Surface–Only Flux Algorithms Working Group Report

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Algorithm Background

CERES uses several Surface–Only Flux Algorithms (SOFA) to compute SW and LW surface fluxes in addition to the more precise model used by SARB. The SOFA 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. Geophysical Research*, **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. Geophysical Research*, **112**, D15102.
SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatology*, **49**, 164-180.
SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatology,* **49**, 1579-1589.
FLASH: Kratz et al. (2014): *J. Appl. Meteor. Climatology*, **53**, 1059-1079.

Edition 4 Improvements to the Surface-Only Flux Algorithms

SW Model Improvements: 1) Replacing the ERBE albedo maps with the 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 4A. 4) Using a revised empirical coefficient in the cloud transmission formula improved the SW surface fluxes for partly cloudy conditions. 5) Work continues on the improvement of the cloud transmission method for 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).

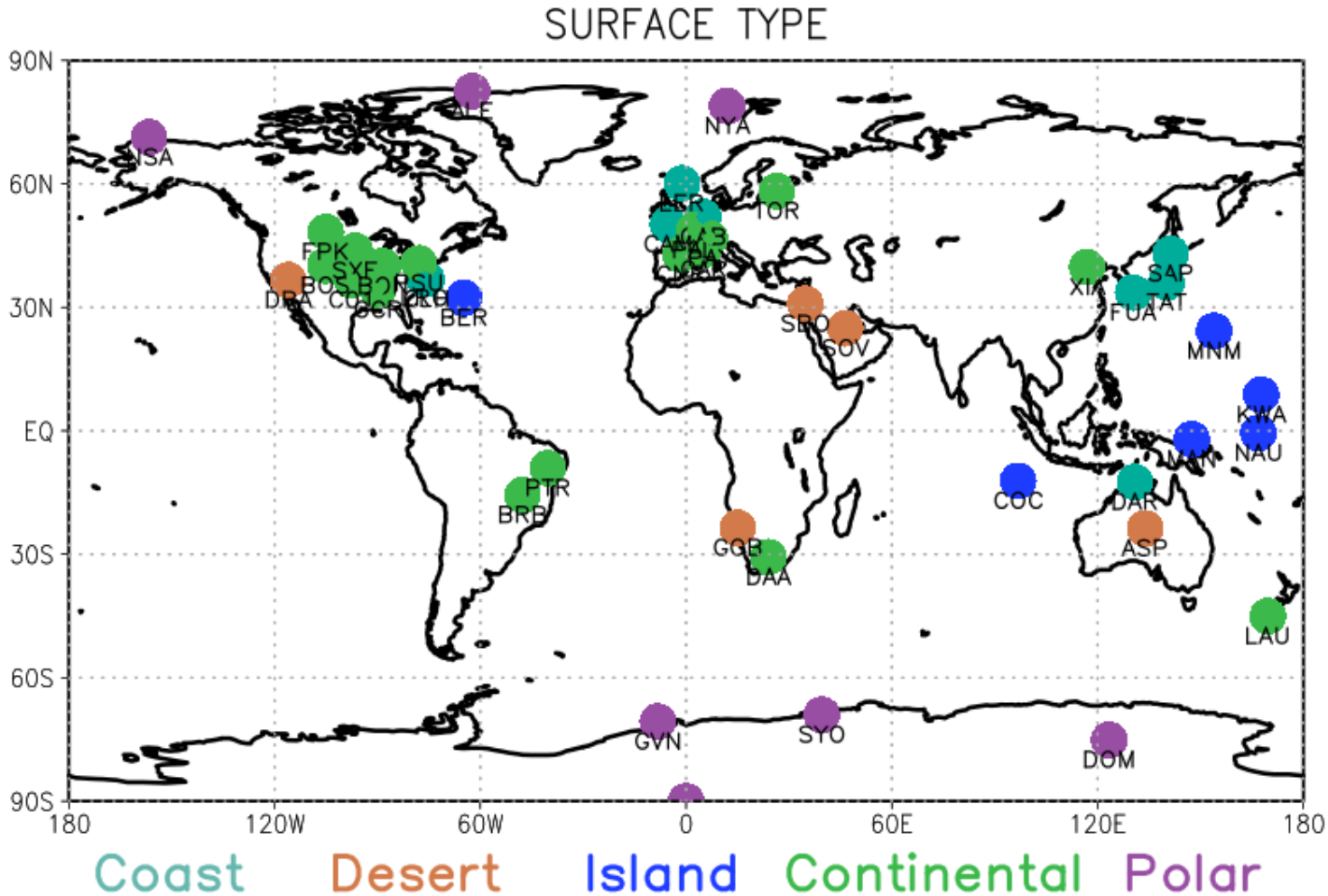
Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 2B	CERES 4A
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

Validation of Surface Flux Algorithms

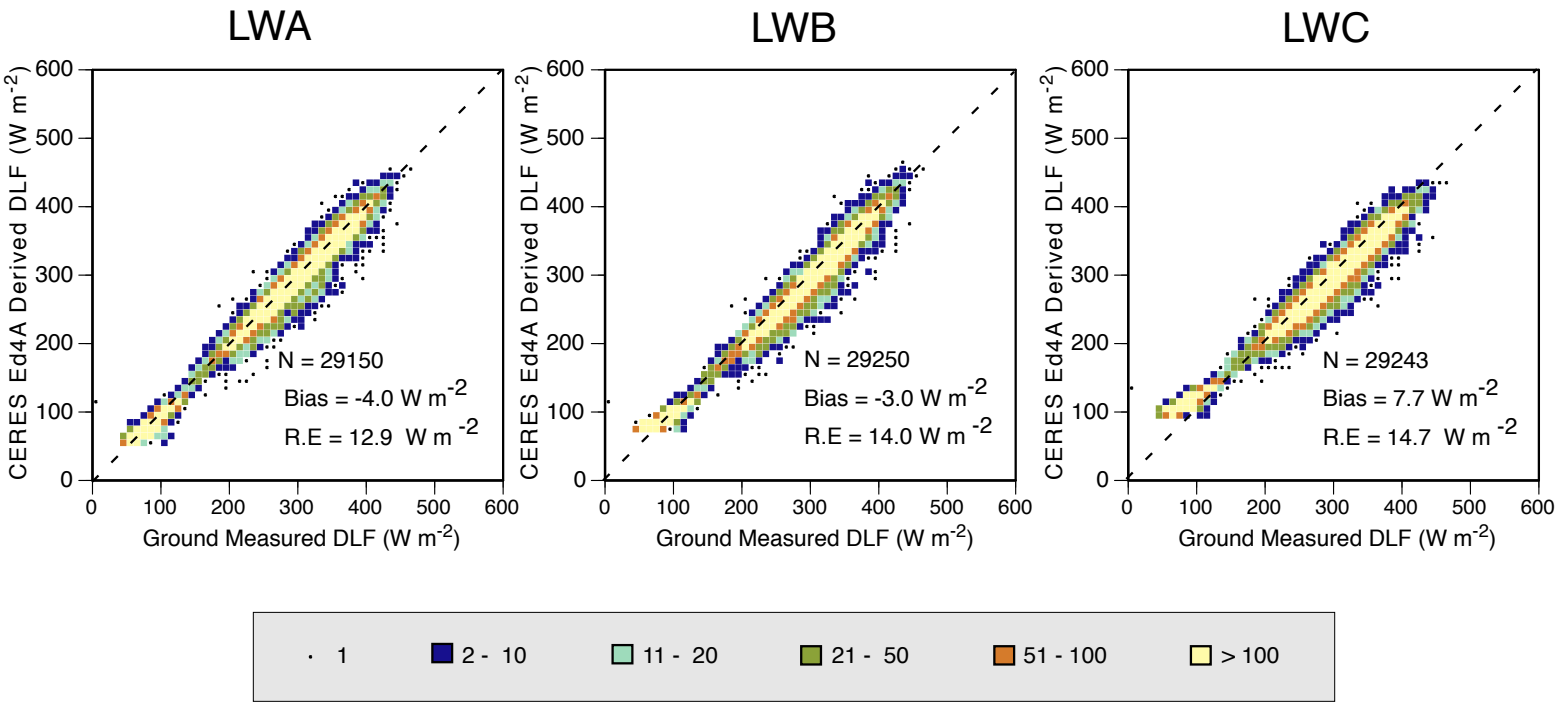
Improve, validate and maintain the CERES Edition 4A Surface–Only Flux Algorithms (SOFA) using the MODIS Collection 5 Imager Data

Surface Sites Available for Validation of Terra & Aqua Ed4A, and NPP Ed1A



CERES Terra Edition 4A LW Ground Validation (Global)

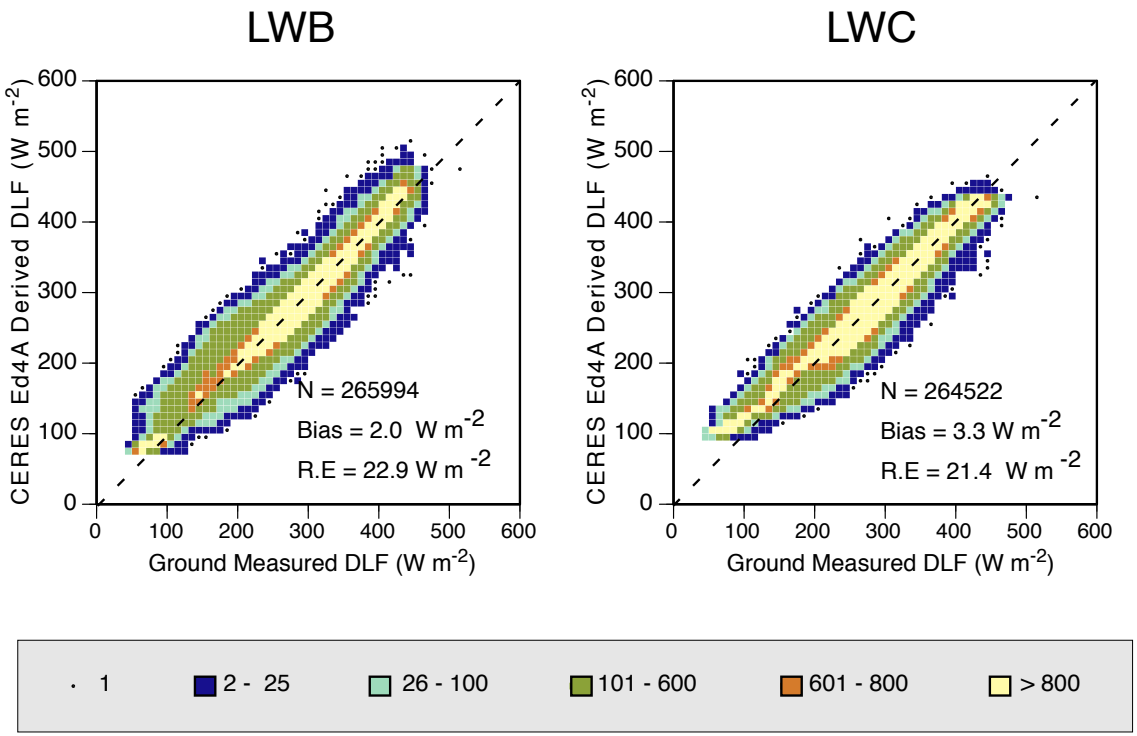
Clear–Sky



Combined LW Ground Validation for Terra (3/2000 through 2/2017).

