Parameter estimation: drivers of extreme discharge in the Northwestern Switzerland

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Introduction

Several catchments in Northwestern Switzerland have been recurrently flooded within the past years. Statistical models that consider all flood processes under the same distribution are commonly used in this region for estimating flood protection measurements.

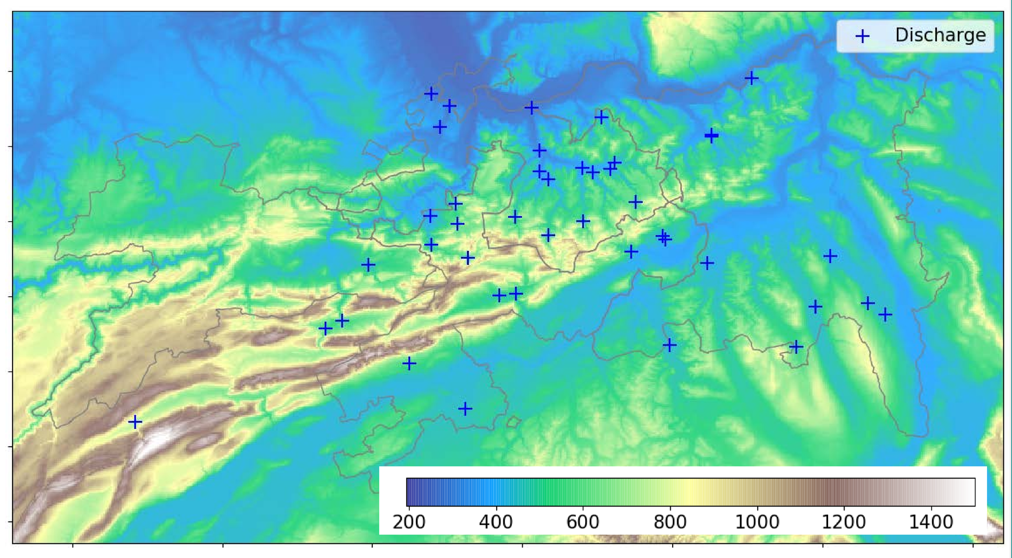

Fig. 1 Northwestern Switzerland drainage net. The discharge stations with high temporal resolution used are the highlighted blue points.

However, this approach does **not** represent the weather variability in time and does not differentiate between flood mechanisms. On the contrary, floods provoked by several mechanisms (e.g. flash floods, rain-on-snow floods, snowmelt floods, etc.) are assumed the same and equally likely to occur.

We investigate regional patterns and dominant parameters that differentiate flood processes, by using discharge observations with high temporal resolution (I.g. 10-15 min) of different catchments sizes (~ 4 to 74 km^2).

Motivation

895 flood events were obtained by using the peak over a threshold (POT) approach. Fig. 2 illustrates the frequency of occurrence of POTs and annual maximum floods (AMax) over the twelve calendar months. Both have a similar frequency distribution over the months: the maximum number of occur in July for the summer season (Apr-May-Jun-Jul-Aug-Sept) and in December for the winter season (Oct-Nov-Dec-Jan-Feb-Mar). Nevertheless the frequency of the POT floods has a smoother distribution, which indicates that the AMax method misses important floods of the not dominant months. Fig. 3 shows an example of the POTs for the data series of one station where on the year 2008 no extreme discharge is selected.

