The GEWEX Surface Radiation Budget Project: Release 4 Integrated Product Progress and Plans

GEWEX Data and Assessments

Panel Meeting

Washington, DC

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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

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 v4 Status Overview

- SRB v4 Beta provided to CSU for year 2007 (3-hourly)
- SRB v4 Beta extended from 2005 – 2009
  - Required to move to MERRA 2 Skin-T (no SeaFlux SST past 2007; ISCCP TS Comp error in 2005/2006)
- SRB Inputs: summarize contrast between v3 and v4 inputs
- SRB Algorithms:
  - Summarize SW changes; present validation
  - Summarize LW changes; present validation
- SRB Production:
  - 1^ox1^o for limited periods (discuss) => reprocess with new HXS
  - ½^o x ½^o progress => Cloud based production
- Conclusions

SRB (Rel 4) 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 (evaluate v2)
Skin Temperature	Blended ISCCP & GEOS-4	ISCCP retrieved (TSCOMP); MERRA 2* & 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

SRB (Rel 4) Integrated Product Data Flow

Gridded 3-hourly Cloud Properties and Radiances Derived from ISCCP-HXS

Spatially & Temporally Gap-filled 3-hourly Cloud Properties & Radiances

Blended Ozone From ISCCP

Aerosols: MAC v1

Regridded 3-hourly Temp. & Humidity Profiles from nnHIRS

MERRA-2 Tskin, SeaFlux SST, LandFlux LST

Trace Gases: CO_2, NH_4, CO

GEWEX SW
(v4.0: modified Pinker/Laszlo)

ISCCP revised topography, surface vegetation maps, ice/snow maps

GEWEX LW
(v4.0: modified Fu et al./ Rose et al)

Surface and TOA SW Fluxes Clear-sky and all-sky, PAR. 3-hourly, Daily, Monthly/3-hourly, and Monthly

Surface and TOA LW Fluxes, Clear-sky and All-sky. 3-hourly, Daily, Monthly/3-hourly, and Monthly

3-hourly Surface and Cloud Properties

ISCCP HXS (Beta)

## ISCCP Beta HXS Processed for SRB v4 Beta Evaluation

- Uses all 10 km pixels with no subsampling
- Revised calibration using MODIS (*Amandar et al. 2016; Rossow & Ferrier, 2015; Inamdar & Knapp, 2015*)
- 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

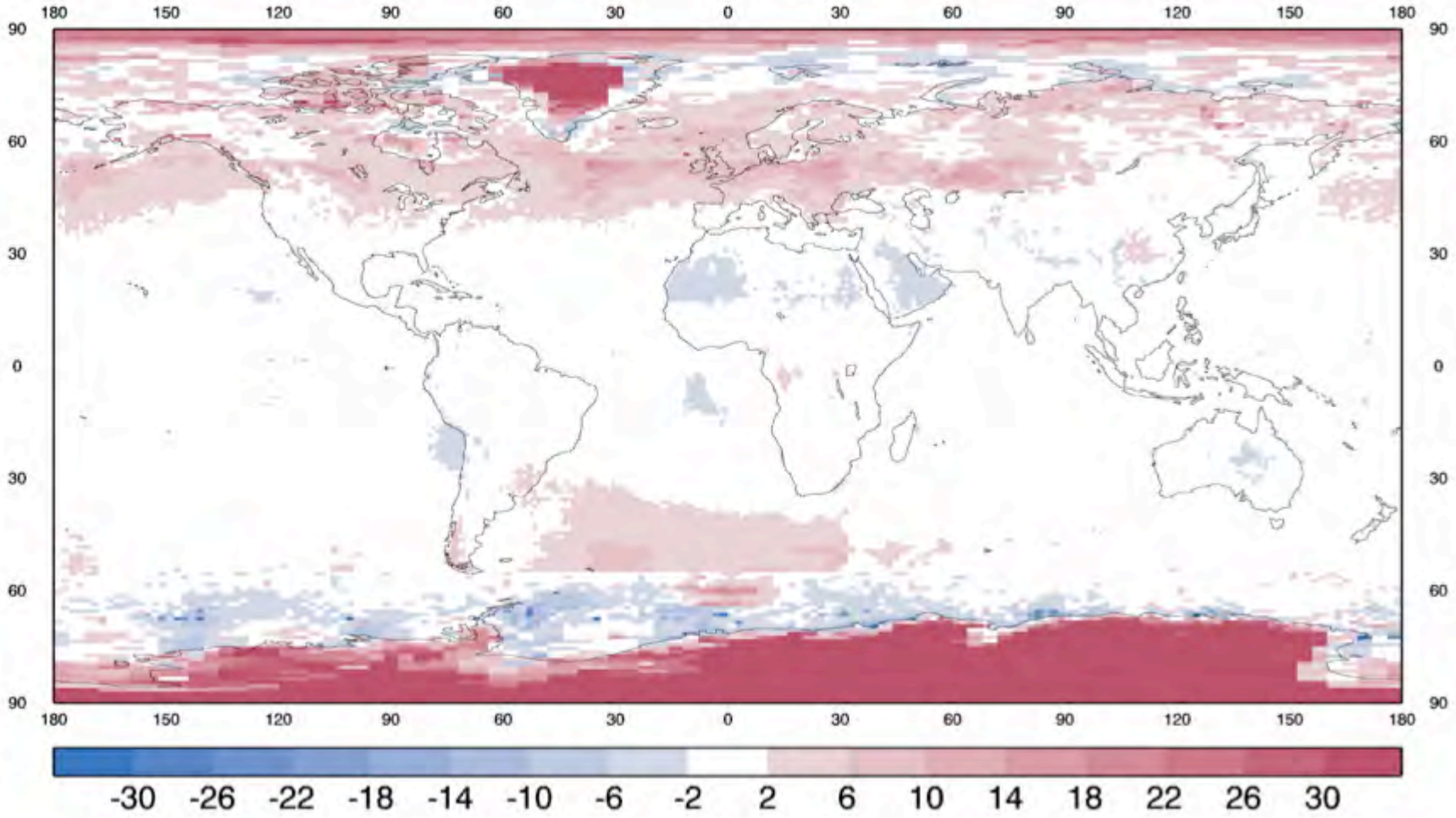- NCEI is processing final Version 1

ISCCP HX GOEA Visible Radiance Jun 01, 2001, 18Z
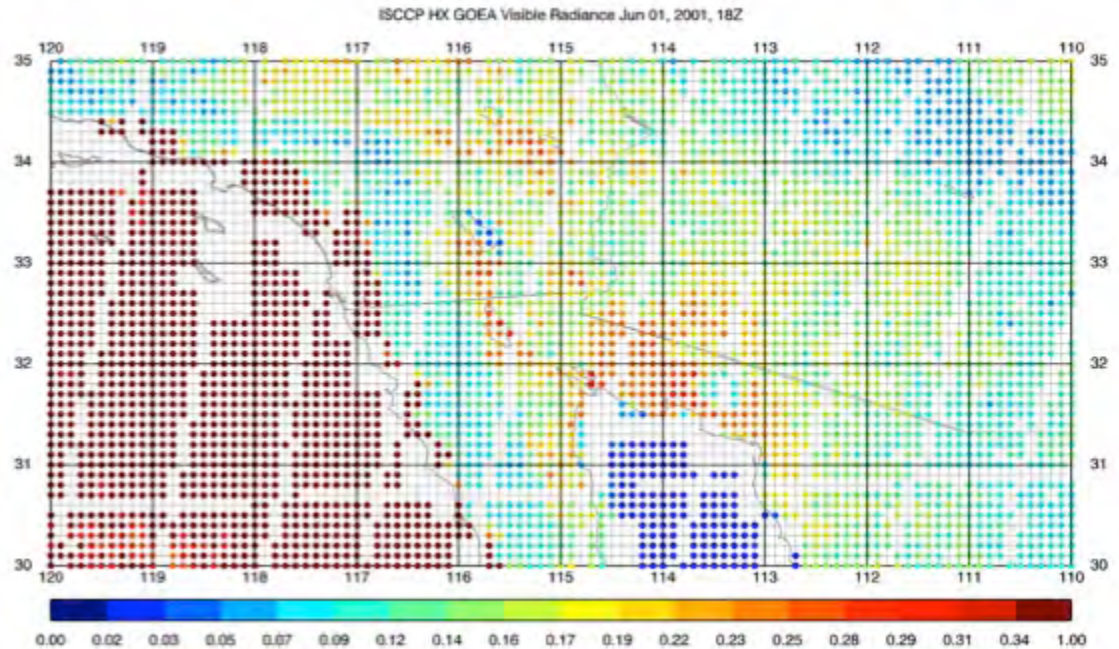
ISCCP HXS-DX Differences for 2007

Cloud Fraction, Annual Average
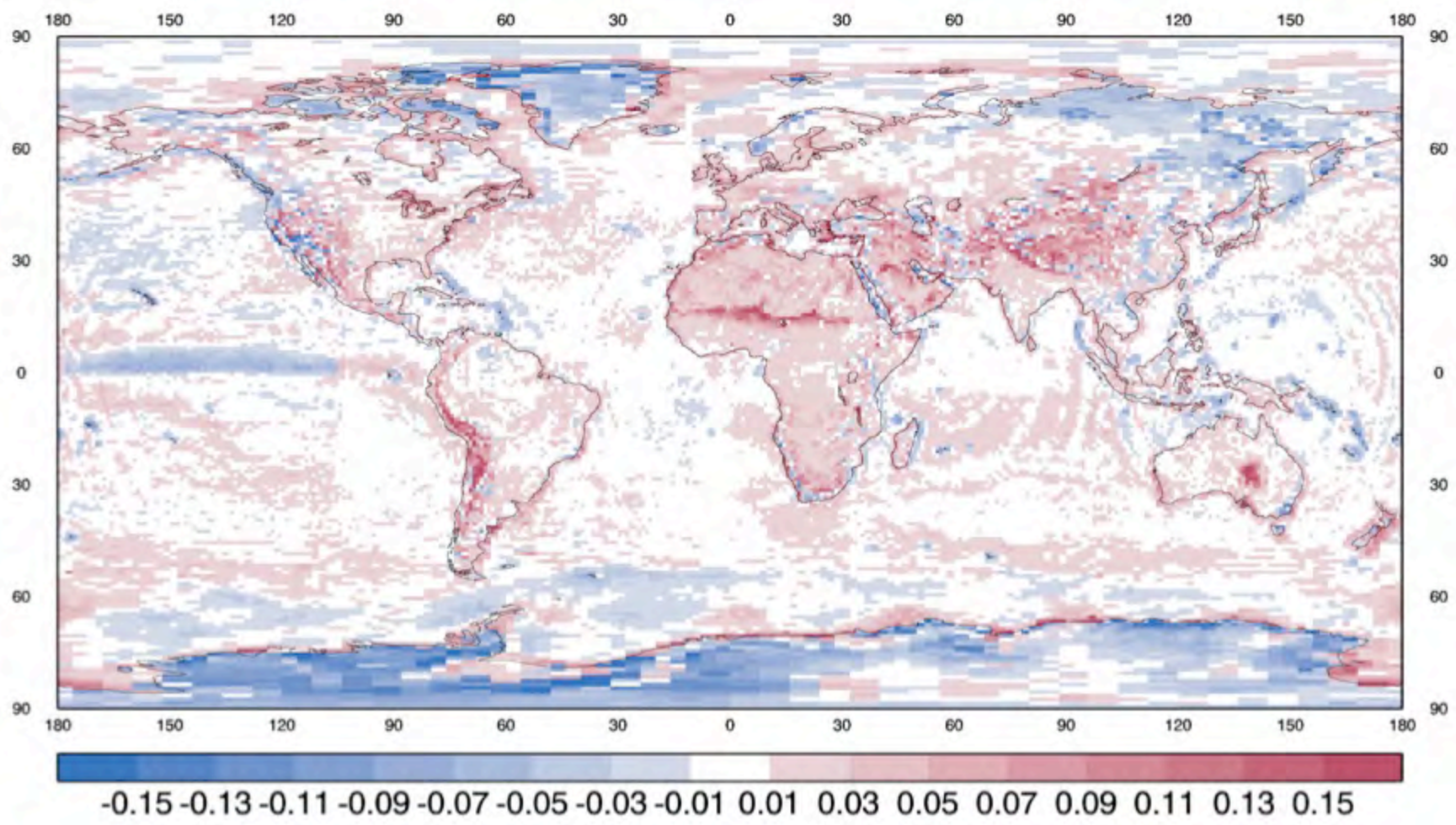
ISCCP HXS-DX Differences for 2007

Cloud Optical Depth, Annual Average

Resolved Artifact from DX to HX

Small flux discontinuities traced to an afternoon orbiter transition that removed low radiances over ocean in DX, resolved in HX
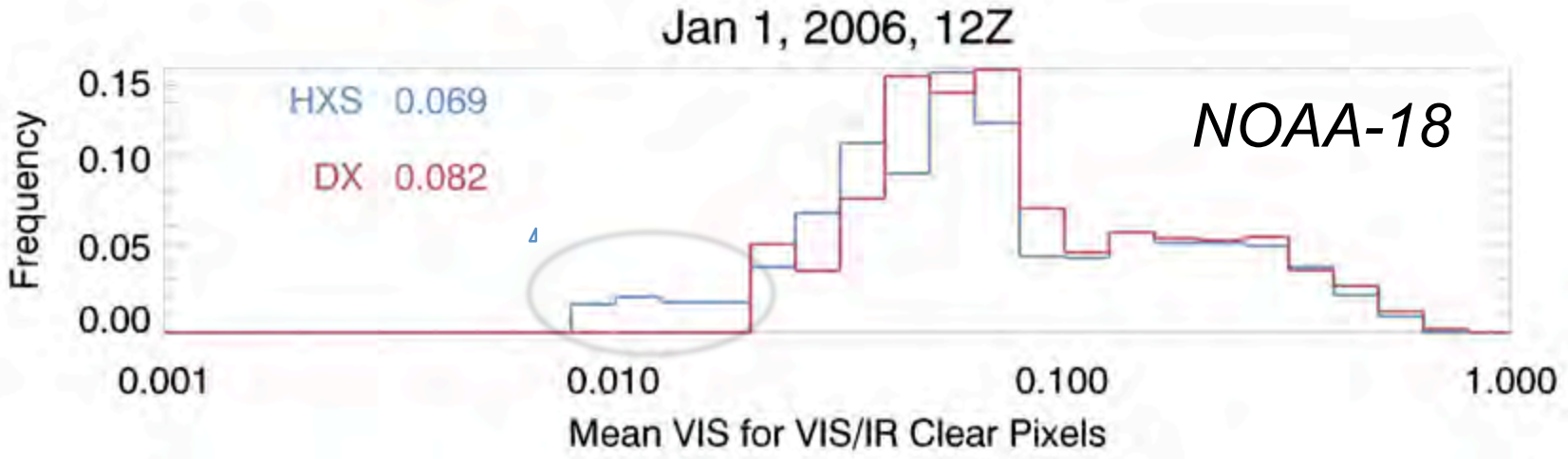
SW Algorithm Improvements for Release 4.0

|	Release 3.0	Release 4.0 Baseline	Release 4.0 Gamma	Release 4.0 Beta
Radiative bands	5	5	18 (from CERES LFL05 model; Fu/Liou based)	18 (from CERES LFL05 model; Fu/Liou based)
Spectral Albedo	Original	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	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	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 HXS; Liquid clouds assumed	ISCCP DX; Liquid clouds assumed	ISCCP HXS; Liquid and ice clouds allowed
TSI	1367	1367	1367	Coddington et al., (2016)
Run Period	1983-2007	2007	1998-2007	2005-2009

