A Status Report of NASA/GEWEX Surface Radiation Budget Project: Comparisons to SRBAVG

CERES Science Team Meeting

May 2-4, 2006

Paul W. Stackhouse, Jr. – NASA LaRC

and

J. Colleen Mikovitz, Dave Doelling, Dave's assistant

Shashi K. Gupta, Stephen J. Cox, Taiping Zhang – Analytical Services and Materials, Inc.

Laura Hinkelman - NIA

NASA/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

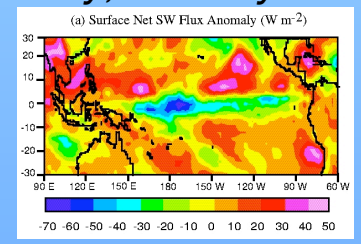
Global Aerosols & Smoke

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)



NASA Applications Energy Forecasting

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.

SRB Version Differences

- **Current Archive:**
  - SRB SW, SWQC, LWQC v2.0/ LW v2.1: ISCCP-DX, GEOS-1, 06/83-10/95
- **Now Available:**
  - SRB SW, SWQC, LW, LWQC v2.5: replace GEOS-1 with GEOS-4, lengthen series 06/83-12/04, upgrade filling for SW
  - SRB SW v2.6: New TOA computation, 06/83-12/04
- **SRB v2.5/2.6 to be available from ASDC within next month**
  - Also being submitted to GEWEX-RFA archive
  - Note: New patch for SW (v2.7) => treat altitude dependence of Rayleigh scatter (ala Laszlo presentation)

TOA Insolation Issue SW v2.0

- **SRB SW v2.0 contains monthly averaged missing data in polar twilight zones where solar zenith never goes below 72.5 degrees.**
- **Raschke et al., 2006, GRL showed differences of 40-50 W m^{-2} in polar zones between ISCCP-FD and SRB SW v2.0**
  - Zonal averages computed from v2.0 without proper filling of missing data
  - A reply is being written to the article
- **SRB v2.5 introduced new filling to prevent missing data: zonal differences reduced to 8-10 Wm^{-2} in zones**
- **SRB v2.6 uses more rigorous insolation relation: zonal differences reduced to less than 1 W m^{-2} after normalization of solar constants**

Global Annual Averages

Parameter	Ohmura & Gilgen (1993) *GEBA Surf. Obs.*		Kiehl and Trenberth (1997) ERBE/ CCM3		Zhang & Rossow (2004) *21-Year Mean (1984-2004)*		NASA/GEWEX SRB Rel. 2.5* (NASA LaRC) *21-Year Mean (1984-2004)*			
							SW, LW		SW, LW QC	
	Flux	% F_0	Flux	% F_0	Flux	% F_0	Flux	% F_0	Flux	% F_0
SW Down	169.0	49.4	198	57.9	189.2	55.4	187.3	54.8	183.7	53.8
SW Net	142.0	41.6	168	49.2	165.9	48.5	164.9	48.3	161.0	47.1
LW Down	345	100.9	324	94.8	343.8	100.6	343.1	100.4	348.7	102.0
LW Net	-40.0	-11.7	-66	-19.3	-49.6	-14.5	-53.0	-15.5	-50.0	-14.6
Total Net	102.0	29.8	102	29.8	116.3	34.0	111.9	32.7	111.0	32.5
SW CRF	--	--	--	--	-53.0	-15.5	-56.2	-16.4	-59.2	-17.3
LW CRF	--	--	46	13.5	29.5	8.6	35.3	10.3	34.3	10.0
Total CRF	--	--	--	--	-23.5	-6.9	-20.9	-6.1	-24.9	-7.3

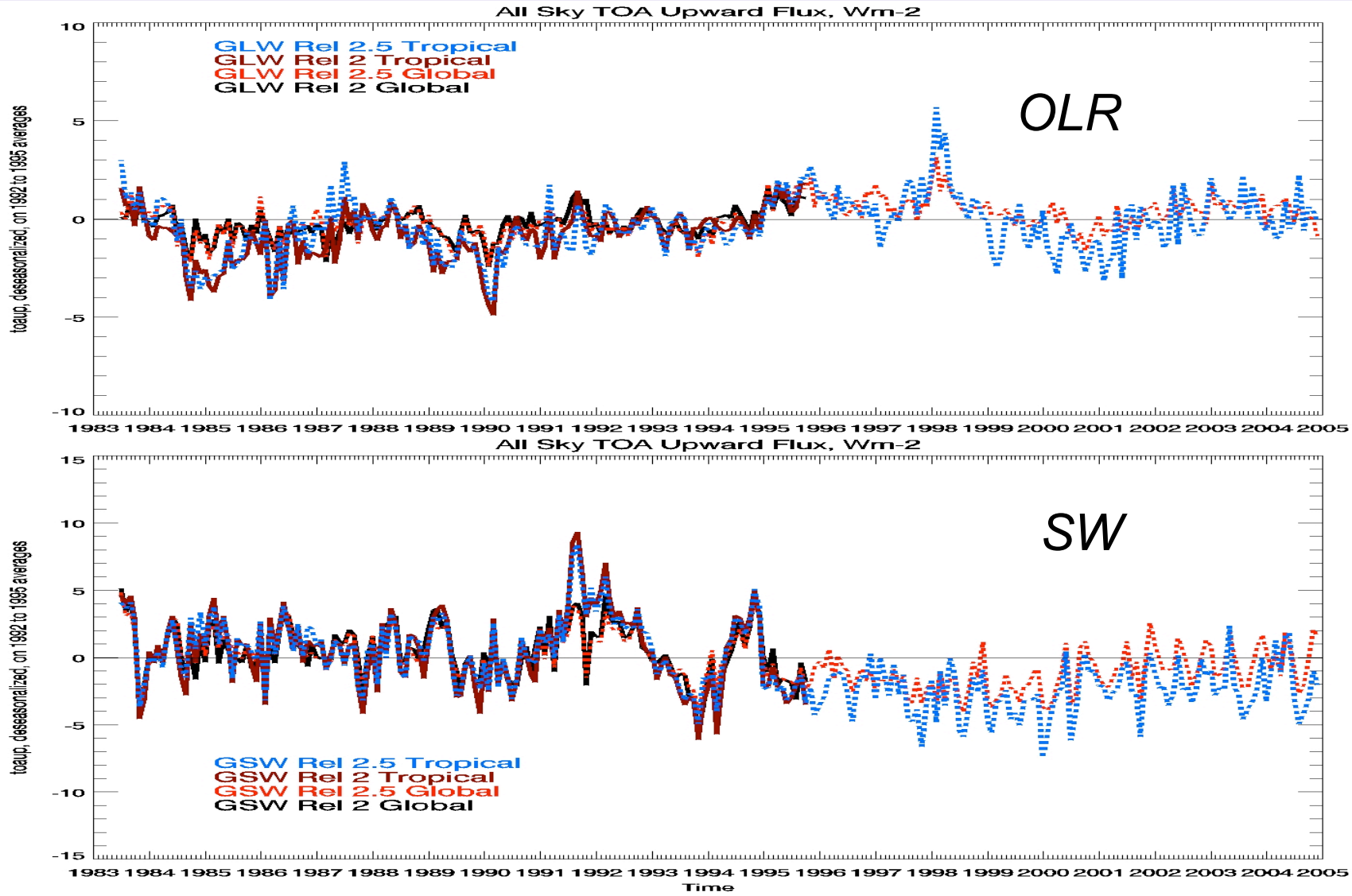
** Normalized to $S_0 = 1367\ W\ m^{-2}$; ($F_0 = S_0/4$)*

Overall Surface Validation Results

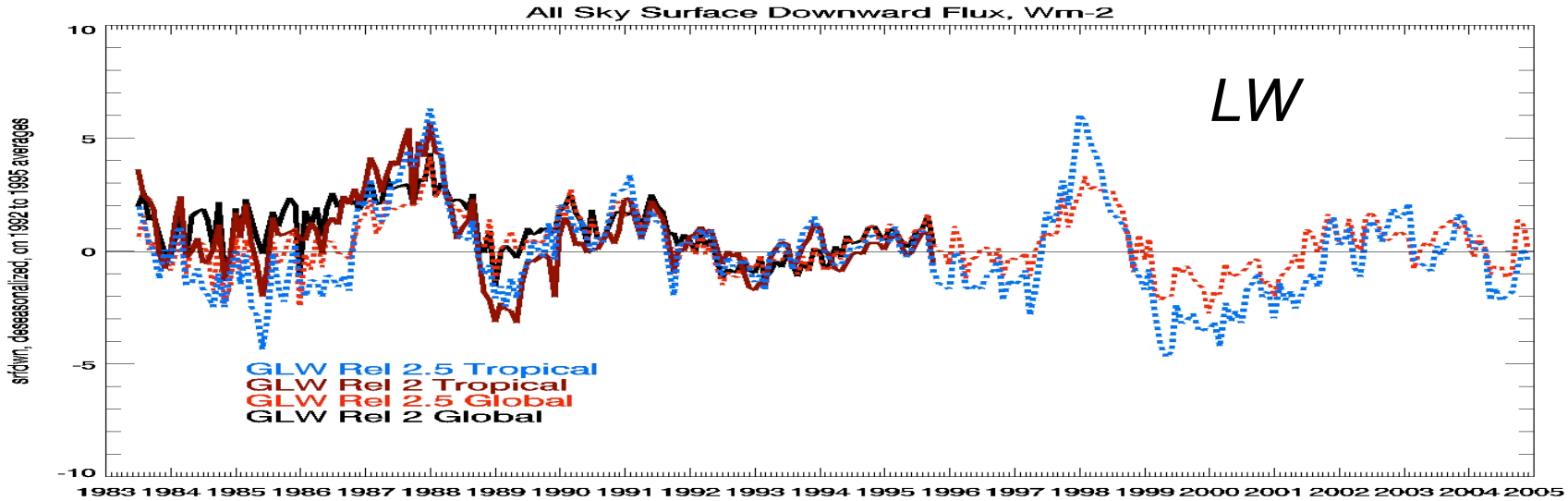
- Input uncertainties
- Assumption uncertainties (RT, sampling)
- Dependencies of the uncertainties:
  - seasonal dependencies/latitude
  - surface or climate type

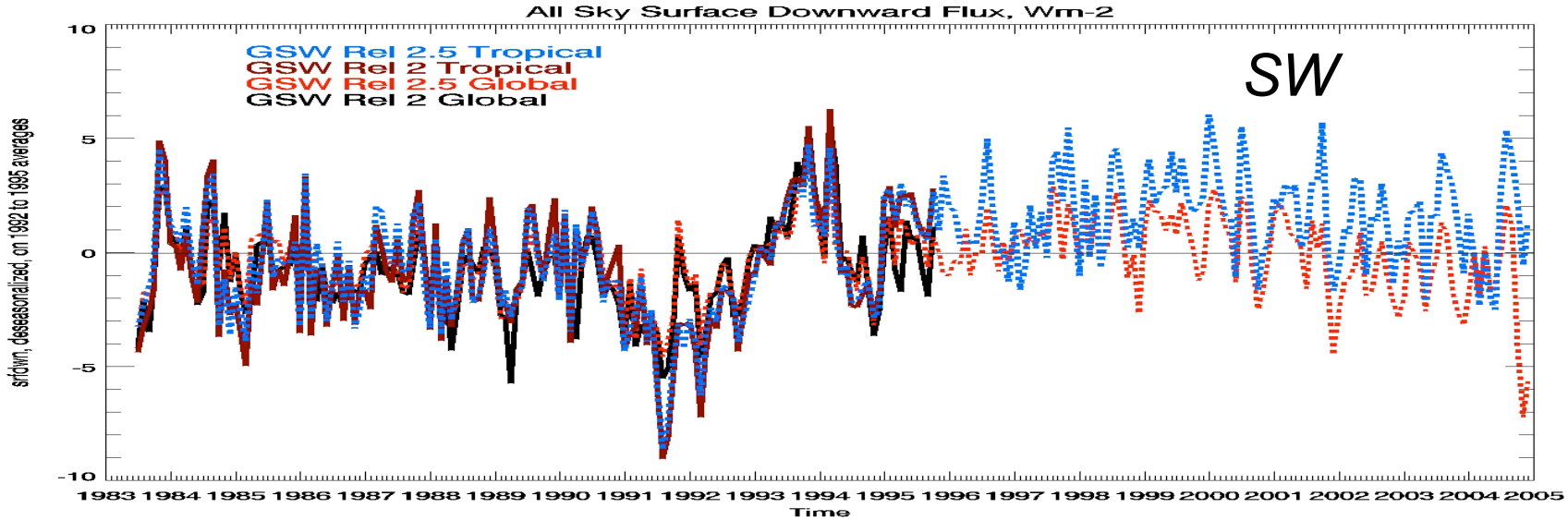
Quantity (Instrument)	Instantaneous Gridded (1 Hour Averaged Obs., 8 times per day; W m^{-2})	1 Day (W m^{-2})	1 Month (W m^{-2})	Monthly Averaged 3-hourly	Longer time averages
LW Broadband	30 - 35	23 -- 29	12 -- 17	18 -- 22	??
SW Broadband	75 - 95	35 -- 45	15 -- 25	38 -- 42	??

