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Strengthening regional climate change projections of rainfall changes through fine-scale dynamical downscaling modelling and analyses of climate drivers at all scales

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General Circulation Models (GCMs) are our best tool for assessing potential changes to our climate on a global scale into the future. However, certain physical processes that influence rainfall at any particular location operate at spatial scales finer than GCMs can simulate. Regional dynamical downscaling of GCMs addresses this problem by simulating relevant processes at a finer scale, whilst retaining the important global scale features simulated in the original GCM. Thus this process simulates relevant climate mechanisms at several length scales. Here we present fine-scale dynamical downscaling model results of rainfall changes and the drivers behind that change for the challenging test case of Tasmania, Australia.

Tasmania is an island with a temperate maritime climate. It is positioned in the roaring 40s of the Southern Ocean and has a temperate maritime climate. It is topographically rugged and has complex rainfall distribution and variability across a small area. Tasmanian rainfall is influenced by a complex suite of large-scale climatic drivers that varies with location and season. Remote drivers of Tasmanian rainfall include the southern annular mode (SAM), El Niño Southern Oscillation (ENSO), Indian Ocean dipole (IOD), the position and intensity of the subtropical ridge (STR) of high pressure, and atmospheric blocking in the adjacent Tasman Sea.

We have produced a set of fine-scale ($\sim$10 km) projections of Tasmanian climate to 2100 using a process of dynamical downscaling. This process retains global-scale features present in GCMs, and then simulates processes at a finer scale in the area of interest. Projected changes to rainfall to 2100 are distinct in the different districts of the state, and vary greatly by season. Each of these changes is driven by a unique combination of drivers and processes. This includes the local expression of large-scale drivers such as ENSO, IOD, SAM and the position of the STR. It also includes the influence of processes that are poorly resolved or completely lacking in GCM simulations, such as atmospheric blocking, the atmospheric response to changes in local sea surface temperature (SST), convection, and the interaction of synoptic systems with rugged topography. In this paper we present a complete view of rainfall changes in the districts of Tasmania, in which we link large-scale drivers and finer scale processes to spatial and temporal changes in rainfall. Such analyses are only possible with fine-scale dynamical downscaling. We conclude that fine-scale dynamical downscaling provides more useful projections of rainfall changes at a local scale into the future, and that an analysis of all the relevant rainfall mechanisms also adds confidence in the use of climate simulations as a tool for understanding future changes to rainfall.