Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure
and Water Management*

Investigating the sensitivity of SEVIRI liquid cloud optical properties retrieval to illumination conditions using two MSG satellites

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Presentation Outline

Introduction

SEVIRI

- On board geostationary satellites Meteosat-8, 9, 10, 11 (aka MSG-1, 2, 3, 4)
- 12 channels
- 15-minute repetition cycle

CM SAF data record CLAAS-2

- 2004 – 2015 (extended to 2017)
- L2: 15-min, native 3 km × 3 km
- L3: daily, monthly mean and monthly mean diurnal cycle (0.05° × 0.05°)
- Cloud fraction, top, phase, τ, r_e, water path

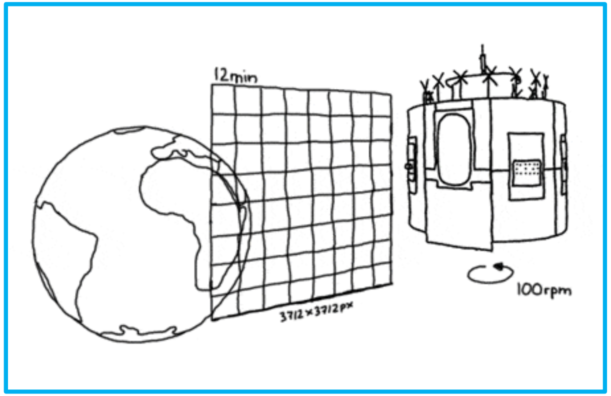
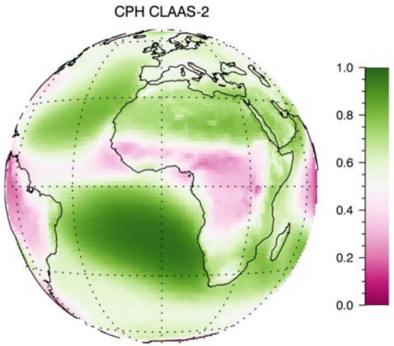


Image credit: moments-from-space.com

The EUMETSAT Network of Satellite Application Facilities

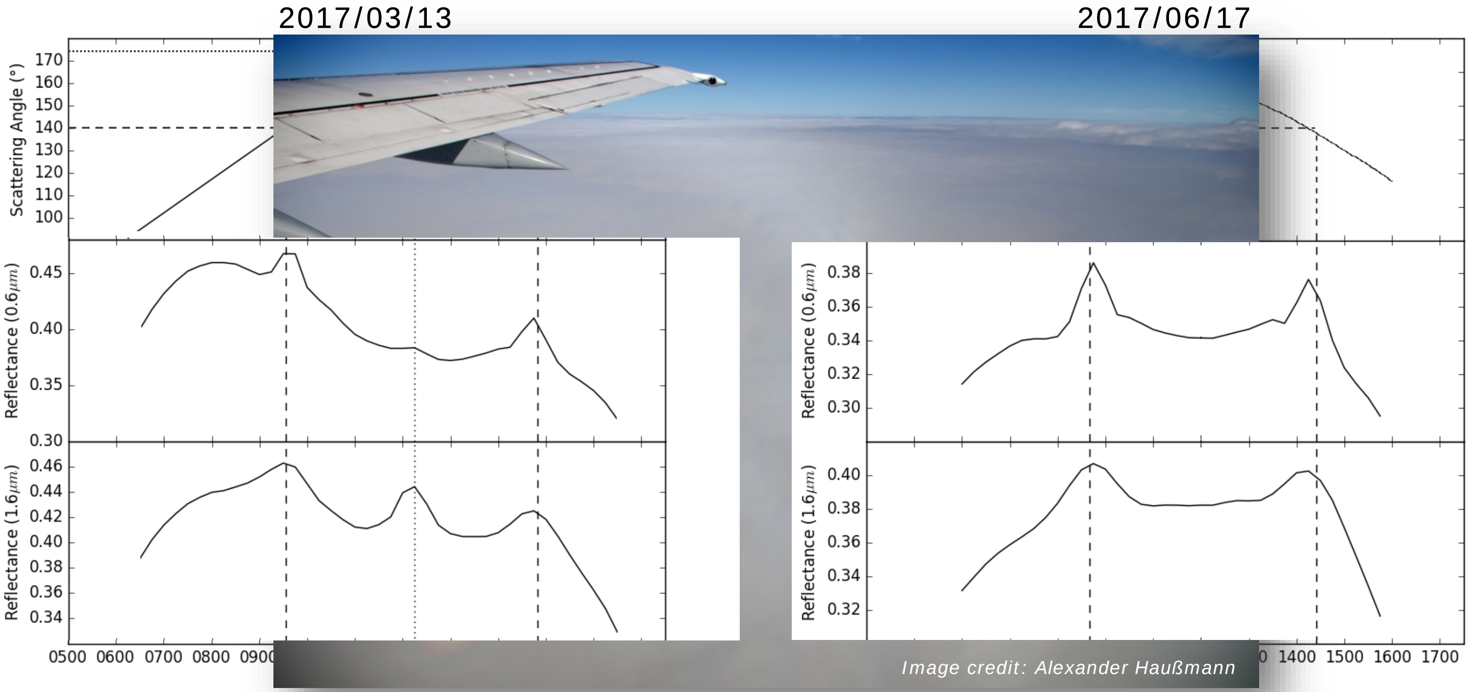
CM SAF Climate Monitoring



Benas et al., 2017

Introduction

Irregularities reported by users when focusing on specific days and places which coincide with cloud glory and cloud bow illumination conditions



