Authors Response to: Interactive comment on "Circulation pattern based parameterization of a multiplicative random cascade for disaggregation of daily rainfall under nonstationary climatic conditions" by Anonymous Referee (Referee #2)

By: Lisniak, D., Franke, J. and Bernhofer, C.

We would like to thank Referee #2 for his / her time to review our manuscript and for his / her specific comments, especially concerning the starting hypothesis of our work. We hope that by addressing the issues raised by Referee #2 our argumentation becomes clearer.

Our answers to the remarks of Referee #2 are structured as follows: We first repeat the part of the Referee's comment (in bold), which we will then reply to. Following this, we account for the technical remarks made by the Referee. Please note that the original source data is not available to the authors at the moment, so certain figures can not be presented in this reply.

Remarks

Firstly, as noted in P10129, it is clear how the use of the frequency of occurrence of specific circulation patterns on a daily scale can be a beneficial aspect of linking the climate signal to rainfall records. However, it is not clear why this consideration can be beneficial to disaggregation methods from daily to hourly data. This is supported in Fig.5, Fig.6 (and Fig.7), where the cumulative distribution functions of hourly rainfall amounts of observed and synthetic data (MRCs methods: MRC-CP and MRC and rainfall generator) are presented for the parameterization and validation periods. In my opinion the results do not suggest that the MRC-CP method provides any obvious improvement, especially in the validation period, […]

We thank Referee #2 for pointing out this circumstance. As we stated before in our reply to a similar comment of Referee #1, we agree that the improvement of the results obtained by the cascade model conditioned on circulation patterns is not so evident. Our aim, however, was to show that the introduction of a new source of complexity does not lead to a decline in performance. This experiment succeeded, even when considering the scarcity of reference data for the validation period.

[…] supporting the argument that the authors make in P10134 over the selected method of circulation patterns classification and principally over the combination of different pressure systems in a given day and their connection to local precipitation. Having this in mind, the authors must elaborate more on their starting hypothesis that (and how) circulation patterns would be useful in a discrete scale such as the hourly scale, considering the physical meaning.

This is a good point, and having in mind that the combination of pressure systems on a daily scale might be in contradiction to the physical meaning of random cascades as a tool for rainfall disaggregation we want to justify our starting hypothesis as follows:

As Referee #2 correctly points out, the selected method of classification for the circulation patterns has its shortcomings, not only because the derivation of circulation patterns based on the moisture regime is less effective than, for example, deriving classes based on the temperature regime (Enke et al., 2005), but also because the relationship between high resolution rainfall at point locations and circulation patterns on a daily time scale and synoptic spatial scale might be not so evident.

Concerning the first point, the chosen method for the derivation of circulation patterns, we agree that it would be favourable to choose a more effective classification method for the moisture regime. However, our choice is motivated by the need of a tool to produce probability distributions of high resolution rainfall as input for climate impact studies. As such, this tool has to map a non-linear climate signal to the probability distributions of rainfall. That climate signal in turn has to be derived from projected climate data. The most consistent data of climate projections are synoptic-scale circulation patterns, so the climate signal chosen by us was the change in frequencies of occurrence of the CPs. So the CPs act as a “carrier” of the climate signal. This climate signal is accounted for by parameterizing a distinct cascade model for each of the CPs. There has not been a more effective way to derive a carrier of a climate signal based on large scale circulation data and conditioned on the moisture regime available to us at the point when our work was completed. When such data becomes available, the cascade model proposed in our work can be easily augmented with this new carrier, provided that one can identify differences between its scaling properties.

Concerning the second point, we want to make clear that we distinguish between a physical domain and a statistical domain when parameterizing the CP-based MRC. First, the physical domain governs the relation of random cascades to atmospheric turbulence, as we stated in the introduction of our manuscript on P10118 L17. It could be argued that this domain is left when one starts to build sub-models based on cell properties such as scale and intensity, especially when having strict multifractality in mind. However, such deviations from multifractality can be justified to some extent by identifying relationships between parameters and cell properties across scales. On the other hand, when conditioning the MRC on circulation patterns, one definitely leaves the physical domain since the differences in scale between the circulation patterns and high resolution rainfall are too large to contain any physical meaning. Instead this puts the cascade parameters into a statistical context by constructing distinct cascade models for each of the circulation patterns (with their own scaling behaviour, see Fig. C1 below) and using them according to the frequencies of occurrence of the CPs (see Fig. C2 below).

