Recent Improvements in CERES Surface-Only Flux Algorithms (SOFA): Implemented in Edition-3 and Preparing for Edition-4

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Background

CERES uses several surface-only flux algorithms to derive SW and LW surface fluxes in addition to the detailed model used by SARB. These algorithms are:

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

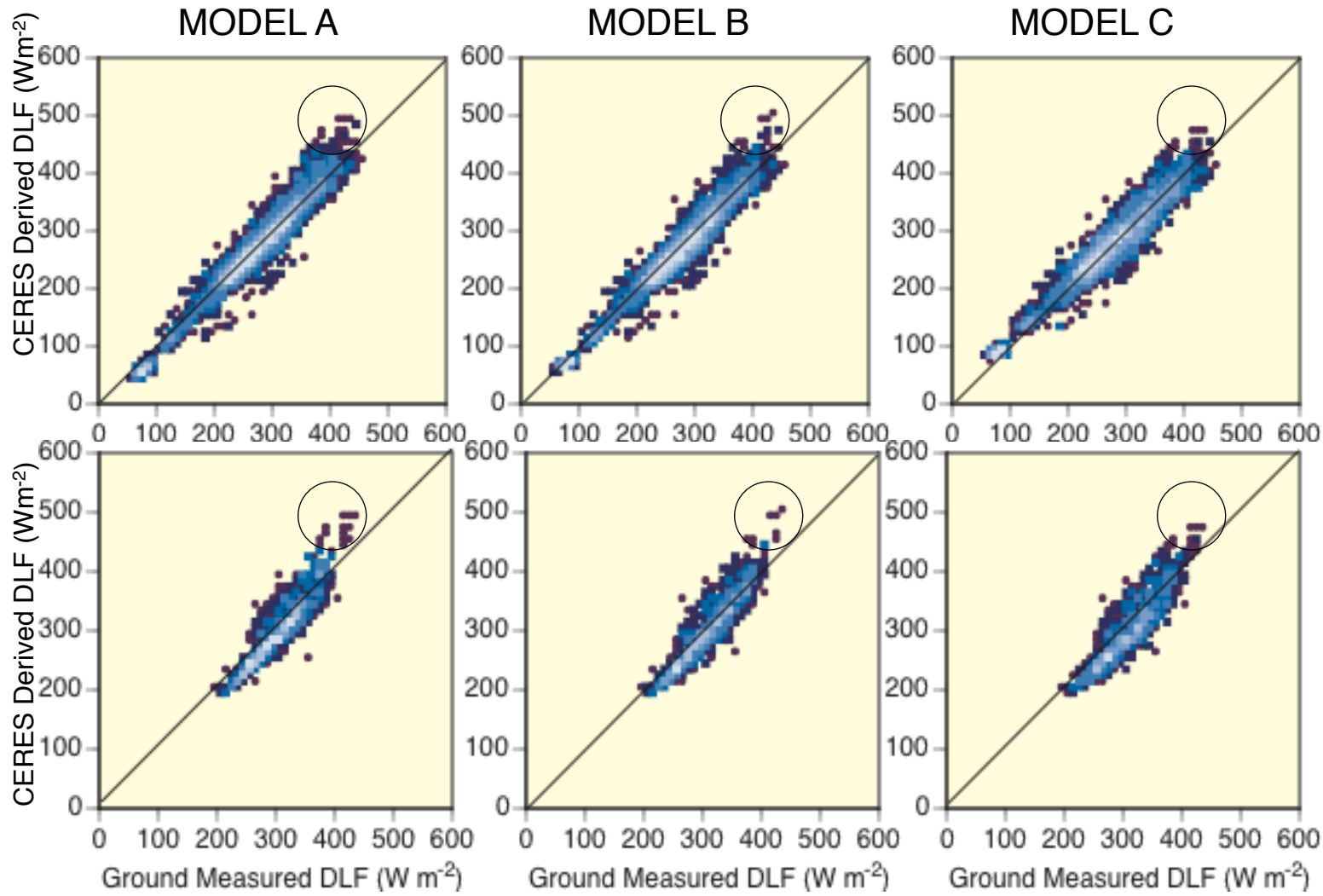
References:

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 (contd.)

- SOFA uses TOA-to-surface transfer algorithms and radiation models that are highly parameterized and very fast. Been called simple surface flux models.
- These models use several ancillary datasets, some empirical values, and a few assumptions to achieve the simplicity and the speed.
- SW Model A was introduced at the start of the project. SW Model B was brought in just before the TRMM launch.
- LW Models A and B have been used since the start of the project. LW Model C will be introduced with Edition-4 processing to keep two independent algorithms when window channel goes away on future CERES instruments.
- Models A and B have undergone extensive validation (*Kratz et al. 2010*). Model C has been improved and tested over the last year or so.
- Validation of models has shown deficiencies. As those have come to our attention, we have made improvements to the models (*Gupta et al. 2010*).
- This presentation is about some such incremental efforts with regard to the SOFA SW and LW models.

Improvement of LW Models
Overestimation of DLF Over Dry/Arid Regions
Clear-Sky (Aqua-2A; July 2002 - March 2005)

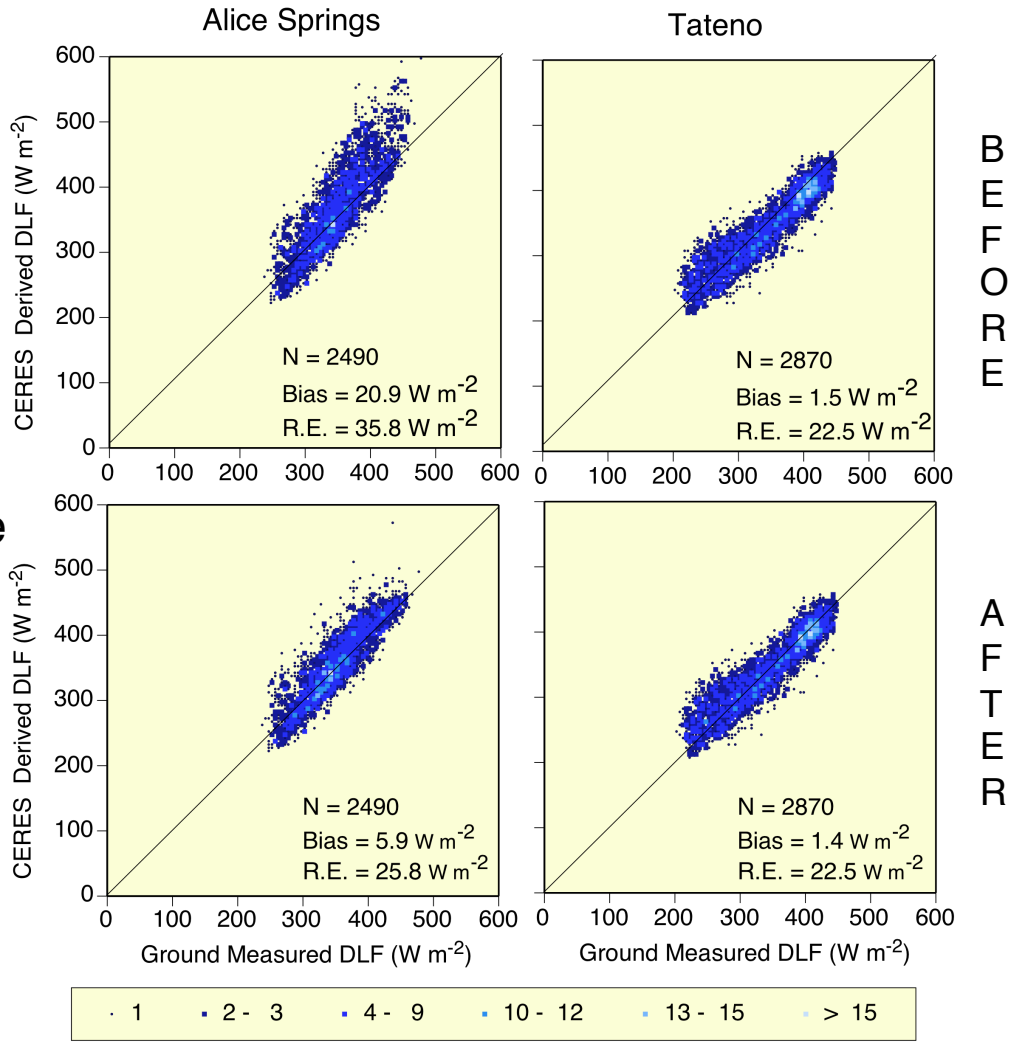


Investigation of Overestimation
(Year 2004; Offline LW Model B)

