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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Event generation for probabilistic flood risk modelling: multi-site peak flow dependence model vs weather generator based approach" *by* Benjamin Winter et al.

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General comments and recommendation

The manuscript by Winter et al. presents an interesting comparison of two quite different approaches for estimating flood risk in a probabilistic framework, both valid and currently established in the research community. The application of these models in a complex environment such as the alpine area and coupling it to a risk assessment is indeed new to my knowledge, and I congratulate the authors for their work! The manuscript is well structured, the methods are described in a comprehensible way or supported by relevant sources, and the discussion provides good points; however,

generally there are quite a lot of relevant numbers /numeric information as well as background information missing. While the authors neatly site sources, they force the reader to go to look for important and relevant information too often, what is laborious and time-consuming first, and an important drawback for both the evaluation and appraisal of the results, resulting in lacking some important considerations in both the results and the discussion parts. This is a pity, because with not too much effort, you might considerably improve the manuscript and better convey relevant take-home messages. The manuscript generally features high-quality and interesting figures, which however would be more easily readable by using larger fonts. In general I found quite a few typing errors. I am reporting all those I found in the technical corrections, but I would generally suggest the authors to read the manuscript thoroughly again. Because of these considerations, I think the manuscript requires further work before it can be recommended for publication. Please find my specific and technical comments here following. Please, don't get scared, some are only suggestions, and some questions are out of curiosity or eventual misunderstanding.

Specific comments

- Introduction: âĂć Please state more clearly the limits and the frames of your application (up to which return period and up to which spatial extent do you think these approaches are applicable and transferable -with this set up? In particular: what do you aim at?) âĂć P2-L17/18: you might want to also cite more recent literature such as Brunner et al. 2019: Modeling the spatial dependence of floods using the Fisher copula, https://doi.org/10.5194/hess-23-107-2019 âĂć P2-L22 Here also there is some more recent literature, such as Evin et al 2018 (Stochastic generation of multi-site daily precipitation focusing on extreme events, https://doi.org/10.5194/hess-22-655-2018) or appeared very recently Raynaud et al.2019 (Assessment of meteorological extremes using a synoptic weather generator and a downscaling model based on analogs, still under discussion, https://doi.org/10.5194/hess-2019-557) âĂć Other two options for generating spatially distributed meteorological fields, more physically based–but also more computationally intensive-, would be to use the output of either global circulation models (e.g. Felder et al.2018, From global circulation to local flood loss: Coupling models across the scales, https://doi.org/10.1016/j.scitotenv.2018.04.170) or of hindcast archives (e.g. National Flood Resilience Review. Tech. rep. HM Government, september 2016. url: https://www.gov.uk/government/publications/national-flood-resilience-review) and downscale these to the required spatial resolution.

- Study area:

âĂć From the map in Figure 1 it seems you are also simulating the Rhine at Lustenau, is this true? If yes, I assume you are using observations at some gauging station upstream of the inflow of the Ill river into the Rhine? If this is the case (and in any case?), I think it would be quite important to note this later on, as the nodes/communities simulated downstream in the Rhine valley should be considered a bit' differently. - Methods and Data: âĂć Please introduce how many meteorological stations and gauging stations are available for this study, for how many years, instead of first mentioning it in the results part. âĂć Hazard Module II: please give more details about how good is the modeling chain working (refer also to comments further below under Results). âĂć P6-L21/22: What do you mean concretely by saying "whereas the underlying hydrological boundary conditions are based on the considerations of the Austrian flood risk zoning project HORA"? âĂć Please add some information about the experimental set up: 100 x 42 years for the analysis of the spatial coherence and 30 x 1000 years for the rest (and also explain why 30 x 1000 years).

- Results: âĂć On the analysis of spatial dependence: Even though it is visible from the maps you show on the diagonal, it would be more fair to mention (and consider at all?) in the text that the four stations you are showing in Fig. 3 are not completely "independent", in the sense that Kennelbach is the downstream station of Thal and in turn Gisingen is the downstream station of Schruns. If you intentionally chose this set up –and I could see good reasons for making this choice-, please state it, and explain why. Furthermore, by reading Winter et al.2019 it occurred to me that first, Thal and Gisin-

