Recent Improvements in Surface-Only Flux Algorithms (SOFA)
(Simple Surface Flux Models)

Shashi K. Gupta[1], David P. Kratz[2],
Anne C. Wilber[1], and Victor E. Sothcott[1]

[1]Science Systems and Applications, Inc.
[2]NASA Langley Research Center

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Background

- CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in addition to 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.)

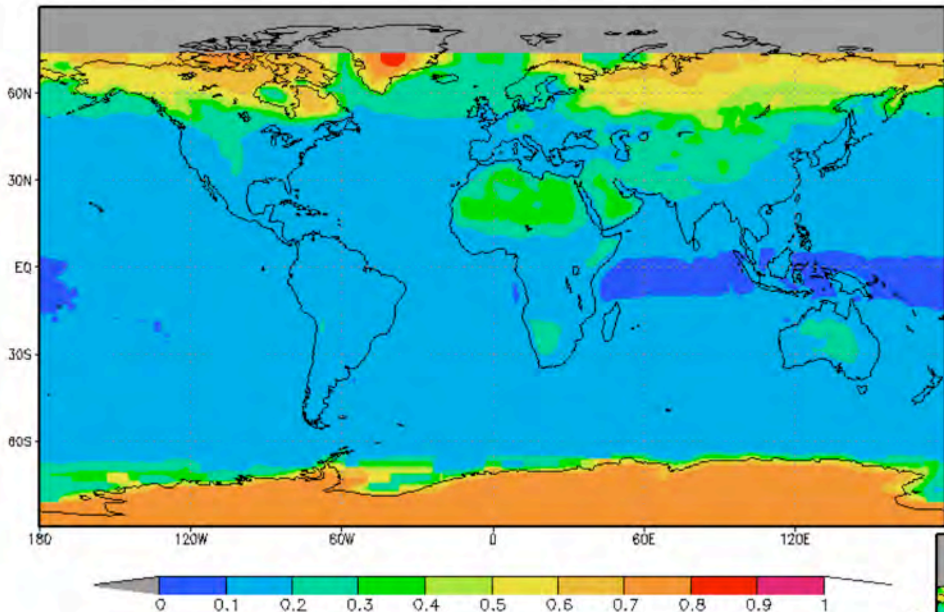
- SOFA Models use either TOA-to-surface transfer algorithms or radiation parameterizations to derive surface radiative fluxes. They also serve as independent checks on SARB results.
- SW Model A and LW Models A & B were incorporated at the start of the CERES project.
- SW Model B was adapted for use in CERES processing just before the TRMM launch.
- LW Model C will be introduced with Edition-3 processing to maintain two independent LW algorithms if CERES window channel becomes unavailable on future CERES instruments.
- SOFA surface fluxes have undergone extensive validation.
- Validation showed some model deficiencies, which were addressed one-by-one as they became apparent.

Improvements to Models and Codes

1. Correction of simple coding errors.
2. Handling of extreme values of input parameters.
   SW Model B: Column $O_3 > 500$ DU.
   LW Model B: $P_s < 500$ hPa
3. Replacement of old ancillary inputs with new ones.
   SW Model B: Replaced ERBE Clear-sky TOA albedos with those from CERES/Terra.
4. Correcting flaws in model formulations.
   LW Models A & C: Use of ln(w) term in flux formula.
5. Correcting errors arising from violations of model assumptions.
   LW Models A, B, &C: Use of T_s as a surrogate for near-surface air temperature resulting in very high lapse rates when surface temperature is too high.

