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Modelling-mapping slope deposits depth and uncertainty assessment by means of machine learning approaches

Emanuele Trefolini (1), Leonardo Disperati (1,2), Vincenzo Vacca (1), Enrico D'Addario (1), Elisa Mammoliti (1,3), Michele Papasidero (1), and Federico Viti (1)

(1) Department of Physics, Earth and Environmental Science, University of Siena, Siena, Italy (emanuele.trefolini@unisi.it), (2) Institute of Geosciences and Earth Resources (IGG - CNR), Pisa, Italy, (3) Earth Science Department, University of Pisa, Pisa, Italy

Shallow landslides triggered by heavy rainfall are a common natural phenomenon in mountain areas. Climate changes and increasing urban pressure make this phenomenon a widespread source of natural hazard. For this reason, the interest of scientific community concerning the development of robust shallow landslide susceptibility/hazard assessment methods for wide areas (regional scale) has steadily increased in the last decades. Many methods are available to achieve this goal, however, researchers are generally focused on statistics (data driven) or physically-based methods. For both approaches, the depth of Slope Deposits (SD: the surficial soil involved by landsliding which covers the bedrock) is an important parameter in order to perform accurate analysis. Furthermore, the SD depth is required for many physically-based models available in the literature. Nevertheless, this information is generally unknown at map scale, which affects uncertainty and reliability of susceptibility/hazard assessments.
In this context, this work is focused on obtaining predictive SD depth maps for wide areas by means of geostatistics methods suitable to consider variability and uncertainty of the input/output data.
The study area is located in Northern Tuscany where, in the last years, we developed research projects on engineering geology characterization of SD. Hence, a large dataset of SD depth obtained by field survey (more than 1,000 oobservations) is used in this work. Many geo-environmental variables such as: geology, land use, morphometric variables, are considered in the analysis. Morphometric variables (eg. flow accumulation, slope and hillslope curvature) are derived from a digital elevation model with cell size of 10 m. Two different machine learning techniques are used to map SD depth: clustering and artificial neural networks. The supervised clustering analysis is performed with probabilistic and fuzzy algorithms. For the unsupervised clustering, the results of various maps obtained by integrating different sets of input variables are spatially combined (data fusion) in order to obtain a single map. The analysis performed with artificial neural networks has been implemented by a feed-forward multi-layer neural network. In order to exploit the field measurement dataset, also the effect of samples geographic neighbourhood were considered.
The results show the feasibility of the methods for regional scale mapping. Moreover the results are discussed and analyzed in order to identify best solutions to evaluate and represent the SD depth uncertainty.