



NASA/GEWEX Surface Radiation Budget: Integrated Data Product With Reprocessed Radiance, Cloud, and Meteorology Inputs, and New Surface Albedo Treatment

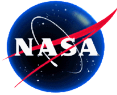
International Radiation Symposium

21 Apr 2016

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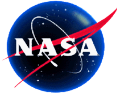
SRB Release 3 Data Products



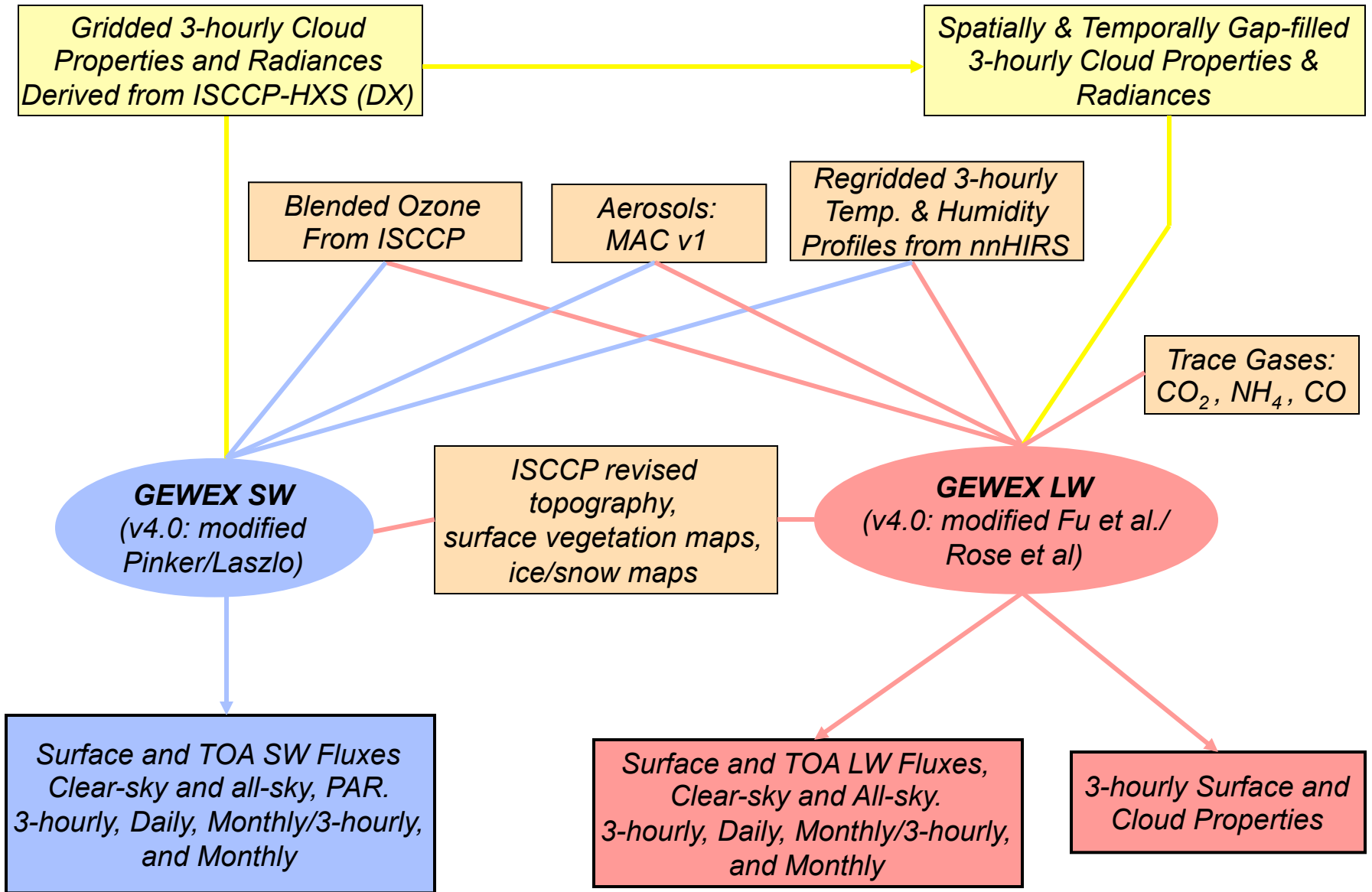
(Spatial Resolution: 1° x 1°; 7/83 – 12/07)

Data Types	Model Name	Temporal Resolution	Parameters
SW	GEWEX SW (Pinker/Laszlo) (v3.0)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged (UTC and local sun time)	All-sky: Surface down, up, PAR down; TOA Down, Up Clear-Sky: Surface Down, Up; TOA Up
	LPSA (Staylor/Gupta) (v3.0)	Daily, Monthly	All-sky: Surface Down, Net, and Albedo Clear-sky: Surface Down
LW	GEWEX LW (Fu/Liou/ Stackhouse) (v3.1)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged	All-sky and clear-sky: TOA up; Surface Up and Down
	LPLA (Gupta) (v3.0)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged	All-sky Surface Downward, Net; Cloud Radiative Forcing
Input Property	CLDPROPS	3-Hourly	Surface emissivity, skin temperature, atmospheric profile; cloud phase, fraction, optical depth and LWC

Note: The LPSA and LPLA algorithms are also used in CERES Surface-Only



SRB Integrated Products Data Flow





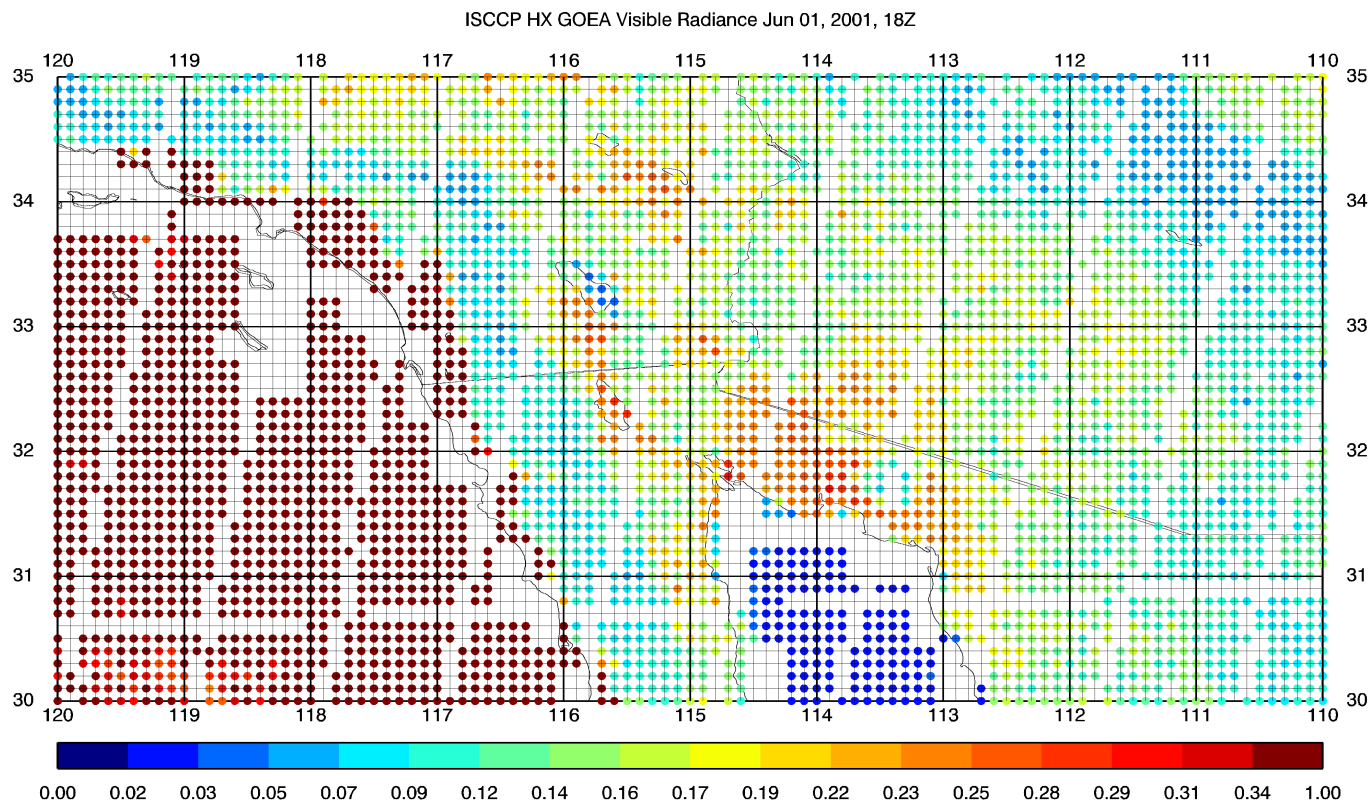
SRB Input Changes

General Inputs	Release 3	Integrated Product
Total Solar Irradiance	Constant mean full ephemeris for annual variability	Daily SORCE normalized time series with full ephemeris
Trace Gases – O3	TOMS, TOVS, SMOBA blend	TOMS, TOVS, OMI blend from ISCCP; with vertical profiles from GOZCARDS
Other Gases	Single values	GISS GCM; NOAA
Surface elevation	GTOPO30 remapped	GTOPO30 remapped
Land Vegetation Cover Map	IGBP remapped to 1x1	Revised IGBP (w/ GISS)
Snow/ice cover	ISCCP snow/ice	ISCCP snow/ice
Surface albedo/emissivity	VIS radiance w/ aerosol; IGBP surface types for spectral albedo/spectral emissivity	VIS radiance w/ aerosol; IGBP surface types for spectral albedo/spectral emissivity
Aerosols	SW – MATCH climatology	MAC v1
Skin Temperature	Blended ISCCP & GEOS-4	ISCCP retrieved (TSCOMP); SeaFlux SST & Princeton HIRS LST
Meteorological Profiles	GEOS-4 reanalysis	nnHIRS (ISCCP produced data that fills, grids and adds diurnal cycle to HIRS retrievals)
Radiance and Cloud Retrieval	ISCCP DX	ISCCP HXS

ISCCP H Series

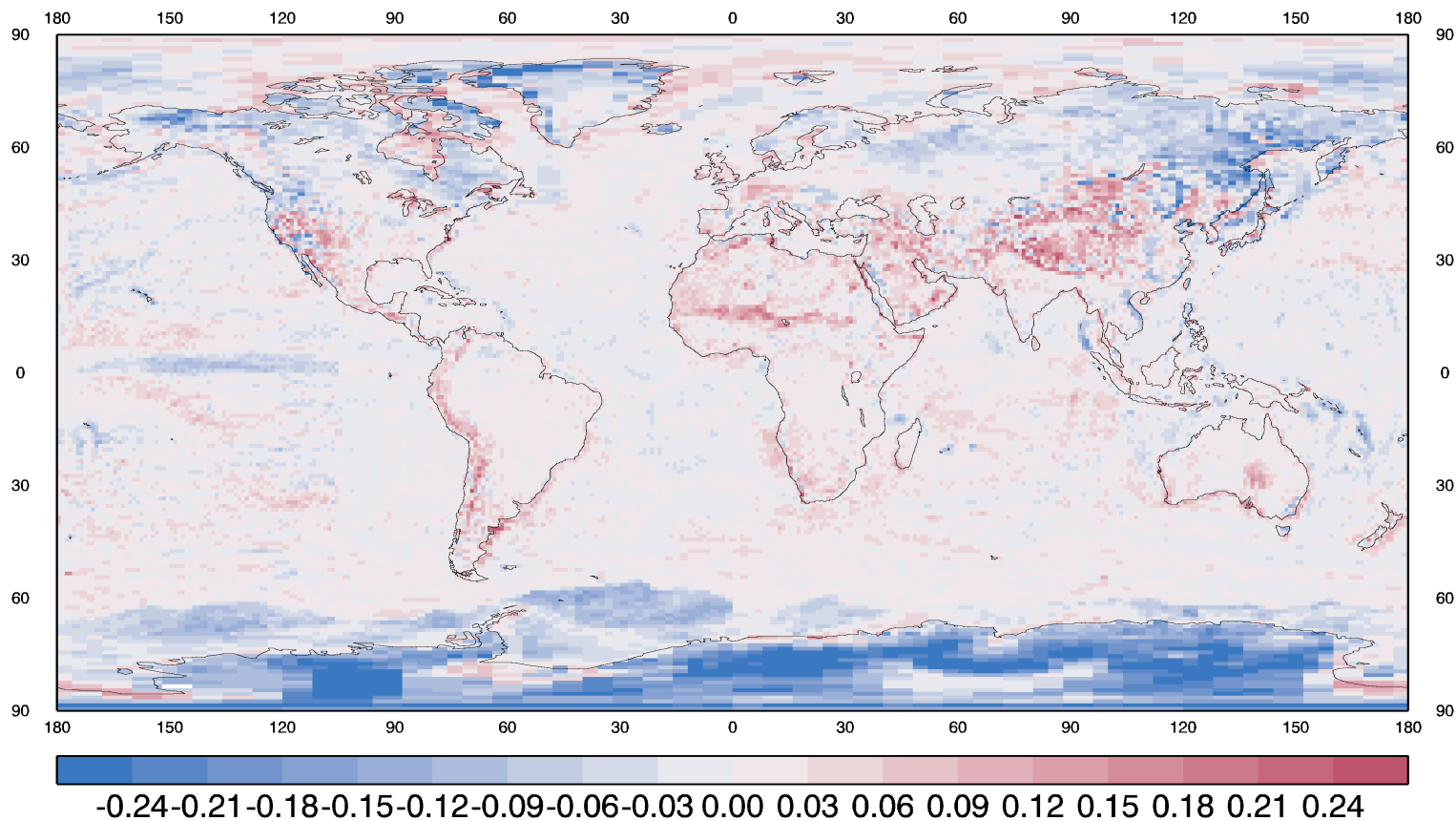
ISCCP is being reprocessed (based at NCDC)