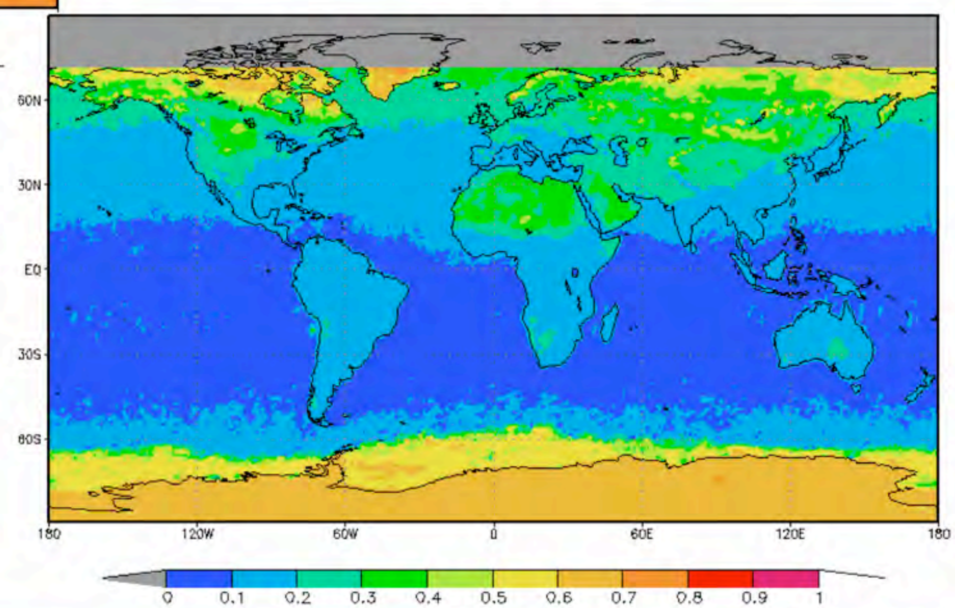
Replacement of Old Ancillary Inputs

ERBE and CERES Clear-Sky TOA Albedos



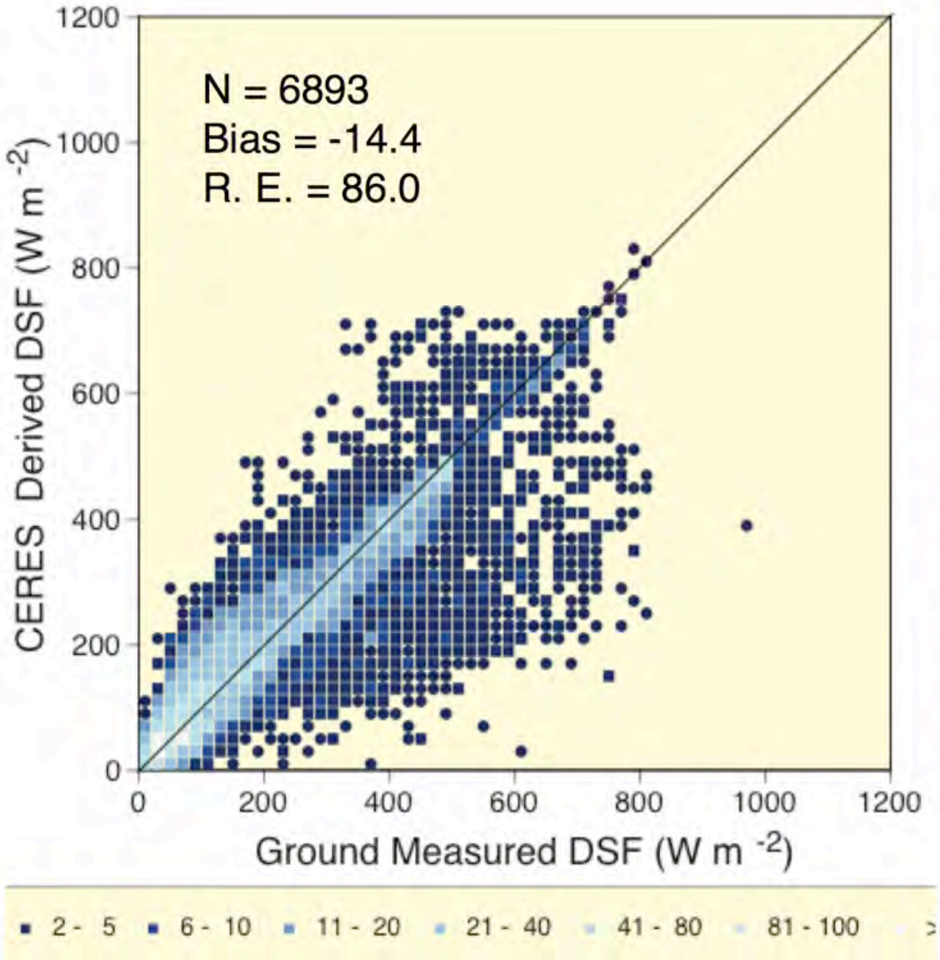
ERBE

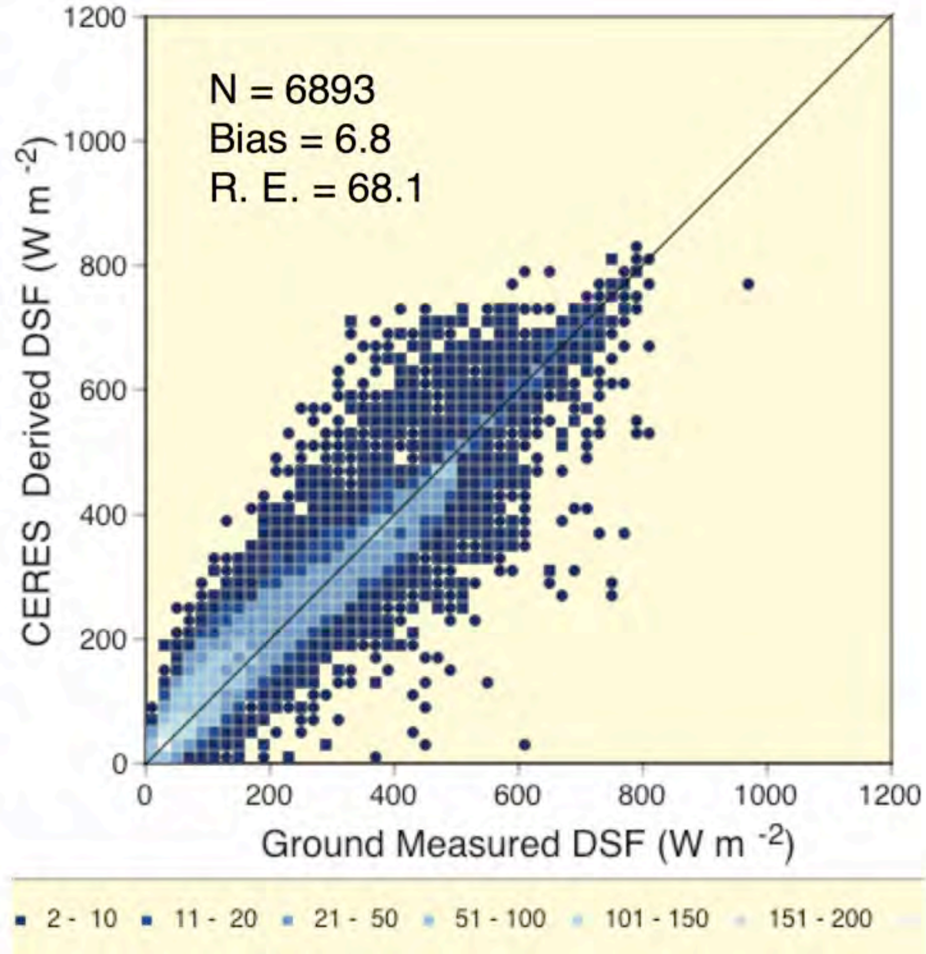
CERES



Polar Sites Comparison Before and After Albedo Change

(South Pole, Syowa, Georg von Neumayer, Barrow, Ny Alesund)





Correcting Flaws in Model Formulations

Improvement of Longwave Model C

Original Algorithm

$$DLF = a0 + c1*ULF + c2*\ln(w) + c3*[\ln(w)]^2$$

$a0 = 123.86$, $c1 = 0.444$, $c2 = 56.16$, $c3 = -3.65$

where

$ULF = \sigma * T_s^4$; w – column water vapor (pr-cm)

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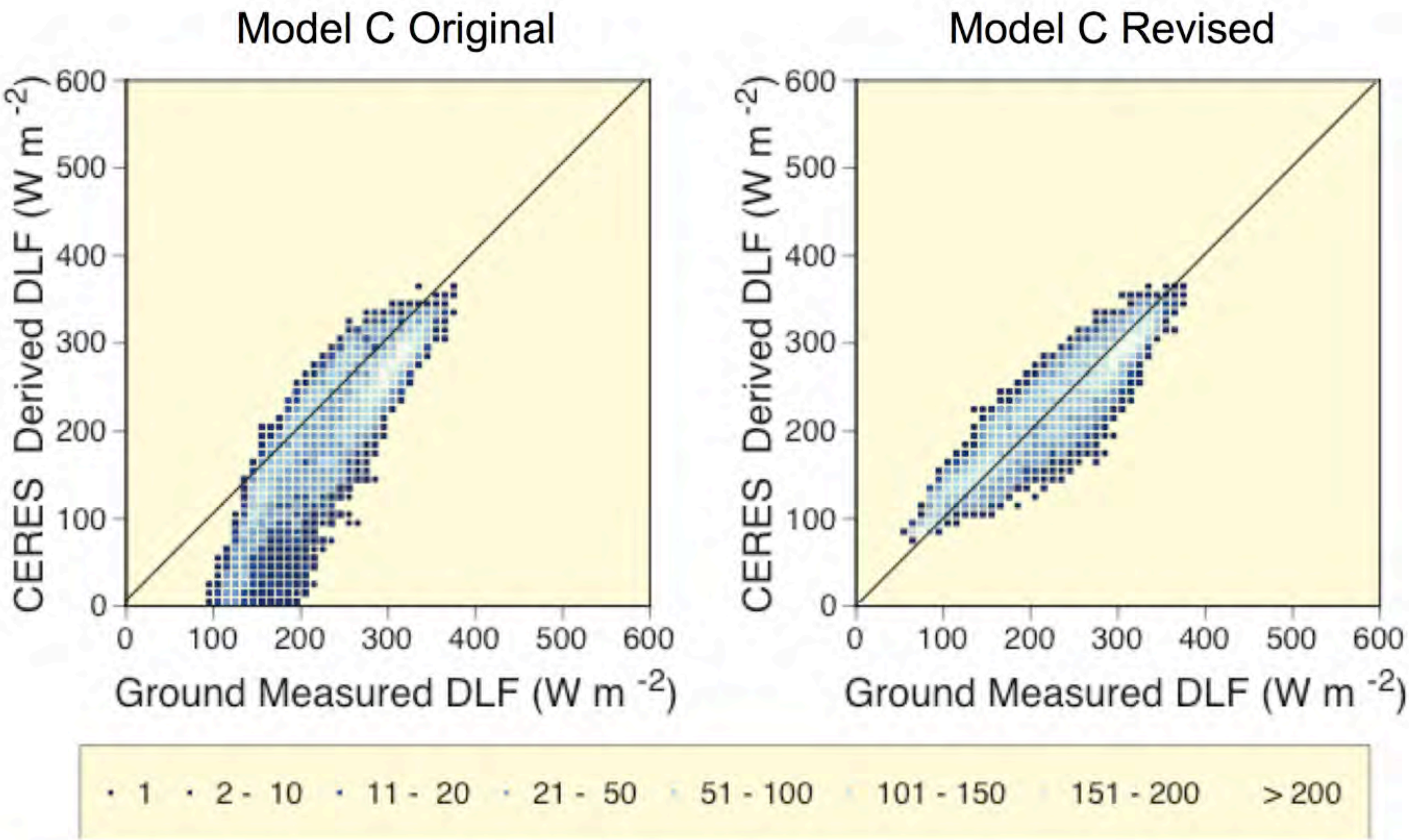
Revised Algorithm

