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Global Analysis, Interpretation, and Modelling: First Science Conference

IGBP

GAIM

25-29 September 1995, Garmisch-Partenkirchen, Germany

GAIM SCIENCE CONFERENCE - NASA GRANT # NAGW 4663

GAIM Science Conference

The First GAIM Science Conference was held on Sept. 24-29 in Garmisch-Partenkirchen, Germany, and consisted of 5 days of oral and poster sessions. The Goal of the Science Conference was to provide a venue for the dissemination of preliminary results for the purpose of steering subsequent research efforts toward reliable prognostic biogeochemical models. The conference was co-sponsored by the German National IGBP Secretariat in Berlin, and supported by NSF, ISF, German National IGBP, START, ENRICH, and the German Development Foundation. GAIM base office support was provided by the USEPA.

The Science Conference focused on papers in the areas of global data analysis and assessment, modelling of biogeochemical systems and their relationship to physical climate and hydrologic systems, and interpretation of current trends as indicated by global databases and model results for extrapolation with regard to future global change. Oral and Poster session topics were grouped by time periods, including "Paleo" (<20k yrs), "Historical" (<2k yrs), "Contemporary" (<20 yrs), and "Future", with an additional session concerned with global systems integration.

Speakers introduced each new topic to establish a basis for posters, and discussion. The format of the conference place a heavy emphasis on poster presentations and informal discussion. Posters were left on display throughout the entire week, although each day focused on one time period. Ample time was left open for individual discussions, meetings, and model result comparisons.

Papers emerging from the GAIM Science Conference will be published in a special issue(s) of Global Biogeochemical Cycles through the normal peer-review process.

A brief synopsis of the meeting is as follows:

MONDAY - The "Paleo" Era
The concern with future Earth system responses to large perturbations in atmospheric composition and climate makes it important to exploit the recent geological record as studied by the IGBP project Past Global Changes (PAGES). The paleo record in fact provides the only means to test such models under conditions (in the past) that are as different from present as the conditions expected to apply in 50-200 years' time.

Hans Oeschger made the first presentation in plenary session with challenges for GAIM from the standpoint of PAGES. Subsequent presentations by J.-C. Duplessy and W.R. Peltier focused on glacial-interglacial variability and Dansgaard-Oeschger oscillations. Additional oral presentations regarding CO2, Ocean circulation, Methane, Orbital variations, Lake records, and model simulations set the stage for a lively discussion centered around the poster sessions.

TUESDAY - The Historical Era
The historical era (<2,000 yrs) is the time during which human activities became a significant forcing factor in global change. The earliest influences were those of land use changes, as agriculture led to deforestation, and diversion of surface water for irrigation led to hydrologic changes on basinal scales. Steadily increasing fossil fuel emissions beginning in about 1860 are thought to have caused most of the observed increase in atmospheric CO_2 concentration. At present, however, we are unable, by accounting for other sources and the redistribution of carbon within its global cycle, to relate observed increases to estimates of past fossil fuel emissions. This questions the veracity of estimates of future CO_2 increase and drives a substantial effort to understand carbon cycle responses to human activities over the past several centuries. The causes since the industrial revolution of increases in other greenhouse gases such as CH_4 and N_2O are less certain, primarily because changes in the distributions and magnitudes of their sources are poorly known.

Oral presentations focused on the Carbon cycle, with talks on Nutrient regulation, Atmosphere-biosphere exchange, atmospheric trace chemistry, Ozone (presented by P. Crutzen, recent Nobel Laureate), ocean carbon, and models of terrestrial ecosystem dynamics and CO2 fertilization. Poster presentations were much more detailed and varied, including such topics as deforestation documentation, the effect of irrigation, biomass burning, sea level changes, and the budgets of P, N, and S.

WEDNESDAY - Global Systems Integration

This special session departed from the temporal sequence structure of the conference, and focused on the interactions and feedbacks between biogeochemical subsystems (e.g. atmosphere, ocean, terrestrial ecosystems, etc.) and integration into whole-Earth models.

