



# Assessing Long-term Radiative Budgets from the GEWEX Surface Radiation Budget Project Release

## 4 Integrated Product

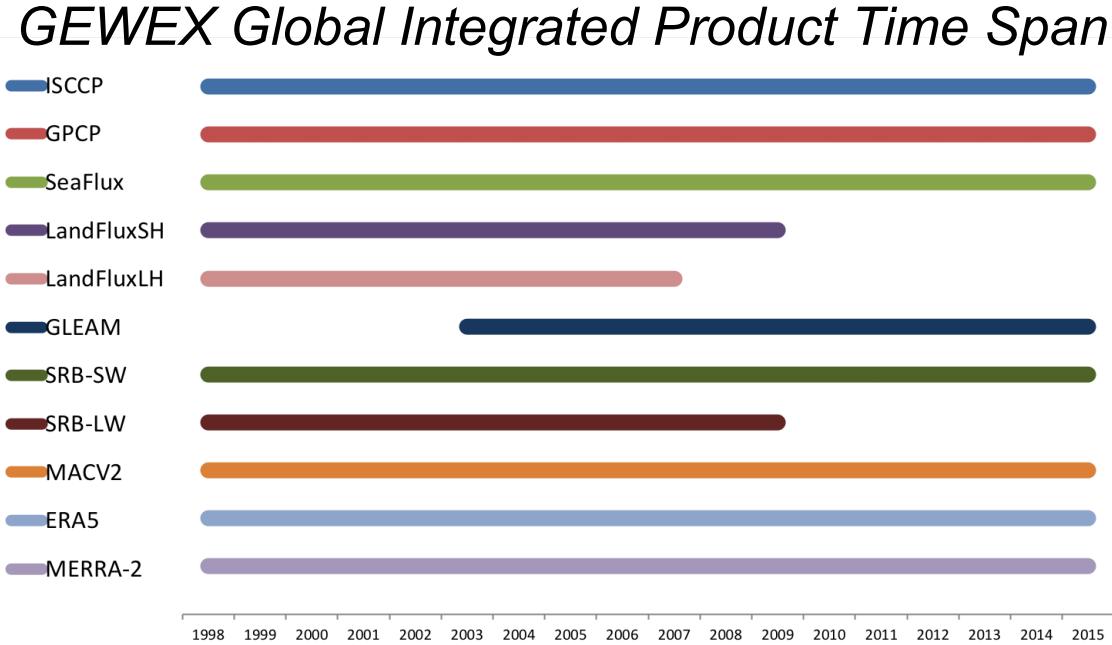
EGU  
Virtual Meeting  
May 4-8, 2020

*Property of US Govt.,  
approved for public  
viewing; acknowledgement  
requested for inclusion in  
presentations; permission  
requested for use in  
publications*

*Paul W. Stackhouse, Jr. – NASA LaRC  
Stephen J. Cox, J. Colleen Mikovitz,  
Taiping Zhang – SSAI*

# Why GEWEX SRB v4 Integrated Product?

- Artifacts in SRB Rel 3
  - Anomalous satellite calibration artifacts
  - Long-term SW trends
  - LW TOVS anomalies
- New inputs from GEWEX global data products
  - ISCCP nnHIRS/snow&ice
  - ISCCP HX
  - MAC v1 aerosol history
  - LandFlux LST and SeaFlux SST
  - Revised snow/ice/vegetation maps
  - Longer time series through June 2015 & beyond