$$DLF = a0 + c1*ULF + c2*\ln(1+w) + c3*[\ln(1+w)]^2$$

$a0 = 37.687$, $c1 = 0.474$, $c2 = 94.190$, $c3 = –4.935$

Longwave All-Sky for Polar Sites

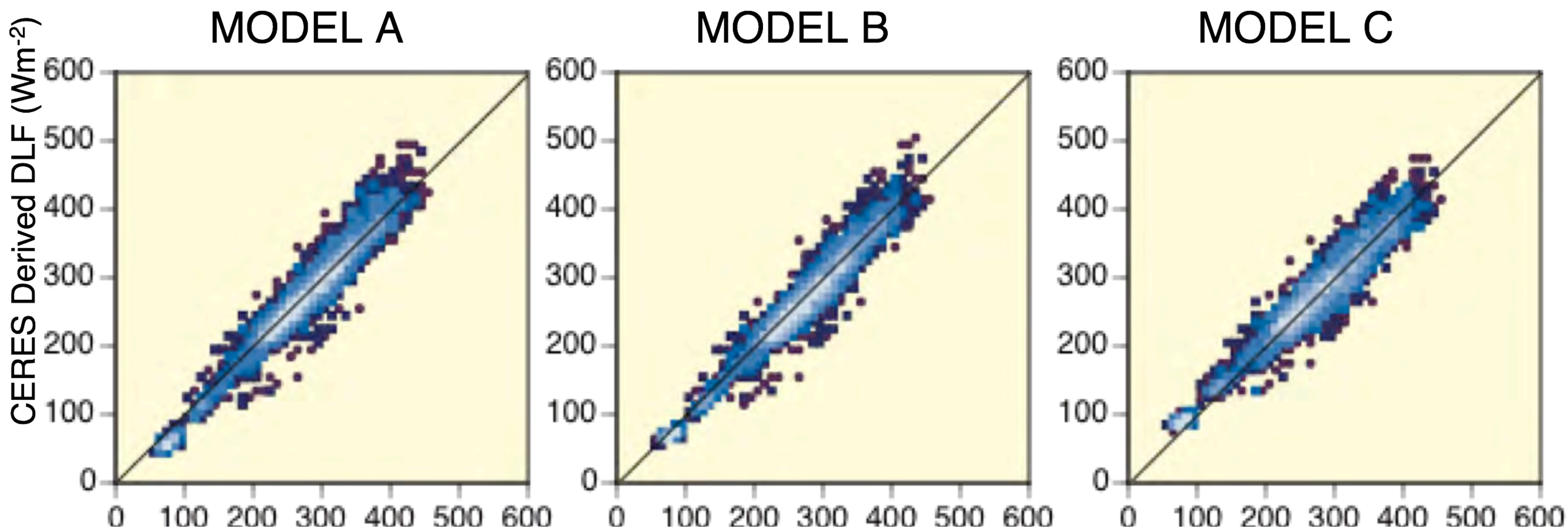


Correcting Errors Arising From Violation of Model Assumptions

Overestimation of DLF Over Desert Regions

Clear-Sky (Aqua-2A; July 2002 - March 2005)

Global



CERES Derived DLF (Wm^{-2})

Overestimation of DLF Over Desert Regions

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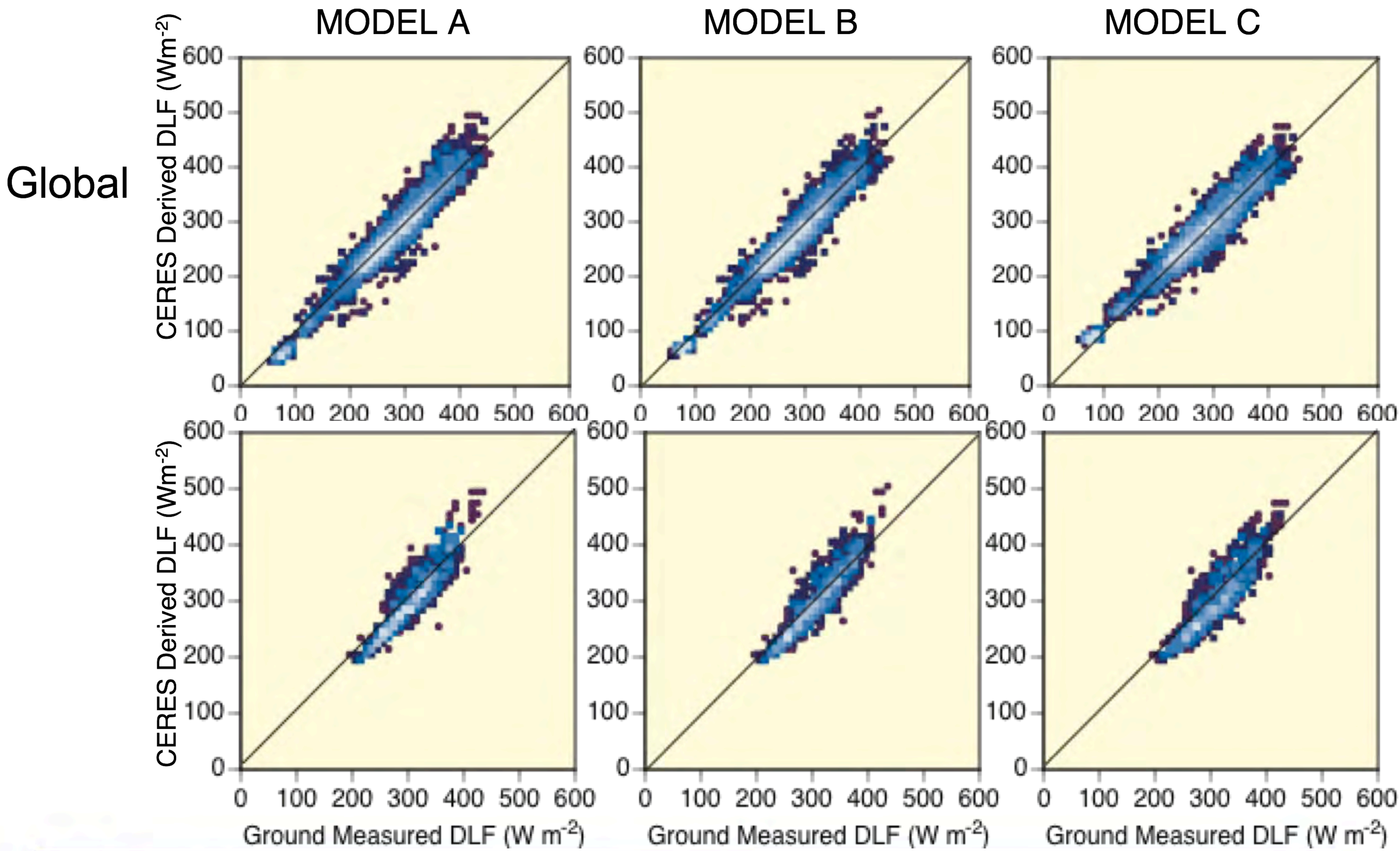

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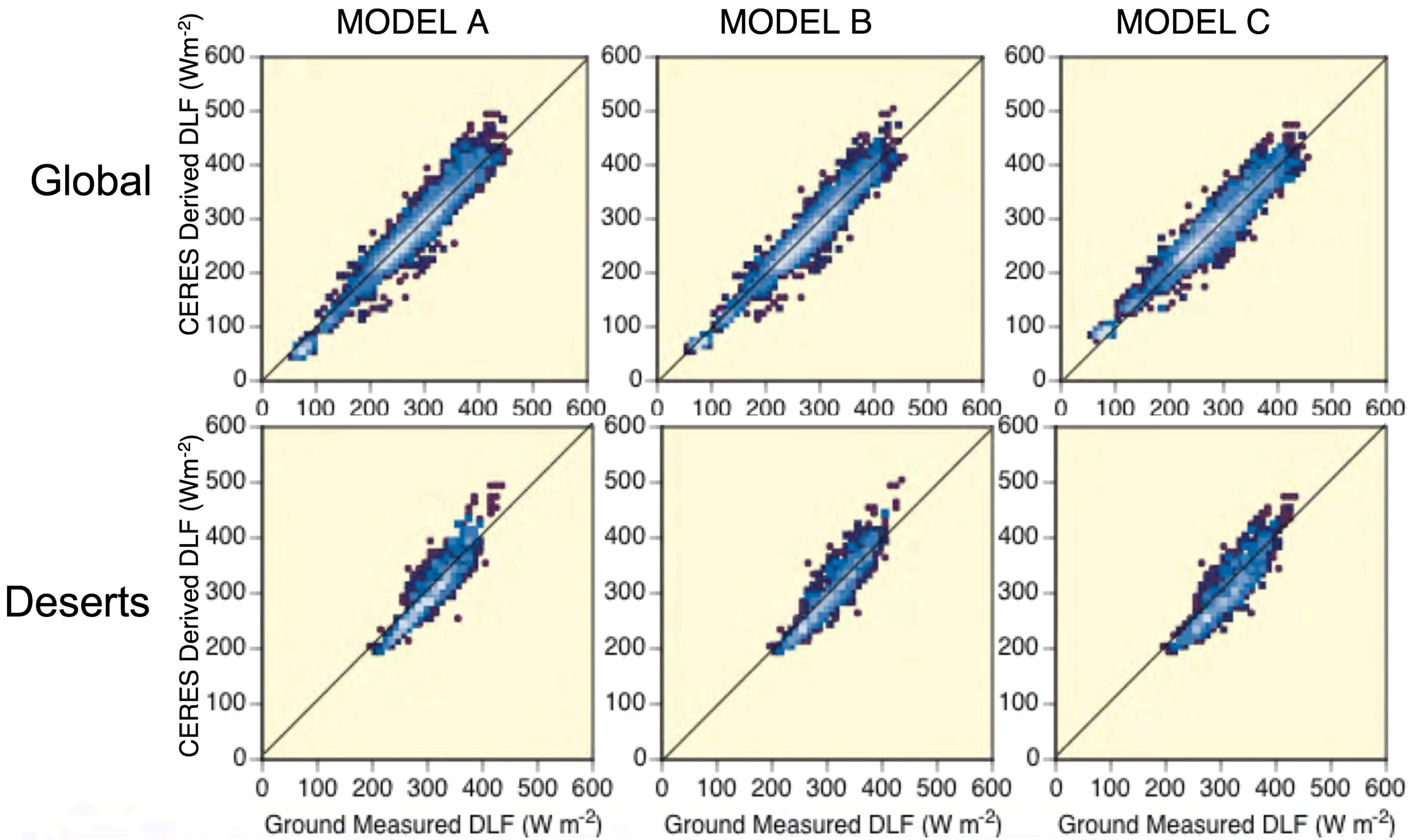


