

Atmosphere Working Group 10-year Roadmap

1. Why Australia needs ACCESS:

- Benefits of sovereign Australian modelling capability (national priorities, building community, international leadership)
 - Who are the users and stakeholders? (Australian government and university researchers)
 - Current benefits, applications and impact pathways.
 - Scope of ACCESS - improving core capability vs expanding the remit.
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- Sovereign modelling capability: Australia's distinctive weather and climate, spanning the tropics, Southern Ocean and Antarctica, require modelling capability tailored to Australian and Southern Hemisphere conditions.
 - Australian priorities: Models developed primarily for other regions do not always adequately represent Australian or Southern Hemispheric processes or address Australian priorities.
 - National resilience: Sovereign modelling capability is essential for predicting, preparing for and adapting to changing climate and weather risks identified in the National Climate Risk Assessment.
 - National research capability: ACCESS provides shared modelling capability for Australian government and university researchers, builds national expertise and supports international leadership.
 - Core role: Maintain and advance national modelling capability and infrastructure, while enabling the broader community to address national priorities.

2. What capability does Australia need in 10 years?

- Scientific priorities
- Government research and development needs
 - Principles for prioritising future ACCESS capability
- Emerging software and infrastructure landscape (AI/ML, GPUs, pressure on HPC/storage)

Scientific priorities

- Regional atmospheric modelling: improve understanding and prediction of Australian weather and climate, particularly extremes, convection, clouds, precipitation, land-atmosphere and atmosphere-ocean interactions.
- Global atmospheric and Earth-system modelling: better represent Australia and the Southern Hemisphere, including atmospheric composition and interactions with the ocean and land.
- Regional-global interactions: understand how large-scale circulation and variability translate into regional weather and climate over Australia.
- Process understanding: use high-resolution modelling and observations to improve representation of key atmospheric processes and parameterisations.
- Future prediction: improve understanding of changes in Australian weather and climate extremes under future climate conditions.

- Flexible modelling: support research across different configurations, including high resolution, low resolution (paleo), atmospheric composition, chemistry and future pathways.

Core capabilities

- High-resolution regional modelling from convection-permitting to sub-kilometre scales.
- Competitive global atmospheric/ESM capability, including atmospheric composition and the relevant land and ocean components.
- Strong alignment with international model development, including closer alignment of the ACCESS codebase with UK Met Office models to facilitate collaboration and uptake of developments.
- Atmospheric composition capability in LFRic, including the ability to develop and integrate relevant processes.
- Model development and code stewardship: a technically capable user and developer community able to modify configurations and source code.
- Clear pathways from research to operational model branches, including systematic testing and integration of successful developments into ACCESS and UM/LFRic.
- Systematic, process-based model evaluation using diverse observations and reproducible workflows.
- Regional-global integration, allowing developments and knowledge to flow between modelling scales.

Emerging software and infrastructure landscape

- Scalable compute and storage to support increasing demands from high-resolution modelling and CMIP.
- AI/ML readiness: support hybrid physics-ML models and emerging model architectures.
- ML-ready data infrastructure: support datasets for ML training and fine-tuning at increasingly fine scales.
- Data-driven methods: enable ML-based reanalysis and data assimilation.
- Data efficiency: explore ML-based compression to manage growing storage and data-movement demands.

3. Current state of ACCESS:

- Model suite (components / configurations and development trajectory)
- User support for running models and analysing output (inc. workflows / training / documentation)
- Infrastructure (software engineering, HPC, storage)
- Community uptake of models/output and engagement in development/evaluation.
- Strengths / gaps (compared to obs / the best international models)

Model suite and development trajectory

- ACCESS-rAM3 and ACCESS-AM3, based on UM13+, provide regional and global atmospheric modelling capability. ACCESS-RCM currently under development.
- CABLE development for both configurations is underway.

- Transition from Cylc7 to Cylc8, workflow post-processing and model optimisation are ongoing.
- Continued development is moving towards closer alignment with international/operational model developments.

User support

- Model releases, ACCESS-Hive, training and community working groups provide support for running and analysing ACCESS atmospheric models.
- Documentation, workflows and training cover model configuration, running simulations and analysis.

Infrastructure

- HPC, storage and associated infrastructure support current ACCESS atmospheric modelling activities.
- Development is ongoing to improve workflow efficiency, post-processing and model performance.

