Validation of CERES Terra & Aqua SSF Surface-only Fluxes

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Terra 2B

Validation of CERES Terra & Aqua SSF Surface-only Fluxes

- Down-welling clear-sky and all-sky SW and LW surface fluxes derived from relationships with TOA fluxes and atmospheric data.
- Each component currently computed from two models

  LPSA/LPLA:
  Langley Parameterized SW/LW Algorithm

		Model A	Model B
SW	Clear	Li et al.	LPSA
	All-sky	-	LPSA
LW	Clear	Inamdar and Ramanathan	LPLA
	All-sky	-	LPLA

- Validation criteria:
  ±20 Wm^{-2} for instantaneous CERES FOV
- Validation data sources: SURFRAD, ARM/SGP, BSRN, & CMDL
- CERES date sources: Terra FM1 and FM2; Aqua FM3 and FM4

Algorithms/References

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

- SW Model B (LPSA/Staylor Algorithm):
  Darnell *et al.* (1988): *J. Climate*, **1**, 820-835.
  Darnell *et al.* (1992): *J. Geophys. Res.*, **97**, 15741-15760.
  Gupta *et al.* (2001): *NASA/TP-2001-211272*, 31 pp.

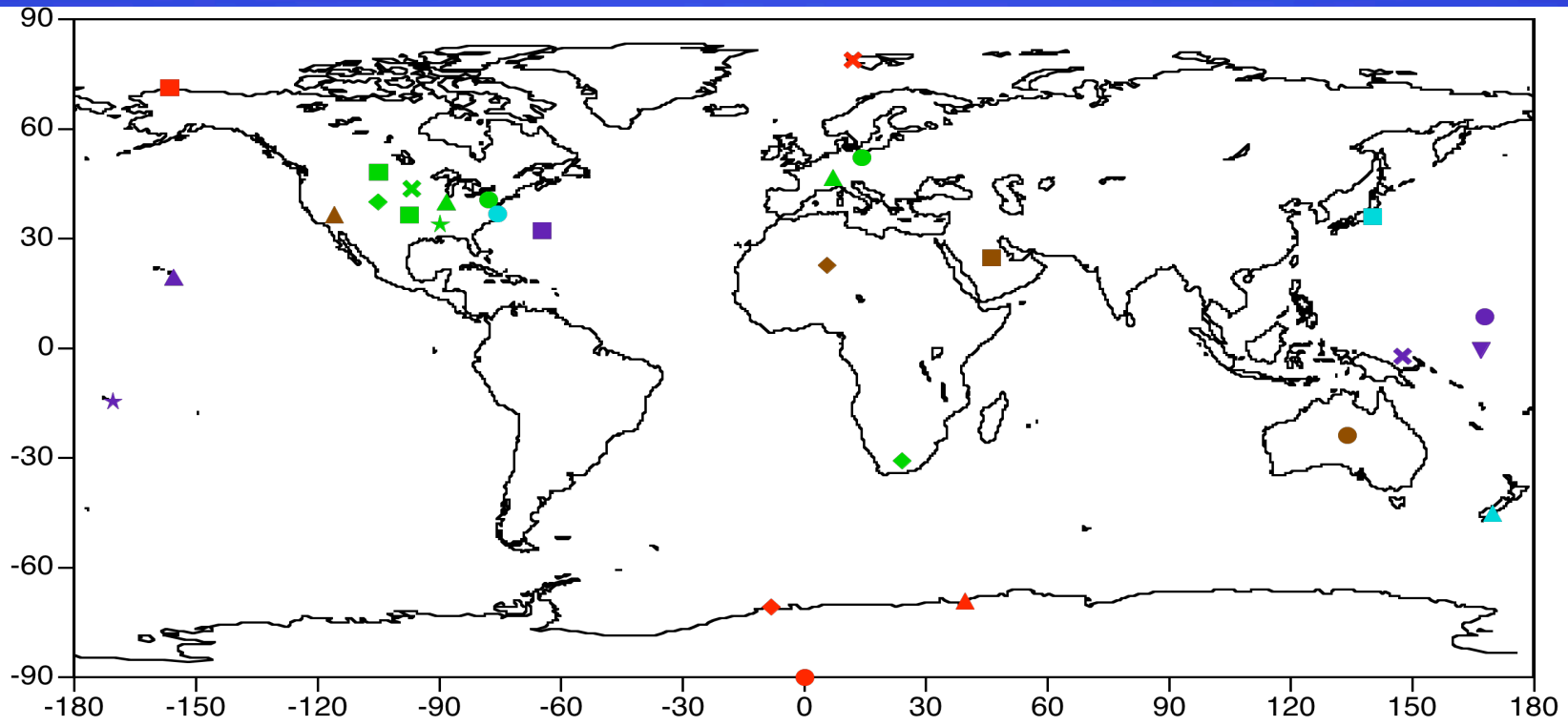
- LW Model A:
  Inamdar and Ramanathan (1997): *Tellus*, **49B**, 216-230.

- LW Model B (LPLA):
  Gupta (1989): *J. Climate*, **2**, 305-320.
  Gupta *et al.* (1992): *J. Appl. Meteor.*, **31**, 1361-1367.

- SW & LW Model B Validation
  Gupta *et al.* (2004): *J. Atmos. Ocean Tech.*, **21**, 742-752.

CERES Terra & Aqua Data Timeframes

- Data acquisition frozen 1-April-2005 to allow sufficient time for processing and comparison.
- Terra 2B: March 2000 through December 2003.
- Aqua 1B: July 2002 through June 2004.



- 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
- 30.67S, 24.0E De Aar
- 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
- 45.03S, 169.7E New Zealand
- 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

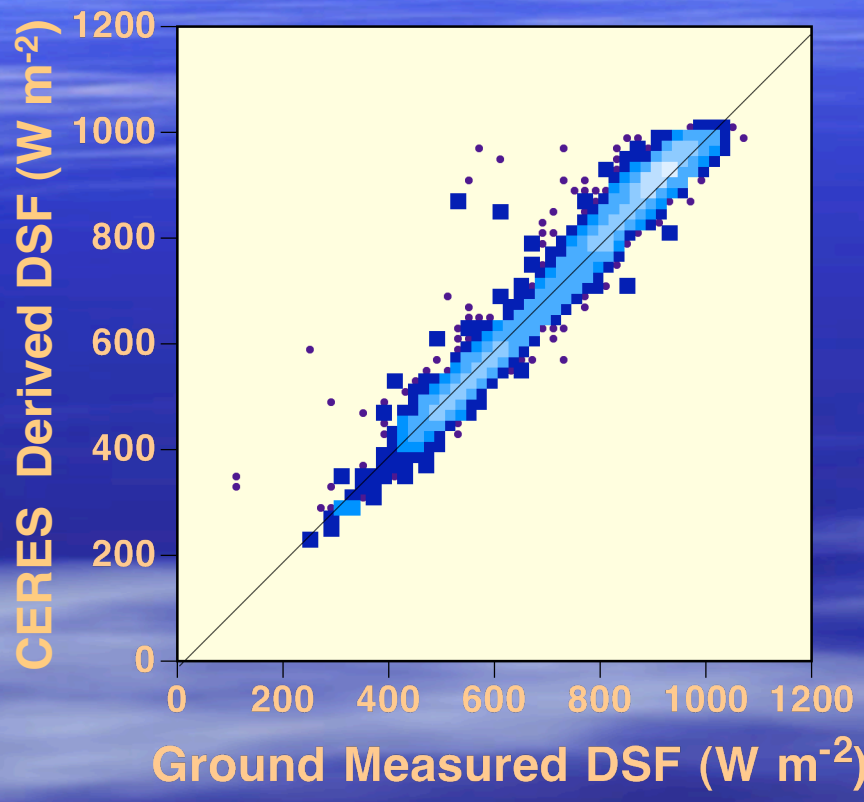
Terra 2B

Terra 2B

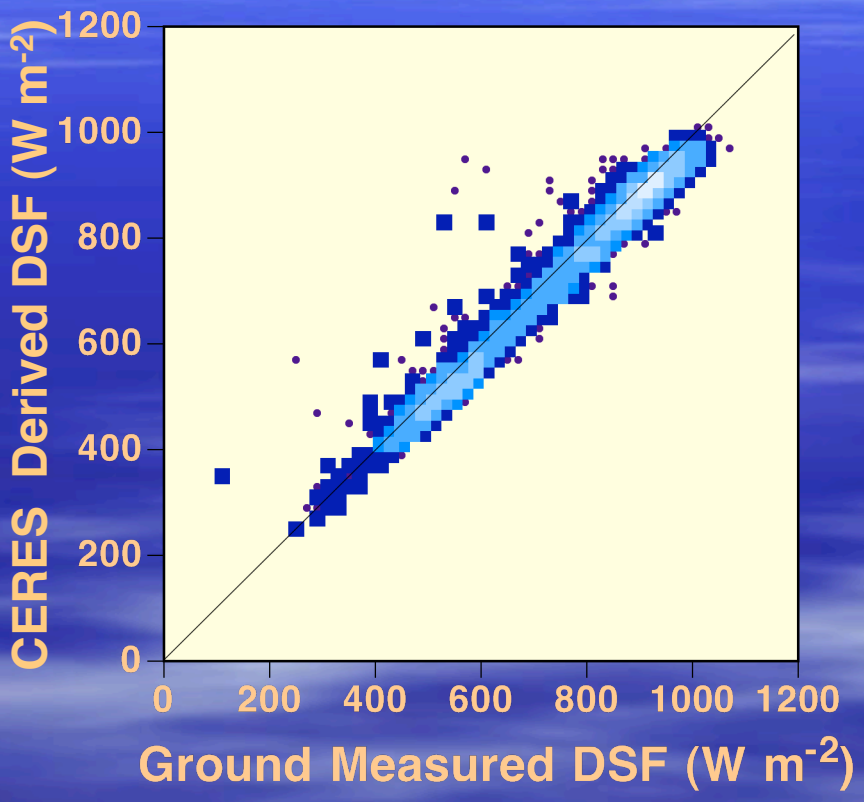
Shortwave Clear-Sky
March 2000 through December 2003

