Morphological analysis of debris flow deposits in steep headwater channel using multi-temporal terrestrial laser scanning: a 4-year case study at Ohya-kuzure Landslide, central Japan

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Since the formation of the Ohya-kuzure landslide in 1707, its steep, rugged terrain has continued production of a vast amount of sediments by frequent debris flows. Recent works of erosion controls have resulted in vegetation recovery in many slopes in the landslide terrain, but in some subcatchments with very steep slopes, slope deformation and sediment transportation by debris flows are still frequently observed. The Ichinosawa subcatchment shows the highest frequency of debris flows in the recent decade. We focus on this subcatchment, in which numerous debris flows occur by several causes favorable for the initiation, including heavy rainfalls, steep channel slopes and frequent recharge of sediments from steep landforms with deformed sedimentary rocks. In this study site, detailed monitoring and related topographic measurements have previously been performed, yet the details of geomorphic processes are still in progress to be further investigated.

Here we perform terrestrial laser scanning of channel bed sediments in the Ichinosawa subwatershed to examine volumetric and morphological changes in the sediments. The TLS data were collected for 3 seasons each year since November 2011, hence comprising 12 datasets. Every point cloud data for different time is georeferenced using GNSS-derived ground control points, while if applicable, alignments of point clouds for adjacent time are further refined by cloud-based registration using the inertial closest point algorithm for unchanged slope characteristics. While the point cloud analysis shows a high potential of morphological measures in the study reach, we also carry out a DEM-based analysis at a resolution of 0.1 m for the basic volumetric and morphometric measurements. Estimated annual sediment storage and yield in the study reach falls into the order of thousands of cubic meters, which corresponds well with the measurements by other approaches. Longitudinal and transverse profile analyses demonstrate the segmentation of the study reach bounded by the narrowing of valley width with bedrock exposures (knickpoint) on the valley floor. Topographic metrics including stream gradient, surface roughness and openness are also examined to show distinctive characteristics of sediment transportation induced by debris flows along the study reach. This study is supported by JSPS KAKENHI Grants (26292077 and 25702014).

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