Status of the Edition 4 Surface-Only Flux Algorithms (First Look at the Edition 4β-1 data)

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Background (Page 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

References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.

SW B: Darnell et al. (1992): *J Geophys. Res.*, **97**, 15741-15760.

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.

Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.
- LW Models A & B as well as 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 TRMM.
- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010), and can be used to provide independent verification of the SARB results.
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C will be introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.

Recent 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 transmission formula using 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 4A
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clearr-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 3A
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

Recent 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 transmission formula using the new Edition 4 clouds.

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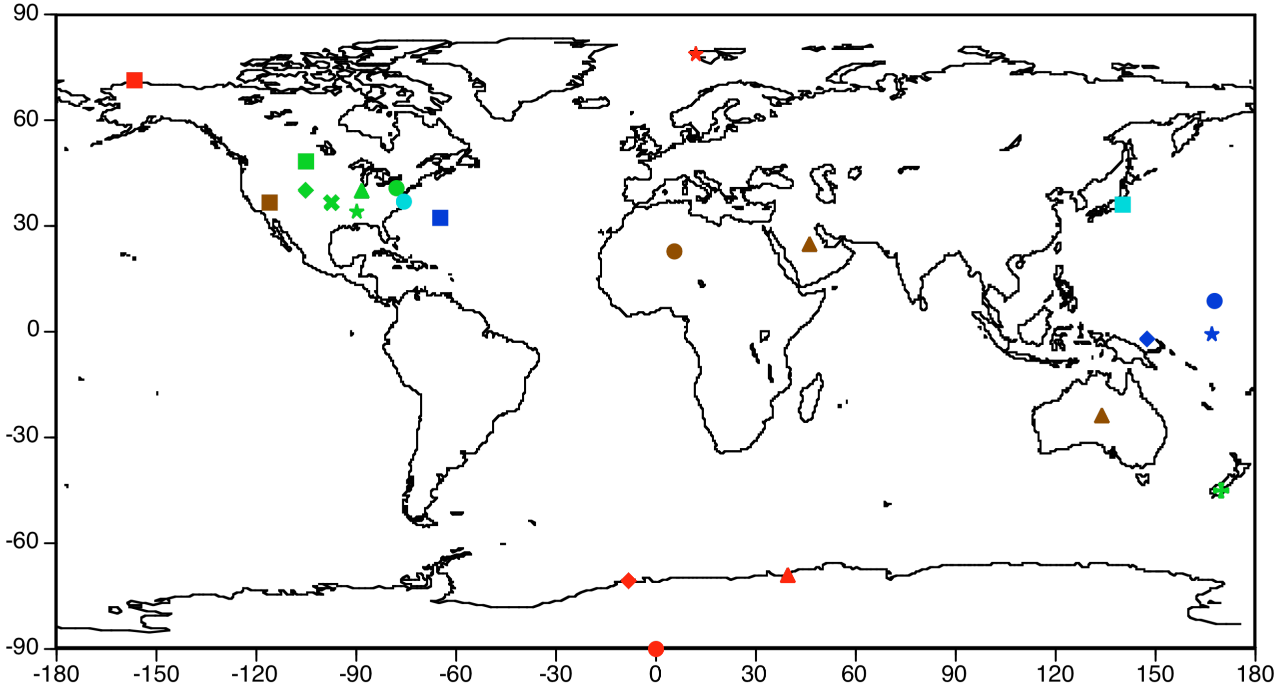
SW and LW Model Improvements: 1) The availability of ocean buoy measurements is expected to allow for improved surface flux retrievals by providing validation over ocean regions.

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

Dataset	CERES 3A	CERES Terra 4A
Clear-Sky TOA albedo Terra	70 month Terra	70 month Terra
Clearr-Sky TOA albedo Aqua	70 month Terra	70 month Terra
Clear-Sky Surf. albedo	70 month Terra	70 month Terra
TOA to Surface albedo transfer	Monthly average	Monthly average
Spec. Corr. Coef.	CERES 3A	CERES 3A
Cos (sza) dependence of Surface Flux	Briegleb-type	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 800 DU	0 to 800 DU
Twilight cutoff	New	New
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	Maximum Lapse Rate 10K/100hPa	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	Polar regions and ps < 700 mb excluded	Maximum Inversion Strength -10K/100hPa

