

Evaluation of bias correction methods for current and future RCM projections in hydrological regional applications

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RCMs produced at $\sim 0.5^\circ$ (available in the NA-CORDEX database esgf-node.ipsl.upmc.fr/search/cordex-ipsl/) address issues related to coarse resolution of GCMs (produced at 2° to 4°). Nevertheless, due to systematic and random model errors, bias correction is needed for regional study applications. However, an acceptable threshold for magnitude of bias correction that will not affect future RCM projection behavior is unknown. The goal of this study is to evaluate the implications of a bias correction technique (distribution mapping) for four GCM-RCM combinations for simulating regional precipitation and, subsequently, streamflow, surface runoff, and water yield when integrated into Soil and Water Assessment Tool (SWAT) applications for the Des Moines River basin (31,893 km²) in Iowa-Minnesota, U.S. The climate projections tested in this study are an ensemble of 2 GCMs (MPI-ESM-MR and GFDL-ESM2M) and 2 RCMs (WRF and RegCM4) for historical (1981-2005) and future (2030-2050) projections in the NA-CORDEX CMIP5 archive. The PRISM dataset was used for bias correction of GCM-RCM historical precipitation and for SWAT baseline simulations. We found bias correction improves historical total annual volumes for precipitation, seasonality, spatial distribution and mean error for all GCM-RCM combinations. However, improvement of correlation coefficient occurred only for the RegCM4 simulations. Monthly precipitation was overestimated for all raw models from January to April, and WRF overestimated monthly precipitation from January to August. The bias correction method improved monthly average precipitation for all four GCM-RCM combinations. The ability to detect occurrence of precipitation events was slightly better for the raw models, especially for the GCM-WRF combinations. Simulated historical streamflow was compared across 26 monitoring stations: Historical GCM-RCM outputs were unable to replicate PRISM KGE statistical results (KGE>0.5). However, the Pbias streamflow results matched the PRISM simulation for all bias-corrected models and for the raw GFDL-RegCM4 combination. For future scenarios there was no change in the annual trend, except for raw WRF models that estimated an increase of about 35% in annual precipitation. Seasonal variability remained the same, indicating wetter summers and drier winters. However, most models predicted an increase in monthly precipitation from January to March, and a reduction in June and July (except for raw WRF models). The impact on hydrological simulations based on future projected conditions was observed for surface runoff and water yield. Both variables were characterized by monthly volume overestimation; the raw WRF models predicted up to three times greater volume compared to the historical run. RegCM4 projected increased surface

runoff and water yield for winter and spring by two times, and a slight volume reduction in summer and autumn. Meanwhile, the bias-corrected models showed changes in prediction signals: In some cases, raw models projected an increase in surface runoff and water yield but the bias-corrected models projected a reduction of these variables. These findings underscore the need for more extended research on bias correction and transposition between historical and future data.

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