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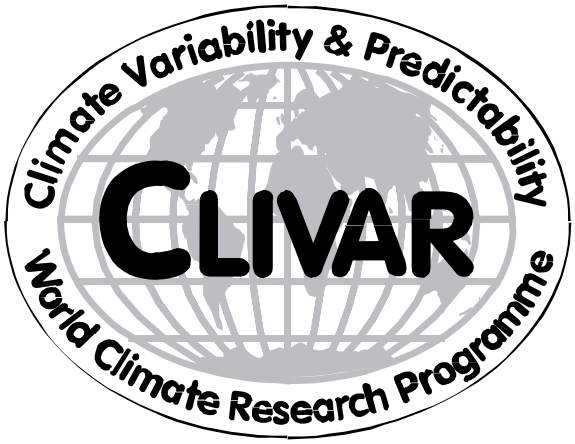

Report of the Thirteenth Session of the JSC/CLIVAR Working Group on Coupled Modelling (WGCM)

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CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organisation, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO. 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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Front row, left to right: Gerald Meehl, Gokhan Danabasoglu, Natalie Mahowald, Pascale Bracannot, Peter Gleckler; second row: Marco Giorgetta, Amy Solomon, Sybil Seitzinger, Ken Sperber, Ron Stouffer; third row: Tony Hirst, George Boer, Ayako Abe-Ouchi, Ghassem Asrar; Fourth row: John Mitchell, Masa Kimoto, Greg Flato, Sandrine Bony; Fifth row: Colin Jones, Jiping Liu, Karl Taylor, Renu Joseph, Ben Santer, Anna Pirani, Cath Senior; back row: David Legler, Joao Teixeira, Filippo Giorgi, Kathy Hibbard, Jean-Francois Lamarque, Curt Covey, Christian Jakob.

See the meeting report for a full list of participants.

Action Items

Overview of WCRP Activities of Relevance to WGCM

WGCM should assess the benefits of going to higher resolution – important to make this clear for funding bodies.

WGCM endorses the workshop on WG1-WG2 that is being organized by the ACC crosscut group

Include an update from WOAP in the agenda for the 14th WGCM Session in 2010

CMIP5 Overview and Update

Apply version numbers to forcing datasets. PCMDI can do this in consultation with CMIP Panel; PCMDI make a copy if data served elsewhere; previous versions should only be replaced if there are major problems; keep in mind that when runs start, you can't start over.

Advise IAM groups (particularly the group responsible for RCP 6.0) to use a post-2100 emission trajectory that stabilizes concentrations somewhere near concentrations in 2100 and to provide the forcing as soon as possible.

Ensure that registration occurs when model data are accessed, who is using which model data and a project name and short description of analysis to be performed.

Recommendation to make it a requirement that the model metadata questionnaire be completed and made available before model output is made available by PCMDI.

Recommendation for developing a system to track model use and reference models; development of equivalent DOI system. (B. Lawrence).

CMIP5 analysts should submit feedback about key results in addition to publication details.

Articulate that CMIP5 archive will continue to accept data that is submitted after the AR5 timeline since CMIP5 is (at least) a 5yr research activity.

Terms of use for CMIP5 archive: Two levels of access - unrestricted and restricted; as long as use is only for research and education, PCMDI will wait for information from Hadley Centre on its requirements, and then iterate with other groups who may have issues with restricted use.

Coordinated Experiments

Endorse CMIP experiment design calling for time-varying "realistic" external forcings in AMIP simulations and simplified time-invariant forcing in aqua-planet runs.

Recommend that groups are consistent in how solar forcing is treated between PMIP-CMIP5 last millennium and historical runs; up to their own discretion as to what values used as long as they are consistent across simulations.

Extend Task Force on Regional Climate Downscaling one more year to fully develop objectives. The Task Force should consult with WCRP on membership, perhaps including a member from AMMA.

WGCM endorse transpose-AMIP and add to catalog of MIPs on web page; C. Senior will be the WGCM representative.

Model Evaluation and Improvement, Observations

WGCM endorses the framework proposed by NASA for providing observations for comparison to model simulations including those in CMIP5; observations are needed in same format as model standard output; Recommend the formation of a contact group with representatives from modelling groups, WOAP, GEWEX; take these recommendations to the next WOAP meeting (K. Taylor is the WGCM contact WOAP); emphasize to WOAP the importance and observational needs for model evaluation; recommend that WOAP invite a presentation on the NASA project at its next meeting; make WOAP aware of ESA initiative and ISENES, (P. Bracconot, C. Senior and N. Mahowald, et al to communicate with K. Taylor to take this forward to WOAP, together with G. Meehl and K. Trenberth).

Model improvement survey - continue collecting responses, the results should be written up (e.g. report to the JSC, a BAMS-like paper for wider distribution) and should clearly target particular goals. The outcomes of the survey should promote model development.

WGCM Discussion Topics

Include an update from the AC&C MIP in the agenda for the 14th WGCM Session in 2010 (J.-F. Lamarque)

Encourage participation, if groups are able to, in demonstration project on geoengineering. Work is ongoing on developing a simplified experimental design over the coming year. Make contact with European groups organizing similar activity. Present outcomes at next WGCM meeting to advocate best practice in this area. Coordinate with SPARC (V. Eyring).

1 Introduction

The 13th Session of the CLIVAR/WCRP Working Group on Coupled Modelling (WGCM) was hosted by the Program for Climate Model Diagnosis and Intercomparison (PCMDI) in Sausalito, San Francisco, USA. PCMDI celebrated its 20th anniversary in 2009, having been established in 1989 at the Lawrence Livermore National Laboratory (LLNL) in Livermore, California. WGCM was extremely grateful for the welcome and organization provided by K. Taylor, P. Gleckler and P. Drumtra of PCMDI that made this meeting so successful.

The two main topics of this meeting were the progress of the Coupled Model Intercomparison Project: Phase 5 (CMIP5) and the theme of model evaluation and improvement. WGCM's partners (including CLIVAR, GEWEX, SPARC, CliC, WGNE, WOAP, IDAG) and the global modelling centres reported on their activities of relevance to CMIP5, including associated coordinated experiments, and progress in model development. Additional WGCM discussion topics included air quality and climate and a proposal for a coordinated geoengineering experiment. The third day of the meeting was held jointly with the Scientific Steering Committee of the IGBP Earth System modelling project, Analysis, Integration and Modelling of the Earth System (AIMES). The mini-workshop addressed the current status of Earth System Model (ESM) development and future directions. The meeting agenda is given in Appendix 1 and the list of participants in Appendix 2.

2 Overview of WCRP Activities of Relevance to WGCM

Planning for the intermediate and longer term future of WCRP and its Projects (CLIVAR, GEWEX, SPARC and CLiC) is underway. For the intermediate term, the WCRP has developed the WCRP Implementation Plan 2010-2015 for the WCRP Coordinated Observation and Prediction of the Earth System (COPES). The WCRP Joint Scientific Committee (JSC) has been charged with developing a strategy for the long-term evolution of WCRP. A new focus on regional activities will be developed to fit into the overall function of WCRP. The role that WCRP plays in capacity building should also be enhanced, involving scientists from all over the world, especially in terms of bringing greater regional expertise into WCRP's activities. The WCRP Task Force on Regional Climate Downscaling (TF-RCD) was initiated in 2008 as part of this drive for a new focus on regional scales.

The Third World Climate Conference, Geneva, Switzerland, 2009 endorsed the establishment of an international framework to guide the development of climate services which will link science-based climate predictions and information with climate-risk management and adaptation to climate variability and change throughout the world. WCRP is implicitly mentioned in the Conference statement due to the recognition of its role in producing the science that feeds into services for society.

In terms of the future of WCRP modelling activities, WGCM will continue to have a leading role. Discussions are underway within WCRP on how to best coordinate WCRP modelling activities as a whole. The WMO EC Task Team on Research has issued recommendations on how to develop a unified approach to multidisciplinary weather, climate, water and environmental prediction research; step up high-performance computing investments to accommodate the increasing complexity and detail of models; and accelerate the development, validation and use of prediction models. WCRP's evolution will be guided by the role it should play within WMO in the seamless approach to weather to climate prediction, with an interest to serving WMO constituents.

