Evaluation and 21st century projections of global climate change models at a regional scale over Australia

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Abstract

This thesis explores the ability of global climate models (GCMs) to simulate observed conditions at regional scales by examining probability density functions (PDFs) of daily minimum temperature (T_{min}), maximum temperature (T_{max}) and precipitation (P). Two new measures of model skill are proposed using PDFs of observed and modelled data. The first metric (S_{score}) compares the amount of overlap between the two PDFs. The second metric ($Tail_{skill}$) is the weighted difference between the PDF tails, where extreme events are represented. The resulting measures of skill are used to differentiate, at a regional scale, between weaker and stronger models. It is investigated whether the weaker models bias future projections given by multi-model ensembles, increasing the uncertainty in the range of projected values and the change from the 20th Century.

The S_{score} is demonstrated to be robust against inhomogenities found in high-density Australian datasets, and is a simple and quantitative measure of how well each GCM can simulate all observed events. This methodology is executed for twelve Australian regions of varying climates for all Intergovernmental Panel on Climate Change 4th Assessment Report models for which daily data was available for 1961-2000. Across T_{min}, T_{max} and P some GCMs perform well, demonstrating that some GCMs provide credible simulations of climate at sub-continental scales.

Projections of the annual and seasonal mean and yearly return values over the A2 and B1 emission scenarios are investigated. Models are omitted from an ensemble based on their ability to simulate the observed PDF at regional scales. The stronger models are generally in agreement with the change in mean values, particularly for T_{min} and T_{max}, though it is shown that they vary in their projections of the yearly return value at least twice as much as projections in the mean values.

Lastly, a means-based evaluation method, the S_{score} and the $Tail_{skill}$ are employed to differentiate between weaker and stronger models for projections in the 20-year return value of T_{min} and T_{max}. Weaker-skilled ensembles project larger increases in 20-year return values than stronger-skilled ensembles, such that in some regions for maximum temperature the ensembles are statistically significantly different. Demonstrably weaker models bias projections given by an all-model ensemble and should be excluded so the most reliable estimates of future climate can be obtained.