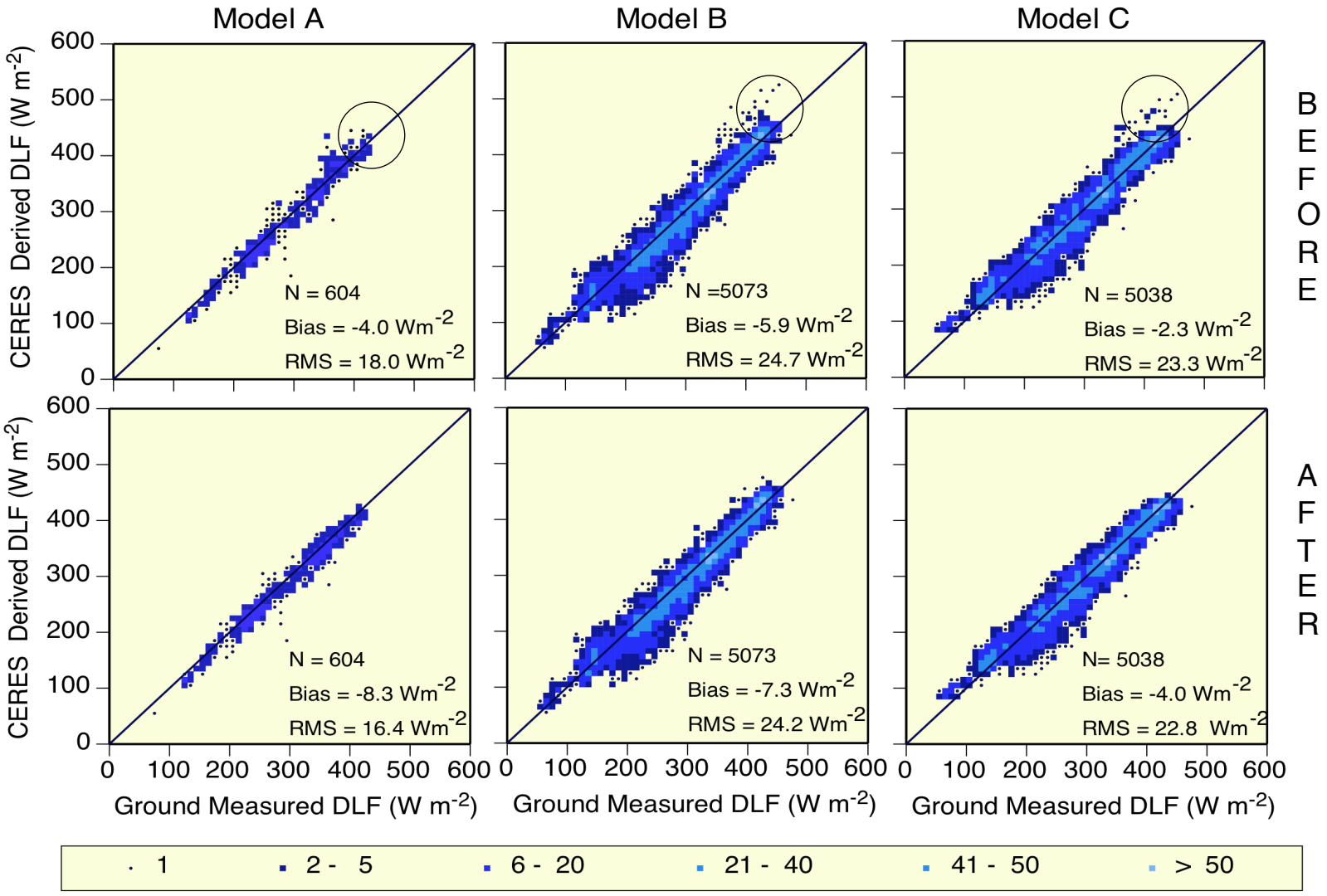
Investigation showed that most egregious overestimation occurred over dry/arid regions.

Reason: These models make use of surface temperature either as a proxy for or to estimate the near-surface air temperature. When the surface overheats, that assumption no longer holds and gives rise to overestimation.

Action: We developed a method to identify conditions under which overestimation occurs and a procedure to remedy it (*Gupta et al. 2010*)



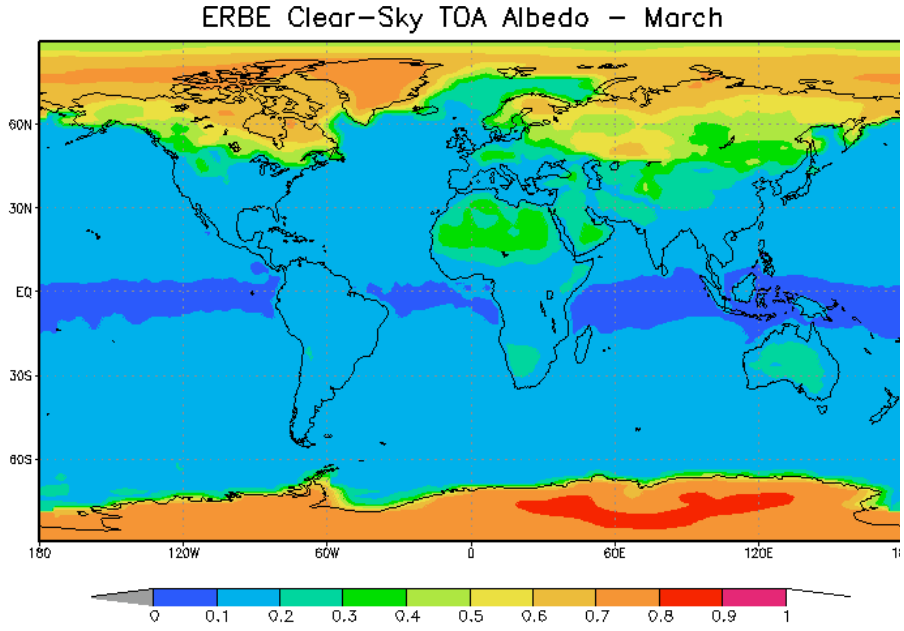
Model Fluxes from CERES Processing – Jan & Jul 2004



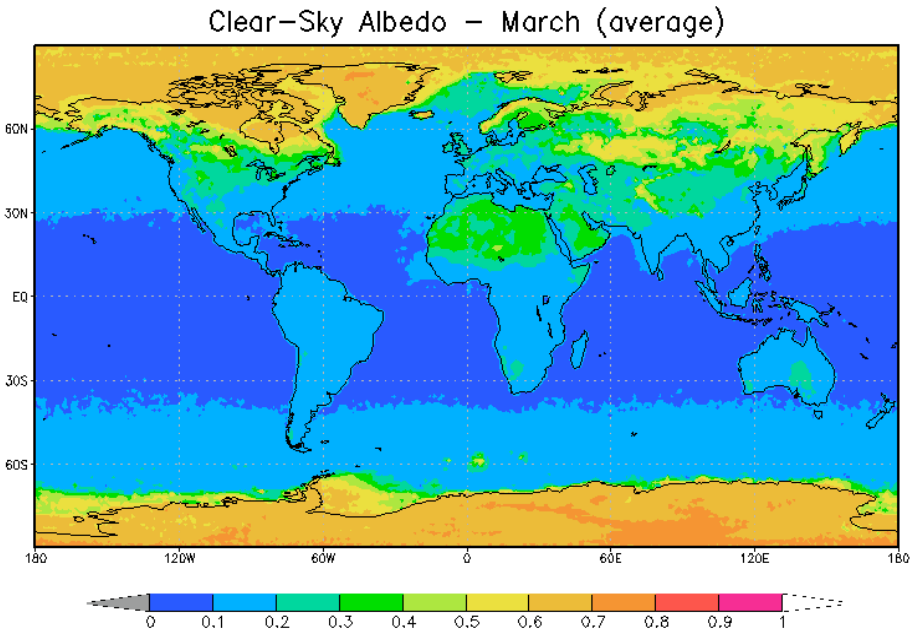
Improvement of SW Models (SW Model B)

- SW Model B used an ancillary dataset of clear-sky TOA albedos that was based on 48 months of ERBE data.
- The ERBE based dataset was replaced by one based on 70 months of Terra/CERES data.

Clear-Sky TOA Albedo from
48 Months of ERBE Data



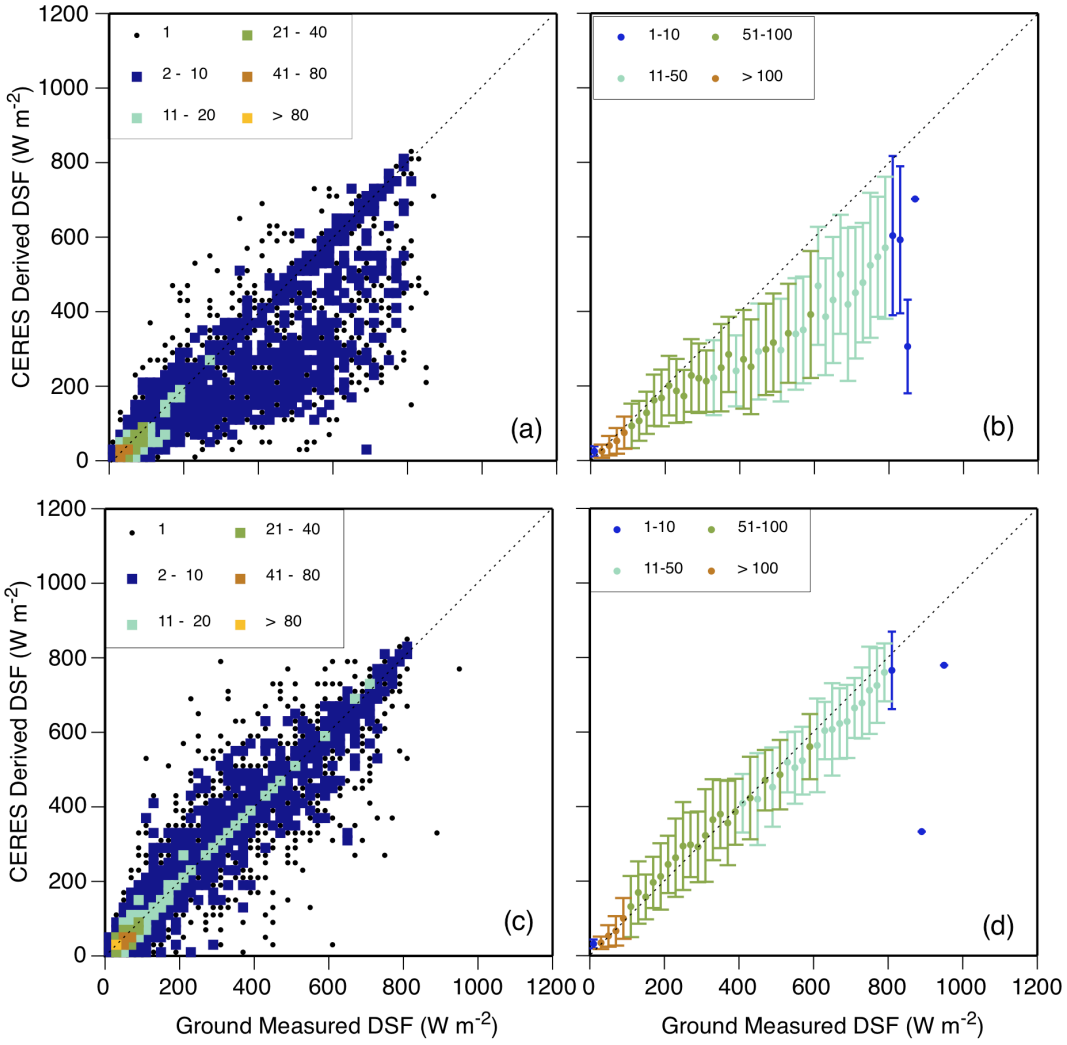
Clear-sky TOA Albedo from
70 Months of Terra Data



