

Results from the Modified CERES Along-Track Scan Mode

**LMD/IPSL
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ERBE & CERES nominal along-track mode

- ERBE: operated for short periods
- CERES/TRMM: 9 days
- CERES/Terra and Aqua: every 15 days

Outline

- Motivation for an improved or 'true' AT (TAT) mode
- Shortcomings of the AT mode
- Definition and Geometrical Characteristics of the TAT mode
- Discussion on the angular consistency of the collocated radiometric observations (LW, SW)

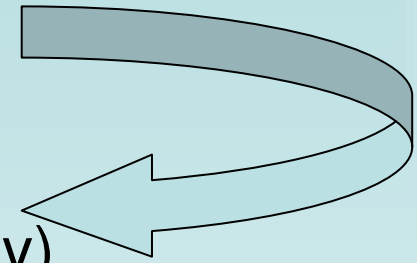
Motivations for a 'true' AT mode

- Create a Simulation dataset for BBR of EarthCARE (ESA-JAXA, project)

triplets of nadir and oblique fore and aft observations (Lopez-Baeza et al., ESA study)

oblique angle 55° : according to Davis (1984), Bodas-Salcedo et al (2003)

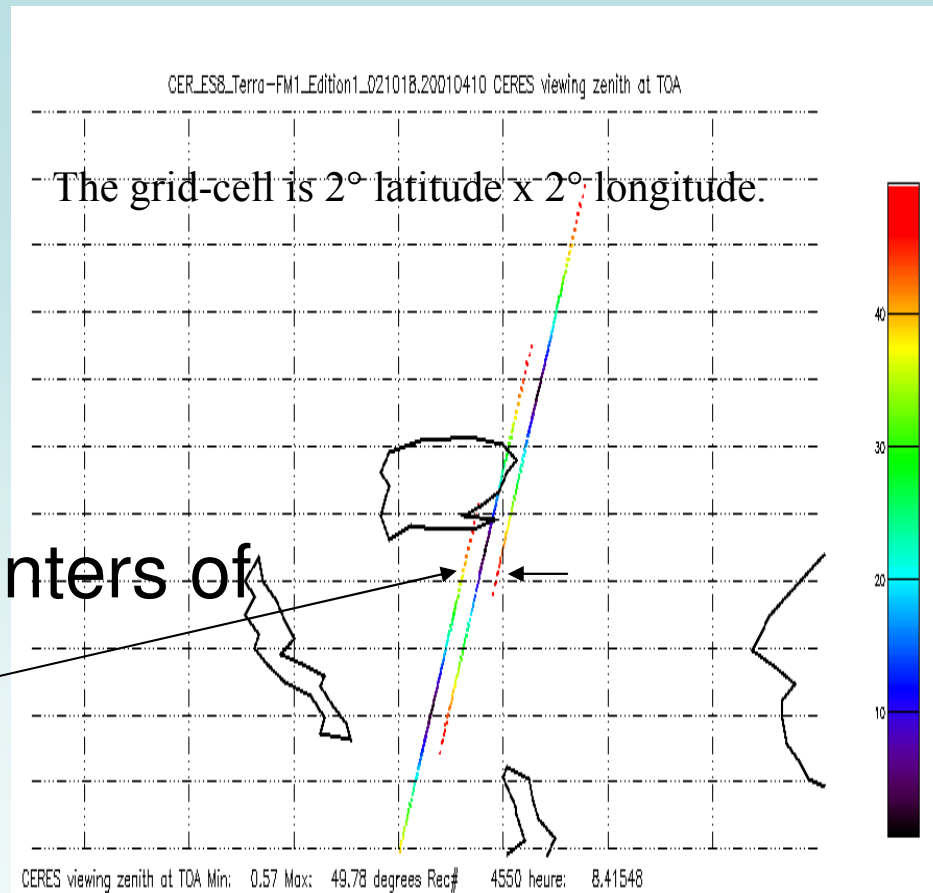
- Contribute to CERES ADM validations



Collocation error (up to 80 km) with the nominal AT mode, due to the Earth rotation

Three along-track CERES/Terra records (centred on Lake Victoria, Africa). The pixel centres (not the footprints) are plotted with colours illustrating the viewing zenith angle (nadir in dark blue, 50° fore and aft in red).

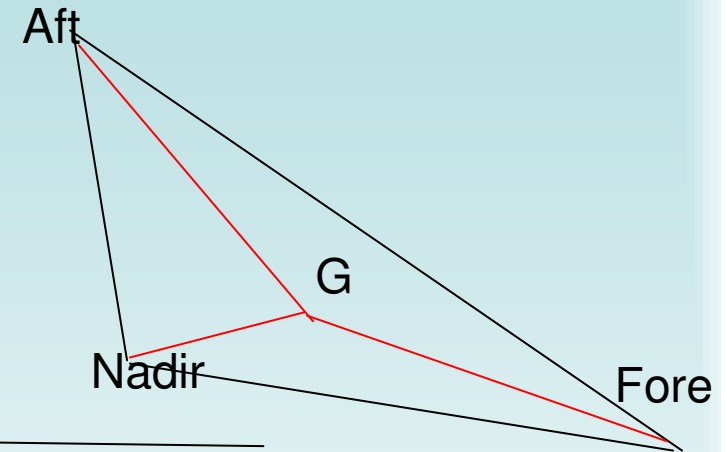
80 km between the centers of the 55° fore and aft observations



