CERES TISA Status: TRMM Edition 2B SFC and SRBAVG

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Overview

- Delivery Status
- Data product progress during last 3 months
  - SFC / FSW
  - GGEO
  - SRBAVG
- GEO calibration efforts
- Validation efforts
- Issues and future work

Delivery Status

- SFC / FSW
  - TRMM Edition 2 delivered and processed
  - Terra Edition ready for delivery
- GEO
  - TRMM Edition 2 delivered
  - Plan to run as Validation for 2 months
  - Few changes planned for Terra (include calibration trends)
- SRBAVG
  - TRMM Edition 2 to be re-delivered after meeting
    - Major error with SW surface fluxes
  - Plan to run as Validation for 2 months
- SYN
  - Scheduled for December

SFC / FSW

- Changes since last Science Team Meeting
  - Added new DRMs
    - DRM correction applied to gridding
  - Surface fluxes now adjusted using CSZ_{obs} / CSZ_{local}
  - Cloud fraction calculation now processes no retrievals consistent with SSF
  - Terra aerosol parameters added
  - Finalized angular model format
    - Mean albedo calculated for 20 most common scene types
  - Clear-sky definition now consistent with SSF
  - Parameter list finalized
  - HDF file reorganized by region (more logical for users)

GGEO

- Changes since last Science Team Meeting
  - GEO monthly calibrations finalized
  - Fixed f = 0. when visible radiance = default
    - Changed to revert to IR-only retrievals
  - Fixed f = 100. near limb of GMS-5
  - Restored images with interpolation errors
    - Now only pixels are removed
  - Eliminated stripes
    - Due to defaults in GOES-9
  - Eliminated METEOSAT-7 data from March 30-31, 2002
    - >15% calibration shift in IR
  - Eliminated Cloud/GGEO disconnect

SRBAVG (Interpolation)

- Changes since last Science Team Meeting
  - Added VIRS to narrowband albedo series
  - CERES ADM now used to calculate albedo from GEO data
  - Incorporated new DRM
    - DRMs based on tau/fraction/phase
    - Interpolation between models in tau
    - nonGEO uses all DRM
      - Based on 20 saved scene types
      - DRM defines shape
      - Total albedo defines magnitude
    - GEO uses clear/overcast DRM only
  - GEO glint data removed

SRBAVG (Averaging)

- Changes since last Science Team Meeting
  - SRBAVG product now includes 2 monthly cloud products
    - GEO + VIRS
    - VIRS only
  - Net flux calculated from mean LW and SW
    - Applied to all time and spatial scales
  - Twilight correction applied
  - All parameters now averaged consistently
    - Only days with CERES observations are used
    - TOA and Sfc SW normalized to integrated solar for month
  - nonGEO clear-sky LW uses monthly half-sine fit

SRBAVG (Miscellaneous)

- Bugs fixed since last Science Team Meeting
  - SW surface flux error fixed (used incorrect solar constant)
  - Corrected misleading parameter names
  - Night SW changed from default to 0.
  - Monthly-hourly LW consistent with monthly mean
  - Operational QC plots fixed
  - GEO and nonGEO cloud now identical over INSAT region
  - “Rabbit ears” and “lollipops” eliminated
  - Surface SW code fixed
  - Area weighting corrected
  - PMOA errors eliminated

Validation Efforts

- Direct Integration
  - Mean diurnal albedos calculated
    - 10° grid
    - 46-day precession cycles
  - Mean albedo calculated using solar energy weighting
  - Compared with monthly means from SRBAVG
    - May/June/July vs. 2 precession cycles
  - Results repeated for CERES and ERBE DRMs
- Monthly mean comparisons
  - ERBE-like vs. nonGEO vs. GEO
  - Scatter plots
  - PDF comparisons
  - Global/zonal breakdowns

Validation (cont.)

- Sampling studies
  - TRMM striping
  - GEO sampling
- Cloud products
  - Histograms and matched comparisons
  - VIRS and ISCCP
- Monthly global maps
  - GEO-nonGEO differences
- Surface flux comparisons
  - Instantaneous vs. ARM sites
  - Monthly means vs. surface sites
  - SRB

Issues & Future Plans

- Validation incomplete
- Add daily means to SRBAVG
- Narrowband/Broadband
  - Expand relation to scene type/angle dependence
- GEO calibration
  - Implementing Minnis et al. 2002 time series for Terra
- Clear-sky LW
  - Use monthly half-sine for GEO? Redo DRMs using ln(f • exp(ln(tau)))
- SYN product
  - Handle large data gaps
  - 1-hourly vs. 3-hourly
  - Start-up issues (staffing?)

Surface Flux Comparisons

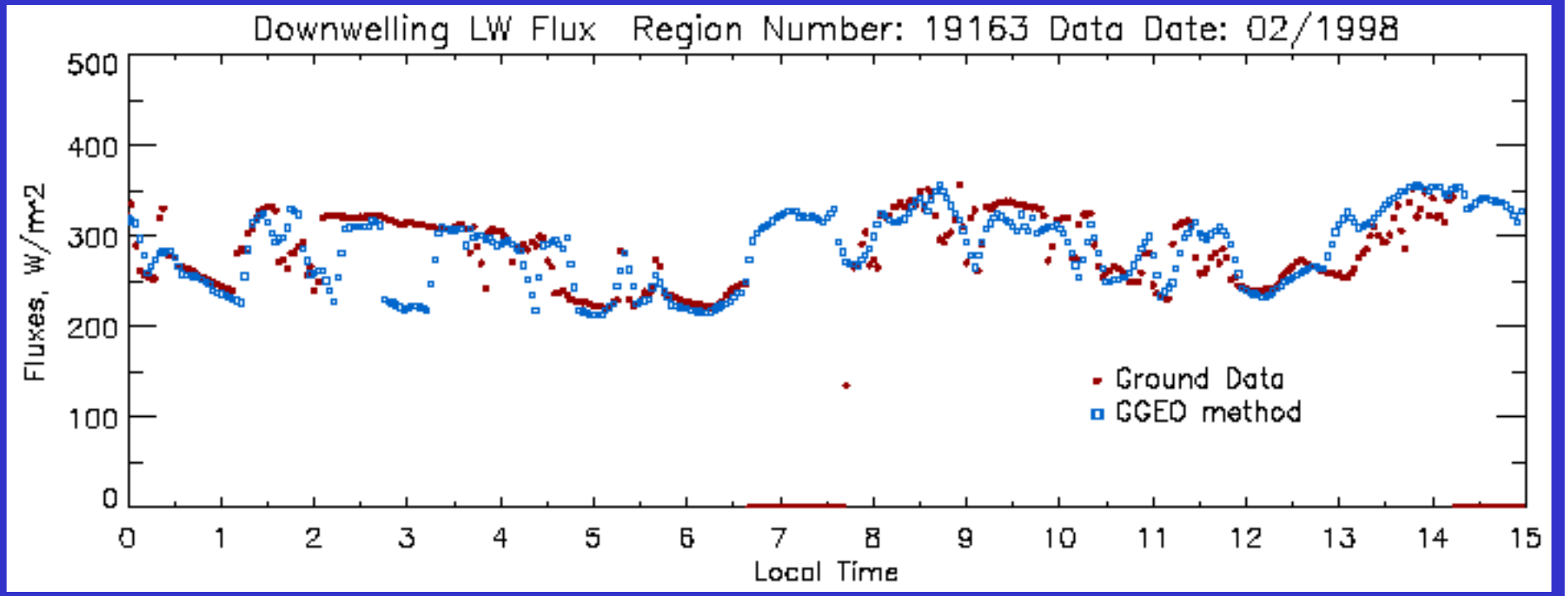
CERES Surface-Only Fluxes

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

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

- Validation data sources:
  - ARM Central facility and extended facilities
  - BSRN and CMDL sites
  - GEWEX SRB monthly means

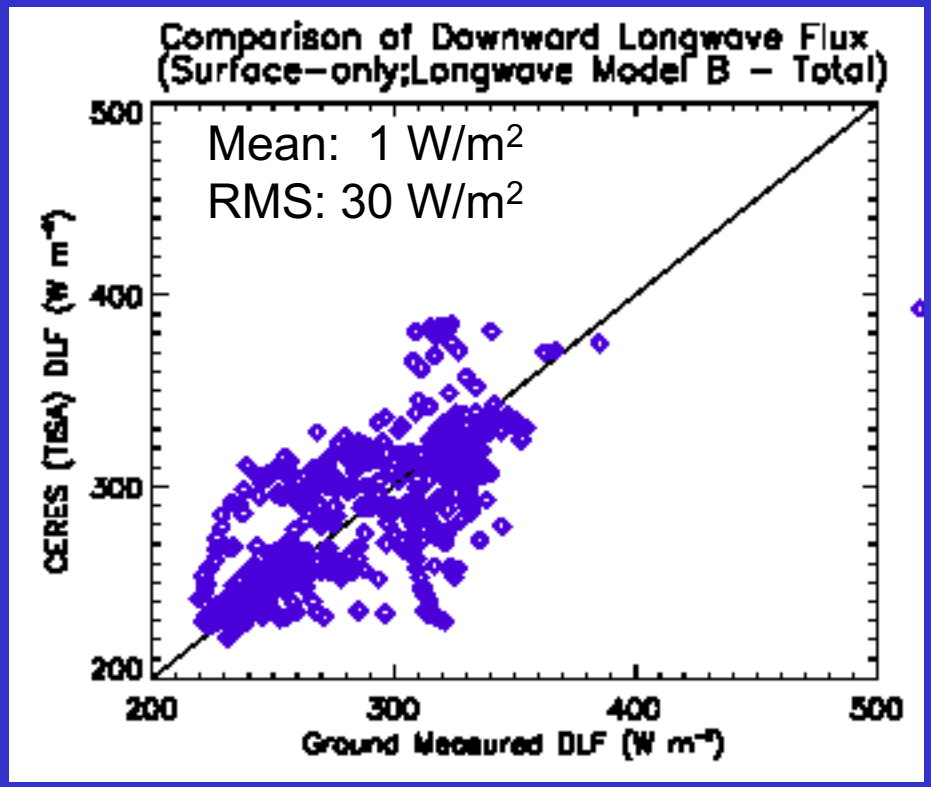
Instantaneous Flux Comparisons



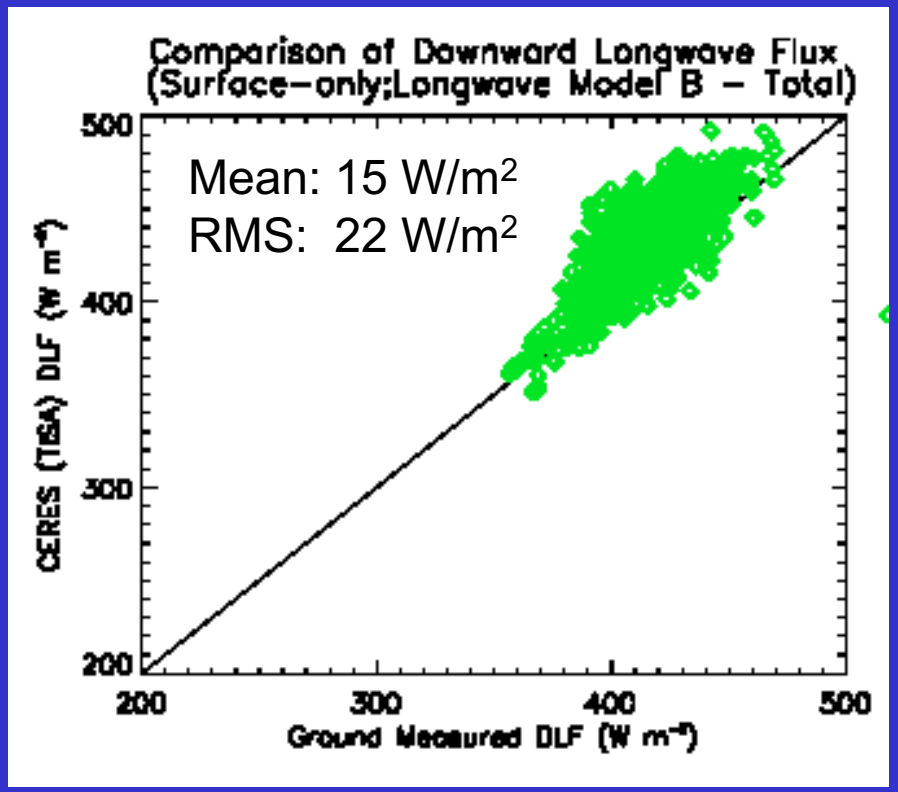
- SRBAVG estimates surface flux at local half-hour
- Surface data averaged over 30 minutes centered on half-hour
- Only days with at least 1 CERES observation considered

Downwelling Total-sky LW Flux (Model B)
ARM SGP Central Facility

February

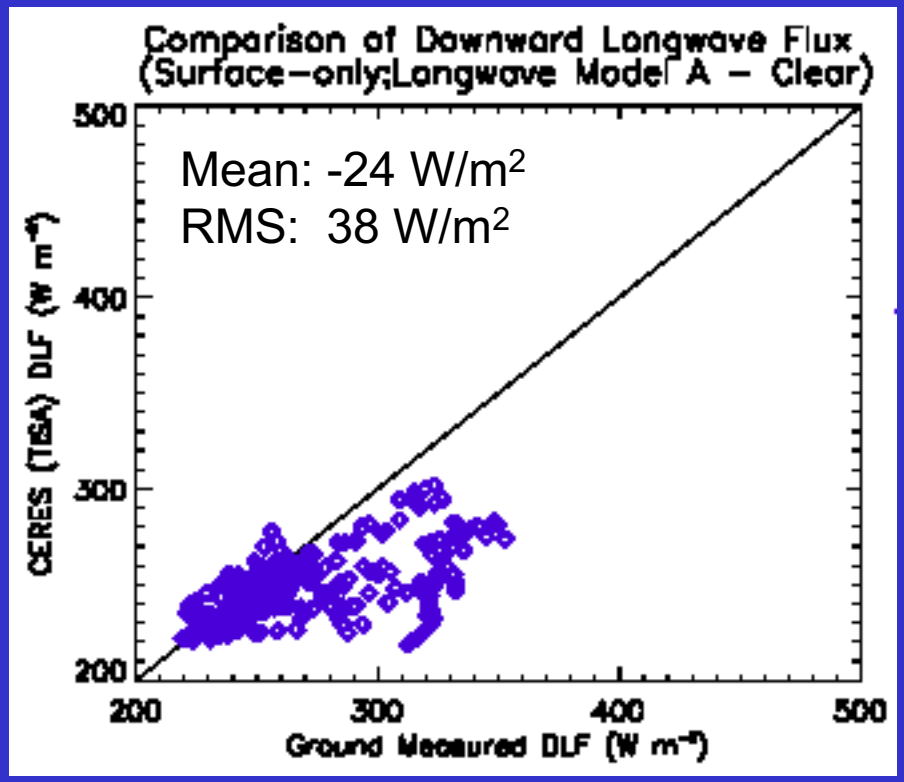


July



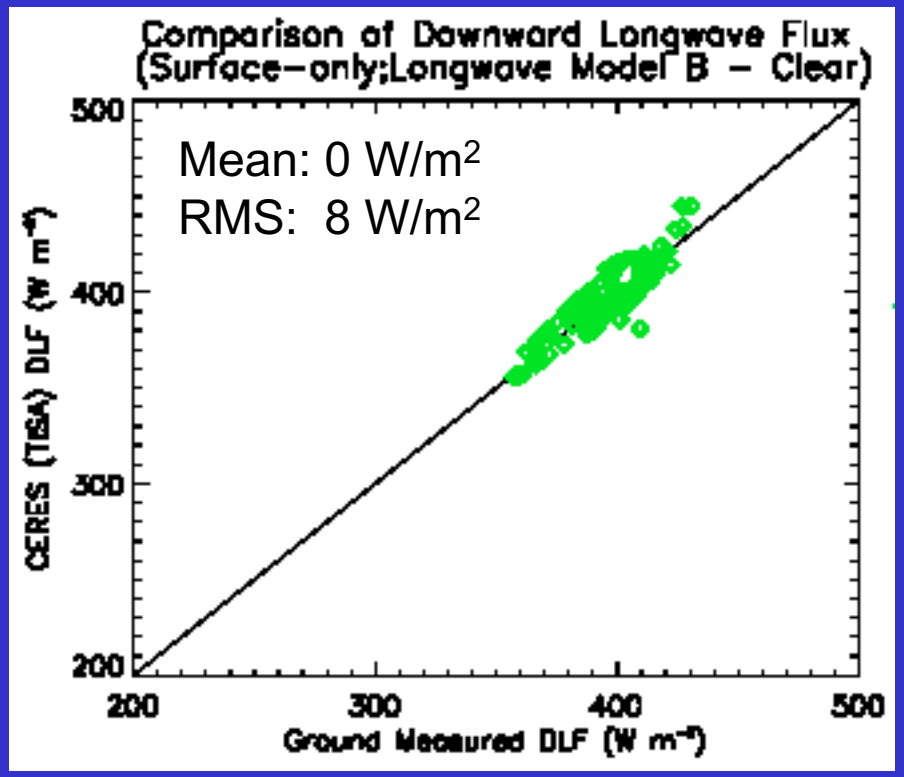
Downwelling Clear-sky LW Flux (Model A)
ARM SGP Central Facility

February



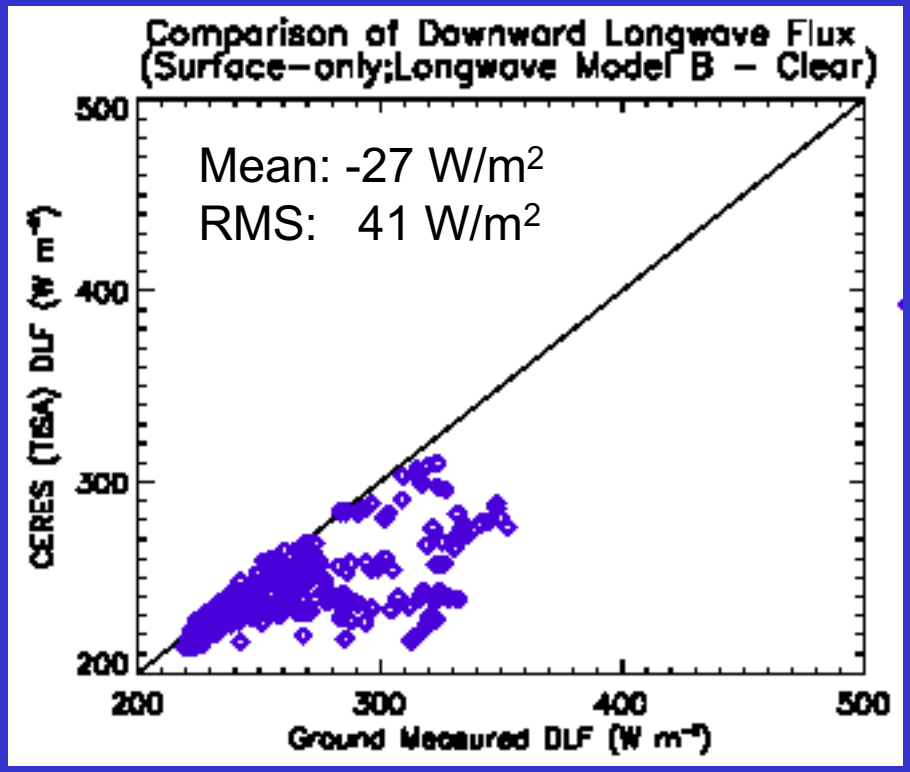
(Cloud contamination)

July



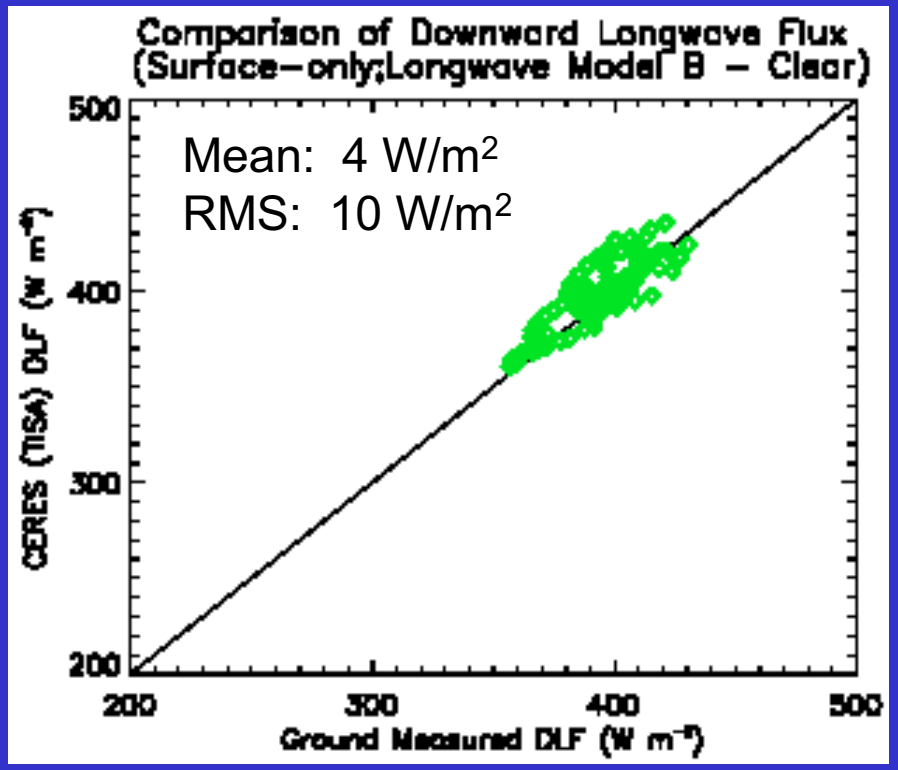
Downwelling Clear-sky LW Flux (Model B)
ARM SGP Central Facility

