

CMIP7 Workshop: updates and new challenges



CMIP7 Workshop Report

This workshop took place in CSIRO Aspendale for two days at the end of February and was co-hosted by the [Australian Earth System Simulator \(ACCESS-NRI\)](#), [CSIRO](#), the [NESP Climate Systems Hub](#) and the [National Computational Infrastructure \(NCI\)](#).

The workshop focused on briefing the climate, weather and Earth system modelling research community, stakeholders and government representatives on the current state of Australia's contribution to CMIP7 — the next phase of the World Climate Research Programme Coupled Model Intercomparison Project – and to gather input on priorities for participation in CMIP7. CMIP's main aim is to better understand past, present and future climate changes arising from natural variability or in response to human activities in a multi-model context.

[See Workshop Program here](#), which includes links to the recorded sessions.

As a globally-coordinated shared resource, CMIP is widely used for research and in producing information for decision-makers, including through national and state climate projections. The 2021 Intergovernmental Panel on Climate Change (IPCC) sixth assessment report featured climate models from CMIP6, while the upcoming IPCC seventh assessment report (AR7) will feature new state-of-the-art CMIP7 models. For CMIP6, Australia submitted two (ACCESS-CM2 and ACCESS ESM1.5) primary model configurations, developed by CSIRO.

AIMS OF THE WORKSHOP

- Discuss amongst the community the status of current plans for CMIP7
- Compare Australia's current approach with other nations, and with CMIP5/6
- Discuss the influence, importance and impact of having an Australian climate model in CMIP7 and the current climate & Earth system model landscape for Australia
- Frame a community-wide strategy for Australia's CMIP7 contributions, including resourcing requirements
- Discuss what questions we hope to address with CMIP7 as a community
- Consider future needs for the use of CMIP in conjunction with other tools – emulators, machine learning, k-scale modelling, downscaling simulations

PARTICIPANTS

We had 97 registrations (40 in person and 57 online) from:

- Universities (Melbourne, Monash, UNSW, USyd, Wollongong, UTAS, UQ, University of Southern Queensland, ANU and Murdoch University)
- Government representatives: the Department of Education, Department of Environment and Science (QLD), Department of Water and Environmental Regulation (WA), Department of Climate Change, Energy, the Environment and Water (DCCEEW) and Climate Change Authority.
- National scientific organisations: CSIRO, The Bureau of Meteorology, NESP, Institute for Marine and Antarctic Studies, ARC Centre of Excellence for Climate Extremes (CLEX), Australian Antarctic Division, Securing Antarctica's Environmental Future, Australian Centre for Excellence in Antarctic Science
- International scientific institutions: Met Office (UK), NIWA (NZ), Centre for Climate Research (Singapore) and the World Climate Research Program (WCRP), with some requesting a recording given time zone differences.
- NCRIS climate infrastructures: ACCESS-NRI and NCI

OUTCOMES

The workshop involved constructive discussions around whether, why and how Australia could contribute to CMIP7. There was strong support from the attendees to encourage a strong CMIP7 contribution, with the primary motivations including:

- Create models that represent climate processes that are important for Australia and the Southern Hemisphere
- Maintain existing, and train new modellers, to provide essential capability for climate and weather models
- Sovereign capability and expertise to identify suitable climate policies, and to contribute to the tools needed for decision-making on climate mitigation and adaptation for Australia
- Provision of accurate sea level and climate forecasts to regional neighbours, particularly Pacific Island States
- Focal point for climate model development
- International collaboration and leveraging rigorous scientific evaluation through broader intercomparison of the ACCESS models
- Visibility of Australia's effort through CMIP7 to the next IPCC assessment report
- Bringing together and expanding Australia's earth systems modelling community
- Have an influence on the CMIP process
- Make explicit the requirements of the global models (ACCESS) for regional downscaling or other downstream use of the data.

In the past, Australia has had successful CMIP contributions (for example, ACCESS-ESM1.5 is the 4th most downloaded model in CMIP6) which has supported our research community and contributed to our international reputation in climate science. But the recent Australian CMIP effort has been under-resourced compared to other international groups and was overly reliant on the expertise of several key individuals who made enormous contributions.

