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Development of a cloud microphysical model and parameterizations to describe the effect of CCN on warm cloud

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Abstract. First, a hybrid cloud microphysical model was developed that incorporates both Lagrangian and Eulerian frameworks to study quantitatively the effect of cloud condensation nuclei (CCN) on the precipitation of warm clouds. A parcel model and a grid model comprise the cloud model. The condensation growth of CCN in each parcel is estimated in a Lagrangian framework. Changes in cloud droplet size distribution arising from condensation and coalescence are calculated on grid points using a two-moment bin method in a semi-Lagrangian framework. Sedimentation and advection are estimated in the Eulerian framework between grid points. Results from the cloud model show that an increase in the number of CCN affects both the amount and the area of precipitation. Additionally, results from the hybrid microphysical model and Kessler's parameterization were compared. Second, new parameterizations were developed that estimate the number and size distribution of cloud droplets given the updraft velocity and the number of CCN. The parameterizations were derived from the results of numerous numerical experiments that used the cloud microphysical parcel model. The input information of CCN for these parameterizations is only several values of CCN spectrum (they are given by CCN counter for example). It is more convenient than conventional parameterizations those need values concerned with CCN spectrum, C and k in the equation of $N=CS^k$, or, breadth, total number and median radius, for example. The new parameterizations' predictions of initial cloud droplet size distribution for the bin method were verified by using the aforesaid hybrid microphysical model. The newly developed parameterizations will save computing time, and can effectively approximate components of cloud microphysics in a non-hydrostatic cloud model. The parameterizations are useful not only in the bin method in the regional cloud-resolving model but also both for a two-moment bulk microphysical model and for a global model. The effects of sea salt, sulfate, and organic carbon particles were also studied with these parameterizations and global model.

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