COMPARISON OF AIRBORNE AND SPACEBORNE MEASUREMENTS OF SOLAR NADIR RADIANCE REFLECTED BY CLOUDS AND RETRIEVED CLOUD OPTICAL PROPERTIES DURING ACRIDICON

T. C. Krisna[1], A. Ehrlich[1], M. Wendisch[1] and F. Werner[2]

[1] Leipziger Institut für Meteorologie (LIM), Universität Leipzig, Deutschland

[2] University of Maryland, Baltimore County, USA

UNIVERSITÄT LEIPZIG

Correspondence :
trismono_candra.krisna@uni-leipzig.de

ACRIDICON - CHUVA Manaus 2014

1. Introduction and Objectives

ACRIDICON-CHUVA : **A**erosol, **C**loud, Precipitation, and **R**adiation **I**nteractions and **D**ynamIcs of **CON**vective Cloud Systems (*Wendisch et al., 2016*)

Measurements

- Airborne for Solar Radiation (***Radiance and Irradiance***)
- Satellite for Solar Radiation (***Radiance***)
- Satellite for Atmospheric Vertical Profile (***Radar Reflectivity***)

to validate AQUA-MODIS remote sensing data (**Radiance and Cloud Properties**)

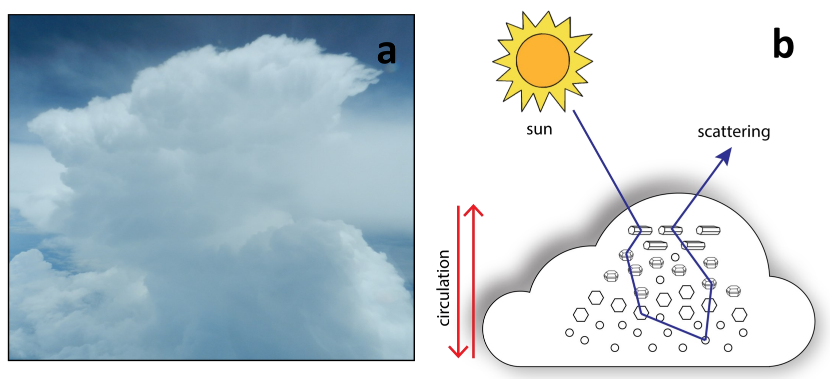


Fig. 01 : *Photo of a Deep Convective Couds (DCCs) during ACRIDICON-CHUVA **(a)** and illustration of solar radiation-cloud interaction **(b)**.*

2. Instrumentation

Instruments of ACRIDICON-CHUVA campaign used in this work :

