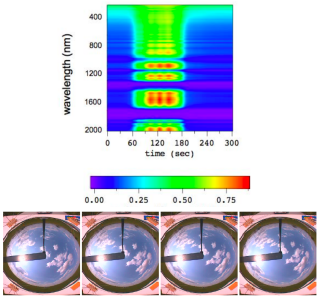
Spectral Invariant Behavior of Zenith Radiance Around Cloud Edges Observed by ARM SWS

Research Highlight

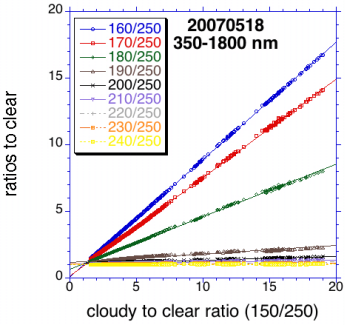
Although clouds seem to have a distinct boundary, remote sensing measurements find it difficult to distinguish between cloudy and cloud-free air. The transition zone is neither precisely clear nor precisely cloudy. This problem has major climatic consequences, in particular on aerosol direct and indirect effect studies, which demand a precise separation of clear and cloudy zones.

ARM scientists studied the transition zone between cloudy and cloud-free areas using shortwave spectrometer (SWS) measurements. SWS looks straight up and every second measures downward solar radiation at 418 wavelengths between 350 and 2200 nm. Because of its high sampling resolution, the SWS provides a unique capability to study the transition zone and to address the important questions of what are the full-spectral radiative characteristics of the clear-cloud transition zone and what is the spectral signature of a weak evaporating cloud.

Analysis of high spectral and temporal resolution SWS measurements (see Figure 1 as an example) led to the surprising discovery of a wavelength-independent function that characterizes the transition zone between cloudy and cloud-free areas (Figure 2). The transition zone spectrum is determined fully by this function and radiances spectra of clear and cloudy sky areas. This finding is essential to both remote sensing and modeling communities. For example, this wavelength-independent function can serve as a good characteristic of pollution in a field with small cumulus clouds. In addition, if the transition zone between ice clouds and cloud-free area is longer and smoother than between water clouds and cloud-free area, the function may help determine the thermodynamic phase.



(top) Time-wavelength color contour plot of ARM shortwave spectrometer (SWS) spectra measured from 21:35:24 to 21:40:24 UTC on 18 May 2007 at the ARM Climate Research Facility (ACRF) Southern Great Plains (SGP) site in Oklahoma. SZA=45°. (bottom) Four total-sky images taken at 21:38:00 (156 s), and 21:38:30 (186 s), 21:39:00 (216 s) and 21:39:30 (246 s) during the time when the small cloud at zenith was moving from inside to outside the field-of-view of the SWS.



Zenith radiance in transition zone for 9 values of time from t=160 s to t=240 s normalized to clear-sky zenith radiance (tclear=250 s) vs. cloudy zenith radiance (tcloudy=150 s) also normalized to clear-sky zenith radiance. To avoid division by small numbers we excluded strong water vapor absorbing spectral intervals. We also masked spectral measurements at wavelengths longer than 2 micron because the clear-sky values of zenith radiance there are too low and too uncertain for normalization.

Reference(s)

Marshak A, Y Knyazikhin, JC Chiu, and WJ Wiscombe. 2009. "Spectral invariant behavior of zenith radiance around cloud edges observed by ARM SWS." Geophysical Research Letters, 36, L16802, doi:10.1029/2009GL039366.

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Radiative Processes