It is likely that there will be a WCRP climate science conference in the Northern Fall of 2011, and there is the possibility of holding a CMIP5 workshop the Northern Spring of 2012. Further details regarding these workshops will be forthcoming.

ACTION: WGCM should assess the benefits of going to higher resolution – important to make this clear for funding bodies.

ACTION: WGCM endorses the workshop on WG1-WG2 that is being organized by the ACC crosscut group

2.1 CLIVAR, US CLIVAR WG Decadal Predictability, WGSIP and WGOMD

Since its last SSG meeting in May 2009, the Climate Variability and Predictability (CLIVAR) Project has identified 7 imperatives to focus its near-term (2010-2015) implementation, in parallel to the WCRP Implementation Plan:

- Anthropogenic Climate Change
- Decadal Variability, Predictability and Prediction
- Intraseasonal and Seasonal Predictability and Prediction
- Improved Atmosphere and Ocean Components of ESMs
- Data Synthesis and Analysis
- Ocean Observing System
- Capacity Building

With the imperative on Improved Atmosphere and Ocean Components of ESMs, there is a renewed focus within CLIVAR on atmospheric and oceanic models improvement, which has been recognized as a key necessity to improve the reliability of model predictions at all time and space scales.

The US CLIVAR Working Group on Decadal Predictability was formed in 2009 and has the following objectives:

- To define a framework to distinguish natural variability from anthropogenically forced variability on decadal time scales for the purpose of assessing predictability of decadal-scale climate variations.

- Work towards better understanding of decadal variability and predictability through metrics that can be used as a strategy to assess and validate decadal climate prediction simulations.

The WG has three scientific foci:

- How best to separate natural decadal variability from anthropogenically forced decadal variations?
- How do we address the issue of potential projection and interaction between the natural and forced variability?
- Do we have robust estimates of observed (or simulated) trends?

A diagnostic package will be developed as a part of the WG's metrics study. There are various areas for collaboration with WGCM for example:

- How best to identify the impact of initialization strategies and model differences on decadal prediction in the CMIP5 runs?
- How to quantify the impact of model error/bias on decadal predictability relative to additional predictability due to natural sources in the CMIP5 near-term prediction runs?

The CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP) is a partner with WGCM in the implementation of the near-term CMIP5 simulations. A WGSIP-WGCM-CMIP panel is in place to provide support to the near-term CMIP5 simulations.

WGSIP is also focused on leading the Climate-system Historical Forecast Project (CHFP). This is a multi-model and multi-institutional experimental framework for sub-seasonal to decadal complete physical climate system prediction. By the complete physical climate system, we mean contributions from the atmosphere, oceans, land surface cryosphere and atmospheric composition in producing regional and sub-seasonal to decadal climate anomalies. This experimental framework is relevant to climate modelling groups as a way to test their model performance in seasonal prediction-mode. The experiment design is flexible enough for simulations to be run with any kind of initialization procedure, whether from climatology or with data assimilation, as long as no future information/constraint is given to the system once the simulation starts (forecast-mode).

The CLIVAR Working Group on Ocean Model Development (WGOMD) organizes scientific workshops each time it meets. The forthcoming meeting for September 2010 is on "Decadal Variability, Predictability and Predictions: Understanding the Role of the Ocean". WGOMD continues to foster the development of ocean-ice models by leading the Coordinated Ocean-ice Reference Experiments. The second phase of these experiments, CORE II, is underway and focuses on hindcast simulations for the period 1948-2006. Not only will these simulations be instrumental in the development of the ocean-ice models taking part, they will also be relevant for the wider community in terms of understanding mechanisms of oceanic variability observed during this period and in terms of providing initial conditions for decadal predictions.

2.2 SPARC

The AC&C/SPARC Ozone Database is available from the CMIP5 website and has the goal of providing a merged tropospheric/stratospheric ozone time series from 1850 to 2100 for use in CMIP5 simulations by models without interactive chemistry. It provides:

A. Historical Database (1850-2009)
- Stratospheric data (Zonal means)
- Tropospheric data (3D but decadal averages)
- Combined stratospheric / tropospheric data (3D but underlying zonal mean in stratosphere)

B. Future Database (2010-2099)
- Stratosphere: multi-model CCMVal-2 mean
- Troposphere: Community Atmosphere Model (CAM) version 3.5
- The data from the observational core and the model time series are combined separately for each latitude band and pressure level using a linear regression model.

C. Combined Ozone Timeseries (1850 to 2100)

The recommendations to WGCM from SPARC are:

- For models that do not have interactive chemistry: prescribe ozone according to the new SPARC/AC&C ozone time series for consistency.
- Advocacy of 'best practice' in modelling as including physically-based, self-consistent representations of key processes, e.g. a unified representation of tropospheric and stratospheric chemistry in CCMs, to remove inconsistencies in models with relaxation of chemical constituents to prescribed values [*Stevenson*, Nature Geosci. 2009], CCM runs with coupled ocean for chemistry-climate interactions studies.
- Support for process-oriented model evaluation activities (such as CCMVal, C^4MIP, CFMIP) in close conjunction with improved measurements; similar efforts for coupled ESMs (ESMVal) [*Eyring et al.,* BAMS, 2005; 2009 in prep.].
- Support for central software for the analysis of climate and Earth system models
- Development of performance metrics for the documentation of model improvements, improved process studies and projections [*Gleckler et al.*, JGR, 2008; *Reichler & Kim*, BAMS, 2008; *Waugh & Eyring*, ACP, 2008; *Santer et al.,* PNAS, 2009]

2.3 CliC and Ice Sheets Community

The main objective of the Climate and Chryosphere (CliC) Project is to assess and quantify the impacts that climatic variability and change have on components of the cryosphere and the consequences of these impacts for the climate system. In addressing this aim, CliC also seeks to determine the stability of the global cryosphere.

CliC is divided into four main themes:

- Terrestrial Cryosphere and Hydroclimatology of Cold Regions (TCHM)
  - role of terrestrial processes in water, energy, carbon cycles of cold regions
  - interactions and feedbacks between terrestrial and other elements of cryosphere/climate
- Ice Masses and Sea Level (IMSL)
  - contribution of glaciers, ice caps and ice sheets to sea level rise
  - how will ice shelves respond to changes in ocean and atmosphere
- The Marine Cryosphere and Climate (MarC)
  - impacts and feedbacks of a reduction in sea ice cover
  - nature of hemispheric differences between the two polar regions
- Global Predictions and the Cryosphere (GPC)
  - impacts of changes on ocean and atmosphere circulation
  - likelihood of abrupt climate changes

Efforts are underway within the CliC community to understand observed and projected changes in ice sheet mass balance and the contributions to sea level rise. Issues that are important are:

- Ice sheet-ice shelf interactions
- Ice shelf-ocean contact, where a warming ocean promotes basal melting
- Ice Stream-Basal Processes and relation to ocean warming
- Lubrication of ice sheet flow by meltwater

Accelerated ice-stream flow has been observed in both Antarctica and Greenland due to reduced ice-shelf buttressing, probably related to ocean warming. The contribution of ice-sheets to future sea-level rise is very uncertain. Regional ocean warming will also be a challenge to predict. Work is

underway to develop models of ocean-ice-shelf-ice-sheet interaction (SeaRISE, Ice2Sea). In Greenland, basal lubrication by surface meltwater commonly leads to accelerated flow, though this is generally not a dominant effect. Increased surface melting could also lead to modest additional ice discharge. Change in Greenland surface mass balance will determine the long-term future of the Greenland ice sheet. There are large uncertainties in models of surface mass balance and regional climate change. The partial loss of the ice-sheet could become irreversible in order of 100 years but the uncertainty in these estimates is huge.

2.4 WOAP

The WCRP Observation and Assimilation Panel (WOAP) is responsible for coordinating WCRP's interests in observational activities. WOAP is also co-sponsored by the Global Climate Observation System (GCOS). K. Taylor is WGCM's representative on WOAP. WOAP's objectives are to improve reanalyses and to sustain the continuity and development of observations for climate studies. This is the panel through which WGCM can communicate its observational data requirements.