Improvement of SW Models (SW Model B)

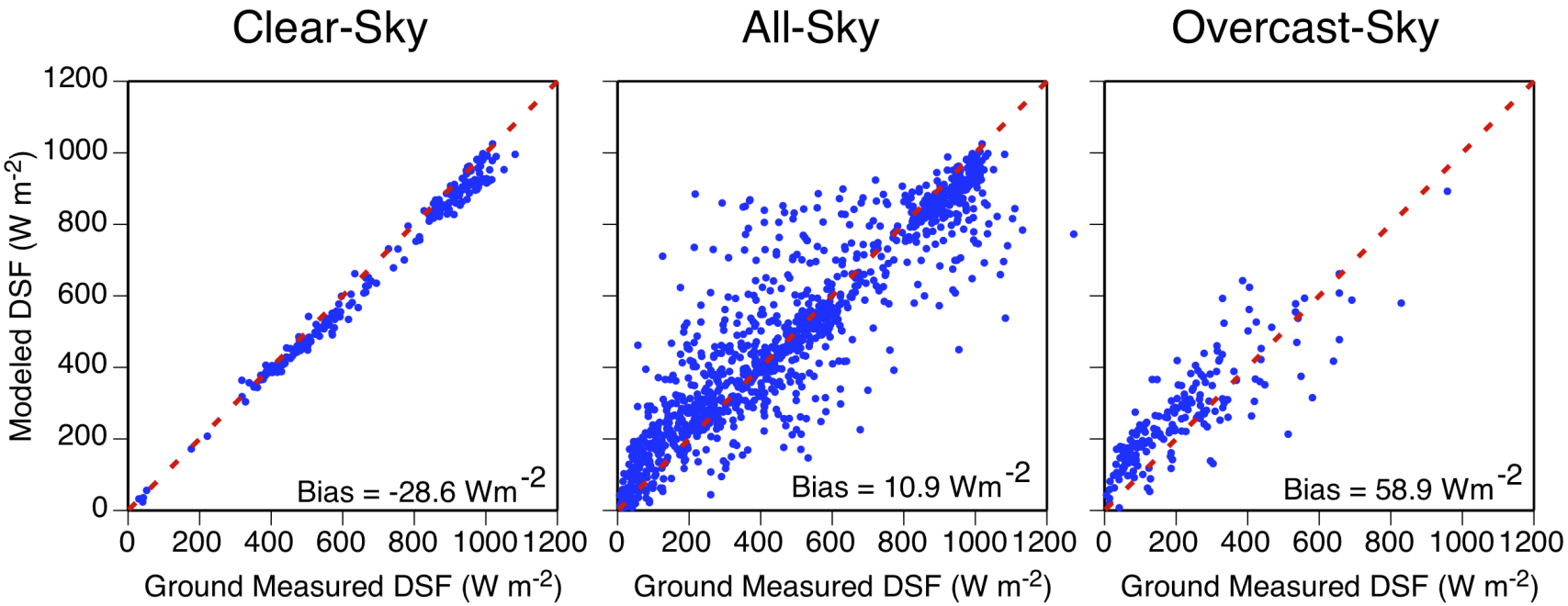
Replacing ERBE based TOA albedo file with the Terra/ CERES based one resulted in remarkable improvement in the biases at polar sites, especially those affected by sea-ice. This figure shows comparisons of CERES retrievals of surface SW fluxes with ground based measurements at Syowa and Georg von Neumeyer sites. The upper panel shows comparison of retrievals using ERBE-based TOA albedos while lower panels show the same for retrievals with CERES albedos.

Source: *Kratz et al. (2010)*



Improvement of SW Models (SW Model B)

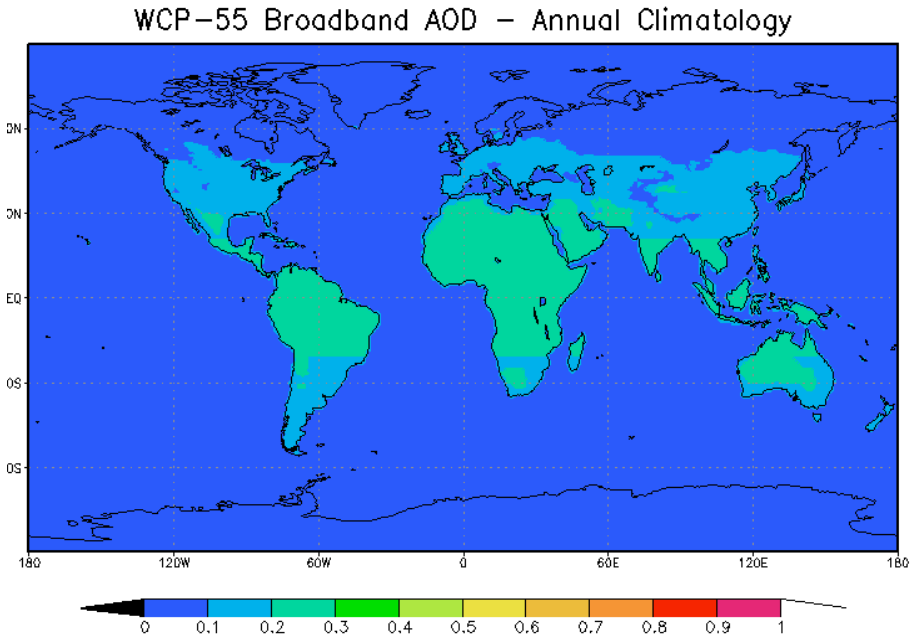
- This model was developed and tested primarily for all-sky conditions.

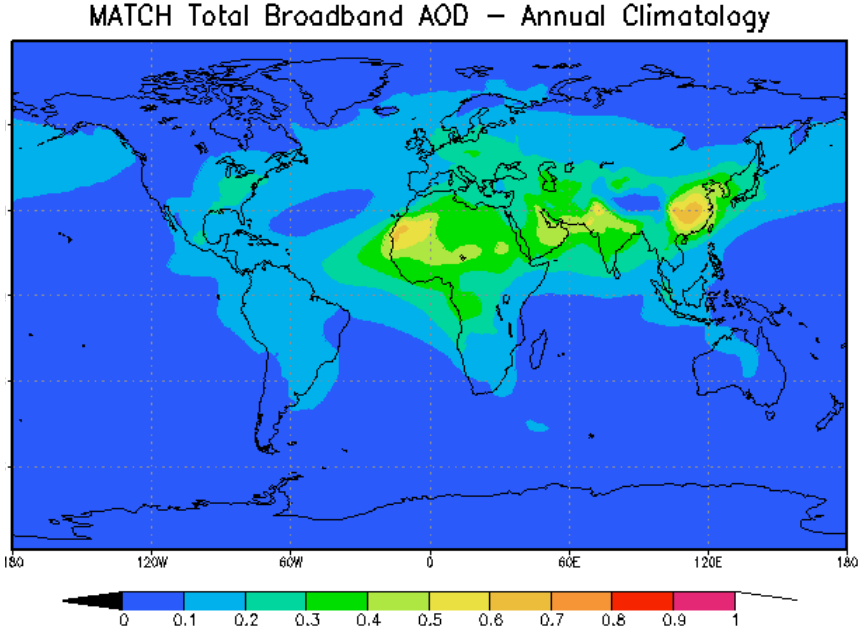


- A model with separate parameterized terms for each attenuating constituent.
- Aerosol attenuation based on properties in Deepak and Gerber (1983): Report of the experts meeting on aerosols and their climatic effects. WCP-55.
- Rayleigh attenuation based on a parameterization that was difficult to verify.

Comparison of WCP-55 and MATCH Aerosol Optical Depths

- MATCH – Model for Atmospheric Transport and Chemistry. AODs derived by assimilating MODIS radiances.
- Broadband properties (AOD, single scattering albedo, and asymmetry parameter) derived using OPAC database information.
- MATCH data provide more realistic distribution of AODs than WCP-55.
- Single scattering albedo and asymmetry parameter were also different.



