# The MT/ScaRaB-3 algorithms and products

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# Outline

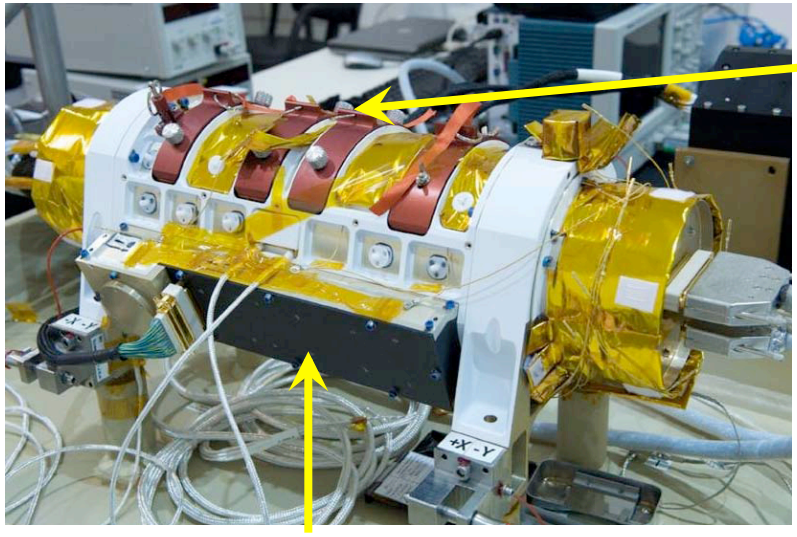
-Introduction

-Level 2

-Clear sky and sampling issue

-CAL/VAL Plan

# The ScaRaB instrument




Calibration module

22 kg, 52 cm width, 40 watts
4 telescopes (in red)

- **2 main channels (# 2 & 3, broad band)**
- **2 auxiliary channels (# 1 & 4 narrow band)**
- **Cross track scanning**
- **40 km resolution at nadir**

**ScaRaB goal : To determine the longwave and shortwave outgoing fluxes observations at the TOA.**

| Channel | Description | Spectral Interval | Filter |
|---|---|---|---|
| 1 | VIS (visible) | 0.55 – 0.65 µm | Interferential |
| 2 | SW (or solar) | 0.2 – 4 µm | Silice filter |
| 3 | T (total) | 0.2 – 100 µm | No filter |
| 4 | IR (Infrared) | 10.5 – 12.5 µm | Interferential |

$$L_{LW\ (daytime)} = L_{TOTAL} - A' \times L_{SW}$$

A' depends on the spectral response of T and SW channels

# ScaRaBs objectives

**ScaRaB 1 & 2 – Time series of regional monthly means fluxes**

Mean accuracy of **5 $Wm^{-2}$** is sought for regional means

**20 $Wm^{-2}$** accuracy for instantaneous fluxes

SEL ➔ ScaRaB ERBE-Like algorithm

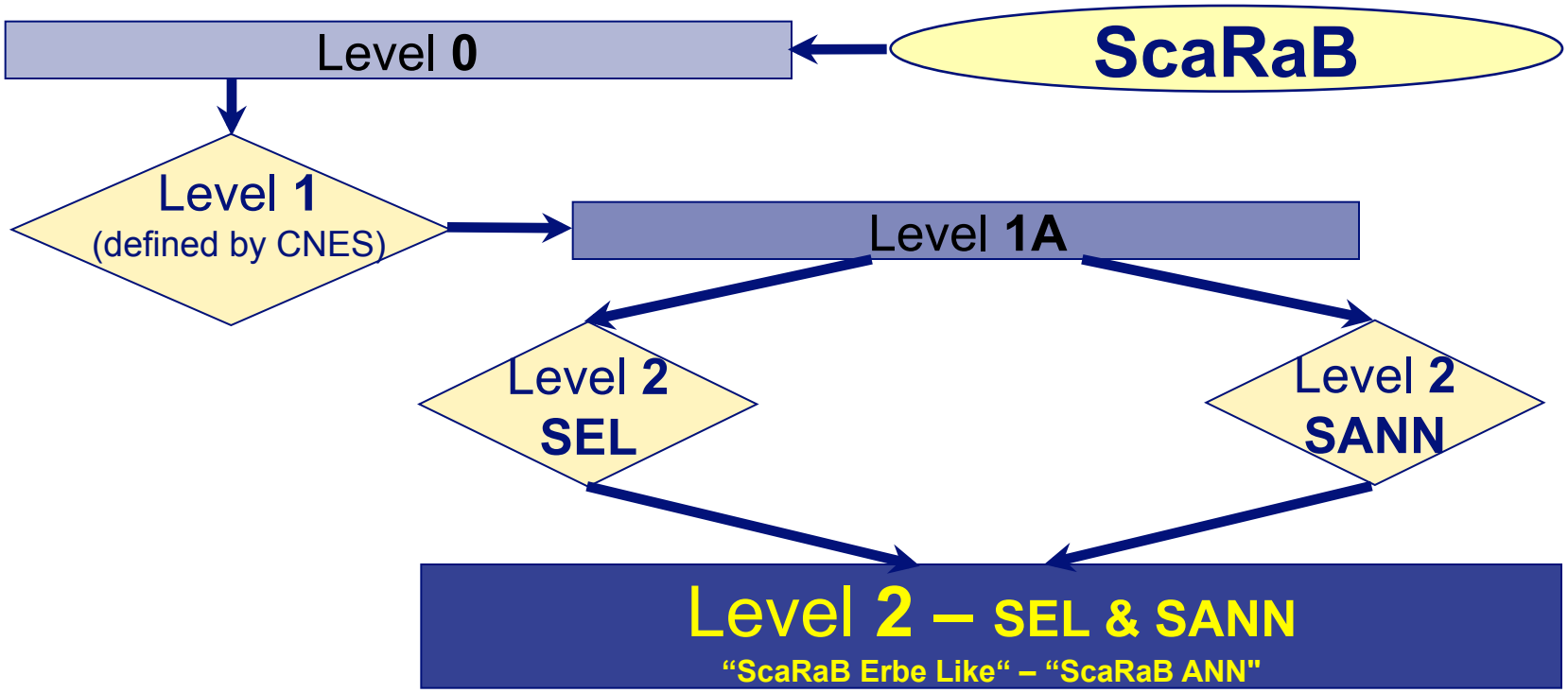
**ScaRaB 3 – To observe simultaneously the radiation fluxes and the water cycle components** (water vapor, clouds, precipitation)

Mean accuracy of **10 $Wm^{-2}$** is requested for instantaneous fluxes

~~SEL ➔ ScaRaB ERBE-Like algorithm~~

SANN ➔ ScaRaB Artificial Neural Network

# ScaRaB products – overview



# LEVEL 2

Instantaneous TOA fluxes

# ScaRaB products – Level 2

**Improve the flux RMS ➔ improve the ADM ➔ improve the scene identification**

CERES team work ➔ new ADM based on an improved scene identification (**hundreds** types instead of **12**) provided by the use of an imaging multi-spectral radiometers (VIRS and MODIS)

