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Hydrology and Earth System Sciences
Discussions

Interactive comment on "The role of precipitation for high-magnitude flood generation in a large mountainous catchment (upper Rhône River, NW European Alps)" *by* Florian Raymond et al.

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The authors would like to warmly thank the anonymous reviewer for his.her useful comments and suggestions which will help to significantly improve the manuscript. Please find below our answers to the reviewer comments:

*) The main findings could be a bit more highlighted and generalized.

response:

According to your feedbacks as well as those from the 2 other reviewers, we realize that the objectives were probably not stated clearly enough in the first version of the

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manuscript. Please find in the response to the reviewer 1 the clarified question and objectives.

This paper focus on the development of a new approach that aims at establishing the links between atmospheric processes and flood occurrences (e.g. Farnham et al., 2018; Schlef et al., 2019). The main objective is to overcome the uncertainties in the high-magnitude floods hazard projections. This approach assumes that i) flood events mainly result from “extreme” precipitation and ii) that atmospheric features associated with such “extreme” precipitation can be used as predictors of these events directly from climate projections. In this study, we explore the first point, i.e. in what extent the generation of high-magnitude flood events in a large mountainous catchment can be explained by precipitation only.

Our key results are:

- Precipitation alone seems sufficient to explain 13 of 28 flood events (types 2 and 4). Conversely, precipitation alone is not sufficient to explain the onset of flooding of types 1 and 3, possibly associated with other processes such as snow or ice melting.

- The largest flood events (return time period > 20 years) clearly result from precipitation accumulations only.

- Precipitation accumulations resulting in these flood events are characterized mostly by the 2-day and secondly by the 8-day accumulation, all ending 1 day before the events

-In this given catchment, only flood events with return time period > 20 years or types 2 and 4 flood events could be associated to atmospheric features. -To link these flood events to atmospheric features, a link between atmospheric processes and 2 and 8-day precipitation accumulations.

We achieve promising results since part (13 of 28 flood events) of the high-magnitude floods seem mainly associated with “extreme” precipitation accumulations only. Inter-

estingly this includes the strongest flood events (return period > 20 years) that have the potential of greatest impacts on societies. Hence, this opens a promising avenue for complementary flood hazard projections if robust links can now be found between atmospheric processes and 2 and 8-day precipitation accumulations.

Since this approach mainly relies on the global gridded ERA-20C reanalysis, it can be applied in any part of the world. The main limitation is the need of a long flow series to get a large sample of high-magnitude flood events. A second limitation may relies on the need of meteorological station data to evaluate the precipitation series from the ERA-20C since they might encompass large biases (as suggested by the reviewers). We trust that this approach could be successfully applied in many parts of the world since we have shown that it can work for high-magnitude events in a mountainous catchment, where the flood-induced hydrometeorological processes are made even more complex by the topography, the presence of snow and ice, etc.

Farnham, D.J., Doss-Gollin, J., Lall, U.: Regional extreme precipitation events: robust inference from credibly simulated GCM variables, water resource research, 54, 3809-3824, https://doi.org/10.1002/2017WR021318, 2018.

Schlef, K.E., Moradkhani, H., Lall, U.: Atmospheric circulation patterns associated with extreme United States floods indentified via machine learning, scientific reports, 9, first online published 9 may 2019, https://doi.org/10.1038/s41598-019-43496-w, 2019.

*)It would really be interesting to look at the precipitation patterns leading to the superimposition of the flood peaks from the three subcatchments. The topology of the river network and the buffering effect of Lake Geneva suggests that the precipitation patterns (spatio-temporal distribtion of rainfall in the three subcatchments) leading to superimpostion of flood peaks and thus to high-magnitude floods must follow a certain pattern. I suggest to elaborate more on that in the discussion when introducing the “type 1 floods” (see, e.g., Pattison, I., Lane, S. N., Hardy, R. J., and Reaney, S. M.: The role of tributary relative timing and sequencing in controlling large floods, Water Re-

sour. Res., 5444–5458, doi:10.1002/2013WR014067, 2014. or Zischg, A. P., Felder, G., Weingartner, R., Quinn, N., Coxon, G., Neal, J., Freer, J., and Bates, P.: Effects of variability in probable maximum precipitation patterns on flood losses, Hydrol. Earth Syst. Sci., 22, 2759–2773, doi:10.5194/hess-22-2759-2018, 2018).

response:

As you said, such extensive study might be very interesting to carry out but it is slightly apart of our objectives; moreover, it will require high-resolution datasets (hourly time steps, few km2) that we do not currently have.

A first analysis of the rainfall and discharge co-evolutions is proposed in Fig. 7c. As a first finding, we observe a good agreement at the daily time scale between the evolutions of the flood peaks and the one-day precipitation sequences for the Arve and Valserine sub-catchments (the Geneva catchment never participate to the flood peak, due to the buffering of the Lake Geneva). The sub-catchment variability of the one-day precipitation sequences is thus probably weak as illustrated in Fig. 7a. However, the resolution of the ERA-20C precipitation series does not allow a more precise study of these processes.

Minor remarks:

*)line 341: In my opinion, the statement on the role of snowmelting cannot be concluded from the present study. The effect of snowmelt was not analysed; line 371: As above, the role of snowmelt, although as mixed process, cannot be stated without having analysed it in detail; line 394: same as above.

response:

We agree that without the use of any specific cryospheric observations, it is impossible to affirm the role of snowmelt in the flood types 3. It is an hypothesis. The manuscript will be changed to avoid the confusion.

*)lines 408-410: Please describe what you mean with “new perspectives”.

response:

We agree with you that the sentence was a bit confusing. By “new perspectives”, we meant that highlighting the predominant role of extreme precipitation for certain types of floods may help to explore the future trends of these high-impact floods. As explained in the response to the reviewer 1, since we showed that flood-types 2 and 4 may be explained by the precipitation alone, the next step is dedicated to the identification of the main associated atmospheric processes. Thus, we will use such proxies to explore the future occurrence of these precipitations and then the future occurrence of high-magnitude floods.

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