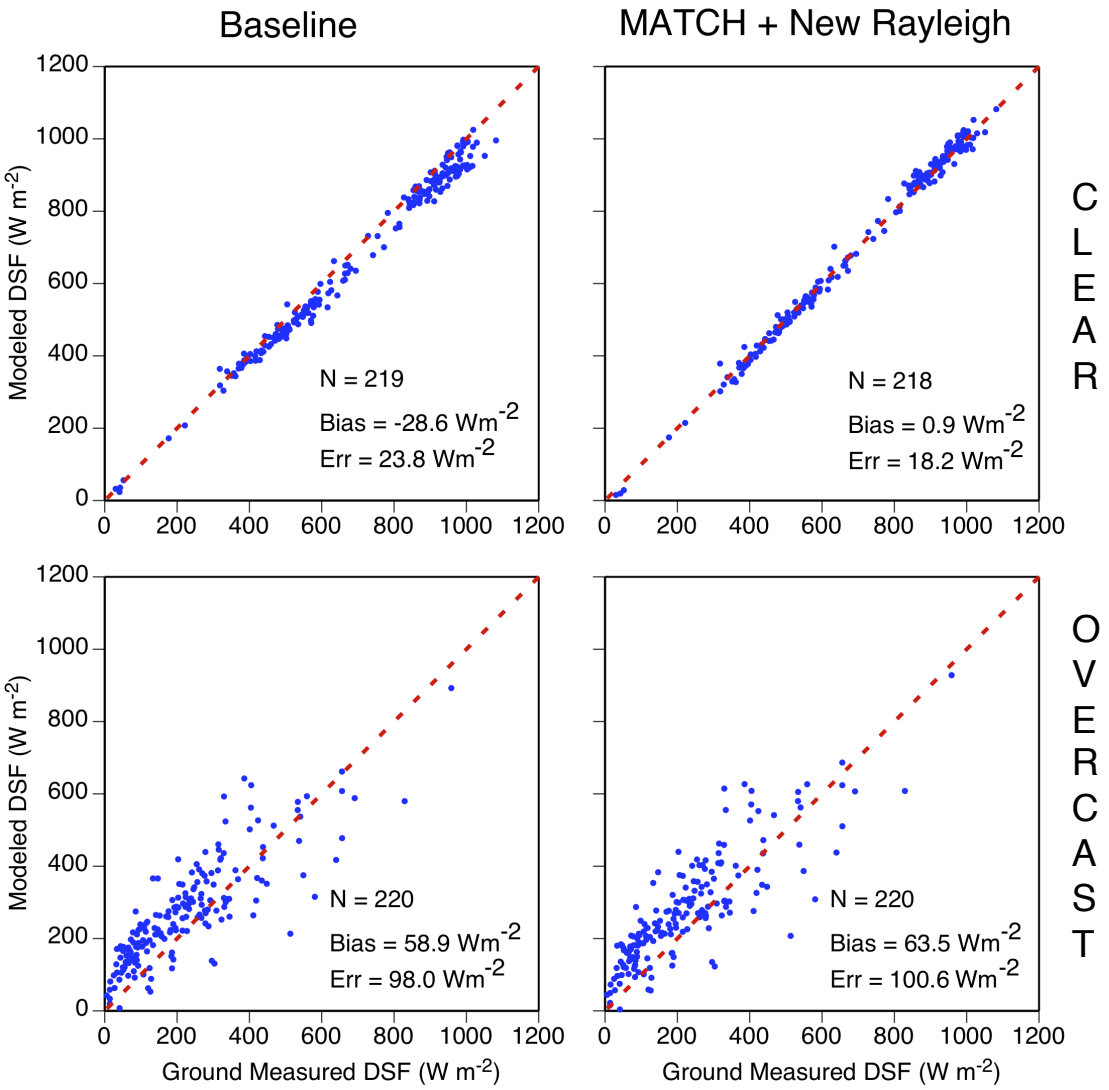


Improvements in SW Model B

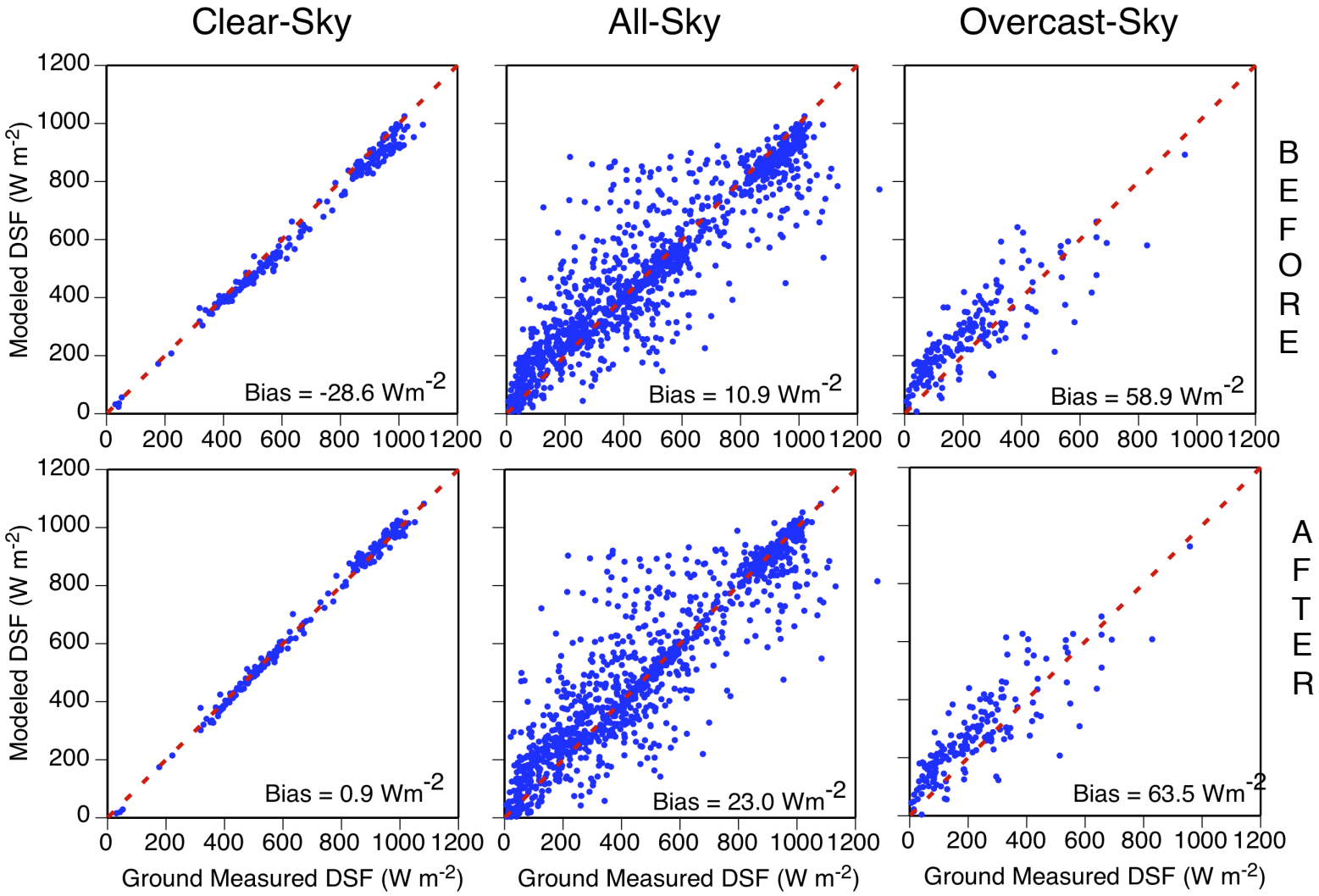
- Revised Rayleigh attenuation term based on:
  Bodhaine et al. (1999):
  On Rayleigh Optical Depth Calculations. *J. Atmos. Oceanic Tech*. **16**, 1854-1861.

- Simultaneous use of MATCH aerosol properties and new Rayleigh attenuation greatly improved clear-sky flux bias.

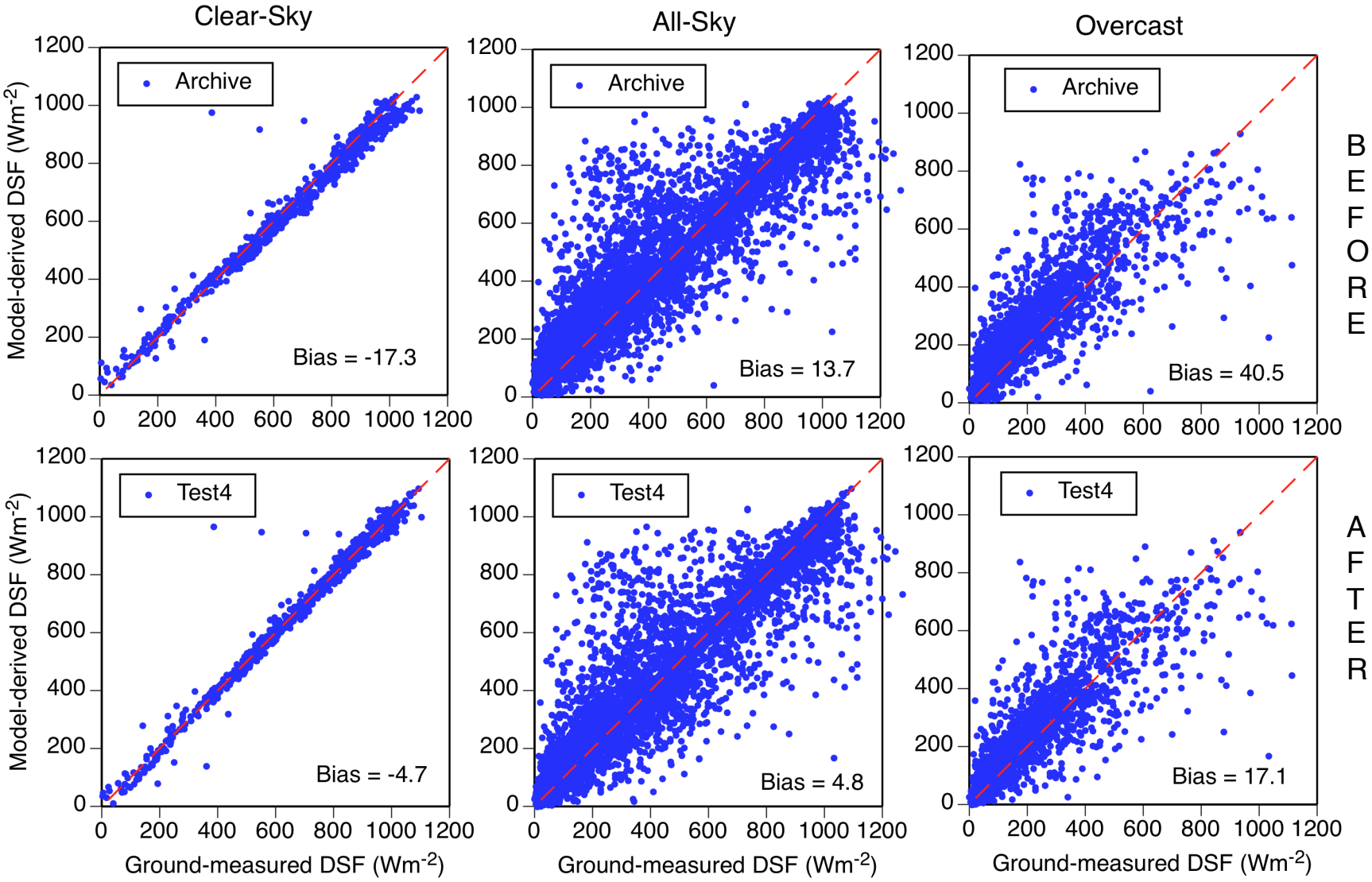
- Overcast bias increases some as does the bias for all-sky conditions.



