

Final

Global Analysis, Interpretation, and Modelling: First Science Conference

I G B P



G A I M

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 CO₂ 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 CO₂ 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 CH₄ and N₂O 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 scientists 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

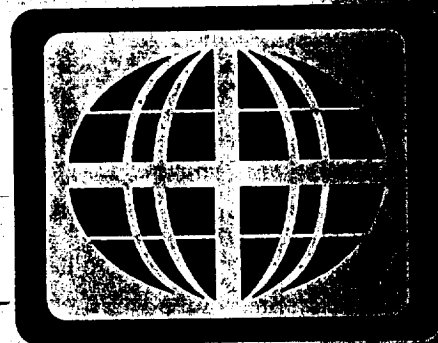
The purpose of the "Future" session of the Science conference will be to bring forth preliminary results and discussion of prognostic biogeochemical models. The capability of biogeochemical models to predict future changes in the Earth system is dependent on the understanding of past global changes. 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:

Dork Sahagian
GAIM Office
EOS, Morse Hall
University of New Hampshire
Durham, NH 03824
USA

ph: 1 603 862 3875
fax 1 603 862 0188
email gaim@unh.edu



ABSTRACT DEADLINE
MAY 1995

GAIM SCIENCE CONFERENCE

Sept. 24-29, 1995, Schloss Reichartshausen, Germany

The abstract deadline for the First Global Analysis, Interpretation, and Modelling (GAIM) Science Conference is rapidly approaching. Abstracts are solicited from ALL interested scientists in the fields of global environmental cycling and modelling.

Science Conference Program Format

The GAIM Science Conference will include oral and poster sessions. Oral and Poster session topics will be grouped by time periods including:

"Paleo" (<20k yrs)- The paleo record of global environmental change, including Earth system models under conditions that are as different from present as possible, over the last 200 years' time.

"Historical" (<2k yrs)- Human activity and its impact on global change, including various land use changes and the effects on the environment.

"Contemporary" (<20 yrs)- Slowly changing environmental conditions over the last millennium, and the present problems of global change.

"Future"- Prognostic models and observations of future global change. Model comparisons will highlight the strengths and weaknesses of different models.

"Global Systems Integration"- Integration of different models and observations of biogeochemical subsystems and their interactions with the atmosphere.

Morning sessions will concentrate on the above topics, while afternoon sessions on modelling.

ABSTRACT INFORMATION

Abstract format information is available on the GAIM website. Presentations may be in oral, poster, or video poster format. Abstracts should be typed in Times 12 font. Please send your hard copy abstract to: IGBP Secretariat, c/o Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany. Also send a 3.5 inch floppy disk with the same information.

Please be sure to submit your abstracts by the deadline of MAY 11, 1995.

For further information, contact: IGBP Secretariat, c/o Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany.

GAIM Task Force on
Institute for the Study of Global Change and
University of New Hampshire
Durham, NH 03824 USA
E-mail: GAIM@UNH.EDU
Phone: 603-862-8875
Fax: 603-862-0188

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 CO₂ 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 CO₂ 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 O₂/N₂ atmospheric ratio (R. Keeling, Scripps Inst. Oceanography) and the isotopic composition (for carbon and oxygen) of atmospheric CO₂ (P. Ciais, Commissariat à l'Energie Atomique). Measurements at various locations are already under way, and their continuation should allow the various CO₂ 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 CO₂? 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 CO₂ 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*.

* *Global Analysis, Interpretation and Modelling: First Science Conference*, Garmisch-Partenkirchen, Germany, 25–29 September 1995.

Garmisch-Partenkirchen, 25-29 September 1995

List of participants

Ahamer, Gilbert

Josef Hubergasse 21, A-8020 Graz, Austria
Tel.: 0043-316-973362, Fax.: 0043-316-973362, E-mail: ahamer@iiasa.ac.at

Ajavon, Ayité-Lô N.

Atmospheric Chemistry Laborat., Université du Bénin, B.P. 1515, Lomé, Togo
Tel.: 228-255094, Fax.: 228-218595/258595, E-mail:

Al-Kharabsheh, Hani Abed Moh'D

Royal Jordanian Geographic Centre, , P.O. Box 20214, Amman, Jordan
Tel.: 00962-68-45188, Fax.: 00962-68-47694, E-mail:

Andreas, Meinrat O.

Max-Planck-Institut für Chemie, Abt. Chemie der Atmosphäre, Postfach 30 60, 55020 Mainz, Germany
Tel.: 06131-305-420/1, Fax.: 06131-305-487, E-mail: moa@diene.mpgch-mainz.mpg.de

Alcamo, Joseph

Global Change Department, RIVM, PO Box 1, NL-3720 BA Bilthoven, The Netherlands
Tel.: 0031-30-743487, Fax.: 0031-30-250740, E-mail: rik.lee-mans@rivm.nl

Alexandrov, G.A.

Institute of Atmospheric Physics, Russian Academy of Sciences, Pyzhevsky Per.3, Moscow 109017, Russia
Tel.: , Fax.: , E-mail: gosha@sakura.cc.tsukuba.ac.jp

Alm, Jukka

Dept. Biology, University of Joensuu, P.O.Box 111, SF-80101 Joensuu, Finland
Tel.: 00358-73-1513502, Fax.: 00358-73-1513590, E-mail: alm@joyl.joensuu.fi

Amlotte-Suchet, P.

Centre de Géochimie de la Surface, CNRS, 1, Rue Blessig, F-67084 Strasbourg, France
Tel.: 0033-88-358584, Fax.: 0033-88-367235, E-mail: wludwig@illite.u.strasbg.fr

Antonovsky, M.

Institute of Statistics, Vienna University, Universitätsgasse 5, A-1010 Wien, Austria
Tel.: , Fax.: 0043-(1)-407-63 55 88, E-mail:

Asrar, Ghassem

NASA/HQ, Code YS, , Washington, DC, USA
Tel.: , Fax.: 001-202-358 2770, E-mail:

Atanassov, Dimitar

Nat. Institute of Meteorology, and Hydrology, blud. Tsarigradsko Chaussee 66, 1784 Sofia, Bulgaria
Tel.: 003592-72272, Fax.: 003592-884494, E-mail: goshko@agromet.rthsf.meteo.bg

Aumont, Olivier

15 Rue Briant, F-75014 Paris, France
Tel.: , Fax.: , E-mail:

Aumann, Hartmut, H.

Caltech/JPL 233-300, 4800 Oak Grove Drive, Pasadena, CA.91109

B.G.Bell, TIGER EYE/

The Institute of Terrestrial Ecology, Edinburgh Research Station, Bush Estate, Penicuik, Midlothian EH26 0QB, United Kingdom
Tel.: 0044-131-445-4343, Fax.: 0044-131-445-3943, E-mail:

Badeck, Franz-Werner

CNRS, Laboratoire d'Ecologie Végétale, Bt 362, Université de Paris XI, 91405 Orsay Cedex, France
Tel.: 0033-1-6941-7961, Fax.: 0033-1-6941-7238, E-mail:

Bartlein, Patrick J.

Dept. of Geography, University of Oregon, , Eugene, OR 97403, USA
Tel.: 001-503-346-4967, Fax.: 001-503-346-2067, E-mail: bartlein@uoregon.uoregon.edu

Becker-Heldmann, Peter

Universität Hamburg, Institut für Bodenkunde, Allende-Platz 2, 20146 Hamburg, Germany
Tel.: 040-4123-2003, Fax.: 040-4123-2024, E-mail: PBekkerH@rz.uni-hamburg.de

Bendtsen, Jørgen

Niels Bohr Institute for Astronomy, Physics and Geophysics, Haraldsgade 6, DK-2200 Copenhagen N, Denmark
Tel.: 0045-35-320617, Fax.: 0045-35-822565, E-mail: jbe@gfy.ku.dk

Bergametti, G.

URA CNRS 1404, Centre Multidiscipl., LISA Universités Paris, 7-Paris 12, 61, Av. du Général de Gaulle, F-94010 Créteil Cedex, France
Tel.: 0033-1-, Fax.: 0033-1-, E-mail: bergametti@univ-paris12.fr

Betts, R.A.

Hadley Centre f.Clim. Pred. and Res., UK Meteorological Office, , Bracknell, Berkshire RG12 2SY, United Kingdom
Tel.: 0044-1-344-856877, Fax.: 0044-1-344-854898, E-mail: rbetts@meto.gov.uk

Bhattacharya, Kashinath

Dept. of Botany, Visva-Bharati University, P.O. Santiniketan, Birbhum State-West Bengal 731235, India
Tel.: , Fax.: , E-mail: root@vbharat.ernet.in

Boko, Michel

Comite National IGBP/Benin, Lab. de Climatologie UNB/FLASH/DGAT, , BP 03-1122 Cotonou, Republique de Benin
Tel.: 00229-360061, Fax.: 00229-331981, E-mail:

Bolle, Hans-Jürgen

Stöcklenstraße 18c, 81247 München, Germany
Tel.: 089-811 05 93, Fax.: 089-811 05 93, E-mail:

Boubnov, Pavel V.

