WCRP REPORT

World Climate Research Programme

WORKING GROUP REPORT

Report of the eighteen session of the Working Group on Coupled Modeling

Grainau/Garmisch-Partenkirchen, Germany,
8-10 October 2014

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WGCM18 participants in front of the Eibsee

WGCM18 participants at the Zugspitze

Executive Summary

The 18th session of the Working Group on Coupled Modeling was held at the Eibsee Hotel, Grainau/Garmisch-Partenkirchen, Germany, 8-10 October 2014 and kindly hosted by the German Aerospace Center (DLR). Most of the session was dedicated to refining the CMIP experimental design in close consultation with representatives of the modeling community, in particular the composition of the DECK, the criteria for MIP endorsement, the CMIP timeline including the review process and forcings, and coordination with the WGCM Infrastructure Panel (WIP) regarding protocols, standards and data request.

The DECK which will serve as an entry card for CMIP will consist of the following four simulations: (a) AMIP simulation (~1979-2014); (b) Pre-industrial control simulation; (c) 1%/yr CO2 increase, and (d) Abrupt 4xCO2 run. In addition, the CMIP6 Historical Simulation has been added which will serve as the entry card for CMIP6 and as a benchmark for CMIP6-Endorsed MIPs. The historical simulation (1850-2014) will use the specific forcings consistent with CMIP6. The CMIP6 Historical Simulation has been introduced in addition to the DECK to better separate CMIP from a specific Phase of CMIP. Both DECK and the CMIP6 Historical Simulation should be run for each model configuration used in the subsequent CMIP6-Endorsed MIPs. Future climate change scenarios will be run as part of ScenarioMIP with a Tier 1 that includes three different scenarios, spanning different possible futures.

The criteria for MIP endorsement have been streamlined and agreed at the WGCM 18th session. They now comprise a single set covering MIPs and their experiments. MIP co-chairs have been asked to tier their simulations and to identify synergies with other MIP experiments since the set of Tier 1 experiments proposed is currently much larger than what the modelling groups are able to run.

A timeline towards MIP endorsement and beyond has been presented and agreed. MIP co-chairs have been asked to complete (except for the information on the data request), scientifically revise and harmonize their applications by 29 November 2014. The completed applications will then be sent out for review by the wider community (e.g., WCGM, WCRP Grand Challenges and the theme of collaboration on biogeochemical forcings and feedbacks, WCRP Core Projects, MIP co-chairs and modelling groups) which will give everyone the opportunity to provide input. It is aimed to finish this review process by mid-January and to provide the MIP co-chairs with a synthesis with comments and recommendations for each MIP by mid-February 2015. Final MIP proposals with all information should then be returned to the CMIP Panel by end of March 2015. The Panel will then be able to endorse the MIPs that fulfil the agreed criteria by the end of April 2015.

To ensure a proper description of the CMIP experimental design, a special issue will open ~April 2015 with envisaged submission of an overview of the CMIP6 design (including DECK and CMIP6 Historical Simulation) by the CMIP Panel and WGCM co-chairs and a description of each of the April-endorsed MIPs by December 2015 at the latest. In addition, it is hoped that the forcing datasets will be described in this Special Issue. Forcing groups will be asked to provide an initial description of their datasets by 31 January 2015 so that all modelling groups can review the datasets. Inputs to the data request will be coordinated by the WGCM Infrastructure Panel.

MEMBERS: Sandrine Bony (WGCM Co-chair), Cath Senior (WGCM Co-chair), Veronika Eyring (CMIP Panel Chair), Anthony Hirst, Masa Kageyama, Michio Kawamiya, Gerald (Jerry) Meehl, Bjorn Stevens, Claudia Tebaldi, Detlef van Vuuren, Bing Wang

EX-OFFICIOS: Julio Bacmeister, V. Balaji, Gokhan Danabasoglu, Pierre Friedlingstein, Peter Gleckler, Gerard Krinner, Jean-Francois Lamarque, Grigory Nikulin, Ron Stouffer, Karl Taylor,

MODELING GROUPS (days 2 and 3): Susanne Bauer, Young-Hwa Byun, Jean-Louis Dufresne, Marco Giorgetta, Silvio Gualdi, Trond Iversen, Colin Jones, Hideaki Kawai, David Salas-Melia, John Scinocca, Zhenya Song, Swapna, Bart van den Hurk, Evgeny Volodin, Masahiro Watanabe, Tongwen Wu, Wei Xu, Jie Zhang, Tianjun Zhou

DLR-LOCAL HOST: Markus Rapp, Sabrina Wenzel

WCRP JPS: Michel Rixen

CLIVAR ICPO: Anna Pirani

EXCUSED: Andy Brown, Peter Cox, Helge Drange, Greg Flato, Filippo Giorgi, Bill Gutowski, Christian Jakob, Sonia Seneviratne, Jean-Noël Thépaut

WGCM-18 session

1. Opening

1.1 Welcome (M. Rapp)

Markus Rapp, Director of the Institute of Atmospheric Physics (IPA) at the German Aerospace Center (DLR) welcomed all participants and provided a short introduction on his Institute. DRL has 7700 employees and includes 32 institutes and facilities distributed across 16 sites and covering research fields in aeronautics, space research and technology, transport and energy. IPA itself involves 130 staff, including 30 PhD students with a budget of 14M € and covers Earth-System Modelling (ESM evaluation group led by V. Eyring), atmosphere trace constituents, remote sensing, transport meteorology and lidar technology.

1.2 Meeting objectives and agenda (S. Bony, C. Senior)

WGCM Co-chairs, Sandrine Bony and Cath Senior, thanked all participants for their attendance, and DLR for their hospitality, and Michel Rixen for his help in the preparation of the meeting. They highlighted the importance of this session mainly dedicated to the CMIP6 preparation, the main objective of the meeting being to reach a final agreement on the experiment design. A quick round table allowed everyone to introduce themselves.

2. CMIP6: Overview and organization (V. Eyring)

Veronika Eyring provided a general overview of the CMIP6 design, organization, timeline, structure and proposals in the context of the WCRP Grand Challenges and **three broad scientific questions**:
1.How does the Earth System respond to forcing?
2.What are the origins and consequences of systematic model biases?
3.How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?

She recalled the proposed 2 elements of CMIP, namely 1) the Ongoing CMIP Diagnostic, Evaluation and Characterization of Klima (DECK) experiments and 2) Standardization, coordination, infrastructure, and documentation functions.

The set of simulations proposed for the DECK at the WGCM 17th Session that was reviewed again at this meeting was:

1. AMIP simulation (~1979-2010);
2. Pre-industrial control simulation;
3. 1%/yr CO2 increase;
4. Switch-on 4xCO2 run;
5. 20thC simulation;
6. Future simulation using an existing scenario (RCP8.5).

She then summarized the main comments received from the community, which supported the more distributed CMIP structure and the limited size of the DECK. Major concerns covered timelines, model documentation, coupling between DECK and CMIP cycles and the ScenarioMIP location within the structure. She stressed that the first 4 components of the DECK do not have dependencies in generating future simulations. A proposal was made for criteria and a process to endorse MIPs, including a proposed threshold number of participating groups. Mappings of MIPs against the CMIP6 questions and Grand Challenges, number of experiments and years of model simulation were presented. Some recommendation was also made for MIPs to tier their experimental design.

The ensuing discussion aimed at seeking an agreement on:
(1) the overall structure;
(2) the composition of the DECK;
(3) communication with CMIP6-Endorsed MIPs and Modelling Groups;
(4) what it means for a MIP to be endorsed by CMIP6 and what is the process for it;
(5) process to approve individual experiments proposed by CMIP6-Endorsed MIPs ;
(6) special issue of CMIP6 experimental design;
(7) process and timeline for CMIP data request list issues to be approved/finalized at the meeting.

Several attendees commented on the nature of the DECK, which should include "well established" and "routine" work at modelling centres, and recommended the DECK to remain small and affordable, with possibly the first four DECK elements (which are typical CMIP continuous simulations) and leaving out elements 5 and 6 (more related to typical CMIP cycle simulations), and any idealized aerosol experiment. LMIP and OMIP were also discussed as being part of the DECK, but unlike AMIP runs which have been the foundation of CMIP exercises since the beginning, it was decided that LMIP and OMIP should not be part of the DECK this time because not all groups are accustomed in running these experiments, but these are potential candidates for the DECK in future phases. To better separate CMIP from a specific phase of CMIP, it was suggested that the CMIP6 Historical Simulation is removed from the DECK and rather displayed separately, and that the future simulation is part of Tier 1 of ScenarioMIP.

3. CMIP6 infrastructure, WGCM Infrastructure Panel (V. Balaji, K. Taylor)

On behalf of the WGCM Infrastructure Panel (WIP) the Co-chairs, V. Balaji and K.E. Taylor reported on its activities. This panel was established 6-months ago, to promote a robust and sustainable global data infrastructure in support of the scientific mission of the WGCM. This has been carried out in the past by a handful of individuals, but with the increasing complexity and scale of CMIP, the WGCM believed that it was best to have this formally managed by a consortium of software developers, and scientific representatives from the modelling groups. The goal is to establish standards and policies for sharing climate model output and ensure consistency across WGCM activities, and to review and provide guidance on requirements of the infrastructure.

The WIP's current strategy is to develop position papers on infrastructural issues to guide development. Over the last several months the WIP has drafted 4 such white papers:

- a paper recommending open access policies, which will simplify and greatly expand the scope of activities that can be performed on ESGF servers;
- a paper on data citation policies, which will ensure proper credit to the modelling groups who provide data, and provide provenance information linking datasets to the simulations;
- a document providing a checklist for the chairs of endorsed MIPs, outlining the steps they need to follow to write a protocol that is compliant with the requirements of the WGCM;
- an ongoing assessment of data volumes to be expected given the experimental design and plans of the modelling centres. This discussion included the possibility of a simplified repository for downstream users, with high-value variables made available on a common grid.

Drafts of the position papers will be released over the course of 2015. In particular, the WIP will work with the CMIP Panel and the endorsed MIP chairs to finalize the CMIP data request by April 2015.

The WIP URL is: http://cog-esgf.esrl.noaa.gov/projects/wip/

The ensuing discussion focused on (1) the role of the WIP in ESGF governance, (2) CMIP data request (DECK, priorities, timeline, and responsibilities), (3) documentation.

WIP Co-chairs noted that the increase in data volume is mainly due to the increased resolution, and to a lesser extent to the number of models and experiments. Attendees expect the WIP to flag data volume issues and to engage with all modelling groups for issues regarding model documentation. It was noted that BADC volunteered to implement a table with information on MIPs and data requests and WGCM endorsed the BADC role. Some suggested using the approach of the satellite community, with various levels of hierarchical details. A generalized trend is emerging using both native and common grids. The question of ocean grids was raised, mainly dealing with native grids with some commonly used fields on a common grid. Concerns were expressed regarding regridding and associated loss of information but some noted that a common grid greatly facilitates the scientific work (e.g. of graduate students). Interpolation weights were viewed as a more complex approach to implement, as methods used are sometimes unclear or poorly documented. The CMIP Chair stressed the need to develop a documentation plan for model simulations. One WGCM Co-chair suggested developing a template for typical model peer-reviewed publications and electronic supplement. It was recalled that David Carlson, Director WCRP is currently the Chief Editor of ESSD and that data sets can be bundled into a single DOI. It was noted that ES-DOC cannot be referenced easily and it remains to be seen who is actually using this information. One WGCM member highlighted the need to ensure credit is given to modelling centres, and to recommend a way to convey this, especially for peer-reviewed publications.

Concerns were also expressed regarding different definitions of years/calendars and the WIP will have to address this issue. Diagnostic MIPs were encouraged to provide detailed requirements so *that modelling centres are able to deliver accordingly. WGCM will review MIPs and also data requests and it was suggested to develop a detailed timeline by the end of the session.*

4. CMIP6 (discussion to be continued with the modelling groups)

Following earlier discussions, Veronika Eyring presented a revised structure of the experimental design, with two inner rings consisting of the DECK including elements 1-4 (as entry criteria for CMIP) and the CMIP6 Historical Simulation as entry criteria for CMIP6. The future RCP8.5 simulations (or an alternative future scenario), and LMIP and OMIP would now be elements of MIPs Tier 1 experiments. She then outlined the plan for a special issue on the "CMIP6 Experimental Design" which would include an overview paper of the final CMIP6 design, a description of the CMIP6-Endorsed MIPs and the forcing datasets. This Special Issue will open ~April 2015.

