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Hydrology and Earth System Sciences Discussions

Interactive comment on "Copula-based downscaling of spatial rainfall: a proof of concept" *by* M. J. van den Berg et al.

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We thank the referee for his work and thoughtful review. Please read our responses below.

Referee 1: the scope for application of this approach. *Do the authors see this approach mainly suited for simulation purposes or for prediction? If the latter, the question of the temporal validity of the copula structure could be of concern, as mentioned and studied in section 5.4.4. Also, do the authors feel that general copula structures could be identified for different types of storms and for various climates?*

We feel that our method is mainly suited towards simulation, although applications in prediction (e.g. downscaling model predictions) can be thought of. For either applica-

tion, the identification of specific copulas for different climates and/or storms would be of interest. However, in our current study, the data is lacking to investigate this. As such, we did not add any remarks on it to our conclusions. Despite this, we do feel that it is likely that different storms and different climates would have specific copulas and that, with enough data, these can be identified.

Referee 1: the general robustness of the approach. *The authors already discuss the robustness of their approach over 2-3 lines in the conclusions section. I would suggest extending this part. A few points are raised throughout the paper would be worth further consideration, for instance regarding the lower performance for quantiles with higher nominal proportions (for which less data is available), or related to the intermittence model (even though the authors seem to explain in section 5.4.3 that the intermittence model did not have much impact on the general performance of the approach). The sensitivity of the approach to the chosen/estimated scaling (r=H) may also be crucial. Finally, the quality of the fitting of marginal laws to coarse-scale and fine-scale data may also be crucial, since the quality of the empirical quality estimated would clearly depend on the quality of the fit of marginal laws to the data.*

We fully agree with the reviewer that these items are very important and that these will have an impact on the obtained results. However, as this is a proof of concept, a thorough discussion on these topics is not included, but rather, we expanded the conclusions section to include more comments regarding future work.

In the conclusions, the following paragraphs were included:

> The proposed method can strengthen current downscaling methods which assume unrealistic sub-pixel distributions. This will require at least a moderate degree of temporal stability of the copula, which has been tentatively shown in this study. Future research will focus on this temporal stability and it will be investigated whether different copulas are needed for different storm types and whether the same scaling can be applied for different storm

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types. As such, future work should not only include a larger dataset, but also involve storm classification to investigate differences in dependence structure between storms.

The current method is, as mentioned, still a proof of concept. However, to obtain a workable downscaling method, a parametrical copula should be identified that best describes the dependence between two scales. Furthermore, the way the copula changes as a result of a change in scales needs to be known. Therefore, a function is needed that relates the parameters of the parametrical copulas to the scales between which these are valid. Future research should also focus on whether a parametrical copula can be fitted such that problems at the extremes of the copula, where little data is available, are solved.

It was shown that the copula-based framework is sufficiently robust to be applied to different storms and time steps, demonstrating its large potential for statistical downscaling and hydrological modeling. Yet, more research is needed to further elaborate the proposed methodology.

Referee 1: *In parallel, I would suggest for the authors to be more specific with respect to the data employed for illustrating the application of their proposal approach. For instance periods for which data is available should be mentioned, number of rain events over this period, dates for the storms used as case-studies given, as well as the characteristics of these storms. This would strengthen the value of the application described.*

We have added the following paragraph to the data section:

The dates, at which radar imagery is available, are selected based on rain-gage readings from a network across Belgium, where the rainfall was required to have a minimum Peak-over-Threshold return period of 10 years

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to be included in the dataset. This resulted in a dataset consisting of the days listed in Table 2. For these days, the number of rainy hours has been listed, along with the average intensity for each rainstorm, and the ratio of dry pixels to wet pixels. Images that did not display rainfall were removed from the dataset as they hold no information.

Specific and detailed changes

In the introduction (p.208, l.19), the location chosen for the references is quite strange. I would suggest moving them to the end of the sentence

Corrected

There is a problem with the year of the reference Rubner (1998/2002). It is indeed 1998 in the reference list, but 2002 when cited in the text of the manuscript

The original paper was presented at a conference in 1998, however, it was bundled in 2002. For clarity, we removed the 1998 date.

There is a typographical mistake remaining in the title of section 5.4.2: "sub-pixel"

Corrected

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