Shortwave Clear-Sky Continental

Model A



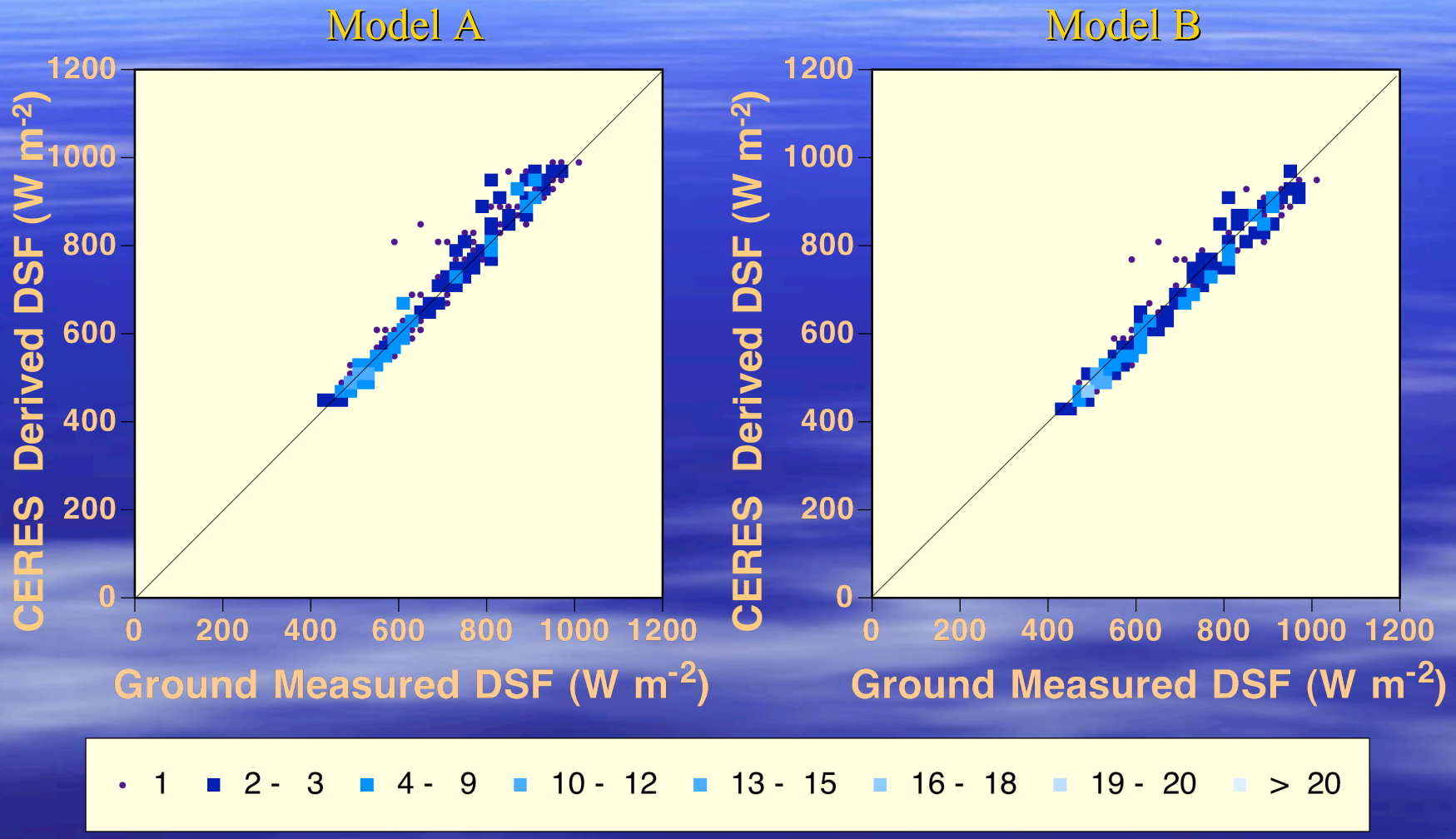
Model B



1 | 2 - 10 | 11 - 20 | 21 - 50 | 51 - 100 | 101 - 150 | 151 - 200 | > 200

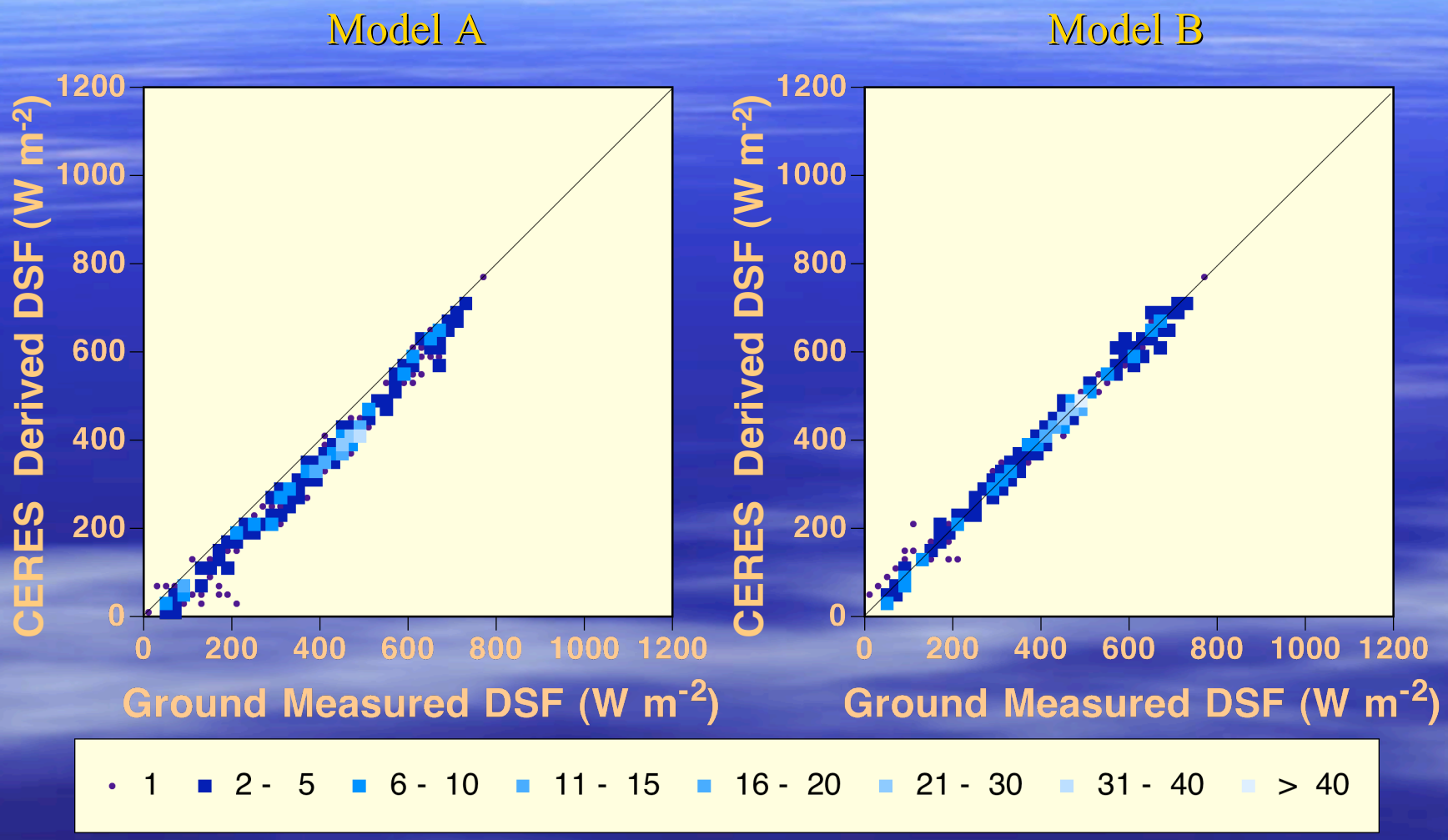
Terra 2B

Shortwave Clear-Sky Coastal



Terra 2B

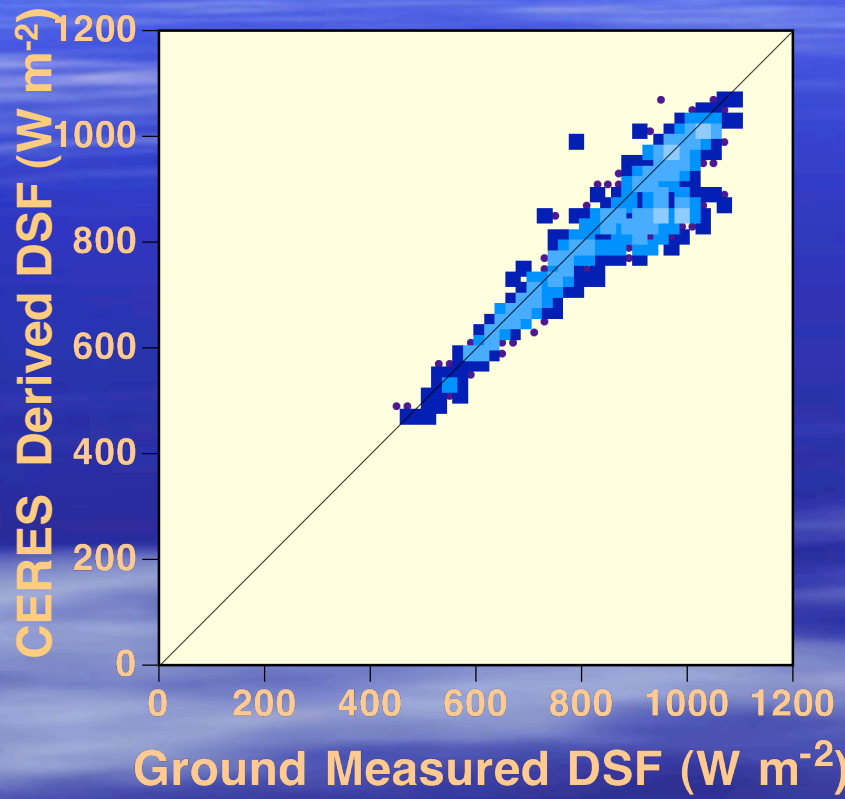
Shortwave Clear-Sky Ant-arctic



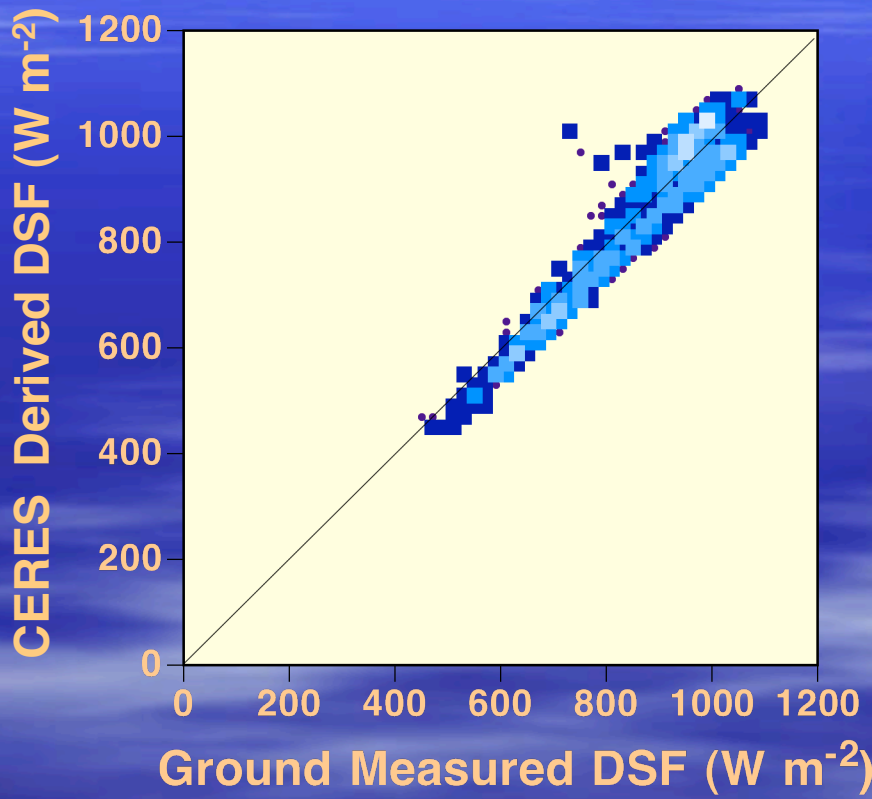
Terra 2B

Shortwave Clear-Sky Desert

Model A



Model B

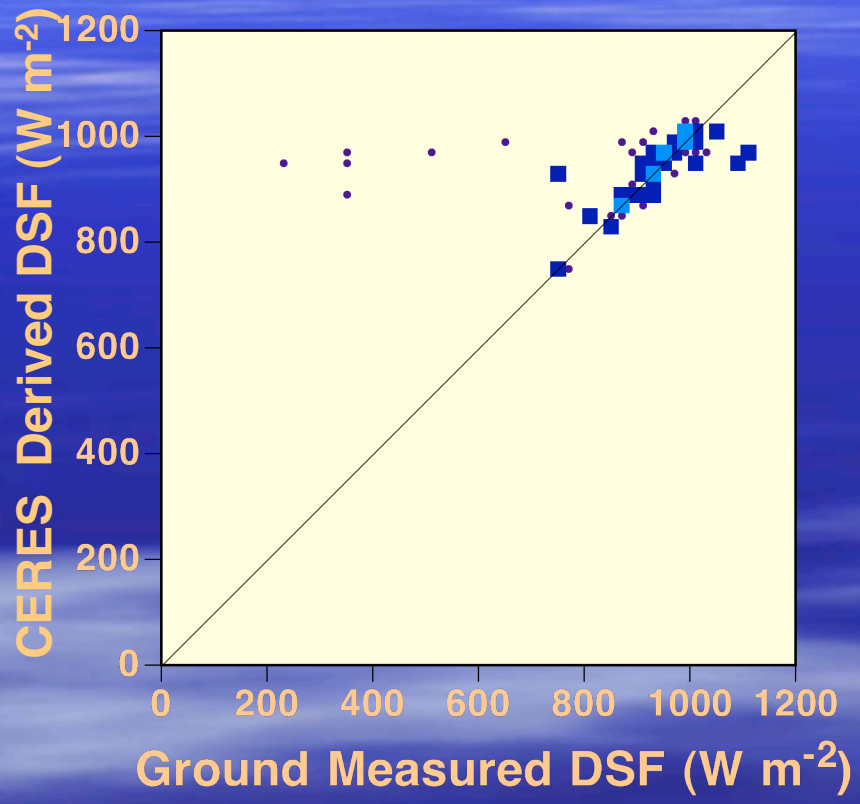


1 2 - 5 6 - 10 11 - 15 16 - 20 21 - 25 26 - 30 > 30

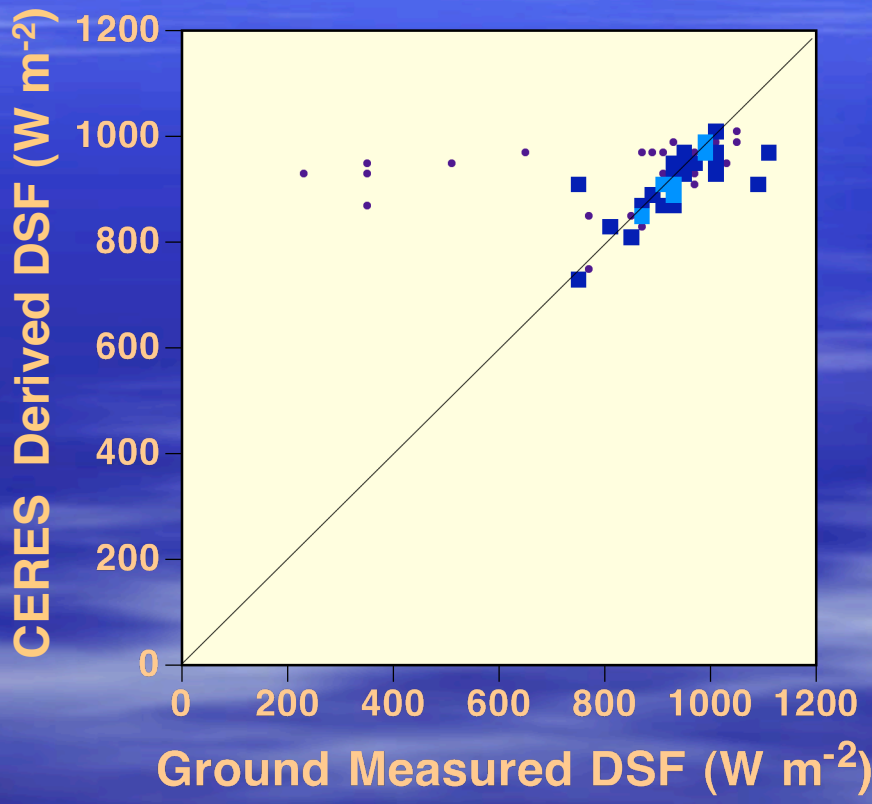
Terra 2B

Shortwave Clear-Sky Island

Model A



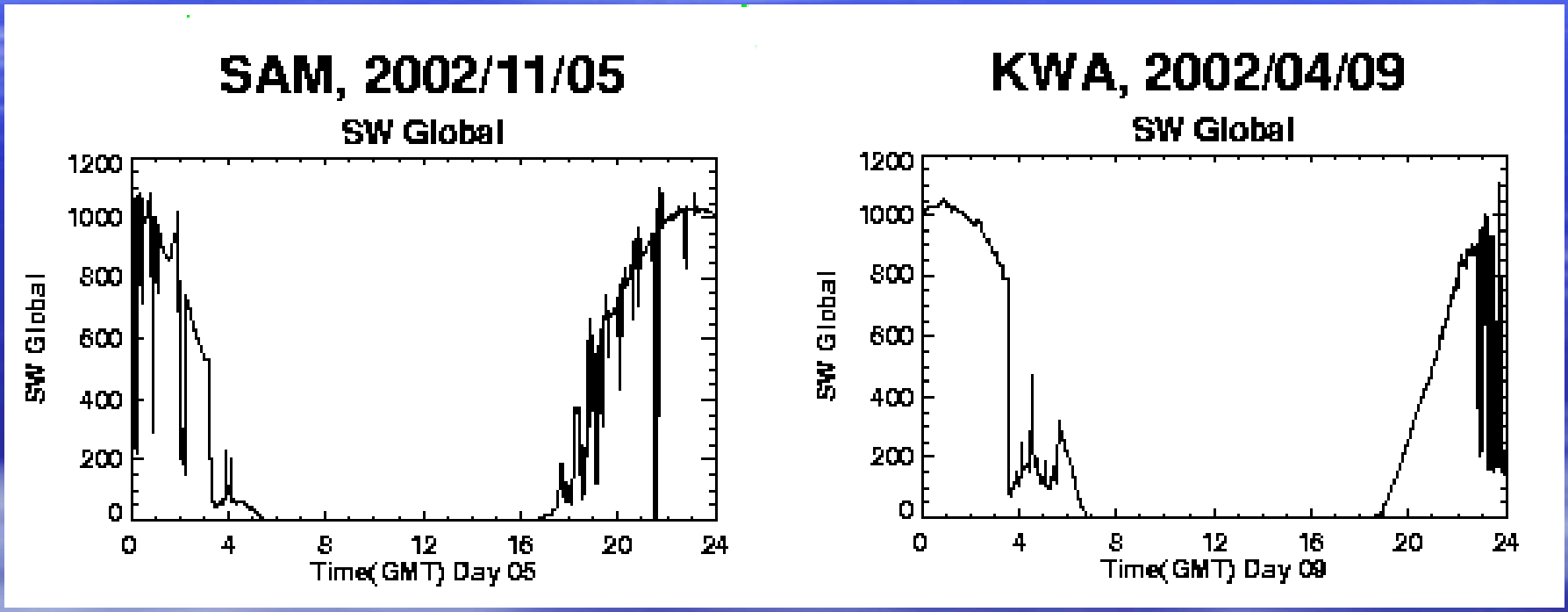
Model B



1 2 - 3 4 - 9 10 - 12 13 - 15 16 - 18 19 - 20 > 20

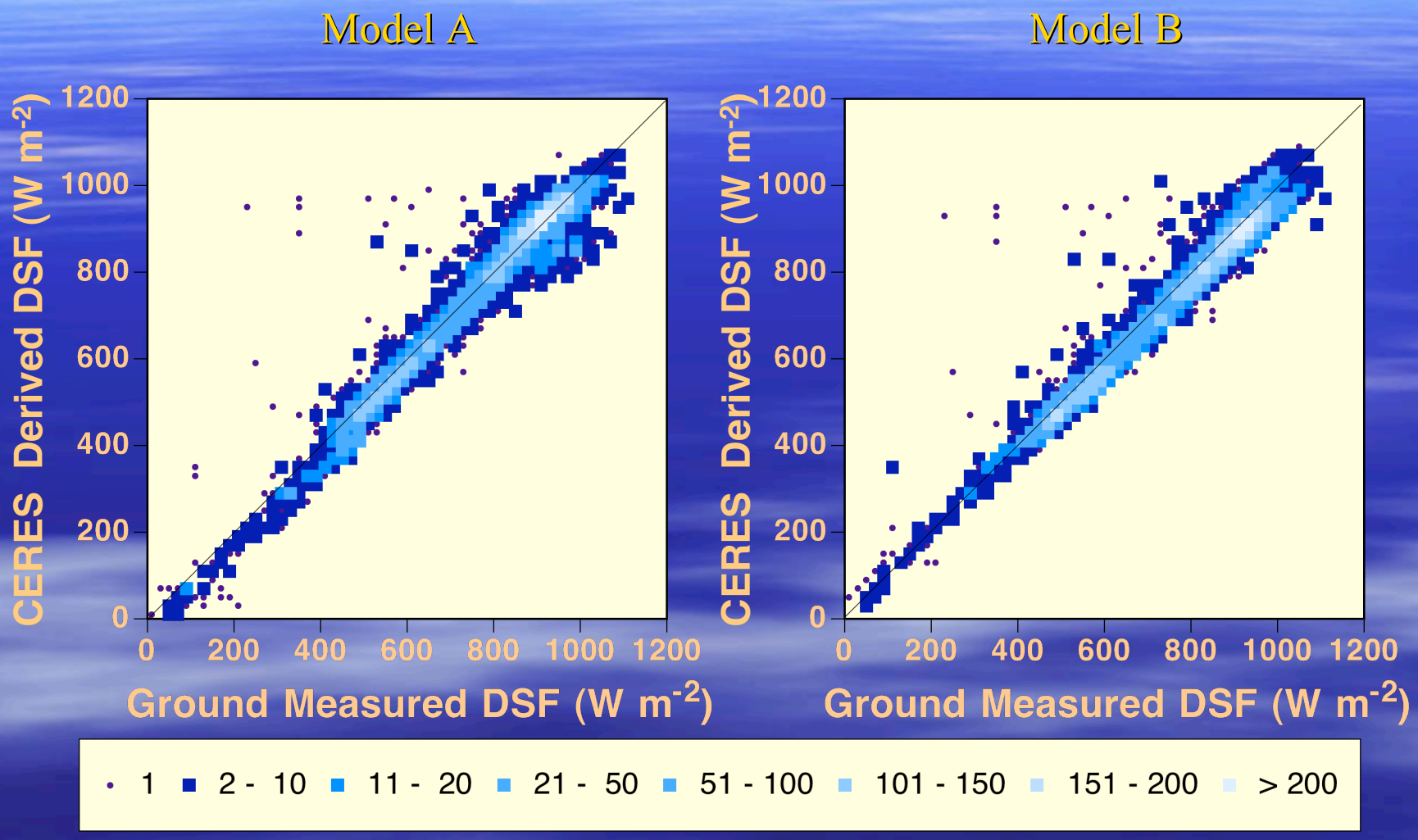
Terra 2B

Shortwave Clear-Sky Island



Terra 2B

Shortwave Clear-Sky Global



Terra 2B

Terra Shortwave Clear-Sky

Sites # of Points		SWA	SWB
Continental 7811	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-3.66 (-0.49) 26.7 (3.6)	-21.95 (-2.93) 24.5 (3.3)
Coastal 284	Bias Wm^{-2} (%) _ Wm^{-2} (%)	8.69 (1.28) 34.0 (5.0)	-13.59 (-2.01) 29.9 (4.4)
Ant-Arctic 461	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-50.21 (-12.42) 23.1(5.7)	-0.03 (-0.01) 14.8 (3.7)
Desert 1448	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-33.12 (-3.88) 45.8 (5.4)	-14.66 (-1.72) 41.9 (4.9)
Island 96	Bias Wm^{-2} (%) _ Wm^{-2} (%)	36.54 (4.05) 57.7 (6.4)	18.52 (2.05) 55.0 (6.1)
Global 10100	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-9.28 (-1.24) 37.3 (5.0)	-19.28 (-2.58) 31.5 (4.2)

Terra Shortwave Clear-Sky

Sites # of Points		SWA	SWB
Continental 7811	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-3.66 (-0.49) 26.7 (3.6)	-21.95 (-2.93) 24.5 (3.3)
Coastal 284	Bias Wm^{-2} (%) _ Wm^{-2} (%)	8.69 (1.28) 34.0 (5.0)	-13.59 (-2.01) 29.9 (4.4)