Discussion**:** *How much should the CMIP6 experiments be prioritized? Overlap and complementarities of the different MIP proposals: what implications for the CMIP panel? A scenario in the DECK? If so, which one?*

Some members insisted on the need to have both historical and future simulations in the DECK. For both historical and future simulations, other members expressed hesitations about including them in the DECK because of the dependency of the forcings dataset to a specific phase of CMIP (and thus also timing issues). For future scenarios an additional discussion concerned the number of runs: one or two (high and low projections). The reason being that having one projection would run the risk this would become de facto 'the' reference projection. It was also remarked that some groups might not have the capability to run all 6 experiments. One member commented on the difficulty to endorse a 'single' scenario design, as the original proposal discussion in Aspen included two scenarios.
One remarked that land issues do not fall under the 'systematic biases' umbrella on the figure and it was suggested to revisit the diagram slightly to that effect. There is an indication that the globally averaged forcing trajectories of GHGs produced according to SSP5 would follow closely the same trajectories under the old RCP8.5 but with some different combination of gases and aerosols. Different assessments were made regarding the use of this scenario for diagnostic purposes (given both the similarity and differences with RCP8.5). A consensus emerged with a new structure consisting of a DECK with elements 1-4 as entry criteria for CMIP, the CMIP6 Historical Simulation as entry criteria for CMIP6 (i.e. without scenario runs) and Tiered MIPs.

Discussion: endorsement of MIPs

WGCM is expected to play an important role in the review process of the MIP proposals.This review will not emerge naturally and needs to be stimulated on all fronts. Concerns were raised regarding potential conflicts of interest between submitters and reviewers of the MIP applications, calling for transparency and objective criteria. The connection to the Grand Challenges would be an important criteria, as the science questions of the Grand Challenges are expected to be the scientific backdrop of CMIP6. It can also help identifying potential overlaps and redundancies. It was noted that WCRP core projects and WGs (or their own constituencies or individual experts) could also play a role in the review process to ensure that science priorities beyond the Grand Challenges are served. The rationale for setting the threshold endorsement limit was unclear, as different criteria may apply (scientific, statistical, exploratory vs mature/recurrent experiment, etc). Some suggested raising the threshold number of modelling centers involved for certain MIPs. A timeline towards a formal review process of the MIPs was suggested.

The need to know computing requirements and allocations was highlighted, as some groups may already be above their limit and it was suggested for MIPs to contact modelling groups to make their case. One WGCM member stressed the cultural CMIP6 shift where direct communication between the MIPs and modelling groups will be paramount, as this will help securing computing resources *and associated science funding. It was initially suggested to offer MIPs 4 weeks to consult with modelling groups, then Grand Challenges and Core Projects for another 4 weeks, and for WGCM to review the MIPs within the following 8 weeks. Others commented on the possibility for MIPs to revise their submission based on the WGCM18 outcomes and deliberations. One attendee remarked that the process could start with the endorsement of the most popular MIPs.*

The discussion followed on endorsement criteria: the threshold number of modelling groups in MIPs, the novelty of science, the CPU limitations, the flexibility of the rules, whether such experiments have been run in previous CMIP cycles, etc. The need to distinguish experiments and MIPs was noted. Members recognized there might be exceptions and that rules may not apply to all MIPs. It was highlighted that the MIPs should define their Tier 1 and deliver a complete application form. One member suggested the MIP review process could occur during WGCM sessions each year with open submissions for new MIPs.

The discussion ended with a quick recap of: (1) the CMIP6 proposal to be presented to the modelling groups (DECK, etc); (2) Issues to be discussed with the modelling groups; (3) MIPs feedback form.

(NB agenda items on CMIP6 forcings, historical emissions and concentrations, and future emissions and concentrations was moved to the next day).

5. WCRP updates

5.1 Updates from WCRP & Report from JSC-35 (M. Rixen)

Michel Rixen reviewed some highlights of the JSC35, which focused on the progress on the implementation of the Grand Challenges, which show some diversity in focus, level of engagement and mapping against core projects and working groups. He noted that the recent meeting in Bern called for a need to focus some of them on short to medium term tangible outcomes. David Carlson has joined as the new WCRP Director in June, after having served on some major international initiatives such as TOGA-COARE and IPY. Guy Brasseur has been elected as the new chair of the WCRP Joint Scientific Committee (JSC), effective 1 Jan 2015. He also remarked that a new International Project Office for CORDEX (IPOC) is being established.

One attendee commented on the similarity of some GCs with the core project. It was noted that the distinction between them will be made on the focus and time-bound objectives.

5.2 Report from WMAC3 (WCRP Modeling Advisory Council) (C. Jakob)

Cath Senior provided a short summary of the outcomes of the WCRP Modelling Advisory Council on behalf of Christian Jakob. WMAC stressed the need for the Working Group on Regional Climate, which has the lead on the Grand Challenge on Regional Climate, to increase its focus on modelling issues. WMAC also encouraged all Grand Challenges and Core Projects to identify model developments issues. WMAC recommended SPARC to serve as focal point for atmospheric dynamics issues within the programme. WMAC also highlighted the importance of model versioning and traceability and called for a clarification on the ESGF governance so that this infrastructure can be used effectively across WCRP. WMAC encouraged obs4MIPs to proceed with the publication of high-resolution spatio-temporal data to support model evaluation and the GEWEX-PROES data set will serve as a test case to identify technical difficulties along the way. WMAC has recently established a WCRP/WWRP International Prize for Model Development. The call for nominations is open with deadline 15 November 2014. A summer school on model development is planned on 15-26 June at MPI in Germany.

5.3 Report on WCRP/IPCC workshop and implications for WGCM (S. Bony)

A workshop was jointly organized by WCRP and IPCC at the International Space Science Institute (ISSI, Bern, 8-10 Sept 2014) on “IPCC AR5: lessons learnt for climate change research and WCRP”. The objectives of this workshop were:
- to promote informal exchanges and brain-storming between scientists involved in climate change research coordination and IPCC authors;
- to discuss key scientific uncertainties (long-standing and/or emerging) highlighted by the AR5, and how they are addressed by WCRP activities, especially the WCRP Grand Challenges;
- to make recommendations to WCRP (e.g. new research directions, priorities or programs) and discuss ways to help IPCC in its future assessments.

The workshop gathered 76 participants (roughly half IPCC authors -mainly from WGI- and half WCRP projects representatives), and was organized around a set of plenary presentations from IPCC CLAs and GC coordinators, and a full day of discussions in breakout group. Six of these breakout groups were closely related to the WCRP GCs. It was decided to have in addition a group focusing on biogeochemical/aerosols/chemistry issues, and a group focusing on decadal attribution and prediction issues. A survey was organized prior to the workshop to collect thoughts and feedbacks from the participants about the IPCC and IPCC-WCRP relationship.

The main outcomes of the workshop were the following:
- the importance of maintaining strong links between WCRP and other partners was reaffirmed;
- GCs sharpened the science questions around which they will focus over the next years;
- it was emphasized that the current structure of IPCC assessment, in which evidences from observations, modelling, process understanding, paleo etc are assessed in different chapters by different teams, was suitable to detect and attribute global aspects of climate change (e.g. global temperature rise, sea-level rise, etc), but that it was much less effective to assess regional aspects of climate change (e.g. changes in regional rainfall, monsoons or extremes). The idea to develop a more “end-to-end” approach for climate change assessments, integrating all possible lines of evidence (from observations, modelling, physical understanding, paleo archives, etc) for regional climate changes, and testing hypotheses or “story lines” about possible future changes, would be a much more effective approach. WCRP is ideally suited for encouraging the development of such an approach. For instance, it was suggested that the WCRP GCs could encourage the writing of community (bottom-up) 'synthesis' papers on a few critical topics. It was recognized that these papers would tremendously facilitate the elaboration of future IPCC assessments;
- the idea to initiate a feasibility study of a reanalysis of the Earth System covering the whole of 20th century (covering both the atmosphere, the ocean, the cryosphere and the biogeochemistry) received a lot of attention. This initiative could be led by WCRP but in close cooperation with other partners (especially for the biogeochemical aspects). It was recognized that such an initiative would fill an important gap and thus would greatly serve the scientific community, would constitute a major highlight for WCRP, and would contribute to strengthen its links to communities outside WCRP.

An article will be written for BAMS (or equivalent) to present the outcome of the workshop and to communicate about the WCRP strategy to tackle key uncertainties in climate change research.

5.4 Second CMIP analysis workshop

The 2nd CMIP analysis workshop will be held on 20-23 Oct 2015 in Dubrovnik, Croatia and will be coupled and supported by the EU EMBRACE project which will hold its final meeting on 19 Oct. The workshop will follow a similar format to the CMIP5 workshop held in Hawaii in 2012. The venue can accommodate about 200 people, of which 150 are expected to be non EMBRACE scientists. A fee of about 175 Euros will apply. It was recommended to further refine and limit the focus of this workshop given the high-expected attendance. CLIVAR noted that a CLIVAR Open Science Conference will be held in Sept 2016 in Qingdao, China.

6. WGCM issues (closed session)

6.1 Next session: venue, dates

It was decided to hold the next WGCM session in conjunction with the CMIP analysis workshop in Dubrovnik, sometime during the week 18-23 Oct 2015, possibly on 18 Oct and during the excursion day of the workshop.

6.2 Memberships

It was proposed to offer a 2-year extension to members whose term expire end 2015. Gerald Meehl will rotate off at the end of 2015.

WGCM session with modelling groups' representatives: day 1

7. Presentation of WGCM and of the meeting objectives (S. Bony)

Sandrine Bony briefly recalled the WGCM missions which are:

- to review and foster the development of coupled ocean-atmosphere models and ESMs;
- to promote and facilitate the models evaluation and diagnosis of shortcomings;
- to facilitate integrated research on climate and climate change;
- to coordinate model intercomparisons;

and the CMIP aims, which are to address three main science questions :

- What are the origins and consequences of systematic model biases?
- How does the Earth system respond to forcing?
- How can we assess future climate changes given climate variability, climate predictability, and uncertainties in scenarios?

The objective of the meeting with modelling groups was to discuss the following points (1) Can we endorse the overall CMIP6 design? (2) Are we happy with the concept and content of the DECK? (3) Would modelling groups sign off the initially proposed CMIP6 design where they choose from the CMIP6-endorsed experiments beyond the DECK entirely based on their scientific interest or would they value a limited CMIP6 'core' of experiments and what should this look like?

8. CMIP6 Overview and context

8.1 CMIP6 proposal (V. Eyring)

Veronika Eyring announced the intention to finalize the CMIP6 design including decisions on the DECK and the CMIP6 historical simulation by the end of WGCM18. She presented the initial design as published in the EOS article and the distributed organization. She outlined the DECK-related open questions for the modelling groups' consideration:

- Does the DECK sufficiently decouple model development from different phases of CMIP?
- Concentration-driven or both (concentration- and emission-driven)?
- The problem that the DECK might depend on forcings from a specific phase of CMIP
- Should a scenario be in the DECK?
- Should other experiments be in the DECK? (e.g., LMIP, OMIP)
- To what extent is the DECK an entry card?

She also highlighted the new emphasis on the Tiered structure for CMIP6-Endorsed MIPs, the proposed threshold of about 8 groups to run Tier 1 experiments and the need to submit a fully completed MIP template form. A proposed timeline for the endorsement process was presented.

The huge effort of the CMIP panel, its Chair and the MIPs was acknowledged on several occasions. It was noted that several institutions need to deliver projections as part of their core mandate, which suggested including RCP simulations into the DECK, as well as tuning strategies and associated documentation. One attendee indicated the possible need for a dedicated aerosols and forcing experiment different from scenario and historical runs, but harmonization of historical forcing data sets has to be addressed, as modelling groups might not want to run several historical or RCP simulations.

