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

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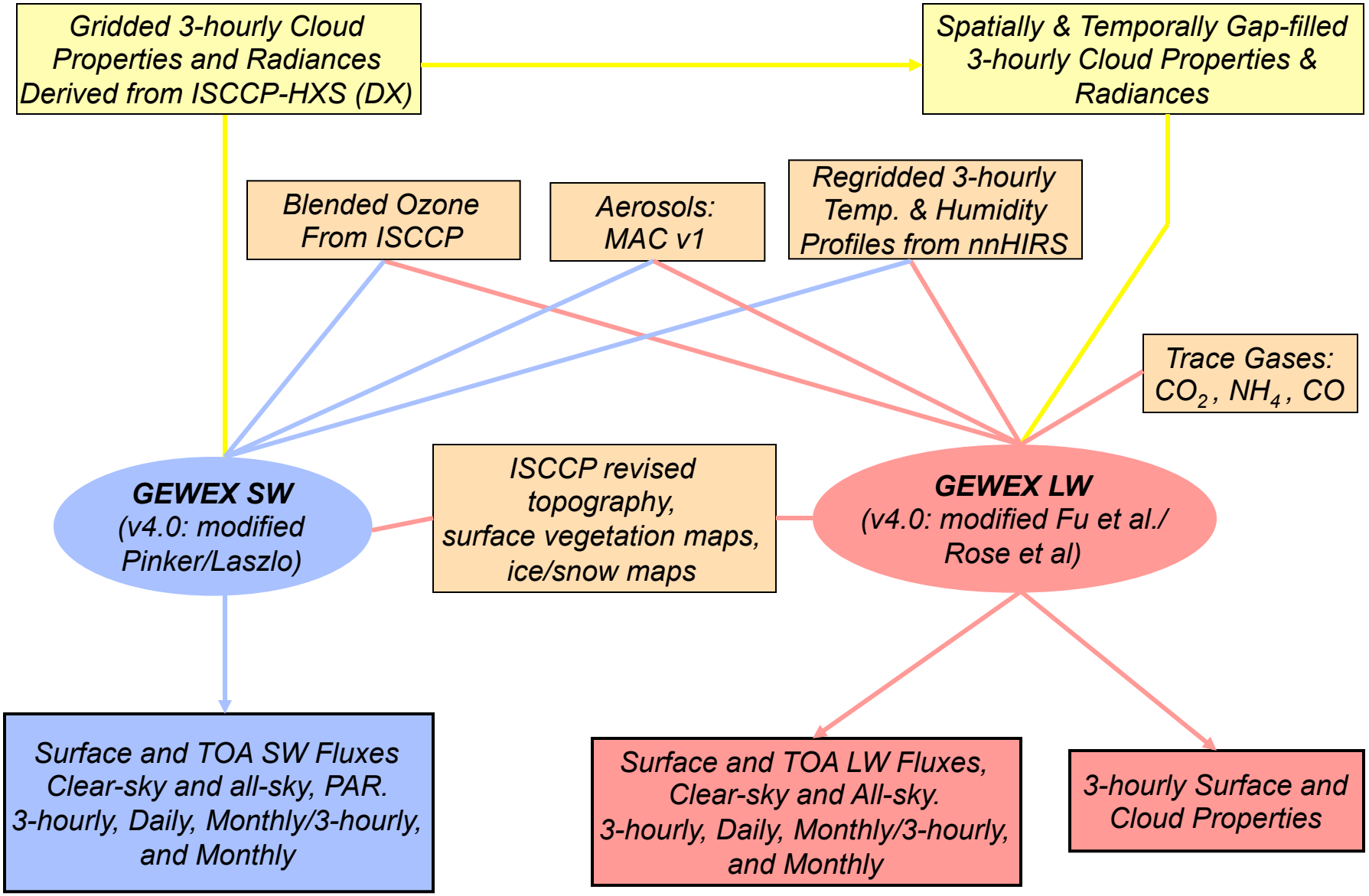
SRB Release 3 Data Products

(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



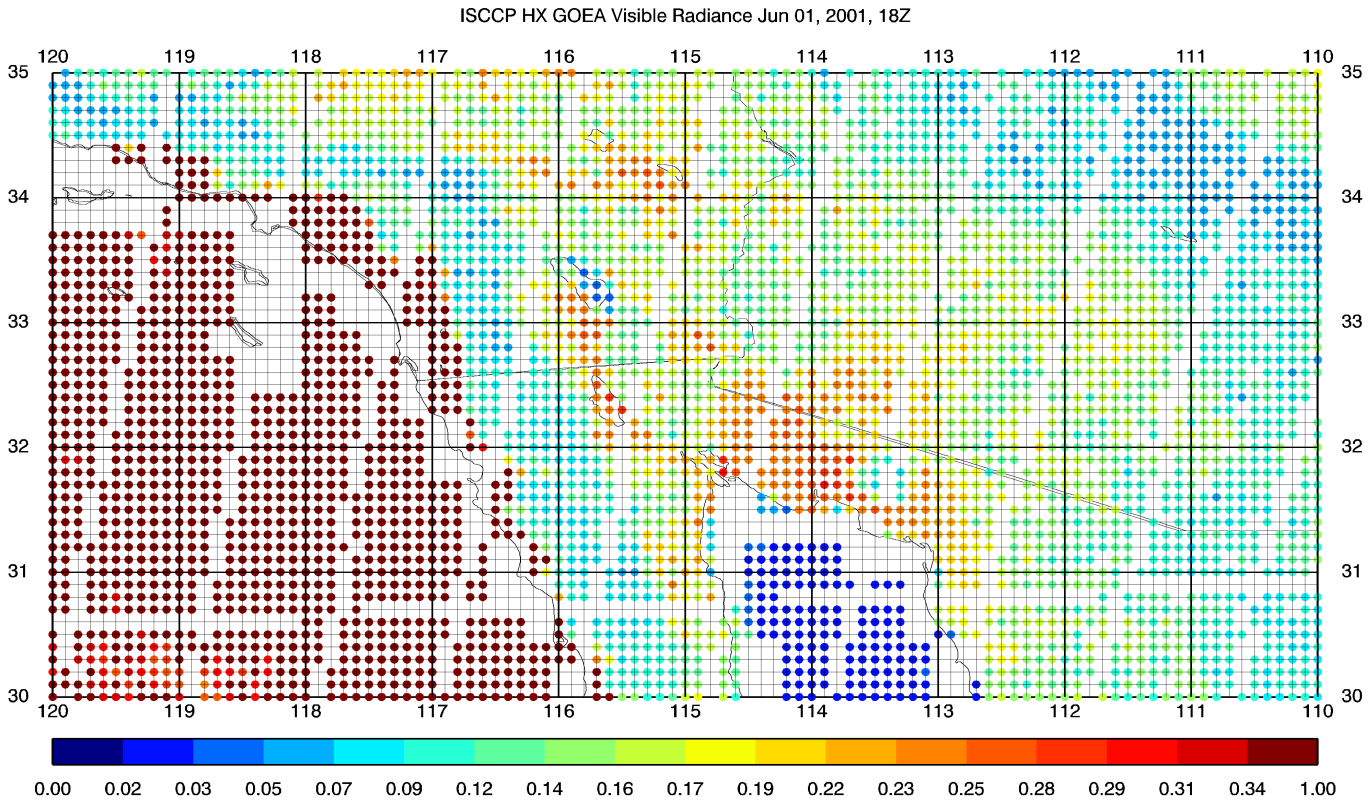
SRB Input Changes

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/ emissitivity	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

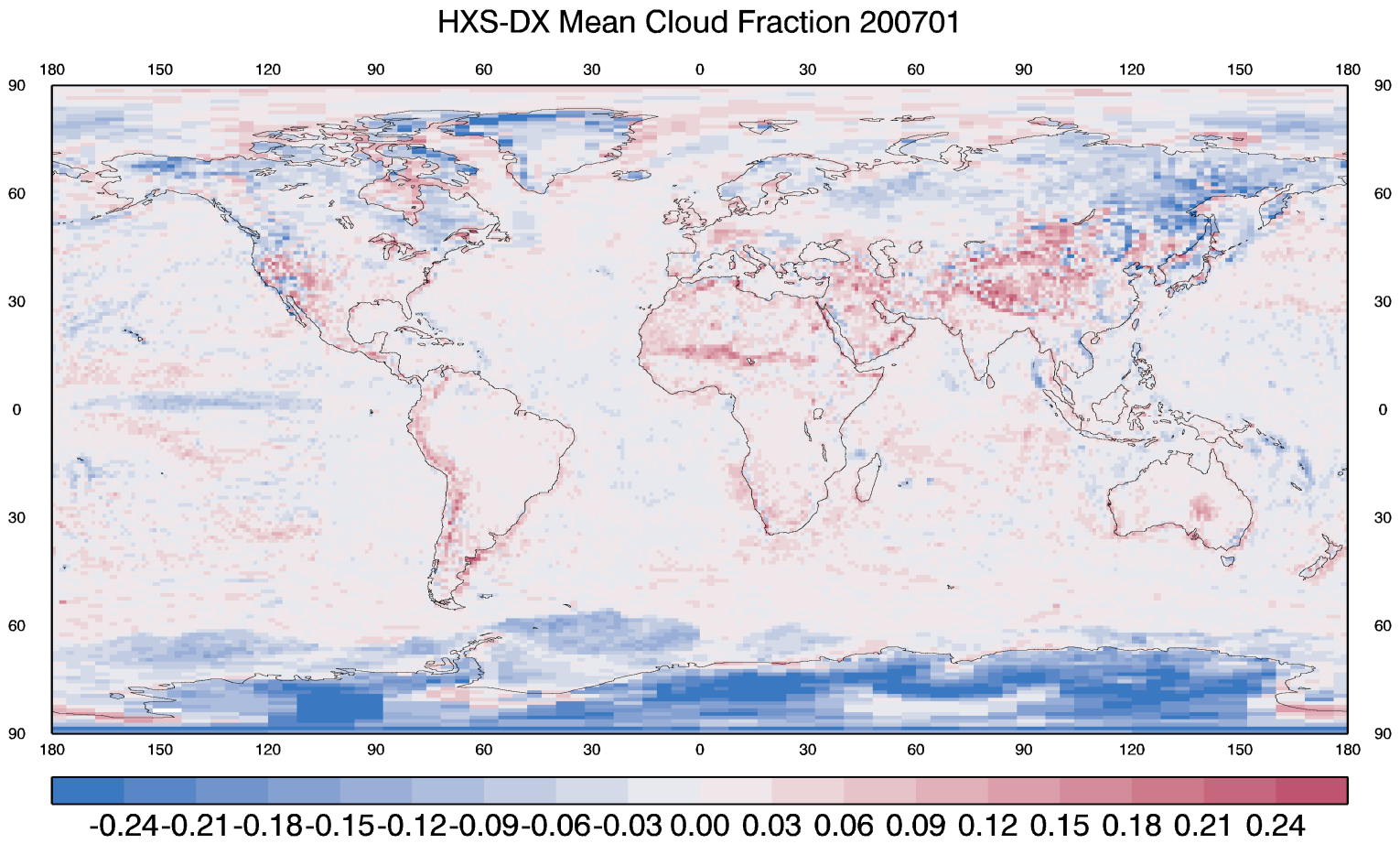
ISCCP H Series

ISCCP is being reprocessed (based at NCDC)