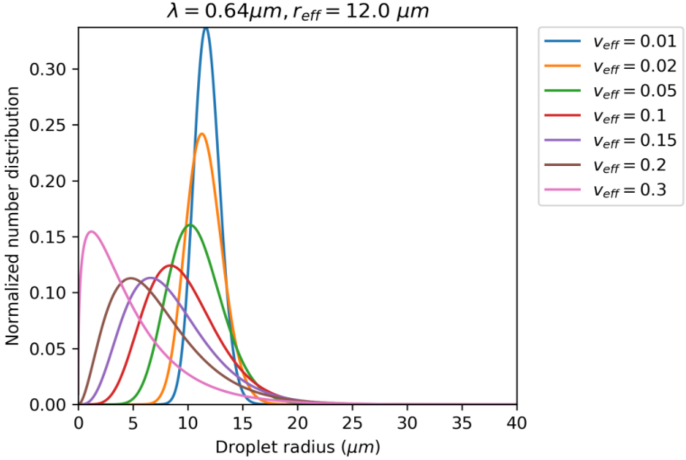
Introduction

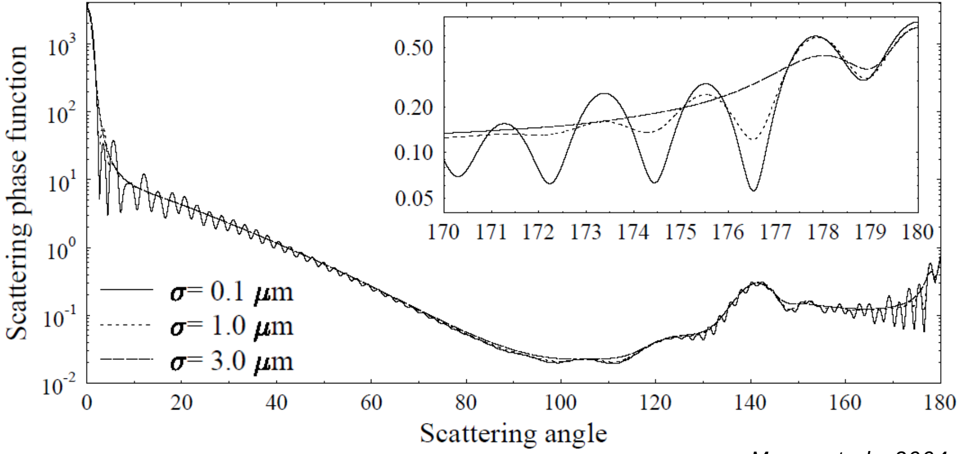
Retrieval details

1. Assume a droplet size distribution

The two parameter gamma size distribution

$$n(r) = N_0 r^{\frac{1-3v_e}{v_e}} \exp\left(\frac{-r}{r_e v_e}\right)$$





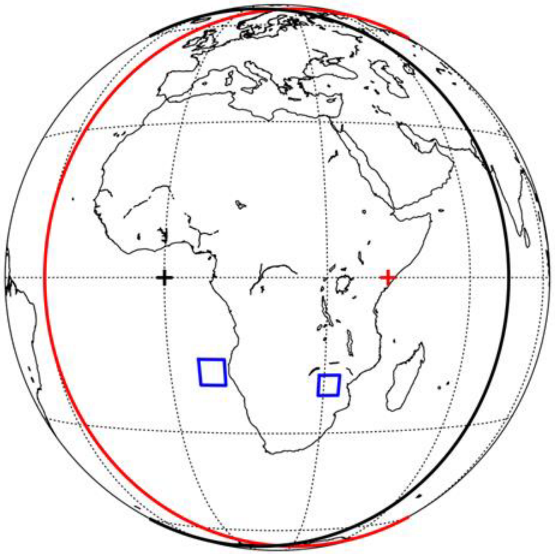
Mayer et al., 2004

Typical values of v_e in satellite retrievals

0.10 (MODIS C6, PATMOS-x)
0.11 (CC4CL)
0.13 (MODIS C5)
0.15 (CLARA-A2, CLAAS-2, ISCCP)