Inst. of Oceanol. Lab. of Biochem., Russian Academy of Sciences, 23 Krasikova Street, IORAN, Moscow 117851, Russia
Tel.: 007 095-124 7742, Fax.: 007 095-124 59 83, E-mail: dmitry@clime.ioran.msk.ru or: hchem@ioran.msk.ru or: stas@ioran.msk.ru

Bousquet, P.

Centre des Faibles Radioactivités, Laboratoire Mixte CNRS-CEA, Bâtiment 709/LMCE, CESAclay, F-91191 Gif-sur-Yvette, Cedex, France
Tel.: , Fax.: , E-mail:

Brevkin, Viktor

Potsdam-Institut für Klimafolgenforschung (PIK) e.V., Postfach 60
12 03, 14412 Potsdam, Germany
Tel.: , Fax.: 0331-288-2600, E-mail: andrey@pik-potsdam.de

Brown, Christopher

NASA, Goddard Space Flight Center, Oceans and Ice Branch, Code
971, Greenbelt MD 20771, USA
Tel.: 1-301-286-0946, Fax.: 1-301-286-0240, E-mail:
chrisb@puffin.gsfc.nasa.gov

Bruno, Michele

Physikalisches Institut, Universität Bern, Sidlerstrasse 5, CH-3012
Bern, Switzerland
Tel.: 0041-31-631-4461, Fax.: 0041-31-631-4405, E-mail: bru-
no@phil.unibe.ch

Carl, Peter

Arbeitsgruppe Klimadynamik, Humboldt Universität, Hausvogtei-
platz 5-7, 10117 Berlin, Germany
Tel.: 030-20377 466, Fax.: 030-20377 470, E-mail:

Chappellaz, Jerome

CNRS-Laboratoire de Glycologie, et Géophysique Environnement, BP
96, F-38402 St Martin d'Hères Cedex, France
Tel.: 0033-76824264, Fax.: 0033-76824201, E-mail: jero-
me@alaska.grenet.fr

Chiba, Yukihiko

Forestry and Forest Products, Res. Inst., University of Tsukuba,
P.O. Box 16, Ibaraki 305, Tsukuba-Norin, Tsukuba, Japan
Tel.: 0081-298-73-3211, Fax.: 0081-298-73-3796, E-mail: chi-
ro@ss.ftpri.affrc.go.jp

Christensen, Torben R.

Dept. of Ecology, Lund University, Ecology Building, S-223 62
Lund, Sweden
Tel.: 0046-46-222-3743, Fax.: 0046-46-222-3742, E-mail: tor-
ben.christensen@planteco.lu.se

Churkina, Galina

School Of Forestry, University of Montana, , Missoula MT 59812,
USA
Tel.: 001 406 243-4632, Fax.: 001 406 243-4510, E-mail: gali-
na@mtsg.umt.edu

Clais, P.

Lab. de Modélisation du Climat et de L'Environnement, CEA, CE
Saclay, Orme des Merisiers, Bâtiment 709, F-91191 Gif-sur-Yvette,
Cedex, France
Tel.: 0033-1-69 08 95 06, Fax.: 0033-1-69 08 77 16, E-mail:

Ciret, Catherine

Climatic Impacts Centre (CIC), Macquarie University, , NSW 2109,
Australia
Tel.: +61-02-850 8433, Fax.: +61-02-850 8428, E-mail: cal-
hy@cic.mq.edu.au

Claussen, Martin

Max-Planck-Institut für Meteorologie, Bundesstr. 55, 20146 Ham-
burg, Germany
Tel.: 040-41173-359, Fax.: 040-41173-366, E-mail: claus-
sen@dkrz.d400.de

Collatz, G. James

NASA, Goddard Space Flight Center, Code 923, NASA/GSFC,
Greenbelt MD 20771, USA
Tel.: 001-301-286-1425, Fax.: 001-301-286-0239, E-mail: jeol-
latz@biome.gsfc.nasa.gov

Costa, Maria Albertina

LSI Lab. Integrated System, Sao Paulo University, , Brazil
Tel.: , Fax.: , E-mail: tina@lsi.usp.br

Cousins, S.H.

Cranfield University, Ecosystems Group, IERC, , Cranfield, Bed-
fordshire MK43 0AL, United Kingdom
Tel.: , Fax.: , E-mail: S.H.Cousins@cranfield.ac.uk

Cramer, Wolfgang

Potsdam-Institut für Klimafolgenforschung (PIK) e.V., Postfach 60
12 03, 14412 Potsdam, Germany
Tel.: 0331-288-2521, Fax.: 0331-288-2600, E-mail: cramer@pik-
potsdam.de

Crutzen, Paul J.

Max-Planck-Institut für Chemie, Abt. Chemie der Atmosphäre,
Postfach 30 60, 55020 Mainz, Germany
Tel.: 06131-305-458, Fax.: 06131-305-436/511, E-mail: air@mpch-
mainz.mpg.d400.de

Culver, James R.

U.S. Department of Agriculture, Natural Resources Conservation
Service, 100 Centennial Mall-North, Room 152, Lincoln, NE
68508-3866, USA
Tel.: 001-402-437-5353, Fax.: 001-402-437-5336, E-mail:
nes6001mwnet1nssc6001jculver

Dahlmann, Roger

Environmental Sciences Division, US Dept. of Energy, , Washing-
ton, D.C. 20585, USA
Tel.: , Fax.: 001-301-903 8519, E-mail:

de Kock, Ansie C.

Department of Chemistry, Port Elizabeth Technikon, Private Bag
X6011, Port Elizabeth 6000, South Africa
Tel.: 0027-41-504-34-97, Fax.: 0027-41-504-34-22, E-mail: ade-
kock@ml.petechn.ac.za

de Jong, Mariette

Kluwer Academic Publishers, , Spuibulevard 50, 3300 AA Dord-
recht, The Netherlands
Tel.: +31-78-392203, Fax.: +31-78-392254, E-mail: AMPde-
JONG@wkap.nl

de Noblet, Nathalie

LMCE, CEA Saclay, Bâtiment 709, Orme des Merisiers, F-91191
Gif-sur-Yvette Cédex, France
Tel.: 0033-1-69087726, Fax.: 0033-1-69008716, E-mail: nath-
duc@asterix.saclay.cea.fr

Dedieu, G.

CESBIO, Unité DNES-CNRS-UPS, 18 av E. Belin, bpi 2801, F-
31055 Toulouse cedex, France
Tel.: 0033-61-5585-26, Fax.: 0033-61-5585-00, E-mail: de-
dieu@cesbio.cnes.fr

Demkin, Vitaly A.

Institute of Soil Science, and Photosynthesis RAS/ISSP RAS, ,
142292 Pushchino, Moscow Region, Russia
Tel.: , Fax.: 007-095-924 04 93, E-mail: demkin@issp.serpukhov.su

den Elzen, M.G.J.

National Inst. of Public Health, & Envir.Projection (RIVM), P.O.
Box 1, 3720 BA Bilthoven, The Netherlands
Tel.: 0031-30-743584, Fax.: 0031-30-250740, E-mail:
cwmmden@gbboz.rivm.nl

Denning, A. Scott

Dept. of Atmospheric Science, Colorado State University, , Fort
Collins, CO 80523-1371, USA
Tel.: 001-970-491-2134, Fax.: 001-970-491-8428/8449, E-mail:
scot@atmos.colostate.edu

Dentener, Frank

Biotechnion, Wageningen Agric. University, P.O. Box 8129, 6700 EV Wageningen, The Netherlands
Tel.: 0031-8370-85097, Fax.: 0031-8370-84457, E-mail: dente-
ner@ws2.luvu.wau.nl

Depta, G.

Bayer. Landesanstalt für Landtechnik, TU München-Weihenstephan (LTW), Voettinger Straße 36, D-85350 Freising, Germany
Tel.: +49 8161-71-5157, Fax.: +49 8161-71-4546, E-mail: dep-
ta@ban.tec.agrar.tu-muenchen.de

Dickinson, R.

Department of Atmospheric Physics, University of Arizona, Tucson, AZ 85721, USA
Tel.: , Fax.: , E-mail: cas@cyclone.atmo.arizona.edu

Diepenbroek, Michael

Alfred-Wegener-Institut, für Polar- und Meeresforschung, Postfach 12 01 61, 27515 Bremerhaven, Germany
Tel.: 0471-4831-503, Fax.: 0471-4831-425, E-mail: mdiepenb@awi-
bremerhaven.de

Dolgin, Svetlana A.

Kazakh Scientific Research, Hydrometeorological Institute, KazNIGMI, 597 Seifurin pr., Almaty 480 072, Kazakhstan
Tel.: 007 3272 542285, Fax.: 007 3272 538031/542285, E-mail: pilifo@kaznigmi.alma-ata.su

Duplessy, Jean-Claude

Centre des Faibles Radioactivités, Laboratoire mixte CNRS-CEA, F-91198 Gif sur Yvette cedex, France
Tel.: 0033 1 69 82 35 26, Fax.: 0033 1 69 82 35 68, E-mail: Jean-
Claude.Duplessy@cfr.cnrs-gif.fr

Dye, Dennis

University of Tokyo, 7-22-1 Roppongi, Minato-Ku, Tokyo 106, Japan
Tel.: 0081-3-3402-6231/2745, Fax.: 0081-3-5411-0441, E-mail: dye@shunji.iis.u-tokyo.ac.jp

Ebenhöh, Wolfgang

Inst. Chemie/Biologie des Meeres, Universität Oldenburg, Postfach 25 03, 26111 Oldenburg, Germany
Tel.: 0441-798-3231, Fax.: 0441-798-3004, E-mail:

Ellingsen, Frank

Research Centre Porsgrunn, PB 25 60, 3901 Porsgrunn, Norway
Tel.: 0047 -35 -562000, Fax.: 0047-35-563142, E-mail:

Emanuel, William R.

