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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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Recommendation: Major revision

GENERAL COMMENTS:
The paper describes a copula-based approach to spatial rainfall where a copula is used to model the dependence structure between the coarse scale and the fine scale rainfall. The paper is well written and the proposed method is interesting and elegant in many ways. However, I feel that an extended discussion of several aspects of the

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method and some additional data analysis would substantially improve the paper. I therefore recommend a major revision based on my comments below.

SPECIFIC COMMENTS:

1. The overall performance of the method will depend heavily on the goodnes-of-fit of the marginal distributions. The marginal distributions used here assume independence of the observed values at each scale. Have the authors tested the validity of this assumption? I would expect this not to be the case, especially at the fine scale. In this light, I find the statement in lines 11-12 on page 210 slightly misleading. The copula will incorporate dependence structure between the coarse scale and the fine scale and thus the local distribution of the depths at the fine scale can vary as a function of the depth at the coarse scale. However, the local dependence structure within data at the fine scale will not change, as the marginals stay the same.

2. The authors could be more precise in their description of the data they analyse in the paper. There is no mention of the size of the entire data set and when in-sample estimation is performed, the authors don't state how large a part of the data set was used for the estimation. Furthermore, as all dry events are removed from the data set, it should be stated how much data was removed.

3. The extension of the method to include the dry observations might be out of the scope of this paper. However, I feel that the discussion of this could be somewhat improved. The authors propose to use the function f given in equation (6) to model the fraction of dry fine scale pixels for a coarse scale pixel as a function of the observed value in the coarse scale pixel. However, high resolution fine scale data is needed in order to estimate the parameters of the function f. This

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is in contradiction to the statement in lines 17-20 on page 208 where it is stated that such data is usually not available. In relation to this, see also my technical correction nr. 5 below.

4. I believe it would be informative to also include a performance measure which demonstrates how well the estimated distributions fit to the individual data points. As noted by the authors, classical measures such as the absolute error and the root mean square error only take into account the distance between the median or the mean of the distribution, respectively, and the corresponding data point. However, there are performance measures which account for both the location and the spread of the distribution. One such example is the continuous rank probability score (CRPS). Furthermore, the multivariate extension of the CRPS, the energy score, can be applied to assess the performance of the full bivariate model, see Gneiting *et al.* (2008). That is, the energy score can be applied to compare the fit of the bivariate copula model and the bivariate independence model which has the same marginals as the copula but assumes independence between the coarse scale and the fine scale data. Here, the energy score must the calculated using Monte Carlo samples from the respective bivariate distribution. Such a comparison should nicely demonstrate the gain in performance offered by the copula and it would especially be of interest for the discussion of the temporal robustness of the copula in section 5.4.4 and of the storm dependence of the copula in section 5.4.5.

TECHNICAL CORRECTIONS:

1. Page 214, equation (7): there is a variable v on the right-hand side that doesn't appear on the left-hand side in the equation.

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2. Page 217, line 9: the authors state that the gamma distribution “exhibits a good fit” to the spatial rainfall fields. How is this quantified? Would it e.g. be possible to add a 95% confidence interval to the MLE estimate shown in Figure 3?

3. Page 217, equation (13) and line 18: in line 18, it is stated that $\theta_\lambda = t\theta_{\lambda'}$. However, I believe that equation (13) should be

$$t\Gamma(k, \theta_\lambda) = \Gamma(k, t\theta_\lambda) = \Gamma(k, \theta_{\lambda'}),$$

which means that $\theta_{\lambda'} = t\theta_\lambda$.

4. Page 218, lines 5-8: there is a word missing from this sentence.

5. Page 219, lines 8-16: the marginal distributions and the copula need not be continuous, see e.g. Hoff (2007). There are certainly complications from having discrete data in a copula approach, but there is nothing wrong with it.

6. Page 221-222: It would be helpful for the reader if the description of the EMD included information on whether it is a positively or a negatively oriented measure.

7. Page 224, lines 19-24: As far as I understand, the fine scale data is not used at any stage of the modelling procedure (and rightfully so, as the method aims to provide a downscaling procedure for situations where fine scale data is only sparsely available). There is thus no reason to expect that the method will recover the empirical distribution of the fine scale data exactly at the zero time-lag. It can only be expected to provide a result that is very similar to the empirical distribution.

8. Page 226, line 1: please correct this line.

9. Page 231, Figure 2: please expand the description of the figure in the caption.

10. Page 237, Figure 8: please add an explanation of the title of each plot to the caption.

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Interactive Comment

References

Gneiting, T., Stanberry, L., Grimit, E., Held, L., and Johnson, N. (2008): Assessing probabilistic forecasts of multivariate quantitites, with an application to ensemble predictions of surface winds. *Test*, **17**, 211-235.

Hoff, P. (2007): Extending the rank likelihood for semiparametric copula estimation. *The Annals of Applied Statistics*, **1**, 265-283.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 207, 2011.