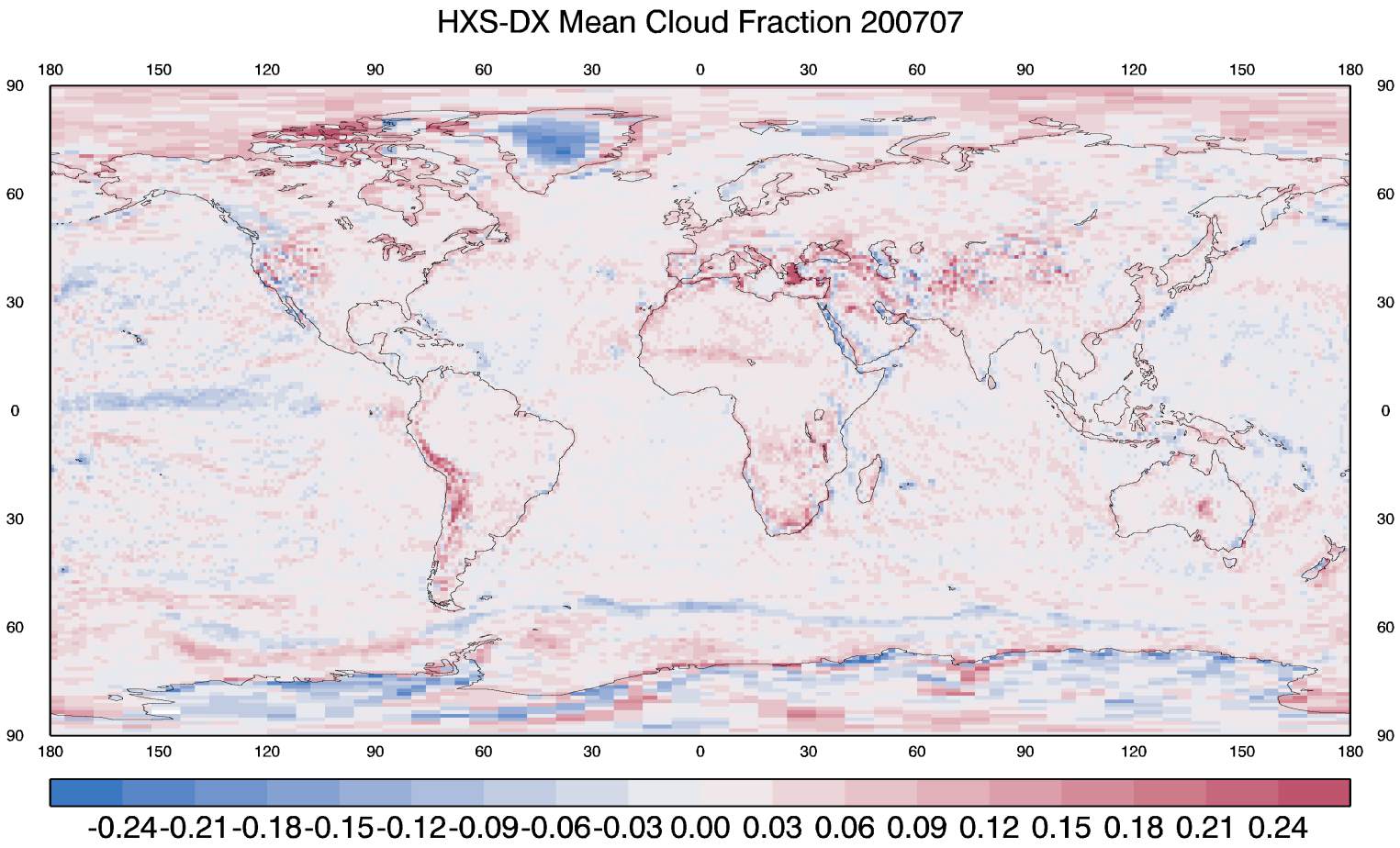
- Uses all 10 km pixels with no subsampling
- Revised calibration using MODIS and Heidinger (et al)
- Pixel 3-hourly, 1x1 3-hourly, and 1x1 monthly data products
- Algorithm Updates
- nnHIRS Gridded & filled data set using T, q retrieval (Shi et al.)
- New surface type maps



ISCCP Cloud Fraction Differences, Jan 2007



ISCCP Cloud Fraction Differences, Jul 2007



Calibration issue affecting Rel3 is resolved

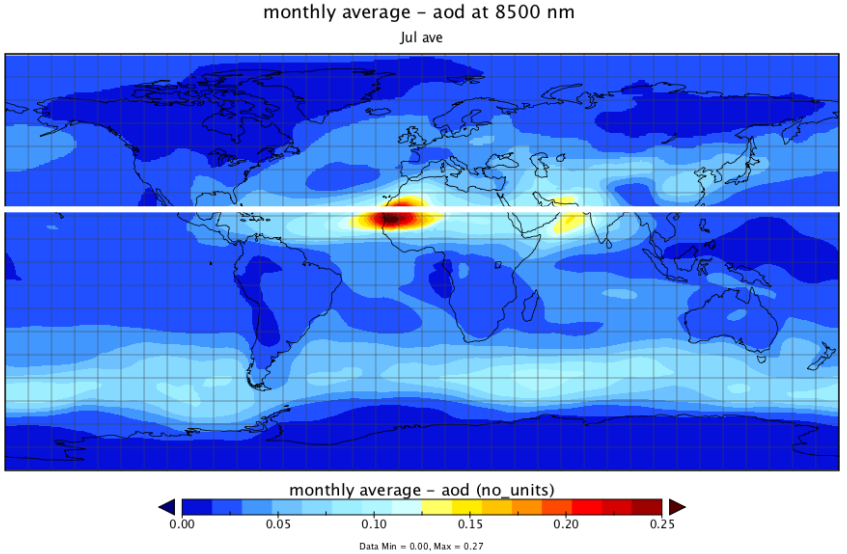
- In ISCCP DX, there is a jump in visible radiances which leads to a jump in SRB shortwave fluxes from Dec 2005 to Jan 2006.
- Specifically, there is an increase in the very low values mostly scene over ocean at sunrise/sunset
- In the new ISCCP HXS, those low values return, and the 2005-2006 flux discontinuities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

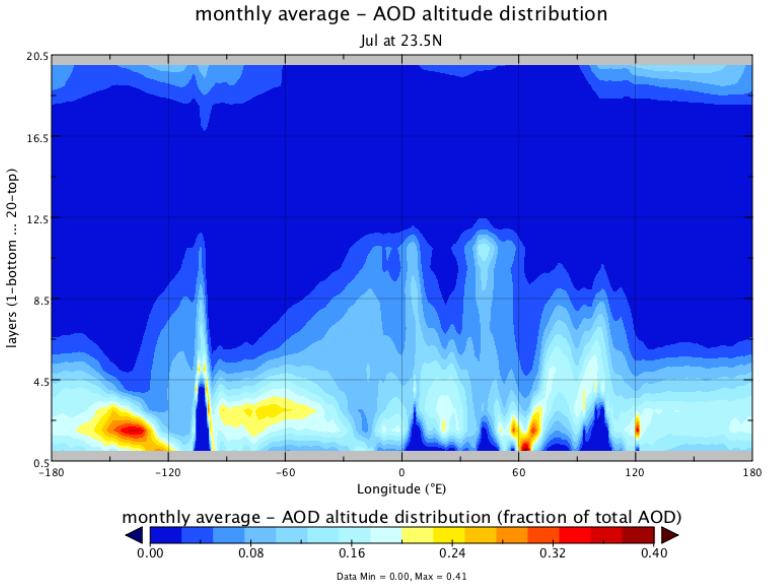
Max Planck Aerosol Climatology (v1)

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

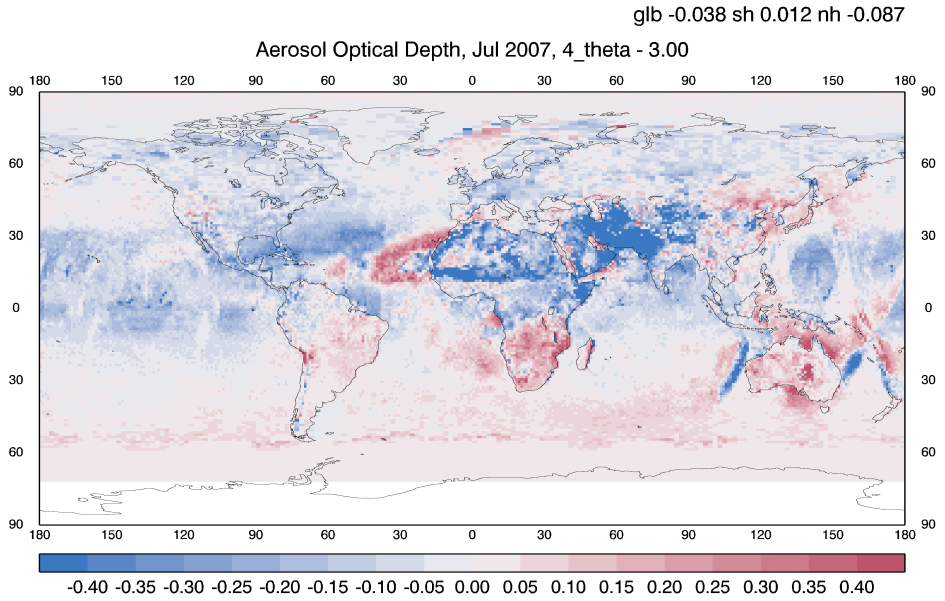
Surface Downward Flux differences (figures to come)

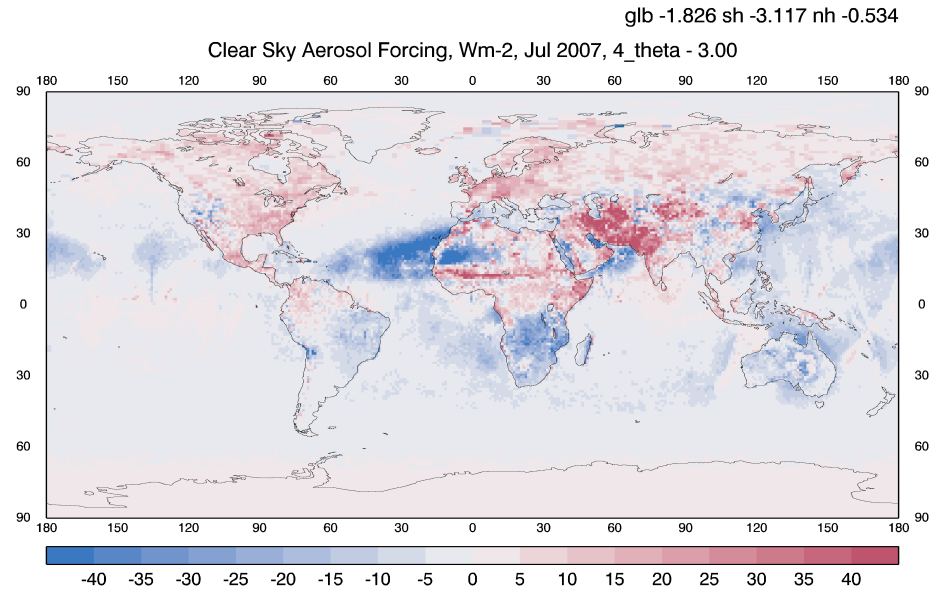
TOA Upward Flux differences (figures to come)