Comparison between surface-measured and CERES-derived fluxes for clear-sky, all-sky and overcast (before and after)



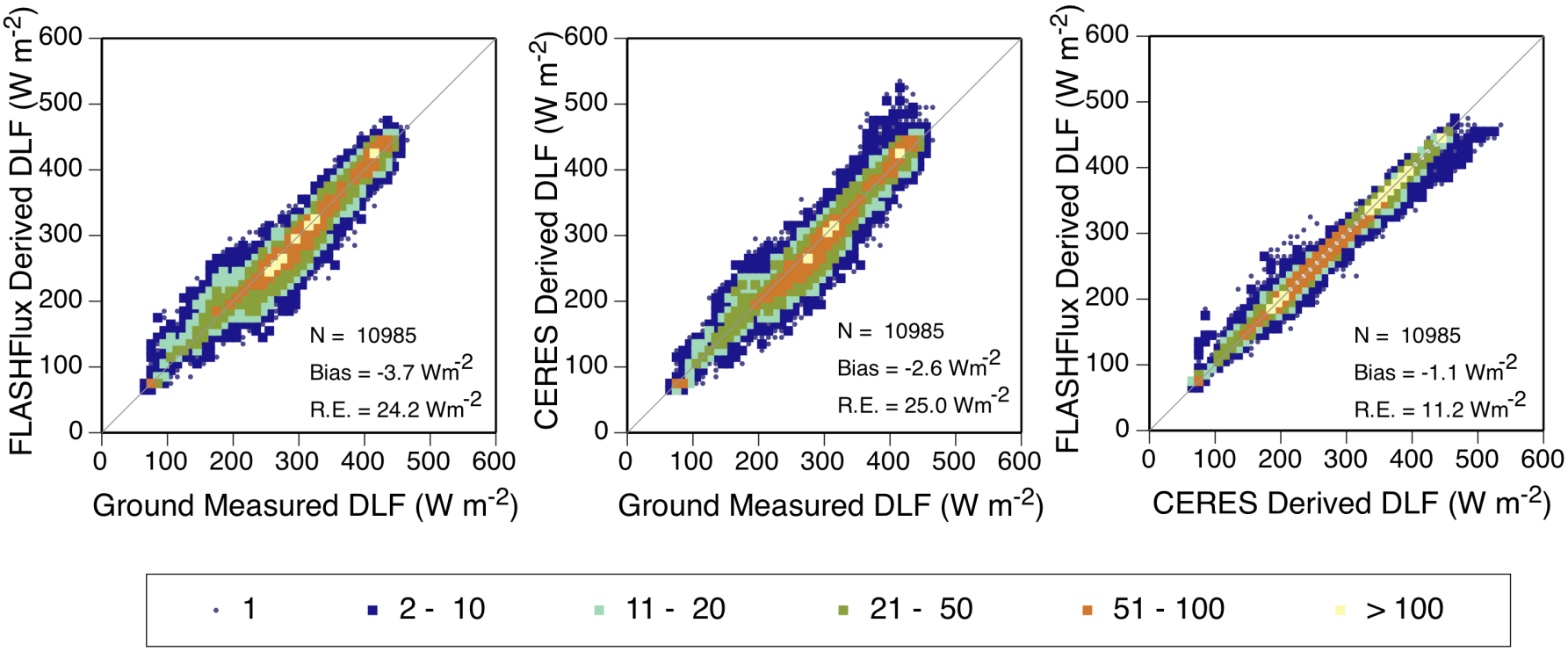
Global Comparisons for Original and Improved Model Results With Ground Data
(Top Row - Original; Bottom Row - Improved)



FLASHFlux – Fast Longwave and Shortwave Radiative Fluxes

- A sub-project within CERES producing TOA and surface radiative fluxes on a near real-time basis. Footprint fluxes within 4-5 days; time-space averaged (daily-gridded) fluxes within 6-7 days of satellite observation.
- Provides CERES TOA and surface fluxes early for many scientific and industrial applications and public outreach: CloudSat product validation, agriculture and solar energy industries, NASA Earth Observatory.
- FLASHFlux uses quick-look CERES instrument data that have not undergone much screening and may have some gaps.
- FLASHFlux uses only cross-track scanner data. Spectral correction coefficients used are those from the previous round of CERES processing.
- SOFA SW and LW Models B are very suitable for FLASHFlux surface flux computation because of simplicity, speed, and all-sky capability. TOA flux computation follows the CERES methodology.
- Caveats: FLASHFlux data are not climate quality; should not be mingled with CERES data. Meant to be taken offline when CERES data for the period become available.

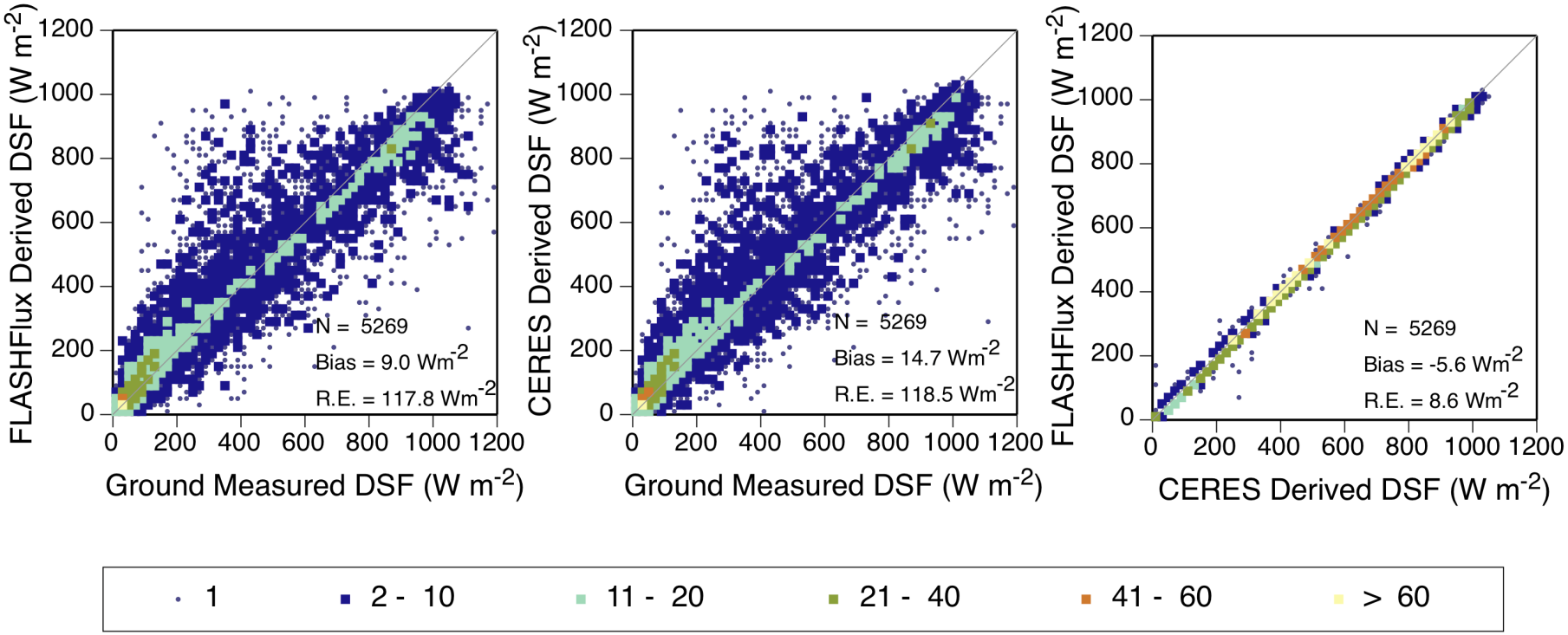
Comparison of Aqua FLASHFlux and CERES Surface LW fluxes With Ground Data and With Each Other for the Overlap Year 2008



Overestimation correction was included in FLASHFlux but not in CERES.
Also, FLASHFlux meteorological input changed during the year:

- CERES input – GEOS-5.2 throughout the year
- FLASHFlux input – GEOS-5.1 to 31 Aug; GEOS-5.2 to the end of year

