Diurnal Variations : preliminary observations with Aqua and Terra

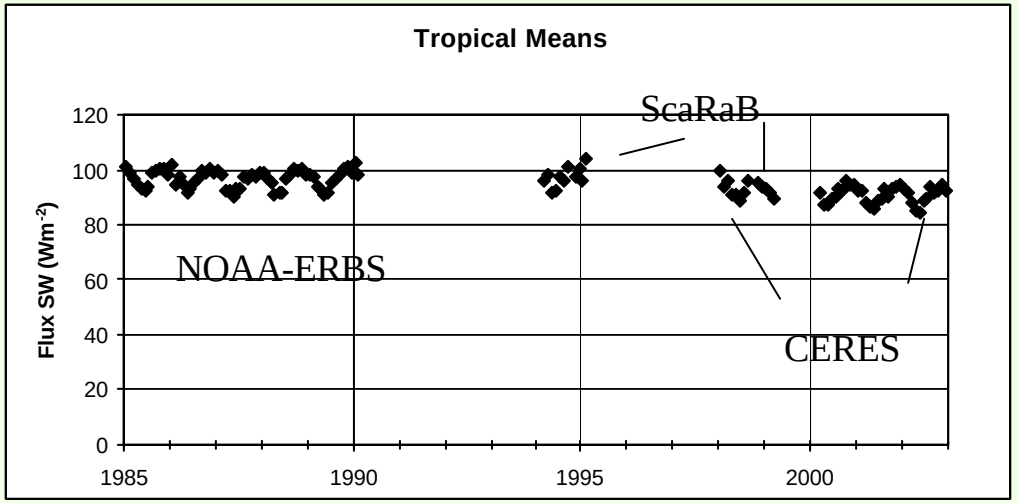
With special emphasis on :

- **SW fluxes**
- **combination with Meteosat-5**

Michel Viollier, Patrick Raberanto, Robert Kandel

Laboratoire de Météorologie Dynamique
IPSL/CNRS, Ecole Polytechnique
Palaiseau, France

and impact on monthly means with an important issue …



can the low 1999-2002 SW fluxes be explained by diurnal effects ? are they linked to the 10:30 observation local time ?

ES4 Terra Edition2 Data Quality Summary : "The CERES SW flux tropical seasonal means are lower than ERBE ERBS by 3-4% which implies that there may be a real difference between ERBE and CERES SW fluxes. This bias persists into 2000, where the CERES Terra total-sky SW fluxes are 5-6% less than the ERBE means for all 3 months"

Outline

- compare regional monthly means computed from Terra and Aqua data separately

- impact on the global and tropical means

- compare diurnal cycles to contemporary Meteosat-5 observations

- contribute to the CERES-GEO validation (SRBAVG)

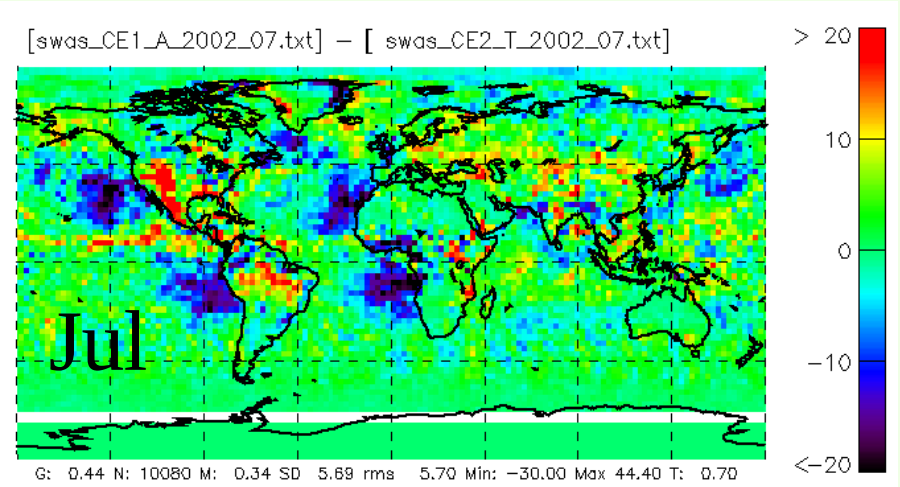
Data used in this study

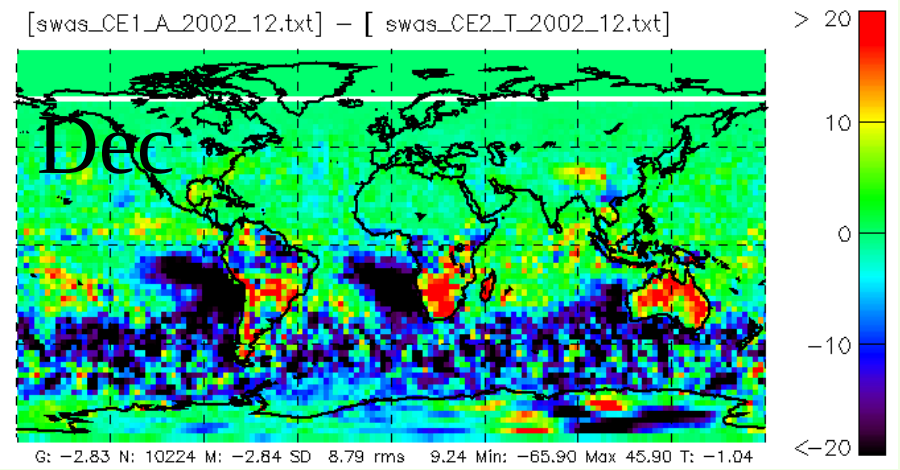
Month MM : July to Dec 2002

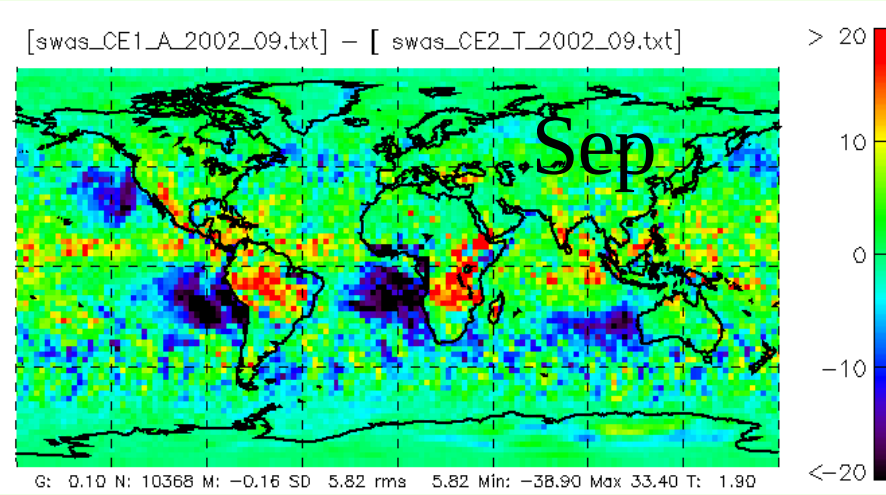
- E-S9 Terra + Aqua : CER_ES9_FM1+FM2+FM3+FM4_Edition1_023022.2002MM - E-S9 Terra alone : CER_ES9_FM1+FM2_Edition2_021019.2002MM - E-S9 Aqua alone : CER_ES9_Aqua-FM3_Edition1_023022.2002MM CER_ES9_Aqua-FM4_Edition1_023022.2002MM	ES9
- E-S8 Terra : CER_ES8_Terra-FM1_Edition2_023019.200207DD CER_ES8_Terra-FM2_Edition2_023019.200207DD - E-S8 Aqua : CER_ES8_Aqua-FM3_Edition1_025022.2002MMDD CER_ES8_Aqua-FM3_Edition1_025022.2002MMDD	ES8

(Most available end Aug 2003, Aqua-Edition 1 available on Sept, 9)

CERES SW : Aqua minus Terra, 2002 July, Sep, Dec.



