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Natural Hazards and Earth System Sciences
Discussions



# *Interactive comment on* "A stochastic event-based approach for flood estimation in catchments with mixed rainfall/snowmelt flood regimes" *by* Valeriya Filipova et al.

**Valeriya Filipova et al.**

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We would like to thank reviewer 2 for the suggestions. We have provided detailed answers to each of the comments below.

**General Comments: As I understood, the main purpose of the work is to propose a methodology to overcome the limitations of more commonly applied event based modelling for flood frequency estimations by a stochastic modelling of preconditions, including SWE, and meteorological input. The individual modelling of the different aspects are described in the manuscript, however, it**

**is hard to follow how the different parts are connected. A preceding sub-section with a less detailed step by step explanation of methodology, maybe including a schematic illustration (inputs/ models/ methods / output), could help to better explain the methodology.**

A similar comment has been made by reviewer 1. We will include a subsection which precedes the full explanation of the method and describes the general approach, including a diagram which illustrates how the various components are connected.

**For the validation of the disaggregation procedure the disaggregated data were compared against hourly station data. Is this correct? I would be interesting to see how well the disaggregation procedure was performing (For example showing a obs-sim, QQ-plot). It is stated that it works better than equal divisions which is not surprising. What is the advantage of the further equal division to 1h if it is stated that 3-houers are already enough? Further, it is not obvious why the gridded seNorge.no Data are matched to the HIRLAM data if they are in the needed temporal resolution already?**

The HIRLAM data is a hindcast dataset with a spatial resolution of around 10 km2 and a temporal resolution of 3 hours. The gridded seNorge data is obtained by triangulation of the observed rainfall dataseries; it has a spatial resolution of 1km2, and a temporal resolution of 24-hours. As the HIRLAM data has a higher temporal resolution than the seNorge data, the HIRLAM data was used to disaggregate the seNorge data to a 3-hour timestep. The performance, including the validation of the disaggregation procedure, is described in Vormoor and Skaugen (2013).

For the work presented here, the precipitation data were further disaggregated to a 1-hour time step by dividing into three equal parts. This was simply done for convenience, as the PQRUT model has previously been calibrated relative to 1-hour





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streamflow data and similar climate input data (i.e. 1-hour data derived from 3-hour data by dividing into three equal parts). A similar comment was raised by reviewer 1, and this section will be revised to include the above clarifications.

**A 1000 years event is extrapolated from daily observation series (length not further specified). Furthermore the results are then multiplied by empirical factors, to match sub-daily peak flows. I am not aware of the engineering practice in Norway, however, I am not sure about the meaning of the results by this extreme extrapolation and at least this should be critically discussed.**

The fitting of an extreme value distribution to estimate the return level for periods longer than the length of a time series is a standard procedure, both in hydrological investigations and in engineering practise. As suggested by the reviewer, the uncertainty of the estimates does increase significantly for longer return periods, relative to the length of record. The length of the daily streamflow series considered here, however, justifies the use of an 'at-site' (cf. a regional) flood frequency analysis as the minimum length is 31 years, while the median is 65 years of data. The following sentences will be added to the text:

*The length of the daily streamflow series justifies the use of at-site flood frequency analysis (Kobierska, et al., 2018); the minimum length is 31 years, while the median is 65 years of data. However, it is expected that the uncertainty will be high when the fitted GEV distribution is extrapolated to 1000-year return period. The 1000-year return period is used here, however, as it is required for dam safety analyses in Norway (e.g. Midttømme, et al., 2011; Table 1). More robust, but potentially less reliable, estimates could be obtained using a 2-parameter Gumbel, rather than a 3-parameter GEV distribution (Kobierska, et al., 2018).*

**The sensitivity analysis is interesting, however, also confusing including Figure 7 and Table 3. It is not obvious on what basis the percentage difference**