SW Aerosol Radiative Effect

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*





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

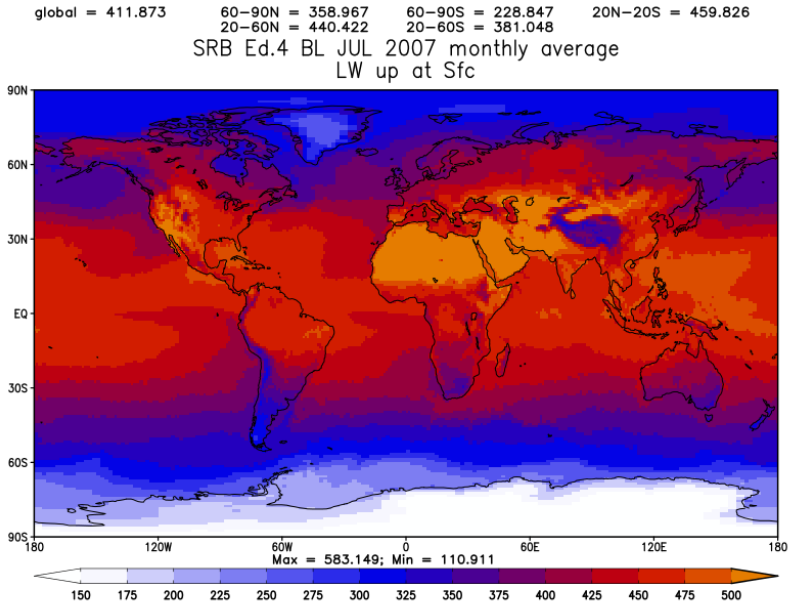
GEWEX SRB: Summary Status

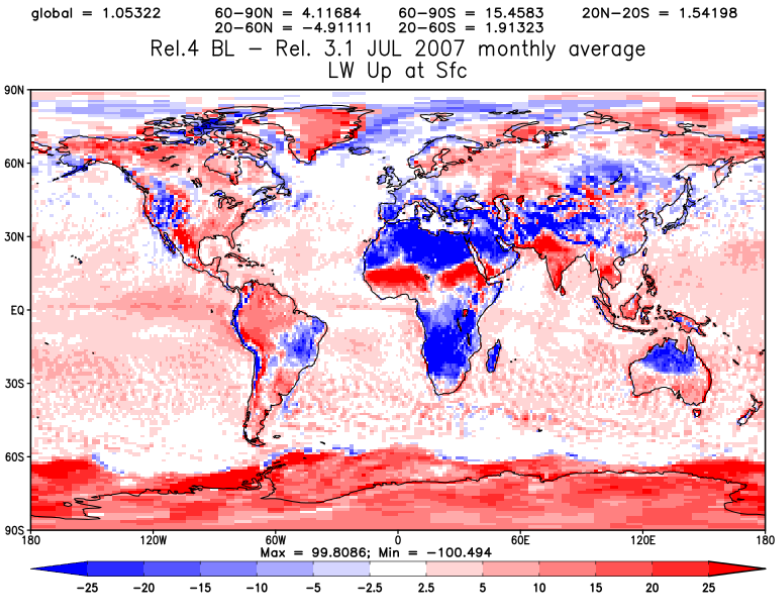
- GEWEX SRB Rel 3: 24 year TOA and surface radiation at 1°x1°.
  - Documentation improved; analysis paper submissions
  - Validation, analysis and collaborative activities crucial to assessing and improving the data set are continuing
- GEWEX SRB Rel 4-IP:
  - New inputs from ISCCP nnHIRS and HXS from 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

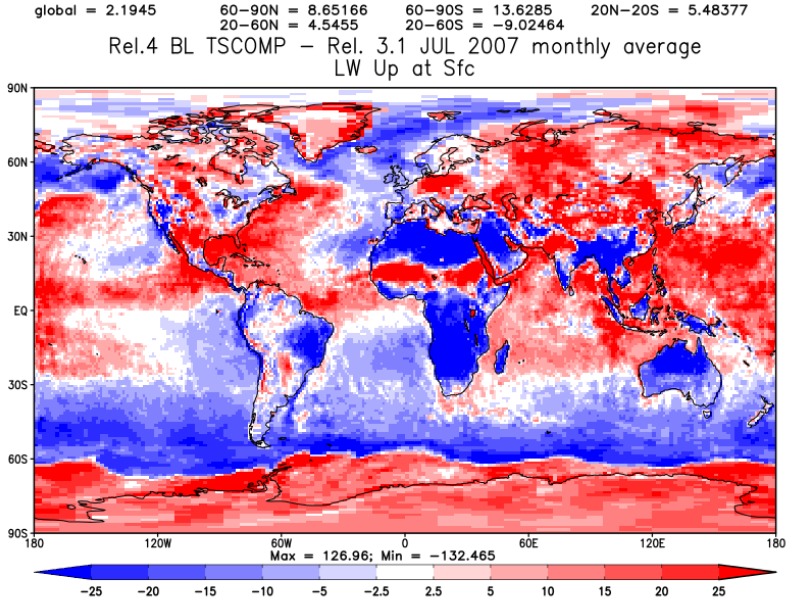
LW Algorithm Improvements for Release 4.0

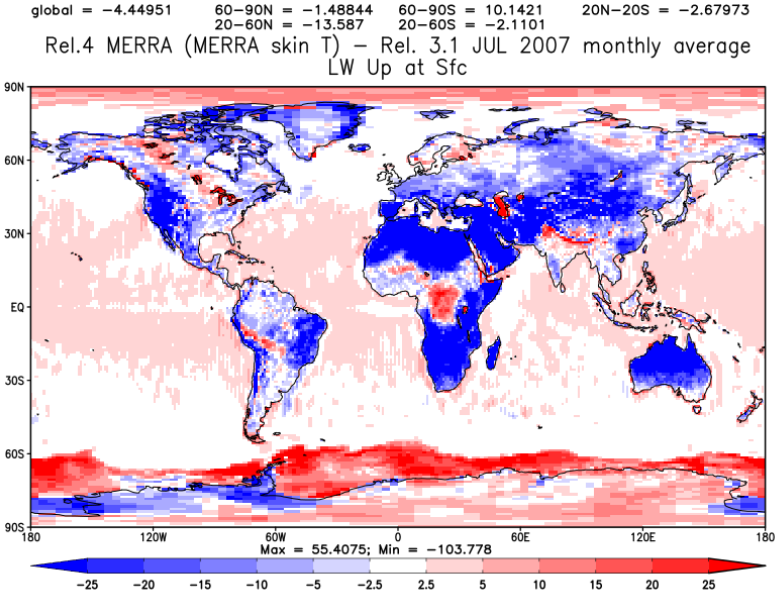
	Release 3.0	Release 4.0 Baseline	Release 4.0
Aerosol Radiative Properties	None	New aerosol radiative property routine - disabled	New aerosol radiative property routine to accommodate full monthly 3D aerosol optical properties; vertical profiles
Cloud Ice Properties	Original ice cloud radiative properties	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

