Geophysical Research Abstracts
Vol. 16, EGU2014-6457, 2014
EGU General Assembly 2014

GIS-based modelling of deep-seated slope stability in complex geology

Martin Mergili (1), Ivan Marchesini (2), Barbara Schneider-Muntau (3), Mauro Cardinali (2), Federica Fiorucci (2), Daniela Valigi (4), Michele Santangelo (2,4), Francesco Bucci (2), and Fausto Guzzetti (2)

(1) BOKU University Vienna, Institute of Applied Geology, Vienna, Austria (martin.mergili@boku.ac.at), (2) CNR-IRPI, Perugia, Italy, (3) Division of Geotechnical and Tunnel Engineering, University of Innsbruck, Austria, (4) Department of Geosciences, University of Perugia, Italy

We use the model r.slope.stability to explore the chances and challenges of physically-based modelling of deep-seated slope stability in complex geology over broad areas and not on individual slopes. The model is developed as a C and python-based raster module within the GRASS GIS software. It makes use of a modification of the three-dimensional sliding surface model proposed by Hovland (1977) and revised and extended by Xie and co-workers (2006). Given a digital elevation model and a set of thematic layers (lithological classes and related geotechnical parameters), the model evaluates the slope stability for a large number of randomly selected potential slip surfaces, ellipsoidal in shape. The bottoms of soil or bedrock layers can also be considered as potential slip surfaces by truncating the ellipsoids. Any single raster cell may be intersected by multiple sliding surfaces, each associated with a computed safety factor. For each pixel, the lowest value of the safety factor and the depth of the associated slip surface are stored. This information can be used to obtain a spatial overview of the potentially unstable regions in the study area.

The r.slope.stability model can be executed both in a soil class-based mode, where the input data are mainly structured according to horizontally defined soil classes, and in a layer-based mode, where the data are structured according to a potentially large number of layers. Here, we test the model for the layer-based mode, allowing for the analysis of relatively complex geologic structures.

We test the model in the Collazzone area, Umbria, central Italy, which is susceptible to landslides of different types. According to field observations in this area, morpho-structural settings (i.e. the orientation and dip of the geological layers) play a crucial role for the distribution of the deep-seated landslides. We have prepared a lithological model based on aerial photointerpretation, field survey and surface information on the strike and dip directions of each layer. We have further investigated the geotechnical parameters (cohesion and internal friction angle) associated to the layers using direct shear tests.

We execute r.slope.stability for various assumptions of the geotechnical parameters, ellipsoid geometry and seepage direction. In this way, we obtain the spatial probability of slope failures which is validated using a pre-existing landslide inventory map, using an ROC plot. Acknowledging the challenges related to the high natural variability of geotechnical parameters in space, the results satisfactorily reproduce the observed distribution of deep-seated landslides in the study area. The assumed direction of seepage (slope-parallel vs. layer-parallel) strongly influences the model results.