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Dependence structure in the weights of a multiplicative random cascade model for rainfall

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Multiplicative random cascade (MRC) models are popular tools for precipitation disaggregation and simulation mainly because of their simplicity and ability to reasonably reproduce the scaling properties in temporal precipitation data. One of the main assumptions in MRC models is that the cascade weights are iid (independent and identically distributed). Defining a measure called oscillation coefficients, Carsteanu and Foufoula-Georgiou (1996, Journal of Geophysical Research) have shown that microcanonical MRC models have in fact a given temporal correlation structure in the cascade weights which should be matched by rainfall data.

Building on this early work we investigate in this paper the dependence structure in the cascade weights of a canonical MRC model and in particular its ability to describe precipitation time series properties including uncertainty. The precipitation data are from 70 stations of the SwissMetNet network with high resolution data (10-min) and long records (on average 25 years). The stations are spread across Switzerland at different altitudes and with different dominant precipitation mechanisms, e.g. convection, stratiform and orographic precipitation. This allows us to investigate seasonal and regional patterns.

We first built a simple stochastic model which includes a Markovian structure in the cascade weights including intermittency. We quantified the relationships between the parameters of this model in the MRC framework (intermittency and correlation) and the oscillation coefficient of Carsteanu and Foufoula-Georgiou (1996), and by simulation we built confidence bounds under the iid assumption for the weights. In a second step we estimated the oscillation coefficient and intermittency from precipitation data on a seasonal basis. The results suggest that the iid assumption for cascade weights in the MRC framework is not fully supported by data. In many cases, the oscillation coefficient lies outside the significance bounds. There are also seasonal and regional signals which suggest that the dependence structure in MRC cascade weights is complex, with a likely link to physical mechanisms of precipitation occurrence.