February



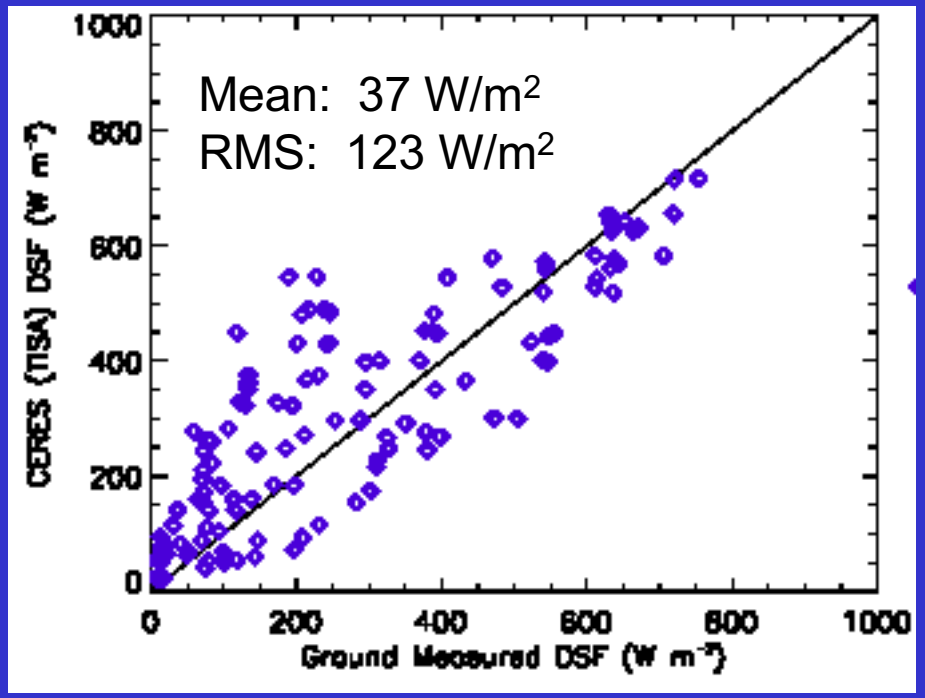
(Cloud contamination)

July

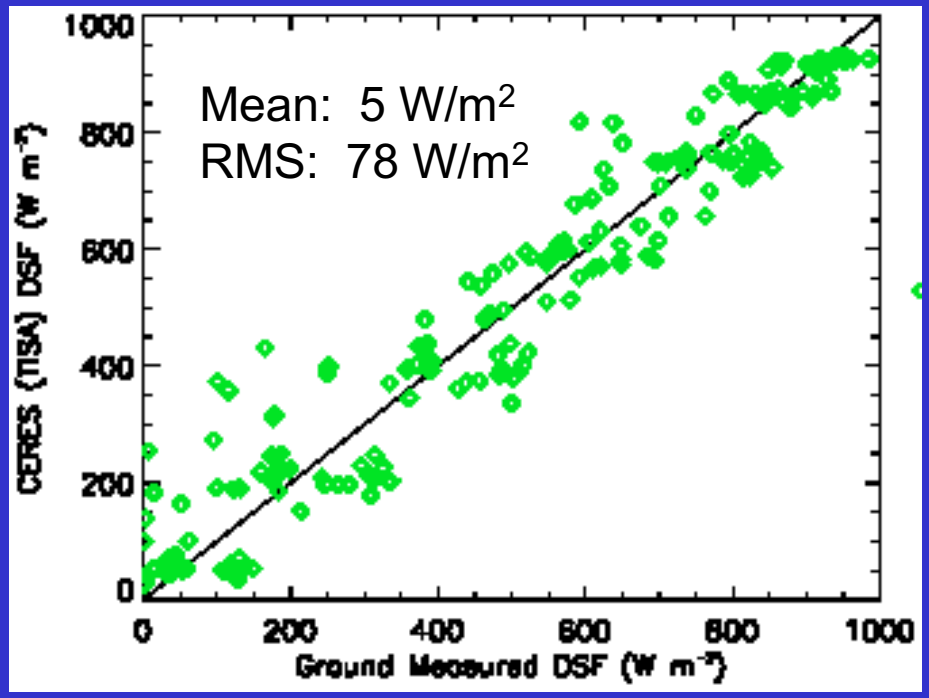


Downwelling Total-sky SW Flux (Model B)
ARM SGP Central Facility

February

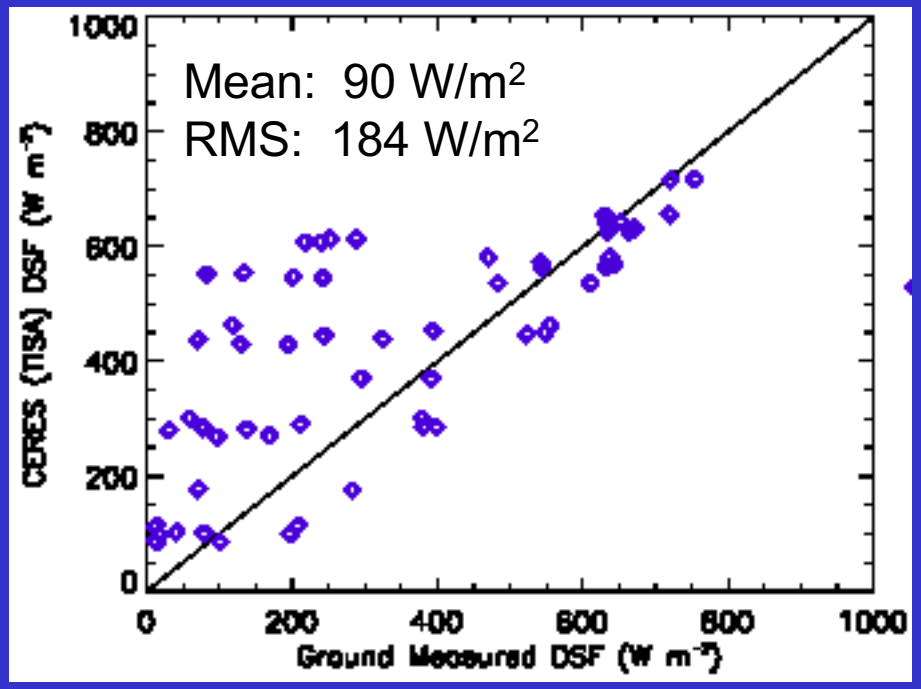


July

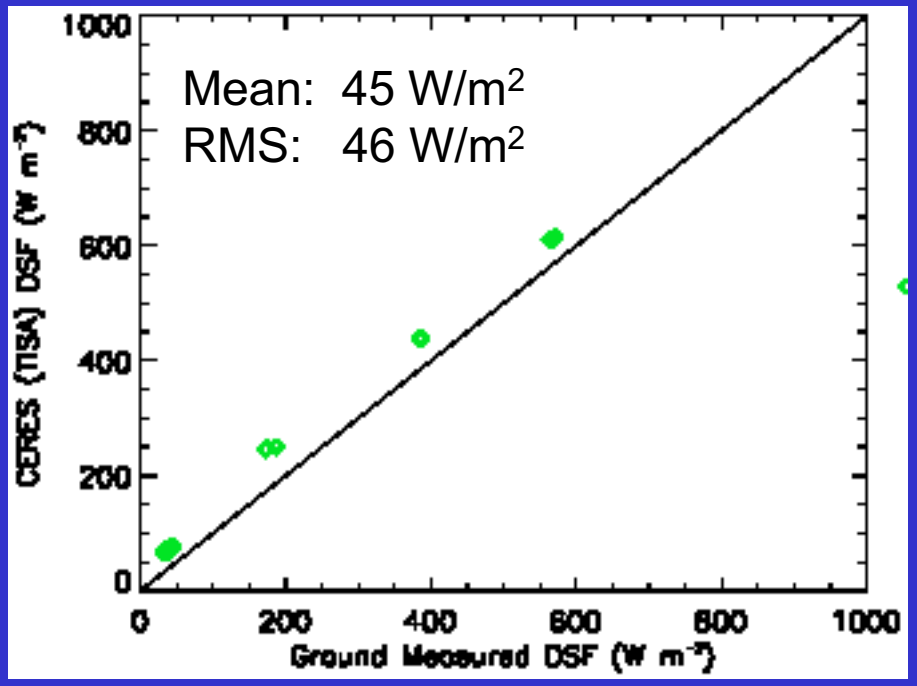


Downwelling Clear-sky SW Flux (Model B)
ARM SGP Central Facility

February



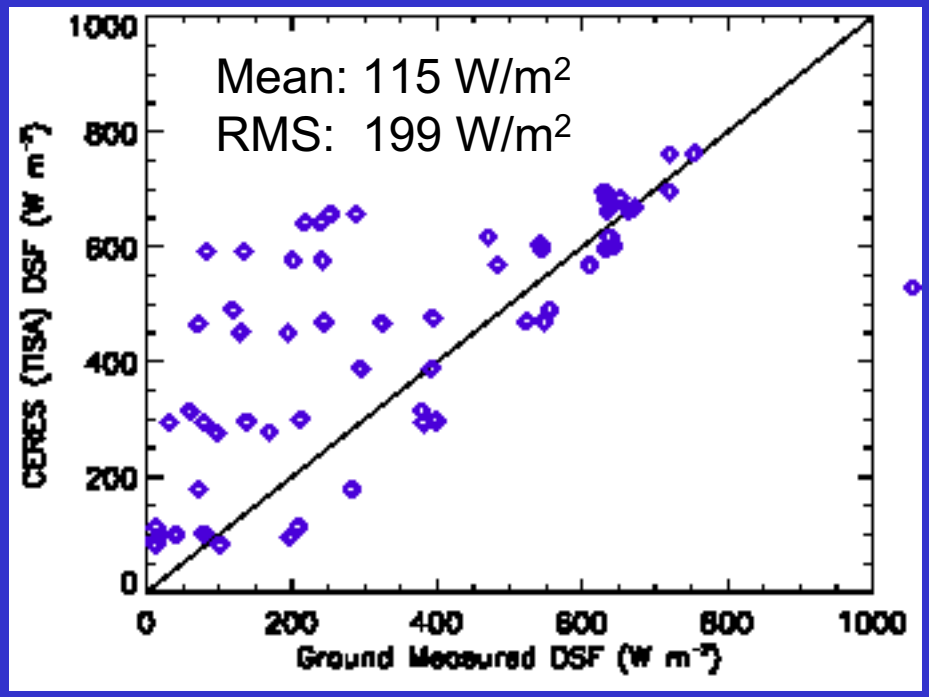
July



(Cloud contamination)

Downwelling Clear-sky SW Flux (Model A)
ARM SGP Central Facility

February



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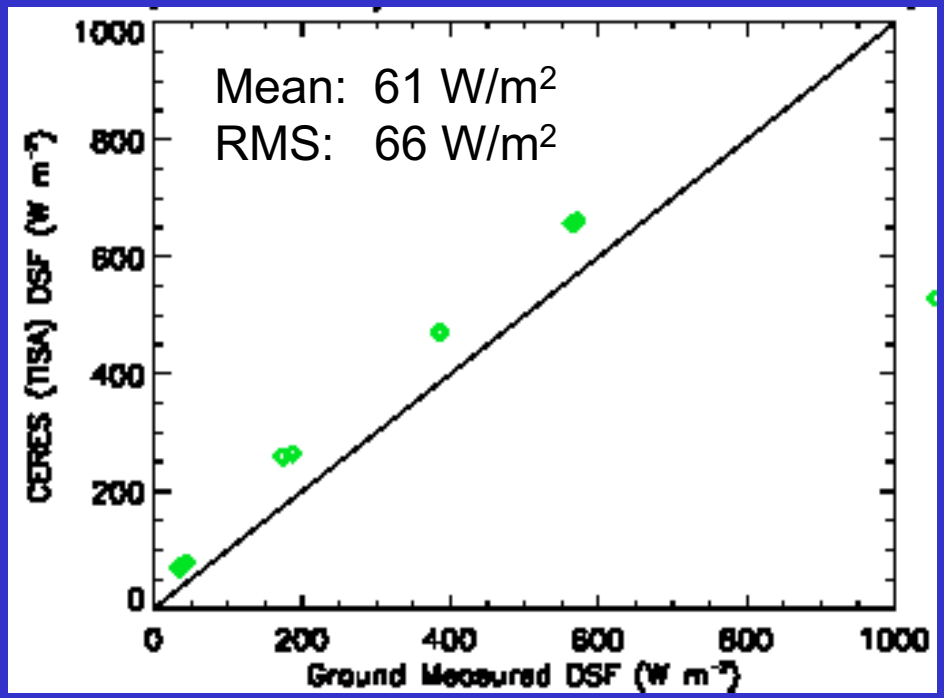
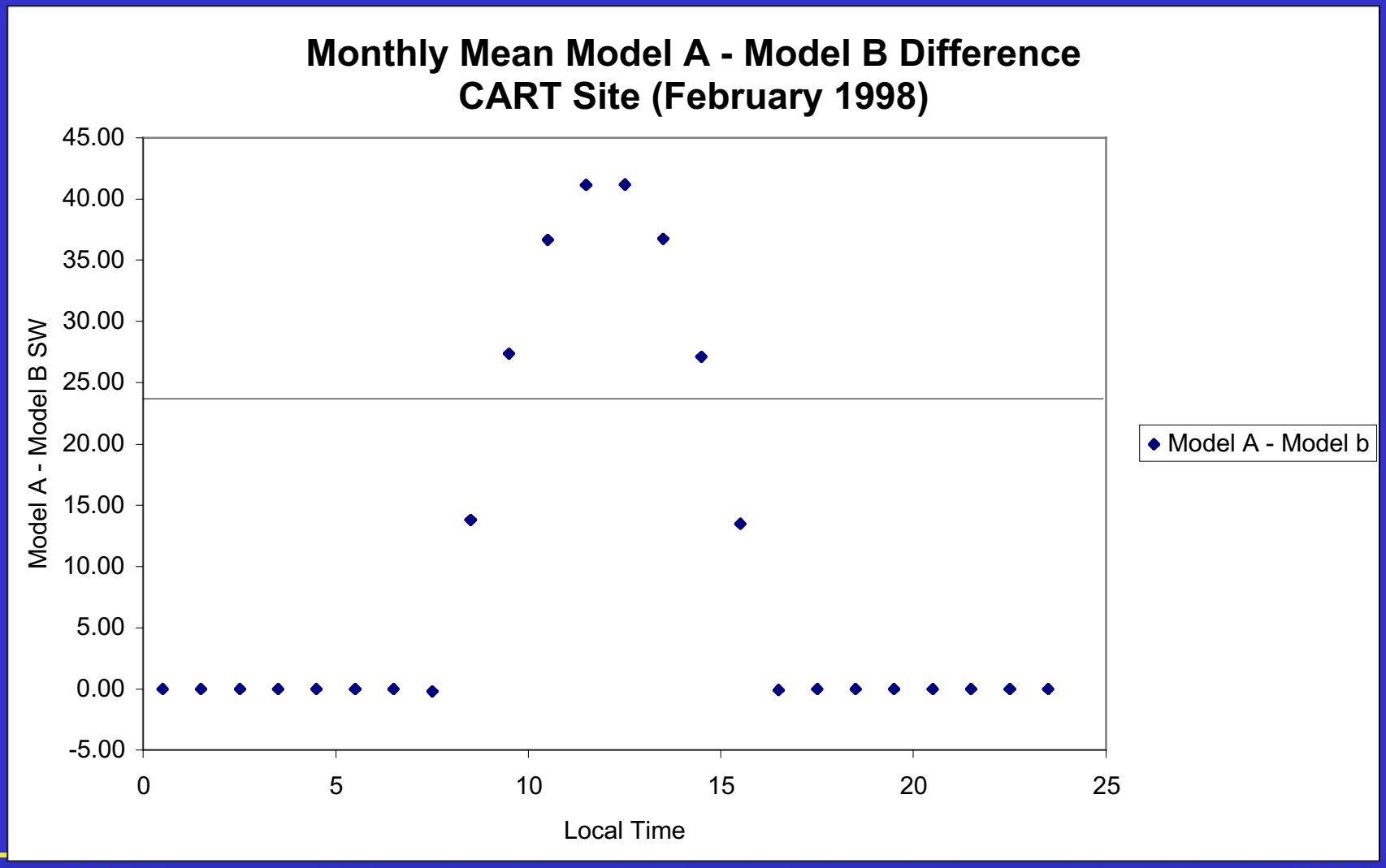
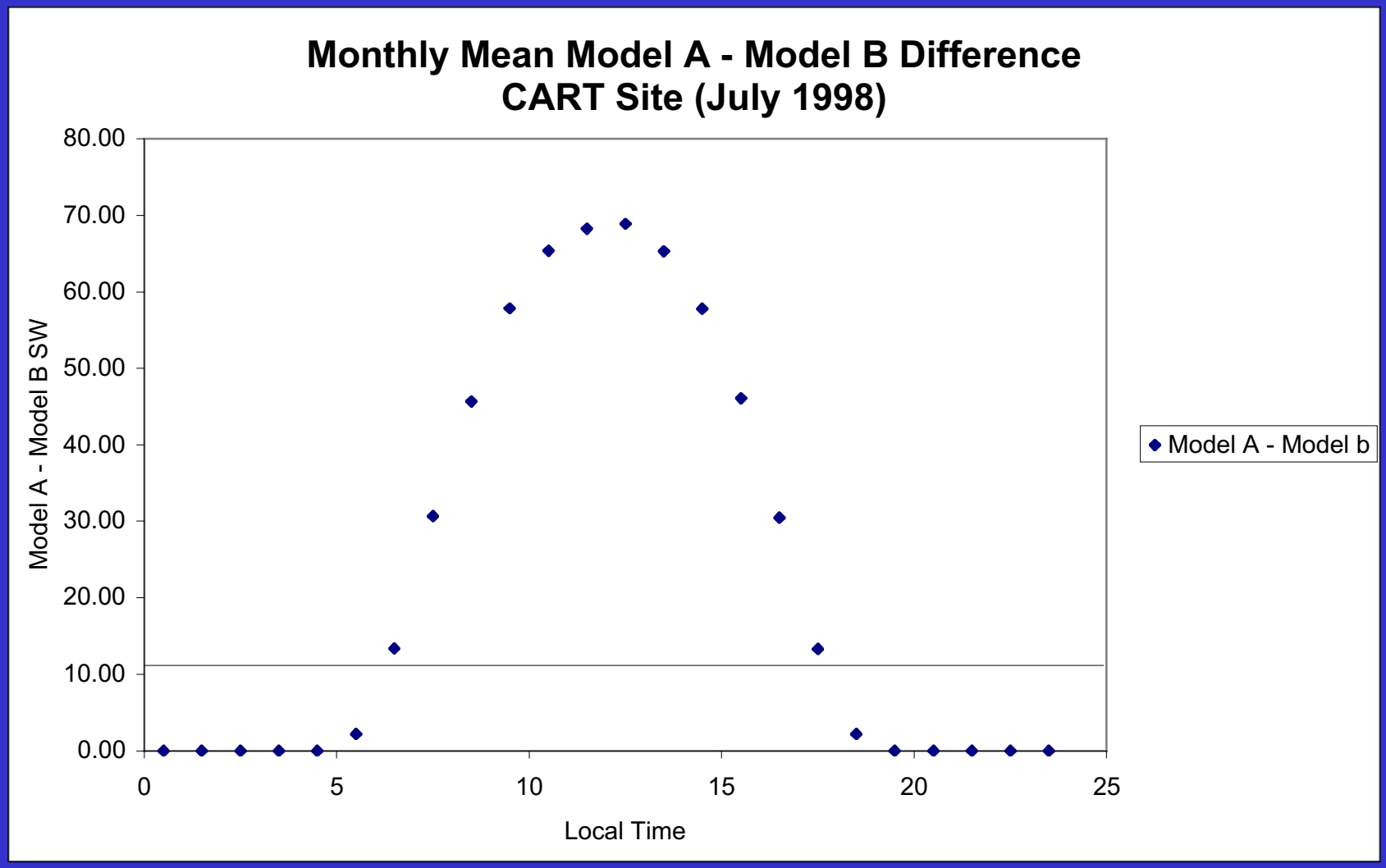


(Cloud contamination)

Clear-sky SW Surface Flux
Model A - Model B (ARM SGP, February 1998)



Clear-sky SW Surface Flux
Model A - Model B (ARM SGP, July 1998)



CERES vs. SRB

Surface Flux Validation Summary

- Clear sky
  - CERES fits clear sky to all hours
  - Screening surface data difficult

Comparison of CERES Monthly Mean Fluxes (ERBE-like, nonGEO, and GEO)

CERES Monthly Mean Products

ERBE-like

- Consistent with ERBE processing
- Useful for comparisons with ERBE climatology

- 2.5° grid
- TOA fluxes
- Limited cloud information

SRBAVG

- Takes advantage of improved CERES fluxes
- Uses improved temporal interpolation to remove sampling effects