CERES Terra Edition 4A LW Ground Validation (Global)

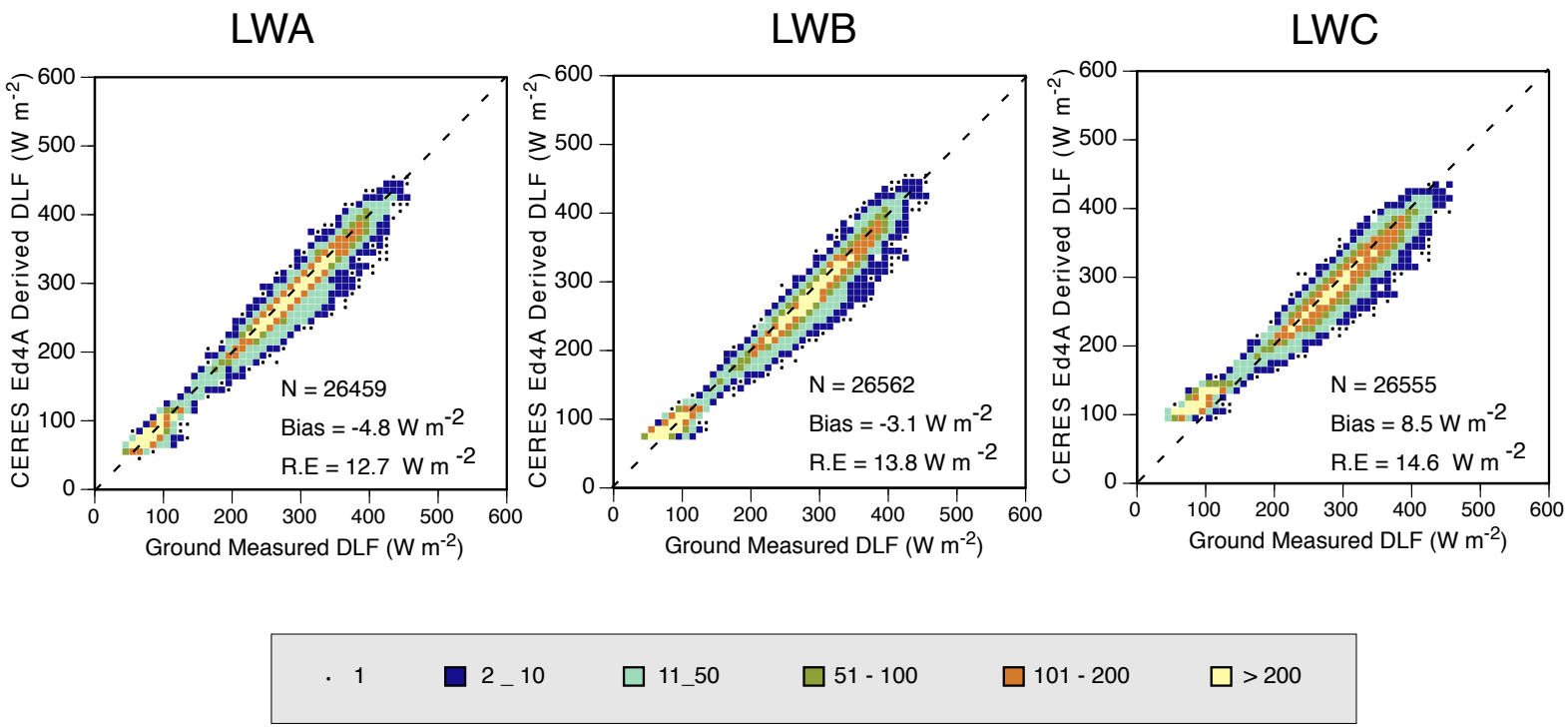
All–Sky



Combined LW Ground Validation for Terra (3/2000 through 2/2017).

CERES Aqua Edition 4A LW Ground Validation (Global)

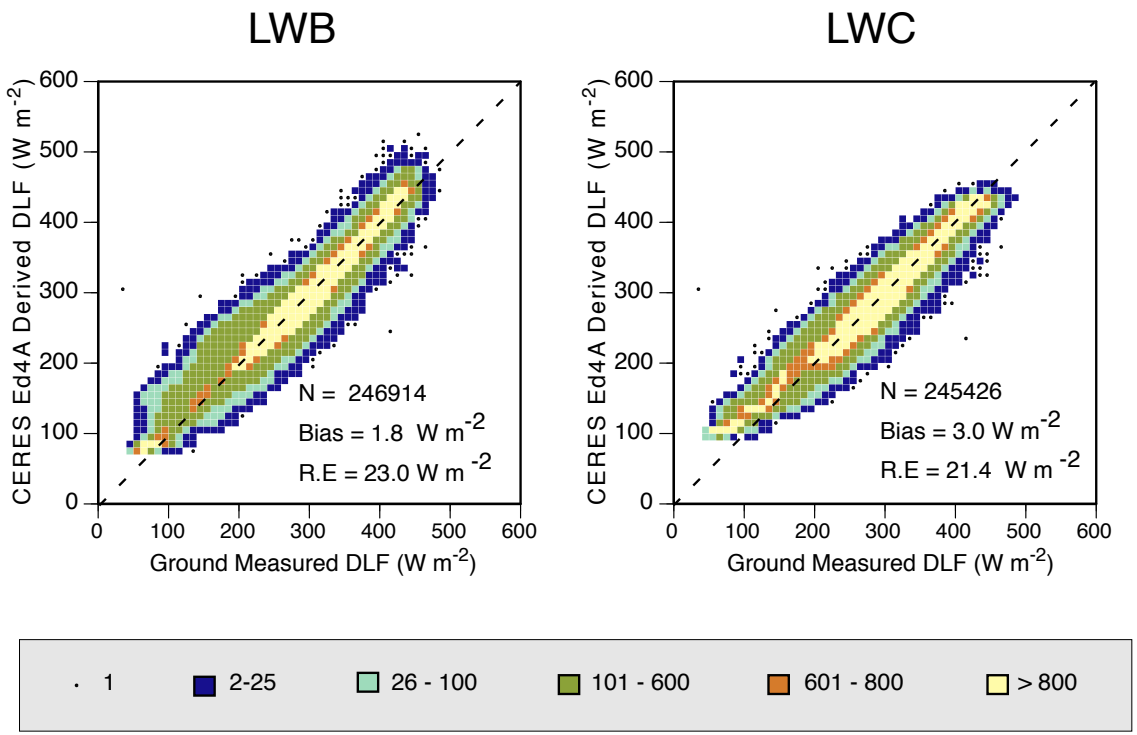
Clear–Sky



Combined LW Ground Validation for Aqua (7/2002 through 2/2017).

CERES Aqua Edition 4A LW Ground Validation (Global)

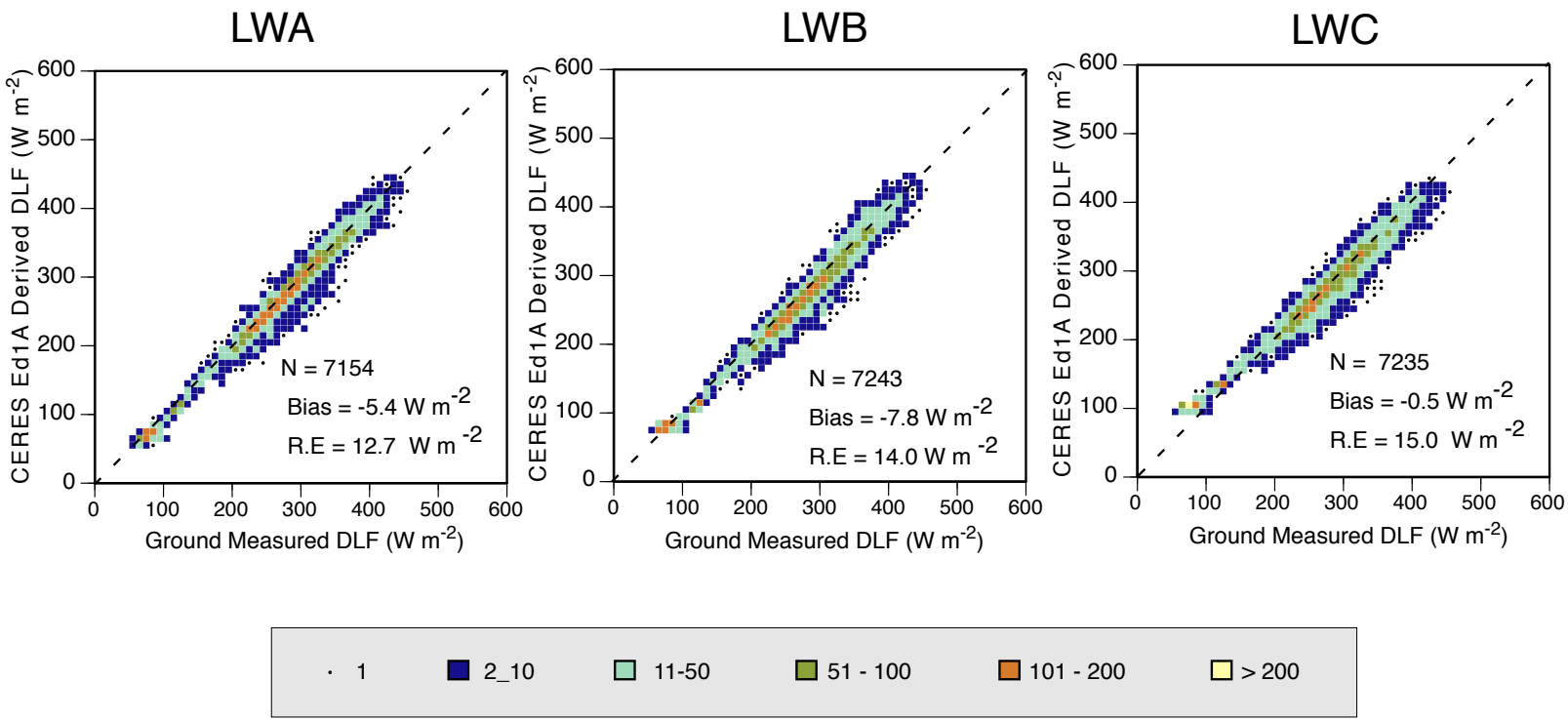
All–Sky



Combined LW Ground Validation for Aqua (7/2002 through 2/2017).