The authors can consider adding in Fig.7 the simulated rainfall amounts of the rainfall generator for the period 1979-1989, supporting thus the reasoning that the non-conditioned MRC method can be used as a valid method for temporal rain disaggregation.

We thank Referee #2 for this suggestion and will add the data of the rainfall generator to Fig. 7 in the revised manuscript. It should be noted that we do not deny that the non-conditioned MRC can be used as a valid method for rainfall disaggregation inside the time slice in question, since it is close to the parameterization period. Moreover, the same can be stated for the validation period. However, as we stated in our reply to the first remark, the CP-based MRC does not perform worse. We believe, a broader data basis for validation would allow us to draw more definite conclusions.

Secondly, the authors must elaborate on convincing on the issue of stationarity in the validation and parameterization periods since the climate conditions addressed are under nonstationarity (P10128 and P10129). It is argued that stationarity holds but the same time they state that the slope of the scaling behaviour between the parameterization and validation periods differs.

We thank Referee #2 for pointing out a possibly misleading choice of words on P10128 and P10129 regarding the coupling of model parameters to a climate signal. We think, the writing style has led to a misunderstanding here, since we did not state that stationarity between the two periods hold. First we want to pinpoint the possible source of misunderstanding. We state in P10128 L15-L17: “If scaling holds, the slopes of the moments become linear in a log-log plot.” Here, we describe the expected result of a moment-scale relationship. After that we continue, stating that: “The slopes of the moments apparently differ for the two periods.” This is the conclusion drawn from Fig. 3 of the manuscript, which suggests different dominating rainfall mechanisms in the two periods. In our view and to some extent, this can be interpreted as the result of different frequencies of circulation patterns as can be seen in Fig. C2 blow. In P10128 L1-L12 we discuss, that parameters taken from the parameterization period (with a steeper scaling behaviour, please see Fig. C3 below) would normally be used for disaggregation of rainfall in the validation period, imprinting that scaling behaviour on the target time slice.

We hope, the misunderstanding can be resolved by reformulating sentence P10128 L15-L16 from: “If scaling holds, the slopes of the moments become linear in a log-log plot.” to “In a log-log-plot the slopes $\tau(q)$ of the moments of order q become linear, which indicates a scale invariant behaviour in this range of scales (Svensson e al., 1996). “

Technical remarks

We will now address the technical remarks of Referee #2 in their order of occurrence:

The orders of Fig. 8 and Fig. 9 have been switched with Fig. 6 and Fig. 7 to match their first mentioning in the text.

P10118 L24: We have split the sentence in question, avoiding the phrase “so that”:

> “The interest in MRCs is related to their simplicity and because they themselves are generic multifractal processes (Lovejoy and Schertzer, 2010a). They have increasingly been used to model other multifractal processes, such as rainfall.”

P10119 L16: We removed “very”.

P10120 L4-L10: We moved a part of the referred sentence (namely P10120 L4-L8) to P10117 L20. The remainder of the paragraph (namely P10120 L8-L13) is changed to:

> “This parameterization approach is meant to enable the user to further disaggregate projected daily precipitation time series, which were generated by scaling down the synoptic scale output of general circulation models (GCMs) for a possible future climate, to hourly resolutions and to use them as input for climate impact studies.”

P10120 L22: We changed “hourly data has” to “hourly data have”.

P10120 L23: We changed “the data was“ to “the data were”.

P10126 L1: We changed “he” to “the”.

References

Enke, W., Schneider, F., and Deutschländer, T.: A novel scheme to derive optimized circulation pattern classifications for downscaling and forecast purposes, Theor. Appl. Climatol., 82, 51–63, doi:10.1007/s00704-004-0116-x, 2005.

Svensson, C., Olsson, J., and Berndtsson, R.: Multifractal properties of daily rainfall in two different climates, Water Resour. Res., 32, 2463–2472, doi:10.1029/96WR01099, 1996.