Surface Sites Available for Validation of Ed 4β-1

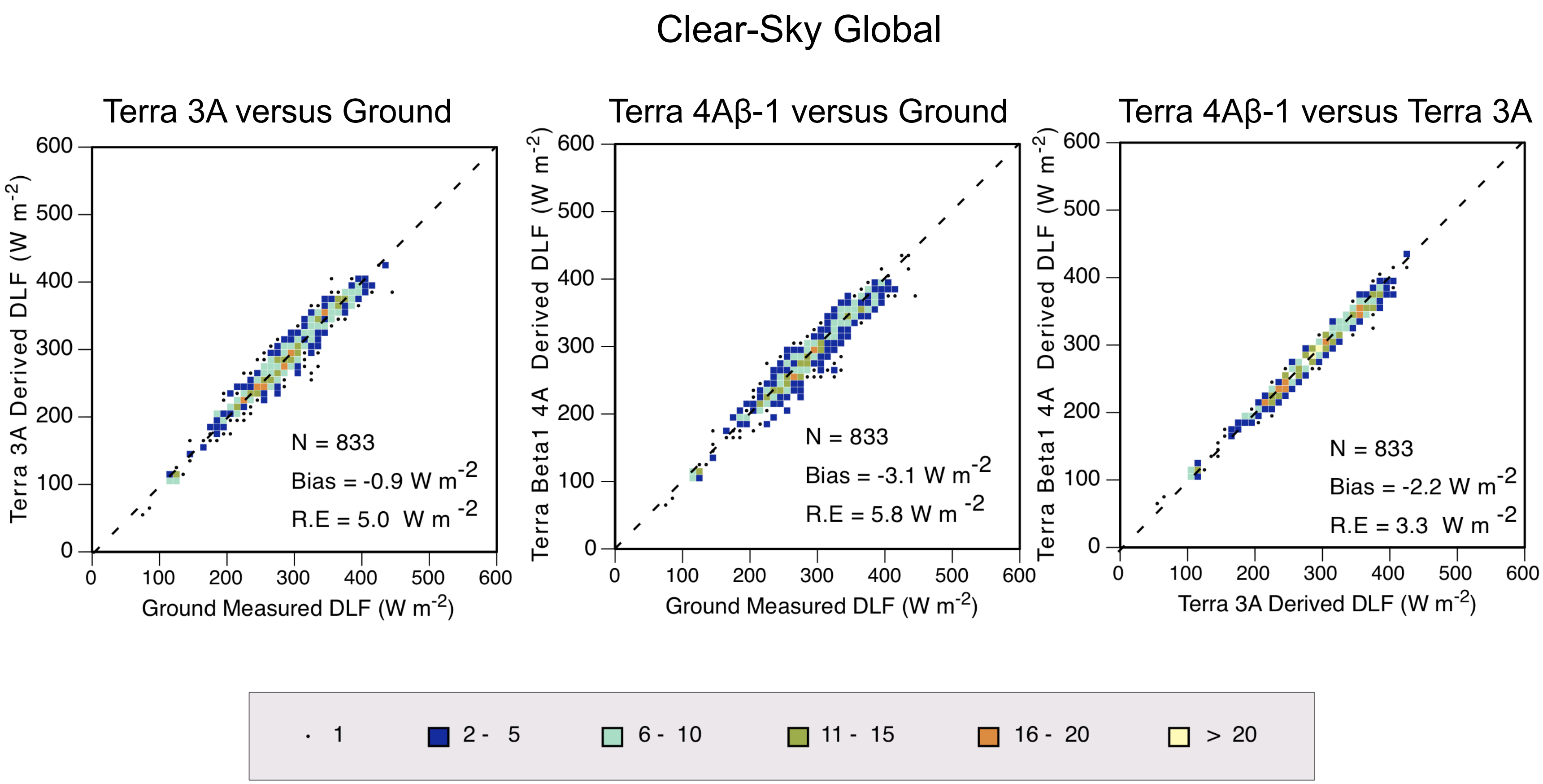


March 2000
through
February 2001

48.31N, 105.10W Fort Peck, MT	45.03S, 169.7E New Zealand	36.9N, 75.71W Ches Light	78.9N, 11.95E Ny Alesund
40.72N, 77.93W Penn State, PA	32.30N, 64.77W Bermuda	71.32N, 156.61W Barrow, AK	23.70S, 133.87E Alice Springs
40.05N, 88.37W Bondville, IL	8.72N, 167.72E Kwajalein	90.00S, 0.00 South Pole	36.63N, 116.02W Desert Rock, NV
40.13N, 105.24W Boulder, CO	2.06S, 147.42 E Manus	69.00S, 39.58E Syowa	22.78N, 5.52E Algeria
34.25N, 89.87W Goodwin Creek, MS	0.52S, 166.9 E, Nauru	70.65S, 8.25W Georg von Neumayer	24.91N, 46.41E Saudi Solar Village
36.60N, 97.48W SGP ARM	36.05N, 140.13E Tatano		

Comparison between CERES Terra Editions 4Aβ-1 and 3A

LW Model A code changes between Editions 3A and 4Aβ-1, which include constraint methods that limit lapse rates and inversions to 10K/100hPa.



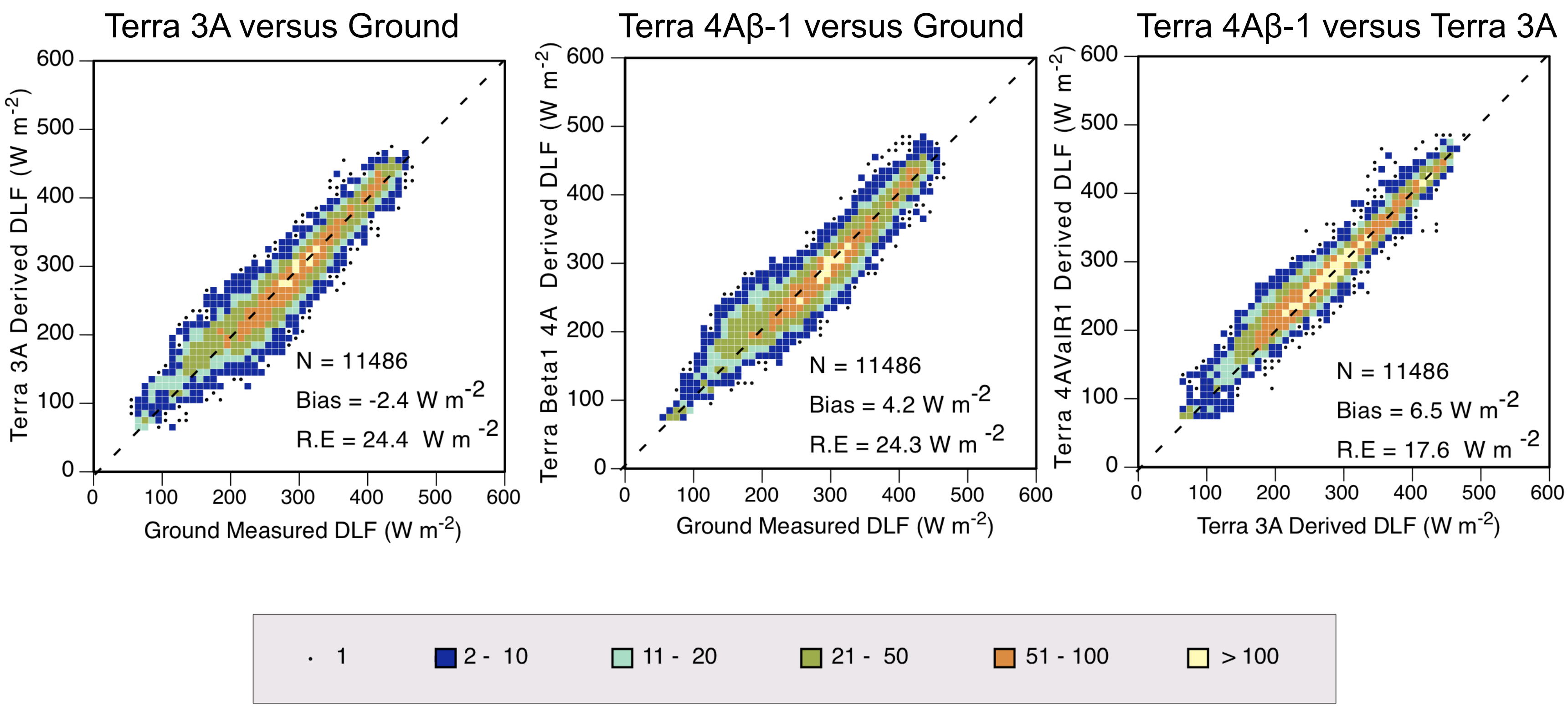
March 2000 through February 2001

Includes input differences

Comparison between CERES Terra Editions 4Aβ-1 and 3A

LW Model B code changes between Editions 3A and 4Aβ-1, which include constraint methods that limit lapse rates and inversions to 10K/100hPa.

