Surface-Only Flux Algorithms Working Group Report

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Background (Part 1)

CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

LPSA/LPLA:
Langley Parameterized SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

SOFA References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.
SW B: Darnell et al. (1992): *J. Geophys. Res.*, **97**, 15741-15760.
SW B: Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.
LW A: Inamdar and Ramanathan (1997): *Tellus,* **49B**, 216-230.
LW B: Gupta et al. (1992): *J. Appl. Meteor.,* **31**, 1361-1367.
LW C: Zhou et al. (2007): *J. Geophys. Res.*, **112**, D15102.
SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatol.*, **49**, 164-180.
SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatol.,* **49**, 1579-1589.
FLASH: Kratz et al. (2014): *J. Appl. Meteor. Climatol.*, **53**, 1059-1079.

Background (Part 2)

- The SOFA LW and SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive the surface fluxes.
- LW Models A and B and SW Model A were incorporated at the start of the CERES project.
- SW Model B was adapted for use in the CERES processing shortly before the launch of the CERES instrument on the TRMM satellite.
- The Edition 2B LW and SW surface flux results underwent extensive validation (See: Kratz et al. 2010).
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C (Zhou et al., 2007) was introduced into the Edition 4 processing to maintain two independent LW algorithms after a broadband LW Channel was chosen to replace the CERES Window Channel for the CERES FM-6 and the follow-on Radiation Budget Instrument (RBI).
- LW and SW Models B were incorporated into the FLASHFlux effort to produce a rapidly available Environmental Data Record (see Kratz et al., 2014)

Recent and Future Improvements to the Surface-Only Flux Algorithms

SW Model Improvements: 1) Replacing the ERBE albedo maps with Terra maps greatly improved the SW retrievals, most notably for polar regions. 2) Replacing the original WCP-55 aerosols properties with monthly MATCH/OPAC datasets while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al. (1999) model significantly improved SW surface fluxes for clear conditions. 3) To account for the short term aerosol variability we have incorporated daily MATCH aerosol data into Edition 4. 4) Using a revised empirical coefficient in the cloud transmission formula has improved the SW surface fluxes for partly cloudy conditions. 5) Work continues on the improvement of the cloud transmission method for the new Edition 4 clouds.

LW Model Improvements: 1) Constraining the lapse rate to 10K/100hPa (roughly the dry adiabatic lapse rate) improved the derivation of surface fluxes for conditions involving surface temperatures that greatly exceeded the overlying air temperatures, see Gupta et al. (2010). 2) Limiting the inversion strength to -10K/100hPa for the downward flux retrievals provided the best results for cases involving surface temperatures that were much below the overlying air temperatures (strong inversions).

SW and LW Model Improvements: 1) The availability of ocean buoy measurements is expected to allow for improved surface flux retrievals by providing validation over ocean regions.

Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 2B	CERES 4
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clear-Sky TOA albedo Aqua	46 month Terra	70 month Terra
Clear-Sky Surf. albedo	46 month Terra	70 month Terra
TOA to Surface albedo transfer	Instantaneous	Monthly average
Spec. Corr. Coef.	CERES 2B	CERES 4A
Cos (sza) dependence of Surface Flux	LPSA	Briegleb-type
Cloud Algorithm Terra	Terra Ed2	Terra/Aqua Ed4
Cloud Algorithm Aqua	Aqua Ed2	Terra/Aqua Ed4
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 500 DU	0 to 800 DU
Twilight cutoff		New
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	No	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	No	Maximum Inversion Strength -10K/100hPa

Status of SW Model Improvements

Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

To account for the short term variability of aerosol properties, we have incorporated the daily aerosol properties into SW Model B.

Results for the mostly cloudy to overcast conditions showed some improvement by revising the a_0 coefficient but strongly suggest that further work on the cloud transmittance calculation is necessary. Our recent attention has focused on developing an empirical method to account for the cloud transmittance.

The ADMs and MATCH aerosols have been revised for Ed4.

SORCE / RMIB daily data are used for Total Solar Irradiance.

Status of TSI Measurements

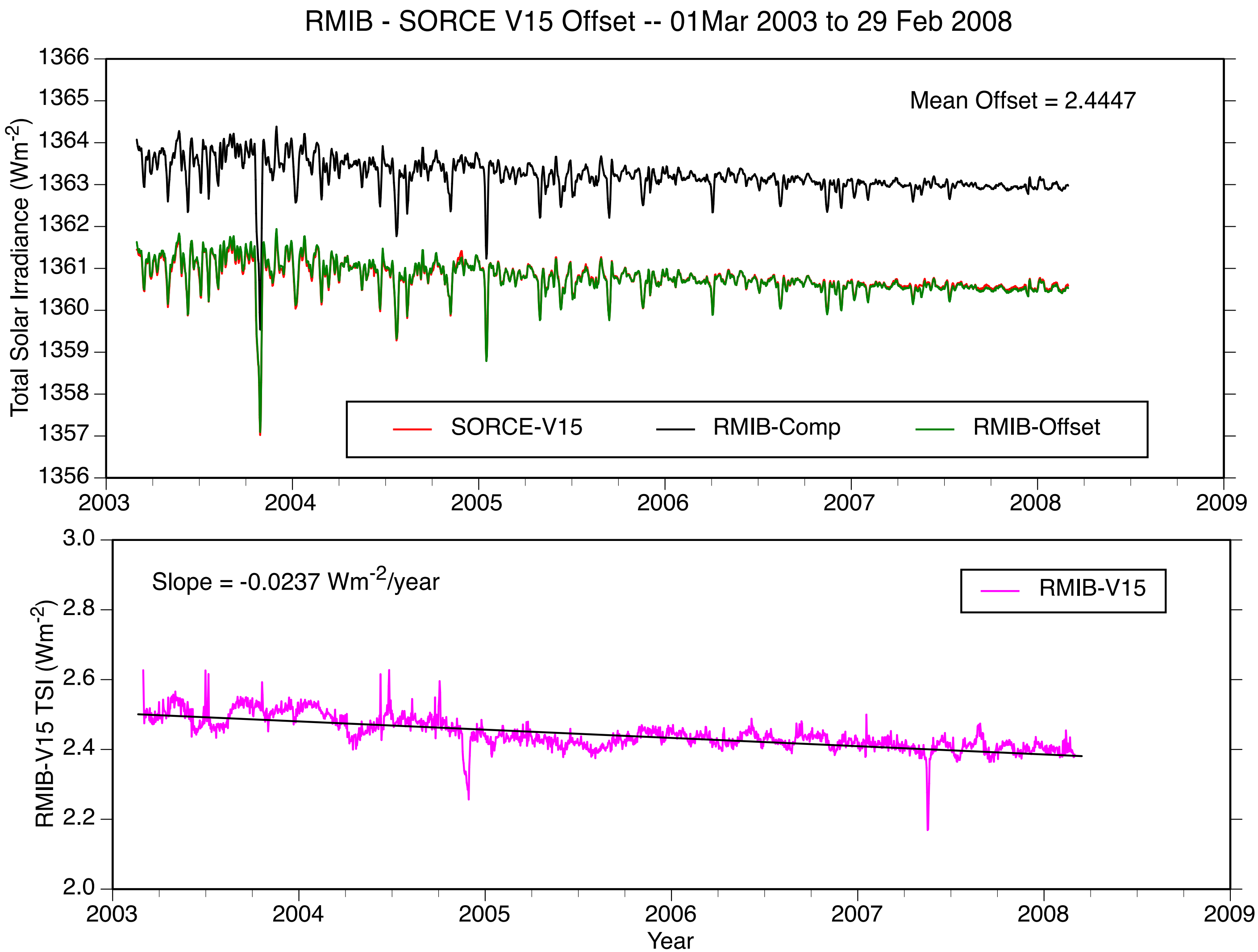
With the malfunction of the CPV6 battery cell on SORCE, TIM and the other instruments were powered off 30 July 2013.

Since the SORCE TIM TSI data were not available on a regular basis from July 2013 through February 2014, we began acquiring the RMIB composite TSI data from Steven DeWitte.

The RMIB data, however, requires an offset from the DIARAD VIRGO mean low value of ~1363 W/m^2 to match the SORCE mean low value of ~1361 W/m^2. Note, for CERES Ed4, all TSI data are offset to match the SORCE TSI Version 15.

