# The GEWEX Surface Radiation Budget Project: Analysis and Plans

## CERES Science Team Meeting

## September 17-19, 2002

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*Science Applications International, Inc. (LaRC ASDC)*

# GEWEX SRB Status and Plans: Outline

I. Project Overview: purpose, activities, description

II. Processing Status: current status, data availability, schedule

III. Analysis and Validation

   1. *Global annual means → regional variability → daily site*
   2. *Monthly/daily validation (WRDC, BSRN)*

IV. GEWEX SRB and CERES

   1. *Inter-comparison activities*
   2. *Improvements*

V. Summary and Conclusions

# GEWEX SRB: Overview

*The energetic interaction between the atmosphere and the earth-surface is the key interface for climate and life.*

*3-Hourly Global Clouds & Surface*

*6-Hourly Global Meteorology*

*Global Aerosols & Smoke*

*Global, 1°x1°, 3-Hourly Surface Radiation*

*Atmospheric and Oceanic Climate and Weather Models (3-hourly, daily, monthly)*

**AMIP**

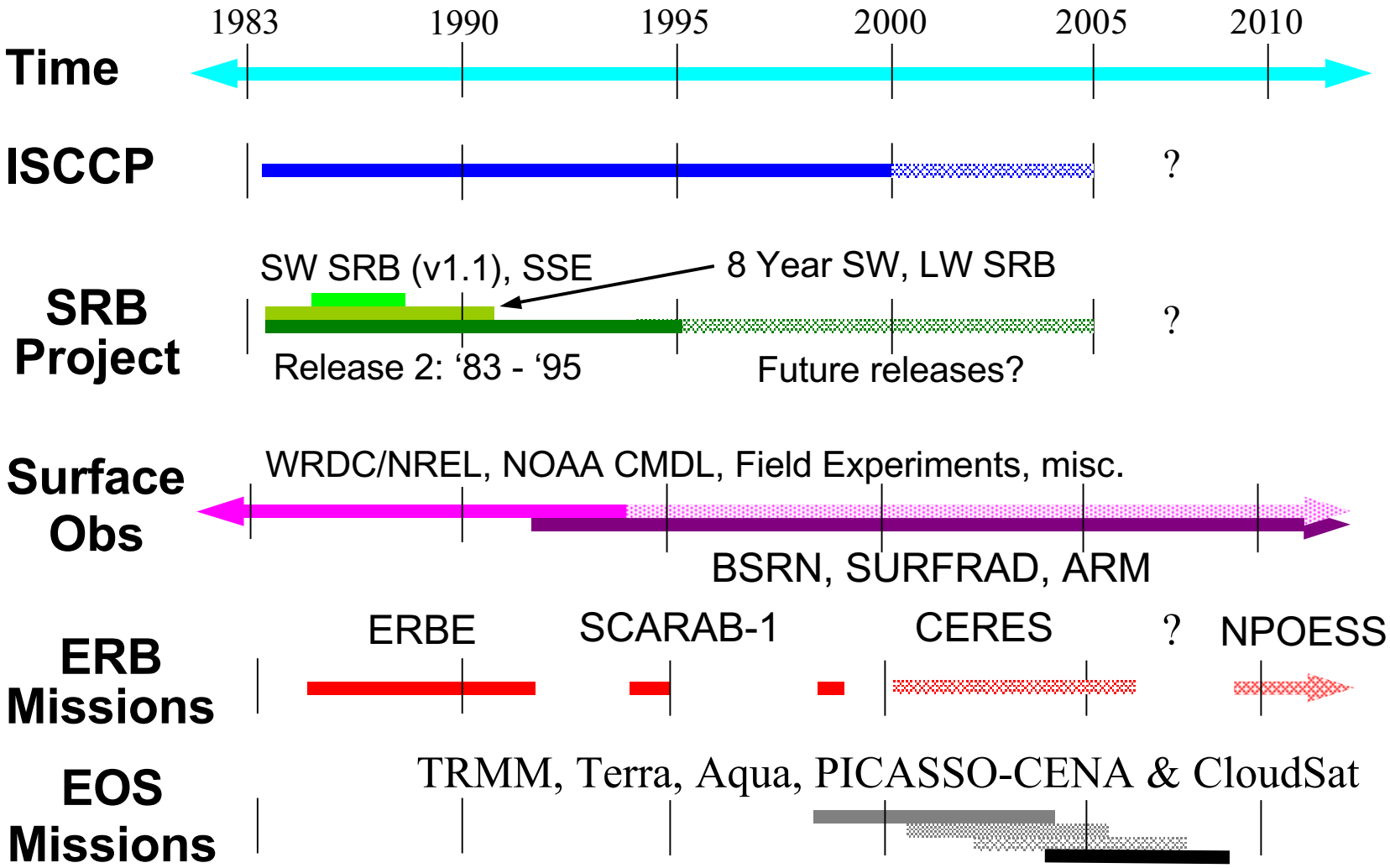
*Global Surface Hydrology (Monthly 3-hourly, Monthly)*

*Regional Inter- and Intra-annual variability (monthly, monthly 3-hourly)*

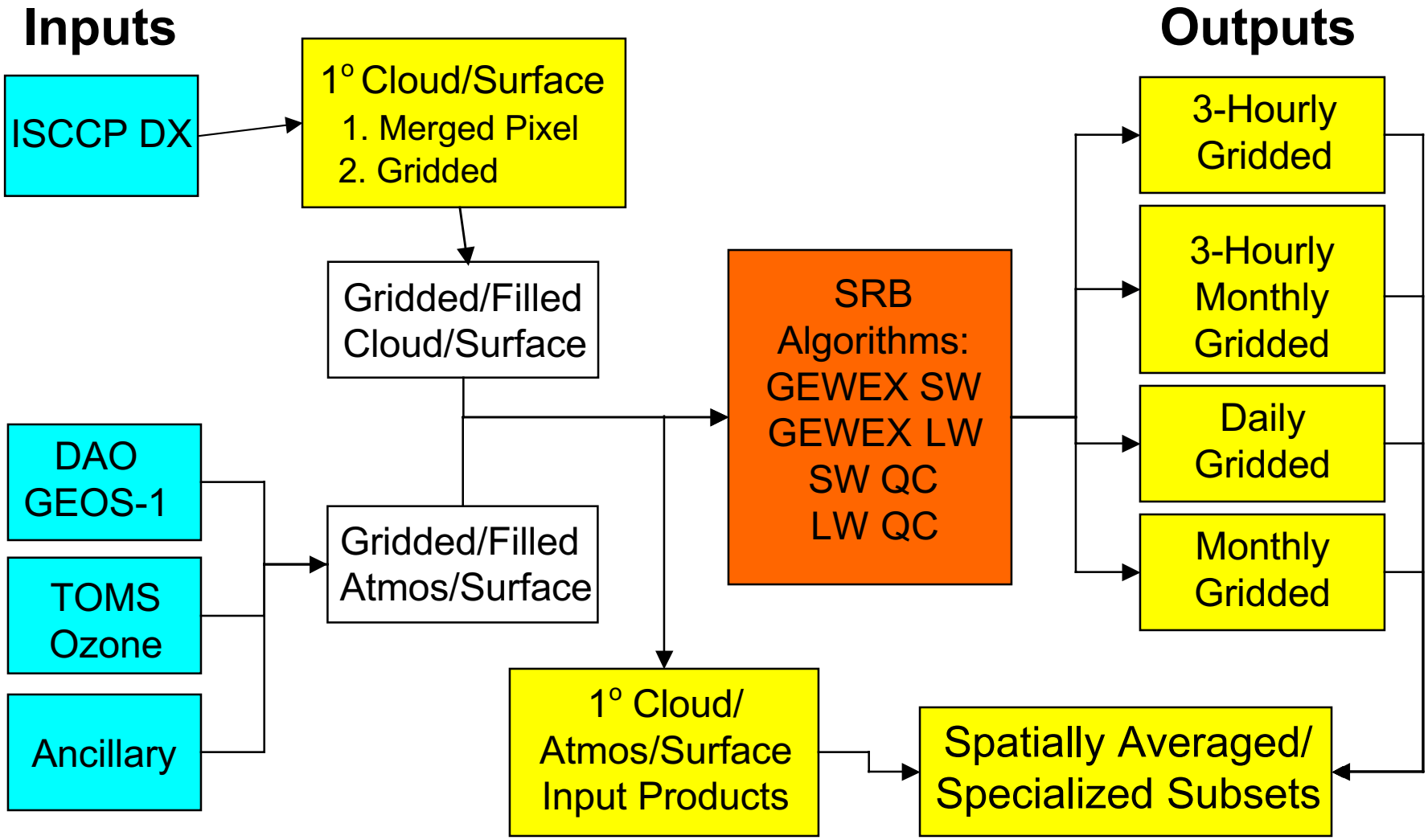
*Solar Energy and Architectural Design, etc. (daily, monthly)*

RETScreen™ Renewable Energy Project Analysis Software

# GEWEX Surface Radiation Budget Project:
## *Establishing a Baseline Through EOS Missions*



# GEWEX SRB: Data Flow (Release 2)



# GEWEX SRB: Flux Algorithms

- **Shortwave (0.3 - 5.0 μm):**
  1. *GEWEX SW* (Pinker/Laszlo, 1992): NB-BB conversion of ISCCP radiances to TOA fluxes using ERBE ADM's, Atmospheric Reflection/Transmission lookup table using Δ-Eddington 2-S; retrieves surface albedo, and PAR.
  2. *GEWEX SW QC* (Gupta *et al*., 2001): Daily averaged SW insolation using broadband transmittance formulation w/ empirical fits of gaseous, aerosol absorbers, effective cloud transmittance; surface albedo retrieved from ERBE fluxes.

- **Longwave (4.5 - ∞ μm)**
  1. *GEWEX LW* (Fu/Stackhouse): uses CERES LW 2/4 S RT model (Fu *et al.,* 1997), random cloud overlap, non-black surfaces, reanalysis meteorology, CERES spectral surface emissivity.
  2. *GEWEX LW QC* (Gupta, 1989, 1992): RT based parameterizations for clear/cloudy downwelling LW flux weighted w/ cloud fraction, reanalysis meteorology, CERES surface emissivity.

# GEWEX SRB: Processing Status

| Nodes | Months Processed | Years Processed to Date | Months Released |
|---|---|---|---|
| ISCCP merged DX | 102 | ’83, ’86 - ’93 | 0 |
| ISCCP gridded DX | 102 | ’83, ’86 -’93 | 0 |
| GEOS-1 | 96 | ’86 -’93 | 0 |
| TOMS (TOVS) $O_3$ | 137 | ’83 - ’95 | 0 |
| SW | 96 | ’86 -’93 | 60 |
| SW QC | 84 | ’86-’90, ’92-’93 | 60 |
| LW | Limited | Parts ’92, ’93 | 0 |
| LW QC | 96 | ’86 - ’93 | 60 |

137 months from Jul. ‘83 – Nov. ‘95

* Monthly averages only to date

# GEWEX SRB Release 2
# Global Annual Means by Year

| Para-meter | GEWEX SRB Release 2 8-Year Global Annual Means: GEWEX SW (Pinker/Laszlo), LW QC (Gupta et al) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Mean |
| SW Down | 186.6 | 187.2 | 186.4 | 186.7 | 187.0 | 185.1 | 185.8 | 189.2 | **186.8** |
| SW Net | 164.8 | 165.3 | 164.8 | 165.2 | 166.4 | 163.4 | 163.6 | 168.3 | **165.2** |
| LW Down | 345.4 | 347.1 | 346.2 | 344.4 | 345.8 | 345.9 | 344.2 | 343.6 | **345.3** |
| LW Net | -46.8 | -45.9 | -46.5 | -47.7 | -47.2 | -47.2 | -47.7 | -48.1 | **-47.1** |
| Total Net | 118.0 | 119.4 | 118.3 | 117.5 | 119.2 | 116.2 | 115.9 | 120.2 | **118.1** |

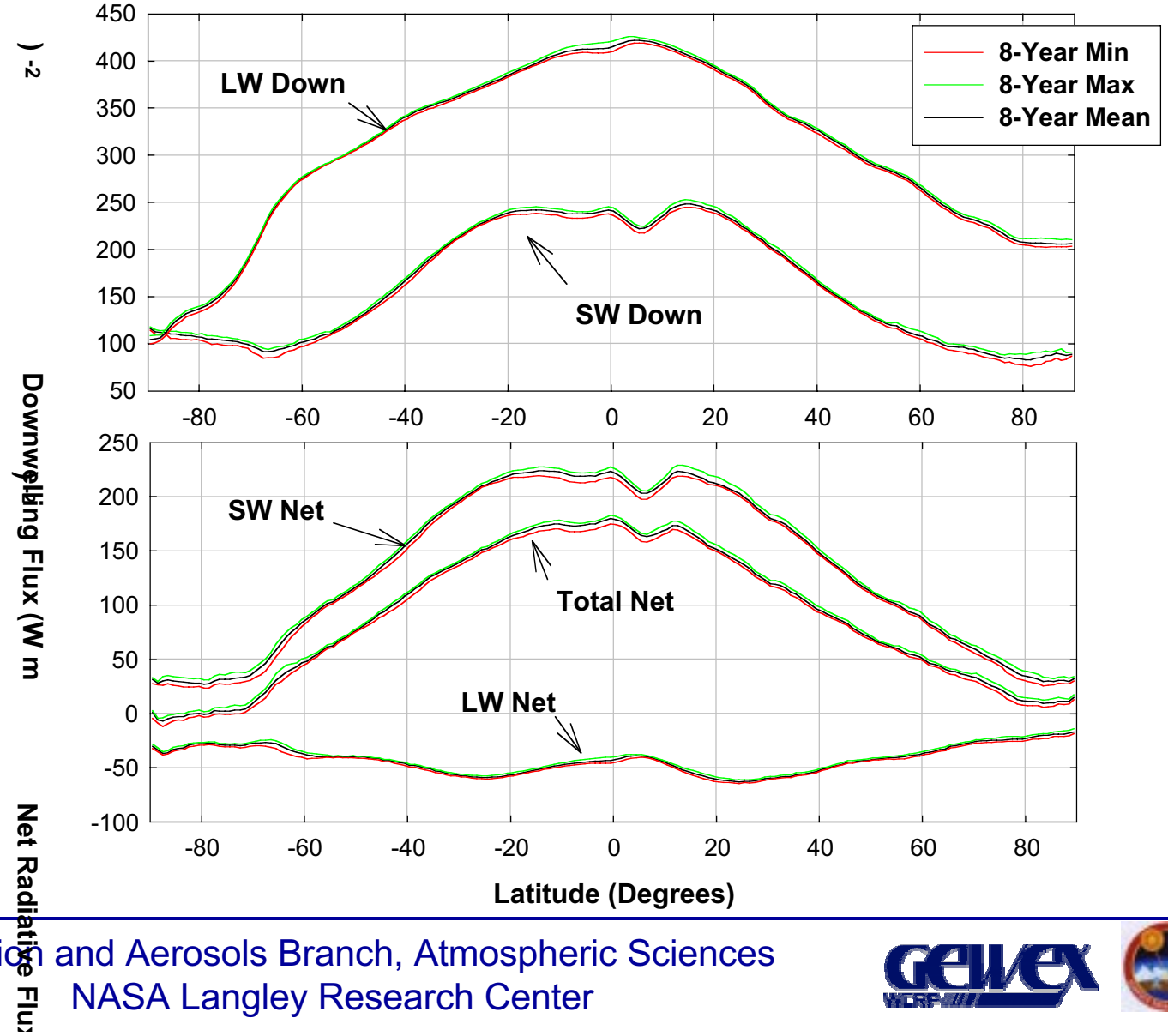
# Global Annual Average Mean Surface Radiation Budget

| Parameter | Rossow & Zhang (JGR, 1995) *4 yr Avg. Mid-Seasonal Months* | Kiehl and Trenberth (BAMS, 1997) ERBE/CCM3 | Gupta et al. (1999)* *10 yr Mean ('83-'93)* | Zhang & Rossow (latest) *5 yr Mean ('85-'89)* | GEWEX SRB Rel. 2* *8 yr Mean ('86 -'93)* |
|---|---|---|---|---|---|
| **SW Down** | 193.4 | 198 | 185.0 | 189.4 | 186.0 |
| **SW Net** | 165.1 | 168 | 161.1 | 164.7 | 164.5 |
| **LW Down** | 348.3 | 324 | 347.8 | 344.6 | 345.2 |
| **LW Net** | -45.8 | -66 | -47.9 | -50.9 | -47.1 |
| **Total Net** | 119.2 | 102 | 113.0 | 113.8 | 117.4 |