Distance between triplets: definition

- Triplet: nadir and the 55° fore and aft co-registered observations

- AN=aft-nadir distance
NF=fore-nadir distance
AF=aft-fore distance

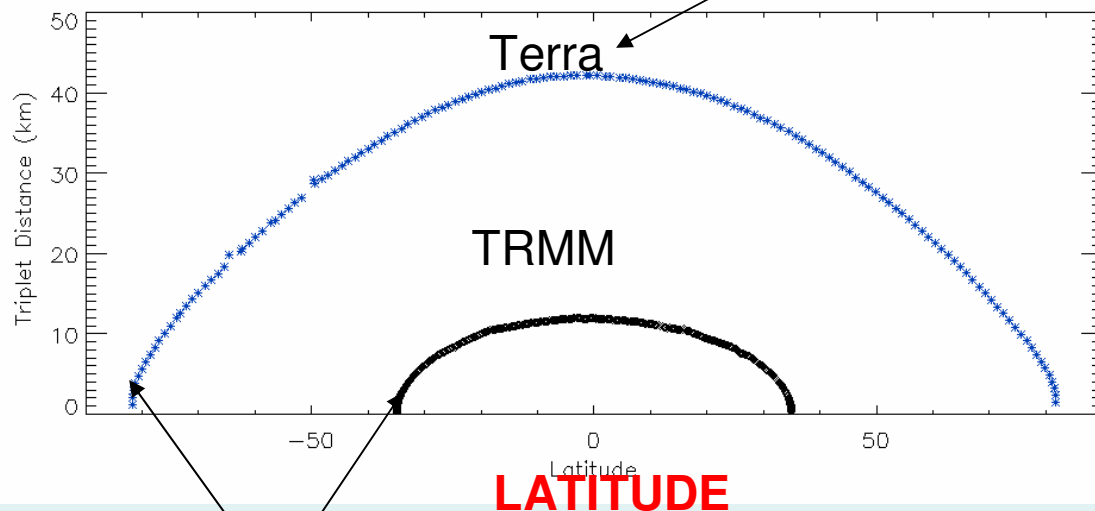


- Euclidean distance $E = \sqrt{AN^2 + NF^2 + AF^2}$
- Distance from g.c. $G = \sqrt{GN^2 + GF^2 + GA^2} = E / \sqrt{3}$

Triplet distance for CERES TRMM and Terra from real data

Maximum due to the Earth's rotation between the observations

TRIPLET DISTANCE (km)



Terra:
2000, Apr. 12

TRMM:
1998, Apr. 23

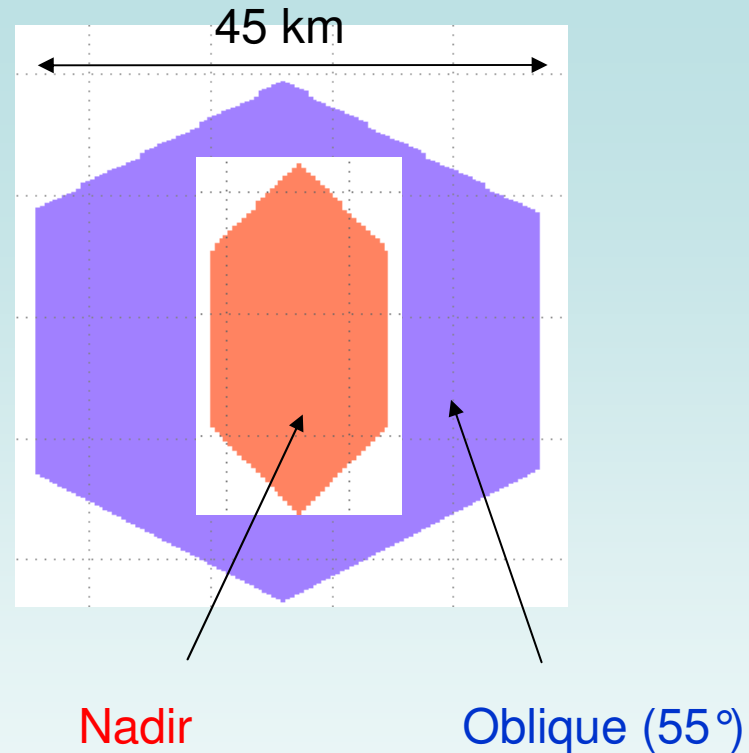
Zero where orbit turns back and the satellite motion accompanies the Earth rotation

Larger FOV at oblique directions than at nadir

Approximate calculation
and no PSF effect

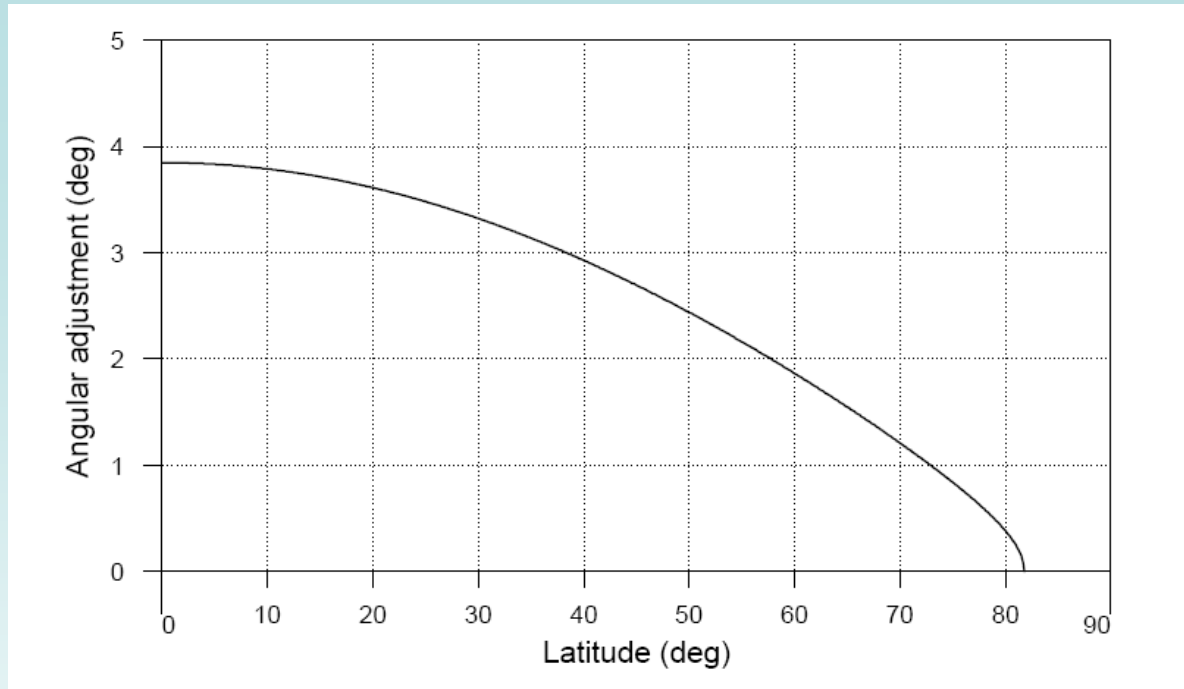
CERES/Terra

Field Of View at



- ERBE AT mode: Statistic validation of the LW ADM (Smith et al., JAM, 1994)
- CERES AT mode: in combination with MODIS or MISR (Loeb et al., 2003, yesterday's presentation)
- → Exploring a 'true' CERES AT mode (with compensation for the Earth's rotation) to reduce collocation errors