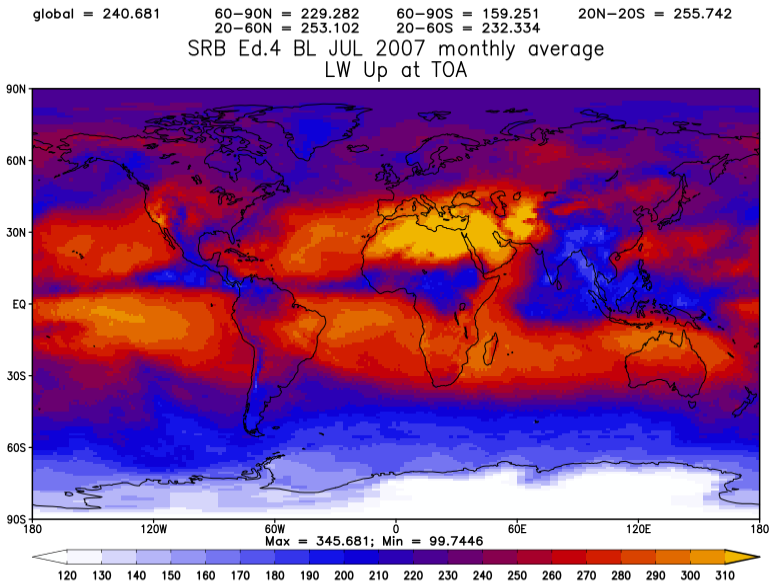


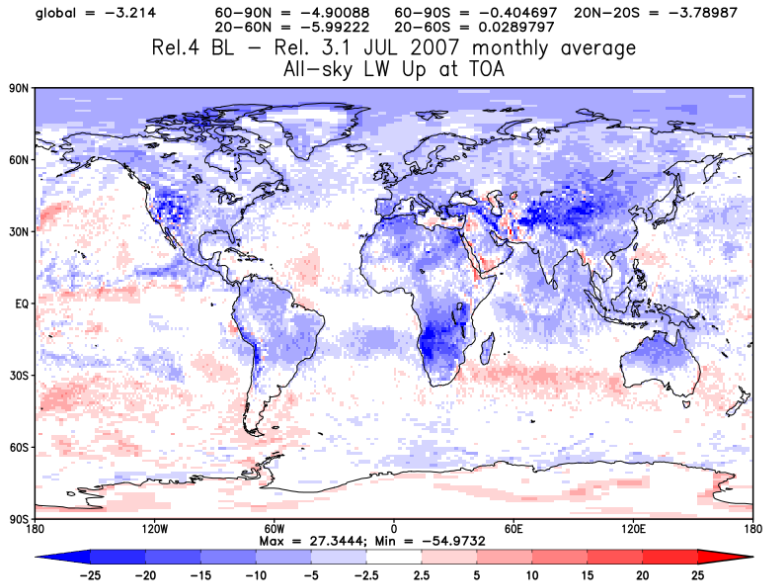


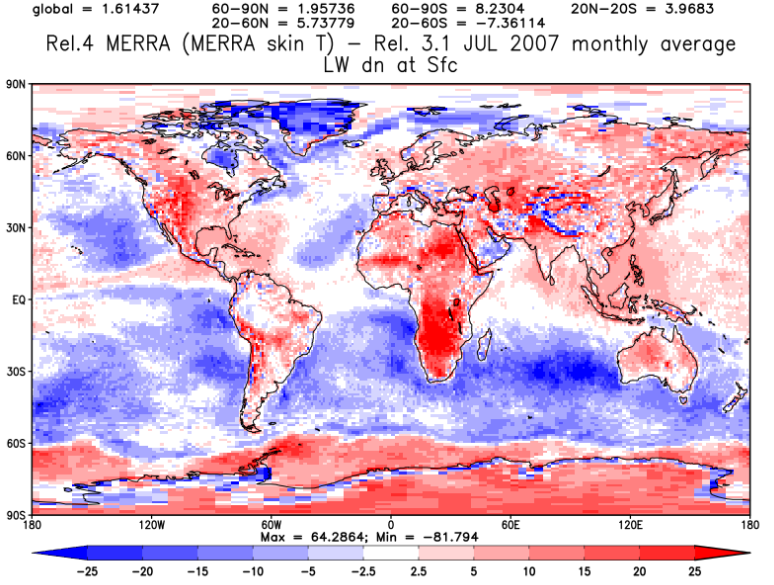


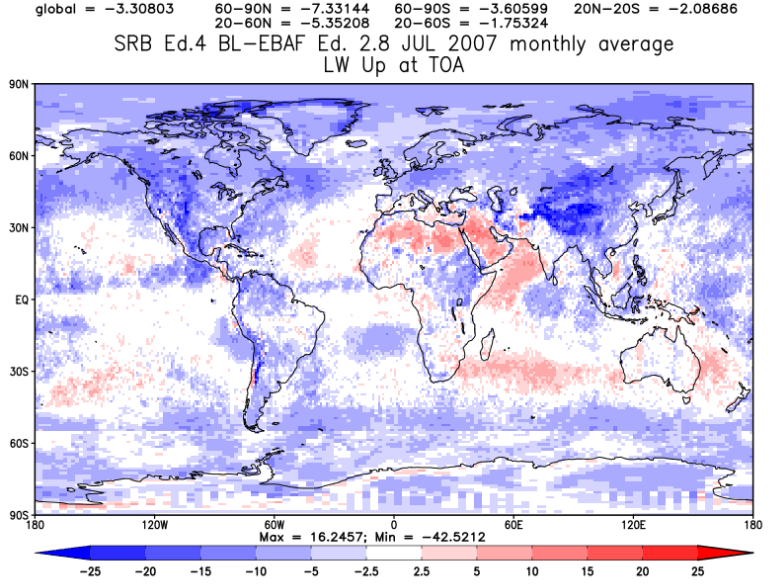


All-Sky Flux Up TOA

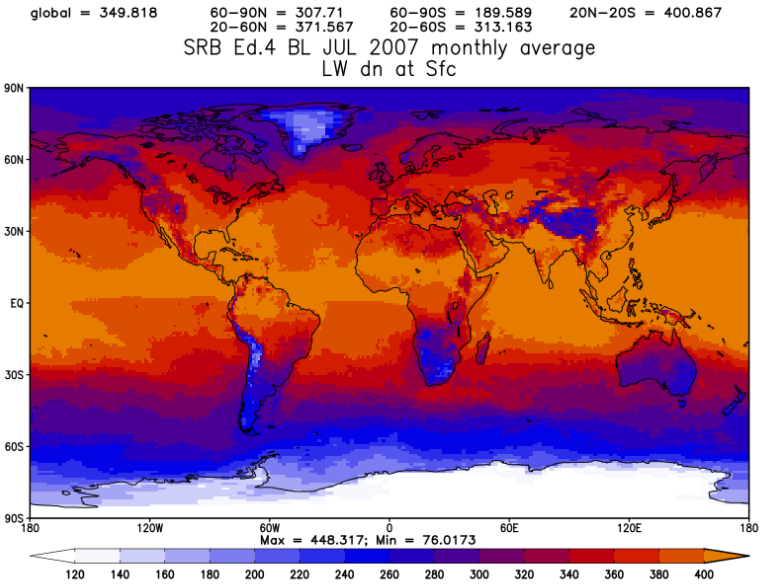


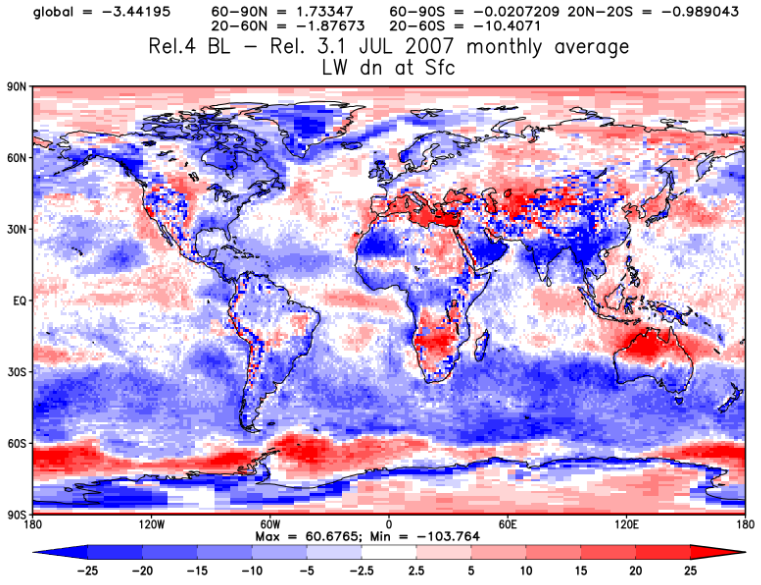


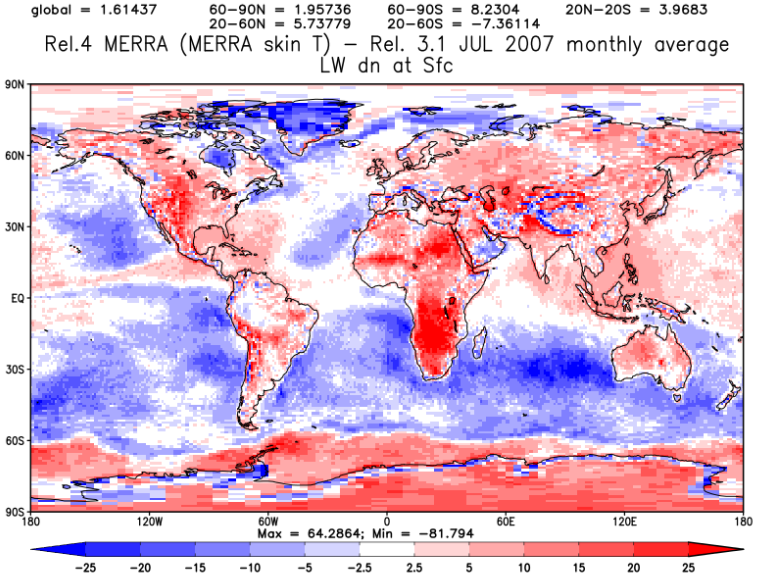


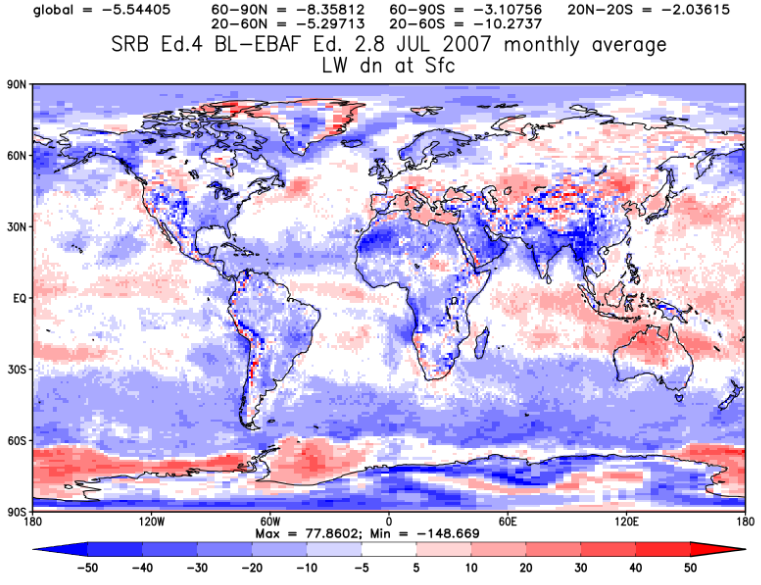


All-Sky Flux Down Surface





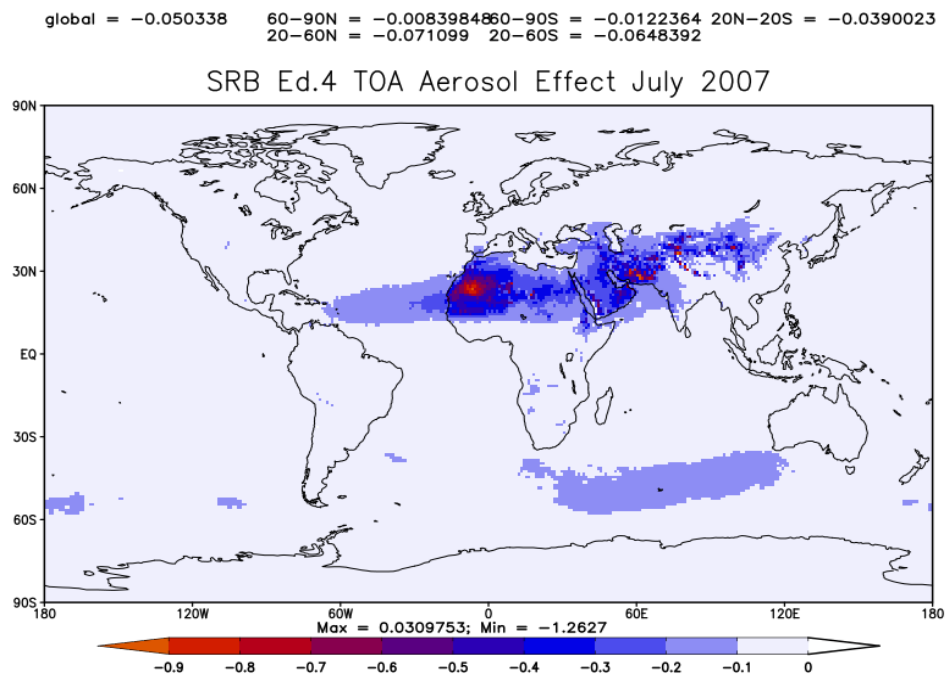


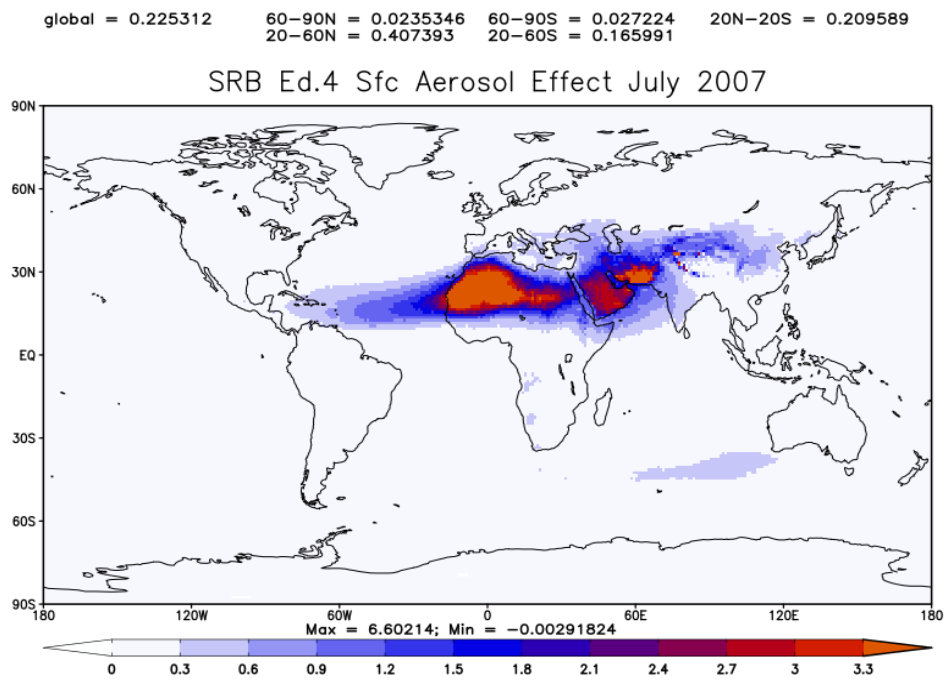


Aerosol Radiative Effect

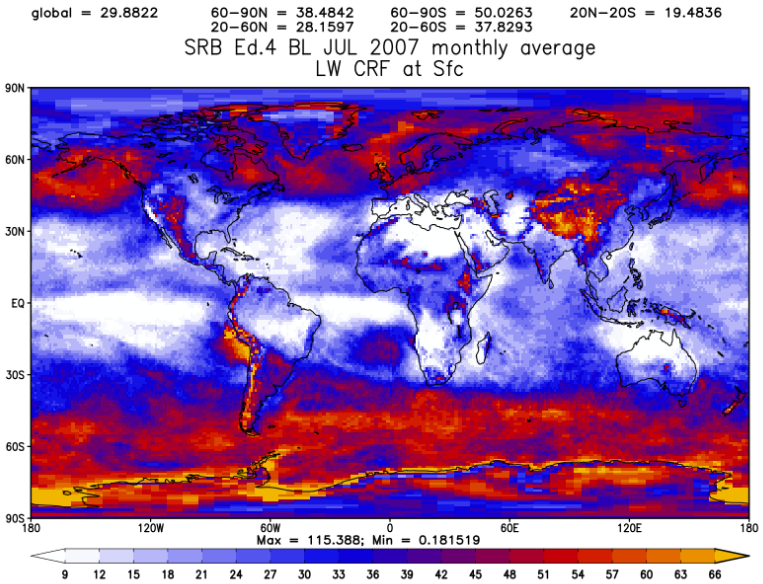
Monthly Averaged LW Aerosol Radiative Effect (July 2007)

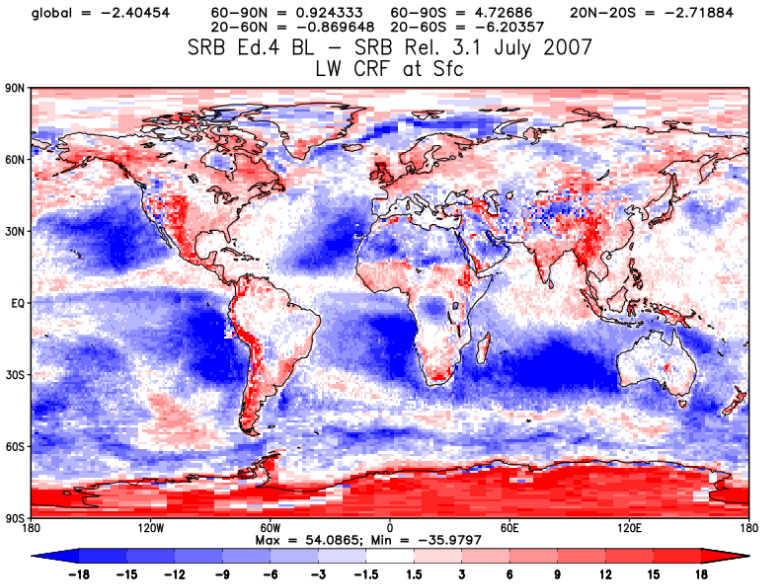
- TOA forcing maximum -1.26 W m^{-2} (TOA flux reduced)
- Surface forcing 6.6 W m^{-2} (Surface flux increased)

