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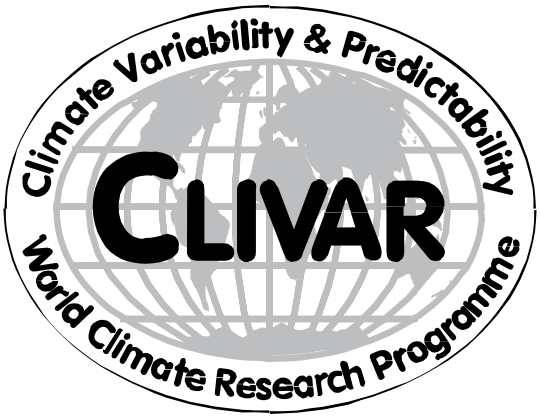
INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME



JSC/CLIVAR Working Group on Coupled Modelling

Report of the 7th Session

24-26 September 2003, Hamburg, Germany

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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.

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1. WGOMD

WGCM endorsed the proposed changes in WGOMD membership *(A. Villwock to communicate to H. Cattle)*

2. GMPP proposal

WGCM endorsed the GMPP proposal *(B. McAvaney to communicate to GMPP)*

3. GAIM/C4MIP

Communicate a summary of the C4MIP Workshop and the next GAIM session to WGCM *(V. Satyan and J. Mitchell)*

4. CMIP

4.1 G. Meehl to communicate to modelling groups (coordinate with IPCC WGI TSU):

a. WGCM recommendations for community runs (adding A2)
b. Radiative forcing recommendation
c. CMIP3 announcement
d. Plan for scenario model data collection at PCMDI and analyses in subprojects
e. Forcing data for 20th and 21st century at PCMDI

4.2 G. Hegerl will contact IADG regarding 20th century common forcing

4.3 Contact decadal variability community regarding availability of CMIP ocean data *(T. Delworth)*

5. Decadal Variability

Increased analysis of variability in CMIP experiments, particularly with increased oceanic data is encouraged.
Experiments focused on predictability are encouraged.
The coordination of such predictability experiments at a future time should be considered if appropriate.

6. Detection

The submission of 20th century run to 20C3M was recommended.
Ensembles simulations were recommended.

7. Data Management

A statement of the importance of this problem should be stated by WCRP (*J. Mitchell to communicate to JSC*).

8. Membership

Communicate the suggested changes in membership to JSC and CLIVAR SSG; follow-up with the CLIVAR *co-chair issue. (J. Mitchell, A. Villwock to JSC/SSG)*

9. Next Meeting

Suggested dates were 25-29 October 2004, or 11-15 October in Tokyo, Japan *(J. Mitchell to negotiate dates with GAIM and to communicate back to WGCM).*

The seventh session of the JSC/CLIVAR Working Group on Coupled Modelling (WGCM) was kindly hosted by the Max-Planck-Institute for Meteorology in Hamburg, from 24-26 September 2003. 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 M. Latif (IfM, Kiel, formerly at MPIfM, Hamburg) (local host), Dr V. Satyan (JPS, WCRP) 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-fourth session of the Joint Scientific Committee (JSC) for the WCRP (March 2003), and the 12th session of the CLIVAR Scientific Steering Group (May 2003). 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), the AMIP Panel and the modelling activities within ACSYS/CliC were provided.

1.1 Twenty-Fourth session of the JSC

Dr P. Lemke, chairman of the JSC, started his report with an overview on the World Climate Research Programme (WCRP). He emphasised that the two main objectives of WCRP are to determine the predictability of climate and to determine the effect of human activities on climate. Within the past two decades the major projects of WCRP have successfully shown the value of international coordinated research efforts, as for instance in the build-up of the ENSO observing system and progress in seasonal prediction during TOGA or our recent advances in the understanding of ocean dynamics and processes through global ocean observations carried out during WOCE. Nevertheless, future challenges in climate research remain, such as:

- Acceleration of the hydrological cycle due to global warming
- Modelling of clouds, radiation, precipitation processes
- Sea level rise due to glacier/ice sheet melt
- Abrupt climate change due to regime change in the cryosphere
- Mechanisms of natural climate variations
- Predictions: models and observations present/past
- Effects of atmospheric composition on climate
- Anthropogenic impacts
- Inclusion of biosphere in climate models
- Effect of bio-geo-chemical cycles on climate

In order to address these questions, a number of prerequisites are required which partly already exist such as:

- earth system models (physics, bio-geo-chemistry)
- improved modelling infrastructure
- operational climate prediction centres
- operational climate observing systems
- integrated assessment for management, policy and development

The new strategy within WCRP will be an overarching and integrating activity with the main focus on the prediction of entire climate (i.e. Earth) system. In order to accomplish this new goal of WCRP, the JSC decided to develop the concept of a long-term Climate system Observational and Prediction Experiment (COPE) as a focus to which all the WCRP projects could aim towards and report progress against. The nature of COPE is still to be fully thrashed out but it will, in particular look to observational and modelling studies in support of:

(i) Description of the structure and variability of the global climate system (atmosphere, ocean, land and cryosphere) for a 40-year period (1979-2020) and to model and understand the mechanisms and coupled processes responsible for observed climate variability and change.

(ii) Determining the extent to which regional climate is predictable by making retrospective forecasts of weekly-seasonal-interannual-decadal variations for a 30-year period (1979-2009), and real time forecasts for a 10-year period (2010-2020).

(iii) Understanding the mechanisms that determine anthropogenic regional climate change and variability and its prediction.

Recognizing the importance of seasonal prediction as a specific objective under COPE, the JSC has recommend that a limited term Task Force on Seasonal Prediction (TFSP) be established. This task force will draw on expertise in all WCRP core projects (i.e. CLIVAR, GEWEX, CliC and SPARC), WGNE, and WGCM, and will report to the JSC in March 2004. The overarching goal of the TFSP is to determine the extent to which seasonal prediction is possible and useful in all regions of the globe with currently available models and data.

In order to provide direct and immediate support and input to the TFSP, the International CLIVAR Project Office (ICPO) and the CLIVAR Scientific Steering Group (SSG) have asked the Working Group on Seasonal-to-Interannual Prediction (WGSIP) to organise a seasonal prediction Workshop drawing on expertise across all the relevant WCRP activities. This Workshop which will be held week of 3 November 2003 in Honolulu, USA, and the emerging TFSP are the first necessary steps in helping COPE and the WCRP meet these objectives.

The overarching objectives of COPE include designing a comprehensive set of WCRP wide coordinated prediction and predictability experiments with ocean-land-atmosphere models that will ultimately lead to seamless weekly-seasonal-interannual-decadal forecasts.

In support of the new WCRP strategy, the JSC decided to create a modelling council, chaired by the JSC member J. Shukla and bringing together all chairs of the WCRP modelling panels. A similar panel is planned to be established for observations and data management.

Finally, Dr Lemke introduced the concept of the "Earth System Science-Partnership" (ESS-P) to the group. He emphasised the emerging collaboration between IGBP, IHDP, WCRP and DIVERSITAS.
More information will become available through the ESS-P website (http://www.ess-p.org).

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

Dr A. Villwock, scientific officer in the International CLIVAR Project Office, summarized briefly the action items and developments relevant to WGCM from the 12th session of the CLIVAR SSG (May 2003, Victoria, Canada).

- The CLIVAR SSG encouraged the Working Group on Seasonal-to-Interannual Prediction (WGSIP) to pursue a Workshop with WGNE and WGCM on ensemble methods, building on results from APCN Symposium on Multi-Model Ensemble for Climate Prediction which is scheduled for October 2003. WGCM should be involved in the planning and implementation of the Workshop. This WGSIP/WGNE/WGCM Workshop on Ensemble Methods is now planned for autumn 2004 at the Met Office, UK.
- Planning for another Workshop on regional modelling should be coordinated with WGSIP and WGNE and further collaboration with START and IPCC should be explored.
- The SSG endorsed WGCM's proposal to integrate C4MIP as part of CMIP.

Other news from the SSG meeting were:

- The setting of a sunset date for CLIVAR which should be 2013.
- The reconstitution of the PAGES/CLIVAR Working Group - new co-chairs have been appointed: A. Weaver (U. Victoria, Canada) and E. Jansen (U. Bergen, Norway).
- A CLIVAR Global Synthesis and Observations Panel (GSOP) is under development. This panel will address in particular ocean reanalysis and synthesis.
- The formation of an Indian Ocean Panel in cooperation with IOC/GOOS was endorsed.

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

- CLIVAR Conference 2004: The meeting will be held in Baltimore, USA, June 21-25, 2004. The second circular in press (http://www.clivar2004.org/). The meeting will be organised in 8 sessions with invited papers and extensive poster sessions. All contributing papers will be in form of posters. The major deadlines are as follows:

    - Dec 15 deadline for abstract submission
    - Dec 15 deadline for application for financial assistance
    - Feb 16, 2004 Poster acceptance communicated to presenters
    - Feb 23, 2004 Notifications regarding financial assistance

  The ICPO in cooperation with the CLIVAR panels will develop a number of flyers and a short brochure. Envisaged published material from the conference: will be a special issue in Journal of Climate, an Abstract volume and PPT - Presentations in electronic form.
- A number of Workshops are being planned for 2004: Atlantic Predictability (Reading, April), Developments in Ocean Models used for Climate Studies (Princeton, June), Variability of the Atlantic THC (Kiel, September), VACS (TBD). In addition, plans for a Data Management Workshop are under development.
- Ms K. Hill has joined the ICPO staff at the end of last year. Her responsibilities lie mainly within the CLIVAR Pacific panel, CLIVAR data management and relationship to carbon programmes.

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

The WGOMD was established in 2000 as a joint working group under WOCE (now replaced by CLIVAR) and WGCM, 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". The membership is comprised of scientists working in both oceanographic and climate centres or departments.

To disseminate and publicize information on the status of ocean models used in climate research, WGOMD provides a Web directory of ocean modelling resources [1] and has published a major review paper [2] in the refereed literature. Activities of the group since WGCM-6 included:

(1) WGOMD-4, Villefranche-sur-Mer, April 13-15, 2003

The 4th session of WGOMD was held back-to-back with the EGS/AGU conference. Part of the session was held jointly with the CLIVAR Atlantic Implementation Panel.
Main themes were:

- review of the pilot study for an Ocean Model Intercomparison Project (P-OMIP): Forcing protocol, diagnostic sub-projects, timeline
- parameterization of ocean mixing: Interaction with US Climate Process Teams (CPTs); guests: P. Schopf, W. Large
- planning for an international Ocean Climate Workshop

(2) P-OMIP

The 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, pool resources (forcing and verification data sets, pre- and post-processing software, archival facilities) across modelling groups, contribute to a shared understanding and broader dissemination of model developments and model results.

The P-OMIP protocol specifies an ERA-15 based forcing data set developed for coupled ocean-ice model integrations. Because some groups had difficulties to strictly comply with all protocol details, the group agreed that modest modifications should be allowed but have to be well documented.

Currently there are 6 contributors: LANL/U. Miami with MICOM/HYCOM (C grid, 16 layers), GFDL/IARC with MOM4 (B grid, 50 levels), CCSR (B grid, 40 levels), MRI (B grid, 48 levels), LODYC with OPA (C grid, 31 levels) and MPI with OM1 (C grid). The effort is coordinated by Anne-Marie Treguier at IFREMER, Brest.