TOA Flux Anomalies

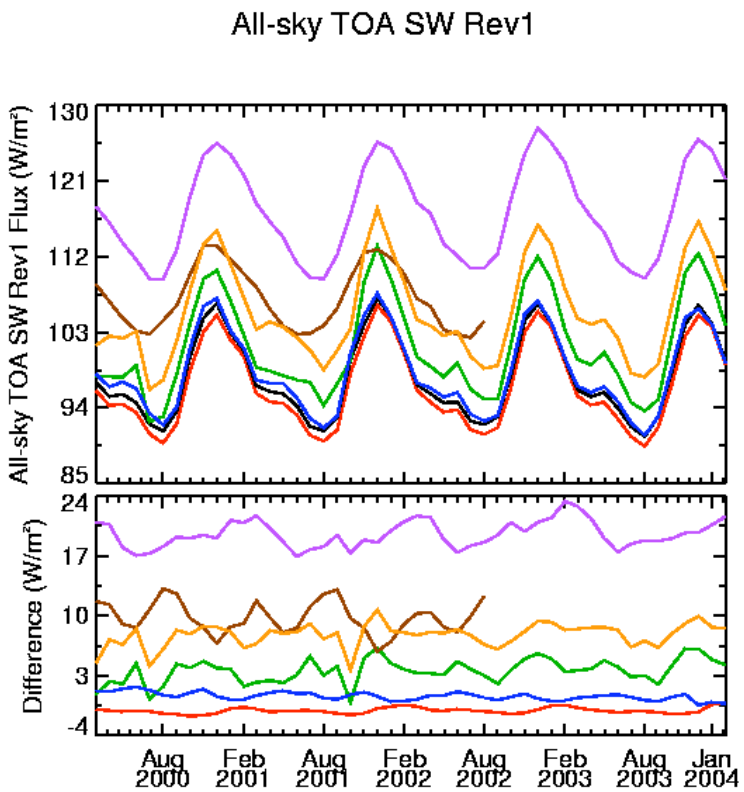


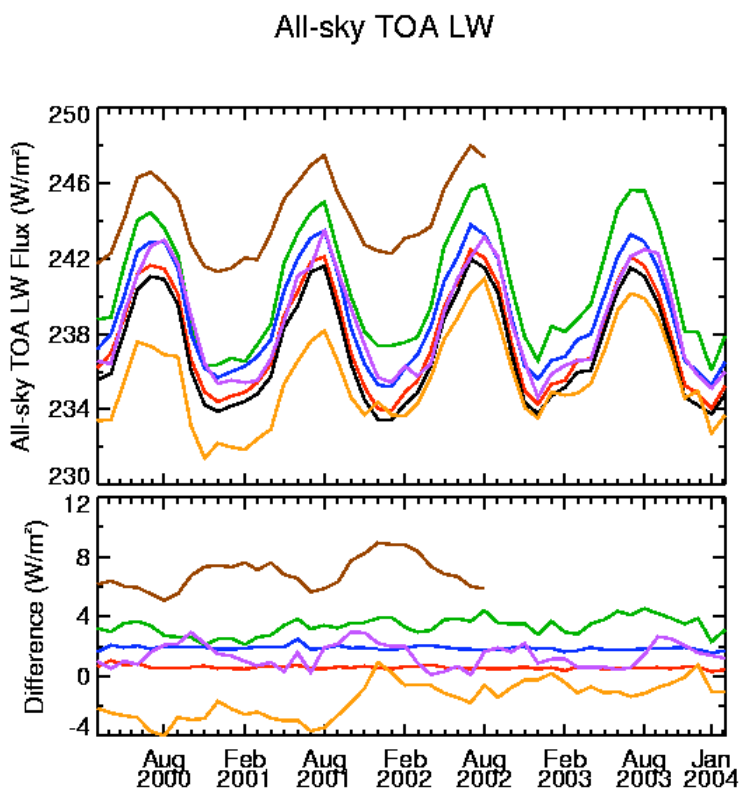
Surface Downward Timeseries





Time Series Comparisons to CERES SRBAVG, ERA-40, NCEP, and ISCCP-FD

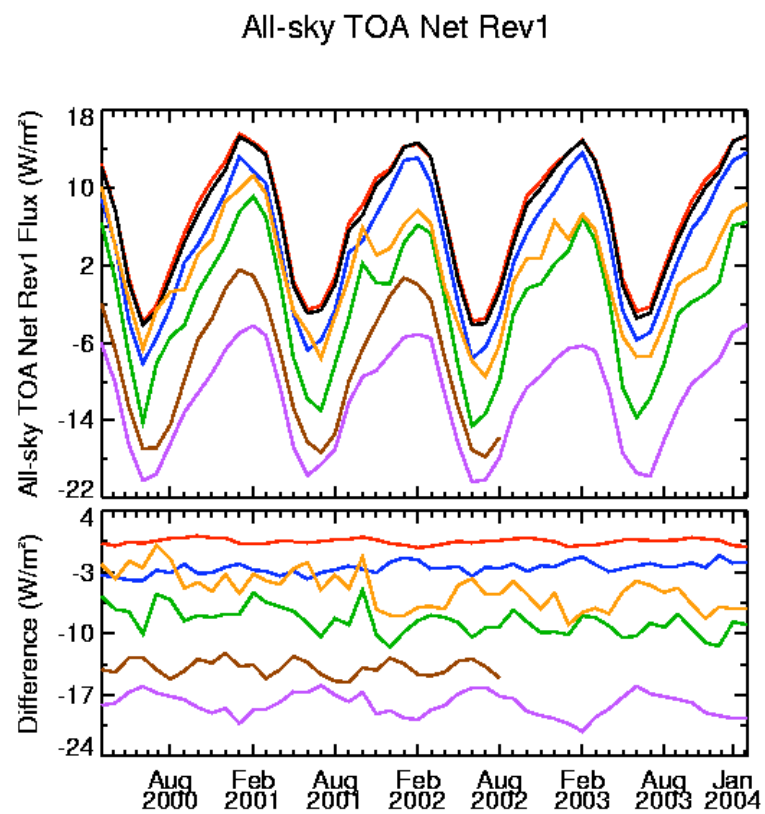




All-sky TOA SW Rev1		Difference		Avg
nonGEO	96.6	nonGEO - GEO		-1.1
GEO	97.7			
SRB	101.3	SRB - GEO		3.6
ERBE_like	98.3	ERBE_like - GEO		0.6
NCEP	117.3	NCEP - GEO		19.6
ECMWF	107.0	ECMWF - GEO		9.8
ISCCP FD	105.5	ISCCP FD - GEO		7.8

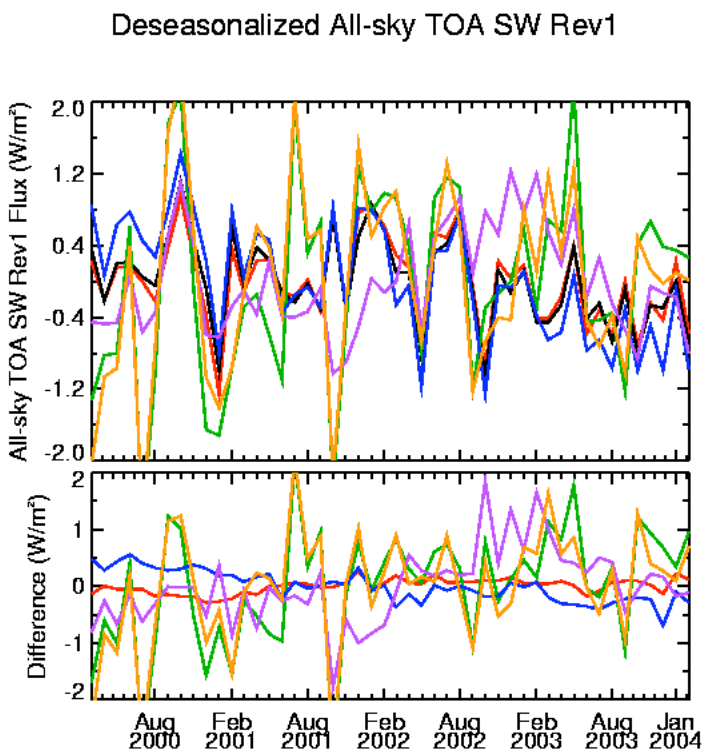
All-sky TOA LW		Difference		Avg
nonGEO	237.7	nonGEO - GEO		0.6
GEO	237.2			
SRB	240.5	SRB - GEO		3.3
ERBE_like	239.0	ERBE_like - GEO		1.9
NCEP	238.5	NCEP - GEO		1.4
ECMWF	244.3	ECMWF - GEO		6.9
ISCCP FD	235.6	ISCCP FD - GEO		-1.5

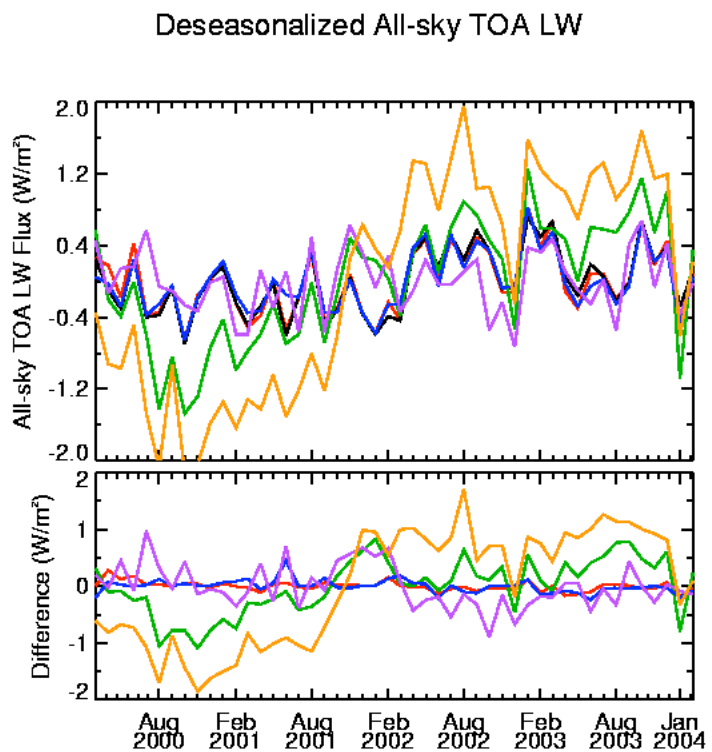
Time Series Comparisons to CERES SRBAVG, ERA-40, NCEP, and ISCCP-FD



All-sky TOA Net Rev1		Difference		Avg
nonGEO	7.0	nonGEO - GEO		0.5
GEO	6.5			
SRB	-2.1	SRB - GEO		-8.6
ERBE_like	3.9	ERBE_like - GEO		-2.5
NCEP	-11.6	NCEP - GEO		-18.1
ECMWF	-8.3	ECMWF - GEO		-13.9
ISCCP FD	1.4	ISCCP FD - GEO		-5.0