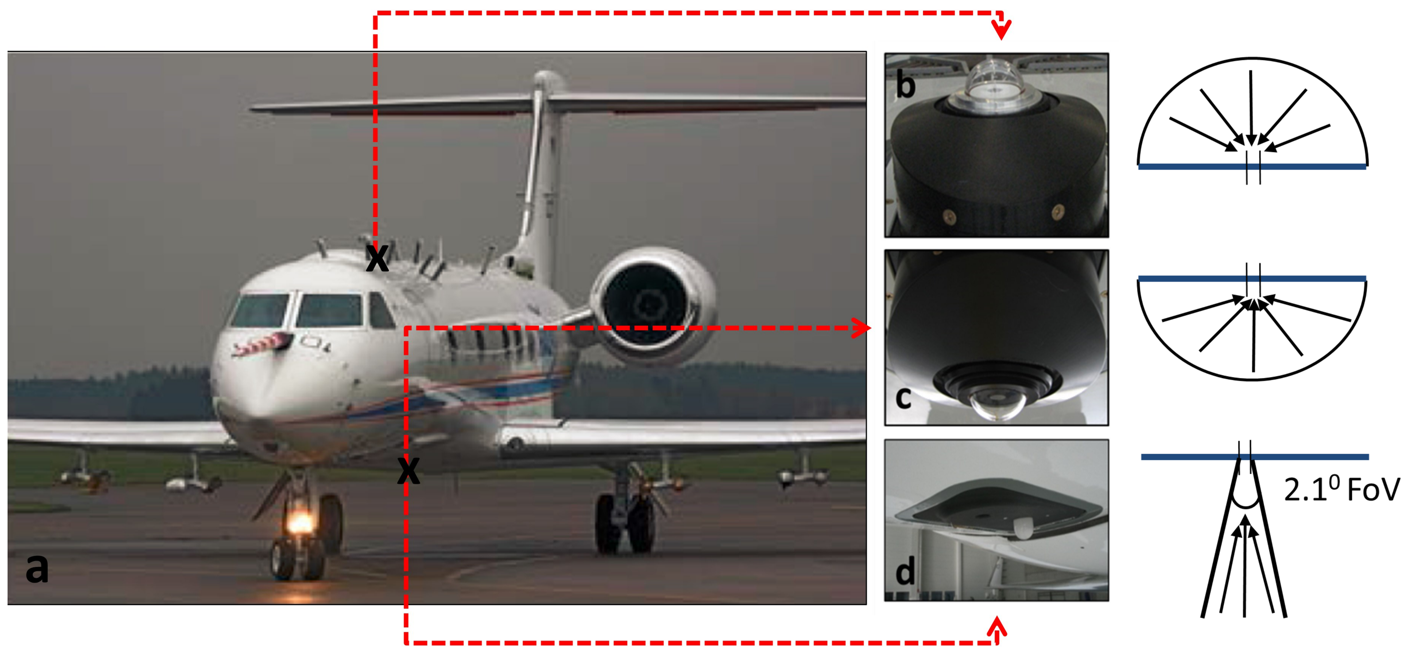
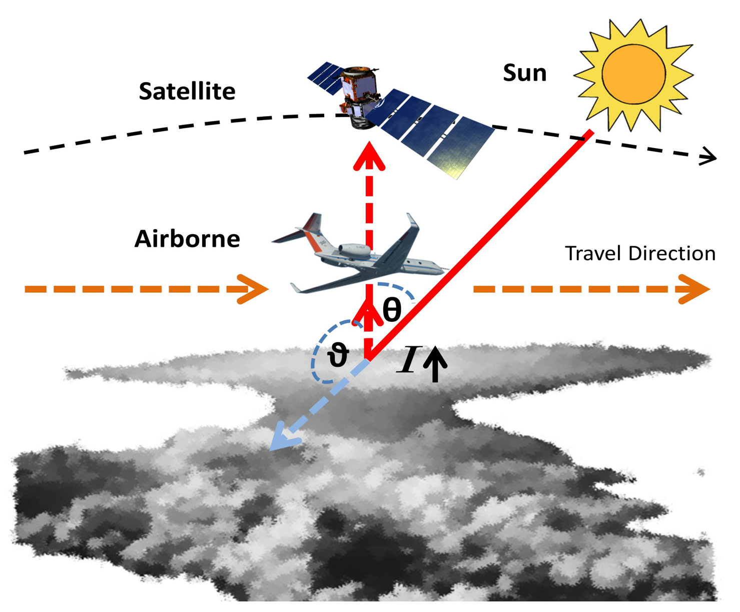


Fig. 02 : *SMART-Albedometer installed on HALO **(a)**, optical inlet and its measurement illustration of downward irradiance F↓ **(b)**, upward irradiance F↑ **(c)** and upward radiance **I↑** with 2.1° FoV **(d)**.*

Table 01 : *Spectral bands and respective resolution for Spectral Modular Airborne Radiation Measurement System (SMART-Albedometer), AQUA-MODIS, and CLOUDSAT.*

Sensor	Spectral Band	Spatial Resolution
SMART	- Spectral 0.3 - 2.2 µm - Spectral resolution 2 -16 nm FHWM	220 meter for 6 km asl (horizontal)
AQUA-MODIS	Discrete 36 bands 0.4 - 14.2 µm	250 - 1000 meter for 705 km asl (horizontal)
CLOUDSAT	Radar (94 GHz)	500 meter (vertical)

3. Measurement Strategy and Methodology



Θ : solar zenith angle **ϑ : scattering angle**

Fig. 03 : *Measurement strategy of solar nadir radiance reflected by the clouds.*

- HALO was designed to fly at the same track and under AQUA-MODIS during satellite overpass which leads nearly the same SZA and SAA.
- Direct validation is the comparison of solar nadir radiance reflected by the clouds.
- Indirect validation is the comparison of retrieved cloud properties (τ and r_{eff}).