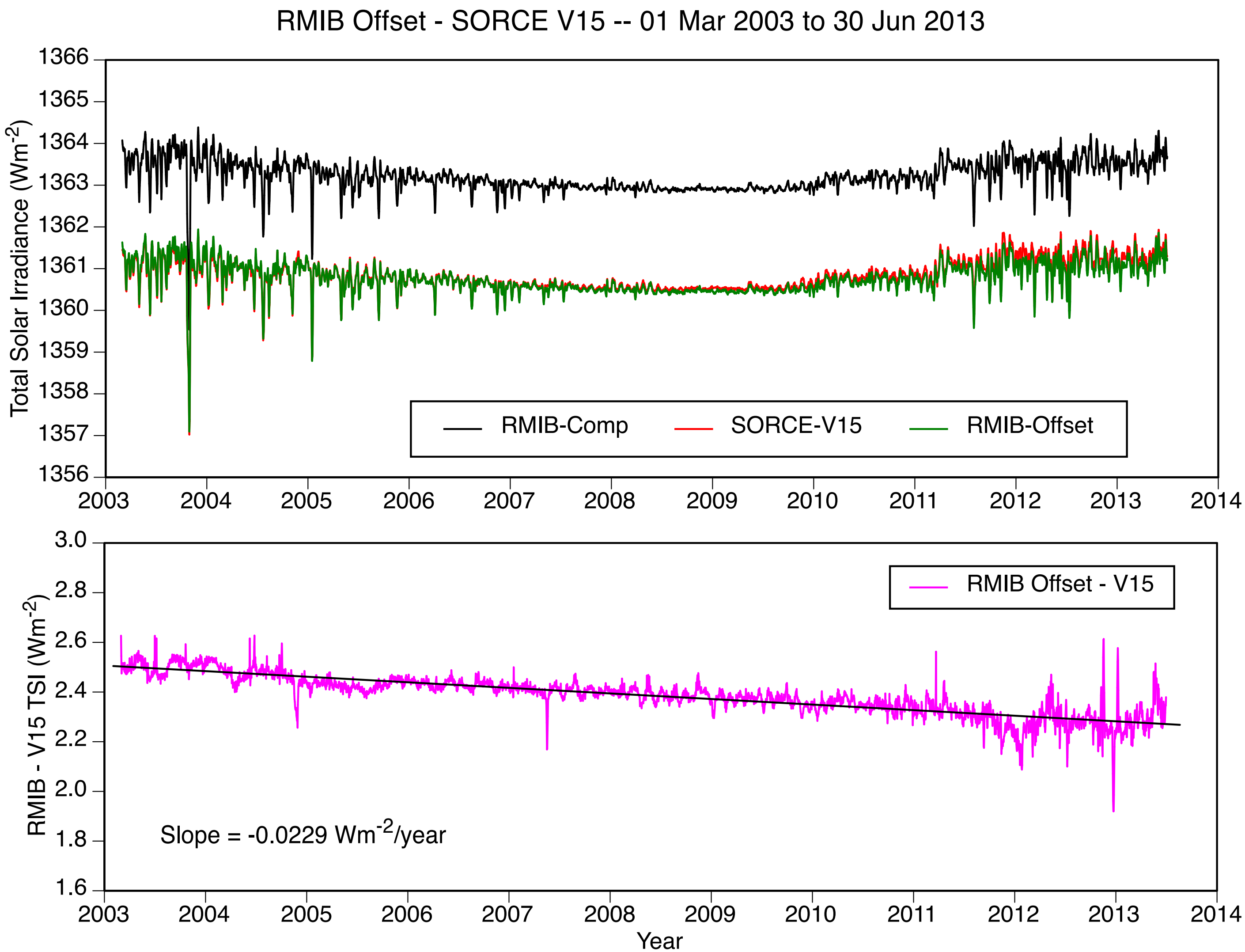
The TSI Calibration Transfer Experiment (TCTE) instrument was integrated into the STPSat3 satellite, along with 4 other satellite instruments, and was launched into orbit on 19 November 2013, and has been providing TSI data since 16 December 2013.

Comparison of TSI data [SORCE(V15) versus RMIB] for the overlap period: 1-Mar-2003 to 29-Feb-2008

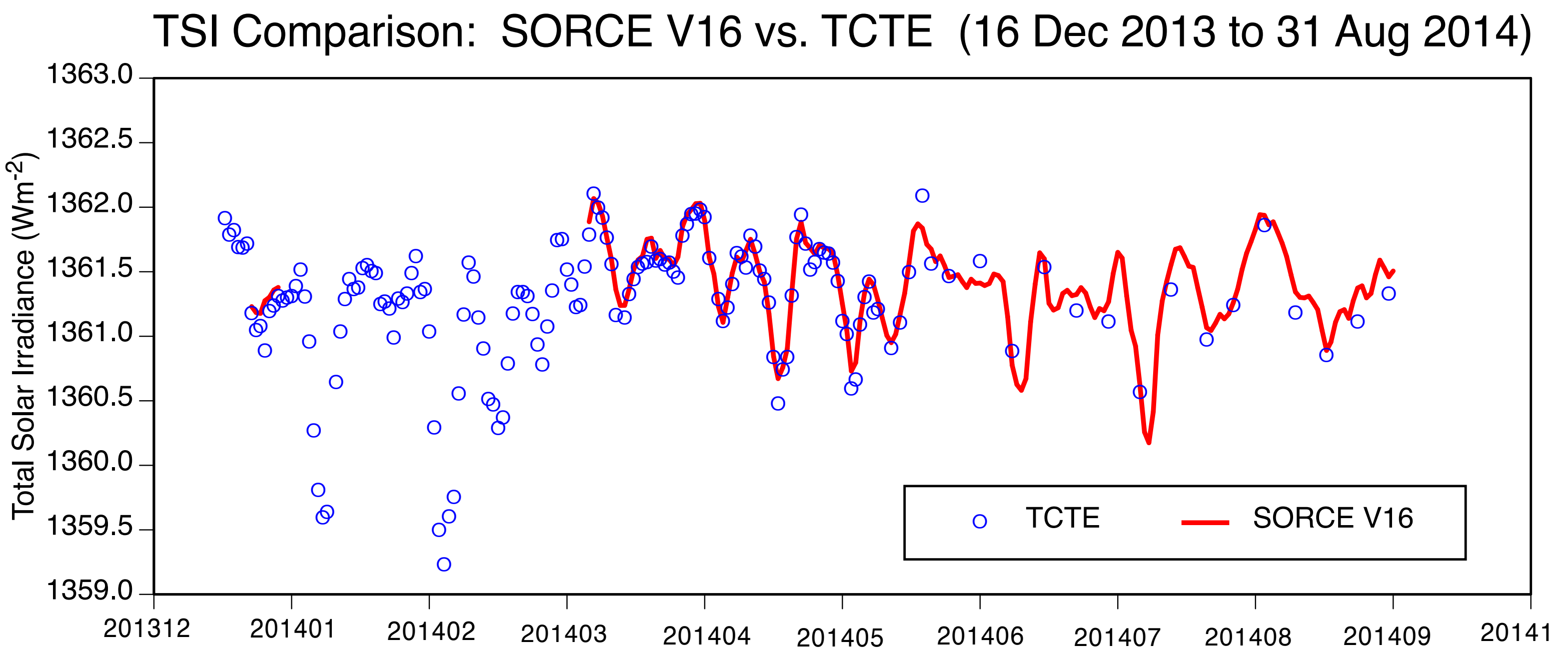


Climate Science Branch, NASA Langley Research Center

Comparison of TSI data [SORCE(V15) versus RMIB] for the entire SORCE period: 1-Mar-2003 to 30-Jun-2013



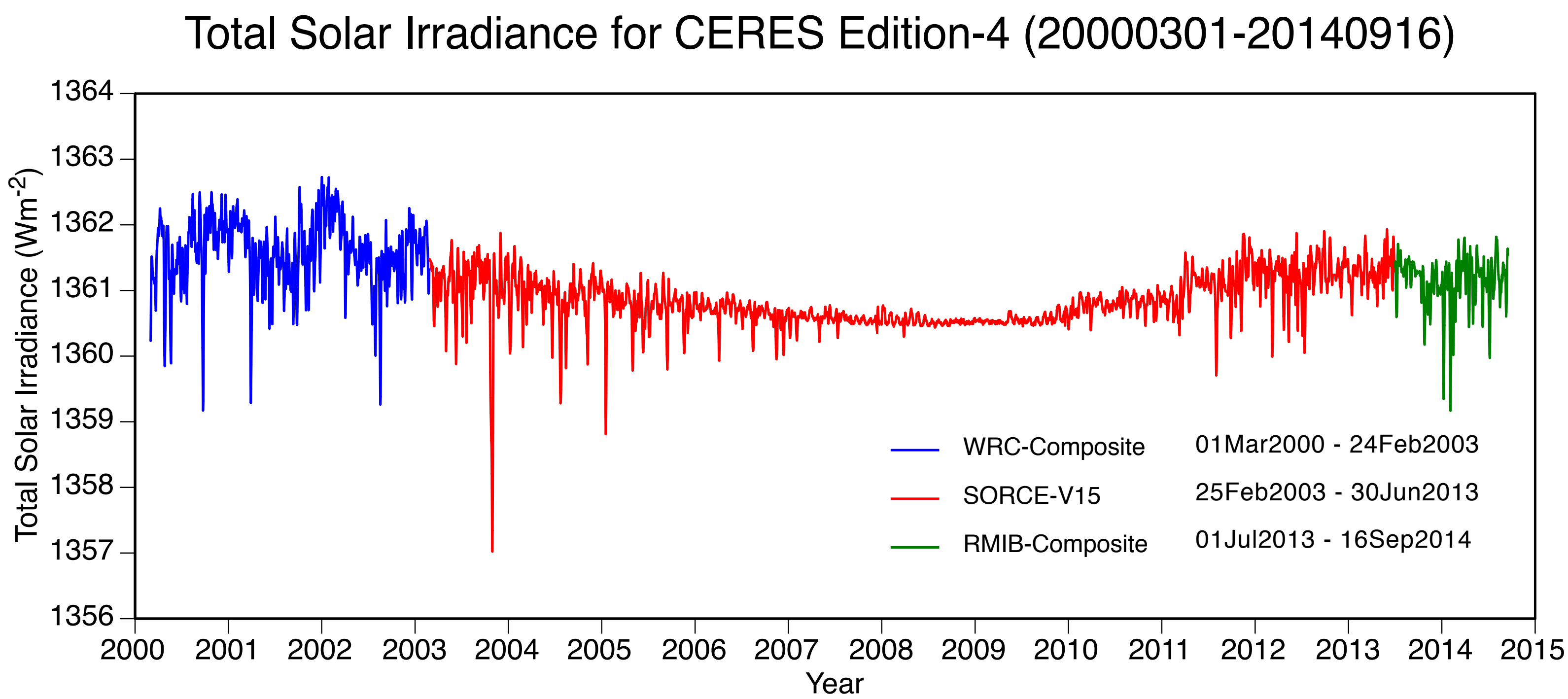
Inter-comparison of SORCE(V16) and TCTE Total Solar Irradiance Retrievals



