



The NASA/GEWEX Surface Radiation Budget Project: Results and Issues

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NASA/GEWEX SRB: Outline

I. Project Review:

Purpose, activities, description; Processing Status: current status, data availability, schedule; Data Accessibility and Information

II. Results for Validation and Analysis (Rel. 2.5/SW 2.5/2.7)

III. Results Upgrades and Analysis

1. BSRN comparisons: overall by temporal average; time series; cloud types (SW only)

2. Project comparisons with CERES SOFA and SARB

3. Time series anomalies -> comparison to ERBE

IV. Future Plans and Strategy for:

1. Continued processing

2. Planned Improvements

3. Strategy for re-processing

V. Summary and Conclusions



SRB Analysis: Global Energy Cycle

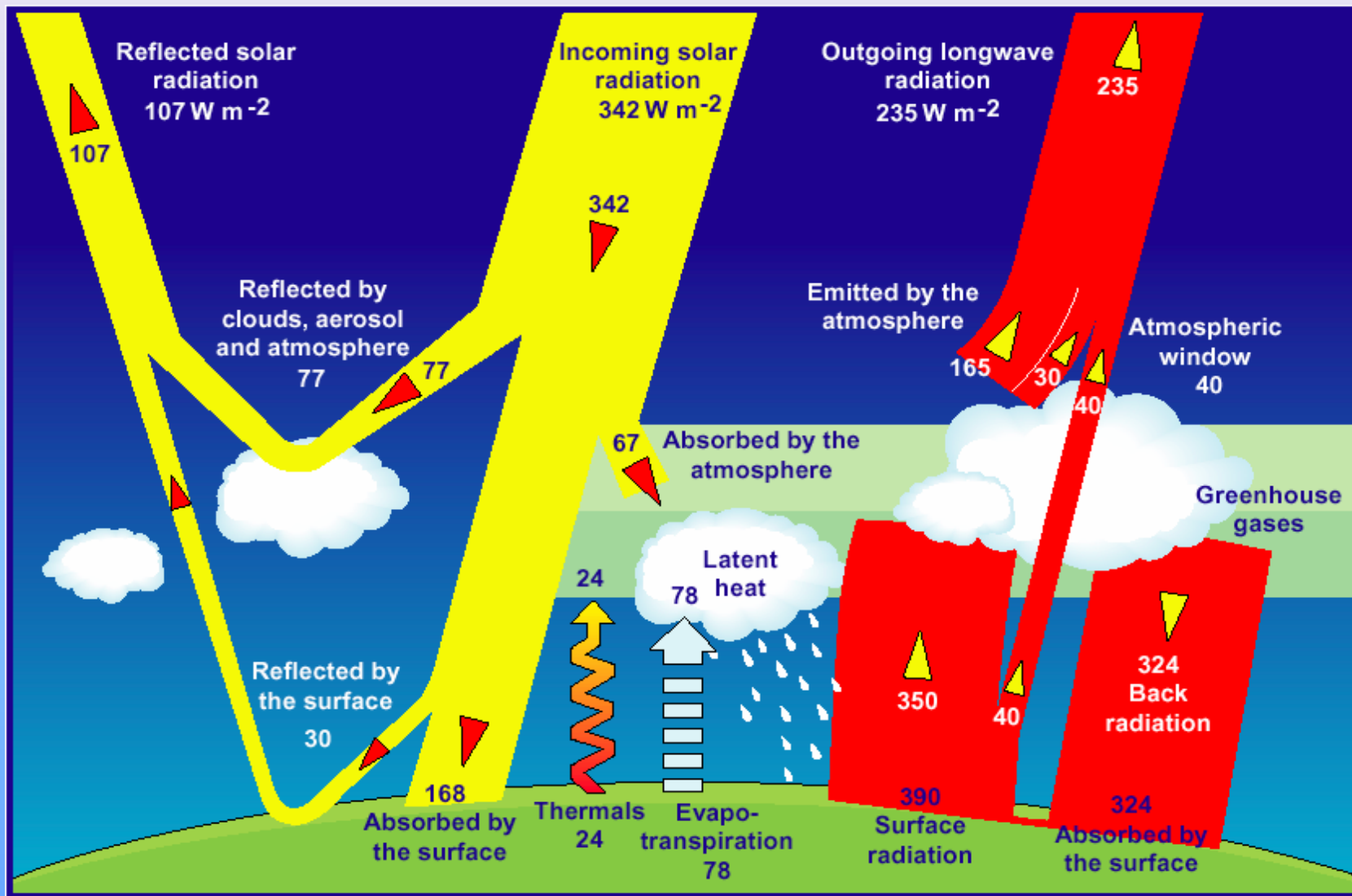


Chart from Kiehl and Trenberth, BAMS 97



NASA/GEWEX SRB: Overview

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

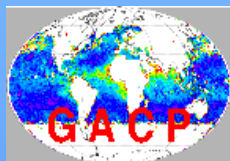
3-Hourly Global
Clouds & Surface



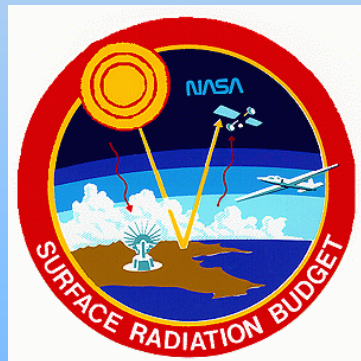
6-Hourly Global
Meteorology



Global Aerosols
& Smoke



Global, $1^\circ \times 1^\circ$,
3-Hourly
Surface
Radiation



NASA Applications
Energy Forecasting



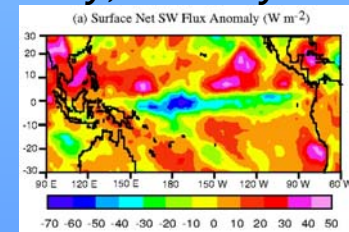
Atmospheric and Oceanic
Climate and Weather Models
(3-hourly, daily, monthly)

AMIP

Global Surface Hydrology
(Monthly 3-hourly, Monthly)

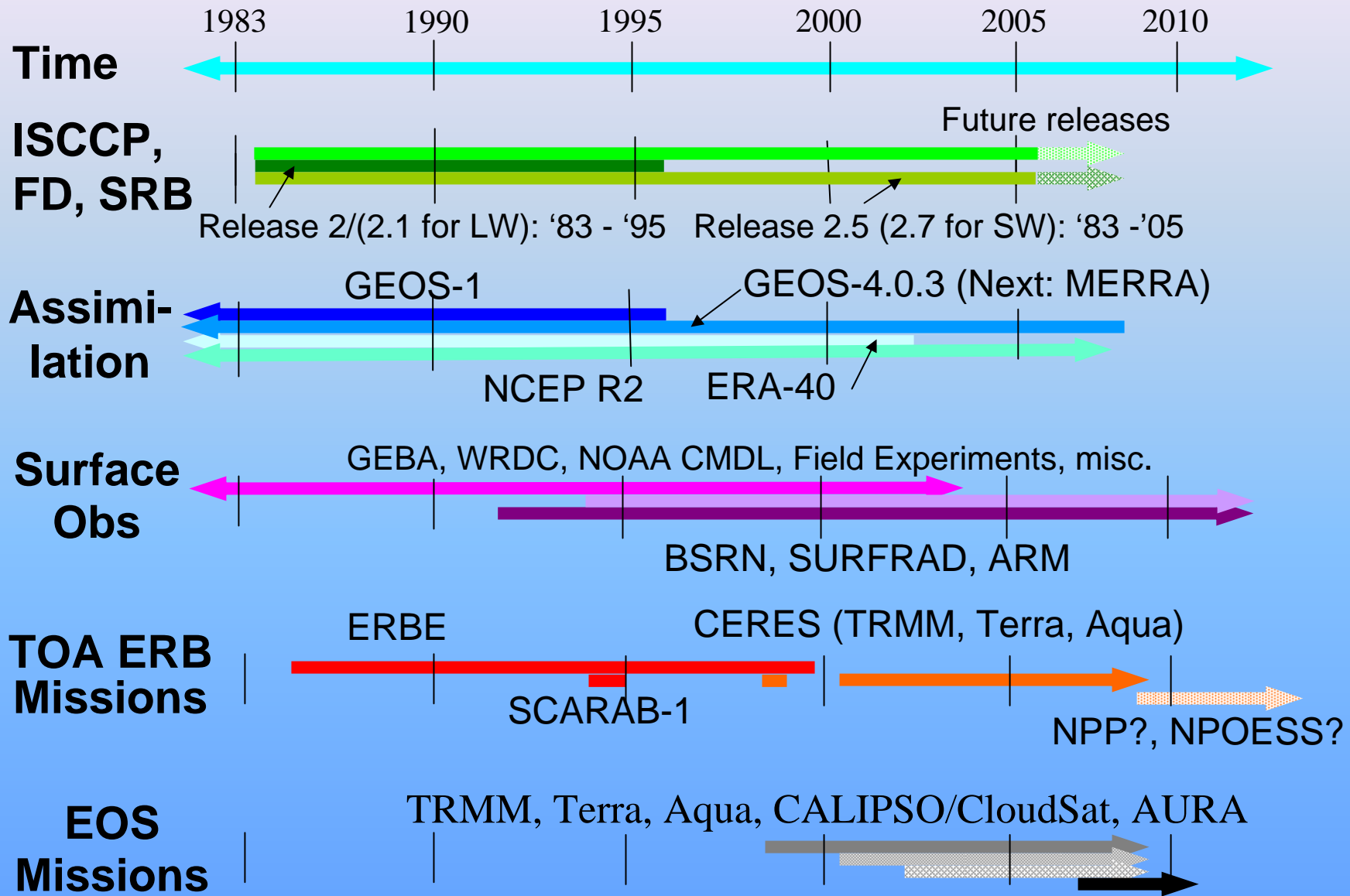


Regional Inter- and
Intra-annual variability
(monthly, monthly 3-hourly)





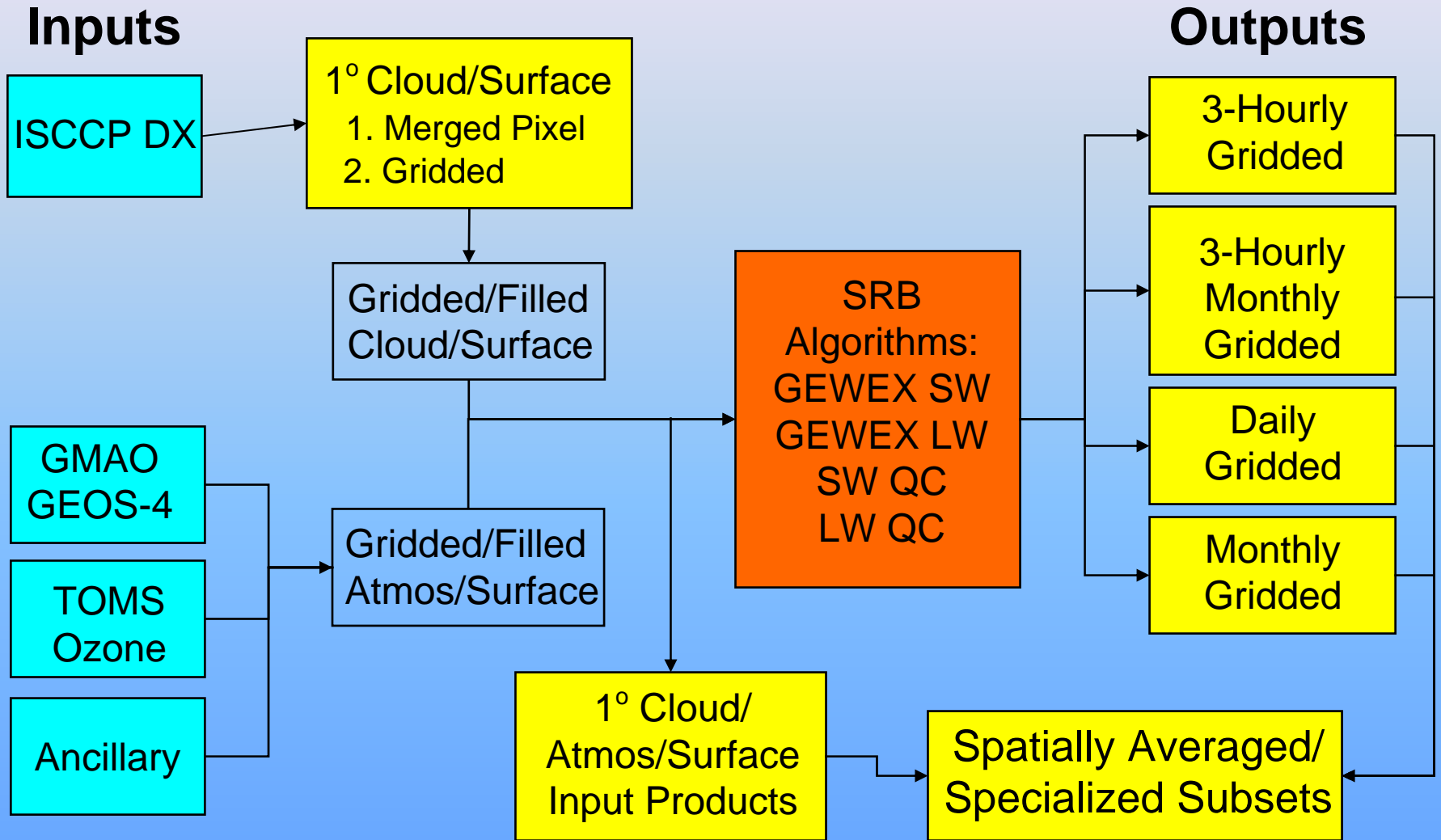
Radiation Dataset Timeline





GEWEX SRB: Data Flow

(Release 2.5/ SW 2.7)





SRB Data Sets

- **Release 2.0 / (LW 2.1)**

- 4 Algorithms: SW (Pinker/Laszlo), LW (Fu-Liou based w/ cloud overlap), SWQC (Staylor/Gupta), LWQC (Gupta)
- GEOS-1
- 3-hourly, 1x1 degree spanning July 1983 - Oct. 1995

- **Release 2.5**

- Inputs: GEOS-4; improved blended TOVS/TOMS ozone
- Same 4 Algorithms: SW improved
 - SW: new filling scheme for polar twilight (released Dec. 2005)
 - SWQC: MATCH climatological aerosols; CERES surface albedos
 - LW, LWQC - modified for GEOS-4
- 3-hourly, 1x1 degree spanning July 1983 - June 2005

- **SW v2.7**

- Additional SW improvements: solar constant (account for all energy in total fluxes) & TOA ephemeris; low sun angle integration bug; improved elevation treatment; pristine-sky fluxes for aerosol forcing
- to be reprocessed starting in October; minor error in filling



Aerosol Treatment in SW Algorithm

- Based on ISCCP clear sky composite radiance-- assumed to be a background
- Reference surface albedo scaled to produce TOA broadband albedo implied by clear sky composite radiance and a climatological AOD chosen for surface type
- AOD then picked to match instantaneous ISCCP radiance



Aerosol Treatment in SW Algorithm

Problems/Potential Improvements?

- *Is ISCCP clear sky composite radiance a reliable dark background?*
- *Will an improved monthly aerosol climatology help?*
- *If a full 1983-present 3-hourly aerosol history is available, will errors/mismatches between ISCCP radiances and the aerosol history drive the algorithm to unrealistic solutions?*



SRB Processing & Archival Status


Nodes	Status	Months Processed	Years Processed to Date	Months Released
ISCCP merged DX	Complete	264	07/83 - 06/05	0
ISCCP gridded DX	Complete	264	07/83 - 06/05	0
GEOS-1 / GEOS-4	Complete / Complete	148 / 264	07/83 - 10/95 / 07/83 - 06/05	0
TOMS (TOVS) O ₃	Complete	264	07/83 - 06/05	0
3-Hourly Meteorology, Cloud and Surface	Complete	264	07/83 - 06/05	264
SW 2.0 / 2.7	Complete/Processing	148 / 258*	07/83 - 10/95 / 07/83 - 12/04	148 / 0*
SW QC 2.0 / 2.5	Complete	148 / 264	07/83 - 10/95 / 07/83 - 06/05	148 / 264
LW 2.1 / 2.5	Complete	148 / 264	07/83 - 10/95 / 07/83 - 06/05	148 / 264
LW QC 2.0 / 2.5	Complete	148 / 264	07/83 - 10/95 / 07/83 - 06/05	148 / 264

**Data not in archive, but is available via request; It is scheduled for general reprocessing beginning this month.*



SRB Enhanced Web Site



<http://gewex-srb.larc.nasa.gov>



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Global Energy and Water Cycle Experiment
GEWEX
WCRP



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RADIATION
BUDGET**

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Access Data

- [Data Format](#)
- [SRB Data Products](#)
- [Examples SRB Data](#)

Documentation

- [About SRB](#)
- [About GEWEX](#)
- [Global Geometry/Resolution](#)
- [Parameter Accuracy/Validation](#)
- [GEWEX/SRB Methodology](#)
- [SRB Publications](#)

Related Links

- [Atmospheric Science Data Center](#)
- [Science Mission Directorate](#)
- [International Satellite Cloud Climatology Project \(ISCCP\)](#)
- [Global Energy and Water Cycle Experiment \(GEWEX\)](#)
- [Earth Radiation Budget Experiment \(ERBE\)](#)

Navigation and Help

- [Partners](#)
- [SRB Archive Statistics](#)
- [Release Notes](#)
- [Acknowledgments Please](#)
- [Questions/Comments](#)

NASA/GEWEX Surface Radiation Budget (SRB) Project

The Global Energy and Water-cycle Experiment (GEWEX) is an integrated program of research, observations, and science activities with the goal of providing data sets to support accurate predictions of global and regional climate change. Research in the areas of Earth radiation budget, hydrometeorology, and modeling/prediction contribute to meeting the goal of GEWEX.


The GEWEX/SRB project is a major component of the GEWEX radiation research. The objective of the GEWEX/SRB project is to determine surface, top-of-atmosphere (TOA), and atmospheric shortwave (SW) and longwave (LW) radiative fluxes with the precision needed to predict transient climate variations and decadal-to-centennial climate trends.

To accomplish this objective, SW and LW SRB data sets are derived on a 1° x 1° global grid with two sets of algorithms, known as primary and quality-check algorithms, and a variety of data sources. The primary SW algorithm is adapted from Pinker and Laszlo (Modeling Surface Solar Irradiance for Satellite Applications on a Global Scale, J. Appl. Met., 31, 194-211, 1992) and the primary LW algorithm is an adaptation of Fu et al. (JAS, Vol. 54, 2799-2812, 1997). The quality-check SW algorithm known as the Langley Parameterized Shortwave Algorithm (LPSA; Gupta et al. - NASA/TP-2001-211272, Dec. 2001; available on the [internet](#)) was developed at the Langley Research Center by W. F. Staylor, and the quality-check LW algorithm is by Gupta et al. (J. Appl. Meteor., 31, 1361-1367, 1992). The primary data sources are: 1) the International Satellite Cloud Climatology Project (ISCCP) DX data set for deriving cloud parameters, and 2) the Goddard Earth Observing System-1 (GEOS-1) reanalysis products for meteorological profiles.

Additionally, column ozone data from the Total Ozone Mapping Spectrometer (TOMS) and clear-sky TOA albedos from the Earth Radiation Budget Experiment (ERBE) data are used as input to the SW models. ERBE TOA measurements are also used for comparisons with the Pinker model output. Ground-based measurements for the validation of model products are obtained from the Baseline Surface Radiation Network (BSRN), the Global Energy Budget Archive (GEBA), and other national and international networks.

