Review of:

“**Brief communication: Visualizing uncertainties in landslide susceptibility modeling using bivariate mapping**”, Matthias Schlögl, Anita Graser , Raphael Spiekermann , Jasmin Lampert , and Stefan Steger. Natural Hazards and Earth System Sciences (NHESS), https://doi.org/10.5194/nhess-2024-213

1. **Related to susceptibility mapping of landslides**

This paper deals with a method for visualizing landslide susceptibility and associated uncertainty through bivariate mapping (randon forest modeling of landslide susceptibility and associated uncertainty, and bivariate mapping).

The model used (random forest) results in the mapping of susceptibility (means) and uncertainty (standard deviations), the combination of which (bivariate mapping) is the subject of this paper.

Landslide susceptibility modeling is based on the “randon forest” method (p. 3 of the article: 2.1 Landslide susceptibility modeling). The implementation of “randon forest” is preceded by the collection, selection and the classification of events (1973 events). What period/years do these events cover?

These events served as target variable (i.e., training labels): in the matrix used by the model (observations in rows and variables in columns), each event is represented by which parameters / characteristics: probability of occurrence, magnitude, damage, etc.?

It would be interesting to indicate the main determinants: elevation, slope, precipitation… (independent variables: Variation Inflation Factor VIF?) selected and the method used to select them (regression coefficient: Ordinary Least Square or other?) with regard to the dependent variable studied (landslide events).

“A more detailed description of the modeling approach as well as an in-depth discussion focusing on statistical performance and geomorphic plausibility is provided in Schlögl et al. (2024)[1]”:

Finally, I propose to better describe both the study site (its dimensions: how many km in length and width, number of pixels in rows and columns, etc.) and the method for modeling landslide susceptibility, this method is apparently considered by another paper (Schlögl et al., 2024) but which is currently being evaluated. The aim is to show that the two maps (susceptibility and uncertainty) are based on a method that is both (statistically) validated and (methodologically) reproducible.

[1] Schlögl, M., Spiekermann, R., and Steger, S.: Towards a holistic assessment of landslide susceptibility models: Insights from the Central Eastern Alps, Environmental Earth Sciences, (Under review), 2024.

The landslide hazard is probably linked to other natural hazards (precipitation, freezing and thawing periods, etc.). Can't we talk about a landslide triggered by other hazards (multi-hazard)? Perhaps we're probably getting off the topic of this paper (Schlögl et al., 2024?).

Uncertainty can be taken into account at different stages/steps:

** when calculating susceptibility (if possible), resulting in only a single dataset (instead of two datasets: means and standard deviations) by "random forest" itself?

** in post-processing (if possible), by crossing the two datasets (means and standard deviations: like the coefficient of variation)?

** or by bivariate mapping, as proposed in the article (e.g. crossing the two rasters: Raster 1 of Susceptibility * Raster 2 of Uncertainty)

2. **Related to mapping of susceptibility and uncertainty**

"We advocate that bivariate mapping is a straightforward yet sound and effective way to communicate landslide susceptibility and the associated uncertainty."

How can we show/verify that the bivariate map is more effective in conveying the message than the two initial maps of susceptibility and uncertainty?

It's a question of visual perception and cognitive understanding of the final map by end-users (elected representatives, citizens, tourists), in order to confirm that the final map is more effective (or not).

When we consider 3 susceptibility classes and 3 uncertainty classes (3 x 3), we obtain 9 classes or 9 color gradations (bivariate map). If we go to 4 x 4, we'll have 16 color gradations, which makes reading the bivariate map even more & more complex...

Secondly, the use of the visual variable color (which can be aesthetic and attractive) certainly brings us closer to human visual perception, which is immediately colorful (and in 3D), but what mental realities do the color used represent of the landscape / site? Is it interesting to represent uncertainty in blue gradation color (high level of uncertainty in blue)?

The paper can try to present / propose a second color combinations.

As future development, the definitive choice of color used (gradation in one color for each of susceptibility and uncertainty) can be determined / confirmed ALSO with the help of end-users (students, researchers, laypersons, decision makers).

The 3D block diagrams in the appendices help to understand the results (visual link between the two variables: slope and high landslide susceptibility-uncertainty).

Is the scale of variation of susceptibility (between 0 and 1) different (or not) from that of uncertainty (standard deviations)? It is the determination of the limits considered for the creation of the 3 classes in both cases that raises the question here in terms of scales of variation of susceptibility and uncertainty. Has uncertainty been standardized?

Finally, here are references related to mapping aspect:

[Bertin 1977] Bertin J. (1977). La graphique et le traitement graphique de l'information, Flammarion, Paris, 277 p.

[Bertin 1983] Bertin J., (1983) *Semiology of Graphics: Diagrams, Networks, Maps.* University of Wisconsin Press, (first published in French in 1967, translated to English by Berg W.J. in 1983)

[Board 1972)] Board C. (1972). Cartographic communication. Cartographica: The International Journal for Geographic Information and Geovisualization, vol. 18, n°2, p. 42-78.

[Brewer 2003] Brewer C. A, Hatchard G. W, Harrower M. A, (2003) ColorBrewer in print: a catalog of color schemes for maps. Cartography and Geographic Information Science. 30(1). 5–32. www.ColorBrewer.org

[Buard et al. 2007] Buard E., Ruas A. Evaluation of colour contrasts by means of expert knowledge for on demand mapping, *Actes de la conférence de cartographie internationale ICA 2007*, Moscou.

[Fuchs 2009] Fuchs S., (2009). Evaluating cartographic design in flood risk mapping. Environmental Hazards, vol. 8, p. 52-70.

[Hegarty et al. 2009] Hegarty M. et al. (2009). Naïve cartography: how intuition about display configuration can hurt performance, Cartographica, vol. 44, n° 3,p. 171-186.

[Meyer et al. 2012] Meyer V., Kuhlicke, C., Luther, J., Fuchs, S., Priest, S., Dorner, W., Serrhini, K., Pardoe, J., McCarthy, S., Seidel, J., Palka, G., Unnerstall, H., Viavattene, C., & Scheuer, S. (2012), Recommendations for the user-specific enhancement of flood maps, Natural Hazards Earth System. Science, vol. 12, n° 5, p. 1701–1716.

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