SORCE: 1 value/day, 22 DEC 2013 through 28 DEC 2013, and 1 value/day 5 MAR 2014 through 31 AUG 2014; Absolute Accuracy: ±0.48 W/m^2 at 1361 W/m^2

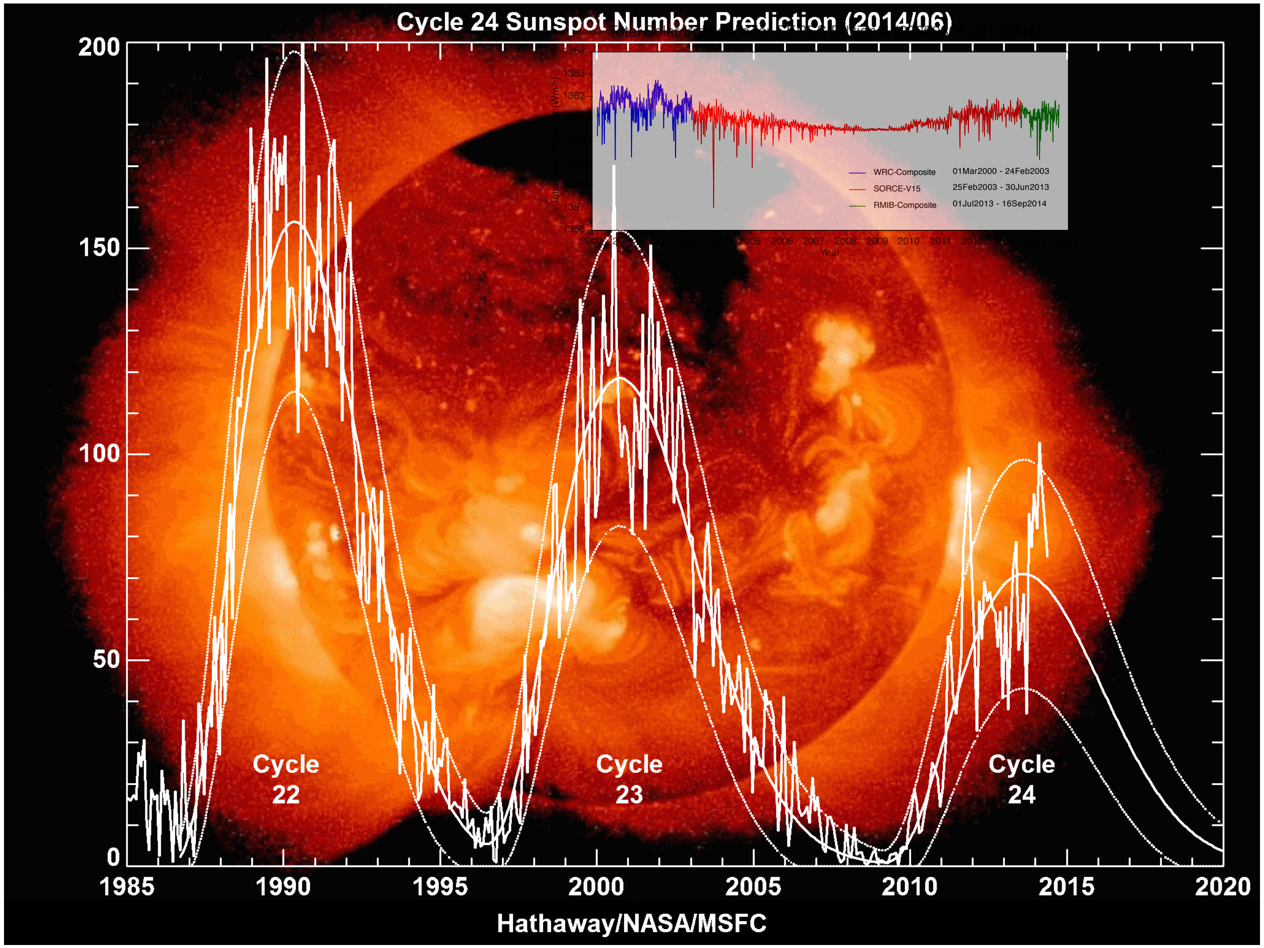
TCTE: 1 value/day, 16 DEC 2013 through 8 May 2014, and 1 value/week 11 MAY 2014 through 31 AUG 2014; Absolute Accuracy: ±1.36 W/m^2 at 1361 W/m^2

TSI composite data from WRC, SORCE(V15) and RMIB for the Timeframe of CERES Terra, Aqua & NPP



For CERES Ed4, all TSI data are offset to match SORCE TSI Version 15

Sunspot Numbers for Solar Cycles 22, 23 & 24



Comparisons of orbital characteristics of NPP with CERES FM5 to Aqua with CERES FM3

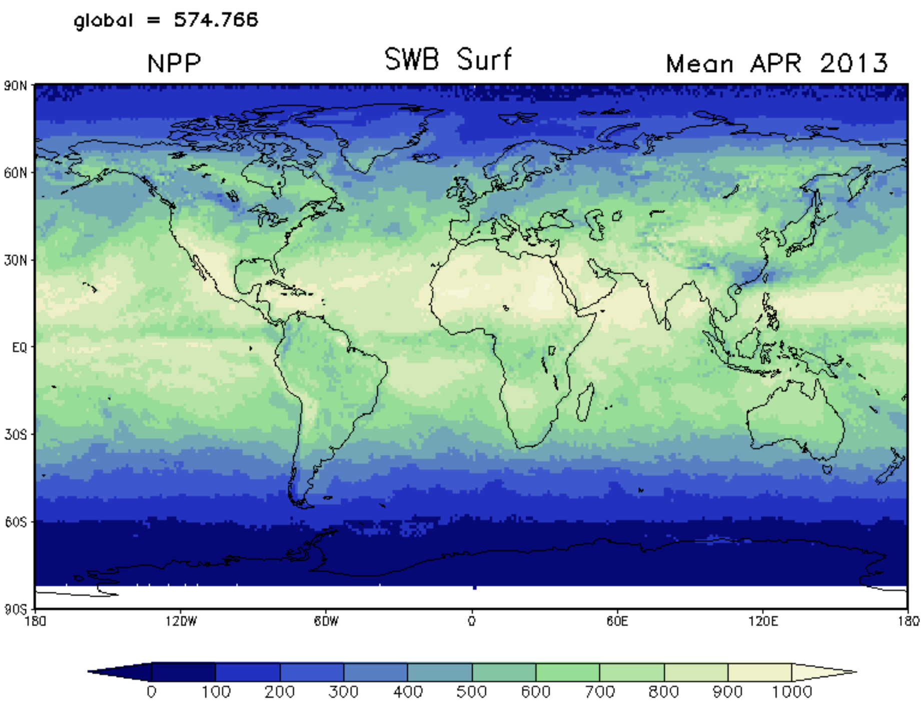
Aqua (Launch 4-May-2002)
COSPAR ID = 2002-022-A
701 X 703 km 98.2087° orbit
14.57091655 revolutions/day
Period = 98.827002 minutes

NPP (Launch: 28-October-2011)
COSPAR ID = 2011-061-A
825 X 828 km 98.7483° orbit
14.19543342 revolutions/day
Period = 101.441070 minutes

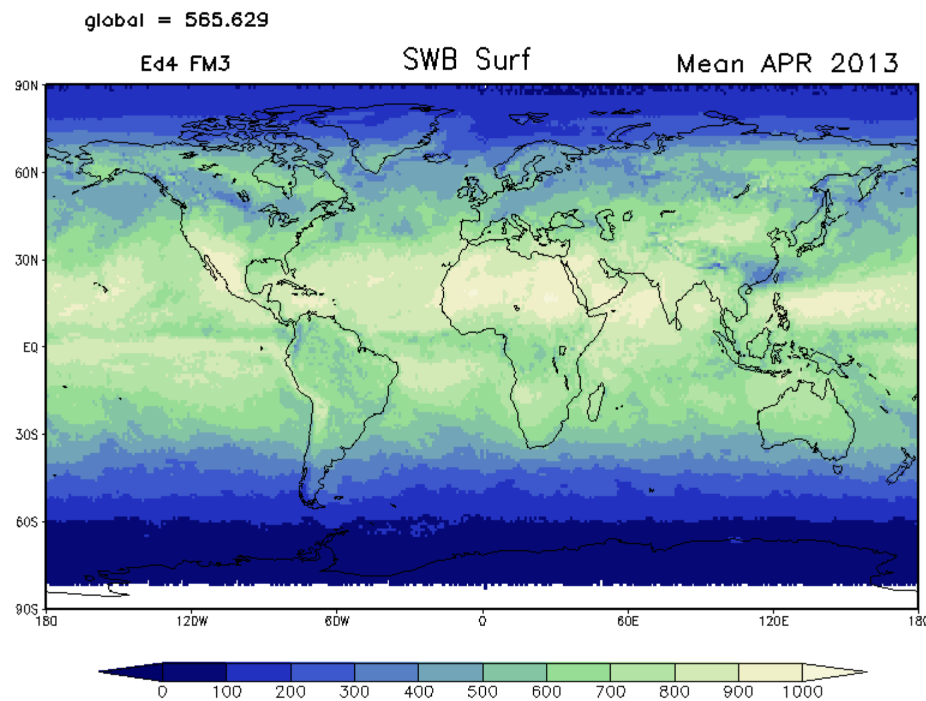
Period(NPP) – Period(Aqua) = 2.614068 minutes
Time to realign orbits = 63.9177 hours
Orbital Data as of 24-Sep-2014

