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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Stochastic generation of multi-site daily precipitation for the assessment of extreme floods in Switzerland" *by* Guillaume Evin et al.

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We thank the two anonymous referees for their constructive suggestions, comments and questions. We truly believe that they will lead to a significant improvement of the manuscript. This response provides a summary of these comments and of our answers.

Overall presentation of the manuscript

Most of the referee's comment are related to the presentation of the methodology and the results. These comments are entirely justified and are appreciated, as they will greatly enhance the paper. The following paragraphs summarize what modifications will be made to the manuscript (more details can be found in the interactive comments):

- **Abstract:** We agree with the referee #1 (comments #1.5. and #3.1.) that the current abstract is not specific enough. Additional details will be provided (summary of the model developments, key results, etc.)
- **Title and introduction misleading:** As pointed out by the referee #1 (comments #1.1. and #3.2.), the title and the introduction seem to indicate that our study shows the results of an hydrological application, which is not the case. We propose to replace the current title by 'Stochastic generation of multi-site daily precipitation focusing on extreme events'. Vague reference to hydrological applications in the introduction will be removed.
- **Classification of the precipitation models:** Both referee (comment #2.3. by referee #1 and comment #2.2. by referee #2) rightly indicated that the terminology 'multi-site models' is too vague and does not describe precisely the references given afterwards. We propose to rename this class of models by 'Statistical multi-site models'. We will provide a detailed summary of the literature for this class of models, including specific extensions of the Wilks' model and how the proposed developments differ from them.
- **Mathematical formulation:** As suggested by referee #2 (comment #1.2.), a more formal mathematical formulation of GWEX could certainly improve the presentation. This will be done in the revised manuscript.

- **Names of the models:** As indicated by referee #1 (comment #1.2.), the current model names are confusing. New names will be given to the different model versions.
- **Flowchart of the models:** As suggested by referee #1 (comment #3.2.), a flow chart could be added in order to clarify the modifications made to the original Wilks' model and to illustrate the different model versions. A flow chart will thus be added to the revised version of the manuscript.
- **Specific sections devoted to parameter estimation and simulation:** In the current version of the manuscript, the methods applied to estimate the model parameters are described all along the different sections. In the same way, details about the generation of the scenarios were provided in sections 2.3 and 3.3. As suggested by referee #2 (comments #1.2., #2.5. and #2.6.), specific sections will thus be devoted to the estimation and simulation steps.

Reduced significance of the results without an hydrological application

The referee #1 raised a concern about the hydrological application (comments #1.4., #2.12., #2.14., #2.16.). In particular, according to the referee, the pertinence of this study can be questioned as the relevance of some metrics (extreme precipitation amounts at different temporal and spatial scales) cannot be proven without an hydrological application. The two following paragraphs motivate the choice of these metrics and explain why the hydrological evaluation is not carried out in this study.

First, we would like to remind the key motivation of this study. The proposed stochastic models intend to preserve the most critical properties of precipitation at different spatial and temporal scales, and especially extreme precipitation amounts. We believe that a precipitation model which has these properties has a better chance to reproduce ade-

quately flood properties for small sub-catchments as well as for large basins. Furthermore, empirical evidences have been provided by Froidevaux (2014) and Froidevaux et al. (2015) in our study area (i.e. Switzerland). Using 60 years of gridded precipitation data, Froidevaux et al. (2015) show that, in Switzerland, the generation of floods is mainly influenced by areal precipitation amounts accumulated on short periods (e.g. 1 to 3 days). Typically, the 2-day precipitation sum before floods is the most correlated to the flood frequency and the flood magnitude. These results are obtained by analyzing a wide variety of catchments, their areas ranging from 10 km^2 to 12,000 km^2. This study clearly motivates the multi-scale evaluation in space and time and the relevance of the precipitation metrics shown in our manuscript. These studies have been very briefly mentioned at the beginning of p.12 and these results must be discussed in more details, as will be done in the revised manuscript.

Second, we agree that hydrological applications would validate the importance of such properties. Actually, hydrological applications are currently undertaken by the University of Zürich. A conceptual hydrological model (HBV) is applied to 87 sub-basins partitioning the whole study area, using precipitation scenarios produced by GWEX as inputs. Numerous technical issues still need to be resolved. Some basins are ungauged, or with very short streamflow series. The hydrological system of the Aare-Rhine river needs to be treated as a whole since floods at larger spatial scales need also to be investigated. Rating curves have very high uncertainties in some basins and need to be re-evaluated. It is also important to note that this hydrological study (as well as our study) is particularly challenging considering the large spatial extent of the Aare river catchment. These studies stand out from similar studies which are usually limited to few precipitation stations and one “small" catchment (see, e.g., Keller et al., 2015, recently published in HESS, with an application to 8 precipitation stations located in a catchment with a size of 1700 km^2, to be compared with our study area of 17,000 km^2). The hydrological evaluation of our weather scenarios can thus not be carried out at the present time. It should be presented in future publications, considering the complexity of this work and the amount of results. However, we agree that the hydrological appli-

cation would emphasize the significance of this study, and this point must be discussed in the manuscript.

Validation and choice of metrics

Both referees (comments #1.7., #1.8., #2.5. by referee #1, and comment #1.3. by referee #2) suggested additional validation criteria. Following their suggestions, QQ-plots of the marginal distributions (empirical versus fitted E-GPD or mixture of exponentials) will be provided in the revised manuscript. Additional figures will also be added in order to assess the reproduction of lagged cross-correlations and autocorrelation of precipitation.

Comment #1.4. by referee 2, as well as comments #2.5 and #2.12. by referee 1, to a lesser extent, criticize the evaluation framework and the significance of the results concerning the reproduction of extremes. In this study, validation of extreme values is mostly performed using metrics computed at all the stations and for different spatial scales (see Figures 14 and 15 of the current manuscript). In our view, it is difficult to dismiss/validate a particular method using visual inspections of the reproduction of extremes (e.g. using Gumbel plots as in Figures 10-13 of the current manuscript, or QQ-plots). In this study, Gumbel plots are mostly shown because they illustrate interesting aspects in terms of extrapolation.

Finally, in this study, we firmly support the application of the CASE framework (Bennett et al., 2017), which enables a more systematic comparison of stochastic models. A consistent way to compute the performance metrics is important in order to obtain a fair assessment of the strengths/weaknesses of the different models. For this reason, in this study, the classification proposed by Bennett et al. (2017) is not modified. This remark will be added to the revised version of the manuscript.

References

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