** Normalized to $F_o$ = 1367 W $m^{-2}$*

# Annual Averaged Zonal Surface Radiation Budget

Zonal ranges vary within +/- 5 W $m^{-2}$ relative to 8 year mean; some polar latitudes exception

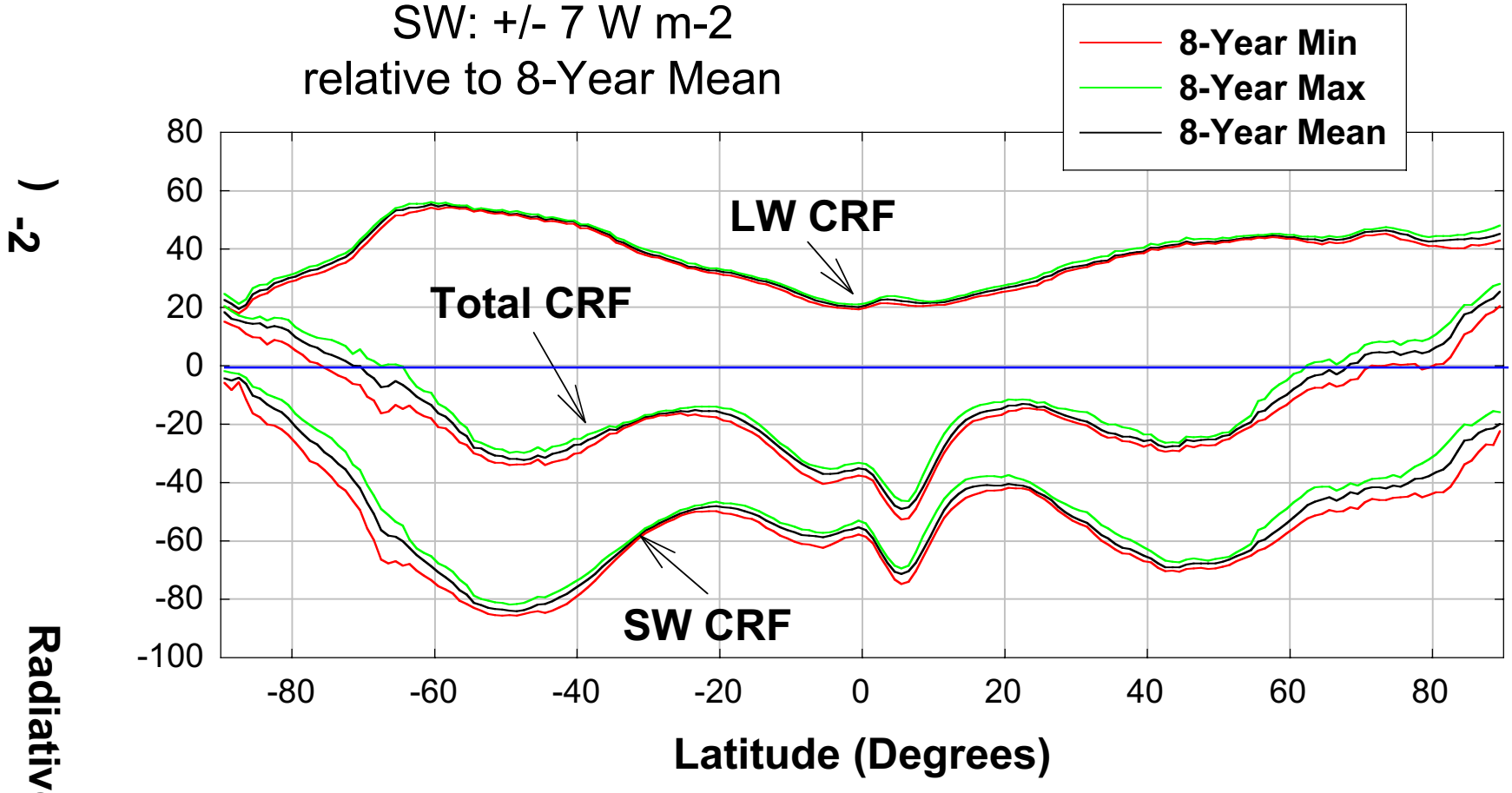


# Global Annual Average Cloud Forcing

| | SRB R2 | | | | | | | | | Zhang and Rossow (latest) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Mean | |
| SW down CRF | -57.8 | -56.8 | -57.5 | -57.9 | -57.5 | -57.9 | -57.4 | -55.5 | -57.3 | -59.0 |
| LW down CRF | 35.9 | 36.1 | 35.9 | 35.8 | 35.3 | 35.5 | 35.6 | 35.0 | 35.6 | 31.1 |
| Total down CRF | -21.9 | -20.7 | -21.6 | -22.1 | -22.2 | -22.4 | -21.8 | -20.5 | -21.7 | -27.9 |

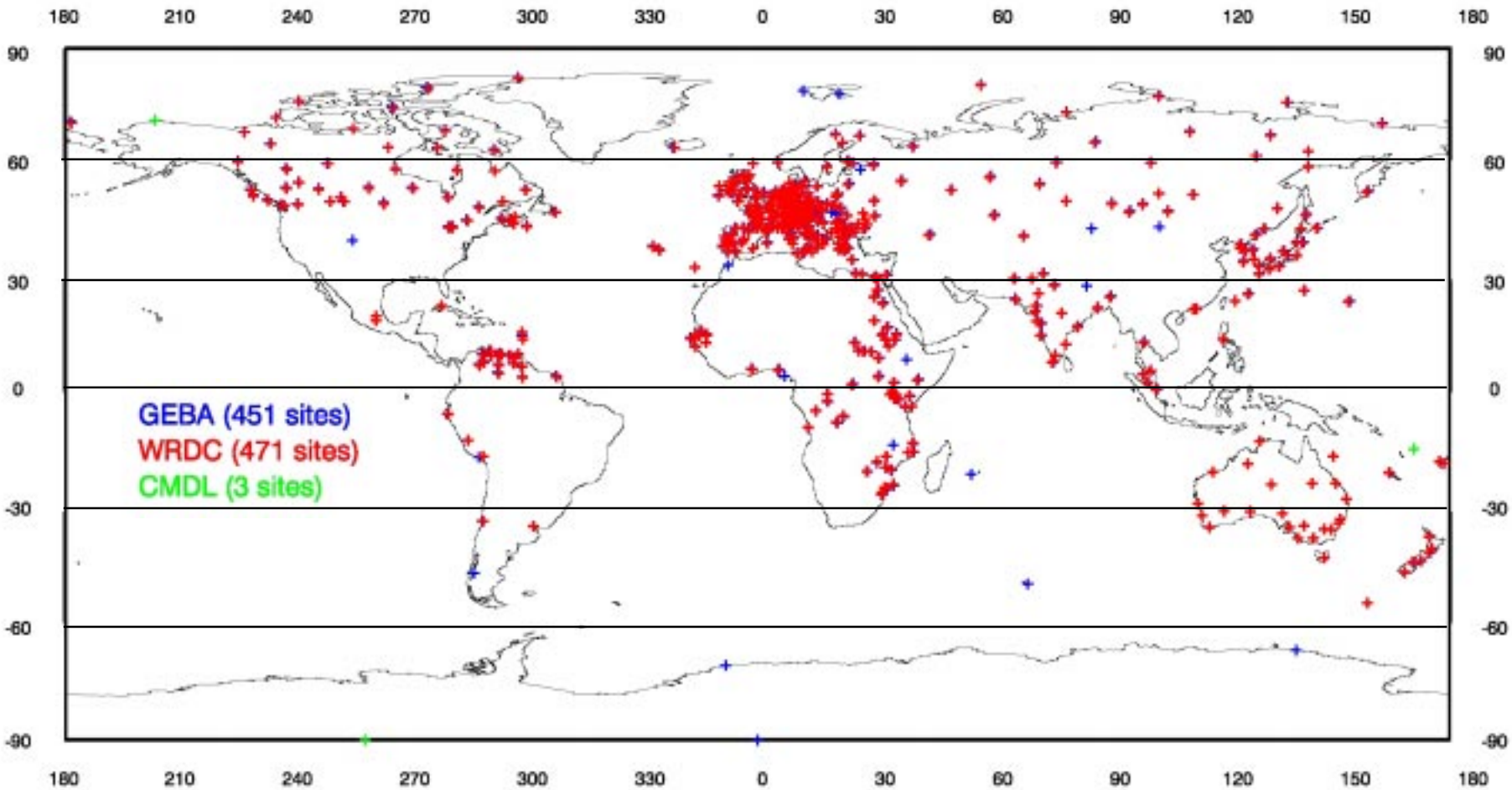
# Annual Averaged Zonal Cloud Radiative Forcing

Zonal CRF range is within
LW: +/- 2 W m-2
SW: +/- 7 W m-2
relative to 8-Year Mean



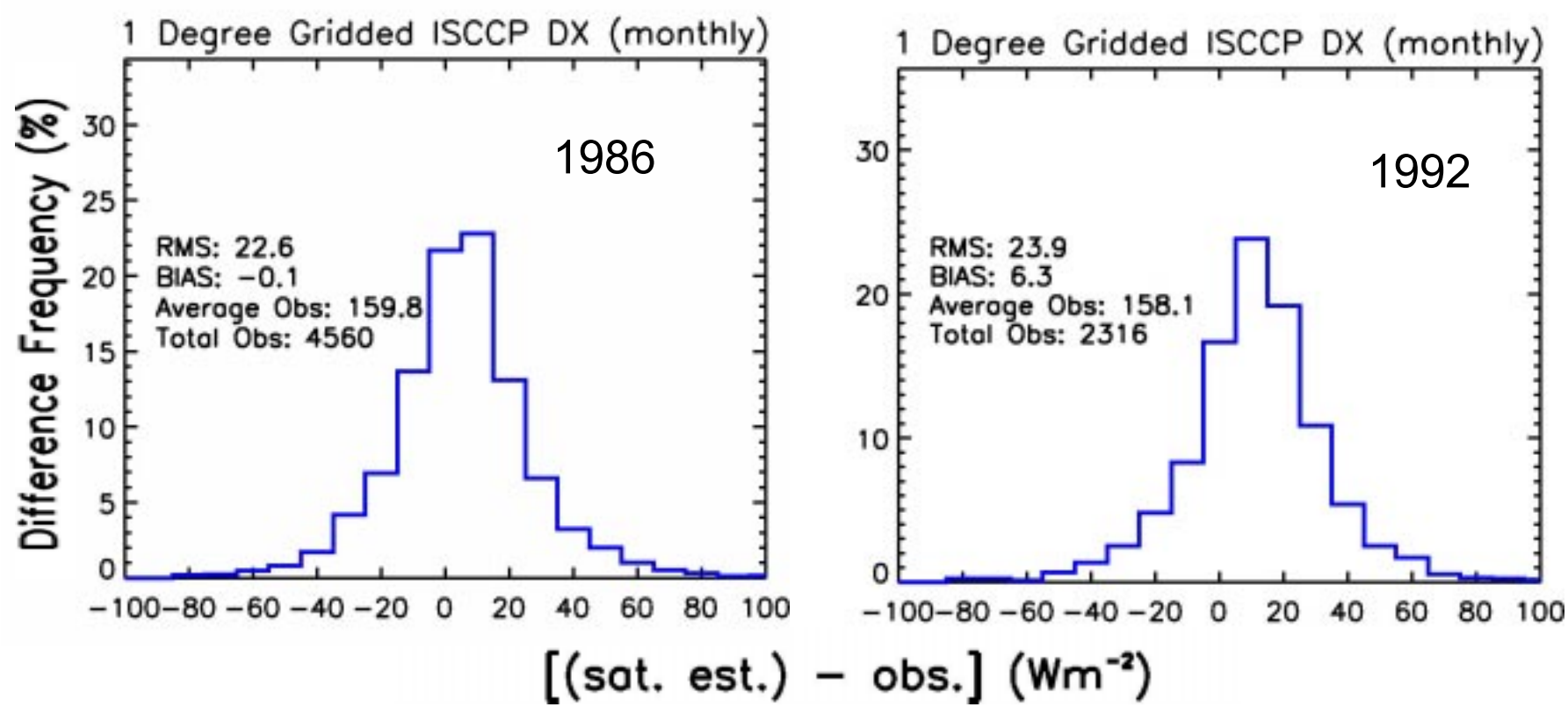
# SRB Project Validation: Surface Observations

## World Radiation Data Centre (WRDC) Monthly Averages



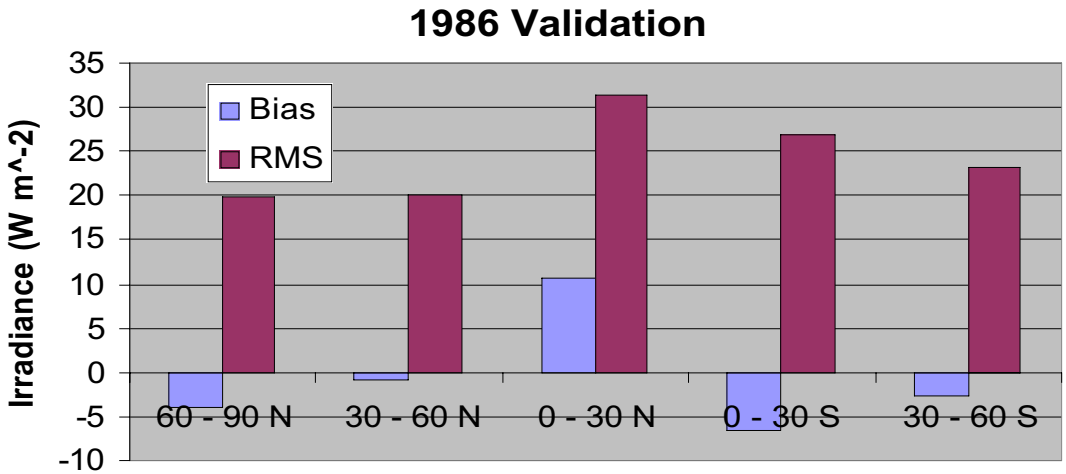
# Monthly Averaged SW Validation
# All Months in1986 and 1992

