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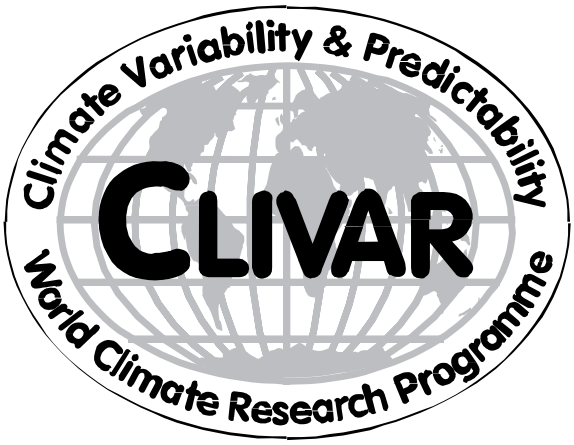
WORLD CLIMATE RESEARCH PROGRAMME



JSC/CLIVAR Working Group on Coupled Modelling

Report of the 6th Session

7-10. October 2002, Victoria, Canada

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CLIVAR is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR. The scientific planning and development of CLIVAR is under the guidance of the JSC Scientific Steering Group for CLIVAR assisted by the CLIVAR International Project Office. The Joint Scientific Committee (JSC) is the main body of WMO-ICSU-IOC formulating overall WCRP scientific concepts.

Bibliographic Citation

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WGCM-6 Action items

1. Banner on Predictability

WGCM welcomes the banner proposal but urges the JSC to re-phrase the title and scope of this important WCRP activity to something which has a more tangible aim- for example: “Measuring and improving predictions on timescales from days to decades”. The major point is that focus of this activity should be shifted from “predictability”, which to many is rather an abstract concept, to “predictions” which is closer to the needs of the organizations funding WCRP.
WGCM would prefer to see this as a refocusing within WCRP rather than a major reorganization. (*A. Villwock to communicate to JSC)*

2. CLIVAR SSG action items

2.1 WGCM will work towards a better co-operation between the other relevant programmes through attendance of WGCM members at their meetings and through invitation of representatives of these groups to WGCM meetings. (*J. Mitchell (JSC), F. Zwiers (SSG), B. McAvaney (GEWEX)*)

2.2 WGCM encourages modellers to use of the indices prepared by the WG/ET CCD, but would also ask the CLIVAR SSG encourage the provision of the original temperature and precipitation time series to help with model improvement. *(A. Villwock to pass to CLIVAR SSG)*

2.3 Concerns have recently been expressed that the results of process-oriented research from GEWEX and other communities is not being integrated into global climate models quickly enough. Some have also expressed the view that models need to be exposed to data more extensively.

After a lengthy discussion the WGCM came to following conclusions: *(A. Villwock to communicate to SSG)*

Climate model development is a continual process of model building, refining and comparison with observations. WGCM welcomes new parametrisations of physical processes.

Due to computational requirements, it is not always possible for comprehensive coupled climate models to undertake detailed sensitivity studies to new parametrisations. These could be done within the context of a hierarchy of coupled models. Coupled climate modellers have a long history of incorporating new and improved parametrisations of physical processes into their operational models (e.g., schemes for atmospheric gravity wave drag, explicit liquid-water cloud schemes, improved representation of penetrating solar radiation into the ocean, and the recent incorporation of the Gent and McWilliams representation of mixing associated with meso-scale eddies). It must be realized that not all parametrisations can be developed in coupled climate models and that difficult choices must be made within modelling groups concerning which particular parametrisation to use.

WGCM welcomes increased collaboration between climate modelling and process-oriented research groups and encourages process-studies to include a modelling component coordinated with WGCM. Another way to foster collaboration would be through extended visits of scientists to different research institutions.

WGCM also agrees that climate models need to be extensively evaluated against observational records. Climate modelling centres have made their model output available to the international scientific community through the CMIP project. WGCM hopes that the broader scientific community will seize the opportunity afforded by the CMIP programmed to assist climate modelling groups in evaluating climate models extensively.

3. WGOMD (P-OMIP)

WGCM welcomes the P-OMIP activity but recommends WGOMD to a) connect the timelines with AMIP and CMIP in order to meet the IPCC requirements and b) to look systematically into the ocean components of coupled model (runs).

WGCM endorsed the present membership but recommended that future changes should reflect a better representation of the variety of ocean models used and developed at present within the community*. (C. Boening to WGOMD)*

4. AR4 (4th IPCC Assessment Report)

In order to meet the timeline for the next IPCC report, WGCM pointed out that the forcing scenarios have to be finalized in early summer 2003.
The group recommended to use the original preliminary scenarios used in for the TAR instead of taking new ones, unless the differences are large, to enable intercomparisons with previous calculations. Furthermore, this would provide a larger sample size for intercomparisons and for impact studies. In addition, it was requested that a simple concentration time series for each atmospheric parameter should be provided for each emission scenario and made available on the IPCC and the TGCIA website.
If the scenarios are changed, then it is very unlikely that WGII will have time to include work from the new scenarios in the AR4 report. This was also the case for the TAR.
(J. Mitchell to draft a letter to the IPCC bureau the above mentioned recommendations.) It should also make clear that IPCC should assess and not direct climate research.

5. Regional Modelling

The task team on regional modelling should proceed in planning a workshop on regional modelling and subsequently plan a model intercomparison study for regional models. In order to meet the requirements for the AR4, a timeline for these activities should be developed. WGCM recommends that the RCM ad hoc panel convene a workshop on optimal ways to use RCMs in different regions for climate change applications. It is suggested that this workshop could be convened in close collaboration with the START community so optimal ways of using RCMs and cautions regarding naïve indiscriminate use can be fully explained to that community. The workshop should be designed to maximise the input of the RCM developer community to the user community prior to the development of regional climate change scenarios and regional climate impacts for the IPCC 4AR. It is suggested that the workshop be held before the end of 2003. The Workshop may also be an opportunity for the RCM community to assess the plans of the ad hoc committee for a co-ordinated assessment of RCM skill in reproducing small scale regional features that may be associated with large scale anomalies on the intraseasonal and interannual time scales (and longer). (*A. Villwock to SSG and JSC*)

6. PRISM

To report to JSC about the two ongoing model infrastructure projects (PRISM and the Earth System Modelling Framework). WGCM strongly recommends that effort should be made to ensure that these make their two systems (code and data) as compatible as possible with a longer term view to producing a single infrastructure. (*A. Villwock to JSC*)

7. PCMDI periodic model assessment

WGCM noted the excellent work of PCMDI on model assessment and encourage them to continue and to extend the good work carried out in AMIP and CMIP in a way that maintains the confidence of the international community and does not adversely prejudice their international respect and reputation for objectivity. (*A. Villwock to JSC*)

8. CMIP/ 20C

WGCM recommended to start a pilot project on Coupled Model Climate of the 20th Century experiments which should be announced through CMIP. There was an agreement on a set of diagnostics. Furthermore it was pointed out that since no single forcing is prescribed for these runs, a comprehensive documentation of the forcing is required for these runs (CMIP panel). One use of these runs is likely to be in detection and attribution studies. *(J. Meehl, ICPO to JSC*)

Two sets of CMIP experiments are currently under way to better understand North Atlantic THC's response in AOGCM's: a) Sensitivity of the THC to heat and water flux forcing and b) so-called 'Water hosing' experiments. Contributions to both experiments should be submitted by end of the year. (*R. Stouffer to send a reminder*).

WGCM notes that it would be very useful if a set of indices were developed to document important modes of variability in the coupled system. Model results could then be compared using these indices. This would provide a simple, clean way of evaluating model performance. (*A. Villwock to JSC, CLIVAR SSG for approval*)

WGCM felt that the Modelling Intercomparison Projects (MIPS) should in time be more integrated towards an Earth System Modelling umbrella. The Coupled Model Intercomparison Project (CMIP) could serve as the overarching MIP. The group encourages the display of the accomplishments of the MIP's in the newsletters of the various programmes. *(A. Villwock to JSC)*

9. Idealized Model Experiments

A letter of invitation for participation will be send out soon. (*B. McAvaney*).

10. Data Management

WGCM to ask the JSC to set up and ad-hoc task team on data management with representatives of all WCRP projects to develop a comprehensive data management strategy for WCRP (*B. McAvaney and PCMDI to develop 'white paper' for JSC*).

11. C20C Project

Since this activity is performed with atmosphere-only AMIP type runs, WGCM felt that this activity would be better placed under the scope of AMIP. Nevertheless, a coordination of the forcing with the ongoing CMIP activity on (coupled) C20C runs would be useful. (*J. Mitchell to report to H. Cattle*).

12. Relationship to C4MIP

WGCM regards the C4MIP as an activity that could be well placed under the expanded scope of CMIP. This issue should be discussed with GAIM, then be brought to the JSC for endorsement. (*WGCM to discuss with GAIM*)

13. Website for WGCM

WGCM asks to pursue the idea for a Website for the panel to be set up under WCRP. (*A. Villwock to contact JPS*)

14. Publicity

A number of contributions are planned to be submitted to the CLIVAR Newsletter Exchanges within the next year. (C20C CMIP (*G. Meehl*), Idealized exp. (*B. McAvaney*), THC/waterhosing (*R. Stouffer*).
In addition, an article about CMIP is planned in the GEWEX newsletter. (*A. Villwock to provide a contact for the GEWEX Newsletter to G. Meehl*)

15. Membership

C. Boening and G. Hegerl reached the end of their terms. WGCM recommended that C. Boening in his function as the chair of the WGOMD should be an ex-officio member of WGCM or send a representative to WGCM meetings, respectively. It was agreed to renew G. Hegerl's term. *(J. Mitchell, ICPO to JSC/SSG)*

16. Next Meeting

The panel agreed to hold its next meeting in 25.-26. September 2003 in conjunction with the WGCM/GAIM International Conference on Earth System Modelling (15-19. Sept. and the CMIP Workshop (22.-24. Sept.), both to be held in Hamburg, Germany. The panel thanked A. Noda for his kind invitation to host a WGCM meeting and desired to meet in Japan in 2004. *(J. Mitchell, ICPO to JSC/SSG)*

REPORT OF THE SIXTH SESSION OF THE JSC/CLIVAR WORKING GROUP ON COUPLED MODELLING

The sixth session of the JSC/CLIVAR Working Group on Coupled Modelling (WGCM) was kindly hosted by the Canadian Centre for Climate Modelling and Analysis (CCCMA) and held in the Laurel Point Inn Hotel in Victoria, Canada, from 7-10 October 2002. The session was partly (9 - 10 October) held jointly with the IGBP group GAIM (Global Analysis Interpretation and Modelling). The list of participants is given in the Appendix to this report.

The participants were welcomed by the Chairman of WGCM, Dr. J. Mitchell, Dr. F. Zwiers (CCCMA) (local organization and CLIVAR SSG) and Dr. A. Villwock (International CLIVAR Project Office).

1. REVIEW OF RELEVANT EVENTS IN THE WCRP AND DEVELOPMENTS IN MODELLING-RELATED ACTIVITIES

Under this agenda item, WGCM was informed of the main discussions at and recommendations from the twenty-third session of the Joint Scientific Committee (JSC) for the WCRP (March 2002), and the 11th session of the CLIVAR Scientific Steering Group (May 2002). In addition, updates of the recent developments within the WGCM/CLIVAR Working Group on Ocean Model Development (WGOMD), the CLIVAR Working Group on Seasonal-to-Interannual Prediction (WGSIP), the JSC/CAS Working Group on Numerical Experimentation (WGNE) AMIP Panel and the modelling activities within ACSYS/CliC were provided.

1.1 23rd session of the JSC

Dr. B. McAvaney reported on the action items relevant to WGCM. He noted that overall, the report on WGCM had been well received by the JSC; its role within WCRP has been valued and better understood. A number of action items related more less directly to WGCM. B. McAvaney reported on the following topics:

Interactions between WCRP and IGBP

The existing joint activities in many areas between WCRP and IGBP were welcomed and encouraged (e.g. CLIVAR/PAGES; SPARC/IGAC; WGCM/GAIM) and the need for increasing collaboration and interaction in a variety of areas was recognized; implications for WCRP of "IGBP Phase II" structure need to be considered, and new opportunities for closer linkages need to be explored (e.g. the new IGBP "Land-Atmosphere" Project and GEWEX; co-operation in Integrated Regional Studies; atmospheric chemistry and climate); however, some concerns were expressed by the JSC at apparent overlaps of new IGBP activities with WCRP and a lack of acknowledgement of the role of WCRP; identification of WCRP as the leader in the physical aspects of Earth System science should be asserted.

"Earth System Science-Partnership" (ESS-P)

The emergence of ESS-P as a formalization of the growing collaboration between IGBP, IHDP, WCRP (and DIVERSITAS) was noted, including proposals for "Integrated Regional Studies" particularly from IGBP: corporate image, communications, resources, and general governance of these activities need to be carefully considered.

START

The overall continuing work of START in capacity-building was acknowledged. The views of WCRP on indiscriminate use of regional climate modelling (see page 10) are to be conveyed appropriately to START community, which should be closely involved in a proposed workshop to consider use of RCMs in various applications. Since this programme is often concerned with application of regional climate modelling, it is critical to make this community aware about the limitations of these models.

Data Management within WCRP

Given the many different approaches, data systems, formats in different WCRP projects with many specific research applications, it is thus not possible/desirable at present to impose one overall programme-wide structure; nevertheless the dialogue between WCRP projects in this area is to continue and, in particular, approaches, concerns, requirements for data delivery/management should be documented; the whole

situation should also be kept under review to take account of the very rapid advances in development of (distributed) data and information systems, data handling and formats.