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**is calculated. This is also not clear in the follow up comparison of the methods. What exactly is the calibrated model? Also the section misses an explanation of the shaded area which is prominently displayed in Figure 7. Furthermore, the different precipitations settings tested are not well explained. A table, summarizing the different tested aspects, would help to guide the reader.**

Thank you for these comments and suggestions. The shaded area represents the simulations based on the 5% and 95% confidence intervals for the regression equations for PQRUT. We will include a table in the revised version of the manuscript.The paragraph that describes the sensitivity analysis will also be revised as follows:
*A sensitivity analysis was performed for the three test catchments, Hørte, Øvrevatn and Krinsvatn, in order to determine the relative importance of the initial conditions, precipitation, and the parameters of PQRUT on the flood frequency curve. To test the sensitivity of the model, we have used several different model runs and calculated the percentage difference of each of these relative to the model simulation, as shown in fig 7. More detailed information on the set up is given in table 3. As these catchments are located in different regions and exhibit different climatic and geomorphic characteristics, we hypothesize that the flood frequency curve will be sensitive to different parameters and hydrological states, as well as local climate and catchment characteristics.*

**The Figures and especially the captions should be improved, as they are often not self-explanatory. This includes also missing units, labels and abbreviations. Maybe consider a professional language proof reading.**

In the revised version of the article, we will provide fuller explanations in the catchment, revise the units, labels and improve the language usage.

**Specific Comments: The abbreviation PQRUT, used from beginning (abstract), is not introduced on page 4 or rather page 8. Please declare the meaning of PQRUT first time mentioned.**

The abbreviation PQRUT comes from P-precipitation, Q- discharge and RUT - routing, this will be explained in the revised manuscript.

**The characterizations of catchments and chosen abbreviations are introduced on P4 and repeated later (P5, l5) without brackets (e.g. "sparse vegetation over tree line (B)" and "sparse vegetation over tree line B"). Either use brackets throughout the manuscript or only use the abbreviation. Additionally by choosing more selfexplanatory abbreviations or using full words (eg. forest; marsh), would be easier to understand, especially in Table 1.**

All of these suggestions will be implemented in the revised manuscript.

**P.5 l.15: The last sentence does not contain important informations and could be omit**

We prefer to keep this sentence as it gives useful information on how the data is derived and increases the reproducibility of the study.

**P.6 l.1: The addition ",which can be used for modelling in ungagged basins." could be omitted, as it seems not connected to the procedure.**

This sentence will be deleted.

**P.6 l.2: A citation should be added to the DDD model or the corresponding R-package.**

The reference is provided earlier in the manuscript, p4.

**P.6 l.11: In my opinion, the meaning of the "critical duration" rather reflects the link between the duration and intensity of precipitation "events" of a certain probability, than to ensure the modelling of the complete flood hydrograph.**

This is a good point, the sentence will be revised to: *When simulating flood response with an event-based model, it is important to specify the so-called critical duration (Meynink and Cordery, 1976) to ensure that the flood peak is correctly modelled. The critical duration is an important factor which effectively links the duration and the intensity of precipitation events of a given probability.*

**P.6 l.32: "individual risk seasons could have been defined". One wonders why it was not done? If not so important for the result, please consider to omit this half sentence.**

This sentence will be deleted. We used this season definition to match the seasonal definition used by the Norwegian Meteorological Institute.

**P.8 l.12-17: Please check grammar and style of the section.**

This section will be revised to also address the issues raised by reviewer 1 as follows:
*The PQRUT model was calibrated for the 45 highest flood events by using the DDS (Dynamically Dimensioned Search) optimization routine (Tolson and Shoemaker, 2007) and the Kling Gupta efficiency (KGE) criterion (Gupta et al., 2009) as the objective function. An additional parameter, lp, was introduced to account for initial*

*losses to the soil zone. The reason for this is that, even though fully saturated conditions are assumed when the model is used to estimate PMF or other extreme floods with low probabilities, the model needs to account for initial losses when actual (more frequent) events are simulated. This procedure is described in more detailed in Filipova et al. (2016 ).*

**P.8 l.28: Was there a specific reason for using the "Gringorten plotting" position?**

The Gringorten plotting positions provide unbiased quantile estimates for the Gumbel distribution. In this case, we don't know the distribution. However, the difference between the plotting positions is usually higher for the low and high quantiles. As reviewer 1 suggests we have increased the number of simulations. This means that differences derived from plotting position formulas will be relatively small when estimating the 1000 -year return period.