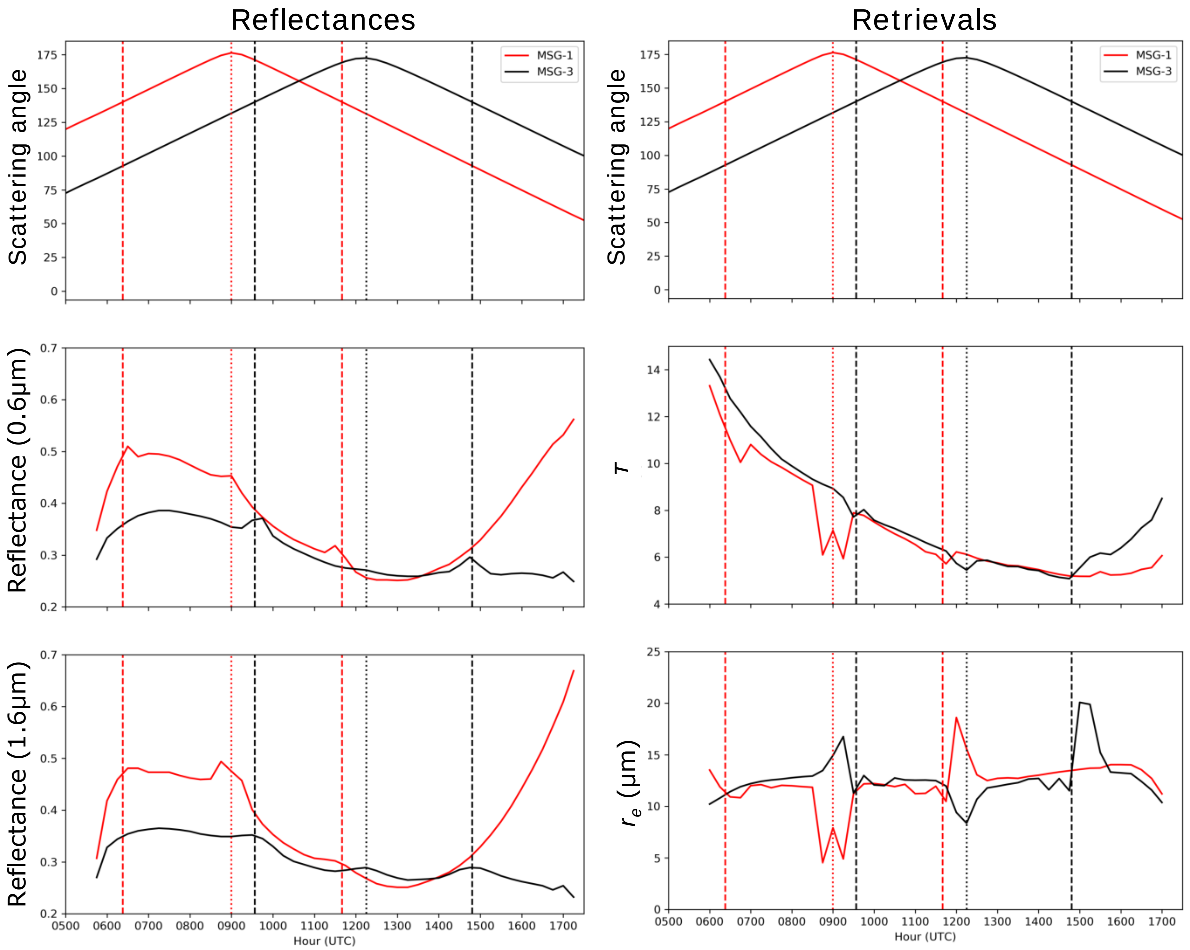
Introduction

- Combined use of **MSG-1** (41.5° E) and **MSG-3** (0.0°)
- Focus on a marine and a continental region and on specific days with uniform cloud cover
- Retrieve optical properties using different v_e and compare
- Repeat for channel pairs (0.6μm, 1.6μm) and (0.6μm, 3.9μm)



Results

MSG-1 vs. MSG-3

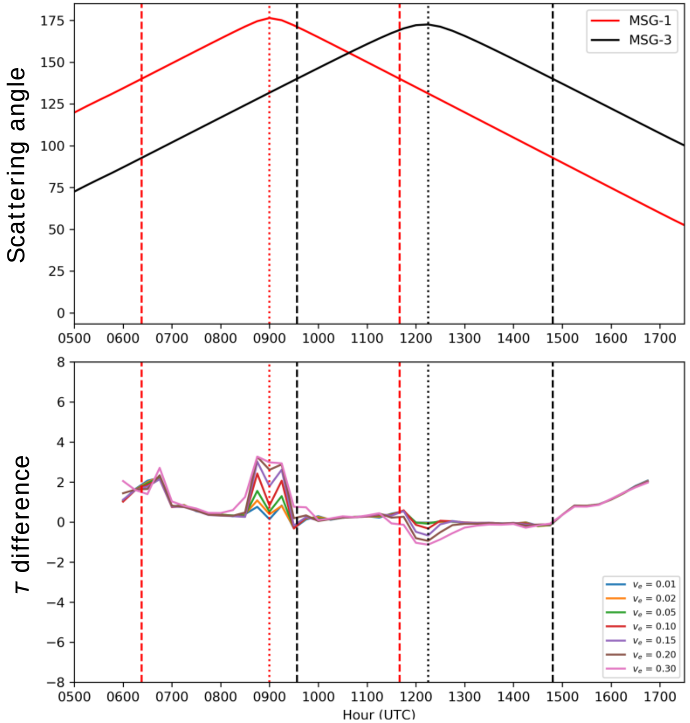


- S. Atlantic, 7 March 2017
- Retrievals with v_e = 0.15
- Irregularities in cloud bow and glory conditions

