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Is bias correction of Regional Climate Model (RCM) simulations possible for non-stationary conditions?

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Regional Climate Models (RCMs) are commonly used in climate-change impact studies to transfer large-scale Global Climate Model (GCM) values to smaller scales and to provide more detailed regional information. There is, however, the problem that RCM simulations often show considerable deviations from local observations due to systematic and random model errors. This issue has caused the development of several correction approaches, that can be classified according to their degree of complexity and include simple-to-apply methods such as linear transformations but also more advanced methods such as distribution mapping. Most of these common correction approaches are based on the assumption that RCM errors do not change over time. It is in principle not possible to test whether this underlying assumption of error stationarity is actually fulfilled for future climate conditions. In this contribution, however, we show that it is possible to evaluate how well correction methods perform for conditions different from those that they were calibrated to. This can be done with the relatively simple differential split-sample test, originally proposed by Klemeš ["Operational testing of hydrological simulation models", Hydrological Sciences Journal 31, no. 1 (1986): 13-24]. For five Swedish catchments, precipitation and temperature time series from 15 different ERA40-driven RCM simulations were corrected with different commonly-used bias correction methods. We then performed differential split-sample tests by dividing the data series into cold and warm respective dry and wet years. This enabled us to cross-evaluate the performance of different correction procedures under systematically varying climate conditions. The differential split-sample test identified major differences in the ability of the applied correction methods to reduce model errors and to cope with non-stationary biases. More advanced correction methods performed better, whereas large deviations remained for climate model simulations corrected with simpler approaches. Therefore, we question the use of simple correction methods such as the widely used delta-change approach and linear transformation for RCM-based climate-change impact studies. Instead, we recommend using higher-skill correction methods such as distribution mapping.