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Effects of volcano profile on dilute pyroclastic density currents: Numerical simulations

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Explosive activity and lava dome collapse at stratovolcanoes can lead to pyroclastic density currents (PDCs; mixtures of volcanic gas, air, and volcanic particles) that produce complex deposits and pose a hazard to surrounding populations. Two-dimensional numerical simulations of dilute PDCs (characterized by a turbulent suspended load and deposition through a bed load) are carried out with the Euler-Lagrange approach of multiphase physics. The fluid phase is modeled as a dusty gas (1.88 kg/m3 dense), and the solid phase is modeled as discrete particles (1 mm, 5 mm, and 10 mm; 1500 kg/m3 dense and irregularly-shaped), which are two-way coupled to the gas, i.e. they affect the fluid turbulence. The initial PDC, which enters a volcano domain 5 km long and 1.9 km high, has the following characteristics: thickness of 200 m, velocity of 20 m/s, temperature of 573 K, turbulence of 5 %, and sediment concentration of 3 % by volume. The actual physics of flow boundary zone is simulated at the PDC base, by monitoring the sediment flux toward the substrate, which acts through the flow boundary zone, and the grain-size distribution. Also, the PDC velocity and dynamic pressure are calculated. The simulations show that PDC transport, deposition, and hazard potential are sensitive to the shape of the volcano slope (profile) down which they flow. In particular, three generic volcano profiles, straight, concave-upward, and convex-upward are focused on. Dilute PDCs that flow down a constant slope gradually decelerate over the simulated run-out distance (5 km in the horizontal direction) due to a combination of sedimentation, which reduces the density of the PDC, and mixing with the atmosphere. However, dilute PDCs down a concave-upward slope accelerate high on the volcano flanks and have less sedimentation until they begin to decelerate over the shallow lower slopes. A convex-upward slope causes dilute PDCs to lose relatively more of their pyroclast load on the upper slopes of a volcano, and although they accelerate as they reach the lower, steeper slopes, the acceleration is reduced because of the upstream loss of pyroclasts (lower density contrast with the atmosphere). The dynamic pressure, a measure of the damage that can be caused by PDCs, reflects these complex relations. Details are found in Valentine et al. (2011).

Reference

Valentine G.A., Doronzo D.M., Dellino P., de Tullio M.D. (2011), Effects of volcano profile on dilute pyroclastic density currents: Numerical simulations, Geology, 39, 947-950.