Potsdam Institute for Climate Impact Research

Biennial Report 2000/2001

Featuring the 10th Anniversary

of PIK

Impressum

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Potsdam Institute for Climate Impact Research (PIK)
Potsdam-Institut für Klimafolgenforschung e.V. (PIK)

Postal address
P.O. Box 601203
14412 Potsdam
Germany

Visitor address
Telegrafenberg
14473 Potsdam
Germany

Phone +49 - 331-288-2500
Fax +49 - 331-288-2600
E-mail pik@pik-potsdam.de
Internet http://www.pik-potsdam.de

Main Editor
Margret Boysen

Technical Management
Dietmar Gibietz-Rheinbay

Layout
Margret Boysen (photo layout), Dietmar Gibietz-Rheinbay (template design),
Wilhelmine Seelig, Ursula Werner (technical assistance).
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Looking Back

The First 10 Years

By Udo E. Simonis

Times of change are times of chances. And so it was when after German re-unification the question arose of where to preserve scientific capacities and where to build new ones, and more so, how to meet the new challenges that were in need of first class science.

Climate research had quite a tradition in both East and West Germany. Climate impacts and global change, however, were still largely unexplored. The decision then to establish an innovative research institute in Potsdam was, probably, an easy one, in reverence for the *genius loci* of that historic center of research. To define the tasks of the new institute was not that easy.

The promoters in the ministries in Bonn and Potsdam, however, had a good idea. They wrote an elemental paper and appointed a founding committee, with experienced administrators and renowned academicians, both from the natural and the social sciences. The new Potsdam Institute for Climate Impact Research (PIK) was thus destined to become an inter-disciplinary and policy-oriented research institution of high international reputation.

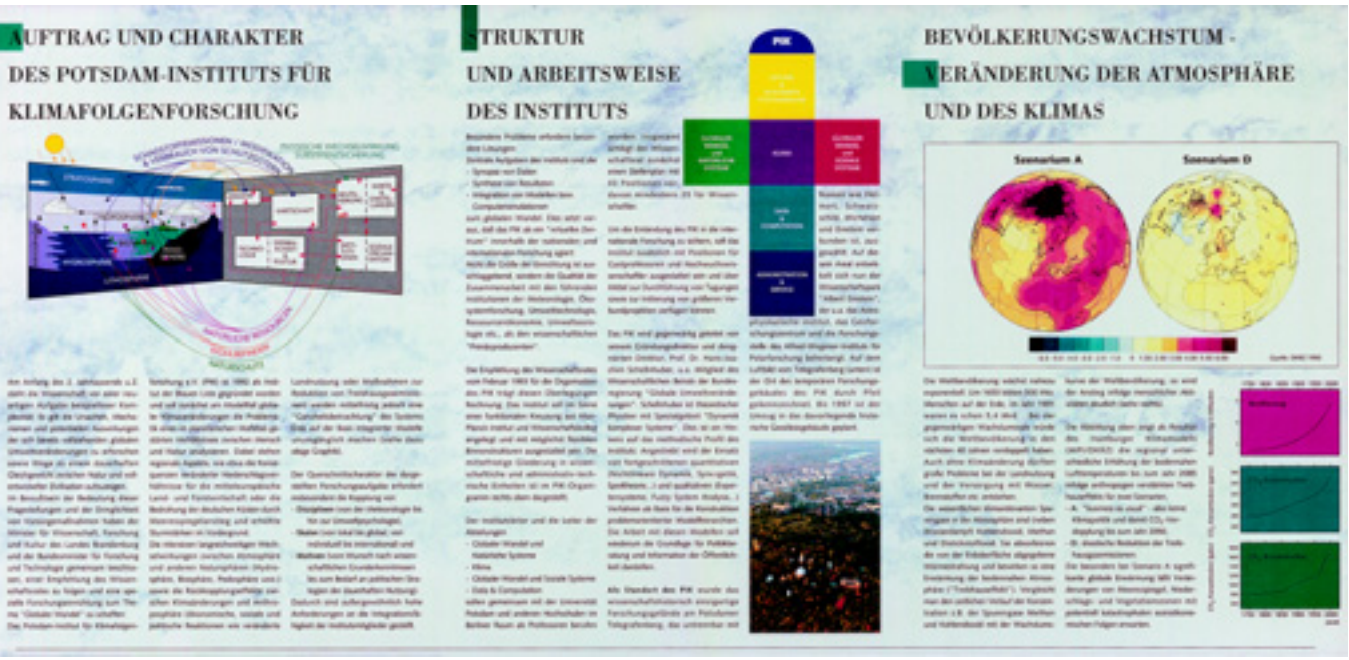
Basically, the founding members discussed Gilbert F. White's suggestion that the future condition of the globe's interlocking natural and social systems might depend more on human behaviour than on the further investigation of natural processes. Thus a strong social science component was agreed upon, intensive debates on the institute's concept and projects started, and the prompt appointment of a brilliant, imaginative director and prominent leading scientists helped to get things going.

Personally, I do recall the struggle with Klaus Hasselmann who, at that time, did not think that the social sciences had much to say on climate impacts. My repeated hints on the role economists – and rather conservative ones at that! - played in US climate research, made him think twice and, later on, he became a respected speaker at international economic institutes ...

The institution's further evolution was, of course, not without struggle and battle on resources, location, appointments, and even on the name and its logo. In historical perspective, however, such contests appear as stimulating and constructive; the Board of Trustees was a reliable and determined guard.

In the minutes of the very first meeting of PIK's founding committee two specific features had been stressed - integrated scientific assessments and innovative societal functions: The challenge, it said, is to develop solutions for highly complex man-nature interactions, to coordinate those solutions and to bridge the gap between theoretical modelling of processes and practical implementation of policies.

1991 July	Recommendation of the Wissenschaftrat (German Science Council) to establish an institute for climate impact research
1991 October	First meeting of the Founding Committee of the Potsdam Institute for Climate Impact Research (PIK), a registered society (e.V.) in Potsdam
1991 December	Inaugural meeting, establishing the statutes of the institute and appointing H.J. Schellnhuber as its Founding Director
1992 January 1	Official foundation of PIK by the German Federal Ministry of Science and Technology and the Ministry of Science, Research and Culture of the State of Brandenburg
1993 April	Inauguration of PIK´s provisional building on the Telegrafenberg in Potsdam - departure from the offices in Berlin
1994 February	Constituent assembly of the international Scientific Advisory Board of PIK
1994 November	Inauguration of PIK's first parallel supercomputer IBM RS 6000 SP by Manfred Stolpe, Prime Minister of the State of Brandenburg
1998 October	Institute review by an evaluation committee of the Wissenschaftsrat to result in an expert report
2001 October	10 years of PIK - inauguration of the new main building and the new high-performance computer during the First Sustainability Days



Parts of PIK´s first brochure.

Over the years, this basic mission of PIK was again and again transmitted to its own members and its outside collaborators. A resourceful Scientific Advisory Board (SAB) was established that took up intensive discussions with an ever growing number of researchers from various disciplines. PIK thus became deeply involved in thoroughly investigating the geophysical, ecological and socio-economic aspects of climate change, and climate-impact research became part of a more comprehensive Earth system analysis.

For various reasons and deliberately so, the concept and structure of the research work at PIK changed in the course of time. The work was first conducted in a matrix structure, and research management was based on departments, the Climate System, Natural Systems, Social Systems and Data & Computation Department, complemented by a Department for Integrated Systems Analysis dedicated to methodologies that cut across traditional scientific boundaries. Actual research work was carried out in projects (with often stimulating acronyms!) that tried to answer key questions, the so-called core projects. Nine such core projects were clustered under three research angles, namely global perspective, regional focus and sectoral view.

For years this structure proved quite successful and led to a first grade evaluation by the "Wissenschaftsrat", the German Science Council, who in 1999 defined PIK as "an outstanding research facility".

Mitigation of and adaptation to climate change were major themes of that first period of research work. Through data analyses, computer simulations and models, PIK provided sound information on and proposed appropriate goals, instruments and strategies for sustainable development, now and in the future. In addition to pro-active publishing in peer-reviewed journals and high-calibre books, scientific advice was given to national and regional authorities, to industry, non-governmental organisations and civil society at large.

Over the years, need was felt to revise the programme and to develop a new research profile – TOPIK^{2K}, an outcome of an elaborate internal contest and major efforts for increased excellence. In close collaboration with the Scientific Advisory Board seven major transdisciplinary research areas were prescribed, and the functions of the departments more clearly defined to support the resources for the research projects and to ensure the quality of the results. TOPIK^{2K} will thus contribute to integrated systems approaches to global change in general and Earth system analysis in particular.

Understanding the Earth system is a task that no institution can tackle alone. PIK therefore closely collaborates with many partners, plays an active role in activities such as the International Geosphere-Biosphere Programme (IGBP), the European Climate Forum (ECF), and the Intergovernmental Panel on Climate Change (IPCC), and coordinates a great number of multi-national research projects.

Excellent research depends, above all, on excellent people. And here PIK was extremely happy, particularly in engaging the Schellnhubers; both John and Petra, in their distinct functions, with their wide range of ideas and enduring creativity, made PIK the exceptional place it is, a well run, first-class institute, attractive to experienced senior and promising junior staff alike.

Petra Schellnhuber, who died so early (see the obituary on the next page), was a charming, but very outspoken woman, the "angel of the institute". The side-events of the annual meetings of the international Scientific Advisory Board, which she took special care of, will be unforgotten. We had never had before and probably will never have again, a board meeting among the mummies in the Egyptian museum ...

Construction of PIK´s provisional building on the Telegrafenberg in Potsdam.

All in all the number of staff now amounts to more than 150. They do cost a lot, but they also earn a lot, in research grants and in academic esteem, in better understanding of complex interactions and in suggesting relevant solutions – as is manifest from the other parts of this report.

Ten years of work - ten years PIK - this is a good occasion to look back. But there is equal reason to look forward, as neither the climate system nor the Earth system has yet reached a sustainable path, and the stability of the ecosphere is seriously threatened by human activities. I therefore would like to see PIK flourish for the next ten years and more, both in intellectual capacity and in excellent research work. Maybe my personal normative criteria for academic life could help to secure these wishes: Your work should be theoretically demanding, empirically relevant and done at the right time.

Congratulations to all PIK members for your work in the past; high expectations for your work in the future!

The author: Prof. Dr. Udo E. Simonis is Research Professor for Environmental Policy at the Science Center Berlin (WZB). He was Chair of PIK´s Scientific Advisory and member of PIK´s Board of Trustees from 1994 - 2001.

PIK´s Paleosites

At the "Ex-Stasi Headquarters", PIK members from four of the future five departments began working together in a makeshift mode. In November 1992, Klaus Bellmann, Head of the Natural Systems Department, was joined there by his collaborator, and later successor, Wolfgang Cramer. These winter months were a peculiar and certainly memorable time for all those working in Berlin's Magdalenenstrasse. The group had found offices in the massive, deserted office complex formerly occupied by the "Ministry of State Security" (Stasi). Germans from both sides of the wall and some colleagues from other countries were working together, with Stasi furniture and phones, western UNIX workstations (but no internet access), and a steady stream of international visitors wanting to see the new institute. The director and the administration were, it seemed, on a different planet, accommodated temporarily in various buildings scattered all over the Telegrafenberg in Potsdam. Head-of-department meetings in Potsdam involved several hours of travel in the institute's grey Wartburg vehicle. These hours were of considerable value: both scientific issues and structural decisions for the institute were thoroughly discussed in Berlin traffic jams or along the bumpy streets crossing what used to be the Berlin wall. This "Berlin era" came to an end when the widely distributed parts of PIK were finally united on the Telegrafenberg in March 1993 M. Stock

Petra Schellnhuber: an Obituary

The Potsdam Institute for Climate Impact Research deeply regrets the death of Petra Schellnhuber. On Friday, September 28, 2001, Petra Schellnhuber, one of the pioneers of our Institute, passed away. She endured a long and severe illness with great courage and faced death with amazing dignity and love. Petra died on her birthday in her own and John Schellnhuber's home in Potsdam.

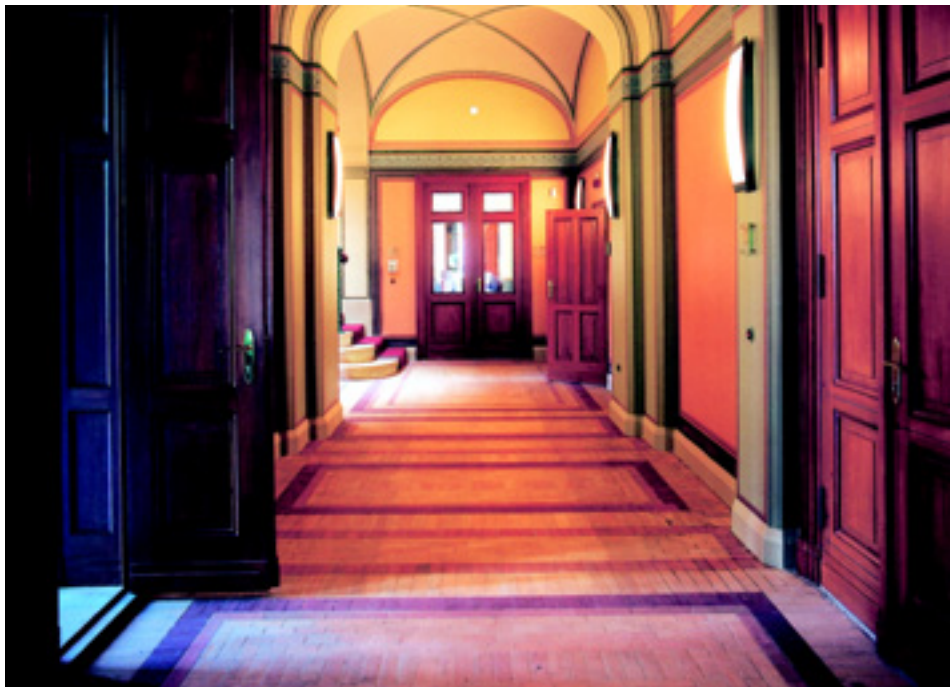
Petra was born in 1950 in Frankfurt/Main. Her university training was in archaeology, completed with a degree from the University of California, Santa Barbara, in 1982. Petra changed direction in her professional career when she helped to establish our institute in 1992/93 as full-time Public Relations Manager. Her illness forced Petra to retire gradually from this position from 1997 on.

The importance of Petra's achievements during the initial phase of the institute cannot be overstated. Creating an interface with the outside world, the general public, governments, funding agencies and media was only one, albeit important, contribution that she made. Helping a growing team of scientists and technical/administrative staff, from different disciplines, academic cultures and nationalities to grow together was another, equally important one.

A crucial factor in Petra's approach to the advancement of PIK's goals was her fearless attitude to the traditional ways to conduct, and manage, research in a multidisciplinary environment. If rules and regulations were helpful to the scientific goals identified by the institute, then she would find them for us and help us all make best use of them. If a personal contact with someone, somewhere, could help identify better solutions, then she would make that contact for us too.

Not only staff members at PIK, but also colleagues and friends worldwide are aware that Petra's contributions to PIK, although poorly visible in a classical sense, are outstanding. Thanking her for these contributions, and for the positive spirit she brought to much of our work, is the least we can do, and we do so wholeheartedly. More in her spirit, however, will be to continue the path she has helped us commence and to pursue our research on a transition to sustainability.

Petra Schellnhuber (1950-2001).



The Institute and its Mission

The Potsdam Approach to the Integrated Investigation of Climate Change

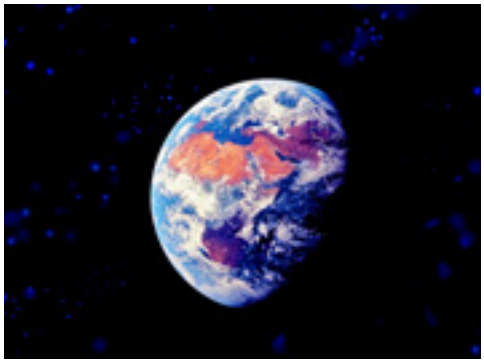
The Mission

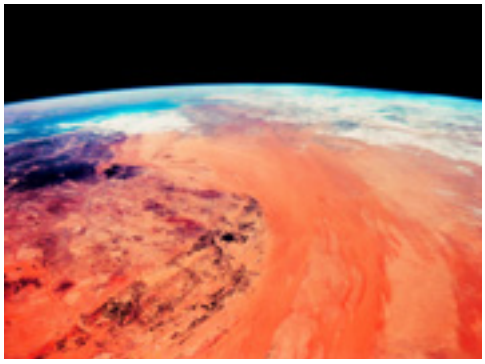
The transformation of the global climate system, set going by the very nature of our technical civilization, represents one of the greatest challenges so far in the history of mankind. The main cause of this development is the emission of greenhouse gases (such as CO_2, CH_4 and N_2O) by industry, traffic and households, which has modified the radiation balance of the Earth's atmosphere and will bring about a planetary warming of two to three degrees Celsius in the 21st Century. And this is happening, moreover, during one of the Earth's warm periods, a time at which our environment is anyway at the peak of a natural fever. The special challenge noted initially relates to the complexity of the expected repercussions, the gigantic spatiotemporal range of the perturbation, the irreversibility of probable damage to innumerable ecological an socioeconomic systems and to the completely novel aspects of international and intergenerational justice that are involved: who pays the price, who is liable, who profits, who makes provision and who provides the aftercare?

Public opinion and politicians began about two decades ago to become interested in these questions, which initially were addressed only gradually at individual scientific conferences. But nowhere did the research capacity exist which could provide well-founded answers to specific problems, not to speak of an integrated assessment of the problem as a whole. In this situation some farsighted representatives of ministries, universities and research communities made use of the short-term window of opportunity arising from the German re-unification to set in motion the foundation of the "Potsdam Institute for Climate Impact Research (PIK)". PIK was to run in a manner appropriate to its subject, in other words with a radically holistic approach. On the one hand scientists from all relevant disciplines (i.e. meteorology, ecology, economic sciences, systems analysis, etc.) should work together closely and without bias ("horizontal integration"), on the other hand all aspects of the relevant problem (from its formulation to proposals for its solution for decision-makers) should equally be considered ("vertical integration"). The possibilities to contain human-induced ("anthropogenic") climate change at a tolerable level, together with suitable measures to adapt to the unavoidable warming of the planet (with its particularly grave consequences for the poorest developing countries), should be at the core of the institute's research.

The Institute

Today, ten years after the official foundation of the institute on 1st January 1992, it can be remarked – in all modesty – that this radical approach has brought success. PIK is located on the Telegrafenberg in Potsdam, on a unique historic science campus, and was able in autumn 2001 to move into its new headquarters, the carefully restored former Astrophysical Observatory, where many of the giants of modern physics worked in the first decades of the 20th Century. More than 170 members of the institute make up the five scientific departments (Integrated Systems Analysis, Climate System, Global Change & Natural Systems, Global Change & Social Systems, and Data & Computation) together with the slim administrative and service units. This structure by no means implies any barrier to interdisciplinary co-operation: the actual research is carried out in small project teams, the "human capital" for which must be drawn from at least two different departments. PIK is a member of the Leibniz Gemeinschaft and has annual care funding of around 6 million euros from the German Federal Republic and the State of Brandenburg, in addition to soft funding from national and international sources amounting to several million Euros, including





major contributions from the European Community. The institute furthermore operates a supercomputer (a 200-processor, IBM SP parallel computer), which will in 2002 achieve teraflop level. This computer has a central importance in the Potsdam research approach. This is due to the fact that no institute in the world could be in a position on its own to collect the data in detail or study all the processes relevant to the whole subject of climate change. Fortunately this is done by tens of thousands of researchers in the international scientific community – in basic research, in remote sensing, and in countless measurement campaigns in the field. All this information, however, needs to be looked at in parallel to get a panoramic view of the problems, in order to provide priorities and possibilities for action for policy-making.

The Research Fields

Such an overall picture, with clear insights into the past, the present and the future, can only be provided through the virtual reality of computer simulation. PIK focuses in particular on this function, which can only be accomplished through massive efforts in data analysis, development of models, numerics and software development. Six broad thematic fields - so called "TOPIKs" (cf page 25) are currently being investigated in this way; these relate to

- the nonlinear dynamics of the ecosphere,
- civilization's handling of extreme events such as storms, droughts or floods,
- the socio-economic driving forces of global environmental change,
- the emergence of a globally interlinked civil society,
- the construction of regional simulators, and
- the vulnerability of economic sectors of climate change.

All these activities should contribute to the process of creating the scientific foundation for global sustainable development, i.e., for the acceptable coevolution of our technical civilization and the natural ecosystems of our planet.

Hans Joachim Schellnhuber, Director of PIK.

Departments

Five Scientific Departments to Advance the Knowledge Base

PIK's five scientific departments maintain and develop the methodological tools, model capabilities and data pools on which the institute's interdisciplinary work programme is based. The actual research at PIK is carried out in a number of medium-termyear, multi-disciplinary research groups ('projects'), in which several departments generally participate. These projects are guided by, and are an integral part of, the main overall research themes of PIK - the TOPIKs (cf page 25). The main function of the five departments within the PIK research structure is to develop, maintain and support the resources for the research projects and the TOPIKs, and to ensure the quality of scientific results. The five departments of PIK are: Climate System, Global Change & Natural Systems, Global Change & Social Systems, Data & Computation, and Integrated Systems Analysis. The first two departments are rooted in the natural sciences, the third in the socio-economic field, and the last two in what could be classified as 'structure sciences', namely computer science and mathematics. Within the past ten years, a rich treasure of more than one hundred simulation models of various scopes and applicabilities has been developed, and it is continuously being extended and enlarged (cf Catalogue of Tools on page 28). The departments are also responsible for promoting the scientific skills and careers of junior researchers at the institute.

Important Acronyms

AIM	Agriculture emphasising Integrated Modelling
BEAR	Biodiversity and Nature Protection Enhancement through Participatory Action Research
BEST	Brandenburg Simulator of Environmental and Socioeconomic Transformations
BIS	Biosphere Interactions in the Earth System
CLAWINE	Climate Adaptability of European Wine Industry
CLIMBER	Climate and Biosphere
EMIC	Earth System Model of Intermediate Complexity
DFG	Deutsche Forschungsgemeinschaft
EUROPA	Modelling, Reflecting and Communicating Possible Futures of Europe in the Context of Global Change
EVA	Environmental Vulnerability Assessment
EVITA	Exergy, Vegetation and Information: Thermodynamics Approach
GAIM	Global Analysis, Integration and Modelling
GloGov	Global Governance - Policy Analysis for Earth System Management
GLOREM	Global Water Resources Modelling and Management
GLOWA-Elbe	Integrated Analysis of Global Change Impacts on the Environment and the Society in the Elbe River Basin
GPP	The Geoscope Preparatory Project - Observing the Anthropocene for Sustainability Science
GRAIN	Guardrails and Indicators for Climate Protection
HSPN	Hochschulsonderprogramm - Nachwuchs
IGBP	International Geosphere-Biosphere Programme
IMEQ	Integrating Models and Ensuring their Quality
INTEGRATION	Integrated Assessment of Changes in the Thermohaline Circulation
LPG-DGVM	Lund-Potsdam-Jena Dynamic Global Vegetation Model
PIAM	Potsdam Integrated Assessment Modules
PIRSIG	Pirsig's Quality
PRUNE	Propagation of Uncertainties in Earth-System Models
QUEST	Quaternary Earth-system Stability
QUIS	Qualitative Intelligence Service
ReCSim	Regional Climate Simulation Models
SAFE	Sensitivity and Adaptation of Forests in Europe under Global Change
SFB	Sonderforschungsbereich
SIMENV	An Integrated Simulation Environment for Quality Assurance and Scenario Analyses
SYNAPSE	Syndrome Assessment and Policy Strategy Evaluation
TRIPEDES	Theoretical Research In Planetary Ecological Dynamical Earth Systems
WADI	Management of Water related Disasters

Climate System

Head: Martin Claussen
Deputy Head: Friedrich-Wilhelm Gerstengarbe

Overview
Understanding the interplay between the various components of the climate system is the key to a comprehensive Earth system analysis. Therefore the Climate System Department focuses on climate analysis and scenarios, climate-system modelling and ocean modelling. The research in these areas includes: i) the statistical analysis of past and present-day climatic data as well as the construction of future climate scenarios; ii) the development of a climate-system model of intermediate complexity; and iii) the investigation of ocean currents, in particular ocean-atmosphere feedbacks.


Martin Claussen

Climate Analysis and Scenarios
Group leader: Friedrich-Wilhelm Gerstengarbe

A prerequisite for any research related to climate is a thorough analysis of past and present-day climate based on high-quality data. Therefore, a PIK DATA Base System has been set up and is continuously expanded and updated in co-operation with the Data & Computation Department. The database contains high resolution, long term time series from all relevant climate stations of the world. Secondly, new multivariate statistical methods have been developed which are used for climate data analysis as well as for the validation of climate models.
For constructing regional climate change scenarios a new method has been formulated. This method considers results from climate models and observed regional climate parameters. It is based on an expanded cluster analysis algorithm and Monte Carlo simulations. The climate change scenarios are used in all PIK projects related to regional climate change.

Climate System Modelling
Group leader: Martin Claussen

In the Climate System Department a climate-system model of intermediate complexity called CLIMBER-2 (for CLIMate and BiosphERe, version 2) has been developed. It is used to focus on an efficient description of the feedbacks between all major components of the natural Earth system on time scales of centuries and millennia. Examples are simulations of the last glacial cycle, changes in carbon isotopes during the last 10,000 years, the greening and aridification of Northern Africa, and an analysis of the effects of volcanism, solar variability and land use on climate change of the past millennium. CLIMBER-2 includes dynamic models of the atmosphere, ocean, vegetation, and inland ice as well as models of terrestrial and oceanic carbon cycles. Currently it is the major tool used in the QUEST project.
For studies of the natural Earth system which require higher spatial and temporal resolution, a new model framework, CLIMBER-3, is under development in co-operation with both the Global Change & Natural Systems and the Data and Computation Departments.

Ocean Modelling
Group leader: Stefan Rahmstorf

Work in the ocean modelling group focuses on understanding the role of the oceans and sea ice in climate change, past and future. A major effort during the past two years has gone into developing the ocean component for the new coupled model CLIMBER-3. This ocean component is based on the GFDL MOM-3 model, which has been extended in various aspects and coupled to a state-of-the-art sea ice model. Further development work has focused on coupling to the atmosphere and on the implementation of an ocean carbon cycle model. Scientific issues that have been looked at were, for example, the role of sea ice in lowering the carbon dioxide levels during glacial times, or the dynamics of the Antarctic Circumpolar Current.

Another avenue of research is the development of simple conceptual, stochastic models of oceanic processes such as open ocean convection, to study aspects of their nonlinear dynamics.

Global Change & Natural Systems

Head: Wolfgang Cramer
Deputy Head: Petra Lasch

Overview
The planet's land surface is covered by a fine-scaled pattern of ecosystems and water bodies. These are all sensitive to changes in the environment and human life depends on them. To assess such changes, including their importance for human society, as well as the feedbacks from them to the atmosphere, is the primary goal of the department.

Most of our work is concerned with "human" scales of time and space. For ecosystems (natural and managed), we focus on landscape processes, such as tree and canopy development. In hydrological systems we assess the potential and risks environmental change might imply for human land use of river catchments. For the analysis of the entire biosphere we study interactions between human exploitation and the global carbon cycle. In none of these three cases can the direct human influence through management (or sometimes destruction) be ignored - often it is found to be the primary reason for concern. Our spatial scope is at multiple levels, ranging from the Elbe catchment, through pan-European studies, to global assessments.

Ecosystems
Group leader: Franz-W. Badeck

The ecosystems group uses empirical data and theoretical concepts to assess changes in ecosystem dynamics related to climate and land use change. It uses a suite of numerical models at different degrees of complexity, as well as major GIS data bases. An important contribution is made to the assessment of the vulnerability of ecosystem services (cf TOPIK projects EVA and SAFE, pages 38 and 50).

Water
Group leader: Zbigniew Kundzewicz

The water group develops a comprehensive understanding of the flow of water and substances transported in it through all stages of the hydrological cycle. The group studies issues of water shortage as well as flood risk, but also broader aspects of land cover change, such as the implications of economic trends on the use of land (cf TOPIK projects BEST and WADI, pages 46 and 37).


Wolfgang Cramer

The Biosphere
Group leader: Wolfgang Lucht

The biosphere group is the primary developer of a leading process-based biosphere dynamics model (LPJ), which is validated against observations from space and the ground. The model and supporting data bases are used to investigate the role of biospheric processes in the overall Earth system, particularly with respect to its stability on the decadal time-scale (cf TOPIK project BIS, page 30).

Interactions
We aim at playing a useful role within several national and international consortia that are concerned with challenging issues such as: vulnerability of ecosystem services, management of agricultural, forest and water resources, impacts and dynamics of land cover change, and the global carbon cycle. This includes the co-ordination of several collaborative research projects, and contributions to the International Geosphere-Biosphere Programme (cf page 103).

Global Change & Social Systems

Head: Carlo C. Jaeger
Deputy Head: Ottmar Edenhofer

Overview
To act responsibly in view of global environmental change will require a socio-economic shift of historic proportions, a sustainability transition. The Department of Global Change and Social Systems investigates the possibilities for and obstacles to such a transition. Sustainable development will involve a whole array of specific transitions. We have formed three research platforms to investigate some of these in depth.

Technology and the Energy Transition
Group leader: Ottmar Edenhofer

The pros and cons of various approaches to climate policy hinge to a very large extent on the prospects for restructuring the global energy system after the age of cheap oil. Sustainability science requires analysing the interaction between technological change and economic growth. Using new modelling techniques, we identify bifurcation points that offer viable policy options.

Social Discourse and the Lifestyle Transition
Group leader: Fritz Reusswig

How many billion cars will be running on planet Earth a few decades from now? What kinds of cars will there be? Such questions show how intimately issues of sustainability are connected to shifts in lifestyles. We combine stakeholder dialogues and lifestyle research to investigate linkages between sustainability and preference changes.

Resilience and the Management Transition
Group leader: Richard Klein

Identifying and alleviating vulnerabilities to various aspects of global change is a key task for a sustainability transition. Protection against specific risks must be embedded in efforts to increase overall resilience and innovative capacity. We study such management patterns by drawing on comparative regional studies and modelling efforts.
The three platforms support flexible task forces working on specific research questions. To connect our research to international research communities we use two interfaces: the European Climate Forum and the concept of a Geoscope (cf the GEOSCOPE project, page 44). The


Carlo C. Jaeger

former provides a network involving research institutes as well as stakeholders. The latter provides a vision of a sustainability transition unfolding through a strategy of learning by doing, gradually developing the worldwide monitoring capability required for this task.

Exemplary Research Tasks
The task force "Endogenous Growth" studies the effect of different investment policies on energy efficiency. A Model of Investment and Technological Development has been developed for this purpose. It turns out that a climate-friendly policy may be economically much more attractive than is often assumed.
The task force "Diffusion of Innovations" develops a simulation tool for the consumption side of the economy. We use it to study diffusion processes of innovative environmentally relevant products.
No comprehensive list of research tasks shall be attempted here, as they are meant to form a rich and fast-changing pattern of activities. For further information on research performed with the help of the Social Systems Department, see the PIK projects on prospects for European climate policy (EUROPA), on risks of changing ocean circulation (INTEGRATION), regional sustainability issues (BEST, AIM), water resources (GLOREM), political institutions for a sustainability transition (GLOBAL GOVERNANCE), and last not least on vulnerability (EVA).
Out of these tasks, we develop software modules that can be coupled for purposes of integrated assessments (cf PIAM). Each assessment, then, can be based on developing and combining relevant software modules according to frameworks defined within an ongoing stakeholder dialogue.

Integrated Systems Analysis

Co-Heads: Hans Joachim Schellnhuber, Yuri Svirezhev
Deputy Head: Gerhard Petschel-Held

Overview
The development of tools and methods within this department takes place within three groups on i) analysis, ii) integration and iii) modelling.

Analysis
Group leader: Hermann Held

This group seeks to develop methods and approaches for analysing characteristic features of coupled systems, particularly the Earth system. This comprises uncertainty analysis, by Bayesian or risk assessment methods (PRUNE project), multi-criteria decision-making analyses (e.g. GLOWA-Elbe project), or methodological issues of sustainability science and vulnerability theory. A particular focus is the switches and chokes within the Earth system (in co-operation with GAIM). Switches and chokes are defined as crucial constituents of the system, where small and relatively continuous changes in few parameters can induce rapid and abrupt changes in the whole system. Examples include the instability of the North Atlantic Deepwater Formation, the possible outburst of methane from the Siberian permafrost regions, or the imaginable collapse of the Amazonian rainforest. Critical events of that type may announce themselves by short- to medium-term signals. Based on this idea, work in the GRAIN project seeks to systemize these signals with regard to properties necessary to use them within an adaptive management strategy to prevent them. (All projects see page 27.)

Integration
Group leader: Matthias Lüdeke

This group develops methods to integrate disciplinary knowledge and models from different scientific fields or societal arenas and which is possibly valid on different spatial or temporal scales.
With respect to model integration, one can distinguish between methods for coupling stand-alone models (*modular approach*) and methods for developing reduced-form models for a particular purpose. The latter include spatiotemporal abstraction and strategic cycling of inductive and deductive model formulation. Spatiotemporal abstraction uses so-called Empirical Orthogonal Functions of a General Circulation Model in designing

H. J. Schellnhuber, Gerhard Petschel-Held

"climate-impact-response functions" which assess the impacts on aggregated areas, e.g. countries or continents. Though spatially explicit, the reduced-form model needs only the global mean temperature as an input. The impact components of PIK's present integrated assessment model (cf ICLIPS1.0 page 61) rely on this method. Knowledge integration from different disciplines is at the heart of the syndromes approach (SYNAPSE) which seeks to recognize basic patterns of (un)sustainable development through a portfolio of methods, ranging from GIS and fuzzy logic to qualitative modelling and case study integration. Other activities relate to the usage of possibility theory for integrated assessment.

Modelling
Group leader: Siegfried Franck

This group develops specific models of complex, coupled systems. Approaches include dynamic systems theory, e.g. neural networks, structural stability or multifractal analysis, as well as soft and set based modelling techniques, e.g. qualitative modelling or fuzzy logic.
Methods of dynamic systems analysis are helpful, for example, to get conceptual ideas about the ecological niche of a system. Within the TRIPEDES project the lifespan of the Earth as a habitable planet was assessed by these means to be about 1.4 billion years - much less than by pure geological methods. Qualitative differential equations can be used if we know only qualitative features of the relationships between variables (QUIS, SYNAPSE). More specific modelling efforts are now undertaken in the development of regional simulators (cf TOPIK 5 page 46), heading for comprehensive decision support models on a regional scale.

Data & Computation

Head: Rupert Klein
Deputy Heads: Karsten Kramer, Michael Flechsig

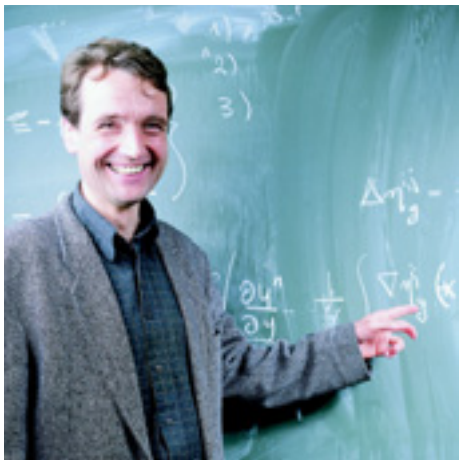
Overview
The D&C Department manages the institute's IT hardware and software infrastructure, and maintains its high technological standards. It is responsible for Scientific Data and Metadata Management, and it operates a Scientific Computing division.

Hardware and Software IT Infrastructure
Group leader: Karsten Kramer

The year 2000 was shaped by intense evaluations of bids for PIK's new high-performance parallel computer (cf page 100), by the selection of an outstanding offer by IBM Corporation and the installation of this machine in the newly built basement of PIK's new headquarters. The IT Infrastructure team guided the design and implementation of the new building's networking system and with remarkable skill and professionalism managed the transition into the new building in late 2001. This move involved about 35 offices and the entire computation, application, and data server infrastructure. During 2001 the new parallel computing environment has rapidly been accepted, and has already been operating at the expected average load since the spring of 2001. New procedures for the management of an increasing number of scientific workstation computers and the rapid deployment of applications have been introduced during 2001. The servers used in this area are characterized by a very high application flexibility and performance.

Scientific Data and Metadata Management
Group leader: Michael Flechsig

PIK's research depends heavily on the availability of a large variety of data, including long-time weather records, various computer simulation results, sociological data, and satellite observations. The Scientific Data Management group supports PIK scientists in handling these data through its xDat-System. This software flexibly integrates a variety of metadata bases with professional quality graphic user interfaces for database inquiries and the mapserver-based graphic representation of query results. Importantly, the system also allows direct access to stored data that have been identified in a metadata search. The system holds 400 metadata sets in the group's CERA-2 system and data from 50,00 measurement stations, amounting to 500 million data entries. During the last six months of the reporting period 30 regular users of the system produced 2,500 logins, and downloaded 200 million time series data entries from 3,000 stations.


Rupert Klein

Scientific Computing
Group leader: Rupert Klein

In 2001 the German climate research community adopted the German Weatherforecast Service's local area model (LM) as the basis for their future common regional climate model. An extension of LM, developed by the Climate System Department and D&C, serves as the base code. Having identified key numerical issues in the dynamical kernel of modern meteorological models, the group has developed a "balanced" numerical scheme which solves the full non-hydrostatic flow equations while still properly representing near-hydrostatic flows. Key ideas for this development stem from the group's unified mathematical representation of simplified meteorological models based on systematic multiple scales asymptotics.
The problem of flexible coupling of existing submodels is a central task in many PIK projects. The group contributes through its "Typed Data Transfer" library, which combines fast data transfer with platform-independent data descriptions using the XML standard.

Project Activities
The department leads the PIRSIQ, ReCSim, and SIMENV projects, and it is developing links to the Scientific Computing group at Freie Universität Berlin through a joint DFG-SFB proposal.

Research

The Evolution of PIK's Research Programme

The real research at PIK takes place not in the departments, but in interdisciplinary projects that have all the departmental know-how at their disposal. How did this come to pass?

From Core Projects to TOPIKs

Relatively early, the classic structure of research organized along departmental and mainly disciplinary lines was rejected at PIK. It soon became clear that transdisciplinary research cannot be organized in a traditional way. The present research structure was arrived at in three stages:

1) 1992-1994 stage of definitions
2) 1994-2000 Core Projects stage
3) from 2001 TOPIK stage

STAGE OF DEFINITIONS

Establishing the departments meant entering the stage of definitions. How was PIK's mission to be translated into a work programme? First of all, the mission had to be specified into concrete tasks, then the necessary know-how had to be identified. In addition, strategic partners would have to be found and contacted, since the challenge of PIK's mission could only be met in alliance with scientific partners.

CORE PROJECTS STAGE

Developing and implementing transdisciplinary Core Projects constituted an essential step in the transition from one-dimensional climate impact research to Earth System Analysis, since it is only within a larger and more complex scope that climate change impact may be investigated successfully. The dynamics of global change have to be taken into account, including both geobiophysical and socio-economic processes of the Earth system.

In August 1994, nine Core Projects dealing with essential issues of global change were selected from more than twenty proposals. As shown in the following list, the Core Projects investigated the Earth system from three different perspectives: global, regional, and sectoral, featuring important economic sectors:

Global perspective

POEM	Potsdam Earth System Modelling
ICLIPS	Integrated Assessment of Climate Protection Strategies
QUESTIONS	Qualitative Dynamics of Syndromes and Transition to Sustainability

Regional focus

EUROPA	European Network Activities
RAGTIME	Regional Assessment of Global Change Impacts Through Integrated Modelling in the Elbe River Basin
WAVES	Water Availability, Vulnerability of Ecosystems and Society in Northeast Brazil

Sectoral view

AGREC	Agro-economic Impacts of Climate Change on German Agriculture in the Context of Global Change
CHIEF	Global Change Impacts on European Forests
RESOURCE	Social Dimensions of Resource Use - Water Related Socio-economic Problems in the Mediterranean.

DEFINING NEW CENTRAL RESEARCH AREAS (TOPIKS)

The sum of experience accumulated in the roughly five years of successfully implementing the Core Projects led to a new concept for a transdisciplinary research programme that was to be even more strongly structured with regard to strategy and content. Incidentally, this was initiated by recommendations of PIK's Scientific Advisory Board in late 1998, in connection with PIK's evaluation by the Wissenschaftsrat (German Scientific Council) presented the following year. Evaluating PIK's work and progress as excellent, the Council in addition offered several suggestions and recommendations about how to proceed in the future.

Limiting research to those central areas of research in which PIK already excels, and focusing projects - including externally funded projects - on these areas, were among the main issues.

This resulted in the "TOPIK^{2k} Research Programme": Proposals were to be submitted internally and to be approved for a limited period of time; previous core projects were to be given one more year for their completion. During the transitional stage, in which internal contest of ideas was strongly encouraged, 51 proposals were handed in, leading to the implementation of 26 PIK projects (cf Table 1 on page 26).

The TOPIK Stage (from 2001 to date)

Essential characteristics of the new research programme are the following:

- definition of new thematic research areas called TOPIKs (cf Tables 2 and 3),

Table 1: Internal Contest of Ideas & Proposals

Date	Activity	Result
Jan. 2000	Internal Contest of Ideas	51
June 2000	Guided Call for Proposals	32
Jan. 2001	Start of Evaluated Projects	26

- departmental concentration on providing state-of-the-art methods and techniques (TOOLs, cf page 28)),
- a set of criteria for initiating, evaluating and concluding PIK projects within this framework,
- priority given to those externally funded projects that correspond thematically to PIK projects.

As a result, PIK projects are being evaluated internally every year. Guidelines have been developed for the approval of new projects (depending on resources being available after conclusion of other activities).

Table 2: TOPIK Research Areas

TOPIK 1 - Nonlinear Dynamics of the Ecosphere - e.g. ice age cycles or the effects of land vegetation and marine biota on climate
TOPIK 2 - Management of Singular Events, which are potentially disastrous - storms, droughts and floods or the risk of abrupt ocean circulation changes
TOPIK 3 - Socio-economic Causes of Global Change - studies of greenhouse gas emissions and options for environmental policy
TOPIK 4 - Emergence of a "Global Subject" in the form of information networks and institutions for global governance, such as the UN conventions on climate change and biodiversity
TOPIK 5 - Development of Regional Simulators - flexible modelling tools for regional environmental management, e.g. in the state of Brandenburg or north-eastern Brazil
TOPIK 6 - Sensitivity of Economic Sectors to climate change, e.g. the adaptability of viticulture, the vulnerability of European forestry and Moroccan agriculture
TOPIK 7 - 'PIKuliar' Scientific Culture at PIK - quality control, dealing with uncertainties and limitations in computer modelling

Guidelines for PIK projects

1) Research activities are evaluated according to
   - quality (scientific potential and results),
   - 'PIKuliarity' with respect to TOPIKs and TOOLS,
   - relevance of questions for stakeholders.
2) Accordingly, an activity
   - will become (part of) a regular PIK project,
   - will become a pilot project to check the scientific potential within one year,
   - will be upgraded to a regular or co-ordinating project,
   - will be continued where there is high yield, or otherwise stopped.
3) Generally, every externally funded activity must prove to be essentially in support of a PIK project.

Organization of Research in TOPIKs and PIK Projects

Corresponding to its main issues, every PIK project will belong to a specific TOPIK and will consist of different TOOL-oriented tasks, which may be funded either internally or externally. Tasks will be established and resources allocated for all projects in accordance with the table of TOPIKS and TOOLs (cf page 27).
A Steering Committee consisting of leading scientists from PIK (the heads of the departments plus director plus mentors specifically appointed for each TOPIK) has been set up to supervise the smooth functioning of the research programme and guarantee that guidelines are observed. The allocation of resources to the projects will be updated regularly.

A survey of the PIK projects assigned to the TOPIKs is given on the next page. There are three types of projects:
- regular projects (R),
- pilot projects (P), and
- co-ordinating projects (C), which include tasks which are linked to other projects.

When the total number of projects and resources allocated to them is looked at, the organizational structure of research activities will emerge as a matrix, with each scientist belonging to a department while at the same time engaged in one or several projects. Incidentally, this is how present industrial production has long been organized.

