PARTITION OF THE FIRST AEROSOL INDIRECT EFFECT AND A NEW AEROSOL DISPERSION EFFECT

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ABSTRACT

Conventional wisdom of the first aerosol indirect effect is that pollution leads to an increase in aerosol number concentration, increasing droplet concentration, reducing effective radius (r_e), and enhancing cloud albedo. A commonly used measure of the first aerosol indirect effect is the relative change of effective radius (r_e) with aerosol number concentration (N_a): $I = dln(r_e)/dln(N_a)$. Here we first show that this metric can be partitioned into two dispersion effects: the effect of aerosol concentration on the relative dispersion of the cloud droplet size distribution, and the effect of the relative dispersion of the aerosol size distribution on cloud properties. We further demonstrate that pollution concurrently alters both aerosol concentration and aerosol relative dispersion, and that the resultant coupling leads to a new first indirect effect — the aerosol dispersion effect that has been overlooked. The magnitude of the aerosol dispersion effect is estimated using theoretical and observational analysis. The results highlight the need to consider aerosol number concentration, mass concentration, and relative dispersion in droplet activation parameterizations.