**CERES ADMs are considered as reference**

**BUT** – No imaging multi-spectral radiometers on MT
– Hard to colocalize ScaRaB pixels with multispectral instruments

To improve ScaRaB radiance-to-flux conversion with no imager aboard

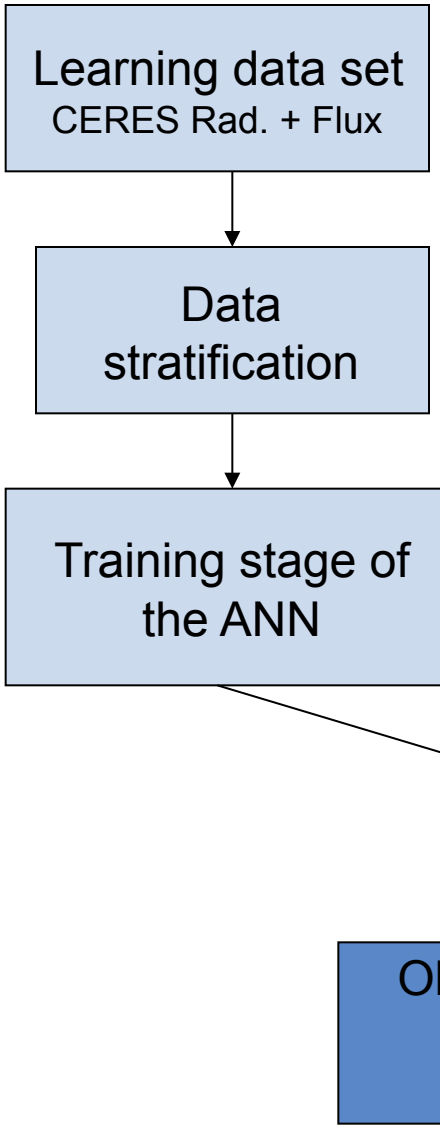
Artificial Neural Network based on CERES new ADM

Work has already be done by CERES team for a backup solution
Shows significant improvement compared to ERBE-Like algorithm

SANN ➔ ScaRaB Artificial Neural Network

# ScaRaB products – Level 2

ANN learning with TRMM data (10 km spatial resolution at nadir)
(orbit near to MT orbit – 35° inclination instead of 20°)




| Variable | Bins # | Bin width |
|---|---|---|
| VZA | 7 | 10° |
| SZA | 9 | 10° |
| RAZ | 9 | 20° |
| LWR | 15 | 10 $W.m^{-2}sr^{-1}$ |
| SWR | 30 | 10 $W.m^{-2}sr^{-1}$ |

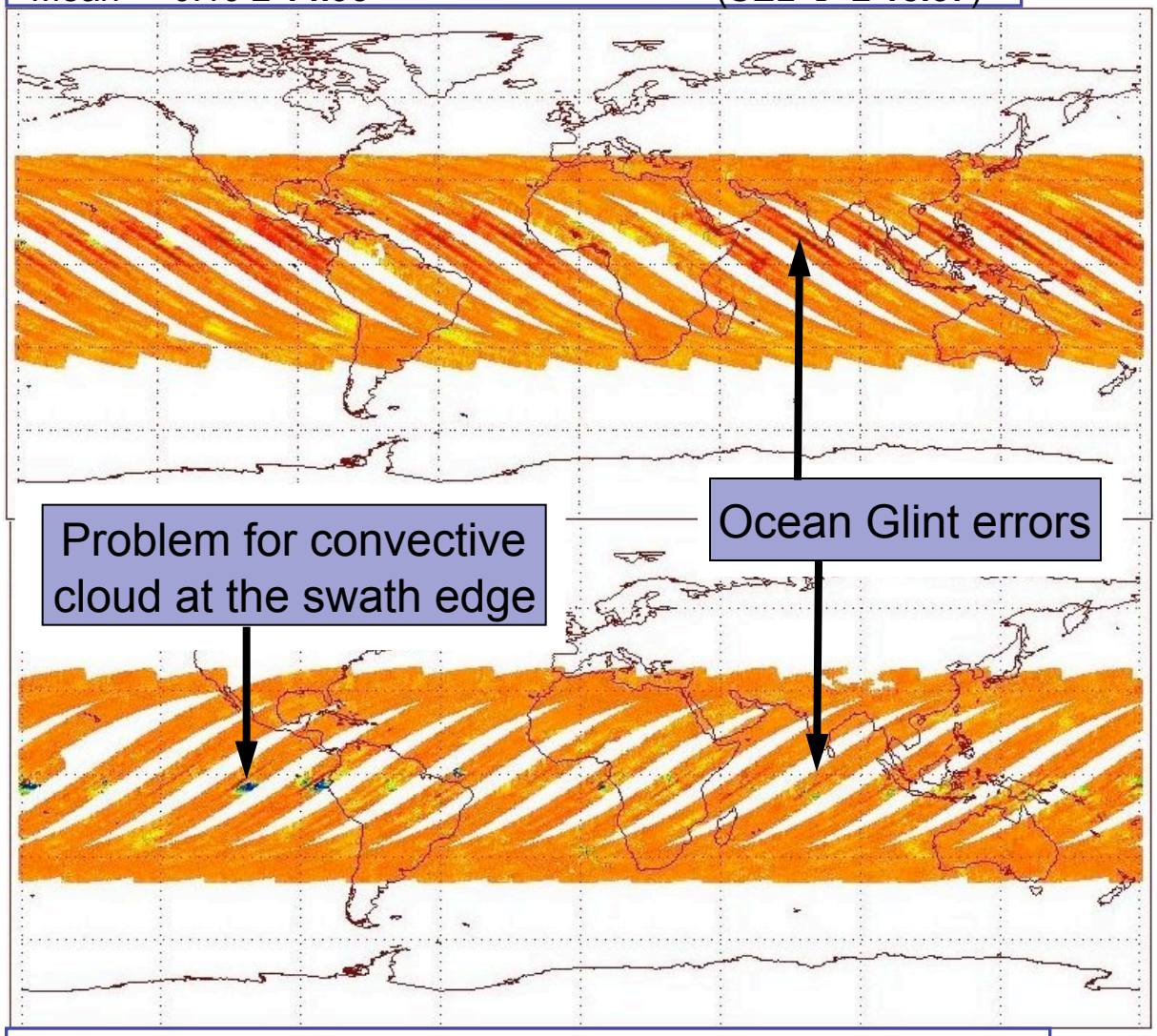
Exemple : **SW** case

Stratification goal : reduce the size of the learning data set by keeping its statistical representation.
7x9x9x15x30=255150 bins

6 scene types
no-glint ocean, glint, medium-high and low medium, tree-shrub, dark and bright desert

# ScaRaB products – Level 2

(SANN **Broadband** – CERES) **SW** Flux ($W.m^{-2}$) ; 08/29/1998
Mean = -0.10 ± **14.93** (SEL ➔ ± **18.57**)




(SANN **Narrowband** – CERES) SW Flux ($W.m^{-2}$) ; 03/20/1998
Mean = -1.15 ± **9.60**


With Broad bands

50% error reduction with respect to SEL (except for ocean/glint scenes where it's worse)

With Narrow bands

40% error reduction with respect to SANN broadband ➔ Essentially due to improvements for ocean/glint scenes