Cause of Flux Overestimation

- Models use T_s as a surrogate for the near-surface air temperature.
- A nominal value of lapse rate is implicit in all model formulations.
- Selected LW Model B to look for the cause and develop a remedy.
- Effective Emitting Temperature:

$$T_{eff} = 0.60\, T_s + 0.35\, T_1 + 0.05\, T_2$$

T_s – Surface skin temperature
T_1 - Average temperature for Sfc. – 800 hPa layer
T_2 - Average temperature for 800 - 680 hPa layer

- Works well when T_s, T_1, and T_2 conform to nominal lapse rates.
- When $T_s \gg T_1$ (and T_2), it results in overestimation of DLF.
- Happens mostly over dry/arid regions during hot times of the day.

Investigation of Overestimation

- Selected two BSRN sites for the study:

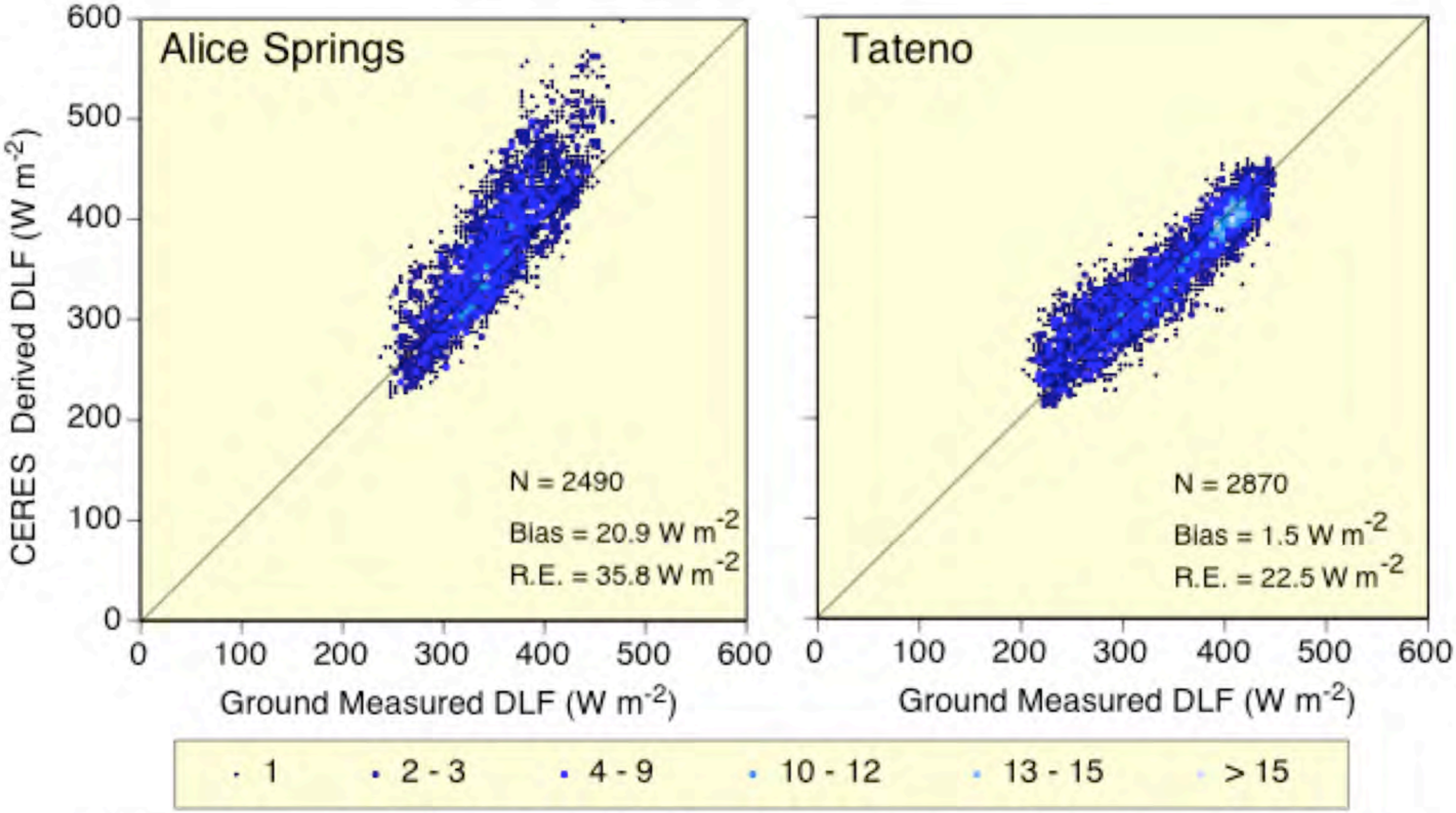
  Alice Springs, Australia - Dry/Arid
  Tateno, Japan – Moderate/Mid-Lat.

- Performed flux computations using an offline version of the model on a 3-hourly time resolution for all months of 2004.

- Compared model-derived DLF with ground-based observations for the above sites obtained from BSRN database.

Model-Derived vs. Ground-Measured BSRN DLF

(Year 2004; Offline LW Model B)