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Curator: [Daniel Mangosing](#)
NASA Official: [Paul Stackhouse](#)
Last Updated: August 01, 2005
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Surface Global Annual Averages

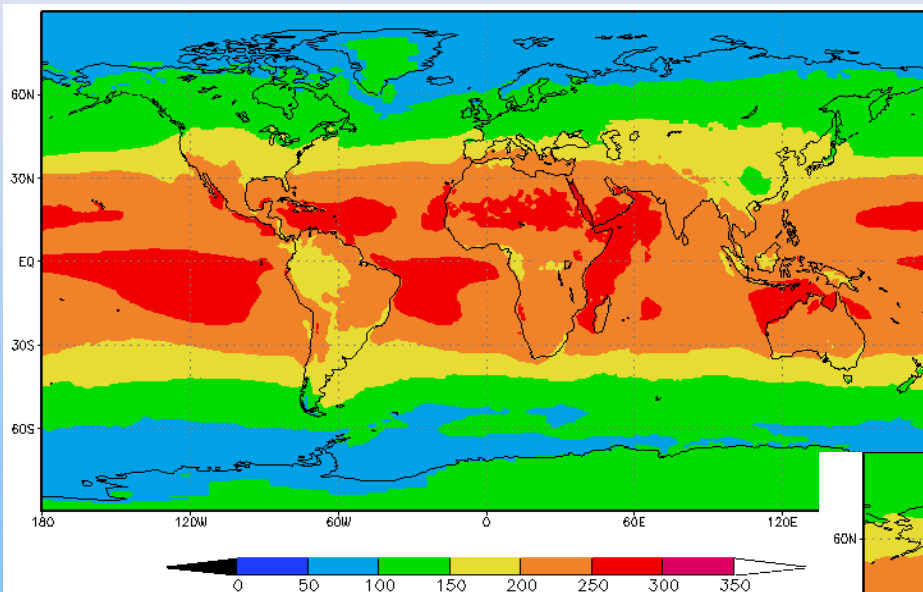
Parameter	Ohmura & Gilgen (1993) <i>GEBA Surf. Obs.</i>		Kiehl and Trenberth (1997) ERBE/ CCM3		Zhang & Rossow (2004) <i>21-Year Mean (1984-2004)</i>		NASA/GEWEX SRB Rel. 2.5/2.7 (NASA LaRC) <i>21-Year Mean (1984-2004)</i>			
							SW, LW		SW, LW QC	
	Flux	% F_0	Flux	% F_0	Flux	% F_0	Flux	% F_0	Flux	% F_0
SW Down	169.0	49.4	198	57.9	189.2	55.4	186.5	54.6	183.7	53.8
SW Net	142.0	41.6	168	49.2	165.9	48.5	163.8	47.9	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	110.8	32.4	111.0	32.5
SW CRF	--	--	--	--	-53.0	-15.5	-56.4	-16.5	-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	-21.1	-6.2	-24.9	-7.3

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



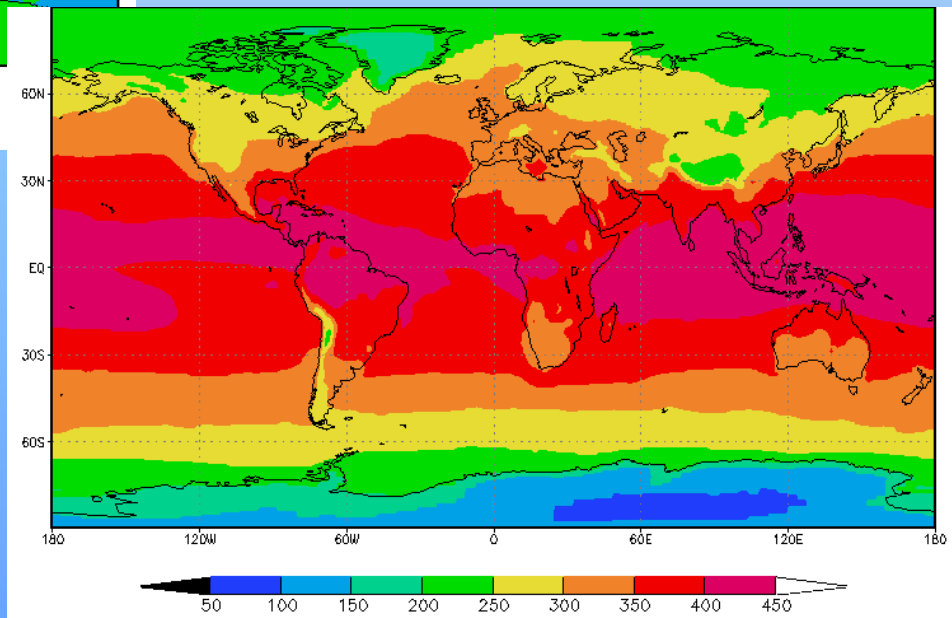
Annual Average Global Surface Fluxes

(21-Year Average; Jan 1984 - Dec 2004)



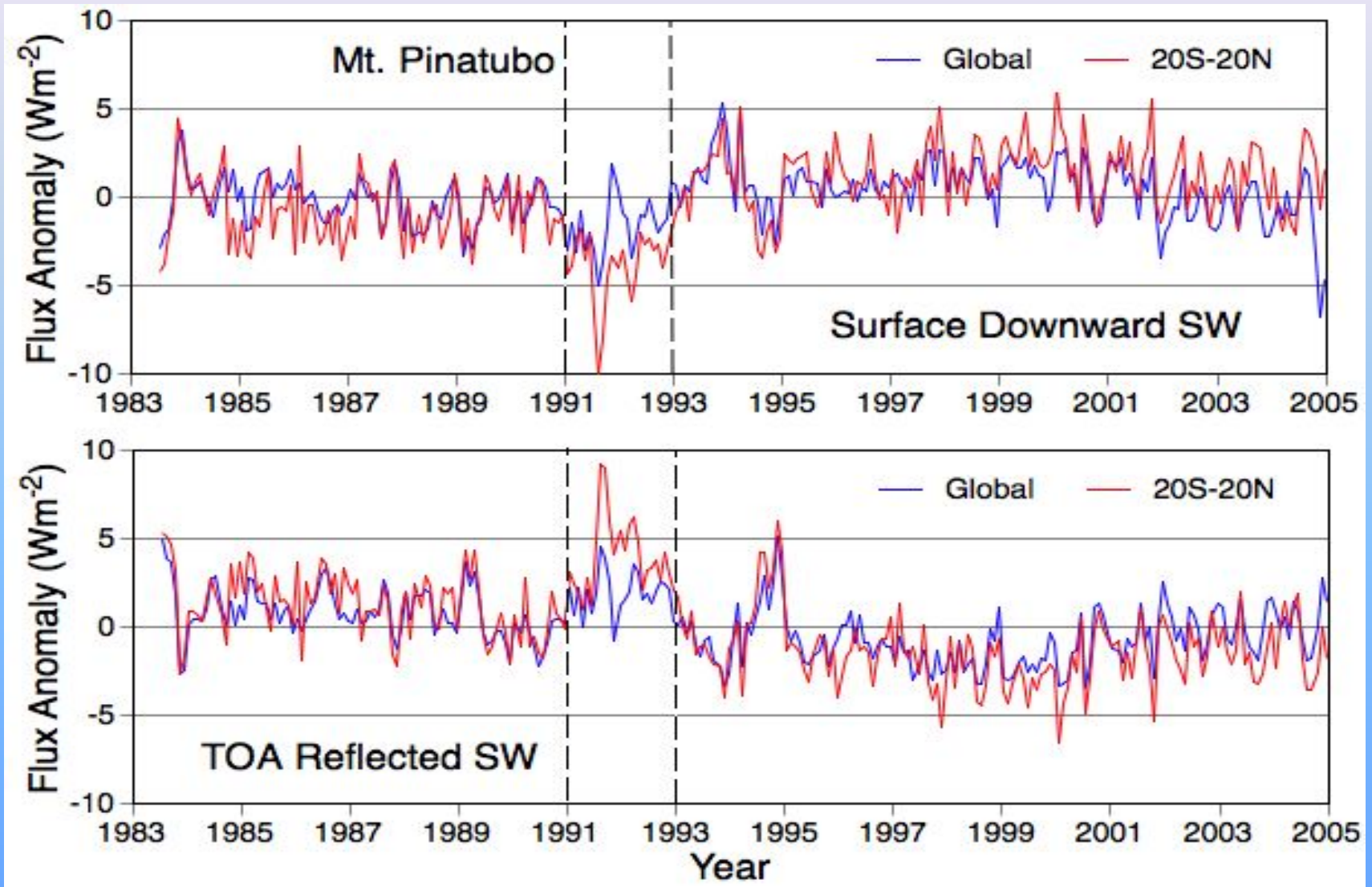
SW Downward Fluxes
(SRB SW v2.7, $W m^{-2}$)

LW Surface Fluxes
(SRB LW v2.5, $W m^{-2}$)



