# Validation and Homogenisation of Cloud Properties Retrievals for RMIB GERB/SEVIRI Scene Identification

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# 1. Introduction

GERB angular conversion, i.e. TOA radiance–to–flux conversions, based on CERES ADMs for solar radiation.

$\Longrightarrow$ For best flux estimation, CERES and GERB SIs need to be as close as possible !

According to CERES ADMs, minimal features for RMIB GERB/SEVIRI SI are:

- ▷ cloud optical depth
- ▷ cloud fraction
- • cloud phase
- • surface type

BUT, CERES and GERB cloud identifications are based on different algorithms and radiative models $\rightarrow$ discrepancies between both cloud products (CPs).

$\Longrightarrow$ Need some corrective scheme to map GERB on CERES CPs.

# 2. Motivations

1. Detection of possible angular bias in the GERB cloud properties retrieval algorithms.

2. Development of some corrective scheme to map Instrument–1 on Instrument–2 CPs.

# 3. Cloud Properties Retrieval Algorithms

## Cloud optical depth $\tau$

- Simulated radiances $L$ for ocean, vegetation and bare–soil surfaces, ice and water clouds with several $\tau$ using SBDART RT code.

- Parametrization ($A$, $B$, $\chi$, $\tau_0$) of empirical relation between mean cloud amount $C$ and $\tau$ (sigmoïd in $\log \tau$) by LSF using those simulated $L$

$$C \triangleq \frac{L(\tau) - L(0)}{L(128) - L(0)} = \frac{A}{B + \left(\frac{\tau_0}{\tau}\right)^{1/\chi}} \tag{1}$$

where all quantities except $\tau$ are $(\theta_0, \theta, \varphi)$ and surface dependent.

- Estimation of $\tau$ with measured radiances $L(\tau)$, $L(0)$, simulated $L(128)$ and parameters associated to scene geometry through inversion of (1).