Community uptake and engagement

- 21st Century Weather has substantially increased community uptake and engagement.
- AAPP/CSIRO are contributing to atmospheric model and physics development, including CASIM/GLOMAP.
- Community working groups provide mechanisms for engagement in model development and evaluation.

Strengths

- Australia now has a documented regional and global atmospheric modelling capability with model releases, training and a platform for community engagement.
- ACCESS-AM3/rAM3 provide a foundation for developing atmospheric models suited to Australian and Southern Hemisphere conditions.
- The broader ACCESS community and programs have significantly strengthened model uptake and development.
- Australia has growing capability to contribute to international atmospheric modelling efforts.

Gaps

- Codebase alignment with international partners has historically been poor, limiting collaboration and slowing uptake of existing developments.
- It remains difficult for researchers outside major programs to contribute to model development and evaluation.
- There are gaps in user capability and support, particularly in documentation, training and practical examples that help users progress from basic model use to more advanced applications, including model modification.
- The pathway from process understanding -> model development -> evaluation -> incorporation into the main codebase needs strengthening.

- Higher-resolution modelling is creating increasing pressure on compute, storage, I/O and data analysis.
- Compared with leading international communities, there is scope to improve collaborative development, workflows and community engagement.

4. Vision for ACCESS in 10 years:

- Scientific capability:
 - Supported configurations
 - Resolution ambitions
 - New components or feature
 - Skill targets
- User capability:
 - Support for running models and analysing output (inc. workflows / training / documentation)
- Technical capability:
 - Required infrastructure (software engineering, HPC, storage)
 - Software transformation (GPU-readiness, AI/ML integration)
- Community capability:
 - User uptake
 - Engagement in development/evaluation.

Scientific capability

- Internationally competitive atmospheric modelling from global to km scales, with targeted sub-km capability where scientifically justified.
- Transition towards LFRic as the main next-generation framework, while retaining selected UM configurations where needed.
- Capability for atmospheric composition and other key process developments.
- Rapid adoption of advances from the UK Met Office and Momentum Partnership.

User capability

- A community able to run, modify and analyse ACCESS atmospheric models.
- Accessible training, documentation and workflows supporting users from model use through to development.

Technical capability

- Modern, maintainable and internationally aligned model codebases, with close alignment with the Momentum Partnership.
- Scalable HPC, storage and data workflows for high-resolution modelling and ensembles.
- AI/ML-ready modelling infrastructure.

Community capability

- A broad community actively developing and evaluating ACCESS atmospheric models.

- Clear pathways for community developments to be tested, integrated and released through ACCESS-NRI.
- Stronger collaboration across universities, government and international modelling centres, particularly through the Momentum Partnership.

5. Implementation roadmap:

- Priorities over 2, 5, 10 year timeframes

2 years - Stabilise and prepare

- Stabilise current atmospheric model releases: ACCESS-rAM3, ACCESS-AM3, AM3-Chem and key CABLE/GLOMAP configurations.
- Improve documentation, workflows, diagnostics and data processing to make models easier to run and evaluate.
- Begin transition to LFRic for both regional and global atmospheric modelling, while maintaining necessary UM configurations.
- Maintain close alignment with the UK Met Office and Momentum Partnership, avoiding divergence of the codebase.
- Ensure reliable compute, storage and CPU/GPU access through the infrastructure transition.
- Strengthen the atmospheric modelling community through training, working groups and cross-WG collaboration.
- Provide training from basic model configuration through to source-code development and contribution to the main branch.

5 years - Transition and consolidate

- Establish LFRic as the main development pathway for ACCESS atmospheric modelling.
- Deliver a competitive global atmospheric model for CMIP8 and ambition for major experiments.
- Maintain flexible regional and global configurations spanning climate to high-resolution applications.
- Establish routine process-based model evaluation as part of model development.
- Enable community developments to be tested and incorporated into supported ACCESS releases.
- Maintain close technical alignment with the Momentum Partnership.

10 years- Next-generation capability

- Establish an internationally competitive Australian atmospheric modelling system spanning global to km scales, with targeted sub-km capability.
- Integrate high-resolution regional and global modelling more seamlessly.
- Support atmospheric composition and other key Earth-system processes where justified.
- Provide comprehensive automated and process-based evaluation.
- Establish a mature research-to-model-development-to-application pathway.
- Have a broad Australian community actively developing, evaluating and contributing to ACCESS models.