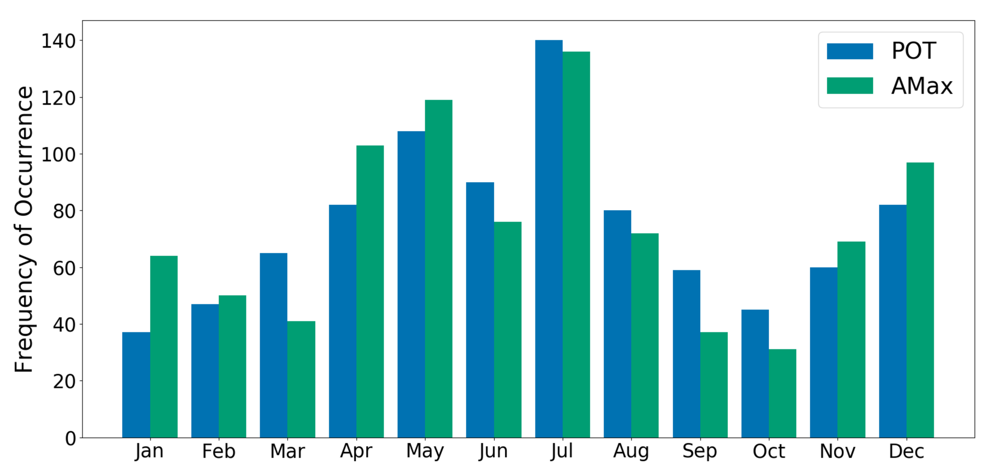

Fig. 2 Flood frequency of occurrence per month considering all catchments. AMax: annual maximum floods. POT: Peak over a threshold floods.

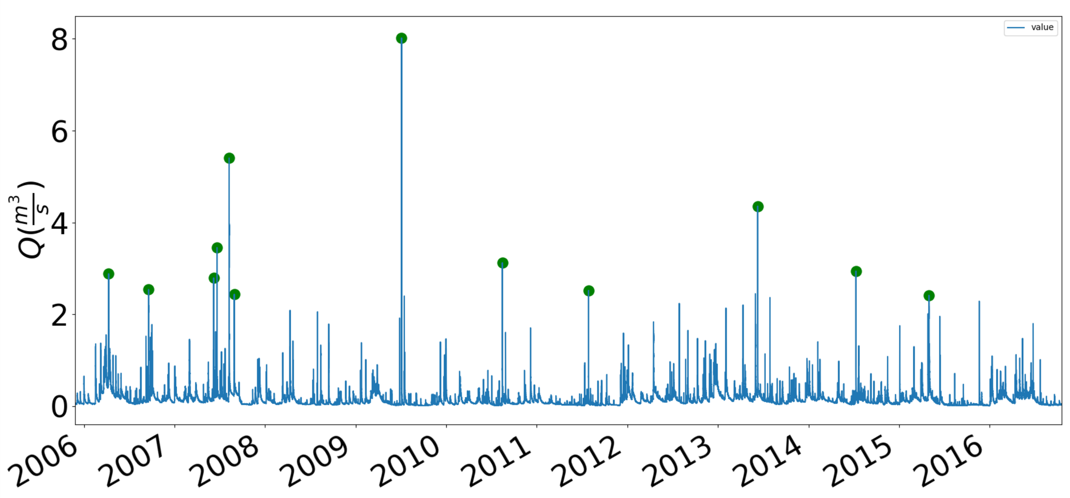

Fig. 3 Example of POTs for a discharge station (17.2 km^2)

Once the extreme floods are identified, flood hydrographs are separated by finding the equilibrium of the discharge difference $\Delta Q(t)$, (see example in Fig. 4).

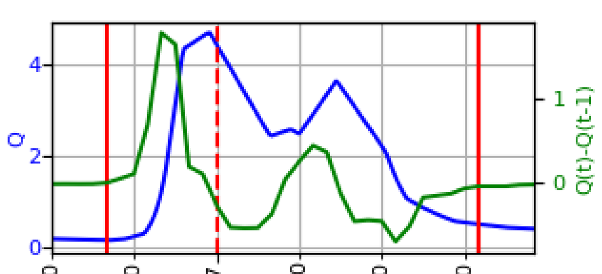

Fig. 4 Example hydrograph separation

As an example, the obtained flood hydrographs of two stations are displayed in Fig. 5 with the color indicating the season when the flood event occurred.

