Validation of CERES Aqua2A SSF Surface-only Fluxes

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Aqua 2A

Validation of CERES Aqua2A 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	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

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

Aqua 2A

SW 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 Algorithms/References

- 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.

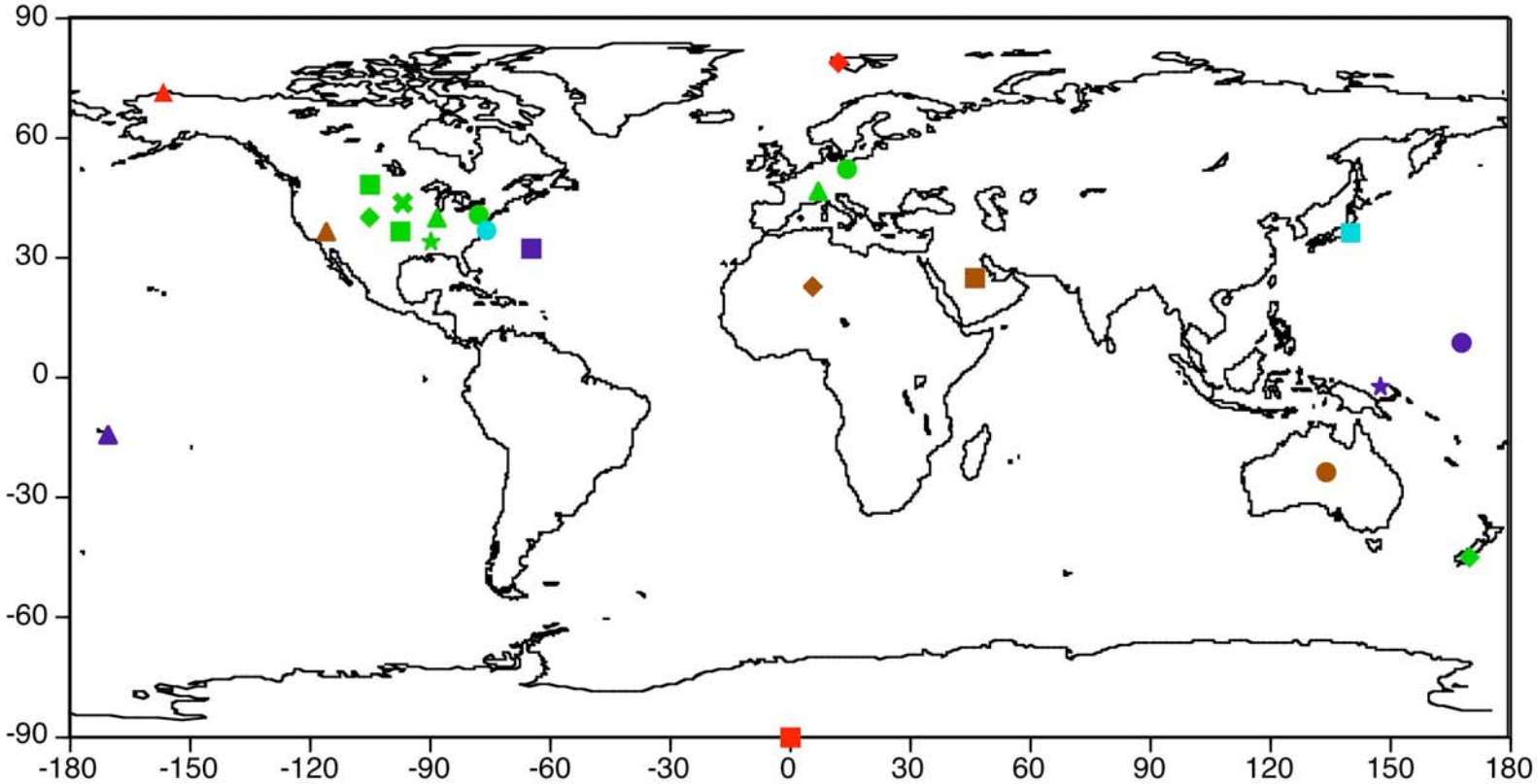
- LW Model C:

  Zhou & Cess (2000): *J. Geophys. Res.*, **105**, 29703-29716.

  Zhou & Cess (2001): *J. Geophys. Res*. 106, 12477-12488.

- SW & LW Model B Validation

  Gupta *et al.* (2004): *J. Atmos. Ocean Tech.*, **21**, 742-752.



- 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
- 14.23S, 170.56W American Samoa
- 2.06S, 147.42 E Manus
- 36.05N, 140.13E Tatano
- 36.9N, 75.71W COVE
- 71.32N, 156.61W Barrow, AK
- 90.00S, 0.00 South Pole
- 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

Recent Changes to the SOFA Algorithms

SW Models

1) Model A: Replaced the GFDL aerosol optical depths with 550nm MATCH* climatological aerosol optical depths.
2) Model B: Replaced WCP-55 aerosol optical depths, and Staylor's single scattering albedos and asymmetry parameters with corresponding climatological broadband properties derived from MATCH* aerosol optical depths and OPAC spectral optical properties.
3) Model B: Replaced monthly climatological ERBE clear-sky TOA albedos with corresponding values derived from 46 months of Terra data.

* MATCH incorporates measurements for the period of 2000-2004.

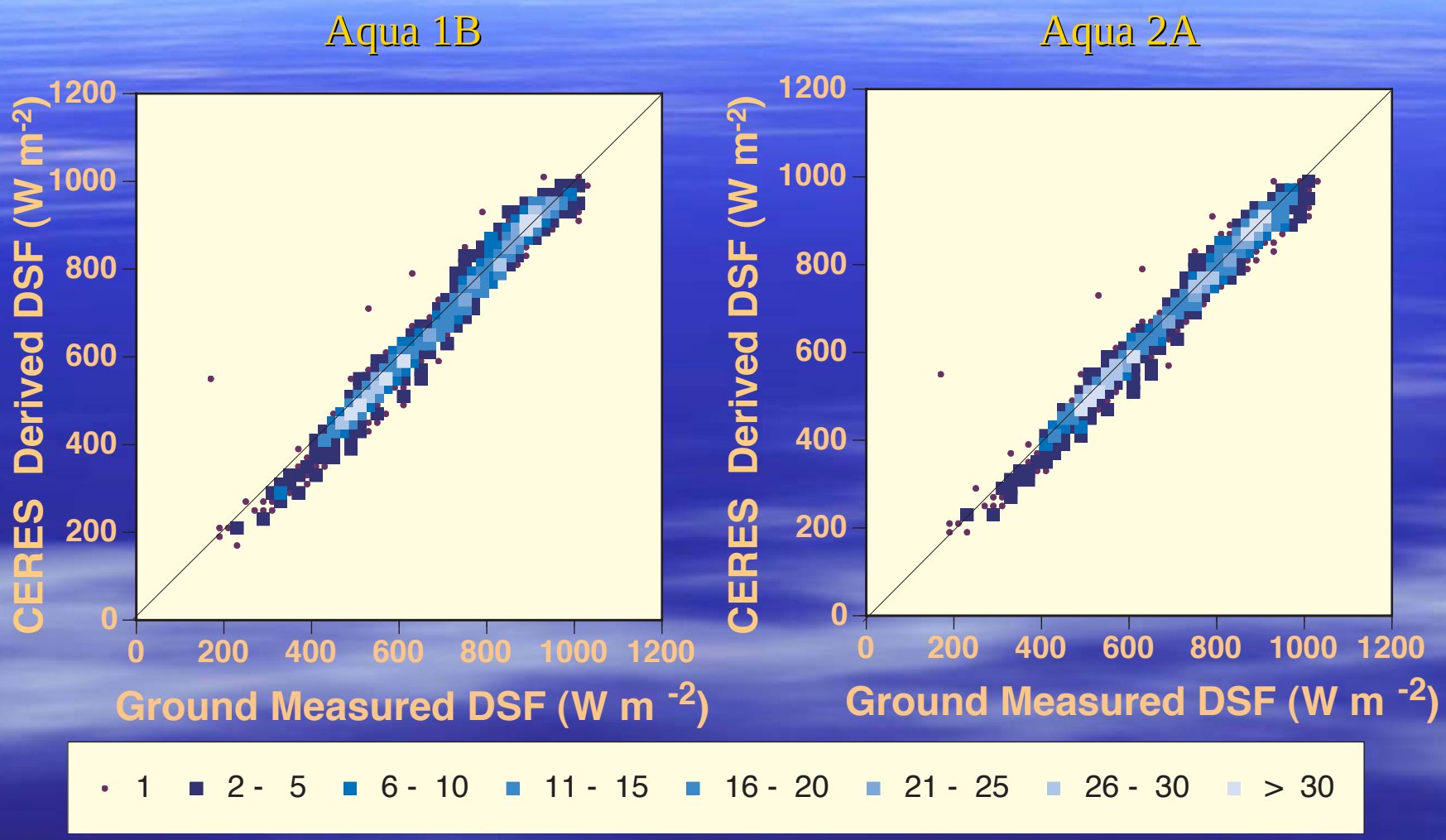
LW Models

1) Model A: No changes.
2) Model B: Modified routine to handle clouds over high altitude areas such as Tibet whenever cloud base pressures are unavailable.
3) Model C: Preparing Zhou-Cess model for delivery.

