**John Schellnhuber to Chair GAIM**

Hans-Joachim (John) Schellnhuber has agreed to chair the GAIM Task Force as of January 1, 2000. John is the Director of the Potsdam Institute for Climate Impacts Research (PIK), in Potsdam, Germany, and holds a Chair for Theoretical Physics at the University of Potsdam. Among many other posts, John is Chairman of the German Advisory Council on Global Change, Vice-Chairman of the National Committee on Global Change of the German Science Foundation (DFG), and Coordinating Lead Author of Chapter II.19 of the Third Assessment Report of IPCC. John brings to GAIM a global systems perspective, and will be building on the foundation laid by Berrien Moore, previous GAIM Chair. As integration and synthesis become an increasingly important part of IGBP, John’s systems-level approach will be invaluable in leading GAIM in its role as “integrator of IGBP.” He has authored over 100 articles and book chapters, and 10 books on topics in Physics, Mathematics, Systems Analysis, Earth System Science, and Global Change. Some of his Earth-system perspectives are nicely outlined in a recent article in Nature (Schellnhuber, HJ., ‘Earth system’ analysis and the second Copernican revolution, NATURE, 1999 DEC 2, V402 N6761 SUPPS:C19-C23). We welcome John Schellnhuber to GAIM and look forward to years of productive research and integrative activities within GAIM and beyond with John at the helm. (See “The Waikiki Principles”, this issue.)

---

**New GAIM Program Assistant**

Jennifer Boles joined the GAIM Task Force Office as Program Assistant in November 1999. She will assist in all office activities and has already been a great help in organizing the office, the systems, and the various GAIM activities. Jennifer has a B.S. in Wildlife Biology from the University of Alaska. While at Alaska, she worked in an equivalent role at the Institute for Arctic Biology. In an amazing feat of determination, she drove her truck solo across the continent, pulling a trailer from Fairbanks, Alaska to New Hampshire. Her energy and determination will be a great asset to GAIM and IGBP in the coming years.
The Waikiki Principles: Rules for a New GAIM
By John Schellnhuber

The first newsletter in the new millennium provides a convenient canvas for re-sketching the basic mission of GAIM, that is, pioneering Earth System science into a state of novel quality. This sounds rather preposterous yet turns into a solid ambition upon closer inspection of (i) the giant explorative strides taken by the big global research programmes (IGBP, WCRP, IHDP, etc.) during the last years, and (ii) the opportunities arising from the think-tank character of GAIM. Let me briefly elaborate on both aspects in the following.

In a recent essay for the Millennium Supplement of Nature (Vol. 402, Supp. 2 Dec 1999, C19-C23) I argued that the “Second Copernican Revolution” is just around the corner. This revolution reverses, in a way, the glorious first one by looking back on our planet from a (real or virtual) distance, striving to understand the so-perceived system as a whole and to develop concepts for global environmental management. The scientific trans-discipline thus emerging may be called Earth Systems analysis; it is supposed to yield a unified formalism for describing the make-up and functioning of the earthsphere machinery as well as its susceptibility to erratic or judicious human interventions. Ultimately, Earth System analysis will be even able to address the challenge of sustainable development in a no-nonsense way by deducing the macro-options for future earthsphere-antroposphere co-evolution from first cognitive and ethical principles.

In order to achieve all this, we clearly still have a long way to go, but the signs of hope accumulate at an ever increasing pace. Take, for instance, the growing stream of insights arising from the separate core projects of IGBP as highlighted at the Second IGBP Congress held in Japan last May (see Berrien Moore’s keynote in Global Change Newsletter 38, and Will Steffen’s reflections in Research GAIM, Summer 1999). This breathtaking progress was most impressively illustrated by Hugh Ducklow’s lecture on the unravelling of the mysteries of the global oceanic flux system. So it seems that “all” that remains to be done is to take the scientific bits and pieces and to put them together.

But integration is much more than a synthetic book-keeping exercise – remember that it took evolution almost 4 billion years to compose the human brain from macro-molecules available already in the early days of life. The virtual scientific reconstruction of the planetary machinery (“Gaia”) is not much smaller a task, although we expect it to be accomplished in less than a couple of eons. What will be needed, at any rate, is a sophisticated integration methodology as transpiring, e.g., from the modern theory of complex non-linear dynamic systems, and it will be necessary to account for all sorts of deterministic and stochastic uncertainties.

This is the point where the New GAIM

Ecosystem Model/Data Intercomparison (EMDI):
An Update and Future Plans
By Kathy Hibbard

The week of December 5-8, the University of New Hampshire, the IGBP-GAIM office in collaboration with the National Center for Ecological Analysis and Syntheses (NCEAS) and the IGBP-DIS hosted 12 international global vegetation modeling teams to compare simulated to observed globally extensive Net Primary Productivity (NPP) predictions. Data for the observed NPP came from the Global Primary Productivity Initiative (GPPDI). The GPPDI held several workshops and established several working groups to develop this global database of measured NPP values. The GPPDI was coordinated by Jonathan Scurlock, Dick Olson of ORNL and Steve Prince of University of Maryland. They assembled over 5000 point estimates of NPP globally from ecological site studies as well as estimates of NPP for regularly gridded regions using agricultural and forestry statistics that have high spatial density over those regions. This represents a more comprehensive database of measurements than has previously existed. The quality varies and the data was broken into 3 categories accordingly. Nevertheless, if global models are to represent some aspect of the terrestrial carbon cycle, this database forms a key source of information with which the models must show some sort of consistency. This work, which is continuing, forms the empirical foundation that allows the model-data comparison project - Ecological Model Data Intercomparison (EMDI) project to attempt something which hasn’t been done before for terrestrial carbon cycle models.

The participating modeling groups represented a broad range of approaches to treating terrestrial carbon dynamics. Groups employing satellite driven radiation interception models, ecosystem biogeochemical models with monthly time steps, detail process models with hourly time steps, and static vegetation and dynamic vegetation variants of these completed runs and were present at the workshop. Each modeling group was provided basic model drivers for the sites and regions or could use their own resources for producing model simulations. The NPP measurements were not provided to the modelers until they submitted their simulation results. At the workshop there were presentations of model details and general discussion concerning what each model was sensitive to and how this affects the range of sites that the models were most appropriate at representing. The bulk of the workshop focused on how well and what aspects of the measurement data the models captured or didn’t capture. This was accomplished by studying the relationships between data and model results site by site, how well they corresponded across climate dimensions, and how well they represented spatial patterns. Breakout groups tackled each of these approaches and had enough interesting results that the outlines of a manuscript for Global Change Biology was drafted the last morning of the workshop.

