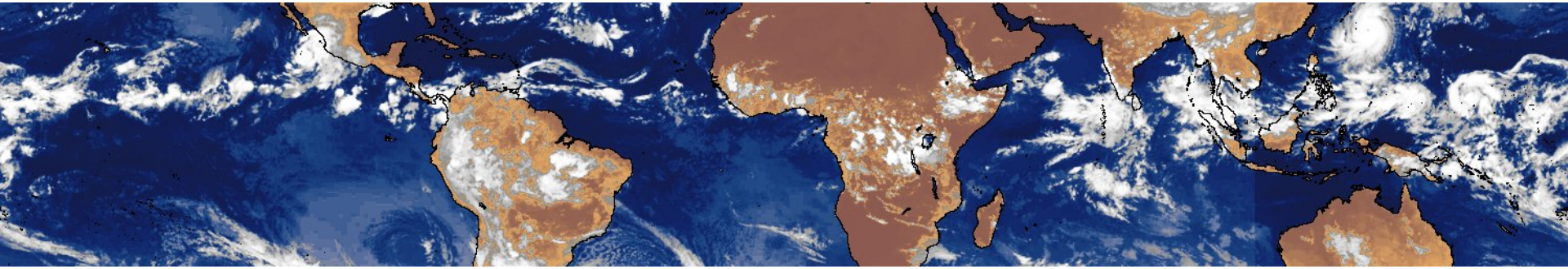
Radiances comparisons between CERES & ScaRaB



03/10/2014 à 1200Z Courtesy SATMOS

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Outline

- Why and how we compare CERES & ScaRaB
- Colocation criteria
- Comparison results

Why we compare ScaRaB & CERES

Objective : To compare CERES & ScaRaB SW and LW radiances in order to
- validate the ScaRaB measurements
- confirm the CERES measurements
- analyse the possible drifts between these instruments

NB : No in-situ measurements

ScaRaB-SW error budget @ 1σ ≈ 1,6%

Items	Value	Type	
Short wave calibration (sphere)	3% @2σ	Biais	1.5%
Error on spectral response		Biais	0.4%
Thermal gain correction	0.08%/° dT= 0.04° @1σ	Random	0.03%
Thermal leak correction	20% of the thermal leak@1σ	Random	0.04%
Location	0.06°@1σ	Random	0.4%
Budget at 1 sigma			1.6%

Rosak et al., 2012

CERES-FM2-SW error budget @ 1σ ≈ 1%

	Bias errors of unknown sign (W m^{-2})				
Source	Incoming solar	Outgoing SW	Outgoing LW	Net incoming	Comment
Total solar irradiance	±0.2	0	0	±0.2	Absolute calibration (95% confidence)
Filtered radiance	0	±2.0	±2.4 (N) ±5.0 (D)	±4.2	Absolute calibration (95% confidence)
Unfiltered radiance	0	±0.5	±0.25 (N) ±0.45 (D)	±1.0	- Instrument spectral response function - Unfiltering algorithm

Loeb et al., 2009 [CERES-FM2 error budget @2σ]
They showed that their error budget was consistent with the climate monitoring.

