



Lakes as recorders of extreme flows: a millennial-scale palaeoflood record from the English Lake District

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Greater insight into the relationship between climatic fluctuations and the frequency and magnitude of precipitation events over recent centuries is crucial in the context of future warming and projected intensification of hydrological extremes. In the absence of suitably long-term quantitative measures of hydrological activity, the potential for natural archives to reveal records of past extreme events is considerable. In particular, upland lake basins can record the geomorphic effects of intense precipitation events as efficient sediment trapping in the coarse-sand to silt range by lakes renders flow-related proxy indicators (e.g., particle size) reflective of changes in river discharge.

We demonstrate that a series of sediment cores (3 – 5 m length) from Brotherswater, English Lake District, contain numerous coarse-grained laminations, discerned by applying high-resolution (0.5 cm) laser granulometry and which are interpreted as reflecting a palaeoflood record extending to ~2000 yr BP. Chronologies were derived for the cores using radionuclide (^{210}Pb , ^{137}Cs , ^{14}C) dating and geochemical markers which reflect the local mining history (e.g., Pb, Zn and Ba). Geochemical and magnetic profiles have enabled precise core correlation and the repeatability of the flood stratigraphy in the lake basin to be assessed. The presence of thick facies which exhibit inverse grading underlying normal grading, most likely reflecting the waxing and waning of flood-induced hyperpycnal flows, supports our palaeoflood interpretation.

The particle size data, normalized using 20-point μ and σ moving windows to negate the impact of long-term variability in the sediment regime, show a strong correlation between coarse-grained facies and the historical flood record for the Eden catchment during the last 300 years. This supports our assertion that the sediment record is strongly coupled to the hydrological regime. The extended 2000-year time series highlights a greater frequency of intense precipitation events in the past two centuries than for other periods. However, earlier phases of hydrological extremes appear associated with periods of agricultural intensification and land settlement in northwest England (e.g., Romano-British and Viking eras), which demonstrates the catchment sediment regime is sensitive to both climatic fluctuations and human activity. These results demonstrate that in process-dominated hydrological systems with a suitable catchment morphology and coupling, lake sediments can yield event- and sub-millennial-scale proxy records of palaeofloods.