University of Virginia, Clark Hall, Charlottesville, Virginia 22903, USA
Tel.: 001-804-924-3762, Fax.: 001-804-982-2137, E-mail: wre6s@virginia.edu

Enting, Ian

Cooperative Centre for Southern Hemisphere Meteorology, CSIRO, Private Bag 1, Modialloc, VIC 3195, Australia
Tel.: +61 3 586 76 96, Fax.: , E-mail: ige@dar.csiro.au

Erickson III, David J.

Atmospheric Chemistry Division, NCAR, P.O.Box 3000, Boulder, CO 80307-3000, USA
Tel.: 001-303-4971424, Fax.: 001-303-4971400, E-mail: erick-
son@acd.ucar.edu

Esser, G.

Institut für Plant Ecology, Justus-Liebig-University, Heinrich-Buff-Ring 38, 35392 Giessen, Germany
Tel.: , Fax.: , E-mail:

Feichter, Johann

Max-Planck-Institut, für Meteorologie, Bundesstr. 55, 20146 Hamburg, Germany
Tel.: , Fax.: , E-mail:

Figge, R.A.

Institute of Arctic and Alpine Res., University of Colorado, Campus Box 450, Boulder, CO, USA
Tel.: , Fax.: , E-mail: figge@stripe.colorado.edu

Fischer, Alberte

Potsdam-Institut für Klimafolgenforschung (PIK) e.V., Postfach 60 12 03, 14412 Potsdam, Germany
Tel.: 0331-288-, Fax.: 0331-288-, E-mail: alberte.fischer@pik-pots-
dam.de

Foley, Jonathan

Climate People & Envir. Program, University of Wisconsin-Madison, 1225 W. Dayton Street, Rm 1333, Madison, WI 53706, USA
Tel.: 001-608-2655144, Fax.: 001-608-2625964, E-mail: jfo-
ley@facstaff.wisc.edu

Francois, L.

Inst.d'Astrophysique et Planétaire, University of Liège, 5, avenue de Coite, B-4000 Liege, Belgium
Tel.: 0032-41-, Fax.: 0032-41-, E-mail:

Friedlingstein, Pierre

NASA-GISS, 2880 Broadway, New York, NY 10025, USA
Tel.: 001-212-678-, Fax.: 001-212-678-5622, E-mail: pier-
re@hermes.oma.be

Friend, Andrew D.

Institute of Terrestrial Ecology, Edinburgh Research Station, Bush Estate, Penicuik, Midlothian EH26 OQB, United Kingdom
Tel.: 0044-131-445-4343, Fax.: 0044-131-445-3943, E-mail: a.friend@ite.ac.uk

Fung, Inez

School of Earth & Ocean Sc., University of Victoria, P.O. Box 17 00, Victoria, B.C. V8W 2Y2, Canada
Tel.: 001-604-472-4005, Fax.: 001-604-472-4016, E-mail: inez@garryoak.seaoar.uvic.ca

Ganopolski, Andrey

Potsdam-Institut für Klimafolgenforschung (PIK) e.V., Postfach 60 12 03, 14412 Potsdam, Germany
Tel.: 0331-288-2576, Fax.: 0331-288-2600, E-mail: andrey@pik-
potsdam.de

Gao, Qiong

Institute of Botany, Chinese Academy of Science, 141 Xiwai Avenue, Beijing 100044, China, CAST
Tel.: 0086-10-831-2840, Fax.: 0086-10-831-9534, E-mail: zhangxs@bepc2.ihep.ca.cn or: QGAO@canrl.cag.uconn.edu

Garstang, Michael

Dept. of Environmental Sciences, University of Virginia, Clark Hall, Charlottesville, VA 22903, USA
Tel.: 001-804-924-1304/979-3571, Fax.: 001-804-979-5599, E-mail: mxg@thunder.swa.com

Gayler, Sebastian

GSF-Research Center for Environment, and Health, PUC, P.O. Box 1129, 85758 Oberschleißheim, Germany
Tel.: 089-3187-4031, Fax.: 089-3187-3369, E-mail: gayler@gsf.de

Geevan, C. P.

Salim Ali Centre for Ornithology, & Natural History, Kalampalayam B.P.O., 641010 Coimbatore, India
Tel.: 91-422-392273, Fax.: 91-422-398232, E-mail: cpg@sacon.emet.in

Gérard, J.-C.

L.P.A.P. Institut d' Astrophysique, University of Liège, 5, avenue de Cointe, B-4000 Liege, Belgium
Tel.: 0032-41-529980, Fax.: 0032-41-527474, E-mail: gerard@astro.ulg.ac.be

Ghazi, Anver

Commission of European Communities, Space Applications Affairs, 200, rue de la Loi, B-1049 Brüssel, Belgium
Tel.: 0032-2-2951111, Fax.: 0032-2-2963024, sonst Contzen, E-mail:

Gilmanov, A.Tagir G.

Global Change Research Group, Department of Biology, San Diego State University, San Diego, California 92182-0057, USA
Tel.: 001-619-594-2887, Fax.: 001-619-594-7831, E-mail: gilmanov@sunstroke.sdsu.edu

Girard, Pierre

Inst. Nacional De Pesquisas, Espaciais/INPE, C.P. 515, 12201-970 Sao Jose dos Campos, Brazil
Tel.: 0055-123-418977, Fax.: 0055-123-218743, E-mail: pierre@met.inpe.br

Gitay, Habiba

Ecosystem Dynamics Group RSBS, Australian National University, ACT 0200, Australia
Tel.: , Fax.: +61-6-249-5095, E-mail: habiba.gitay@anu.edu.au

Gregson, Keith

Environmental Science Section, University of Nottingham, Sutton Bonington Campus, Loughborough, LE12 5RD, United Kingdom
Tel.: 0044-115-7516251, Fax.: 0044-115-7516261, E-mail: keith.gregson@nottingham.ac.uk

Greiner, C.

Research Institute for Applied, Knowledge Processing (FAW), Helmholtzstraße 16, D-89081 Ulm, Germany
Tel.: +49 731-501 950, Fax.: +49 731-501 999, E-mail: greiner@faw.uni-ulm.de

Grieb, Thomas M.

Environm. Engin. & Health Science Lab., University of California, Berkeley, CA, USA
Tel.: 001 510 283-3771 (at Tetra Tech. Inc), Fax.: 001 510 283-0780 (at Tetra Tech. Inc), E-mail: grieb@stat.berkeley.edu

Grossmann, W.

Institute for Statistics, University Vienna, Universitätsstraße 5, A 1010 Wien, Austria
Tel.: 0043-1-407 63 55/70, Fax.: 0043-1-407 63 55/88, E-mail: wgross@smc.univie.ac.at

Gruber, Nikolas

Physics Institute, University of Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland
Tel.: 0041-31-631-3402, Fax.: 0041-31-631-4405, E-mail: gruber@climate.unibe.ch

Gutowski, William J.

Atmospheric Science Program, Iowa State University, Ames, 3021 Agronomy, Iowa 50011, USA
Tel.: 001-515-2945632, Fax.: 001-515-2943163, E-mail: gutowski@iastate.edu

Häger, Christof

Inst. f. Theor. u. Phys. Chemie, Universität Frankfurt/Main, Marie-Curie-Str. 11, D-60439 Frankfurt/Main, Germany
Tel.: , Fax.: , E-mail:

Hahn, Jürgen

Fraunhofer Institut für, Atmosphärische Umweltforschung, Kreuzackbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany
Tel.: 08821-183210, Fax.: 08821-73573, E-mail: hahn@IFU.FHB.DE

Hait, Arghya K.

Center for Study of Man & Environment, CK-11, Sector-II, Salt Lake City, Calcutta 700 091, India
Tel.: 0091-33-359 0781, Fax.: 0091-33-376290, E-mail:

Harris, Lella

National Science Foundation, , 4201 Wilson Boulevard, Arlington, Virginia, 22230, USA
Tel.: 001-703-306 0891, Fax.: 001-703-306 0372, E-mail: iharris@nsf.gov

Harrison, Sandy P.

Dept. of Physical Geography, Lund Univ./Global Systems Group, Sölvegatan 13, S-223 62 Lund, Sweden
Tel.: +46 46 104093, Fax.: +46 46 104011, E-mail: la-kes@dungbeatle.planteco.lu.se

Haugan, Peter M.