It was recalled that the DECK simulations should be those typically run as part of the model development cycle (which includes historical runs for some groups) and are expected to be used for benchmarking. In the future they could include new idealized experiments in the future (e.g. to diagnose aerosol forcings) and experiments facilitating the diagnostic of systematic biases such as OMIP and LMIP, especially regarding systematic biases. Many communities, such as CORDEX, will use CMIP6 projections, which have to be visible in the overall design. Several comments were made around the need to precisely define historical runs in terms of forcings, number of members and experiments. Year 1979 was suggested as the start date for AMIP runs.

Given an alternative proposal to involve IPCC in the scenario component, some members noted that scenario design is not the role of IPCC. Other members also noted the possible risk for endorsement decisions to depend on the final design and partitioning between MIP and DECK/CMIP6 Historical experiments. 20th century and projection configurations should be consistent. A balance should be aimed for between systematic biases, forcing and predictability efforts within the design.

The discussion concluded on a general agreement on the new design with the DECK as entry criteria for CMIP and a historical simulation surrounding the DECK as entry criteria for CMIP6.

8.2 CMIP6 infrastructure (V. Balaji and K. Taylor)

Balaji presented the overall CMIP6 infrastructure design and issues to be addressed by modelling groups.

CCCma noted it will take an action to send a list of crucial information to put on the WIP CoG, such as availability of forcing data, the publication of WIP white papers, etc. Consistent, DOI-based model documentation should be aimed for, avoiding duplication between peer-reviewed publications and ES-DOC. The concern was expressed regarding the re-branding of CMIP data without properly crediting the many communities that make CMIP possible (in particular the modelling groups). WGCM called for a more balanced mechanism of crediting the CMIP community on user interfaces to CMIP information and model output. CMIP will recommend a common calendar year approach. It was noted that CMIP is still very much coupled to IPCC assessments in terms of timing, even if the intention is to decouple these to some extent (e.g. through the continuous nature of the DECK). Some 'dark' servers exist for practical reasons, but ESGF should be promoted as much as possible. Many science groups are still struggling with unstructured grids and gridded data are preferred. The WIP will recommend a list of commonly used parameters for re-gridding.

8.3 Overview of science questions from WCRP Grand Challenges and the theme of collaboration on biogeochemical forcings and feedbacks (S. Bony)

Given that the WCRP Grand Challenges (GCs) are meant to be the scientific backdrop for CMIP6 (Meehl et al., EOS, 2014), an overview of the 6 WCRP GCs (plus the WGCM-AIMES topic of collaboration on biogeochemical forcings and feedbacks) was presented at the meeting. Then the different opportunities offered by ensuring a good connection between GCs, CMIP6 and modelling groups were discussed.

The WCRP GCs focus on high priority and exciting research issues that require international partnership and coordination. Unlike WCRP Core Projects, they are not meant to cover all important topics of climate research, but to be highly specific and highly focused. They focus on a few specific questions whose current lack of answer represents a critical barrier for the advancement of climate science, and for which targeted research efforts are likely to lead to a significant progress over the next 5-10 years. The first step in the development of GCs is therefore to identify which are these critical science questions, which are the gaps that need to be filled to overcome the current barriers, and what are the opportunities that may be exploited for this purpose.

Since July 2012, six GCs are supported by the WCRP: "Cryosphere in a changing climate" (led by CLIC), "Sea-level rise and regional impacts" (led by CLIVAR), "Changes in water availability" (led by GEWEX), "Understanding and predicting weather and climate extremes" (led by GEWEX), "Provision of regional information on regional scale" (led by WGRC), and "Clouds, Circulation and Climate Sensitivity" (led by WGCM).

Other science topics which are meant to also contribute to the scientific backdrop of CMIP6 are not currently covered by the WCRP GCs. For this reason, WGCM decided to consider the WGCM-AIMES topic of collaboration on "biogeochemical forcings and feedbacks" as playing a similar role as the WCRP GCs regarding the design of CMIP6. In the text below, no distinction is made between this "topic of collaboration" and GCs.

Based on a wide consultation of the community, each GC has started to identify the few key science questions around which they will focus their efforts over the next years. Although the level of advancement of the different GCs on that matter remains contrasted, an overview of these science questions was presented at the meeting.

Then, the opportunities associated with a close connection between GCs, CMIP6 and modelling groups were discussed:

- WGCM will ask the GCs (as well as the Core Projects leading the GCs) to review and comment on the MIPs proposals proposed to CMIP6. This review progress will help identify gaps, overlaps and opportunities to best address the science questions which are at the heart of the GCs. WGCM will also ask the GCs to highlight which of the MIPs and MIPs experiments or outputs are most relevant to address their science questions, and why. Such a highlight may help the modelling groups advocate for some support to participate in CMIP6-endorsed MIPs.

- CMIP6 represents a great opportunity (i) for the GCs, to interact with the modelling groups and model developers through the CMIP6-endorsed MIPs (it is hoped that this interaction will help draw the attention of model developers to the GCs' science questions and will help focus model development efforts accordingly); (ii) for the MIPs, which could take advantage of the GCs to highlight the importance of some specific experiments they propose; (iii) for the modelling groups, which could take advantage of the GCs to advocate for support to participate in the CMIP6-endorsed MIPs, and could more easily contribute to the momentum generated in the scientific community by the GCs.

Some attendees expressed the need for the GC on Regional Climate to better link with the modelling community. CliC and CLIVAR emphasized the need to consult with Grand Challenges and WCRP Core Projects on MIPs. One WGCM Co-chair noted that GCs have a 5-year time horizon, being independent of the IPCC timeline. GCs can help linking modelling centres to WCRP science priorities.

8.4 Obs4MIPs, Metrics Panel and evaluation tools for CMIP6 (P. Gleckler)

Peter Gleckler provided an update on several efforts to make the evaluation of CMIP simulations increasingly systematic and traceable. This included discussion of the obs4MIPs project that is overseen by the WCRP's Data Advisory Council (WDAC) and its Task Team on Observations for Model Evaluation (co-chaired by P. Gleckler and D. Waliser). The fundamental goal of obs4MIPs is to provide observational data that is technically aligned with CMIP (in terms of format, metadata, and accessibility via the ESGF) in addition to a well-defined documentation protocol that facilitates the usefulness of obs4MIPs data for model evaluation. Since the WGCM's last session, obs4MIPs has advanced considerably, with project information and ESGF data search now available through the obs4MIPs CoG site (https://www.earthsystemcog.org/projects/obs4mips). Over 50 datasets are now available from satellite agencies (NASA and ESA), CFMIP-OBS, and imminent contributions from NOAA and EUMETSAT. In May 2014, a meeting of experts in satellite products and climate modelling took place (hosted at NASA's D.C. Headquarters) to plan for the evolution of the obs4MIPs in support of CMIP6. Many potential additions to the obs4MIPs database were discussed and there was particular interest in targeting higher frequency and other process-oriented products. A BAMS meeting summary is under review and a detailed meeting report is available via the obs4MIP's CoG site. The WDAC's task team is actively working to advance the protocol for contributions to obs4MIPs, and efforts are underway to further coordinate with ana4MIPs, an analogous effort that makes reanalysis data available aligned with CMIP (https://www.earthsystemcog.org/projects/ana4mips).

In addition to enabling future CMIP research, the DECK and Historical CMIP6 represents a potential design target for advancing community-based capabilities that can be re-applied to new simulations as they become available. The WGNE/WGCM Metrics Panel is beginning to catalogue analysis capabilities that have potential for repeated use on new simulations as soon as they are archived in the CMIP DECK/CMIP6. Examples include two complementary efforts under development in support of DECK/CMIP6 evaluation: the PCMDI metrics package and the ESMValTool, with efforts underway to further coordinate these capabilities. Others include diagnostic tools that have been developed as part of CFMIP, the NCAR variability diagnostics package, and a benchmarking tool under development as part of ILAMB. The metrics panel strives to identify and document these and other efforts, with a longer-term objective of building a community-based capability for evaluating DECK and other CMIP experiments.

It was noted that the evaluation tools could be very useful and that CMOR brought the right level of standardization with now a timely opportunity to integrate WIP and the metrics panel work into some long-term perspective. All MIPs are encouraged to contribute specific packages to the CMIP evaluation tool that are envisaged to run routinely on CMIP simulations.

9. MIPs proposals for CMIP6

The objective of this agenda item was to present the MIP proposals to the modelling groups to get their feedback. The MIPs were grouped by topics, and each presentation was tasked to address the following points: the science question addressed, link to Grand Challenges, experimental design plans, diagnostics for model evaluation, possible timescales, etc.

9.1 Systematic biases (P. Gleckler)

Seven of the proposals submitted to be part of CMIP6 were identified with systematic biases as the highest scientific priority for the MIP. Of these, five were full MIP proposals for OCMIP, SensMIP, LS3MIP, GMMIP, and HighResMIP. The complexity and estimated commitment level required for each of these proposals was quite varied, and there were some concerns about the limited number of modelling groups interested in several proposals. The main discussion point however was the need for coordination between several of the proposals to ensure the final list of agreed upon experiments (across all MIPs) had minimal redundancy while ensuring the key science questions could be addressed. Specific issues discussed included OCMIP-OMIP coordination, whether or not data from an initial SensMIP needed to be widely available, the feasibility and experimental design of fully coupled HighResMIP simulations, and the complexity of LS3MIP and the GMMP proposals.,

Two additional proposals were identified as "Diagnostic MIPs" because they did not propose new simulations, but instead requested extensions to the standard model output requested from several of the DECK experiments. These included proposals related to CFMIP (using the COSP simulator) and DynVar. There was broad support of the scientific rationale of both proposals - most of the discussion focused on the effort required by the modeling groups (both human and CPU).

Clarification was sought on the consistency and traceability between the model setups of MIP, DECK and Historical CMIP6 simulations and how strongly this should be enforced, e.g. for HighResMIP. This would be very expensive for some MIPs such as AerChemMIP. It was recalled that the DECK is an entry criteria for MIPs, recognizing there are exceptions to this design.

The use of COSP was highlighted in the context of the DECK and the CMIP6 Historical simulations, which can be used for comparison with observations and to diagnose cloud feedback. COSP can be run online or offline (but in that case it would need high frequency input data) and can now help diagnose the cloud phase.

It was recommended that OCMIP, which addresses ocean biogeochemistry, should coordinate with OMIP and the question arose whether the DECK should be limited to climate physics, an issue which also applies to LMIP. It was also suggested that the Global Monsoons Modelling Inter-comparison Project (GMMIP), the Global Dynamical Downscaling Experiment (GDDEX) and HighResMIP could coordinate some of their efforts and share some part of their experimental strategy.

9.2 Forcings and response (B. Stevens)

Broadly speaking thirteen MIPs were proposed that could be categorized as a response to forcing. Some of these, like CFMIP, C4MIP and PMIP are long standing MIPs having a long history of working closely with WGCM and CMIP. Other MIPs are relatively new. Only the water availability grand challenge was relatively poorly represented in terms of response-to-forcing MIPs, although for a few other grand challenges overlap was concentrated in one of the proposed MIPs. In their initial proposals, the thirteen response-to-forcing MIPs requested a total of 25000 simulation years and 310 experiments. About 11000 years and 174 experiments were identified as a top priority. These numbers are probably a factor of five higher than what the modelling groups can expect to support. The prioritization among the MIPs was also very uneven, with some MIPS (usually the more established ones) showing a great deal of prioritization, new proposals tended to be more ambitious.

The MIPs were generally falling into three categories. One for which there seems to be relatively few questions, in that the MIPS scientific plan and experimental strategy is clear, and the proposed simulations are well prioritized. C4MIP, CFMIP, FAFMIP, PMIP, RFMIP, nonlinMIP all fell into this category, although FAFMIP and nonlinMIP received relatively little support from the modelling centres, perhaps because they are new and groups were unfamiliar with their objectives. FAFMIP in particular was roundly seen as a very promising idea with a compact experimental design that merited more participation. Some questions were raised relating to the offline activities within RFMIP, which could be challenging for modelling centres, and PDRMIP for which important information was missing. Two additional MIPs, ISMIP and DAMIP were seen as very straightforward with a clear experimental design, but their scientific objectives required more simulation time, making them computationally more demanding. Finally four MIPs were in greater need of further refinement, either because they lacked clear prioritization (AerChemMIP, GeoMIP and VolMIP) or the novel aspects of the MIP raised questions (GeoMIP, LUMIP), or their was a sense that the experimental design was overly ambitious (AerChemMIP, GeoMIP).

