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 247 mm with an average range of 38 mm. Peak intensity measurements, which is also potentially influential in triggering landslides, were also highly variable with an average range of 8.8 mm/hr and at times as much as 72 mm/hr. Next, we compare the intensity and duration of storms at landslide sites to existing published Intensity-Duration Thresholds to determine which products acheive the highest Equitable Threat Score for landslide predictions using these existing models. Finally, we discuss the implications of precipitation uncertainty in the context of real-time landslide predictions, indentifying strengths and weaknesses of different products and approaches.