SRB Rel 4 versions, global fluxes: 2007

|	Rel 3.0	Rel 4 baseline (OLD algorithm, NEW inputs)	Rel 4 gamma (NEW algorithm, OLD inputs)	Rel 4 iota (NEW algorithm, NEW inputs)
Surface down	186.1	186.1	182.3	184.3
Surface down diffuse	104.1	105.8	95.0	96.2
TOA Up	104.4	104.2	103.1	100.4
Clear surface down	247.6	246.8	240.5	239.9
Pristine surface down	258.5	258.5	252.8	252.1
Aerosol Optical Depth	0.187	0.204	0.154	0.153
Cloud Optical Depth	17.2	15.8	14.5	13.6
Cloud Radiative Effect	-61.5	-60.7	-58.2	-55.6

2007 TOA Upward SW Flux Differences

Initial Algorithm Changes
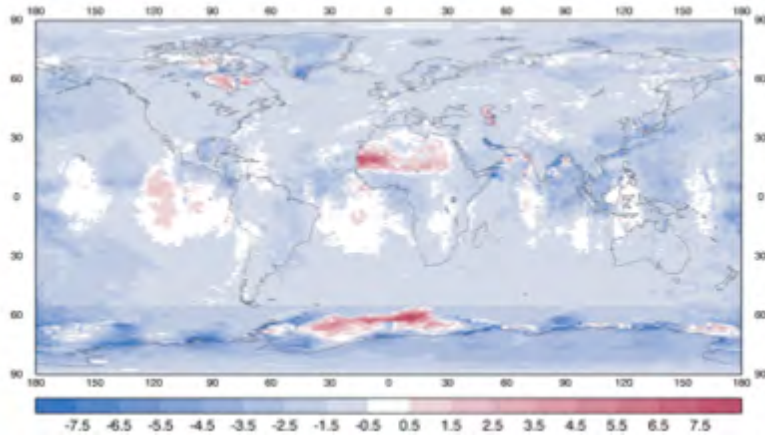
Change ISCCP DX to HXS
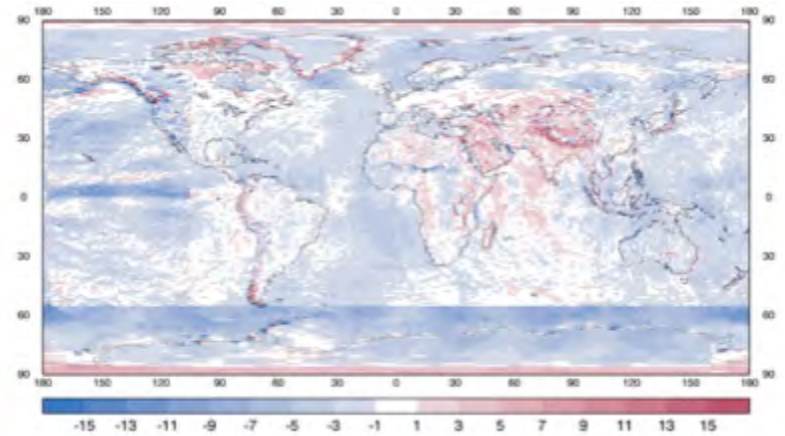
Change Ocean/Ice/Snow Albedo
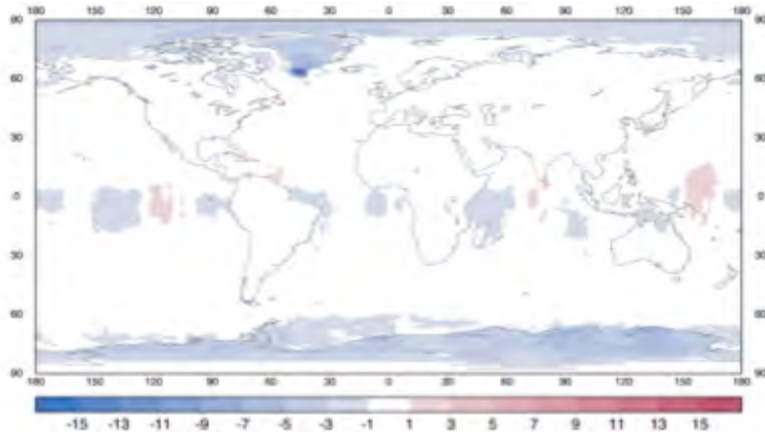
Total Rel4_theta – Rel3
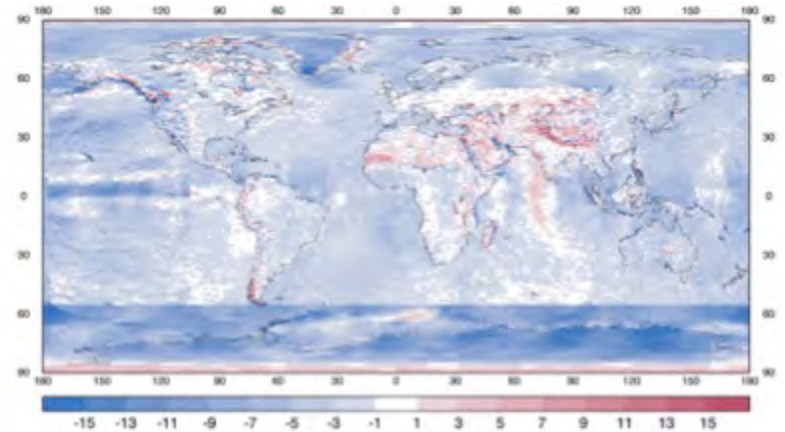
2007 Srf Down SW Flux Differences

Initial Algorithm Changes
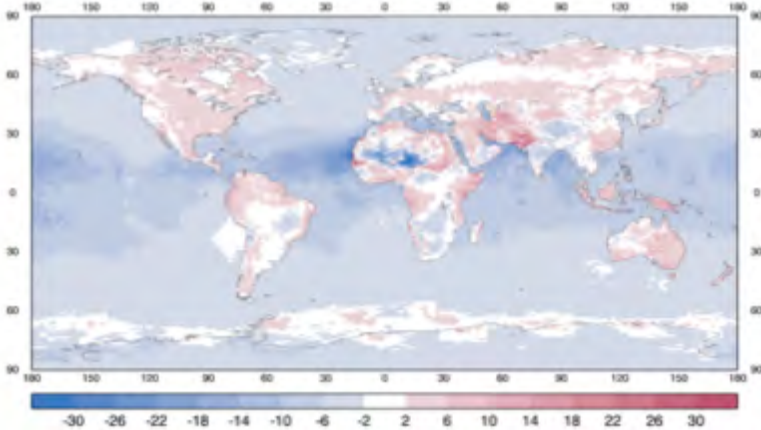
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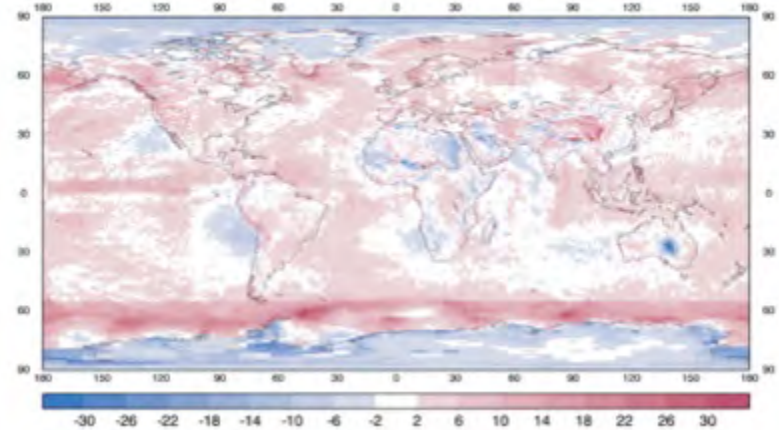
Change Ocean/Ice/Snow Albedo
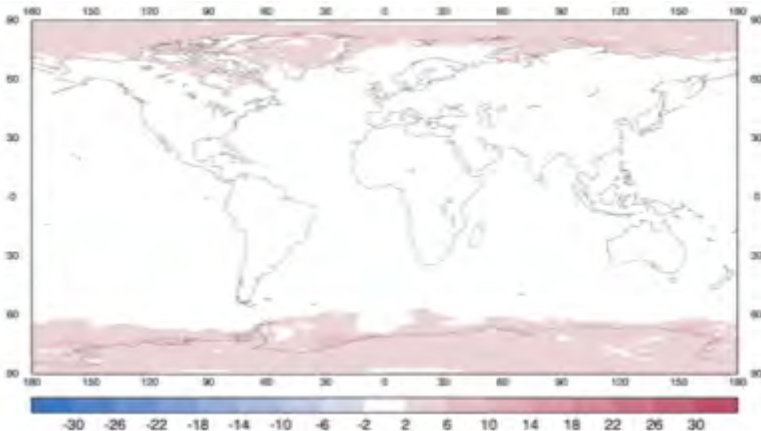
Total Rel4_theta – Rel3
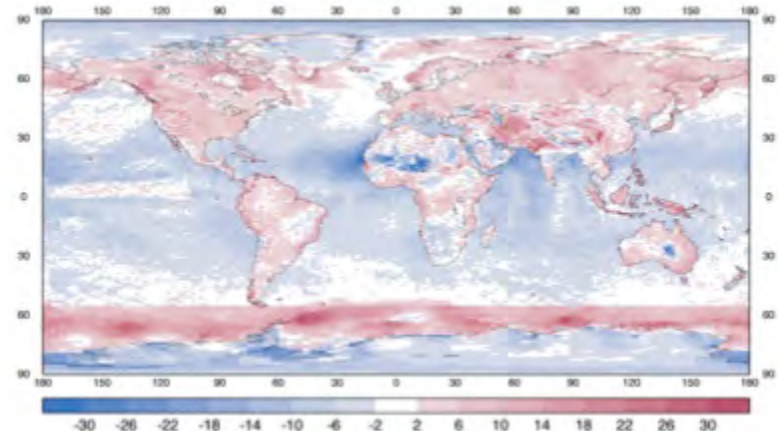
SRB vs CERES 5 Year Annual Averages

SRB Rel 4_iota, comparisons to EBAF and SYN1DEG: 2005-2009

	SRB Rel4_iota	CERES EBAF (Ed 2.8)	CERES SYN1DEG (Ed 3)
Surface down	184.6	186.7	188.1
TOA Up	100.0	99.5	98.7
Clear surface down	240.0	244.2	242.4
TOA Cloud Radiative Effect	-50.8	-47.1	-45.8
Surface Cloud Radiative Effect	-55.3	-57.5	-54.3