ACTION: Include an update from WOAP in the agenda for the 14th WGCM Session in 2010

2.5 YOTC and MJO WG

The Year of Tropical Convection (YOTC) is a joint WWRP-THORPEX and WCRP project consisting of the coordinated observing, modeling and forecasting of organized tropical convection and its influences on predictability. YOTC has an intensive observing period covering May 2008 – April 2010, during which a number of synoptic periods of interest are being identified. High-resolution, global analysis and forecast data sets are being made available to the community from ECMWF (e.g. T799, includes diabatic fields), NCEP and GMAO/NASA. NASA is funding the satellite data (e.g., NASA A-Train, TRMM, geostationary) dissemination framework (NASA Giovanni). There are various overlapping field programs (e.g., T-PARC, VOCALS, AMY) that will benefit from and contribute to YOTC. At the July 2009 Implementation Planning workshop, a number of coordinated modeling experiments were also discussed and developed. The Science and Implementation Plans, along with relevant meetings and science sessions, data links, contacts etc can be found at the project website (www.ucar.edu/yotc).

A Joint WWRP-THORPEX/WCRP YOTC Task Force on the Madden Julian Oscillation (MJO) is close to being finalized. The MJO TF builds on the success of the US CLIVAR Working Group on the MJO (see Sperber and Waliser, 2008, CLIVAR MJO Working Group, 2009, Kim et al. 2010, Gottschalck et al. 2010). The Task Force will further develop process-oriented diagnostics/metrics that improve insight into the physical mechanisms necessary for the robust simulation of the MJO, with emphasis on vertical structure, diabatic processes, microphysics, etc. It will also further develop MJO forecast metrics and their application, with additional focus on boreal summer and ensemble development. Its activities include the development of a multi-model hindcast to assess MJO predictability and forecast skill. Additional diagnostic output will be produced during the YOTC period.

The prospects for resolving the MJO are improving. Now, a number of models have MJO-like variability (e.g., Kim et al., 2010), in a few cases too much, and a few operational centers appear to be demonstrating some useful skill in forecasting the bulk features of the MJO out to about 20 days (e.g., ECMWF, ABOM).

The need to involve more model developers (e.g. developers of convective parameterizations) in YOTC has been raised. There was a general concern expressed regarding the lack of model developers in the modeling community at large, with some discussion on the need to develop the means to draw in and retrain such expertise.

2.6 IDAG

The International Detection and Attribution Group (IDAG) has been in existence since the late 1980s. It was initially funded by the U.S. Dept. of Energy, and is now jointly funded by the U.S. DOE and NOAA. IDAG synthesizes detection and attribution results from individual members "to arrive at a fuller understanding of the human contribution to climate change". It has made substantial contributions to the IPCC process and to Synthesis and Assessment Reports of the U.S. Climate Change Science Program (CCSP). It also provides input to U.S. DOE and NOAA by means of review papers.

Recent IDAG work includes a review and summary of all climate sensitivity estimates, including the problem of combining constraints from multiple sources(Knutti and Hegerl, 2008).

The future goals of the IDAG group are to:

- Quantify and reduce uncertainties in global climate change projections using climate observations
- Quantify and reduce uncertainty in projections of impact-relevant climate variables, including regional changes and extremes
- Review the status of detection and attribution ("D&A") studies in preparation for IPCC AR5 Report

Future directions for IDAG include:

- Regional and "impact-relevant" D&A studies (changes in extremes, drought, etc.)
- Constraining projections of future climate change, with a particular focus on:
    - Multi-model techniques
    - "Detection of mitigation"
    - Analysis of CMIP-5 decadal prediction experiments
    - Analysis of carbon cycle feedbacks

2.7 IPCC AR5 Assessment Schedule

A report on the IPCC AR5 scoping meeting was given, with a discussion of the outline of the WG-I and WG-II reports. It is likely that 10 chapters (out of 13) of WG-I will assess CMIP5 simulations. There will be more interactions between WG-I and WG-II assessments than in the AR4. Two expert meetings are already planned: one in Boulder, USA on 25-27 Jan 2010 on "Assessing and combining multi-model climate projections", and one in Lille, France on June 14-16 2010 on "Regional Climate: Facilitating the production of climate information and its use in impact and adaptation work".

Since WGCM met in September, the AR5 assessment schedule has been extended (the final plenary has been moved from February 2013 to September 2013) – see Appendix 3.

The schedule is not intended to provide hard deadlines, but should provide some guidance regarding the schedule and when, during that process, papers submitted, accepted, or published can be assessed. There are a number of thresholds for papers to be assessed that are tied to the preparation

and review of the chapters at different stages of their development. In general, the earlier papers enter the assessment process the better.

3 CMIP5 Overview and Update

Over 20 global modelling groups are in the process of starting to generate their contributions to the Coupled Model Intercomparison Project, Phase 5 (CMIP5). The PCMDI CMIP5 website is in place and includes the full set of forcings for CMIP5 (emissions and concentrations) and the list of fields to save from the simulations.

ACTION: Apply version numbers to forcing datasets. PCMDI can do this in consultation with CMIP Panel; PCMDI make a copy if data served elsewhere; previous versions should only be replaced if there are major problems; keep in mind that when runs start, you can't start over.

Table 1: List of current CMIP5 participants.

Modelling Center	Country	Primary Contact
NERSC	Norway	M. Bentsen, H. Drange
Hadley Center	UK	M. Collins, C. Jones
University of Reading	UK	L. Shaffrey
IPSL	France	J-L. Dufresne, S. Bony
CERFACS & CNRM	France	L. Terray, D. Salas-Melia
CCCMa	Canada	G. Flato
MPI	Germany	M. Giorgetta
INGV	Italy	S. Gualdi
INM	Russia	E. Volodin
EC-Earth consortium	Europe	W. Hazeleger
NCAR	USA	J. Hurrell, G. Meehl
GFDL	USA	T. Delworth, I. Held, L. Horowitz, R. Stouffer
NASA GISS	USA	G. Schmidt
NASA GSFC	USA	M. Suarez
MRI	Japan	M. Kimoto
NIES & U. Tokyo	Japan	S. Emori, M. Kawamiya, M. Kimoto
METRI (with Hadley Centre)	Korea	W-T. Kwon
BCC	China	Q. Li, Y. You, Z. Wang, T. Wu, Y. Xu
LASG IAP	China	T. Zhou, B. Wang
CSIRO & QCCCE	Australia	T. Hirst, K. Puri
CSIRO & BMRC	Australia	L. Rotstayn, J. Syktus, S. Jeffrey

3.1 Representative Concentration Pathways (RCP)

The effort in developing Representative Concentration Pathways (RCP) has been ongoing between the climate modelling and Integrated Assessment Modelling (IAM) communities for over 15 years, but was particularly catalyzed since meeting in Aspen in 2006. All three RCP user communities have endorsed the agreement on the "parallel" RCP development process:

- Climate modelling community—need scenarios to provide a coherent, internally consistent, time-paths for Earth System Models.
- Impacts, adaptation & vulnerability modelling community—need scenarios to provide a coherent, internally consistent, time-paths to assess the consequences of potential climate changes and to set the context for adaptive strategies.
- Integrated assessment community—to provide a coherent, internally consistent, time-paths to assess the costs of emissions mitigation

The RCPs database of emissions, concentrations, and land-cover change projections as originally hosted at two sites in slightly different formats and with one site resolving the annual cycle:

IIASA: http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=welcome
Juelich: ftp://ftp-ipcc.fz-juelich.de/pub/emissions/gridded_netcdf/

The IIASA site provides all data that is available from the Juellich site and in addition also aerosol concentration fields and land-cover change information for the history and the RCPs. A web-based working environment supports comparisons across RCPs and base-year inventory data, quick data visualization and downloading of regional and spatial data

Information about the RCPs and the scenario development process for the IPCC AR5 can be found in the IPCC Expert Meeting Report on New Scenarios (Moss *et al.*, 2008). For a draft work plan summarizing the data exchange between the Integrated Assessment and Climate Modelling community see also the "Representative Concentration Pathways (RCPs) Draft Handshake" (van Vuuren, 2009, draft).

The Representative Concentration Pathways (RCP) database has been extended since the WGCM meeting to include a section with CMIP5 recommended data. This section includes:

1) Historical atmospheric concentrations as well as concentrations for the RCPs (2005-2100) and their extension to 2300 (ECPs). In total, atmospheric concentration of the following gases are provided: CO2, CH4, N2O, all flourinated gases controlled under the Kyoto Protocol (HFCs, PFCs, and SF6), and ozone depleting substances controlled under the Montreal Protocol (CFCs, HCFCs, Halons, CCl4, CH3Br, CH3Cl).