# 3. Cloud Properties Retrieval Algorithms

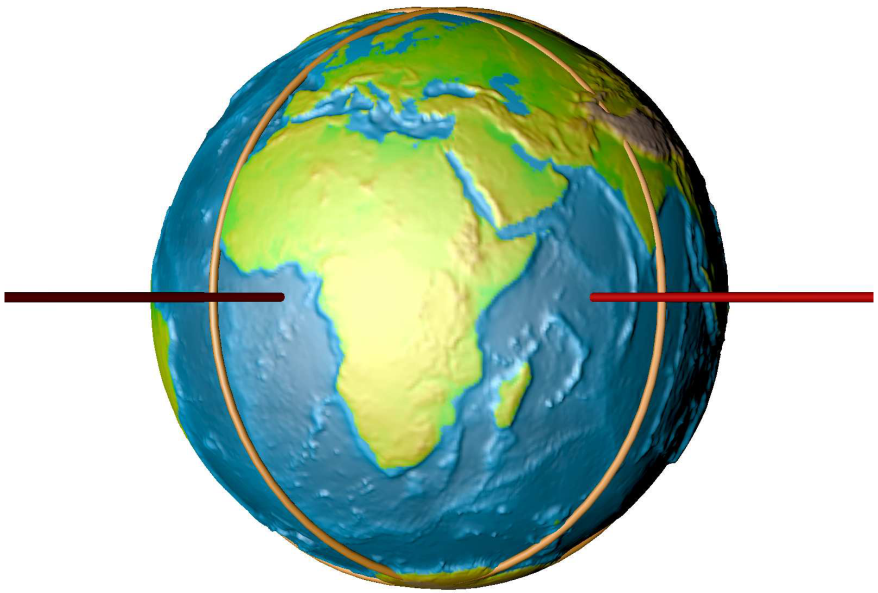
## Cloud fraction $f$

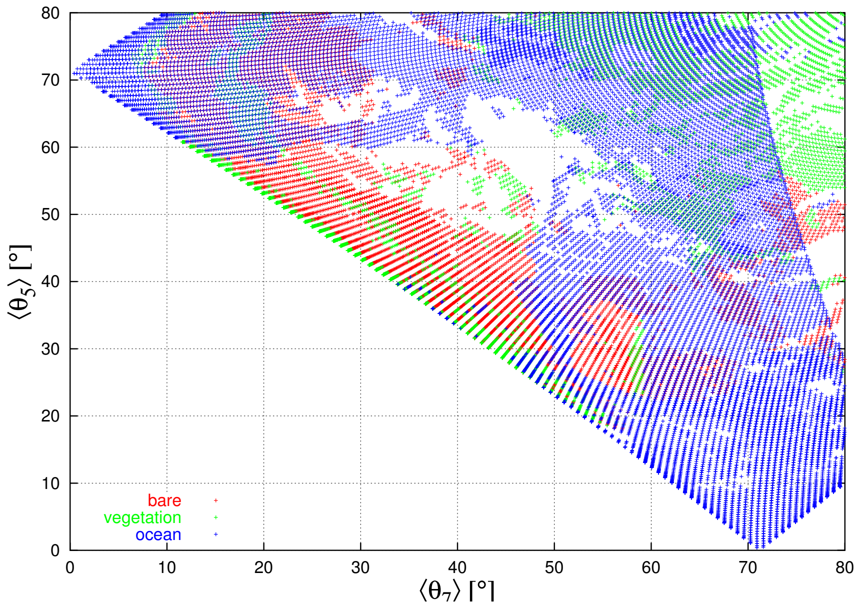
- Defined on some footprint, i.e. a set of pixels.
- Relative fraction of *cloudy* pixels within the footprint.
- *Cloudy* pixel if its $\tau > 1$ (this limit leads to approx. half of cloudy pixels in MS7 & 5 FOVs).

# 4. Data Description

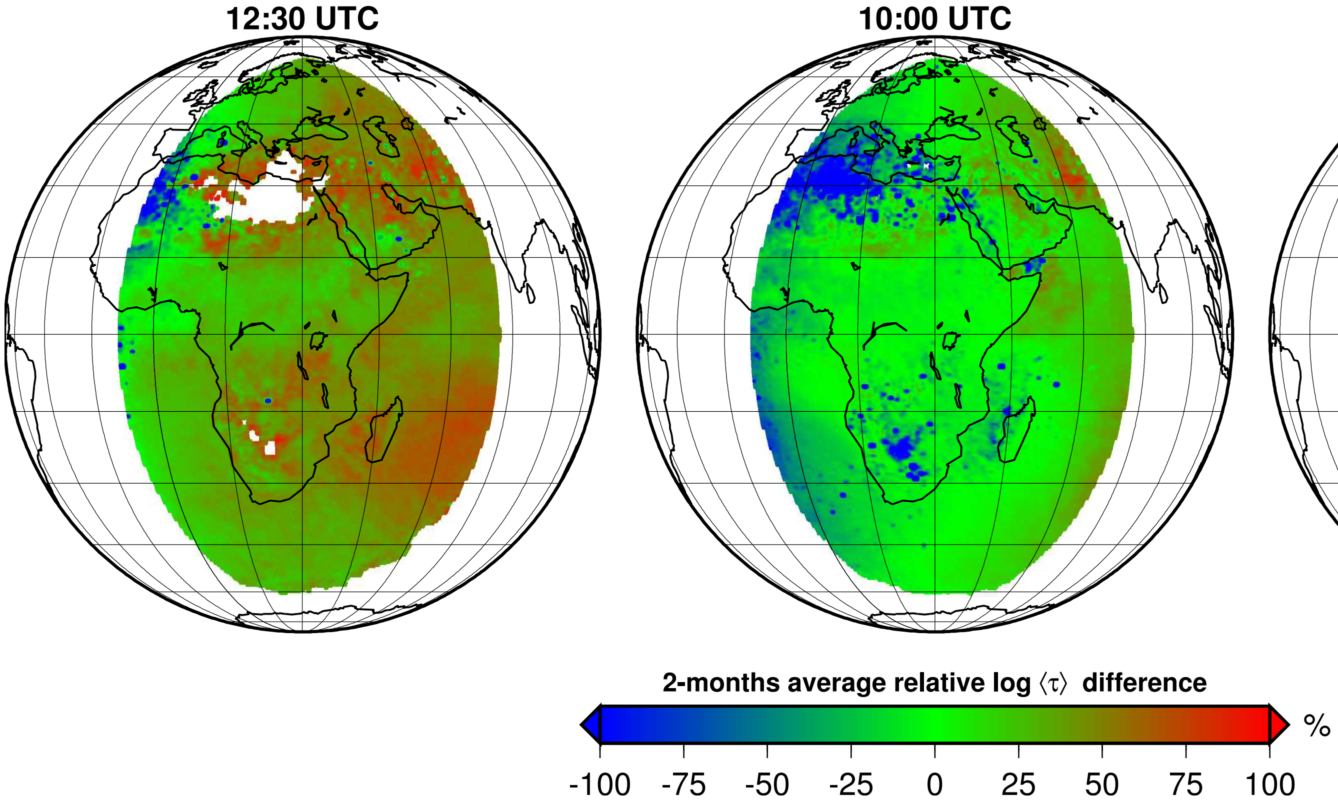
- visible MS7 and MS5 images from July+August 1998 at 12:30, 10:00 and 8:00 UTC.
- Intersection of both FOVs provides identical scenes with different geometries $(\theta_0, \theta_7, \varphi_7)$ & $(\theta_0, \theta_5, \varphi_5)$.
- To avoid cloud shadowing and cloud parallaxes sensitivity in FOVs $\Longrightarrow$ footprint–basis mean comparisons with nearly identical projected sizes on surface ($2500\,\mathrm{km}^2$ and $50 \times 50\,\mathrm{km}^2$ at $\pm 45^{\mathrm{o}}$ of latitude)
- For each footprint and satellite, we estimate $(\langle\theta_0\rangle, \langle\theta_i\rangle, \langle\varphi_i\rangle)$, mean surface, $f_i$, $\langle\tau_i\rangle$ where $i = 5, 7$.