TOA Up Annual Cycle Differences SRB & CERES

SRB SW Iota All-sky SW Up TOA : Month Average 2005-2009

SYN-1deg All-sky SW Up TOA: Month Average 2005-2009
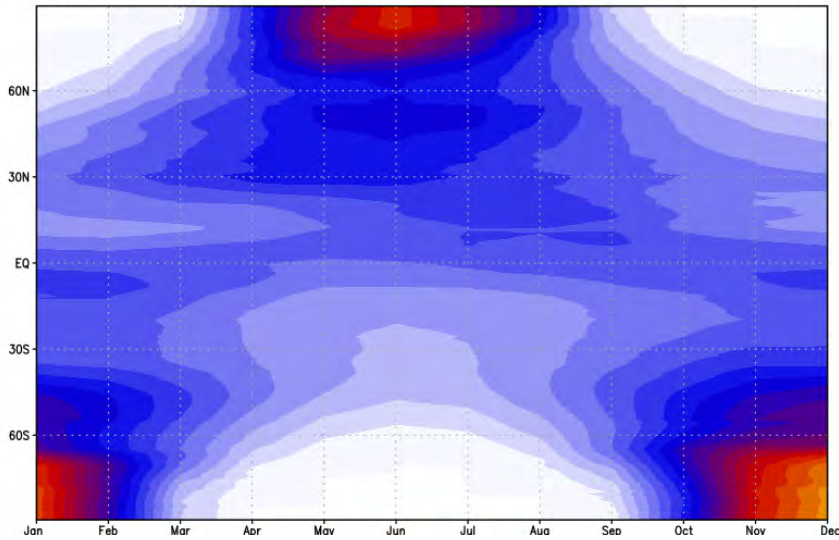
SRB SW Iota – SYN1deg All-sky SW Up TOA
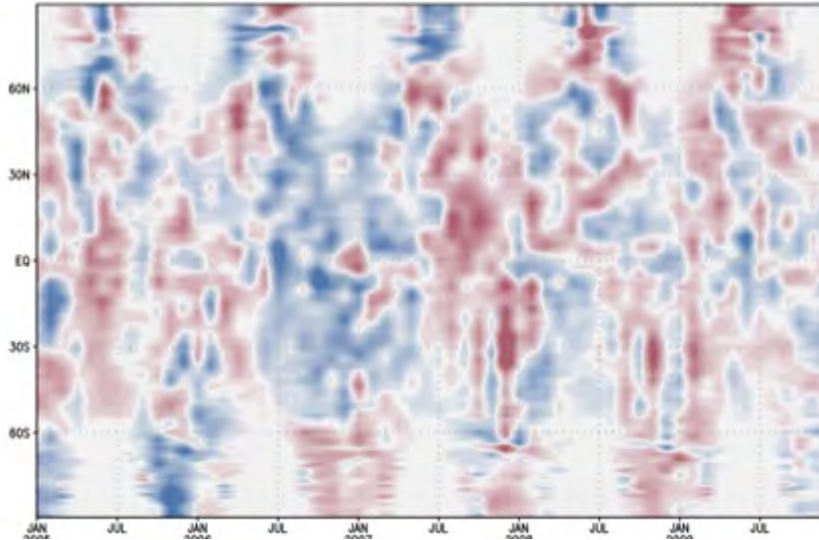Month Average 2005-2009
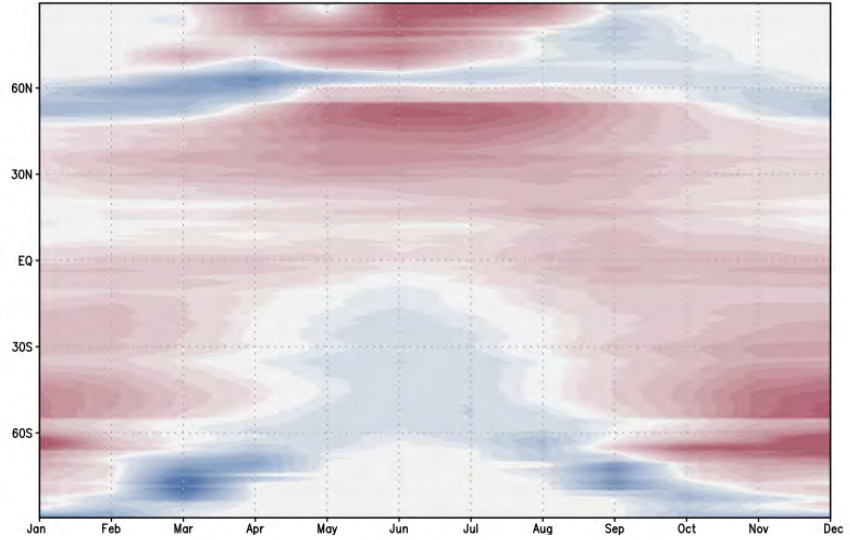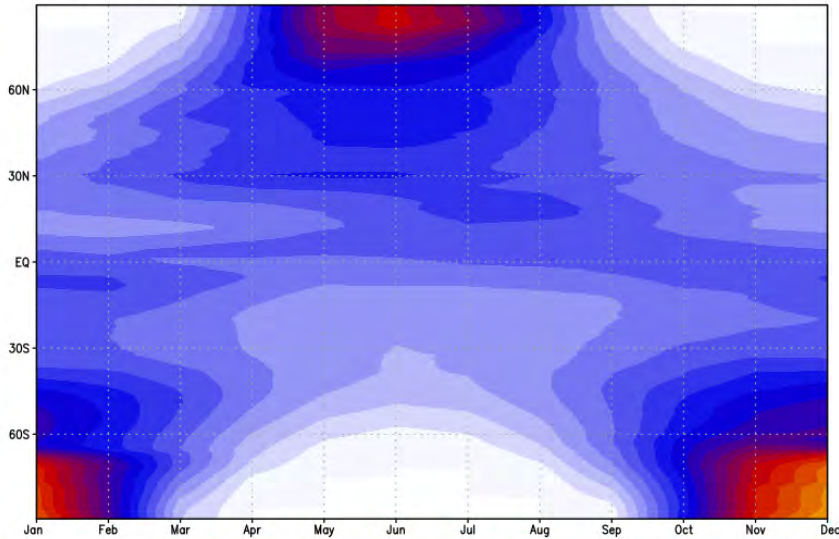
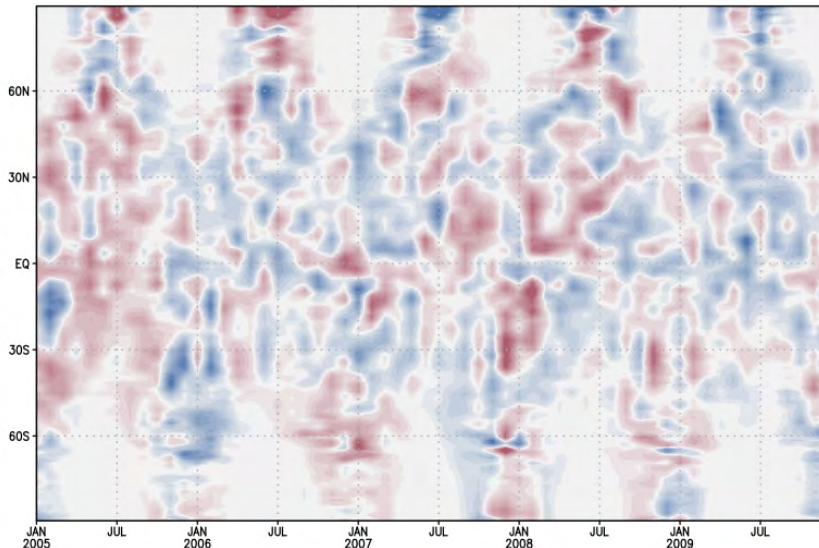SRB SW Iota – EBAF All-sky SW Up TOA
Month Average 2005-2009
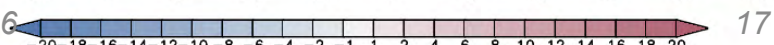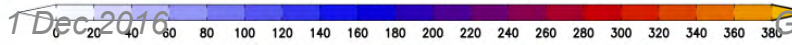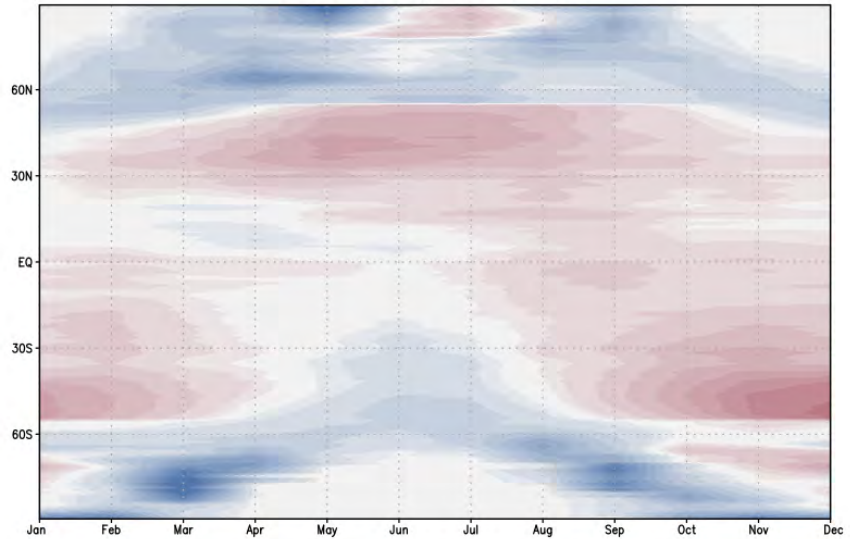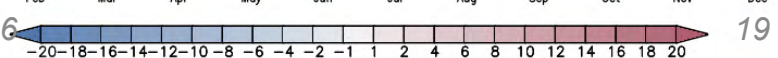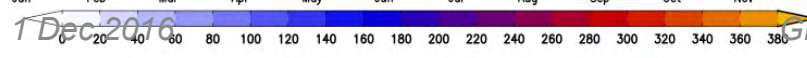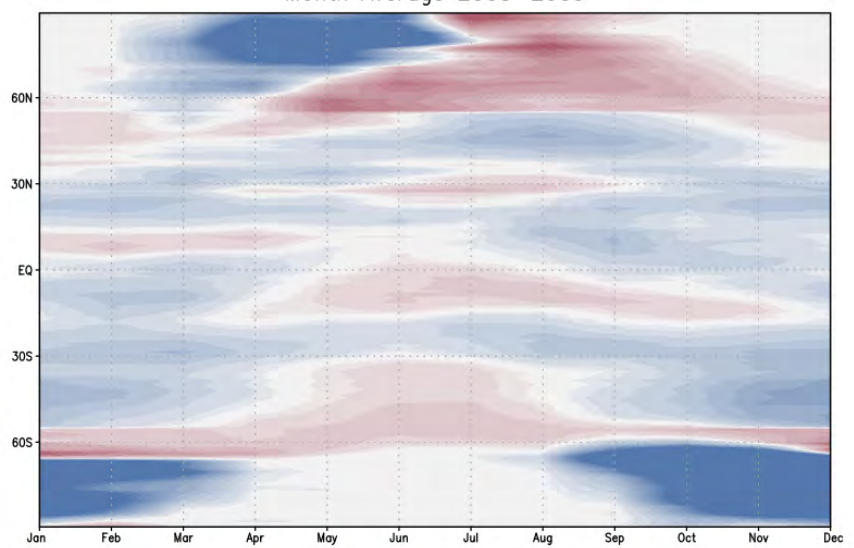
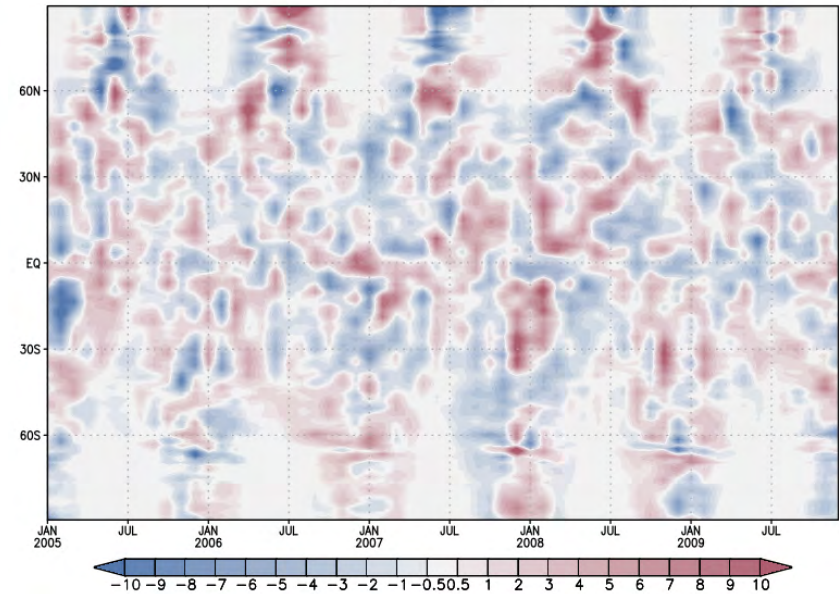# TOA Up Annual Cycle Differences SRB & CERES

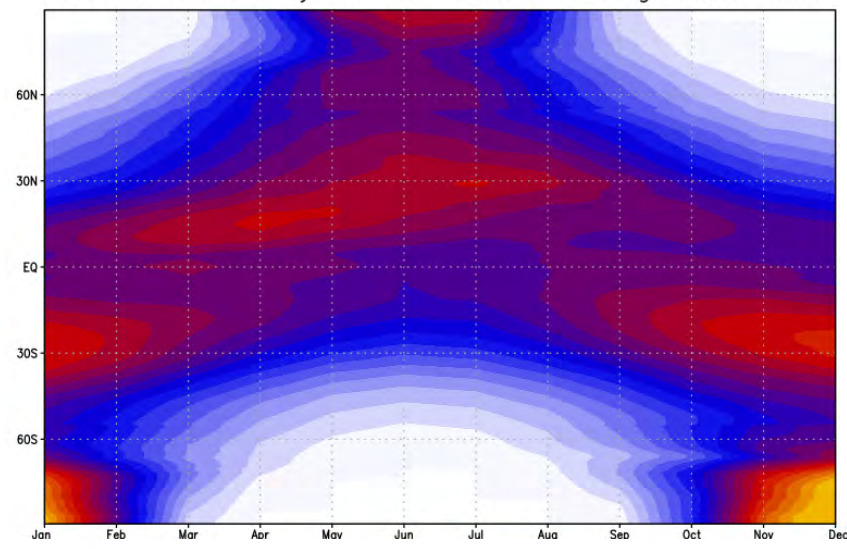SRB SW Iota All-sky SW Up TOA : Anomaly

SYN-1deg All-sky SW Up TOA: Anomaly
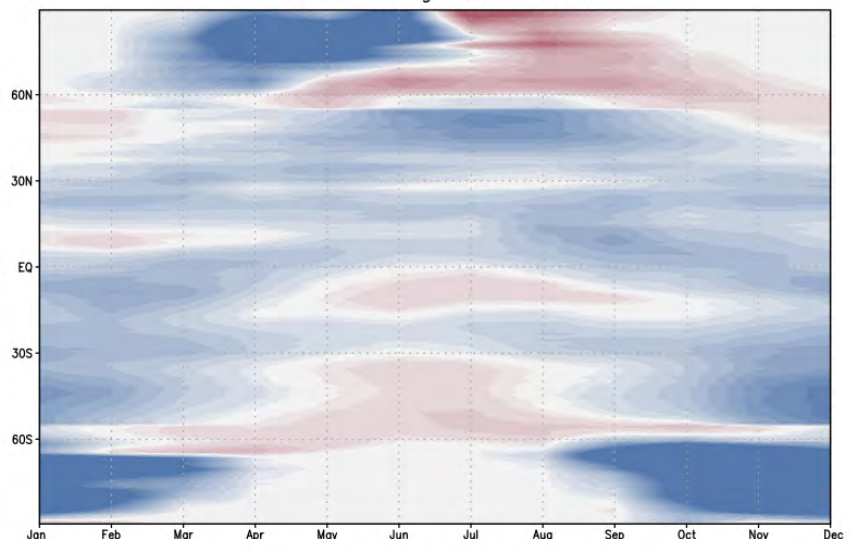
EBAF SW All-sky SW Up TOA : Anomaly
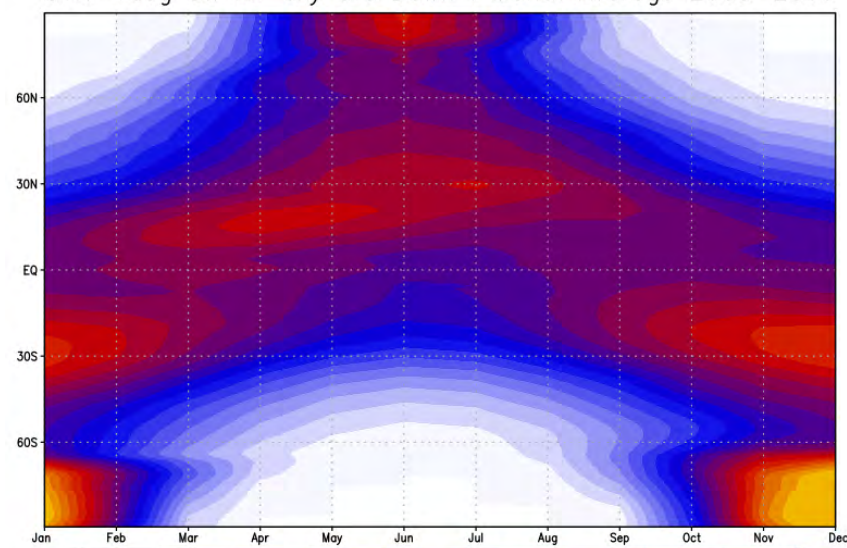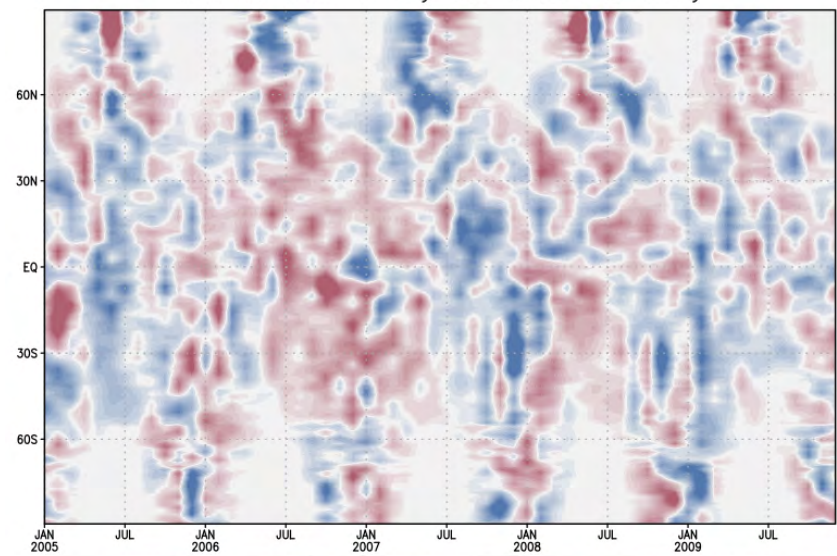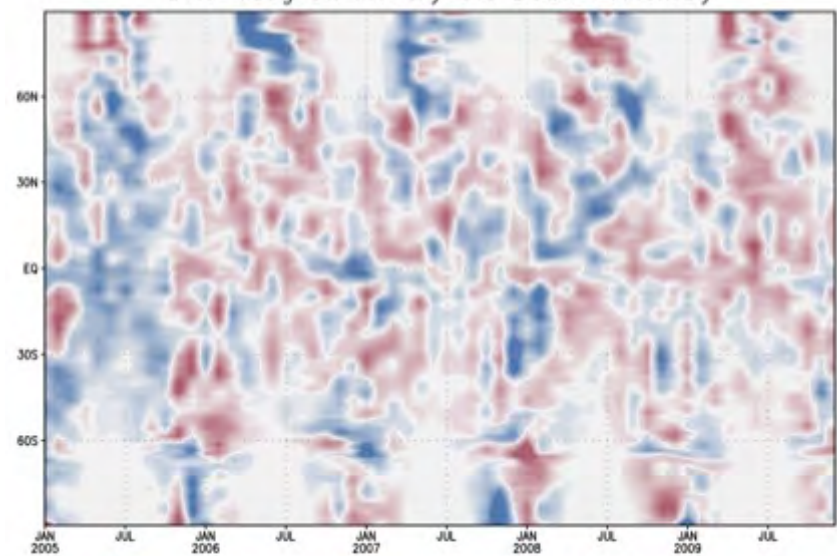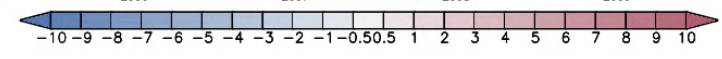
Sfc Dn Annual Cycle Differences SRB & CERES

