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Robust climate scenarios for sites with sparse observations: A two-step empirical-statistical bias correction approach

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Climate change impact assessment and the development and implementation of related adaption measures require accurate climate observations and projections at continental to very local scales. The projections often rely on global and regional climate model (GCM, RCM) ensembles. However, even the output of current RCMs operating at grid resolutions around 10-50km is still too coarse to be directly applied in local impact studies, in particular in regions of complex topography where climatic variations over an RCM grid box can be tremendous. Furthermore, model simulations are subject to considerable model biases. To bridge the gap between models and both the desired scales and the desired accuracy, empirical-statistical downscaling (ESD) methods are a promising tool. Their principle is to reveal a statistical relationship between a model and observations in historical periods. These relations are then used to translate RCM (GCM) projections to the local scale, and to correct for some of the model biases. Due to decadal variability, a robust applicability of ESD is constrained to sites at which observations are sufficiently long and continuous. In many cases, this limits the choice of target sites to only a few weather stations run by meteorological services or to interpolated datasets. In the framework of climate sensitivity studies, various climate scenario end-users have equipped sensitive environments with meteorological stations. Yet, the quality and length of data from such sites is not sufficient enough for a robust application of ESD.

This study presents a solution towards more robust local scenarios over the region of Switzerland, specifically tailored for the use in climate impact studies. A two-step approach based on the well-established quantile-quantile mapping (QM) methodology is employed. In a first QM step regional climate model simulations are bias corrected to match long-term observations at operational sites of the Swiss weather service MeteoSwiss. In a second QM step, the bias corrected scenarios are transferred to additional target sites for which only sparse data series are available. The approach includes the objective selection of a most representative station out of the long-term observational network for each target site. The applied methodology also enables to approximately reconstruct observational data at target sites for non-measured periods, allowing for a more robust calibration of impact models.

This contribution will present a validation and feasibility study of the two-step approach and will show an example end-user application addressing climate change impacts on high-alpine permafrost in the Swiss Alps. It is shown that the proposed two-step procedure is versatile and provides promising attractive quality, even at extreme station locations. In addition, particular findings regarding the stationarity of the statistical relations and the temporal consistency related to the application of QM to time series will be presented.