# ScaRaB products – Level 2

## One day result (August 17th 1998) : SANN SW flux – CERES SW flux

**6 surface types**

| | OVERCAST | | | | CLEAR | |
|---|---|---|---|---|---|---|
| % clear sky | 0 – 10 | 10 – 30 | 30 – 60 | 60 – 90 | 90 – 100 | 0 – 100 |
| ocean glint | -6.88 ± 12.06 | -8.25 ± 14.90 | -6.73 ± 13.46 | -2.53 ± 9.51 | 1.90 ± 8.60 | -2.26 ± 11.32 |
| | 4.15% | 0.99% | 1.55% | 3.01% | 7.89% | 17.61% |
| ocean no glint | 0.95 ± 8.42 | 0.27 ± 7.45 | 0.15 ± 6.35 | 0.17 ± 5.21 | -0.51 ± 4.08 | 0.37 ± 6.92 |
| | 21.36% | 3.55% | 5.18% | 7.69% | 10.79% | 48.56% |
| LMTS | -0.59 ± 9.53 | 0.08 ± 9.24 | 0.09 ± 7.83 | 0.18 ± 7.03 | 1.98 ± 5.99 | 0.29 ± 8.34 |
| | 5.98% | 0.93% | 1.14% | 1.54% | 3.49% | 13.08% |
| MHTS | -0.64 ± 9.03 | 0.01 ± 8.79 | 0.02 ± 7.66 | -0.30 ± 7.15 | 1.34 ± 5.96 | -0.10 ± 8.18 |
| | 3.29% | 0.55% | 0.66% | 0.78% | 1.26% | 6.54% |
| BD | 1.32 ± 12.25 | 1.96 ± 9.07 | -3.09 ± 8.19 | -2.02 ± 7.07 | 0.97 ± 3.62 | 0.76 ± 4.80 |
| | 0.28% | 0.11% | 0.16% | 0.38% | 6.53% | 7.46% |
| DD | 2.54 ± 18.03 | 4.72 ± 13.14 | -1.86 ± 10.68 | -0.99 ± 8.78 | 0.85 ± 5.11 | 1.03 ± 10.35 |
| | 1.34% | 0.38% | 0.47% | 0.66% | 3.89% | 6.75% |
| all scene | -0.28 ± 9.99 | -0.80 ± 10.27 | -1.19 ± 8.89 | -0.55 ± 6.98 | 0.82 ± 5.84 | -0.06 ± 8.32 |
| | 36.41% | 6.51% | 9.17% | 14.06% | 33.86% | 100.0% |
| all scene except glint | 0.57 ± 9.36 | 0.55 ± 8.52 | -0.06 ± 7.11 | -0.01 ± 5.99 | 0.49 ± 4.64 | 0.41 ± 7.45 |
| | 32.25% | 5.51% | 7.61% | 11.05% | 25.97% | 82.39% |

Overall results

## 32 days result : SANN SW flux – CERES SW flux

Overall results for 3 NN

| Scene type | all | all but ocean/glint | ocean/ glint | ocean/ no glint | LMTS/ land | MHTS/ land | bright desert | dark desert |
|---|---|---|---|---|---|---|---|---|
| ANN-BB-RAP | -3.87 ±14.33 | -2.48 ±9.21 | -9.77 ±23.68 | -3.59 ±8.76 | +0.28 ±10.26 | -0.10 ±9.68 | -1.00 ±6.22 | -0.28 ±9.45 |
| ANN-BB-XT | -0.91 ± 9.96 | -0.72 ± 7.67 | -1.72 ± 15.68 | -1.00 ± 7.32 | -0.23 ± 8.79 | -0.56 ± 8.30 | 0.27 ± 5.44 | -0.10 ± 8.03 |
| ANN-NB-XT | -0.70 ±8.84 | -0.54 ±7.14 | -1.46 ±13.36 | -0.83 ±6.29 | -0.14 ±8.73 | -0.45 ±9.59 | +0.81 ±5.72 | +0.25 ±7.45 |

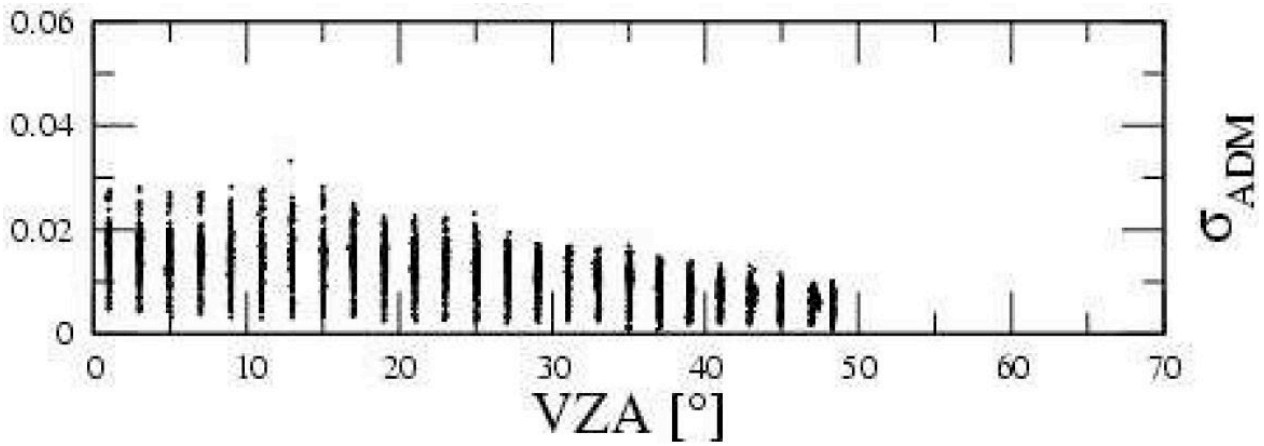
# ScaRaB products – Level 2

| Leaning data | Input |
|---|---|
| RAP 68 days 01/98 – 08/98 | VZA, PW, LLw, Lsw |
| XT 16 days 07/98 – 08/98 | VZA, Lir, Llw, Lsw |
| XT 16 days 07/98 – 08/98 | VZA, PsAbs, Lir |
| XT 16 days 07/98 – 08/98 | VZA, PsAbs |

*compared to the intrinsic model error 2.4 $Wm^{-2}$

| Version | Error $Wm^{-2}$ | Rms error reduction $Wm^{-2}$ |
|---|---|---|
| ERBE | +2.94 ± 3.15* | 4.30 |
| ANNa | -0.60 ± 2.89* | 2.95 (30%) |
| ANNc | -1.20 ± 2.99* | 3.22 (25%) |

For each bin, the standard deviation of the ADM~0.01 (corresponding to 2.4 Wm-2 for a global LW means of 240 Wm-2) which marks the intrinsic accuracy of the model.



