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Quantifying the seismogenic impact on mass movements in the Alps in terms of Arias Intensity

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Earthquakes are – amongst many others – one type of triggering factors for mass movements in mountainous regions such as landslides, deep-seated gravitational slides (DSGSD), rockfalls, mudflows, etc. Hence, the emerging hazard would require an area-wide assessment of seismogenic impact to better apprehend the interplay of different triggering factors contributing to mass movement activity. However, seismicity itself is difficult to assess for several reasons. On the one hand, there are various parameters describing ground motion, and not all of them are suitable for area-wide assessments due to their availability or complexity. On the other hand, phenomena such as attenuation and topographic amplification must be taken into account, especially when the region of interest is an orogen.

Considering the criteria mentioned above and aiming for a mapping approach ascribing one value of seismogenic impact to one geographic location, we developed a strategy based on two empirical laws approximating Arias Intensity: the first law estimates Arias Intensities for a particular location as a function of earthquake magnitudes and focal depths; the second law corrects these estimated Arias Intensities in relation to the height differences to the nearest channel beds. Finally, we sum all corrected Arias Intensities resulting from different earthquakes in one particular location. Values obtained in this last step do not represent a physical entity; nevertheless, they allow for quantitative assessment of seismic exposure with respect to a given earthquake dataset covering a specific time frame, also allowing for color coding and comparative mapping approaches in GIS for other factors triggering mass movements.

In our case study, we assess the seismic exposure of a set of several hundreds of landslides, DSGSD, and rockfalls located in a rectangular area in the Italian Central Alps. In a first step, the area was discretized using a quadratic grid with increments of 1 km in order to assign points of evaluation to the previously mapped polygons representing landslides, DSGSD, and rockfalls. Additionally, to each polygon, a centroid point was attributed to avoiding the loss of polygons smaller than 1x1 km. In a second step, we computed the seismic exposure in each point resulting from two earthquake datasets covering the Alps, including a 500 km wide buffer zone: instrumental earthquake data of the ISC Bulletin covering a period from 1900 to 2019; macro-seismic earthquake data of the SHARE European Earthquake Catalog covering a period from 1000 to 2006.

The study serves as a preliminary test for assessing wider areas across the Alps, which either

geologically or geographically belong together. We illustrate our mapping approach in a series of maps discussing the effects of the number of earthquakes, magnitudes, distances, topography, and time frame.