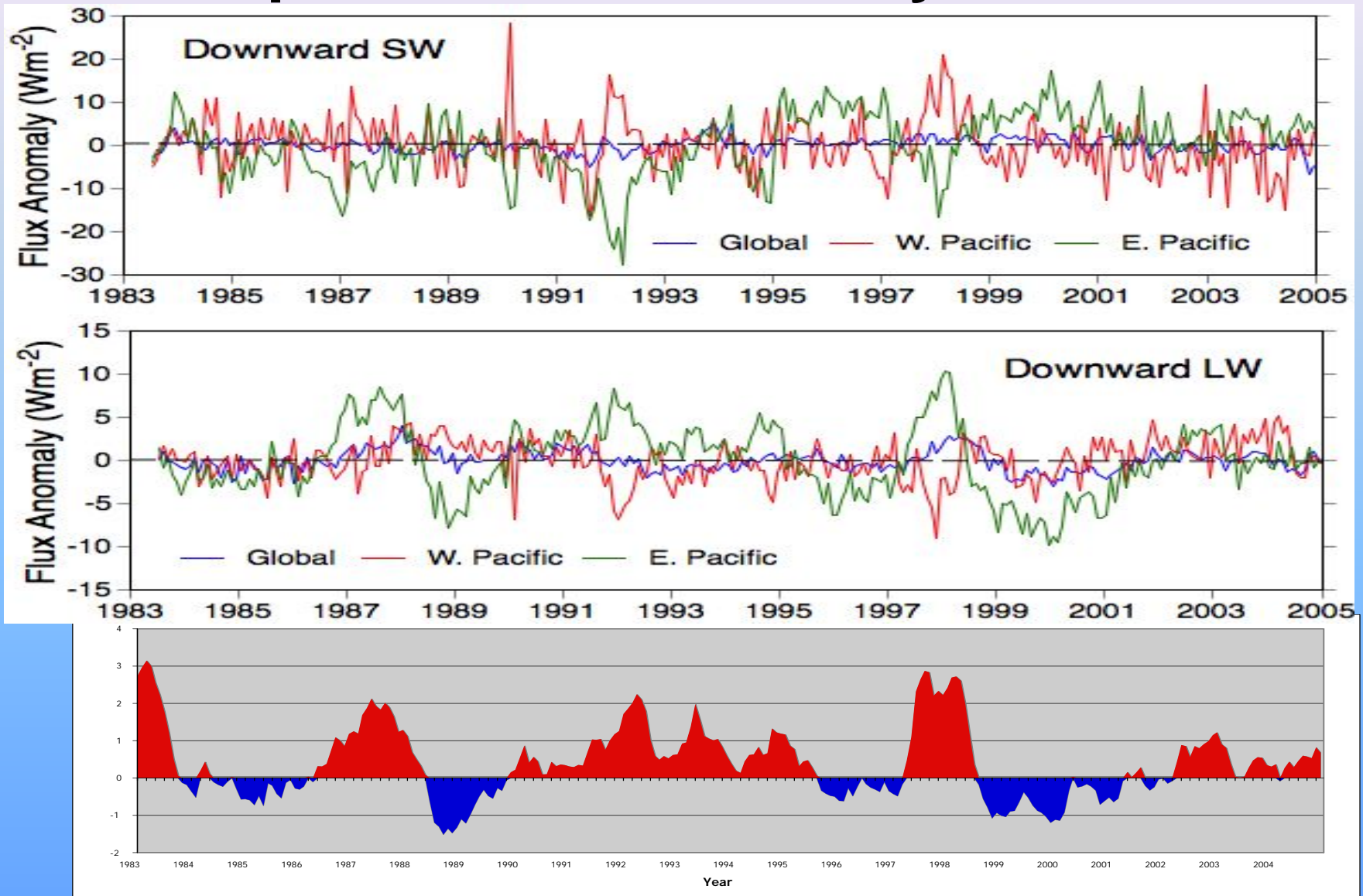


Deseasonalized Anomalies of SW Fluxes





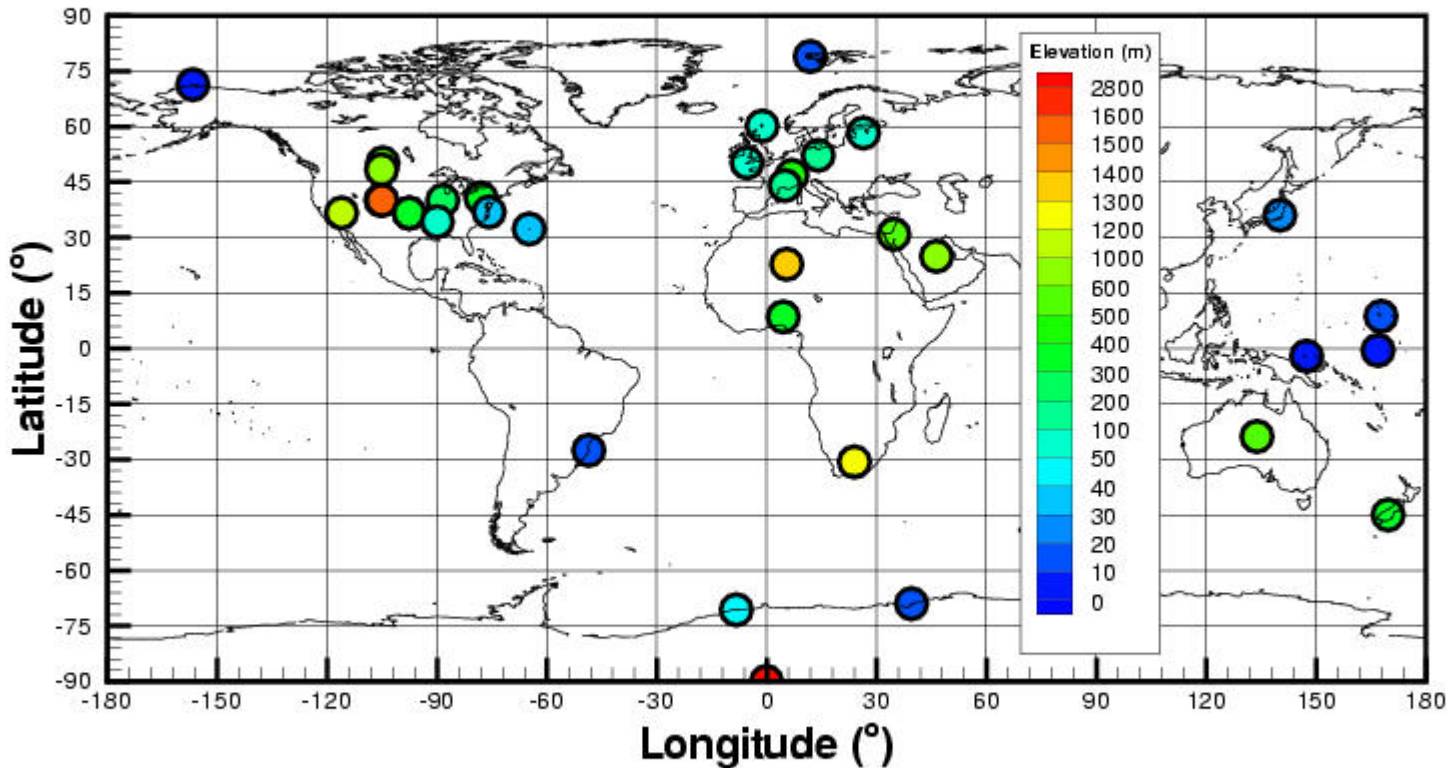
Tropical Pacific Anomaly Time Series





35 BSRN Sites with 2849 Site-Months of Data from 1992-2004

Baseline Surface Radiation Network (BSRN) Sites with Data

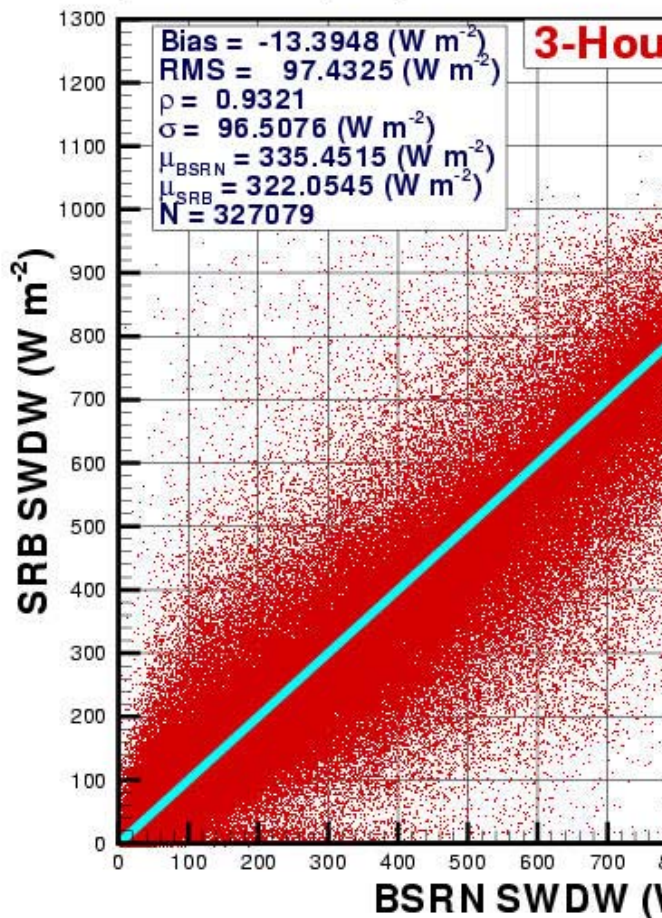




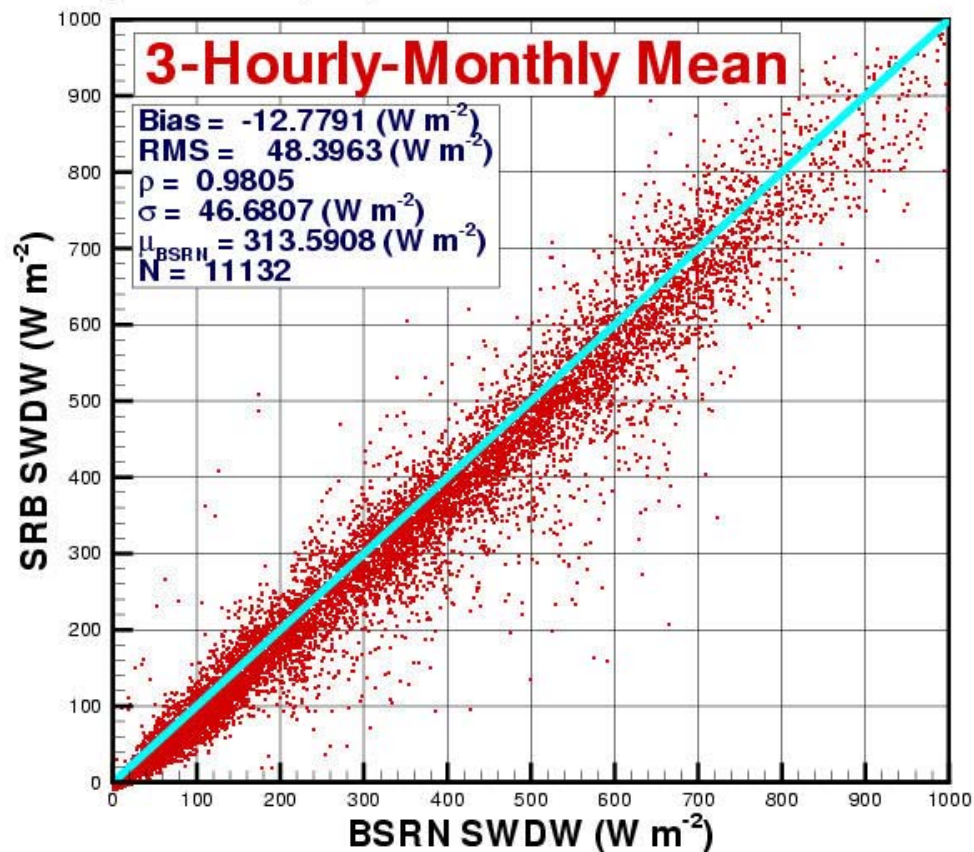
Shortwave Downward Flux Validation

Daytime Only

Comparison of SRB(V2.7) and BSRN Data for All BSRN Sites for 1992- 2004



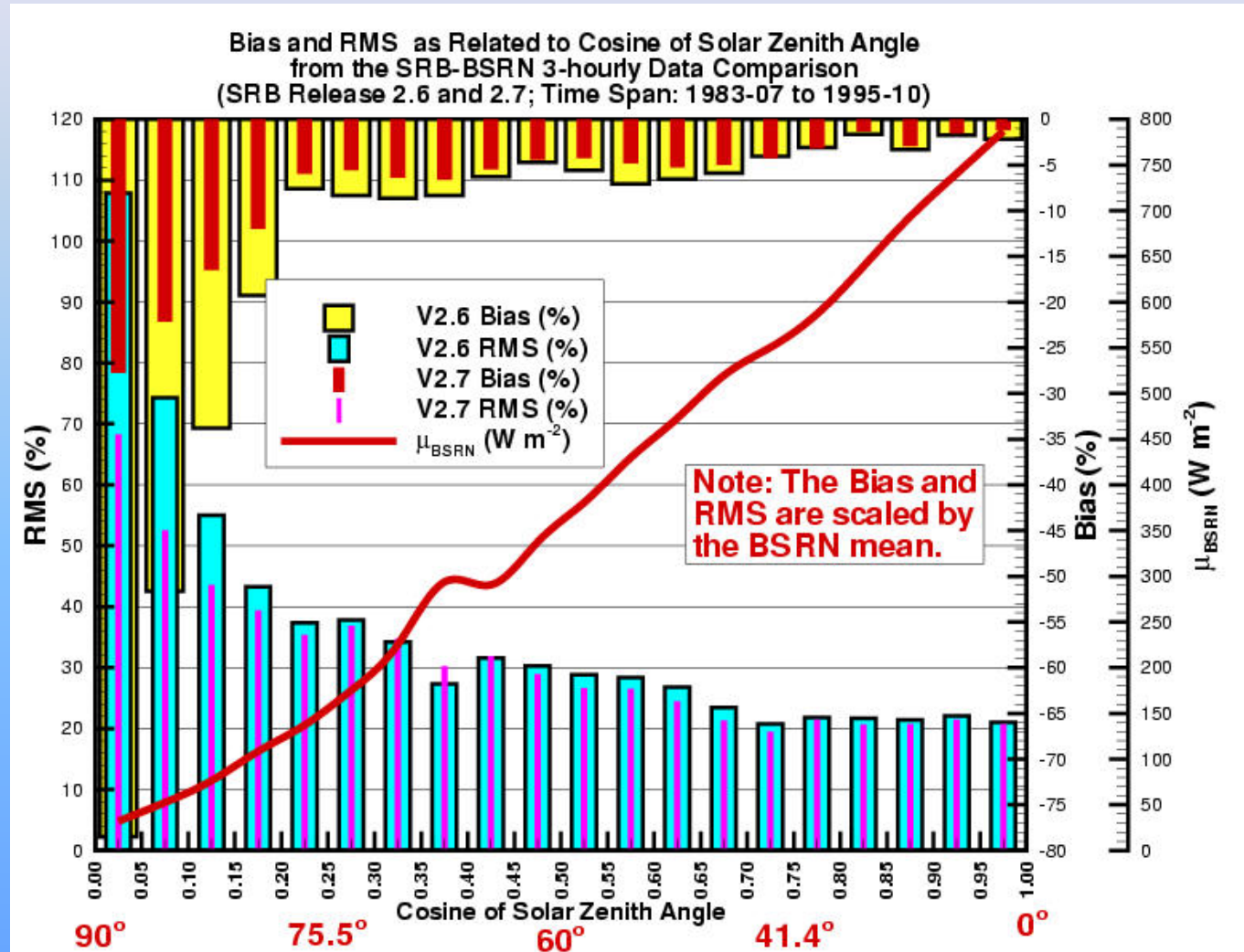
Comparison of SRB(V2.7) and BSRN Data for All BSRN Sites for 1992 - 2004





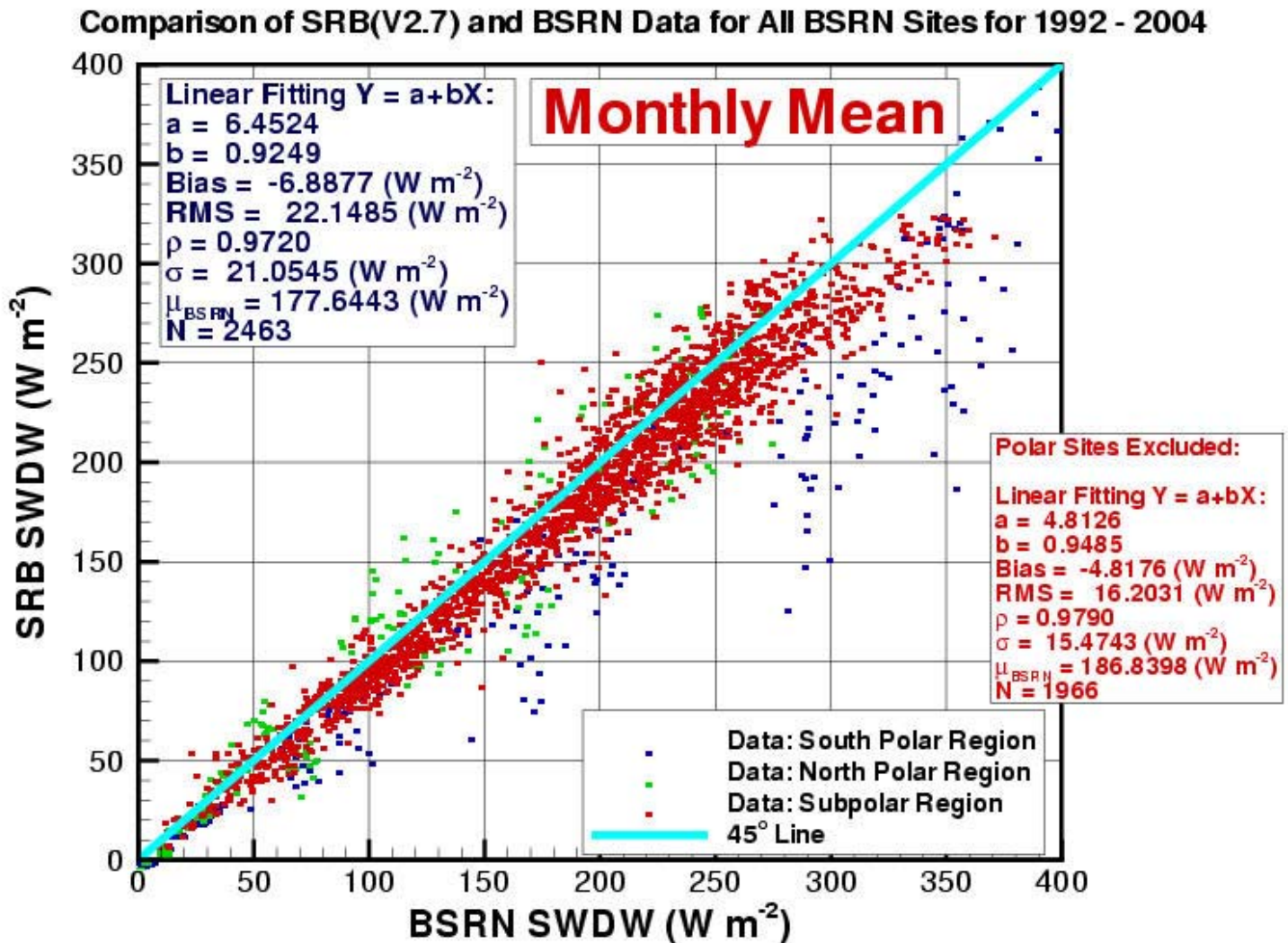
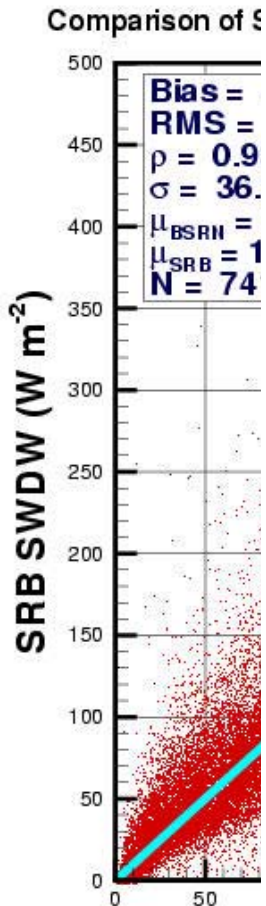
3-Hourly SW BSRN Observations: Use for Algorithm Improvement Verification

- Observations sorted by solar zenith angle bins
- SRB estimates compared
- Latest SRB Version improved at all angles





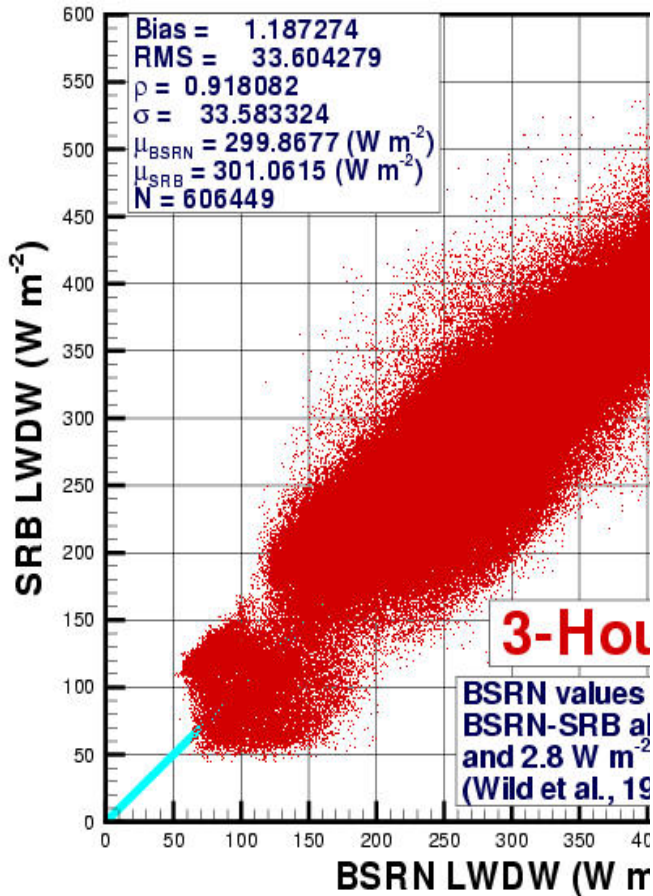
Shortwave Downward Flux Validation



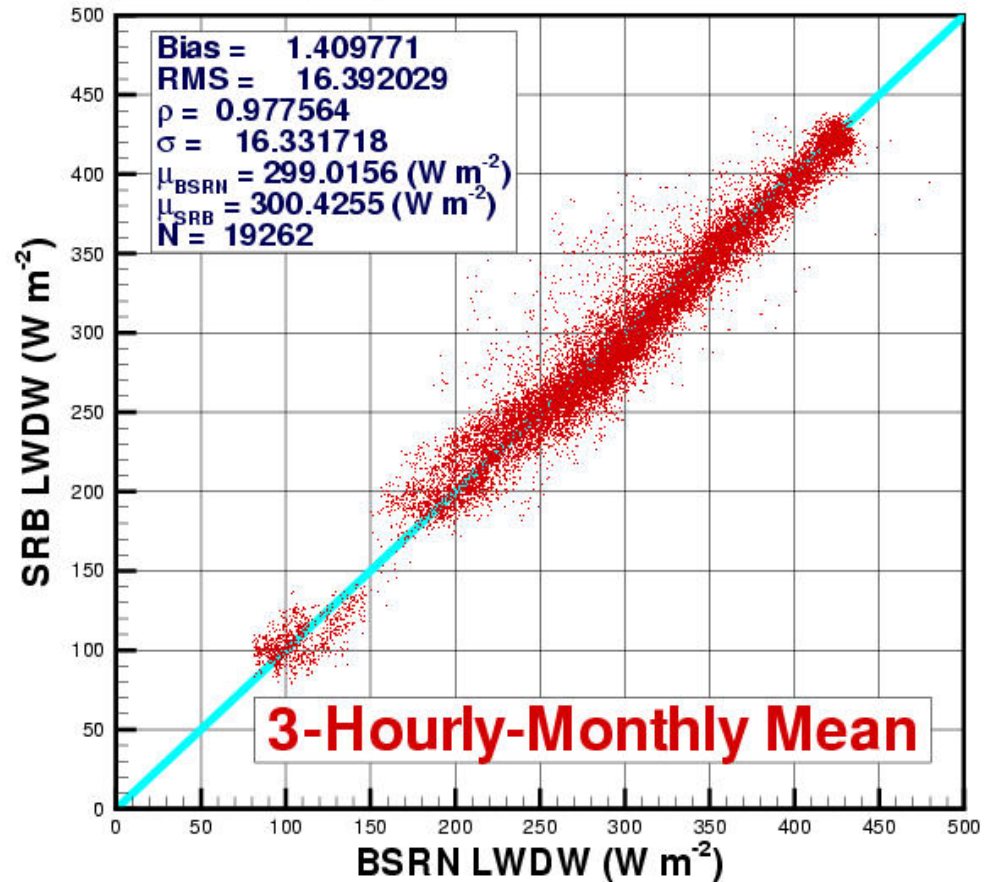


Longwave Downward Flux Validation

Comparison of SRB and BSRN Data for All BSRN Sites for 1992 - 2004



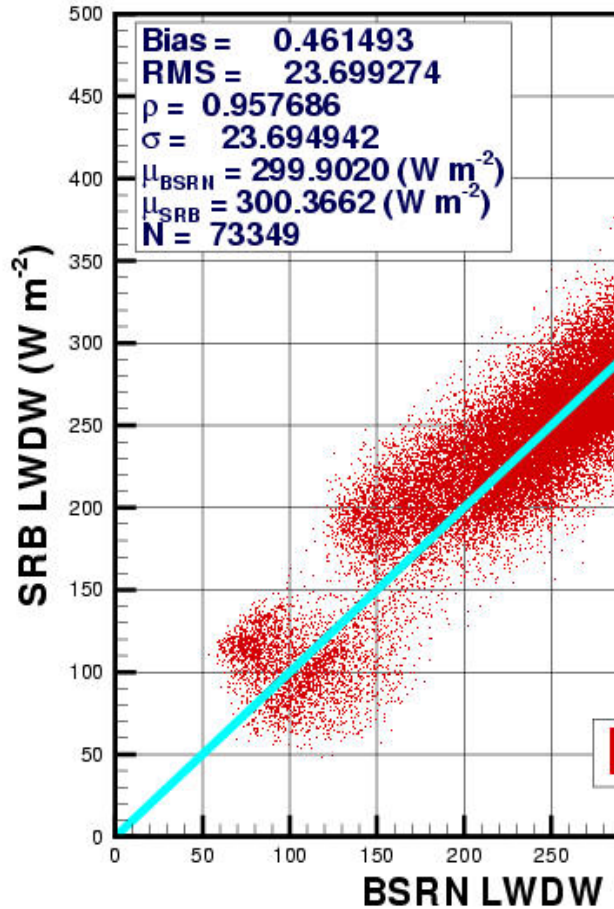
Comparison of SRB(V2.5) and BSRN Data for All BSRN Sites for 1992 - 2004



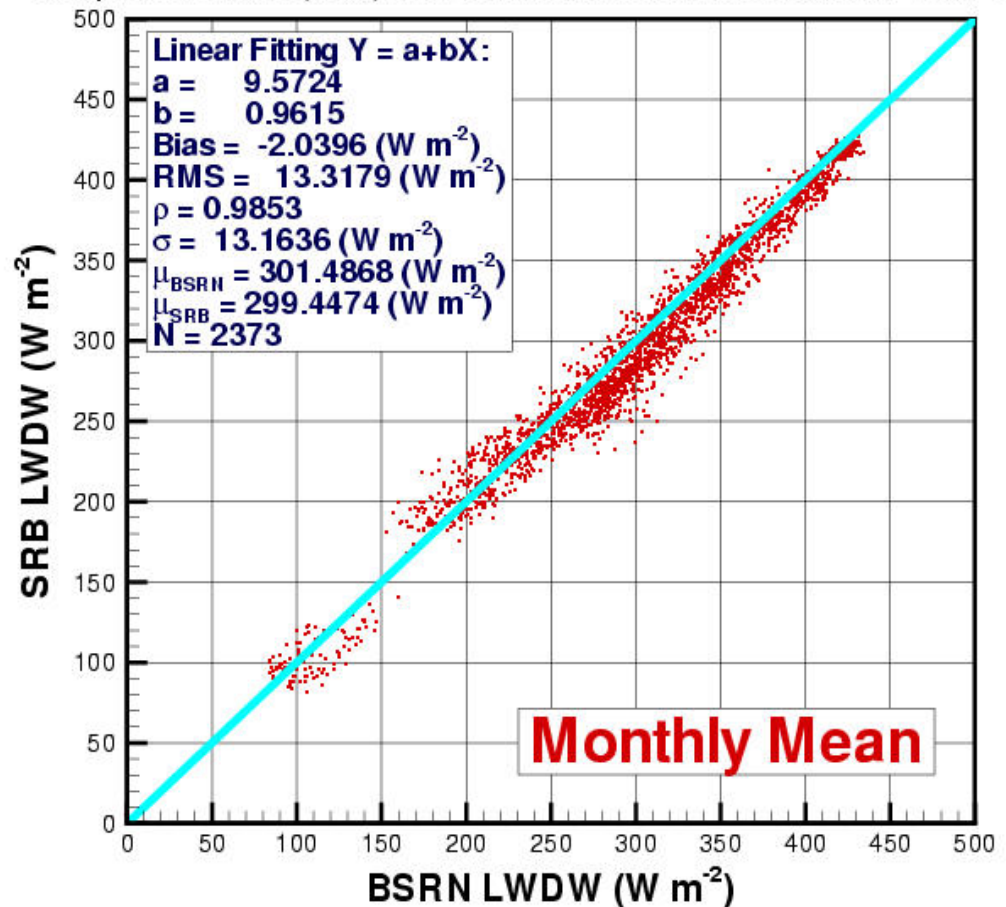


Longwave Downward Flux Validation

Comparison of SRB(V2.5) and BSRN Data for All BSRN Sites for 1992 - 2004



Comparison of SRB(V2.5) and BSRN Data for All BSRN Sites for 1992 - 2004





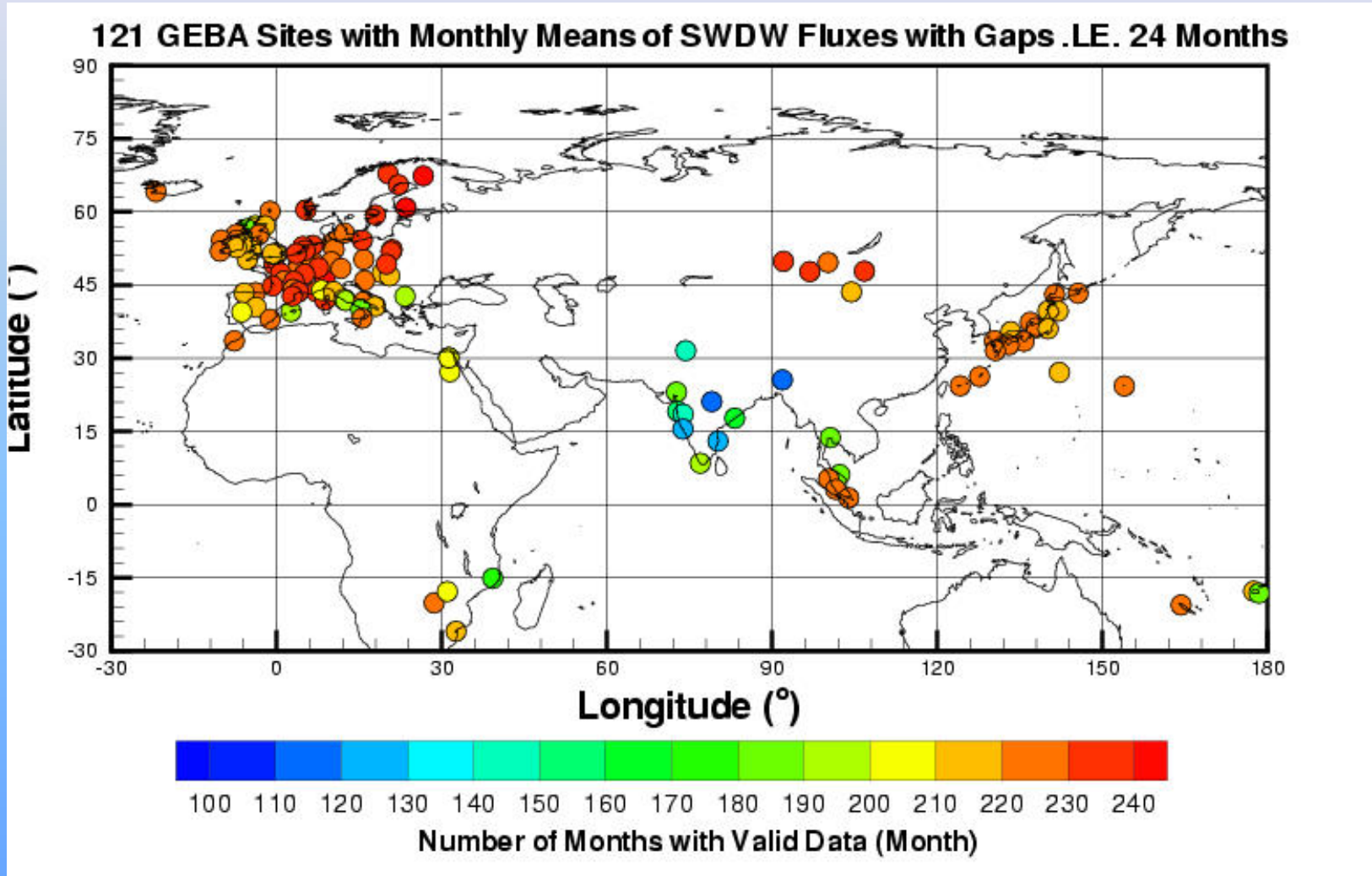
Overall Surface Validation Results

Quantity (Instrument)	Instantaneous Gridded (1 Hour Averaged Obs., 8 times per day, SW daytime only; $W m^{-2}$)		Daily ($W m^{-2}$)		Monthly Averaged 3-hourly ($W m^{-2}$)		Monthly Averaged ($W m^{-2}$)	
	Bias	1 Std Dev	Bias	1 Std Dev	Bias	1 Std Dev	Bias	1 Std Dev
LW Broadband	1.2	33.6	0.5	23.7	1.4	16.3	-2.0	13.2
SW Broadband	-13.4	96.5	-7	36.5	-12.8	46.7	-6.9	21.1