# ScaRaB products – Level 2

## SANN Conclusion

- SANN is developped with TRMM data (10 km resolution at nadir). ScaRaB data will be 40 km resolution at nadir. The impact of the decrease of the spatial resolution has been studied and was found small : 3 Wm-2 for SW

These errors are independent

- In CERES TRMM data, VZA<50°

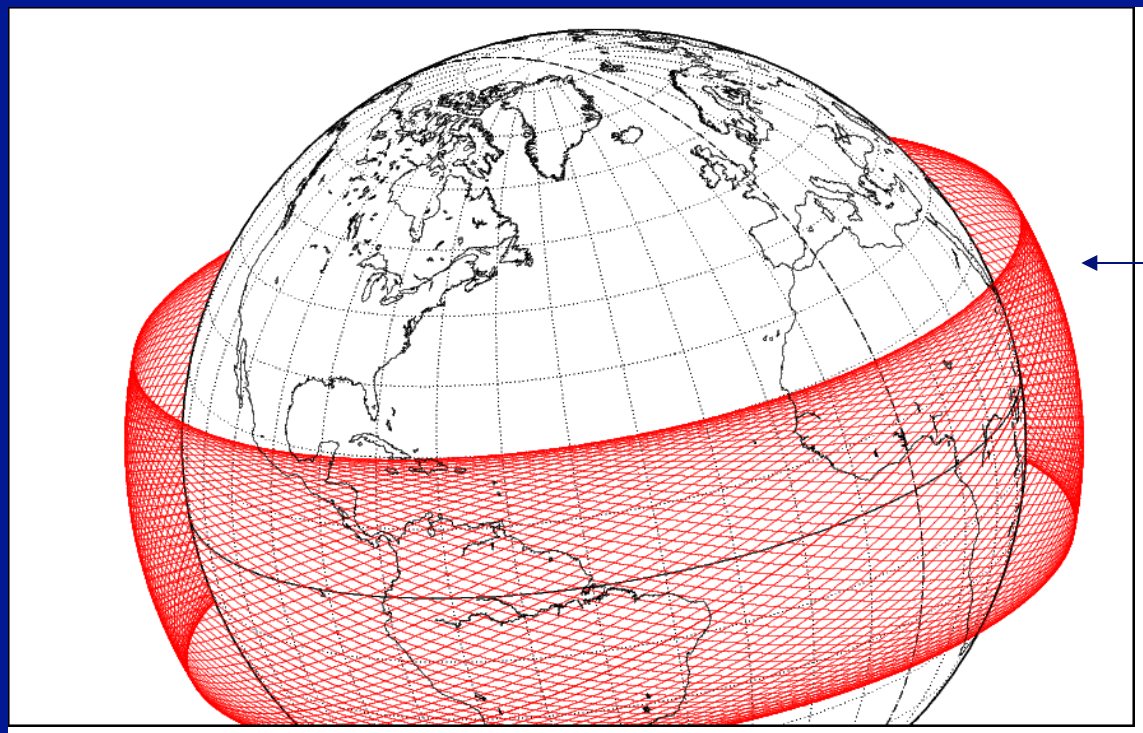
In ScaRaB MT, VZA can be >50°
Need to flag data with VZA>50° in our product.

- Flag to inform the users of the accuracy of the product

# Clear sky

Sampling issue

# ScaRaB products – Level 3

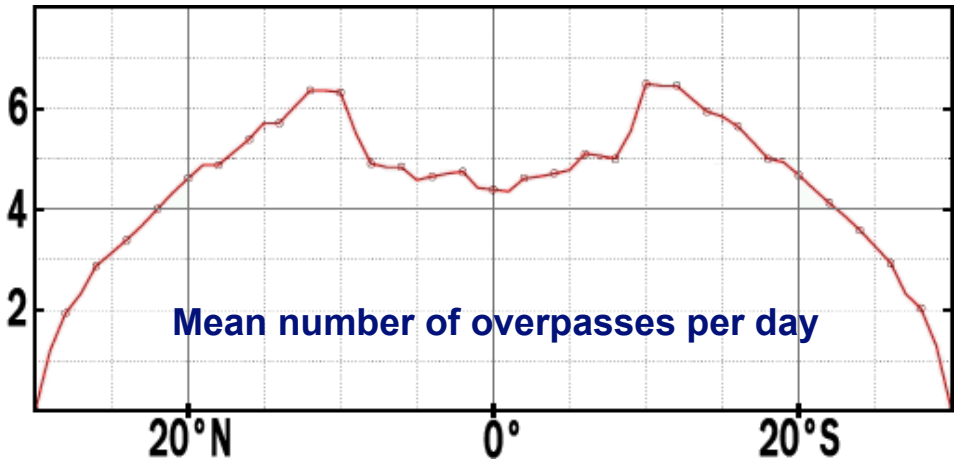


Inclination : 20°
Repeated cycle : 7 days
MT altitude : 865 km
ScaRaB FOV : 48.9°
Coverage : 30°N – 30°S

**<u>Mission objectives</u> :**

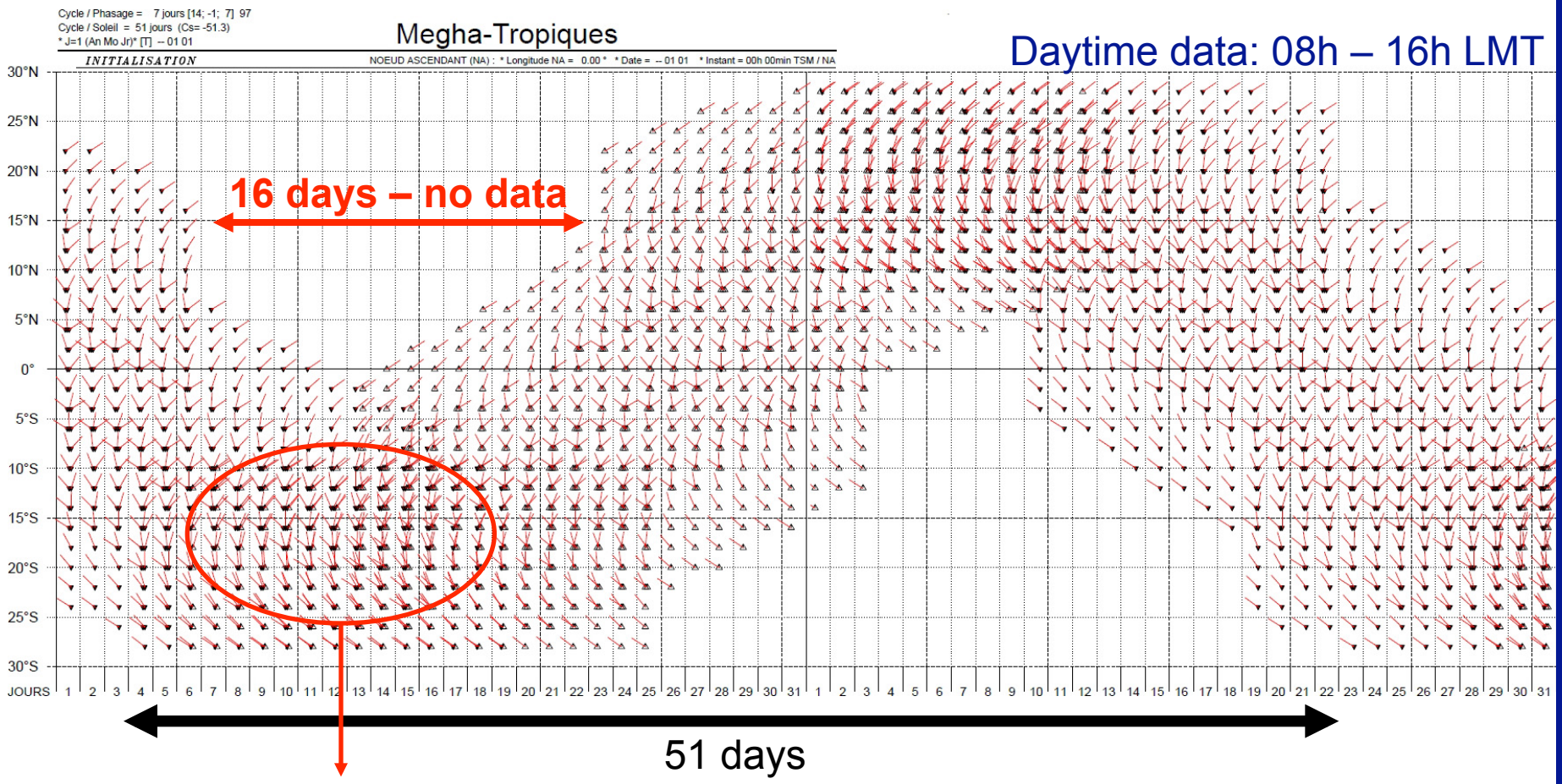
- **To observe & analyse the energy & water exchanges in the tropics.**
- **To study the life cycle of the convective systems and their interactions with the environment.**

