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ALS-based hummock size-distance relationship assessment of Mt Shasta debris avalanche deposit, Northern California, USA

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The failure of destabilized volcano flanks is a likely occurrence during the lifetime of a stratovolcano, generating large debris avalanches and drastically changing landforms around volcanoes. The significant hazards associated with these events in the Cascade range were demonstrated, for example, by the collapse of Mt St Helens (WA), which triggered its devastating explosive eruption in 1980. The rapid modification of the landforms due to these events makes it difficult to estimate the magnitude of prehistoric avalanches. However, the widespread preservation of hummocks along the course of rockslide-debris avalanches is highly significant for understanding the physical characteristics of these landslides.
Mt Shasta is a 4,317 m high, snow-capped, steep-sloped stratovolcano located in Northern California. The current edifice began forming on the remnants of an ancestral Mt Shasta that collapsed ~300-380k years ago producing one of the largest debris avalanches known on Earth. The debris avalanche deposit (DAD) covers a surface of ~450 km2 across the Shasta valley, with an estimated volume of ~26 km3.

We analyze ALS data on hummocks from the prehistoric Shasta valley DAD in northern California (USA) to derive the relationship between hummock size and distance from landslide source, and interpret the geomorphic significance of the intercept and slope coefficients of the observed functional relationships. Given the limited extent of the ALS survey (i.e. 40 km2), the high-resolution dataset is used for validation of the morphological parameters extracted from freely available, broader coverage DTMs such as the National Elevation Dataset (NED). The ALS dataset also permits the identification of subtle topographic features not apparent in the field or in coarser resolution datasets, including a previously unmapped fault, of crucial importance for both seismic and volcanic hazard assessment in volcanic areas. We present evidence from the Shasta DAD of neotectonic deformation along a north south tending fault and a comparison with the NED-derived DTM.

This work aims to improve our understanding of the Shasta DAD morphology and dynamics, and provide insight into the cause and timing of events as well as the mode of emplacement of the DAD. The Cascade range includes numerous large extinct, dormant or active stratovolcanoes. Size-distance relationships will enable us to estimate the volume of the collapsed mass and the travel distance of the avalanche, and the knowledge of the link between basement structures and the Shasta DAD will elucidate the causes of edifice instability and may be used to target priority areas for volcanic hazard mapping.