Australia's Earth system model revamped for a clearer view of past and future climate

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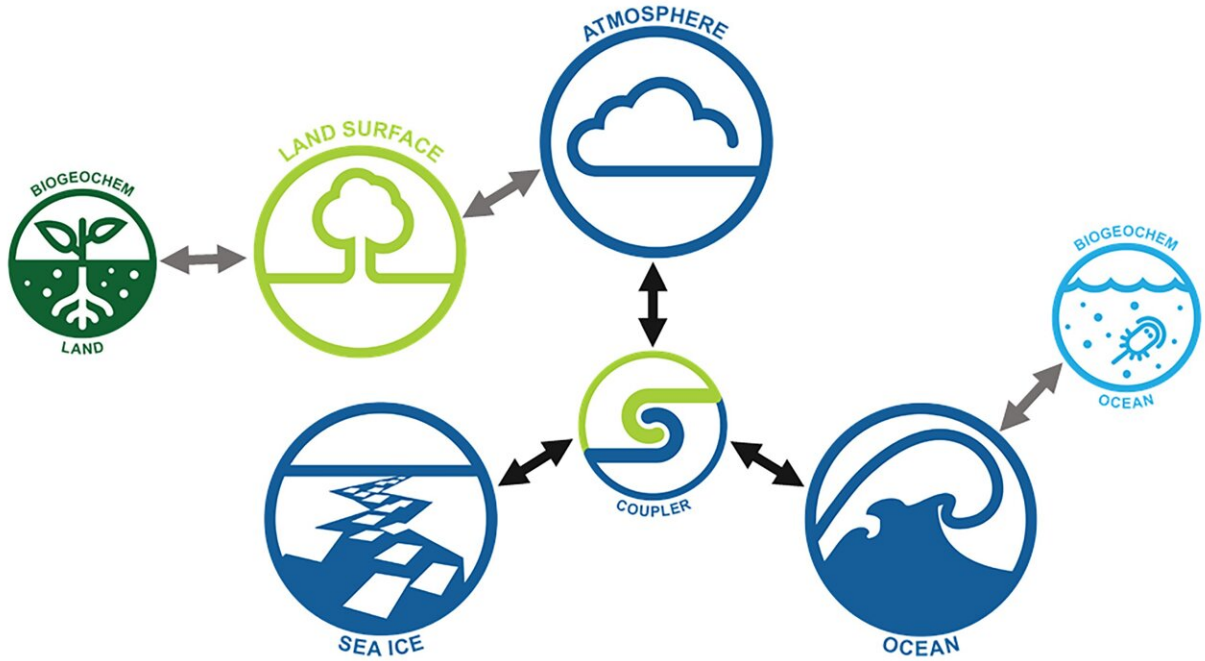

ACCESS-NRI/The ACCESS ESM1.5 model. Credit: ACCESS-NRI

Just as astronomers use powerful telescopes to peer into the vast expanse of the universe, climate scientists use sophisticated climate models to gaze into the future and look back into the distant past, simulating the complex interactions that shape our planet's climate.

An Earth system model (ESM) is a type of climate model that combines components of the Earth's system: the atmosphere, oceans, land, ice, and biogeochemical cycles, to simulate interactions and feedback processes that influence global and regional climates.

Developed by CSIRO, the ACCESS Earth System Model 1.5 (ACCESS-EM1.5) has been heavily used by the research community in many areas, both globally and in Australia, as a tool for understanding and projecting climate change with a unique Australian focus.

Now, Australia's climate simulator (ACCESS-NRI) has improved this essential climate research infrastructure.

"The model now uses the ACCESS-NRI software pipeline and best practices including continuous integration, deployment and testing to ensure reliable results and make it easy for researchers to use," says Dr. Aidan Heerdegen, team leader of the ACCESS-NRI Model Release team.

"The build pipeline creates a unique fingerprint that identifies all the code and software used, providing essential provenance information, and so that it can be reliably built again," says Dr. Heerdegen.

CSIRO's climate scientist Dr. Tilo Ziehn, lead developer of the ESM1.5 model, points out that "the latest release of ESM1.5, as well as the training and technical support provided by the ACCESS-NRI has been a big game changer for the climate research community.

"It has allowed researchers to run the model themselves, and now we have a common approach on how to set up the model with different configurations. The infrastructure and the support that comes from the ACCESS-NRI enable everything that we do, including the development of the next version of the model, ESM1.6."

ESM1.5 has an impressive user record ranging from researchers using it to understand climate variability and drivers, future emission pathways, consequences of meeting or failing to meet Paris agreement targets and changes in natural carbon sinks to the role of Atlantic Meridional Overturning Circulation (AMOC) and El Niño Southern oscillation (ENSO), as well as to educate the next generation of climate scientists.

"ESM1.5 is crucial for Australian researchers as it gives us the ability to focus on the regions that are of interest to us and to address the kind of research and policy questions that are important to us. We know that ACCESS-ESM1.5 performs very strongly over the Southern Ocean and for the terrestrial carbon cycle, compared to other models. The model is also unique in that it includes phosphorus limitation, which could be an important limiting factor for plant growth and carbon uptake in nutrient-poor areas like the Australian continent," says Dr. Ziehn.

ESM1.5 has also been used by the paleoclimate community to understand the climate of the Earth from thousands to millions of years ago. Paleoclimates provide a unique perspective on climate change by allowing researchers to test and improve climate models, ensuring they can accurately simulate past climate conditions and project future scenarios. The ACCESS-NRI team has included some new features in this release that makes their work easier, faster and more precise.

"We designed preset model configurations for the paleoclimate community because they run the model for thousands of years, producing an incredible amount of data. It can take approximately two months to run 1,000 years of simulations continuously. These presets allow the researcher to more easily choose which data they want to keep or discard, accelerating the process of setting up an experiment," says ACCESS-NRI research software engineer Spencer Wong, who developed this new feature.

"This release also includes a way to change the degree of the tilt of the Earth's axis, also called orbital parameters. We have added a 'time dial' into the model, so researchers can match the right value of the orbital tilt at different past climates," he says.

Dr. David Hutchinson, a paleoclimate researcher from the University of New South Wales and user of the models, says, "We know the tilt of the Earth plays a critical role in shaping the planet's climate as it affects the distribution of solar radiation between the equator and the poles. It has been a key driver of the ice-ages in the last one to 2 million years.

"Previously, it was quite difficult for us to modify this variable in the model's code. This new feature of the model enables us to change the orbital parameters ourselves, which has been on the wish-list of the paleoclimate community for a long time," he says.

ESM1.5 has also been used to contribute to many multi-model studies and in international collaborations like the Coupled Model Intercomparison Project (CMIP). "I have used ESM1.5 as one of 16 models around the world, to compare its performance and outputs to other climate models," says Dr. Nicola Maher, a researcher from the ARC Center of Excellence for Weather of the 21st Century. "I think it is extremely important to have an Australian model, so we can further improve the focus on the region and answer the questions that are important for us," she says.

The importance of ESM1.5 in helping us navigate the challenges posed by a changing climate in Australia and in our region can't be overstated. Maintaining and improving this essential software infrastructure and enabling it to evolve according to researchers' needs is critical to better understand and predict climate change.

Provided by ACCESS-NRI