PROJECT REPORT

Report of the twentieth session of the Working Group on Coupled Modelling (WGCM)

Princeton, NJ, USA
1-2 November 2016

Attendees of the WGCM-20 session

PRESENT: Sandrine Bony (Co-Chair), Cath Senior (Co-Chair), V. Balaji, Gokhan Danabasoglu, Veronika Eyring, Greg Flato, Pierre Friedlingstein, Peter Gleckler, Christian Jakob, Masa Kageyama, Michio Kawamiya, Simon Marsland, Catherine Michaut, Jerry Meehl, Alex Ruane, Gavin Schmidt, Bjorn Stevens, Ron Stouffer, P. Swapna, Karl Taylor, Claudia Tebaldi, Bart van den Hurk, Bin Wang, Ayrton Zadra (remotely)

WCRP JPS: Michel Rixen, Catherine Michaut

1. Introduction

This report only summarizes discussions and outcomes of the 20th session of the WCRP Working Group on Coupled Modeling. Full presentations delivered during the meeting can be found on the corresponding WCRP web page.

a. Welcome and meeting objectives (WGCM Co-Chairs)

WGCM Co-Chairs Sandrine Bony and Cath Senior welcomed all participants, thanked Balaji and University of Princeton for hosting the meeting and making all necessary logistics arrangements, and introduced Greg Flato, who will become the next WGCM Co-Chair on Jan 1st 2017 (after Sandrine Bony rotates off). Greg Flato has been a long time member of the WGCM, a member of the JSC (and for several years the liaison between the JSC and WGCM), and more recently the Co-Chair of CliC. He is also a member of the IPCC bureau. A quick round table allowed all participants to introduce themselves.

b. WCRP update (M. Rixen)

It was commented that liaison between WGCM and the Earth System Grid Federation (ESGF) governance was essential to meet the CMIP timeline and plan for the future evolution of the ESGF to serve the programme.

Members felt that the process of developing the WCRP Ahead Document was somewhat rushed and would not allow a comprehensive strategic thinking across the programme. Co-Chairs offered to provide inputs in response to the call for contributions.

c. WMAC update and plans for pan-WCRP modeling meeting in 2017 (G. Meehl/C. Jacob)

The pan Working Group meeting of Oct 2017 will provide an opportunity to improve communication across modeling groups and to interact with other entities such as the Grand Challenges, the core projects and sister programmes. The meeting will have both plenary and standalone sessions. WMAC members suggested adopting JSC session arrangements of earlier years by having WGs reporting directly at the JSC session before the WMAC session. A WMAC newsletter was suggested as a way to convey latest modeling information across the programme. It was suggested to revise the call for

nomination of the International Prize on Model Development to explicitly welcome applicants from other earth system domains besides the atmosphere: ocean, land and cryosphere. The upcoming 4th ICESM conference to be held in Hamburg (28 Aug – 1 Sept 2017) was highlighted.

2. CMIP

a. CMIP6 status (V. Eyring)

In preparation of the WGCM-20 meeting, input has been requested from the Co-Chairs of the CMIP6-Endorsed MIPs on the status of their MIPs and from the modeling groups on the status of the implementation of the forcings. The resulting two presentations are available from the WGCM-20 meeting website. In addition, Veronika presented a broad overview on the status of CMIP6 which was reviewed by the WGCM at this meeting.

- More than 30 modeling groups will participate in CMIP6 with a variety of different model versions. Among those are eleven modeling groups that have not participated in CMIP before.

- The status of the forcing datasets was presented. While in CMIP6 the initial description of the forcing datasets were sent out for review by the modelling groups and CMIP6-Endorsed MIPs, ideally all forcing datasets should have a contributing paper in the GMD special issue before the data set is finalized.

- Several groups have indicated that they need to start running DECK and historical runs no later than the end of this month. Finalizing data requests is a top and urgent priority conditioning the success of CMIP6. A version of the CMIP6 data request and the historical forcings will be released by the end of November.

