ARM Summer Training and Science Applications

Cloud Birth and Fraction Report

Participants:
Jingyi Chen, Stony Brook University
George Duffy, Vanderbilt University
Elizabeth Smith, Pacific Northwest National Laboratory
Wei Zhao, University of Washington

Instructors:
Allison McComiskey, National Oceanic and Atmospheric Administration
Dave Turner, National Oceanic and Atmospheric Administration

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1.0 Cloud Birth and Fraction

A case of low-level cumulus was observed over the ARM Southern Great Plains (SGP) site on 5 July 2015. We employed data from several ARM instruments to explore the definition of cloud and cloud fraction. The Total Sky Imager (TSI) was used as a basic observation to which we could compare retrieved cloud fraction from other instruments. The Atmospheric Emitted Radiance Interferometer (AERI) measured infrared radiance that was processed through an approximation radiative transfer model to retrieve clear-sky brightness temperature and cloud optical depth time series. Clouds were defined with their optical depth larger than identified uncertainty, and only considering the uncertainty of each instrument. The same method was used to calculate cloud fraction from the Microwave Radiometer-measured radiance at around 30 and 90 GHz. The Micropulse Lidar signal was converted to optical depth using Beer's Law. Clouds were defined excluding disturbances from aerosols and solar angle. Finally, the Ka ARM Zenith Radar (KAZR) data was first filtered using a new technique different from that implemented by ARM to eliminate the background noise and was then used in tandem with the Ceilometer data to retrieve significant return time series identifying cloud occurrence.

Figure 1 shows the resulting ensemble of hour-averaged cloud fraction. Colored lines indicate cloud fraction from each instrument, black solid line shows ensemble mean, and black dash lines show spreads. In this selected period with both clear sky and cloudy sky (based on TSI), spreads of cloud fraction is larger when mean cloud fraction is larger. Possible reasons for the spread are summarized:

1) Sensitivities to liquid water are different when we use various instruments with different wavelengths, which lead to various ranges of cloud optical depth. To better quantify the uncertainties and better define cloud fraction, the retrieved optical depths from all the instruments are suggested to be converted to a 'universal optical depth,' which is normalized by an absorption coefficient of corresponding wavelength.

2) Uncertainties from passive instruments limit the sharpness to identify cloudy or clear sky.

3) Disturbances from insects or aerosols matter when active measurements are considered. The analyses also demonstrate that cloud fraction can be different for different applications.

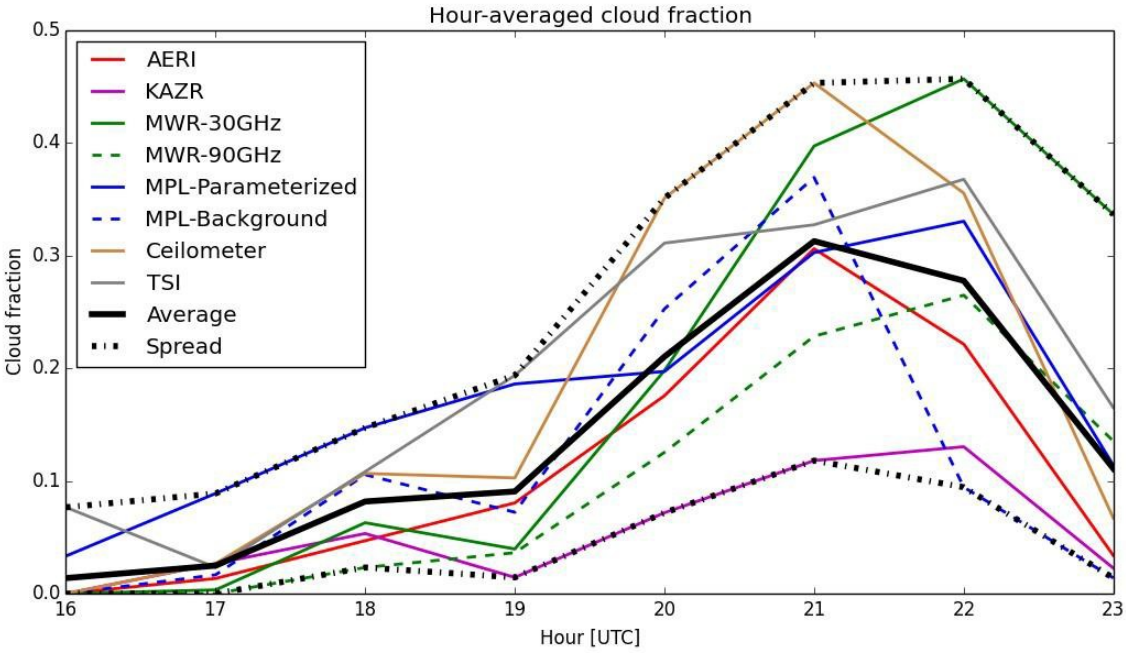

Figure 1. Retrieved hour-averaged cloud fraction from the considered ARM instruments during the day of 5 July, 2015 over the SGP ARM site.