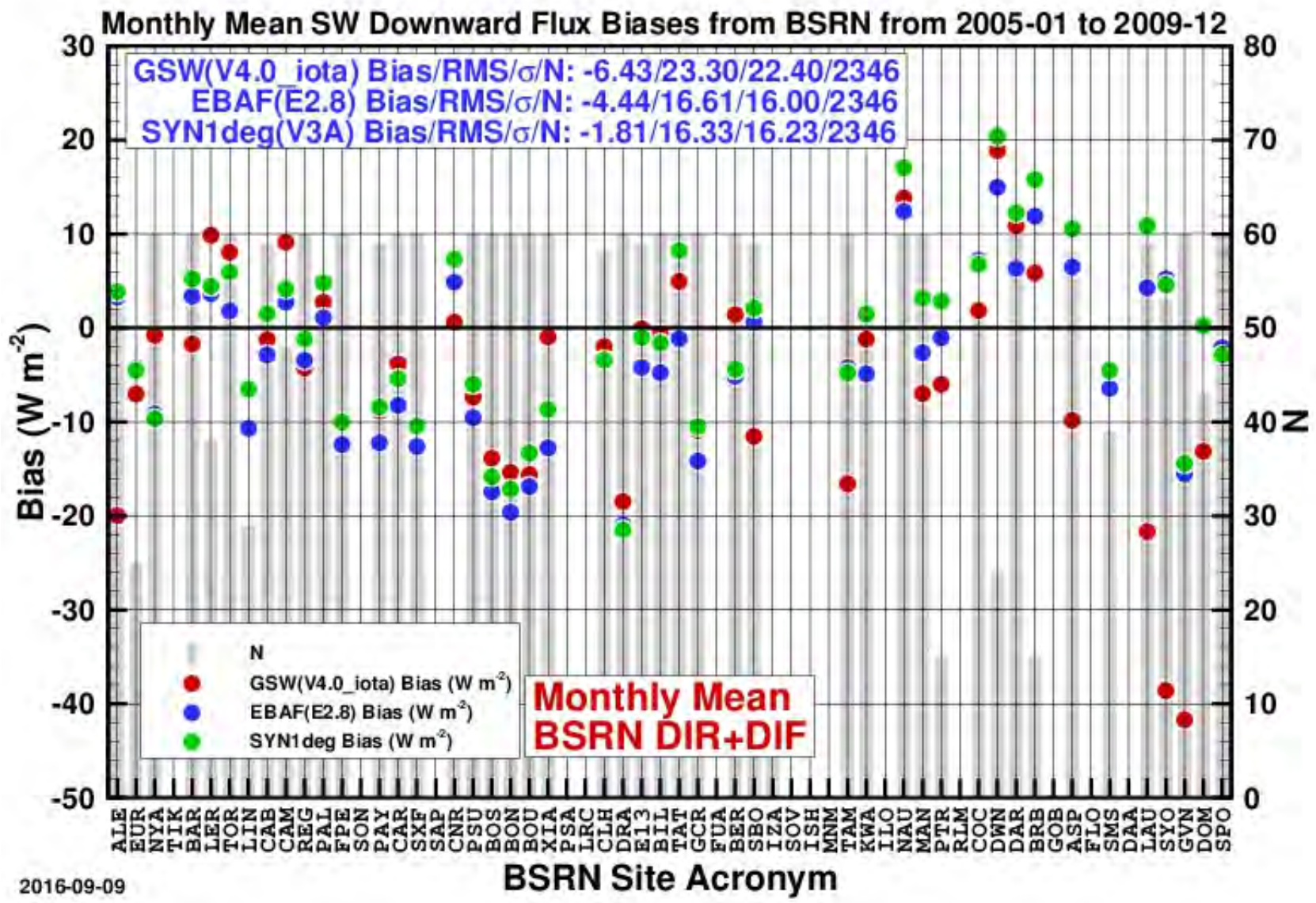# Sfc Dn Annual Cycle Differences SRB & CERES
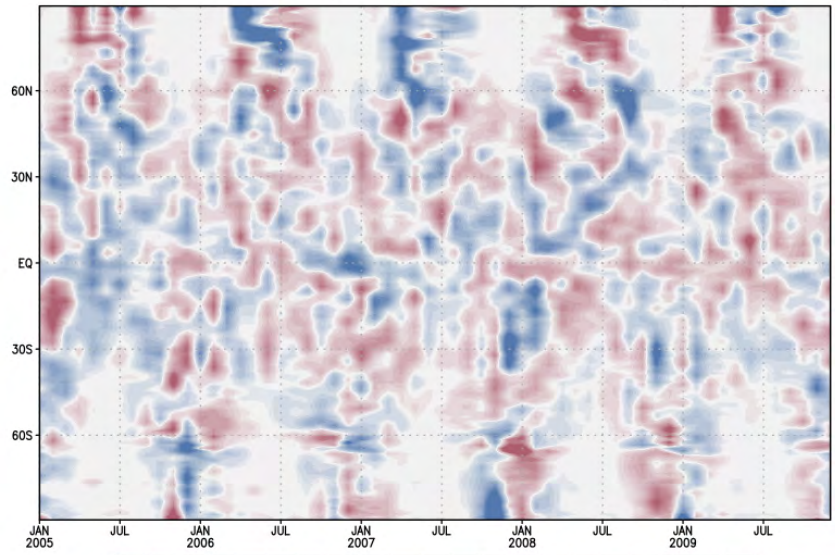
SW Surface Down Validation

GEWEX GSW-BSRN, -PMEL, -GEBA and -WRDC monthly mean shortwave downward flux comparison statistics for the period from 2005-01 to 2007-12.
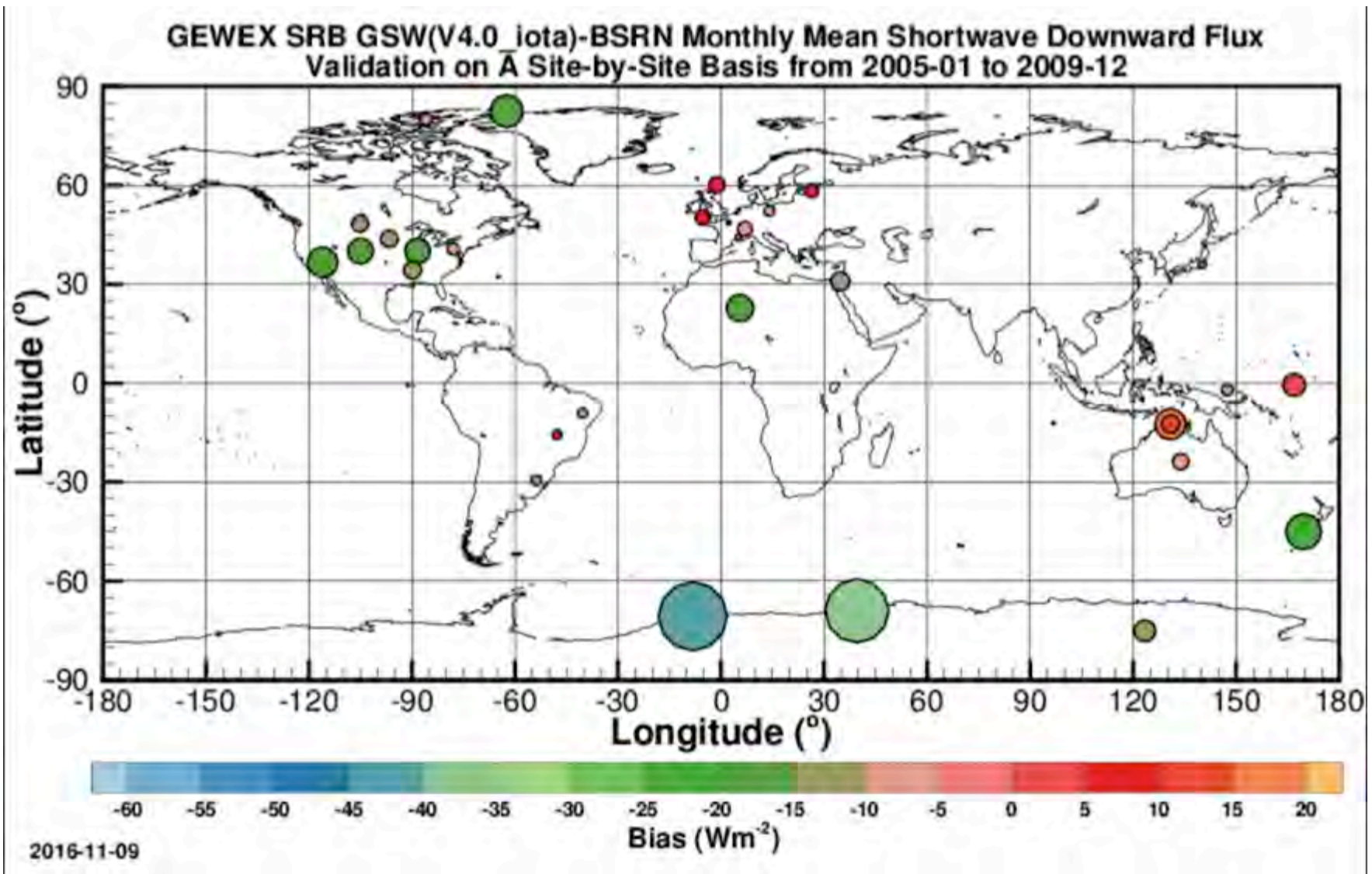
Version	Bias	RMS	ρ	σ	μ_{GSW}	N
GEWEX GSW-BSRN Monthly Mean						
GSW(V3.0)	-6.81	23.39	0.9716	22.39	165.92	1366
GSW(V4.0 iota)	-5.24	21.12	0.9764	20.46	167.49	1366
CERES EFAF(E2.8)	-3.90	15.49	0.9874	15.00	168.83	1366
CERES SYN1deg(V3A)	-1.21	15.09	0.9873	15.04	171.52	1366
GEWEX GSW-PMEL Monthly Mean						
GSW(V3.0)	8.94	19.47	0.8899	17.31	249.71	610
GSW(V4.0 iota)	0.70	16.87	0.8951	16.87	241.47	610
CERES EFAF(E2.8)	1.02	15.95	0.9087	15.93	241.79	610
CERES SYN1deg(V3A)	1.52	15.47	0.9153	15.41	242.29	610
GEWEX GSW-GEBA Monthly Mean						
GSW(V3.0)	1.63	22.03	0.9610	21.97	162.87	11349
GSW(V4.0 iota)	5.29	21.78	0.9640	21.13	166.54	11349
CERES EFAF(E2.8)	2.44	18.84	0.9719	18.68	163.68	11349
CERES SYN1deg(V3A)	6.50	19.94	0.9718	18.84	167.75	11349
GEWEX GSW-WRDC Monthly Mean						
GSW(V3.0)	0.81	19.58	0.9719	19.57	164.86	10574
GSW(V4.0 iota)	3.82	19.06	0.9745	18.68	167.87	10574
CERES EFAF(E2.8)	1.14	16.11	0.9812	16.07	165.19	10574
CERES SYN1deg(V3A)	4.66	16.87	0.9810	16.21	168.72	10574

Surface SW Down SRB & CERES vs BSRN

Monthly Mean SW Downward Flux Biases from BSRN from 2005-01 to 2009-12

GSW(V4.0_iota) Bias/RMS/σ/N: -6.43/23.30/22.40/2346
EBAF(E2.8) Bias/RMS/σ/N: -4.44/16.61/16.00/2346
SYN1deg(V3A) Bias/RMS/σ/N: -1.81/16.33/16.23/2346

Legend:
- N
- GSW(V4.0_iota) Bias (W m^{-2})
- EBAF(E2.8) Bias (W m^{-2})
- SYN1deg Bias (W m^{-2})

Monthly Mean
BSRN DIR+DIF

GEWEX SW vs BSRN

GEWEX SRB GSW(V4.0_iota)-BSRN Monthly Mean Shortwave Downward Flux
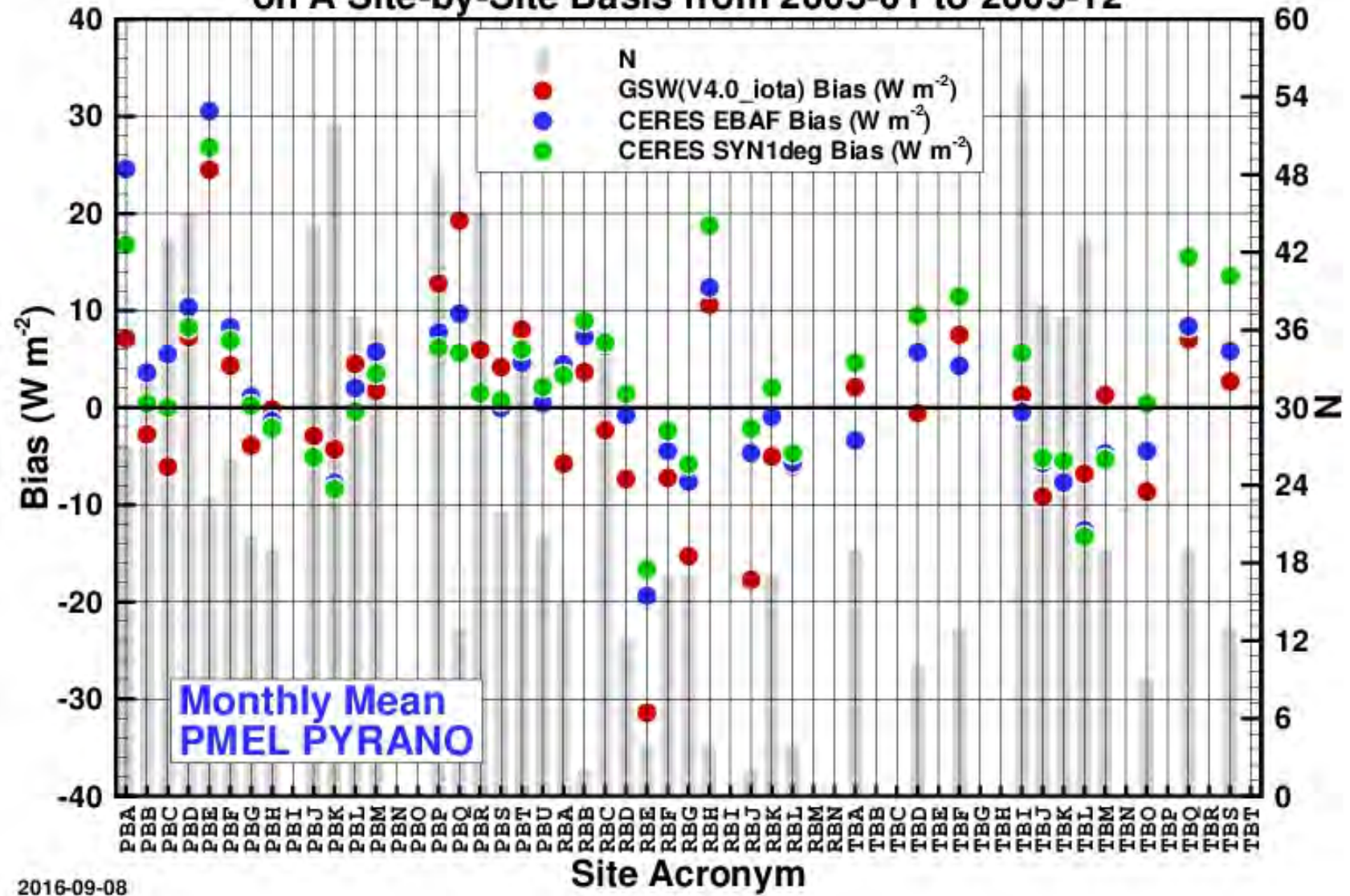Validation on A Site-by-Site Basis from 2005-01 to 2009-12