Most of the NPP data are being compiled at ORNL and UMD with funding from Diane Wickland, at NASA. In addition, NCEAS funded a series of workshops that reviewed the NPP data used in this model data intercomparison, including.
EMDI-
developing methods to scale field NPP measurements to scales used in regional models. Despite the enormous amount of work that went into preparing for this workshop – assembling the NPP data, locating and making available the site and region environmental data, performing the model simulations - there was a realization that model data comparison is an extraordinarily complex task that we are only beginning. There was enthusiasm among the workshop participants that we were embarking on an important new direction in model evaluation. Given the low level of funding for this initiative it will take about 10 to 12 months to fix some problems in the provided environmental data, harmonize the vegetation classifications between the various sources of data, redo the model runs, and complete an in-depth analysis of this first exercise. There were problems with the monthly precipitation fields provided by PIK as well as a lack of coordination in defining the land cover, or vegetation type by the modelers. These issues were quickly identified and resolved during the course of the workshop itself. In addition, those models that required sub-daily time steps agreed that a consensus method at calculating sub-daily climatology would be required. It was agreed that the groups would coordinate and re-calculate a common sub-daily climatology using the ECMWF/CRU re-analysis dataset. It was agreed that all of the modelers would prefer to re-run their simulations with the new land cover and climate datasets before making results public, however, it was strongly felt that there was enough material and results that were likely unaffected by these errors that a paper based on an ‘ensemble’ model (average of all submitted model results) would be the primary product from this workshop.

Initially, there were five questions that the workshop was designed to focus on:

- **How does the simulated NPP compare with the data?**
- **How sensitive are models to site-specific climate?**
- **Does additional mechanistic detail in models result in a better match with field measurements?**
- **How useful are the measures of NPP for evaluating model predictions?**
- **How well do models represent regional patterns of NPP?**

It was determined that given problems with the environmental and land use datasets, the first question would be the most straightforward to address in a publication with the ensemble model. The group broke up into three sub-groups to explore the results with respect to how the simulated NPP compared to the observed with respect to: climate space (variability with respect to AET, extremes, etc), site variability (bias and error), and variability by biome type.

The current draft outline for the paper first discusses the observed data with respect to its representativeness, and how it was assembled. The second section of the paper will discuss how the ‘ensemble’ model data varies in climate space: temperature, precipitation, and AET as well as the spatial patterns of predicted NPP in climate space and site variability. The site analyses will be used by biome and model with this first set of runs where the bias = predicted – observed NPP both as a percent deviation from observed as well as an MAE. The third section of the paper will focus on issues with respect to an outlier analysis of the observed and ‘ensemble’ runs. It was agreed that a definition of ‘outliers’ would include those observations that were ± 2 standard deviations in biome space and/or where observed was ± 2 standard deviations when compared to the average modeled AET. Appropriate figures and tables for each section were identified for the paper.

In addition to ironing out difficulties with the current exercise - identifying and explaining the cause of outliers in both data and model predictions, consistency between environmental factors that are associated with actual field measurements and the environmental factors that are used to derive model projections, there was a discussion of additional data sources and future directions. Of particular importance is the validation of time dependent projections. The current exercise is largely, though not entirely, and evaluation of how well models capture current terrestrial dynamics. This is only the beginning of what these models are intended to accomplish. To gain confidence of how well models do under changing environmental conditions (CO2 increase, climate change) we need to evaluate how model and field measurements correspond with interannual variation. There were several presentations for alternative validation analyses including long-term experimental research plots (like the ORNL TDE, LTER projects), flux towers, forest inventory re-measurement data, agricultural production data, and hydrology measurements that link to the terrestrial carbon cycle (e.g. runoff and streamflow).

Some groups have expressed interest in whether the terrestrial models that are being used to make projections of the future role of terrestrial systems in the carbon and water cycles are validated and how much confidence can we place in the projections. This EMDI project is one of the most ambitious groups of people training considerable (though largely voluntary at this point) resources directly on this question. The project will, in addition to cleaning up and meeting again on the initial results of the model-data comparison in about 6 to 8 months, be working on developing a proposal for the more advanced stages of model-data comparison which focus on spatial scaling and capturing temporal dynamics.

The next step for EMDI will be to host another workshop that evaluates the second set of simulations. In addition, each modeling group that was present at the December workshop provided the group with the time step and suite of additional variables that their model could provide in an effort to evaluate model results in light of a complete carbon and water budget (e.g. output NEP, GPP, runoff, AET, etc). This will facilitate model comparisons to flux tower sites and other (e.g. hydrologic) observations. The flux-tower community was well represented by Beverly Law who suggested that at least 15 Ameriflux sites were willing and eager to participate in this important next step. In addition, additional groups will be invited in that were either unable to attend or participate in this workshop (e.g. Friend, Hurtt, others) for the next generation EMDI.
Waikiki-

enters the scene: During the recent meeting of the Task Force in Waikiki, Hawaii (31 January – 2 February 2000), the integration challenge was intensively discussed and identified as the central research issue of the next decade of global change science. And the group, which embraced the top representatives and executives of IGBP, concluded unanimously that GAIM shall become the central driving force for Earth System analysis by fully utilizing the potential resulting from its cross-sectoral design. In order to be specific, an explicit survey among the participants was conducted for revealing individual priorities and suggestions regarding the longer-term targets to be met. A clear-cut picture emerged which may be summarized in the following three “Waikiki Principles”.

I. GAIM is to explore and promote cognitive opportunities arising from the appropriate combination of core project results and tools. This means, in particular, to play the role of a trans-project topics scout and a feasibility assessor.

II. GAIM is to advance the integration of wisdom inside and outside IGBP. This means, on the one hand, to make available the best integrative methodologies and, on the other hand, to include the systems and problems dimensions primarily investigated by the sister programmes WCRP and IHDP.

III. GAIM is to implement Earth System analysis by organizing the construction, evaluation and maintenance of a hierarchy of Earth System models. This means, in particular, to help generate models of different degrees of complexity and to employ the resulting complementary ensemble for conducting virtual planetary experiments with respect to past, present, and future global changes.

As a consequence, the acronym GAIM should from now on stand for “Global Analysis, Integration and Modelling”. Principle I is illustrated by the TRACES (Trace Gas and Aerosol Cycles in the Earth System) Initiative; principle II by the intra-IGBP Carbon Project and the envisaged inter-programmatic cross-cutting themes like water and food fibre; principle III by the EMIC (Earth System Models of Intermediate Complexity) Initiative and the “Flying Leap” towards a fully coupled state-of-the-art ocean-atmosphere-biosphere model. There is no doubt that GAIM will keep on providing the IGBP community with sophisticated services like well-designed model and data intercomparisons, but its thrust will be focused on research at the Earth-system level.

It has to be emphasized that the Waikiki Rules for the New GAIM have yet to be approved by the “legislative and executive bodies” of IGBP, but I am confident that they will gladly help to open up this avenue towards the scientific horizon.

