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An Aerosol Initiated Transition from Widespread-Shallow to Isolated-Deep Precipitating Marine Boundary Layer Clouds

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Thin, low-level stratiform clouds cover a substantial portion of the earth's oceans, and thus, have the potential to impact the radiation budget and hydrologic cycle. The stability and precipitation efficiency of such cloud regimes is largely controlled by large scale forcing, boundary layer stability, and cloud microphysical properties. Variability in the in situ cloud droplet nucleating aerosol field can lead to changes in the size and number concentration of cloud droplets and the resulting rate and size at which rain drops are created through collision-coalescence processes. Modifications to the precipitation rates and amounts can impact precipitation cold pool strength, outflow speed, and low-level stability.

A high resolution numerical modeling study of the impacts of aerosols on precipitating tropical marine stratocumulus clouds was conducted to determine the potential aerosol influence on precipitation rates, cloud fraction, and cloud depth. In an environment without large-scale subsidence, an initial field of widespread stratocumulus clouds transitions into a field of isolated but deeper convective cells due to an increase in aerosol concentration. The transition to deeper convection is attributed to convective invigoration processes, while the erosion of the widespread stratiform layer is attributed to increases in entrainment, downdrafts, and cloud droplet evaporation resulting from more numerous, but substantially smaller cloud droplets generated from high concentrations of aerosols. These aerosol responses lead to a reduction in precipitation volume and a decrease (increase) in averaged light (relatively heavy) precipitation rates.