Improvements in the Surface-Only Flux Algorithms (SOFA) Since the First CERES-II Science Team Meeting

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Ninth CERES-II Science Team Meeting

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Background

- 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

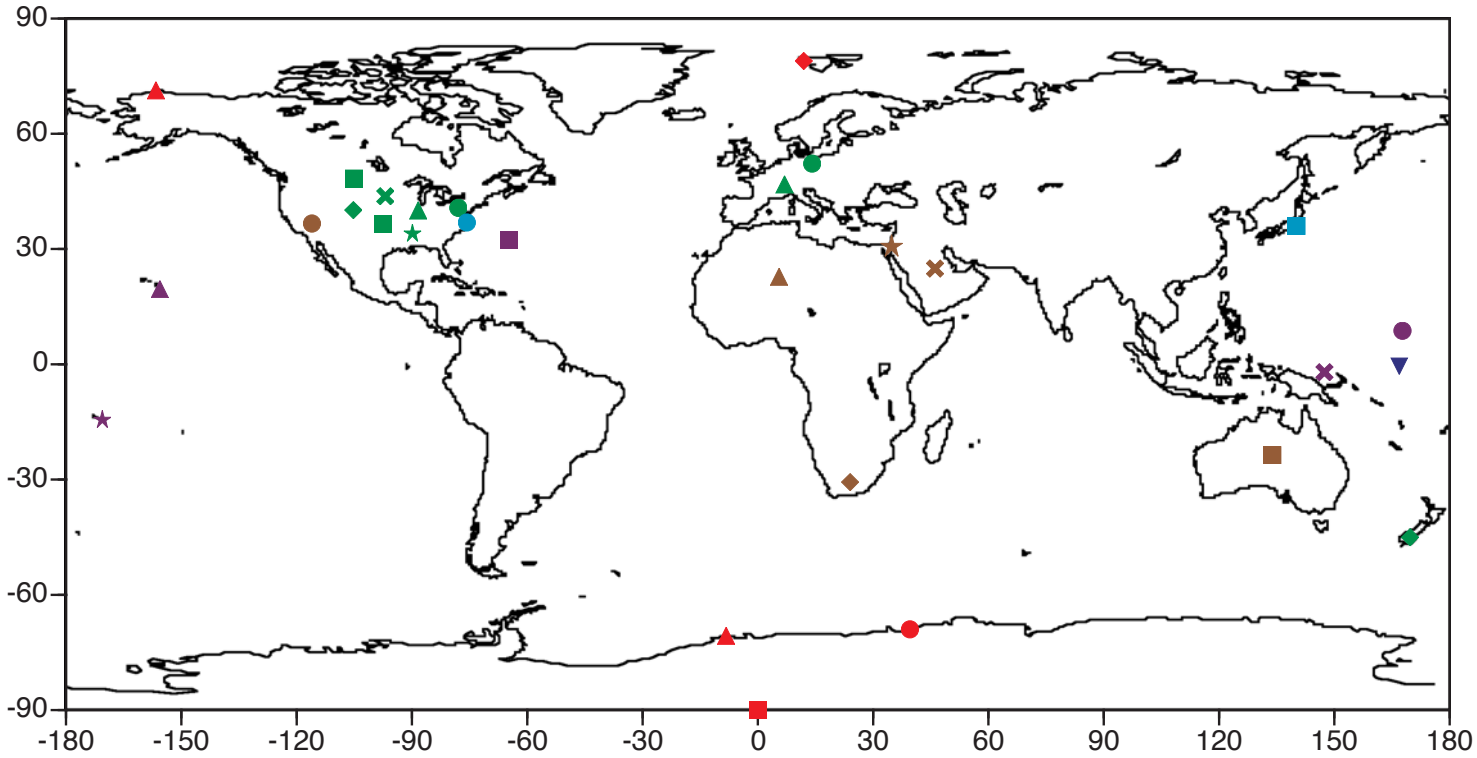
		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

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 and Cess (2001): *J. Geophys. Res.,* **106**, 12477-12488.
Zhou et al. (2007): *J. Geophys. Res.*, **112**, D15102.

Background (contd.)

- The SOFA SW & LW Models use rapid parameterizations to calculate the transfer of energy from TOA to surface.
- The SOFA calculated surface fluxes have undergone extensive validation and act as an independent verification of the SARB results.
- SW Model A and LW Models A & B 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.
- LW Model C to be introduced in Edition-3 processing to maintain two independent LW algorithms should the CERES Window Channel be replaced in future versions of the CERES instrument.



- 48.31N, 105.10W Fort Peck, MT
- 40.72N, 77.93W Penn State, PA
- 40.05N, 88.37W Bondville, IL
- 40.13N, 105.24W Boulder, CO
- 34.25N, 89.87W Goodwin Creek, MS
- 43.73N, 96.92W Sioux Falls, SD
- 36.60N, 97.48W SGP ARM
- 52.22N, 14.12E Lindenberg
- 46.82N, 6.95E Payerne
- 45.03S, 169.7E New Zealand
- 32.30N, 64.77W Bermuda
- 8.72N, 167.72E Kwajalein
- 19.54N, 155.58W Mauna Loa, HI
- 14.23S, 170.56W American Samoa
- 2.06S, 147.42 E Manus
- 0.52S, 166.9 E, Nauru
- 36.05N, 140.13E Tatano
- 36.9N, 75.71W COVE
- 71.32N, 156.61W Barrow, AK
- 90.00S, 0.00 South Pole
- 69.00S, 39.58E Syowa
- 70.65S, 8.25W Georg von Neumayer
- 78.9N, 11.95E Ny Alesund
- 24.91N, 46.41E Saudi Solar Village
- 23.70S, 133.87E Alice Springs
- 36.63N, 116.02W Desert Rock, NV
- 22.78N, 5.52E Algeria
- 30.67S, 24.0E De Aar
- 30.9N , 34.8E, Sede Boger, Israel

SW Algorithm Improvements

- SW Model A: Replaced GFDL aerosol optical depths with 550nm MATCH aerosol optical depths (Aqua Edition 2A).
- SW Model B: Replaced monthly climatological clear-sky TOA albedo maps based on ERBE data with corresponding albedo maps based on 46 months of Terra data (Aqua Edition 2A).
- SW Model B: Corrected a code limitation that prevented flux calculation for O_3 column abundances exceeding 500 Dobson units (Edition 3).
- SW Model B: Modified formulation to provide a more realistic dependence of instantaneous surface albedo on cosine of the solar zenith angle (Edition 3).

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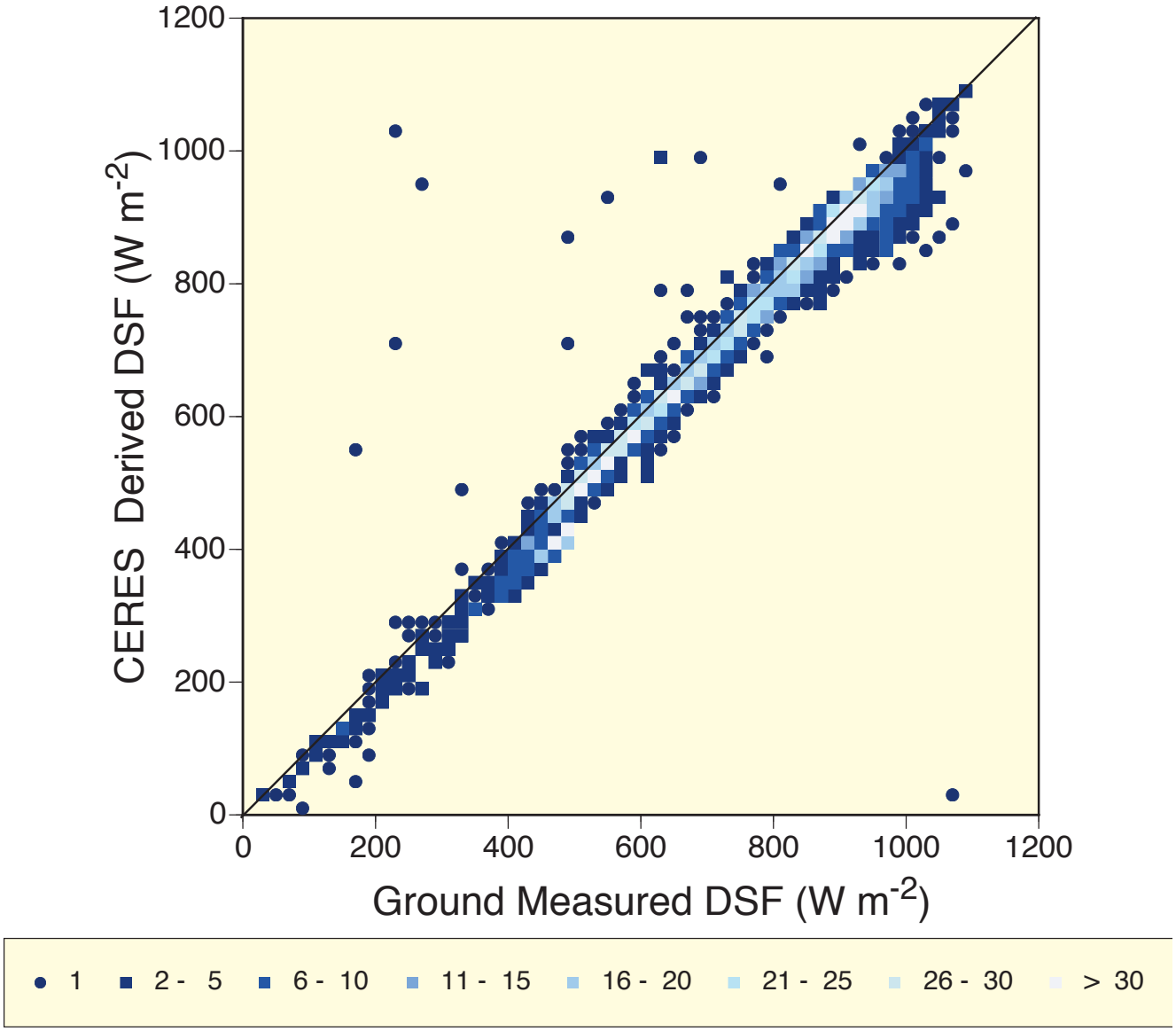
Shortwave Model A; Aqua 1B and Aqua 2B

Sites # of points		Aqua 1B	Aqua2B
Continental 896	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-10.2 (-1.5) 31.3 (4.6)	-12.1 (-1.8) 29.4 (4.3)
Coastal 99	Bias Wm^{-2} (%) σ Wm^{-2} (%)	6.8 (1.0) 35.3 (5.3)	1.3 (0.2) 31.5 (4.7)
Desert 519	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-25.8 (-3.2) 61.7 (7.6)	-27.9 (-3.5) 62.9 (7.8)
Island 32	Bias Wm^{-2} (%) σ Wm^{-2} (%)	37.3 (4.4) 71.6 (8.4)	45.2 (5.3) 69.3 (8.1)
Polar 288	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-51.6 (-12.0) 26.3 (6.1)	-46.5 (-10.9) 22.8 (5.3)
Global 1834	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-19.3 (-2.8) 49.8 (7.3)	-20.4 (-3.0) 48.9 (7.2)