WGCM/GEWEX

Cloud Feedbacks

The co-operation between GEWEX (Radiation Panel) and WGCM in exploring this complex issue and new methods for analysing non-linear feedbacks, with organization of an appropriate workshop was strongly encouraged. This workshop will take place in November 2002 in Atlanta, USA.

Air-Sea Fluxes / SOLAS (Surface Ocean Lower Atmosphere Study)

The JSC agreed that WCRP should be a "co-sponsor" of SOLAS (although not a "principal" co-sponsor at the same level as IGBP and SCOR): the formalities and details have to be worked out with IGBP, SCOR and SOLAS SSG; WCRP. Attention needs to be given particularly to the subset of relevant activities..

Modelling

The JSC endorsed the general thrust of modelling activities, in particular AMIP which should be continued with special emphasis on intercomparison with observations.

Data Formats and Exchange of Climate Model Data Sets

Careful consideration is needed in the definition of and formats for standardized exchanges of metadata (perhaps in conjunction with consideration of overall WCRP data management and information systems, see data management, section 5.2).

Increased association of WCRP/WGCM with the IPCC Data Distribution Centre (DDC)

It was considered that the DDC and WGCM/PCMDI (CMIP) data bases should be maintained separately in view of their different roles and purposes: WGCM/PCMDI data bases should be particularly designed to serve the scientific modelling community and to understand why different models give different results and have different climate sensitivities: nevertheless full awareness of DDC activities and interactions is to be maintained.

Regional climate modelling (RCM)

WCRP (through WGNE, WGCM and a joint ad hoc panel) are to keep this issue under review, monitor technical developments, and maintain awareness of potential pitfalls in use of RCMs; the organization of a workshop in 1-2 years time is encouraged to consider use of RCMs in various applications and to plan a co-ordinated assessment of RCM skill in reproducing fine-scale regional features that may be associated with large-scale year-to-year anomalies

Banner on Predictability

The proposal for a new "banner" for WCRP - a "Predictability Assessment of the Climate System" with the aim of major steps forwards in climate prediction (development by 2010 of prototype prediction systems for climate on time scales from weeks to a century, and testing/improvement of systems for the full climate system 2010-2020) - has been made by the JSC; this would be a total WCRP activity involving all projects, beneficial to society and a contribution to the planning of sustainable development; emphasis would be given to showing the importance of the data from the new satellite systems and provision of a firm basis for requesting developments of these systems; a task force has been set up to develop ideas and proposals for implementation to report to JSC-XXIV (March 2003): all project groups are to discuss the "banner" and approach, and provide views to the task force by 31 July 2002.

WGCM discussed this proposal and the feedbacks will be provided to the task force (convener B. Hoskins, members: J. Shukla, J. Church, representatives of all WCRP projects). Dr. A. Villwock (ICPO) provided a view from the CLIVAR standpoint. Overall, the scientific issues of the banner proposal are currently being addressed through CLIVAR. The implementation of such a proposal would lead to a further concentration of WCRP modelling activities directly under the JSC and thus presumably further disconnect these activities from the observational studies instead of fostering them.
Other panel members raised the issue that the overarching topic should better focus on ‘prediction’ rather

than 'predictability. Climate prediction is the more exciting issue for the public and could increase the visibility of WCRP as a whole.

The WGCM concluded:

WGCM welcomes the banner proposal but urges the JSC to re-phrase the title and scope of this important WCRP activity to something like: "Measuring and improving predictions on timescales from days to decades". The major point is that focus of this activity should be shifted from predictability to predictions. In addition, WGCM would prefer to see this as a refocusing within WCRP rather than a reorganization. (**Action item: Chair WGCM to report to JSC**).

1.2 11th session of CLIVAR Scientific Steering Group and Report from the ICPO

Dr. F. Zwiers, member of the CLIVAR Scientific Steering Group, reported on the action items relevant to WGCM from the 11th session of the CLIVAR SSG (May 2002, Xi'an, China).

1. The SSG encouraged WGCM to report to CLIVAR SSG on the capability of the latest generation of GCMs to represent coupled phenomena such as ENSO, the tropical Atlantic mode, and the thermohaline circulation, in free-running century and longer timescale climate integrations.
   In response WGCM **(A. Weaver)** will put together a list of examples that documents where WGCM is already addressing CLIVAR's concern about the connection between process studies and modelling.

   Furthermore, WGCM will work towards a better cooperation between the other relevant programmes through attendance of WGCM members at their meetings and through invitation of representatives of these groups to WGCM meetings. **(chair, all)**

2. The SSG had asked WGCM to consider the indices prepared by the Working Group / Expert Team on Climate Change Detection (WG/ET CCD) when evaluating their climate change integrations.

   WGCM encourages modellers to use the indices prepared by the WG/ET CCD, but also encourages the provision of the original temperature and precipitation time series to help with model improvement.

Dr A. Villwock provided some news from the CLIVAR Project Office

- Dr. Howard Cattle has succeeded Dr. John Gould as the director of the ICPO. Dr. Cattle came from the Met Office with a strong background in climate modelling. He had chaired the ACSYS/CliC Scientific Steering Committee for some years., Dr. Daniela Turk has left the ICPO. Her post is likely to be filled by end of the year.
- The ICPO has introduced a number of new services on their website. The scientific articles published in the CLIVAR newsletter Exchanges are now available in a reprint style for download. A new section highlighting CLIVAR-relevant literature in a number of high-profile journals is also available through the CLIVAR website, which will appear in a new look shortly.
- The CLIVAR scientific conference is currently being planned for June 21-25 2004 in Baltimore, USA.

1.3 WOCE/WGCM Working Group on Ocean Model Development (WGOMD)

The chair of the Working Group on Ocean Model Development, Dr. C. Boening, reported about the recent developments within this panel which met in Hamburg, Germany, in May 2002.

The WGOMD was established in 2000 as a joint working group under the WOCE SSG and the WGCM. The reporting relationships are currently under revision, with the end of the WOCE program in 2002. The WGOMD group has been active for three years. The membership is comprised of scientists working in both oceanographic and climate centres or departments. The WGOMD is charged to "stimulate the development of ocean models for research in climate and related fields, with a focus on decadal and longer timescales at mid- and high-latitudes."

To disseminate and publicize information on the status of ocean models used in climate research, the WGOMD provides a Web directory of ocean modelling resources [1] and has published a major review paper [2] in the refereed literature.

The most significant activity undertaken by the WGOMD thus far, has been the establishment of the Pilot Ocean Model Intercomparison Project. This pilot study is intended to determine the feasibility and merit of a broad intercomparison among ocean and ocean-ice models used in coupled climate system modelling. The OMIP under consideration is intended to support CMIP in providing quantitative evaluations of the models participating in the IPCC and other climate assessments. In addition, it is expected that an OMIP will provide

a common reference point for investigating sensitivities to model formulation, enable a pooling of resources (forcing and verification data sets, pre- and post-processing software, archival facilities) across modelling groups, and contribute to a shared understanding and broader dissemination of model developments and model results.

The challenges faced in designing an OMIP include:

- Difficulties in finding the appropriate level of detail for the protocol: It needs to provide for a meaningful comparison without being so detailed as to be too difficult for groups to comply with.
- Difficulties in defining the forcing: A large number of poorly known fields are required.
- Costs: Groups will probably need to do runs specially for this intercomparison that will require significant expenditure of computer resources

The P-OMIP builds on a mini-OMIP conducted by MPIfM and AWI, most significantly by utilizing the ERA-15 based forcing data set developed for that project. The P-OMIP protocol specifies that the experiments be conducted as coupled ocean-ice integrations. In the first phase of the Pilot-OMIP 7 models are participating. These first experiments already indicate a number of robust behaviours (both positive and negative) and suggest that an OMIP of this type should be feasible and have merit. Before a full blown OMIP can commence however, resources to support the coordination and infrastructure will need to be identified. The WGOMD plans to make a recommendation on whether or not to proceed with a full blown OMIP at its next meeting in spring 2003.

[1] http://www.clivar.org/organization/wgomd/index.html
[2] Griffies, S. et al (2000) Developments in ocean climate modelling. Ocean Modelling, 2, 123-192.

WGCM welcomed the P-OMIP activity but recommended WGOMD a) connect the timelines with AMIP and CMIP in order to meet the IPCC requirements and b) look systematically into the ocean components of coupled model (runs).
WGCM endorsed the present membership but recommended that future changes should reflect a better representation of the variety of ocean models used and developed at present within the community.

1.4 JSC/CAS Working Group on Numerical Experimentation (WGNE) and Atmospheric Modelling Intercomparison Project (AMIP)

Since no direct representation of WGNE was present at the meeting, Dr. K. Taylor from PCMDI reported about the progress within the Atmospheric Model Intercomparison Project (AMIP) which is carried out under the auspices of WGNE. AMIP, like other model intercomparison studies such as CMIP and PMIP is hosted by the Program for Climate Model Diagnosis and Intercomparison (PCMDI) at the US Department of Energy Lawrence Livermore National Laboratory. Dr. Taylor elaborated the following topics:

Model Intercomparison: Evaluation

AMIP's facilitates community-wide analysis of model simulations by providing output in a common form by enabling "economies of scale" in the analysis of model results and allowing innovative diagnostics to be tested on a variety of models. It helps to identify common deficiencies that can help focus model development on critical issues and serves as a benchmark experiment for evaluating models and documenting changes in their performance.

Model Intercomparison: Challenges

The identification of systematic errors rarely provides a roadmap to model improvement. The MIP proliferation taxes resources of some modelling groups and the enthusiasm wanes when the direct rewards for participation are delayed (i.e., new insights into their model's behaviour or new perspectives of its performance are not promptly received).

Towards a new AMIP Philosophy

It can be assumed that model developers will continue to rely on AMIP-style simulations to evaluate how modifications affect model performance. The periodic submission of new AMIP model results to PCMDI is encouraged in order to produce a large suite of standard diagnostics for the benefit of the submitting group (using a largely automated procedure) and to feature an assessment of the model's performance relative to other recent AMIP model runs. In addition it is expected that once a model is being used in application mode, its AMIP output will be released for community-wide analysis and for use by the IPCC.

A new PCMDI/WGNE Simulation Report Series is under consideration. These reports should include a wide variety of traditional figures, augmented with new, innovative diagnostics. The reports will be available online and serve as citable documentation of the model (e.g., by the IPCC). Contributing modellers could be first authors (if they provide documentation of model formulations for the appendix). The initial focus will be on AMIP simulations, but should also be extended to include CMIP simulations.

Immediate AMIP plans are an upcoming workshop to be held at Meteo-France, Toulouse, November 12-15, 2002 with emphasis on:

- New diagnostic approaches
- Use of state-of-the-art observations
- Further identification of common errors

The discussions at the workshop will include:

- Refining the AMIP experimental protocol (e.g., standard output)
- Coordinating AMIP with CMIP (WGCM views?)
- Coordinating AMIP with the C20C (prescribed SST experiment

Exploiting the AMIP Infrastructure to support CMIP

- Access to AMIP simulations by the atmospheric component of a coupled model would help isolate the origin of coupled model errors.
- Most diagnostics being developed for AMIP analysis can be applied to coupled models.
- The AMIP Diagnostic Report Series should be extended to include CMIP runs.

What would increase the value of AMIP?

- Continue to push for AMIP simulations to be run in parallel with CMIP simulations (i.e., identical AGCM used for both)
- Further define and promote an experimental protocol for CMIP that could be periodically revisited (e.g., Control and 1% CO2/year)
- Advance the CMIP "Standard Output"
- Adhere to data standards developed for AMIP (or to the so-called CF-metadata conventions for NetCDF files)

WGCM welcomed the presentation and the recent developments within AMIP. The panel discussed possible overlaps with the GEWEX GLASS activity and a closer coordination between AMIP and CMIP. It recommended involving the GEWEX community in the specification of future AMIP work (e.g. common standard output formats). AMIP subprojects co-sponsored by GEWEX are welcomed. In this context the presence of WGCM in Land-Surface groups of GEWEX was recommended. With respect to CMIP, same versions within these two MIP's should be considered.

Overall WGCM felt that the MIP's should be more integrated towards an Earth System Modelling umbrella. The Coupled Model Intercomparison Project (CMIP) could serve as the overarching MIP. The group encourages the display of the accomplishments of the MIP's in the newsletters of the various programmes (**Action item**).

1.5 ACSYS/CliC Numerical Experimentation Group

Dr. G. Flato, chair of the ACSYS/CliC Numerical Experimentation Group, reviewed the activities within the reconstituted ACSYS/CliC programme. The Arctic Climate System Study (ACSYS) started in 1993 with and will end in 2003. It focused on the Arctic region only. The Climate and Cryosphere Project (CliC was approved in 2001 and will continue the ACSYS activities, but expands its scope to include the global Cryosphere.
The ACSYS Objectives are to

- understand the interactions between the Arctic ocean circulation, ice cover and the hydrological cycle
- initiate long-term climate research and monitoring programmes for the Arctic
- provide a scientific basis for an accurate representation of Arctic processes in global models

Some ACSYS achievements are

- Sea-ice model intercomparison project (SIMIP)
  Focused on sea-ice dynamics

- Historical data rescue/analysis
  ADIS' -- http://acsys.npolar.no/Oelke/adis.html
- Upward-looking sonar ice thickness observations
  Coordination and evaluation
- Reanalysis Panel contributions to ERA-40

The final ACSYS wrap-up conference is planned in St. Petersburg, Russia, in November 2003. It will summarize what was learned about the Arctic climate system during the ACSYS decade.