## High temporal sampling



# ScaRaB products – Level 3

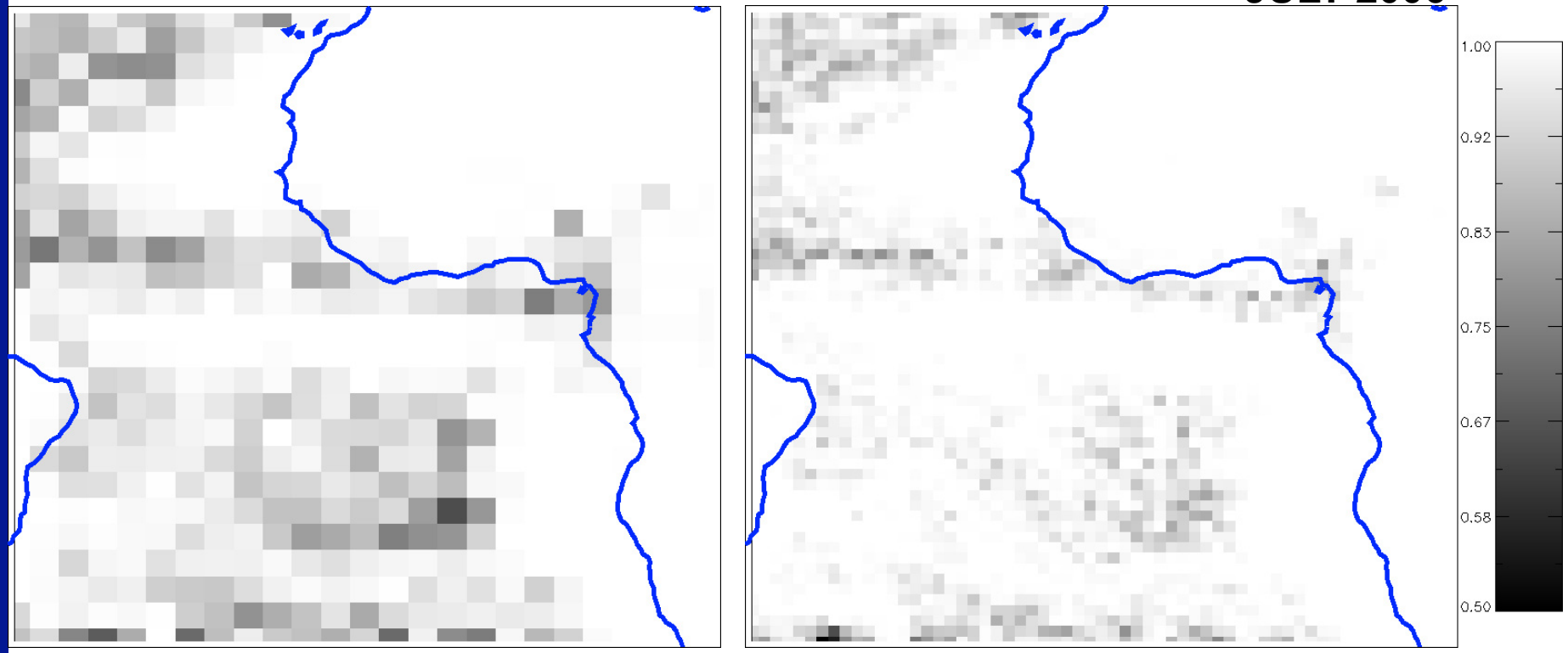
Megha-Tropiques precession cycle : 51 days




