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Sensitivity of aerosol-cloud-precipitation interactions to autoconversion parameterization in WRF model

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Autoconversion process is an important bridge between aerosols, clouds, and precipitation, in that the change of the cloud microphysical properties by aerosols could influence the spatial and temporal changes of the surface precipitation, as well as the total precipitation amount. Three types of autoconversion parameterization are considered in our study including the Kessler scheme (Kessler, 1969), the KK scheme (Khairoutdinov and Kogan, 2000), and the Dispersion scheme (Liu et al., 2005). The Kessler scheme doesn't consider aerosol indirect effect and the KK scheme can study the aerosol indirect effect; while the Dispersion scheme can both consider the aerosol indirect effect and the influence of cloud droplet spectral dispersion.

In this study, the aerosol effects on clouds and precipitation in mesoscale convective systems are investigated using the Weather Research and Forecast model (WRF) with the Morrison two-moment bulk microphysics scheme. Considering the different types of the autoconversion parameterization schemes including the Kessler scheme, the KK scheme, and the Dispersion scheme, a suite of sensitivity experiments are performed using an initial sounding data of the deep convective cloud system on 31 March 2005 in Beijing under different aerosol concentrations (varying from 50 cm-3 to 10000 cm-3). Numerical experiments in this study show that the aerosol induced precipitation change is strongly dependent on the autoconversion parameterization. For the Kessler scheme, the average cumulative precipitation is enhanced slightly with increasing aerosols. In the meantime, precipitation is reduced significantly with increasing aerosols for the KK scheme. The surface precipitation varies nonmonotonically for the Dispersion scheme, increasing with aerosols at lower concentration, while decreasing at higher concentration. These distinct trends in aerosol-induced precipitation are mainly due to the rain water content change under the different autoconversion parameterization schemes.

Hence, our results suggest that accurate parameterization of cloud microphysical processes, especially the autoconversion process is very important to improve the understanding of aerosol-cloud-precipitation interactions.

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