+ errors due to the collocation

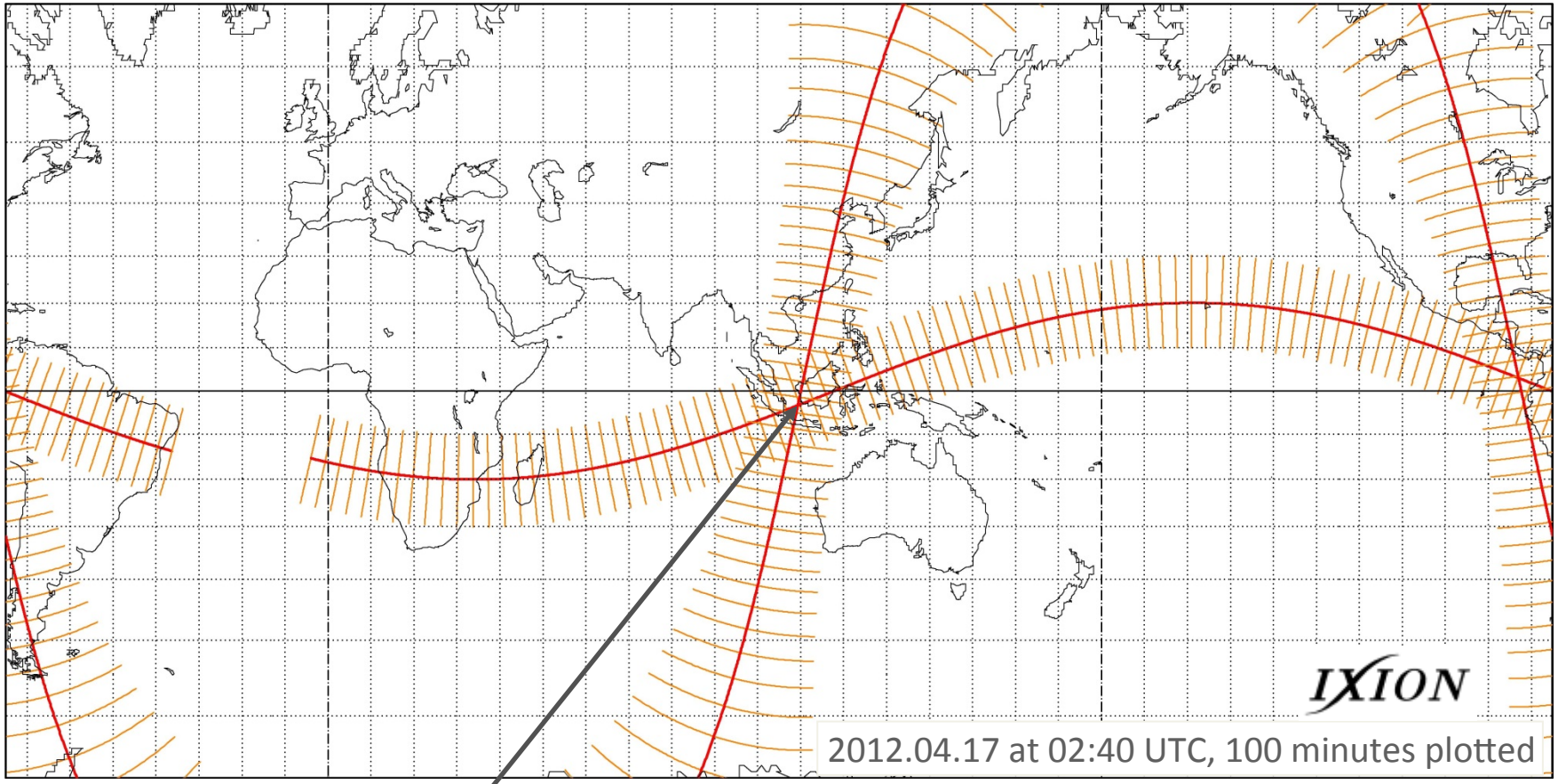
- Not the same instrument technologies
- independent measurements

→ Comparisons between ScaRaB & CERES
(instantaneous comparisons i.e. pixel by pixel).

