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Hydrology and Earth System Sciences Discussions

Interactive comment on "A stochastic design rainfall generator based on copulas and mass curves" *by* S. Vandenberghe et al.

Anonymous Referee #1

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General Comments

The manuscript presents a copula-based method for simulating rainfall with a given return period. The manuscript addresses an important yet useful topic on rainfall generation. The subject matter of the paper is suitable for Hydrology and Earth System Sciences and should be interesting to a broad international audience. Overall, I would say the paper can be considered as a contribution to the field. However, I think the paper needs major revisions on several levels before it can be considered for publication. The authors can find more specific comments below.

Specific Comments

- The authors present their model without taking any effort to validate their methodology. Testing the copula fit should not be considered as a validation measure for the presented model. That, in fact, is a requirement to use a specific type of copula. Given the large sample of data (105 years), the authors have a wide variety of methods (e.g., bootstrap technique) to validate their methodology.
- Page 3624: "*For a specific season, the empirical copula is constructed. The storm with the largest empirical copula value (the highest point in a 3-D-representation of the empirical copula) is thus the most extreme storm in the considered season out of a data set of 105 years.*" I'm afraid the way the empirical return periods are derived may not be correct. If you are looking at the empirical distribution function of a specific season, you cannot claim that the highest value has a return period of 105 years, although the data is sampled from 105 years of data. Of course you can derive a return period, but I think you are altering the physical meaning of YEAR. Even if you are using the entire 105 year of data, the highest value will refer to a 105-year return period. However, the second value may not necessarily correspond to a return period of 52.5 years. The empirical return periods, used in practice, are obtained by sampling the annual maxima from the entire data set.
- At some parts the authors explain what they performed without sufficient discussion. For example: "*Figure 7 shows the outcome of the random generation of such a cumulative internal storm structure, together with the 10% and 90% percentile curves which serve as boundaries in the random generation.*" Provide a detailed discussion for each figure. What does the figure mean? What does it represent?

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- Page 3622: "*An A12 copula (Vandenberghe et al., 2010a,b; Nelsen, 2006) is fitted to (W,D) for each season separately, resulting in four parameters.*" When referencing to a model you should reference the original publication only and not every application. Vandenberghe et al., 2010a,b are not appropriate references for readers who want to learn about A12 copula; Nelsen, 2006 suffices.
- I think it would be good to include the equation of A12 to make the manuscript more stand-alone.
- Table 2: the copula parameter for winter, spring, summer, and autumn are estimated as 1.8622, 1.6953, 1.5485 and 1.7786, respectively. Are the differences statistically significant? Have you tried estimating the parameters with all data together? I think these are important issues that should be addressed.
- Page 3623, Line 18, T_{SEC}: Explain all notations although they may be obvious e.g., secondary return period (T_{SEC}).
- Equation 8: I think it is better to use ***I*** as indicator function instead of ***1***.
- Please add an informative legend to Figure 4.
- Page 3615: Consider revising Lines 18-21.
- Page 3626: "*Figure 4 shows different Huff curves which are constructed considering all storms in a specific season and quartile group, regardless of their return period.*" Again, please provide a detailed discussion for each figure. What does the figure mean? What does it represent?
- Please revise the legend and/or line styles in Figure 5; it is quite difficult to distinguish one line from another.
- Figure 5: I am not quite sure why the authors are showing the plots for return periods of 0.04 to 0.24 years. These return periods have no value in practical

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applications which is highlighted in the Abstract and Introduction. Please plot the figure for more meaningful and common return periods used for design purposes.

- Figure 6 is not discussed in the manuscript. I understand that the discussion on the bottom of Page 3626 is related to Figure 6. However, the authors are expected to explicitly discuss every figure in the text and explain every panel in enough details.
- Please use Figure or Fig. consistently throughout the text.
- Page 3627: "*. . .of the total storm duration are randomly generated, constrained by the fact that these cumulative storm depths should lie between the 10% and 90% percentile. . .*" Please explain exactly how the above constrains on randomly generated rainfall are applied.
- Section 4: I think this part needs a major review. I don't understand why the authors select a secondary return period of 2.79 and a storm that occurred 100 years ago. I think you should choose a more common return period (e.g., 10, 20, 25). Furthermore, I think you need to provide the input and output ensemble to show how the model works. The provided figures do not give any idea about the ensembles.
- Figure 9: I think it is better to remove the gray area and show a clear figure of the storm (black line) and the ensemble bounds. Figure 9 in its current form is not informative at all.
- Since you are presenting an ensemble generator you need to validate your ensemble too. A typical way to evaluate and validate one-dimensional ensembles is to derive the rank histogram (also referred to as Talagrand diagram). Please provide the rank histogram of your generated ensemble.

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- The authors are expected to provide a compelling conclusion that indicates the work is worthwhile. However, the current version of Conclusions is more like a summary/abstract of the paper.
- The Conclusions does not acknowledge the limitations of the study. Please discuss the limitations of the proposed model.
- Many of the blow references are irrelevant to this manuscript. They are applications based on the same data used in this manuscript. Please refer to one or two of them and remove those that are not relevant: Willems, 2000; Demar′ee, 1985; Laurant, 1976; Ntegeka and 10 Willems, 2008; De Jongh et al., 2006; Blanckaert and Willems, 2006; Vaes et al., 2002; Gellens, 2000; Schmitt and Nicolis (2002); Schmitt et al. (1998); Vaes et al., 2000, 2001; Vaes and Berlamont, 2000, 2001; Vaes, 1999.
- I think the work can benefit from a comprehensive literature review. Many relevant publications on application of copulas in simulation of rainfall fields are not acknowledged in the manuscript. Some of which are listed below. Please conduct a careful literature review and discuss relevant works:

  Bárdossy, A. and Pegram, G.: Copula based multisite model for daily precipitation simulation, Hydrol. Earth Syst. Sci. Discuss., 6, 4485-4534, doi:10.5194/hessd-6-4485-2009, 2009.

  Serinaldi, F., 2009, A multisite daily rainfall generator driven by bivariate copula-based mixed distributions, Journal of Geophysical Research – Atmospheres, D10103.

  AghaKouchak, A., Bárdossy, A., Habib, E., 2010. Conditional simulation of remotely sensed rainfall data using a non-gaussian v-transformed copula.

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Advances in Water Resources 33 (6), 624-634.

Serinaldi, F, 2009, Copula-based mixed models for bivariate rainfall data: an empirical study in regression perspective, Stochastic Environmental Research and Risk Assessment, 23 (5), 677-69.

Villarini, G; Serinaldi, F; Krajewski, WF, 2008, Modeling radar-rainfall estimation uncertainties using parametric and non-parametric approaches Advances in Water Resources , 31 (12), 1674-1686.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 3613, 2010.