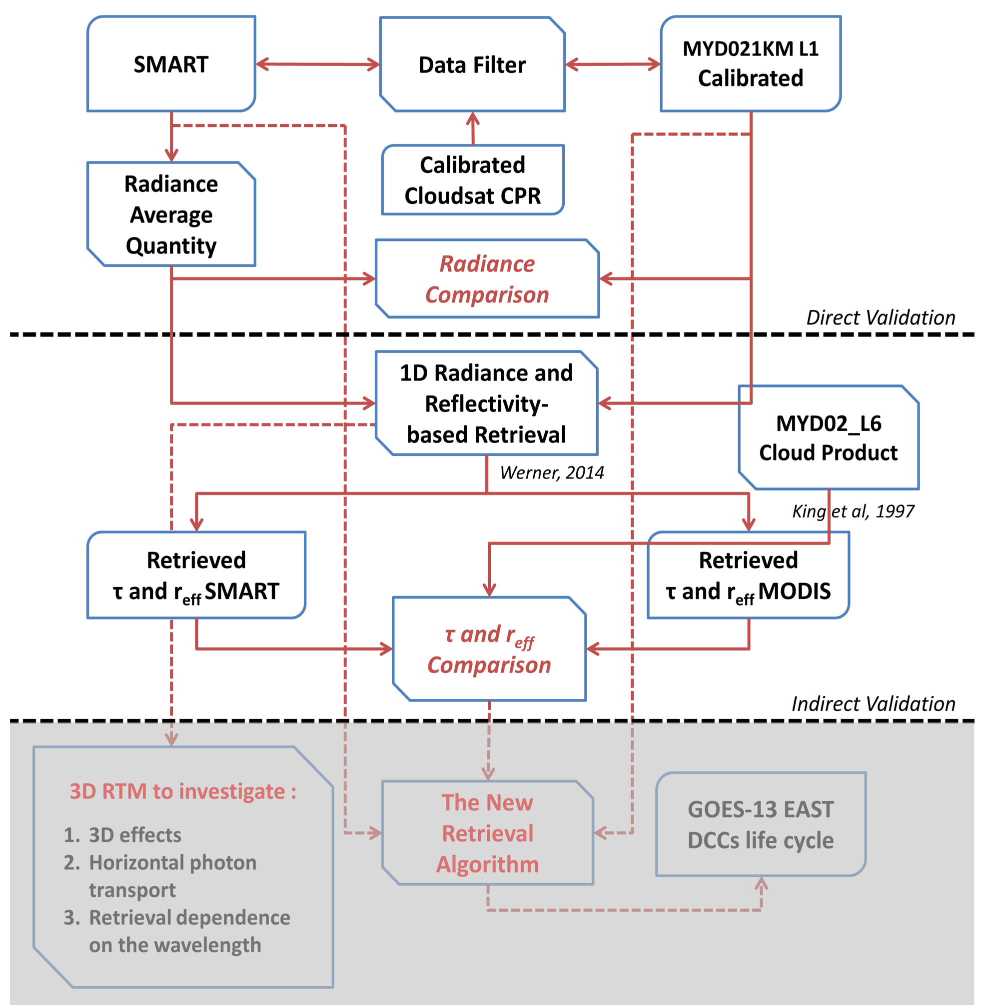


Fig. 04 : *Flow diagram of the methodology. Shaded area indicates ongoing activities.*