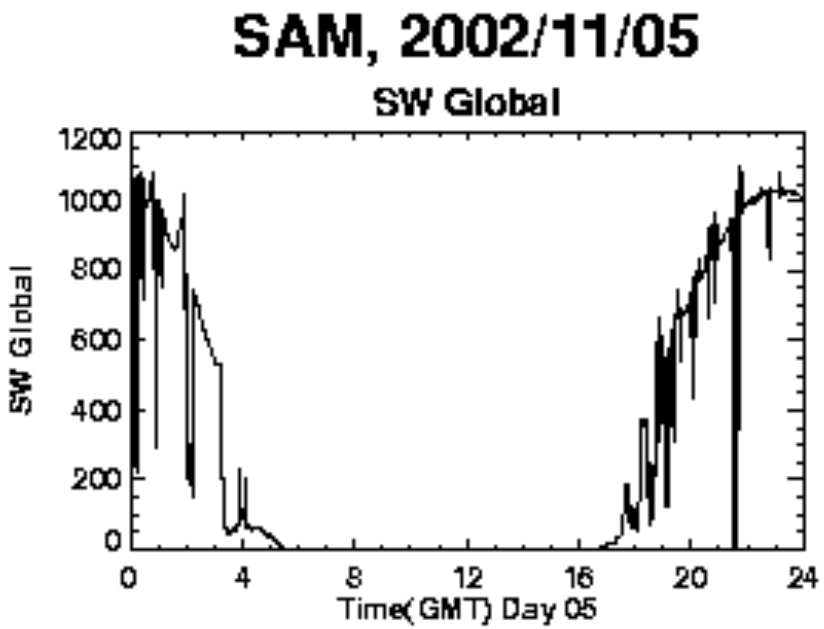
SW Model A Clear-Sky Comparisons, 1 minute data

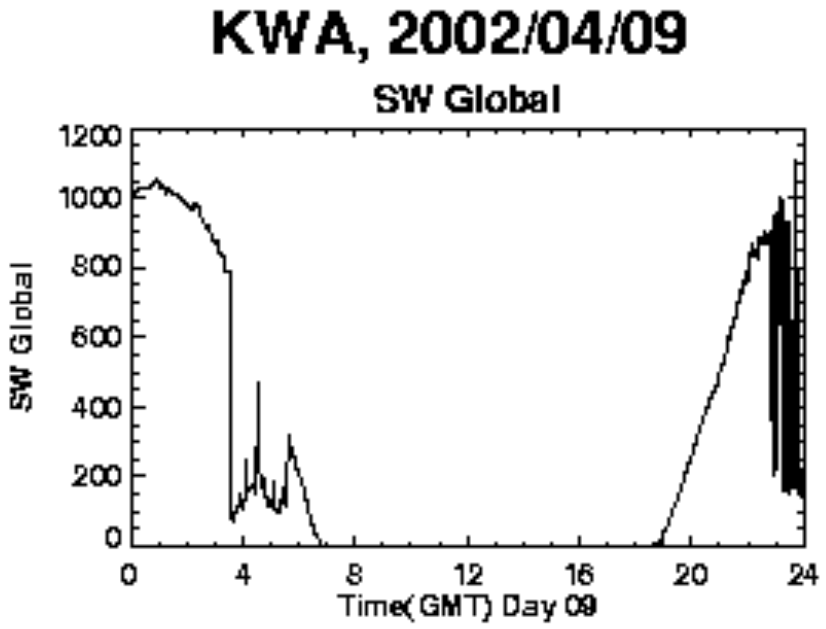


SW Model A Clear-Sky Comparisons, 1 minute data

Sites	# of Points	Mean Bias W/m^{-2} (%)	Random Error Wm^{-2} (%)
Continental	1345	-10.2 (-1.4)	32.4 (4.6)
Coastal	132	0.5 (0.1)	31.8 (4.6)
Desert	658	-27.5 (-3.4)	57.4 (7.1)
Island	43	43.2 (5.0)	69.6 (8.1)
Polar	338	-45.8 (-10.8)	23.3 (5.5)
Global	2516	-18.1 (-2.6)	46.9 (6.7)

Shortwave Measured at Islands





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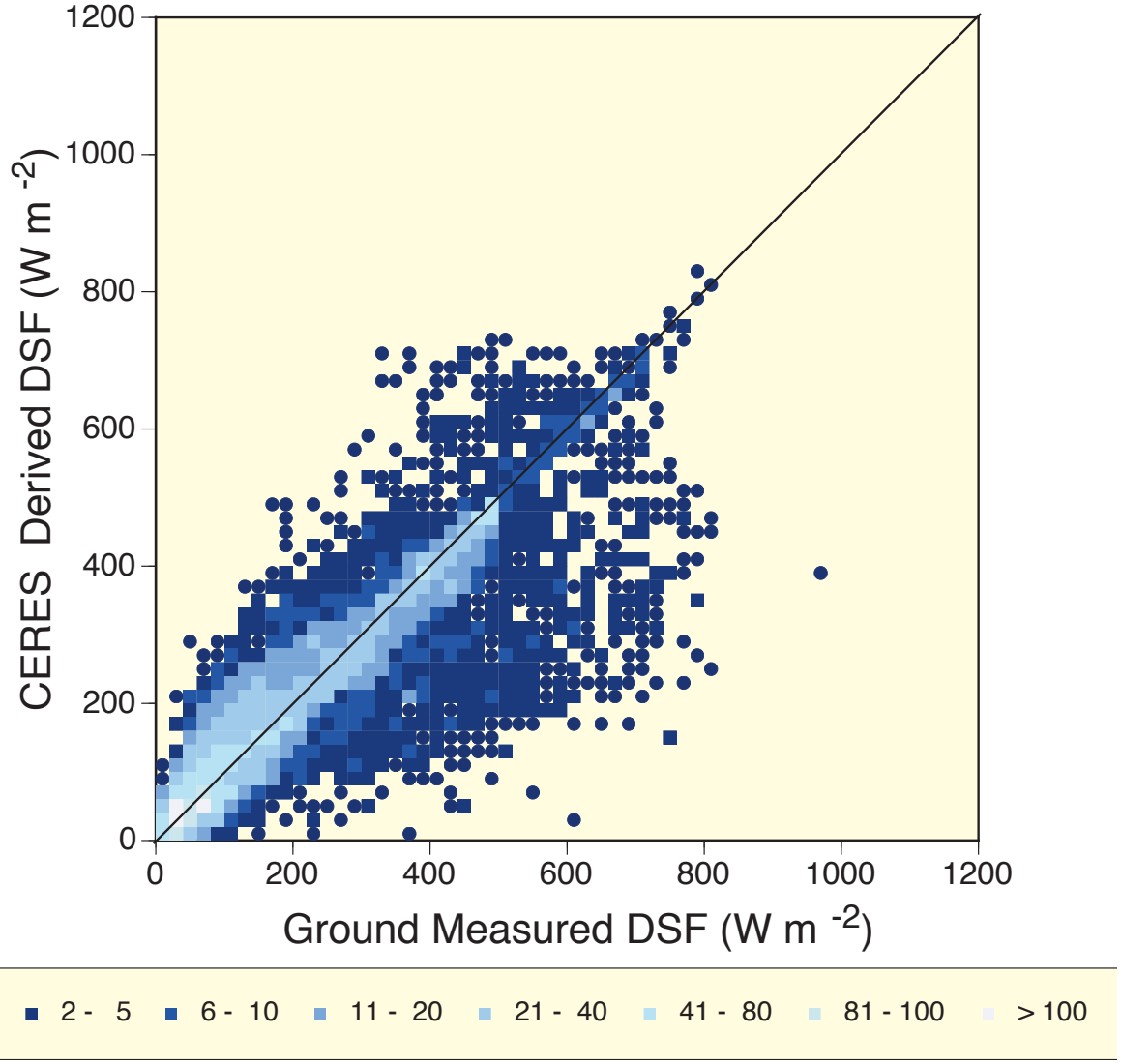
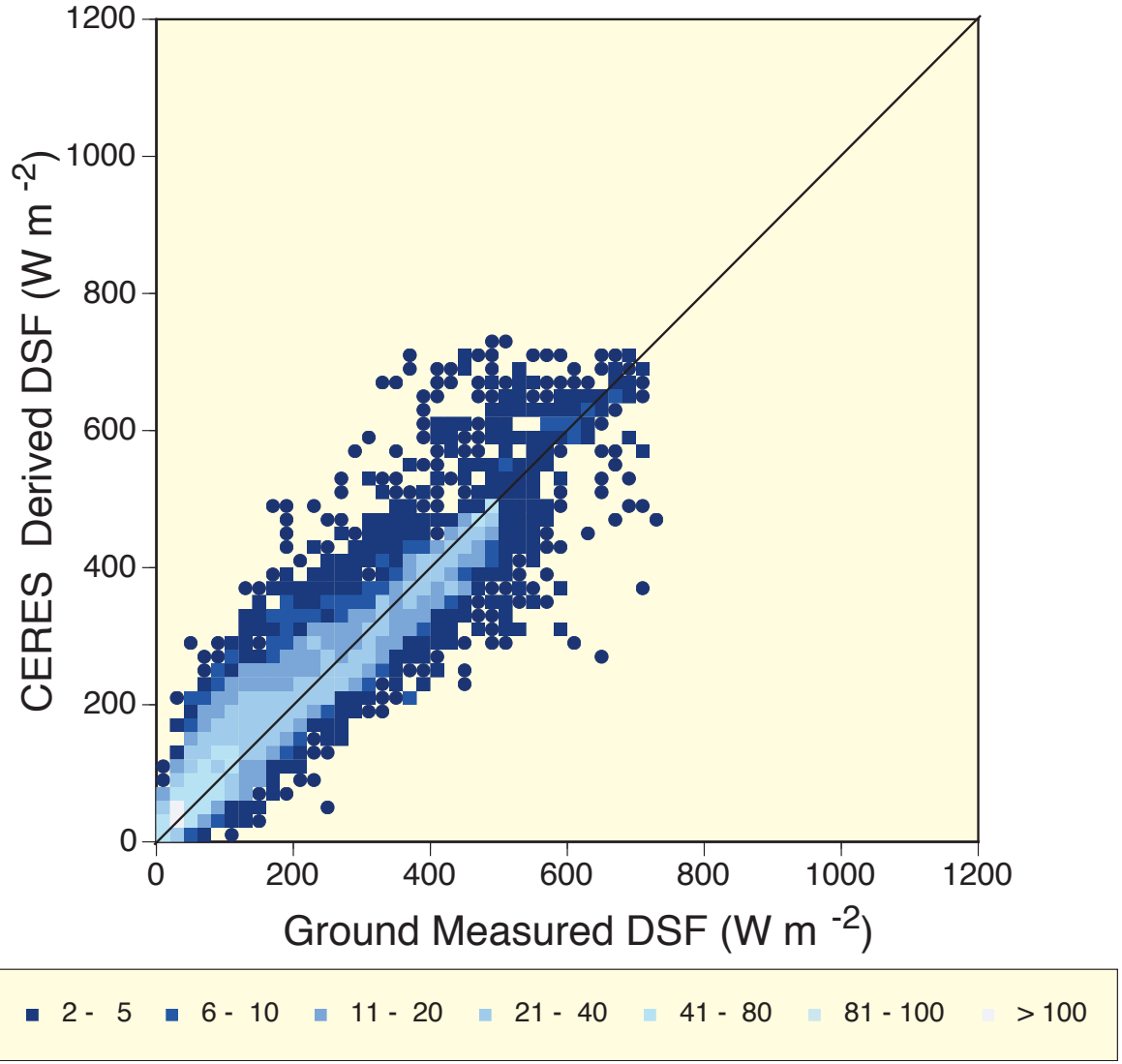
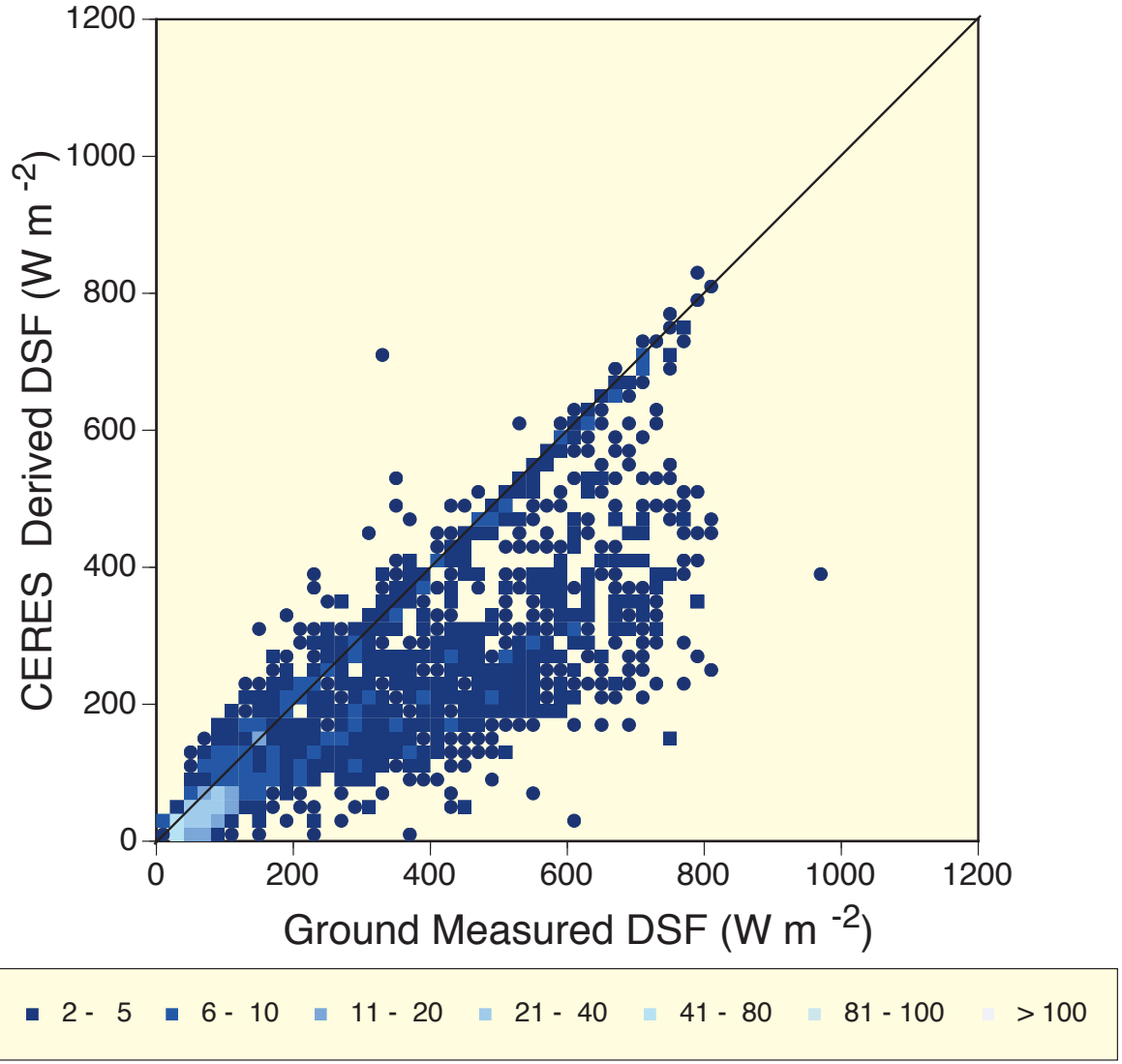
SWB All-sky Aqua 1B ERBE-derived TOA albedo Polar (BAR, SPL, NYA, GVN and SYO)