All-Sky Global



March 2000 through February 2001

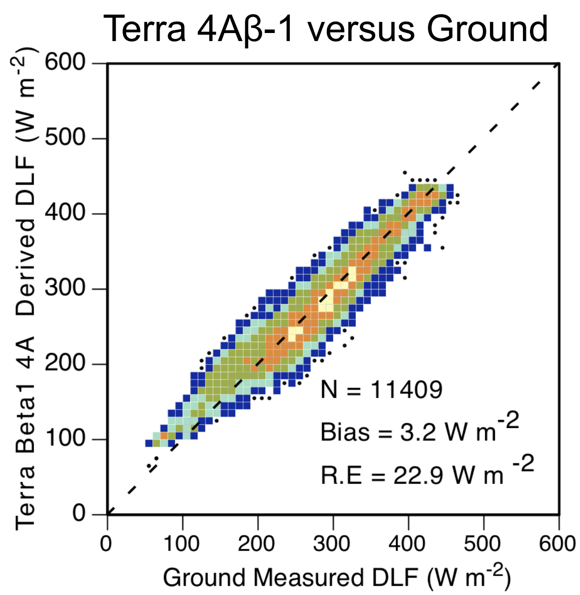
Includes input differences

Climate Science Branch, NASA Langley Research Center

Comparison between CERES Terra Editions 4Aβ-1 and 3A

LW Model C code changes between Editions 3A and 4Aβ-1, which include constraint methods that limit lapse rates and inversions to 10K/100hPa.

All-Sky Global



· 1 | 2 - 10 | 11 - 20 | 21 - 50 | 51 - 100 | > 100

March 2000 through February 2001

Includes input differences

Results of Recent 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, see Gupta et al. (2010).

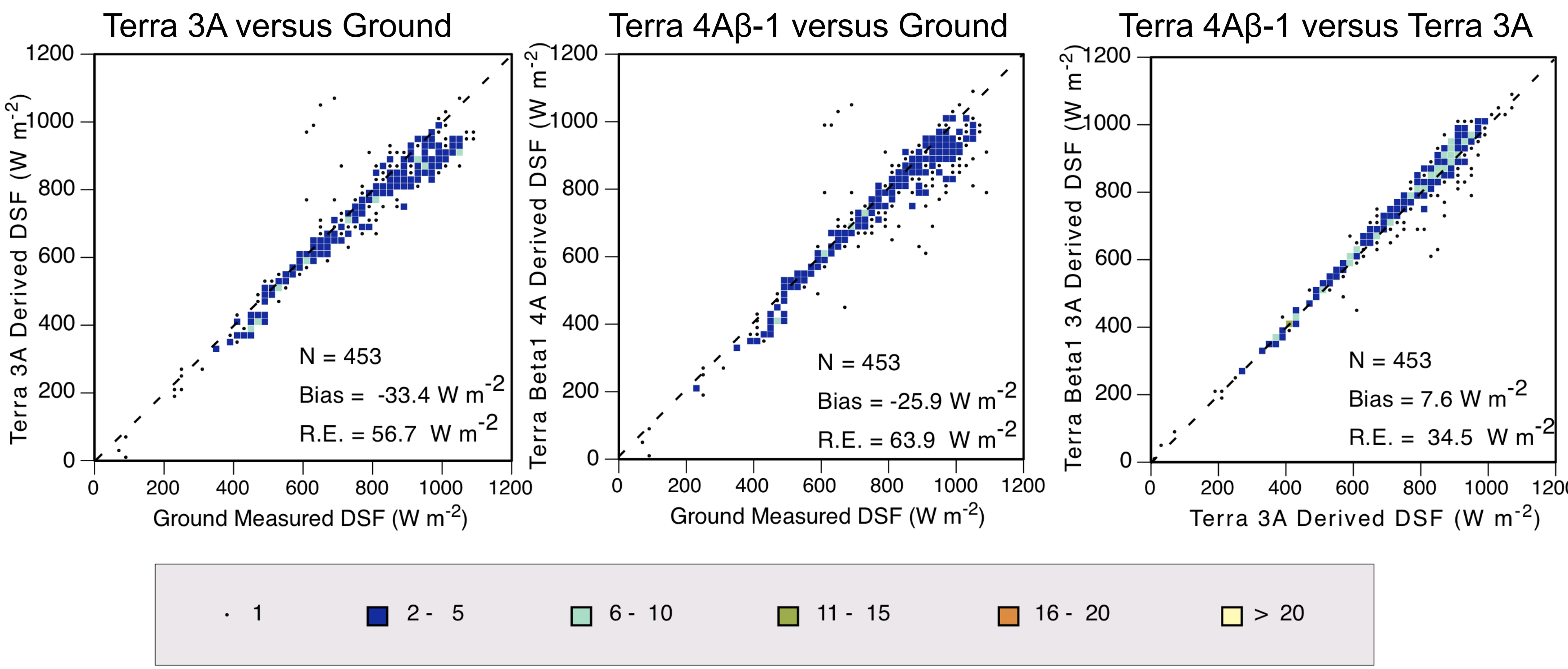
For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10K / 100hPa for the downward flux calculations provides the best results for all conditions.

Edition 4β-1 inputs into the LW model are providing the expected results.

Comparison between CERES Terra Editions 4Aβ-1 and 3A

SW Model A code changes between Editions 3A and 4Aβ-1, which includes the 550nm MATCH aerosol optical depths for Ed 4Aβ-1.