- Uses all 10 km pixels with no subsampling
- Revised calibration using MODIS and Heidinger (et al)
- Pixel 3-hourly,
1x1 3-hourly,
and 1x1 monthly
data products
- Algorithm
Updates
- nnHIRS
Gridded & filled
data set using
T, q retrieval
(Shi et al.)
- New surface
type maps

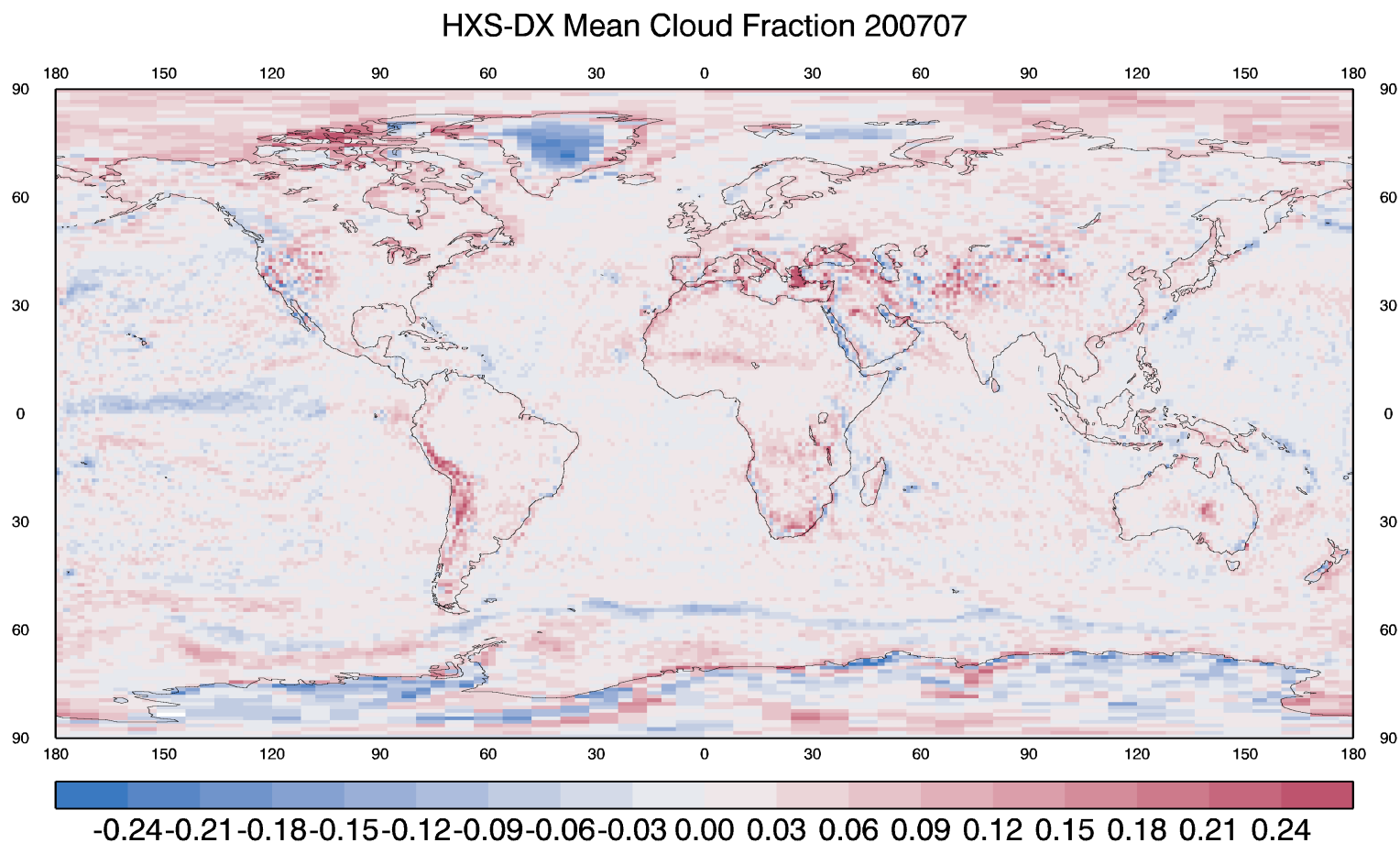


ISCCP Cloud Fraction Differences, Jan 2007

HXS-DX Mean Cloud Fraction 200701



ISCCP Cloud Fraction Differences, Jul 2007





Calibration issue affecting Rel3 is resolved

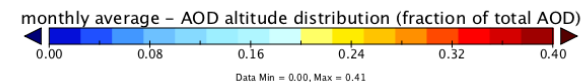
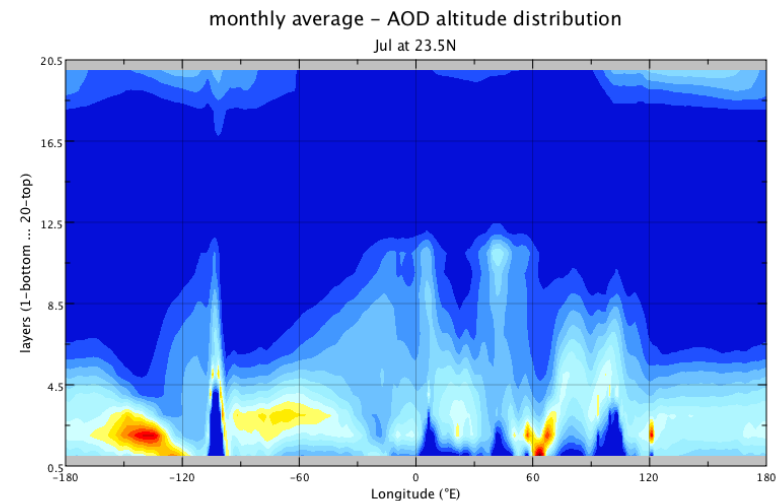
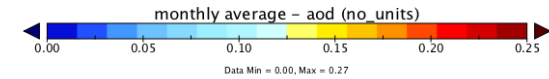
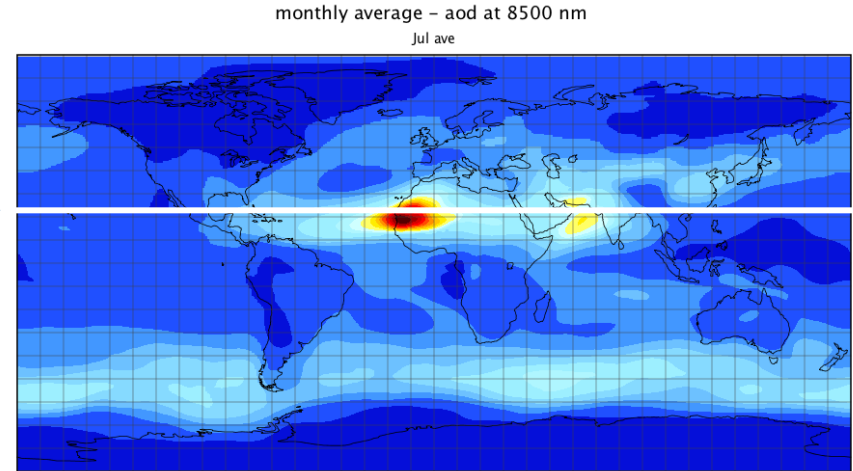
- In ISCCP DX, there is a jump in visible radiances which leads to a jump in SRB shortwave fluxes from Dec 2005 to Jan 2006.
- Specifically, there is an increase in the very low values mostly scene over ocean at sunrise/sunset
- In the new ISCCP HXS, those low values return, and the 2005-2006 flux discontinuities are gone

Max Planck Aerosol Climatology (v1)

MAC (v1)

(Kinne et al., 2015, submitted)

- Monthly averaged climatology at 1°x1° from 1980 to 2100
- Fine and coarse modes treated; coarse varies in time
- Based upon complete AEROCOM analysis for year 2000 & merged to ECHAM aerosol model for background coarse mode variability
- SW and LW optical depth, absorption aerosol optical depth and Angstrom parameter
- Vertical profiles
- *Used by GEWEX for Integrated products*





SW Algorithm Improvements for Release 4.0

	Release 3.0	Release 4.0 Gamma	Release 4.0 Theta
Radiative bands	5	18 (from CERES LFL05 model; Fu/Liou based)	18 (from CERES LFL05 model; Fu/Liou based)
Spectral Albedo	Original	New expanded albedo from MODIS and ASTER	New expanded albedo from MODIS and ASTER, Jin (2004) ocean, ice, and snow albedos
Aerosol Radiative Properties	One land aerosol, one ocean	Variable asymmetry parameter and single scatter albedo permitted with expanded LUT	Variable asymmetry parameter and single scatter albedo permitted with expanded LUT
Input aerosol	MATCH modal optical depth, monthly climatology	Max-Planck Aerosol Climatology, with variable optical depth and composition through product time period (1983-present)	Max-Planck Aerosol Climatology, with variable optical depth and composition through product time period (1983-present)
Clouds	ISCCP DX; Liquid clouds assumed	ISCCP DX; Liquid clouds assumed	ISCCP HXS; Liquid and ice clouds allowed
Run Period so far	1983-2007	1998-2007	2005-2009



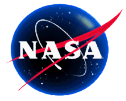
New surface albedo treatment for ocean, snow, ice

- (figures to come)



SRB Rel 4 versions, global fluxes: 2007

	Rel 3.0	Rel 4 gamma (NEW algorithm, OLD inputs)	Rel 4 theta (NEW algorithm, NEW inputs)
Surface down	186.1	182.3	185.1
Surface down diffuse	104.1	95.0	96.7
TOA Up	104.4	103.1	100.9
Clear surface down	247.6	240.5	241.0
Pristine surface down	258.5	252.8	253.3
Aerosol Optical Depth	0.187	0.154	0.153
Cloud Optical Depth	17.2	14.5	13.6
Cloud Radiative Effect	-61.5	-58.2	-55.9



Surface Downward Flux differences (figures to come)



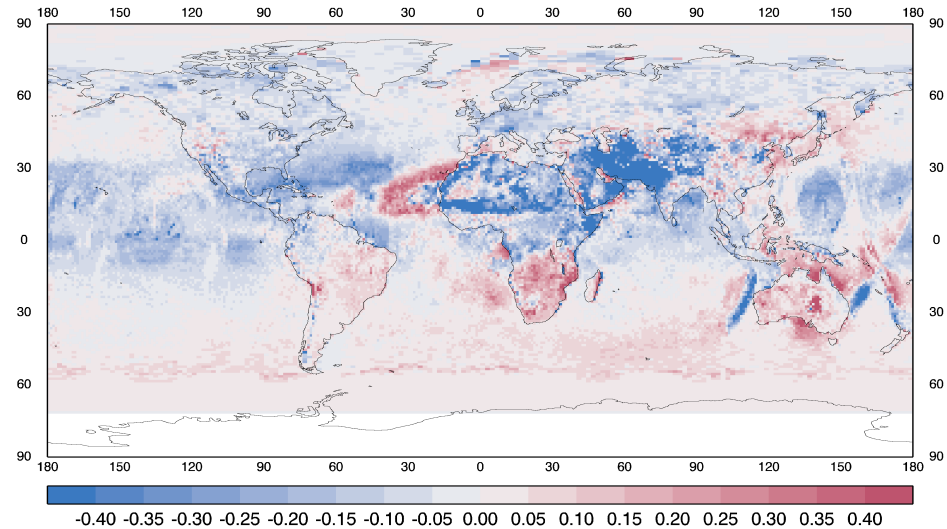
TOA Upward Flux differences (figures to come)

MAC v1 Effects in SW

- Optical depth over oceans *increased off Africa and Arabian peninsula; mainly reduced elsewhere*
- *Surface aerosol radiative effect becomes larger (negative off Africa and Arabian Peninsula)*

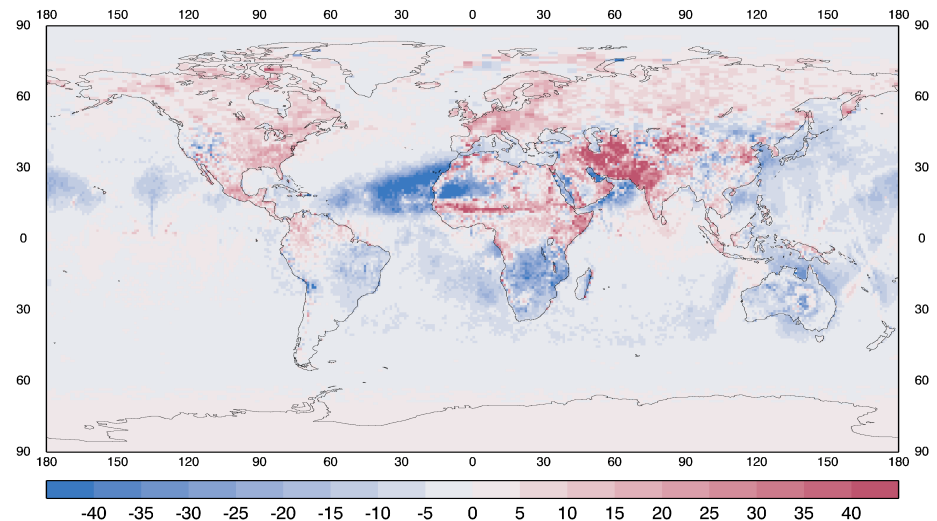
glb -0.038 sh 0.012 nh -0.087

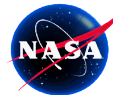
Aerosol Optical Depth, Jul 2007, 4_theta - 3.00



glb -1.826 sh -3.117 nh -0.534

Clear Sky Aerosol Forcing, Wm⁻², Jul 2007, 4_theta - 3.00





SRB Rel 4 SW: 3-Hourly Validation (updates to come)