The CliC Science Objectives are based on interactions of
- Atmosphere, snow/ice, and land;
- Land ice and sea level
- Sea ice, oceans, and atmosphere
- Global scale climate interactions
- and the cryosphere as an indicator of global climate change

CliC is organized under the leadership of a Scientific Steering Group (meeting in Beijing, 21-25 October 2002), with
- Observation Products Panel (OPP)
- Data Management and Information Panel (DMIP)
- Panel on Polar Products from Reanalysis (PPPR)
- Numerical Experimentation Group (NEG)

The present NEG activities encompass:
- SIMIP – sea-ice dynamics intercomparison
- SIMIP2 – sea-ice thermodynamic intercomparison
- An Ice Sheet Model Intercomparison is being planned now to follow-up to 'EISMINT' with a focus on grounding line processes and higher-order 3-D models.
- Informal coordination of Southern Ocean process modelling activities

In addition the NEG "co-sponsors" the
- Arctic Ocean Model Intercomparison Project (AOMIP)
  - Initial evaluation of existing Arctic ocean model output.
  - Coordinated model experiments underway now.
- Arctic Regional Climate Model Intercomparison Project (ARC-MIP)
  - Joint with GEWEX Working Group on Polar Clouds
  - RCM experiments using common domain and boundary conditions.
  - 5 RCM groups participating.
  - Oct/97 – Oct/98

In future the NEG is hoping to foster closer connections with the WGOMD.
Common interests are in protocols and forcing data for global sea-ice and ocean model intercomparisons, and diagnostic projects related to polar oceans and their ice cover. Snow and permafrost modelling are potential topics to pursue. An initial CliC Science Conference tentatively scheduled for 2004

1.6 Intergovernmental Panel on Climate Change (IPCC)

Dr. J. Mitchell reported about the recent developments within the IPCC. The new chairman of IPCC is Dr. Rajendra K. Pachauri (India), and the WG1 is co-chaired by Dahe Qin (China) and Susan Solomon (USA). The structure of the 4th Assessment Report (2006/7) (AR4) is currently under discussion. Dr. Mitchell also elaborated on the developments within the Task Force on Climate Impact Assessment (TGCIA). The TGCIA informally recommended that if modelling groups plan to run the new SRES tey run A2 and B2 first After A2 and B2 the preferred order is: A1FI, B1 and A1B.

In order to meet the timeline for the next IPCC report, WGCM pointed out that the forcing scenarios have to be finalized in early summer 2003.
The group recommended the original preliminary scenarios be used in for the TAR instead of taking new ones, unless the differences are large, to enable intercomparisons with previous calculations. Furthermore, this would provide a larger sample size for intercomparisons and for impact studies. In addition, it was requested that a simple concentration time series for each atmospheric parameter should be provided for each emission scenario and made available on the IPCC and the TGCIA website.
(**Action item**: J. Mitchell to draft a letter to the IPCC bureau the above mentioned recommendations. It

should also make clear that IPCC should assess and not direct climate research.)

Other topics:

A Workshop on Climate Sensitivity is in the planning stage.

Data Distribution Centre
The following SRES scenario computation are expected to be at the IPCC Data Distribution Centre (DDC):

- Results from the Hadley model for A1FI from Sept/Oct 2002.
  - Results from the Japan model for A1B from Sept/Oct 2002.
  - Results for the Japan model for A1FI and A1T about August 2002.

This will provide at least 3 GCM sets of results on the DDC each with 4 SRES scenarios

A short draft note on material available at the DDC will be published in Global Environmental Change in October 2002. Multiple offprints will be mailed by the WGII TSU to the user community.
The paper by Swart, Raper, Morita and Mitchell on stabilisation scenarios will be revised and likewise published, reprinted and circulated;

Additional values for the DDC are:

- Global sea-level data are on the DDC.

A sub-group was asked to re-consider the need for daily data. Users needing daily data are to be directed to modelling groups. A list of appropriate contacts in the modelling centres is to be drawn up and placed prominently on the DDC (after checking with the groups)

1.7 Regional Modelling

Dr. J. Mitchell noted that the report of the ad-hoc panel on regional modelling had been endorsed by the JSC. WGCM recommended that the task team on regional modelling should proceed in planning a workshop on regional modelling and subsequently plan a model intercomparison study for regional models. In order to meet the requirements for the AR4, a timeline for these activities should be developed. WGCM further recommended that the RCM ad hoc panel convene a workshop on optimal ways to use RCMs in different regions for climate change applications. It was suggested that this workshop could be convened in close collaboration with the START community so that optimal ways of using RCMs and cautions regarding indiscriminate use of output can be fully explained to that community. The workshop should be designed to maximise the input of the RCM developer community to the user community prior to the development of regional climate change scenarios and regional climate impacts for the IPCC 4AR. It was suggested that the workshop be held before the end of 2003. The Workshop may also be an opportunity for the RCM community to assess the plans of the ad hoc committee for a co-ordinated assessment of RCM skill in reproducing small scale regional features that may be associated with large scale anomalies on the intraseasonal and interannual time scales (and longer). (**ICPO to inform the ad-hoc panel**)

2. NEWS FROM RELEVANT NATIONAL AND MULTINATIONAL PROJECTS

2.1 PRISM (Project for integrated Earth System Modelling)

Dr. J. Mitchell provided a status report on the European PRISM project.

The goal of PRISM (**Pr**ogram for **i**ntegrated Earth **S**ystem **M**odelling is to develop an European Framework for Earth system modelling. It started December 2001 funded by the European Commission (4.8 M euros) PRISM involves development of a system for flexible coupling of current state-of-the-art atmosphere, ocean, sea-ice, atmospheric chemistry, land-surface and ocean-biogeochemistry models. There are 22 partners participating, including leading climate researchers and computer vendors. A portable, efficient and user-friendly system based on state-of-the-art models with diagnostics and visualization will be developed.

Current Status (Aug. 2002)
The system specification is complete and will be publicly available in autumn. The first project meeting was held in May 2002 in Toulouse,. The implementation phase has now started. For more information see http://prism.enes.org/

A similar project (the Earth System Modelling Framework) has been set up in the United States.

WGCM welcomed the status report and recommended to report to JSC about the two ongoing model infrastructure projects (http://www.esmf.ucar.edu/)). WGCM further strongly recommended that efforts should be made to ensure that these make their two systems (code and data) as compatible as possible with a longer term view to producing a simple infrastructure. (**ICPO to JSC**)

The Earth Simulator

Dr. A. Noda gave a status report about the Earth Simulator. The World's largest computer system. It has been installed with a peak performance of 40 Tflops and a main memory of 10Tb. 5120 processors are bundled on 640 nodes with 8 Gflop/64 Gflop peak performance per processors / node, respectively.
The following activities have started as part of the Human-Nature-Earth Symbiosis Project.
1. The Global Warming "Japanese Model" Mission with the goals
    - Development of high resolution AOGCM(s),
    - Development of integrated earth system model(s) for global warming projection
    - Improvement of physical process parameterizations
    - Development of very high resolution climate model(s)
2. The Water Cycle Variability Prediction Mission with the goals
    - Improvement of water cycle modeling over Asian monsoon region
    - Improvement of water resources modeling
3. The Development of common basic technology by improvement of 4-dimensional data assimilation and data services.

In total there are (July, 15, 2002) 15 projects within atmosphere/ocean science, 8 in solid earth science, 3 in computational science and one other research project (nuclear reactor) accepted to use the Earth Simulator.

2.2 PCMDI periodic model assessment

PCMDI announced that it will carry out a periodic model assessment in order to assess the state of climate models similar to IPCC, but more frequently. A first draft, using the available output from present CMIP simulations should be available for the CMIP workshop in late 2003 with a final publication in early 2004. The modelling groups have already been contacted in order to get permission to use the data for this purpose. After some discussion WGCM noted the excellent work of PCMDI on model assessment and encouraged them to continue and extend the good work carried out in AMIP and CMIP in a way that does not adversely prejudice their international respect and reputation for objectivity. (**ICPO to JSC**).

3. CONTRIBUTIONS FROM OTHER MODELLING GROUPS

3.1 CCCma Model Development

Dr. G. Flato reported about the recent CCCma model developments.

Atmospheric Model Development
The development of a new atmospheric model component AGCM4 is currently under way. Apart from increasing resolution (now 35 vertical levels), changes in the physical and dynamical packages, such as radiative transfer (correlated K distribution), clouds (now prognostic), moist convection (new shallow convection) and atmospheric components (sulphate aerosols and chemistry) are most prominent.

Coupled Model Development
- AGCM3 atmospheric component, with CLASS land surface scheme, at T47/L31 resolution.
- OGCM modified version of NCAR's NCOM1.3.
- new MPI-based coupler.
- variable velocity river routing scheme.
- simple ice-sheet parameterization returns land ice to the ocean.

Two versions being tested:
a) No flux adjustment.
- Model initialized with observationally-based ocean climatology.
- Run for 150 years with modest drift overall, but significant local errors especially in N. Atlantic.

b) Annual mean flux adjustment.
- 50 year 'adaptation' to estimate flux adjustments.
- Control simulation follows.
- Run for 35 years so far – ongoing.
- Drift is necessarily smaller.

Considerable effort has been invested in improving the model components so as to eliminate the need for flux adjustment. It is not obvious that there is a 'universal cure' –different groups have had success with different improvements. It appears that we still need some modest flux adjustment in CGCM3, but small compared to previous versions.
CMIP2 (1%/yr) and SRES scenario runs will be conducted with this version.

Development of a New Coupler
Over the past 6 months or so, a new version of the coupler code has been worked on with the following objectives:
- More efficient operation (reducing the number of processors, reducing I/O overhead, ...)
- More streamlined (improved time manager, more 'user-friendly' code structure, …)
  This will make maintenance and upgrades easier.
- More flexible (different configurations, different coupling frequency, additional components, …)
  This will facilitate implementation and testing of C-cycle components.

3.2 Change of Precipitation in CO_2 in a Global Warming Scenario

Dr. Noda reported that global change scenarios with CO_2 doubling and 2% increase of the solar constant have been investigated to study the potential changes in precipitation. The MRI_CGCM-1 model has been used to perform ensemble experiments. 5 ensemble members have been generated for the CO_2 doubling and for the 2% increase in solar constant case, respectively. The initial conditions originate from the control experiment on Jan. 1 every 5 years.

Results:
The precipitation decreases just after the CO_2 concentration of the atmosphere is doubled. Two mechanisms have been proposed:
- The heat content of land is much smaller than that of the ocean, so that the heat low will be dominant over land, providing subsiding air over the ocean to suppress the evaporation from the sea surface. (Land-sea effect)
- The main effect of CO_2 on long-wave cooling in the troposphere is to reduce the long-wave cooling due to water vapour through the spectral overlap at 15 micron band, resulting in the reduction of convective heating to keep the heat balance in the troposphere. (CO_2 effect)

In the radiative convective one dimensional atmosphere, evaporation and precipitation decrease due to the

CO_2 effect because no land-sea effect exists.
In the three dimensional atmosphere both effects can work. In order to find the relative importance, ensemble experiments have been made with doubling CO_2 and with 2% increase in solar constant. As a result, the land-sea effect is estimated to be twice larger than the CO_2 effect as the initial response.

3.3 Modelling at NCAR

Dr. G. Meehl reported about the recent progress on model development at NCAR.
The new CCSM (Community Climate System Model) (http://www.ccsm.ucar.edu/) is a coupled climate model for simulating the earths climate system. The CCSM Model components are:

- Atmosphere: NCAR Community Atmosphere Model 2 (CAM2)
  - T42, 26 levels
  - 1-D decomposition
  - Improved Dynamics, Radiation and Parameterizations
- Ocean: Parallel Ocean Program (POP1.4.3)
  - ~1 degree horizontal grid, 40 levels
  - 2-D data decomposition
- Sea-Ice: CSIM4
  - Elastic-viscous-plastic (EVP) dynamics, ice thickness distribution & energy conserving thermodynamics
  - High/Low resolutions on POP grids
- Land: Community Land Model (CLM2)
  - Global Land surface model
  - 10 vertical soil layers, 128x64 horizontal points
  - 16 different vegetated types
  - Surface hydrology and river runoff

The model development is organized through the CCSM Advisory Board (CAB), a Scientific Steering Committee and 9 Working Groups (Atmosphere, Ocean, Sea-ice, Land surface, Biogeochemistry, Natural Variability, Paleoclimate and Software engineering). For Climate Change and Assessment, the general topic for the next 5 years is to quantify uncertainty in climate change projections. To accomplish this objective, a "forcing repository" would be useful, so that all groups can use the same forcing. In addition, single forcing experiments are still useful. Further steps encompass:

- Improvement of regional climate simulations and extremes
- Probabilistic projections of climate change using ensemble simulations with various forcings and scenarios
- A better understanding of the model response due to changes in forcing, since climate sensitivity is likely to be a main issue for the next IPCC assessment.

Sufficient resources in computational power, data transfer, storage and access will be essential to meet these requirements. The IPCC AR4 will require additional scenarios, such as A1F1, A1B and B1 (in addition to A2 & B2).
At present the following experiments are planned within the next 5 years or so.