Time Series Comparisons to CERES SRBAVG, ERA-40, NCEP, and ISCCP-FD

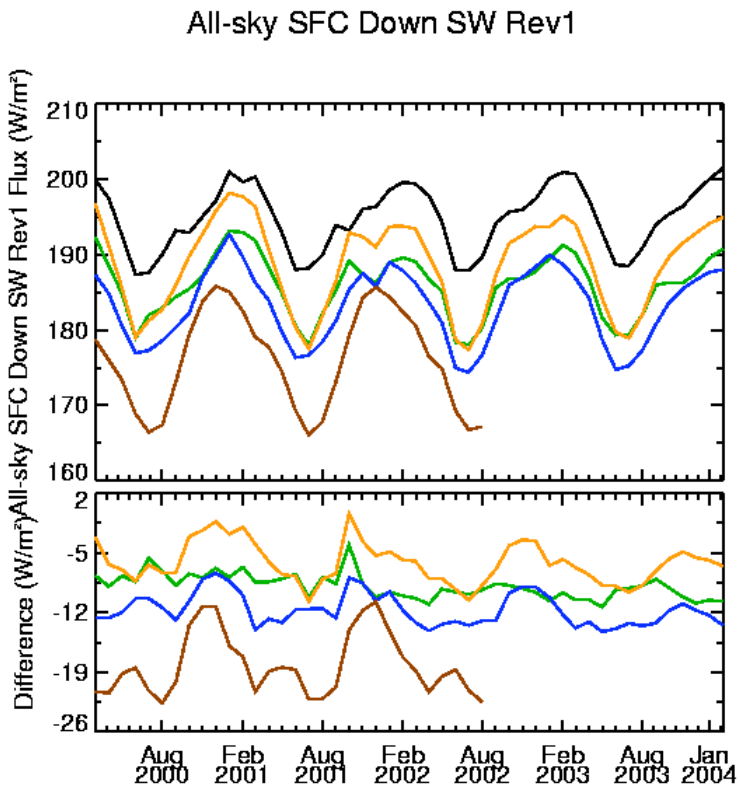


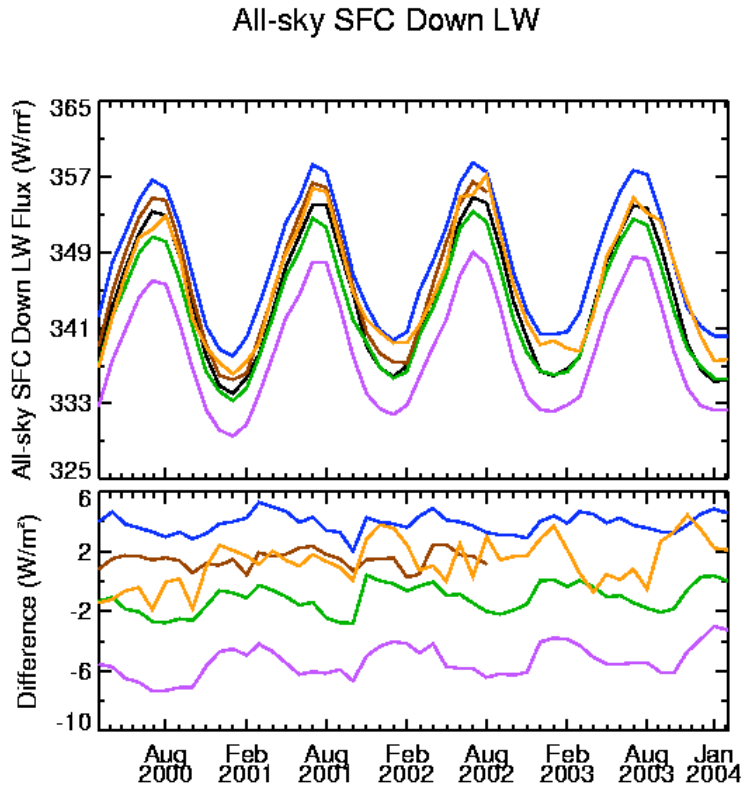


All-sky TOA SW Rev1		Difference		Avg
nonGEO	-0.0000	nonGEO - GEO		-0.0000
GEO	0.0000			
SRB	0.0000	SRB - GEO		0.0000
ERBE_like	0.0000	ERBE_like - GEO		0.0000
NCEP	-0.0000	NCEP - GEO		-0.0000
ISCCP FD	-0.0000	ISCCP FD - GEO		-0.0000

All-sky TOA LW		Difference		Avg
nonGEO	0.0000	nonGEO - GEO		-0.0000
GEO	0.0000			
SRB	0.0000	SRB - GEO		-0.0000
ERBE_like	0.0000	ERBE_like - GEO		0.0000
NCEP	0.0000	NCEP - GEO		0.0000
ISCCP FD	0.0000	ISCCP FD - GEO		0.0000

Time Series Comparisons to CERES SRBAVG, ERA-40, NCEP, and ISCCP-FD

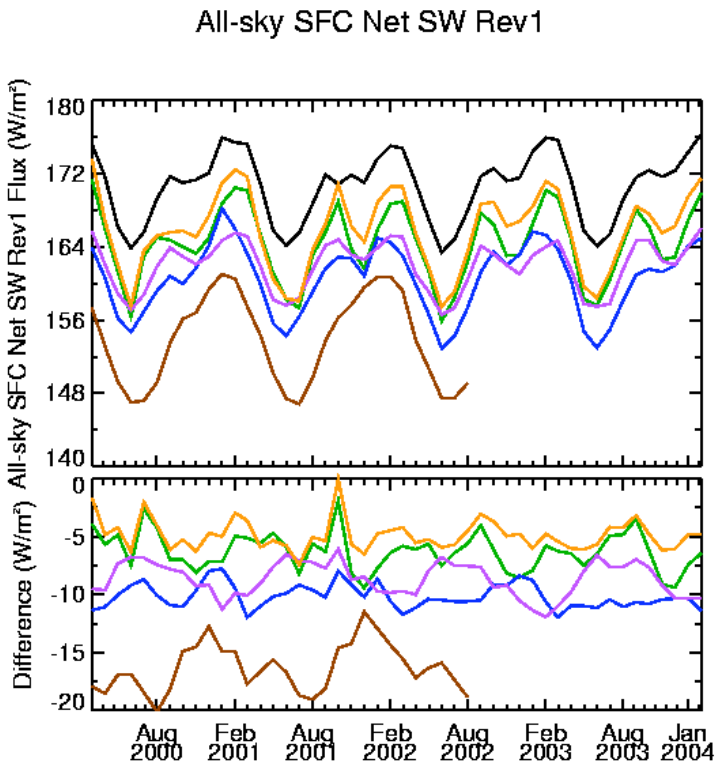


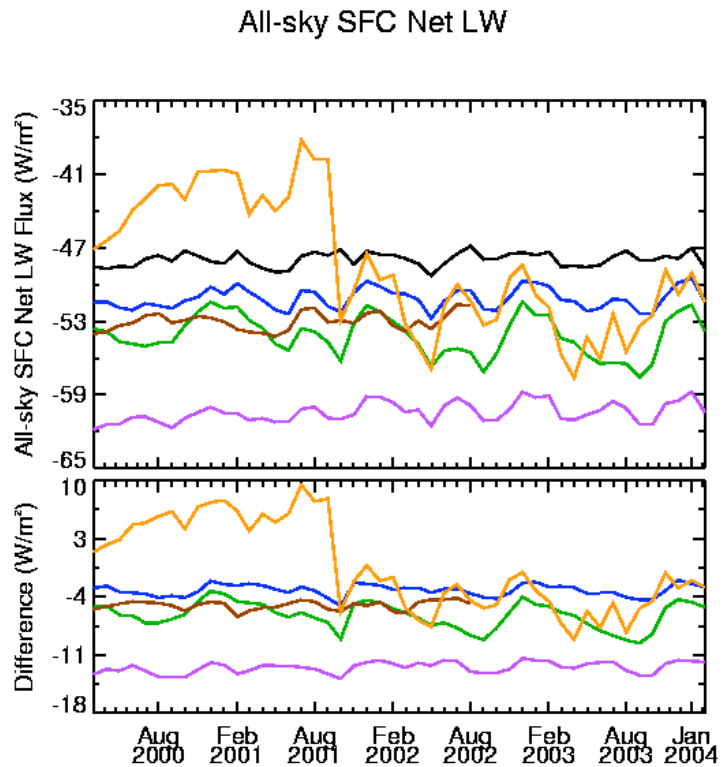


All-sky SFC Down SW Rev1		Difference		Avg
modelA		modelA - modelB		
modelB	194.9			
SRB	186.0	SRB - modelB		-8.9
SRB_QC	183.2	SRB_QC - modelB		-11.7
NCEP		NCEP - modelB		
ECMWF	176.0	ECMWF - modelB		-18.2
ISCCP FD	188.7	ISCCP FD - modelB		-6.2

All-sky SFC Down LW		Difference		Avg
modelA		modelA - modelB		
modelB	344.1			
SRB	342.9	SRB - modelB		-1.1
SRB_QC	347.9	SRB_QC - modelB		3.9
NCEP	338.7	NCEP - modelB		-5.4
ECMWF	346.2	ECMWF - modelB		1.5
ISCCP FD	345.4	ISCCP FD - modelB		1.3

Time Series Comparisons to CERES SRBAVG, ERA-40, NCEP, and ISCCP-FD

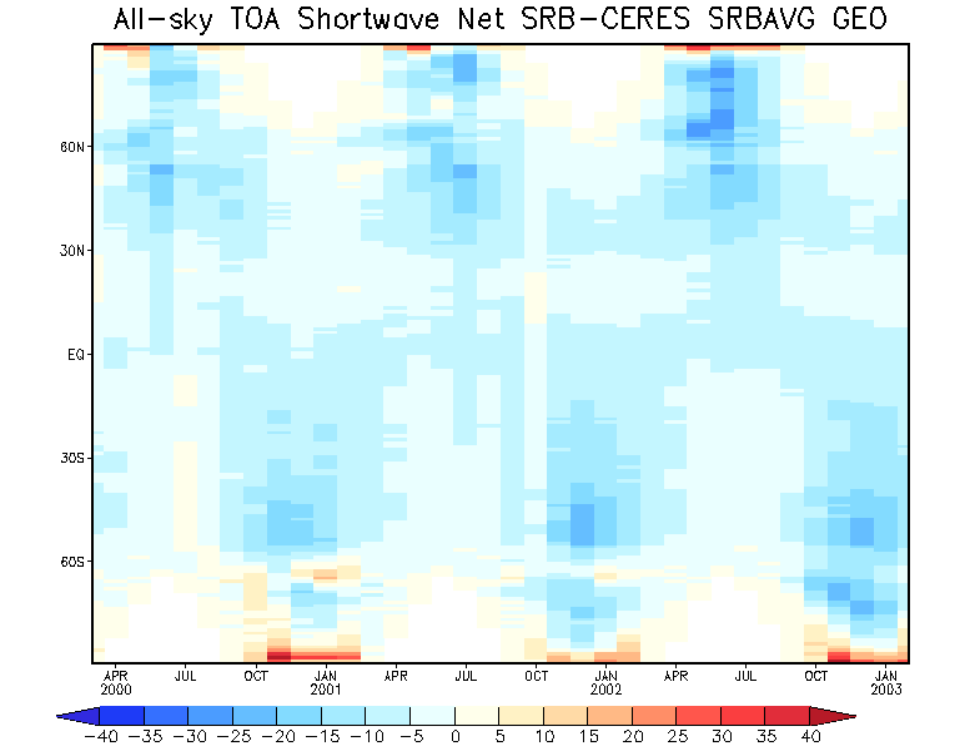


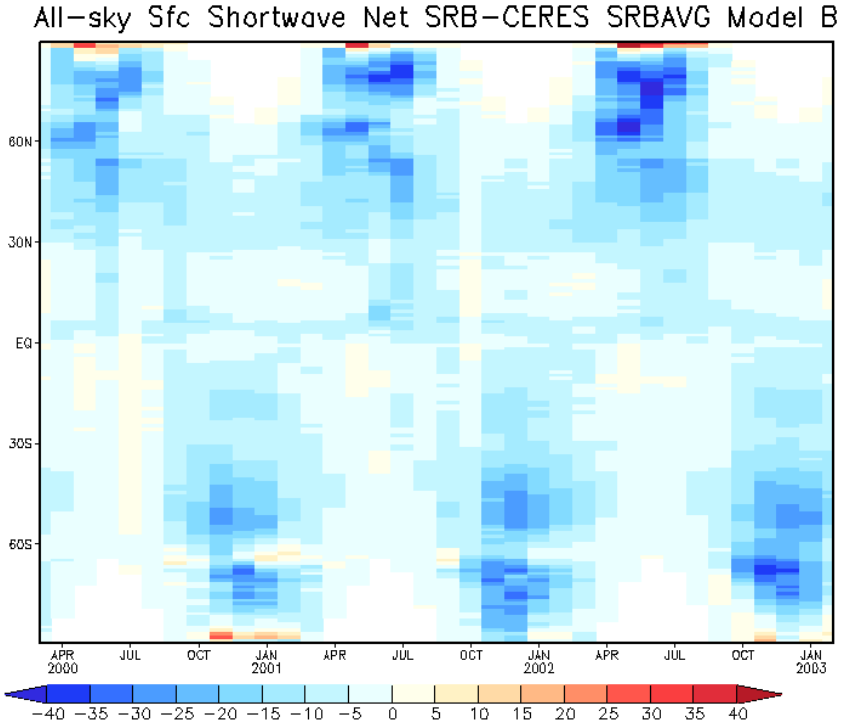


All-sky SFC Net SW Rev1		Difference		Avg
modelA		modelA - modelB		
modelB	170.6			
SRB	164.4	SRB - modelB		-6.3
SRB_QC	160.5	SRB_QC - modelB		-10.2
NCEP	162.0	NCEP - modelB		-8.7
ECMWF	153.8	ECMWF - modelB		-16.3
ISCCP FD	165.8	ISCCP FD - modelB		-4.8

