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# Sensitivity analysis for rainfall-induced landslide models

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## Résumé

Landslide is the mass movement of soil and rocks down slopes. Landslides are geological processes that occur when a slope becomes unstable. Natural and anthropogenic activities can cause mechanical imbalance in which shear stress exceeds shear strength and initiates landslides (1). Intense rainfall events are one of the main causes of slope instability. In particular, rainfall infiltration increases water saturation and body load on soil, which locally increases the shear stress, and can also negatively affect shear strength (2).

As a result of climate change, rainfall-induced landslides (RILS) are becoming frequent. This naturally occurring geologic hazard is unavoidable in the context of climate change. But, it is possible to reduce potential serious risks by developing warning systems via modeling. Modeling RILS requires integrating a hydro-mechanical model with landslide susceptibility indicators (3). The hydromechanical processes can be described with the Richards and local equilibrium equations (3). The Mohr-Coulomb failure criterion-based local factor of safety (LFS) concept helps to calculate and visualize slope stability as a landslide susceptibility indicator (4).

Model input parameters can be uncertain because they are gathered by calibration with observations with limited data. These uncertainties can go through the model and affect the outputs. The influence of uncertainty on model outputs can result in unreliable predictions. For this reason, an uncertainty analysis (UA) should be performed for predictions on RILS. However, UA is not an easy task because it demands dealing with several challenges such as model nonlinearities, high CPU time, high dimensionality of the model, relevant metrics, and verifications. The main aim of this work is to suggest an appropriate strategy for UA of RILS.

We developed an advanced COMSOL® model to deal with nonlinearities and to optimize the computational cost for data generation, required for UA. Implementation of sensitivity analysis (SA) is a fundamental aspect of solving high-dimensionality obstacles. We suggest an appropriate SA that consists of 2 main steps: the first step is applying the screening technique (ST), and the second is implementing a global sensitivity analysis (GSA). ST uses folded Plackett–Burman (PB) screening design to eliminate insignificant parameters. The second step is GSA. It helps in ranking the remaining major parameters by order of importance. In this study, GSA relies on the surrogate model-based polynomial chaos expansion (PCE) technique. PCE technique computes polynomial coefficients that allow the forward

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evaluation of the Sobol indices. In turn, Sobol indices characterize the importance of parameters by ranking them. According to the results of our study case, the Poisson ratio is the most impacting parameter on the output. The area of the failure zone is a relevant metric (output) and helps to decipher relations with input parameters in an efficient way. Analytical expressions of LFS, in simple cases where it can be obtained, match very well the results of our study, which validates our approach.

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