almost symmetrically, the equator. It therefore experiences both northern and southern hemispheric climatic influences.


The ever-shrinking Lewis Glacier on Mount Kenya. Photograph courtesy of Jérôme Chappellaz.

The workshop assembled palaeoscientists working in Africa to enhance collaboration, networking and information exchange amongst African scientists, and to establish strong connections with scientists from beyond the continent. The workshop emphasised the relevance of palaeoclimatic research to better understand modern day and future climate and environmental change, and helped capacity building and strengthening of institutional linkages within Africa.

Discussion sessions examined the science, networking and collaboration facets of PAGES, INQUA (International Union for Quaternary Research) and IDEAL (International Decade for the East African Lakes). Participants formed geographical sub-region groups to develop joint research proposals under the PAGES Science Framework. This will enhance palaeoscience in Africa and contribute to a more strongly networked and active African research community. Workshop papers will be published in the journal Quaternary International.

Artic Climate Impact Assessment

The Artic Climate Impact Assessment – an international project of the Arctic Council and the International Arctic Science Committee (IASC) – has completed an evaluation and synthesis of knowledge on climate variability and change and their consequences. The fully referenced and independently reviewed synthesis – "Impacts of a Warming Artic" – will be released in January 2005 by Cambridge University Press. A comprehensive full colour report and a short plain language 'highlights' document are also available from www.acia.uaf.edu. The results of the study and their implications were discussed and communicated to stakeholders and politicians at the ACIA International Scientific Symposium in November 2004.

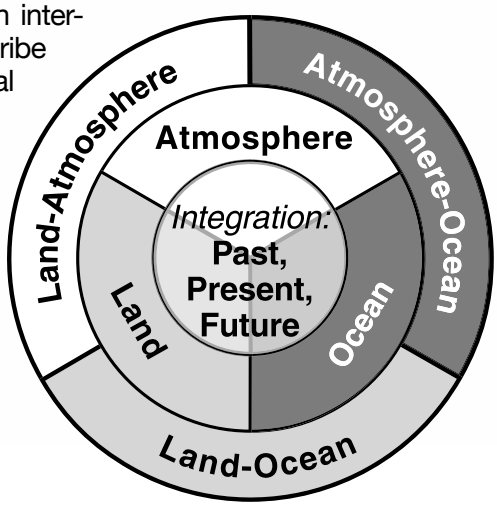
A clear conclusion is that the Arctic is warming much more rapidly than previously known, at nearly twice the rate as the rest of the globe, and increasing greenhouse gases from human activities are projected to make it warmer still. However, the study analysed the full range of likely Artic impacts including shrinking summer sea ice, melting of the Greenland Ice Sheet, rising sea levels, thawing permafrost, coastal erosion, and the consequences for Artic flora, fauna and indigenous peoples. The study also considered the likely global impacts of Artic processes, that in additional to global sea level rise, may include the positive feedbacks associated with reducing albedo, changes in ocean circulation resulting from increased freshwater runoff to the Artic Ocean, and changes in greenhouse gas exchanges. Greenhouse gas exchanges are likely to change significantly due to release of methane and carbon dioxide from thawing permafrost and increasing methane and carbon dioxide emissions from warming forests and tundra. These increases may be regionally offset to some extent by an increased capacity for absorption of carbon dioxide in a more exposed and biologically active Artic Ocean.

Editors Note

Contributors and readers are alerted to the fact that as from issue 59 onwards, citations in Global Change NewsLetter articles that have more than three authors (or editors) will be listed as Primary Author et al.

The International Geosphere-Biosphere Programme

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



IGBP helps to

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

IGBP produces

- data, models, research tools
- refereed scientific literature, often as special journal editions, books, or overview and synthesis papers
- syntheses of new understanding on Earth System science and global sustainability
- policy-relevant information in easily accessible formats

Earth System Science

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

Participate

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

Contributions

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

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

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

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