CERES NPP Edition 1A LW Ground Validation (Global)

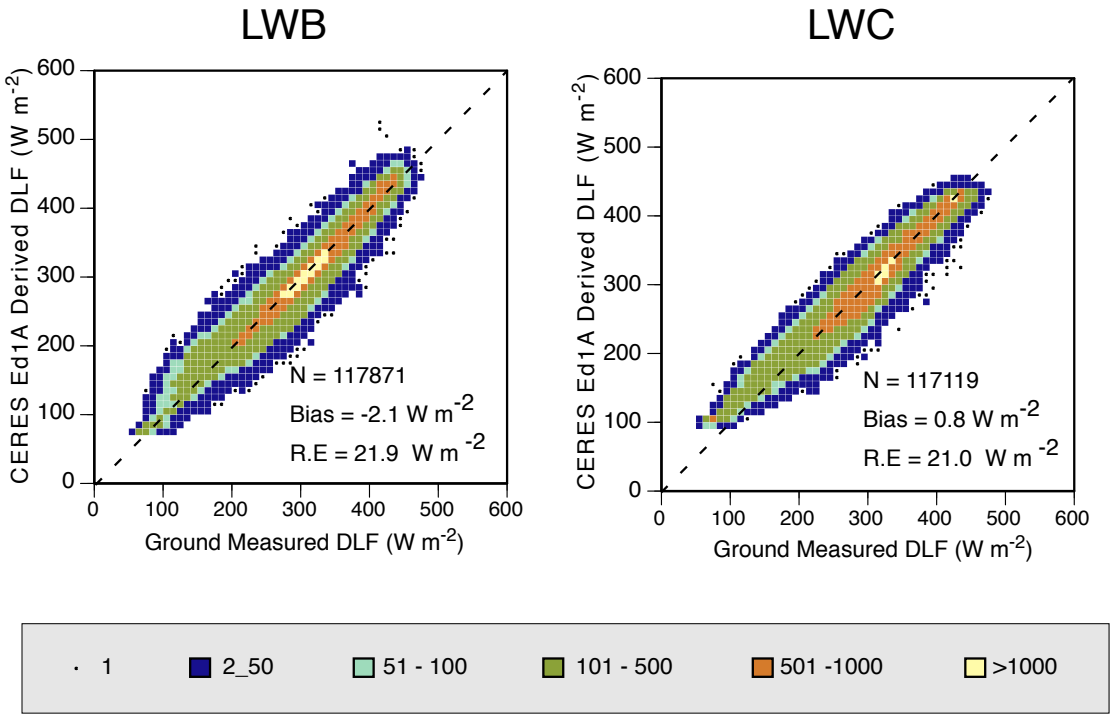
Clear–Sky



Combined LW Ground Validation for NPP (1/2012 through 3/2017).

CERES NPP Edition 1A LW Ground Validation (Global)

All–Sky



Combined LW Ground Validation for NPP (1/2012 through 3/2017).

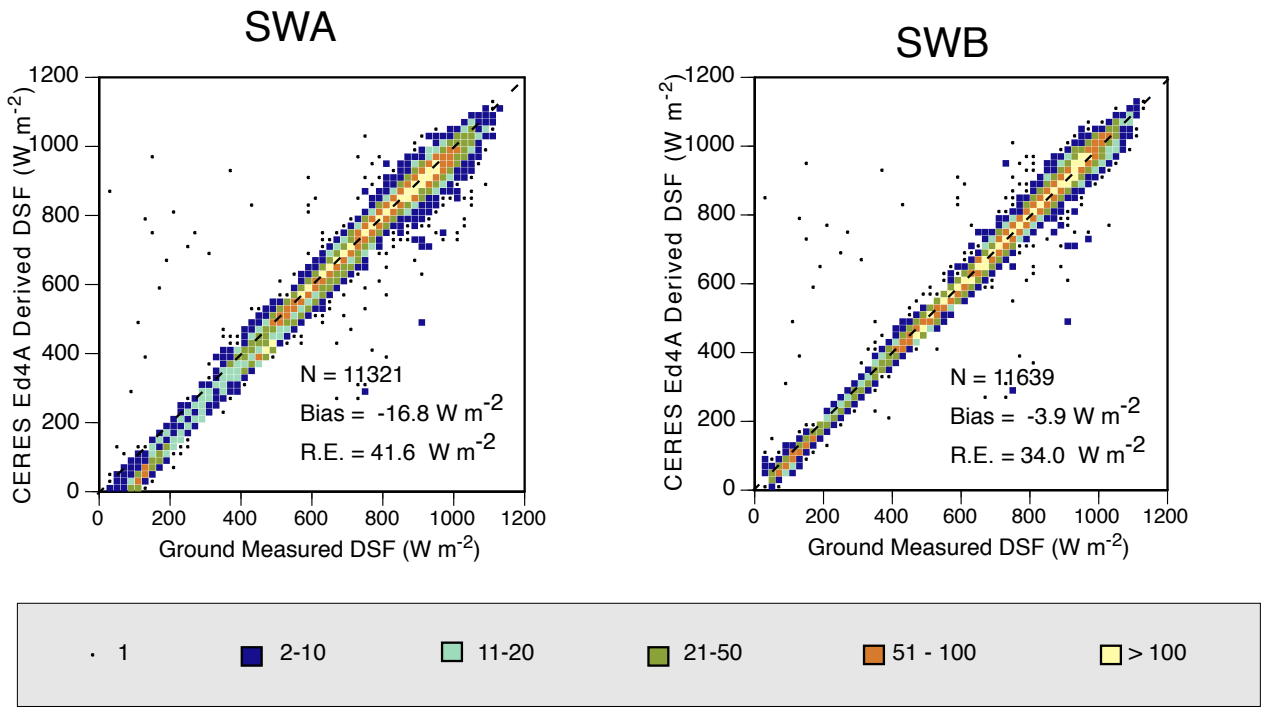
LW Surface Flux Results

The Terra, Aqua and NPP LW fluxes derived for Clear-Sky conditions show biases ≈ –4 to +8 W/m^2 and uncertainties ≈ 12 to 15 W/m^2.

The Terra, Aqua and NPP LW fluxes derived for All-Sky conditions show biases ≈ ±3 W/m^2 and uncertainties ≈ 21 to 23 W/m^2.

CERES Terra Edition 4A SW Ground Validation (Global)

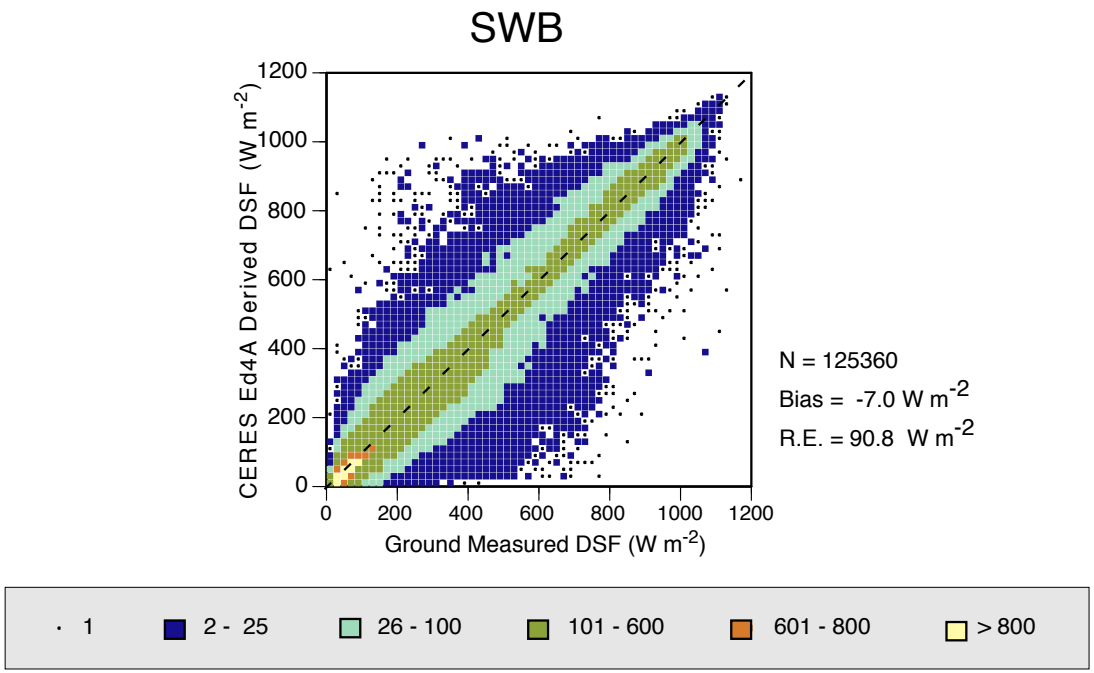
Clear–Sky



Combined SW Ground Validation for Terra (3/2000 through 2/2017).

CERES Terra Edition 4A SW Ground Validation (Global)

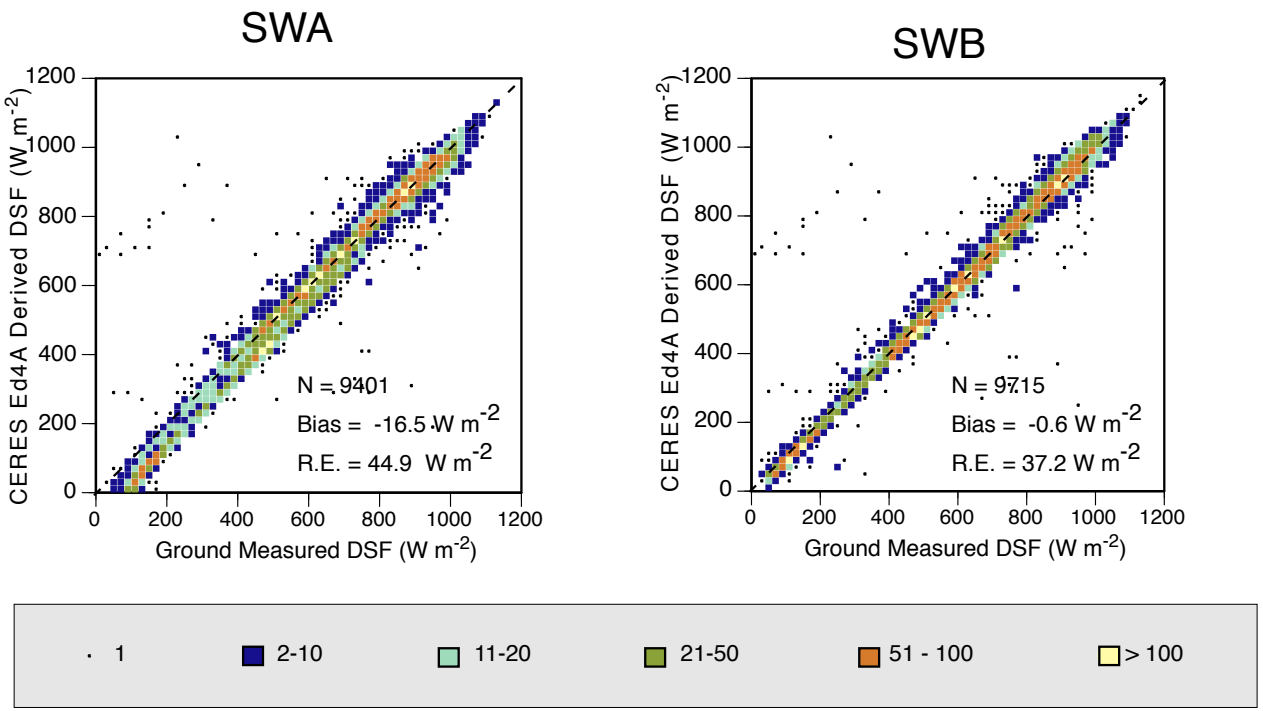
All–Sky



SWB Ground Validation for Terra (3/2000 through 2/2017).