- There was a specific question on the biomass burning forcing dataset whether these are total, anthropogenic or natural emissions. Guido van der Werf clarified they cannot exactly partition the fires that are occurring into anthropogenic and natural, but they would advise to the modelers that already have fires build in to only use the deforestation and agricultural fires. The files provided have a data layer that tells what fraction of the emissions is associated with those fire types. An additional issue concerns models that have deforestation. These should not include deforestation fire $CO2$ estimates to prevent double counting. The readme file will be updated accordingly and the GMD paper will provide further details.

- The CMIP Panel once again strongly encourages all CMIP6 modelling groups to participate in RFMIP-lite which includes fixed SST simulations to diagnose the forcing. The modest additional effort would enable the radiative forcing to be characterized for both historic and future scenarios across the model ensemble. Knowing this forcing would lead to a step change in efforts to understand the spread of model responses for CMIP6.

- The presentation also included first recommendations for a future CMIP7 cycle and how the federation of MIPs should work in the future. A concern was raised that too many key deliverables are based on unfunded, voluntary work.

b. CMIP6 infrastructure (K. Taylor, V Balaji)

It was suggested to advertise WIP position papers within the community (MIPs, modeling groups, WGCM) and to ask for feedback within a month. Members recommended using open literature and endorsing data citation as part of terms of use encoding of CMIP6 model output. Only one or two groups have limited the use of their simulations to non-commercial applications. Modeling groups are invited to choose a license consistent with their own institutional policies and to record this in their global file attribute. Members were invited to endorse new WIP recommended licensing policy.

CCCma, China and India have volunteered for beta testing on the model documentation ESDOC so that the corresponding description can be reviewed by WGCM around Feb 2017. Realm description for land is lagging behind. Model tuning details would need to be included in ESDOC. Following last year's recommendation, template tables summarizing key aspects of the model documentation should be prepared by the WIP and made available to the modeling groups, to be included in the model reference papers that will be peer-reviewed.

Some modeling groups are not willing to offer re-gridding services but are ready to provide weight files. Some further coordination is needed to ensure a unified approach to that effect. It was suggested to interpolate some selected variables at higher resolution via the weight files. Some members expressed the need to do on-site computation of diagnostics or re-gridding as data volume would prevent easy download.

It was confirmed that the DECK data requests should include CMIP5 requirements as a minimum, complemented by CMIP6-endorsed MIPs requests. Data requests should be finalized soon so as to allow modeling groups to start their simulations. It was suggested to seek help from ocean, sea-ice, land, atmosphere, and chemistry communities to meet the hard deadline of end of November.

c. Discussion

There are some discrepancies between MIP descriptions and Martin Jukes data request tool which need to be addressed. The community should be provided with some guidance to perform quality control on their data. OpenDAP sub-setting allows extraction of e.g. one level from an ESGF NetCDF file. Tools to compute averages such as annual mean would be welcome and such need was already expressed during the previous CMIP cycle. It was suggested to add at least one member from Asia to the WIP.

d. VIACS AB – links to the climate modelling community (Alex Ruane)

The relevance of the Vulnerability, Impacts, Adaptation, and Climate Services (VIACS) Advisory Board within CMIP6 was highlighted, WGCM connecting now with a richer and broader interdisciplinary research community. VIACS AB involves a different set of users (with a range of capacity in climate output analysis) and is calling attention to the need to assess uncertainty cascades. MIPS provide a useful framework via multi-model simulations and their associated spread, but signal might not always be robust. Members encouraged close collaboration between the CMIP and VIA community so as to ensure informed use of simulations and a continuous assessment of fitness for purpose of these products. The VIACS AB expressed an interest in working with MIP leaders to write papers providing guidance on the potential use of MIP outputs for VIACS studies, including strengths as well as limitations. Concerns were expressed on how to use GCM outputs for VIA applications without higher resolution simulations (e.g. HighResMIP) or downscaling. New GCM output variables were also presented as requested by the VIACS community. VIACS AB is currently limited to GCMs (and possible bias adjustments) within CMIP6 and could make a case for defining a

subset of gridded core variables to address bandwidth issues, facilitating access and exploitation, and evaluating impacts-relevant output metrics.

e. Obs4MIPs, metrics panel and evaluation tools for CMIP6 (P. Gleckler/V. Eyring)