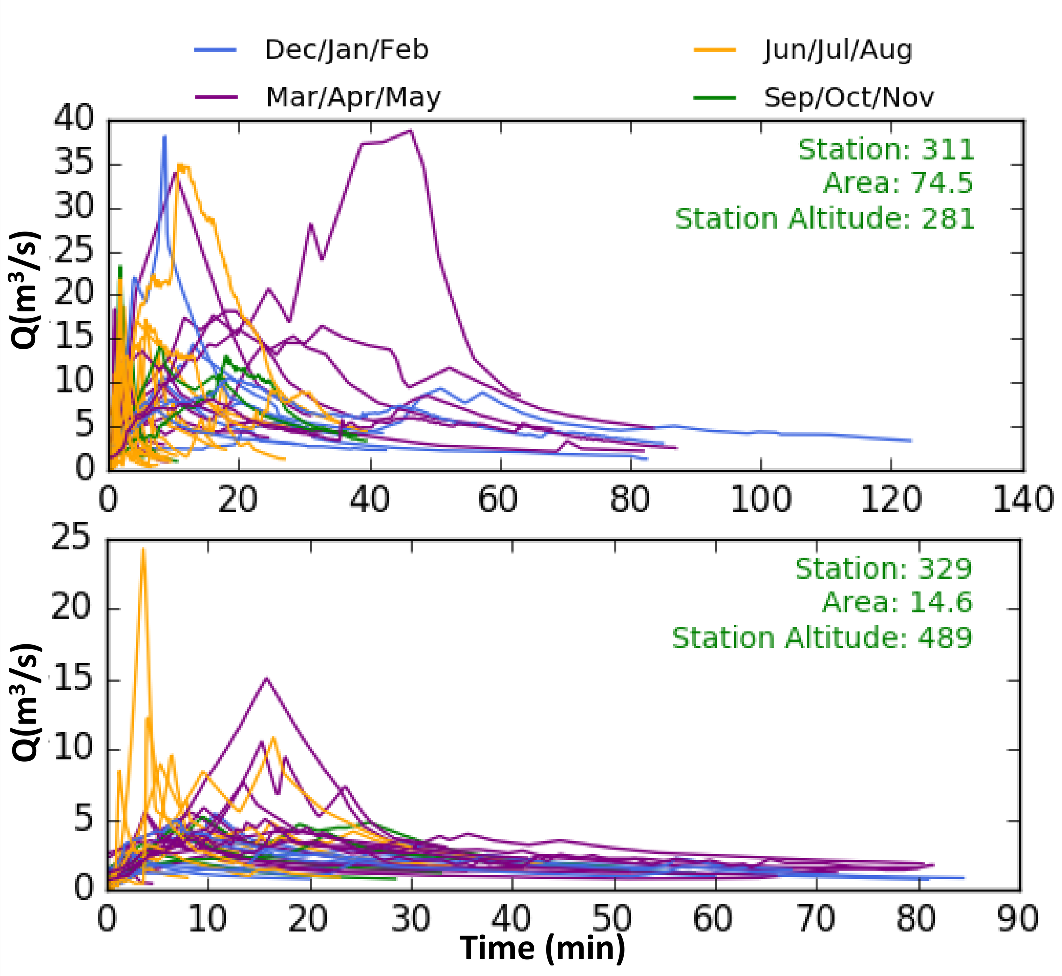

Fig. 5 POT hydrographs of two discharge stations. Color coded with the season at which the flood occurred.

The curves in Fig. 5 show that the hydrograph shapes are different and correspond to different mechanisms. Sep-Oct-Nov floods do not occur very frequently and have rather small peaks, which agrees with the data in Fig. 2. Jun-Jul-Aug floods have sharp and slim peaks, which are indicators of flash floods produced by convective precipitation. Larger floods with a long period are typical of Mar-Apr-May.