Shortwave Model A Clear-Sky

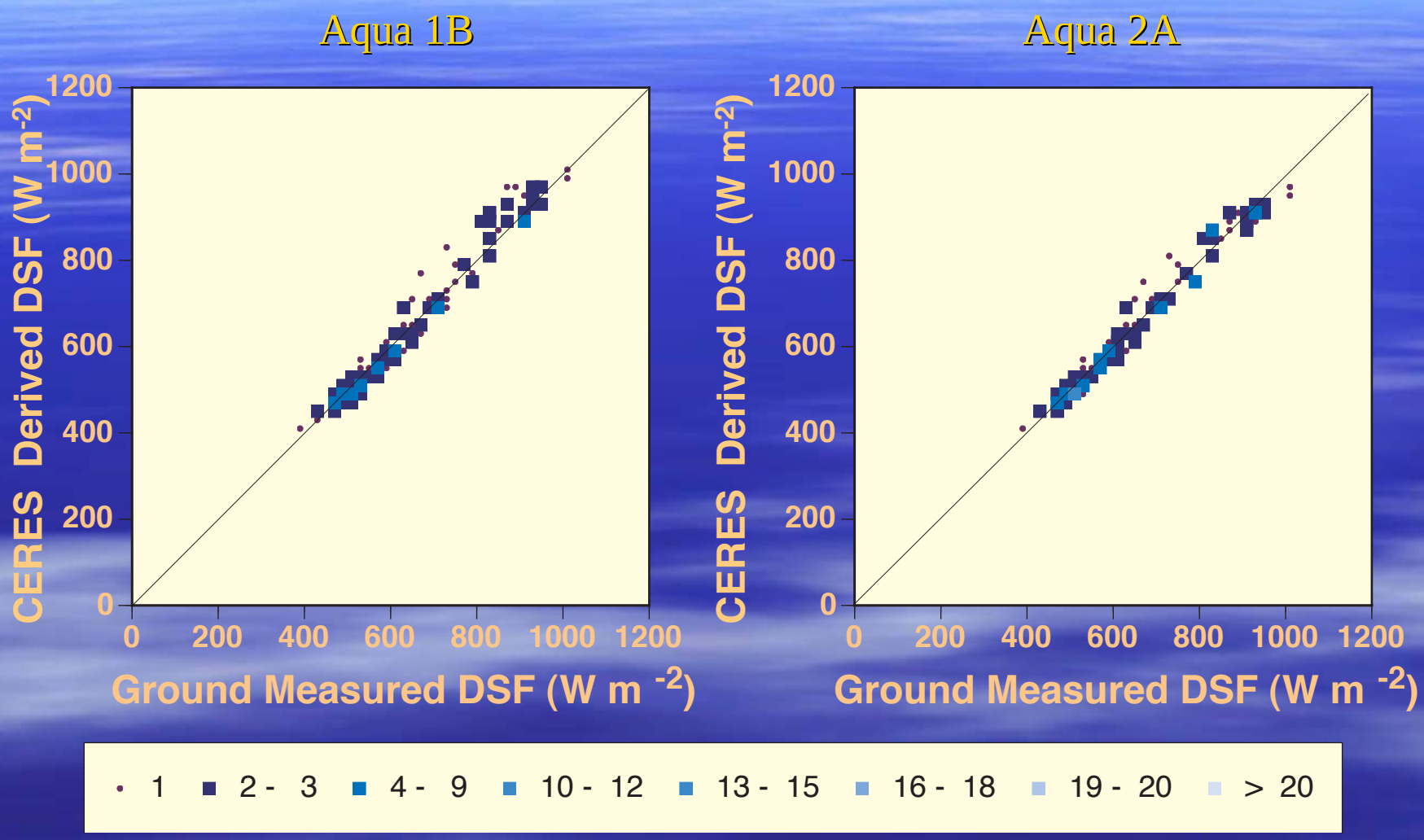
Aqua 2A vs Aqua 1B

Shortwave Model A Clear-Sky Continental



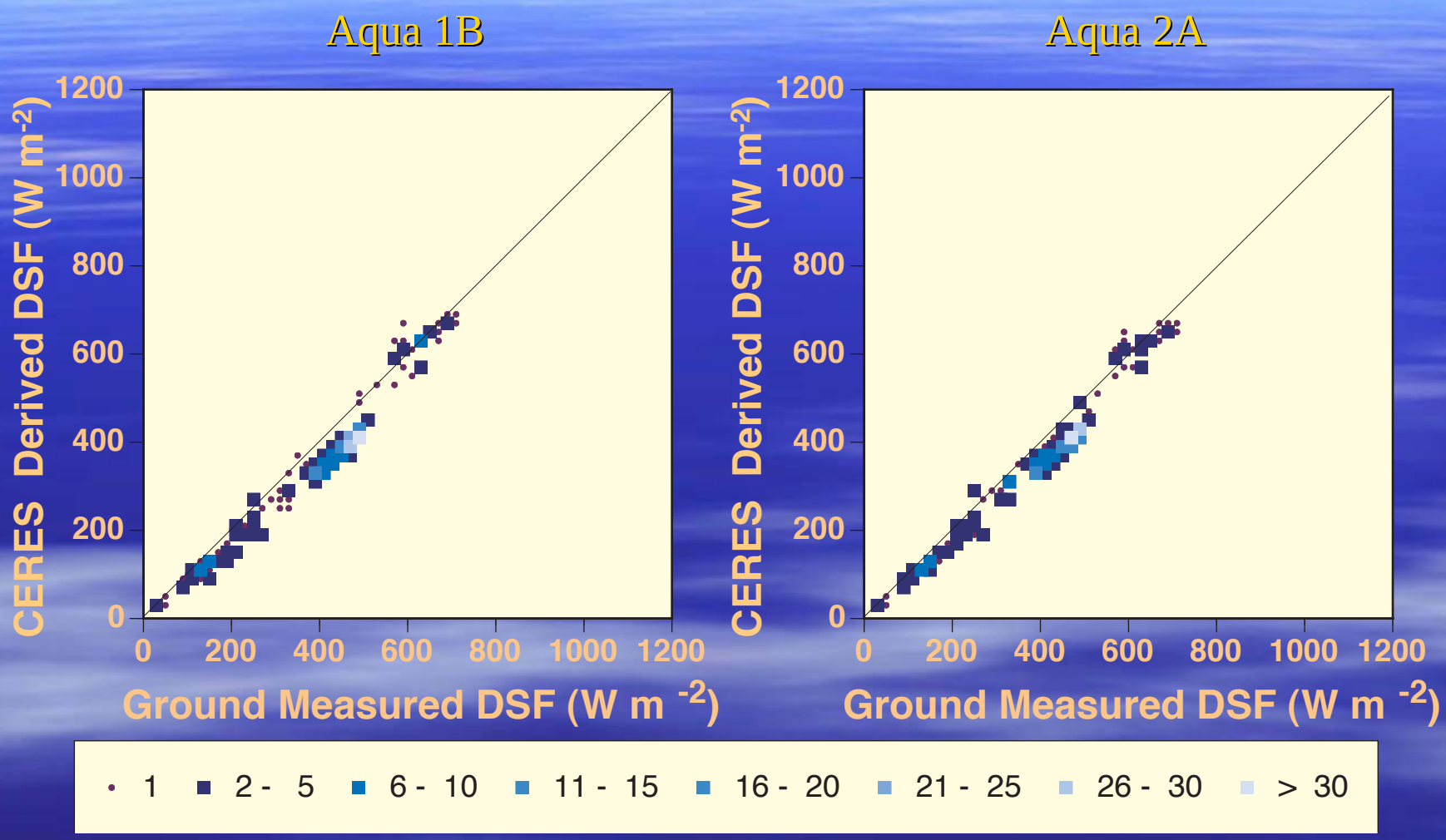
Aqua 2A

Shortwave Model A Clear-Sky Coastal



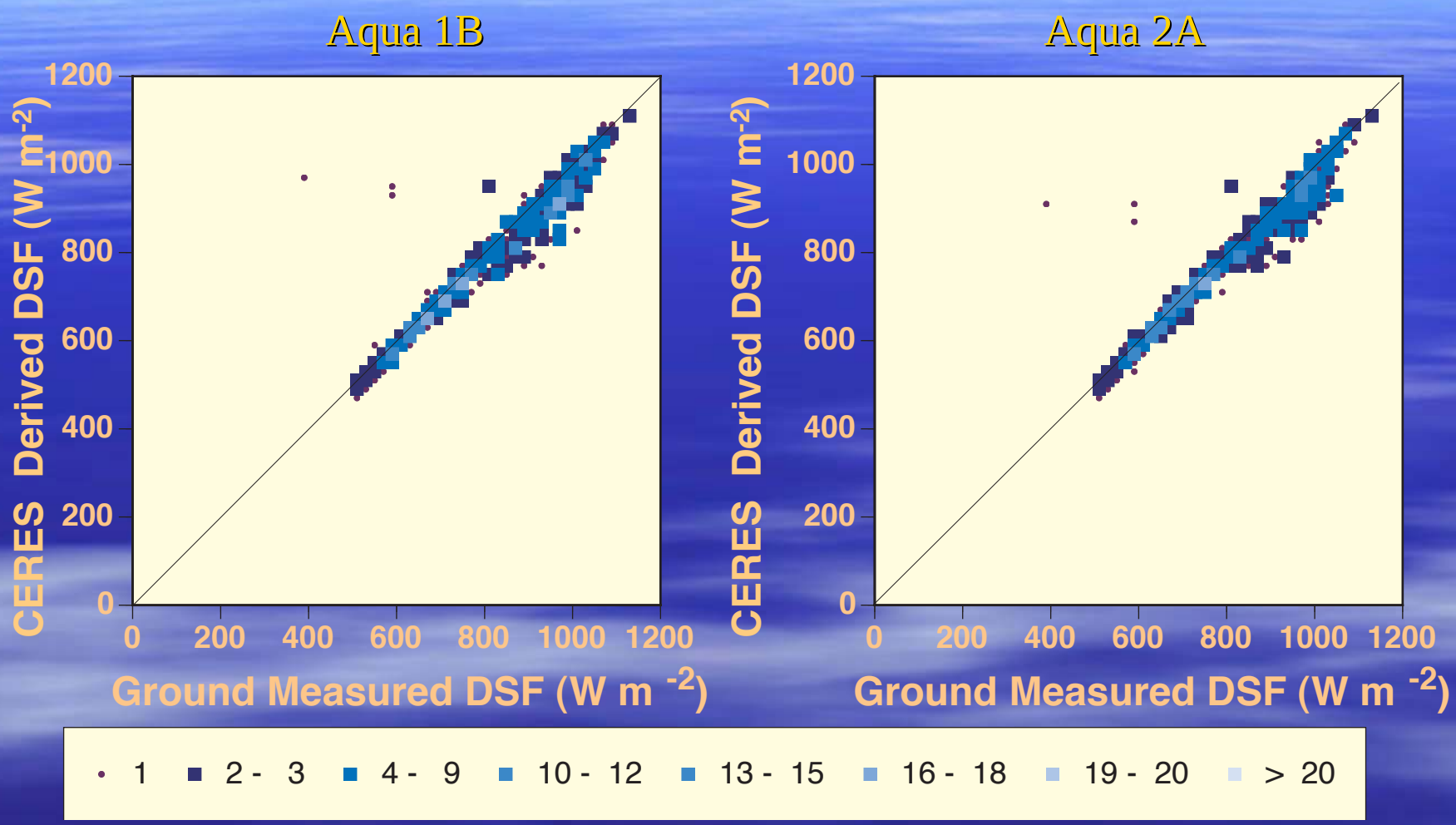
Aqua 2A

Shortwave Model A Clear-Sky Ant-arctic



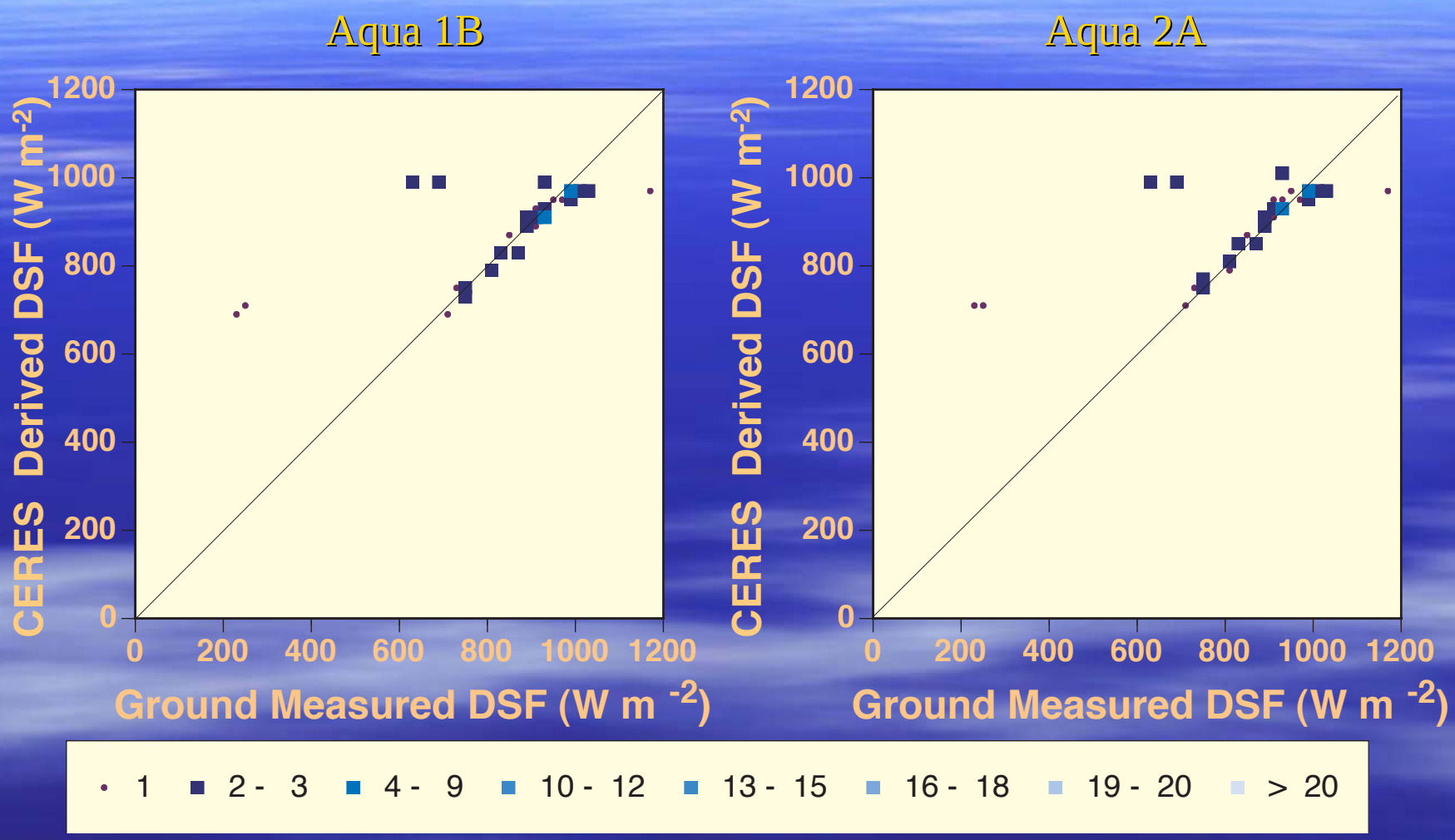
Aqua 2A

Shortwave Model A Clear-Sky Desert



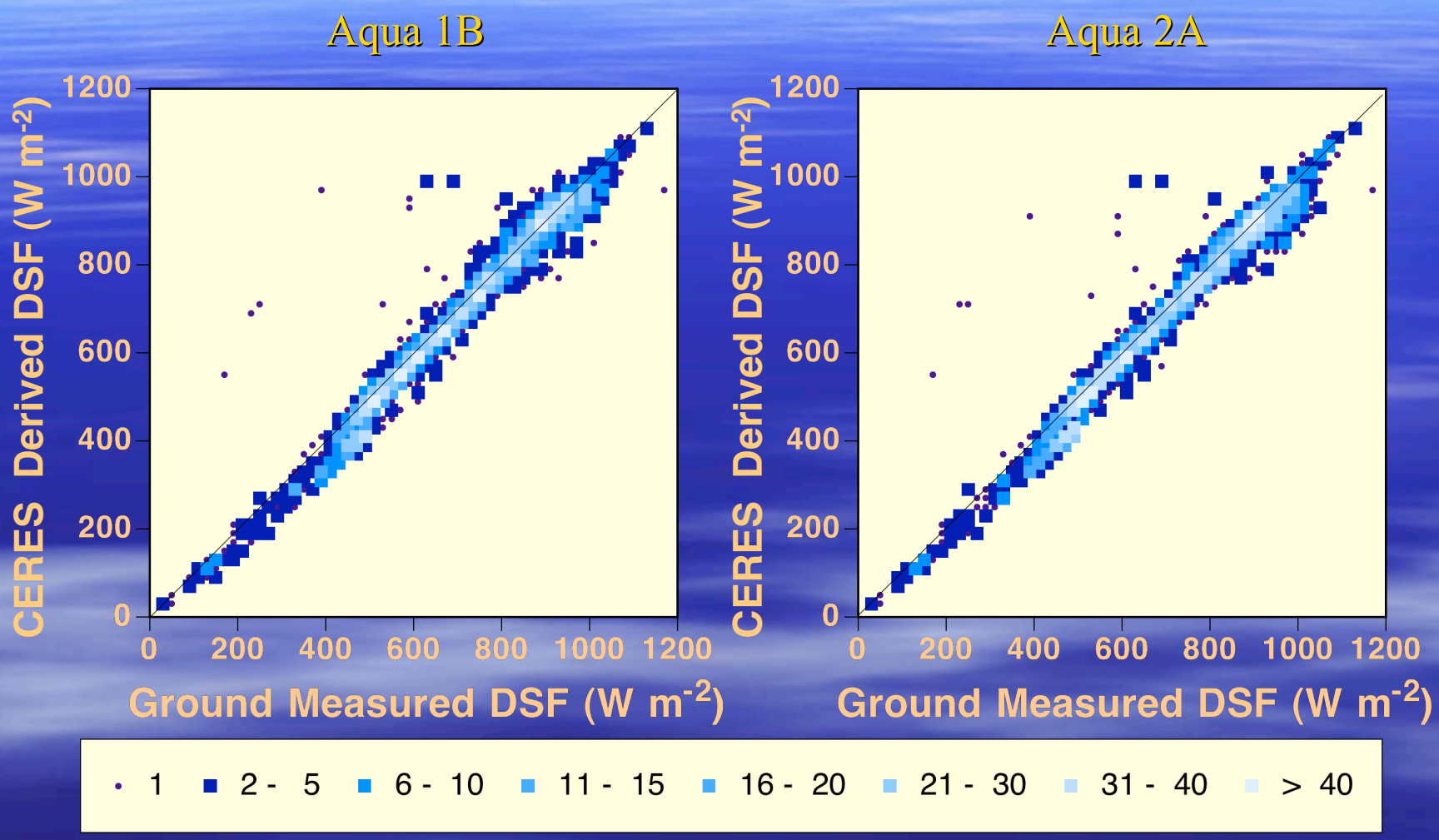
Aqua 2A

Shortwave Model A Clear-Sky Island



Aqua 2A

Shortwave Model A Clear-Sky Global



Aqua 2A

Shortwave Model A Clear-Sky

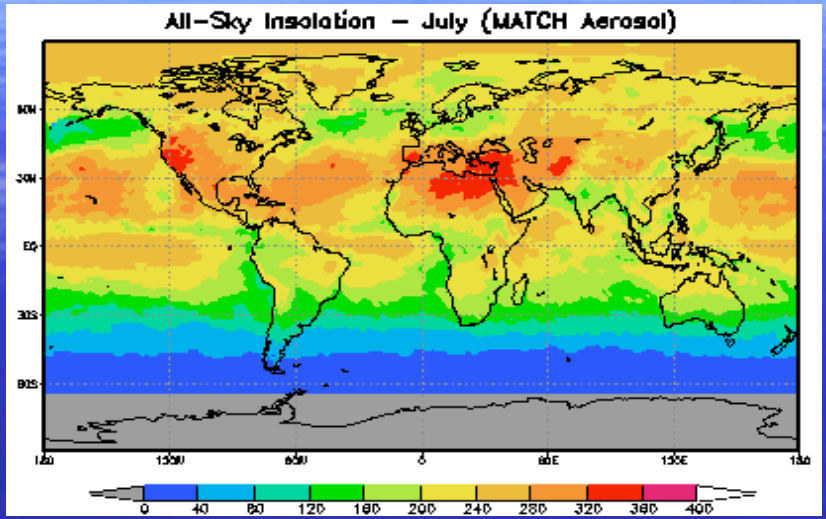
Sites # of Points		Aqua1B	Aqua2A
Continental	Bias Wm^{-2} (%)	-10.61 (-1.51)	-12.49 (-1.78)
1681	σ Wm^{-2} (%)	26.9 (3.8)	25.1 (3.6)
Coastal	Bias Wm^{-2} (%)	2.54 (0.38)	-1.92 (-0.29)
158	σ Wm^{-2} (%)	27.9 (4.2)	23.4 (3.5)
Ant-Arctic	Bias Wm^{-2} (%)	-50.62 (-12.62)	-44.72 (-11.15)
319	σ Wm^{-2} (%)	28.6 (7.1)	24.9 (6.2)
Desert	Bias Wm^{-2} (%)	-25.59 (-3.08)	-25.02 (-3.01)
636	σ Wm^{-2} (%)	41.3 (5.0)	39.7 (4.8)
Island	Bias Wm^{-2} (%)	29.60 (3.42)	37.81 (4.37)
52	σ Wm^{-2} (%)	70.9 (8.2)	68.7 (7.9)
Global	Bias Wm^{-2} (%)	-16.97 (-2.43)	-17.39 (-2.49)
2846	σ Wm^{-2} (%)	39.7 (5.7)	37.3 (5.3)

