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Evaluating the potential of visual interpretation of airborne LiDAR datasets for the identification and mapping of small landslides

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The analysis of surface topography by using LiDAR (*Light Detection and Ranging*) technology proved to be effective in landslide inventory mapping during the last two decades. Among the leading methods is the visual interpretation of LiDAR Digital Terrain Model (DTM) derivatives, applied for the mapping of different landslide types along diverse environments. Landslides are usually first being searched for by interpreting the hillshade map, while the landslide delineation is commonly followed by interpretation of the slope and the contour line maps. Several studies have also demonstrated the curvature map and the topographic roughness map to be effective tools in landslide detection and mapping. However, the landslide features topography can be poorly or even barely observable on the hillshade map, so a certain amount of landslides may be omitted from the final inventory if other derivatives are not visually inspected in detail. Hence, the thematic accuracy of a landslide inventory map depends on the geomorphic expression of landslides on the hillshade map, while the geographical accuracy depends on the adopted mapping procedure and the type of derivatives used for landslide delineation. Despite the overall usefulness of the visual interpretation of LiDAR DTM derivatives in landslide studies, the effectiveness of particular LiDAR DTM derivatives for the identification and precise delineation of individual landslide features has not been tested yet.

This study quantitatively ranks the airborne LiDAR datasets derived from the 1-m DTM, used for the production of the geomorphological landslide inventory map of the Vinodol Valley (65 km^2) in Croatia, according to their effectiveness for identification and precise delineation of particular landslide features. Landslides are mapped by one and the same expert, by interpreting a total of nine DTM derivatives. Six steps were carried out in this study: (*i*) the creation of the landslide dataset, which consisted of 394 small debris slides; (*ii*) the classification of landslides according to their geomorphic expression on the hillshade map, distinguishing four classes; (*iii*) the grading of the each DTM derivative for its effectiveness in precise delineation of particular landslide feature (i.e., crown, right flank, left flank, foot, toe), by assigning the grade of 0, 1, or 2 to each map; (*iv*) the statistical analysis of a total of 15,760 grades using the Friedman test; (*v*) the ranking of DTM derivatives in total of eight ranks based on the post-hoc analysis; and (*vi*) the classification of the DTM derivatives according to their effectiveness in mapping small landslides, considering the geomorphic expression of a landslide on the hillshade map. Finally, two categories of LiDAR DTM derivatives are proposed: (*i*) the main LiDAR DTM derivative, i.e. the most effective one for the

precise delineation of particular landslide feature of particular geomorphic expression on the hillshade map; and (*ii*) the secondary LiDAR DTM derivative, which is still considered to be effective for the precise delineation of particular landslide feature of particular geomorphic expression on the hillshade map, but should be visually interpreted coupled with other secondary map(s), or with the main DTM derivative.