The first experiments already indicated a number of robust behaviours (both positive and negative) and suggest that an OMIP of this type should be feasible and have merit. Main challenges faced by most of the groups include: Lack of funding, and the costs of doing runs especially for this intercomparison (and not for addressing scientific questions). Before a full blown OMIP could commence, resources to support the coordination and infrastructure need to be identified.

Preliminary results from the pilot phase were presented (by F. Bryan, NCAR) at the ACSYS/CliC NEG meeting in 2002, and opportunities were discussed for participation and collaboration in diagnostic "subprojects" focused on the polar regions.

(3) Interaction with CLIVAR basin panels

The CLIVAR-SSG requested WGOMD to cooperate closely with the CLIVAR ocean basin panels, and to investigate the response of ocean models to forcing variations on interannual to decadal time scales

(3.1) Atlantic Implementation Panel

Links with this panel were intensified with a joint session of the two groups in Villefranche, April 15. Main themes were: Ocean data reanalysis and assimilation activities (guest: D. Stammer); definition of data sets for testing models, particularly with respect to the Atlantic thermohaline circulation and its variability (D. Wright); development of model experiments to explore THC responses and sensitivities (T. Delworth, leading a subgroup formed by the Atlantic panel).

The joint session endorsed plans to hold a CLIVAR Workshop on North Atlantic Thermohaline Circulation Variability: This Workshop with high relevance to both groups will take place in Kiel, Germany, September 13-16, 2004. More information is available under [3].

(3.2) Pacific Implementation Panel

WGOMD panel member Hiroyasu Hasumi attended the Pacific Panel Implementation meeting on July 14-16, 2003. The group suggested including a number of diagnostics (equatorial thermocline structure, eastern boundary upwelling) in the OMIP. Because of their interest in the low frequency variability in the Pacific, they expressed strong interest in extending the current phase of OMIP by a phase with variable atmospheric forcing.

(4) Ocean Climate Model Workshop: Princeton, June 16-18, 2004

During the latter part of 2003, major climate modelling centres will be freezing their coupled models used to address IPCC 2007 questions. Additionally, US CLIVAR has announced the formation of two Climate Process Teams (CPTs) starting October 2003. One CPT is focusing on gravity current entrainment and the other on interactions between meso-scale eddies and the mixed layer. Their goal is, within 2-3 years, to enhance the physical integrity and robustness of the IPCC-class of global ocean models. WGOMD hence considers 2004 to be an opportune time to organize a scientific Workshop to evaluate the ocean component for climate studies.

In revision of the original plan (already endorsed by CLIVAR SSG) to hold the meeting at CSIRO Marine Labs, Hobart, Australia, March 9-11, 2004, the WGOMD now proposes: The meeting will be held at GFDL, Princeton, June 16-18, 2004 (i.e., the week prior to the CLIVAR Conference in Baltimore); the scientific organization is led by Dr S. Griffies from GFDL.

The goal for this Workshop is to bring together leading ocean scientists who focus on issues related to global climate as well as high resolution models, process physics, and large-scale observations and to foster a candid and critical evaluation of the state-of-the-art in the ocean models used in the IPCC class of climate models, and to discuss strategies for improving the physical integrity of these models.

A particular challenge is how coupled ocean-ice model simulations can be systematically compared addressing questions like: Can the community coalesce around a protocol, and associated dataset, for running the models, such as within the context of an Ocean Model Intercomparison Project (OMIP)? How valuable will an OMIP be for evaluating the ocean and sea ice components of coupled climate models? Does OMIP provide a useful venue for comparing model sensitivities to parameterizations arising from the CPTs?

In preparation for the Workshop, various groups expressed interest in performing analysis of OMIP output, aiming at the representation of these key processes and phenomena in comparison to observed behaviours and insight from process studies. A preliminary announcement can be found under: http://www.clivar.org/recent/wgomd_wksp.htm

(5) Membership issues

Present members are:

C. Böning (Chair)	IfM Kiel, Germany
F. Bryan	NCAR, Boulder, USA
E. Chassignet	SMAS, Miami, USA
R. Gerdes	AWI, Bremerhaven, Germany
S. Griffies	GFDL, Princeton, USA
H. Hasumi	CCSR, Tokyo, Japan
A. Hirst	CSIRO, Aspendale, Australia
A.-M. Treguier	IFREMER, Brest, France
D. Webb	SOC, Southampton, UK

The WG proposes to start rotation of members in the following way: Rotate off 2003: D. Webb and R. Gerdes. For 2004 it is proposed to extend the WG by one additional member: The candidates, already endorsed by CLIVAR SSG are: H. Drange (Bergen, Norway), R. Wood (Hadley, UK), and R. Greatbatch (Dalhousie, Canada).

[1] http://www.clivar.org/organization/wgomd/index.html
[2] Griffies, S. et al. (2000) Developments in ocean climate modeling. Ocean Modelling, 2, 123-192.
[3] http://www.ifm.uni-kiel.de/allgemein/news/nawshp_04htm

WGCM thanked Dr Böning for his report and endorsed the proposed changes in membership (*Action item*).

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

Dr K. Puri gave an overview about the developments within WGNE. Traditionally, WGNE has close relationships to the modelling activities of GEWEX[1] which are coordinated through the GEWEX Modelling and Prediction Panel. Relevant activities are:

a) GEWEX Cloud System Study (GCSS) focussing on cloud/radiation parameterisation with working groups on:

- Boundary layer clouds (WG1)
- Cirrus clouds (WG2)
- Extra-tropical layer clouds (WG3)
- Precipitating convectively-driven clouds (WG4)
- Polar clouds (WG5)

b) Global Land-Atmosphere System Study (GLASS)

- Land-surface parameterisation schemes
- Global Soil Wetness Project

c) GEWEX Atmospheric Boundary Layer Study (GABLS)

Comparison of atmospheric model simulation
A number of studies are performed to intercompare atmospheric model simulations, such as

1. General climate model intercomparisons

- *Atmospheric Model Intercomparison Project (AMIP)*
  Dr P. Gleckler gave a summary of the second AMIP Workshop which was held November 12-15, 2002 in Toulouse, France. The main focus was on innovative diagnostics, less on intercomparison, and to increase the connections with observational communities, e.g., GEWEX. The model diagnostic sessions were broken into:

[1] More detailed information about GEWEX can be found under item 1.6

- General Circulation
- Tropical Variability and Monsoons
- Fluxes and Cloud-Radiative effects
- The Hydrological Cycle
- Land Surface Processes
- Extra-Tropical Variability

Several discussion forums were devoted to refining the experiment and prioritizing future activities. Some general impressions from the Workshop were:

- Despite limitations, the idealized AMIP SST experiment is still a powerful diagnostic test
- A "mean AMIP model" generally outperforms any individual model and is a useful reference
- Diagnostic Subproject analysis has become an increasingly useful exercise
- There was encouraging synergism with GEWEX modelling projects
- There was strong support by Workshop attendees to see AMIP continue in some form

Evolving priorities for AMIP:

- Comprehensive diagnostic report to be available to modelers soon after they submit a simulation to PCMDI
- AMIP should be exploited as a diagnostic of the coupled system. The WGNE and WGCM should work together to integrate atmospheric and coupled projects such as AMIP and CMIP
- Process studies should become an increasing diagnostic focus, a natural fit for a WGNE - GMPP collaboration

WGNE will continue to strongly support the continuation of AMIP as an experimental protocol providing an independent evaluation of atmospheric models and facilitating increasingly diagnostic research.

- *International Climate of the Twentieth Century Project*
  Given that AMIP and C20C have a number of common features, WGNE expressed the view that both projects would gain through closer collaboration.
  For example:
  - C20C could follow AMIP in establishing a tighter experimental protocol
  - AMIP should consider using the HadlSST for any future phases

- *Transpose AMIP/CAPT*
  The basic idea of 'Transpose AMIP' -
  - Apply climate models to forecasts
  - Examine how well the models predict the detailed evolution of the atmosphere at the spatial scales resolved by these models
  - Comparison with analyses/reanalyses and with data from field campaigns should give insight into errors in parameterisations and lead to improved formulations

  The key aspect is the initialisation of the models
  - The mapping of the atmospheric state variables is straight forward
  - The mapping of parameterised variable that have time history (e.g. Cloud water) is less obvious, but might not be critical

  Initialisation aspects
  Land model variables are more problematic because it is difficult to map:
  - the discrete/discontinuous land variables between different grids
  - there may be different dominant land types in the two systems
  - there is no uniform definition of land model state variables

  One approach currently being tried to obtain initial land model state is
  - Spin up the land, and possibly atmospheric parametrised variables over a period of time by having them interact with the atmospheric model constrained to follow the analyses in time by –
    - Updating the atmospheric state
    - Adding a term to the model to force the state to follow the analyses to some degree (nudging)

Current status

- WGNE is duly developing a project along these lines
- Although a number of questions need to be resolved, the work to date is promising
- Appropriate contacts will be taken with potential participants in discussing how to proceed
- Advantage will be taken of the experience in GLASS which has faced similar problems in the initialisation of land surface and soil variables

2. Standard climate model diagnostics
   - *Extension to include climate variability in models*

3. Comparison of dynamical cores of atmospheric GCMs
   - *Aqua-planet experiments as an AGCM test-bed*
     - The dynamical core experiments reported at WGNE sessions have proven a useful comparison tool for atmospheric model representation of the adiabatic, frictionless equations.
     - For testing parameterisation of individual physical processes, the single column model is invaluable.
     - However the next step is usually the full GCM - what appears to be missing is a test-bed for the interaction of physics parameterisations with each other and with the dynamics.
     - WGNE has recognised that aqua-planet experiments could have wide application in testing numerics and parameterisations and has endorsed the proposal for an *'aqua-planet intercomparison project'*
     - The intercomparison will be led by the University of Reading together with NCAR and PCMDI
     - An experimental design and data to be collected has been developed and a list of diagnostics to be computed and compared have been prepared

4. Model-derived estimates of ocean-atmosphere fluxes and precipitation
   - *WGNE SURface Flux Analysis (SURFA)*

5. Model treatment of snow and ice-fields
   - *Snow Models Intercomparison Project (SNOWMIP)*

6. Model stratospheric intercomparisons
   - *Comparison of deterministic predictions of stratospheric activity*
   - *SPARC-GRIPS activity*

7. Modelling large-scale atmospheric transports

8. Regional climate modelling

   In the RCM discussions, further concerns were expressed by WGNE members such as:

   - Possible problems at boundaries due to the different response of the land surface model
   - Ability of RCMs to simulate the variability of extreme events
   - It was agreed that members would communicate their concerns in writing to the Chairman of the RCM panel.
   - Following satisfactory resolution of these concerns, the RCM Report will be finalised and submitted for publication in a general journal such as BAMS

   Plans for the RCM Workshop

   A number of options for a joint WGNE/WGCM sponsored Workshop have been considered:

   - Holding a special session at an already scheduled RCM-related meeting
   - The favoured alternative currently being considered is for a joint WGNE/WGCM/IPCC RCM Workshop (~April 2004)

