A 3-D probabilistic stability model incorporating the variability of root reinforcement

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Process-oriented models of hillslope stability have a great potentiality to improve spatially-distributed landslides hazard analyses. At the same time, they may have severe limitations and among them the variability and uncertainty of the parameters play a key role. In this context, the application of a probabilistic approach through Monte Carlo techniques can be the right practice to deal with the variability of each input parameter by considering a proper probability distribution.

In forested areas an additional point must be taken into account: the reinforcement due to roots permeating the soil and its variability and uncertainty. While the probability distributions of geotechnical and hydrological parameters have been widely investigated, little is known concerning the variability and the spatial heterogeneity of root reinforcement. Moreover, there are still many difficulties in measuring and in evaluating such a variable.

In our study we aim to: i) implement a robust procedure to evaluate the variability of root reinforcement as a probabilistic distribution, according to the stand characteristics of forests, such as the trees density, the average diameter at breast height, the minimum distance among trees, and (ii) combine a multidimensional process-oriented model with a Monte Carlo Simulation technique, to obtain a probability distribution of the Factor of Safety.

The proposed approach has been applied to a small Alpine area, mainly covered by a coniferous forest and characterized by steep slopes and a high landslide hazard.

The obtained results show a good reliability of the model according to the landslide inventory map.

At the end, our findings contribute to improve the reliability of landslide hazard mapping in forested areas and help forests managers to evaluate different management scenarios.