**P.12 l.3: A more detailed explanation what exactly is analyzed here is missing.**

The sentence will be revised to:
*A comparison of the stochastic PQRUT with the standard methods for flood estimation shows that there is a large difference between the results of the three methods for both Q100 and Q1000 (fig 9 and 10).*

**P.12 l.25: Maybe the catchment steepness should be introduced in the section "study area".**

Thanks for the suggestion. This will be added to the the section "study area".

**P.13 l.25: Why is it peak to volume? I thought it is daily mean to daily**

**max discharge?**

This refers to converting the daily volume (obtained from the daily mean) to the peak value.

**Table 1: Missing units. Furthermore, the variables could be sorted and clustered more logically (e.g. temperature and precipitation; Q and AMAX).**

Thanks, this will be revised in the revised version of the manuscript.

**Table 3: Why are 100 values sampled? Does T mean the threshold Parameter Trt ?**

For the sensitivity analysis we used 100 samples, as larger number will increase the computational time. We assume that this number is sufficient to calculate the intervals. Trt refers to the parameter of the PQRUT model, thanks for spotting this error.

**Figure 2: Labels and units are missing**

This will be corrected for the revised version of the manuscript.

**Figure 3: Labels and units are missing**

This will be corrected for the revised version of the manuscript.

**Figure 7: is confusing because of the large number of different colored lines. Maybe two plots can help to distinguish between the different aspects as for example the precipitation input and other aspects. The legend is confusing as well. GDP was fitted to what? Y-Axes should start at 0, x-axes missing a label**

**and to be consistent with the rest of the work it should not exceed 1000.**

This issue was also raised by reviewer 1 and the figure will be improved and revised based on the newer, longer simulations.

**Figure 8: It is impossible to distinguish between 20 colors. Do the colors have any meaning? If they should be recognizable, numbering would be a better option. The numbers could then also be used in Figure 10, so the link between the performance of the model and the results are given.**

The colors just represent different catchments but also as reviewer 1 suggests, scatterplots will be used instead in the revised version.

**Figure 9: What exactly is shown in the plots. Please add a more detailed explanation.**

A more detailed explanation of Figure 9 will be included in the revised manuscript.

**Figure 10: The scale "percentage difference" should be unambiguous. The base of the "difference" should be clarified.**

This will be clarified in the figure description in the revised version of the manuscript.

**Technical Notes:**
**"Figure" and "Table" should start with capitals**
**Please use the degree symbol e.g. 4âŮę C (P.5 l.10, P8 l23 +26,. . .)**
**Please use [mm year-1] instead of [mm / year]**
**P.3 l.22: grammar ", as is often used"**
**P.5 l.3: Subscript i in ai and Ai (ai and Ai)**

**P.7 l.6: Missing link to "section"**
**P.7 l.20: Typo: "multivariat" instead of "mul- tivariat"**
**P.7 l.23: Whitespace, "values,p,"**
**P.9 l.1: Whitespace, "where,P"**
**P.9 l.34: Whitespace, "(29**
**P.11 l.3: Whitespace, "GL(Generalised. . ." P.11 l.10: Typo, "mm//ŮęC"**
**Check citation "Beven, Keith, . . . 2014"**
**Check citation "Chow, . . . 1988"**
**Check citation "Fleig, . . . 2013"**

Thanks, these revisions and suggestions will be taken into use in the revised manuscript.