

THE FIRST AEROSOL INDIRECT EFFECT: BEYOND TWOMEY

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Presented at the
Eighteenth Annual Atmospheric Radiation Measurement (ARM)
Science Team Meeting,
Norfolk, VA
March 10-14, 2008

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ABSTRACT

The traditional first aerosol indirect effect or the Twomey effect involves several fundamental assumptions. Some of the assumptions (e.g., constant liquid water content) are explicitly stated in studies of the Twomey effect whereas others are only implicitly embedded in the quantitative formulation. This work focuses on examining the implicit assumptions. In particular, we will show that anthropogenic pollution not only increases aerosol loading and droplet concentrations but also alters the relative dispersions of both the aerosol and subsequent droplet size distributions. The indirect effects resulting from the two altered relative dispersions (aerosol dispersion effect and droplet dispersion effect) are likely opposite in sign and proportional in magnitude to the conventional Twomey effect. This result suggests that the outstanding problems of the Twomey effect (i.e., large uncertainty and overestimation reported in literature) may lie with violation of the constant spectral shapes of aerosol and droplet size distributions implicitly assumed in evaluation of the Twomey effect, and therefore, further progress in understanding and quantification of the first aerosol indirect effect demands moving beyond the traditional paradigm originally conceived by Twomey.