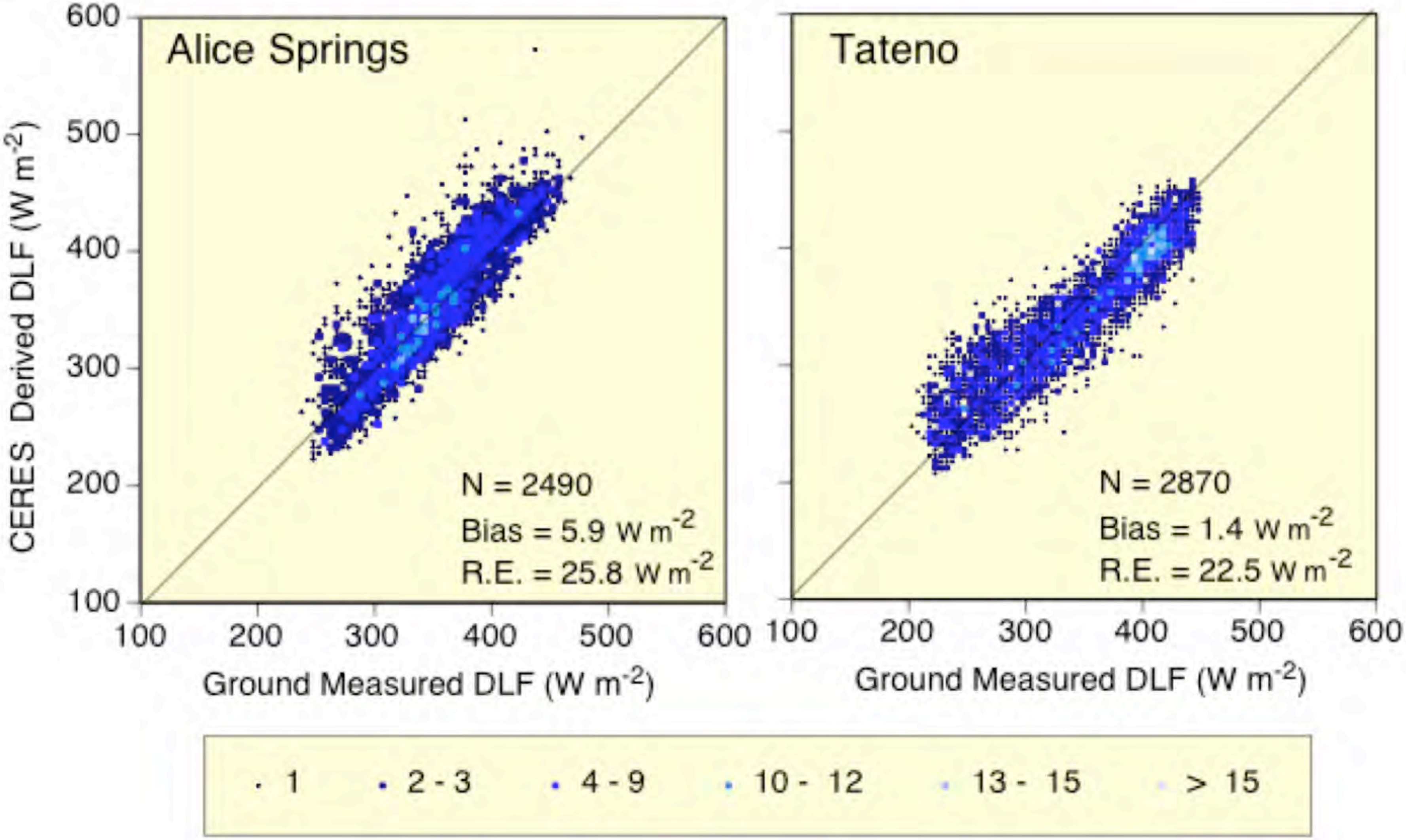


Significant overestimation over Alice Springs; almost none over Tateno

Analysis of Alice Springs Overestimation

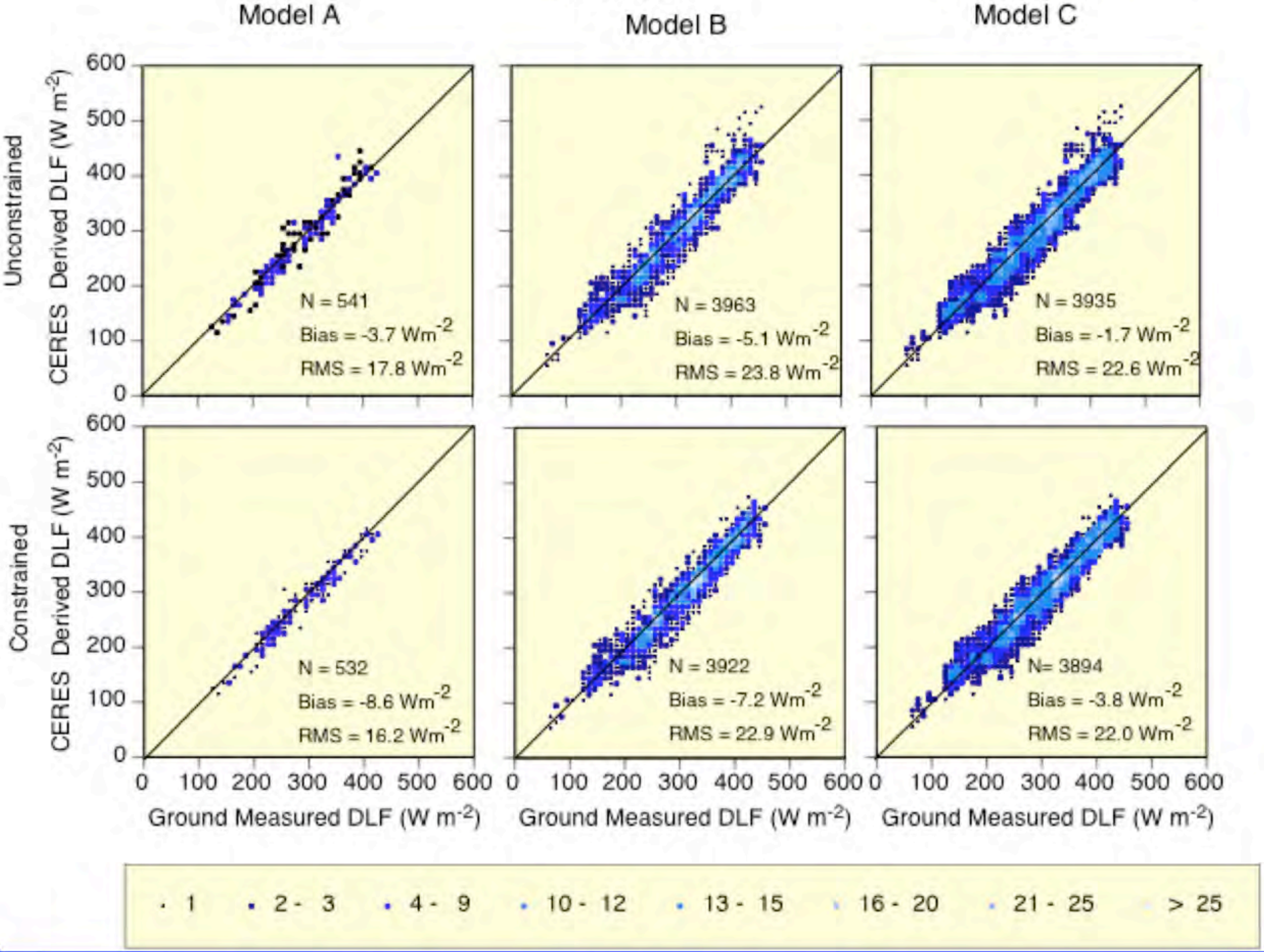
- Points with overestimation of > 100 Wm^{-2}
  78 points during the year (47 in DJF)
  Mean = 117 Wm^{-2}; Range: 100-177 Wm^{-2}
  T_s: Mean = 325.5 K; Range: 291-337 K
  P_s: Mean = 940 hPa; Range: 932-947 hPa
  T_{800}: Mean = 292.7 K; Range: 275.8-299.9 K
  $T_s - T_{800}$: Mean = 32.8 K; Range: 8.6-42.2 K
- $T_s - T_{800}$ should be about 10 K, but no more than 15 K
- Decided that lapse rates > 10K/100hPa in the lower layer are too steep, and need to be constrained.
- Constrained skin temperature to not violate the 10K/100hPa limit and used that only for DLF computation.

Results From the Modified Computation



Bias for Alice Springs - reduced greatly; Change for Tateno- minimal

Model Fluxes from CERES Processing – Jan & Jul 2004



Summary

- Validation of SOFA products showed some model deficiencies, which were addressed as they became apparent.
- Use of CERES-based clear-sky TOA albedos improved SW Model B surface insolation values over polar regions.
- Modifying water vapor term in LW Model C improved DLF retrievals over polar regions.
- Overestimation of DLF in all LW models remedied by constraining T_s as used in DLF computation.
- Note: Constrained T_s was used only for DLF computation.

Work in Progress

- Replace aerosol properties used in SW Model B (WCP-55) with those from newer sources.

•These improvements and validation of SOFA algorithms have been written up for two separate publications.

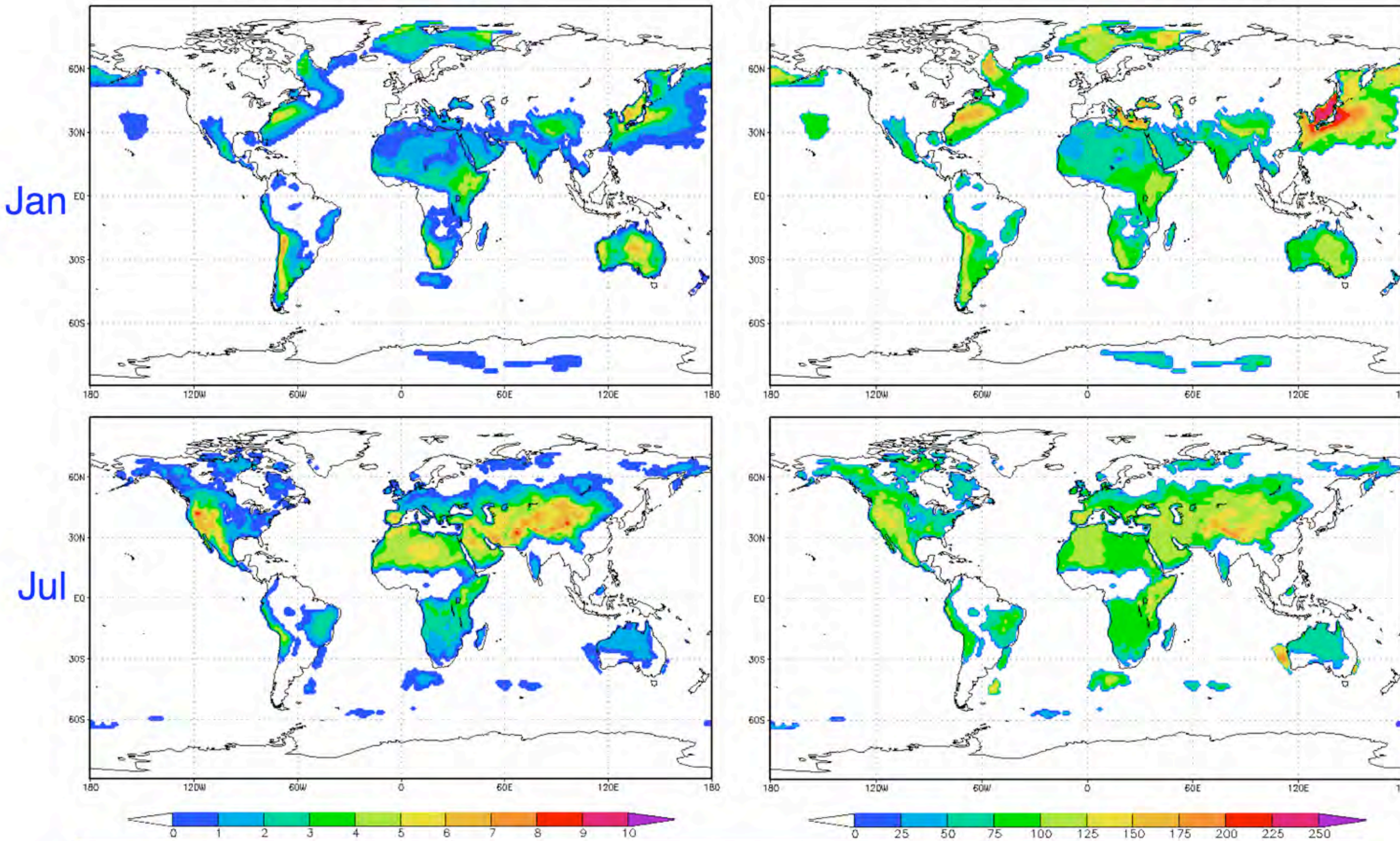
Validation of the CERES Edition 2B Surface-Only Flux Algorithms - Kratz et al. (2009).