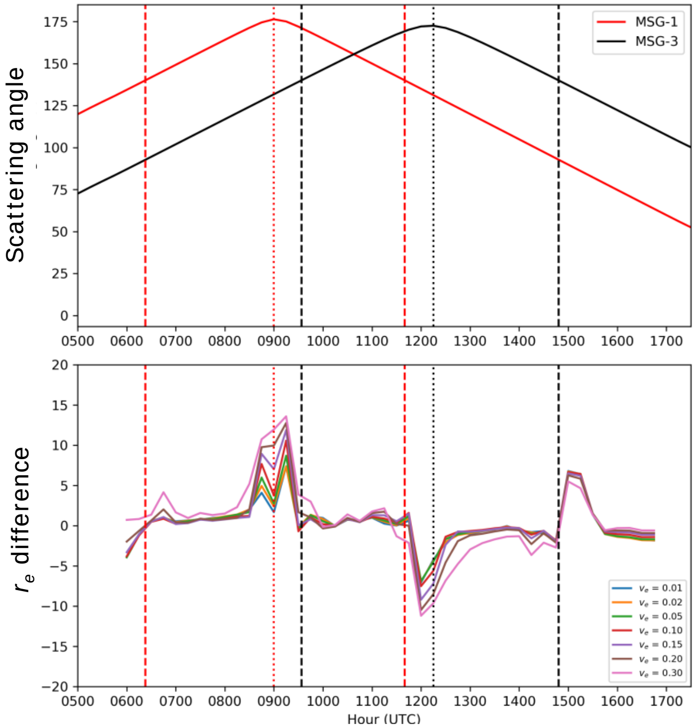
Results

Biases with varying v_e

MSG-3 – MSG-1 τ



MSG-3 – MSG-1 r_e

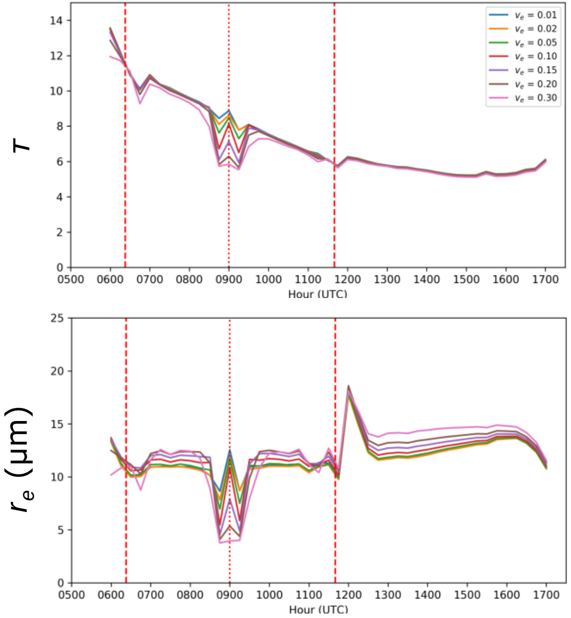


- Effect in τ pronounced in the cloud glory
- Overlap of glory and bow effects in r_e