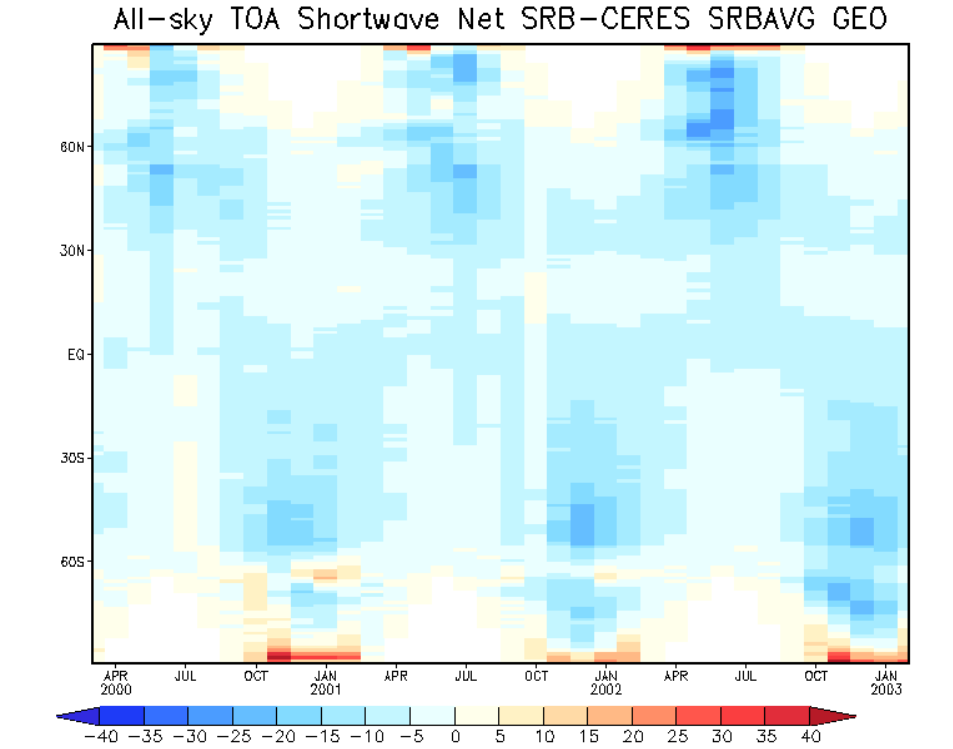
All-sky SFC Net LW		Difference		Avg
modelA		modelA - modelB		
modelB	-47.9			
SRB	-54.2	SRB - modelB		-6.2
SRB_QC	-51.1	SRB_QC - modelB		-3.2
NCEP	-60.4	NCEP - modelB		-12.5
ECMWF	-53.0	ECMWF - modelB		-5.0
ISCCP FD	-48.3	ISCCP FD - modelB		-0.4