2) Historical emissions data (1850 - 2000) as well as emissions for the RCPs (2000-2100). In total emissions of the following gases are provided: CH4, SO2, NOx, CO, NH3, as well as of BC, OC and VOC. Other additional species such as C2H4O (acetaldehyde), C2H5OH (ethanol), C2H6S (dimethyl sulphide), C3H6O (acetone), etc. are available only for historical biomass burning emissions.

3) Historical aerosols data (1850 - 2000) on the following species: sulfate (SO4), ammonium nitrate (NH4NO3), hydrophobic black carbon (CB1), hydrophilic black carbon (CB2), hydrophobic organic carbon (CB1), hydrophilic organic carbon (CB2), secondary organic aerosols (SOA), dust (DST01-04, small to large sizes)) and sea-salt SSLT01-04). In addition, temperature (T) and surface pressure (PS) is provided to enable unit conversion (all aerosol are in kg/kg, dry mass). Spatial aerosol data for the future RCPs are added at the moment.

4) Historical and RCP land-cover projections.

Registered users of the database will receive information about further developments and updates of the database (download is only possible after registration).

The data for RCP 6.0 has recently been subject to internal review within the Integrated Assessment Modelling (IAM) community. Non-harmonized information for RCP 6.0 is available at the RCP database for many sources. Final datasets with fully harmonized baseline emissions for RCP 6.0 is under development, and will be made available soon.

ACTION: Advise IAM groups responsible for RCP 6.0 to use a post-2100 emission trajectory that stabilizes concentrations somewhere near concentrations in 2100 and to provide the forcing as soon as possible.

3.2 CMOR2 and Model Output Metadata

Version 2 of CMOR has been released for writing model output in compliance with CMIP5 requirements. It can be accessed from C, FORTRAN, and python codes. CMOR2 "input tables" are not yet available (awaiting completion of standard output tables).

The following are the changes in output requirements that are now in place relative to CMIP3:

- Output may be on native grid, rather than longitude-latitude grid
- New requirements for "station data" (for CFMIP runs)
- New requirements for "climatological" data
- New requirements for filenames and directory structures
- Additional global attributes: modelling_realm, tracking_id, model_id, creation_date, forcing, initialization_method, physics_version

The model and simulation documentation will be more complete than for CMIP3 with "type 2" metadata. The improved documentation process involves three steps:

- Developing a standardized vocabulary for describing models and model simulations
- Developing an interactive web-based questionnaire that makes it easy for modelling groups to provide the model and simulation documentation
- Placing the information in a searchable database linked to the model output

This is being led by two collaborative and interactive groups: Metafor (developing controlled vocabulary and schema for describing simulations) and Earth System Curator (developing web-based tools for ingesting metadata). A web-based questionnaire is being developed for modelling centres to fill in the details of which models are used, which forcing fields are used for each simulation, etc.

The CMIP5 "Data Reference Syntax" (DRS) has been defined for identifying CMIP5 output (GO-ESSP, BADC, NOAA, PCMDI) (Taylor *et al*., 2009). This specifies vocabulary for identifying models, simulations and the model output and will facilitate data discovery and automated processing of CMIP5 output.

ACTION: Ensure that registration occurs when model data are accessed, who is using which model data and a project name and short description of analysis to be performed.

ACTION: Recommendation to make it a requirement that the model metadata questionnaire be completed and made available before model output is made available by PCMDI.

ACTION: Recommendation for developing a system to track model use and reference models; development of equivalent DOI system. (Brian Lawrence).

ACTION: CMIP5 analysts should submit feedback about key results in addition to publication details.

3.3 ESG and CMIP5 archive

The Earth System Grid (ESG) has been developed by multiple partners, led by PCMDI, and is being deployed and tested now. The software needed by modelling centres to serve their data should be ready for deployment early in 2010.

CMIP5 model output will be served either by:

- "Publishing" it on a "node" of the ESG, or
- Sending it via multi-Tbyte disks (or via the web) to PCMDI (or in Europe, to the BADC or WDCC)

The ESG comprises of:

- A few "Gateway" portals, which keep track of all the data on the ESG and serve as the interface to the end-users
- Multiple "Data Nodes" where the data resides and which "publish" the data to the ESG.

PCMDI, BADC, WDCC, and possibly the other gateways will "mirror" a core subset of data harvested from the nodes. Data can be explored via a web interface and can be downloaded via GridFTP or other alternatives.

ACTION: Articulate that CMIP5 archive will continue to accept data that is submitted after the AR5 timeline since CMIP5 is (at least) a 5yr research activity.

3.4 CMIP5 Terms of Use

CMIP data will likely be divided into two classes: unrestricted and restricted-use. PCMDI will require agreement to the terms of use as part of the registration procedure but it does not accept responsibility for enforcement of the terms of use:

- PCMDI could rescind access privileges to the archive, but there would be nothing to prevent the offenders from re-registering.
- Legal proceedings against any offenders would be the responsibility of individual modelling centres.

ACTION: Terms of use for CMIP5 archive: Two levels of access - unrestricted and restricted; as long as use is only for research and education, PCMDI will wait for information

from Hadley Centre on its requirements, and then iterate with other groups who may have issues with restricted use.

4 Coordinated Experiments

4.1 CCMVal

The objectives of the Chemistry-Climate Model Validation (CCMVal) Activity, an Activity of WCRP's Stratospheric Processes And their Role in Climate (SPARC) Project, are to improve the understanding of chemistry-climate models (CCMs) through process-oriented evaluation and to provide reliable projections of stratospheric ozone and its impact on climate. The process-orientated evaluation is explained by Eyring *et al.* (2005) and divides CCMs into four basic process categories (see Figure 3, Eyring *et al.* (2005)): transport, dynamics, radiation, and stratospheric chemistry and microphysics. The four categories are fundamentally interdependent and interactive and require as inputs knowledge of human activities and natural processes. The CCM output includes a wide array of parameters and diagnostics associated with the four different categories. Table 2 of Eyring *et al.* (2005) lists the core processes used to evaluate CCMs with a focus on their ability to model future stratospheric ozone.

The CCMVal concept takes as a starting point the premise that model performance is most accurately assessed by examining the representation of key processes, rather than just the model's ability to reproduce long-term ozone trends, as the latter can be more easily tuned and can include compensating errors. The comparisons of model diagnostics and other outputs with atmospheric observations and meteorological analyses are the key to process-oriented CCM validation. The results of the comparisons can be used to provide feedback to the representation of processes in CCMs in order to improve the CCMs subsequently. In this way, the uncertainties in future trends in stratospheric ozone and other key model outputs can be reduced.

Around 100 scientists have analyzed the output of 18 CCMs for the second phase of CCMVal (CCMVal-2) and this will be published as part of the SPARC CCMVal Report in the first half of 2010 (see http://www.pa.op.dlr.de/CCMVal/SPARC_CCMValReport/SPARC_CCMValReport.html). A key aspect of the model evaluation within the SPARC CCMVal Report is the application of observationally based performance metrics to quantify the ability of models to reproduce key processes for stratospheric ozone and its impact on climate. There will also be a special issue of JGR. The process-oriented evaluation concept is currently being extended to Earth System Models (ESM) (also see talk by P. Friedlingstein, WGCM-AIMES joint day, 30/12/09), where the definition of processes will depend on the aspect of climate change of interest (temperature, precipitation, stratospheric-tropospheric dynamics, etc.).

4.2 CFMIP

The Cloud Feedback Model Inter-comparison Project Phase-2 (CFMIP-2) connects climate modelling, cloud processes, and satellite observations to understand and evaluate the simulation of cloud feedback processes. The CFMIP component of CMIP5, both experiments and outputs, has been finalized, the details of which are available on the CFMIP website.

CFMIP has developed the CFMIP Observations Simulator Package (COSP), a community tool for facilitating the comparison of model with satellite data. COSP currently includes simulators of ISCCP, CloudSat, CALIPSO, Parasol and MISR satellite data. For the first time, the vertical

distribution of model clouds can be compared with satellite data. More than 20 modeling groups (climate, NWP and CRM) have downloaded COSP and a fraction of them is already using it. Observations consistent with COSP diagnostics are available from http://climserv.ipsl.polytechnique.fr/cfmip-obs.html. A new version of COSP (V1.2) will be compliant with CMIP5 (and CMOR2) data format requirements.