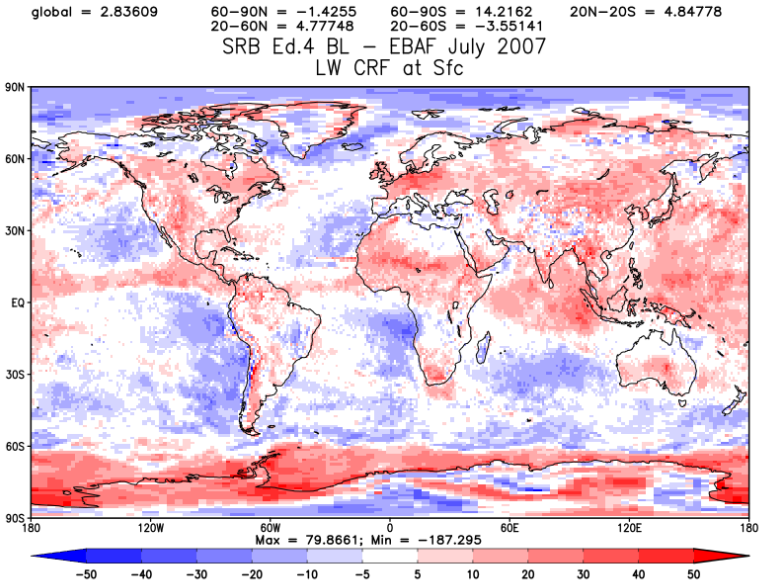




Surface Cloud Radiative Effect







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

SRB Rel 4 LW: 3-Hourly Validation

GLW vs. BSRN

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

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}.

GLW vs. Ocean Buoy

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

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+Tscomp; 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

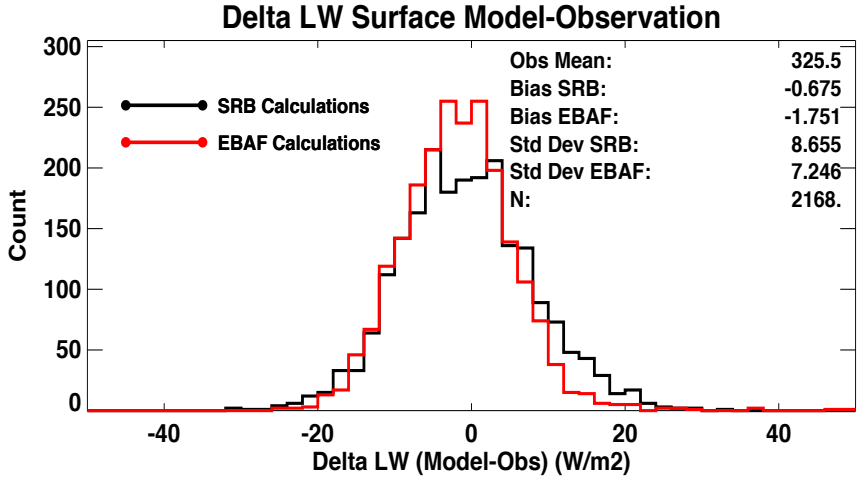
3. **NCDC THREDDS Server**

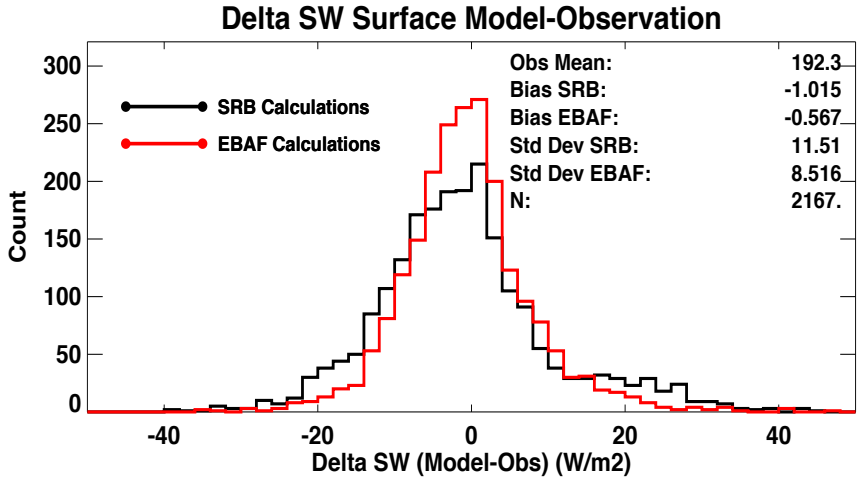
   http://www.ncdc.noaa.gov/oa/rsad/netcdf-access/index.php?name=srb

Extras

SRB BSRN/Buoy Validation

BSRN Land (2001-2007)

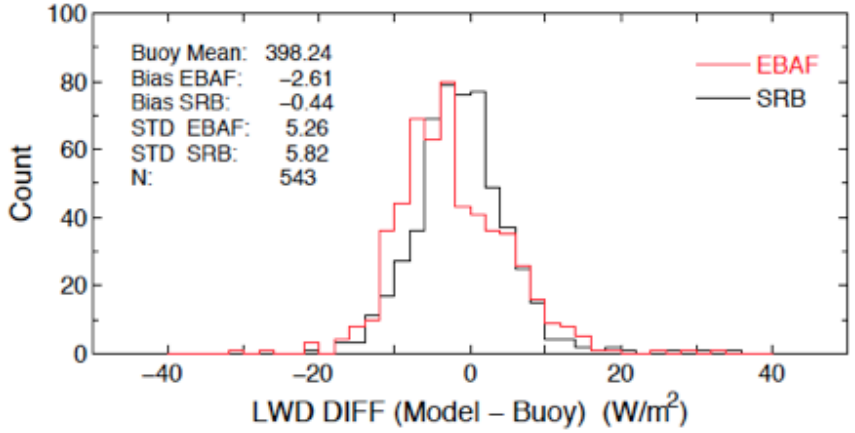


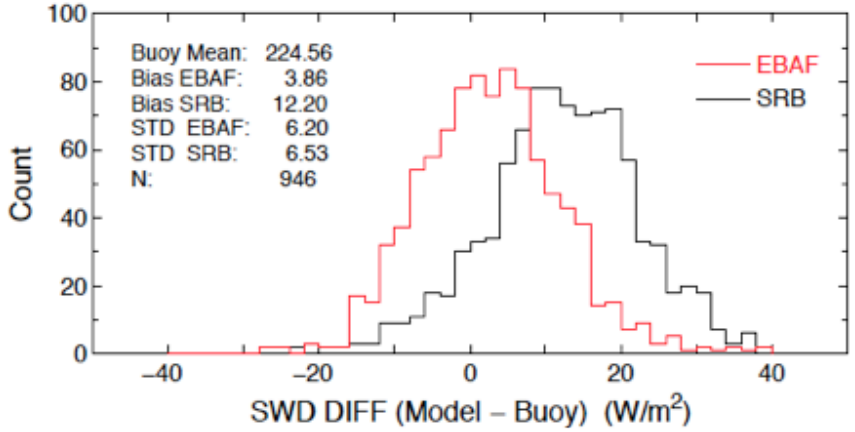


Rutan, CERES Team

Ocean Buoy Networks (2001-2007)

(from Weller & Yu, WHOI)