9. Other climate-related modelling initiatives
   - *Frontier Research Programme for Global Change*
   - *Accelerated Climate Prediction Initiative (ACPI)*
   - *Weather Research and Forecast (WRF) modelling system*

10. Review of model systematic errors

Data assimilation and analysis
Dr Puri summarized the status of the three major reanalysis projects, namely:

1. **ECMWF, ERA-40** has been completed - A number of assessments indicate that ERA-40 is superior to ERA-15 in many respects. ERA data will be:
   - Available to all Member States via direct access
   - Condensed onto CD with limited levels and parameters
   - Available nationally via specific data Centres such as NCAR, MPI, BADC, IPSL
   - Available to non-Member States via ECMWF (handling charges)
   - Available in small subsets on the ERA-40 website

2. **NCEP/NCAR, Regional Reanalysis** (1979-2004)
   - The original NCEP/NCAR reanalysis from 1948 is continuing to be carried forward to the present in a quasi-operational manner. The reanalyses distributed through NCAR, CDC and NCDC are readily available either electronically or on CD-ROM
   - The current initiative is the preparation of a *regional reanalysis (RR)* over the USA for the period 1979-2004
   - The production of the RR is now in progress
   - It is planned to complete most of the production by end-August 2003

3. **Japanese Reanalysis Project JRA-25** (1979-2004)
   - This is a five-year joint project of JMA and the Central Research Institute of Electric Power Industry (CRIEPI)
   - The objective is to provide a comprehensive data set for the period 1979-2004
   - T106L40 global model and 3DVAR will be used
   - The first announcement for the evaluation group was made in October 2002

Reanalysis: Issues for WCRP:
- WGNE members reiterated that the JSC/WCRP needs to seriously consider making reanalysis an ongoing effort
- The current situation is unsatisfactory and wasteful
- Expertise built up for a reanalysis phase is lost when the phase is completed, and the has to be reassembled
- An ongoing exercise would also facilitate research that is relevant to WCRP projects

Thus, a key question is whether *Reanalysis should be a project under the new 'banner'?*

Short- and medium-range prediction
- The CAS World Weather Research Programme (WWRP)
- Performance of the main global operational forecasting models
  Status of models used in numerical weather prediction was shown. Improvements in skill (500 hPa height) were highlighted.
- Intercomparison of typhoon track forecasts
  A WGNE Intercomparison of Tropical Cyclone Track Forecasts 2001 has been performed.
- Verification and comparison of precipitation forecasts

Ensemble Prediction
Ensemble prediction has become an established part of operational global weather (and seasonal) prediction at a number of Centres (CMC, ECMWF, JMA, NCEP, UKMO)

- Till recently the practical application of ensemble prediction systems has been restricted to the extra-tropics
- However recent developments have allowed their application to the tropics
- There is also a move towards the application of EPS to severe weather events
- Multi-Model Multi-Analysis "Poor Man's" Ensemble Project has been started by the Met Office
- Given the significant application of Ensemble Prediction in NWP, seasonal forecasts and climate studies a joint WGNE/WGCM/WGSIP
- *Workshop on Ensemble Techniques* will be held at the Met Office, Exeter in October 2004. The Workshop will concentrate on scientific aspects rather than operational applications of ensemble Prediction

THORPEX – A global atmospheric research programme

- THORPEX is an international research programme designed to accelerate improvements in the accuracy of 1 to 14-day weather forecasts for the benefit of society and the economy
- The programme builds upon ongoing advances within basic research and operational forecasting communities
- *The international co-ordination for THORPEX will be under the auspices of the CAS World Weather Research Program (WWRP) and WGNE*

Core research objectives:

- Contribute to the design and demonstration of interactive forecast systems that allow information to flow interactively between forecast users, numerical forecast models, data assimilation systems and observations
- Advance the knowledge of global-to-regional influences on the initiation, evolution, and predictability of high-impact weather
- Collaborate with numerical forecast centres in the development of advanced data assimilation and forecast model systems
- Develop and apply new methods to enhance the utility of improved weather forecasts
- Perform THORPEX Observing-Systems tests (TOSTs) and THORPEX Regional field Campaigns (TReCs)
- Demonstrate the full potential of THORPEX research results for improving high-impact weather on time scales out to two weeks. This demonstration includes the THORPEX Global Prediction Campaign (TGPC)

WGNE co-sponsored meetings

- Joint WGNE/WGCM/IPCC *Workshop on Regional Climate Modelling* (~April 2004)
- Joint WGNE/WGCM/WGSIP *Workshop on Ensemble Techniques* (October 2004)
- Joint WGNE/WWRP *Data Assimilation Symposium* (2005)

1.5 ACSYS/CliC Numerical Experimentation Group

Dr A. Villwock summarized some main highlights of this WCRP programme. The Arctic Climate System Study (ACSYS) started in 1993 with and will formerly end in November 2003 with a major scientific conference held in St. Petersburg, Russia. Whereas ACSYS has focused on the Arctic region only, the new Climate and Cryosphere Project (CliC) approved in 2001 will continue the ACSYS activities, but expands its scope to include the global Cryosphere.

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 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

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 is tentatively scheduled for 2004.

1.6 GEWEX

Dr B. McAvaney gave a short overview about recent developments in GEWEX. The main objectives of the **GEWEX Phase II** are to:

- Produce consistent descriptions of the Earth's energy budget and water cycle and their variability and trends, and data sets for the validation of models
- Enhance the understanding of how energy and water cycle processes contribute to climate feedbacks
- Develop improved parameterisations encapsulating these processes and feed-backs for atmospheric circulation models
- Interact with the wider WCRP community in determining the predictability of energy and water cycles
- Interact with the water resource and applications communities to ensure the usefulness of GEWEX results.

GEWEX SSG directions for Phase II

- Greater focus on global and combined analyses of WEBS (Water and Energy Cycle Budget Estimations) to satisfy the first objective
- Increase focus on precipitation while continuing acquisition of:
  1) long-term global & 2) local process data sets
- Improve connections between large scale forcing and cloud microphysics, aerosols, and precipitation
- Redefine objectives of GHP WRAP (Water Resources Applications Project) to provide more proactive interactions with the hydrology community (e.g., joint project with IAHS – PUB)
- Develop a more structured “road map” for achieving each objective

Principal scientific questions are:

- Is the cycling of water through the atmosphere accelerating as a result of climate change?
- To what extent are variations in local weather, precipitation, and water resources responses to global climate change (rather than random intrinsic variability)? How precisely can precipitation be predicted on scales of interest for hydrologic applications?
- How can the cumulative outcome of wet atmospheric processes be accurately taken into account (parameterized) in weather forecasting and climate models? What is their effect on the climate variability at the various time scales?

Highlights of the GRP (GEWEX Radiative Panel) Plans

- The review of GCM radiative transfer code features and metrics for testing clouds and radiation in GCMs will be completed.
- An effort to define and apply a "standard" set of statistical and diagnostic analyses to all of the GEWEX global data products (and possibly a few others) will resume. The purpose of this exercise is to characterize the variability of all the measured quantities in one common way as a prelude to a joint analysis. This activity was delayed until after the Climate Feedback Workshop.

- More development of feedback analysis methods is needed and the best way to do this is in joint data-model teaMs The GRP will work with WGCM to formulate a plan of action.

The goal of the **GEWEX Modelling and Prediction Panel (GMPP)** under the joint oversight of GEWEX and WGNE is to develop and validate models used to represent the water and energy exchanges in the atmosphere and on continents. The topics covered are:

- GCSS: GEWEX Cloud System Study
- GLASS: Global Land/Atmosphere System Study
- GABLS: GEWEX Atmospheric Boundary Layer Study

There is no closed theory of these processes at the macroscopical scale, although they are well understood at the microscopic scale. As a consequence GMPP has had to learn to deal with conceptual models. These models are often called parameterizations!

GMPP activities in 2003:

- GCSS: Aims to study a tropical convection case with a focus on the diurnal cycle. The details are still under discussion
- GLASS:
  - Global off-line evaluation (GSWP-2)
  - Compare the intensity of surface/atmosphere coupling in coupled models (GLACÉ)
  - Continue the point/off-line evaluation (PILPS)
- GABLS: A simple arctic case will be studied with LESs and PBL parameterizations. A Workshop will be held in September 2003.

WCRP Satellite Working Group

It was set up as an informal WCRP Working Group in May 2002 with the main objective to identify gaps in existing or planned space systems and possible weaknesses in data management. A report was presented at WMO consultative meeting on high-level policy on satellite matters in Feb. 2003, at GEWEX SSG and JSC.

Data Management Priorities

- Good calibration of individual sensors and cross-calibration of similar sensors to allow global integration of observations
- Continuous validation of products
- Access to full calibration and validation documentation
- WCRP to generate guidelines for archiving and retrospective re-processing with state-of-the art algorithms and updated calibration data

Proposed follow-on activities

- Develop a joint strategy with space agencies for global climate products
- Extend WG consultation with other space agencies and wider research community
- Produce a consolidated report for end of year through Workshop proposed for October 2003

In the following the action items from the last GEWEX SSG were presented.

Finally, Dr McAvaney reported about a Workshop on Climate System Feedbacks which was held 18-20 November 2002, in Atlanta, Georgia, USA organized by the GEWEX Radiation Panel and the JSC/CLIVAR Working Group on Coupled Models. The goals of the meeting were to discuss:

- Advanced analysis methods for complex, nonlinear dynamical systems; and
- Better applications of the concept of feedbacks for understanding, evaluating and improving climate models.

The desired outcome of the meeting was suggestions for new lines of research to develop better analysis approaches to be applied to both climate observations and climate model outputs and assessments of possible metrics for evaluating climate model feedbacks and sensitivities.

A number of aspects of model sensitivity testing were discussed and some specific suggestions for the design of such activities were made and incorporated into the WGCM plan for a "cloud feedback" experiment. Also, several aspects of model-data comparisons were discussed, leading to a specific decision to employ the "International Satellite Cloud Climatology Project (ISCCP) simulator" (http://gcss-dime.nasa.gov/simulator.html), which converts model cloud output into a form that allows for direct comparison of the space-time distributions of cloud top pressure and optical thicknesses as seen by satellites in the ISCCP data set, in the WGCM cloud feedback exercise.

Nevertheless, the basic questions of how to make progress on quantifying climate feedbacks and verifying models of them remained unanswered.

A tentative conclusion was that the whole feedback approach may not be viable, when applied to such a complicated system as the climate, but that a focus on a more general diagnosis of the dynamic relationships among variables in the system, using methods capable of handling non-linear, multi-variate relationships, would be useful.

Another conclusion was that, whatever advanced analysis techniques were to be developed, they would have to determine quantities from models that can also be determined from observations.

Although not well defined, the next steps would seem to include the formulation of a small set of analysis tasks that all of the proposed analysis methods could be applied to, using the same data sets and the outputs from a hierarchy of climate models of varying complexity. The purpose would be to compare and evaluate the results obtained by the different analysis methods to learn what aspects of the dynamical system they are describing and to examine how the results depend on the complexity of the system being considered. Also, this comparison of different diagnostics when applied to different kinds of climate models could help determine what information about the model's feedback processes can be extracted in practice.

The participants agreed to continue discussions towards more definite plans for such coordinated studies, possibly leading to another Workshop in about 18 months.