# 4. Data description

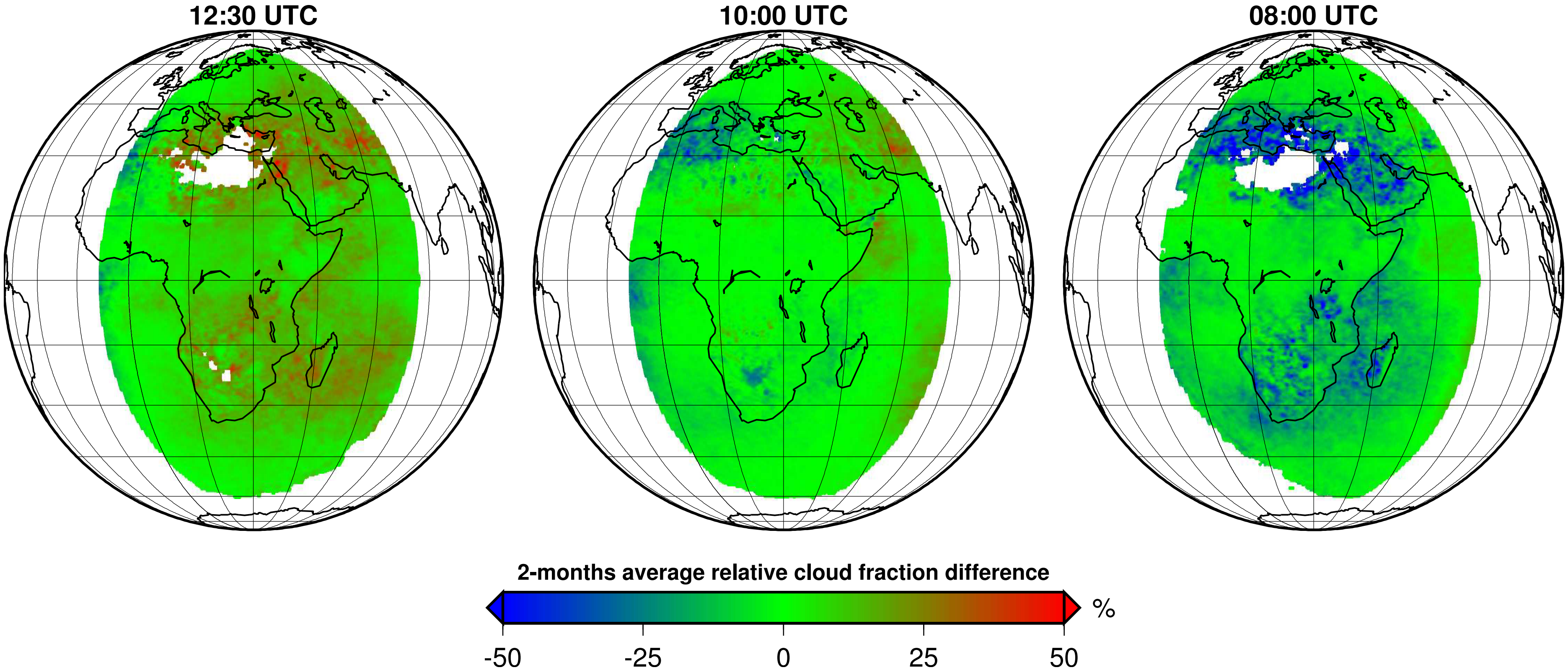




# 5. Analysis of the Retrievals



# 6. Analysis of the Retrievals



# 6. Analysis of the Retrievals

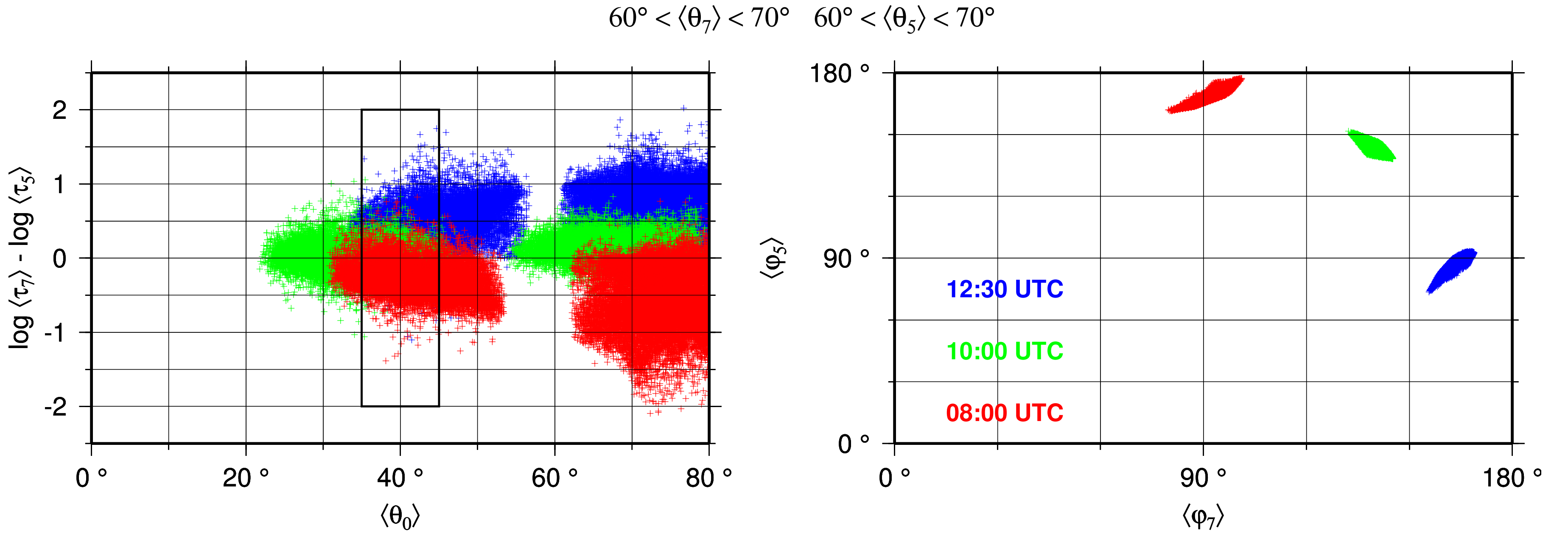
- $\tau$ variations according to surface type resolved by our algorithm.

▷ Sensitivity of $\tau$ retrievals according to all 3 angles $(\theta_0, \theta, \varphi)$ ?

- Due to the *cloudy* pixel boolean test, cloud fraction retrievals are less affected by scene geometry angles.