GEBA Data for 7/83-6/03

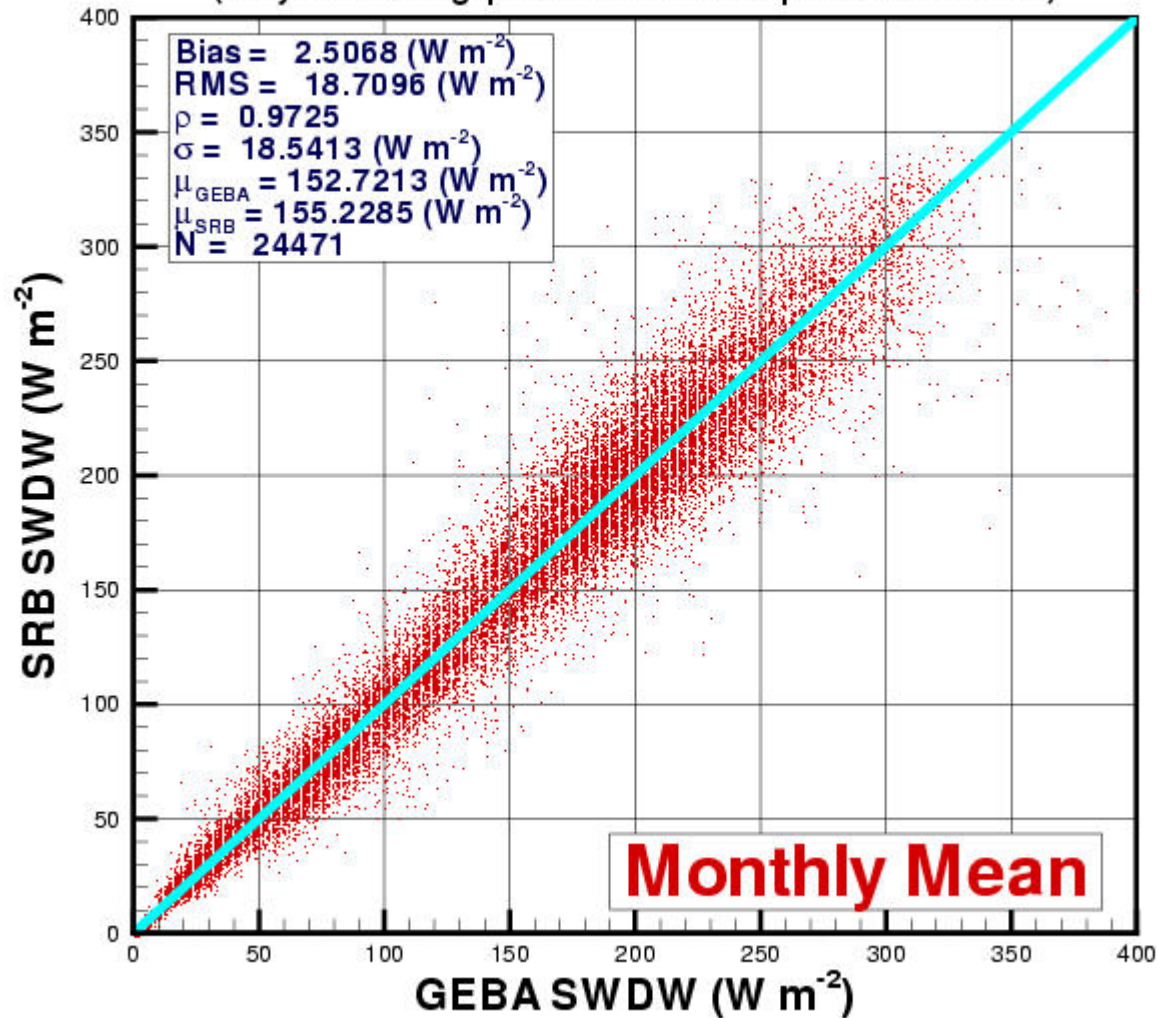
(courtesy Hans Gilgen, Atsumu Ohmura, Martin Wild)





GEBA Validation

Comparison of SRB(V2.7) and GEBA Data for All GEBA Sites for 1983-07 to 2003-06
(Only sites with gaps of less than or equal to 24 months.)





SRB Continuing and Near-Future Work

- **Processing, Archival, and Dissemination**

- Reprocess and complete SW v2.7; process with new ISCCP-DX
- Improve documentation on web
- Complete Web site upgrades and increased availability
- Complete data delivery to GEWEX-RFA archive

- **Validation and Analysis**

- Continue to evaluate Rel. 2.5 / SW 2.7 in comparisons to old versions consistent with GEWEX-RFA goals
- Complete assessment relative to BSRN, other surface measurement networks (repeat cloudy/clear analysis)
- Complete comparisons of SRB to ISCCP-FD and CERES
- Emphasize polar and desert areas

- **Near-term Improvements**

- **SW (w/ UMd): testing new climatological aerosols, CERES ice/snow ADMs being tested, surface albedos: spectral dependence, ocean**
- LW: skin temperature/near-surface temperature discontinuities



Long-Term Work Plans

- Upgrade RT model physics for better cloud and aerosol treatments
- Evaluate aerosol/cloud radiative forcing
- Add new data products: UV, Window fluxes, layers
- Increase spatial resolution (follow ISCCP in using B1 based cloud products)
- *Reprocess toward late 2008 following significant progress above and new inputs from ISCCP and other projects*



GEWEX SRB: Conclusions

- GEWEX SRB has produced 21+ year climatology of surface radiation at $1^\circ \times 1^\circ$.
 - *Data quality is being quantified; on space/time scales*
- Validation, analysis and collaborative activities crucial to assessing and improving the data set are being pursued:
 - *Intercomparison w/ GISS/GFSC/ESRB/MSG SRB.*
 - *Overlap w/ CERES-SARB; intercomparison.*
 - *Improvements regarding aerosols and aspects of algorithms being pursued.*
 - *Input from users and GEWEX-RFA*
- Goal: process overlap with CERES-SARB for testing/validation of improvements; reprocess SRB in entirety starting end 2008/early 2009.



Backup Slides



Long-Term Work Plans

- Evaluate and implement homogenization of SRB inputs/ancillary data sets. Potential data parameters include (what other GEWEX areas can contribute?):
 - Surface and atmospheric temperature and water vapor profiles (alternative to GEOS-4, MERRA)
 - Ozone and other trace gas concentrations
 - Total solar irradiance and variability
 - Surface spectral emissivity w/ interannual variability
 - Surface spectral albedo treatments
 - Cloud microphysical properties
 - **Aerosol properties in climatological and historical sense**
- Improve SW model with implementation of clear and all-sky CERES' ADMs; improved NB -> BB conversion
- Improve general representation of cloud layers (CLOUDSAT/CALIPSO)
- Evaluate/Upgrade Time and Space Averaging



SRB Validation and Analysis

- **Analysis Contributions:**

- Koster et al => energy and water cycle from ISLSCP
- Zhang et al inputs assessment
- Raschke comparing ISCCP-FD and SRB
- Mediterranean Radiation Budgets (Vardavas Group)
- Intra-annual/diurnal variability (Smith et al)

- **Validation Analysis**

- BSRN and other measurements (including Tibetan papers)
- Time series analysis (GEBA data)
- Clear/cloudy analysis with Chuck Long's derived fluxes products
- Comparisons to ISCCP-FD and CERES for both TOA and Surface fluxes



Needs and Special Issues

- Long-term surface measurements that overlap with BSRN period => GEBA!
- GEWEX SRB funding dependent on follow-on proposal in FY06



SRB Application Success Stories

- **NASA project POWER (Prediction of Worldwide Energy Resource) active in adapting SRB and other scientific data sets to Energy Sector Applications**
- **Examples:**
 - Surface Meteorology and Solar Energy (SSE) web site: 200+ on-fly parameters in simplified format; 5 million hits; 1 million data downloads since 1999. Direct links to:
 - RETScreen (NRCan, UNEP) world's most comprehensive renewable energy technology planning DSS
 - HOMER (NREL) - hybrid optimization DSS
 - International Energy Agency task to benchmark solar irradiance methods from satellite measurements => GEOSS
 - POWER data deliveries to:
 - ASHRAE and DOE - building design manuals
 - PNNL MiniCAM Energy Market Forecast Model
 - NREL for National Solar Radiation Database (planned)
 - USDA crop growth and climate change analysis



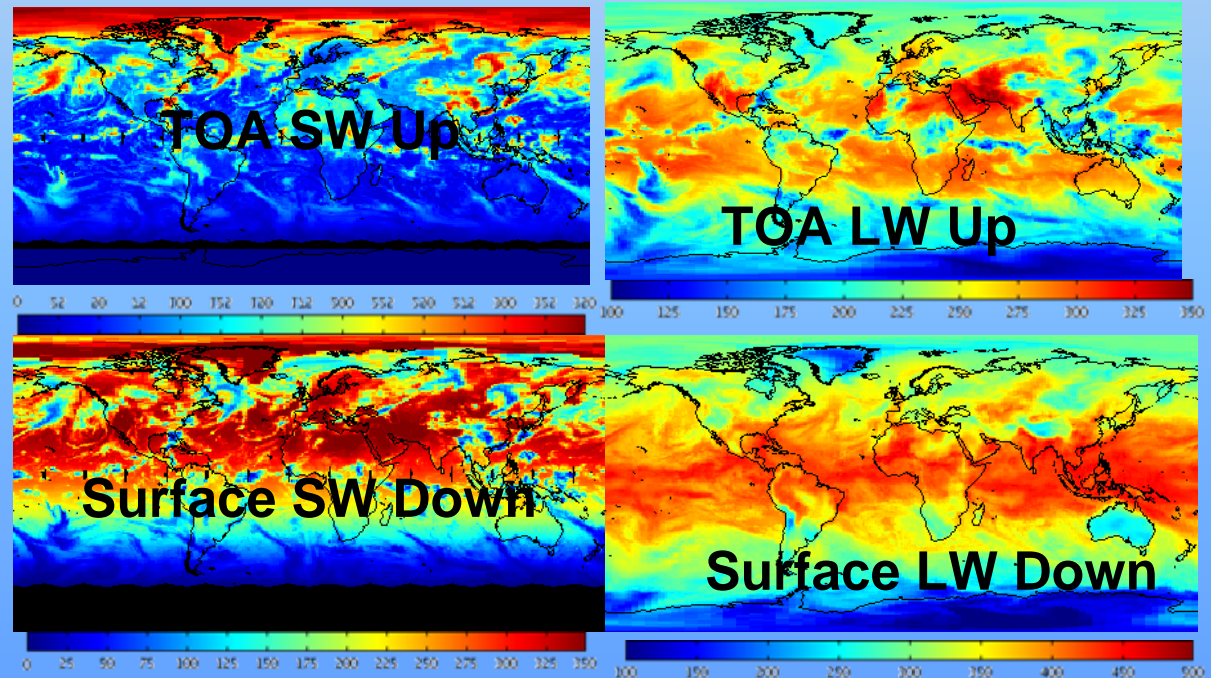
FLASHFlux: TOA and Surface Fluxes from CERES within a Week of Observation (Wm^{-2})

(Daily Composite Terra + Aqua, June 12, 2006)

Objective: Fill gap between observation and CERES data release. Provide data sets for: CLOUDSAT, validation field campaigns, land and ocean assimilation, research on development of extreme conditions (i.e., El Nino, fire environments, etc.), applications (agriculture - harvest information)

**Time interpolation
Combines Aqua
And Terra**

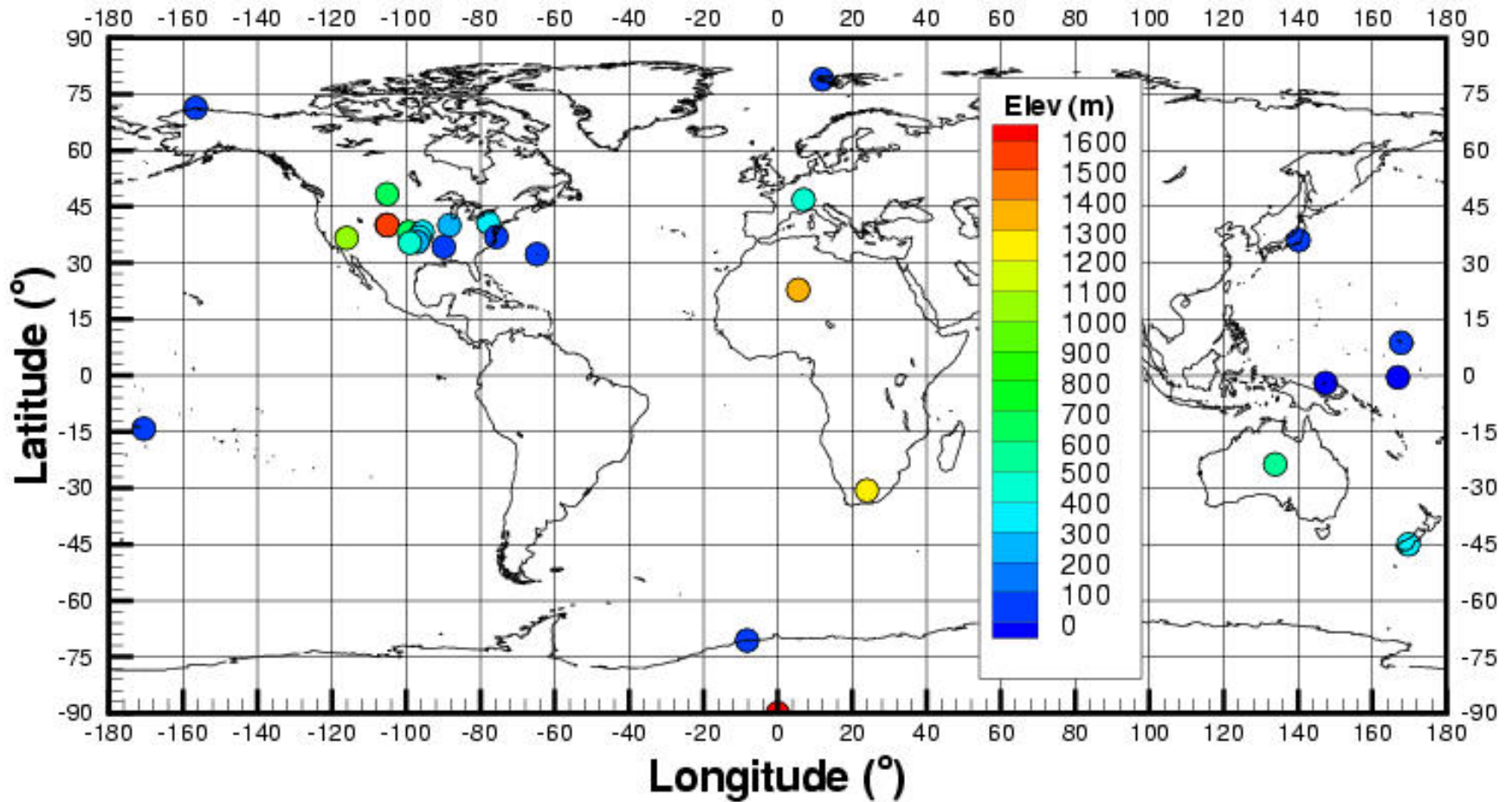
**Gridded flux
Products available
In Beta form at:
NASA LaRC
ASDC**





SRB/CERES SRBAVG Comparison

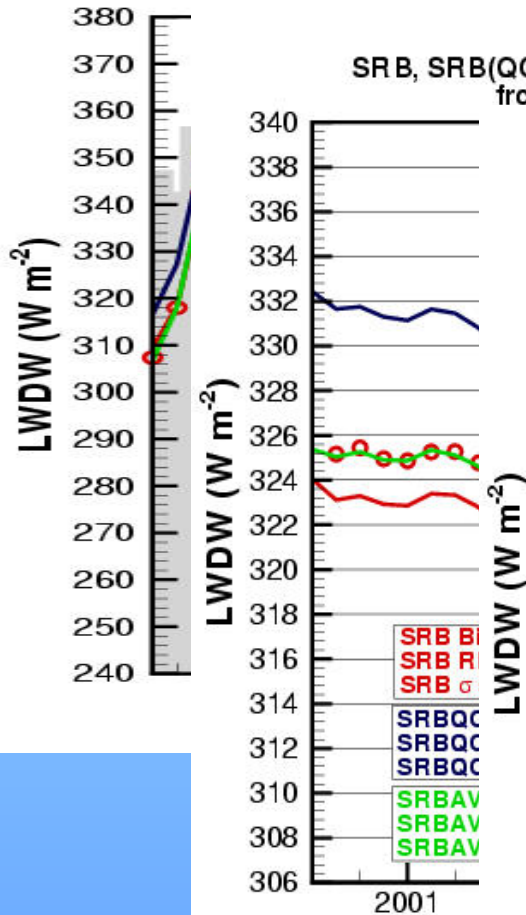
28 CAVE Sites from ARM, BSRN, SURFRAD and CMDL



