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Geometry of gullies and shallow landslides obtained from VHR stereoscopic satellite images

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In many areas, gullies and shallow landslides contribute to shape the landscape through soil mobilization and loss of soil coverage. Accurate estimation of the volume of soil eroded by gullies or mobilized by shallow slope failures is essential for monitoring soil processes, and to quantify landscape evolution. The assessment of the volume of the material eroded by individual gullies or mobilized by single slope failures is a difficult and uncertain operation that requires information on the geometry (length, width, depth) of the gullies, and on the extent and surface and subsurface geometry of the landslides. Most commonly, these measurements are obtained through extensive field surveys, or by visual interpretation of stereoscopic aerial photographs. We present the results of a study aimed at measuring the volume of material eroded by gullies and mobilized by shallow landslides using stereoscopic, optical images obtained by satellite sensors. For a study area in Umbria (central Italy), where gullies and shallow landslides are caused chiefly by prolonged rainfall and rapid snowmelt, we used stereoscopic, optical images taken by very-high-resolution satellite sensors to recognize and map recent gullies and shallow landslides, and to obtain measurements of the mapped features. Analysis of the stereoscopic images allowed for the measurement of: (i) the length and width of the individual gullies, (ii) the surface area of the shallow landslides, and (iii) the height of the landslide escarpments, in the landslide source areas. The stereoscopic images used for the experiment were: (i) panchromatic images acquired by the WorldView satellite sensor on 8 March 2010, and (ii) panchromatic images taken by the GeoEye satellite sensor on 27 May 2010. All the satellite images used for the experiment have a ground sampling distance, GSD = 50 cm. This spatial resolution is adequate for mapping and measuring most of the shallow landslides, and is probably sufficient to detect and map many gullies in the study area. Ground information used to calibrate and validate the interpretation of the satellite images and the associated geometrical measurements was acquired through specific field surveys in the period from March to May 2010. We discuss the results obtained in view of their relevance for (i) the systematic characterization of the geometry of the gullies and the shallow landslides, (ii) the calculation of the volume of the material eroded by gullies or mobilized by shallow landslides, and (iii) the computation of the rates of soil erosion and landslide mobilization, in the study area. We further consider the advantages and potential limitations of the use of very-high-resolution stereoscopic satellite images to detect, map, and measure gullies and shallow landslides in different physiographical environments.