Clear-Sky Global



March 2000 through February 2001

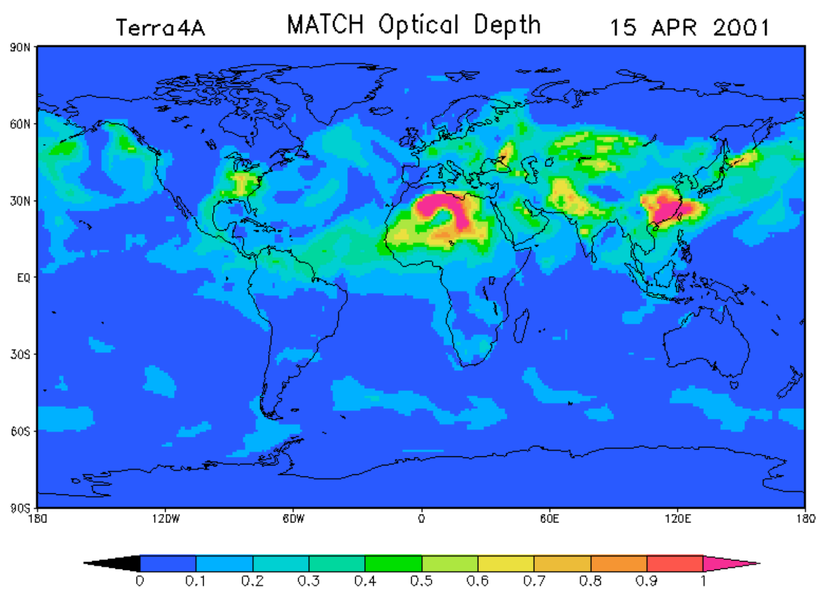
Includes input differences

Climate Science Branch, NASA Langley Research Center

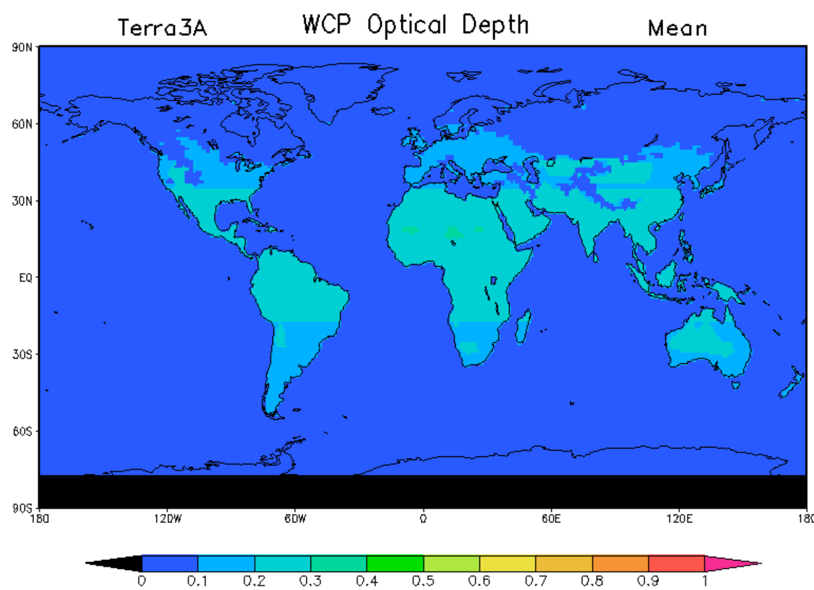
Comparison of monthly averaged aerosol optical depths used in CERES Editions 4Aβ and 3A for the SW surface fluxes for Terra data in April 15, 2001.

(Change to MATCH daily aerosols causes dominant impact)

Terra 4Aβ MATCH April 15 Aerosols

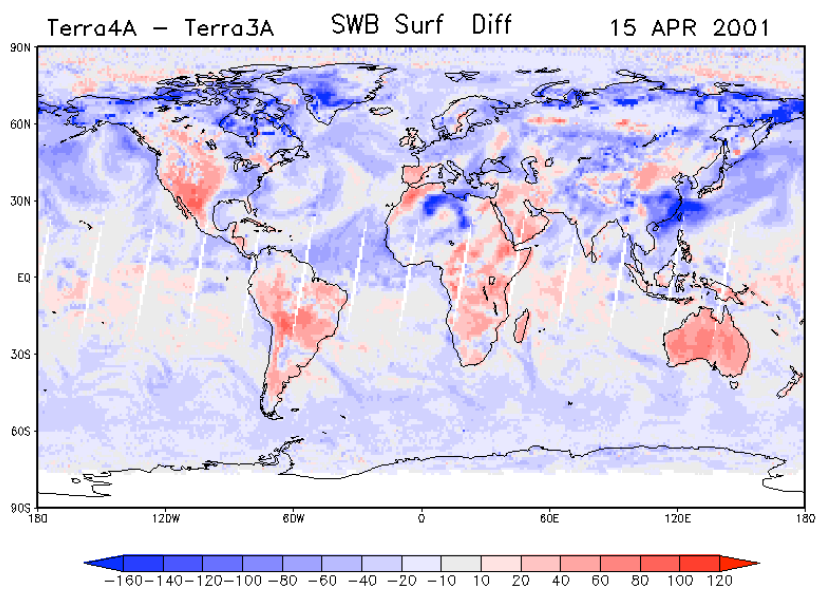


Terra 3A (WCP-55 Aerosols)



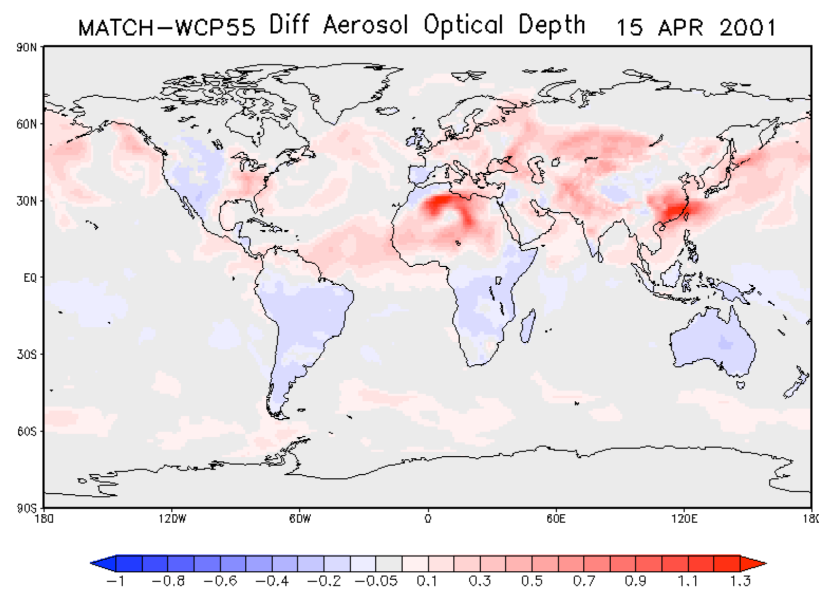
Comparison of the CERES Editions 4Aβ and 3A differences in the daytime downward SW surface fluxes with the corresponding differences in the aerosol optical depths for Terra data for April 15, 2001.