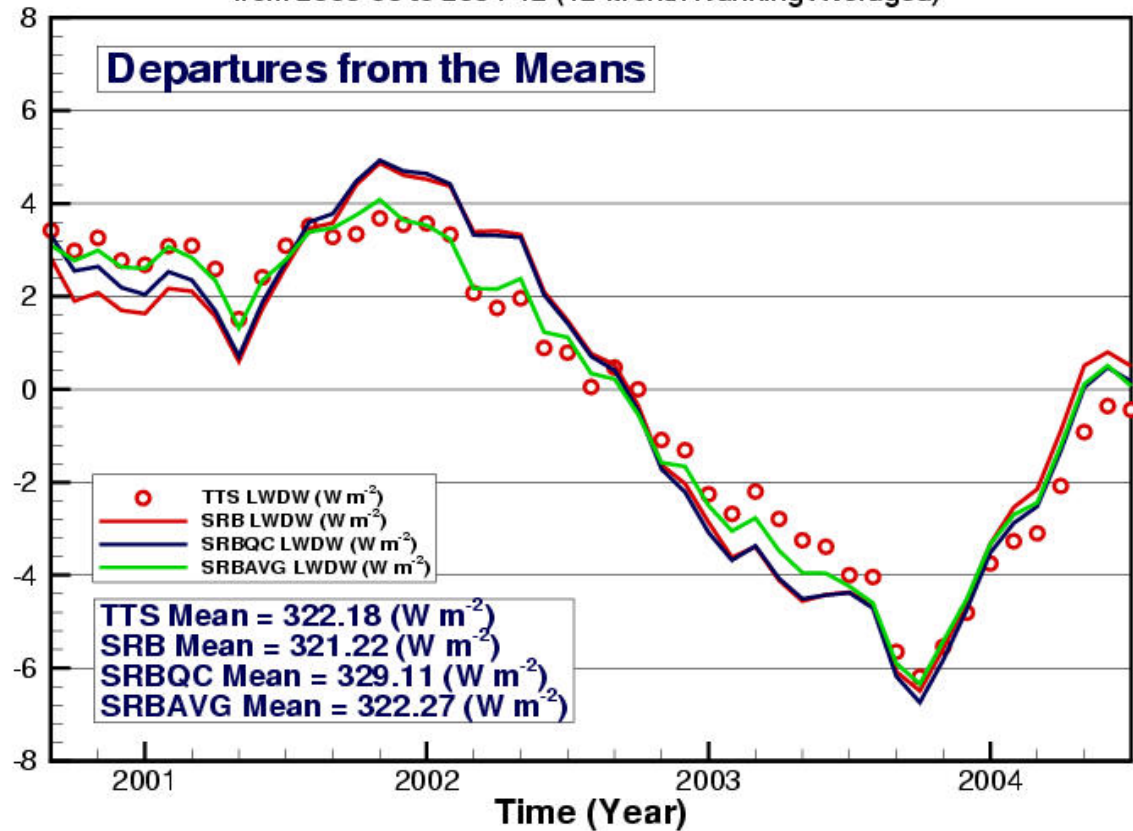


LW Mean Time Series

SRB, SRB(QC) and SRBAVG in Comparison with TTS LW DW Monthly Means from 2000-03 to 2004-12



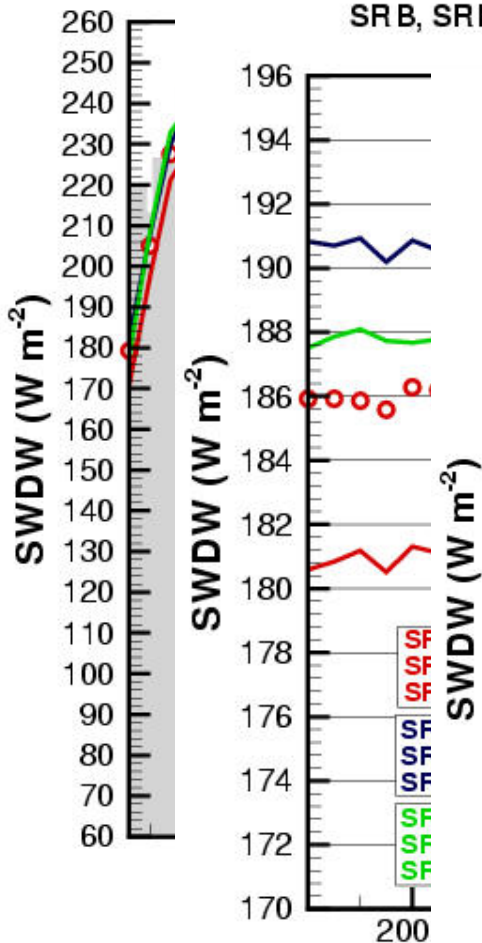
SRB, SRB(QC) and SRBAVG in Comparison with TTS LW DW Monthly Means from 2000-03 to 2004-12 (12-Month Running Averaged)



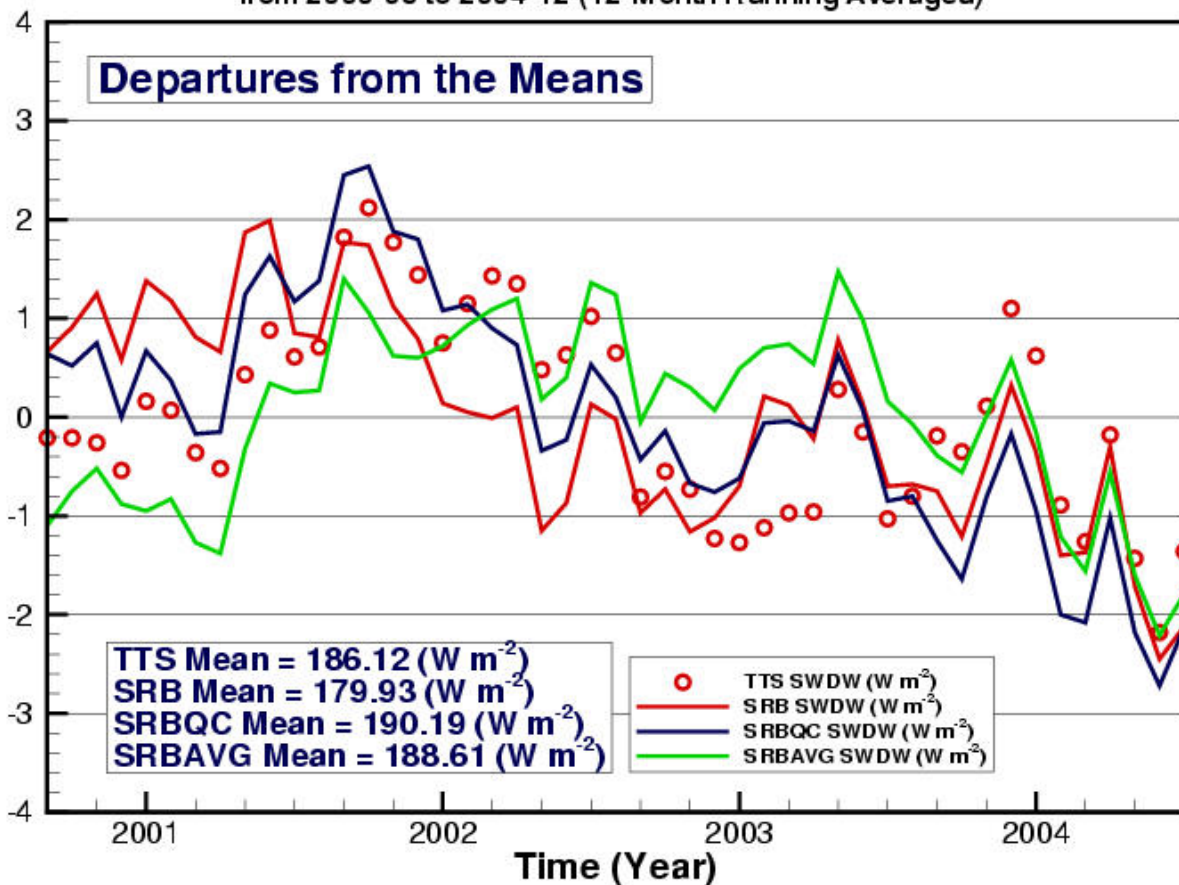


SW Mean Time Series

SRB, SRB(QC) and SRBAVG in Comparison with TTS SWDW Monthly Means
from 2000-03 to 2004-12 (12-Month Running Averaged)

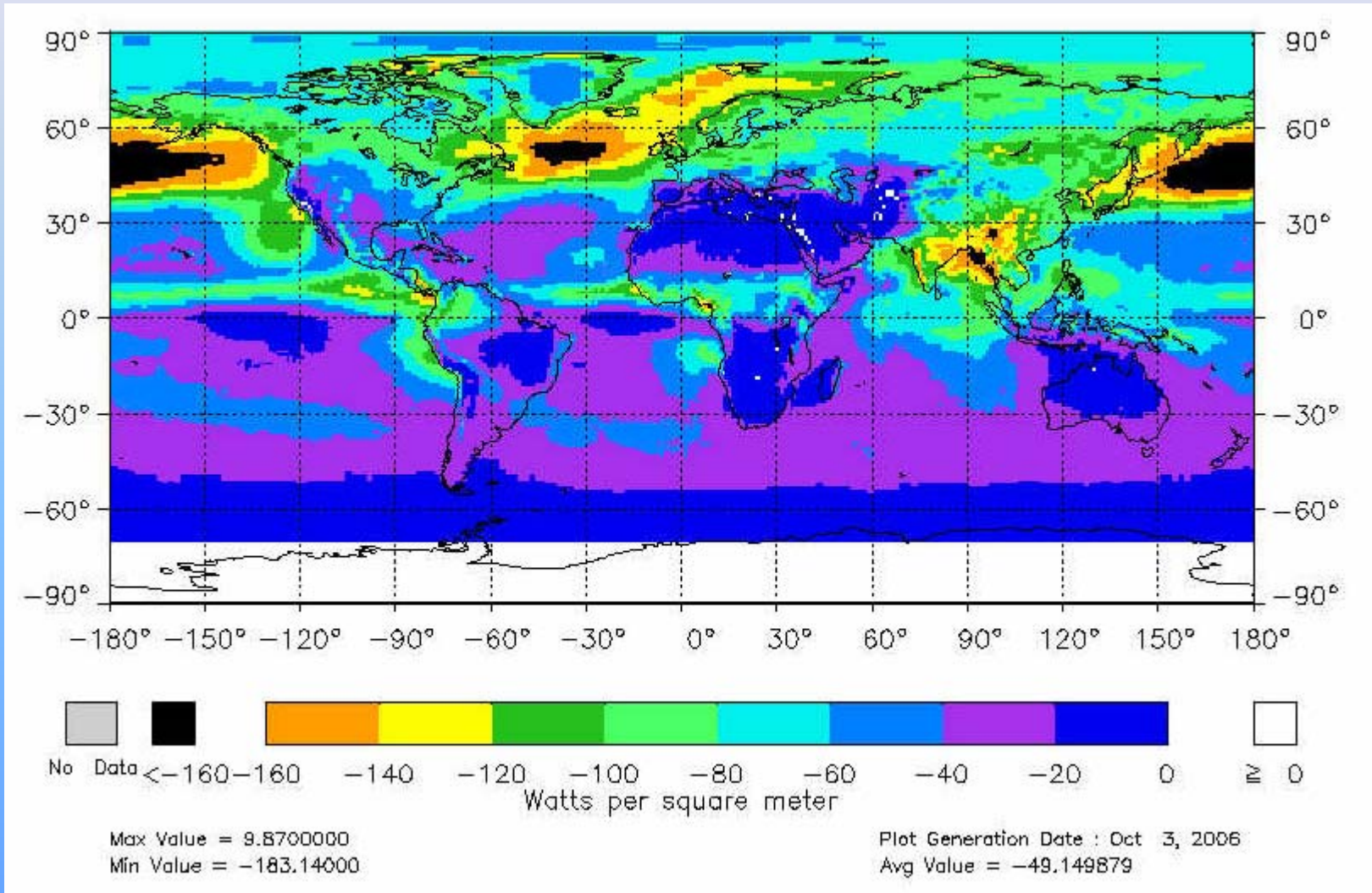


SRB, SRB(QC) and SRBAVG in Comparison with TTS SWDW Monthly Means
from 2000-03 to 2004-12 (12-Month Running Averaged)



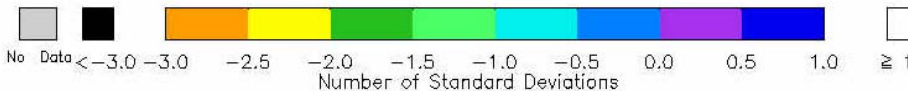
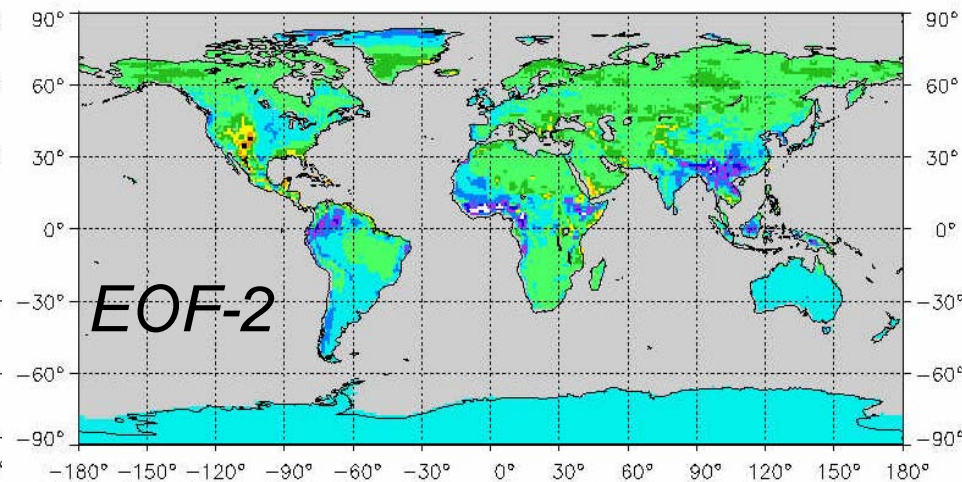
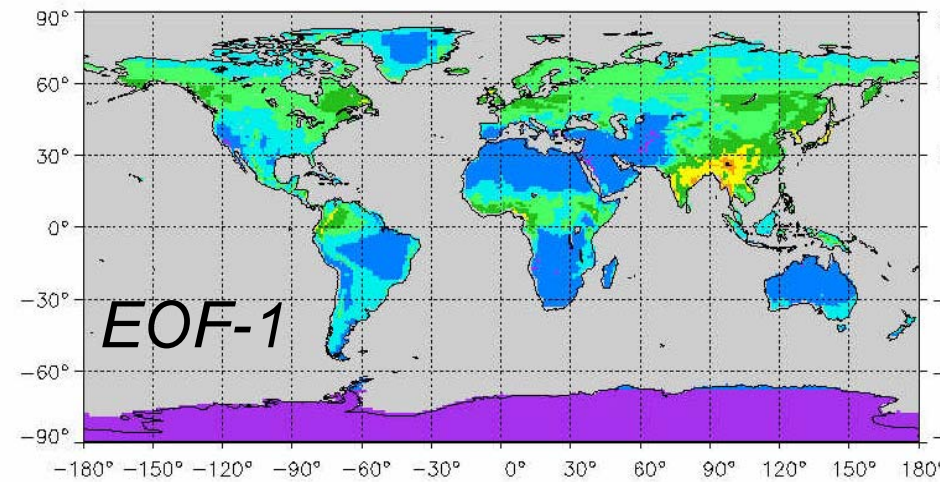
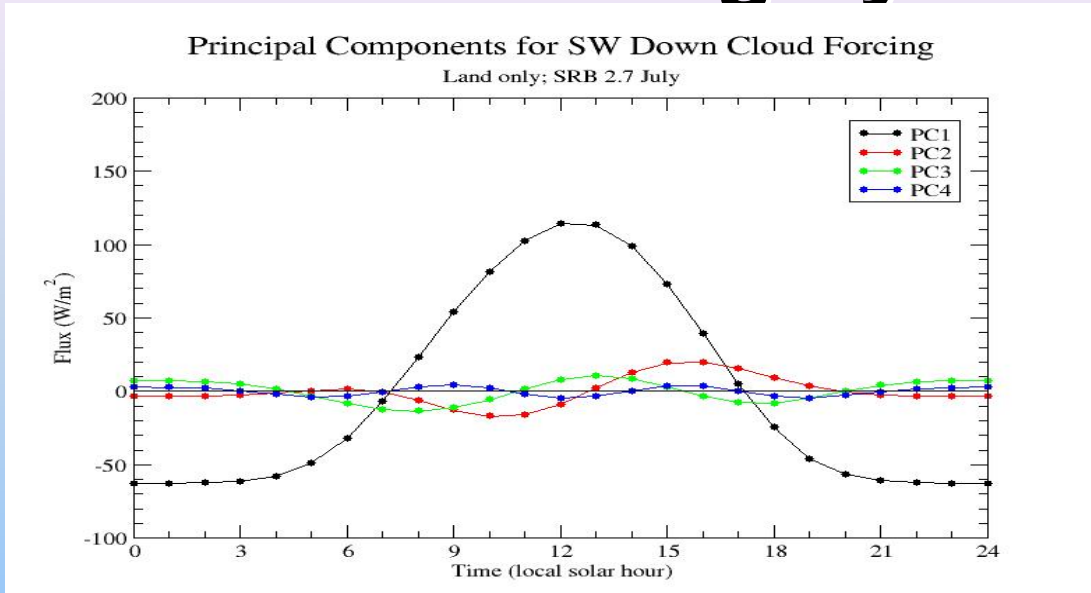


Mean July Surface Cloud Radiative Forcing (Courtesy Lou Smith/Pam Mlynczak)





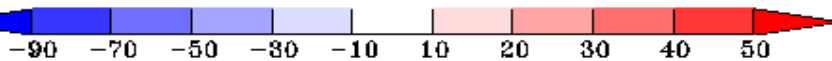
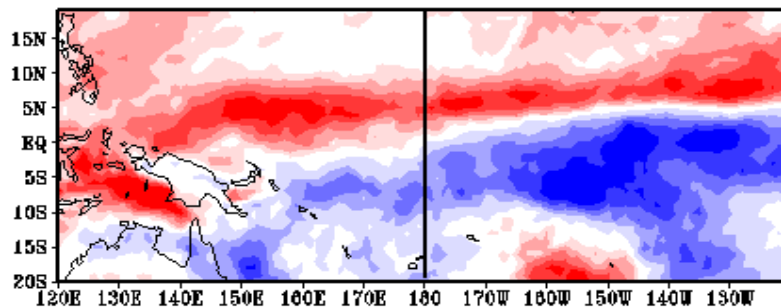
EOF Cloud Forcing by Local Time



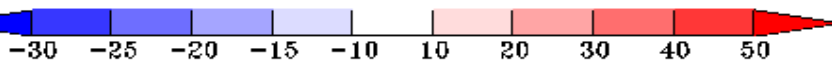
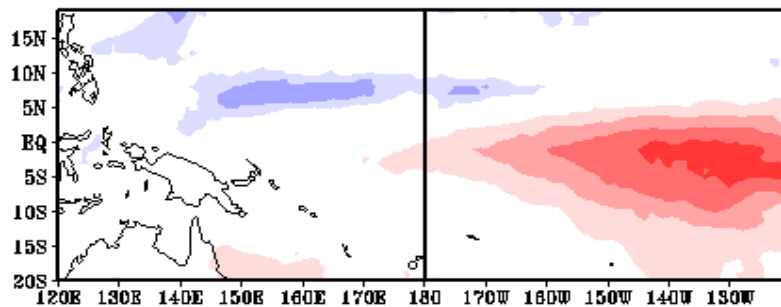


Flux/Meteorology Anomalies El Nino - January 1998

Surface DSF Anomaly

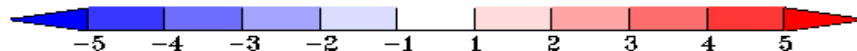
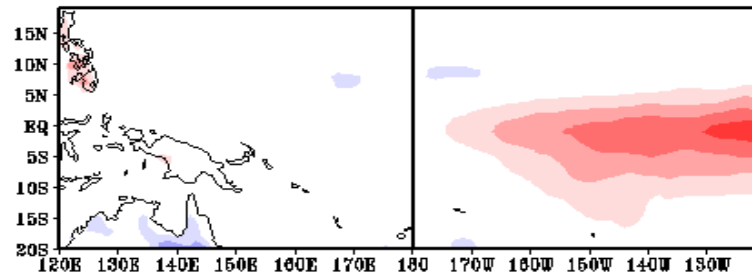


Surface DLF Anomaly

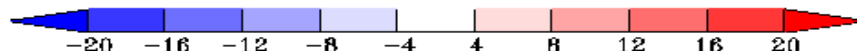
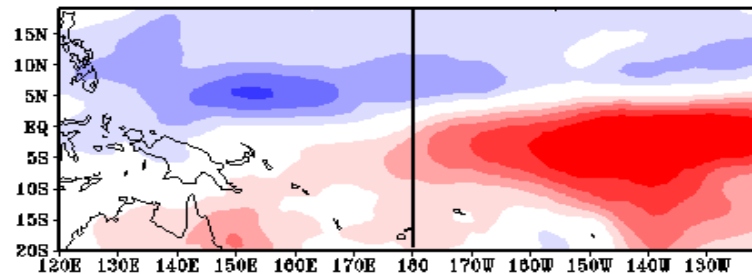


