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Application of regional physically-based landslide early warning model: tuning of the input parameters and validation of the results

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The Aosta Valley region is located in North-West Alpine mountain chain. The geomorphology of the region is characterized by steep slopes, high climatic and altitude (ranging from 400 m a.s.l of Dora Baltea's river floodplain to 4810 m a.s.l. of Mont Blanc) variability. In the study area (zone B), located in Eastern part of Aosta Valley, heavy rainfall of about 800-900 mm per year is the main landslides trigger. These features lead to a high hydrogeological risk in all territory, as mass movements interest the 70% of the municipality areas (mainly shallow rapid landslides and rock falls).
An in-depth study of the geotechnical and hydrological properties of hillslopes controlling shallow landslides formation was conducted, with the aim to improve the reliability of deterministic model, named HIRESS (HIgh REsolution Stability Simulator). In particular, two campaigns of on site measurements and laboratory experiments were performed. The data obtained have been studied in order to assess the relationships existing among the different parameters and the bedrock lithology.
The analyzed soils in 12 survey points are mainly composed of sand and gravel, with highly variable contents of silt. The range of effective internal friction angle (from 25.6° to 34.3°) and effective cohesion (from 0 kPa to 9.3 kPa) measured and the median ks (10E-6 m/s) value are consistent with the average grain sizes (gravelly sand).
The data collected contributes to generate input map of parameters for HIRESS (static data). More static data are: volume weight, residual water content, porosity and grain size index. In order to improve the original formulation of the model, the contribution of the root cohesion has been also taken into account based on the vegetation map and literature values.
HIRESS is a physically based distributed slope stability simulator for analyzing shallow landslide triggering conditions in real time and in large areas using parallel computational techniques. The software runs in real-time by assimilating weather data and uses Monte Carlo simulation techniques to manage the geotechnical and hydrological input parameters. In this context, an assessment of the factors controlling the geotechnical and hydrological features is crucial in order to understand the occurrence of slope instability mechanisms and to provide reliable forecasting of the hydrogeological hazard occurrence, especially in relation to weather events.
In particular, the model and the soil characterization were applied in back analysis, in order to assess the reliability of the model through validation of the results with landslide events that occurred during the period.
The validation was performed on four past events of intense rainfall that have affected Valle d'Aosta region between 2008 and 2010 years triggering fast shallows landslides. The simulations show substantial improvement of the reliability of the results compared to the use of literature parameters. A statistical analysis of the HIRESSS outputs in terms of failure probability has been carried out in order to define reliable alert levels for regional landslide early warning systems.