<u>With T42 Atmosphere</u>

1. 1870 control run, spin-up, and 250 stable years (500 years)
2. 20th century all-forcings run (GHGs,+SA+SV+V) (130 years)
3. 21st century climate change with SRES A2 (100 years)
4. 21st century climate change with SRES B2 (100 years)

<u>With T85 Atmosphere</u>

1. Control run with present day climate (500 years)
2. 1% CO_2 increase to doubling (199 years)
3. 1870 control run, spin-up, and 250 years (500 years)
4. 20th century all-forcings ensemble (5) 1870-2000 (GHGs,+SA+SV+V) (650 years)
5. 21st century climate change with SRES A2 5 member ensemble (500 years)
6. 21st century climate change with SRES B2 5 member ensemble (500 years)
7. 21st century climate change with SRES A1FI (1) (100 years)
8. 21st century climate change with SRES A1B (1) (100 years)
9. 21st century climate change with SRES B1 (1) (100 years)
10. CO_2 stabilization around doubling or 650ppm (300 years)
11. CO_2 stabilization around quadrupling (300 years)
12. Sensitivity experiments with different forcing combinations (4000 years)

With T170 Atmosphere

1. 1870 control run, spin-up, and run (300 years)
2. 20th century all-forcings run (GHGs,+SA+SV+V) (130 years)
3. 21st century climate change with SRES A2 (100 years)

In parallel to the development of CCSM, three other coupled models are still in use for multiple applications:

- CSM (atmosphere: CCM3.2, T42, 18L; ocean: NCOM (NCAR CSM Ocean Model), 2 deg., 45L, GM, KP; sea ice: cavitating fluid; land: LSM)
- PCM (Parallel Climate Model): atmosphere: CCM3.2, T42, 18L; ocean: POP, 2/3 to 1/2 deg. in eq. tropics, 32L, biharmonic diffusion, Pacanowski & Philander vertical mixing; sea ice: dynamic (EVP), thermodynamic (Naval PG School); land: LSM
- PCTM (PCM-CSM Transition Model): atmosphere: CCM3.2, T42, 18L; ocean: POP, 2/3 to 1/2 deg. in eq. tropics, 40L,GM, KPP; sea ice: dynamic (EVP), thermodynamic (Hunke/Dukowitz/Bitz/Lipscomb); land: LSM

3.4 Modelling at GFDL

Dr. Stouffer gave a short overview about the recent developments at GFDL

1. Flexible Modeling System (FMS)

A Flexible Modeling System (FMS) is currently developed as part of the Earth System Modeling Framework (ESMF). FMS is a software framework for supporting the efficient development, construction, execution, and scientific interpretation of atmospheric, oceanic, and climate system models. FMS comprises the following:

1. A software infrastructure for constructing and running atmospheric, oceanic, and climate system models. This infrastructure includes software to handle parallelization, input and output, data exchange between various model grids, orchestration of the time stepping, 'makefiles', and simple sample run scripts. This infrastructure should largely insulate FMS users from machine-specific details.
2. A standardization of the interfaces between various component models.
3. Software for standardizing, coordinating, and improving diagnostic calculations of FMS-based models, and input data preparation for such models. Common pre-processing and post-processing software are included to the extent that the needed functionality cannot be adequately provided by available third-party software.
4. Contributed component models that are subjected to a rigorous software quality review and improvement process. The development and initial testing of these component models is largely a scientific question, and would not fall under FMS. The quality review and improvement process includes consideration of (A) compliance with FMS interface and documentation standards to ensure portability and inter-operability, (B) understandability (clarity and consistency of documentation, comments, interfaces, and code), and (C) general computational efficiency without algorithmic changes.
5. A standardized technique for version control and dissemination of the software and documentation.

FMS does not include the determination of model configurations, parameter settings, or the choice amongst various options. These decisions require scientific research. Similarly, the development of new component models is a scientific concern that is outside of the direct purview of FMS. Nonetheless, infrastructural changes to enable such developments are within the scope of FMS. The collaborative software review process of contributed models is therefore an essential facet of FMS. More information under http://www.gfdl.noaa.gov/~fms/

2. Current Coupled GFDL Model (CM2)

The current coupled model used at GFDL comprises the following "State-of-Art" components:

- Atmospheric model: N45L18, RAS, Mellor-Yamada mixing, Ram's latest radiation, Klein clouds
- Ocean Model: MOM4: tri-polar grid, 2 deg mid-lats, 2/3 deg in tropics, 1 deg high lats, 54 levels, free surface, GM
- Land-vegetation model: 5 layers, 11 vegetation types, bucket, rivers
- Sea ice model: Full dynamic, 3 level thermodynamic, brine pockets

Current experiments are trying to find stable control integrations without applying flux adjustments. Nevertheless, the climate drift is still large with positive values in the tropics and mid-latitudes and negative in the subtropics and high latitudes

Next Generation Model (CM3)

Major changes to CM2 are:

- Atmosphere: N45L32, Donner conv., Bretherton-Grenier mixing, new gravity wave scheme. Others?
- Ocean: 1 deg mid-lats, 1/3 deg in tropics, 1/2 deg in high latitudes, 54 levels
- Land: Dynamical vegetation
- Carbon cycle

The developments of the model components have started. The design of the system should enable to perform four runs of 100 model years per months using half of the current system.
The following experiments are envisaged:
"Standard" IPCC type runs, with a special interest on the1850 to present (C20C) period but also onward to 2100. Other foci are:

- Future stabilization of GHG concentrations
- Last 1000 years
- Paleo – LGM, 6KBP, "surprises"
- Seasonal to Interannual Prediction

3. The NOMADS Project:

To address a growing need for remote access to high volume numerical weather prediction and global climate models and data, the National Climatic Data Center (NCDC), along with the National Centers for Environmental Prediction (NCEP) and the Geophysical Fluid Dynamics Laboratory (GFDL), initiated the NOAA Operational Model Archive and Distribution System (NOMADS) project. The NOMADS framework was developed to facilitate climate model and observational data inter-comparison issues as discussed in documents such as the Intergovernmental Panel on Climate Change (IPCC 1990, 1995, 2001) and the U.S. National Assessment (2000). NOMADS is being developed as a Unified Climate and Weather Archive to provide Web access to model information so that users can make decisions about their specific needs. This on time scales from days (weather), to months (El Nino), to decades (global warming). NOMADS also addresses model data access needs as outlined in the U.S. Weather Research Program (USWRP) Implementation Plan for Research in Quantitative Precipitation Forecasting and Data Assimilation to "redeem practical value of research findings and facilitate their transfer into operations." For more information see: http://data1.gfdl.noaa.gov/.

NOMADS is a network of data servers using established and emerging technologies to access and integrate model and other data stored in geographically distributed repositories in heterogeneous formats. NOMADS enables the sharing and inter-comparing of model results and is a major collaborative effort, spanning multiple Government agencies and academic institutions. The data available under the NOMADS framework include model input and Numerical Weather Prediction (NWP) gridded output models from NCEP; and Global Climate Models (GCM) and simulations from GFDL and other leading institutions from around the world. The goals of NOMADS are to:

- Improve access to NWP and GCM's datasets.
- Improve the linkages between the research and operational modeling communities.
- Foster collaborations between the climate and weather communities.
- Provide the observational data and model analysis initialization products for regional models.
- Improve the verification process of forecast and climate models.
- Promote product development and collaborations within the geo-science communities (ocean, weather, and climate).
- Provides cost effective pull technologies for "hyper-slabs" of high volume data sets.

At present the following model experiments are available in the NOMADS data base: (Mostly monthly data, some daily)

- 400 yrs. - Control GFDL_R30_c
- 3 "GS" runs, 1866 –2100
- 1 IPCC SRES A2 1965-2100
- 1 IPCC SRES B2 1965-2100
- "GSSV" coming soon

In total about 1 TB of Dec-Cen data is currently available.

3.5 Coupled Modelling at BMRC

Dr. B. McAvaney reported about the couple modelling activities with BMRC. The Australian Academy of Science has started a national initiative for climate modelling. In addition, a review of the Australian Greenhouse Science Program has been completed, and the modelling aspects of the programme have performed well.
The BMRC Atmospheric Model (BAM) is used for various applications, such as meso-scale, regional and medium range forecasting (uncoupled), and seasonal forecasting and climate (change) simulations (coupled).

Coupled Modelling
The POAMA (Predictive Ocean Atmosphere Model for Australia) is a joint project between BMRC and CSIRO Marine Research to develop a Coupled Model for seasonal to inter-annual prediction. It uses the Australian Community Ocean Model (ACOM2) developed by CSIRO Marine Research and the BMRC unified Atmosphere Model (BAM).
Operational trials have been performed to deliver operational forecast input to NCC's climate outlook (Web site: http://www.bom.gov.au/bmrc/ocean/JAFOOS/POAMA/)

The BMRC Coupled Model consists of the ACOM 2 Ocean Model developed by CSIRO Marine Research with an enhanced tropical grid and improvements to representation of tropical oceans, e.g. parametrization of tidal mixing in the Indonesian Throughflow region. The atmospheric components is the BMRC unified Atmosphere Model (BAM) in its latest version BAM 3. The horizontal resolution is T47 with 17 vertical levels. For the interface, the OASIS Coupler developed by CERFACS, Toulouse is used. In the operational set up a forecast every 3 days (within 1 day of real time) with 10 Member ensembles per month are carried out. The Initialisation is using the latest ocean and atmospheric observations.

3.6 Coupled modelling at CSIRO

Dr. A. Hirst reported about the coupled modelling at CSIRO Atmospheric Research, Aspendale, Victoria. Themain focus of this work is climate change research and projection. The Division supports a global coupled climate model (the CSIRO "Mark 3") and a regional climate model for dynamical downscaling. Mark 3 model consisted of an atmospheric component of resolution T63L18, the Met Office convective parameterization, and an advanced cloud liquid water scheme. The ocean component was built round the GFDL MOM code (version 2.2) with a resolution of 0.9°x 1.8° and 31 levels, a Richardson mixing scheme, and third order advection. A dynamical sea-ice model was also included (Flato Hibler rheology, Semtner thermodynamics). No flux adjustment is applied. (Reference: Gordon et. al, 2002, CSIRO Tech. Note 60).
Climate change scenario (A2) integrations reveal that the Mark 3 model displays significantly less warming than in the old Mark 2 version, although the response patterns were similar. The inference drawn was that the positive feedbacks associated with clouds and with the snow albedo were weaker in the more recent model.
The ENSO simulation of the new model is much more realistic than in the old one, in particular the size of the SST anomalies in the equatorial Pacific is now comparable to observations. The equatorial cold tongue is still too strong and extends further west than observed. A climate change scenario (A2) integration shows a modest reduction of the North Atlantic overturning circulation in the 21st century compared to the control integration.
Further plans with the CSIRO model encompass contributions to CMIP2+ and DDC. Within the model development the foci are to:

- mitigate biases in the physical model (tropical/southern hemisphere focus)
- introduce an interactive biosphere (terrestrial and oceanic)
- include explicit modelling of aerosol concentrations (impact on regional climate)

Further expansion of the linkages with Australian Universities and BMRC are envisaged under the national initiative on climate modelling (see section 3.5). In addition, it will be examined how best to support rapidly growing demand for climate impact assessments on the local to regional scale.

3.7 Hadley Centre

Dr. J. Mitchell gave a general overview of Hadley Centre plans. The atmospheric component of the next version of the Hadley Centre model will be based on the Met Office "new dynamics" core with semi-Lagrangian advection and a semi-implicit time step. The envisaged resolution of the new atmospheric component was 1.25 x 1.875°, with 48 levels in the vertical (a 38-level version also exists). The ocean model would be 1°x 1° but with enhanced resolution in the tropics. It was intended inter alia, to prepare ensembles of scenario runs, and undertake work to understand the thermohaline circulation and decadal prediction.

4. REVIEW OF WGCM INITIATIVES

4.1 Coupled Model Intercomparison Project (CMIP)

CMIP (http://www-pcmdi.llnl.gov/cmip/) was one of the most important and long-standing initiatives of WGCM, having been started in 1995. There are now three components: CMIP1 to collect and document features of global coupled model simulations of present-day climate (control-runs); CMIP2 to document features of control runs and climate sensitivity experiments with CO_2 increasing at 1% per year; CMIP2+, as CMIP2, but many extra fields and data, and monthly means, and some daily data were being collected.

Dr. J. Meehl (Chairman of the CMIP panel set up by WGCM to oversee the detailed organization of the project) and Dr. C. Covey (PCMDI)) reported on the current status. The range of extra fields at higher temporal resolution being assembled in CMIP2+ (compared to the limited fields, in CMIP1 and CMIP2) was enabling in-depth study of many additional aspects of coupled model simulations (e.g. feedback mechanisms, ocean processes, explaining higher frequency phenomena and why different models had different responses,).

Status of the CMIP2+ database in October 2002

The following model results have been submitted to PCMDI

- CSIRO Mk2*
- CSM1
- GFDL R30*
- HadCM2*
- HadCM3*
- PCM*

* Includes daily frequency data

In addition, model output from the following models will become available soon

- BCM
- CCCma
- ECHAM/HOPE
- ECHAM/OPYC

The atmospheric data has been processed and released to subprojects (about 0.6 Tbytes), the ocean model output will follow soon.

CMIP subprojects and publications:

For CMIP1, 10 subprojects were initiated whereas 6 have contributed to or produced at least one publication.
CMIP2, started in 1998, 22 subprojects were initiated whereas 10 have contributed to or produced at least one publication. In addition PCMDI scientists have published 3 CMIP papers and three CMIP2 subprojects have contributed to the IPCC TAR.
CMIP2+, started in August 2001. At present, 16 subprojects have been defined and one paper has already been published.
(A complete list of CMIP diagnostic sub-projects can be obtained from http://www-pcmdi.llnl.gov/cmip/).

Issues for CMIP

1. Maintaining the existing database, provide support to other intercomparisons including subprojects, complete archival and access to CMIP2+ monthly and daily data; closing submission to present CMIP phases over the next two months.
2. The relationship with the IPCC DDC in Hamburg; 20th century runs and daily data.
3. Engage other communities to use CMIP2+ ocean data
4. Continue to monitor technological developments regarding distributed model data access (e.g. Earth System Grid)
5. A CMIP Workshop planned back to back to the WGCM/GAIM Conference on Earth System Modelling in Hamburg, September 22. – 24., 2003.
6. The start of a new CMIP phase in early 2004, to be coordinated with AMIP and OMIP.