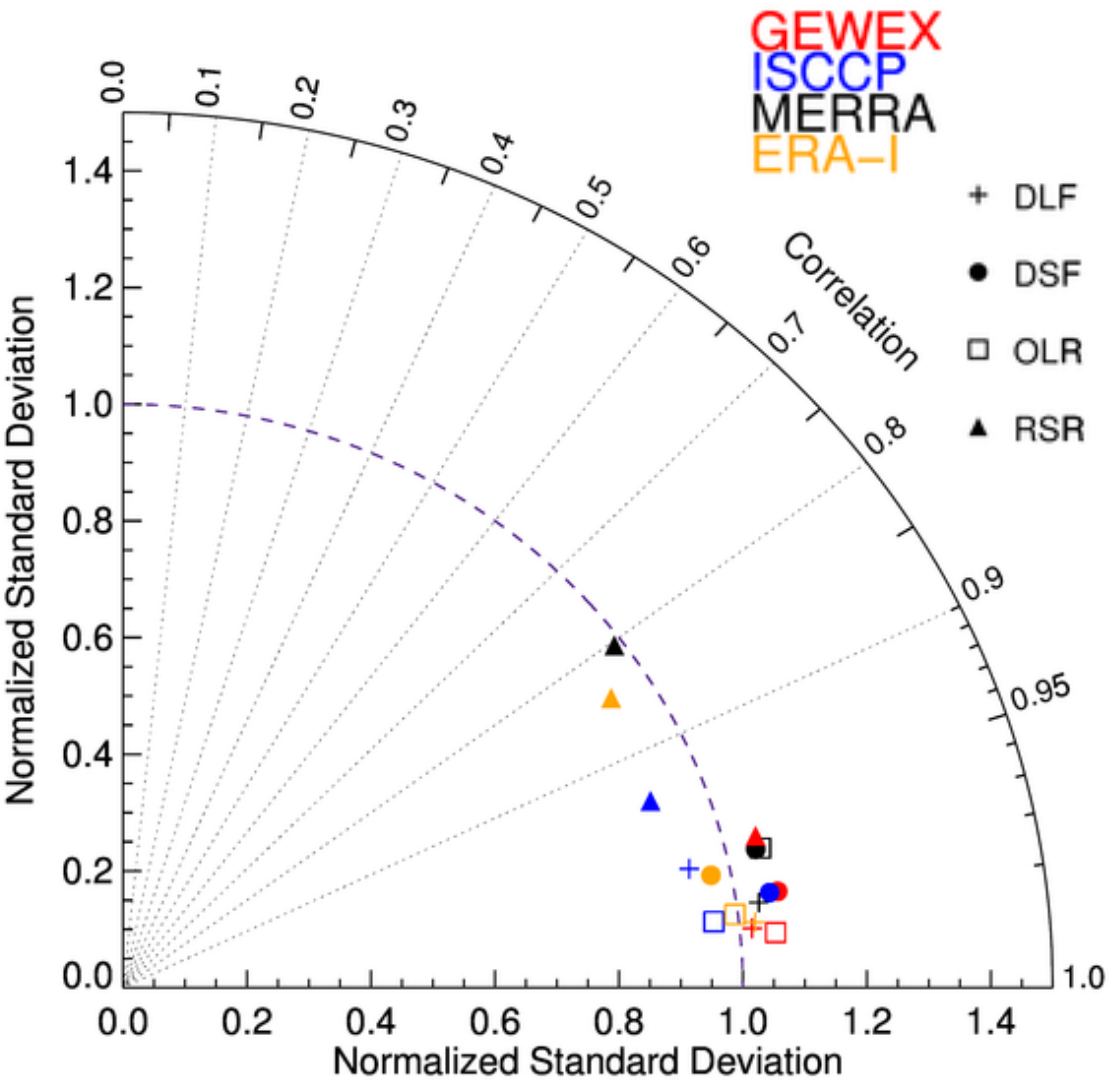




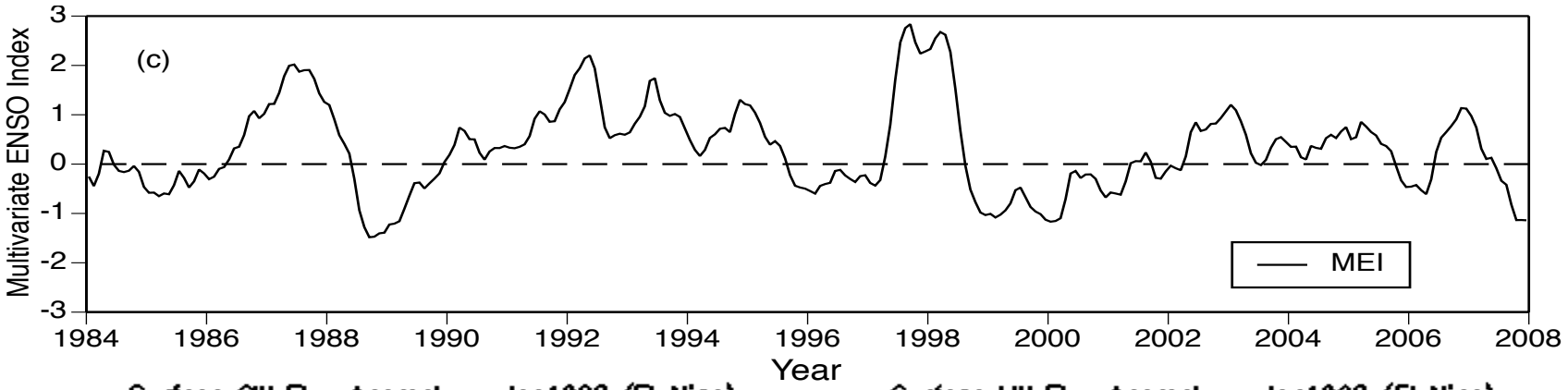
Kato et al., 2013

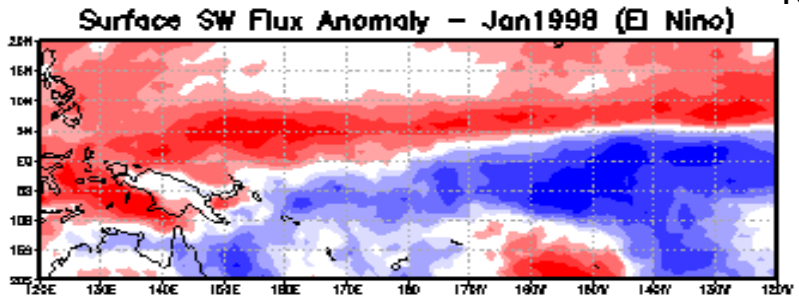
Multi-Data Set Flux Assessment

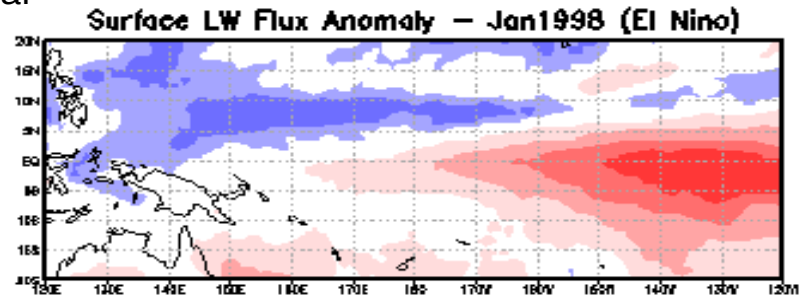
- *Centered Taylor Diagram GEWEX SRB Rel 3.1, ISCCP FD, MERRA and ERA-I vs the CERES TOA and Surface EBAF Data sets*
- *Overlap years 2001 – 2007*
- $\sigma_n = \sigma_{test} / \sigma_{EBAF}$
- *SRB shows high correlation; more spatial variability than CERES EBAF*

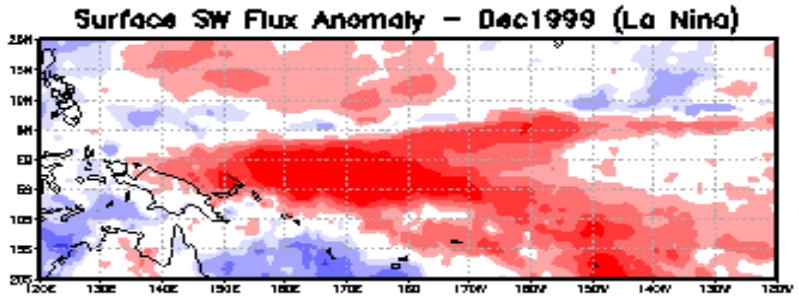


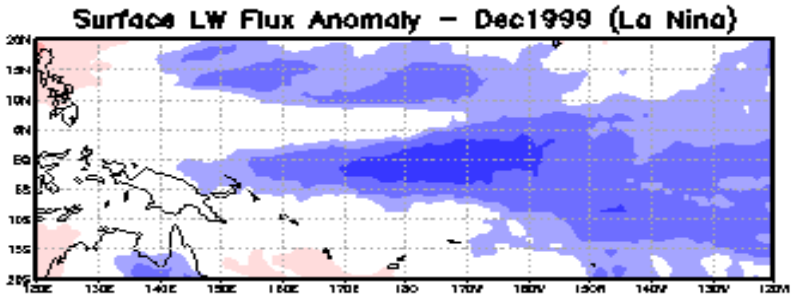
Response to El Nino (Jan1998)/La Nina (Dec1999)