It was proposed to summarize the discussion for the MIPs, particularly the breakdown into MIPs that were, based on their initial description, deemed to be attractive to the modelling centres because of clear prioritization, a well defined scientific question, and a compelling experimental strategy and

MIPs where it was felt that further work was required before they would be ready for a thorough evaluation.

It was emphasized that modelling centres involved in a MIP should commit to all Tier 1 simulations (or those associated with at least one science question if Tier1 is organized into different science questions). The list of variables to be archived is still to be clarified to get a better handle on the archive demand. The critical issue is to address the science and any reduction in the number of members or simulations should be critically justified and not become a driver to get endorsed. It was noted that VolMIP has a large ensemble, but that chasing a signal might be challenging. Several suggestions were made to reduce the length of simulations. It was remarked that some MIPs (such as Flux-Anomaly-Forced Model Intercomparison Project - FAFMIP and Non-linear Model Intercomparison Project - nonlinMIP) have very clear goals but only little interest from modelling groups, raising the question as to their endorsement. Some members expressed the need for good practice in recognizing the effort of modelling centres, e.g. via co-authorship in the CMIP6 special issue. Aquaplanet simulations were part of CMIP5 and the question arose whether groups would still be able to run these. Some MIPs could conduct joined or coordinated experiments (e.g. PDRMIP and AerChemMIP, AerChemMIP and DAMIP, nudged experiments, etc), as they may serve multiple purposes. It was also suggested to identify contact points at each modelling centres for each experiment to improve coordination.

9.3 Variability, predictability and scenarios

9.3.1 Long-term climate projections (C. Tebaldi and D. van Vuuren)

Detlef van Vuuren presented the current ScenarioMIP proposal and started off by pointing out that scenarios play a very important role in connecting the research in three main research areas involved in climate change research: 1) the climate modelling community, 2) the community looking into climate impacts and adaptation, and 3) the integrated assessment and mitigation community. Scenarios facilitate the interactions within and between these large research communities by providing 1) a common basis for scientific papers, enhancing comparability of different papers, and 2) enabling synthesis as support for national and international assessments. Regular updates of these scenarios are needed as a result of new insights into historical and future socio-economic trends, new data needs of improved models and new research questions. ScenarioMIP therefore aims to contribute to the development of new integration scenarios within CMIP6.

As such the goal of ScenarioMIP can be formulated as simulating future climate outcomes based on alternative plausible scenarios. It is proposed that ScenarioMIP itself would focus mostly on ‘synthesis scenarios” (covering a wide range of possible futures) while ScenarioMIP would cooperate with other MIPs for more specific/targeted research questions concerning land-use, aerosols and overshoot. In the past few years, IAM and impact researchers have developed a matrix framework to link two key factors in climate research: 1) the future level of climate change, and 2) future socio-economic development. This matrix is meant as an organizational framework for scenario work in general – and cannot be directly used for ScenarioMIP. Instead, the ScenarioMIP experimental design should be coupled to this framework. Aware of the limits – due to computational costs – to filling out exhaustively the matrix space a method for how climate model runs should be chosen to best contribute to this overall framework was identified over the past year. Of all methods considered, selecting a subset of scenarios within the matrix was found to be most practical.

Based on a set of criteria, a first – still to be fully specified – proposal for scenarios in ScenarioMIP was developed. In Tier 1, three scenarios are selected that represent high, medium and low forcing levels and that are linked to the current RCP forcing levels. In Tier 2, 3 more scenarios are proposed that target levels that are connected to intermediate forcing levels (between the two extremes). The proposal set is characterized by a small number of scenarios based on new estimates of drivers and can be connected to scenario runs in LUMIP, RFMIP, C4MIP and AerchemMIP. Further elaboration of the scenarios specific drivers and the design will be done in the next few months. It is planned that the final data for future forcings becomes available in autumn 2016 (in order to allow harmonization with the historical data that becomes available early 2016).

Detlef van Vuuren recalled that the choice of scenarios needs to useful from a policy and research perspective. Because of concerns for CPU cost, with regard to a recommendation for initial condition ensemble size, ScenarioMIP will choose one specific scenario – likely a medium or high forcing scenario – to use for IC ensembles, as part of Tier 2 experiments so that CPU won't be wasted in running few IC members for many scenarios like in the past but a substantial number of IC members will be produced under one scenario and the information. How to address geo-engineering in this context still needs to be discussed with GeoMIP. The precise selection of the scenarios for Tier 1 and Tier 2 and how SSPs relate to RCPs is to be decided by March 2015 when a final proposal will be submitted. WGCM Co-chairs thanked the ScenarioMIP leadership for achieving a nice compromise and for integrating the comments received from the community.

9.3.2 Decadal Predictions (G. Meehl and G. Danabasoglu)

CMIP5 was a landmark event because it formally recognized a new field of climate science called "decadal climate prediction". This consisted of a separate set of "near term" CMIP5 experiments that were distinguished for the first time from the more traditional "long term" climate change projections.

The CMIP5 decadal climate prediction experimental design was formulated at an Aspen Global Change Institute session in August, 2008, and approved at WGCM in Paris in October, 2008. At that time a group was formed to coordinate the decadal experiments called the "Joint WGCM-WGSIP Contact Group on Decadal Predictability/Prediction" (this group is now the "Decadal Climate Prediction Panel"). Since then the science has evolved, and in CMIP6, Decadal Climate Prediction will be one of the MIPs included in the main body of CMIP6.

Decadal Climate Prediction Panel (DCPP) members come from WGCM and WGSIP and the CLIVAR Decadal Variability and Predictability focus, and is co-chaired by George Boer and Doug Smith. The focus of the DCPP is the development and support of both the science and practice of decadal prediction, the provision of an archive of decadal prediction information for research and applications, to advise on CMIP5 practicalities, and to propose and oversee a new generation of coordinated experiments for CMIP6.

Some things learned so far from the CMIP5 decadal prediction experiments include the need for a long sequence of historical forecasts initialized every year since at least 1960. This is to maximize the statistical stability of results, to provide historical skill assessment, and to allow better calculation of bias adjustments. Second, it has now been shown that there is considerable annual, multi-annual skill for temperature, but not so much for precipitation. Initial condition skill tends to dominate for several years, and then dies away leaving skill from forced component. Additionally, skill varies a great deal geographically, with higher skill over the North Atlantic compared to the North Pacific, and there has been documented skill for predicting large decadal shifts in Pacific and Atlantic. Finally, there is a disconnect between potential and actual skill over land, and lower skill over the Southern Ocean.

One major conclusion that has become very clear from the analyses so far is that *model error is a major issue*, requiring bias adjustments to evaluate hindcasts and predictions. To that end, single and multi-model assessments of CMIP5 results are still underway and producing useful results.

The proposal for CMIP6 involves three components, labelled "A", "B" and "C".

Component A: CMIP6-decadal

- Ensembles of multi-model multi-member hindcasts (*retrospective forecasts)* made each year from 1960 to the present (~2014);
- 5-10 year predictions for each start year, recommend 10 ensemble members (3000-6000 years)
- Volcanoes included;

Component B: Experimental decadal forecasts

- Decadal predictions (not hindcasts) currently being made by a number of groups;
- Collection, calibration and combination of forecasts;
- Forecasts and data made available in support of research and applications;
- To evolve as a CMIP6 activity (need guidance as to which scenario to use from ScenarioMIP); 10 year prediction, 10 ensemble members (100 years)

Component C: Mechanisms, Predictability and Case Studies

- *Predictability*: a feature of the climate system reflecting its "ability to be predicted";
- *Skill*: the "ability to predict" aspects of the system;
- What are the mechanisms and processes determining decadal predictability and permitting (or making difficult) decadal prediction skill?
- Proposals being developed for coordinated multi-models experiments include:
    - Hiatus+: the nature and predictability of both positive and negative long timescale variations in temperature and other quantities as exemplified by the current hiatus; connection between Pacific and Atlantic;
    - Volcanoes: the actual and potential consequences of volcanic activity on predictions of the forced and internally generated components of temperature and other variables;
    - Modelling groups are now running prototype experiments 2014 to mid-2015; a workshop in mid-2015 will review results and formulate one or two coordinated experiments for Component C.

Regarding DCPP Component C on volcanoes, it was suggested to coordinate with VolMIP and explore synergies with other MIPs. It was noted that Doug Smith quantified the impact of volcanoes on skill, which result in 10-15% differences. One attendee noted that a big active volcano can generate a strong signal on the climate response but that the cumulative impact of medium size volcanoes can be as high.

DCPP has a direct relevance to Climate Services and members cautioned there were too high expectations under CMIP5, whilst research has also demonstrated the limitation of such products with current models.

The panel recommended DCPP to tier their experiment. *Statistics and bias correction may not be robust for limited number of members (e.g. UKMO on NAO prediction requires 20+ members, with consequently shorter runs). The question was raised whether to save ensemble averages or single members outputs and whether to save raw or bias corrected simulations. Members recommended saving both, but only for some fields. One member cautioned that for Component A, 1960 is about as far back as one can go for a reliable ocean field.*

One attendee confirmed that most (if not all) groups now do full field initialization, instead of anomaly initialization, partly due to the presence non-linearities in the system, e.g., ocean equation of state. It was also asked whether WGCM could recommend any method to perturb initial conditions. The general agreement was that this decision should be left to modelling groups, given the diversity of methods used.

10. CMIP6: forcings and timeline

10.1 Overview of CMIP6 forcings (V. Eyring)

Veronika Eyring indicated that pre-industrial forcings will be available by 1 Jan 2016 and future forcings by around Oct 2016. She also confirmed that average volcano forcing would be provided by CMIP. PCMDI indicated they would still provide SST forcing for AMIP runs. Solar forcing should be spectrally resolved. It was suggested to address and discuss last millennium runs and preindustrial forcing consistently, as well as future ozone and solar cycle consistency.

10.2 Historical emissions and concentrations (J.-F. Lamarque)

J.-F. Lamarque indicated that the plan is moving forward according to the schedule defined at the Aspen meeting this summer. Steve Smith (PNNL) is the main point of contact for the development of the historical anthropogenic emissions. This is part of a community effort for both generating emissions and concentrations. It is planned to have historical emissions available by end of 2015, future emissions by autumn 2016 and historical concentrations by Apr 2016. It was noted that the 1850 anthropogenic and biomass burning emissions for aerosols and ozone precursors will not be modified from the CMIP5 dataset.

MPI indicated that they are developing aerosol concentration for 1950 onward. NASA was wondering about which aerosol and ozone climatology to use. It was agreed to include a dedicated contribution on these matters in the CMIP6 special issue.

10.3 Future emissions and concentrations (D. van Vuuren)

The IAM are currently planning to have the scenario ready by early 2015. However, further preparation of the data is needed before it can be used for CMIP6, regarding the consistency with the historical data and harmonisation across different scenarios. This needs to be done for land use, air pollutants emissions and concentrations and greenhouse gases. It was suggested to use a meeting of opportunity to further explain scenarios and emissions. It was also agreed to develop a contributed paper on these matters for the CMIP6 special issue. The final forcing data is available by the end of 2016 mostly driven by the fact that first the historical data needs to be developed.

11. Summary of discussions with modelling groups

Cath Senior provided a recap of the day with first decisions and discussion points to be re-visited during the next day. She invited attendees to speak up on any of the CMIP6 design issues, in particular:

- issues on definition of historical simulations;
- endorsement process and criteria;
- WIP issues (re-gridding, calendar);
- COSP in relation to the deck;
- evaluation tools and implications for data structures.

One member suggested the commitment to publication in the special issue to become an explicit endorsement criteria, avoiding a fine grain selection and endorsement at Tier level, as MIPs should be endorsed preferably as a whole. This presents however some difficulty for some MIPs such as

PMIP which has some Tier 1 'unrelated' expensive simulations. There remains a wording confusion between CMIP6 "inclusion" and "endorsement". It was commented that the endorsement would be conducted by the CMIP panel and WGCM co-chairs. Further comments were made on the delicate selection of the threshold number of participating modelling group in a MIP and how strict this rule would be enforced.

There was a consensus that there was too much fine grain on the endorsement process of the experiments, but the issue of potential overlap between MIPs was noted and needed to be addressed. Some attendees suggested developing Tier 1 science questions but it was preferred to build on Grand Challenge and CMIP questions directly.

