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Session 1: Geophysical fluid dynamics I - Volcanoes

Flow transformation in explosive volcanic eruptions: Multiphase and multiscale interactions in pyroclastic density currents

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Explosive volcanic eruptions produce turbulent, multiphase flows that encompass a vast range of scales from micron-scale ash to eruptive plumes that can extend 100s of kilometers. Abrupt flow transformation (e.g. from dense to dilute pyroclastic density currents) can arise due to the energy exchange across multiple length scales and phases. Understanding these emergent phenomena is predicated on describing the phase-relative motion of many particle sizes and the multiphase transport physics of the transition from dilute to dense flows. I will discuss the use of multiphase models in addressing these different scales of fluid motion as well as how they can provide a platform to integrate microphysical, analogue experiments and observational constraints. Microphysical experiments can provide the necessary closure for statistical mechanics based models, and provide a way to examine grain-scale processes in a probabilistic manner. Such small-scale processes can dramatically alter the flow dynamics. For example, steam explosions associated with pyroclastic density currents entering the sea at Montserrat can be produced if energy exchange at the scale of the smallest particles is considered, while only considering large scale heat transfer results in passive steam production. Propagation of pyroclastic density currents and plume dispersal is also strongly controlled by the grain size distribution of particles, which can evolve as a result of both comminution and aggregation processes occurring at the grain scale. Scaled analogue experiments can provide insight into emergent flow dynamics such as secondary plumes in pyroclastic density currents, and can be compared in detail with direct numerical simulations of these turbulent phenomena. Multiphase modeling also provides a means of linking granulometry in deposits to grain size sorting by dynamic structures and flow transformations from dense to dilute flows. In particular I will focus on flow transformation related to particle-fluid thermal energy exchange, particle-boundary energy exchange and resuspension, and abrupt flow transformation due to comminution, breaks in slope and topographic barriers. Each process will be discussed in the context of a natural example using the Kos Plateau Tuff eruption, eruption of Mount St. Helens in 1980, the dome-collapse eruptions at Montserrat, and the boiling-over eruption of Tungurahua in 2006 as end-members.