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Modeling transport and aggregation of volcanic ash particles

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A complete description of ash aggregation processes in volcanic clouds is an very arduous task and the full coupling of ash transport and ash aggregation models is still computationally prohibitive. A large fraction of fine ash injected in the atmosphere during explosive eruptions aggregate because of complex interactions of surface liquid layers, electrostatic forces, and differences in settling velocities. The formation of aggregates of size and density different from those of the primary particles dramatically changes the sedimentation dynamics and results in lower atmospheric residence times of ash particles and in the formation of secondary maxima of tephra deposit. Volcanic ash transport models should include a full aggregation model accounting for all particle class interaction. However this approach would require prohibitive computational times. Here we present a simplified model for wet aggregation that accounts for both atmospheric and volcanic water transport. The aggregation model assumes a fractal relationship for the number of primary particles in aggregates, average efficiencies factors, and collision frequency functions accounting for Brownian motion, laminar and turbulent fluid shear, and differential settling velocity. We implemented the aggregation model in the WRF+FALL3D coupled modelling system and applied it to different eruptions where aggregation has been recognized to play an important role, such as the August and September 1992 Crater Peak eruptions and the 1980 Mt St Helens eruption. Moreover, understanding aggregation processes in volcanic clouds will contribute to mitigate the risks related with volcanic ash transport and sedimentation.