Geophysical Research Abstracts
Vol. 21, EGU2019-5306, 2019
EGU General Assembly 2019

Shallow landslide hazard assessment using a particle finite element model with emphasis on landslide evolution. The case of the 2013 Cà Mengoni, Northern Apennines, Italy, landslide

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Numerical modelling is a powerful tool to study the mechanism of landslides and constructs the foundation of many physically based hazard assessment models applied to natural hazards. Usually, numerical analyses of landslides are carried out on the failure mechanism and on the propagation process separately. With the advantage of dealing with large deformation problems, the particle finite element method (PFEM), which is the particle extension of the traditional finite element method, has the capability of simulating the entire evolution of the landslide from the generation to the deposition phase. To figure out the difference between a unified PFEM simulation (dynamic analysis) and the usually adopted approaches that separate failure mechanism (static analysis) and run-out analysis (dynamic analysis), the 2013 Cà Mengoni shallow landslide, Northern Apennines, Italy, is chosen as a case study to implement our approach. The present numerical technique is first employed by using the shear strength reduction method for the slip surface identification (static analysis) and then, basing on the results of such analysis, it is used for landslide run-out computations. In a further step, we use the unified PFEM approach to simulate the landslide evolution with different strength parameters. According to the back-analysis of the run-out distance using the unified PFEM simulation, the material strength parameters found in landslide propagation result to be lower than the values obtained through the static analysis, which indicates the existence of a material weakening process during the landslide evolution. The present model can be implemented in landslide hazard assessment models, since it can be further enhanced with various physical factors (i.e. seismic loads and rainfall effects) due to the flexibility of the finite element approach.