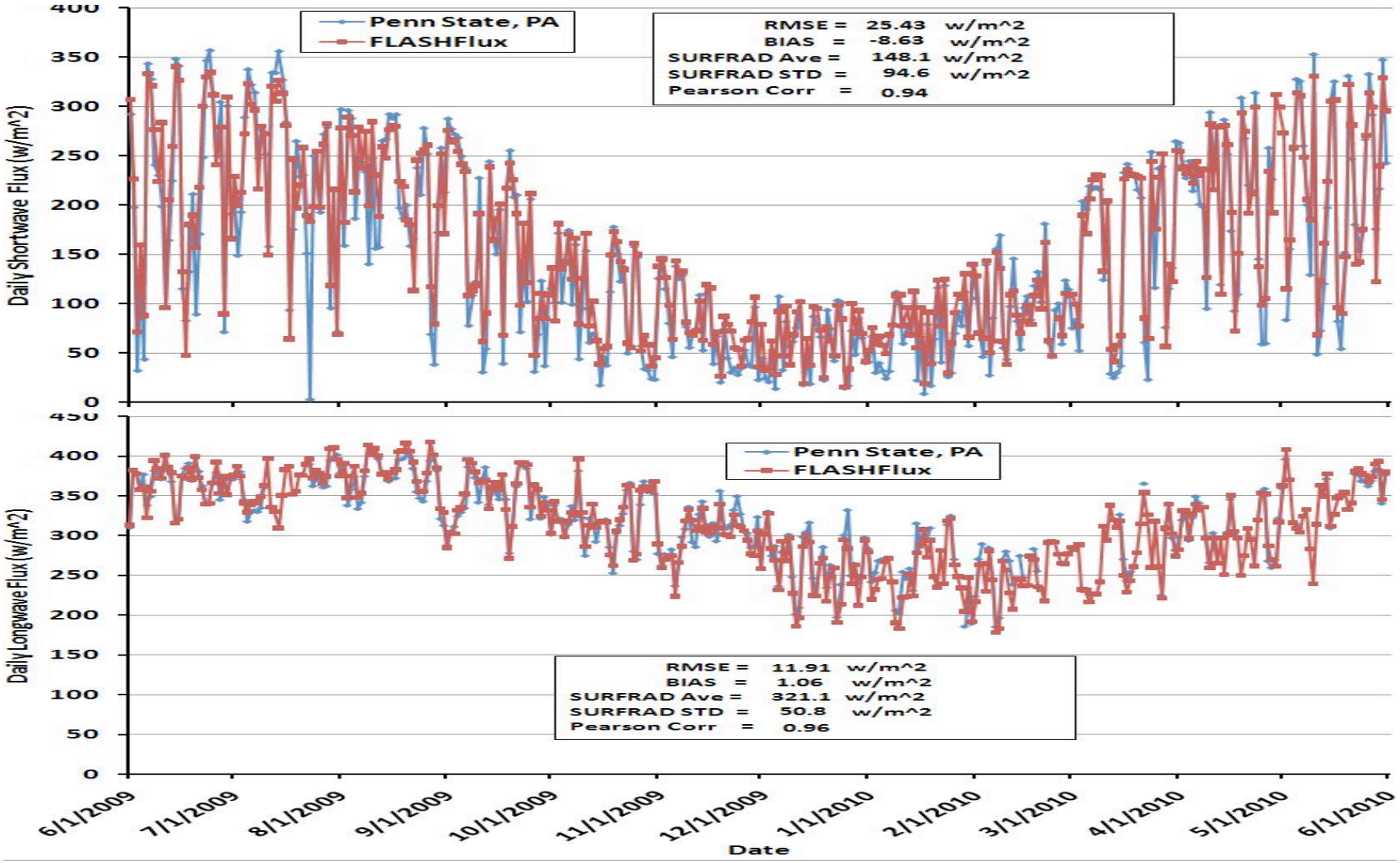
Comparison of Aqua FLASHFlux and CERES Surface SW fluxes With Ground Data and With Each Other for the Overlap Year 2008



Differences arise from use of different spectral correction coefficients.
Also, meteorological input for FLASHFlux changed during the year:
CERES input – GEOS-5.2 throughout the year
FLASHFlux input – GEOS-5.1 to 31 Aug; GEOS-5.2 to the end of year

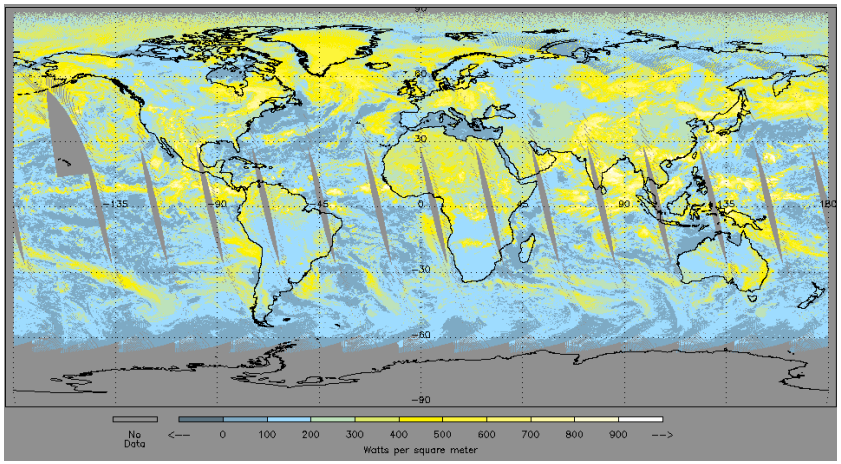
Comparison of Daily Time Series of FLASHFlux Surface SW and LW Fluxes

(SURFRAD Site at Penn State: 1 June 2009 – 1 June 2010)

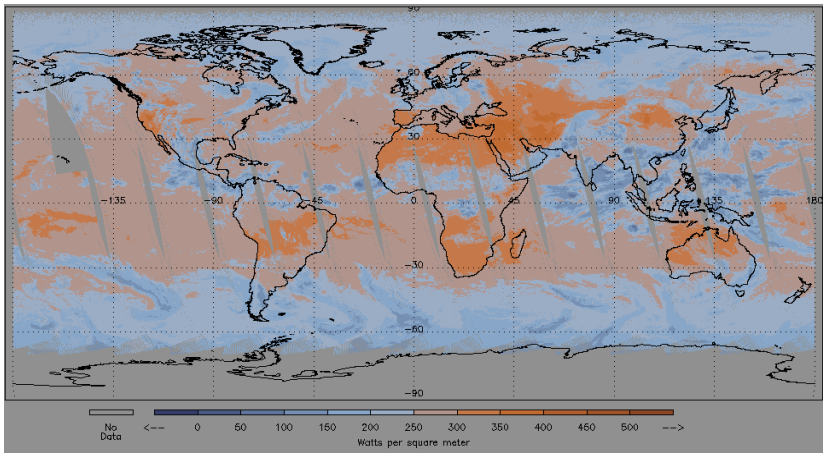


Sample FLASHFlux Data: Aqua Footprints (≈20 km) – 28 July 2010

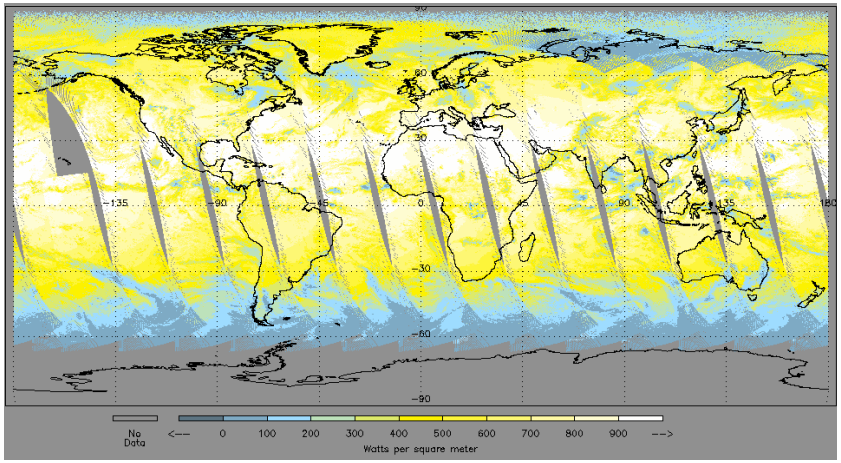
TOA Reflected SW



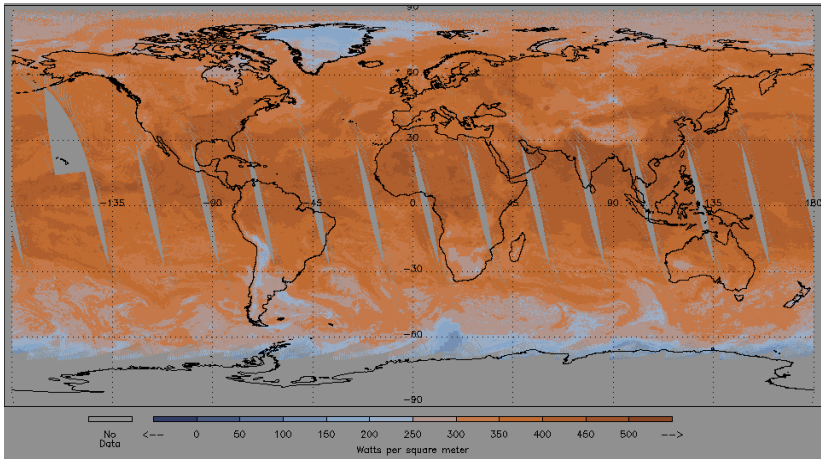
TOA Outgoing LW



Surface Downward SW



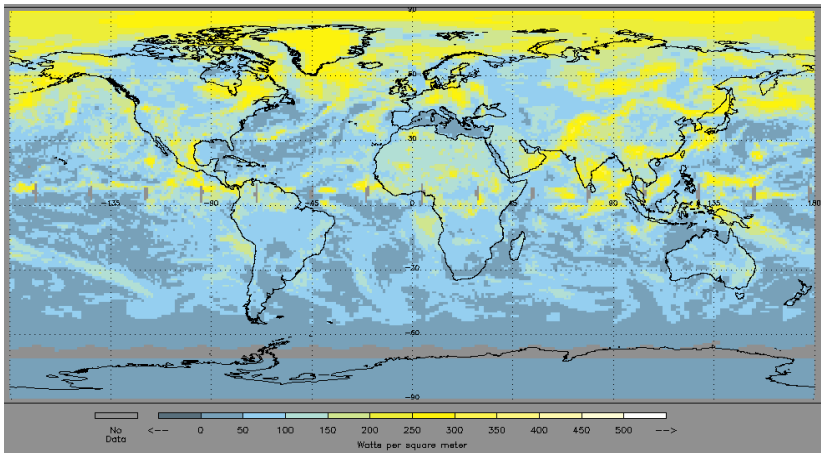
Surface Downward LW



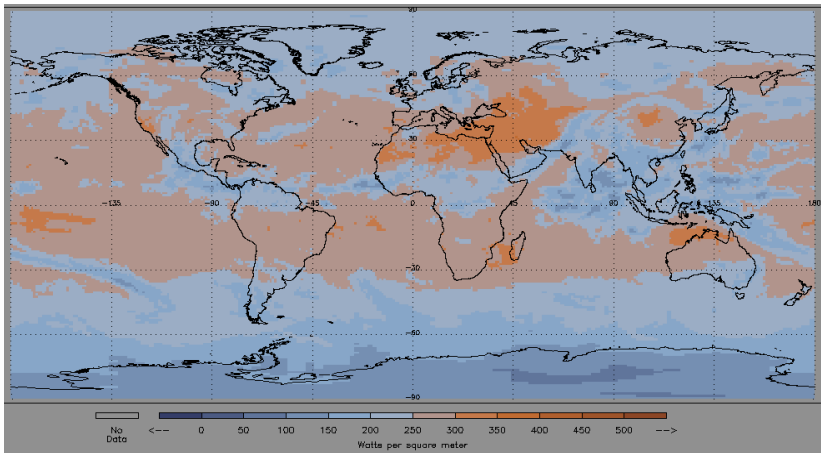
Available at Langley ASDC: eosweb.larc.nasa.gov/flashflux/table_flashflux.html

