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A study of microphysical mechanism for correlation patterns between droplet radius and optical thickness of warm clouds simulated idealized and downscaling simulation by a three-dimensional spectral bin microphysics model.

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Three-dimensional Idealized simulation assuming dynamical condition of DYCOMS-II RF02 experiment (Ackermann et al. 2009) using a Spectral Bin Microphysics (SBM) model were conducted with 30 km x 30 km calculation domain to investigate effects of aerosols and resolution of model on the microphysical properties and structure of warm clouds. We conducted sensitivity experiments of changing horizontal grid resolutions with two types of aerosol amount (e.g. pristine and polluted). The results show that the change in aerosol amount tends to modify the correlation pattern between droplet radius and optical thickness. The positive and negative correlation pattern is found to be dominant for pristine and polluted aerosol conditions, respectively, where the characteristics of correlation patterns are mainly determined by aerosol amount. The grid resolution was also found to have some effects on the correlation statistics. It was also shown that high resolution (e.g. 100m, 50m) is necessary to reproduce the open and closed cell structures (Wang and Feingold, 2009) by our model.

Three-dimensional downscaling simulations were also performed to investigate not only effects of aerosols but also those of dynamics of atmosphere on the microphysical properties of marine stratocumulus (Sc) off the coast of California at FIRE period. We implemented the regeneration process of aerosols into the model, and conducted sensitivity experiments to change how to treat the regeneration process of aerosols. Simulated results showed that the regeneration process is essential in SBM to reproduce the satellite-observed optical properties of Sc. We also conducted sensitivity experiments to examine how the correlation patterns are influenced by aerosol and dynamics of the atmosphere. These experiments showed that the amount of aerosol modifies the correlation patterns through changing the cloud particle number concentrations as in idealized simulations, while dynamics of the atmosphere modifies correlation patterns through changing the liquid water path. The present study provides an interpretation for the successful reproduction of correlation patterns by previous two-dimensional idealized studies (Suzuki et al., 2006, 2010a, 2010b), which suggests that correlation patterns represent the growth stage of cloud droplet as another previous study by satellite observation (Nakajima and Nakajima 1995).

In spite of the successful reproduction, there are differences in complexity, simulation setup between the present and previous models. Considering these differences, we suggest that the correlation pattern does not show the growth stage of cloud, but shows the property of airmass of domain.