

EFFECT OF AEROSOL CHEMICAL COMPOSITION ON CCN CONCENTRATION AND AEROSOL FIRST INDIRECT RADIATIVE FORCING

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ABSTRACT

Previous studies have shown that compared to chemical composition, aerosol size distribution is the more dominant parameter on CCN activation [Feingold, GRL 2003; Dusek et al, Science, 2006]. In this study, the effects of aerosol chemical composition on CCN concentration is first characterized using data collected at Point Reyes, California during the Marine Stratus Experiment (MASE) in July 2005. Using simultaneous aerosol size distribution and CCN concentration measurements, we derived the 50% cut off diameter $D_{p,50}$ (i.e. particle diameter at which 50% particles are activated), which ranged from 98 to 136 nm at 0.18% and 52 to 66 nm at 0.43% supersaturation. The variation of $D_{p,50}$ at a fixed supersaturation reflects the change of aerosol chemical composition during the MASE. To evaluate the effect of aerosol chemical composition on the CCN concentration (N_{ccn}), we recalculated the N_{ccn} using each measured aerosol size distribution and $D_{p,50}$ averaged over the campaign, and compared it to direct CCN measurements. It was found that neglecting the variation of chemical composition (i.e. $D_{p,50}$) at Point Reyes leads to an error of $\pm 20\%$ on N_{ccn} at 0.18% supersaturation. For assumed global distributions of marine stratus clouds, such an error in N_{ccn} corresponds to an error of 0.4 Wm^{-2} in estimation of the aerosol first indirect effect on the radiation budget.

The effect of aerosol chemical composition on N_{ccn} was also studied by examining the sensitivity of N_{ccn} to particle activation diameter, defined as $d\ln N_{\text{ccn}}/d\ln D_{p,50}$. The sensitivity, which strongly depends on the shape of aerosol size distribution, was analyzed for major aerosol types including the marine background aerosol. Previous measurements have shown the size distribution of marine background aerosol often consists of an Aitkin mode and an accumulation mode, separated by a valley referred to as "Hoppel minimum". It is general agreed that the accumulation mode and the Hoppel minimum are result of cloud processing of aerosols. Marine background aerosol measured during previous studies exhibit a sensitivity $d\ln N_{\text{ccn}}/d\ln D_{p,50}$ that often reaches a local minimum at the Hoppel minimum, which approximates the particle activation diameter at the supersaturation in marine status clouds. As a result, the error in CCN concentration introduced by using the average chemical composition (i.e. neglecting the variation of chemical composition) is low for marine background aerosol, and the resulting error in the aerosol first indirect radiative forcing is mostly below 0.2 Wm^{-2} . Compared to marine background aerosol, the sensitivities of other major aerosol types are often much higher, and the error in the aerosol first indirect radiative forcing introduced by neglecting the variation of aerosol chemical composition are larger, which are consistent with the results from MASE measurements.