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Hydrology and Earth System Sciences Discussions

Interactive comment on "Changes in flood frequencies in Switzerland since 1500" *by* P. Schmocker-Fackel and F. Naef

P. Schmocker-Fackel and F. Naef

petra.schmocker-fackel@alumni.ethz.ch

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We thank Referee #1 and Paola Allamano for their comments on our paper. In the following we will address the comments of the two referees.

Major comments of Referee #1

Why did you do only a differentiation between 'floods' and 'large scale floods' and not a more detailed intensity classification?

For the Rhine in Basel a more detailed intensity classification like the one done by Sturm et al.(2001) would have been possible, since information about water levels (e.g. water level one arm length below bridge, bridge flooded) or the extend of flooding in the city of Basel are well documented. However, for the other 13 catchments not

enough information is available to follow this approach or only in a very subjective way. The spatial extend of the historic floods can be determined much better and more objectively. We therefore differentiated between local floods (affecting less than 3 catchments) and large scale floods (affecting more than 3 catchments).

Why did you not distinguish between different trigger mechanisms?

The majority of floods in our 14 catchments occurred in summer or fall. The triggering mechanisms were either local convective rainfall events of high intensity and short duration or large scale rainfall events of long duration and high rainfall amounts but lower intensities. Additionally, the cero degree line has to be high in the very mountainous catchments (e.g Alpenrhein, Plessur, Schächen, Reuss, Renggbach, Muota). In the large catchments like the Alpenrhein, the Thur or the Rhine only the large scale events cause large floods while in the small catchments like the Renggbach the local events are most important. For the medium sized catchments Sitter, Urnäsch and Schächen both event types can cause floods. Here it would have been interesting to distinguish between the two trigger mechanisms. However, the historic information was not sufficient to do so. The triggering events 'barrier effects by drift-ice' and 'rapid snow melting' are of no importance in our catchments. In Switzerland snowmelt floods only occur in the Jura mountains. No catchment of the Jura mountains could be included into the study due to missing historical data. As requested by Referee #1 we will include a paragraph to this effect in the revised version of our paper.

The discussion of dynamic aspects of historical flood frequencies has to be improved.

Our discussion of changes in large scale circulation patterns and flood frequencies has been short. We are thankful for the suggested literature and have re-written chapter 3.3 to a large extend, included further literature and own results. Using time series from more than 80 Swiss rivers and historical information, we identified the largest flood events in Switzerland since 1850 and determined the flow direction over the Alps at the 500 hPa pressure level during these events. This analysis has been published

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in Schmocker-Fackel and Naef (2010). We will include a summary of this analysis and put it into context to the results of this paper.

Major comments Referee # 2 P. Allamano:

Chapter 2 Methods: The analysis seems to be accurate but the exposition is a bit chaotic

As suggested by Referee #1in the minor comments, we will restructure the chapter and also include some more references.

Chapter 3.2: The discussion on “flood periodicities” is too peculiar and very often subjective in its conclusions.

The only source of knowledge about floods in the past centuries are chronics, written by laymen with huge differences in quality and reliability. It would be nice to have better data to do research on the distribution of floods over the last 500 years, but such data does not exist. We therefore invested a large amount of time to derive from this sources information on the occurrences and magnitude of floods. This required a lot of personal judgement that has a subjective component. In chapter 3.2 on periodicities, we presented the data in a form that we felt is adequate for this type of data. Due to the increase in information and more realistic background over the time, the series are certainly not homogeneous. However, we think that despite all the uncertainties, the message about changes in flood frequencies is reliable.

...given the statistical definition of flood event as a discharge larger than the 10-year flood, I am doubtful about the possibility of identifying periods less-than-50 years long as possible evidences of flood fluctuations.

In Fig. 5 and 6, we defined periods rich and poor in floods and showed them together with the underlying data. Therefore the reader can make his own judgement of the differences in floods over time. The question, how long a period has to be to allow reliable conclusions goes far beyond our paper. Our paper offers some indications that

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short term increases, as we experienced in the last decades, occurred several times before. It seems worth to discuss this result in spite of the many present papers that make conclusions on the effect of climatic change on floods, based on flood records of short durations.

It is not clear, how these results could be extended or employed by other scientists.

We present some results based on the analysis of 500 years of reports of large floods in Switzerland and compared them with studies in other regions. We think that the results are interesting and worthwhile to be reported. There are several possibilities how these results can be extended or employed by other scientists.

- For the hydrology community it is important to know that flood frequency is not constant over time and that large parts of the Swiss measured runoff time series falls into a period of low flood frequency (Low 4). This should be considered for design flood estimations and in flood statistics. This has to be considered for climate change studies as well, since many flood series starting in the 1960s show a positive trend, while time series starting around 1900 do not.

- The data of this study is valuable for a comparison with other reconstructed data (e.g. floods reconstructed from lake sediments, data from dendrochronology).