Improvement of Surface Longwave Flux Algorithms Used in CERES Processing – Gupta et al. (2009).

Back-up Slides

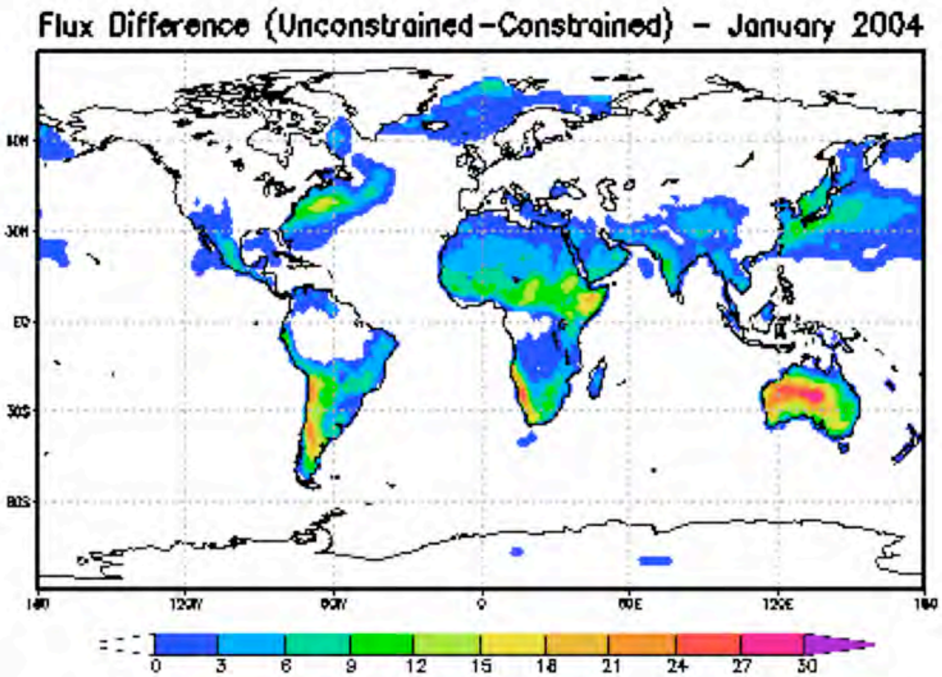
Monthly Temperature Adjustment and Frequency

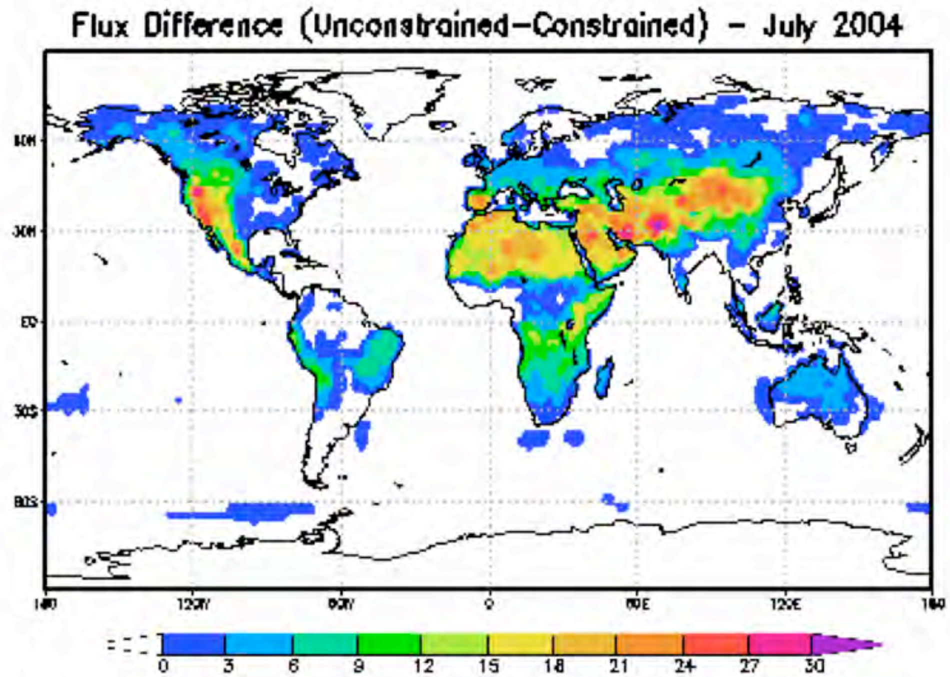
Temperature Adjustment | Adjustment Frequency



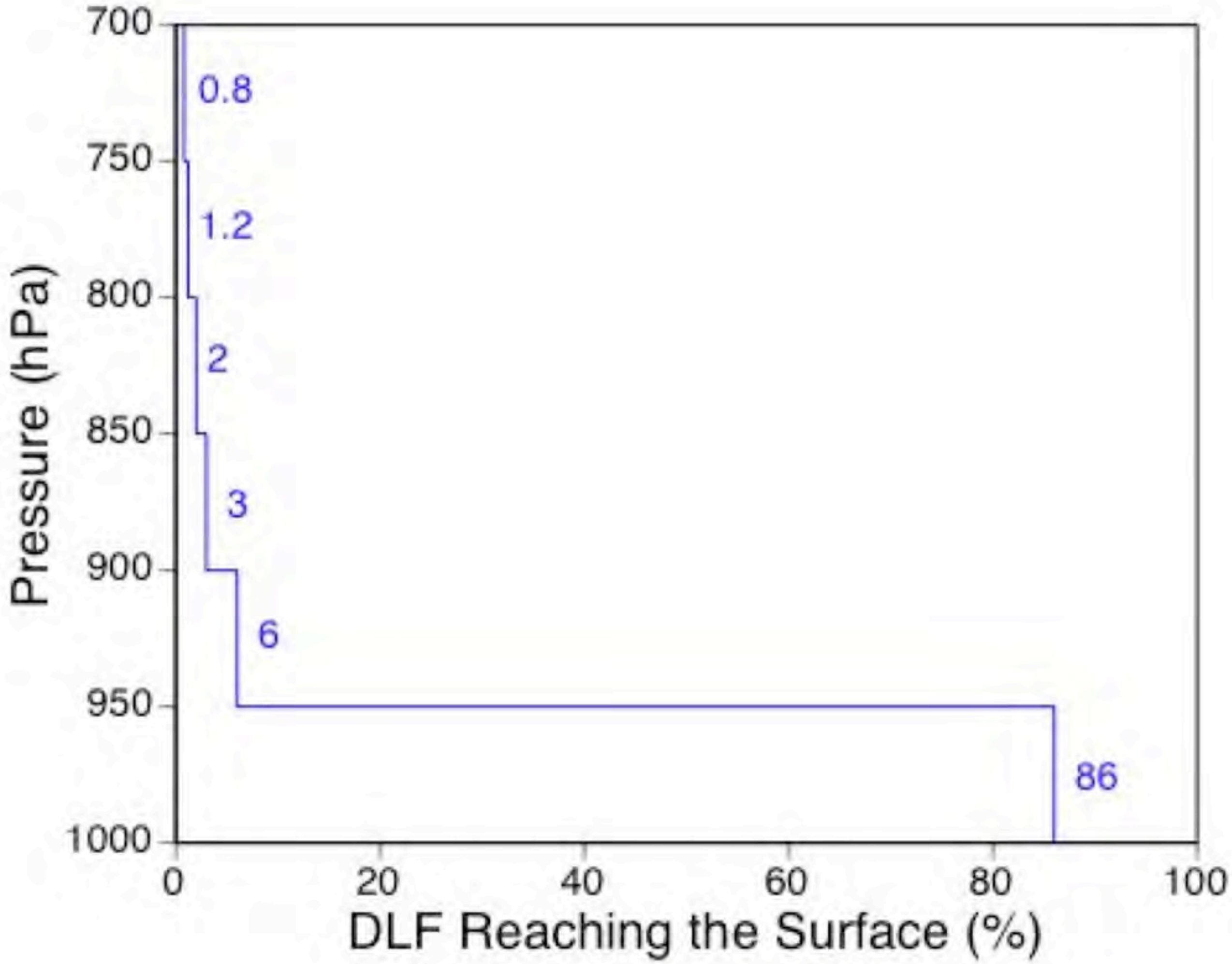
Climate Science Branch, NASA Langley Research Center

