EGU23-3697, updated on 27 Apr 2024
https://doi.org/10.5194/egusphere-egu23-3697
EGU General Assembly 2023

Accounting for Precipitation Asymmetry in a Multiplicative Random Cascade Disaggregation Model

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Multiplicative random cascades (MRC) have been widely used for the disaggregation of coarse-resolution time series (e.g. daily) to high-resolution ones (e.g. sub-hourly). With MRCs, the amount of precipitation at any time step is partitioned into two parts, attributed respectively to the first and second sub-division of this time step. The partition is repeated throughout the cascade levels until the final temporal resolution is achieved.

In the so-called micro-canonical MRCs, the partition is conservative. The rainfall amounts R_1 and R_2 attributed respectively to the first and second sub-divisions of the considered time step (with rainfall amount R_0), are expressed as $R_1=W_1 \cdot R_0$ and $R_2=W_2 \cdot R_0$ where the weights W_1 and W_2 are complementary, i.e. $W_1+W_2=1$. The possible values of W_1 are:

$$W_1 = \begin{cases} 0 \text{ with probability } p_{01}, \\ 1 \text{ with probability } p_{10}, \\ x \in (0,1) \text{ with distribution } f_{W^+}. \end{cases}$$

Therefore, for a given time step, the disaggregation is determined by the value of $W:=W_1$.

The probabilities p_{01}, p_{10} and the distribution f_{W^+} define the cascade generator of the MRC. For a given location, they have been found to depend on different factors. The cascade generator depends for instance on temporal scale, on precipitation intensity and on precipitation temporal asymmetry, i.e. on the temporal pattern of precipitation amounts R_{i-1},R_i,R_{i+1} around the amount of precipitation to disaggregate R_i (e.g. Olsson, 1998; Hingray and BenHaha, 2005). p_{01} tends to be higher than p_{10} in the case of a so-called "ascending" precipitation pattern ($R_{i-1}<R_i<R_{i+1}$) and, p_{01} tends to be smaller than p_{10} in the case of a "so-called" descending pattern ($R_{i-1}>R_i>R_{i+1}$). Different models have been proposed to estimate p_{01},p_{10} and f_{W^+} . Analytical scaling models are used very often because very convenient for simulation, but to date, they have disregarded the dependency on asymmetry (Paschalis et al., 2014).

Our work presents an analytical MRC modelling framework that merges the strengths of some of the different MRC models proposed in past years, allowing the cascade generator to depend in a continuous way on temporal scales, precipitation intensity and precipitation asymmetry.

We first define a precipitation asymmetry index and show how it influences the parameters of the cascade generator. This index is used to model the scaling dependency on asymmetry. We then compare four different analytical MRC models that account for the dependency on the temporal scale, precipitation intensity and/or precipitation asymmetry. An application to 81 stations in Switzerland is presented where the performance of the models is assessed. Including the asymmetry of precipitation in a model brings significant improvements in the reproduction of observed temporal persistence of precipitation in the disaggregated time series. The proposed model, with a simple parametrization, shows a great potential for regionalization, thus for the application of the approach to sites with coarse-resolution data only.

References

Hingray, B., Ben Haha, M., 2005. Statistical performances of various deterministic and stochastic models for rainfall series disaggregation. Atmospheric Research 77, 152–175.doi:10.1016/j.atmosres.2004.10.023.

Olsson, J., 1998. Evaluation of a scaling cascade model for temporal rainfall disaggregation. Hydrology and Earth System Sciences 2, 19–30. doi:10.5194/hess-2-19-1998.

Paschalis, A., Molnar, P., Fatichi, S., Burlando, P., 2014. On temporal stochastic modeling of precipitation, nesting models across scales. Advances in Water Resources 63, 152–166. doi:10.1016/j.advwatres.2013.11.006.