Precipitation Entropy

$$H = -\sum_{i=1}^{N} r_i log(r_i)$$

where: $r_i = \frac{P_i}{\sum_{i=1}^{N} P_i}$

$0 \le r_i \le 1$

$0 \le H \le log(N)$

P_i: Precipitation of the interval

N: Intervals (Measurements)

We investigate the entropy of precipitation as a parameter that describes the meteorological input of the flood event. Higher entropy values indicate that the input is uniformly distributed within all intervals of the evaluated period. On the other hand lower entropies indicate that the precipitation came within a short time interval.

Fig. 6 illustrates the spatial linear correlation coefficient of the entropy and the daily precipitation for extreme precipitation events of different durations (selected with different aggregations). The space correlation of the entropy and the daily precipitation increase as the duration of the extreme event does (Fig. 6), because poor entropy correlations correspond to local convective events (Top) and larger entropy correlations correspond to frontal events, that take place in larger areas (Bottom). For all durations analyzed (only 30 min and 360 min shown), the entropy correlations are larger than the daily precipitation correlations. Fig. 6 suggests entropy as a better estimator of the spatial distribution of the meteorological extremes than the daily precipitation.

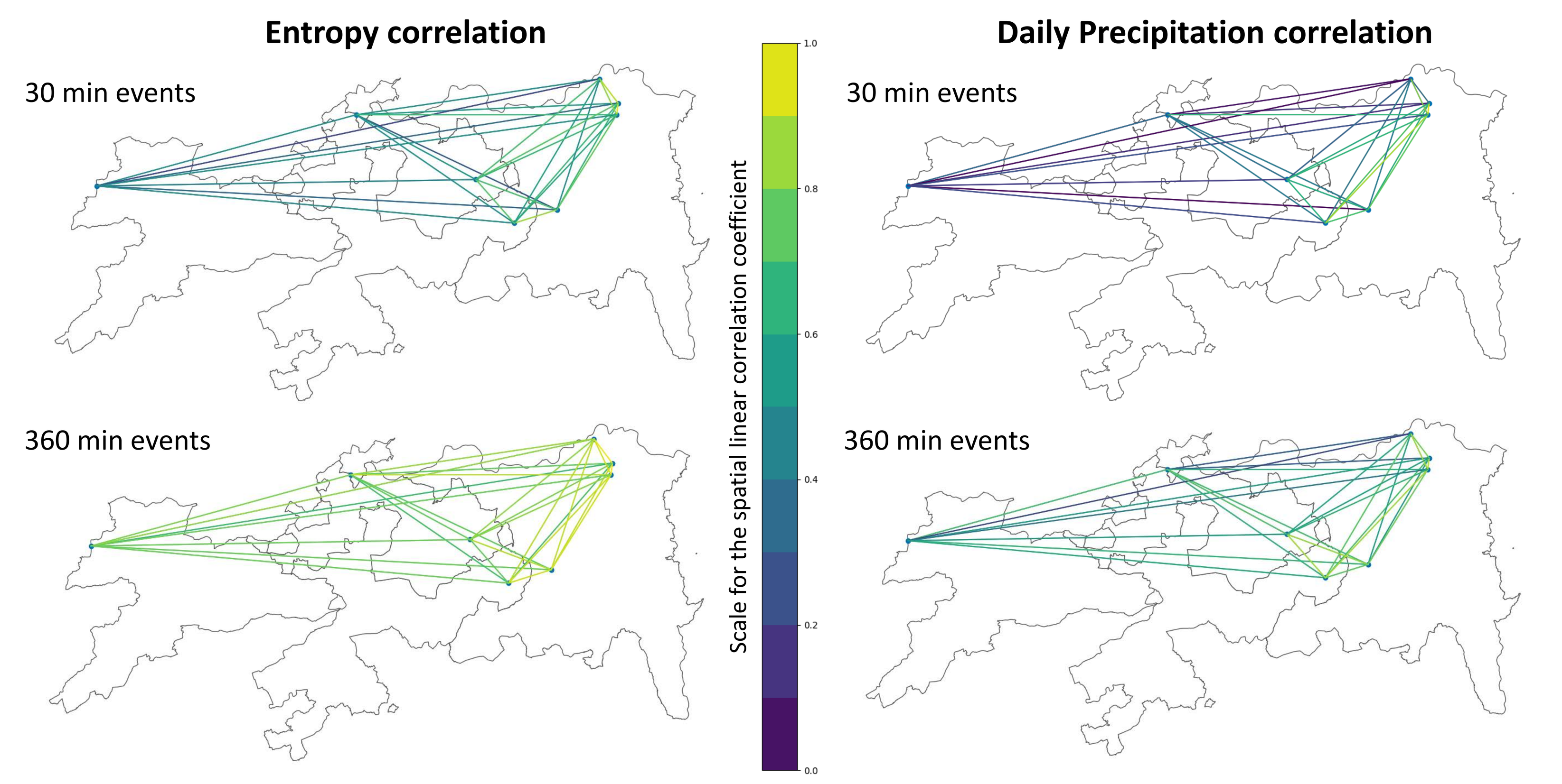

Fig. 6 Entropy and daily precipitation space correlation for 30 min and 360 min extreme event duration

Next the precipitation entropy for the time interval of a day (12 hours before/after the peak) was calculated for all defined POTs. Fig. 7 shows this entropy vs. the peak to volume ratio, the different colors identify the seasons. In winter the entropies are by average higher than those in summer, due to the presence of convective precipitation in summer (Fig. 7). This is also notable by the higher average peak to volume ratios, where convective precipitation leads to flashfloods.

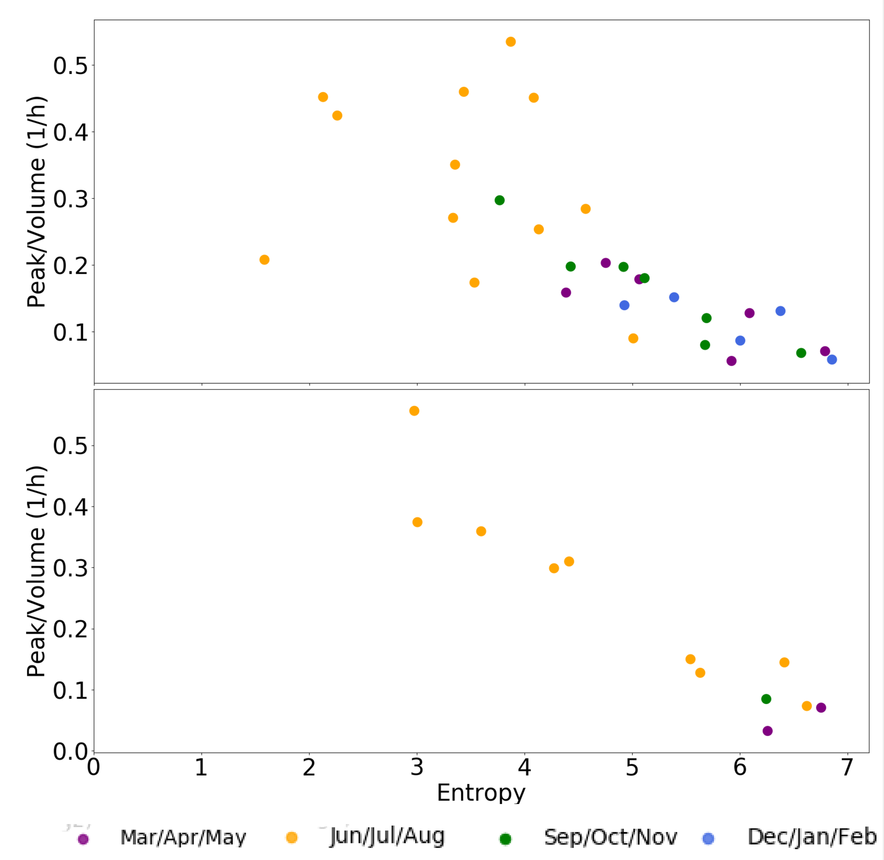

Fig. 7 Precipitation entropy when a extreme discharge occurs vs. Peak/Volume ratio. For two discharge stations with catchment areas of 12.9 km^2 (top) and 17.2 km^2 (bottom)

