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Three-dimensional modelling of Uttarakhand slides using smoothed particle hydrodynamics (SPH)

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On 7 February 2021, a massive flood occurred in the river Dhauliganga that damaged two hydroelectric stations, five bridges and trapped 100 to 150 casualties who are feared dead. Some evidence has been indicated that caused by a landslide, an avalanche, or a portion of the Nanda Devi glacier that broke off early in Uttarakhand's Joshimath area Chamoli district. The magnitude of the flood caused by the collapse was so large that it far exceeds the collapse itself. Two potential explanations were proposed to explain: the frictional heating of the avalanche may result in high temperatures in the sliding face, which is sufficient for ice and frozen sediments melting to occur in the path. The high-water content generated debris flows that enhanced the mobility of flowing. Another explanation is that it could be related to a glacial lake outburst flood or a temporary lake that eventually broke through its debris dam and poured down the valley. In any case, the collapse materials hold very high moisture content and fast mobility. In this study, a three-dimensional Smoothed Particle Hydrodynamics (SPH) method is adopted to model the flow-like Uttarakhand slides and to explore the physical processes during this event. The SPH is an adaptive, mesh-free, Lagrangian method that simulates free surfaces, moving interfaces, and large flow deformations. A non-Newtonian debris flow model, the Bingham rheological relationship, was incorporated into the SPH framework to describe source materials' characteristics. Besides, the whole flow processes of the flow-like Uttarakhand slides across the 3D terrain are represented. The time history of the velocity, acceleration, and forces were obtained from modelling to analyze the landslide dynamics.