hess-2019-487
Response to anonymous referee #1

Erwin Rottler, Till Francke, Gerd Bürger and Axel Bronstert

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Dear Anonymous Referee,

thank you very much for reviewing our manuscript. We are very grateful for your comments and suggestions. In the following, detailed responses to all your comments.

On behalf of all authors,

sincerly,

Erwin Rottler

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1 Specific comments

1.1 Comment 1

> The introduction is very compact (nothing wrong with that), but should explore and elaborate a bit more on the weaknesses of current approaches to analyse long time series of data. The statement (page2, line 22) ". . . new sets of analytical tools to extract information stored in this times series needs to be developed, tested, and applied . . ." is not justified by a critical review of currently available methods. Also, the advantage of then developed (own developments??) or applied methods to existing ones needs to be demonstrated.

Indeed, an overview of traditionally used methods to analyse long time series and their weaknesses/strengths is missing. We tried to point at the advantages and limitations of our approach, but you are right, we need to put this into context and formulate it more precise. We will prepare respective paragraphs and incorporate it into the introduction and discussion.

1.2 Comment 2

> You use many abreviations – as far as I can see they are all properly introduced/defined the first time mentioned, but a list of symbols/abbreviations would very much help, especially when reading the manunscript over longer time periods.

We will work through our manuscript to see what abbreviations are actually needed. Yes, a list could be useful, so the reader can look them up easily if needed. Thank you for mentioning this.

1.3 Comment 3

> The calculation of QMOV is not fully clear to me. From Fig.3 and section 3.1 (Discharge observations) it looks like daily quantiles are calculated from 148 values (single date, 1869-2016). How are "Changes in Seasonality" calculated – section 3.2 mentions the application of a 30day moving window. Is it operation on the previously extracted daily quantiles or does it operate on the daily runoff values and the quantiles are calculated from there. In my opion there would be arguments for both ways. You should also clearify than when you filter the data are highly correlated and I am not sure whether the TST estimator is made for these conditions. Please clearify and add some information on this.

Quantile estimations on a daily basis (QDAY) and quantile estimation within a moving window (QMOV) are two independent steps. QMOV operates on discharge data. In a way, QMOV

is similar to QYEA (quantile estimations using all values of one year), but with QMOV we only use part of the values of a year, the one within a 30-day window. We realize that we need to improve our description in the method section to make sure our approach is understood more easily. We will clarify and add some more information. Thank you very much for the hint.

2 Minor comments

P2, l28-30: Why focus on snow cover, as a hydrologist I would be mor interested on the snow water equivalent.

With 'snow cover' we do not think of the areal extent of snow, but indeed changes in water being stored in the temporary snow cover. It seems the wording we chose is not precise enough. We will think of a formulation that describes our ideas more clear and prevents any ambiguity.

P3, l13: It would be good to hear something about the test for homogeneity.

We will try to find out more about the tests conducted by [Pfister et al., 2006] that made them state that the time series can be considered homogeneous.

P3. L5ff: Please use dot for separating decimal figures throughout the manuscript (1.20 10^4)

Thank you for pointing this out. We will replace commas with dots.

P5, l2: which plots are addressed here.

We address the two right columns of Fig. 4, Yes, you are right, we need to mention this here specifically and refer to the figure.

P5, l13: How you define flood?

We do not specifically define 'flood' in our paper, yet. Yes, you are right, we need to better explain what our quantile estimates represent and, more importantly, what they do not. With regard to floods, it might help to discuss quantile values in relation to return periods and extreme value statistics. We will work on this and include it in our manuscript.

P11, l29: "anthropogenic" - is this a statement that CC is mainly driven by men, otherwise I would CC-driven changes.

We included the 'anthropogenic' here to emphasise that recent changes in snow cover are not due to large-scale climate variability (which are important to understand changes in alpine snow cover, see e.g. [Scherrer et al., 2004]), but due to rising temperatures being part of recent climatic changes. We will reformulate corresponding sentences to make them more clear.

References

[Pfister et al., 2006] Pfister, C., Weingartner, R., and Luterbacher, J. (2006). Hydrological winter droughts over the last 450 years in the Upper Rhine basin: A methodological approach. *Hydrological Sciences Journal*, 51(5):966–985.

[Scherrer et al., 2004] Scherrer, S. C., Appenzeller, C., and Laternser, M. (2004). Trends in Swiss Alpine snow days: The role of local- and large-scale climate variability. *Geophysical Research Letters*, 31(13).