A more routine benchmarking and evaluation of models is envisaged to be a central part of CMIP6 (Eyring et al., 2016a). One purpose of the DECK and CMIP historical simulations is to provide a basis for documenting model simulation characteristics. A few analysis packages currently under development will be routinely executed whenever new model experiments are contributed to the CMIP archive. The foundation that will enable this to be efficient and systematic is the community-based experimental protocols and conventions of CMIP, including their extension to obs4MIPs and ana4MIPs, which serves observations and reanalysis data in parallel to the CMIP output on the ESFG. Our initial goal is that two capabilities will be coupled to the ESGF to produce a broad characterization of CMIP6 DECK and historical simulations as soon as new model experiments are published on the CMIP6 archive: the Earth System Model Evaluation Tool (ESMValTool, Eyring et al., 2016b) that includes other model evaluation packages such as the NCAR Climate Variability Diagnostics Package (CVDP, Phillips et al., 2014), and the PCMDI Metrics Package (PMP, Gleckler et al., 2016). ESMValTool includes a variety of diagnostics and metrics, including reproduction of the analysis in the IPCC AR5 model evaluation chapter. The PMP includes a diverse suite of summary statistics to objectively gauge the level of agreement between model simulations and observations. Both capabilities are open source, have a wide range of functionality, and are being developed as community tools with the involvement of multiple institutions. Collectively, the PMP, ESMValTool and other packages offer valuable capabilities that will be crucial for the systematic benchmarking of the wide variety of models and model versions contributed to CMIP6. This evaluation activity can, compared with early phases of CMIP, more quickly and openly relay to analysts and modelling centers the strengths and weaknesses of the simulations including the extent to which long-standing model errors remain evident in newer models.

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- Phillips, A.S., Deser, C. and Fasullo, J., 2014. Evaluating Modes of Variability in Climate Models. Eos Trans. AGU, 95(49): 453-455.

f. Post COP21 outcomes for WGCM, AR6 and special reports (G. Flato)

It was noted that there would not be additional formal RCPs to support the 1.5°C special report. Some groups however, such as NCAR, are planning to run new experiments to address 1.5°C vs 2°C increase in time for the special report. One could identify times in existing simulations when 1.5 °C increase would happen. It is very likely that CMIP6 models will not be available on time for the special reports. New reports would follow the same philosophy as previous ones, with a small recap followed by new scientific knowledge.

Regarding the timeline of the AR6, WGI will be published in Apr 2021 (i.e. deadline for the acceptance of cited papers will be near summer 2020), WGIII in Jul 2021 and WGII in Oct 2021.

g. 'Out of the box meeting' discussion (C. Jacob)

Climate research has evolved from "assessing whether the world is warming" to "how is the world warming and what are the expected impacts", putting emphasis on current science challenges. The meeting converged to 3 fundamental questions:
- Where will the carbon go?
- How will weather vary with climate?
- How will climate change impact the habitability of our planet and its regions?

It was commented that these questions help communicating in a rather concise way science priorities internally, within the community and also to the general public. The last question is very much related to Vulnerability, Impact and Adaptation as societal response is triggered by amplitude and frequency of weather events. The relevance of the GC on Clouds, Circulation and Climate Sensitivity was highlighted, in particular the focus on storm tracks, ITCZ, their dynamics and attribution questions.

3. Group reports

a. Australia (Simon Marsland)

It was commented that the bias in the Southern Ocean might be due to fresh water biases and resulting mixed layer depth problems.

b. Canada (Greg Flato)

Some data request and forcing issues were flagged. It was suggested to circulate the WIP position papers for comments. Fast-Track MIP is de facto built into the design of CMIP (as the DECK development is a continuous process) and would increase the consistency between various CMIP cycles.

c. China (Bin Wang)

The presentation included some work on initial shocks and drifts on decadal predictions. The number of models and their interdependencies, and opportunities for developing a model from scratch were discussed.

d. EC Earth (Bart van den Hurk)