CERES Aqua Edition 4A SW Ground Validation (Global)

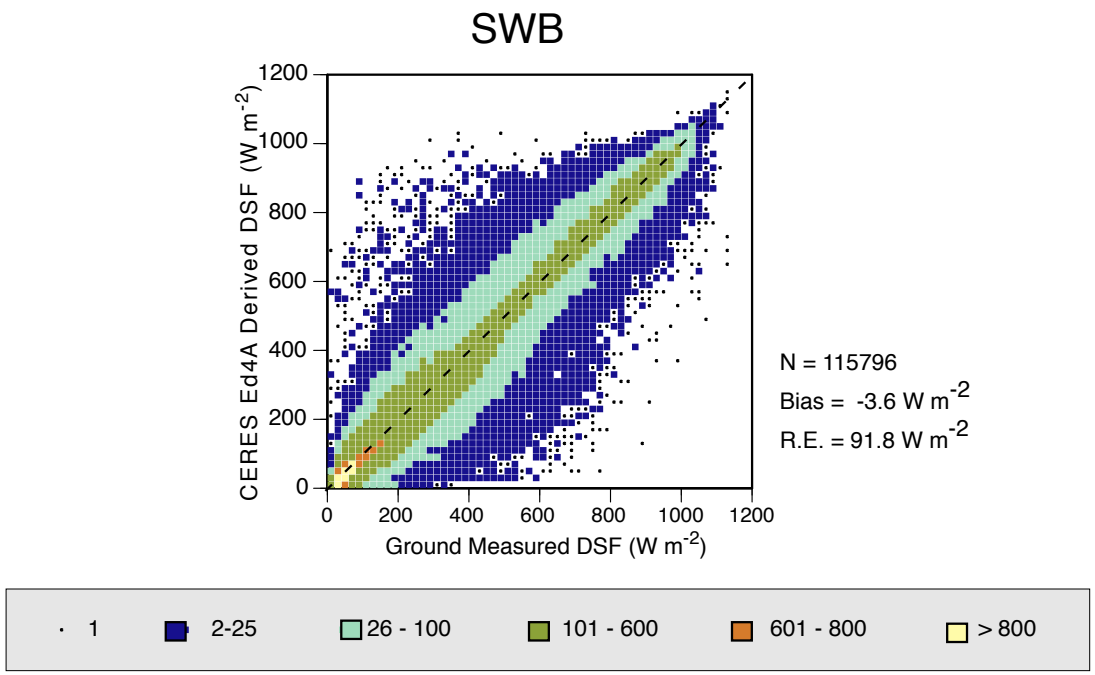
Clear–Sky



Combined SW Ground Validation for Aqua (7/2002 through 2/2017).

CERES Aqua Edition 4A SW Ground Validation (Global)

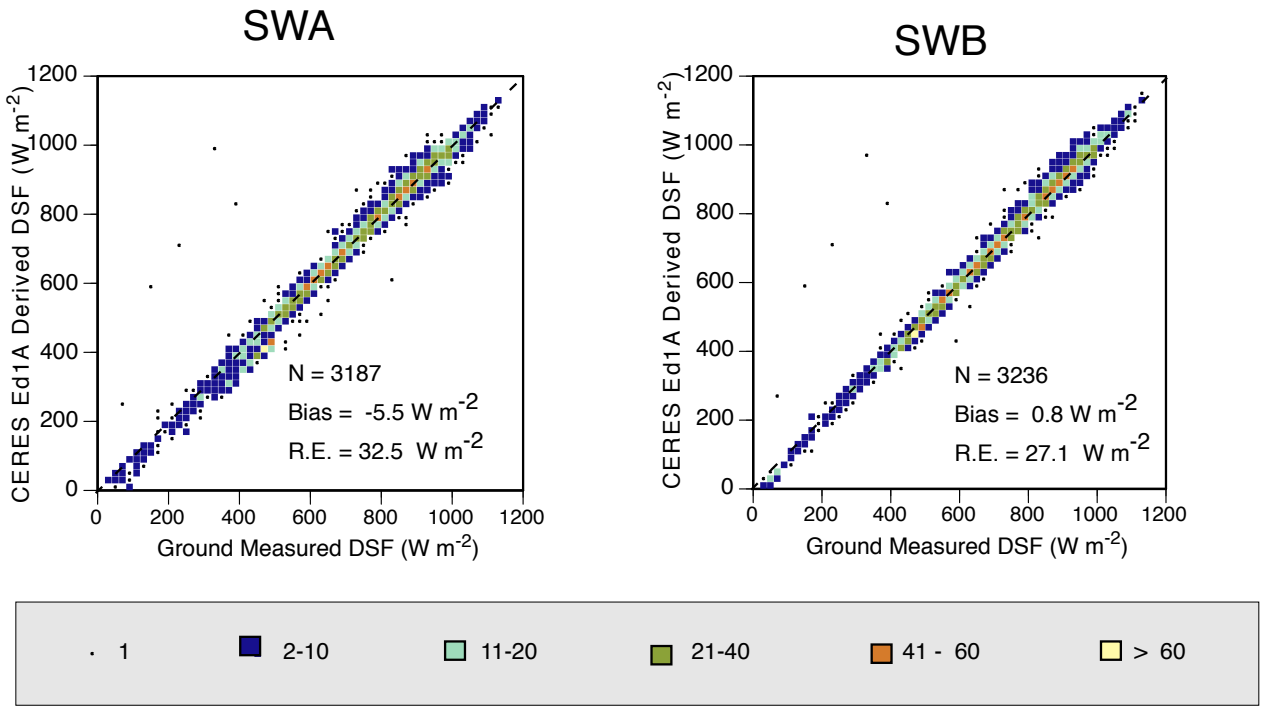
All–Sky



SWB Ground Validation for Aqua (7/2002 through 2/2017).

CERES NPP Edition 1A SW Ground Validation (Global)

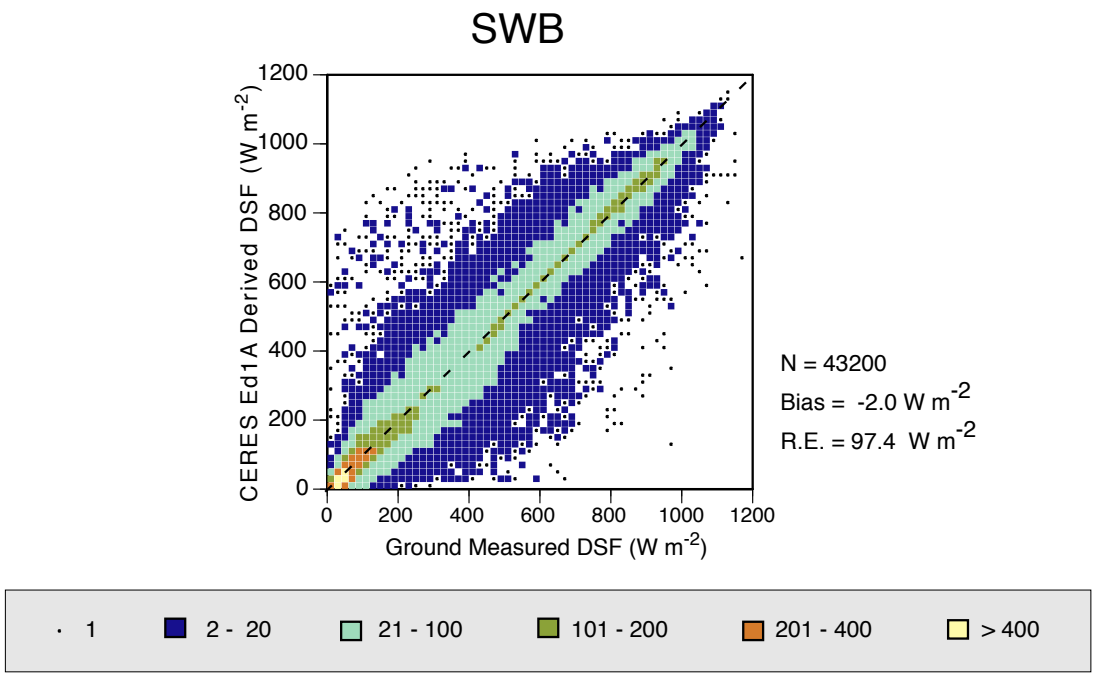
Clear–Sky



Combined SW Ground Validation for NPP (1/2012 through 3/2017).

CERES NPP Edition 1A SW Ground Validation (Global)

All–Sky



SWB Ground Validation for NPP (1/2012 through 3/2017).

SW Surface Flux Results

The Terra, Aqua and NPP SW fluxes derived for Clear-Sky conditions show biases ≈ –17 to –5 W/m^2 and uncertainties ≈ 25 to 40 W/m^2.

The Terra, Aqua and NPP SW fluxes derived for All-Sky conditions show biases ≈ –8 to –4 W/m^2 and uncertainties ≈ 90 W/m^2.

Our current effort is focused on finding methods to reduce the large uncertainties in the retrieved SW Cloudy Sky surface fluxes.

Conclusions for SOFA Ed4A algorithms

Validation studies have demonstrated that revisions to both the LW algorithms and the SW algorithms are working well, though further revisions to the cloud transmission method are underway to improve SW Model B.

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

The Terra, Aqua and NPP flux retrievals show good agreement with the ground–based measurements.