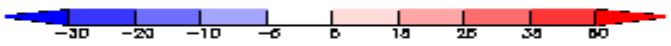




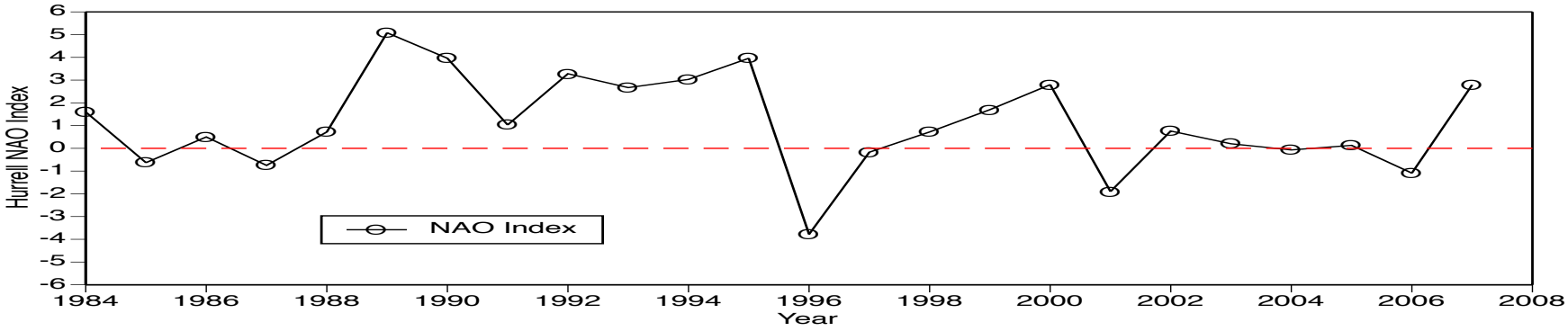


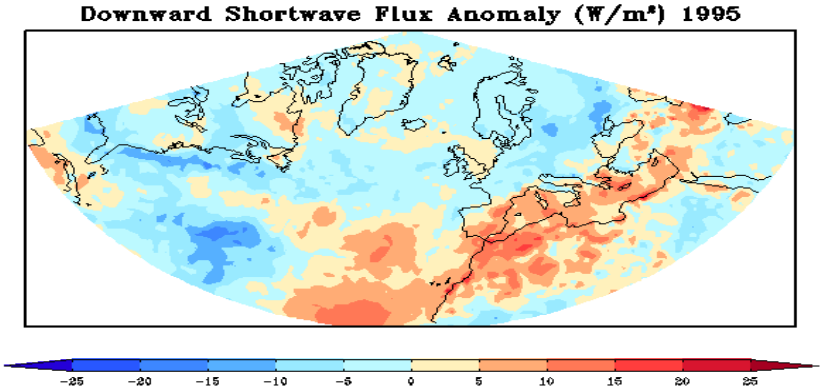


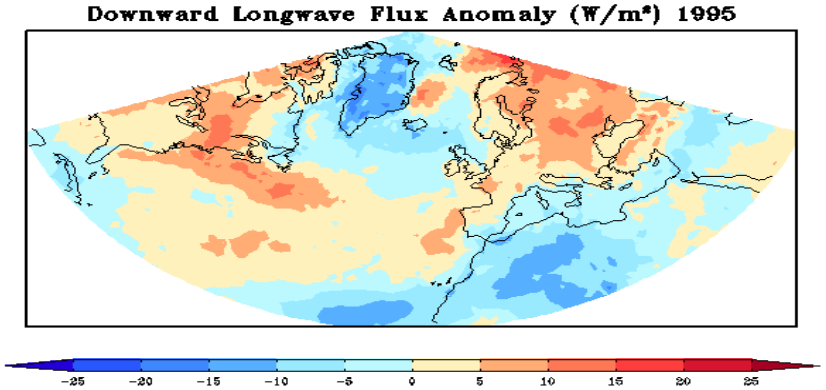


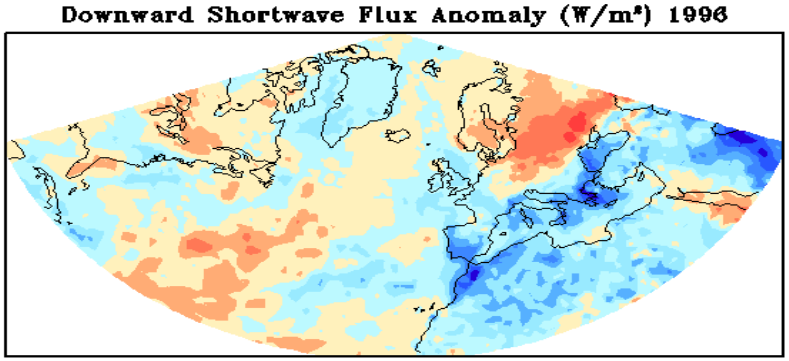


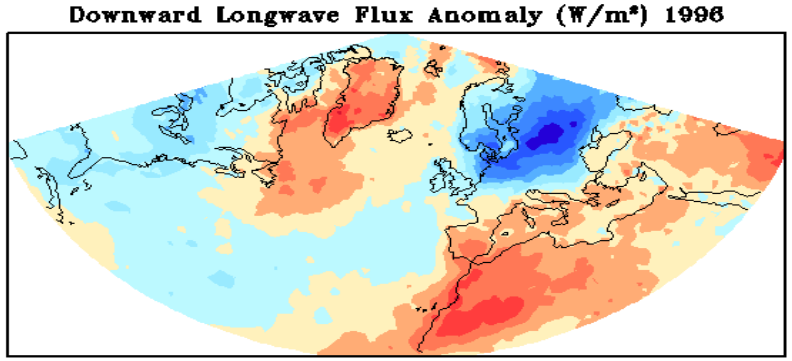
Response to North Atlantic Oscillation











ISCCP/SRB Uncertainties

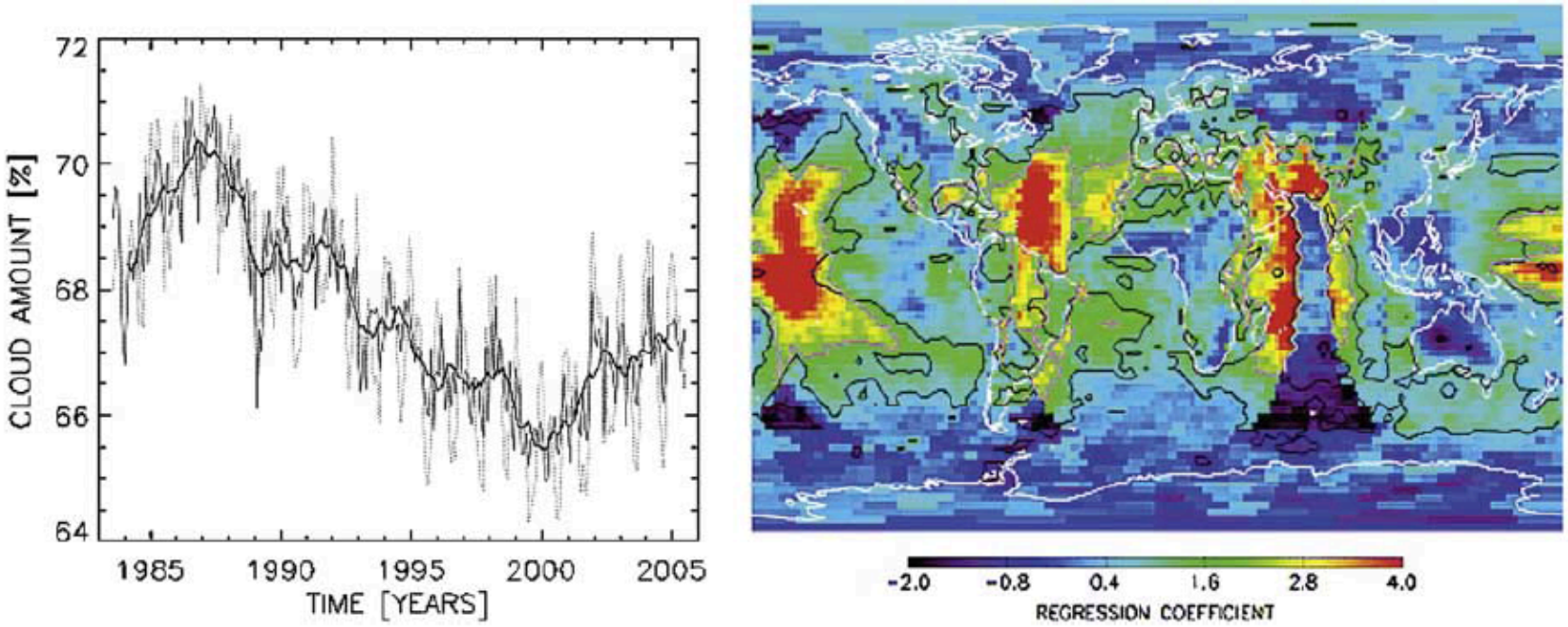
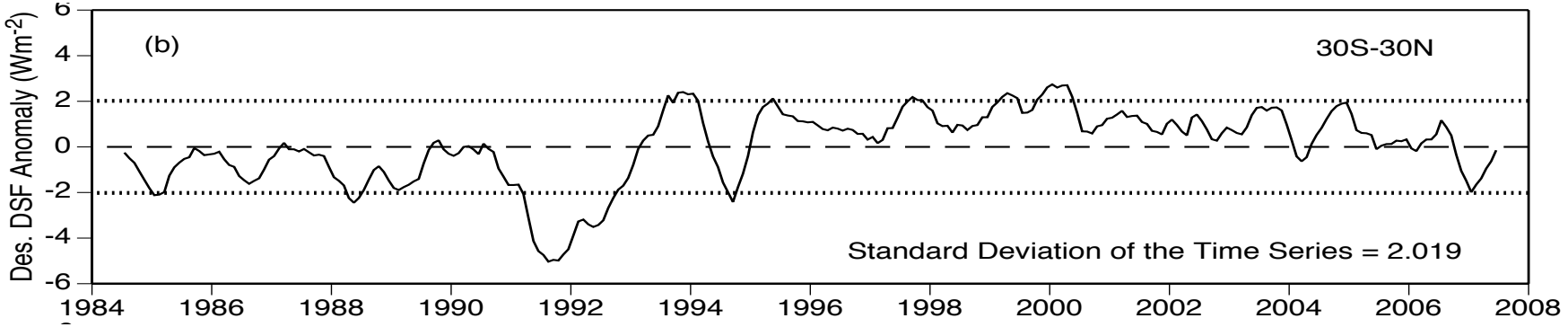
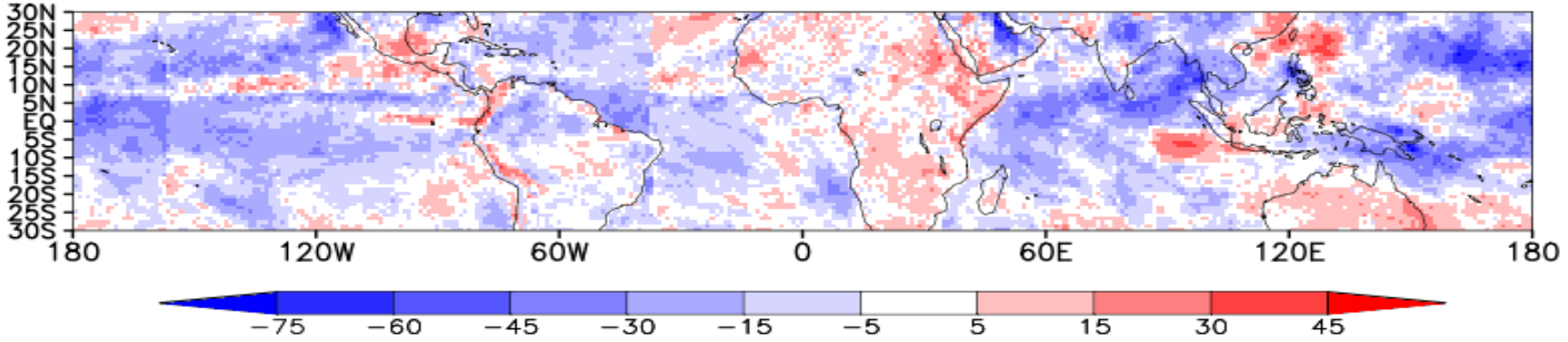


Figure 1. Figures 1 and 2 from *Evan et al.* [2007]. (left) Raw (dotted line), deseasonalized (light solid line), and smoothed (dark solid line) time series of infrared cloud amount from ISCCP between 60°S and 60°N after removal of El Niño signal. (right) Regression coefficients for smoothed average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

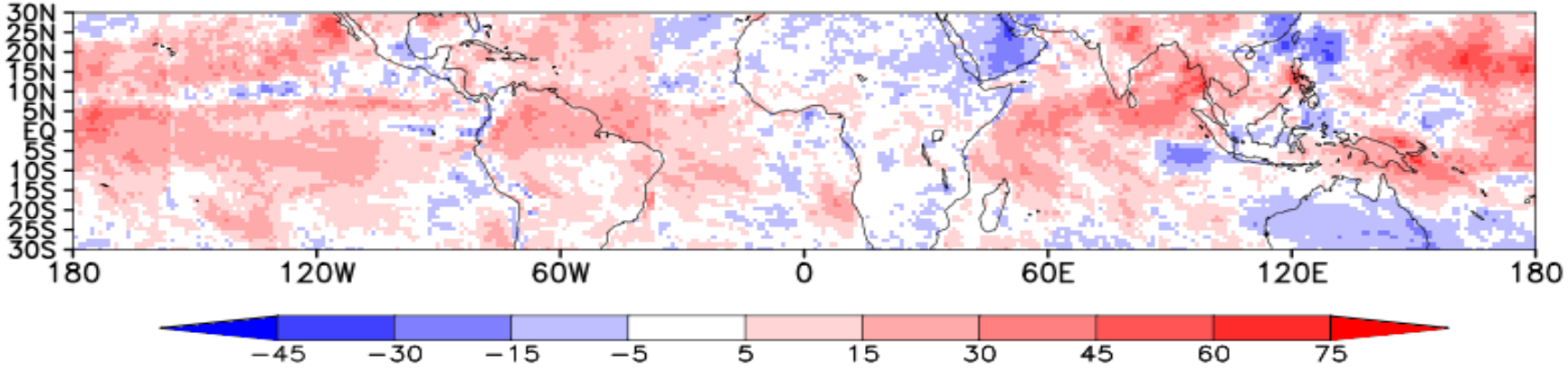
DSF and RSR Anomalies – Mt. Pinatubo (Aug 1991)