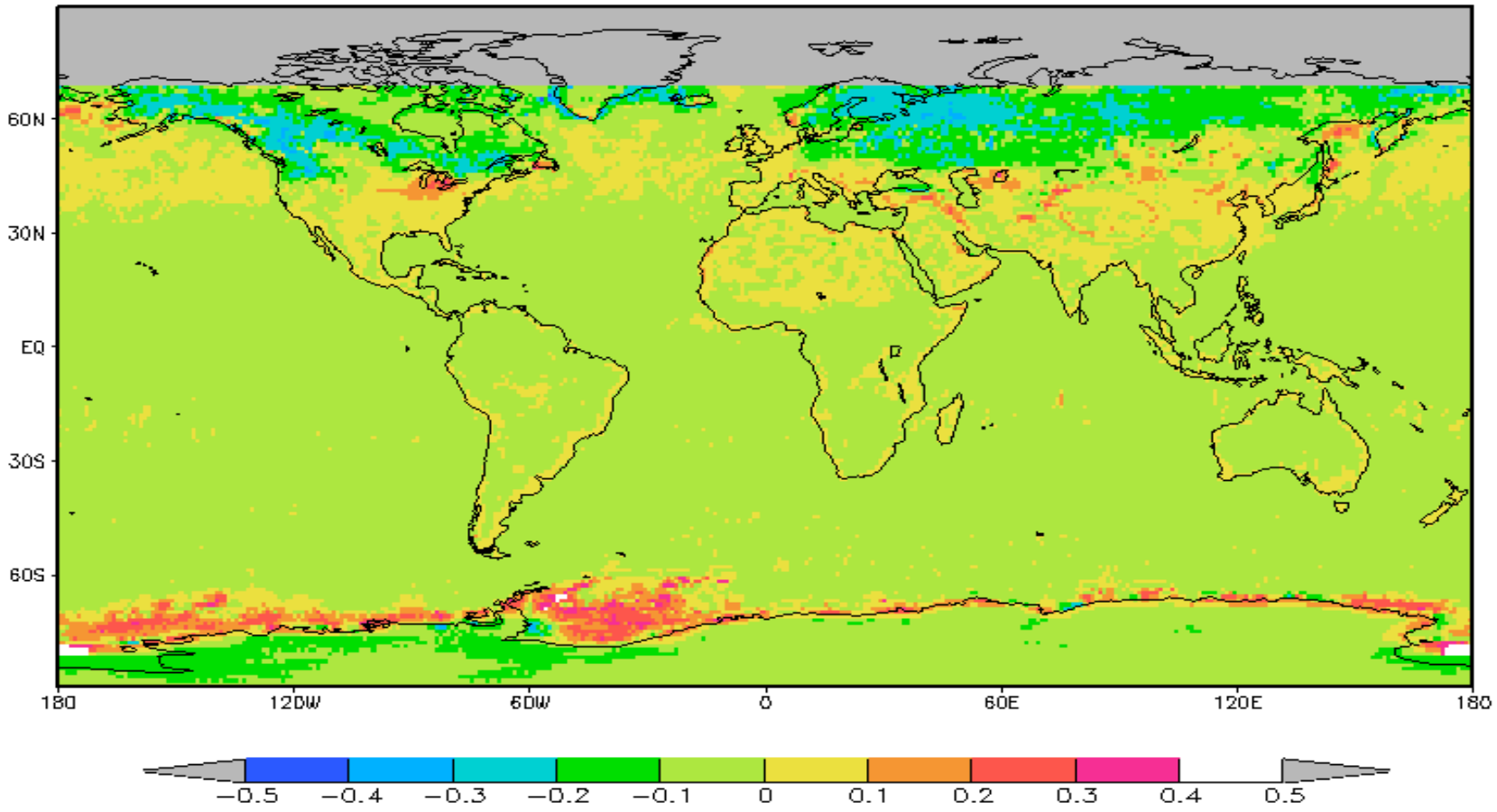
SWB All-sky Aqua 1B ERBE-derived TOA albedo Polar (BAR, SPL and NYA)



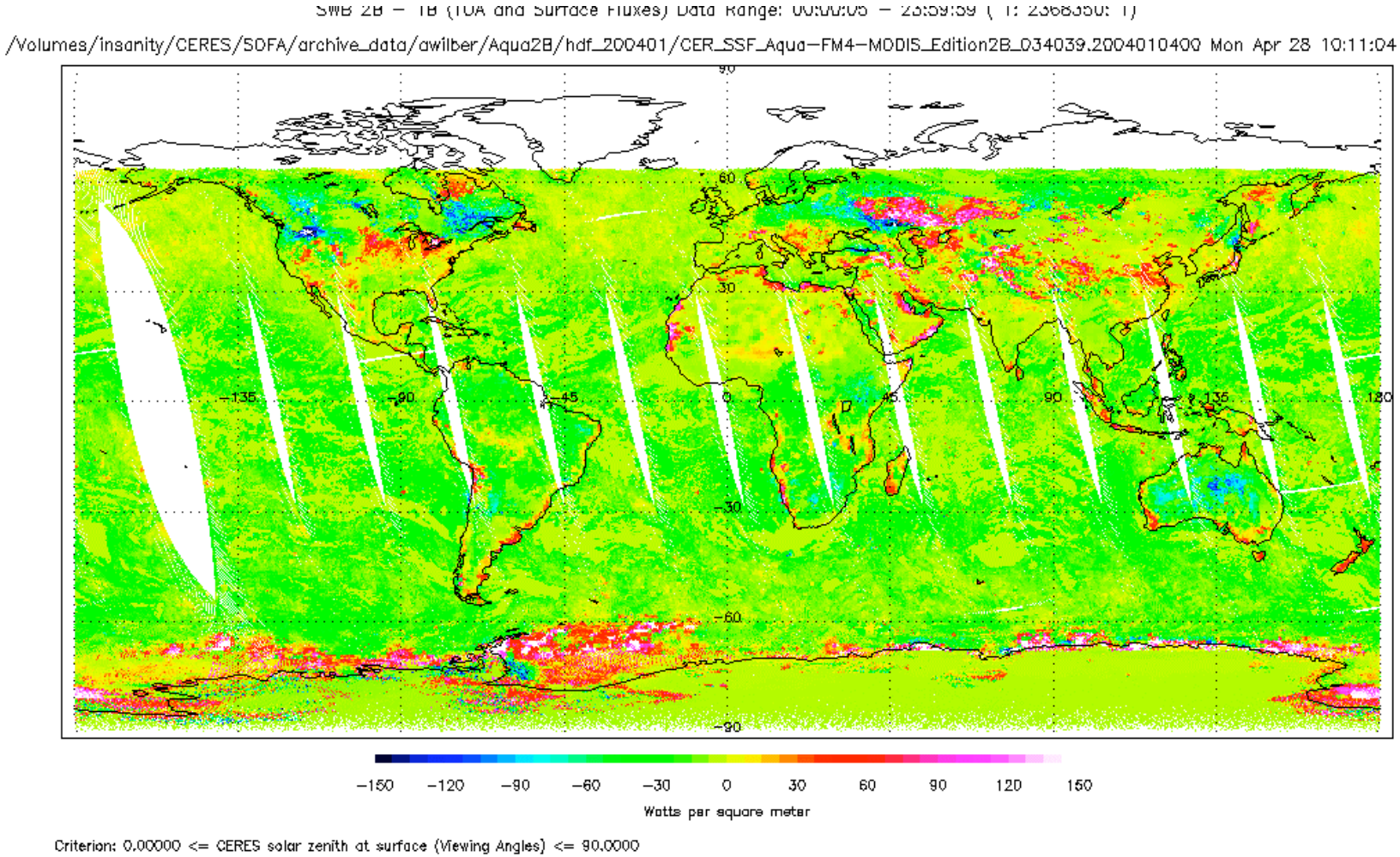
SWB All-sky Aqua 1B ERBE-derived TOA albedo Polar (GVN and SYO)