Modified or True along track mode: Latitude-dependent yaw angle



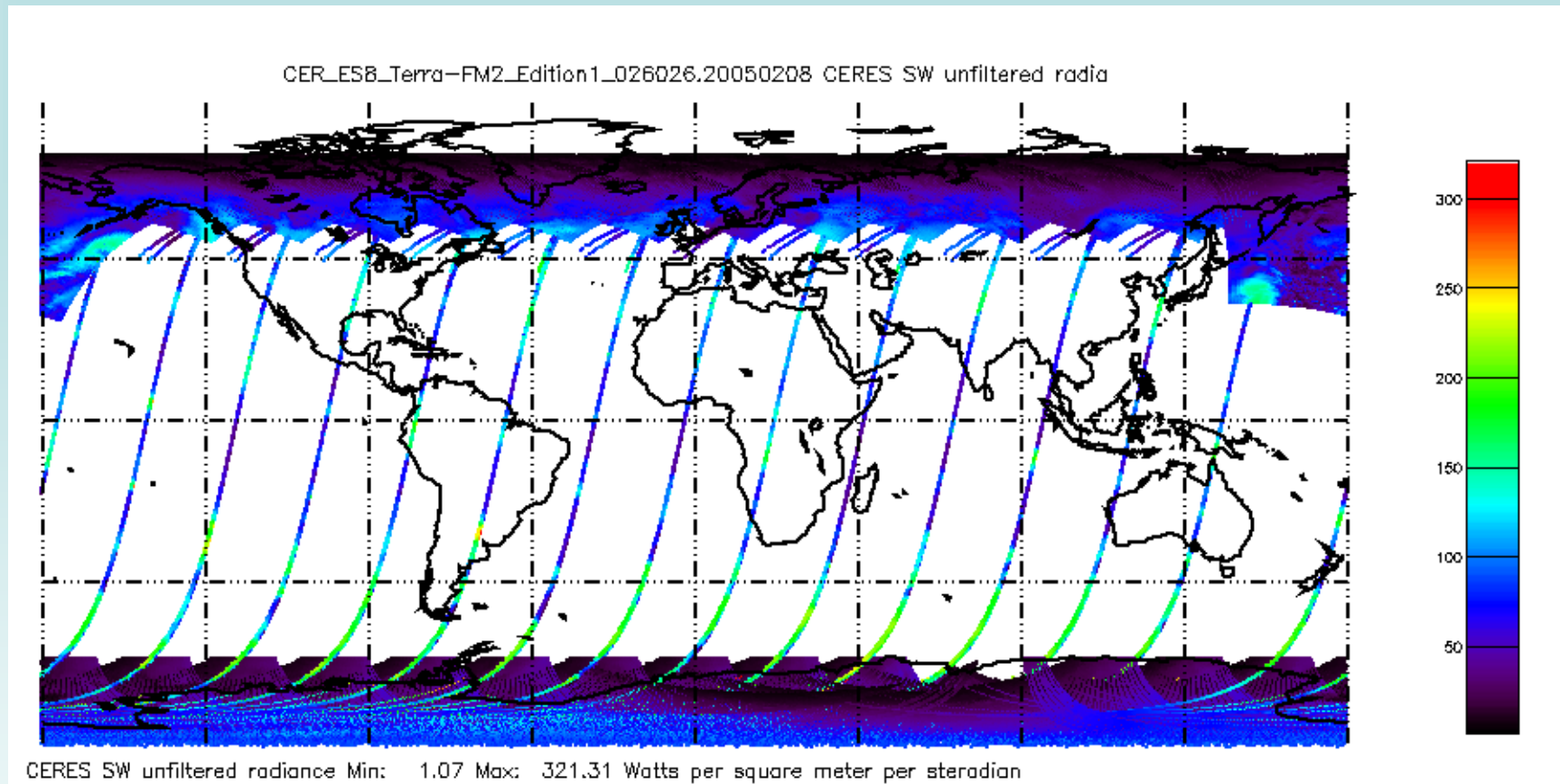
To
compensate
the Earth's
rotation

Theoretical Bases: see M. Capderou satellites: orbits and mission, p 187-188 , SPRINGER, 2005

Modified along track mode

- Incited by the BBR/EarthCARE study with a specific 'Instrument Coverage Request'
- Experienced with the CERES/Terra FM2 and Aqua FM3 instruments, thanks to Z. Peter Szewczyk
- Several days for Terra and Aqua during February and March 2005

