Smoluchowski kernels for dry particle aggregation: Cellular Automata and experimental investigations

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Particle aggregation is considered as a key process that may affect dispersal and sedimentation of volcanic ash, with significant implications for the associated hazards. Smoluchowski coagulation equation is commonly used to describe the expected time evolution of the size distribution of ash particles that can collide and stick together. This approach is based on the use of theoretical kernels that come from the theory of diffusion and turbulent motion of charged and uncharged particles. We propose a wind-tunnel experiment to estimate Smoluchowski kernels and compare the results with numerical simulations. We focused mainly on dry ash aggregation dominated by electrostatic charges. Particles are suspended in a vertical wind tunnel for a period of time sufficient to create collisions and to produce consequential electrostatic charging by friction. Temperature and humidity are parameters that can affect the results so are kept under control in the device during the experiments. Using a high-speed camera and a dedicated Particle Tracking Velocimetry software is then possible to monitor the change of the initial mass distribution in time due to aggregation. Knowing the time evolution of aggregates gives us the opportunity to estimate empirically the kernels of the Smoluchowski coagulation equations and to make some comparisons with the theoretical kernels for a pure dry phenomenon dominated by electrostatic forces. Moreover it is possible to have a first validation of the use of Smoluchowski coagulation equations with a real laboratory experiment. The experimental kernels were integrated within a dedicated cellular automata model for ash sedimentation. This study represents a first step to merge theoretical and experimental studies of particle aggregation.