

## **Regional rainfall thresholds for landslide occurrence using a centenary database**

Teresa Vaz, José Luís Zêzere, Susana Pereira, Sérgio Cruz Oliveira, and Ivânia Quaresma

Centre for Geographical Studies, Institute of Geography and Spatial Planning, Universidade de Lisboa, Lisbon, Portugal  
(tvaz@campus.ul.pt)

Rainfall is one of the most important triggering factors for landslides occurrence worldwide. The relation between rainfall and landslide occurrence is complex and some approaches have been focus on the rainfall thresholds identification, i.e. rainfall critical values that when exceeded can initiate landslide activity. In line with these approaches, this work proposes and validates rainfall thresholds for the Lisbon region (Portugal), using a centenary landslide database associated with a centenary daily rainfall database. The main objectives of the work are the following: i) to compute antecedent rainfall thresholds using linear and potential regression; ii) to define lower limit and upper limit rainfall thresholds; iii) to estimate the probability of critical rainfall conditions associated with landslide events; and iv) to assess the thresholds performance using receiver operating characteristic (ROC) metrics.

In this study we consider the DISASTER database, which lists landslides that caused fatalities, injuries, missing people, evacuated and homeless people occurred in Portugal from 1865 to 2010. The DISASTER database was carried out exploring several Portuguese daily and weekly newspapers. Using the same newspaper sources, the DISASTER database was recently updated to include also the landslides that did not caused any human damage, which were also considered for this study.

The daily rainfall data were collected at the Lisboa-Geofísico meteorological station. This station was selected considering the quality and completeness of the rainfall data, with records that started in 1864.

The methodology adopted included the computation, for each landslide event, of the cumulative antecedent rainfall for different durations (1 to 90 consecutive days). In a second step, for each combination of rainfall quantity-duration, the return period was estimated using the Gumbel probability distribution. The pair (quantity-duration) with the highest return period was considered as the critical rainfall combination responsible for triggering the landslide event. Only events whose critical rainfall combinations have a return period above 3 years were included. This criterion reduces the likelihood of been included events whose triggering factor was other than rainfall.

The rainfall quantity-duration threshold for the Lisbon region was firstly defined using the linear and potential regression. Considering that this threshold allow the existence of false negatives (i.e. events below the threshold) it was also identified the lower limit and upper limit rainfall thresholds. These limits were defined empirically by establishing the quantity-durations combinations bellow which no landslides were recorded (lower limit) and the quantity-durations combinations above which only landslides were recorded without any false positive occurrence (upper limit). The zone between the lower limit and upper limit rainfall thresholds was analysed using a probabilistic approach, defining the uncertainties of each rainfall critical conditions in the triggering of landslides. Finally, the performances of the thresholds obtained in this study were assessed using ROC metrics.

This work was supported by the project FORLAND – Hydrogeomorphologic risk in Portugal: driving forces and application for land use planning [grant number PTDC/ATPGEO/1660/2014] funded by the Portuguese Foundation for Science and Technology (FCT), Portugal. Sérgio Cruz Oliveira is a post-doc fellow of the FCT [grant number SFRH/BPD/85827/2012].