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Challenges in bias correcting climate change simulations

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Biases in climate model simulations - if these are directly used as input for impact models - will introduce further biases in subsequent impact simulations. In response to this issue, so-called bias correction methods have been developed to post-process climate model output. These methods are now widely used and a crucial component in the generation of high resolution climate change projections. Bias correction is conceptually similar to model output statistics, which has been successfully used for several decades in numerical weather prediction. Yet in climate science, some authors outrightly dismiss any form of bias correction. Starting from this seeming contradiction, we highlight differences between the two contexts and infer consequences and limitations for the applicability of bias correction to climate change projections. We first show that cross validation approaches successfully used to evaluate weather forecasts are fundamentally insufficient to evaluate climate change bias correction. We further demonstrate that different types of model mismatches with observations require different solutions, and some may not sensibly be mitigated. In particular we consider the influence of large-scale circulation biases, biases in the persistence of weather regimes, and regional biases caused by an insufficient representation of the flow-topography interaction. We conclude with a list of recommendations and suggestions for future research to reduce, to post-process, and to cope with climate model biases.