Numerical studies of aerosol impact on warm rain using a cloud resolving model with the super droplet method

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It is well known aerosols affect formation and behavior of clouds. Albrecht (1989) showed that precipitation amount decreases and the cloud lifetime increases with high number concentration of aerosol while precipitation amount increases and cloud lifetime decreases with smaller number concentration of aerosol. To properly consider the interaction of aerosol and clouds, a detailed numerical simulation based on basic physical laws is necessary. In particular, impacts of aerosol on a very intense rainfall of about 100 mm from a warm rain should be studied using a detailed cloud model with resolving size distribution of particles (e.g. aerosol, cloud, and precipitation droplets). Takahashi et al. (1989) investigated precipitation process over the ocean near the Island of Hawaii using a numerical model with a bin method. They found that the process of drizzle is important for heavy rain formation. In the present study, we studied this type of heavy rain and an aerosol impact on the heavy rain.
We coupled the Super Droplet Method (SDM, Shima 2008; Shima et al., 2009) with the Cloud Resolving Storm Simulator (CReSS; Tsuboki and Sakakibara 2001; 2002) to calculate the detailed behavior of aerosol, cloud, and precipitation particles. The purpose of this study is to investigate the influence of change in aerosol number concentration on the heavy precipitation system. In the warm rain, water vapor deposition process and the collision and coalescence processes are important for the particle glows. These processes are considered precisely in the SDM. The sounding data of atmosphere used for the initial field was provided by Wyoming University.
Results of numerical experiments conducted with different aerosol number concentrations, time evolution of cloud and rain mixing ratio had changed drastically. In addition, particle size distributions and their temporal changes were obtained in the experiments. It showed that precipitation decreased while cloud increased with the increase of initial aerosol number concentration. When the initial number concentration decreased, precipitation amount increased. Particle growth was observed around a radius of 0.3 mm at the beginning of precipitation formation in the low aerosol concentration case. This indicates formation of drizzle particles and their growth. Particle growth was observed around 0.6 mm while the formation of drizzle was suppressed when the precipitation is in mature stage.
The effect of aerosol on cloud lifetime was suggested for warm clouds. When the initial aerosol number concentration is low [10.5], precipitation was remarkably increased (over 50 mm). On the other hand, no precipitation occurred when the aerosol concentration was 100 times as large as the low concentration case. In this case, evaporation of cloud droplets becomes dominant and the lifetime of cloud decreases.

Keywords: aerosol-cloud interaction, super droplet method, cloud-resolving model

