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# Calculating cascading and cumulative error at multiple scales for landslide runout modelling and hazard zonation.

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Due to the complexity inherent in all natural systems there is uncertainty in the value of all input variables used to model landslide runout. This uncertainty is frequently carried through the modelling process and included in the designation of hazard zones, often expressed as a number that can be added to or subtracted from the final output. Methods to include uncertainty in runout modelling range from very simple estimations (i.e. an "educated best guess" or "rule of thumb") to complex statistical methods that calculate the variance of modelled data against large empirical datasets.

The 2016 Kaikōura Earthquake triggered over 27,000 landslides over an area of 10,000 $km^2$ and had a wealth of geospatial data collected prior to and post the earthquake. This data provides the opportunity to calculate and compare the error for multiple modelling variables and test how this error is propagated from data collection through to hazard zonation. Furthermore, the differing types of data (i.e. sensor platforms and processing techniques) provide the opportunity to compare how error changes when using variable datasets and also to test the impacts of differing scales.

One of the variables that can impact landslide runout at all scales is volume. The data collected prior and post the Kaikōura earthquake using terrestrial laser scanning, aerial laser scanning and photogrammetric (UAV and fix wing aeroplane) can be used to calculate and compare the volumes of landslides. By comparing all data sources to the terrestrial laser scanning data, the uncertainty from the other methods can be estimated and the impact of variation of derived landslide volume tested with a runout model. Furthermore, comparison between these data sources could be used to provide the basis for scale dependent cost/benefit analysis of which data source or sources provide the most cost-effective method for deployment post a natural disaster.