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Dependence of cloud microphysical and macrophysical properties on aerosol in Northeast Asia

In-Jin Choi (1), Sang-Woo Kim (2), and Soon-Chang Yoon (2)

(1) Korea Institute of Atmospheric Prediction Systems, Korea, Republic Of (ij.choi@kiaps.org), (2) Seoul National University, Korea, Republic Of

The effects of aerosol on the microphysical and macrophysical properties of shallow stratocumulus over Northeast Asia are investigated a bin-based meso-scale cloud model with inhomogeneous aerosol fields, in terms of aerosol composition and number concentration. We selected two shallow stratocumulus cases with maritime and polluted conditions during March 2005. To attempt to interpret aerosol-cloud link, numerical simulations are designed with switching aerosol condition as well as employing a wide variation in aerosol concentrations, while keeping the synoptic forcing the same. The reduction of cloud effective radius and the enhancement of optical depth with increasing column aerosol number concentration are obvious regardless of aerosol composition and meteorological settings. Enhanced aerosol number concentration results in increased liquid water path in humid case, but invariant liquid water path in dry case primarily due to the difference in microphysical cloud droplet growth by aerosol. The changes of cloud microphysical properties are more predominant for small aerosol burden than for large aerosol burden with the retarded changes in cloud mass and size due to inactive condensation and collision-coalescence processes. Chemical composition of aerosol induces a significant change in cloud microphysical properties even under same aerosol number concentration. A large sensitivity factor in this study compared to the previously reported values suggests that a strong aerosol-cloud interaction would be possible in a favorable condition of the formation and development for shallow stratocumulus in the target region. Cloud top heights are calculated similarly under maritime and polluted conditions, and they increase slightly with the increase in columnar aerosol number concentration in humid case by longer cloud lifetime. The increase in cloud bottom heights is less apparent than cloud top change because cloud base might be dictated by atmospheric thermodynamics, leading to a little enhancement of cloud geometrical depth in humid case. Cloud fraction shows a remarkable increase with aerosol number concentration in humid case, while invariant cloud fraction is found in dry case. Sensitivity factors of cloud macrophysical properties in humid case have larger values by one order than those in dry case.