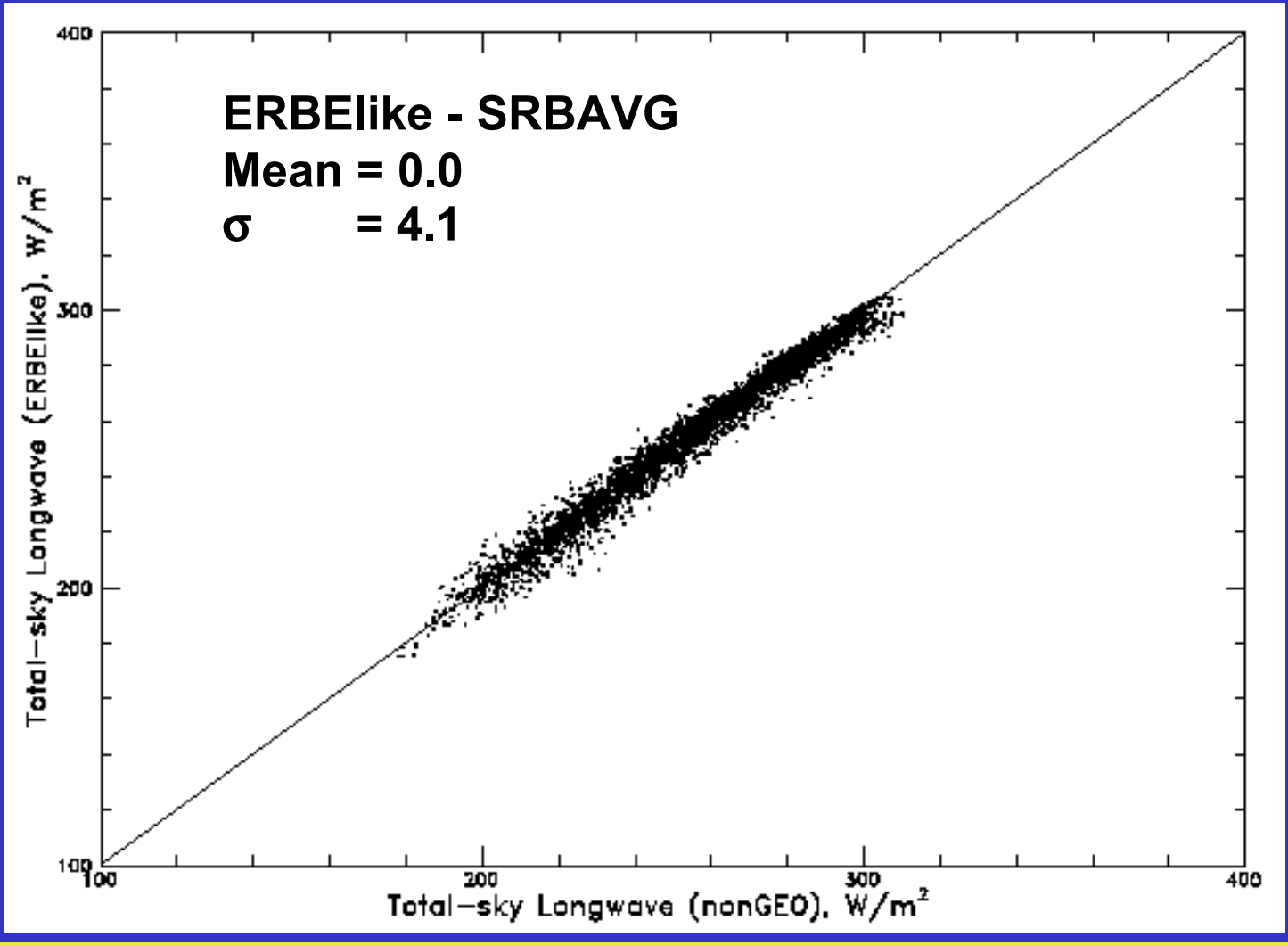
- 1.0° grid
- TOA and surface fluxes
- Detailed cloud properties

- Product contains GEO and nonGEO monthly means

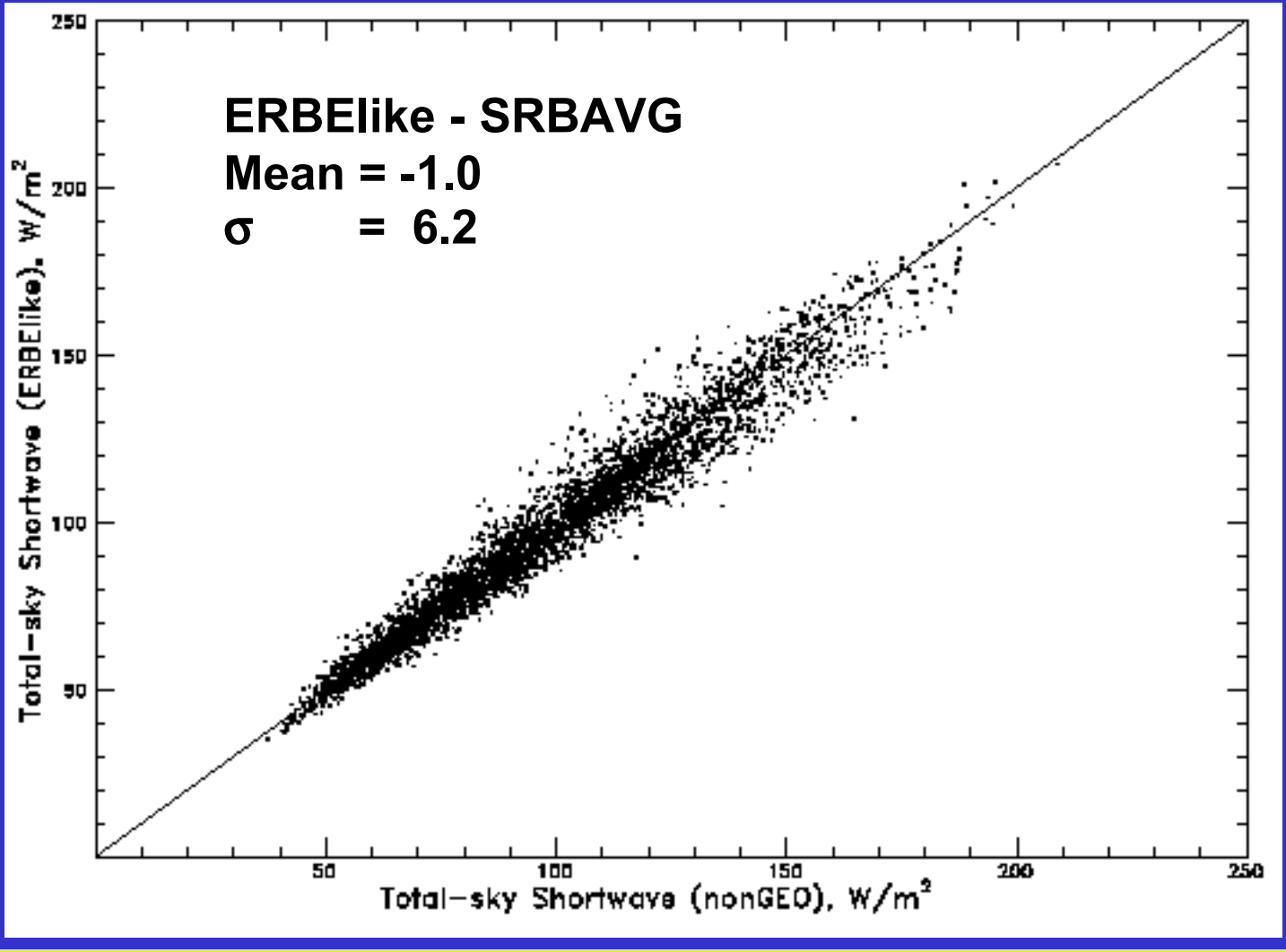
ERBE-like / nonGEO Comparisons

- nonGEO interpolation algorithm similar to ERBElike
- Major differences
  - 1° grid
  - CERES DRMs for SW
  - Input flux differences
    - CERES vs. ERBE ADM
    - Reference altitude: Surface vs. 30-km
    - VZ limit: 48° vs. 70°
- Comparisons use matched monthly means on 2.5° grid
  - SRBAVG nonGEO regridded to 2.5° grid

ERBElike vs nonGEO Total-Sky LW Flux February 1998



ERBElike vs nonGEO Total-Sky SW Flux February 1998



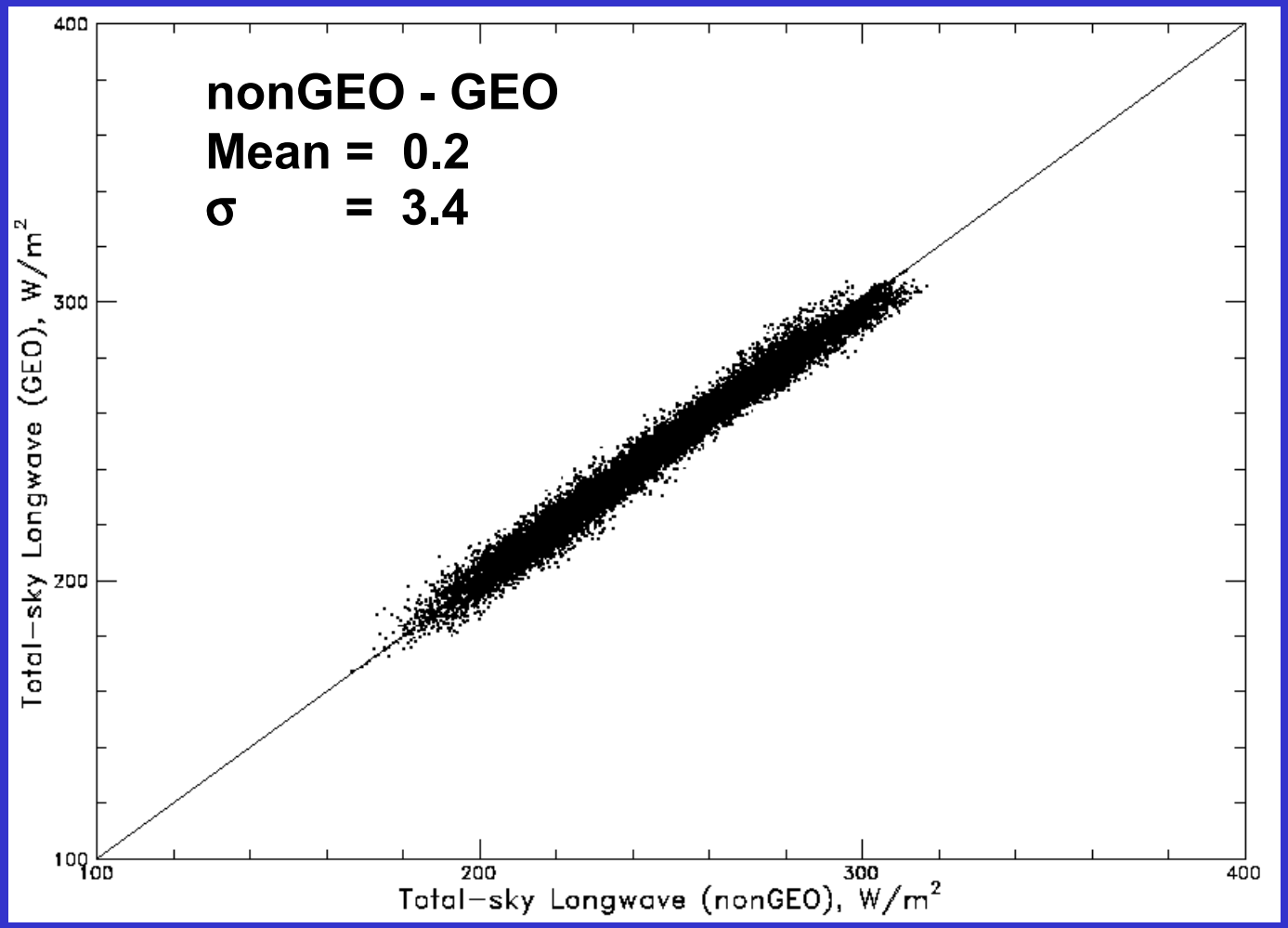
ES4 ERBE-like and SRBAVG Flux Summary February 1998

40°N - 40°S W/m²		ERBE-like (ES-4)	SRBAVG nonGGEO	ES4 - SRBAVG
Total-Sky LW Flux	Mean	258.4	258.4	0.0
	Sigma	28.5	28.5	4.1
Total-Sky SW Flux	Mean	96.6	97.6	-1.0
	Sigma	29.9	30.4	6.2
Clear-Sky LW Flux	Mean	287.3	287.4	-0.1
	Sigma	12.9	14.0	2.9
Clear-Sky SW Flux	Mean	50.2	49.7	0.4
	Sigma	18.5	18.3	5.7

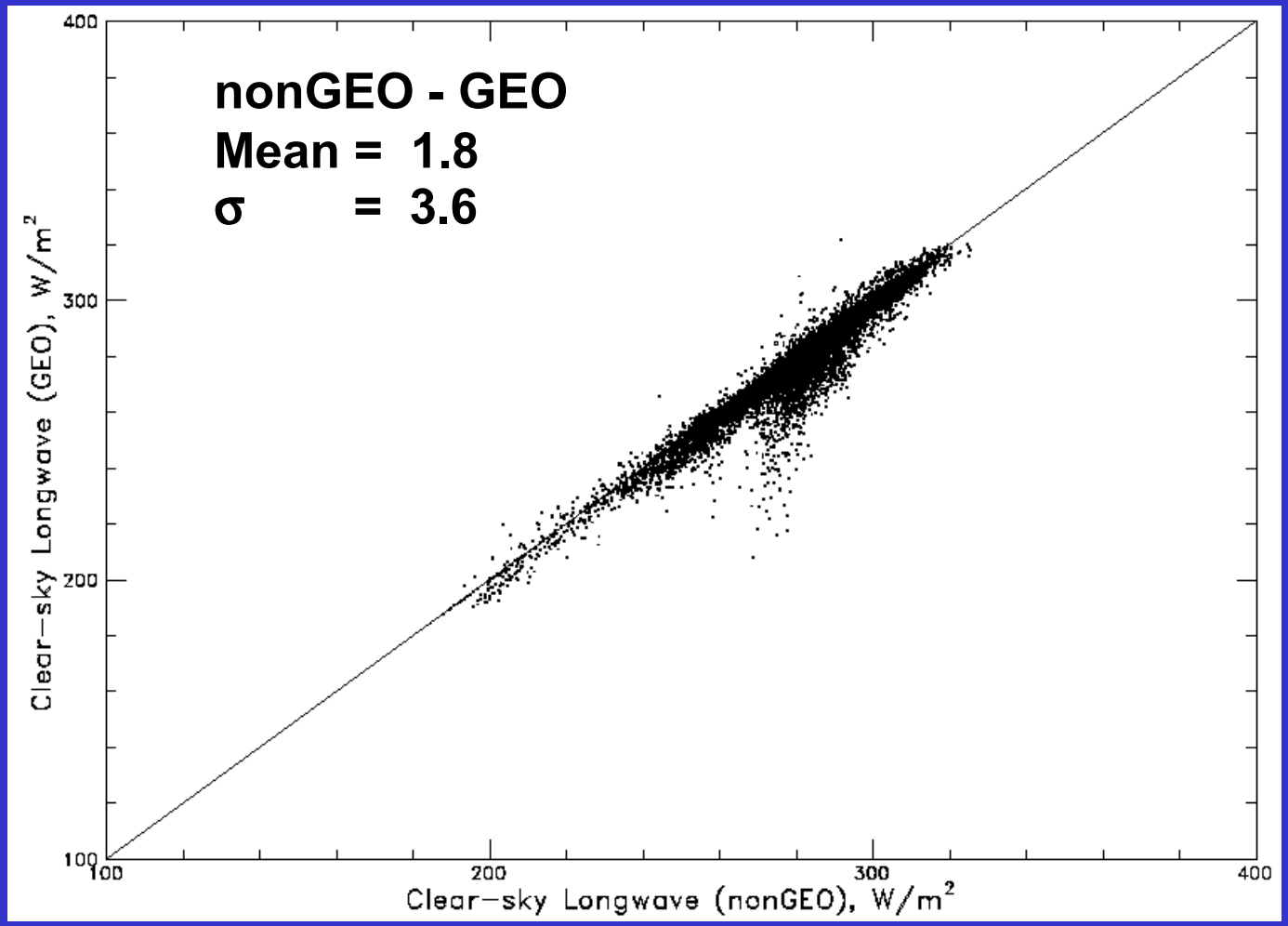
SRBAVG nonGEO vs. GEO Fluxes

- Comparison demonstrates changes due to inclusion of GEO data
  - GEO goal is reduction of temporal sampling errors
  - Major improvement expected in mean diurnal variation
- More direct comparison than ERBElike
  - Same input fluxes
  - Same 1° grid
- No GEO SW clear-sky fluxes

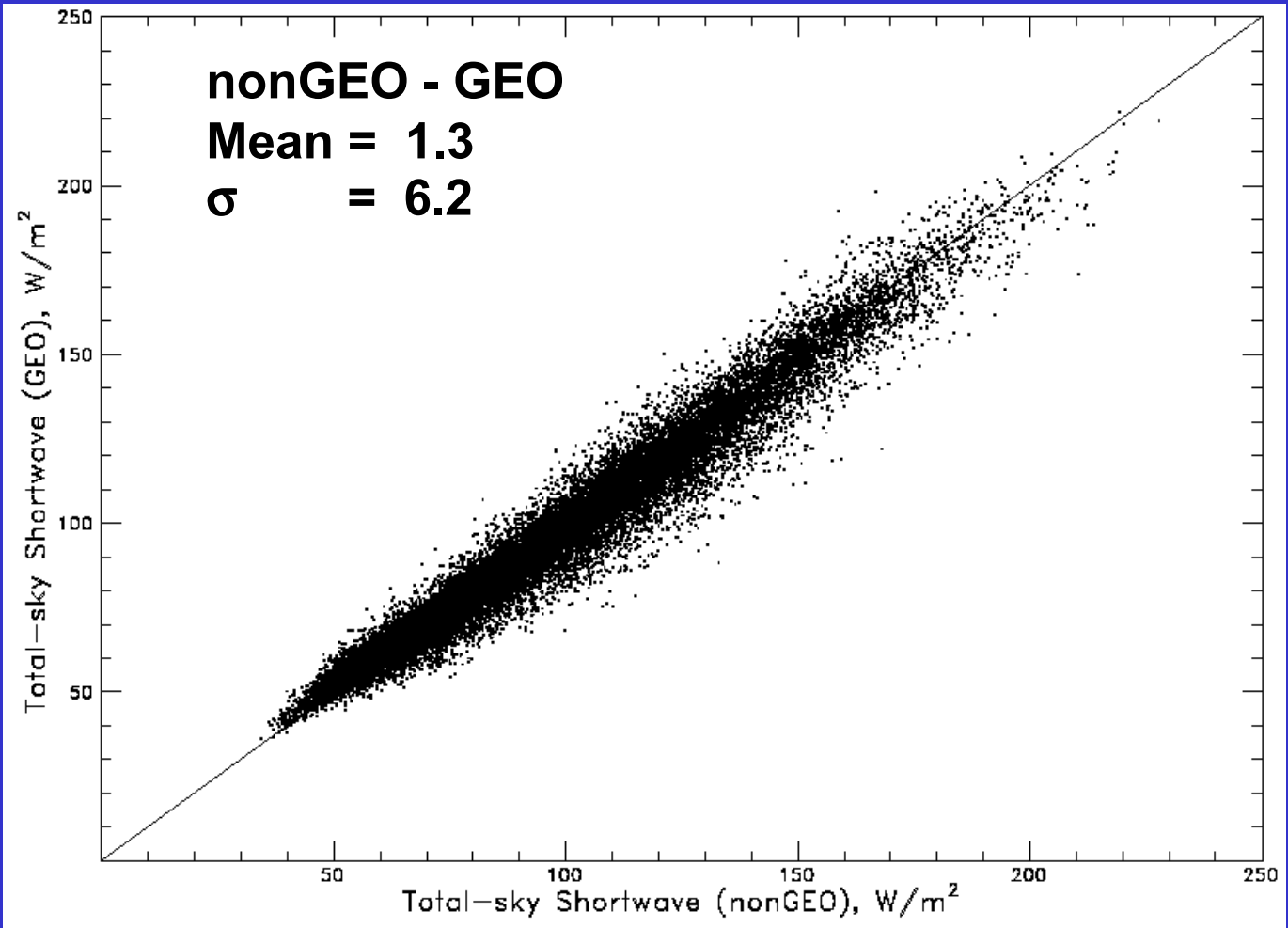
nonGEO vs. GEO Total-sky LW Flux February 1998



nonGEO vs. GEO Clear-sky LW Flux February 1998



nonGEO vs. GEO Total-sky SW Flux February 1998



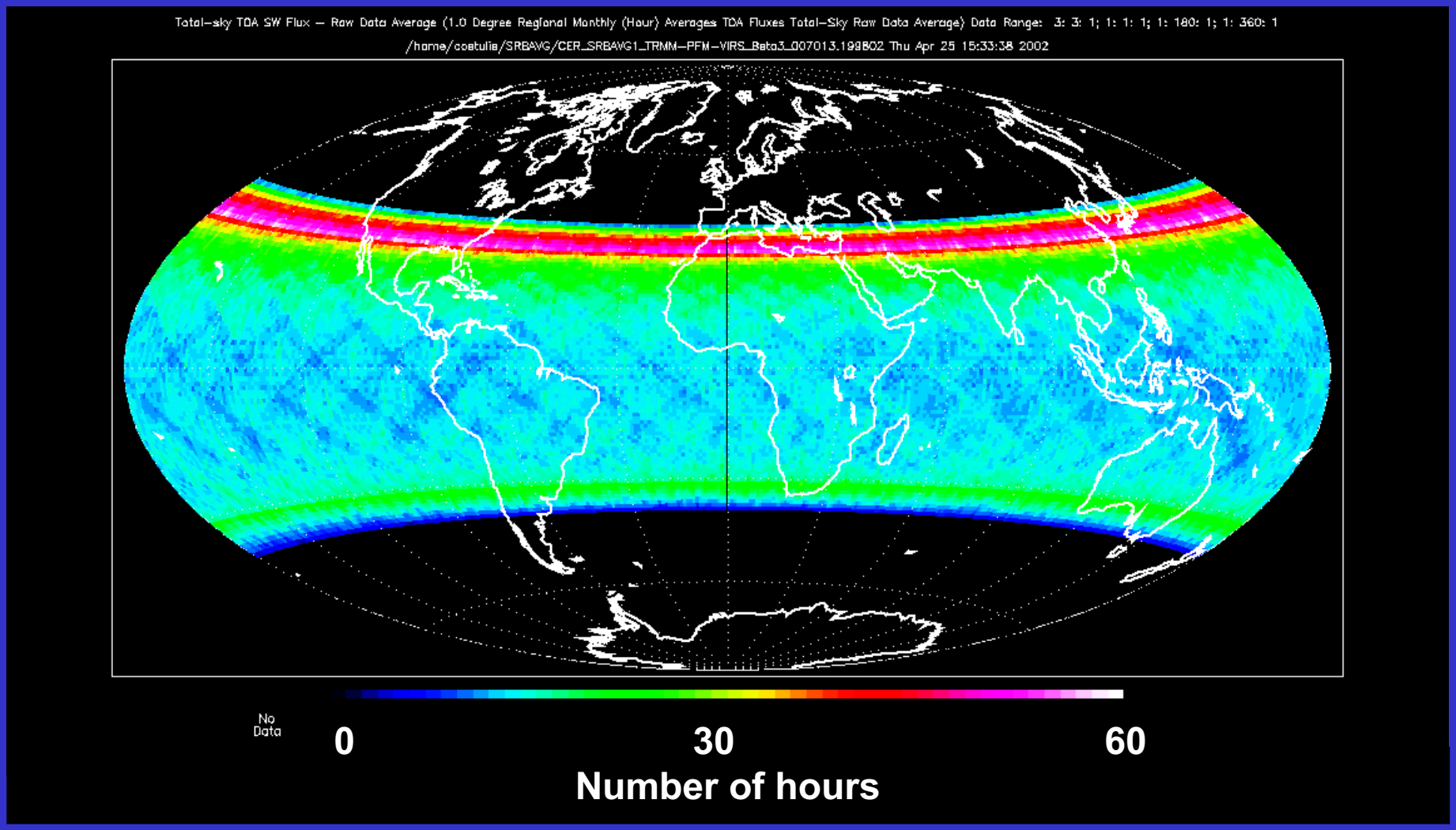
SRBAVG nonGEO and GEO Flux Summary February 1998

