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Convective Instabilities in Volcanic Plumes

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Convective instabilities driven by particle sedimentation have been frequently observed during volcanic eruptions and may play an important role in tephra fallout but are not described in most models for tephra dispersal. Convective instabilities occur in density stratified fluids and are characterised by the formation of fingers. With the settling of particles, a thickening interface layer becomes gravitationally unstable and instabilities could start to develop. Experiments were conducted to parameterize the influence of settling fingers inside and below buoyant plumes. Experiments were carried out in a Plexiglas tank where a removable and flexible PET sheet is placed to separate two different layers of fluid and ensure an initially sharp interface. The upper part consists in a lighter suspension of water and particles; the lower part is filled with a denser sugar solution. Experiments consisted in removing the separation and analyzing the formation of fingers. Each experiment was filmed by a HD camera. A process of calibration was carried out to correlate the different grey levels of a film image to different levels of concentration. Experiments were made with unmixed or continuously mixed upper layer. Existing models of particle sedimentation in presence of convective instabilities were applied and compared with experimental data: one considering a quiescent upper layer, and another one considering a turbulent upper layer [Hoyal et al, 1999]. Results show that fingers do not influence the sedimentation in the upper layer but strongly affect the sedimentation in the lower layer. The model that considers a turbulent upper layer better fits both mixed and unmixed experiments, interpreted as if fingers changed the incoming flux into the lower layer and acted as an intermediate turbulent layer. These experimental and theoretical observations challenge the traditional view of tephra sedimentation, since deposit thinning must be affected by fingers developing at the base of spreading of volcanic currents and frequently observed especially associated with bent-over plumes (e.g., Eyjafjallajokull 2010 eruption).