➔ Validation of the GEO interpolation, in complement to GERB

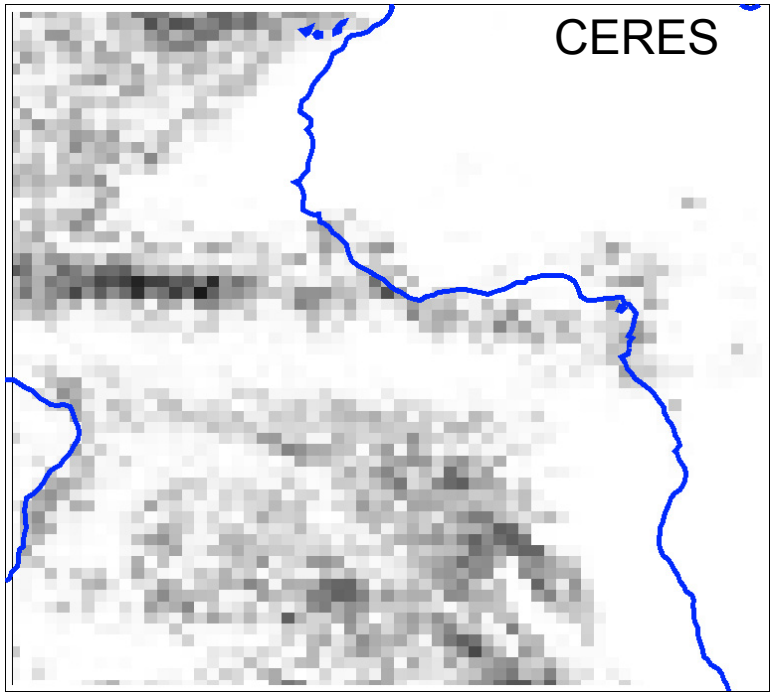
# ScaRaB products – Level 3

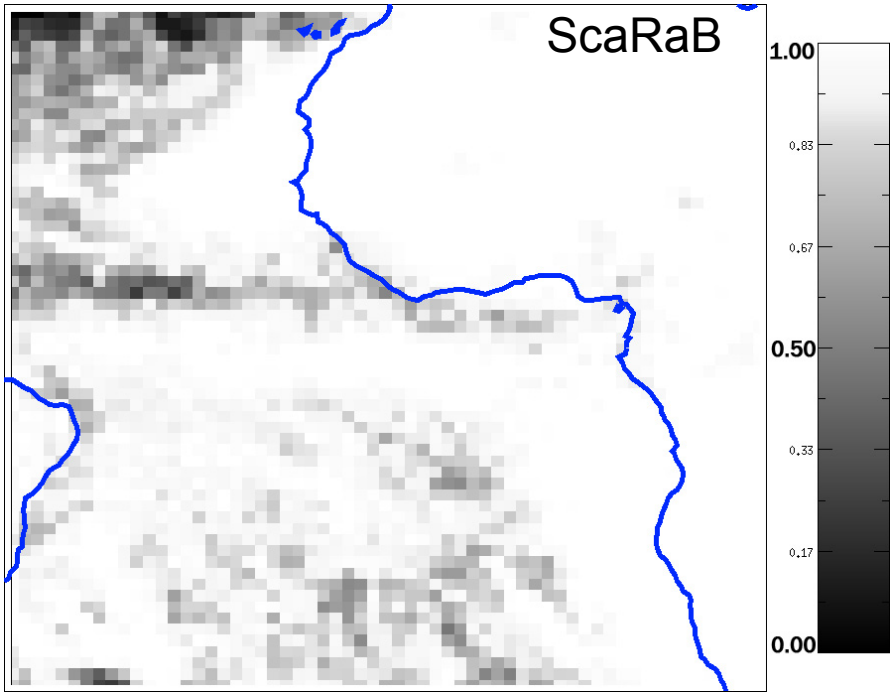
Clear sky detection (2.5° boxes vs. 1° boxes)




1- ScaRaB synthetic orbit
2- Cloud mask from SAF NWC projected on ScaRaB orbit
3- CS % mean computation on each ScaRaB pixel
4- ScaRaB on grid (1°x1° or 2.5°x2.5°)
5- CS% computation for each point of grid

# ScaRaB products – Level 3

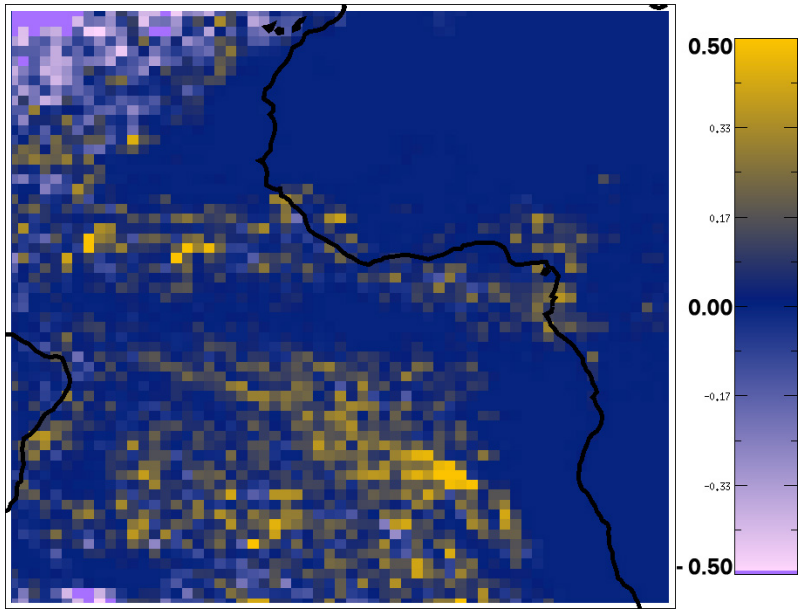



Period : 10 days

20-29 june 2006

Nigh/day




Difference
ScaRaB - CERES

## ScaRaB products – Level 3

**Level-3 conclusion**

- Regional means.

  ScaRaB + GEO + CERES

  Extrapolation without the half-sinus

  Without large bias errors due to MT orbit characteristics

- Clear-sky product better than those from CERES due to the MT orbit.
  Use ScaRaB + CERES to consolidate it ?

# CAL/VAL PLAN

## ScaRaB CAL/VAL plan

- Radiometric quality check before & after launch
  - Spectral characterization
  - Gain determination

  } ~ 2% SW ; ~ 1% LW

  - Independence of TOA fluxes on the viewing geometry

- Vicarious calibration (indirect methods)
  - With terrestrial targets with known SW reflectance such as desert (precision ~ 2%)
  - or thick cloud with the DCC method to calibrate LW & SW radiances (precision ~ 1 %)

- Comparison with other ERB instruments
  - CERES & GERB real time (monitoring)
  - Comparison with historical data

# Possible ScaRaB/others Comparisons

- Radiances comparisons of simultaneous co-located and co-angular observations

  **SW radiances**

  Co-angular ($\theta_{zenith}$ ±5° & $\theta_{azimuth}$ ±10° or conical aperture < 10° or 5°)

  Simultaneous ($\Delta T$ ± 7.5 mn)