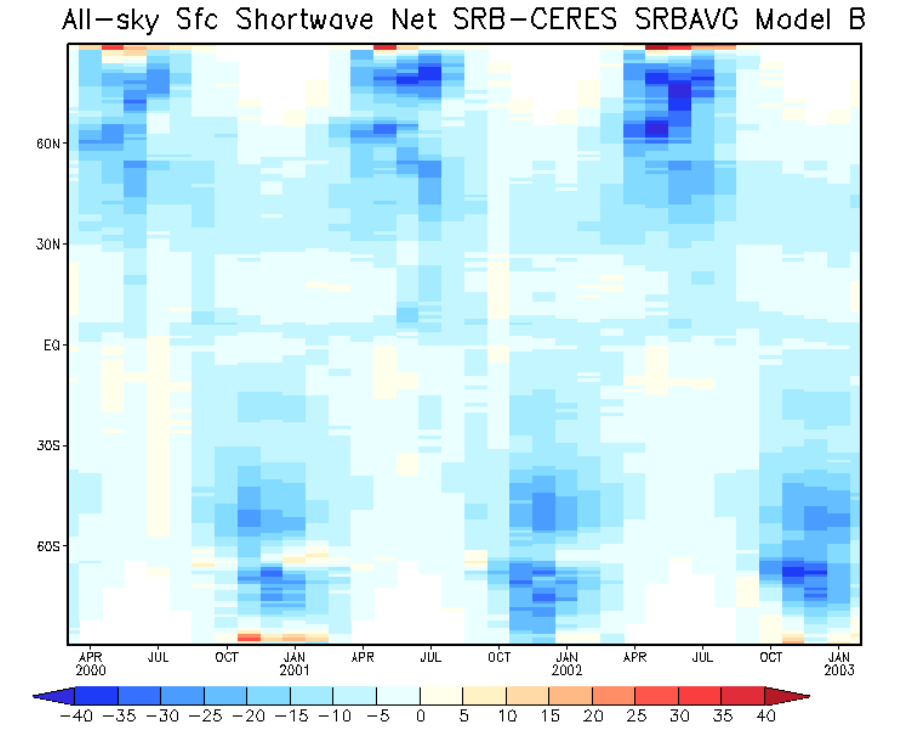
Map Intercomparisons



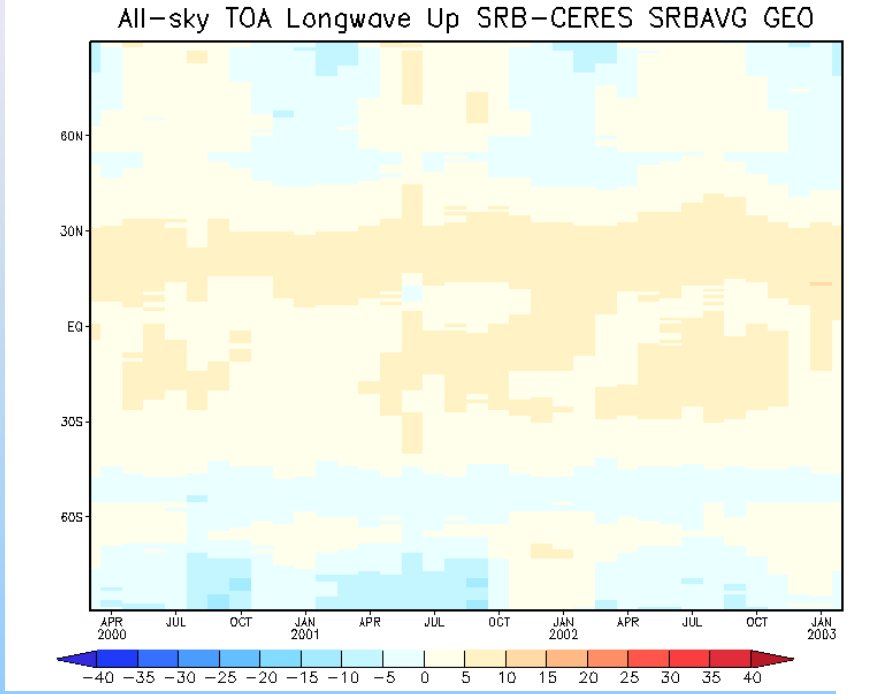


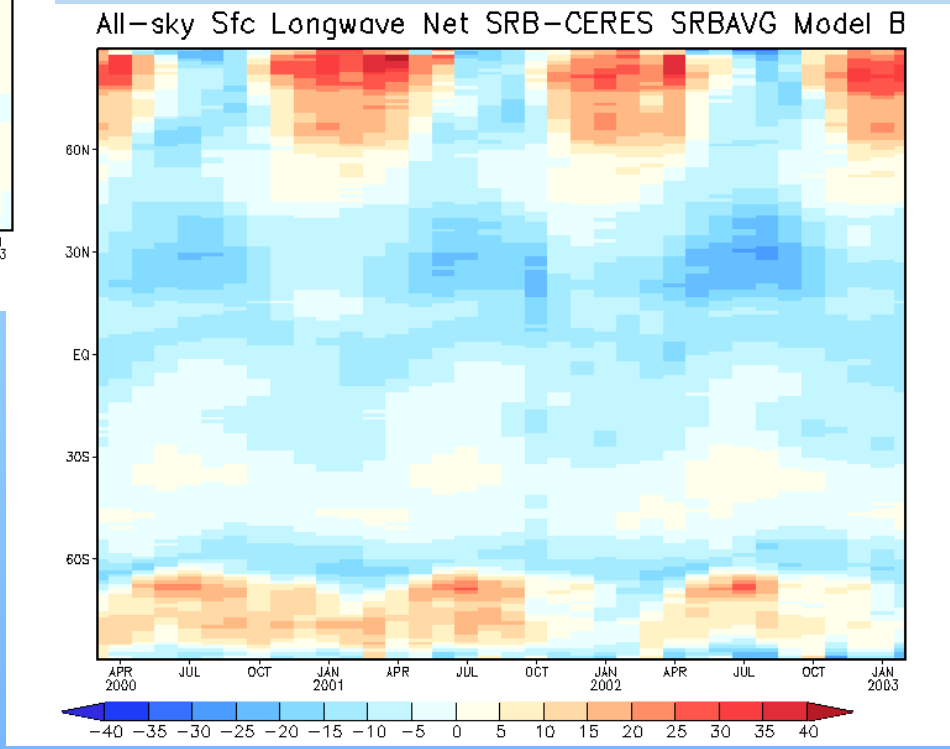
SW Zonal Time Series Differences



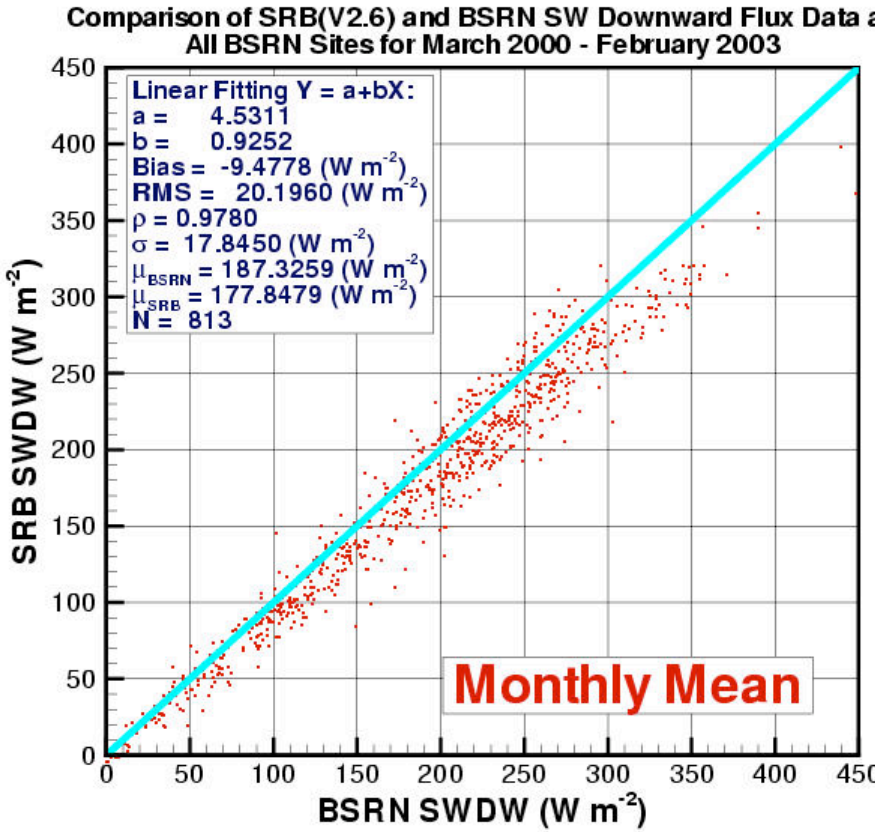


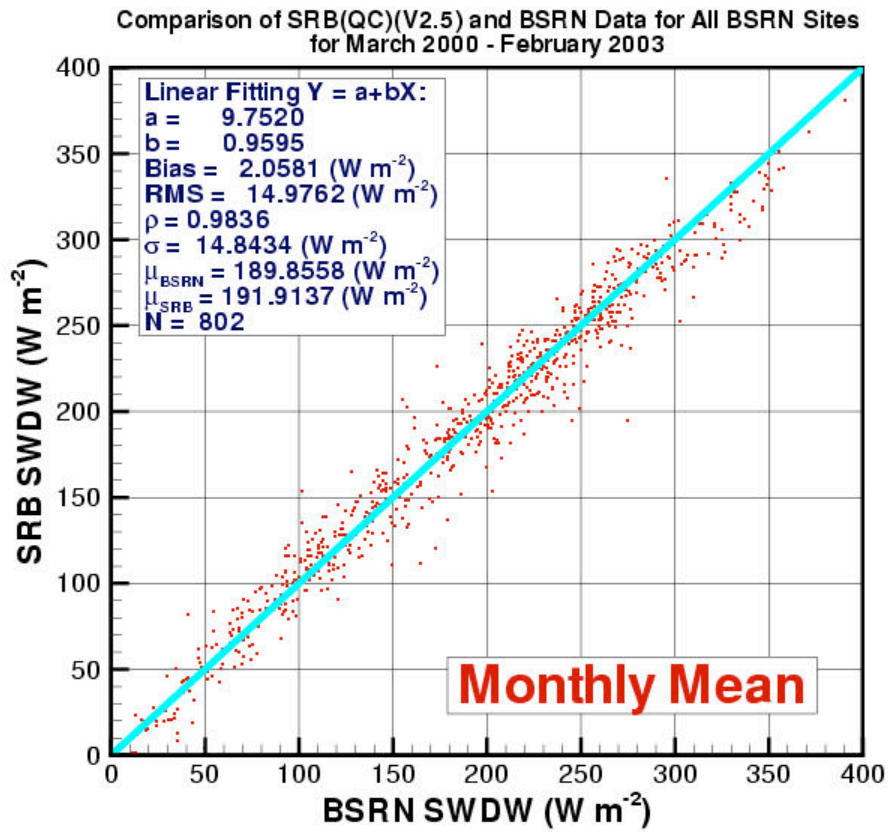
LW Zonal Timeseries Differences



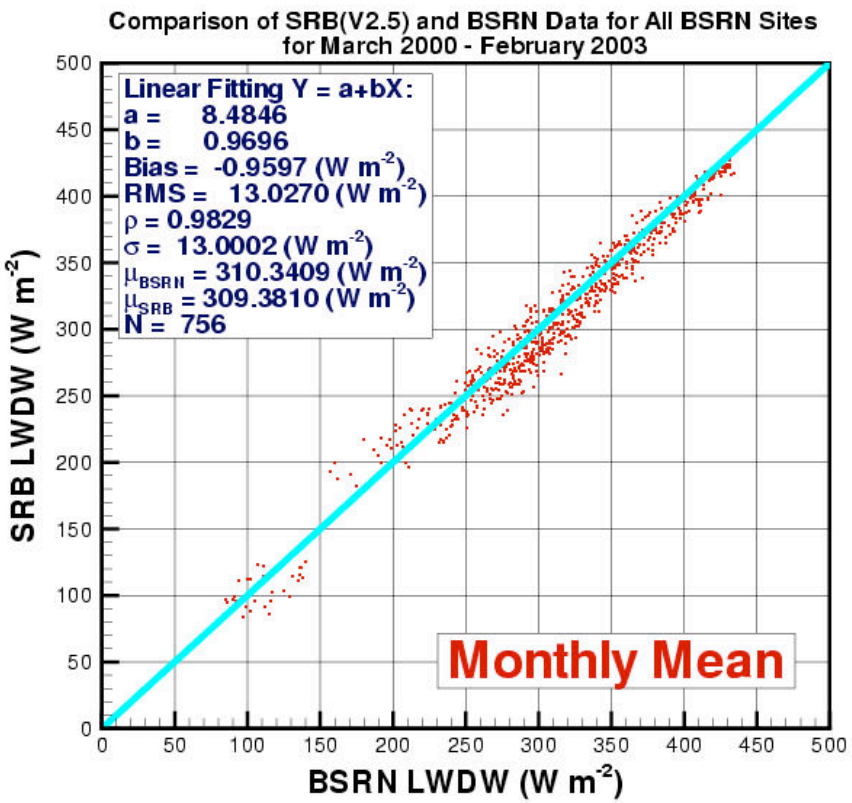


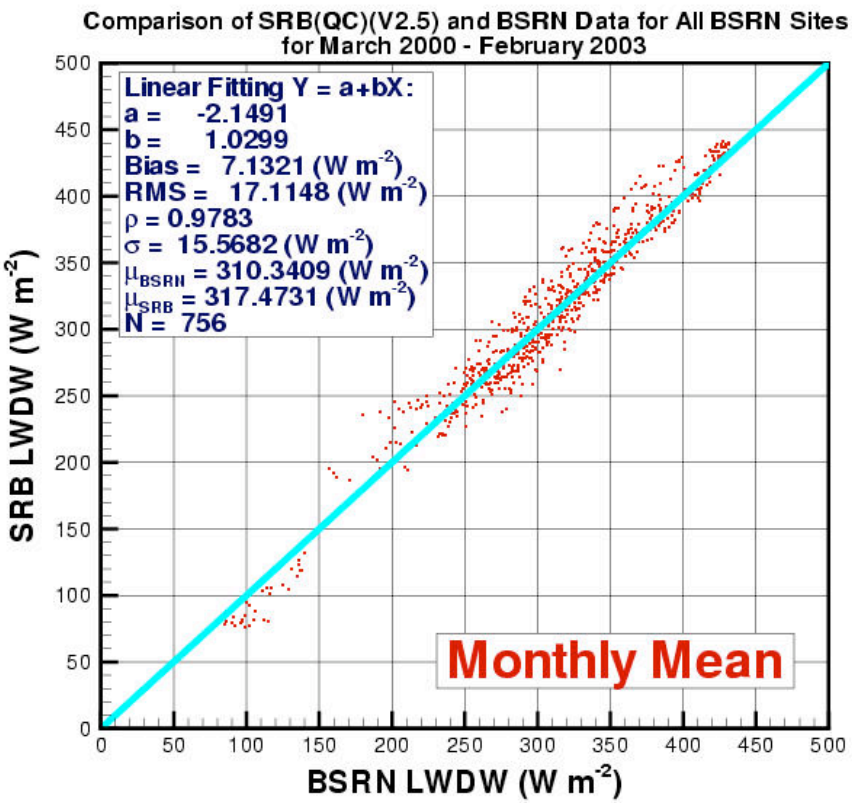
SRB SW Validation





SRB LW Validation





Surface Validation Comparison

SRBAVG: Mar. 2001 - Feb. 2003

(%)	SW		LW	
	SOFA	SRBAVG	SOFA	SRBAVG
Bias	3.3	1.5	-0.6	0.6
RMS	15.0	9.6	7.4	3.3

SRB: Mar. 2001 - Feb. 2003

(%)	SW		LW	
	P/L	QC	FL/S	QC
Bias	-5.1	1.1	-0.3	2.2
RMS	10.8	7.9	4.2	5.5

SRB Conclusions

- **Processing, Archival, and Dissemination**
  - Rel. 2.5/2.6 (SW) being completed, archived, delivered to GEWEX-RFA web site
  - TOA insolation issues addressed
- **Comparison to CERES SRBAVG**
  - Good consistency between SRB and SRBAVG during the time period
  - Global means usually within a few W m^-2 and closer than furtherest outlier
  - Large differences do exist: SW over poles; LW deserts
  - Bias and RMS validation consistent with SRBAVG fluxes and consistent global maps
- **Future Work**
  - Continued analysis and intercomparisons
  - Address differences and identify sources of error
  - Ultimately improve SRB algorithms and analysis using CERES

Backup Slides

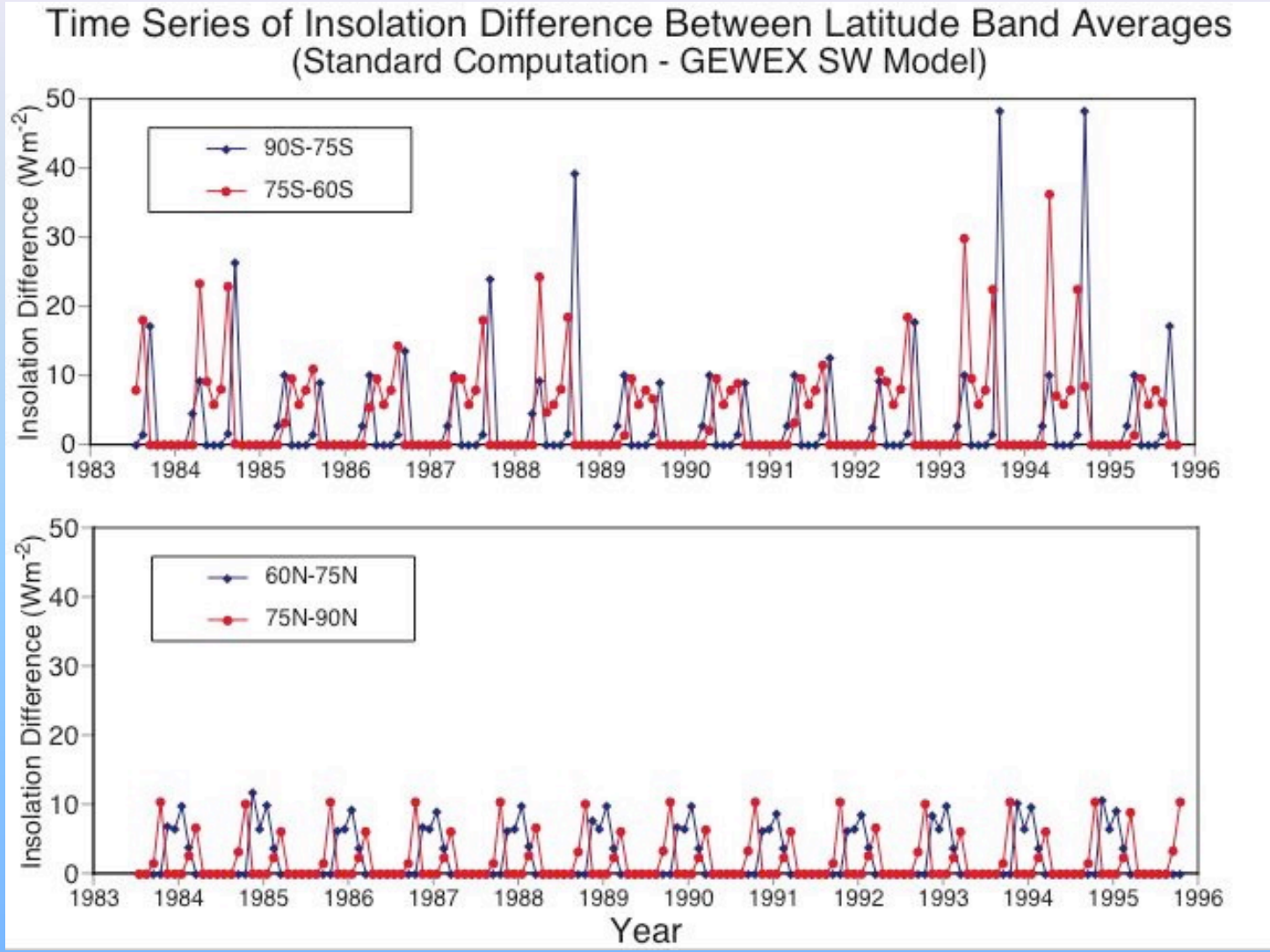
SRB Conclusions Cont'd

- **Comparisons to Surface Sites (cont'd)**
  - Bias with time => a measure of stability; GEBA sites show variation in time of +/- 5 W m^{-2}
  - Standard Deviation => a measure of precision;
    - SW: 18 - 24 W m^{-2}
    - LW: 10 - 14 W m^{-2}
  - Not shown: difference statistics vary by site and some sites show systematic biases relative to season cycles; errors do show solar angle dependence; polar sites in particular show larger errors (but mainly concentrated at a limited number of sites - GVN, SYO)
- **Time Series analysis**
  - Least squares change analysis shows large sensitivity to sampling and no significant relationship relative to global average changes
  - SRB and ISCCP show agreement within confidence bounds and correlation 0.83 and 0.9 respectively