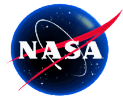


GSW vs. BSRN (land)

Dataset	Bias	RMS	ρ	σ	μ_{BSRN}	N
GSW(R3.0)	-12.57	88.41	0.9502	87.51	303.43	54577
GSW(R4.0_baseline)	-13.52	86.91	0.9519	85.86	303.44	54576
GSW(R4.0_gamma)	-11.29	88.27	0.9504	87.55	303.40	54583
GSW(R4.0_beta)	-7.56	85.00	.9535	84.66	303.18	54623

GSW vs. buoy (ocean)

Dataset	Bias	RMS	ρ	σ	μ_{PMEL}	N
GSW(R3.0)	18.67	97.86	0.9570	96.06	383.66	23613
GSW(R4.0_baseline)	18.95	95.53	0.9592	93.64	383.69	23611
GSW(R4.0_gamma)	(Validation not complete)					
GSW(R4.0_beta)	6.44	91.37	0.9592	91.14	383.66	23613



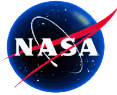
GEWEX SRB: Summary Status

- GEWEX SRB Rel 3: 24 year TOA and surface radiation at $1^\circ \times 1^\circ$.
 - Documentation improved; analysis paper submissions
 - Validation, analysis and collaborative activities crucial to assessing and improving the data set are continuing
- GEWEX SRB Rel 4-IP:
 - New inputs from ISCCP nnHIRS and HXS from 2005-2009 processed and being assessed through various sensitivity studies and product intercomparison and surface measurements
 - Improvement of SW fluxes with new inputs and algorithms relative to surface measurements observed
 - Ocean fluxes reduced; land fluxes increased
 - TOA reflectance reduced
 - Polar fluxes over snow and ice improved
- Next Steps:
 - Awaiting official release of ISCCP H product/nnHIRS meteorology. Will continue algorithm improvements. General processing from 1983 to near present scheduled once demonstrated improvements realized



LW Algorithm Improvements for Release 4.0

	Release 3.0	Release 4.0 Baseline	Release 4.0
Aerosol Radiative Properties	None	New aerosol radiative property routine - disabled	New aerosol radiative property routine to accommodate full monthly 3D aerosol optical properties; vertical profiles
Cloud Ice Properties	Original ice cloud radiative properties	Updated ice cloud radiative properties	Updated ice cloud radiative properties
Input aerosol	MATCH modal optical depth, monthly climatology	MATCH modal optical depth, monthly climatology	Max-Planck Aerosol Climatology, with variable optical depth and composition through product time period (1983-present)
Cloud High Water	Assumed no water clouds above 440 mb	Modified cloud overlap to treat high water clouds	Modified cloud overlap to treat high water clouds
Data Product Changes	TOA and surface flux only; UT; Clear and all-sky	TOA and surface flux only; UT; Clear and all-sky	Added Pristine-sky (no aerosols), Local time, and several atmospheric levels (50 mb, 500 mb and 700 mb; tropopause and PBL experimental)



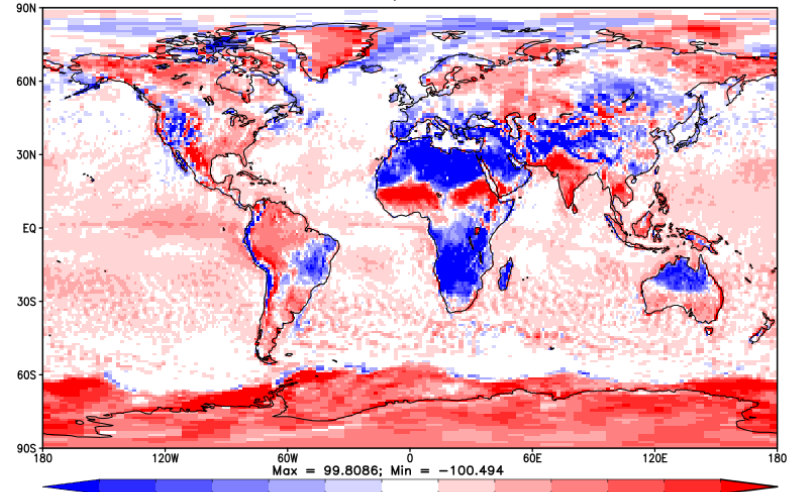
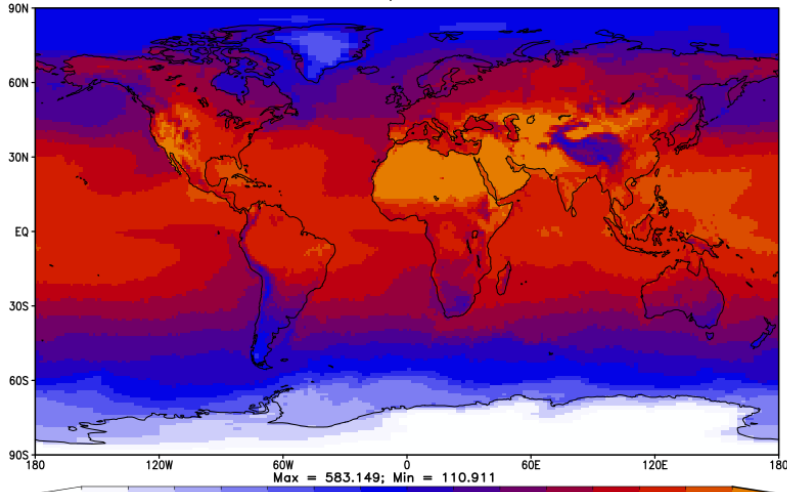
LW Flux Up Sensitivity

global = 411.873 60-90N = 358.967 60-90S = 228.847 20N-20S = 459.826
 20-60N = 440.422 20-60S = 381.048

SRB Ed.4 BL JUL 2007 monthly average
 LW up at Sfc

global = 1.05322 60-90N = 4.11684 60-90S = 15.4583 20N-20S = 1.54198
 20-60N = -4.91111 20-60S = 1.91323

Rel.4 BL - Rel. 3.1 JUL 2007 monthly average
 LW Up at Sfc

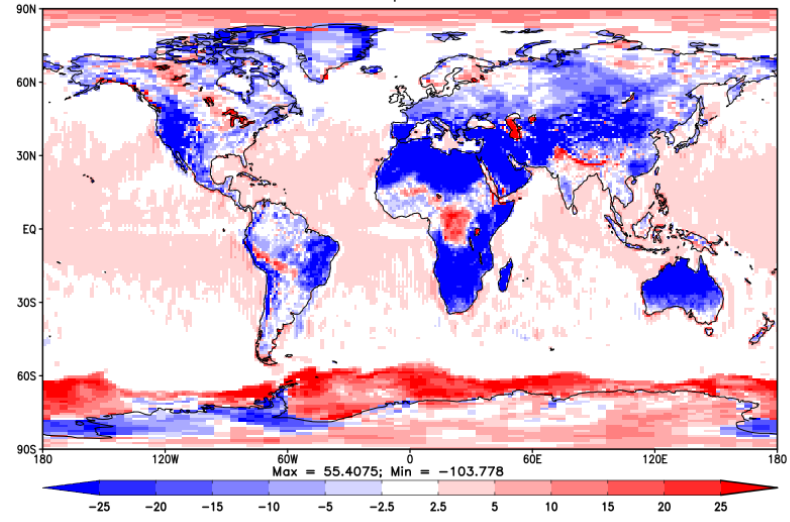
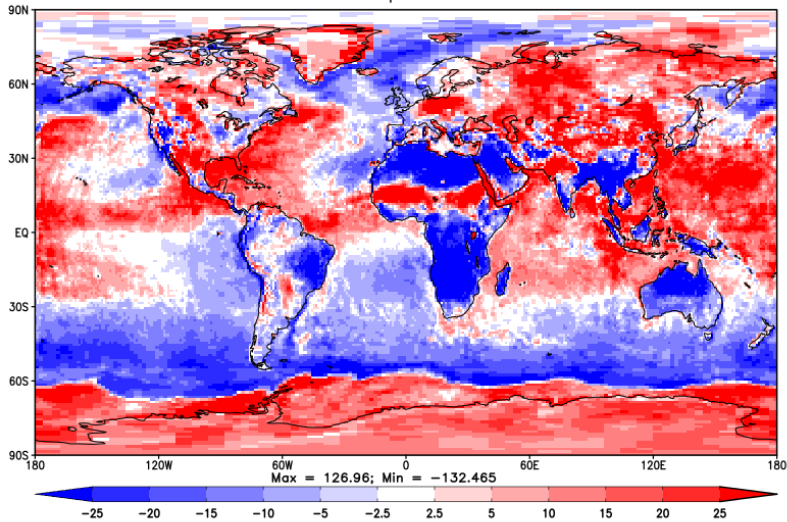


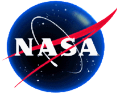
global = 2.1945 60-90N = 8.65166 60-90S = 13.6285 20N-20S = 5.48377
 20-60N = 4.5455 20-60S = -9.02464

Rel.4 BL TSCOMP - Rel. 3.1 JUL 2007 monthly average
 LW Up at Sfc

global = -4.44951 60-90N = -1.48844 60-90S = 10.1421 20N-20S = -2.67973
 20-60N = -13.587 20-60S = -2.1101

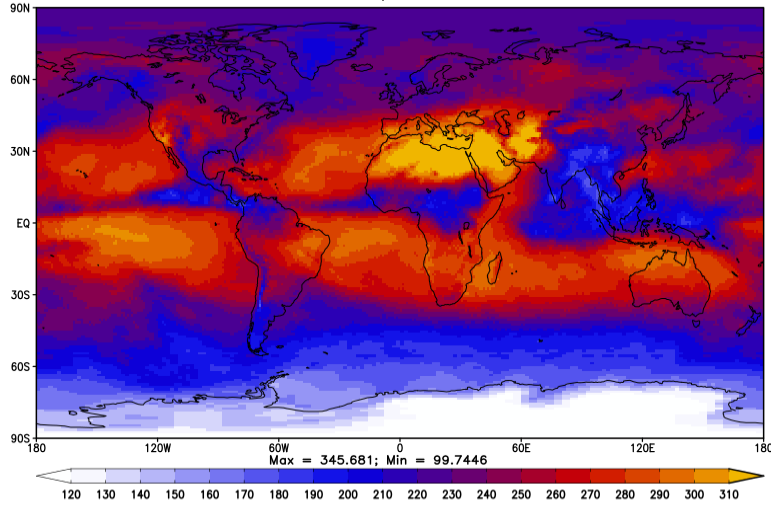
Rel.4 MERRA (MERRA skin T) - Rel. 3.1 JUL 2007 monthly average
 LW Up at Sfc



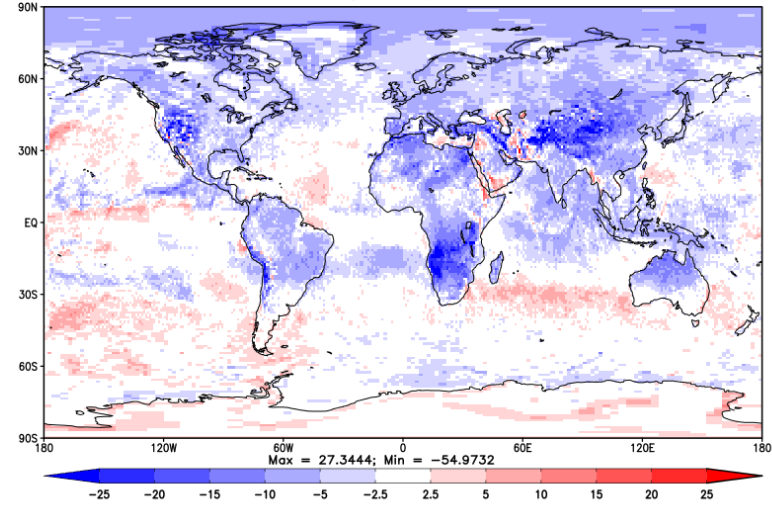


All-Sky Flux Up TOA

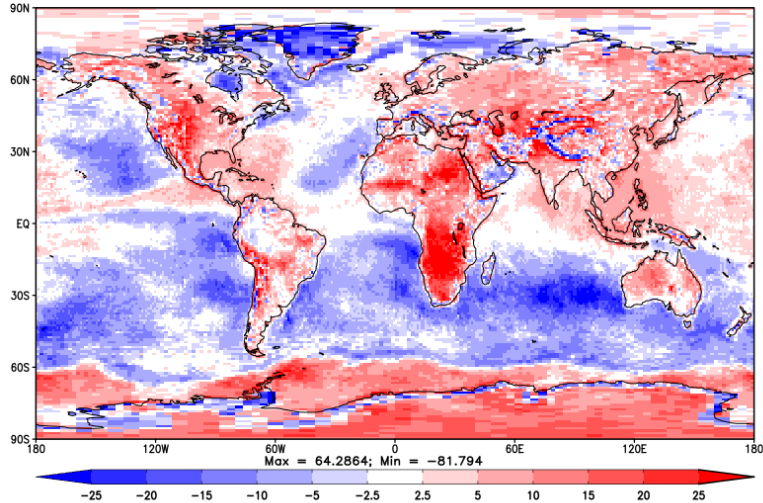
global = 240.681 60-90N = 229.282 60-90S = 159.251 20N-20S = 255.742
 20-60N = 253.102 20-60S = 232.334
 SRB Ed.4 BL JUL 2007 monthly average
 LW Up at TOA