CORDEX, DynVar and VIAAB are categorized as diagnostic MIPs which have data requirements, for which some slightly different endorsement approach was suggested, e.g. by selecting a subset of criteria.

WGCM session with modelling groups' representatives: day 2

12. Review of update experimental design (WGCM co-chairs & V. Eyring)

Veronika Eyring presented a revised experimental design. During discussions, a general consensus emerged that model configurations should aim for consistency at all levels (DECK, CMIP6 Historical Simulations and MIPs) and differences, even minor, should be properly documented. It was noted that paleoclimate and decadal simulations for example represent a particular case as they have their own historical simulations.

The work of the session proceeded with a revised set of endorsement criteria, now organized to allow the distinction between standard and diagnostic MIPs.

Whilst these criteria serve mainly as guidance, it was understood that MIPs need to provide the necessary complete template and to meet a reasonable number of modelling groups' commitment to Tier 1 simulations so as to be endorsed.

It was stressed that MIPs should engage with modelling groups in the planning, execution and reporting of resulting science in an inclusive approach wherever possible. Modelling groups in turn are expected to commit to Tier 1 simulations and were again strongly encouraged to engage with the WIP on infrastructure issues and with the CMIP panel on further developments on the design and implementation. The CMIP panel offered to finalize the criteria wording.

13. Modelling groups perspective

Presenters were given the following instructions

"One person per group presents short update on CMIP6 plans (addressing the following points):

- *Overview of models to be used and main point of contact*
- *Feedback on each of the CMIP DECK simulations, keeping the criteria of the DECK in mind*
- *The suite of CMIP6 simulations will consist of the DECK plus the additionally endorsed experiments from CMIP6-Endorsed MIPs (each individually approved). Which CMIP6 design do you prefer (a) no further prioritization beyond the DECK so that modelling groups choose from the MIP experiments (that are prioritized in Tiers for some MIPs) entirely based on their scientific interest, or (b) the definition of a CMIP6 CORE that would consist of the CMIP DECK plus a yet to be defined set of very high priority simulations of selected CMIP6-endorsed MIP experiments; if (b) what are your proposed criteria to define this set of very high priority simulations?*
- *Feedback on MIP proposals and your group's relative scientific interest in the different MIPs proposals*
- *Approximate number of years of experiments to be run for CMIP6 and infrastructure issues*
- *Other issues related to CMIP6?"*

13.1 ACCESS, Australia (Tony Hirst)

The Australian model contributing to CMIP6 will be ACCESS-CM2/ESM2. This model is planned to have all new component codes relative to the CMIP5 entries of ACCESS1.0 and ACCESS1.3, with

the coupled model (CM) configuration to include the Met Office GA6.0 (or GA7.0) atmosphere, GFDL MOM5 (or MOM6) ocean, the LANL CICE5 sea ice, the CERFACS OASIS-MCT coupler and the CABLE2 land surface scheme. The Earth System Modelling (ESM) configuration will also include the CASA-CNP terrestrial biogeochemistry model and the CSIRO ocean biogeochemistry model. The Australian partners contributing to the model development are CSIRO, Bureau of Meteorology and the ARC Centre of Excellence for Climate System Science.
The initial focus is on development of a (relatively) low-resolution version, featuring an atmosphere of “N96” (1.25˚ lat by 1.875˚ lon) horizontal resolution and 85 levels in the vertical. Multi-decadal test simulations are currently underway with the coupled model version (ACCESS-CM2). The aim is to add the ESM components to this version, which will then be known as “ACCESS-ESM2”. The subsequent focus is expected to be on the development of a higher resolution version of the coupled model, featuring an atmosphere of “N216” (0.55˚ lat by 0.83˚ lon) horizontal resolution and again 85 levels in the vertical. This version will be known as “ACCESS-CM2-hr” or similar, and it will not include the additional ESM (biogeochemistry and atmospheric chemistry) components. Its development for CMIP6 will depend on the adequacy of computational resources. The ACCESS modelling group, and also members of the Australian climate analysis and projections community, participated in the feedback process for the CMIP6 experimental design, returning a range of comments and suggestions to the CMIP committee.

Discussion emphasized the need to agree on the end year of AMIP runs, i.e. 2014 and whether the 4xCO_2 would cover 150 years or 5x30 years. It was also suggested to use common initial ocean conditions, e.g. Levitus climatology for the 500 years pre-industrial control runs.

13.2 BCC, China (Tongwen Wu)

In recent years, the BCC modelling group has worked towards improving the Beijing Climate Center Climate System Model BCC-CSM) model for the coming CMIP6. There are three versions of BCC models including a low-resolution version of BCC Earth System Model (BCC-ESM1-LR), a medium-resolution version of BCC-CSM2-MR, and a high-resolution version of BCC-CSM2-HR. Their main differences are their atmospheric resolutions i.e. T42L40 in BCC-ESM1-LR, T106L40 in BCC-CSM2-MR, and T266L40 in BCC-CSM2-HR. Their have however the same oceanic resolution, that is, 1/3 degree in tropics and 1 degree in high latitudes. All the three versions of BCC models will be frozen before June 2016. Different configurations will be run for separate CMIP-MIPs and BCC plans to contribute simulations to 13 MIPs including AerChemMIP, C4MIP, CFMIP, DAMIP, DCPP, GDDEX, GMMIP, HighResMIP, LS3MIP, LUMIP, OCMIP6, RFMIP, and ScenarioMIP. There are six MIPs of FAFMIP, GeoMIP, ISMIP6, JCOMM, PDRIP, PMIP we do not plan to contributions to. Based on estimates of computer resources available for CMIP6, there are about 15000 of total model years that can run at BCC.

Members wonder whether the ESM runs were planned for the DECK and recommended both CM and ESM to run DECK experiments if they are significantly different.

13.3 BNU, China (Yongjiu Dai)

N/A

13.4 CanESM, Canada (John Scinocca)

CCCma's model development goals for CMIP6 are to unify its chemistry-climate and earth-system modelling capabilities under one model version, update its ocean GCM and atmospheric model dynamical core, and improve its existing physical packages. The primary focus of CCCma model development is on the package of physical parameterizations used for all of its applications (e.g. seasonal/decadal prediction, regional downscaling and long-term climate projections). To that effect, in the face of increasing MIPs and other model applications, CCCma has instituted a parallel 18-month model development cycle in which the development of individual components (atmosphere, ocean, land carbon, and ocean carbon development) are undertaken simultaneously. Another key component of this development cycle is the introduction of documenting simulations of individual components and new model versions, which essentially represent CCCma in-house versions of the proposed DECK experiments. An important advantage of focusing on the physics in this way is that other activities such as the testing of new dynamical cores and spatial resolutions can go on in parallel with the physics development activities.

Discussions noted that ocean physics are resolution dependent. CCCma noted that resolution will depend on new computing resources to be available soon, the final architecture being still unknown. CCCma will aim at running all decadal prediction, CFMIP and as many MIPs as possible, probably ¾ of all of them.

13.5 CESM, USA (Jean-Francois Lamarque)

CESM is looking at releasing its CMIP6 version in June 2016, with two main versions (1^o atmosphere/1^o ocean and $1/4^o$ atmosphere/1^o ocean) but with various degrees of complexity (chemistry, biogeochemistry, vertical extent). Primary interest for MIPs is being dictated by interest from CESM community members. Computational request is pending (overlap of 2 computers and external allocations) but should be sufficient for allowing both versions to be part of the DECK/CMIP6 Historical experiments and some of the MIPs.

Discussions confirmed that CESM chemistry runs will also apply to the DECK, but maybe slightly simplified for part of these runs. The inclusion of isotopes will depend on the CAM5.5 evolution.

13.6 CFS- IITM-ESM, India (P. Swapna)

The Centre for Climate Change Research (CCCR) at Indian Institute of Tropical Meteorology (IITM) is focusing on the detection, attribution and projection of global climate with special emphasis on the Asian Monsoon. Many of the CMIP models have shown wide spread in capturing the mean and variability of monsoon, especially the Asian and African Monsoons. A new global ocean-atmosphere coupled model, based on National Centre for Environmental Prediction (NCEP) Climate Forecast System version 2 (CFSv2) has been implemented at IITM, India, for Seasonal and Extended Range Monsoon Prediction under a joint collaboration with NCEP, USA.

The CFSv2 has demonstrated good skill in capturing the mean and variability of the climate system and the South Asian monsoon in particular. However, long simulations of the CFSv2 coupled model indicated cold bias in the sea surface temperature (SST) and ocean mixed layer biases. With the objective of developing the first version of the IITM Earth System Model (IITM ESMv1), the ESM team at CCCR has replaced the ocean component in CFSv2 by an improved ocean model Modular Ocean Model (MOM4p1). In addition to improved physics, the MOM4p1 model includes interactive ocean biogeochemistry. A 100-year simulation with IITM ESM showed significant improvements in the mean state and near surface biases, especially the SST in the tropics and in the northern subtropical gyres. The IITM ESM has shown better skill in capturing dominant modes of climate variability, El Niño-Southern Oscillation and Pacific Decadal Oscillation and their interaction with monsoon. The ENSO-monsoon teleconnection is well captured in IITM ESM. It is proposed that CCCR-IITM will be contributing to the DECK and Historical experiments of CMIP6 using the IITM ESM.

IITM confirmed its intention to perform the DECK and CMIP6 Historical runs and possibly some MIPs, such as the monsoon MIP as also suggested by the CMIP Chair.

13.7 CMCC, Italy (Silvio Gualdi)

CMCC will contribute to CMIP6 with climate simulations performed with its climate model implemented into two configurations: i) an Atmosphere-Ocean GCM (CMCC-CM), which, includes a land-surface and a sea-ice modules; ii) an Earth System Model (CMCC-CESM), which, besides the physical components of the CMCC-CM, includes marine and terrestrial biogeochemistry modules. Specifically, the new CMCC ESM is based on the NCAR Community Earth System Model (CESM) version 1.1.2 and on the NEMO ocean model version 3.4. (including the Marine Biogeochemistry model BFM5.1 developed at CMCC), which has been fully integrated into the NCAR CESM, replacing the default CESM ocean model (POP2).
The CMCC-ESM and CMCC-CM models will be used with different horizontal resolutions, ranging from 1°x1° to 1/4°x1/4°, for both the oceanic and atmospheric components.
CMCC is in favour of having no further prioritization beyond the DECK, leaving the MIPs entirely based on groups' scientific interests. Also, CMCC agrees with the inclusion of the AMIP (from 1979 to 2014), pre-industrial, 1%/yr CO_2 increase and 4xCO_2 experiments in the DECK simulations, the CMIP6 Historical simulations from 1850 to 2014.
Besides the DECK simulations, CMCC plans to contribute to the following MIPs: C4MIP, DCCP, HighResMIP, LS3MIP, LUMIP, OCMIP6, PMIP and ScenarioMIP, producing about 10000 model years of simulations.
Finally, CMCC stresses the importance of a thorough analysis of the use of the data produced in the previous CMIPs in order to design a meaningful and efficient data production and storage in CMIP6.

Members supported the point about the importance of analyzing data from previous CMIP cycles to develop CMIP6. Noting that CAM has a satellite simulator, CMCC remarked that their participation in CFMIP is resource dependent.

13.8 CNRM, France (David Salas-Melia)

The CNRM-CERFACS group contributes to the different phases of CMIP by using the CNRM-CM AOGCM. This model consists of ARPEGE-Climat (atmosphere), NEMO (ocean), SURFEX (surface platform), TRIP (river routing). The couplings within this system are managed by OASIS. For CMIP5, the resolution of CNRM-CM5.1 was 1°L42 in the ocean and 1.4°L31 in the atmosphere. More than 13000 years of simulation were produced, including participation to the decadal part of CMIP5 (4000 years), and a large ensemble of historical simulations (30 members) for detection and attribution (D&A).
The CNRM-CERFACS group will use CNRM-CM6 AOGCM and CNRM-ESM2 (with carbon cycle and/or atmospheric chemistry and aerosols) for CMIP6. Both models will be used at high (0.25°L75/0.5°L91 in the ocean/atmosphere) and low resolution (1°L75/1.4°L91). It will participate to AerChemMIP, C4MIP, CFMIP, DAMIP, DCPP, HighResMIP, LS3MIP, LUMIP, OCMIP6, RFMIP, ScenarioMIP. It will not participate to GDDEX, PDRIP and SensMIP. The participation to other MIPs is still uncertain.
Since not all modelling groups will participate to DAMIP, they should be encouraged to submit at least 3 historical members in the CMIP6 Historical experiment. An alternative would be to reduce DAMIP Tier 1 to a minimum, in order to encourage the groups to participate. Also, since D&A has an interest mostly 1950 onwards, DAMIP experiments could only start from e.g. 1900. Alternatively, the diagnostics could be requested only from 1900 or 1950, even if modelling groups run the historical experiments from 1850.

