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Demystifying fog microphysics: A high-resolution Large-Eddy Simulation study with coupled particle based microphysics

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Forecasting fog is still a challenging task in numerical weather prediction (NWP).
The relevant physical processes for the life cycle of radiation fog are influenced by a multitude of physical processes, like radiative cooling/heating, turbulent mixing, and microphysics, which all interact on different scales. In particular, microphysical processes are highly parameterized in NWP models and respective parameterizations are usually not designed especially for fog layers. However, an improved fog prediction is an essential task for safety reasons in transport as well as for economic needs.

In this talk we present results from a three dimensional Large-Eddy Simulation study of radiation fog with an embedded Lagrangian cloud model (LCM) that allows resolving all microphysical processes relevant for fog by first principles instead of parameterizing them. By simulating several hundred million fog droplets as Lagrangian particles explicitly this approach include a size-resolved activation and diffusional growth representation, and on-demand a state of the art collision and coalescence process.
Since it is impossible to simulate a realistic number concentration for a whole fog layer by individual particles the LCM is based on the so-called superdroplet method, in which one simulated particle (superdroplet) represents a large number of real droplets or aerosols.
With this method, activation and diffusional growth of fog droplets, which are key processes for fog were investigated in more detail. The ratio of activated and unactivated (but maybe swollen) cloud condensation nuclei was determined for different aerosol environments which is typically overestimated in bulk-approaches. The number of activated fog droplets have a significant feedback to optical properties of the fog layer as well as to the sedimentation process, as it shown with our simulations.