Ant-Arctic 461	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-50.21 (-12.42) 23.1(5.7)	-0.03 (-0.01) 14.8 (3.7)
Desert 1448	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-33.12 (-3.88) 45.8 (5.4)	-14.66 (-1.72) 41.9 (4.9)
Island 91	Bias Wm^{-2} (%) _ Wm^{-2} (%)	6.12 (0.66) 47.0 (5.0)	-11.84 (-1.27) 45.1 (4.8)
Global 10100	Bias Wm^{-2} (%) _ Wm^{-2} (%)	-9.28 (-1.24) 37.3 (5.0)	-19.28 (-2.58) 31.5 (4.2)

Aqua Shortwave Clear-Sky

Sites # of Points		SWA	SWB
Continental 3049	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-11.24 (-1.55) 28.6 (3.9)	-29.56 (-4.08) 25.4 (3.5)
Coastal 79	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-7.33 (-1.09) 20.5 (3.1)	-5.15 (-0.77) 16.7 (2.5)
Ant-Arctic 143	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-40.05 (-9.78) 28.8 (7.0)	3.55 (0.87) 15.8 (3.9)
Desert 118	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-44.81 (-5.59) 34.3 (4.3)	-16.61 (-2.07) 43.3 (5.4)
Island 35	Bias Wm^{-2} (%) σ Wm^{-2} (%)	82.74 (10.19) 82.1 (10.1)	74.77 (9.21) 75.6 (9.3)
Global 3424	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-12.55 (-1.76) 36.1 (5.1)	-26.10 (-3.66) 33.0 (4.6)

Conclusions: Shortwave Clear-sky

CERES derived SW surface fluxes are generally within desired accuracies (biases) for model B. In contrast, the results for model A are satisfactory only for coastal and continental cases but not for the (ant)arctic, desert and island cases. A major source of the error has been attributed to the current aerosol maps, which are in the process of being replaced with the climatological aerosol maps based upon 46 months of the Model for Atmospheric Transport and Chemistry (MATCH) data.

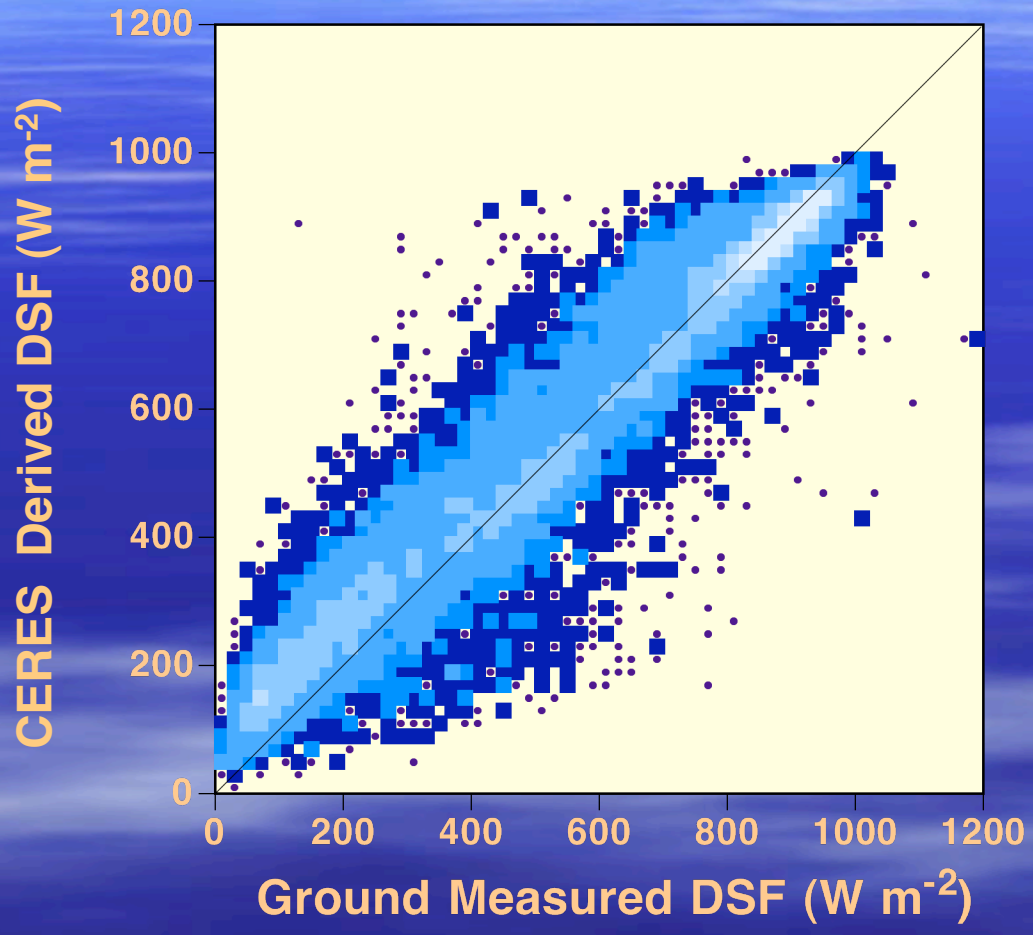
Precision still requires substantial improvement, with mismatches in scene identification being a major source of error.

Terra 2B & Aqua 1B results are similar for clear-sky.