Australia is already playing a strong role in the CMIP7 process, through membership on the CMIP panel and 5 of 6 Task Teams to set up the forcings, data processes and coordination for CMIP7. These memberships are sourced from a range of Australian institutions/universities and represent a cross-section of career stages.

The key elements of Australia's CMIP7 process include engagement with the international community about forcing, endorsed experiments and data protocols through the CMIP7 Task Teams, as well as the urgent need to create a system for model testing and evaluation with rapid feedback to the development process.

The decision on model development pathways is complex, and may involve a "minimal" development pathway, an ambitious single-model strategy, or a twin strategy that supports multiple model configurations (as in CMIP5 and

CMIP6). The level of ambition on the model development will depend upon the resource available and the CMIP7 timelines (which remain unclear). For any type of submission, the resource required to conduct computations, store the CMIP7 archive and support users (even beyond the CMIP7 timeline) need to be considered.

There was broad support for greater community involvement in Australia's CMIP7 submission, given the potential for CSIRO to work with the ACCESS-NRI, NCI and other partners to facilitate that community involvement, potentially through a consortium approach. The meeting participants identified the following next steps:

- To finalise a meeting report (this document)
- To form a small working group to explore the scope of a community approach and to begin preparing supporting material (value proposition, business case, options for model development/configurations) along with identifying existing capacity and gaps. The group should include early career scientists and a diverse range of contributors.

APPENDIX: Session Summaries

Session 1 – Introduction

This session introduced the workshop and the background of the CMIP project and included 6 talks:

- World Climate Research Programme (WCRP) coordinates activities on problems too big to be addressed by single nations, but doesn't fund research.
- 6 core projects, including Earth System Modelling and Observations (ESMO) which encapsulates the Working Group for Coupled Modelling (WGCM) and the Coupled Model Intercomparison Project (CMIP).
- CMIP is driven by scientists, is a high priority in WCRP and has very large impact.
- Australia is well-represented in the WCRP which is a two-way benefit – Australia benefits from overseas science and resources and the world benefits from Australia's perspective (especially around the role Antarctica, the Southern Ocean and other processes phenomena that are so important to our climate (such as ENSO) plays in the world's climate)
- CMIP exists to coordinate fundamental research, identify systematic biases and expose our climate and Earth system models to scrutiny and benchmark their relative performance. There is no "best" model.
- CMIP6 had 3 main science questions and many endorsed "MIPs".
- CMIP7 planning is underway, with deadlines likely in 2026 (though there's still uncertainty in IPCC timescale). Design may differ from CMIP6 – with both DECK and CORE MIPs.

Questions identified to resolve – in this workshop or beyond:

- What is the value of having an Australian contribution to CMIP7, and what are the risks of not submitting?
- What are the benefits of a CMIP7 contribution to decision-making?
- What will CMIP7 contribute that CMIP5/6 did not?
- How much information from CMIP6 we can reuse and what will be new in CMIP7?
- What are the options spanning possible ranges of involvement?

Reasons and resources available to support participating in CMIP7:

- Capacity building/training – Long term consequences for Australia's research if we don't participate – if you lose this you can never rebuild this engagement
- Get our science and modelling into IPCC and then inform policy – not possible if Australia's perspective is not included
- Computing and data resources – Climate is the national flagship of NCI – more than 50% of the resource.
- CMIP7 should have a community approach and resources to match our ambitions
- CMIP is the vehicle. Science questions and user needs as our foremost driver

Session 2 – Lessons from past CMIP5/CMIP6

This session featured 5 talks on lessons learnt from past CMIPs including resourcing, technical challenges, usability and outcomes:

- Australia has contributed to all CMIPs 1, 2, 3, 5 & 6, as well as AMIPs that preceded CMIP (there was no CMIP 4) and the Coordinated Regional Downscaling Experiment (CORDEX).
- Have often contributed 2 models – a more mature configuration and a forward-looking one.
- CSIRO has contributed roughly 10 FTE to the CMIP6 development and submission process plus compute; NCI contributed compute and storage and 5 FTE to model HPC improvements and for data management.
- CMIP6 plans had to be adjusted to achieve a successful submission. Initial plans for an ACCESS-ESM2- would not have met the IPCC deadlines leading to separate physical (ACCESS-CM2) and earth system (ACCESS-ESM1.5) submissions. Timelines were still tight increasing the risk of not finding significant bugs. However,

there were also unforeseen benefits of the two submissions including their different climate sensitivities and the lower compute cost of ACCESS-ESM1.5, allowing for larger ensembles.

