Systematic errors in a high-resolution version of the ACCESS atmospheric model

Preliminary evaluation results from an analysis of the ACCESS atmospheric model show that, overall, the model does a good job in realistically simulating the major features of the surface climate and atmospheric circulation. However, rainfall, temperature, radiation and circulation biases have been identified. The next step is to identify the cause of these biases so they can be addressed in the model. This will improve ACCESS's ability to realistically simulate our climate, resulting in better climate projections to inform decisions and policy.

The ACCESS model

The Australian Community Climate and Earth System Simulator (ACCESS) is a state-of-the-science comprehensive climate model.

Just as the climate system is the result of interactions between the atmosphere, oceans, land and sea ice (among others), ACCESS comprises atmosphere, ocean, land surface and sea-ice models that are 'coupled' to communicate the relevant information between them. In this way, it can more realistically simulate the climate system.

Climate models represent the world in a series of three-dimensional grid cells. The smaller the grid cell, the higher the model resolution. Ideally, the higher the model resolution the better the model simulation should be.

However, in practice, models cannot always be run at high resolutions due to the high computational costs (modelling a complex system like the climate in fine detail takes a lot of computer time). Also, while we expect that higher resolution will improve simulation for all variables and regions, this may not turn out to be the case.

To assess which aspects are improved by higher resolution modelling, different model components are assessed at different resolutions (independently of the other components).

While ACCESS is among the top performing climate models internationally, like all models it has different biases (also referred to as model systematic errors) in its simulation of the climate. To improve the performance of the model, these biases in key climate variables need to be documented and the processes causing them need to be identified. We can then improve how the processes are represented in the model, so simulations better match the observed climate.

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Assessing the ACCESS atmospheric model

Earth Systems and Climate Change Hub researchers examined a high-resolution (60-km grid) configuration of the latest version of the atmospheric component model (UK Met Office UM GA7) of ACCESS. To identify the biases, researchers compared model output with observational and reanalysis (a dataset obtained by combining models with observations) datasets.

Biases in the atmospheric model

Preliminary results show that, overall, the high-resolution atmospheric model does a better job realistically simulating the major surface and atmospheric climate features than the low-resolution version. However, there are still significant biases that need to be investigated further to understand their causes. Some of these biases are:

- Surface temperatures are colder than observed over the continents during winter.
- Air pressure at sea level is higher than observed over the high-latitude Southern Ocean.
- Downward shortwave radiation (visible sunlight) is greater than observed over the Southern Ocean (which causes a major warm bias there).
- Rainfall is wetter than observed over the tropical western Pacific and Indian Oceans and drier than observed over the Maritime Continent (the region between the Indian and Pacific Oceans).
- Atmospheric convection (that is, upward motion) over the Maritime Continent is weaker than observed (leading to lower than observed rainfall).
- Southern Hemisphere storm tracks are located farther south than observed.
- The dominant Hadley Cell is slightly displaced upward (affecting the position of the jet stream, which in turn affects the paths of weather systems).

Increasing the horizontal resolution of the model (from 135 km to 60 km) significantly reduces the dry rainfall bias over the Maritime Continent. Earlier studies (using GA6, the previous version of the atmospheric model) showed that this is largely due to the more realistic representation of mountains in the region in the high-resolution model. However, while increasing the resolution improves simulation of the amount of rainfall, it does not improve the simulation of the timing (day/night) of the rainfall.

Next steps

Having identified the biases, the next step is to understand the causes of some of these errors. This will require additional research. When the causes have been identified, representations of these processes can be updated accordingly in subsequent versions of the model.

Hub researchers will also collect and archive the software tools used for model evaluation so they can be made available to other potential users of the model.

Other modelling work will include conducting a coupled simulation with the high-resolution atmospheric model as part of the full ACCESS coupled model, which will then be used as a platform for further model development.

Ongoing development of ACCESS, underpinned by research to better understand the components of the climate system will ensure that Australia's climate modelling capability remains world-class. More importantly, it will ensure that governments, businesses and communities across the country have access to the best possible information about Australia's climate with which to make decisions about the future.

For more information, please refer to the full technical report:

Rashid H, Zhu H and Sun Z (2017) Initial documentation of key systematic errors in a high resolution (60 km grid) version of the current ACCESS atmospheric model. Earth Systems and Climate Change Hub Technical Report No. 1, NESP Earth Systems and Climate Change Hub, Australia.

The report is available at **www.nespclimate.com.au**.