Terra 2B

Shortwave B Cloudy-Sky
March 2000 through December 2003

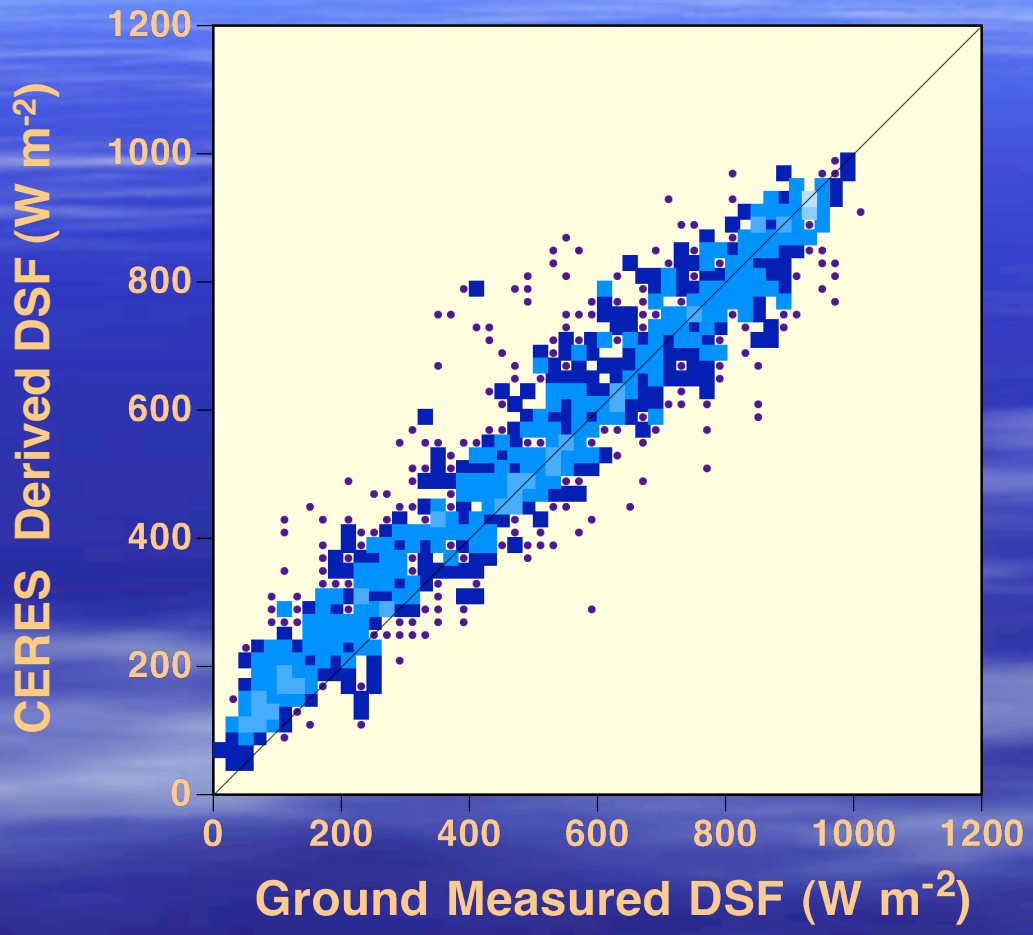
Shortwave B Cloudy-Sky Continental



• 1 ■ 2 - 5 ■ 6 - 10 ■ 11 - 20 ■ 21 - 40 ■ 41 - 80 ■ 81 - 100 ■ > 100

Terra 2B

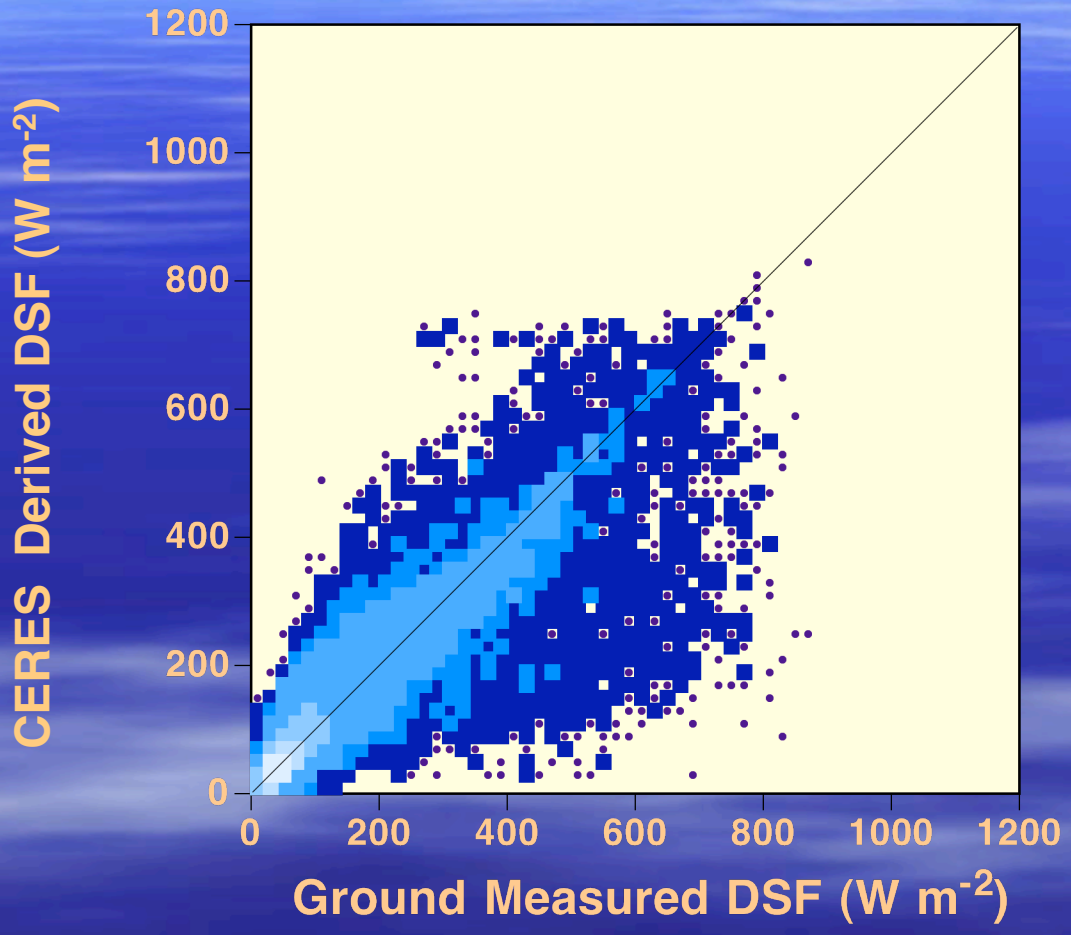
Shortwave B Cloudy-Sky Coastal



1 | 2 - 3 | 4 - 9 | 10 - 12 | 13 - 15 | 16 - 18 | 19 - 20 | > 20

Terra 2B

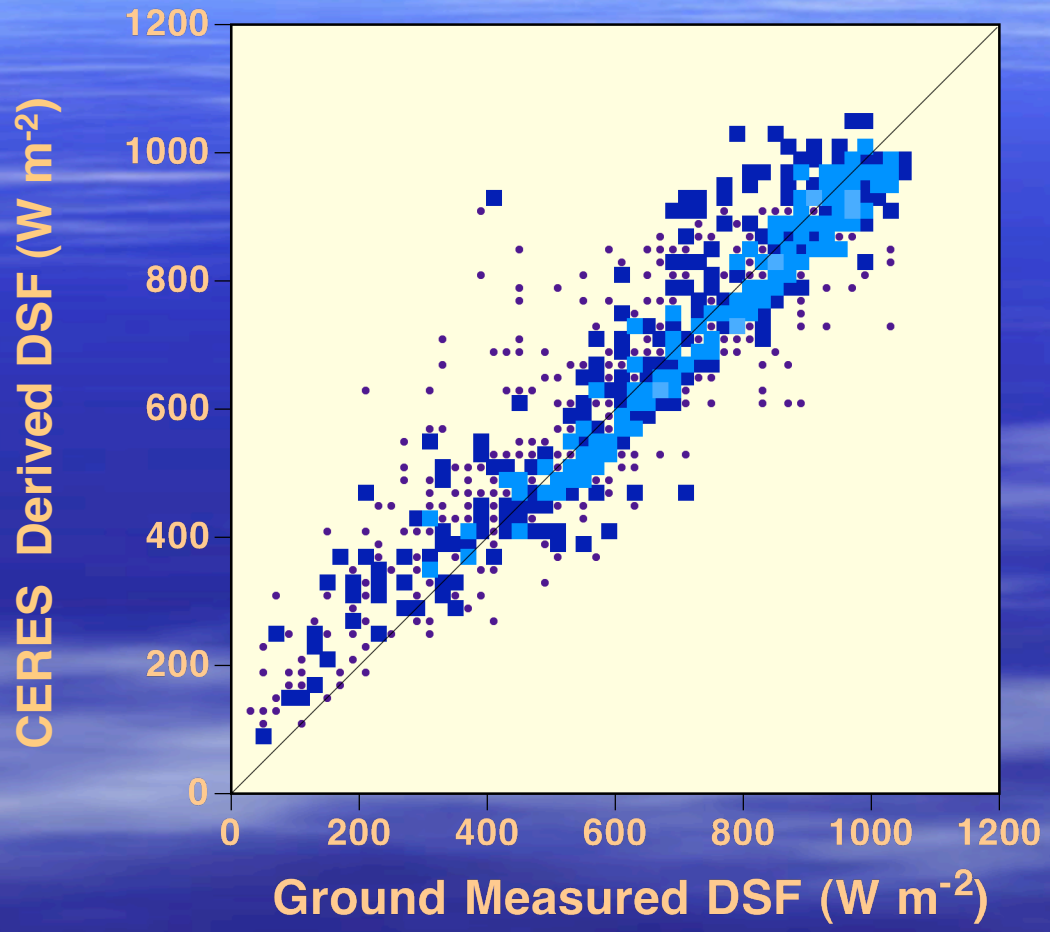
Shortwave B Cloudy-Sky
Ant-arctic



• 1 ■ 2 - 10 ■ 11 - 20 ■ 21 - 50 ■ 51 - 100 ■ 101 - 150 ■ 151 - 200 ■ > 200

Terra 2B

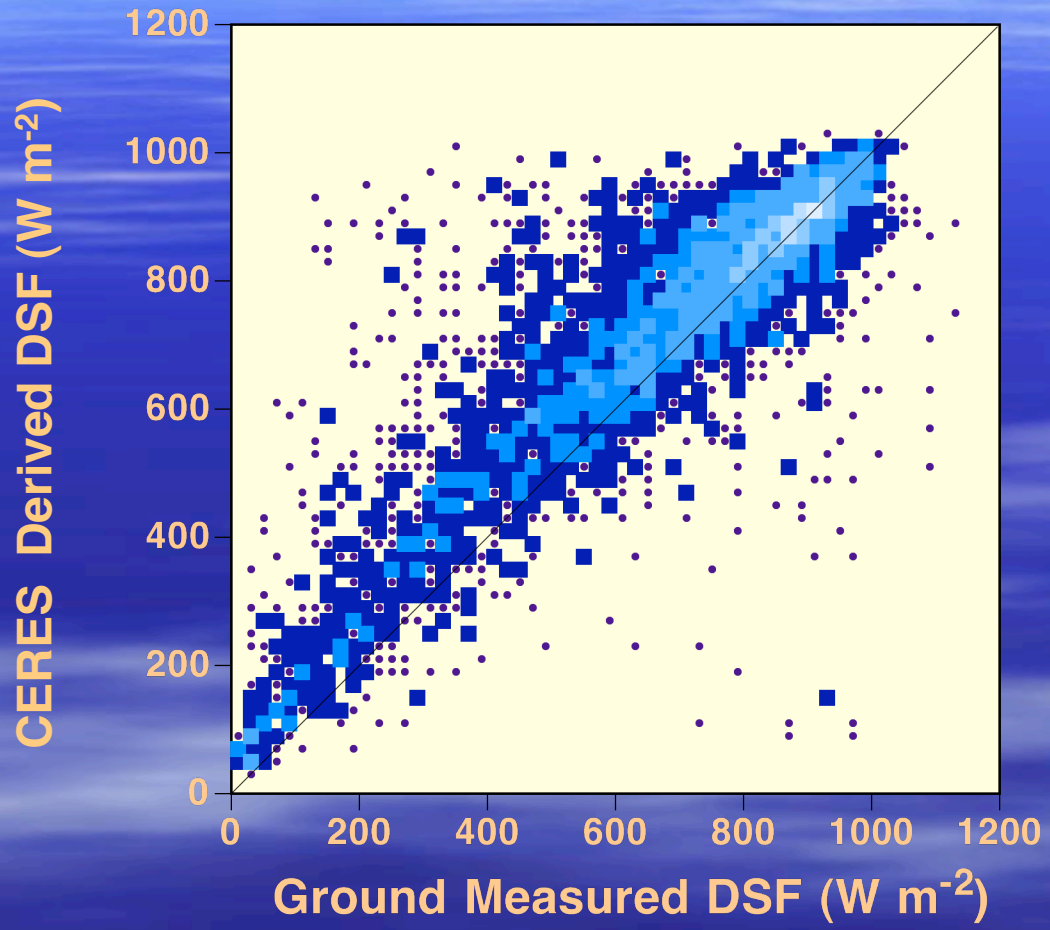
Shortwave B Cloudy-Sky Desert



1 | 2 - 3 | 4 - 9 | 10 - 12 | 13 - 15 | 16 - 18 | 19 - 20 | > 20

Terra 2B

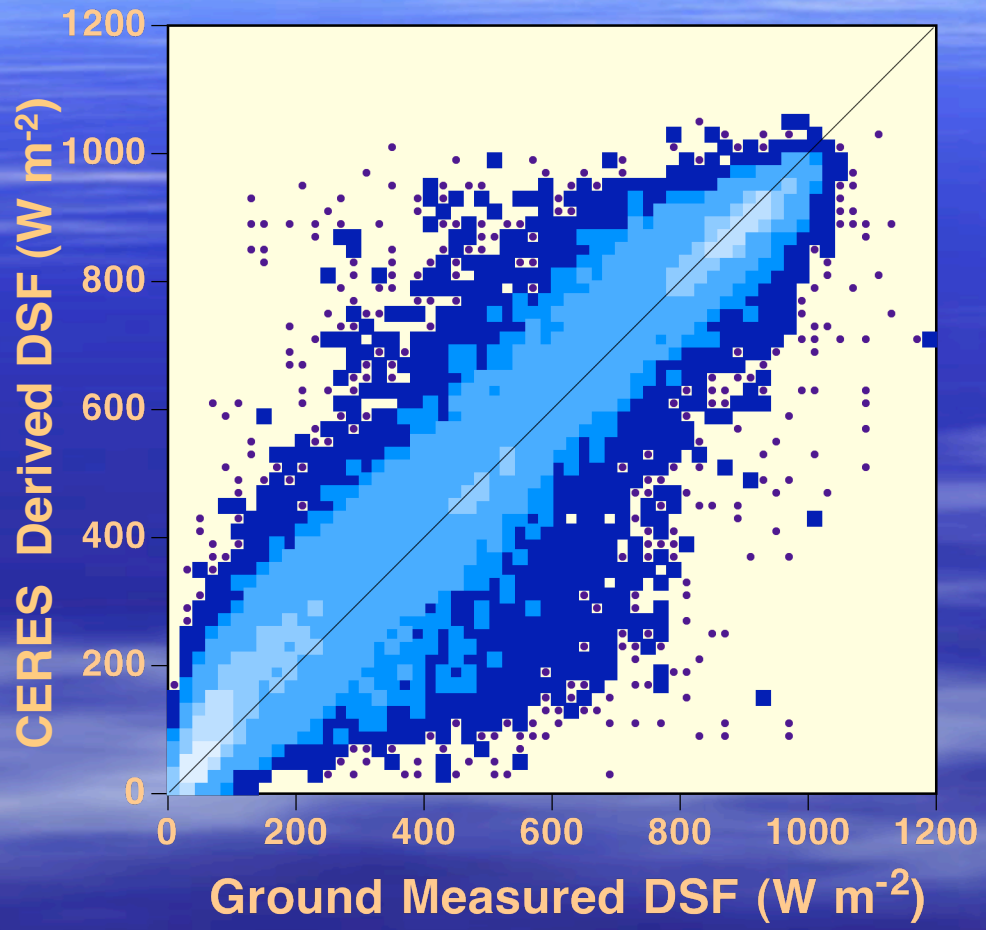
Shortwave B Cloudy-Sky Island



1 2 - 5 6 - 10 11 - 20 21 - 30 31 - 40 41 - 50 > 50

Terra 2B

Shortwave B Cloudy Global



1 ■ 2 - 10 ■ 11 - 20 ■ 21 - 50 ■ 51 - 100 ■ 101 - 150 ■ 151 - 200 ■ > 200

Terra 2B

Terra Shortwave B Cloudy-Sky

Sites # of Points		SWB
Continental 19988	Bias Wm^{-2} (%) σ Wm^{-2} (%)	26.24 (5.05) 83.7 (16.1)
Coastal 1951	Bias Wm^{-2} (%) σ Wm^{-2} (%)	33.80 (6.88) 68.1 (13.9)
Ant-Arctic 14043	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-18.69 (-7.68) 95.2 (39.1)
