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Short and long term probabilistic slope stability analyses of a large area of unsaturated pyroclastic soils

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The analysis of slope stability over large areas is a demanding task for several reasons, such as the need for extensive datasets, the uncertainty of collected data, the difficulty of accounting for site-specific factors, and the considerable computation time required due to the size of investigated areas, which can pose major barriers, particularly in civil protection contexts where rapid analysis and forecasts are essential. However, as the identification of zones of higher failure probability is very useful for stakeholders and decision-makers, the scientific community has attempted to improve capabilities to provide physically based assessments. This study combined a transient seepage analysis of an unsaturated-saturated condition with an infinite slope stability model and probabilistic analysis through the use of a high-computing capacity parallelized platform. Both short- and long-term analyses were performed for a study area, and roles of evapotranspiration, vegetation interception, and the root increment of soil strength were considered. A model was first calibrated based on hourly rainfall data recorded over a 4-day event (December 14–17, 1999) causing destructive landslides to compare the results of model simulations to actual landslide events. Then, the calibrated model was applied for a long-term simulation where daily rainfall data recorded over a 4-year period (January 1, 2005–December 31, 2008) were considered to study the behavior of the area in response to a long period of rainfall. The calibration shows that the model can correctly identify higher failure probability within the time range of the observed landslides as well as the extents and locations of zones computed as the most prone ones. The long-term analysis allowed for the identification of a number of days when the slope factor of safety was lower than 1.2 over a significant number of cells. In all of these cases, zones approaching slope instability were concentrated in specific sectors and catchments of the study area. In addition, some subbasins were found to be the most recurrently prone to possible slope instability. Interestingly, the application of the adopted methodology provided clear indications of both weekly and seasonal fluctuations of overall slope stability conditions.