Oral presentations considered the physical climate subsystem, tropospheric chemistry, linking the terrestrial biosphere and atmosphere, dynamic vegetation, and ocean CO2. Posters were presented on such topics as ecosystem dynamics, the hydrologic cycle, biome models, ocean circulation, ocean-atmosphere-ecosystem coupling, and preliminary integrative Earth system models.

WEDNESDAY - Integrating the Developing World in Global Change Modelling

A special session focused on the concerns of START and ENRICH was held on Wednesday afternoon. GAIM recognizes the importance of linking regional research programs into the global research questions on which it focuses. Moreover, there is a growing realization of the importance of tropical and subtropical regions in the study of global environmental changes and data requirements to global change issues. The success of GAIM depends on gathering expertise as well as data from the entire planet.

Current modelling results were discussed as well as future global data needs to encourage collaboration and involvement with ongoing international modelling efforts. In addition, many issues emerged which served to better identify the resource and other needs of scientists from developing countries. It is clear that these needs must be fulfilled so that they can more effectively gather, assess, and integrate global change data from their regions. In many countries, leading sicentists do not have even the most basic computation or communication facilities which would make involvement in international global change research programs feasible.

Presentations were made by Berrien Moore (GAIM Chair), Peter Tyson, (START Chair-designee), Anwer Ghazi (ENRICH Director), Wandera Ogana (Kenya IGBP Secr. & African GAIM working group coord.), and Carlos Nobre (GAIM Task Force Member from Brazil). The session ended with an open discussion of links between issues of local scientific interest in developing countries (e.g. land use change and sustainability) and global scientific issues, and resource requirements and funding mechanisms for enhancement of global change research in developing countries.

THURSDAY - The Contemporary Era

The Contemporary Era (the period from immediate past to immediate future) provides the greatest availability of data over the immediate past and the easiest task of validation over the immediate future. Further, now is a time of rapid change, representing the most rapid change available to study over the last millennium. The period of 20 years is the shortest time scale available to look at for this "decades to centuries" change.

This session highlighted papers directed at the global budgeting and modelling of the present-day state of the major biogeochemical cycles. Oral presentations introduced the issues of the effects and interpretation of atmospheric CO2 variations, greenhouse gases, N and O, Ocean carbon, terrestrial carbon model validation, deforestation/desertification, hydrology, and atmospheric aerosols. Posters included presentations on the interactions of climate and ecosystems, Net Primary Productivity, Satellite observations, and Remote sensing databases.

FRIDAY - The Future

The purpose of the "Future" session of the Science conference will be to bring forth preliminary results and discussion of prognostic biogeochemical models. The capability of biogeochemical models to predict future changes in the Earth system is dependent on the understanding of past global changes. For instance, by comparing "contemporary" rates of change to those of older and longer time periods, prognostic models may more accurately predict magnitudes of change in Earth systems and subsystems. While prognostic biogeochemical models are presently in a very primitive stage of development, comparison of the models will lead to better identification of data needs, shortcomings in our understanding of rates and interactions between changing subsystem components, and sensitivities of models to uncertainties in each subsystem component as well as component interactions.

In this session, oral presentation discussed the observational search for predicted temperature changes, coupled ice-atmosphere-ocean models, oceanic radiocarbon, and finally, the link between global change and human society. Posters considered the effects of doubled CO2, the desirability for "optimistic" predictions, projection of various subsystem scenarios, and future agricultural interactions with climate and natural ecosystems.

Abstracts from the GAIM Science Conference are available on the World-Wide-Web on the GAIM home page, http://gaim.unh.edu or can be requested from the GAIM Task Force Office:

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I G B P [illegible] Biosphere Programme

[illegible] DEADLINE [illegible] 1995

G A I M [illegible] Interpretation, and Modelling

GAIM SC[illegible]ERENCE

Sept. 24-29 [illegible]kirchen, Germany

The abstract deadline for the First G[illegible] approaching. Abstracts are solicited from ALL interested scientis[illegible] cycling and modelling.

