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Contribution of Heliborne Electro-Magnetic survey for landslide prediction: application to La Martinique (West Indies, France)

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Landslide hazard and risk assessment (LHA & LRA) in French West Indies is a big challenge, because of several factors contributing to high sensitivity of slopes to landslide (complex weathered volcanic grounds, hurricane seasons, heavy land pressure).The initial step is to assess the spatial probability (and sometimes temporal) of failure (i.e. landslide susceptibility assessment; LSA) for a given area. LSA can be evaluated by several approaches (i.e. knowledge approach, data-driven approach, physically based approach). Physically based approaches are used to calculate a slope stability factor taking into account mechanical, geotechnical, hydrological and hydrogeological parameters.

However, the parametrization of these models can be difficult because of a lack of information (i.e. soil depths, precipitations chronicles, lithology sometimes due to a difficult ground access, particularly in French Indies. Thus, HEM (Heliborne Electro-Magnetic Survey) appears as a solution to obtain specific information quickly and over large areas. Since 2000, the HEM method is increasingly used for environmental studies: geomorphological and hydrogeological studies. In 2013, The French Geological Survey conducted an HEM survey over La Martinique (West Indies). Resistivity contrasts were imaged up 250-300 meters depth with a horizontal resolution around 30 m and a vertical resolution between 3 and 8 m. Even if the resistivity has not a straightforward relationship with soil mechanical properties (which are key parameters for LHA) it provides relevant information on both the thickness and the extension of formations.

The aim of this study is to evaluate the contribution of HEM survey to recognize landslide prone areas and landslide prone formations in volcanic environment. Once the different formations defined, they are introduced in a physically based model to assess the susceptibility of slope for different landslide types with hydrogeological control. The methodology is split in four steps:

i. In the first step, the analysis of the HEM data to assess location and thicknesses of lithological and surficial formations is performed by comparisons and correlations with field data and drilling;

ii. In the second step, given the numerous geotechnical parameters required (i.e. cohesion,angle of friction, specific bulk unit weight), a sensitivity analysis on representative cross sections is conducted to obtain the best set of geotechnical parameters adapted to the sites;

iii. In the third step, a geological model, integrating surficial formation and lithology obtained after the first step, is built;

iv. In the fourth step, the geological model is integrated in a physically based model called ALICE® (Assessment of Landslides Induced by Climatic Events) to assess and to map the landslide susceptibility of slopes for selected areas. Different simulations, integrating different type of failures (translational and rotational), different resolutions (i.e. 5m, 10 m, 25 m) and the variation of the ground water table, are performed.

For each step, statistical and expert evaluation (by calculation of success rates, exchanges between field observations, boreholes and geomorphological features) are conducted allowing the models validation. Finally, this approach is a first step, though it shows promising results in assessing and forecasting landslide hazard by integration of precipitation thresholds, the contributions and weaknesses of the method are discussed, as well as proposals to improve the latters.