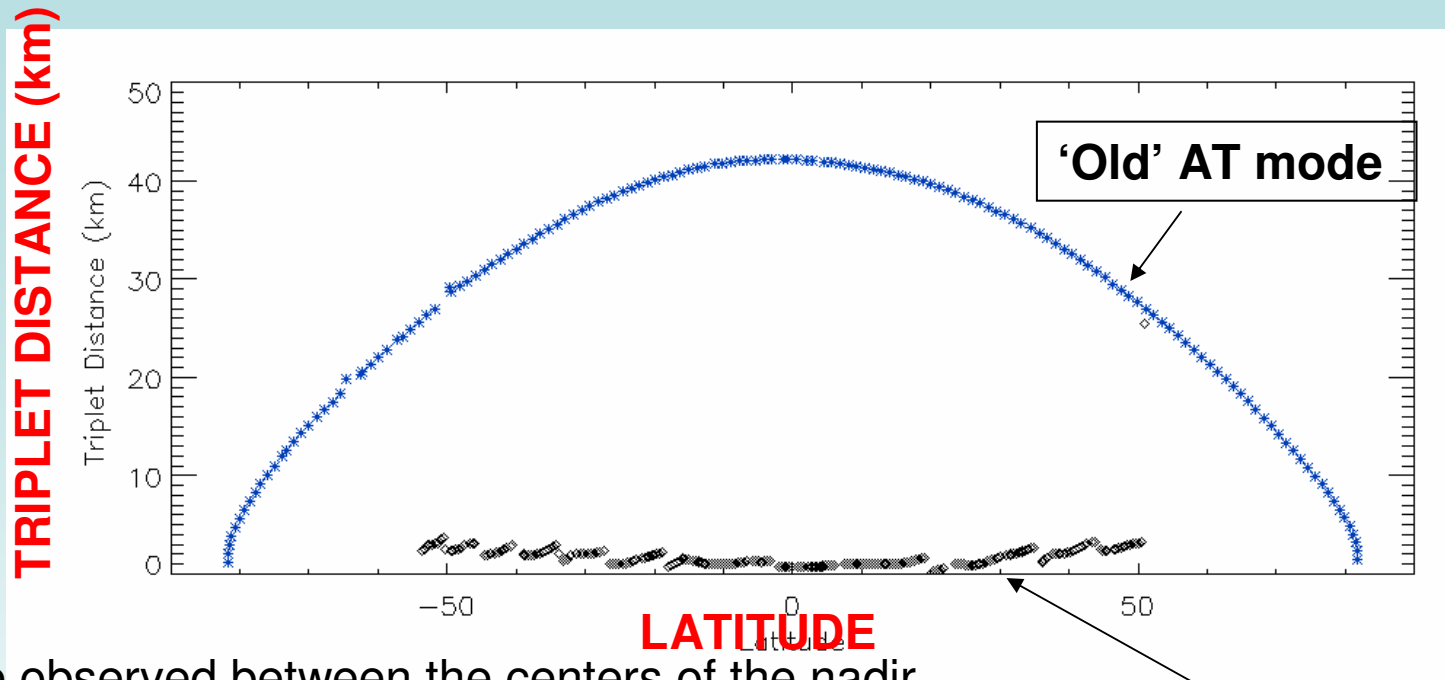
2005, Feb, 08



True AT mode on the daytime side

AT vs TAT

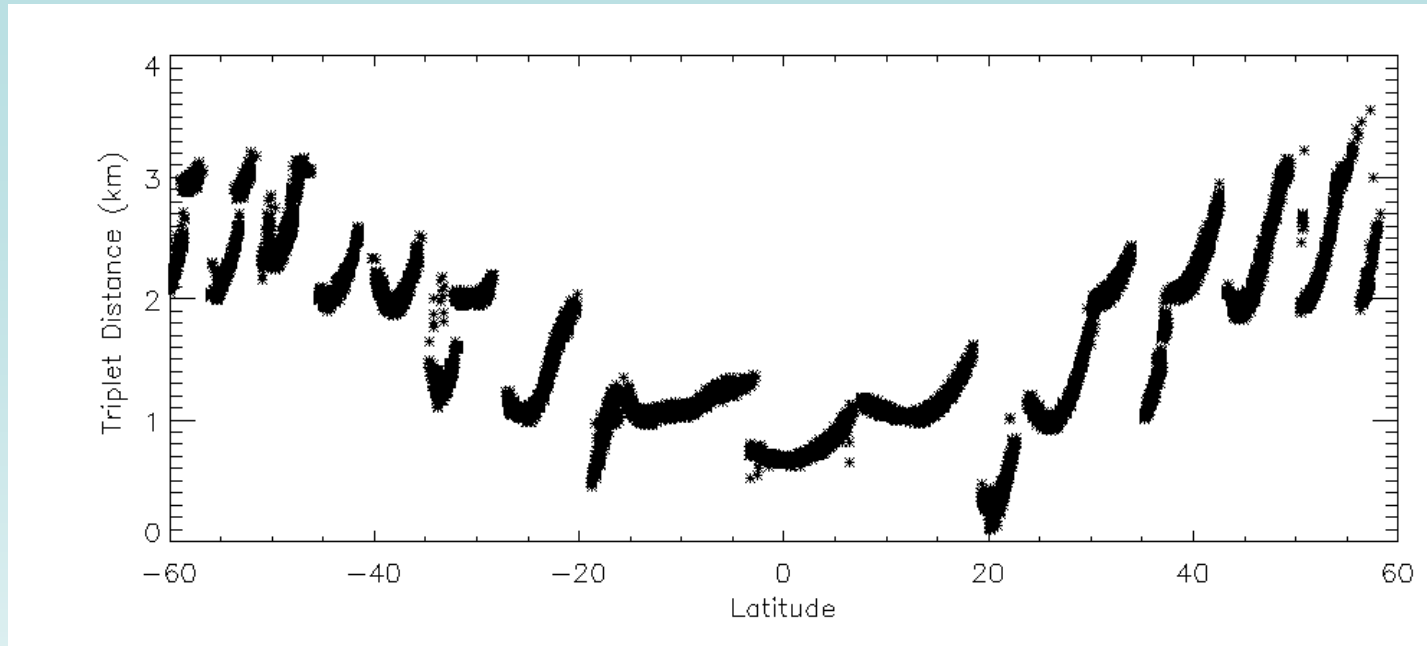
Minimum distance for CERES Terra from real data



Distance observed between the centers of the nadir and the aft and fore 55° oblique observations. Comparison between the old and new along track scanning modes (M. Capderou and M. Viollier, JAOT, in press)

**Modified or True
AT mode on Terra
2005/02/08**

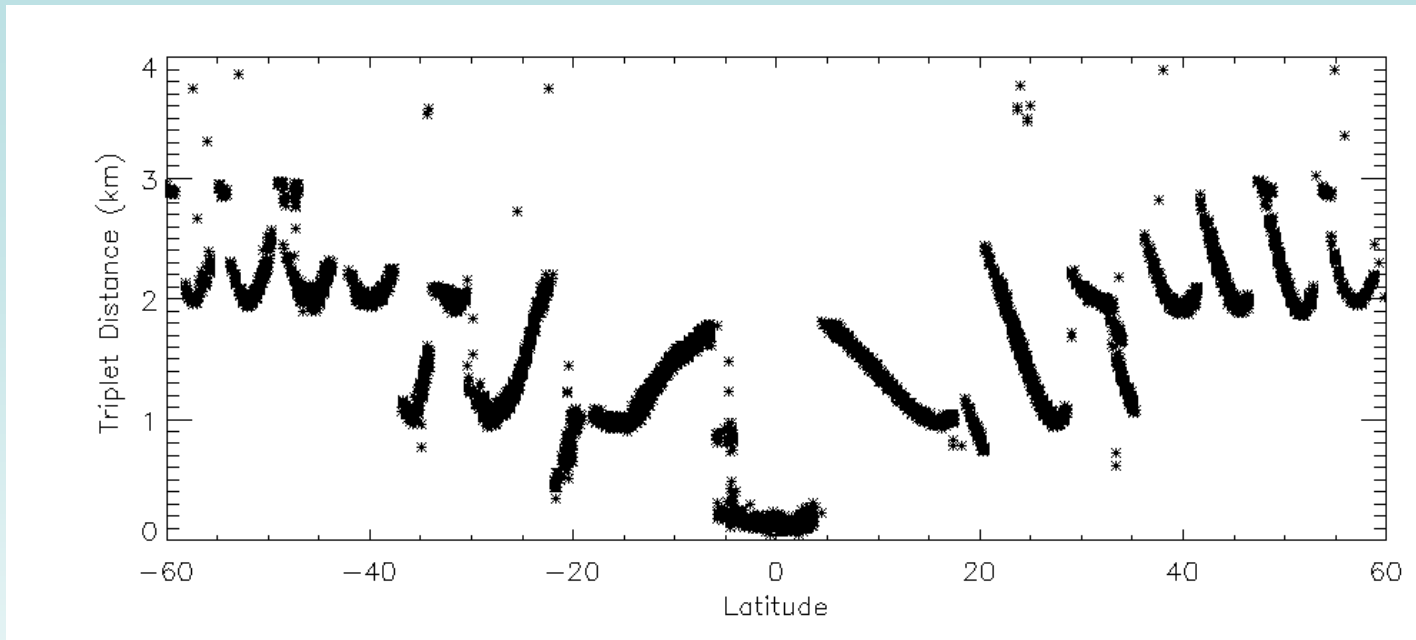
Triplet Euclidean distance



Distance between the centers of the nadir and the two oblique observations at 55° , for the six days of Terra TAT data (February 8, 22, 25, 26, 27 and 28) in 2005.

