Retrievals of cloud optical depth and effective radius from Thin-Cloud Rotating Shadowband Radiometer

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Introduction

- **Cloud optical depth** and **effective radius** are key properties of clouds.
- The ability to accurately measure the cloud optical properties is limited, especially for the optically **thin clouds (LWP < 100 gm-2) .**
- **Thin-Cloud Rotating Shadowband Radiometer (TCRSR)** is developed for simultaneously measuring the optical depth and effective radius of thin clouds.

Thin-Cloud Rotating Shadowband Radiometer (TCRSR)

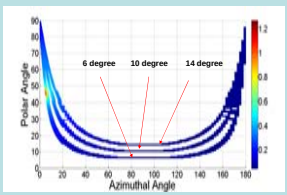
The TCRSR measures the angular distribution of light scattered by clouds in the sun-sensor direction in six narrow spectral bands: 415, 500, 610, 660, 870, and 940 nm. Passband of 415 nm is selected for our retrieval.

The outer shadowband yield occultation angles of 2.13º .

Retrieval Algorithm

$$e_0 = b_0 - F_0(\alpha_{sza}, \alpha_0, r_e, \tau) - \exp(-\tau / \cos(\alpha_{sza}))$$
$$e_i = b_i - F_i(\alpha_{sza}, \alpha_i, r_e, \tau), i = \pm 1, \pm 2, \ldots . \pm m$$

The TCRSR scans across the sky from one side to the other side. For the Sun-sensor direction ($\alpha_0 = 0$), the measured radiance (b_i) contains both **attenuated solar beam** and **forward scattering components**. The effective radius and optical depth can be evaluated as the least squares minimum of the difference between the measured and modeled radiances in the above equations.

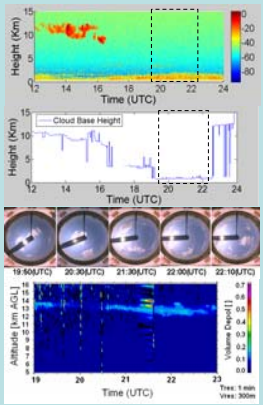


Simulation of the blocked sky radiation by a 2 ° shadowband for blocking angles of 6, 10 and 14 degrees.

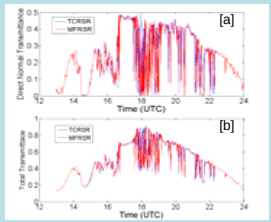
Measurements and Retrieval

Cases from 19:30 to 22:30 UTC On July 3, 2008 at SGP site.

- *For this period, the MMCR reflectivity, MPL cloud-base height and TSI images indicated that there were low level optically thin clouds in the Sun-sensor direction.*
- *But the Volume Depolarization from lidar indicated that a very thin ice cloud (tau<0.2) existed above 12 km.*
- *For the retrieval, we assume a thin ice cloud layer (tau=0.15) over low-level water clouds.*



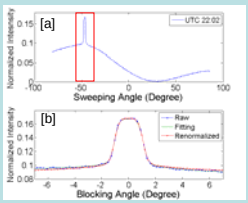
Calibration and Pre-Processing



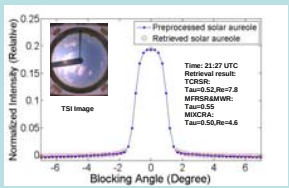
- *The accuracy of a lab calibration for TCRSR is about 4%.*
- *For the MFRSR, the accuracy of Langley calibration, for the passband 415 nm, is within 1%.*
- *We calibrate TCRSR against the collocated and well-calibrated MFRSR.*

(a)Normalized blocked intensity for the 2 ° band of the TCRSR during a sweep ;

(b) Expanded view around the solar aureole region in terms of blocking angle,.



Retrieval and Evaluation

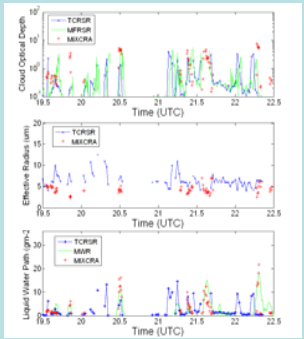


One case of the preprocessed solar aureole from TCRSR measurements and the retrieved solar aureole.

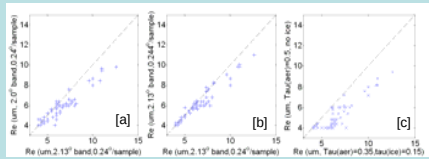
Intercomparison with MFRSR and MWR, MIXCRA

Comparison of cloud optical depth, effective radius, and LWP inferred from TCRSR, MFRSR, AERI, and MWR for cases on July 3, 2008 at the ARM SGP site.

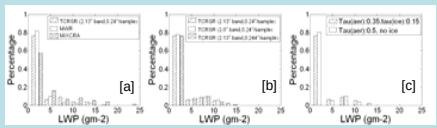
They show reasonable agreements with each others.



Sensitivity studies



Comparison of cloud effective radius with a narrower shadowband (a), a fast rotating speed (b), and without ice cloud considering (c).



Distributions of LWP from MWR, AERI, and TCRSR, including LWP distributions from TCRSR sensitivity tests.

Conclusion

After carefully calibrating and pre-processing, our results indicate that **TCRSR** is able to retrieve simultaneously **cloud optical depth, effective radius**, and **LWP** for optically thin water clouds. The retrieved cloud properties show reasonable agreements with other measurements even for this complicated situation (thin ice cloud over low-level water clouds).

Contact information

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