Aerosol Effects on Cloud Cover as Determined by Ground- and Space-based Sensors

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The effect of aerosols on the extent of clouds (i.e. cloud lifetime or 2nd indirect effect) remains one of the largest uncertainties in climate science. Most observational and modeling studies show an increase in cloud fraction (fc) with increasing aerosol optical depth (AOD). Others show a reduction in fc for shallow cumulus clouds, particularly in regions with absorbing aerosol. This study combines MODIS data with ground-based data from the U.S. Surface Radiation budget (SURFRAD) network to illustrate the confounding effects of clouds on AOD measurements, and the limitations imposed by those effects on satellite studies. The advantage of SURFRAD data is that its collocated radiation, AOD, meteorological, and fc measurements allow many of these effects to be assessed, and thus better define the relationship between aerosols and cloud lifetime. The composite result in the figure below, derived from six SURFRAD stations, shows systematically enhanced AOD within ~20 minutes of cloud edges. To address the 2nd indirect effect, fc versus AOD plots have been made separately using all AOD data, and AOD isolated from cloud effects (i.e., > 20 min. from cloud edges). Cloud fraction increases with AOD for both stratifications, but the slopes of the fc vs. uncontaminated AOD plots are approximately half of those made with cloud-contaminated AOD data. The same analysis using MODIS-derived AOD nearly matches the SURFRAD result with cloud contamination, indicating that near-cloud aerosol effects may artificially enhance the 2nd indirect effect estimations from MODIS data. Using SURFRAD data, we have been also able to show that meteorological co-variation has no bearing on the fc–AOD relationship.

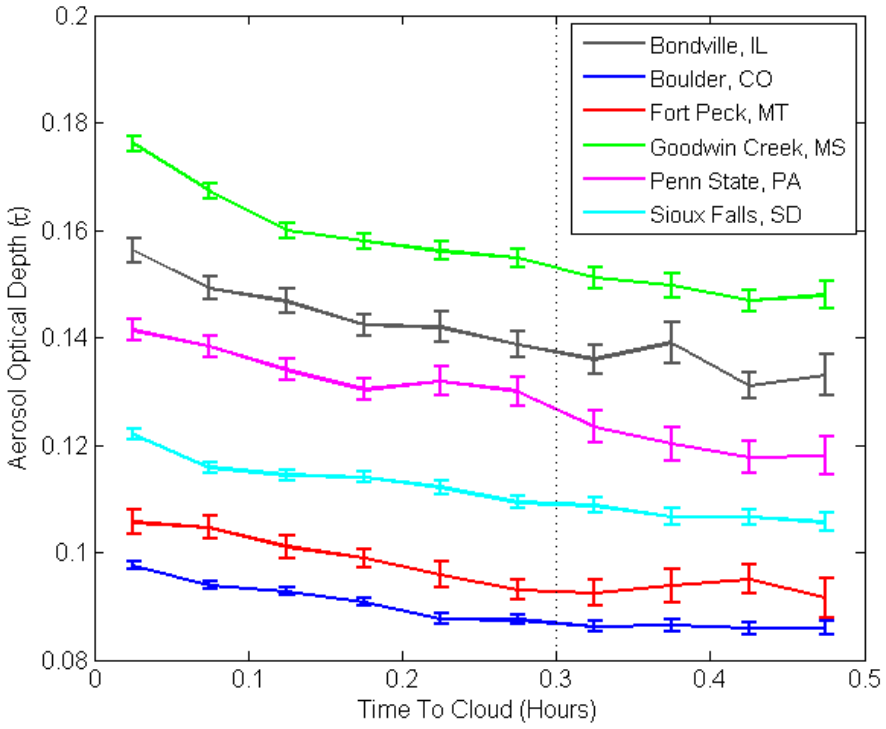

Figure 1. Composite mean surface 550 nm aerosol optical depth as a function of time-to-cloud within a three-hour window of Aqua satellite passage times for six SURFRAD sites (2006-2001). The vertical line indicates ~20 min. from a cloud edge.