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A two-layer numerical model for simulating the frontal plowing effect of flow-like landslides

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Many flow-like landslides entrain material from their paths during motion. At the flow front and along the lateral margins the sliding mass can plow into the path material pushing or entraining the existing soil. Although plowing can be a dominant mechanism for landslide mobility, a mathematical description is still lacking and little attention has been paid to this phenomenon compared to other entraining mechanism such as basal scouring. In this paper, a two-layer finite difference model is proposed to simulate the frontal plowing. The frontal erodible mass and the sliding mass are simplified as two separated layers based on the assumption that they are immiscible in their propagation processes. The interaction (i.e. thrusting and shear) between the two layers is simulated by the normal force and shear force acting on the two-layer interface. The governing equations for the two-layer model are deduced from the mass and momentum conservation of a soil column and transformed into a finite difference form for numerical solving. Then the proposed model is tested in the back analysis of a typical loess flow-like landslide: the Ximiaodian landslide at the south bank of the Jing River, China. The simulated results show that the frontal plowing effect has significant influence on the propagation of this landslide, especially on the final topography of the deposit. Without considering this effect, the thickness of the final deposit tends to be underestimated, while the propagation duration, area and distance are likely to be overestimated. The proposed model can provide more accurate and reliable simulations for rapid flow-like landslides with frontal plowing effects.
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