CFMIP and GCSS (GEWEX Cloud System Study) collaborate on the study of cloud-climate feedbacks and processes. As a result of this collaboration, and to involve more efficiently the process community into the evaluation of GCMs and the analysis of cloud-climate feedbacks, high-frequency model output has been defined for CMIP5 for selected locations where field experiments or instrumented sites are (or have been) available, and in regions where the spread of model cloud feedbacks is large in climate change. CFMIP and GCSS also collaborate in the application of a hierarchy of models, from LES, CRM to GCMs to study cloud feedback processes. An ensemble of coordinated experiments (run either by LES, CRMs or single-column versions of GCMs) has been designed for this purpose (CGILS: CFMIP-GCSS Intercomparison of Large-Eddy and Single-Column Models, http://atmgcm.msrc.sunysb.edu/cfmip_figs/Case_specification.html).

The inclusion of the Cloud Feedback Model Inter-comparison Project, Phase 2 (CFMIP2) experiments in CMIP5 has created a direct link between the process and climate communities. At least 10 groups are currently participating and more are expected. A composite SST forcing dataset is available for patterned SST change experiments as well as a protocol for running aqua-planet experiments.

A question was raised on how aerosol forcings should be treated in AMIP and aqua-planet runs. WGCM urges groups to follow the CMIP5 specifications, which call for realistic inclusion of all external forcings (including aerosols). A mixture of approaches should be avoided because it makes a difference for top of the atmosphere (TOA) fluxes of shortwave and stratospheric temperature trends (to name just two). In aqua-planet runs, however, the focus is on idealized responses to SST or CO2 changes alone, so if aerosols (and any other forcings) are included, then they should not evolve over time.

ACTION: Endorse CMIP experiment design calling for time-varying "realistic" external forcings in AMIP simulations and simplified time-invariant forcing in aqua-planet runs.

4.3 PMIP

The Paleoclimate Modelling Intercomparison Project (PMIP) has entered its third phase (PMIP3) and is contributing to the CMIP5 list of simulations on the last glacial maximum (LGM), the Mid-Holocene and the last millennium. The experimental design of the experiments has been finalized (http://pmip3.lsce.ipsl.fr/). With regards to the LGM simulations, the vegetation map is not finalized yet and there is an ongoing discussion on the ice sheet reconstruction. The ice sheets reconstructed by ICE5-G for PMIP2 were too high in West Antarctica. Two possibilities are under discussion in PMIP3: the use of ICE6-G that has been improved on since ICE5-G, or the use of the newly developed MOCA ice sheet, which will also be used in PMIP3 deglaciation simulations. A call to the community has been done and the open discussion can be access on PMIP wiki (https://pmip3.lsce.ipsl.fr/wiki/doku.php/pmip3:index)

The last millennium PMIP3-CMIP5 simulations will assess the relative role of external forcing and internal variability in shaping the climate on interdecadal to multi-centennial time scales, ensuring

continuity with the CMIP5 control integrations. Experiments can be run from 850AD to 1850 AD, or continuing on to the year 2100, switching to CMIP5 boundary conditions after 1850. Most of the boundary conditions for the last millennium are ready and updates are available from the PMIP3 wiki page. A decision will be taken imminently on the default set of forcings that all groups must use, after which additional sensitivity simulations can be run with other choices of forcings.

Other PMIP3 areas include the PaleoCarbon Modelling Intercomparison Project (PCMIP) that focuses on the coupling between climate and the carbon cycle on Quaternary time scales and is a Tier 2 experiment for CMIP5. Groups running a ESM model with interactive carbone cycle are thus encourage to store the carbon fluxes as it is required for the CMIP5 RCP simulations. The Mid-Pliocene is also being simulated as part of PMIP3 since CO2 concentrations were higher than in pre-industrial conditions and the world was in a warmer equilibrium state.

About 15 groups will be participating in PMIP3 and more are expected to join. PMIP recommends that groups use the same model version as is being used for simulations of the current and future climate, though recognizing that the stress on resources may mean that different resolutions are used. It is recommended that groups be consistent with how the solar constant is treated between simulations of the last millennium and the CMIP5 historical runs to avoid discontinuities. There was also a comment that the paleoclimate modelling community is somewhat detached from the rest of the modelling community and more should be done to integrate paleoclimate in areas such as climate sensitivity, feedbacks, etc.

ACTION: Recommend that groups are consistent in how solar forcing is treated between PMIP-CMIP5 last millennium and historical runs; up to their own discretion as to what values used as long as they are consistent across simulations.

4.4 Task Force on Regional Climate Downscaling and CORDEX

The Task Force on Regional Climate Downscaling (TF-RCD) was formed in 2008 with a one-year mandate to design a framework for

- Evaluating and possibly improving RCD models
- Providing a coordinated set of RCD-based projections/predictions for regions worldwide
- Facilitating communication with the impact community and involvement of the research community from developing countries

The main outcome for the TF-RCD this year has been to organize the Coordinated Regional Climate Downscaling Experiment (CORDEX) that is aimed at fostering coordination between regional downscaling efforts around the world, and at assessing and understanding the sources of uncertainty in RCD-based projections. CORDEX has a model evaluation framework consisting in a set of simulations at 50 km resolution using ERA-Interim reanalyses as boundary conditions over the period 1989-2007, and a climate projection framework related to the RCP 4.5 and 8.5 CMIP5 simulations, contributing to the near-term, decadal runs. CORDEX will evaluate what is the added value of downscaling and address issues of uncertainty at small scales. The aim is to look at the regional changes in climate and air quality associated with the evolution of GHGs, aerosols, land use changes, etc, and to assess their possible impacts. The initial focus will be on Africa. One of the aims of CORDEX is to create teams of regional expertise to develop regional diagnostics and evaluate the simulations. A CORDEX website is being developed, there is commitment from global modelling groups to provide the necessary output, hosted by PCMDI, and results will be held in CORDEX databanks.

Overall, the TF-RCD has been very successful, with a good response from the regional climate modelling community. Some problems that the TF-RCD has encountered in its first year have been that only part of the TFRCD members have been regularly active and there is still insufficient involvement of the statistical downscaling, impact, and developing country communities. More representatives from these communities are needed on the task force. Since the CORDEX effort is only just beginning, it should continue to be overseen by a body that is in contact both with WGCM and WGNE. What this body should be is not clear yet, whether it should be a working group like WGCM, a small sub-group of WGCM or a task force of limited lifetime such as the TF-RCD. The recommendation is that the mandate of the TF-RCD be extended by another year so that the CORDEX activity can get underway and then a decision can be taken on how to best continue to coordinate it.

ACTION: Extend Task Force on Regional Climate Downscaling one more year to fully develop objectives. The Task Force should consult with WCRP on membership, perhaps including a member from AMMA.

4.5 Transpose AMIP

The aim is to run climate models in NWP-mode to test parameterizations while the circulation is still credible. In other words, if the clouds are wrong, it is probably due to parameterization issues. Model errors have been shown to develop in the first days of the forecast. More details and documentation is available on the project website: http://www.transpose-amip.info.

ACTION: WGCM endorse transpose-AMIP and add to catalog of MIPS on web page; C. Senior will be the WGCM representative.

5. Model Evaluation and Improvement, Observations

Now that CMIP5 is underway, WGCM and the wider modelling community has the opportunity to start the process necessary to achieve major improvements to develop the next generation of models, with an eye on a future CMIP6. WGCM will be strengthening its partnership with the WCRP Working Group on Numerical Experimentation (WGNE) that is also aiming to drive this process, working on parameterization development, metrics, organizing focused workshops, etc. As part of this partnership, a joint WGNE-WGCM initiative (named Transpose-AMIP, see section4.5) aimed at evaluating climate models in a numerical weather prediction mode has been endorsed. The community needs a major initiative to:

- Make model development a well-coordinated activity across WCRP (and beyond) that can benefit as much as possible from the various WCRP resources in observations, process studies and modeling.
- Balance the “resolution will solve everything” belief with a more holistic approach of improving resolution along with understanding feedbacks and physical processes that would be vital for the climate change problem
- Inspire young people to come into model development
- Engage and support major modelling centres

5.1 Observations for CMIP5 Simulations

A framework to facilitate the use of observations to evaluate CMIP5 simulations has been proposed, initially for NASA, but hopefully for expansion to other agencies and data centres (a discussion

about this is underway within WOAP). The proposal aims to identify the observational datasets that are pertinent for CMIP5 analysis, something never done before, engaging the observational community directly. A strategy is being developed to provide the community of researchers that will access and analyze CMIP5 model results access to analogous sets of observational data in a common and convenient format:

- Analogous sets in terms of periods, variables, temporal/spatial frequency
- Activity to be carried out in close coordination with the corresponding CMIP5 modelling entities and activities
- It will directly engage the observational (e.g. mission and instrument) science teams to facilitate production of the corresponding data sets.