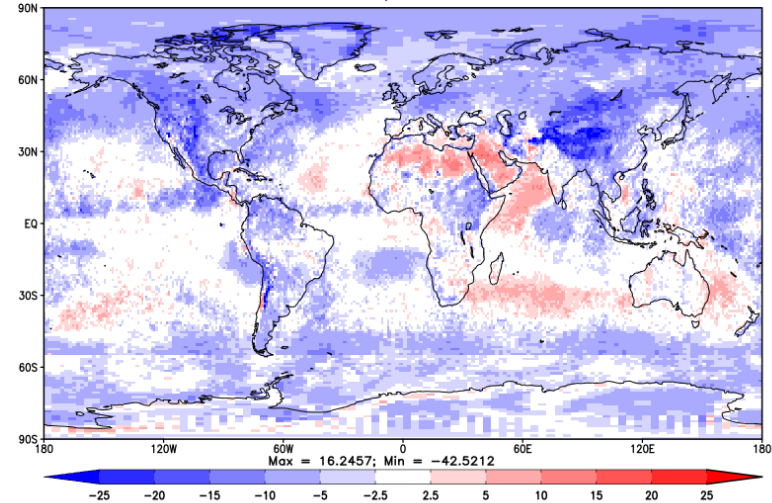
global = -3.214 60-90N = -4.90088 60-90S = -0.404697 20N-20S = -3.78987
 20-60N = -5.99222 20-60S = 0.0289797
 Rel.4 BL - Rel. 3.1 JUL 2007 monthly average
 All-sky LW Up at TOA

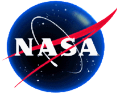


global = 1.61437 60-90N = 1.95736 60-90S = 8.2304 20N-20S = 3.9683
 20-60N = 5.73779 20-60S = -7.36114
 Rel.4 MERRA (MERRA skin T) - Rel. 3.1 JUL 2007 monthly average
 LW dn at Sfc



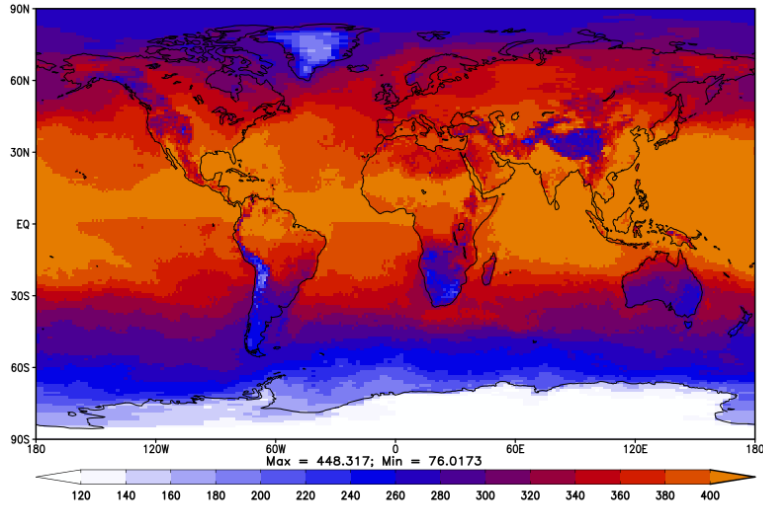
global = -3.30803 60-90N = -7.33144 60-90S = -3.60599 20N-20S = -2.08686
 20-60N = -5.35208 20-60S = -1.75324
 SRB Ed.4 BL-EBAF Ed. 2.8 JUL 2007 monthly average
 LW Up at TOA



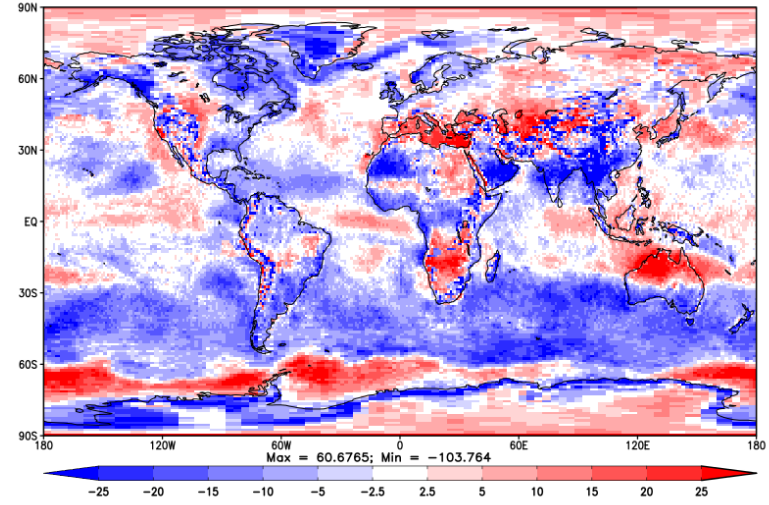


All-Sky Flux Down Surface

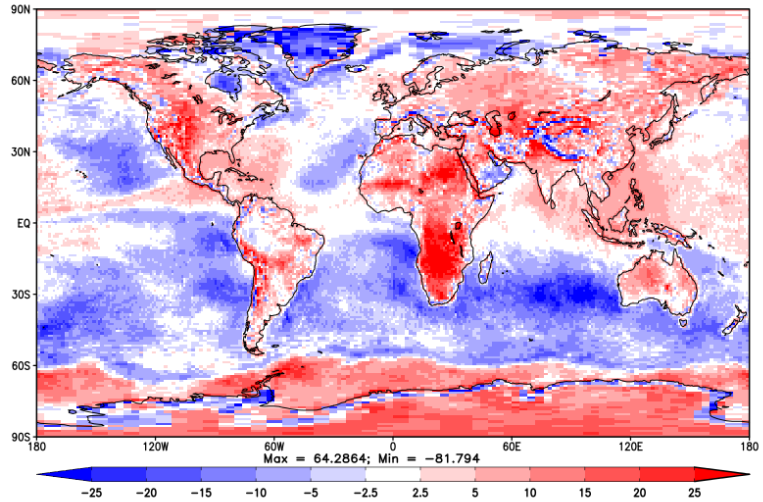
global = 349.818 60-90N = 307.71 60-90S = 189.589 20N-20S = 400.867
 20-60N = 371.567 20-60S = 313.163
 SRB Ed.4 BL JUL 2007 monthly average
 LW dn at Sfc



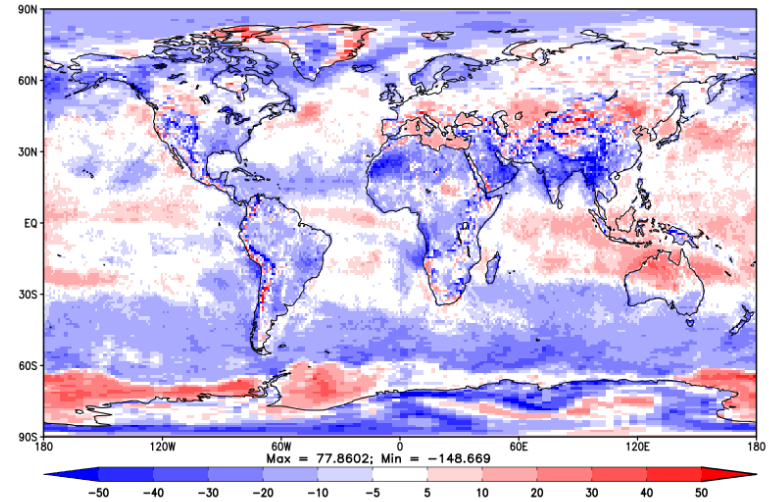
global = -3.44195 60-90N = 1.73347 60-90S = -0.0207209 20N-20S = -0.989043
 20-60N = -1.87673 20-60S = -10.4071
 Rel.4 BL - Rel. 3.1 JUL 2007 monthly average
 LW dn at Sfc



global = 1.61437 60-90N = 1.95736 60-90S = 8.2304 20N-20S = 3.9683
 20-60N = 5.73779 20-60S = -7.36114
 Rel.4 MERRA (MERRA skin T) - Rel. 3.1 JUL 2007 monthly average
 LW dn at Sfc



global = -5.54405 60-90N = -8.35812 60-90S = -3.10756 20N-20S = -2.03615
 20-60N = -5.29713 20-60S = -10.2737
 SRB Ed.4 BL-EBAF Ed. 2.8 JUL 2007 monthly average
 LW dn at Sfc



Aerosol Radiative Effect

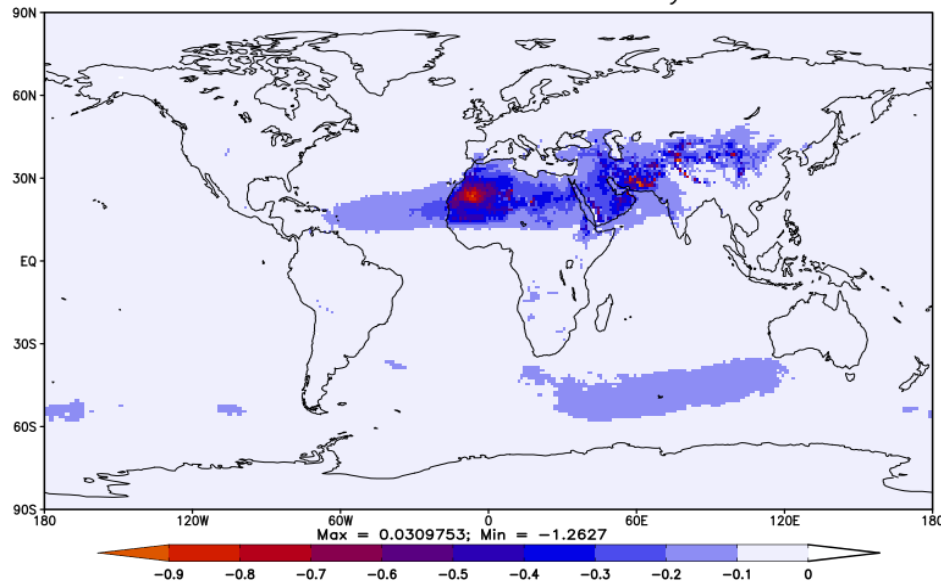
Monthly Averaged LW Aerosol Radiative Effect (July 2007)

- TOA forcing maximum -1.26 W m^{-2} (TOA flux reduced)
- Surface forcing 6.6 W m^{-2} (Surface flux increased)

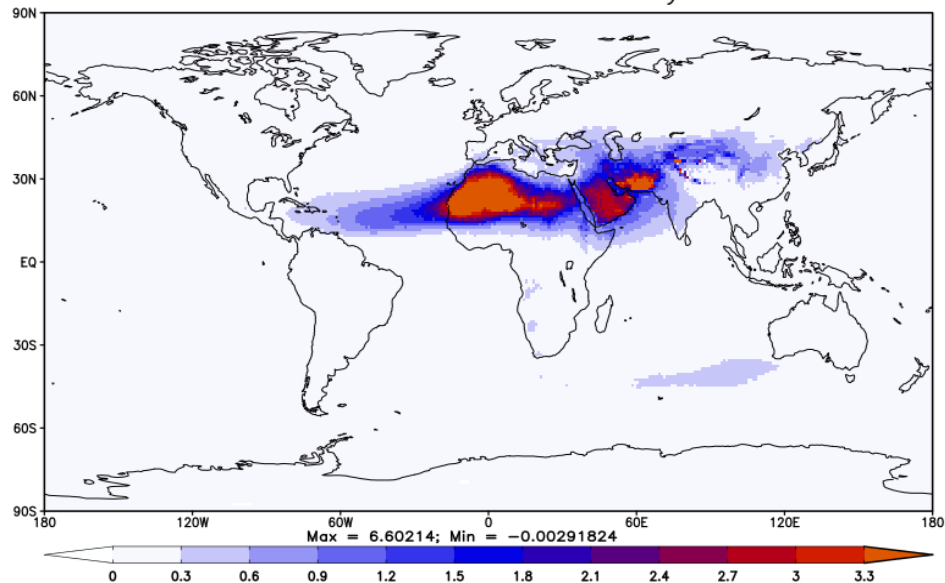
global = -0.050338 60-90N = -0.0083984860 60-90S = -0.0122364 20N-20S = -0.0390023
 20-60N = -0.071099 20-60S = -0.0648392

global = 0.225312 60-90N = 0.0235346 60-90S = 0.027224 20N-20S = 0.209589
 20-60N = 0.407393 20-60S = 0.165991

SRB Ed.4 TOA Aerosol Effect July 2007

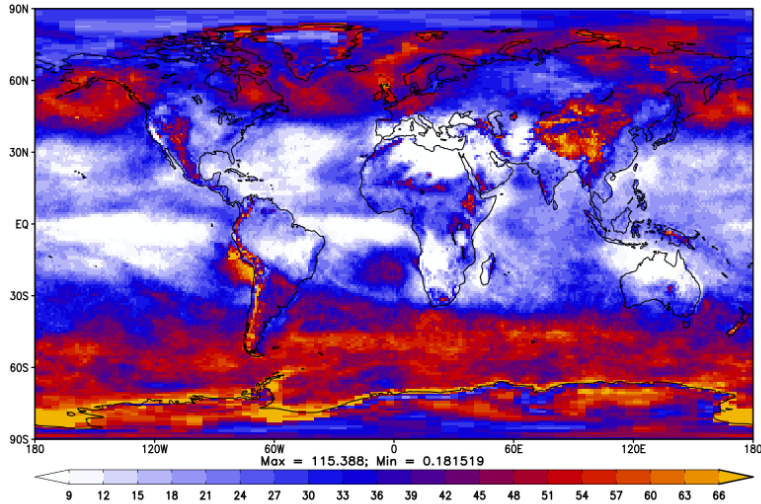


SRB Ed.4 Sfc Aerosol Effect July 2007

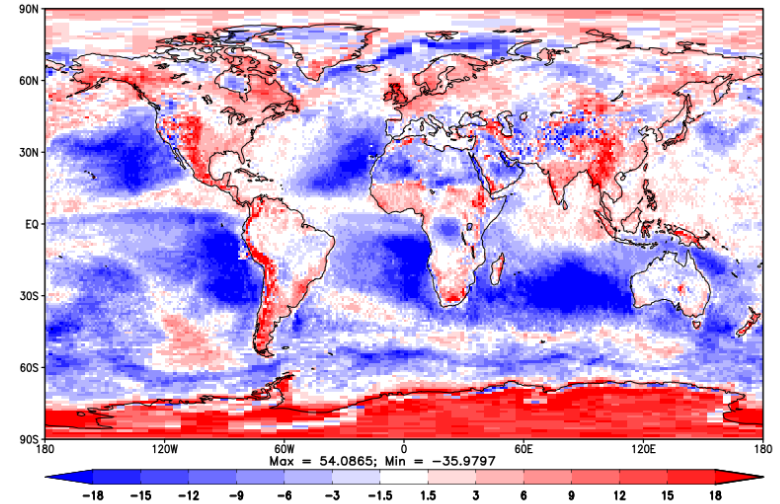


Surface Cloud Radiative Effect

global = 29.8822 60-90N = 38.4842 60-90S = 50.0263 20N-20S = 19.4836
 20-60N = 28.1597 20-60S = 37.8293
 SRB Ed.4 BL JUL 2007 monthly average
 LW CRF at Sfc