Table 3: TOPIKs and PIK projects

TOPIK 1	Nonlinear Dynamics of the Ecosphere	
QUEST	QUaternary Earth-system STability	C
BIS	Biosphere Interactions in the Earth System	R
EVITA	Exergy, Vegetation and Information: Thermodynamics Approach	R
CLIMBER-3	Earth System Model of Intermediate Complexity	R
TRIPEDES	Theoretical Research In Planetary Ecological Dynamical Earth Systems	R
TOPIK 2	Management of Singular Events	
EVA	Environmental Vulnerability Assessment	R
GRAIN	Guardrails and Indicators for Climate Protection	R
INTEGRATION	INTEGRAted Assessment of Changes in the Thermohaline CirculaTION	R
WADI	Management of Water-related Disasters	P
TOPIK 3	Socio-economic Causes of Global Change	
EUROPA	Modelling, Reflecting, Communicating Possible Futures of Europe in the Context of GC	C
BEAR	Biodiversity and Nature Protection Enhancement through Participatory Action Research	P
GLOREM	GLObal water Resources Modelling and Management	P
TOPIK 4	Emergence of a Global Subject	
PIAM	Potsdam Integrated Assessment Modules	C
GloGov	Global Governance - Policy Analysis for Earth System Management	P
GPP	The Geoscope Preparatory Project - Observing the Anthropocene for Sustainability Science	P
TOPIK 5	Regional Simulators	
BEST	Brandenburg Simulator of Environmental and Socioeconomic Transformations	R
ReCSim	Regional Climate Simulation Models	R
SYNAPSE	SYNdrome Assessment and Policy Strategy Evaluation	R
TOPIK 6	Sectoral Climate Sensitivity	
AIM	Agriculture emphasising Integrated Modelling (Focus: Morocco)	R
CLAWINE	Climate Adaptability of European Wine Industry	R
SAFE	Sensitivity and Adaptation of Forests in Europe under Global Change	R
TOPIK 7	PIKuliar Culture	
IMEQ	Integrating Models and Ensuring their Quality	C
PRUNE	Propagation of Uncertainties in Earth-System Models	R
PIRSIG	Pirsig's Quality	R
QUIS	Qualitative Intelligence Service	R
SIMENV	An Integrated Simulation Environment for Quality Assurance and Scenario Analyses	R

Catalogue of TOOLs

INTEGRATED SYSTEMS ANALYSIS

- Dynamical Systems Analysis
- Concepts of Integrated Modelling
- Soft and Set-based Modelling
- Assessing Uncertainty Implications
- Decision-Making Analysis

CLIMATE SYSTEM

- Meteorological Data Base
- Statistical Models
- Scenario Models
- Dynamical Regional Climate Models
- Ocean Models
- Climate System Models

GLOBAL CHANGE & NATURAL SYSTEMS

- Ecophysiological Simulation Models
- Hydrological Simulation Models
- Forest Dynamics Models
- Ecosystem Dynamics Model
- Data Retrieval Techniques

GLOBAL CHANGE & SOCIAL SYSTEMS

- Model of Endogenous Growth
- Multi-Sector Models
- Multi-Level Models
- Conceptual Analysis & Stakeholder Dialogue

DATA & COMPUTATION

- MODelling ENVironment (MODENV)
- Graphic Simulation Builder
- Parallelization Tools
- VISual ANAlysis (VISANA)
- Model Improvement Support
- Metadata Model and Interfaces

TOPIK 1 - Nonlinear Dynamics of the Ecosphere

The ecosphere is a complex dynamic system which encompasses the abiotic geosphere (mainly atmosphere, oceans, ice masses, the Earth interior) and the living world as composed of the terrestrial and marine biosphere; humankind is considered here as an external driver. This TOPIK explores the nonlinear behaviour of the ecosphere as well as its resilience to large-scale natural and anthropogenic perturbations. Examples of the latter are the continuing release of fossil fuel combustion products into the atmosphere, sub-continental changes in land cover, and variations in solar luminosity. Investigations include exploration of so-called switches and choke points in the ecosphere, i.e. regions in which slight external forcings/disturbances can trigger massive changes of climate and other vital Earth system elements.

QUEST
Quaternary Earth System Stability

Project speaker: Martin Claussen
PIK project members: Eva Bauer, Victor Brovkin, Reinhard Calov, Siegfried Franck, Andrey Ganopolski, Alexa Griesel, Matthias Hofmann, Anja Hünerbein, Claudia Kubatzki, Till Kuhlbrodt, Miguel Maqueda, Marisa Montoya, Vladimir Petoukhov, Stefan Rahmstorf, Yuri Szirezhev.
External project collaborators: Danish Centre for Earth System Science (Denmark), Dept. of Quaternary Geol./ Palaeoecology, Vrije Univ. Amsterdam (The Netherlands), Inst. d'Astronomie et de Géophy. Georges Lemaître: Univ. Catholique Louvain (Belgium), Inst. u. Museum f. Geol. u. Palöontologie, Univ. Tübingen (Germany), Laboratoire des Sciences du Climat et d' Environnement (France), Royal Netherlands Meteorological Institute (The Netherlands), KIHZ (Klima in histor. Zeiten) project partner (Germany).

Research Questions

Human interventions play a significant role in the Earth system. We are altering the character of the Earth at an increasing rate, and the present dynamic stability of the Earth system itself may be endangered. Therefore the QUEST project is designed to improve our understanding of the dynamics of the natural Earth system in its present geological epoch, the late Quaternary (the last several hundred thousand years). QUEST addresses the following questions:

(a) Can we identify the processes and feedbacks that have kept the natural Earth system within stable bounds during the last 400,000 years?

(b) Can we explain the abrupt climate changes found in records of the last glacial?

(c) How resilient is the natural Earth system in its present state to large-scale natural and anthropogenic perturbations?

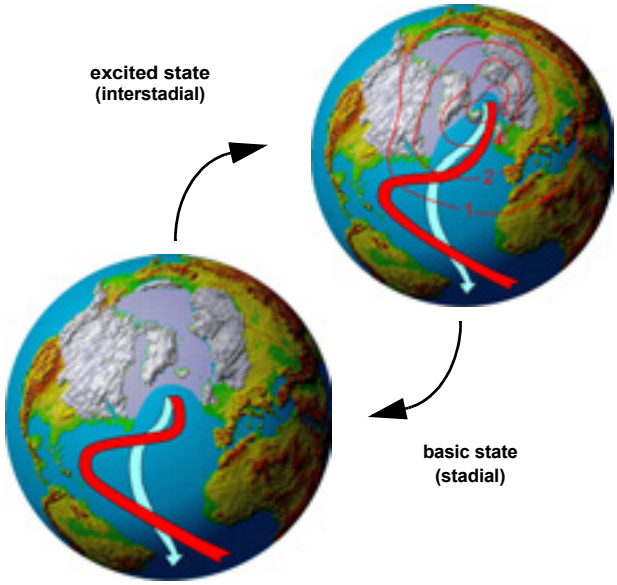


Fig. 1: Schematic of the two glacial climate states described in Ganopolski and Rahmstorf (Nature, 2001). Bottom: the stable "cold" or "stadial" mode. Top: the unstable "warm" or "interstadial" mode. Contours show the surface air temperature difference relative to the stable state. Ocean circulation is shown schematically, surface currents in red and deep currents in light blue. Continental ice sheets are based on the reconstruction of Peltier, prescribed in the simulations.

First Results

DANSGAARD OESCHGER CYCLES

Abrupt changes in climate, termed Dansgaard-Oeschger (D/O) and Heinrich (H) events, have punctuated the last glacial period (~100,000 - 10,000 years ago) but not the

Holocene (the past ~10,000 years). By using CLIMBER-2, Ganopolski and Rahmstorf (Nature, 2001) found that only one model of Atlantic Ocean circulation is stable in the glacial climate: a cold mode with deep water formation in the Atlantic Ocean south of Iceland. However, a 'warm' circulation mode similar to the present-day Atlantic Ocean is only marginally unstable, and temporary transitions to this warm mode can easily be triggered. This leads to abrupt warm events in the model which share many characteristics of the observed D/O events. For a large freshwater input (such as a large release of icebergs), the model's deep water formation is temporarily switched off, causing no strong cooling in Greenland but warming in Antarctica, as is observed for H events. This stability analysis provides an explanation of why glacial climate is much more variable than Holocene climate.

LARGE-SCALE LAND COVER CHANGE

Large-scale changes in land cover affect near-surface energy, moisture and momentum fluxes owing to changes in surface structure and the atmospheric CO_2 concentration caused by changes in biomass. For convenience, we call the former processes biogeophysical feedbacks, and the latter, biogeochemical feedbacks. Claussen et al. (Geophys. Rev. Lett., 2001) have quantified both the relative magnitude of these processes and their synergisms by using CLIMBER-2. Their sensitivity studies show that biogeochemical and biogeophysical processes triggered by large-scale land cover changes oppose each other on the global scale. Tropical deforestation tends to warm the planet because the increase in atmospheric CO_2, and hence atmospheric radiation, outweighs the biogeophysical effects. In mid and high northern latitudes, however, biogeophysical processes, mainly the snow-vegetation-albedo feedback through its synergism with the sea-ice-albedo feedback, win over biogeochemical processes, thereby eventually leading to a global cooling in the case of deforestation and to a global warming, in the case of afforestation.

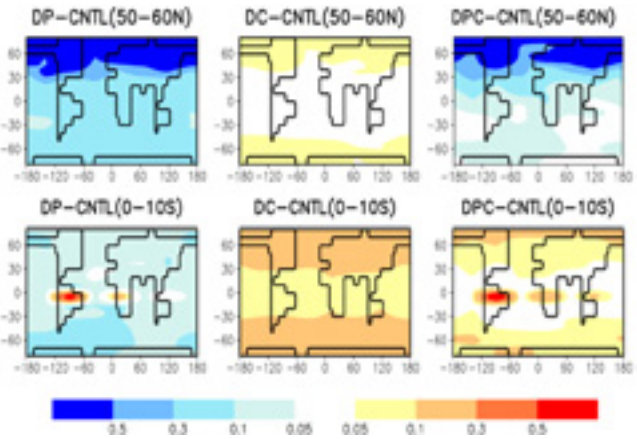


Fig. 2: Global pattern of temperature differences between three deforestation simulations (DP, DC, DPC) and the control climate (CNTL). In all deforestation simulations, deforestation is applied to boreal forests the zonal belt between 50°N and 60°N (labelled 50-60N) and to tropical forests in the belt between 0° and 10°S (0-10S). The control climate is computed for pre-industrial CO_2 concentration using a fully coupled atmosphere-ocean-vegetation model including terrestrial and oceanic carbon cycles. Vegetation is assumed to be in equilibrium with climate, hence no anthropogenic land cover change has been taken into account. The simulation DPC depicts the response of the fully coupled system. In DP, the carbon storages are fixed to values found in the control climate CNTL, i.e., DP reflects the effects of biogeophysical feedbacks only. In DC, near-surface energy, moisture and momentum fluxes are not directly affected by deforestation, but the carbon fluxes are allowed to change, i.e., DC shows the pure biogeochemical effect of deforestation.

This project is partly funded by BMBF, DFG, and the EU.

BIS
Biosphere Interactions in the Earth System

Project speaker: Stephen Sitch
PIK project members: Franz Badeck, Werner von Bloh, Alberte Bondeau, Victor Brovkin, Wolfgang Cramer, Dieter Gerten, Wolfgang Lucht, Tanja Rixecker, Sibyll Schaphoff, Birgit Schröder, Yuri Svirezhev, Kirsten Thonicke, Irina Venevskaia, Sergey Venevsky, Sönke Zähle.
External project collaborators: Centre for Geobiosphere Studies, Lund University (Sweden), Max Planck Institute for Biogeochemistry (Germany), Climate and Environmental Physics (Switzerland), Max Planck Institute for Meteorology (Germany), Laboratoire des Sciences du Climat et d' Environnement (France), Centre for Remote Sensing and Dept. of Geography, Boston University (USA), Dept. of Geography and Dept. of Geomatic Engineering, University College London (UK), Dept. of Geography, University of Jena (Germany).

Goal

To study the role of the land biosphere as a provider of the human environment and services and as part of the coupled physical and biogeochemical Earth system, on the time-scale of historic and future human intervention, i.e. years to a few centuries.

Research Questions

In this project, we address the following questions:
(a) What is the current and future structure and function of the land biosphere as a provider of the human environment and services?
(b) What is the current and future role of the land biosphere as part of the coupled Earth system on the ("human") time-scale of years to a few centuries?

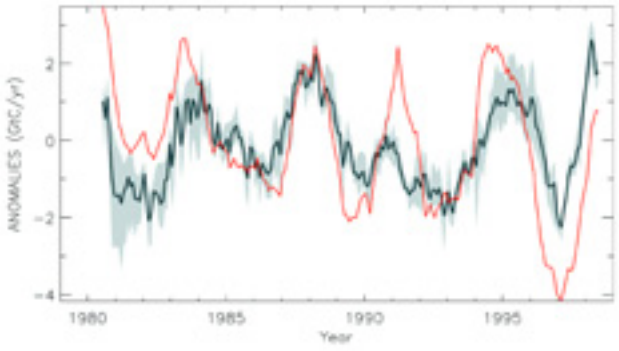


Fig. 3: Interannual Terrestrial carbon exchange anomalies (from the 1980-98 mean) using the bottom-up LPJ-DGVM approach (red), compared against top-down atmospheric inversion. Mean inversion is in black (Bousquet, Peylin, LSCE), the range of 20 inversions (grey).

Tools and development

The Lund-Potsdam-Jena Dynamic Global Vegetation Model (LPJ-DGVM) is one of the world's leading models of the global biospheric carbon cycle and of vegetation dynamics. Continued development of key components of the model, their validation with observed ecosystem data on several scales, and the study of the past and future of the global carbon cycle are the current focus of PIK's work using LPJ. E.g. inclusion of permafrost, a key influence on ecology in the boreal regions, into LPJ-DGVM led to a considerable increase in model performance. LPJ-DGVM representation of the hydrological cycle has been improved and successfully validated against seasonal, local- to global-scale data.

First Results

RECENT TERRESTRIAL CO_2 EXCHANGE

LPJ-DGVM seasonal carbon exchange has been compared over regions with those derived from atmospheric inversions. The importance of such work is first to locate the main source-sink regions, important for environmental policy (e.g. Kyoto debate), and second to identify, understand and model the underlying processes sensitive to current climatic variability, giving an insight into possible future environmental changes.

GREENING OF THE NORTHERN LATITUDES

Using time series of climate data, the LPJ-DGVM models an advance of spring in the last two decades and an increase of vegetation abundance in the global boreal zone. This is in excellent agreement with the observed trends found independently in satellite data. The model also reproduces the impact of atmospheric aerosols from the Mount Pinatubo volcanic eruption in 1991 on vegetation productivity and phenology in northern latitudes.

MODELLING OF REGIONAL FIRE PATTERNS

LPJ-DGVM simulates fire disturbance taking into account multiple natural and anthropogenic causes and processes such as fire spread. A regional version of this fire model adapted to the Iberian Peninsula, successfully reproduces both the number of fires occurring and the area burnt, factors that co-determine local ecosystems.

This project is partly funded by BMBF, DFG, and the EU.

EVITA
Exergy, Vegetation and Information: Thermodynamics Approach

Project speaker: Yuri Svireshev
PIK project members: W. Steinborn
External project collaborators: Kiel Ecology Centre

Goal

EVITA is a sub-project of BIS. EVITA aims to describe the state of vegetation by applying the concept of thermodynamics, in particular so-called exergy, to the observed spectra of the radiation balance.

Research Questions

- How do we define the *exergy* (one of the main thermodynamic characteristics of open systems far from equilibrium) of solar radiation interacting with vegetation?
- How do we use the exergy as an integrated index of the state and structure of vegetation under seasonal and annual variations of climate?
- How do we design experiments and observations in order to test our *minimax* hypothesis?
- What is the physical (biological) basis of the *minimax* principle?
- Can we use satellite monitoring data to calculate the exergy?

TRIPEDES
Theoretical Research in Planetary Ecological Dynamical Earth Systems

Project speaker: Siegfried Franck
PIK project members: Werner von Bloh, Christine Bounama, Pavel Egorov, Antony Z. Owinoh, Hans Joachim Schellnhuber, Yuri Svirezhev, Sergey Venevski.
External project collaborators: Konrad J. Kossacki, Warsaw University (Poland), Timothy Lenton, Centre for Ecology and Hydrology (UK), Georg A. Zavarzin (Russian Academy of Sciences).

Goal and Principal Question

The aim of the TRIPEDES project is to develop and to analyse Earth system models for long time scales under changing internal and external forcing (Figure 4). TRIPEDES addresses the principal question: What are the limits to self-regulation in the process of co-evolution of the biosphere and the other components of the ecosphere?

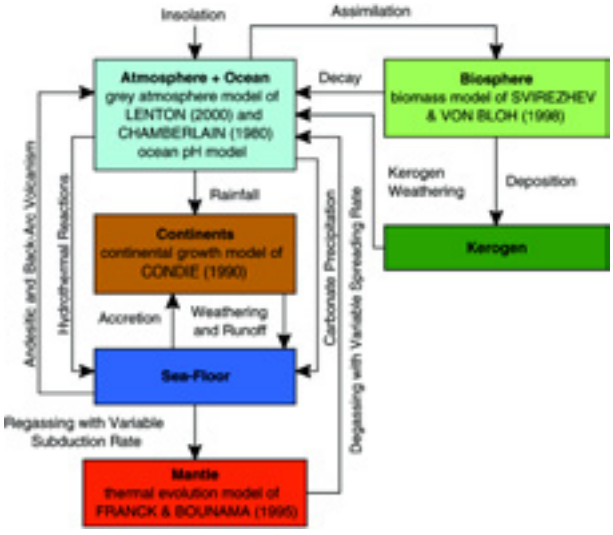


Fig. 4: Six-box model of the global carbon and water cycle. Special attention is given to the parameterization of the weathering process.

Historic Minimum of Surface Temperature

As shown in Figure 5, the present surface temperature of the Earth system is just at a point in its long-term evolution where external forcing of increasing insolation takes over the main influence from geodynamics. The present geological epoch is not only characterized by the lowest global mean surface temperature but also by remarkable biosphere cooling.

Habitable Zones

A simplified version of our integrated systems approach can be used to calculate the habitable zone (HZ) as the band of orbits around a central star where photosynthetic-based life can exist on an Earth-like planet (Figure 6).

Extrasolar Habitable Planets

The combination of our results for extrasolar HZs with new results for the formation rate of Earth-like planets allows us to determine the number of habitable planets in the Milky Way over cosmological time scales (Figure 7)

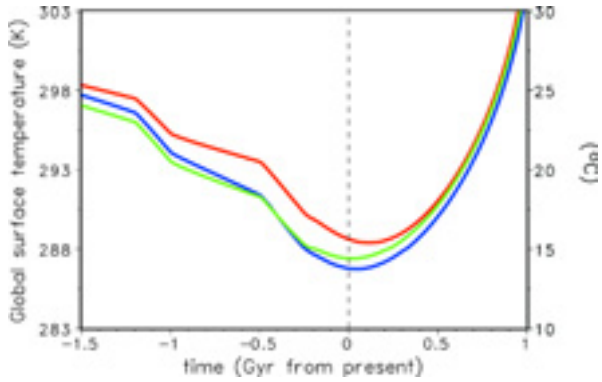


Fig. 5: Global surface temperature evolution. The red line denotes model results without biosphere, the blue line model results with biosphere but without kerogen, and the green one the full model.

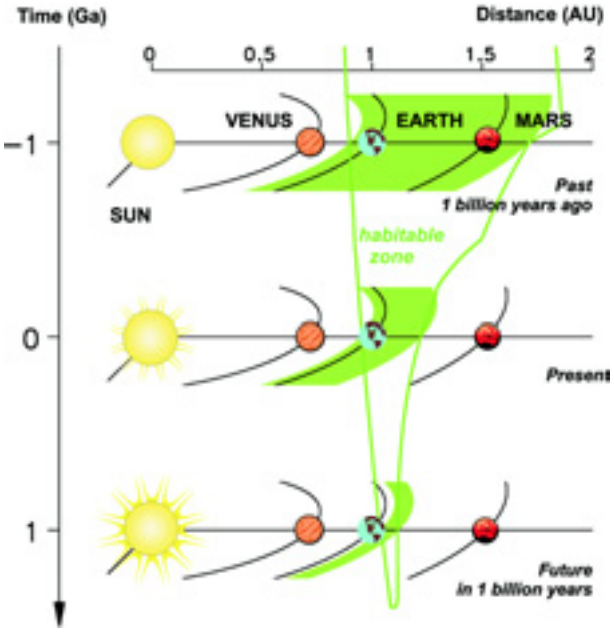


Fig. 6: The evolution of the solar system HZ.

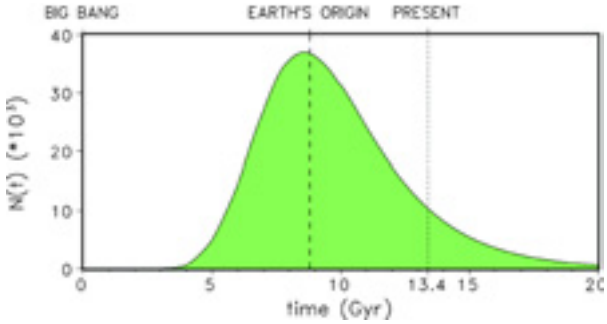


Fig. 7: Number of habitable planets N(t) in the Milky Way over cosmological time with a maximum at the time of Earth's origin.

This project is funded by HSPN and DFG.

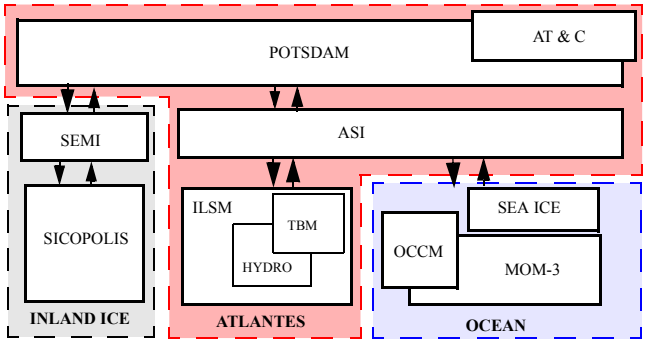
CLIMBER-3
Earth System Model of Intermediate Complexity

Project speaker: Andrey Ganopolski
PIK project members: Victor Brovkin, Reinhard Calov, Martin Claussen, Sergej Grafutko, Matthias Hofmann, Claudia Kubatzki, Miguel Morales Maqueda, Marisa Montoya, Vladimir Petoukhov, Stefan Rahmstorf, Stephen Sitch, Sergey Venevsky.
External project collaborators: Institute of Atmospheric Physics (Moscow).

Motivation

In order to understand the nonlinear dynamics of the Earth system, its past and future evolution, its stability and sensitivity, a new class of computer models is required - Earth System Models. The goal of the project is to develop an Earth System Model of the new generation: CLIMBER-3.

Compared to the CLIMBER-2 model (cf page 63) currently used at PIK for Earth system studies, the new model will be superior in the number of considered processes, degree of realism and spatial resolution. CLIMBER-3 will be used for millennial-scale simulations planned in QUEST (cf page 29) and other related projects.



ATLANTES (ATmosphere, LANd, Terrestrial ecosphere and Surface interface)
POTSDAM (POTsdam Statistical-Dynamical Atmosphere Model)
AT&C (Atmospheric Transport and Chemistry model
ASI (Atmosphere-Surface Interface) worker

ILSM (Integrated Land Surface Model)
TBM (Terrestrial Biosphere Model)

OCEAN
MOM-3 (Modular Ocean Model)
OCCM (Oceanic Carbon Cycle model)
SEA ICE model

INLAND ICE
SEMI (Surface Energy and Mass balance Integrator)
SICOPOLIS (SImulation COde for POLythermal Ice Sheets)

Fig. 8: Principal scheme and main components of the CLIMBER-3 model. Small boxes correspond to individual modules, coloured boxes represent macromodules.

Model Structure and Design

The design of CLIMBER-3 is based on the experience gained in the development and application of CLIMBER-2, as well as the experience of several contributing teams in different fields of the Earth sciences. Although the new model will employ more sophisticated components than CLIMBER-2, it still belongs to the class of Earth system models of intermediate complexity (EMICs). CLIMBER-3 is designed as a scientifically based, internally consistent, and flexible model. The essential features required of the model design are:

- Explicit description of the most important processes and feedbacks.
- Conservation of energy and other substances in the Earth system.
- Direct coupling of the modules without using flux correction and explicit empirical information.

This project is funded partly by DFG, the EU and the McDonnell Foundation.

TOPIK 2 - Management of Singular Events

This TOPIK is concerned with extreme events, such as severe storms, floods or droughts, and with abrupt changes in the Earth system, such as the break-up of a large ice sheet. Meteorite impacts or major volcanic eruptions are further examples of singular events. They are characterized by a major impact or change occurring over a relatively short time, in contrast to insidious trends. Singular events can have a particularly damaging effect on natural and socio-economic systems. This TOPIK aims at characterizing singular events with respect to their mechanisms and potential consequences, at defining and assessing associated risks, and at developing mitigation and adaptation strategies.

GRAIN
Guardrails and Indicators for Climate Protection

Project speaker: Elmar Kriegler
PIK project members: Nico Bauer, Ottmar Edenhofer, Hermann Held, Thomas Kleinen, Elmar Kriegler, Gerhard Petschel-Held.
External project collaborators: Thomas Bruckner, (Technical University Berlin).

Motivation

The GRAIN project addresses the issue of robust climate protection strategies under uncertainty and nonlinearity. How can we account for the large uncertainty about the complex human-environment system? How can we detect possible indicators of nonlinear thresholds? Which structural changes of the socio-economic system are needed to address climate change?

Decision under Uncertainty and Imprecision

The objective uncertainty about climate change can in many cases not be quantified by precise probabilities. Hence we are investigating theories which allow us to capture not only uncertainty, but also imprecision. We are particularly interested in the implications for decision-making; with imprecise information the decision-maker can adopt a range of equally rational attitudes ranging from a pessimist to an optimist perspective. Preliminary results show that the decision-making model behaves rather pessimistically, if there exists an intolerable domain of future developments which has to be strictly avoided.

Indicators of Critical Thresholds

Nonlinear effects, such as bifurcations and thresholds, can be very important for the behaviour of the climate system. As a prominent example we consider the North Atlantic thermohaline circulation (THC). The THC

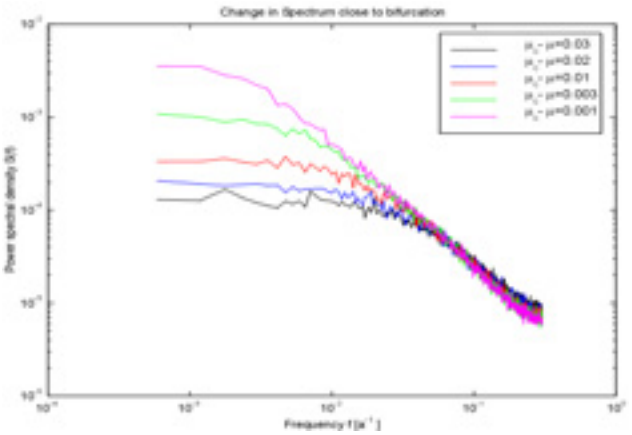


Fig. 1: The "typical" red spectrum becomes much “redder” close to the bifurcation and may even change to an algebraic relationship.

breaks down if the freshwater input into the North Atlantic basin reaches a critical value. This behaviour has been observed both in conceptual models and GCMs.

We are investigating the simplest model of the THC, the 2-box Stommel model. The model undergoes a bifurcation at a critical freshwater flux μ_c. We have added a stochastic freshwater flux with mean value μ. Figure 1 shows that the power spectral density of the circulation strength changes markedly when the system approaches the bifurcation. We are investigating whether this method can be applied to other systems and be used as an indicator for critical thresholds.

Technology and Investment

The energy system today is based on fossil fuels. To limit emissions we have three strategic options:
1) Efficiency: increasing the energy efficiency,
2) Substitution: conversion to renewable energy,
3) Sufficiency: stabilizing consumption.

We have built a module of investment and technological development (MIND) that relates technological change to investment in four ways: investment in fossil and renewable energy technologies, and investment in improving energy and labour productivity.

MIND indicates that we could limit climate change by increasing energy efficiency in the short term and substituting the energy system in the long run without excessive welfare losses. We will extend the model in terms of specific technologies and investment aspects.

This project is partly funded by the Volkswagen Foundation.

INTEGRATION
Integrated Assessment of Changes in the Thermohaline Circulation

Project speakers: Stefan Rahmstorf, Carlo C. Jaeger
PIK project members: Franz Badeck, Gerd Bürger, Wolfgang Cramer, Stefan Pohl, Frank Wechsung, Kirsten Zickfeld.
External collaborators: Alfred-Wegener Institut f. Polar- und Meeresforschung (Germany), Institute of Marine Research (Norway), ZMK, Univ. Hamburg (Germany).

Motivation
The risk of serious ocean circulation changes due to anthropogenic global warming has received much public attention in recent years, yet little scientific information exists on the likelihood or the possible consequences of such an event. A complete shutdown of the Atlantic thermohaline circulation would represent a major change in the heat budget of the Northern Hemisphere, as this circulation is believed to warm North-Western Europe by 5-10 °C in the present climate.

The INTEGRATION project aims to analyse uncertainties in projecting ocean circulation changes, as well as to make a first assessment of likely impacts on marine and terrestrial ecosystems and society.

Main Research Goals
The objective of this project is to investigate the risks and impacts of two types of ocean circulation change:

- A substantial weakening of the North Atlantic Current and deep convection by 20-50%, as simulated by most climate models for the coming 50-100 years.
- A (practically irreversible) complete shutdown of convection and the Atlantic thermohaline circulation, as simulated in some "pessimistic" model scenarios for the 22nd century.

Climate Scenarios
Identifying threshold values for a nonlinear change of the thermohaline circulation requires the investigation of a multitude of different multi-century radiative forcing scenarios accompanied by sensitivity studies with respect to major uncertain model parameters. Simulations both with CLIMBER-2 and CLIMBER-3 (cf page 33) will be used for this purpose. Statistical downscaling techniques are applied to define scenarios that are useful for impact assessments.

Impacts on Marine Ecosystems
The North Atlantic is the only high-latitude ocean which experiences an extensive spring diatom bloom which, in its eastern part, is followed by equally extensive blooms of coccolithophorids later in the season. A circulation reduction or collapse may cause alterations in the mixed layer depth and nutrient supply of the ocean and may change the structure of functional groups, and could ultimately lead to a considerable change in the CO_2 uptake by the ocean.

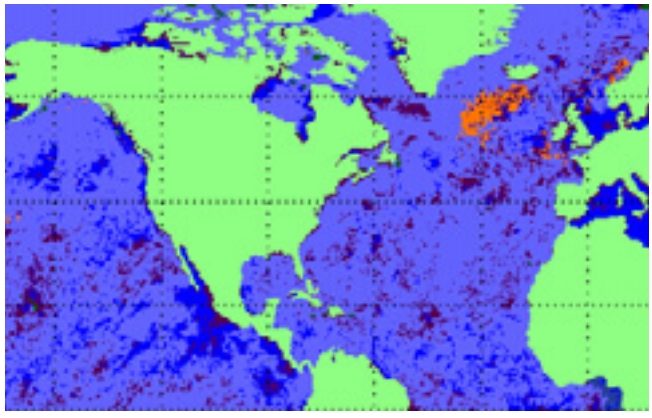


Fig. 2: Satellite-derived image of a plankton bloom in the North Atlantic. The high productivity of this region could be a consequence of the thermohaline circulation.

Large fish populations are adapted to large-scale features of the ocean circulation. Changes in the circulation pattern are likely to affect fish recruitment and population size.
To study these marine ecosystem impacts, models of the distribution of plankton and fish will be developed and applied in the project.

Impacts on Land Ecosystems and Agriculture
The sensitivity of European crop production to a climatic cooling will be explored for a set of major European crops. The investigation will focus on climate-related changes in crop suitability and yield.

Land ecosystems play an important role as providers of food and fibre, for recreation, as part of the hydrological cycle and for biodiversity. Rapid changes of land ecosystems triggered, for example, by rapid nonlinear climate changes could be detrimental for many ecosystem services. With the Lund-Potsdam-Jena DGVM (DGVM = Dynamic Global Vegetation Model) we will simulate the ecosystem structure and its dynamics at continental scale as well as the carbon- and water balance in the ecosystem.

Socio-economic Impacts
We use the integrated assessment model FUND to investigate the possible consequences of a major ocean circulation change. The model assesses monetary damages and simulates welfare changes, e.g., in the forestry, agricultural and water sectors due to ecosystem change.

The project will also determine guardrails for CO_2 emissions (safe corridors) that minimize the risk of major ocean circulation changes.

This project is partly funded by the German Ministry of Science.

WADI
Management of Water Related Disasters

Project speaker: Lucas Menzel
PIK project members: Friedrich-Wilhelm Gerstengarbe, Torsten Grothmann, Holger Hoff, Maarten Krol, Zbigniew Kundzewicz, Martin Welp, Peter C. Werner.
External collaborators: Humboldt University Berlin and the Universities of Potsdam, Marburg and Heidelberg (Germany).

Motivation
There are a number of indications of mankind's growing vulnerability to water-related disasters. The increasing exposure of a growing population settled in areas at risk, human-induced environmental degradation, loss of traditional adaptation strategies and changing lifestyles contribute to a steep rise in mortality and economic damage as a consequence of floods and droughts. Additionally, increasing climatic variability and climate change are expected to affect the frequency and severity of those events.

Scientific Concept
The guiding principle within WADI is the integration of selected branches of research into an inter-disciplinary approach. A first step towards this aim is the definition of common interfaces for data exchange and model coupling. The specific approaches from the individual disciplines will then be combined in an integrated model. This model includes a description of inter-relationships and feedbacks between relevant natural processes and human activities in view of extreme, water-related events. It serves as a tool for risk assessment before, during and after the occurrence of floods and droughts. The overall aim of the WADI project is the application of the integrated model as an expert system in support of risk management strategies in affected countries, jointly with international organizations.

Fig. 3: In December 1999, heavy rainstorms with debris flows and flash floods along Venezuela's coastal areas caused severe property destruction, and resulted in a death toll estimated at 19,000 people.

The implementation of this inter-disciplinary research approach includes the following disciplines: integration and risk analysis, climatology, hydrology and water resources management, ecology, agriculture, medicine, social sciences, economics and remote sensing. The WADI core group consists of a supra-regional research network of German competence centres, including PIK, the Humboldt University Berlin and the Universities of Potsdam, Marburg and Heidelberg.

Additional international partners, i.e. scientists and stakeholders from the case study regions, contribute to WADI through comprehensive assessments of local adaptation and mitigation practices to floods and droughts and the further development and adaptation of scientific methods for the integrated model. One of the case study regions will be in southern Africa, where both droughts and floods occur.

EVA
Environmental Vulnerability Assessment

Project speakers: Wolfgang Cramer, Richard Klein.
Project scientists: Lilibeth Acosta-Michlik, Anne de la Vega-Leinert, Thies Eggers, Markus Erhard, Hans-Martin Füssel, Torsten Grothmann, Jochen Hinkel, Fritz Reusswig, Dagmar Schröter, Frank Thomalla, Söhnke Zaehle.

The EVA Research Questions

The research questions addressed within EVA are those that stakeholders have indicated and will indicate as important. EVA takes a stakeholder approach to its work because it recognizes that science, policymakers, the private sector and the public need to work together to reduce vulnerability to global change.

Each project within EVA has its own set of research questions but the overarching research questions for EVA are as follows:

What will be the combined effects of global change on terrestrial and coastal ecosystems and the functions and services they provide to society?

- How will these changes affect social and economic processes in society and how will they interact with other ongoing developments?
- What capacity do ecosystems and society have to adapt to global change and what opportunities and constraints are there to increase this capacity?

The EVA Projects

EVA approaches these three research questions in the following collaborative, externally funded projects:

- *Advanced Terrestrial Ecosystem Analysis and Modelling (ATEAM)* - Assesses the vulnerability of European ecosystem services to environmental change, using numerical models of ecosystems, multiple scenarios of changing environmental forcings and explicit involvement of stakeholders.
- *Dynamic and Interactive Assessment of National, Regional and Global Vulnerability of Coastal Zones to Climate Change and Sea-Level Rise (DINAS-COAST)* - Develops a CD-Rom based model that allows users to analyse coastal vulnerability to climate change at various scales for a range of greenhouse-gas emission, sea-level rise, adaptation and other scenarios.
- *Socio-Economic Vulnerability to River Flood Events (SEVERE)* - Uses risk assessment and management techniques and takes a stakeholder approach to iden-

Welfare of human society depends on ecosystem services such as drought prevention and promotion of slope stability.

tify differential flood risks and risk perceptions in the lower Rhine Valley in Germany.

- *Security Diagrams: Improving a New Approach to Assessing the Risk of Extreme Climate Events on Society* - Develops a quantitative approach to evaluate the capacity of countries to cope with water crises. Includes a case study in India.
- *Climate Change Adaptation Strategies for Human Health (cCASHh)* - Identifies and evaluates climate change adaptation options for human health in Europe with regard to thermal stress, extreme weather events, vector-borne diseases and food- and water-borne diseases.
- *Indicators for Recent and Future Impacts of Anthropogenic Climate Change in Europe (WAKE)* - Defines indicators to characterize climate change and its impacts in the recent past, the present and the near future in Europe and its regions.

TOPIK 3 - Socio-economic Causes of Global Change

In this TOPIK, we study the human causes of global change. Global change results from the modern, planetary-scale interaction of the anthroposphere and the ecosphere. On the human side, proximate causes are visible, e.g., in the commercial energy system, in world-wide urban dynamics, in the transportation and traffic sector, and in the role of globalized capital and resource markets for overall economic development. Indirect causes may be found in institutional arrangements, in value orientations, and in patterns of knowledge. At present, global socio-economic dynamics are constrained to paths which are not sustainable. We investigate characteristics and causes of these constraints, possibilities for their future evolution, and opportunities to achieve a transition to sustainability.

EUROPA

Project speaker: Ottmar Edenhofer
PIK project members: Maren Ewald, Katrin Gerlinger, Armin Haas, Carlo Jaeger, Marian Leimbach, Ina Meyer, Fritz Reusswig, Detlef Sprinz, Martin Welp.

A Leading Role for Europe?
The EUROPA project addresses the main question: How can Europe take a leading role in global climate protection strategies, acting in an environmentally responsible and in an economically beneficial way at the same time? The European Union is already a key player in international climate policies, and has taken action within the UNFCCC framework. But in order to have a significant impact on the global climate, exclusively European protection strategies may not be effective. Thus it is necessary to think about allies in other regions and/or about the diffusion of effective European measures around the world. Usually, climate protection is seen as a burden, producing additional costs and hampering the economy. The project tries to take an innovation-oriented perspective, looking at economies from a dynamic perspective. It will be embedded in a continuous stakeholder dialogue (cf ECF on page 106) in order to be part of a mutual knowledge transfer to decision-makers in the European Union.

The Research Questions
Three research questions are focal points:
1) Which economic sectors and consumer lifestyle patterns can be identified as main drivers of CO_2 emissions?
2) Which socio-technical innovations and related diffusion processes can engender a substantial reduction of CO_2 emissions?
3) Can Europe play a pioneering role in bringing about such innovations?

These questions are answered by using a wide range of methodological tools from different social sciences. Economic modelling will play a key role, and it has to endogenize technological progress both in the fossil and the renewable energy sectors. Furthermore political and institutional factors that affect the innovative capacity of Europe and the rest of the world are included. Finally, the influence of lifestyles and lifestyle changes as well as their diffusion over the globe are part of the project. EUROPA follows a modelling philosophy that does not aim at one super-model but is based on a modular approach.

First Results
First results show that mitigation costs are exaggerated in conventional integrated assessment models because these models neglect technological change. Once technical change is taken into account, the standard trade-off between economy and ecology may vanish and give way to a world where economic prosperity and ecological stability are no longer contradictory. In particular, a transition of the energy system may even be economically superior to sticking to the present fossil base. If suitably managed, research and development dynamics may bring about this transition without energy prices rising.

In our stakeholder dialogue, it turned out that various business and industry players are well aware of such possibilities and are interested in using them profitably. They develop strategies for their future business and try to anticipate and influence the strategic measures taken by their business partners and competitors and by policy- makers.

A commonly held view is that environmental impacts of human economic activity follow an environmental Kus-

nets curve: with ongoing economic development the environmental impacts and damage increase in a first phase, peak at some time and decline thereafter due to gains in economic efficiency and an increased environmental awareness of consumers. This idea crucially depends on the evolution of lifestyles and the consumption patterns induced by them. Therefore, we consider the study of lifestyles an important step towards answering the research questions of the EUROPA project. To perform such an assessment, we plan, e.g., to model the dynamics of car passenger transport and car use induced by different scenarios of lifestyle patterns.

GLOREM
Global Water Resource Modelling and Managing

Project speaker: Uwe Haberlandt
PIK project members: Thomas Beckmann, Axel Bronstert, Andreas Güntner, Valentina Krysanova, Zbigniew Kundzewicz, Matthias Lüdeke, Lucas Menzel, Stephen Sitch, Martin Welp.

Population growth, the overall increase in water consumption, and climate change are some of the driving forces causing water stress. For these and other reasons, fresh water is becoming an ever-more limited, and sometimes even contested, global resource. In many climate models and climate impact studies the assessment of freshwater resources and their management by social actors and systems is an underdeveloped issue, however. The GLOREM pilot project was launched in order to close this gap.

It had three main purposes: (a) to review approaches for global freshwater resources modelling and management; (b) to define research requirements in the TOPIK framework related to global water; and (c) to develop a scientific concept and a specific proposal for a regular water project at PIK.

Sub-groups reviewed global water availability models, studies on global water use and different types of criticality measures in global water assessments. One sub-group systematized management options related to global water problems and further elaborated the link between the Syndrome approach (cf SYNAPSE in this report) and water management. The project identified crucial limitations and missing components in current modelling efforts, and the group suggested that future water-related research at PIK should in the first step focus on water for agriculture and the food trade, and the implications of land cover changes and human use on water resources.

BEAR
Biodiversitiy and Nature Protection Enhancement through Participatory Action Research

Project speaker: Susanne Stoll-Kleemann
PIK project members: Fritz Reusswig, Julia Schwarzkopf, Martin Welp, Volker Wenzel, Birgit Soete.

The biosphere is not only a bio-geophysical reality, it is a social reality as well. The BEAR project treats the biosphere and its protection from a social science viewpoint, following two major lines of research. First, we investigated nature conservation areas in Germany and South Africa as social settings, looking for organization-related and communication problems in protection strategies.
In a second line, we focused upon "nature" and "nature conservation" as social constructs and asked how these constructs are linked to different social groups within Germany. The lifestyle concept, common in sociology and marketing research, was used here in order to build a typology of eight lifestyle groups and to identify their different preferred views of nature and nature protection. The lifestyle research is funded by the German Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN). We discovered a communication gap between conservationists and the general public. Conservationists - often natural scientists by training - tend to focus upon scientific and moral arguments when it comes to justifying the necessity for nature conservation, whereas society prefers a (cultural) identity and sustainable use point of view.

TOPIK 4 - Emergence of a Global Subject

The management of global change requires a subtle interplay between the most diverse political strategies and millions of "rational" everyday decisions. Out of this arises, through worldwide communication, something like a planetary will, which may be symbolized as a fictitious Global Subject. The interactions between very different actors play a decisive role in this, since, e.g., the effectiveness of climate protection programmes depends to a critical degree on the economic planning of politicians, multinational concerns and protagonists of the financial markets. The projects in this TOPIK investigate how the Global Subject may develop in order to increase, i.a., the efficiency of global environmental management. The tremendous progress made in all globalizing technologies such as the internet and air traffic will be the primary focus of attention here, but also of the growing number of global environmental institutions and organizations as well as the intensified dialogue between scientific communities and decision-makers.

Fig. 1: Cartoon of the Global Subject as a trinity of scientific assessment, global governance and observation. Modern communication technologies, scientific understanding, and global co-operation might be seen as the neural system of the Global Subject.

PIAM
Potsdam Integrated Assessment Modules

Project speaker: Carlo C. Jaeger
PIK project members: Ottmar Edenhofer, Rupert Klein, Gerhard Petschel-Held.

Overview
The third generation of integrated assessments has to be organized as a modular process. Within this structure, modules are developed as separate units to be coupled in accordance with the questions raised by decision-makers. With well-defined interfaces between modules, a fruitful competition between different modules becomes possible. This is more productive than competition between monolithic integrated assessment models and it promotes co-operation between different disciplines and different institutions.

The Modular Approach
To assess problems of global environmental management, often rather complicated integrated assessment models are set up. Their features make them difficult to comprehend, thus limiting both their potential use by stakeholders and their further improvement by scientists. To tackle this problem, PIAM aims at integrating comprehensible modules in a comprehensible way.

PIAM has the potential to integrate different modelling activities emerging in different PIK projects. To operationalize its approach, PIAM has to tackle questions of interface support, modularization and coupling of existing modules. To accomplish its task, PIAM provides a software platform with the following characteristics:

Modularity

The different modules are exchangeable with different versions coming from different sources. The modules can be written in different programming languages. Figure 2 shows an example based on different versions for modelling the climate system, the biosphere, and the global economy.

