



## **Statistical approaches for the definition of landslide rainfall thresholds and their uncertainty using rain gauge and satellite data**

Mauro Rossi (1), Daniela Valigi (2), Dalia Kirschbaum (3), Maria Teresa Brunetti (1), Silvia Peruccacci (1), and Fausto Guzzetti (1)

(1) CNR IRPI, Perugia, Italy (mauro.rossi@irpi.cnr.it), (2) Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, Perugia, Italy, (3) NASA Goddard Space Flight Center, Hydrological Sciences Laboratory, Greenbelt, Unites States

Models for forecasting rainfall-induced landslides are mostly based on the identification of empirical rainfall thresholds obtained exploiting rain gauge data. Despite their increased availability, satellite rainfall estimates are scarcely used for this purpose. Satellite data should be useful in ungauged and remote areas, or should provide a significant spatial and temporal reference in gauged areas. In this paper, the analysis of the reliability of rainfall thresholds based on rainfall remote sensed and rain gauge data for the prediction of landslide occurrence is carried out. To date, the estimation of the uncertainty associated with the empirical rainfall thresholds is mostly based on a bootstrap resampling of the rainfall duration and the cumulated event rainfall pairs (D,E) characterizing rainfall events responsible for past failures. This estimation does not consider the measurement uncertainty associated with D and E. In the paper, we propose (i) a new automated procedure to reconstruct ED conditions responsible for the landslide triggering and their uncertainties, and (ii) three new methods to identify rainfall threshold for the possible landslide occurrence, exploiting rain gauge and satellite data. In particular, the proposed methods are based on Least Square (LS), Quantile Regression (QR) and Nonlinear Least Square (NLS) statistical approaches. We applied the new procedure and methods to define empirical rainfall thresholds and their associated uncertainties in the Umbria region (central Italy) using both rain-gauge measurements and satellite estimates. We finally validated the thresholds and tested the effectiveness of the different threshold definition methods with independent landslide information. The NLS method among the others performed better in calculating thresholds in the full range of rainfall durations. We found that the thresholds obtained from satellite data are lower than those obtained from rain gauge measurements. This is in agreement with the literature, where satellite rainfall data underestimate the “ground” rainfall registered by rain gauges.