OCMIP Carbon Analysis gets Underway
by James Orr

Analysis of OCMIP-2 carbon simulations has just begun, after two years of preparation and the combined efforts of 13 modeling groups. The carbon component of the OCMIP database is now burgeoning with model output from carbon simulations from most of its members. More carbon output will be submitted over the next couple of months. Centralized analysis is now underway, while output from the OCMIP carbon simulations is undergoing consistency checking.

So far, carbon analysis has focused on anthropogenic CO₂. Modern global uptake is consistent between models (see table - pg 5). Yet despite global agreement, regional differences between models are still large for the modern era, particularly in the Southern Ocean. Spatial differences at present are suggestive of potentially larger differences in the future. As anthropogenic CO₂ invades further into the deep ocean, in part through its link with the surface of the Southern Ocean, additional differences become more apparent. Over the next century, model estimates diverge under future IPCC scenario S650. These results are consistent with the results from phase one of the same project, OCMIP-1, with four models.

Anthropogenic CO₂ analysis will further investigate if some differences between models can be classified according to underlying model physics. Previous CFC validations, carried out on the same OCMIP-2 models, showed similar trends between certain classes of models for the vertical and horizontal penetration of tracer. Those validations suggest that models coupled with a sea-ice model as well as models with sub-grid scale mixing oriented along surfaces of constant density (isopycnals) provide consistently more realistic penetration of tracer from the high latitudes into the interior ocean. Anthropogenic CO₂ is a different tracer, having a longer atmospheric history, slower air-sea equilibration rate, and a
The OCMIP anthropogenic CO₂ simulations will be examined further, regarding how they compare with available data. Classically, model estimates for anthropogenic CO₂ have been compared to data-based estimates of bomb C-14, another transient tracer. More recently, models have been directly validated with new data-based estimates for anthropogenic CO₂ itself. OCMIP will exploit both available data sets. Additionally, OCMIP will help estimate regional uncertainties for these data-based estimates, by using the same data-based methodologies with model output fields (instead of data) and comparing those calculated results with simulated anthropogenic CO₂. OCMIP will further use multi-tracer analysis (anthropogenic CO₂ vs. bomb C-14; anthropogenic CO₂ vs. CFC) to attempt to categorize model differences possibly as an added validation tool.

OCMIP modeling groups are also submitting results from a steady-state (preindustrial) simulation with a common biological model. Analysis will concern both the mean state and the seasonal cycle. It will emphasize how the different circulation fields (from the different models) influence the common biogeochemical model. Results will be evaluated with new seasonal data sets for oxygen and phosphate. Modeled p CO₂ (preindustrial) will be added to the anthropogenic component from OCMIP’s Abiotic run for comparison with recently derived, observationally based global maps.

Although OCMIP’s carbon analysis has required substantial preparation, it is now underway. Over the next year, OCMIP will produce refined limits for the global and regional uptake of anthropogenic CO₂ and a better understanding of the effect of changes in circulation on ls-predictions from ocean biogeochemical models.

### Atmospheric CO₂ Inversion Intercomparison Project (TransCom)

*By Scott Denning*

The area-mean exchange of CO₂ between the surface and the atmosphere can be deduced from atmospheric concentration measurements using chemical tracer transport models (CTMs). Such “inverse” calculations are important to IGBP because they provide an integral constraint for process models developed at local scales. The current suite of carbon budget inversion studies produce results which are difficult to reconcile with one another. TransCom is a model intercomparison project which seeks to understand the strengths and weaknesses of inverse models of the carbon budget, with the aim of improving the reliability of such calculations.

TransCom Phase 1, completed in 1995, conducted experiments to compare the simulations of atmospheric concentration resulting from fossil fuel emissions and from seasonal exchange with terrestrial biota. These processes are primarily responsible for the annual mean gradient from north to south and the seasonal cycle of atmospheric CO₂, respectively. 12 modeling groups participated in the experiments, revealing significant differences relevant to the inversion problem. Phase 2, completed in 1998, involved a calibration experiment comparing simulations of SF₆ across the various CTMs. Besides quantitative evaluation of the simulated transport, Phase 2 included detailed diagnosis of mechanisms in the models that produce the different behavior.

Having developed in Phases 1 and 2 a description of the transport differences among CTMs and the effects of these differences on the mean distribution and annual cycle of CO₂, we are now engaged in Phase 3, which involves intercomparison of the full inversion calculation of sources and sinks from the observed concentration.

The objectives of TransCom Phase 3 are (1) to determine the effect of differences in simulated tracer transport, choice of observational data, and inversion methods on the calculated regional fluxes; (2) to diagnose the mechanisms that produce these differences and (3) to suggest improvements to models and the global observing system to produce more robust inversions. Each participating CTM group will perform forward simulations of the concentration field that arises from a unit flux in each of agreed-upon set of

"TransCom" pg 6
TransCom-

regional “basis functions.” The results of the forward simulations will be submitted to a central Coordinator and archived. Inversions of the fluxes using each model’s result will then be performed by a variety of mathematical methods, to allow comparison of the calculated fluxes both across CTMs and across inversion methods.

The experimental design reflects the tension between greater participation and greater diagnostic detail. We have chosen to specify a minimum experimental protocol that is straightforward to implement (to maximize participation by keeping the entry barrier low), and allow for more detailed experiments by those groups with sufficient resources and interest. This strategy is best pursued by centralizing many of the tasks to be performed, so that participation in the experiment requires a minimum of effort by a CTM group. All data and model output will be available through an open archive to all participants, and analysis will be distributed across several groups in four countries.

Products
1. Regional (continental) estimates of annual and seasonal flux of CO$_2$ to/from the atmosphere

TransCom 3

TransCom 3 is an international intercomparison of CO$_2$ inverse models, which is intended to quantify the contributions of simulated transport, data selection, and inverse methods on the computation of atmospheric carbon budgets.

TransCom 3 participants are busily cranking through the tracer simulations that provide the grist for the inversion mill. Peter Rayner at CSIRO in Australia is developing inverse code to analyze these results. Philippe Peylin from Saclay France spent a month at CSU this fall, and we have discussed ways to streamline the analysis process and visualize results. Level 1 results (leading to an intercomparison of annual mean inverse fluxes) are expected to be archived in early 2000, and Level 2 results are expected later in the year. We plan our next international meeting in Paris May 18-19, 2000.