SW Surface Flux Differences between NPP and Aqua FM3 for April 2013

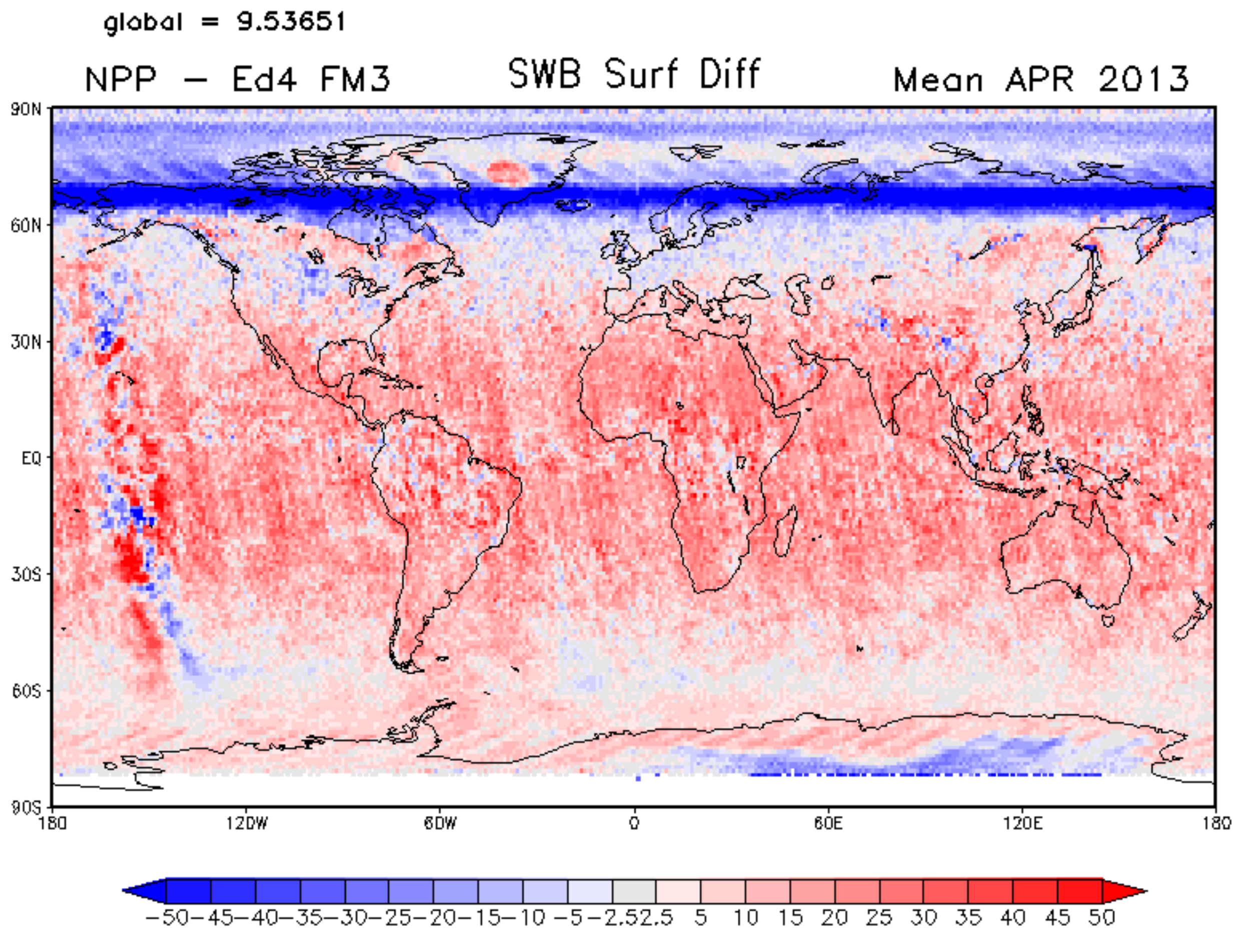
NPP SW Surface Flux W/m^2



Aqua SW Surface Flux W/m^2

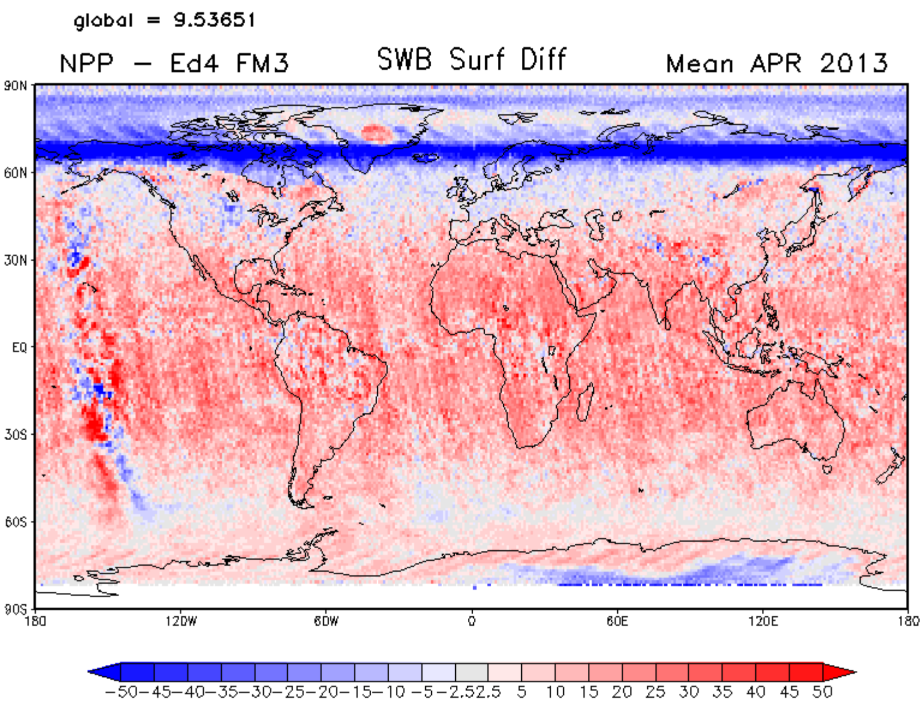


SW Surface Flux Differences between NPP and Aqua FM3 for April 2013

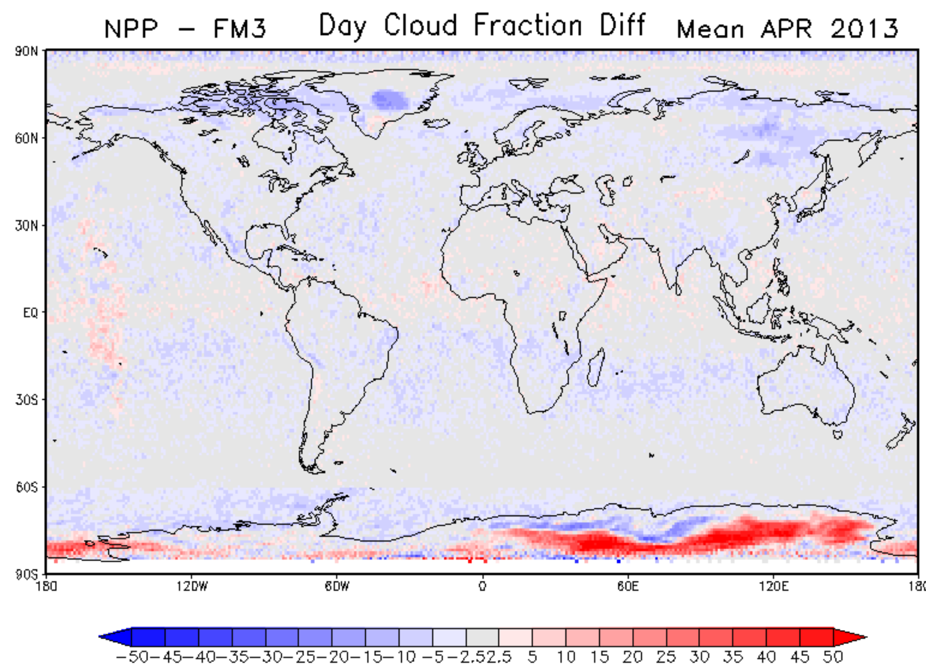


SW Surface Flux and Cloud Fraction Differences between NPP and Aqua FM3 for April 2013

