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A framework for assessing sediment volumes mobilized by debris flows: the case study of the Liera catchment (Dolomites)

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Extreme meteorological events can trigger widespread environmental damages, particularly in mountain areas where landslides and debris flows express their full destructive potential. An intense storm, named Vaia, occurred from 27th to 30th October 2018 over Northeastern Italy, triggering mass wasting processes, generating slope instabilities, causing widespread windthrows, and damaging anthropic structures. The Liera catchment (37.7 km^2) in the Dolomites (Northeastern Italy), was severely affected by the Vaia storm and 34 sub-basins featured debris flows. Mapping sediment source areas and quantifying sediment volumes mobilized by debris flows in extraordinary events greatly contributes to reliable and accurate hazard assessment. The objectives of the present study are to create and compare pre- and post-event sediment source inventories and to quantify debris flows mobilized volumes. To this end, a combination of field surveys, orthophotos interpretation, rainfall analysis, and high-resolution multi-temporal LiDAR data processing was carried out in the Liera catchment test area. The main outcomes of this study encompass (i) reliable and detailed pre- and post-event sediment sources inventories from which it was possible to identify new source areas generated by the Vaia storm, (ii) the quantitative estimation of mobilized material from each sub-basin through DEM of Difference (DoD) and (iii) the assessment of the debris yield rate (i.e. the volume eroded for unit channel length) of each homogeneous channel reach. Sediment sources identified and mapped in 2015 in the Liera catchment were 1,346, ranging in area from 10 to 347,000 m^2, with a total area of about 1,890,000 m^2. The 2019 post-event inventory shows 815 more sediment sources, 550,000 m^2 more than the 2015 inventory. Results indicate that the total amount of sediment mobilized from the sub-basins was about 307,000±63,500 m^3, and the total net volume balance exiting the basins was -64,000±14,500 m^3. The latter value encompasses the volume entered the Liera stream and the material that has been removed during and after the emergency operations. Despite the great impact of the event, only a limited amount of the total material mobilized reached the Liera torrent. We propose the approach devised and tested in the Liera catchment as an effective way to recognize the sources and assess the volumes of sediment mobilized by debris flows at the event

and catchment scales, making an effective use of data commonly available in alpine catchments.

KEY WORDS: DEM of Difference (DoD); debris flow; geomorphometry, LiDAR; sediment delivery; natural hazard.