40°N - 40°S W/m²		SRBAVG nonGEO	SRBAVG GEO	GEO - nonGEO
Total-Sky LW Flux	Mean	257.3	257.1	-0.2
	Sigma	29.2	29.0	3.4
Total-Sky SW Flux	Mean	98.2	96.8	-1.3
	Sigma	31.9	31.1	6.2
Clear-Sky LW Flux	Mean	286.1	284.3	-1.8
	Sigma	15.1	16.0	3.6

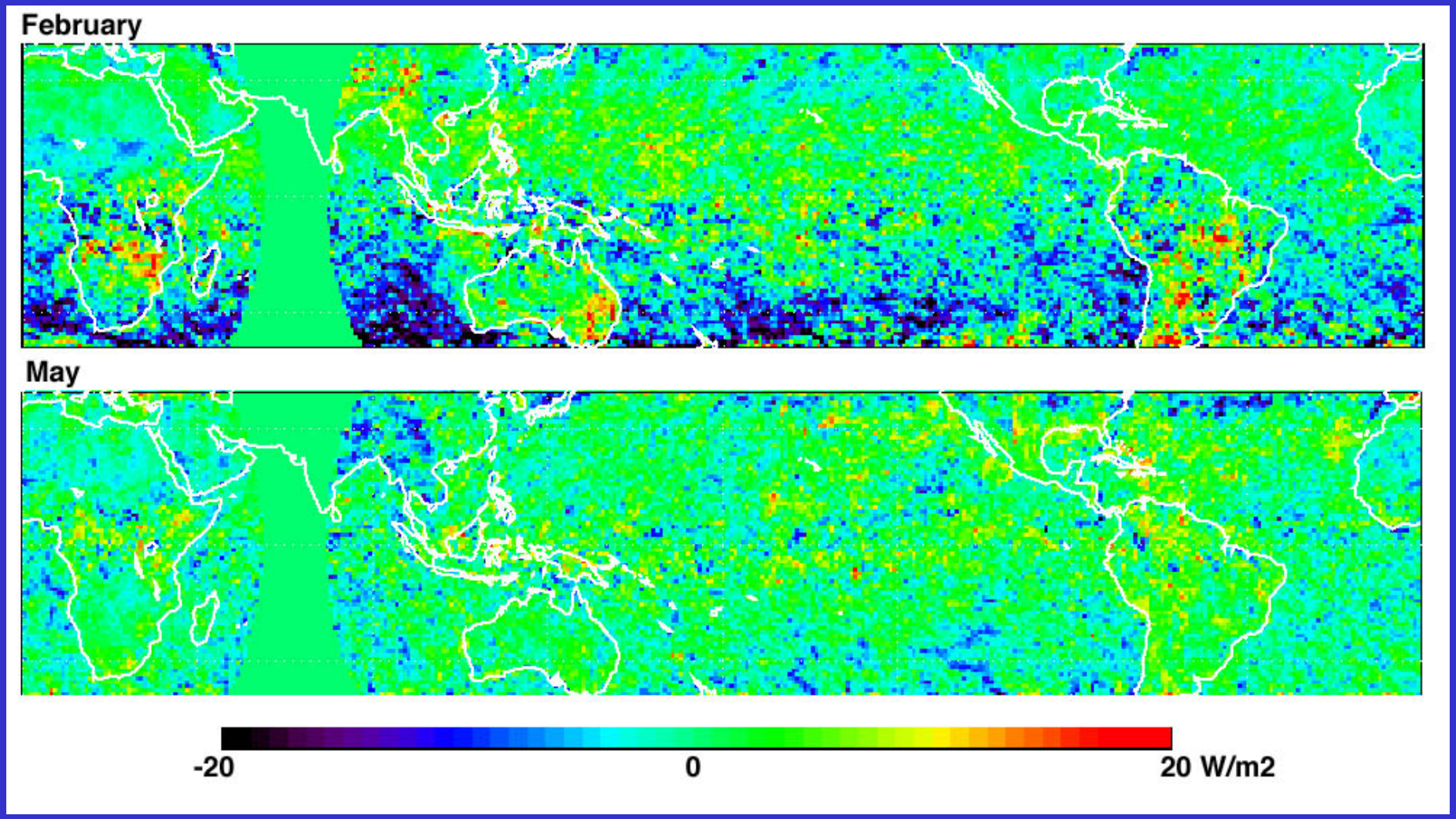
SRBAVG GEO - nonGEO Fluxes February/May/June/July 1998

40°N - 40°S W/m^2		Feb	May	June	July
Total-Sky LW Flux	Mean	-0.2	0.1	-0.3	0.2
	Sigma	3.4	2.9	3.4	3.2
Total-Sky SW Flux	Mean	-1.3	0.2	0.1	-0.2
	Sigma	6.2	4.4	4.0	4.5
Clear-Sky LW Flux	Mean	-1.8	-1.0	-1.0	-1.4
	Sigma	3.6	1.6	1.7	2.2

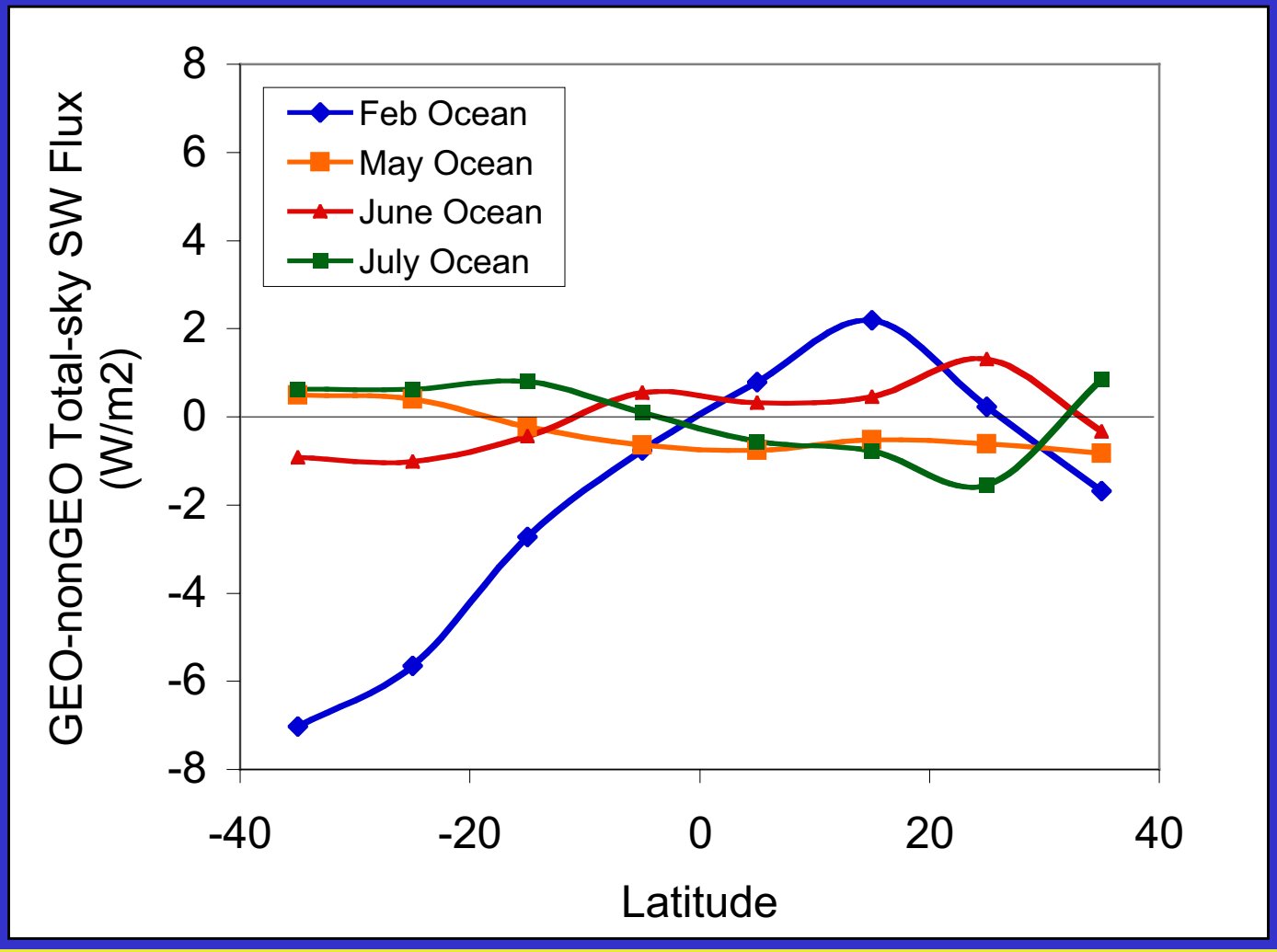
February 1998 SW Sampling



Monthly Mean GEO-nonGEO Total-sky SW Flux

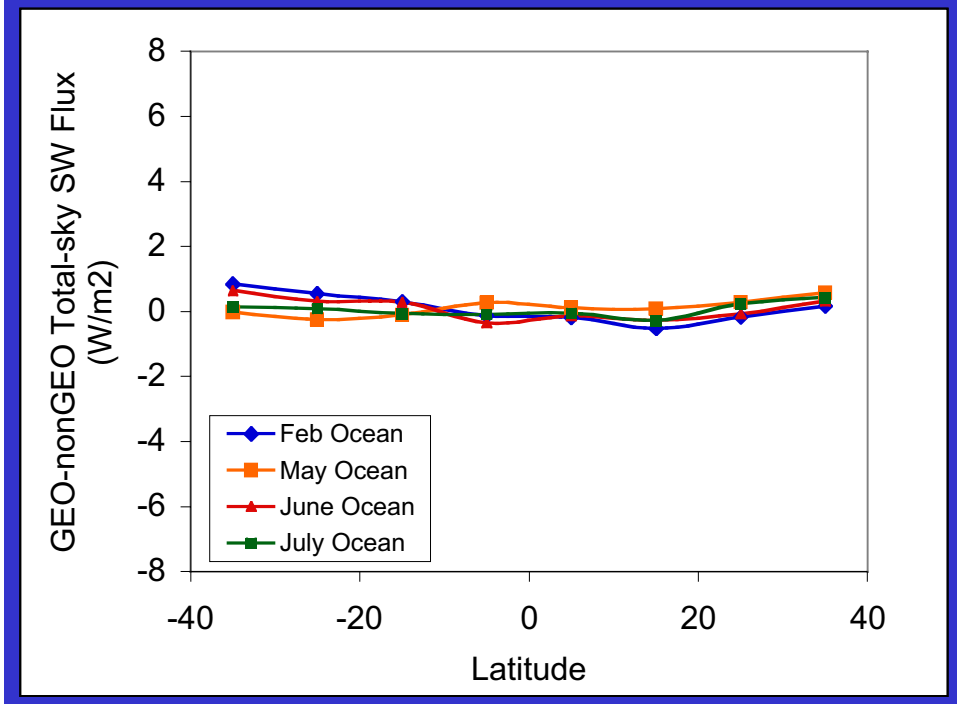


Zonal Mean GEO-nonGEO Total-Sky SW Flux Differences

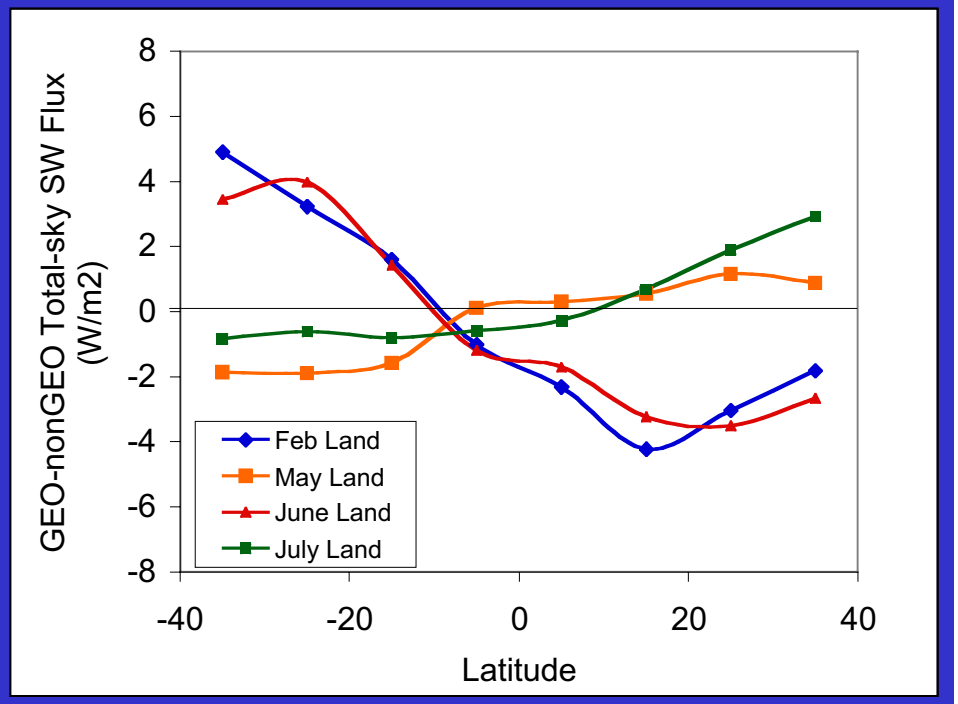


April Zonal Mean GEO-nonGEO LW Flux Differences

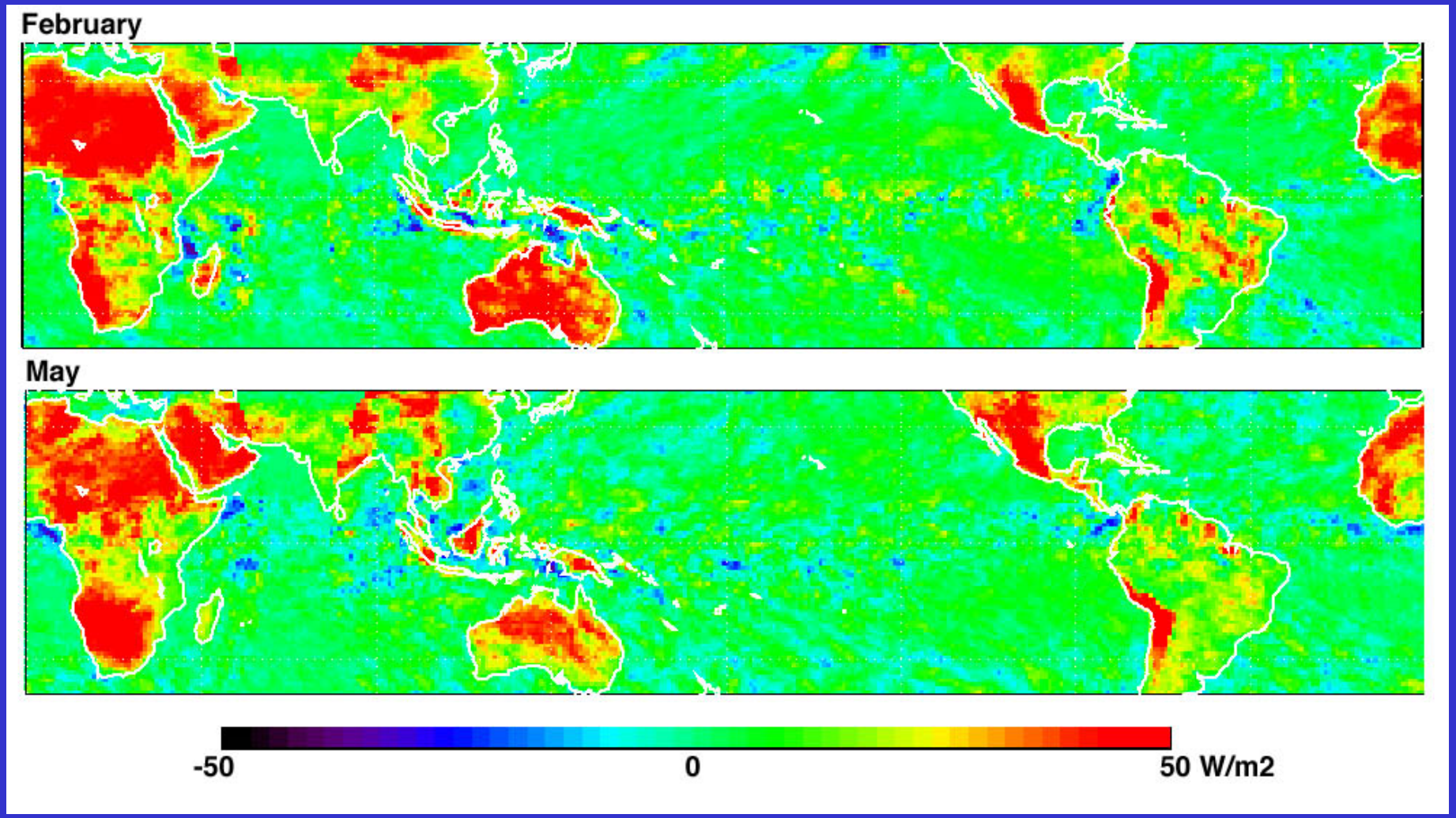
Ocean



Land



Monthly Mean GEO-nonGEO Total-sky LW Flux Diurnal Range



Flux Comparison Summary

- Mean fluxes very similar for all three monthly means
- Differences consistent with sampling
- Major improvement in GEO LW diurnal range