CNRM commented that in CMIP5, 60% of the 9000 years of simulations were dedicated to Detection and Attribution. For CMIP6, most MIPs selected are those CNRM was involved in CMIP5. A member wondered whether multiple historical runs should be part of the DECK. CMIP Chair advised not to, but with the possibility for groups to provide more than one historical run.

13.9 EC-Earth, Europe (Bart van der Hurk)

The EC-Earth consortium (presented by Bart van den Hurk) is a multi-national community modelling structure. It participated to CMIP5 with a physical AOGCM configuration (V2.3), and will join CMIP6 with V3.1, in which a number of ESM components are added to the modelling system (LIM3 sea ice, LPJ-Guess vegetation, TM5 chemistry). The implementation and analysis of an ocean bio-geochemistry module (PISCES) is not secured, in spite of being embedded in the NEMO3.6 ocean model. Therefore simulations with a fully interactive carbon cycle cannot be guaranteed. The focus of the consortium currently is on "smoothing" the technical I/O and data transfer. Distributing model simulations over the consortium partners is well structured, but the post-processing and data exchange needs to be made more efficient and robust.

Apart from the DECK simulations, EC-Earth has shown interest in the following MIPs: HiRESMIP, OCMIP, AerChemMIP, LUMIP, CGMIP, RFMIP, LS3MIP, PMIP, ScenarioMIP, PRDMIP, S2DMIP.
In many cases participation is subject to the commitment of an individual EC-Earth partner and resources that depend on external (EU) funding.

EC-Earth confirmed that simulations are mainly run at ECMWF, with some ensemble members performed at different institutions.

13.10 FGOALS, China (Tianjun Zhou or Wei Xu)

The Flexible Global Ocean Atmosphere Land System Model (FGOALS) has been developed by scientists in the State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences, with contributions from university partners including Tsinghua University, Nanjing University, and many others. Two versions of FGOALS will be used in CMIP6. (1) The first is the FGOALS climate system model, the AGCM component can be either FAMIL2.1 (25 km) or GAMIL2.1 (100km). The ocean component is LICOM2.1, which holds a horizontal resolution of either 25 km or 10 km pending on the computer resources. The land component is CLM4.5 with improved schemes of exploitation and consumption, and scheme of dynamic root distribution. The sea ice component is CICE4.0 with varying sea ice salinity, improved surface albedo scheme, and ice-ocean heat flux scheme. The four components are coupled together through NCAR coupler CPL7. (2) The second is the FGOALS Earth System model. The model framework is the same as FGOALS climate system model except that the biogeochemical cycle modules in the land and ocean models are included. The ocean carbon cycle module coupled to LICOM2.1 OGCM is HAMOCC from MPI-M. The ESM version of FGOALS will be run at a lower resolution, the horizontal resolution of AGCM is about 2-degree, while the horizontal resolution of OGCM is 1-degree.

FGOALS stressed that their model nudges SST for GMMIP tier-1 experiment to include the observed changes of IPO phase and includes a water consumption/irrigation scheme. Statistics on simulation years per model are available.

13.11 FIO, China (Zhenya Song)

In this presentation, the preparation work for CMIP6 of FIO-ESM, including the development of FIO-ESM, the interested in MIPs experiments and two suggestions for CMIP6, were introduced.
As opposed to most other CMIP5 models, FIO-ESM version 1 included a surface wave model, with non-breaking wave-induced vertical mixing. In the next version of FIO-ESM (FIO-ESM version 2), building on FIO-ESM version 1, the resolution will be improved from 300km with 26 layers, 100km with 40 layers and 200km to 100km with 50 layers, 50 km with 60 layers and 100 km for atmosphere, ocean and wave models respectively. Moreover, for the physical processes, the breaking wave mixing and Langmuir circulation effect from surface waves will be considered. The sea surface roughness with surface wave height and latent and sensible fluxes with wave breaking will also be included into the FIO-ESM version 2.
FIO-ESM is planning to contribute simulation to the DECK, CMIP6 Historical experiment and five possible MIPs experiments (C4MIP, DCPP, GMMIP, JCOMM and OCMIP6).
It was suggested to include the OMIP experiment into the DECK to diagnose ocean model biases and its contribution to coupled models biases. Previous studies indicated that surface waves are important for improving climate models, including biases in the tropics, in ocean mixed layer depth (especially in the southern ocean). Three modelling groups (FIO, GFDL and NCAR) have incorporated the surface wave model into their climate models, and other modelling groups were encouraged to do so as well.

One WGCM Co-chair remarked that OMIP will not be part of the CMIP6 DECK but this could be considered for future CMIP cycles. CMIP Chair noted that JCOMM will not apply for CMIP endorsement, because their model is not mature enough. CLIVAR highlighted that surface gravity wave have an impact of the order of 5-10% on results and are gradually implemented within the community.

13.12 GFDL, USA (Ron Stouffer)

It is likely that the amount of computer time available for CMIP6 at GFDL will be similar to that for CMIP5. Because of planned CMIP6 increased model resolution and complexity at GFDL, fewer model years are considered. The data volume should be similar to CMIP5 depending on the variable list requested by the MIPs. Comments on MIPs given before MIP proposals were available. GFDL is involved in about 1/3 of the proposed CMIP6 MIPS, suggesting that GFDL would fully participate in those MIPs. For other experiments, there was not enough information to determine the level of interest. For a few, no interest was expressed. There is an ongoing concern on the resources (CPU and storage) needed to participate in the MIPs, which may inhibit GFDL to commit to CMIP6 on a wider scale.
Finally, it was noted that an important gap in CMIP5 is the estimate of the radiative forcing. Different methods must be developed to give more reliable results for radiative forcing.

One CMIP member commented on the difficulty to secure funding for the CMIP science on top of computing/simulation resources. Another member stressed on the tension between AOGCM and ESM resources available for MIPs.

13.13 GISS, USA (Susanne Bauer)

GISS's participation in CMIP is driven by overlapping interest between the CMIP strategy and scientific goals as NASA's climate modelling centre. GISS contributed to CMIP5 more than 400 distinct simulations of 80,000 model years with six different model configurations, including two ocean models, and three configurations of varying complexity of atmospheric composition. Participation in CMIP6 is planned with the next version of the NASA model, GISS-E3. The atmospheric component will be on a cubed sphere with a C180 resolution (~0.5º) and 80-100 vertical layers. The ocean will be on a similar resolution and two configurations are anticipated, on z and isopycnical coordinates, within the same arbitrary Lagrangian Eulerian framework. Concentration and emission driven simulations will be performed, including detailed parameterizations for cloud and aerosol microphysics. A full carbon cycle model, GISS-E3-CC is being developed. Regarding the improvements of the CMIP infrastructure, it is suggested to include, more basic analysis diagnostics such as, global and hemispheric means, transient radiative forcings, complete budget terms for water, mass energy and carbon. Further a new index, RIPF, including forcing was recommended.

It was stressed that the CMIP science questions help promoting the initiative within NASA. One attendee raised the issue of increased resolution vs ensemble size. Total CPU resources at NASA are still unknown and the CMIP6 model is still under development. A WIP Co-chair noted that ESGF and diagnostic tools will discussed in detail within the WIP.

13.14 INM, Russia (Evgeny Volodin)

In CMIP6, INM intends to run models with resolution of 1.5 degrees and 73 levels in vertical for the atmosphere, 0.5x0.25 degrees and 40 levels in vertical for the ocean. For some projects where long runs are required, model with coarser resolution might be used. In comparison, CMIP5 models used 1.5 degrees and 21 levels for the atmosphere, and 0.5 degrees and 40 levels for the ocean. Progress with respect to CMIP5 will include an increased vertical resolution for the stratosphere (stratospheric warmings, QBO), an increased horizontal resolution for the ocean and interactive aerosols.

The plans for CMIP6 is to run all DECK and CMIP6 Historical experiments (planned to start in 2016) with participation in C4MIP (very likely) and GEOMIP, PMIP, ISMIP6, DCPP (likely).

INM made some concrete suggestions regarding DCPP Component C such as the study of potential predictability events of very high (low) AMO and PDO index in piControl runs with ensembles of ~30 year runs using a “perfect model” approach and the study of actual predictability of AMO and PDO for time intervals of about 30 years which cannot be derived from routine decadal forecasts proposed in DCPP part A and B.

A WGCM member recommended liaising with DCPP Co-chair George Boer on the DCPP part C experiment. Another member suggested looking at the contribution of land to predictability in that component.

13.15 IPSL-ESM, France (Jean-Louis Dufresne)

The model IPSL-CM6 will be developed for CMIP6. It will be an improved version of IPSL-CM5B model used in CMIP5 and will have a low resolution (LR, Atm: 2.5x1.5°L79; Oce: 1° L75), a medium resolution (MR, Atm: 1.3x0.6°L79, Oce: 0.25° L75) and possibly a higher resolution. Total model years will be between 20 000 and 40 000 years. This model will be used with 3 configurations: (i) standard: physical + carbon cycle + prescribed aerosol and ozone (ii) standard but interactive aerosol (iii) standard but interactive aerosol and chemistry (only LR). Some simulations will be performed with both prescribed and interactive aerosol and chemistry.

IPSL agrees on the proposed design for CMIP6 and strongly supports modelling centres being involved in the design of MIPs. IPSL is interested in many MIPs but will limit its involvement in MIPs so that the DECK and Tier 1 simulations will be no larger than 30% of the total number of simulated years. Partial contribution to some MIPs, with a focus on specific questions should be possible in some cases (e.g. paelo runs, decadal projections). IPSL suggests extending some AMIP runs from 1950, to perform some AMIP runs with nudging, to start some D&A runs later than 1850. For the historical runs, the nomenclature of the runs should differentiate the runs with prescribed CO_2 concentration versus emission, interactive versus prescribed aerosol and chemistry, in addition to the number and type of forcings considered. In CMIP5, the interpretation of some simulations was limited due to too few members and/or insufficient length of runs. The MIPs proposing sensitivity experiments should provide some estimate of the expected difference between simulations to help modelling group to choose the number of members and the number of experiments they will perform. For the output, priorities are expected (that may depend on period, member number...) for a list and description of variables that can be read by a program, and there is interested in some light quality check tools that can be run before publishing data.

One WGCM Co-chair suggested that 3 ensemble members of DAMIP could have the same status as OMIP or LMIP in the future. A WGCM member recommended MIPs to engage closely with modelling groups regarding the balance between model resolution and ensemble members. One attendee highlighted the need to target the detection of climate change signal.

13.16 MIROC, Japan (Masahiro Watanabe or Michio Kawamiya)

Joint work is being conducted between the MIROC modelling group among Atmosphere and Ocean Research Institute (AORI), University of Tokyo, National Institute for Environmental Studies (NIES), and Japan Agency for Marine-Earth Science and Technology (JAMSTEC), towards the development and improvements of both the CGCM and ESM CMIP6 models. The major updates include the improvement of cloud processes, the increase of horizontal/vertical resolution of the atmosphere, and the implementation of further Earth system modules such as the nitrogen cycle. The MIROC modelling activity has been supported by the Program for Risk Information on Climate Change ('SOUSEI' program), which may be renewed in 2017. The CMIP6 models will be frozen by 2016, but the resolution depends on the replacement of their supercomputer (Earth Simulator) scheduled in March 2015. It is planned to start DECK and CMIP6 Historical experiments using both MIROC-CGCM and -ESM contingent upon the availability of forcing data. Some of the MIROC group members have been working in the science steering committee in 10 MIPs (M. Watanabe in CFMIP, H. Shiogama in DAMIP and RFMIP, M. Kimoto in DCPP and HighResMIP, K. Yoshimura in GDDEX, A. Abe in PMIP and ISMIP, T. Takemura in PDRMIP, M. Sekiguchi in RFMIP, H. Kim and T. Oki in LS3MIP). Participation in other important MIPs could be envisaged (e.g. AeroChemMIP, C4MIP, ScenarioMIP). As a close collaboration with MIROC, a modelling team for the global cloud-system resolving model NICAM will participate in CFMIP and HighResMIP although DECK experiments will not be possible with NICAM.