Desert 1229	Bias Wm^{-2} (%) σ Wm^{-2} (%)	12.42 (1.86) 83.3 (12.4)
Island 4883	Bias Wm^{-2} (%) σ Wm^{-2} (%)	55.44 (8.38) 108.9 (16.5)
Global 42094	Bias Wm^{-2} (%) σ Wm^{-2} (%)	14.59 (3.26) 101.5 (22.7)

Aqua Shortwave B Cloudy-Sky

Sites # of Points		SWB
Continental 13653	Bias Wm^{-2} (%) σ Wm^{-2} (%)	21.11 (4.06) 86.5 (16.6)
Coastal 1284	Bias Wm^{-2} (%) σ Wm^{-2} (%)	27.40 (5.73) 80.2 (16.8)
Ant-Arctic 4273	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-9.47 (-3.86) 86.6 (35.3)
Desert 891	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-26.03 (-3.55) 74.4 (10.2)
Island 2068	Bias Wm^{-2} (%) σ Wm^{-2} (%)	69.37 (11.37) 111.9 (18.3)
Global 22169	Bias Wm^{-2} (%) σ Wm^{-2} (%)	18.19 (3.78) 95.3 (19.8)

Conclusions: Shortwave Cloudy-Sky

CERES SW surface fluxes derived with model B provide results close to the desired accuracies (biases) for most cases, but accurate results remain challenging for the coastal and island cases.

Precision still requires substantial improvement, with mismatches in scene identification being a major source of error.

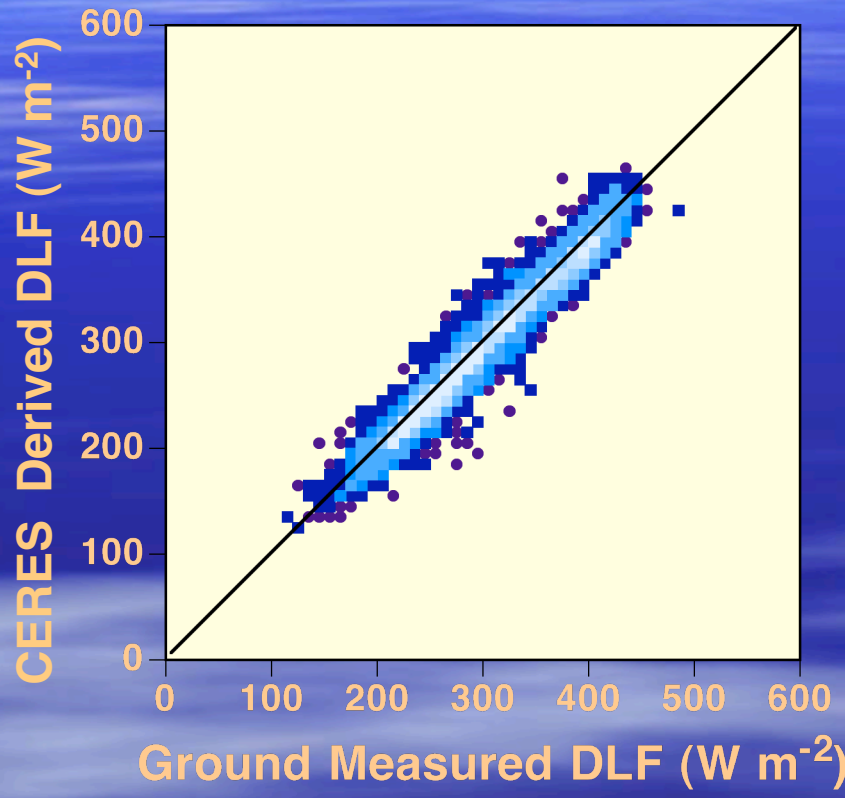
Terra 2B & Aqua 1B results are similar for cloudy-sky.

Terra 2B

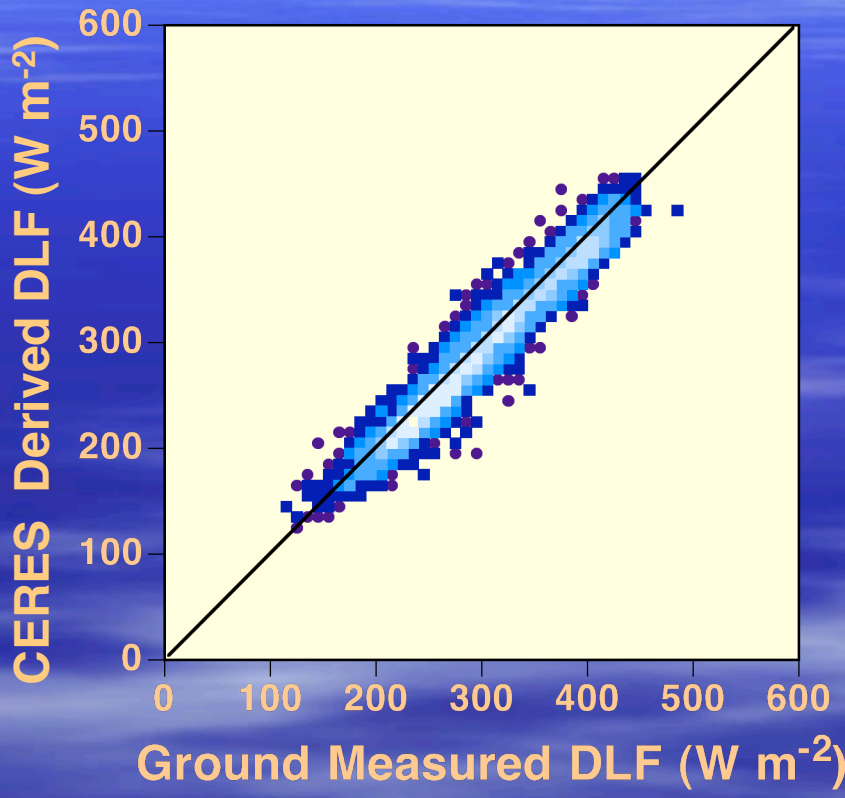
Longwave Clear-Sky
March 2000 through December 2003

