Satellite sensing of precursory motion for landslide inundation forecasting

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Abstract

Landslide failures often start with slow movement, yet upon a catastrophic failure, they can turn into highly mobile debris flows and produce intensified, cascading hazards along their flow path. Accurate forecasting of landslide inundation beyond the initial source zone is crucial for reducing casualties and property damage. Here, we introduce a workflow to forecast dynamic landslide inundation by bridging satellite-captured precursory deformation into the open-source flow model, D-claw. We demonstrate its application to the 2021 Chunchi, Ecuador landslide, which failed catastrophically and evolved into a mobile flow after four months of precursory creeping motion, destroying 68 homes and killing 150 cattle. Using Sentinel-1 InSAR (Interferometric Synthetic Aperture Radar) measurements from ascending and descending tracks, we captured the accelerating surface displacements of the landslide preceding the runout failure and utilized them to invert for the depth of the landslide basal surface by assuming a plug-flow rheology. The inverted basal surface was subsequently input into the D-claw model to produce dynamic inundation forecasts. Comparison between our forecasts and the drone-acquired post-landslide damage assessment from lidar and optical sensors demonstrates that our proposed workflow is effective for informing landslide hazard mitigation and rapid response. Adaption of our methodology could prove useful for evaluating other similar landslides globally.