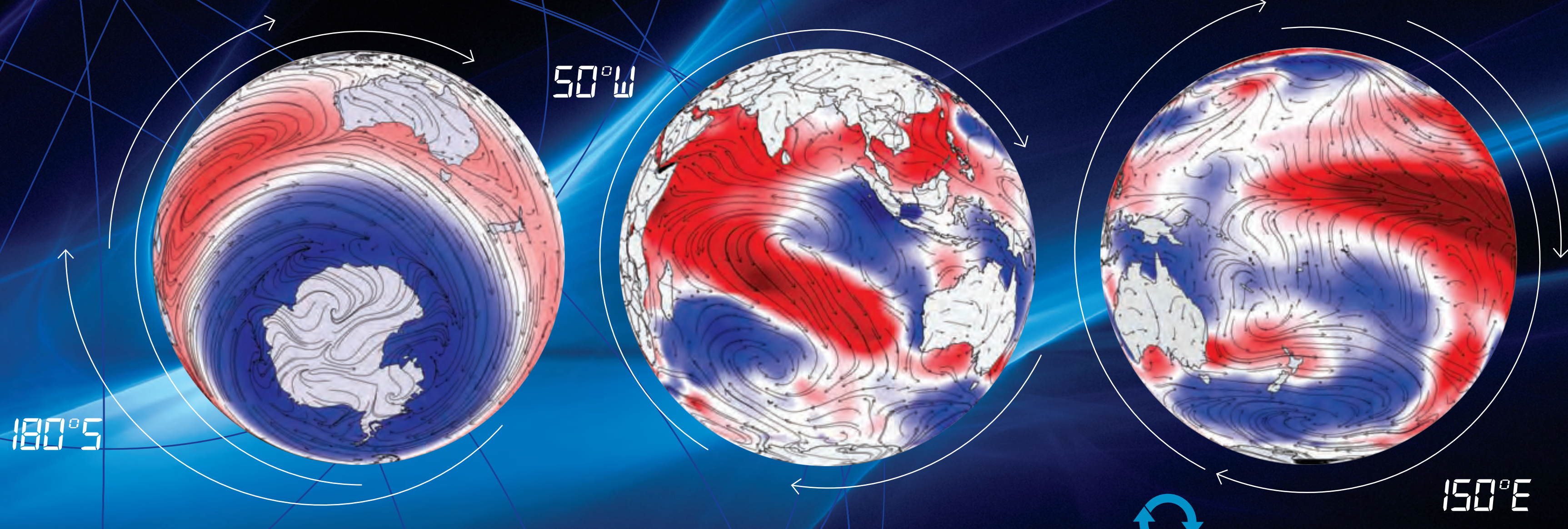
NATIONAL COMPUTATIONAL INFRASTRUCTURE

CLIMBING INSIDE AUSTRALIA'S **CLIMATE ENGINE**

RESEARCHERS ARE INVESTIGATING HOW THREE GIANT WEATHER MACHINES DRIVE OUR CLIMATE



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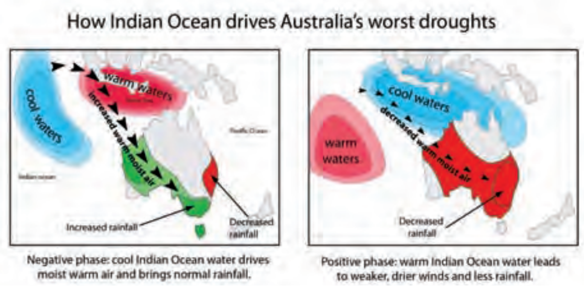
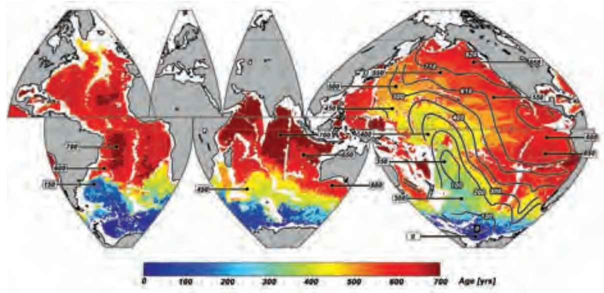
The vast apparatus that powers Australia's climate is being explored in unprecedented depth and detail, as scientists probe the drivers of drought, flood and climate variability, using the nation's most powerful supercomputer to decipher how our world is changing.