SRB Conclusions

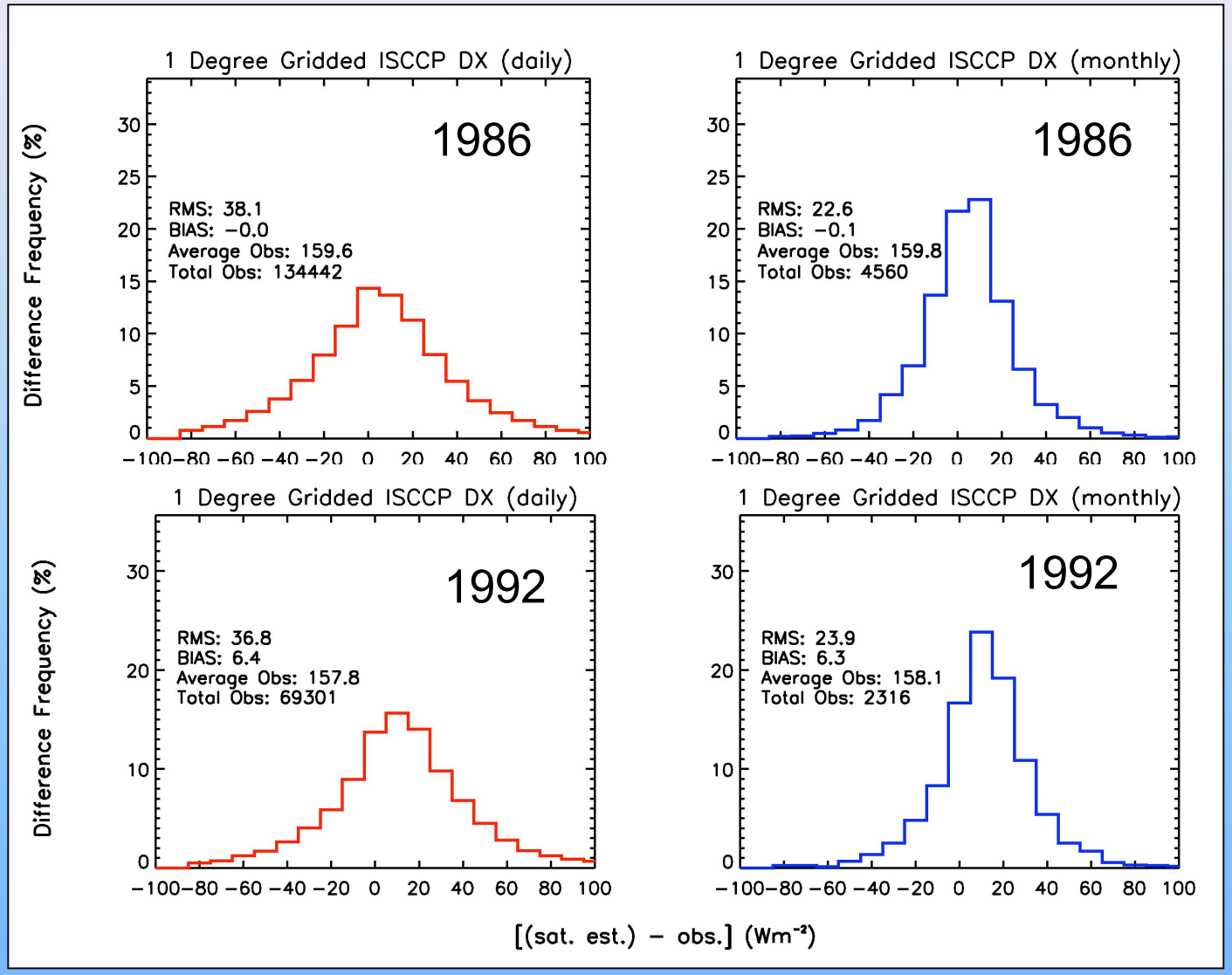
- **Suggested and Needed Improvements to SRB**
  - SW: CERES ADM's, NB-BB conversion, improved climatological aerosols, surface albedos: spectral dependence
  - LW: Boundary layer temp./humidity, skin temperature (assess GMAO improvements), spectral surface emissivities, cloud base

SW TOA Zonal Average Biases

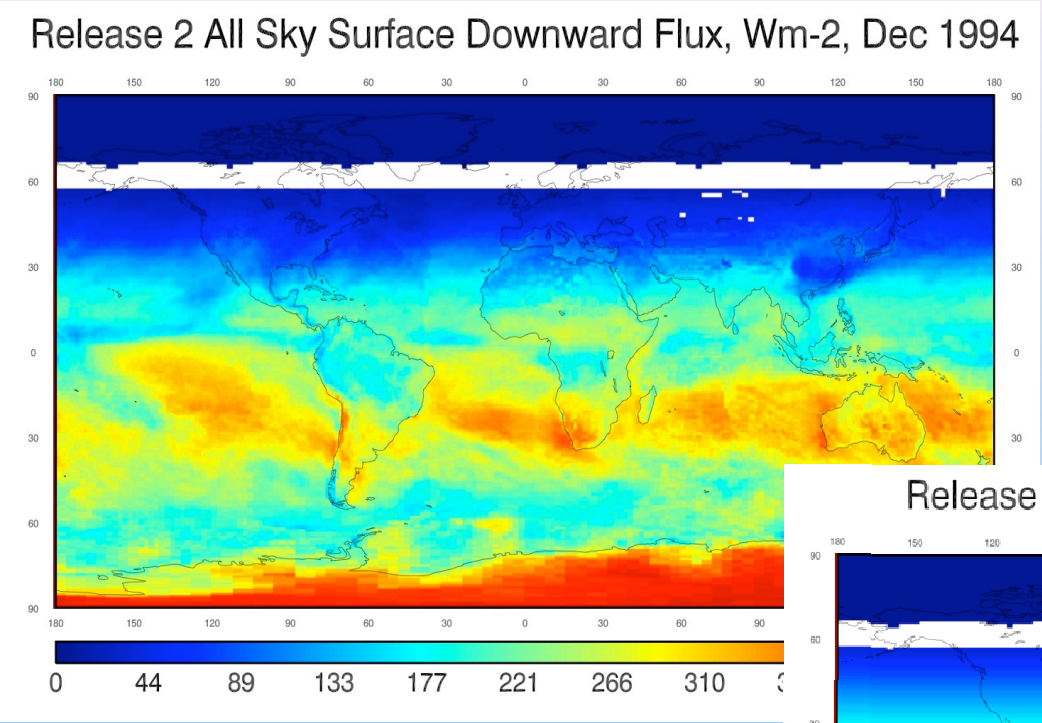


SW SRB R 2.0 Validation

World Radiation Data Centre (WRDC) Daily Averages



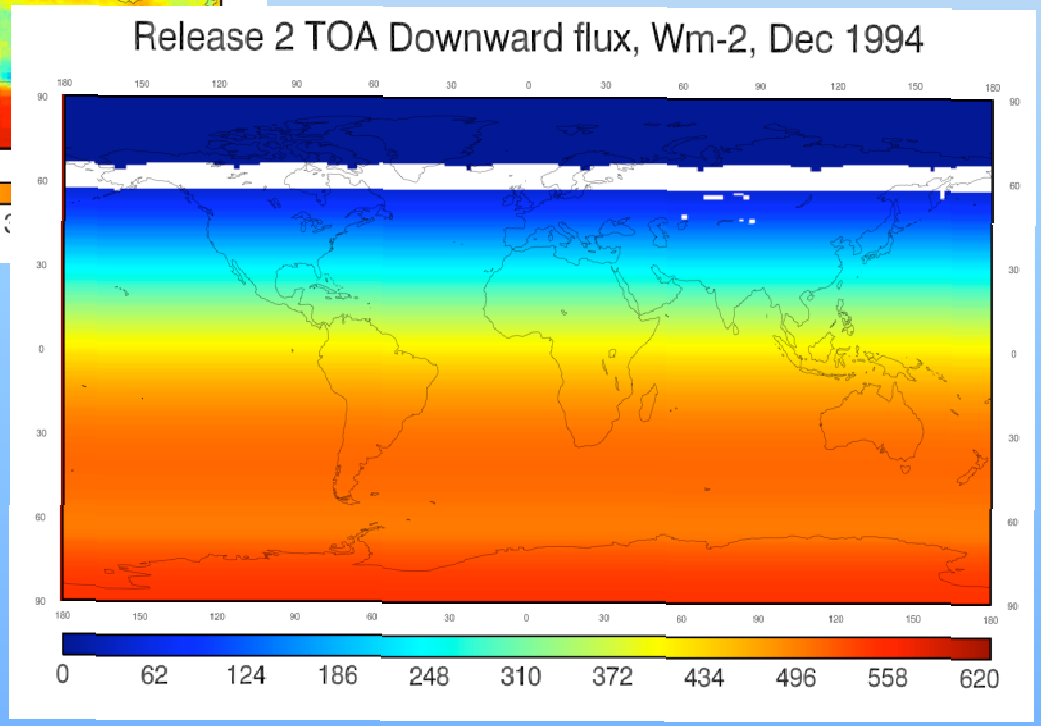
Missing SW data and TOA Fluxes



Missing Data Results because:

- ISCCP sets DX to "night-time", μ_o<0.2

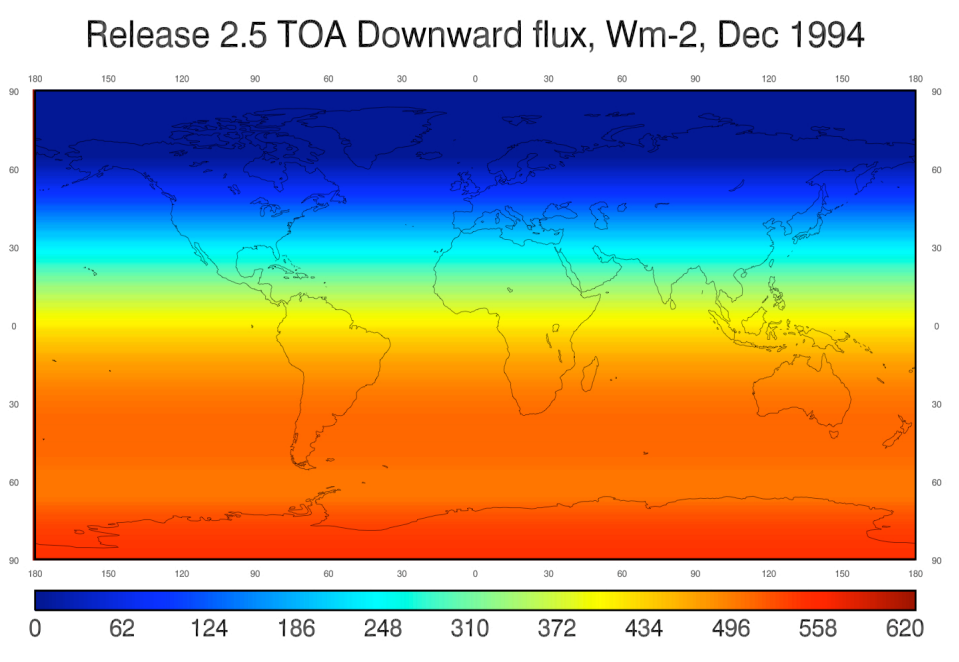
-R. 2 implementation needed nearest east or west box to fill



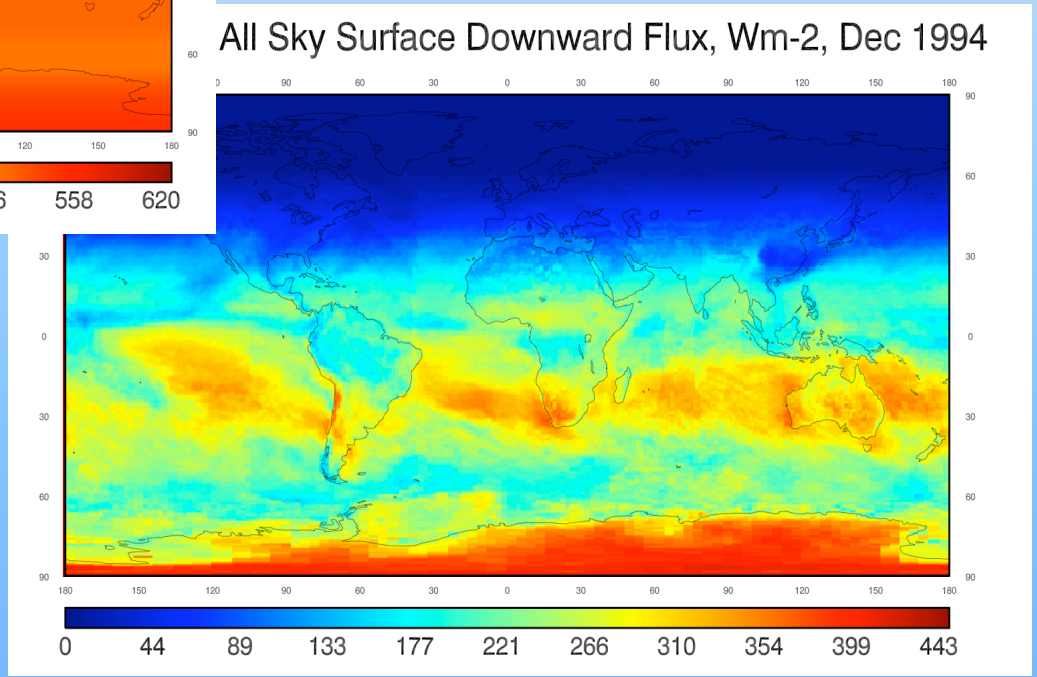
- No box so data marked at polar twilight missing