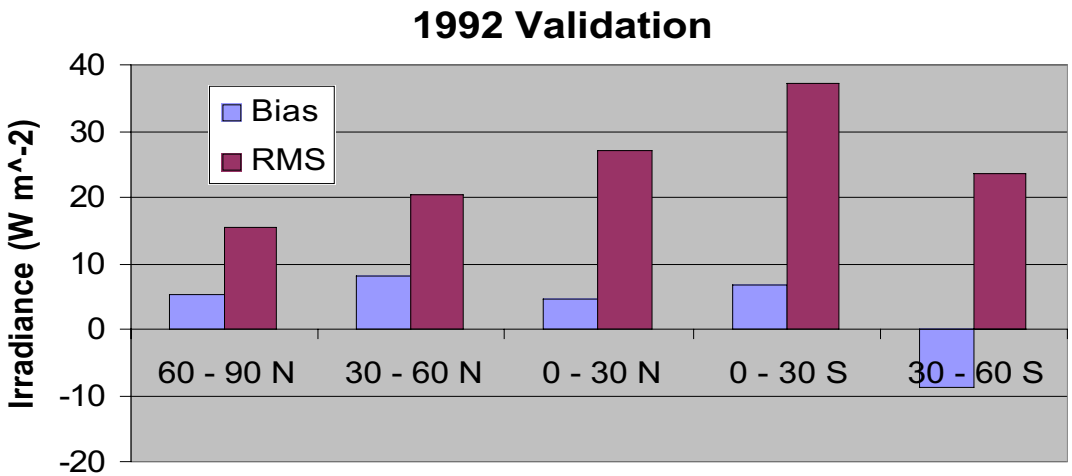
## World Radiation Data Centre (WRDC) Monthly Averages



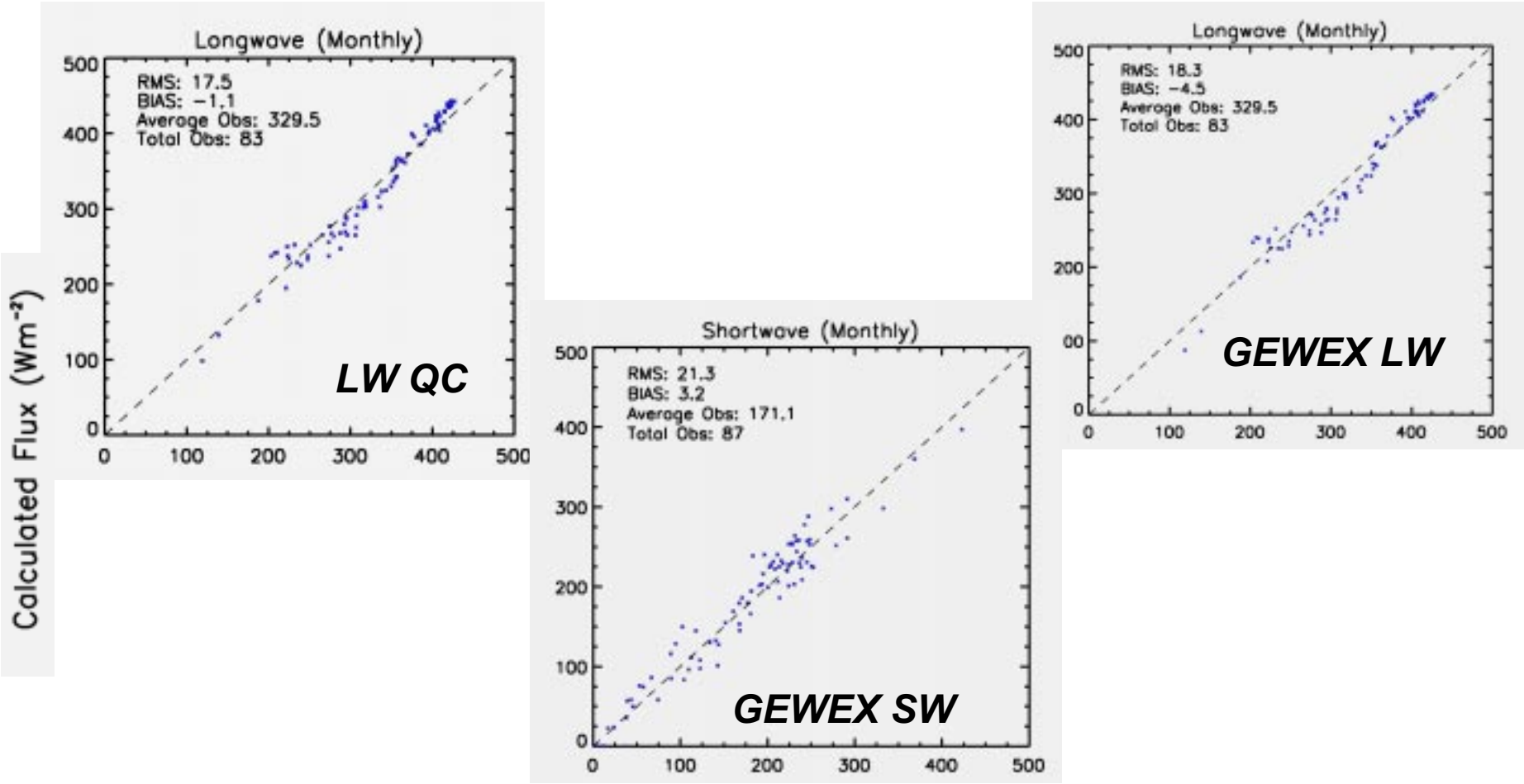
# Validation of Downward SW in Zones

***All WRDC Sites in 1986 & 1992***

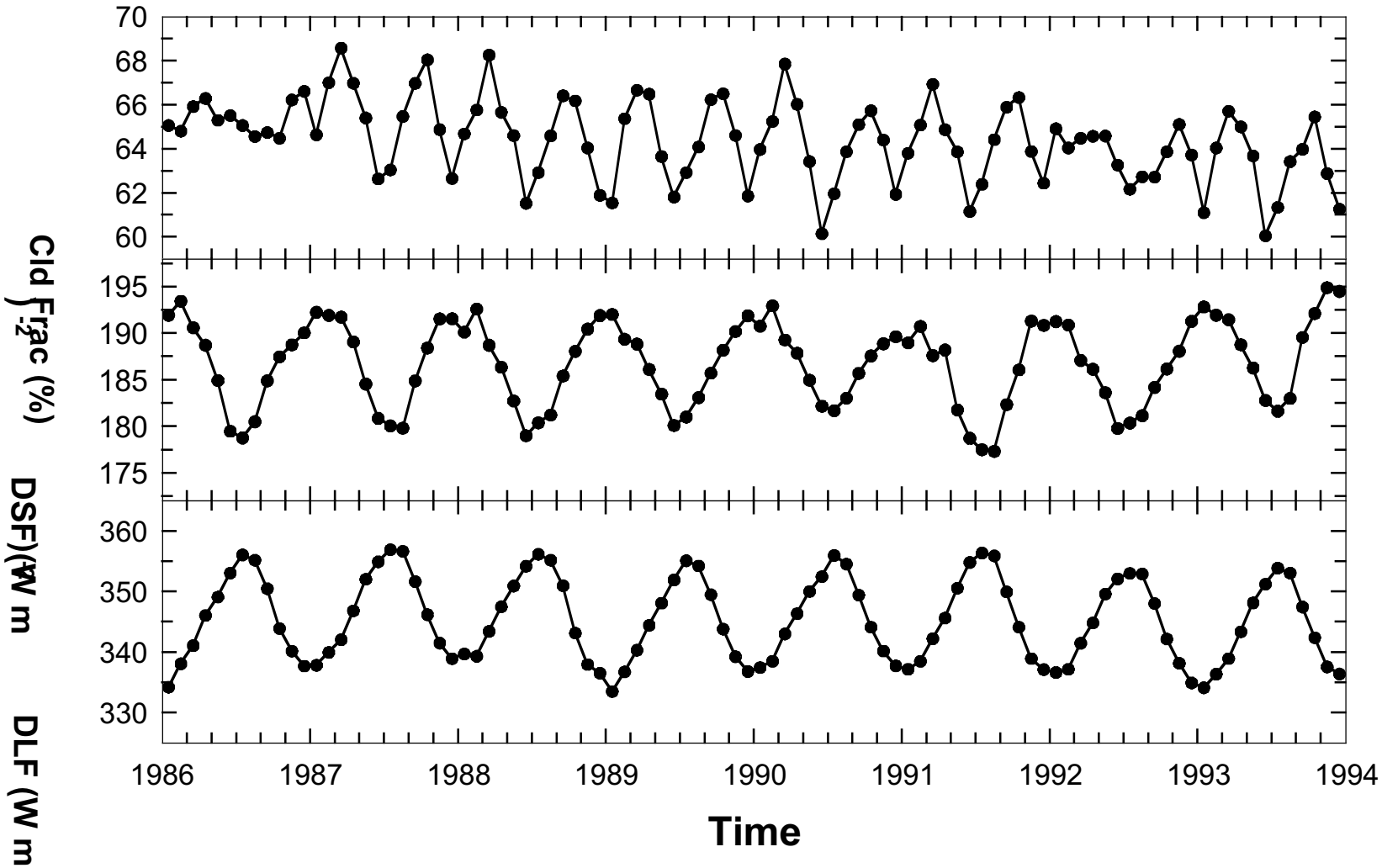


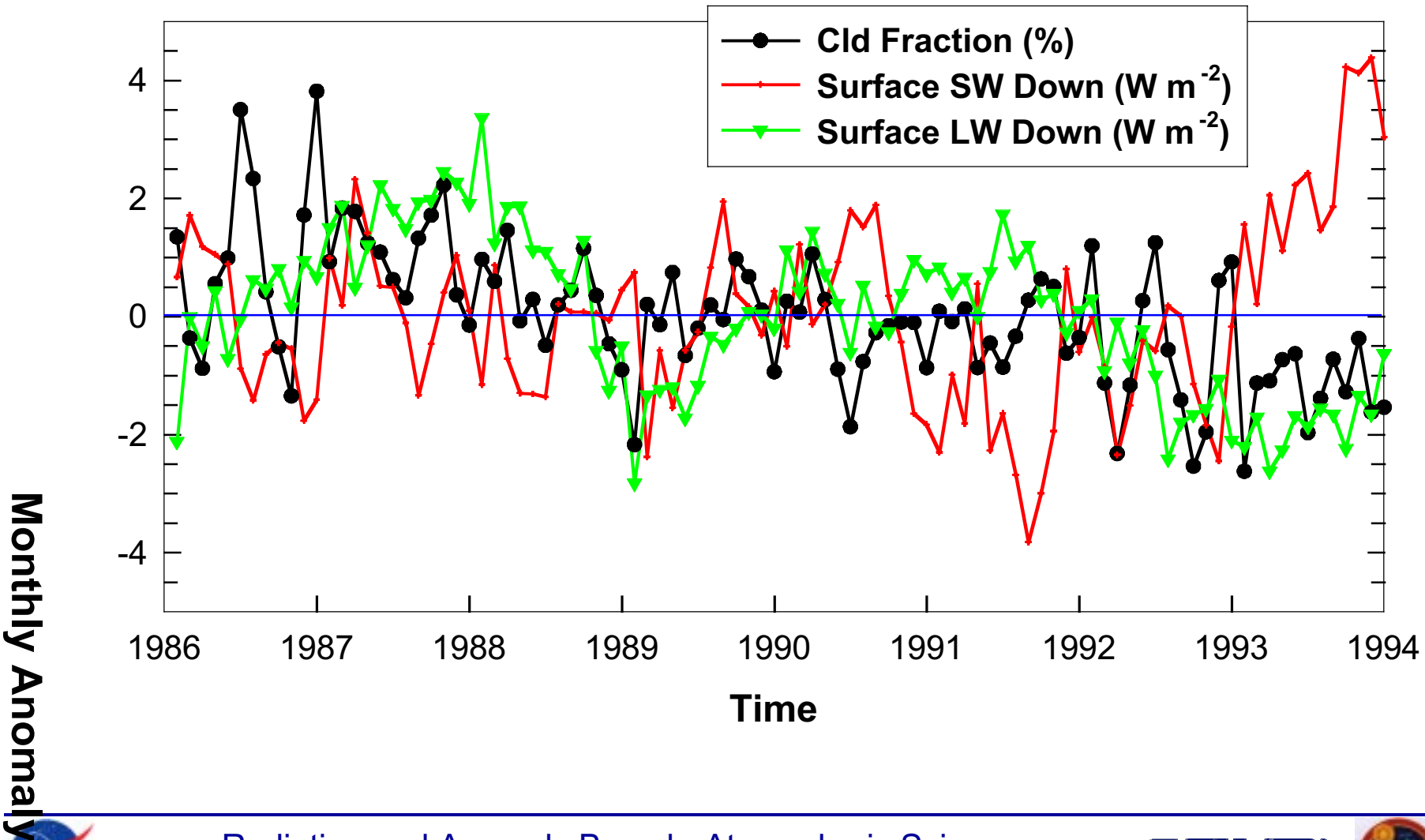
# Monthly Averaged BSRN Validation
# All Months for 1993