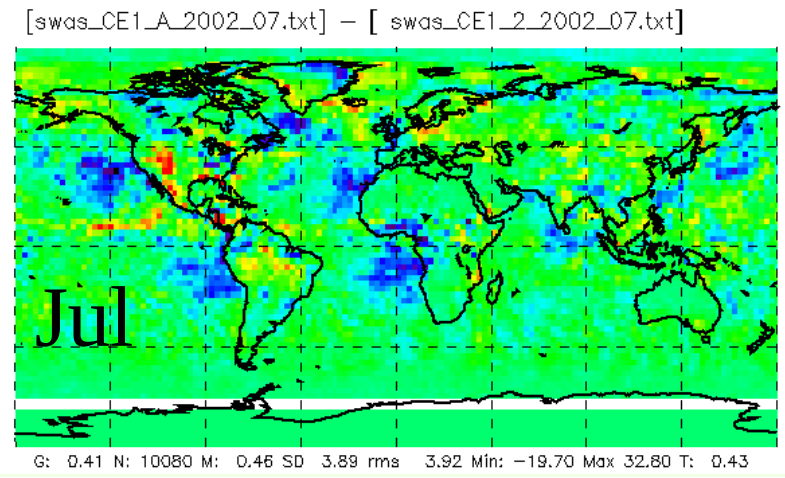


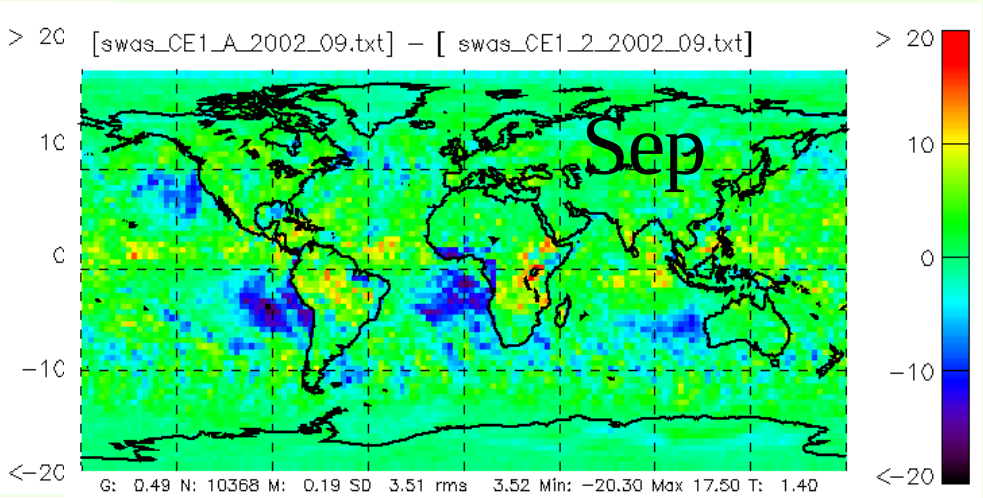


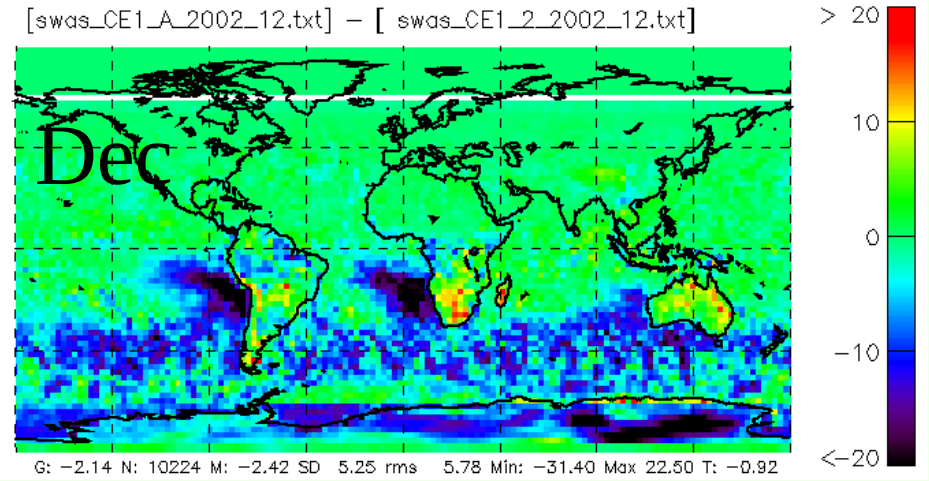
Compared to Terra, Aqua misses morning reflected flux from marine stratus, but is sensitive to afternoon convective activity on continents, and vice versa.

[December/Antartic: instrument/angular differences are amplified by the very large solar incident flux]

CERES SW : Aqua minus S9(Ter+Aq), 2002 July, Sep, Dec.





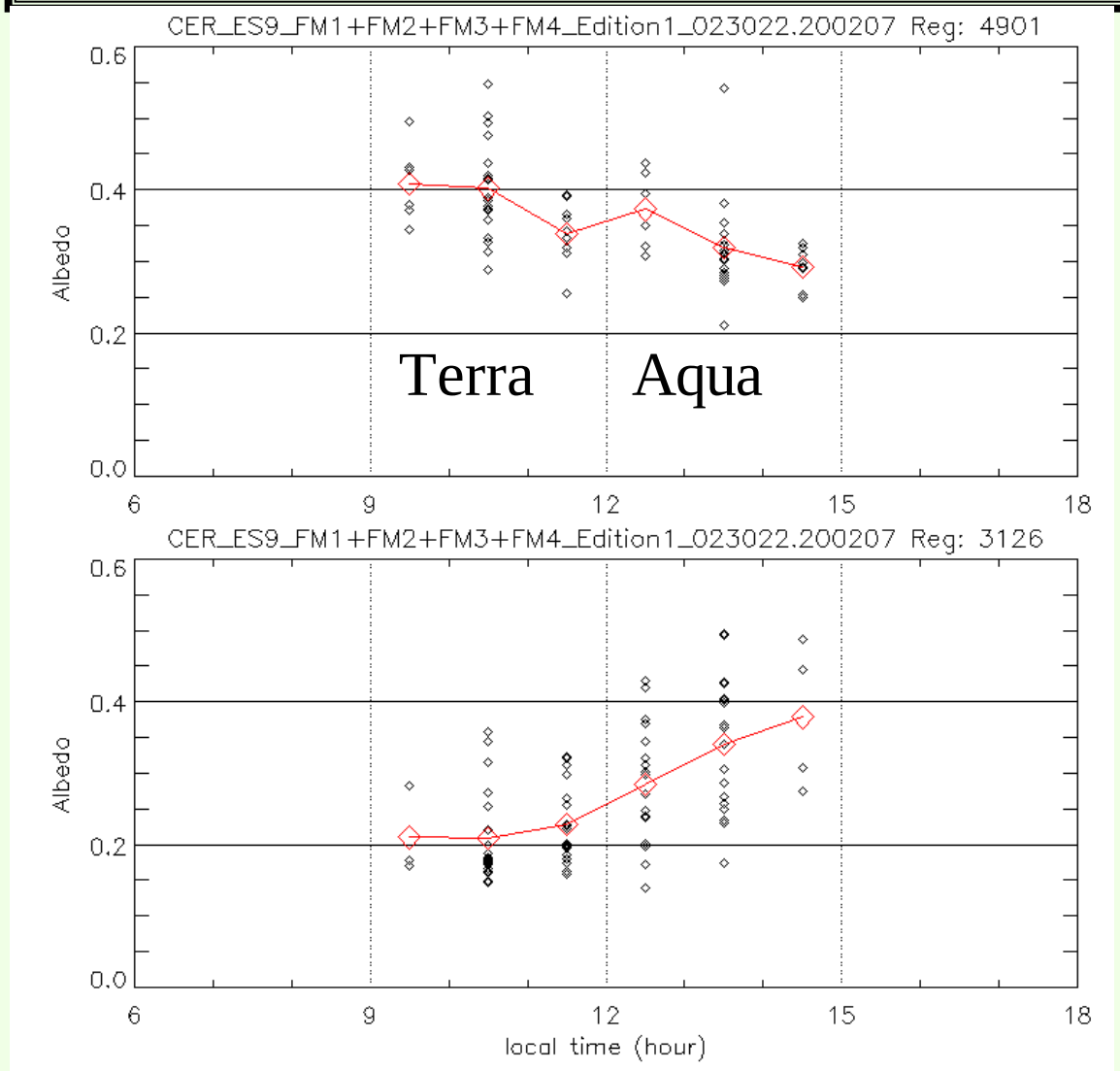


Smaller differences than
in 'Aqua minus Terra'
+/- 30 Wm^{-2}
instead of +/- 50 Wm^{-2}

Aqua, Terra ES 9 differences: Min and Max (Wm^{-2})

	Minimum differences near western continent coast		Maximum differences inland areas	
	ERBE Region	Wm^{-2}	ERBE Region	Wm^{-2}
Jul 2002	4901 Cameroon	-30	3126 New Mex. US	44
Sep 2002	5622 Angola	-39	5126 Lake Victoria	33
Dec 2002	6306 off Peru	-31	6211 Madagascar	22

Aqua, Terra ES 9 regional instantaneous albedo



July 2002

Cameroon /east Atlantic sw flux monthly m.