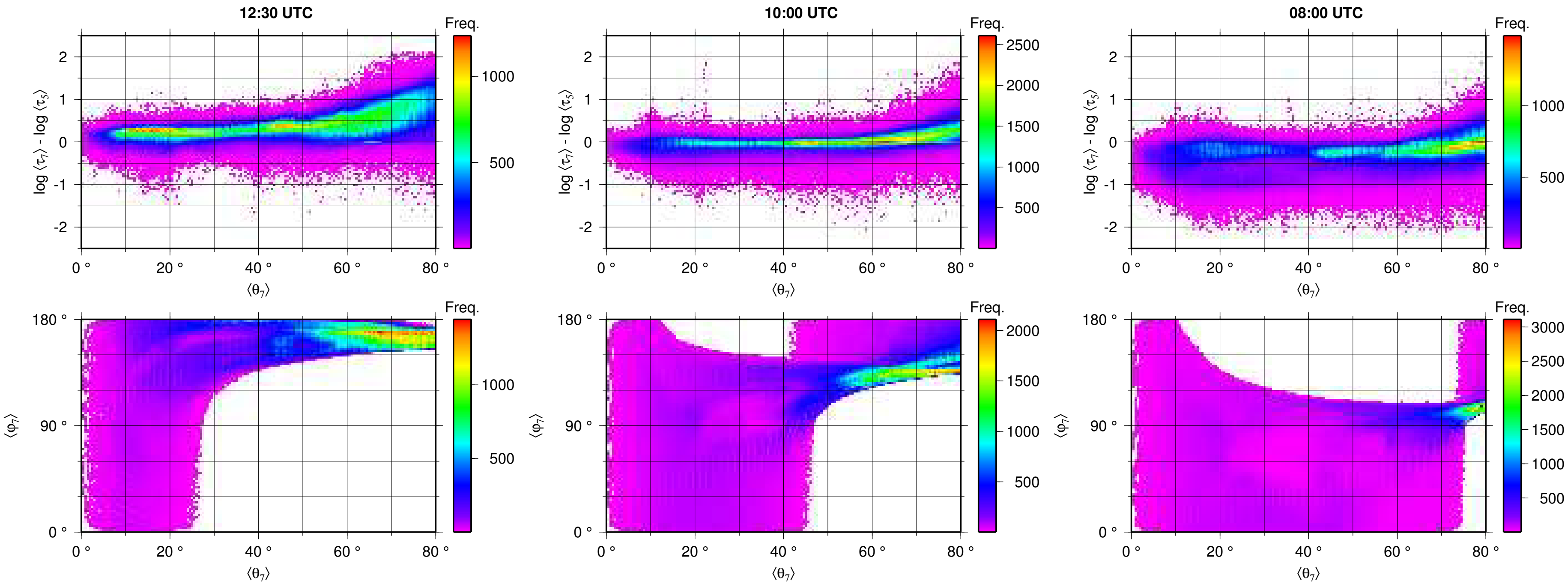
# 6. Analysis of the Retrievals

## Sensitivity of $\tau$ retrievals



# 6. Analysis of the Retrievals

## Sensitivity of $\tau$ retrievals



# 6. Analysis of the Retrievals

## Sensitivity of $\tau$ retrievals

$\tau$ retrieval errors are dependent of $(\theta, \varphi)$ (SBDART = plane–parallel code).

BUT, due to satellites configuration, each MS SLOT has a limited $\varphi$ variation.

$\Longrightarrow$ Homogenisation according to $\theta$ will be performed for each SLOT separately !

# 7. Homogenisation of the Cloud Optical Depths

1. Define a reference point which fixes values of one satellite compared to the other:
   ▷ Selection of footprints with $60^{\rm o} \leq \langle\theta_5\rangle \leq 70^{\rm o}$
   $\Longrightarrow$ $\langle\tau_5\rangle$ retrievals independent of $\langle\theta_5\rangle$ due its restricted variation.
   $\Longrightarrow$ scatter plot entirely explained by the $\langle\theta_7\rangle$ dependency of $\langle\tau_7\rangle$.

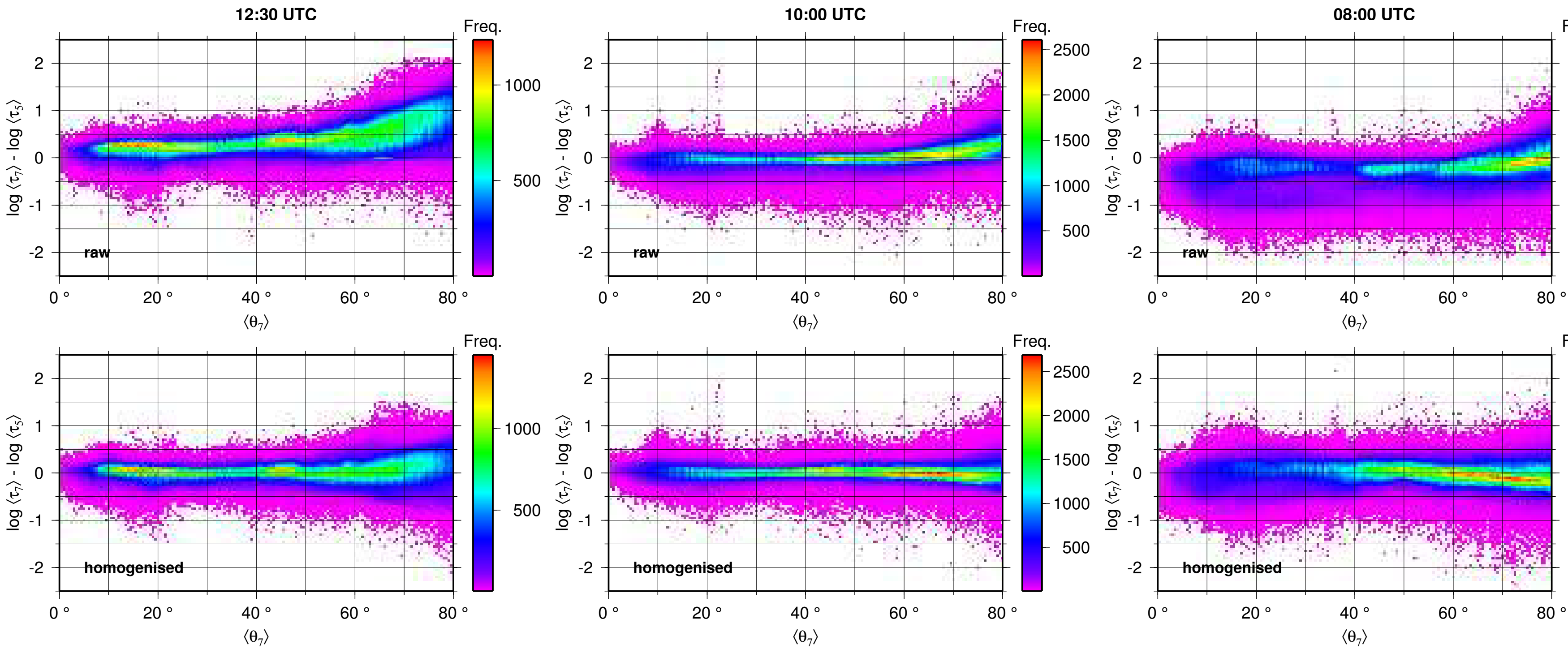
2. Modelize this dependency by LSF: $\log\langle\tau_7\rangle - \log\langle\tau_5\rangle = \mathcal{P}_3(\langle\theta_7\rangle)$.