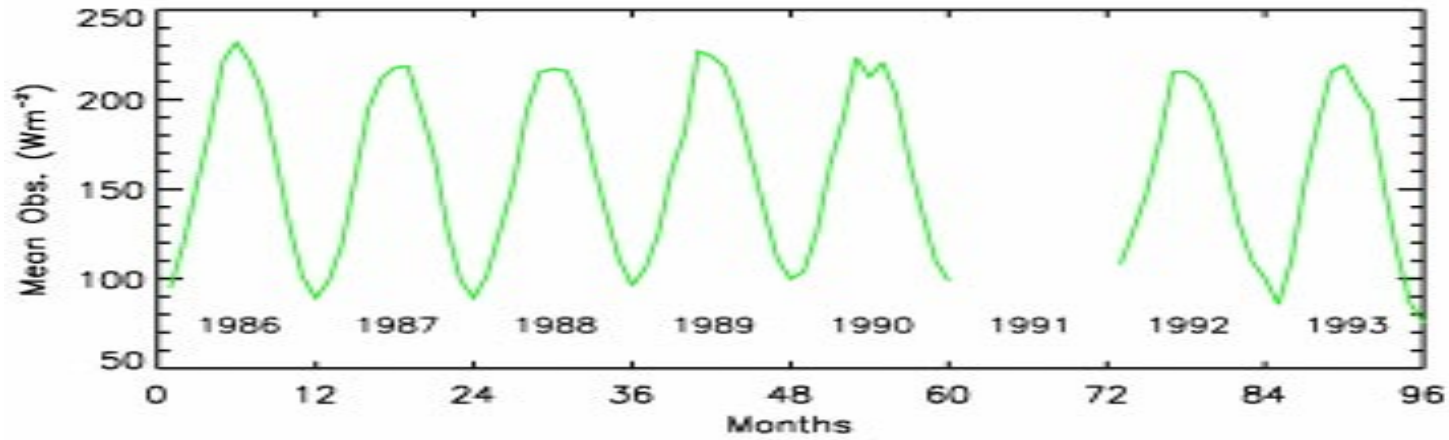
# Global Monthly Averages

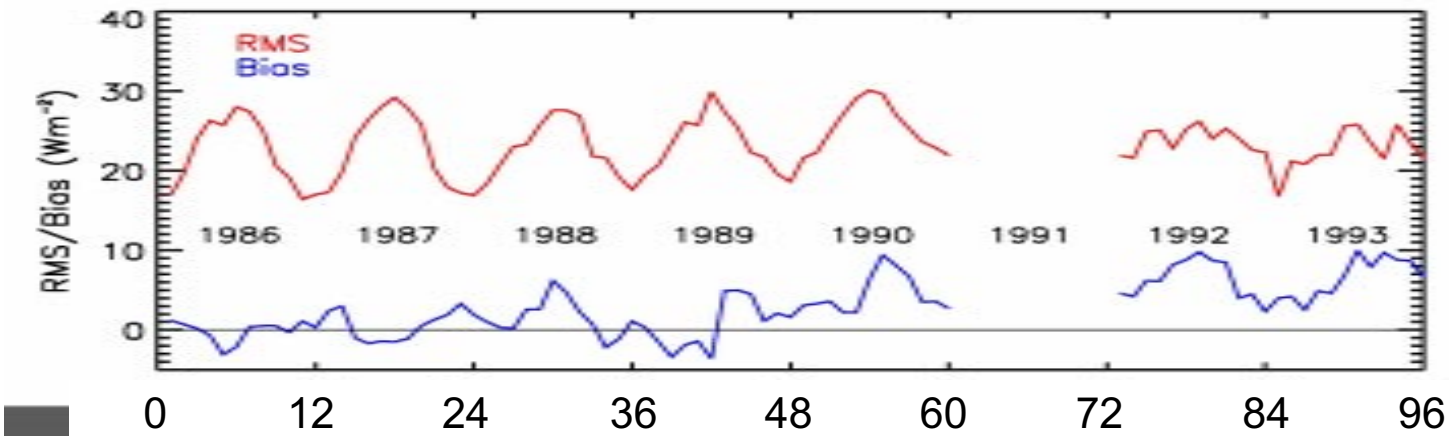


# Global Monthly Averaged Anomalies

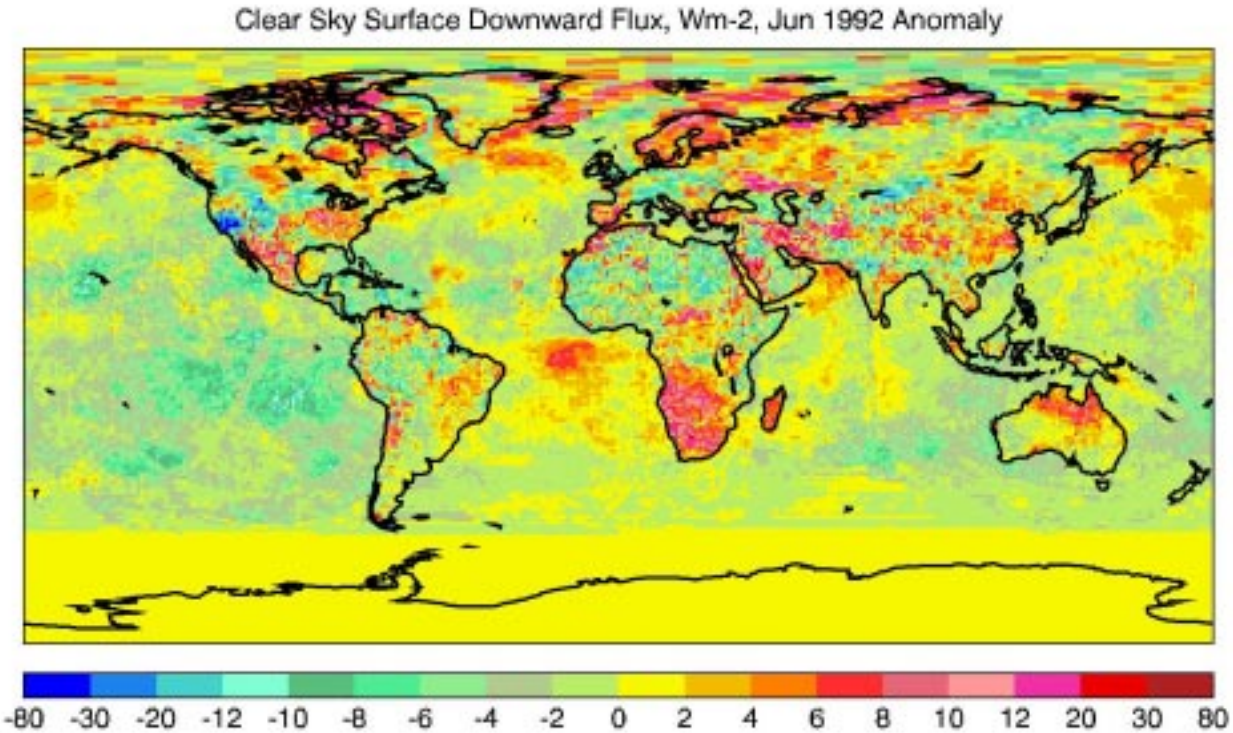


# Monthly Averaged Time Series Validation

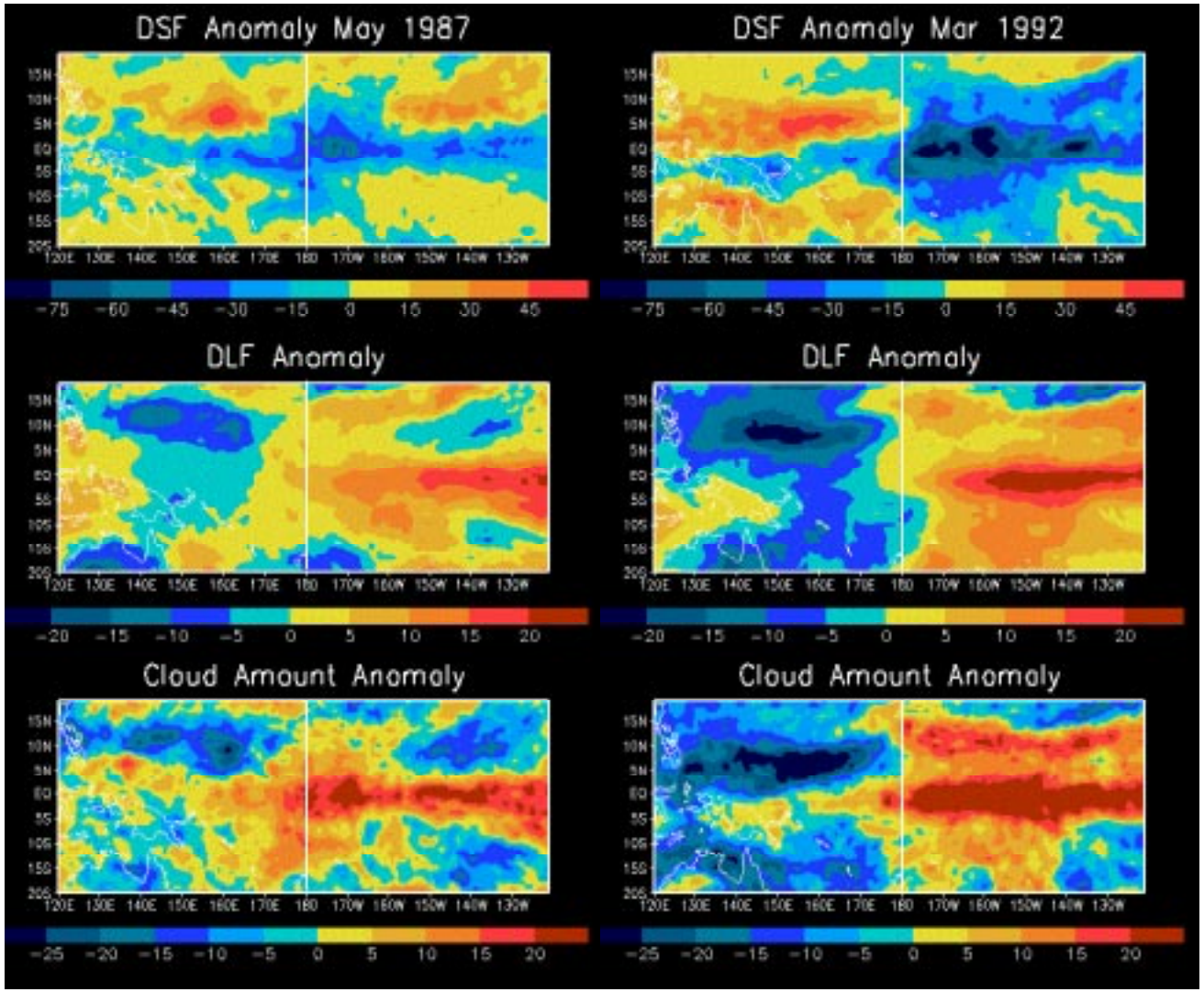


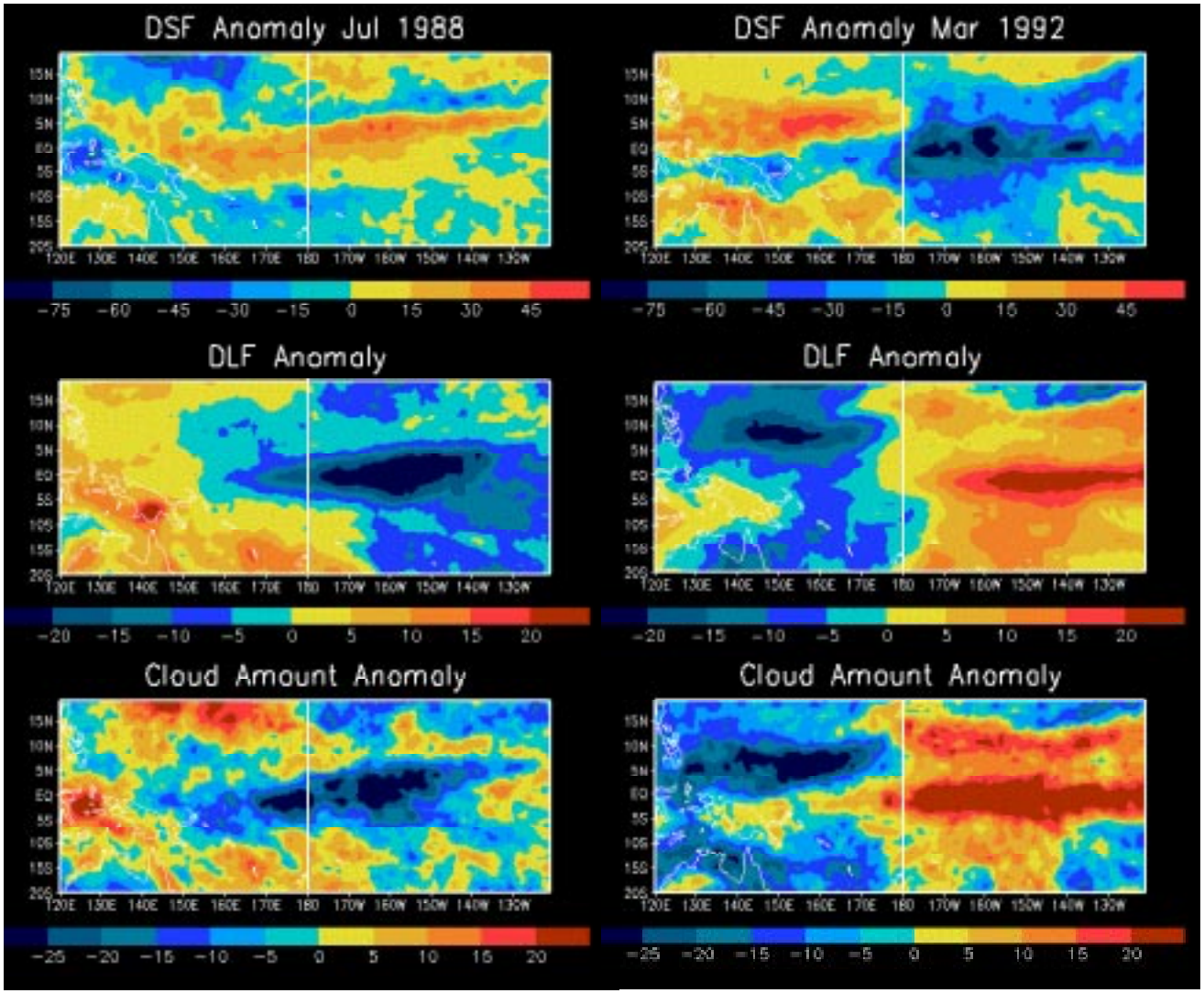
# Monthly Averaged Global Anomalies: Mt. Pinotubo (?)