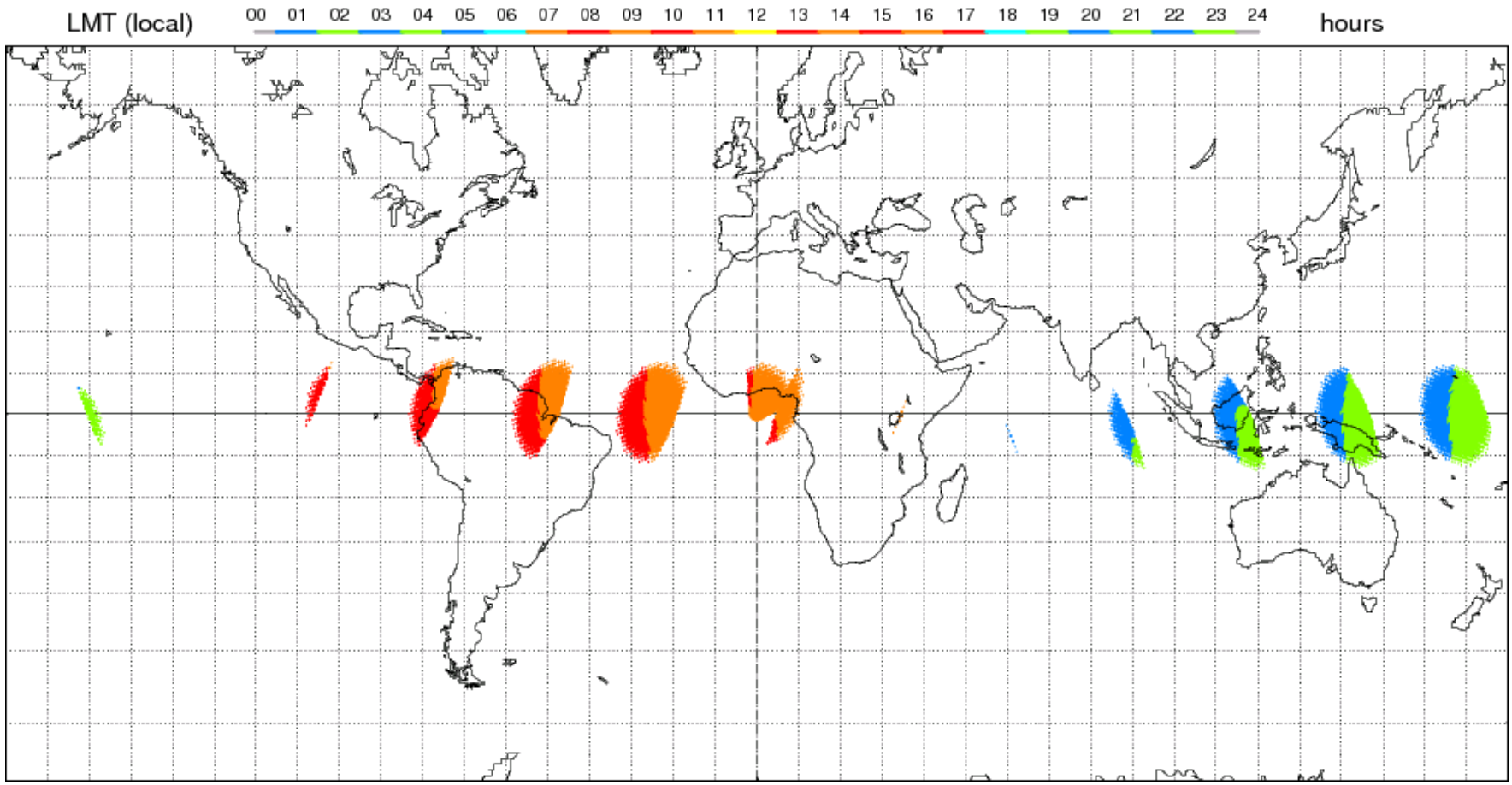
  **LW radiances**

  Same as SW without the $\theta_{azimuth}$ constraint

- More comparisons !
  - Fluxes of simultaneous co-located observations
  - Monthly means fluxes of the common tropical area ?

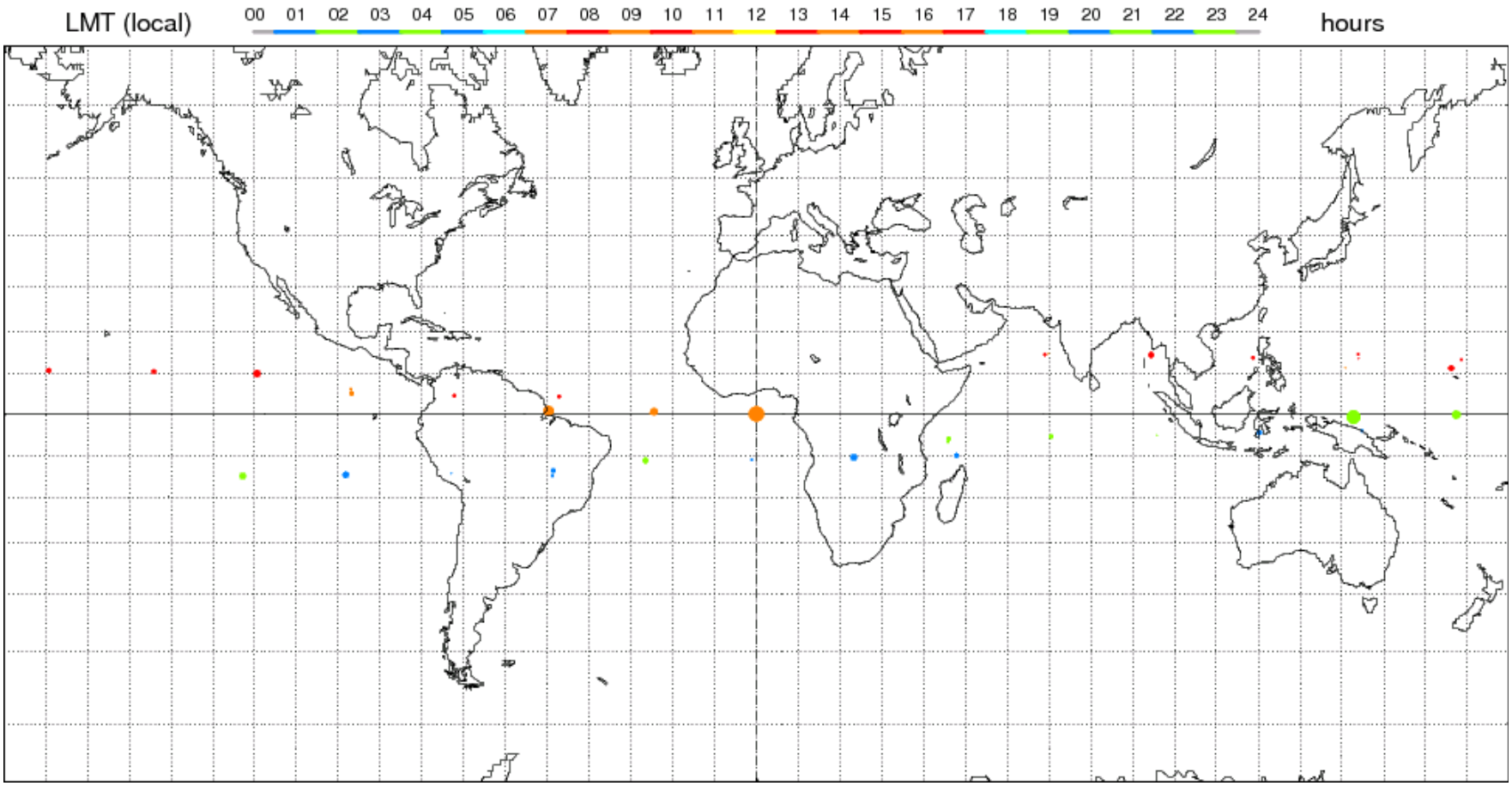
# ScaRaB CAL/VAL plan

CERES/AQUA & ScaRaB/MT
Represented period : 2 days
Temporal co-location : 7’30”