SW Surface Difference W/m²

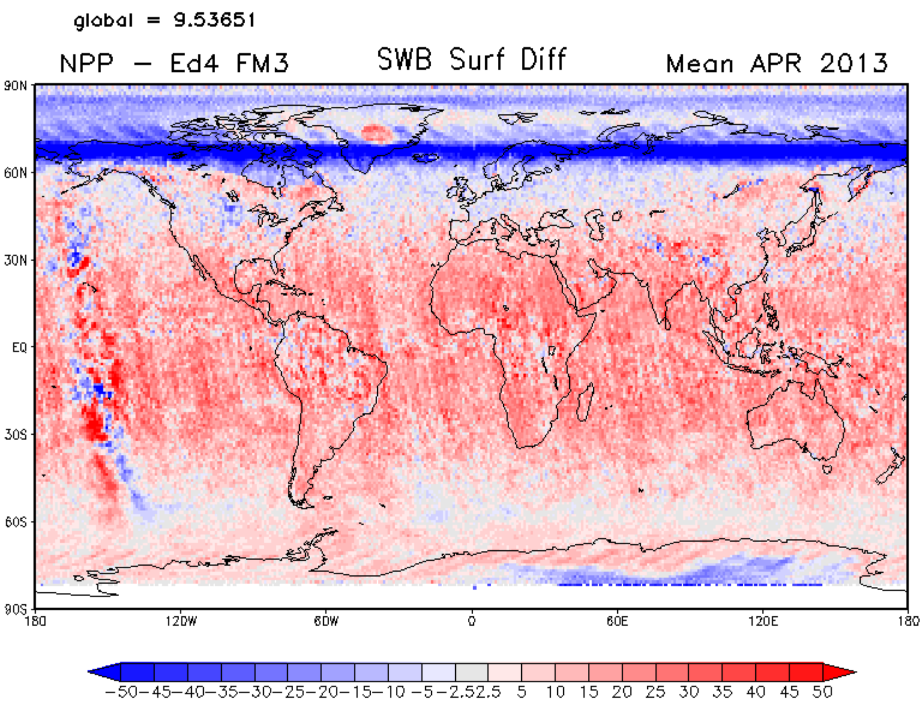


Cloud Fraction Difference

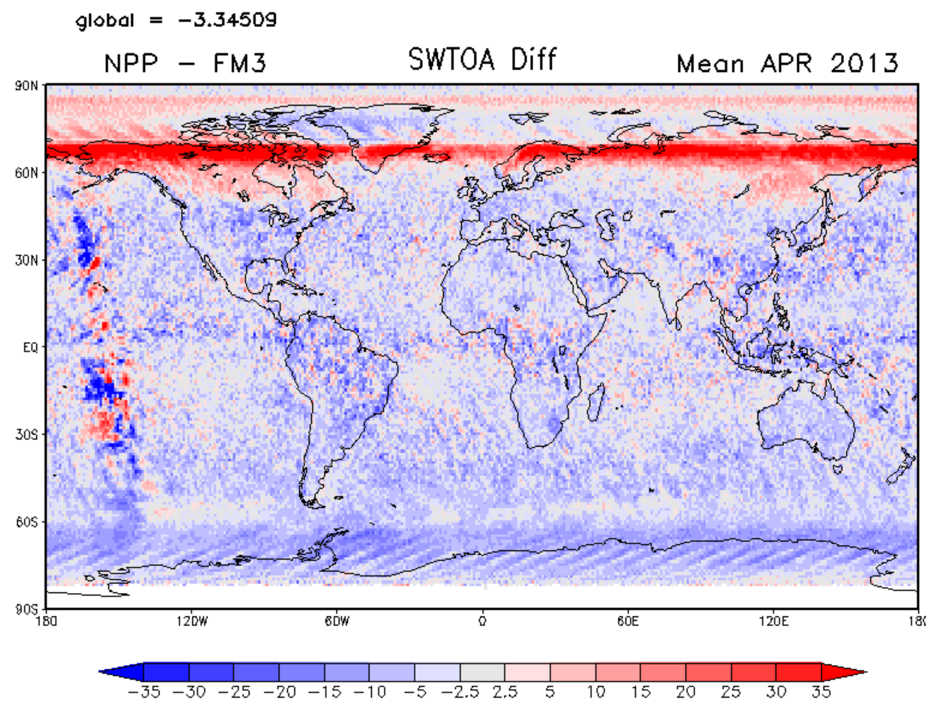


SW Surface and TOA Flux Differences between NPP and Aqua FM3 for April 2013

SW Surface Difference W/m²

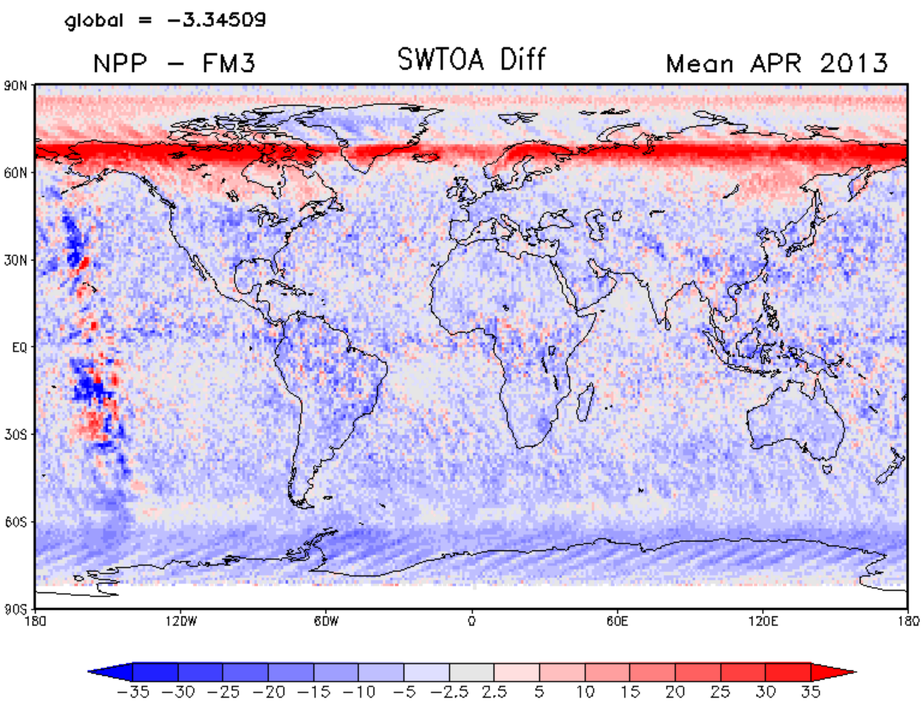


SW TOA Difference W/m²

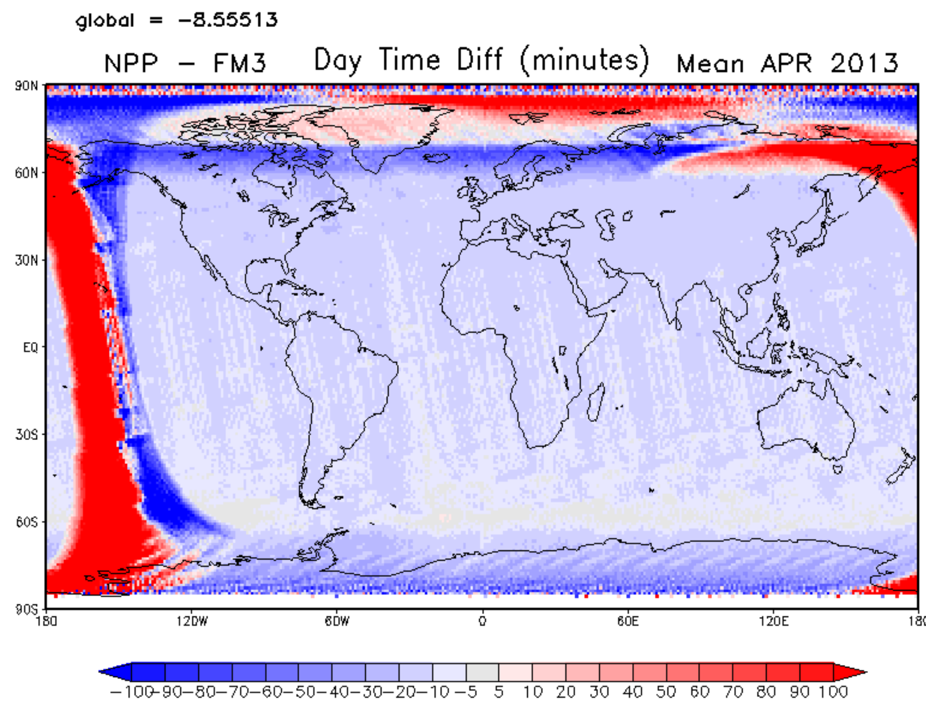


SW Surface Flux Differences between NPP and Aqua FM3 for April 2013

SW TOA Difference W/m^2

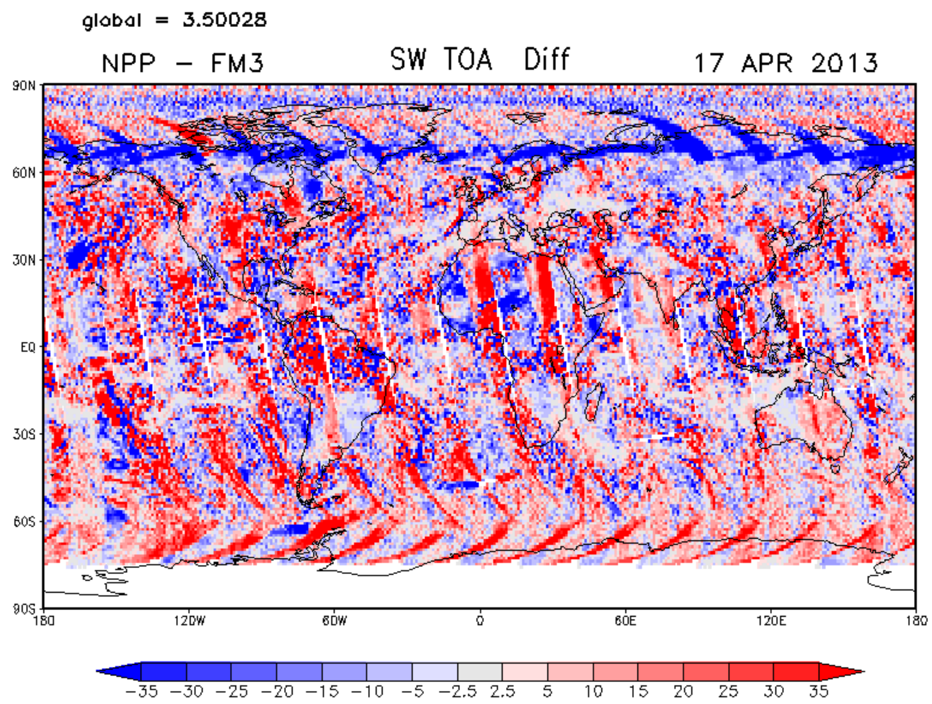


Time of Observation Difference

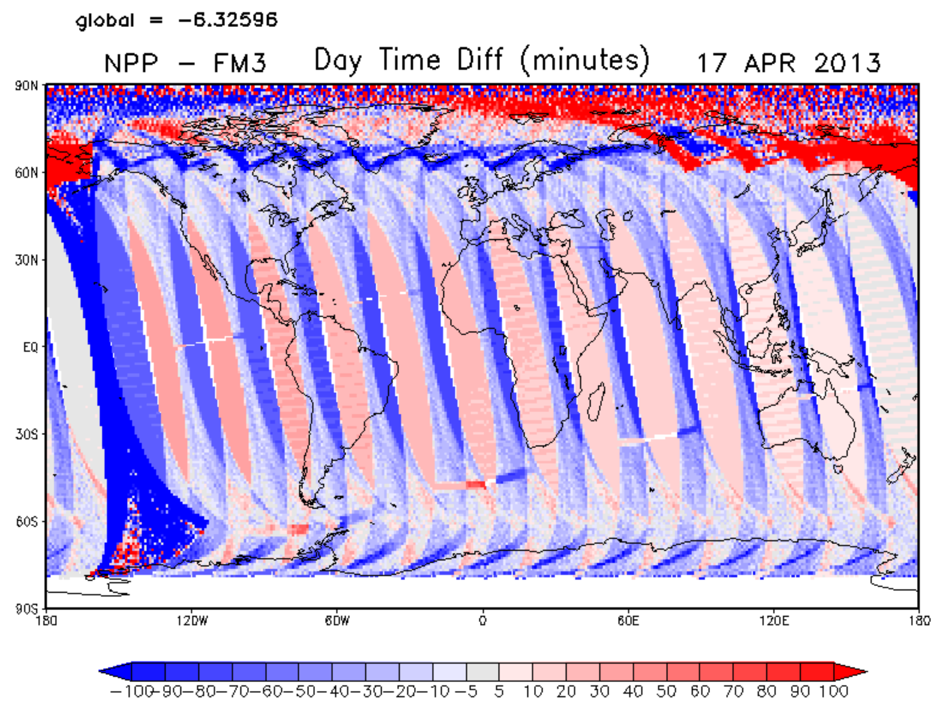


SW Surface Flux Differences between NPP and Aqua FM3 for April 17, 2013

SW TOA Difference W/m^2



Time of Observation Difference



SW Surface Flux Results

The inter-comparison of the NPP and Aqua results for the SW demonstrated that the largest of the observed differences could be attributed to differences in the orbital parameters associated with the NPP and Aqua satellites. Differences in the orbits affect the time of observation, which affects the solar zenith angle, which consequently affects the measured value of the incoming TOA and surface SW fluxes.

