Radiative Forcing of the First Aerosol Indirect Effect

A. McComiskey[1] and G. Feingold[2]

[1]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309; 303-497-6189, Fax: 303-497-5590, E-mail: Allison.McComiskey@noaa.gov
[2]NOAA Earth Systems Research Laboratory, 325 Broadway, Boulder, CO 80305

For a number of years various investigators have demonstrated success in detecting the effects of aerosols on cloud microphysical properties from surface and satellite remote sensing. Nevertheless, because of the importance of aerosol-cloud interactions for climate change, it is important to quantify this effect. To date, it is unclear to what extent the range of detected responses are physical and to what extent measurement errors play a role. Moreover, it is unclear what the accuracy requirements are for various measures of the aerosol indirect effect in terms of W m^{-2} of forcing for climate change applications.

To address these issues we use a radiative transfer model to establish the sensitivity of cloud forcing to anthropogenic aerosol influences. The shortwave (0.28 - 4.0 μm) radiative forcing at the surface was calculated for the range of physical indirect effect (IE) values. The change in cloud optical depth (τ_c) for increasing cloud condensation nucleus concentration (N_{CCN}), used as model input, is shown for the range of IE at two fixed LWP (left panel). Instantaneous (middle panel) and diurnally averaged (right panel) forcings are calculated for each of the IE values as the difference in irradiance for N_{CCN} = 500 cm^{-3} and N_{CCN} - 25 cm^{-3}, representing polluted versus clean conditions. This exercise demonstrates that uncertainties in measures of the first aerosol indirect effect will translate to large uncertainties in radiative forcing estimates for climate change applications. We further quantify these uncertainties and their relationships in this presentation.

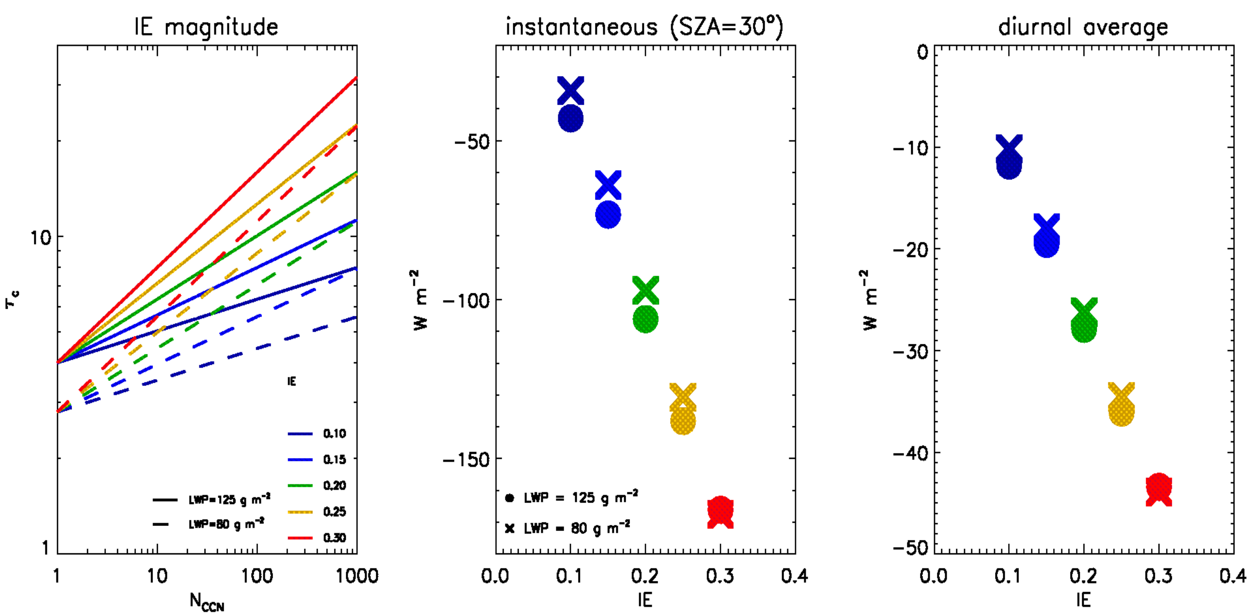

Figure 1. The radiative forcing for several different values of the first aerosol indirect effect (IE) (left panel) at two different liquid water path quantities for instantaneous radiation (middle panel) and diurnally averaged radiation (right panel).