Terra 4Aβ - 3A SW Surface Flux Difference



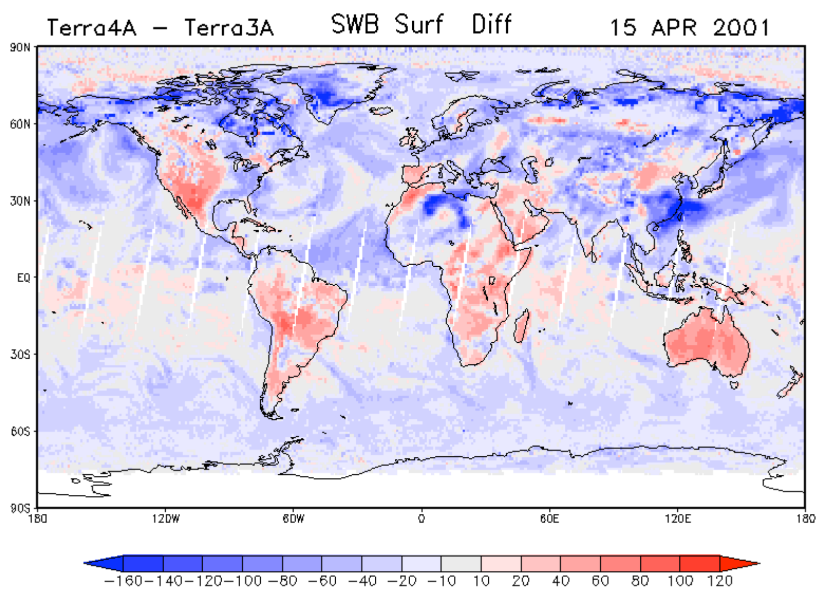
W/m2

Terra 4Aβ (MATCH) - 3A (WCP-55)



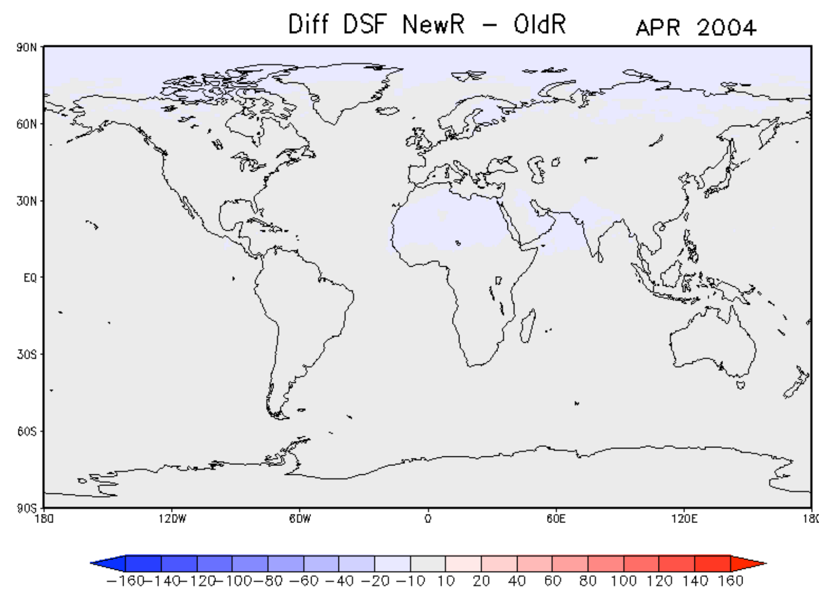
Comparison of the CERES Editions 4Aβ and 3A differences in the daytime downward SW surface fluxes with the corresponding differences in the Rayleigh formula for Terra data for Apr. 15, 2001. (Revision in Rayleigh formula has persistent but modest impact.)