Standardization of Interfaces

In order to integrate different modules, the interfaces between them must be well-defined. Every research group must comply to these interface definitions, but is free to design the internal structure of the module according to their specific modelling approach.

Mode of Interaction

The modules are integrated by an object-oriented platform which can operate both in simulation mode and in optimization mode.

Exploring Uncertainty

The PIAM concept allows us to explore uncertainties about the structure of its individual modules and helps us to assess parametric uncertainties in a standardized way.

Some of the modules are based on existing programs modified so as to fit the modular structure. Other, new modules are developed in cooperation with various PIK projects. As a rule, PIAM puts a strong emphasis on decision-making in the face of climatic risks.

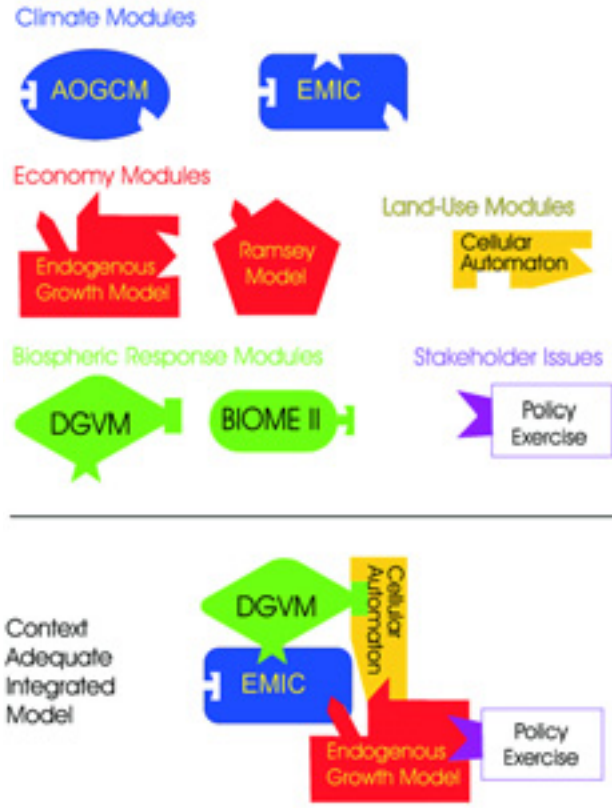


Fig. 2: Modularity represents the basic strategy of PIAM. By implementing an interface standard, it becomes possible to integrate modules for a specific context or policy question.

GloGov
Global Governance

Project speaker: Frank Biermann
PIK project members: Bernd Siebenhüner (deputy project leader), Aarti Gupta (visiting fellow, 2000/1), Lilibeth Acosta-Michlik, Torsten Grothmann, Richard Klein, Gerhard Petschel-Held.
External collaborators: Columbia University's Center for Science, Policy and Outcomes; Environmental Policy Research Unit of Free University of Berlin (Germany); Institute for Economic Research; Joint Global Change Research Institute of the Pacific, Northwest National Laboratory and the University of Maryland; Harrison Program on the Future Global Agenda of the University of Maryland at College Park; Harvard University; Oldenburg University.

Research Tasks

The Global Governance Project analyses international institutions, organizations, actors and political processes that influence the emerging system of global environmental governance. The focus is on questions of institutional and organizational effectiveness, learning processes in environmental policy, inter-linkages, and equity. Analytical tools are qualitative social science methods, like structured case studies, as well as legal analysis.

Subproject MANUS - "Managers of Global Change: Effectiveness and Learning of International Environmental Organizations"

Recent scholarship has questioned the adequacy of the organizational framework for global environmental governance. Some authors call for far-reaching reforms, including the establishment of a "world environment organization", while others argue in favour of an incremental improvement of decentralised systems. Little research, however, has yet been directed to an in-depth analysis of international environmental organizations. How effective are international environmental organizations, after all, and in what ways can they improve their effectiveness and "learn"? How can mathematical modelling techniques such as qualitative modelling help in understanding these processes? To explore these questions, the Global Governance Project has set up this new sub-project. The project will be supported by the Volkswagen Foundation under its transdisciplinary environmental research programme. MANUS is linked to the emerging political debate on the reform of international environmental governance and on strengthening the United Nations system in the field of sustainable development.

Subproject MOSAIC -"Multiple Options, Solutions and Approaches in Climate Policy"

In climate policy we observe the emergence of several parallel policy approaches that encompass equally important segments of international society and that may develop into parallel regulatory mechanisms and regimes. We are witnessing, in a sense, a 'mosaic' of different climate policies. This situation poses significant challenges. A lack of uniform approaches may jeopardise the success of the segmented policies adopted by individual coalitions, and the possibly strong economic implications of a stringent climate policy adopted by one coalition of states may have severe ramifications for other policy arenas, most notably the world trade regime that unites both the 'Kyoto coalition' and the 'anti-Kyoto coalition'. On the other hand, an international climate policy mosaic may have several advantages: it could allow, for example, for the testing of innovative policy instruments in some nations, with subsequent diffusion to other regions. Thus, an urgent need exists to explore the likely consequences of parallel approaches and regimes in climate policy and to analyse what response strategies policy-makers could avail of. To this end, the Global Governance Project is initiating this new sub-project.

Other Research Areas

- *Science and Global Governance:* Here we explore the interface of science and politics, for example regarding the "effectiveness" of the IPCC.
- *Environment and Security:* Several studies have suggested that environmental degradation will lead to an increase in the number of violent conflicts within and among states. Is that so? Apart from smaller studies on environmental security and migration, GLOGOV addresses these issues mainly in collaboration with the Security Diagram sub-project under EVA.
- *Power and Ecological Interdependence:* Traditional theory of international relations understands the power of nations in terms of material indicators, such as military might, industrial production, or population. The global environmental crisis, in particular climate change, forces a change in this traditional conception to include additional factors, such as "environmental power", in the equation.

GPP
The Geoscope Preparatory Project

Project speaker: Wolfgang Lucht
PIK project members: Carlo C. Jaeger, Hermann Lotze-Campen.

Research Aims: Observing the Anthropocene for Sustainability Science

Achieving a sustainability transition is a major challenge to global society. Meeting this challenge requires new theories and new data - data of a type that we currently do not have. This includes time series to monitor management and policy measures aiming at sustainability. It has to merge satellite data with on-the-ground social research and to look at the whole of the earth system, emphasizing the human dimension. It should be derived from theories that may guide economic development to sustainability and include data and theory capable of generating new images of our world in transition. In other words: a Geoscope.

A Sustainability Geoscope

Sustainability Geoscope is a national and international initiative co-ordinated at PIK for creating a multi-faceted instrument to serve as eyes for sustainability science. The instrument is to be designed to observe the world at the global scale, combining regional in-depth studies within a global theoretical, mental and methodological framework. The Geoscope is to observe the anthropocene: the rapidly approaching time period characterized by far-reaching fundamental interactions between the human and the natural systems of the planet, their variability and their change. To be based upon a large spatial sample and observed time series of key variables, and on a combination of satellite remote sensing with on-the-ground data, a Sustainability Geoscope is essential for constructing, validating and operating next-generation theories of sustainability in the world's economies and societies, for deciding between competing pools of current and future theories concerning the sustainability transition, and for integrating the human dimension into analyses of the variability and vulnerability of natural systems. It is to be built upon comparative regional studies of measures and actions affecting sustainability.

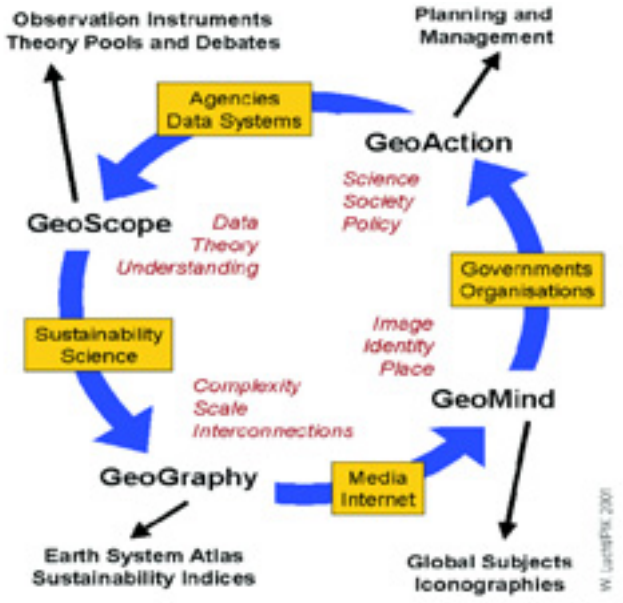


Fig. 3: Elements of a strategy for Sustainability Science. Activity in observational, analytical, mental and political categories is required to make the interplay between science and society successful. The Sustainability Geoscope is one element of this web of action and interaction. (Copyright W. Lucht, PIK, 2001).

First Steps Toward a Geoscope

A Sustainability Geoscope has to be built step by step. First steps are becoming a reality at PIK, on the national level, and internationally. On behalf of the National Committee on Global Change Research, a series of two national, one international and one mixed national/international workshops on the Sustainability Geoscope have been held in the year between November 2000 and November 2001. The three goals of these workshops were (1) to substantiate the structure and content of a Geoscope instrument, (2) to develop a research framework for a German Sustainability Geoscope research programme to be submitted in various parts to national funding agencies, and (3) to integrate the Geoscope initiative into the internationally emerging global change science focus on sustainability. These workshops were a great success, bringing together a diverse community in discussions of next-generation observation strategies, and establishing the Geoscope concept as part of the ongoing debate on next steps. At PIK, this effort is being co-ordinated while work has begun to investigate through basic research the following themes in the upcoming period with a view toward the Geoscope: interaction between the biospheric water cycle and human water demand, interaction between agricultural demand, the economic system and the global carbon cycle, and interaction between the biosphere, lifestyles and storylines of technological development (www.sustainability-geoscope.net).

This project has been funded by PIK and partially by the German Ministry for Education and Research under the "Climate, Vegetation and Carbon (CVECA)" project of the DEKLIM programme.

TOPIK 5 - Regional Simulators

Different regions are likely to face varying impacts of global change and are likely to respond differently to similar challenges. The vulnerability of a region and the people living there will depend on their ability to act and adapt to these challenges. This TOPIK aims at developing and applying region-specific models to simulate especially the consequences of planning decisions, their effectiveness and possible non-sustainable side effects. To achieve this goal, the relevant ecological, social and economic processes will be identified and assessed, appropriate sub-models will be selected or developed, and integrated. The resulting Regional Integrated Models are problem-oriented representations of the actual state of scientific knowledge. A Regional Simulator adds two further elements: one is the use of appropriate indicators to detect relevant deviations between real development and simulation. The other is an interface with users inducing feedback between simulation and real decision-making.

BEST
Brandenburg Simulator of Environmental and Societal Transformations

Project speaker: Frank Wechsung
PIK project members: Maarten Krol, Valentina Krysanova, Petra Lasch
External project collaborators: H. Rosé (FhG-FIRST).

Introduction

The State of Brandenburg, Germany, will undergo significant transformations in the coming decades, including those resulting from internal processes such as population ageing, and external drivers including climate change, globalization and extension of the EU. The general aim of BEST is to construct a regional simulator which makes possible the assessment of historic and plausible future long-term transformations in Brandenburg.

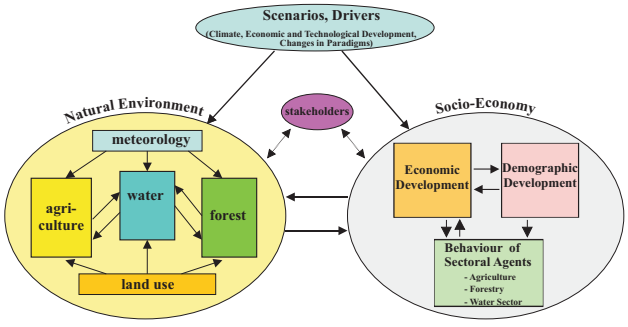


Fig. 1: Structure of the modelling approach.

Central foci of integration are water, the landscape and mankind's use of natural resources, in studying

- transformations of the landscape in Brandenburg as driven by international and national changes in the agricultural and forestry sector, or by changes in climate. These changes have impacts on ecosystem productivity, the water balance and carbon balance.
- effects of liberalization of agricultural markets and of EU policies, that could lead to a strong decrease in cropping area or cropping intensity.
- population dynamics in Brandenburg, characterized by a decrease and an ageing of population, leading to shifts in regional demand for natural resources, e.g. through impacts on settlement development.

Concept of the Regional Simulator

The natural environment is represented by spatially explicit models of the dynamics of the water cycle, agrosystems and forestry under climate and land use forcing. To describe the hydrological cycle, vegetation, soil erosion, and nutrient cycles at the river basin scale, the SWIM model is used. Forest succession, productivity and carbon balance are simulated using the forest model 4C. Socio-economic elements will be represented at the macro level (demography and economic growth). Agent-based models of agriculture, forestry, and the water sector will simulate decision-making on natural resource use. A demographic cohort model reflects socio-economic conditions affecting fertility and mortality. At the technical level, models are coupled in a scheme of open linkages, where the models can run in parallel with structured interfaces and centralized model control, developed in co-operation with the Fraunhofer-Institut für Rechnerarchitektur und Softwaretechnik.

Applications

Examples of the basic causal chains that will be studied in applications of the regional simulator are:

External drivers		Consequences		
climate change	⇒	water availability crop yield forest production carbon sequestration	⇒	sectoral economic output environmental quality tourism
globalisation/EU - effects on agricultural policy and markets	⇒	changes in intensity of agriculture	⇒	water quality water availability economic output
EU-extension	⇒	migration, population land use for settlement	⇒	water availability landscape attractiveness
decline in brown coal mining	⇒	water availability	⇒	water quality tourism

GLOWA-Elbe, funded by BMBF, and Grobraster, funded by the VW Foundation, are intensively intertwined with BEST.

Preliminary Results

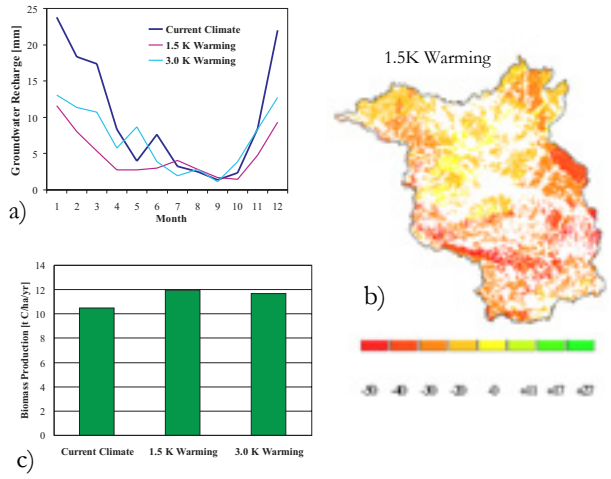


Fig. 2: Examples of climate change impacts on Brandenburg up to 2030: average groundwater recharge (a), percentage change in winter wheat yield (b), and mean annual biomass production of a pine forest stand (c).

SYNAPSE
Syndrome Assessment and Policy Strategy Evaluation

Project speaker: Gerhard Petschel-Held
PIK project members: Klaus Eisenack, Jürgen Kropp, Matthias Lüdeke, Fritz Reusswig
External project collaborators: Inst. for Geography, University of Marburg (Germany), Dept. of Economics, University of Oldenburg (Germany).

Rationale

Within the Syndrome Approach processes governing the dynamics of non-sustainable global change are decomposed into patterns of human-nature interactions. Syndromes emerge from incompatibilities of political and socio-economic processes of human use of nature on the one hand and natural processes of resilience, recovery, and renewal on the other. They are stabilized by internal interactions and represent entities of the coupled human-nature system.

Methodology

Pattern modelling requires a generalizing technique representing whole classes of (fictional) conventional regional models. There are, however, no such regional models and it might be misleading to assume there ever will be. Thus we need to define the classes by specifying the *common* properties without the models. This is done with help of qualitative differential equations (QDE, see QUIS), which characterize classes of functional relations in terms of monotonicity properties.

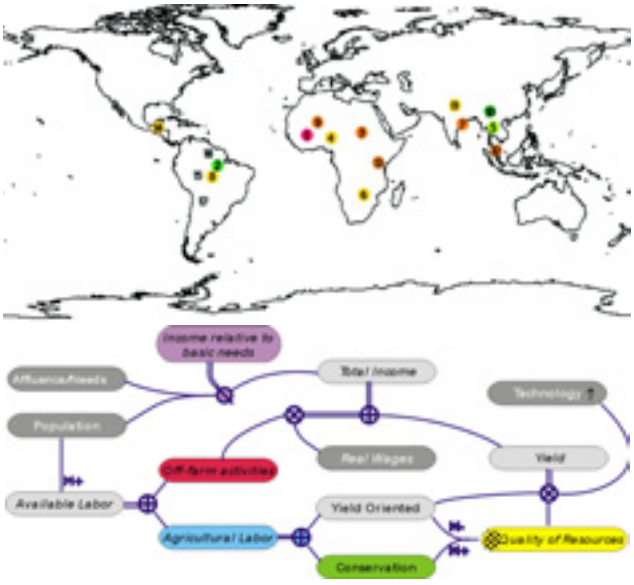


Fig. 3: Location of land-use case studies used so far (upper panel) and generalizing qualitative model (lower panel). The colour indicates the criticality of the region where red indicates high values and green low values.

Land-use Change in Developing Countries
Land-use change is particularly suited for pattern analysis. Work has focused on the syndrome-based analysis of deforestation on the one hand and the modelling of local decision-making of smallholders on the other. Based on a set of presently 15 case studies (see Figure 3), a qualitative model has been developed to integrate the case studies. The model exhibits the mechanism of the Sahel Syndrome (see SYNAPSE) to be related to the interplay between an *increasing* rate of soil degradation and a *limited* rate of yield increase due to social, economic and environmental circumstances.

Overexploitation of Marine Resources
The global pattern of overfishing has been examined with a focus on capital accumulation. Extending previous bio-economic models by QDEs, time series of resource use were reconstructed and general problems of fishery development identified (Figure 4). The generalized character of the model allows general conclusions for policy action. Model results show that a fishery needs perpetual adjustment, because the disaster case cannot be reliably avoided under the usual normative framework. Yet the adjustment should not be restricted to a single policy (e.g., catch quotas), but comprise a policy basket.

Further work will integrate alternative regulatory frameworks and improve the decision-making module. This will provide direct advice for the EU fisheries policy.

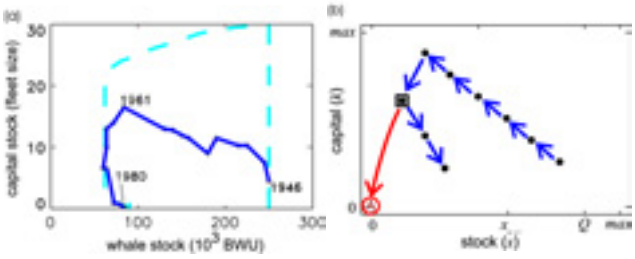


Fig. 4: Phase plot (a) of the development of the blue whale hunting industry (solid line), compared to results of former models (dashed line) and our qualitative model (b). The red arrow corresponds to the disaster case, emerging from the critical branching point.

Outlook
As well as further work in the two fields of syndrome analysis described here, a new focus will be on environmental issues of urban sprawl. This will be the subject of an EU project utilizing underlying case studies for which research is already ongoing.

ReCSim
Regional Climate Simulation Models

Project speaker: Rupert Klein
PIK project members: Nicola Botta, Friedrich-Wilhelm Gerstengarbe, Detlef Hauffe, Martin Kücken, Susanne Langenberg, Antony Owinoh.
External project collaborators: U. Böhm (Univ. Potsdam), G. Doms (DWD), U. Schättler (DWD), J. Steppeler (DWD), B. Rockel (GKSS), K. Keuler (BTU Cottbus).

The Climate-Limited Area Model CLM
Regional climate modelling refers to the practice of nesting a limited area model (LAM) in a general circulation model (GCM) to infer the combined impact of global driving fields and small-scale forcings on the climate of a region. This project will provide PIK with such a dynamic regionalization tool as a contribution to general integrated assessment technologies. PIK has joined the German climate research community in developing such a regional climate model (CLM) based on Deutscher Wetterdienst's Local Model (LM).

Operational Framework and Statistical Analysis
The first activity within ReCSim contributes an operational framework suitable for long-time computations and the associated data analysis, modern statistical and non-statistical validation schemes, and improved parameterizations. This is the basis for comprehensive model intercomparison and the validation of the new regional climate model against real data.

Figure 5 illustrates our new statistical cluster analysis tools by exhibiting the result of a spatial error estimation. The production of these results required the regional adaptation of the model, the development of software to drive the LAM with global analyses, as well as the incorporation of the group's statistical analysis tools within the CLM-operational framework.

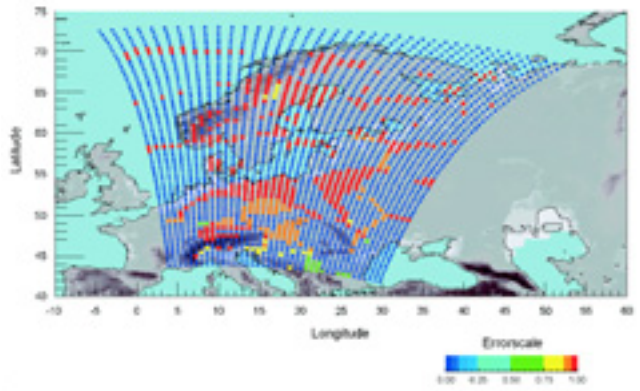


Fig. 5: Spatial error distribution of the comparison of the LM forecast version versus a three-month analysis period.

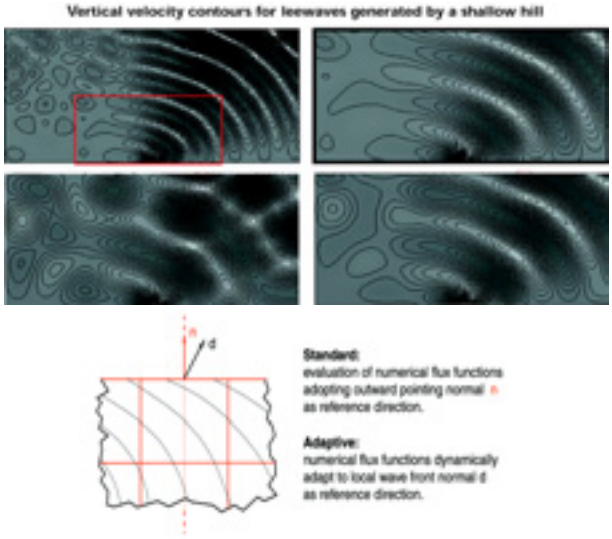


Fig. 6: Non-reflecting boundary conditions for non-hydrostatic compressible models based on rotated boundary Riemann problems.

Numerics for Regional Climate Models

Regional climate models are often derived from numerical weather forecast models by extending and adjusting the parameterizations of unresolved processes to account for climatic scales. Although appealing, this approach has several shortcomings associated with the numerical and statistical methods used, and this is the focus of the second ReCSim activity. An example of our efforts concerns the elimination of the computationally expensive lateral and vertical sponge layers usually employed in LAM-GCM coupling. Figure 6 shows preliminary computations done with "spongeless" radiative boundary conditions. Our numerical flow solver requires a reference direction for evaluating numerical fluxes for mass, momentum, and energy. A directionally adaptive flux computation is used near the boundaries aligning the reference direction with the gradient of vertical velocity. The result (lower right) is compared with the standard approach (lower left), and with the adaptive boundary condition on an enlarged domain (top pictures).

This project has been funded in part by the Deutsche Forschungsgemeinschaft, grant KL 611/6.

TOPIK 6 - Sectoral Climate Sensitivity

The projects within this TOPIK address the climate sensitivity of relevant ecological systems and economic sectors. Using special-purpose methods and models, the probable reactions of those exposure units to consistent global-change scenarios are quantitatively explored. The investigations focus on issues that have particular need of additional studies, such as the consequences of global warming for the European wine production and marketing system or the opportunities provided by alternative management strategies for temperate forests.

SAFE
Sensitivity and Adaptation of Forests in Europe under Global Change

Project speaker: Petra Lasch
PIK project members: Franz-W. Badeck, Thies Eggers, Ylva Hauf, Beate Klöcking, Marcus Lindner, Peter Mohr, Jörg Schaber, Felicitas Suckow.

Introduction

The overall objective of the project is the analysis of likely impacts of global change (CO_2 increase, nitrogen deposition, climate change and relevant socio-economic trends) on forests in Europe. Changes in growth and productivity of forest species may influence the competitive relationships among the species, the carbon sequestration, water budgets and biodiversity at local and regional scale. The project is focused on the integrated evaluation of the multi-functionality of natural and managed forests including economic and other social impacts of global change. Alternative management options are evaluated for different future scenarios.

Integrated Forest Sector Impact Assessment

An integrated impact assessment is based on linking:

- ecosystem dynamics,
- decision-making in forest management,
- wood production and socio-economic consequences,
- impacts of climate change and management on ecosystem services like carbon storage, water protection and yield, biodiversity, and recreation.

Using the physiology-based forest dynamics model 4C (Forest Ecosystems in a changing Environment) the effect of management intensity on carbon storage of forests in Germany was investigated. 4C was applied to 12 forest stands of pine, spruce, beech, oak and mixed spruce-pine in 6 forest growth regions. The application of three harvesting strategies leads to differences in total carbon storage over a period of 60 years. Current thinning practices (corresponding to the 5% scenario) do not strongly reduce the storage capacity (Figure 1).

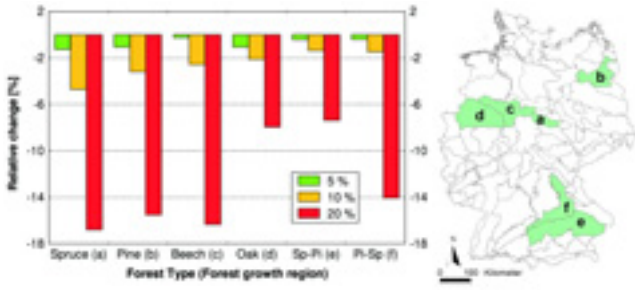


Fig. 1: The model stands are situated in 6 forest growth regions of Germany (map, right). Site data were provided by the BMBF project 'German Forest Sector under Global Change' (cf completed projects, CHIEF). Removing woody biomass by 5, 10, or 20% every five years resulted in reductions of total carbon storage (biomass, soil, removals) in comparison with carbon storage of an unthinned forest. In this case more carbon was stored than in any of the management scenarios.

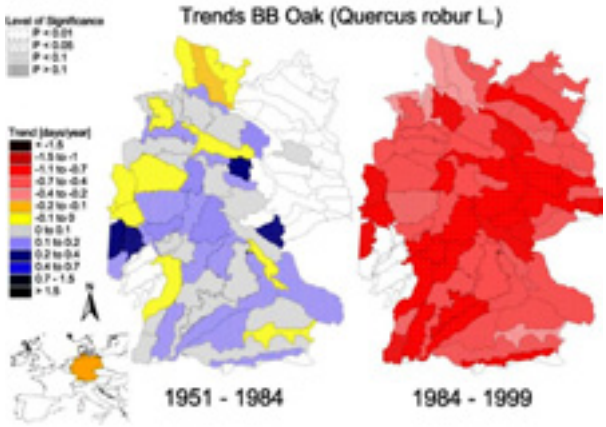


Fig. 2: Bud burst of oak at two periods in Germany.

Phenology

Growing season length and especially the start of the growing season marked by bud burst has substantial impact on the annual carbon balance of trees. Analysing records of bud burst in Germany from 1880-1999 showed that at the regional level the global warming sig-

nal is masked by multidecadal climate fluctuations. Consistent cooling trends of April temperatures in Germany between 1951 and 1984 and a warming from 1984 to 1999 led to both a delay and an advancement of bud burst for trees with bud burst in late spring (Figure 2). Early flushing trees showed an increasingly advanced budburst leading to a possible competitional advantage over late flushing spring trees. Models of bud burst were developed to incorporate this important aspect into simulations of ecosystem dynamics and carbon balance.

This project has been partly funded by BMBF and the EU.

CLAWINE
Climate Adaptability of European Wine Production

Project speaker: Manfred Stock
PIK project members: Wilfried Ahrens, Franz Badeck, Antonella Battaglini, Friedrich-Wilhelm Gerstengarbe, Peggy Gräfe, Thomas Kartschall, Gerhard Petschel-Held.
External collaborators: DWD-Geisenheim, Schloß Johannisberg (partners 2-25 cf Figure 3).

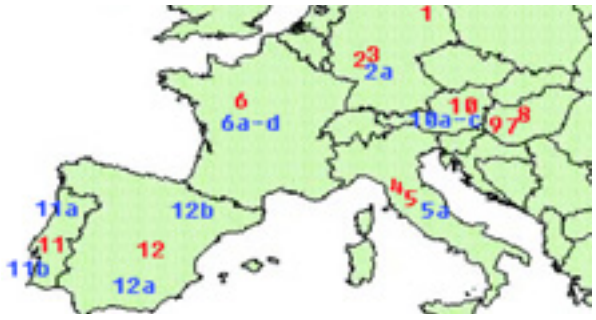


Fig. 3: Location of project partners, with 12 scientific and 14 producing partners.

Objectives

The overall objective of CLAWINE is to the evaluate the role and potential of European wine production in the context of climate change. Wine plays a key role for the economy of several regions. Grapevine is grown under conditions often termed marginal for agriculture, thus it is vulnerable to climate change. CLAWINE will develop and evaluate necessary adaptation measures by:

- correlating grape yield/quality and environment,
- downscaling climate scenarios for selected regions,
- assessing risks,
- estimating necessary adaptation costs.

The main goal is a grapevine decision support system. The work will be done within five work packages (Figure 4). It is planned to disseminate the results to policy-makers, advisors, organizations and wine producers through involvement in the project and knowledge transfer.

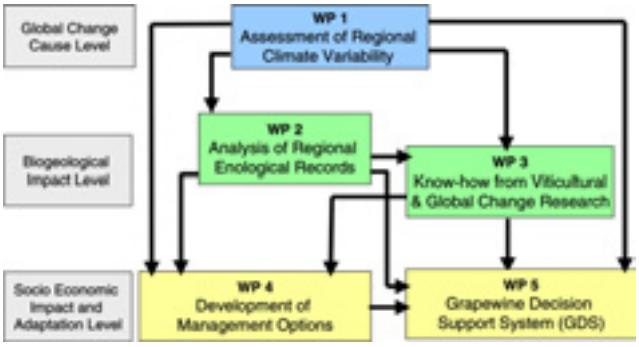


Fig. 4: Information flow chart from climate change to phenological and socio-economic impacts and management decisions.

Results in 2000 and 2001

1) A climate scenario (period 2001-2050) for the Rheingau region based on weather records from 1951-2000 was generated and distributed to the partners.
2) Using this scenario, impact studies on phenological development for *Riesling* have been conducted. They indicated an acceleration of phenology by 10-14 days. This tendency is also visible in harvest data from 1950-2000 (Figure 5). Such a shift is capable of endangering the typical character of the Rheingau Riesling, because of:
   - early maturity, shifting vintage to mid September; and ripening under higher night-time temperatures,

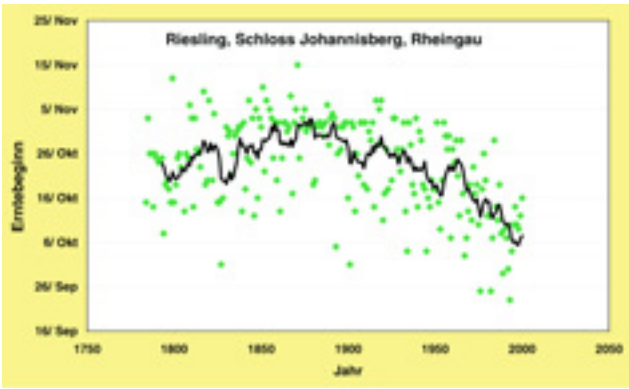


Fig. 5: Effect of climate change on start of harvest in the Rheingau.

resulting in unbalanced sugar/acid ratio and flavour contents.

3) A preliminary study on conceptual basics for the Grapevine Decision Support System was conducted.

Outlook for 2002 and 2003

Homogenous data sets/climate scenarios for all included regions will be built up. Analogous studies of impact on phenology for the typical varieties in these viticultural areas will be conducted. A socio-economic/management questionnaire will be developed, distributed and evaluated. Existing grapevine and physiological submodels will be integrated for detailed impact studies.

AIM
Agriculture emphasising Integrated Modelling for Morocco

Project speaker: Gerd Bruschek
PIK project members: Gerd Bruschek, Ylva Hauf, Frank Wechsung.

Introduction

AIM translates weather extremes and climate shifts into changes of agricultural production and assesses the combined effects of these. Integrated assessments include here second order effects of changes in agricultural productivity on the economic sector on the micro- and macro-scales, and the ecological consequences related to the changed extent and intensity of agricultural production. In the case of Morocco, we take the example of an extremely marginal situation for both climate and society to explore climate-related response patterns in the economic and social spheres of regions which strongly depend on agricultural production. We explore not only the current nature of the problem but also attempt to improve the ability to adapt to year-to-year climate fluctuations by improved medium-term precipitation and yield predictions.

Morocco

38.6% of Morocco's population depend directly on agriculture for their livelihood. The mean agricultural share of the Gross Domestic Product (GDP) amounts to 16.6%. 21.5% of the total land area can be used for arable and permanent crops. The cropping season for the two major cereals, wheat and barley, lasts from December to May in a sub-humid to arid climate. Morocco maintains one of the world's highest wheat consumption rates per capita for food supply (202 kg/yr in 1996). Self-sufficiency in wheat (ratio of production to domestic demand) fluctuated between 111% in 1968 and only 19% in 1995. The variability in wheat yield explains almost all of the year-to-year fluctuation of the wheat self-sufficiency rate during recent years.

Research Tasks

- Integration of empirical relationships between climate modes and precipitation, crop yields and other second order effects (i.e. year-to-year fluctuation in water storage and availability, hydro-energy production, irrigation, food imports, port capacity requests, unemployment rate, disposable income, gross domestic product) based on teleconnections.
- Identification of typical qualitative response patterns to climate-related shifts in precipitation and crop production potential for marginal developing countries, in particular at semi-arid sites.
- Regular prediction of year-to-year fluctuations in Morocco's precipitation, cereal yields and related second order effects.
- Monitoring the reliability of predictions and the effect of those predictions on adaptation measures.

Results

A system of prediction measures was developed which delivers estimates of changes in cereal yields (wheat, barley) in comparison to the previous cropping season for

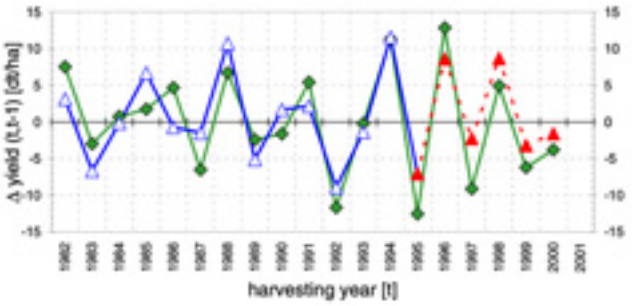


Fig. 6: Comparing year-to-year changes in Moroccan national observed wheat yield (filled rhombus) for 1982-2000 with simulated changes using MID a) in 1982-95 (open triangle), the period the model was calibrated to; and b) in 1996-2000 (filled triangle), when the model was run in a predictive mode.

the coming harvest. Predictions will be supplied for the crops wheat and barley and for the mean cereal yield before planting, shortly after planting and at mid-season by the statistical models PRE, POST and MID. PRE is based on correlations between pre-planting Atlantic sea surface temperatures (SST) and yield, POST uses correlations between the NAO (North Atlantic Oscillation) at planting time and local precipitation to calculate first the change in precipitation, and from that the alteration of yield, and MID (Figure 6) derives a yield change estimate from the NAO between planting time and mid-season.

TOPIK 7 - PIKuliar Culture

PIK operates in a vast scientific field - global change and Earth system analysis - that is as yet largely unexplored. Serious challenges arise from the complexity of the systems considered, from the necessity for truly interdisciplinary research which they imply, from the absence of a comprehensive data base, and from the fact that most of the pursued research activities rely heavily on computational modelling. In response, within "PIKuliar Culture", PIK intends to establish a functioning interdisciplinary dialogue, to reflect the philosophical background of its research, to develop common priorities and standards of quality, and to synchronize and, if necessary, extend existing disciplinary scientific procedures.

IMEQ
Integrating Models and Ensuring their Quality

Project speaker: Gerhard Petschel-Held
PIK project members: Nicola Botta, Hermann Held, Cezar Ionescu, Rupert Klein.

Research Questions

IMEQ's goal is to develop principles of high-quality integrated modelling and strategies for implementing them. Particular emphasis was to be given to the coupling of models with the aim of answering specific research questions. In this context, the following issues were raised:

- How can individual models in global change research be classified to pave the way for integration and quality assurance? Which categories are helpful with respect to a model's object (atmosphere, ocean, economics etc.), structure, scales, implementation, capacity for coupling, and integration? Which categories relate to each model's aims, i.e., the questions each model is supposed to answer, and the questions it is capable of answering?
- How can we classify "integrated" research questions, i.e., questions that can be answered by coupling individual models? How is such a classification related to the classification of individual models? Can we develop a joint classification scheme for models and questions which would allow us to deduce which models need to be coupled in which way in order to obtain answers to specific types of integrated research questions?
- How does uncertainty assessment, including intrinsic model limitation assessment and error estimation, relate to quality assurance in integrated models?
- What do model interfaces (both in a model-inherent disciplinary, and in a software-technological sense) look like? How general a definition can be found for interfaces and how flexible do they have to be?

State of Work and the Project's Future

There are basically two complementary approaches to tackle the questions raised:

- Analyse and categorize existing models along internal specifics and categories like physiological/functional/statistical or numerical/symbolic. This might be called a bottom-up approach.
- Starting from a set of requirements on quality of individual and integrated models, set up a catalogue of criteria and standards to be used as a guideline for the models and coupling procedures.

The project's first target was the organization of the mathematically oriented symposium in the framework of the First Sustainability Days. From its sessions the following conclusions were drawn:

- Concepts used in applied mathematics and computing science offer significant potential for improvement of current models in sustainability science and for their quantitative assessment.
- Modern software engineering is at the core of recent developments of model coupling technologies aiming at the much-desired modularity of applications.
- There is a range of different uncertainty types which might be classified according to the language used (e.g. the temperature is 15.0 °C vs. it is warm) and the measures quantifying the degree of uncertainties (e.g. probability vs. possibility).
- Hybrid modelling has been advanced considerably, combining quantitative with qualitative information.

Despite a general feeling that the conceptual work within IMEQ is greatly needed to achieve PIK's ambitious goals, the project's activities have been regrouped under two other related PIK projects: PIAM and PIRSIQ. PIAM (cf page42) focuses on practical implementations

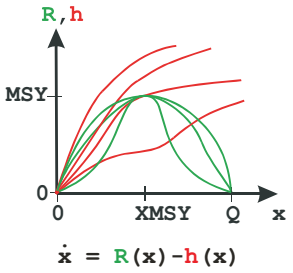
of a flexible, modular model coupling technology, thereby challenging IMEQ's conceptual thread. PIRSIQ will now incorporate some of the practical aspects of quality assurance previously pursued within IMEQ.

QUIS
Qualitative Intelligence Service

Project speaker: Matthias Lüdeke
PIK project members: Klaus Eisenack, Jürgen Kropp, Gerhard Petschel-Held.
External project collaborators: B. Kuipers (Univ. Texas), J.-P. Aubin (Univ. Paris-Dauph.).

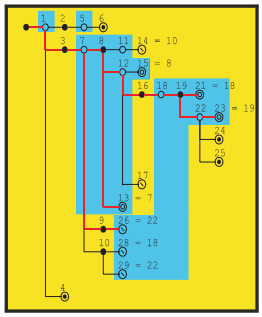
Task
QUIS aims at building a bridge between quantitative and semi-quantitative and qualitative modelling techniques, e.g. qualitative differential equations (theory of classes of ODEs where the right-hand values are largely characterized by their monotony characteristics) or differential inclusions (r.h.s. are set-valued functions). The application of these methods allows an adequate representation of uncertain quantitative knowledge and intrinsically qualitative relations in dynamic models. It also enables the sound generalization of quantitative or qualitative knowledge on relations as derived from a large number of different case studies. The findings will be used in particular, i.a., in SYNAPSE and GlobGov, to describe man-environment interactions and heterogeneous or weakly defined systems.

Fig. 1: Simple example of a qualitative model: a single fish stock x with logistic growth function R and a harvest function h depending on x. R and h are only defined by their monotony properties and the existence of the landmarks MSY, (denoting the unknown maximal growth), XMSY and Q (the carrying capacity).



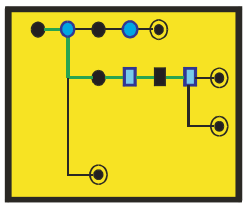
Qualitative Models
Qualitative differential equations (QDE) were introduced by Kuipers (1994). Improvements in techniques for the simplification and analysis of solutions of QDEs are illustrated by a simple bioeconomic model of resource exploitation (cf Figure 1). Its evaluation with the basic QSIM algorithm is shown in Figure 2.

Fig. 2: All solutions consistent with Figure 1. Each symbol denotes a qualitative state characterized by the direction of change and the relation of the variables to landmark values. Each branch of the tree denotes a qualitative trajectory, starting with the initial state in the upper left corner. Circles with dots denote steady states, double circles stand for cycles, double state numbering for continuation at the respective state.



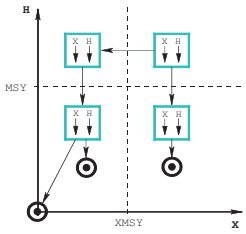
Chatter Box Abstraction
This technique simplifies the solution tree by making irrelevant distinctions invisible (Clancy 1997). It was improved and reimplemented as part of a new C version of the QSIM algorithm. States which exhibit so-called chatter (changes in derivatives without feedback on other variables) are combined to abstract states - in our example this leads to a remarkable reduction of the number of trajectories (13 -> 4, cf Figure 3).

Fig. 3: Simplified or "abstracted" behaviour tree (blue symbols stand for the blue "chatter" areas in Figure 2). The four resulting "relevant" trajectories describe the ways to the stable equilibria "extinction", "low and high equilibrium" and the - rather improbable - MSY saddle point.



Focus Graphs
The representation of the solution as a tree often obscures qualitative values of the variables and important transitions. Moreover, some states and variables may be of limited interest. Thus an alternative representation, the focus graph, was developed (cf Figure 4). It is a projection of the solution onto the subspace spanned by the important variables, enabling a "gestalt view" of the system dynamics.

Fig. 4: Focus graph for the example model enabling an effective overview ("gestalt view"): the state in the upper right corner denotes a bifurcation, irreversibly leading either to the high equilibrium or the low equilibrium/extinction path.



Next Steps

Further work will profit from graph theoretical algorithms to investigate, i.a., viability domains in complex behaviour trees and properties of coupled systems. Another activity will address the integration of differential inclusions to a hybrid systems approach.

PIRSIQ
Pirsig's Quality

Project speaker: Rupert Klein
PIK project members: Cezar Ionescu, PIK staff at large.

Motivation

PIK's interdisciplinary research goals necessitate a conscious activity aiming at the development of a joint "PIKuliar sense of quality". PIRSIQ supports this development by initiating cross-disciplinary discussions and philosophical reflections on our research work.

Interdisciplinary Research

Our objects of study are generally quite complex and inhomogeneous in terms of the involved disciplines, and thus provide inherent difficulties for any of our research projects. These *inherent* difficulties, while also at the core of the PIKuliar Culture TOPIK, are *not* central to PIRSIQ. In contrast, we focus here on *contingent* complexity due to, i.a., different languages, metaphysical concepts, sets of priorities, educational backgrounds, etc.. But this troublesome diversity is actually one of PIK's most important assets and the very basis of the PIRSIQ project.

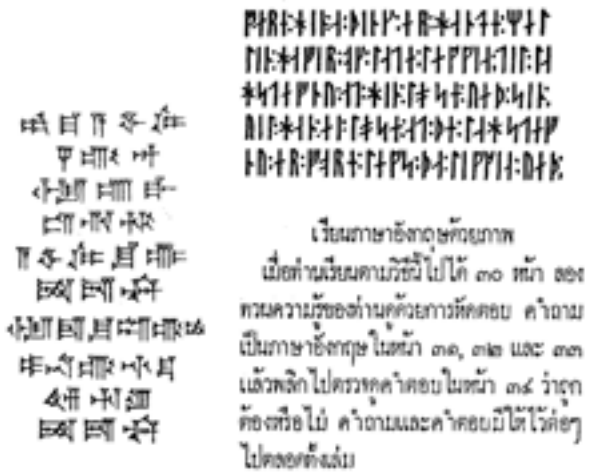


Fig. 5: Contingent Complexity, Inherent Beauty.