Fluxes (Wm^{-2}); T_s (K); WV (kgm^{-2})

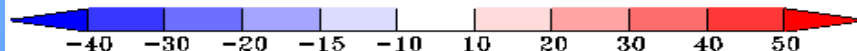
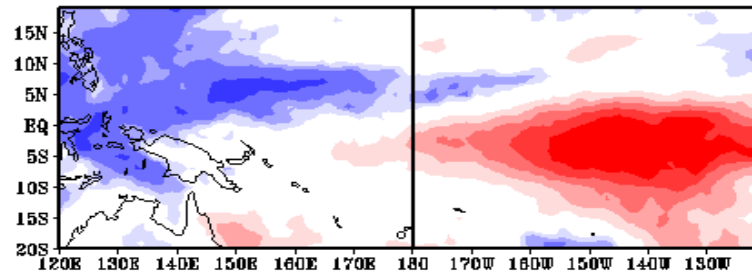
Surface Temperature Anomaly



Column Water Vapor Anomaly



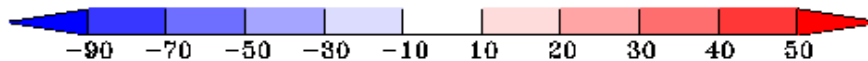
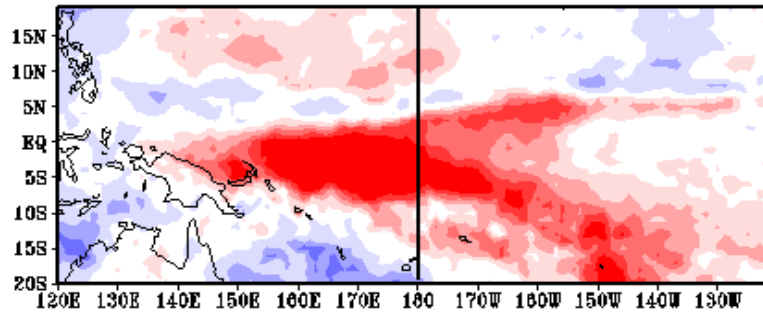
Cloud Amount Anomaly



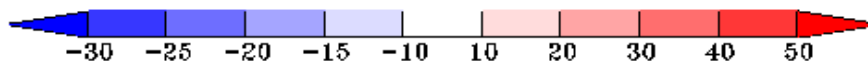
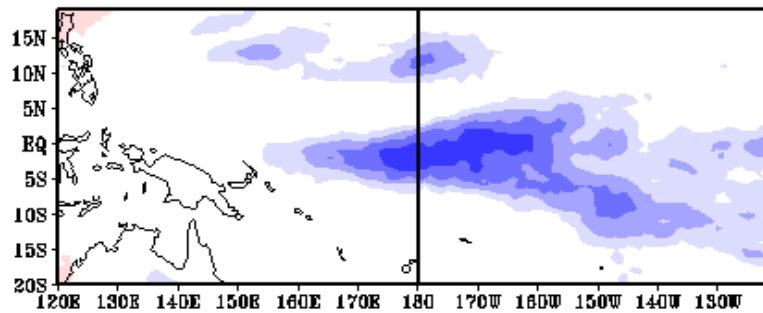


Flux/Meteorology Anomalies La Nina - December 1999

Surface DSF Anomaly

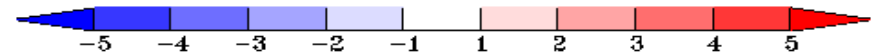
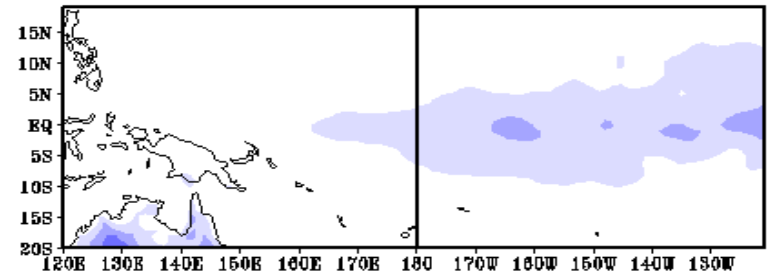


Surface DLF Anomaly

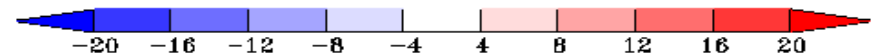
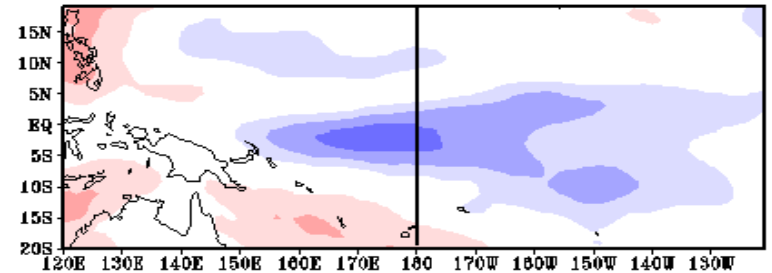


Fluxes (Wm^{-2}); T_s (K); WV (kgm^{-2})

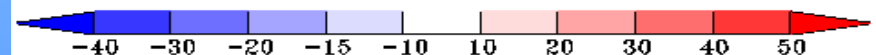
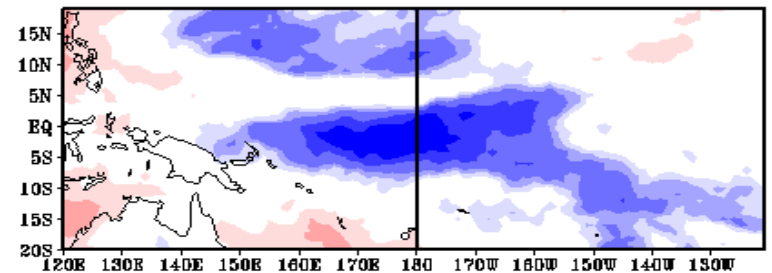
Surface Temperature Anomaly



Column Water Vapor Anomaly

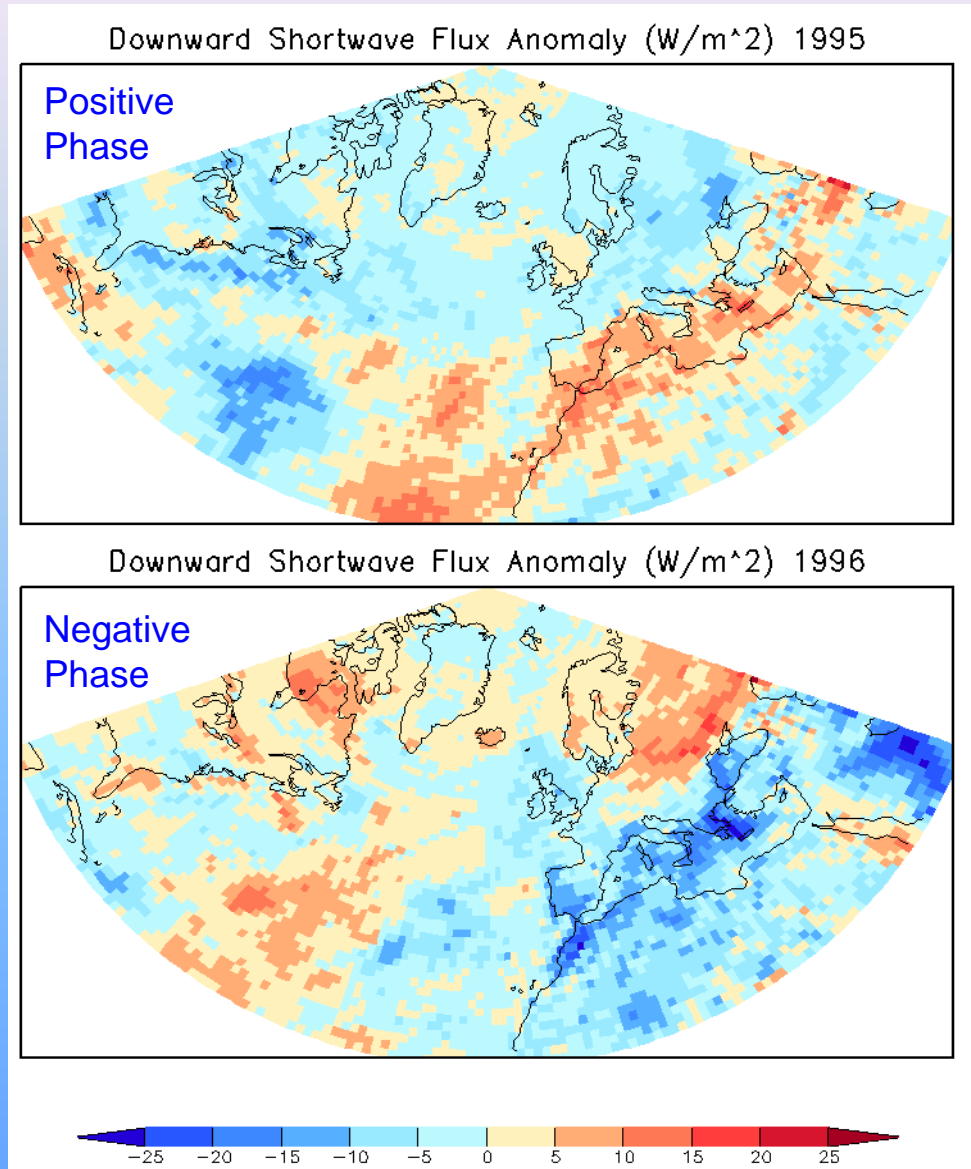


Cloud Amount Anomaly





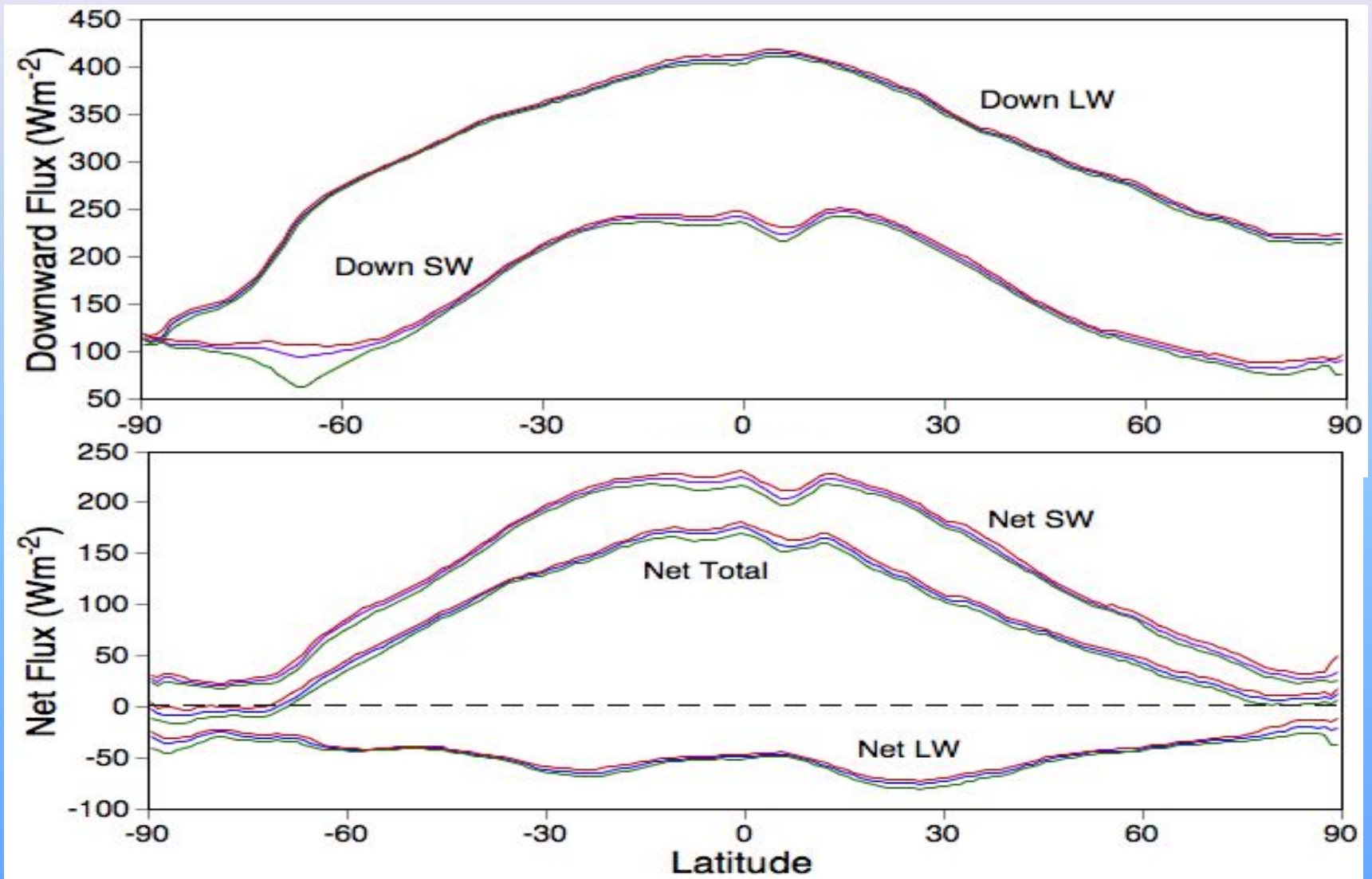
SW SRB Anomalies for NAO Phases - DJFM





21-YEAR ZONAL AVERAGE FLUXES

(January 1984 - December 2004)





SRB Data Archive

Atmospheric Science Data Center:

<http://gewex-srb.larc.nasa.gov>

Langley ASDC -- SRB Data Sets

http://eosweb.larc.nasa.gov/PRODOCS/srb/table_srb.html

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ATMOSPHERIC SCIENCE DATA CENTER

The Surface Radiation Budget (SRB) computed using models. The main inputs for the Release 2.5 data set in June 2005. Please refer to [SRB Prev](#)

- Langley

Available data products: [3 Hourly A](#)

For convenience in ordering a speci

Data Set Name (Select to Order)	Documents	Sample Read Software	Parameter(s)	Temporal Coverage
SRB_REL2.5_LW_DAILY.	Readme 2.5.	Fortran 2.5.	Cloud Forcing, Longwave Radiation, Net Radiation, Outgoing Longwave Radiation, Radiative Flux, Radiative Forcing	07/01/1983 - 06/30/2005
SRB_REL2.5_QCLW_DAILY.	Readme 2.5.	Fortran 2.5.	Cloud Forcing, Longwave Radiation	07/01/1983 - 06/30/2005
SRB_REL2_SW_DAILY.	Readme.	Fortran.	Viewing Geometry, Incoming Shortwave Radiation, Radiative Flux, Solar Irradiance, Solar Radiation, Photosynthetically Active Radiation, Direct/Diffuse Solar Radiation	07/01/1983 - 10/31/1995
SRB_REL2.5_QCSW_DAILY.	Readme 2.5.	Fortran 2.5.	Shortwave Radiation	07/01/1983 - 06/30/2005
Monthly Averages				
Data Set Name (Select to Order)	Documents	Sample Read Software	Parameter(s)	Temporal Coverage
SRB_REL2.5_LW_3HRLY_MONTHLY.	Readme 2.5.	Fortran 2.5.	Cloud Forcing, Longwave Radiation, Net Radiation, Outgoing Longwave Radiation, Radiative Flux, Radiative Forcing	07/01/1983 - 06/30/2005
SRB_REL2.5_LW_MONTHLY.	Readme 2.5.	Fortran 2.5.	Cloud Forcing, Longwave Radiation, Net Radiation, Outgoing Longwave Radiation, Radiative Flux, Radiative Forcing	07/01/1983 - 06/30/2005
SRB_REL2.5_QCLW_3HRLY_MONTHLY.	Readme 2.5.	Fortran 2.5.	Cloud Forcing, Longwave Radiation	07/01/1983 - 06/30/2005
SRB_REL2.5_QCLW_MONTHLY.	Readme 2.5.	Fortran 2.5.	Cloud Forcing, Longwave Radiation	07/01/1983 - 06/30/2005
SRB_REL2_SW_3HRLY_MONTHLY.	Readme.	Fortran.	Direct/Diffuse Solar Radiation, Incoming Shortwave Radiation, Photosynthetically Active Radiation, Radiative Flux, Solar Irradiance, Solar Radiation, Viewing Geometry.	07/01/1983 - 10/31/1995
SRB_REL2_SW_MONTHLY.	Readme.	Fortran.	Viewing Geometry, Incoming Shortwave Radiation, Radiative Flux, Solar Irradiance, Solar Radiation, Photosynthetically Active Radiation, Direct/Diffuse Solar Radiation	07/01/1983 - 10/31/1995
SRB_REL2.5_QCSW_MONTHLY.	Readme 2.5.	Fortran 2.5.	Shortwave Radiation	07/01/1983 - 06/30/2005

Done



Data Accessibility: Live Access Server

Web site: <http://mynasadata.larc.nasa.gov>

MY NASA DATA Live Access Server

http://mynasadata.larc.nasa.gov/las/servlets/constrain?va

My NASA Data

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Firefox prevented this site from opening a popup window. Click here for options...

MY NASA DATA

Mentoring and inquiry using NASA Data on Atmospheric and earth science for Teachers and Amateurs

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single data set **compare two**

Select Datasets
Show Variables
Set Constraints
View Output
Output Options
Previous Output
Define variable
About Live Access Server
LAS UI Version 6.4

Datasets > Atmosphere > Atmospheric Radiation
Variable(s): **Pinker All-Sky Downward Shortwave Monthly Surface Irradiance (SRB)**

Select your desired view (geometry of output) and output (type of product).
Then set the 4-D region (lon-lat-depth-time) and any additional constraints. [Help](#)

Select view: Longitude-Latitude Map [Next >](#)
Select output: Shaded plot
Select region: Full Region **Go**
[Use map applet](#)

Help **Reset**

89 N
180 W 180 E
89 S **Go**

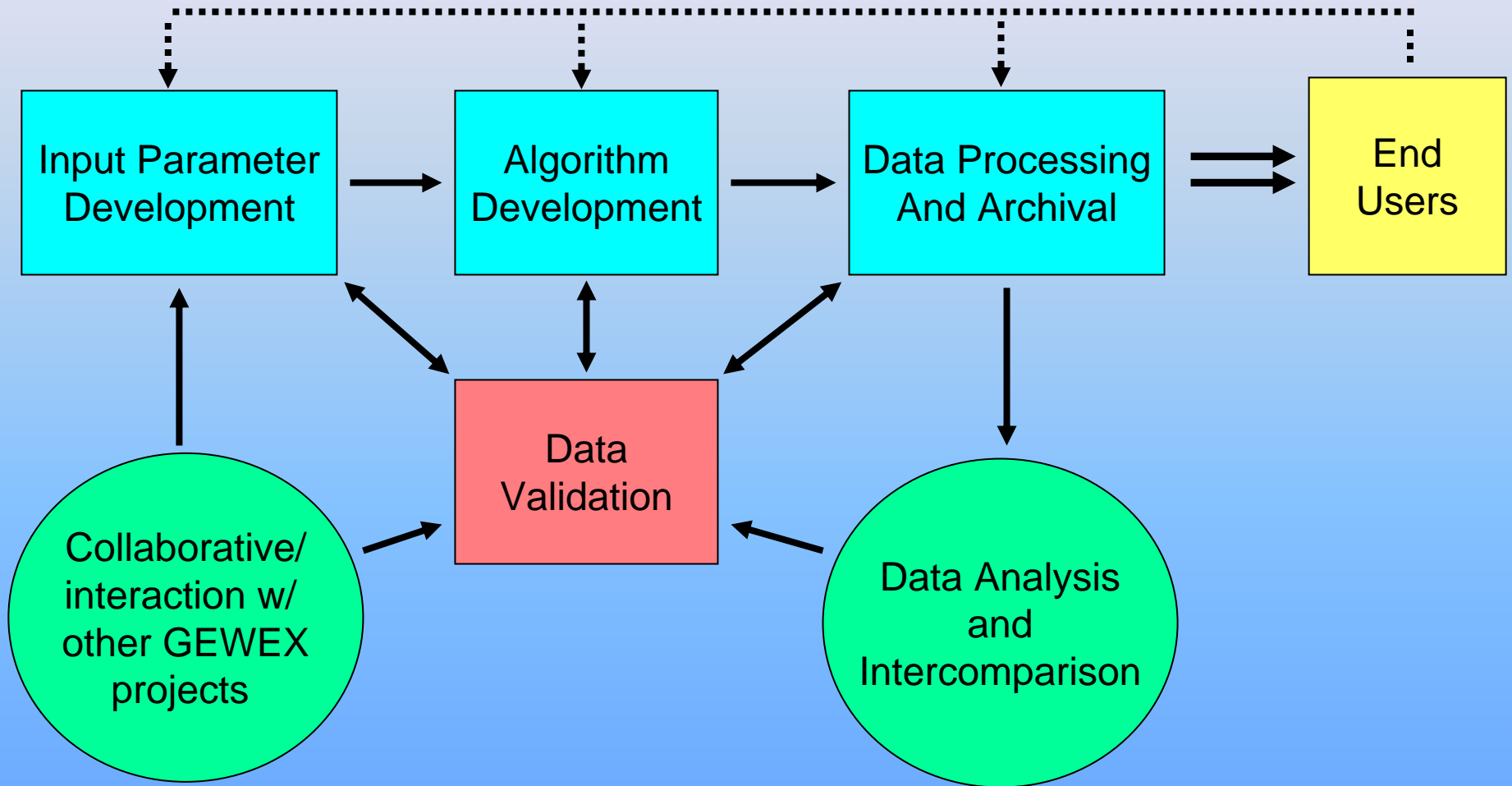
Zoom + **Zoom -**

Select time: 01 Jan 1985 01-Jan-1985

Connecting to mynasadata.larc.nasa.gov...