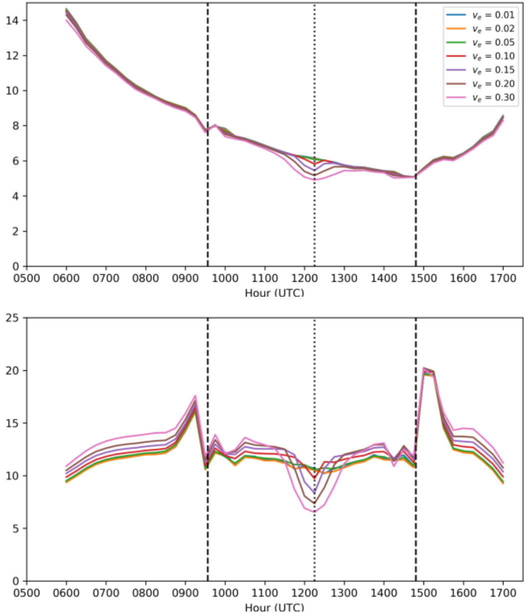
Results

Retrievals with varying v_e

MSG-1



MSG-3



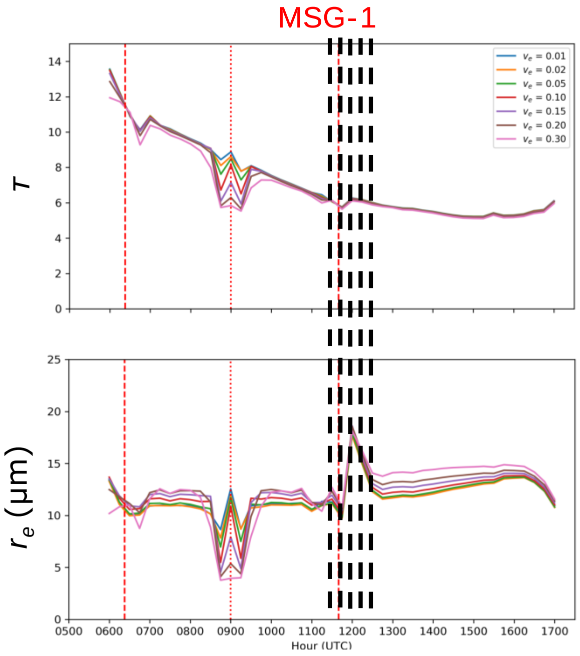
- <u>Differences due to v_e</u>

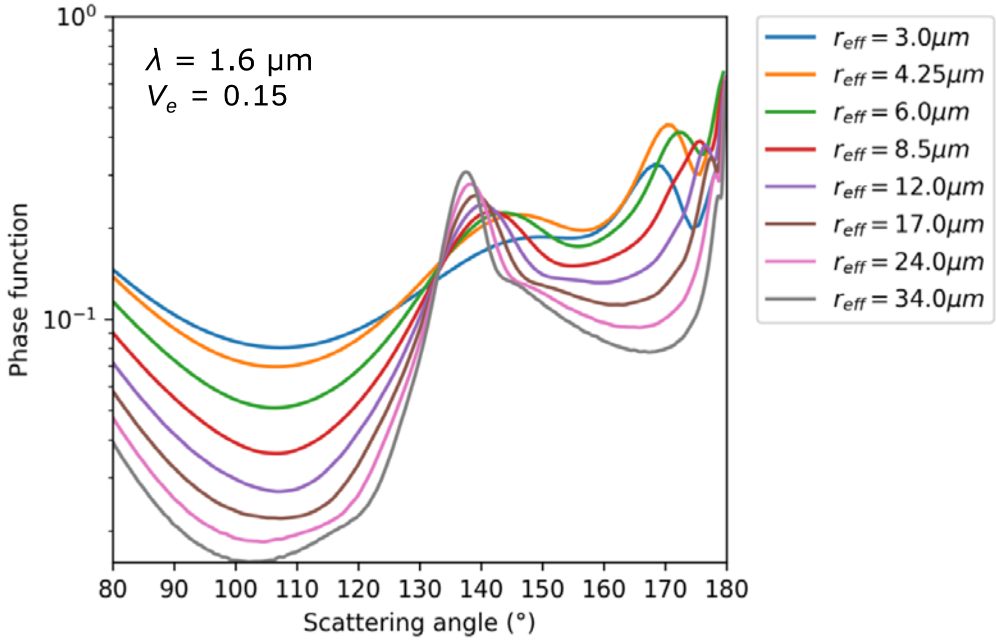
	τ	r_e
Mean diurnal	0.4	1 μm
Glory time slots	2.0	5 μm