MIPS simulations with three ESM versions will start in Feb-March 2017. Runs have been distributed across several centers. The tuning strategy also addresses the transient GCM response and the rate of change over the 20th century. The too cold ocean most likely reflects some bias at the TOA.

e. France (Masa Kageyama/Sandrine Bony)

There is a need to finalize the data requests and to confirm needs for regular grid interpolation requirements by November 2016.

f. Germany (Bjorn Stevens)

The climate sensitivity of the model is 3.3K. The Earth System Model includes bio-geochemistry which can be turned off. ICON is being developed jointly with DWD. CMIP is becoming more operational but remains funded as a research activity. It was suggested to address the sustainability of CMIP resourcing and research/operations linkages at the upcoming WMAC6 session.

g. India (Swapna)

There is on-going work in further tuning the model with respect to the TOA and surface fluxes.

h. Japan (Michio Kawamiya)

Japanese CMIP6 models include those of MIROC and MRI family and NICAM. With all the Japanese models combined, the endorsed MIPs are fully covered. For computer resource, The Earth Simulator (1.3PFlops) run by JAMSTEC, and the K Computer (11PFlops) by RIKEN, plus MRI supercomputer will be used. NICAM is run on 870m resolution, which is however only experimental. Coarser resolution is used for MIPs runs. The IT program DIAS is planning to contribute Earth System Grid also for CMIP6.

i. UK/Korea (Cath Senior)

The climate sensitivity of the HadGEM3-GC3.0 model is on the high side of the CMIP5 range and tests are underway with the final HadGEM3-GC3.1 version. Historic runs have not been done as part of the model development, so no tuning of the ECS has been applied. Work to understand the very strong aerosol ERF has been undertaken and further physical development of the aerosol scheme has resulted in a reduced forcing, although still relatively strong in comparison to the CMIP5 range.

j. USA

<u>NCAR - Claudia Tebaldi/Jerry Meehl</u>

CESM is a community effort, having its center of gravity at NCAR. Some ocean simulations will be performed at 1/10 degrees to avoid the 'grey zone' issue in the ocean. The high resolutions simulations will not cover all DECK runs except maybe the 1%. Some problem with the Labrador Sea freezing is now fixed, but caused a 4 months delay.

<u>GFDL - Ron Stouffer</u>

Some MIPS are addressed with CPU less intensive models. ESM4 and CM4 are using MOM6.

<u>GISS - Gavin Schmidt</u>

It was recommended to explore the characterization of uncertainties on forcings and their impact on climate projections, and that some coordination between modeling groups would be useful to that effect. This could take place within Fast-Track MIP. Entrainment and cold pool physics are key in improving the MJO in simulations. The QBO is self –generated and can be tuned to match observations, but when introducing ozone, retuning is needed. It was suggested to have two versions of solar forcing, as the one currently proposed has not physical basis. Simulations suggest that irrigation matters.

k. Other groups (Cath Senior)

Short summaries of the status of the INPE-BESM (Brazil), NorESM (Norway) and CMCC (Italy) were presented.

Members suggested encouraging modeling groups to contribute to (the 'light') RFMIP.

4. WCRP Grand Challenges and possible new ideas

a. Clouds, Circulation and Climate Sensitivity GC (S. Bony/B. Stevens)

This Grand Challenge is articulated around four science questions (Bony et al., Nature Geosci. 2015). Several workshops were organized on these questions. Each question is associated with intensive research efforts and the science advances fast. Five initiatives were highlighted: (1) NAWDEX, a field campaign over the Northern Atlantic (Sept 2016) initiated by the WMO THORPEX programme, that will help understand the influence of diabatic processes (i.e. clouds) on mid-latitude Rossby waves and weather systems; (2) TRAC-MIP (Tropical Rain belts with an Annual cycle and Continent MIP, https://sites.google.com/site/tracmip), a model intercomparison in an idealized framework aiming at better understanding shifts of circulation and rainbelts under solar and greenhouse forcings (mimicking either paleo or future changes), (3) RCE-MIP (an intercomparison of CRMs and GCMs run in radiative-convective equilibrium, discussed at the Model Hierarchies workshop) that will help understand convective aggregation and the interaction of convection with large-scale circulations, and will bridge CRMs and GCMs (4) the EUREC^{4}A field experiment, that will be organized in 2020 to

elucidate the role of convection in low-cloud feedbacks (www.mpimet.mpg.de/en/science/the-atmosphere-in-the-earth-system/narval2-eurec4a/); and (5) plans for an Equilibrium Climate Sensitivity community assessment (to be completed by March 2018), whose purpose will be to make a thorough assessment of climate sensitivity based on multiple lines of evidence and by applying a reasoning by refutation (Stevens et al., Earth Future, 2016).