Coupled 20th Century runs (C20C)

The main problem with these experiments is the definition of the forcing. It was agreed that each participating group makes their best attempt to simulate the 20th century. Thus, each group may have different combinations of forcings or forcing datasets, so that an accurate documentation of the forcing used is required. The experiments start in late 19th century, e.g.1870.

a) A limited amount of data will be archived at PCMDI. These experiments will find applications within a) Detection / Attribution, b) Model Validation / Decadal Variability, and c) Downscaling.
b) During the discussion it was pointed out that for regional modelling and downscaling high-resolution data sets would be required (e.g. 6h, 3-dim., 20y window).
c) In addition, extremes would be of interest for various applications.

WGCM recommended to the starting of a pilot project on Coupled Model Climate of the 20th Century experiments which should be announced through CMIP. There was an agreement on a set of diagnostics. Furthermore it was pointed out that since no single forcing is prescribed for these runs, a comprehensive documentation of the forcing is required for these runs (CMIP panel). **(J. Meehl, ICPO to JSC**)

Two sets of CMIP experiments are currently under way to better understand THC's response in AOGCM's: a) Sensitivity of the THC to heat and water flux forcing and b) so-called 'Water hosing' experiments. Contributions to both experiments should be submitted by end of the year. (**R. Stouffer to send a reminder**).

WGCM notes that it would be very useful if a set of indices were developed to document important modes of variability in the coupled system. Model results could then be prospected onto these indices. This would provide a simple, clean way of evaluating model performance.

The Working Group also discussed the general role of CMIP as an overarching Model Intercomparison Project (MIP) guiding and coordinating the activities of other MIP's. It was suggested to explore mechanisms to oversee the various MPI's. In view of the joint session with the IGBP GAIM group in the second part of the meeting, WGCM discussed its potential role in C4MIP. WGCM concluded to offer GAIM/C4MIP to coordinate this activity with CMIP, include. Handling of the data. (**to be discussed in the joint session).**

4.2 Intercomparison of cloud feedbacks in models / Idealized Experiments

In recent years, WGCM has undertaken an initiative entitled "idealized sensitivity experiments" involving intercomparisons of results from equilibrium doubled CO_2 experiments, in which the atmosphere was coupled to a slab ocean, thus not involving the complexity of the ocean response. This work has shown significant differences in inferred cloud forcings and changes in top-of-the atmosphere fluxes in different models (and had been drawn upon in the IPCC Third Assessment Report).

The scientific community had expressed considerable interest in continuing this study and various means for diagnosing feedbacks. At the previous session WGCM endorsed a proposal, put forward by Drs B. McAveney and H. LeTreut, for systematic intercomparison of cloud feedbacks in climate models in the approach to understanding climate feedbacks. Drs. B. McAvaney and H. LeTreut reported about the recent developments of this WGCM project. They recalled that WGCM proposed to a project on 'Idealized Experiments' with the following characteristics:

- Multi-phase
- Builds up from past
- Transition to slab ("mixed layer") ocean as the base model
- Include observational component
- Links to GEWEX Global Radiation Panel (GRP) and GEWEX Cloud System Study (GCSS)
- Different analyses promoted

It was presented to JSC XIII – March 2002 and was well received as a "pragmatic approach", complimentary to the GEWEX GRP. Some refinement of "slab ocean" q-flux requirement is needed– testing of impact underway in one model (BMRC)
A 3-day workshop on climate feedbacks will be held November 18-24, 2002 in Atlanta. Drs. H. LeTreut and K. Taylor are participating. About 30 participants are expected. The main foci will be on:
Analysis of multivariate nonlinear dynamical systems: climate

- Predictability
- Parametrisation
- Methods of model-data comparison

In addition, breakout groups will concentrate on

- How to evaluate new analysis methods?
- How to diagnose climate and climate model behaviour?
- How to compare models and observations?

The authors reported the proposal by Steve Klein

- It was developed independently of WGCM – (ISCCP simulator[1] – by Webb and Klein)
- It has some support in USA and UK
- +2/-2K experiments with ISCCP simulator added (determine which cloud types changed)
- Move toward "slab ocean"

The authors suggested that WGCM accepts and supports this proposal. A pilot study of use of ISCCP simulator should be initiated and a wider participation was encouraged. A letter of invitation for participation should be send out soon.
Further timelines are:

- ISCCP simulator – Klein – mid 2003
- +2/-2K – raw results (without simulator) – early 2003
- Slab ocean – late 2003 – pilot study mid 2003.

WGCM thanked the authors for their efforts and endorsed the proposed strategy. Dr. B. McAvaney was asked to send out the announcements within the next month. (**B. McAvaney**).

4.3 Forcing scenarios

They were no specific items reported. See also the discussion about future forcing scenarios under the progress report on IPCC (see section 1.6).

4.4 Initialization of coupled models

Dr. R. Stouffer introduced this item. The problem that all modelling groups performing model experiments from past (pre-industrial) conditions are facing, are the unknown initial conditions of the ocean. Since there are no adequate observational data available, most groups are using (present state) initial conditions, in particular that compiled by Levitus. At present the only alternative would be long coupled spin-up experiments which imply a very high demand in computer resources because of the lengthy time-scales involved.

It was questioned whether there is an appropriate body to address this problem in more detail. WGCM will keep this topic on the agenda, although no major breakthrough is expected for the near future.

4.5 Variability found in GCM's used in Climate Change Studies

Dr. R. Stouffer addressed the question of how well present coupled AOGCM's simulate natural modes of variability, such as ENSO, NAO, AAO, with special emphasis on the GFDL model results. Although, some modes of variability can in principle be reproduced, substantial differences amongst the models, and, compared to observations, in the spatial structure as well as in the frequency distribution, are still obvious.

4.6 Ocean model development

The progress report on the Ocean Model Intercomparison Project can be found in section1.3. In addition, Dr. David Webb gave a short introduction to the present capabilities of eddy-resolving ocean models. Amongst others he showed results from a 1/12º Ocean Model simulation of the meandering Gulf Stream and the tropical Pacific Ocean. In terms of heat transport and overturning in the North Atlantic, high resolution ocean-only models are in general closer to observational estimates than coupled models used in the IPCC assessment, although, especially, the heat transport and, for some models, the overturning are somewhat lower than observed values. The top-to-bottom temperature difference in these regions is in good in agreement to observations, in contrast to the coupled models that show often significant differences. Nevertheless, the computational requirements for such high-resolution ocean-only models are enormous. For instance a global 1/12º Ocean Model has 608 million grid cells, needs 60 Gbyte storage and 40 x 10^{15} floating point operations/model year and produces a 20 Gbyte data set every 3 model days. Thus, even with present capabilities, these models cannot be used for climate investigation where typically up to 32 runs, each of 200 years are needed.

[1] Software package to simulate ISCCP cloud products from GCM inputs

4.7 Detection and attribution of climate change

Dr. G. Hegerl summarized for WGCM the range of outstanding issues with respect to detection and attributes to climate change. She started with some results from a multi-signal detection technique also used for the IPCC TAR. The method generally considered the most rigorous and powerful for this purpose was the multiple regression technique, "optimal fingerprint detection" (as described in the IPCC WG1 Third Assessment Report, Ch. 12, section 12.4.3). The method required ideally ensembles of simulations of twentieth century climate with individual forcing agents to provide "fingerprints", and very long (multi-centennial or even millennial) control simulations to assess internal climate variability. Several groups have used this approach, with strong indications of anthropogenic influences on surface temperature being found: the results from different groups were consistent and inter-implementation differences small. The technique could also be employed to scale simulations of the twenty-first century to infer predictions or mean temperature change relative to twentieth century observations and to estimate key parameters such as climate sensitivity, ocean heat uptake and sulphate aerosol forcing.

Global-scale Temperature Detection

In the field of global scale temperature detection, some efforts have been made towards accounting for climate model uncertainty:

- Multimodel detection: see the contribution from Nathan Gillett below)
- Climateprediction.net. This effort, led by Dr. Myles Allen and others will try to get Monte Carlo simulations of climate change experiments a distributed PC-based system, everybody with sufficient resources can subscribe to. More details under http://www.climateprediction.rl.ac.uk/. The project is likely to get started by early 2003.

Other issues in this context are:
Forcing uncertainty:
There are a number of issues with respect to absorbing aerosols, black carbon, land use change, indirect aerosols.Thus the attribution of warming to greenhouse gas forcing is subject to uncertainty.

Longer timescales:
Use of paleo data is required but the different reconstructions of the past 1000 years show a large uncertainty in total level of natural variability; some more confidence can be found in the 19th century.

Observational record:
Example: MSU versus surface measurements:
Wentz and Schabel reprocessed MSU 2 data (according to the Spencer/Christy algorithm) and found differences in inter-satellite calibration. MSU2 shows more warming, consistent with ECHAM4/OPYC runs (Santer et al. 03). It is questionable whether MSU2 in the lower troposphere is reliably calculable according to Wentz and Schabel or whether the trend difference due to tropical processes not resolved in models.

Issues beyond detection of anthropogenic climate change in global scale temperatures:

- "Probabilistic" forecasts of future climate based on simulations of 20th century
- Changes in variables that are more relevant to decision making

Detection of temperature signals on "regional" scales
Some initial activities are under way (Allen; Zwiers / Zhang; Stott, in prep. (GHG detected in 20th century in N America, Asia, S America, Africa). Other activities are planned and coordinated through an International ad hoc Detection Group (chair: T. Crowley) and an NCAR initiative, by L. Mearns et al.

Other possible variables used for detection are:

- Precipitation (Allen and Ingram)
- Sea level pressure (see N. Gillet)
- Extremes (see below)
- Multi-variable Bayes (Schnur and Hasselmann)

Detection of changes in Extremes
An important issue are the scale differences between model and station data extreme indices. Would gridded data be a solution? Can seasonal mean data or monthly data be substituted for daily data?
Rare events should have smaller signal-to-noise ratio: how "extreme" is still detectable? Thus, indices scan transition from seasonal mean to once/yr events.

Dr. F. Zwiers elaborated further on the detection on regional scales. He described an experiment with the following specifications:
Area and method:
Six nested analysis domains were used:

- Global
  - Northern Hemisphere
    - Northern Hemisphere mid-latitudes (30N-70N)
      - NH land areas
        - Eurasia
        - North America

The data were averaged into a similar number of boxes in all domains which implies that increasing signal detail is obtained as domain size decreases. The dimension was further reduced by EOF analysis

Data
Observations

- Jones monthly mean temperature anomalies
- 20th century, for the globe, 5^{o}x5^{o} lat-long grid boxes
- Averaged (area weighted) into analysis domain boxes

Natural variability

- Last 600 years of CGCM1 control + 1000 year CGCM2 control
- Drift removed
- Divided into two 300+500 year control samples
- Averaged into analysis domain boxes, and masked

Signal

- Ensemble mean of 6 CGCM1/2 transient runs using historical 20th century greenhouse gas and sulphate aerosol forcing
- Averaged into boxes and masked.

The investigations have shown that there is now some tentative evidence that a greenhouse gas and aerosol (GS) signal may be detectable at the continental scale but there is only one , and a single run, at this stage. The multiple signal analysis poses both challenges and opportunities.

Dr. N. Gillet reported about detection of anthropogenic influence on temperature and SLP with a multi-model ensemble. Multimodel methods came in fashion during the past years, e.g. Lambert and Boer (2001) showed that a multi-model climatology matches observations better than that of individual models, Krishnamurti et al. (1999) demonstrated that a multi-model seasonal forecast has more skill. Is the same true for the response to anthropogenic forcing? A multi-model ensemble is used to detect greenhouse gas and sulphate aerosol influence in observations of surface temperature and sea level pressure following Allen et al. (2002), but taking the mean forced response and using concatenated control for signal-to-noise optimisation and hypothesis testing. The results show that multi-model detection provides a way to synthesize results from different models and reduces the uncertainties in a simultaneous detection of G and S in surface temperature. This is at least partly due to the larger ensemble sizes and longer control available. Modelled and observed SLP trends show a decrease over the Arctic, Antarctic and N. Pacific, and an increase over the subtropical N. Atlantic. The Greenhouse gas + sulphate aerosol response could be detected in sea level pressure but the SLP changes simulated in response to greenhouse gas + sulphate aerosol forcing are significantly smaller than those observed.

4.8 Palaeo-climatic modelling

Dr. P. Braconnot reported on the recent development in the area of paleo-climatic modelling, and in particular the Palaeoclimate Modelling Intercomparison Project (PMIP) (http://www-pcmdi.llnl.gov/pmip/). The PMIP panel met in Cambridge, UK, June 22-27, 2002 and defined research priorities for the next phase of the PMIP project.

Background:
PMIP is an international project involving members of all the major climate modelling groups worldwide and endorsed by the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP). The project was launched in 1994 with the dual aims of:

a. understanding the mechanisms of climate change by examining such changes in the past, when the external forcings were large and relatively well known and when various kinds of geological information

provide evidence of what actually happened;
b. providing a framework for the evaluation of climate models in order to determine how far they are able to reproduce climate states radically different from that of the present day.

In its initial phase, designed to test the atmospheric component of climate models (atmospheric general circulation models: AGCMs), the project focused on the last glacial maximum (LGM: ca 21,000 years before present, 21 ka BP) and the mid-Holocene (6000 years before present, 6 ka BP). The results of this study formed a crucial part of the evaluation of climate models in the Third Assessment Report of the Intergovernmental Panel on Climatic Change.

