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How sensitive are debris flow modeling results to the choice of rheological parameters?

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Over the past decades, many numerical models have been developed to understand, simulate and predict debris flow processes. Typically, these models simplify the complex interactions between water and solids using a single phase approach and different rheological models to represent flow resistance. Further, different rheological models have different sets of uncertain parameters that need to be specified to simulate debris flow. In this study, we perform a sensitivity analysis for a debris flow numerical model (FLO-2D) to identify the most sensitive parameters for a suite of relevant simulated variables (i.e. run-out distance, maximum flow velocity, minimum flow velocity, deposit depth). We use the Distributed Evaluation of Local Sensitivity Analysis (DELSA) method, which is a hybrid local-global technique.

Specifically, we analyze the debris flow event occurred in northern Chile on March 25, 2015. We include two different ravine types: (i) La Mesilla ravine, characterized by a big alluvial fan where considerable sedimentation occurs, and (ii) Acerillas ravine, characterized by a marked narrow channel with almost none alluvial fan, where sediments are mainly transported to the river. We apply the DELSA method for the above ravines, considering eight FLO-2D parameters used to estimate the friction factor. We also examine the influence of topography and grid cell size on parameter sensitivities. Our results show that volumetric concentration and beta2 - a parameter related to yield stress - are the most sensitive parameters, regardless of the target variable. Additionally, different parameter sensitivities are obtained for each debris flow variable (i.e. flow velocity, flow height, deposited area, run-out, etc.).