

CFMIP report, WGCM-17, Victoria, Oct 2013

On behalf of the CFMIP co-chairs (M. Webb and C. Bretherton) and CFMIP coordination committee members (S. Bony, S. Klein, B. Stevens, M. Watanabe), S. Bony presented an overview of CFMIP activities and CFMIP recommendations for CMIP6.

CFMIP activities are organized along three main threads:

- the understanding of cloud-climate feedbacks through a hierarchy of models, model experiments and model configurations
- the consistent evaluation of model clouds against observations, especially those from satellites using the CFMIP Observations Simulator Package (COSP)
- the understanding and evaluation of model clouds and cloud feedback processes at the process level through the analysis and comparison of GCM outputs with field experiments and process model outputs, including the joint CFMIP/GASS CGILS project (CFMIP-GASS Intercomparison of Large Eddy Models and Single Column Models)

The main science questions that were in the focus of CFMIP2 were : (i) how well do climate models simulate clouds ? (ii) what is the role of fast adjustments to CO₂ ? and (iii) what are the physical processes underlying cloud feedbacks and precipitation changes ?

A brief overview of some of the main lessons learned from CFMIP2/CMIP5 regarding these issues was presented, including the evidence that :

- the use of COSP in CMIP models (outputs from more than 10 models are currently available) made it possible to point out biases in the representation of clouds and cloud processes (including in areas such as polar regions where cloud evaluations has long been known to be difficult) which are likely to contribute to some of the systematic biases of coupled models (e.g. warm bias at the eastern side of the ocean biases, SST biases over the southern ocean).
- COSP outputs are not only useful for the evaluation of clouds but also for the diagnostic and physical understanding of cloud feedbacks, as COSP outputs make it possible to break down the global cloud feedback into cloud types and processes.
- the hierarchy of CFMIP2/CMIP5 experiments (in OAGCM, AMIP and aqua-planet configurations) aiming at separating the climate responses to CO₂ and temperature has led to new insights into cloud feedback and adjustment mechanisms, and precipitation responses to climate change ; these experiments have also formed the basis for additional CFMIP experiments.
- high-frequency process outputs (cfSites) at locations where a wealth of observations is available from field experiments or instrumented sites has a lot of potential regarding the evaluation of the diurnal cycle of models and the interpretation of cloud feedback processes.

To date, several dozens of CFMIP2/CMIP5 publications have already been published or submitted.

However, the analysis of CFMIP2/CMIP5 outputs is still ongoing and data are still being received from some modeling groups, so the full value of CFMIP experiments and outputs is yet to be realised.

Considering these lessons, but also recognizing the science gaps of CFMIP2/CMIP5, CFMIP makes a number of suggestions and recommendations for CFMIP3/CMIP6 :

- to strengthen, develop and generalize the benefit of CFMIP2/CMIP5, it is recommended to favor the continuity with CFMIP2/CMIP5 to encourage a more extensive participation of modeling groups to CFMIP experiments and outputs.
- to better assess and understand cloud feedbacks and adjustments in *coupled* models, it is suggested (i) to suggest experiments aiming at better diagnosing the time-varying radiative forcing of models in historical and future experiments, (ii) to propose idealized experiments with an abrupt solar forcing (+/- 3%), and to request process outputs (e.g. 3D tendencies of water and temperature) from a subset of coupled experiments.
- to better understand the impact of clouds and cloud changes on changes on regional temperatures, circulation and precipitation, CFMIP recommends to propose idealized experiments in simplified frameworks such as AGCMs or aqua-planets ; CFMIP is also promoting sensitivity experiments such as COOKIE (Clouds On/Off Klima Experiments) to assess the role of cloud-radiative effects on the climate system in present day and in climate change.
- to test physical hypotheses and emerging constraints on the link between cloud feedback processes and model formulation, CFMIP suggests to encourage a hierarchy of short-term Transpose-AMIP experiments (control, 4xCO₂, +4K), sensitivity tests to parameterizations such as SPOOKIE (Selected Processes On/Off Klima Experiments), and idealized global Radiative-Convective Equilibrium experiments (RCE) ; these latter experiments also constitute an opportunity to fill the gap between GCMs and Cloud-Resolving Models.

More specific recommendations for CMIP6 include : the need to better communicate the rationale for experiments and outputs to tackle science gaps, in connection with the WCRP Grand Challenges, the encouragement to raise the priority of inexpensive idealized experiments, and to attribute a « high priority » to a limited set of key simulator and process diagnostics.

CFMIP is also concerned that key diagnostics (such as COSP or process diagnostics) will need to be in the basic set of CMIP characterization experiments for the hierarchy of CFMIP experiments to be useful. In this perspective, CFMIP will do its best to define the CFMIP design and outputs requirements as early as possible, and to communicate the rationale of CFMIP experiments and diagnostics to modeling groups.