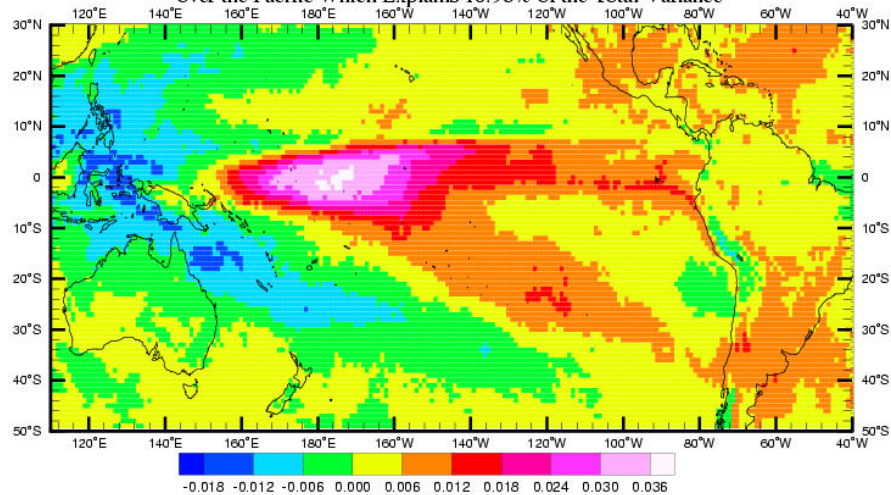
SRB Logistical Flow



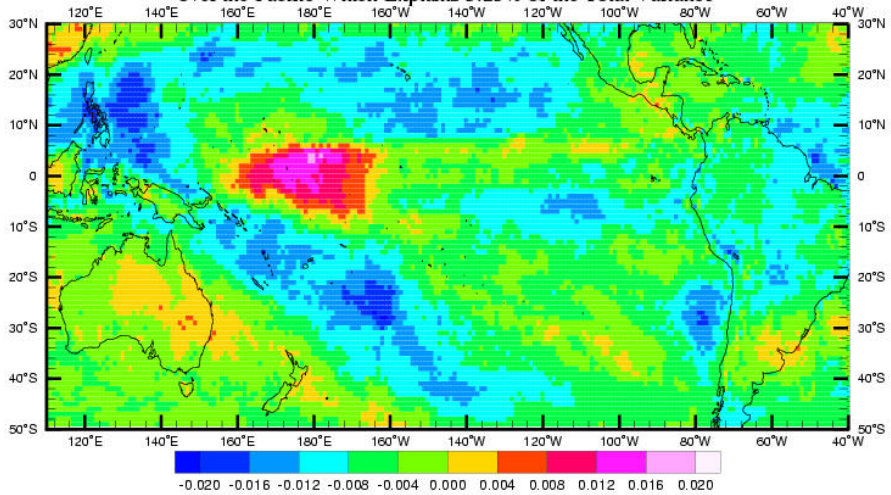


SRB Analysis: EOF Components

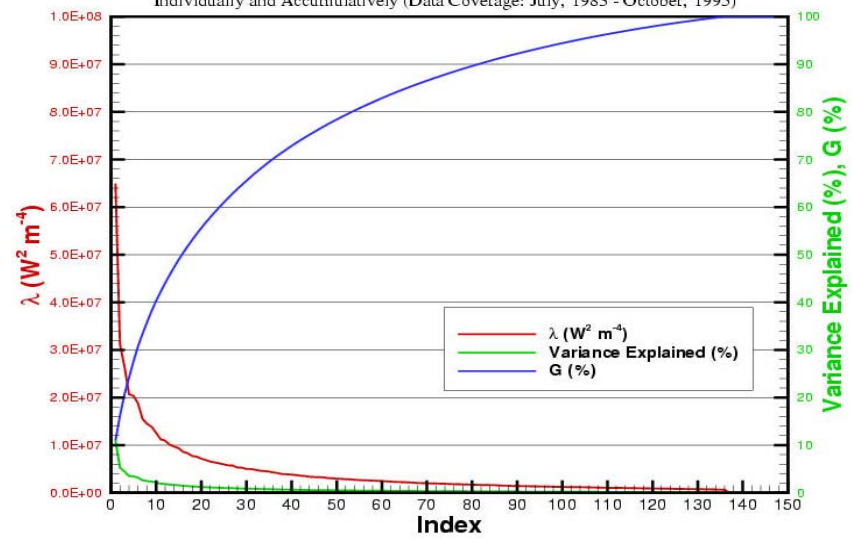
The First Empirical Orthogonal Function (EOF) of the Deseasonalized SRB Net Downward Shortwave Flux from July, 1983 to October, 1995 over the Pacific Which Explains 10.96% of the Total Variance



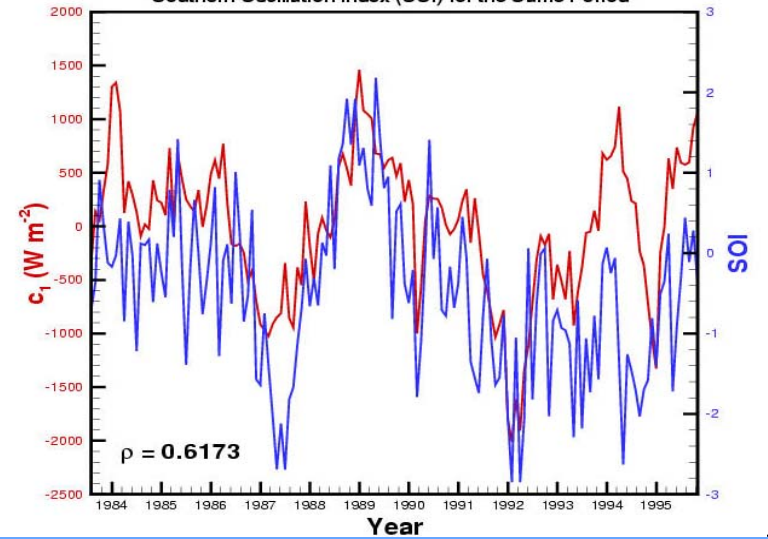
The Second Empirical Orthogonal Function (EOF) of the Deseasonalized SRB Net Downward Shortwave Flux from July, 1983 to October, 1995 over the Pacific Which Explains 5.25% of the Total Variance



Eigenvalues Corresponding to EOFs of the SRB Monthly Means of Deseasonalized Shortwaved Downward Flux over the Pacific (Range 01) Only and Variance Explained Individually and Accumulatively (Data Coverage: July, 1983 - October, 1995)



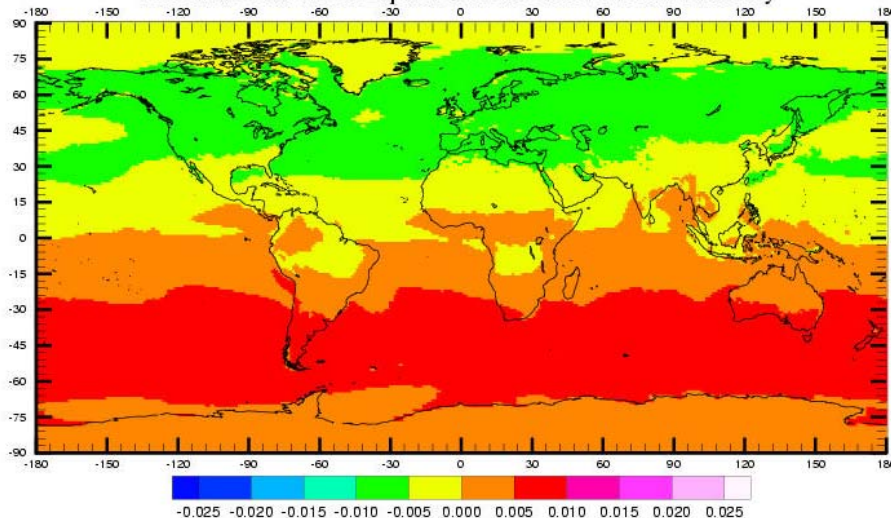
The Coefficient of the first EOF of SRB Deseasonalized Net Downward Shortwave Flux from July, 1983 - October, 1995 over the Pacific in Comparison with the Southern Oscillation Index (SOI) for the Same Period



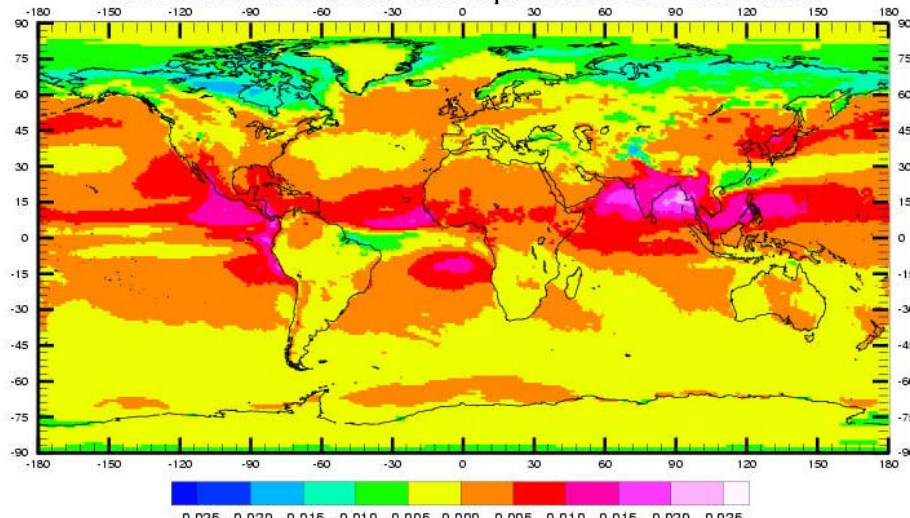


SRB Analysis: EOF Components

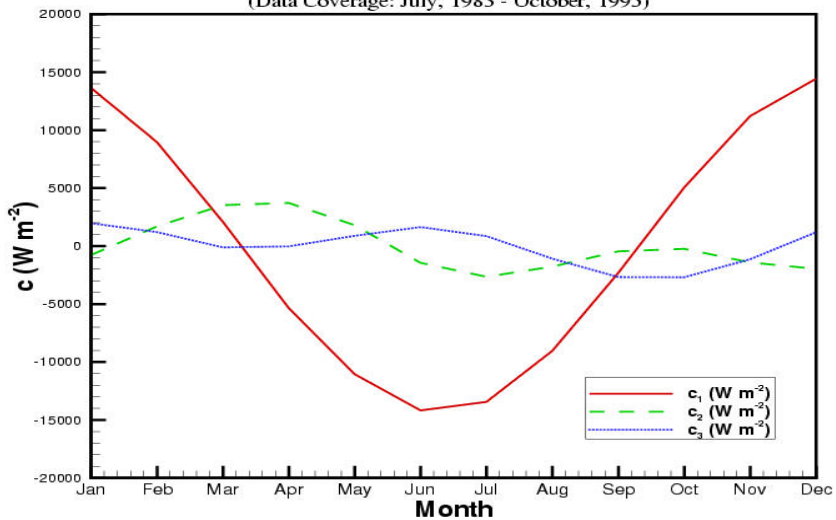
The First Empirical Orthogonal Function (EOF) of 12-Year Averages of SRB Net Downward Shortwave Flux Which Explains 92.61% of the Seasonal Variability



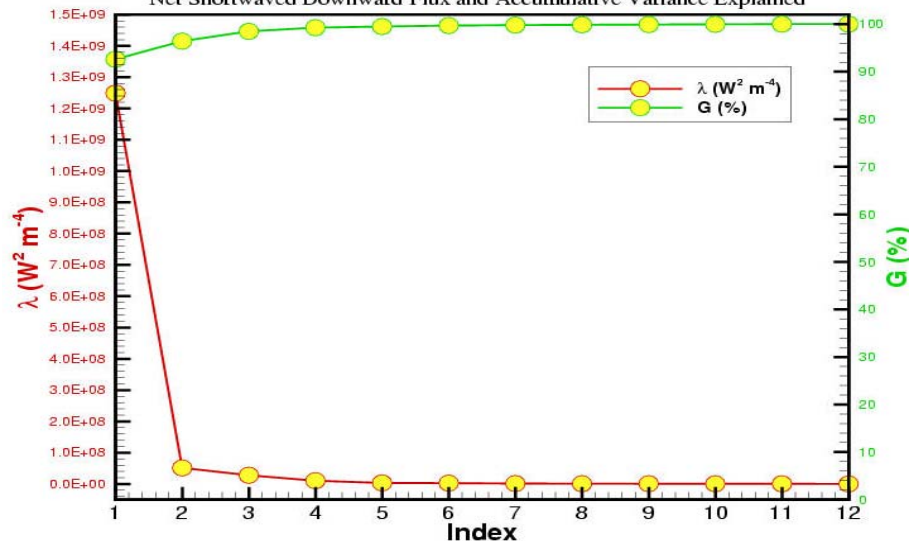
The Second Empirical Orthogonal Function (EOF) of the 12-Year Averages of SRB Net Downward Shortwave Flux Which Explains 3.81% of the Total Variance



The Coefficients of the First Three EOFs of the SRB 12-Year Averages of Net Shortwave Downward Flux (Data Coverage: July, 1983 - October, 1995)



Eigenvalues Corresponding to EOFs of the SRB 12-Year Averages of Net Shortwave Downward Flux and Accumulative Variance Explained





GEWEX SRB: Flux Algorithms

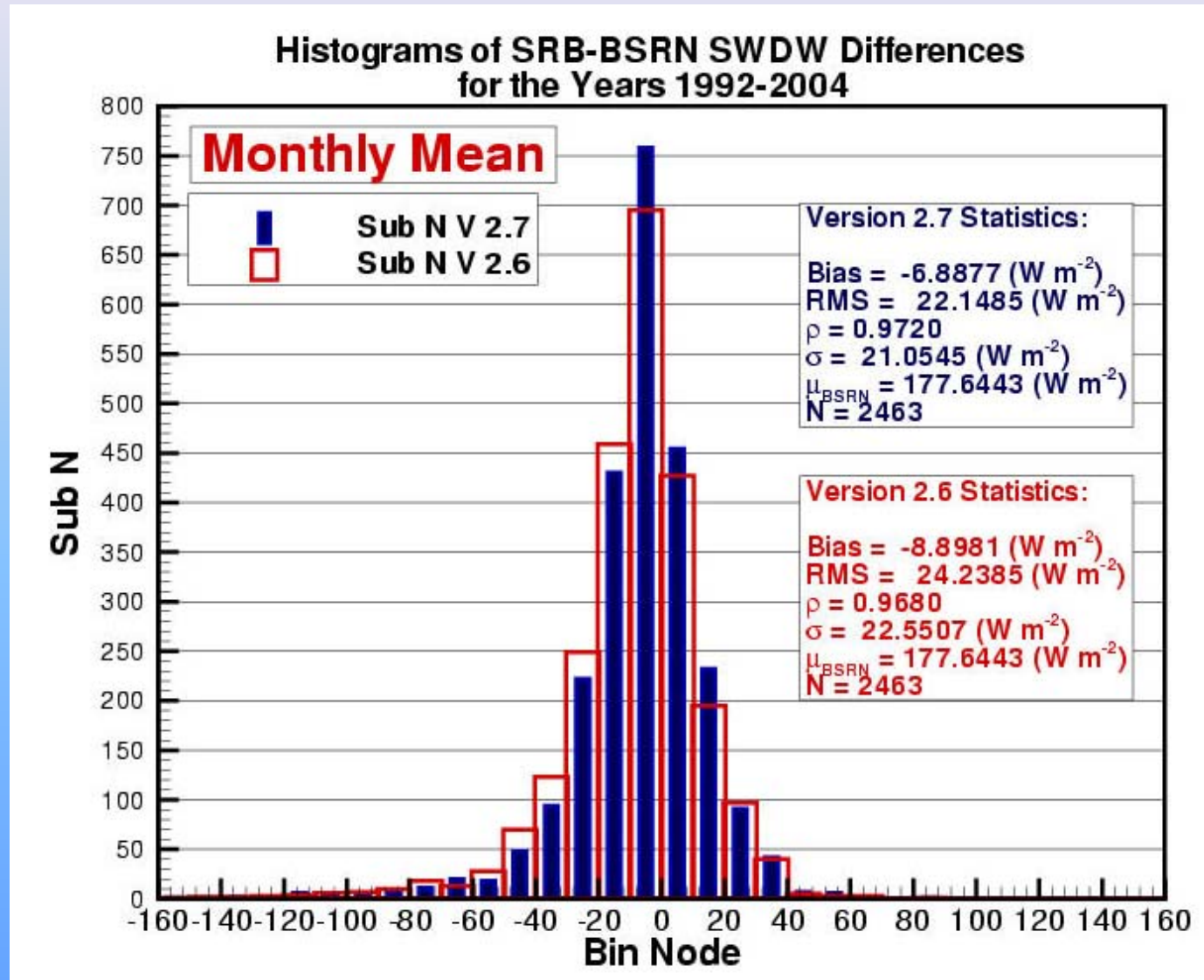
- Shortwave (0.3 - 5.0 μm):
 1. *GEWEX SW* (Pinker/Laszlo, 1992): NB-BB conversion of ISCCP radiances to TOA fluxes using ERBE ADM's, Atmospheric Reflection/Transmission lookup table using Δ -Eddington 2-S; retrieves surface albedo, and PAR.
 2. *GEWEX SW QC* (Gupta *et al.*, 2001): Daily averaged SW 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.