MODIS Collections 5, 6 and 6.1(future)

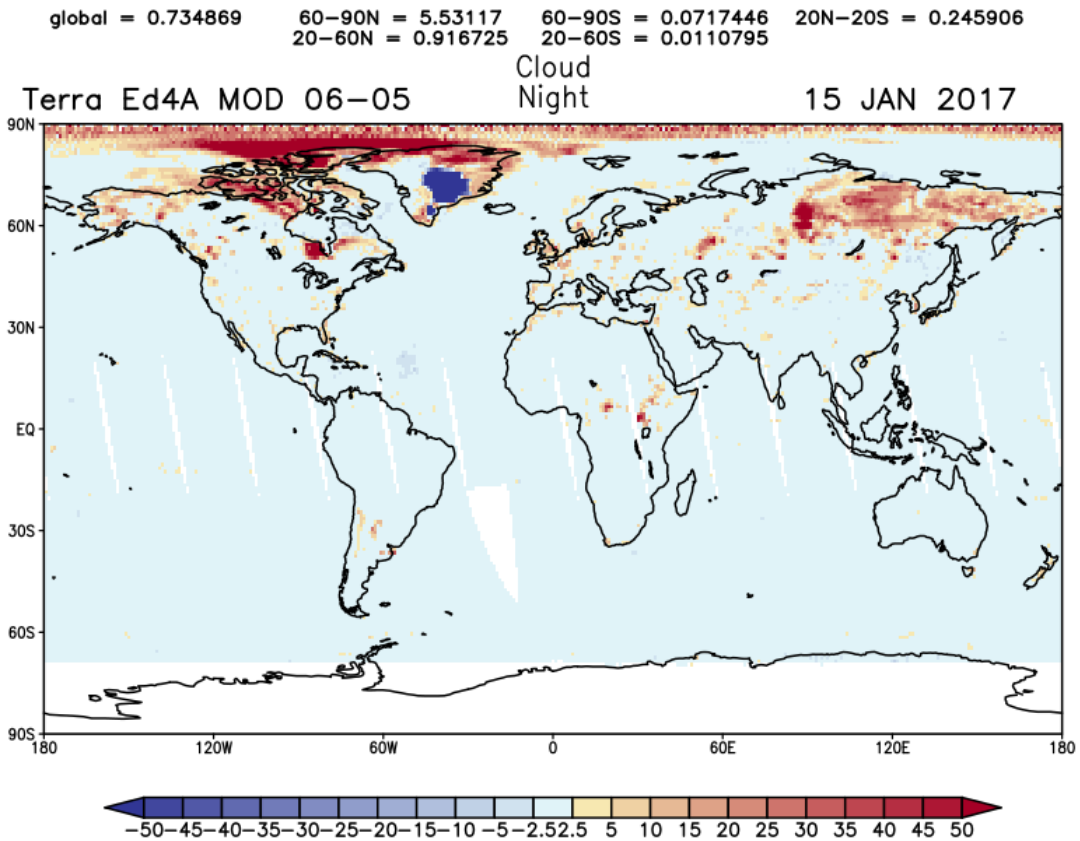
- For CERES Edition 4, which covered the timeframe from March 2000 through February 2017, MODIS Collection 5 was used for the imager data.

- For March 2017 forward, MODIS Collection 5 was no longer available, thus the need to upgrade to MODIS Collection 6.

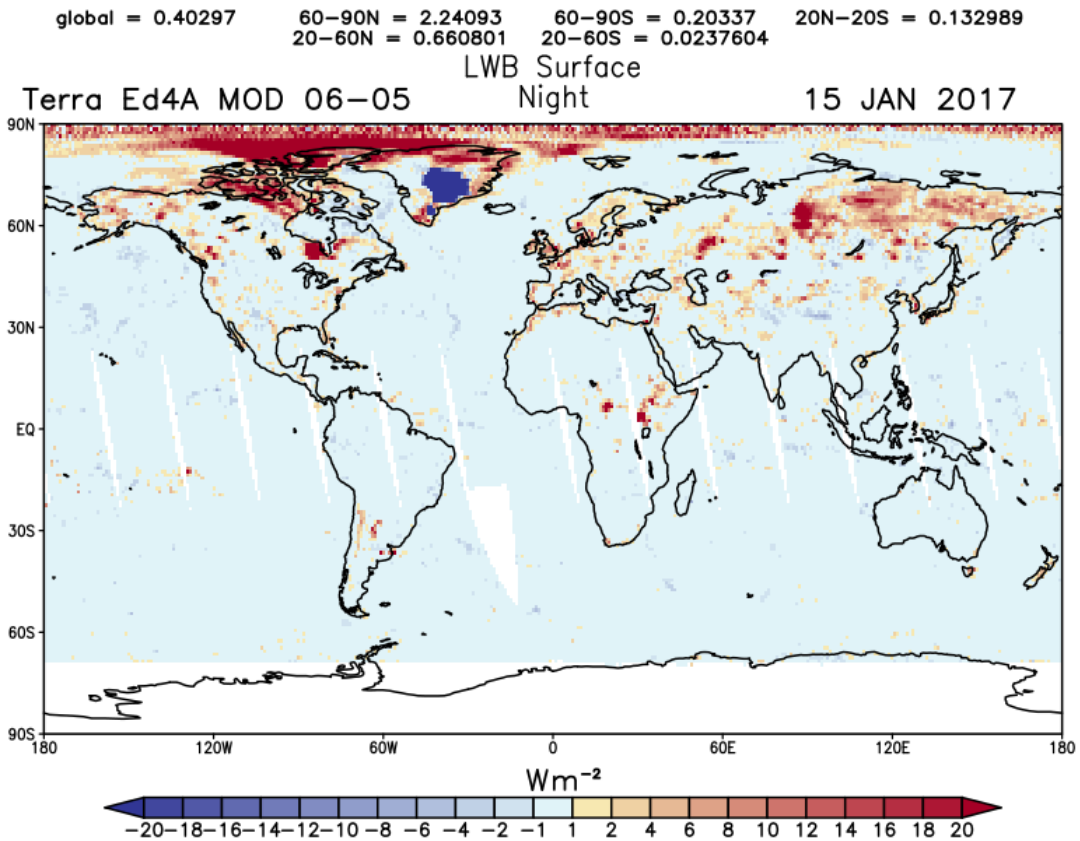
- Uncompensated Crosstalk within the MODIS Water Vapor Channels 27, 28 & 29 on Terra produced spurious results for MODIS Collection 6, and thus, the need to upgrade to MODIS Collection 6.1 once that dataset becomes available.

- MATCH aerosols have also been improved significantly.

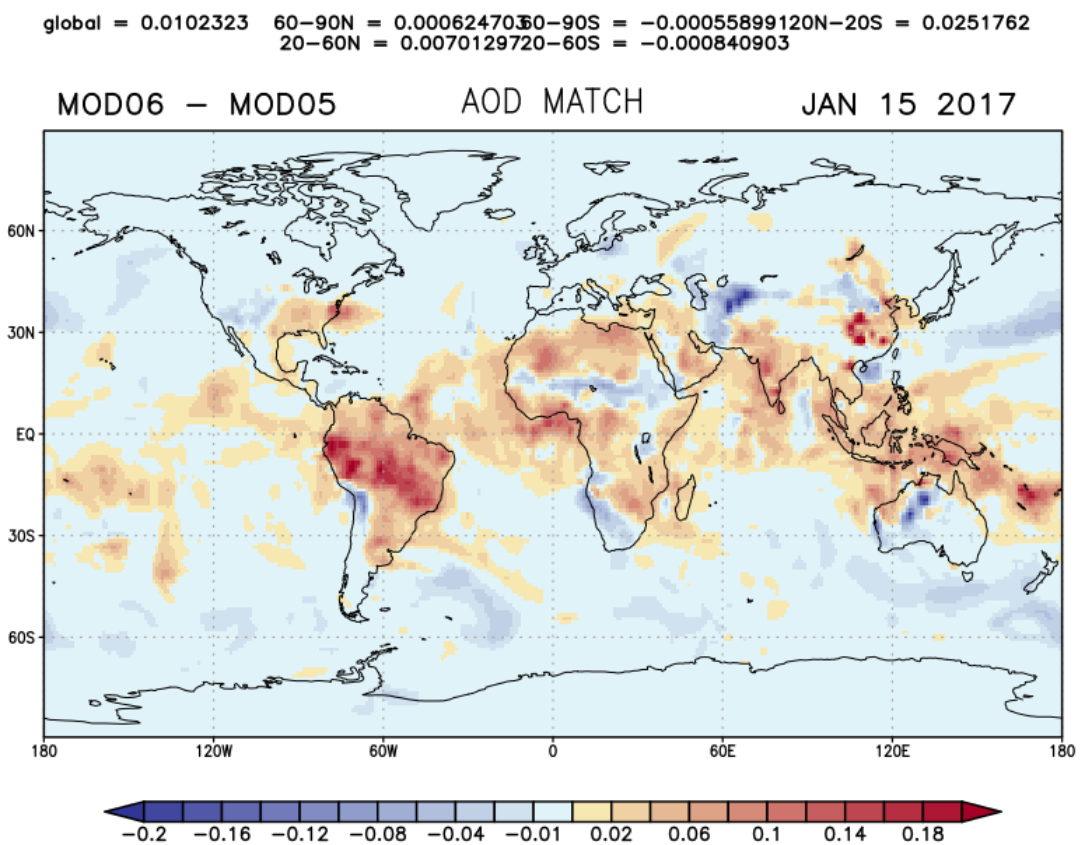
Difference between Nighttime Cloud Fraction; Terra MODIS Collection 6 minus Terra MODIS Collection 5



