Minimal Shortwave Anomalous Absorption Found over ACRF Sites

Contributors

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Research Highlight

Atmospheric column absorption of solar radiation (Acol) is a fundamental part of the Earth's energy cycle but is extremely difficult to measure directly. It has been the subject of several ARM field campaigns. To investigate Acol, surface observations were taken under optically thick Deep Convective Systems (DCS) over the Department of Energy Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) Tropical Western Pacific (TWP) and Southern Great Plains (SGP) sites from March 2000-December 2004. Observations were collocated with coincident top-of-atmosphere (TOA) shortwave broadband measurements and cloud property retrievals from the Clouds and Earth's Radiant Energy System (CERES) on the Terra and Aqua satellites. The surface data were averaged over a two-hour interval centered at the satellite overpass time, and the satellite data were averaged within a 1-deg area centered on the ACRF sites. Cloud optical depths and particle sizes derived from a moderate-resolution imaging spectroradiometer (MODIS) using the CERES algorithms (same as the ARM geostationary operational environmental satellite [GOES] cloud retrieval algorithms) and the ARM surface albedos were used as inputs in the National Aeronautics and Space Administration (NASA) Langley modified Fu_Liou 2-stream radiative transfer model Fu-Liou code to compute TOA albedo and atmospheric and surface absorption.

Cloud particle size is important for TOA albedo and Acol, although the surface absorption is independent of cloud particle size. This study finds that Acol in the tropics (0.297) is ~0.011 more than that in the middle latitudes. This difference disappears, i.e., the Acol values at both regions converge to the same value (~0.27 of the total incoming solar radiation) in the optically thick limit (# > 50). Comparing the observations with the Fu-Liou code, the difference between observed and model-calculated surface absorption, on average, is less than 0.01, but the model-calculated TOA albedo and Acol differ by 0.01 to 0.04, depending primarily on the cloud particle size observation used.The model versus observation discrepancies found are smaller than many previous studies and are just within the estimated error bounds.

No evidence was found for a large cloud absorption anomaly at the optically thick limit of extensive ice cloud layers. A more modest cloud absorption difference of 0.01 to 0.03 cannot yet be ruled out. The remaining uncertainty could be reduced with additional cases, and by reducing the current uncertainty in cloud particle size.

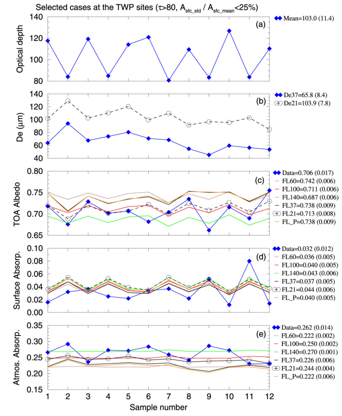

Figure 1. CERES-MODIS (a) # and (b) De (3.7μm for De37; 2.1 μm for De21) means (95% conf interval), blue diamonds in (c), (d) and (e) from observations. FL60, FL100, FL140 from Fu-Liou code with CERES-MODIS He and # inputs, and fixed layer-mean De=60/100/140 μm, Rsfc=0.064, μ0=0.9, #aer=0.2, and std tropical sounding. FL37/FL21 computed with De37/De21. FL_P inputs same as FL37 but use De and # vertical profiles. Satellite results averaged over 20-km box; 0.5-h surface observation averages.

Reference(s)

Dong, X., B. A. Wielicki, B. Xi, Y. Hu, G. G. Mace, S. Benson, F. Rose, S. Kato, T. Charlock, and P. Minnis, 2008: Using observations of deep convective systems to constrain atmospheric column absorption of solar radiation in the optically thick limit. J. Geophys. Res., 113, D10206, doi:10.1029/2007JD009769.

Working Group(s)
Radiative Processes