BSRN Observations: Use for Algorithm Improvement Verification

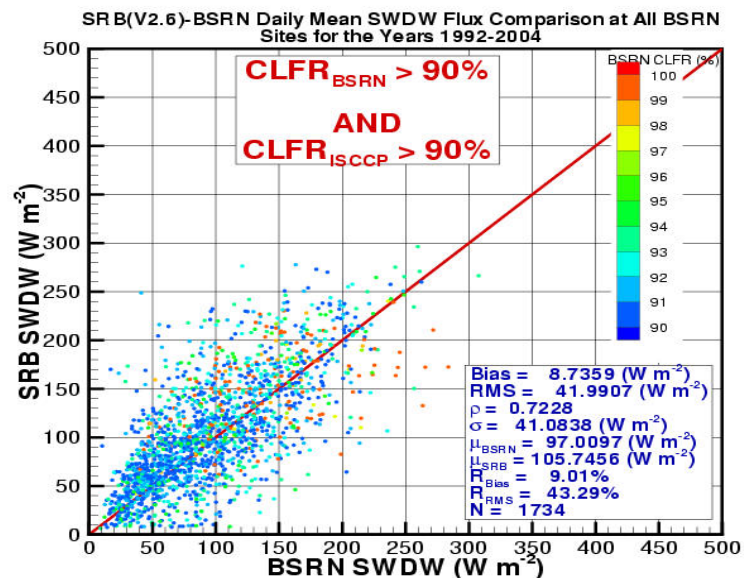
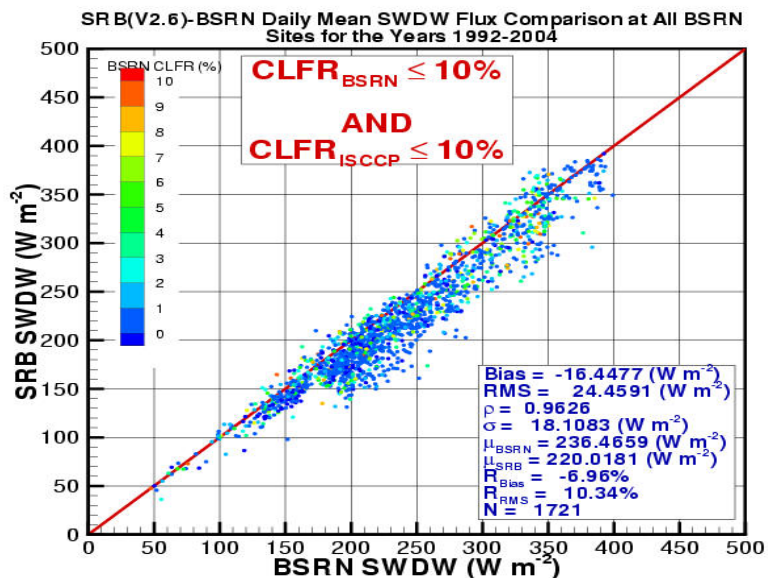
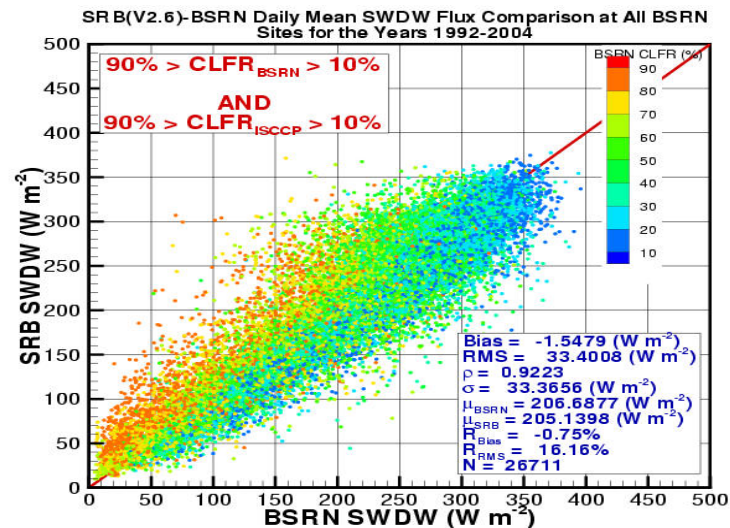
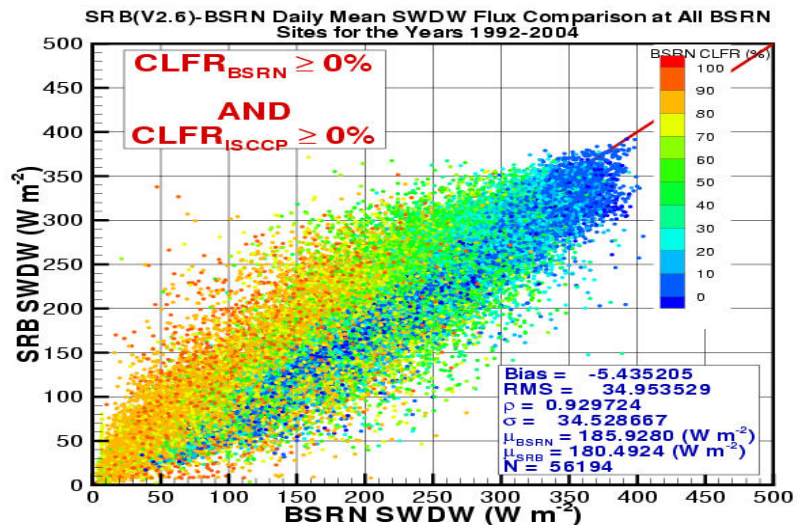
Difference histograms showed improved distributions from one version to next.

Distribution more narrow and less skewed than previous SW version





Validation by Cloud Amount





SRB Regional Annual Averages

		Flux Up TOA (Wm^{-2})	Flux Down Surface (Wm^{-2})	Flux Up Surface (Wm^{-2})	Cloud Radiative Forcing T (Wm^{-2})	Cloud Radiative Forcing Surface (Wm^{-2})	Net Flux Surface (Wm^{-2})	TOA Net Flux (Wm^{-2})	Atmospheric Net Flux (Wm^{-2})	Surface Albedo
Shortwave Fluxes	Global	103.72	186.53	22.83	47.78	57.32	166.53	241.74	75.21	0.148
	NH	103.53	186.54	25.13	44.50	53.55	163.42	240.32	76.89	0.163
	SH	103.86	186.52	20.52	50.43	60.23	167.94	240.89	72.95	0.133
	20N - 20S	99.68	237.48	19.95	45.98	53.41	217.53	310.13	92.66	0.085
	Global Land	115.92	177.77	44.26	35.20	45.05	138.48	218.00	79.52	0.283
	Global Ocean	98.50	191.20	14.31	52.74	62.04	179.23	252.92	73.69	0.093
Longwave Fluxes	Global	240.29	342.76	395.36	-27.72	35.06	-52.59	-240.29	-187.70	
	NH	240.95	344.09	399.49	-27.72	32.57	-55.40	-240.95	-185.55	
	SH	239.62	341.42	391.20	-27.72	37.56	-49.79	-239.62	-189.84	
	20N - 20S	259.88	402.84	457.22	-30.24	22.63	-54.38	-259.88	-205.49	
	Global Land	232.13	306.17	372.25	-25.36	31.20	-66.08	-232.13	-166.10	
	Global Ocean	244.13	357.52	405.04	-28.45	36.74	-47.52	-244.13	-196.66	



SRB Regional Variability

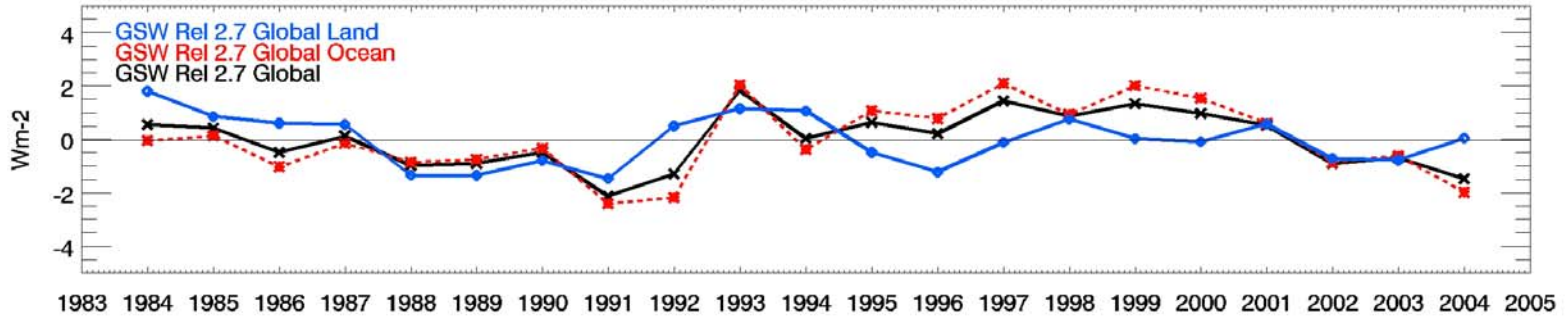
Standard Deviation of De-seasonalized Anomalies

		Flux Up TOA (Wm^2)	Flux Down Surface (Wm^2)	Flux Up Surface (Wm^2)	Cloud Radiative Forcing T (Wm^2)	Cloud Radiative Forcing Surface (Wm^2)	Net Flux Surface (Wm^2)	TOA Net Flux (Wm^2)	Surface Albedo
Shortwave Fluxes	Global	1.73	1.69	1.20	1.45	1.65	1.99	1.77	0.006
	NH	2.18	1.91	1.37	1.33	1.76	2.43	2.17	0.007
	SH	1.83	2.44	1.49	2.23	2.43	2.15	1.92	0.007
	20N - 20S	2.63	2.42	1.04	1.60	1.94	3.05	2.65	0.005
	Global Land	2.04	1.83	2.26	1.29	1.79	2.33	2.11	0.011
	Global Ocean	1.91	2.11	1.02	1.77	1.79	2.23	1.95	0.006
Longwave Fluxes	Global	0.86	1.21	1.13	0.70	0.98	1.15		
	NH	1.32	1.52	1.58	0.91	1.24	1.63		
	SH	1.09	1.21	0.90	0.87	0.86	1.04		
	20N - 20S	1.47	1.95	1.58	1.30	1.43	1.23		
	Global Land	1.65	1.99	2.80	1.01	1.25	2.87		
	Global Ocean	0.90	1.10	0.78	0.74	0.99	0.97		

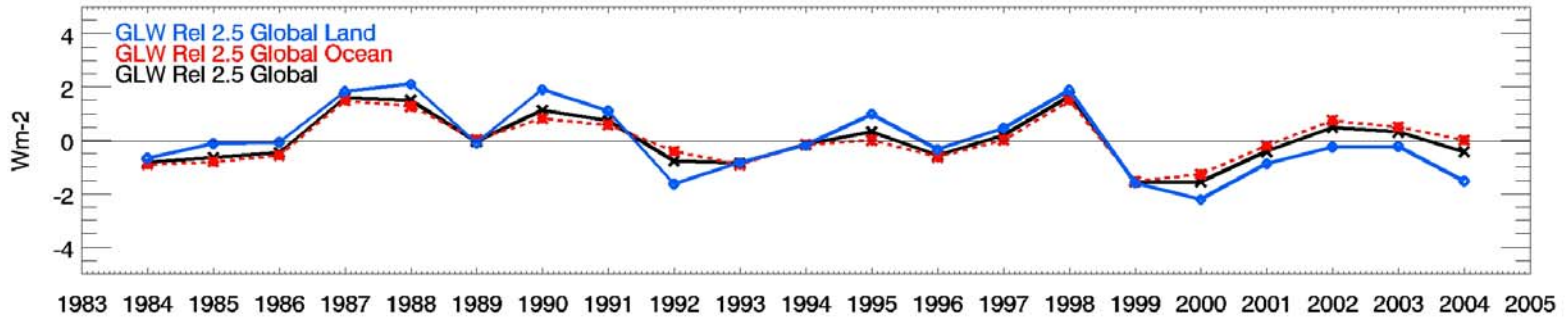


12 Month Averaged Surface Fluxes

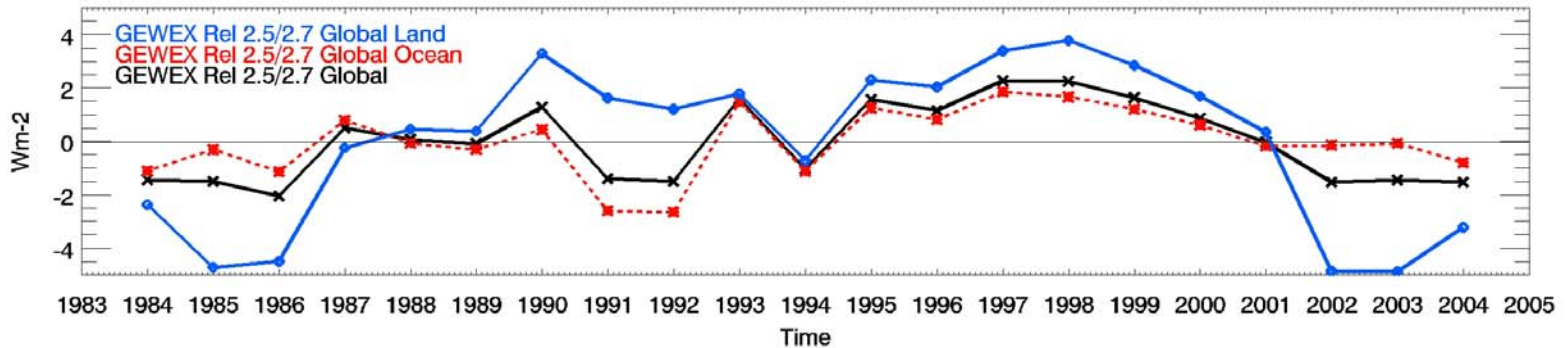
Shortwave All Sky Surface Downward Flux, Wm^{-2}



Longwave All Sky Surface Downward Flux, Wm^{-2}



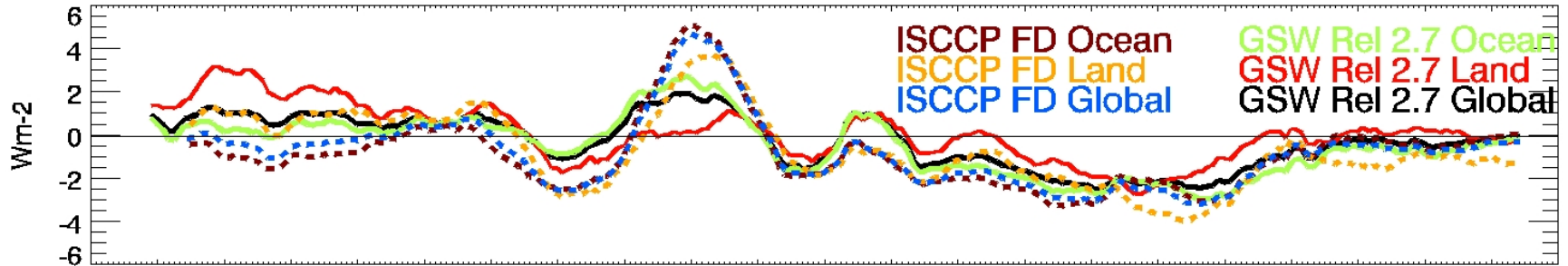
Surface Total Net Flux, Wm^{-2}



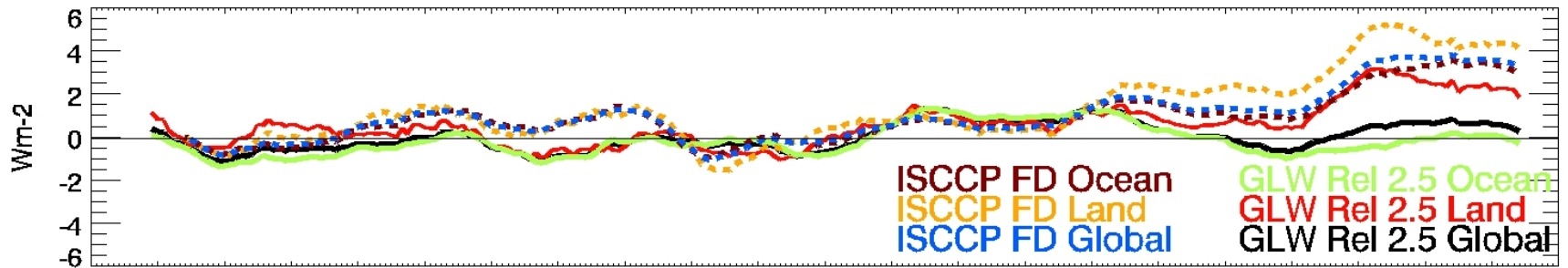


Long-term Monthly Average Anomalies

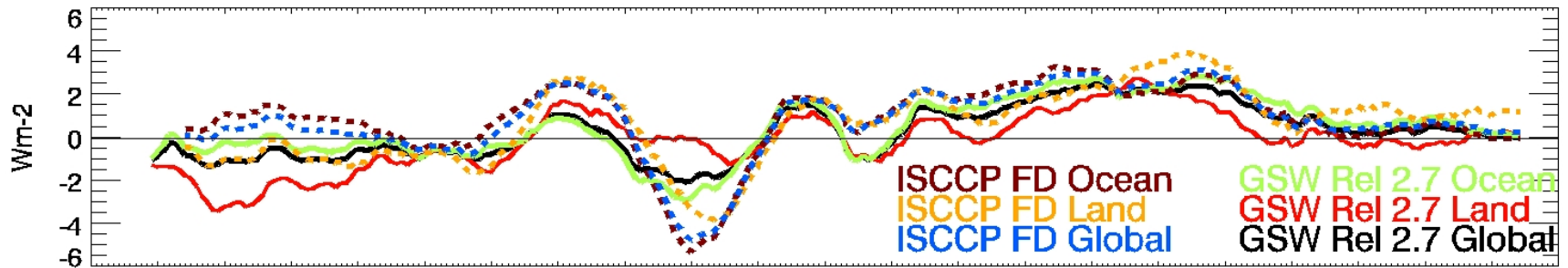
All Sky Shortwave TOA Upward Flux; Deseasonalized Running Average



All Sky Longwave TOA Upward Flux; Deseasonalized Running Average



All Sky Shortwave TOA Net Flux; Deseasonalized Running Average

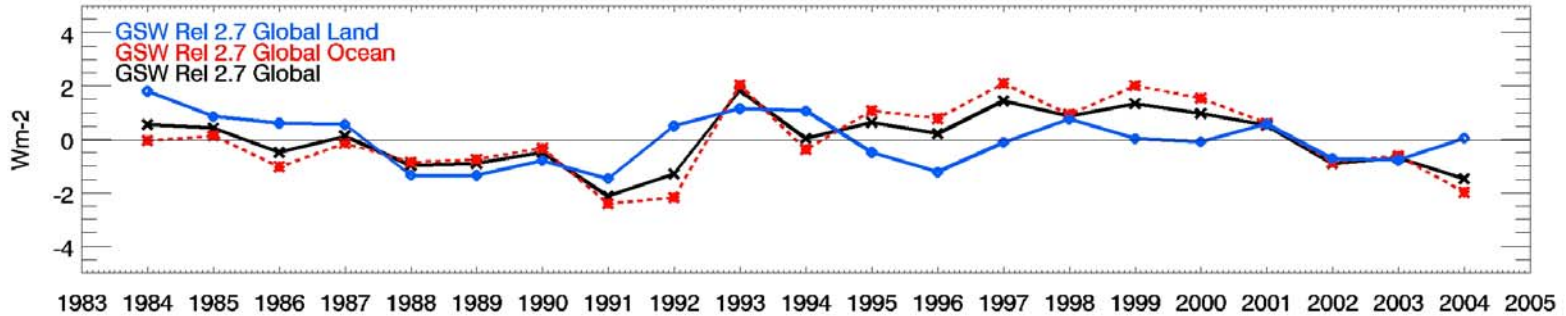


1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Time

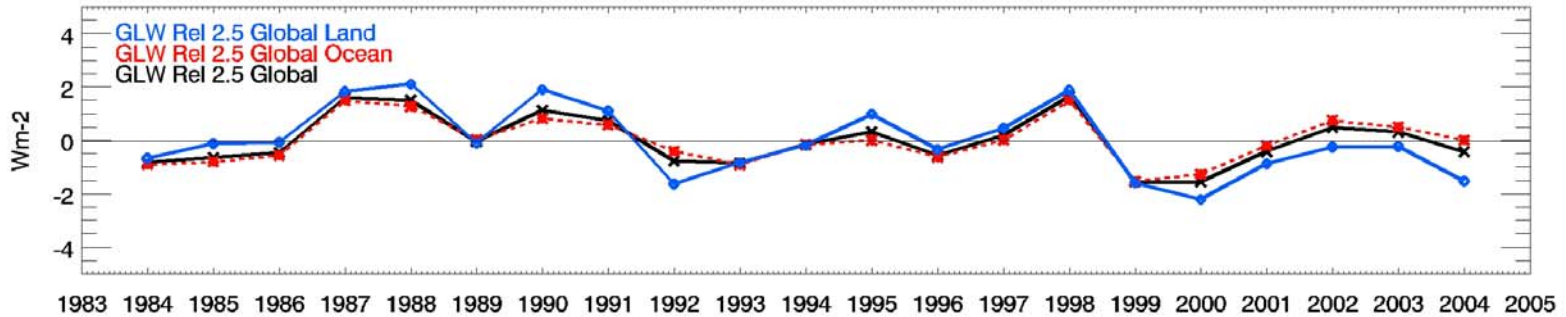


12 Month Averaged Surface Fluxes

Shortwave All Sky Surface Downward Flux, Wm^{-2}



Longwave All Sky Surface Downward Flux, Wm^{-2}



Surface Total Net Flux, Wm^{-2}

