Sensitivity of cloud resolving simulations for maritime and continental deep convective systems to aerosol and humidity

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Thermodynamics and aerosol concentrations are two distinct factors that impact the characteristic differences of continental and maritime convective systems. This study conducted cloud-resolving model simulations to investigate the effects of cloud condensation nuclei (CCN) loading and convective available potential energy (CAPE) on tropical maritime and mid-latitude continental deep convection. The Weather Research and Forecasting (WRF) model with spectral-bin cloud microphysics was used. The CCN loading was perturbed between the target maritime and continental conditions, roughly 40 –2000 cm^{-3} at 850 hPa and 1% supersaturation, in the framework of dynamic aerosol downscaling from large-scale aerosol simulations. Thermodynamic fields were perturbed by reducing water vapor mixing ratios homogenously. Surface precipitation rates monotonically increased with increasing CCN loading for both the maritime and continental situations, while these monotonic increases were disrupted in the simulations with reduced CAPE. The increase in precipitation was in the form of convective precipitation, at the expense of stratiform precipitation. CCN increases promoted increases in supercooled cloud water, in agreement with previous modeling studies. However, the changes in supercooled water had different impacts on the cloud microphysics in the maritime and continental simulations. Increased supercooled water contents led to more hail and less graupel in the continental simulation. For the maritime simulation, enhanced supercooled cloud water contents promoted an increase in graupel since little or no hail is produced. This distinction was due to the difference in relative magnitudes and peak altitudes of supercooled water and snow amounts, which was further attributable to moisture and dynamical differences in the two cases.

Keywords: aerosol and cloud, regional modeling, convective system, precipitation

