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Landslide magnitude and temporal occurrence in the Ubaye Valley from the analysis of a multi-date inventory.

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Abstract:

Landslides are difficult to predict and create a lot of damages and deaths all over the world. Landslide inventory maps need to be prepared to document the extent of the phenomena in a region and evaluate its spatial and temporal occurrences. Statistics and size distributions of landslide events allow evaluating landslide hazard. A landslide inventory map records several categories of information, such as the landslide type, the evolution of the landslide boundaries, important geomorphological features within the landslide body and the evolution of the soil surface state. These parameters can be used to estimate the temporal and spatial displacement pattern over long periods in absence of instrument monitoring. It also allows defining frequency-magnitude relationships. Landslide frequency–area distributions allow quantitative comparisons of landslide distributions between landslide-prone regions and/or different time periods. They can reveal some correspondences between landslide sizes and their location. However, an error in mapping the boundary of a large landslide may affect significantly the measure of the size of the landslide, thus affecting the frequency-area statistics that can be obtained from event inventory maps. The contribution of remote sensing and multi-source data to the mapping and monitoring of mass movements may help to increase the accuracy of the inventories. Creating landslide inventory maps is not straightforward and requires experienced geomorphologists trained in the recognition and analysis of slope processes. It is therefore hampered by some uncertainties which need to be assessed, and those uncertainties are associated with the scale and characteristics of the source documents, the changing vegetation coverage, and the expertise of the scientist in charge of the analysis.

Located in the intra-alpine zone (South French Alps), the Ubaye Valley is highly affected by different types of landslides with various geomorphological features and displacement rates. Landslides in that area show a remarkable recurrence, they affect the allochtonous geological formation constituted by two nappes of flysches (Pelat and Autapie) and the autochthonous formation constituted by stratified black marls. Landslide detection and mapping is carried out through the evaluation of boundaries and spatial distribution of each landslide within the study area partitioned in three morphological units (North, South, East). The produced multi-date landslide inventory combine information from existing reports (RTM catalogues from 1850 to 2010), aerial orthophotographs (1956, 1972, 1984, 1995, 2000, 2004, 2009), geomorphological and geological maps (1975, 1989, 2001), a 5-m resolution hillshade DTM raster (2009), results of Differential InSAR using ALOS/PALSAR images (2007-2010) and field surveys (2012-2013). This multi-date landslide map portrays the distribution of the existing and past landslides and their observed changes over a period of 53 years. It distinguishes five types of slope movements (i.e. translational slide, rotational slide, rock-block-slide, mudslide or deep-seated gravitational deformation). Degree of activity (i.e. continuously active, permanently active, dormant, relict) is determined based on

observations of geomorphological features and variations in vegetation coverage. An accuracy indicator based on the visibility of the (re)activation is proposed according to the data set considered.

Statistics indicate that ca. 15% of the total area (272 km2) is affected by landslides in 1956 and ca. 17% in 2009. The number of landslides amounts to 744 events in 1956 and 853 events in 2009. Ca. 80% of these landslides are considered active with different types of evolution: with an extension upslope (retrogression), with an extension donwslope or laterally (enlargement), without any relevant surface change but with important changes in surficial features (secondary scarps, lobes, erosion, etc). All these types of activity are documented in the inventory and analysed in terms of return frequency. Landslide density maps are calculated and compared. Further, geometric and topographic variables (e.g. perimeter, area, difference in elevations, mean and maximum slope angle, …) are calculated for each landslide and used as a proxy of landslide intensity. The probability of occurrence within a certain period is linked to possible triggering factors recorded, as for example increase of intense and/or long rainfall events. The temporal frequency (or the recurrence) of landslide events can be established from multi-date inventory. The Poisson model is used to determine the probability of future landslides for the different number of years..