1.6.1 GMPP Proposal - A Diurnal Theme

Dr B. McAvaney presented the following proposal made by the GEWEX Modelling and Prediction Panel (GMPP) and asked WGCM for endorsement. Why diurnal:

- Very prominent cycle in water and energy exchanges within climate system
- Inadequate attention to date.

Background reasons:

1. AMIP
   - Annual Cycle reasonable
   - Diurnal needs improvement
2. AOGCMS
   - Systematic errors in diurnal cycle related to water and energy cycle
3. Observations
   - Many contain diurnal cycle
4. Regional - Impacts

Proposed Implementation:

- Off-line intercomparisons
  GCSS, GLASS and GABLS
  - Identify problem areas
  - Explore limits of off-line
- AMIP
  Identify geographic regions, seasons and weather regimes with deficiencies in diurnal cycle
  Extra diagnostics for AMIP
  Additional runs
- Limited coupled environment
  Progressively introduce feedback

Possible AMIP Extension

- Viterbo et al (1999) technique
  Gentle relaxation towards analysed fields above PBL (removes dynamical feedbacks on errors in diurnal cycle)
- Dynamical compositing

WGCM connection

- Excellent link to GEWEX Process Community
- MJO
- Improved information for impacts
- WGCM Contribution?
  Diurnal variation in clouds – feedback?
  Diurnal cycle and MJO?
  Change in diurnal amplitude?

WGCM thanked Dr McAvaney for his comprehensive presentation and endorsed the GMPP proposal.

1.7 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 following community runs for AR4 have been approved by TGCIA, mid 2003:

1. 20th century simulation to year 2000, then fix all concentrations at year 2000 values and run to 2100 (CO_2 ~ 360ppm)
2. 21st century simulation with SRES A1B to 2100, then fix all concentrations at year 2100 values to 2200 (CO_2 ~ 720ppm)
3. 21st century simulation with SRES B1 to 2100, then fix all concentrations at year 2100 values to 2200 (CO_2 ~ 550ppm)

For a more detailed discussion on issues related to IPCC, see section on CMIP.

1.8 Regional Modelling

WGCM was briefed about the organisation of the joint WGNE/WGCM/ international Workshop, aiming at promoting better knowledge of the potential and limitations of RCM. The Workshop entitled “High-resolution climate modelling: Assessment, added value and applications” will be held in Lund, March 29 - April 2, 2004 (https://dvsun2.gkss.de/domino/html/Lund.nsf). The event is held jointly with a meeting of the PRUDENCE WG1 and 2. The focus of the Workshop is on comparing the merits and limitations of various approaches to climate modelling at regional scale, including limited-area nested models, variable-resolution or stretched-grid global models, and uniform high-resolution global models. Contributions are invited on topics such as the role of resolution beyond physiographic details, and on the best strategy to achieve progress in regional-scale climate modelling. While the focus of the Workshop will be on climate time scales, some contributions on non-climate applications will also be considered, e.g. Numerical Weather Prediction (NWP), Seasonal to Inter-seasonal Prediction (SIP), and intermediate time scales (e.g. PIRCS). The organising committee is composed of the following members: René Laprise (UQÀM; Chair), Lars Barring (Lund U.), Filippo Giorgi (ICTP; Lead co-author on Chap. 10 of IPCC TAR), Jens Hesselbjerg Christensen (DMI; Coordinator of PRUDENCE project), Richard Jones (the Met Office), Ben Kirtman (COLA; Member of WGSIP), Harry Lankreijer (Lund U.), Anders Lindroth (Lund U.), Markku Rummukainen (SMHI), Hans von Storch (GKSS), Werner Wergen (DWD; former member of WGNE).

2. NEWS FROM RELEVANT NATIONAL AND MULTINATIONAL PROJECTS

2.1 PRISM (Programme for Integrated earth System Modelling)

Dr R. Budich provided a status report on the European PRISM project.

The goal of PRISM (**PR**ogramme for **I**ntegrated earth **S**ystem **M**odelling) is to develop a 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.

The present status of the software development (Sept. 2003) is as follows:

- System Specification ready, handbook is available
- levels of PRISM compliance are envisaged:
    1. Technical compliance to OASIS. Code changes required
    2. System compliance (architecture of directories, compiling and running environment): Changes of environment & 1.
    3. Standard physical interface compliance ("Physical model"): Changes of model & 1., 2.
- Coupler:
    - OASIS 3 available
    - OASIS 4 will be available after project, including 3D coupling
- Interface Library
    - PSMILe prototypes available
- Standard environment available
- Interface definitions available
- First Models start to be available in PRISM compliant form are:
  ECHAM5, MPI-OM, Arpège, ORCA/OPA, LIM, MOM, Mozart, TM3, Pisces, HamOCC, others to follow
- Demo Run Definition is expected for end Nov 2004. The demonstration experiments have two stages:
  1) Technical demonstration (funded) under specific configurations such as:
    - Different Atmosphere/ocean configurations under the complete system
    - One combination with all options
    - A regional configuration

  Run for a limited amount of model time < 1 yr
  2) Scientific demonstrations (non-funded) which will use the configurations from above and perform longer runs, climatologies, scenarios, etc.

After the end of the PRISM project the software; i.e. coupler, interface libraries, SCE, visualization- and analysis-tools will be available under an Open Source License for Earth System research purposes. The PRISM System (PRISM software, Component Models, Graphical User Interface, etc will be available under the respective licenses of the components for Earth System research purposes at no cost within Europe.

PRISM is part of the **E**uropean **N**etwork for **E**arth **S**ystem Modelling, http://www.enes.org/. The ENES community encompasses 50 Partners around Europe: Academia, research labs, industry … The ENES objectives are:

- to help in the development and evaluation of state-of-the-art climate and Earth System models
- to facilitate focused model inter - comparisons in order to assess and improve these models
- to encourage exchanges of software and model results
- to help in the development of high performance computing facilities dedicated to long high-resolution multi-model ensemble integrations

EU-Projects under the ENES:

- Program for integrated Earth System Modelling PRISM (SW infrastructure) (funded)
- CLIMSTER (data) (not funded)
- ECCF (hardware) (pending)
- **ENSEMBLES (science) (funded, to start in 2004)**
- CAPRI (PRISM follow on) (not funded)

Present PRISM collaborations are: NCAR, GFDL, PCMDI (US), Frontier (J) and Earth Simulator (J) and BoM (Aus) (in preparation). More co-operations are envisaged. For more information see http://prism.enes.org/.

2.2 Earth Simulator

Dr A. Noda gave an overview about the climate research project currently running on the Earth Simulator and future plans and developments.

GCM projects on the Earth Simulator

	GCM	**Resolution**	
		2002-2005	**2006-2007**
RR2002.1 CCSR, NIES, FRSGC	CCSR/NIES CGCM? A:CCSR/NIESAGCM5.7 O: COCO3.3 AGCM	T106(120km), L56; 10 nodes Land: 1/2 x 1/2 River: 1/2 x 1/2 1/4 x 1/6, L48; 78 nodes	T213(60km) - T630(20km)
RR2002.1 CRIEPI, NCAR, LANL,…	C: CSM-2	A: 150km O: 100km	A: 40km O: 10km
RR2002.2 FRSGC	AGCM:CCSR/NIES Integrated Earth System model		
RR2002.4 JMA, MRI	AGCM RAGCM	TL969(20km)L60; 60 or 120 nodes 5km – 1km; 64 nodes	
Earth Simulator Center	AGCM: AFEST 1279(10km) 640 nodes 26.6 TF 64% of 64GF/node OGCM:OFES AOGCM:CFES		

Development of Super High Resolution Global and Regional Models at JMA-MRI

Objectives of the project

(1) To develop super high resolution Models
Global atmospheric circulation model of 20 km in horizontal resolution
Regional cloud resolving model of 2-3 km in horizontal resolution
(2) To provide reliable scientific information about the effect of global warming on severe weather such as Baiu front, typhoon, and heavy precipitation using the Earth Simulator

JMA-MRI Unified Global Model

- Collaborative work
  - NPD/JMA
  - Climate Research Department of MRI
- JMA: Next operational global NWP model
- MRI: Next generation climate model
- Based on operational JMA-GSM
- Fortran90 coding style
- Semi-Lagrangian Scheme

Regional Cloud Resolving Model

MRI/NPD-NHM (Saito et al., 2001)

- Basic equations: *Fully compressible*
- Precipitation scheme: *Bulk cloud microphysics scheme*
  Explicitly predicting the mixing ratios of six water species (water vapour, cloud water, rain, cloud ice, snow and hail)
- Other physical processes: *Atmospheric radiation, Mixing in the PBL*

NHM on the Earth Simulator (Muroi et al., Fujita et al., 2003)

- Based on the MRI/NPD-NHM
- MPI for communication between processor nodes
- Code optimization for the Earth Simulator

2.3 PCMDI model appraisal (Periodic Simulation Appraisal)

Dr C. Covey reported about the current status of the PCMDI model appraisal. Although independent, PCMDI's effort is meant to be supportive of -- rather than competitive with -- IPCC's assessment work. PCMDI's first appraisal will be released in early 2004 and will use (with permission) the CMIP2+ model output database. As a consequence, it will focus on coupled ocean-atmosphere "control runs" and scenarios of 1% per year increasing atmospheric CO2. PCMDI's second appraisal will use output from the simulations contributing to the IPCC 4AR and will be released in time to be assessed by the IPCC 4AR itself. Subsequent appraisals will be released frequently enough to track model improvements and other developments in the state of the art.

PCMDI is willing to receive contributions not passed through the subroutines, provided that they conform to the standards that the subroutines implement. These standards are spelled out on their Web site http://www-pcmdi.llnl.gov/cmip/standard_output.html. Improved documentation of model version used in benchmark experiments should be encouraged as well as community contributions to the standard diagnostic routines applied to model output.

3. CONTRIBUTIONS FROM OTHER MODELLING GROUPS

3.1 CGCM Activities at MRI

Dr A. Noda gave an overview about the coupled modelling activities at MRI. Most of the simulations are performed on the Earth Simulator (see section 2.2). Scenario runs for IPCC AR4 are planned with:

- MRI-CGCM2 (T42L30; 2.5x(0.5-2) L23)
- MRI-CGCM3 (T63L40; 1x(0.3-1) L50)

Model details can be found in the table on p 17.

