The fate of sediment after a large earthquake

Oliver Francis¹, Tristram Hales¹,², Daniel Hobley¹, Xuanmei Fan³, and Runqiu Huang³

¹Cardiff University, School of Earth and Ocean Sciences, Cardiff, United Kingdom
²Cardiff University, Sustainable Places Research Institute, Cardiff, United Kingdom
³The State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, Chengdu 610059, Sichuan, China

Large continental earthquakes can produce $10^4 – 10^5$ years of erosion in a geological instant through coseismic landslide generation. Local erosion rates increase by an order of magnitude immediately after an earthquake, but rapidly return to background levels. The short-lived nature of the enhanced erosion rates is insufficient to clear the orogen of coseismic landslide material, which can remain stored for centuries to millennia. The sediment which remains affects topographic evolution and potential hazards until it is removed from the orogen. We examine the processes by which the $3\text{km}^3$ of sediment, generated by the coseismic landslides of the 2008 Mw7.9 Wenchuan Earthquake, move through and within catchments. Using 10 years of satellite imagery and literature derived values, we can, for the first time, describe and measure the export of sediment by fluvial erosion, debris flows and overland flow. We find that less than 15% of the sediment, produced by the earthquake, has transitioned from the hillslope through tributary channels (of order $<5$) into the major orogen draining rivers. The transport of sediment through tributary channels is controlled by the frequency and magnitude of debris flows, which transport 60% of the sediment. Fluvial undercutting of landslide deposits plays a minor role in controlling sediment export, likely due to the low stream power and coarse nature of the sediment in tributary channels. Our observations suggest that the long-term evolution of channels in these range front catchments may be governed by the stochastic delivery of earthquake derived sediment.