Jumps are caused by the step-wise changes in AZ (constant within 0.6°)

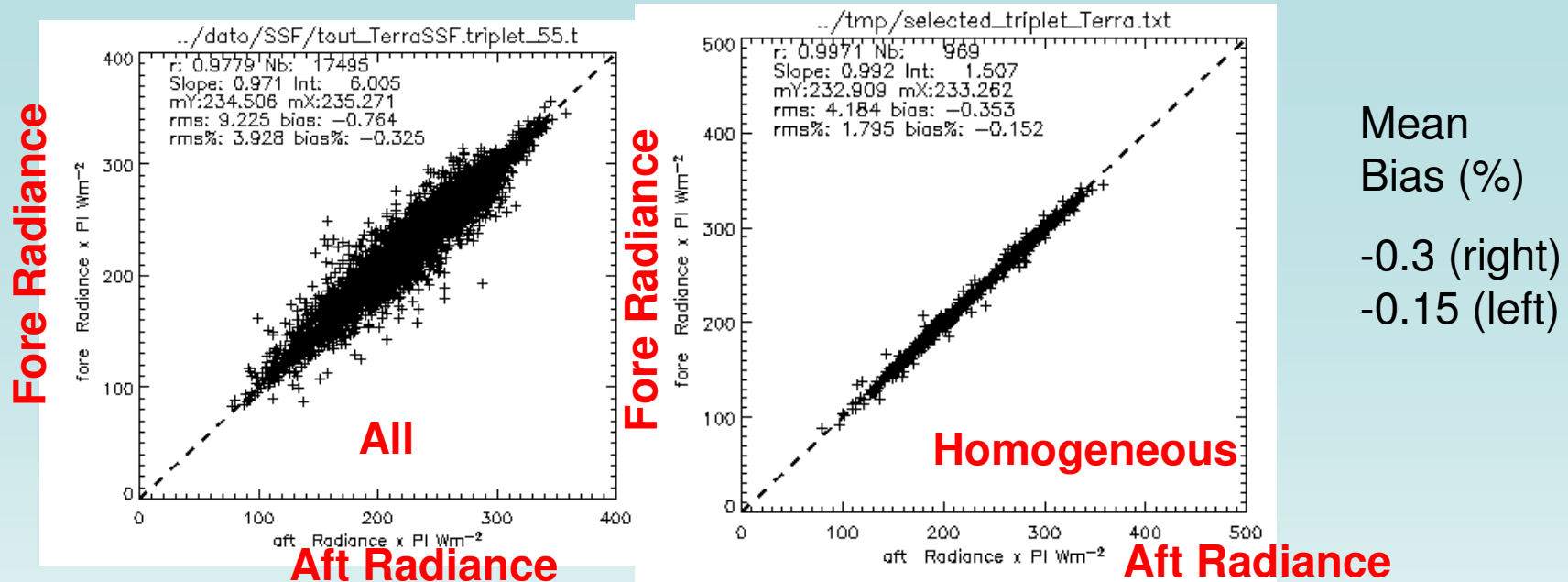
Same but three days of Aqua data (February 8, March 8 and 22) in 2005



Radiance and flux

1 – LW angular comparisons

Oblique (55°) aft and fore



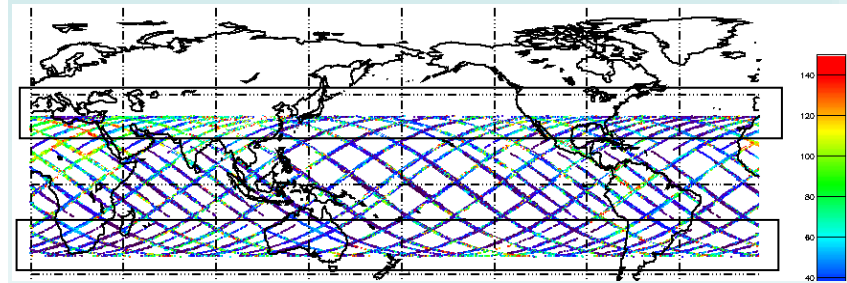
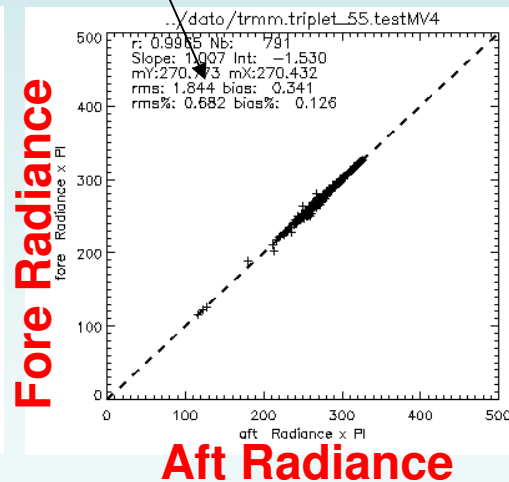
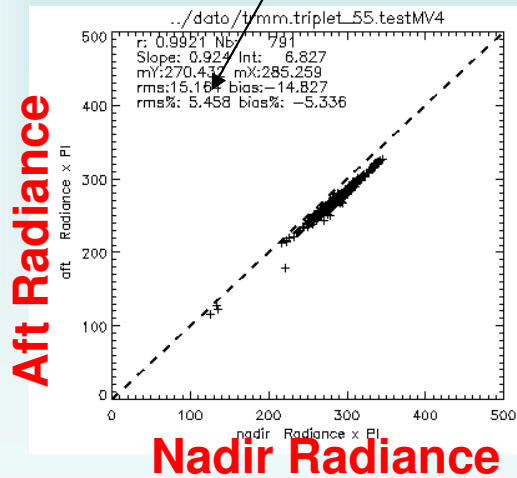
Comparison between the LW radiances from the 55° aft and fore directions, for all the triplets (left) and for homogeneous area (right).