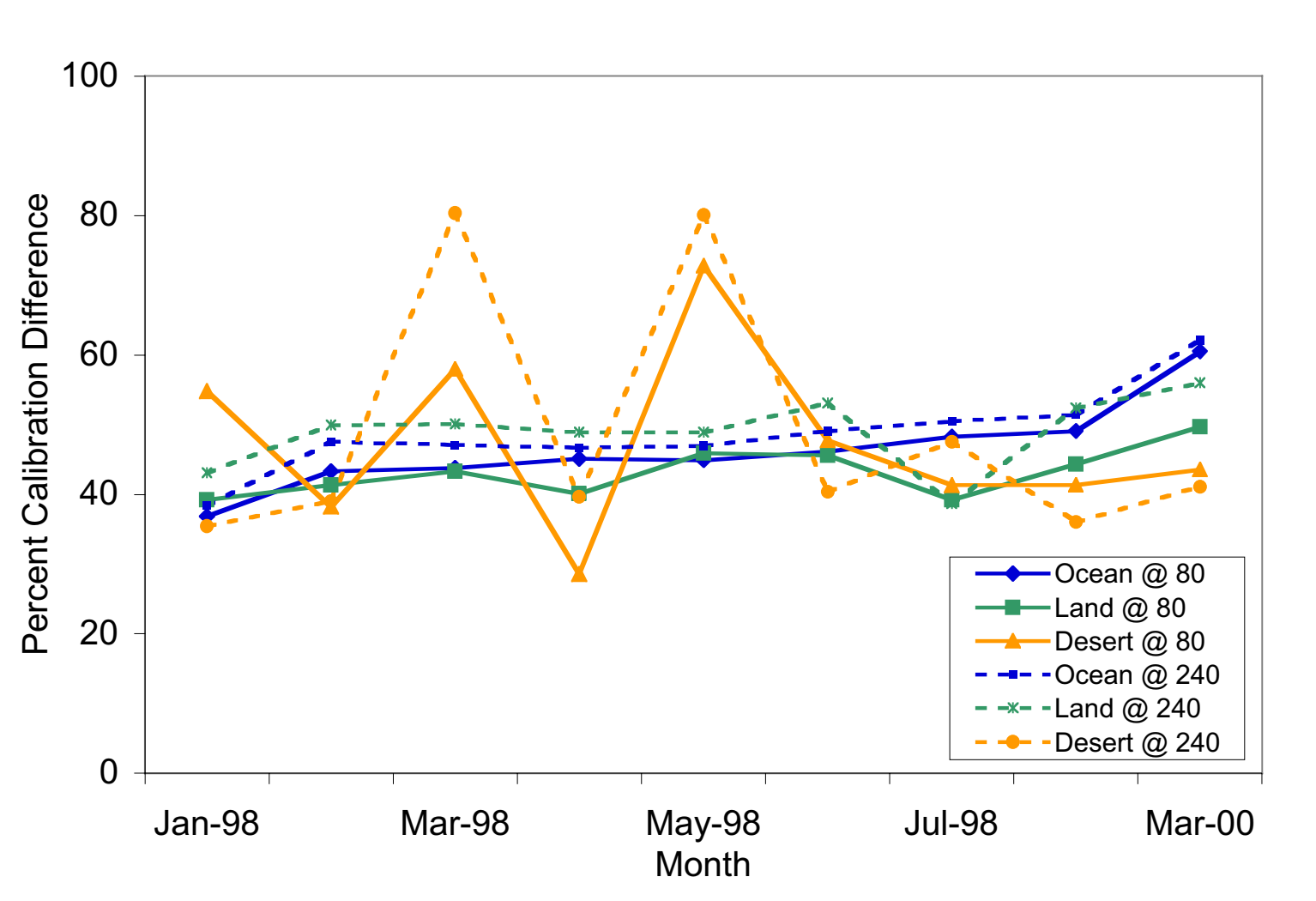
GEO Calibration and Cloud Retrievals

- GEO cloud properties retrieval goals:
  - Improvement of TOA flux interpolation (primary goal)
  - Improvement of diurnal modeling of cloud properties
- GEO calibration goals:
  - Consistency with VIRS calibration
  - Consistency with VIRS cloud retrievals
    - Most important parameter: cloud fraction
    - Optical Depth also used for DRM selection
    - Cloud temperature only used to sort by height
- Limitations
  - Only two channels (0.6 and 10.8 μm)
  - Single channel used at night
  - GEO spectral differences

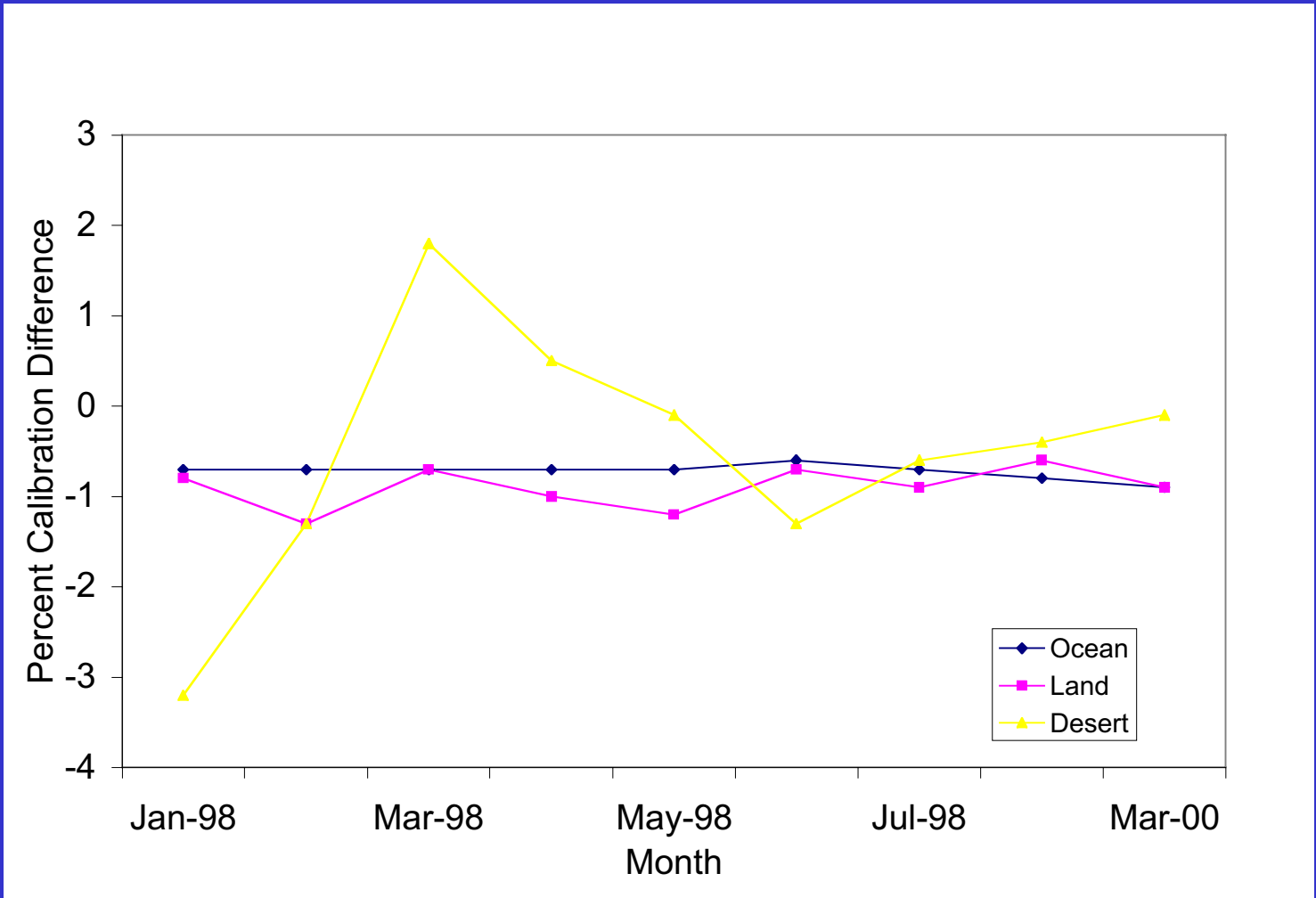
GEO Calibration (Technique)

- VIRS/GEO calibration relationship calculated for:
  - Each Month
  - Each GEO satellite
  - Ocean / land / desert
  - 0.65 and 11 µm channels
- VIRS / GEO matched in space/time/viewing geometry
- Visible fit solves for slope and offset
- IR fit uses fixed intercept
- Time series of calibration used to check consistency
  - VIRS vs. nominal calibration compared at high and low radiance values (evaluates combined offset + gain)
  - Some variation expected due to sampling
  - Minnis et al. 2002 uses mean trend line

GOES-8 Visible Calibration Time Series



GOES-8 IR Calibration Time Series



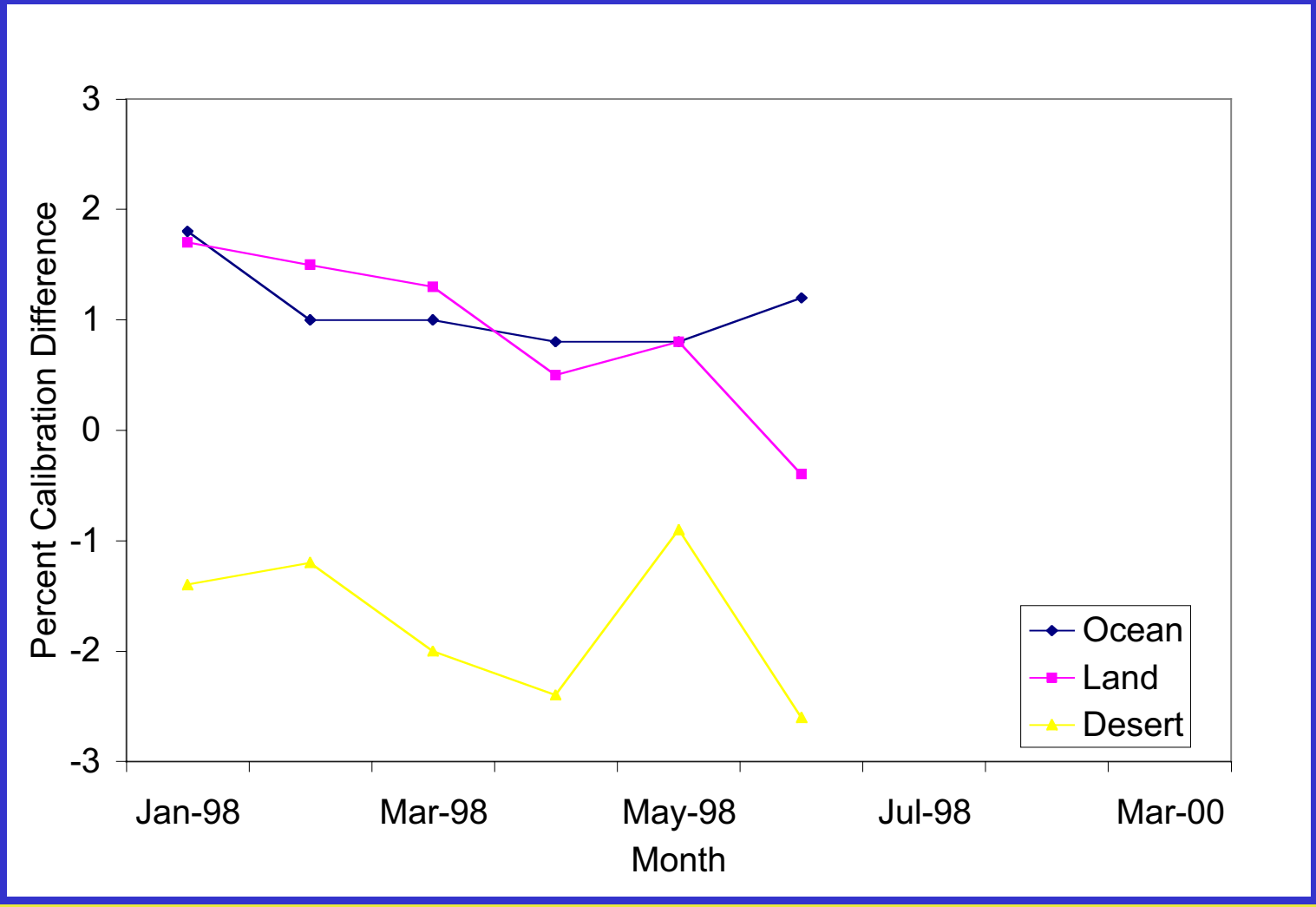
GOES-8 Calibration Summary

- OCEAN calibrations used for land and desert
  - Land calibration consistent with Ocean
  - Desert sampling too limited for consistent results
  - GOES spectral bands narrow enough to ignore scene type differences
- Calibration consistent month-to-month
  - Calibration comparison consistent for high & low radiances
- Visible drift consistent with Minnis et al., 2002

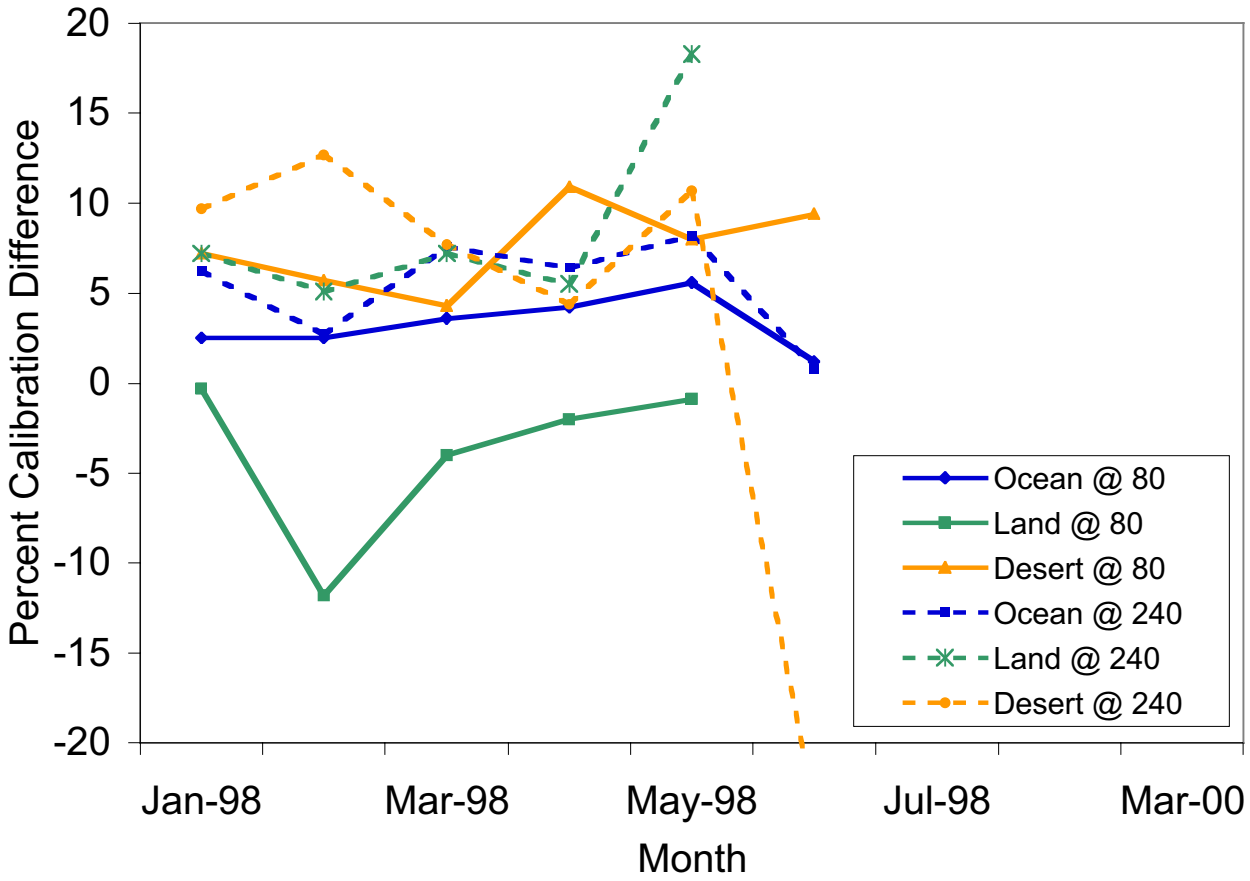
METEOSAT and GMS

- Broader spectral intervals
  - Surface emittance differences with scene type
- Noisier data
  - Some fits are based on combining several months
  - Difficulty in modeling trends
- More extensive deserts in viewing area
  - Allows separate land/desert fits

METEOSAT-6 IR Calibration



METEOSAT-6 Visible Calibration



GEO Calibration Results

- GOES
  - Calibration consistent month-to-month
  - Drifts consistent with Minnis et al., 2002
  - OCEAN calibrations used for land and desert
- METEOSAT
  - Separate calibrations for ocean/land/desert
  - Desert/land use mean 1998 fits
  - Bad sampling months replaced
  - March 2000 IR calibration shows large shifts
- GMS-5
  - Visible offset problem solved using fixed intercept
  - Desert/Land use mean 1998 fits

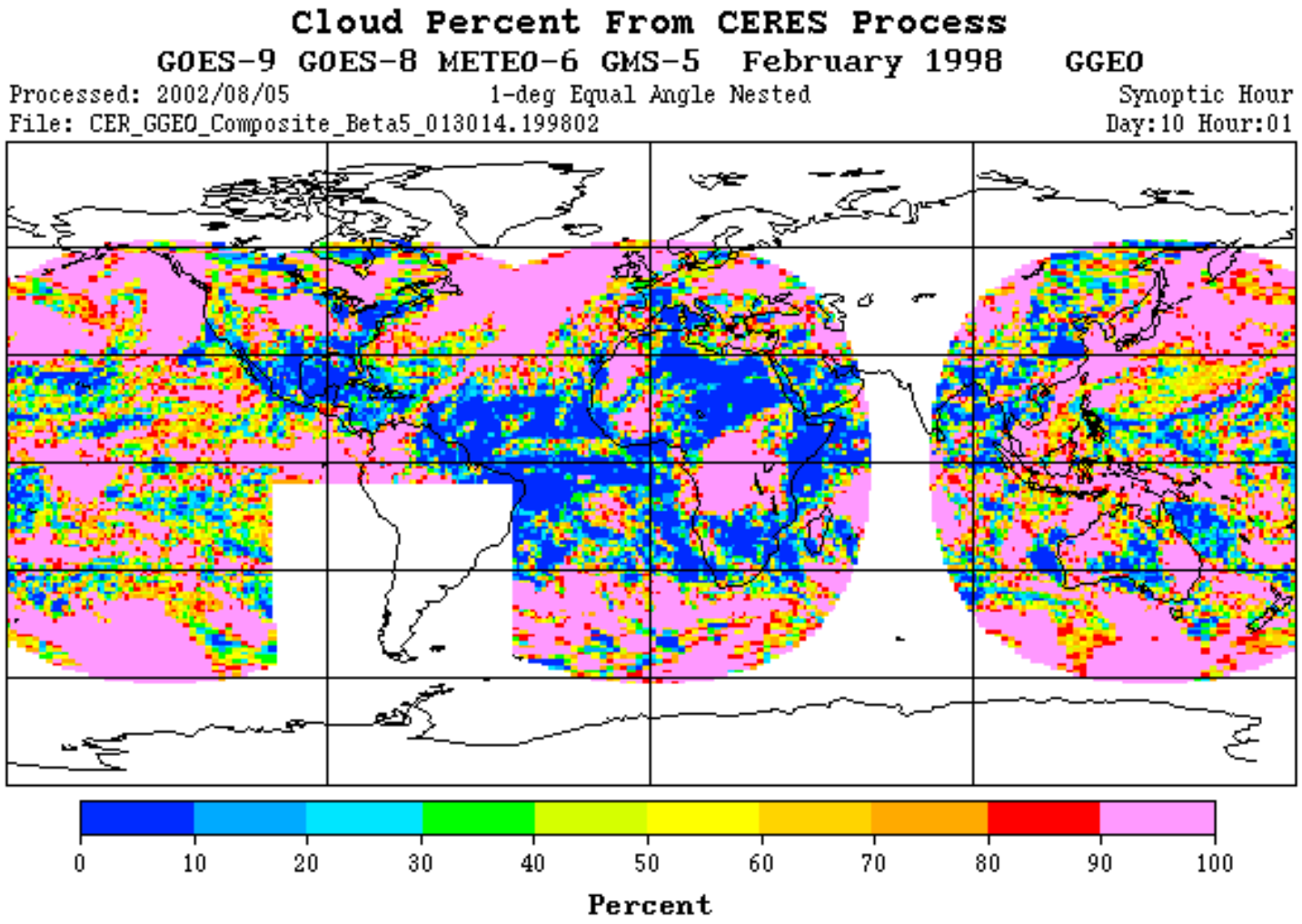
GEO Calibration (Testing)

- GEO cloud and radiance validation tests
  - Parameters
    - Radiance
    - Cloud fraction
    - Optical Depth
    - Cloud Temperature
    - Clear Temperature
  - Matched VIRS / GEO data
    - Scatter plots
    - Zonal means
    - VZ/SZ dependence
  - Probability Density Functions
    - GEO vs. VIRS
    - GEO vs. ISCCP

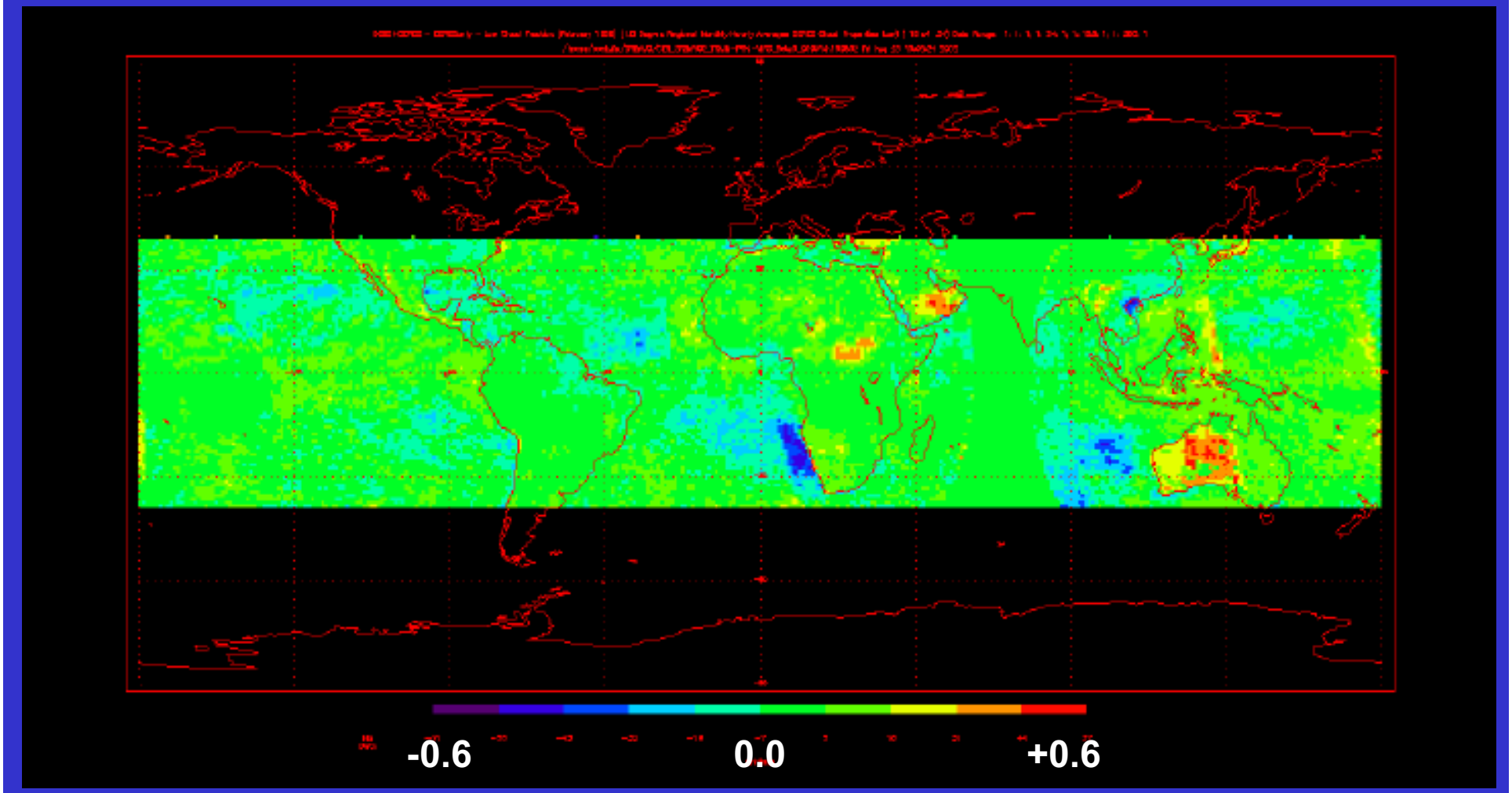
GEO Calibration (Testing cont.)