Aqua –Terra= - 30 Wm^{-2}

New Mexico USA /inland area

Aqua –Terra= + 44 Wm^{-2}

Red=monthly mean

CERES Aqua, Terra : SW Global Means (Wm^{-2})

2002	Aqua FM3 Ed1	Terra Ed2	S9(Aq+Te) Ed1	Aqua minus Terra	Terra minus S9(Aq+Te)
Jul	94.29	93.72	93.75	+0.6	0
Aug	92.33	92.32	92.13	0	+0.1
Sep	92.50	92.40	92.01	+0.1	+0.4
Oct	96.63	97.55	96.55	-0.9	+0.9
Nov	101.71	104.83	103.75	-3.1	+1.09
Dec	103.94	106.76	106.07	-2.8	+0.7

$< 1\ Wm^{-2}$

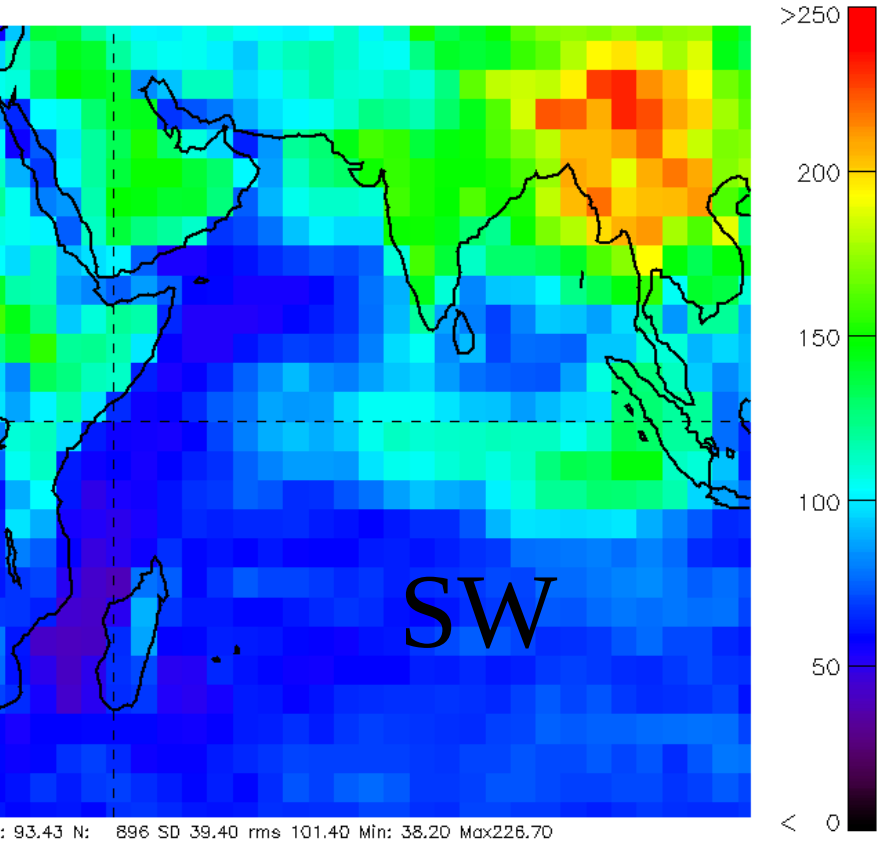
CERES Aqua, Terra : SW 20°S-20N Means (Wm^{-2})

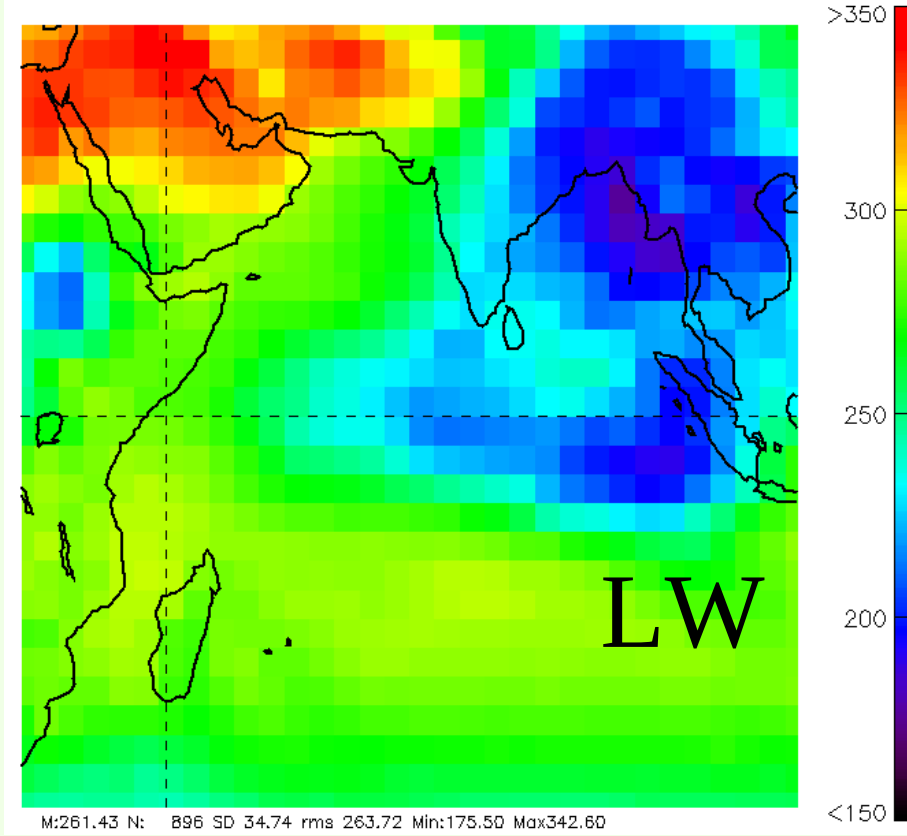
2002	Aqua FM3 Ed1	Terra$_E$ d2	S9(Aq+Te) Ed1	Aqua minus Terra	Aqua minus S9(Aq+Te)
Jul	90.45	89.76	90.02	+0.7	-0.3
Aug	94.23	93.63	93.88	+0.6	-0.2
Sep	93.93	92.03	92.53	+1.9	-0.5
Oct	94.27	92.57	92.98	+1.7	-0.4
Nov	93.85	94.75	94.81	-0.9	-0.1
Dec	91.51	92.55	92.43	-1.0	+0.1

< 0.5 Wm^{-2}

Compare ES9 Terra and Aqua with contemporaneous Meteosat-5 : JULY 2002

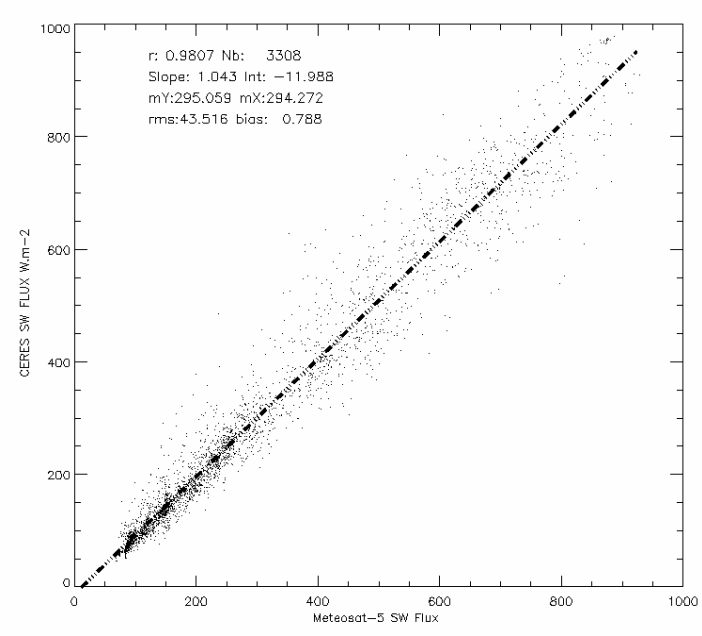
Study over the INDOEX area (1999 study following on)