NERSC, , EDV. Griegs Vei 3A, 5037 Solheimsviken, Norway
Tel.: 0047-55-297288, Fax.: 0047-55-200050, E-mail: peter@fram.nrs.no

Haxeltine, Alex

Global Systems Group, Lund Univ./Dept. of Ecology, Sölvegatan 37, S-22362 Lund, Sweden
Tel.: 0046-46-103132, Fax.: 0046-46-1044, E-mail: Alex@planteco.lu.se

Hayashi, Yousay

National Institute of Agro-, Environmental Sciences, 3-1-1 Kanno-noai, Tsukuba, Ibaraki, Japan
Tel.: 0081-298-38 82 06, Fax.: 0081-298-38 81 99, E-mail: hayyou@ap-a.cc.affrc.go.jp

Heimann, Martin

Max-Planck-Institut für Meteorologie, Bundesstr. 55, 20146 Hamburg, Germany
Tel.: 040-41173-240, priv. 04163-6285, Fax.: 040-41173-293, E-mail: heimann@dkrz.d400.de

Henderson-Sellers, Ann

Climatic Impacts Centre (CIC), Macquarie University, , NSW 2109, Australia
Tel.: , Fax.: +61-02-850 8428, E-mail: ann@mqclimat.cic.mq.edu.au

Hoekstra, Jeljer

Kema, , P.O.Box 9035, 6800 ET Arnhem, The Netherlands
Tel.: 0031-85-562383, Fax.: 0031-85-515022, E-mail: hoekstra@mta6.kema.nl

Hoff, Holger

Potsdam Institute for, Climate Impact Research (PIK), P.O. Box 60 12 03, D-14412 Potsdam, Germany
Tel.: 0331-288-2543, Fax.: 0331-288-2600, E-mail: bahc@pik-potsdam.de

Hoffstadt, Johannes

Pflanzenökologie, Justus-Liebig-Universität, Heinrich-Buff-Ring 38, 35392 Gießen, Germany
Tel.: 0641-702-5865, Fax.: 0641-702-5866, E-mail: hoffstadt@bio.uni-giessen.de

Hofmann, Matthias

Alfred-Wegener-Institut, für Polar- und Meeresforschung, Postfach 12 01 61, 27515 Bremerhaven, Germany
Tel.: 0471-4831-829, Fax.: 0471-4831-425, E-mail: mhofmann@awi-bremerhaven.de

Horvath, Helmuth

Institut für Experimentalphysik, Universität Wien, Boltzmanngasse
5, A-1090 Wien, Austria
Tel.: 0043-1-313673077, Fax.: 0043-1-3102338/2683, E-mail: hor-
vath@pap.univie.ac.at

Hudson, R.J.M.

Institute of Marine Sciences, University of California, Santa Cruz,
CA 95064, USA
Tel.: , Fax.: , E-mail:

Hunt, E. Raymond

Department of Botany, University of Wyoming, P.O.Box 31 65,
Laramie, WY 82071-3165, USA
Tel.: 001-307-766-3921, Fax.: 001-307-766-2851, E-mail: er-
hunt@uwyo.edu

Ikeda, Hiroaki

National Institute of Agro-Environmental Sciences, 3-1-1 Kannon-
dai, Tsukuba, Ibaraki, 305, Japan
Tel.: 0081-298-38 81 71, Fax.: 0081-298-38 8199, E-mail: ike-
dah@ss.niaes.affrc.go.jp

Isaksen, Ivar S.A.

Institute of Geophysics, University of Oslo, PO Box 1022 Blindern,
N-0315 Oslo 3, Norway
Tel.: 0047-2-855822, Fax.: 0047-2-855269, E-mail:

Jäkel, Ulrich

Inst. f. Phys.u.Theor. Chemie, Universität Frankfurt, Marie-Curie-
Str. 11, 60439 Frankfurt am Main, Germany
Tel.: , Fax.: , E-mail:

Janetos, Anthony C.

NASA HQ 300 E ST., Office Code YSE, SW Washington DC
20546, USA
Tel.: 1-, Fax.: 1-202-358-2771, E-mail:

Jenkins, Alan

Institute of Hydrology, Wallingford, Oxon. OX10 8BB, United
Kingdom
Tel.: 0044-1 491-692232, Fax.: 0044-1 491-692430, E-mail: A.Jen-
kins@unixa.nerc-wallingford.ac.uk

Ji, Jinjun

Institute of Atmospheric Physics, Chinese Academy of Sciences, ,
Beijing 100029, China, CAST
Tel.: 0086-10-2041268, Fax.: 0086-10-2562604, E-mail:
hyc@sgis0s.iap.ac.cn

Jiang, Da-Yong

Chinese Academy of Meteorological Sciences, Beijing 100081,
China
Tel.: 0086-2131133-2062, Fax.: 0086-1-8347390, E-mail: ji-
asr@mimi.cma.ac.cn

Jin, Zhiqing

Jiangsu Academy of Agricultural Sciences, Nanjing 210014, ,
Jiangsu Province, China, CAST
Tel.: 0086-25-4430826, Fax.: 0086-25-4432691, E-mail:

Johnson, Donald R.

Space Science and Engineering Center, University of Wisconsin,
1225 W. Dayton Street, Madison, WI 53706, USA
Tel.: , Fax.: , E-mail: donj@sscmail.ssec.wisc.edu

Jolly, Dominique

Dept. of Ecology, Ekologi Huset, Lund University/ Global Systems
Group, Sölvegatan 37, S-223 62 Lund, Sweden
Tel.: +46 46 10 31 32, Fax.: +46 46 10 37 42, E-mail: djol-
ly@dungbeatle.planteco.lu.se

Jonas, Matthias

Österreichisches Forschungszentrum, Seiversdorf, 2444 Seivers-
dorf, Austria
Tel.: 0043-2254-780-3879/3870, Fax.: 0043-2254-780-3888, E-mail:
jonas@zdfzs.arcs.ac.at

Joos, Fortunat

Physikalisches Institut, Universität Bern, Sidlerstrasse 5, CH-3012
Bern, Switzerland
Tel.: 0041-31-631-4461, Fax.: 0041-31-631-4405, E-mail:
joos@phil.unibe.ch

Joubert, Alec

Climatology Research Group, University of the Witwatersrand, P.O.
Wits, 2050 Johannesburg, South Africa
Tel.: 0027-11-7162998, Fax.: 0027-11-716316, E-mail:
alec@crg.bpb.wits.ac.za

Kaiser, K.F.

Swiss Federal Institut for Forest, Snow & Landscape Research, ,
CH-8903 Birmensdorf, Switzerland
Tel.: 0041-1-7392386, Fax.: 0041-1-7392215, E-mail: kai-
ser@wsl.ch

Karol, Igor L.

Main Geophysical Observatory, 7 Karbyshev St., St. Petersburg
194018, Russia
Tel.: 007-812-245-9309, Fax.: 007-812-247-8661/0103, E-mail:
karol@mgo.spb.su

Karte, Johannes

Deutsche Forschungsgemeinschaft, Referat Geowissenschaften I,
Postfach 20 50 04, 53170 Bonn, Germany
Tel.: 0228-885-2319, Fax.: 0228-885-2221, E-mail:

Kawamitsu, Michio

Center for Climate System Research, University of Tokyo, Komaba
4-6-1 Meguro-Ku, Tokyo 153, Japan
Tel.: 0081-3-54533961, Fax.: 0081-3-54533964, E-mail:
KWMY@ccsr.u-tokyo.ac.jp

Keeling, Ralph F.

Scripps Inst. of Oceanography, La Jolla CA 92093-0220, USA
Tel.: 001-619-534-7582, Fax.: 001-534-29997, E-mail: rkee-
ling@ucsd.edu

Kergoat, L.

CESBIO, 18 av E. Belin, bpi 2801, F-31055 Toulouse cedex,
France
Tel.: , Fax.: , E-mail: annerjasper.stanford.EDU

Kettunen, Anu

Systems Analysis Laboratory, Helsinki University of Technology,
Otakaari 1 M, 02150 Espoo, Finland
Tel.: 00358-0-4513061, Fax.: 00358-0-4513096, E-mail: anu.kettu-
nen@hut.fi

Kheshgi, Haroon

Exxon Research & Engineering Co., Route 22 East, Annandale, NJ
08801, USA
Tel.: 001-908-730-2531, Fax.: 001-908-730-3301, E-mail:
hkheshgi@ereng.com

Kicklighter, David

The Ecosystems Center, Marine Biological Lab., Woods Hole, MA
02543, USA
Tel.: 001-508-, Fax.: 001-508-, E-mail:

Kindermann, J.

Inst. für Phys. und Theor. Chemie, J.W. Goethe Universität, Marie-
Curie-Straße 11, D-60439 Frankfurt/Main, Germany
Tel.: , Fax.: , E-mail:

King, Anthony W.

Environmental Sciences Division, Oak Ridge National Laboratory,
Oak Ridge, TN 37831-6335, USA
Tel.: 001 615 576-3436, Fax.: 001 615 574-2232, E-mail:
awk@ornl.gov

Kislov, Alexander

Dept. Meteorol. and Climatol., University of Moscow, , 119899
Moscow, Russia
Tel.: , Fax.: , E-mail: kislov@gis.geogr.msu.su

Knorrenschild, Michael

GSF - PUC, , Postfach 11 29, 85758 Oberschleißheim, Germany
Tel.: 089-3187-2953, Fax.: 089-3187-3369, E-mail: knorren@gsf.de

Kohlmaier, G.H.