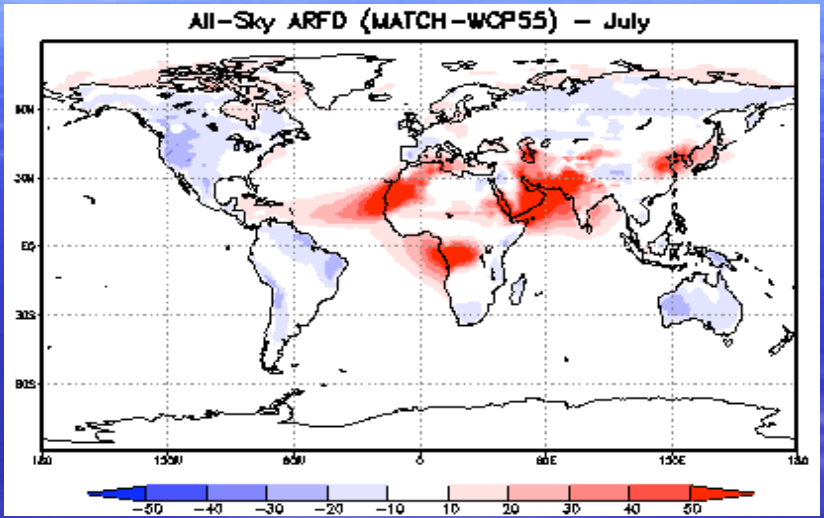
Aqua 2A

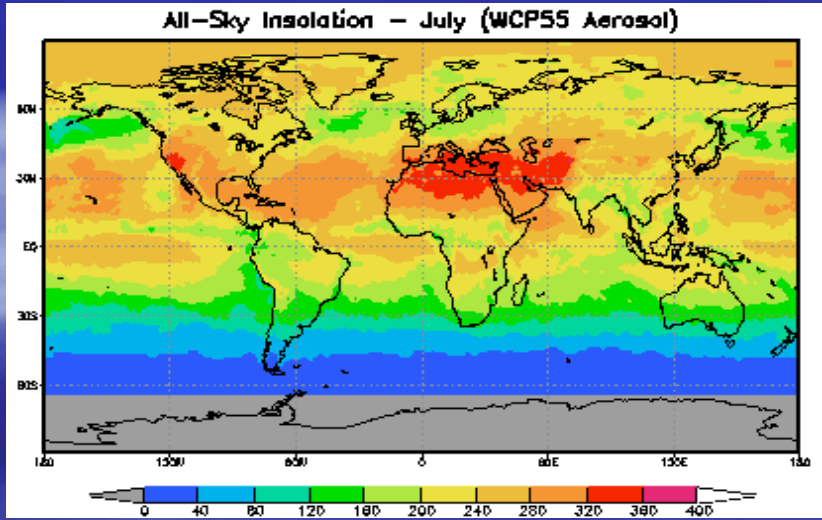
Shortwave Model B Clear-Sky

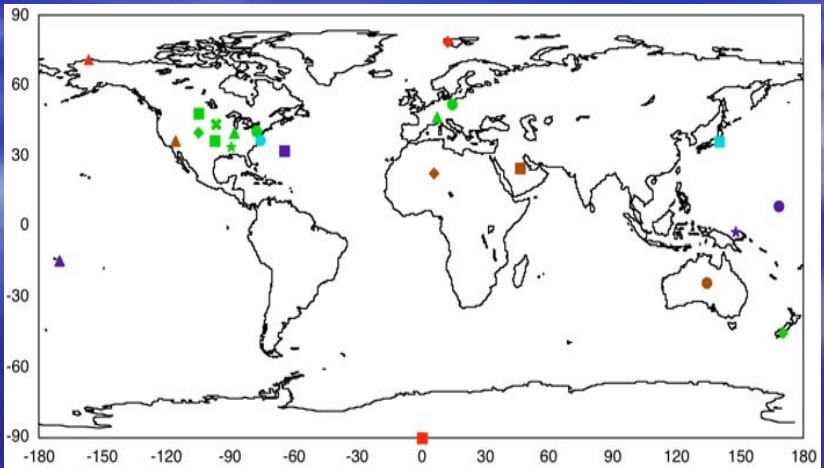
Aqua 2A vs Aqua 1B

Comparison of Insolation and Aerosol Radiative Forcing



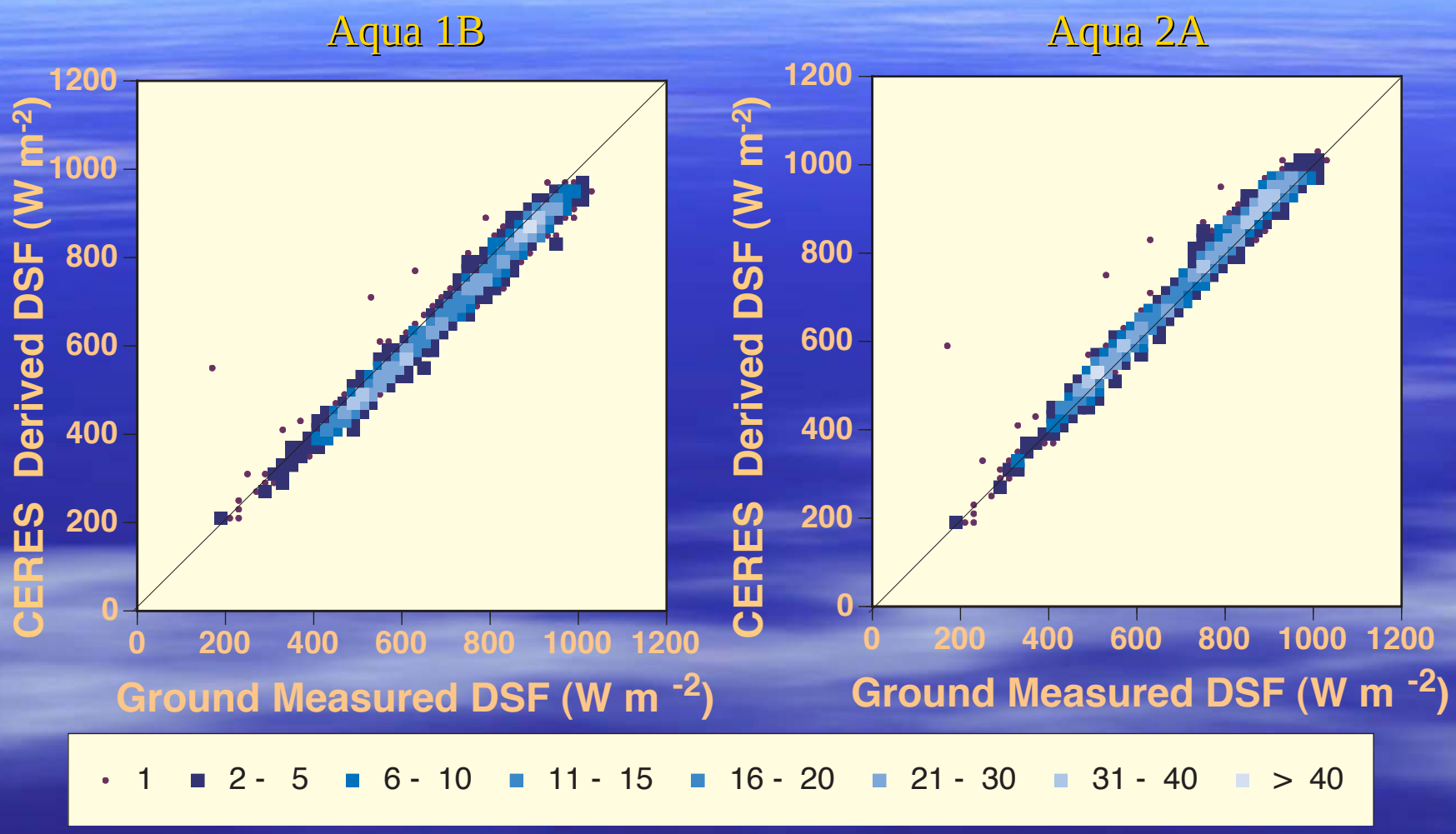






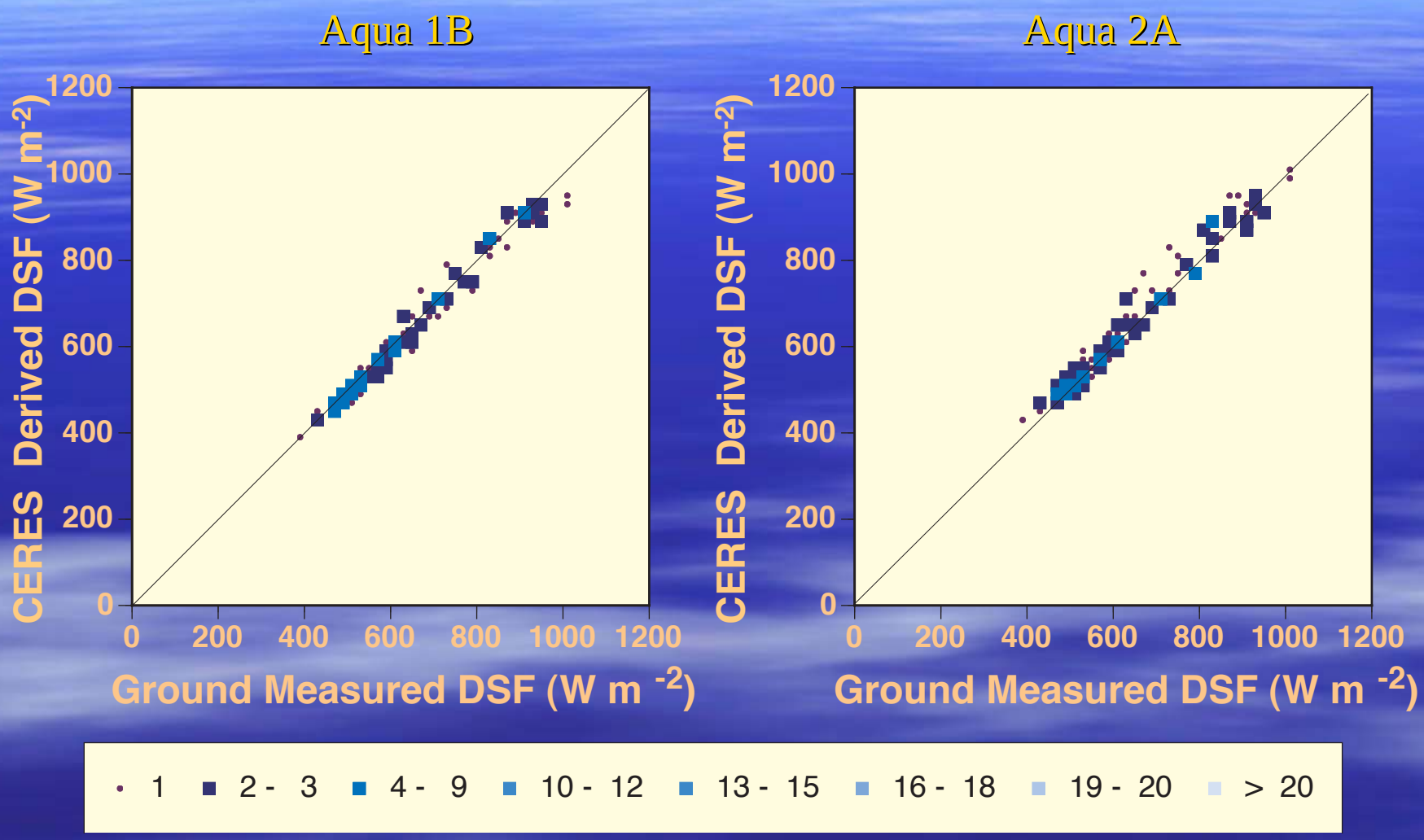
Aqua 2A

Shortwave Model B Clear-Sky Continental



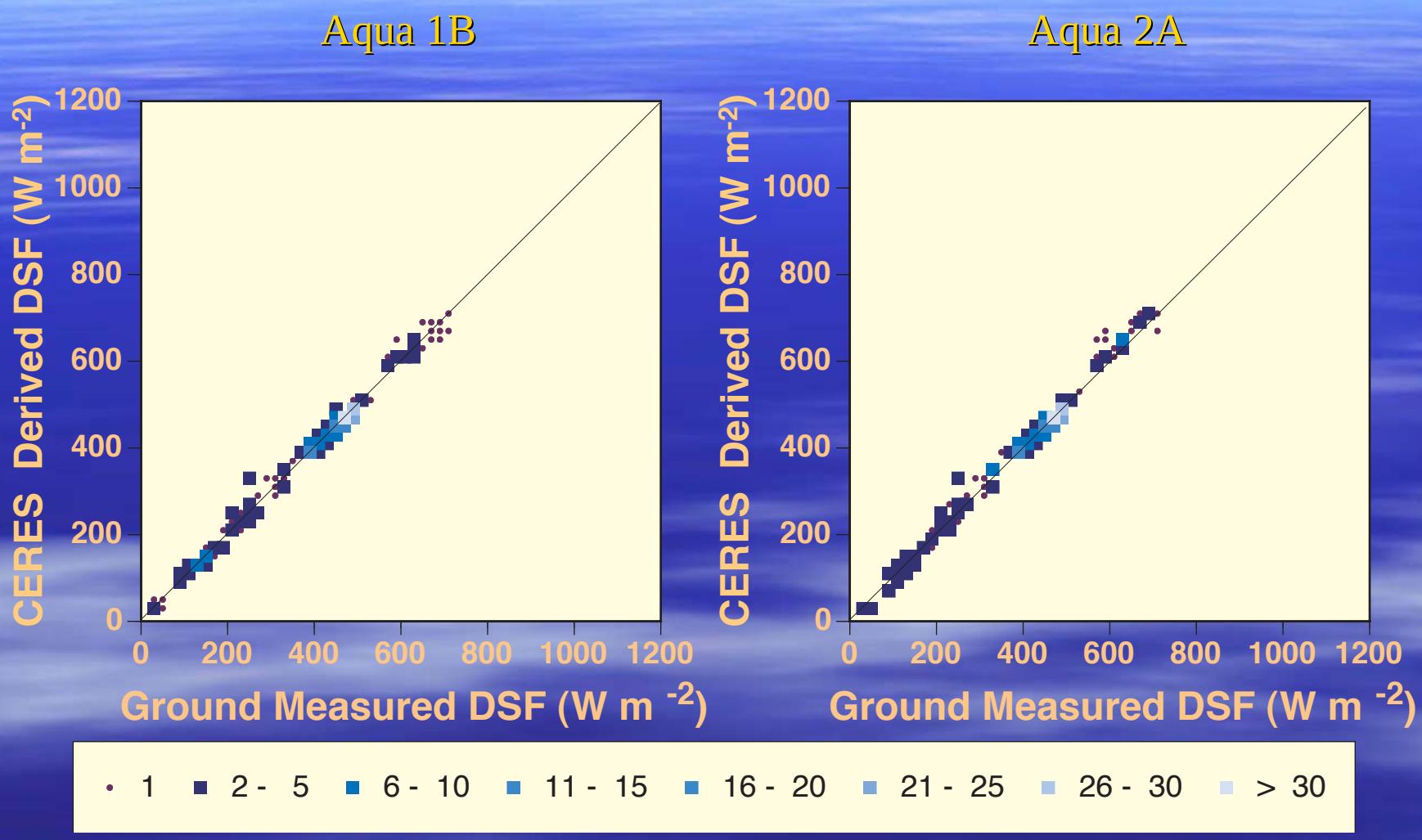
Aqua 2A

Shortwave Model B Clear-Sky Coastal



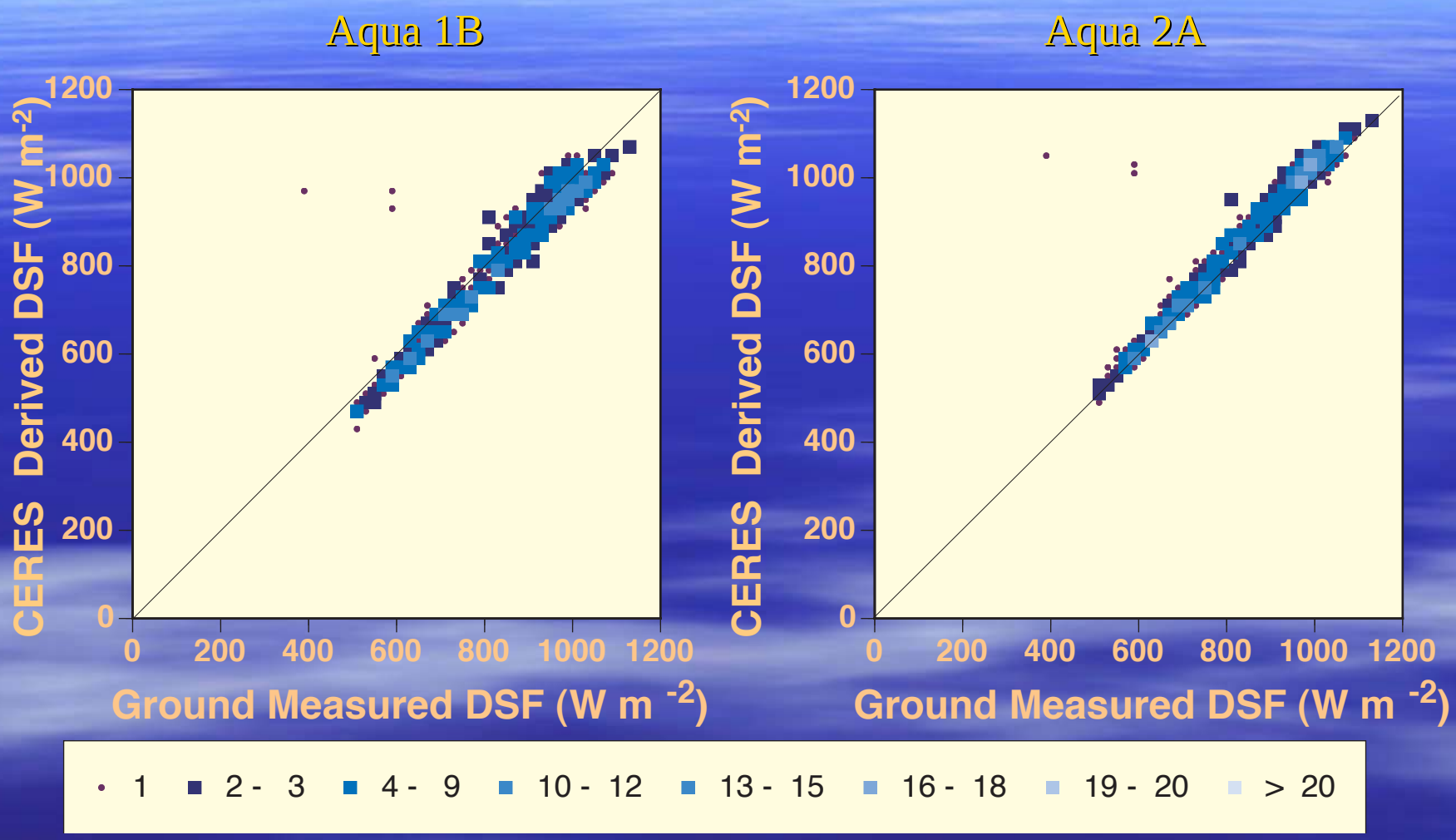
Aqua 2A

Shortwave Model B Clear-Sky Ant-arctic



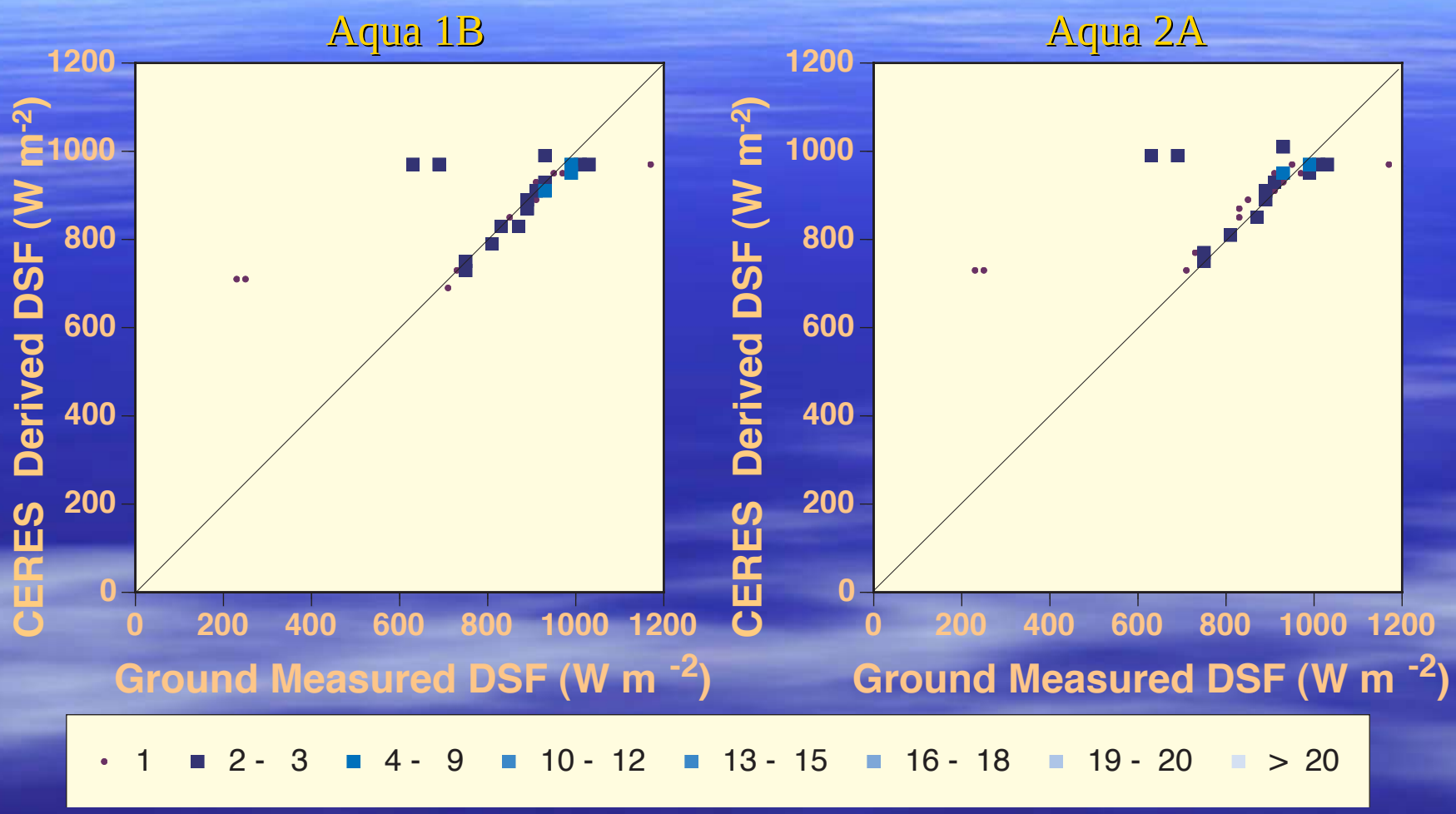
Aqua 2A

Shortwave Model B Clear-Sky Desert



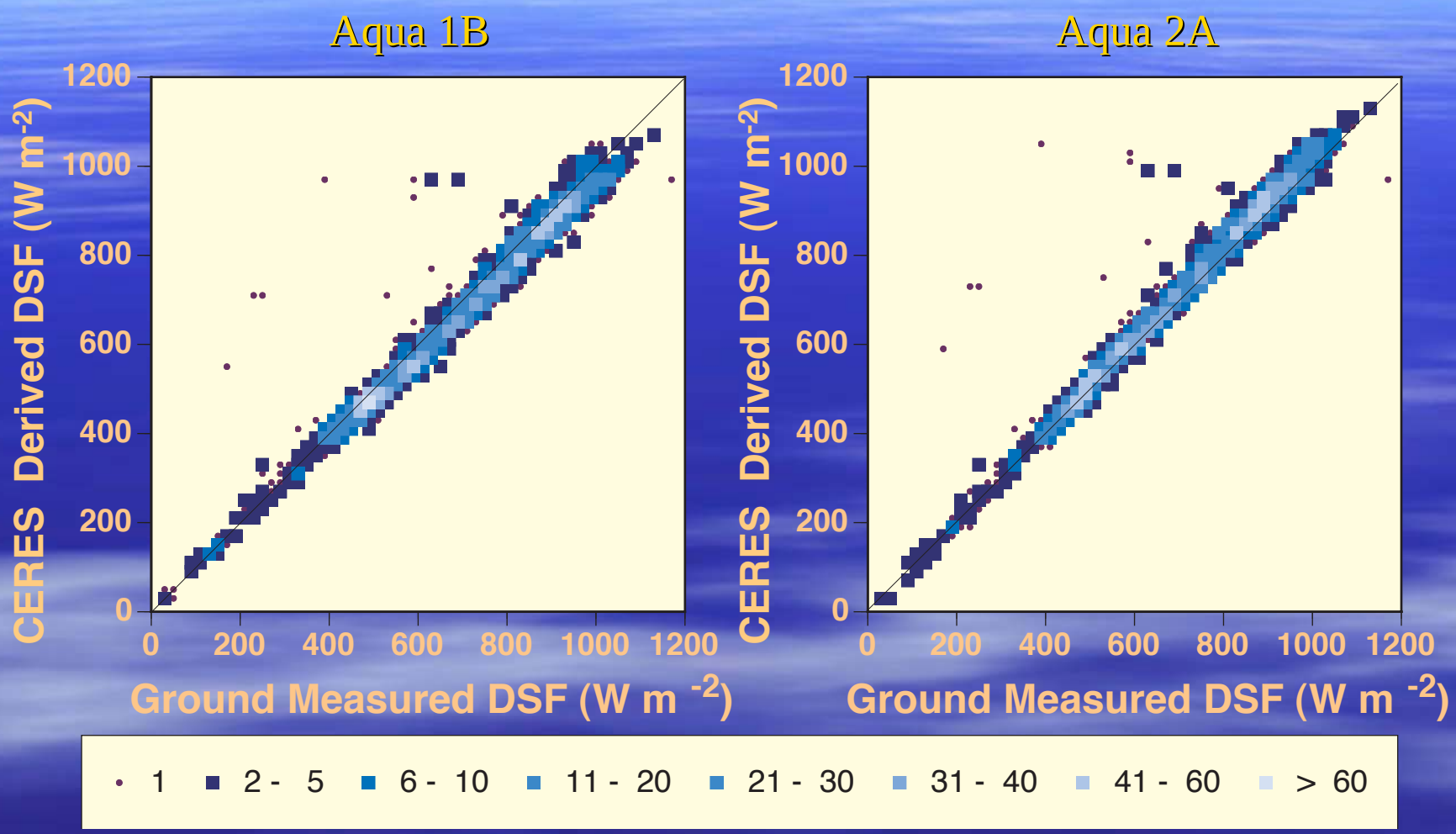
Aqua 2A

Shortwave Model B Clear-Sky Island



Aqua 2A

Shortwave Model B Clear-Sky Global



Aqua 2A

Shortwave Model B Clear-Sky

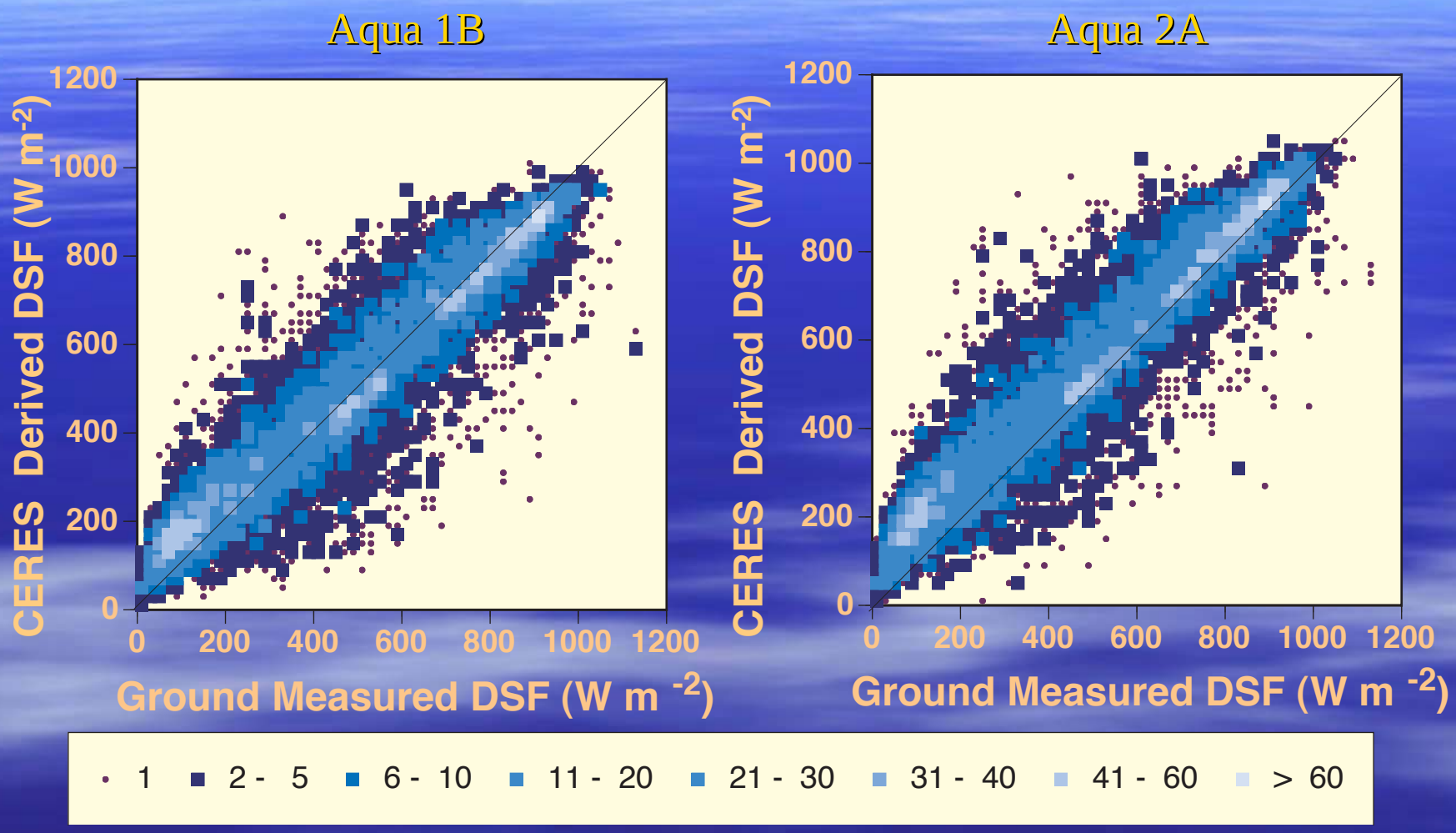
Sites # of Points		Aqua1B	Aqua2A
Continental	Bias Wm^{-2} (%)	-26.76 (-3.81)	17.31 (2.46)
1681	σ Wm^{-2} (%)	22.3 (3.2)	22.7 (3.2)
Coastal	Bias Wm^{-2} (%)	-6.82 (-1.03)	13.43 (2.03)
158	σ Wm^{-2} (%)	20.6 (3.1)	26.6 (4.0)
Ant-Arctic	Bias Wm^{-2} (%)	-0.07 (-0.02)	1.82 (0.45)
319	σ Wm^{-2} (%)	14.1 (3.5)	16.1 (4.0)
Desert	Bias Wm^{-2} (%)	-24.50 (-2.95)	23.96 (2.89)
636	σ Wm^{-2} (%)	43.9 (5.3)	40.8 (4.9)
Island	Bias Wm^{-2} (%)	23.75 (2.75)	43.55 (5.03)
52	σ Wm^{-2} (%)	67.4 (7.8)	65.7 (7.6)
Global	Bias Wm^{-2} (%)	-21.23 (-3.04)	17.32 (2.48)
2846	σ Wm^{-2} (%)	34.2 (4.9)	33.3 (4.8)