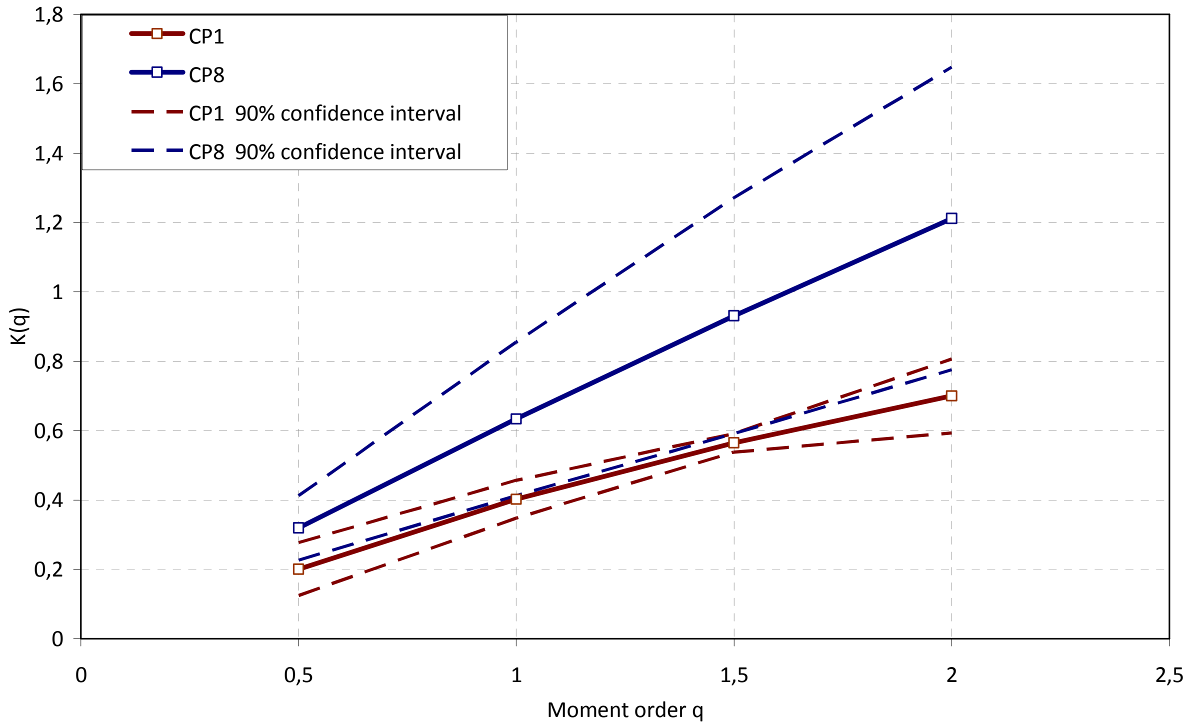

Figure C1: Exponents K(q) of the moment-scale relationship for the driest (CP1) and the wettest circulation pattern class (CP8) for the parameterization period with their corresponding uncertainties.