Terra 4Aβ - 3A SW Surface Flux Difference



W/m²

Terra 4Aβ - 3A Rayleigh Formula

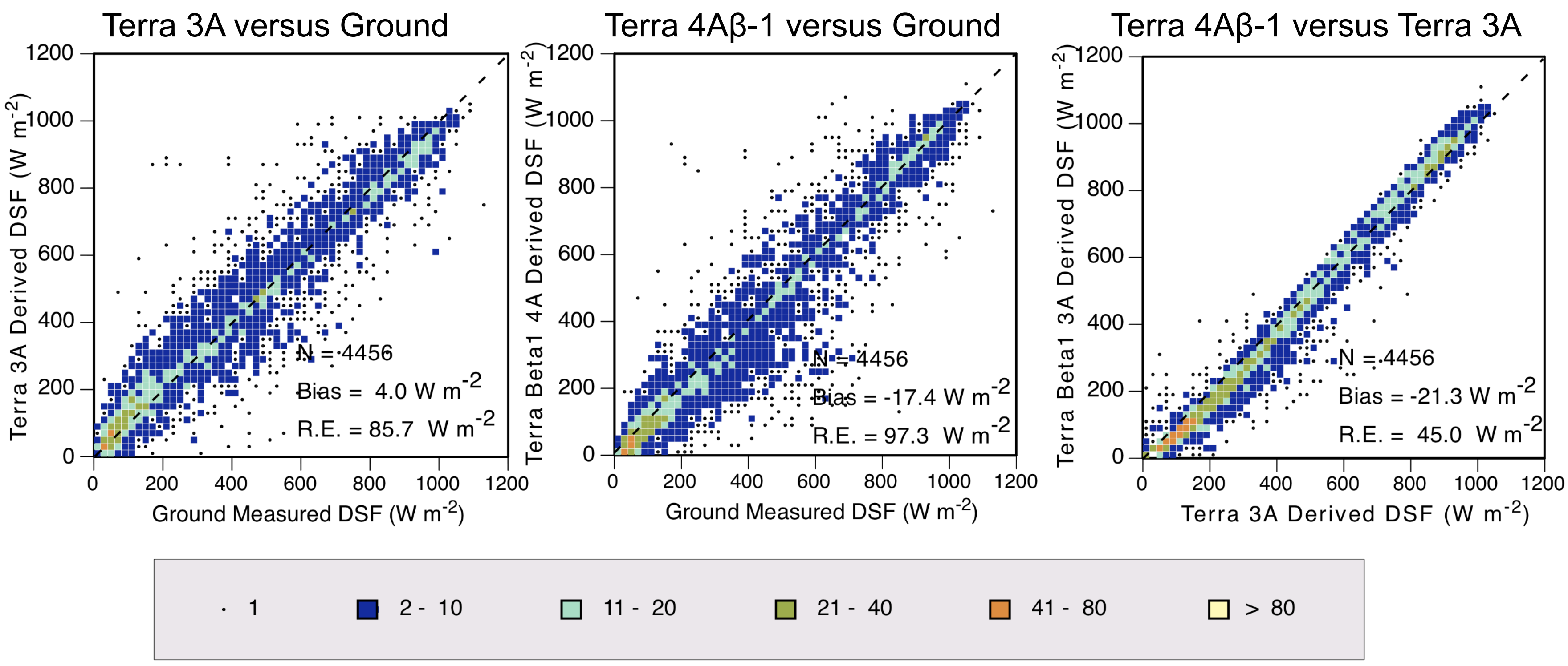


W/m²

Comparison between CERES Terra Editions 4Aβ-1 and 3A

SW Model B code changes between Editions 3A and 4Aβ-1 include the revised Rayleigh scattering formula and MATCH aerosol optical depths.

All-Sky Global



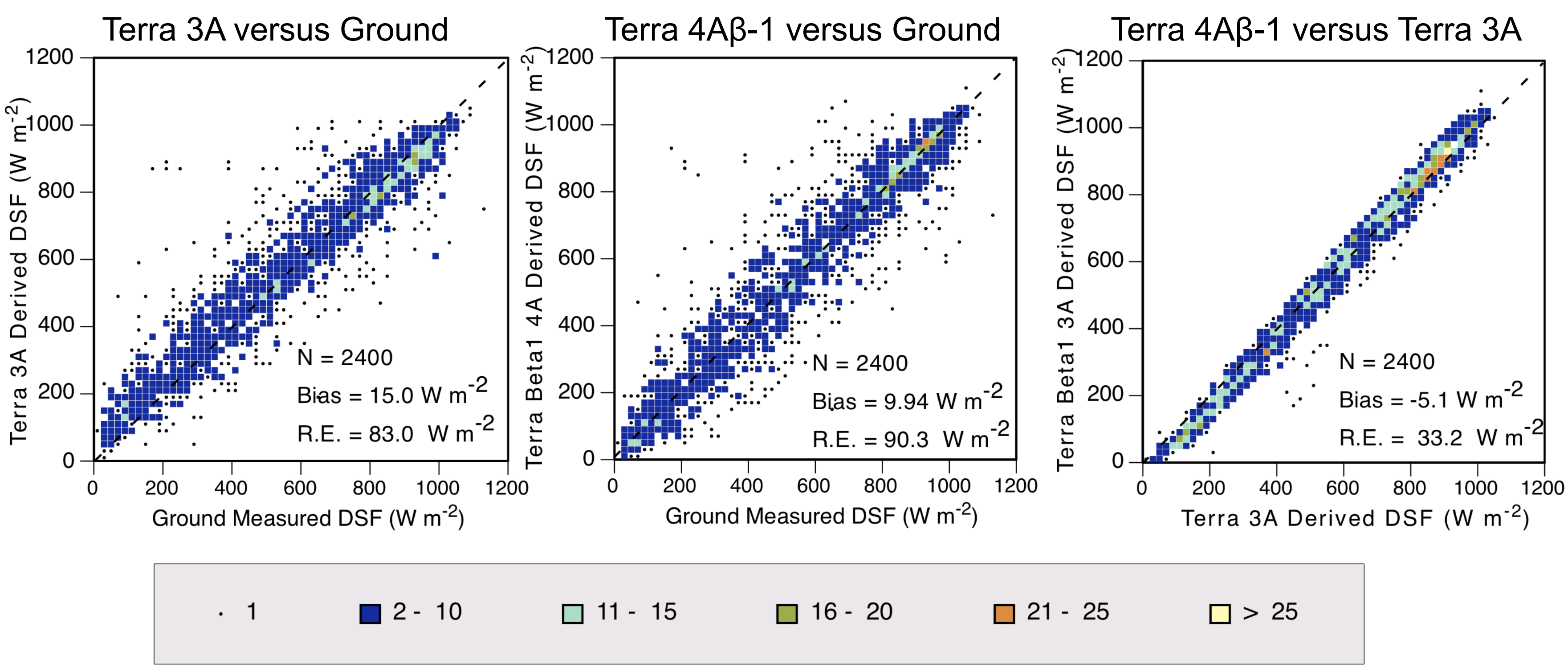
March 2000 through February 2001

Includes input differences

Comparison between CERES Terra Editions 4Aβ-1 and 3A

SW Model B code changes between Editions 3A and 4Aβ-1 include the revised Rayleigh scattering formula and MATCH aerosol optical depths.

All-Sky Global (Non-Polar)



March 2000 through February 2001

Includes input differences

Results of Recent SW Model Improvements and Course of Action for the Future

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 show some improvement gained by revising the a_0 coefficient but strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on the formulae used for the cloud transmittance and the overcast albedo.