Aqua 2A

Shortwave Model B Cloudy-Sky

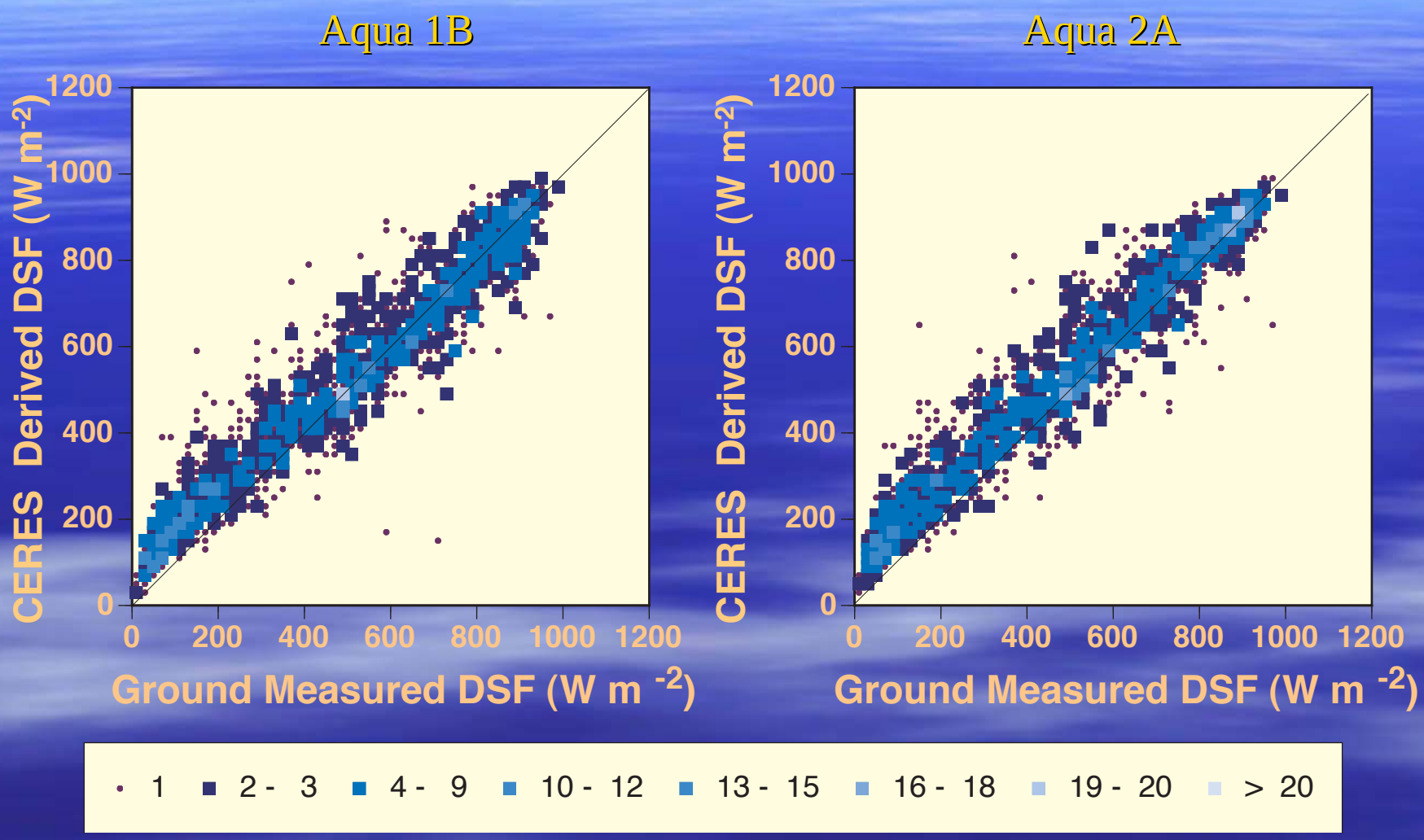
Aqua 2A vs Aqua 1B

Shortwave Model B Cloudy-Sky Continental



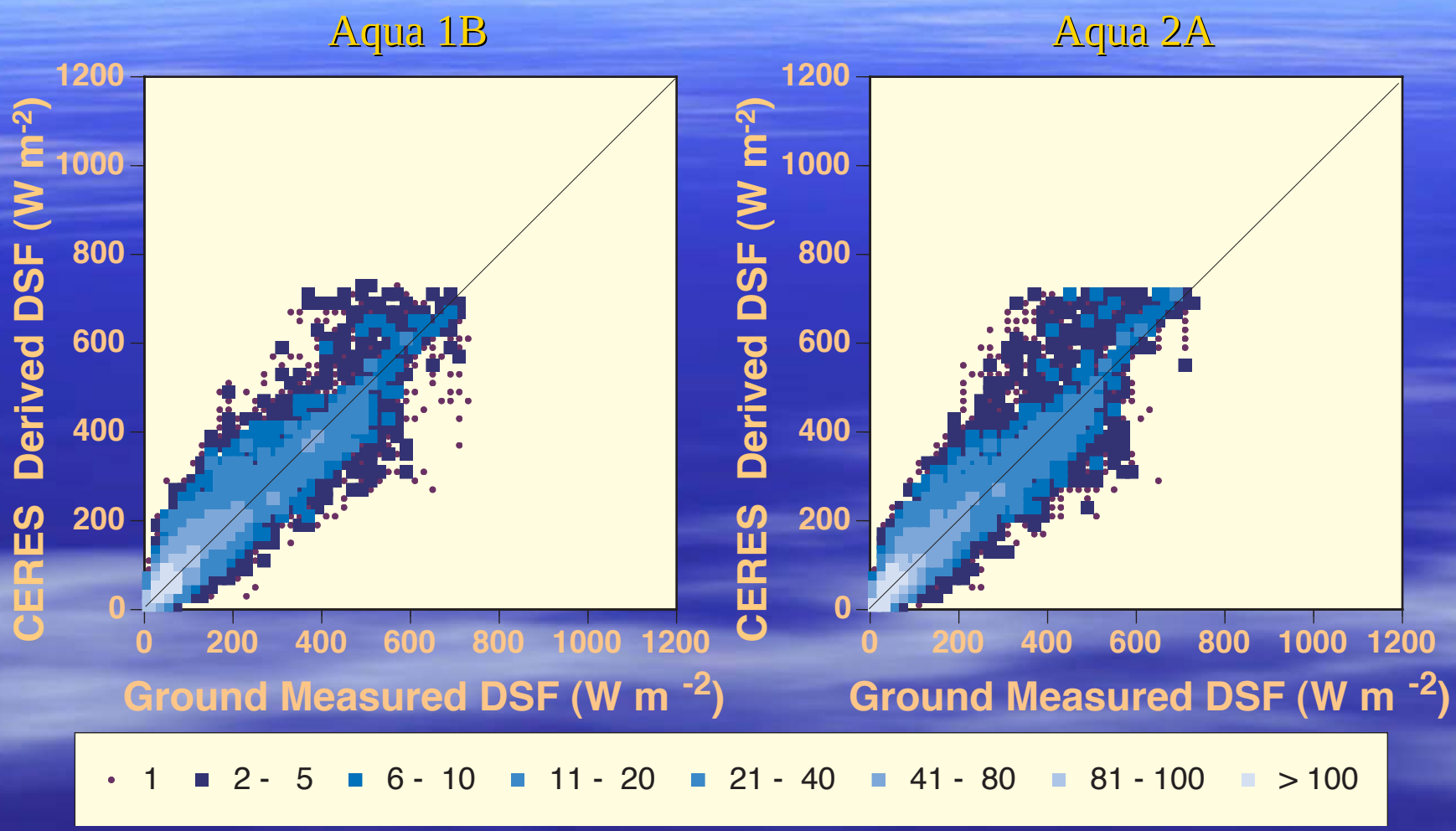
Aqua 2A

Shortwave Model B Cloudy-Sky Coastal



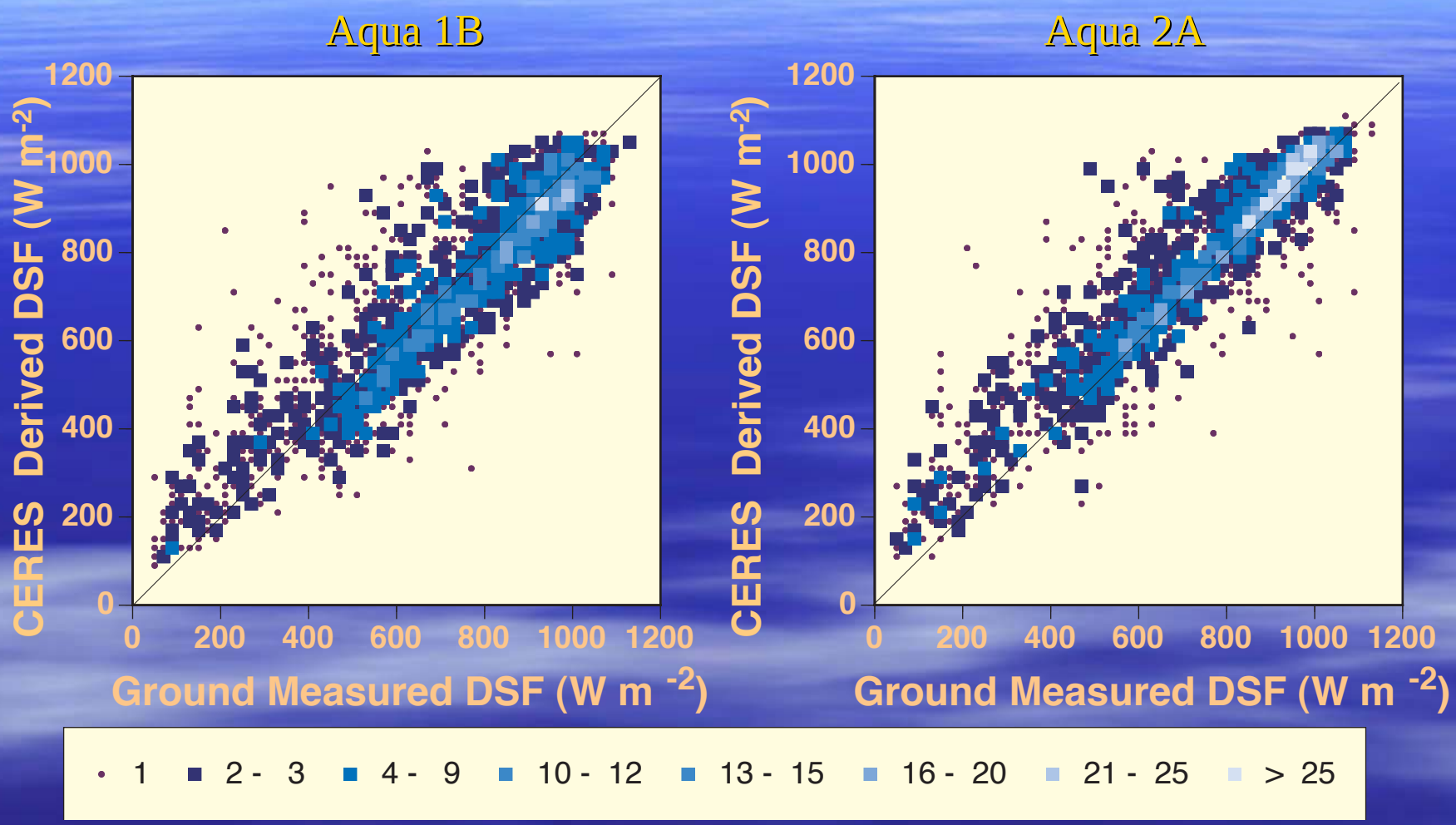
Aqua 2A

Shortwave Model B Cloudy-Sky Ant-arctic



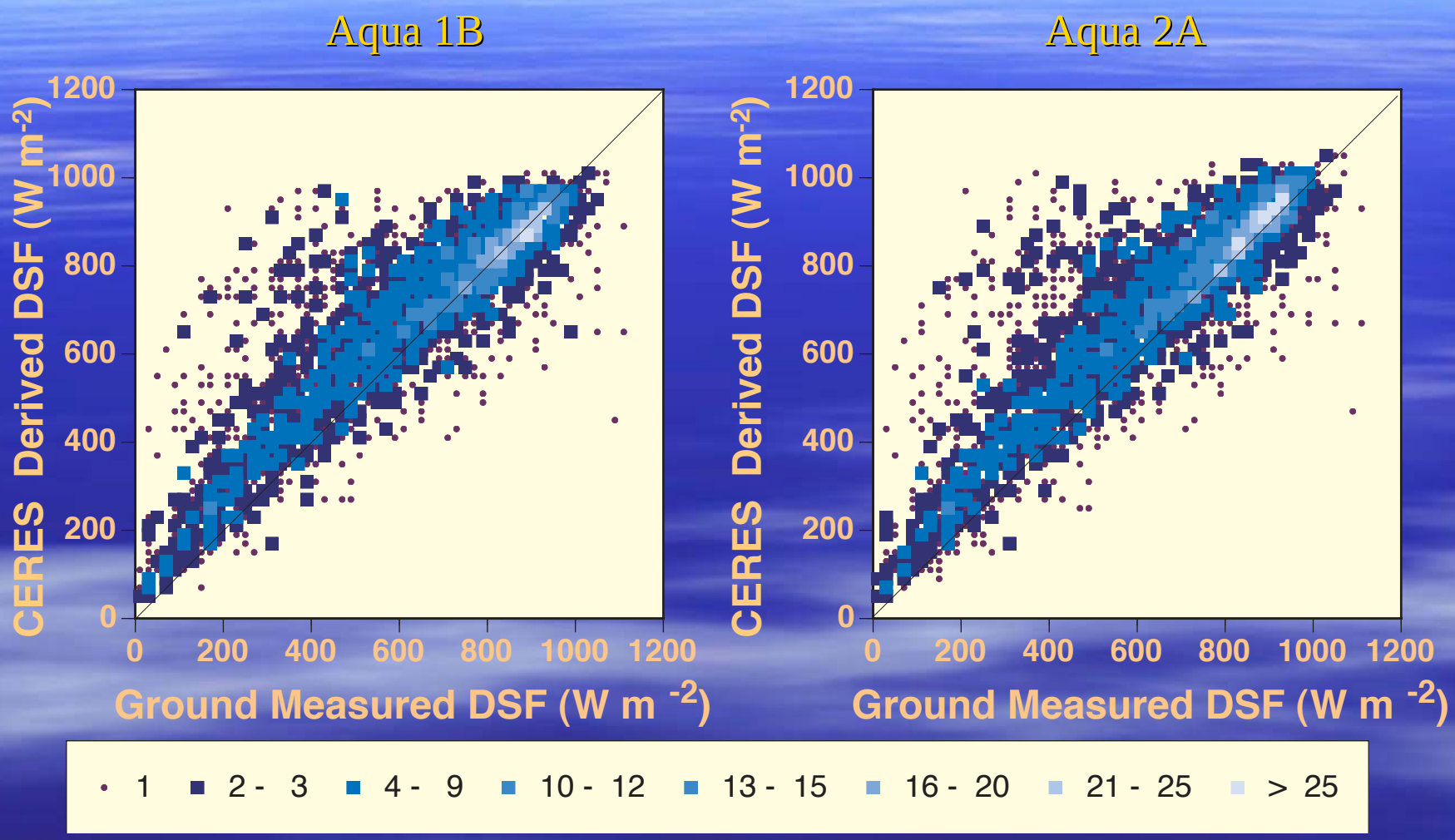
Aqua 2A

Shortwave Model B Cloudy-Sky Desert



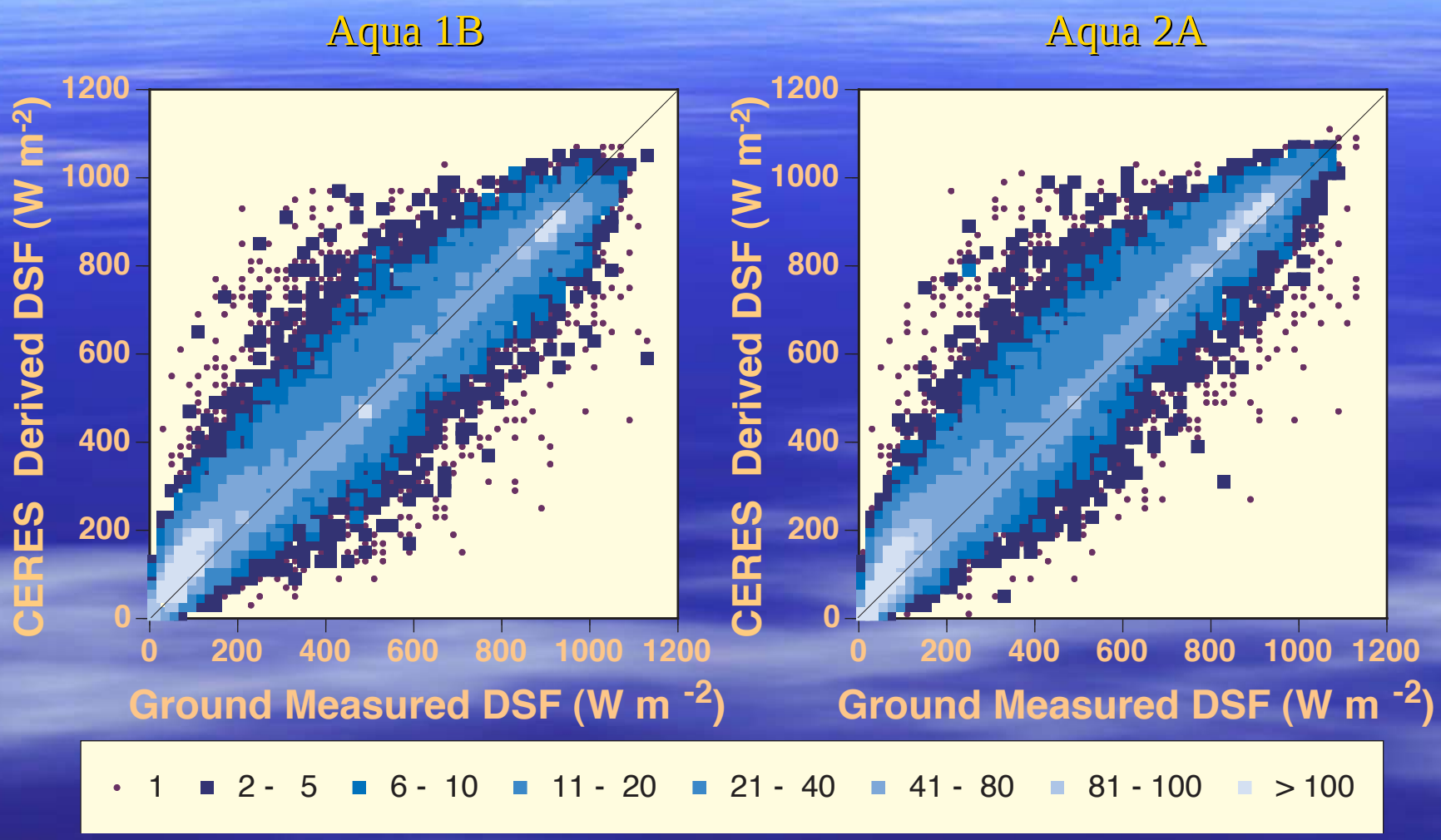
Aqua 2A

Shortwave Model B Cloudy-Sky Island



Aqua 2A

Shortwave Model B Cloudy-Sky Global



Aqua 2A

Shortwave Model B Cloudy-Sky

Sites # of Points		Aqua1B	Aqua2A
Continental	Bias Wm^{-2} (%)	14.73 (2.99)	51.95 (10.55)
10881	σ Wm^{-2} (%)	91.4 (18.6)	89.8 (18.2)
Desert	Bias Wm^{-2} (%)	-9.16 (-1.26)	42.31 (5.84)
2376	σ Wm^{-2} (%)	95.1 (13.1)	80.9 (11.2)
Coastal	Bias Wm^{-2} (%)	32.66 (6.62)	49.41 (10.02)
1724	σ Wm^{-2} (%)	71.4 (14.5)	67.0 (13.6)
Island	Bias Wm^{-2} (%)	63.73 (10.37)	76.93 (12.52)
3218	σ Wm^{-2} (%)	107.1 (17.4)	110.9 (18.0)
Ant-Arctic	Bias Wm^{-2} (%)	16.11 (7.41)	14.98 (6.89)
8526	σ Wm^{-2} (%)	63.5 (29.2)	66.5 (30.6)
Global	Bias Wm^{-2} (%)	20.10 (4.57)	42.14 (9.57)
26725	σ Wm^{-2} (%)	90.5 (20.6)	90.9 (20.7)

Aqua 2A

Zhou-Cess Longwave (LWC) Algorithm

Original Algorithm

$$SDLW = a + b*SULW + c*\ln(PWV) + d*[\ln(PWV)]^2 + e*\ln(1+f*LWP)$$

$a = 123.86$, $b = 0.444$, $c = 56.16$,

$d = -3.65$, $e = 5.30$, $f = 1226.0$,

Zhou-Cess Longwave (LWC) Algorithm

Possible revision to prevent low water vapor runaway

$$SDLW = a + b*SULW + c*\ln(1+PWV) + d*[\ln(1+PWV)]^2 + e*\ln(1+f*LWP)$$

Zhou-Cess Longwave (LWC) Algorithm

Revised (Clear-Sky)

$$SDLW(clr) = a0 + c1*SULW + c2*\ln(1+PWV) + c3*[\ln(1+PWV)]^2$$

a0 = 37.687, c1 = 0.474, c2 = 94.190,

c3 = –4.935

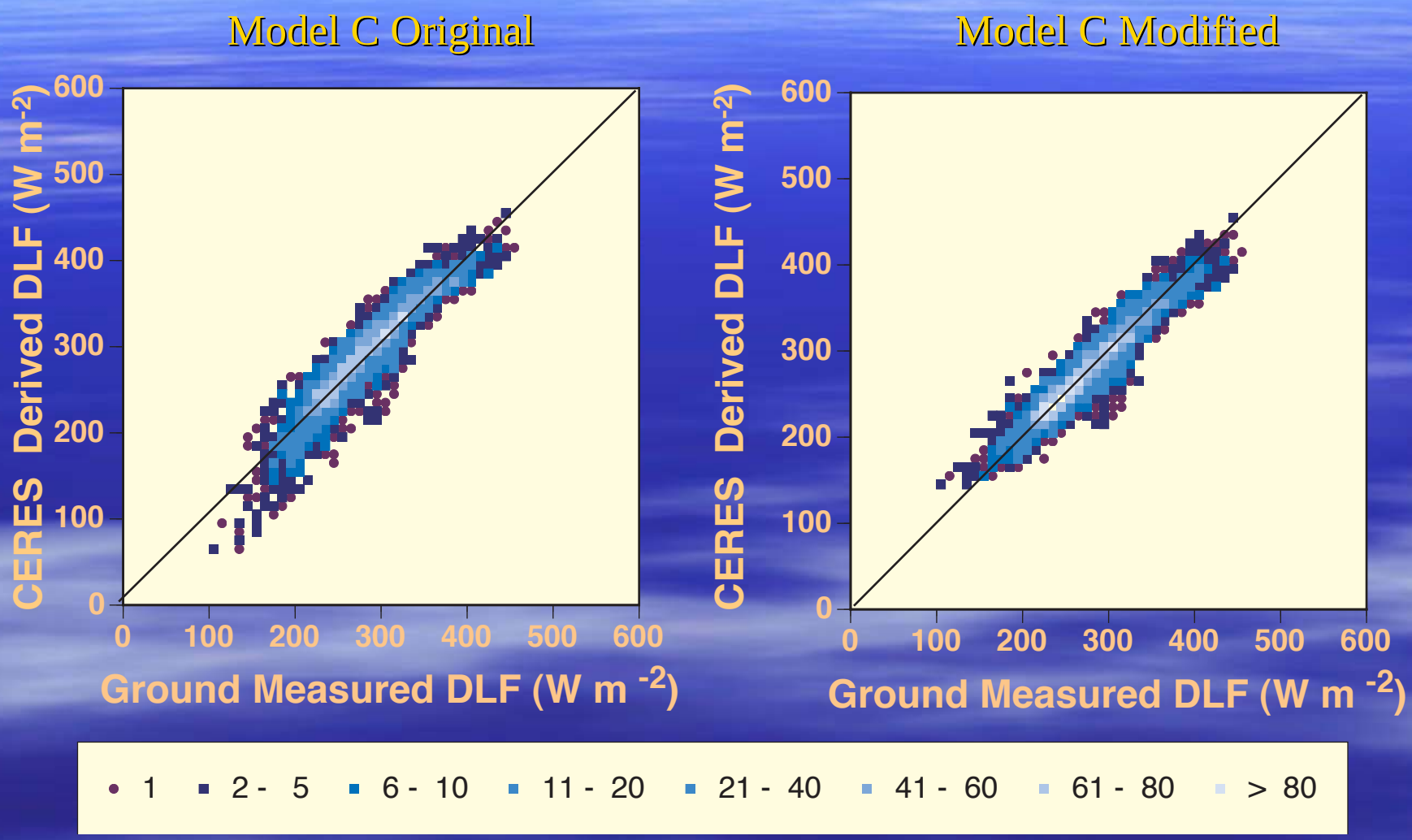
$$SULW = _*T_s^4, \ Area(clr) \geq 99.9\%$$