Furthermore, MRI coupled modelling activities contribute to WGCM projects such as:

- CMIP
- C20C
- Paleo Climate
- THC
- (Cloud Radiative Forcing)

Earth System modelling:

- chemical transport model in the stratosphere
- aerosol model (MASINGER)
- carbon cycle model (land, ocean)

Results from ensemble simulations:

- 0.75˚C increase at 1990s
- The model reproduced observed trend and interdecadal change
- The observed variation is within range of the ensemble scatter
  Rapid warming starts 1970s, ~10 years earlier than observation

3.2 Modelling at NCAR

Dr G. Meehl reported about current and planned coupled modelling efforts at NCAR. Current coupled models encompass:

1. PCM

- atmosphere: CCM3.2, T42, 18L
- ocean: POP, 2/3 to 1/2 degree in eq. tropics, 32L, biharmonic diffusion, Pacanowski/Philander mixing.
- sea ice: dynamic (EVP), thermodynamic
- land: LSM

Feature	MRI-CGCM3	MRI-CGCM2
Atmospheric component		
Horizontal resolution	T63	T42 (~2.8° x 2.8°)
Layers (top)	40 (0.4 hPa)	30 (0.4 hPa)
Solar radiation (SW)	Shibata and Uchiyama (1992) H_2O, O_3, CO_2, O_2aerosol	Shibata and Uchiyama (1992) H_2O, O_3, CO_2, O_2aerosol
Long wave radiation (LW)	Shibata and Aoki (1989) H_2O, CO_2, O_3, CH_4, N_2O	Shibata and Aoki (1989) H_2O, CO_2, O_3, CH_4, N_2O
Convection	Prognostic Arakawa-Schubert Randall and Pan (1993) +revision	Prognostic Arakawa-Schubert Randall and Pan (1993)
Planetary Boundary Layer (PBL)	Mellor and Yamada (1974) level 2 + non local mixing	Mellor and Yamada (1974) level 2
Gravity wave drag	Iwasaki et al. (1989) Rayleigh friction	Iwasaki et al. (1989) Rayleigh friction
Cloud type	Penetrative convection, Large-scale condensation, stratus in PBL	Penetrative convection Large-scale condensation
Cloudiness	predicted	Function of relative humidity
Cloud overlap	Random + correlation	Random + correlation
Cloud water content	predicted	Function of temperature
Land process	4-layer Sib + multi-snow layer	3-layer simple biosphere (SiB)

Feature	MRI-CGCM3	MRI-CGCM2
Oceanic component		
Horizontal resolution	1° (long) x 1° to 0.3° (lat)	2.5° (long) x 2° to 0.5° (lat)
Layers (min. thickness)	50	23 (5.2 m)
Surface	free	rigid lid
Eddy viscosity	H. visc. m^2s^{-1} V. visc. m^2s^{-1}	H. visc. 1.6 x 10^5 m^2s^{-1} V. visc. 1 x 10^{-4} m^2s^{-1}
Eddy mixing	Isopycnal mixing + Gent and McWilliams (1990) m^2s^{-1} m^2s^{-1}	Isopycnal mixing + Gent and McWilliams (1990) Isopycnal 2.0 x 10^3 m^2s^{-1} Diapycnal 1.0 x 10^{-5} m^2s^{-1}
Vertical viscosity and diffusivity	Mellor and Yamada (1974, 1982) level 2.5 KPP (option)	Mellor and Yamada (1974, 1982) level 2
Sea ice	dynamical (rheology)	Mellor and Kantha (1989)
Atmosphere-ocean coupling		
Coupling interval	hours	24 hours
Flux adjustment	none	Heat, salinity + wind stress (in the equatorial band 12°S to 12°N)

2. *CCSM CCSM2.0 (circa 2002):*
   - atmosphere: CAM2, T42, 26L
   - ocean: POP, 1 to 1/2 degree in eq. Tropics, 40L, GM, KPP
   - sea ice: dynamic (EVP), thermodynamic
   - land: CLM

3. *CCSM3.0 (circa September 2003):*
   - atmosphere: CAM3, T42 and T85, 26L
   - ocean: POP, 1 to 1/2 degree in eq. Tropics, 40L, GM, KPP
   - sea ice: dynamic (EVP), thermodynamic
   - land: CLM

Existing and planned PCM simulations:

- Solar-only, 1870-2000, 4 members
- Volcano-only, 1870-2000, 4 members
- Ozone-only, 1870-2000, 4 members
- GHG-only, 1870-2000, 4 members
- Sulfate aerosol-only, 1870-2000, 4 members
- GHG+ozone, 1870-2000, 4 members
- Solar+ozone, 1870-2000, 4 members
- GHG+sulfates+ozone, 1870-2000, 10 members
- GHG+sulfates+ozone+solar, 1870-2000, 4 members
- GHG+sulfates+ozone+solar+volcano, 1870-2000, 4 members
- Solar+volcano, 1870-2000, 4 members
- Solar+volcano+ozone, 1870-2000, 4 members
- GHG+sulfates, 1870-2000, 4 members
- control simulation (1000 years)
- 1% CO_2 increase to doubling (5 members), and quadrupling (1 member); 150 years at $2XCO_2$, 150 years at $4XCO_2$; (CMIP)
- ACACIA "Business as Usual", 5 members, 2000-2100; 1 member to 2200
- ACACIA "stabilization", 5 members, 2000-2100, 1 member to 2200
- SRES A2, B2, A1B (single members), A1FI and B1 (five members), 2000-2100
- 20^{th} century stabilization (five members)
- Land surface change (in progress)

Simulations planned by the climate change working group:

T85 class coupled model for climate change simulations:

- Baseline simulations: $2XCO_2$ slab ocean, 1% CO_2 increase fully coupled then hold $2XCO_2$ fixed and run for 200 years for idealized stabilization, 500 year control run
  -Simulations with CCSM2.x for IPCC (community and experimental)
- Community:
  1) 20^{th} century stabilization (20^{th} century all-forcings, then yr 2000 concentrations held constant to 2100),

  2) 21^{st} century stabilization (yr 2000-2100, then yr 2100 concentrations held constant to 2200, A1B) ensemble, one member to 2300

  3) 21^{st} century stabilization (yr 2000-2100, then yr 2100 concentrations held constant to 2200, B1), ensemble, one member to 2300

  4) 21st century A2 (yr 2000-2100)

- Experimental:
  1) absorbing aerosols, indirect sulfate aerosol effects
  2) time and space evolving emissions
  3) coupled WACCM model

A preliminary schedule for these runs was presented.

3.3 GFDL Climate Model Development

Dr T. Delworth reported about the climate model developments at GFDL.

1. Overview of macro-scale changes within GFDL

- Unified modelling environment throughout GFDL
- Completely new model codes

- Written in FMS (Flexible Modeling System)
- New emphasis on public availability of GFDL models
- Enhanced collaboration with Princeton University in model development

2. Model design and formulation

Atmospheric model

- Grid point formulation 2^o lat, 2.5^o lon, 24 vertical levels
- Top at ~ 30Km
- Radiation: diurnal cycle with 3 hour frequency
- Effects of CO_2, H_2O, O_3, O_2, N_2O, CH_4 and 4 halocarbons included
- Prescribed 3-dimensional monthly natural and anthropogenic aerosol climatology. Species represented include sulfate, hydrophobic and hydrophilic carbon, dust, and sea salt.
- Relaxed Arakawa Schubert Convection
- Prognostic cloud scheme (Klein)
- 3 prognostic cloud tracers which are advected and diffused: cloud liquid, cloud ice and cloud fraction

Ocean model

- MOM4 code
- 1^o lat, 1^o lon, 50 vertical levels (20 in top 200m)
- $1/3^o$ latitudinal resolution in tropics
- Tripolar grid (poles at 90^oS, Eurasia, and North America)
- Free surface, fresh water flux
- GM, KPP, partial bottom cells

Sea ice and land models

Sea Ice:

- Full dynamics with viscous-plastic rheology (elastic-viscous-plastic solver)
- Three level (2 ice, 1 snow) thermodynamics with penetrating solar radiation and brine pockets
- N-thickness category scheme to represent the sub-grid scale ice thickness distribution

Land Model:

- Non-water stressed stomatal resistance
- Vegetation and soil-dependent surface parameters
- Soil sensible heat storage
- Groundwater storage reservoir
- River routing scheme

3. Current status and simulations

- Active development of physical component of coupled model (CM2) for several years
- Model is stable for multiple centuries without flux adjustments
- Plan to freeze CM2 for IPCC work within 1-2 months

4. Areas of development and tuning focus

- Cold bias in NH
- Circum-Antarctic ocean warm bias
- Tropical Pacific cold bias
- Final evaluation of two candidate atmospheric models

5. Plans

- Plans for a more complete Earth System Model
- Terrestrial Carbon Cycle plus Vegetation Dynamics (Pacala et al, Princeton University)
    - Testing underway of carbon cycle and interactive vegetation dynamics coupled to atmospheric model.

- More complete soil physics (Milly, USGS)
  - Soil water profiles, phase changes, etc.
- Ocean biogeochemistry (Dunne, Gnanadesikan, et al.)

Summary

- Plan to freeze new coupled ocean-atmosphere model within the next 1-2 months for IPCC simulations.
- Higher horizontal resolution (1^o, 0.5^o) versions of global atmospheric model will be used for time-slice experiments
- Over the next 1-2 years there will be intensive development to incorporate
- interactive terrestrial carbon cycle and vegetation dynamics
- ocean biogeochemistry
- atmospheric chemistry coupling

3.4 Coupled Modelling at BMRC

Dr B. McAvaney reported about recent model developments at BMRC. The new model consists of the BAM3 coupled with ACOM2 using an OASIS coupler. It has a T47L17 atmosphere, a simple thermodynamic sea ice model and the ACOM2.2 with fine resolution at the equator. It is used for seasonal prediction (operational) and in future for climate variability and change studies (drift problems).
Immediate future developments are:

- Improved sea ice component
  - Antarctic CRC
- Improved Land Surface Component
  - Viterbo (1995)
  - SECHIBA/ORCHIDEE (experiments)
- Climate of 20th Century
  - Simplified Forcing

Current climate projects

- MJO in seasonal prediction
- Variability and predictability at interannual to decadal time scales

Atmospheric Modelling climate

- SST forced climate of 20th Century.
- Seasonal Prediction - SST forced.
- Predictability.
- Complexity of SEB.
- Strength of land-atmosphere coupling
  - GLACE
- Climate change Uncertainty
  - Time slice

Possible new directions

- Add socio-economic model to “model of intermediate complexity”
  - GTEM (Global Transient Equilibrium Model)
    - ABARE
  - CLIMBER; U-Vic
- Provide tool for “optimal policy guidance”

3.5 Coupled modelling and analysis at CSIRO – activities relevant to IPCC AR4

Dr T. Hirst reported about the current status of the modelling activities at CSIRO. CSIRO climate models:

1. Global coupled model – CSIRO Mk 3 consists of:
Atmosphere: Grid T63 (1.9° x 1.9°); 18 levels - hybrid □,p
Land surface: Soil model – 6 levels, 9 soil types, 13 vegetation types
Snow cover model – 3 layer

Ocean: MOM 2.2 code; Grid 0.95°NS x 1.9°EW; 31 levels (8 in top 100 m)
Sea Ice: Flato-Hibler cavitating-fluid rheology, Semtner Thermodynamics (3 layer)

Reference: Gordon et al., 2002 http://www.dar.csiro.au/publications/gordon_2002a.pdf

2. Regional climate model
- Conformal-Cubic Atmospheric Model (C-CAM)

The initialization of the coupled model is done by spinning up the Mk3 AGCM for 60 years forced with climatological SSTs. The ocean Mk3 spin up is done through:

1000 years (accelerated)
10 years (not accelerated)
AGCM fluxes + Relaxation to climatological T & S (c.f. Mk 2)
Surface stresses from AGCM

A new version: Mk 3.4 model is currently developed with the aim to further reduce the model drift. The new version includes some code improvements, e.g.,
- several sources of non-conservation removed
- improved sea ice numerics

and a "more gentle" initialisation

A complete basic set of IPCC AR4 simulations will be performed with Mk 3.0 or revised version. The main issue whether it is better to perform two/three simulations for each of the prescribed scenarios with Mk 3.0, or one simulation for each with a modestly improved version.