PMIP has not confined itself to analysing and evaluating the benchmark LGM and mid-Holocene experiments. Complementary experiments, examining the role of the ocean and of the land surface in past climate changes, were also carried out by several of the participating groups. Perhaps one of the most important conclusions emerging from the first phase of PMIP was the importance of including ocean and vegetation feedbacks in model simulations in order to simulate the regional patterns and magnitude of past climate changes correctly. Largely as a result of this realisation, PMIP created a working group to design protocols for palaeo-experiments using fully coupled models.

At the Cambridge Workshop it was decided that Phase II of PMIP will have five modelling foci:

1. Coupled ocean-atmosphere (OAGCM) and ocean-atmosphere-vegetation (OAVGCM) simulations of the response to mid-Holocene (6 ka BP) insolation changes (contact: Pascale Braconnot, LSCE, France). The 6 ka BP experiment, which will be started from year 200 of the control experiment, will be run for at least 500 years altogether in order to investigate changes in annual- to centennial-scale climate variability. In addition to the baseline 6ka experiment, the role of individual feedbacks will be diagnosed in a series of experiments in which the ocean, the vegetation, and both the ocean and vegetation, are sequentially turned off.
2. Coupled ocean-atmosphere (OAGCM) and ocean-atmosphere-vegetation (OAVGCM) simulations of the response to glacial conditions (contact: Chris Hewitt, Hadley Centre, UK). The 21 ka BP experiment, which will be started from year 200 of the control experiment, will be forced towards the glacial state and then run for a further 500 years at least in order to investigate changes in annual- to centennial- scale climate variability. The role of individual feedbacks will be diagnosed in a series of experiments in which the ocean, the vegetation, and both the ocean and vegetation, are sequentially turned off.
3. Early Holocene (10,000 calendar years BP, 10 ka) simulations of the climate response to insolation changes in combination with ice sheet changes (contact: Paul Valdes, Reading). This experiment will be run initially with an atmospheric model coupled to a simple mixed-layer ocean models in order to facilitate comparisons with the AGCM experiments used in the first phase of PMIP. The temporal focus was chosen in order to avoid the rapid changes occurring at the end of the deglaciation because equilibrium climate experiments (such as proposed here) are not well suited to study such intervals.
4. Early glacial (115,000 calendar years BP, 115ka) simulations designed to understand the processes underlying glacial inception (contact: Gilles Ramstein, LSCE, France). The details of the design of this experiment will be discussed further at a Workshop on Last Glacial Inception to be held in Potsdam from October 24- 25, 2002.
5. Prescribed freshwater fluxes experiment (contact: Ron Stouffer, GFDL, USA). This experiment will compare the response of coupled models to a prescribed amount and duration of freshwater input in the high latitudes (ca 50-70°N) of the Atlantic. The freshwater flux experiment is being run as a joint initiative of the Coupled Model Intercomparison Project (CMIP) and PMIP.

Dr. Braconnot reported specifically about the first focus of PMIP-II, the coupled simulations for 6ka BP. Using available coupled simulations for 6 ka BP the objectives were to document:

- the robust differences between OAGCM and AGCM simulations
- the role of the ocean response in the timing of the changes in the seasonal cycle, and more specifically the role of ocean dynamics in the mid-Holocene enhancement of the northern hemisphere monsoons (i.e. the Asian, African and North American monsoons)
- how the simulated climates compare with palaeoenvironmental data, focussing on regions such as northern Africa, Europe and the high northern latitudes where standard data-model comparisons have been developed and used for the evaluation of the basic PMIP simulations

Results from the coupled OAGCM simulations for 6ka show basically the same features as the basic PMIP AGCM simulations. However, the ocean causes a subtle shift in the timing of the response to insolation forcing. In the basic PMIP AGCM simulations, orbitally-induced warming starts in May and persists through

into August. In the coupled OAGCM simulations, the ocean remains relatively cold in the spring and orbitally-induced warming is not registered until July. However, warmer conditions persist longer into the autumn because the warmer ocean delays the onset of orbitally-induced winter cooling. These ocean-induced changes in the seasonal cycle of temperature have implications for the response of the African monsoon to mid-Holocene orbital forcing. Ocean feedbacks enhance the African monsoon
and cause a northward expansion of the monsoon precipitation belt compared to the basic PMIP simulations. The monsoon season is also lengthened in the coupled simulations.

Several groups investigate the changes in the interannual variability at 6ka. In particular some simulations show a decrease in the interannual variability of precipitations in the tropics, except in the normative part of the ITCZ. Comparisons between the IPSL_CM1 and NCAR CSM1.2 models show consistent increase in summer surface temperature variability over Eurasia, whereas these two models produce very different results over Europe. Analyses of changes in ENSO variability from the MRI model suggest a shift towards lower frequencies, which is also seen from simulations with the IPSL model.

New coupled simulations, considering not only the ocean and atmosphere system, but also a fully interactive land-surface model (with dynamic vegetation) are becoming available. Results with the HADCM3 model results confirm the validity of the asynchronous coupling technique of Braconnot et al (GRL, 1999). The vegetation feedback strengthens the response of summer monsoon system to the insolation forcing. It also contributes to warm the north-Atlantic ocean through changes in the land-sea transfer of heat. All these features need to be investigated further from several model simulations. This is planned in the second phase of PMIP and a new European project MOTIF (Model and Observation to test climate feedbacks).

Overall, the evaluation of the PMIP experiments is crucially dependent on the existence of spatially-explicit data sets which can be compared with output from the model simulations. Although the construction of palaeoenvironmental data sets for model evaluation began earlier, PMIP has played a key role in stimulating the continued development and improvement of such data sets and has been instrumental in the creation of new data sets (e.g.: the BIOME 6000 data set and the 21ka Tropical Terrestrial Data Synthesis). The need to evaluate new aspects of the climate system in coupled models - not only aspects of the simulation of the ocean or the land surface but also the simulation of climate variability on timescales ranging from years to centuries - means there is an urgent need for the creation of new, global palaeoenvironmental data sets. The PMIP data-model comparison committee (contact: Sandy Harrison, MPI-Biogeochemistry, Germany) plans to sponsor a series of workshops in the next few years to stimulate the creation of such data sets and to facilitate their use for model evaluation in the second phase of PMIP.

WGCM welcomed this new activity and encouraged PMIP to proceed and to further cooperate with groups within WCRP and IGBP, such as CMIP, PAGES/CLIVAR and GAIM, as appropriate.

4.9 Carbon-cycle modelling

Issue relevant to this topic were discussed in more detail during the joint session with GAIM. As stated previously, WGCM being the oversight body for global coupled modelling intercomparison studies of the physical climate system would suggest that GAIM jointly lead the "Coupled Carbon Cycle Climate Model" (C4MIP) intercomparison project.

5. OTHER ISSUES AND ACTIVITIES

5.1 Simulations of climate of the twentieth century (Atmosphere-only AMIP-type)

This activity led by C. Folland and J. Shukla has recently asked CLIVAR for official endorsement. Since there have been controversial views about this issue, this has not been decided yet.

Background
The Climate of the Twentieth Century (C20C) project was originally established by the Hadley Centre in the early 1990s. Then, as now, the main purpose was to run many atmospheric general circulation models (AGCMs) in ensemble mode against a common sea surface temperature (SST) and sea ice extent data set to study climate variability and predictability on time scales of a season to many decades. C20C differs from the Atmospheric Model Intercomparison Project (AMIP) in several ways. Firstly the length of the integrations is considerably greater. Some integrations are carried out since the late nineteenth century, with a core period from 1950 onwards which has better verifying data. The C20C project is more about predictability than is AMIP and includes decadal time scales, though aspects of model evaluation are included. One of the important goals of C20C is to determine the extent to which atmospheric models are able to simulate the observed climate variations during the 20^{th} century. Of particular importance is the potential ability of ensembles of AGCM runs to simulate specific historical events such as regional floods and droughts, the Dust Bowl in North America, the persistent drought in the Sahel and other extreme seasons. C20C is also concerned with simulating trends and so provides an interface with more formal climate change detection projects. Although use of AGCMs remains central to the project, coupled ocean-atmosphere general circulation models (CGCM)s now play an important role. They are used to explore the limitations of AGCM runs and to guide the design of AGCM climate variability analyses on longer time scales, e.g. for identifying possible thermohaline circulation-related climate variations.

For more details, see CLIVAR Exchanges, Vol. 7, No.2, June 2002.

Since this activity is performed mainly with atmosphere-only AMIP type runs, WGCM felt that this activity would be better placed under the scope of AMIP. Nevertheless, a coordination of the forcing with the ongoing CMIP activity on (coupled) C20C runs would be useful. (**J. Mitchell to report to H. Cattle**).

5.2 Data Management

WGCM to ask the JSC to set up and ad-hoc task team on data management with representatives of all WCRP projects to develop a comprehensive data management strategy for WCRP (**B. McAvaney and PCMDI to develop 'white paper' for JSC**).

5.3 Website for WGCM

At present, there are two sites with information about WGCM: Websites: http://www.clivar.org/organization/wgcm/ and http://www.wmo.ch/web/wcrp/wgcm.htm On the WCRP site only the Terms of References and the Membership are displayed. In addition to that CLIVAR provides access to the publications of the panel and information about the activities of the panel. WGCM asks to pursue the idea for a more comprehensive Website for the panel to be set up under WCRP. (**A. Villwock to contact JPS).**

5.4 Publicity

A number of contributions are planned to be submitted to the CLIVAR Newsletter Exchanges within the next year. (C20C CMIP (G. Meehl), Idealized exp. (B. McAvaney), THC/waterhosing (R. Stouffer).
In addition, an article about CMIP is planned in the GEWEX newsletter. (**A. Villwock to provide a contact for the GEWEX Newsletter to G. Meehl**)

6. MEMBERSHIP

By end of the year, two panel members, Drs. C. Boening and G. Hegerl, are reaching to the end of their terms. WGCM recommended that C. Boening in his function as the chair of the WGOMD should be an ex-officio member of WGCM, or send a representative to WGCM meetings, respectively. It was agreed to renew G. Hegerl's term. In addition, A. Weaver volunteered to rotate off next year. F. Zwiers was suggested as his successor. *(***J. Mitchell, ICPO to JSC/SSG***).*

7. ORGANIZATION OF FUTURE ACTIVITIES

WGCM thanked Dr. A. Noda for his kind invitation to host the next meeting of the working group. Nevertheless, the group preferred to hold its next years meeting September 24-26, 2003 in Hamburg in conjunction with the WGCM/GAIM International Conference on Earth System Modelling September 15-19, 2003 and the CMIP Workshop September 22-23, 2003. In 2004, the group will meet again jointly with GAIM in Japan.

8. CLOSURE OF THE SESSION

The participants expressed their thanks to the local organizer Dr. Francis Zwiers and his team, in particular to Mrs. D. Scott, for hosting this session, their excellent arrangements made, and the facilities and hospitality offered. The sixth session of WGCM was closed at 12.00 hours on 9 October 2002.

9. MINUTES OF THE JOINT GAIM - WGCM SESSION

Wednesday, 9 October

The meeting was opened on Wednesday 9th October at 1400 hours by John Mitchell, the chairman of WGCM and Wolfgang Cramer, on behalf of the chairman of GAIM, John Schellenhuber, who sent his apologizes for being unable to attend.

WGCM

John Mitchell welcomed GAIM to Victoria and described the general objectives of WGCM.
WGCM reports both to the JSC and CLIVAR. Its mission is to review and foster the development of coupled climate models, including organization of model intercomparison as a basis for model validation and diagnosis of shortcomings (e.g. the Coupled Model Intercomparison Project, CMIP). In general, models display a wide range of variability in results regarding predicted changes in temperature and precipitation. A goal is to reduce the uncertainties and differences between model results on the basis of better understanding of climate forcing and response. Critical feedbacks include clouds, ice/snow, and water vapour, in addition to basic black body radiation. Quantifying model uncertainty is an important activity for WGCM.

Some current WGCM activities encompass

- Coupled Model Intercomparison Project
  - CMIP1 - control simulations
  - CMIP2 - 1%/year CO_2 increase experiments
- Idealised sensitivity experiments
- Standard forcing scenarios SRES/historical/etc.
- Detection and attribution of climate change
- Decadal predictability
- Palaeo climatic modelling - PMIP (with PAGES)
- Ocean model development - WGOMD
- Carbon Cycle Modelling - GAIM
- Regional Climate modelling - WGNE
- Liason with IPCC

Websites: http://www.clivar.org/organization/wgcm/ and http://www.wmo.ch/web/wcrp/wgcm.htm

GAIM

Wolfgang Cramer described GAIM's development and goals to the group.
GAIM's role in Earth system science is to identify the links and operation of the Earth system. This began in an investigation of the carbon cycle, a unifying theme that bridges across systems within the Earth. GAIM has recently adjusted its focus to Earth system level issues, based on the achievements of the previous efforts within GAIM, IGBP, and the ESSP. This led to expansion of the scope of GAIM beyond biogeochemistry, into physical climate as well as human dimensions, thus giving new significance to links with WCRP and IHDP.

The Waikiki Principles are basic operating principles for GAIM. They include acting as a "topics scout," integrator of global change research, and facilitator of the development of a hierarchy of Earth system models.

GAIM activities are now based on the Waikiki Principles, based on Analysis, Integration, and Modelling. Analysis activities include development of the Hilbertian questions, conceptual exploration of total Earth system assessment, and multi-regional hot spot analysis. Integrative activities include the Earth System Atlas, development of a post-doc network, TRACES, and the Land-atmosphere interaction initiative. Modelling activities include the Earth system model spectrum initiative, dynamical large-scale marine biosphere model development (Green Ocean), C4MIP, and model-data intercomparison activities.