DSF Anomalies



RSR Anomalies



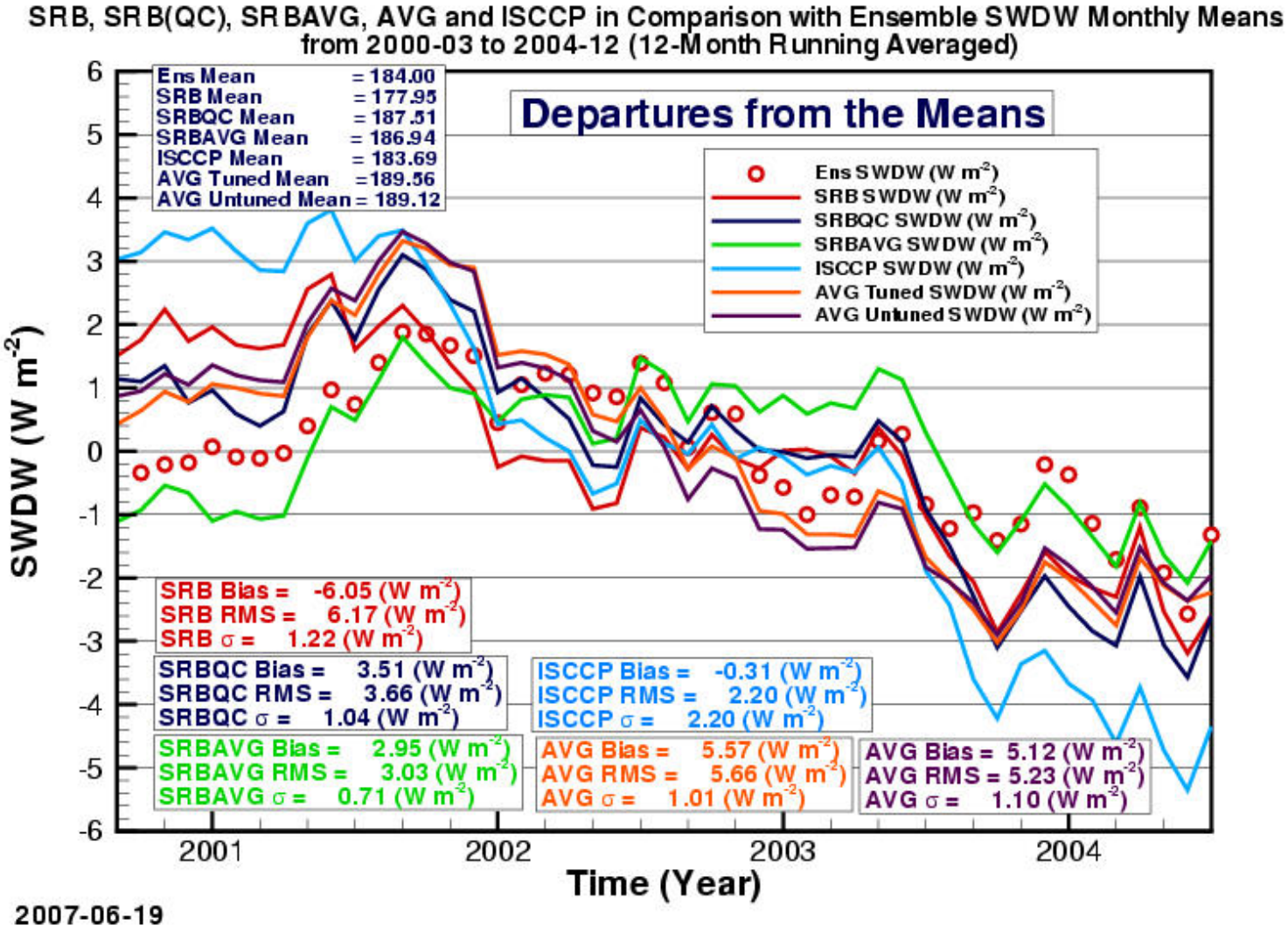
SRB Release 4 Baseline Data Products

(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

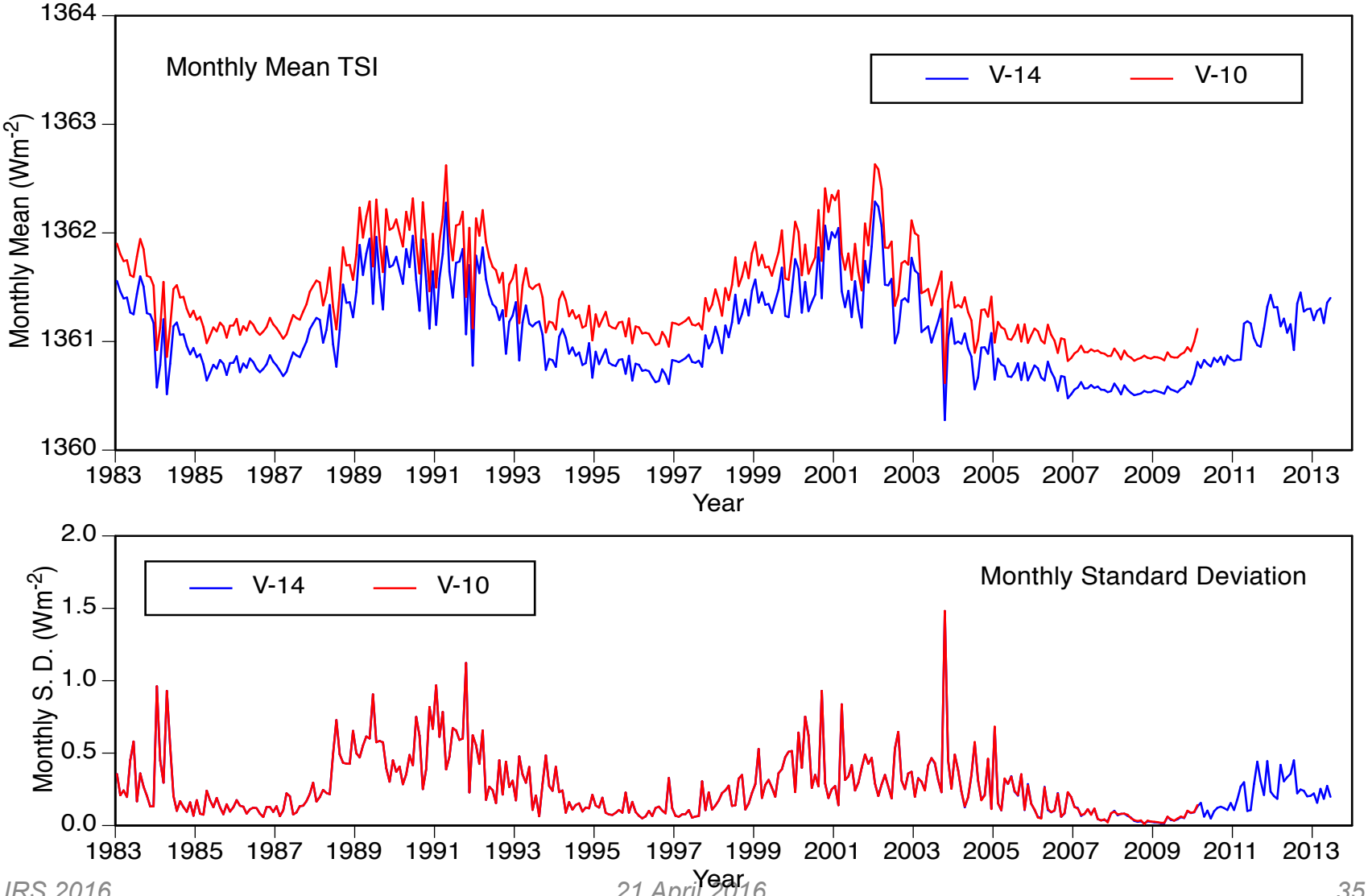
Validation: Time Series vs. CERES



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.



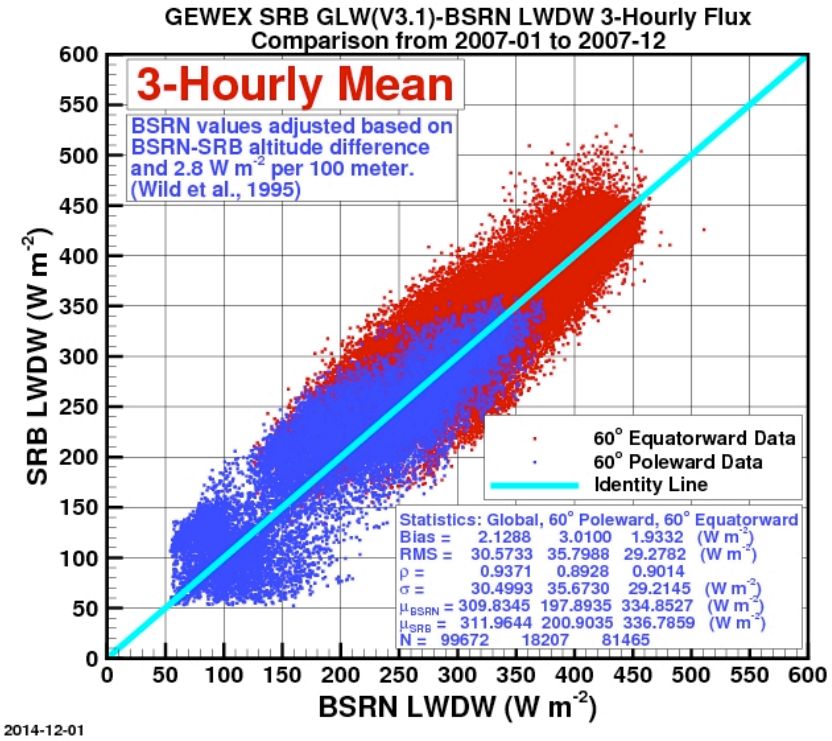
SW Land Validation: BSRN

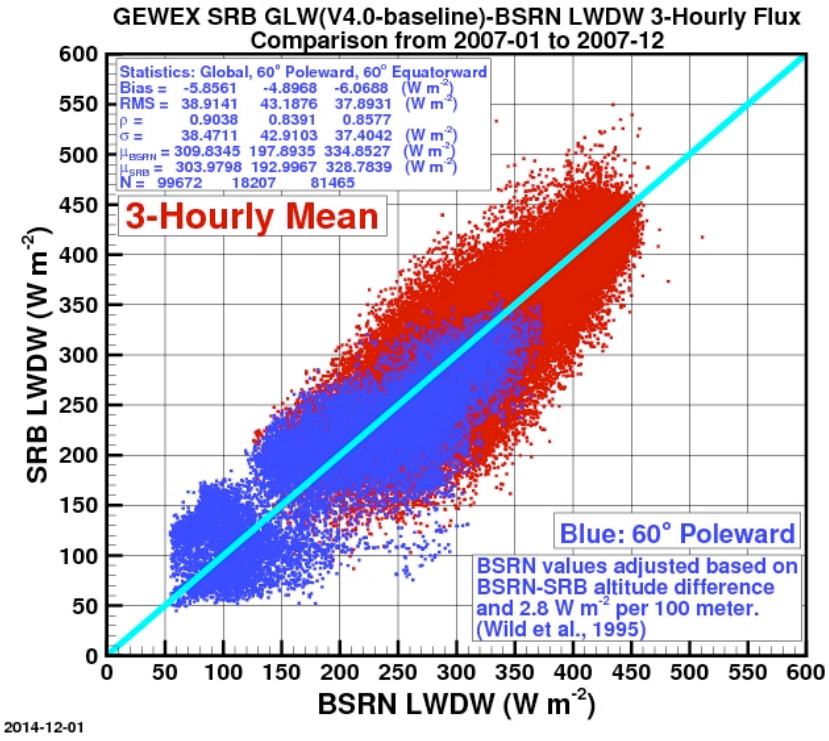
GEWEX SRB GSW-BSRN surface SW downward flux comparison from 2007-01 to 2007-12. BSRN Global 1, or DIR+DIF, is used

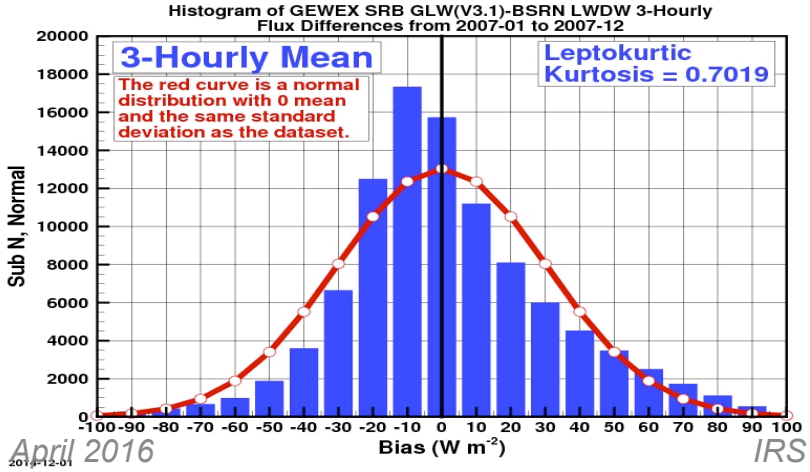
Dataset	Bias	RMS	ρ	σ	μ_{BSRN}	N
GSW (V3.0)	-12.57	88.41	0.9502	87.51	303.43	54577
	-6.88	35.27	0.9439	34.60	182.89	11114
	-9.70	23.94	0.9720	21.90	181.16	406
GSW (V4.0-baseline: old algorithms, new inputs)	-13.52	86.91	0.9519	85.86	303.44	54576
	-7.43	35.00	0.9451	34.20	182.89	11114
	-10.48	24.04	0.9727	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

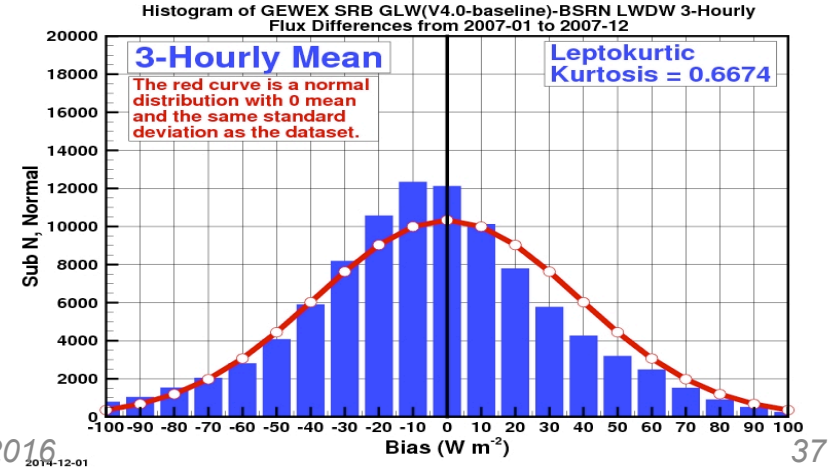
*The **3-hourly**, **daily** and **monthly** statistics are in **red**, **blue** and **green**, respectively. The units of Bias, RMS, σ and μ_{BSRN} are all W m^{-2}.*

LW 3-hourly Flux Validation: BSRN









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 Bias Rel. Bias (%)	238.03 -1.78 -0.74	101.99 2.39 2.40	344.29 -0.98 -0.28	186.93 0.24 0.13
ISCCP-FD Bias Rel. Bias (%)	236.30 -3.51 -1.46	105.51 5.91 5.92	346.25 0.98 0.28	186.61 -0.07 -0.04
MERRA Bias Rel. Bias (%)	242.39 2.58 1.08	99.56 -0.04 -0.04	330.88 -14.39 -4.17	191.66 4.98 2.67
ERA-Interim Bias Rel. Bias (%)	245.95 6.14 2.56	98.59 -1.01 -1.01	341.84 -3.43 -0.99	186.07 -0.61 -0.33

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

SW Cloud Radiative Effect

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