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Stochastic downscaling of precipitation in complex orography

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The spatial resolution currently achieved by global and regional climate models is still insufficient to describe the small-scale structure of precipitation at fine-scales ($\sim$1 km) and capture extreme precipitation events. In absence of proper physically-based models, a common approach to bridge the scale mismatch are stochastic rainfall downscaling methods. These techniques usually provide a statistically homogeneous distribution of fine-scale precipitation in each grid element of the large scale dataset to downscale. Therefore, the heterogeneities in local precipitation patterns at spatial scales finer than those resolved by the large-scale input field, due for example to orographic effects, are not commonly accounted for in stochastic downscaling. For this reason, stochastic downscaling techniques may be not reliable in areas with complex topography or when specific sub-grid precipitation patterns exist.

Here we test a simple method to introduce realistic fine-scale precipitation variability into precipitation fields downscaled with a state-of-the-art stochastic downscaling method. The proposed approach relies on the availability of a reference fine-scale precipitation climatology, from which corrective weights are derived and used to adjust to the downscaled precipitation fields. We demonstrate the method by applying it to the Rainfall Filtered AutoRegressive Model (RainFARM, Rebora et al., 2006; D'Onofrio et al., 2014) stochastic rainfall downscaling algorithm (Terzago et al 2018, in review).

The modified RainFARM method has first been tested on an area of complex topography encompassing the Swiss Alps in a "perfect model experiment" in which high resolution (4 km) simulations performed with the Weather Research and Forecasting (WRF) regional model are aggregated to a coarser resolution (64 km) and then downscaled back to 4 km to be compared to the original data. In a second experiment, the modified RainFARM is applied to the E-OBS gridded precipitation data (0.25 degrees spatial resolution, a datasets building on in-situ station observations) over Switzerland, where high-quality gridded precipitation climatologies and accurate in-situ observations are available for comparison with the downscaled data.

The perfect model experiment shows that the modified RainFARM method is capable of representing significantly better the probability distributions of daily precipitation in sites characterized by high and low average annual precipitation, respectively. The "real" experiment allows to discuss the limitations and usefulness of the method as a function of the reliability of the forcing fields.