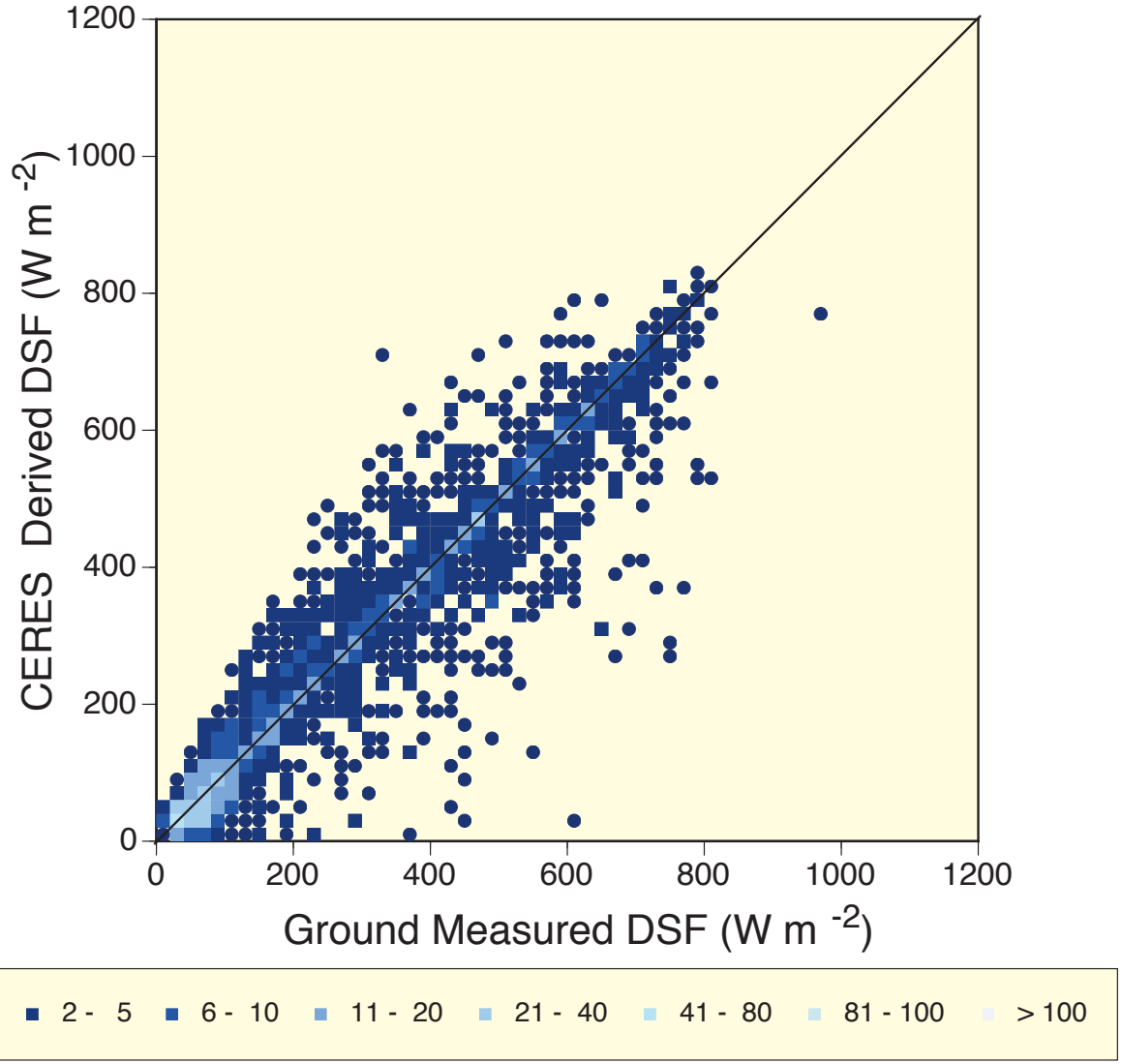
TOA Albedo Aqua2B - Aqua1B
January



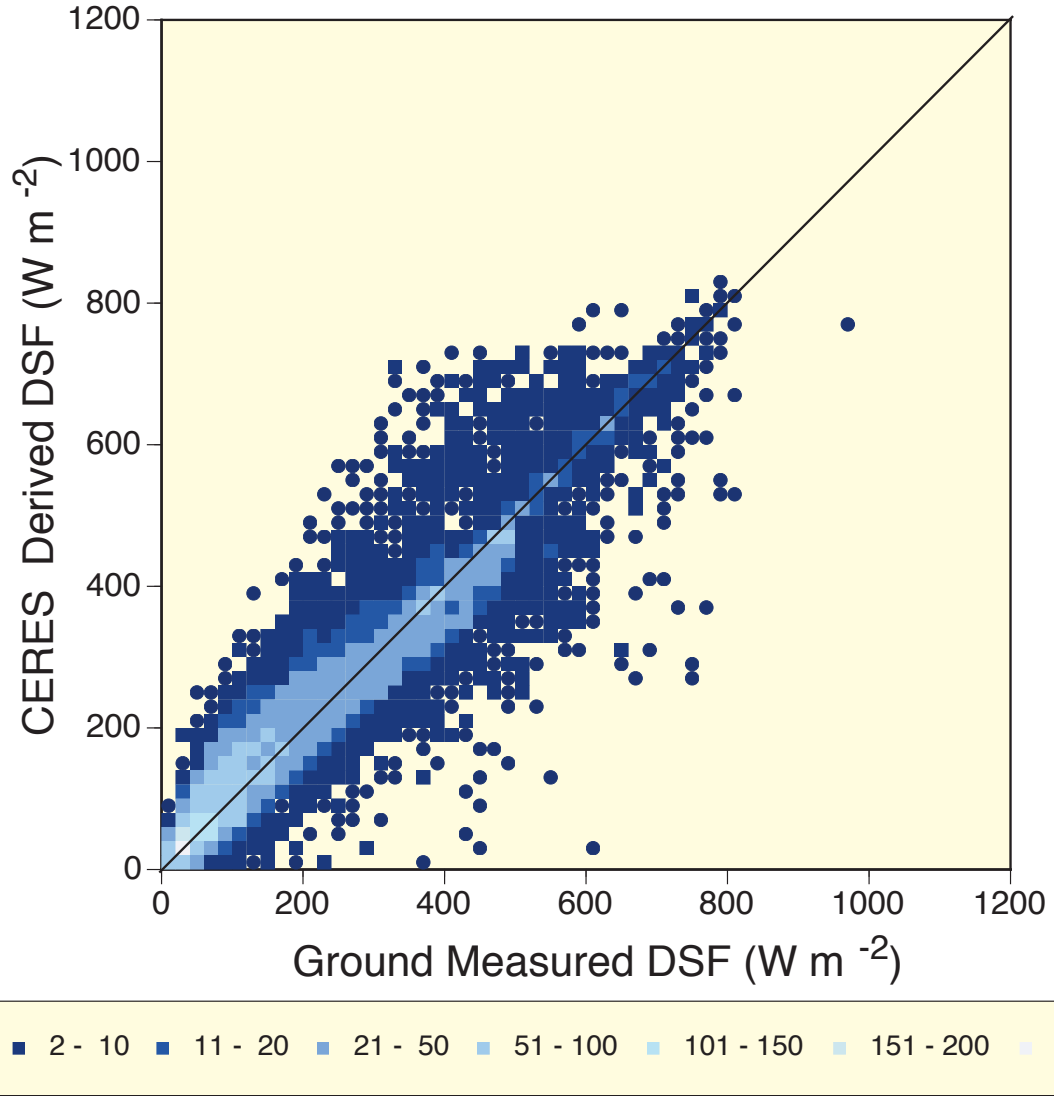
SWB Aqua2B - Aqua1B
2004/01/04



SWB All-sky Aqua 2B Terra-derived TOA albedo Polar (GVN and SYO)



SWB All-sky Aqua 2B Terra-derived TOA albedo Polar (BAR, SPL, NYA, GVN and SYO)



Shortwave Model B; Aqua 1B and Aqua 2B
All-sky

Sites # of points		Aqua 1B	Aqua2B
Continental 5928	Bias Wm^{-2} (%) σ Wm^{-2} (%)	17.0 (3.4) 81.3 (16.0)	20.2 (4.0) 75.7 (14.9)
Coastal 951	Bias Wm^{-2} (%) σ Wm^{-2} (%)	20.7 (4.0) 86.4 (16.8)	25.1 (4.9) 85.5 (16.6)
Desert 2547	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-15.2 (-2.2) 92.8 (13.6)	-6.6 (-1.0) 82.6 (12.1)
Island 2077	Bias Wm^{-2} (%) σ Wm^{-2} (%)	64.5 (10.3) 106.3 (16.9)	56.1 (8.9) 106.5 (17.0)
Polar 6893	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-14.4 (-5.7) 86.0 (34.2)	6.8 (2.7) 68.1 (27.1)
Global 18396	Bias Wm^{-2} (%) σ Wm^{-2} (%)	6.4 (1.4) 98.3 (21.9)	15.8 (3.5) 84.6 (18.8)