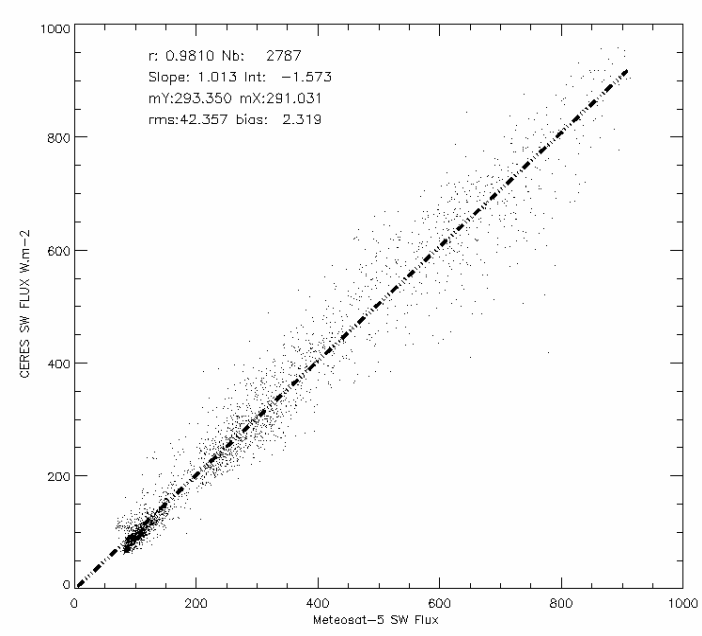


Estimation of Meteosat-5fluxes by comparison to CERES. Examples: July 2002

FM2 (Terra)



FM4 (Aqua)



Meteosat flux conversion: based on ScaRaB 1999 analysis (submitted to JGR)

Intercomparisons between instantaneous SW fluxes from CERES and Meteosat-5

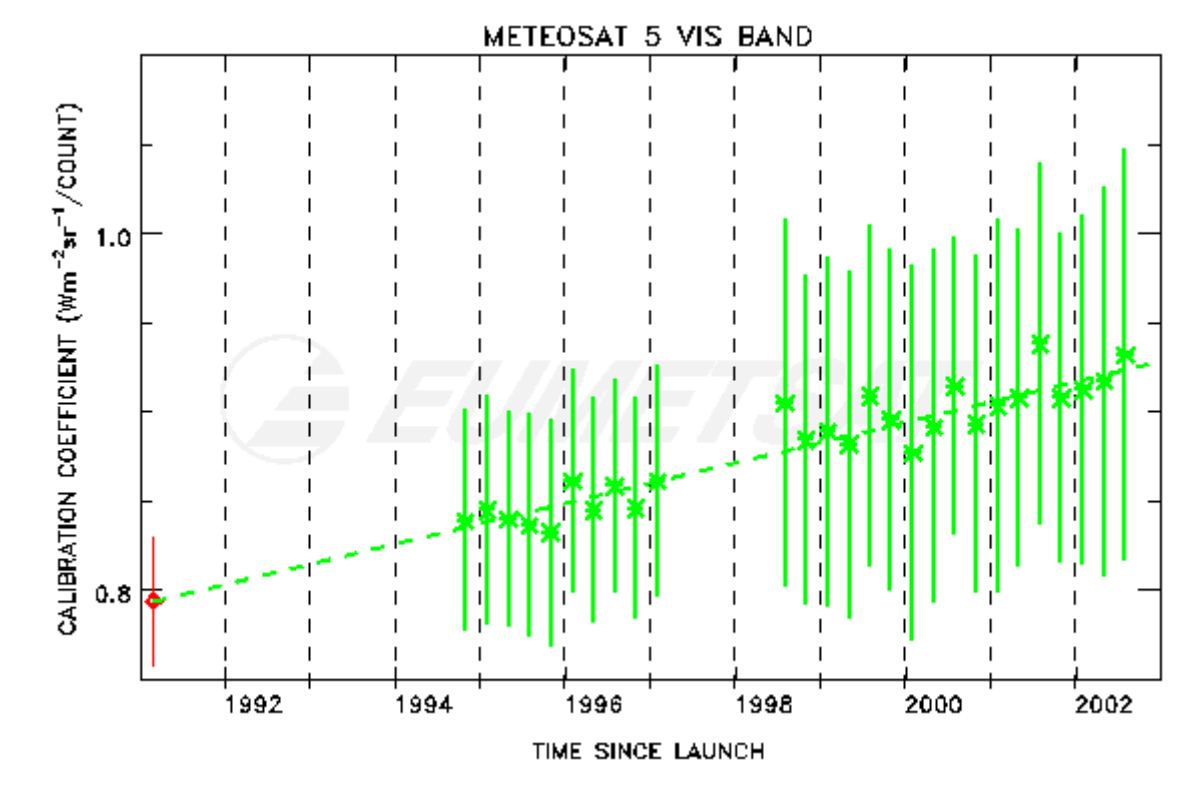
Instrum	Month	Nb days	Pop. size	Mean Flux	R	rms diff.	mean diff. (%)
ScaRaB	1999 03	27	7909	207.1	0.947	43.2	0.8 ((0.3)
ScaRaB	1999 03	27	3480	211.3	0.987	22.7	-1.9 (-0.9)
PFM-Ops	1999 03	18	15456	192.0	0.966	45.6	-5.5 (-2.7)
PFM	2000 03	4	9334	217.8	0.976	41.7	-7.8 (-3.5)
FM1-Ed1	2000 03	11	13962	218.9	0.975	38.4	-9.4 (-4.2)
FM2 -Ed1	2000 03	12	14795	232.9	0.981	35.7	-9.3 (-4.2)
FM1-Ed2	2001 03	31	38452	206.8	0.977	34.8	-8.6 (-4.1)
FM2-Ed2	2001 03	31	37515	208.3	0.976	35.8	-10.8 (-5)
FM1-Ed2	2002 03	31	37289	209.4	0.976	35.3	-9.4 (-4.5)
FM2-Ed2	2002 03	31	37810	202.9	0.976	35.2	-9.0 (-4.4)
FM1-Ed2	2002 07	2	3390	284.4	0.983	40.2	-2.7 (-0.9)
FM2 -Ed2	2002 07	3	3308	295.0	0.981	43.5	0.8 (+0.3)
FM3 -Ed1	2002 07	3	2721	295.0	0.983	40.4	+3.5 (+1.2)
FM4 -Ed1	2002 07	3	2787	293.3	0.981	42.4	+2.3 (+0.8)

Meteosat flux conversion: based on ScaRaB 1999 intercomparison including inhomogeneous areas.

from
- 4.5 to + 1 %

Regression results, selecting homogeneous areas.

Meteosat-5 VIS Band Drift



~ 1.4 % /year

Source : http://www.eumetsat.de/en/index.html

SW Monthly Means Computations with CERES/Meteosat-5 combinations

basically the same approach as the GEO interp. of CERES/SRBAVG

- estimate instantaneous fluxes from Meteosat-5

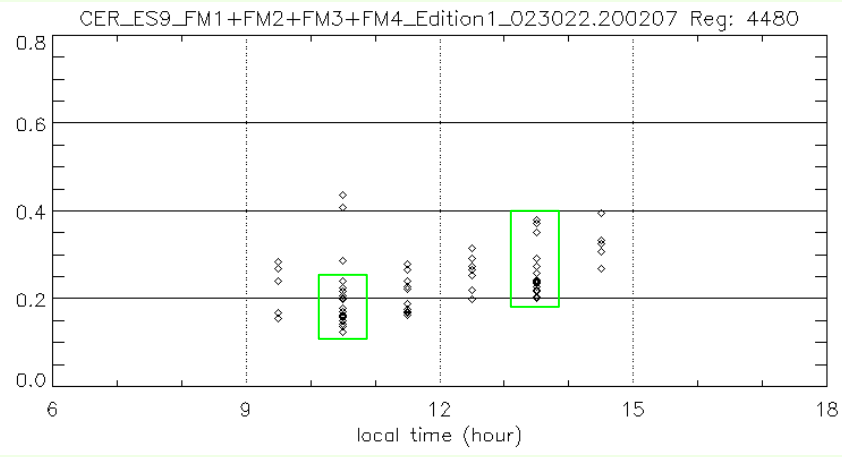
- average the fluxes (2.5°x2.5°) and fill the 24x31 day-hour table (applying cos SZA corrections between observation time and local half-hour, eliminating spurious data, twilight and night-time data)