TransCom is open to all interested participants. Complete information (including a detailed experimental protocol, all required input datasets, and some analysis software) is available at http://transcom.colostate.edu).
Climate models currently predict that the global mean surface temperature will increase in the coming decades in response to increasing greenhouse gases in the atmosphere. As one of the serious consequences of this climate change, a substantial rise of the global mean sea level is expected. Knowledge of the rate of sea-level rise to be expected on regional to global scale is most significant because of the potentially devastating impact on human society and coastal ecosystems. In fact, a large proportion of the world’s population (currently about 2.5 billion), live within 60 km of the coast, and these areas often have a well developed infrastructure that could be severely disrupted by further sea level rise. Therefore, observations and scientific research are needed which can give guidance in the proper development of coastal zones in order to mitigate the social and ecological impact of future climate change in an effective and economically affordable way. The specific future research priorities for addressing these issues were formulated at the conference and are included below.

**Conference Objective**

The objective of the conference was to provide a forum for critical discussion of the present state of knowledge of sea-level variability in relation to the hydrological cycle both at global and regional scales. The main focus was on the identification of problem areas which need to be investigated and key parameters which need to be monitored in order to improve our understanding of the physical phenomena and their interactions governing the spatial and temporal variations of sea level. The key areas were identified as measurement & monitoring, quantification of global hydrologic balance, and evaluation of impacts as they pertain to policy issues and the IPCC process.

**Key Issues**

The issues confronting investigations of modern sea level rise can be grouped into three categories:

- **Measurement**
- **Mechanisms**
- **Impacts.**

**Measurement** of sea level change in the 20th century has traditionally been based on tide gauge records, corrected for coastal epeirogeny in response to glacial re-equilibration. The relatively long tide gauge records make it possible to extract a secular signal from highly variable short-term observations. For almost two centuries, sea-level observations have been provided from a network of tide gauges with sites along the coasts all around the world (but mostly in the northern hemisphere). Tide gauges measure sea-level relative to the land surface at the local coast. Therefore, vertical crustal movements originating, for example, from local subsidence, tectonics and post-glacial rebound influence such measurements. In order to decouple global sea-level changes from local effects, epeirogenic motion needs to be monitored and better understood on the basis of models of the Earth’s mantle and lithosphere. In this way, the relative sea level recorded by tide gauges can be converted to the more globally relevant eustatic sea level which depends on the relative volumes of the global ocean water and the global ocean basin.

More recently, satellite radar altimeter observations of sea level have made it possible to record variations in the open ocean as well as along the coastline, but these records exist only for the last decade or so making it difficult to extract secular sea level trends. They will, however, become increasingly important in the 21st century. Because these measurements are based on the satellite height relative to the center of mass of the Earth in a well-defined terrestrial reference system, rather than to the local land surface, global and regional absolute sea-level changes can now be determined. However, radar altimeter instruments experience drifts on the order of 1-2 mm/yr and must be calibrated or modeled, causing the use of these instruments to measure sea level change very challenging.

Available space and in situ techniques must be used routinely and combined for the monitoring of absolute and relative sea level changes at various spatio-temporal scales, i.e., from local or regional to global scales and from seasonal to inter-decadal time scales. Such observations are of fundamental importance for the understanding of how the volume and mass of the oceans change in response to global change as well as of the physical interactions between the cryosphere, hydrosphere and atmosphere involved in sea level changes.

In addition to measurements of global sea level change, satellite altimetry makes it possible to measure the spatial variability of sea level. This will enable the assessment of ocean circulation model and coupled model performance. For projections of the magnitude of future sea level rise, it is necessary to understand the mechanisms by which water is transferred between the ocean and other storage reservoirs. As such, measurement is closely coupled to mechanisms.

The mechanisms of sea level change can be grouped into two types—those that change the volume of the Earth’s ocean basin, and those that change the volume of the Earth’s ocean water. On the time scales of concern in modern global change (decade to century), only water volume changes are important globally, as the tectonic influences on basin geometry act slowly relative to the time scale of interest. (However, locally, “tectonic” processes such as glacial rebound and subsidence due to ground water withdrawal can significantly affect local relative sea level.) Global ocean water volume is increased by adding water to the ocean by melting grounded ice, by add-
Predicting future sea level changes is both important and difficult. Model projections for future global and regional sea level changes are still highly uncertain due to uncertainties in the heat and mass balance of the ocean as well as to the near-term effect of climate change on Antarctic ice budgets. Although there is no doubt that a global warming will cause ocean thermal expansion, present results based on Atmosphere-Ocean General Circulation models are not yet reliable enough to predict future ocean thermal structure because of the difficulty in modelling the complex thermodynamic interactions between ocean and atmosphere (in addition to difficulties modelling the ocean and atmosphere individually). On climatological time scale, the cryosphere has the largest potential to contribute to ocean mass and sea-level changes. Unfortunately, the present mass balance of polar ice sheets is not precisely known. Model predictions do not agree on the amount of warming expected at high latitudes rendering it difficult to understand how the equilibrium of polar ice masses will be altered by the changing relationships between increases in precipitation and increases in ablation. While there is some consensus that mountain glaciers and Greenland ice sheet will lose mass in the future and contribute to sea level rise, the role of Antarctica, the largest potential contributor is very poorly constrained. There is general consensus that in the short-term, atmospheric warming will lead to southern ocean surface warming and will increase precipitation on the Antarctic ice sheet, but the counteracting effects (and time scale) of warming on ice rheology, ice streams, and the West Antarctic grounding line in the long-term are less clearly defined, and remain unquantified. Moreover, contributions from other reservoirs such as ground water or terrestrial surface waters are difficult to estimate and more difficult to predict. Considering this present situation, a detailed monitoring of the sea-level variability is essential.

The impacts of sea level rise are of greatest concern to the general population, particularly in and near coastal communities. Direct hydrologic consequences include flooding of coastal wetlands, salinization of coastal aquifers, alterations of estuarine steam flow, and exacerbation of storm damage to both ecosystems and human-built structures (e.g. houses, roads, bridges, etc.). The present natural coastal defenses are, in most cases, insufficient because they rely on a dynamic interaction between sea level, wave energy, and sediment transport that is corrupted by the presence of artificial structures. Most existing man-made coastal defenses will be unable to accommodate an increase in storm activity super-imposed on a significant rise in mean sea-level. A better documentation of the rate of sea level rise (measurement) and understanding of the causes (mechanisms) will lead to better prediction of the consequences of future sea level rise. It is hoped that this will place policymakers and others in coastal communities in a better position for rational decision-making regarding local responses.

The most serious impacts of sea level rise were identified at the Sea-level conference as:

Shoreline erosion- Shoreline systems, most notably beaches, are subject to increased erosion as sea level rises. The loss of material is not necessarily limited to the shoreline, however. There is an equilibrium profile to be maintained in the coastal zone that will respond to sea level rise by eroding as much as a kilometer inland from the present shoreface, thus extending the region of impact. Nearshore topography and land use need to be documented at the local level in order to be able to predict the impacts of sea level rise on local shorelines. Exacerbation of storm wave damage- Given the historical frequency and severity of coastal storms such as hurricanes and typhoons, any rise in sea level will greatly increase the extent of damage within the coastal zone, particularly during high tide. If there is an increase in storm frequency or severity as a part of other aspects of global change, then sea level rise will further exacerbate the risk of severe storm damage due to high waves.

