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The role terrestrial laser scanning in the documentation and numerical modeling of landslides and debris flows

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Terrestrial laser scanning (TLS) is a portable, rapid, time of flight, reflectorless survey system that can be used at ranges in excess of 600 m to document landslide sources and deposits. Data can be collected at a resolution and density such that a natural surface can be characterized to an unprecedented degree. The resulting x, y, z, coordinates are directly georeferenced and provide a 3-dimensional model that can be interrogated for a range of important data suitable for numerical modeling and also for monitoring using a time-series of scans.

This paper reports on the use of TLS in the Himalayan Kingdom of Bhutan, a country ranging in altitude from 200 m a.s.l. to in excess of 7500 m a.s.l. The resulting terrain is geomorphically, climatically and also tectonically complex; both the Main Central Thrust and Main Boundary Thrust traces run through the country. A survey of a problematic section of the major east – west highway was undertaken and TLS deployed on a range of landslide and debris flow deposits that regularly necessitate closure of the road and have claimed several hundred lives. The detailed TLS results from a bedrock landslide are presented and compared to a traditional engineering geological survey. Both stereonet and statistical clustering techniques (hierarchical and K-means) are presented to extract discontinuity data and shed light on the initiation and failure style of the landslide. The resulting data, in combination with surfaced TLS models from which cross sections and highly detailed surface mapping can be derived provide a direct input into a range of commercially available numerical modeling packages.