# Regional Variability in the Tropical Pacific: El Nino



# Regional Variability in the Tropical Pacific: El Nino v. La Nina

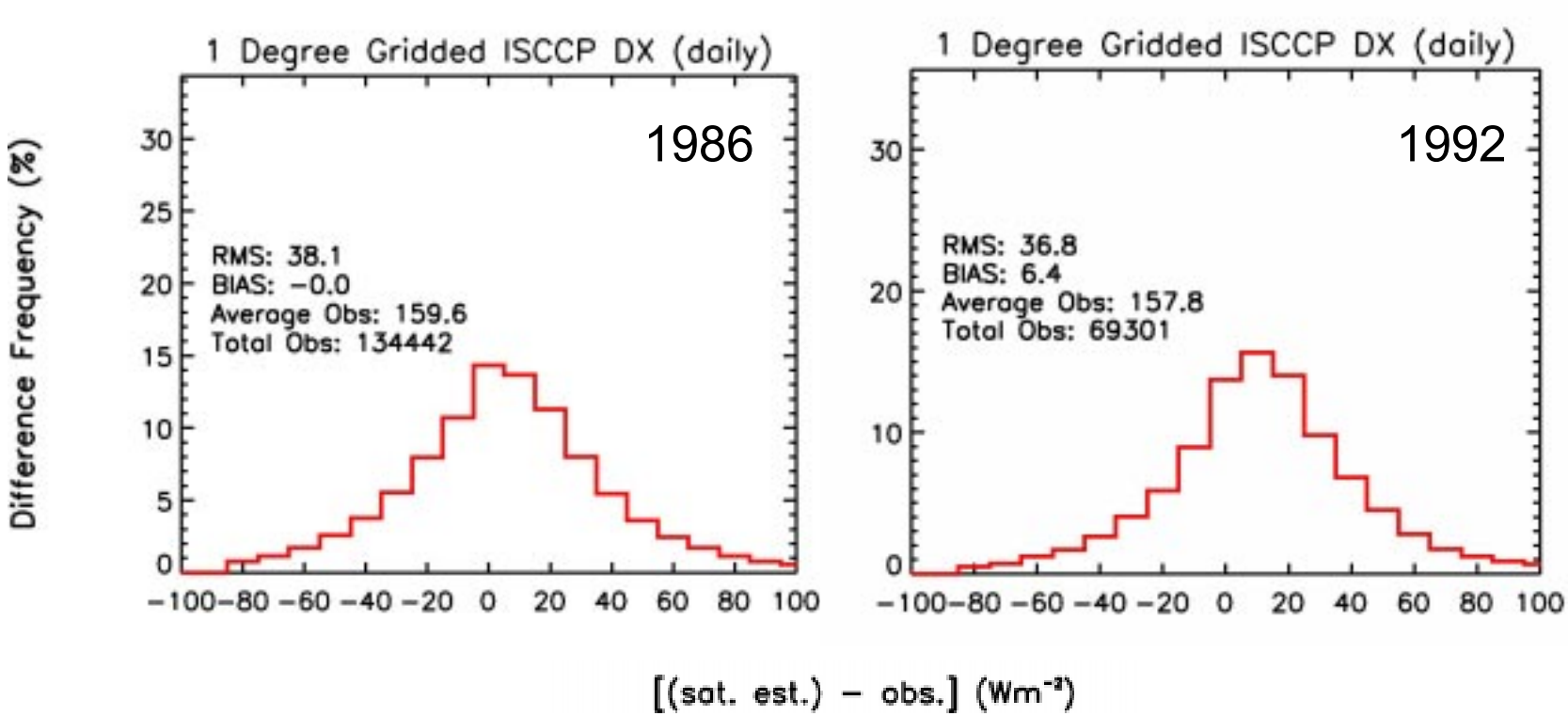


# Tropical Pacific Regional Variability:
## Surface Downwelling SW

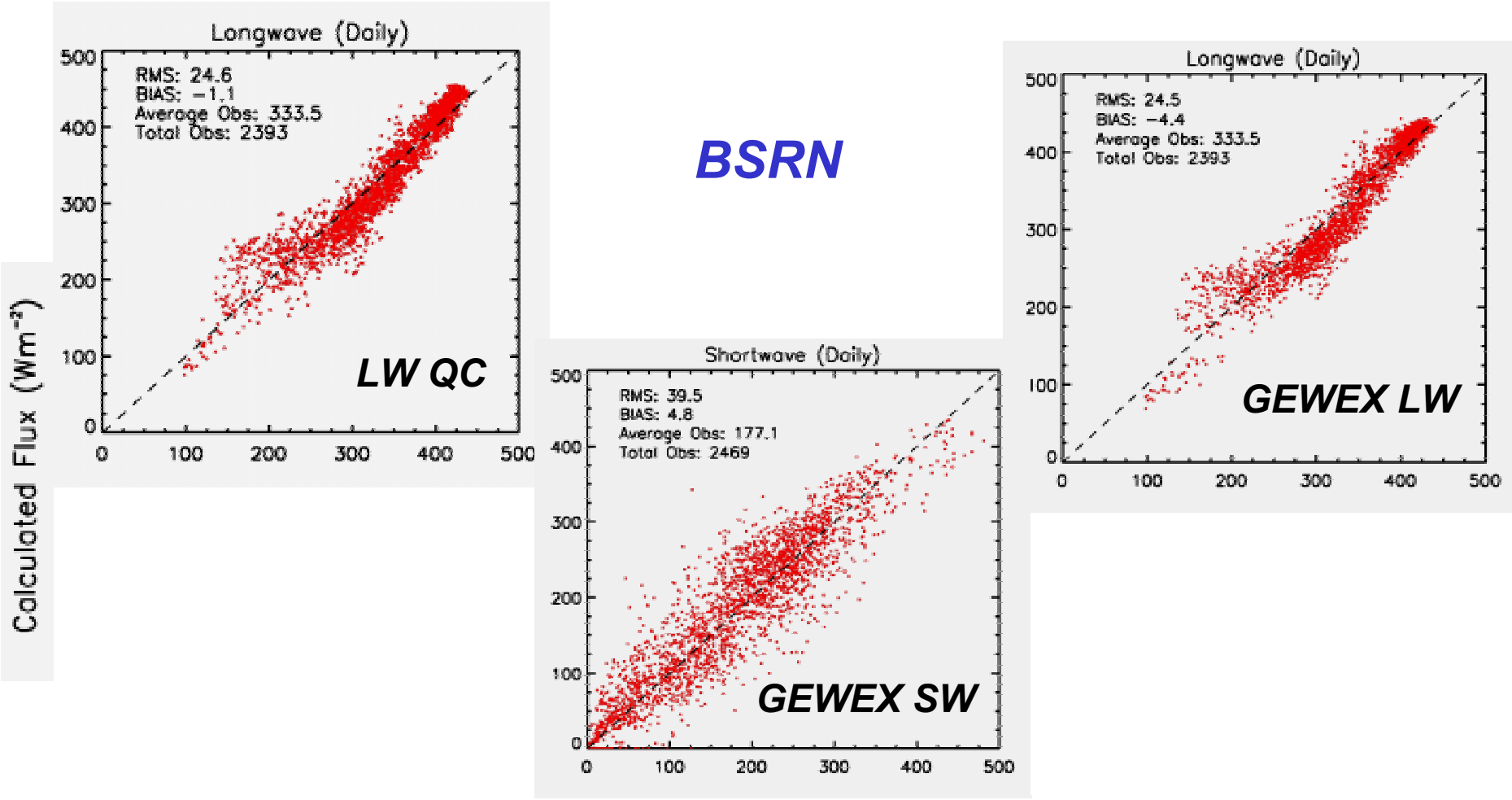
# Tropical Pacific Regional Variability:
## Surface Downwelling LW

# Monthly Averaged SW Validation
# All Months in1986 and 1992

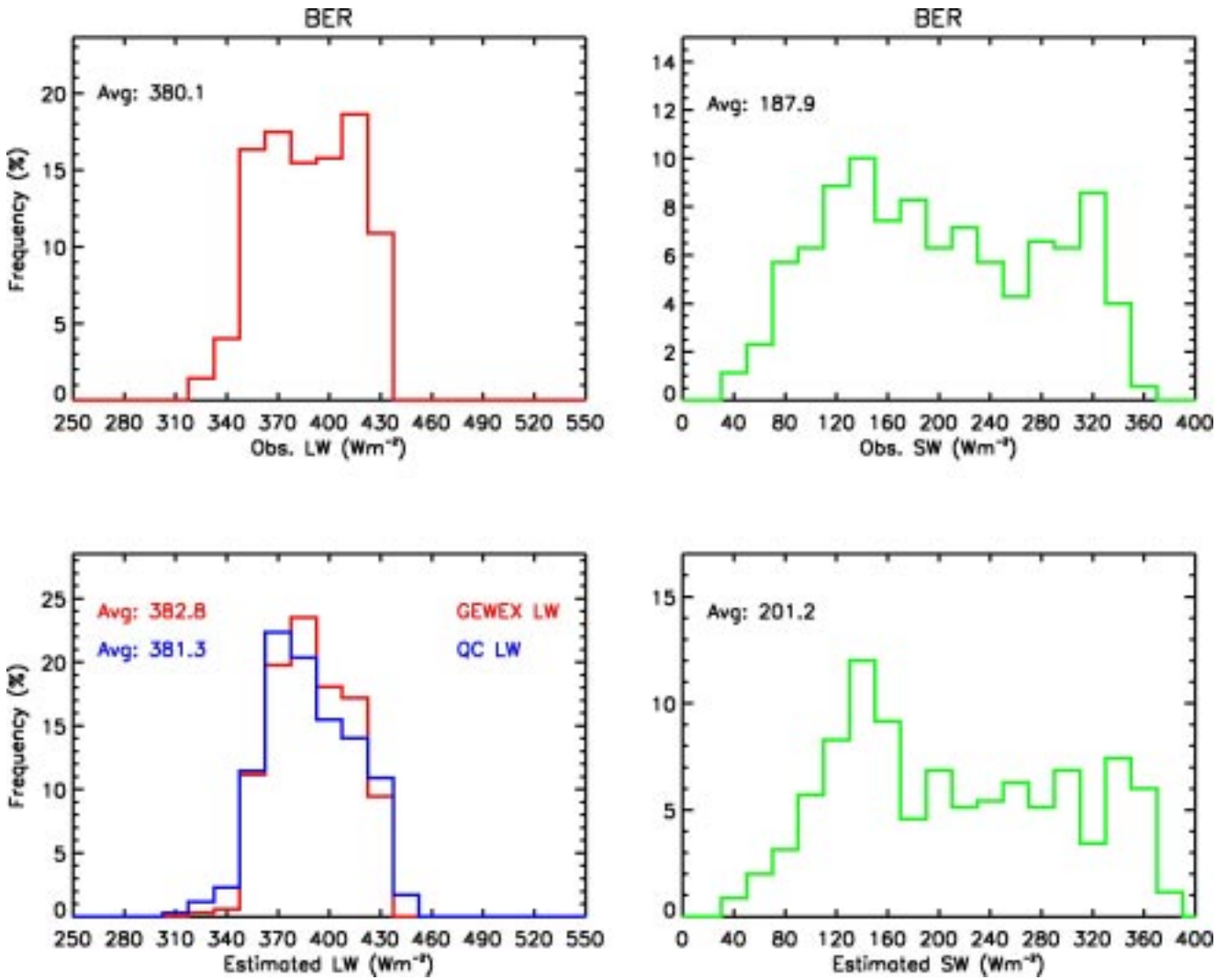
## WRDC Daily Averages



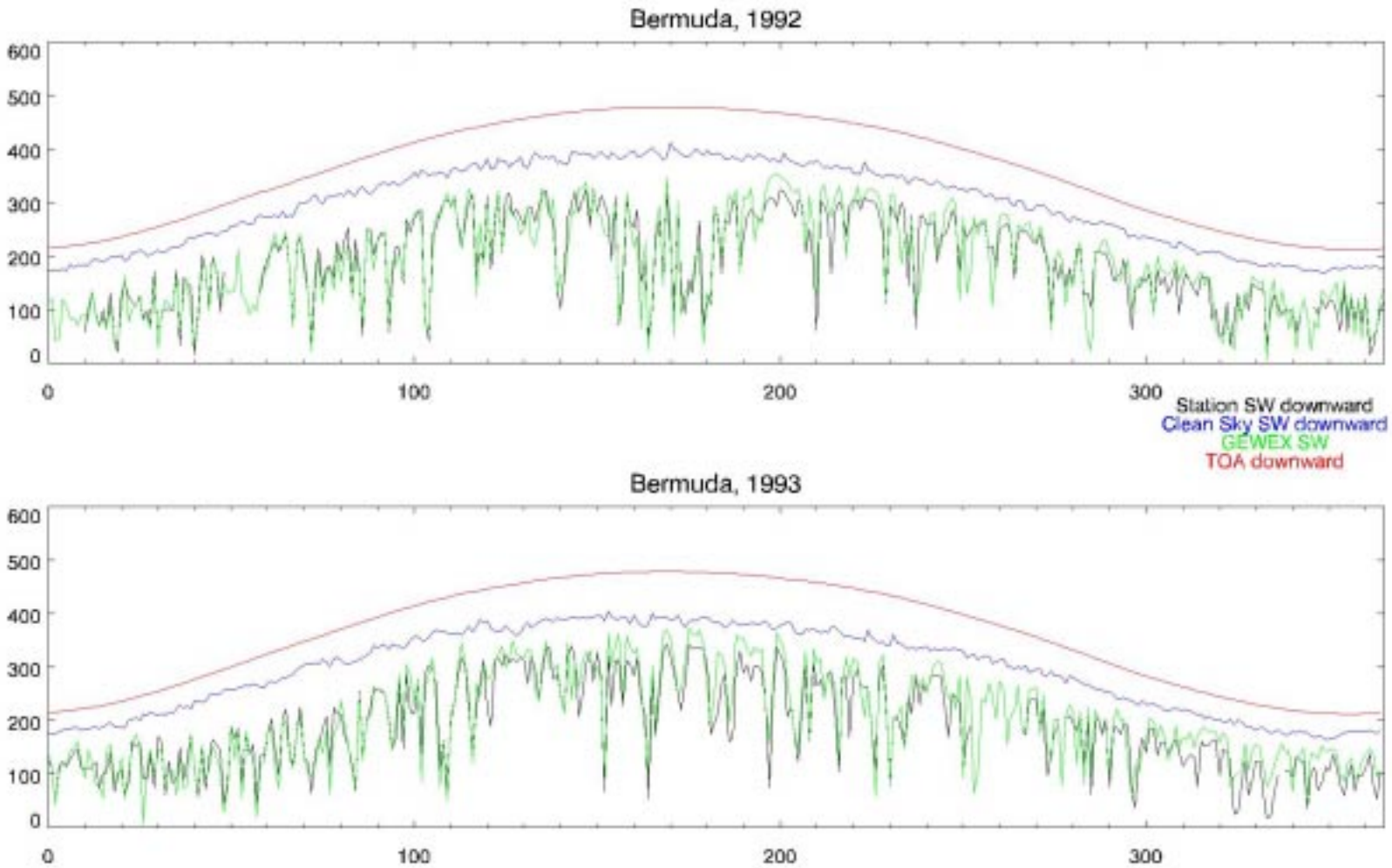
# Daily Averaged Validation: All Days during 1993



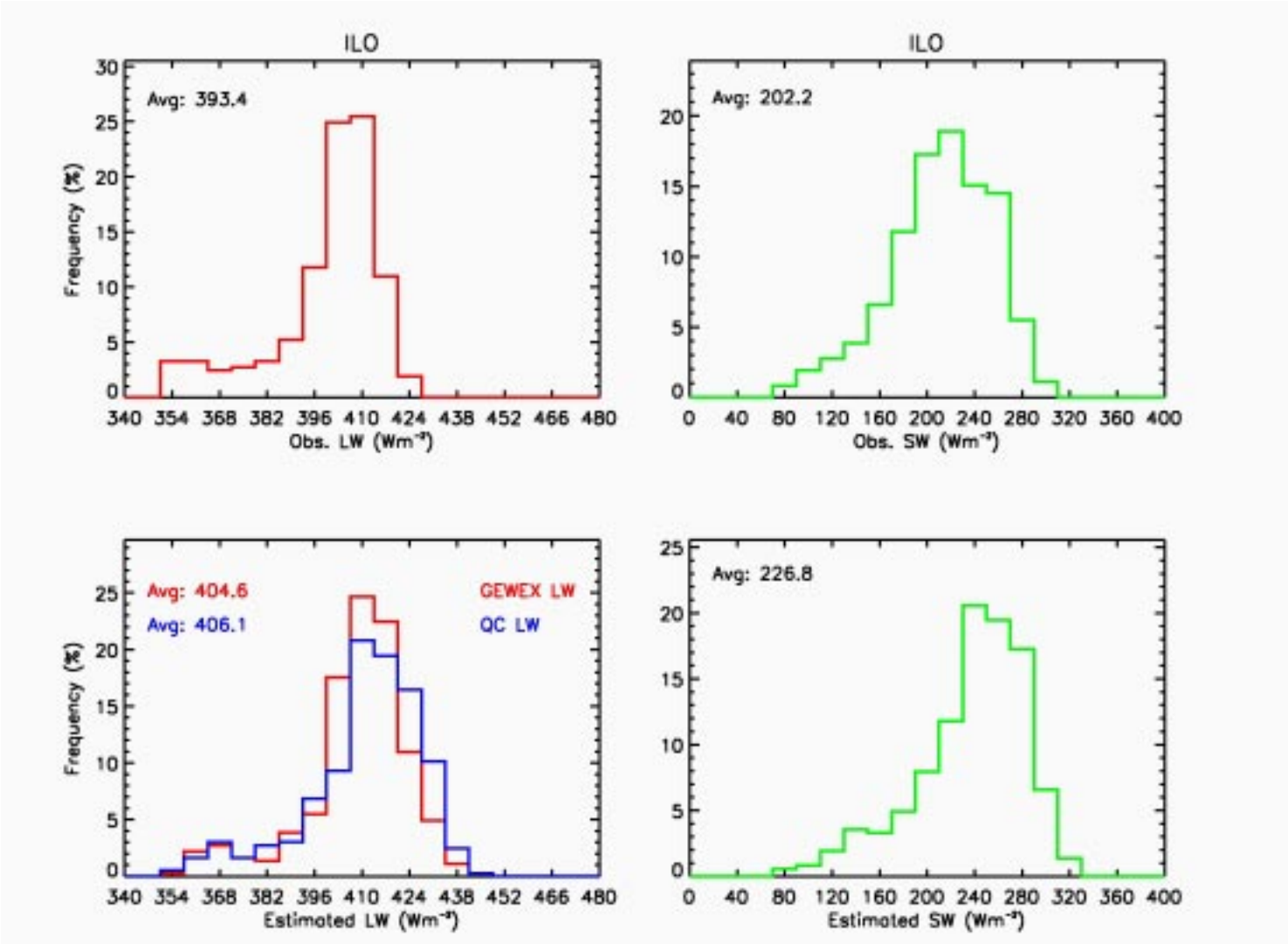
# Daily Averaged Histograms: Bermuda, 1993



