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Model investigation into rain enhancement by hygroscopic seeding in mixed-phase convective clouds

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Intentional release of large hygroscopic particles in a cloud, i.e. cloud seeding, is potentially capable of increasing rain formation. In this work, we focus on convective clouds of moderate intensity observed over the United Arab Emirates, where we use a large eddy simulator coupled with detailed bin aerosol-cloud microphysics module (UCLALES-SALSA) to study the processes controlling the seeding efficacy. Despite numerous field experiments, the conditions that favor efficient seeding induced rain enhancement are not well characterized. Models such as UCLALES-SALSA provide the means to study the microphysical effects in varying ambient conditions in a controlled setting. The clouds targeted by our simulations have a mixed-phase component and rain is primarily produced by the cold precipitation process. The results show that the fast growing droplets formed by the relatively large hygroscopic seeding aerosol affect the riming process in the mixed-phase region inside the clouds. The collision rate between the hydrometeors in the mixed-phase region is enhanced, producing larger frozen particles. Consequently, the ice tends to get more heavily rimed, as indicated by the fraction of rimed ice from the total ice mass, which promotes increased particle fall velocities.

However, the impact of seeding on the riming process depends on the state of the cloud and its environment. In conditions already favoring high rime fraction, often associated with relatively strong surface precipitation events, the effect of seeding is hindered, at least in terms of relative difference. Nevertheless, even if the effect of seeding on the total precipitation yield is small, it may still affect the timing of the precipitation onset, a topic currently under investigation. Work is also in progress to characterize the dependence between ambient conditions (in terms of aerosol and the thermodynamic properties of the atmospheric column) and the susceptibility of the mixed-phase clouds to seeding injection.