Differences in the cloud effect play an important, though secondary role in producing the differences between the NPP and Aqua results.

Status of LW Model Improvements

For the condition involving surface temperatures that greatly exceed the overlying air temperatures, constraining the lapse rate to 10K / 100hPa (roughly the dry adiabatic lapse rate) has significantly improved the results for both MOA and CWG T_s, see Gupta et al. (2010).

For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10K / 100hPa for the downward flux calculations provides the best results for all conditions for both MOA and CWG T_s.

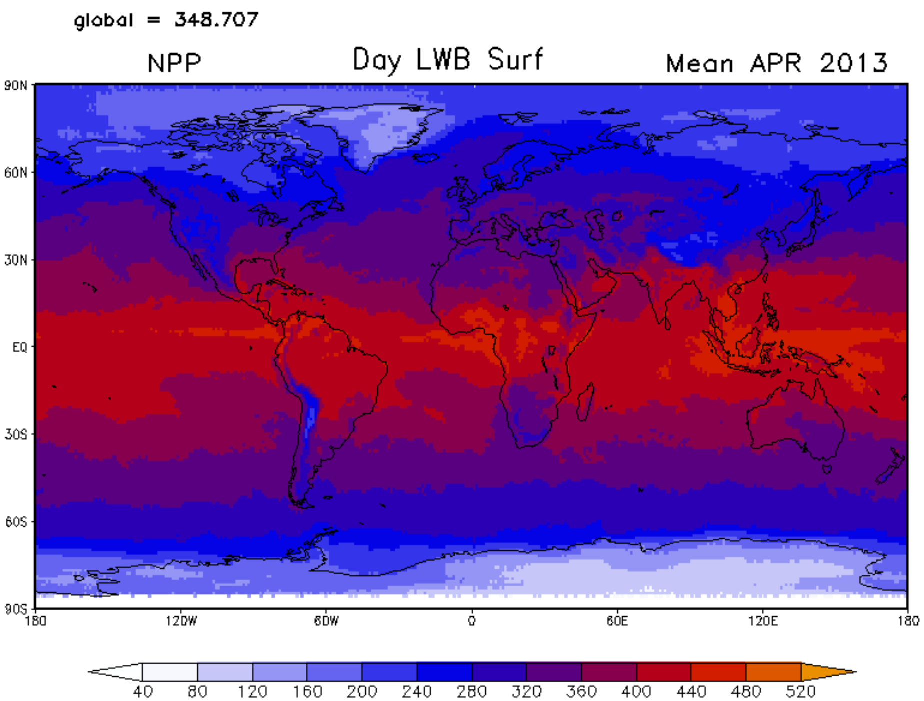
The CWG skin temperatures have a significantly greater dynamic range than the MOA surface temperatures.

The use of the CWG skin temperatures will, therefore, tend to have a wider range of fluxes at the surface. Constraining the CWG and MOA surface temperatures using the SOFA methods, however, tends to yield comparable results.

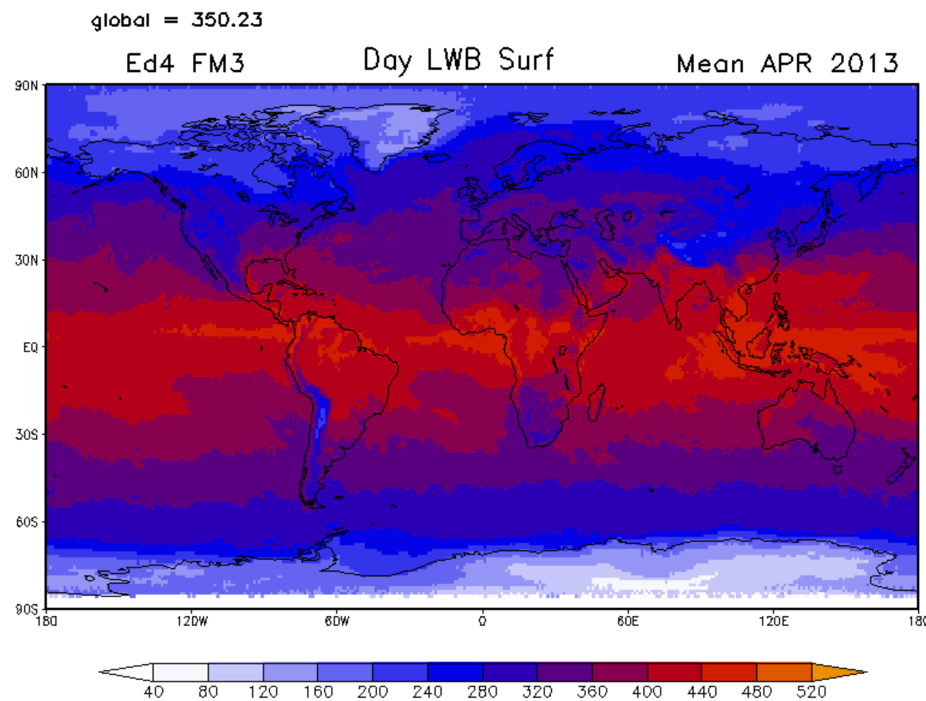
Edition 4 inputs into the LW model are providing the expected results.