GEWEX SW vs. PMEL Ocean Buoy

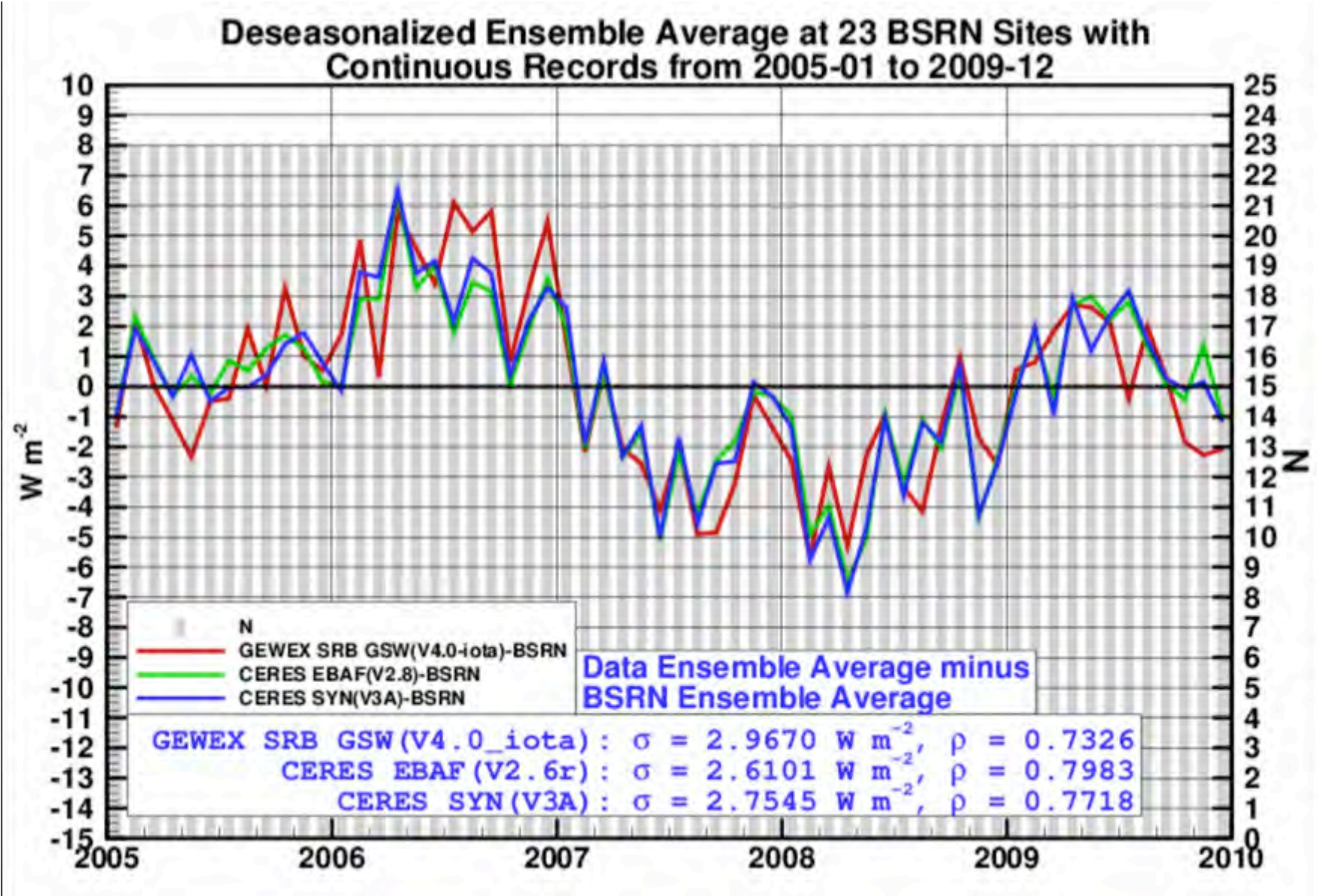Validation against PMEL Monthly Mean SW Downward Flux on A Site-by-Site Basis from 2005-01 to 2009-12

GEWEX SRB GSW(V4.0_iota)-PMEL Buoy Monthly Mean Shortwave Downward Flux Validation on A Site-by-Site Basis from 2005-01 to 2009-12

Ensemble Anomalies vs. BSRN

Deseasonalized Ensemble Average at 23 BSRN Sites with Continuous Records from 2005-01 to 2009-12
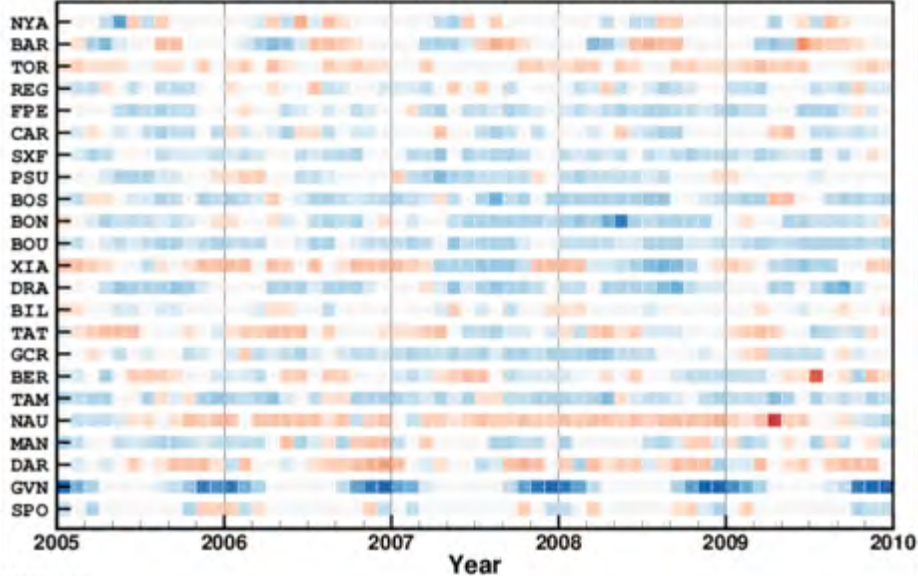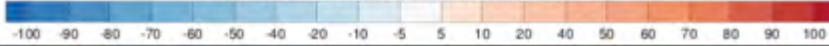
Legend:
- GEWEX SRB GSW(V4.0-iota)-BSRN (red)
- CERES EBAF(V2.8)-BSRN (green)
- CERES SYN(V3A)-BSRN (blue)
- BSRN Ens (W m⁻²) (orange circles)

GEWEX SRB GSW(V4.0_iota): $\sigma = 2.9760$ W m^{-2}, $\rho = 0.7326$
CERES EBAF(V2.8): $\sigma = 2.6101$ W m^{-2}, $\rho = 0.7983$
CERES SYN(V3A): $\sigma = 2.7545$ W m^{-2}, $\rho = 0.7718$

Ensemble Anomalies vs. BSRN

Deseasonalized Ensemble Average at 23 BSRN Sites with Continuous Records from 2005-01 to 2009-12

Data Ensemble Average minus BSRN Ensemble Average

GEWEX SRB GSW(V4.0-iota)-BSRN
CERES EBAF(V2.8)-BSRN
CERES SYN(V3A)-BSRN

GEWEX SRB GSW(V4.0_iota): $\sigma = 2.9670$ W m^{-2}, $\rho = 0.7326$
CERES EBAF(V2.6r): $\sigma = 2.6101$ W m^{-2}, $\rho = 0.7983$
CERES SYN(V3A): $\sigma = 2.7545$ W m^{-2}, $\rho = 0.7718$

GEWEX SW/CERES vs BSRN by Site & Time

Monthly Mean GSW(V4.0_iota)-BSRN (W m⁻²)

Monthly Mean EBAF(E2.8)-BSRN (W m⁻²)
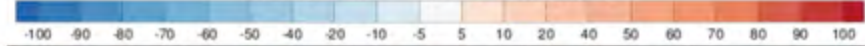
Monthly Mean SYN1deg(V3A)-BSRN (W m⁻²)
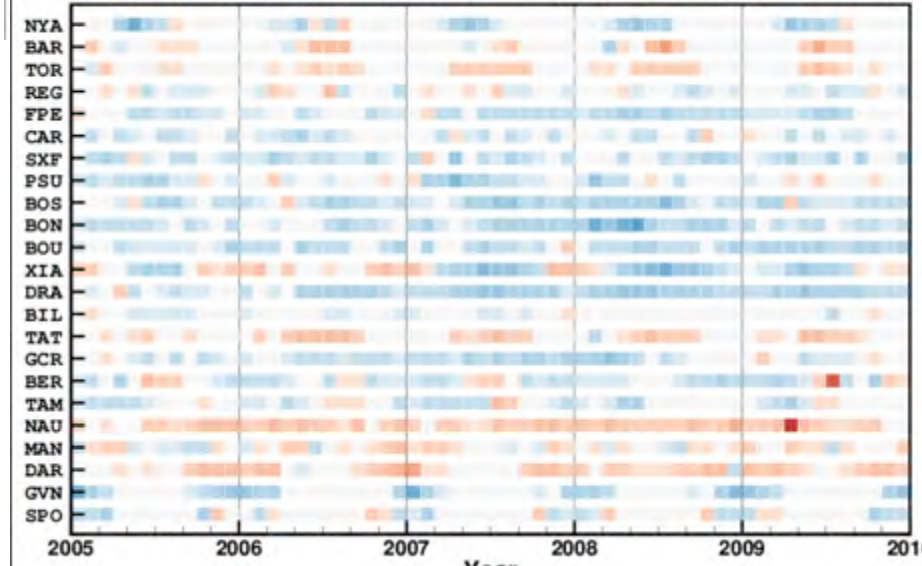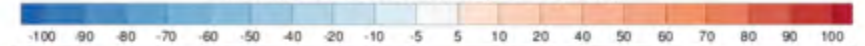
LW Algorithm Improvements for Release 4.0

|	Release 3.0	Rel. 4.0 Beta	Rel 4.0 Beta MERRA-2 skin
Aerosol Inputs	None	MAC v1 Aerosols	MAC v1 Aerosols
Cloud Ice Properties	Original ice cloud radiative properties	Updated ice cloud radiative properties	Updated ice cloud radiative properties (change in effective size in H products)
High Water Cloud Type	Assumed no water clouds above 440 mb	Modified cloud overlap to treat high water clouds	Modified cloud overlap to treat high water clouds
T, q profile	GEOS-4	nnHIRS	nnHIRS
Tskin	GEOS-4/ISCCP Ts blend	Blend SeaFlux SST/ LandFlux Ts/ISCCP Ts	MERRA-2 Ts
Data Product Changes	TOA and surface flux only; UT; Clear and all-sky	Pristine-sky (no aerosols), local time, atmospheric levels.	Pristine-sky (no aerosols), local time, atmospheric levels.
Years Run	1983-2007	2007	2005 - 2009

nnHIRS TPW Annual Differences

nnHIRS−GEOS4 Total Column PW (mm)
Annual average 2007
Max = 13.103; Min = −22.8725
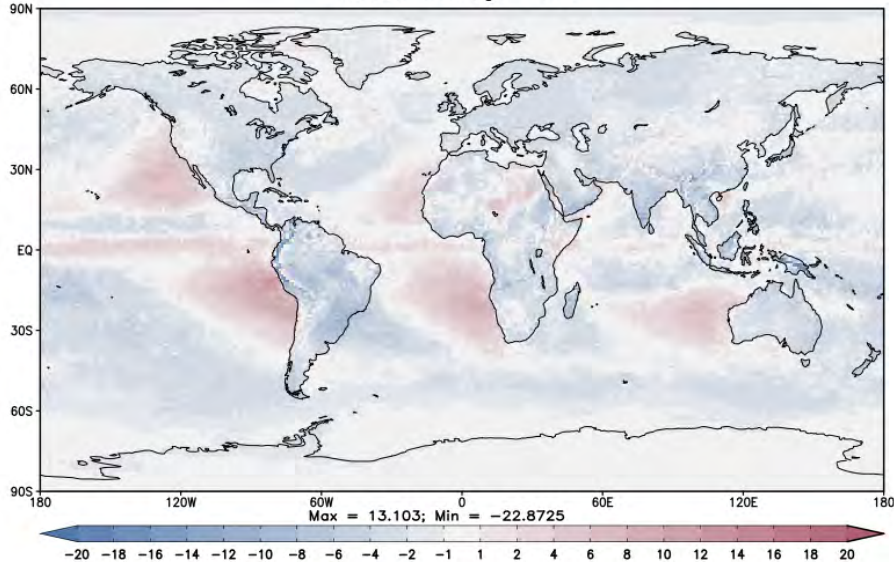
nnHIRS−NVAP Total Column PW (mm)
Annual average 2007
Max = 32.3001; Min = −38.1902
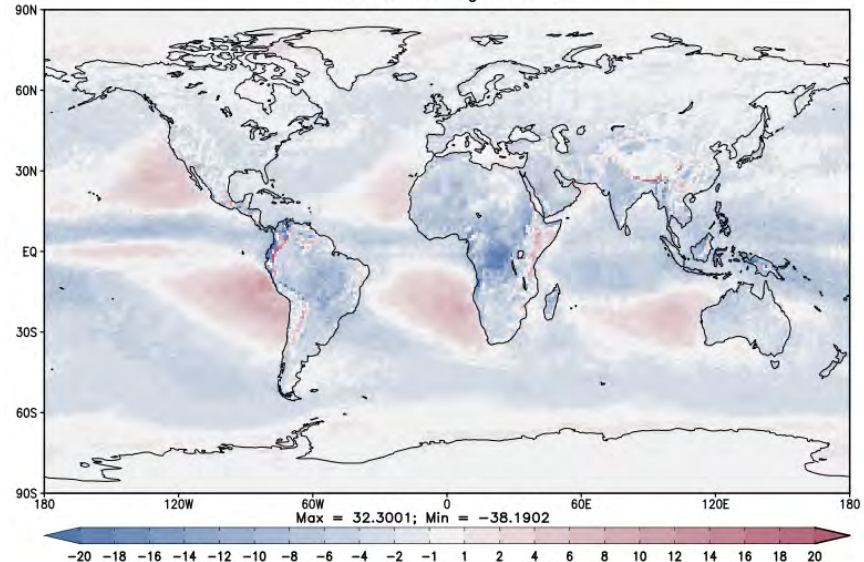
nnHIRS−RSS V7 Total Column PW (mm)
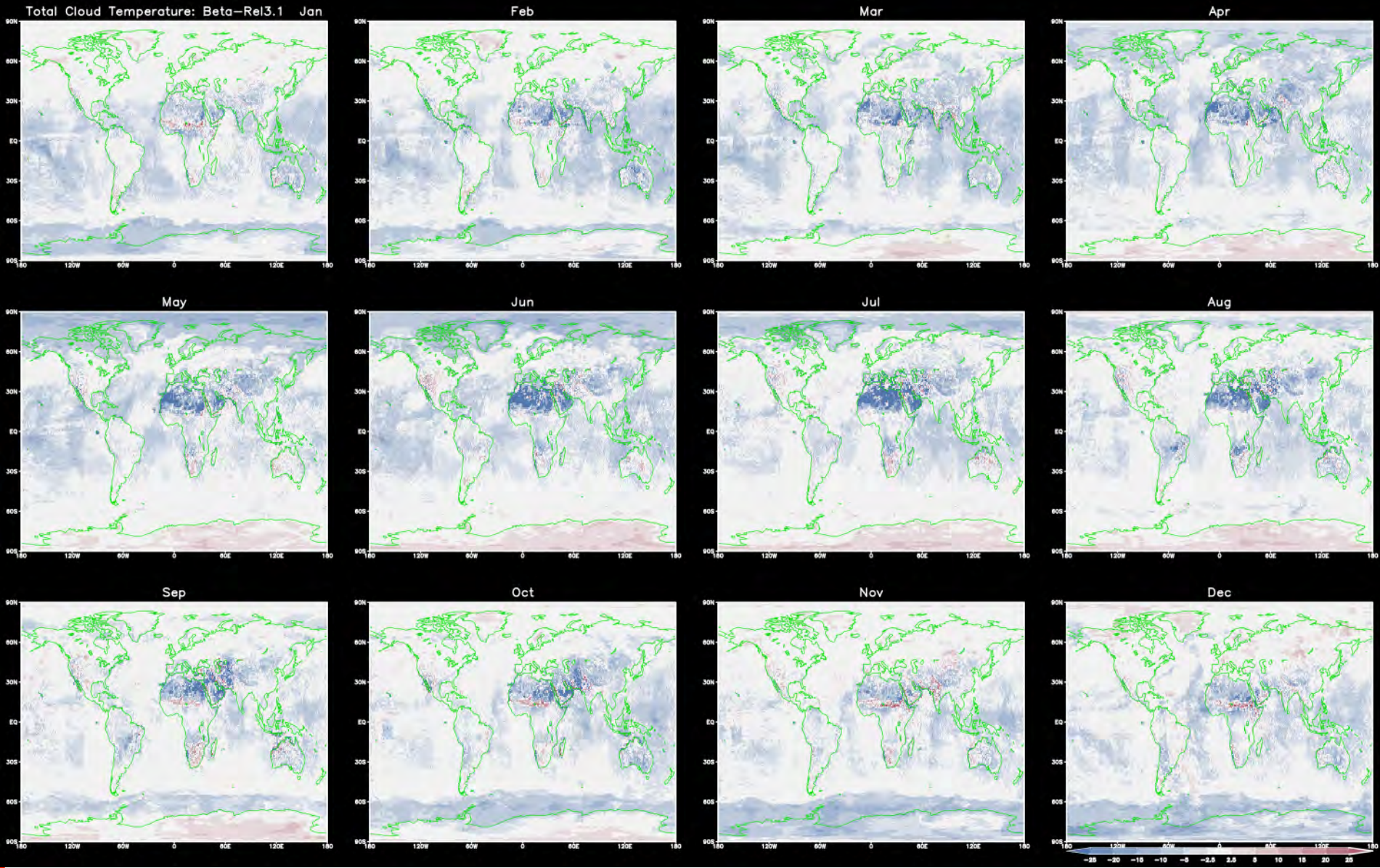Annual average 2007
Max = 13.8198; Min = −20.6642
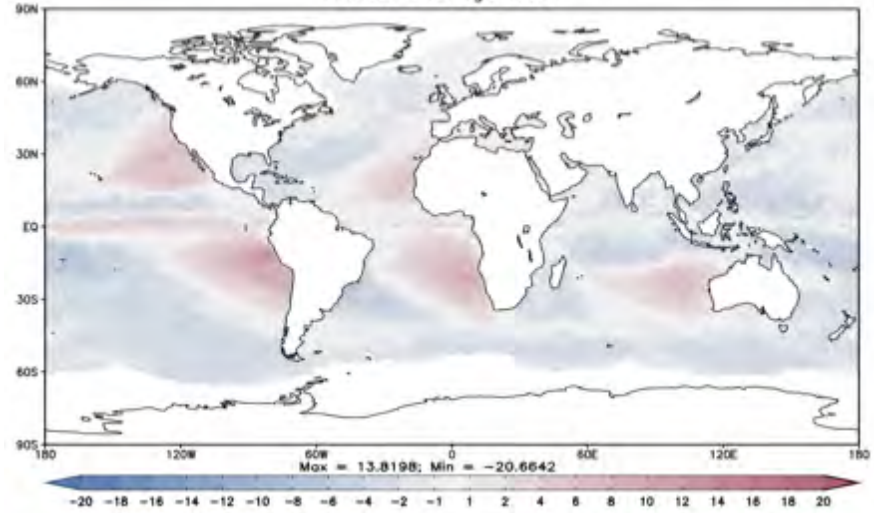
Global and 20°N-20°S (in parentheses) areal annual averages of 2007 for total column water (mm).