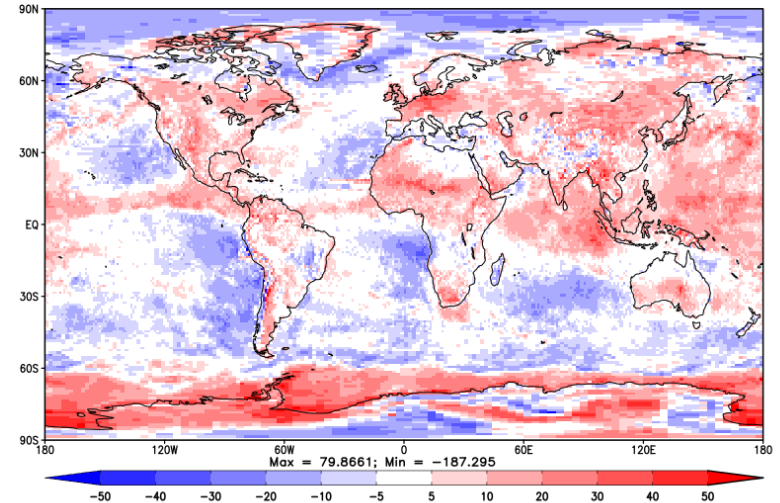
global = -2.40454 60-90N = 0.924333 60-90S = 4.72686 20N-20S = -2.71884
 20-60N = -0.869648 20-60S = -6.20357
 SRB Ed.4 BL - SRB Rel. 3.1 July 2007
 LW CRF at Sfc



July 2007 Surface CRE

- Reduced CRE over oceans (implies more moisture); agrees better with CERES Surface EBAF
- Increased CRE over continents (implies less moisture); extremes mitigated but bias shown

global = 2.83609 60-90N = -1.4255 60-90S = 14.2162 20N-20S = 4.84778
 20-60N = 4.77748 20-60S = -3.55141
 SRB Ed.4 BL - EBAF July 2007
 LW CRF at Sfc





SRB Rel 4 LW: 3-Hourly Validation

Table 1. GEWEX SRB GLW-BSRN 3-hourly LW downward flux comparison for the *mid-season* months January, April, July, and October of 2007.

*GLW vs.
BSRN*

Dataset	Bias	RMS	ρ	σ	μ_{BSRN}	N
GLW (V3.1)	2.60	30.78	0.9364	30.67	308.83	33754
GLW (V4 Beta)	-4.99	39.25	0.9008	38.93	308.83	33754
GLW (V4 Beta: I)	-4.80	39.31	0.9006	39.01	308.83	33754
GLW (V4 Beta: MERRA)	6.54	31.33	0.9365	30.64	308.83	33754

Note:

The units of Bias, RMS, σ and μ_{BSRN} are all $W m^{-2}$.

Table 2. GEWEX SRB GLW-PMEL LW downward flux comparison for the *mid-season* months January, April, July and October of 2007.

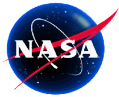
*GLW vs.
Ocean Buoy*

Dataset	Bias	RMS	ρ	σ	μ_{PMEL}	N
GLW (V3.1)	0.93	16.84	0.7282	16.84	407.60	3674
GLW (V4 Beta)	2.94	18.43	0.6344	18.20	407.60	3674
GLW (V4 Beta ISCCP)	3.54	18.42	0.6362	18.08	407.60	3674
GLW (V4 Beta MERRA)	0.83	17.02	0.7573	17.00	407.60	3674

Note:

The units of Bias, RMS, σ and μ_{PMEL} are all $W m^{-2}$.

Version Guide: Beta = nnHIRS+Combined Tskin; Beta ISCCP = nnHIRS+Tscmp; Beta MERRA = MERRA Temp. and Hum. Profiles+Combined Tskin



SRB Web Site and Data Sources

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

1. Atmospheric Science Data Center (main archive):

http://eosweb.larc.nasa.gov/project/srb/srb_table

2. My NASA Data Live Access Server

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

3. NCDC THREDDS Server

<http://www.ncdc.noaa.gov/oarsad/netcdf-access/index.php?name=srb>

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Global Energy and Water Exchanges Project
GEWEX WCRP

SURFACE RADIATION BUDGET

Home SRB Data Products Examples of SRB Data Access SRB Data

Data

- Access Data
- Data Format
- SRB Data Products
- Examples SRB Data
- Known Data Irregularities
- Alternate Data Access through MY NASA DATA (monthly and daily)

Documentation

- About SRB
- About GEWEX
- Global Geometry/Resolution
- Parameter Accuracy/Validation
- GEWEX/SRB Methodology
- SRB Publications
- Acknowledgments Please

Related Links

- Atmospheric Science Data Center
- LaRC Science Directorate
- Science Mission Directorate
- International Satellite Cloud Climatology Project (ISCCP)
- Global Energy and Water Exchanges (GEWEX)
- Earth Radiation Budget Experiment (ERBE)
- SRB Team Site (limited access)

NASA/GEWEX Surface Radiation Budget (SRB) Project

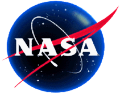
SRB Rel. 3.0/3.1 Sfc Total Net Flux, 24 Yr Average for Oct

The Global Energy and Water Exchanges (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 NASA/GEWEX SRB project is a major component of the GEWEX radiation research. The objective of the NASA/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.

Special Release Announcement

The NASA/GEWEX SRB project team announces a modified version of the GEWEX Longwave data set. Denoted as version 3.1, this version corrects for a numerical instability issue that was found to affect a small number of 3 hourly grid box TOA outgoing and surface downward fluxes. The approximate number of grid boxes affected ranged from 7-12 (out of 8 hours x 30 days x 44016 total grid boxes) per month. The 3-hourly values in those instances were significantly in error but had little effect on daily, 3-hourly monthly and monthly averaged values. Users analyzing 3 hourly fields are advised to obtain the new data set. Please contact us if you have more specific questions.



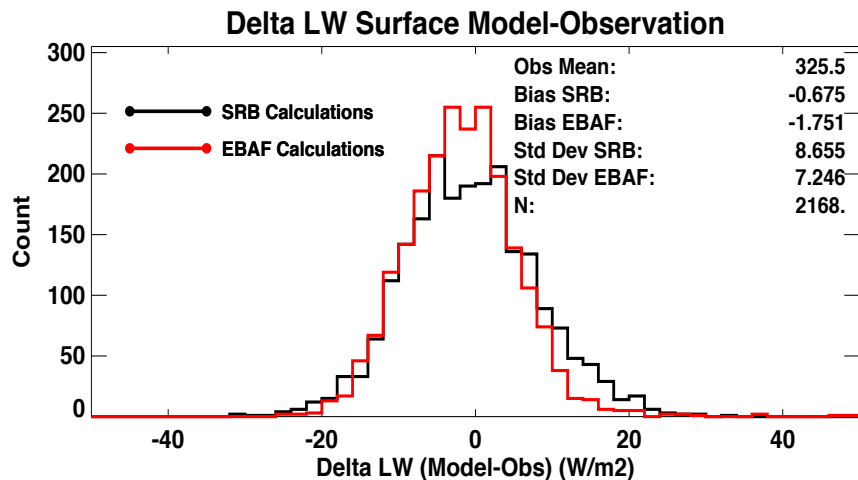
Extras



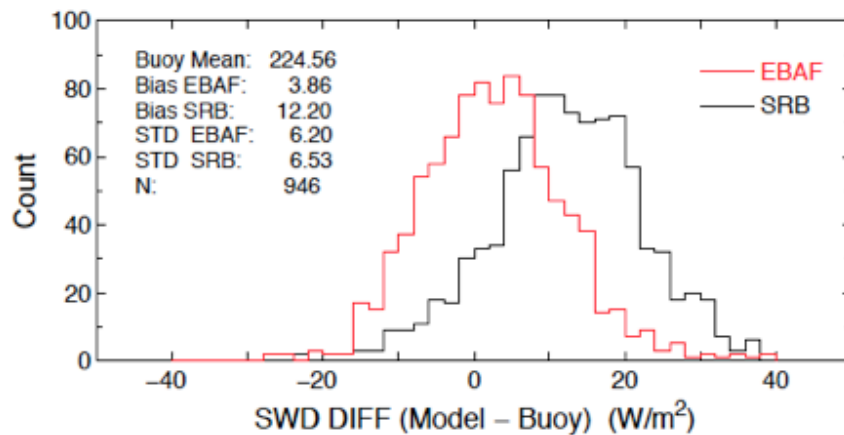
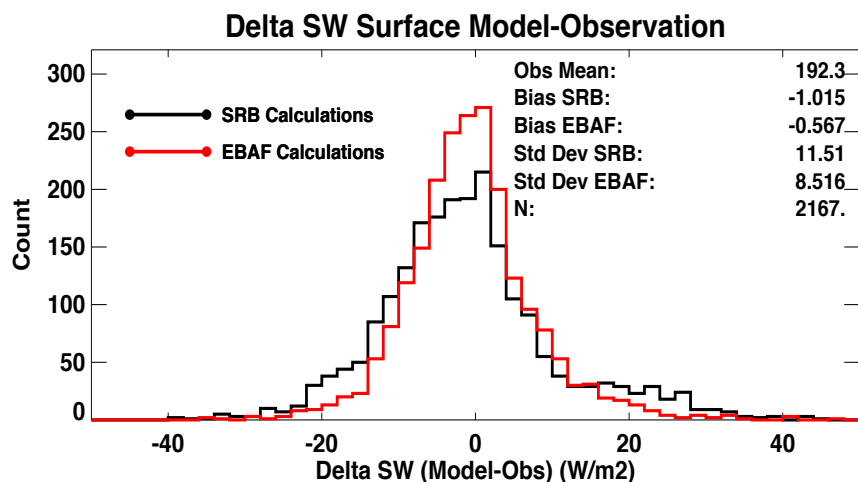
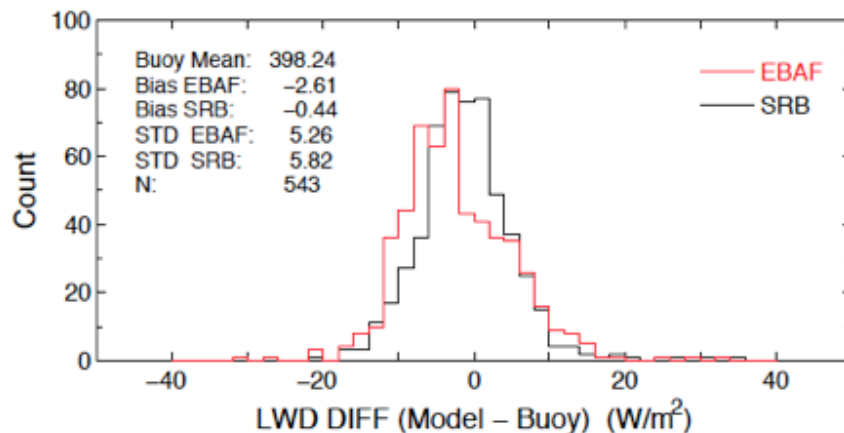
SRB BSRN/Buoy Validation



BSRN Land (2001-2007)



Ocean Buoy Networks (2001-2007) (from Weller & Yu, WHOI)