Inst. für Phys. und Theor. Chemie, J.W. Goethe Universität, Marie-
Curie-Straße 11, D-60439 Frankfurt/Main, Germany
Tel.: , Fax.: , E-mail:

Kolb, Eckart

Lehrstuhl für Bodenkunde, und Standortslehre, Hohenbachernstr.22,
85354 Freising, Germany
Tel.: 08161-714829, Fax.: 08161-714738, E-mail: kolb@lmu-bo-
ku.boku.foro.uni-muenchen.de

Kozlov, Michael

School of Energy and Materials, King Mongkut's Inst. of
Techn. Thonburi, Rataburana, Bangkok 10140, Thailand
Tel.: 662-4270162, Fax.: 662-4279062, E-mail:
imiczl@cc.kmit.ac.th

Kozoderov, Vladimir V.

Inst. of Computational Math., Russian Academy of Sci., Leninsky
Prospect, 32 A, Moscow 117334, Russia
Tel.: 007-095-9385515, Fax.: 007-095-2925616/1245551, E-mail:

Kramm, Gerhard

Fraunhofer-Institut für Atmosphärische, Umweltforschung, Kreu-
zeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany
Tel.: , Fax.: , E-mail:

Krenke, Alexander N.

Institute of Geography, Russian Academy of Sciences, Staromonetny
29, Moscow 109017, Russia
Tel.: 007-095-230 20 90, Fax.: , E-mail: climat@glas.apc.org (c/o
Andrey B. Shmakin)

Kriest, Iris

Institut für Meereskunde, Universität Kiel, Düsternbrooker Weg 20,
24105 Kiel, Germany
Tel.: 0431-597-4019, Fax.: 0431-565-876, E-mail: ikriest@ifm-uni-
kiel.d400.de

Kromer, Bernd

Heidelberg Academy of Sciences, , INF 366, 69120 Heidelberg,
Germany
Tel.: 06221-563357, Fax.: 06221-563405, E-mail:
kr@uphys1.uphys.uni-heidelberg.de

Kröppeln, Stefan

INQUA-PAGES Secretariat, Freie Universität Berlin, Podbielskiallee
62, 14195 Berlin, Germany
Tel.: 030-838-6368/(4887), Fax.: 030-841-0036, E-mail:
skroe@zedat.fu-berlin.de

Kühr, Helmut

DLR, PT-Aug/USF, Südstr. 125, 53175 Bonn, Germany
Tel.: 0228-3821-142/247, Fax.: 0228-3821-251/229/227, E-mail:
kuehr@usf.bg.dlr.de

Kustra, Clara

GAIM Office (EOS), University of New Hampshire, Morse Hall,
Durham, NH 03824-3524, USA
Tel.: 001-603-862-1792, Fax.: 001-603-862-0188, E-mail:
dork@pyramid.unh.edu; gaim@unh.edu

Kutzbach, J.E.

Climate People & Envir. Program, University of Wisconsin, 1225
W. Dayton Street, Rm 1333, Madison, WI 53706, USA
Tel.: , Fax.: , E-mail: jfoley@facstaff.wisc.edu

Kuwagata, Tsuneo

Tohoku National Agricultural, Experiment Station, 4 Akahira,
Shimo-Kuriyagawa, Morioka, 020-01, Japan
Tel.: 0081-196-43 34 61, Fax.: 0081-196-41 77 94, E-mail: ku-
wa@tnaes.affrc.go.jp

Landmann, G.

Institute for Biochemistry and, Marine Chemistry, Jungiusstr. 6, D-
20355 Hamburg, Germany
Tel.: 040-4123-2317, Fax.: 040-4123-6593, E-mail:

Langer, Ines

IGBP-Sekretariat, Institut für Meteorologie, FU Berlin, Carl-Heinrich-
Becker-Weg 6-10, 12165 Berlin, Germany
Tel.: 030-83871118, Fax.: 030-83871217, E-mail: igbp@zedat.fu-
berlin.de

Laun, Kerstin

FB VI, Physische Geographie, Universität Trier, , D-54286 Trier,
Germany
Tel.: , Fax.: , E-mail: laun@alpine.for.nau.edu

Laval, Katia

Laboratoire de Meteorologie Dyn., Ecole normale superieure, 24 rue
Lhomond, F-75231 Paris cedex 05, France
Tel.: , Fax.: , E-mail:

Law, R.M.

CRC for Southern Hemisphere, Meteorology, 8 Redwood Dr., Not-
ting Hill, 3168, Australia
Tel.: , Fax.: , E-mail: rml@vortex.shm.monash.edu.au

Lelleveld, Jos

Air Quality Department, Wageningen University, P.O. Box 8129,
6800 EV Wageningen, The Netherlands
Tel.: , Fax.: , E-mail:

Lentner, Inigo

Institut für Botanik, PkDB, Universität Hohenheim (210), , 70593
Stuttgart, Germany
Tel.: 0711-459-2188, Fax.: 0711-459-3355, E-mail: lent-
ner@rs1.rz.uni-hohenheim.de

Levin, Ingeborg

Institut für Umweltphysik, Universität Heidelberg, INF 366, 69120
Heidelberg, Germany
Tel.: +49-6221-563330, Fax.: +49-6621-563405, E-mail:
lv@uphys1.uphys.uni-heidelberg.de

Llousse, Catherine

Centre des Faibles Radioactivités, CNRS-CEA, Ave de la terrasse,
F-91198 Gif sur Yvette, France
Tel.: , Fax.: , E-mail:

Liss, Peter S.

School of Environmental Sciences, University of East Anglia, , UK-
Norwich NR4 7TJ, United Kingdom
Tel.: 0044-1603-592563, Fax.: 0044-1603-507714, E-mail:

Lomas, M.

, University of Sheffield, , Sheffield S10 2UQ, United Kingdom
Tel.: , Fax.: 0044-1742-760159, E-mail:

Ludwig, Wolfgang

Centre de Geochimie de la Surface, CNRS, , 1, Rue Blessig, F-67084 Strasbourg, France
Tel.: 0033-88-358584, Fax.: 0033-88-367235, E-mail: wludwig@illite.u.strasbg.fr

Lukas, John

Desert Research Institute, P.O. box 5625, Reno, NV, USA, c/o Universidad del Pais Vasco until Feb. 1996, Ibaeta, s/n, 2008, San Sebastian, Spain
Tel.: +3443-218438, Fax.: +3443-219402, E-mail: lucas@sg.ehu.es

Luker-Brown, Martin

University of Sheffield, , Sheffield B10 2TN, United Kingdom
Tel.: , Fax.: , E-mail:

Lüttkeimer, Sabine

IGBP-Sekretariat, Institut für Meteorologie, FU Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany
Tel.: 030-8387117, Fax.: 030-83871217, E-mail: igbp@zedat.fu-berlin.de

Mabuchi, Kazuo

Meteorological Research Institute, , 1-1 Nagamine, Tsukuba-shi, Ibaraki 305, Japan
Tel.: 0081-298-538592, Fax.: 0081-298-552552, E-mail:

Mahender, Kotha

Department of Geology, Goa University, Goa university, P.O., Goa, 403 205, India
Tel.: 0091-832-22 92 49, Fax.: 0091-832-22 41 84/220218, E-mail: ganesh@unigoa.ernet.in

Maler-Reimer, E.

Max-Planck-Institut für Meteorologie, Bundesstraße 55, D-20146 Hamburg, Germany
Tel.: , Fax.: +49 40 41173-293/298, E-mail:

Manabe, Syukuro

Geophys. Fluid Dynam. Laboratory/NOAA, Princeton University, , Princeton, NJ 08542, USA
Tel.: , Fax.: , E-mail:

Manning, Martin

P.O. Box 31-311, Lower Hutt, New Zealand
Tel.: 0064-4566-6166

Marengo, J.A.

Centre f. Weather Forecast.+Climate Res., National Inst. f. Space Research (INPE), 12630-000 Cachoeira Paulista, Sao Paulo, Brazil
Tel.: 0055-, Fax.: 0055-, E-mail:

Marshall, Stewart

Environmental Science Section, University of Nottingham, Sutton Bonington Campus, Loughborough, LE12 5RD, United Kingdom
Tel.: 0044-115-9516257, Fax.: 0044-115-9516261, E-mail: stewart@sbn2.nott.ac.uk

Marticorena, Béatrice

Lab. Interuniversitaire des Systèmes, Atmosphériques/Univ. Paris VII-XII, 61, Av. du Général de Gaulle, F-94010 Creteil Cedex, France
Tel.: 0033-1-45171595, Fax.: 0033-1-45171564, E-mail: bea@asill.univ-paris12.fr

Martin, Tim J.

British Antarctic Survey, , High Cross, Madingley Road, Cambridge, CB3 0ET., United Kingdom
Tel.: 0044-1223-251616, Fax.: 0044-1223-62616, E-mail: u_tm@uk.ac.nerc-bas.vaxc

Matear, Richard

Institute of Ocean Sciences, , PO Box 6000, Sidney, B. C. V8L 4B2, Canada
Tel.: 001-604-363-6507, Fax.: 001-604-363-6776, E-mail: rjma@ios.bc.ca

Matthews, Elaine

NASA-GISS, , 2880 Broadway, New York, NY 10025, USA
Tel.: 001-212-678-5628, Fax.: 001-212-678-5552, E-mail: cxeem@nasagiss.giss.nasa.gov

McGuire, A. David

The Ecosystems Center, Marine Biological Lab., , Woods Hole, MA 02543, USA
Tel.: 001-508-289-7490, Fax.: 001-508-547-1548, E-mail: amcguire@lupine.mbl.edu

Medillo, J.

