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Multi-scale landslide hazard assessment: Advances in global and regional methodologies

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The increasing availability of remotely sensed surface data and precipitation provides a unique opportunity to explore how smaller-scale landslide susceptibility and hazard assessment methodologies may be applicable at larger spatial scales. This research first considers an emerging satellite-based global algorithm framework, which evaluates how the landslide susceptibility and satellite derived rainfall estimates can forecast potential landslide conditions. An analysis of this algorithm using a newly developed global landslide inventory catalog suggests that forecasting errors are geographically variable due to improper weighting of surface observables, resolution of the current susceptibility map, and limitations in the availability of landslide inventory data. These methodological and data limitation issues can be more thoroughly assessed at the regional level, where available higher resolution landslide inventories can be applied to empirically derive relationships between surface variables and landslide occurrence. The regional empirical model shows improvement over the global framework in advancing near real-time landslide forecasting efforts; however, there are many uncertainties and assumptions surrounding such a methodology that decreases the functionality and utility of this system. This research seeks to improve upon this initial concept by exploring the potential opportunities and methodological structure needed to advance larger-scale landslide hazard forecasting and make it more of an operational reality.

Sensitivity analysis of the surface and rainfall parameters in the preliminary algorithm indicates that surface data resolution and the interdependency of variables must be more appropriately quantified at local and regional scales. Additionally, integrating available surface parameters must be approached in a more theoretical, physically-based manner to better represent the physical processes underlying slope instability and landslide initiation. Several rainfall infiltration and hydrological flow models have been developed to model slope instability at small spatial scales. This research investigates the potential of applying a more quantitative hydrological model to larger spatial scales, utilizing satellite and surface data inputs that are obtainable over different geographic regions. Due to the significant role that data and methodological uncertainties play in the effectiveness of landslide hazard assessment outputs, the methodology and data inputs are considered within an ensemble uncertainty framework in order to better resolve the contribution and limitations of model inputs and to more effectively communicate the model skill for improved landslide hazard assessment.