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Ash aggregation in volcanic plumes: the role of water

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The importance of liquid and solid water in volcanic aggregation processes has been demonstrated in several experimental and field investigations. After theoretical studies have suggested to describe wet aggregation adopting Ennis model, which is commonly used to describe industrial granulation processes, analogue experiments have successfully proven its suitability to qualitatively describe volcanic aggregation. However, a quantitative description of volcanic wet aggregation processes has not yet been achieved due to the difficulty in estimating the thickness of the water layer that forms around volcanic particles. This parameter, which determines the threshold relative velocity below which particles can aggregate, depends on the relative humidity in subsaturated environments, and on the amount of collected water droplets in saturated environments. Both conditions were considered in this study, where we used plume modelling and cloud microphysics to estimate the thickness of water layers forming around volcanic particles within the convective plume, inside the volcanic cloud and in the free atmosphere. We have performed Lagrangian simulations of particles of different sizes, for two eruptive scenarios characterized by different eruption parameters and meteorological conditions (Eyjafjallajökull, 2010 and Mount St. Helens, 1980) to track the temporal and spatial evolution of water layers around volcanic particles. This information was used to compute the critical sticking velocity as a function of particle size and particle location. Comparing the sticking velocity with the collision velocity, independently estimated, we could quantify the range of particle sizes that each particle can potentially scavenge at each location. Besides providing a quantitative method to predict volcanic particle aggregation in wet conditions, this study shows how the grain size distribution of aggregates can shed some light on their history, and, in particular, on the regions in which they have formed (vertical plume, horizontal cloud, atmosphere).