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# Landslides induced by seismic events: An overview in France and Europe.

Gilles Grandjean<sup>1</sup>, Rosalie Vandromme<sup>1</sup>, Séverine Bernardie<sup>1</sup>, Olivier Sedan<sup>2</sup> and \*Myriam Belvaux<sup>1</sup>

<sup>1</sup>Risks and Prevention Division, BRGM, Orléans, France

<sup>2</sup>Water, Environment & Ecotechnologies Division, BRGM, Orléans, France

\*Corresponding author: m.belvaux@brgm.fr

Landslide hazard assessment is the estimation of a target area where landslides of a particular type, volume, run out and intensity may occur within a given period. The first step to analyze landslide hazard consists in assessing the spatial and temporal failure probability (when the information is available, i.e. susceptibility assessment). Two types of approach are generally recommended to achieve this goal: qualitative (i.e. inventory-based methods and knowledge data driven methods) and quantitative (i.e. data-driven methods or deterministic physically-based methods).

To take into account heterogeneity of the materials, spatial variation of physical parameters, and landslides typology, BRGM, the French Geological Survey) has developed a physically-based model (PBM) implemented in a GIS environment. This PBM couples a global hydrological model (GARDENIA®) including a transient unsaturated/saturated hydrological component with a physically-based model computing the stability of slopes (ALICE®, Assessment of Landslides Induced by Climatic Events) based on the Morgenstern-Price method for any slip surface. The variability of mechanical parameters is handled by the Monte Carlo method.

During the last years, the model has been applied at different scales for different geomorphological environments: (i) at regional scale (1:50,000-1:25,000) in the French West Indies and in the French Polynesian islands, (ii) at local scale (1:10,000) for two geologically complex mountainous areas, (iii) at the site-specific scale (1:2,000). In each study, the 3D geotechnical model has been adapted. The different studies have allowed: (i) to discuss the different factors included in the model especially the initial 3D geotechnical models; (ii) to precise the location of probable failure following different hydrological scenarii; and (iii) to test the effects of climatic change and land-use on slopes for two cases. For example, the model has been applied to understand the behaviour of a large landslide in the Reunion Island, where the extreme climatic conditions produce large deformations within the active landslide.

Finally, it is shown that it is possible to obtain reliable information about future slope failures at different scales for different scenarii with an integrated approach. The final information about landslide susceptibility (i.e. probability of failure) can be integrated in landslide hazard assessment and is an essential information source for future land-use planning.

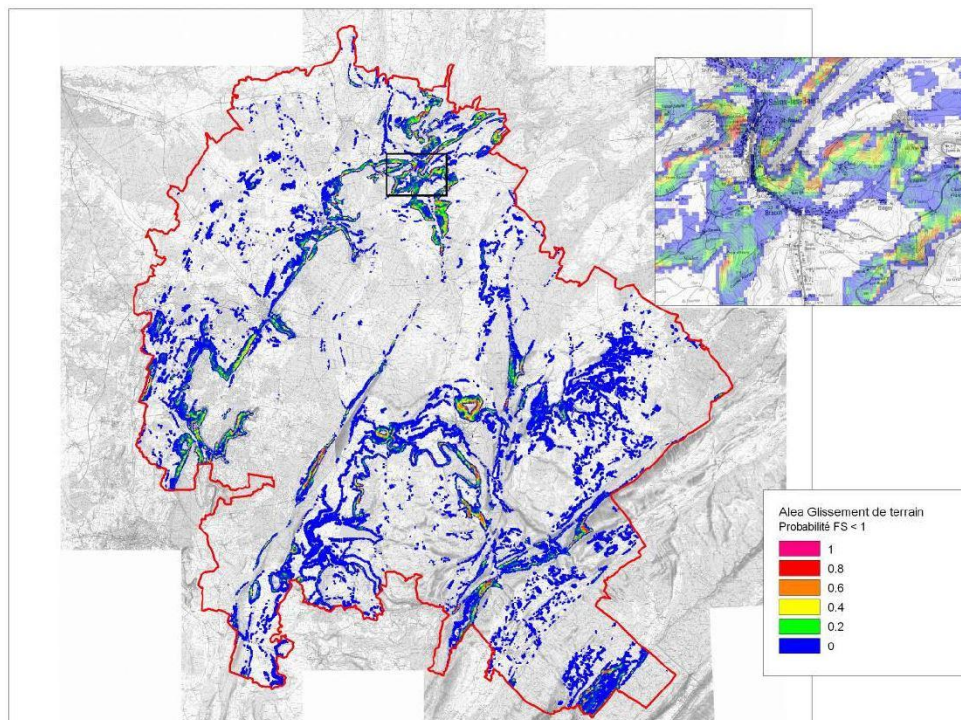


Fig. 1, Landslides hazard map for Jura department, France (from BRGM/RP-59065-FR)