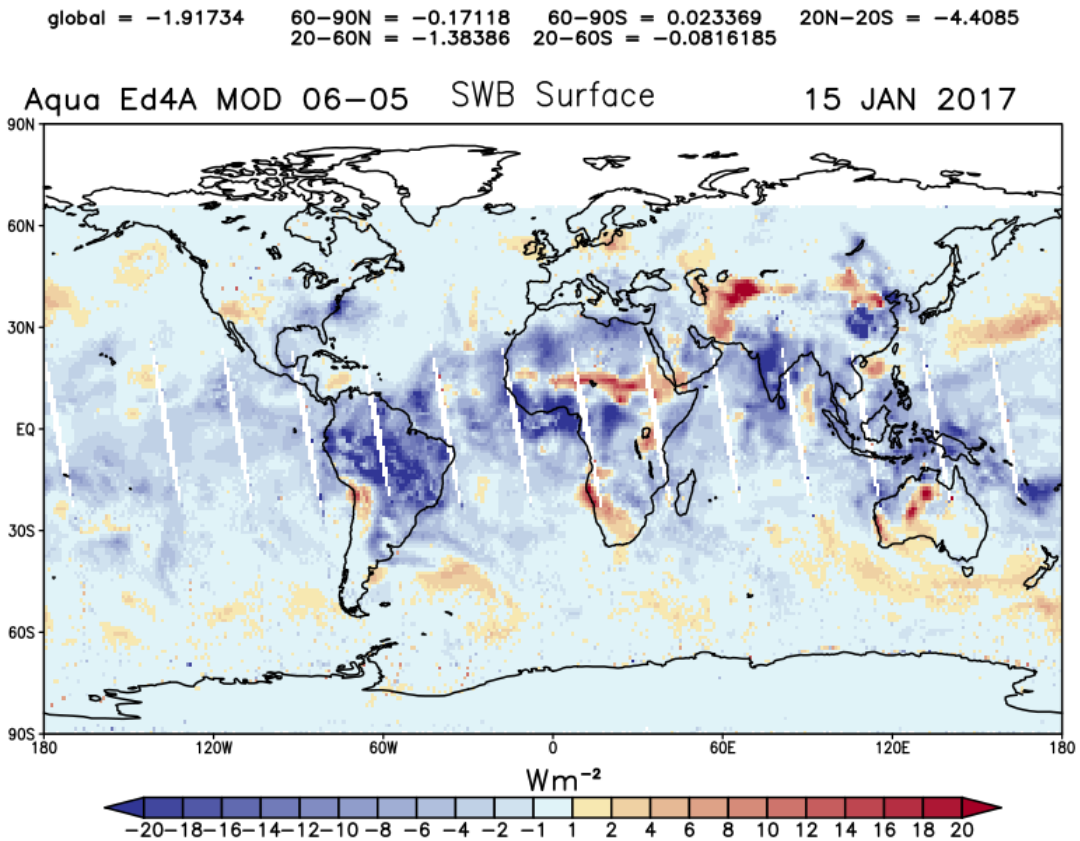
Comparison of Terra Longwave Surface Fluxes; MODIS Collection 6 minus MODIS Collection 5



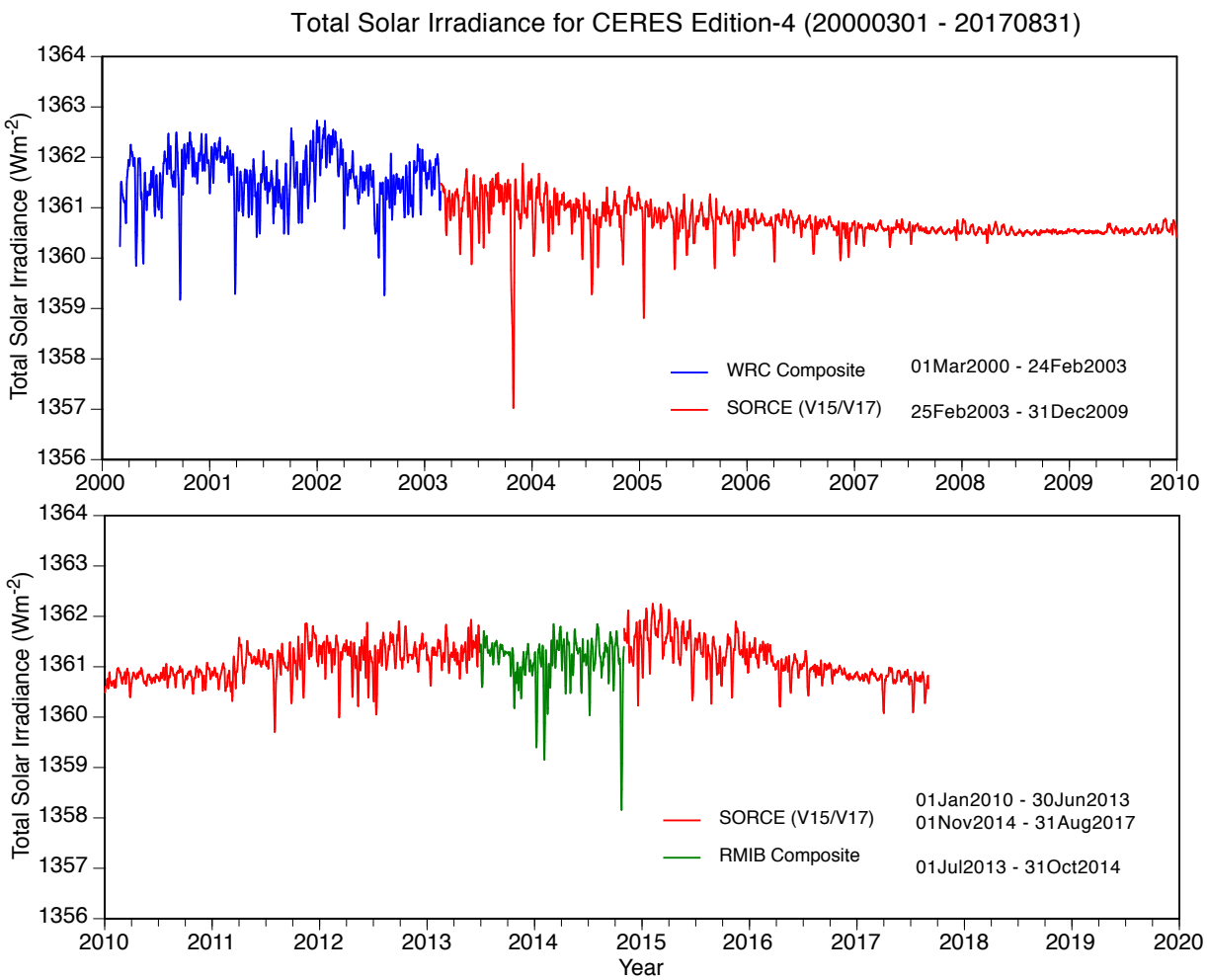
Comparison of Aerosol Optical Depths using MATCH Aerosols from MODIS Collection 6 to MATCH Aerosols from MODIS Collection 5



Comparison of Surface Shortwave Fluxes
MODIS Collection 6 minus MODIS Collection 5



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



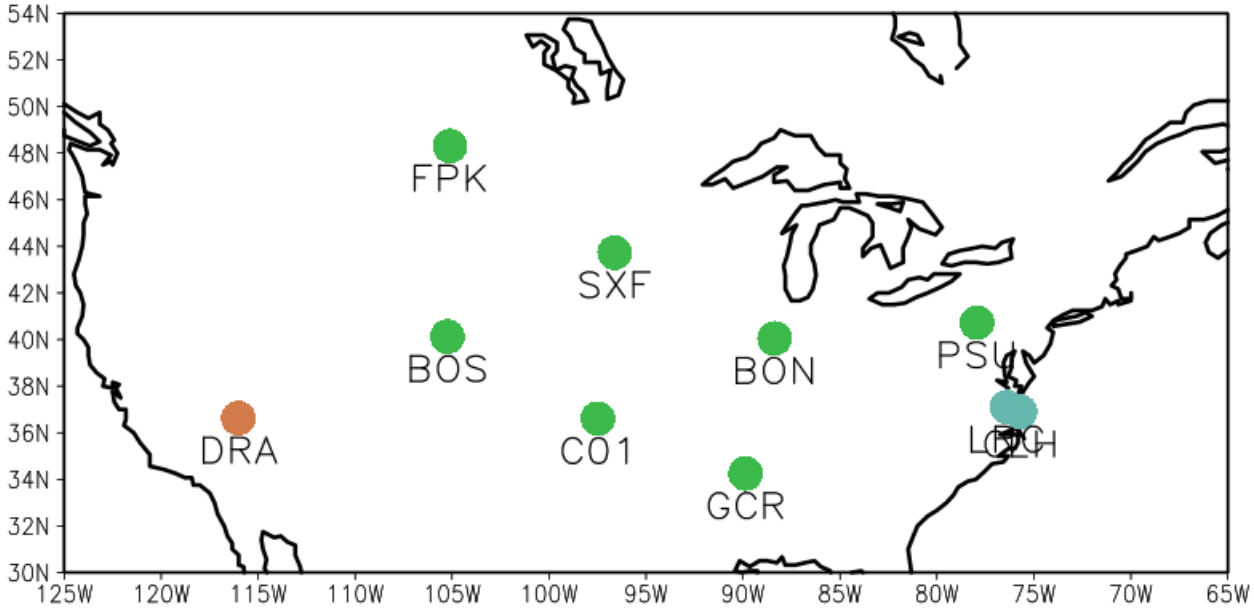
For CERES Ed 4A, all TSI data are offset to match SORCE TSI Version 15

Impact of 8/21/2017 Total Solar Eclipse on CERES data

17:15 UT (11:15 CDT)
17:45 UT (11:45 CDT)
18:15 UT (12:15 CDT)
18:15 UT (12:45 CDT)

See: http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2017/08/170821_g16_vegetation_b3_conus_anim.gif

Continental United States (CONUS) Sites Available for Validation of Terra & Aqua Ed4A, and NPP Ed1A



Data from ARM SGP MFRSRs showing the reduction in direct normal broadband radiation during the solar eclipse of 8/21/2017