Some ongoing analysis projects are:

- Regional sea level rise - Church et al.
- Southern Ocean change (THC, other) – Rintoul et al.
- Southern mid-latitude atmospheric/coupled system change – Cai et al.

Lastly, Dr Hirst reported about some ongoing work addressing the question: How to mitigate equatorial cold tongue bias?

1. OGCM: Representation of TIW effects
2. AGCM: Surface wind stress over cold tongue is too strong in both AGCM and CGCM

3.6 Hadley Centre

Dr J. Mitchell gave a progress report on recent developments at the Hadley Centre.

Potential solar influence on climate
- Current climate models could underestimate the observed climate response to solar forcing over the 20th century as a whole
- Hadley Centre results indicate that increases in solar irradiance could have had a greater influence on global-mean temperatures in the first half of the 20th century than the combined effects of changes in anthropogenic forcing
- Degeneracy between solar and greenhouse patterns means that we could have attributed some of observed warming to solar forcing when caused by greenhouse gas increases (perfect model studies)
- The results confirm previous analyses showing that greenhouse gas increases explain most of the global warming observed in the second half of the 20th century - IPCC 2001 assessment still stands even if there is a factor 2 to 3 enhancement of climate response to solar forcing

Regional attribution
- Attribution has been carried out in each of 6 continental scale regions using sub-regions to define the pattern of change
- On the scales considered (approx 2000km) model has an adequate representation of internal variability
- The warming effects of increasing greenhouse concentrations have been detected in all continental regions including North America and Europe

In most regions cooling from sulphate aerosols counteracts some of the greenhouse.

Quantifying Model Uncertainty

The ensemble mean change is highly robust for surface temperature but varies widely with location for precipitation and circulation.

Probabilistic prediction of the response to doubled CO_2.

- Linear statistical combination of individual parameter perturbations will not produce reliable estimates of regional changes, so a second large GCM ensemble featuring is needed.
- Improved sampling of parameter space
    - Allow multiple perturbations relative to "standard" model version
    - Allow parameters to take any value within their uncertainty ranges

The work on this topic is still progressing

Interactive Carbon Cycle

The inclusion of sulphate aerosol in simulations with an interactive carbon cycle was shown to improve the simulation of present day climate.

Causes of vegetation change in the LGM

- In Siberia: cooling and drying destroy most of the vegetation North of 50^{o}N. The CO_2 reduction favoured grass vs shrubs south of that zone.
- In Mexico: increase in water availability preserves trees, but needleleaves are more dominant because of the cooling. Although the broadleaf / needleleaf transition is not that simple.
- In Australia: increase in vegetation (surprising vs data) due to increased precipitation in the model.
- The Amazonian forest is not threatened by the climatic change: the negative effect of drying is more than compensated for by the cooling. Its 8 % area reduction is solely caused by the CO_2 decrease, that overcompensates the beneficial effects of cooling

Coupled Ice sheet Modelling

First results from a climate model with a 2-way coupled Greenland ice sheet were reported.

Summary of cloud compositing studies

- A compositing method to investigate cloud changes was applied to Hadley Centre slab models
- The IPCC estimate of the climate sensitivity range has never been reduced since it was first estimated and most of the uncertainty is still thought to be associated with cloud processes. This is the case despite the RMS error in the net cloud radiative forcing being reduced over the past decade (Karl Taylor, pers comm.).
- Compositing individual cloud types by key variables may permit a more process based evaluation of models. However, the processes must be relevant for climate change if the uncertainty in the climate sensitivity is to be reduced.
- Preliminary results suggest that around half of the cloud response to a doubling of CO_2 in two versions of the Hadley Centre model can be associated with changes in vertical velocity and stability.
- The Cloud Feedback Model Intercomparison Project (CFMIP) will allow techniques such as these to be tested in a range of climate models in order to assess the generality of the relationships and (hopefully) provide a detailed evaluation of the models.

HadGEM - the next generation model

HadGEM, the next generation coupled model is currently developed at the Hadley Centre. HadGEM components are:

HadGEM atmospheric submodel HadGAM1

- Horizontal resolution: 2.5° latitude x 3.75° longitude "workhorse version" + 1.25° latitude x 1.875° "high-resolution version"
- Vertical resolution: 38 or 50 levels.
- 30-minute timestep.
- Met Office Unified Model new dynamical core.
- Suite of physics changes.
- New orography dataset.
- Improved land surface scheme.
- Sulphur cycle and non-sulphate climatological aerosols.
- Interactive chemistry sub-model.

HadGEM ocean submodel HadGOM1

- Horizontal resolution: 1° x 1° outside the tropics, increasing to 0.34° x 1° on the Equator.
- Vertical resolution: 40 level Z-type coordinate system.
- 60-minute timestep.
- Linear free surface height.
- Bottom boundary layer parameterisation.
- Coupled to the atmosphere once per day.

Improvements over HadCM3:

- Atmosphere vertical temperature structure
- Vertical velocity
- Marine stratocumulus cloud amount
- Indonesian throughflow
- Sea ice velocity

Still to be addressed:

- Tropical Pacific SST cold bias (windstress forcing)
- Precipitation
- Grid point storms
- Sea ice concentration
- Run-time cost

3.7 Coupled Modelling at IPSL

Dr P. Braconnot reported about the current status of the new IPSL coupled model. The model consists of the LMD atmospheric model, the ORCA ocean, a sea-ice and interactive land component. An OASIS coupling interface is used. At the moment the model runs in two resolutions:

a) Low: LMDZ 72x45x19 ORCALIM: 4°;
b) Medium: LMDZ 96x71x19 ORCALIM: 2°

A higher resolution is planned. New model features encompass:

- Energy and water conservation
- New interpolation scheme;
- New river routing scheme;
- Introduction of interface model in LMDZ boundary layer;
- New coupling LMDZ-ORCHIDEE and ORCA-LIM
- Model environment: ioipsl, modipsl, atlas.

The basic criteria for the new model were:

- Stable climate;
- Realistic equator-poles gradient;
- Realistic mean climatology;
- Realistic variability;
- User-friendly interface.

These criteria have been fulfilled mainly because of a new physical parametrization and adjustment of the radiative forcings in the atmospheric component (Hourdin et al., in prep).

3.8 Coupled Modelling at LMD

H. LeTreut (ppt or summary not available)

3.9 Local Presentations

Aerosol in Climate Modelling

Dr J. Feichter gave an overview on aerosol in climate modelling. Background: The aerosol cycle is part of the hydrological cycle:

- cloud droplets act as chemical reactors
- evaporating clouds are the major source of aerosols
- removal by precipitation is the main sink of aerosols

Aerosols influence the hydrological cycle. Aerosols:

- act as CCN and IN
- influence the cloud droplet and the ice crystal number concentration and the autoconversion rate
- reduce the incoming solar radiation at surface
- reduce the evaporation rate and damp the amplitude of the hydrological cycle
- change the precipitation rate and distribution

Requirements to simulate the aerosol impact:

- The chemical composition controls the hygroscopicity
- Hygroscopicity and particle radius control the activation, the removal by rain, the aerosol load and the microphysical properties of clouds.
- Hygroscopicity controls the uptake of water
- Size and mixing-state control the optical properties

Thus, the prediction of size-distribution, composition and mixing-state is essential.

The ECHAM5-HAM Aerosol Model is a modal aerosol model for:

- sulfate
- black carbon
- organic carbon
- sea salt
- dust

with prognostic treatment of

- size-distribution
- composition
- mixing state

The ECHAM-5 model has the following components relevant for aerosol modelling:

- Sulfur chemistry (Feichter et al., 1996)
- Size-dependent dry- and wet-deposition (Ganzeveld et al., 1998; Slinn and Slinn, 1980; Feichter et al., 1996; ...)
- Online emissions of dust, sea salt and DMS (Tegen et al., 2002; Schulz et al., 2002; Kettle and Andreae, 2000;...)
- Aerosol Microphysics M7 (Vignati, Wilson, and Stier, *in preparation*)
    - Nucleation of sulfate particles
    - Condensation of sulfate on existing particles
    - Coagulation
    - Transfer from insoluble to soluble modes
    - Thermodynamical equilibrium with water vapour
- Radiation module (Boucher and Stier)
- Cloud microphysics (Lohmann and Roeckner, 1996 ⇔ Lohmann et al., 1999; …)

A model comparison is carried out through the **AEROCOM** project (*M. Schulz CNRS/Paris and S. Kinne MPI/Hamburg*).

- Emission inventory of the year 2000
- Compilation of in-situ and remote sensing data

- Simulation of the year 2000
- Intercomparison of model data and comparison to observational data

Impact of Biology in a Coupled Climate Model

Dr M. Latif summarized a study on the impact of biology in a coupled climate model. The model used is the MPI-OM1 ocean model (1.5^{o}x1.5^{o} near equator, 40 levels), coupled to ECHAM5 (T31, L19) and the HAMOCC5 for the biology.

Experiments performed were a:

- Control: 80 yr coupled run
- Biology: 80 yr coupled run with biological feedback

The penetration depth changes due to biological activity was parameterized through:

$$E(z)= 0.5*E_0/\exp[(B_0 + C_0*CC)*z] + 0.5*E_0/\exp[B_1*z]$$

E_0: incident short wave radiation
B_0, B_1: background absorption coefficients.
C_0: Chlorophyll absorption coefficient
CC: Chlorophyll concentration

The experiments showed that

- Biological feedbacks may have a significant impact on tropical Pacific climate and its variability
- These results are not conclusive, but they suggest that biological feedbacks may be important and thus merit further investigation

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 G. Meehl (Chairman of the CMIP) reported on the current status

1. Significant accomplishments of CMIP, Oct. 2002 – Sept. 2003

- 20^{th} Century Climate in Coupled Models (20C3M), approved as a CMIP pilot project (Oct. 2002), data collection has begun
- Ocean data from CMIP2+ now available for analysis of subprojects from PCMDI
- Catalogue of MIPs completed with cooperation of WGCM and GAIM, and now on the CLIVAR web page with link from the CMIP web page (http://www.clivar.org/science/mips.htm)
- CMIP and 20C3M summaries published in CLIVAR Exchanges (end of 2002); CMIP Summary published by GAIM (early 2003)
- CMIP subprojects have produced 25 peer-reviewed publications, 6 other publications, 4 PCMDI publications, significant contributions to IPCC TAR; As of September 2003 there are 28 CMIP2+ subprojects currently active, in addition to 10 completed subprojects from CMIP1 and 22 from CMIP2
- Second CMIP Workshop held Sept. 22-23, 2003 in Hamburg. 35 people attend and 25 presentations were provided. Emerging themes were:

    1. Multimodel means give better agreement to observations than single models on regional scales (*Kunkel, Raisanen*)
    2. Useful to compare coupled and uncoupled components e.g. CMIP, AMIP, CFMIP (*Sun, Sperber*)
    3. Multi-models can provide probabilistic estimates of future climate change (*Raisanen*), and quantify nature of errors with estimates of observed sensitivity (*Drange, Vlodin*)