- Diurnal variations smoother for $v_e < 0.10$
- No effect of v_e on cloud bow

Results

Retrievals vs. LUTs

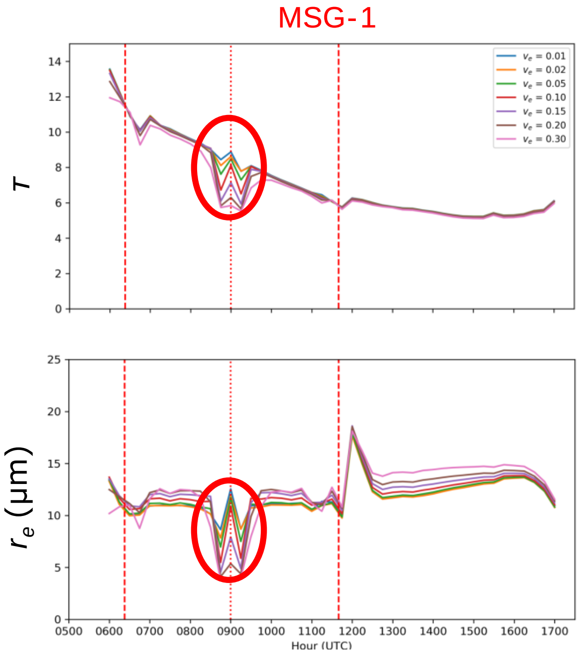


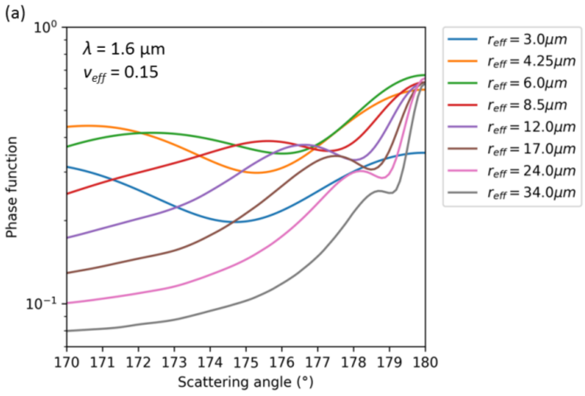


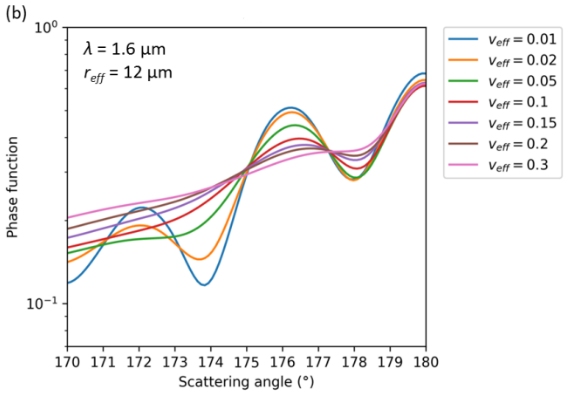
See also Cho et al. (2015)