3. MS5 is the reference, thus $\langle\tau_5\rangle \rightarrow \langle\tau\rangle$ can be seen as the MS7 homogenized value relative to the selected $\langle\theta_5\rangle$ range:

$$\langle\tau\rangle = \langle\tau_7\rangle \cdot 10^{-\mathcal{P}_3(\langle\theta_7\rangle)}.$$

Similar results hold when choosing MS7 as reference ($60^{\rm o} \leq \langle\theta_7\rangle \leq 70^{\rm o}$).

# 8. Validation of the Homogenized Retrievals



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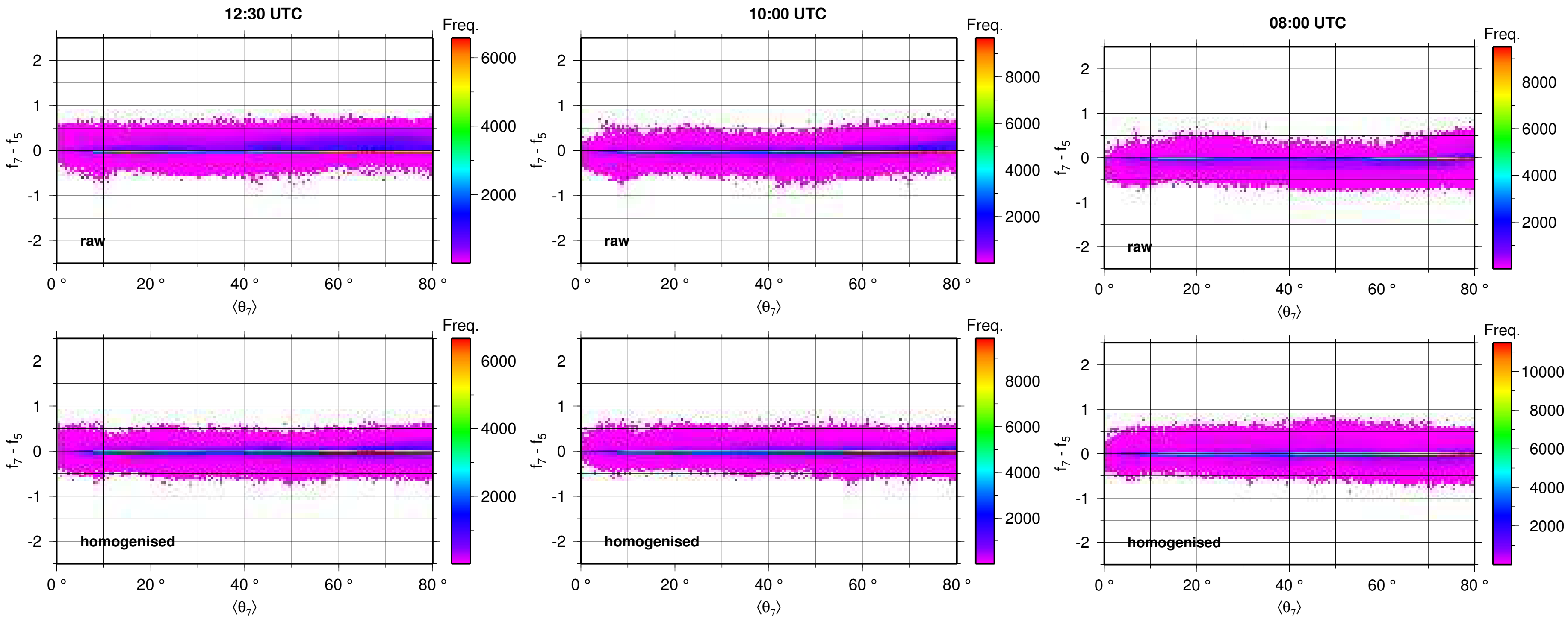

