Working Group on Coupled Modelling (WGCM) Report
(draft 1)

1. Highlights for JSC

- **Planning, coordination and delivery of CMIP6**. This has been executed by two sub-groups of WGCM: the CMIP panel and the WGCM Infrastructure Panel (WIP)
    - **CMIP6 planning** for a more continuous and distributed approach started in 2013. Engagement with modelling groups and the wider science community was at the heart of the design (including a WGCM-led paper on lessons learnt from CMIP5 (Stouffer et al), Survey of groups and users, face-to-face workshop). The design of a distributed approach and endorsed MIPS was agreed at the WGCM-18 meeting with modelling groups in 2014.
    - **CMIP coordination** has delivered 23 endorsed MIPS; forcing datasets for the required common experiments: DECK (AMIP, PI-Cntl, 1%, 4xCO2, historical simulation, and ScenarioMIP future RCP scenarios; a data request to support diagnostics across all ~100 Tier-1 experiments in the DECK and MIPs, ESDOC documentation; co-ordination of data delivery to the ESGF. Documentation of the science and technical coordination is in the CMIP6 special issue on experimental design and infrastructure (https://www.geosci-model-dev.net/special_issue590.html).
    - **CMIP delivery** from more than 30 models so far (126 models registered) has been published on the ESGF (https://pcmdi.llnl.gov/CMIP6/ArchiveSatistics/esgf_data_holdings/) covering DECK and MIP experiments. Data from these models is being used directly in the IPCC 6th Assessment Report, used to drive regional model simulations under CORDEX and is being downloaded by climate science researchers across the globe with an expectation that 1000s of science papers will result.

- **Organisation and delivery of a series of CMIP analysis workshops** showcasing results from CMIP5 (Dubrovnik, 2015) and CMIP6 (Barcelona 2019). The First CMIP6 analysis workshop in Barcelona delivered first results and emergent properties of the CMIP6 multi-model ensemble. A WGCM-led paper (Meehl et al, 2020) that arose from discussions at the Barcelona workshop regarding the climate sensitivity of the CMIP6 ensemble has been accepted for publication in Science Advances.

- **Routine monitoring and evaluation of CMIP6 model data**. For CMIP6, routine evaluation tools have been applied to all model data uploaded to the ESGF. This has been designed to allow community evaluation tools (so far including ESMValTool, PMP and other packages) giving modelling groups early insight into model performance across a broad range of metrics and with reference to other CMIP6 models. See Eyring et al, 2016; https://www.earth-syst-dynam.net/7/813/2016/esd-7-813-2016.pdf. These tools are also being used extensively by authors of the IPCC 6th Assessment Report currently in preparation.

- **WCRP Grand challenges on Cloud, circulation and Climate Sensitivity and Carbon cycle feedbacks** were initiated in 2014 and 2016 are led from WGCM**.** These grand challenges have brought together wide expertise on focussed themes under these topics and are delivering new understanding and strong vibrant research communities working on these key uncertainties. The GC on clouds, circulation and climate sensitivity has delivered 2 community assessment reports on climate sensitivity and aerosol forcing, synthesising multiple lines of evidence. These were submitted for publication in 2019 and are central to the IPCC AR6 WG1 science report.

2. Primary science issues (looking ahead, 3 to 5 years)

- **CMIP Future**. CMIP6 is an extremely ambitious undertaking that is already generating a lot of new scientific activity (e.g. understanding processes that influence climate sensitivity). However, the logistics on organizing and executing such a large, distributed but interwoven project is straining the capacity of the CMIP Panel, WIP and WGCM, challenging the feasibility of such a distributed organization, and pushing the limits of staff and computing resources at many climate modelling centres. In order for CMIP to continue delivering the large, coordinated, multi-model ensemble of historical simulations, process experiments, and future predictions and projections, a new approach may be required. WGCM will this year start the process of engagement with the International modelling community and the broad range of users of model output to try and build consensus on ways forward for CMIP
- **Extracting maximum value from the CMIP Multi-Model Ensemble (C-MME)**. The C-MME arises from a heterogeneous mix models, some of which share components, some of which are minor variants of others, all of which have errors or biases of some sort for different quantities or locations, have different sensitivity, different resolution, different levels of complexity in representing different physical or biogeochemical processes. An emerging topic that the WGCM would like to pursue more vigorously is improved methods for analysing this MME – questions of model weighting, model independence, the role of ensemble size, the benefits of MMEs vs LMEs (large individual model ensembles, etc. This will be essential to providing robust model information to support policy development and decision-making as well as providing science direction for the International modelling centres and the wider climate science community.

3. Issues and challenges, for example:

- WGCM activities are well integrated with research coordinated in other Core Projects. Many of the individual MIPs arose from, and are coordinated by, research teams that are primarily affiliated with a Core Project or Grand Challenge, and the analysis often relies on observational products that arise from other WCRP activities.
- The WGCM is the only body through which global Earth System Modelling Centres have an opportunity to plan joint activities, share experiences, and develop community perspectives or respond to questions/issues in a coordinated way. This has an influence on membership, in particular the issue that in order to be effective, a large portion of the WGCM membership must be from a modelling center and serve as a conduit to one or more centres.
- CMIP has been run as a volunteer effort since its inception. Many countries contribute extensively to the funded activities that underpin it – the development and execution of complex earth system models and the supercomputing facilities on which they run, the development, archival and dissemination of forcing and evaluation data, the archival and dissemination of CMIP model output, the development of evaluation tools, file and data standards, etc. At this point, without a project office to coordinate and advocate for these activities, CMIP is at risk. And the many entities that have come to rely on it (the IPCC, National climate

assessments, the climate science community in general) may not be well-served if we do not address this urgent need.