SW Algorithm Improvements

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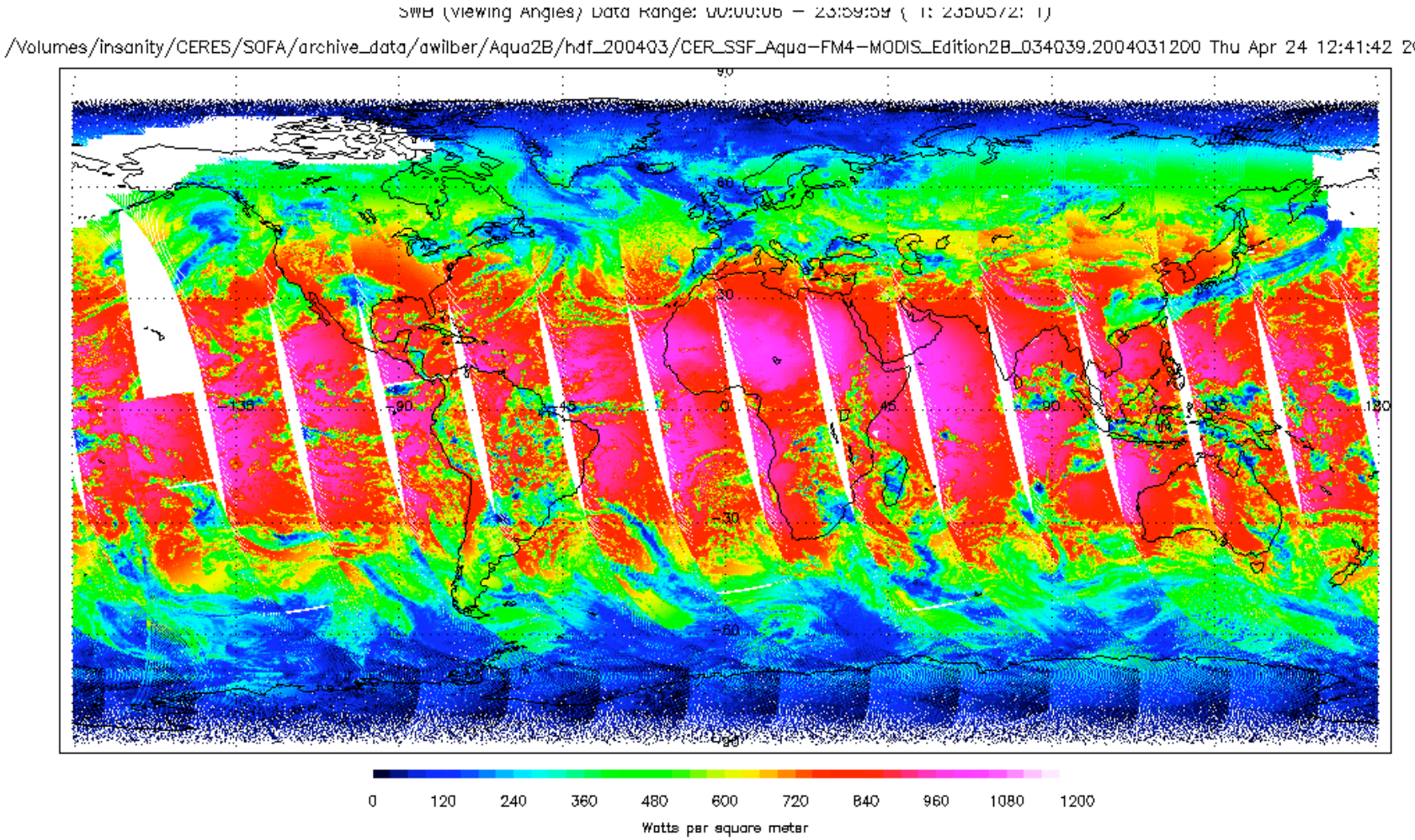
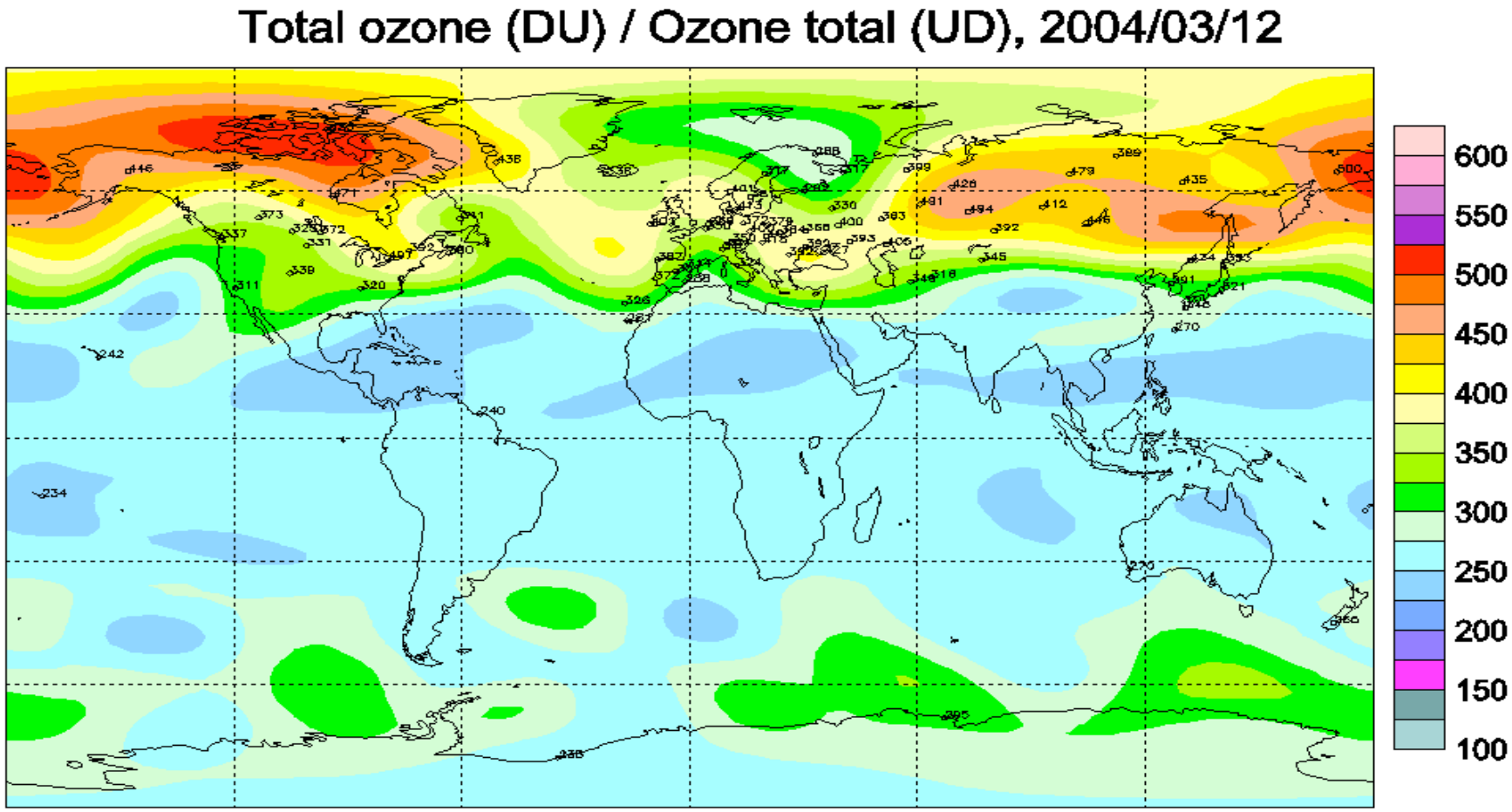
SWB 2004/03/12
Missing fluxes due to not include O_3 > 500 DU



Ozone Environment Canada



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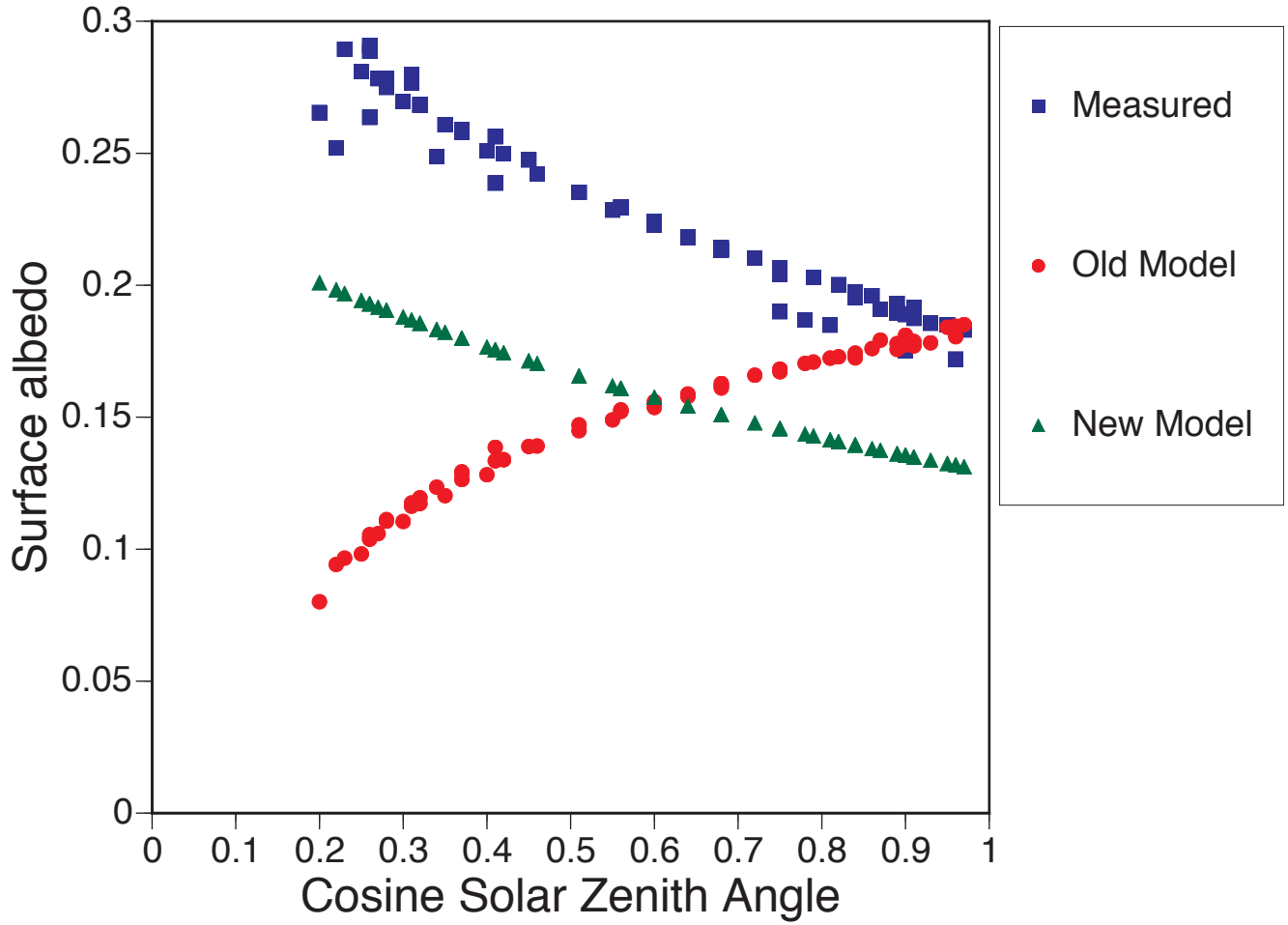
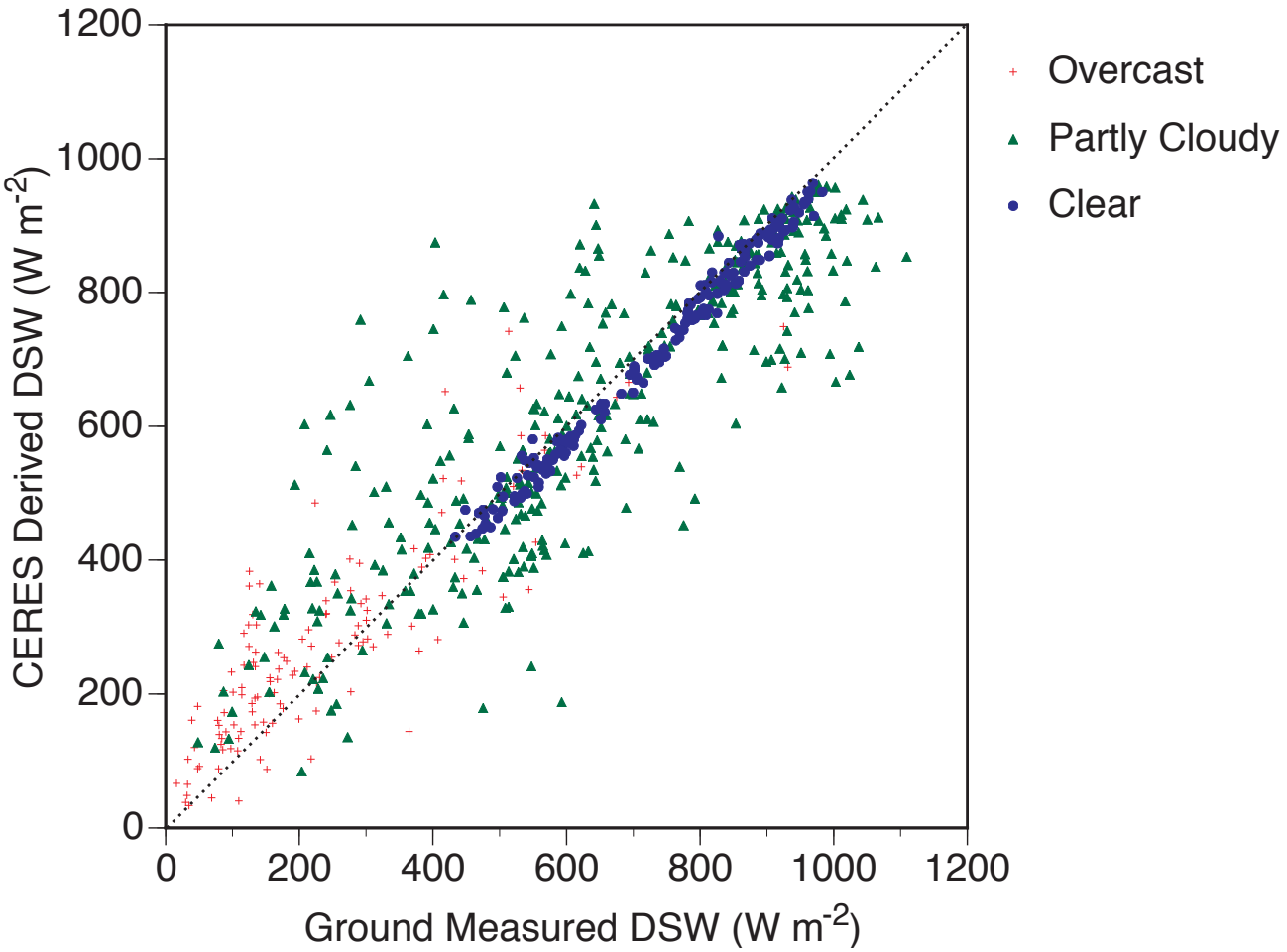
Surface Albedo at ARM SGP July 2004