Aqua 2A

Longwave Model C Clear-Sky
July 2002 through March 2005

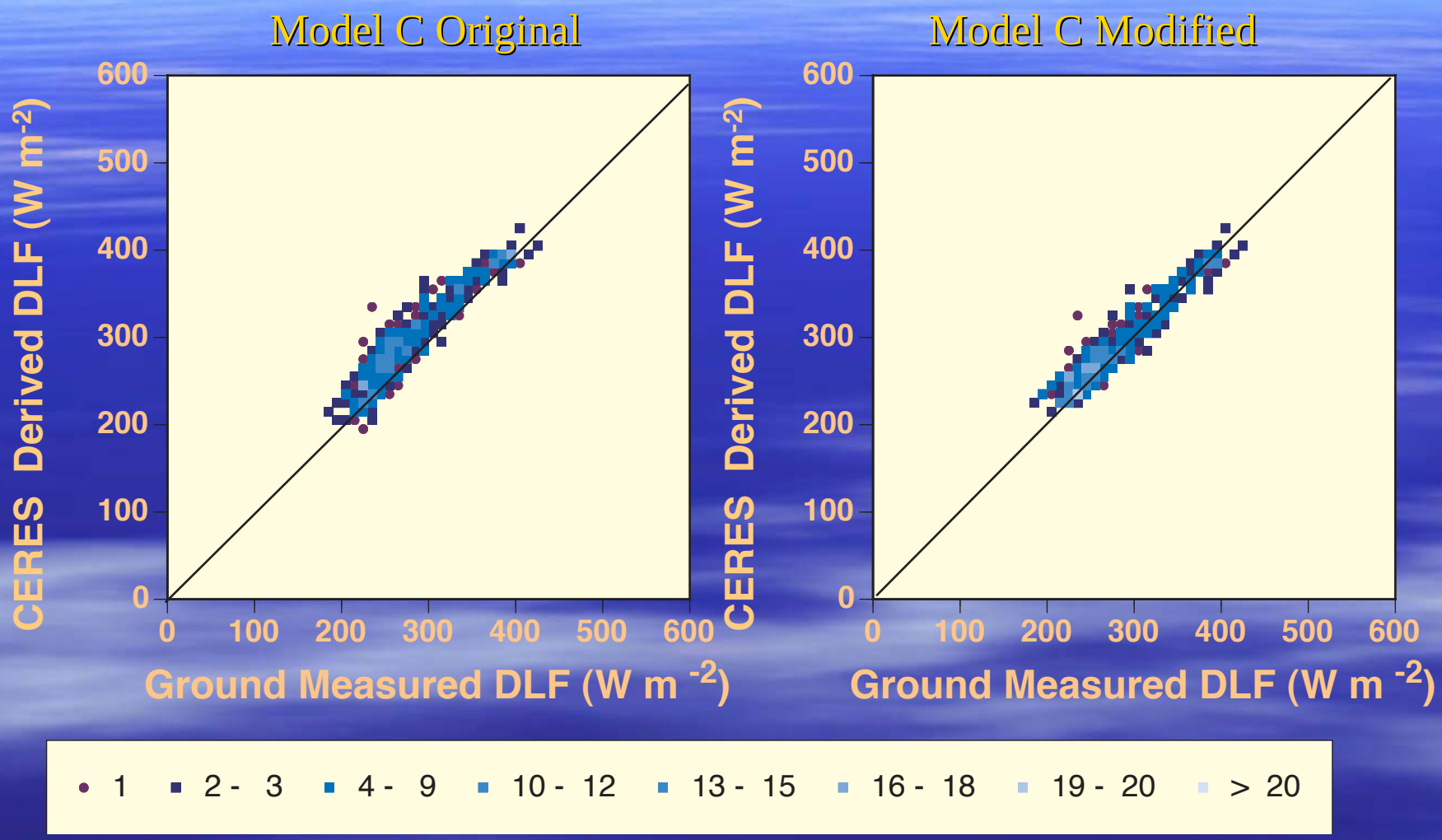
Aqua 2A

Longwave Clear-Sky Continental



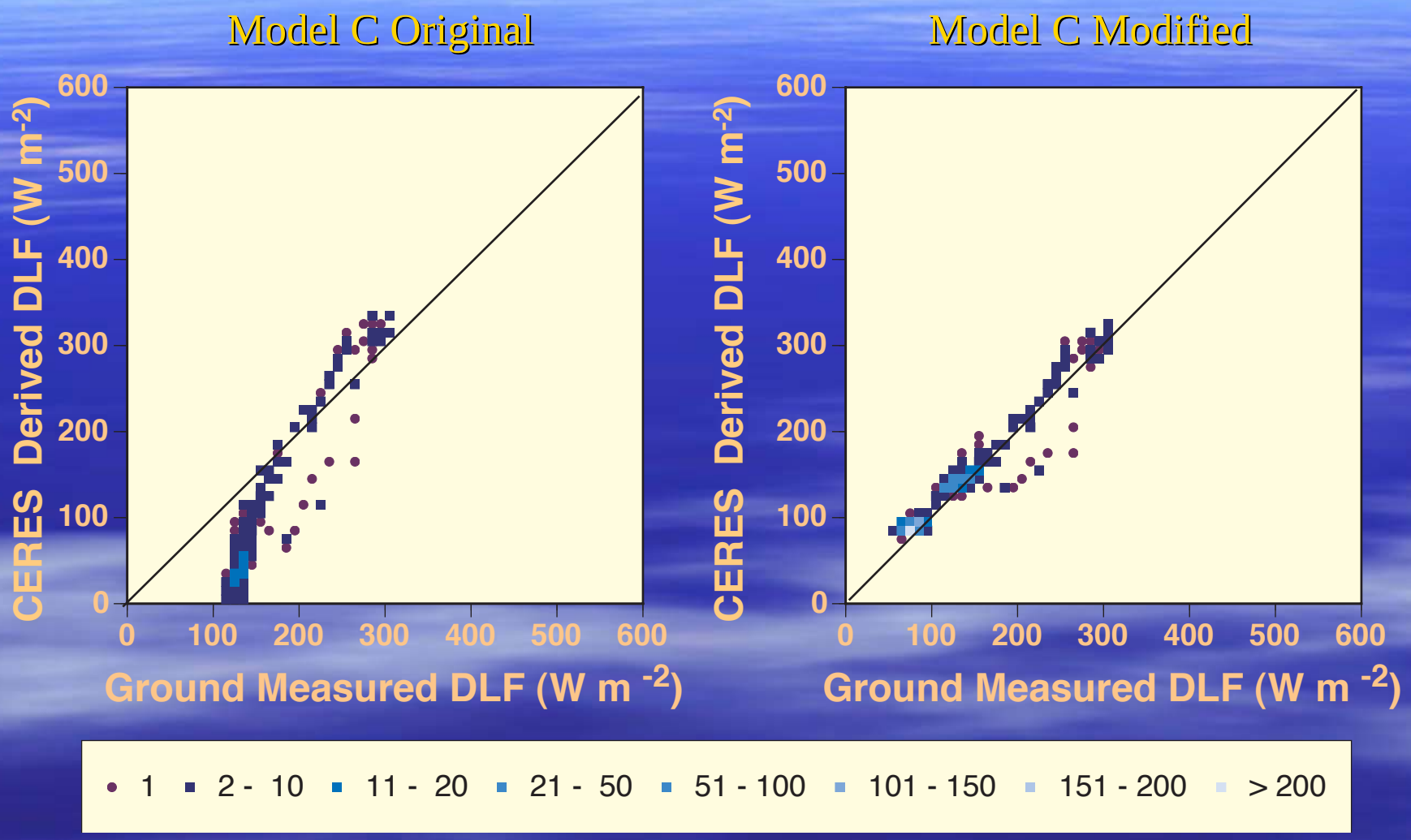
Aqua 2A

Longwave Clear-Sky Coastal



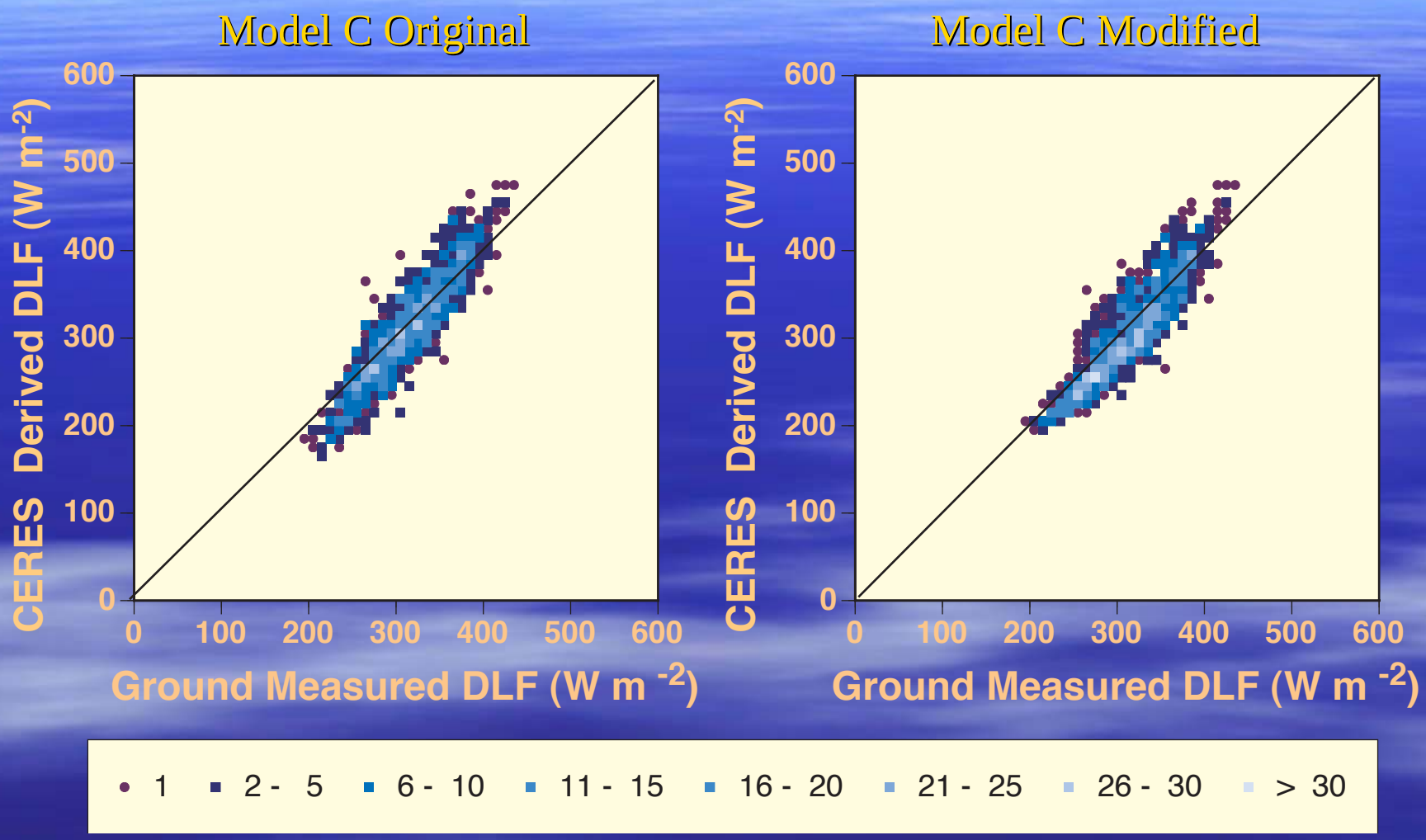
Aqua 2A

Longwave Clear-Sky Ant-arctic



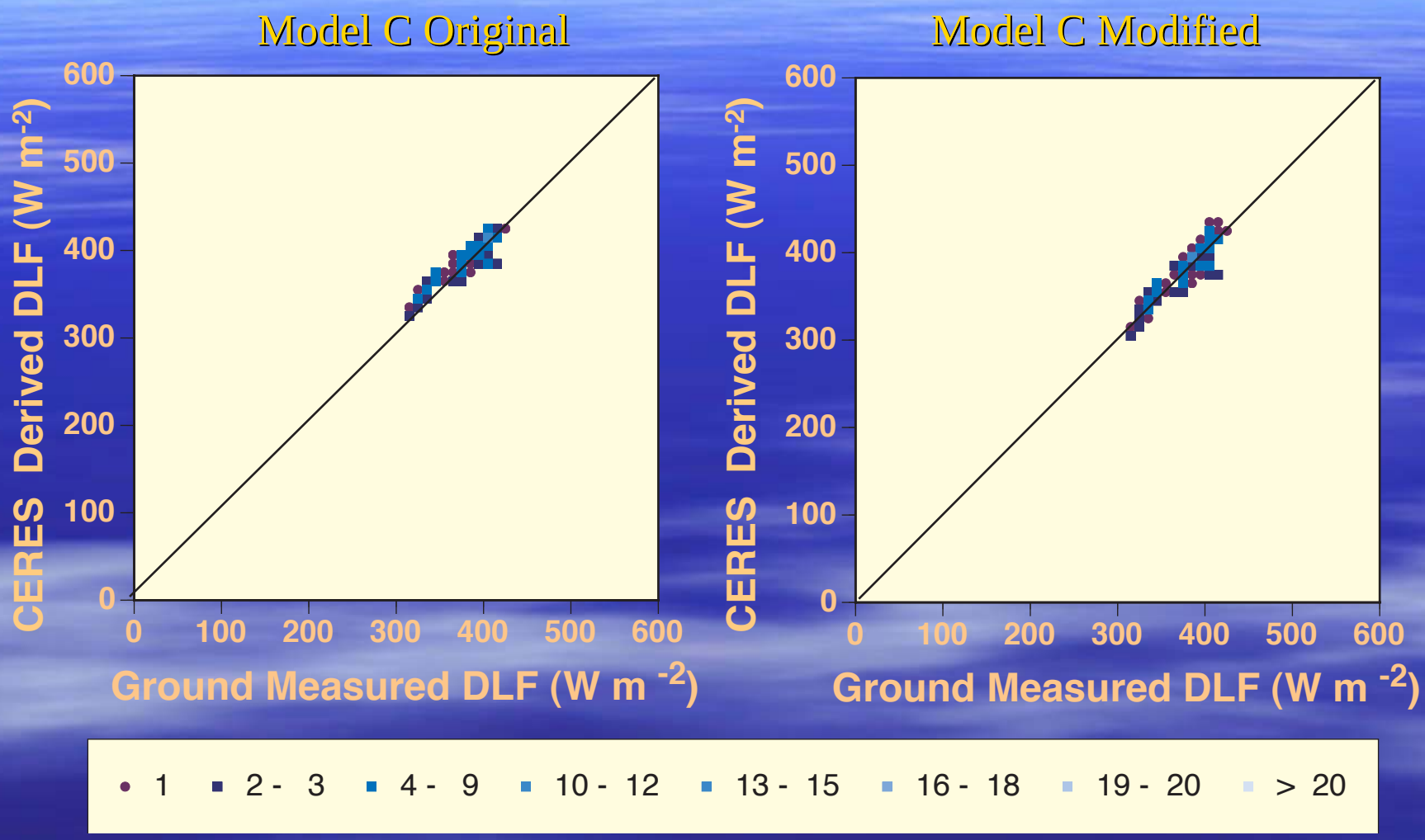
Aqua 2A

Longwave Clear-Sky Desert



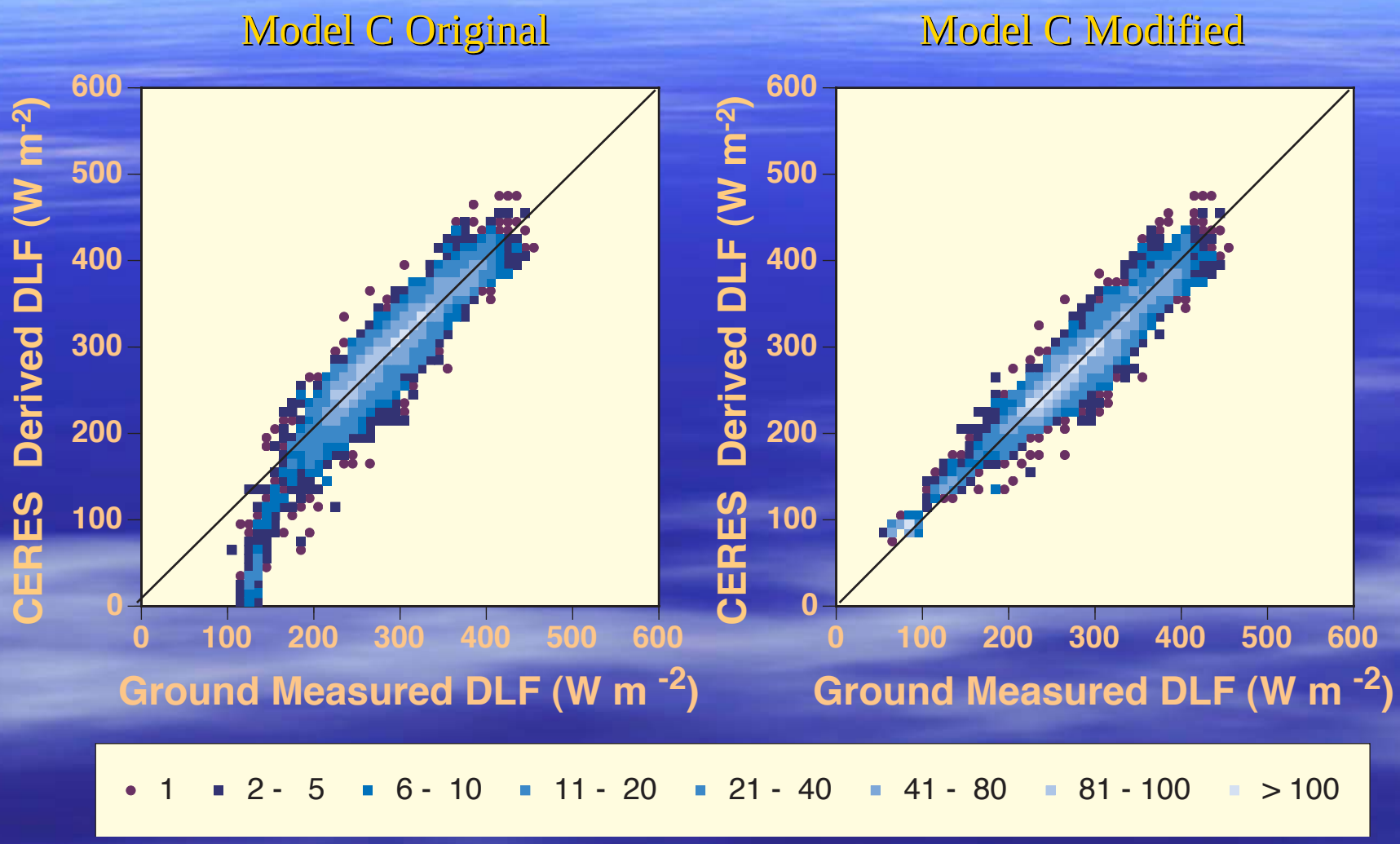
Aqua 2A

Longwave Clear-Sky Island



Aqua 2A

Longwave Clear-Sky Global



Aqua 2A

Longwave Clear-Sky

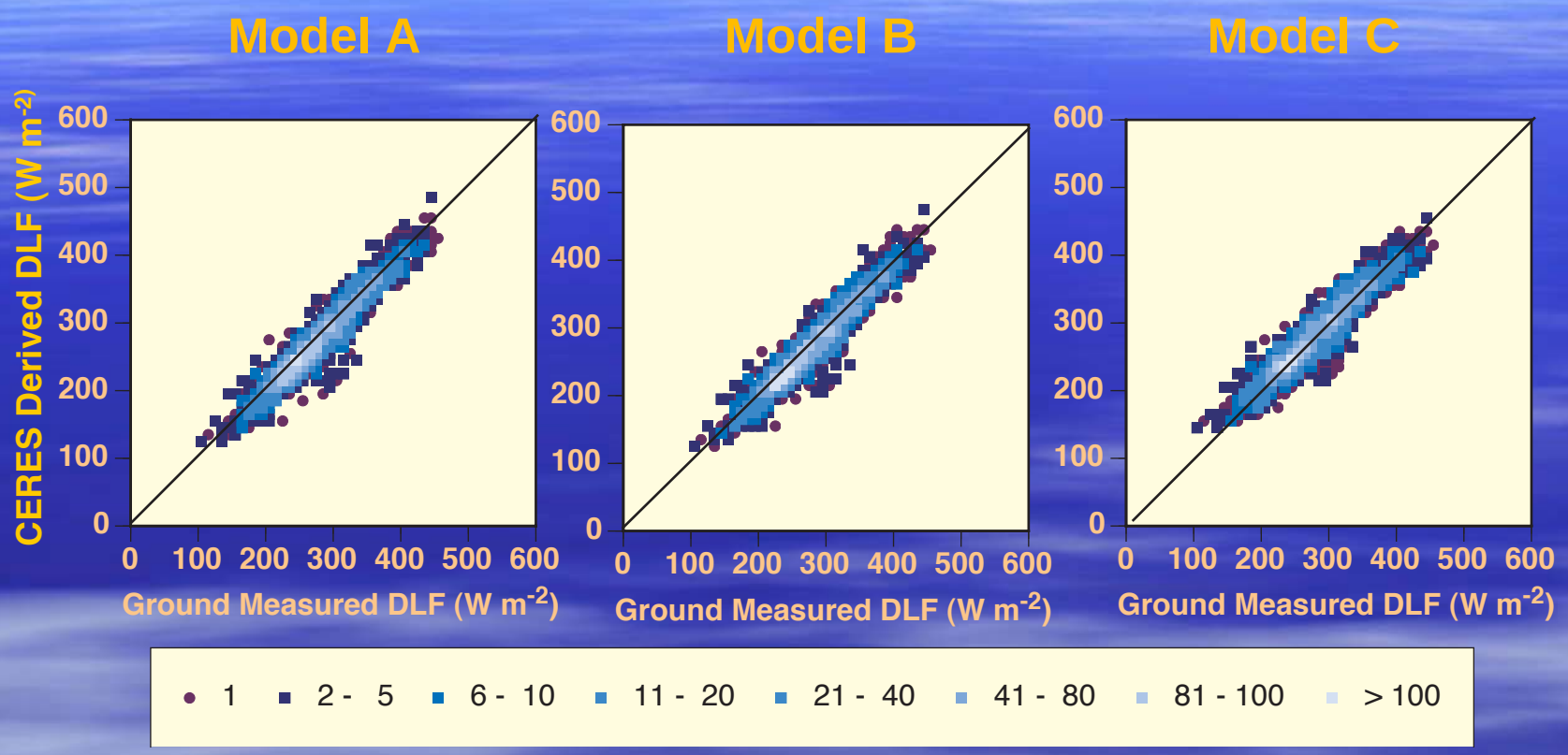
Sites # of Points		Original LWC	Modified LWC
Continental 5209	Bias Wm^{-2} (%)	6.71 (2.38)	10.03 (3.52)
	σ Wm^{-2} (%)	20.9 (7.4)	14.8 (5.2)
Coastal 618	Bias Wm^{-2} (%)	16.66 (5.84)	10.45 (9.30)
	σ Wm^{-2} (%)	17.8 (6.3)	11.1 (9.9)
Ant-arctic 936	Bias Wm^{-2} (%)	-137.00 (-121.96)	-7.12 (-2.27)
	σ Wm^{-2} (%)	34.5 (30.7)	23.9 (7.6)
Desert 1693	Bias Wm^{-2} (%)	-1.68 (-0.53)	2.92 (0.77)
	σ Wm^{-2} (%)	24.4 (7.8)	12.6 (3.3)
Island 140	Bias Wm^{-2} (%)	9.31 (2.47)	0.42 (0.15)
	σ Wm^{-2} (%)	10.3 (2.7)	18.5 (6.8)
Global 8596	Bias Wm^{-2} (%)	-9.81 (-3.61)	10.03 (3.52)
	σ Wm^{-2} (%)	41.4 (15.3)	14.8 (5.2)

