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Fan delta evolution and environmental changes in the Bernese Alps during Late Holocene: natural and anthropogenic contributions

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The understanding of Holocene fluvial processes influenced by human-environmental interactions is crucial for flood hazard assessment and spatial planning. Multi-proxy palaeoenvironmental approaches including sedimentology, geomorphology, palynology and documentary sources have potential to study the influence of climatic variability and land uses on aggradation and flooding processes.

The spatial coexistence of wetland, alluvial and fluvial environments on the low-gradient Lütschiene and Lombach fan deltas provide high-resolution fluvial records of peat, organic-rich fine-grained sediments and floodplain and channel deposits. The sedimentary record showed four mayor geochemistry and mesic tree cycles during the Subatlantic that correlate with δ^{18}O GISP2 record and the δ^{14}C anomalies. For the last millennium, the anthropogenic impact changed the depositional conditions, reducing wetland environments. Moreover, this impact masks the climate signal of the pollen and geochemistry proxies.

The coarse-grained layers of the Lütschine fan delta, deposited during palaeofloods about 400 yr BC, 100, 700, 1100, 1550, and 1830 yr AD, correlate with positive radiocarbon anomalies. The return interval of recorded flood events of the last 2400 years varies between 300 and 600 years. The fluvial-alluvial aggradation occurred in

the transition periods between maximum and minimum percentages of mesic arboreal pollen as well as during minimum percentages. According to the traced correlations with several alpine palaeoclimate records, floods occurred mainly during cold and wet periods. However, the 2005 flood doesn't match with this pattern.

Peat formation, dated around 1160, 470 and 100 yr BC and 20, 180, 370 and 870 yr AD, occurred on the Lütschine and Lombach fan deltas predominantly during warmer climate periods (e.g. Roman Climate Optimum and the Medieval Warm Period), whereas organic-rich paludal sediments were deposited during colder and warmer periods.

For the period from 1425 to 1880 yr AD the building inventories of 21 municipals of the Lake Brienz and Thun area were used as palaeoflood proxies of different catchments. Periods of enhanced house building coincides with periods of increased solar activity and vice versa. Two of the three minimums of construction match with two gravel layers of the Lütschine fan delta and with periods of increased flooding in the Swiss Alps (around 1550; 1815-1835 AD). The influences of flood hazard on settlements can also be drawn from the spatial distribution of the historical buildings of the village of Bönigen on the Lütschine fan delta.

We conclude that these multi-decadal changes of house construction provide evidences for the influence of climate forcing on the settlement on the fan delta, whereas the long-term increase of construction results from socio-economic and demographic factors, improved flood protection since the end of the 18^{th} century and the well-preservation of younger buildings.