Pirsig's Quality

In "Zen and the Art of Motorcycle Maintenance" Robert Pirsig develops a fascinating vision that unifies what he calls the "classic" and the "romantic" views of the world. His notion of the "classic" approach is closely related to the natural sciences, abstract rational thinking, and pure reason. The "romantic" approach is related to an artist's view, to feelings, intuition, the free will, and aesthetics. Pirsig identifies in the concept of Quality the bridge between these two points of view.

One of the most demanding challenges PIK is facing at this point is the integration of socio-economic and natural sciences. This problem is in many ways analogous to the integration of the romantic and classic world views, for which the concept of Quality proved essential. It is reasonable to expect that this concept will also prove useful to our task.

Activities

The project has invited all PIK members to join an electronic discussion forum, designed as an open platform for exchanges on our scientific activities. We have

Fig. 6: Robert Pirsig and his son Chris on "roads less travelled by".

started by focusing on the issue of modelling, challenging contributors to comment on questions such as "What is a model?", "When is a model scientific?", or "Is the computer useful for modelling?"

Also, we intend to set up a guest programme. A guest is invited to visit the institute for a period of days, weeks, or even months. This person would observe our everyday life and research, participate in the PIRSIQ discussions, and would be specifically encouraged to be openly critical and to challenge us in every possible constructive way.

In parallel we hold non-electronic meetings including joint reading sessions, seminars, and panel discussions to crystallize controversial issues and develop common philosophical foundations.

This project is supported through PIK's regular funds.

PRUNE
Propagation of Uncertainties in Earth System Models

Project speaker: Hermann Held
PIK project members: Brigitte Knopf, Thomas Schneider von Deimling, Hans Joachim Schellnhuber.

Introduction
The issue of uncertainty in Earth system modelling becomes increasingly important for the assessment of global change. In this project, uncertainty is analysed in a two-fold way. A conceptually oriented branch addresses a particular yet crucial type of uncertainty which arises from the possibility of abrupt changes. Such changes are caused by bifurcations rooted in the existence of nonlinear feedbacks. We ask how the successive coupling of modules which characterizes current Earth system modelling practice would change bifurcation diagrams and stability properties of dynamical equilibria. Such a conceptual analysis serves as prerequisite for a guided investigation of complex models. A more practically oriented branch of the project aims at a "complete" uncertainty analysis of CLIMBER-2 (cf page 63), PIK's climate model of intermediate complexity. The analysis is optimized according to the needs of an integrated assessment of future climate change.

Uncertainty Analysis of Model Coupling
In the climate system, nonlinear phenomena like transitions from one equilibrium to another or thresholds caused by bifurcations in the underlying dynamics can be observed. Any sensible assessment of future behaviour utilizing climate models has to take into account the existence of nonlinearities.

The Earth system is often modelled by coupling several nonlinear submodules. For predicting the climate with these models the following uncertainties play an essential role: parameter uncertainty, uncertainty in initial conditions or model uncertainty. As the process of coupling is an important part of modelling, one main aspect of this project is the investigation of uncertainties that are due to the coupling process.

For this study we use conceptual models which, compared to General Circulation Models (GCMs), have the advantage that the model can be treated in a mathematically elaborated way. As the time for executing the model is much shorter, it is also possible to perform longest runs on palaeo time scale. Palaeodata provide a very important resource for validation, because they show abrupt changes that mostly have not been predicted by GCMs. In consideration of these facts it appears attractive and feasible to analyse the whole phase space of the conceptual model.

The process of coupling is investigated by using different methods of examining (successively) coupled systems including continuation techniques. Finally, we propose to construct a "toy model" to represent all the different aspects of coupling and of uncertainty. This toy model should be a representation of key aspects of the whole Earth system.

Uncertainty Analysis of CLIMBER-2
One of the major challenges of climate prediction is the estimation of uncertainties related to the modelling results. Various assumptions on model structure and different settings of parameters and initial conditions can alter the model output crucially - especially in the case of model-inherent thresholds and the existence of nonlinearities within the model equations. A multi-run experiment (e.g. Monte Carlo Simulation) can serve as a tool to

investigate the effect of uncertainty in model parameters. Due to limited computer power this method fails for complex models like PIK's fully coupled atmosphere-ocean-vegetation model CLIMBER-2. To circumvent this problem we are constructing a reduced model to emulate the behaviour of the original code. We have chosen the polynomial chaos expansion/probabilistic collocation method (Webster and Sokolov, Climatic Change, 2000) for this.

By means of the computationally efficient reduced model, extensive uncertainty analyses become feasible for various parameters of interest. This procedure yields far more information on the uncertainty of the model result than sensitivity analyses of single parameters (as often presented). Comparison of the model output of the 2.5D atmosphere and the 2D zonally averaged ocean with observational data will strongly constrain and correlate multiple parameters. It is planned to illustrate how the characteristics of input probability density functions are constrained and transformed by such a state-of-the-art climate model which displays pronounced nonlinearities like a possible breakdown of the thermohaline circulation. Bayesian belief networks will serve here as a versatile tool for a unifying representation of uncertainties stemming from experimental data and model parameters.

The investigations aim at qualitatively improved estimates of the uncertainties in climate change projections.

SIMENV
An Integrated Simulation Environment for Quality Assurance and Scenario Analyses

Project speaker: Michael Flechsig
PIK project members: Uwe Böhm, Arnulf Günther, Jochen Hinkel, Cezar Ionescu, Ciaron Linstead, Claus Rachimow, Markus Wrobel.

Aim
Simulation is one of the cornerstones of research in global change. The goal of the SIMENV project is to develop a toolbox-oriented simulation environment that enables the modeller to deal with model-related quality assurance matters and scenario analyses. Both research foci require complex simulation experiments for model inspection, validation and control design without changing the model in general.

Approach
SIMENV aims at model evaluation by performing ensembles of simulation runs in a co-ordinated manner. Co-ordination is achieved by pre-defined experiment types representing typical multi-run simulation tasks.

According to the strategy of a selected experiment type a model M is re-adjusted numerically (mainly by a subset p of model drivers, parameters, boundary and initial values) before each single simulation run. Each experiment type results in a sequence of model outputs over the single runs for the state variables z which can be post-processed specifically.

The following experiment types form the base of the SIMENV multi-run facility, other types may be identified for implementation by PRUNE and SAFE - the co-operating TOPIK2k projects - during the course of the project:

- Behavioural analysis: Inspection of the model's behaviour in a space spanned from p with discrete numerical adjustments and a flexible inspection strategy for the whole space.
  Used in: model verification, numerical validation, deterministic error analysis, deterministic control design, scenario analysis and spatial patch model applications.
- Sensitivity analysis: Determination of model (state variables) sensitivity to p. Can be performed either by finite difference derivative approximations from M or more accurately and stably by an algorithmically generated code of the tangent linear model to M.
  Used in: numerical validation purposes, model analysis, sub-model sensitivity.
- Monte Carlo and stochastic analysis: Perturbation of p according to probability density functions pdf; determination of moments, confidence intervals and heuristic pdf for z.
  Used in: error analysis, uncertainty analysis, verification and validation of deterministic models.
- Optimization: Iterative determination of an optimal value of p for mono- or multi-criterial cost functions derived from z of the model M or its adjoint model.

Used in: model validation (system - model comparison), control design, decision-making.

General System Design

SIMENV makes use of modern IT concepts. Figure 7 shows the main pathways from the original model to experiment evaluation and finally model update.

To interface a model with SIMENV the source code of the original model is transformed by implementing SIMENV function calls for adjustments of p and for model output. XML descriptions of adjustments and model output are generated semi-automatically. Both XML descriptions and transformation functions are adapted from the Typed Data Transfer approach TDT of the MODENV project at PIK.

Experiment performance supports local, remote, distributed and parallel architectures.

Experiment-specific result postprocessing enables navigation in the experiment - model output space and interactive filtering of model output and reference data by statistical operators. Result evaluation will be dominated by application of pre-formed visualization modules and will offer data interfaces for a more detailed result processing outside SIMENV.

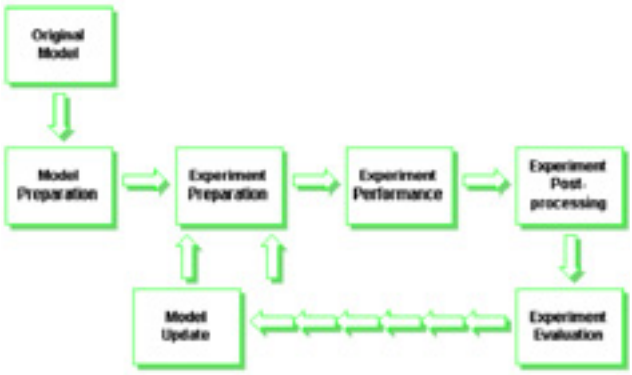


Fig. 7: SIMENV system design.

Completed Projects

QUESTIONS
Qualitative Dynamics of Syndromes and Transition to Sustainability

Project leader: Gerhard Petschel-Held
PIK project members: Martin Cassel-Gintz, Matthias Lüdeke, Fritz Reusswig, Hans Joachim Schellnhuber.

Rationale

Global change results from a manifold of processes, ranging from climate change on the global scale to local processes like land-use decisions or community policies. Within the syndromes approach this variety of processes is clustered into patterns which represent new entities for analysing global change (Figure 1)..

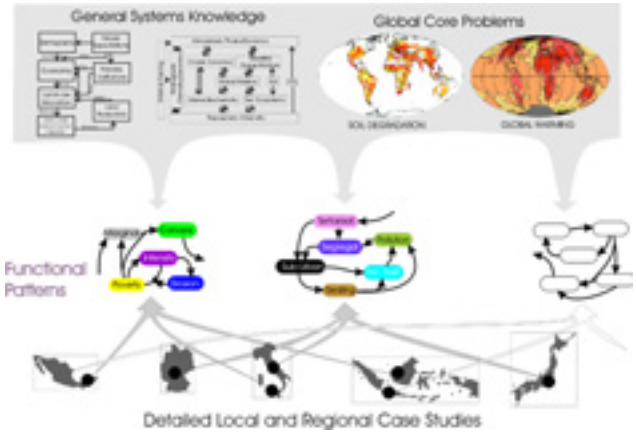


Fig. 1: Syndrome approach: global and local processes of global change are clustered into typical functional patterns.

Syndrome Diagnosis

In 1996 the German Advisory Council on Global Change (WBGU) proposed a set of 16 syndromes. This set represented the basis for the work within the QUESTIONS project, seven syndromes being analysed in greater detail. One example, the analysis of the FAVELA SYNDROME, is depicted in Figure 2.

Syndrome Coupling

Individual syndromes describe major processes of Global Change. Yet the processes of each syndrome might induce or reinforce each other. Deforestation, for example, is often initiated by profit-oriented timber exploitation (OVEREXPLOITATION SYNDROME) which opens up the forest and entails in-migration of farmers (SAHEL and DUST-BOWL SYNDROME). This leads to an enhanced endangerment of forests, the assessment of which is depicted in Figure 3.

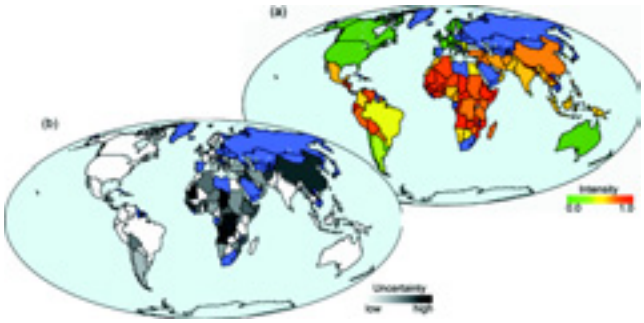


Fig. 2: The FAVELA SYNDROME describes the socio-ecological degradation through uncontrolled urban growth and development. Map (a) in the central panel shows the countries where the syndrome occurred during the 1980s and early 1990s. Due to data gaps, however, high uncentainties exist. These are mapped out in bottom panel. For countries coloured in blue no data exist.

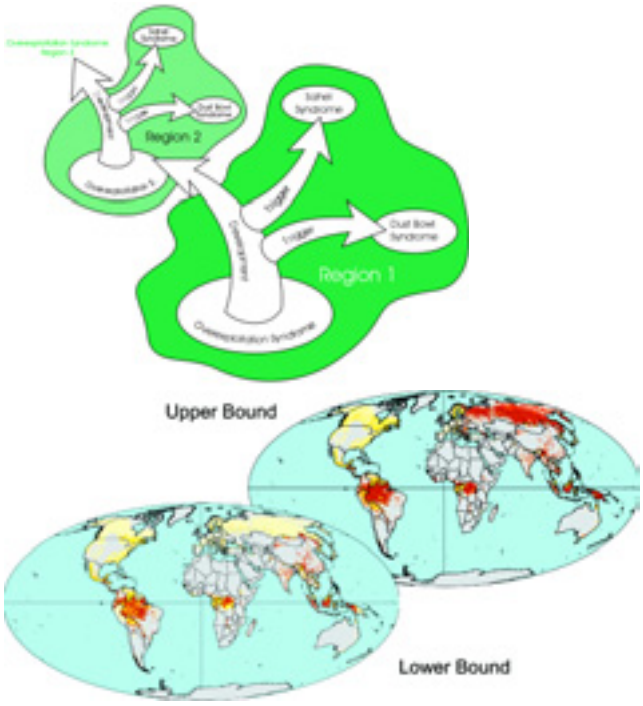


Fig. 3: Threat to the world's forests through syndrome coupling as sketched by the successor graph. The assessments of the intensity and disposition of the syndromes involved are combined to compute an upper and a lower bound for the threat by coupled processes of land-use change (yellow: low threat; red: high threat).

ICLIPS
Integrated Assessment of Climate Protection Strategies

Project speaker: Ferenc Toth
PIK project members: Hans-Martin Füssel, Marian Leimbach, Gerhard Petschel-Held, Hans Joachim Schellnhuber, Eva Tothne-Hizsnyik.
External project collaborators: Thomas Bruckner (Inst. for Energy Engineering, Technical University of Berlin).

Main Goals

The ICLIPS project represented an international and interdisciplinary research activity whose aim was to provide an Integrated Assessment of Climate Protection Strategies. This assessment is intended to support the decision-making community in realizing the United Nations Framework Convention on Climate Change (Article 2: "prevent dangerous anthropogenic interference with the climate system"). This calls for an inverse approach that provides information about possible emission strategies subject to specified environmental and economic constraints. Early attempts by scientists depicted emission paths with respect to given concentration targets. Subsequent work took climatic attributes (change in global mean temperature) or geophysical consequences (sea level rise) as environmental targets. While these analyses provide useful insights into the stabilization issue, they are only remotely related to the ultimate concerns about climate change, its possible adverse effects. The main research objective was to develop an Integrated Assessment model (IAM) that extends the inverse approach to address this ultimate concern.

Methods and Models

The inverse approach is formulated as a kind of generalized cost-benefit analysis for which two types of normative inputs are required. The first type is based on the use of climate impact response functions (CIRFs) that depict reactions of climate-sensitive socioeconomic and natural systems to climate change forcing. As users of the ICLIPS model, social actors can specify their willingness to accept a certain amount of climate change impacts in their own jurisdiction. The same social actors can reveal their perceptions about their society's willingness to pay for climate change mitigation and about acceptable international burden-sharing principles which represent the second type of normative input. The ICLIPS IAM then determines whether there exists a corridor of emission paths that keeps the climate system within the permitted domain without exceeding the specified social costs.
The ICLIPS IAM is a tightly interconnected system of models built on a platform of carefully harmonized assumptions. The core of the model system is a fully integrated climate-economy model. It is linked to an impact module that consists of a comprehensive set of global and regional CIRFs.

Main Results

After developing and integrating the different modules of the ICLIPS framework, applications and policy analyses were performed in different ways. The results reveal the strong nonlinearity and sensitivity of the climate policy space to impact constraints.

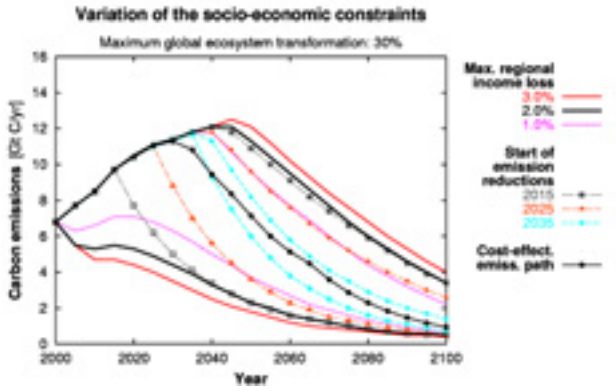


Fig. 1: Corridor for energy-related CO_2 emissions in the 21st Century.

Figure 1 shows an explanatory result. The carbon emission corridor is based on an assumed policy agreement that transforming more than 30% of the Earth's ecosystems would constitute a dangerous climate change impact. The sensitivity of the emission corridor is analysed by varying the mitigation cost limit and the starting year of emission reductions. It requires at least about 1% of per capita consumption in at least one region in at least one period to have an open corridor. If effective reductions are postponed until 2015, 2025, and 2035, the resulting corridors become increasingly narrower. The emission corridor widens when the impact threshold is relaxed to 35%. Due to the emissions already in the atmosphere and the inertia of the Earth system, it is not possible, however, to constrain the transformation of ecosystems to significantly less than 30% on the global scale by reducing carbon emissions alone.

A major part of the project has been funded by BMBF and BMU.

POEM
Potsdam Earth System Modelling

Project convenor: Hans Joachim Schellnhuber
Project speakers: Martin Claussen (CLIMBER), Wolfgang Cramer (DGVM), Yuri Svireshev (COEM).

POEM Components

The focus of POEM was the problem of Earth system stability by analysing (i) the land biosphere and its feedbacks to the atmosphere, (ii) the interactions between all major components of the Earth system (atmosphere, ocean, biosphere, ice masses), and (iii) the long-term evolutionary dynamics of the geophysical Earth system. Accordingly, three main POEM components were set up to focus on the particular processes of geosphere-biosphere interactions. The resulting models were used to study the stability of the Earth system under a broad range of scenarios for modified boundary conditions.

- The short-term (days to centuries) atmosphere-biosphere interactions and vegetation dynamics were addressed by the development of a Dynamic Global Vegetation Model (LPJ-DGVM), incorporating plant physiology and vegetation dynamics (including disturbances).
- At the time scales of centuries to millennia the feedback between atmosphere, ocean, vegetation and inland ice becomes important. This is described by the CLIMBER (CLIMate and BiosphERe) model. This activity has received international attention since it served as the nucleus for EMIC (Earth system Models of Intermediate Complexity) research, e.g. in the IGBP.
- The long-term evolution and development of the biogeochemical cycles is influenced by variations in the luminosity of the sun, plate tectonics, and changes in the geosphere, which is the focus of the CO-Evolutionary biosphere and geosphere Model (COEM).

Progress and Perspective

DGVM

The POEM DGVM group is the core of an international team that develops the Lund-Potsdam-Jena Dynamic Global Vegetation Model (LPJ). LPJ simulates plant functional types (PFTs) performance as a function of ambient temperature, water availability, CO_2 and radiation. Canopy structure and soil carbon dynamics are modelled with realistic inertia and rapid (disturbance-related) short-term changes.
Recent developments include a realistic fire dynamics model, a permafrost routine and successful validation against satellite remote sensing data.
From 2001, the DGVM project has been continued under the project name BIS (cf page 30).

CLIMBER

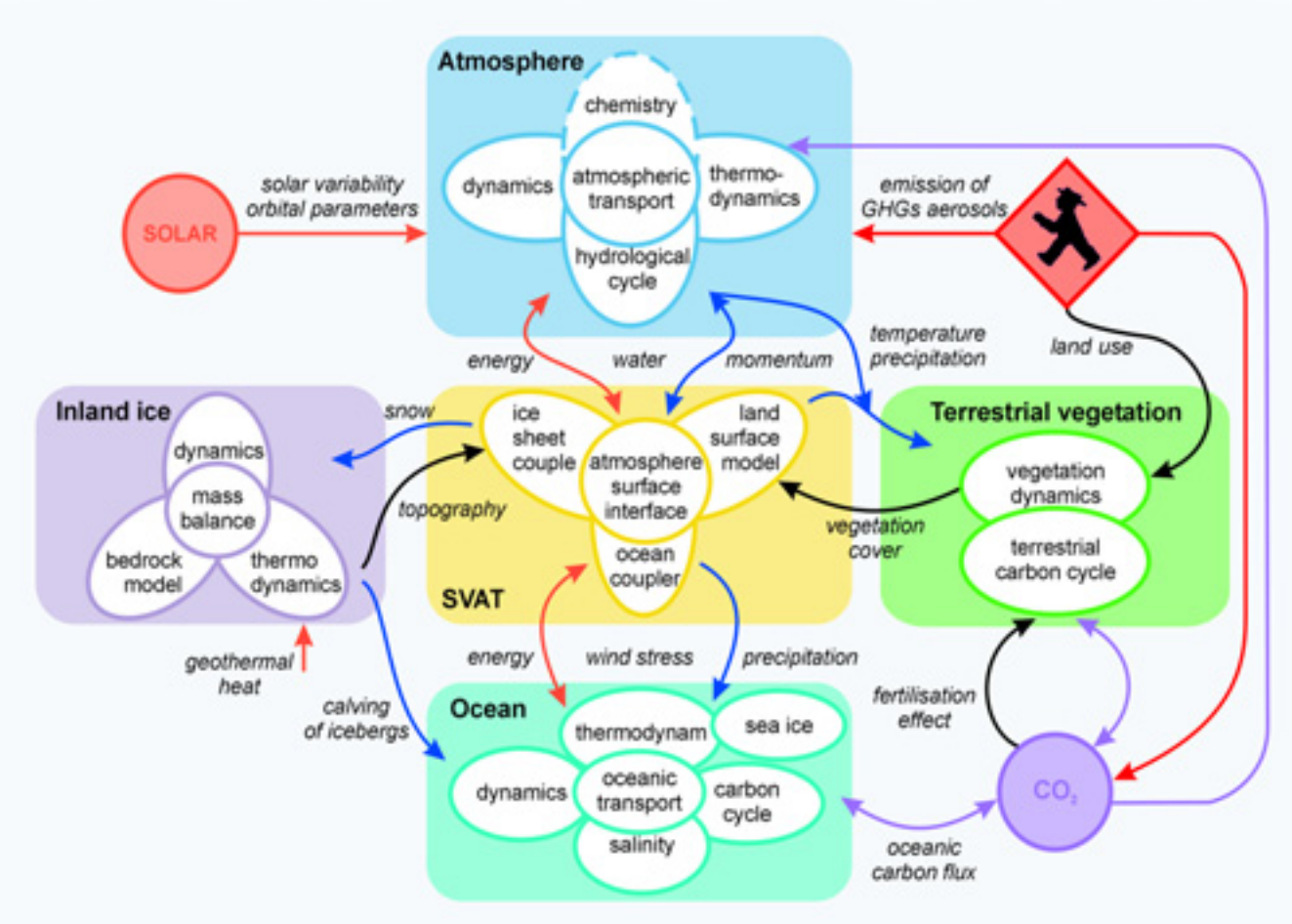
A model of oceanic biogeochemistry and the inland-ice model SICOPOLIS (Simulation code for polythermal ice sheets) were successfully implemented into the new version CLIMBER-2 (cf next page). Using CLIMBER-2 fully coupled simulations of the last glacial inceptions (which occurred some 115,000 years ago) as well as simulations of the present interglacial (the last ~10,000 years), including the terrestrial and oceanic carbon changes, are under way.
In 2001, the CLIMBER activities were merged into the new project named QUEST. Construction of a high-resolution Earth system model is the focus of the new CLIMBER-3 project.

COEM

The fate of the Earth´s ocean was investigated. It was shown that about 25% of contemporary ocean will be subducted by the Earth`s mantle in the next 1 billion years. Furthermore a model, which describes the intensification of chemical weathering by terrestrial ecosystems, intercontinental and epicontinental seas, has been developed. It allows estimation of the role of the biosphere in carbon uptake from the atmosphere in different geological epochs. In 2001, the COEM project was merged into the new project TRIPEDES.

POEM was funded in part by the EU, BMBF, and DFG.

Fig. 1: Structure of CLIMBER-2. The climate system model CLIMBER-2 consists of four modules which describe the dynamics of the climate components: atmosphere, ocean, terrestrial vegetation, and inland ice. These components interact via fluxes of energy, momentum (e.g. wind stress on the ocean), water (e.g. precipitation, snow and evaporation) and carbon. Also the land-surface structure is allowed to change in the case of changes in vegetation cover or the emergence and melting of inland ice masses, for example. The interaction between climate components is described in a so-called Soil Vegetation Atmosphere Transfer Scheme (SVAT). CLIMBER-2 is driven by insolation (which can vary owing to changes in the Earth orbit or in the solar energy flux), by the geothermal heat flux (which is very small, but important in the long run for inland ice dynamics), and by changes imposed on the climate system by human activities (such as land use or emission of greenhouse gases (GHG) and aerosols).



RAGTIME
Regional Assessment of Global Change Impacts Through Integrated Modelling in European River Basins

Project speaker: Alfred Becker
PIK project members: Werner Lahmer, Valentina Krysanova, Beate Klöcking.

RAGTIME covered a variety of projects for the regional modelling of global change impacts. Some of the topics were finished in 2001, others are being continued within the new BMBF-funded project "Integrated Analysis of Global Change Impacts on the Environment and the Society in the Elbe River Basin" (GLOWA-ELBE) and the "Brandenburg Simulator of Environmental and Socio-oeconomic Transformations in the context of Global Change" (BEST, cf TOPIK 5, page 46).

RAGTIME Deliverables

Results from RAGTIME research were primarily provided within externally funded projects, in particularly "Impacts of landuse on the water and nutrient balance in the Elbe river basin" (Elbe Ecology, BMBF) and "Water and material retention in the Elbe river lowland" (WaStor, BMBF).

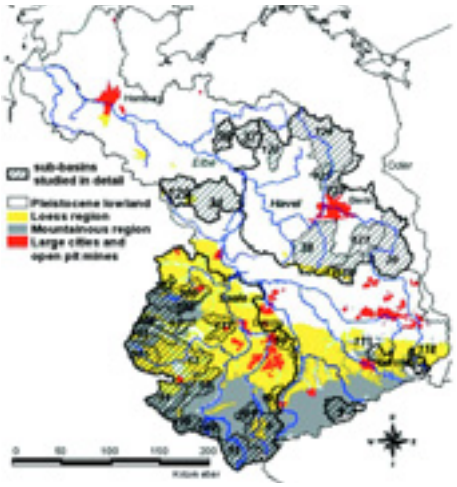


Fig. 1: German part of the Elbe basin including its natural structure and the sub-basins in the Saale and Havel basins studied in detail.

Methods and program systems (ArcEGMO, SWIM) have been developed and applied to calculate aerial distribution patterns of water balance components, including three runoff components and associated nutrient flows in dependence on climate and land-use characteristics, and changes in these. Figure 1 gives an overview of major natural regions of the Elbe basin and on the sub-basins studied in detail. The results of both projects will be published in separate books.

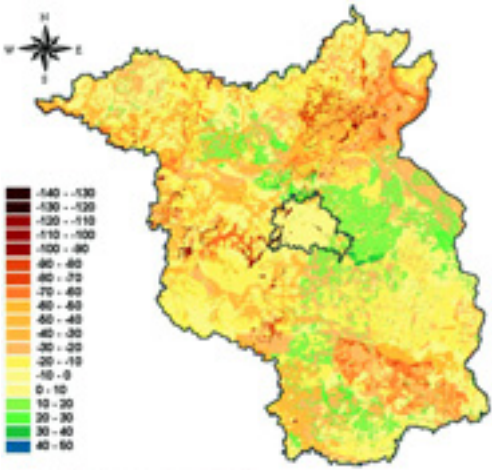


Fig. 2: Absolute changes of percolation calculated for the State of Brandenburg in the period 1961-1998 (in mm/year).

Two studies were performed in collaboration with the Environmental Protection Agency Brandenburg, which provide basic input for water management activities in the State of Brandenburg. In addition to the spatially distributed modelling of water balance components, trend analyses of percolation have been performed, which indicate considerable changes already under the current climate. The absolute changes of percolation in the period 1961-1998 given in Figure 2 show reductions in about 75% of the total area. Impacts of climate change on the water balance were also studied in Brandenburg and some other regions. Some of the results are summarized within the project KLIMOSTAT, funded by the German Foundation for the Environment (DBU).

Perspectives

The European Water Framework Directive aims at a general improvement of water quality in European river basins. As a contribution to this directive, two research projects funded by BMBF started in 2001, one in the Unstrut and the other in the Havel basin. Both projects are closely linked to GLOWA-ELBE and also form an integral part of BEST.

WAVES
Water Availability, Vulnerability of Ecosystems and Society in the Northeast of Brazil

Project speaker: Friedrich-Wilhelm Gerstengarbe
PIK project members: Uwe Böhm, Axel Bronstert, Andreas Güntner, Detlef Hauffe, Annekathrin Jaeger, Maarten Krol, Martin Kücken, Hermann Österle, Peter C. Werner, Ursula Werner, Martin Wodinski.
External project collaborators: Technische Universität München-Weihenstephan, Universität Stuttgart-Hohenheim, Universität Köln, Gesamthochschule-Universität Kassel, Hydroisotop Schweitenkirchen, Universidade Federal do Ceará, Fortaleza, Universidade Federal do Piauí, Teresina, Fundacao Cearense de Meteorologia e Recursos Hídricos, Fortaleza.

Final Summary

The population of semi-arid regions, in particular in developing countries, is extremely vulnerable to global climate change. Therefore tools for a sustainable water and land-use management under climate change conditions have been developed. As a case study, the Brazilian states Piauí and Ceará were chosen. Integrated regional scenarios have been elaborated in close co-operation with Brazilian partners, in particular with local government and scientific institutions. This co-operation guaranteed interdisciplinary communication between scientists of different backgrounds and between scientists and stakeholders. As a main result of the WAVES project a number of methods and tools - listed below - are now available to Brazilian scientists and authorities to develop future strategies in water and land-use management. In this way it is possible to supply semi-arid regions of Brazil with water of sufficient quality and quantity in a sustainable way. A comprehensive report discussing the major results and its potential applications achieved in the WAVES project is in press (PIK, 2002).

Fig. 1: Investigation area, Piauí and Ceará in Brazil.

	Achievements	Potential Application
MACROSCALE	Semiarid Integrated Model	Long-term strategic planning of sustainable development of land use and water management
	Climate scenarios	Long-term planning for the period of 2000-2050
	Soil and Land Resource Information System	• Data base of soils and land resources • Large-scale agro-ecological zoning • Identification of areas with high production potential or high erosion risk in relation to climate, soil and management
	Model of Water Availability in Semiarid Environments	• Simulation of natural water availability in surface waters and dams • Simulation of the effects of investments in the water storage or water transposition on availability of water in the individual municipalities and river catchments
	Nordeste Water Use Model	• Estimation of water demand per municipality as a function of population growth, infrastructure, water pricing and irrigated areas
	Hydro-sedimentation	Calculation of sedimentation in large water reservoirs
	Data base of water costs	Estimating the costs for the supply of water as a function of water extraction technologies
	Regional Agricultural Sector Model of Ceará and Piauí	• Spatial distribution of water demand in the agricultural sector, in relation to farm size and farm technology level • Income structure according to the regional availability of resources
	Migration Flow	• Estimation of changes in life quality per municipality • Estimation of net migration rates
MESOSCALE	Model for sustainable development of land use	Medium-term strategic planning of sustainable development of land use and water management
	Soil and Land Resource Information System	• Soil database • Estimation of yield losses
	Modeling of Water Availability and Quality in Rio Guaribas Basin	Estimation of water availability in surface and ground waters
	Survey of water quality and water infrastructure in the municipalites of Picos and Tauá	• Recommendations for improving drinking water supply and suitability of waters for irrigation
MICROSCALE	Erosion Productivity Impact Calculator	Identification of optimal crop management (fertilization, irrigation) in relation to soil, weather conditions and crop
	Testing of crop management options in maize and cowpea cropping systems	Management recommendations for agricultural extension services
	Assessment of soil water balance as a function of weather conditions, soil and vegetation	Calculation of irrigation requirements
	Botanical survey in Caatinga vegetation	Identification of genetic resources for potential economic use

Fig. 2: Models and scenarios for the investigation area in co-operation with stakeholders.

The WAVES project was mainly funded by the German Ministry of Education and Research (BMBF) and by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) of Brazil.

EUROPA
European Network Activities on Global Change

Project leader: Manfred Stock

Overview

A number of project activities at PIK, most of them financed externally by the European Union, were bound together to a kind of 'concerted action' named EUROPA, to support internal and external scientific co-operation and exchange. Most of the topics and results are closely connected to the other core projects and these are included elsewhere (see table below).

Project Activities and Concerted Actions

ACACIA

The final report, published Nov. 2000, two weeks before the climate conference in The Hague and in the wake of disastrous floods in southern England and the Alps, reveals that parts of Europe can expect more flooding, but may reap some benefits from climate change, reducing energy needs for heating and increasing potential for forestry and some types of agriculture. More important, the project team with members from PIK and headed by Martin Parry, concludes that adverse effects of climate change will be greater in southern than in northern Europe, with increased desertification, water shortage and forest fires in the Mediterranean region. This has major implications for environmental policy in the EU. The report gives almost 50 recommendations for policy and research (www.jei.uea.ac.uk/acacia_report.html).

CLIMPACT

The European Arctic is a particularly sensitive part of the global system. Through a series of three workshops, this ESF network brought together two important research communities, regional climate modellers and impact researchers. With participation from PIK it has helped to enhance Europe's capacity to carry out regional integrated impact studies, combining both the natural and the socio-economic aspects of global change impacts on a regional level.

Outlook

This core project ended in 2000. In the new research programme TOPIK, starting 2001, another project also named EUROPA adopted parts of this network activities, by modelling, reflecting and communicating possible futures of Europe in the context of global change. Other European activities are associated to respective PIK projects according to their subjects.

The project activities in EUROPA were funded by the EU.

Table 1: List of project activities under **EUROPA** and other projects.

Acronym	European Network Activity	see project (end of act.)
ACACIA	A Concerted Action Towards a Comprehensive Climate Impacts and Adaptation Assessment for the EU)	(Report: 02.11.2000)
CLD	Modelling the Effect of Land Degradation on Climate	POEM (30.04.2001)
CLIMPACT	Regional Climate Modelling and Integrated Global Change Impact Studies in the European Arctic (Concerted Action)	(30.09.2000)
DART	Dynamic Response of the Forest-Tundra Ecotone to Environmental Change	CHIEF (31.03.2001)
EUROTAS	European River Flood Occurrence and Total Risk Assessment System	RAGTIME (31.12.2000)
LTEEF-II	Long-Term Regional Effects of Climate Change on European Forests: Impact Assessment and Consequences of the Carbon Budget	CHIEF (30.06.2000)
MAGEC	Modelling Agroecosystems Under Global Environmental Change	AGREC (30.03.2001)
RICAMARE	Research In Global Change in the Mediterranean: A Regional Network (Concerted Action)	RESOURCE **(**in **2002)**

AGREC
Assessment of Agro-Economic Impacts of Climate Change

Project speaker: Frank Wechsung
PIK project members: Gerd Bruschek, V. Krysanova.

Introduction

The AGREC project mainly focused on simulation studies on the impact of climate change on regional crop production. In addition, the statistical modelling of Morocco's wheat yield fluctuation using teleconnections and circulation measures was continued (cf AIM p. 52). Below, we give an example of a regional crop yield study carried out for the State of Brandenburg.

Brandenburg Crop Study

Regional simulations of crop yield have been carried out for present-day climate and a series of climate change scenarios using the eco-hydrological model SWIM. The crop spectrum was restricted to the three crops winter barley, winter wheat and silage maize. The model SWIM was run under present-day climate conditions around 1951-1990 (referred to as period A) and under altered climates referred to as periods B and C. The dates of sowing and harvesting were the same for the control period and for the climate scenarios. The atmospheric CO_2 concentrations for the control period A and the two scenario periods B and C were set to 346, 406 and 436 ppm, respectively. Higher CO_2 is likely to stimulate photosynthesis and to decrease transpiration per unit leaf area. However, the real extent of these effects at the regional scale is still in question. Therefore, we considered three cases (C0, C+, C++) reflecting the impact of elevated CO_2 concentrations on crop yield. In the case C0, the CO_2 impact was neglected. The CO_2 effect on photosynthesis was only taken into account in the variant C+, and in the case C++, CO_2 was allowed to affect both photosynthesis and transpiration.

Climatic Sensitivity of Brandenburg's Wheat, Barley and Silage Maize Yields

The correlation between temperature change and yield fluctuation was negligible for all crops. Results of regression analysis indicate that wheat is most sensitive and silage maize least sensitive to decreasing precipitation. The sensitivity decreases from C0 to C++, which relates to the effects of higher CO_2 on photosynthesis and transpiration. In conclusion, crop production in the State of Brandenburg appears more sensitive to precipitation than to temperature changes. Expansion of maize cropping can be expected under drier climate conditions, because it decreases the vulnerability of Brandenburg's fodder production to drought.

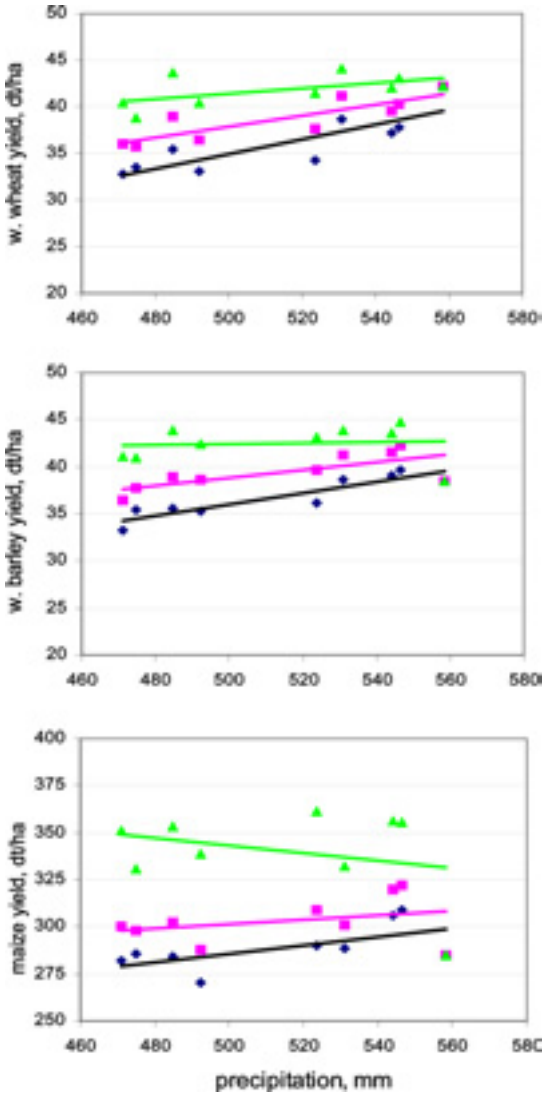


Fig. 1: Regression lines showing the dependence between crop yield and precipitation. Depicted are the results for winter wheat (top), winter barley (middle), and silage maize (bottom). The results are based on simulated regional means for the reference climate and eight climate scenarios, and for three cases of varying sensitivity of crops to atmospheric CO_2 concentrations: 'CO' (black), 'C+' (pink) and 'C++' (green).

AGREC was partly funded by BMBF.

CHIEF
Global Change Impacts on European Forests

Project speaker: Petra Lasch
PIK project members: Franz -W. Badeck, Markus Erhard, Ylva Hauf, Markus Lindner, Jörg Schaber, Felicitas Suckow.

Introduction

The project CHIEF aimed at the assessment of possible impacts of global environmental change on forests in Europe with main emphasis on

- forest growth and carbon storage,
- species composition,
- economic consequences,
- secondary functions of forests,
- interaction with hydrology.

Analyses and impact studies were focused on different levels of spatial and temporal resolution with special emphasis on the regional scale.

German Forest Sector under Global Change

In the 'German Forest Sector under Global Change' (GFS) study, an interdisciplinary team of forest scientists investigated impacts of climate change on forest succession, growth and yield projections, decision-making in forest management, and forest economics. The projected impacts of climate change on the German forest sector are very sensitive to the amount and annual distribution of precipitation in the future climate. Especially spruce and beech may suffer from increased drought stress. Significant negative ecological and socio-economic impacts are possible in regions with warm and dry site conditions. However, the overall conclusion was that climate change constitutes a manageable risk to the national forest sector.

The GFS study was the first integrated climate impact assessment study for the German forest sector and it covered a broad range of disciplinary simulation approaches that is unparalleled in current forest impact studies. The results underlined the importance of considering both the ecological and economic impacts of climate change.

Analysis of Hydrological Fluxes of Forest Stands

At six sites of the Pan-European Programme for Intensive and Continuous Monitoring of Forest Ecosystems (Level II) with managed pine forest stands in Brandenburg, Germany (see Figure 2, right), the forest model 4C (FORESt Ecosystems in a changing Environment) was applied to investigate the sensitivity of the forest water budget to climate change.

Two simulations were carried out with current climate (1996-1999) and a climate scenario with a 20% reduction in precipitation at all sites. The comparison of results showed that under dryer conditions the percolation from the rooting zone of soil declined for all stands. Additionally, the share of percolation in the total water budget decreased by about 7% and the share of interception and transpiration increased by 3-4% (see Figure 2,). This underlines that groundwater recharge was most affected by reduced precipitation.

Fig. 1: Components of the GFS study: Several simulation models were linked to a forest estate model representing the most important forest types of German forests. Different management strategies were investigated under current and future climate scenarios.

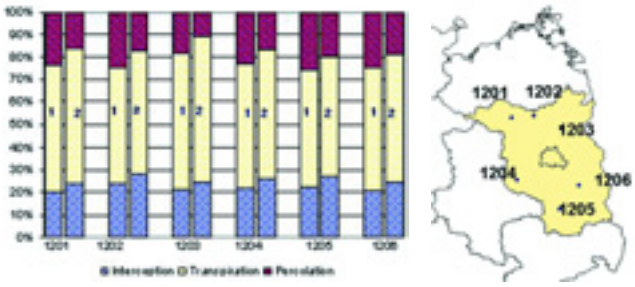


Fig. 2: Left - Shares of simulated yearly water budget (mean of period 1996 - 1999) [1] with measured meteorological data [2] climate change scenario with percolation reduction (20%).
Right - Map of Level II monitoring sites in Brandenburg: 1201 Natteheide, 1202 Beerenbusch, 1203 Kienhorst, 1204 Weizgrund, 1205 Neusorgefeld, 1206 Schwenow.

This project was partly funded by BMBF and the European Commission.

RESOURCE
Social Dimensions of Resource Use

Project speaker: Manfred Stock
PIK project members: Holger Hoff, Friedrich-Wilhelm Gerstengarbe, Richard Klein, Lucas Menzel.

Rationale
In RESOURCE we investigated socio-economic factors and processes concerning use of fresh water under global change and the way these interacted with natural processes. The Mediterranean was identified as a suitable study region to investigate how adaptation and sustainable management options could serve to reduce vulnerability of water resources to climate change. The report for 2000 and 2001 concentrates on two project activities, a joint European project and a German-Israeli co-operation.

RICAMARE - Research In global ChAnge in the Mediterranean: A REgional network
RICAMARE was a concerted action which ran for three years and organized several courses and workshops on different issues of global change (see http://medias.obs-mip.fr/ricamare/). The goals were capacity building and identification of research needs. PIK was involved in the steering committee and contributed mainly to two workshops:

- Assessment of the costs of global change in the Mediterranean, 18-19 February 2001, Milan,
- Assessment assimilation, and validation of data for global change related research, 21-24 February 2001, Casablanca.

RICAMARE ended in 2001 having established a network and an action plan recommending further research activities ('The RICAMARE Manifesto').

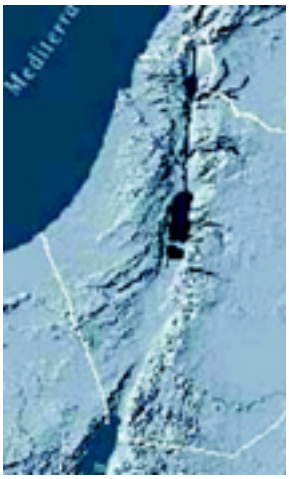
German-Israeli Co-operation: GLOWA Jordan River
PIK has established a collaborative project with partners from the eastern Mediterranean region. The project aims to carry out an integrated assessment of global change impacts on water resources and develop strategies for sustainable management of water resources. A research network with partners in Israel, Jordan and the Palestinian Authority was initiated through:

- a visit of PIK scientists to the region, July 2000, and
- the BMBF-funded GLOWA Jordan River project, with a meeting in the region in November 2001.