Grand Challenges are supposed to have a limited lifetime (2012-2022 for this one). Grand Challenges have been helpful mobilizing resources around focused efforts as illustrated by the EU European Research Council project EURE[4]CA awarded to Sandrine Bony. This project and associated field experiment could benefit from a wider international support and resource mobilization (e.g. WWRP, etc).

b. Carbon Feedbacks in the Climate System GC (P. Friedlingstein)

The Grand Challenge on Carbon Feedbacks in the Climate System (https://www.wcrp-climate.org/grand-challenges/gc-carbon-feedbacks) aims to enhance the understanding on how biogeochemical cycles and feedbacks control CO_2 concentrations and impact the climate system. The Grand Challenge will be addressed through community-led research initiatives focussing on the following guiding questions:
• what are the drivers of land and ocean carbon sinks?
• what is the potential for amplification of climate change over the 21st century via climate-carbon cycle feedbacks?
• how do greenhouse gases fluxes from highly vulnerable carbon reservoirs respond to changing climate (including climate extremes and abrupt changes)?

This Grand Challenge has been officially endorsed by the WCRP Joint Scientific Committee in April 2016. This new activity has close connections to the earlier collaboration between WGCM and AIMES. WGCM would be the natural home for this Grand Challenge.

c. Evaluating and improving the simulation of precipitation in models (C. Jacob)

Christian Jakob presented an idea to galvanize WCRP around "Evaluating and improving the simulation of precipitation in models" organized as follows:
- Step 1: A WCRP assessment report (and review paper) on the state of the art measured quantitatively
- Step 2: A serious attempt to increase the number of developers in this area achieved by engaging modelling centers and funding agencies
- Step 3: A repeat of the assessment report in N years, where 5<N<10

Phase 1 and 3 would leverage existing tools and process oriented metrics. It was suggested this could be part of the Grand Challenge on Cloud, Circulation and Climate sensitivity. Whilst this effort includes a focus on rain bands and storm tracks, there is a need to address precipitation on a global scale. The use of global metrics was debated, as they provide a clear target but may be too convoluted to make improvements on a regional scale. The value of process-oriented metrics was highlighted. Climate Process Teams in the US were mentioned in this context.

Phase 2 would advocate for increased focus on these issues with modeling centers and agencies. It was commented that improvement should be physically sound, not limited to tuning to selected metrics.

The opportunity to include these ideas in the WCRP Ahead document was discussed.

5. WGCM Business

a. Membership

Sandrine Bony will end her term as WGCM Co-Chair in 2016 and will be replaced by Greg Flato. Members expressed their gratitude and thanks for her valuable contribution and leadership. Terms of eight Members are up for renewal for a second of third term into 2018 and beyond.

b. Pan-WCRP modeling meeting – ideas for joint sessions

It was suggested to have each group meeting individually for up to 2 days and use the remaining time for joint sessions, possibly held in parallel, around selected topics. Some proposed themes included:
- model evaluation (noting the relevance of the JWGFVR and the WGCM/WGNE Metrics Panel)
- cryosphere (and relevance to some MIPs and CliC)
- added value of regional modeling (and relevance to CORDEX)
- High resolution modeling (cf HighResMIP)
- Connection to impact community (VIACS-AB, CORDEX)
- Precipitation (e.g. Christian Jakob's proposal)
- Seasonal forecasts to inform climate models: how do performances compare? (links to WGSIP)

c. Action arising

All actions from WGCM-19 were completed. WGCM-20 actions are outlined in Appendix A.

d. Next meeting

WGCM-21 will be held in conjunction with the pan Working Group meeting at the UK Met Office, 9-13 October 2017. It was suggested to explore holding the WGCM-22 session in Asia and to invite WGCM Asian members to consider hosting the meeting.