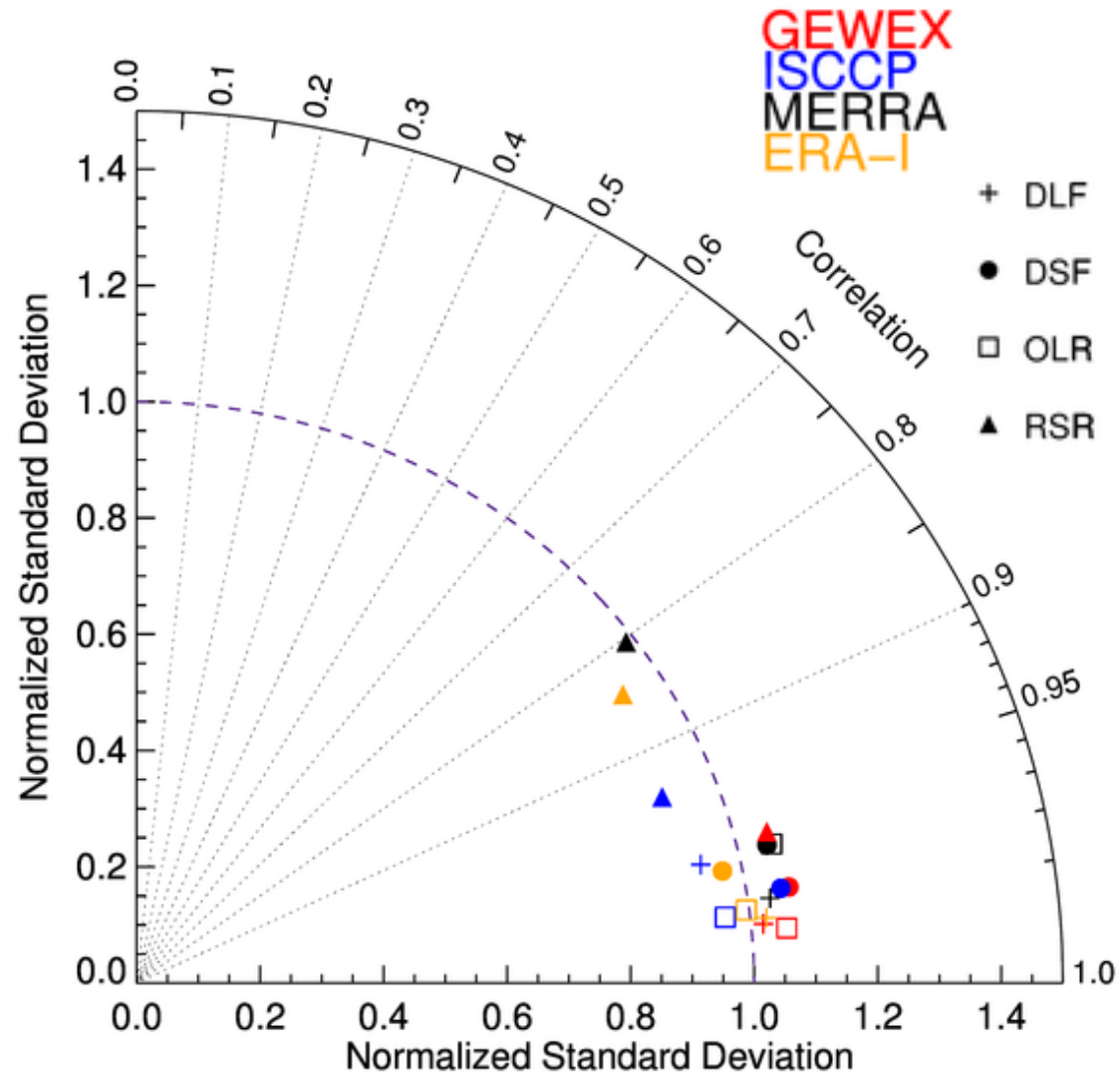


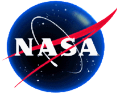
Rutan, CERES Team

Kato et al., 2013

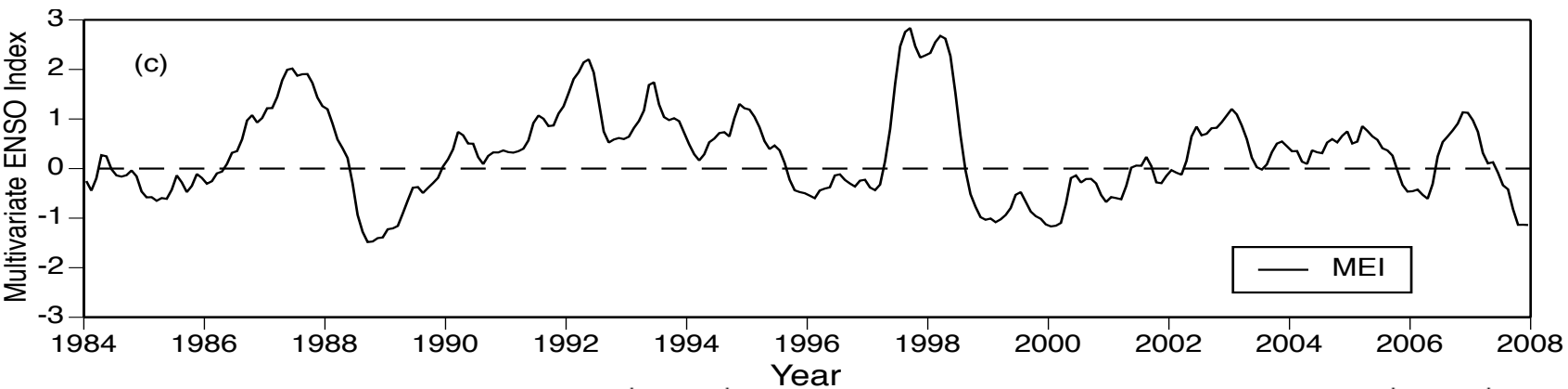
Multi-Data Set Flux Assessment

- *Centered Taylor Diagram GEWEX SRB Rel 3.1, ISCCP FD, MERRA and ERA-I vs the CERES TOA and Surface EBAF Data sets*
- *Overlap years 2001 – 2007*
- $\sigma_n = \sigma_{test} / \sigma_{EBAF}$
- *SRB shows high correlation; more spatial variability than CERES EBAF*

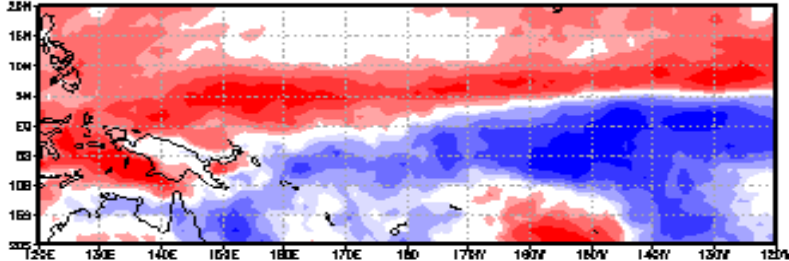




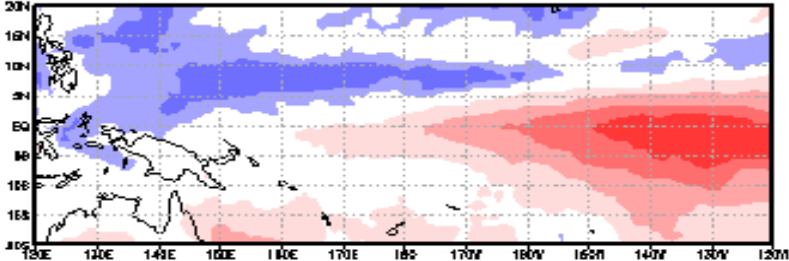
Response to El Nino (Jan1998)/La Nina (Dec1999)



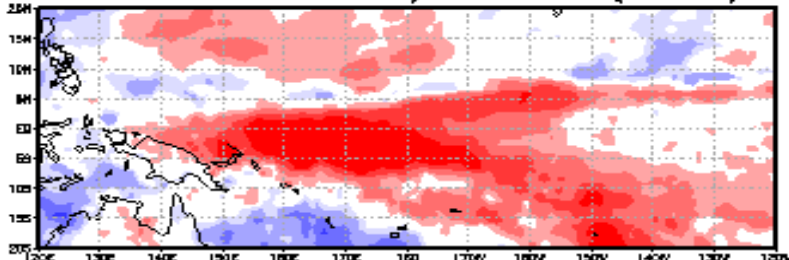
Surface SW Flux Anomaly - Jan1998 (El Nino)



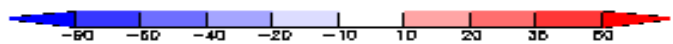
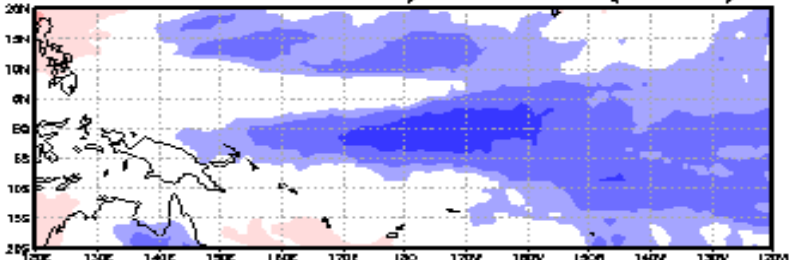
Surface LW Flux Anomaly - Jan1998 (El Nino)



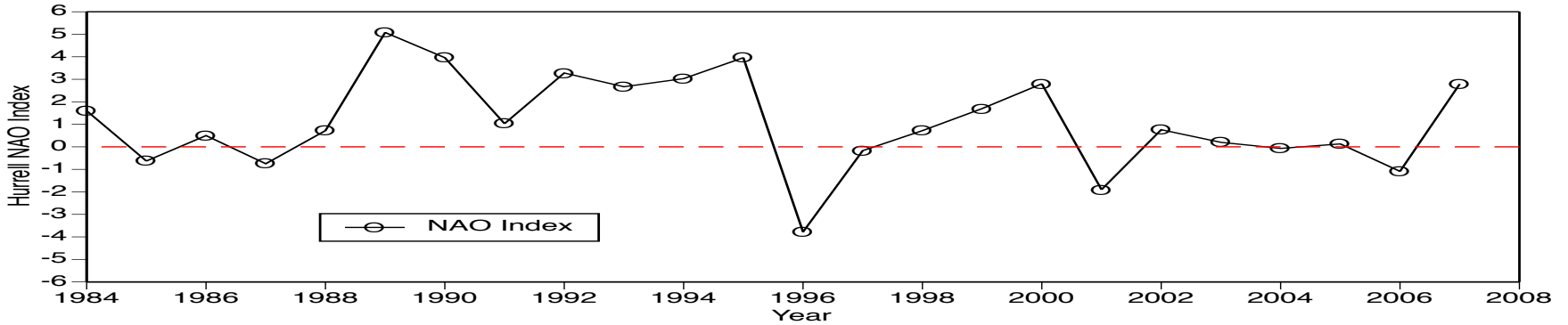
Surface SW Flux Anomaly - Dec1999 (La Nina)



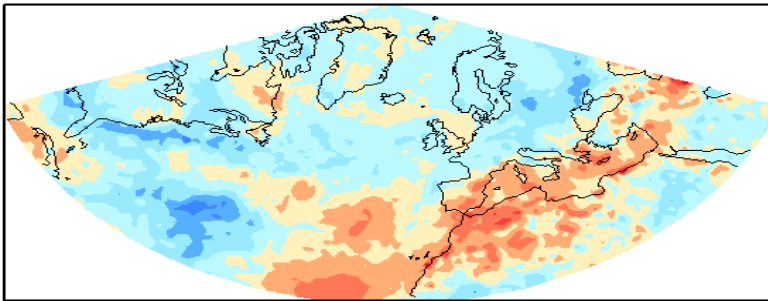
Surface LW Flux Anomaly - Dec1999 (La Nina)



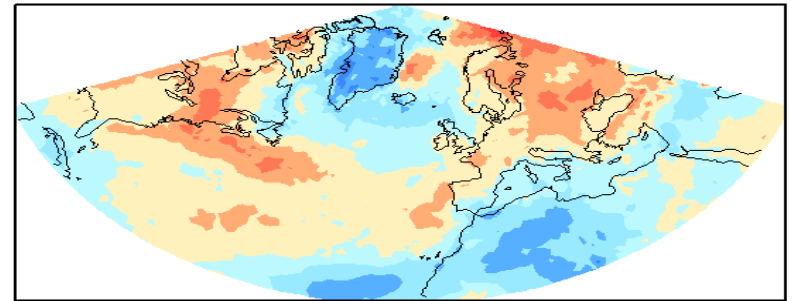
Response to North Atlantic Oscillation



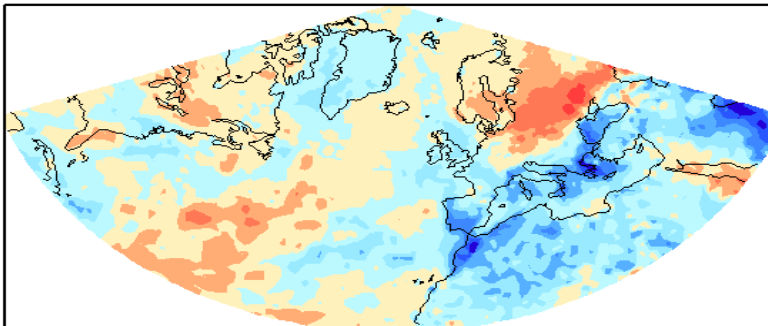
Downward Shortwave Flux Anomaly (W/m^2) 1995



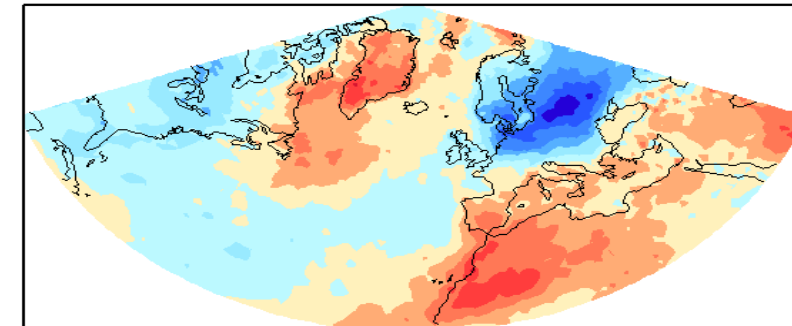
Downward Longwave Flux Anomaly (W/m^2) 1995