4. Multi-model output can be used to force embedded models for regional/local change, e.g. hurricanes (Knutson)
5. Ocean heat uptake and ocean dynamical response important for climate system response (*Achuta Rao, Watterson, Latif, Meehl, Sun*)
6. Analysis of extreme events from multi-model experiments (*Meehl*)
7. Source of uncertainty from parameterizations in climate models can be quantified through parameter-varying experiments (*Collins*)
8. Preliminary results from first CMIP coordinated experiment for MOC show importance of heat relative to fresh water flux in affecting MOC strength, EMICs can show roughly comparable responses on global scale but not regional, and partial coupling is useful for diagnosing model differences (*Stouffer, Gregory, Sokolov*)
9. Several systematic errors that have been present in nearly all generations of coupled models are proving difficult to eliminate, such as overly strong equatorial Pacific cold tongue and double ITCZ in the Pacific (*Sperber, Hirst*)
10. The nature of regional responses to increasing CO_2 can cause quite different patterns of temperature change e.g. El Nino-like, AO-like (*Noda, Watterson*)
11. PCMDI will continue to play a major role in CMIP, with promotion of netCDF, CF metadata standard and PCMDI-supplied subroutines to provide uniform data structure (*Covey, Gleckler, Taylor*), with other MIPs standing to gain as well e.g. PMIP (*Braconnot*)
12. Climate sensitivity and response must be compared among models for 20th century as well as last 1000 years (*Cubasch, Ogura, Yu*), and cloud feedback (even the sign) is a major factor (*Boer, Meehl*)
13. Most modeling groups have either just recently completed or are in the final stages of completing development of new model versions, with a strong awareness of timing new model versions for upcoming IPCC AR4; most models roughly near 1.5° to 2.5° resolution in atmosphere, and around 1° – 2° in ocean often with enhanced resolution in equatorial tropics of around 0.5°; preliminary indications are that sensitivities of new model versions may be converging near 2°C – 3°C; reasons for this need to be understood (science or sociology?)

2. CMIP and IPCC

The following community runs for IPCC AR4 have been approved by TGCIA mid-2003:

1. 20th century simulation to year 2000, then fix all concentrations at year 2000 values and run to 2100 (CO_2 ~ 360ppm)
2. 21st century simulation with SRES A1B to 2100, then fix all concentrations at year 2100 values to 2200 (CO_2 ~ 720ppm)
3. 21st century simulation with SRES B1 to 2100, then fix all concentrations at year 2100 values to 2200 (CO_2 ~ 550ppm)

WGCM recommended adding a 4th experiment to ensure continuity with respect to the last assessment and to facilitate intercomparisons.

4. 21st century simulation with SRES A2 to 2100

WGCM made the following comments with respect to relationship to IPCC and the AR4 process:

1. PCMDI will archive a collection of forcing datasets for 20th and 21st century climate simulation. These will include the recent standardized sulphate aerosol concentrations from Olivier Boucher, one CO_2 and trace gas time series for 20th and each of the 21st century SRES scenarios, as well as the Ammann and Sato volcanic forcing datasets, the two solar forcing datasets (Hoyt and Schatten; Lean), and the NCAR and Hadley Centre ozone dataset for 20th and 21st century for stratospheric and tropospheric ozone. Curt Covey will coordinate this in cooperation with the CMIP Panel
2. PCMDI will collect data from the four community runs for a subset of fields [*to be determined from the union of DDC, 20C3M, and CMIP2 lists and consistent with calculation of Frisch et al. extremes indices*]. Additionally, daily data will be collected for periods during the experiments (1960-2000, 2035-2055, 2080-2100, 2180-2200; to be the same as periods in TAR). All data must be submitted in netCDF and CF metadata standard, and using PCMDI-supplied software to facilitate archival of standardized data. This exercise is aimed to assist WG1 scientists. If the DDC wants the data they can contact PCMDI to obtain a set, and PCMDI can send them what has been submitted.

3. WGCM, through the IPCC Liaison Panel, will advertise for volunteers to analyse the multi-model data collected above with a list of suggested topics as well as an open invitation for all analysis topics. The announcement will go to the CMIP email alias and to others in the climate community. Recommended topics for analysis include: ENSO, AA monsoon, NAO and annular modes, extreme events from the Frisch et al. indices, NH and SH thermohaline circulation. It is anticipated that these model runs will begin at some centres this winter, some will be collected summer 04, and the announcement can be sent after next WGCM meeting in fall 04 (right after the first IPCC Lead Author (LA) meeting in Trieste). More model simulations will be done over that fall and winter, with all data collected and analyses completed by spring 05 with at least preliminary results from the subprojects forwarded to the IPCC LAs. Subproject PIs must commit to this schedule at the outset, since these are time-sensitive analyses of direct relevance to the AR4 content.
4. WGCM stresses that, to understand model response, the CMIP idealized forcing experiments must be used in conjunction with the scenario simulations. Analyses of scenarios simulations should not be viewed as replacements of analyses of idealized forcing experiments.
5. In response to scientists who advocate a 20^{th} century experiment with common forcings, Dr Hegerl will contact the detection/attribution group (Informal Ad-hoc Detection Group (IADG), with copy to S. Solomon and G. Boer) for more details and justification for such an experiment. The WGCM cannot sanction such an experiment at this time (see letter from G. Hegerl to IADG for details).
6. WGCM endorsed a common radiative forcing diagnostic and recommends calculation of radiative forcing for model intercomparison as follows:

Recommend one requirement and one option:

1. Required from all groups: For model intercomparison purposes (following the Gordon Conference group recommendation) save 12 two-dimensional fields as the model runs: clear and cloudy sky, net short-wave and net long-wave, at a) top-of-atmosphere, b) 200 hPa, and c) surface. These can be plotted as monthly mean time series to give an estimate of total radiative forcing for the sum of all constituents.

2. It is strongly recommended that groups calculate the radiative forcing from respective model constituents taking into account stratospheric adjustment. This can be one estimate for CO_2 and GHGs from a $2XCO_2$ equilibrium slab ocean run and scaled in the scenario runs to produce a time series. Aerosol and ozone radiative forcing can be calculated (every 20 years centred at year 2000 as the coupled model runs) with two timestep calls over the diurnal and seasonal cycles and saving the 12 two dimensional fields in 1 above. The techniques for doing this calculation must be documented (e.g. Tett et al., 2002). Alternatively, an off-line calculation can be performed to derive the radiative forcing from the respective model constituents.

WGCM also recommends that some person or group test the different methods of computing radiative forcing in one model to compare the differences of using various radiative forcing calculations

3. Next phase of CMIP (CMIP3)

The next phase of CMIP (CMIP3) will begin in October 2003. This will include requirements as before for CMIP2, with fields collected as decided for the IPCC and other runs comparable to CMIP2:

1. 1% CO_2 run to year 80 where CO_2 doubles at year 70
2. 100 year (minimum) control run including same time period as in 1 above
3. $2XCO_2$ equilibrium with atmosphere-slab ocean
4. $1XCO_2$ control with atmosphere-slab ocean

Strongly recommended:

5. 20C3M simulation
6. participate in AMIP, OMIP, and CFMIP

Recommended idealized stabilization simulations:

7. An additional 150 years after CO_2 doubling with CO_2 fixed at $2XCO_2$
8. 1% CO_2 run to quadrupling with an additional 150 years with CO_2 fixed at $4XCO_2$

CMIP action items:

1. G. Meehl to communicate to modelling groups (coordinate with IPCC WGI TSU):
    i. WGCM recommendations for community runs (adding A2)
    ii. Radiative forcing recommendation
    iii. CMIP3 announcement
    iv. Plan for scenario model data collection at PCMDI and analyses in subprojects
    v. Forcing data for 20th and 21st century at PCMDI
2. G. Hegerl will contact IADG r.e. 20th century common forcing
3. Contact decadal variability community r.e. availability of CMIP ocean data (T. Delworth)

4.2 Intercomparison of cloud feedbacks in models/Idealized Experiments

Dr B. McAvaney reported about the progress of the International Cloud Feedback Model Intercomparison Project which was launched at the last session of WGCM. Currently, 12 groups are participating, two subprojects (experimental protocols): FANGIO and SLOM are defined and first results are becoming available. A website and a newsletter will be available in late autumn. A Workshop is planned for April 2004 in Exeter, UK. Furthermore, it is planned to contribute to the Climate Sensitivity Workshop, July 2004 in Paris, France. The participation in that project is severely limited by funding.

4.3 Forcing scenarios

(See discussion on CMIP and IPCC)

4.4 Initialization of coupled models

Dr R. Stouffer introduced this item. He presented a new proposal for a coupled initalization which works as follows:

- Start at present day conditions
- Either immediate switch back to 1850 forcing or run clock back to 1850
- Run some 100 years with 1850 forcing (400-600y recommended)
- Start 20th century integration.

Unresolved issues with this procedure are:

- Use switch or jump-back to 1850 radiative conditions or run radiation conditions backwards to 1850 from present day
- Determining how long to run using 1850 conditions held constant before starting 20th century simulations

Problems:

- Expensive: 4-6 centuries of AOGCM integration to find 1850 initialization
- “1850” conditions vary from model to model
- Poor choice for “big” changes in radiative forcing (e.g. ice age)

Advantages:

- Forcing, SSTs, etc all on same clock
- Likely to yield reasonable present day conditions if model drift is small
- Framework to generate initial conditions
    - 1850
    - Present day for future scenarios (no “cold start”)
- Independent of flux adjustment usage

4.5 Decadal Variability

Dr M. Latif gave a presentation on the predictability and stability of the THC. Multi-decadal variability and predictability and the stability of the THC in GHG integrations was investigated with the MPI global climate model ECHAM5/MPI-OM1 (without flux correction). The following experiments were performed:

- Coupled control run, duration 500 years (Jungclaus et al. 2003)
- El Niño hindcasts, 1970-present (Keenlyside et al. 2003)
- Decadal predictability studies (Pohlmann et al. 2003) (performed in the framework of PREDICATE)
- GHG integrations (1% CO_2), ensemble with 4 members (Latif et al. 2003)
- Paleo (6K) integrations, with and without the effects of vegetation (Schnitzler et al. 2003)

The results of these experiments show that:

- There exists rather strong multi-decadal variability in the North Atlantic region.
- The multi-decadal variability is closely related to variations in the THC
- The multi-decadal variability appears to be predictable a few decades ahead.
- The multi-decadal variability may mask a potential anthropogenic signal for some time.
- The characteristic SST pattern associated with changes in the THC may serve as a fingerprint to detect anthropogenically induced changes of the THC.

In an additional paper Dr R. Stouffer focused on the following questions:

- Is there predictability in the climate system beyond the ENSO timescale based on internal variability of the climate system? (probably yes in the Atlantic)
- Does this predictability extend over continents? (possibly a relatively small signal)
- For climate change predictions, is it important to initialize models from “observed” state of the ocean/ice/land system?

Investigations with the GFDL R30 model document that perfect predictability experiments show decadal scale predictability in North Atlantic (THC and SST). A question is whether or not this is of any atmospheric relevance? Grötzner et al. stated that “… the signal to noise ratio of the extra-tropical atmosphere is generally too low to gain relevant predictive skill from this memory.” However, recent results with another model (HADCM3) suggest that the answer may be a qualified ‘yes’.