- Global retrieval time series
  - Operational plots saved on web
  - 3-hourly plots of tau / fraction / Cloud T
- Global monthly and monthly-hourly plots
  - From SRBAVG
  - GEO+VIRS - VIRS only
  - Look for discontinuities

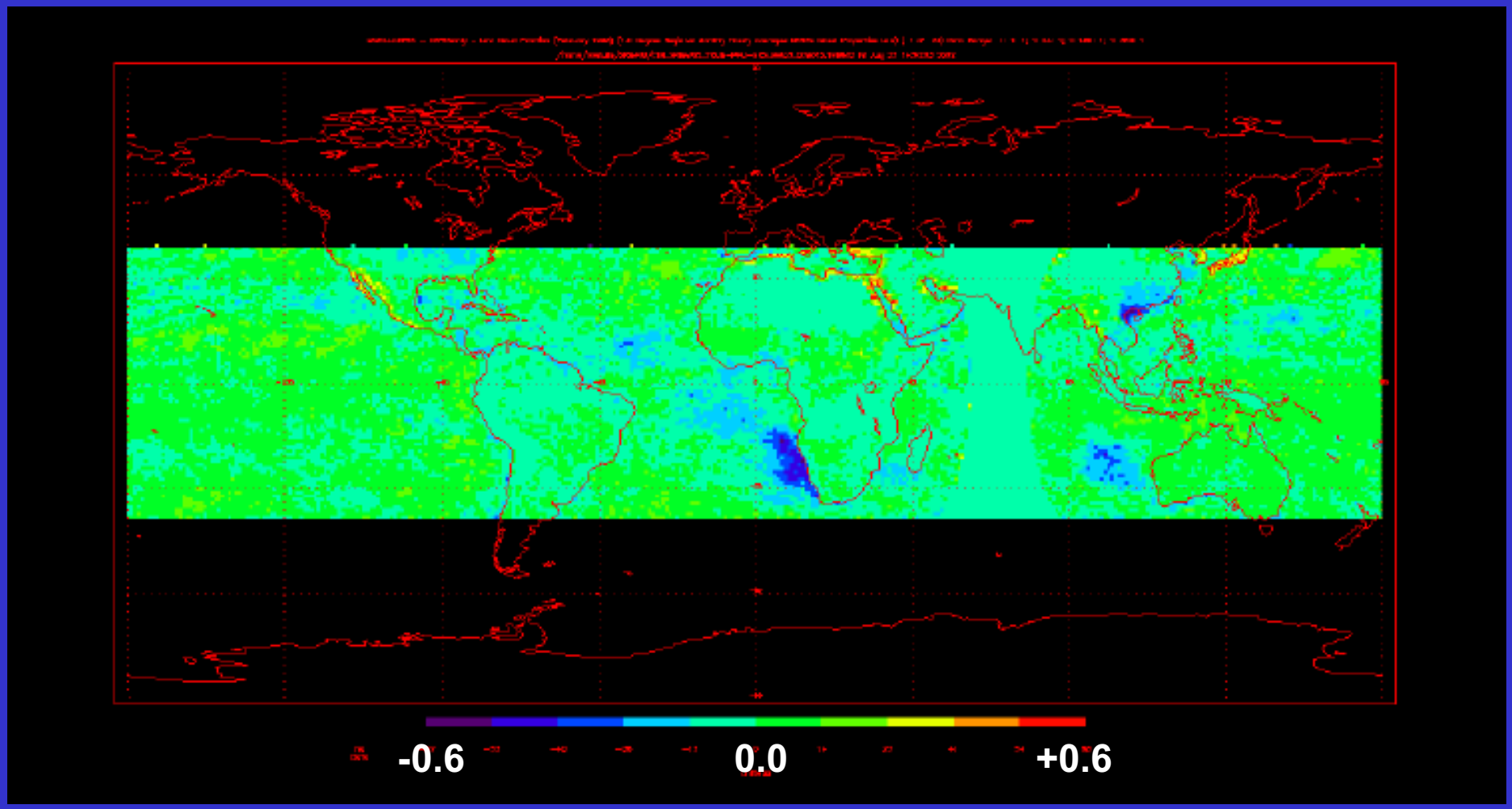
Time Series of Cloud Fraction



GEO+CERES - CERES only Low Cloud Fraction (6:30 LT)



GEO+CERES - CERES only Low Cloud Fraction (0:30 LT)



Global comparisons

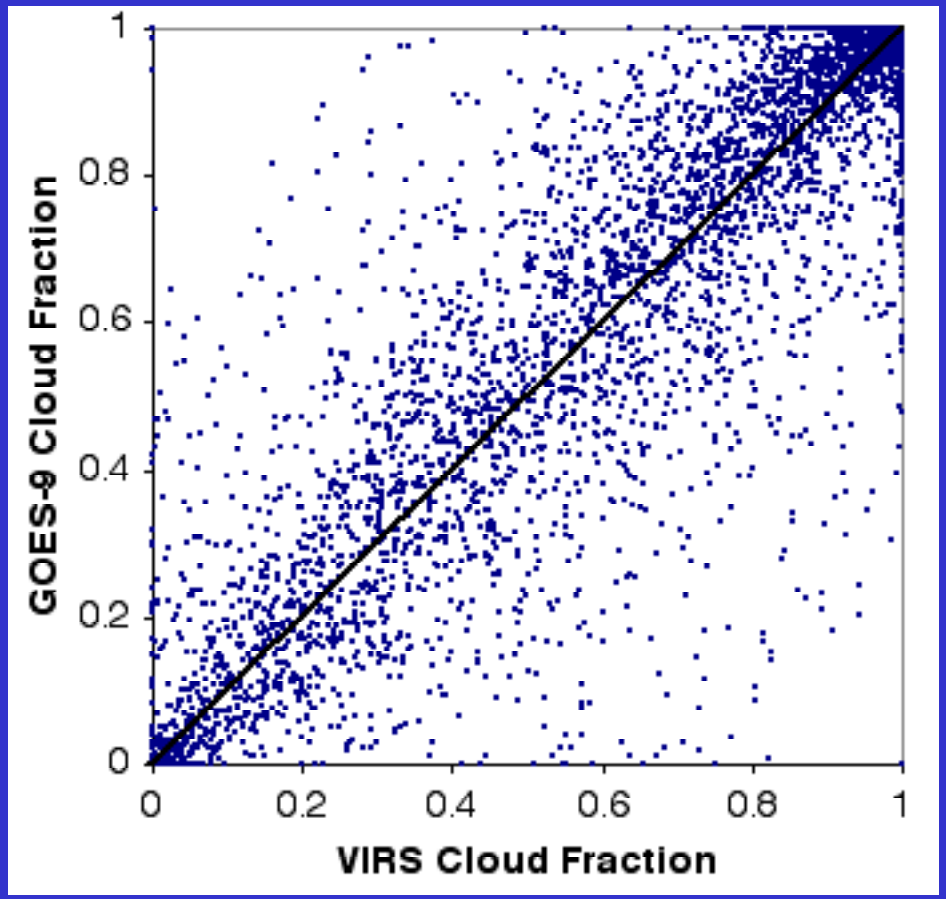
- Successfully used to identify terminator issues
- Monthly global plots used to identify and eliminate intersatellite calibration issues

Instantaneous GEO/VIRS Comparisons

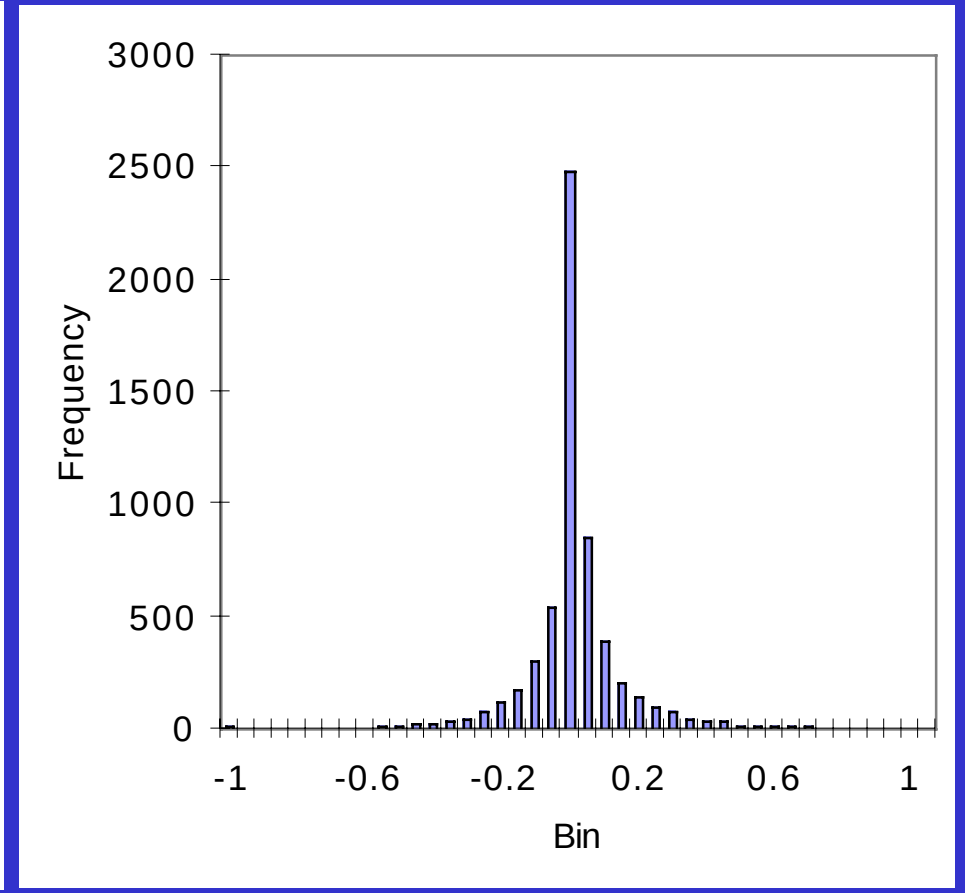
- Comparisons use 1° gridded data
  - Data matched in space and time
  - Viewing angle differences included
- Separate comparisons for each:
  - Month
  - GEO satellite
  - Day/Night
  - Surface Type
- Comparisons used as first check of VIRS/GEO differences
  - Identify calibration problems
  - Characterize GEO cloud properties relative to VIRS

Instantaneous VIRS-GOES-9 Comparison
Ocean Daytime Cloud Percentage

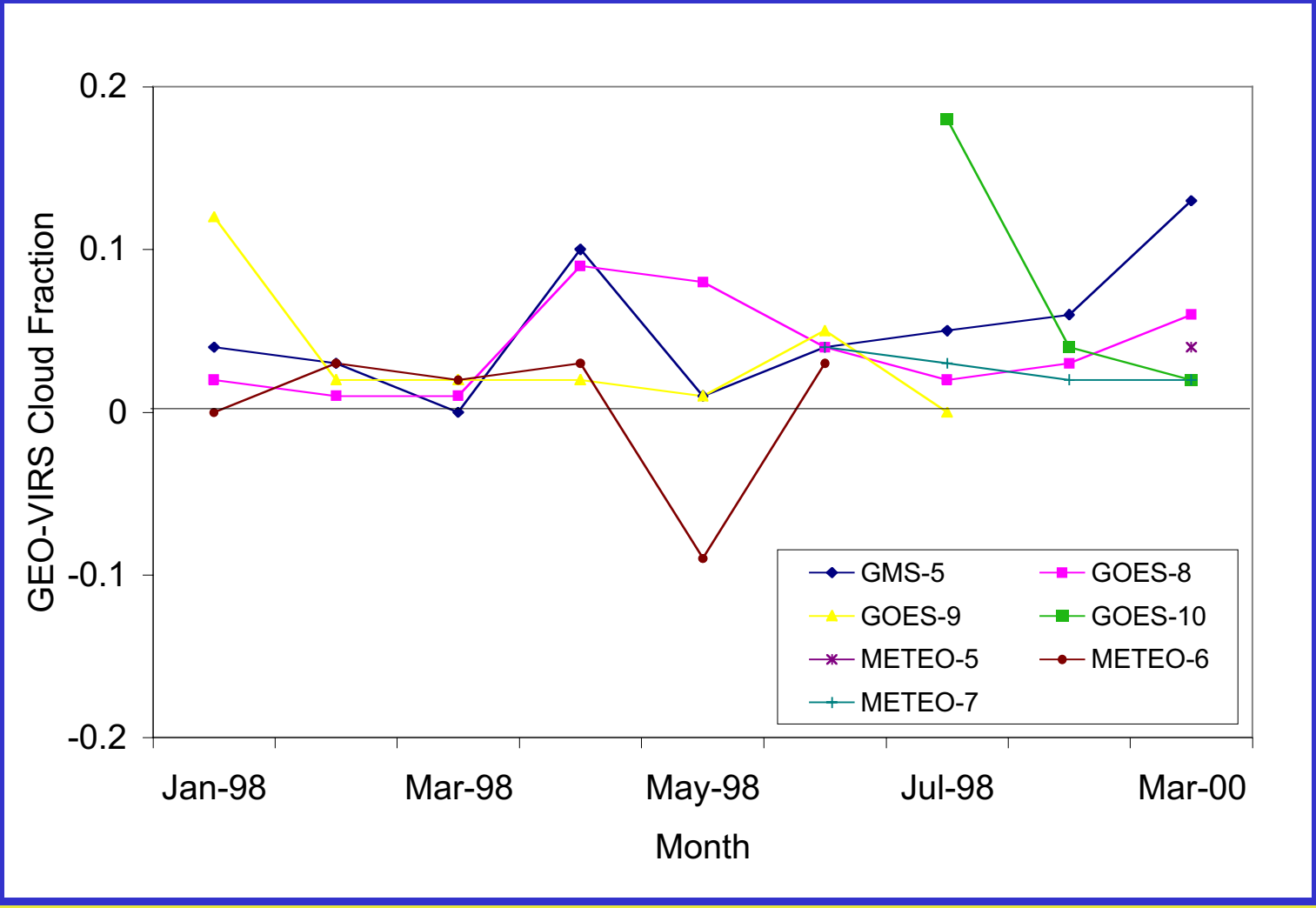
VIRS: 71.1% **GOES-9: 71.7%**



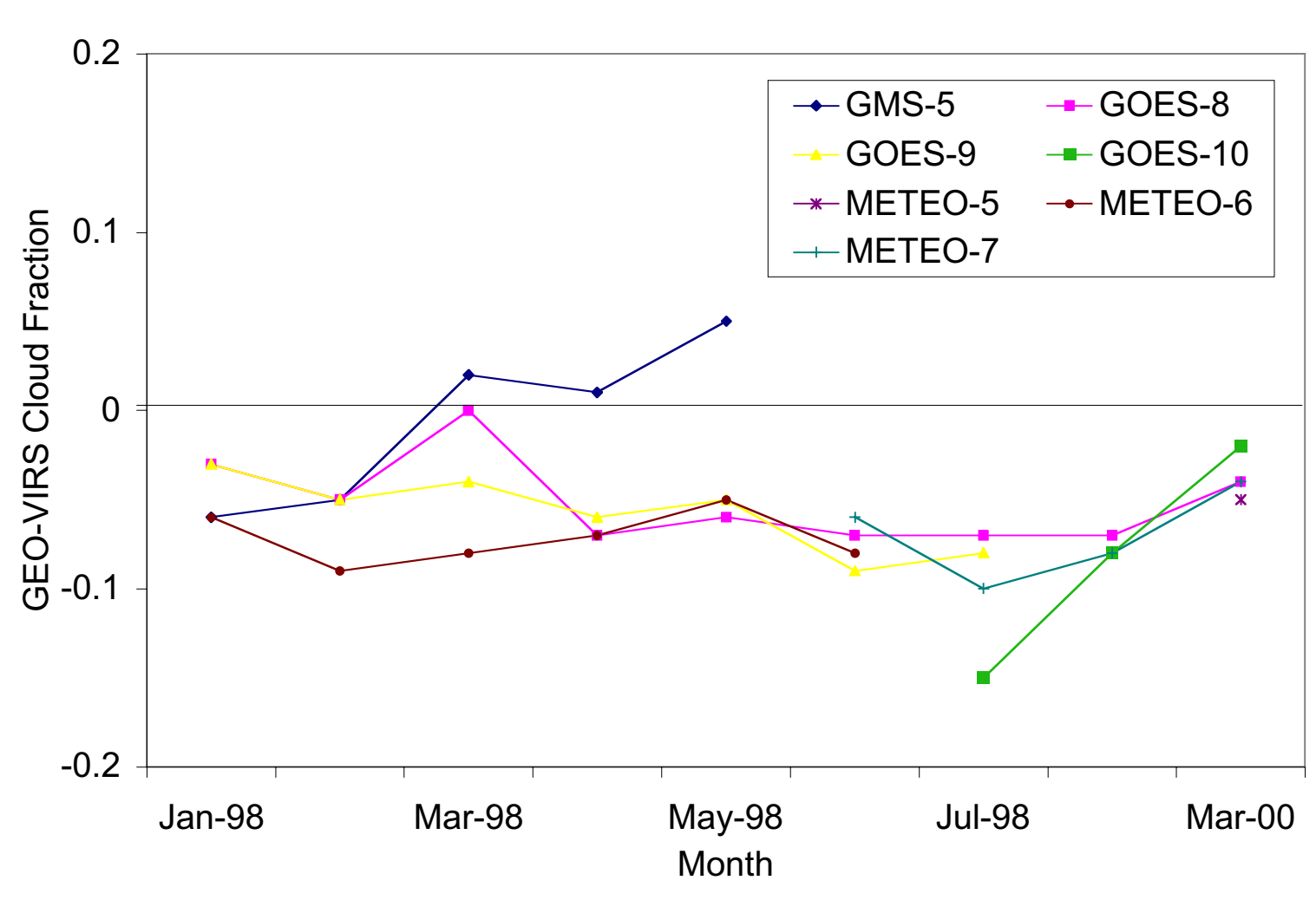
Mean Difference: 0.6% **RMS:14.1%**



Time Series of GEO-VIRS Daytime Ocean Cloud Fraction Differences



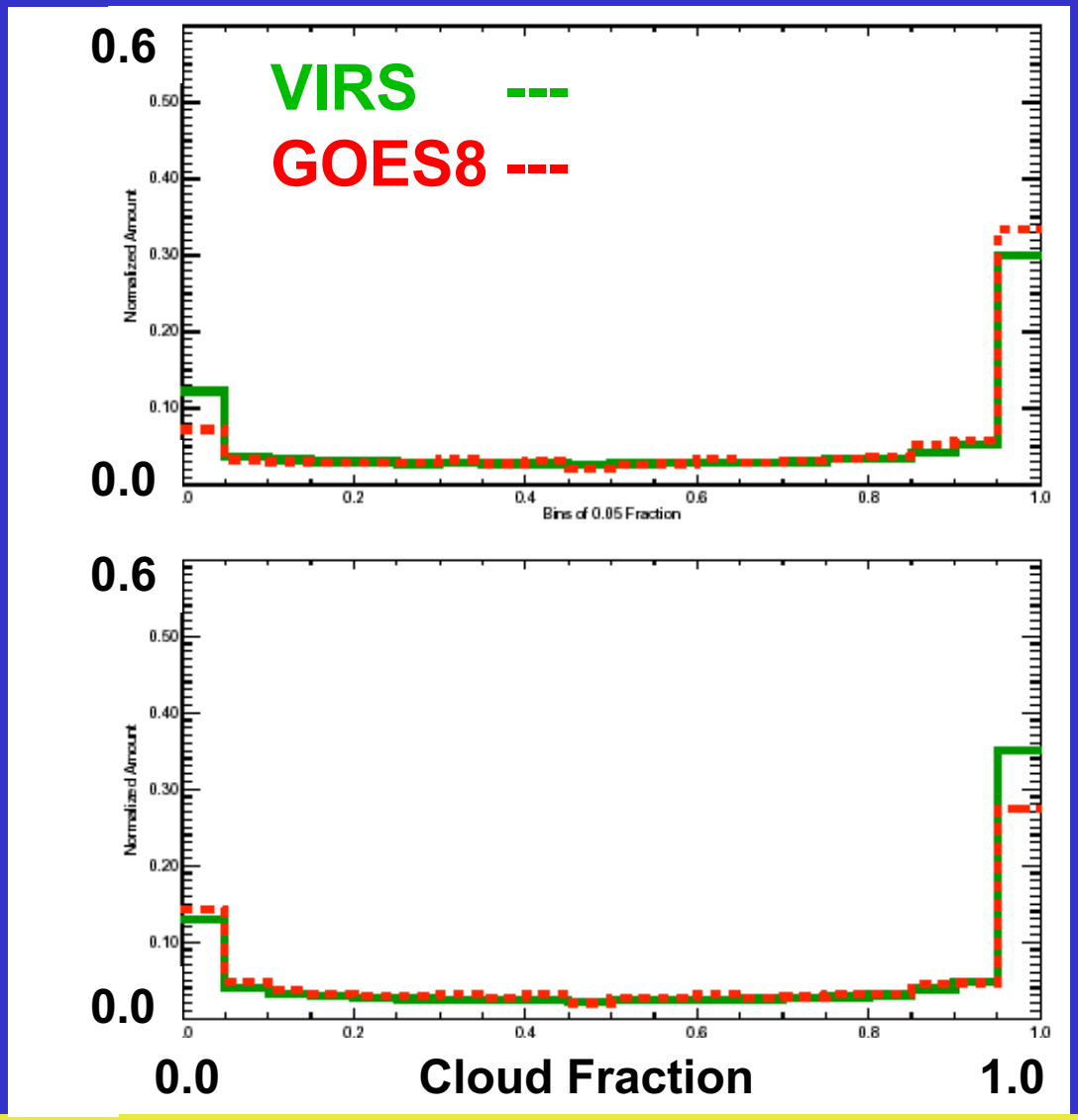
Time Series of GEO-VIRS Nighttime Ocean Cloud Fraction Differences