PIK is engaged in the co-ordination of the GLOWA Jordan river project together with the University of Potsdam. Further contributions by PIK are:

- nested regional climate modelling for the eastern Mediterranean,
- development of a catalogue of regional climate change scenarios,
- land-use and land-cover scenarios and derived land-surface parameters,
- effects of changing water availability on agricultural vegetation,
- modelling agricultural productivity, water-use efficiencies, and bi-directional vegetation-atmosphere interactions,
- basin-wide vulnerability assessment and integrated river basin management,
- stakeholder participation.

In 2001 the activities became part of the project WADI.



GLOWA Jordan River Project - Work Packages (WP):

WP I Global change scenarios of climate and land use
WP II Water resources: changes of water availability and demand
WP III Water in (semi-)natural ecosystems: interaction & management
WP IV Water and agriculture: interaction & management
WP V Integration and stakeholder participation: risk perception in regional land & water management

Fig. 1: Map of Israel and the river Jordan valley and list of work packages in the GLOWA Jordan River project.

RICAMARE was financed by the European Commission as part of ENRICH (European Network for Research into Global Change). GLOWA Jordan River is partly funded by the BMBF.

Sustainability Science

Integrating Science for Sustainability

The 21st century will either witness the transition to global sustainability or the further separation of cultures and generations into winners and losers under accumulating environmental and developmental pressures.
Sustainability science is an emerging discipline of science dealing with the question of how our societies can be transformed in order to bring about a sustainability transition. This sustainability transition will change our social, political, and economic institutions and procedures in a way that is beneficial for both human societies and the ecological systems they are part of. Examples are the transformation of the energy system from being carbon based to a non-carbon solution; an approach for how a growing world population can use its nutrition base without degrading it; or a world water management which makes sure that clean drinking water is available all over the world. Research on the sustainability transition involves various scientific disciplines from the natural and social sciences, because a profound and practical scientific understanding is required of the myriad of processes and interconnections that make up our living Earth - be it the formation of sea ice, the breathing of forests or the use of land and water resources by human society. Studying parts in isolation will not suffice: an integrated science of the Earth system is called for.

Coevolution of Nature, Society and Science - The Dynamics of a Complex Relationship Becomes Critical

By John Schellnhuber

The term "sustainable development" has become a fashionable expression in the vocabulary of the modern cosmopolitan. It indicates a *balanced interaction of ecological, economic and social concerns*, and does so in a conveniently vague way. The literal German translation as "Nachhaltige Entwicklung" goes even one step further, offering an almost vacuous concept whose content can be (mis)construed to suit the aims of almost any interest group - especially in the context of contemporary politics. The German Bundestag recently established a "Sustainability Council" comprising influential representatives from all societal segments and strata, who discuss and, if necessary, negotiate the integration of socio-economic and ecological development. The intention is entirely praiseworthy, and the Council may indeed prove constructive - if its members succeed in setting aside their own particular interests and address the heart of the matter without further delay.

But what exactly is the "heart of the matter"? Countless more or less scientific publications have addressed the subject of sustainable development since it was catapulted into the discursive arena by the Brundtland Commission in the 1980s. Unfortunately, most of these discussions have failed to arrive at an acceptable definition which goes beyond the well-meaning but simplistic notion of "satisfying basic human needs without destroying the Earth!". Thus, a few years ago, I set out to unearth the logical core of the concept of sustainability. My efforts have led me to the conclusion that this core is divided into distinct chambers that house fundamentally different interpretations: The rigorous adherence to minimum ecological and socio-economic standards; the perpetual maximization of global social welfare; the containment of potentially disastrous risks; the establishment of the equity principle in an everlasting intergenerational contract; and the implementation of an acceptable state of planetary equilibrium, which would mark the end of all environmental history - each of these paradigms (individually or combined) could be made the objective of sustainable development [1].

The general discussion on "sustainability" has recently been refuelled, gaining considerable depth of focus. This was evident at the Global Change Open Science Conference in July 2001, which brought together in Amsterdam more than 1800 environment & development researchers from 100 countries at what can be considered the scientific counterpart to the political Earth Summit in Rio de Janeiro in 1992. In a plenary session at the conference initiated by Bill Clark (Harvard University, USA), the birth of a new science, christened "sustainability science", was announced. In his subsequent characterization of the fledgling discipline, Clark drew heavily on the seminal essay that appeared in the American Science magazine in April 2001 and was written by an interdisciplinary team of authors (including two PIK researchers) [2]. In view of the introductory remarks about semantic vagueness, I will employ my authorial privilege and henceforth interpret the term sustainability science as

"coevolution science". This also provides an adequate translation into German, namely "Koevolutionswissenschaft".

For in fact, the envisaged new science involves a vast complex of factors, namely the closely linked and reciprocally accelerating evolutions of nature, society and knowledge on a global scale - a process, which must not only be concisely explained by the scientific system, but in which this system has to reinvent itself. Thus, *nota bene*, coevolution science is both the objective science of human-environment coevolution and a subjective coevolving factor of that dynamic interaction. These statements require further explanation. I would like to offer one by relating the true story of a fictitious microcosm.

The Parable of La Trinidad

On the rocky plateau of the most remote south-eastern flank of the Pyrenees, high above the Noguera River, perches the mountain village of *La Trinidad*. When water flows in this river at all, it radiates a beguiling forget-me-not blue only encountered in the high-lying regions of Aragòn or Catalonia. Over the course of the centuries, the grey slate houses of the village have slowly crept up to the precipice of the cliffs, becoming an organic extension of their steep wall. Since time immemorial, the village's inhabitants have supported themselves through local agriculture and simple handicrafts: Cultivating wine, fruit and olives in the tillable soils of the slopes above the village, carving household tools from the wood of the box tree, weaving leather shoes or producing other such crafts. A simple and monotonous, in other words, controllable and predictable existence. But life in La Trinidad is threatening to be thrown out of balance.

More and more members of the community complain of cracks and fractures in their buildings, stone avalanches have frequently swept goats and sheep over the precipice, and a crevice - wider than the hand of a child and with no recognizable bottom - has materialized through the centre of the Plaza Mayor. Most inhabitants are bewildered, some frightened and a few already prophesy the demise of the village, whose ruins will plunge into the Noguera far below, shoring up its waters to form a massive lake.

The leaders of La Trinidad are called upon to take action. The mayor convenes a special assembly of the community council, which after long debate decline to reach any concrete conclusions or undertake measures without first getting a problem analysis from a "top-notch expert commission". Its members are quickly found: The head of the local school; a geologist from Zaragoza, who with his own laborious efforts converted a half-deteriorated stable into a comfortable holiday home in the village; and, finally, the prior of the nearby abbey, Nuestra Señora de los Àngeles, who is widely reputed for his architectural knowledge. The experts take ample time to conduct on-site investigations of the troubling changes, to search for potentially similar developments in neighbouring villages, to go through the libraries of the province's capital for relevant information, and to lead a number of heated debates. After five months, they present the results of their investigation in another special assembly of the community council: Everything points to the conclusion that massive tensions are building up within La Trinidad's host mountain, which are manifesting themselves in distinct but, as yet, still moderate structural damage. Potential causes include natural, as well as external factors, perhaps even human influence. Causal relationships can only be established through an extensive and costly measuring process over a minimum of two to three decades. An immediate collapse of the entire plateau is unlikely, but cannot be completely ruled out...

The report serves to exacerbate the confusion: Must we, can we, should we do anything given the slim body of evidence? Several council members argue that, for the time being, the findings should not be released, but after intense debate it is agreed that the council must unconditionally fulfil its duty to inform the community. This could only happen by quickly organizing a citizens' meeting. The following Saturday evening, village locals stream onto the Plaza Mayor - gathering, indeed, on the putatively safer slope of the damaged area. The mayor briefly portrays the seriousness of the situation and calls the public to discuss the crisis with the words: "The future of La Trinidad is in your hands!" The discussion slowly gathers momentum although nobody yet realizes that this evening marks the turning point in the village's fate.

A flood of conjectures - banal, astute, ridiculous - circulate among the villagers: Too many new buildings have been constructed in the last few years, whose weight can no longer be supported by the rock. The heavy all-terrain vehicles used intermittently by tourists, but also the tractors employed of late by several farmers, bring the ground into dangerous vibration. No, cry others, fault lies alone with the provincial government and its foolish development projects funded by the European Commission. Who could still doubt that blasting the gigantic new

tunnel to France through the neighbouring mountain range has compromised the structural integrity of the entire region? Other citizens, whose spokesman has studied geo-ecology in Madrid for years but regularly returns to La Trinidad for the semester breaks, contend that the actual cause is to be found in human-driven environmental changes. Have we not let the terraces behind the village, which generation after generation has built into the slopes to fight ground erosion, visibly deteriorate? And what of the heavy harvesting machines that compress the soil of the fields to impenetrable cement? Is the groundwater level not sinking due to the numerous wells dug to enable the transition from traditional agriculture to quasi-industrial production as encouraged by the new national support guidelines? Corn instead of millet, apricot trees instead of olive groves, dessert grapes instead of age-old wine varieties, such as Garnacha and Cariñena: The thirst of these "cash crops" has proven to be nearly insatiable. And worst of all the attempts to reforest the barren Sierra on both sides of the village with Eucalyptus trees. A tiny but unyielding minority of the congregation is of an entirely different opinion: Not human beings but the moon determines the fate of La Trinidad! Decades of observations gathered by a sheep herder with a flare for the natural sciences have clearly shown that the cliffs work in precise rhythm with the phases of the Earth's companion.

At some point the focus of the discussion turns from determining the causes of the phenomenon to the practical consequences for the lives of the villagers:
Indeed, we may know precious little, but we know enough to take action. The most urgent goal must be to stabilize the structural foundation of the ensemble, possibly by permanently sealing the largest cracks in the natural rock; only if these measures prove unequivocally futile would an evacuation plan be drawn up as an *ultima ratio*. These apparently entirely rational suggestions raise strong objections from the more spiritual members of the group: The superior force of nature can hardly be stopped in its tracks by such stop gap measures. The modest financial reserves of the community should be used instead to organize a monumental candle procession - after all, this had already proven successful against the great drought of 1786. But the wait-and-see position also has its say: Who acts over hastily now will in all certainty proceed incorrectly and waste the savings of the community, which are desperately needed to satisfy immediate needs, such as the construction of the long-desired public swimming pool. Not to mention that there have always been cracks in the walls of the houses and the grandchildren of today's inhabitants will most likely leave the village for the city anyway.

It is long past midnight by the time the chorus of arguments and counter-arguments begins to subside. The village leaders briefly withdraw to confer; then they present their summation and an astounding proposal: Evidently, a solution for the enigma of La Trinidad remains to be found, however, the day's discussions have brought forth many valuable suggestions. It would seem that there is no simple overarching explanation due to the apparent interrelation of a number of factors not recorded in any available textbook. Nevertheless, the community could not wait for new literature to appear - conceivably, the fate of the village was already hanging in the balance. If the current obdurate dealing with nature continues, the scales could tip catastrophically. The situation called for an immediate change of attitude to make decisions which none of their forefathers had ever faced. They could attempt to defend the entire village with every means at their disposal in a bid to conquer the nameless, menacing adversary. Of course, they might also decide to relinquish the most unstable parts of the village, salvaging what they could and in certain cases must. First and foremost, the early 12th century Santa Bàrbara church with its unique Romanesque fresco. The virtually dilapidated pauper dwellings at the precipice, on the other hand, hardly seemed worth investing any major effort. Ultimately, the villagers might have to come to terms with the regrettable fact that La Trinidad would eventually have to be completely abandoned. The villagers could only survive this exodus, however, with substantial support from the

state government, whose promises could not be trusted without reservation. Indeed, the authorities would gladly lend a helping hand to rescue the church fresco, in the interest of placing it in the world-famous museum on the Montjuic in Barcelona.

The local council, however, did not consider itself in the position to take responsibility for decisions of such enormity. This critical situation required the total mobilization of joint resources and a new formulation of political demands and objectives. Therefore, they would immediately establish a "welfare committee", comprising the relevant social forces, to which all individual observations of and speculations about pertinent developments should be reported and which would continuously process this information. The committee was expressly authorized to prepare priority lists for the preservation or relocation of valuables and to carry out a preliminary economic assessment of these objects - for the purpose of insurance claims and compensatory payments. From now on, the community meeting was to take place on this square quarter-yearly to discuss the welfare committee's report and to update both its mandate and its configuration. This process was designed to forge a new identity for the village community that would either unite to find a solution to the crisis, or perish together in full awareness...

Global Coevolution

The parable of La Trinidad lends contour and substance to the dynamical interactions between society, nature and science as stylized in the introduction. In the imagined (yet by no means imaginary) scene, far-reaching changes in socio-economic structures trigger an inexorable chain of events. The interaction of these human factors - coupled, perhaps, with the unpredictable processes of nature - rapidly transform the familiar environment and, in turn, alter the community through numerous hitherto unknown burdens and risks. Since existing policies of crisis management are no longer effective - in part because the inherited cognitive system cannot provide adequate or timely problem-solving knowledge - the social body (along with all its organs for knowledge production and the adoption of political objectives) must continuously re-design itself in tune with the "unbridled" forces of nature. The village's very survival may depend on this.

Today, an analogous process of rapid, open coevolution has seized the planetary system as a whole and taken on a unique dimension in history. The aforementioned Amsterdam conference has corroborated this view with an impressive array of insights and data accumulated over the past fifteen years [3]. The central message of the conference summary maintains that, since the onset of the industrial revolution, the Earth System has been forced to deviate from its natural modes of operation through the manifold influences of civilizations around the globe. Human-driven changes - such as variations in the physiochemical composition of the atmosphere, alterations of the continental surfaces brought about by agriculture, and the perturbation of global water and sediment balances - produce multiple interrelated environmental effects which cascade through the planetary machinery in complex ways. Because the operation of this machinery is to a large extent nonlinear (with disproportionate reactions to all kinds of intervention), it is not unimaginable that our civilization could inadvertently activate "ecological switches", triggering abrupt changes in regional or even global environmental conditions. Frequently cited examples of such "critical phenomena" include the suppression of warm ocean currents through the shift of large-scale precipitation patterns in response to anthropogenic climate change as well as the reorganization of the Asian monsoon system as a result of changing meteorological properties of the region's terrain due to expanding agricultural activity, excessive deforestation, and accelerated colonization. Moreover, it is virtually impossible to quantify the probability - let alone the timing - of such events with our current state of knowledge. Humanity must therefore live with environmental risks which can be categorized somewhere between Don Quixote's windmills and Damocles' sword. This lends particular charm to the "Anthropocene", as Nobel Prize winner Paul J. Crutzen refers to our current geological epoch.

The profundity of the problems involved and the scope of the potential consequences represent an unprecedented challenge not only for international politics, but also for our scientific community as a whole. In this context, the classic paradigm of "optimal control" - where we freely choose objectives for the system at stake and implement them down to the last detail with the help of precise expert knowledge pre-collected to cope with any eventuality - becomes a chimera. For instance, it is absolutely impossible to accurately predict the impacts of, let's say, a ten-fold increase in the CO_2 content of the atmosphere - and who would be prepared to undertake such an experiment in the interests of ascertaining the truth? But even the identification of appropriate objectives - for economic growth, improved quality of life, environmental integrity - has become a task that no one

is really willing to tackle, not even the most legitimate and best-fed think tanks of the world. This observation reveals an element of dubiosity in the entire sustainability debate: anticipating the needs of future generations means to *construct* those needs, and thereby guide the development of the planet in such a way that our descendants will have no choice but to accept the demands that we, in the truest sense of the word, have provided for them! More serious, however, is the fact that research can say virtually nothing about the needs of the vast majority of *present-day* generations, since these people happen to have been born far from the citadels of Western welfare [4]. The landmarks of progress fade into the fog...

Facets of Coevolution Science

The Amsterdam Declaration attempts to address the problematic sketched above by fostering the development of a concerted *global system* for environmental sciences in the broadest sense. This system is to distinguish itself through innovative integration methods, transnational structures and perpetual dialogue with affected individuals and interest groups throughout the world. Such aspirations bundle and "earth" a powerful contemporary discourse which is dedicated to the project of "reinventing science" in an age of proliferating uncertainty [5]. Protagonists of this debate stress that today's scientific knowledge is produced within the rapidly thickening *context* of its social effectivity. Furthermore, they argue, this context is not quietly absorbed by the scientific system, digesting and ruminating the cognitive progress, but speaks back to the system at full volume via a thousand-and-one channels. This is not something to be feared - on the contrary, it should be seen as an opportunity to establish a good partnership between society and science based on dialogue and mutual respect.

The Pantocrator (Christ represented as the ruler of the universe). Romanesque church fresco from Sant Climent de Taüll (Vall de Boí, Pyrenees, Spain).

Within the emerging conception of coevolution science, all these facets are assembled and allocated through a "grand unification" of nature, civilization, cognition and their interrelationship. This is a vitally necessary step, as the three respective bilateral relationships in this *ménage à trois* have meanwhile reached critical intensities. Yet coevolution science is not just contemplating (and possibly explaining) the total Earth System, but also represents the potential balance spring of this machinery. For example, it constructs scenarios of technological progress and anticipates its impact on the environment and society, whereby this very progress may be either fostered, rejected, or modified in the first place.

Coevolution science will distinguish itself in essential ways from the "classical" Popperian fairytale world: It will frequently be strategic, not contemplative; qualitative, not exact; hypothetical, not falsifiable; preliminary, not categorical; contextual, not universal; participatory, not objective. And nevertheless, it will seek to establish the highest degree of clarity, creativity and precision. However, our object of study is no longer a single, eternal electron immersed in a perfect, infinite magnetic field. Instead, we must examine complex ecological systems whose individual determinants are impossible to sort out, so that we are forced to employ sophisticated methods for causal pattern recognition. We must study dynamics that are either too slow to be perceived by automated monitoring systems, or too erratic to be predicted using conventional approaches. The virtual reality of computer simulations will at least allow us to access fuzzy caricatures of those processes. We must study the most vulnerable elements of the general nature-humanity relationship, since a comprehensive exploration of the causal matrix involved lies beyond all analytical capability. Inverse approaches, which depart from those elements to construct their multidimensional perturbation potentials, may prove to be the appropriate cognitive tools in this context. Finally, we must study the totality of limited-rational actors, whose environmental and developmental behaviour is at best governed by weak statistical laws. Coevolution sci-

ence will not hesitate to stage the self-modelling of those actors in digital "decision theatres" and to thereby realize the *coproduction* of knowledge in its true sense.

Even this brief illumination of but a few facets of the new science should make evident that giant creative wheels of wisdom must be set in motion. This will require many strong and indefatigable shoulders pushing ahead in unison. In this light, the aspirations outlined in the German government's Sustainability Strategy in December 2001 appear rather weak and unimaginative: By means of a shopping list approach of "twenty-one indicators for the twenty-first century" [6], we are to find our bearings on the road towards a long-term pact among nature, industry and civil society. In the process, however, the strategy is mistaken for its operationalization, and ritual hearings of notorious interest groups are confused with the genuine coproduction of sustainable insight. This is all the more regrettable as the conditions necessary to provide such insight rapidly unfold around us. As long as volition and wisdom (or, in old-fashioned terms, might and mind) fail to unite in an intensive, dynamic and respectful partnership, however, many a temptingly obvious strategy will lead us astray in the long run.

Tidings from the Pyrenees

It has just been announced that a quarter of La Trinidad has plunged into the Noguera river below. There are few casualties, however, as the inhabitants of the affected area had already evacuated their homes. This bit of good fortune is attributable to the work of the welfare committee, which had come to the conclusion that the destabilization of the village was due to the dehydration of aquiferous sediments in the host mountain brought about, in turn, by land use changes and, perhaps, other factors. In recent years, the once firm layer of "cushioning" had begun to give way, triggering a geological chain reaction. Through the most intensive co-operation with the local population, the committee was fortunately able to roughly identify the main disturbances in the water storage system, as well as the location of the most critical tension spots. Now the local community intends to focus all efforts on defending the remaining village torso through a number of measures. A series of practices considered potentially dangerous have been temporarily forbidden. Yet the people will have to dance on the razor's edge of speculation for a considerable period of time ahead. It is nevertheless surprising that the majority of inhabitants are resolute in their decision to stay and help prevent their village from sharing the same fate as countless other ghost towns in the Spanish Pyrenees: La Trinidad will endure for the very reason that it must continually fight for survival ...

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The First Sustainability Days

The First Sustainability Days and the 10th Anniversary of PIK

In October 2001, PIK celebrated its 10th anniversary. It received precious gifts: on October 4th, the totally renovated astrophysical observatory was inaugurated as PIK's new main building. In its basement, this building hosts a new IBM SP high performance computer which was symbolically put into operation on that day. These gifts were given by the State of Brandenburg, the Federal Republic of Germany, and the European Union.

But PIK in turn made a gift to its community by celebrating its jubilee of ten years of innovative research with another scientific invention: the First Sustainability Days. These First Sustainability Days (from 28 September to 5 October 2001) were a pilot series of symposia on sustainability science opening up an annual sequence of similar events, the Second Sustainability Days having already been held at Columbia University, New York, in 2002. The Third Sustainability Days are planned to take place at the University of East Anglia, Norwich.

The Sustainability Days were opened by the Prime Minister of Brandenburg, Dr. Manfred Stolpe, and the Mayor of Potsdam, Jann Jakobs. The Prime Minister highlighted the important contribution made by PIK in shaping the overall concept of "Sustainability". In 1996, the State of Brandenburg joined the "Charter of Valencia" of European regions supporting sustainable development. As a symbolic act the Prime Minister planted an oak in front of the new building.

At the opening event, Professor William C. Clark gave a lecture transmitted live from Harvard University. He discussed the role of the Sustainability Days for establishing sustainability science. Clark addressed three main questions: he asked how global change alters the role of science and technology; what additional knowledge and know-how is needed to promote a sustainability transition; and how to design research systems capable of achieving this knowledge and know-how. In science and technology, a comprehensive approach is needed to overcome the present division of disciplines dealing with sustainability questions and to integrate the diverse levels and actors in civil society. Examples of pressing practical needs are the world-wide urbanization process, declining trends in African agriculture, and the fight against syndromes of mutual degradation of human and natural systems. In order to tackle these problems, it is important to overcome the present situation characterized by the predominance of single scientific disciplines and a research process that is either problem driven or fundamental and not directly linked to decision processes. Instead, there should be truly interdisciplinary research and a steady stakeholder dialogue. Expertise and applications are to be linked across scales, and the research process should be integrated with decision procedures (see ECF-workshop on page 86). Regional centres are needed to organize local stakeholder processes and to channel knowledge and expertise to solve urgent problems on the local level.

The festive inauguration of the main building marked the social highlight of the Sustainability Days. Erwin Staudt, Director of IBM Germany, one of PIK´s sponsors, Dr. Michaele Schreyer, EU Commissioner for Finance, Professor Johanna Wanka, Minister of Science and Research of Brandenburg and Professor Schellnhuber, Director of PIK, symbolically set the new high performance computer into operation.

In their addresses, our donors pointed out their reasons for spending a total of 18 million DM on PIK. Dr. Schreyer made clear that climatic change is a key issue in European policy. PIK is a "good customer", she said, in the shop of European research funding, which was all the more remarkable as PIK was celebrating just its tenth anniversary. Professor Johanna Wanka and Wolf-

Michael Catenhusen, Parliamentary Secretary of State, Federal Ministry for Education and Research, both pointed out the important role of PIK in the scientific landscape of the state of Brandenburg and of Germany as a whole. Professor Hans-Olaf Henkel, President of the Leibniz-Gemeinschaft, confirmed his image as a nonconformist by bringing a highly political spirit into the inauguration event. He argued that sustainability should be a universal concept for the survival of our society and should comprise environmental as well as political and economic aspects. Concerning economic and political aspects, he argued against the German eco-tax and cast doubt on the potential benefits Germany might derive from a pioneer role in environmental policy. He judged both these strategies to be unsustainable in economic terms.

Matthias Platzeck, First Mayor of Potsdam and at the time Chair of the German Federal Council for Sustainable Development, took the opportunity to oppose these theses by arguing that the pioneering role of Germany can induce competitive advantages and thus be beneficial both for environment and economy. They would indeed thus be sustainable in the definition of Professor Henkel himself.

After this policy debate, Nobel Prize Laureate Professor Paul Crutzen made his contribution to the inauguration. In 1995 he won the Nobel Prize for Chemistry for his research in atmospheric chemistry concerning the chemical processes causing the ozone hole. He emphasized the crucial role of the climatic stability of the Holocene for the take-off of human culture. With the large-scale emission of greenhouse gases, humankind gave rise to a new geological epoch he calls the "Anthropocene", where human actions have a considerable and possibly fatal impact on natural systems. He was optimistic, however, that this crucial problem could be tackled. He pointed out that in the 1960s the photo-chemical processes of ozone destruction were not known. It was the outcome of theoretical research which, once comprehended, paved the way for effective policy measures that eventually resulted in the Montreal Protocol and the ban of fluorochlorocarbons all over the world. For him, this is a blueprint for climate impact research. The more the impact and mechanisms of climatic change are understood, the more the pressure towards taking political measures will increase.

Sustainability science is an emerging trans-discipline of science dealing with the question of how our societies can be transformed in order to bring about a sustainability transition for our societies. This sustainability transition will change our social, political, and economic institutions and procedures in a way that is beneficial for both human societies and the ecological systems they are part of. Examples are the transformation of the energy system from being carbon-based to a non-carbon solution; an approach for how a growing world population can use its nutrition base without degrading it; or a world water management which makes sure that clean drinking water is available all over the globe. Research on the sustainability transition involves various scientific disciplines from the natural and social sciences.

With this encouraging statement in mind, the audience moved to our new main building where Friedrich Karl Borck, the architect responsible for the renovation, gave a short tour through the building. If you could not take part, see his article on page 90 or have a glimpse at the workshops results.

The gifts being unwrapped, the scientists of PIK were eager to take hold of them. As a first step, a big housewarming party took place on the evening of the inauguration day. Excellent food and wine, swinging tunes from a marvellous trio, a Wilhelminian jewel of architecture and the good mood of the PIK team were perfect ingredients for an outstanding evening of out-of-the-ordinary academic life.

Scientific Symposia on the First Sustainability Days

To sketch the scientific space sustainability science spans, the Sustainability Days comprised symposia focusing on diverse topics.
The symposium "Methods and Models of Vulnerability Research, Analysis and Assessment" dealt with vulnerability questions and worked towards a definition of vulnerability upon which a research agenda can be built. Vulnerability can be understood as the degree to which an ecosystem service is sensitive to global change in combination with the degree to which a society - or parts of a society that rely on this service - is unable to cope with changes in the quality or quantity of the service (see below). In the symposium "Enhancing the Capacity of Developing Countries to Adapt to Climate Change" 45 experts from developing and industrialized countries, NGOs and multilateral and bilateral donor organizations set up a research agenda to investigate how developing countries could enhance their adaptive potential to hazardous changes of their environment. These hazardous changes comprise both local impacts resulting from climate change and other global change issues. The symposium "Palaeoperspectives on Global Sustainability" took a historic point of view on climate dynamics. Understanding past cyclic variations in temperature and greenhouse gas concentrations is a crucial step for our ability to predict the consequences of large-scale perturbations of the climate system. "Alliances for the Sustainability Transition: The European Climate Forum" was the opening event of this Forum. It was a platform for bringing together stakeholders and scientists in order to jointly define and conduct research related to climate change. The symposium "Contributions to Sustainability Science from Applied Mathematics and Software Engineering" dealt with the specific modelling problems sustainability science poses. Various methods of software engineering, soft computing and numerical mathematics, and their potential to tackle various modelling problems were discussed.

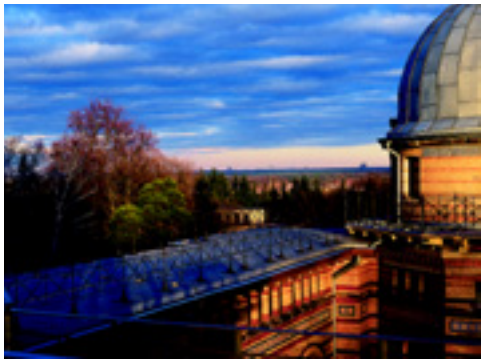
Vulnerability: Methods and Models of Vulnerability Research, Analysis and Assessment
Organizers: Wolfgang Cramer, John Schellnhuber, Bob Corell (Harvard University, USA).

The Vulnerability Workshop was the first part of the "Potsdam Sustainability Days", an annual event that started in Potsdam in 2001 and which it is hoped will wander across the globe in the years to come, promoting sustainability science.

The concept of vulnerability recently emerged from sustainability science as society became aware of global environmental risks such as climate change. Vulnerability assessment turns its attention to changes in the interaction between nature and society, in addition to dealing with the anatomy of environmental changes themselves. The question is "What is the cause of observable changes in the human environment", rather than "What might be likely consequences of drivers of global change". However, a powerful formal methodology to assess environmental vulnerability is still lacking and current approaches use conflicting conceptual frameworks. The Vulnerability Workshop documented, reviewed and discussed the state of methods and models of vulnerability research, analysis and assessment, and set an agenda for future research in this field.

Workshop participants agreed on a first operational definition of vulnerability. They found that vulnerability is a function of a system's exposure to global change stimuli (e.g. climate change, land use change) and of its adaptive capacity. Vulnerability assessment therefore works from two sides: the bottom-up side applies state-of-the-art models of natural systems to describe ecosystem services and their sensitivity to global changes. Simultaneously, in a top-down approach, the adaptive capacity of human sectors is explored in a dialogue between scientists and





relevant stakeholders. Vulnerability as assessed by this approach is the degree to which an ecosystem service is sensitive to global change plus the degree to which the sector that relies on this service is unable to cope with the changes.

The workshop identified the most critical steps in the methodological framework for vulnerability assessment: (1) to include all relevant global change forcing factors and their interactions, e.g. atmospheric changes, N deposition, climate change, land use change; (2) to involve stakeholders from the public and private sectors; and (3) to find ways of quantifying, representing and communicating uncertainty. Strategic partnerships to tackle these highly interdisciplinary research issues were built and reinforced during the workshop. Workshop results are presented on a website dedicated to this purpose - a special issue for a scientific journal is in preparation.

Adaptation: Enhancing the Capacity of Developing Countries to Adapt to Climate Change
Organizers: Richard Klein, Joel Smith (Stratus Consulting, USA), Ferenc Tóth.

The countries and communities most vulnerable to climate change are those that are particularly exposed to hazardous impacts and have limited adaptive capacity. Adaptive capacity is the ability to plan, prepare for, facilitate and implement adaptation measures. It is determined by factors such as economic wealth, technology, information and skills, infrastructure, institutions, equity and social capital. There is an urgent need to better understand adaptive capacity, how it relates to vulnerability and sustainable development and how it can be effectively enhanced. Without such understanding countries run the risk of making ill-advised adaptation investments that do not produce benefits as effectively or efficiently as intended or which are even counterproductive.

The Potsdam Institute for Climate Impact Research and Stratus Consulting (USA) organized a workshop to develop a research agenda targeted at the adaptive capacity of developing countries. The workshop brought together 45 experts from developing and industrialized countries, NGOs and donor organizations. The research agenda, as well as an edited book volume, will be presented at the World Summit on Sustainable Development (Johannesburg, South Africa, September 2002). The workshop was made possible through sponsorship from the World Bank, the Electric Power Research Institute (USA), the Canadian International Development Agency, the German Federal Ministry for Economic Cooperation and Development /Gesellschaft für Technische Zusammenarbeit and the United Nations Development Programme. Additional support was provided by Environment Canada, the Netherlands Climate Change Studies Assistance Programme and the United Nations Environment Programme.

The research agenda developed at the workshop is framed around six questions, which reflect the importance to "mainstream" adaptation to climate change in sustainable development activities. The six questions are the following.

- How does vulnerability to climate change manifest itself and how should it be defined and assessed to identify adaptation requirements?
- How and in what forms does adaptation to climate change occur, what processes and actors are involved and how can it be modelled?
- What constitutes an enabling environment for implementing adaptation options, what is the role of social capital and how can it be enhanced?
- How can adaptation to climate change be integrated into sustainable development and how can synergies with other policy objectives be created?
- How can priorities for adaptation to climate change be set?
- How can the research capacity and intellectual capital of developing countries be effectively strengthened to address adaptation to climate change?



Palaeoperspectives on Global Sustainability
Organizers: Martin Claussen, Stefan Rahmstorf.

One important aspect in the discussion on global sustainability concerns the resilience of the natural Earth system to large-scale natural and anthropogenic perturbations (e.g. changes in solar luminosity, volcanic activity, land use, greenhouse-gas emissions, ...). Of particular interest are the last several hundred thousand years. For this period many climate archives, in particular the ice core records, provide a fascinating picture of the metabolism of the natural Earth system. Temperature and greenhouse gases show cyclic variations of long cold periods and shorter warm interglacials, within apparently stable bounds. On the other hand, Dansgaard-Oeschger and Heinrich events show the possibility of very large and abrupt climate swings, while the subtle changes during the "relatively quiet" Holocene need to be well understood in order to put the recent climate change into context.

Approximately forty palaeoclimatologists and palaeoclimate modellers discussed the following topics: lessons to be learnt from the astronomical theory of climate, the role of the ocean in rapid climate change, the problem of leads and lags between climate changes found in Arctic and Antarctic records, and lake sediments as climate indicators. Discussion on palaeoclimate models covered the full range of the spectrum of climate system models ranging from conceptual models of the late Pleistocene (the last ~700,000 years), models of intermediate complexity focusing on simulations of the last glacial cycle, and comprehensive models which are used to zoom into short time intervals of the last glacial maximum.

It was generally agreed that there is no direct analogue for potential future climate change. However, analyses of palaeoclimatic records have proven to be extremely useful in validating climate models - a prerequisite for assessing potential impacts caused by anthropogenic perturbations of the climate system. In particular it was recognized that terrestrial climate archives are of particular importance. Some terrestrial archives reveal an annual resolution - as shown in the example above which was provided by one of the workshop participants - thereby allowing the reconstruction of decadal climate variability.

Contributions to Sustainability Science by Applied Mathematics and Software Engineering
Organizers: Rupert Klein, Gerhard Petschel-Held, Nicola Botta, Cezar Ionescu.

A review lecture summarizing key challenges in sustainability science was followed by two sub-sessions focusing on two distinct research areas in which mathematics and computing science can contribute to the field.

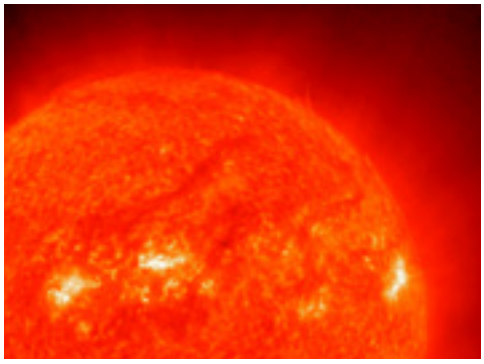
MATHEMATICAL MODELLING AND COMPUTATIONAL METHODS

Sustainability science deals with regimes where anthropological impacts significantly affect the balance of the Earth system. Since such situations are unprecedented, related computational models cannot generally be validated entirely on the basis of measured data. How can we then achieve reliability of integrated models and their components? This session gave some answers from applied and computational mathematics. The contributions included:

- reduced model equations for geophysical fluid mechanics and their rigorous justification,
- the use of advanced computational models in revealing complex physical mechanisms,
- adaptive numerical methods,
- software engineering challenges in model coupling,
- innovative approaches to data assimilation, and
- thermodynamics concepts in ecological modelling.

UNCERTAINTY AND SOFT COMPUTING

Many aspects of sustainability science are specified in soft, qualitative terms only. This is particularly true for the social sciences and the linkage between anthroposphere and nature. Furthermore, available data are often



uncertain, vague or incomplete. This leads to intensifying demands for systematic approaches to uncertainty assessments for given, quasi-deterministic models, and for modelling approaches geared towards the exploration of inherently uncertain or "soft" knowledge. The contributions to this session included:

- relative entropy-measures in quantitative uncertainty estimates,
- foundations, classifications, and generalized concepts of multi-valued logics, and
- qualitative and semi-quantitative reasoning, set-valued methods, and possibility theory.

Alliances for the Sustainability Transition: The European Climate Forum

Organizers: Baldur Eliasson (ABB Corporate Research Ltd, Switzerland), Regine Günther (WWF Germany), Klaus Hasselmann (Max Planck Institute for Meteorology, Germany), Carlo C. Jaeger, Martin Welp.

The workshop was the official opening of the European Climate Forum (ECF), which is a non-profit organization carrying out joint studies on climate change. The focus of this workshop was on future orientation in climate change research. It was organized by ECF jointly with PIK and explored the various expectations and conflicts of interest related to climate change issues.

The event brought together key stakeholders and researchers. The stakeholders included selected representatives from the insurance sector, coal industry, renewable energy industry as well as environmental NGOs, the European Union and public media.

The starting point was that different stakeholders have their own underlying assumptions, interests and distinctive expectations concerning the issue of climate change. Some representatives gave more emphasis to adaptation research while others formulated more research needs in, for example, carbon sequestration. To discuss these differences parallel break-out group session took place on the following topics:

- climate policy instruments,
- renewable energy technologies and CO_2 sequestration,
- coping with extreme weather events,
- the pioneering role of Europe in climate protection,
- managing uncertainties in climate change research.

In the groups two main questions were addressed. First, what research questions relevant for stakeholders can be identified? Second, are there at present strong differences of views among different stakeholders concerning these research questions?

Results of the workshop were used to develop Joint Forum Studies and to consolidate the working groups. The workshop documentation can be downloaded from the ECF- website (http://www.European-Climate-Forum.net).

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Gerling Global Rück
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The New Main Building

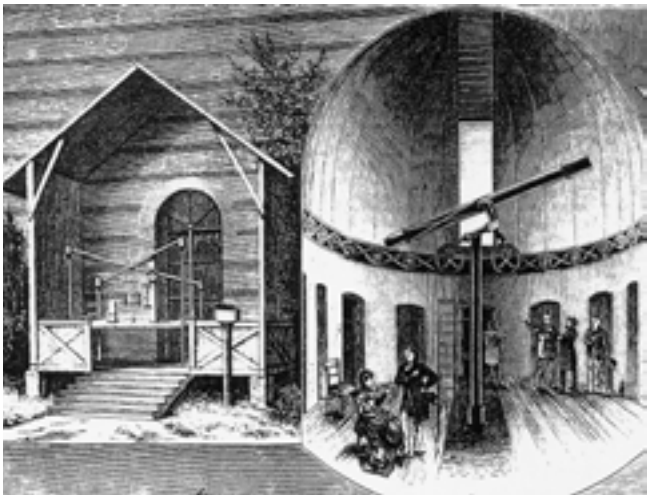
The Historic Astrophysical Observatory

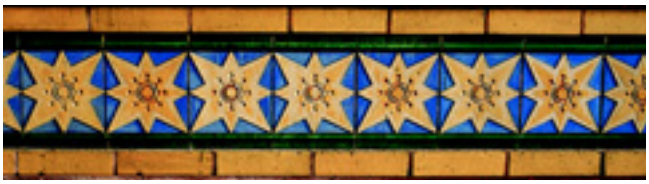
Even with its rusty cupolas and a birch tree pushing up through its brickwork, the 120-year old Astrophysical Observatory inspired admiration. Following the loving restoration over the past few years, however, the decadent charm acquired by the building after World War II has disappeared and its serious interest in scientific research has resurfaced.

The basic renovation under the direction of architect Friedrich Karl Borck, costing approximately DM 8 million, and the underground extension constructed for PIK's new high-performance IBM computer at a cost of DM 2.7 million, were carried out with funding from the European Union, the State of Brandenburg and the German Federal Government.

The listed building with its three characteristic cupolas is to become PIK's new head office. The new rooms can only accommodate about 40 of the approximately 190 staff, mainly management and administrative staff. The conference and seminar room is located under the central cupola. This room and the other cupolas were used by astrophysicists as a solar observatory up to the end of the last century. Night-time observation was gradually transferred to more favourable observation sites as far back as the 1970s. Only the eastern cupola has retained its rotating and retractable roof and following restoration astronomers will continue to use it as a solar observatory. The other cupolas have been fixed and insulated at great expense as part of the renovation process.

The Potsdam Astrophysical Observatory was established in 1879. It was the first of the Royal Observatories and other scientific buildings to be designed by architect Paul Emanuel Spieker on the Telegrafenberg and the first





institute in the world to bring together astronomy and physics. The predominant interest at that time was in the physics of the sun but also in the connections between sun, climate and the Earth. This is also reflected in the subsequent scientific buildings on the Telegrafenberg. In 1881 in the basement under the eastern cupola of the Astrophysical Observatory, Albert A. Michelson for the first time performed his famous experiment proving that the speed of light in a vacuum is identical in every direction and is a maximum speed that cannot be exceeded. Consequently, according to the initial premise of the experiment, the orbital movement of the Earth has no influence on the speed of light. In attempting to understand the results of this experiment, Albert Einstein established his Special Theory of Relativity in 1905. From 1885 to 1916 Karl Schwarzschild was Director of the Observatory. He was responsible for the first accurate solution to Einstein's equations, epitomizing the General Theory of Relativity. The so-called "Schwarzschild Solution" is now of fundamental importance in many areas of physics.

Architecturally, the building can be regarded as neoclassical. Spieker studied under Friedrich August Stüler, a student of Schinkel. In addition to the personal style of Karl Friedrich Schinkel, the building also recalls the regional traditions of Brandenburg brick construction. Spieker referred to the Royal Observatories, which were all created under his direction, as "functional scientific buildings". Given the loving details such as star friezes created from glazed tiles, the use of sandstone capitals or the two-tone facade walls with different edging accents, as well as the use of blind masonry, this description strikes us as somewhat strange today. Lavish wall paintings were discovered inside the building during the restoration work and these have been reconstructed using appropriate templates. For more details about the architecture of this unique building see next page.

The meteorological station (west arbour) and the interior of the middle domed hall. Wood engraving by H. Nisle, 1887.

Above: frieze with star motif.

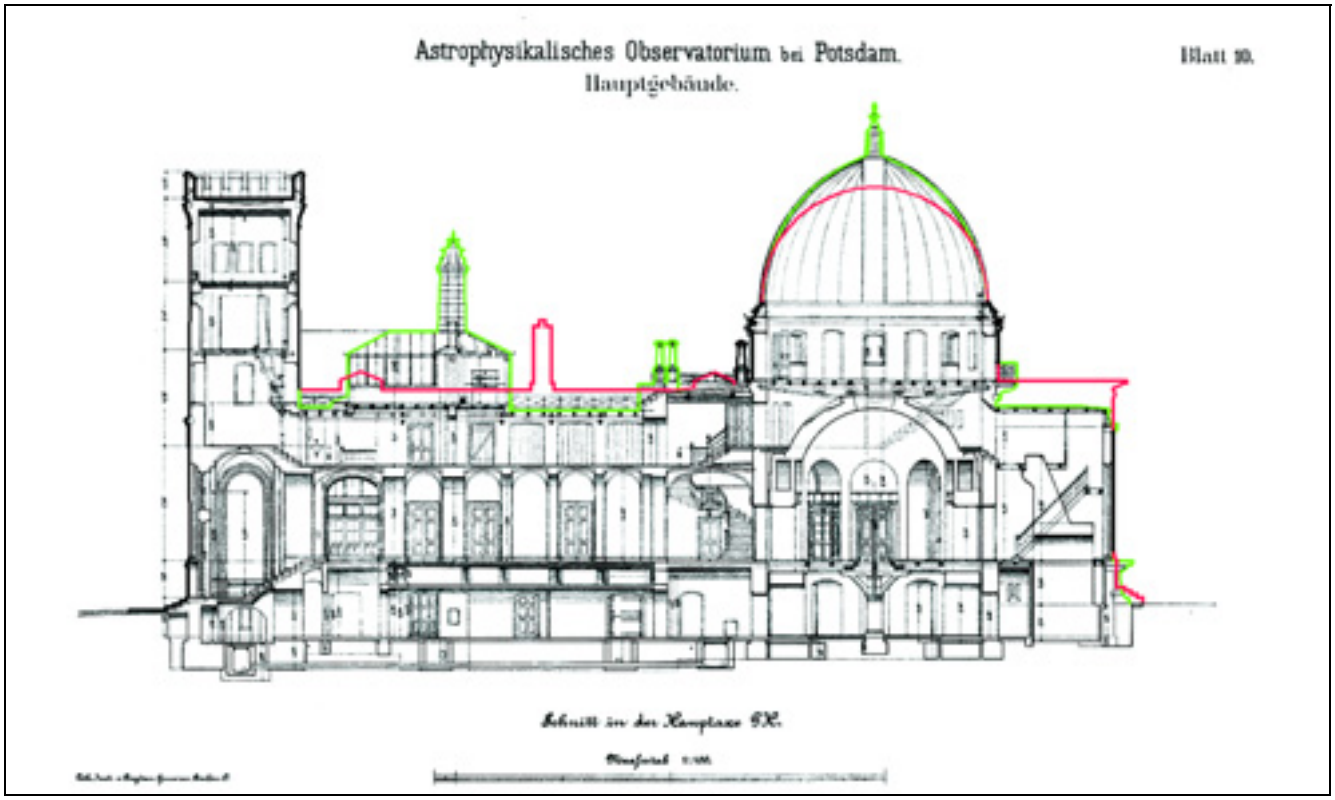
From the Royal Astrophysical Observatory to the Climate Impact Research Institute

By Friedrich Karl Borck

It is an architect's dream come true. Immediately after reunification, the Telegrafenberg, now Albert Einstein Science Park, stood near the top of the list of sites to be visited in the former East Germany, especially for architects. After all, the park, located in Potsdam, boasts one of the most famous, if not *the* most famous, High Modernist structures in and around Berlin – Erich Mendelsohn's Einstein Tower. After crossing through the park's gateway, sometimes still referred to today as the guardhouse and virtually inaccessible before 1990, an enchanted world of the nineteenth century opens before us, just as it had back then: measuring stations, observation towers, machine rooms, and living quarters are scattered throughout a magnificent tree-filled park. Towering brick walls mark the end of lanes that run along the park borders. A massive building laid out in the shaped of a 'T' sits at the highest point of the hill, reachable only by winding paths. Its distinctive design is dominated by a well-fortified square tower at the base and three towers, each crowned by a dome, along the top axis. The two outer towers are connected to the middle tower by arcades, lending them a striking appearance reminiscent of a mosque. In fact, historian Michael Bollé once used the phrase "astronomy mosques" to describe the towers, since they belong to the world's first Royal Astrophysical Observatory, the first and, for a long time, most important astrophysics building on the Telegrafenberg. Immediately upon entering the park, this extraordinary vision piqued our curiosity: we wanted to know more about the building and the master plan for the entire park, which could only have originated in a single mind.

