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Landslide intensity prediction for different typologies and at different scales: towards an upscaling paradigm

F. Catani (1), G. Gigli (1), V. Tofani (1), V. Ettorre (1)
University of Firenze, Department of Earth Sciences - filippo.catani@unifi.it

An essential part of any landslide hazard and risk assessment procedure is the prediction of the character of the intensity. In itself, intensity should express the potential impact energy, hence destructive power, of a landslide. Usually the intensity is considered as depending upon kinetic energy, mass and/or velocity. Unfortunately, though, this quantity is not easily measurable, let alone predictable at the basin scale. This is mainly due to the lack of studies on the argument and to the difficulty in defining a common framework or paradigm for the assessment of landslide intensity when we move from hillslope to catchment scale. In this work we try to define one such methodology starting from the detail scale study of energy/intensity for three different existing mass movements and moving to a conceptual definition of the various parameters needed in each case. The three case studies, located in the Northern Apennines in Central Italy, are a rotational earth slide (Ricasoli), a deep-seated rock slide (Monte Beni) and a rock fall (Sesto di Moriano). There, the parameters and methods to assess intensity have been investigated at hillslope scale. The Ricasoli rotational earth slide shows very small movement rates (in average some mm/year) which may increase during periods of intense rainfall to decrease again to average values afterwards. The prediction of kinetic energy should thence require the definition of the volume and the time evolution of velocities in probabilistic terms. In this case detailed information about the depth of the sliding surface has allowed the estimation of the volume and monitoring devices (mainly inclinometers) have provided a significant record of velocity evolution at different times. In general, however, in this kind of mass movement the range of velocity is very limited and the volume can be considered a proxy for the intensity itself in case monitoring data are not available. Thus, important elements for the definition of intensity are essentially volume and/or area plus eventually the spatial distribution of velocities. The Monte Beni rock slide is a fast and sudden movement.

The slide moves as a single mass. In this case empirical and numerical approaches have been used for predicting the failure character and timing and to investigate the definition of the kinetic energy. Here, the most important parameter is the velocity plot along the profile and even common approximate methods such as the slide model offer a suitable prediction of intensity once the mass volume is known. Finally, the rock fall analyzed shows, as expected, variable volumes and velocities. This requires the prediction of block volumes and velocities along different possible run-out paths in terms of expected frequency. Many different methods are available in the literature for carrying out such probabilistic simulations. Some of them have been used here to understand the spatial distribution of intensity probability at each point downslope of the source areas. In a following phase of the research, not yet completed, we will start from the preceding hillslope scale understanding of the governing parameters and attempt to propose and test simplified methods, based on readily available or easily measurable basic parameters, for the assessment of intensity at basin scale. For the moment we propose a very simple method for the estimation of landslide volume as a proxy for intensity in the case of basin-scale prediction of deep-seated slow-moving reactivated earth slides. We also present the basic statistics and first validation of such model applied to the Arno river basin which encompasses more than 25,000 earth slides.