The Ecosystems Center, Marine Biological Lab., , Woods Hole, MA 02543, USA
Tel.: 001-508-, Fax.: 001-508-, E-mail:

Millan, Millan M.

Centro de Estudios Ambientales del Mediterraneo (CEAM), Parque Techn., Sector Oeste/Calle 4, ES-46980 Paterna (Valencia), Spain
Tel.: 0034-6-131-8227, Fax.: 0034-6-131-8190, E-mail:

Miller, Norman

Global Climate Research Division, Lawrence Livermore Nat. Lab., P.O. Box 808, Livermore, CA 94550, USA
Tel.: 001-510-422 32 44, Fax.: 001-510-422-36 88, E-mail: norm@LLNL.gov

Monfray, P.

Centre des Faibles Radioactivités, Laboratoire Mixte CNRS-CEA, Bâtiment 709/LMCE, CE Saclay, F-91191 Gif-sur-Yvette, Cedex, France
Tel.: , Fax.: , E-mail:

Monson, Russell K.

Dept. of Environmental, Popl. , University of Colorado, , Boulder, Colorado 80309, USA
Tel.: 001-303-492-6319, Fax.: 001-492-8699, E-mail: monson@colorado.edu

Moore III, Berrien

Inst. for Study of Earth, Oceans, and Space, Univ. of New Hampshire, Morse Hall, Durham, NH 03824-3524, USA
Tel.: 001-603-862-1766, Fax.: 001-603-862-1915, E-mail: b.moore@unh.edu

Mugedo, James Z.A.

Dept. of Chemistry, Maseno University College, Private Bag, Maseno, Kenya
Tel.: 00254-35-51-008/51267/51268/51622/51153, Fax.: 00254-35-51221/51153, E-mail:

Müller, Jens

LS f. Allg., Angew. u. Ingenieur-, Geologie, TU München, Lichtenbergstr. 4, 85748 Garching/München, Germany
Tel.: 089-32093177, Fax.: 089-32093168, E-mail:

Munhoven, G.

Laboratoire de Physique, Atmosphérique et Planétaire, 5, avenue de Cointe, F-4000 Liège, Belgium
Tel.: , Fax.: , E-mail:

Nadler, Andreas

Inst. f. Phys.u.Theor. Chemie, Universität Frankfurt, Marie-Curie-Str. 11, 60439 Frankfurt am Main, Germany
Tel.: , Fax.: , E-mail:

Nakayama, Y.

Remote Sensing Techn.Center of Japan, , 7-15-17 Roppongi,
Minato-Ku, Tokyo 106, Japan
Tel.: 0081-3-3402-, Fax.: 0081-3-, E-mail:

Namaratne, Sarath Yasalal

Institute of Fundamental Studies, , Hantana Road, Kandy, Sri Lanka
Tel.: 0094-08-32002, Fax.: 0094-08-32131, E-mail: nama@ifs.ac.lk

Nemry, B.

L.P.A.P. Institut d' Astrophysique, University of Liège, 5, avenue de
Cointe, B-4000 Liege, Belgium
Tel.: 0032-41-, Fax.: 0032-41-, E-mail:

Newton, Phillip

Nature Macmillan Magazines, , 4, Crinan St., London NI 9XW,
United Kingdom
Tel.: , Fax.: 0044-171-843-4596, E-mail:

Noble, Ian

Australian National University, Ecosystems, SSBS, , Canberra 6200,
Australia
Tel.: , Fax.: , E-mail:

Nobre, Carlos A.

CPTEC, Rodovia Presidente Dutra, Km 40, P.O. Box 001 12.630-
000, C. Paulista / SP, Brazil
Tel.: 0055-125-612822, Fax.: 0055-125-612835, E-mail: no-
bre@cptec.inpe.br

Nurzaman, A.

Atmospheric Research &, Dev. Ctr, LAPAN, Jl. Dr., Djundjuran
No. 133, Bandung 40173, Indonesia
Tel.: 0062-22-637445/612606, Fax.: 0062-22-637443/614998, E-
mail:

Nziramanga, Norbert P.

Southern Centre for, Energy and Environment, 31, Frank Johnson
Avenue, Eastlea, Harare, Zimbabwe
Tel.: 00263-4-737351, Fax.: 00263-4-737351, E-mail: scen-
tre@mango.zw

Obata, Atsushi

Meteorological Research Institute, , Nagamine 1-1, Tsukuba, Ibaraki,
305, Japan
Tel.: 0081-298-53-8656, Fax.: 0081-298-55-1439, E-mail: aoba-
ta@mri-jma.go.jp

Oedekoven, Lucian

GSF - Projektträger, Umwelt- und Klimaforschung, Kühbachstr. 11,
81543 München, Germany
Tel.: 089-651088-57, Fax.: 089-651088-44/54, E-mail:

Oeschger, Hans

Pages Core Project Office, , Bärenplatz 2, CH-3011 Bern, Switzer-
land
Tel.: 0041-31-, Fax.: 0041-31-, E-mail:

Ogana, Wandera

Honorary Secretary, Kenya National Academy of Sciences, PO Box
39450, Nairobi, Kenya
Tel.: 00254-2-721138/721345, Fax.: 00254-2-721138/336885, E-
mail: knas@avcc.kaact.kenya-net.org or wogana@ken.healthnet.org

Oglesby, Robert J.

Dept. of Earth & Atmosph. Sciences, Purdue University, 1397
CIVIL Bldg., West Lafayette, IN 47907, USA
Tel.: , Fax.: , E-mail:

Ollveira, Kloeber R.

Graduate Studies, CATIE, , Turrialba, Costa Rica
Tel.: 00506-556-0169, Fax.: 00506-556-0914, E-mail: koli-
veir@computo.catie.ac.cr

Opoku-Ankomah, Yan

Water Resources Research Institute, CSIR, P.O. Box M. 32, Accra,
Ghana
Tel.: 00233-21-775351, Fax.: 00233-21-777170, E-mail:
wri@ghastinet.gn.apc.org

Orr, J.C.

Lab.de Modelisation du Climat et de, l'Environm., DSM, CE Saclay,
CEA, L'Orme des Merisiers, Bât. 709, F-91191 Gif-sur-Yvette,
Cedex, France
Tel.: , Fax.: , E-mail:

Otto, R.

Inst f.Phys. u. Theoretische Chemie, J.W. Goethe Universität,
Marie-Curie-Str. 11, 60439 Frankfurt/M, Germany
Tel.: , Fax.: , E-mail:

Oura, Norik

National Institute of , Agro-Environmental Sciences, 3-1-1 Kannon-
dai, Tsukuba, Ibaraki, Japan 305, Japan
Tel.: 0081-298-38 83 56, Fax.: 0081-298-38 81 99, E-mail: no-
ri@niaes.affrc.go.jp

Overpeck, J.

NOAA Paleoclimatology Program, National Geophysical Data
Center, 325, Broadway, Boulder CO 80303, USA
Tel.: , Fax.: , E-mail: jto@mail.ngdc.noaa.gov

Owill, Odhiambo John

Institute for Meteorological, Training and Research, P.O. Box
30259, Nairobi, Kenya
Tel.: , Fax.: 00254-2-567888, E-mail: matayo@dmc-nrb.rio.org or:
dmc@arcc.kaat.kenya-net.org

Pandey, Jai Shankar

National Environmental Engineering, Research Institute, Nehru
Marg, Nagpur-440 020, India
Tel.: 0091-712-226071/71/73/74/75/76, Fax.: 0091-712-
231529/222725, E-mail:

Paul, D. K.

Indian Institute of Tropical, Meteorology, Dr. Homi Bhabha Road,
Pashan, Pune 411008, India
Tel.: 330846, Fax.: 0212-347825, E-mail: mon-
soon@tropmeternet.in

Peltier, W. Richard

Department of Physics, University of Toronto, 60 St. George Street,
Toronto, Ontario M5S 1A7, Canada
Tel.: 001-416-978-2938, Fax.: 001-416-978-8905, E-mail: pel-
tier@rainbow.physics.utoronto.ca

Pereskokov, Anatoly

All-Russian Research Institute of, Hydrometeor. Inf., World Data
Center, 6, Korolyov Str., 249020 Obninsk, Russia
Tel.: , Fax.: , E-mail: vjaz@storm.iasnet.com

Pesochina, Ludmila

Institute of Soil Science, and Photosynthesis RAS, , 142292
Pushkino, Moscow Region, Russia
Tel.: , Fax.: , E-mail: pesochina@issp.serpukhov.su

Piketh, Stuart

Max-Planck-Institute for Chemistry, CRG WITS, Postfach 30 60,
55020 Mainz, Germany
Tel.: 06131-305 466, Fax.: 06131-305-525, E-mail: pi-
keth@quagga.mpch-mainz.mpg.de

Piper, S.C.