Science Conference Program Forma[illegible]

The GAIM Science Conference will in[illegible] sessions. Oral and Poster session topics will be grouped by time periods includin[illegible]

"Paleo" (<20k yrs)- The paleo recor[illegible] system models under conditions that are as different from [illegible] 200 years' time.

"Historical" (<2k yrs)- Human activit[illegible] global change, including various land use changes and the [illegible] emissions.

"Contemporary" (<20 y[illegible] to study over the last millennium, and the present provi[illegible] for model validation.

"Future"- Prognostic models [illegible] present global change. Model comparisons will high[illegible] sensitivity to uncertainties.

"Global Systems Integratio[illegible] and feedbacks between biogeochemical subsystems and [illegible]

Morning sessions will concentrate o[illegible] sessions on modelling.

ABSTRACT INFORMATION [illegible]

Abstract format information [illegible] presentations may be in oral, poster or video poster form[illegible] Times 12 font. Please send your hard copy abstrac[illegible] Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany. Als[illegible]

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Please be s[illegible] May.

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CLIMATE SYSTEM

Perspectives past and present

Philip Newton

UNDERSTANDING the intricate web of processes controlling interactions between the Earth's climate and its ecosystems is a daunting task, but an essential one if we are to play any kind of informed role in minimizing climate and ecosystem perturbations due to anthropogenic activities. Intergovernmental policy decisions on practices that carry a perceived threat to climate or ecosystem stability have been — as is clear from the present prevarication on CO_2 emission policy — largely based on balancing a desire for minimal perturbation against short-term economic costs; we simply do not yet have a sufficient physical, biological and chemical understanding of the integrated 'Earth system' to argue otherwise.

A conference in September*, convened by the International Geosphere–Biosphere Programme (IGBP), aimed to serve as a focus for steering future research towards the development of dynamic biogeochemical ecosystem models that interact realistically with the physical ocean–climate–land system. What emerged was a melting-pot of different models, rapidly evolving as a result of being continually constrained by data, yet liberated by ever more ingenious computational techniques. At this rate, the ability to predict the broad characteristics of regional climate — and the anthropogenic contribution to it — on seasonal to interannual timescales could be realised within the next ten years.

Our entire understanding of the functioning of the Earth system is based on observations. Characteristics of the Earth's past climate have been preserved in the geological, ice and vegetation records, noted by historians and, over the past few decades, measured directly. The varying timescales and resolutions of these observations dictate the timescales on which the Earth system can be modelled. The conference was tailored accordingly, being divided into sessions on the palaeo, historical, recent and future eras.

Changes over the past 200,000 years, encompassing the last ice-age and the preceding interglacial period, can give us a perspective on the functioning of the Earth system under natural forcing, such as changes in the Earth's orbit and ocean circulation. Studies over the past 2,000 years enable the growing influence of mankind to be followed, first as land-use changes (agriculture, deforestation, irrigation), then as industrialization (largely affecting trace gas emissions) over the past 150 years. On a yet shorter timescale, the past few decades have provided the most observations as well as being a period of relatively rapid change in atmospheric composition and land use.

Participants at the meeting were treated to a fascinating range of perspectives on our present 'best-guess' as to how the Earth system has changed and responded to change over each of these timescales. On the key question of what is happening now, and what will happen in the near future, the evidence is mounting that the elusive 'missing sink' of carbon (the fraction of anthropogenic CO_2 emissions that cannot be accounted for by present estimates of atmospheric, oceanic and terrestrial sinks) lies predominantly in the terrestrial biosphere. The ability to measure gas concentrations and their isotopic signatures with unprecedented accuracy now allows the detection of variations in the O_2/N_2 atmospheric ratio (R. Keeling, Scripps Inst. Oceanography) and the isotopic composition (for carbon and oxygen) of atmospheric CO_2 (P. Ciais, Commissariat à l'Energie Atomique). Measurements at various locations are already under way, and their continuation should allow the various CO_2 sinks to be located and quantified ever more accurately as the time-series data accrue.