Aqua 2A

Longwave Model A, B, C Clear-Sky Comparison for July 2002 through March 2005

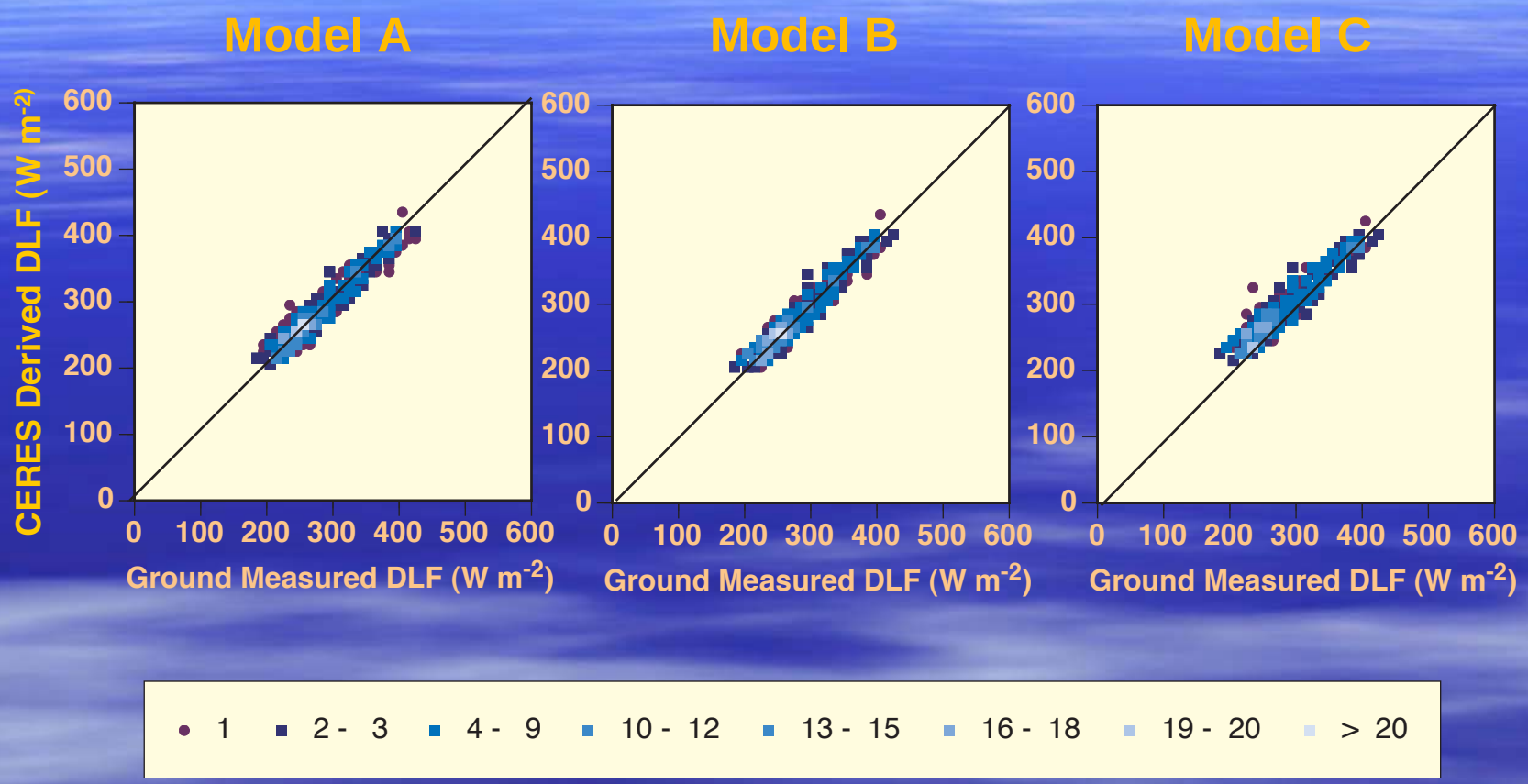
Aqua 2A

Longwave Clear-Sky, Continental



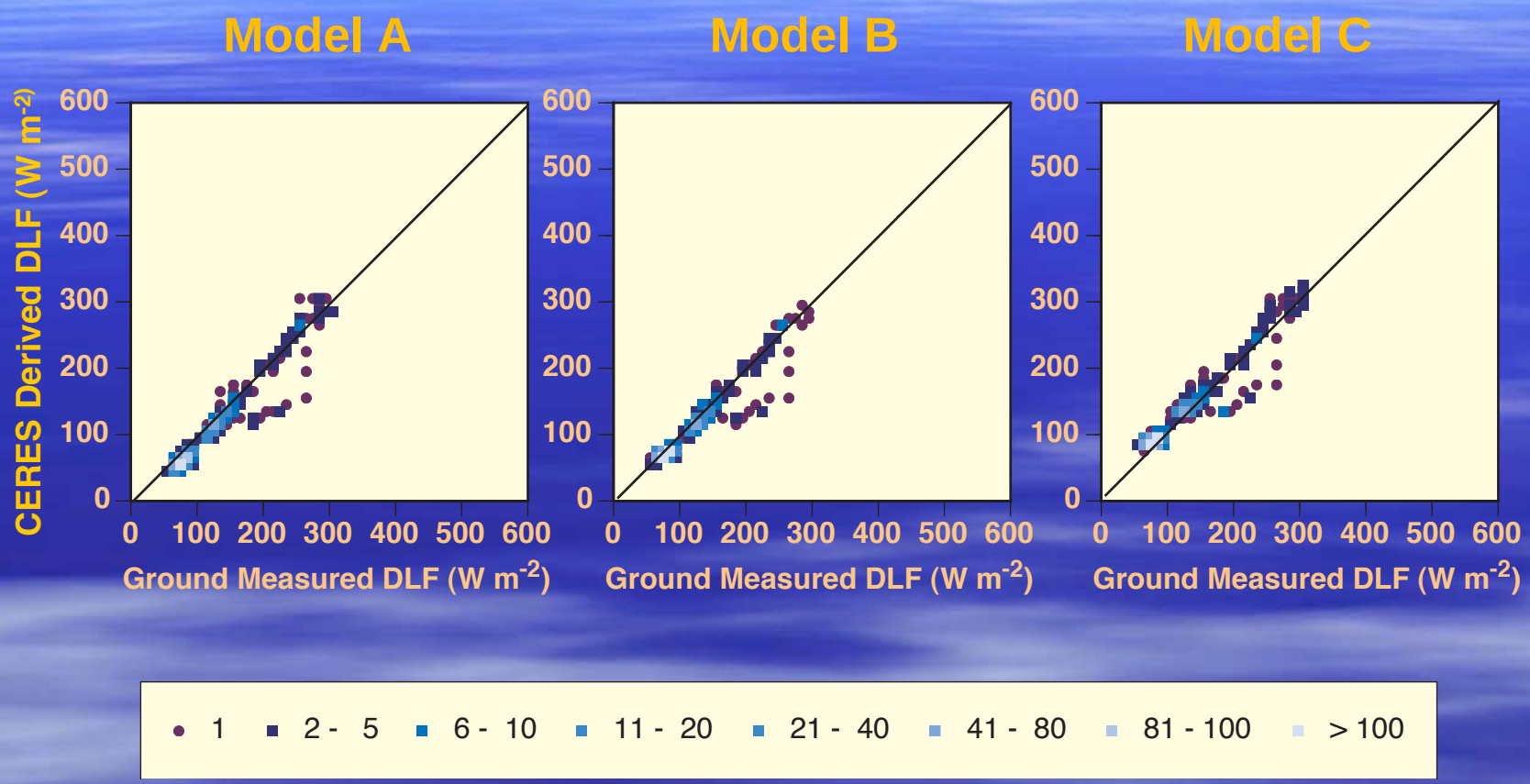
Aqua 2A

Longwave Clear-Sky, Coastal



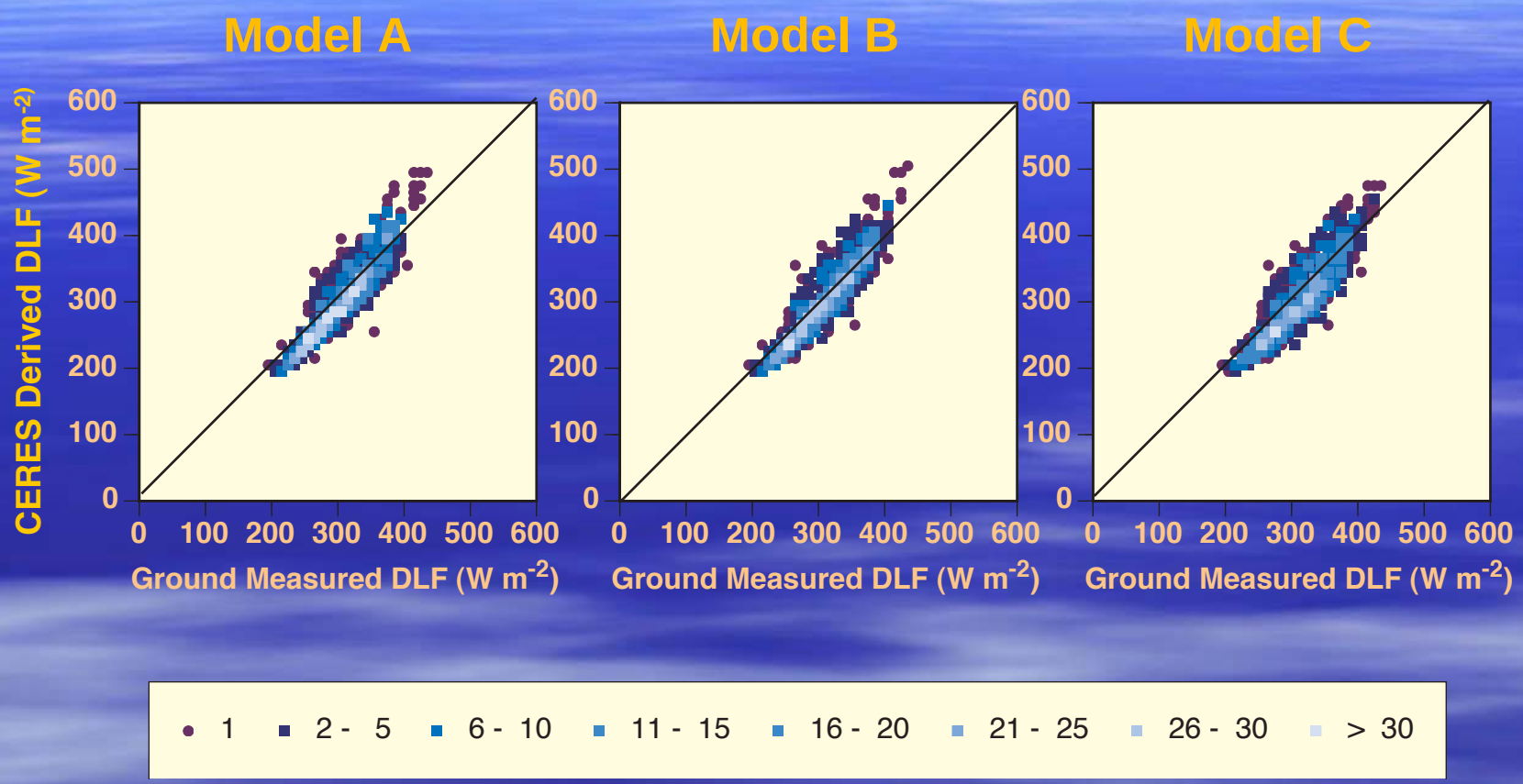
Aqua 2A

Longwave Clear-Sky, Ant-arctic



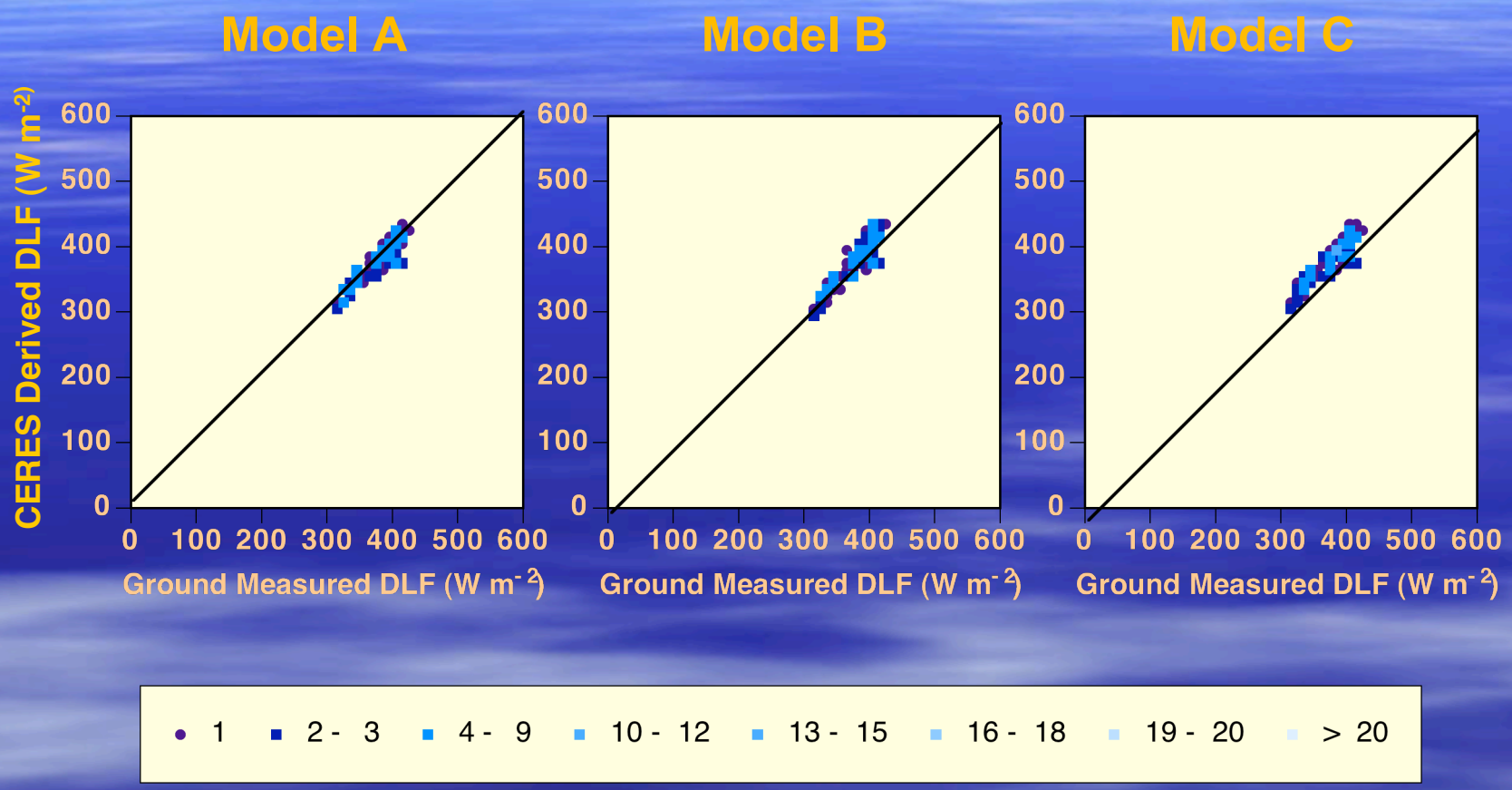
Aqua 2A

Longwave Clear-Sky, Desert



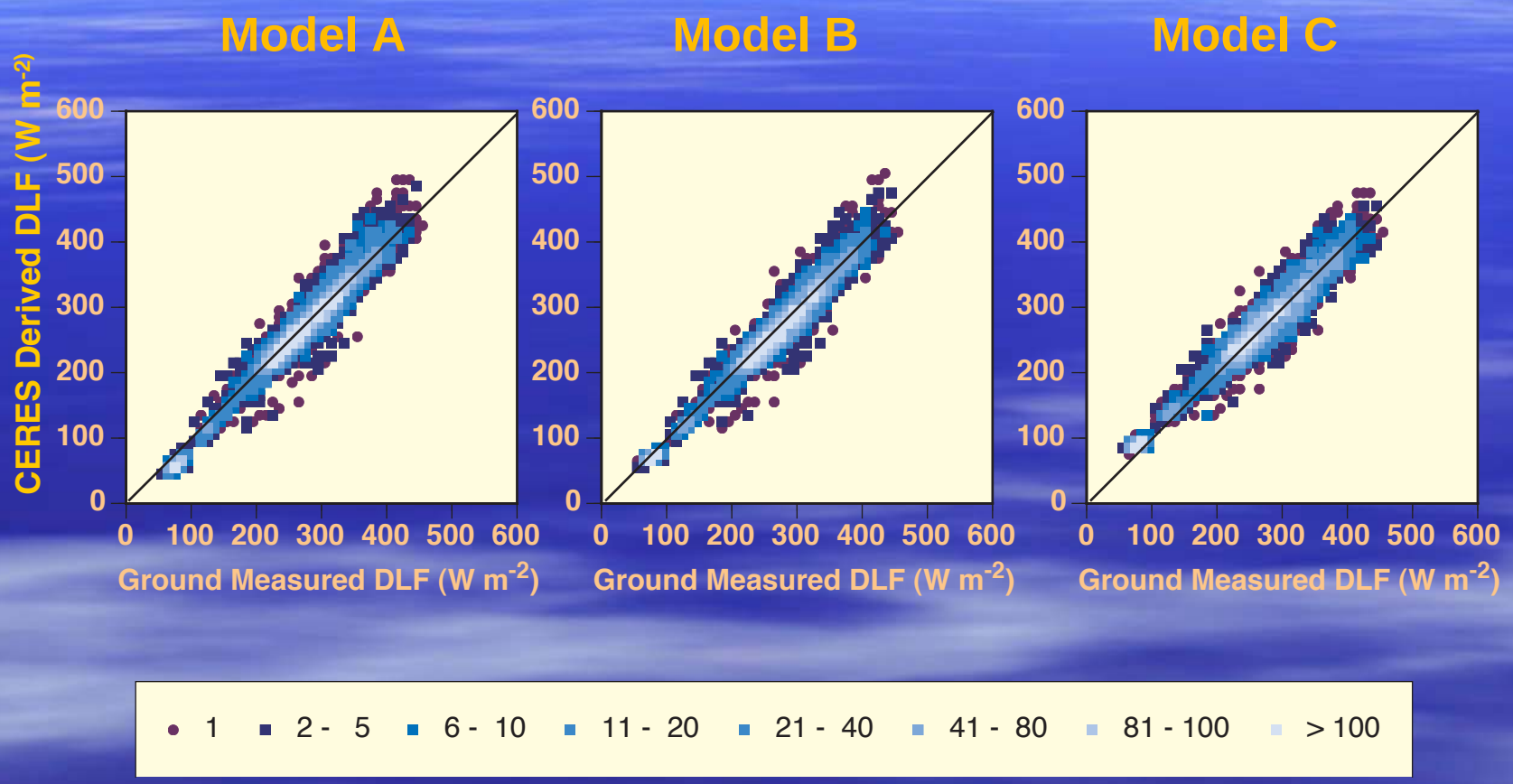
Aqua 2A

Longwave Clear-Sky, Island



Aqua 2A

Longwave Clear-Sky, Global



Aqua 2A

Longwave Clear-Sky

Sites # of Points		LWA	LWB	LWC
Continental	Bias Wm^{-2} (%)	-4.48 (-1.59)	-6.93 (-2.46)	-0.15 (-0.05)
5012	σ Wm^{-2} (%)	15.8 (5.6)	15.38 (5.46)	16.59 (5.89)
Coastal	Bias Wm^{-2} (%)	4.92 (1.72)	-0.15 (-0.05)	10.06 (3.53)
607	σ Wm^{-2} (%)	12.9 (4.5)	13.23 (4.64)	14.79 (5.18)
Ant-arctic	Bias Wm^{-2} (%)	-16.02 (-14.30)	-8.83 (-7.88)	10.45 (9.33)
899	σ Wm^{-2} (%)	11.0 (9.9)	11.05 (9.86)	11.11 (9.91)
Desert	Bias Wm^{-2} (%)	-0.41 (-0.13)	-5.15 (-1.64)	-7.19 (-2.29)
1634	σ Wm^{-2} (%)	22.8 (7.3)	21.07 (6.71)	23.91 (7.61)
Island	Bias Wm^{-2} (%)	-0.75 (-0.20)	-0.77 (-0.20)	2.92 (0.77)
138	σ Wm^{-2} (%)	12.0 (3.2)	13.76 (3.65)	12.64 (3.35)
Global	Bias Wm^{-2} (%)	-4.18 (-1.54)	-6.19 (-2.28)	0.41 (0.15)
8290	σ Wm^{-2} (%)	17.7 (6.5)	16.77 (6.18)	18.49 (6.81)

Aqua 2A

Zhou-Cess Longwave (LWC) Algorithm

Revised (Cloudy-Sky)

$$SDLW(cld) = a1 + b1*SULW + b2*\ln(1+PWV) + b3*[\ln(1+PWV)]^2 + b4*\ln(1+LWP) + b5*\ln(1+IWP)$$