4. Direct and Indirect Validation

Reflected Solar Radiance and Cloud Optical Properties comparison

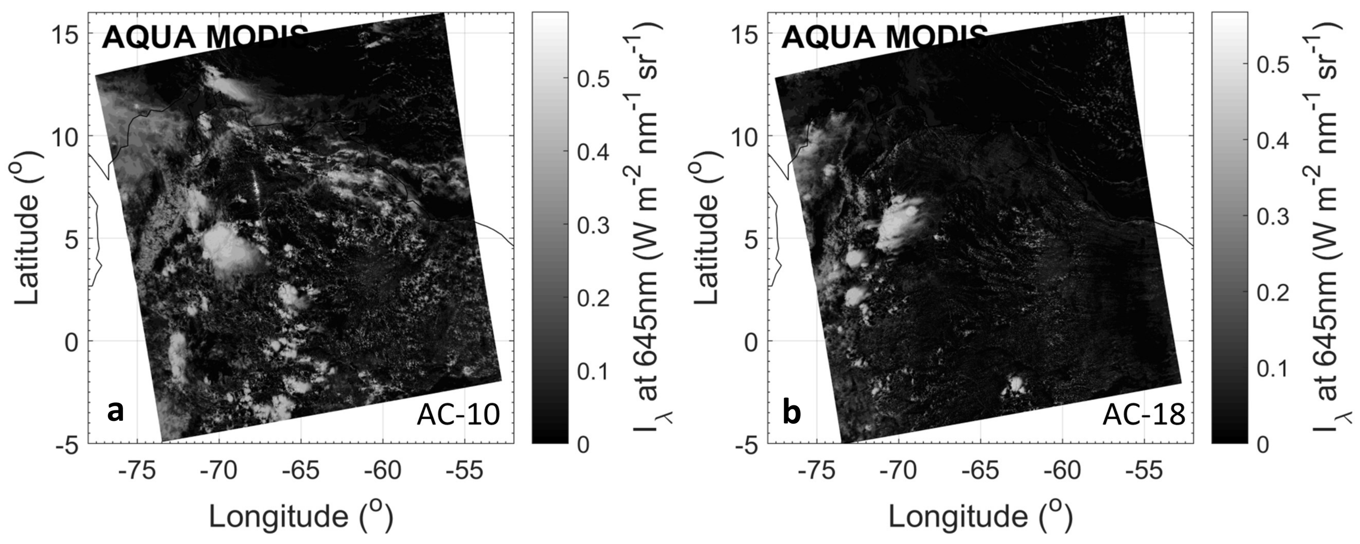


Fig. 05 : *The 250 m spatial resolution of **I↑** measured by MODIS MYD021KM band 1 (**λ** = 645 nm) during satellite overpass in AC-10 **(a)** and AC-18 **(b)**.*