Conclusions for SOFA Ed4β-1 algorithms

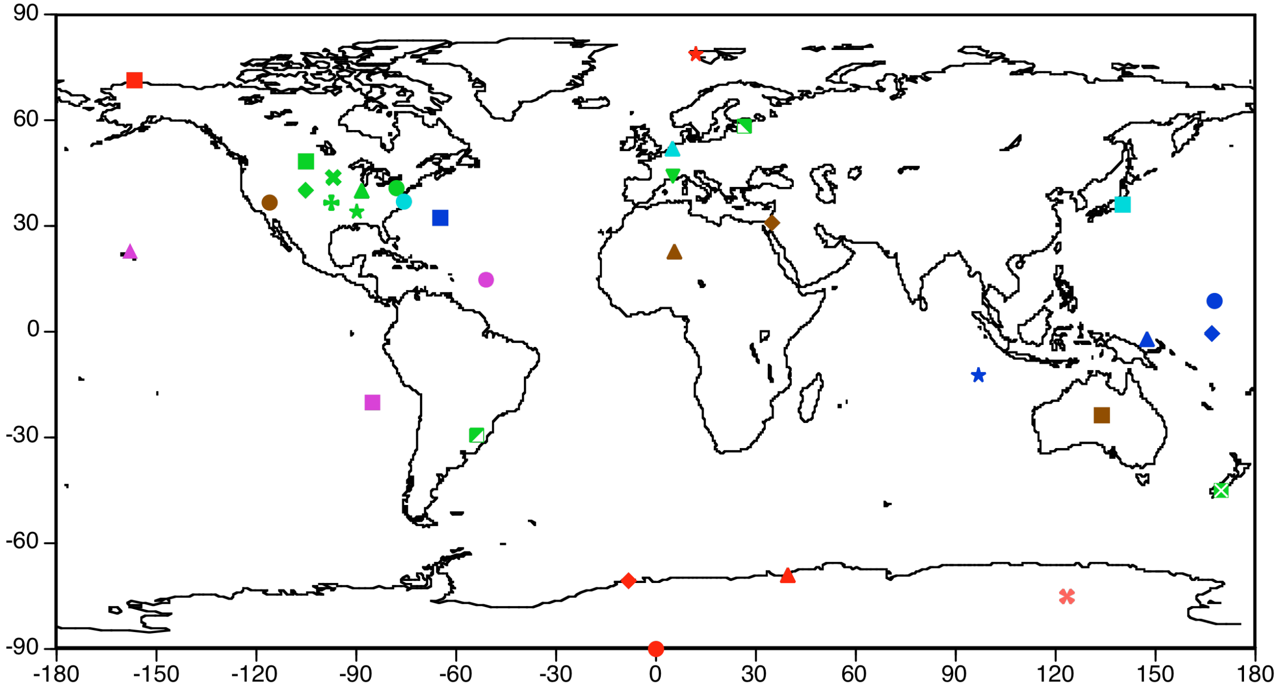
Validation studies have shown that revisions to both the LW and SW algorithms appear to be working well, though further revisions to the cloud transmission formula and/or overcast albedo method appear to be needed for SW Model B.

A preliminary analysis of the LW and SW surface only flux algorithm results using the Edition 4Aβ-1 inputs, especially those from the Clouds Subsystem, indicate improved accuracies for most locations.

FLASHFlux: Fast Longwave and Shortwave Radiative Fluxes

- Purpose: Provide CERES-based TOA and surface fluxes on a near real-time basis for programs requiring immediate access to results.
- Scientific (Field Experiments and Earth Observatory Applications), Educational (S'COOL) and Commercial Applications (Solar Energy, Agricultural and Construction).
- Capture variability of CERES fluxes to extrapolate CERES record.
- Rapid CERES processing stream: Produce CERES-like fluxes within 1 week of satellite observations.
- Uses calibration coefficients from existing CERES results rather than waiting for the updated calibration.
- Processes cross-track scanner data from both Terra and Aqua.

Surface Sites Available for Validation of FLASH



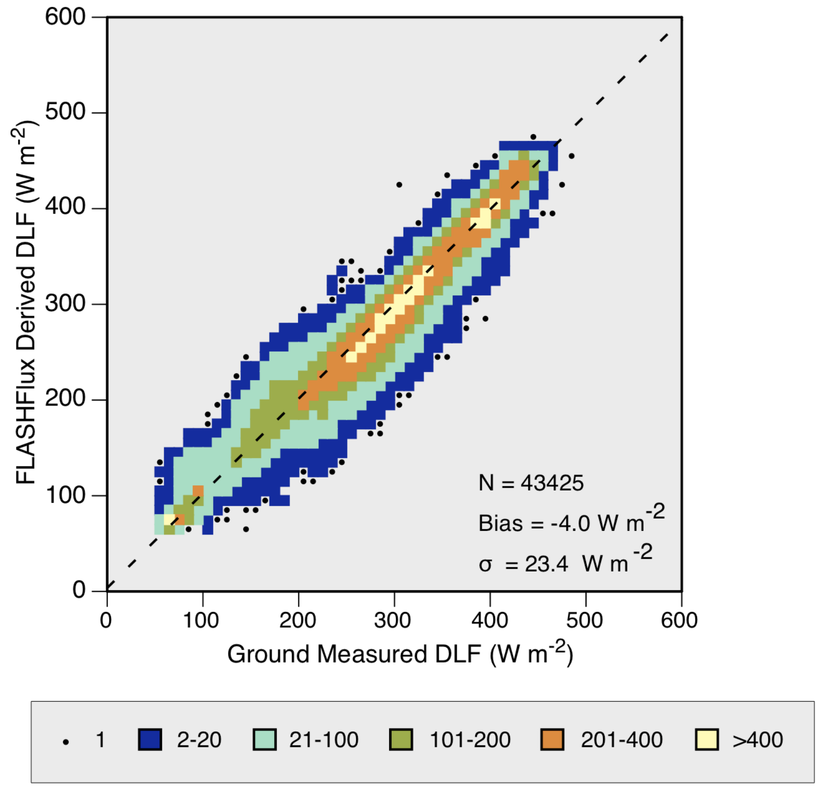
January 2009
through
December 2010

48.31N, 105.10W Fort Peck, MT	44 N, 5.1E Carpentras, FR	36.05N, 140.13E Tatano	75S 123E Dome Station
40.72N, 77.93W Penn State, PA	29.4S, 53.8W Brazil	36.9N, 75.71W Ches Light	23.70S, 133.87E Alice Springs
40.05N, 88.37W Bondville, IL	58.3N, 26.5E Toravere, Estonia	51.97N, 4.9E Cabauw, Netherlands	36.63N, 116.02W Desert Rock, NV
40.13N, 105.24W Boulder, CO	32.30N, 64.77W Bermuda	71.32N, 156.61W Barrow, AK	22.78N, 5.52E Algeria
34.25N, 89.87W Goodwin Creek, MS	8.72N, 167.72E Kwajalein	90.00S, 0.00 South Pole	30.9N , 34.8E Sede Boger, Israel
43.73N, 96.92W Sioux Falls, SD	2.06S, 147.42 E Manus	69.00S, 39.58E Syowa	20.2S, 85.2W WHOI Stratus
36.60N, 97.48W SGP ARM	0.52S, 166.9 E, Nauru	70.65S, 8.25W Georg von Neumayer	14.5N, 51W WHOI NTAS
45.03S, 169.7E New Zealand	12S 97E Cocos Isl	78.9N, 11.95E Ny Alesund	22.8N, 157.9W WHOI Hawaii

