EMS Annual Meeting Abstracts
Vol. 11, EMS2014-125, 2014
14th EMS / 10th ECAC

Stochastic modelling of daily precipitation over complex topography consistent with the space-time covariance of present-day observations

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There is a growing demand for high-resolution precipitation time-series at the local scale that are both consistent in time and in space. This is of high relevance for climate impact models that are sensitive to averaged rainfall amount over a specific region and over multiple days (e.g. to model river runoffs). In this regard, weather generators (WGs), calibrated at multiple sites, are an appealing technique that allow the simulation of synthetic series with the appropriate spatio-temporal correlation structure. To date, only a few multi-site WGs have been documented in the literature and those that exist have been rarely tested over topographies as complex as the Alps. Here, we present novel results from multi-site precipitation simulations with a Richardson-type WG that has been inspired by Wilks (1998). The prescription of the spatial correlation structure is derived from pair-wise correlations among measurement stations. A first-order two-state Markov process is chosen to simulate daily precipitation occurrences, while precipitation amounts are re-sampled from a mixture model of two exponential distributions fitted at individual stations. Our multi-site WG is tested and evaluated here at the example of the hydrological catchment “Thur” in the Swiss Alps. The catchment covers around 1700 m2 and its precipitation regime is subject to a strong spatio-temporal heterogeneity. The WG is calibrated on a monthly basis at eight stations over the time-period 1961-2011.
The evaluation of the WG reveals that the observed spatio-temporal correlation structure and distributional characteristics are realistically reproduced. The incorporation of inter-station dependencies in the stochastic process improves the quality of area averaged quantities substantially compared to multiple single-site WGs regarding for instance areal precipitation sums over several days. This is especially the case when the precipitation regime is subject to a large spatial and temporal heterogeneity such as over the Swiss Alps.