Hilbertian Questions

The Hilbertian questions were developed as a catalogue of exciting questions that would stimulate others to work on critical unifying issues in Earth system analysis. They involve both horizontal and vertical integration across the Earth system. They are grouped according as Analytical, Operational, Normative, and Strategic questions. Colin Prentice raised a question regarding the uniqueness of the "normative questions", which do not have specific answers obtainable from analysis of the natural world, but that depend on human decision making and preferences.

Dork Sahagian explained the differences between the four types of questions. The "analytical questions" are the scientific question for which we must find answers within the scientific community (mostly of ESSP). The "operational questions" address the development of techniques and perspectives for answering the analytical questions. The "normative questions" pertain to the issues of values and what we want in the future as a global society, and the "strategic questions" address the means toward the end of obtaining what we want based on the normative questions.

John Mitchell queried the group as to the logical sequence for delving into the research that would answer the questions. Wolfgang Cramer responded that it depends on each question individually. David Webb asked what activities GAIM is conducing at present to address the questions. Wolfgang Cramer responded that there is not a one-to-one correspondence between the questions and specific research projects, but rather, that a suite of present, planned and future activities should address the suite of questions in various combinations or as a whole.

GAIM is currently planning to write a book about these fundamental questions where every question is addressed through an essay-style contribution written by a group of authors. GAIM invited WGCM to take part of this endeavour by taking the lead for some of the questions, in particular those addressing problems related to the physical climate system.

Spectrum of Earth System Models

Martin Claussen defined and described EMICs as a part of the full spectrum of Earth system models. Earth system models must include the physical side of the system as well as the biological and human components. At the simplest level, "conceptual models" in the Earth system are pictorial of graphical, rather than defined on the basis of analytical formulation. At the other extreme, comprehensive models include details of complexity of processes and resolution, but at typically less integrated than conceptual models. EMICS occupy the middle ground, in an attempt to capture all of the critical system-level process, while remaining computationally simple enough to run over long model times on existing computers. As a community activity, there will be a workshop in Potsdam on 24-25 October 2002 to apply EMICs to the case of the last glacial inception. M. Claussen also presented the various Earth system modelling-related session of he joint AGU-EGS-EUG conference in Nice, scheduled for April 2003.

UVic EMIC

Andrew Weaver presented the UVic EMIC. Rotated coordinates allow focus on high latitudes. The model has the following characteristics:

- Oceanic component: MOM-type GCM (3.6° (zonal) ´1.8° (meridional) resolution; 19 vertical levels);
- Atmospheric Component: A dynamic energy-moisture balance model (snow model, water vapour feedback, precipitation parametrization);
- Sea ice Component (Dynamics using elastic-viscous-plastic rheology, multi level thermodynamics);
- Continental Ice Dynamics Model (Marshall and Clarke, 1997);
- Inorganic carbon Cycle component (Closely follows the protocol set up by the Ocean Carbon-Cycle Model Intercomparison Project (OCMIP))
- Land surface component (two versions):
    1. Simple bucket Model (Manabe, 1969)
    2. Leaky bucket version of Hadley Centre MOSES scheme (Cox et al., 1999)
- Terrestrial Dynamic Vegetation Component (based on Hadley Centre TRIFFID dynamic global vegetation model (Cox et al. 2000, 2001)

Coupling:

- Exchange of latent, sensible and radiative heat fluxes
- Exchange of water at the air/sea, air/land or air/sea ice interface
- Brine rejection/ice melt and heat exchange at the sea/sea ice interface which includes a parametrisation for local convection due to brine rejection under multi-category sea ice
- Wind feedback

The model accurately reproduces the Antarctic and Greenland ice sheets, while not producing spurious ice sheets in the Himalayas, etc. The model uses the Triffid model for the vegetation component. A dynamic energy moisture balance model is used for the climate component. Various components (e.g. vegetation models) can be swapped out to conduct sensitivity studies. As such, the utility of this may be as a tool for modellers, more than a model for realistic predictions. Depending on the chosen range of parameters, it is possible to get the "right" answer for any desired level of model complexity. Rick Leemans queried Andrew Weaver about the meaning of socio-economics in the model. A. Weaver replied that new modules are being developed so that socio-economic paths will be specified in order to determine emissions and land use, rather than specifying emissions and land use directly.

Charge to the group

Before adjourning for the day, Dork Sahagian presented a "homework assignment" for the group to dwell on activities that could be enhanced by collaboration and coordination between WGCM and GAIM, as well as any new activities that may be enabled by such collaboration.

Thursday, 10 October

Earth System Atlas

Wolfgang Cramer described the Earth System Atlas. The overarching goal is to publicize as broadly as possible the results of global change research. Specific objectives are to establish a single source of information that has undergone peer review, to present the research results in an easily understandable form, provide updates, enable superposing of various data sets, link maps and time series with original data, and identify conceptual and data gaps that will need to be filled by the scientific community through the development of new research projects. Data sources will include both ground based and remotely sensed data.

Wolfgang Cramer stressed the importance of the peer review aspect of the atlas. A mechanism will need to be established for peer review- necessarily more complex than peer review of journal papers, but equally important. Buy-in by the various components of the global change research community is necessary from the outset. GAIM is not attempting to set an agenda for other programmes with regard to data dissemination and atlas format, but rather, is striving to solicit input in the form of suggestions regarding atlas scope, content, format, etc.

Peter Rayner suggested that the difficult part of "buy in" would be from the scientists who gather and work with the data. We can only offer money, prestige, or some form of central command. The first and third are unlikely, but the second has potential, so that scientists seek out the atlas and seek to have their data included, as would be the case of publishing in a prestigious journal.

Natalie suggested convening a meeting to solicit input from educators, policy makers, and the like to ensure that the atlas will provide the tools they need with regard to global change and the Earth system. Bob Costanza suggested broadening the intent from strictly an "atlas" to a general "knowledge base".

Claus Boening asked how the atlas would cope with different interpretations of data that could be illustrated on a map. The ‘optimal’ choice of a data set or data products can be very challenging because either different products of comparable quality exist (e.g. SST) or products exist that differ considerably and no community-wide accepted data set is available (e.g. Solar forcing). Thus, the selection of any product might be subjective and difficult. Wolfgang Cramer responded that the interpretation would be explained. Colin Prentice added that this is the core of the atlas effort and is the reason why the atlas is necessary. Dork Sahagian summarized that there are two aspects of this central issue. The first is with regard to the choice of data sets. This will have to be justified in terms of the specific application, and why one was chosen over another, with all relevant data sets mentioned, and the choice explained. The other aspect is the interpretive path taken for the raw data to the final map image. This will need to be explained in detail with the quality one could expect in a peer reviewed journal article. These two are the core of the value that can be added by the atlas.

C4MIP (http://www.atmos.berkeley.edu/c4mip/)

Pierre Friedlingstein presented the latest status of C4MIP. The long-term goal is to compare and analyse feedbacks between the carbon cycle and climate, and to evaluate the sensitivity of the coupled carbon-climate system to anthropogenic perturbations. The project focuses on CO_2 emissions and concentration and

the response of the Earth System to CO_2 forcing, given a fixed scenario for future emissions (e.g. Rayner and Law, 1995). This "experiment" uses an increase in atmospheric CO_2 concentration of 1%/yr. While this may be a modest increase relative to "business as usual" scenarios, it provides a useful baseline for this initial development and application of full complexity models. C4MIP introduces terrestrial and oceanic carbon cycle modules into coupled atmosphere-ocean-land climate models, with CO_2 as a prognostic variable, to investigate the co-evolution of climate and CO_2 given emission scenarios. The excitement lies in the identification and investigation of interactions in a climate space beyond known experience.

In a pilot phase, results from the Hadley Centre model and the IPSL coupled climate CO_2 OAGCM have been compared. GCM sensitivity to CO_2 concentration differs between the IPSL and Hadley models. Also, Hadley has more land carbon uptake than IPSL as a result of climate change, but the situation is reversed in the ocean. While land response to increased CO_2 is comparable, ocean uptake is much more for IPSL than Hadley. Swapping land and ocean between the two models revealed that the land component drives the difference between the models. The first phase of C4MIP focuses on historical land-atmosphere forcing. Six groups are involved already. A workshop to present initial model results is planned for summer, 2003.

The phase one experiments are important for organization and internal development of the project. However, phase two is of the greatest interest to IPCC and others. Scheduling to coordinate with PCMDI's handling of the CMIP data would be beneficial, so some collaborative planning with the CMIP C20C activity will be helpful.

CMIP (http://www-pcmdi.llnl.gov/cmip/)

Jerry Meehl described the CMIP project. CMIP was initiated in 1995 and has been one of the most important and long-standing initiatives of WGCM. Its mission is to coupled ocean, atmosphere, land surface, and sea ice models.

The first phase of CMIP (CMIP1) was an intercomparison of the simulations of present climate from the control runs of coupled models, and includes specifically:

- a systematic documentation of errors in the control simulations of global coupled climate models (atmospheric, oceanic and cryospheric components);
- quantifying to the extent possible the effects of flux adjustment on simulations of mean climate and climate variability;
- documentation of simulated features of climate variability on a variety of time and space scales.

There are now three components: CMIP1 to collect and document features of global coupled model simulations of present-day climate (control-runs); CMIP2 to document features of control runs and climate sensitivity experiments with CO_2 increasing at 1% per year; and CMIP2+, like CMIP2, but with many extra fields and data, monthly means, and some daily data collected in order to enable in-depth study of many additional aspects of coupled model simulations (e.g. feedback mechanisms, ocean processes, why different models had different responses, higher frequency phenomena).

In addition, a pilot experiment to investigate 20th century simulations in coupled climate models is under way.

A workshop evaluating the CMIP2+ results and planning for a new phase of CMIP is scheduled for Sept. 22 – 24, 2003 in Hamburg back to back with the WGCM/GAIM Conference on Earth System Modelling and the next meeting of WGCM.

PMIP (http://www-pcmdi.llnl.gov/pmip/)

Pascale Bracconot described the Palaeoclimate Modelling Intercomparison Project (PMIP), whose goals are to explore the mechanisms of climate change, sensitivity of model parameterizations, and evaluation of climate models. The project was launched in 1994 with the dual aims of:

a. understanding the mechanisms of climate change by examining such changes in the past, when the external forcings were large and relatively well known and when various kinds of geological evidence provide evidence of what actually happened;
b. providing a framework for the evaluation of climate models in order to determine how far they are able to reproduce climate states radically different from that of the present day.

Paleo time slices include LGM (21K), and Holocene optimum (6K). One focus in PMIP is developing methodologies to compare models and paleodata. The BIOME6000 activity has been a participant in this.

PMIP phase II involves coupled O-A-(Vegetation) models on shorter time scales (pre-industrial) for a control case with application to 21K and 6K. For groups without interactive vegetation, there is the possibility of asynchronous OAV simulations. A common archive includes mean seasonal cycle, monthly values, daily values, preprocess diagnostics for models/data, and data to force other models such as biome, ice sheet, carbon, ocean, etc. For the last glacial inception, PMIP will link with EMICs, and participate in the upcoming workshop at PIK. Recommendations that have emerged: reconstruction at sites (not gridded); bioclimate variables; examining uncertainties; linking data to models.

Martin Claussen suggested that PMIP base a sensitivity experiment to determine the driving force of D-O events (e.g. high latitude vs. tropics).

Ron Stouffer described some of the specific PMIP experiments. The first was the role of surface fluxes in weakening of the THC. The second was the response of THC to fresh water fluxes (water hosing experiment). The recover to THC after water hose shut off was rapid, but the variability was different than the unperturbed case. The reason for this is uncertain.

TransCom (http://transcom.colostate.edu/)

Kevin Gurney summarized the TransCom project, the objective of which is to quantify and diagnose the uncertainty in inversion calculations of the global carbon budget that result from errors in simulated atmospheric transport, the choice of measured atmospheric carbon dioxide data used, and the inversion methodology employed. The experiment has involved three phases. The most recent, TransCom3, was directed to determine source and sinks of CO_2 by model intercomparison and inversions. The focus of TransCom Phase 3 was an Atmospheric Carbon Budget Inversion Intercomparison experiment which was conducted through a series of experiments in which 16 chemical tracer transport models from around the world were used to calculate the global carbon budget of the atmosphere.
The specific scientific objectives were:
- To quantify the contribution of simulated tracer transport, inversion methodology, and choice of data to the overall uncertainty associated with regional source/sink estimates produced by inversion calculations
- Identify the mechanisms responsible for the inversion differences
- Recommend and prioritize improvements to models and the existing carbon observing system for better constrained inversions

Main Conclusions from Transcom 3:
The experiment was structured such that the forward simulations across all the participating models would begin with the level 1 simulations and sequentially finish with Level 3. Though analysis continues on the recently received seasonal and interannual aspects of the experiment, a number of conclusions can be drawn from the annual mean and preliminary seasonal inversion results.
- The annual mean/model mean estimated flux finds a northern hemisphere land carbon sink evenly distributed across longitude.
- For the annual mean inversion, the uncertainty resulting from different modelled transport is roughly equivalent to that due to the “data uncertainty”. In particular, estimated fluxes in all regions will likely benefit from more observations in the tropical regions.
- All the models consistently agree on a lessened Southern Ocean carbon uptake in the annual mean relative to fluxes based on ΔpCO_2 measurements.
- The model mean/annual mean flux estimates are relatively insensitive to details of the inversion set-up such as the prior flux estimates and prior flux uncertainties.
- The model mean/annual mean flux estimates are relatively insensitive to data uncertainty choices though certain observational stations can have an influence on particular regions.
- Individual model results for the annual mean inversion show sensitivity to the transport of the pre-subtracted tracers. This is particularly true for the regionally aggregated results. When examined at the full regional resolution, generalization about response to background tracers is harder to come by. In some cases, results are idiosyncratic and result from sensitivities to particular stations.
- The model mean seasonal inversion flux estimates for the northern hemisphere land show less emission outside the growing season and more uptake during the growing season when compared to the neutral biospheric prior flux. This feature appears in all the regions at full resolution except for Boreal North America.
- The ability of the individual models to capture the maximum peak to peak concentration at the observational stations used in the seasonal control inversion tends to scale with the strength of the seasonal rectifier. Those models with stronger rectification tend to capture this seasonality better than those with weak rectification.

