Landslide frequency-magnitude analysis to better define warning levels criteria in Sogn og Fjordane (Norway)

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The county of Sogn og Fjordane in western Norway has a climate and topography which makes it vulnerable for debris avalanches, debris flows and slush flows. The recently established landslide forecasting and warning service at Norwegian Water Resources and Energy Directorate (NVE), at www.varsom.no, is able to predict their regional spatial and temporal occurrence.

The landslide warning levels, which goes from 1 to 4, suggest an expected outcome pursuant to the upcoming hydro-meteorological event. These levels are defined based on the expected number of landslides that will occur in a warning area with an extension of 10.000-15.000 km2. The expected possible size of threatening landslides is also included within the definition of warning levels, in a qualitative and very general way. For example, an orange level 3 warning level will indicate that "Large landslides that disturb infrastructure and roads may occur". However, NVE has throughout the first 5 years of the operation observed that, depending of the region, not always only "large" landslides occur during this level, but many small landslides may occur causing severe damages and serious disruptions to the society.

The Norwegian landslide database is quite rich of landslide records registered through many years. However, the events do not contain landslide magnitude information. In this study, the following questions are addressed: How large are the rainfall-induced landslides in the county of Sogn og Fjordane, and which landslide magnitude is the most frequent in this region? How the landslide magnitude information can be included within the definition of the regional landslide warning levels?

The main objective of the study was to perform frequency-magnitude (FM) analysis and prepare FM curves for the selected region. To achieve this objective, a better landslide inventory was prepared, in which, each landslide record contains information of magnitude. All landslides that were triggered by rainfall and snow melting episodes in the period between 2011 and throughout 2017 (e.g. debris avalanches, debris flows, slush flows and soil slides) in Sogn og Fjordane were mapped and event-inventory maps were prepared. The landslide extension was mapped using a large variety of sources, like aerial photos and satellite images, field observations and other remote sensing techniques. In addition, the triggering meteorological conditions were analysed and evaluated the performance of the warning levels sent.

Finally, it was investigated how the landslide magnitude can be introduced as a criteria in the definition of warning levels and how this information can be communicated to the public and to the emergency authorities. This work is part of ongoing project that aims to map more systematically the magnitude of recent landslides events at national level, because a better understanding of these processes, their spatial distribution, dimensions, mechanisms and frequency is needed to improve the performance of the landslide forecasting and warning service, especially at local scale.