Geophysical Research Abstracts, Vol. 9, 03509, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03509


# Rainfall-triggered landslides occurred in the Lisbon Region in 2006: Validation of regional rainfall thresholds and relationships with the North Atlantic Oscillation

**J.L. Zêzere** (1), R. Trigo (2), S.C. Oliveira (1), R.A.C. Garcia (1), M. Fragoso (1)

(1) Geographical Research Centre, University of Lisbon, Portugal, (2) Geophysical Centre, University of Lisbon, Portugal

Landslides occurred in the region north of Lisbon during the last 50 years were induced by rainfall, and landslide activity has been confined to very wet periods. Previous results obtained using empirical relationships between rainfall intensity and slope instability show that critical rainfall conditions for failure are not the same for different types of landslides (Zêzere and Rodrigues, 2002). Shallow translational soil slips have been related to intense rainfall periods ranging from 1 to 15 days, while deep slope movements (translational slides, rotational slides and complex and composite slope movements) have been occurred in relation to longer periods of less intense rain, lasting from 30 to 90 days. The different time span is consistent with the distinct hydrological triggering conditions related to different types of landslides. Intense rainfall is responsible by the rapid growth of pore pressure and by the loss of the apparent cohesion of thin soils, resulting in failure within the soil material or at the contact with the underlying impermeable bedrock. Long duration less intense rainfall periods allow the steady rise of the groundwater table and the occurrence of deep failures by the reduction of shear strength of affected materials. In a recent work, daily precipitation data for the reference rain gauge of S. Julião do Tojal was used to derive a general trend relating rainfall amount and the rainfall critical duration for 19 landslide events registered between 1958 and 2001 (Trigo et al, 2005). The regression line is given by the equation Cr = 7.4D+107 where Cr is the cumulative rainfall in mm, and D is the duration in days. Furthermore, the distinction between landslide types concerning the number of days relevant to the antecedent rainfall was confirmed combining the

daily rainfall and the calibrated antecedent rainfall (CAR) that accounts for the decrease of the impact of a particular rainy event in time due to drainage processes. The best results for shallow landslide episodes are obtained with the combination between the daily rainfall and the 5 days CAR through the exponential rule Dr = 167.28e-0.0355CAR, where Dr is the daily rainfall. On the other hand, deep landslide events are better discriminated by a combined threshold of daily rainfall = 16 mm and 30 days CAR = 85 mm (Zêzere et al., 2005). Recently, three new rainfall-triggered landslide events occurred in the Lisbon region, namely in March, October and November 2006. In this communication we characterize these landslide events and we discuss the rainfall conditions that were responsible for their trigger. Additionally, these new landslide events are critically compared with the established regional regression models respecting rainfall intensity/duration, in order to validate critical rainfall thresholds. Landslide events occurred in March and October 2006 include shallow translational slides and few debris flows, and the corresponding absolute antecedent rainfall is above the threshold for durations ranging from 5 to 15 days. These events also fit the combined threshold of daily and 5 days CAR values. The landslide event occurred in late November 2006 includes some rotational slides with deeper slip surfaces, when compared with slope movements dating from March and October. Moreover, the corresponding absolute antecedent rainfall is above the rainfall threshold for the period of 40 days. Finally, we analyse the role played by the North Atlantic Oscillation (NAO) during those months marked by landslide activity in order to establish possible relationships between this important pattern of atmospheric circulation variability in the Northern Hemisphere and regional slope instability events. It is shown that the NAO index was consistently negative between October 2005 and March 2006, and again characterised by negative values between August and October 2006.

References:

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