Response to Reviewer 1

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A 2600-year history of floods in the Bernese Alps, Switzerland: frequencies, mechanisms and climate forcing

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Response to Dr. Benito, Reviewer #1.

We are grateful to the Reviewer #1 for his positive evaluation and his critical comments. We are especially gratified because Dr. Benito has s a strong commitment with the field of fluvial geomorphology, paleofloods and paleoclimate and the related research community.

Discussion point 1:

"A point for discussion is the cycle issue. It is nice to find some periodicities on the spectral analysis of the geochemical indicators, and how those more or less match with periodicities on NAO, TSI, O18, etc.. Similar cycles can be found in economy (K wave), business cycles (bankruptcy), pathologies, etc.. In addition, when we tried to fit 1 to 1 peaks on these records it is totally impossible to get a good match, and then we blame the chronology. I wonder if these cycles are artefacts built by our mathematical methods of analysis or the authors are comfortable with the influence of global drivers to explain the local geochemical content of a sedimentological log."

We are aware of the possibility that the estimation of periodicities of flood time series can include artifacts. We applied the spectral analysis to the generated paleoflood records and on other paleoclimate time series to investigate the frequencies which explains the total variance of the variables (p. 3404, L. 1-9).

The methods mostly used for spectral analysis are the Blackman-Tukey method (Jenkins and Watts, 1968) and the Maximum Entropy Spectral Analysis-MESA (Burg, 1967). The major drawback of these methods is that they require time series with evenly spaced data. In general, this requirement is not satisfied by paleoclimatic series whose time spacing is not constant. Therefore, the application of the above methods requires some type of interpolation. Statteger and Schulz (1997) showed that the interpolation produces a bias improving the low frequency components at the expense of high frequency components. Thus, the spectrum of the interpolated time series becomes too "red" (increase of the red noise) compared to the real spectrum. To solve this problem, the authors propose Lomb-Scargle Fourier-Transformed (LSFT Lomb, 1976; Scargle, 1982, 1989) for series not equally spaced over time in combination with the method of Welch-Overlapped-Segment-Averaging (WOSA; Welch 1967; Percival and Walden, 1993) to obtain mathematically consistent spectral estimates.

Considering the uncertainty ranges of the obtained radiocarbon dating (±30 yr for radiocarbon ages; ±50yr - ±129 yr for 2σ calibrated radiocarbon ages) we use only periodicities ≥ 60 yrs (P. 3413, L.8) Chambers and Blackford, 2001, J. Quater. Sci. 16 (4), 329-338). The signals were tested by white noise (Siegel, 1979) and red noise assessment (section 3.4). Periodicities of the different paleoclimate and environmental proxies coincide quite closely as shown in table 2. However, we also should keep into mind that statistic artifacts could not only affect our paleo flood record but also other paleoclimate time series.

If mean values of recurrence intervals are calculated from the flood proxy illustrated in figure 8, we obtain for the period from AD 1300 to 1875 (pre-river correction) the following results: around 95 yrs for the 6 major flood clusters (double or triple maxima; note reverse plot in Fig.8), around 82 yrs when the single flood peak of 1762 is included, and 191 yrs when only maxima flood cluster (F1 scores higher than 1.5) are considered. These estimations are close to the periodicities obtained by spectral analysis presented in table 2. Furthermore, when individual F1 score pulses are considered, they would match to the spectral signal of 53 yrs in figure 6. To conclude, we cannot exclude a priori artifacts in our spectral analysis, but the arguments and tests by mean values supports the accuracy of the spectral analysis applied.

In addition, we tested our geochemical (F1 scores) and sedimentological (coarse-grained flood layers) flood proxies by historical data where pristine chronology is available. Therefore, the chronological control of the these reference data (historical and dendrochronological data) provide an annual resolution. As pointed out in the section 6 (Conclusions, P. 3429, L. 17-24) the uncertainty interval of our proxy data increase with regard to prior time series where calibration by historical data is not available and comparison is limited to outstanding anomalies in the paleoclimate and paeloflood time series.

We are comfortable with the influence of global and supra regional drivers because the atmospheric circulation connects the Alps and alpine catchments to the North Atlantic dynamics (NAO, SNAO, ^{18}O). However, in the case of the TSI we agree that the link between solar activity, atmospheric dynamics and hydrological-terrestrial system is poorly understood (Wanner et al., 2008). However, there exist a large number of natural archives that show the solar signal (Versteegh, 2005). This occurs also in the case of the Swiss lake records (e.g. Stewart et al., 2011; Wirth et al., 2013) and fluvial sediments (e.g. Benito et al., 2003; Schulte et al., 2004; 2008). In addition, association are detected between atmospheric circulation and reduced solar activity (Gray et al., 2010; Wirth et al., 2013).

Specific Comments:

P.3392, L.7: modified according to the referee #1.

P.3392, L.17: modified according to the referee #1.

P.3398, L.5: modified according to the referee #1.

P.3401, L.20: We prefer to maintain the term “textural sources” (Pfister, 1999; Barriendos et al., 2014).

P.3402, L.11: We changed section 3.3 to section 3.1.

P.3418, L.1: modified according to the referee #1.