Downward Shortwave Flux Anomaly (W/m^2) 1996



Downward Longwave Flux Anomaly (W/m^2) 1996



ISCCP/SRB Uncertainties

D00D20

HINKELMAN ET AL.: SURFACE INSOLATION TRENDS

D00D20

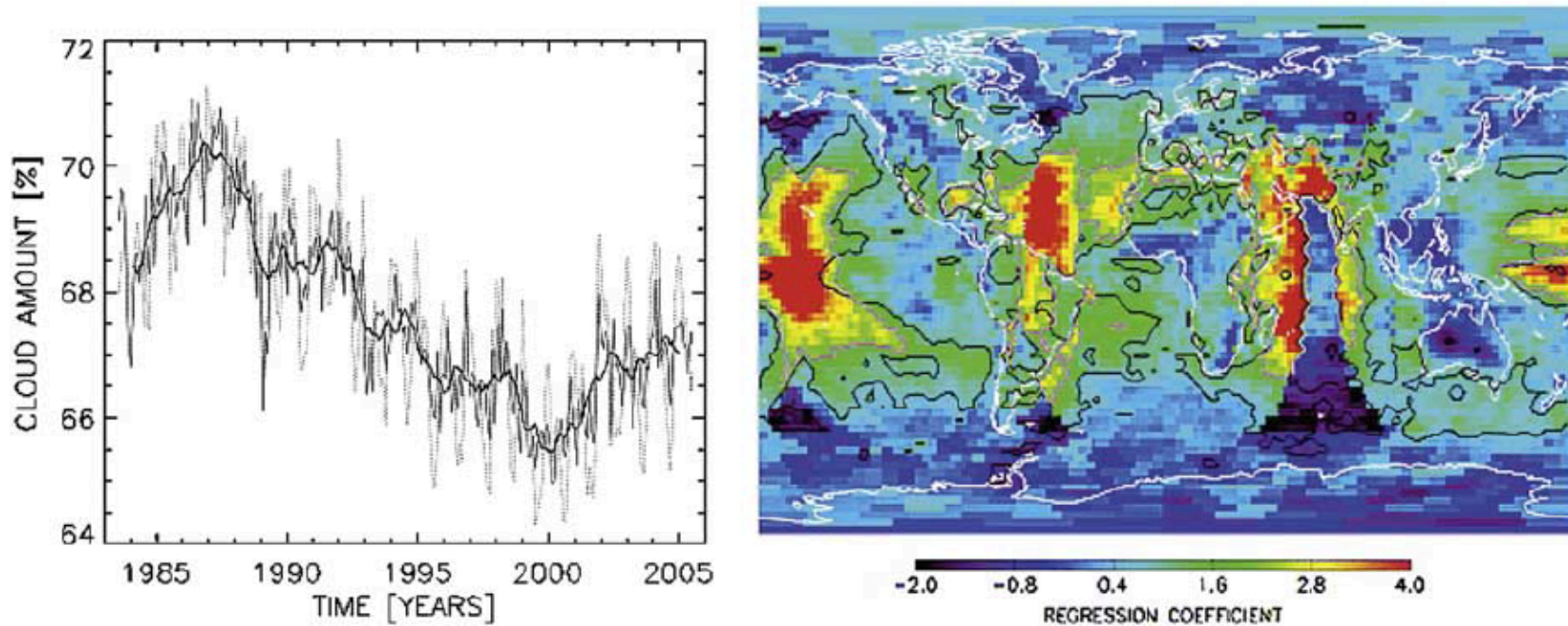
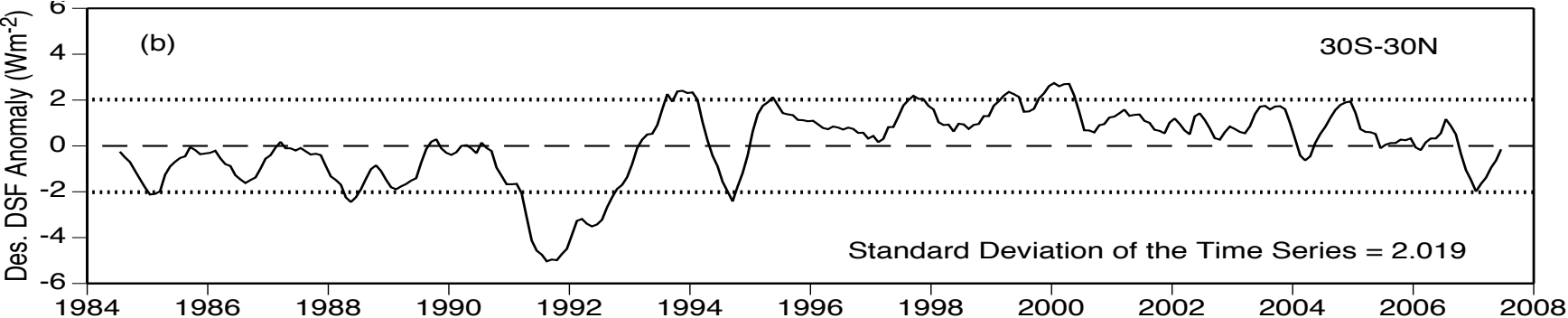
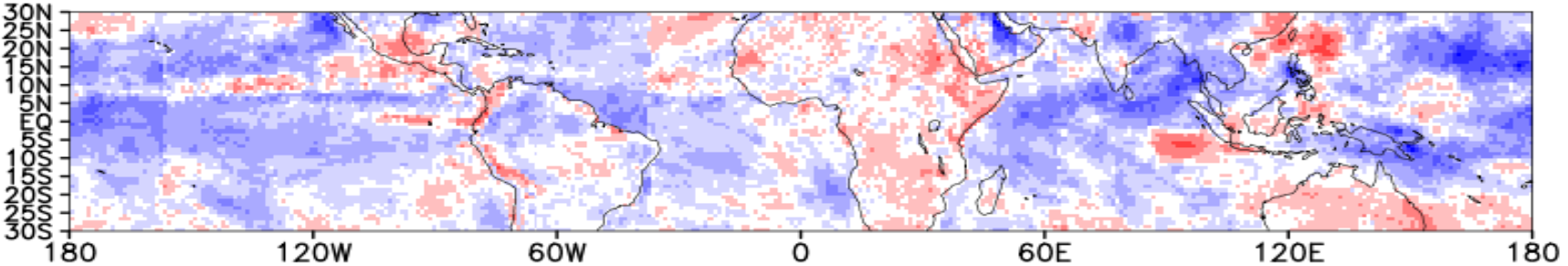


Figure 1. Figures 1 and 2 from *Evan et al.* [2007]. (left) Raw (dotted line), deseasonalized (light solid line), and smoothed (dark solid line) time series of infrared cloud amount from ISCCP between 60°S and 60°N after removal of El Niño signal. (right) Regression coefficients for smoothed average time series (Figure 1, left) and corresponding time series from individual ISCCP grid cells.

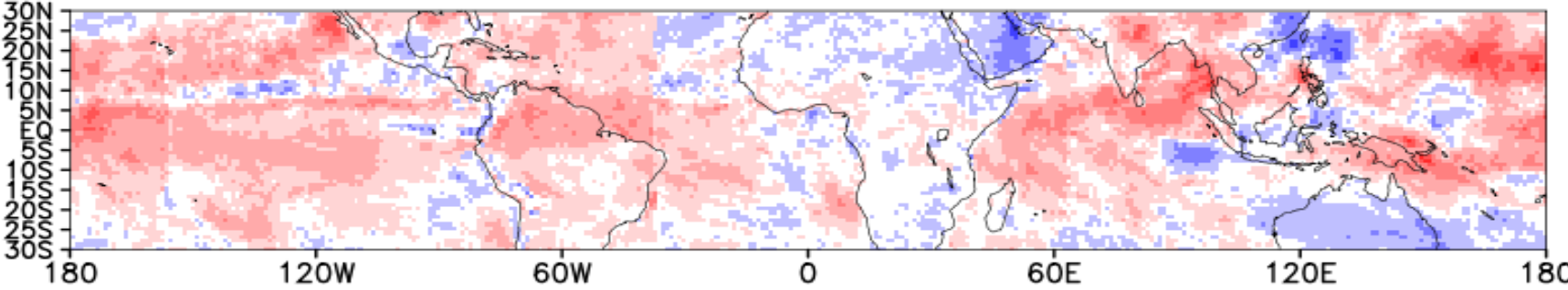
DSF and RSR Anomalies – Mt. Pinatubo (Aug 1991)

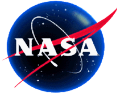


DSF Anomalies



RSR Anomalies





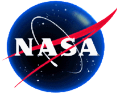
SRB Release 4 Baseline Data Products



(Spatial Resolution: 1° x 1°; 0.5° x 0.5°)

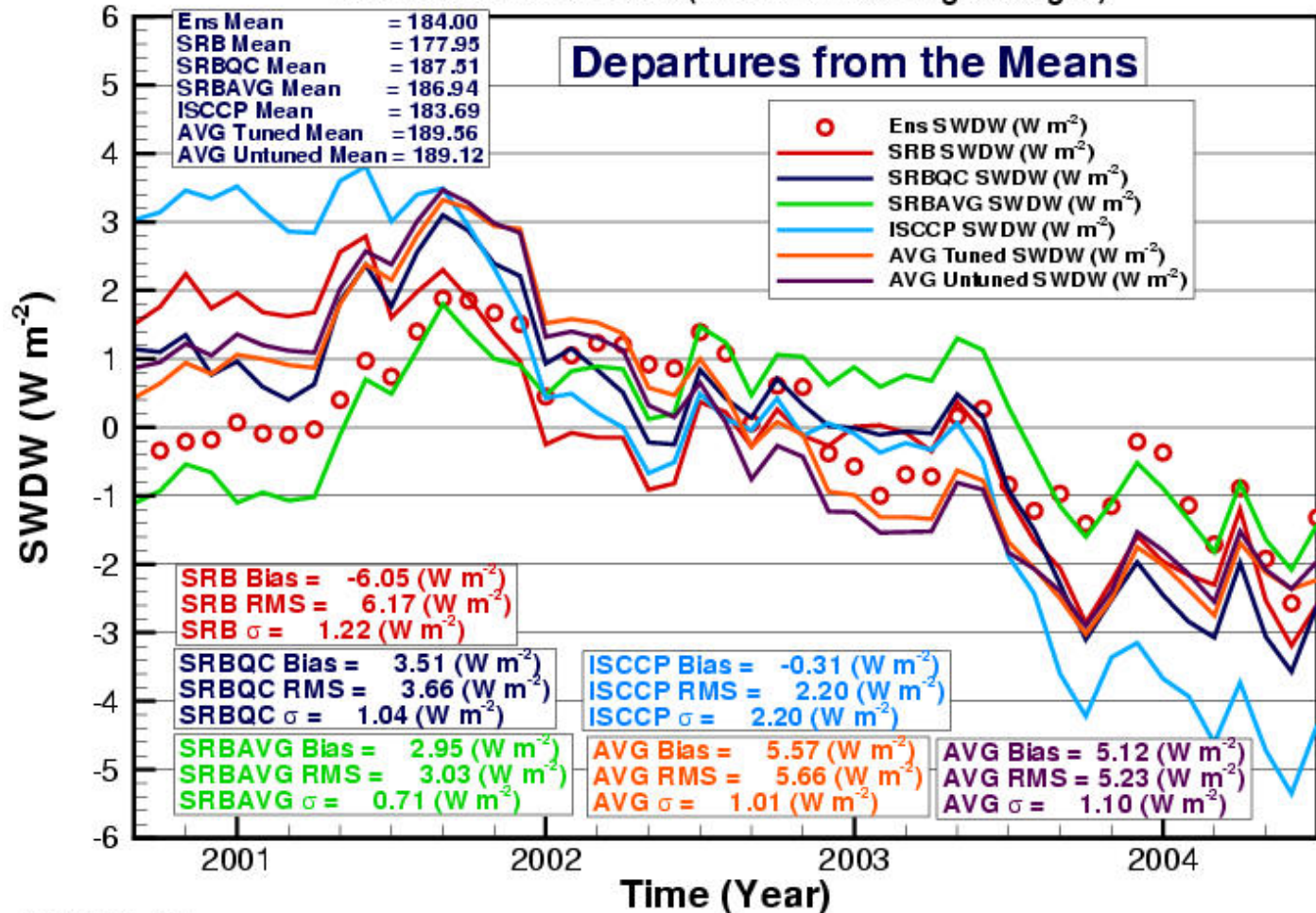
Data Types	Model Name	Temporal Resolution	Parameters
SW	GEWEX SW (Pinker/Laszlo)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged (UTC and local sun time)	Pristine-sky, Clear-sky & All-sky: Surface down, up, PAR down, direct and diffuse down ; TOA Down, Up
	LPSA (Staylor/Gupta)	Daily, Monthly	All-sky: Surface Down, Net, and Albedo
			Clear-sky: Surface Down
LW	GEWEX LW (Fu/Liou/Stackhouse)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged (UTC and local sun time)	Pristine-sky, Clear-sky & All-sky: TOA up, Surface Up and Down; 4 additions levels: PBL, 700 mb, 500 mb, tropopause
	LPLA (Gupta)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged	All-sky Surface Downward, Net; Cloud Radiative Forcing
Input Property	CLDPROPS	3-Hourly	Surface emissivity, skin temperature, atmospheric profile; cloud phase, fraction, optical depth and LWC