Sample FLASHFlux Data: Terra+Aqua Daily-Gridded (1°x1°) – 28 July 2010

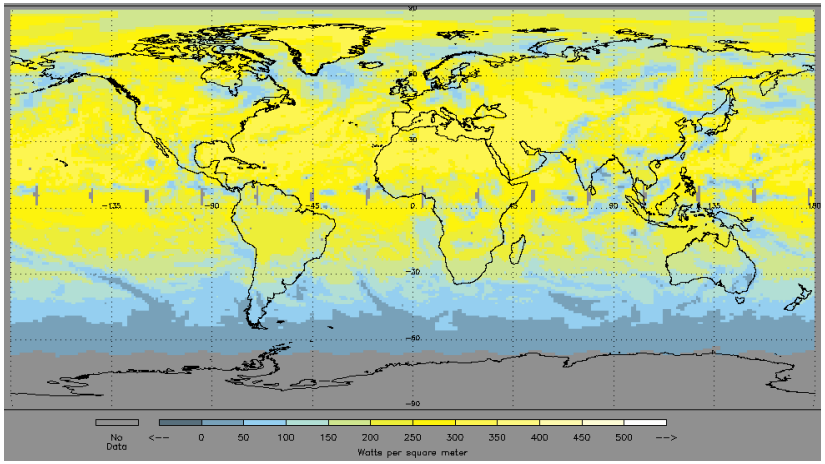
TOA Reflected SW



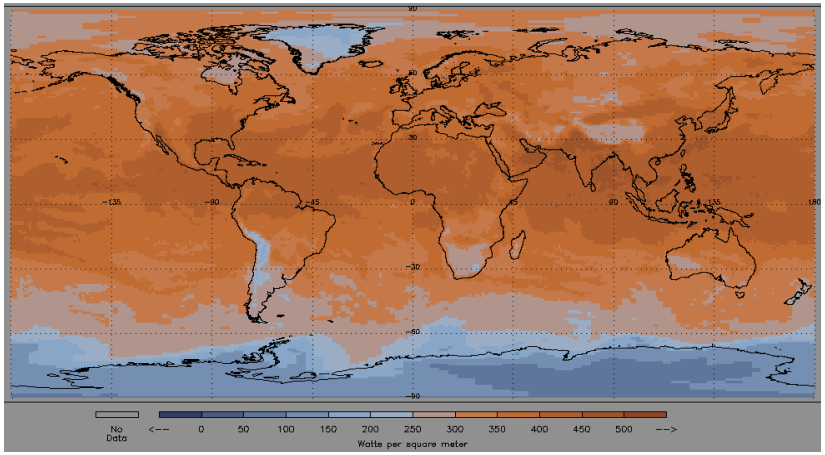
TOA Outgoing LW



Surface Downward SW



Surface Downward LW



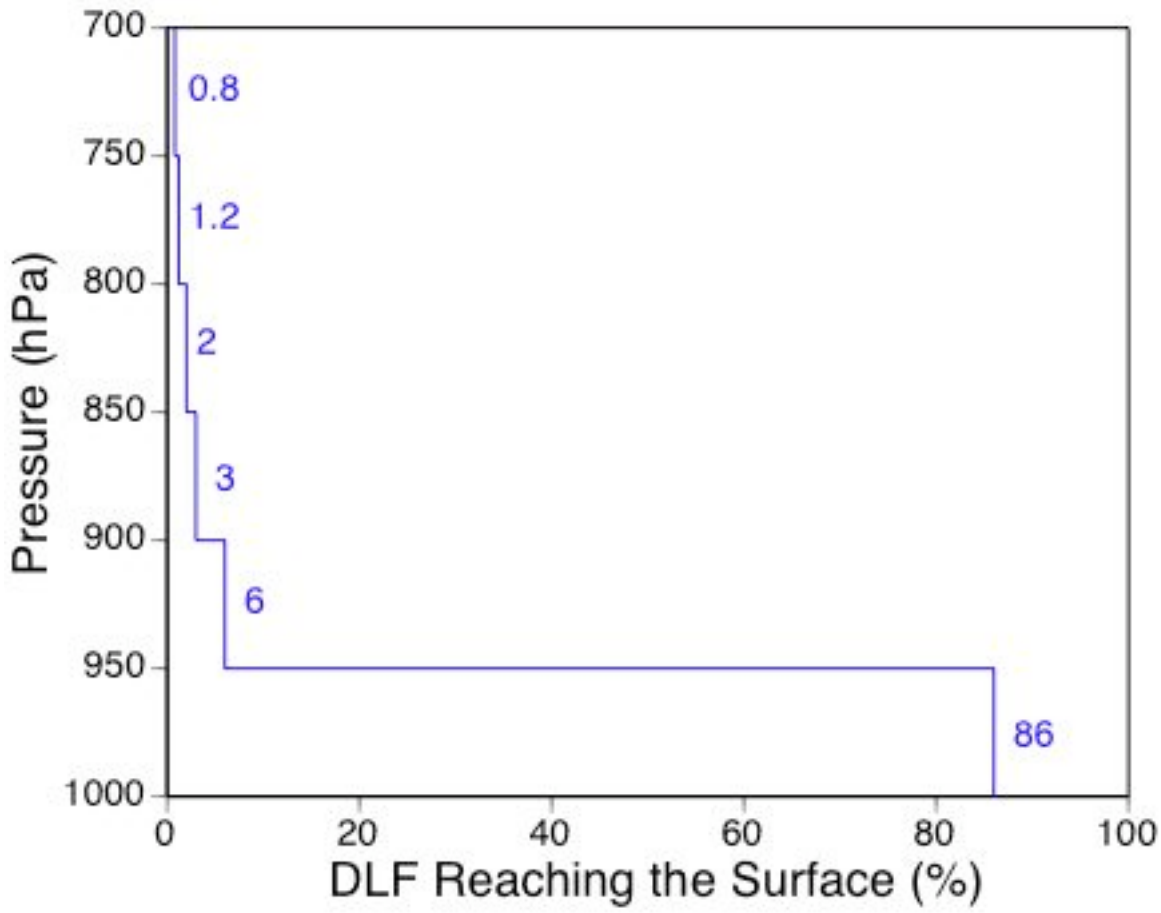
Available at Langley ASDC: eosweb.larc.nasa.gov/flashflux/table_flashflux.html

Summary

- CERES makes use of several highly parameterized models in the SOFA subsystem for deriving surface fluxes. SOFA Models B are all-sky and provide complete global coverage.
- Validation of SOFA SSF (instantaneous-footprint) data have shown where these models needed improvements.
- Improvements were developed and applied where needed. For example:
  - Overestimation of LW fluxes over dry/arid regions.
  - Underestimation of SW fluxes for clear-sky conditions.
  - Overestimation of SW fluxes for cloudy-sky conditions.
- Future work:
  - Remedy underestimation of LW fluxes in presence of inversions.
  - Improve cloud transmission for full range of sky conditions.
- FLASHFlux
  - SOFA improvements are quickly implemented in FLASHFlux
  - FLASHFlux SSF fluxes are very close in quality to CERES fluxes.

