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Three-dimensional numerical simulations of a pyroclastic surge over natural terrain

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I will talk about three-dimensional numerical simulations of a pyroclastic surge affected by topography. Example calculations on a pyroclastic surge triggered by the collapse of a lava dome as occurred at Mt. Unzen in 1990-1995 will be presented. The calculations were performed with the numerical model that is a straightforward extension of the two-dimensional model developed by Ishimine (J. Volcanol. Geotherm. Res. 2005, Vol. 139, pp33-57). The numerical model is based on the Navier-Stokes equations for time-dependent flows of a single-phase compressible fluid. This formulation implies that pyroclastic surges consist of a dilute suspension in which solid particles (hot fragments of lava) and the surrounding gases are homogeneously mixed owing to vigorous turbulence. The equation of state for the gas-particle mixture is chosen so as to appropriately evaluate the density increase due to the load of solid particles as well as the density decrease due to the thermal expansion of the ambient air mixed into a pyroclastic surge. CIP method, which is a high-accuracy upwind differencing scheme, and C-CUP method, a kind of pressure-based solver, are used in the numerical model. The effect of subgrid turbulent mixing is evaluated by adopting the Smagorinsky model. Natural terrain is described with a digital elevation model. I calculated flows generated by the instantaneous release of a gas-particle mixture whose density is initially larger than the ambient air density. The behavior of calculated flows agreed fairly well with actual pyroclastic surges observed during the eruptions at Mt. Unzen. The released fluid spread toward the foot of the mountain along the topography at the initial stage. As time progressed, buoyancy forces were generated by the thermal expansion of mixed air and a mushroom-shaped plume rose above the horizontally spreading current.