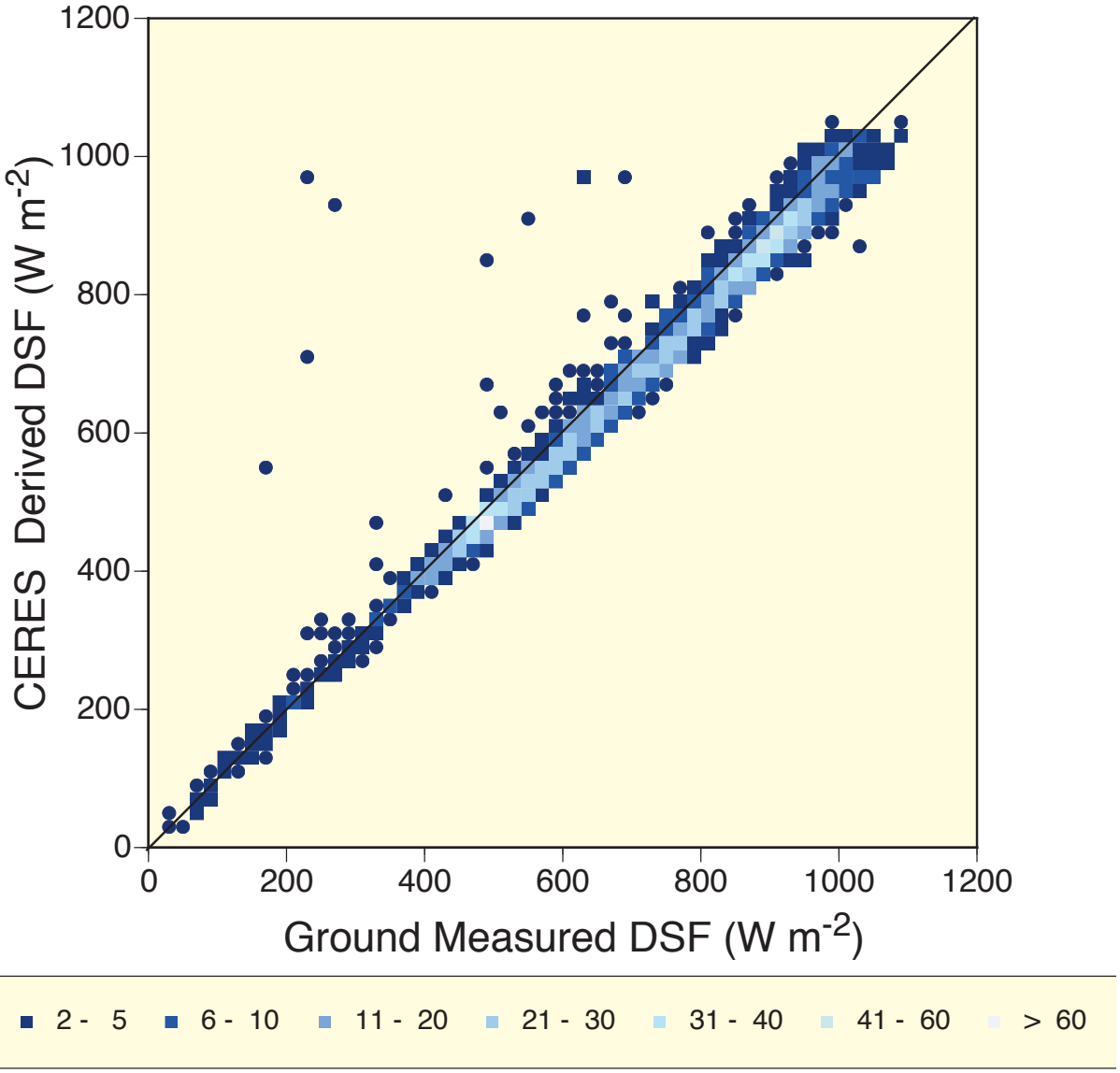
SW Algorithm Improvements (Tentative)

- SW Model B: Investigating the reasons why validation studies show large differences between cases involving clear-sky and cloudy-sky conditions (Hopefully ready for Edition 3).
- SW Model B: Investigating the possibility of replacing WCP-55 aerosol optical depths with broadband MATCH aerosol optical depths (Hopefully ready for Edition 3).
- SW Model B: Investigating the possibility of replacing single scattering albedos and asymmetry parameters provided by Staylor with the corresponding values from OPAC - Optical Properties of Aerosols & Clouds (Hopefully ready for Edition 3).

SWB SGP Terra2B



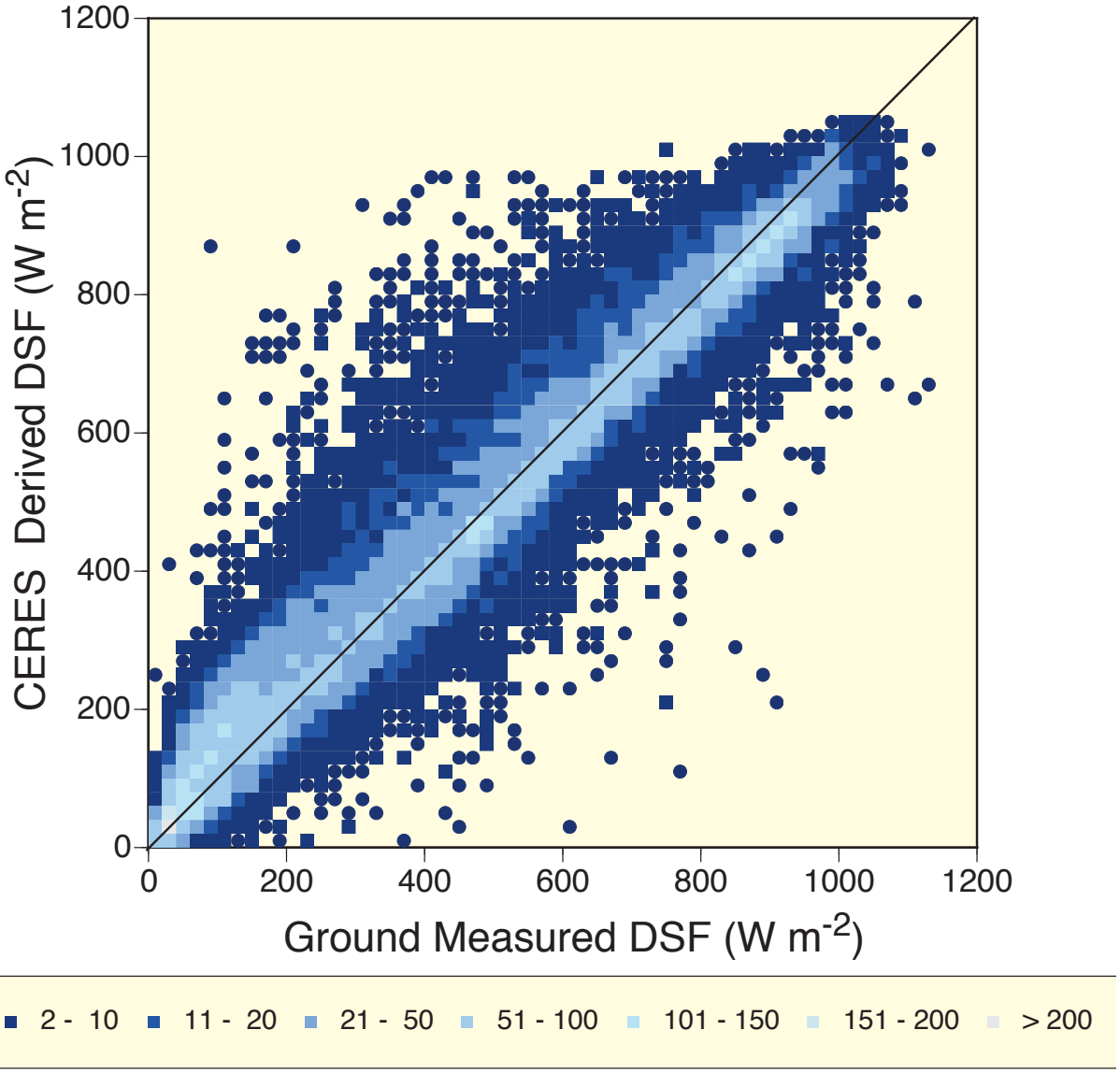
SW Model B Clear-Sky Comparisons, 1 minute data



SW Model B Clear-Sky Comparisons, 1 minute data

Sites	# of Points	Mean Bias W/m^{-2} (%)	Random Error Wm^{-2} (%)
Continental	1351	-23.2 (-3.3)	29.7 (4.2)
Coastal	134	-2.4 (-0.3)	28.7 (4.1)
Desert	664	-25.4 (-3.1)	43.2 (5.3)
Island	43	26.0 (3.0)	66.8 (7.8)
Polar	353	-2.4 (-0.6)	13.6 (3.3)
Global	2545	-19.0 (-2.7)	36.9 (5.3)

SW Model B All-Sky Comparisons, 60 minute data



SW Model B All-Sky Comparisons, 60 minute data

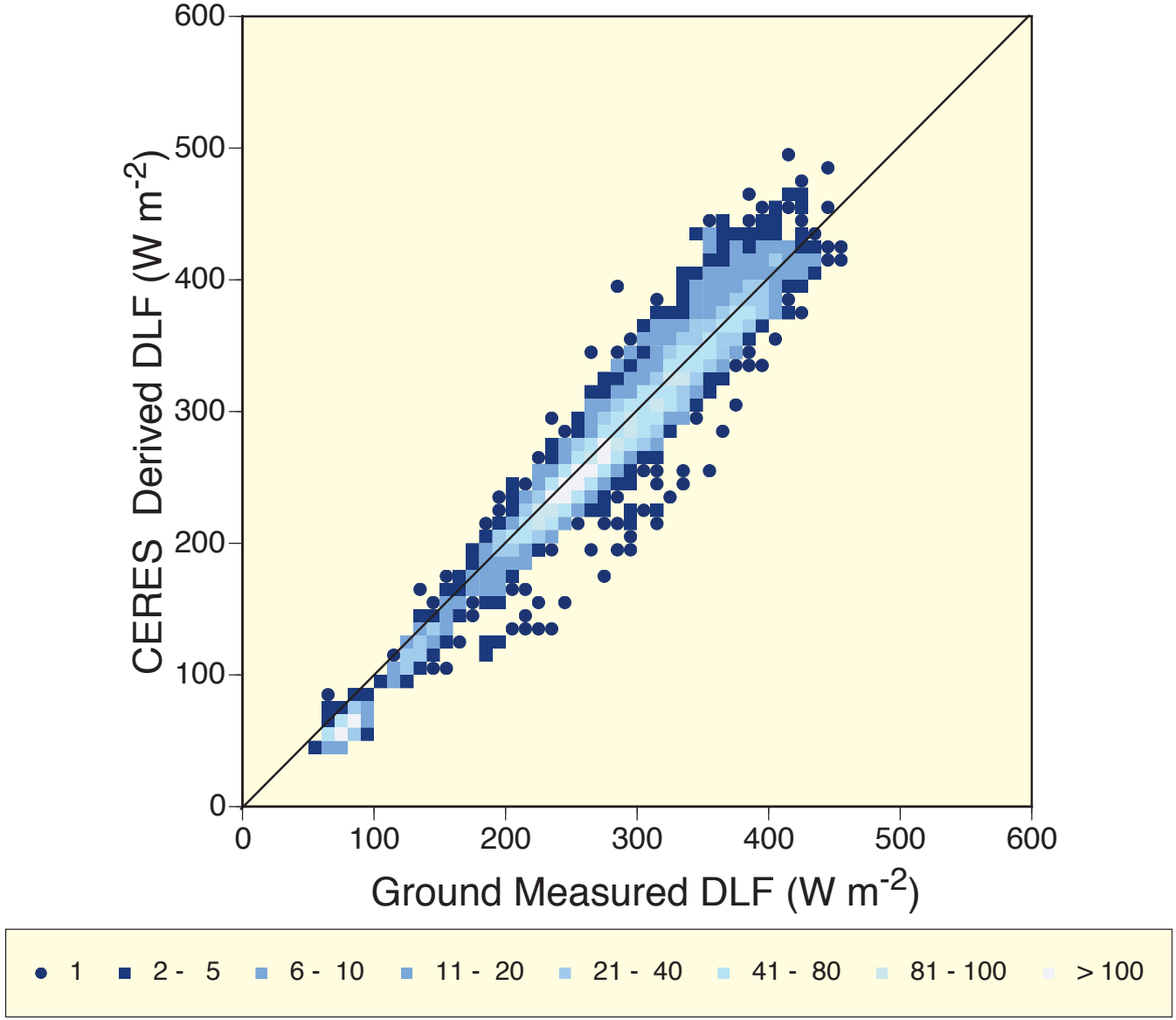
Sites	# of Points	Mean Bias W/m^{-2} (%)	Random Error Wm^{-2} (%)
Continental	8114	20.3 (3.8)	74.1 (14.0)
Coastal	1358	28.3 (5.3)	83.5 (15.6)
Desert	3223	-4.9 (-0.7)	82.0 (12.0)
Island	2900	54.1 (8.5)	103.5 (16.3)
Polar	8837	8.3 (3.3)	66.9 (27.0)
Global	24432	17.1 (3.7)	83.4 (18.1)