Daytime LW Surface Flux Differences between NPP and Aqua FM3 for April 2013

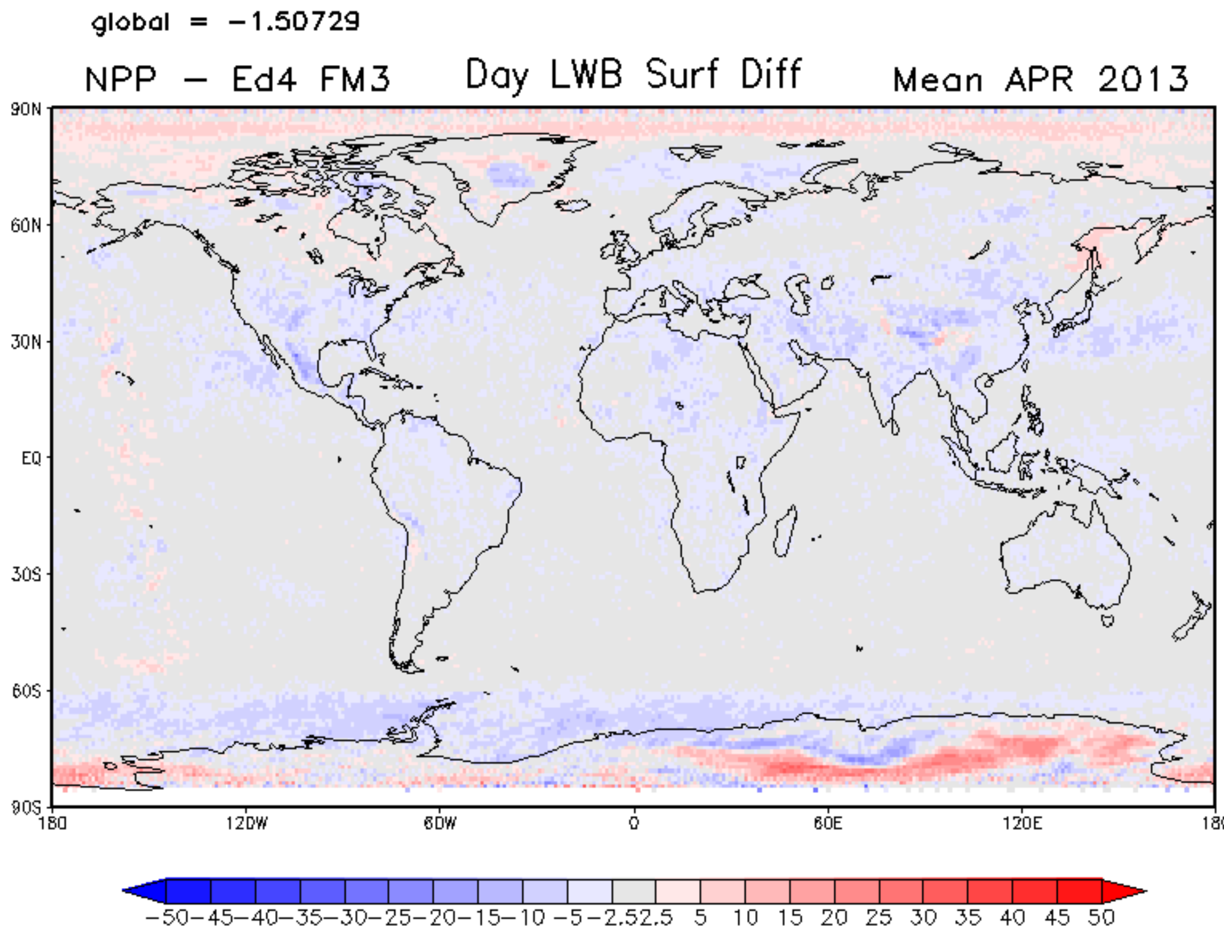
NPP LW Surface Flux W/m^2



FM3 LW Surface Flux W/m^2

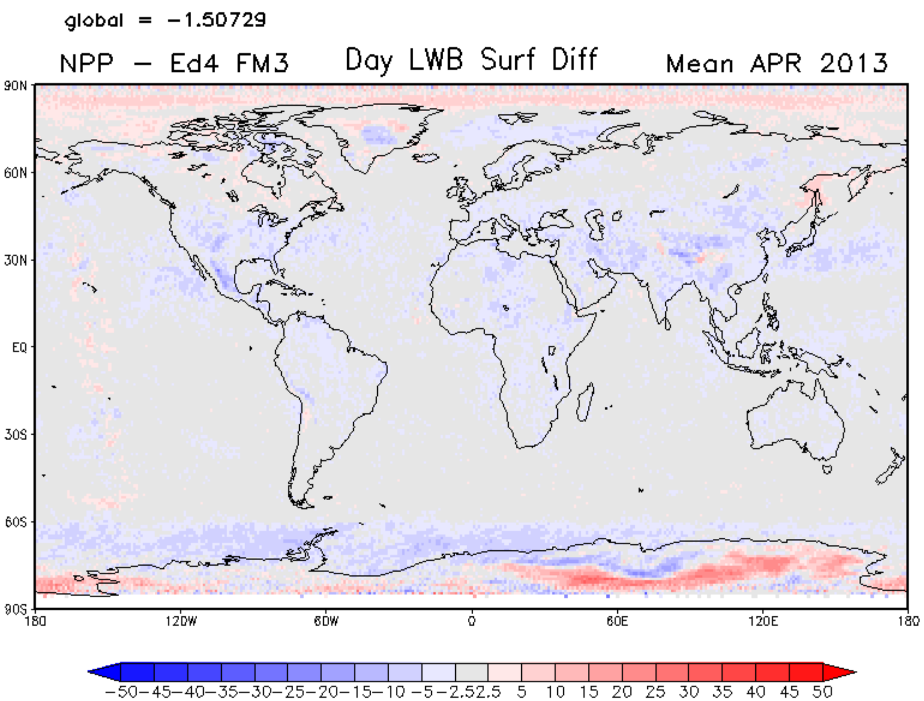


Daytime LW Surface Flux Differences between NPP and Aqua FM3 April 2013

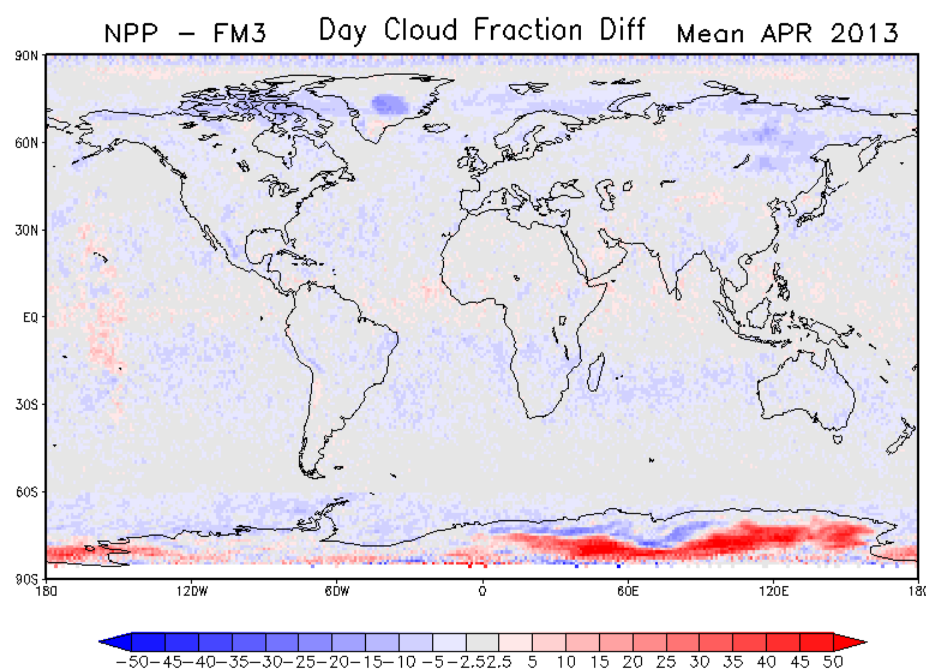


Daytime LW Surface Flux and Cloud Fraction Differences between NPP and Aqua FM3 for April 2013

