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Empirical estimates of precipitation conditions for landslide triggering in France and Norway

José Mauricio Cepeda (1), Jean-Philippe Malet (2), and Alexandre Remaître (2)

(1) International Centre for Geohazards (ICG) / Norwegian Geotechnical Institute (NGI), Oslo, Norway (jose.cepeda@ngi.no, +47 22230448), (2) National Center for Scientific Research (CNRS), School and Observatory of Earth Sciences (EOST), Institut de Physique du Globe de Strasbourg (IPGS), Strasbourg, France (jeanphilippe.malet@eost.u-strasbg.fr, a.remaitre@unistra.fr / +33 (0) 368850125)

The characterisation of precipitation conditions for triggering of landslides is a key component in the design and implementation of early-warning systems and in the estimation of hazard maps for current and future climate scenarios. Physical modelling of those triggering conditions may be usually feasible for individual slopes, but not for local or regional scales, where practical difficulties generally arise due to the lack of estimates of spatially distributed hydraulic and mechanical parameters, and to complexities of ground conditions on susceptible slopes. In those situations, where the implementation of a physical model is not feasible, the preferred approach is to formulate empirical relationships between measurements of precipitation and occurrence of slope movements. This paper presents 3 different empirical models applied to 3 datasets of slope movements from France and Norway. This contribution presents some of the experiences of Work Package 1.3 "Statistical studies for precipitation-induced landslides" as part of the SafeLand project funded by the 7th Framework Programme of the European Commission.

The implemented empirical models were: antecedent precipitation, intensity-duration, and a recently introduced intensity-antecedent precipitation-duration form. The models were optimised using classification trees and discriminant analyses. The datasets of mass movements included inventories of events as well as hourly or daily observations of precipitation. The types of events in the inventories were predominantly soil slides and debris flows, and a few rock slides and rock falls. The locations of the datasets were: the Barcelonnette basin (France), the Norangselva catchment (Norway), and the Nedre-Romerike area in south-eastern Norway.

The results indicate that the occurrence of soil slides and debris flows can be predicted using precipitation observations. On the other hand, models fail to predict rock falls and rock slides, presumably due to the predominant influence of other triggering factors (e.g., wedging of vegetation, influence of freeze-thaw cycles on fractures, seismic activity). Soil slides are controlled by antecedent precipitation ranging between 7 and 46 days. On the other hand, debris flows are controlled by instant precipitation characterised by triggering durations of less than 10 hours. In this case, real-time monitoring is required for a successful implementation in practice. Two main challenges were identified for a reliable calibration of thresholds: inventories should be complete in order to identify at least the time and location of initiation, as well as the type of landslide according to international conventions; and the selection of locations for rain gauges should ensure that the monitored values are representative of precipitation conditions in initiation areas. Finally, this contribution presents a simple but innovative procedure to incorporate the uncertainty in the time of occurrence into the estimation of thresholds. This procedure is applied to the dataset from Nedre Romerike.