OCMIP (http://www.ipsl.jussieu.fr/OCMIP/)

Jim Orr described the Ocean Carbon Intercomparison Project (OCMIP). OCMIP was initiated by GAIM in 1995 as a means to develop international collaboration to jointly improve the predictive capacity and accelerate development of global-scale, three-dimensional, ocean carbon-cycle models through standardized model evaluation and model intercomparison. The first phase included circulation and biology as individual modellers saw fit. In the second phase, with fully funded projects with dedicated post-docs, much more coherent results were obtained. Benchmarks were defined, analysis tools were developed, and in general, constraints were defined regarding ocean carbon uptake and the global carbon cycle. Simulation tracers used CFCs, natural and bomb C-14, and He-4. Zonal means show that the model are not capturing the data very faithfully, mostly because of the variations in the southern ocean, and high northern latitudes. In part, this may be because the data may not be representative in these regions. The models show agreement in ocean uptake of anthropogenic CO_2. They also bracket observed CFCs and natural C-14.

Ongoing and Planned Activities
Support from EC and U.S. funding agencies for OCMIP-2 ended in 2001. Nevertheless, work continues to exploit the model output archive generated through this community effort. A group of OCMIP-2 papers will be submitted as special section to *Global Biogeochemical Cycles*.
Ongoing work includes three new funded activities that together form OCMIP-3. These include

- **NOCES** (Northern Ocean Carbon Exchange Study), an EC project led by J. Orr at LSCE-IPSL (France)

The project has three objectives:
i) to assess interannual-decadal variability of air-sea CO_2 flux (ocean model-data comparison),
ii) to evaluate prognostic coupled carbon-climate models (with respect to interannual variability), and
iii) to improve constraints on the terrestrial carbon sink (ocean model sea-air CO_2 fluxes as a priori estimates for inverse atmospheric models). NOCES will be the first ocean model intercomparison to focus on interannual to decadal variability (1 regional and 5 global ocean models). It will also be the first to simulate decadal variability (NCEP 1950-present) and associated mechanisms, and finally, it will include an inverse atmospheric modelling component.

- **Constraining the air-sea exchange of natural and anthropogenic CO_2 by inverse modelling**, a NASA project led by N. Gruber (UCLA, USA)

The project builds on a recently developed Green's function method that uses interior ocean observations of dissolved inorganic carbon together with models in order to determine the air-sea exchange of anthropogenic and pre-industrial carbon (Gloor et al., 2002). This recently funded project has three objectives: (i) to assess and quantify the robustness and uncertainties of this ocean inverse method by using Green's functions from five U.S. OGCMs (NCAR, LLNL, MIT, Princeton and ECCO) and two international OGCMs (LSCE: France, CSIRO, Australia), (ii) to continue the development of the inversion method by incorporating additional observations, such as surface ocean pCO_2, wind speed, and atmospheric CO_2 as constraints, and (iii) to improve the understanding of the mechanisms controlling the air-sea CO_2 fluxes by testing and optimising gas exchange parameterizations.

- **AutoMOD** (Automated Model Ocean Diagnostic Facility), a NASA and DOE project led by K. Caldeira at (LLNL, USA)

The project will provide a community service by developing an Automated Model Diagnostic facility for ocean model output. The goal is to provide the community with an automated overview of model performance free of charge through an easy-to-use interface. This will in turn allow scientists to spend less time on routine analysis and more time on reflecting how to improve models. Models will be compared to datasets such as those used during OCMIP-2 and to NASA's satellite data products. This automated analysis system will evolve to incorporate new standards in model-model and model-data comparison. In cooperation with NOCES, an early emphasis of AutoMOD will be automating evaluation of modelled seasonal, interannual, and decadal variability.

Green Ocean (http://www.bgc-jena.mpg.de/bgc_prentice/projects/green_ocean/index.html)

Colin Prentice described the "Green Ocean" effort to develop a biogeochemical model of the marine ecosystem. This project brings together physical, chemical, biological and paleo-oceanographers with a common interest in modelling and its applications to Earth system problems, to develop a new, more comprehensive model of the oceanic compartment of the Earth system; with a view to improving our understanding of the functioning of the global ocean in the past, present and future. The biological pump is critical to the discussion because it can drastically alter the air-sea CO_2 flux. There are distinct phytoplankton functional types, explicit treatment of light-nutrient interactions, use of physiological data, and the use of a wide range of evaluation procedures. The objective is to understand the feedbacks from marine

bioprocesses of the physical climate system. This will hopefully result in the ability to do forward projections in the marine carbon cycle, and understand glacial-interglacial CO_2 changes. Ultimately it would be good to be able to incorporate this sort to model into Earth system models on the one hand, and fisheries models on the other. Benchmark data sets include SeaWIFS biweekly composites, global patterns of HPLC pigment-depth distributions, global data set of in situ measurement of photosynthesis-light parameters, time series of abundances of functional groups, a world ocean atlas for 3D fields of nutrients, 3D sediment trap data, proxies for export production, coccolithophorid primary productivity, isotopic composition of benthic forams, and atmospheric potential oxygen.

Integrated Assessment Models (IAM)

Rik Leemans described IAMs such as the Image model. The range of current Integrated Assessment Models covers a wide range from simple to very comprehensive models. IAMs include population, economics, land cover, energy demand, emissions, biogeochemical cycles, and physical climate parameters. The objectives including developing a joint knowledge infrastructure and fundamental advance in integration of sciences of sustainability. Topics include the balance between adaptation and mitigation, decarbonization of the economy, sustainable land use, vulnerability, and socio-economic development objectives. A number of different modelling approaches are necessary. Testing of the simplified IAMs must be evaluated with respect to full-form models such as those in the X-MIPs. In addition, stakeholder dialog is needed to engage the policy community. There are several tasks that will need to be part of the next generation of IAMs (e.g. linkages, agricultural economy, extreme events, biodiversity, human behavior, etc.). IAMs are distinct from EMICs on the basis of time frames of interest- IAMs start in 1990 and look forward 100 years or so, while EMICs are applied to much longer time scales.

GUMBO

Bob Costanza described ecosphere-anthrophosphere interactions and how they can be modelled, using a Stella model (GUMBO) as an example. GUMBO is a Global Unified Metamodel of the Biosphere to simulate the integrated earth system and assess the dynamics and values of ecosystem services. It is a ‘metamodel’ in that it represents a synthesis and a simplification of several existing dynamic global models in both the natural and social sciences at an intermediate level of complexity. The current version of the model contains 234 state variables, 930 variables total, and 1715 parameters. GUMBO is the first global model to include the dynamic feedbacks among human technology, economic production and welfare, and ecosystem goods and services within the dynamic earth system. GUMBO includes modules to simulate carbon, water, and nutrient fluxes through the *Atmosphere*, *Lithosphere*, *Hydrosphere*, and *Biosphere* of the global system. Social and economic dynamics are simulated within the *Anthroposphere*. GUMBO links these five spheres across eleven biomes, which together encompass the entire surface of the planet.

Traditional economic models allow perfect replaceability between natural resources, industrial productivity, etc. Also, the value of direct ecosystem goods and services (that directly or indirectly support human welfare) are not traditionally included. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16-54 trillion per year, with an average of US$33 trillion per year. Proper treatment must take these and other factors into account. Four scenarios (Star Trek, Mad Max, Big Government, Ecotopia) are defined based on the relationship between assumptions regarding future conditions, and environmental and economic policies implemented.

Climate Change Metrics

Richard Betts proposed alternative measures of climate change, beyond greenhouse gas forcing. For instance, land use can affect regional climate in ways that are independent of greenhouse gases. Consequently the question becomes "What is the appropriate metric of climate change?" Some options may include climate variables, ecosystem variables, impacts variables, all of the above global means, some measure of regional means.

Upcoming meetings of interest

- Earth System Modelling Conference, Hamburg, 15-19 Sept., 2003
- EMIC Workshop, Potsdam, Germany, Oct. 2002
- Traces Fire Workshop, Ilse sur la Sorgue, France, Oct 22-25, 2002
- AGU-EGS-EUG in Nice April 2003

Joint GAIM/WGCM activities and collaboration

1- X-MIPs- The group agreed that information should be shared between MIPs.

As a starting point, each MIP should list and link to other MIPs on their web sites.
Action item: Each MIP web site will list and link to the other MIPs

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Action item: Each MIP will send Jerry Meehl a short summary of the MIP and a key reference or two. Dork Sahagian will coordinate with Jerry Meehl.

2. Atlas- WGCM is well versed in data management through its PCMDI activities, and could contribute significantly to the atlas effort.

Action item: WGCM will discuss potential involvement in the atlas effort. Wolfgang Cramer and Dork Sahagian will be in touch with WGCM to assess possibilities.

3. Future Meetings- In order to foster the cooperation, both groups agreed that future joint meetings should be considered. One possibility is a two-year schedule, in which GAIM meets with WGCM and some part of IHDP in alternating years. The next joint opportunity for WGCM and GAIM is fall 2004 in Japan.

APPENDIX

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WGCM agenda 7 –10 October 2002

Monday, October 7th

9.00 **Welcome** (*F. Zwiers, J. Mitchell, A. Villwock*)
Opening arrangements (*J. Mitchell, A. Villwock*)

9.20 **Review of WCRP events, developments**
22nd session of JSC- (*B. McAvaney, A. Villwock*)
9.35 **CLIVAR SSG and ICPO** (*F. Zwiers, A. Villwock*)
9:45 **Other modelling activities**
WGOMD (*C. Böning*)
WGSIP (*A. Villwock)*
AMIP (*K. Taylor*)

10.30 **Coffee**

11.00 **Other WCRP programmes and developments**
ACSYS/Clic (*G. Flato*)
IPCC (*J. Mitchell and others*)
4th Assessment - update-
Sensitivity workshop: planning status
What WGCM needs to have in place?
TGCIA (*J. Mitchell*)- Preferred runs incl. stabilization
Daily data
Black carbon (October meeting)
Regional modelling (*J. Mitchell*)
Workshop
Intercomparison Project

12.30-13.45 **Lunch**

13.45 **News from relevant national and multinational projects**
PRISM (*J. Mitchell*),
Projects using the Earth Simulator (*A. Noda*)
PCMDI's periodic model assessment (*C. Covey, K. Taylor, L. Gates*)

15.00 **Coffee**

15.15 **Contributions from modelling groups**
BMRC (*B. McAvaney*)
CCCma (F. Zwiers)
CSIRO (*T. Hirst*)
NCAR (G. Meehl)
GFDL (R. Stouffer)
MRI (A. Noda)
LMD (H. LeTreut)
Hadley Centre (J. Michell)

Tuesday, October 11th

9.00 **WGCM activities**
(i) CMIP (*G. Meehl*)-
(ii) Idealised experiments (*B. McAvaney*)
(ii) Initialization of models (*R. Stouffer*)
(iii) Variability in Coupled GCM's (*R. Stouffer*)

10.30 **Coffee**

(iv) Ocean modelling (*D. Webb*)
(v) Detection (*G. Hegerl, F. Zwiers*)
(vi) Data Formats (B. McAvaney)

12.30 **Lunch**

14.00 **WGCM activities (continued)**
(vii) Paleo (*P. Braconnot*)
(viii) Long-term climate integrations
- C20C simulations (fixed SST; *J. Mitchell*)
- US DOE (*C. Covey*)
- Forcing diagnostics (*J. Mitchell, G. Meehl*)
- Other diagnostics (*G. Hegerl*)

Wednesday, October 12th

9.00 **GCM activities (continued)**
(ix) Multi model detection (*N. Gillett* (local)) Presentation given on Wednesday

11.00 **GAIM – issues for discussion in joint meeting**
Longer term relationship between GAIM, WGCM

Other business:
WGCM representatives on other committees (JSC? CLIVAR? GAIM? GEWEX)
Next session
WGCM membership

12.30 **Lunch**

14:00 **Joint Session with GAIM** (separate agenda)

AGENDA
2002 Joint GAIM-WGCM meeting
Victoria, Canada

Weds. PM, Oct 9 (joint)

Welcome and outline of joint GAIM, WGCM interests (Wolfgang Cramer, John Mitchell)
Hilbertian Programme (Cramer)
Earth System Modelling of Appropriate Complexity (Martin Claussen, Andrew Weaver)

Thurs. AM, Oct 10 (joint)

Earth System Atlas/Geoscope (Wolfgang Cramer)
C4MIP (Peter Rayner, Pierre Friedlingstein)
CMIP (Gerald Meehl)
PMIP (Pascale Braconnot)
Integral Assessments, e.g. LBA (Richard Betts)

Thurs. PM, Oct 10 (joint)

TRANSCOM
OCMIP
Green Ocean Model (Colin Prentice)
Modular-Distributed Approach to Integrated Modelling and Assessment (Wolfgang Cramer)
GUMBO (Bob Constanza)
Joint GAIM-WGCM-MPIM Event in 2003* (Mitchell, Schellnhuber, Brasseur)
GAIM-WGCM Co-operation. (Wolfgang Cramer, John Mitchell)

Fri. Oct 11 (GAIM alone)