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Reconstructing post-earthquake sediment cascades in mountain landscapes from the sedimentary record

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Strong ground motions from major earthquakes trigger tens of thousands of landslides in mountain landscapes initiating a sediment cascade that ultimately elevates sediment and carbon fluxes in rivers. The magnitude and duration of the fluvial response to earthquake-induced landsliding is relevant for quantifying post-earthquake hazard, landscape evolution and carbon cycling but remains poorly constrained in many mountain settings because post-earthquake sediment cascades are rarely captured by instrumental data series. The sedimentary record may provide a valuable archive of the landscape response to earthquakes in the absence of instrumental data but requires the signature of post-earthquake sediment cascades to be reliably identified and quantified. Here we use sedimentary archives of lakes adjacent to the Southern Alps, New Zealand to reconstruct earthquake-induced erosion in response to great earthquakes on the range bounding Alpine Fault; the timing, location and magnitude of which have been well constrained by independent paleoseismic data. High-resolution chronology combined with volumetric reconstructions of lacustrine sedimentary fills based on a dense network of sediment cores from two lakes fed by range front catchments allow sediment and carbon fluxes to be quantified over millennial timescales. The volumetric reconstructions show earthquake-induced landsliding increased suspended sediment and organic carbon (OC) transfers from the mountain belt by more than an order of magnitude immediately after each earthquake. While elevated fluxes persisted for decades, the majority of sediment and OC was exported within the first five to ten years after each large earthquake. In total, the last four M_w>8 earthquakes on the Alpine Fault have driven sediment and OCtransfers that equate to ~40% of the total flux over the last millennium. Further, biomarkers encoded in the OC allow the location and depth of earthquake-triggered landslides to be reconstructed. The Southern Alps case study demonstrates that post-earthquake sediment cascades in mountain catchments are reliably recorded in the sedimentary record. These records provide unprecedented insights into post-earthquake hazard in settings where major earthquakes have not occurred during the period of instrumental observation.