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# Early Warning System for hydrogeological risk forecasting in mountain environments: The Rio Croso case study.

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The Italian peninsula has one of the highest hydrogeological risk levels in Europe, characterised by a geomorphologically varied and geologically complex territory. In particular, mountainous areas are characterized by fragile environments that are frequently affected by floods and instability.

The weather events that have struck our country in recent decades have often triggered/reactivated natural instability processes that have been particularly damaging in terms of structures and infrastructure. In mountainous and hilly areas, both muddy-debris flows and surface landslides are particularly widespread. The former is triggered within secondary basins, often fed by surface landslides, and are particularly evident on alluvial conoids, affecting population centers. There are many variables, both meteorological and territorial, that make forecasting these phenomena very difficult.

In view of the intensification of these severe weather events, it is important to set up an advanced hazard forecasting system in mountain locations that allows geological analyses to be integrated with atmospheric and hydrological modelling. In this context, the identification of areas susceptible to landslides cannot be performed using a conventional approach, since hydrological-hydraulic methods have a poor or poor calibration.

In response to the need of fast communication to make the Early Warning System more effective, allowing an immediate assessment of the risk and its spatial and temporal location, we propose the use of specially designed indices that, although deduced from the predicted physical fields, allow warning messages to be provided both on the basis of observed and predicted rainfall, and on the basis of the flow forecasts of the monitored rivers and their main tributaries.

We therefore propose a new approach, based on a forecasting chain that brings together geomorphological information, reliable high-resolution weather forecasts and hydrological models.

In this work, a pre-operational chain was set up, coupling off-line the high-resolution Weather Research and Forecasting (WRF) meteorological model and the Cetemps Hydrological Model (CHyM). Different stress indices were calculated useful to identify the debris flows of the Croso river and possible criticalities on the other river basins.