- If night-time no SW calculation was done even for TOA

Resolution of Polar Twilight Gaps



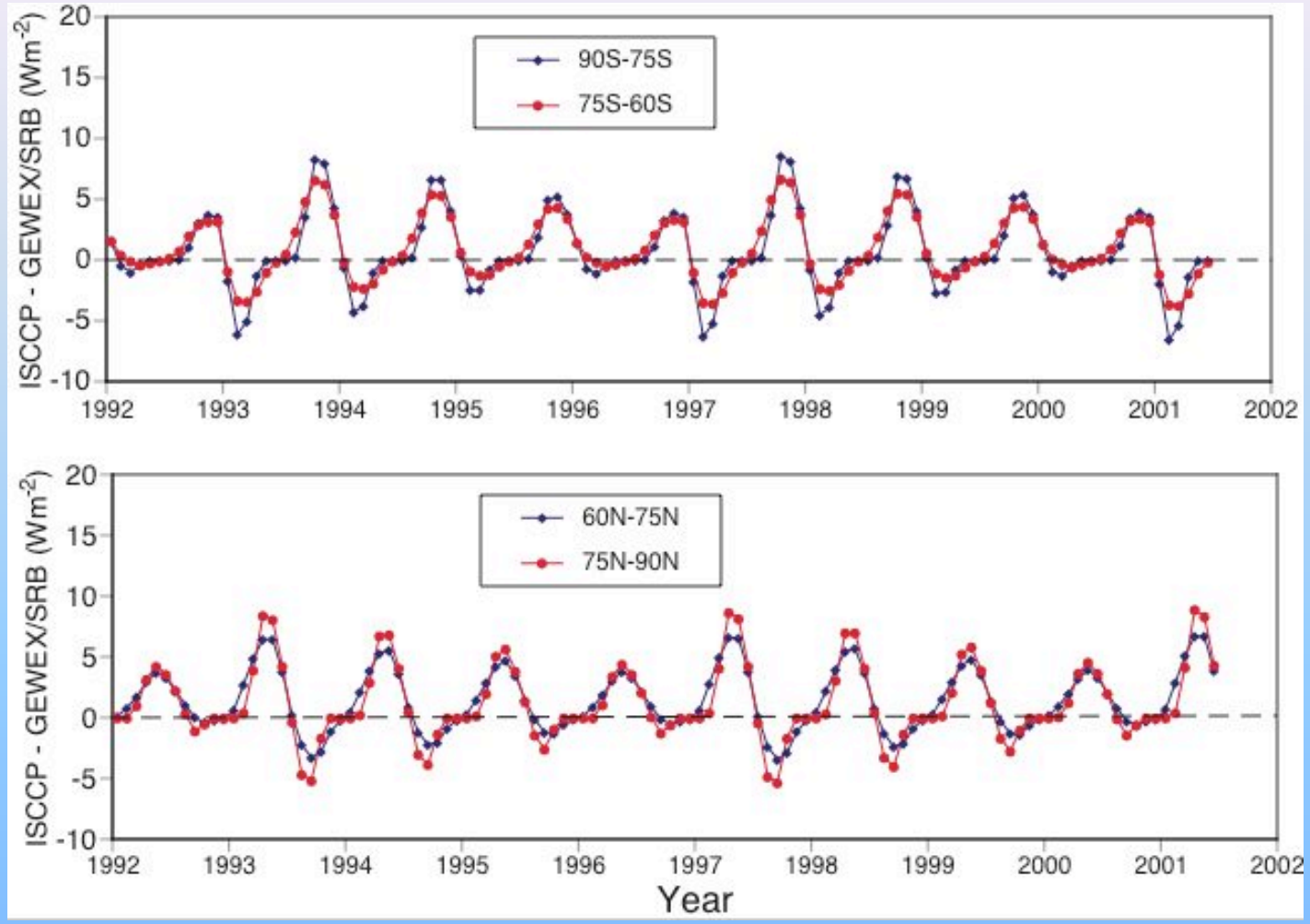
Devised filling strategy IR-only cloud fraction with climatological optical depth



Also extended low angle R and T tables to accommodate smaller angles

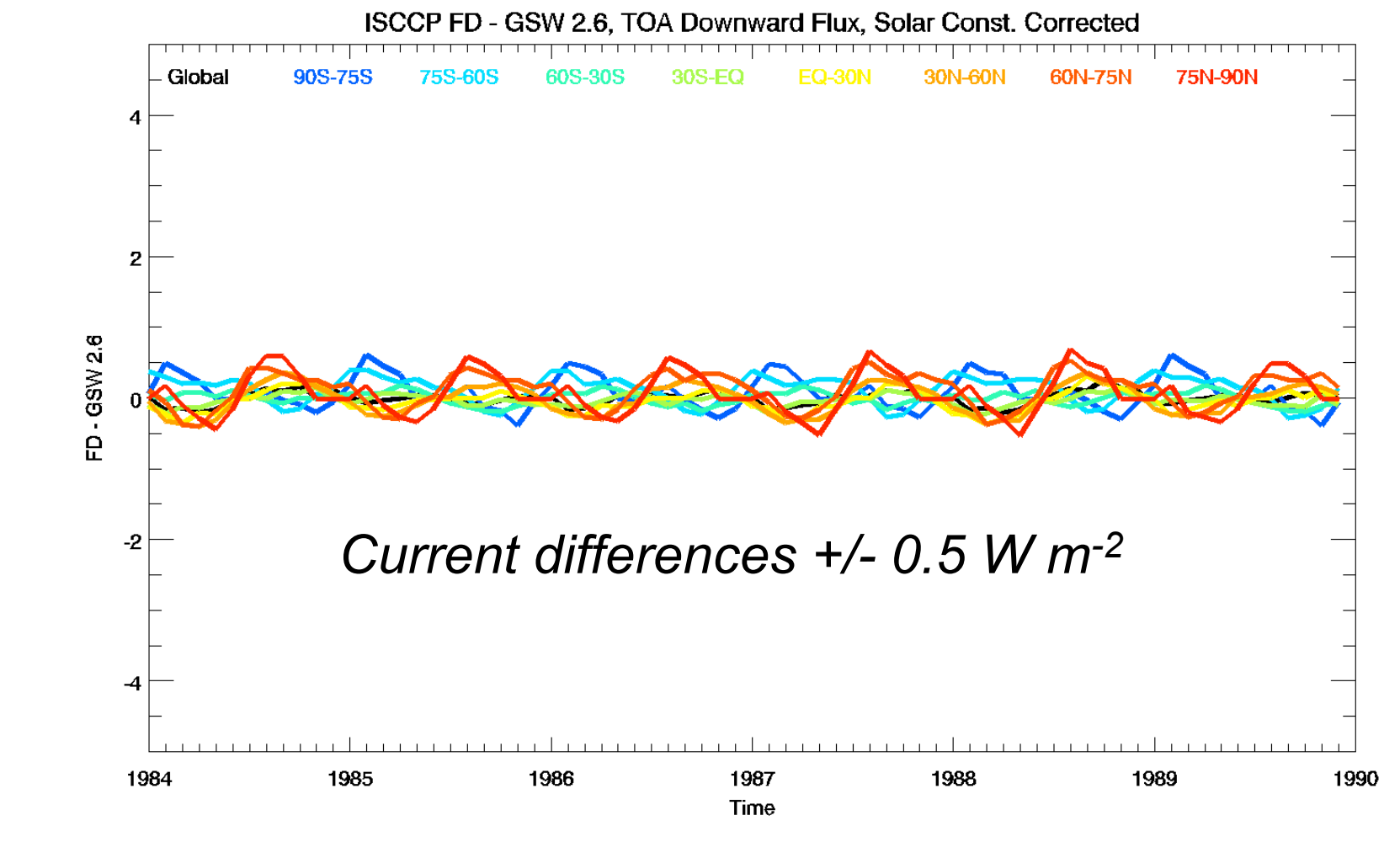
ISCCP-FD and SRB SW 2.5

New zonal averages with filled flux estimates at polar terminator



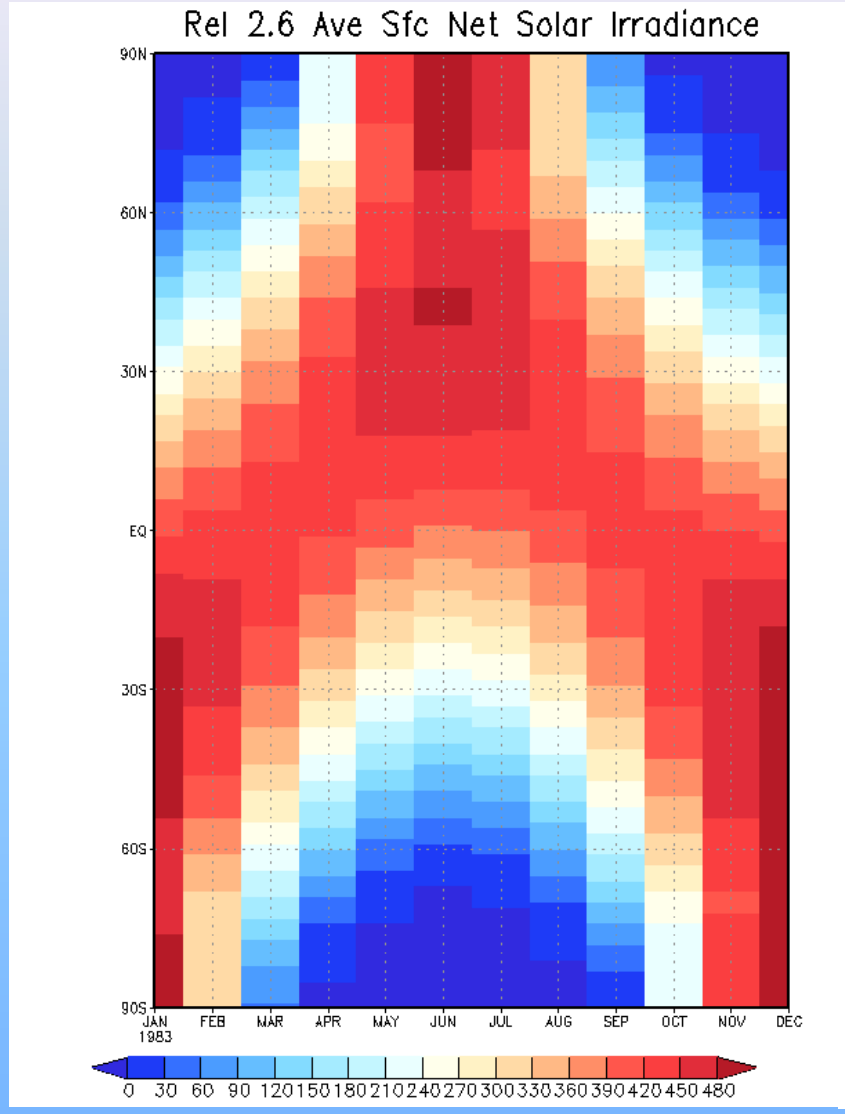
Normalized for solar constant: ISCCP-FD to 5 μm = 1367.0 W m^{-2}
SRB to 4 μm = 1358.8 W m^{-2}