Appendix A: WGCM-20 DRAFT ACTION LIST

<u>CMIP forcings</u>

1. Need to clarify whether fires are anthropogenic vs natural – CMIP Panel

2. Decide whether O3 database should be given an extra deadline for an update version - CMIP Panel

3. Send a Thank You letter to those who produced forcings – WGCM Co-Chairs

4. Decide whether the interannual variations of the biomass burning emissions should be filtered out – CMIP Panel

5. Work with Martin Juckes and Karl Taylor to define a 'declared' version of the data request by end of November and send an email to MIPs and modeling center to advise them that this 'declared' version will be available by end Nov 2016 – WGCM Co-Chairs and CMIP Panel

6. Email to MIPs and modeling centers that forcing datasets and the data request version 1.0 will be available by end Nov – CMIP Panel

7. Release historical forcings and data request version 1.0 (early December) - CMIP Panel

8. Put official CMIP6 acknowledgement on CMIP Panel website - CMIP Panel

9. Create a table on input4MIPs that provides an overview of the forcing datasets that are available alongside with links to the documentation. – PCMDI

<u>CMIP Infrastructure</u>

10. Advertise WIP position papers to community (MIPs, modeling groups, WGCM) – WIP

11. Endorse data citation as part of CMIP6 model output Terms of Use – WGCM Co-Chairs

12. Endorse new WIP recommended licensing policy – WGCM Co-Chairs

13. Ask modeling groups to choose a license consistent with own institutional policies and record in global file attribute. Inform WIP if the two recommended licenses are both unacceptable – WIP

14. Beta testing on model documentation ESDOC - CCCMA, China and India

15. Ask for model tuning details on ESDOC + provide template of model documentation table to the modeling groups to be included in their description paper (Jan 2017) - WIP

16. Send out email to modeling groups and CMIP6-Endorsed MIPs for a review of the scientific content / questions of ESDOC to meet the release in Feb 2017 - WIP

17. Explore ways to support WIP on data requests so as to meet critical deadlines – CMIP Panel

18. Make recommendation about the software of quality control that the modeling groups should use – WIP

19. Agree on a standard for regridding weights file and a standardized subset of outputs, small in size to accommodate users without large resources in terms of bandwidth or storage - WIP

20. Extend WIP membership by adding one or two members and consider representation from Asia (India? China? Japan?) – WGCM Co-Chairs and WIP

<u>MIPs</u>

21. Encourage modeling groups to run RFMIP-lite - WGCM Co-Chairs

22. Reply to John Scinocca on Fast-track MIP - WGCM Co-Chairs

<u>Metrics</u>

23. Announce CMIP evaluation capability to modelling groups and MIPs – CMIP and Metrics Panel

24. Check y-transport north orientation convention – OMDP/S. Marsland and G. Danabasoglu

<u>Grand Challenges</u>

25. Help mobilizing additional resources for EUREC[4]A - All

26. Propose WGCM as home for GC Carbon to JSC - WGCM Co-Chairs and P. Friedlingstein

<u>WCRP Strategy</u>

27. Provide inputs to "WCRP Ahead" document - WGCM Co-Chairs

28. Reflect on CMIP6 and develop a concept for future CMIP phases and resourcing on the long run that meets the growing expectations and demands including research, infrastructure, and operational services needs, October 2017 in time for WGCM-21 – WMAC Co-Chairs and CMIP Panel, WGCM and WIP Co-Chairs

<u>Next meetings</u>

29. Propose WGCM to report to JSC session directly instead via WMAC session – WGCM Co-Chairs

30. WGCM-21 session in 2017: consult with WGs on topics of interest (e.g. high resolution modeling, model evaluation and verification, modeling gaps, commonalities between seasonal forecast and climate projections, focus on precipitation, research/operations, etc) – WMAC and WGs Co-Chairs

31. WGCM-22 session in 2018: explore hosting possibility – WGCM Asian members

APPENDIX B – CONTACT LIST

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