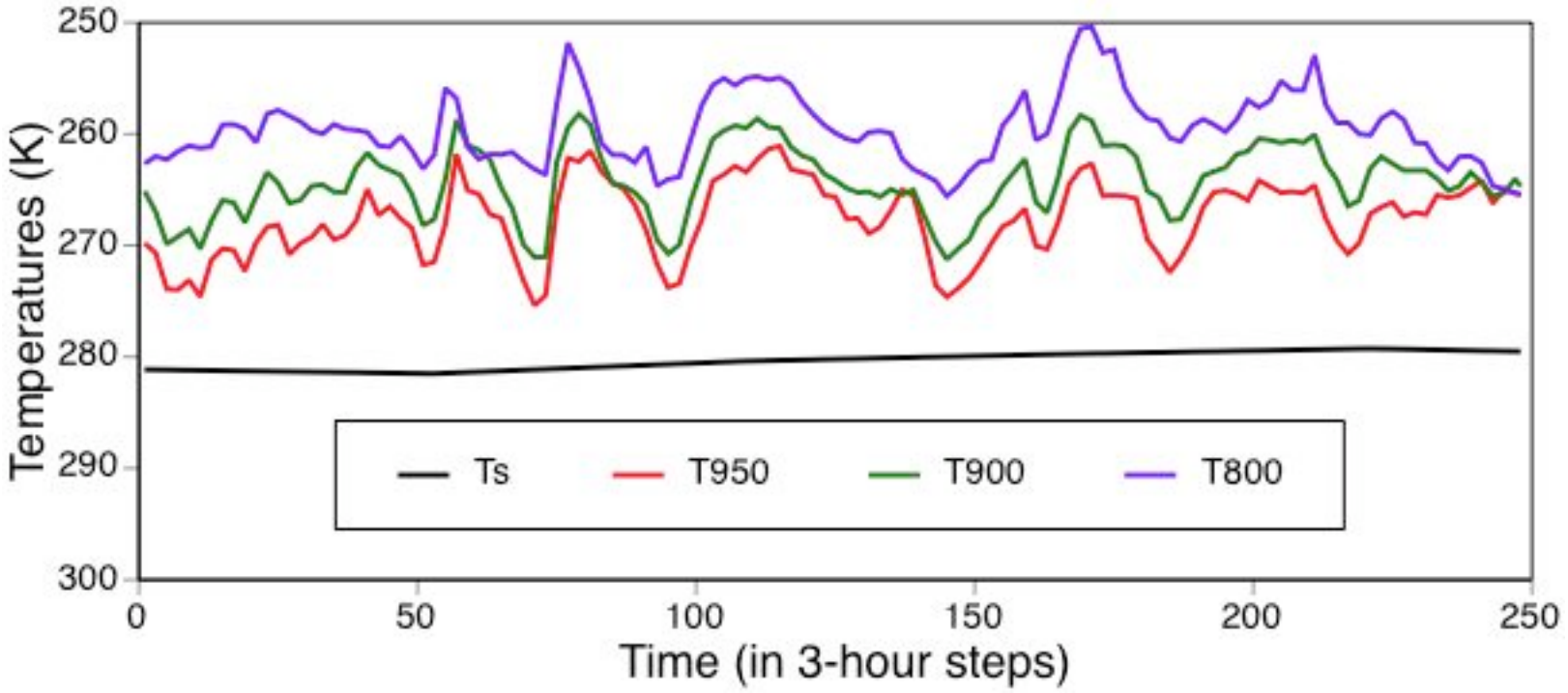
Back-up Slides

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



Surface and Atmospheric Temperatures Over Sea of Japan

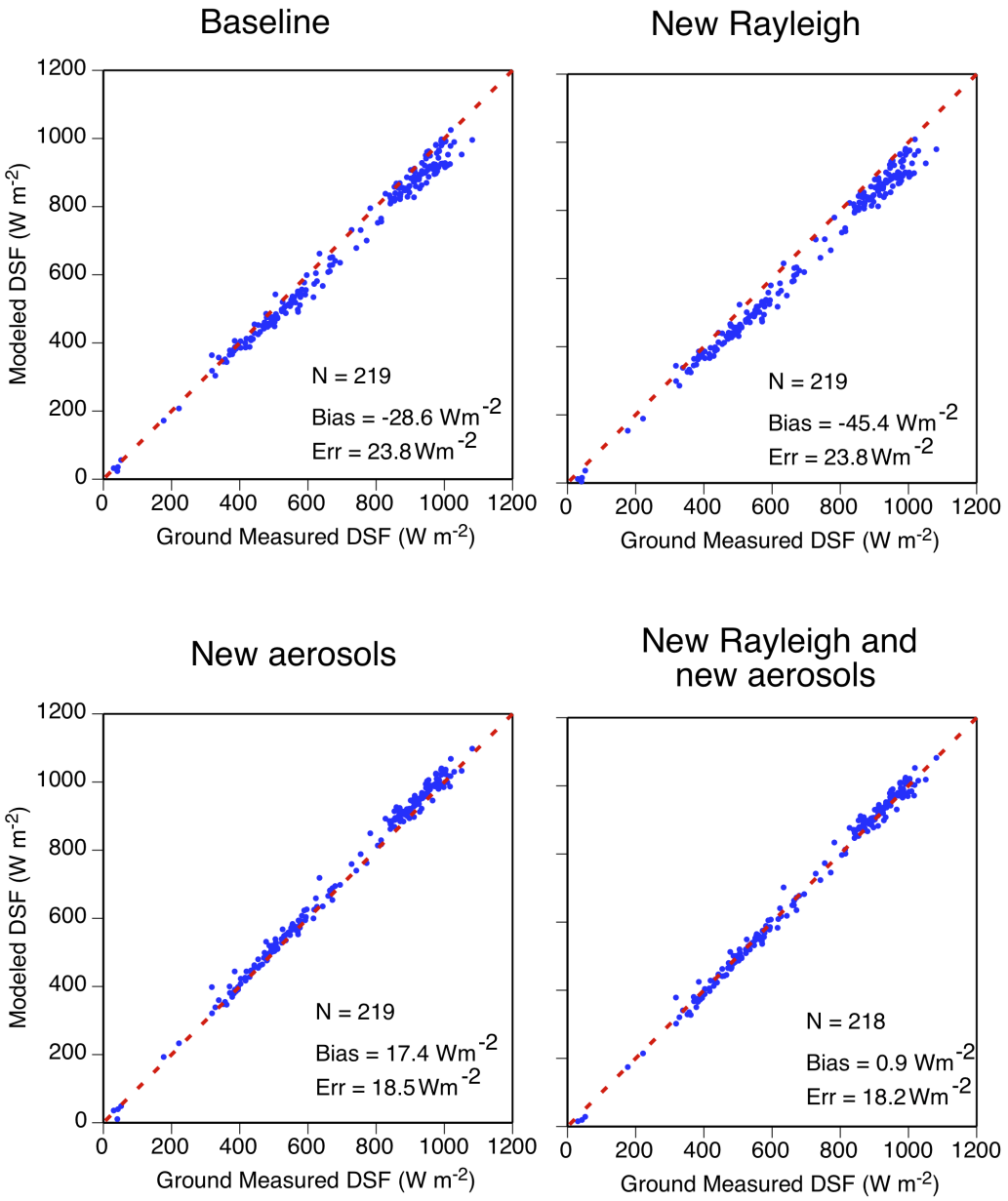
January 2004



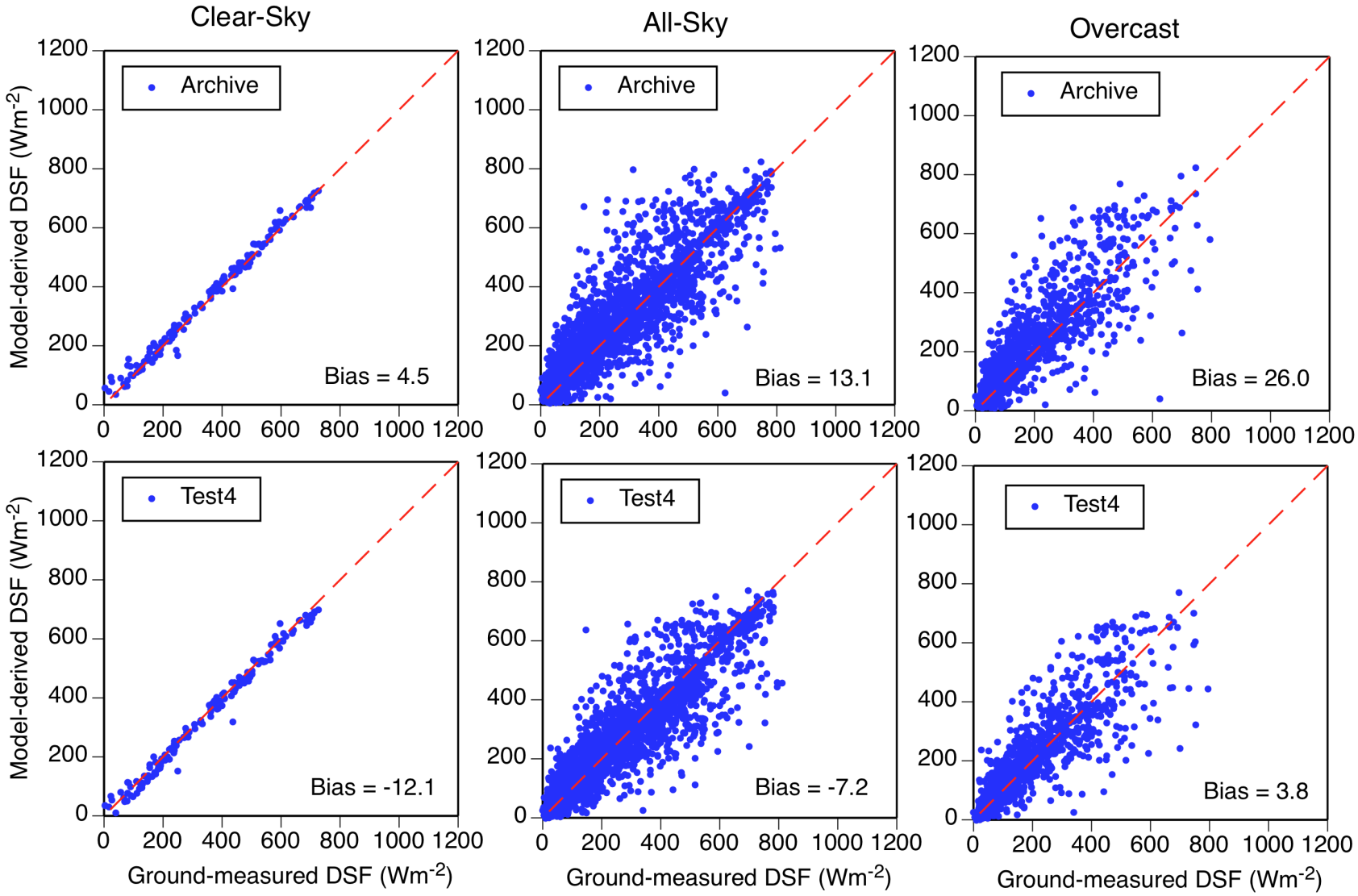
Comparison between surface-measured and CERES-derived fluxes: Clear-Sky

Clear-sky results for comparisons among the results for a) WCP-55 aerosols & old Rayleigh algorithm, b) WCP-55 aerosols & new Rayleigh algorithm, c) MATCH aerosols & old Rayleigh algorithm, and d) MATCH aerosols & new Rayleigh algorithm.

For the clear-sky case, the new formulation with the MATCH aerosols & the new Rayleigh algorithm shows a remarkable improvement.



Polar Comparisons for Original and Improved Model Results With Ground Data
(Top Row - Original; Bottom Row - Improved)



Non-Polar Comparisons for Original and Improved Model Results With Ground Data
(Top Row - Original; Bottom Row - Improved)