Building an Earth System Model: Scientific and Technical Challenges

The Centre for Australian Weather and Climate Research

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Abstract A25B-04

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1. A new earth system model for Australia

The Australian Community Climate and Earth System Simulator (ACCESS) is a state-of-the-art, fully-coupled earth system model. Being developed as a joint initiative between CSIRO, the Bureau of Meteorology and the Australian universities, it will be used for both climate research and numerical weather prediction.

ACCESS represents a trend in earth system modelling towards models that are increasingly complex, and which are increasingly modular in nature. The construction of such a model therefore presents considerable scientific and technical challenges. This presentation discusses progress by the ACCESS team to date, including some of the challenges that have been encountered and the solutions that have been developed.

2. A modular model

ACCESS is composed of a number of separate components, as shown in Figure 1.

It is built around the OASIS coupler, with the core physical components being the UM atmosphere model, the MOM4 ocean model and the CICE sea ice model. Other components include the CABLE terrestrial model, which has been developed by CSIRO, the vegetation model LPJ, and modules for atmospheric chemistry and oceanic biogeochemistry. Ultimately, it is intended to incorporate socio-economic processes as well.

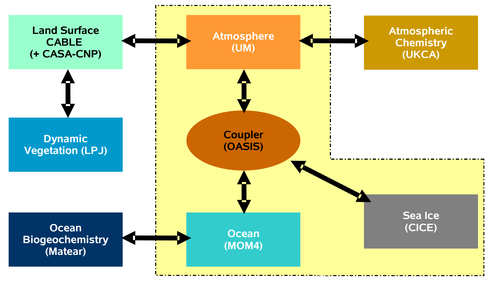
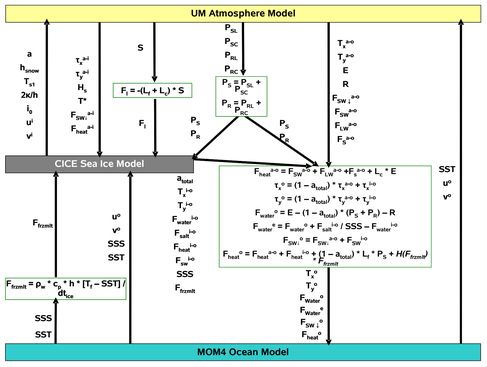


Figure 1: The structure of the ACCESS earth system model, showing the core physical components and the additional biogeochemical modules.

3. Coupling the components

Differences between the physical interfaces of each component model can represent an obstacle to coupling.

An example of this is encountered when coupling the UM atmosphere model to the CICE sea ice model, as both models depend upon being free to calculate the surface temperature and surface heat flux. The solution to this apparent incompatibility is to modify the physics of CICE so that these quantities are instead prescribed as the upper boundary condition.



The atmosphere, sea ice and ocean models can then be coupled as follows:

- The sea ice and ocean models pass the temperature and conductivity of their upper layers to the atmosphere model.
- The atmosphere model calculates the surface temperature and the surface heat flux, which it then passes back.

This arrangement is illustrated in Figure 2.

Figure 2: The proposed coupling strategy for the ACCESS earth system model, showing the fields exchanged by the atmosphere, sea ice and ocean models.

4. Managing the source code

The development of ACCESS involves a much larger effort than previous Australian climate or weather prediction models, with a large number of developers spread across multiple institutions and multiple sites. It is also necessary to manage the source code for multiple component models, including applying code updates as required.

The solution is to use the Flexible Configuration Management (FCM) system, which is based upon the subversion version control system. Trac is also used for project management and bug tracking (Figure 3).

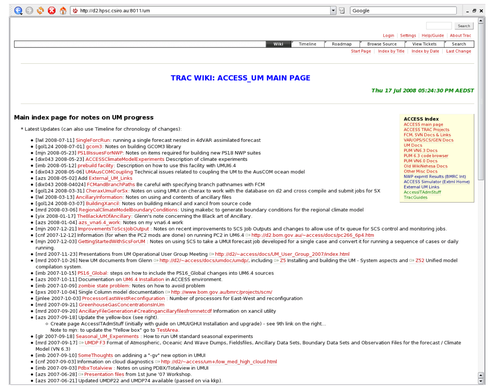


Figure 3: The ACCESS Trac wiki.

5. Initial results

The ACCESS atmosphere model is able to accurately simulate the spatial patterns of temperature and rainfall across Australia (Figures 4 and 5).

The ACCESS ocean model also demonstrates an impressive ability to simulate the interannual tropical climate variability associated with El Niño (Figure 6).

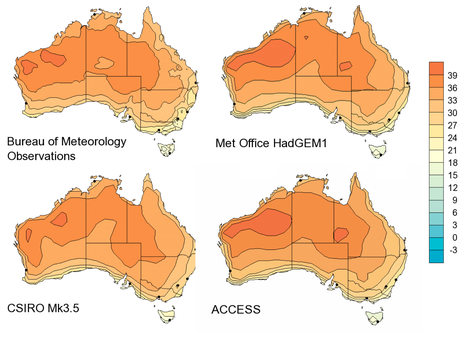


Figure 4: Observed and simulated summer maximum temperatures over Australia (°C).

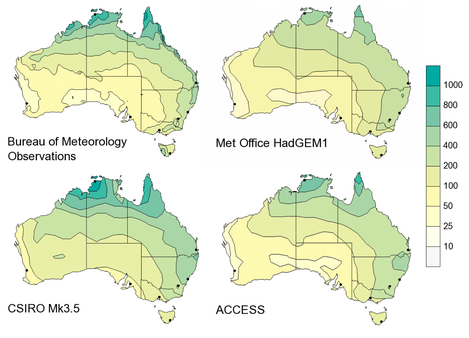


Figure 5: Observed and simulated summer rainfall over Australia (mm).

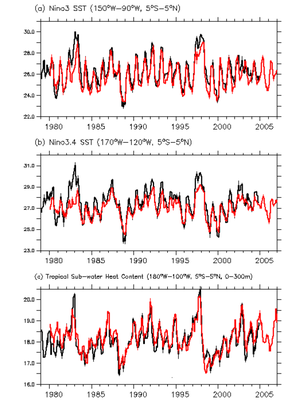


Figure 6: Tropical climate variability: observations (red) and the ACCESS ocean model (black).

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