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Monitoring internal deformation of unstable cohesionless slopes: insights from DEM modeling

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Most of previous studies on landslides focus on surface displacements using field data and monitoring techniques and/or progressive propagation of a failure surface using numerical modeling. However, few studies focus on the mode and style of internal deformation of a sliding mass during landslides. In this study, unstable cohesionless slope models with three different internal friction angles (θ=19°, 30° and 35°) were simulated with particle flow modeling. We mainly monitored and quantified the internal deformation of the sliding mass, investigated the characteristics of displacement within the sliding mass and analyzed the topography change of the slope surface during landslides. In addition, the effect of internal friction on the deformation of the sliding mass was studied. Model results show the following features related to a sliding mass:

(1) The sliding mass glides downwards in a wavy pattern with a distinctive velocity heterogeneity both in time and in space which results in a wavy displacement contour lines. Model results show that the mass slides faster and further in the model with lower internal friction and the sliding area (volume in 3D) increases with decreasing the internal friction. (2) The slope surface topography changes from a straight line in the undeformed stage to several slopes with slope breaks which become steeper towards the toe of the sliding mass. The slope angle at the bottom indicates more or less the internal friction angle of the sliding material. However, the slope surface remains as a straight line in the models with very low internal friction (θ=19°). (3) Dilatation occurs within the sliding mass due to the increase of porosity during the movement of the sliding mass. Volumetric strain grows larger in the model with higher internal friction. (4) The sliding mass deforms internally and heterogeneously. The distribution of extension axes shows a wavy flow similar to the velocity vector fields. Generally, in all models, strain magnitude increased from the failure surface to slope surface. However, strain becomes larger at the location where the extensional orientation changes.