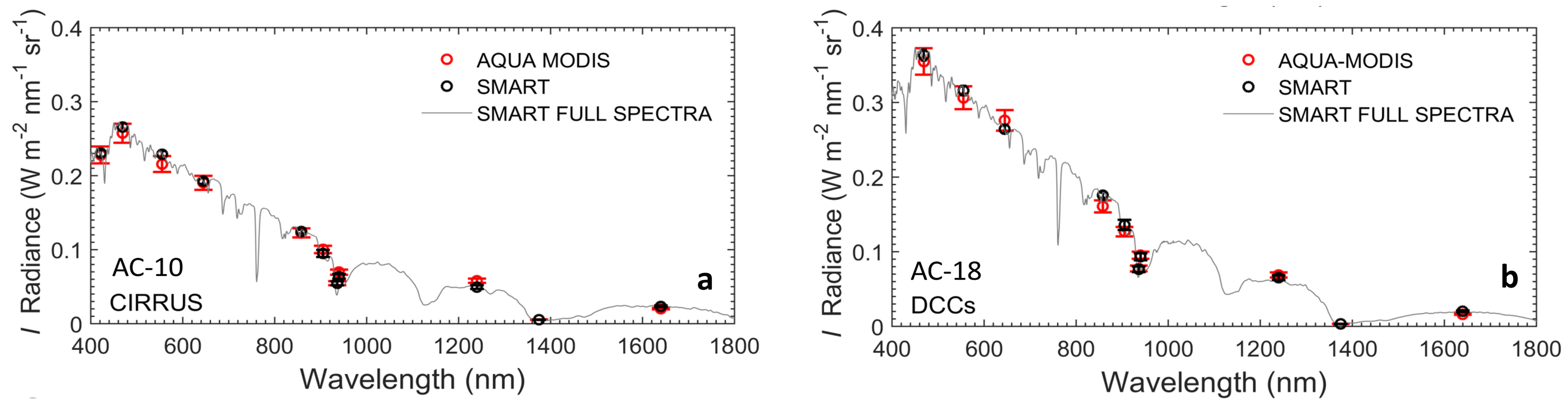


Fig. 06 : *Direct validation for Cirrus **(a)** and DCCs **(b)** case. SMART full spectra was integrated with the Relative Spectral Response (RSR) of AQUA-MODIS. Errorbars indicate measurement uncertainties.*

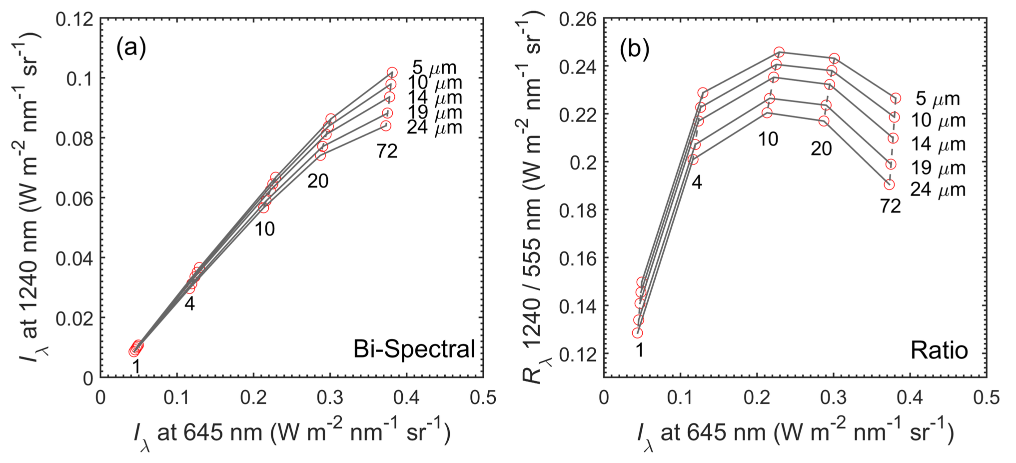


Fig. 07 : *Lookup table of Radiance methods. Standar Bi-spectral Retrieval (SBR) algorithm **(a)** and Ratio Retrieval (RR) algorithm **(b)** according to Werner et al (2014). SZA = 37° and SAA = 32° and various τ and r_{eff}. 1D RTM was performed using LibradTran 2.0.*

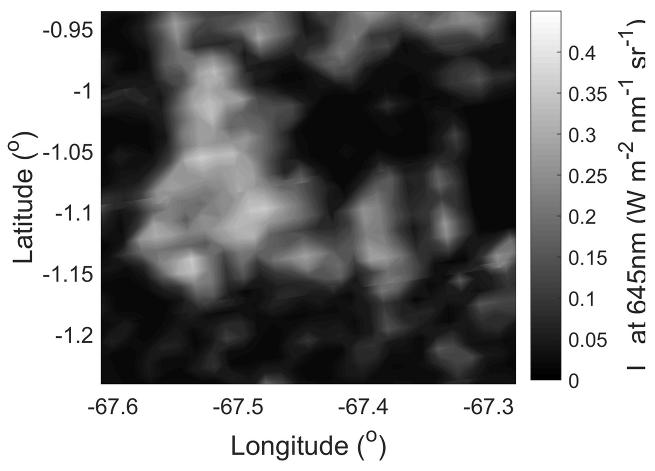


Fig. 08 : ***I↑** at 645 nm of the investigated Deep Convective Clouds (DCCs) at AC-18. HALO fly above DCCs during 17:56 - 17:58 UTC*