a1 = 60.349, b1 = 0.480, b2 = 127.956,

b3 = –29.794, b4 = 1.626, b5 = 0.535

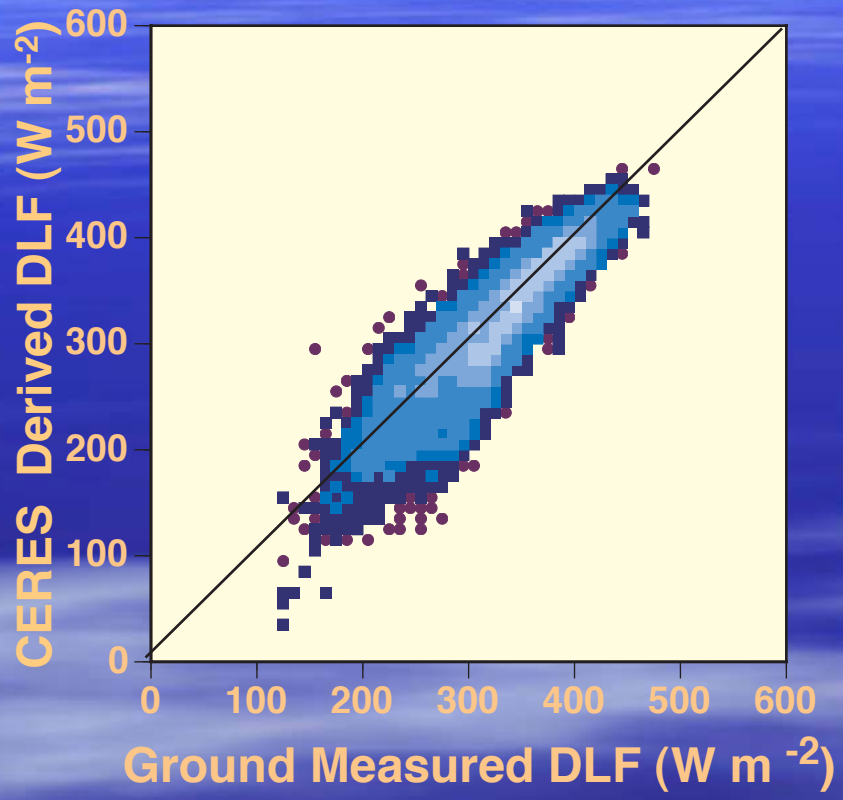
Aqua 2A

Longwave Model C Cloudy-Sky
July 2002 through March 2005

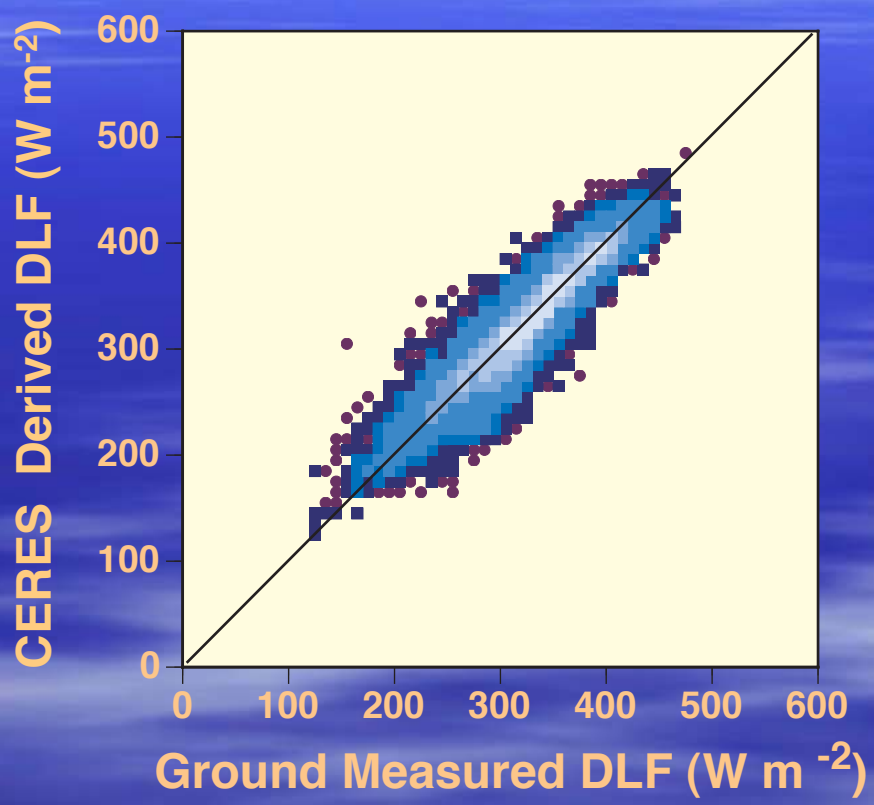
Aqua 2A

Longwave Cloudy-Sky Continental

Model C Original



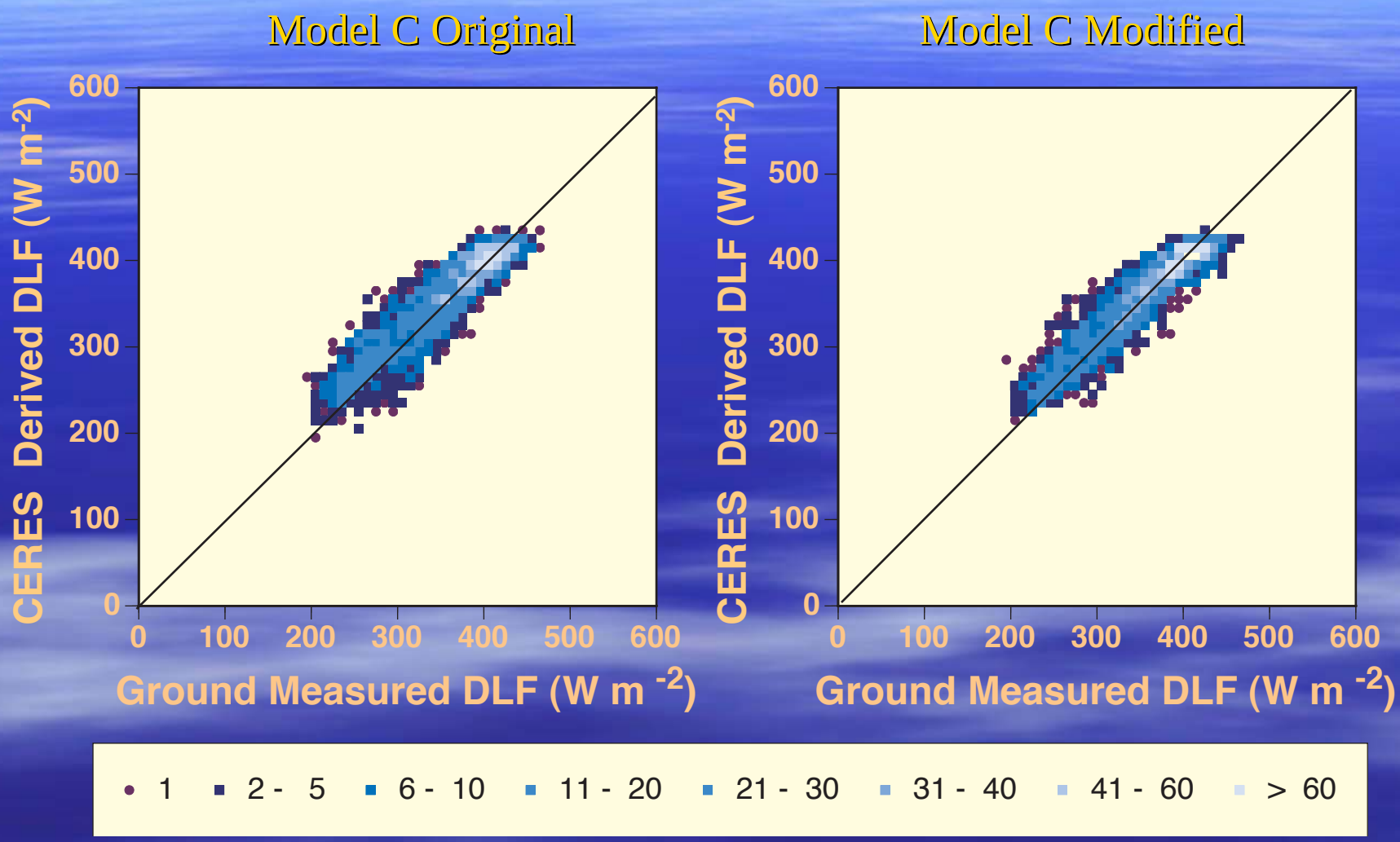
Model C Modified



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

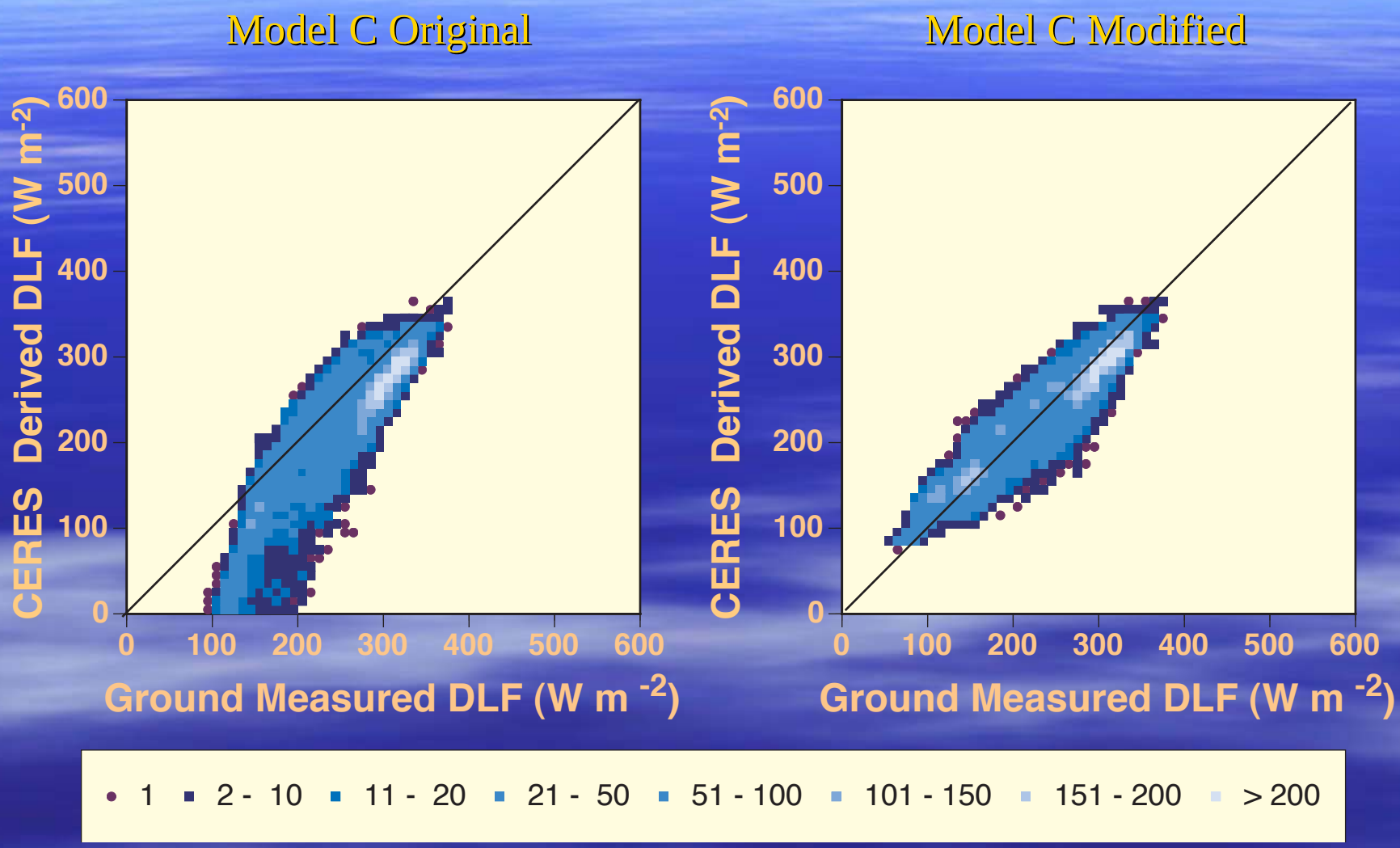
Aqua 2A

Longwave Cloudy-Sky Coastal



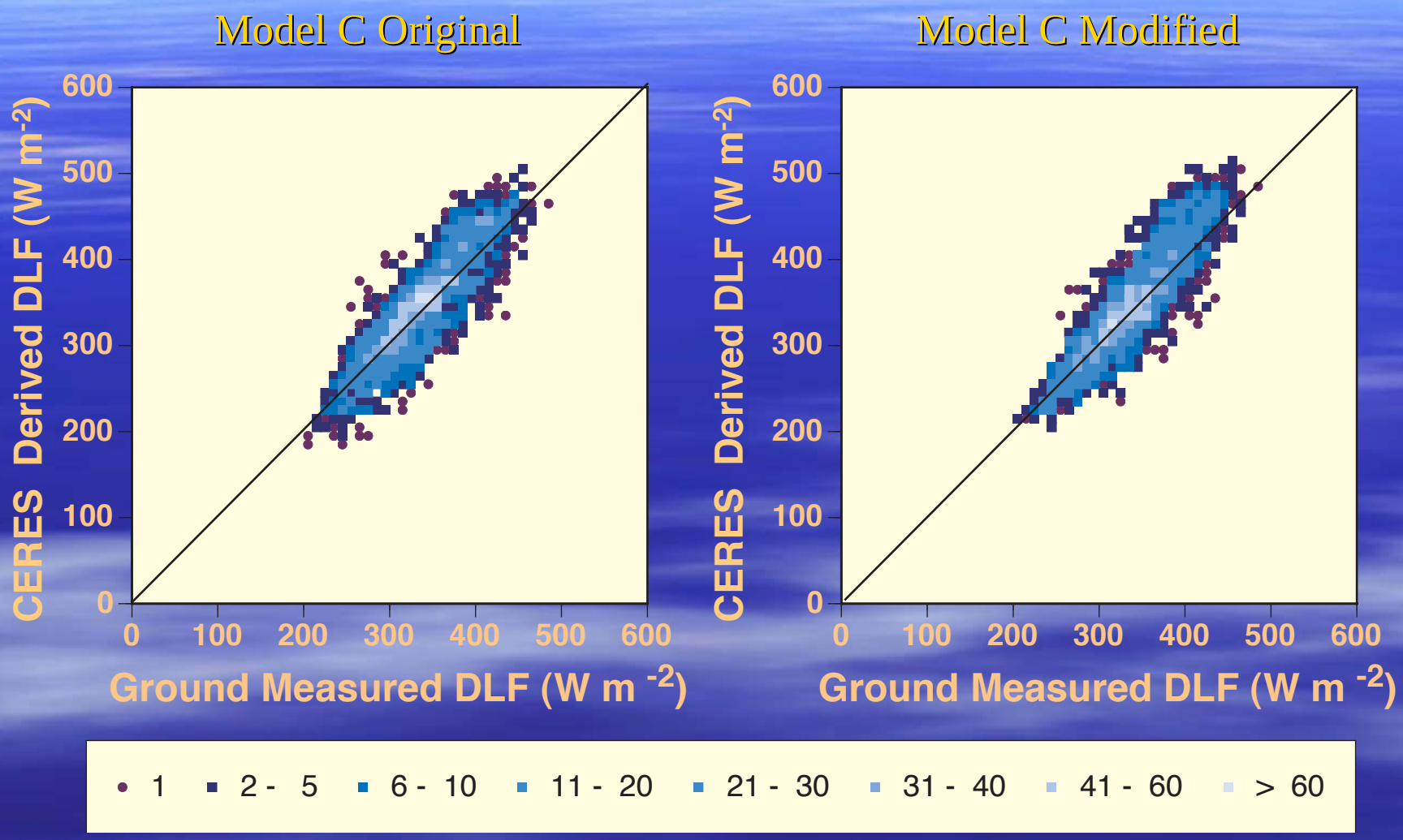
Aqua 2A

Longwave Cloudy-Sky Ant-arctic



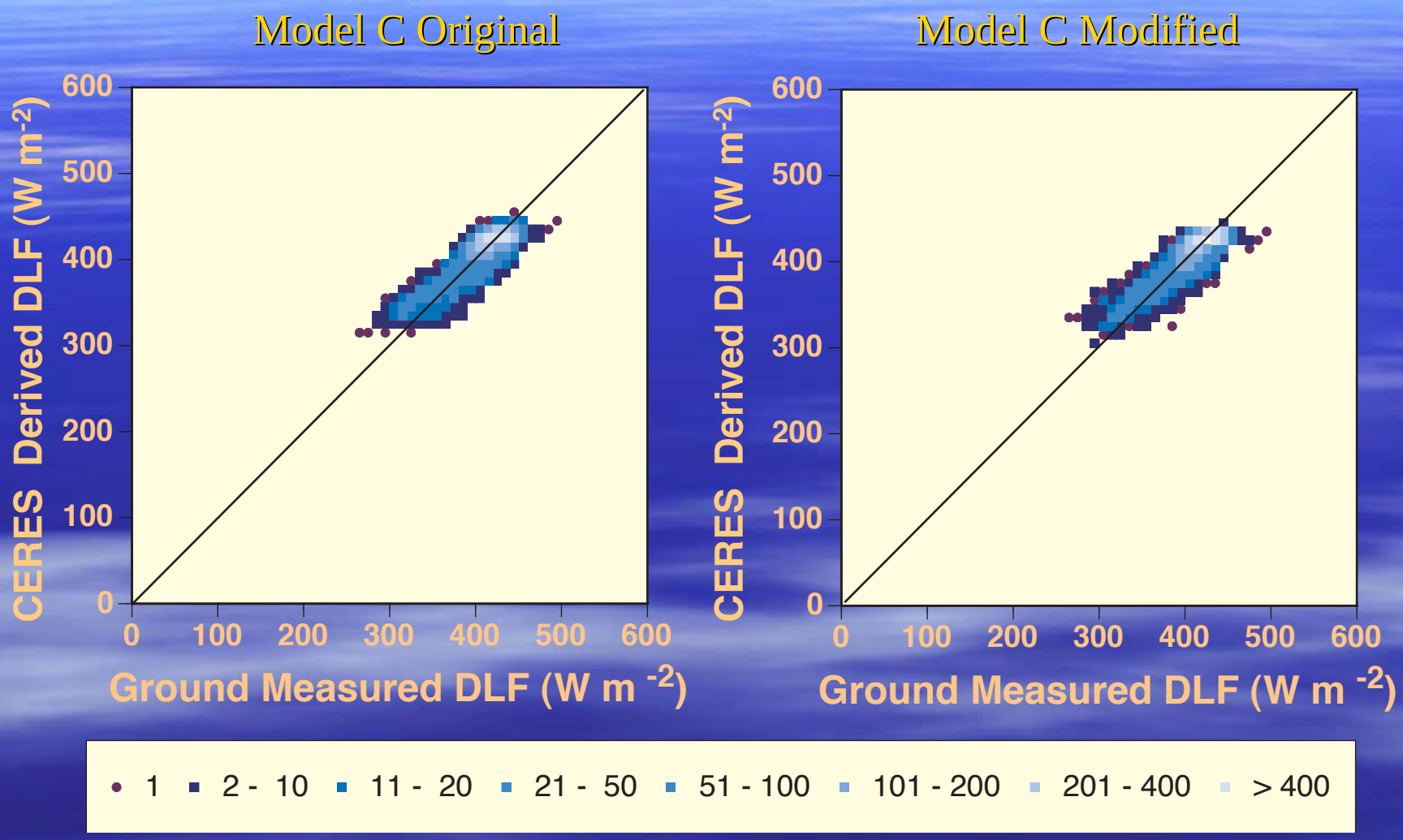
Aqua 2A

Longwave Cloudy-Sky Desert



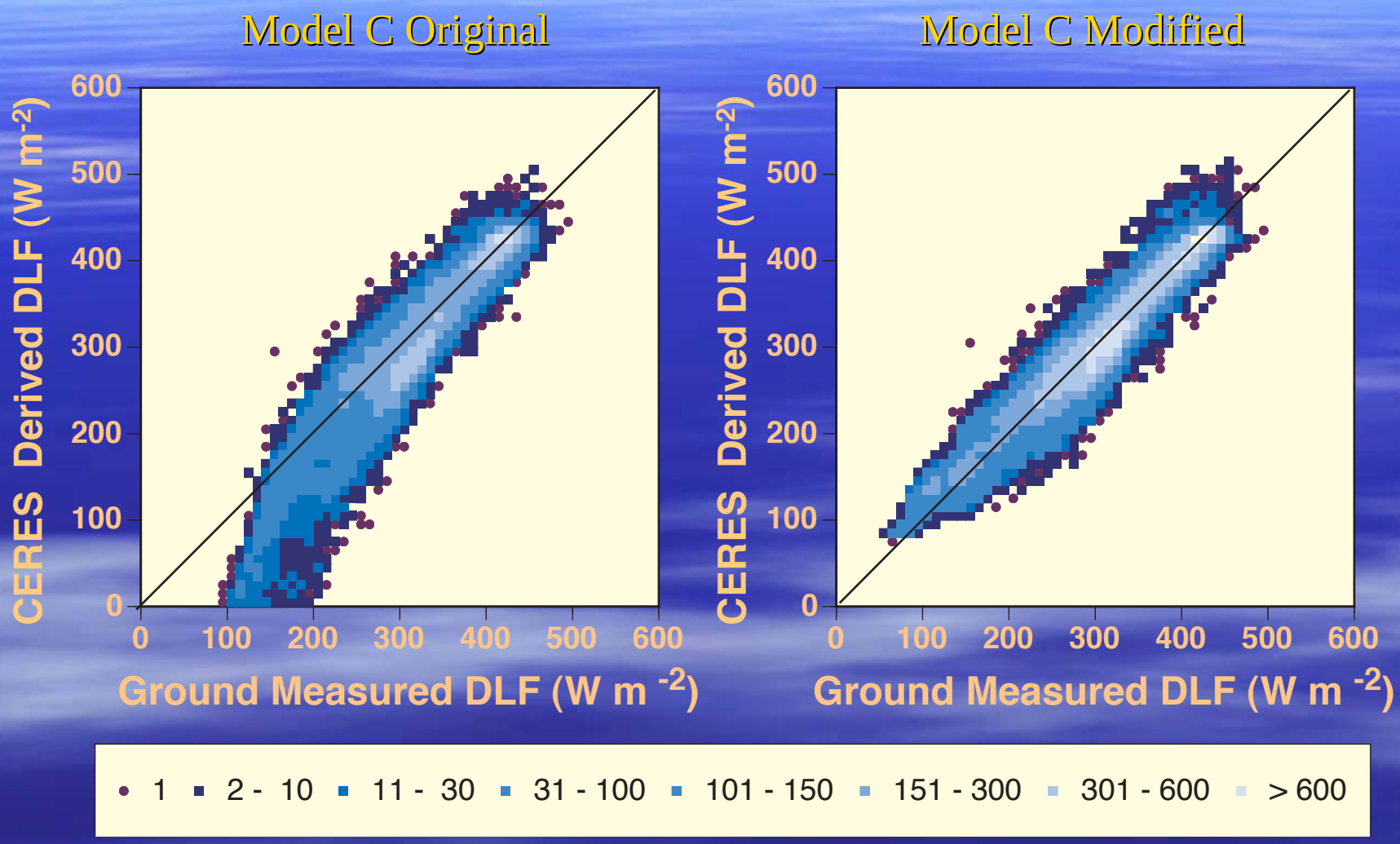
Aqua 2A

Longwave Cloudy-Sky Island



Aqua 2A

Longwave Cloudy-Sky Global



Aqua 2A

Longwave Cloudy-Sky

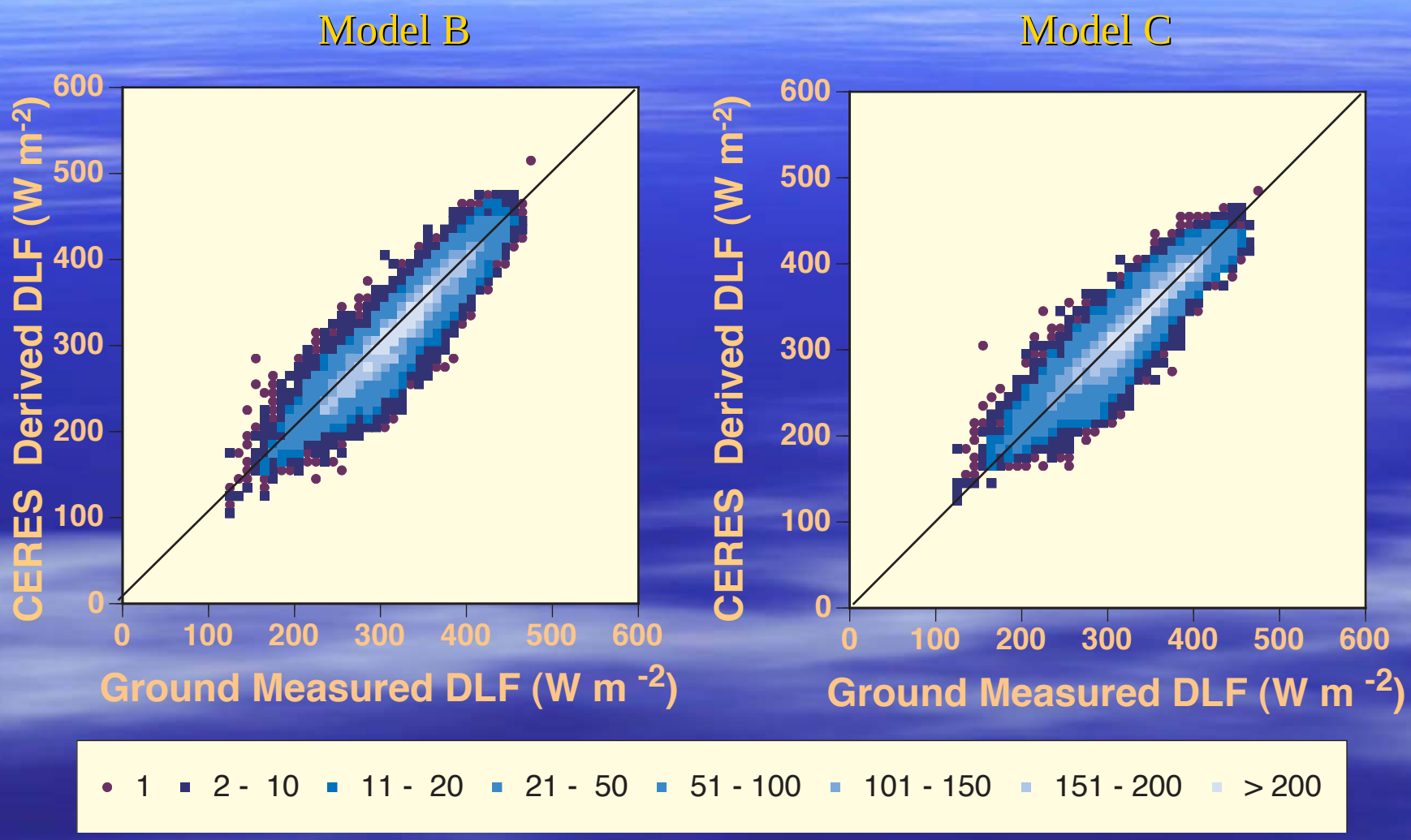
Sites # of Points		Original LWC	Modified LWC
Continental	Bias Wm^{-2} (%)	-7.42 (-2.33)	0.61 (0.19)
21420	σ Wm^{-2} (%)	28.0 (8.8)	22.6 (7.1)
Coastal	Bias Wm^{-2} (%)	1.80 (0.52)	6.00 (1.72)
3332	σ Wm^{-2} (%)	21.2 (6.1)	18.5 (5.3)
Ant-arctic	Bias Wm^{-2} (%)	-46.63 (-20.17)	-0.89 (-0.39)
17923	σ Wm^{-2} (%)	50.6 (21.9)	23.6 (10.2)
Desert	Bias Wm^{-2} (%)	8.19 (2.42)	9.67 (2.85)
4178	σ Wm^{-2} (%)	28.1 (8.3)	27.7 (8.2)
Island	Bias Wm^{-2} (%)	0.58 (0.14)	0.95 (0.23)
6812	σ Wm^{-2} (%)	13.5 (3.3)	12.5 (3.0)
Global	Bias Wm^{-2} (%)	-17.67 (-5.80)	1.20 (0.39)
53665	σ Wm^{-2} (%)	40.1 (13.2)	23.6 (7.8)

