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Interactions between small scale processes and large scale dynamics in pyroclastic density currents (Robert Wilhelm Bunsen Medal Lecture)

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Explosive volcanic eruptions produce turbulent, multiphase flows that encompass a vastrange of scales, from micron-scale ash to plumes and density currents that extend for hundreds of kilometers. One of key challenges in understanding these flows is reconciling the role of microphysical processes that occur at the scale of individual particles with the macroscopic and collective dynamics in plumes and pyroclastic flows. Of particular interest is understanding large-scale emergent dynamics that arise from the mass, momentum and energy exchanges at small scales.

To account for processes that occur at scales smaller in space and time than those resolved in simulations of large scale dynamics (typically meters, and fractions of a second) we have developed subgrid scales models based on laboratory experiments. We perform the experiments with natural volcanic particles at conditions similar to those that exist in real flows. We identify multiphase dimension less groups that are important formass, momentum and energy transfer and show how subgrid scale processes can be included into a multiphase, continuum equations describing large scale dynamics.

We illustrate this approach and the importance of sub grid models with three examples: the role of steam generation at the particle-scale when pyroclastic flows enter the ocean, the generation of ash-size particles through particle interactions within conduits and pyroclastic flows, and the role of boundary conditions. All three examples illustrate the two-way coupling that occurs between large scale dynamics and micro-scale phenomena.