This opportunity was afforded us in 1995 to an extent none of us had dared to dream. The scientific park was to be the subject of a study that, along with the park's structural restoration, sought to find a new use for the Royal Astrophysical Observatory. Already all but abandoned by astrophysicists in the 1970s, the buildings showed signs of increasing deterioration, most apparent on the visibly rusty domes. Through the study of documents and plans, preserved as exquisite lithographs stored in the library at the Scientific Park, we came to

The red line marks the current silhouette, the green the original: the classic baroque rotating roof in the dome-style of St. Peter's Basilica in Rome, a number of chimneys, a dome shutter between the north and south wings and, over the latter, the glass photo studio with flanking chimneys are reminiscent of a miniature chapel.



The Royal Astrophysical Observatory in 1890, north view (left) and south view (right).

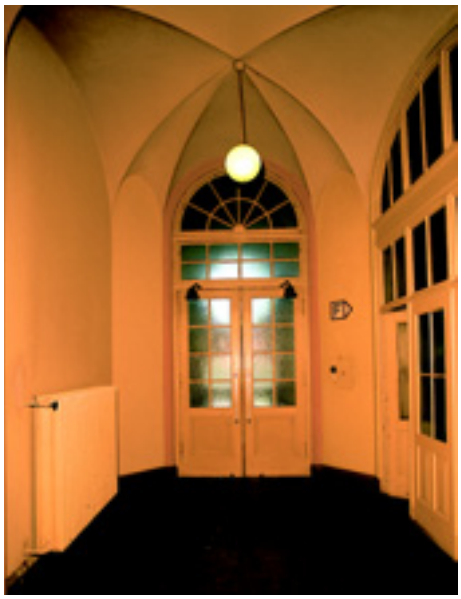
Next page top: rusty cupola of the eastern Tower in 2001.

Next page middle: the ground-floor hallway before renovation.

Next page bottom: the entrance foyer after renovation in 2001.

know Paul Emanuel Spieker, who for the first 25 years served as chief architect on the Telegrafenberg. In a comprehensive 1991 study performed by Alexandra Restorers, Spieker (1826-1896) was portrayed as one of the defining forces of nineteenth-century architecture. As a student of Friedrich August Stüler, he is considered a member of the Late Schinkel School of Architecture. After designing the *Kruppsche Villa Hügel* in Essen and the prison at Berlin-Plötzensee, Spieker received a contract to design the Berlin Metronomical Institute. Wilhelm Julius Foerster, director of the Imperial Standards Commission and the Royal Observatory in Berlin, was closely associated with the institute, which led to his long and fruitful collaboration with Spieker. In 1871, Foerster received a commission from one of Crown Prince Friedrich Wilhelm's tutors, the physicist Schellbach, to begin organizational planning for a solar observatory. Before long, however, the project evolved into the Royal Astrophysical Observatory, as it came to be known. All of this happened with the enthusiastic support of the Crown Prince, the later Kaiser Friedrich III, as a memorial plaque in the foyer of the main entrance reminds visitors today.

Designed by Schinkel and completed in 1835, the Berlin observatory initially served as a site for the study of astrophysics as well, a then-emerging science. The rapidly expanding city of Berlin was quickly ruled out as a location for a new observatory in favour of Potsdam's Telegrafenberg, whose seclusion from troublesome vibrations, disruptive light dispersions and other emissions made it ideal. The only signs of development in the area were the rather unobtrusive telegraph lines between Berlin and Coblenz. Spieker, in those days privy councillor, was head of construction in the preparatory commission for the new observatory, but was soon named chief architect of the project. Spieker devoted nearly 25 years of his career to the design of astronomical and other types of observatories, which he described as a "fascinating and challenging task". Indeed, observatory design acquired a special significance within his architectural oeuvre, which already included structures devoted to the sphere of science. Possible models for the design of the new observatory include those in Pulkowo near St. Petersburg and at the University of Vienna. Both feature primary and secondary towers in severely symmetrical composition with corresponding primary and secondary axes. While in Vienna a massive structure takes the form of a cross with four towers, Pulkowo boasts a spacious, palatial layout. In his posthumously published paper "Astronomical and Other Observatories," Spieker observed that an expansive building of reduced structural dimensions decreases heat emissions from the sun-warmed brickwork, which create a shimmer effect, and is thus better-suited to the study of the sky than a more compact architectural style. Emissions in the observation field arising from heating systems must also be avoided. Spieker solved this problem in his master plan with a spacious, widely-dispersed construction. Thus, for example, the two towers are connected to the main building by open arcades – windows were first installed after 1961. The reduction of heat radiation was additionally achieved through a grass-covered roof, no longer in place today. According to Spieker, an astrophysical observatory is distinguished from an astronomical observatory by "the close relationship between the long-distance observation rooms and chemical, physical and photographic laboratories, as well as equipment for spectral analyses". Thus only the most important rooms were located in the main building, situated with its principal axis on the 76th meridian, while each of the adjacent observation towers sits at the end of a transverse axis. Familiarity with Spieker's characterization of observatories as "an interrelated group of distinct structures" is essential for visualizing the original layout today. Modifications to the building's interior undertaken in 1950 required the raising of the northern section, which resulted in the height differences of the roof (see illus., page 90). The north tower, which once housed a water tower fed by a well at the park entrance, and the main entrance are connected to the north wing, where the administrative offices were located. This wing was dis-



tinctly set apart from the higher, southern laboratory in ground plan. Conversion of the domes into a spherical shape was undertaken in 1911 in order to enlarge the observation aperture. At the same time, the design of the opening mechanism was improved.

Features such as the alternating red and yellow brick facade, the variety of sandstone elements, the wrought iron trellis on the flat roofs and tower arcades reveal Spieker's adherence to the principles of the Late Schinkel School of Architecture. Also characteristic of this school are the multi-coloured enamelled bricks frequently used in friezes, at the observatory a network stars creates a thematically-related motif. Spieker continued to use these materials in the design of later buildings for the Science Park (he designed meteorological and geodesy observatories as well as the large refractor, which was only completed after his death with slight alterations to his design). However, despite the uniformity suggested by the choice of materials, upon closer observation the four large buildings prove remarkably different: almost playful and yet fully functional, the astrophysical observatory seems almost excessive in its variety of structural forms; by contrast, the other two buildings are "puzzlingly unadorned boxes," to use a phrase Heidrun Laudel once applied to the building housing Schinkel's academy of architecture in Berlin. The design of the large refractor, in turn, appears understated yet has the force of a mature work – it was also the final creation in the industrious life of the architect. The charm of his accomplishment in the design of this scientific arcadia remains to this day. The uniformity of materials among its buildings, distinguished architecturally according to their various functions, arouses the interest of the observer and, at the same time, imbues a sense of serenity through its harmonious relationship to the park grounds with its old growth of trees.

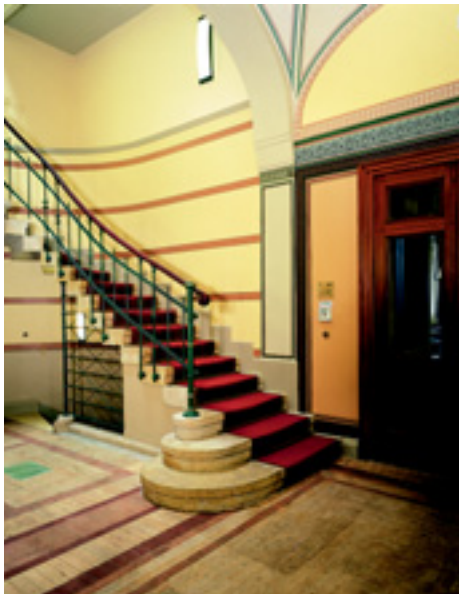
It is perhaps worth mentioning at this point the great importance traditionally accorded by architects to the construction of towers, especially in the nineteenth century. Schinkel's dream of crowning Potsdam's silhouette was ultimately fulfilled with the construction of the *Nikolaikirche* by Stüler, who also adorned the west wing of the Berlin castle with a tower. What a sublime feeling it must have been, then, for Spieker to erect several towers at once – all devoted to the science of the universe in the broadest sense. In the language of architecture, after all, towers symbolize the expansive canopy of sky. Indeed, one of the most fascinating aspects of this project for us was the dawning realization of the profound importance of architecture for science in the nineteenth century. Numerous sources provide evidence that a "Religion of Science" played a formative role in social life, inspiring architecture to employ elements of the sacred.

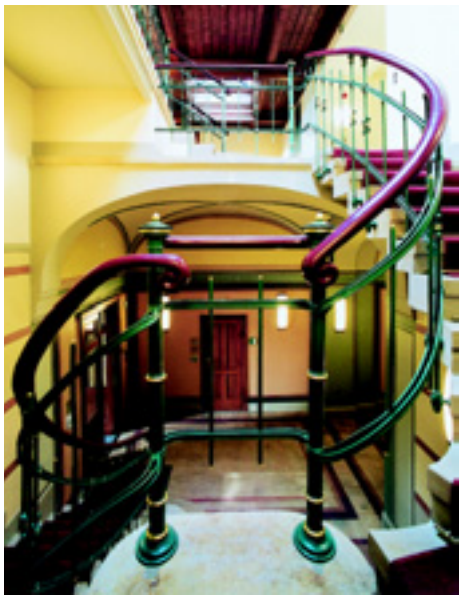
We now direct our steps to the interior of the main institute. Above the entryway to the north tower through a window adorned with a rosette, light enters the foyer surmounted by a domical vaulted ceiling and high ribbed walls. The sacral quality of this place is enhanced by a vaulted corridor whose stark divisions are underscored by pilasters and formerets, and sustained by the alternating red and yellow brick floors laid out in a carpet-like pattern. Luxurious daylight falls upon a characteristic sandstone stairway at the end of the corridor which connects to a domed hall, complementing this sacredness with its apsidiole-like niches and southern exedra housing the heliographs

(the later south entrance). The function of these "arching hollow structures" is not at first apparent, but can be understood only in relation to the dome high above: the walls and arches of the hall, separated by joints from the rest of the building, served as the foundation for the original observation instrument located in the middle dome, which had to remain absolutely motionless. A suspended walkway leading to the foot of the instrument, further ensuring the stability of the platform, offers an architecturally intriguing solution.

Yet another dream came true with the decision to hand over the main astrophysical institute to the Potsdam Institute for Climate Impact Research. Our company received the commission to carry out the restorations and architectural modifications. For us, this experience would prove to be a series of surprises and ever-increasing fascination.

In comparison with the other observatories, the condition of the main institute at the end of the 1990s showed signs of extreme dilapidation: corrosion had eaten away at two of the domes, and the third had, in the mean time, been covered with bitumen shingles. The sandstone crown of the north tower had been reinforced with steel bands to prevent collapse, the southern entrance was likewise damaged through fissures in the sandstone cornices, and of the two wooden thermographic observation arbours only one remained, fallen and in grave disrepair. While the inner rooms and decorative murals in the geodesy observatory retained their former splendour, not a single room in the main institute was preserved in what could be considered its original version. Walls had not only been coated with several layers of paint in various shades, but extensive plaster renovations removed any trace of the original décor. Only a thorough and time-consuming investigation enabled us to determine the original colours to carry out our restorations. What is more, we were stunned by the entirely unnecessary painting of intact wooden doors and fixtures. Such actions make the success of the restoration firm Heinz Karo, which literally drew the original wood finishes and colours to the surface and then restored them in close collaboration with monument preservationists, all the more remarkable. Today it is difficult to imagine that bland colours once coated the building's interior and a layer of linoleum hid the foyer floor. The astonishingly opulent foyer decoration, featuring bordered bands of palmette, laurel bay, flower pots with various tinted backgrounds, lends greater force to the spatial tectonics of the walls and cross beams, jointed with pilasters and formerets. At the same time, according to Gottfried Semper, the most important German architect in the second half of the nineteenth century, it fulfils the aesthetic expectations of a building with artistic pretensions. Thus, the niches and domes of the central rotundas were also adorned with a colourful border and playful band of flower pots and lines, which serves to accentuate the edges and structural height and zenith of the space. The dome in the east tower library is ornamented with flowers and foliage. The wood and plaster moulding on the ceiling in the director's office creates a particularly impressive effect.
Professor Schellnhuber, director of the Institute, was quite pleased with the handling of materials by restoration specialists (see pictures on page 96).





Top: the stairway to the first floor before renovation.
Middle: the renovated stairway restores the original brilliance of its sandstone steps.
Bottom: kingly aspirations: the institute's new stairway.

A project to expand the building was undertaken after the Second World War, which resulted in the enclosure of the arcades and the elevation of the north wing. These modifications were achieved with such tremendous effort and professional skill that reconversion was never seriously considered. Furthermore, apart from financial considerations, the increased usable space afforded by these modifications made the building ideal for the new institute. Reconstruction of the middle and largest observation tower for the seminar and conference centre thus became the central focus of our restoration efforts, since without such space the suitability of the former observatory for the Climate Impact Institute remained in question. Our biggest obstacles, at this point, consisted in replacing the timber frame and the interior wood panelling, as well as covering the dome with sheets of a titanium zinc composite to provide the necessary heat insulation. The towers were fitted with sound-absorbing panels and an electronically controlled loud speaker system to guard against focus effects common to these structures. The mandatory secondary emergency exit for approximately sixty people also bears mentioning. After rejecting the initial suggestion to employ a slide escape, like those used in large aircraft for emergency landings, we decided on a fire-resistant reinforcement of the platform over the south entrance where the fire department could set up ladders. Luckily, simple solutions could be found for many of our problems. A mere listing of the measures carried out should provide an impression of our continuous struggle to meet the guidelines for renovating an historical monument, in which even the director of the institute became personally involved. Despite the high costs of restoring this relatively small space, our efforts were ultimately of great value for the institute.

Housing the main computer was of especial importance for the new use of the building. No room in the building was suitable for it, neither in terms of size nor in secondary specifications such as a climate control or double-bottomed computer flooring for the installation of a reversible network. A direct enlargement of the building was impossible, since the building, under protection as a historical monument, must remain a solitary structure. After presenting a number of proposals to the fastidious preservationist authorities, the solution of a completely underground annex was finally accepted. It has the added advantage of thermal isolation against the heat of summer. Direct access to the original building was cre-

The library with its elegant gallery had lost its lustre over the years.

The cosy atmosphere of the small library has been restored.

ated through an entrance beneath the west arbour to the three underground rooms housing the main computer (see illustration, page 100). Large computer components were conveniently transported to their new underground home by a hoisting platform visible only when in use. Our visiting microchip specialists were particularly impressed by this comparatively simple mechanism.

What images remain? The more than five meter deep excavation pit in the immediate vicinity of the building and the anxiety that the ground wanted to close up again. The presence of a variety of craft specialists gave the impression of an old-fashioned construction site. The most distinctive among them were the stonemasons with their outdoor workshop. Admittedly it was easier to watch them work when the weather was good than in the midst of snow flurries, which did not deter them from their task. The plumbers, too, embodied highly-skilled craftsmanship. At least, near the tower, they were protected from rain and snow by an imposing, wind-resistant scaffolding. On occasion time seemed to stand still. During the construction of the east arbour, the carpenters took visible pleasure in practising the traditional art of wood jointing. Their well-equipped workshop was ideally located above one of the arcades, as it provided generous storage space for doors, windows and the like. Strength resides in calm, or more precisely, the determination to achieve a goal. In any case, the restorers could not be distracted from their work, despite the occasional outbreaks of chaos beneath their ladders and scaffolds. Finally, one last unforgettable image from the rainy weekend before the formal opening is the imposing figure of the landscape foreman with the mohawk and several assistants who he thought might be Kurdish. He was not sure, however, since they did not speak German.

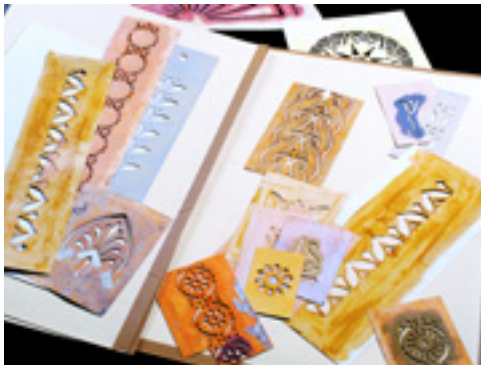
In his reflections on the design of observatories, Paul Emanuel Spieker maintains that from the outset meteorological study must be taken into consideration along with other heavenly observations. The two wooden arbours, which originally served for the observation of air temperature – in short, weather stations – have since been reconstructed. The building's scientific tradition is being continued, in a modern context, now that it is occupied by the Institute for Climate Impact Research.

The one-time observation tower is now home to the institute's seminar room.

Rediscovering hidden beauty.

Reconstructing the ornamentation...

... and recreating the stencils.

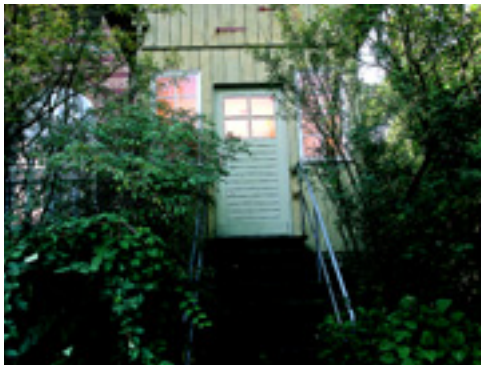


Ceiling in the director's office.

Inspecting the ceiling.

The ceiling in detail.

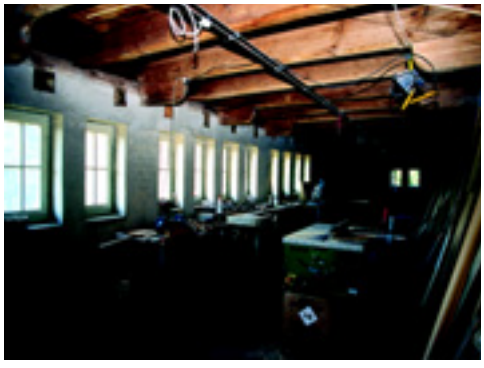
Spoiled beauty: completely closed-in west arbour.



Detail of west arbour.

Traditional wood joints of new wood.

The provisional wood workshop.



Rafters before their restoration.

Installing the skylights in February 2001.

The New
High-Performance
Computer

The Big 42-Check - an Interview

Q: Mr. Klein, PIK is running a new high-performance computer. What kind of computer is it?

Klein: We are running a 200-processor parallel machine, type IBM SP. The processors are grouped in so-called "nodes", within which extremely fast communication is possible and which form autonomous units. The nodes are connected through a somewhat slower but still outrageously fast "switch". This enables true large-scale parallel computations, where one simulation is worked on by hundreds of processors, at the same time. Our machine features forty-two 4-processor nodes and two 16-processor nodes. The computer is, by the way, among the 150 fastest worldwide.

Q: Is speed the deciding criterion for PIK's research needs?

Klein: This machine has a wide range of qualities and all of them are valuable for PIK. Its most outstanding asset for us is its flexibility. Its architecture makes it a high-performance tool for a very wide range of tasks. Thus it excels on large-scale computations, it efficiently operates on multiple decoupled runs of smaller models and it features a novel parallel file system for high-throughput data transfer, management and analysis.

Q: How will the computer be used at PIK?

Klein: The majority of computing time will be spent on large-scale parallel computations and batches of multiple runs of smaller-scale models. Another kind of run is typically set up when the parameter space of a model needs to be explored. An example would be multiple simulations with a global climate model for a large number of different predicted paths of global CO_2 emissions.

Q: Does the computer run only climate simulations?

Klein: The computer supports the work of all the disciplines represented at PIK. Their models describe interactions between the different components of the physical Earth system and their interactions with social actors. But PIK's task is not only to produce series of future projections using different climate and socio-economic scenarios. Rather, PIK's task is to help to improve the overall understanding of the Earth system, so that models have a firmer base and the inherent uncertainties associated with computer-based modelling can be evaluated. Therefore, the computer will also be used extensively to investigate the response of our models to judiciously selected perturbations. Through this approach one often learns more about the workings of a complex system than from all-encompassing full-scale model runs.

Rupert Klein talking to Margret Boysen in autumn 2001.

Q: Could you give an example of such a computer model?

Klein: Take the regional climate model currently being developed at PIK in co-operation with the German Weather Service, the GKSS Research Centre and others. Such a model is essentially a discrete, computer-digestible analogue of the researchers' knowledge. One must first identify the relevant system components; in this case, the atmosphere, its water content in the form of water vapour, droplets and ice particles and a representation of the surface water balance, including river flows, lakes and other components, etc. Next, the interaction of these components is quantified. For example, computational rules that determine the rate of water vapour condensation and precipitation from the atmosphere's vertical temperature and from predicted local vertical motions. Once these interactions have been formulated, a computer code is developed and adapted to run on parallel machines. After validating the model by comparing its results for selected test cases, the code can then go "into production".

Q: Which PIK model could give the answer "42"?

All of them would, of course. The 42-check is one of the first validation tests each of our models has to pass!

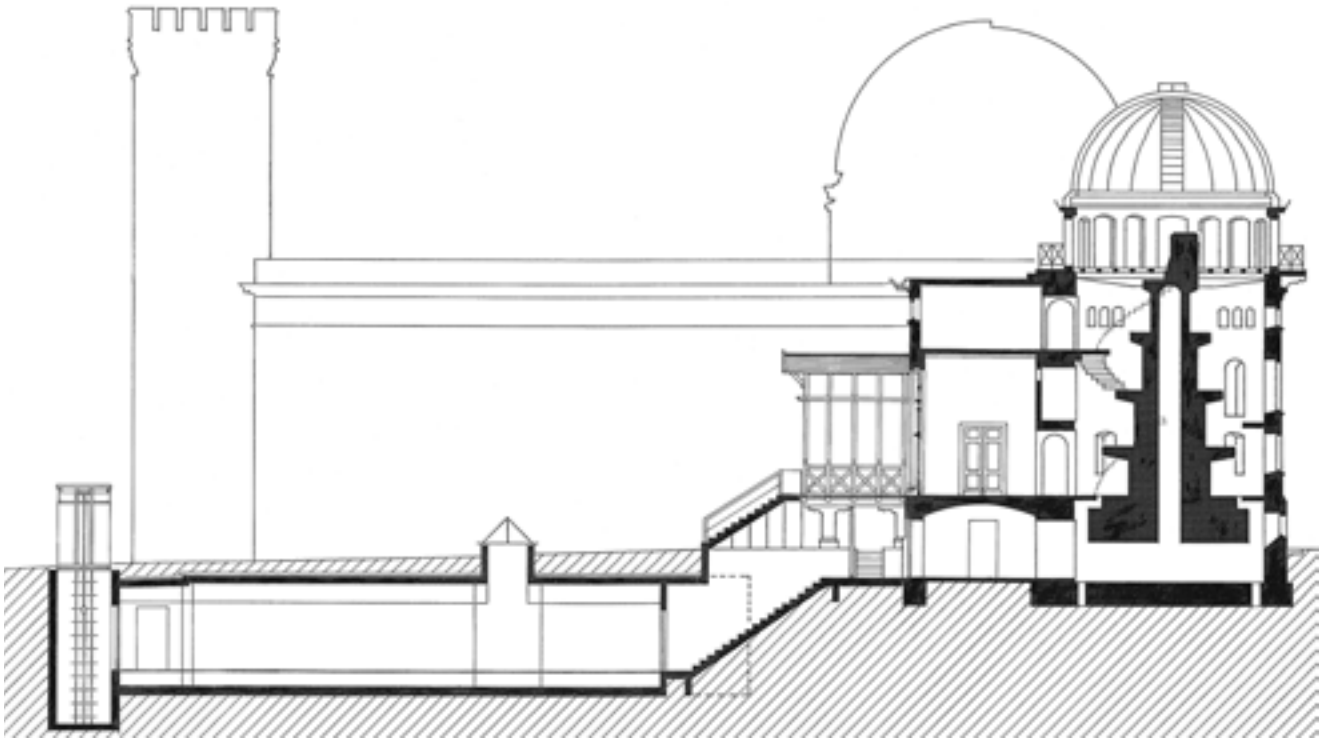
Karsten Kramer watches the transfer of the new supercomputer to the lift.

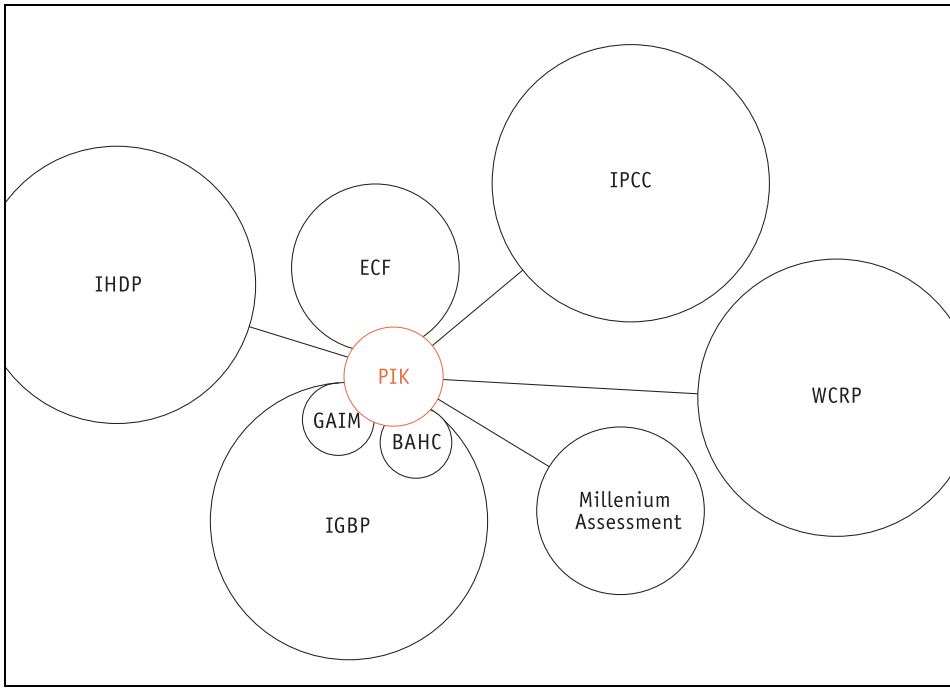
One of the computer towers with door open.

Technical Data

The new system is composed of a compute server IBM SP with a total of 200 Power3-II CPUs, operating at 375 MHz and utilizing 8 MB of private second level cache, an additional, high-performance, high-availability IBM S80 enterprise server and 7 Terabyte of external SSA disk storage. These disks have been divided into standard RAID-Arrays and a parallel file system which is able to deliver a sustained bandwidth of about 600 MBps to parallel applications. Inside the SP all CPUs are grouped into either 4-way or 16-way SMP nodes. All nodes, as well as the S80 enterprise server, are connected via the SP TB3 switch, which delivers a maximum-throughput of ~140 MBps and a minimum latency of ~19 ms for Message Passing Interface [MPI] programmes.

Access to the underground extension for the main computer lies beneath the wooden arbours which were originally used as a weather station. The hoisting platform, shown open here, is used to transfer large pieces of equipment to the underground annex.





Scientific Relations

A Network for Our Future

Understanding the Earth system is a tremendous task that no institution or country can tackle alone. PIK closely collaborates with many international partners, including those making measurements in the field, satellite observations or experimental studies. PIK is playing an active role in activities such as the International Geosphere-Biosphere Programme (IGBP, e.g. BAHC and GAIM), the Intergovernmental Panel on Climate Change (IPCC), the International Human Dimensions Programme of Global Environmental Change (IHDP), the World Climate Research Programme (WCRP), the European Climate Forum (ECF), and the Millennium Assessment. PIK co-ordinates a number of large European and national research projects (cf the list of co-operations on page 141). We are thus part of a growing global network for sustainability science, dedicated to our common future.

BAHC
Biospheric Aspects of the Hydrological Cycle

Executive Officer: Holger Hoff
Project Officer: Sabine Lütkemeier
Administration: Wilhelmine Seelig

The International Geosphere-Biosphere Programme (IGBP), of which BAHC is one of the Core Projects, is moving into a new phase of integrated research for sustainability. The BAHC project, which has focused on the question "How does the land surface interact with the physical processes of the hydrosphere?" is supporting IGBP in its transition to the new phase through preparing two major activities:

- the new Joint Water Project of IGBP and its partners, the International Human Dimensions Programme of Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP) and
- the new Land/Atmosphere Component of IGBP.

The International Project Office (IPO) of BAHC, hosted by PIK since 1995, facilitates and co-ordinates the international science programme by synthesizing the results of BAHC research, preparing new science activities, and co-ordinating with stakeholders, in particular by organizing and conducting scientific meetings. Some highlights of IPO activities in 2000/2001 are given below.

Synthesis
The BAHC Synthesis was a major effort co-ordinated by the IPO, which will be completed in 2002 with publication by Springer-Verlag. Under the title "Vegetation, Water, Humans and the Climate: a New Perspective on an Interactive System" it will cover questions like "Does land surface matter in climate and weather?" or "How measurable is the Earth system?" and will summarize 10 years of BAHC existence.

New Initiatives
The IPO of BAHC has launched a new African initiative on sustainable use of groundwater resources.

The IPO is co-organizing a series of events in a new dialogue between climate science and water management in the Dialogue on Water and Climate.

Meetings Conducted Through the IPO
The IPO organized and conducted several conferences, workshops and meetings, e.g. the BAHC Scientific Steering Committee (SSC) meeting in Caracas in 2000 in conjunction with a South American workshop on "The Role of Biosphere in the Climate System: the tropical South America Case" and the BAHC SSC meeting in 2001 in conjunction with the Open Science Conference "Challenges of a Changing Earth" in Amsterdam of which the IPO organized several sessions.

Project Co-ordination

- The IPO is co-ordinating partner of the GLOWA Jordan River project and supported the proposal, preparation and kick-off of that project.
- The IPO is supporting the development of the WADI project at PIK.

This project has been funded by the German Federal Ministry of Education and Research.

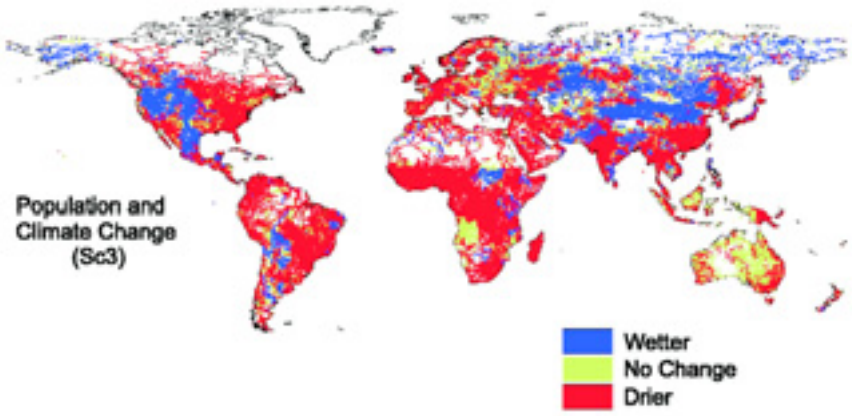


Fig. 1: Pressure on water resources in the future: Changes in the ratio of total water withdrawal (including domestic and industrial sectors as well as irrigation) over the available water supply given as river discharge (measured as surface and shallow subsurface runoff) with estimates of population growth and economic development over the next 25 years. It shows that most areas on Earth will have a greater water demand in the future than today.

GAIM
Global Analysis, Integration and Modelling, a Task Force within the International Geosphere-Biosphere Programme (IGBP)

Task Force Chair: Hans Joachim Schellnhuber
PIK Task Force Members: Wolfgang Cramer (Vice Chair), Martin Claussen.
Postdoc: Hermann Held

GAIM's Role

GAIM was established within IGBP to "promote the development of a suite of global biogeochemical Earth system models." As such, GAIM is charged with constructing an integrated whole from the various parts of the Earth system being explored by each of the Core Projects. This presents two unique challenges. Firstly, GAIM must be able to identify the most critical links between subsystems and any gaps in our understanding within and between parts of the Earth system. This introduces a "think-tank" character that necessitates a comprehensive vision of the Earth as a unit, and an integrated approach to GAIM activities. Secondly, GAIM must be able to effectively link the efforts and results produced by the Core Projects as well as interface with the other Earth System Science Partners (ESSP) WCRP (World Climate Research Programme), IHDP (International Human Dimensions Programme on Global Environmental Change) and DIVERSITAS.

Moving to the Earth system level required expanding the scope of GAIM's activities beyond the strictly biogeochemical, and into the physical, on the one hand, and the socio-economic, on the other. As such, GAIM aims to act as a "lighthouse" for the broader global change research community to ensure that it does not overlook any key issues that will prove to be important at the system level.

Analysis

GAIM poses questions and challenges the broader community to address them in ways that ultimately contribute to Earth system level investigations (i.e. Hilbertian Questions, cf box p. 108). The set of issues so defined by GAIM will need to be addressed by all of IGBP and the community at large. As such, it is hoped that the products of GAIM's analysis role will inspire the research community by extending the scope of its research to explore challenging questions at the system level that are not presently investigated.

Integration

GAIM works closely with the IGBP Core projects and beyond IGBP to promote and conduct research activities that are broader than the scientific scope of individual (or pairs of) Core Projects, but require input from across a wide range of IGBP scientists. It would be overly ambitious to assert that GAIM, with its limited number of scientists and resources, can unilaterally tie all the pieces of global change research together into a unified whole. We therefore focus on those integrative activities which can pave the way for others to join in integrated Earth system analysis.

Modelling

The models that GAIM is charged to develop must be based on a solid foundation of analysis of the critical

issues, and integration of disciplinary science into a suite of Earth system models. The development of protocols for model intercomparison is one of GAIM's most notable achievements to date. Earth system analysis relies on a spectrum of simulation models, so these are being developed across a range of complexity. In order to explore the relationships between system components that may determine the behaviour of the system as a whole, it is necessary to develop models that capture the critical feedbacks and interactions that drive the highly nonlinear system to one mode of operation or another. Consequently it is necessary to develop Earth system Models of Intermediate Complexity (EMICs) that can run quickly on present-generation machines for thousands of model years.

New Activities

The recently developed 23 fundamental ("Hilbertian") Earth system analysis questions (cf p. 108) are to be elaborated by a set of high-quality essays, written by the best scientists in the respective field, during the year 2002. In addition, GAIM now embarks on the development of an Earth system atlas, which is intended to be a one-stop access point to critical data sets on Earth system conditions, their past evolution, and state-of-the-art assessments of their possible future development. An important feature of this atlas will be the peer review procedure which will build on the IGBP community for assurance of quality and relevance of data transported by the atlas.

IHDP
International Human Dimensions Programme on Global Environmental Change

IHDP is the smallest amongst the big international global change research programmes. It addresses the specific role of humans - social actors and systems - in the context of global environmental change. Human dimensions research concerns the causes and consequences of people's individual and collective actions that lead to modifications of the earth's physical and biological systems. Feedback effects that affect the human quality of life and options for sustainable development in different parts of the world are included. The major questions are: How do human actors influence their environment, and what are the reasons and causes that they do so? How do global environmental changes affect social actors and systems? And what actions can be taken and by whom to respond to, reduce and mitigate the effects of global environmental change?

The spectrum of disciplines that engage in answering these questions includes economics, political science, sociology, psychology, geography, and more. New research fields such as Integrated Assessment are becoming more and more relevant to IHDP. Having no substantial research funding budget of its own, IHDP operates through other incentives relevant to scientists: interest, reputation, international networking, interdisciplinarity, global responsibility of science. Three major instruments have been developed. Firstly, IHDP organizes international and interdisciplinary conferences worldwide. Secondly, it defined and supports four major fields of research (Industrial Transformation (IT), land use and land-cover change (LUCC; together with IGBP), Global Environmental Change & Human Security (GECHS), and Institutional Dimensions of Global Environmental Change (IDGEC)). Finally, IHDP actively engages in the capacity building of global-change-related social sciences in the developing world (START, SysTem for Analysis, Research and Training, a joint WCRP/IGBP/IHDP programme).

PIK has participated in and co-operated with IHDP activities in different ways. Carlo Jaeger, Social Systems Department head at PIK, is a member of the IHDP Scientific Committee. One of his major areas of work is the cross-cutting theme ”water” that both PIK and IHDP will pay increasing attention to in the future.

Members of the Social Systems Department present their research results at international IHDP meetings on a constant basis. The last IHDP Open Meeting of the Human Dimensions of Global Environmental Change Research Community (6-8 October 2001, Rio de Janeiro) was attended by a number of PIK scientists.

IHDP officials have been involved in the PIK-sponsored international workshop on a Sustainability Geoscope workshop held in Berlin in October 2001.

An international conference on the Human Dimensions of Global Environmental Change, "Global Change and the Nation State" was held in Berlin, 7-8 December 2001, co-sponsored by PIK, the Institutional Dimensions of Global Environmental Dimensions (IDGEC)

programme of IHDP, and the Environmental Policy and Global Change Working Group of the German Association for Political Science (DVPW).
http://www.uni-bonn.de/ihdp/

Contribution to the Third IPCC Report

Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. Its Third Assessment Report (TAR) "Climate Change 2001" provides a comprehensive and up-to-date assessment of the policy-relevant scientific, technical, and socio-economic dimensions of climate change. The IPCC has three working groups (WGs), addressing the scientific aspects of the climate system and climate change (WG I), the vulnerability of socio-economic and natural systems to climate change, impacts of and adaptation to climate change (WG II), and options for limiting greenhouse gas emissions and otherwise mitigating climate change (WG III).

Scientists from PIK have been heavily involved in the work of the IPCC over many years, also contributing to a substantial degree to preparation of its Third Assessment Report in the years 1998-2001. Co-ordinating lead authors of IPCC TAR chapters (i.e., individuals responsible for the shape of particular chapters) from PIK are shown in the upper table, lead authors in the lower table.

Kundzewicz	WG II	Chapter 13
Schellnhuber	WG II	Chapter 19
Toth	WG III	Chapter 10

Toth	WG II	Chapter 2
Cramer	WG II	Chapter 5 & 13
Richard Klein	WG II	Chapter 18

A number of PIK scientists have also contributed as contributing authors, as reviewers and as review editors. The list of references of all IPCC TAR volumes contains numerous publications by PIK scientists, demonstrating that the research in the institute has found a broad, international resonance.

ECF
European Climate Forum

Chairperson: Carlo C. Jaeger
Contact person: Martin Welp

Objectives
The European Climate Forum (ECF) in a non-profit association which brings together representatives of different parties concerned with the climate problem. It was established in July 2001 in Brussels and is based at PIK in Potsdam. The core of the ECF activities is to jointly define and carry out climate change studies.

Members
ECF cultivates an open dialogue between various institutions and individuals concerned with the climate problem: the coal, oil and gas industries, companies engaged in renewable energy technologies, major energy users, and finance sectors, NGOs, and scientific experts investigating climate change and options for sustainable development. Membership is open to companies, NGOs and research institutes as well as private persons. The founding scientific members are: Potsdam Institute for Climate Impact Research, Max Planck Institute for Meteorology (Hamburg), Centre for Marine and Climate Research (Hamburg University), Tyndall Centre for Climate Change Research (UK), ENI Enrico Mattei (Milano), Nansen Environmental and Remote Sensing Centre (Bergen) and the Paul Scherrer Institute (Zürich). Chairperson of ECF is Prof. Carlo C. Jaeger (PIK) and Vice-Chairperson Prof. Klaus Hasselmann (Max Planck Institute for Meteorology).

Activities
In the first half year after the founding of ECF several activities took place. The official opening event took

place in October 2001 and was part of the Sustainability Days (see pages 81-86). In working groups researchers and stakeholders jointly defined socially relevant research questions. The ECF pilot topics include the following: policy instruments, extreme events, technology assessment and data pool. A position paper was launched in November 2001 and distributed to the public media in several European countries. This consensus document further outlined the research and communication strategy of ECF.

Outlook

In future the Forum joint studies will encompass several aspects relevant to climate policy, with emphasis on problems for which there exist at present strong differences of views among different stakeholders. The goal is to bridge differences and produce scientifically founded analyses that summarize and advance our state of knowledge in critical problem areas. The Forum cultivates a pluralistic exchange in which different points of view can be freely expressed and debated on a basis of mutual respect.

Relevant Forum studies include global aspects of the interaction of climate change and the socio-economic system, regional impacts of climate change, economic and political instruments for controlling greenhouse gas emissions and climate change on global and regional levels, and technological approaches to the reduction of greenhouse gas emissions through CO_2 sequestration and sinks, more efficient energy use and the introduction of renewable energy technologies.

The activities of the Forum will be closely co-ordinated with corresponding national and European programmes. Although it is anticipated that the principal regular membership will be European, there is no geographical restriction on membership.

For further information see the ECF website:
http://www.European-Climate-Forum.net.

ECF
European
Climate Forum

23 Hilbertian Questions - by John Schellnhuber

Analytic Questions

What are the vital organs of the ecosphere in view of its operation and evolution?
What are the major dynamical patterns, teleconnections and feedback loops in the planetary machinery?
What are the critical elements (thresholds, bottlenecks, switches) in the Earth System?
What are the characteristic regimes and time-scales of natural planetary variability?
What are the anthropogenic disturbance regimes and teleperturbations that matter at the Earth System level?
Which are the vital ecosphere organs and critical planetary elements that can actually be transformed by human action?
Which are the most vulnerable regions under global change?
How are abrupt and extreme events processed through nature-society interactions?

Methodological Questions

What are the principles for constructing "macroscopes", i.e., representations of the Earth System that aggregate away the details while retaining all systems-order items?
What levels of complexity and resolution have to be achieved in Earth System modelling?
Is it possible to describe the Earth System as a composition of weakly coupled organs and regions, and to reconstruct the planetary machinery from these parts?
Is there a consistent global strategy for generating, processing and integrating relevant Earth System data sets?
What are the best techniques for analysing and possibly predicting irregular events?
What are the most appropriate methodologies for integrating natural-science and social-science knowledge?

Normative Questions

What are the general criteria and principles for distinguishing non-sustainable and sustainable futures?
What is the carrying capacity of the Earth as determined by humanitarian standards?
What are the accessible but intolerable domains in the co-evolution space of nature and humanity?
What kind of nature do modern societies want?
What are the equity principles that should govern global environmental management?

Strategic Questions

What is the optimal mix of adaptation and mitigation measures to respond to global change?
What is the optimal decomposition of the planetary surface into nature reserves and managed areas?
What are the options and caveats for technological fixes like geoengineering and genetic modification?
What is the structure of an effective and efficient system of global environment & development institutions?

