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Investigation of the Effects of Regenerated CCN on Marine Stratocumulus Cloud Development Using the WRF-LES with Spectral Bin Microphysics Scheme.

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Spectral Bin Microphysics (SBM) scheme in Weather Research and Forecasting (WRF) model treats size (number) distributions of CCN and hydrometeors explicitly and therefore it can calculate detailed cloud microphysical evolution in cloud. The scheme includes embryonic droplet activation, diffusional growth, collision and coalescence, and breakup of drops, but no CCN regeneration process. After evaporation of cloud hydrometeors, the remaining particles can be replenished as CCN and such regenerated CCN can contribute to new droplet activation. To include this important process in the SBM scheme, we assume five different regenerated CCN distributions and implement them into the SBM scheme. To evaluate these five regeneration methods, we simulates a day time Marine Stratocumulus Cloud (MSC) measured in the aircraft campaign during the Variability of the American Monsoon System Ocean-Cloud-Atmosphere-Land Study Regional Experiment (VOCALS-REx). Drop evaporation and CCN regeneration processes are found to greatly influence the development of VOCALS MSC because of the inversion layer covering its top with very dry air. Entrainment of warmer and drier air from above the cloud top evaporates cloud drops so efficiently. Without the CCN regeneration process, the number concentration of total particle (CCN and Cloud drops) is significantly reduced over time, resulting in the growth of very large drops due to reduced competition among the drops. When CCN regeneration is considered, such problem disappears but the effects depends strongly on the regeneration methods. We also find that larger regenerated CCN cause more vigorous convection at stratocumulus topped boundary layer and it mitigates decoupling structure of boundary layer, which hampers moisture and heat transfer between the sea surface and cloud.