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Annually laminated lake sediments as recorders of flood events: evidence from combining monitoring and calibration

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The relation of changing climate and the occurrence of strong flood events has been controversially debated over the last years. One major limitation in this respect is the temporal extension of instrumental flood time series, rarely exceeding 50-100 years, which is too short to reflect the full range of natural climate variability in a region. Therefore, geoarchives are increasingly explored as natural flood recorders far beyond the range of instrumental flood time series. Annually laminated (varved) lake sediments provide particularly valuable archives since (i) lakes form ideal traps in the landscape continuously recording sediment flux from the catchment and (ii) individual flood events are recorded as detrital layers and can be dated with seasonal precision by varve counting.
Despite the great potential of varved lake sediments for reconstructing long flood time series, there are still some confinements with respect to their interpretation due to a lack in understanding processes controlling the formation of detrital layers. For this purpose, we investigated the formation of detrital flood layers in Lake Mondsee (Upper Austria) in great detail by monitoring flood-related sediment flux and comparing detrital layers in sub-recent sediments with river runoff data.
Sediment flux at the lake bottom was trapped over a three-year period (2011-2013) at two locations in Lake Mondsee, one located 0.9 km off the main inflow (proximal) and one in a more distal position at a distance of 2.8 km. The monitoring data include 26 floods of different amplitude (max. hourly discharge=10-110 cbm/s) which triggered variable fluxes of catchment sediment to the lake floor (4-760 g/(sqm*d)). The comparison of runoff and sediment data revealed empiric runoff thresholds for triggering significant detrital sediment influx to the proximal (20 cbm/s) and distal lake basin (30 cbm/s) and an exponential relation between runoff amplitude and the amount of deposited sediment.
A succession of 20 sub-millimetre to maximum 8 mm thick flood-triggered detrital layers, deposited between 1976 and 2005, was detected in two varved surface sediment cores from the same locations as the sediment traps. Calibration of the detrital layer record with river runoff data revealed empirical thresholds for flood layer deposition. These thresholds are higher than those for trapped sediment flux but, similarly to the trap results, increasing from the proximal (50-60 cbm/s; daily mean=40 cbm/s) to the distal lake basin (80 cbm/s, 2 days>40 cbm/s). Three flood events above the threshold for detrital layer formation in the proximal and one in the distal lake basin were also recorded in the monitoring period. These events resulted in exceptional sediment transfer to the lake of more than 400 g/sqm at both sites, which is therefore interpreted as the minimum sediment amount for producing a visible detrital layer.