Climate Science Branch, NASA Langley Research Center

FLASHFlux SSF Validation

Comparison of Derived Downward Longwave Flux from Terra and Aqua data with measurements from Ground Sites from Jan 2009 - Dec 2010 (Kratz et al. 2013)



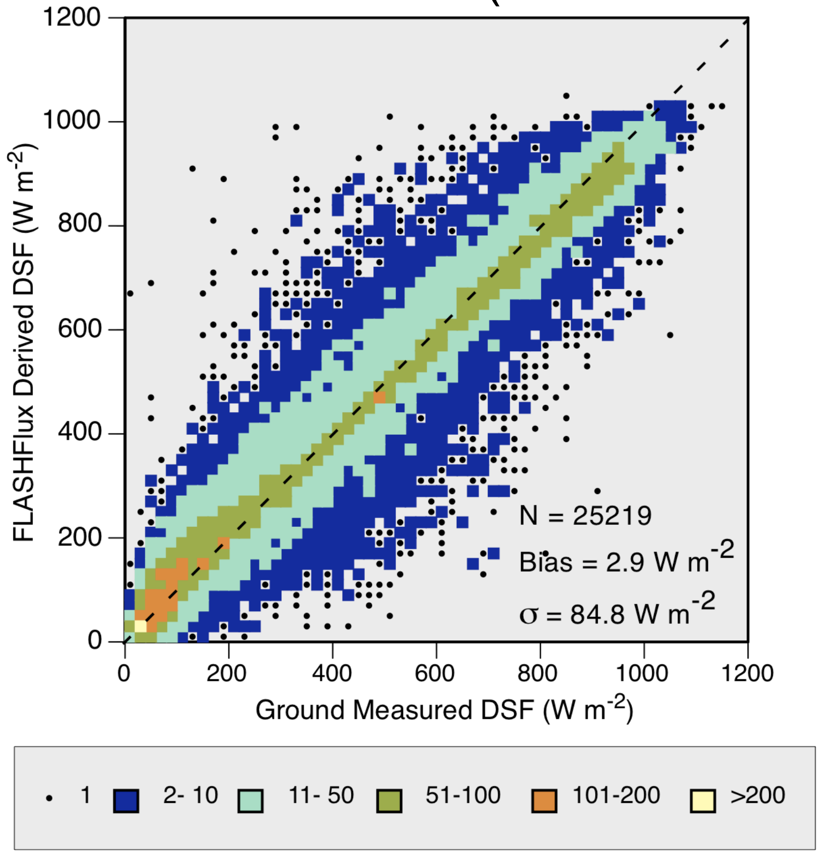
FLASHFlux SSF Validation

Comparison of Derived Downward Longwave Flux from Terra and Aqua data with measurements from Ground Sites by Surface Type

	FLASH		FLASH - Ground	
Surface Type	n	Mean	Bias	sigma
		Wm^{-2}	Wm^{-2} (%)	Wm^{-2} (%)
Island	4242	415.3	3.9 (0.9)	13.9 (3.4)
Coast	4426	332.6	-3.7 (-1.2)	17.7 (5.2)
Polar	23799	207.0	-2.0 (-1.0)	24.8 (11.9)
Continental	13757	302.0	-9.4 (-3.0)	22.4 (7.2)
Desert	5406	325.4	-4.5 (-1.4)	16.9 (5.1)
Ocean Buoy	2989	383.2	-5.3 (-1.4)	16.4 (4.2)
All	54619	278.6	-4.0 (-1.4)	23.4 (8.3)

FLASHFlux SSF Validation

Comparison of Derived Downward Shortwave Flux from Terra and Aqua data with measurements from Ground Sites from Jan 2009 - Dec 2010 (Kratz et al. 2013)



FLASHFlux SSF Validation

Comparison of Derived Downward Shortwave Flux from Terra and Aqua data with measurements from Ground Sites by Surface Type

	FLASH		FLASH - Ground	
Surface Type	n	Mean	Bias	sigma
		Wm^{-2}	Wm^{-2} (%)	Wm^{-2} (%)
Island	2198	700.0	39.8 (6.0)	99.2 (15.0)
Coast	2173	503.1	21.1 (4.4)	64.7 (13.4)
Polar	10029	246.6	-9.9 (-3.9)	73.4 (28.6)
Continental	6899	508.33	4.0 (0.8)	78.9 (15.6)
Desert	2742	740.6	-14.7 (-2.0)	68.8 (9.1)
Ocean Buoy	1178	732.3	43.8 (6.4)	97.2 (14.1)
All	25219	456.2	2.9 (0.6)	84.8 (18.7)

CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word “CERES” in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (http://ceres.larc.nasa.gov/docs.php).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at (anne.c.wilber@nasa.gov).

CERES Journal Publication Citation Values (10/1/2012)

Year	All References[1]	Journal Articles[2]	Citation[3] (c1)	Citation[4] (c2)	Citation[5] (c3)
2012	39	24	10	906	1953
2011	62	46	136	1539	3318
2010	65	61	255	1370	2839
2009	48	47	701	1119	2413
2008	62	61	704	957	2063
2007	39	31	359	806	1738
2006	44	40	1228	592	1276
2005	49	47	1484	531	1145
2004	39	39	1139	409	882
2003	51	48	1551	380	819
2002	78	69	4496	353	761
2001	50	44	2054	202	436
2000	34	32	1095	218	470
1999	24	21	680	155	334
1998	20	20	3863	78	168
1997	9	9	280	44	95
1996	5	5	672	47	101
1995	1	1	17	13	28
1994	1	1	3	11	24
1993	6	6	36	0	0
Total	726	652	20863	9677	20863

Citation c1 = # of citations for papers published in that year.

Citation c2 = # of citations in ISI for papers published in all years using a specified set of categories.

Citation c3 = renormalized # of citations for papers published in all years so that the total number of citations in c3 = c1