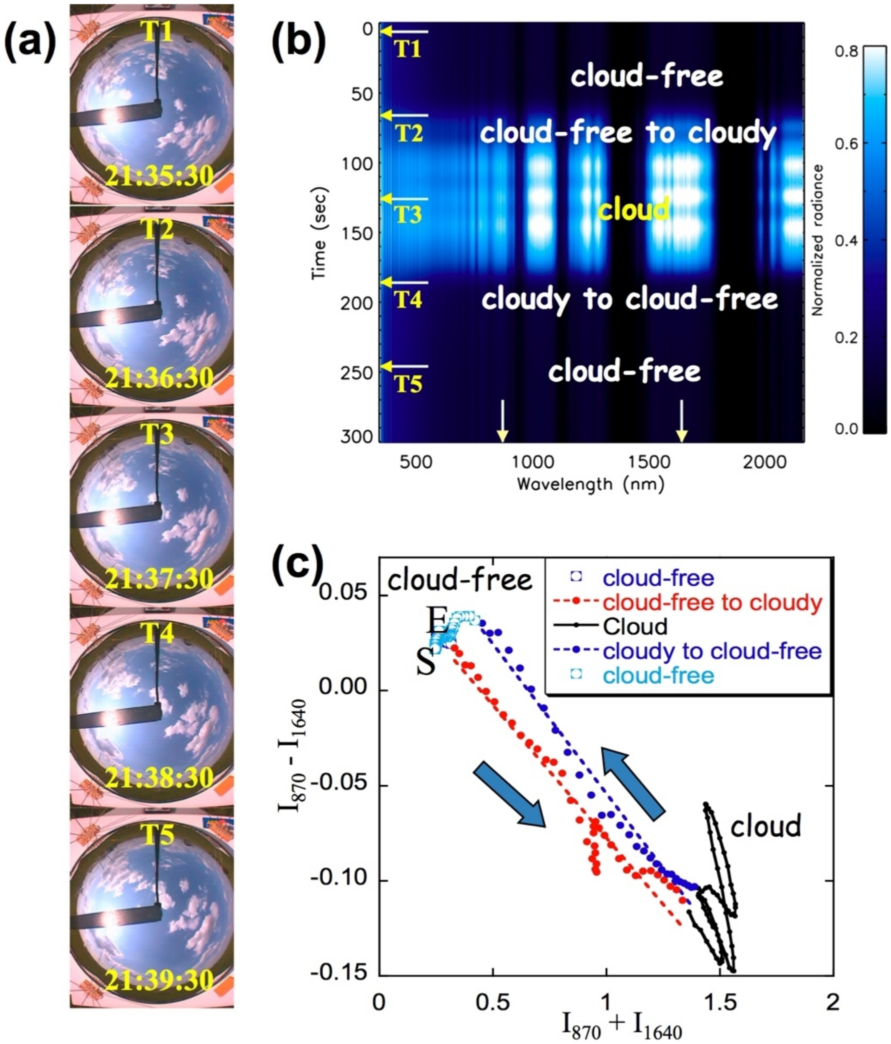
Using the ACRF Shortwave Spectrometer to Study the Transition Between Clear and Cloudy Regions



To the naked eye, clouds appear to have sharp boundaries; however, this is merely an illusion. Cloud boundaries are actually somewhat fuzzy, with the transition from cloud to clear stretching over as little as 50 m to as much as several hundred meters. Fuzzy cloud boundaries create major headaches for studies of aerosol indirect effect and aerosol radiative forcing – especially when, as with most satellite instruments, spatial resolution is too poor to resolve the transition zone. This argues strongly for the use of ground-based instruments with spatial resolution on the order of meters, and temporal resolution better than a few seconds, to study the transition zone. One-second-resolution zenith radiance measurements from the new Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) shortwave spectrometer (SWS) provide a unique opportunity to analyze the transition zone. We have used two wavelengths, 870 and 1640 nm, from the SWS spectra to study the transition zone on the sides of clouds. These two wavelengths provide information about optical depth and particle size and are nearly free of the confounding effect of Rayleigh scattering. In the transition zone, we find a remarkable linear relationship between the sum and difference of radiances at 870 and 1640 nm wavelengths. The linear behavior allows us to neatly separate effects of aerosols and clouds. The intercept of the line is determined mostly by aerosol optical depth and size, while the slope of the line is determined mostly by cloud droplet size. This linearity also can be predicted from simple theoretical considerations and furthermore supports the hypothesis of inhomogeneous mixing, whereby optical depth increases as a cloud is approached but the effective drop size remains unchanged.

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