To further study the influence of the precipitation entropy on the hydrograph shape, the skewness and kurtosis of the hydrograph were calculated assuming each flood wave as a distribution function. Fig 8. shows that as the entropy decreases both the kurtosis and the skewness increase, explained by the rapid reaction of the catchment to intense events (convective precipitation) resulting on a steeper hydrograph (flash flood). Lower skewness and kurtosis for flatter hydrographs representing longer catchment respond to precipitation events with and evenly temporal distribution.

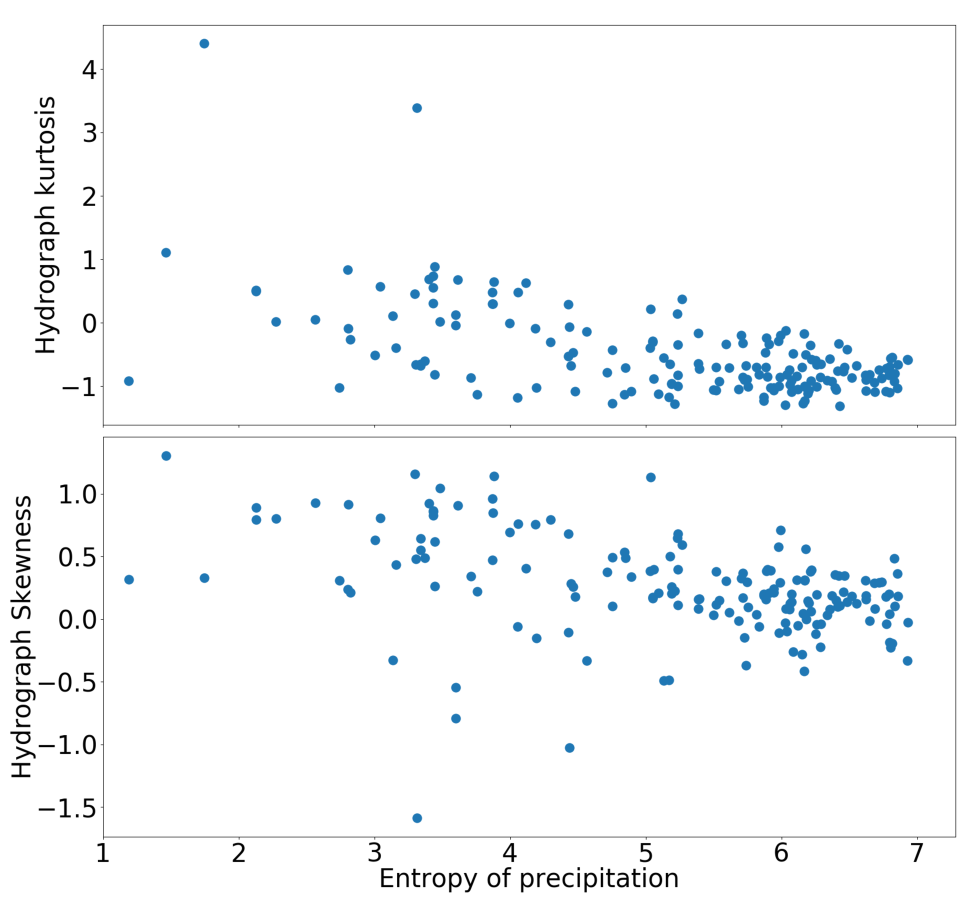

Fig. 8 Hydrograph kurtosis (top) and hydrograph skewness (bottom) vs entropy of the precipitation interval 12 hours before and after the peak for all studied catchments.

As next step the spatial distribution of the flood causing precipitation entropies will be investigated. A comparison of catchment characteristics (as slope, length, area, shape, etc.) will be developed, looking for regionalization potential to ungagged catchments.

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