The corresponding homogeneity requirement is based on the radiance scatter over distance of 50 km in the along-track direction, and selected if the standard deviation is less than 5% of the mean radiance

LW: comparison between day and night

	N Obs.	Rad LW rms diff (%)			Flux LW rms diff (%)		
		Aft /nad	Fore /nad	Fore /aft	Aft /nad	Fore /nad	fore/ aft
Day	708	5.93	6.4	1.43	1.20	1.36	1.48
Night	791	5.46	5.32	0.68	1.07	1.03	0.70

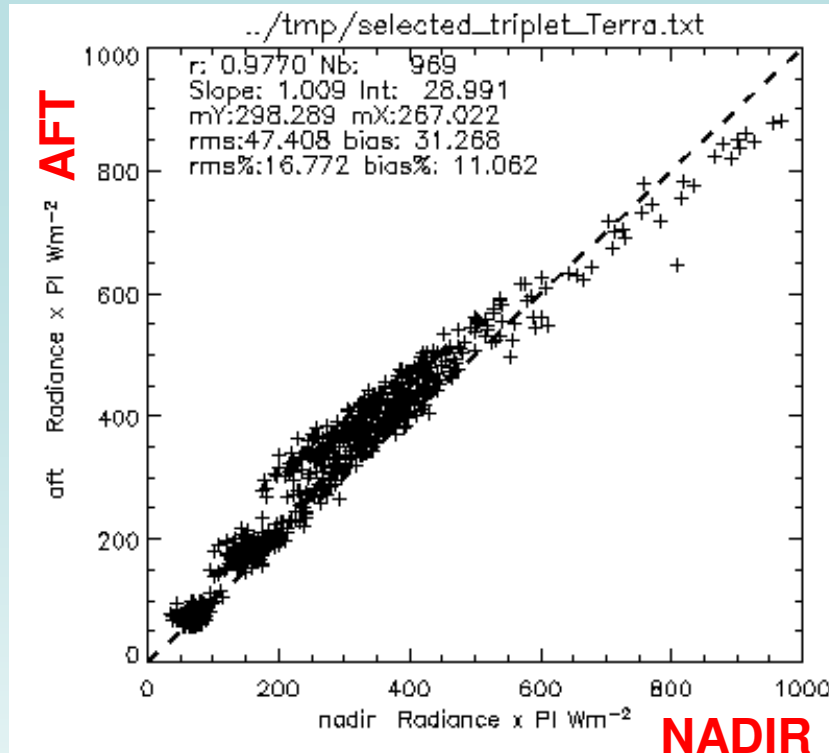
For the 9 days of AT mode on CERES/TRMM, with triplet distance <5 km and with spatial homogeneity constraints