The CMIP5 protocol can be used to extract information on what variables, periods, temporal frequencies etc are being analyzed in the model output. The participation of observational teams would be requested in a similar way as of modelling groups for CMIP5. The need to inform modellers about observations, uncertainties and differences across algorithms has been raised and will be taken into account.

The main tasks of this project will be to:

- Work with modelling/observational communities to identify data sets;
- Work with observational teams to establish the metadata for datasets while documenting as best as possible the quality of observations;
- Work with the observational science teams to facilitate production of the identified datasets, with the needed characteristics and formats;
- Organize these datasets and provide a strategy for accessing them in close parallel with the model data archive.

ACTION: WGCM endorses the framework proposed by NASA for providing observations for comparison to model simulations including those in CMIP5; observations are needed in same format as model standard output; Recommend the formation of a contact group with representatives from modelling groups, WOAP, GEWEX; take these recommendations to the next WOAP meeting (K. Taylor is the WGCM contact WOAP); emphasize to WOAP the importance and observational needs for model evaluation; recommend that WOAP invite a presentation on the NASA project at its next meeting; make WOAP aware of ESA initiative and ISENES, (P. Bracconot, C. Senior and N. Mahowald, et al to communicate with K. Taylor to take this forward to WOAP, together with G. Meehl and K. Trenberth).

5.2 WCRP-WWRP-THORPEX Survey on Model Evaluation and Improvement

Model errors and biases are key limitations of the skill of model predictions over a wide range of time and space scales. This is not a new story and the increase in resolution and model complexity has not solved the problem. In an effort to reinvigorate the discussion of how to make progress in model development, a bottom-up community-wide consultation has been initiated within WCRP and its core project working groups and panels, WWRP and THORPEX, and IGBP. The groups surveyed range from the process study, theoretical and observational communities to the NWP and climate modelling communities. The fact that WCRP is undergoing a period of evolution in its structure is an opportunity to put the recommendations from the survey into action.

The survey (download Word or PDF) asks a series of questions to highlight what are the key uncertainties/deficiencies/problems of current models, whether there are gaps in current knowledge or practice, whether there are resources available that should be better exploited and what could make the model improvement processes more effective.

More than 100 responses have been received so far, many of which are group, lab or project-wide responses. The survey recommendations and outcomes will be available on a dedicated website and the results will be synthesized for the WCRP, WWRP and THORPEX steering committees. The survey outcomes will help to provide advice regarding where international coordination and efforts need to be strengthened. The results will also be published in the peer-reviewed literature.

The initial evaluation of the survey responses indicates the following needs of the communities that have been surveyed:

- Promote the growth of the model development community
- Organize systematic and coordinated investigations (physical/statistical) of the link between model errors and prediction errors
- Reduce the gap between large-scale modelling/processes/observations communities
- Reduce the gap between climate/NWP/assimilation communities
- Observations – facilitate access, the use for model evaluation and sustain the observing system
- Facilitate the sharing and the distribution of resources (data, simulators, diagnostics tools and codes)
- Adapt the configuration of international programmes to facilitate exchange and collaboration between different disciplines and communities

ACTION: Model improvement survey - continue collecting responses, the results should be written up (e.g. report to the JSC, a BAMS-like paper for wider distribution) and should clearly target particular goals. The outcomes of the survey should promote model development.

6. WGCM Discussion Topics

6.1 Air Quality and Climate

An international effort has been underway to provide improved emissions for the period 1850-2300, harmonized across the years 2000-2005 for anthropogenic (including shipping and aircraft) and biomass burning of reactive gases (not ODSs) and aerosols. The resolution is sufficiently high to assess the sub-national distribution of emissions.

A WCRP Atmospheric Chemistry and Climate (AC&C) model intercomparison activity has been initiated that includes all major chemistry-climate modelling groups. The specific science issues relevant to the AR5 are:

- Diagnostic and analysis of radiative forcings
- Climate penalty of air quality
- Understanding long-term trends in tropospheric chemistry
- Climate impact of reducing ship emissions

Phase 1 of the AC&C MIP involves:

- Timeslice experiments to complement AR5
- Emission sensitivity studies (isoprene, CH4, …)
- Sensitivity to IAM modelling of emissions for each RCP
- Assessment of the spread from using climatology (chemistry-climate models only)

The increase in model resolution enables the representation of pollution events (surface condition for ozone, CO, aerosols) and regional impacts on climate, though the accuracy of emissions is a limitation. There may be feedbacks related to air quality on vegetation and CO_2. An issue for this activity is that there is no direct link to the air quality impact community. Also, these efforts on emission/concentration development should become a more integrated part of the planning process for CMIP, putting in place a connection to WGCM.

ACTION: Include an update from the AC&C MIP in the agenda for the 14th WGCM Session in 2010 (J.-F. Lamarque)

6.2 Geoengineering

The discussion at WGCM acknowledged the scientific interest of exploring, with a range of models, how climate might respond if a reduction of the shortwave radiation absorbed by the climate system was imposed to offset the greenhouse gas warming. Several groups have already conducted such experiments, but all have done different experiments with respect to global warming and geoengineering forcing. To address this research problem and to assess the robustness of the model results (e.g. the regional response of the hydrological cycle to a combination of greenhouse and solar forcings), coordinating geoengineering-like experiments would be useful.

WGCM encourages a few modelling groups to participate in a pilot experiment, then update WGCM in 2010 on progress made over the year, perhaps advocating a more general coordinated geoengineering experiment based on the pilot experience. Since such experiments may involve stratospheric aerosols at some point, the advice is to keep SPARC (V. Eyring, WGCM representative) updated regarding these activities in case some members of their community want to get involved.

Since the WGCM meeting, Kravitz *et al*. (2009) have submitted a proposal to the wider community that aims to evaluate the efficacy and risks of stratospheric geoengineering with sulfate aerosols. Standard forcing scenarios applied to a variety of climate models will allow the comparison of results and determination of the robustness of different responses. Two experiments have been proposed. In one (called G1), models will be forced with solar constant reductions to just counter-act the positive radiative forcing from a 1% increase in CO2 per year started from a control run. In the other (G2), starting from the RCP 4.5 runs at year 2020, the models will apply SO2 or sulfate aerosols to the stratosphere to counteract the subsequent anthropogenic radiative forcing, taking advantage of each model's ability to create, grow, and transport aerosols, and affect O3 chemistry or the carbon cycle.

In an on-going discussion, WGCM notes the addition of a simpler, more idealized experiment, to help diagnose and understand differences in model responses and learn more about the physical processes that control the regional temperature and hydrological responses. However, any of these simplified coordinated geoengineering experiments must recognize the many other aspects involved that complicate this issue considerably, not only ethical and equity-related, but those involved with

physical science, for example the fallout of stratospheric sulfate that could form acid rain. This process and others must be addressed in more comprehensive models.

ACTION: Encourage participation, if groups are able to, in demonstration project on geoengineering. Work is ongoing on developing a simplified experimental design over the coming year. Make contact with European groups organizing similar activity. Present outcomes at next WGCM meeting to advocate best practice in this area. Coordinate with SPARC (V. Eyring).

7. Current status of ESM development and future directions.

The final day of the WGCM meeting was held jointly with the IGBP Earth System modelling project Analysis, Integration and Modelling of the Earth System (AIMES) Scientific Steering Committee. It included updates on the state of the art in ESM in Japan, Europe and the USA as well as a discussion on what the increasing complexity of ESMs means for evaluating uncertainties, feedbacks and climate sensitivities.