How we compare ScaRaB & CERES

→ Intersections + same angular conditions

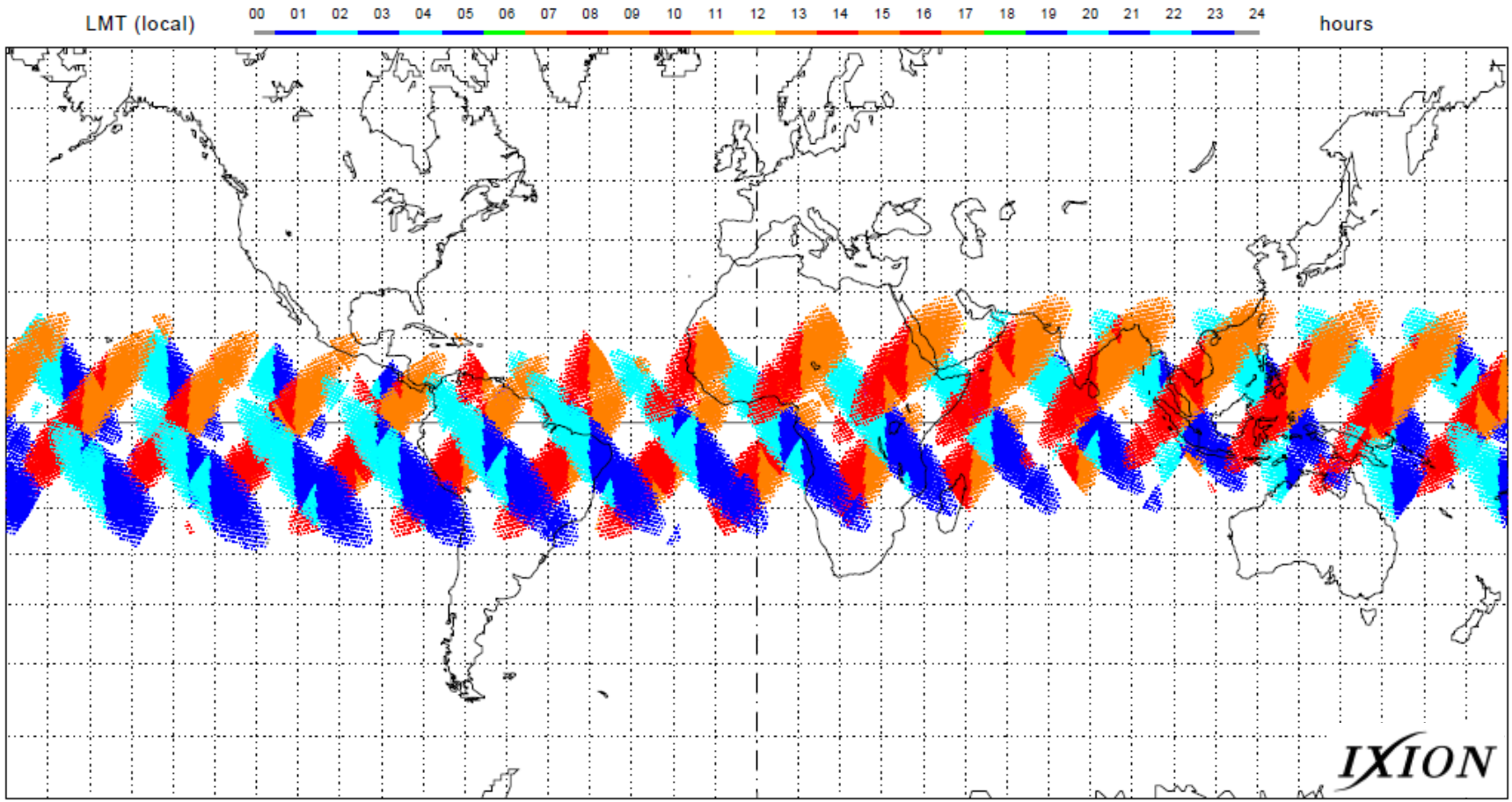
ScaRaB on MT ➔ 20° inclination, half-swath: 48.9° - XT mode
CERES on TERRA ➔ 98.2° inclination, half-swath: 55.2° - XT mode



CERES & ScaRaB crossing ; same angular conditions only near nadir.