- use ‘our ERBE-type’ code, with CERES flux estimates

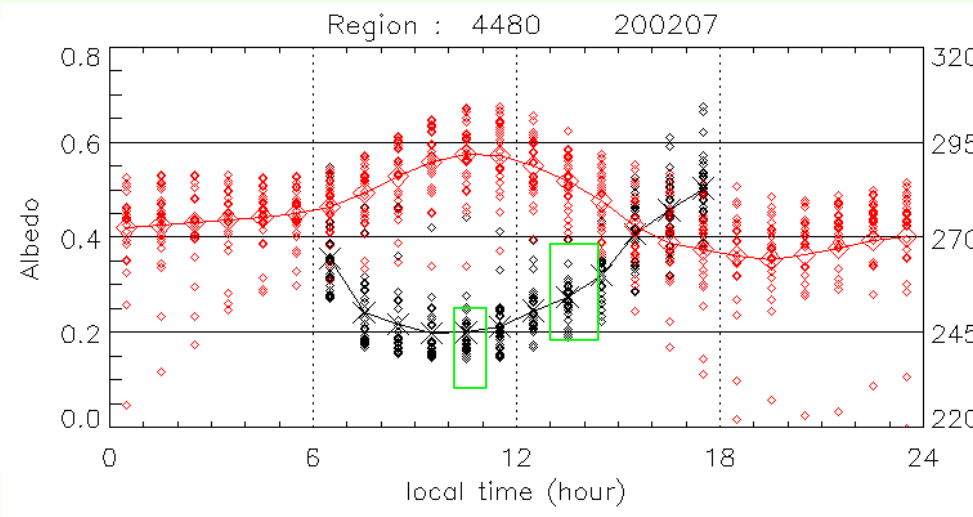
- use the GEO observed diurnal albedo variation shape in place of the ERBE modeled albedo