Results

Retrievals vs. phase functions

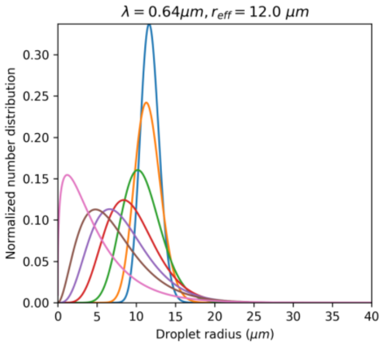




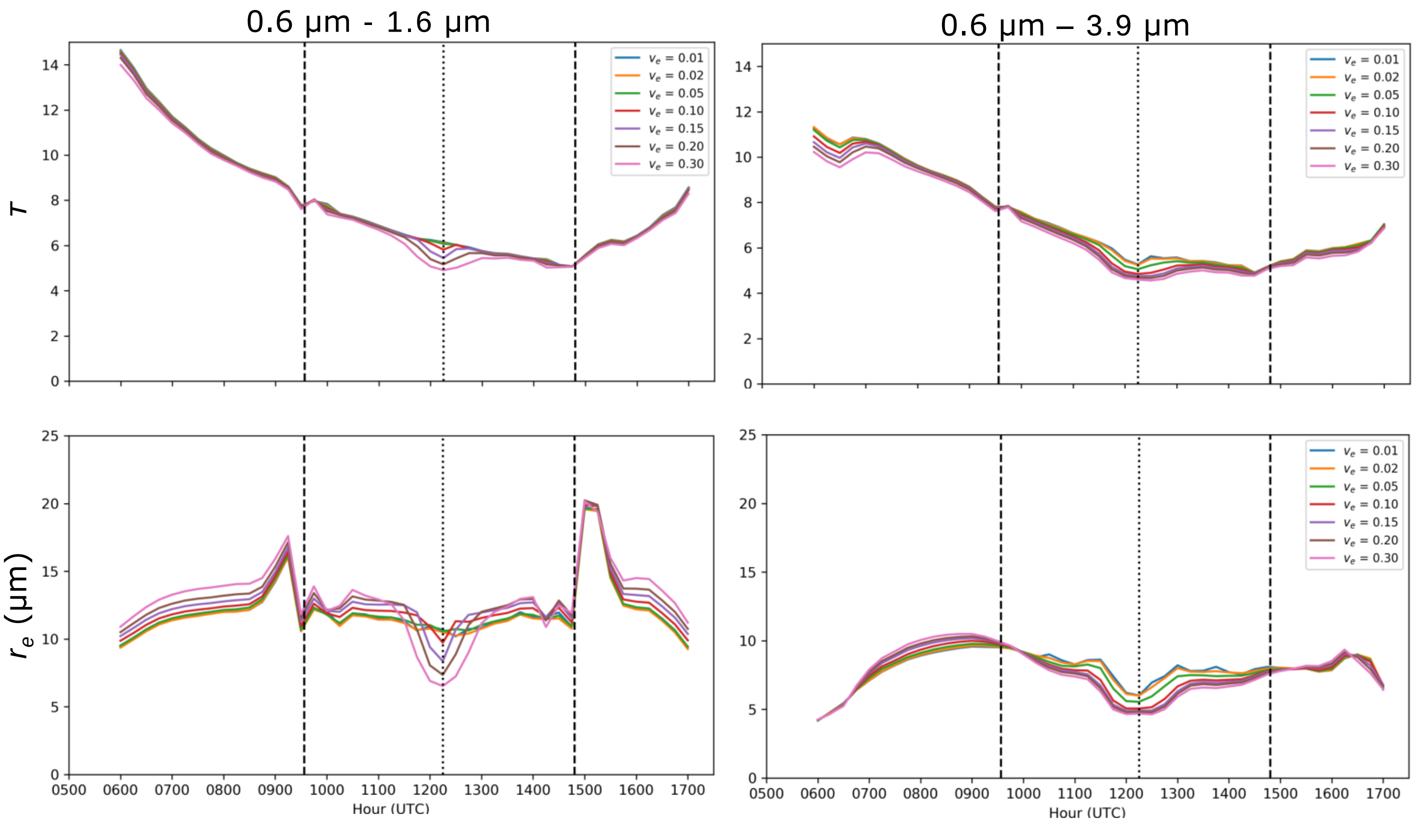


Results

Using the 3.9 µm channel



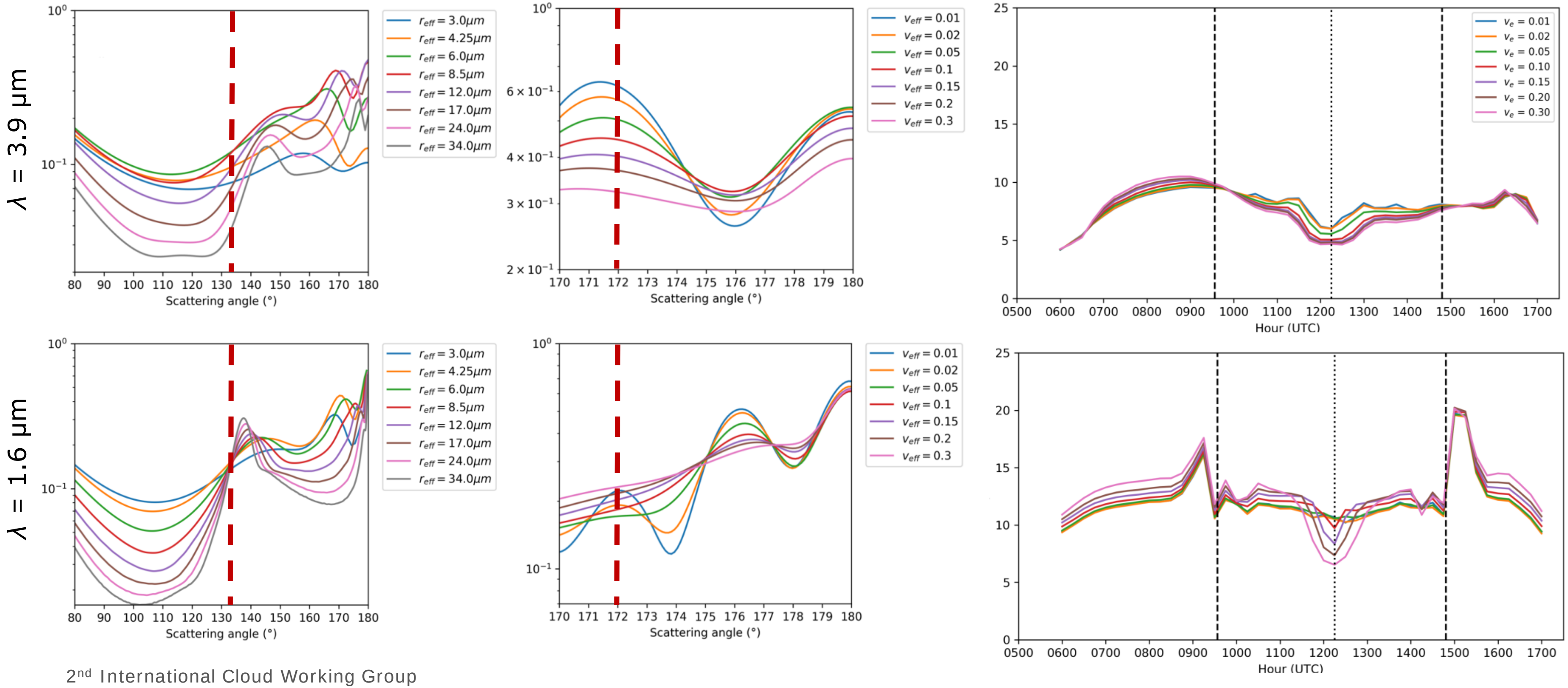
- The narrower DSD, the better?
- No apparent improvement for v_e < 0.10 in MSG-3
- 3.9 µm retrieval also suggests narrower distributions



Results

Using the 3.9 µm channel

v_e = 0.15 | r_e = 12 µm | Retrieved r_e (µm)