Scripps Inst.of Oceanography A-20, Geosciences Research Division,
La Jolla, CA 92093-0220, USA
Tel.: 001-619-534 42 30 ext.12, Fax.: 001-619-534 88 14/534 0784,
E-mail: piper@cdrgsun.ucsd.edu or scpiper@ucsd.edu

Pittelka, Louis F.

EPRI, P.O. Box 1 04 12, Palo Alto, California 94303, USA
Tel.: 001-415-855-2969, Fax.: 001-415-855-1069, E-mail: lpittelka@msm.epri.com

Plöchl, M.

Potsdam Institute for, Climate Research, P.O. Box 60 12 03, D-144 12 Potsdam, Germany
Tel.: , Fax.: , E-mail:

Popova, Ekaterina, E.

Institute of Oceanology, St. Petersburg Branch, 30 Pervaya Liniya, 199 053 St. Petersburg, Russia
Tel.: 007-812-2182729, Fax.: 007-812-3143360, E-mail: kgn@io.spb.su

Post, Wilfred M.

Environmental Sciences Division, Oak Ridge National Laboratory, , Oak Ridge, TN 37831-6335, USA
Tel.: , Fax.: , E-mail: wmp@ornl.gov

Prentice, Iain Collin

Department of Plant Ecology, University of Lund, Östra Vallgatan 14, S-223 61 Lund, Sweden
Tel.: 0046-46-104176/-415-22248(home), Fax.: 0046-46-104423/-415-22031(home), E-mail: colin@planteco.lu.se

Qian, Yun

Department of Atmospheric Sciences, Nanjing University, , Nanjing 210093, China, CAST
Tel.: , Fax.: 0086-10-256 23 47, E-mail: rswu@nju.edu.cn

Rabah, Kefa V.O.

Dept. of Physics, University of Nairobi, Box 30197, Nairobi, Kenya
Tel.: 00254-2-442014, Fax.: 00254-2-449616/449539, E-mail: dindi@uongeo.rio.org

Rajagopalan, Geeta

Indian Institute of Science, Centre for Ecological Sciences, , Bangalore 560 012, India
Tel.: 0091-80-3340985, Fax.: 0091-80-3341683, E-mail: rgeeta@ces.iisc.ernet.in

Ram, M. Yiyatal

National Inst. of Oceanography, Regional Centre, Sea shell, Seven Bungalows, Andheri, Versova, Bombay - 400 061, India
Tel.: 0091-22-626-3773/627-0419, Fax.: 0091-22-627-0426, E-mail:

Ramesh, R.

Physical Research Laboratory, , Navrangpura, Ahmedabad 380009, India
Tel.: 0091-79-462129, Fax.: 0091-79-460502, E-mail: ramesh@prl.ernet.in

Rapley, Chris G.

IGBP, Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden
Tel.: 0046-8-166448, Fax.: 0046-8-166405, E-mail: cgr@igbp.kva.se

Rasool, Ichtlague

IGBP-DIS, Université de Paris VI, Tour 26, 4ème étage, Aile 26-16, 4, Place Jussieu, F-75230 Paris Cedex 05, France
Tel.: 0033-1-44276168, Fax.: 0033-1-44276171, E-mail: rasool@biogeodis.jussieu.fr

Reynolds, James F.

Department of Botany, Duke University Phytotron, Box 90340, Durham, NC 27708 0340, USA
Tel.: 001-919-6607400, Fax.: 001-919-6607425, E-mail: jfrey-nol@Acpub.duke.edu

Risch, J.S.

Pacific Northwest Laboratory, , Batelle Blvd., Richland, WA 99352, USA
Tel.: 001-509-372-6052, Fax.: , E-mail: jb_risch@pnl.gov

Roelandt, C.

Inst.d'Astronomie et de Géophysique, Université de Louvain, 2, Chemin du Cyclotron, B-1348 Louvain-la-Neuve, Belgium
Tel.: , Fax.: , E-mail:

Ryabchenko, Vladimir A.

Shirshov Institute of Oceanology, St. Petersburg Branch, 30 Pervaya Liniya, 199 053 St. Petersburg, Russia
Tel.: 007-812-2182729, Fax.: 007-812-3143360, E-mail: rya@io.spb.su

Rykiel, E.J.

Battelle Pacific Northwest Laboratory, , , Richland, WA 99352, USA
Tel.: 001-509-372-1202, Fax.: 001-509-372-3515, E-mail: ej_rykiel@pnl.gov

Sahagian, Dork

GAIM Office (EOS), University of New Hampshire, Morse Hall, Durham, NH 03824-3524, USA
Tel.: 001-603-862-1792, Fax.: 001-603-862-0188, E-mail: dork@pyramid.unh.edu; gaim@unh.edu

Saltzman, Barry

Dept. of Geology & Geophysics, Yale University, P.O. Box 208109, New Haven, CT 06520-8109, USA
Tel.: 001-203-4323147, Fax.: 001-203-4323134, E-mail:

Sanderson, Michael

Dept. of Chemistry, University of Cambridge, Lensfield Road, Cambridge CB2 1EW, United Kingdom
Tel.: , Fax.: 0044-1223-336473, E-mail:

Santer, Ben

Climate Modelling & Intercomp. Lab., LLNL, , Livermore, CA 94550, USA
Tel.: , Fax.: , E-mail:

Sanz, Maria-Jose

Centro de Estudio Ambientales del Mediterraneo (CEAM), Parque Techn., Sector Oeste/Calle 4, ES-46980 Paterna (Valencia), Spain
Tel.: 0034-6-131-8227, Fax.: 0034-6-131-8190, E-mail:

Sarmiento, J.L.

Program in Atmosph. & Oceanic Sci., Princeton University, , Princeton, NJ, USA
Tel.: , Fax.: , E-mail: sarmiento@ubclu.unibe.ch

Sato, Y.

Meteorological Research Institute, Japan Meteorological Agency, 1-1 Nagamine, Tsukuba-shi, Ibaraki 305, Japan
Tel.: 0081-298-, Fax.: 0081-298-, E-mail:

Sauf, Walter

Inst. for Study of Earth, Oceans, and Space, Univ. of New Hampshire, Morse Hall, Durham, NH 03824-3524, USA
Tel.: , Fax.: , E-mail:

Schimmel, David

NCAR, P.O. Box 3060, Boulder CO 80307-3000, USA
Tel.: , Fax.: , E-mail: schimmel@isis.cgd.ucar.edu

Schloss, Annette

Inst. for Study of Earth, Oceans, and Space, Univ. of New Hampshire, Morse Hall, Durham, NH 03824-3524, USA
Tel.: 001-603-862-, Fax.: 001-603-862-1915, E-mail:

GAIM Science Conference - List of participants

von Storch, Hans

Max-Planck-Institut, für Meteorologie, Bundesstraße 55, D-20146
Hamburg, Germany
Tel.: +49 40 41173-232, Fax.: +49 40 44 17 87, E-mail:
storch@dkrz.d400.de

Vörösmarty, C.

EOS, University of New Hampshire, , Durham, NH 03824, USA
Tel.: 001-603-862-1792, Fax.: 001-603-862-0188, E-mail:
cv@cycling.unh.edu

Watts, Robert G.

Dept. of Mechanical Engineering, Tulane University, , New Orleans
LA 70118, USA
Tel.: , Fax.: , E-mail:

Webb III, Thompson

Department of Geological Sciences, Brown University, , Providence,
RI 02912-1846, USA
Tel.: 001-401-8633128, Fax.: 001-401-8632058, E-mail: thomp-
son_webb_iii@brown.edu

Welchert, G.

Erlenweg 32, 25469 Halstenbek, Germany
Tel.: , Fax.: , E-mail:

Wells, R.

Department of Biology, University of Joensuu, P.O. Box 111, FIN-
80101 Joensuu, Finland
Tel.: , Fax.: , E-mail:

Winguth, Arne

Max Planck-Institut, für Meteorologie, Bundesstraße 55, 20146
Hamburg, Germany
Tel.: 040-41173214, Fax.: 040-41173298, E-mail: win-
guth@dkuz.d400.de

Witte, H.J.L.

Hugo de Vries Laboratories, University of Amsterdam, Kruislaan
318, 1098 SM Amsterdam, The Netherlands
Tel.: 0031-20-5257950, Fax.: 0031-20-5257662, E-mail: herok-
witte@sara.nl

Wittenberg, Uwe

Institut für Plant Ecology, Justus-Liebig-University, Heinrich-Buff-
Ring 38, 35392 Giessen, Germany
Tel.: 0641-702-5865, Fax.: 0641-702-5866, E-mail:
uwitt@prosopis.bio.uni-giessen.de

Wolf, Ulrich

Inst. für Ostseeforschung, , Seestr. 15, 18119 Warnemünde, Germa-
ny
Tel.: , Fax.: , E-mail: uli@lotte.io-warnemuende.de

Wolff, Ulrich

JOOPS-Core Project-Office, Inst.f.Meereskunde, Uni. Kiel, Düstern-
brookweg 20, 24105 Kiel, Germany
Tel.: 0431-597-4019, Fax.: 0431-565-876, E-mail:

Woodward, F.I.

