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Quantifying uncertainty in global climate models when predicting species distributions: a case study in South-Eastern Australia

K. J. McGregor and T. J. Regan
The School of Botany, The University of Melbourne, Melbourne, Australia (karenm@student.unimelb.edu.au)

Effectively managing biodiversity in the face of climate change requires an understanding of how and when future climates may alter species' ranges. Typically this is done using species distribution models (SDMs) which predict suitable habitat based on correlations between known occurrences of species and climatic and/or other environmental characteristics. These models are projected into the future using global climate models (GCMs), which characterize changes in climatic variables through time. Multiple GCMs have been produced, relying on different parameters and functions. This results in considerable variation among GCMs. The influence of GCM choice on predicted habitat suitability in the future is not well understood. In order to effectively manage for the continued survival of species it is important to understand how the choice of GCM influences predicted species distributions, and what environmental drivers are causing any differences.

This study aims to quantify the influence the choice of GCM has on predicted species distributions under climate change and to understand the underlying environmental drivers of any differences. We developed a presence-only maxent model for Xanthorrhoea resinosa, a long lived plant species found along the east coast of Australia. We projected the model into the future using five GCMs: the IPCC ensemble, CSIROMk3.5, GFDL 2.0, Max Planck and HadGEM1, for the A1FI emissions scenario. Results suggest there is large variation in how suitable habitat will change over time depending on the GCM used. Further interrogation highlighted that precipitation of the driest period, influenced the differences the most. This research draws general conclusions regarding the choice of GCM for species whose distributions are driven by similar climatic conditions. When projecting SDMs into future climates we recommend several exploration tools to better understand future predictions and to guide evaluation and model development.

Uncertainty is fundamental to this research, as the many available global climate models produce very different maps of future species distributions. There is considerable uncertainty as to which GCM is most appropriate to use. This research uses a range of metrics to quantify the differences between the GCMs, attempting to focus on what is most variable between alternative GCMs. It also looks into the predictor variables of the GCMs, to see what is driving these differences and considers what could be done to remove some of this inconsistency. This study will contribute to understanding and providing guidance to users of GCMs as to the level of certainty with which they interpret maps of species' future distributions, and what they can do to remove some of that uncertainty.