How we compare ScaRaB & CERES

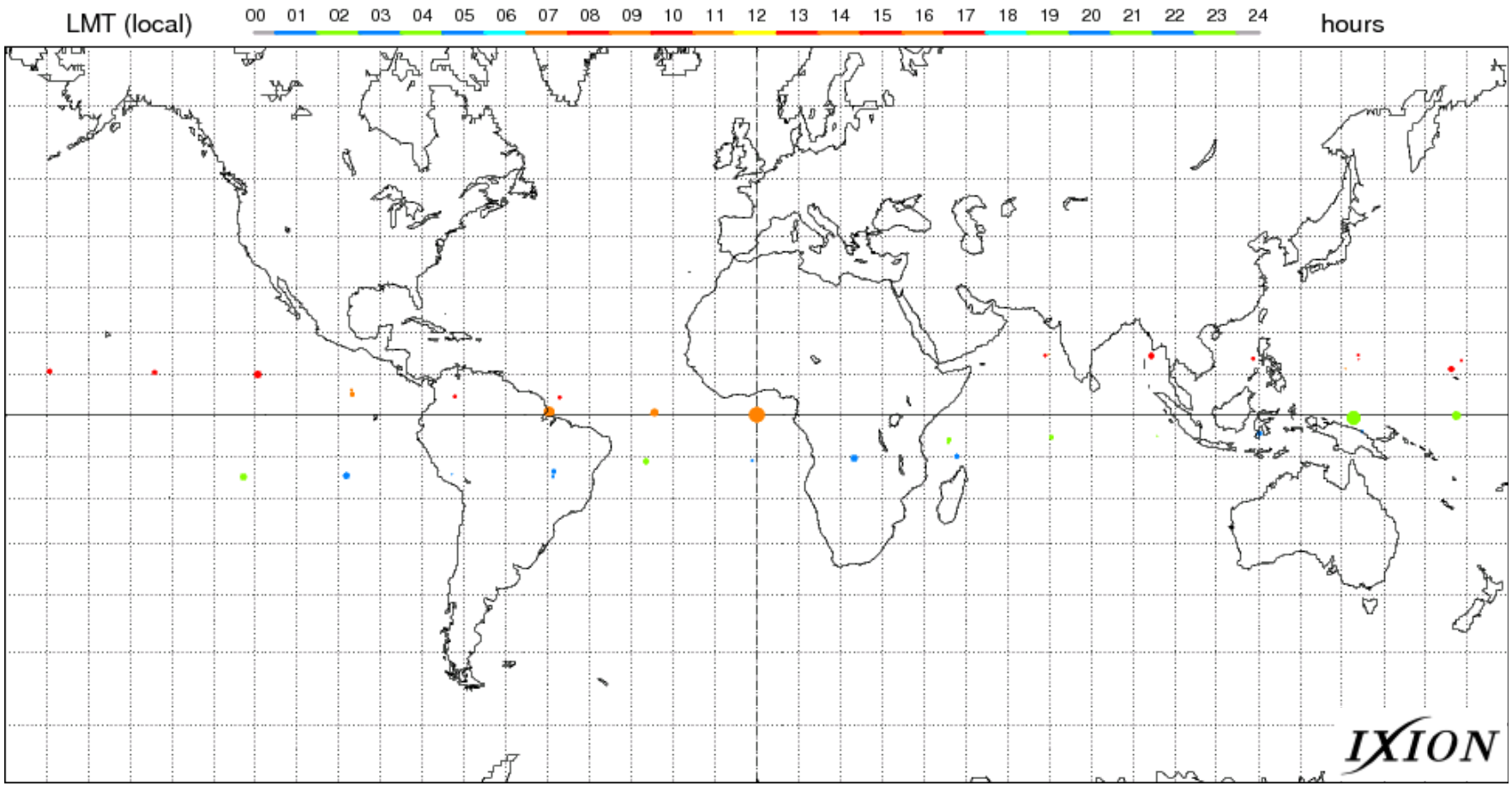
CERES/TERRA & ScaRaB/MT
Represented period : 16 days
Temporal colocation : 5’



No co-angular restriction here !

How we compare ScaRaB & CERES

CERES/TERRA & ScaRaB/MT
Represented period : 16 days
Temporal colocation : 5'
Conical aperture = **5°** ← **Angular constraint**



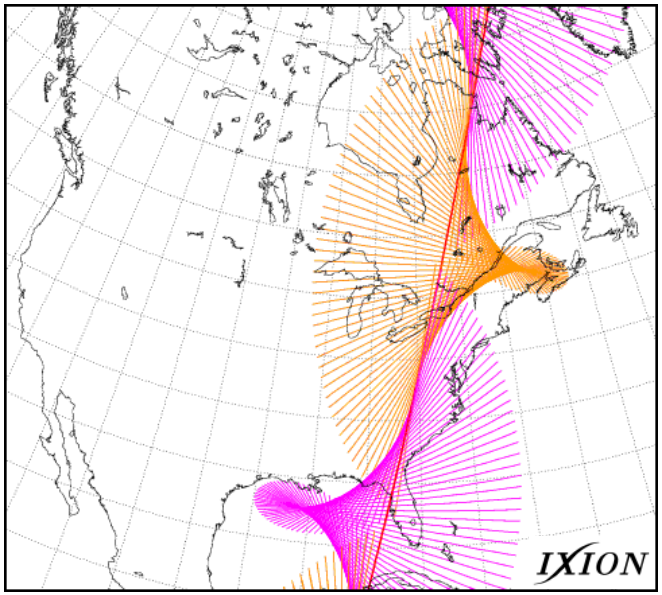
How we compare ScaRaB & CERES

It is required to have measured radiances under the same angular conditions to improve radiances matching for highly anisotropic scenes ➔ inconvenient poorer statistics in XT mode

To optimize the frequency of co-angular observations: use the CERES others scanning modes

CERES can change the angle of his axis scan.

PAPS mode: rotating angle is fixed for a required period ⟶ Possibility to align CERES and ScaRaB swaths.