Storm surges- In addition to damage caused by waves and erosion, flooding due to storm surges will increase un-
Sardinia—under conditions of higher sea level. As is true at present, damage due to flooding will be most severe when the surges strike during high tide.

Coastal ecosystem loss- As sea level rises, coastal ecosystems are subject to flooding, and in many cases cannot keep pace with rapidly rising sea level so are drowned. Because the existing equilibrium profile is often artificially maintained with levees, seawalls, and other means of “protection”, the low-level ecosystems cannot migrate landward and can be lost completely in these cases. The resulting loss of hatcheries for coastal fisheries also had serious consequences regarding the ability of marine ecosystems to continue to provide fishstocks for human consumption.

Aquifer salinization- A significant fraction of world population relies on groundwater drawn from coastal aquifers for their fresh water supply. As sea level rises, the depth of the freshwater lens in the coastal zone is greatly reduced, leading to salinization of water supplies. In extreme cases exacerbated by over-pumping, the aquifer may rapidly become unsuitable for drinking and even for irrigation.

Research Recommendations
It became clear at the conference that IPCC projections are limited by the lack of both observational data and quantitative understanding of the global hydrologic balance. It would appear that the uncertainties in sea level projections for the next 100 years have not greatly improved since the second IPCC assessment because the necessary observational and conceptual gaps have not been filled in the intervening years. Consequently, attention was paid at the conference to the identification of the few most critical areas in which focused research will provide the necessary insights to enhance the reliability of sea level projections.

After a number of presentations of research results pertaining to measurement, analysis and modelling of ice and other hydrologic budgets, and impacts & policy, the conference concluded with a session aimed at identifying the research priorities appropriate for addressing the key outstanding issues. Although we separate measurement, causes and impacts in the discussion below, the three are intimately related, and conference participants recognized the need for the research community to forge stronger links between these research areas.

Measurement

Tide Gauges- The tide gauge record is invaluable because of its longevity, despite the difference between records caused by local tectonics and postglacial rebound. With tide gauge stations tied to the Terrestrial Reference Frame using space geodetic techniques such as GPS, these records will provide an increasingly reliable means to monitor future sea level variations globally. Toward that end, it was determined that additional state-of-the-art tide gauges in the record-poor, but globally important southern ocean, will be critical to the coming years. While century-long records will not be available from new tide gauges for another century, geocentrically-referenced gauges will be of value immediately, as they will record not only relative sea level, but coastline epeirogeny as well.

Global ocean surface height records from TOPEX-POSEIDON and other radar altimeters with greater high-latitude coverage (Geosat, ERS-1, and ERS-2) have provided a quantum leap in our ability to measure the topography of the global ocean, and even in the short time satellite altimetry has been operational and despite of the uncertainty of its accuracy at the level of less than 1 mm/yr (due primarily to instrument drift), a clear signal of sea level change has been recorded. This change is not globally uniform, but varies spatially depending on climate, ocean circulation patterns, and non-homogeneities in the changes in mixed layer thermal structure. Additional satellite altimeters with greater high-latitude coverage are operational or planned for the near future by NASA, the US Navy, CNES and ESA (e.g. GFO-1, JASON-1, ENVISAT), making the future bright for a global satellite observational network, provided the satellites are indeed launched, and the data become available to the scientific community. Radar altimeters can also measure large-scale elevation change for interiors of ice sheets. Spaceborne laser altimeter, IceSat, to be launched in 2001, is anticipated to enable the definitive determination of mass balance of the ice sheets, and thus their impact on sea level change. Advanced satellite gravity mapping missions, CHAMP, GRACE, and GOCE, to be launched by the middle of the next decade, will enable five-fold improvement of the mean gravity field (geoid) of the Earth, and will allow accurate measurements of mass redistribution of the Earth system components with a spatial scale of 300 km. GRACE is anticipated to be able to measure large-scale mass balance of the ice sheet, mass change of the hydrosphere and the ocean, to provide insights to the cause of the sea level change. The most critical need identified at the conference pertaining to satellite records was the need to continuous operation and thus records. Gaps in records can lead to uncertainties and errors in the time series of these critical observations. The high-latitude coverage is obtained by merging the ERS and GFO altimetry with the TOPEX/POSEIDON altimetry. It is recommended that these altimeter systems be calibrated and monitored for their respective instrument and geophysical and media correction drifts as well as their links to each other, using permanent calibration sites and island tide gauges, toward a consistent and long-term observation system for the long-term monitoring of global sea level change.

Causes

Continental hydrologic budget- In what seemed at first as a surprising conclusion from a primarily oceanographic research community, the most critical need (highest priority) was identified as better quantification of the hydrologic budget of the continents. This need arises from the large and variable water flux between oceans and continental interiors, as well as the knowledge that these fluxes are being altered by land use and water resource utilization. A comprehensive data set is necessary for global information regarding river hydrographs, ground water levels, lake and reservoir levels, soil moisture, and land cover for at least the present time, and if possible for the last century as well. A few of these issues are beginning to be addressed through international research programs.
such as WCRP, IGBP and IHDP, but it is not clear that they have the necessary resources available for this major international task. Much of the necessary data already exist in a multitude of local, regional, and national archives, but the task of organizing and assembling these data into an integrated global data set is a major undertaking in itself, even before it is used to identify data gaps for future observational programs. As such, it is imperative that activities be initiated as soon as possible toward the goal of establishing a global hydrologic data base.

**Ice budgets** - The balance between increased melting as a result of atmospheric warming, and increased precipitation (as snow) in Antarctica plays a critical role in the global hydrologic budget. As such, research is needed in observation of ice accumulation rates on the basis of surface elevations, monitoring of meteorology in and around the southern ocean and coastal Antarctica, and modeling of the relationship of sea surface temperatures to Antarctic atmospheric circulation and precipitation patterns.

**Ocean temperature** - Because a major factor in modern sea level rise is the thermal expansion of the mixed layer, better monitoring of ocean temperature will increase our ability to assess the present and future contribution to sea level rise. While sea surface temperatures are monitored adequately, the thermal structure of the mixed layer over which we must integrate to determine its contribution to sea level rise, is very poorly known. As a result, IPCC projections presently must include broad scenarios with great uncertainty regarding this term. However, detailed gravity data may provide the necessary constraints to determine the density profile of the mixed layer. It was concluded at the conference that these should be collected and applied to the problem of shallow ocean density. On longer time scales, thermal structure of the deep ocean plays an increasingly important role.