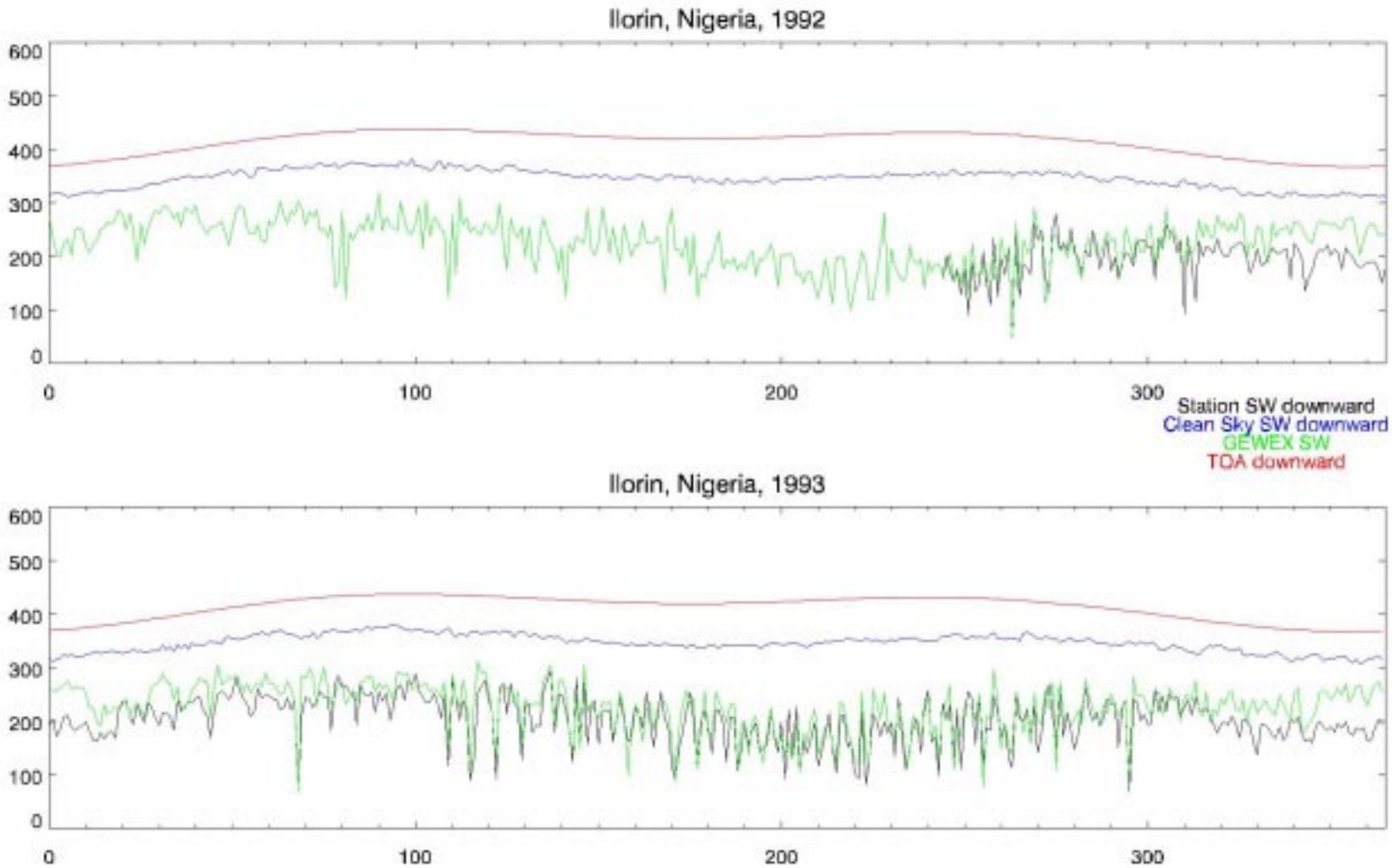
# Daily Averaged BSRN Time Series: Bermuda



# Daily Averaged Histograms: Illorin, 1993



# Daily Averaged BSRN Time Series: Illorin

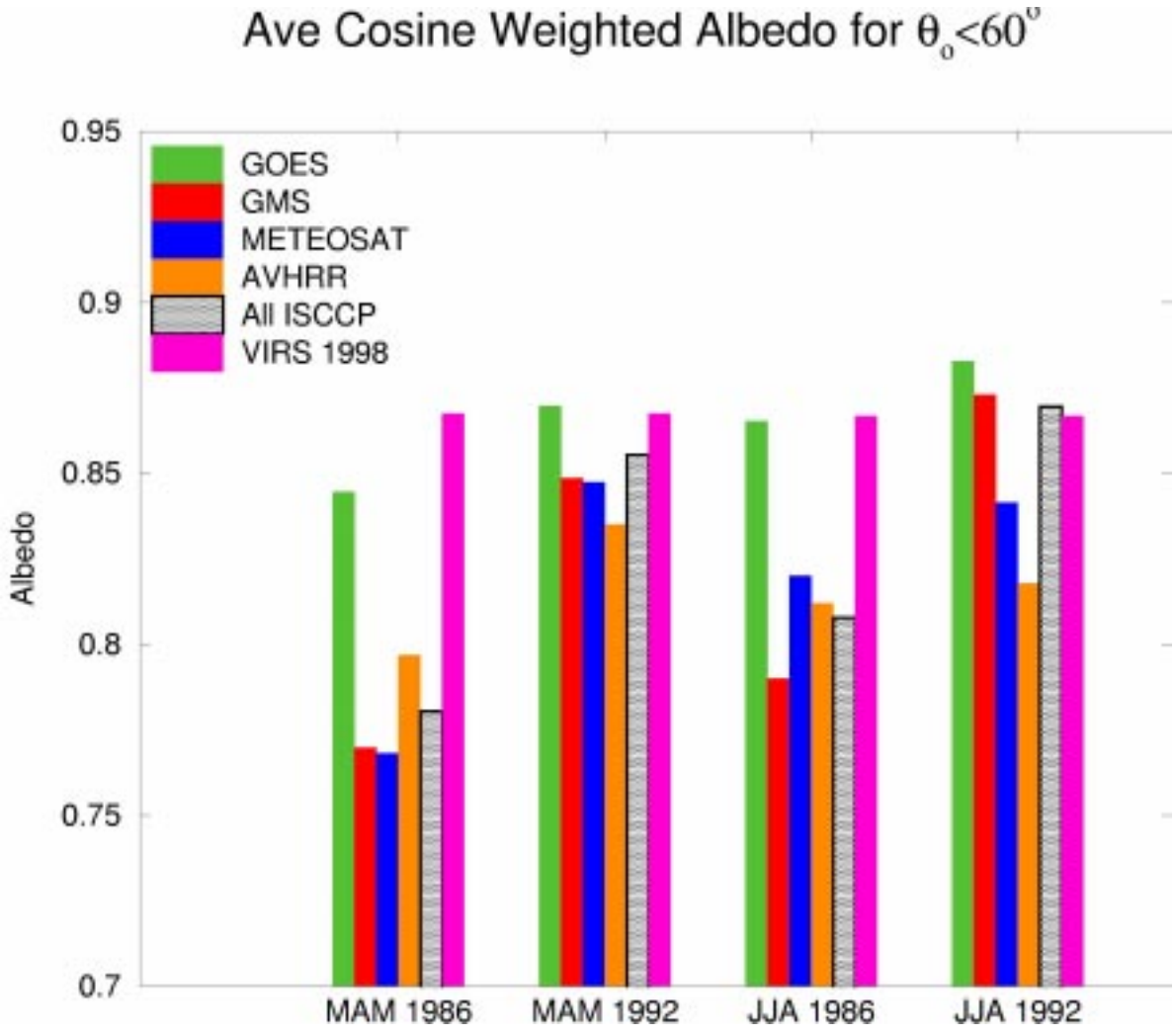


# GEWEX SRB and CERES

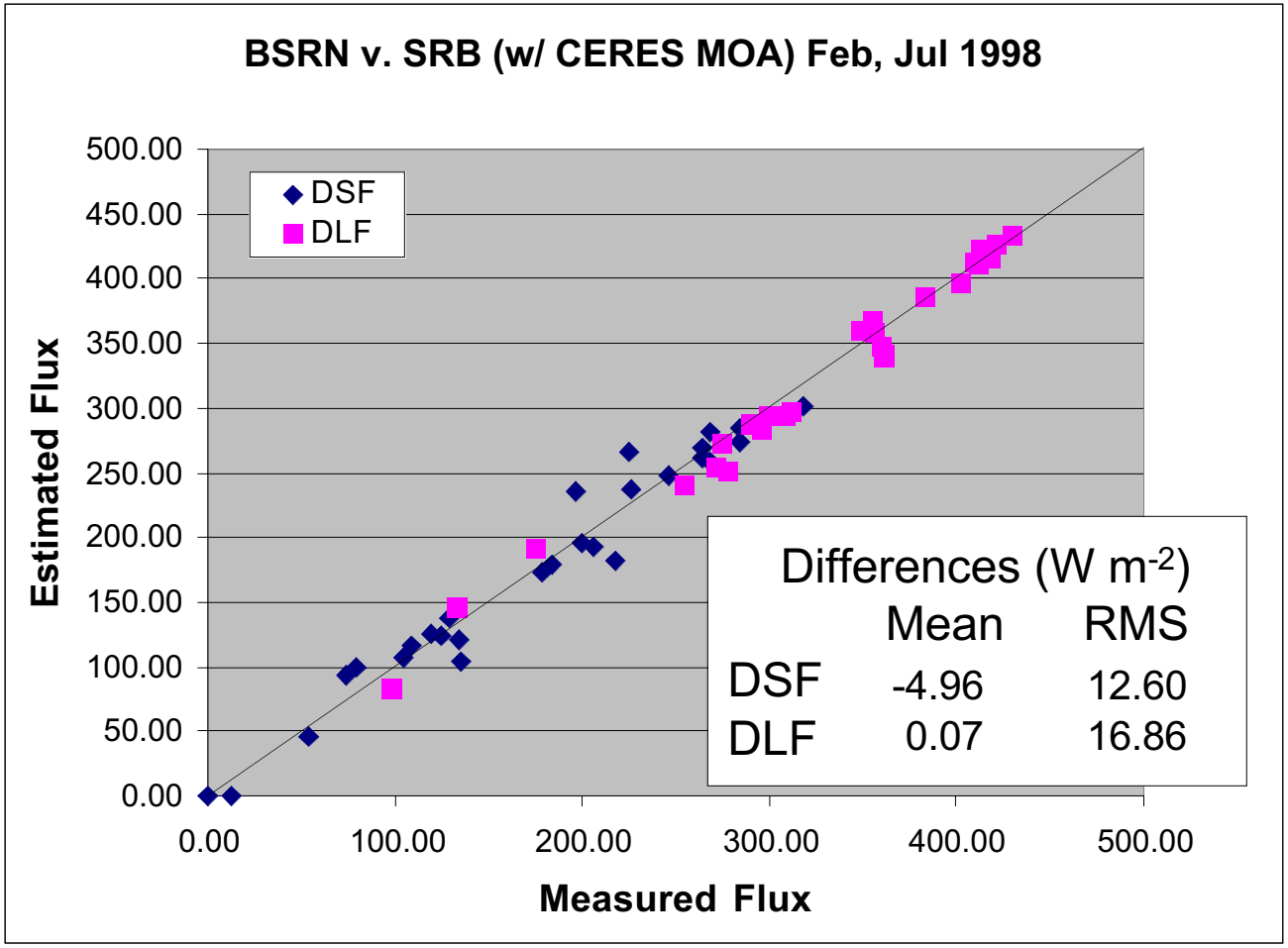
- Calibration Intercomparison
  - VIRS/MODIS v. AVHRR (ISCCP)
- CERES ADM's
- SRB v. CERES SARB & Surface Only
  - Intercomparisons of fluxes
  - Surface albedos
  - Aerosol properties and distributions

# Cross-Calibration of EOS/ISCCP

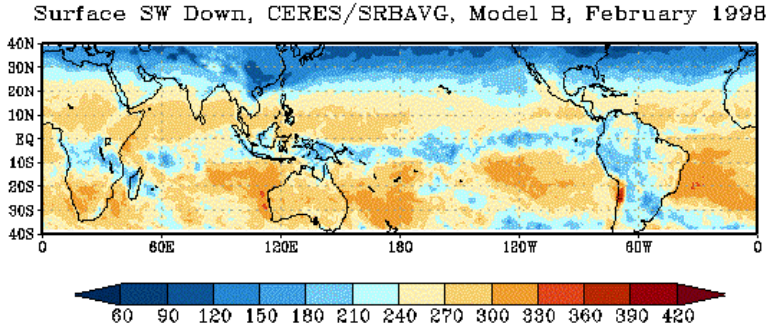
*Convective Cloud Top Visible Albedos (pixels w/ BT < 205K From 40S – 40N)*
*- apply anisotropic models for ice*

