Geophysical Research Abstracts
Vol. 19, EGU2017-3855, 2017
EGU General Assembly 2017

A parametric approach for simultaneous bias correction and high-resolution downscaling of climate model rainfall for practical applications

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Among different approaches to bias correct climate model (CM) results, distribution mapping has been identified as the most efficient one in reproducing the statistics of rainfall at regional scales, and at temporal resolutions suitable to run hydrologic models (e.g. daily). Yet, its implementation remains at a basic level, based on empirical distributions derived from control samples (referred to as non-parametric, or empirical distribution mapping), which makes the method's performance sensitive to sample length variations, the presence of outliers, the spatial resolution of CM results, and may lead to significant biases, especially when focus is on extreme rainfall estimation. In an effort to address these shortcomings, we use a two component theoretical distribution model (i.e. a generalized Pareto (GP) model for rainfall intensities above a specified threshold u*, and an exponential model for lower rainrates) to propose a parametric bias correction procedure suited for regional frequency analysis. The latter is implemented by proper interpolation of the corresponding distribution parameters on a user-defined high-resolution grid, using kriging for uncertain data (KUD). To assess the performance of the suggested parametric approach relative to non-parametric distribution mapping, we use daily raingauge measurements from a dense network in the island of Sardinia (Italy), and climate model rainfall data from 4 CMs of the ENSEMBLES project, to apply both methods to different combinations of control and validation periods. The obtained results shed light on the competitive advantages of the parametric approach relative to the non-parametric one, with the former being more accurate and considerably less sensitive to the characteristics of the control period, independent of the climate model used. This is especially the case for extreme rainfall estimation, where the GP assumption allows for more accurate and robust estimates, also beyond the range of the available data, allowing for improvements in hydrologic risk assessment at a regional level.