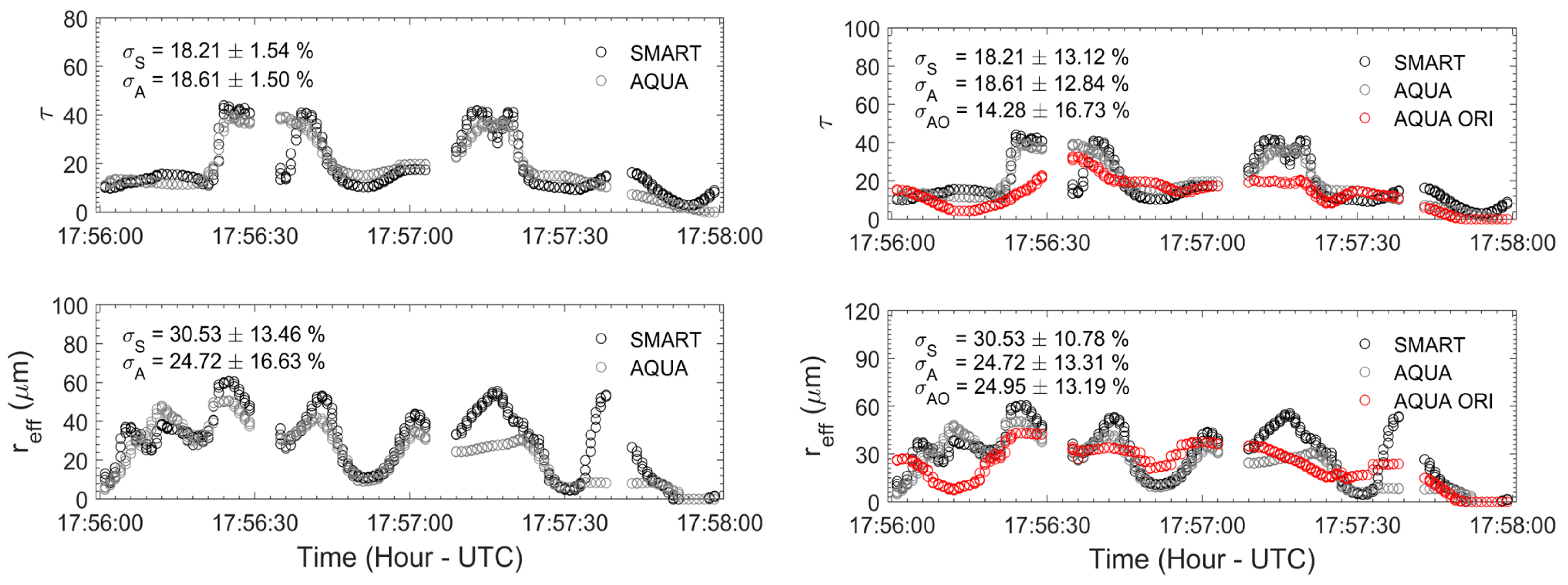


Fig. 09 : *Retrieved cloud properties using a combination between 645 nm and ratio of 1240 / 550 nm (**left**). Comparison with MYD02_L6 Cloud product (red circle) in **right** side. The retrieval assumed liquid water cloud thermodynamic phase. Mean absolute deviation (MAD) is calculated to quantify the agreement.*