7.1 Evaluation of ESMs

There will be new issues emerging with CMIP5 now that some modelling groups are running first generation ESMs, with new questions arising on how to evaluate them and how to inter-compare them. The level of complexity in the biogeochemical cycles simulated by the ESMs, which will certainly differ between groups, involves:

- Land and ocean carbon cycle models
- Vegetation dynamics
- Land cover change
- Nitrogen cycle
- Methane sources
- Emissions from fires
- VOCs, aerosols (land and ocean sources)

Land cover change is a driver for most ESMs. There is not a single methodology to account for transitions in land cover and the associated changes in emissions. Problems also will arise when the prescribed land cover change is inconsistent with the modelled vegetation cover. The nitrogen cycle is a key control on photosynthesis and carbon uptake. The size and nature of the effect of including nitrogen on the carbon cycle feedback appears to be model dependent. Accounting for methane emissions affects both methane (CH_4) and CO_2 concentrations since they interact. Fire will modulate the carbon cycle feedback, the vegetation distribution, aerosols emissions, CH_4 emissions, etc.

There is the risk that the analysis of CMIP5 simulations will lead to a very large apparent uncertainty so there is the need to separate apparent versus real uncertainty and to clearly identify/differentiate families within CMIP5, for example:

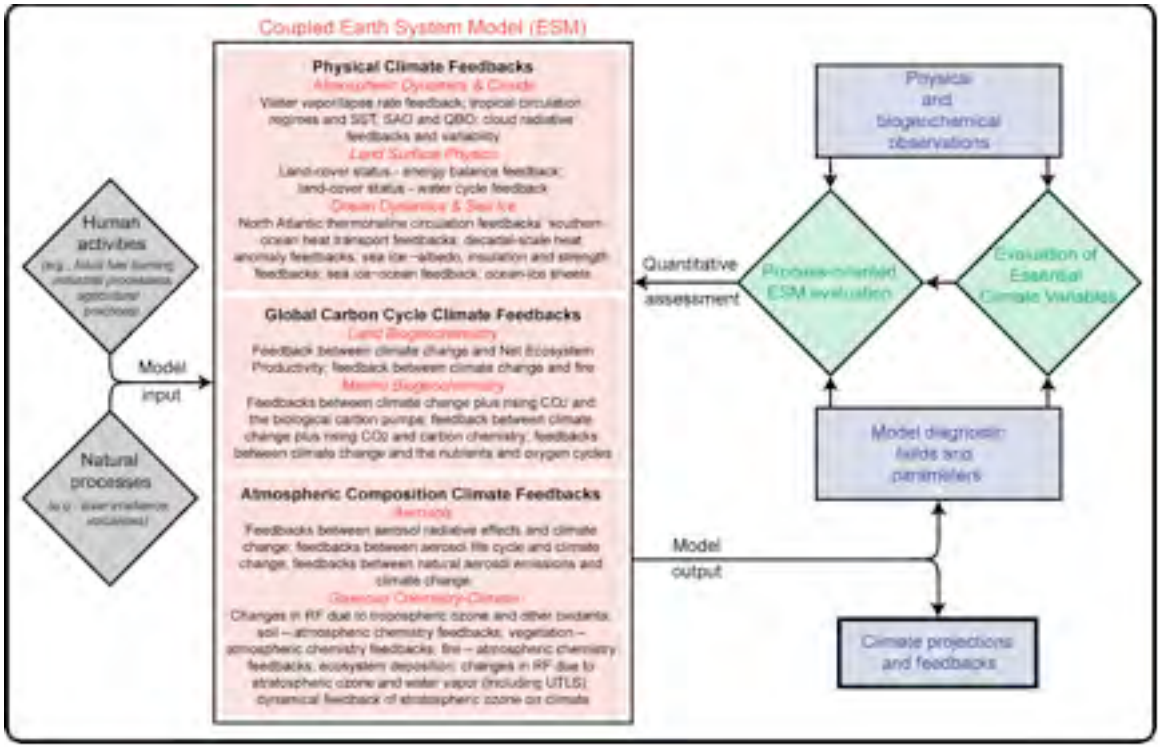
- Carbon cycle feedback
  - Carbon only models vs. C-N models
  - Dynamic vegetation vs. static vegetation
- Compatible emissions

- Land use cover emissions computed vs. imposed
- Total emissions vs. fossil fuel only

- Radiative forcing
  - Interactive vs. offline CH4, aerosols, etc.

The need to coordinate efforts on the process-oriented analysis and evaluation of ESMs across the different MIPs (C^4MIP, CFMIP, CCMVal, etc) has been recognized. The Coupled Carbon Cycle Climate Model Intercomparison Project (C^4MIP) proposes to coordinate the "carbon cycle oriented" analysis of CMIP5 ESM simulations in terms of model evaluation, feedback analysis, the detection and attribution of changes in the carbon cycle, uncertainty in compatible emissions, etc. The concept of process-oriented ESM evaluation, Figure 1, has evolved from the CCMVal experience (Eyring et al., BAMS, in prepratation, 2010).

Figure 1: ESM process-oriented evaluation



7.2 Forecasting biogeochemistry and biology in the Earth System

The model and data needs of forecasting biogeochemistry and biology in the Earth System were discussed together with a presentation of the National Ecological Observatory Network (NEON), an observing system in the USA with 20 eco-climatic zones. NEON data is being integrated to produce analyses and forecasts, for example, of the suitability of habitats for invasive species. Long-term observations of relevant quantities are necessary to assess and develop models.

7.3 Coupling IAMs and ESMs

The meeting addressed the future directions for Integrated Assessment Models (IAMs), including the prospects for coupling IAMs to ESMs, and adding human dimensions. There have been three

major transformations in the human population over time, the last being since the industrial revolution. From an Integrated Assessment Modelling (IAM) perspective, there will be a new change in population over the next century. This will be in part intentional, due to policies and choices in development paths, and in part depending on natural processes and climate. This gives the motivation for coupling the IAM and ESM disciplines.

IAMs conduct human systems research that is historically focused on the energy-emissions interface. The IIASA Modelling Framework couples state of the art models from different disciplines, for example forestry management models, agricultural models, etc. There is scope to go further in coupling human dimensions to ecosystems and other components of the natural system. Coupling to ESMs would permit, for example, a better representation of land use.

There are three possibilities for coupling IAMs and ESMs:

- Soft-linking as an extension of current RCP "hand-shake" approach by an iterative coupling.
- Hard-linking could be based on nesting IAMs within ESMs or through some other method of "endogenizing" anthropogenic drivers of land-use change and emissions including mitigation and adaptation.
- Ultimate objective is to link the human with natural earth systems – the Integrated Anthropocene (human and Earth) System Model (IASM).

IASMs could couple human well being and earth systems in an internally consistent way by integrating emissions, land-use and land-cover, carbon and nitrogen cycles, energy, industry, transport, settlement patterns, agriculture, forestry with the physical climate system.

7.4 Links between WCRP and IGBP

The closing discussion of the joint meeting focused on the common interests between WCRP and IGBP in pursuing a coordinated strategy for Earth System Modelling, looking at what are the key questions that should be addressed by a suite of ESMs and how to best develop the models needed to address these questions, including what are the climate related questions and what additional dimensions could be included into ESMs. The idea is to think ambitiously on where ESMs are going in the future and whether other collaborations are necessary that are outside the traditional WCRP-IGBP partnership. Future plans should also include a 'deliverables' dimension on how observations and model improvements lead to capabilities for those investing in the fundamental research as well as users of the output information.

The question arises of which aspects of social sciences need to be brought into ESM development, though difficulties are inevitable since the differences within the social sciences are even greater than those between disciplines of the natural sciences. The human response to questions that are presented by ESMs needs the appropriate expertise, whose current point of contact is through AIMES. More collaborations may be necessary and in addressing interdisciplinary questions, these need to be activated early, giving 'ownership' of the problem and model development to the new partners. At what point does, or can, ESM science become coupled to policy and stakeholder involvement? The deficiencies of the current model components, including those of the underlying physical system, are such that these models may only be ready for studies to understand the system, and not for predictions, in other words, it may be too early to be raising expectations of deliverables for policy etc.

