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Forecasting granular flow on steep terrains after interacting with an array of obstacles

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Natural disasters such as landslides dominated by granular material may cause catastrophic consequences. Therefore, the protection of human-made facilities in mountainous areas is of great significance. An effective protective measure is to install an array of obstacles upstream of the structure that needs to be protected. We need to numerically simulate the interaction between granular flow and obstacle array, and forecast the flow path and stacking position of granular flow after interacting with an array of obstacles. The constitutive behavior and structure-interaction mode of granular material differs substantially from water flow-dominated hazards (e.g., floods). We have developed a depth-averaged model that can accurately simulate the interaction between granular flow and obstacles. Numerical simulations were performed for the case of granular flow facing a large number of different obstacles arrays to produce a dynamical process of granular flow and the depth changes of fixed detection points. We obtain different obstacles arrays by changing, including but not limited to, the type, geometric size of the obstacles, and row spacing of the arrays. We found that obstacles play roles of dissipation, deflection and hindrance, on the granular flow. For some types of obstacles, such as tetrahedron, the previous two mechanisms are dominant. Our research results show that the existence of obstacle arrays can indeed protect specific areas downstream. Furthermore, we can achieve better protection effects by changing the parameters of the array. These research results help us better forecast the result of the interaction between granular flow and an array of obstacles in space, and provide guidance for the structural design and assessment for hazard mitigation in mountainous regions. These findings advance the understanding of flow structures of fast granular flow facing obstacles, which provides guidance for structural design and assessment for hazard mitigation in mountainous.