LW Algorithm Improvements

- LW Model B: Modified to successfully calculate cloud effects for high altitude regions, such as Tibet, where cloud base heights were often not available from the SSF (Aqua Edition 2A).
- LW Model C: Reformulated to handle cases involving cirrus and low water vapor amounts (Edition 3).
- LW Model C: Currently in the process of being incorporated into CERES processing (Edition 3).
- LW Models A, B & C: Implemented near-surface air-temperature constraint to handle cases where the skin surface temperature greatly exceeds the overlying air temperatures, e.g., daytime deserts and cold continental outbreak events over oceans (Edition 3).

Status of LW Models A & B for Aqua 2B

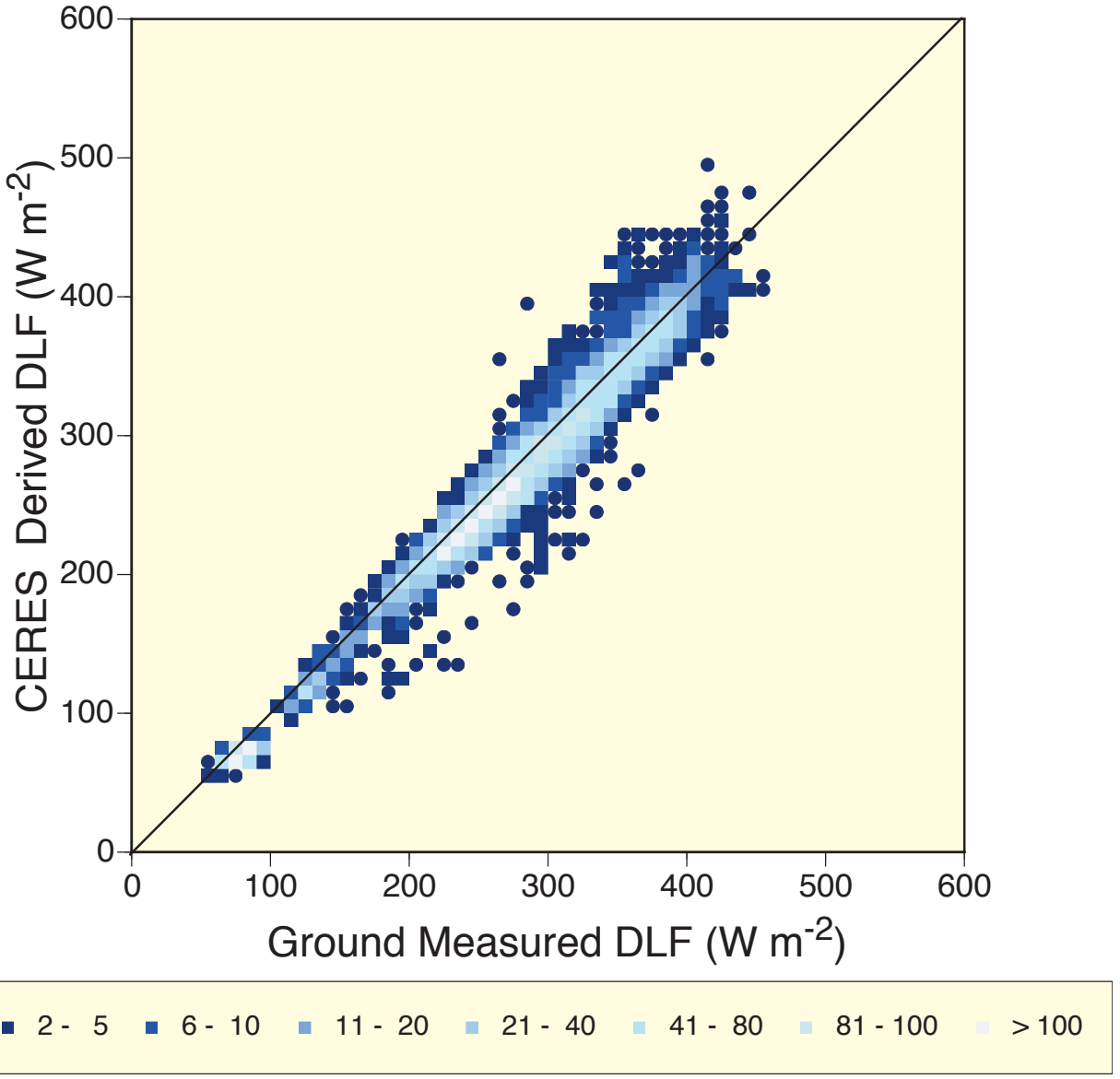
LW Model A Clear-Sky Comparisons, 1 minute data



LW Model A Clear-Sky Comparisons, 1 minute data

Sites	# of Points	Mean Bias W/m^{-2} (%)	Random Error Wm^{-2} (%)
Continental	3647	-5.1 (-1.8)	13.4 (4.6)
Coastal	455	5.0 (1.7)	12.9 (4.5)
Desert	1669	0.0 (0.0)	24.3 (8.0)
Island	118	0.3 (0.1)	11.6 (3.0)
Polar	960	-15.0 (-12.9)	11.7 (10.0)
Global	6849	-4.5 (-1.7)	17.3 (6.4)

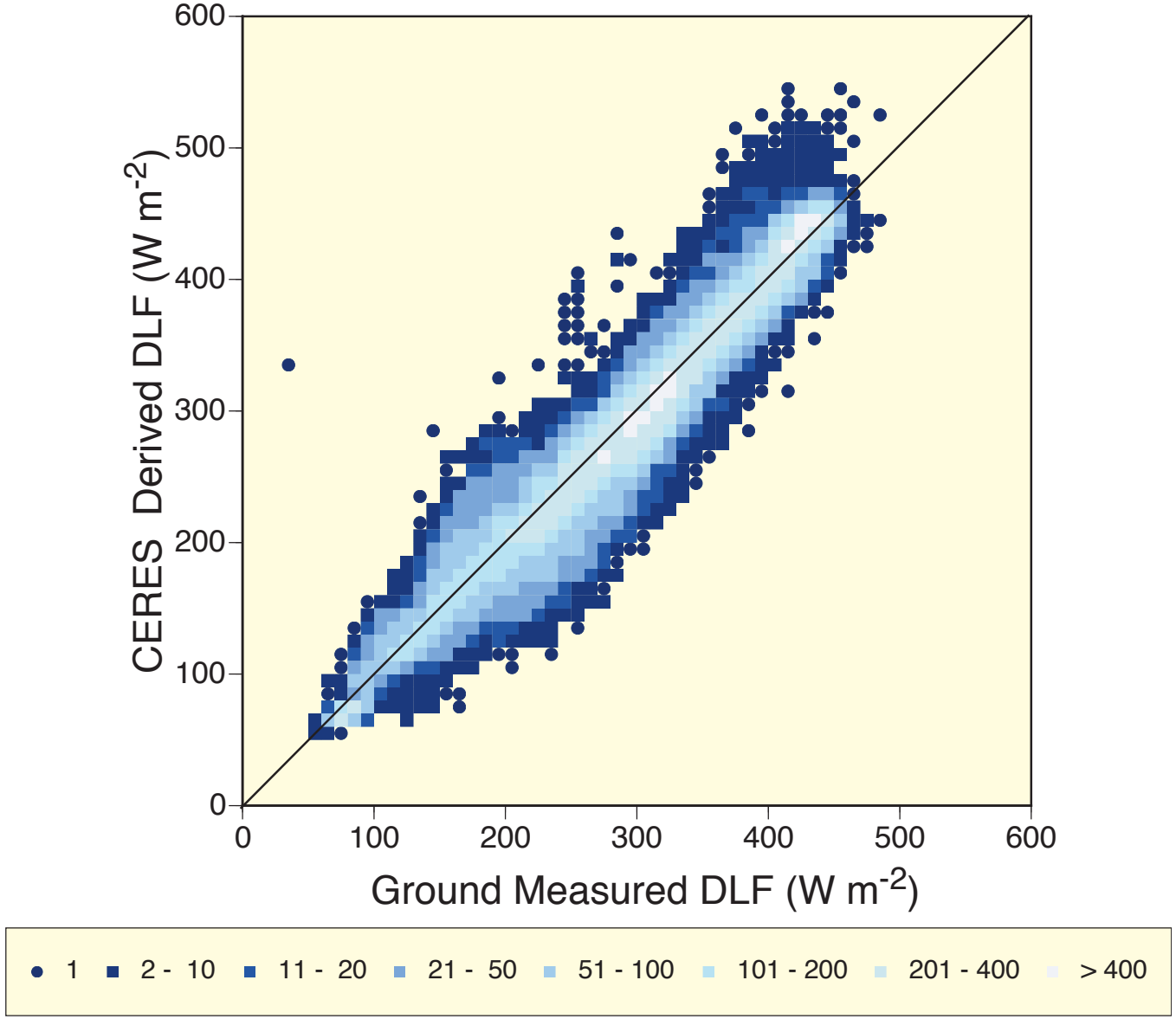
LW Model B Clear-Sky Comparisons, 1 minute data



LW Model B Clear-Sky Comparisons, 1 minute data

Sites	# of Points	Mean Bias W/m^{-2} (%)	Random Error Wm^{-2} (%)
Continental	3663	-8.0 (-2.8)	13.1 (4.5)
Coastal	460	-0.2 (-0.1)	13.4 (4.7)
Desert	1681	-4.0 (-1.3)	22.7 (7.4)
Island	119	2.5 (0.6)	13.3 (3.4)
Polar	972	-8.8 (-7.5)	11.3 (9.7)
Global	6895	-6.4 (-2.4)	16.4 (6.1)

LW Model B All-Sky Comparisons, 1 minute data



LW Model B All-Sky Comparisons, 1 minute data

Sites	# of Points	Mean Bias W/m^{-2} (%)	Random Error Wm^{-2} (%)
Continental	16475	-4.8 (-1.5)	19.9 (6.3)
Coastal	2748	4.2 (1.2)	21.5 (6.4)
Desert	5812	5.1 (1.6)	28.7 (8.9)
Island	5819	5.4 (1.3)	14.8 (3.6)
Polar	19727	-8.1 (-3.8)	26.9 (12.5)
Global	50581	-3.3 (-1.1)	25.0 (8.6)