Longwave Clear-Sky Continental

Model A



Model B

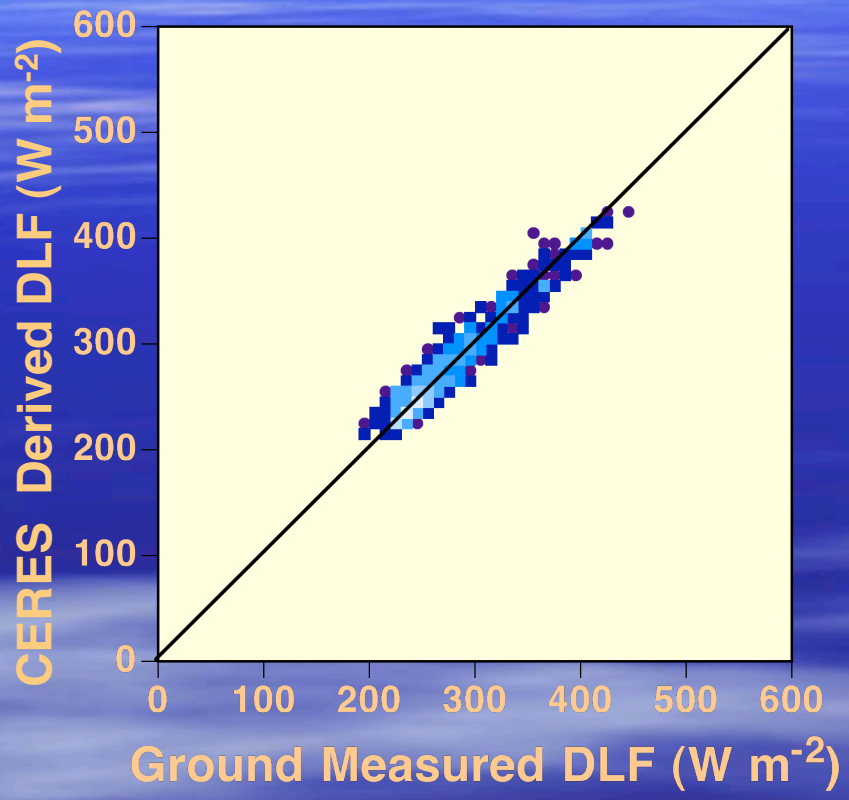


• 1 ▪ 2 - 10 ▪ 11 - 20 ▪ 21 - 50 ▪ 51 - 100 ▪ 101 - 150 ▪ 151 - 200 ▪ > 200

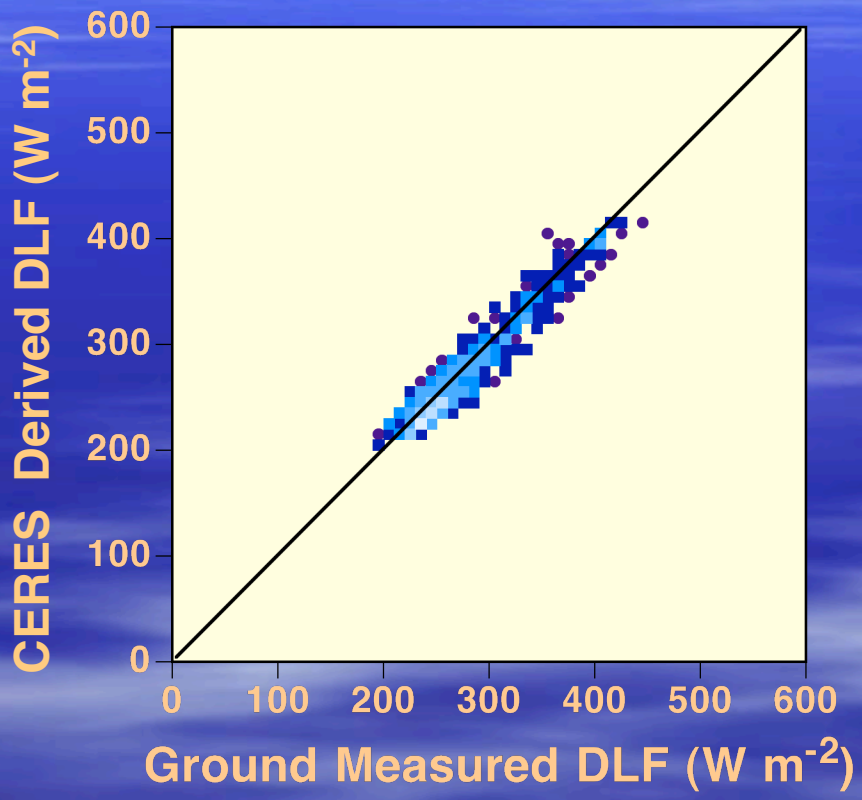
Terra 2B

Longwave Clear-Sky Coastal

Model A



Model B

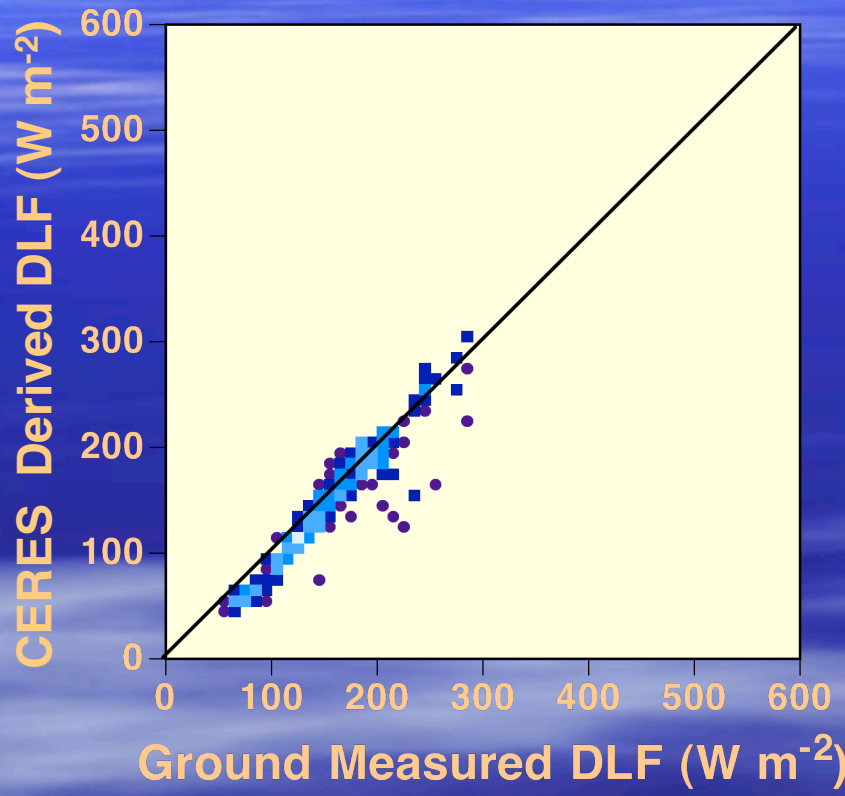


• 1 ▪ 2 - 5 ▪ 6 - 10 ▪ 11 - 15 ▪ 16 - 20 ▪ 21 - 25 ▪ 26 - 30 ▪ > 30

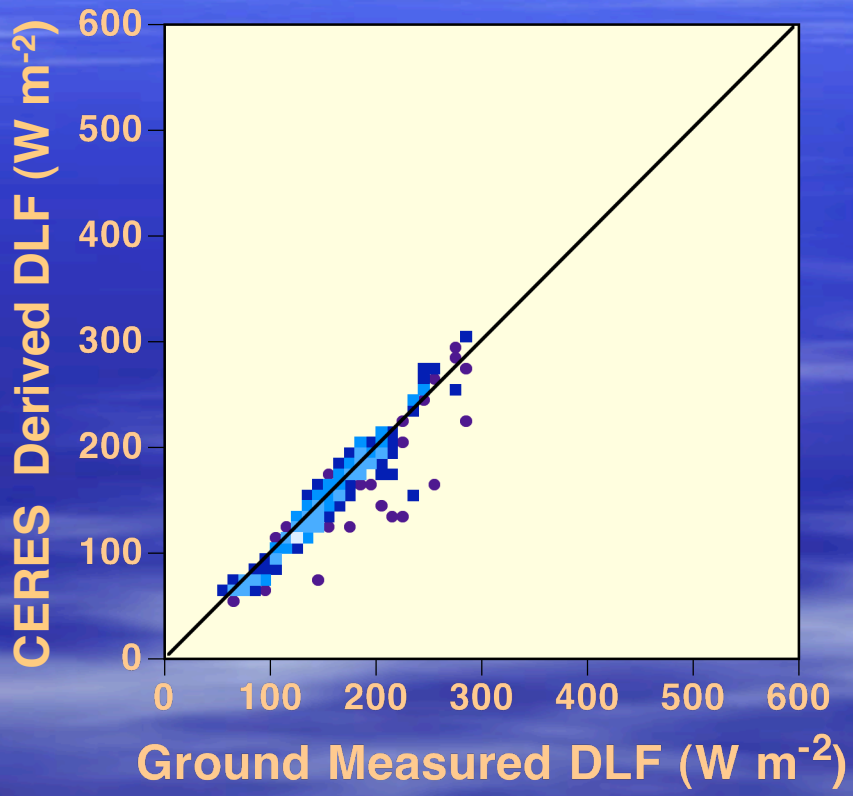
Terra 2B

Longwave Clear-Sky Ant-arctic

Model A



Model B

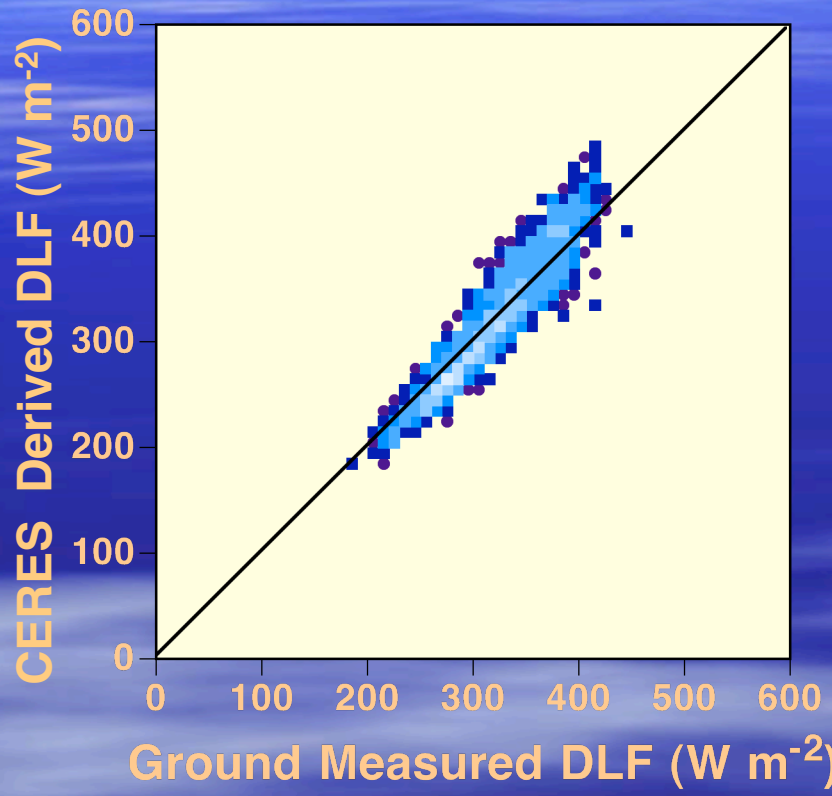


• 1 ■ 2 - 5 ■ 6 - 10 ■ 11 - 20 ■ 21 - 30 ■ 31 - 40 ■ 41 - 60 ■ > 60

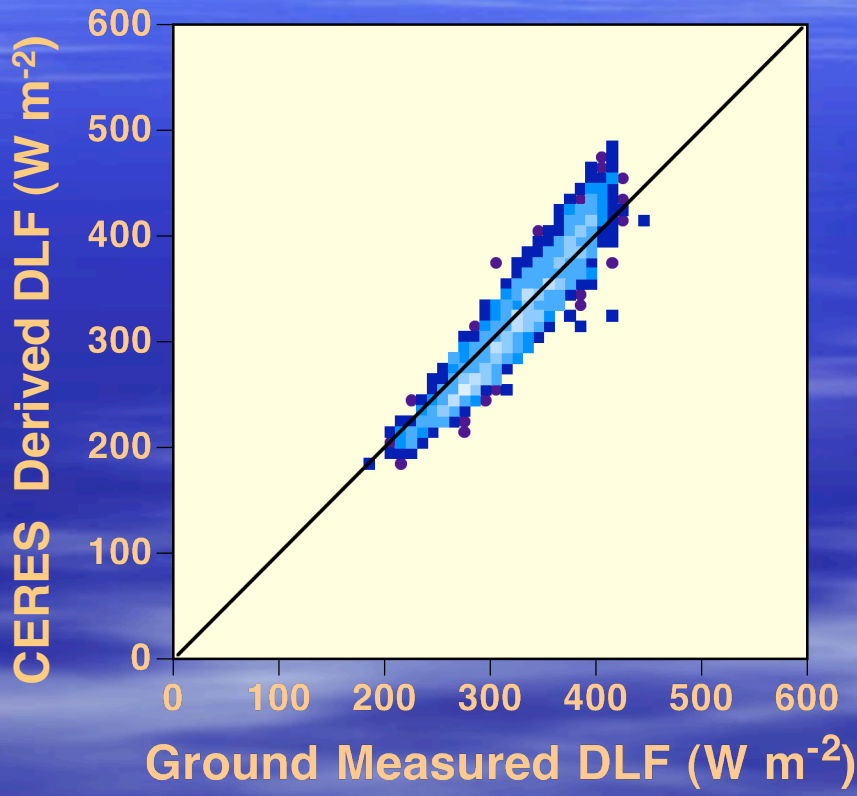
Terra 2B

Longwave Clear-Sky Desert

Model A



Model B

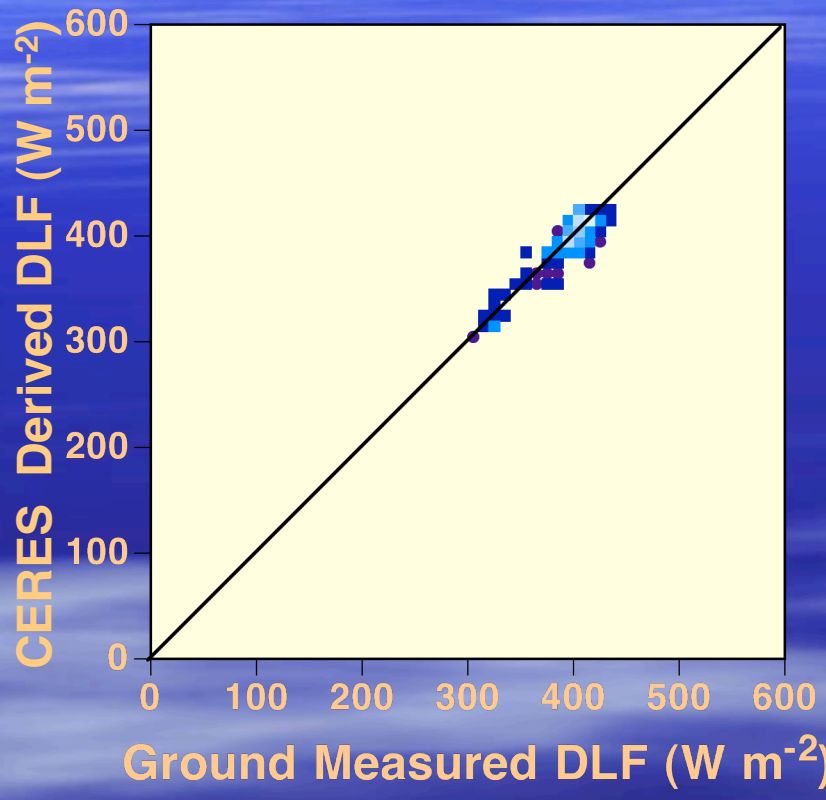


• 1 ■ 2 - 5 ■ 6 - 10 ■ 11 - 20 ■ 21 - 30 ■ 31 - 40 ■ 41 - 60 ■ > 60

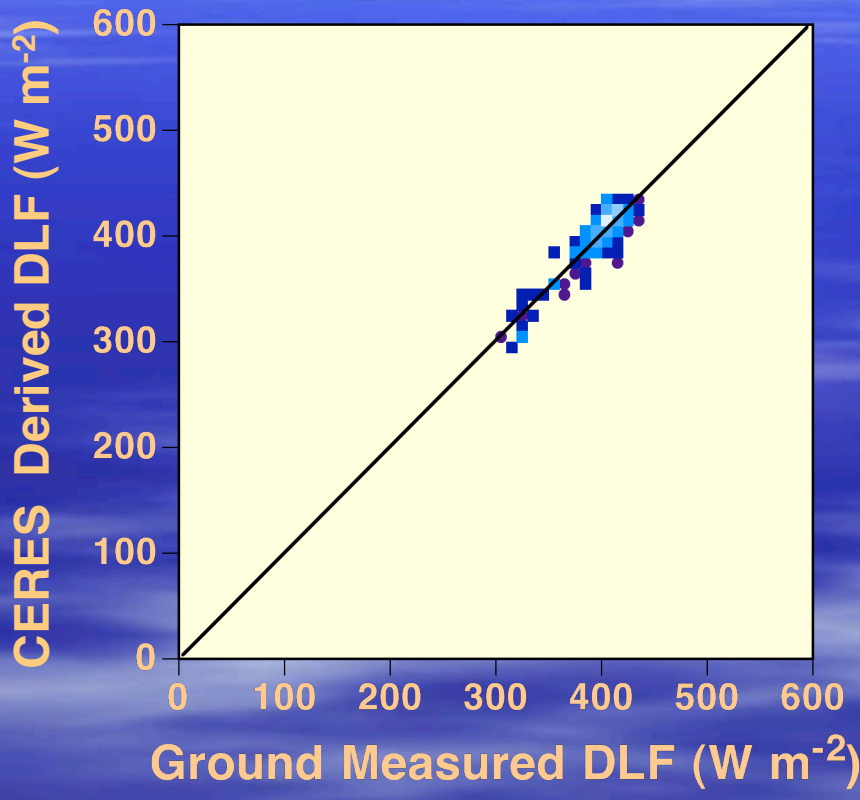
Terra 2B

Longwave Clear-Sky Island

Model A



Model B

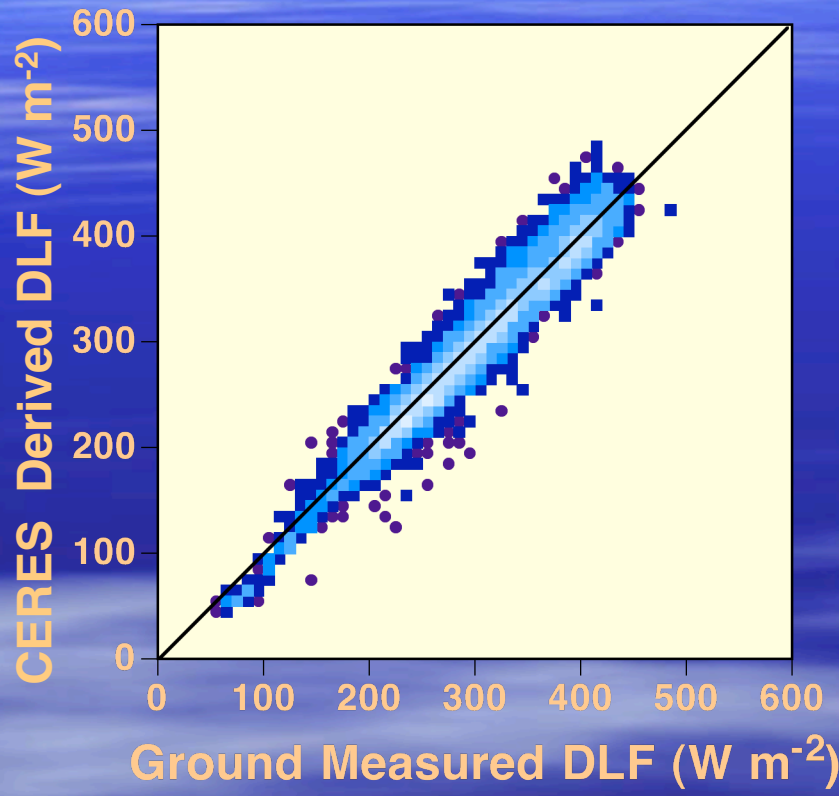


1 2 - 3 4 - 9 10 - 12 13 - 15 16 - 20 21 - 25 > 25

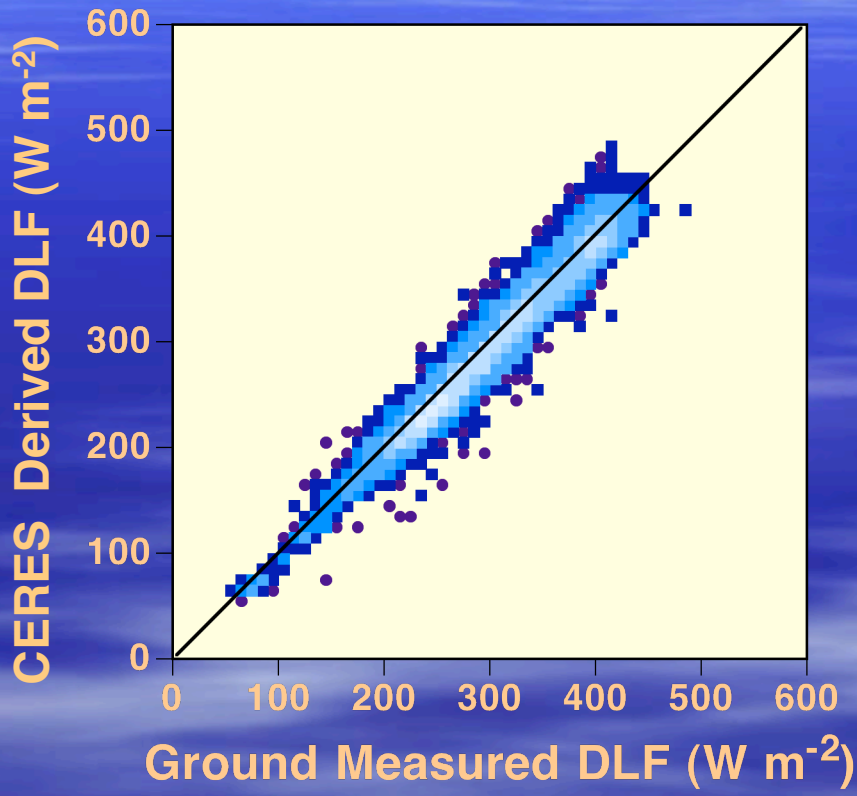
Terra 2B

Longwave Clear-Sky Global

Model A



Model B



• 1 ▪ 2 - 10 ▪ 11 - 20 ▪ 21 - 50 ▪ 51 - 100 ▪ 101 - 200 ▪ 201 - 400 ▪ > 400

Terra 2B

Terra Longwave Clear-Sky

Sites # of Points		LWA	LWB
Continental 16608	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-4.65 (-1.54) 13.2 (4.4)	-7.47 (-2.47) 13.2 (4.4)