	nnHIRS	GEOS-4	NVAP	MERRA-2	RSS
Land and Ocean	23.5 (39.4)	24.5 (40.2)	25.5 (42.6)	24.9 (40.8)	
Ocean Only	29.0 (42.0)	29.3 (41.8)	30.7 (44.2)	29.5 (42.0)	29.6 (42.3)

Total Cloud Temperature: Beta−Rel3.1

2007 LW Runs vs. CERES

	Rel. 4 nnHIRS /Beta	Rel. 4 GEOS-4/Beta	Rel. 4 MERRA -2/Beta	Rel. 4 GEOS-4 /DX	Rel. 3.1 GEOS-4 /DX *	CERES EBAF Ed. 2.8	CERES SYN 1-deg
Sfc Down	344.2 (405.1)	345.1 (405.6)	344.9 (406.1)	348.5 (409.2)	344.8 (404.5)	345.5 (403.9)	341.8 (399.3)
Clear Sfc Down	313.8 (390.4)	315.9 (388.7)	316.2 (389.3)	315.7 (388.7)	311.4 (383.4)*	316.8 (390.7)	314.3 (386.0)
Prist. S. Dn	312.4 (389.1)	314.5 (387.3)	314.8 (388.0)	314.3 (387.3)			
Sfc CRE	30.4 (17.7)	29.2 (17.0)	28.7 (16.7)	32.8 (20.5)	33.4 (21.1)	28.7 (13.2)	27.5 (13.3)
OLR	233.5 (251.7)	235.0 (252.5)	234.4 (251.8)	236.9 (255.4)	238.3 (256.6)	240.0 (256.7)	238.7 (255.2)
Clear OLR	264.1 (285.7)	264.1 (284.4)	262.7 (282.7)	263.8 (284.5)	265.3 (285.9)*	266.0 (286.6)	266.3 (287.5)
Prist. OLR	265.4 (287.0)	265.3 (285.5)	263.8 (283.8)	264.9 (285.6)			
TOA CRE	30.6 (34.0)	29.1 (31.9)	28.3 (30.9)	26.8 (29.2)	27.0 (29.3)	26.0 (29.9)	27.6 (32.3)

Surface

Runs for GEWEX LW for various configurations

TOA

No aerosols

Annual Averaged Differences of new LW compared to v3.1 and CERES

Ver.4 nnHIRS, Beta – SYN 1-deg
2007 Average: All-sky LW Up at TOA

Max = 19.4938; Min = -36.603

Ver.4 nnHIRS HXS (Beta) – GEOS-4 DX
Annual average 2007: All-sky LW Up at TOA
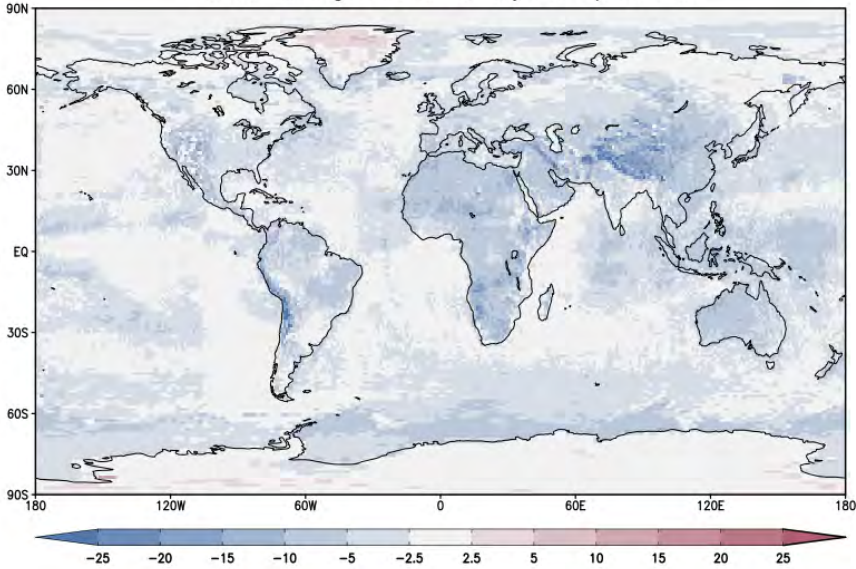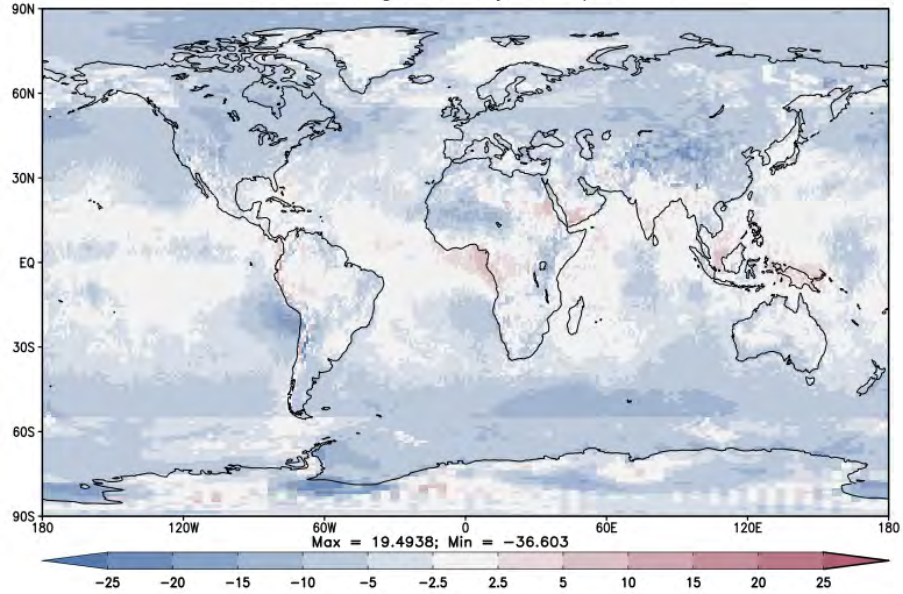
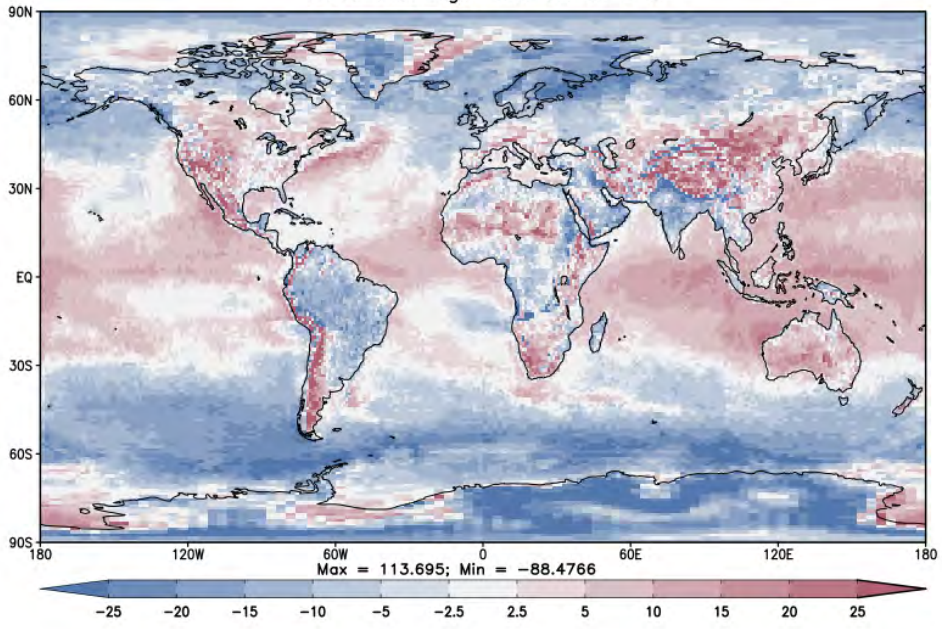Ver.4 nnHIRS, Beta – EBAF
2007 Average: All-sky LW Up at TOA

Max = 6.80834; Min = -50.3167
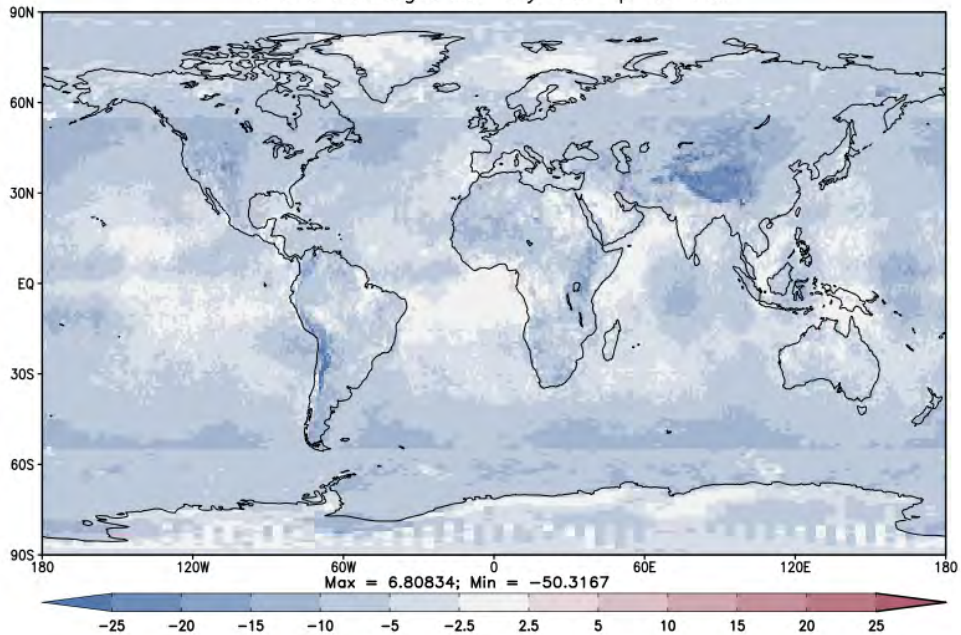
Annual Averaged Differences of new LW compared to v3.1 and CERES

Ver.4 nnHIRS HXS (Beta) − GEOS-4 DX
Annual average 2007: LW dn at Sfc
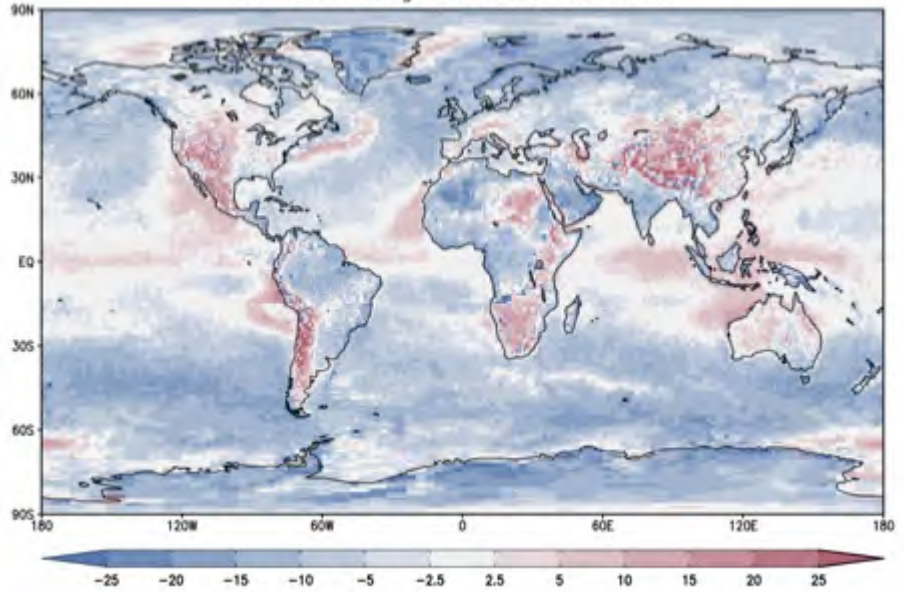
global = −1.24364   60−90N = −9.59478   60−90S = −13.1995   20N−20S = 4.17874
20−60N = 0.767373   20−60S = −5.1411
Ver.4 nnHIRS, Beta − EBAF
2007 Average: LW dn at Sfc