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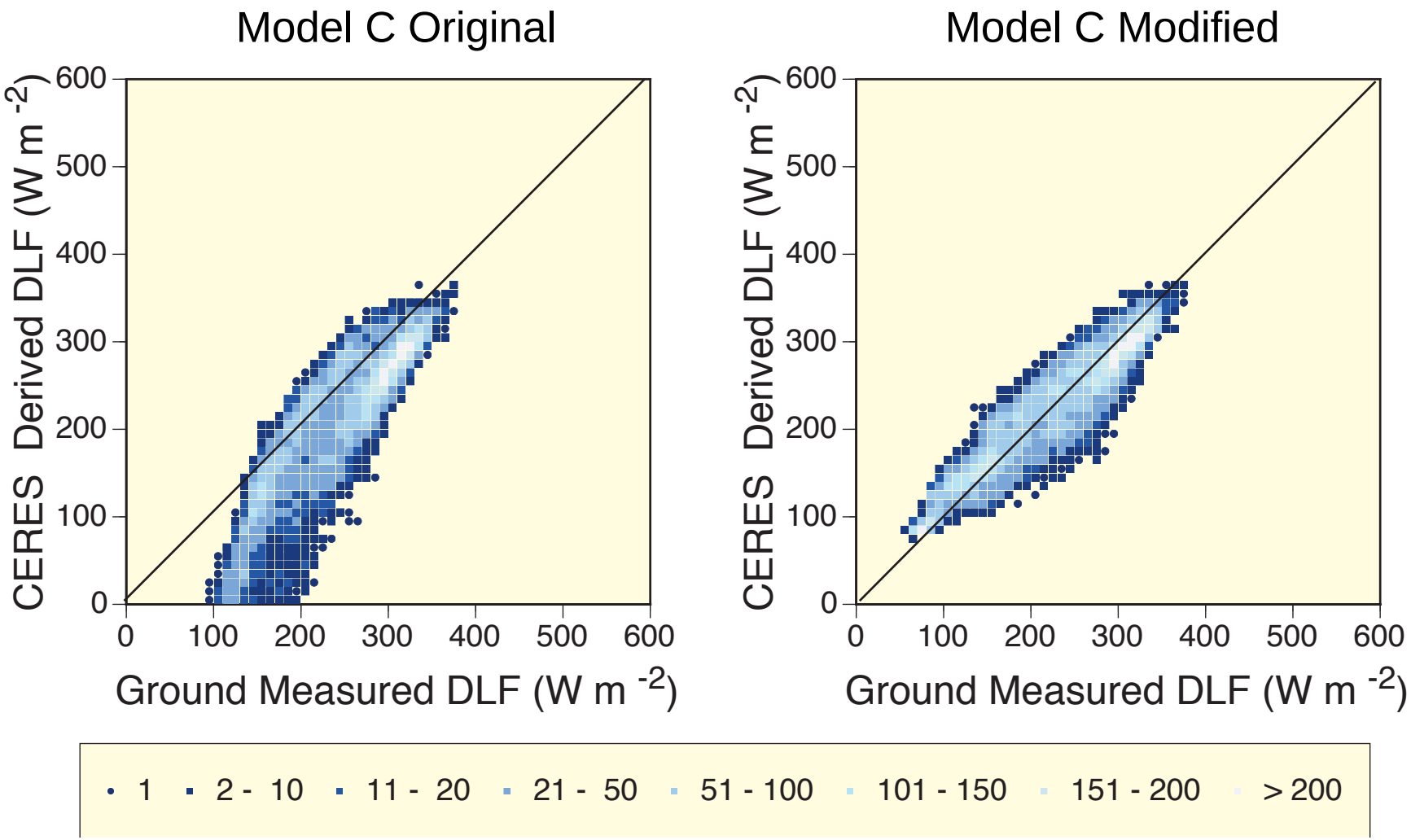
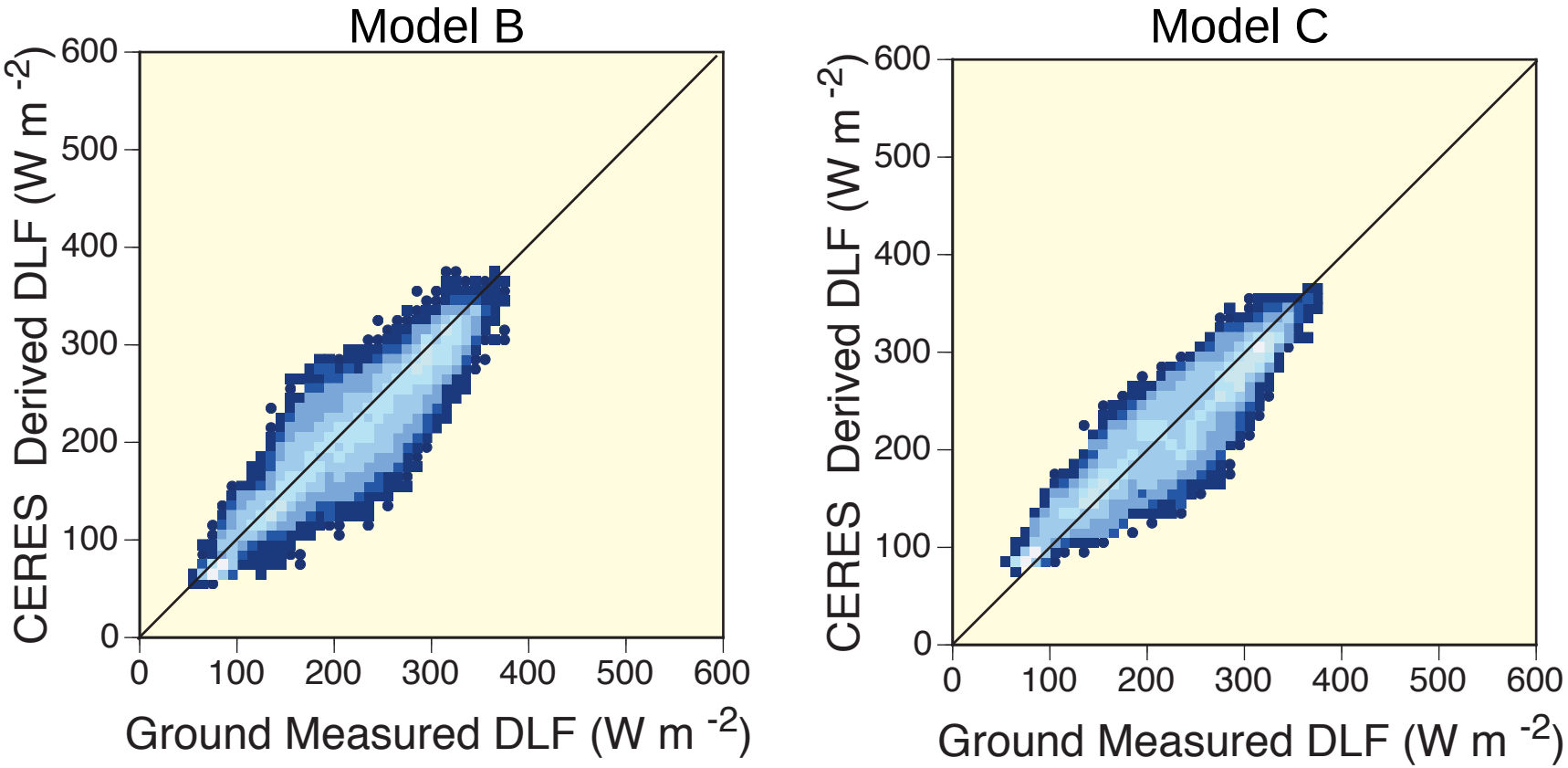
Longwave All-sky Polar



Longwave All-sky Polar



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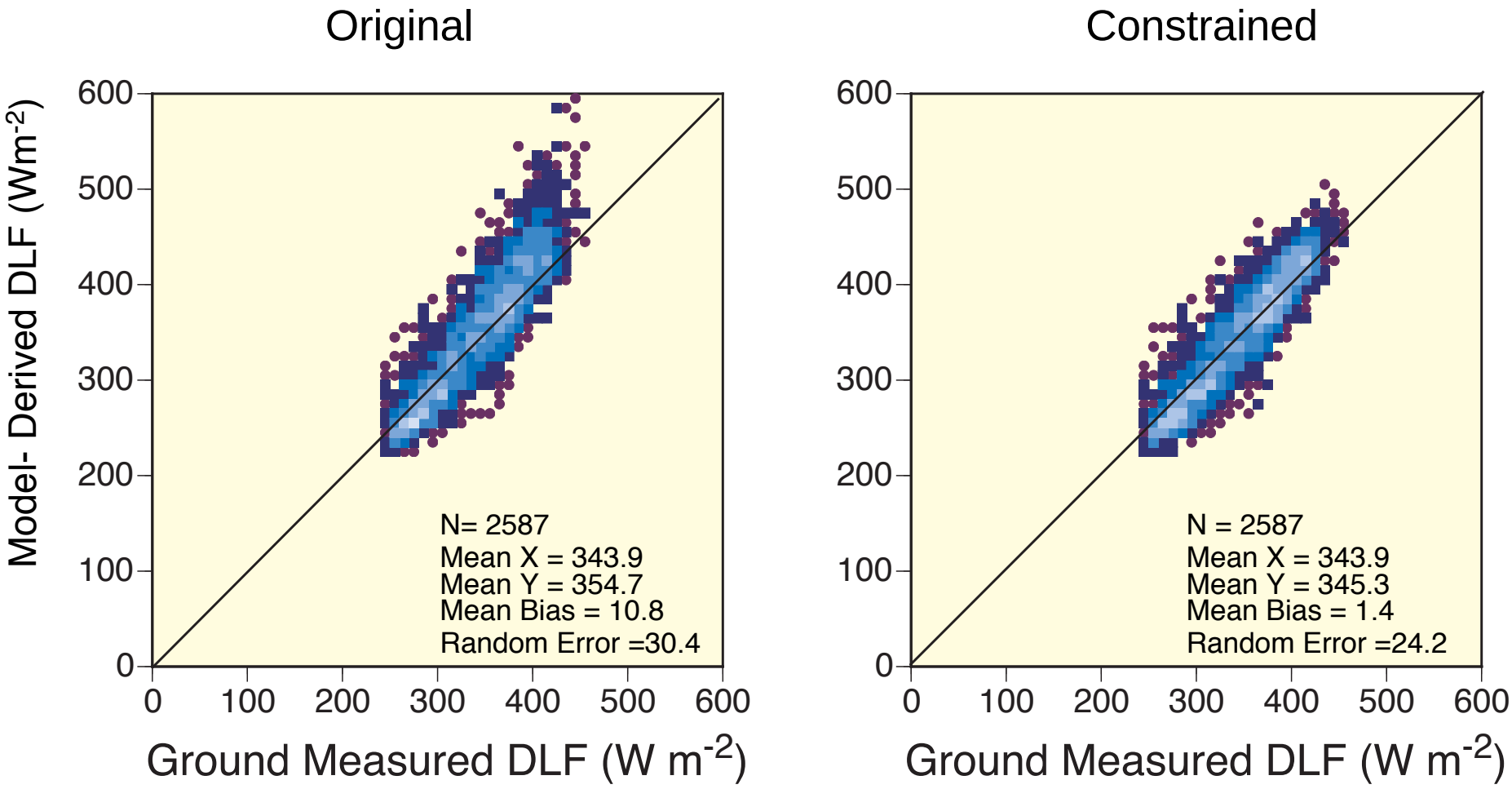
Original and Modified Computation - Alice Springs



Bias for Alice Springs is greatly reduced

Conclusions

- SW Model A provides satisfactory global flux retrievals, though there remain problems with cloud contamination and significant flux underestimations for cases with low water vapor amounts.
- SW Model B has been improved significantly; however, additional improvements are still required.
- LW Models A provides very good clear-sky results for most validation sites; however, the polar sites yield a modest negative bias due to a known discrepancy at low water vapor amounts.
- LW Models B & C provide very good clear-sky and all-sky results for all of the validation sites that were considered.