Earth Systems and Climate Change Hub
National Environmental Science Programme

REPORT NO. 3: SUMMARY

A comprehensive report of model systematic errors in the latest ACCESS climate models

Building on a preliminary evaluation which identified temperature, rainfall, radiation and circulation biases in the ACCESS climate model, Earth Systems and Climate Change Hub researchers conducted further simulations to understand the cause of the identified biases and the potential modifications required to improve the ACCESS climate model. This will improve the ability of ACCESS to realistically simulate our climate, resulting in better climate information to inform decisions and policy.

The ACCESS climate model

The Australian Community Climate and Earth System Simulator (ACCESS) is a comprehensive climate model comprised of atmosphere, ocean, land surface and sea-ice models. These models are 'coupled' to more realistically represent the climate system.

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, the processes causing them need to be identified and modifications to improve the biases need to be tested. This will allow improvements in how the climate variables are represented in the model, so simulations better match the observed climate.

Assessing the ACCESS atmospheric model

Preliminary evaluation of the ACCESS model conducted by Rashid et al (2017; see Earth Systems and Climate Change Hub Report 1) showed that, overall, the high-resolution atmospheric model does a better job of realistically simulating the major surface and atmospheric climate features than the low-resolution version. However, the preliminary evaluation found that there were still significant biases that need to be investigated further to understand their causes.

Building on these preliminary findings, Earth System and Climate Change Hub researchers conducted further simulations on the latest ACCESS climate model to understand the causes of biases identified. These investigations focused on the simulation of tropical rainfall including the diurnal (daily) rainfall cycle and Madden-Julian Oscillation (MJO); surface heat fluxes; surface wind speeds and radiation fluxes.

In this evaluation, model systematic errors in the recent versions of the ACCESS climate model using the GA7 and GA7.1 atmospheric model physics are

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compared and documented. The ACCESS Singular Column Model (SCM) (with the GA6 model physics package) is also used in this evaluation to identify the model systematic errors and test possible modifications to model representations of tropical convection to reduce those errors.

Evaluation findings

Rainfall biases

The representation of rainfall in ACCESS models is generally 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). This evaluation found that by increasing model resolution, both these biases are reduced. This also leads to improved Madden-Julian Oscillation model simulations.

Diurnal rainfall cycle biases

The diurnal cycle of rainfall over tropical land is not well represented in the model. A modification to the parameterised convection scheme by implementing the convective memory scheme resulted in a reduction in the drying bias over the Maritime Continent and, due to the interconnections through the Walker Circulation, a reduction to the wet biases in the Indian Ocean and West Pacific Ocean. The representation of diurnal rainfall cycles over tropical land also improved.

Surface heat fluxes and surface wind speeds biases

Surface heat fluxes and surface wind speeds show consistency with other climate models. The high-resolution model performs better in representing global energy exchanges at the surface and surface winds.

Biases in radiation and heat fluxes

Southern Ocean shortwave radiation biases in the ACCESS climate model with the GA7.1 physics package are much improved compared to previous versions of the model. This may also lead to improvements in sea surface temperature simulations.

Increased spatial resolution reduces the relatively large positive biases occurring in lower resolution models in sensible and latent heat flux in the polar regions, however biases are increased in the equatorial and southern mid-latitude oceans.

ACCESS Singular Column Model experiments

The ACCESS SCM is used in this evaluation to test possible modifications to the model representation of tropical convections with an aim to reduce model systematic errors. Using ACCESS SCM to examine the modifications to the elements of deep convection representation in the ACCESS model showed that implementing a different trigger to the convection reduces the intermittency of rainfall. A preliminary investigation using ACCESS SCM was also undertaken to determine the potential cause for the wet bias over the tropical ocean, and the role of shallow convection in the representation of water transport from the sub-tropics into the tropics. Due to the lack of the large-scale circulation feedbacks, the SCM experiments require further investigation using a full climate model.

Next steps

Although modifications to the convection scheme in this evaluation resulted in improvements in the representation of the diurnal rainfall and the reduction in rainfall biases, some rainfall biases associated with the model variability still persist. Future investigations will be conducted to further improve the model biases and its impacts will be documented.

The modifications to deep convection and shallow convection conducted with the ACCESS SCM model is currently being tested using a full climate model.

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

Zhu H, Jakob C, Ma Y, Warren R, Santra A, Yorgun S, Sun Z. 2018. A comprehensive report of model systematic errors in the latest ACCESS climate models. Earth Systems and Climate Change Hub Report No. 3, NESP Earth Systems and Climate Change Hub, Australia.

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