Catchment scale simulations of the climatic regulation of fine sediment evacuation after widespread landsliding

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In mountain ranges, widespread landsliding triggered by large earthquakes can mobilise large amounts of non-cohesive sediment and organic matter that can be transported by rivers during the post-seismic landscape relaxation phase. The timescales over which this occurs are likely to be decades, meaning that it is difficult to establish the controls on post-seismic sediment evacuation from modern-day case studies. River gauging station data, reservoir and lake sediments have been helpful to constrain the temporal dynamics of fine sediment evacuation. However, key unknowns remain, particularly with regard to the competition between sediment supply and river transport capacity in space and time. Here, we attempt to tackle this using a 2D morphodynamic approach by applying the numerical model Eros at the catchment scale. We aim to systematically investigate how the properties of landslide populations and the runoff intensity and variability combine to control fine sediment export as suspended load from storm events to years and decades. Our focus is on the Potters Creek catchment located in the Southern Alps of New Zealand, where the Alpine Fault can generate Mw 8 earthquakes and which has one of the highest precipitation rates measured in the world. The chosen tectonic scenarios encompass different earthquake shaking intensities that translate to various landslide densities. Landslide properties are randomly sampled from empirical scaling relationships and the mobilised sediment is introduced in the landscape using a runout algorithm. The runoff distribution is constrained by empirical data and applied as climate forcing of the simulations. Prior to the quantification of the sediment export, we set up a calibration phase to constrain the sediment entrainment and deposition laws against data measured in the West Coast of New Zealand. Subsequently, an exploration phase is developed to quantify the sediment evacuation sensitivity to climatic parameters and the earthquake-derived landslide distribution properties. We find that the post-seismic sediment discharge is strongly controlled by the amount of sediment supplied and the accessibility of the sediment to fluvial transport. These two properties control the power-law scaling relationship (intercept and slope) between daily sediment concentration and water discharge. Runoff intensity and the sequence of
discharge events plays a central role on the export velocity of the fine sediment. Simulations show that fine sediment transport can rapidly (with year) return to apparent pre-disturbance levels, before experiencing a renewed wave of sediment at the catchment outlet from more distal sources. These simulations provide new insight on the common controls and complexities of the evacuation of fine sediment from earthquake-triggered landslides.