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Impact of Aerosols on Convective Clouds and Precipitation

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Aerosols are a critical factor in the atmospheric hydrological cycle and radiation budget. As a major reason for clouds to form and a significant attenuator of solar radiation, aerosols affect climate in several ways. Current research suggests that aerosol effects on clouds could further extend to precipitation, both through the formation of cloud particles and by exerting persistent radiative forcing on the climate system that disturbs dynamics. However, the various mechanisms behind these effects, in particular the ones connected to precipitation, are not yet well understood. The atmospheric and climate communities have long been working to gain a better grasp of these critical effects and hence to reduce the significant uncertainties in climate prediction resulting from such a lack of adequate knowledge.

In this presentation, we will identify the effect of aerosols on precipitation processes on one tropical oceanic and one mid-latitude land convective system. A regional scale model (NASA Unified WRF or Nu-WRF) coupled with an aerosol transport model (Goddard Chemistry Aerosol Radiation and Transport Model or GOCART) is used for this modeling study. The spectral bin microphysics is also used for this modeling study. Specifically, this paper addresses the following topics: how the precipitation processes affected by CCN concentration, and results from NU-WRF simulations. In addition, the model-simulated hydrometeors will be compared with CSU (Colorado State University) hydrometeor identification using radar observation.

The results showed that tropical and mid-latitude CCN loadings are simply interchanged, and a 10% increase in the areal-averaged convective rain rate is found when CCN concentrations are increased to mid-latitude values in the tropical oceanic case. We find increased graupel contents in this “polluted” simulation, consistent with previous studies on convective invigoration by CCN. Convective rain rates are seriously reduced in the mid-latitude continental case when “clean” CCN profiles are used. Additionally, we also will report on the response to simultaneously modifying CAPE and CCN.