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Static and dynamic controls on slope instabilities: the interplay of litho-structural conditions and climate change in the Aosta Valley Region (Western Alps, Italy)

Marco Giardino (1,2,4), Sara Ratto (3), Mauro Palomba (1), and Walter Alberto (4)

(1) University of Torino, Earth Sciences, Torino, Italy (marco.giardino@unito.it, 011 6705146), (2) University of Torino, NatRisk, Torino, Italy , (3) Centro Funzionale Regione Autonoma Valle d'Aosta, (4) ImaGEO spin-off University of Torino, Torino, Italy

In recent years global climate change became a topic of great interest, causing debates either in the society and the scientific community. The effects of climate change are particularly evident in the alpine environment: glaciers retreat and permafrost degradation are taking place in last decades thus causing increased slope instability events on mountain slopes.

In this context, geomorphology may contribute significantly to the reconstruction of slope sensitivity under the forcing of climate fluctuations. Our research deals with the analysis of the controlling factors for slope instabilities in the Aosta Valley Region, aimed to a better comprehension of the "slope system" behaviour and to reconstruct possible future scenarios following climatic trends. The choice of the study area is mainly due to the considerable amount of available data, either at a regional or at the local scale. Distributions of climatic, geological and geomorphological variables have been derived from regional inventories, then compared to detailed analysis by field mapping and monitoring of single instability phenomena of different size, from large-slope instabilities to debris flows.

Results from our participation to the IFFI project in the Aosta Valley (5200 inventoried landslides, over 600 km2 of total affected area, 18% of the regional territory) were cross-examined with litho-structural and geomorphological data. A "Regional Geological Approach" (RGA) by GIS technologies allowed statistical analysis and interpretation of independent variables, offering a "static" conditioning to the slope system (e.g. landslides: "internal" causes, lowering shear strength). Geo-structural and litho-technical classes have been individualized, offering differential response to mountain slope dynamics, in term of frequency, magnitude, and mechanism of instabilities.

A "Local Morphodynamic Approach" (LMA) was applied for the study of characteristic landforms and processes of natural instabilities, based on the RGA classes. Selected case studies were mainly location relevant to risk analysis, due to the local availability of monitoring systems/metheorological stations and/or rich bibliographic data on historical/prehistorical events, hazard maps for municipality land planning restriction and drainage basin technical studies. LMA allowed control on conditioning dynamic factors of natural instabilities (e.g. landslides "external" causes, increasing shear stress). Different RGA classes proved different sensitivity to climatic trends of temperature and/or precipitation increase; moreover they showed a diversity of geomorphological responses to extreme meteo-hydrological events.

The original analysis of 220 single debris flows, compared to the existing scientific and technical literature, clearly showed the relationships existing between rainfall amount, intensity and duration of rainy period and the single or simultaneous activation of drainage basins by shallow slope instabilities. Since climate plays an important role in determining the nature and the intensity of geomorphological processes, the forewarned increase of frequency and intensity of extreme meteorological events in the Alps in the next decades could be the trigger of a larger number of debris flows and/or other shallow instabilities in the Aosta Valley.

Data collected in our research will be useful also to an improved environmental hazard assessment and management of landslides at a local and regional scale. The proposed classification map based on litho-thechnical properties of superficial deposits and bedrock is relevant to assessment of unstable debris potential and sensitivity of upper slopes to rock falls induced by permafost melting.