Note: Potential new parameters for full Release 4 data products



Validation: Time Series vs. CERES

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



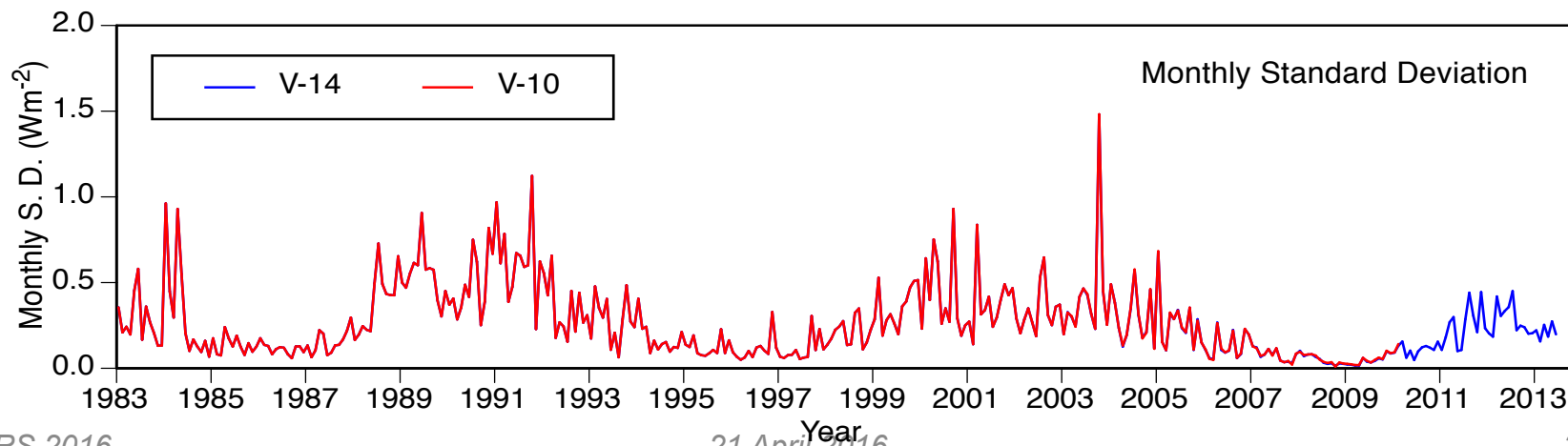
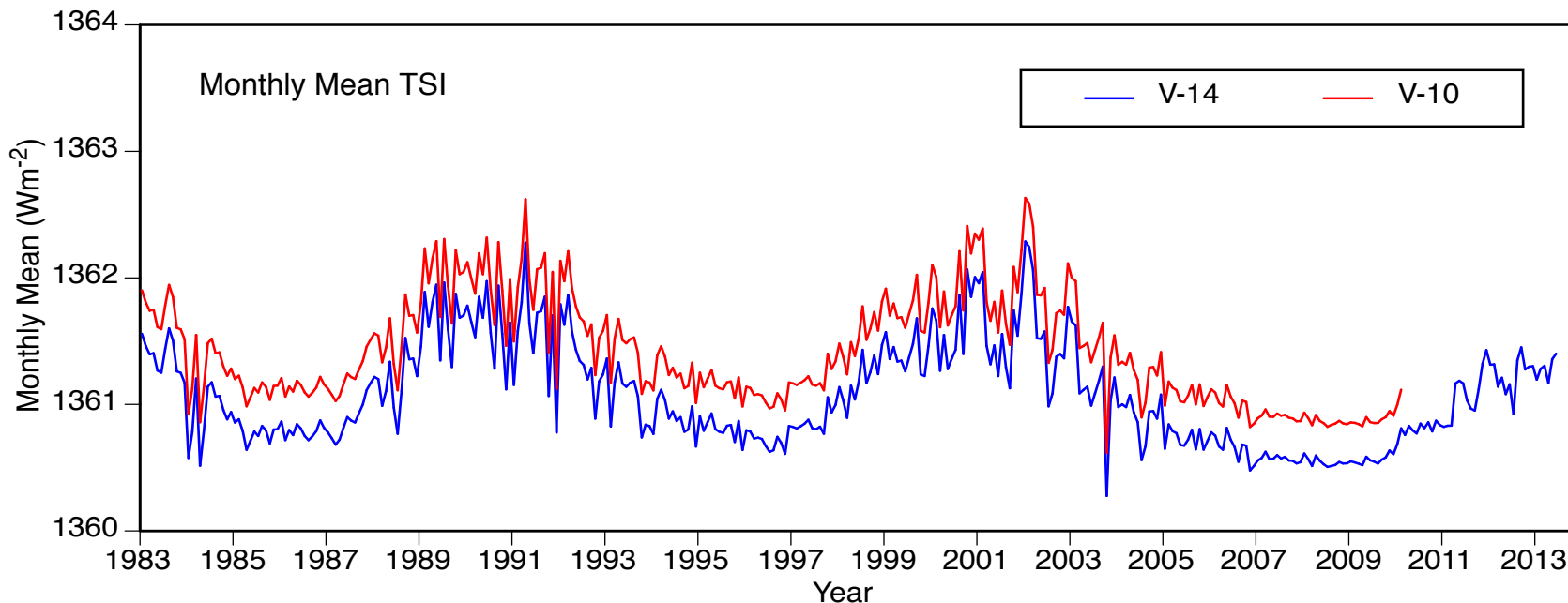
2007-06-19



Integrated Product TSI

V-10: 1361.41 W m^{-2} ; V-14: 1361.07 W m^{-2}

Comparison of SORCE TSI V-14 and V-10 Monthly Mean and S. D.



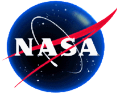


SW Land Validation: BSRN

GEWEX SRB GSW-BSRN surface SW downward flux comparison from 2007-01 to 2007-12. BSRN Global 1, or DIR+DIF, is used

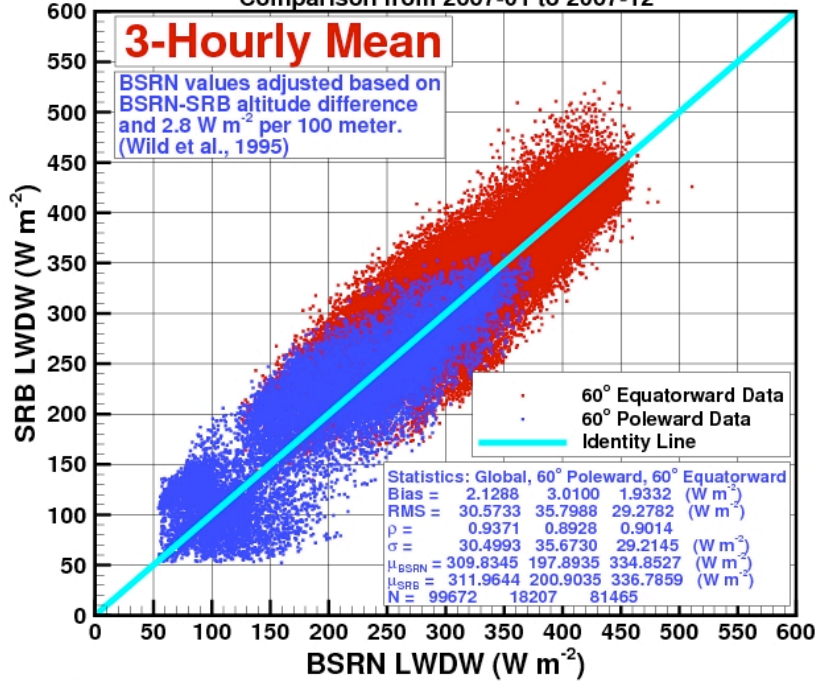
Dataset	Bias	RMS	ρ	σ	μ_{BSRN}	N
GSW (V3.0)	-12.57	88.41	0.9502	87.51	303.43	54577
	-6.88	35.27	0.9439	34.60	182.89	11114
	-9.70	23.94	0.9720	21.90	181.16	406
GSW (V4.0-baseline: old algorithms, new inputs)	-13.52	86.91	0.9519	85.86	303.44	54576
	-7.43	35.00	0.9451	34.20	182.89	11114
	-10.48	24.04	0.9727	21.66	181.16	406
GSW (V4.0-alpha: new algorithms GEOS-4)	-9.95	85.31	0.9533	84.73	303.26	54607
	-6.04	33.47	0.9491	32.92	182.89	11114
	-9.15	21.59	0.9778	19.58	181.16	406
GSW (V4.0-beta: new algorithms nnHIRS)	-7.56	85.00	0.9535	84.66	303.18	54623
	-4.62	33.23	0.9490	32.91	182.89	11114
	-7.65	20.50	0.9791	19.04	181.16	406
GSW (V4.0-MERRA)	-10.38	85.39	0.9533	84.76	303.28	54605
	-6.30	33.54	0.9490	32.95	182.89	11114
	-9.42	21.79	0.9776	19.67	181.16	406

The **3-hourly**, **daily** and **monthly** statistics are in **red**, **blue** and **green**, respectively. The units of Bias, RMS, σ and μ_{BSRN} are all $W m^{-2}$.



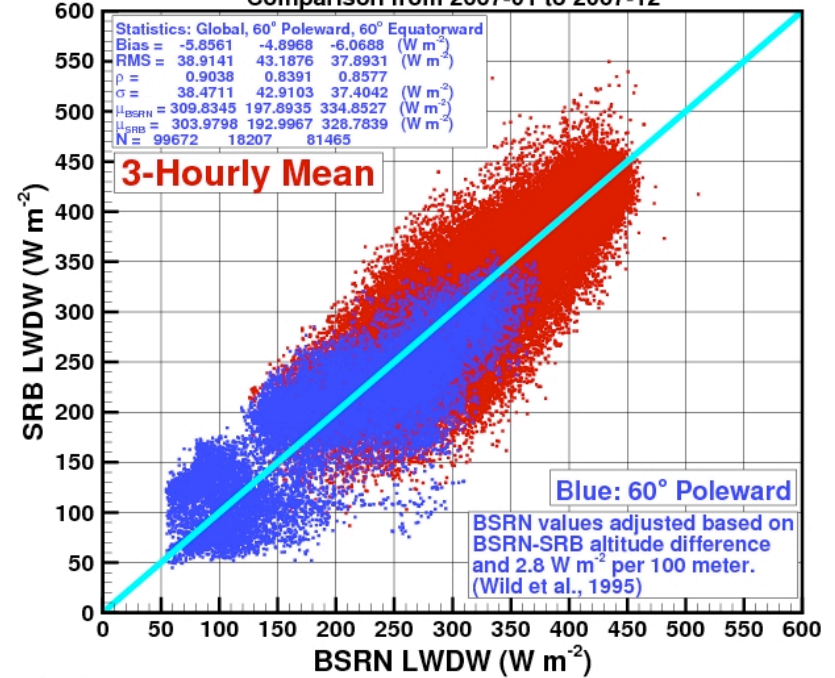
LW 3-hourly Flux Validation: BSRN

GEWEX SRB GLW(V3.1)-BSRN LWDW 3-Hourly Flux Comparison from 2007-01 to 2007-12



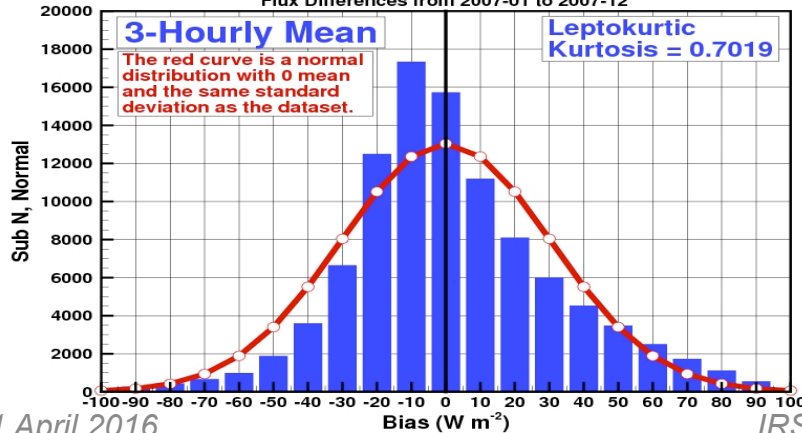
2014-12-01

GEWEX SRB GLW(V4.0-baseline)-BSRN LWDW 3-Hourly Flux Comparison from 2007-01 to 2007-12



2014-12-01

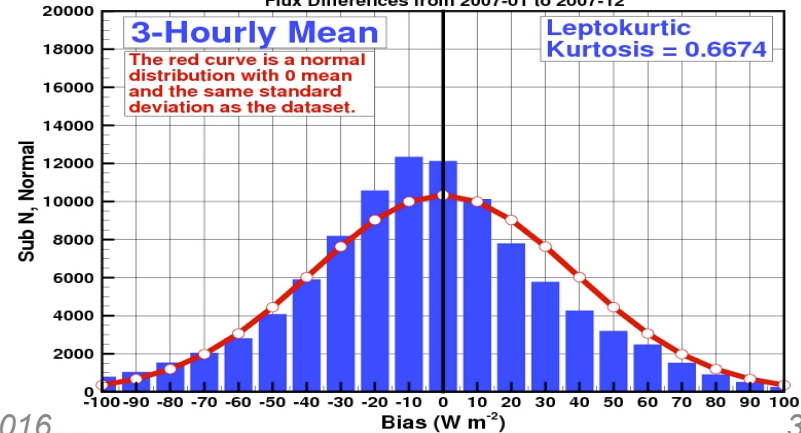
Histogram of GEWEX SRB GLW(V3.1)-BSRN LWDW 3-Hourly Flux Differences from 2007-01 to 2007-12



21 April 2016

2014-12-01

Histogram of GEWEX SRB GLW(V4.0-baseline)-BSRN LWDW 3-Hourly Flux Differences from 2007-01 to 2007-12



IRS 2016

2014-12-01



Multiyear Global Averages and Biases

Flux Model	OLR	RSR	DLF	DSF
EBAF (2.8/2.7)	239.81	99.60	345.27	186.68
GEWEX-SRB	238.03	101.99	344.29	186.93
Bias	-1.78	2.39	-0.98	0.24
Rel. Bias (%)	-0.74	2.40	-0.28	0.13
ISCCP-FD	236.30	105.51	346.25	186.61
Bias	-3.51	5.91	0.98	-0.07
Rel. Bias (%)	-1.46	5.92	0.28	-0.04
MERRA	242.39	99.56	330.88	191.66
Bias	2.58	-0.04	-14.39	4.98
Rel. Bias (%)	1.08	-0.04	-4.17	2.67
ERA-Interim	245.95	98.59	341.84	186.07
Bias	6.14	-1.01	-3.43	-0.61
Rel. Bias (%)	2.56	-1.01	-0.99	-0.33

Bias = Test Value – Reference Value
Relative Bias = Bias/Reference Value
Relative Bias (%) = Relative Bias x 100

ISCCP Effects in Surface SW

- > 0 means less radiative effect (i.e., less negative) => corresponds to changes in aerosol
- < 0 means increased radiative effect => corresponds to changes in cloud fraction
- Consistent with ISCCP changes

