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A simple method to include complex orography in the RainFARM stochastic precipitation downscaling method for climate studies

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Orographic precipitation mechanisms play an important role in determining patterns of small-scale precipitation in areas with complex orography, but several current stochastic precipitation downscaling procedures cannot take into account orographic effects at scales smaller than those resolved by the original precipitation field to downscale. As a result, the long-term climatology at individual grid points may differ significantly from observations.

We introduce a simple method to take fine-scale orography into account when the stochastic method RainFARM is applied to downscale precipitation from climate simulations. The method is based on the availability of a reference fine-scale climatology, such as gridded observations from a dense network or high-resolution dynamical simulations. This reference climatology allows to derive corrective weights which are applied to the realisations of stochastic fields generated by RainFARM, allowing to reproduce a more realistic long-term precipitation climatology at fine scales.

We first demonstrate the method in a perfect model example: large-scale (64km) precipitation fields, obtained by aggregating high-resolution precipitation fields (4km) from WRF simulations over the Swiss Alps, in the period 1980-2008, are downscaled back to the original fine resolution. We compare the resulting probability distribution of precipitation extremes with that represented by the original fine-scale data. In this case, a perfect knowledge of the desired precipitation climatology is assumed, and the climatology resulting from the fine-scale WRF data is used.

Further, we demonstrate the method in a more realistic setup, in which we downscale E-OBS precipitation data (25km to 1km) over the Swiss Alps and compare the resulting fields with high-quality in-situ observations from MeteoSWISS, in the period 1981-2010. We compare the impact of using different data sources for the weights and we show that a high-resolution climatology derived from regional model simulations, even if affected by important biases, can provide useful weights, comparable to those which can be obtained from dense observation networks. This would allow to apply this method, without any calibration, also in areas where a high-resolution precipitation climatology from observations is not available or reliable.