LW Surface Difference W/m^2

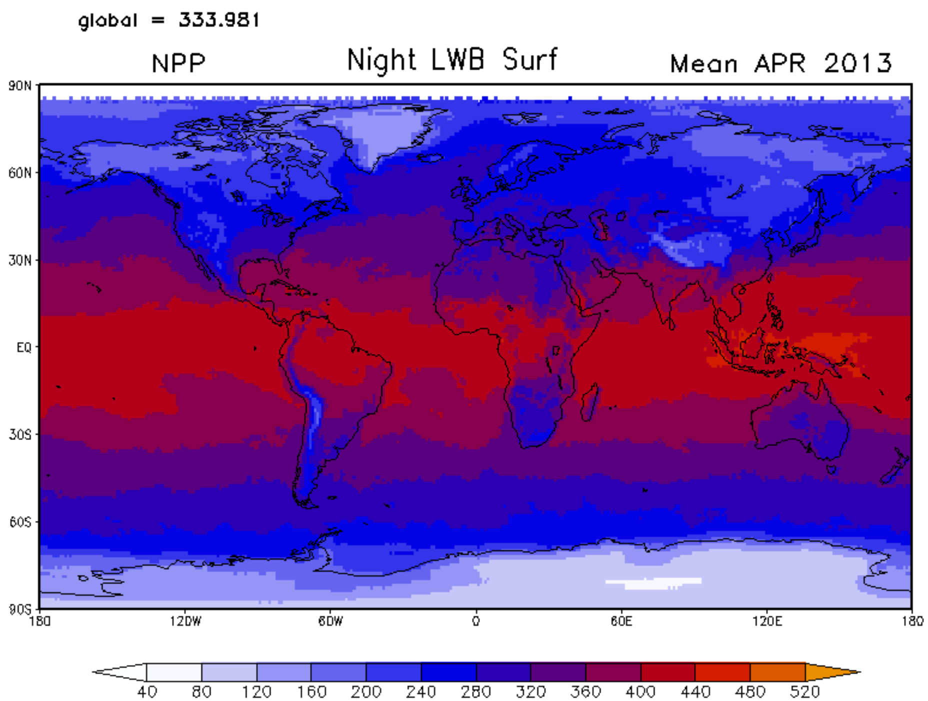


Cloud Fraction Difference

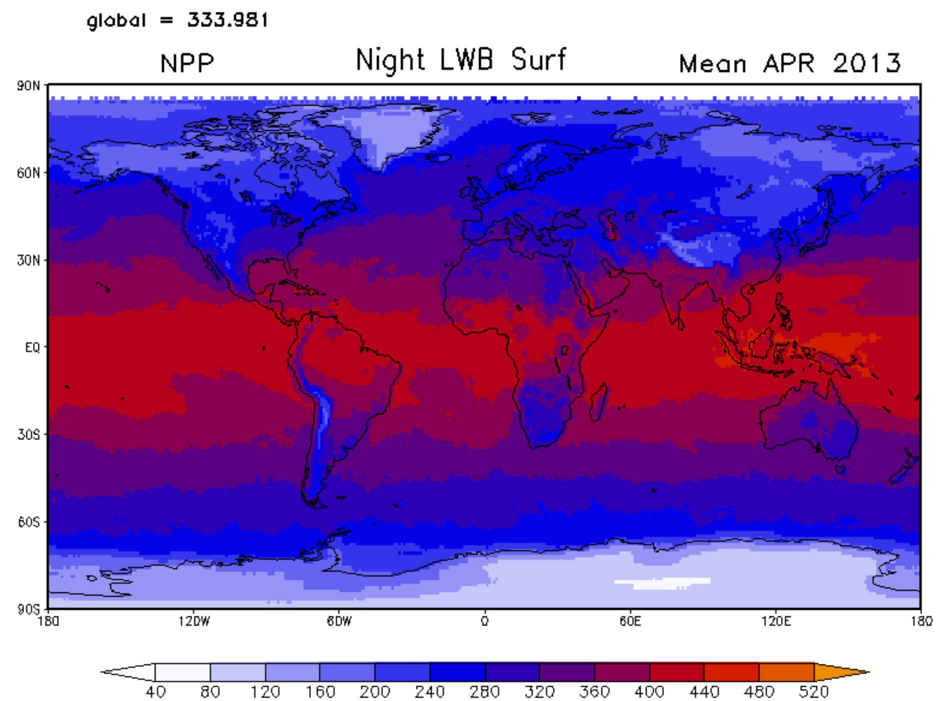


Nighttime LW Surface Flux Differences between NPP and Aqua FM3 for April 2013

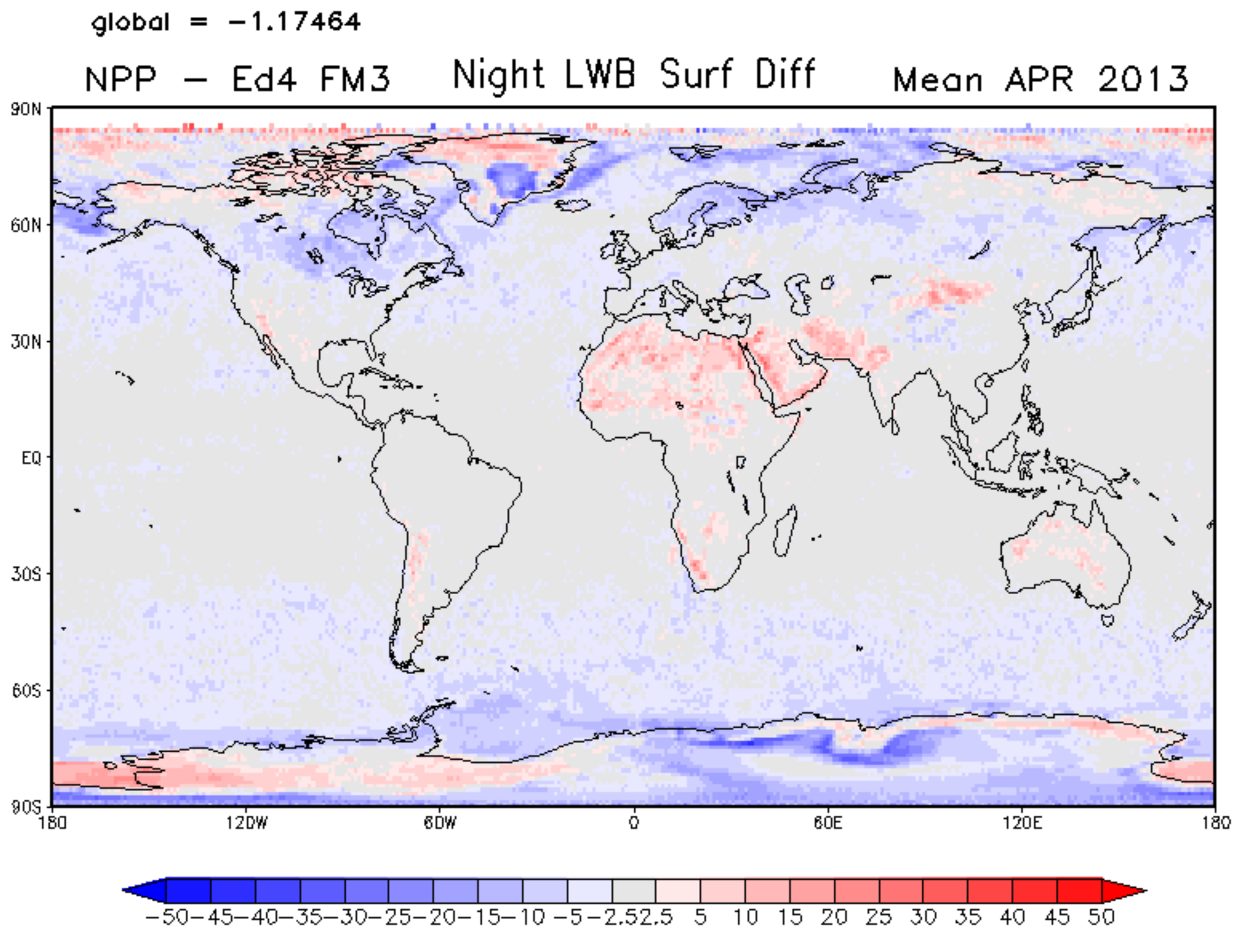
NPP SW Surface Flux W/m^2



FM3 SW Surface Flux W/m^2

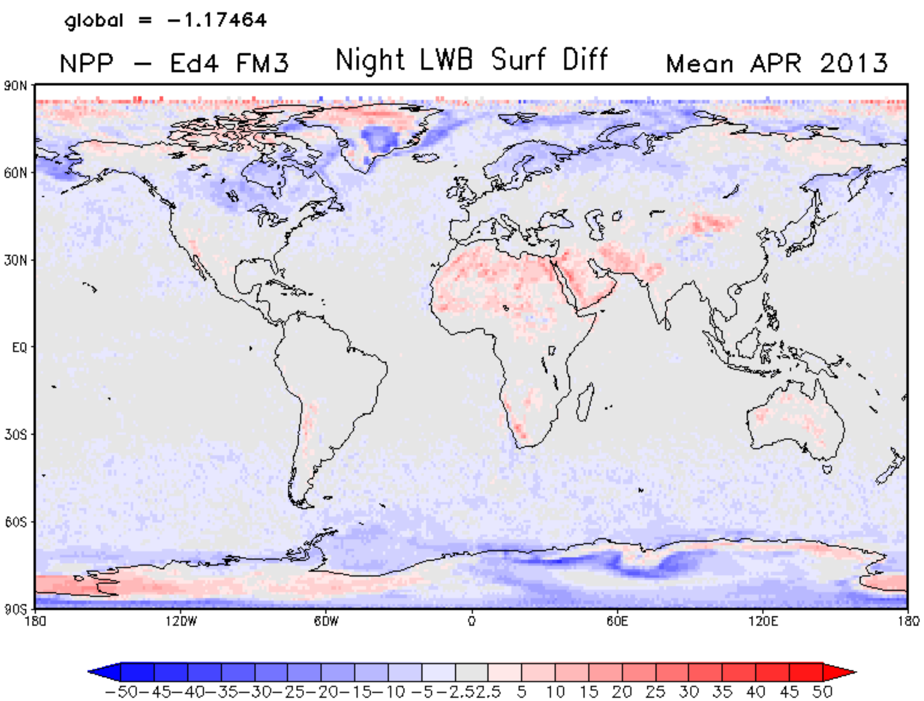


Nighttime LW Surface Flux Differences between NPP and Aqua FM3 for April 2013

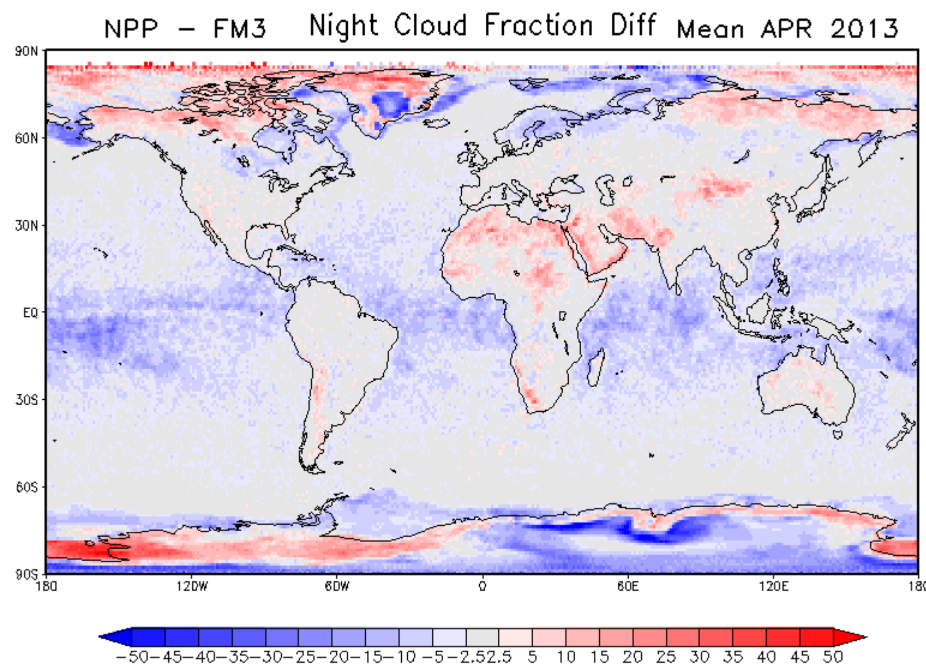


Nighttime LW Surface Flux and Cloud Fraction Differences between NPP and Aqua FM3 for April 2013

LW Surface Difference W/m^2



Cloud Fraction Difference



LW Surface Flux Results

Differences in the cloud effect play the dominant role in producing the observed differences between the NPP and Aqua LW fluxes for both Day and Night.

Conclusions for SOFA Ed4 algorithms

Previous validation studies have demonstrated that revisions to both the LW algorithms and the SW algorithms (for clear to partly cloudy conditions) appear to be working well, though further revisions to the cloud transmission method and/or overcast albedo method are needed for SW Model B. Our attention for future improvements is focused on deriving a regression fit to the cloud transmission data.

A preliminary analysis of the LW and SW surface only flux algorithm results using the Edition 4 inputs, especially those from the Clouds Subsystem, indicated improved accuracies for most locations.

A comparison of the NPP and Aqua flux retrievals show the anticipated results.