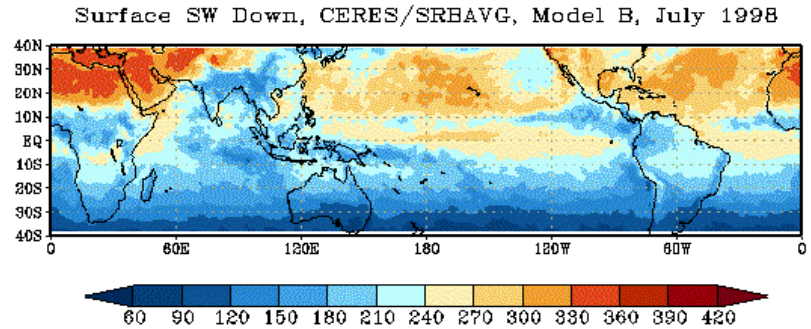


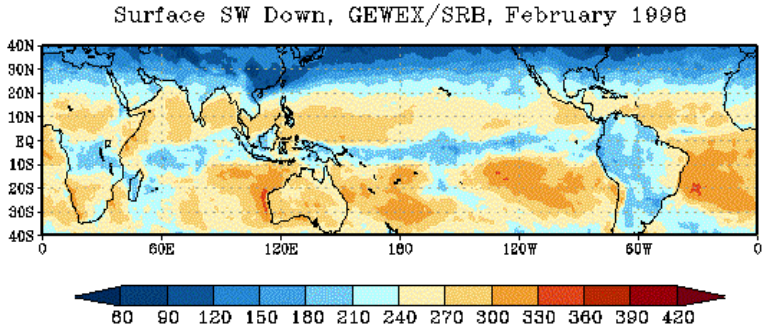
# BSRN Validation Feb, Jul 1998

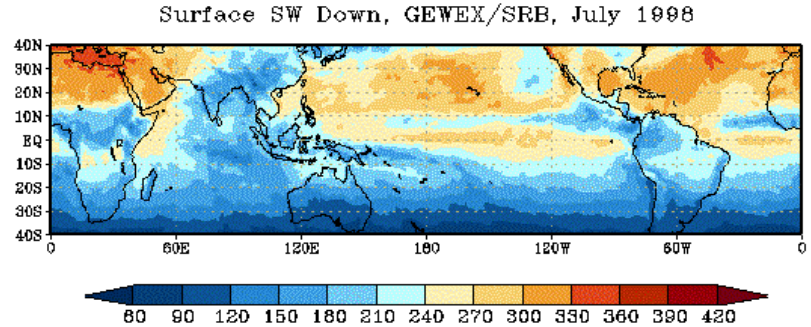


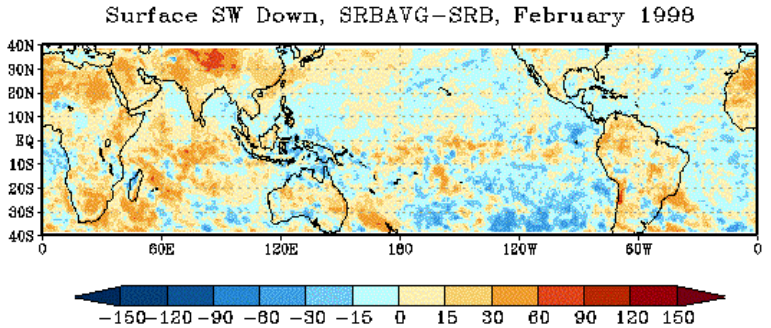
# SRB v. CERES Surface Only SW (Model B)

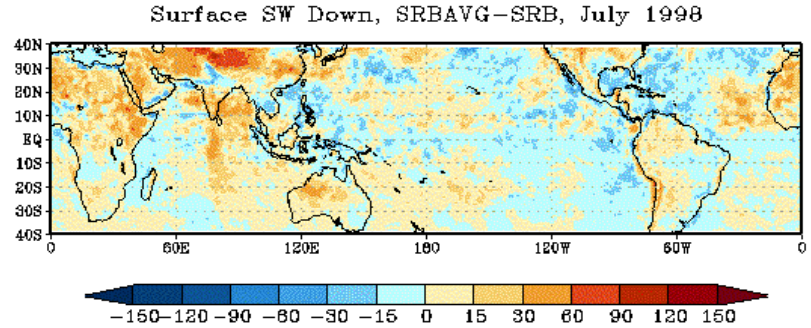


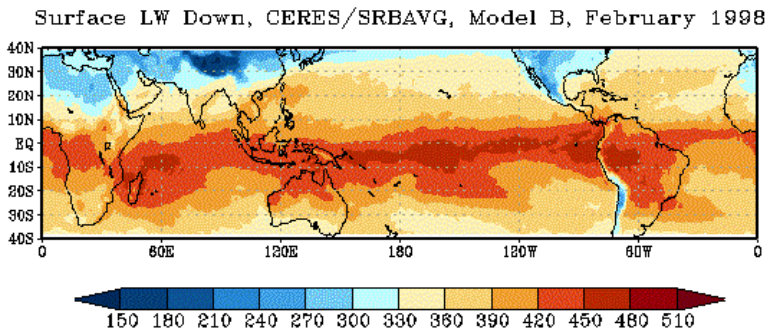



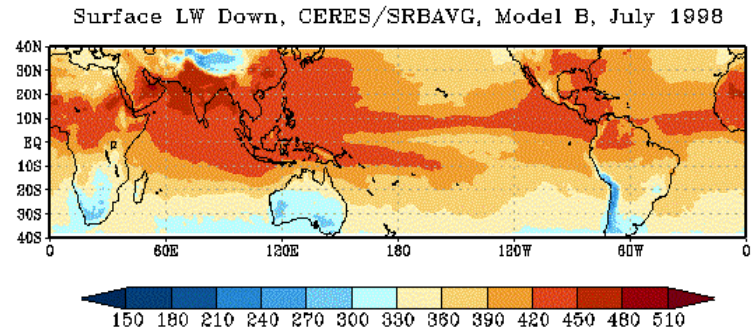



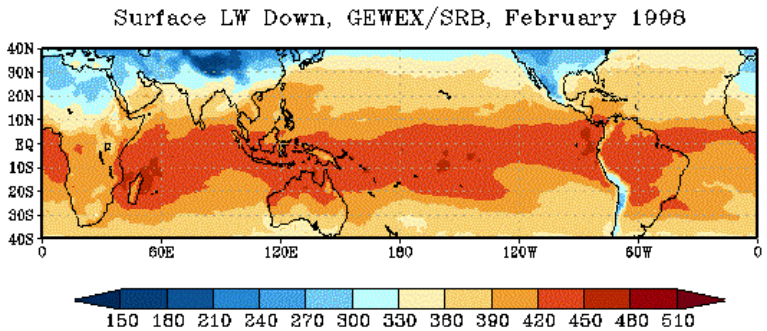



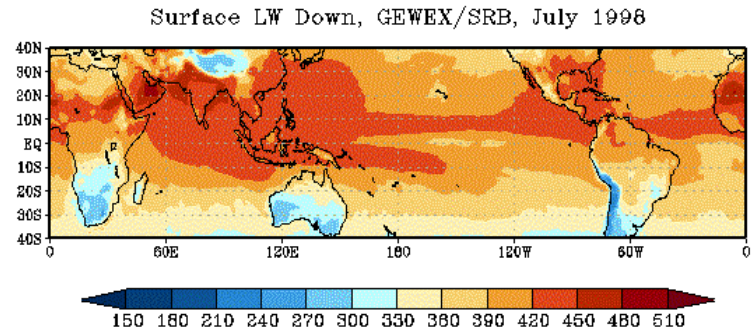



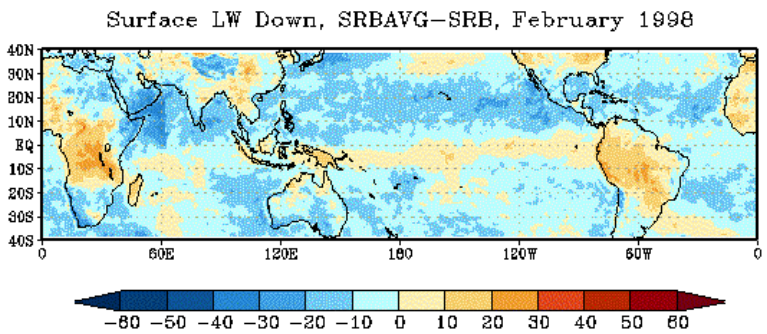
# SRB v. CERES Surface Only LW (Model B)

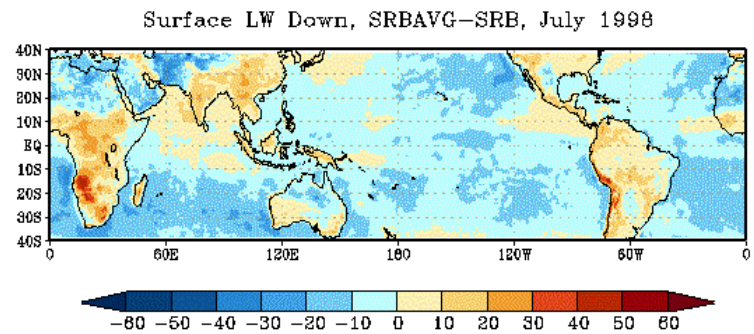


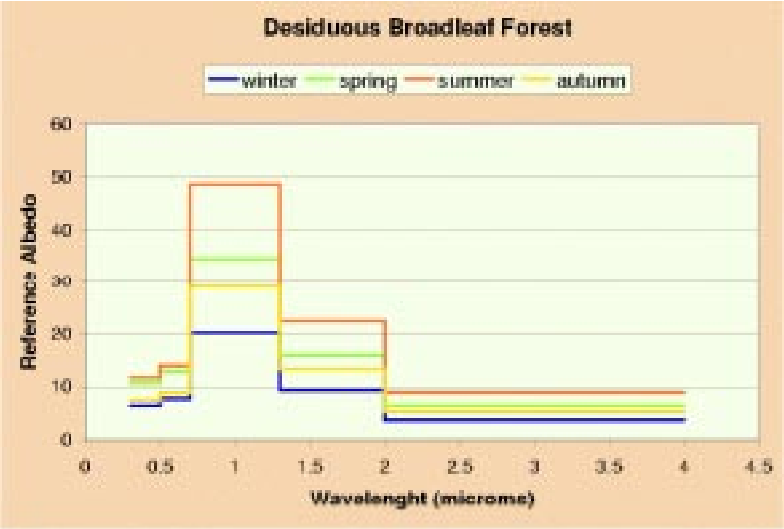
# Surface Only Fluxes v. SRB
# Feb and July 1998

*Intercomparison of Common Grid Boxes*

# GEWEX SW Improvements (U.Md)

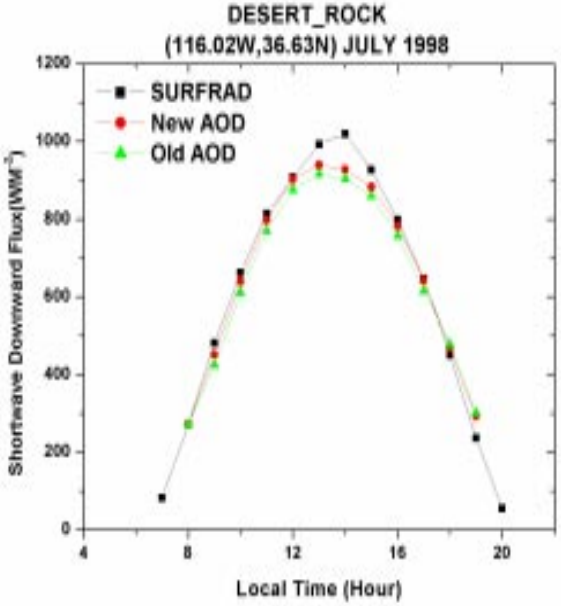
## *Spectral Surface Albedo*

- *Use AVHRR NDVI, ASTER spectral library, literature, U.Md. Surface Cover*
- *5 spectral intevals*
- *12 surface types*
- *monthly variation*




## *Aerosol Upgrade*

- *accommodate aerosol optical properties from climatology*
- *U.S. GCIP aerosol maps*



# GEWEX SRB: Conclusions

- **GEWEX SRB has produced 8+ of 12 year climatology of surface radiation.**
  - *Data quality is being quantified; on space/time scales*
  - *2+ years of data available now via ftp on request*
  - *Data to be available through ASDC (end Aug.)*
  - *5 years of data already provided to ISLSCP.*
- **Validation, analysis and collaborative activities crucial to assessing and improving the data set are being pursued:**
  - *GISS/GFSC/ESRB/MSG SRB*
  - *GEWEX SRB v. CERES Surface Only and SARB*
- **Working for limited public release in November 1, 2002.**

# Backup Slides

# GEWEX SRB: Release 2 Schedule

*2002* *2003*

*Sep Oct Dec Feb Apr Jun Aug*

1. *Complete current GEWEX SW, SW QC, LW QC processing 1983 – 1995*

   Nov. 15

   *Deliveries to ISLSCP, ESRB*

2. *Validation, intercomparison, analysis*

   *Using BSRN for validation, ERBE, other SRB and ERB data sets*

3. *Public access and documentation (web based)*

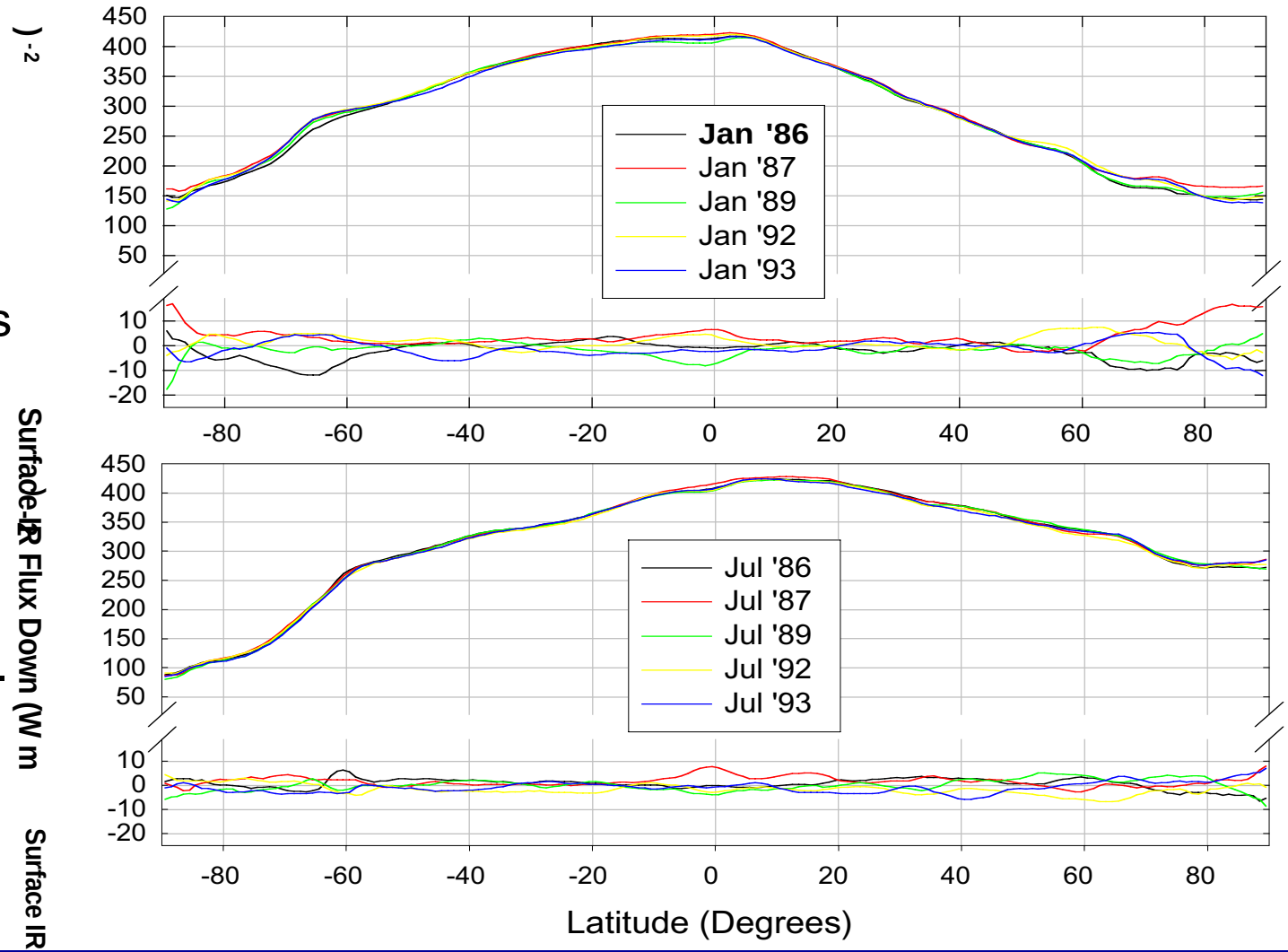
   *Years '86–'90; '92-'93 via ftp now (monthly averages only); access through NASA LaRC ASDC archive*