Public Relations

Potsdam Institute for Climate Impact Research in the Public Eye

Public interest in global change, especially in the changing climate, remains high. The number of articles on the Potsdam Institute for Climate Impact Research appearing in the press over the last two years, suggests even that a tremendous growth in public interest has taken place. While some 400 articles appeared in the years 1998 and 1999, nearly double so many – 720 – appeared in 2000 and 2001. This figure represents only those articles in our records, taking into account no online publications and only a percentage of those in the foreign press. Additionally, conversations with people outside the institute make evident that the institute's media presence is well recognized. Though the focus of our public relations is, in the first instance, quality rather than quantity, the institute is indeed well represented with an average of one newspaper article per day.

Media interest was particularly high in early summer 2001, during the negotiations on the Kyoto Protocol and with the appearance of the IPCC Report on the climate and climate impact, in which a number of the institute's scientists played a significant role. The events of September 11, 2001, caused a noticeable shift of media interest to other issues. Though these recent trends do not fall within the period covered by this report, the gradual shift of media interest back to climate change was anticipated in the first half of 2002 and appears to be returning to a level typical of the last few years.

Moreover, the media appears to be conveying an increasingly more complex understanding of climate change, indicating that the message from scientists concerning the complexity of the Earth system and the compelling relationship between global warming and environmental problems is reaching more publishers and "sinking in" to more heads. Media interest revolves less and less on the question of whether or not the weather last Tuesday had anything to do with global warming. The public no longer appears to want a simplified understanding of scientific questions and answers. Increasingly, it tends to recognize the probabilistic character of climate and climate impact research and does not shy away when complex and thus more complicated issues are raised, which cannot be addressed with a simple "yes" or "no". This holds true for schools, organizations, individuals and politicians who come to us for materials, lectures and consultations.

Margret Boysen, PIK´s Public Relations Manager and Main Editor of the Biennial Report.

The growth in public concern on global warming and climate change can be readily observed in the press and public relations office. The numerous public lectures held by institute scientists has certainly contributed to this growth. Yet this is a trend that could all too readily come to an end as a result of one or another shift in political relations, which strongly influence the media.

Despite its considerable success, our public relations efforts in the area of television have proved difficult. With the exception of interviews (in 2000-2001 the institute was represented in more than a hundred radio and television interviews), TV's hunger for pictures cannot always be satisfied. Given its limited resources, the work of the institute gives preference to model calculation rather than the visualization of research results. Moreover, scenarios developed by the institute are not prophecies. We are often concerned that catastrophic images of the future only fulfil the need for sensation and fear and, in the long run, will have no impact upon viewers. The Potsdam Institute for Climate Impact Research thus strives continuously to awaken public interest in the fascinating, intricate relationships involved in environmental research. These are complex interrelationships which must first be mastered cognitively, not tactilely or visually. Even when the visual is clearly desirable, it is not of foremost concern for the institute. Our press release on stochastic resonance as a trigger for extreme temperature fluctuations during the last ice age demonstrates that even complicated subjects are well received by newspapers and their readers. The number of German articles at six was rather low, but the quality of the articles in view of their complexity was surprisingly good.

On the whole, the media representation of the institute in the last two years indicates our continued success and commitment to making the results of our research known to the public.

One project, which has been underway since October 2001 and which we have been anxious to share with the public, is finally far enough along to warrant introduction: The institute's new research building astounds nearly every visitor, and we are endeavouring to share our delight for this architectural jewel, an astrophysics observatory conceived more than 120 years ago by Paul Emanuel Spieker. The official inauguration ceremony during the First Sustainability Days in Potsdam was just the beginning (cf page 81). A small exhibition, which is to be expanded in the near future, explains how the building's cupola was constructed. In the article by architect Friedrich Karl Borck on page 90, he describes in detail the exciting task of restoring the building for its new users and returning it to its former grandeur.

Access to PIK's Homepage (www.pik-potsdam.de)

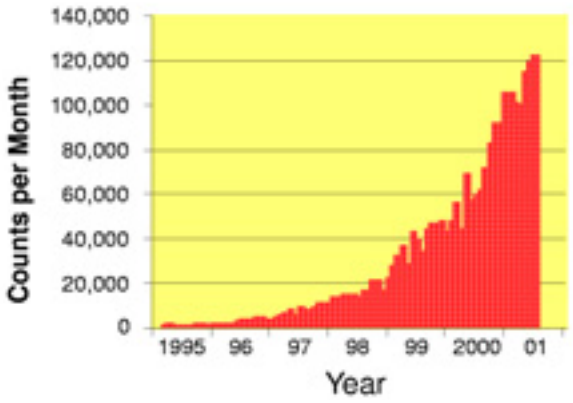


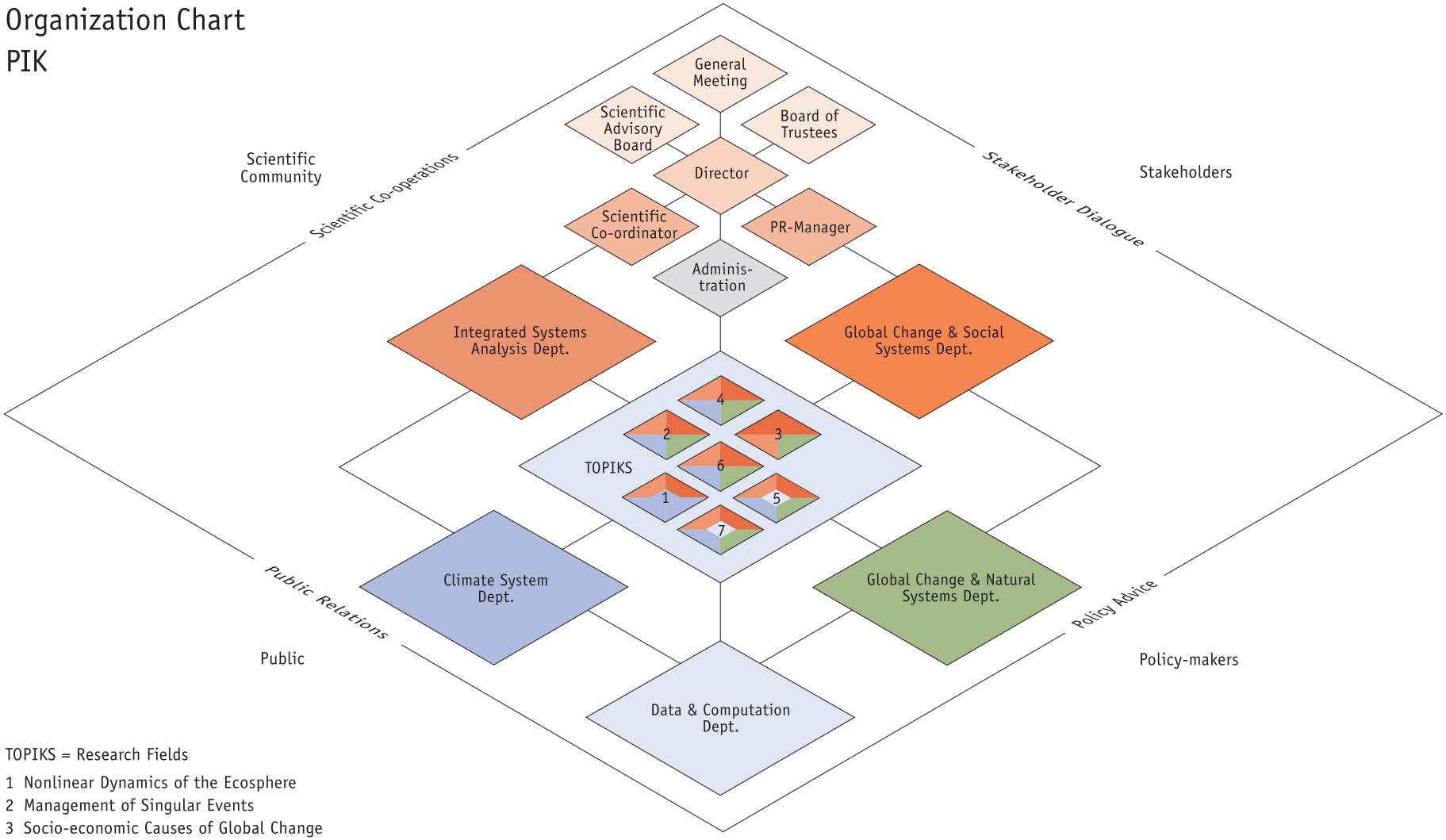
Fig. 1: Development of Access to PIK's Homepage 1995-2001.

The Top 25 Newspapers Featuring PIK

Potsdamer Neueste Nachrichten	49
Berliner Zeitung	40
Berliner Morgenpost	32
Märkische Allgemeine Zeitung	31
Die Süddeutsche	24
Märkische Oderzeitung	17
Der Tagesspiegel	15
Die Welt	13
Frankfurter Rundschau	13
die tageszeitung	10
Frankfurter Neue Presse	10
Frankfurter Allgemeine	09
Hamburger Abendblatt	09
SPIEGEL	09
Mitteldeutsche Zeitung	08
Die Kitzinger	07
Hanauer Anzeiger	07
Stuttgarter Zeitung	07
Thüringische Landeszeitung	07
Aachener Nachrichten	06
BILD Berlin-Brandenburg	06
Der Prignitzer	06
Die Zeit	06
Lübecker Nachrichten	06
Neues Deutschland	06

Appendix

Organization Chart
PIK



TOPIKS = Research Fields

1 Nonlinear Dynamics of the Ecosphere
2 Management of Singular Events
3 Socio-economic Causes of Global Change
4 Emergence of the Global Subject
5 Regional Simulators
6 Sectoral Climate Sensitivity
7 PIKuliar Culture

Boards

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Professor Peter Gaethgens	Präsident der Freien Universität Berlin
Professor Hartmut Grassl	Max-Planck-Institut für Meteorologie, Hamburg
Professor Peter Lemke	Alfred-Wegener-Institut, Bremerhaven

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Scientific Events

Lectures at PIK

Date	Type of Lecture	Scientist	Institute	Title
24.01.2000	Colloquium	Dr. Michael J. Grubb	Energy and Environment Programme, The Royal Institute of International Affairs, London, United Kingdom	The developing architecture for implementing Kyoto
24.01.2000	Colloquium	Dr. Tom Downing	Environmental Change Unit, University of Oxford, United Kingdom	Vulnerability assessment
26.01.2000	Institute Seminar	Prof. Dr. Stefan Turek	Institute for Applied Mathematics, University of Dortmund, Germany	Effiziente numerische Lösungstechniken am Beispiel der inkompressiblen Navier-Stokes Gleichungen
27.03.2000	Colloquium	Professor William C. Clark Harvey Brooks Professor of International Science	Public Policy and Human Development, John F. Kennedy School of Government, Harvard University, Cambridge, USA	New agenda for sustainability science
05.04.2000	Institute Seminar	Josef Herkendell	Directorate General 'Agriculture', European Commission, Brussels, Belgium	Intensive monitoring of forest ecosystems in Europe
24.05.2000	Institute Seminar	Professor Andrew J. Majda	Courant Institute of Mathematical Sciences, New York University, USA	A theory for statistical prediction of the spreading phase of open ocean convection
04.07.2000	Institute Seminar	Dr. Vladimir Semjonow	Max Planck Institute for Meteorology, Hamburg, Germany	Secular trends in characteristics of daily precipitation simulated by a GCM
05.07.2000	Institute Seminar	Professor David Archer	Department of the Geophysical Sciences, University of Chicago, USA	What causes the glacial/interglacial atmospheric CO_2 cycles?
14.07.2000	Institute Seminar	Professor J. David Neelin	Department of Atmospheric Sciences, University of California, Los Angeles, USA	Dynamical mechanisms affecting summer monsoon convection zones
08.08.2000	Institute Seminar	Professor Wandera Ogana	Department of Geology, University of Nairobi, Kenya	Potential impact of climate change on fisheries in lakes Naivasha and Victoria
12.09.2000	Colloquium	Professor Uri Shamir	Water Research Institute Technion, Institute of Technology, Haifa, Israel	Negotiating over water: International and personal experiences
20.09.2000	Colloquium	Professor Lawrence A. Mysak Canada Steamship Lines Professor	Dept. of Atmospheric and Oceanic Sciences, McGill University, Montreal, Canada	Is there a dominant timescale of natural climate variability in the Arctic?
26.09.2000	Colloquium	Dr. Marco Bindi	Dept. of Agronomy and Land Management, University of Florence, Italy	The combined use of experimental and modelling tools for studying the effect of climate change at different spatial scales

Lectures at PIK (continued)

Date	Type of Lecture	Scientist	Institute	Title
29.09.2000	Colloquium	Dr. Ian Burton, Dr. Saleemul Huq, Richard Klein, Dr. Olga Pilifosova, Professor H.J. Schellnhuber, Professor Barry Smit	Lead Authors of the IPCC Working Group II Third Assessment Report	Adaptation to climate variability and change
09.10.2000	Institute Seminar	Professor Julian C.R. Hunt	Professor of Climate Modelling, Department of Space & Climate Physics, University College London, United Kingdom	Effects of climate change on urban areas: Modelling, planning and devolved decision making
30.11.2000	Institute Seminar	Prof. Dr. Gundolf Kohlmaier, Prof. Dr. Meinrad Rohner Prof. Dr. Joseph Alcamo, Gerald Busch Prof. Dr. Ulrich Hampicke	Johann Wolfgang Goethe-University Frankfurt/Main University Kassel University Greifwald	Results of the Volkswagen project: Biosphere, climate and economy in the global carbon cycle
04.12.2000	Institute Seminar	Professor Helmut Elsenbeer	Department of Civil & Environmental Engineering, Environmental Hydrology Program, The University of Cincinnati, Ohio, USA	Pedotransfer-Funktionen in hydrologischen Modellen - Sind sie schon gut genug?
19.12.2000	Institute Seminar	Prof. Dr. Yuri Svirezhev	Integrated Systems Analysis Dept., Potsdam Institute for Climate Impact Research, Germany	Some thermodynamic speculations around the biosphere
27.02.2001	Institute Seminar	Dr. Frank Thomalla	Centre for Risk in the Built Environment, The Martin Centre for Architectural and Urban Studies, University of Cambridge, United Kingdom	Coastal settlements at risk: A study of England's east coast integrating hydrodynamical modelling and building surveys for storm surge impact assessment on the east coast of England
02.03.2001	Institute Seminar	Dr. Claudia Pahl-Wostl	EAWAG, Dübendorf, Switzerland	Regionales Management von Wasserressourcen: Akteurmodellierung und Partizipation
06.03.2001	Institute Seminar	Professor Georgiy Stenchikov	Department of Environmental Sciences, Rutgers - The State University of New Jersey, New Brunswick, USA	Sensitivity of arctic oscillation to volcanic aerosols and the QBO
24.04.2001	Institute Seminar	Dr. Dimitrios Gyalistras	Climatology and Meteorology, Institute for Geography, University of Bern, Switzerland	Wie unsicher sind regionale Klimaszenarien? Beispiele für Europa
10.05.2001	Institute Seminar	Dr. Doris Breuer	Institute for Planetology, Münster University	Die Entwicklung des Mars

Lectures at PIK (continued)

Date	Type of Lecture	Scientist	Institute	Title
15.05.2001	Colloquium	Professor Tom Burns together with Professor Anna Gomolinska Department of Mathematics, University of Bialystok, Poland	Uppsala Theory Circle, Department of Sociology, Uppsala University, Sweden	The general theory of games: Multi-modal decision-making, fuzzy processes, and normative equilibria
05.06.2001	Institute Seminar	Professor Sergey Pegov	Centre of International Projects, Moscow, Russia	Climate change impact on Russian economy and agriculture
25.06.2001	Institute Seminar	Dr. Lars-Eric Cederman	Center for International Affairs, Harvard University, Cambridge, USA	Agent-based modeling in the social sciences
02.08.2001	Colloquium	Dr. Ben Matthews	Choose Climate, United Kingdom	Geocybernetics in cyberspace: A dynamic Java climate model linking science and policy
01.11.2001	Institute Seminar	Dr. Kai Wirtz	ICBM, Carl von Ossietzky University Oldenburg, Germany	Environmental determinants of early human history: Global dynamical simulation studies vs. the contingency paradigm
09.11.2001	Institute Seminar	Dr. Manfred A. Cuntz	Department of Physics, University of Texas at Arlington, USA	Planets around other stars and star-planet interactions
16.11.2001	Institute Seminar	Dr. habil. Alfons Balmann	University of Applied Sciences, Neubrandenburg, Germany	Adjustment costs of agri-environmental policy switchings - A multi-agent approach
04.12.2001	Institute Seminar	Prof. Dr. Gustav Feichtinger	Institute for Econometry, Operations Research and Systems Theory, Technical University Vienna, Austria	The economics of deviant behaviour: A dynamic cost-benefit analysis
11.12.2001	Institute Seminar	Professor Eugene Rosa	Visiting Professor at the Institute for Environmental Sociology, University of Stuttgart, Germany	The STIRPAT Research Program: Integrating human ecology with social scientific theories

Symposia

Name of Event	Place and Date	Scientist(s) in charge
Arbeitsberatung DFG-Verbundprojekt „Laterale Abflüsse“ *(Workshop DFG Joint Project "Lateral Flows")*	Potsdam, January 31, 2000	Alfred Becker
MAGEC Project Meeting	Potsdam, March 14, 2000	Frank Wechsung
Workshop „Landschaftswasser- und -stoffhaushalt im Elbe-Einzugsgebiet“ *(Nutrient and Water Dynamics in the Elbe River Basin)*	Potsdam, March 14, 2000	Uwe Haberlandt
1st CLAWINE Workshop	Potsdam, May 29, 2000	Thomas Kartschall
MIT/PIK Global Change Forum XVI	Berlin, June 21-23, 2000	Ferenc Toth
Workshop "Human Dimensions of Global Change" together with DFG and NKGCF	Schloß Wendgräben, July 13-15, 2000	Carlo C. Jaeger Ottmar Edenhofer
2nd CLAWINE Workshop	Potsdam, September 27-30, 2000	Thomas Kartschall
European Conference on Advances in Flood Research	Potsdam, November 1-3, 2000	Christine Bismuth
Climate and Land Degradation (CLD) Project Meeting	Potsdam, November 2-3, 2000	Martin Claussen
Workshop "A Sustainability Geoscope"	Bad Honnef, November 2-3, 2000	Carlo C. Jaeger Wolfgang Lucht
SIADCERO Project Meeting	Potsdam, November 28-29, 2000	Ferenc Toth
Workshop "Stakeholder Successes in Global Environmental Management"	Potsdam, December 8, 2000	Carlo C. Jaeger Martin Welp
Workshop „Datengruppen“ *(Data Groups)*	Potsdam, January 22-23, 2001	Michael Flechsig
IRMA Workshop	Potsdam, February 1-2, 2001	Christine Bismuth
Kick-off Workshop ATEAM	Potsdam, March 5-7, 2001	Wolfgang Cramer
Workshop "GLOWA-Elbe"	Potsdam, March 7, 2001	Beate Klöcking
WADI Workshop	Potsdam, April 10, 2001	Lucas Menzel
Workshop "Model Coupling and Related Numerical Issues"	Potsdam, May 16-19, 2001	Rupert Klein
Workshop "CLAWINE"	Potsdam, June 14-15, 2001	Thomas Kartschall
ECF Preparatory Meeting	Brussels, July 12, 2001	Carlo C. Jaeger Martin Welp
Kick-off Workshop DINAS-COAST	Potsdam, July 18-20, 2001	Richard J.T. Klein
Workshop „Nächste Schritte der Global Change Forschung in Deutschland: Entwurf eines Geoskops“ *(Next Steps of Global Change Research in Germany: Modelling of a Geoscope)*	Schloß Weilburg an der Lahn, September 10-11, 2001	Carlo C. Jaeger Wolfgang Lucht Hermann Lotze-Campen
Kick-off Workshop INTEGRATION	Potsdam, September 19-20, 2001	Stefan Rahmstorf Carlo C. Jaeger
First Sustainability Days Sponsors: IBM Gerling Global Rück	Potsdam, September 28- October 5, 2001	H.J. Schellnhuber Manfred Stock

Name of Event	Place and Date	Scientist(s) in charge
Symposium „Methods and Models of Vulnerability Research, Analysis and Assessment“	Potsdam, September 28-29, 2001	Wolfgang Cramer H.J. Schellnhuber
Symposium „Enhancing the Capacity of Developing Countries to Adapt to Climate Change“	Potsdam, September 30-October 2, 2001	Richard Klein Ferenc Toth
Symposium „Palaeoperspectives on Global Sustainability“	Potsdam, October 2-3, 2001	Martin Claussen Stefan Rahmstorf
Symposium „Alliances for the Sustainability Transition: The European Climate Forum (ECF)“	Potsdam, October 3-4, 2001	Carlo C. Jaeger Martin Welp
Symposium „Contributions to Sustainability Science from Applied Mathematics and Software Engineering“	Potsdam, October 4-5, 2001	Rupert Klein Gerhard Petschel-Held Nicola Botta Cezar Ionescu
Inauguration of the New PIK Head Office	Potsdam, October 4, 2001	H.J. Schellnhuber Manfred Stock
Panel Discussion: Sustainable Potsdam - Global Environmental Change and the Local Agenda 21	Potsdam, October 5, 2001	H.J. Schellnhuber Manfred Stock
Stakeholder Workshop ATEAM	Isle-sur-la-Sorgue, October 22-24, 2001	Wolfgang Cramer
Workshop „A Sustainability Geoscope - Observing, Understanding and Managing the Sustainability Transition“	Hotel Intercontinental Berlin, October 25-26, 2001	Carlo C. Jaeger Wolfgang Lucht Hermann Lotze-Campen
WADI Workshop	Potsdam, November 1-2, 2001	Lucas Menzel
Workshop „Forschungsschwerpunkte für ein künftiges deutsches Rahmenprogramm 'Nachhaltigkeits-Geoskop'“ *(Research Foci for a Future German Frame Programme 'Sustainability Geoscope')*	Sorat Hotel Humboldtmühle, Berlin, November 19-20, 2001	Carlo C. Jaeger Wolfgang Lucht Hermann Lotze-Campen

External Funding

Project Name	Acronym	Reference No.	Sponsor	Total Funding	Period of Funding	Project Leader
Integrierte Analyse der Auswirkungen des globalen Wandels auf die Umwelt und die Gesellschaft im Elbegebiet	GLOWA	07 GWK 03	BMBF / GSF	DM 8,793,828	01.05.2000-30.04.2003	Becker
"EUROPA - Modeling, Reflecting and Communicating Possible Futures of Europe in the Context of Global Change"	CLUSTER	EMO 0005	BMBF/DLR	DM 5,022,382	01.10.2000-30.09.2005	Jäger
INTEGRATION - Integrated Assessment of Changes in the Thermohaline Circulation	INTEGRATION	UFLD01096900	BMBF/DLR	DM 2,624,425	01.04.2001-31.03.2005	Rahmstorf
Integrierte Abschätzung von Klimaschutzstrategien: Methodisch-naturwissenschaftliche Aspekte	ICLIPS	01LK9605/0	BMBF/DLR PT-USF	DM 2,249,737	01.04.1996 - 30.06.2000	Tóth
"Klima, Vegetation und Kohlenstoff: Jahreszeitliche und langfristige gekoppelte Dynamik"	CVECA	01LD0008	BMBF/DLR PT-USF	DM 1,970,788	01.04.2001-31.03.2006	Lucht
Ökologische Forschung in der Stromlandschaft der Elbe	ELBEÖKO	339577	BMBF PT BEO Berlin	DM 1,313,200	01.01.1997 - 31.05.2001	Becker
BAHC "Internationales Kernprojektbüro für das IGBP-Kernprojekt Biosphärenaspekte des Wasserkreislaufs" - Verlängerung	BAHC	BAHC9901	BMBF	DM 1,303,838	01.01.1999 - 31.12.2001	Hoff
Einrichtung eines "Deutschen Forschungsnetzes Naturkatastrophen" (DFNK)	DFNK	01SF9970/1	BMBF	DM 1,053,358	01.01.2000 - 31.12.2002	Schellnhuber / Menzel
Wasserverfügbarkeit im semi-ariden Nordosten Brasiliens - Analyse und Modellierung	WAVES-K	01LK9712	BMBF/DLR PT-USF	DM 750,400	01.08.1997 - 31.07.2000	Gerstengarbe
Wasserverfügbarkeit im semi-ariden Nordosten Brasiliens - Integrierte Modellierung	WAVES-I	01LK9713	BMBF/DLR PT-USF	DM 652,450	01.08.1997 - 31.07.2000	Bronstert / Krol
Variabilität und Dynamik des Klimasystems während der letzten Interglaziale	EEM	01LD0041	BMBF/DLR PT-USF Universität Mainz	DM 600,460	01.06.2001-31.12.2003	Claussen
Stabilität der Selbstregulation im System Erde	Selbstregulation	24/2598-04/325-2000	MWFK	DM 597,000	01.01.2001-31.12.2003	Franck
FE-Vertrag: GIS-Basierte Szenarienanalyse im Havelgebiet und integrierende Bewertungen	FGM	330227	Uni Potsdam	DM 556,860	01.10.2001-30.09.2004	Lahmer
Grobrasteranalyse zu den Möglichkeiten für umweltentlastende Landnutzungsänderungen in Folge des globalen Wandels	Raster	II/75141	Volkswagenstiftung	DM 550,000	01.10.1999-30.09.2002	Cramer

Project Name	Acronym	Reference No.	Sponsor	Total Funding	Period of Funding	Project Leader
Befristete Einrichtung einer Doktoranden-Nachwuchsgruppe im Zusammenhang mit den EU-Projekten ATEAM/SILVISTRAT/ DINAS COAST	HSP N	24/2598-04/ 323-2000	MWFK	DM 437,766	01.01.2001- 31.12.2003	Cramer
Europäische Ökosysteme 1989 - 1998: Quantitative Analyse unter Verwendung von Satellitenfernerkundungsdaten	Europ.Ökos.	01LA9828/0	BMBF/DLR	DM 420,807	01.11.1998 - 31.10.2000	Cramer
Klimatologie und Prognose klimainduzierter Änderungen hydrographischer Größen in Nord- und Ostsee; Teilprojekt A: Seegangsberechnungen zur Gewinnung einer spektralen Seegangs-Klimatologie	KLINO	03F0185A	BMBF/KFA Jülich	DM 401,541	01.11.1996 - 31.10.1999	Claussen
Wissenschaftliches Sekretariat zur Unterstützung des neuen Vorsitzenden von IGBP-GAIM	IGBP-GAIM	07 GCH 02	BMBF	DM 359,917	01.03.2000- 28.02.2003	Schellnhuber/ Held
Wasser- und Stoffrückhalt im Tiefland des Elbeeinzugsgebietes	WASTOR	0339585-TP3	ZALF	DM 359,741	01.10.1997 - 30.09.2000	Becker
Quantifizierung des Einflusses verschiedener Maßnahmen auf den Verlauf von Hochwasserereignissen	FLAT	29724508	UBA	DM 338,900	01.10.1997 - 28.02.2001	Bronstert
Simulation der langfristigen Variabilität im Klimasystem des Holozäns mittels eines gekoppelten Atmosphäre-Ozean-Biosphäre-Modells mittlerer Komplexität	Holozän	01LG9906	BMBF/DLR	DM 337,742	01.10.1999 - 30.09.2002	Claussen
Modellvalidierung und Ignoranzdynamik	Ignoranzdynamik	01LG0002	BMBF / DLR	DM 333,528	01.02.2001- 31.04.2004	Held
Asymptotisch adaptive Verfahren zur Simulation von Mehrskalenproblemen der Strömungstechnik	Simulation	KL 611/6-3 KL 611/6-4	DFG	DM 319,400	01.01.2001- 31.12.2003	Klein
Deutsche Waldstudie; Teilprojekt 2: Natürliche Waldentwicklung	WALD2	01LK9528/2	BMBF/DLR	DM 312,225	01.07.1997 - 30.06.2000	Cramer
Sequentielle indikatorbasierte Regelungsstrategien im Rahmen des Leitplankenansatzes in der integrierten Klimaschutzanalyse	Regelungsstrategie	II/76186	VW-Stiftung	DM 297,480	01.03.2000 - 28.02.2003	Bruckner
Vom Eem ins Holozän: Modellierung des letzten Warm-Kaltzeitzyklus mit Hilfe eines Klimasystemmodells mittlerer Komplexität	ZYKLUS	CL 178/2-1 CL 178/2-2	DFG	DM 294,200	01.01.2000 - 31.12.2002	Claussen
Hydrologische Flussgebietsmodellierung unter Berücksichtigung von Steuerungsmöglichkeiten zur Prognose der antropogenen salinaren Belastung der Unstrut	Unstrut	330028	BMBF	DM 288,902	01.07.2001- 30.06.2004	Klöcking

Project Name	Acronym	Reference No.	Sponsor	Total Funding	Period of Funding	Project Leader
CLIVAR marin; Teilprojekt: Untersuchung der thermohalinen Atlantikzirkulation in einem hocheffizienten globalen Ozean-Atmosphären-Modell	CLIVAR	03F0246H	BMBF/KFA Jülich	DM 281,561	01.03.1999 - 28.02.2002	Rahmstorf
Analyse und Modellierung der Wasserverfügbarkeit im Elbegebiet und die Hochwasserabflußbedingungen im Odergebiet in Abhängigkeit von Klima und Landnutzung	Abflußbed. Oder/Elbe	01LA9810	BMBF/DLR	DM 263,206	01.03.1999 - 28.02.2001	Becker
Indikatoren für rezente und zu erwartende Wirkungen des anthropogenen Klimawandels in Europa	WAKE	201 41 256/0	BMBF/DLR	DM 245,723	01.05.2001- 30.06.2003	Erhard
Abschätzung der regionalen Kohlenstoffbilanz von mitteleuropäischen Wäldern unter dem Aspekt des globalen Wandels	REGKO	01LA9876/0	BMBF/DLR	DM 197,200	01.07.1999 - 30.06.2001	Suckow
HSP III - Evolutionsmodelle des Systems Erde (Fortsetzung)	HSP III	24-04/035-2000	MWFK	DM 187,000	2000	Franck
Kleinskalige Instabilitäten als Bausteine der turbulenten Energiekaskade	Instabilitäten	KL611/10/1	DFG	DM 171,000	01.11.1999 - 31.10.2001	Klein
Security Diagrams - Ein innovativer Ansatz zur Abschätzung der Gefährdung durch extreme Klimaereignisse	Security Diagrams	01LD0018	GhK	DM 164,981	01.04.2001- 31.03.2003	Jäger
Elastizität der Selbstregulation in einfachen Erdsystemmodellen	Erdsystem-modelle	Fr 910/9-3	DFG	DM 145,000	01.01.99- 31.12.2000	Franck
Modellgestützte Erforschung der lateralen Abflüsse	laterale Abflüsse	Be 1575/4-1	DFG	DM 128,000	01.08.98- 31.07.2000	Becker
Szenarien hydrologischer Extreme - Zweidimensionale Downscaling von Klimamodellen auf tägliche Niederschläge mit Anwendungen in der Hydrologie	SYE	BU 728/2-1	DFG	DM 113,200	01.11.2000- 30.10.2002	Bürger
Extreme hydrologische Ereignisse in Mitteleuropa seit 1500 - Prozesse und Wirkungen	EXEME1500	WE 2356/1-1	DFG	DM 106,900	01.01.99- 31.12.2000	Werner
Bundesweite Betrachtung der Zusammenhänge zwischen Agrarstatistiken und aktuellen Daten zur Bodennutzung	Agrarstatistik	200 71 247	UBA	DM 98,347	01.11.2000- 31.10.2001	Wechsung
Möglichkeiten und Grenzen qualitativer und semiqualitativer Modellierung von Natur-Gesellschafts-Interaktionen	Modellierung	07 SOE 11	BMBF	DM 95,319	01.07.2000- 30.06.2001	Schellnhuber Moldenhauer
Third Assessment Report of IPCC	MPI	01LG99016-PO	MPI-BGC Jena	DM 87,829	01.08.99- 31.07.2001	Schellnhuber

Project Name	Acronym	Reference No.	Sponsor	Total Funding	Period of Funding	Project Leader
Statistisch-Physikalischer Zugang zur Atmosphären-Variabilität	Variabilität	SCHE 234/9-1	DFG	DM 84,000	01.10.2001-30.09.2003	Schellnhuber
Lebenstile und Naturschutz	BFN	80081005	Uni GhK Kassel	DM 70,000	15.08.2000-14.02.2002	Reusswig
Koordination des Arbeitskreises und Erstellung einer Textvorlage für den Band des Elbe-Ökologie-Kompendiums	Elbe-Öko-Kompendium	U/861.11/3694	BFG	DM 68,000	01.04.2001-01.02.2002	Becker
Modellgestützte Erforschung der lateralen Abflüsse und ihrer Wechselbeziehungen zur Bodenfeuchte	laterale Abflüsse	BE 1575/4-3	DFG	DM 63,250	01.08.2000-31.07.2001	Becker
Verlängerung und Aufstockung: Extreme hydrologische Ereignisse in Mitteleuropa seit 1500 - Prozesse und Wirkungen	EXEME1501	WE 2356/1-3	DFG	DM 55,000		Werner
Modelltheoretische Untersuchung des Einflusses von Änderungen der Leuchtkraft der Sonne auf das Klima der letzten 12.000 Jahre	PAST12K	01LD0039	Heidelberger Akademie der Wissenschaften	DM 45,972	01.04.2001-31.03.2005	Claussen
FE-Vertrag: Gemeinschaftliche Erarbeitung eines Projektantrages zum BMBF-Projekt: "Bewirtschaftungsmöglichkeiten im Einzugsgebiet der Havel"	Havel	330012	Uni Potsdam	DM 31,050	01.09.2000-31.12.2000	Bronstert
Orts- und zeitdiskrete Ermittlung der Sickerwassermenge im Land Brandenburg	Sickerwasser	Z5-ZB BA0517	Landesumweltamt Brandenburg	DM 24,970	01.04.2001-31.07.2001	Lahmer
PPP-Norwegen 2001	PPP	313/PPP-N1-1k	DAAD Bonn	DM 19,715	01.07.2001-30.06.2003	Sprinz
Projektbezogener Personenaustausch mit Grossbritannien	ARC	313/ARC-1k	DAAD Bonn	DM 12,800	01.07.2000-30.06.2002	Klein
Projektbezogener Personenaustausch mit Portugal	AL	314/AL-p-dr	DAAD Bonn	DM 12,000	01.01.2001-31.12.2002	Cramer
Arbeiten zur Verdunstungskarte Rheinland-Pfalz	Verdunstungskarte	1.-4.03.00 1572/98	Landesamt für Wasserwirtschaft Rheinland-Pfalz	DM 12,000	2000/2001	Menzel
Werkvertrag: Erstellung Teil-Konzepte für Befragungen, Durchführung von Analysen	Monitoring		Land Schleswig-Holstein	DM 12,000	06.11.2001-31.11.2002	Reusswig
Wissenschaftlich-technologische Zusammenarbeit mit Polen	WTZ	POL-199-96	DLR	DM 10,204	01.01.98-31.12.2001	Franck

Project Name	Acronym	Reference No.	Sponsor	Total Funding	Period of Funding	Project Leader
Living with Floods - Antrag auf Erstattung der durch die Koordination eines EU-Antrages entstandenen Mehraufwendungen	Living with Floods		BMBF/DLR	DM 9,692	2000	Bronstert
DAAD-Austauschdienst	DAAD	9724279	DAAD Bonn	DM 6,971	1999-2000	Lindner
Einladung eines tschechischen Wissenschaftlers	TSE	436 TSE 17/1/99	DFG	DM 6,300	1999/2000	Werner
Unterstützung EU-Antragstellung zum Vorhaben: Regional Agricultural Model Application	RAMA	BCT 0559-58	BMBF/KFA Jülich	DM 6,127	01.06.99-30.11.1999	Kartschall
Vorbereitung eines trilateralen Projekts "An Interdisciplinary Study on the Role of Climate and Land-Use Changes on Water Availability and Related Socio-economic Impacts in the Eastern Mediterranean"	Israel Reisen	418 ISR 111/9/00	DFG	DM 4,768	2000	Hoff
Advanced Terrestrial Ecosystem Analysis and Modelling	ATEAM	EVK2-CT-2000-00075	EU	Euro 2,851,823	01.01.2001-31.12.2003	Cramer
"Dynamic and Interactive Assessment of National, Regional and Global Vulnerability of Coastal Zones"	DINAS-COAST	EVK2-2000-22024	EU	Euro 1,412,903	01.05.2001-30.04.2004	Richard Klein
Integrated Assessment of Vulnerable Ecosystems under Global Change	AVEC	EVK2-CT2001-00074	EU	Euro 652,508	01.10.2001-30.09.2004	Cramer
Quantifizierung des Einflusses der Landoberfläche und der Ausbaumaßnahmen am Gewässer auf die Hochwasserbedingungen im Rheingebiet	LaHoR	3/DU/1/002	IRMA	Euro 576,520	01.12.98-31.12.2001	Bronstert
A concerted action towards a comprehensive climate impacts and adaptation assessment for the European Union	ACACIA	ENV4-CT97-0531	EU	Euro 384,000	32 Mon.	Schellnhuber
European Terrestrial Ecosystem Modelling Activity	ETEMA	ENV4-CT95-0052	EU environment and climate programme	Euro 291,000	01.05.96-30.04.00	Cramer
Dynamic response of the forest-tundra ecotone to environmental change	DART	ENV4-CT97-0586	EU	Euro 268,700	01.04.98-31.03.2002	Cramer
"Response Strategies to Global Climate Change in Forest Management for Sustainable Forest Production, Carbon Sequestration and Biodiversity in the European Forests"	SilviStrat	EVK2-CT-2000-00073	EU	Euro 220,392	01.12.2000-30.11.2003	Badeck
Modelling agroecosystems under global environmental change	MAGEC	ENV4-CT97-0693	EU	Euro 214,000	01.04.98-31.03.2001	Cramer

Project Name	Acronym	Reference No.	Sponsor	Total Funding	Period of Funding	Project Leader
European River Flood Occurrence and Total Risk Assesment System	EUROTAS	ENV4-CT97-0535	EU	Euro 174,980	01.01.98-31.12.2000	Bronstert
Freshwater Resources in sub-Saharian Africa with Emphasis on Regional Scale Interactions of Land Use and Climate	ENRICH	ENV4-CT98-0771	EU	Euro 145,000	01.11.98-31.10.2001	Fosberg
Modelling the effect of land degradation on climate	CLIMATE & LAND DEGR.	ENV4-CT98-0696	EU	Euro 120,000	01.05.98-30.04.2001	Claussen
Strategic Integrated Assessment of Dynamic Carbon Emission Reduction Policies	SIADCERO	EVK2-CT-1999-00002	EU	Euro 109,701	01.04.2000-30.09.2001	Toth
Long-Term regional Effects of Climate Change on European Forests: Impact Assessment and Consequences for Carbon Budgets	LTEEF-II	ENV4-CT97-0577	EU	Euro 97,625	01.01.98-30.06.00	Cramer
Climate change and adaption strategies for human health in Europe	CCASHH	EVK2-CT-2000-00070	EU	Euro 66,020	01.05.2001-30.04.2004	Richard Klein
European Phenology Network	EPN	EVK2-CT-2000-20005	EU	Euro 45,420	01.01.2001-30.09.2003	Flechsig
Development of flood management strategies for the Rhine and Meuse basins in the context of integrated river management	IRMA/ SPONGE	99 15 183 01/3/ NL/1/164	IRMA	Euro 45,000	01.10.2000-31.12.2001	Bronstert
Programme for Integrated Earth System Modelling	PRISM	EVR1-2000-00511-PRISM	EU	Euro 40,246	01.09.2001-31.08.2004	Ru.Klein
James S. McDonnell Foundation	McDonnell	99-5 CF-SPE .03	James S.McDonnell Fountation	USD 1,00,650	01.04.1999-31.03.2005	Rahmstorf

Co-operations

Institution / Location	Type of co-operation
Australia	
Australian National University, Centre for Resources and Environmental Studies (ANU-CRES), Canberra	Scientific information and data exchange: Developing Global Climate Surfaces
Global Change and Terrestrial Ecosystems (GCTE-CPO), CSIRO Division of Wildlife and Ecology, Lyneham, Canberra	Vegetation-Atmosphere-Hydrosphere Interactions
Climatic Impacts Centre, Macquarie University, North Ryde	Scientific information and data exchange: IGBP-BAHC core project
University of New South Wales, Sydney	Scientific information and data exchange: ocean modelling
Austria	
Technische Universität Wien, Department of Operations Research and Systems Theory	Exchange on operations research and game theory
Universität für Bodenkultur, Institut für Waldbau, Wien	Modelling of forest succession and model validation: SAFE
	EU project: SILVISTRAT
Österreichisches Institut für Nachhaltige Entwicklung	Climate sensitivity and adaptation of VINE
	Co-operation agreement
International Institute for Applied System Analysis (IIASA), Laxenburg	Supervisory board / Co-operation agreement: IGBP Core project LUCC
	DFNK sub-project: SEVERE
	Research and development project: core project ICLIPS
Belgium	
Institut d' Astronomie et de Géophysique, Université Catholique de Louvain,	EMIC network model and data exchange
	EU project: PRISM
Département de Géologie et de Géographie	EU project: ATEAM
Brazil	
Center for Weather Forecasting and Climate Studies (CPTEC-INPE), Cachoeira	Research association LBA - Large-Scale Biosphere-Atmosphere Experiment in Amazonia
Funedação Cearense de Meteorologia e Recursos Hídricos (FUNCEME), Fortaleza	Project agreement, core project WAVES
Universidade Federal da Bahia, Salvador de Bahia	Project agreement, core project WAVES
Universidade Federal Do Ceará, Fortaleza, Ceará	Project agreement, core project WAVES
Departamento de Hidráulica	Scientific information, data exchange, joint model development on large-scale hydrology and erosion: core project WAVES
Canada	
Canadian Forest Service, Integrative Climate Change Modelling, Edmonton, Alberta	Scientific information and data exchange
University of British Columbia, Sustainable Development Research Institute, Vancouver	Human dimensions of global change
University of Victoria, School of Earth and Ocean Sciences	Scientific information and data exchange: conceptual ocean modelling
World Academy of Art and Science (hosted at Simon Fraser University, Burnaby)	Collaboration on planned global governance project
China	
Chinese Academy of Sciences, Inst. of Geography and Natural Resources, Department of Hydrology, Beijing	Water resources research and Chinese BAHC Programme
Czech Republic	
Academy of Sciences of the Czech Republic, Prague	Scientific information and data exchange
Czech Hydrometeorological Institute, Regional Branch, Ostrava	Scientific information and data exchange

Institution / Location	Type of co-operation
Institute of Atmospheric Physics, Dept. of Climatology, Prague	Scientific information and data exchange: model validation
National Institute of Public Health, Centre of Epidemiology and Microbiology, Prague	EU project: cCASHh
Department of Geography, Masaryk University, Brno	Scientific information and data exchange: climate analysis
Denmark	
Danish Centre for Earth System Science, Nils Bohr Institute for Astronomy, Copenhagen	Scientific information, model and data exchange, EMIC network
Danish Meteorological Institute, Copenhagen	EU project: PRISM
Danmark Farmaceutiske Hojskole (DFH), Institute for Environmental Chemistry	Scientific information and data exchange: core project BBM/GAIA - Thermodynamic criteria for validation of global model
Risø National Laboratory, Roskilde	EU project: AVEC
The Royal Veterinary and Agricultural University, Department of Agricultural Sciences, Frederiksberg	EU project: EPN - European Phenology Network
Finland	
European Forest Institute, Joensuu	EU projects: ATEAM, SILVISTRAT
Finnish Environment Institute (SYKE)	EU project: ATEAM
Finnish Forest Research Institute, Vantaa	Scientific information and data exchange: SAFE
University of Helsinki, Dept. of Forest Ecology, Helsinki	Scientific information and data exchange: SAFE
University of Joensuu, Faculty of Forestry	EU project: SILVISTRAT
France	
Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), Montpellier	EU projects: ATEAM, AVEC
Centre d'Etudes Spatiales de la Biosphère (CESBIO), Toulouse	Scientific information and data exchange: Remote sensing data assimilation for ecosystem models; joint project
Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique, Toulouse	EU project: PRISM
Centre de Recherche en EpistemologieAppliquée, École Polytechnique Paris	Co-operation on complexity of dynamic networks
Centre National de la Recherche Scientifique, Paris	EU project: PRISM
Laboratoire d'Ecophysiologie végétale, Université de Paris-Sud XI, Orsay	Scientific information and data exchange
Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-sur-Yvette	Scientific information and data exchange
	EU project: ATEAM
	Scientific information, model and data exchange; EMIC network
MEDIAS France, Toulouse	Global Change and remote sensing
	EU project: RICAMARE
Météo France Ouest, Rennes	Data aquisition for studies of climate sensitivity of vine
Météo France, Paris	EU project: PRISM
Société de Mathématiques Appliquées et de Sciences Humaines, Paris	EU project: SIADCERO
UNESCO-IHP (International Hydrological Programme), Paris	Support of various projects, workshops, etc.
	Groundwater research; HELP
	Joint BAHC-IHP workshops and planned publication of the book "The value of coupling in hydrology"
Université de Paris 6, Laboratory of Applied Geology	Freshwater research
University of Reims	Project: WADI