Coastal 824	Bias Wm^{-2} (%) σ Wm^{-2} (%)	3.15 (1.12) 12.7 (4.5)	-2.99 (-1.06) 13.1 (4.6)
Ant-Arctic 630	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-8.79 (-5.87) 12.8 (8.6)	-5.89 (-3.93) 12.3 (8.2)
Desert 2763	Bias Wm^{-2} (%) σ Wm^{-2} (%)	2.28 (0.70) 20.1 (6.2)	-2.09 (-0.64) 19.0 (5.8)
Island 242	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-0.50 (-0.13) 10.9 (2.8)	2.98 (0.76) 12.0 (3.0)
Global 21067	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-3.51 (-1.17) 14.9 (4.9)	-6.42 (-2.13) 14.7 (4.9)

Aqua Longwave Clear-Sky

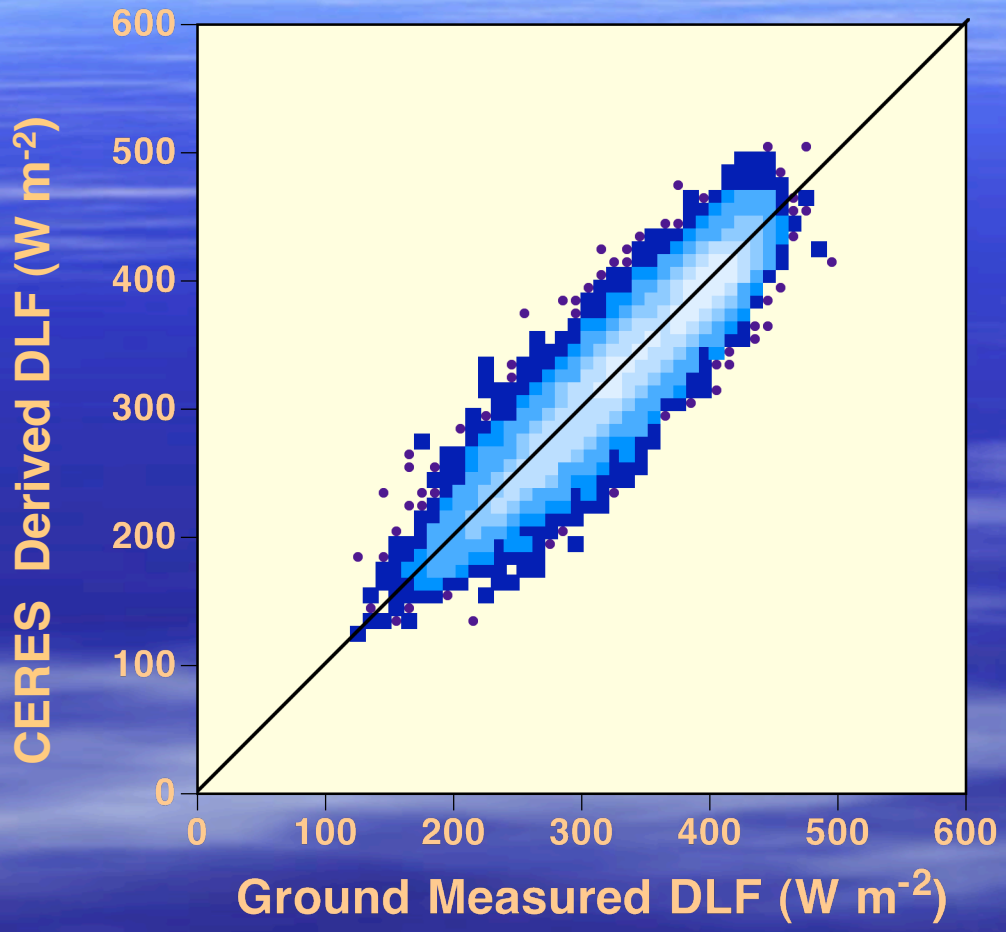
Sites # of Points		LWA	LWB
Continental 8296	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-4.26 (-1.47) 14.5 (5.0)	-7.45 (-2.58) 14.3 (5.0)
Coastal 378	Bias Wm^{-2} (%) σ Wm^{-2} (%)	5.18 (1.82) 16.3 (5.7)	1.12 (0.39) 15.8 (5.6)
Ant-arctic 448	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-15.57 (-14.03) 8.7 (7.8)	-8.33 (-7.51) 8.8 (7.9)
Desert 661	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-10.05 (-3.30) 17.3 (5.7)	-12.40 (-4.08) 17.4 (5.7)
Island 92	Bias Wm^{-2} (%) σ Wm^{-2} (%)	0.17 (0.04) 13.1 (3.4)	2.11 (0.54) 15.0 (3.9)
Global 9875	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-4.75 (-1.68) 15.3 (5.4)	-7.41 (-2.62) 15.0 (5.3)