4. *Process/validate GEWEX LW for '83 - '95*

   *Using BSRN for validation and comparing to LW QC, ERBE, other SRB and ERB data sets*

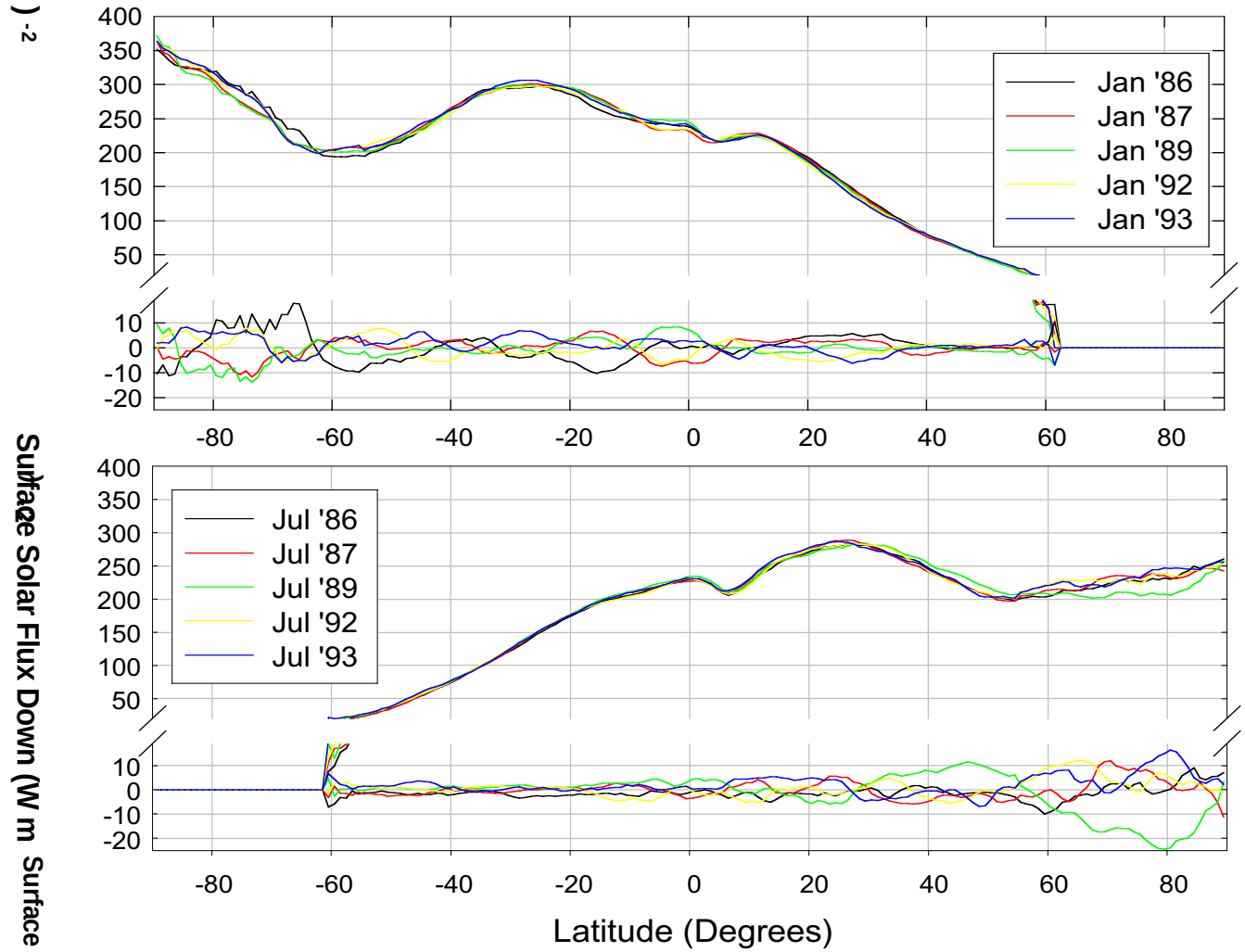
# Monthly Average Zonal Means for 5 years: Jan. and July

Except for Polar regions year-to-year variability within +/- 10 W $m^{-2}$ Relative to 5 year mean.



# Monthly Average Zonal Means for 5 years: Jan. and July

July differences smaller Than January between the years

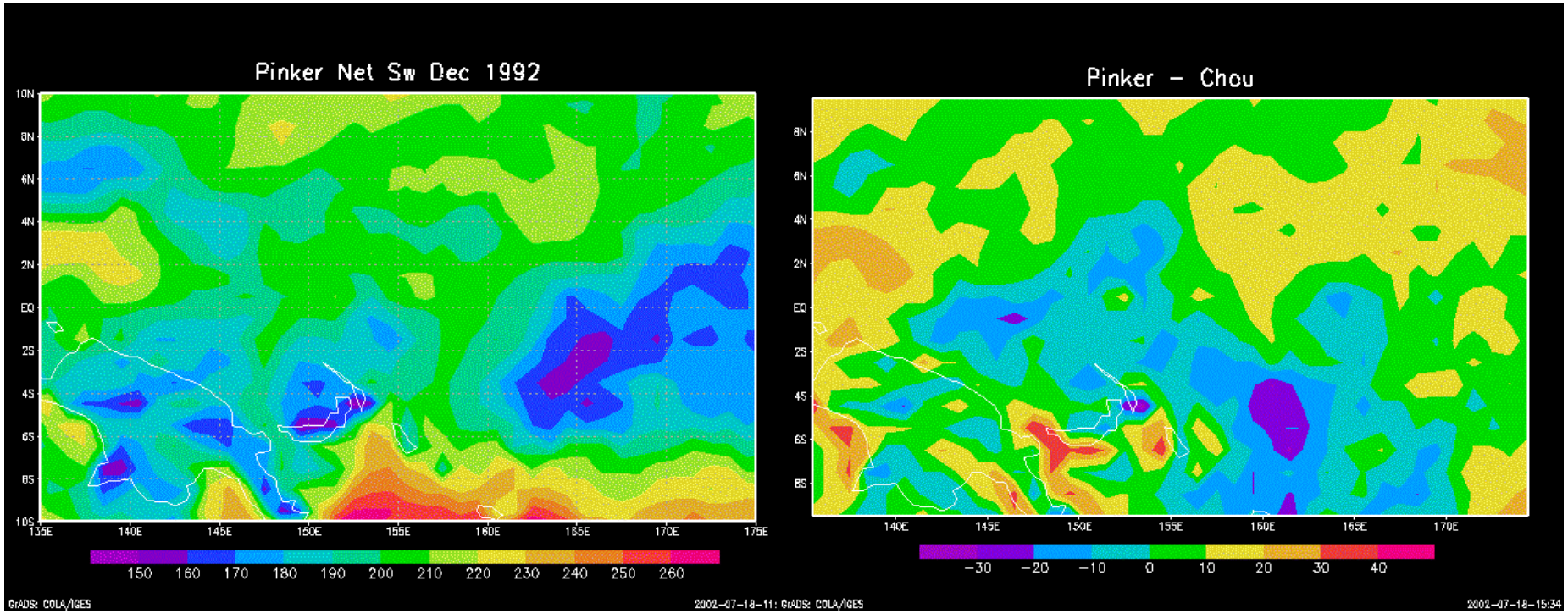


# GEWEX SRB:

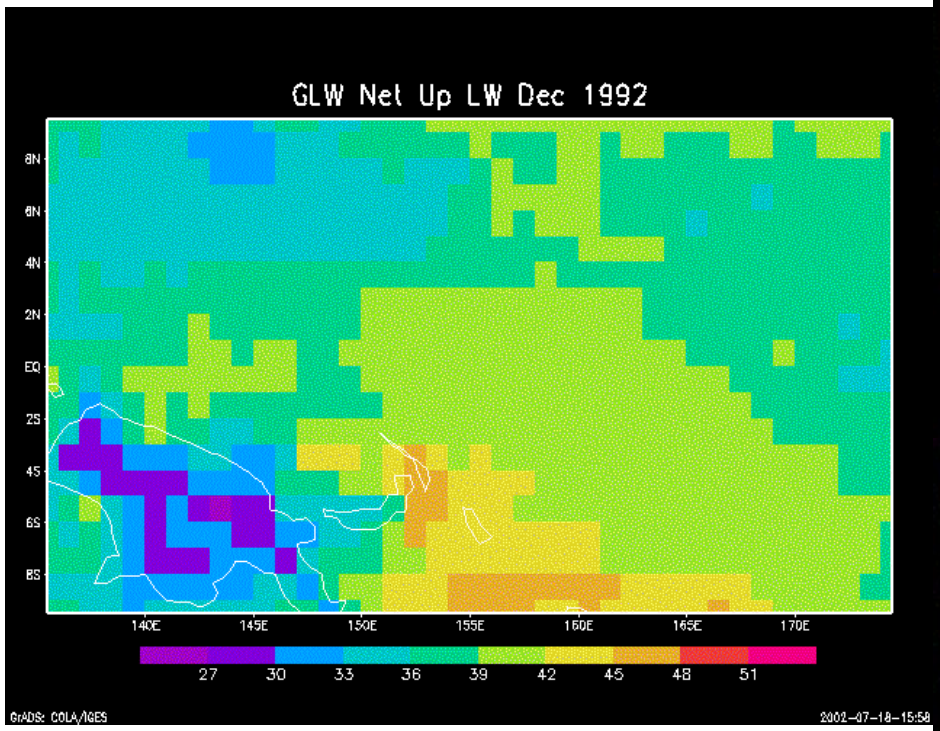
## *SW Differences by Zones*

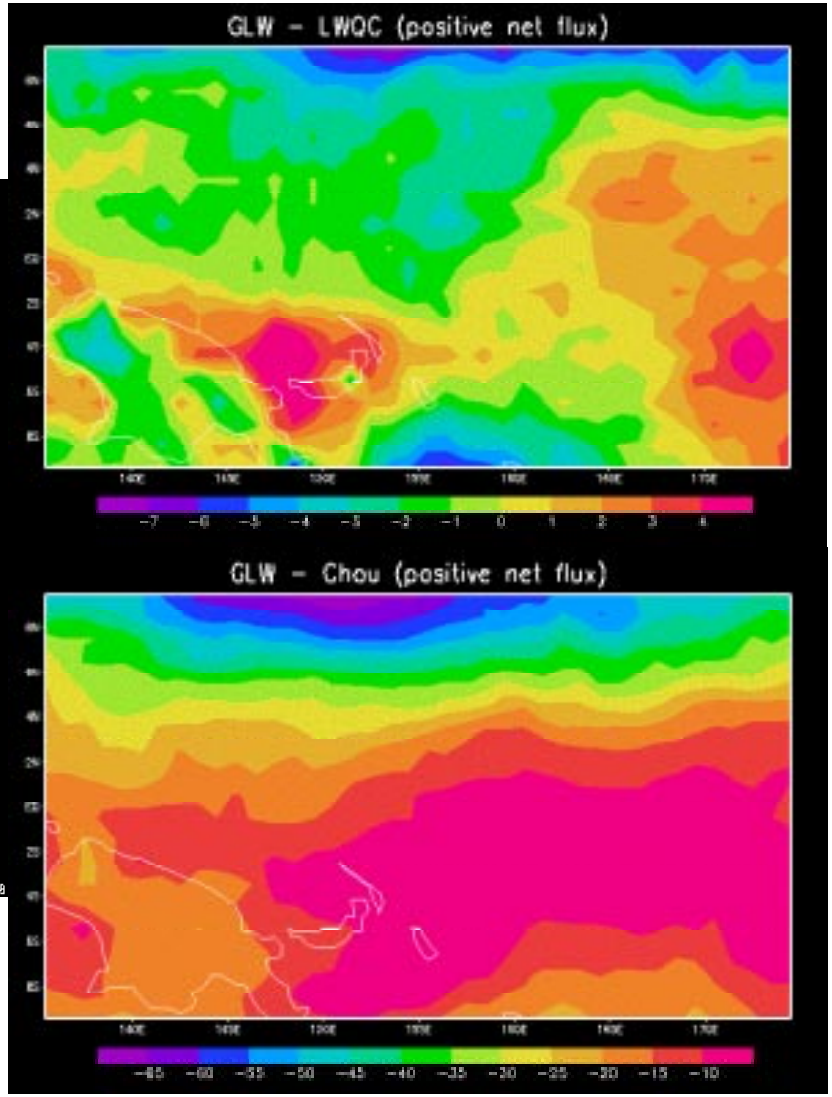
*1992*

# Intercomparison TOGA-COARE: Net SW



# TOGA–COARE Intercomparison: Net LW



# TOGA-COARE Tropical Validation

| | Site | Obs. | GEWEX SW |
|---|---|---|---|
| Downward SW Dec. 1992 | | | |

| | |
|---|---|
| LW Components Dec. 1992 | |

# GEWEX SRB: Strategic Plans

| Activity | Time Horizon | |
|---|---|---|
| | 0 – 1 years | 1 – 2 years |
| **Processing** | - Complete SRB R2 (GLW)<br>- Special process 1998 (Feb, July)<br>- Begin w/ NCEP R2 if no 1°x1°<br>•- R2 documentation w/ data quality | - Continue processing w/ NCEP met. to keep pace w/ ISCCP<br>- If no 1°x1° reprocess first 10 years w/ NCEP; if yes begin reprocessing immediately |
| **Validation** | - BSRN (monthly 3-hourly), ARM<br>- TOGA-COARE<br>- GSW, GLW TOA | - BSRN, ARM, Surfrad+<br>- Compare w/ CERES-SARB '98 |
| **Improve-ments** | - SW: CERES ADM's, spectral albedos, aerosols (w/ U.Md)<br>- LW: parallelize, cloud overlap, emissivities (w/ GISS, SARB) | - SW models: new ADM's , NB-> BB conversions (w/ VIRS, MODIS), Fu-Liou SW<br>- EOS/ISCCP calibration |
| **Analysis** | - Comparison w/ GISS/Chou/ESRB<br>- Long-term SRB flux assessment<br>- Clear v. all-sky assessment | - Compare w/ GISS/ESRB/MSG<br>- Long-term SRB/TOA regional<br>- GEWEX Colloborations |

# GEWEX SRB: Strategic Plans

| Activity | Time Horizon | |
|---|---|---|
| | **2 - 3 years** | **3 - 5 years** |
| **Processing** | - Reprocess w/ 1°x1° meteorology, full Fu/Liou, Pinker/Laszlo w/ improvements | - Re-Process w/ new ISCCP version<br>- Historic aerosols |
| **Validation** | - BSRN, ARM, SURFRAD+<br>- Overlap comparison to CERES-SARB from Terra/Aqua | -BSRN, ARM, SURFRAD+<br>-CERES-SARB |
| **Improve-ments** | - Aerosol climatologies<br>- SW: direct/diffuse, UV, PAR<br>- Skin/Surface T (w/ new met and emissivities) | - New cloud/aerosol information from CLOUDSAT/CALIPSO (bases, multi-level, etc.)<br>- Increased resolution to 0.5°(?) |
| **Analysis** | - GEWEX collaborations: self-consistency, merging, GCIP<br>-- EOS/ISCCP overlap | - ISSCP + EOS -> 20+ years of SRB |