Evaluation of dynamically downscaled CMIP6 models using CCAM over Australia. New approach to added value of downscaling using information on climate extremes

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High-resolution climate change projections are increasingly required to inform climate policy and adaptation planning. Downscaling of global climate models (GCMs) is required to simulate the climate at the spatial scale relevant for local impacts. Here, we dynamically downscaled 15 CMIP6 GCMs to a 10 km resolution over Australia using CCAM (Conformal Cubic Atmospheric model) for SSPs 126, 245 and 370. We compared the host CMIP6 models and downscaled simulations to the AGCD observational dataset, and evaluated performance using Kling-Gupta efficiency, and the Perkins skill score. The new added value index was derived by assessing the daily, monthly (annual cycle and amplitude) and seasonal climate for 1981-2100 period by comparing combined skill of CMIP6 host models and CCAM downscaled simulations. In addition to assessing the Perkins score for entire PDF, the 5 and 95 percentile for mean, minimum and maximum temperatures and fraction of dry days and 95 percentile of precipitation were considered. The combined skill score index/added value of downscaling was normalised and relative skill score of individual models can be compared for major IPCC regions and local government planning areas in Australia.

Downscaling CMIP6 models improved performance for seasonal and annual cycles for temperature (10% and 6%) and precipitation (43% and 13%). CCAM downscaling also improved the fraction of dry days, reducing the bias for too many low rain days by nearly half. The largest improvements were found in extremes, with improvements to extreme minimum temperatures in all seasons (varying from 142 to 201%), and improvements of 52% to extreme precipitation in Austral winter (JJA) and 47% in summer (DJF). The ensemble average overall skill score improved by 19% with downscaling. Temperature and precipitation biases were also reduced in mountainous and coastal areas. CCAM downscaling therefore adds value to the CMIP6 models, so this dataset will be a valuable resource for understanding future climate changes in Australia. The new CMIP6 dataset is the largest in term of number of simulations and resolution for Australia and will contributed to CORDEX and Australian Climate Service database. Work is continuing on deriving climate extreme indices such as drought, heatwaves, fire weather, tropical cyclones and convective extrems, including specific focus on climate hazards.