Probability Density Comparisons

- Compare large-scale VIRS and GEO cloud statistics
- All GEO and VIRS data used (no matching)
- Used to characterize GEO cloud properties
  - Calibration problems can also be seen in shifts in frequency peaks
- Separate comparisons for each:
  - Month
  - GEO satellite
  - Day/Night
  - Surface Type

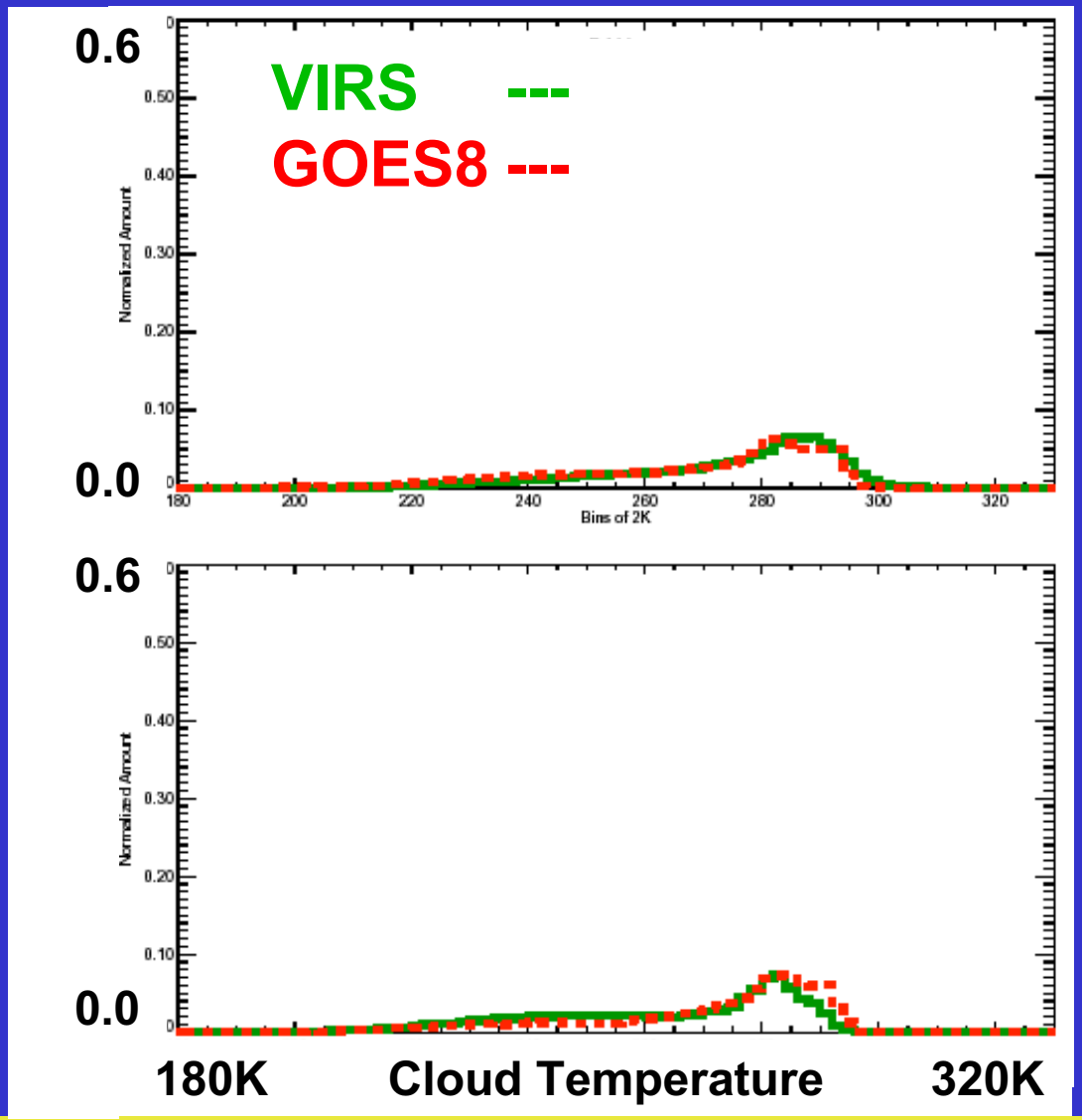
Cloud Fraction Frequency Comparison



Day

Night

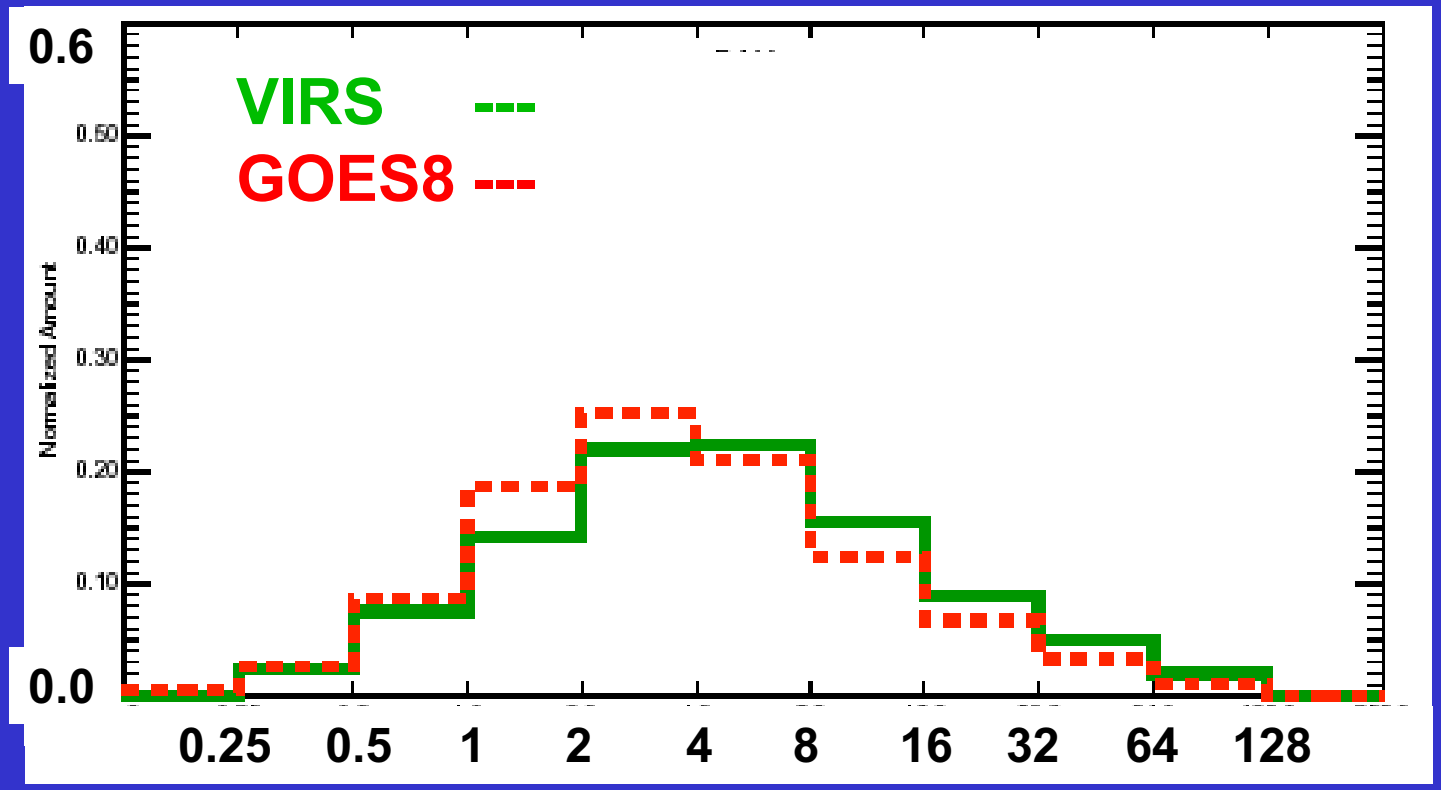
Cloud Temperature Frequency Comparison



Day

Night

Cloud Optical Depth Frequency Comparison



9-Month Mean GOES-8 / VIRS Differences (From Matched Data)

	Cloud Fraction	Optical Depth	Cloud Temperature (K)
Daytime Ocean	+0.04	-1.6	-3.7
Nighttime Ocean	-0.05	----	10.9
Daytime Land	+0.10	-3.0	-7.4
Nighttime Land	+0.04	----	14.3

GEO Cloud Property Summary

- Cloud Fraction
  - Generally good agreement with VIRS
  - Overestimate over land (possibly due to surface emittance)
  - Clear-sky underestimated in daytime
  - Day/night differences consistent with IR-only night retrievals
- Cloud Optical Depth
  - Overall GEO underestimates compared with VIRS
    - Higher VZ
    - 8 km vs 2 km resolution
- Cloud Temperature
  - GEO underestimates in daytime (due to lower optical depths)
  - GEO overestimates at night (due to lack of emittance correction)
- All differences consistent with limited GEO channels

GEO Calibration Sensitivity Tests

- Goal: Test effect of imager calibration on monthly mean fluxes
- Test by varying imager gain by ±5%
- Calibration affects both radiances and cloud retrievals
  - Cloud properties affect selection of DRMs
  - Cloud mask affects selection of clear-sky radiances

Calibration Sensitivity Summary

(Change in monthly mean flux due to a ±5% imager calibration error)

	Mean Flux	Mean & (rms) Flux Difference (W/m^2)			
		IR + 5%	IR - 5%	Vis + 5%	Vis - 5%
Total-sky LW	257.6	0.01 (0.08)	-0.01 (0.08)	0.00 (0.00)	0.00 (0.00)
Total-sky SW	99.3	-0.04 (1.35)	0.54 (3.10)	0.94 (1.31)	-0.94 (1.31)
Clear-sky LW	284.7	-0.29 (0.69)	0.30 (0.92)	0.01 (0.27)	-0.02 (0.26)

Future Plans

- Final calibration coefficients delivered
- Final GEO for TRMM running at ASDC
- Comparisons with VIRS will be redone
- Calibration trends from Minnis et al. will be implemented for Terra/Aqua

Directional Models: Construction and Validation

Outline

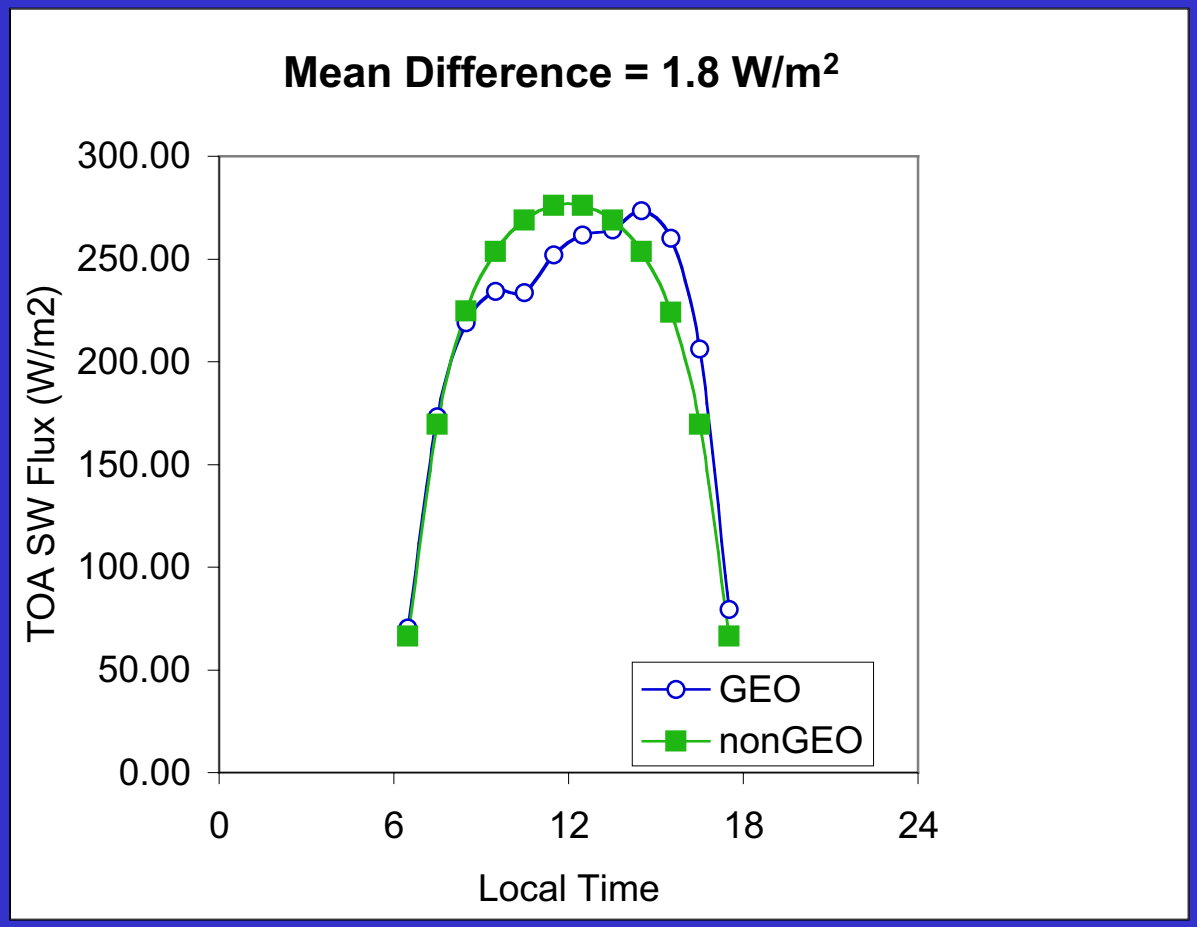
- Creation of new directional models (DRM)
- Comparison of monthly means using CERES and ERBE DRM
- Validation (Direct Integration)

CERES Directional Models

- Derived from CERES instantaneous fluxes
- Use same classifications as CERES ADM
  - Phase
  - Optcal Depth
  - Cloud Fraction
  - Surface Type
- Applied to SW fluxes differently for GEO and nonGEo
  - nonGEO uses all DRM
    - Based on 20 saved scene types
    - DRM defines shape
    - Total albedo defines magnitude
  - GEO uses only clear/overcast DRM