CERES in RAPS mode
(Scan angle modified over time)

How we compare ScaRaB & CERES

Alignment of the CERES scan axis with the ScaRaB Scan axis :

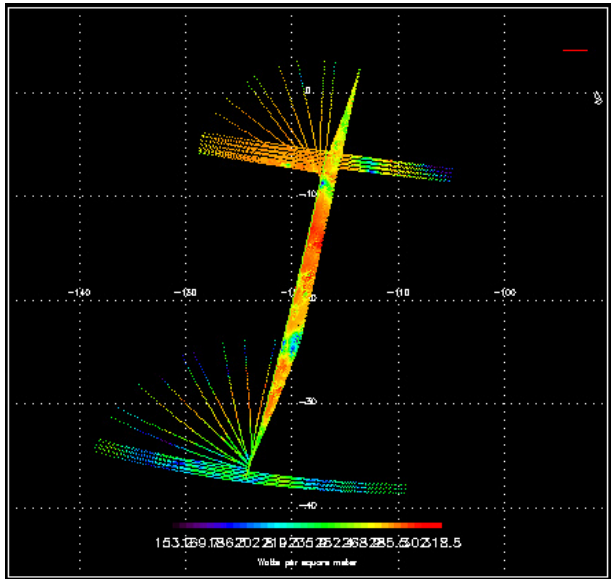
The PAPS campaign

1 – 51 days (precession cycle of MT) : April 17 to June 8 ,2012.

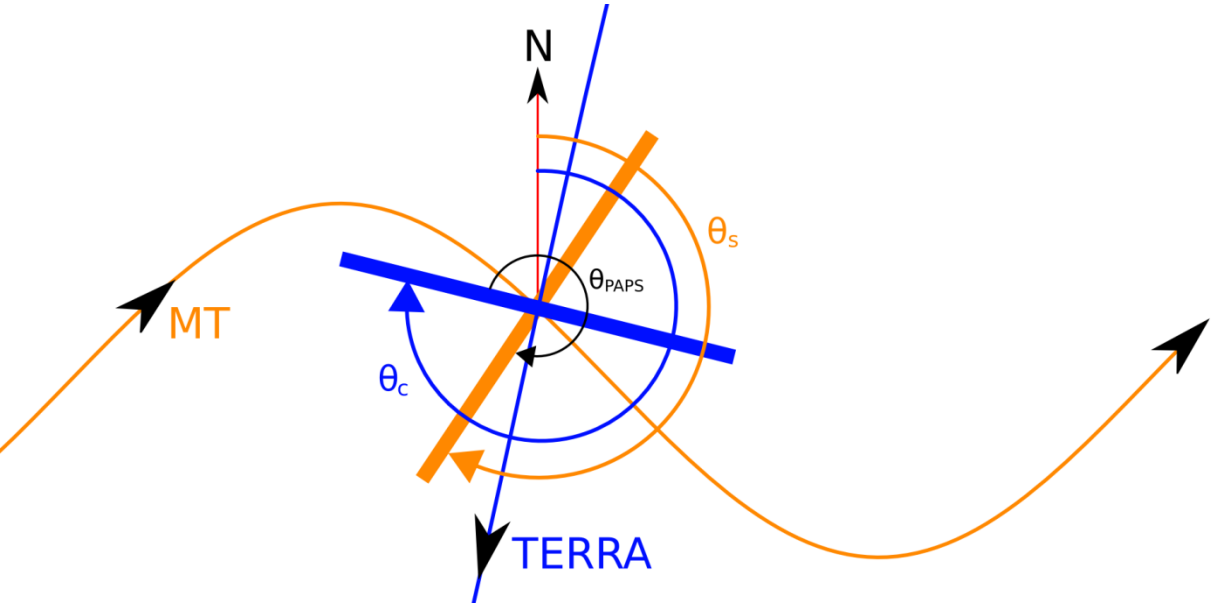
2 – Only during daytime (for SW).

3 – Crossing forecasts (computed with IXION and NORAD data) with durations & PAPS angles sent to NASA.

4 – Advantages: Increase the collocated pixels between the 2 instruments + all swath pixels has been collocated.



CERES-FM2 on PAPS mode
(backward scan only)



Colocation criteria

- Comparisons with another ERB instruments

  Pixels colocation: geographical, temporal and angular
  (because of the anisotropy of the observed scenes).