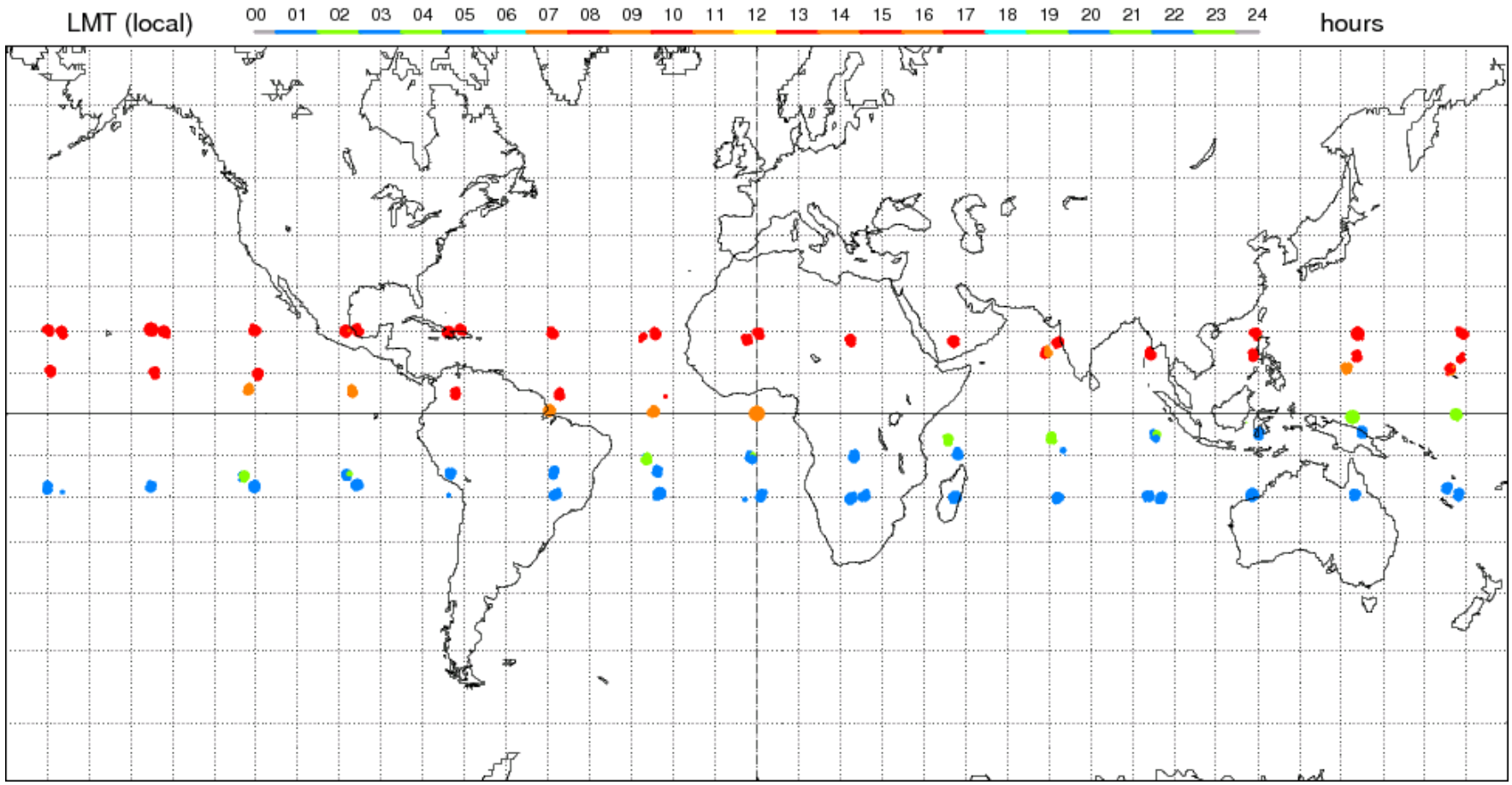
# ScaRaB CAL/VAL plan

CERES/AQUA & ScaRaB/MT
Represented period : 16 days
Temporal co-location : 7’30”
Conical aperture **< 5°**

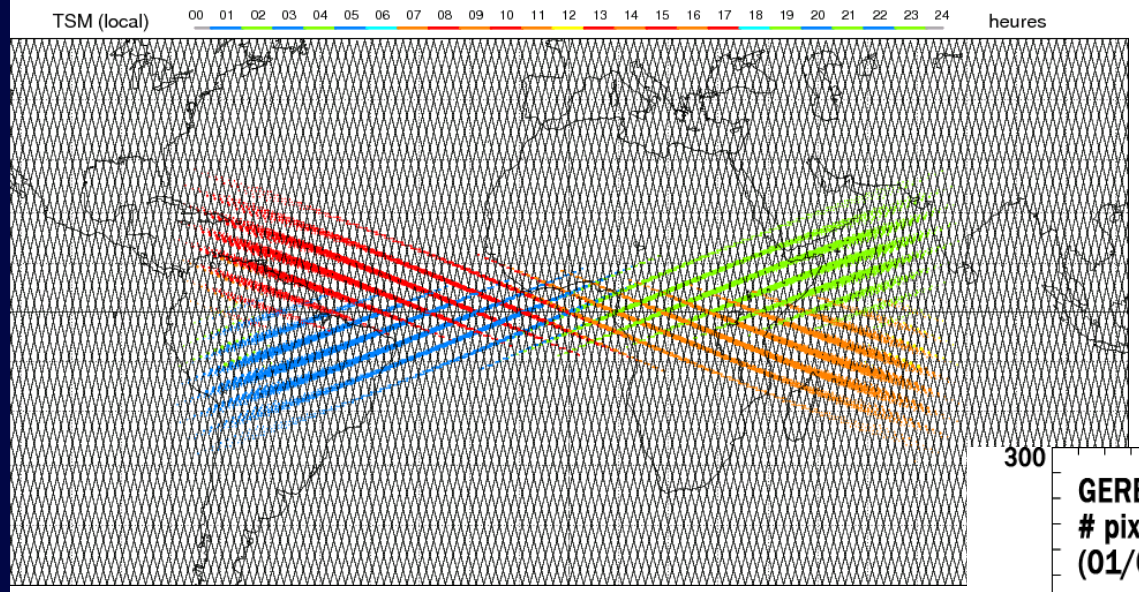


# ScaRaB CAL/VAL plan

CERES/AQUA & ScaRaB/MT
Represented period : 16 days
Temporal co-location : 7’30”
Conical aperture **< 10°**

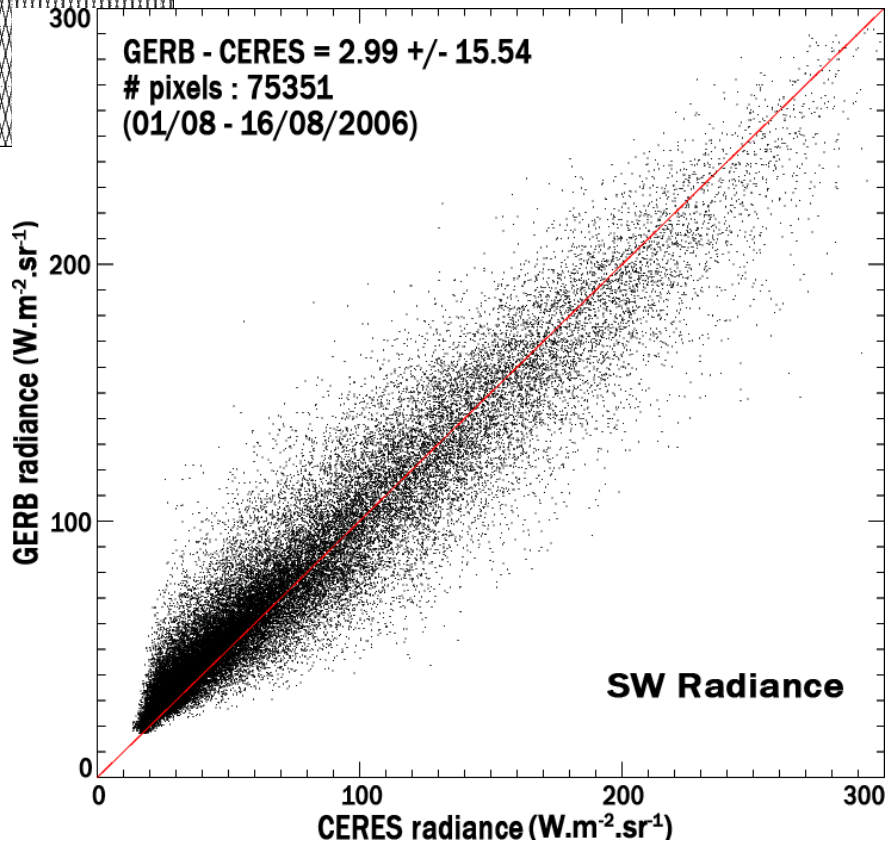


# ScaRaB CAL/VAL plan




← Co-location between GERB & CERES (Terra) within 7'30" and 5° cone aperture.

GERB SW radiances vs. CERES SW radiances. →
16 days in august 2006.
Co-location with a 5° cone aperture.



**Thank you**