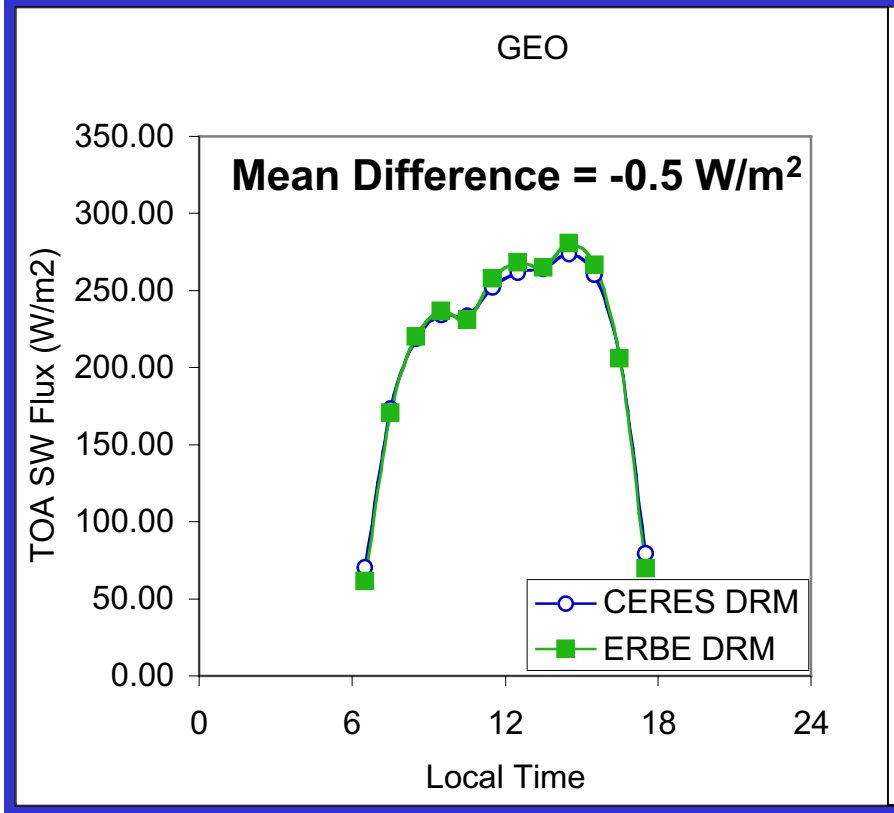
GEO vs. nonGEO Mean Diurnal Cycle

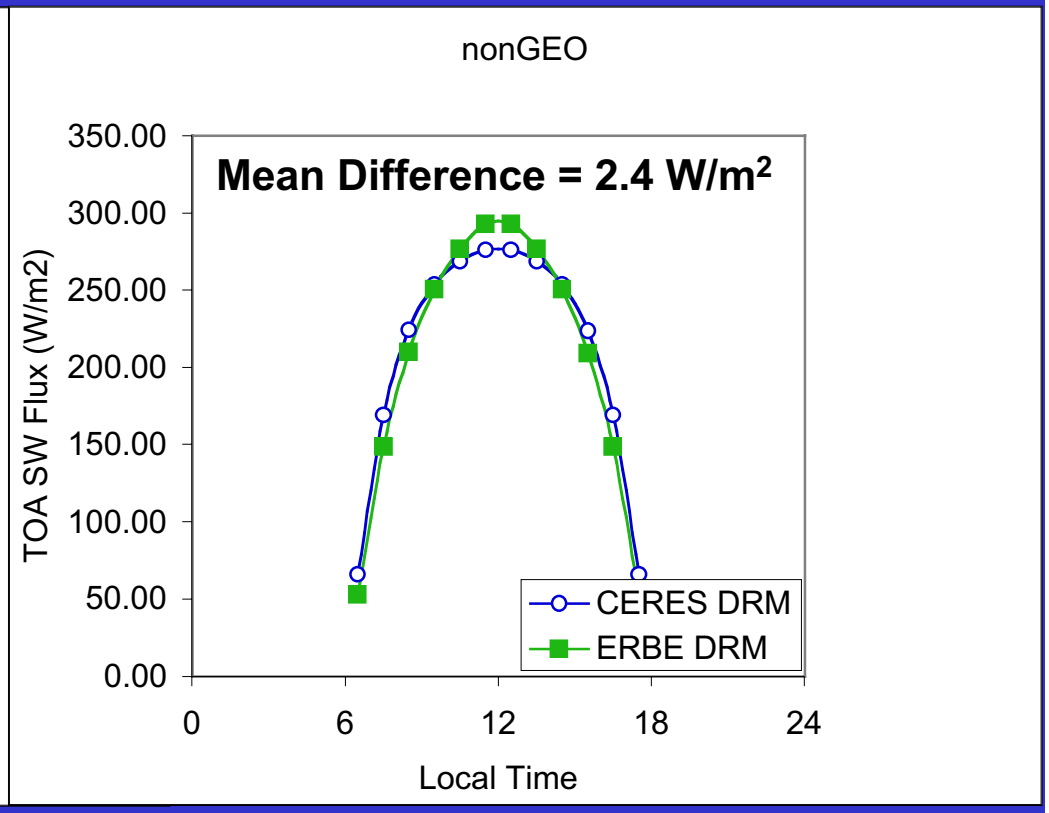
Equatorial Pacific Region CERES DRM



Comparison of ERBE and CERES DRM

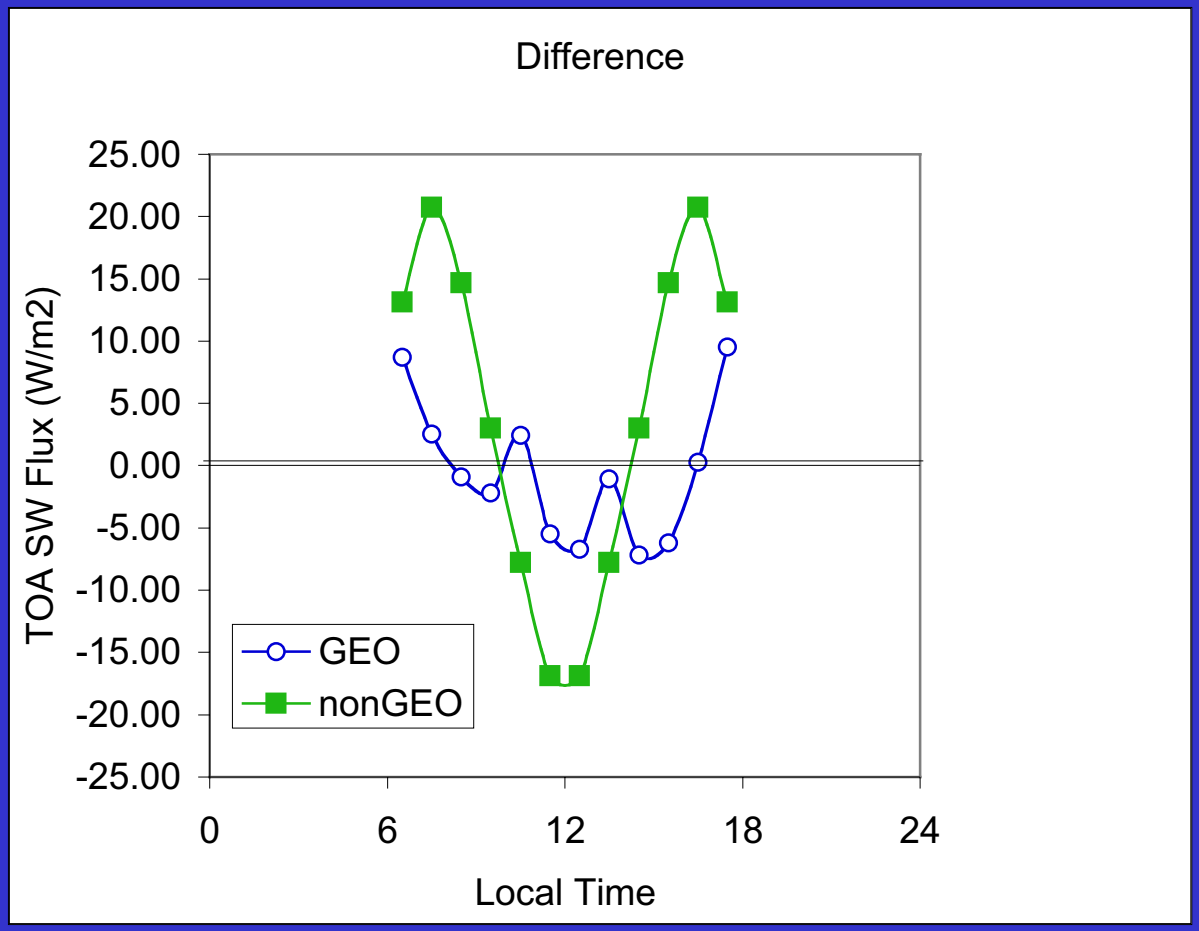
Equatorial Pacific Region





CERES - ERBE SW Flux Difference

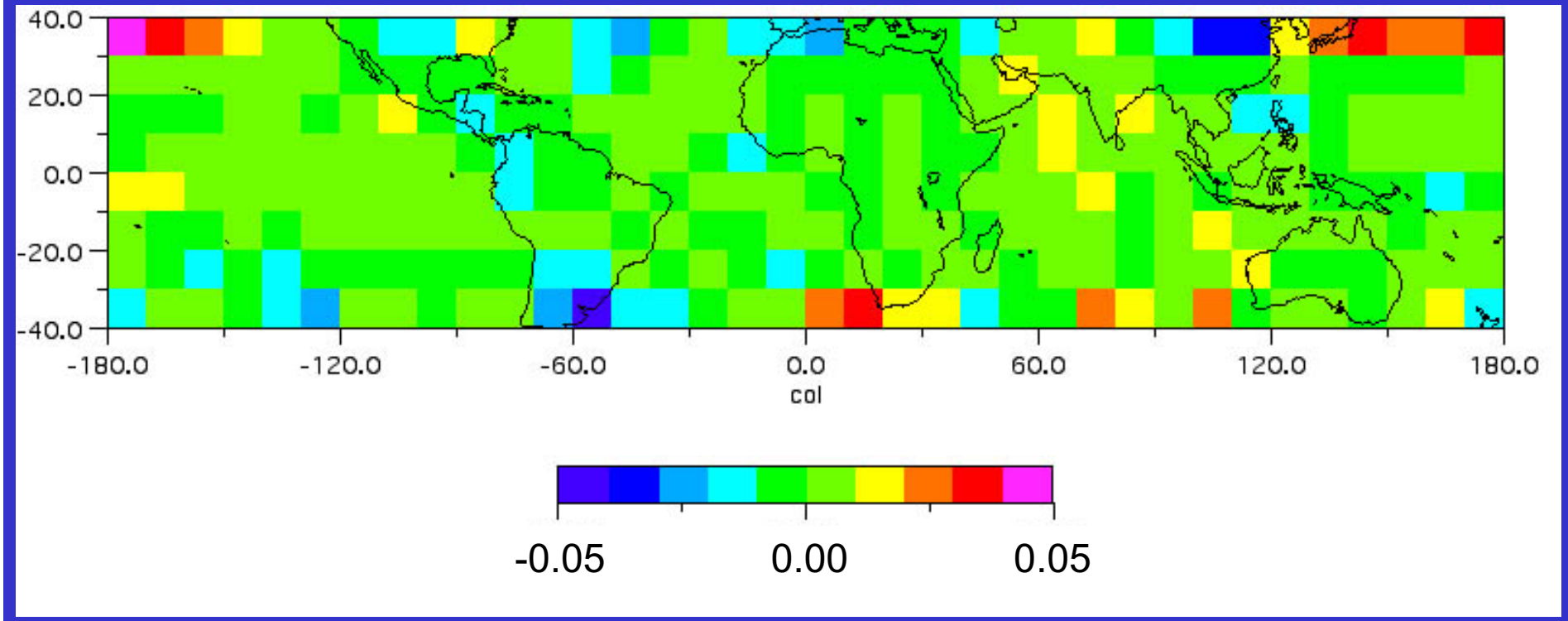
Equatorial Pacific Region



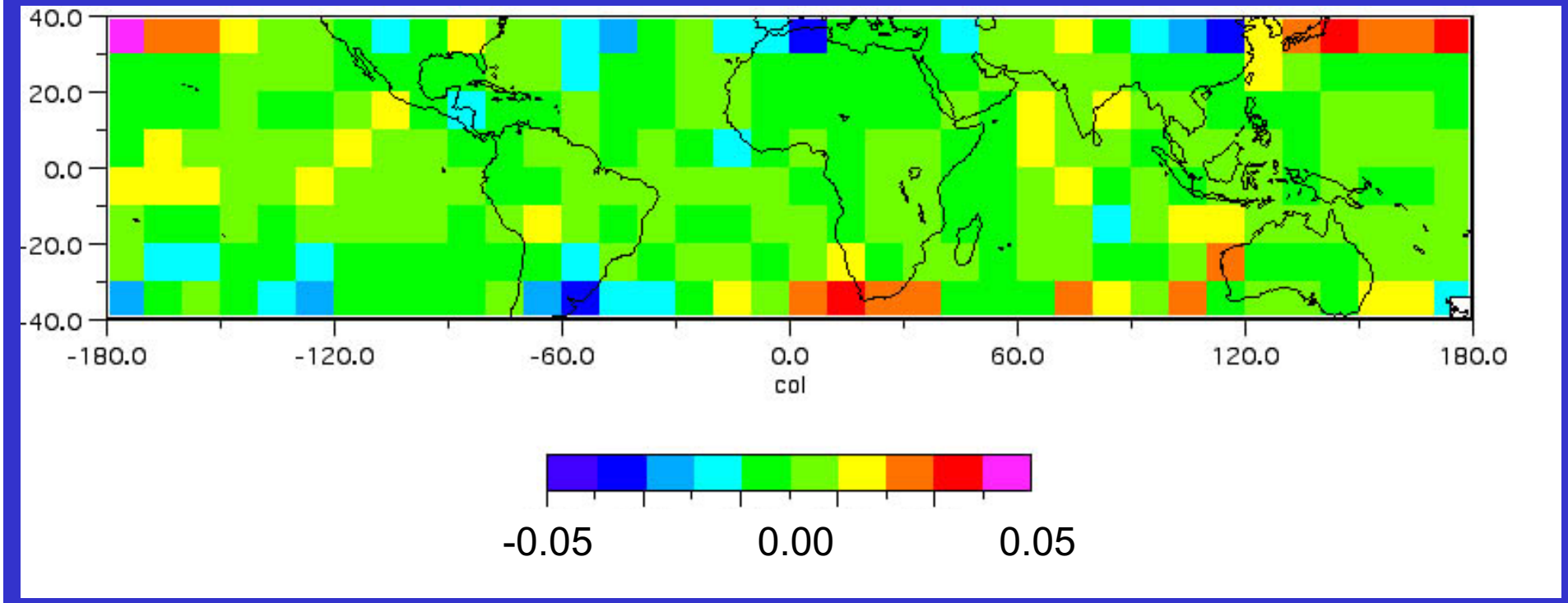
Direct Integration Approach

- Comparison performed on 10° x 10° grid
- May/June/July SRBAVG vs 2 TRMM precession cycles
- Direct Integration
  - Use CERES SSF footprint data from 2 46-day pression cycles
  - Save mean albedo vs sza (5° bins)
  - Integrate using correct solar weighting
- SRBAVG data
  - Combine 1° grid data on 10° grid from 3 months

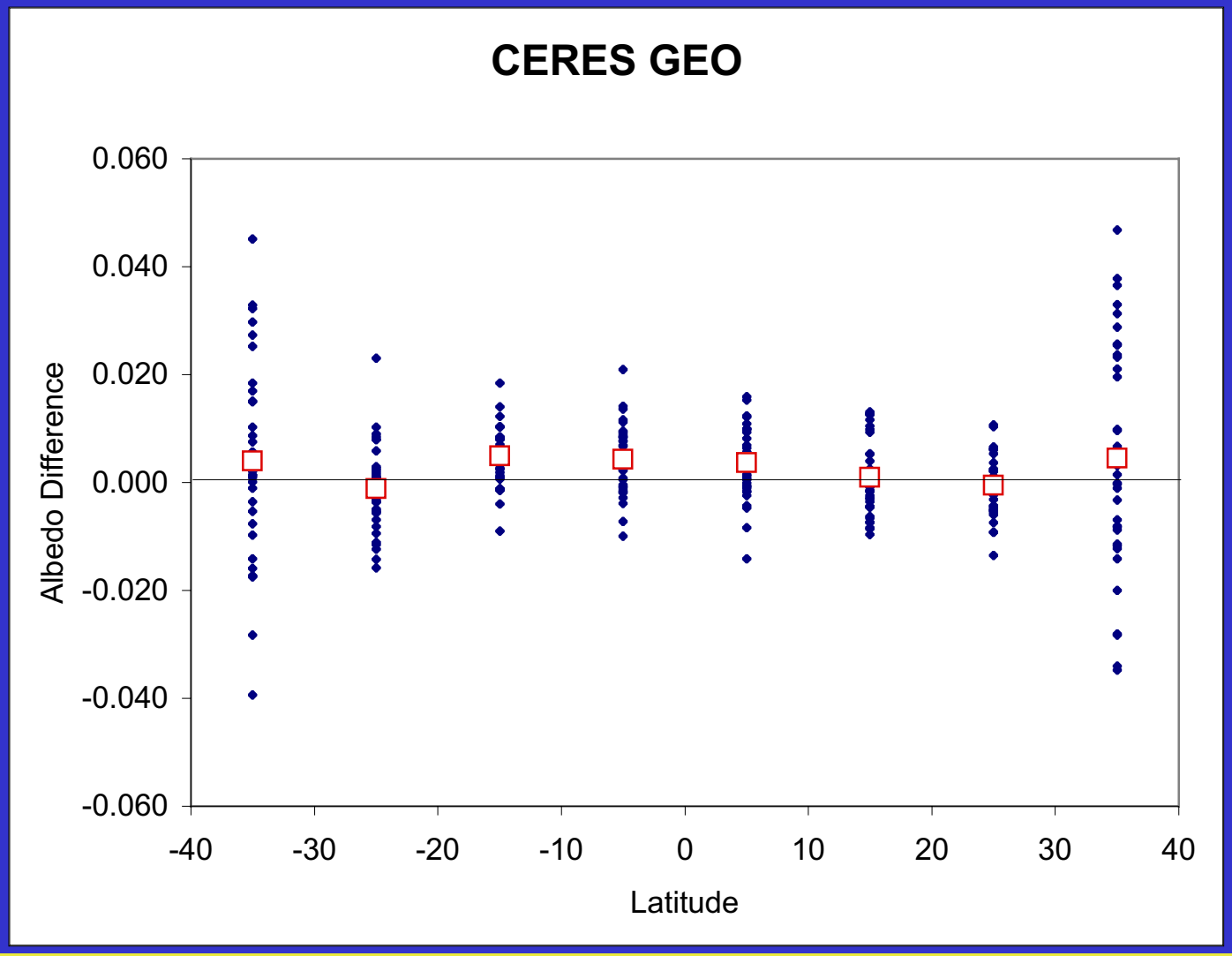
nonGEO - Direct Integration Albedo



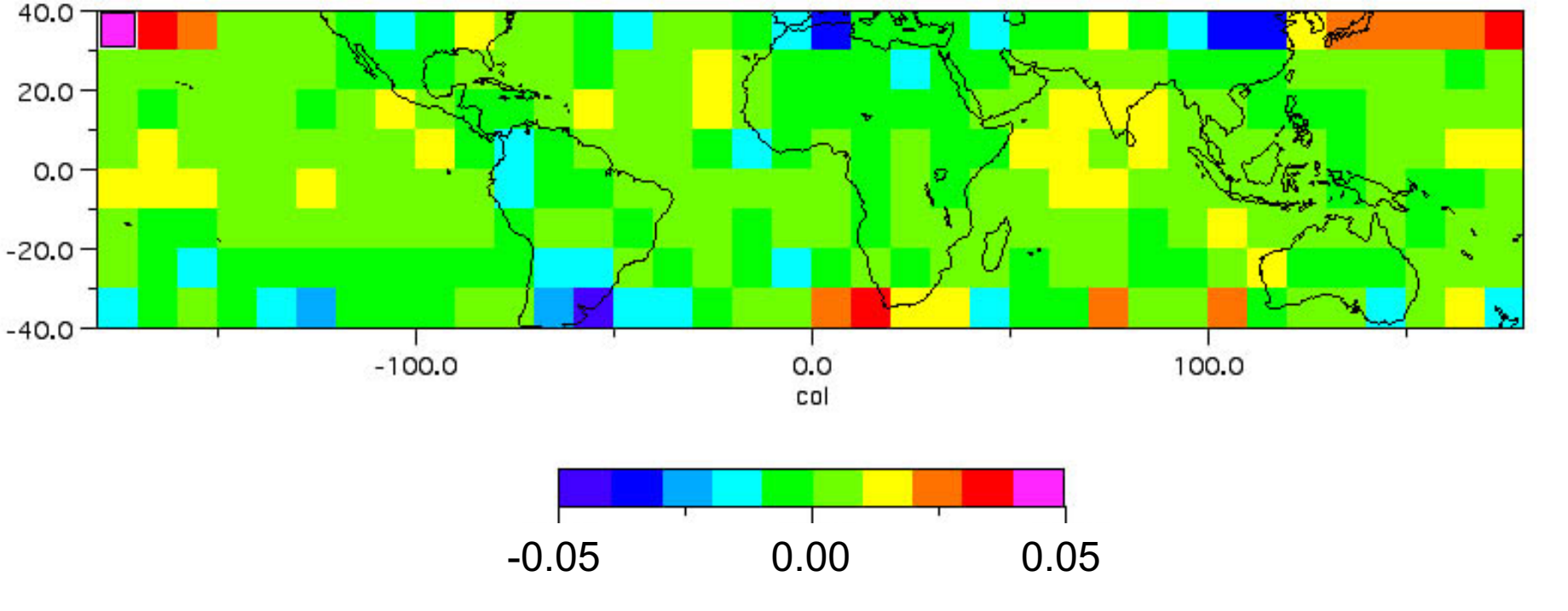
GEO - Direct Integration Albedo



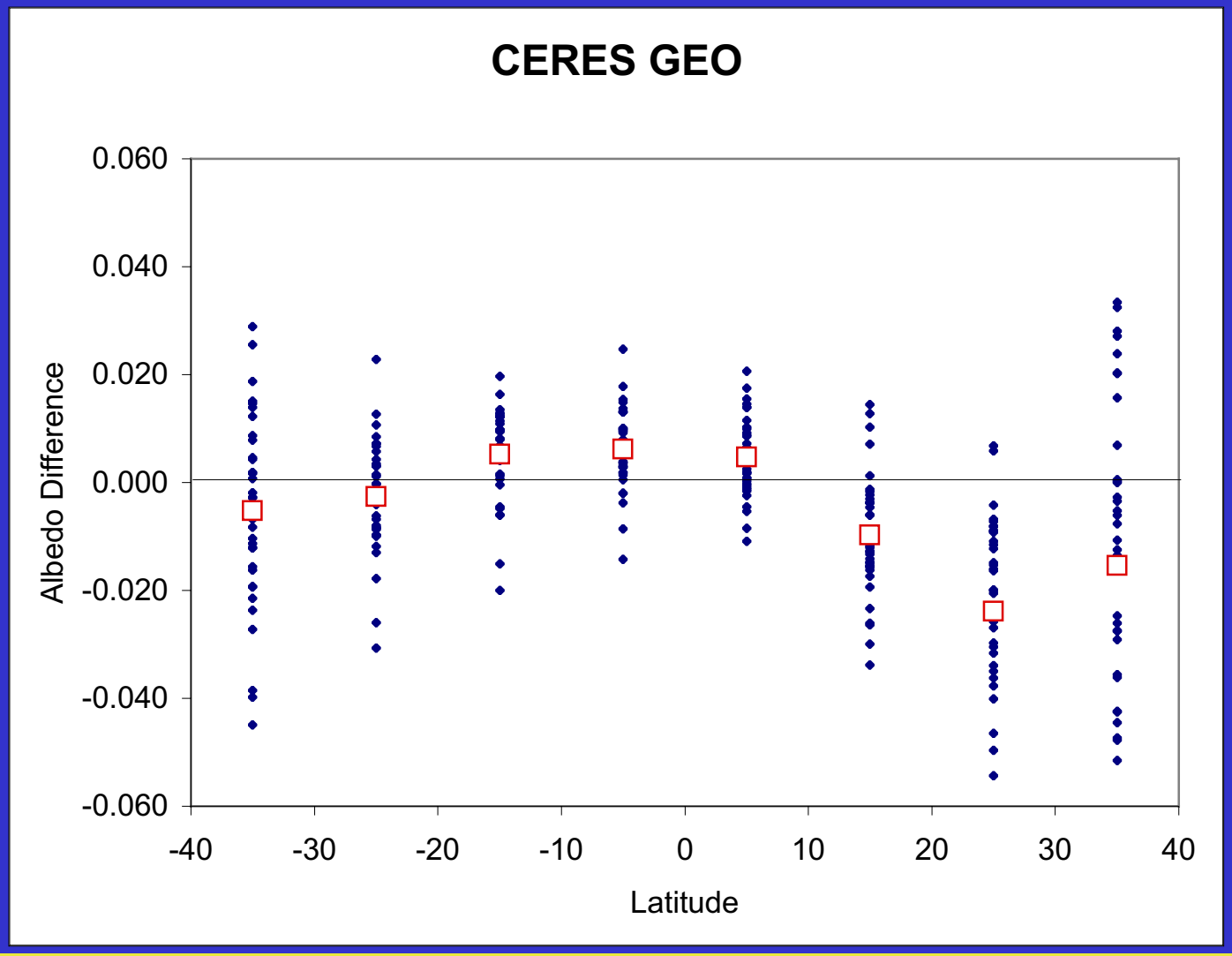
GEO - Direct Integrated Albedo



GEO - Direct Integration Albedo (ERBE DRM)



GEO - Direct Integration Albedo (ERBE DRM)



Summary of Direct Integration Results

40N - 40S	nonGEO (CERES DRM)	GEO (CERES DRM)	GEO (ERBE DRM)
Mean Albedo Difference	0.001 (0.6%)	0.002 (0.7%)	-0.006 (-2.4%)
RMS Difference	0.010 (4.1%)	0.011 (4.3%)	0.018 (7.3%)

30N - 30S	nonGEO (CERES DRM)	GEO (CERES DRM)	GEO (ERBE DRM)
Mean Albedo Difference	0.001 (0.6%)	0.002 (0.6%)	-0.004 (-1.6%)
RMS Difference	0.006 (2.6%)	0.006 (2.7%)	0.015 (6.4%)

Direct Integration Summary

- Both GEO and nonGEO monthly mean albedos agree well with directly integrated albedo
  - Bias: 0.6%
  - Sigma: ~ 3%

- CERES DRM major improvement to ERBE DRM