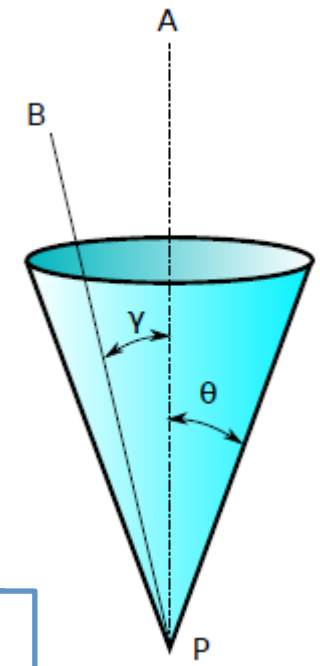
SW radiances

Co-angular ($\theta_{zenith} \pm x°$ & $\theta_{azimuth} \pm x°$ or conical aperture with an aperture of x°)

Simultaneous ($\Delta T \pm x$ mn)

LW radiances

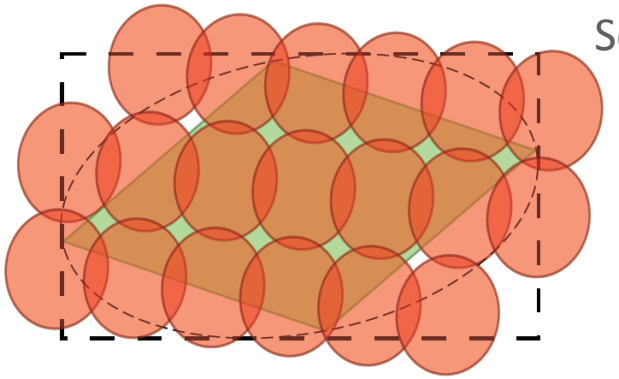
Same as SW without the $\theta_{azimuth}$ constraint



$\theta_{cône} = 5°$ et $\Delta T = 5'$

Colocation criteria

- Spatial colocation

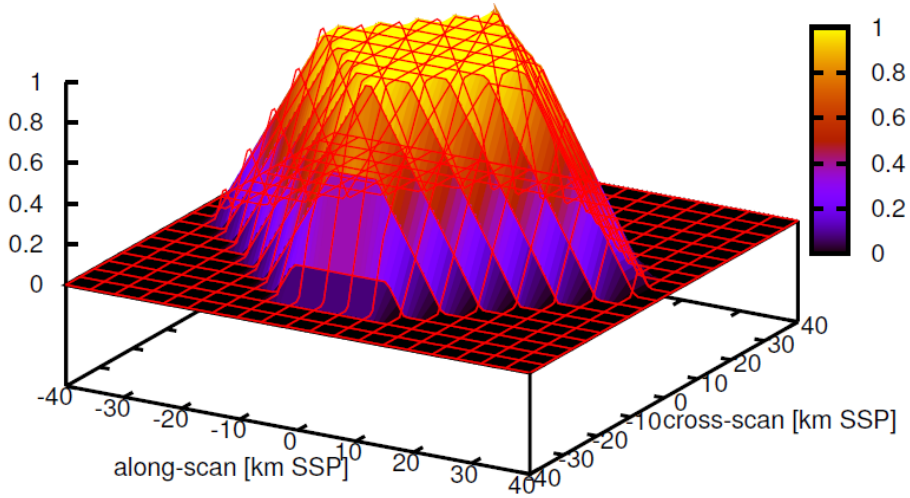


ScaRaB **(green)** = master pixel ; CERES **(red)** = slave pixel

Pixels with different sizes, shapes and weighting functions

The deformation of the pixels are taken into account

The PSF-weighted co-location estimates the contribution of each slave **(red)** pixel inside the master **(green)** one

