Comparison of univariate and multivariate bias-adjusting methods for hydrological impact assessment under climate change conditions

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Climate change is one of the largest challenges currently faced by society, with an impact on many systems, such as hydrology. To locally assess this impact, Regional Climate Model (RCM) data are often used as an input for hydrological rainfall-runoff models. However, RCMs are still biased in comparison with the observations. Many methods have been developed to adjust this, but only during the last few years, methods to adjust biases in the variable correlation have become available. This is especially important for hydrological impact assessment, as the hydrological models often need multiple locally correct input variables. In contrast to univariate bias-adjusting methods, the multivariate methods have not yet been thoroughly compared. In this study, two univariate and three multivariate bias-adjusting methods are compared with respect to their performance under climate change conditions. To do this, the methods are calibrated in the late 20\textsuperscript{th} century (1970-1989) and validated in the early 21\textsuperscript{st} century (1998-2017), in which the effect of climate change is already visible. The variables adjusted are precipitation, evaporation and temperature, of which the resulting evaporation and precipitation are used as an input for a rainfall-runoff model, to allow for the validation of the methods on discharge. The methods are also evaluated using indices based on the calibrated variables, the temporal structure, and the multivariate correlation. For precipitation, all methods decrease the bias in a comparable manner. However, for many other indices the results differ considerable between the bias-adjusting methods. The multivariate methods often perform worse than the univariate methods, a result that is especially pronounced for temperature and evaporation.