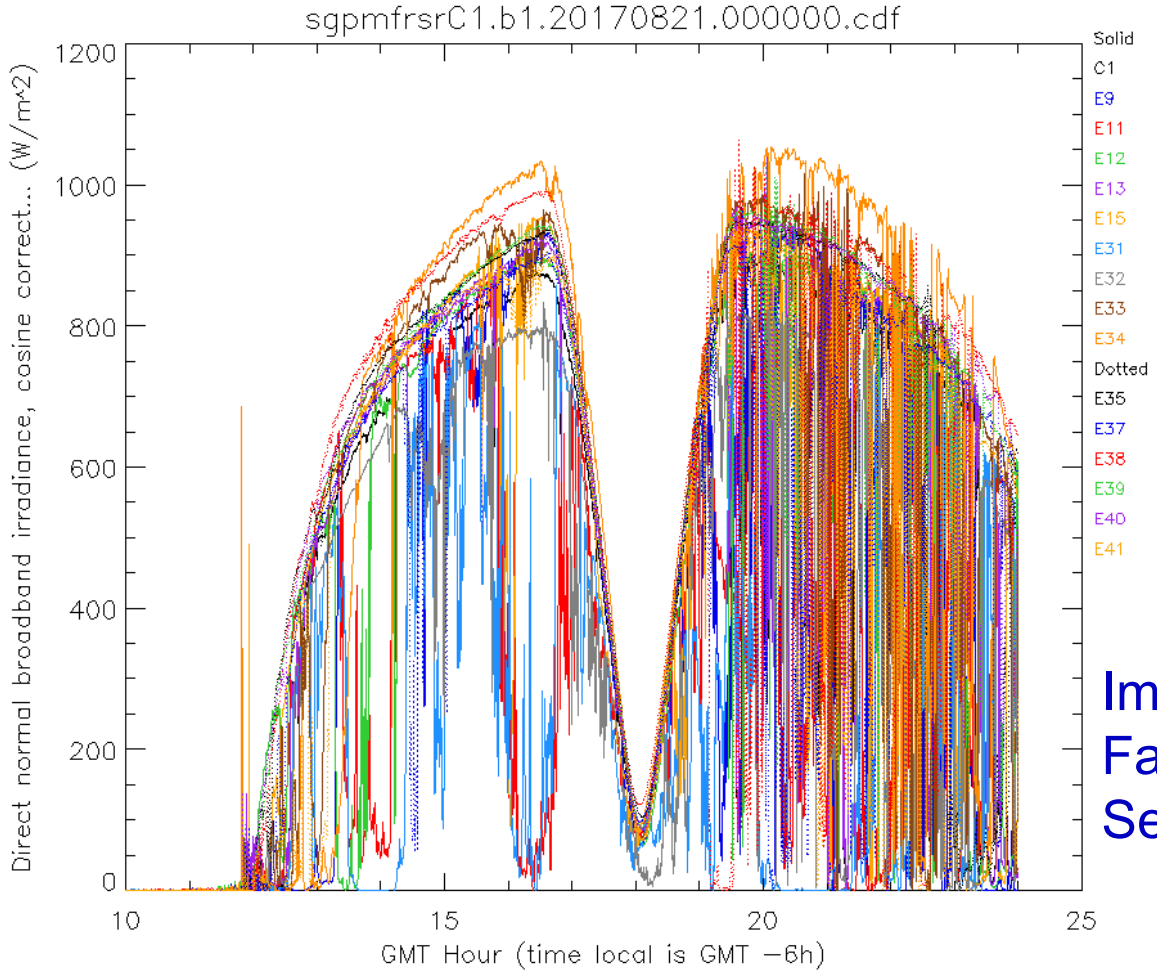
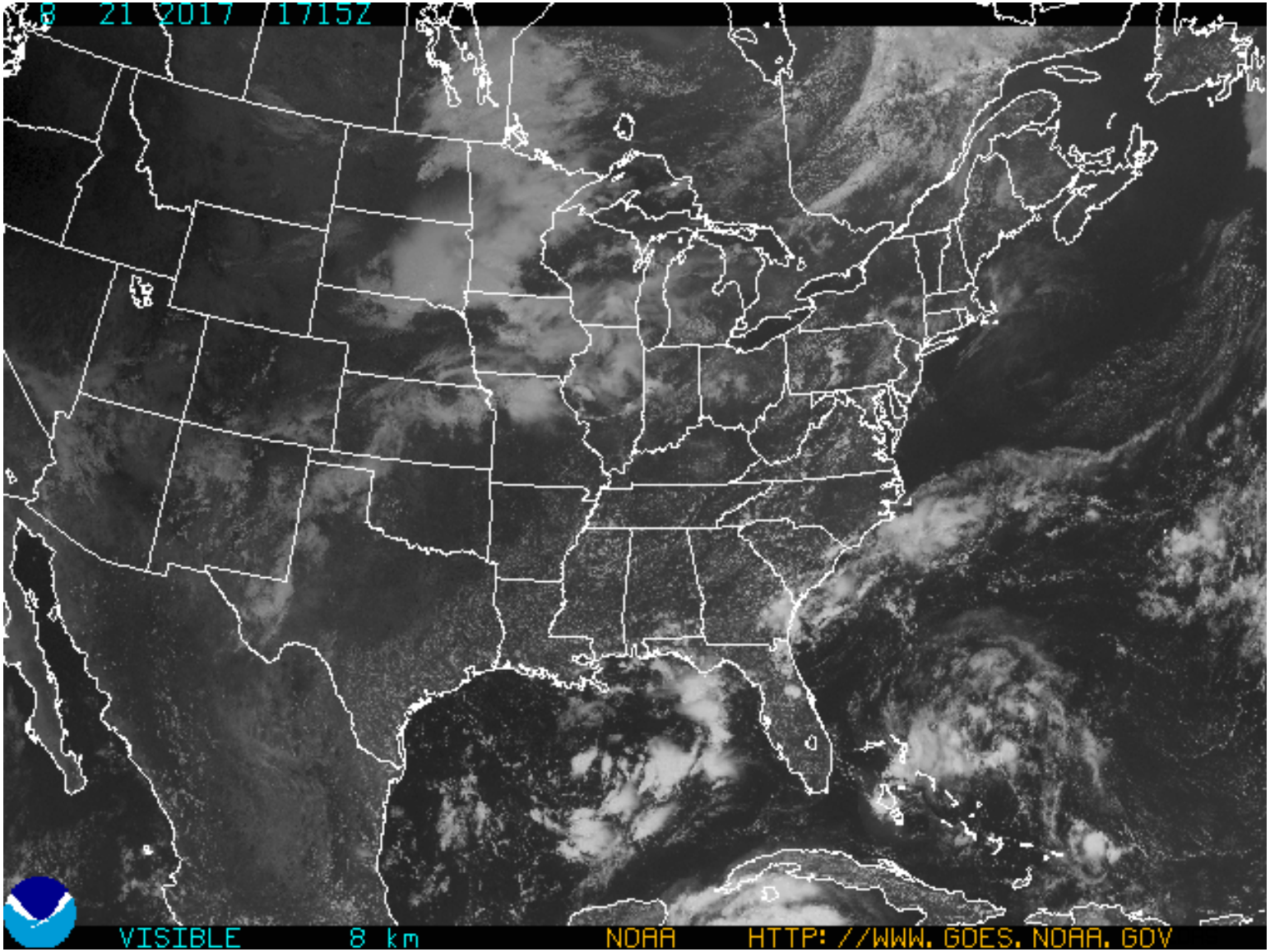
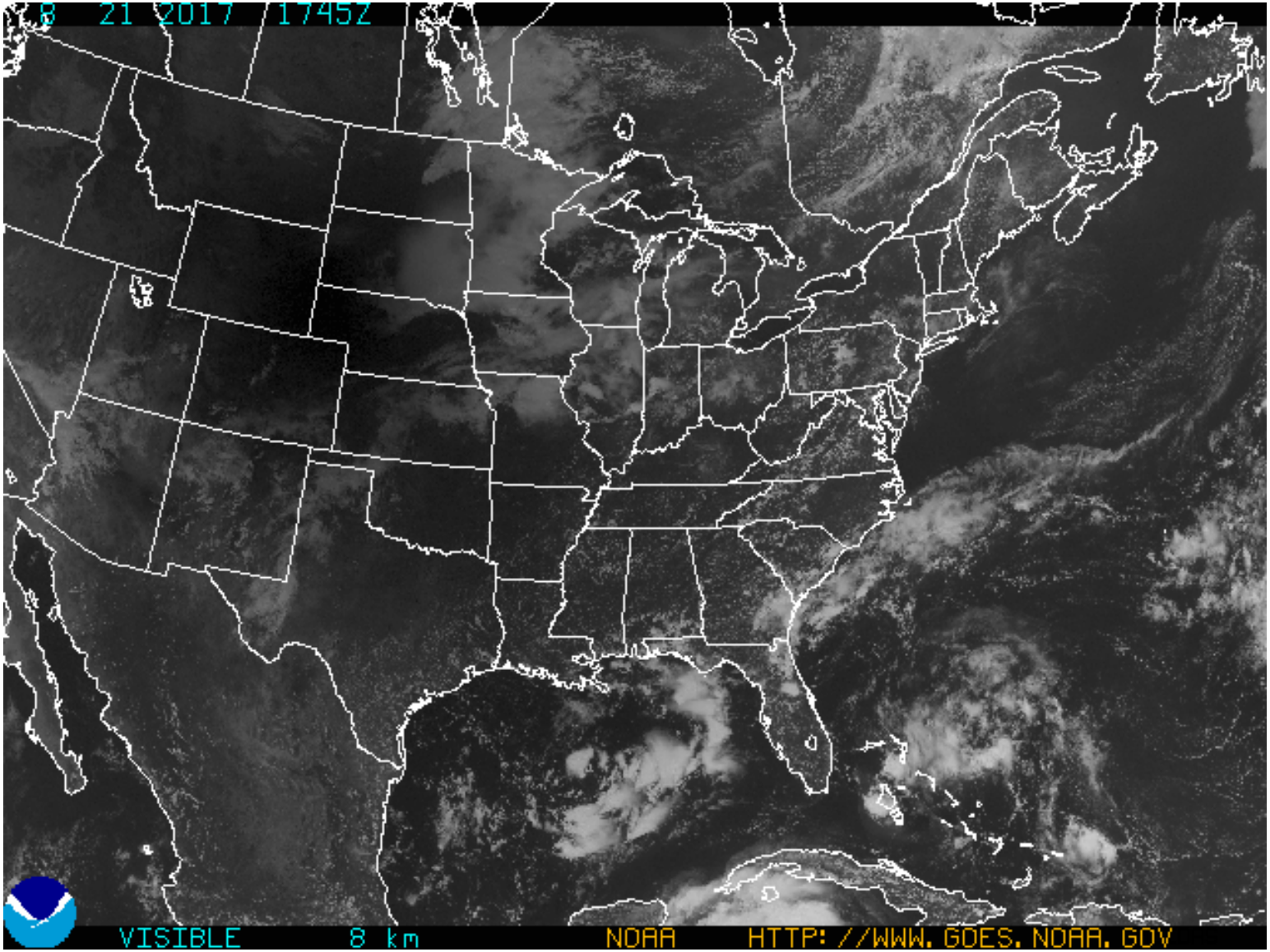
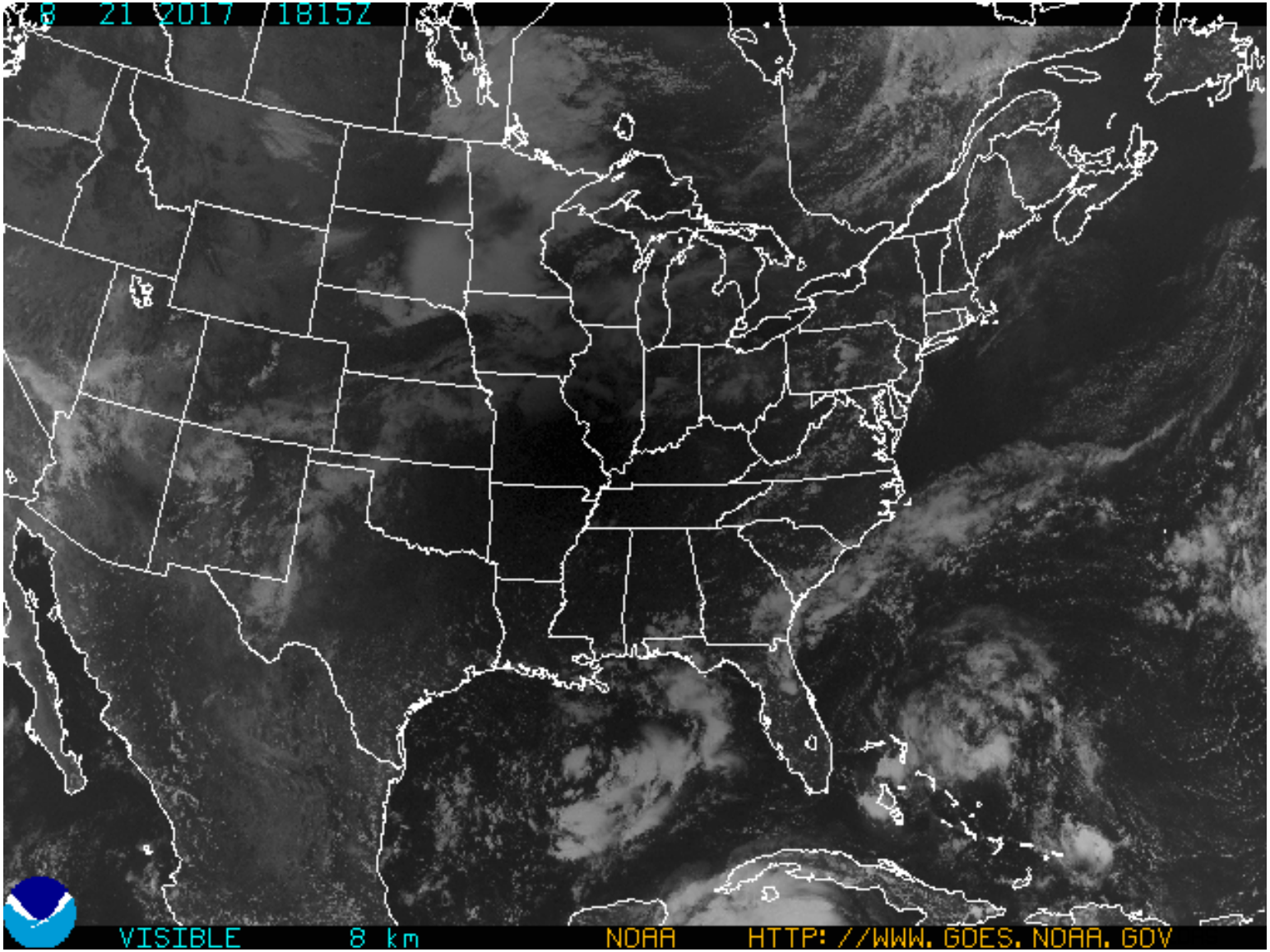


