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A six year satellite-based assessment of the regional variations in aerosol indirect effects

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Abstract. Aerosols act as cloud condensation nuclei (CCN) for cloud water droplets, and changes in aerosol concentrations have significant microphysical impacts on the corresponding cloud properties. Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol and cloud properties are combined with NCEP Reanalysis data for six different regions around the globe between March 2000 and December 2005 to study the effects of different aerosol, cloud, and atmospheric conditions on the aerosol indirect effect (AIE). Emphasis is placed in examining the relative importance of aerosol concentration, type, and atmospheric conditions (mainly vertical motion) to AIE from region to region.

Results show that in most regions, AIE has a distinct seasonal cycle, though the cycle varies in significance and period from region to region. In the Arabian Sea (AS), the six-year mean anthropogenic + dust AIE is −0.27 Wm^{-2} and is greatest during the summer months (<−2.0 Wm^{-2}) during which aerosol concentrations (from both dust and anthropogenic sources) are greatest. Comparing AIE as a function of thin (LWP<20 gm^{-2}) vs. thick (LWP⩾20 gm^{-2}) clouds under conditions of large scale ascent or decent at 850 hPa showed that AIE is greatest for thick clouds during periods of upward vertical motion. In the Bay of Bengal, AIE is negligible owing to less favorable atmospheric conditions, a lower concentration of aerosols, and a non-alignment of aerosol and cloud layers. In the eastern North Atlantic, AIE is weakly positive (+0.1 Wm^{-2}) with dust aerosol concentration being much greater than the anthropogenic or sea salt components. However, elevated dust in this region exists above the maritime cloud layers and does not have a hygroscopic coating, which occurs in AS, preventing the dust from acting as CCN and limiting AIE. The Western Atlantic has a large anthropogenic aerosol concentration transported from the eastern United States producing a modest anthropogenic AIE (−0.46 Wm^{-2}). Anthropogenic AIE is also present off the West African coast corresponding to aerosols produced from seasonal biomass burning (both natural and man-made). Interestingly, atmospheric conditions are not particularly favorable for cloud formation compared to the other regions during the times where AIE is observed; however, clouds are generally thin (LWP<20 gm^{-2}) and concentrated very near the surface. Overall, we conclude that vertical motion, aerosol type, and aerosol layer heights do make a significant contribution to AIE and that these factors are often more important than total aerosol concentration alone and that the relative

importance of each differs significantly from region to region.

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