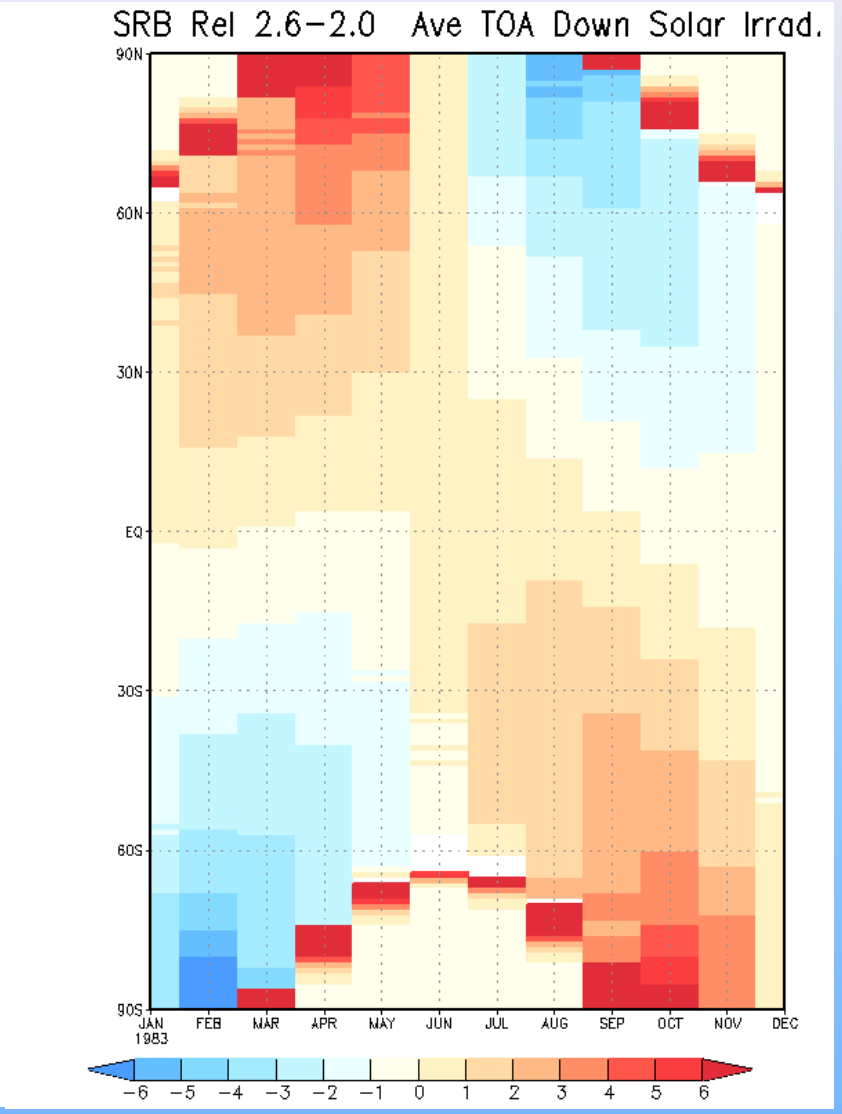
ISCCP-FD and SRB SW 2.6



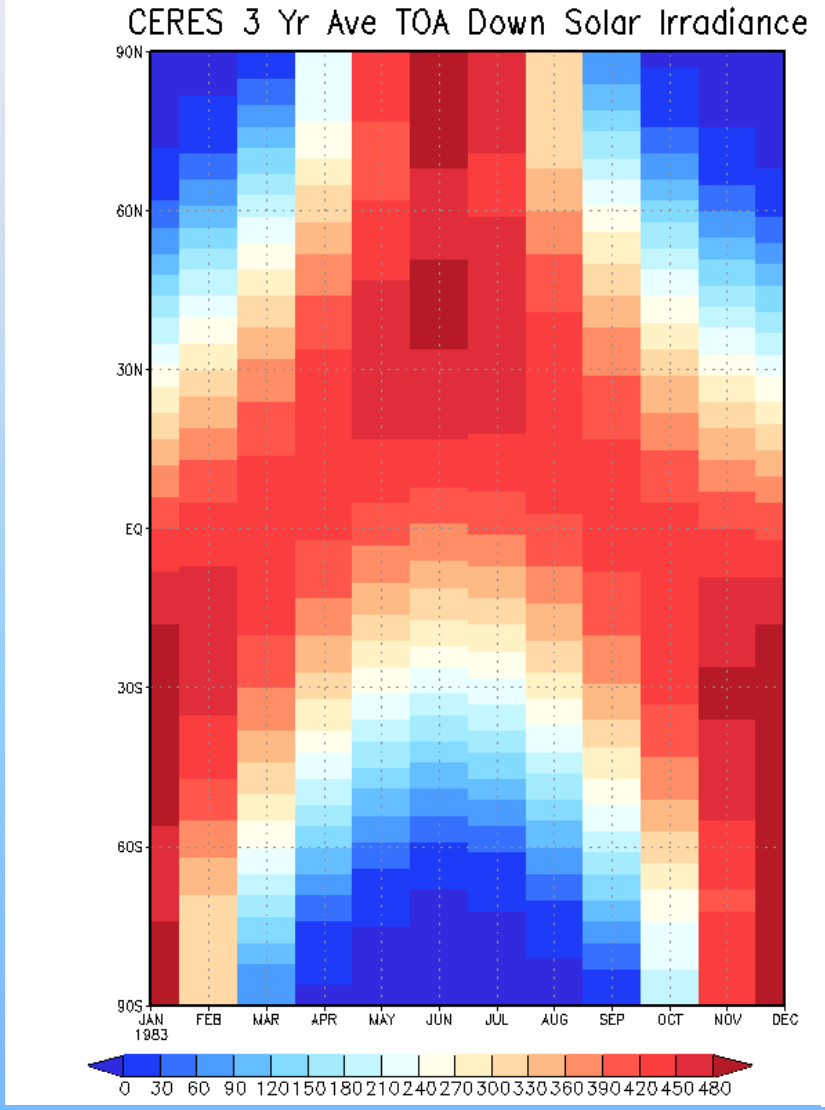
Implemented ERBE like ephemeris

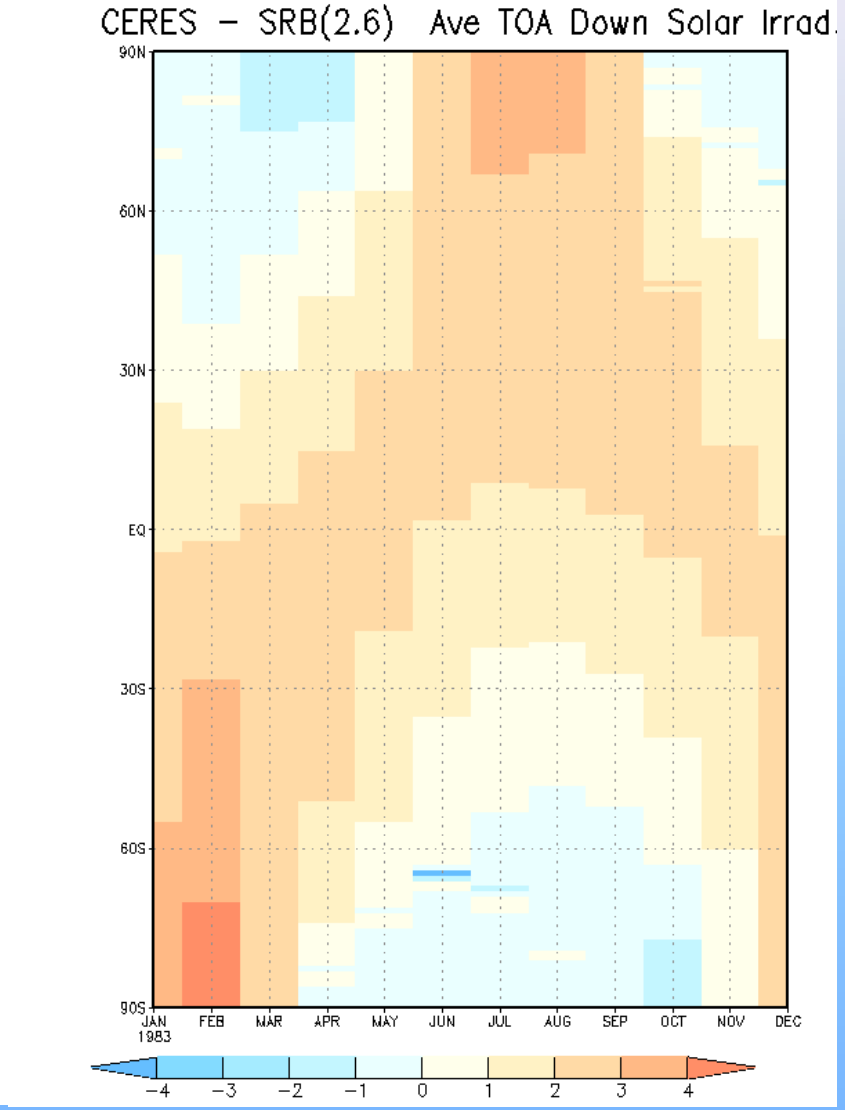
New TOA


Rel 2.6 Ave Sfc Net Solar Irradiance
90N
60N
30N
EQ
30S
60S
90S
JAN 1983
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480

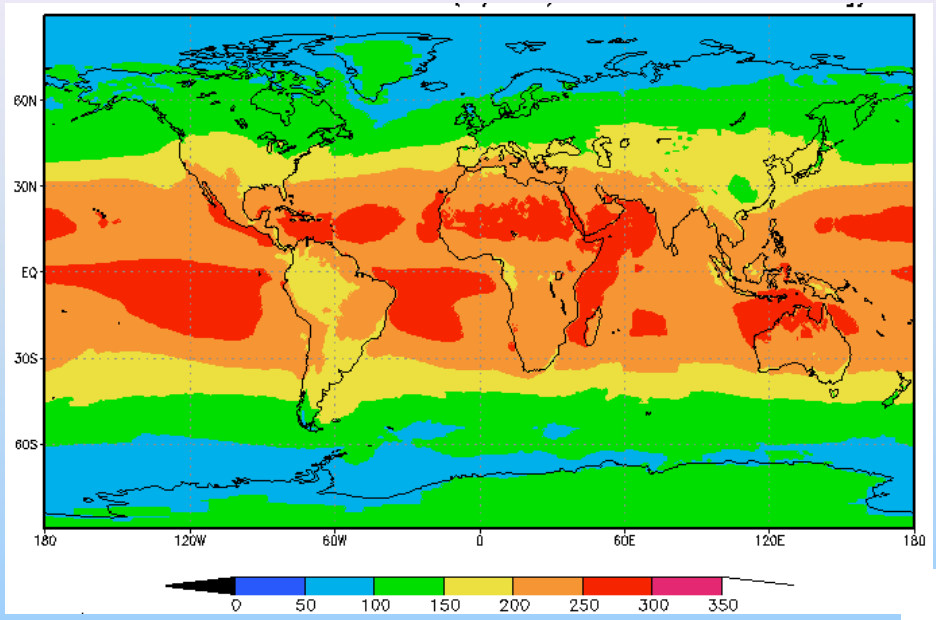

SRB Rel 2.6−2.0 Ave TOA Down Solar Irrad.
90N
60N
30N
EQ
30S
60S
90S
JAN 1983
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
−6 −5 −4 −3 −2 −1 0 1 2 3 4 5 6

Absolute Differences with CERES

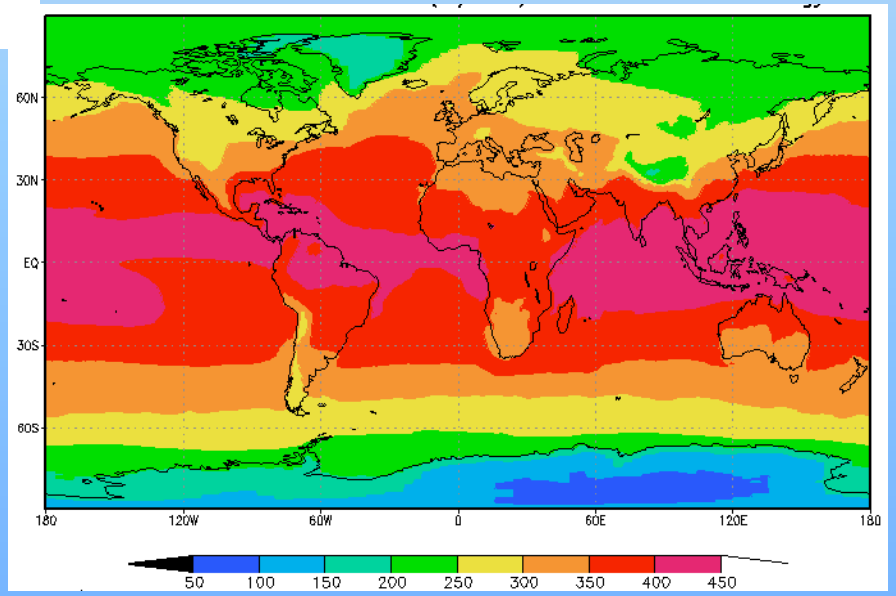




Long-term Spatial Annual Averages



Downward Surface SW Flux (Wm^{-2})



Downward Surface LW Flux (Wm^{-2})

Moving to GEOS 4.0.3

- **GMAO developed new version assimilation - GEOS 4.0.3**
  - 1x1.25 degrees
  - 36 pressure levels
- **CERES uses GEOS 4.0.3 for operational processing**
  - Comprehensive testing of skin temperature was required

GEOS 4.0.3 v GEOS 1

Example Skin Temp and Precipitable Water