The Impact of Instrument Selection and Sampling on Cloud Fraction at the ARM Southern Great Plains Site

Research Highlight

The Atmospheric Radiation Measurement (ARM) Climate Research Facility has been providing high-quality, actively sensed observations of clouds at the Southern Great Plains (SGP) site for nearly two decades. The Active Remote Sensing of Clouds (ARSCL) value-added product (VAP) is commonly used to determine cloud macrophysical properties from millimeter-wavelength cloud radar (MMCR), micropulse lidar (MPL), and ceilometer instruments.

The selection of instruments impacts the calculation of cloud fraction (CF), and instrument downtime introduces error when statistics are aggregated over longer periods such as a month. This limits the ability to compare time series of CF to other instrument or model records. This study explores these properties and calculates confidence intervals based on instrument downtime using ARSCL at the ARM SGP site from 1997–2010.

Bootstrapping was used to quantify the uncertainty in monthly total CF due to instrument downtime. Error increases nearly linearly for instrument availabilities from 100 to 30%. Below this point, the probability of the instruments observing a particular weather pattern increases, and as a result, error rapidly rises. Uncertainty due to instrument downtime is greatest during the first seven years of the record, primarily because of the MPL. Other than a period from 2001–2003, the MMCR has relatively low uncertainty for monthly total CF.

Selection of MMCR or combined MMCR and MPL cloud masks changes little in the overall understanding of CF from 1997–2010. The addition of the MPL increases the climatological total CF by 9.3%, predominantly through the year-round inclusion of optically thin cirrus clouds and mid-level clouds during the summer. There is evidence of a systematic decrease in MMCR CF after the radar upgrades were completed in 2003. The instrument records were separated into two 7-year periods (1997–2003 and 2004–2010). Although the combined MMCR and MPL total CF is within a fraction of a percent, MMCR CF decreases by 6.1% from 1997–2003 to 2004–2010. This decrease in total CF is primarily associated with a decrease in the detection of high- and mid-level cloud types.

Users should be cognizant of instrument selection and instrument downtime when investigating cloud macrophysical properties. Despite an apparent decrease in MMCR sensitivity after 2003, the latter period offers the best estimate of CF due to the increased availability of the MPL. Prior to this year, users should be aware MPL availability is lower; however, this is countered by the MMCR detecting a higher percentage of clouds seen by the MPL.

Reference(s)

Kennedy AD, X Dong, and B Xi. 2013. "Cloud Fraction at the ARM SGP Site: Instrument and sampling considerations from 14 years of ARSCL." Theoretical and Applied Climatology (Springer), , .

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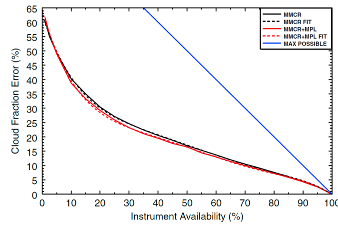
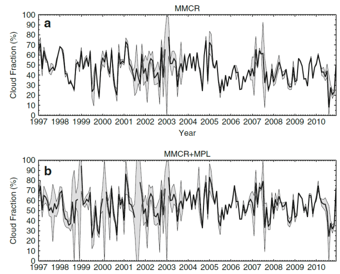
Working Group(s)

Cloud Life Cycle



Ninety-five percent confidence error for MMCR (black) and MMCR+ MPL (red) observations. Fifth-order polynomial fits are given by the respective dashed lines. The blue line denotes the maximum possible error given the scenarios where an instrument samples a completely cloudy/clear condition, and the time period of downtime has the opposite sky condition.



Monthly MMCR total cloud fraction (a) and MMCR+MPL total cloud fraction (b) from 1997–2010. Ninety-five percent confidence intervals calculated from instrument uptime are given by the grey boundaries.