Assessing the impact of bias correction approaches on climate extremes and the climate change signal

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Abstract: We assess the impact of three bias correction approaches on present day means and extremes, and climate change signal, for six climate variables (precipitation, minimum and maximum temperature, radiation, vapour pressure and mean sea level pressure) from dynamically downscaled climate simulations over Queensland, Australia. We used the Kling-Gupta Efficiency (KGE) and the Perkins score (PS) to evaluate the impact of bias correction on spatial patterns and extremes respectively. We ranked the bias-correction methods based on the KGE. We found that linear-scaling and empirical quantile mapping are the best approaches for Queensland for mean climatology. On average, bias corrections led to an improvement in the KGE score of 23% annually. However, in terms of extreme values, quantile mapping and statistical distribution-based transfer function approaches perform best, and linear scaling tends to perform worst. Our results show that, except linear scaling, all approaches impact the climate change signal, and therefore care needs to be taken when correcting bias of downscaled simulations.

Results show that all bias-correction methods are effective at removing systematic model biases during the validation period, however the results are variable and season dependent. Linear scaling preserves the climate change signals for temperature, while quantile mapping and the distribution-based transfer function modify the climate change signal and patterns of change. The Perkins skill score (Perkins et al., 2007) was also applied for the 5th and 95th percentiles and was used to evaluate how well the climate model matches the observed extremes. Bias correction improved Perkins score for extremes for some variables and seasons.

We also developed a dynamical thresholding frequency correction for precipitation to be implemented prior to the bias correction for intensity. It was designed to correct for drizzle effect, and too many dry days, which is required in Australia to avoid a systematic wet biases in arid areas. Our approach corrects both dry and wet day occurrence for precipitation and can be seamlessly integrated into most univariate intensity bias correction methods such as statistical distribution-based transfer function method and quantile delta mapping (QDM) (Cannon et al., 2015). The improvements are supported by the Perkins skill scores in the lower tail of distribution of daily precipitation. For example, Perkins skill scores for the lower tail of distribution improved by 14% annually, 12% in DJF and 21% in JJA for CMIP5 ACCESS1-3Q downscaled model (Syktus et al., 2020) when dynamical thresholding is applied prior to QDM. For CMIP5 ACCESS1-0Q downscaled model, the corresponding improvements are 21% annually, 12% in DJF and 21% in JJA, respectively. Currently we are extending the dynamical thresholding approach to multivariate bias correction method.

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