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Landslides in Emilia-Romagna (Italy) from 2000 to 2006: rainfall thresholds and landslide prediction with the SIGMA model.

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SIGMA is an experimental warning system for predicting rainfall-induced landslide events over large areas. The method is based on rainfall thresholds derived from statistical analyses of historical series of landslides and rainfall.

Cumulated daily rainfall series are examined with windows of variable length (ranging from 1 to 365 days); due to their different and irregular distribution, the original values of cumulative rainfall are transformed to obtain the standard normal distribution, checking the fit with the original data. As a result, cumulative rainfall values, for each duration, are associated to probability values.

Combinations of probability curves related to standard deviation figures (1.5σ, 2σ and 3σ) are used as rainfall thresholds. The model indicates two landslide warning levels, linked to increasing probability curves, and considers variable lengths (from 1 to 365 days) of prior precipitation data to account for both shallow (quick response) and deep-seated (long-term response) movements.

The model has been developed for one of the most landslide prone areas of the Apennine chain: the Emilia-Romagna region (Italy). The region has been divided into 19 areas and, for each of them, specific rainfall thresholds have been defined, based on the analysis of historical data from 1951 to 2006. A single automatic rain gauge per area operates as actual rainfall data source, while meteorological forecasts provide data for landslide warning predictions.

The SIGMA model was tested on several cases that took place in Emilia-Romagna from 2000 to 2006. All the events were characterised by severe meteorological con-

ditions, consequent landsliding and involved large areas. In some cases precipitations triggered a great number of failures over a very wide area (November 2000, April 2005), in others (October 2002, March 2004, October 2005 and September 2006) phenomena were more limited. In any case the whole region was subjected to the test as all 19 investigated areas were interested by at least one landslide producing event.

Results of the back-analysis indicate a good agreement between model warnings and ground effects, with only a small number of false alarms. Predictions of catastrophic events are very accurate and in many cases an adequate warning of landslides is produced. Warnings related to residual risk are also provided by the model.

These results indicate that the SIGMA model can be employed in Emilia-Romagna as a trial warning system, in order to prevent and reduce landslide-related risks.