Furthermore, Dr Stouffer noted that there will be a number of Workshops related to this topic, namely:

- NASA-CCR-CRCES Workshop on Decadal Climate Variability in 23-26 February 2004 in Hawaii (contact V. Mehta)
- Predictability Workshop in Reading, UK, 19-23 April 2004
- Workshop on the Variability of the Thermohaline Circulation in Kiel, Germany, 13-16 September 2004.

Ongoing research on predictability on decadal timescales was highlighted (PREDICATE).

Dr Stouffer proposed the following actions from WGCM:

- To encourage increased analysis of variability in CMIP experiments, particularly with increased oceanic data.
- To encourage experiments focused on predictability.
- Possibly to coordinate such predictability experiments at a future time if appropriate.

4.6 Detection and attribution of climate change

Dr G. Hegerl reported about progress in detection and attribution of climate change. The large-scale temperature signals are detected and distinguished from natural forcing in global scale temperature (e.g. Hegerl et al., 1997; Tett et al., 1999, Allen et al., 2003). This could be attributed to GS forcing in a Bayesian analysis (Zwiers et al. 2003) Ocean heat content changes could also be detected (Barnett et al.,

1999 Reichert et al., 2001; Banks et al.). With respect to regional attribution analysis has been performed in:

- Global, hemispheric, and continental scale regions (Eurasia, N. America) using boxes to define pattern of change (Zwiers and Zhang)
- 6 continental scale regions (Europe, Asia, Africa, N Am., S. Am., Australia) using sub-regions for patterns (Stott et al.)

Warming effects of increasing greenhouse concentrations were detected in all continental regions including North America and Europe, and anthropogenic climate change detectable in indices (Karoly et al.).

Analyses of paleoclimate simulations were investigated to estimate the solar signal. Results show that:

- in paleo simulations: solar explains ca 30-40% variance (Ammann et al.);
- solar not detectable and smaller than simulated in most reconstructions if multiple forcings and long time horizons are considered;
- solar possibly enhanced in the instrumental record

The importance of land surface changes is still unclear. In other variables than large-scale temperature changes could be detected in:

- tropospheric temperature (Santer et al., 1995, distinguished from natural forcing in Thorne et al., 2002)
- tropopause height (Santer et al., 2003)
- sea-level pressure (Gillett et al., 2003)

With respect to detection of changes in "societally relevant variables such as changes in precipitation and climate extremes, preliminary results show that:

- Changes in temperature extremes: quite robustly detectable
- Changes in precipitation extremes very model sensitive.
  - Signal more robust for extreme than mean
  - Data very uncertain, scaling issue between model data and station data!
- Evidence for change in width of tail in models: wider for precipitation, often narrower for temperature

Dr Hegerl concluded that daily data is required for a more comprehensive analysis. Open questions and recommendations are:

- Forcing and role of solar variability?
- What climate sensitivity is consistent with all records?
- Can the observed record be used to constrain future changes in societally relevant variables, e.g. rainfall?
- Full range of model uncertainty: As a very valuable contribution in this context climateprediction.net (http://www.climateprediction.net) was highlighted.
- Extremes –scaling issues, data…- Can indices of extremes be found that can be compared reasonably well between point processes and model grids? Percent? Exceedance of threshold?? – Are the Frich indices suitable?
- The submission of 20th century run to 20C3M was recommended.
- Ensembles simulations were recommended.

4.7 Paleo-climatic modelling

Dr P. Braconnot reported on the recent development in the area of paleo-climatic modelling, and in particular the Paleoclimate Modelling Intercomparison Project (PMIP) (http://www-pcmdi.llnl.gov/pmip/). A new phase of PMIP-2, now also using coupled models is starting. The goal of this phase is to study the role of climate feedbacks arising for the different climate subsystems (atmosphere, ocean, land surface, sea ice and land ice) and evaluate the capability of state of the art climate models to reproduce climate states that are radically different from those of today. Results from both coupled ocean-atmosphere models and ocean-atmosphere-vegetation models will be considered in this second phase. The forcing data will become

available soon. The main foci are on 6K and 21K BP. See http://www-lsce.cea.fr/pmip2/ for more information.

4.8 Carbon-cycle modelling

Dr J. Mitchell reported that the C4MIP group met the week before WGCM in Hamburg. Unfortunately a cross-representation of the two groups was not possible. The next meeting of the IGBP GAIM group will be in October. In order to ensure a close cooperation, WGCM should be informed about the outcome of these two meetings *(Action item: J. Mitchell and A. Villwock to get action items of these two meetings to WGCM).*

5. OTHER ISSUES AND ACTIVITIES

5.1 Simulations of climate of the 20th century (Atmosphere-only AMIP-type)

(See section 1.4 on WGNE and AMIP).

5.2 Data Management

Dr R. Stouffer emphasised the lack of a data portal for model data. This problem is continuously ignored, in particular by the funding agencies. He stated that there is a need to provide access to 2, 3, 4-D model and observational data sets through:

- Web interfaces
- Search functions
- Maps and other graphical displays
- Data downloads
  - Security
  - Data formats
  - Subsets: space and time and time averages

Data users are:

- Other scientists (collaborators, IPCC, MIPs)
- Other scientists (non-collaborators)
- Students (college and high school)
- Industry
- Policymakers

There is a need for comprehensive information about:

- Experiment details
- Model details
- Variable details
- Grid/data information

Finally, he recommended having PCMDI develop prototype language or framework to describe climate runs:

- Experienced
- Good mix of computer and climate scientists

and to report to WGCM for approval and forward to JSC

Dr B. McAvaney presented a proposal for data management for WGCM/WCRP. He stated that the vision for the data management for model output would be to have access to data for analysis and visualization that is as simple as access to documents is today through a Web browser interface. He recommended that WCRP/WGCM should encourage national funding agencies to support the development of general data management tools that benefit the entire scientific community. Can WGCM help to facilitate the funding problem? Options could be to:

- Promote the win-win nature of a well-integrated system.

- Promote concept of “data citation” as a “deliverable”

The value of publishing data should be stressed to strengthen the value of data management efforts. On the national levels funding for DM efforts should be encouraged.

Furthermore it was recommended to conduct a WCRP Workshop on Data Management that brings together policy advisors and software engineers so that details of a WCRP “vision” can be explored. Aspects of this climate data Workshop are:

- Audience – Scientists and data managers
- MIP data management
- Information exchange
- Promotion (and explanation) of standards
  - netCDF/CF
- Standards for higher level metadata
- The “Big Picture” from climate modelling viewpoint.
- Seeing how things do and don’t “fit”
- GEWEX and CLIVAR participation

In this context the role of WCRP was emphasised. The JSC in its twenty-fourth session recommended that WCRP should set up a new “WCRP Data Management Group” to take care of all data needs across WCRP. Data issues are important to both the Modelling and Observation Councils of WCRP. This group will interact closely and collaborate with the two Councils and also with project groups and working groups to evolve a comprehensive data policy for WCRP including mechanisms and structures necessary for data management, climate system data assimilation/ synthesis/reanalysis and model initialization. In addition, plans for a DM Workshop are under way. WGNE was mentioned as a good example for a functioning data management concept.

Dr D. Bader responded that PCMDI might be able to act as such a proposed clearing house if the data is submitted in a suitable format. Furthermore, PCMDI would be willing to host such a Workshop.

Action item: A statement of the importance of this problem should be stated by WCRP (J. Mitchell to communicate to JSC).

6. WGCM BUSINESS

6.1 Future perspectives of WGCM

The group discussed perspectives and priorities for the next 3-5 years. The participants expressed major interest in the following topics:

- WCRP and IGBP GAIM cooperation (carbon cycle & chemistry)
- Systematic errors
- Climate sensitivity
- Variability and changes of variability
- Long control runs for variability, 1% /y runs for response to increasing greenhouse gases, 20th century climate runs for detection and attribution
- Initialization
- Convergence of model for different time scales
- Parameterizations for high resolution models
- Ensembles (e.g. climateprediction.net results)

6.2 Membership

CLIVAR has been approached for nomination of a Co-chair; decision is awaited. Nomination for the replacement for D. Webb are:

1) Inez Fung (Lamont)

2) Pierre Friedlingstein (Paris)
3) Peter Cox

J. Mitchell, A. Villwock to communicate the suggested to changes to the JSC and CLIVAR SSG and to follow up with the co-chair issue (action item).

6.3 Organization of Future Activities

WGCM had agreed during its last year's meeting to accept the kind invitation of Dr A. Noda to host the next meeting of the working group. Suggested dates were: first choice 25-29 October 2004, second 11-15 October 2004 but these have to be negotiated with the GAIM group since plans are to team-up with the group for part of the meeting.

J. Mitchell to negotiate dates with GAIM and to communicate back to WGCM (action item).

6.4 Closure of the Session

The participants expressed their thanks to the local organizers Dr M. Latif and Dr A. Villwock for hosting this session, the excellent arrangements made, and the facilities and hospitality offered. The sixth session of WGCM was closed at 13.30 hours on 26 October 2003.

APPENDIX A

LIST OF PARTICIPANTS

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APPENDIX B

WGCM AGENDA

Wednesday, September 24

9.00 Welcome (*M. Latif, J. Mitchell, V. Satyan, A. Villwock*)
Opening arrangements (*as above*)

Introductions
Times, agenda, local arrangements

9.20 Review of WCRP events, developments
24th session of JSC (*P. Lemke, V. Meleshko, V. Satyan, J. Mitchell*)

9.35 CLIVAR SSG and ICPO (*A. Villwock*)

9:45 Other modelling activities
WGOMD (*C. Böning*)
WGSIP (*A. Villwock)*
WGNE. (*K. Puri*)
AMIP (*P. Geckler*)

10.30 Coffee break

11.00 Other WCRP programmes and WGCM relevant activities
ACSYS/Clic (*A. Villwock*)
GEWEX (*B. McAvaney, K. Puri, V. Satyan*)
IPCC (*J. Mitchell and others*)
- 4th Assessment - update-
- Sensitivity Workshop: planning status
- What WGCM needs to have in place?

TGCIA (*J. Mitchell*)
Update on regional modelling (*J. Mitchell*)

12.30-13.45 Lunch

13.45 News from relevant national and multinational projects
PRISM (*R. Budich*)
Earth Simulator (*A. Noda*)
PCMDI (*D. Bader, C. Covey*)
Contributions from modelling groups
Local presentations

15.00 Coffee break

15.15 Continuation plus discussion

Thursday, September 25

9.00 Data Management for Model Output – Distributed Data Server
(lead R. Stouffer and PCMDI rep.)

9.30 WGCM activities

(i)	CMIP, Review of the CMIP Workshop	(*G. Meehl, P. Geckler*)
(ii)	Idealised experiments	(*B. McAvaney*)
(iii)	Forcing scenarios	(*J. Mitchell*)
(iv)	Initialization of models	(*R. Stouffer*)
(v)	Detection	(*G. Hegerl*)

12.30 Lunch

14.00 WGCM activities (continued)

(vi)	Paleo	(*P. Braconnot*)
(vii)	Atm.– ocean variability and predictability on decadal timescales	(*M. Latif, T. Delworth*)

Friday, September 26

9.00 WGCM activities (continued)
- Goals of WGCM over the next 3-5 years

11.00 Other business:
Next session- time, place
WGCM membership

12.30 Adjourn