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EXAMINATION OF AEROSOL INDIRECT EFFECTS UNDER CONTRASTING ENVIRONMENTS DURING THE ACE-2 EXPERIMENT

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ABSTRACT

We have adopted a cloud resolving model, ATHAM (Active Tracer High-resolution Atmospheric Model), to examine the aerosol indirect effect in contrasting clean and polluted cloudy boundary layers during the Second Aerosol Characterization Experiment (ACE-2). Model results are in good agreement with available in-situ observations, which provides confidence in the model.

Sensitivity tests have been conducted to examine the response of the cloud fraction (CF), cloud liquid water path (LWP), and cloud optical depth (COD) to changes in aerosols in the clean and polluted cases. For both cases we show that CF and LWP would decrease or remain nearly constant with an increase in aerosols, a result which shows that the second aerosol indirect effect is positive or negligibly small in these cases. Further investigation indicates that the background meteorological conditions play a critical role in the response of CF and LWP to aerosols. When large-scale subsidence is weak as in the clean case, the dry overlying air above the cloud is more efficiently entrained into the cloud, and in so doing, removes cloud water more efficiently, resulting in lower CF and LWP when aerosol burden increases. However, when the large-scale subsidence is strong as in the polluted case, the growth of the cloud top is suppressed and entrainment drying makes no significant difference when aerosol burden increases. Therefore, the CF and LWP remain nearly constant.

In both the clean and polluted cases, the COD tends to increase with aerosols, and the total aerosol indirect effect (AIE) is negative even when the CF and LWP are decreased with an increase in aerosols. Therefore, the first AIE dominates the response of the cloud optical depth to increases in aerosols.