Dominant afternoon cloud, JULY 2002

Terra and Aqua



Meteosat-5

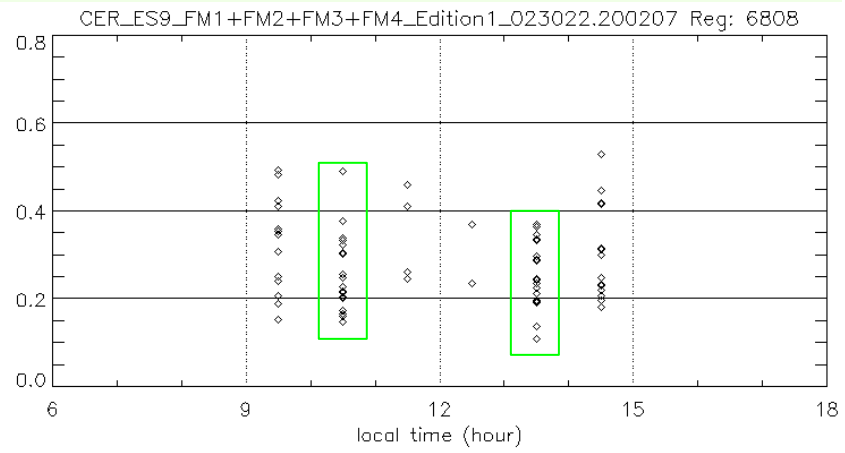


Albedo diurnal variation

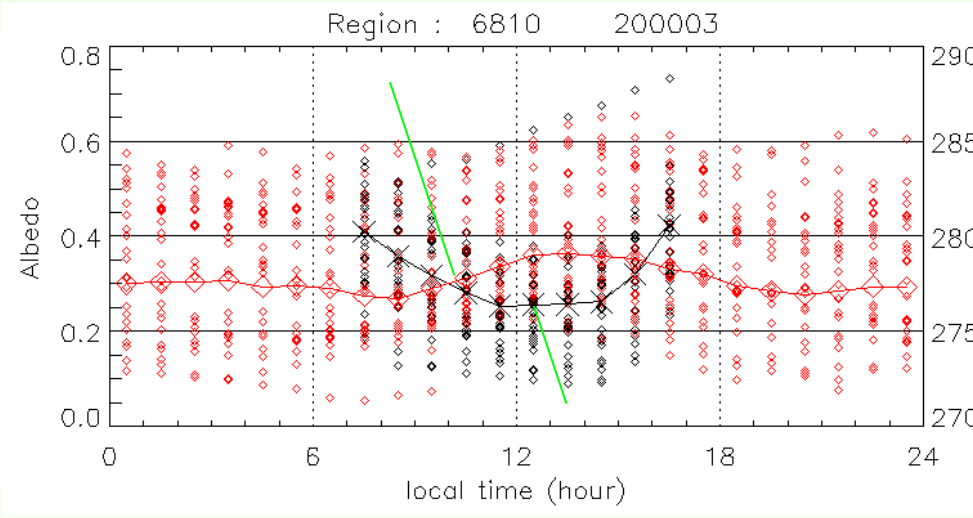
Ethiopia

Dominant morning cloud, JULY 2002

Terra and Aqua

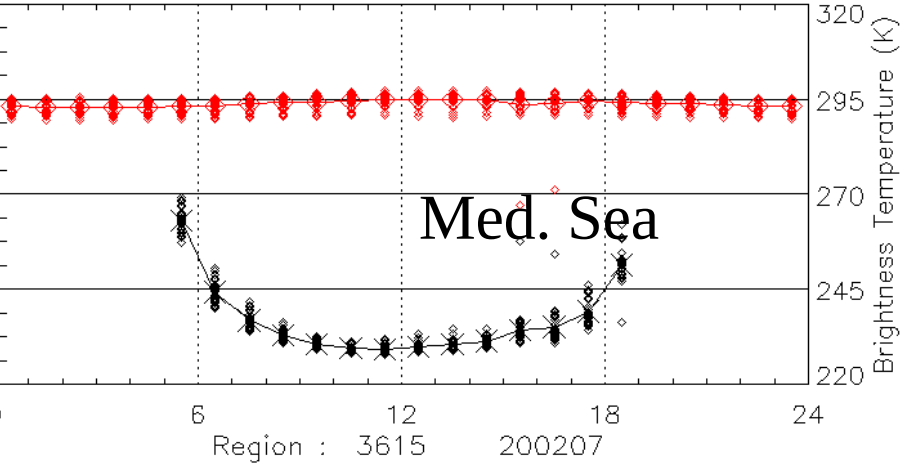


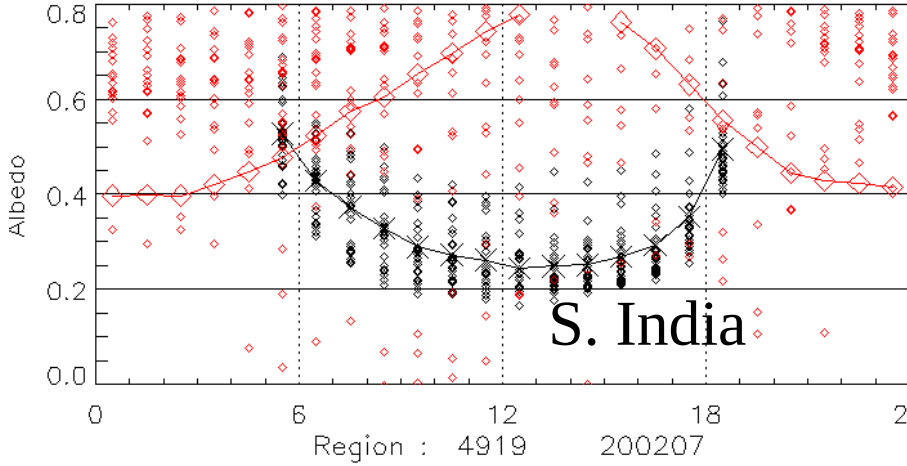
Meteosat-5

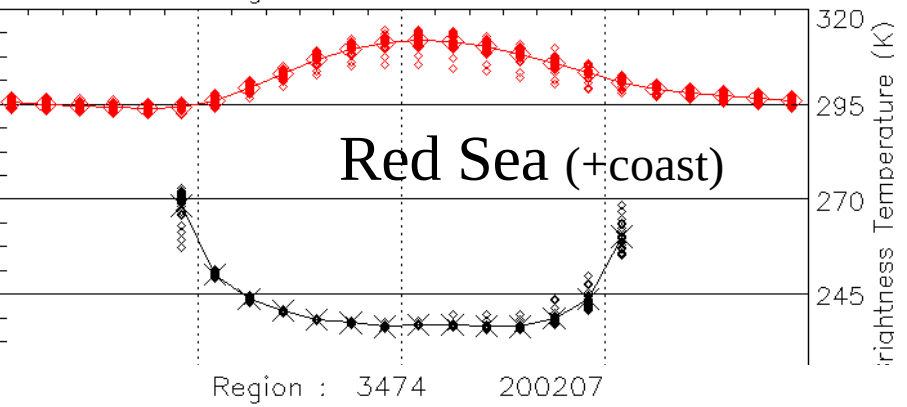


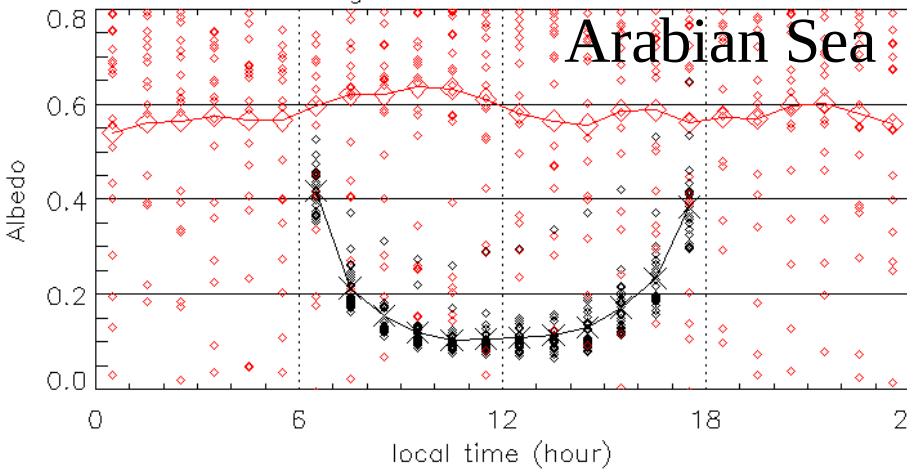
Albedo diurnal variation

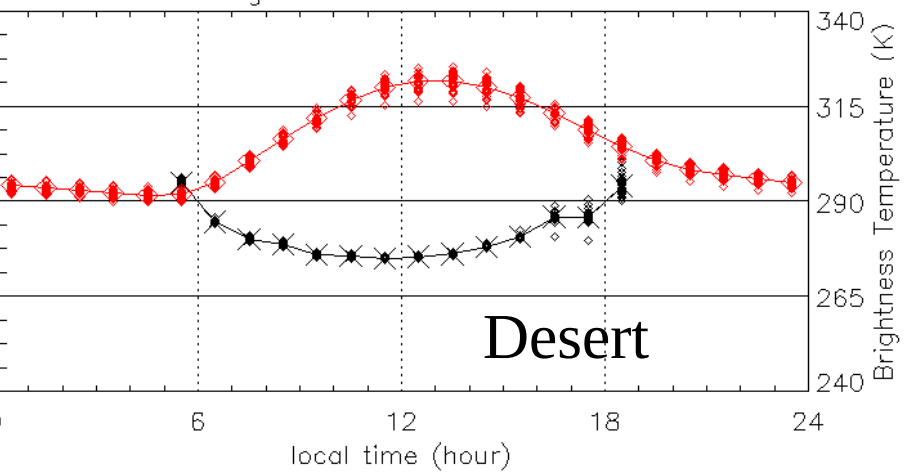
Ocean W. of Australia







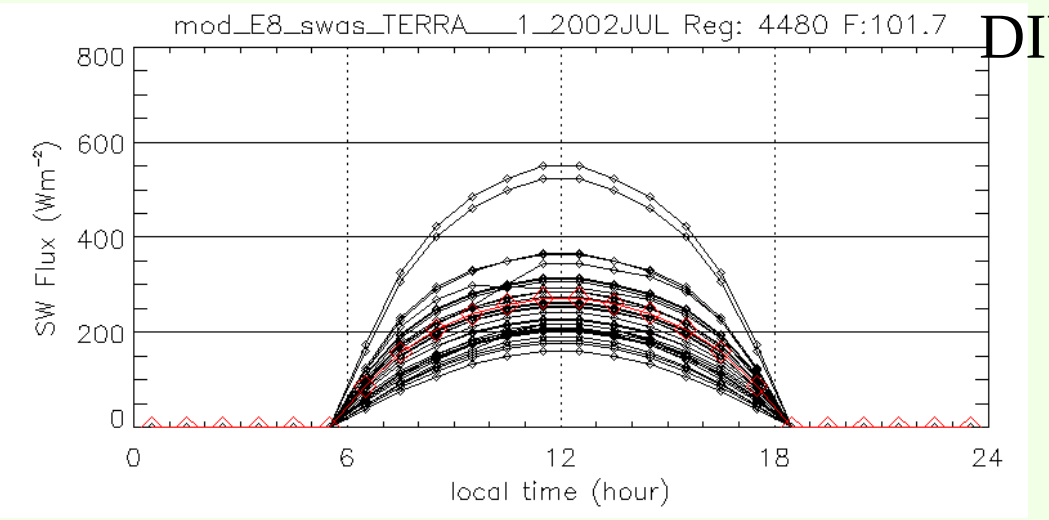


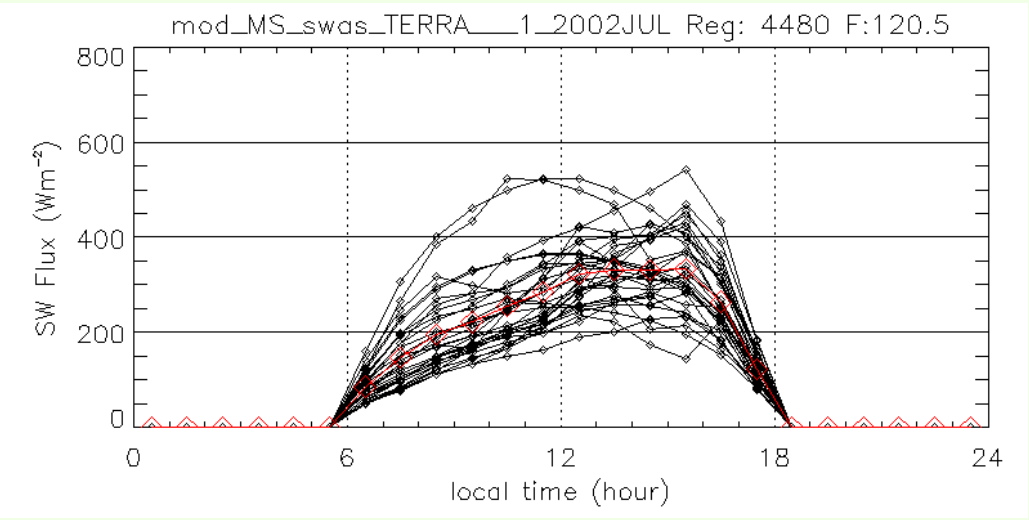


Clear sky (left)

Cloudiness variation (right)