Aqua 2A

Longwave Model B & C Cloudy-Sky Comparison for July 2002 through March 2005

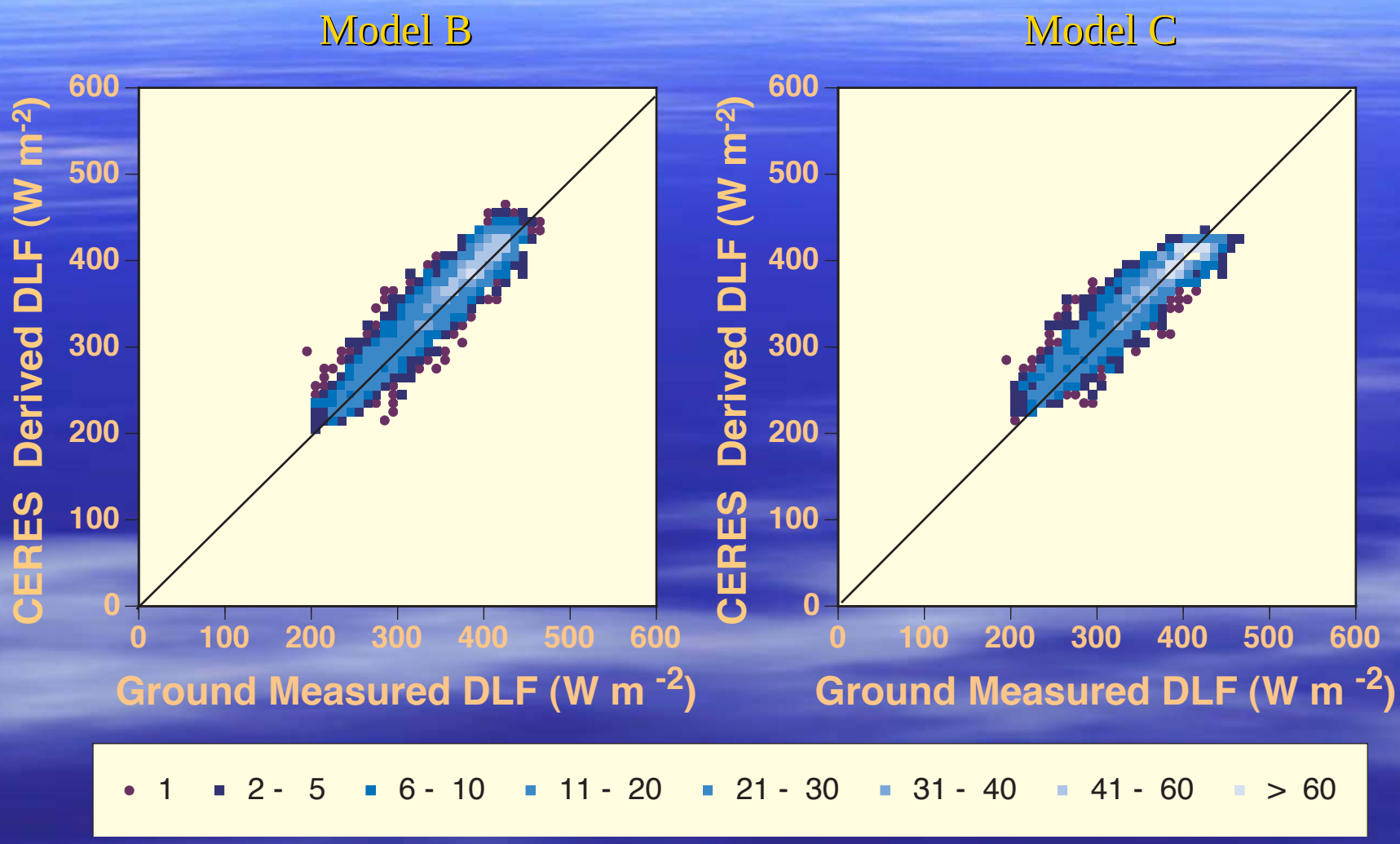
Aqua 2A

Longwave Cloudy-Sky Continental



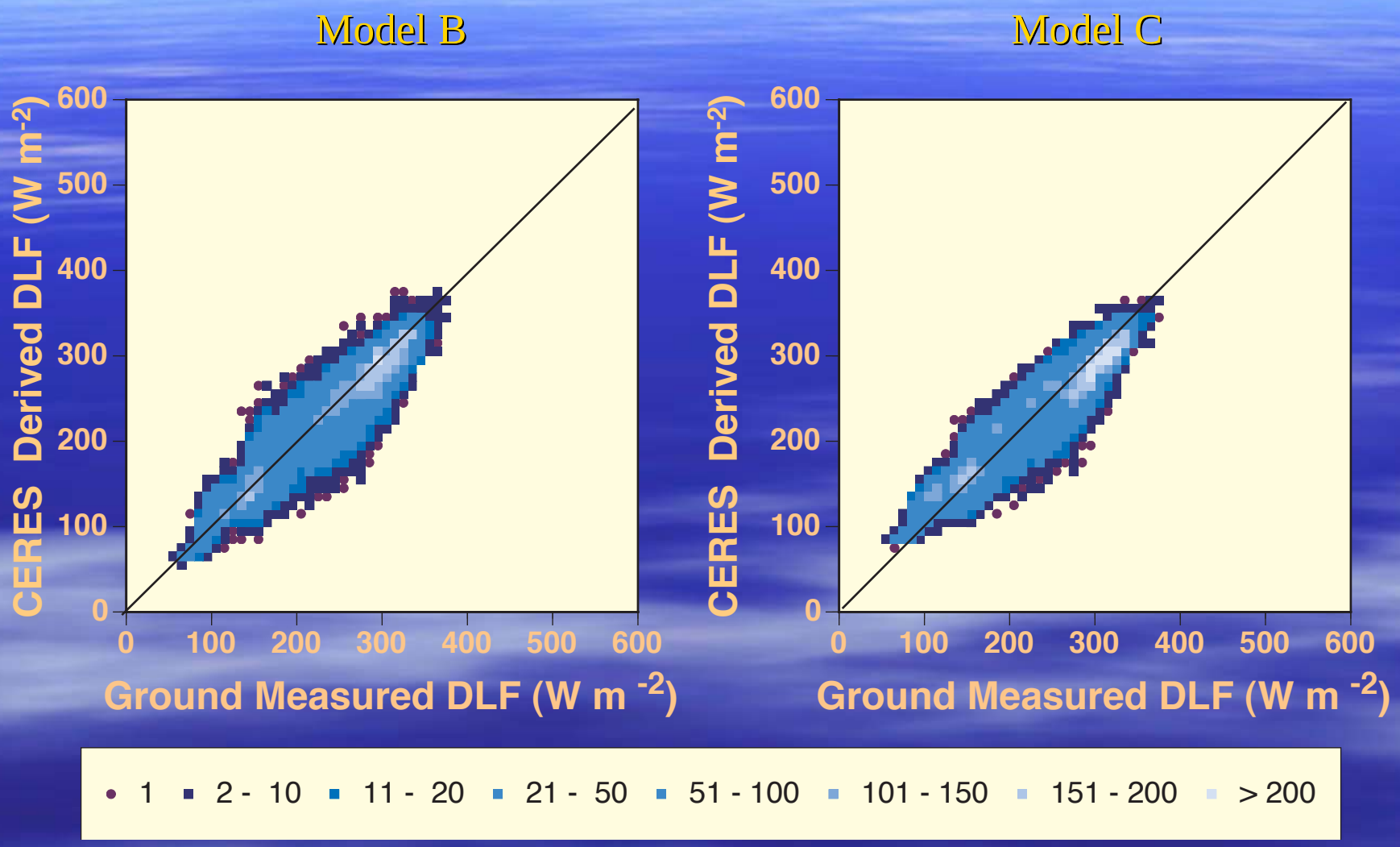
Aqua 2A

Longwave Cloudy-Sky Coastal



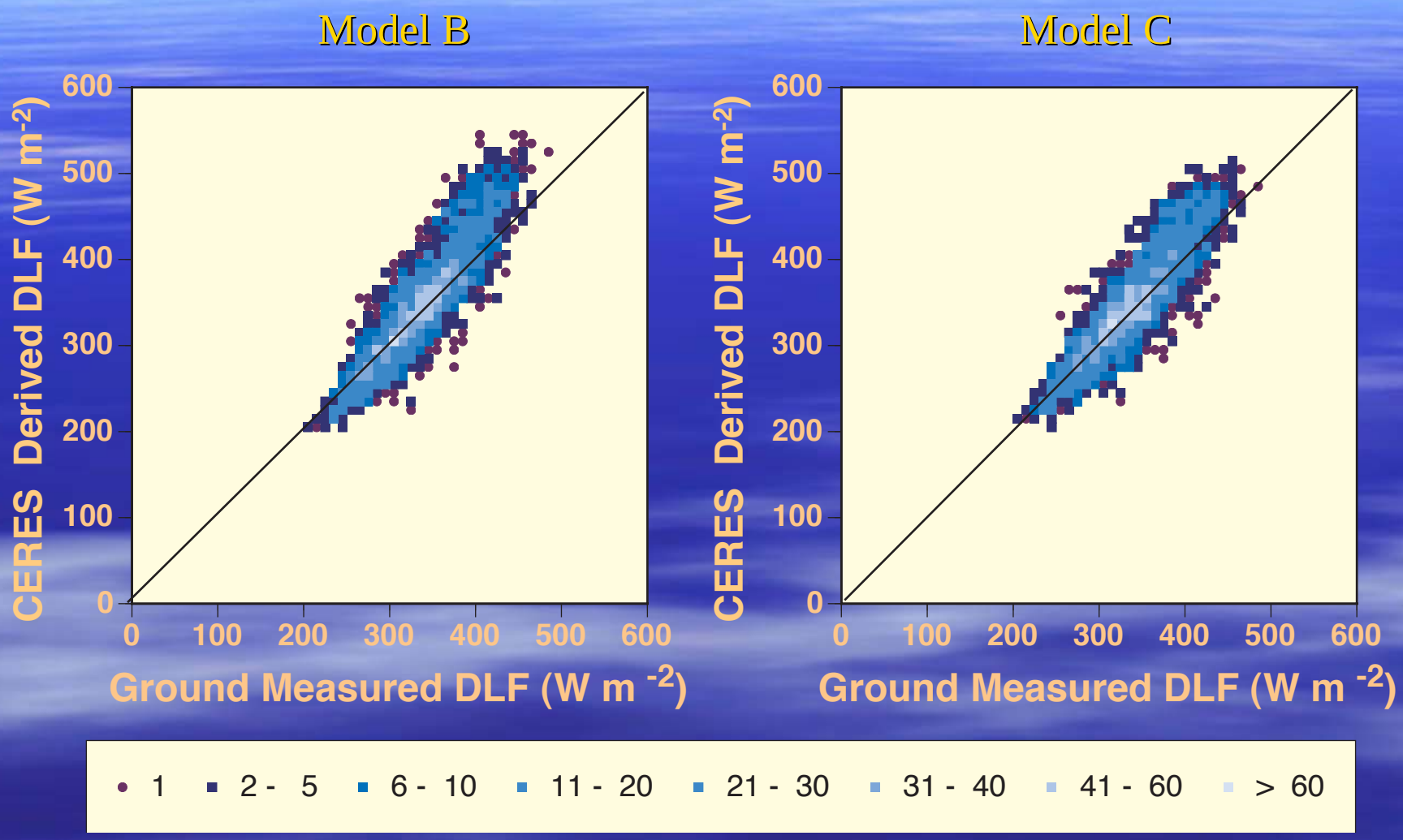
Aqua 2A

Longwave Cloudy-Sky Ant-arctic



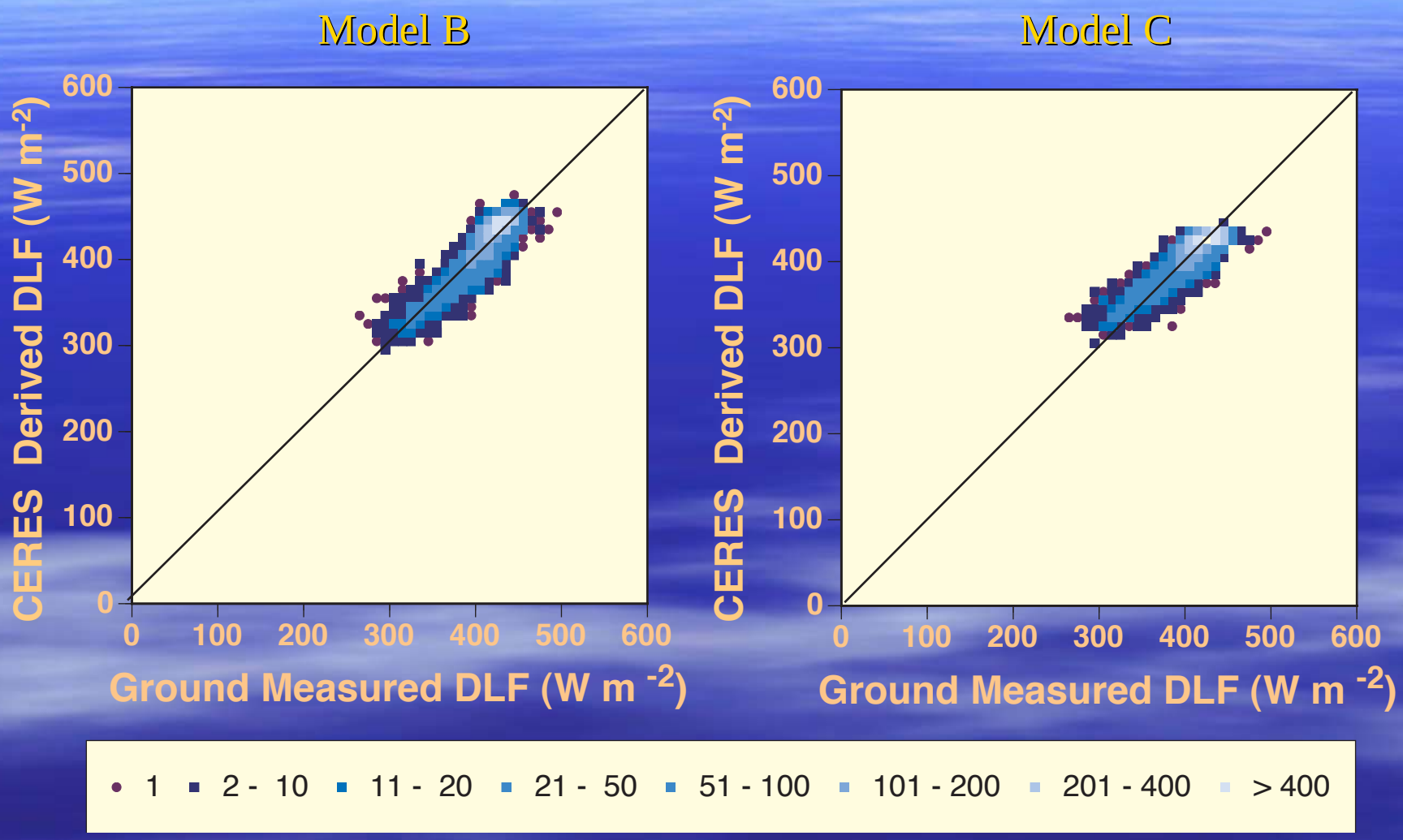
Aqua 2A

Longwave Cloudy-Sky Desert



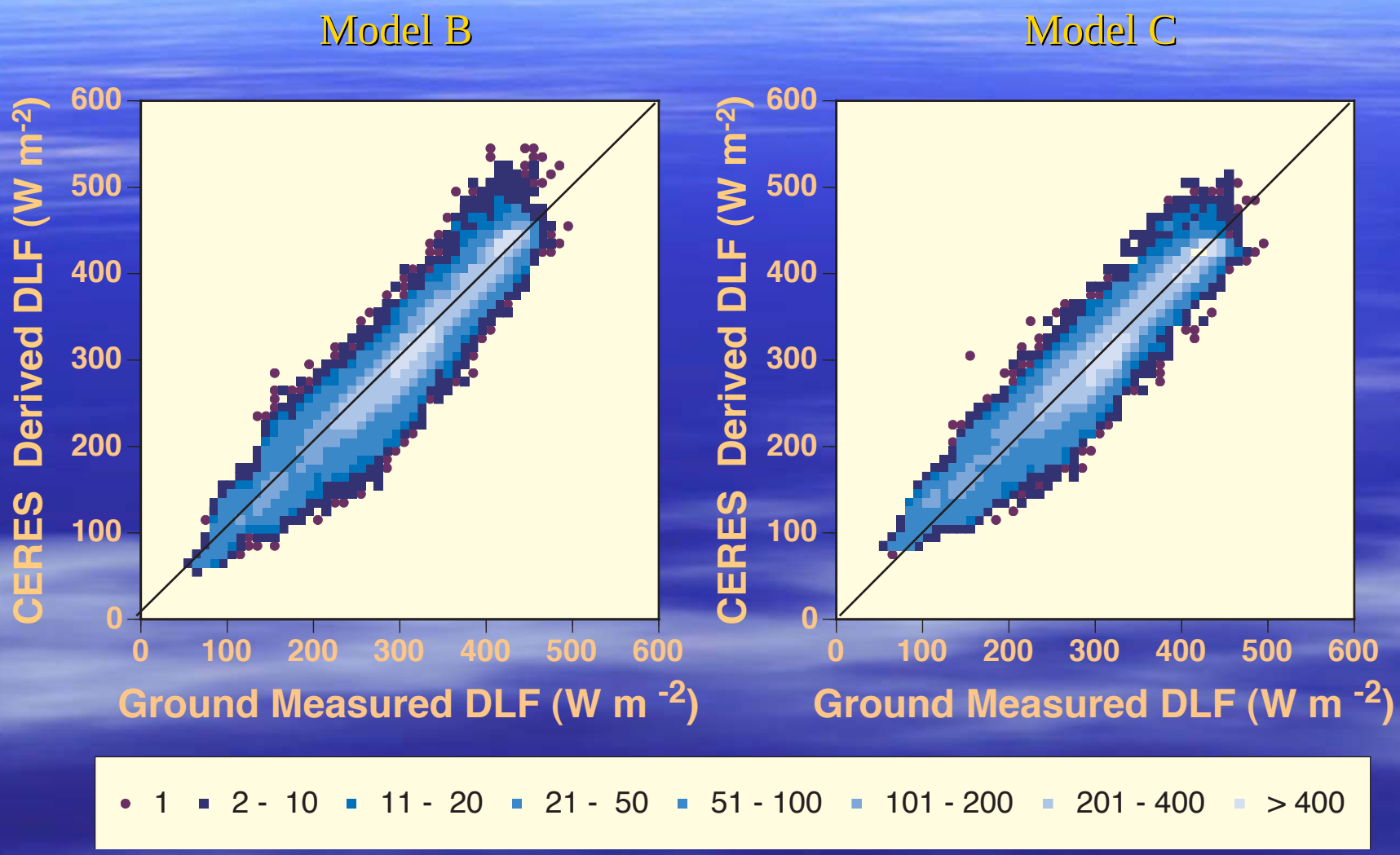
Aqua 2A

Longwave Cloudy-Sky Island



Aqua 2A

Longwave Cloudy-Sky Global



Aqua 2A

Longwave Cloudy-Sky

Sites # of Points		LWB	LWC
Continental 21106	Bias Wm^{-2} (%)	-3.38 (-1.06)	0.61 (0.19)
	σ Wm^{-2} (%)	22.4 (7.0)	22.6 (7.1)
Coastal 3300	Bias Wm^{-2} (%)	2.51 (0.72)	6.00 (1.71)
	σ Wm^{-2} (%)	19.0 (5.4)	18.5 (5.3)
Ant-arctic 17653	Bias Wm^{-2} (%)	-6.17 (-2.67)	-0.89 (-0.39)
	σ Wm^{-2} (%)	25.0 (10.8)	23.6 (10.2)
Desert 4155	Bias Wm^{-2} (%)	11.88 (3.51)	9.62 (2.84)
	σ Wm^{-2} (%)	28.8 (8.5)	27.7 (8.2)
Island 6729	Bias Wm^{-2} (%)	5.71 (1.39)	0.95 (0.23)
	σ Wm^{-2} (%)	14.8 (3.6)	12.5 (3.0)
Global 52943	Bias Wm^{-2} (%)	-1.59 (-0.52)	1.19 (0.39)
	σ Wm^{-2} (%)	24.4 (8.0)	23.6 (7.8)

Aqua 2A

Zhou-Cess Longwave (LWC) Algorithm

Revised (All-Sky)

SDLW(all) = SDLW(clr)*Area(clr)*0.01 + SDLW(cld)*Area(cld)*0.01

where Area(cld) = (100.0 – Area(clr))

$$SULW = _*_*T_s^4 + (1-_)*SDLW$$

$$LWC_{net} = SDLW - SULW = _*(SDLW - _*T_s^4)$$

Aqua 2A

Conclusions: Longwave

CERES derived LW surface fluxes are within desired accuracies (biases) for both the clear-sky models (A, B & C) and the cloudy-sky models (B & C).

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).