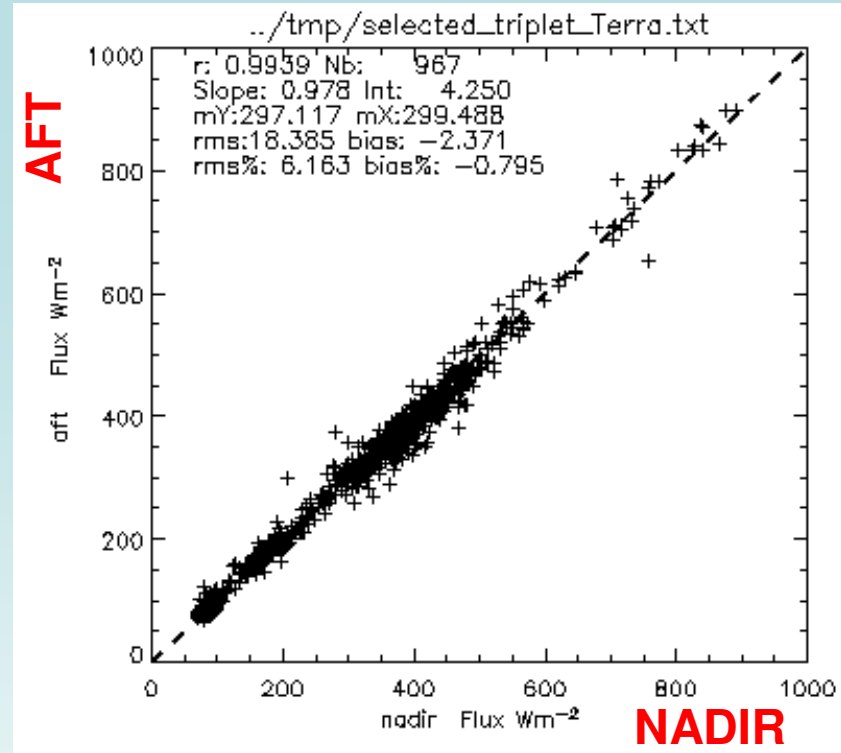
Radiance and flux

2 – SW angular comparisons

Terra, 55° aft vs nadir

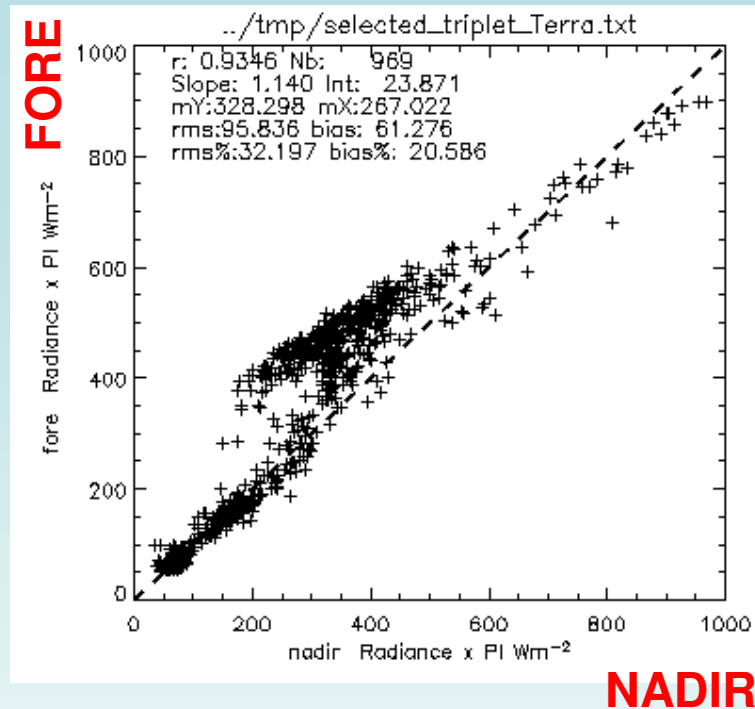


RADIANCE
rms:16.8%

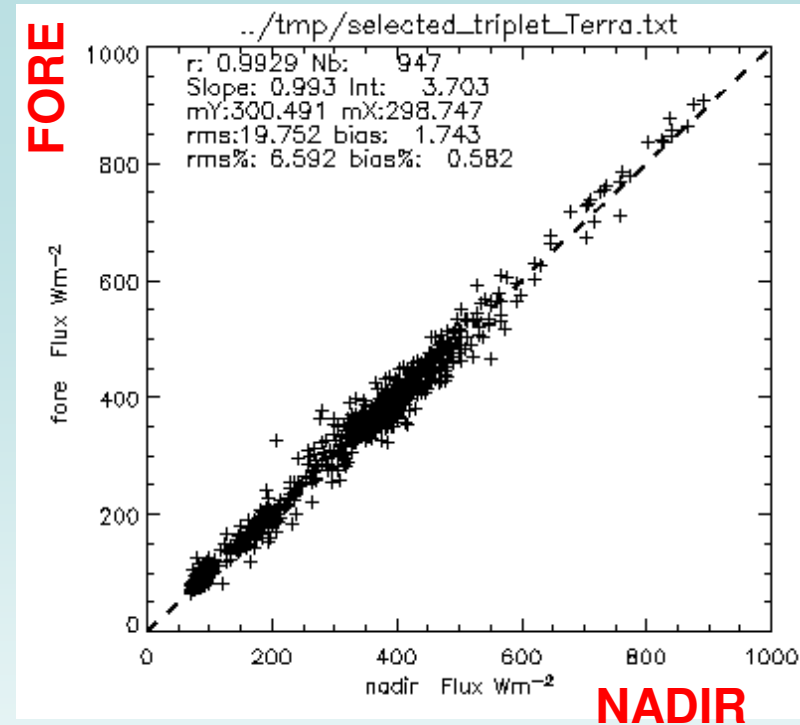


FLUX
rms:6.1% mean=-0.8%

Same, but the fore/nadir couple



RADIANCE
rms:32.2%



FLUX
rms:6.6% mean=0.6%

RMS Differences between pairs of TAT TERRA observations: SW and LW, radiance and flux (SSF estimates)

TAT TERRA	SW rms difference (%)		LW rms difference (%)	
	Radiance	Flux	Radiance	Flux
Aft/Nadir	16.4	6.1	7.4	3.0
Fore/Nadir	32.2	6.6	7.6	3.1
Fore/Aft	19.0	6.2	1.8	1.8

Same for AQUA

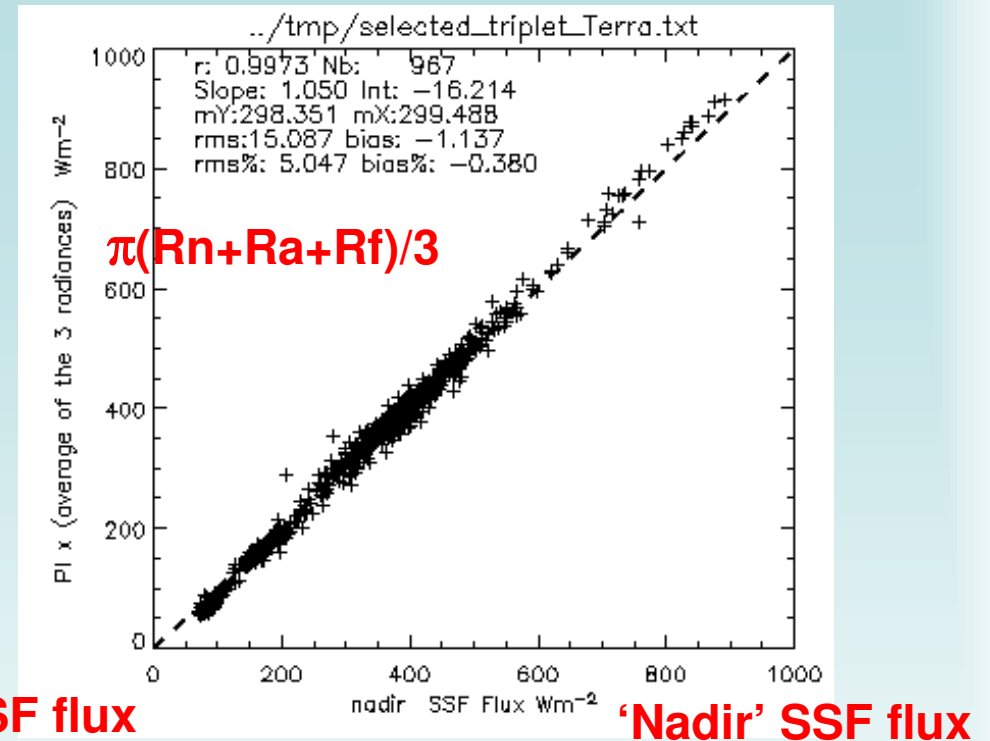
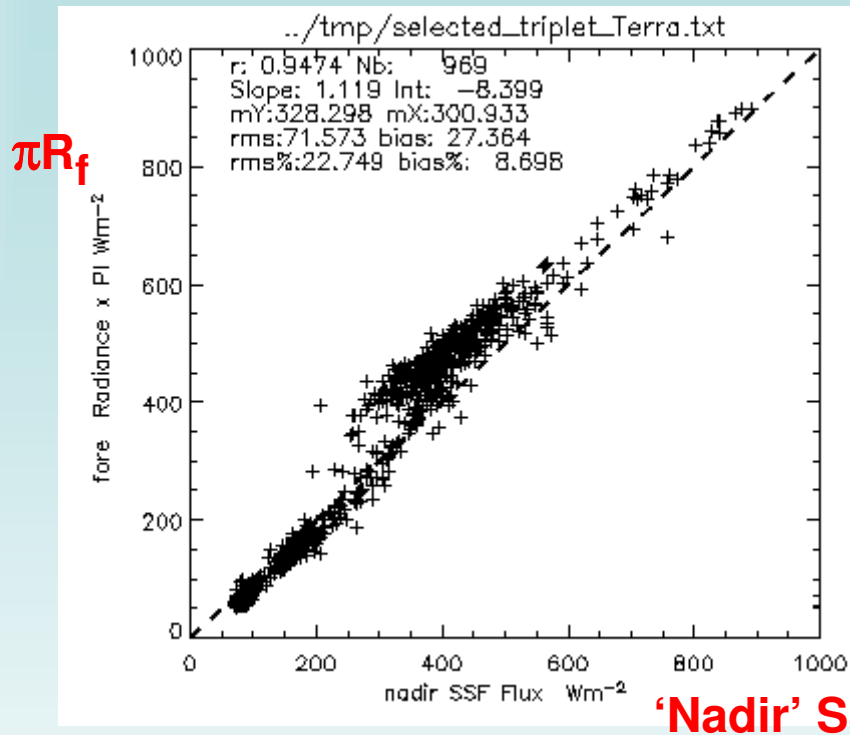
TAT Aqua°	SW rms difference (%)		LW rms difference (%)	
	Radiance	Flux	Radiance	Flux
Aft/Nadir	14.2	7.7	8.0	3.0
Fore/Nadir	24.0	8.6	8.3	3.1
Fore/Aft	16.2	7.9	1.9	2.3