Achieving this goal is crucial, as, if we cannot describe the present-day global carbon cycle, there is little hope of predicting what the future holds. And even if we can balance the global carbon budget, we must also understand the underlying processes. How robust is the terrestrial sink for anthropogenic CO_2? Will it saturate, and if so when, and how will it be affected by global change, such as changes in vegetation or nutrient cycling? Indeed, there were intriguing allusions (S. Piper, Scripps) to preliminary data analyses that suggest that the large terrestrial sink of anthropogenic carbon in the Northern Hemisphere may have been much less significant 10 years ago. If so, we may already be seeing a dynamic and evolving ecosystem response to global anthropogenic perturbation.

In general terms, we have a better understanding of the functioning of the atmosphere than of the ocean, and of the ocean than of the terrestrial biosphere. This ranking is reflected by the sophistication of existing models. The terrestrial biogeochemists are trailing because of a comparatively late start and what is probably a more complex system to model. But the first dynamic biogeochemical ecosystem models, aiming to simulate the full range of ecosystem responses to changing climate — such as vegetation changes or migration, and perturbations to the global biogeochemical and hydrological cycles — are just starting to emerge (F. Woodward, Univ. Sheffield; J. Melillo, Woods Hole Oceanographic Inst.; A. Friend, Inst. Terrestrial Ecology).

So where do we go from here? The half-dozen or so model intercomparison exercises presented revealed that, in general, global analyses are in better agreement than regional analyses, but that the discrepancies are large. The different models need to be better constrained by data in order to produce more accurate outputs. But global data sets are expensive, and resources are few, so we must invest wisely.

What are the right kind of data? One example of how to go about answering this question was given by I. Fung (Univ. Victoria). We are most likely to find direct field evidence for (and thus be able to quantify) the 'missing sink' in the ecosystems where the sink is both detectable and statistically significant compared to that due to natural variability. She applied a simple carbon model of the biosphere forced by 100-year data sets of temperature, precipitation, nitrogen deposition and atmospheric CO_2 concentrations to show how one might, in principle, optimize site selection and sampling strategy. Her analysis suggested that we are most likely to be able to make unequivocal observations of the 'missing' terrestrial carbon sink if we look in the soil carbon, over timescales of up to ten years or so, and where — geographically — to look (suitable sites seem to be few in North America and western Europe). This particular sampling strategy should not be taken too seriously, as the model lacks sophistication, but the principles of the approach were met with enthusiastic approval.

In the short term, there is the goodwill to share available data archives, to undertake more rigorous model intercomparisons as part of the process of model evolution, and to anticipate collective data needs. Can we achieve the goal of reliably predicting the broad characteristics of regional climate on seasonal to interannual timescales within the next ten years? G. Asrar (NASA) firmly believes so, and that the required remote-sensing framework is already in place. Predictions on decade timescales would be a few years further down the line, and those scientists working on what is possibly the critical piece in the jigsaw — modelling a dynamic interactive terrestrial biosphere — are not alarmed by this timetable. It seems that the expertise is in place and willing, as is the guiding framework of the IGBP. The key to success will probably be making the right measurements at the right places at the right times — and, as always in science, having the resources to do so. □

Philip Newton is an assistant editor of Nature.

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MONDAY, 25 September 1995 - The "Paleo" Era

The concern with future Earth system responses to large perturbations in atmospheric composition and climate makes it important to exploit the recent geological record (last 20,000 years) as studied by the IGBP project Past Global Changes (PAGES). With ingenuity, this "paleo record" can be made to provide tests of Earth system models under conditions substantially different from those at present. The paleo record in fact provides the only means to test such models under conditions (in the past) that are as different from the present as the conditions expected to apply in 50-200 years' time.