Max = 113.695; Min = −88.4766

global = 1.84263   60−90N = −6.64844   60−90S = −6.76347   20N−20S = 6.82746
20−60N = 4.03511   20−60S = −2.48577
Ver.4 nnHIRS, Beta − SYN 1−deg
2007 Average: LW dn at Sfc

Max = 88.6657; Min = −65.8076
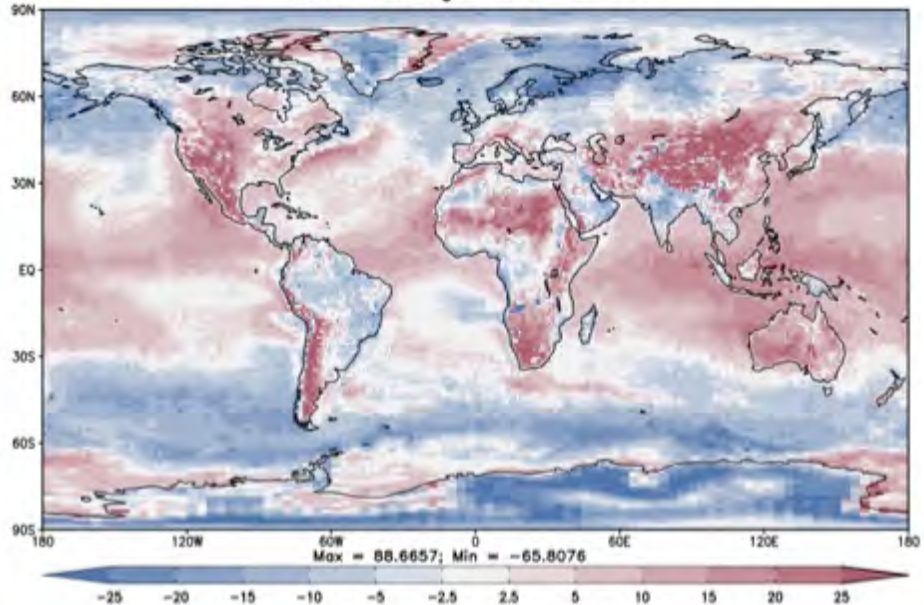
Various GEWEX LW Version vs BSRN & PMEL

		Bias	RMS	ρ	σ	μ_{GLW}	N
Rel. 4 nnHIRS/Beta	BSRN	2.36	17.57	0.9767	17.42	308.94	464
	PMEL	7.76	10.38	0.8806	6.97	414.71	50
Rel. 4 GEOS-4/Beta	BSRN	4.26	13.81	0.9864	13.15	310.84	464
	PMEL	-0.10	6.97	0.9397	7.01	406.84	50
Rel.4 MERRA-2/Beta	BSRN	5.21	13.78	0.9871	12.77	311.79	464
	PMEL	-1.03	7.65	0.9462	7.66	405.91	50
Rel. 4 GEOS-4/DX	BSRN	4.88	13.75	0.9870	12.86	311.46	464
	PMEL	4.43	7.30	0.9371	5.86	411.39	50
Rel. 3.1 GEOS-4/DX	BSRN	2.09	12.30	0.9882	12.23	308.08	464
	PMEL	-0.07	6.17	0.9342	6.23	406.88	50
CERES EBAF Ed. 2.8	BSRN	1.01	10.02	0.9922	9.98	308.12	464
	PMEL	-2.12	5.10	0.9297	4.69	404.82	50
CERES SYN 1-deg	BSRN	-3.66	10.29	0.9927	9.62	303.44	464
	PMEL	-2.95	5.57	0.9285	4.77	403.99	50

GEWEX SRB GLW(V4.0_nnhirs_combskinmerra_betacld)-BSRN Monthly Mean Longwave Downward Flux Validation on A Site-by-Site Basis from 2005-01 to 2009-12
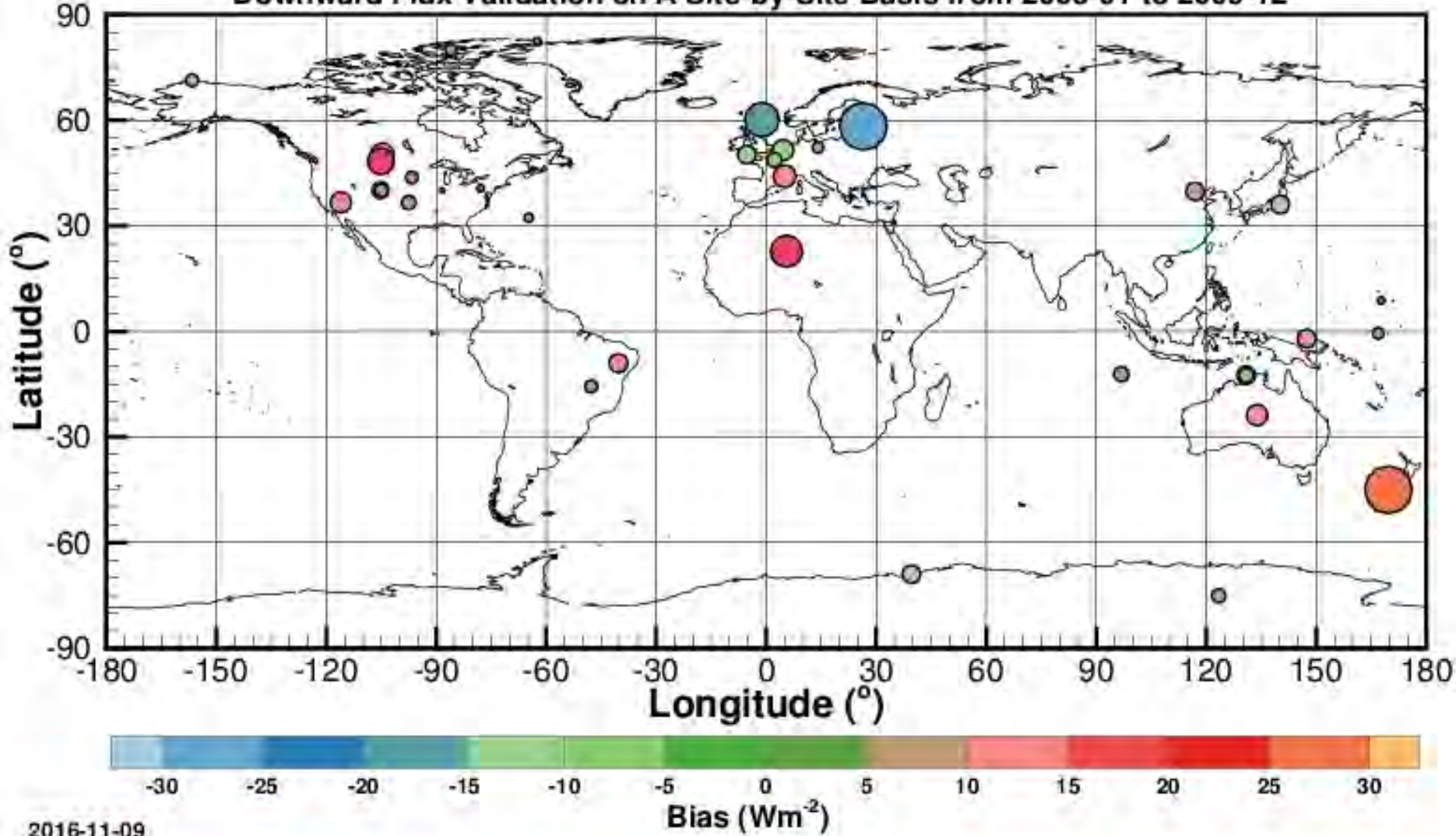
GEWEX LW vs. PMEL Buoy

GEWEX SRB GLW(V4.0_nnhirs_combskinmerra_betacld)-PMEL Monthly Mean Longwave Downward Flux Validation on A Site-by-Site Basis from 2005-01 to 2009-12
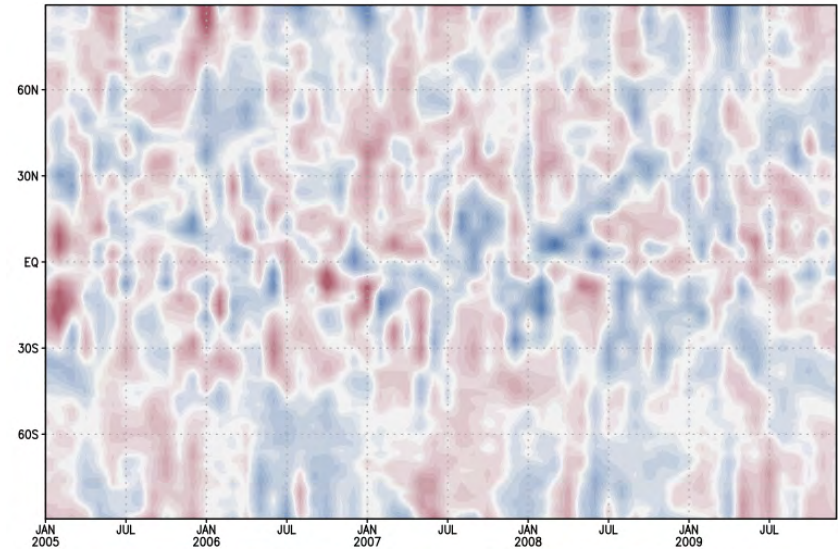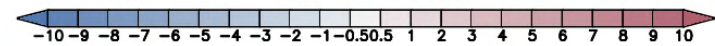
2016-10-31
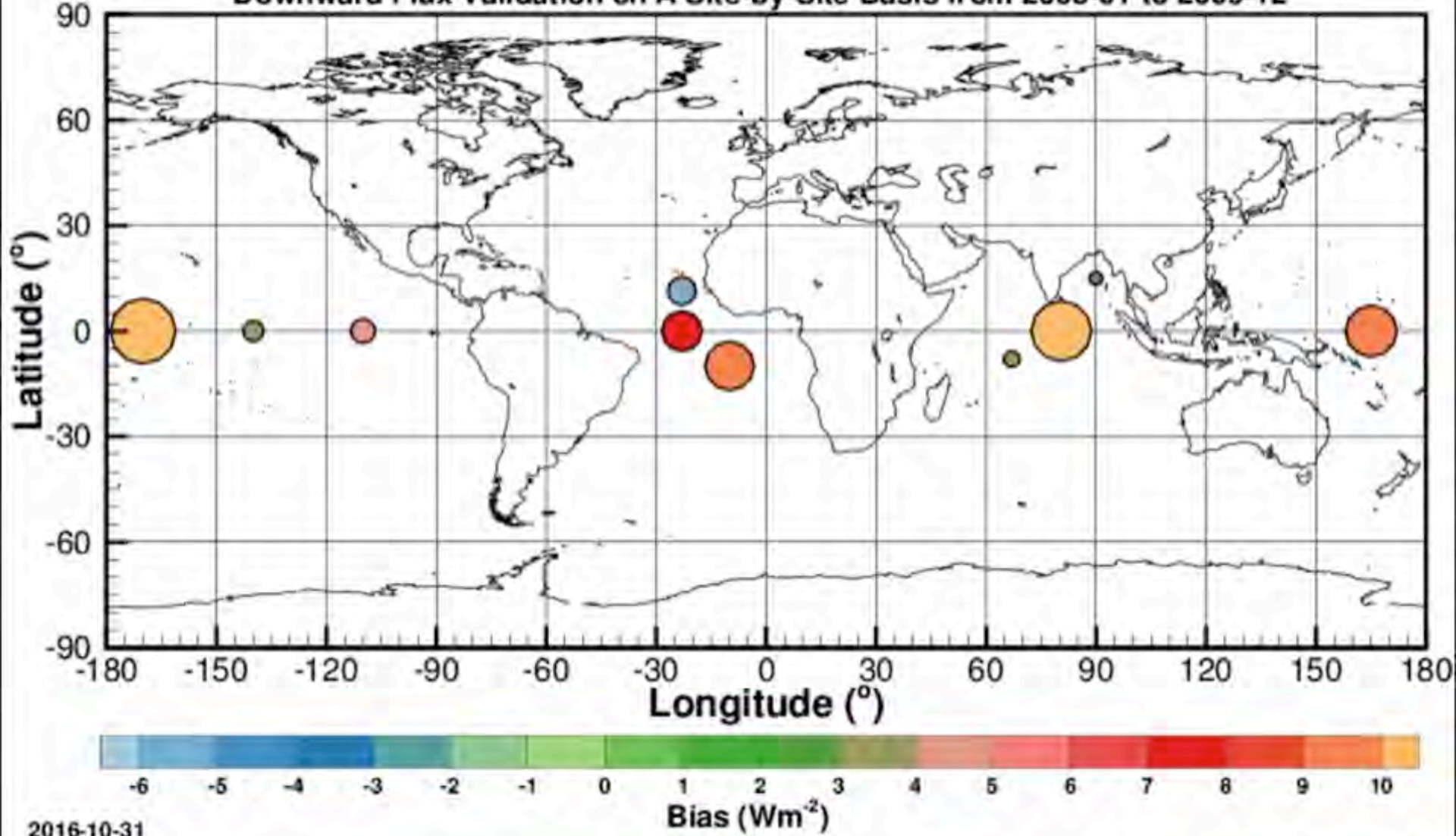
Annual Cycle TOA LW Dn SRB & CERES

SRB All-sky LW Up TOA: Anomaly

SYN-1deg All-sky LW Up TOA: Anomaly

EBAF All-sky LW Up TOA: Anomaly
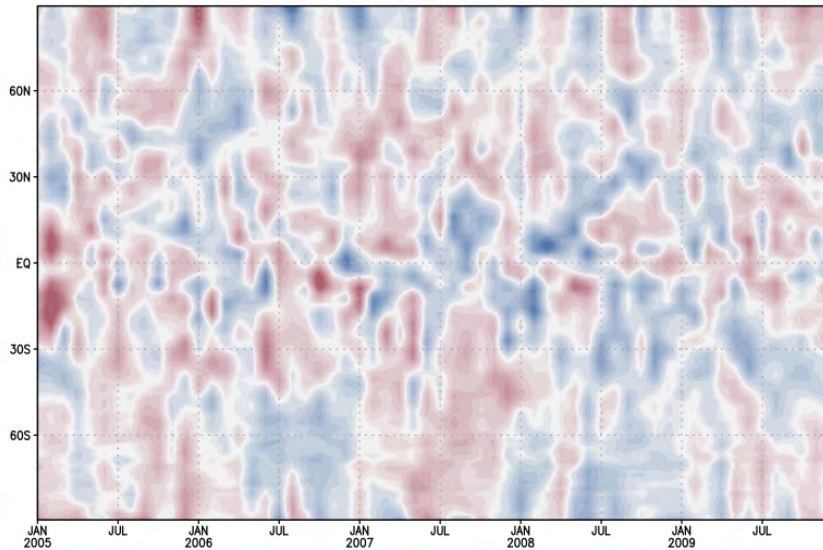
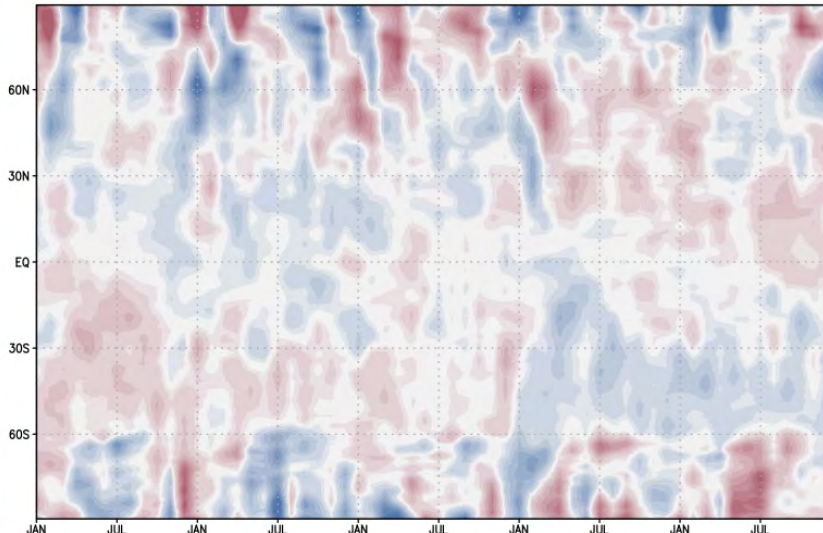# Annual Cycle SFC LW Dn SRB & CERES