Institution / Location	Type of co-operation
Germany	
Abwassertechnischer Verband/Deutscher Verband für Wasserwirtschaft und Kulturbau Hennef	Scientific working group on evapotranspiration
adelphi research GmbH, Berlin	BMBF project: Security Diagrams
Akademie für Raumforschung und Landesplanung (ARL), Hannover	Arbeitskreis "Raumorientiertes Risikomanagement"
Alfred-Wegener-Institut für Polar und Meeresforschung (AWI), Bremerhaven and Potsdam	Scientific information and data exchange: core project BBM/GAIA
	BMBF project: KIHZ
	PIK project: INTEGRATION, modelling of marine biota
	Working group on environmental data management
	Development and application of metadata model CERA-2
Astrophysikalisches Institut Potsdam (AIP)	HSPN project: "Modelling habitable zones"
Auswärtiges Amt, Berlin	Global environmental negotiations
Bayrisches Landesamt für Wasserwirtschaft, München	Large-scale hydrological modelling, ARC/EGMO, ASSGI, SWIM
Büro für Angewandte Hydrologie (BAH), Berlin	Scientific information/data exchange: BMBF project "Elbe-Ökologie"
	BMBF project: GLOWA-Elbe
	Programme development and application, joint studies in Brandenburg, collaboration in BMBF project "Havel"
Bundesamt für Gewässerkunde, Koblenz and Berlin	Influence of land use and river training measures on the Rhine basin (EU project LAHOR)
	BMBF project: GLOWA Elbe
	DFG project: EXTREME 1500
	Deutsches Forschungsnetz Naturkatastrophen (DFNK)
	Scientific information and data exchange
	Co-operation within the BMBF project "GLOWA Elbe"
Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin und Hannover	Scientific information and data exchange: Expo 2000
Bundesforschungsanstalt für Forst- und Holzwirtschaft, Institut für Forstökologie und Walderfassung, Eberswalde	BMBF project: "Wälder und Forstwirtschaft Deutschlands im Globalen Wandel" (SAFE)
Institut für Ökonomie, Hamburg	VW foundation project MESSAGE
Institut für Forstgenetik, Großhansdorf	BMBF project: "Wälder und Forstwirtschaft Deutschlands im Globalen Wandel" (SAFE)
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), Climate Department, Berlin	Contact on current climate negotiations
Daimler-Chrysler, Stuttgart	TOPIK project: GRAIN; EU project: EUROPA
Deutsche Gesellschaft für die Vereinten Nationen e.V., Landesverband Berlin-Brandenburg	Member of Executive Committee
Deutscher Wetterdienst (DWD), Offenbach/ Potsdam	Framework agreement for collaboration in the area of meteorology, Exchange and transfer of data and models, Joint national and international research projects, Scientific information and data exchange
	EU project: EPN (European Phenology Network)
	Data acquisition for PIK's data bank system
	RECLIM project (Improved Dynamical Techniques for Deriving Regional Climate Information)
	EU project: cCASHh
	Development of the LM of DWD to a regional climate model
	Regional climate model application

Institution / Location	Type of co-operation
Deutsches Elektronen-Synchrotron - Institute for High Energy Physics (DESY-IfH), Zeuthen	HPSC-Forum Berlin-Brandenburg
Deutsches Institut für Ernährungsforschung, Potsdam	MAN-Vertrag (Metropolitan Area Network)
Deutsches Institut für Wirtschaftsforschung (DIW), Berlin	Scientific information and data exchange Core project RESOURCE, core project ICLIPS
	BMU project: "Implementation of polluter-pays principle in world trade law" for the Enquete Commission "Globalisation" of the German Bundestag
	Scientific information and data exchange
Deutsches Krebsforschungszentrum, Heidelberg	Working group on environmental data management
Deutsche Telekom	Study "Development of a sustainability portfolio"
Deutscher Verband für Wasserwirtschaft und Kulturbau (DVWK)	Membership of Scientific Commission
Deutsche Vereinigung für Politische Wissenschaft	Environmental Policy and Global Change Working Group; Organization of the 2001 Berlin Conference on Human Dimensions of Global Environmental Change
Deutsches Zentrum für Luft- und Raumfahrt, Deutsches Fernerkundungs-Datenzentrum, Oberpfaffenhofen	Working group on environmental data management
Dresdener Grundwasserforschungszentrum e.V.	BMBF project: GLOWA-Elbe
Europäische Akademie Bad Neuenahr/Ahrweiler	Arbeitskreis "Klimavorhersage und -vorsorge"
Fachhochschule Brandenburg	MAN-Vertrag (Metropolitan Area Network)
Fachhochschule Potsdam	MAN-Vertrag (Metropolitan Area Network)
Fernuniversität GH Hagen, FB ESGW / ökologische Psychologie	Scientific information and data exchange: Core projects: QUESTIONS, RESOURCE, ICLIPS
Forschungsgesellschaft für Agrarpolitik und Agrarsoziologie (FAA), Bonn	VW foundation project: "Grobrasteranalyse zu den Möglichkeiten für umweltentlastende Landnutzungsänderungen in Folge des Globalen Wandels" UBA project: "Bundesweite Betrachtung der Zusammenhänge zwischen Agrarstatistikdaten und aktuellen Daten zur Bodennutzung"
Forschungszentrum Jülich, LIFA	Working group on environmental data management
Institut für Chemie und Dynamik der Geosphäre	BMBF project: KIHZ
Programmgruppe Systemforschung	Collaboration in BMBF project "Elbe-Ökologie"
Forschungszentrum Karlsruhe, Institut für Meteorologie und Klimaforschung	Working group on environmental data management
	Development and application of metadata model CERA-2
Forschungsstätte der Ev. Studiengemeinschaft, Heidelberg	Scientific information and data exchange + network project proposal BMBF
Fraunhofer-Institut für Atmosphärische Umweltforschung IFU, Innovative Produkte, Garmisch-Partenkirchen	Development and application of metadata model CERA-2
Fraunhofer-Institut für Systemtechnik und Innovationsforschung (ISI), Karlsruhe	BMBF project: GLOWA-Elbe (effects of improvements in water-technology on water quality in river basins in the German part of the Elbe region)
Fraunhofer-Institut für Rechnerarchitektur und Softwaretechnik	Scientific information and data exchange, BEST
Freie Universität Berlin Inst. f. Geographie, Abt. f. Physische Geographie	Co-operation in teaching and research; joint appointments: a) C4: Modelling of global environmental systems (D&C Department) b) C3: Theoretical Climatology (Climate System Department)
	BMBF project: GLOWA-Elbe
Fachbereich für Politik- und Sozialwissenschaften	VW foundation project: MANUS
	Co-operation in teaching and research, Adjunct Professorship
Forschungsstelle für Umweltpolitik	Scientific co-operation on environmental policy and economics
Institut für Meteorologie	BMBF project: EEM (palaeo climate modelling)

Institution / Location	Type of co-operation
GeoForschungsZentrum (GFZ), Potsdam	Telegrafenberg user association
	Deutsches Forschungsnetzwerk Naturkatastrophen (DFNK)
	KIHZ
	Working group on environmental data management
	Collaboration in BMBF project "Havel"
	Potsdam-MAN contract (Metropolitan Area Network)
Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn	Project: WADI
	Projects: WADI, GLOWA Jordan River; other freshwater initiatives
Zweigstelle Berlin	Scientific information and data exchange
Gesellschaft für Wasserwirtschaftliche Planung und Systemforschung mbH (WASY), Berlin-Bohnsdorf	Software systems, development and application
	BMBF project: GLOWA-Elbe
GKSS-Forschungzentrum Geesthacht GmbH	KIHZ
	Development of the LM of DWD to a regional climate model
	Working group on environmental data management
	Scientific information and data exchange: development of a regional "community" climate model
	BMBF project: EEM (palaeo climate modelling)
	BMBF project: Impact of Climate and Landuse and their Changes on Water Availability and Flood Events
Grundwasserforschungsamt, Dresden	BMBF project: GLOWA
GSF-Forschungszentrum für Umwelt u. Gesundheit, Neuherberg	Regional climate model application
Institut für Hydrologie	BMBF project: GLOWA Jordan River
Institut für Atmosphärenphysik	BMBF project: KIHZ
Hamburgisches Welt-Wirtschafts-Archiv	Research programme on international climate policy
Heidelberger Akademie der Wissenschaften	BMBF project: EEM (palaeo climate modelling)
Institut für Umweltpysik	BMBF project: DEKLIM (palaeo climate modelling)
Hellriegel-Institut e.V., Fachhochschule Anhalt, Bernburg	Bernburg Study 1997; comparative study on the FACE Wheat Experiment Maricopa (BMBF-sponsored project); joint research and development project (BMBF): Validation and regional application of agro-ecosystem models
Hochschule für Film und Fernsehen, Potsdam	MAN-Vertrag (Metropolitan Area Network)
Humboldt-Universität zu Berlin	Establishment of a special research area (SFB); scientific information and data exchange; execution of joint projects
	Mantle project FACE (BMBF project)
Institut für Geographie	Collaboration in BMBF project "Havel"
Institut für Pflanzenbauwissenschaften und Agrarmeteorologie	Project: WADI
IBM Deutschland Informationssysteme GmbH, Stuttgart	Co-operation agreement: "Wissenschaftliches Rechnen" University chair (Stiftungsprofessur)
Institut für Agrartechnik Bormin e.V.	MAN-Vertrag (Metropolitan Area Network)
Institut für Gewässerökologie und Binnenfischerei (IGB), Berlin	BMBF project "Elbe-Ökologie"; area water and nutrient budgets
	BMBF project: GLOWA Elbe
Institut für Ökologische Raumentwicklung e.V. (IÖR), Dresden	Collaboration in BMBF project "Havel"
Institut für Ökologische Wirtschaftsforschung (IÖW), Berlin	Scientific information and data exchange; BMBF network project proposal
Institut für Ökologische Wirtschaftsforschung, Wuppertal	Scientific information and data exchange: social dimensions of global change
Institut für Regionalentwicklung u. Strukturplanung (IRS), Berlin	Scientific information and data exchange: city development

Institution / Location	Type of co-operation
Institut für sozial-ökologische Forschung GmbH, Frankfurt/M.	Scientific information and data exchange: social dimensions of global change
International Council of Local Environmental Initiatives (ICLEI), European Secretariate, Freiburg	EU project: URBS PANDENS
Konrad-Zuse-Zentrum für Informationstechnik, Berlin	Co-operation agreement with FUB: "Wissenschaftliches Rechnen"
	HPSC-Forum Berlin-Brandenburg
Landesamt für Geowissenschaften und Rohstoffe Brandenburg, Kleinmachnow	Working group on environmental data management
Landesamt für Verbraucherschutz und Landwirtschaft (LVL), Teltow, Abt. Landwirtschaft und Gartenbau	Collaboration in BMBF project "Havel"
Landesamt für Wasserwirtschaft Rheinland-Pfalz, Mainz	Study on the impact of environmental change on water resources in Rheinland-Pfalz
Landesanstalt für Wald und Forstwirtschaft Thüringen	Scientific information and data exchange, SAFE
Landesforstanstalt, Eberswalde	Scientific information and data exchange, SAFE
Landesumweltamt Brandenburg (LUA), Potsdam	Water and nutrient budgets of river basins (Stepenitz, etc.)
	Project: Stabilization and Improvement of the Water Balance in Brandenburg
Abt. Gewässerschutz und Wasserwirtschaft	BMBF project "Havel"
Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., München	EU project: PRISM
Max-Planck-Institut für Biogeochemie, Jena	Working group on environmental data management
	Scientific information and data exchange
	Modelling Environmental Thresholds
	EU project: ATEAM
Max-Planck-Institut für Meteorologie, Hamburg	BMBF project: GLOWA-Elbe
	BMBF project: EEM (palaeo climate modelling)
	Development of the LM of DWD to a regional climate model
	EMIC network: Scientific information and data exchange
	Research and development project: core project ICLIPS
	BMBF project DFNK
	European Climate Forum (ECF): joint study projects
	Development and application of metadata model CERA-2
	Core project WAVES
Gruppe Modelle und Daten	EU project: PRISM
Münchner Projektgruppe für Sozialforschung	Scientific information and data exchange: Core project QUESTIONS, BMBF project "Syndromdynamik"
Münchener Rückversicherung, Forschungsgruppe "Geowissenschaften"	Scientific information and data exchange
	Dialogue on water and climate
NEC Deutschland GmbH	EU project: PRISM
Niedersächsische Energieagentur, Hannover	Scientific co-operation on EXPO 2000 (theme park)
Niedersächsische Forstliche Versuchsanstalt, Göttingen	BMBF project: "Wälder und Forstwirtschaft Deutschlands im Globalen Wandel"; SAFE
Ökologie-Zentrum für Internationale u. Europäische Umweltforschung, Berlin	BMBF project: Security Diagrams
Sächsische Akademie der Wissenschaften zu Leipzig, Freiberg	BMBF project: EEM (palaeo climate modelling)
Sächsische Landesanstalt für Forsten	Scientific information and data exchange, SAFE
Silicon Graphics GmbH	EU project: PRISM
Sun Microsystems GmbH	EU project: PRISM

Institution / Location	Type of co-operation
Technische Fachhochschule Wildau	MAN-Vertrag (Metropolitan Area Network)
Technische Universität Berlin	VW Foundation project MESSAGE
	Co-operation within the BMBF project GLOWA-Elbe
Fachbereich Mathematik	Research and development project "Automatic differentiation of complex models"
Institut für Energietechnik	TOPIK project: GRAIN
Fachbereich Umweltökonomie	Modelling in social and economic systems
Institut für Ökologie und Biologie	VW Foundation project "Grobrasteranalyse zu den Möglichkeiten für umweltentlastende Landnutzungsänderungen in Folge des Globalen Wandels"
Technische Universität Cottbus, Fakultät Umweltwissenschaften	Scientific information and data exchange
Institut für Boden, Wasser, Luft	BMBF project: GLOWA-Elbe
Lehrstuhl für Bodenschutz und Rekultivierung	Deutsches Forschungsnetz Naturkatastrophen (DFNK)
Lehrstuhl für Hydrologie und Wasserwirtschaft	Scientific information and data exchange: social dimensions of global change
Lehrstuhl für Umweltmeteorologie	Scientific information and data exchange: development of a regional "community" climate model
	Development of the LM of DWD to a regional climate model
	Collaboration in the project KLIMOSTAT
Technische Universität Darmstadt, Interdisziplinäre Arbeitsgruppe Naturwissenschaft, Technik und Sicherheit	Co-operation on mathematical conflict modelling and environmental conflicts
Technische Universität Dresden, Institut für Hydrologie und Meteorologie	DFG focus programme "Regionalisierung in der Hydrologie" Water and nutrient budgets, large-scale modelling
Technische Universität München (Weihenstephan), Lehrstuhl für Waldwachstumskunde und Lehrstuhl für Forstpolitik und Forstgeschichte	BMBF project: "Wälder und Forstwirtschaft Deutschlands im Globalen Wandel"; SAFE
FG Geobotanik	"Vegetationsentwicklung auf Sturmwurfflächen"
Institut für Landespflege und Botanik	Project agreement: core project WAVES
Thiele&Büttner GbR - Ingenieurgemeinschaft für Hydrologie, Hydraulik und Hydroinformatik, Erfurt	Collaboration in the project KLIMOSTAT
Thüringer Landesanstalt für Landwirtschaft, Jena	BMBF projects: GLOWA-Elbe, "Elbe-Ökologie"
Umweltbundesamt (UBA), Berlin	Co-operation and advisory discussions; integration of WBGU; ICLIPS research results; scientific information and data exchange
	Projects: WAKE "Bundesweite Betrachtung der Zusammenhänge zwischen Agrarstatistikdaten und aktuellen Daten zur Bodennutzung"
Umweltforschungszentrum Leipzig-Halle GmbH (UFZ), Sektion Agrarlandschaften und Abt. Angewandte Landschaftsökologie	Scientific information and data exchange Core project QUESTIONS, HGF Project "Sustainable Global Development - Perspectives for Germany"
	Working group on environmental data management
Sektion Ökosystemanalyse	BMBF project: GLOWA Jordan River
	BMBF project: GLOWA-Elbe
	EU project: URBS PANDENS
Sektion Ökonomie, Soziologie und Recht	BMBF project: GLOWA Elbe
Universität Bochum, Geographisches Institut, Bodenkunde	BMBF project: GLOWA Jordan River

Institution/Location	Type of co-operation
Universität Bonn	Co-operation agreement: Climate analysis and climate diagnosis
	Project agreement, core project WAVES
	VW Foundation project MESSAGE
	BMBF project: EEM (palaeo climate modelling)
Institut für Paläontologie	BMBF project: KIHZ
International Human Dimensions Programme (IHDP)	Organization of the IDGEC-endorsed 2001 Berlin Conference on Human Dimensions of Global Environmental Change
Universität Bremen, Fachbereich Geowissenschaften	Scientific information and data exchange; EMIC network
	BMBF project: KIHZ
Universität Frankfurt/M.	Co-operation agreement: Climate analysis and diagnosis
	Scientific information and data exchange: social dimensions of global change
Universität Gesamthochschule Kassel	Scientific information and data exchange: PIK project SYNAPSE
	BMBF project: GLOWA-Elbe
	Scientific information and data exchange: core project WAVES
	BMBF project: Impact of Climate and Landuse and their Changes on Water Availability and Flood Events
	Research and development project: core project ICLIPS
Zentrum für Umweltsystemforschung	BMBF project: Security Diagrams
Universität Gießen	EU project: AVEC
Universität Halle, Institut für Acker- und Pflanzenbau	Project agreement: BMBF project; mantle project FACE
Universität Hamburg	Scientific information and data exchange: EMIC network
Zentrum für Marine Tropenökologie	EU project DINAS-COAST
Zentrum für Meeres- und Klimaforschung	European Climate Forum (ECF): joint study projects
	Project: INTEGRATION
Meteorologisches Institut	BMBF project: KIHZ
Botanisches Institut	Modelling economic growth
Fachbereich Wirtschaftswissenschaften	Research on statistics and climate analysis
	Project: WADI
Universität Heidelberg, Medizinische Fakultät, Abt. für Tropenhygiene und Öffentliches Gesundheitswesen	Project: WADI
Universität Hohenheim, Institut für Bodenkunde und Standortlehre	Project agreement: core project WAVES
Universität Jena, Arbeitsgruppe Meteorologie	Scientific information and data exchange
Lehrstuhl für Wirtschaftspolitik II	BMBF project: GLOWA-Elbe
Universität Kiel, Institut für Meereskunde	BMBF project: KIHZ
Institut für Weltwirtschaft	Research and development project: core project ICLIPS
Projektzentrum Ökosystemforschung	BMBF project: WaStor; exchange of data and methods; scientific co-operation
Ökologiezentrum	Scientific information and data exchange: hydrological analyses in the Oder catchment, water and nutrient budgets (BMBF project "Elbe-Ökologie")
Ökologiezentrum	Scientific Advisory Board
Universität Köln	Scientific information and data exchange: core project WAVES
Universität Leipzig, Institut für Geologie und Geophysik	BMBF project: EEM (palaeo climate modelling)
Universität Magdeburg, Institut für Psychologie	Proposal in framework of BMBF project "Nachhaltiges Wirtschaften" Scientific information and data exchange
Universität Mainz, Institut für Geowissenschaften	BMBF project: KIHZ
	BMBF project: EEM (palaeo climate modelling)

Institution / Location	Type of co-operation
Universität Marburg, FB Wirtschaftswissenschaften	Scientific information and data exchange: Core project QUESTIONS, BMBF project "Syndromdynamik"
Universität Marburg, FB Geographie	DFG project: "Land-use change types"
Institut für Kooperation in Entwicklungsländern	Project: WADI
Universität München, Institut für Geographie	Laterale hydrologische Flüsse in komplexen Landschaften
Lehrstuhl für Bioklimatologie und Immissionsforschung	EU project: EPN (European Phenology Network)
Universität Münster	Meta databases on global change
Universität Oldenburg	Co-operation agreement and scientific information and data exchange on: pattern recognition and systems analysis with neural networks, vulnerability of ecosystem complexes (mud-flat sediments), description of biotic induced weathering processes
Scientific Pool of Environmental Economic Disciplines (SPEED)	Modelling in environmental and energy policy
Wirtschaftswiss. Fakultät	VW Foundation project: MANUS
Universität Osnabrück, Institut für Umweltsystemforschung	BMBF project: GLOWA Elbe (integrated research on environment and society)
Universität Potsdam Institut für Physik	Joint teaching and appointments (Berufungen) Co-operation agreement Sonderforschungsbereich 555 "Komplexe Nichtlineare Prozesse" HSPN project: "Stability of Earth System Models"
Wirtschafts- und Sozialwissenschaftliche Fakultät	Potsdam-MAN contract (Metropolitan Area Network)
	Research and teaching on modelling in international relations
	Common DFG project proposal: Integration in times of social change
Institut für Geoökologie	Project: WADI
	Joint editing of the book "The value of coupling in hydrology" in the framework of BAHC-IHP co-operation
	Co-operation agreement; project proposal: "Selbstregulation im globalen Ökosystem Erde"; Ecosystem research
Mathematisch-Naturwiss. Fakultät, Vegetationsökologie u. Naturschutz	BMBF project: GLOWA Jordan River
Institut für Biochemie und Biologie	Project: Wadi; BMBF project: GLOWA-Jordan
Inst.f. Geoökologie, Inst. f. Ökologie u. Naturschutz, Inst. f. Biochemie und Biologie	Collaboration in BMBF project "Havel"
Universität Rostock, Institut für Ostseeforschung	DFG project: VISANA
	BMBF project: KIHZ
Institut für Computergraphik	EU project: SIADCERO
Universität des Saarlandes, FB Sozial- und Umweltwissenschaften; Saarbrücken	Scientific information and data exchange: Northern summer/ Brandenburg Study
Universität Stuttgart, Institut für Navigation	Pilot project: WADI
Universität Tübingen, Institut und Museum für Geologie und Paläontologie	Scientific information, model and data exchange; palaeoclimate simulations
Universität Würzburg, Geographisches Institut	DFG project: Extreme - 1500
Vereinigung Deutscher Wissenschaftler (VDW), Berlin	Co-ordination of VDW Global Change Working group
Wissenschaftlicher Beirat der Bundesregierung Globaler Umweltveränderung (WBGU), Geschäftsstelle am Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven	Chairman (Prof. Schellnhuber) Scientific information and data exchange with the advisory board members and their institutes Core project QUESTIONS, BMBF project "Syndromdynamik"
	Contribution to energy study
Wissenschaftskolleg zu Berlin	Scientific exchange
Wissenschaftszentrum Berlin (WZB)	Scientific information and data exchange; SAB (Prof. Simonis)

Institution / Location	Type of co-operation
Wuppertal Institut für Klima-Umwelt-Energie	Scientific information and data exchange Execution of joint projects and workshops
Zentrum für Agrarlandschafts- und Landnutzungsforschung (ZALF), Müncheberg	Research and development project: mantle project GRANO Scientific information and data exchange: core project AGREC Network project in framework of BMBF project Elbe-Ökologie
	BMBF project: GLOWA-Elbe
	Collaboration in Brandenburg study
	Scientific Advisory Board
Greece	
University of Aegean, Biodiversity Conservation Laboratory, Mytilini	EU project: AVEC
Department of Geography	EU project: URBS PANDENS
Hungary	
Budapest University of Economics	Scientific information and data exchange: core project ICLIPS
	EU project SIADCERO
Central European University (CEU), Budapest	Research and development project: "EEFSU Socioeconomic and Environmental Data"
Israel	
Ben Gurion University, Jacob Blaustein Institute for Desert Research	BMBF project: GLOWA Jordan River
Haifa University, Natural Resource and Environmental Research Centre	BMBF project: GLOWA Jordan River
Ministry of Science and Technology (MOST)	Scientific information and data exchange
	BMBF project: GLOWA Jordan River
Tel Hai Academic College	BMBF project: GLOWA Jordan River
University of Tel Aviv	Scientific information and data exchange: regional climate modelling, climate scenarios
	BMBF project: GLOWA Jordan River
Italy	
Fondazione ENI Enrico Mattei, Milano	EU project: cCASHh
	European Climate Forum (ECF): joint study projects
Istituto Nazionale di Geofisica e Vulcanologia, Rome	EU project:PRISM
Istituto Sperimentale per le Colture Industriali, Bologna	EU project: MAGEC
Joint Research Centre (JRC), Institute for Systems Engineering and Informatics, Ispra	Multi-criteria and conflict analysis
Space Application Institute	EU project: EPN - European Phenology Network
Universitá de Napoli, Portici	EU project: AVEC
Università di Venezia, Dept. of Environmental Sciences	INTAS project: Modelling of point and nonpoint pollution in watersheds
Università di Viterbo, Dept. of Forest Sciences	FLUXNET, BAHC key theme 1
World Health Organization, European Centre for Environment and Health, Rome	EU project: EPN - European Phenology Network
	EU project: CCASHh
Japan	
Institute for Global Environmental Strategies, Hayama, Kanagawa	Scientific information exchange; visiting researchers; memberships in boards
National Institute for Environmental Studies, Tsukuba	International climate policy and simulation
Yamanashi University, Department of Civil and Environmental Engineering	Freshwater research

Institution / Location	Type of co-operation
Kenia	
University of Nairobi, Department of Geology	Freshwater research
Netherlands	
Alterra - Green World Research, Wageningen	Modelling of forest regeneration and model validation: SAFE
	BAHC; dialogue on water and climate
	Joint publication of the BAHC Synthesis Book
Commission for Hydrology of the river Rhine (CHR), The Hague	Scientific information and data exchange for the German Research Network on Natural Disasters (DFNK)
Department of Environmental Sciences, Wageningen	EU projects: ATEAM, AVEC
	EU project: SILVISTRAT
DLO Research Institute for Agrobiology and Soil Fertility (AB), Wageningen	EU project: MAGEC
Foundation for Sustainable Development, International Center for Environmental Assessment	EU project: EPN - European Phenology Network
Institute for Environmental Communication, GLOBE, Utrecht	EU project: EPN - European Phenology Network
International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE), Delft	Dialogue on water and climate
Maastricht University, International Center for Integrative Studies (ICIS)	EU project: EPN - European Phenology Network
	EU project: cCASHh
National Institute of Public Health and the Environment (RIVM), Bilthoven	UBA project: WAKE
Research Institute for Agrobiology and Soil Fertility, Haren	EU project MAGEC
Royal Netherlands Meteorological Institute (KNMI), De Bilt	EU project: PRISM
University of Utrecht, Department of Geography	EU project IRMA/SPONGE
Vrije Universiteit Amsterdam, Faculty of Earth Science Institute for Environmental Studies	DFG project (palaeo climate modelling)
	EU project: DINAS-COAST
Wageningen Agricultural University, Department of Theoretical Production Ecology	Project agreement: mantle project FACE (BMBF project) Scientific information and data exchange: AGRAR/ GCTE Wheat Network
Dept. of Environmental Sciences	Soils and water research
Environmental Systems Analysis Group, Laboratory of Geo-information Science and Remote Sensing	EU project: EPN - European Phenology Network
WL Delft Hydraulics, Delft	EU project: DINAS-COAST
Nigeria	
University of Lagos, Faculty of Environmental Sciences, Lagos	Groundwater research
Norway	
Dep. of Political Science and CICERO, Oslo	Modelling political decisions & research on regime effectiveness
Institute of Marine Research, Bergen	PIK project: INTEGRATION, modelling of marine biota
Nansen Environmental and Remote Sensing Centre, Bergen	EU project: PRISM
	European Climate Forum (ECF): joint study projects
University of Oslo	DAAD & Norwegian Research Council: contract on methodology of regime effectiveness
Poland	
Research Centre of Agricultural and Forest Environment, Polish Academy of Sciences, Poznan	Scientific information and data exchange

Institution / Location	Type of co-operation
Warsaw Agricultural University, Dept. of Silviculture	Agreement on co-operation: data exchange and modelling of pristine forest succession: SAFE
Warsaw University, Faculty of Geography andRegional Studies	EU project: URBS PANDENS
Institute of Geophysics	Scientific co-operation (WTZ project) in dynamic earth system modelling
Portugal	
Universitade de Trás-os-Montes e Alto Douro (UTAD), Department of Forestry, Vila Real	DAAD project
	Scientific information and data exchange: SAFE
Romania	
National Institute for Research and Development in Informatics, Bucharest	Agreement on data exchange
Russia	
All-Russia Research Institute of Hydrometeorological Information, World Data Centre, Obninsk	Data exchange contract
Moscow State University	INTAS project (International Association for the promotion of co-operation with scientists from the independent states of the former Soviet Union): Moscow Global Biosphere Model (MGMB)
Russian Academy of Sciences, Institute for Microbiology	Modelling Archaean biosphere
Russian Academy of Sciences, Institute for Physics of the Earth	Scientific information: projects COEM and TRIPEDES
Russian Academy of Sciences, Moscow	INTAS project (International Association for the promotion of co-operation with scientists from the independent states of the former Soviet Union): Moscow Global Biosphere Model (MGMB)
Slovenia	
Urban Planning Institute of the Republic of Slovenia	EU project: URBS PANDENS
South Africa	
University of Natal, Pietermaritzburg	Project: WADI
Dept. of Agricultural Engineering	Freshwater and groundwater research; dialogue on water and climate
Spain	
Institute for Prospective Technological Studies of the European Commission - Directorate General Joint Research Centre, Seville	EU project: SIADCERO
Laboratorio Ecología, Facultad de Medio Ambiente, Universidad Castilla-La Mancha, Toledo	Scientific information and data exchange
Universitat Autonoma de Barcelona, Centre de Recerca Ecològica i Aplicacions Forestals (CREAF)	EU projects: SILVISTRAT, ATEAM
Sweden	
International Geosphere-Biosphere Programme (IGBP), Stockholm	BAHC and IGBP activities
Lund University	Scientific information and data exchange: SAFE
Climate Impacts Group, Plant Ecology, Department of Ecology	EU project: ATEAM
Stockholm University, Centre for Research on Natural Resources and the Environment	EU project: CCASHh
Institute for Urban Studies	EU project: URBS PANDENS
Sveriges Lantbruksuniversitet, Uppsala, Department for Production Ecology	EU project: SILVISTRAT
Swedish Meteorological and Hydrological Institute, Norrkøping	EU project: PRISM
University of Uppsala, Department of Sociology	Exchange on social systems dynamics

Institution / Location	Type of co-operation
Switzerland	
Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft, Birmensdorf	Scientific information and data exchange, modelling of forest succession and model validation: SAFE Data provision contract: "Sturmschäden im Ural: Ursache und Bewertung" (STURMURAL)
Eidgenössische Technische Hochschule Zürich (ETHZ), Departement für Forstwissenschaften	Modelling of forest succession and model validation: SAFE
	Co-operation with BAHC within the Mountain Research Initiative (MRI)
	EU projects: PRISM, ATEAM
Genfer Hochschulinstitut für Internationale Studien	Publication project: International relations and global climate change
Mountain Research Initiative (MRI), Bern	Joint co-ordination of MRI, BAHC contribution to MRI
Paul Scherrer Institut, Villingen	European Climate Forum (ECF): joint study projects
Universität Basel	EU project: AVEC
Universität Bern, Historisches Institut	DFG project Extreme - 1500
Physikalisches Institut	Scientific information and data exchange
Institut für Geographie	DFG project Extreme - 1500
	EU project: EPN - European Phenology Network
World Meteorological Organization, Genf	Project: WADI
World Climate Research Programme	Freshwater research
United Kingdom	
ADAS, Wolverhampton	Scientific information and data exchange: large-scale modelling of hydrology and water quality
Central Laboratory of the Research Councils, Computational Science & Engineering, Daresbury	Development and application of metadata model CERA-2
Centre for Ecology and Hydrology (CEH), Wallingford	Groundwater research
Climate Research Unit, UEA, Norwich	EU project: ATEAM
Cranfield University, International Ecotechnology Research Centre	Scientific information and data exchange: core project BBM/GAIA Modelling human responses to global change
European Centre for Medium Range Weather Forecasts (ECMWF), Reading, Berkshire	Scientific information and data exchange: Regional climate model
	EU project: PRISM
Fujitsu European Centre for Information Technology, Uxbridge	EU project: PRISM
IACR Rothamsted, Soil Science Department, Harpenden, Hertfordshire	EU project: MAGEC
	EU project: ATEAM
Institute of Terrestrial Ecology, Edinburgh Research Station	Exchange of scientific visitors and joint venture research on geophysical modelling
Jackson Environment Institute, University College, London	Research and development project: core project ICLIPS
Liverpool John Moore University, School of the Built Environment	EU project: URBS PANDENS
London School of Hygiene and Tropical Medicine	EU project: CCASHh
Middlesex University, Flood Hazard Research Centre	Research and methodological development for coastal vulnerability assessment and adaptation
	EU project: DINAS-COAST
Monks Wood and Edinburgh Research Stations	EU project: AVEC
National Environment Research Council, Institute of Terrestrial Ecology, Huntingdon	EU project: EPN - European Phenology Network
NEC Europe Ltd, London	EU project: PRISM
Rutherford Appleton Lab., Department of Space Sciences, Chilton/Didcot	Scientific information, model and data exchange

Institution/Location	Type of co-operation
Secretary of State for Defence, London	EU project: PRISM
Silsoe Research Institute	EU project: ATEAM
Tyndall Centre for Climate Change Research	European Climate Forum (ECF): joint study projects
University College London, Department of Geomatic Engineering, Department of Geography	Global satellite land surface data for biophysical modelling
School of Public Policy	EU project: CCASHh
Department of Space and Climate Physics	Scientific information and data exchange ARC-DAAD-Programm: Projektbezogener Personenaustausch PPP
University of Aberdeen, Department of Plant and Soil Science	EU project: ATEAM
University of Durham	EU project: AVEC
	Scientific information and data exchange; EU project: DART
University of Essex, Dept. of Biology, Colchester	Project agreement: mantle project FACE (BMBF project)
University of Oxford, Environmental Change Institute	EU project: AVEC
University of Reading	EU project: PRISM
University of Sheffield, Dept. of Animal & Plant Sciences	EU project: ATEAM
University of Southampton, Department of Geography	EU project: ATEAM
USA	
Battelle Pacific Northwest National Laboratories, Washington	Research and development project: core project ICLIPS
Boston University, Center for Remote Sensing and Department of Geography	Production of global biophysical remote-sensing data (MODIS)
Brookhaven National Laboratory Biosystems Division, Upton, Long Island	Project agreement: mantle project FACE (BMBF project)
Center for Environmental and Estuarine Studies, University of Maryland	Scientific information and data exchange: Integrated modelling of water and biogeochemical cycles
Center for Political Studies, Institute for Social Research, University of Michigan, Ann Arbor	Scientific information and data exchange
Electric Power Research Institute, Palo Alto, CA	Scientific information and data exchange: core project ICLIPS
Geophysical Fluid Dynamics Laboratory (GFDL), Princeton	Scientific information and data exchange: Ocean modelling (informal co-operation)
Georgia State University, Athens, Georgia	Scientific information and data exchange: BBM/GAIA
Goddard Space Flight Center, NASA, Greenbelt, Maryland	Research Network LBA - Large-Scale Biosphere-Atmosphere Experiment in Amazonia
International Geosphere-Biosphere Programme IGBP-START, Washington	Support of various projects, workshops, etc.
John Hopkins University, Baltimore, Maryland	Project-related exchange of scientist (NFS-DAAD-Programme): "Numerical simulation of complex flows using asymptotic-based schemes" (informal co-operation)
Lawrence Berkeley Laboratory, Berkeley, California, Ann Almgren	"Multiple scales asymptotics and numerics of atmospheric flows"
Lawrence Livermore National Laboratory, Global Climate Research Division, Livermore	Project agreement: mantle project FACE (BMBF project)
Massachusetts Institute of Technology (MIT), Joint Program on the Science and Policy of Global Change, Cambridge	Exchange of scientific information, joint organization of forums
New York University, Courant Institute of Mathematical Sciences	Multiple Scales Mathematical Modelling for Equatorial Flows
NOAA Office of Global Programs, Silver Spring, Maryland	Freshwater research, IGOS water cycle project
Northwestern University, Evanston/Ill., Dept. of Political Science	Edited book in "The analysis of international relations"
United States Department of Agriculture (USDA), Agriculture Research Service, U.S. Water Conservation Lab., Phoenix, Arizona	Project agreement: mantle project FACE (BMBF project)
US Department of Agriculture (USDA), Agricultural Research Service, Grassland, Soil and Water Research Lab., Temple, Texas	Scientific information and data exchange: Catchment modelling with GIS, SWAT and SWIM models

Institution / Location	Type of co-operation
University of Georgia, Athens, Georgia	EU project: ATEAM
University of New Hampshire, Complex Systems Research Center, Durham, New Hampshire	Freshwater research
Institute for the Study of Earth, Oceans and Space	Scientific and logistic co-operation within IGBP Task Force GAIM
US Dept. of Energy, Oak Ridge National Laboratory, Tennessee	Scientific information and data exchange: Global Primary Production Data Initiative (GPPDI)
Yale University, New Haven, Connecticut, Center for Environmental Law and Policy	Collaboration in the Global Environmental Governance Dialogue
Usbekistan	
Central Asian Hydrometeorological Research Institute, Glavgidromet Sanigmi, Tashkent	Scientific information and data exchange: project preparation (Aral Sea)
Venezuela	
Universidad Simón Bolívar, Department of Statistics and Mathematics	Vulnerability of water resources

Members of Staff

Stand 01.01.02

Director
Schellnhuber, Prof. Dr. Hans Joachim

Deputy Director
Stock, Dr. Manfred

Public Relations
Boysen, Margret

Scientific Departments

Integrated Systems Analysis
Bounama, Christine
Franck, Prof. Dr. Siegfried
Egorov, Pavel
Eisenack, Klaus
Füssel, Hans-Martin
Held, Dr. Hermann
Jaeger, Annekathrin
Kleinen, Thomas
Knopf, Brigitte
Koscielny-Bunde, Eva
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Wenzel, Dr. Volker
Zickfeld, Kirsten

Climate System
Ahrens, Dr. Wilfried
Bauer, Dr. Eva
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Brovkin, Dr. Victor
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Global Change & Natural Systems
Badeck, Dr. Franz-W.
Becker, Dr. Alfred
Beckmann, Dr. Thomas
Bondeau, Alberte
Bronstert, Prof. Dr. Axel (guest)
Cramer, Prof. Dr. Wolfgang
Dress, Gabriele
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Erhard, Dr. Markus
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Schaphoff, Sibyll
Schlums, Alison

Schröder, Birgit
Schröter, Dr. Dagmar
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Sitch, Dr. Stephen
Smith, Pascalle (guest)
Ströbl, Bernhard
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Wattenbach, Martin
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Weng, Reinhard
Zaehle, Sönke

Global Change & Social Systems
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Leimbach, Dr. Marian
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Data & Computation
von Bloh, Dr. Werner
Botta, Dr. Nicola
Dress, Gabriele
Flechsig, Michael
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Ionescu, Cezar
Klein, Prof. Dr. Rupert
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Uhlmann, Dr. Markus
Wrobel, Markus

Administration
Galda, Dagmar
Großmann, Vera
Haneberg, Frauke
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Heuer, Kerstin
Kramer, Monika
Lehmann-Lullies, Renate
Lindenhan, Lothar
Lindow, Annett

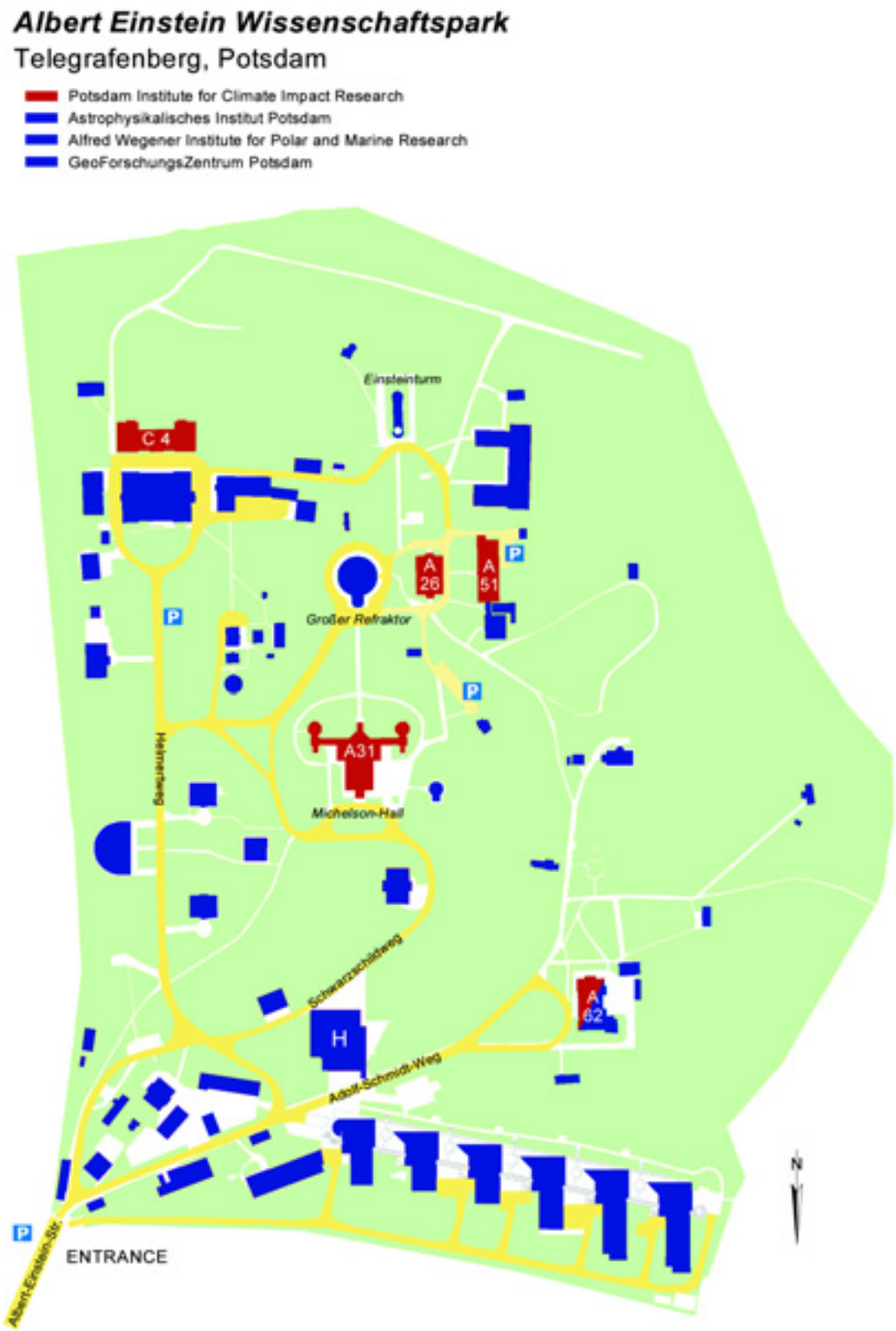
BAHC
Hoff, Holger
Lütkemeier, Dr. Sabine
Seelig, Wilhelmine

IGBP-DIS
Szejwach, Gérard

Notes

Notes

Campus Map


Albert Einstein Wissenschaftspark
Telegrafenberg, Potsdam
Potsdam Institute for Climate Impact Research
Astrophysikalisches Institut Potsdam
Alfred Wegener Institute for Polar and Marine Research
GeoForschungsZentrum Potsdam
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ENTRANCE
N

Corrigendum

Owing to an error the peer-reviewed publications for 2000
were missing from the biannual report 2000/2001. The list follows below.

Publications 2000

Publications, peer-reviewed

Barnsley, M.J.; Hobson, P.D.; Hyman, A.H.; Lucht, W. (2000): Characterising the spatial variability of broadband albedo in a semi-desert environment for MODIS validation. *Remote Sensing of the Environment*, 74, 1, 58-68.

Bauer, E.; von Storch, H.; Stolley, M. (2000): Sensitivity of ocean waves to speed changes of the weather stream. *The Global Atmosphere and Ocean System*, 7, 2, 91-106.

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Breitung, W.; Chan, C.; Dorofeev, S.B.; Eder, A.; Gelfand, B.E.; Heitsch, M.; Klein, R.; Malliakos, A.; Shepherd, J.E.; Studer, E.; Thibault, P. (2000): State of art report on flame acceleration and DDT in nuclear reactor safety, Paris, OECD.

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