Surface-based Cloud Radiative Properties for Improved Understanding of Aerosol-cloud Interactions

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Aerosol-cloud interactions carry large uncertainties for climate prediction. They are driven by microphysical processes but manifest in changes to the radiation budget at coarser scales of interest to climate through cloud radiative forcing (CRF). However, variability in CRF is dominated by meteorology, so quantifying the aerosol signal has proven challenging. Conventional practice entails creating metrics that describe the response of cloud microphysical and macrophysical properties to changes in aerosol, but these metrics must then be related to changes in cloud radiative properties. This approach is reductionist and often results in large errors in aerosol-cloud interaction radiative forcing estimates. A better understanding of the relationship among cloud microphysical, macrophysical, and radiative properties is required before uncertainties in the aerosol-cloud interaction radiative forcing can be reduced. Surface-based remote sensing has typically been used to quantify the aerosol-cloud microphysical response but not the radiative response. We use a new approach to deriving cloud albedo, cloud fraction, and cloud radiative forcing from existing, long-term surface radiation products that can be used to directly assess relationships among cloud microphysical, macrophysical, and radiative properties. We then show how coincident surface-based measures of aerosol concentration, cloud liquid water, vertical velocity, and other meteorological parameters, allow for attribution of changes in cloud properties to either aerosol or meteorology.

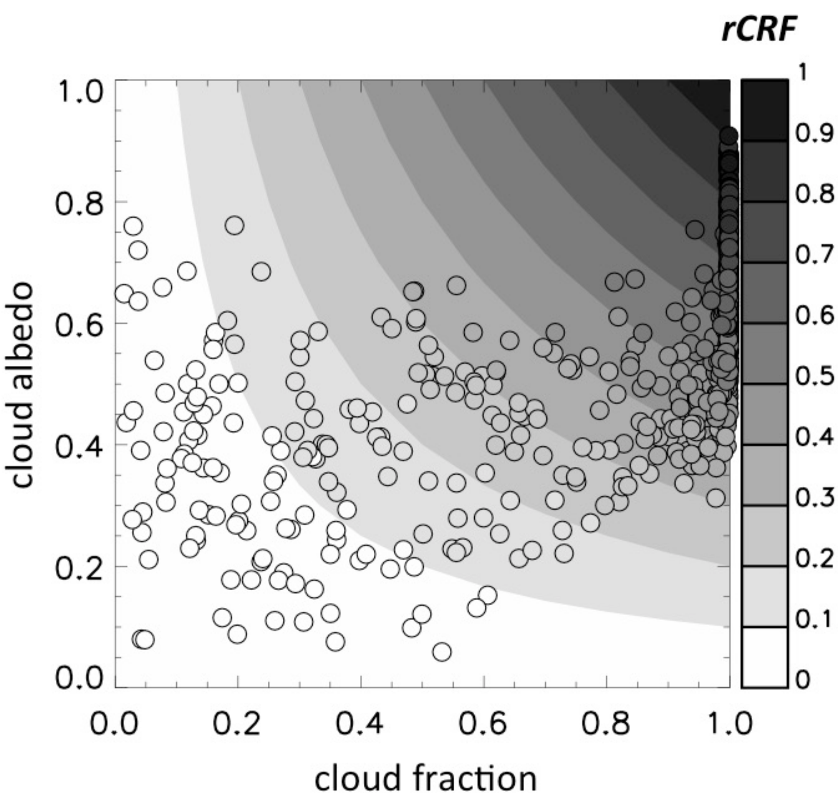

Figure 1. Theoretical (contours) and observed (symbols) relationships among relative cloud radiative forcing (rCRF), cloud fraction, and cloud albedo for low clouds at the Southern Great Plains site, January-June 2009.