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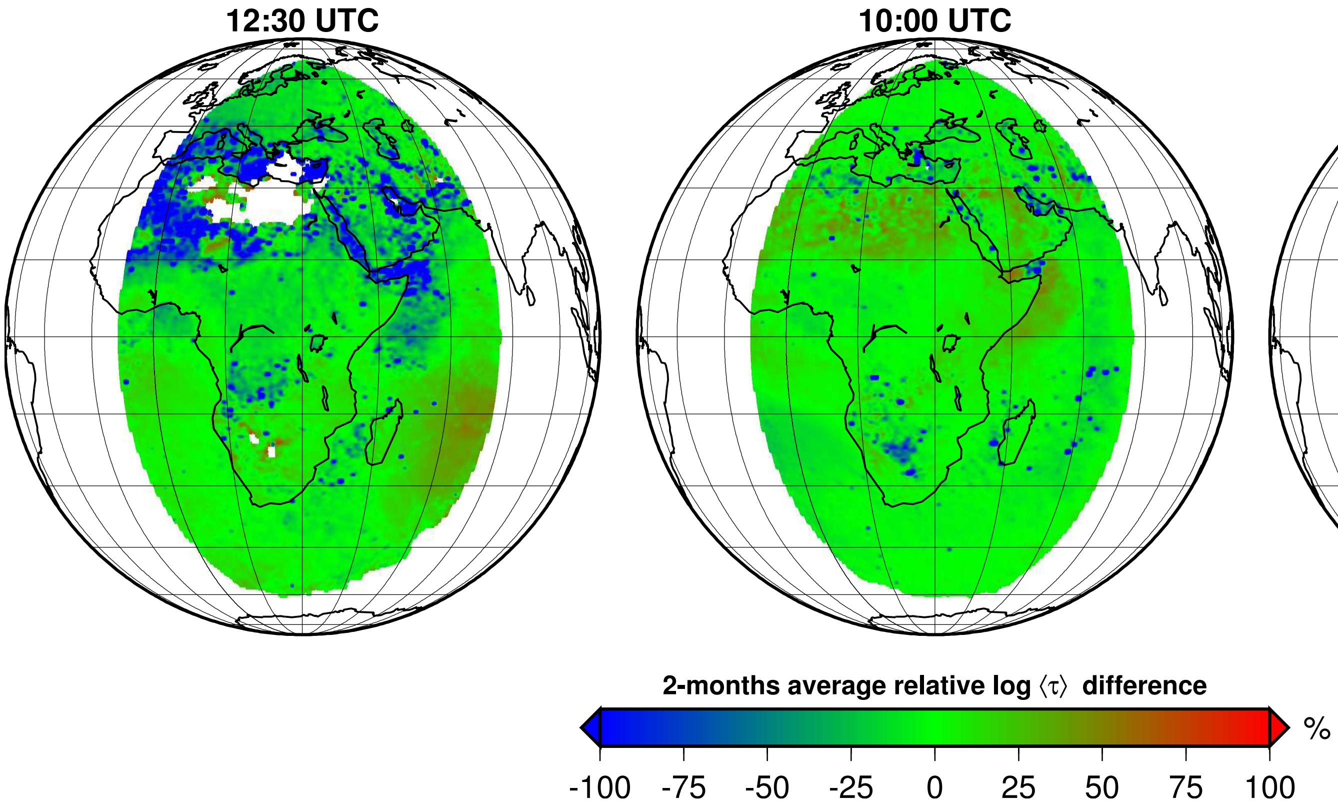

