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Shallow landslide occurrence and propagation in tropical mountainous terrain with open source models. A case study in the Colombian Andes.

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Colombia is located in a tropical environment with mostly warm and humid climatic conditions and complex mountainous terrain, where landslides triggered by intense rainfall are very common. Therefore, determining the occurrence and propagation of these events is of great interest in risk management and territorial planning programs.

Landslide propagation is difficult to predict due to uncertainties of rheological properties as well as initiation and dynamics of rock or sediment mobilization. In Colombia, methodologies and models for landslide propagation have been less addressed than those corresponding to the occurrence, even though the consequences on people and infrastructure are generally are strongly related to travel distances and impact areas. Most propagation models are based on empirical methods to establish the travel distance of the sliding material, employing geometric approximations or geomorphological interpretation. In the last decades, physically based dynamic landslide propagation models have been proposed. These models use digital elevation models in combination with flow parameters. Their application represents a complex task because of the difficulty in constraining – depending on the model – sometimes the large number of relevant flow parameters.

In this study, we apply two open source models that work as extensions to the GRASS GIS software: (i) the *r.slope.stability* model for slope stability assessment using a limit equilibrium model for different sliding surface geometries, together with a probabilistic analysis applied to a range of geotechnical parameters (cohesion, internal friction); and (ii) *r.avaflow* for landslide propagation, which employs a multi-phase model considering solids and fluids. The models are implemented in the catchment area known as La Arenosa (9.9 km^2), located in the municipality of San Carlos (Antioquia, Colombia). On September 21, 1990, an event of rainfall of short duration and high intensity precipitated on La Arenosa catchment. approx. 200 mm of precipitation fell within the study area in less than 3 hours, triggering approx. 700 landslides many of which have converted into hillslope debris flows. The zones categorized with a high probability of failure through *r.slope.stability* are defined as source areas and propagated down with *r.avaflow*. The

results are evaluated against the landslide inventory in order to evaluate the potential of the proposed model combination for predictive simulations.