Monthly Average Flux Difference
(Unconstrained – Constrained)



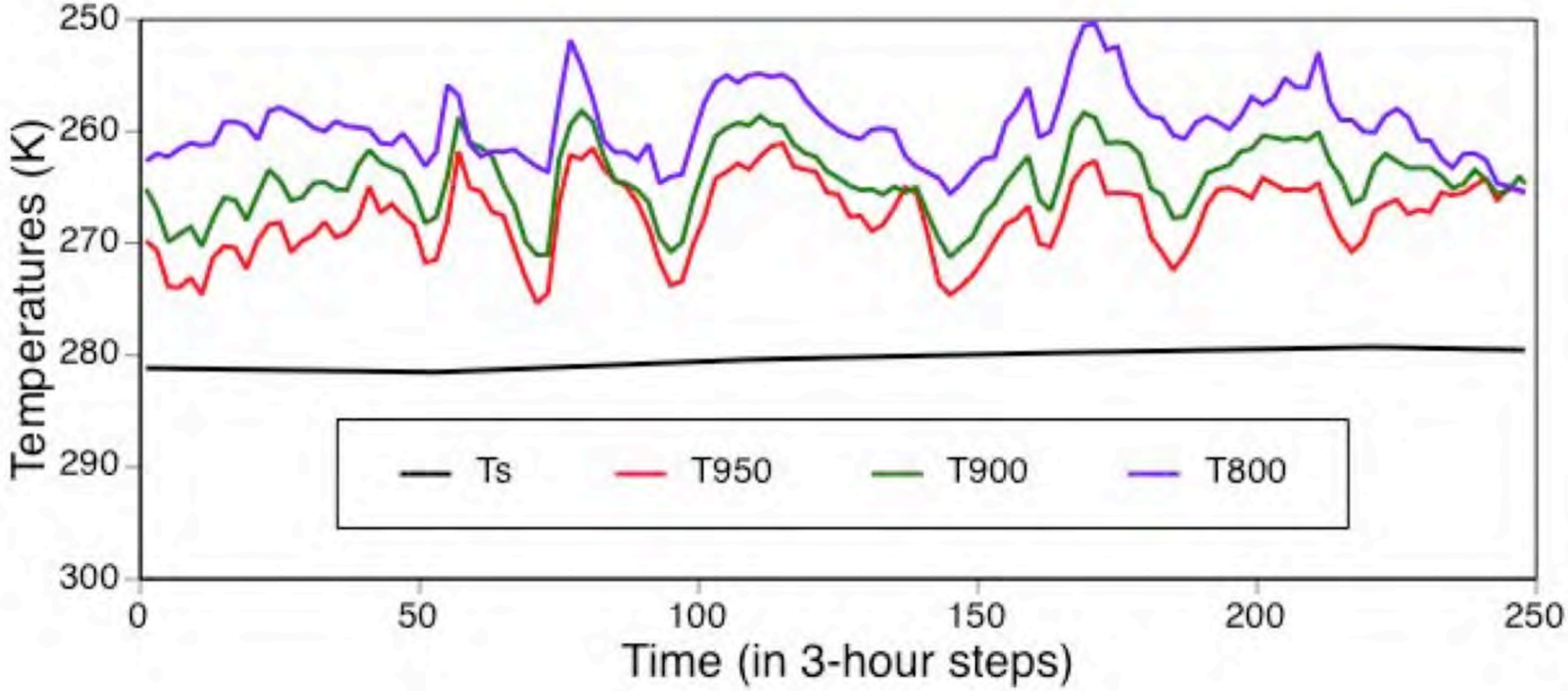


Weighting Function for DLF Reaching the Surface
(Mid-Latitude Atmosphere – 50 hPa Layers)

