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Simulating rainfall at hourly and kilometer scales for future climate scenarios using a weather generator

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Abstract

Weather generators (WGs) are numerical tools which produce synthetic time series of meteorological variables for a given climate and location. Most of the existing WGs are designed for station-scale applications or as multi-station generators, and simulate climate variables at daily or coarser temporal resolutions. However, in order to analyze the impact of climate variability on spatial distribution of weather variables or to provide a more realistic forcing for hydrological models, it is necessary to simulate climate on a high temporal and spatial resolution. An ensemble of high-resolution climate data that represents the natural (stochastic) climate variability is essential to estimate the uncertainty derived from the chaotic nature of climate, and how it propagates throughout the catchment response and hydraulic infrastructures. Using a novel two-dimensional stochastic weather generator, AWE-GEN-2d [Peleg et al., 2017], we produced gridded rainfall simulations for three Swiss catchments (Thur, Maggia and Kleine Emme) based on observations from weather stations, weather radar systems and satellite images to reproduce the current-climate rainfall on a 2-km and hourly resolution.

The model satisfactorily reproduces rainfall patterns in space and time, e.g. rainfall annual totals (Fig. 1), seasonality and daily extreme rainfall intensities (Fig. 2). AWE-GEN-2d was then re-parameterized to simulate climate ensembles for future periods (2020-2090) based on climate statistics obtained from the EURO-CORDEX regional climate models using the factor of change method [Fatichi et al., 2011]. Moreover, rainfall uncertainties were quantified under different emission scenarios and climate model projections for the following decades.

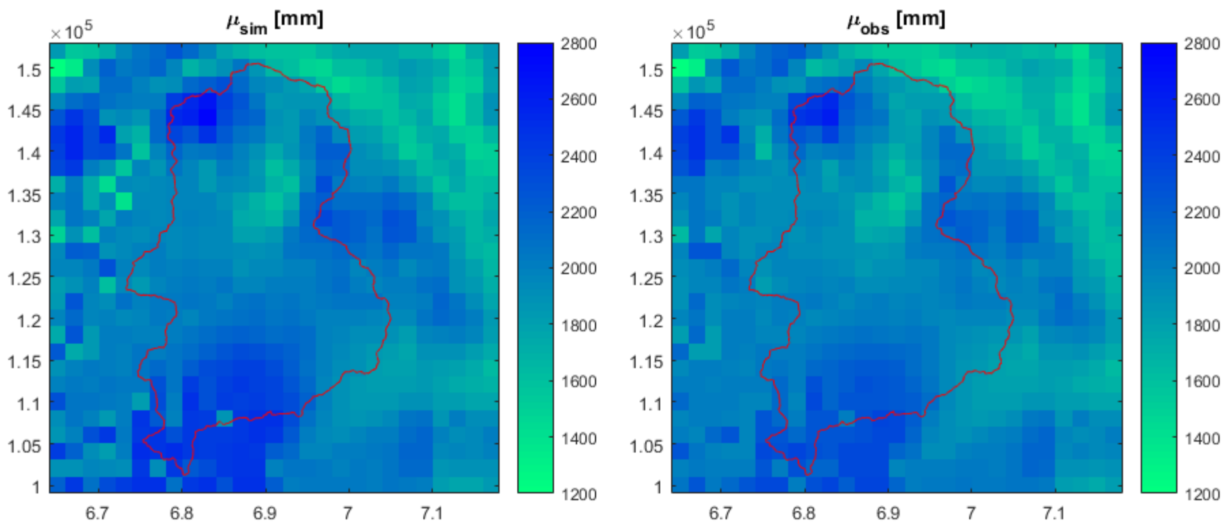

Fig 1: Simulated (μ_{sim}) and observed (μ_{obs}) mean annual rainfall (in mm) for the Maggia catchment.

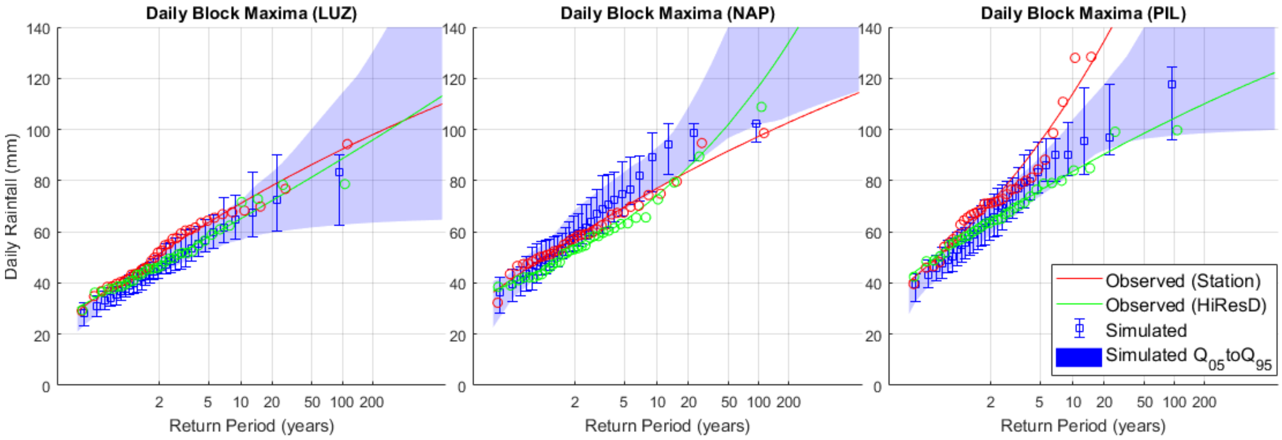

Fig 2: Daily rainfall annual return periods using Gringorten's empirical quantiles for observed data obtained from weather stations (red), gridded product (green) and simulated data using AWE-GEN-2d (blue, with whiskers representing the 5th and 95th quantiles). The solid red and green lines show the fit to a Generalized Pareto (GP) distribution, while the blue shade shows the GP fits to the simulation outputs within the 5th and 95th quantiles. The results correspond to the location of the Lucerne (LUZ, left), Napf (NAP, centre), and Pilatus (PIL, right) weather stations in the domain of the Kleine Emme catchment.

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