- CMIP6 was critically reliant on the experience and dedication of a few key individuals, particularly amongst the CSIRO modelling team.
- Model development should be driven by science goals (how will weather change, where does carbon go, pathway to net-zero) that contribute to planning for adaptation and mitigation.
- Need to leverage technological advances of HPC.
- Science drivers motivate *both* high resolution and additional processes (it is not either/or). Also, ensembles, reduced biases ...
- Downscaling process (currently conducted after CMIP has finished) is of high value which rely on the CMIP7 model data (critically the Australian data, but also international model data). Should be incorporated into CMIP7 planning processes, though has its own set of requirements and drivers addressed by the National Partnership for Climate Projects (NCPC).

Session 3 – Breakouts to discuss the value of CMIP7

Should we get involved in CMIP7 and what would be the benefits to the Australian research community and society?

- Models that represent climate processes that are important for Australia and the Southern Hemisphere (landscapes, vegetation, Southern Ocean, ENSO) [7 groups]
- Maintenance and training capability for climate and weather research [5]
- Sovereign capability, control over our modelling system, ability to critique “odd” results from OS (esp around net-zero and defence) [4]
- Focal point for climate model development [3]
- Broad intercomparison and rigorous evaluation, leveraging the international community [3]
- Visibility of Australia’s effort – building a community of modellers and encouraging the confidence for others to buy in [3]
- International collaboration [2]
- Have an influence on the CMIP process [2]
- Make explicit use of links between global models (ACCESS) and regional downscaling (e.g. BARPA) [2]
- Is Australia a lifter or a leaner? We have a responsibility to contribute [2]
- Facilitate research on land surface and vegetation
- Our old and eroded landscapes and river basins are different to NH
- A credible ACCESS needs CMIP for validation
- Modelling is a crucial communication tool
- Urban modelling – our cities differ from NH cities
- Antarctic treaty
- Community effort and scrutiny leads to enhanced scientific understanding
- Robust value chain for impact assessments

On the negative side:

- Regional downscaling a more useful tool for decision-making
- We could just use other models?
- We could skip straight to CMIP8?

What are the key areas we can address by participating in CMIP7 with an Australian model?

- Water cycle
- Net zero
- Climate sensitivity
- Antarctic ice melt
- ENSO

- Southern Ocean cloud physics
- Better Antarctic modelling
- Physical model development (not just ESM)
- Urban climate
- Agriculture
- Climate intervention (geoengineering and carbon sequestration)

Session 4: Australia's role in CMIP7

Australia is well-represented in the CMIP7 Task Teams, and we heard about:

- Climate forcings, learning from CMIP6 lessons, possibly extending forcing back to 1750.
- Data citation, including a future data citation service.
- Data requests to support specification of formats and metadata and to support WCRP-endorsed MIPs.
- A strategic approach to ensemble design without adding to the overhead for CMIP modelling centres.

Session 5: Model development options

This session featured 7 talks which reviewed:

- Existing CMIP modelling capacity (ACCESS-CM2, -OM2 and -ESM1.5)
- Progress towards the development of ACCESS-OM3
- Ambitions to enhance the land surface, carbon cycle and vegetation dynamics in CABLE
- Coupled ice sheet-climate modelling
- Capacity to model atmospheric composition
- Model evaluation and its role in the model testing/development cycle
- The key role of tropical variability, and tropical biases that occur in CMIP models

Session 6 + reporting

Discussed 5 different topics in smaller groups to focus on how an Australian CMIP7 contribution could be coordinated.