For the mean differences

TAT TERRA	SW mean difference (%)	LW mean difference (%)
	Flux	Flux
Aft/Nadir	-0.8	-0.6
Fore/Nadir	+0.6	-0.7
Fore/Aft	1.3	-0.2

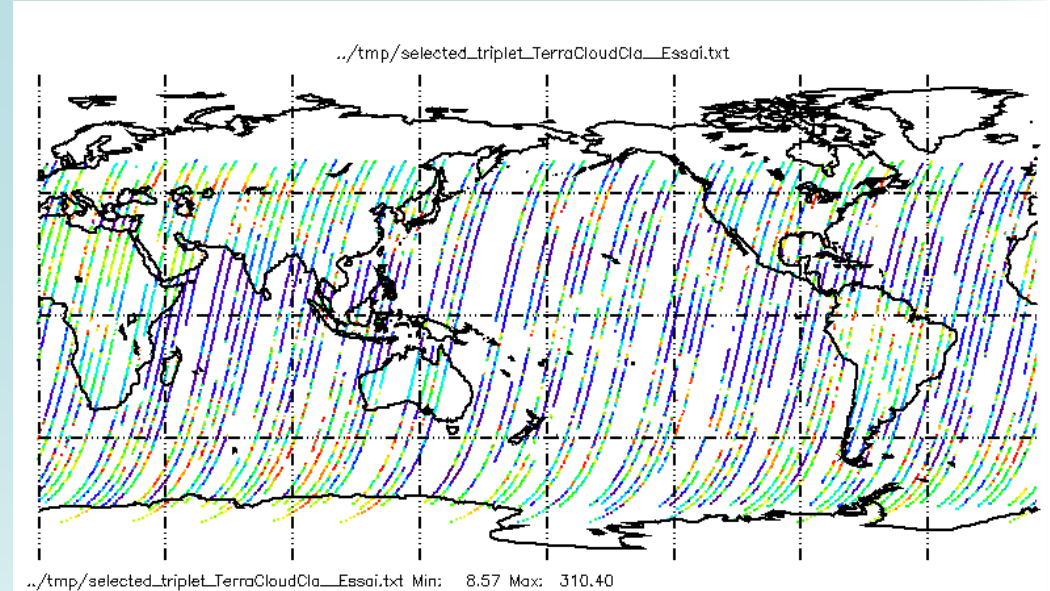
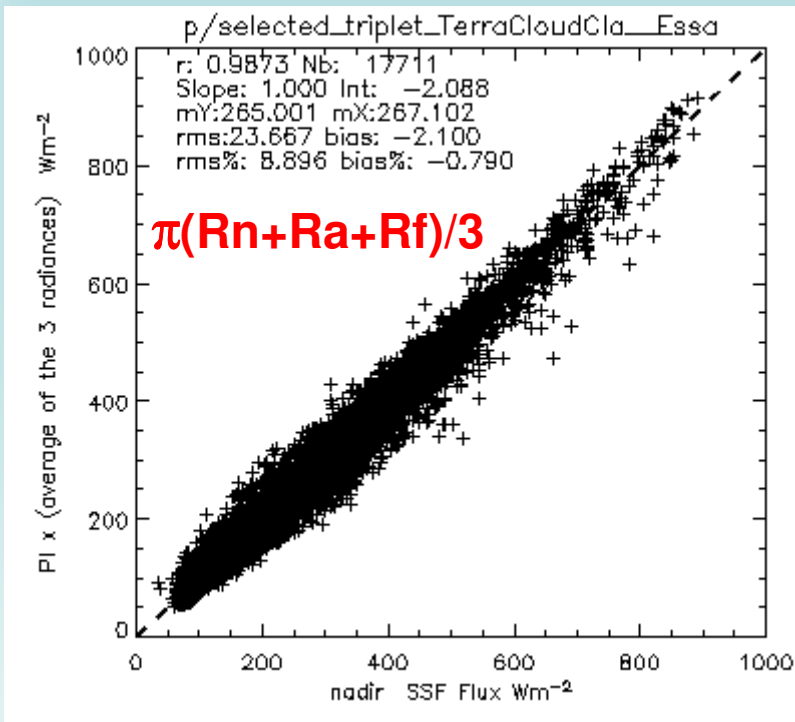
→ no significant mean differences

The average of the 3 radiances agrees with the CERES flux estimate



Comparisons between a single radiance (multiplied by π) and the SSF flux estimates from the nadir direction (left); same but with the average of the 3 radiances on Y-axis (right).

Same but for all the triplets



'Nadir' SSF flux

RMS difference: 8.9%

Mean difference: -0.8 %

Conclusion

- The modified CERES AT mode provides well collocated BBR triplets (distance < 3km)
- Mean biases between the nadir and oblique flux estimates are not significant ($\pm 0.5\%$)
- RMS flux differences are small (6% SW, 3% LW) only over homogeneous scenes (residual co-registration errors)
- The average of the 3 radiances ($\times\pi$) agrees well with the CERES flux estimate (5% rms, 0.5% bias) – at least for the studied Terra and Aqua conditions
- Further studies: analysis by cloud type and comparison with theoretical calculations (Valencia University)

TAT available data (ES8, SFF)

- 2 orbits in December 2004:

CER_ES8_Terra-FM2_Edition1_026025.20041207
CER_ES8_Terra-FM2_Edition1_026025.20041225

- 6 days for February 2005: 8, 22, 25, 26, 27, 28 (6 FM2 and 1 FM3)

CER_ES8_Terra-FM2_Edition1_026026.20050208
CER_ES8_Terra-FM2_Edition1_026026.20050222
CER_ES8_Terra-FM2_Edition1_026026.20050225
CER_ES8_Terra-FM2_Edition1_026026.20050226
CER_ES8_Terra-FM2_Edition1_026026.20050227
CER_ES8_Terra-FM2_Edition1_026026.20050228

CER_ES8_Aqua-FM3_Edition1_026026.20050208

- 2 days for March 2005, 8 and 22

CER_ES8_Aqua-FM3_Edition1_026026.20050308
CER_ES8_Aqua-FM3_Edition1_026026.20050322