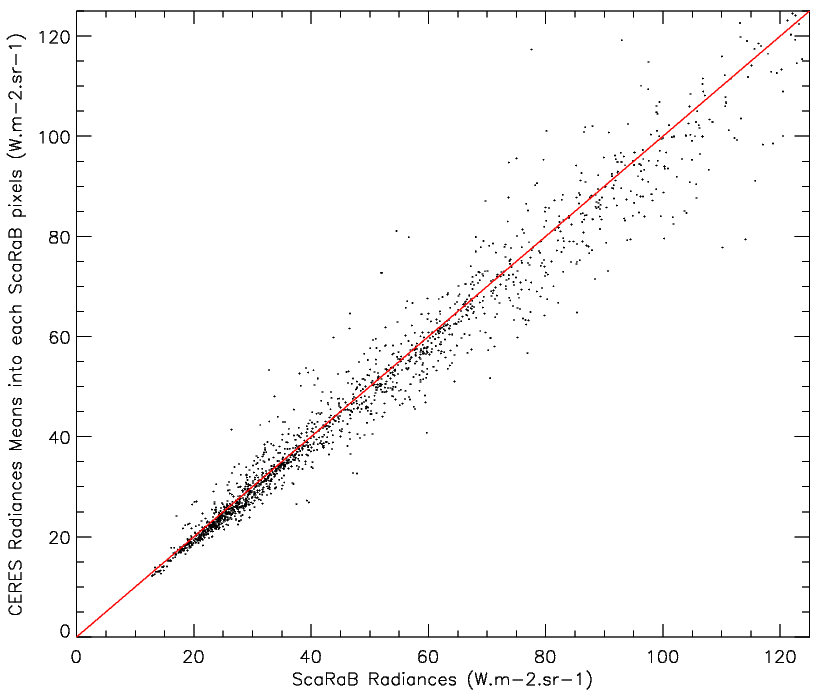


Exemple of ScaRaB PSF

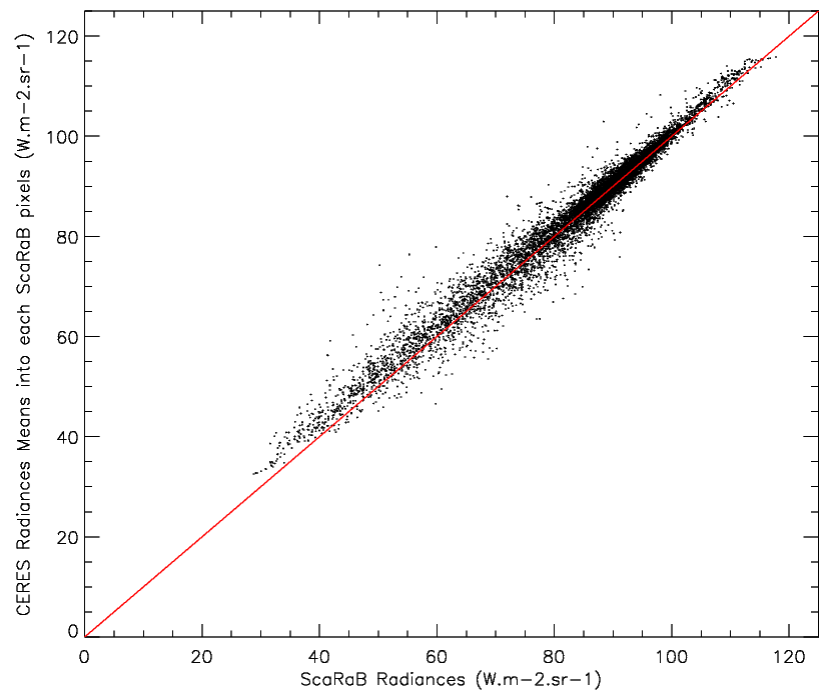
Comparisons between an averaged value (CERES pixels into a ScaRaB pixel) and the ScaRaB measurement.

Results – PAPS Campaign

Unfiltered ScaRaB SW Radiances vs. Unfiltered CERES-FM2-PAPS SW Radiances
51 days, with 5', 5° & coverage of at least 80% (surface) of the ScaRaB pixel.
Daytime data only.



SW Radiances – 51 days – 5° 5' 80%.



LW Radiances – 51 days – 5° 5' 80%.

# collocated pixels	$\frac{ScaRaB - CERES}{mean(CERES)}$ (in %)
2085	1.88 ± 9.78

# collocated pixels	$\frac{ScaRaB - CERES}{mean(CERES)}$ (in %)
10769	-0.74 ± 2.88

Results – PAPS Campaign

Statistics are not surface dependent or pixels (in the ScaRaB swath) dependent.

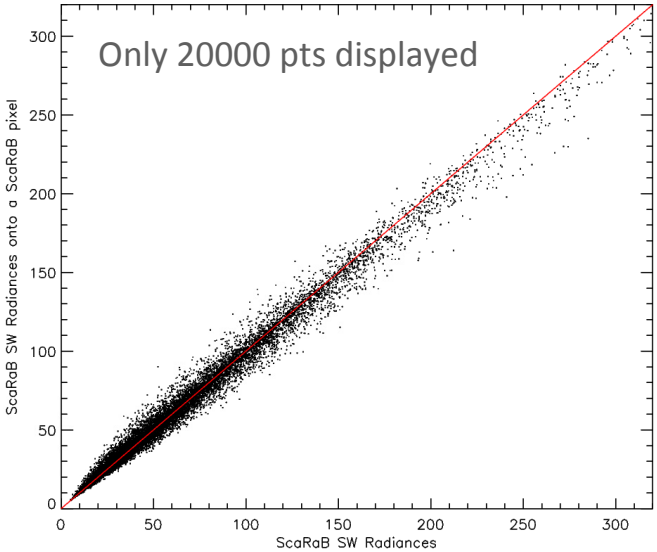
To validate ScaRaB it's better to compare homogeneous pixels between them (to be sure that bias & std are not due to the scene heterogeneity)