One attendee suggested combining nudged experiments (hiatus, etc). Overlapping experiments and data requirements should be identified and WIP Co-chairs will consolidate these into a table.

13.17 MPI-ESM, Germany (Marco Giorgetta)

MPI-M plans to use two model systems for CMIP6: MPI-ESM-1.1, which is an improved version of the model used for CMIP5, and MPI-ESM-2, which is based on the new ICON model components. The resolution of the models will be determined once the new computer system at DKRZ becomes available in 2015. Resolutions allowing turnover rates of ~20 years/day on ~10% of the machine are aimed for. Current estimates of the resources would allow simulating ~7000 years for CMIP6. The proposed structure with the DECK, the CMIP6 Historical runs and MIPs fits well to the practices at MPI-M, where the model development relies strongly on the DECK simulations. Keeping the historical simulation separate from the scenarios in a dedicated scenario-MIP is a good solution as it provides flexibility for updated forcings and new scenarios.

MPI noted its preference for prioritized Tier 1 experiments. CMIP Co-chair advised waiting for CMIP6 forcings for the historical experiments, whilst AMIP and piControl runs could use CMIP5 forcings because they are part of the model development cycle. One WIP Co-chair advised waiting for final forcings for idealized experiments. One WGCM member remarked that the land use component of forcing, based on ScenarioMIP discussions, would not change much before 1850.

13.18 MRI, Japan (Hideaki Kawai)

In CMIP5, MRI-CGCM3, which consists of an atmospheric model, an ocean model and an aerosol model, was used for almost all experiments, and MRI-ESM1, which contains an ozone model and carbon cycles in addition to MRI-CGCM3 components, was used for several experiments. For CMIP6, a developed version of MRI-ESM1 will be used as a basis for all experiments. The vertical resolution of the atmospheric model will be increased from L48 to L80 in CMIP6, while the horizontal resolution of TL159 will be maintained. The model is now under development, and a lot of aspects have been improved including stratospheric QBO, low clouds, Asian summer monsoon, and sea ice distribution in the winter North Atlantic.
MRI has performed time-slice experiments using 20km AGCM since 2002 on the Earth Simulator to study future changes in extreme events including tropical cyclones, extreme rainfall, blockings, and extra-tropical cyclones. As a future SST for the time-slice experiment, multi-model mean SST patterns projected by CMIP models are used. The impact of different SST patterns on the simulation is also investigated using different SST patterns generated by clustering analysis.
The planned total number of simulation years is 20,000 years for CMIP6 and MIPs. It is envisaged to contribute to AeroChemMIP, C4MIP, CFMIP, DAMIP, DCPP, HighResMIP, OCMIP6, PMIP, VolMIP etc.

One attendee wondered about possible marked changes between past and future variability and MRI noted that the assumption is they remain similar.

13.19 Nor-ESM, Norway (Trond Iversen)

The NorESM is a global earth system model designed for long-term climate simulations. It belongs to the “NCAR-family”. Any public and published version of the model system is based on an open and published version of the model available through NCAR, the CESM. NorESM is developed as a national co-operation in Norway: The Norwegian Meteorological Institute (aerosol chemistry and physics and radiation interactions, and some extensions of the sea-ice model), University of Oslo (cloud microphysics and interactions with aerosols), The Bjerknes Centre and University of Bergen (replacing the NCAR ocean model with an isopycnic coordinate-surface model, and a model for the ocean carbon cycle). There are also contributions to aerosol treatments from the Universities of Helsinki and Stockholm.
Two NorESM versions are envisaged to be qualified through CMIP DECK and CMIP6 historical simulations. NorESM2-ME will be run with an horizontal resolution of ~1 degree in the atmosphere (CAM5-Oslo) and ¼ degree in the ocean (MICOM-Bergen). The number of levels in the vertical will be 30 (or higher, depending on the recommendations for the imported CAM5-version from NCAR), and the configuration will enable both emission-driven and concentration-driven climate simulations. Depending on the actual available computer technology during the main production, it is expected to produce ~5000 years of model simulation with this version. It is also envisaged to qualify a coarser resolution version for some of the MIP experiments in CMIP6: NorESM2-LE will have a horizontal resolution of ~2 degrees in the atmosphere and ~1 degree in the ocean. It is expected to produce ~5000 model years with the coarser resolution version. A few new model versions are being developed for scientific interest but will probably not be completed for CMIP DECK experiments.

With the two versions of NorESM2, it is envisaged to run Tier 1 and Tier 2 of the *ScenarioMIP*. For other MIPs, only Tier 1 experiments will be performed: *AerChemMIP, DAMIP, RFMIP, C4MIP, OCMIP6, SensMIP, and PRDMIP.* These ambitions may have to be adjusted when the final design of the MIPs will be validated. At present stage (the preliminary proposals for MIPs before the WGCM-meeting) there are too many experimental model years proposed in Tier 1. It is recommended (and even expect) that these ambitions be considerably reduced before endorsement. Harmonization of Tier 1 experiments in ScenarioMIP and C4MIP was also recommended so that emission-driven and concentration-driven simulations can be run in pairs and earth-system feedbacks be quantified. Harmonization should also be made between AerChemMIP, DAMIP, and RFMIP to reach well supported conclusions from the experiments. There is also a need to re-formulate the experimental design of the historic AMIP-run for the production of time-dependent forcing (ERF). The SSTs should be taken from the pre-industrial run.

13.20 UKESM, UK (Colin Jones and Cath Senior)

Preliminary plans for a UK contribution to CMIP6 were presented. The UK Met Office Hadley Centre (MOHC) and UK research centres funded by the Natural Environmental Research Council (NERC) are collaborating on the development of a new Earth System model (UKESM1), based on the core physical model HadGEM3-GC3. These 2 models will be the main tools used in CMIP6, both by MOHC and NERC centres. Where appropriate UKESM1 will be applied in a given MIP, where Earth system components are of minimal importance then only the physical coupled model HadGEM3-GC3 will be applied. The standard resolution of HadGEM3-GC3 will be N216 (~60km) in the atmosphere and 0.25° in the ocean. UKESM1 will be developed at 2 resolutions; UKESM1-HI will employ the same resolution as HadGEM3-GC3, while the resolution of UKESM1-LO is not yet fully decided, it will be in the range 140-280km (atmosphere) and likely 1° in the ocean. UKESM1-LO is targeted for generating large ensembles and investigating a range of future scenarios within ScenarioMIP. HadGEM3-GC3 will be frozen in autumn 2015 while UKESM1 is targeted to be ready for science application in the summer of 2016. Outcomes from a preliminary discussion of which CMIP6 MIPs, in addition to the CMIP-DECK and CMIP6 historical experiments, the UK community will contribute to were presented. This list of MIPs will likely evolve as the details of each MIP become better defined. Each MIP will be assigned a science lead either from MOHC or NERC who will be the main UK contact point for that MIP. The majority of UK CMIP6 simulation will be performed over the period 2016-2019.

The discussion highlighted the use of UKESM1-HI also for decadal runs, the 30 ensemble members for UKESM1-LO, the 3 members ensemble for historical runs, the use of prescribed ozone.

13.21 KMA (Young-Hwa Byun)

Recently, KMA has developed a coupled climate model based on UKMO's unified model (UM) and GFDL's ocean model (MOM4). This model known as "Advanced Climate Earth system model (ACE)" is going to be configured by next year, based on an upgrade of its atmospheric component (UM) in collaboration with the Met Office. The ACE is participating as an AOGCM to DECK core simulations and historical runs and it is being used for future projection through participation to ScenarioMIP.

KMA will also collaborate with UKMO on joint DECK, historical and ScenarioMIP simulations as well as AerChemMIP and LUMIP simulations using UKESM. Detailed discussions are taking place as to which version the UKESM to use.

CMIP Chair will add KMA to the distribution list.

13.22 OMDP (formerly WGOMD) (Gokhan Danabasoglu)

Danabasoglu's brief presentation focused on three topics. First, the CLIVAR Ocean Model Development Panel (OMDP, formerly WGOMD) plans to propose an Ocean Model Intercomparison Project (OMIP) based on their very successful efforts involving the Coordinated Ocean-ice Reference Experiments (COREs). The proposed OMIP will use inter-annually varying atmospheric data sets covering the recent past to force ocean and sea-ice models following the CORE-II protocol. Such hindcast simulations provide a framework for: i) evaluation, understanding, and improvement of ocean models; ii) investigation of mechanisms for seasonal, inter-annual, and decadal variability; iii) evaluation of robustness of mechanisms across models; and iv) complementing data assimilation in bridging observations and modelling and in providing ocean initial conditions for climate (decadal) prediction simulations. As many ocean modelling groups from around the world are already performing these hindcast experiments as part of their ocean and sea-ice model evaluation process, an OMIP can be considered as part of the DECK set in future CMIPs. The second topic concerns the challenges associated with eddy-permitting and/or -resolving (high resolution) ocean modelling. As many modelling centres consider using 0.25º horizontal resolution in their ocean components, it is important to be aware of associated challenges. Indeed, a recent workshop organized by the CLIVAR OMDP covered these topics and the outcomes and recommendations of the workshop are available in a CLIVAR Exchanges Special Issue (Number 65, July 2014; http://www.clivar.org/documents/exchanges-65). The third topic concerns the importance of obtaining small top-of-the-atmosphere (TOA) heat flux imbalances (order 0.1 W/m^2) for long, pre-industrial control simulations. Such imbalances are directly reflected in the ocean heat content -- or potential temperature -- time series. If the TOA imbalances are large, say order 0.25 - 0.5 W/m^2, after a 500 - 1000 year control simulation, ocean model water masses will depart substantially from those of nature. If comparisons of ocean model drifts and water mass properties across the models participating in CMIP are of interest, it may be important to have the ocean models initialized similarly and to specify a minimum integration length for the pre-industrial control simulations.

One attendee noted that there are 2 methods to get an initial state of the ocean, either at a target date, or adjusted stable state, noting it is difficult to get both at the same time.

13.23 INPE (WGCM co-chairs)

BESM model components were presented and include:

- Atmosphere: CPTEC global spectral model, originated from COLA model, with new physical parameterizations (deep and shallow cumulus convection, short and longwave radiation, RRTMG, modified CLIRAD);
- Ocean: GFDL's MOM4p1 with marine ice and biogeochemistry; River discharges;
- Surface: INPE's version of NCAR's IBIS with improved representation of tropical biomes, forest fires and continental hydrology;
- Chemistry/Aerosol: from MPI HAMMOZ implemented at INPE's AGCM.
- Coupler: Hourly coupling via GFDL's FMS.

Corresponding resolution details were provided. INPE will commit to CMIP6 DECK, DCPP and HighResMIP simulations.

It was noted that CSIR in South Africa is also developing an ESM. Contact is Francois Engelbrecht.

14. Synthesis of main CMIP6 recommendations from modelling groups (J. Meehl)

There is general agreement on the new CMIP6 structure. The connection between modelling groups and MIPs was viewed favourably and must be done. Most groups have discussed MIPs and have an initial assessment of interest in specific MIPs. The prioritization of DECK and endorsed MIPs with tiers was generally viewed as helpful. The biggest CMIP6 constraints are people, computer resources and storage. Many groups will have a medium resolution (~1 to 2 degree atmosphere, about 1 to 0.5 degree ocean) and high resolution (~0.5 to 0.25 degree atmosphere, ~1 to 0.25 degree ocean) model versions, with coupled carbon cycle and chemistry usually in the lower resolution versions. Models illustrate a mix of high and low top versions, most new model versions will be ready in the 2014-2016 time frame, with runs starting in 2015-2017.

