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Frequencies, mechanisms and climate forcing of paleofloods in the Bernese Alps (Switzerland) inferred from natural, historical, and instrumental time series

Lothar Schulte (1), Juan Carlos Peña (1,2), Filipe Carvalho (1), Ramon Julià (3), Antonio Gómez-Bolea (4), Francesc Burjachs (5), Jaime Llorca (1), Patricio Rubio (1), and Heinz Veit (6)

(1) Fluvalps-PaleoRisk Research Group and ICREA, Department of Physical and Regional Geography, University of Barcelona, Spain, (2) Meteorological Survey of Catalonia, Generalitat de Catalunya, Barcelona, Spain, (3) Institute of Earth Sciences Jaume Almera, CSIC, Barcelona, Spain, (4) Dept. Biologia Vegetal - Botànica, University of Barcelona, Spain, (5) ICREA at the Catalan Institute of Human Paleoecology and Social Evolution, Tarragona, Spain, (6) Institute of Geography, University of Bern, Switzerland

The aim of this contribution is the reconstruction of a 2600-yr long flood series generated from high-resolution deltaplain sediments of the Hasli-Aare and Lütschine delta, which reproduces the fluvial dynamic and related mechanisms, including trends, clusters and gaps of floods in alpine catchments. Paleofloods frequencies were reconstructed from geoarchives particularly by sedimentary, geochemical (XRF-core scan, conventional XRF, LOI and grain size), mineralogical, geomorphological, pollen and lichenometric records. An important issue is the question if these paleofloods can be calibrated (exact dating) by data series from historical sources (textual and factual) and by instrumental data. Not less than 12 of 14 severe and catastrophic events before the termination of the River Aare Correction in 1867, are detected during the last 700 years also by coarse-grained flood layers, ln(Zr/Ti) peaks and Factor 1 scores.

Spectral analysis of the geochemical and pollen time series and climate proxies (δ14C, TSI, δ18O isotopes from the Greenland ice, temperatures and precipitation reconstruction from tree-rings, NAO, SNAO) evidence similar periodicities of 60, 85, 105, 120 and 200 yrs during the two last Millennia. Thus, the mechanisms of the flood processes are strongly influenced by the North Atlantic dynamics and solar forcing. The composite 2600-yr sedimentary floodplain record illustrates that periods of organic soil formation and deposition of phyllosilicates (medium high catchment area) match very clearly to maxima of Total Solar Irradiance (Steinhilber et al., 2009) pointing to reduced flood activity during warmer climate pulses.

The aggradation of the paleoflood clusters (e.g. 1300-1350, 1420-1480, 1550-1620, 1650-1720 and 1811-1851 cal yr AD) with contribution of siliciclasts from highest catchment area (plutonic bedrock) occurred predominantly during periods with cooler summer temperature, reduced solar irradiance and phases of drier spring climate (Büntgen et al., 2011). Cooler climate trends promotes glacier advance, more extensive snow cover and snow patches through summer. Water storage and larger area susceptible for melting processes associated to rainfall episodes and abrupt temperature rise can increase surface run off on slopes.

The comparison between the historical flood intensities and score F1 from the Hasli valley and the 11-yr smoothed Summer NAO index from 1670 to 2000 (Hurrel et al., 2003) shows the following relation: severe and catastrophic floods of the Aare occurred mostly during positive trends of SNAO modes (e.g. 1749 and 1762 floods). However, in the case of the sever 1703, 1707, 1851 and 1876 floods, the episodes correlate to short positive SNAO pulses following years and even decades dominated by negative SNAO and cooler annual temperature. This combination point to the importance of the effect of snowmelt during short warm episodes within cool climate periods characterized by larger snow cover and glaciers.

The determination of historical flood discharges that defined the damage threshold is challenging and we present only some rough estimations. From the historical data we can assume that before 1875 the magnitude of 351 m3s-1 level (conservative estimation) produced damages of small-medium intensities M$\geq$1, whereas discharges of 500 m3s-1 or higher may caused catastrophic damage (M$\geq$3.5).