** Anthropogenic influences** - Given the numerous mechanisms by which human activity directly transfers water between continental interiors and the ocean, it will not be possible to accurately account for past (20th century) sea level changes, nor to project future changes without some simple analysis of human intervention in the hydrologic cycle. Activities such as ground water mining, deforestation, and draining of wetlands contribute to sea level rise, while construction of new dams ameliorates sea level rise caused by other factors. In particular, the volume of water stored behind dams both as surface and ground water is poorly constrained, but may be significant. The latter half of the 20th century is the time period of the greatest rate of dam-building and water impoundment. It is also the time over which most tide gauge data is derived. Consequently, by impounding water at a significant rate globally, we be masking the sea level rise being caused by other factors. If the rate of major new dam construction slows or stops, then we should expect the observed rate of sea level rise to increase accordingly in the 21st century, even if other factors remain unchanged from the 20th century. The magnitudes of the various anthropogenic effects is not reliably known, but can be readily assessed through simple observational and data compilation programs.

**Summary of Research Recommendations**

- **Measurement**
  - Satellites-continuity, high latitude coverage, GPS buoys, Linked GPS-Tide Gauge system
  - Tide Gauges-addition of new gauges in southern ocean (while maintaining existing gauges)

- **Causes**
  - Continental Hydrologic Budget
  - Ice Budgets
  - Ocean Temperature Anthropogenic influences

- **Impacts Assessment**
  - Coastal Zone Elevation (cm-scale resolution)

- **Policy**
  - Scientific input into IPCC process
  - Community Position Statement on Sea Level

---

**Impacts**

The assessment of the impacts of sea level rise over the next century is hindered by a lack of knowledge of the detailed topography of the near shore. New global elevation maps based on detailed surveys at cm resolution will make it possible to accurately determine the areas which will be inundated by storm surges under conditions of rising sea level. This will require a concerted effort by the satellite altimetry community as well as local ground-based geodetic surveyors in all coastal areas world-wide.

The policy sector is most concerned with the impacts of sea level rise because they could have significant economic, social, and therefore political consequences. While environmentally logical and scientifically expedient solutions to sea level rise may include policies directed at “rolling easements”, and other land use regulations, these might be considered Draconian measures by those landowners involved, and would thus be exceedingly difficult to enact locally. It was agreed at the conference, however, that the scientific community can contribute to the process most effectively by placing assessments of flooding and storm damage risk into the context of the framework convention on climate change and should be an integral part of the IPCC process.

The issue of how involved the scientific community should become in the politi-
Acknowledgements

The conveners thank the US National Science Foundation (EAR, SBE) and the EU (DG12) for travel support for many of the participants. We are also grateful to European Geophysical Society for organizational support, and to Sabine Lubba for logistical and other detailed arrangements.

AGU Embraces ‘Biogeosciences’ as new Section

The structure of the American Geophysical Union (AGU) has been unchanged for decades, but in response to evolving research directions, societal concerns and recent research results, the AGU council unanimously voted to approve “Biogeosciences” as a new section of AGU. (Two positive votes are required for such an action, so they must vote again at the spring AGU meeting.) This followed an excellent turnout of the biogeoscientific community at the Fall meeting in San Francisco, where the importance of biogeochemistry, biogeophysics, and global ecosystems was highlighted in over 20 scientific sessions that related biological to geophysical systems.

The next AGU meeting will be in Washington D.C. (May 30-June 3, 2000), and Biogeosciences should play an equally important role at the meeting. In the Washington meeting, there will be the added emphasis on Policy issues (given the venue). Biogeoscientists are encouraged to submit an abstract to the “B” section in general, or to one of the “special sessions” already formulated. The abstract deadline for the meeting is March 9 for (electronic submission) to http://www.agu.org. For more information, contact AGU or Dork Sahagian at the GAIM Office.
The evolution of atmospheric methane bears on the fundamental questions posed in the GAIM PLAN (1998). An inaugural workshop for a new GAIM activity involving methane was held in conjunction with the 6th IGAC Scientific Conference in Bologna on 13 September, 1999, and attended by 33 scientists. Five task areas were considered, each being introduced by one or more experts and then discussed for approximately an hour. Some participants were able to meet subsequently during the IGAC conference and develop more specific ideas for work within the activity. The results are summarised below first in terms of identified key issues and then in terms of the types of interaction that the GAMeS project should promote. These will now be used to develop a more specific action plan with identified participants for specific activities.

Key issues and directions for future research

Atmospheric observations.

Global coverage (contemporary): Most in situ mixing ratio and isotopic measurements have been located at marine or clean air sites. An increased emphasis on measurements closer to major sources is now justified, and will be necessary to improve regional source estimation using model based inversion techniques.

Campaign data (contemporary): The potential for use of ad hoc data – e.g. ship or aircraft samples on tracks which are not repeated regularly – to determine sources using chemical tracer models needs to be clarified.

Calibration: The NOAA/CMDL GLOBALVIEW CH4 co-operative project merges recent mixing ratio data from several groups that are able to convert their measurements to a common nominal concentration scale. Other groups making such measurements, but not yet able to convert to the CMDL scale, should be encouraged to do so, as this will extend the global coverage of consistent data. A well validated absolute mixing ratio scale is required to ensure accuracy in long term trends.

Isotopic measurements: An increase in the availability of both contemporary and ice-core or firn air $^{13}$CH$_4$/CH$_4$ data is expected in the near future. Laboratories making such measurements are urged to set in place on-going inter-comparison projects to ensure that their data can be merged usefully.

Ice core data corrections: Past atmospheric methane mixing ratios can now be reliably found from ice core and firn air. However, recovery of accurate isotope ratio values from ice-core and firn air requires further testing and validation of gravitational and diffusion corrections in air-ice enclosure models.

Ice core data coverage: Valuable extensions of existing data can come from measurements of air from equatorial ice sheets and improved temporal resolution during the Holocene, particularly in the northern hemisphere.

Emissions

Focus where uncertainties are largest: The greatest uncertainties in paleo methane sources are associated with wetland emissions. For contemporary sources the greatest uncertainties are associated with wetlands, rice paddies, biomass burning, and landfill emissions. All these sources are spatially diffuse and influenced by a variety of environmental factors. Uncertainties in other source types may be important in specific circumstances.

Process models: Process models have generally been developed and validated for regional or local scale emissions. Only a few process-model based estimates of wetland or rice emissions are available at the global scale and further global studies are required. Process models should also be used to estimate diurnal as well as seasonal cycles in emission flux. Spatially and temporally resolved estimates of uncertainty in emissions are useful in some inverse model approaches.

Data for process models: Use of process models is often constrained by lack of appropriate input data. Compilation of appropriate data, e.g. on soils, vegetation, hydrological factors and rice management practices, is required.

Regional validation: For some source types, validation of emission process models can be based on well designed atmospheric measurements and use of mesoscale transport models to perform bottom-up vs top-down comparisons.