Subsequent discussions pointed to the need for a workshop and white paper to be completed near the end of the CMIP5 and IPCC AR5 time frames, in mid or late 2012. The goal would be to evaluate the collaborations orchestrated by CMIP5, identify any research gaps that emerged in the AR5 process, and formulate a strategy to go beyond 2013 for next steps in ESM development and further collaborations between WGCM and AIMES.

8. WGCM Business

8.1 Membership

C. Senior (UK Met Office) and N. Mahowald (Cornell University) have joined WGCM as new members. M. Kimoto, F. Giorgi, M. Giorgetta and D. Karoly have all agreed to renew their terms.

8.2 Next Meeting

The 14th WGCM Session will take place at the UK Met Office on 4-6 October 2010, hosted by C. Senior.

WGCM will look into the possibility of holding a joint meeting with WGNE in the near future, likely in 2011.

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Appendix 1

13th Session of the Working Group on Coupled Modelling
September 28-30 2009, San Francisco USA
Day 3: 4th Joint WGCM-AIMES Meeting
Tidewater rooms A and B
Cavallo Pt., Sausalito, CA, USA

Agenda
(last updated September 24)

DAY 1 - Monday, September 28

0800 – 0900 Breakfast and registration

0900 - 0915

Welcome - G. Meehl and S. Bony
PCMDI host welcoming, local arrangements (P. Gleckler/K.Taylor)
Agenda and objectives of meeting (G. Meehl and S. Bony)

0915 - 1015 (10 minutes each)

WCRP restructuring update (G. Asrar)
Report from JSC-30 Maryland (G. Asrar)
Report from CLIVAR SSG (S. Bony)
Report from WCC3 (G. Meehl)
Report on IPCC Scoping Meeting Venice (S. Bony)

1015 - 1045 BREAK

1045 - 1115 CMIP update

Status of current archive, readiness and preparation for CMIP5, fields list, data distribution, archiving capability (R. Stouffer, K. Taylor, P. Gleckler)

1115 - 1130 RCP update

Review RCP issues from past year, post-2100 issues, readiness issues, evaluate process (N. Nakicenovic)

1130 - 1145 CMIP5: Dedadal prediction

WGCM-WGSIP Contact Group, WGSIP, upcoming workshops (G. Boer)

1145 - 1230 CMIP5: Other aspects, including Long Term (10 minutes each)

CFMIP and cloud feedback experiment status (S. Bony)
PMIP and paleo experiment status (P. Braconnot)
SPARC and ozone status (V. Eyring)
WGOMD and ocean model status (G. Danabasoglu)

1230 - 1400 LUNCH

1400 - 1445 CMIP5: Other aspects, including Long Term aspects (10 minutes each, continued)

Regional climate and CORDEX (F. Giorgi)
IDAG (B. Santer)
CLIC, ice sheet status and sea level rise (A. Abe-Ouchi, 15 minutes)

1445 - 1530 Observations, model evaluation and development (10 minutes each)

Observations, WOAP (K. Taylor)
YOTC/MJO (D. Waliser)
NASA initiative on obs for CMIP5 (J. Teixeira)

1530 - 1600 BREAK

1600 - 1630 Observations, model evaluation and development (10 min each, continued)

WGNE, transpose AMIP (C. Jakob)
Presentation of model improvement survey and synthesis discussion (S. Bony, A. Pirani)

1630-1730 Discussion and re-cap of day
Session ends for the day ~1730
No host reception and PCMDI hosted dinner at Cavallo Point
Guest Lecture by K. Sperber

DAY 2 - Tuesday, September 29

0800 – 0900 Breakfast and registration
0900 - 0915 Review previous day and outline agenda for the day
(G. Meehl and S. Bony)

0915 - 1030 Reports on national activities in preparation for CMIP5
(12 minutes each, 3 minutes for questions)

USA, GFDL (R. Stouffer)
USA, NCAR (G. Meehl)
Canada, CCCMa (G. Flato)
Japan, CCSR/FRGC/U. Tokyo/NIES; MRI (M. Kimoto)
China, LASG; BCC (J. Liu)

1030 - 1100 BREAK

Australia, ACCESS (T. Hirst)
U.K., Hadley Centre; Reading (C. Senior and John Mitchell)
Italy, ICTP; INGV (F. Giorgi)
Germany, MPI (M. Giorgetta)
France, IPSL; Meteo France (P. Braconnot and S. Bony)
EC-Earth (C. Jones)
Other groups, GISS, NGFC, Korea, Denmark, Norway (G. Meehl)

1230 - 1430 LUNCH with visit to Kirby Cove
(we will be taking a picnic to this secluded beach with great views of San Francisco)

1430 - 1600 Discussion topics (10 minutes each)

TC-MIP (T. Hirst, on behalf of K. Walsh)
Air quality and climate change (J.F. Lamarque)
Connections to WG1, WG2, IGBP, CRC Workshop report (G. Meehl, K. Hibbard)
Connect to modelling in other parts of WCRP, WCRP re-org, (G. Meehl, G. Asrar)
Coupling IAMs to ESMs (N. Nakicenovic)

1600 - 1630 BREAK

1630 WGCM business
Spring 2011 model analysis workshop/WCRP workshop; 2010 AIMES workshop in Edinburgh
Discuss joint meeting with AIMES tomorrow
Membership
Next meeting
Adjourn ~1800
Evening out in San Francisco

DAY 3 - Wednesday, September 30: 4th Joint WGCM-AIMES Meeting

0800 – 0900 Breakfast and registration

Current status of ESM development and future directions.

0845-0900 Welcome and outline of joint WGCM-AIMES session
(G.Meehl, D.Schimel, I.C.Prentice)

0900-1030 Session I: G. Meehl to moderate, WGCM perspective

0900-0930 Prospects and the future of earth system modeling: Japan (M. Kimoto)
0930-1000 Prospects and the future of earth system modeling: U.S. (R. Stouffer)
1000-1030 Prospects and the future of earth system modeling: Europe (C. Senior)

1030-1100 BREAK

1100-1230 Session II: I.C. Prentice to moderate, IGBP perspective

1100-1130 Earth System Prediction (D. Schimel)
1130-1200 Biogeochemistry and Earth system Modeling (P. Friedlingstein)
1200-1230 Complex Systems Modeling (Jae Edmonds/John Finnigan)

1230-1400 LUNCH

1400-1530 Session III: D.Schimel to moderate
Discussion: Next steps, Opportunities, Cross cutting themes, coordinated experiments

1530-1600 BREAK

1600-1730 Session IV: G. Meehl to moderate
Discussion: Future directions for WCRP and IGBP, Ghassem Asrar, Sybil Seitzinger

1730 Adjourn

1800 Joint AIMES/WGCM Social Event TBD

Appendix 2
Attendees

Attendee List

WGCM Meeting
Cavallo Point
Sausalito, CA

Sept. 28-30, 2009

Name	Affiliation	Email address
Abe Ouchi, Ayako	Center for Climate System Research, Univ. of Tokyo	abeouchi@ccsr.u-tokyo.ac.jp
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Appendix 3
IPCC AR5 WG1 publication guidelines (December 7, 2009)

IPCC AR5 WG1 publication guidelines (December 7, 2009)

(denotes provisional key dates for publications to be assessed)**

This is still an approximative list which needs to be confirmed by WGI. It is intended to provide rough guidelines concerning timing of the IPCC AR5 process for assessing papers

First Lead Author meeting November 2010

**Zero order draft formulated November 2010 – Feb 2011: preprints, papers submitted, accepted, in press, and published are all eligible for consideration

Informal zero order draft reviewed April—June, 2011

Second Lead Author meeting July 2011

**First order draft formulated July--October, 2011: preprints, papers submitted, accepted, in press, and published are all eligible for consideration

First round of formal review December 2011—February 2012

Third Lead Author meeting April 2012

**Second order draft formulated April-July 2012: preprints no longer eligible; submitted papers no longer assessed after 31 July 2012; papers accepted, in press, and published still eligible for consideration

Second round of formal review October—November 2012

Fourth Lead Author meeting January 2013

**Final draft formulated January-March, 2013: pre-prints and submitted papers no longer eligible; papers must be in press, or published. Final versions of papers must be officially accepted by 15 March 2013 (letter of confirmation by editor);

Final review June—August, 2013

IPCC AR5 WG1 Plenary September 2013

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