A significant aim of the Science Conference is to compare the results with paleoecological data worldwide, for a period when global climate was substantially different from the present, but without the major differences in the distribution of land and sea ice that complicate the interpretation of the popular 18,000 year BP (glacial maximum) simulations.
For this session contributions are invited on topics such as

- the extent to which vegetation distribution modifies itself through feedbacks to climate via mechanisms such as increased evapotranspiration leading to increased precipitation inland,

- evolution of atmospheric methane during glacial-interglacial transitions, analysis of rapid variations in the coupled ice-ocean system and their consequences for terrestrial ecosystems and atmospheric composition,

- the role of biogeographical feedback in the response of atmospheric circulation and ecosystems to orbital forcing.

TUESDAY, 26 September 1995 - The Historical Era

The historical era (<2,000 yrs) is the time during which human activities became a significant forcing factor in global change. The earliest influences were those of land-use changes, as agriculture led to deforestation, and diversion of surface water for irrigation led to hydrologic changes on basinal scales. Steadily increasing fossil fuel emissions beginning in about 1860 are thought to have caused most of the observed increase in atmospheric CO_2 concentration. At present, however, we are unable, by accounting for other sources and the redistribution of carbon within its global cycle, to relate observed increases to estimates of past fossil fuel emissions. This questions the veracity of estimates of future CO_2 increase and drives a substantial effort to understand carbon cycle responses to human activities over the past several centuries. The causes since the industrial revolution of increases in other greenhouse gases such as CH_4 and N_2O are less certain, primarily because changes in the distributions and magnitudes of their sources are poorly known. In addition to papers regarding land-use changes and land surface/hydrologic physical/chemical modifications, this session will highlight papers relating to the reevaluation and refinement of our understanding of the carbon cycle and the perturbations of interest from several standpoints:

- The oceans may remove carbon from the atmosphere more readily than current models indicate.

- Other ecosystem responses, including the potential responses to changes in climate over the last 2,000 years, may compensate for decreases in terrestrial carbon storage due to land use and other activities.

- Estimates of historical fossil fuel emissions or of releases of carbon from vegetation and soil may be wrong.

WEDNESDAY, 27 September 1995 - Global Systems Integration

This special session will depart from the temporal sequence structure of the conference. It will focus on the interactions and feedbacks of biogeochemical subsystems (e.g. atmosphere, ocean, terrestrial ecosystems, etc.) and integration into whole-Earth models. While there is considerable disagreement between existing models, comparison of results should lead to subsequent refinement of modelled interaction between subsystems, and highlight any gaps in present subsystem modelling efforts that should be explored in the immediate future.

This session will provide an opportunity for the needs and shortcomings of Earth system models to be addressed with the broad community of scientists who will ultimately fill those needs by providing appropriate data and subsystem models.

Afternoon: Time reserved for working group discussions

THURSDAY, 28 September 1995 - The Contemporary Era

The Contemporary Era (the period from immediate past to immediate future) provides the greatest availability of data on the immediate past and the easiest task of validation for the immediate future. Further, now is a time of rapid change, representing the most rapid change available to study over the last millennium. The period of 20 years is an obvious choice of the shortest time scale available to look at for this "decades to centuries" change. On the basis of interactions betweeen individual biogeochemical components inferred for older and longer time frames, the impact of rapid contemporary changes in some of these components on others may be assessed.

This session will highlight papers directed at the global budgeting and modelling of the present-day state of the major biogeochemical cycles with particular emphasis on

- validation of comprehensive global biogeochemical model simulations,
- model and data intercomparison,
- understanding and quantifying climate-biogeochemical feedback mechanisms.

These will include the areas of the

- global carbon cycle,
- interaction of the sulfur cycle with the climate system,
- cycle of methane and other climate-relevant trace gases,
- interaction between the hydrological cycle and vegetation.

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(continued on inside back cover)

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(*continued from outside back cover*)

Author and Subject Indexes follow page 838