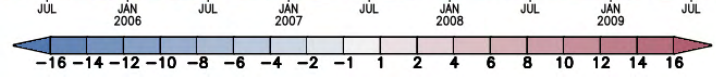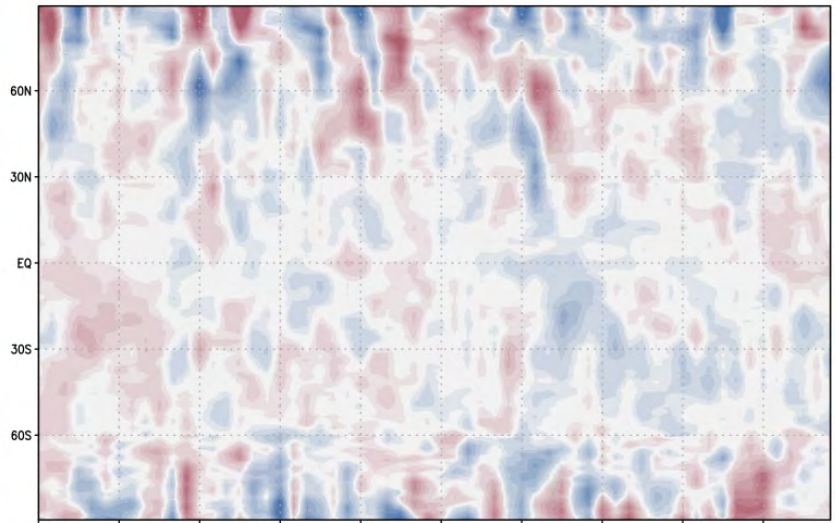# Annual Cycle Anomalies in SFC LW Dn

SRB All-sky LW Down: Anomaly

EBAF All-sky LW Down Sfc: Anomaly

SYN-1deg All-sky LW Down: Anomaly

Ensemble Anomalies vs. BSRN

Deseasonalized Ensemble Average at 28 BSRN Sites with Continuous Records from 2005-01 to 2009-12

Ensemble Anomalies vs. BSRN

Deseasonalized Ensemble Average at 28 BSRN Sites with Continuous Records from 2005 to 2009
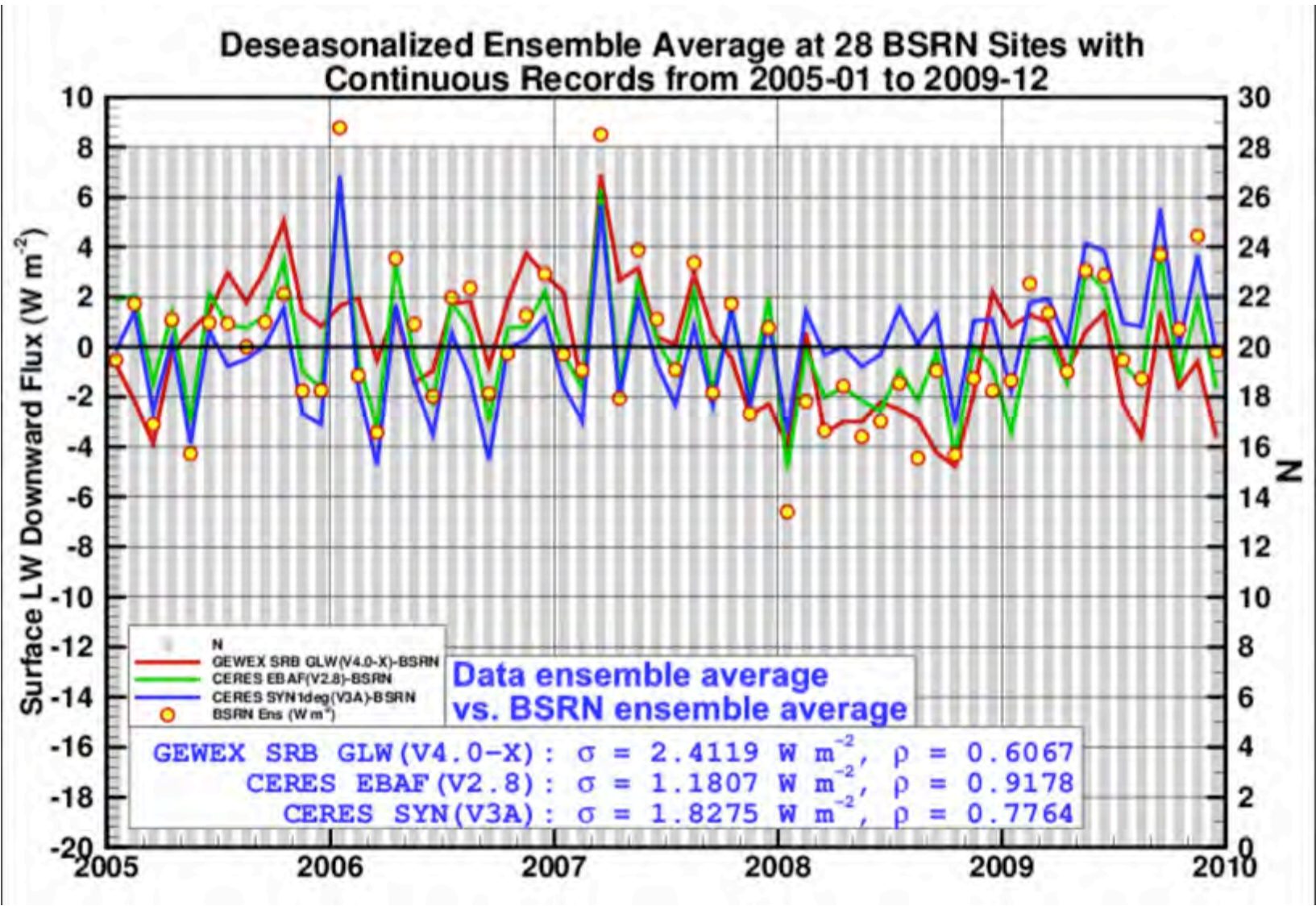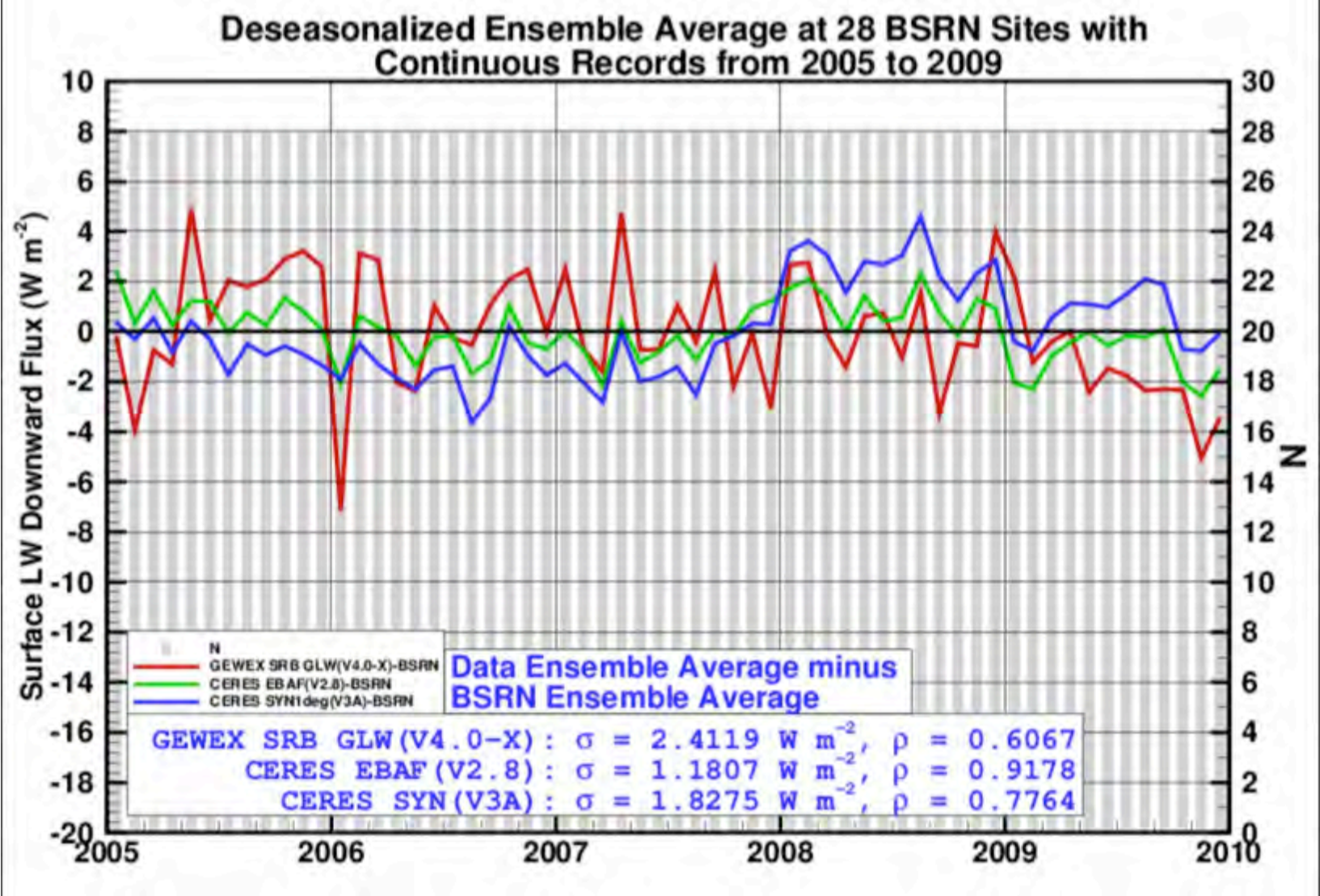
Monthly Mean SYN1deg(V3A)-BSRN (W m⁻²)

Monthly Mean GLW(V4.0-X)-BSRN (W m⁻²)

Monthly Mean EBAF(E2.8)-BSRN (W m⁻²)
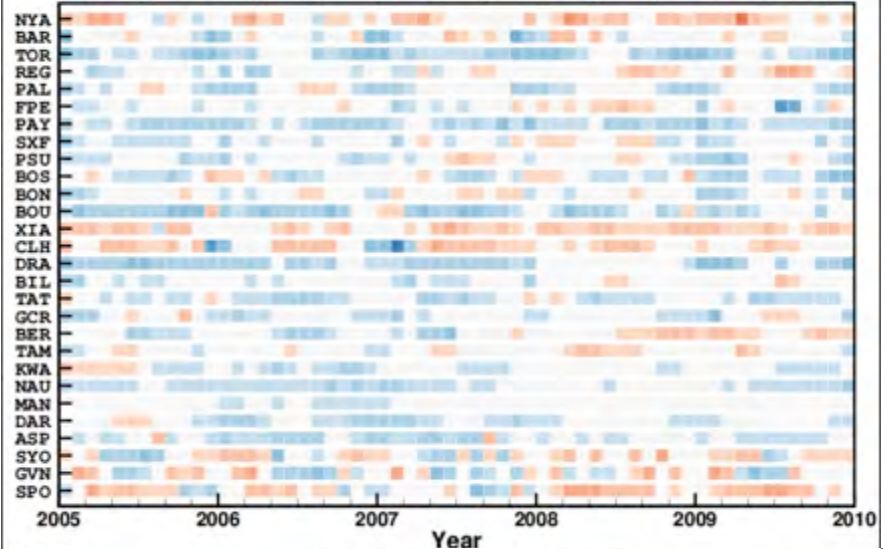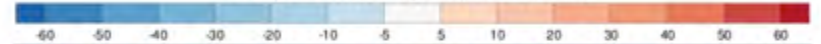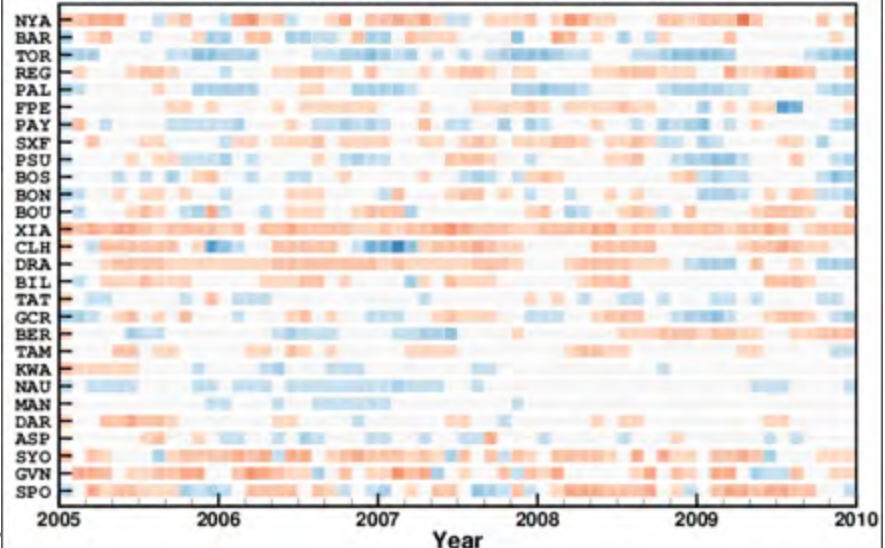
GEWEX SRB: Summary Status

- ## GEWEX SRB Rel 4-IP:

  - New inputs from ISCCP nnHIRS and HXS processed were assessed and new algorithms processed for $1^o \times 1^o$

    - versions delivered for SRB Rel 4-IP Beta

  - Analysis shows improved SW fluxes relative to BSRN and ocean buoy measurements and also new inputs and algorithms relative

    - Ocean fluxes reduced; land fluxes increased
    - TOA reflectance reduced

  - Analysis shows LW not improved

    - nnHIRS appears too moist over tropical oceans leading to biases relative to surface measurements and CERES EBAF v2.8/SYN1Deg
    - HXS cloud rendering testing/assessment ongoing; homogenization with new microphysics

Summary and Conclusions

- ## Next Steps:
  - Will reprocess both SW and LW fluxes with Version 1 HXS at 1° x 1°; will reprocess 2005-2009 with revised calibration tables and cloud properties
    - Will be assessing changes to cloud production
  - Redeliver at 1x1 time periods needed; considering not reprocessing 30 years at 1x1 => proposal: 5 years each decade
  - Progress of conversion to $\frac{1}{2}^o$ x $\frac{1}{2}^o$ nearly completed
    - Using full equal area sampling and data production grid
    - Will provide data provides at the $\frac{1}{2}^o$ x $\frac{1}{2}^o$ equal angle