CMIP7 experimental design

- Concept of a CORE set of MIPs is useful (DAMIP, ZECMIP, CDRMIP ...)
- Need to delineate priority of SSPs
- 1750 start date for forcing would be a positive, albeit with additional cost for participants; also need to extend beyond 2100 (to 100 years from today?)
- Ensemble size vs model complexity
- Land Use Change scenario choices
- Outputs need to be service-oriented, consider the needs for the downscaling model groups
- High resolution is a priority.

Model Evaluation

Goal here is to have an evaluation and testing framework which reduces the overhead in model development and tuning. Pathway to a successful evaluation:

1. Look at existing tools, create a system for tracking issues with models
2. Add capacity for ESMValTool
3. Community engagement and training on all evaluation tools
4. Add specific evaluation workflows for each community
5. Robustness of evaluation tools: Continuous Integration/Continuous Deployment (CI/CD)
6. All tools to use supported programmable interfaces.

Intent is to drive a connection between model developers and the active researcher community.

Data and infrastructure

Priorities include:

1. Data storage – volume, data management strategies, should it be provider-agnostic (NCI vs cloud)?

2. Post-processing model output – APP built into runtime software, flexibility of model output, systematic naming conventions, sustainability plan(??)
3. Publishing to ESGF and citations
4. Data uses and usability
5. Streamline QA, even/especially after CMIP is complete

ACCESS-ESM2 development pathway

A CMIP7 contribution built on ACCESS-CM2 (expanded to -ESM2) is viewed as a safe option, but does not preclude a more ambitious target in parallel. Key improvements needed include:

- More systematic model evaluation
- Improve accumulated carbon
- Vegetation dynamics
- Higher resolution options
- Fix the ENSO problem
- Improve SO warm bias (likely intractable)

Options include:

1. ESM2.5:
 - a. CABLE-3 + POP-LUC
 - b. WOMBAT
 - c. No GLOMAP?
 - d. Chemistry in DECK-light
 - e. Improve/tune parameterisation schemes
 - f. Should we enhance resolution in our base models?

Maintain ESM1.5 as development platform.
2. After this, consider moving components towards CM3/ESM3

ACCESS-CM3/ESM3 development pathway

Agreed on a definition of ACCESS-CM3 which would include ACCESS-OM3 (MOM6/CICE6), CABLE-3 and GAL-9 from the UM, possibly coupled with NUOPC (TBC). ESM3 would add other Earth system components (WOMBAT, POP/POP-LUC). Chem included with UM.

Pathways/Timelines:

- GAL9 is stable enough to couple, although tuning still going on in GC5.
- OM3 configuration has been tested, COSIMA aiming for full version in 2023
- ESM1.5 is being used as a base for all future CABLE development.

Priorities:

- COSIMA could alter priority to emphasise global over regional
- NUOPC coupling – testing with UM
- Systematic testing/evaluation framework

Options (depending on CMIP timelines):

- Explicit 2-model approach (ESM2 and CM3?)
- Is CM3 entirely constrained by CMIP7, or does it have independent value as a research tool?
- Accelerated spinup options, esp for BGC.

Department would need a costed and detailed plan which shows ambition, benefit and resource need.

Session 7 – Summary & Next Steps

Should we aim for a community consortium approach to CMIP7? Consensus was yes. Some issues that were discussed:

- Importance of involving EMCRs, to broaden the range of views supporting the planning process
- Do we need to put together an options paper, business case or project plan?
- Important decisions need to be made with different timelines
- Can we learn from the way CMIP7 is being organized (project office and task teams) – do we need a CMIP7 coordinator role and an Australian task team?
- Resources needs to be planned for since it is a significant investment (much from other sources). e.g. alignment with the HPC+data planning, particularly around NCI and NCRIS
- Involve the department (s)

Next Steps:

- Write a draft report from this meeting (8 Mar)
- Finalise meeting report (22 Mar)
- Small group to draft options in the next 6 weeks. Spell out existing capacity and what a wider approach would bring. Include EMCRs & diverse contributors.