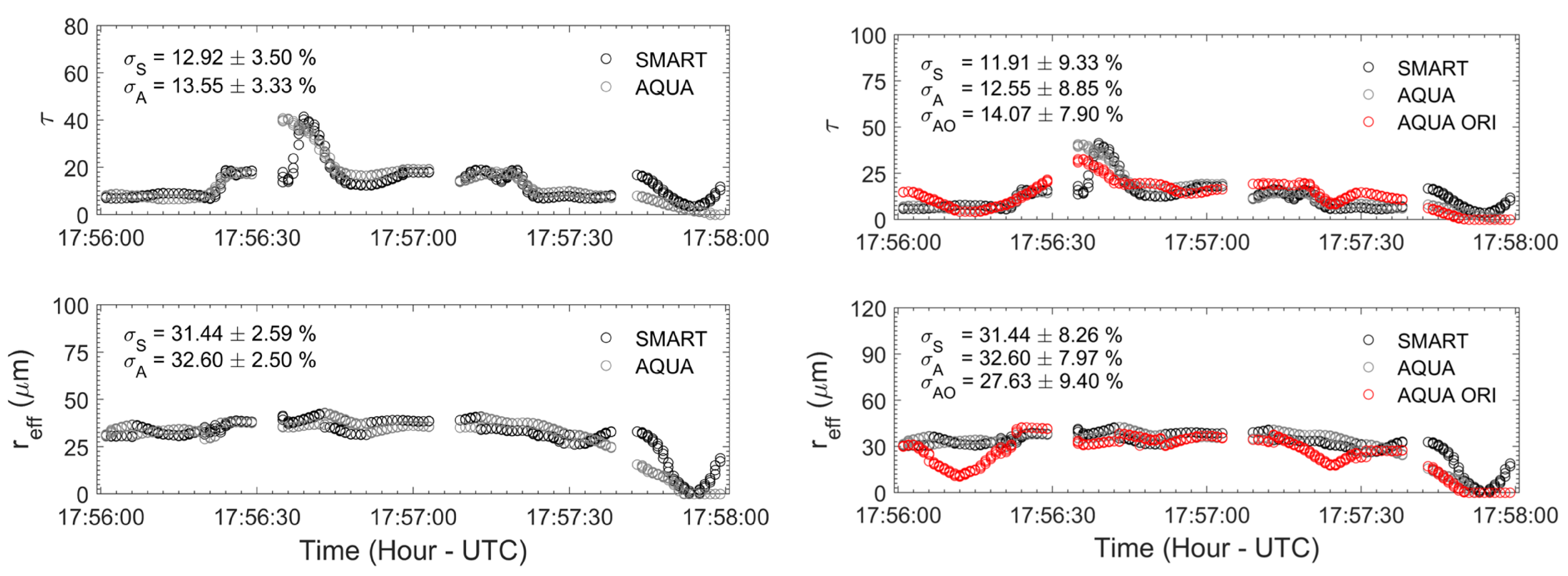


Fig. 10 : *Retrieved cloud properties using a combination between 645 nm and ratio of 1640 / 550 nm (**left**). Comparison with MYD02_L6 Cloud product (red circle) in **right** side. Cloud thermodynamic phase (liquid water and ice clouds simulation) has been integrated on the retrieval.*

Interpretation :

Direct Validation

- High agreement is achieved with overall σ ≤ 5%, except on 1240 nm which result σ ± 12%

Indirect Validation

- Retrieval deviation (σ) correspond to the direct validation result.
- DCCs contain complex cloud thermodynamic phase (ice, liquid water, and mixed phase).
- MYD02_L6 use reflectivity-based SBR 645 nm and 2100 nm according to *King et al., 1997*, where 2100 nm was approached by 1640 nm on the retrieval due to low signal on SMART 2100 nm.
- Cloud properties retrieval is dependence of the choosen wavelength. In addition 3D effect on DCCs has significant role which can't be handled by using 1D plane parallel RTM.

5. Outlook

I. Building a new retrieval to be applied on GOES-13 East in order to investigate DCCs life cycle.

II. Performing 3D RTM to investigate 3D effect and retrieval dependence on the choosen wavelength due to vertical photon transport.

Reference

[1] M. Wendisch et al (2016), The ACRIDICON-CHUVA campaign : Studying tropical deep convective clouds and precipitation over Amazonia using the new German research aircraft HALO. *Bull Am Meteorol Soc, doi : 10.1175/BAMS-D-14-00255.1.*

[2] F. Werner (2014), Twomey Effect of Trade Wind Cumuli. *PhD Dissertation*. Leipziger Institut für Meteorologie (LIM), Universität Leipzig.

[3] King et al (1997), Cloud Retrieval Algorithms for MODIS : Optical Thickness, Effective Particle Radius, and Thermodynamic Phase. *MODIS Algorithm Theoretical Basis Document No. ATBD-MOD-05.*

Acknowledgement

- Special thank to the DAAD for the scholarship funding.
- Thanks to all of the ACRIDICON-CHUVA members.

Version 06.07.2016