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Enhancing the completeness of statistical landslide susceptibility modeling by integration of release and propagation zones

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Statistical landslide susceptibility models have been satisfactorily fulfilling the aim of predicting where future slides might happen, or more specifically, be initiated. By aiming to answer where landslides are likely to be initiated, those models mostly build upon mapped landslide release zones to create spatial predictions. The potential downslope propagation zones are usually neglected. This is a substantial limitation with regard to their applicability in the context of risk assessment in areas characterized by steep slopes. In fact, slide-type movements often evolve into flow-like movements, traveling long distances and thereby impacting also moderate and even nearly flat slopes. At this point, the integration of modeling approaches able to predict downslope landslide routes can contribute to enhance the completeness of the model.

This study aims to explore the added value of combining statistical modeling of landslide release areas with a data-driven runout model for a 54 km² catchment in the Nova Friburgo area in southern Brazil. In January 2011, a severe rainfall event in that mountainous region triggered numerous landslides, some of them evolving into hillslope debris flows affecting downslope areas. The hundreds of slides mapped after this event are here used as reference data.

The methodology consists of three steps: (a) the creation of multiple statistical landslide release susceptibility models; (b) back-analyzing the probability density functions of the angle of reach and travel distance, derived from the observed runout zones with the r.randomwalk model; (c) integration of the best performing release susceptibility model with r.randomwalk, computing the propensity of downslope regions to be affected, based on the release susceptibility and the probability density functions derived in (b).

Despite the appropriateness of purely statistical models for predicting future slide release zones, these models indeed overlook downslope propagations. The combined model, in its turn, not only succeeds in informing where landslides would initiate, but also about their downslope impact areas. The difference between the models is even more evident when analyzing how both models would predict the susceptibility for settled areas. While the release susceptibility model assigns more than 60% of this area to the low and very low susceptibility classes, the combined model predicts that actually less than 30% of this area would be assigned to the same classes. In a region where thousands of people are living, this difference might inform a large number of people and

key infrastructure prone to be landslide affected. This greatly enhances the potential of landslide susceptibility models to be applied for hazard and risk management purposes also in those areas where landslides develop into hillslope debris flows.