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Simulating the effects of semivolatile aerosol species on cloud formation and lifecycle

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The effect of aerosol has been acknowledged to cause a significant uncertainty in estimating the anthropogenic aerosol effect on climate. Research efforts on the formation and growth of atmospheric particles to sizes where they become cloud condensation nuclei have been extensive. In comparison, much less attention is given on cloud processing of particles and aerosol removal through wet deposition. However, aerosol removal processes largely dictate how well aerosol is transported from source regions. This means that in order to model the global distribution aerosol, both in vertical and horizontal, wet deposition processes have to be properly modelled. However, in large scale models, the description of wet removal and the vertical redistribution of aerosol by cloud processes is very limited.

Here we present a novel aerosol-cloud model SALSA, where the aerosol properties are tracked though cloud processes including: cloud droplet activation, precipitation formation, ice nucleation, melting, and evaporation. It is a sectional model that includes separate size sections for non-activated aerosol, cloud droplets, precipitation droplets, and ice crystals. The aerosol-cloud model was coupled to a large eddy model UCLALES which simulates the boundary-layer dynamics. In this study, the model has been applied in studying the wet removal as well as interactions between clouds and semi-volatile compounds, ammonia and nitric acid. These compounds are special in the sense that they co-condense together with water during cloud activation and have been suggested to form droplets that can be considered cloud-droplet-like already in subsaturated conditions. In our model, we calculate the kinetic partitioning of ammonia and sulfate thus explicitly taking into account the effect of ammonia and nitric acid in the cloud formation. Our simulations indicate that especially in polluted conditions, these compounds significantly affect the properties of cloud droplets thus significantly affecting the lifecycle of aerosol.