- We hope that climatologists will use our data for further research on past and future climate. Especially, an investigation of connections between flood frequency and atmospheric circulation in Switzerland might be very interesting.

- The European comparison could and should be extended (in time, in temporal resolution e.g on decadal time scale and in spatial extend). Unfortunately, Fig.3 was replaced with Fig. 6 in the electronic manuscript. In Figure 3 the number of floods per decade for all 14 catchments are displayed and therefore available to everyone to use in future studies. We attached the correct Fig. 3 to this response.

Chapter 3.3: this chapter needs improvement.

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As written in our reply to Referee #1, we will adapt chapter 3.3 as proposed.

General:

I suggest that the authors may try to extend their analysis by considering all year round temperatures.

We also considered reconstructed winter temperatures and yearly mean temperatures. However, no correlation with the changing frequencies of our data was found. Since around 70% of our flood events occurred during summer, we decided to display only summer temperatures.

... the comparison with flood patterns in other countries, despite the valuable set of information presented, does not help to reach conclusive indications (about the connections between flood frequency and climatic parameters)

In our view, the interesting result of our study of historical floods is that flood rich and poor periods are not synchronised over all of Europe but that similar patterns evolve. In our opinion, the most plausible theory is that changes in large scale atmospheric circulation cause the variations in flood frequency. We will try to clarify this point in our final version. And in doing so we hope to add one piece of the puzzle how climate influences flood frequency.

Minor comments

In the following we will answer some of the minor comments. Those we do not comment on we agree with and will change accordingly in the revised version of this paper.

Why do you focus just on the last 500 years?

In most of our catchments, the historical flood data is not sufficient to extend the analysis further back in time.

After starting with Northern Switzerland, you now mention Central and Northern Switzerland and later on you talk about Swiss flooding frequencies.

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All our catchments lie in northern Switzerland. Central Switzerland is a region of northern Switzerland. In the revised version, only the term northern Switzerland will be used.

You should discuss why higher thresholds sometimes occur for HQ10, sometimes for 'same frequency'. Is it by chance or is it possible to identify systematic variations.

This depends on whether discharges causing damages are larger or smaller than the HQ10. In some catchments discharges exceeding HQ10 cause no damage (e.g. Muota and Plessur). In other catchments, like the Alpenrhein or the Schächen already much smaller discharges caused damage. We will extend our discussion about these variations in Chapter 3.1.

Please specify how you have considered the effect of flood protection measures and reservoir construction.

We considered these effects by excluding catchments which are heavily influenced by this from our analysis. Additionally, in Fig. 3 it is shown, when major flood protection measures were constructed and reservoirs built. Unfortunately, Fig.3 was replaced with Fig. 6 in the electronic manuscript. This error will be corrected. We then checked if flood frequencies decreased following the construction.

I wonder that spring floods are of minor importance. Is there no substantial melting influence?

In the catchments of this study, spring floods are of minor importance due to several reasons: In the high altitude catchments, melting occurs in late spring and early summer. Most precipitation between late fall and late spring are in form of snow. Due to the large differences in elevation, melting occurs not over the whole catchment at the same time, therefore contribution by melting is low compared to the high rainfall intensities and amounts observed during summer and fall floods in Switzerland.

Fig. 1 (Fig. 3 of paper)Decadal flood frequencies and one and three decadal mean

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running flood frequencies for 14 catchments in northern Switzerland. For the period with runoff measurements different methods were used to define a flood. Also shown are changes in the river or catchments which influence flood damage and or flood discharge.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 529, 2010.

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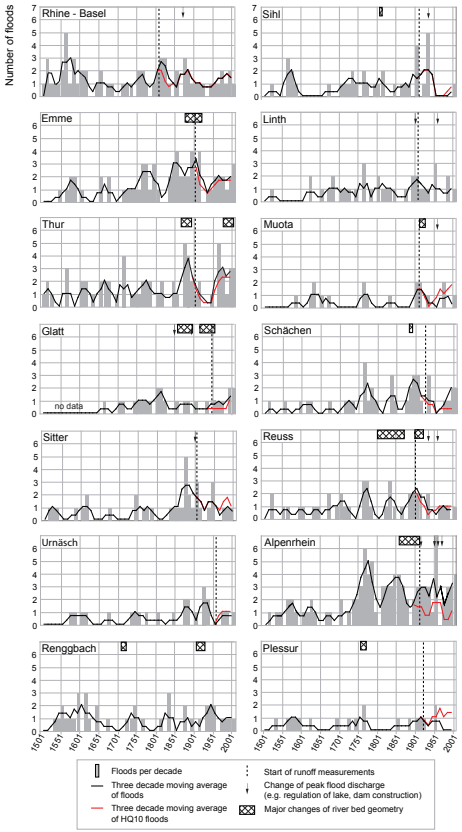

Fig. 1.

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