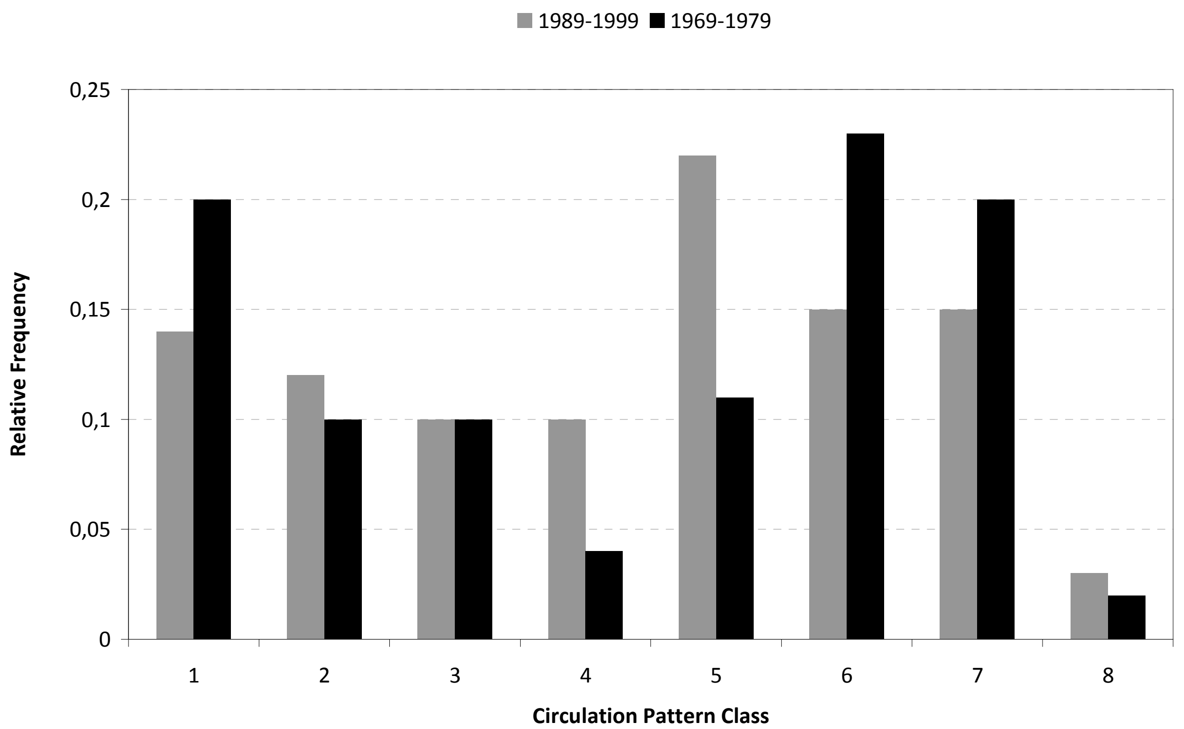

Figure C2: Relative frequencies of occurrence for circulation pattern classes in the parameterization period (1989-1999) and validation period (1969-1979).

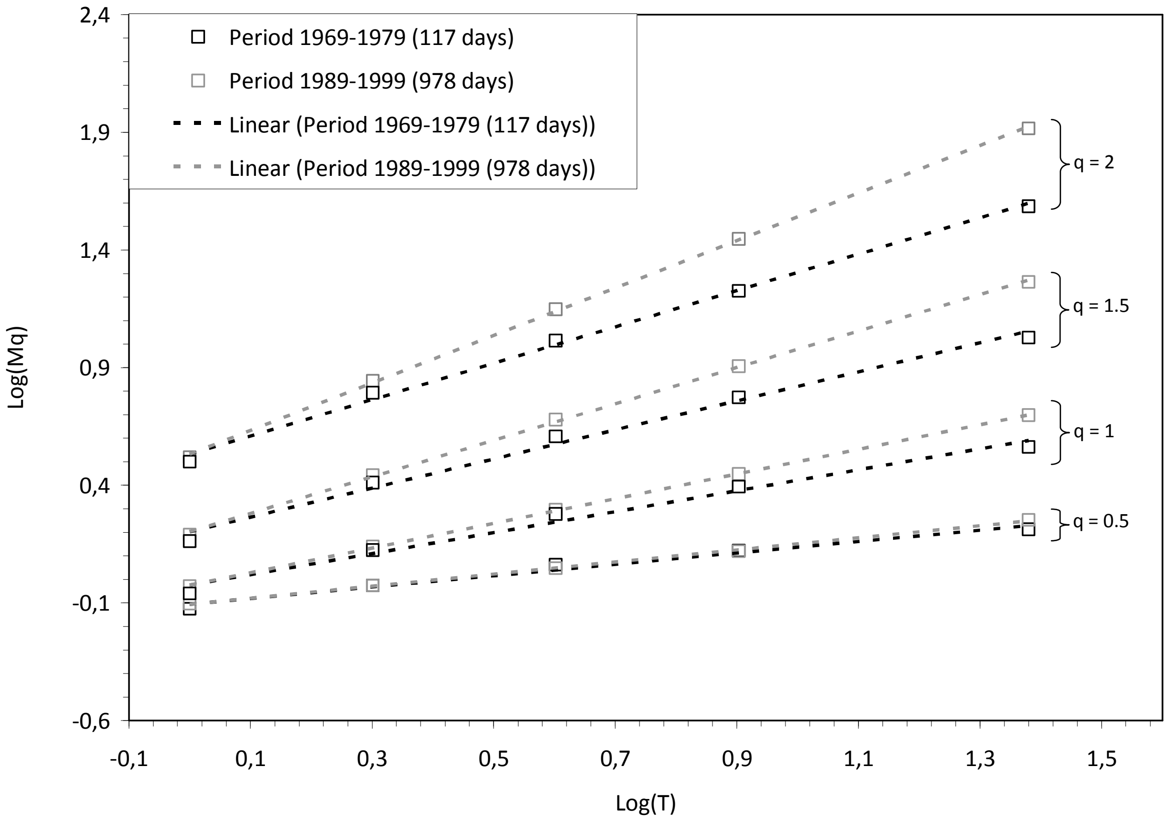

Figure C3: Moment-scale power-law relationships of the parameterization period (1989-1999) and the validation period (1969-1979). Moments of validation period are shifted to match the intercept of the corresponding regression line of the parameterization period to better compare their slopes.