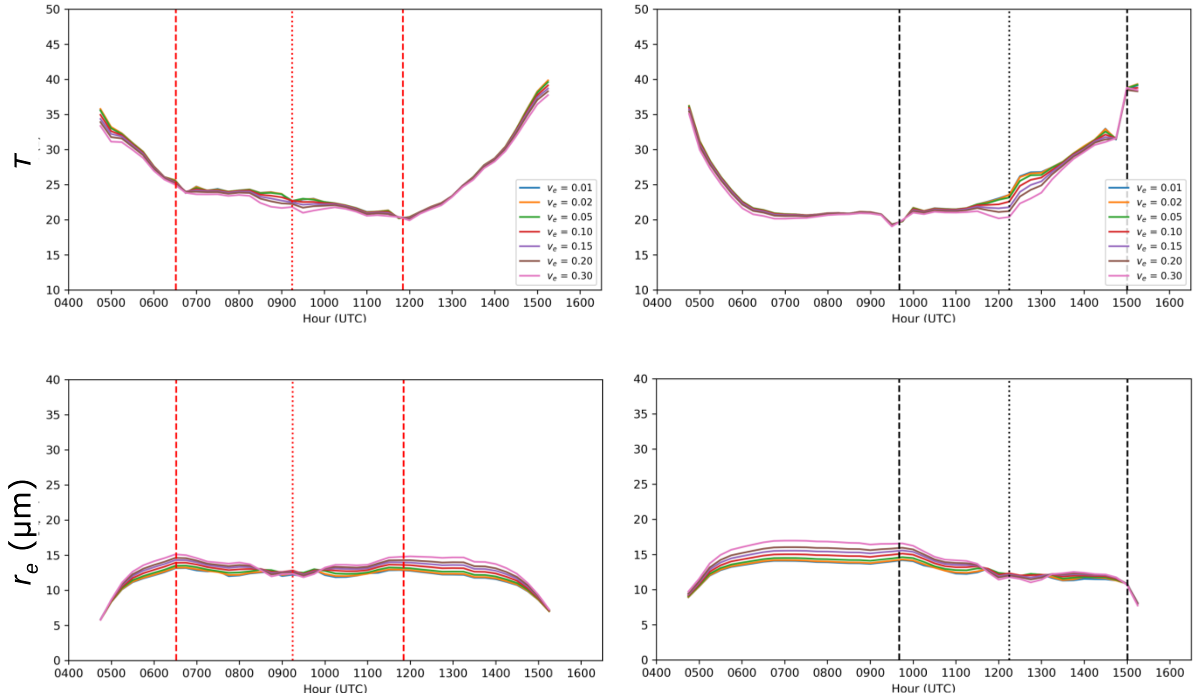


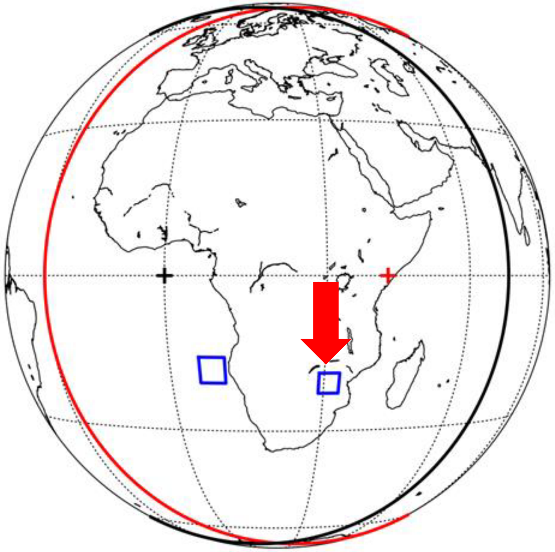
Results

Focusing on another region

MSG-1

MSG-3





- Indications of broader size distributions
- r_e “collapse” in cloud glory due to different max. angle

Discussion

$v_e = ?$

Cloud type	$\boldsymbol{v_e}$ **(μ ± 1σ)**
Continental *(Miles et al., 2000)*	0.20 ± 0.17
Marine *(Miles et al., 2000)*	0.17 ± 0.15
Marine Sc *(Miles et al., 2000)*	0.13 ± 0.08
Marine Sc *(Mayer et al., 2004)*	0.01 ± 0.002
Shallow Cu *(Igel and van den Heever, 2017)*	0.09 ± 0.04
Marine Sc *(Painemal & Zuidema, 2011)*	0.07 ± 0.04 (average profile) 0.04 ± 0.04 (cloud top)

Summary

- **Irregularities** reported in diurnal cycles of cloud optical properties were associated with **cloud bow** and **cloud glory** illumination geometries

- **Cloud bow** irregularities are **not affected** by varying the size distribution width, but **disappear** when the **3.9 µm channel** is used instead of the 1.6 µm.

- Retrievals in the **cloud glory** are clearly linked to the **width of the droplet size distribution** used.

- Our results and the literature suggest **optimal values of v_e around 0.05**, at least for marine low clouds, contrary to the typical values used in satellite retrievals (0.10-0.15)

- Potential to **retrieve v_e** in certain regions under specific illumination conditions

CLAAS-3 outlook

- **Update** in liquid cloud v_e (CLAAS-2: 0.15)
- **Retrieval** of liquid cloud optical properties **from both 1.6 µm and 3.9 µm** (CLAAS-2: only 1.6 µm)
- Estimation and inclusion of **CDNC** in the data record
- Reconsiderations in **cloud mask** and cloud **height** retrieval algorithms
- Improved **uncertainty estimates**
- Cover period: **2004 – 2020** (CLAAS-2: 2004 – 2015/2017)
- Planned release: **2021**