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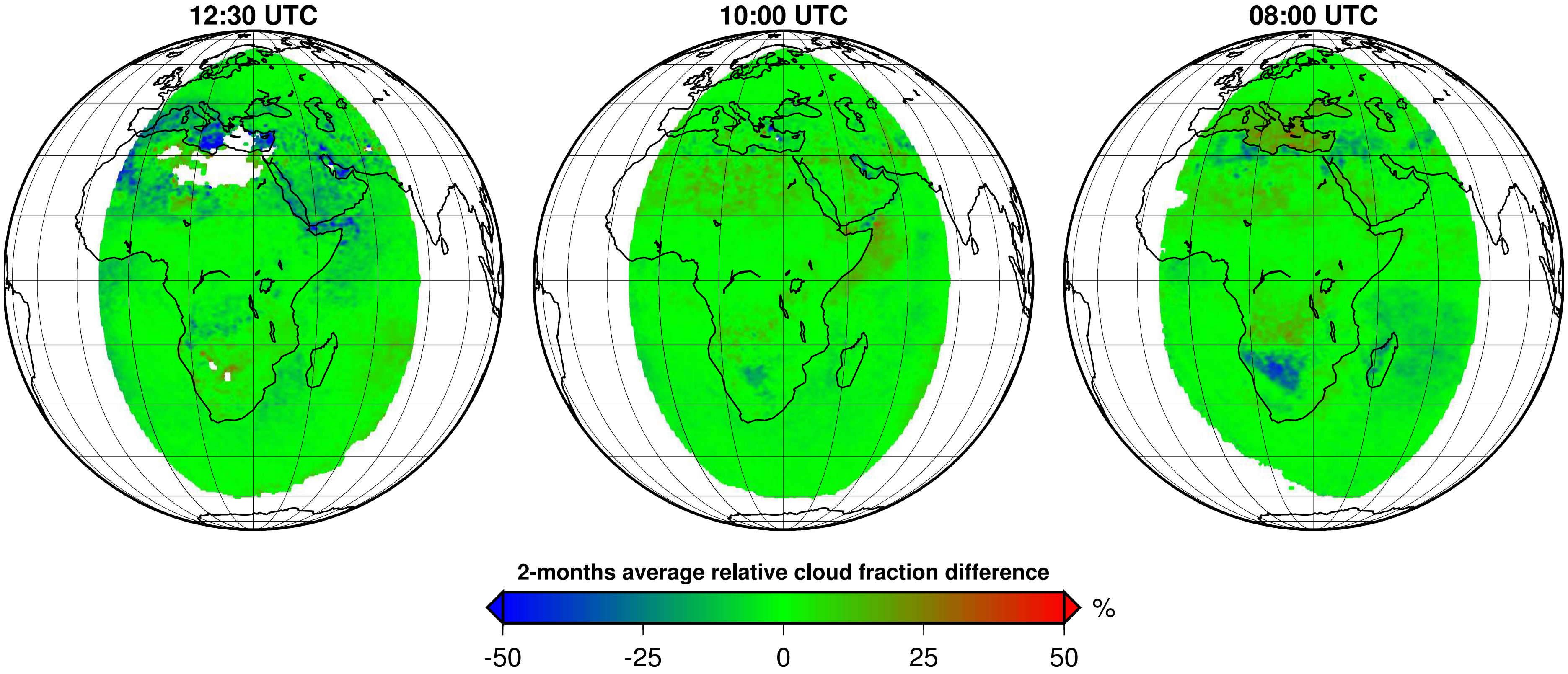

# 8. Validation of the Homogenized Retrievals

- $\tau$ angular dependency significantly decreased.
- No more over/under–estimation of $\langle\tau_7\rangle$ compared to $\langle\tau_5\rangle$, as shown in $f_7 - f_5$ plot.
- Decrease of the scattering in both comparison plots.

| Fitting laws | $\log\langle\tau_7\rangle - \log\langle\tau_5\rangle$ hom. | raw | $f_7 - f_5$ hom. | raw |
|---|---|---|---|---|
| constant | 0.2353 | 0.3343 | 0.0958 | 0.1281 |
| linear | 0.2334 | 0.2707 | 0.0957 | 0.1258 |
| quadratic | 0.2318 | 0.2601 | 0.0955 | 0.1257 |
| cubic | 0.2317 | 0.2587 | 0.0954 | 0.1257 |

# 9. Future Works

- Homogenised values are SLOT dependent $(f(\varphi))$:
  - ▷ Need one more corrective step.
  - ▷ Test if $\varphi$ dependence is decreased with use of non–Lambertian surfaces in RTM.

- Need to understand the source of scattering:
  - ▷ Detection of calibration errors by building thick–cloud radiance fields from MS7 & MS5 images and comparing them.
  - ▷ Use of these experimental $L(\tau = 128)$ to compute mean cloud amount $\Longrightarrow C$ computed using only measured radiances.
  - ▷ Apply a phase retrieval scheme to cloudy pixels and use the associated SBDART phase thick–cloud radiance to compute $C$.