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A 3600-year fan delta record of alpine floods: Potentialities of flood hazard assessment

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During the last decade the significance of flood magnitude, frequency and triggering forces in mountain regions is discussed in the context of Global Change. In the Swiss Alps these variables have also been even more investigated and modeled on a local scale due to the outstanding magnitude of discharges and economic losses (211 million CHF) of the 2005 flood event on August 23rd.

With regard to the discussion about future extreme events as a consequence of present day global warming, the key question arises if floods occurred in the past during warmer or cooler climate conditions. The variability of fluvial environments of the Lütschine and Lombach catchments in the Swiss Alps during Late Holocene is traced from a composed 3600-year fan delta record using a multi-proxy approach integrating methods of various disciplines as sedimentology, geochronology, pedology, geomorphology, hydrology, palynology, history and archaeology. Furthermore, the paper examines the potential of fluvial archives with regard to flood hazard assessment.

The lithology and geochemical data of the Lütschine and Lombach fan delta records studied in several key sections and cores show several aggradation phases from 3600 cal yr BP to present. The major aggradational pulses of the Lütschine fan delta recorded by coarse grained flood layers occur at intervals from 580 to 200 years, whereas in the Lombach catchment intervals range from 350 to 120 years. At least nineteen minor aggradational pulses indicated by the Ca/Ti ratios and organic carbon content are reported in the Lütschine catchment at a medium recurrence interval around 116 years at least from 3300 yr cal BP until 1100 yr cal BP and in the Lombach basin 10 pulses at an average interval of 105 years from 2800 yr cal BP until 1150 yr cal BP.

Despite the different fluvial regimes, glacio-nival regime of the Lütschine river and pluvio-nival of the Lombach river, the following correlation can be pointed out: a) synchronous trends of the Ca/Ti ratios, b) major flood events at 2250, 2100, around 1850 and at 1300 yr cal BP and c) formation of organic-rich horizons and peat at 2820, 2300, 1600 and 1450 yr cal BP.

Because of the spatial extension of the coarse grained flood layers, these beds were interpreted as mayor flood events deposited at average intervals of 370 yrs in the Lütschine catchment and 262 yrs in the Lombach catchment while minor deposition events defined by the Ca/Ti ratio could be seen as return period of moderate flood intensity. Tentative correlation between the pattern of the Ca/Ti pulses and the variability of the oxygen isotope record of GISP 2 can be drawn regarding the period from 1600 BC to 1 AD where the highest time resolution of the fan delta records we obtained. In addition these minor pulses occurring at intervals between 70 and 150 years could be related to solar forcing cycles detected at centennial scale, such as the Gleissberg cycle, in other sedimentary records. The solar influence on regional hydrological regime is proposed as the main factor

triggering the flooding events. However, the impact of land-use changes in the region at least since 3600 cal yr BP was detected by pollen and geochemical proxy data from fluvial deposits.

Despite the methodological limits of our multiproxy research, our studies may contribute some evidence regarding the characterization of the 2005 flood in the Lütschine catchment. Our data indicate that mayor floods over the last 3600 years coincide predominantly with positive radiocarbon anomalies (decreased solar activity) and cold phases in the Alps and do not correspond to the warmer climate peaks of the oxygen isotope GISP2 record from Greenland. But in fact, the 2005 flood occurred in both river systems during one of the warmest periods of the Holocene.

The elaboration of a flood index processing the flood calendar of Swiss rivers compiled by A. Gees (1997) shows that extreme events in Swiss river basins over the period from 1800 to 1975 occurred predominantly during years with lower annual mean temperatures (particularly about 1880 and 1915), but after 1975 this pattern changed. Since 1975 flood frequency increased significantly showing a positive tendency (up to 95%) toward a synoptic atmospheric circulation pattern defined by an omega block.

However, the ongoing research on historical flood levels reconstruction from written sources and the location of historical buildings in the apex area of the Lütschine fan delta provide preliminary evidences, that the magnitude of the warm climate pulse 2005 flood was considerable smaller than the 1831 flood during the Little Ice Age. Thus the Fluvalps-3000 project provides useful data for local authorities involved in future flood risk assessment. For example, adjustment of hazard maps and new planning of emergency measures can be considered in the future as necessary actions.