Non-stationary radar precipitation ensembles: a stochastic nested generator and orographic precipitation growth and decay trends

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Stochastic precipitation simulation is a fundamental component for hydrological applications, which can be used for design storm modelling, precipitation nowcasting and downscaling of model output, among others.

An ensemble of precipitation fields can be generated by multifractal simulation following the principle of linear generalized scale invariance. However, the statistical properties of real precipitation fields are usually not the outcome of a single global process, but depend on the spatial location (e.g. Lovejoy and Schertzer, 2013). Nerini el al. (2017) developed a non-stationary stochastic generator based on the Short-Space Fourier transform to account for the spatial heterogeneity of the statistical structure of precipitation fields. The stochastic generator is based on the local Fourier-filtering of a white noise field, where localization is achieved by applying a Hanning window on the precipitation field.

The spatial localization of the Fourier transform inevitably leads to a loss of power at the scales that are larger than the window size. In this study, we develop and evaluate a strategy to overcome this limitation by computing the local Fourier transform as a nested combination of Fourier transforms over windows of decreasing size. The nested stochastic generator is tested on composite radar rainfall images over the Swiss Alps displaying spatially heterogeneous anisotropies and correlation ranges.

The mountains do not only lead to changes in the orientation of the rainfall anisotropy, but also induce systematic trends due to orographic precipitation growth and decay processes, which also need to be considered in the stochastic simulation. In order to understand these trends we stratified a 10-year archive of composite radar images as a function of freezing level height and mesoscale flow direction and speed.

References:
• Lovejoy, S. and Schertzer, D.: The Weather and Climate, Emergent Laws and Multifractal Cascades. Cambridge University Press, 2013.
• Nerini, D., Besic, N., Sideris, I., Germann, U., and Foresti, L.: A non-stationary stochastic ensemble generator for radar rainfall fields based on the short-space Fourier transform, Hydrol. Earth Syst. Sci., 21, 2777-2797, 2017.