DIURNAL EXTRAPOLATION



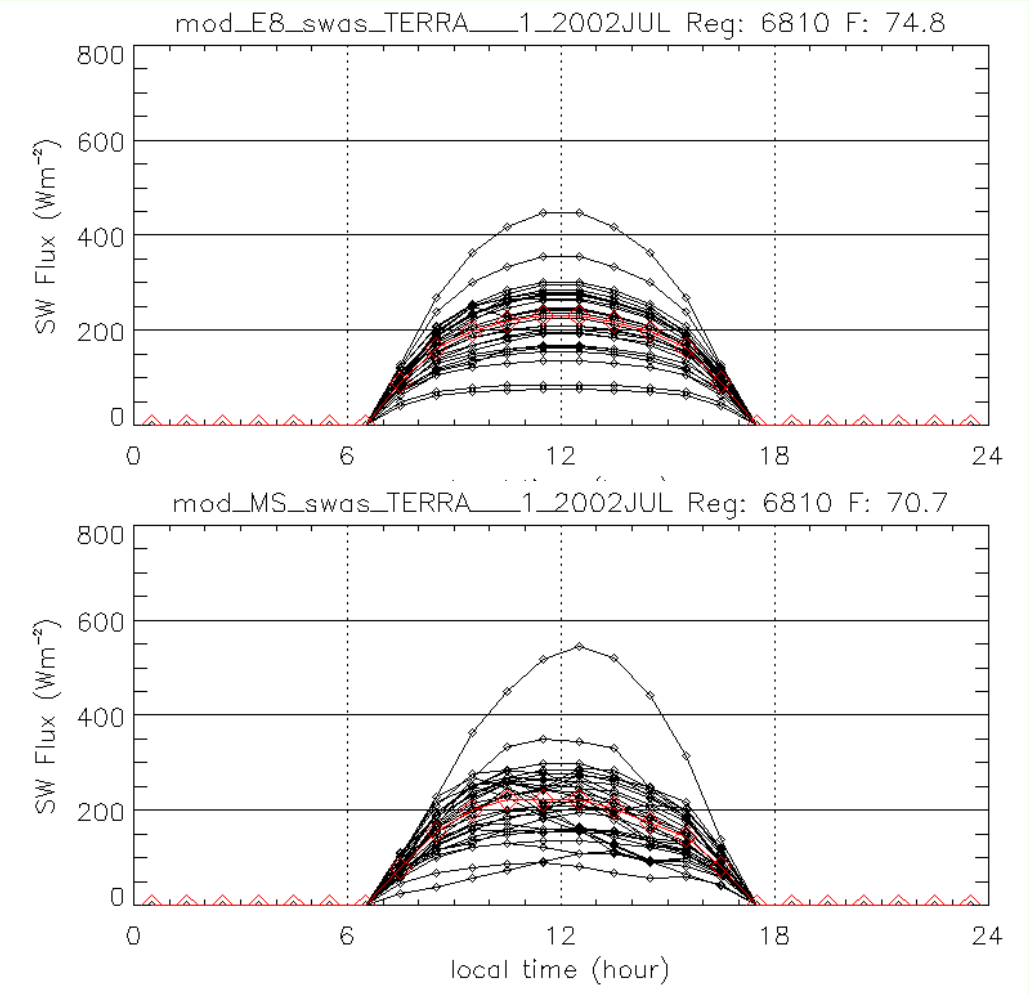


Ethiopia

ERBE-type extrapolation

with Meteosat

Diff= 120-102=18 Wm^{-2}

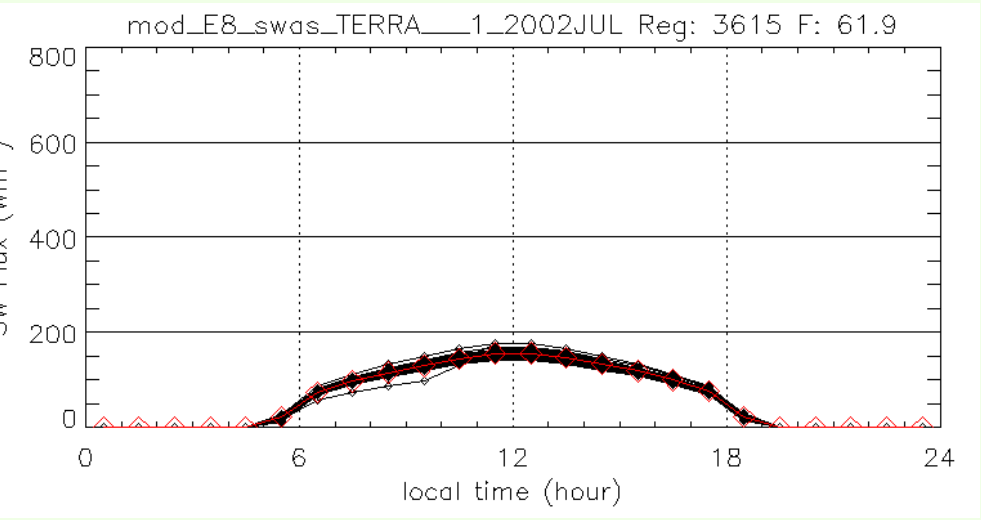


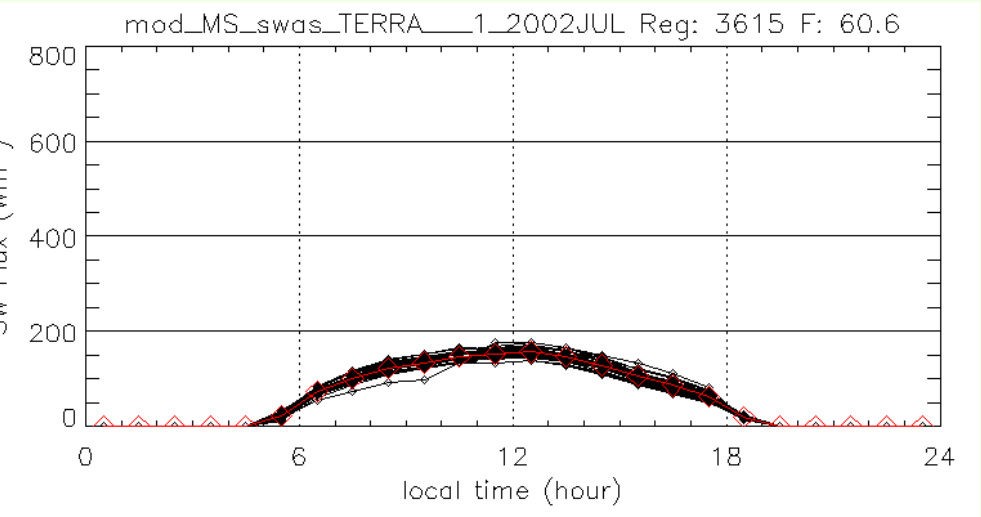
Ocean W. Australia

ERBE-type extrapolation

with Meteosat

Diff= 70.7-74.8=-4 Wm^{-2}



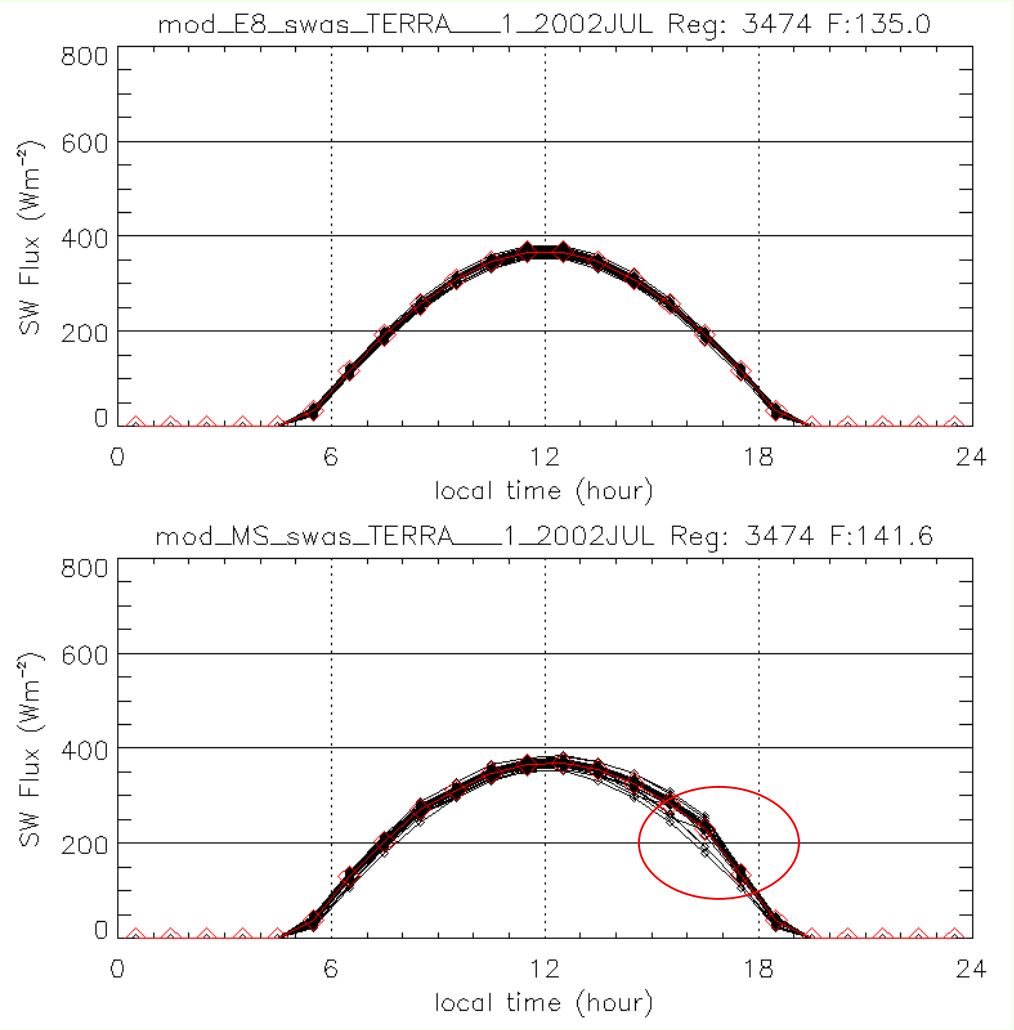


Red Sea

ERBE-type extrapolation

with Meteosat

Diff= 60.6-61.8=-1,2 Wm^{-2}



Desert

ERBE-type extrapolation

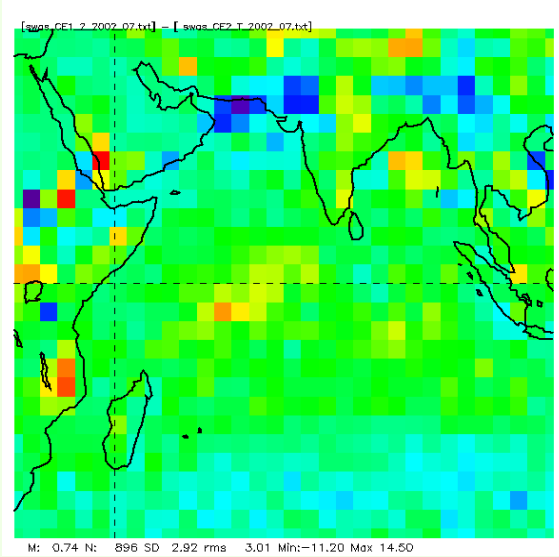
with Meteosat

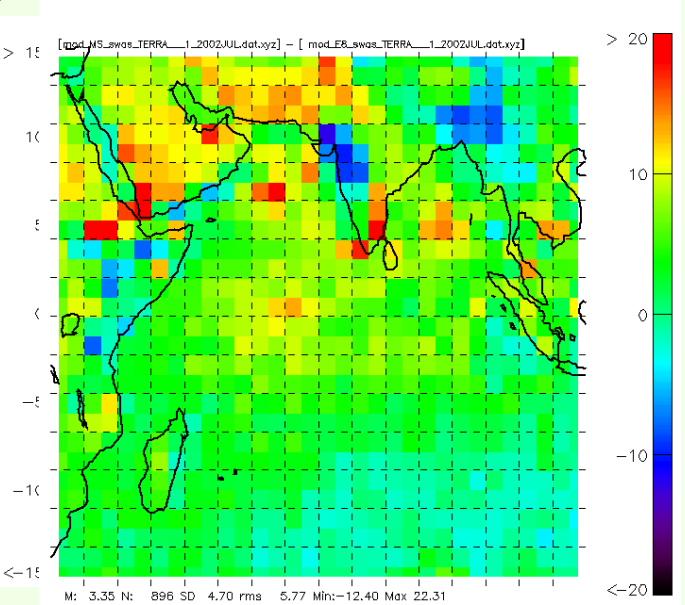
Diff= 141.6-135. =6.6 Wm

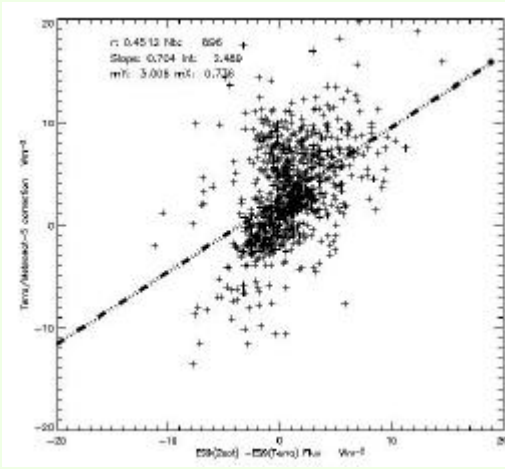
due to differences after 01:30

Compare ES9 Terra and Aqua with Meteosat-5 JULY 2002

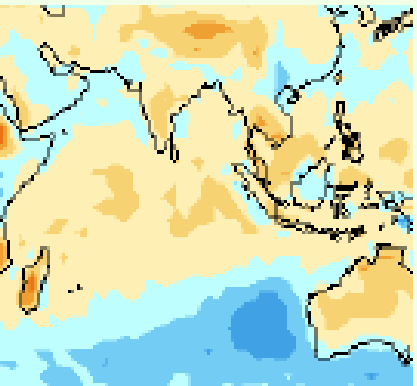
ES9(2 sat) - ES9(Terra) Terra/Meteosat-5 correction







R=0.45

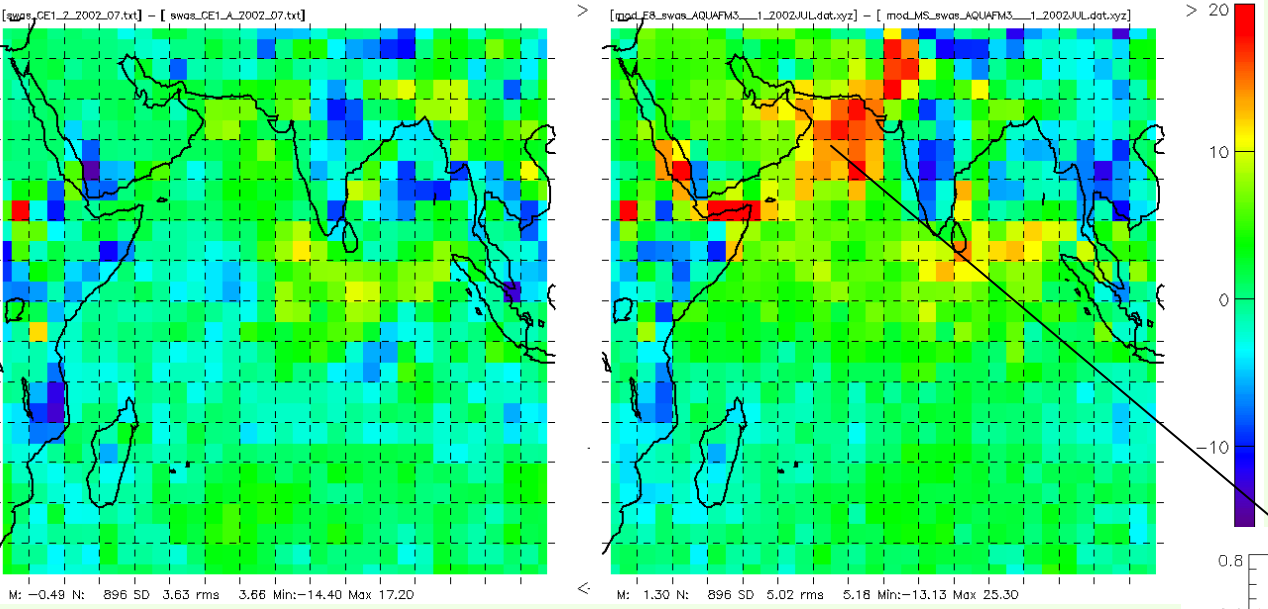


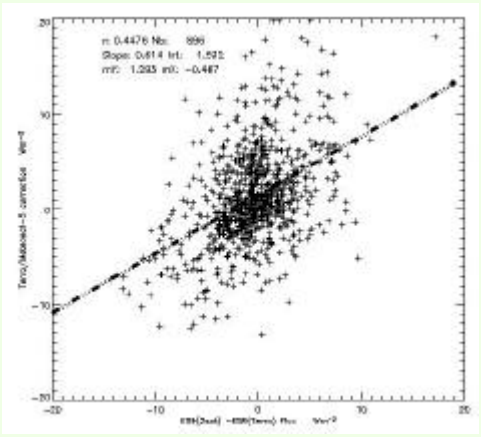
but 27-31 July Meteosat data not still available to u

—— Aqua –Terra (Takmen Wong, Oct. 15)

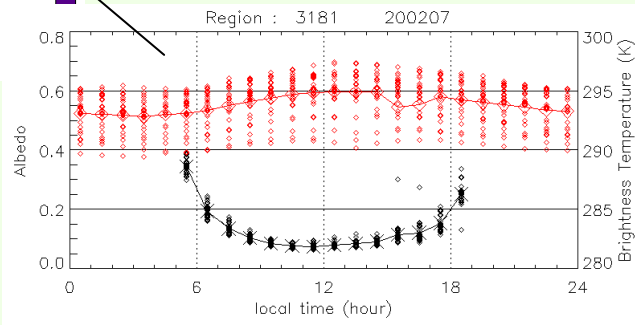
Same but from Aqua

ES9(2 sat) - ES9(Terra) Aqua/Meteosat-5 correction





R=0.45



