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Late Pleistocene and Holocene Climatic Variability in the Carpathian-Balkan Region

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Holocene flood frequency as reconstructed by lake sediments from multiple archives: A record influenced by solar forcing and atmospheric circulation patterns

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The frequency of large-scale heavy precipitation events in mountain ranges is expected to undergo substantial changes with current climate change. Hence, knowledge about the past natural variability of floods caused by heavy precipitation constitutes important input for climate projections and natural hazard analyses. We present a comprehensive Holocene (10,000 years) reconstruction of the flood frequency in the Central European Alps combining 15 lacustrine sediment records. These records provide an extensive catalog of flood deposits, which were generated by flood-induced underflows delivering terrestrial material to the lake floors. The multi-archive approach allows suppressing local weather patterns, such as thunderstorms, from the obtained climate signal.

We found that flood frequency was higher during cool periods, coinciding with lows in solar activity. In addition, flood occurrence shows periodicities that are also observed in reconstructions of solar activity from 14C and 10Be records. As atmospheric mechanism, we propose an expansion/shrinking of the Hadley cell with increasing/decreasing air temperature, causing dry/wet conditions in Central Europe during phases of high/low solar activity. Furthermore, differences between the flood patterns from the Northern Alps and the Southern Alps indicate changes in North Atlantic circulation. Enhanced flood occurrence in the South compared to the North suggests a pronounced southward position of the Westerlies and/or blocking over the northern North Atlantic, hence resembling a negative NAO state (most distinct from 4.2 to 2.4 kyr BP and during the Little Ice Age). South-Alpine flood activity therefore provides a qualitative record of variations in a paleo-NAO pattern during the Holocene. Additionally, increased South Alpine flood activity contrasts to low precipitation in tropical Central America (Cariaco Basin) on the Holocene and centennial time scale. This observation is consistent with a Holocene southward migration of the Atlantic circulation system, and hence of the ITCZ, driven by decreasing summer insolation in the Northern hemisphere, as well as with shorter-term fluctuations probably driven by solar activity.

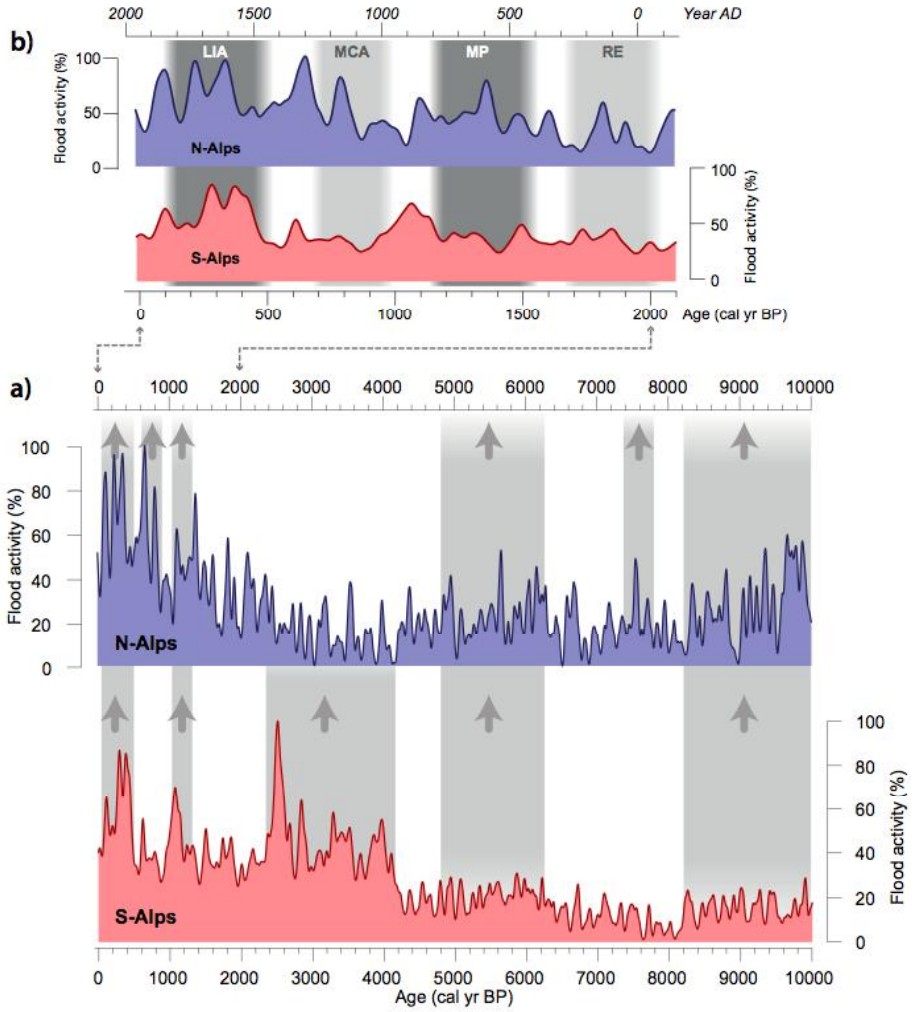

Fig. 1 Stacked flood records for the N- and S-Alps (100-year low-pass filtered) spanning (a) the past 10 kyr and (b) the past 2 kyr. Both representations show strong decadal- to millennial-scale fluctuations in flood activity. In a), gray areas and gray arrows mark periods with increased flood activity. In b), important historic and climatic periods characterized by rather high/low flood occurrence are marked with dark/light areas. LIA: Little Ice Age; MCA: Medieval Climate Anomaly; MP: Migration Period; RE: Roman Empire (from Wirth et al., 2013, Quat. Sci. Review)

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