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Slope unit size matters - why should the areal extent of slope units be considered in data-driven landslide susceptibility models?

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Grid cells (GC) and slope units (SU) are the most common mapping units in landslide susceptibility modeling. SU-based models have recently gained popularity in the field because of the availability of user-friendly software and certain advantages over GC approaches. For example, SUs are often described as more geomorphologically meaningful, less sensitive to positionally inaccurate landslide data and more flexible in representing specific variables (e.g., binary vs. count responses). In contrast to GCs, SU sizes can vary considerably within a study area. Spatially varying mapping unit sizes may be accompanied by a spatially varying likelihood of a SU being affected by a landslide. We assume that larger SUs are more likely to be labeled as "landslide-affected" than smaller SUs, which are just as susceptible to landslides simply because of their larger spatial extent. In other words, the larger the area of investigation, the more likely a landslide can be found. This may have relevant effects on subsequent landslide susceptibility models, especially if certain predictor variables correlate with SU sizes.

To our knowledge, the effects of different SU sizes on landslide susceptibility models have rarely been investigated, and no approaches to explicitly consider SU size have yet been presented. In this contribution, we use Generalized Additive Mixed Models (GAMM) to confront four different strategies for dealing with spatially varying SU sizes in landslide susceptibility modeling. The analyses focus on the provided SU-based dataset related to a part of the Umbria region in Central Italy (~4,100 km²). In the first strategy, all predisposing factors, including those directly related to SU size (i.e., SU area and distance/SU area), are used for model fitting and spatial prediction. The second strategy builds upon strategy 1, but it does not consider the size of the SUs for model fitting and spatial prediction. The third strategy demonstrates the ability of SU size to discriminate SUs with landslides from those without landslides and consists of a single-variable model with the area of the SUs as its only predictor. Then, in the fourth strategy, all predictors are used for model fitting, but the effect of SU size is averaged out from the spatial prediction (i.e., the size effect is not predicted into space, but its potentially confounding effect is isolated during the model fitting).

The first tests support the assumption that larger SUs are more likely labeled as landslide-affected SUs and that associated confounding effects should be considered in landslide susceptibility modeling. We present the four strategies in terms of modeled relationships, relative variable importance, spatial prediction pattern and quantitative validation results.