([8h-17h]=70% day flux)

CERES/Terra time-sampling bias

	latitude	longitude	Month	Bias Wm-2
Young et al, JAM, 1998	45N-40S	America	July 85	-6.0
Young et al, JAM, 1998	45N-40S	America	April 85	-0.5
Standfuss et al. J.Cl. 2001	50N-50S	all	June Dec. 1994	0 -1
Terra/Aqua Diff.	20N-20S	all	July 2002	0-1
This presentation	20N-20S	Indoex	July 2002	-4.0

Significant bias or not ? the analysis of the broadband radiances of GERB on MSG-1 and the accurate GEO interpolation of CERES should definitely settle this important issue in the Earth Radiation Budget observations.

Conclusions

- satisfying data-set from the Aqua-Terra combined ES9 product
- SW differences between computations from one (Terra) or two satellites (Ed1) are low for global and tropical means (< 1 and 0.5 Wm^{-2}), lower than the ERBE-CERES differences
- but regionally : +/- 30 Wm^{-2} , on areas of pronounced systematic diurnal cycles
- in a first approach: good agreement between diurnal cycles observed both by Terra/Aqua and Meteosat-5
- uncertainty on the diurnal Terra bias (tropical means : 0 or ~ -4 Wm^{-2} ?). Question open. Waiting for CERES GEO interpolation and GERB.