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RPAS-SfM 4D mapping of shallow landslides activated in a steep terraced vineyard

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The presence of roads is closely linked with the activation of land degradative phenomena such as landslides. Factors such as ineffective road management and design, local rainfall regimes and specific geomorphological elements actively influence landslides occurrence. In this context, recent developments in digital photogrammetry (e.g. Structure from Motion; SfM) paired with Remotely Piloted Aircraft Systems (RPAS) increase our possibilities to realize low-cost and recurrent topographic surveys. This allows the realization of multi-temporal (hereafter 4D) and high-resolution Digital Elevation Models (DEMs), fundamental to analyse geomorphological features and quantify processes at the fine spatial and temporal resolutions at which they occur. In this research is presented a 4D comparison of geomorphological indicators describing a landslide-prone agricultural system, so as to detect the noticed high-steep slope failures. The possibility to analyse the evolution of landslide geomorphic features in steep agricultural systems through high-resolution and 4D comparison of such indicators is still a challenge to be investigated. In this research, we considered a case study located in the central Italian Alps, where two shallow landslides (L1, L2) were activated below a rural road within a terraced vineyard. The dynamics of the landslides were monitored through the comparison of repeated DEMs (DEM of Difference, i.e. DoD), that reported erosion values of above 20 m^3 and 10 m^3 for the two landslides zones and deposition values of more than 15 m^3 and 9 m^3 respectively. The elaboration of Relative Path Impact Index (RPII) highlighted the role played by the road in the alteration of surface water flow directions. Altered water flows were expressed by values between 2σ and 4σ of RPII close to the collapsed surfaces. The increasing of profile curvature and roughness index described landslides evolution over time. Finally, the multi-temporal comparison of features extraction underlined the geomorphological changes affecting the study area. The computation of the quality index underlined the accuracy of features extraction. This index is expressed in a range between 0 (low accuracy) and 1 (high accuracy) and resulted equal to 0.22 m, regarding the landslide observed during the first RPAS survey (L1-pre); 0.63 m, concerning the same landslide detected during the second RPAS survey (L1-post); 0.69 m for L2. Results prove the usefulness of high-resolution and 4D RPAS-based SfM surveys for the investigation of landslides triggering due to the presence of roads at hillslope scale in agricultural systems. This work could be a useful starting point for further studies of landslide-susceptible zones at a wider scale, to preserve the quality and

the productivity of affected agricultural areas.