gen are actually the two stations with the worst performance both, in the calibration and in the validation periods (if the hydrological model is not able to reproduce well the hydrological features of some subcatchments, depending on the reasons for the low perfomance, I wouldn't place too much confidence in the results for any other application of this, and rather ask myself if I am ev. not propagating some structural problem in the modeling chain), and second, that apparently both Kennelbach and Gisingen are influenced by hydropower operations (you also state in Winter et al. 2019 "..the influence of hydropower reservoirs cutting peak discharges, especially for the upper Ill catchment. This effect is not considered in the hydrological model set-up, but is contained in the discharge records." => even though I would generally expect this kind of weather generator to overestimate spatial dependence in a complex mountainous environment, this information is relevant when judging the strength of the dependence shown by the WeGen approach). I think you should provide more "background" and or critical information, and accordingly discuss more critically the results. You might be actually attaching too much guilt to the weather generator and/or the WeGen approach. Please do correct me if I am wrong. Another information I am missing here is to what correspond the exceedance probabilities 0.99 and 0.997 (what is the return period we are talking about here? I am not sure I fully understood how you derived the quantiles, sorry if this might be a stupid question). A follow-up consideration: To my knowledge, flood protection measures in Austria are designed whenever possible against a 100 years flood event. For example Felder et al.2017 (The effect of coupling hydrological and hydrodynamic models on maximum flood estimation, http://dx.doi.org/10.1016/j.jhydrol.2017.04.052) have shown that there might be considerable potential in re-shaping the hydrograph by coupling a simple 1D hydrodynamic model, in particular in terms of the timing of the peak. While I assume that the effect of retention in the floodplains in your study area is negligible, I would assume that this might become more important downstream for floods with return periods larger than 100 years, let's say for example in the main Rhine valley. As you also look at return periods up to 300 years in the vulnerability module, and you actually make use of inundation maps generated by hydrodynamic models, when and where do you think the coupling to a hydrodynamic model becomes relevant and what are in this sense the limits of the applicability of the WeGen approach? âĂć Please comment on the larger spread produced by the WeGen approach.

- Discussion: âĂć Weather generators in general: any weather generator makes a quite strong assumption about the tail behaviour, so that the higher the return period resp. the extremeness of the simulated precipitation, the larger should be the structural model uncertainty, which in turn is expected to quite influence the corresponding estimated hydrological load. While a 100 years event might be just at the boundary of what we might be able to extrapolate from about 40 years observations – with still some degree of confidence- anything beyond will very likely be strongly related to the tail models. Could you please elaborate on this, and state what do you think might be the impact of the use of another weather generator on your results? âĂć -P13-L26: Actually in Figure 5 you are showing the "overall" uncertainties of the two modelling chains, what do you mean with and why do you write single uncertainty sources here? âĂć This is just a consideration /suggestion: Of course volumes cannot be considered by applying the HT model, however besides flood peaks, flood volumes can play an important role in flood risk analysis. You correctly mention that one of the advantages of applying WeGen is the ability to produce continuous hydrographs (and accordingly event volumes), however you might want to mention it explicitly? Flood volumes play an important role for hydraulic infrastructure such as reservoirs/lakes/etc.. (and thus in hydraulic design engineering), and also in the case of presence of floodplains with retention potential. On the other side, volumes might be another validation measure for the WeGen approach, as –depending also on how good is working the hydrological model- indirectly indicate how well or bad is the weather generator doing by reproducing persistence at longer time scales (a week and beyond), as I would generally expect this kind of weather generator to be underestimating persistence. This is something you might want to check in the future?

Technical corrections

- Figure 2: it is full of typing errors (refer to Obseravtions, topographie, Geometrie) - Please use the word realizations instead of repetitions - Please use more consistently the word severity (e.g. in the of Figure 4 use return period instead of level of severity => what might be confusing, as you define and quantify severity by the UoFH later on) - P2-L3/4: what do you mean with floods hazard characteristics? - P6-L24: "..a linear interpolated interpolation.." please reformulate better - P7-L8: ..can be statistically.. - P7-L21: dependence matrices instead of dependence metrices - P7-L26: Each simulation instead of Each simulations - P8-L1: the data are too few instead of the data are to few - P10-L6/7: either remove a , in "a significat lower damages.."or change damages to singular - P10: please reformulate the last sentence (90% of exceeding sites sounds weird) - P11-L1: .., simulate (remove a) complex spatially heterogeneous patterns. . . - P11-L5: On the contrary. . .only indirectly .. - P11-L11: just a suggestion=> capability instead of feature? - P11-L13/14: One possible reason could ..be? , - P11-L15/16: might effect ..?=> please reformulate - P12-L2: instead of overall estimation => overestimation ? - P12-L5: ..estimate of (=> better with? Or by?)) WeGen approach - P12-L14: just a suggestion: instead of On the contrary => At the same time? On the other hand?

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