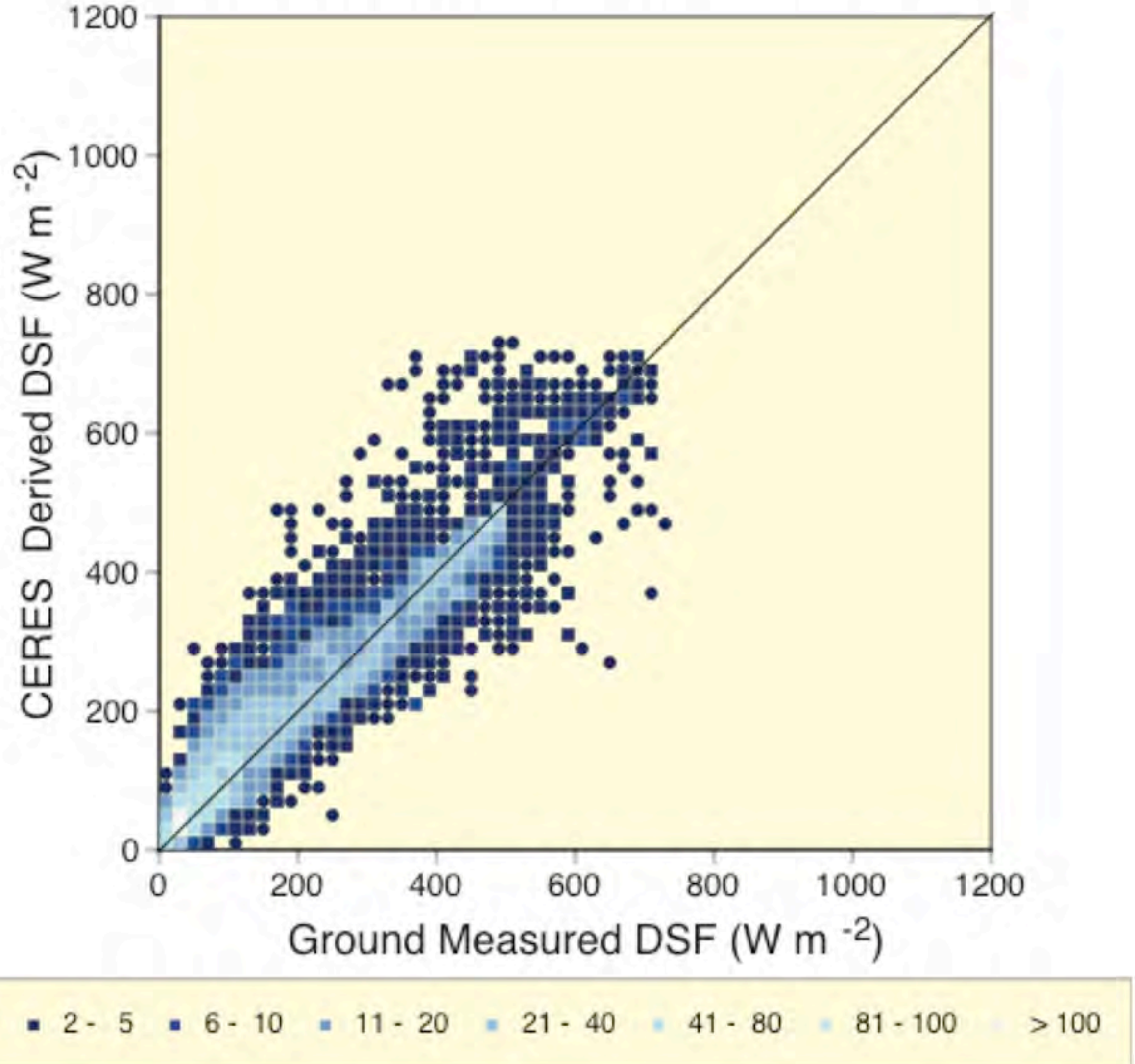


Surface and Atmospheric Temperatures Over Sea of Japan

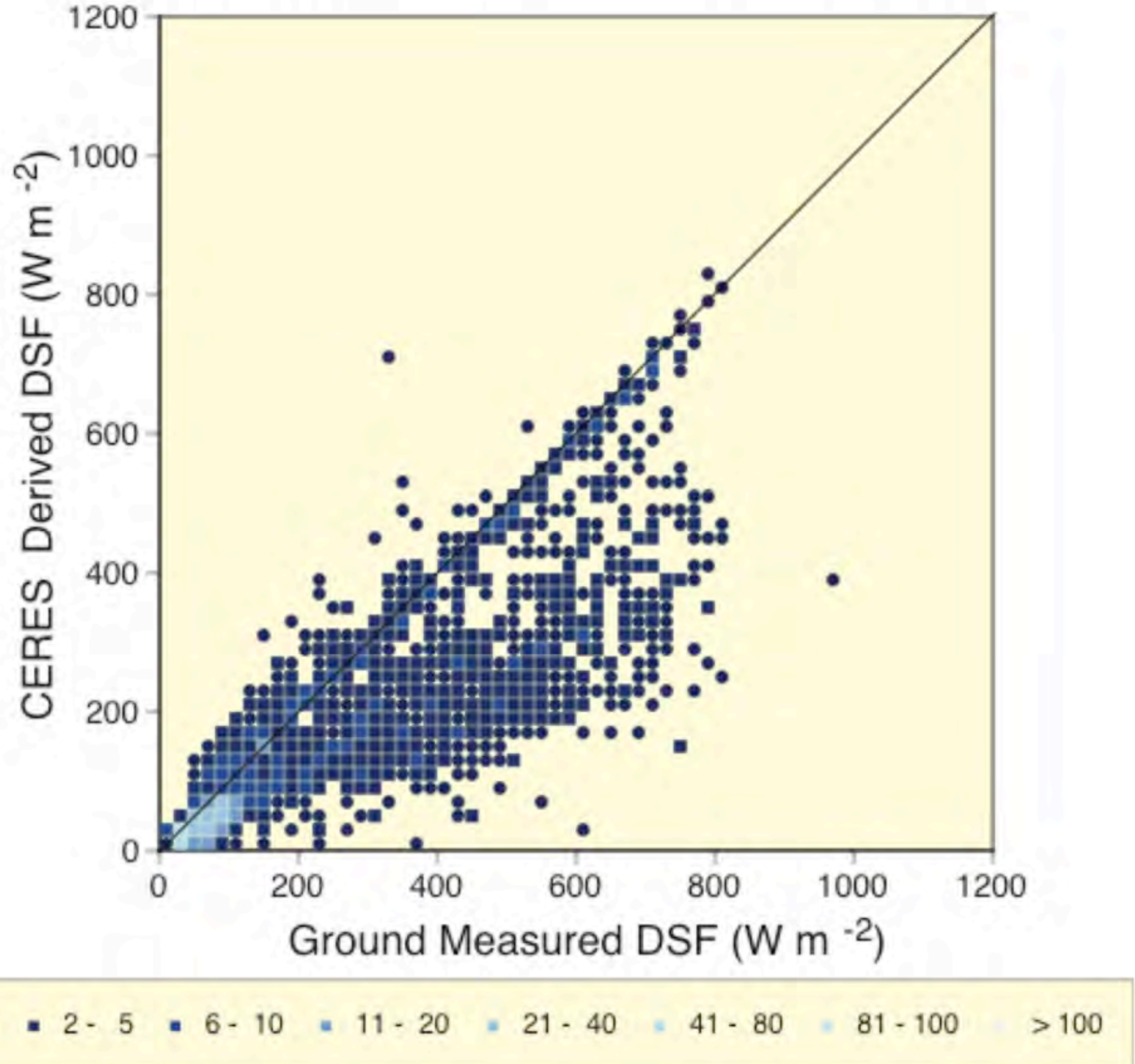
January 2004



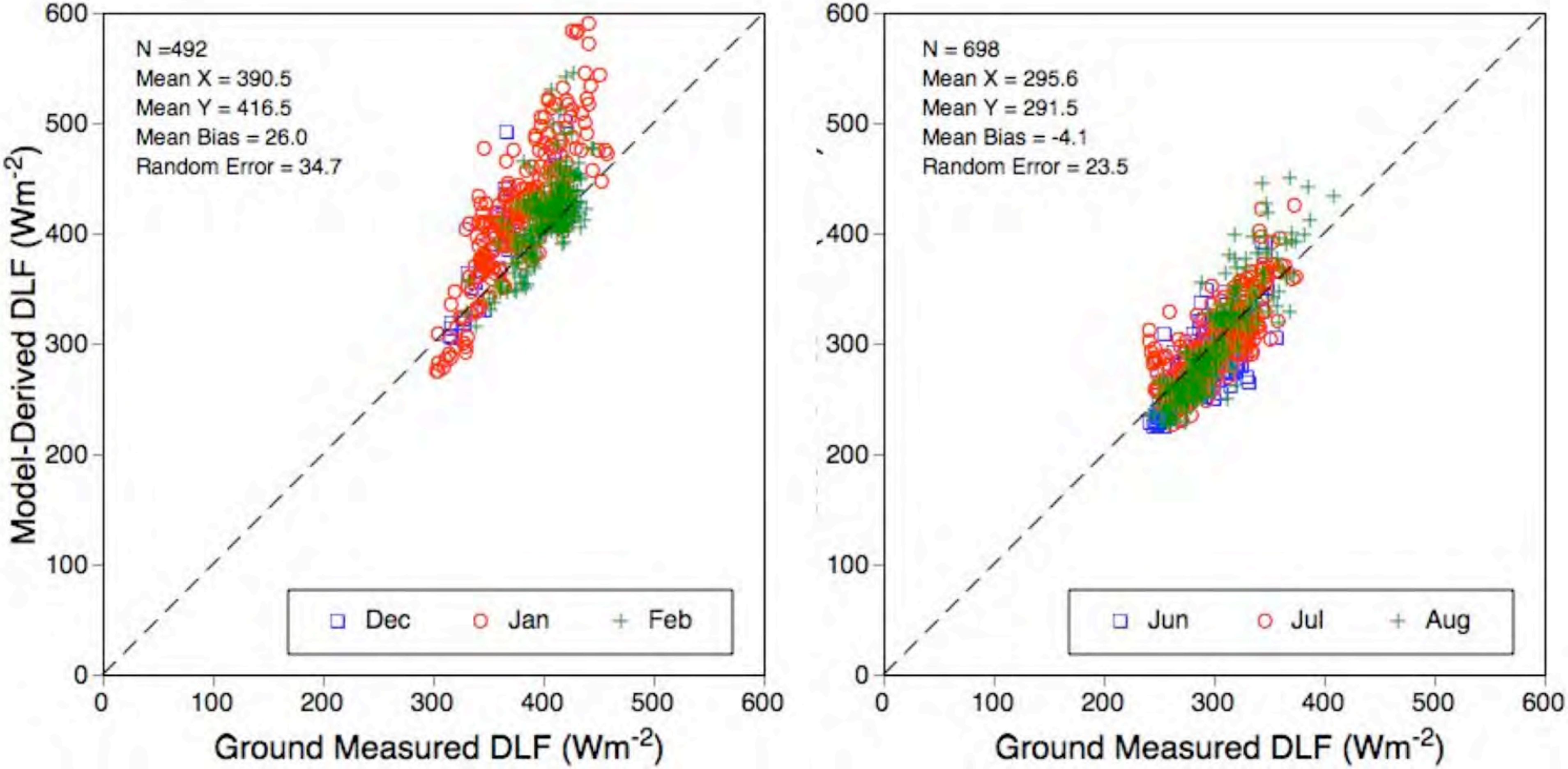
SWB All-sky Aqua 1B ERBE-derived TOA albedo Polar without GVN and SYO



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



Model-Derived vs. Ground-Measured DLF
(Offline LW Model B)
Alice Springs



Severe overestimation during DJF; slight underestimation during JJA