Aqua 1B

Terra 2B

Longwave B Cloudy-Sky
March 2000 through December 2003

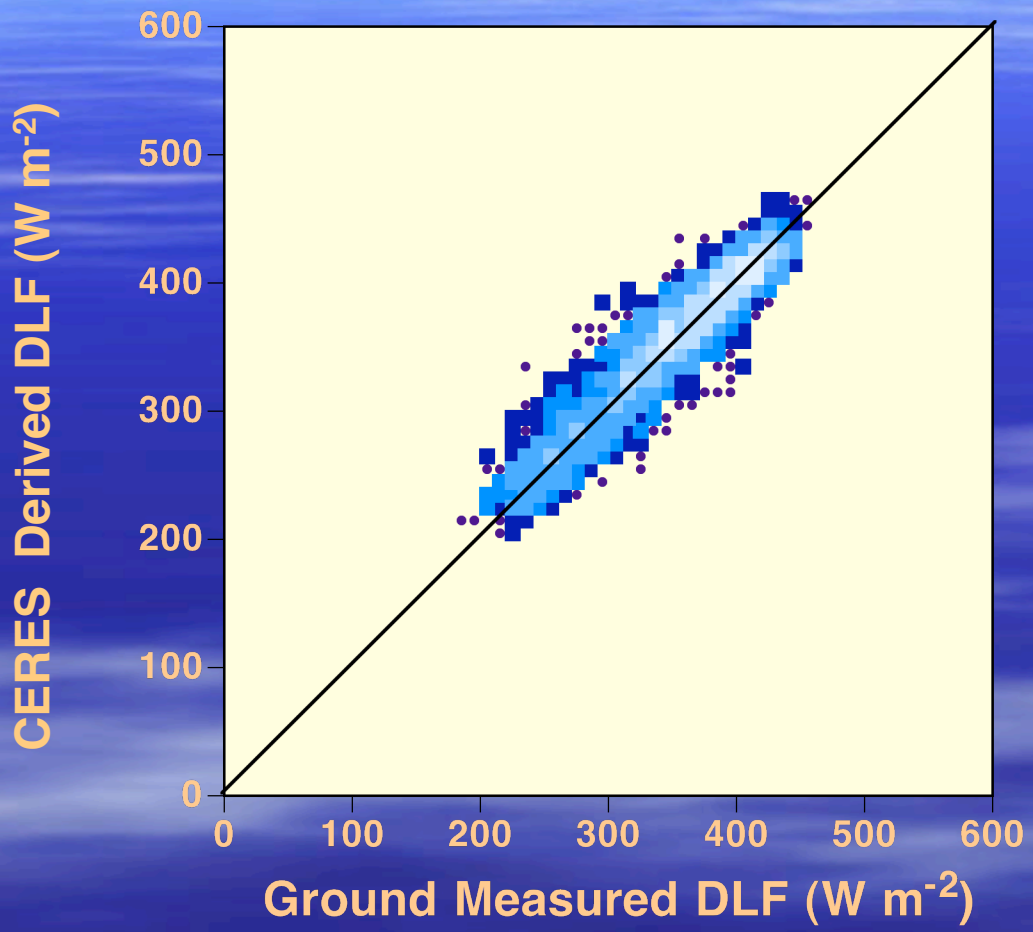
Longwave B Cloudy-Sky Continental



• 1 ■ 2 - 10 ■ 11 - 20 ■ 21 - 50 ■ 51 - 100 ■ 101 - 200 ■ 201 - 400 ■ > 400

Terra 2B

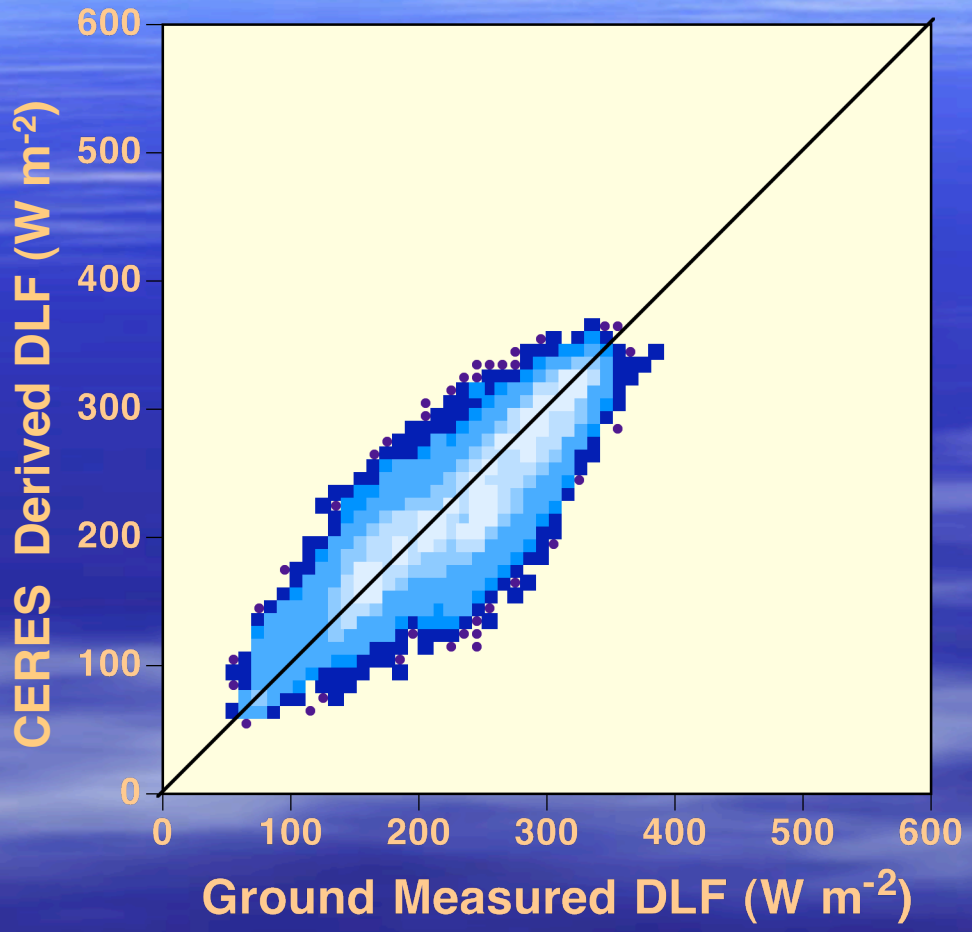
Longwave B Cloudy-Sky Coastal



• 1 ■ 2 - 5 ■ 6 - 10 ■ 11 - 20 ■ 21 - 30 ■ 31 - 40 ■ 41 - 60 ■ > 60

Terra 2B

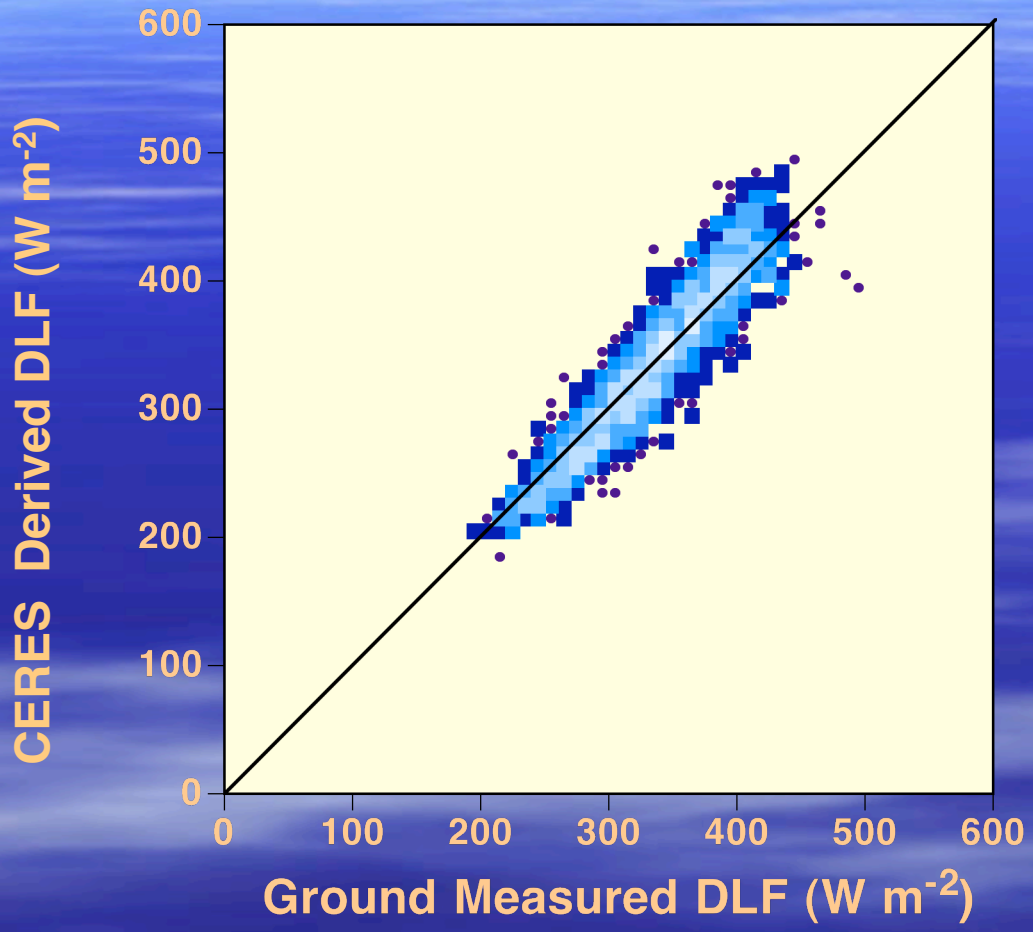
Longwave B Cloudy-Sky
Ant-arctic



• 1 ■ 2 - 10 ■ 11 - 20 ■ 21 - 50 ■ 51 - 100 ■ 101 - 150 ■ 151 - 200 ■ > 200

Terra 2B

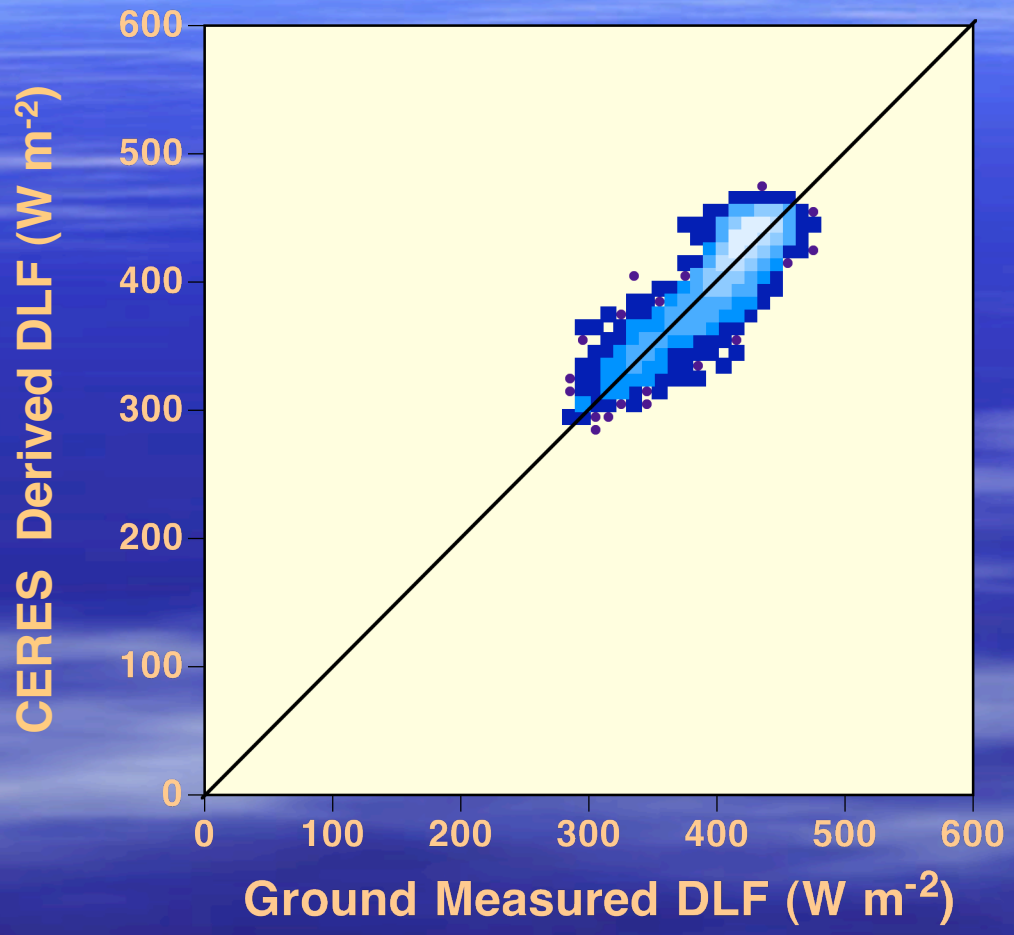
Longwave B Cloudy-Sky Desert



• 1 ■ 2 - 5 ■ 6 - 10 ■ 11 - 15 ■ 16 - 20 ■ 21 - 30 ■ 31 - 40 ■ > 40

Terra 2B

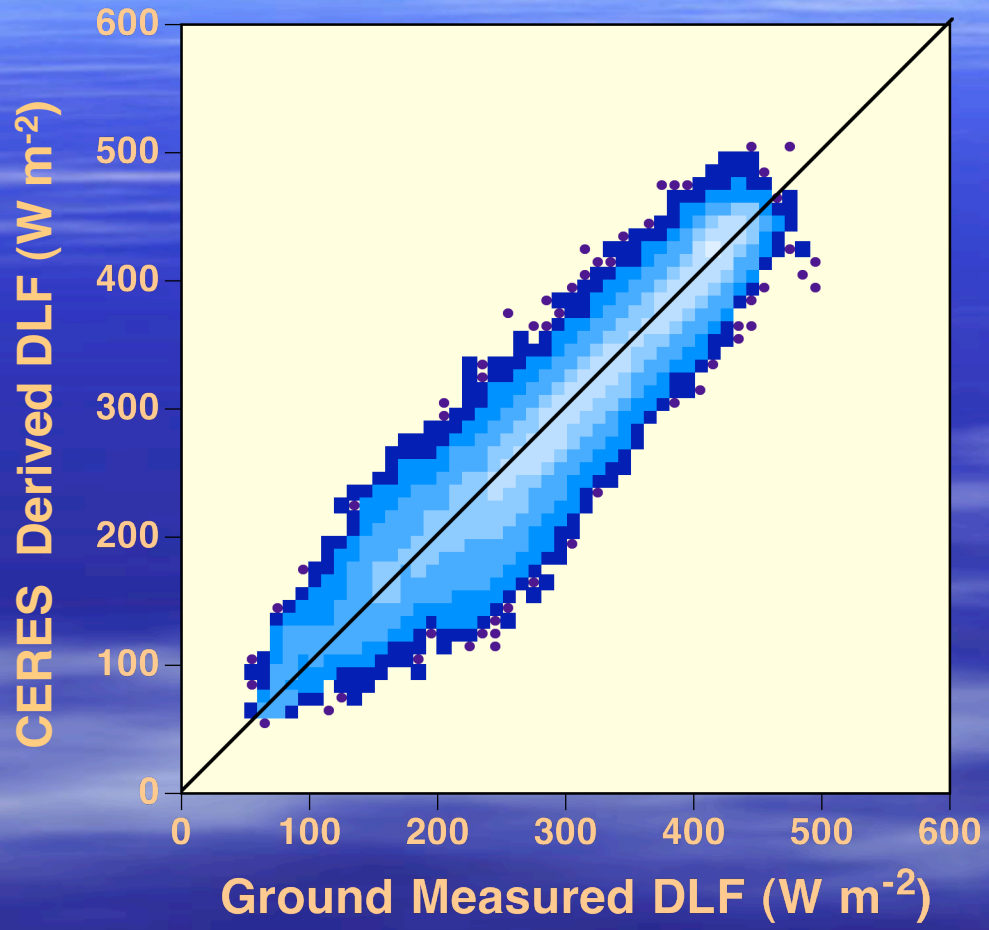
Longwave B Cloudy-Sky
Island



• 1 ■ 2 - 10 ■ 11 - 30 ■ 31 - 100 ■ 101 - 150 ■ 151 - 300 ■ 301 - 600 ■ > 600

Terra 2B

Longwave B Cloudy Global



1 2 - 10 11 - 50 51 - 100 101 - 200 201 - 500 501 -1000 >1000

Terra 2B

Terra Longwave B Cloudy-Sky

Sites # of Points		LWB
Continental 41220	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-1.64 (-0.49) 20.2 (6.1)
Coastal 4133	Bias Wm^{-2} (%) σ Wm^{-2} (%)	5.11 (1.48) 19.6 (5.7)
Ant-Arctic 32658	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-5.11 (-2.26) 27.6 (12.2)
Desert 3025	Bias Wm^{-2} (%) σ Wm^{-2} (%)	2.17 (0.65) 20.9 (6.3)
Island 10333	Bias Wm^{-2} (%) σ Wm^{-2} (%)	5.48 (1.33) 14.5 (3.5)
Global 91369	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-1.64 (-0.54) 23.8 (7.8)

Aqua Longwave B Cloudy-Sky

Sites # of Points		LWB
Continental 26837	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-2.37 (-0.72) 21.8 (6.6)
Coastal 2545	Bias Wm^{-2} (%) σ Wm^{-2} (%)	4.39 (1.27) 20.2 (5.9)
Ant-arctic 9159	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-7.00 (-3.10) 26.7 (11.8)
Desert 1493	Bias Wm^{-2} (%) σ Wm^{-2} (%)	5.01 (1.52) 24.6 (7.5)
Island 4388	Bias Wm^{-2} (%) σ Wm^{-2} (%)	6.57 (1.57) 13.7 (3.3)
Global 44422	Bias Wm^{-2} (%) σ Wm^{-2} (%)	-1.80 (-0.57) 23.3 (7.3)

Conclusions: Longwave

CERES derived LW surface fluxes are within desired accuracies (biases) for both clear-sky (models A & B) & cloudy-sky (model B) cases.

Precision is within desired limits for clear-sky cases.

Precision is close to desired limits for cloudy-sky cases, with the increased scatter between TOA & surface measurements being attributed to mismatches in derived cloud properties (scene identification).

Terra 2B & Aqua 1B results are very similar.