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Challenges for operational forecasting and early warning of rainfall induced landslides

Fausto Guzzetti

Consiglio Nazionale delle Ricerche, Istituto di Ricerca per la Protezione Idrogeologica, via della Madonna Alta 126, 06128 Perugia, Italy, email: F.Guzzetti@irpi.cnr.it

In many areas of the world, landslides occur every year, claiming lives and producing severe economic and environmental damage. Many of the landslides with human or economic consequences are the result of intense or prolonged rainfall. For this reason, in many areas the timely forecast of rainfall-induced landslides is of both scientific interest and social relevance. In the recent years, there has been a mounting interest and an increasing demand for operational landslide forecasting, and for associated landslide early warning systems. Despite the relevance of the problem, and the increasing interest and demand, only a few systems have been designed, and are currently operated. Inspection of the – limited – literature on operational landslide forecasting, and on the associated early warning systems, reveals that common criteria and standards for the design, the implementation, the operation, and the evaluation of the performances of the systems, are lacking. This limits the possibility to compare and to evaluate the systems critically, to identify their inherent strengths and weaknesses, and to improve the performance of the systems. Lack of common criteria and of established standards can also limit the credibility of the systems, and consequently their usefulness and potential practical impact.

Landslides are very diversified phenomena, and the information and the modelling tools used to attempt landslide forecasting vary largely, depending on the type and size of the landslides, the extent of the geographical area considered, the timeframe of the forecasts, and the scope of the predictions. Consequently, systems for landslide forecasting and early warning can be designed and implemented at several different geographical scales, from the local (site or slope specific) to the regional, or even national scale. The talk focuses on regional to national scale landslide forecasting systems, and specifically on operational systems based on empirical rainfall threshold models. Building on the experience gained in designing, implementing, and operating national and regional landslide forecasting systems in Italy, and on a preliminary review of the existing literature on regional landslide early warning systems, the talk discusses concepts, limitations and challenges inherent to the design of reliable forecasting and early warning systems for rainfall-triggered landslides, the evaluation of the performances of the systems, and on problems related to the use of the forecasts and the issuing of landslide warnings. Several of the typical elements of an operational landslide forecasting system are considered, including: (i) the rainfall and landslide information used to establish the threshold models, (ii) the methods and tools used to define the empirical rainfall thresholds, and their associated uncertainty, (iii) the quality (e.g., the temporal and spatial resolution) of the rainfall information used for operational forecasting, including rain gauge and radar measurements, satellite estimates, and quantitative weather forecasts, (iv) the ancillary information used to prepare the forecasts, including e.g., the terrain subdivisions and the landslide susceptibility zonations, (v) the criteria used to transform the forecasts into landslide warnings and the methods used to communicate the warnings, and (vi) the criteria and strategies adopted to evaluate the performances of the systems, and to define minimum or optimal performance levels.