Main suggestions and questions for CMIP6 include:

- AMIP runs: start either 1850 or 1950 and run to 2014?
- Instantaneous 4XCO2: single 150 year run or three 50-year runs?
- Radiative forcing is needed, especially for aerosols. Historical forcing will be available end of 2015, future forcings lat 2016. What about solar constant and volcanic aerosols for pre-industrial runs (e.g. background volcanic aerosols?)
- What is MIP timeline? (the initial endorsement process ends mid-2015, but what about new MIPs?)
- What are the deadlines for modelling groups to complete MIPs?
- How can data request be reduced? How is data request decided?
- Maybe run single forcing runs from 1950 to present? (or at least 1900 to present?) (an issue for DAMIP?)
- Difficult to run DECK with high-resolution models
- Multiple ensembles easier to run that multiple experiments
- Need to harmonize experiments across MIPs to avoid direct overlap and/or very similar experiments run for different MIPs. It was suggested to have a table on a web page with all the MIPs listed, noting which ones have been endorsed and how many modelling groups are intending to run each (included the ones not yet endorsed)

Regarding radiative forcings, it was suggested RFMIP could look into this in the next 6 months. The RFMIP description has a procedure on this and it was commented that it also serves as a diagnostic for the historical runs. It was recommended to limit the number of deadline to review MIPs, for example only during WGCM meetings. MIPs are encouraged to consult with modelling groups on these issues. The WIP will synthesize data requests. Diagnostic MIPs needs to provide data requests to modelling groups.
CMIP Chair confirmed that the historical runs will cover 1850-2014. It was suggested to run shorter simulations for D&A. CMIP will aim at providing a mean aerosol equivalent to average volcanic contributions for the preindustrial period. MIPs are invited to list any dependency with other MIPs.
The responsibility on provision of solar constant remains to be clarified. It was noted that all groups can publish their simulations on the ESGF but only those endorsed by the panel would be called CMIP6. The WIP Co-chair commented that the CoG could be shaped to meet the needs of the groups.

15. Final discussion and decisions

15.1 Implications for CMIP6 plans (V. Eyring)

V. Eyring thanked everyone for a very constructive and successful WGCM meeting. Based on discussions at the meeting, the CMIP6 design and organization could be finalized.

The DECK which will serve as an entry card for CMIP will consist of the following four simulations: (a) AMIP simulation (~1979-2014); (b) Pre-industrial control simulation; (c) 1%/yr CO2 increase, and (d) Abrupt 4xCO2 run. In addition, the CMIP6 Historical Simulation has been added which will serve as the entry card for CMIP6 and as a benchmark for CMIP6-Endorsed MIPs. The historical simulation (1850-2014) will use the specific forcings consistent with CMIP6. The CMIP6 Historical Simulation has been introduced in addition to the DECK to better separate CMIP from a specific Phase of CMIP. Both DECK and the CMIP6 Historical Simulation should be run for each model configuration used in the subsequent CMIP6-Endorsed MIPs. Future climate change scenarios will be run as part of ScenarioMIP with a Tier 1 that includes three different scenarios, spanning different possible futures.

The criteria for MIP endorsement have been streamlined and agreed at the WGCM 18th session. They now comprise a single set covering MIPs and their experiments. MIP co-chairs have been asked to tier their simulations and to identify synergies with other MIP experiments since the set of Tier 1 experiments proposed is currently much larger than what the modelling groups are able to run.

A timeline towards MIP endorsement and beyond has been presented and agreed. MIP co-chairs have been asked to complete (except for the information on the data request), scientifically revise and harmonize their applications by 29 November 2014. The completed applications will then be sent out for review by the wider community (e.g., WCGM, WCRP Grand Challenges and the theme of collaboration on biogeochemical forcings and feedbacks, WCRP Core Projects, MIP co-chairs and modelling groups) which will give everyone the opportunity to provide input. It is aimed to finish this review process by mid-January and to provide the MIP co-chairs with a synthesis with comments and recommendations for each MIP by mid-February 2015. Final MIP proposals with all information should then be returned to the CMIP Panel by end of March 2015. The Panel will then be able to endorse the MIPs that fulfil the agreed criteria by the end of April 2015.

To ensure a proper description of the CMIP experimental design, a special issue will open ~April 2015 with envisaged submission of an overview of the CMIP6 design (including DECK and CMIP6 Historical Simulation) by the CMIP Panel and WGCM co-chairs and a description of each of the April-endorsed MIPs by December 2015 at the latest. In addition, it is hoped that the forcing datasets will be described in this Special Issue.

Forcing groups will be asked to provide an initial description of their datasets by 31 January 2015 so that all modelling groups can review the datasets.

Inputs to the data request will be coordinated by the WGCM Infrastructure Panel (WIP, co-chairs V. Balaji and K. Taylor), following agreed actions and timeline as discussed at the session:

- Template for CMIP data request sent to MIP co-chairs (WIP co-chairs, 15 December 2014)
- Experiment and variable list sent to WIP co-chairs (MIP co-chairs, 31 January 2015)
- Synthesized data request ready (WIP co-chairs in collaboration with CMIP Panel, 15 March 2015)
- Data request reviewed and sent to WIP co-chairs and CMIP Panel chair (Model groups and MIP co-chairs, 30 April 2015)
- Final data request published (15 July 2015)

There will hence be an opportunity to review the data requests before they are finalized.

This process requires continuous effort from MIPs towards the first goal to describe all the experiment protocols of the CMIP6-Endorsed MIPs in the planned special issue and to finalize the data request. However, it is hoped that this effort, including the review process, will pay off on the long-term and will lead to a more concise and targeted CMIP6 experiment protocol that can be supported by the modelling groups and that will enable scientific progress in the three science questions that have been formulated for CMIP6.

Initial estimates of the number of model years the model groups plan to run have been provided as well as a first expression of interest of modelling groups to participate in MIPs experiments. These should only be taken as a first indication and might well change. Modelling groups will be invited to look again through the MIP applications and send direct contacts for each MIP they plan to contribute to, so that the MIP co-chairs can directly iterate with them towards their final protocols. The MIP-specific contacts can differ from the main contact already provided for the model.

The CMIP Panel website at http://www.wcrp-climate.org/index.php/wgcm-cmip/about-cmip serves as a reference where important information and updates will be posted.

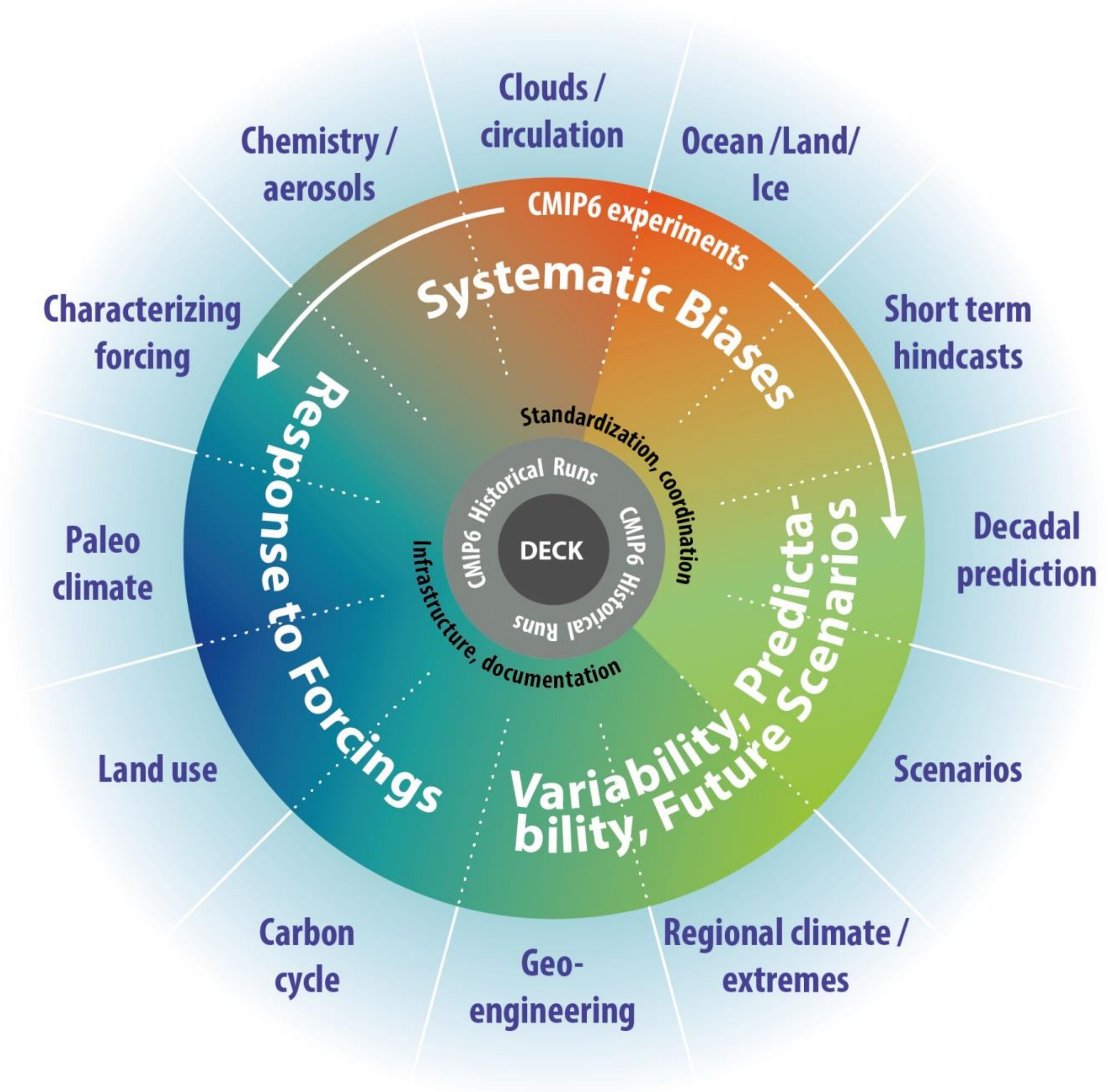

Fig 1. CMIP revised experimental design including DECK, CMIP6 Historical Runs and CMIP6 Endorsed MIPs.

15.2 Final discussion on CMIP6 design and next steps (WGCM co-chairs)

Cath Senior presented the final proposed design and the 10 “commandments” endorsement criteria. Proto-DECK experiments LMIP and OMIP will be part of CMIP6 Tier 1. AMIP simulations will run up to 2014 and the CMIP6 Historical Simulation will cover 1850-2014. In terms of timeline, data requests will be worked out in parallel to the Grand Challenge review to save time. Peter Gleckler and Bjorn Stevens offered to write a small feedback summary of the MIPs review. Forcing groups would send prototype data so modelling groups can get prepared for the final forcing data.

Balaji then reviewed WIP actions. He noted a general consensus on the open access approach and the WIP will need to contact modelling centres to seek a final agreement on this. The WIP will also work on consolidating data requests where aggregation is possible. The WIP CoG was proposed as the one stop-shop web site to inform the community on relevant issues and MIPs are encouraged to use and consult and refer to the CoG. The WIP infrastructure design details will be finalized by the end of next year and maybe sooner, e.g. by summer 2015. It was noted that the NetCDF4 format has compression. It was also commented that ICON data might be worked out through interpolation weights. Several groups indicated they plan to use SST provided by PCMDI, which can be updated once or twice a year.

It was suggested the WGCM19 session would involve MIPs representative at least during a one-day joint meeting. Some joint meeting with WGNE should also be envisaged in the years to come.

Sandrine Bony concluded with a presentation on the evolution of the CMIP6 design over the last year, illustrated by the various diagrams proposed along the way.

Michel Rixen and WGCM Co-chairs thanked all the participants, the CMIP Chair and Panel, WGCM members and ex-officios and modelling groups for their very active and constructive participation and DLR for hosting the meeting.

Appendix A: Actions

1. Michel Rixen: add “Sampling the ocean” doc on WGCM web page

2. CCCma: send a list of crucial information to put on the CMIP website or WIP CoG

3. BADC: implement a table with information on MIPs and data requests and WGCM endorsed the BADC role.

4. WGCM co-chairs: send a letter to the WIP about the need to find a balanced way of crediting the many communities involved in the provision of CMIP data.

5. Karl Taylor (or colleagues): assess the need to revise the source of SST dataset used to force AMIP simulations.

Appendix B: contact list

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