Professor Matthew England, Professor Andy Pitman and colleagues at the University of NSW use the National Computational Infrastructure's supercomputer to run an enormous mathematical model that combines the effects of the oceans, atmosphere, sea-ice and land vegetation cover, as they seek to penetrate the mysteries of our future continental weather systems.

"Research into climate variability and change is vital to Australia," Matthew says. "Many sectors such as agriculture, bushfire management, water supply, energy resources, health and tourism depend on accurate climate forecasts." The knowledge his team is building through the models is yielding fresh insight into the workings of the climate system, with the ultimate goal of better long-term forecasts and optimal strategies to mitigate or adapt to climate change.

This groundbreaking research seeks to interpret the links between three gigantic systems that dominate Australian weather patterns and climate. Besides the familiar El Niño / Southern Oscillation, which brings drought to the east of the continent, Australia is subject to the baleful influences of the Indian Ocean Dipole (IOD) and the Southern Annular Mode (SAM). The team recently established that the 10-year "Big Dry" over southeastern Australia was primarily driven by the IOD, an irregular cycle of warming and cooling of the waters across the tropical Indian Ocean. This temperature see-saw regulates the strength and moisture of the winds that flow towards southeastern Australia, affecting drought cycles from year-to-year and decade-to-decade.

The Southern Annular Mode is the leading driver of climate variability over the midlatitude Southern Hemisphere. The SAM is defined by the gradient in pressure between Antarctica and the southern mid-latitudes, which whips up the mighty winds of "The Roaring Forties". The SAM exerts a dynamic influence over ocean circulation, water-mass formation and the distribution of heat and energy around the entire planet. In positive mode, it drags low pressure systems southward, reducing rainfall over southwest WA, Tasmania, Victoria and South Australia. Unfortunately, both greenhouse gas increases and polar stratospheric ozone depletion are driving the SAM toward a positive phase, reducing rainfall over the southern margins of the continent.

Interpreting the interlocked complexity of these three systems calls for colossal computational power. "It's a huge model, hundreds of thousands of lines of computer code — perhaps four Sydney phone books if printed in full," Matthew says. His team also employs three other internationally acclaimed coupled climate models, run for comparison against one another or studied independently, with options for sub-modelling the ocean and atmosphere in isolation. For atmospheric process studies, each experiment is typically run around 100 times in an ensemble set using slightly perturbed initial conditions. This enables the researchers to recover a robust signal from the chaotic 'noise' that is inherent in atmospheric dynamics and flow patterns.

Yet the model applications can be supremely practical. "Some States are making decisions about whether or not to install desalination plants costing billions of dollars. You'd like those decisions to be founded on a good understanding of what is likely to happen in the future, not just a short-term response to what might be a naturally-occurring dry spell," he says.

How climate change will affect El Niño, the Indian Ocean Dipole and the SAM is of vital concern to Australian water planners and grain farmers, and also to policymakers seeking to stabilise the world's carbon emissions: "The Southern Ocean is a natural sink for the world's excess carbon," Matthew explains. "How much it can absorb and its continuing ability to do so depends to a large degree on the modes of circulation in the ocean and how they will change into the future. This in turn feeds into decisions about how much and how quickly we need to reduce emissions to reduce the risk of dangerous human-induced climate change."

Linking the three great drivers of Australia's climate to the known trajectory of global climate change — currently tracking at the high end of the predictions by the Intergovernmental Panel on Climate Change — is a primary mission for the UNSW team. "Recently the Indian Ocean has warmed more rapidly than the other major ocean basins. We think this might have had a major influence on Australian rainfall patterns — for example, recent research suggests this has brought increased rainfall to the north and northeast of the continent. Climate change is already affecting the oceans — and they in turn impact on our climate patterns."

Developing useful regional forecasts from the mass of chaotic variability and complexity that is the climatic engine remains a massive challenge, he admits. "It is in many ways a lot easier to predict what the climate will be like in 100 years in a broad-scale mean sense, for a given trajectory of greenhouse gas emissions, than it is to forecast with confidence what the next few seasons will bring in rainfall to parts of Australia. But we're getting there."

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