➔ Statistics over the values of $\dfrac{\sigma_{CERES(in\ each\ ScaraB\ pixel)}}{mean(CERES)_{in\ each\ ScaraB\ pixel}}$

$\dfrac{\sigma_{CERES}}{mean(CERES)}$	N	$\dfrac{ScaRaB - CERES}{mean(CERES)}$ (in %)
0- 5%	342	1.52 ± 3.69
5-10%	534	2.20 ± 5.81
10-15%	363	2.18 ± 9.38
15-20%	245	2.95 ± 10.29
20-25%	207	2.09 ± 11.46
25-50%	360	0.99 ± 15.97
50-100%	34	-6.84 ± 20.12
0-100%	2085	1.88 ± 9.78

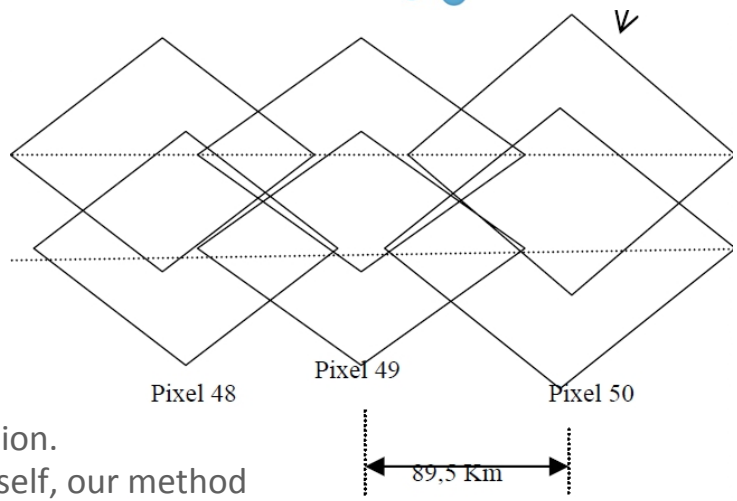
SW Radiances – surface > 0.8 – 5 min – 5°

Results – PAPS Campaign



ScaRaB L1A2, XT mode, MT
vs.
ScaRaB L1A2, XT mode, MT

SW Radiances
(**2545273** colocated pixels)
-0.02 ± 9.38 % (RMS : 9.4%)



Same colocation criteria, same algorithm ➔ Small biais but large dispersion.
When comparing same instrument with overlaping pixels with himself, our method brings std.

$$\frac{\sigma_{CERES}}{mean\ (CERES\ )} = 0 - 100\%$$

; surface > 80%
; 51 days (PAPS campaign)

Criteria	N	SW Radiances
5° - 5min	1998	1.81 ± 9.71 %
5° - 2min	606	0.95 ± 9.99 %

Restrict the criteria (ex. temporal)
↓
Improve the statistics
↓
But also reduce N

Conclusions & perspectives

CERES & ScaRaB are in good agreement.

➔ biais ≈2% in SW, with
error budget ScaRaB≈1.6%, CERES≈1% (at 1 σ)
+ errors brought by the colocation method > 1,5%

Comparisons in XT mode all along MT mission to analyse the possible drifts between instruments. All these comparisons are instantaneous comparisons.

$$\frac{\sigma_{CERES}}{mean\ (CERES\ )} = 0-5\% \quad ; \ 5\ \text{min} \ ; \ 5^{\circ}$$

YEARS	SW Radiances (psf > 0.7)	LW Radiances (psf > 1.2)
2012	(1124) 2.19 ± 3.80 %	(271393) -0.793 ± 1.140 %
2013	(1238) 2.19 ± 3.98 %	(290524) -0.815 ± 1.231 %
2014	(605) 2.84 ± 4.40 %	(149122) -0.840 ± 1.214 %

Thank you!