Dept. of Animal & Plant Sciences, University of Sheffield, P. O.
Box 601, Sheffield S10 2UQ, United Kingdom
Tel.: 0044-1742-824376, Fax.: 0044-1742-760159, E-mail:
F.I.Woodward@sheffield.AC.UK

Xu, Yi-Jun

Inst.für Bodenkunde und Waldernährung, Universität Göttingen,
Büsgenweg 2, 37077 Göttingen, Germany
Tel.: 0551-399764, Fax.: 0551-393310, E-mail: yxul@gwdg.de

Wüth, Gudrun

Institut für Physik und Theoret. Chemie, , Marie-Curie-Straße 11,
60439 Frankfurt, Germany
Tel.: 0691-79829416, Fax.: 0691-79829445, E-mail:

Yajnik, Kirit S.

Centre f.Mathematical Modelling and, Computer Simulation, N.A.L.,
Belur Campus, Bangalore - 560037, India
Tel.: , Fax.: 0091-80-526-0392/527-7929/526-7781, E-mail:
yajnik@cmmacs.ernet.in

Yakushev, Evgeniy V.

P.P.Shirshov Institute of Oceanology, Russian Academy of Sciences,
Krasikova St, 23, Moscow 117218, Russia
Tel.: 007-095-1247742, Fax.: 007-095-1245983, E-mail: yakus-
hev@qku.msk.ru

Yokosawa, Masayuki

National Institute of , Agro-Environmental Sciences, 3-1-1 Kannon-
dai, Tsukuba, Ibaraki, Japan 305, Japan
Tel.: 0081-298-38 83 56, Fax.: 0081-298-38 81 99, E-mail: myo-
koz@ss.niaes.affrc.go.jp

Zbell, B.

Zentrum f. Agrarlandschafts- u., Landnutzungsforschung (ZALF)
e.V., Eberswalder Str. 84, 15374 Müncheberg, Germany
Tel.: 033433-82324, Fax.: , E-mail:

Zhang, Huqiang

Climatic Impacts Centre, Macquarie University, N.S.W 2109, ,
Australia
Tel.: 0061-2-8508395, Fax.: 0061-2-8508428, E-mail: hu-
qiang@cic.mq.edu.au

Zhou, Guangsheng

Lab. of Quantitative Vegetation Eco., Chinese Academy of Scien-
ces, 141 Xizhimenwai Avenue, Beijing 1000 44, China, CAST
Tel.: 0086-10-8353831-293, Fax.: 0086-10-8319534, E-mail:
zhangxs@bepcz.ihep.ac.cn

Zimmermann, Peter

Max-Planck-Institut für Chemie, Abt. Chemie der Atmosphäre,
Postfach 30 60, 55020 Mainz, Germany
Tel.: 06131-305-454, Fax.: 06131-305-388, E-mail:
pez@ipp.garching.mpg.de

Zimov, Sergei A.

North-East Scientific Station of, Pacific Inst. for Geogr. RAS, Far
East Branch, p/b 18 Cherskii, Rep. of Sakha, Yakutia, Russia
Tel.: 007-2-30-13, Fax.: , E-mail: Jfreynol@Acpub.duke.edu

Schmitz, Roger A.

, University of Notre Dame, 202 Main Building, Notre Dame, IN 46556, USA
Tel.: 001-219-6317573, Fax.: 001-219-6316897/2, E-mail: Roger.A.schmitz.1@nd.edu

Schmullius, Christiane

DLR, Inst. für Hochfrequenztechnik, Postfach 11 16, 82230 Wessling, Germany
Tel.: 08153-28-2337, Fax.: 08153-28-1135, E-mail: schmullius@ohf015.hf.op.dlr.de

Schotterer, Ulrich

PAGES, , Bärenplatz 2, CH-3011 Bern, Switzerland
Tel.: , Fax.: , E-mail:

Selno, Hiroshi

National Institute of, Agro-Environmental Sciences, 3-1-1 Kannon-dai, Tsukuba, Ibaraki 305, Japan
Tel.: 0081-298-38 82 04, Fax.: 0081-298-38 81 99, E-mail: hselno@niaes.affrc.go.jp

Sellers, Piers J.

NASA, Goddard Space Flight Center, Code 923, NASA/GSFC, Greenbelt MD 20771, USA
Tel.: 1-301-286-4173, Fax.: 1-301-286-0239, E-mail: piers@imogen.gsfc.nasa.gov

Selvarajan, M.

from NOV 15: NNRMS, ISRO-HQ, New Bel Road, Bangalore, 560094 India, E-mail: selva@isro.ernet.in
until Nov 15: SARP Visiting Scientist, Inst. of Agro Biol.& Soil Fertility, AB DLO, NL-6700 AA Wageningen, The Netherlands
Tel.: 0031-8370-75700, Fax.: 0031-8370-23110, E-mail: sarpwag@ab.agro.nl

Sharma, Hari Shanker

A-3 Shanti Niketan Colony, University of Rajasthan, Kisan Marg, Tonk Road, Jaipur 302015, India
Tel.: 0091-141-514046, Fax.: , E-mail:

Sharma, C.

National Physical Laboratory, , Hillside Road, New Delhi, India
Tel.: 91-11-474-7166, Fax.: 91-11-575-2678, E-mail:

Shugart Jr., Herman H.

Department of Environm. Sciences, University of Virginia, Clark Hall, Charlottesville, Virginia 22903, USA
Tel.: , Fax.: 001-804-982-2137, E-mail:

Siegel, Elena

Dept. of Engineering & Public Policy, Carnegie Mellon University, , Pittsburgh PA 15213-3890, USA
Tel.: , Fax.: 001 412 268 3757, E-mail:

Simpson, Ian

UK GER Office, Polaris House, North Star Avenue, Swindon SN21 EU, United Kingdom
Tel.: 0044-1-793-411734, Fax.: 0044-1-793-444513, E-mail: iss@wpo.nerc.ac.uk

Sitch, Stephen

Global Systems Group, Lund University/Dept. of Pl. Ecology, Sölvegatan 37, S-22362 Lund, Sweden
Tel.: 0046-46-2223743, Fax.: 0046-46-2223742, E-mail: stephen.sitch@planteco.lu.se

Sladkovic, R.

Fraunhofer Institute for, Atmospheric Environment Research, Kreuzackbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany
Tel.: , Fax.: , E-mail:

Slemr, F.

Fraunhofer Institute for, Atmospheric Environment Research, Kreuzackbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany
Tel.: , Fax.: , E-mail:

Spekat, Arne

IGBP-Sekretariat, Institut für Meteorologie, FU Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany
Tel.: 030-8387118, Fax.: 030-83871217, E-mail: igbp@zedat.fu-berlin.de

Starkel, Leszek

Inst. of Geogr. & Spatial Organization, Polish Academy of Sciences, SW, Jana 994, Pol.Ar. 31018 Krakow, Poland
Tel.: 0048-12-224085, Fax.: 0048-22-267267/-12-224085, E-mail:

Sweda, T.

Dept. of Biol. Res. a Environment, Nagoya University, Chikusa, Nagoya 464-01, Japan
Tel.: 0081-52-789-4053, Fax.: 0081-52-789-4012, E-mail: h44530a@nucc.cc.nagoya-u.ac.jp

Sykes, Martin T.

Dept. of Ecology, Ekologi Huset, Lund University/ Global Systems Group, , S-223 62 Lund, Sweden
Tel.: +46 46 222 9298, Fax.: +46 46 222 3742, E-mail: martin@planteco.lu.se

Syktus, Jozef

Division of Atmospheric Research, CSIRO, Private Bag No. 1, Mordialloc, Victoria 3195, Australia
Tel.: 0061 3 586 7548, Fax.: 0061 3 586 7600, E-mail: jozef.syktus@dar.csiro.au

Taylor, John A.

Centre f. Resource & Environm. Studies, Australian National University, , Canberra, Australia
Tel.: , Fax.: , E-mail:

Thompson, Matthew V.

Department of Biological Sc., Stanford University, , Stanford, CA 94305, USA
Tel.: 001-415-3251521/ext.222, Fax.: 001-415-3256857, E-mail: matt@arbutus.stanford.edu

Thorpe, Robert

Selwyn College, , Cambridge, United Kingdom
Tel.: , Fax.: 0044-1223-33 64 73, E-mail:

Tyson, P.

National Committee for the IGBP, Deputy Vice Chancellor, University of Witwatersrand, PO Wits 2050, South Africa
Tel.: 0027-11-7162998, Fax.: 0027-11-7163161, E-mail:

Uriarte, Anton

Universidad del Pais Vasco, , Plaza de Euskadi 1, San Sebastian 20002, Spain
Tel.: 0034-, Fax.: 0034-43-219402, E-mail: auriarte@si.ehu.es

van Minnen, Jelle

Intern Institute for, Applied System Analysis, , A-2361 Laxemburg, Austria
Tel.: , Fax.: , E-mail:

von Gyldenfeldt, A.

Institut und Museum für, Geologie und Paläontologie, Sigwartstr. 10, 72076 Tübingen, Germany
Tel.: 07071-297548, Fax.: 07071-296990, E-mail: anna-von.gyldenfeldt@uni-tuebingen.de

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 CO₂ 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 CO₂ 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 CH₄ and N₂O 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 between 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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