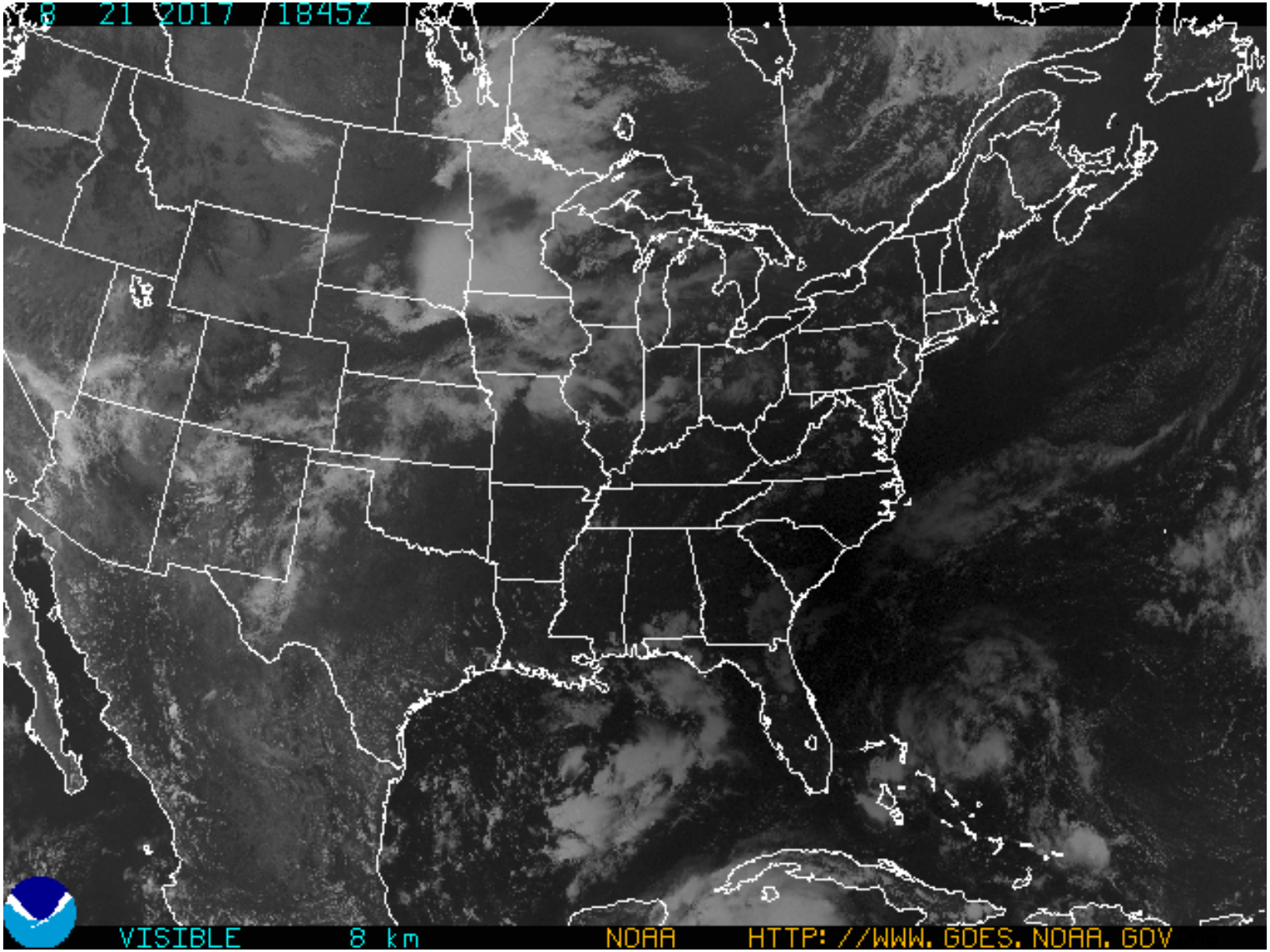
Image from ARM Facility News, September, 2017

Maximum eclipse was 89% at the SGP Central Facility in Lamont, OK

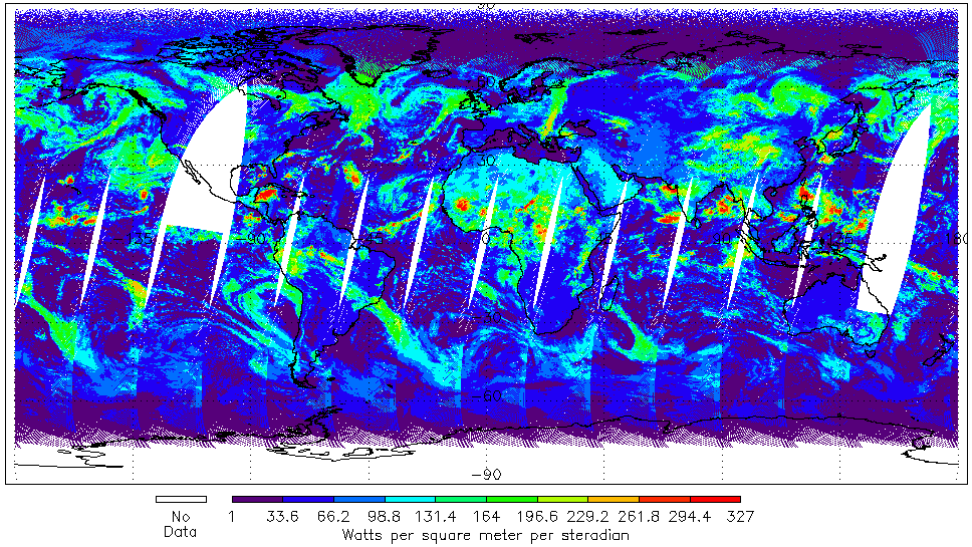

8 21 2017 1715Z
VISIBLE 8 km
NOAA
HTTP://WWW.GOES.NOAA.GOV


8 21 2017 1745Z
VISIBLE 8 km
NOAA
HTTP://WWW.GOES.NOAA.GOV

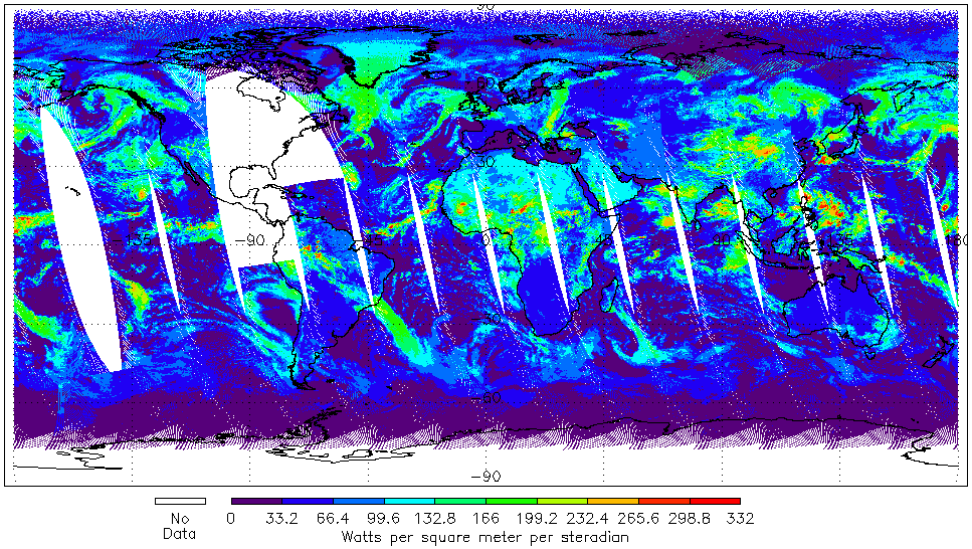

8 21 2017 1815Z
VISIBLE 8 km
NOAA
HTTP://WWW.GOES.NOAA.GOV


8 21 2017 1845Z
VISIBLE 8 km
NOAA
HTTP://WWW.GOES.NOAA.GOV

Total Solar August 21, 2017



Terra



Aqua