Reassessment of source estimates: A critical assessment of the literature on methane sources may lead to rejection of some early estimates and tighter ranges than provided by generic assessments such as those of the IPCC. A suitable process for such an assessment needs to be considered. This needs to reflect the fact that methane sources are continually changing, as is evident for the 1990’s.

Interface with IGAC/GEIA: Current emission inventory estimates compiled for the GEIA project (Global Emissions Inventory Activity) will be used in GAMeS and new results from this project will feed back to GEIA.

Chemistry

CH4 chemistry: Although detailed CH4 and OH chemistry schemes are available in the literature, these may not be complete. More work is needed to validate current views of feedbacks between CH4, CO, NOX, NMHCs and OH. Better estimates of the emissions of these associated species are needed. Some isotopic observations suggest that fractionation effects in CH4 chemistry are not well understood and this may indicate as yet unidentified atmospheric chemistry pathways.
WORKSHOP ANNOUNCEMENT

Short Course on Modeling in the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)

July 17-28, 2000, CPTEC-INPE, Cachoeira Paulista, Brazil

GAIM, in conjunction with the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) is planning to hold a workshop for the purpose of developing the modelling capacity of the Amazonian global change community. GAIM emphasizes activities designed to expand upon the development, testing, and analyses of integrative data sets and models of the biogeochemical aspects of the Earth system. LBA is designed to create the new knowledge needed to understand the climatological, ecological, biogeochemical, and hydrological functioning of Amazonia, the impact of land use change on these functions, and the interactions between Amazonia and the Earth system.

The Goals of the workshop are to:
- demystify modelling within the Amazonian research community
- teach the operation and interpretation of state of the art models
- teach model-building techniques
- teach how to obtain and assimilate data

The Objectives of the Workshop are to:
- assist in the coordination of simulation modeling of terrestrial ecosystem processes in the early stages of LBA.
- establish general operational objectives, initial data requirements, and the collaborative aims of terrestrial ecosystem modellers with the other potential participants in LBA.
- to develop an overall conceptual understanding of the interacting systems and processes contained within Amazonia, using this as a miniaturization for the Earth System in general.

The Workshop will focus upon:
- analyzing key models and data with particular relevance to Amazonia,
- interpreting the capability of these models and experimental programs against the demands for knowledge,
- building the international modelling and data infrastructures needed to support fully the IPCC process, and
- expanding the capability within Amazonia to use models focused upon two key topics within the overall theme of global change and the carbon cycle:
  - national emissions
  - The effect of land use change on carbon and nutrient cycling.

The training provided through the proposed workshop is directed to support several efforts within the LBA scientific structure:
- Model Assessment
- Model Synthesis
- Integrated LBA Modelling Strategy

Participants
Workshop participants will be selected on the basis of maximizing capacity building in their home institutions and within the broader Amazonian global change modelling community and the likelihood of successful interaction and involvement with ongoing international global change research programs. Both nominations and applications will be considered. Selected applicants and nominees will be South American scientists, in their early to mid-careers, with some modelling experience and familiarity with computers. Knowledge of at least one programming language (Fortran, C, etc.) would be preferred but is not expected. It is expected that participants will use and disseminate modelling techniques developed at the workshop in their ongoing research, and selections will be made with that in mind. The participants will represent a teaching force which will maximize the positive impact of the workshop on building modelling capacity among the Amazonian global change research community. Thus the international research community will benefit from the input of Amazonian scientists’ insights regarding regional data and interpretations, and the Amazonian modelling community will benefit from interaction with and incorporation into international global change research programs (e.g. IGBP Core Projects). In addition, we will seek to maintain representation from a broad distribution of Amazonian countries in a way that will maximize new interactions within South America and between South American scientists and international collaborators. It is our hope that these relationships will continue to build in the future as a result of the activities at and subsequent to the proposed workshop.

Those wishing to nominate one or more scientists for participation in the workshop should send a brief letter to Carlos Nobre, and an email to Dork Sahagian and Michael Keller. All applicants, including nominees, must complete an application form, available from the GAIM Office.

International Organizing Committee
Dork Sahagian- GAIM Office, Morse Hall, University of New Hampshire, Durham NH 03824 USA, fax- 1-603-862-3874, email- gaim@unh.edu
Michael Keller- LBA Office, Morse Hall, University of New Hampshire, Durham NH 03824 USA, email- michael.keller@unh.edu
Carlos Nobre- CPTEC-INPE, Cachoeira Paulista, Brazil, email- nobre@cptec.inpe.br
Berrien Moore- EOS, Morse Hall, University of New Hampshire, email- b.moore@unh.edu
Methane—Climate Interactions

Chemistry – climate interactions: Detailed studies of the interactions between global climate change and CH₄ chemistry are needed, taking into account the full range of past changes (pre-industrial and glacial to inter-glacial conditions) and likely future climates. Global average OH levels and the distribution of OH between tropics and extra-tropics are the key factors required.

OH history and trends: Further clarification of the role of anthropogenic emissions of CO, NOₓ and related species on OH history and trends is required in order to study the evolution of the CH₄ budget from pre-industrial time to the present and into the future. The present ambiguity in the sign of the current trend in OH needs to be resolved. Measurements of CH₄ mixing ratios and isotopic ratios may place some constraints on estimates of OH levels and trends.

Stratosphere – troposphere exchange: Improved estimates are needed of net CH₄ loss rates to the stratosphere and isotopic fractionation in the stratosphere. Important couplings also occur through production of stratospheric H₂O by CH₄ oxidation and the impact of stratospheric O₃ depletion and UV irradiance increases on tropospheric chemistry.

Contemporary budgets

Inversion studies: The Bayesian or synthesis inversion technique needs good a priori source distributions, while the adjoint technique needs comprehensive atmospheric data. Better comparisons of these techniques are needed, as are better understanding of their sensitivity to selection of observation sites, deficiencies in model transport, a priori estimates, and OH distributions.

Improved model transport: Study of recent inversion results suggests that better boundary layer meteorology is required, particularly to explain observations near source regions. Extension of observations to surface continental sites will place greater demands on the accuracy of model transport and use of model results appropriate to actual sampling conditions.

Regional scale inversion studies: Use of mesoscale models or nested regional/global models may provide valuable inversion results in some circumstances—e.g. where regional observational networks provide high spatial resolution.

Time dependent budgets: Most inversion results are for sources which do not change from year to year and for an atmosphere in equilibrium with these sources. Additional studies need to consider time-dependent inversions and the potential for disequilibrium conditions to bias source estimates. Recent work suggests that disequilibrium effects are particularly important when interpreting isotopic data.

