A multi-sensor evaluation of precipitation uncertainty for landslide-triggering storm events

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Rainfall-triggered landslides result in numerous casualties and extensive damage each year in populated mountainous regions. There are many sources of uncertainty that present challenges to skillful predictions and therefore effective mitigation of these destructive natural disasters. One of the largest source of uncertainty in landslide probability comes from the volume and spatial distribution of precipitation volume and intensity during and immediately preceding the landslide event. A key challenge for practitioners is selecting among the wide range of precipitation measurements across different available datasets. Here we investigate the degree of precipitation uncertainty in these landslide-triggering storm events and the impact of that uncertainty on predicted landslide probability using established operational models. First, we compare the average intensity, peak intensity at the smallest interval available, duration and NOAA Atlas return periods of the landslide-triggering storms, at 257 landslide locations across the continental US and Canada. Precipitation data are taken from five products that cover disparate measurement methods: near real-time and post-processed satellite (Global Precipitation Mission IMERG Early and Final calibrated precipitation), radar (Multi-Radar Multi-Sensor gauge bias-corrected precipitation), gauge (North American Land Data Assimilation System v. 2 Forcing precipitation), and numerical weather prediction (High-Resolution Rapid Refresh real-time precipitation). These products also cover a range of spatial and temporal resolutions as well as spatial extent and real-time or near real-time availability. In order to evaluate the effects of resolution on the results, we also included a comparison of each dataset re-gridded to match the coarsest spatial and temporal resolution (NLDAS2). Landslide-triggering precipitation was found to vary extensively on the basis of the measurement source with the depth of individual storm events diverging by as much as 100 mm and the intensity by as much as 20 mm/h. Furthermore, the distribution of storm properties across all 257 events also varied extensively based on the choice of measurement with the range of storm depths varying by as much as 250 mm and the range of intensities varying by over 40 mm/h. Next, we compare the intensity and duration of the precipitation to existing regional Intensity-Duration Threshold landslide prediction models. Finally, we explore the implications of precipitation uncertainty to accurate real-time landslide predictions with the potential to save lives and otherwise enhance operational landslide responses.