Paleo budgets

Interface with PAGES: Global scale models for ecosystem and land-cover changes appropriate to the Holocene and earlier periods are becoming available. These need to be used in the GAMeS project for paleo-budget studies of CH₄. Data on past distributions and numbers of animals also appears to be available in greater detail than used so far. Pre-industrial anthropogenic sources need further consideration.

Interface with GAIM/TRACES. A related new GAIM activity that will be interacting with, and ultimately envelop GAMeS, is TRACES (Trace Gas and Aerosol Cycles in the Earth System), our PaleoTrace Gas and Aerosol Challenge. TRACES is directed toward understanding the decadal to multi-millennial-scale regulation, feedback and forcing between chemical components of the atmosphere (CO₂, N₂O, CH₄, other reactive gases, SO₄²⁻ aerosols, mineral aerosols) over the past 150,000 years. A better understanding methane resulting from GAMeS is a key component of TRACES.

Climate – source relationships: The response of natural sources to climate change needs to be investigated further over the full range of glacial to inter-glacial conditions, and during the Holocene. This is particularly true for wetland emissions where both the total magnitude and latitudinal distribution are expected to be central to paleo-budgets.

Chemistry – climate interactions: (see above)

Holocene variations: Large and sometimes rapid variations in CH₄ mixing ratios over the Holocene period are evident from ice-core data. These are still not adequately explained.

Synthesis with related species: Co-variation of CH₄ with CO₂ and N₂O and known associations between sources of these different gases should be used to construct more robust paleo-budgets.

Specific inter-disciplinary interactions to be promoted by GAMeS

Observations and Inversion modeling. This will link those responsible for inversion models and for observational networks. The aims will be to consider potential use of campaign data, improvements in network design for source determination, and issues involving time-dependent inversions.

Process models and CTM / Climate models. This will link those responsible for emission process models and for chemical tracer and climate models. The aims will include: coupling of both types of models to investigate climate feedbacks; the significance of diurnal cycles in some types of methane emissions; and the combined effects of external forcing (e.g., the environmental and chemical effects of UV changes caused by, for example, ozone depletion or aerosol increases).

Evolution of the CH₄ budget. This will link PAGES, those compiling paleo-budgets for CH₄ and related species (TRACES), and those compiling contemporary budgets. The aim will be to develop consistent histories of emissions by source and region based on all available information.
A Flying Leap into the Future
By Dork Sahagian

At the recent GAIM Task Force Meeting, plans were made for conducting a “Flying Leap” experiment for developing full-form comprehensive models to project Earth system responses to anthropogenic CO$_2$ forcing, as a start. The idea is to take a “flying leap” into the untested waters of full-form coupled model prognostication to see what can be learned. A great deal will hopefully be learned about the complexities of coupled model behavior, as well as sensitivities to parameterization schemes and boundary conditions, even if such full-form models fail to predict “expected” values for atmospheric chemistry and other biogeochemical systems. The goal for this first endeavor is to determine the spatial distribution and controls on the growth rate of atmospheric CO$_2$. The project will include coupling of energy, water, and carbon with feedbacks on climate. It will be a challenge to the ecosystem models as well. The philosophy is NOT to predict the entire system, only to take a tractable step in relating ONLY CO$_2$ in the analysis of climate response. Additional issues will be left for later, such as dynamic vegetation, land cover changes, nitrogen deposition, and river fluxes. The project will involve the community at large with land and ocean modules of various levels of sophistication and complexity. It will not be a top-down approach, but rather the modelling teams will be defining the common protocols for model development and “tests” to pass for inclusion in the activity. In the first part, a run in 1800 will be done, with objectives to examine land-atmosphere interactions. The rate of atmospheric CO$_2$. The project will enters climate space that has not been seen before, so that we must extrapolate from the present conditions into the future with prescribed fossil fuel emissions with atmospheric CO$_2$ with 1% increase per year. Workshops will be convened to bring modellers together with experts in the terrestrial and marine systems to assess model performance and predictions. It is not a real “prediction” because it uses present-day rules other than those that may apply under conditions of elevated CO$_2$. Links with both WCRP and IHDP will be necessary as the project develops.

Workshop on EMICs to be held during the 25th General Assembly of the EGS
By Martin Claussen

Investigating the dynamic behavior of the Earth system remains a “grand challenge” for the scientific community. It is motivated by our limited knowledge about the consequences of large-scale perturbations of the Earth system by human activities, such as fossil-fuel combustion or the fragmentation of terrestrial vegetation cover. Will the system behave resilient with respect to such disturbances, or could it be driven towards qualitatively new modes of planetary operation? This question will be tackled by so-called Earth system models. But, what do we know about such models? Ibis was the issue addressed at the IGBP workshop (co-hosted by GAIM, BAHC, GCTE and PIK) in Potsdam on June 15-16th. Ad hoc, it was proposed to define the Earth system as an envelope of the natural environment, i.e. the climate system or the ecosphere, and the anthroposphere. The workshop focussed mostly on the natural dimension of the Earth system with the anthroposphere as a prescribed boundary condition (land use, CO$_2$ emissions).

The workshop discussed a hierarchy of Earth-system models. Depending on the nature of questions asked, there are, on the one extreme, zero-dimensional “tutorial” or “conceptual” models like those in the “Daisyworld” family. At the other extreme, three-dimensional comprehensive models are under development by several groups. A major limitation in the application of the latter models are their high computational costs (usually allowing ensemble calculations only at a very limited scale), whereas the former lack many important processes and feedbacks operating in the real world. In between the two extremes, Earth-System Models of Intermediate Complexity (EMICs) come into the game.

At the Potsdam workshop, the general idea of using EMICs was discussed, and first results were presented. In a follow-up workshop to be held during the 25th General assembly of the EGS, the structure of individual EMICs will be analysed. It is proposed to have an in-depth discussion of why some components and processes were selected and not others. The purpose is not to show a set of results, but rather to enter the physics of each EMIC. One of the aims would be to learn more about the physical processes included in these EMICs. To which extend might they be complicated. Is it realistic to have some oversimplified? To which extend is the complexity of individual process related to the power of the feedbacks in which they are imbedded?

This workshop addresses the EEMIC (European Network on Earth system Models of Intermediate Complexity) community; however, everybody interested is welcome. Moreover, this activity is closely related to the EGS session on “Feedbacks in the Climate System”.
If you are not on our mailing list but would like to receive this and subsequent issues of *Research GAIM*, or if your address has changed, please fill in this form and mail to:

GAIM Task Force Office  
Rm. 164, Morse Hall  
39 College Road  
University of New Hampshire  
Durham, NH. 03824

Check one:  
New address ☐  Change of Address ☐

Name:  
Address:

________________________________________________________________________
________________________________________________________________________

________________________________________________________________________

You can also fax this information to: (603) 862-3874  
Or send email to the GAIM office at: gaim@unh.edu