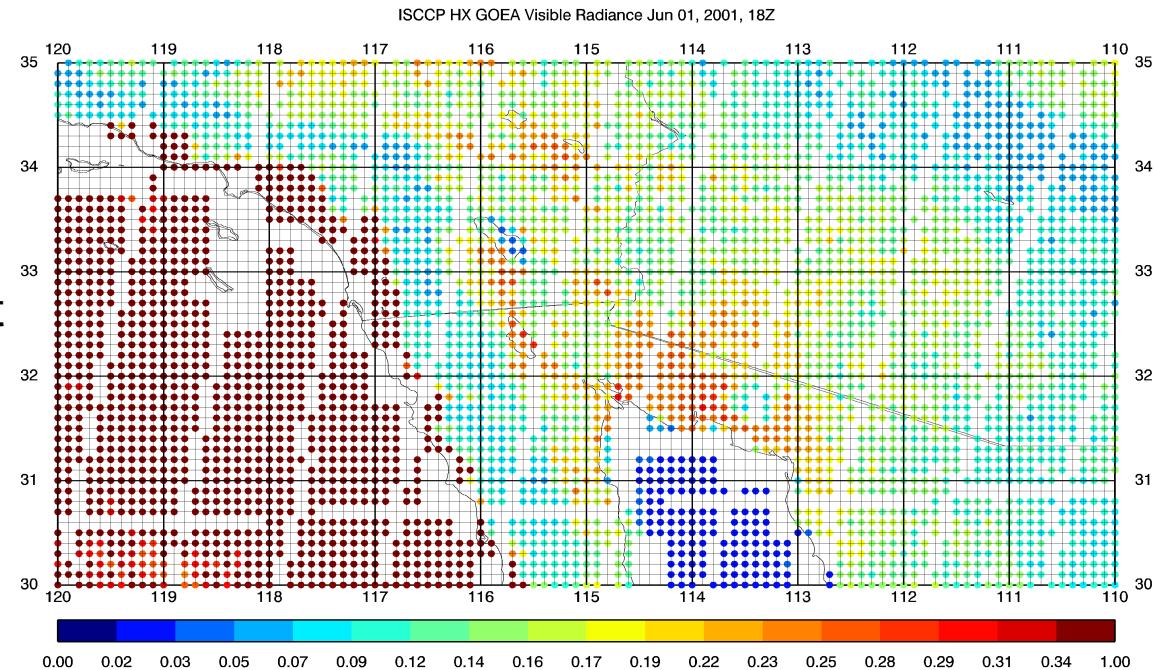


- Improved radiative algorithms for SRB
  - Updated SW LUTs, SW & LW microphysics
  - Additional output data products

# SRB v4-Integrated Product (3-hourly, 1x1)

## ISCCP HX (*production based at NCEI through June 15*)

- Uses all 10 km pixels with no subsampling, 3-hourly by satellite
- Revised calibration and cloud retrieval algorithms
- nnHIRS: Gridded & filled T, q data set using HIRS neural net retrieval (Shi et al.)
- New surface vegetation type maps; emissivity corrections
- Revised & extended snow/ice
- Extended O<sub>3</sub>
- Max Planck aerosol climatology (AEROCOM)





# SW Algorithm Improvements for Release 4.0

	Release 3.0	Release 4.0 IP (GSW with HXS v1)
Radiative bands	5	18 (from CERES LFL05 model; Fu/Liou based)
Spectral Albedo	Original	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
Input aerosol	MATCH modal optical depth, monthly climatology	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 and ice clouds supported, use Water/Ice temperature threshold.
TSI	1367	Coddington et al., (2016)
Run Period	1983-2007	July 1983 – June 2015



# SRB (R4-IP) SW Global Annual Averages Fluxes for 2001-2007

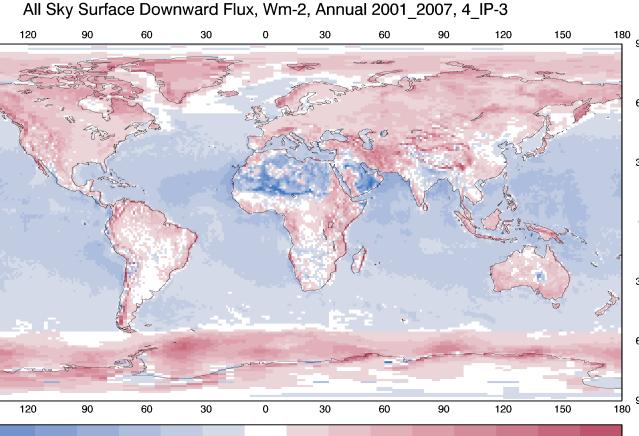
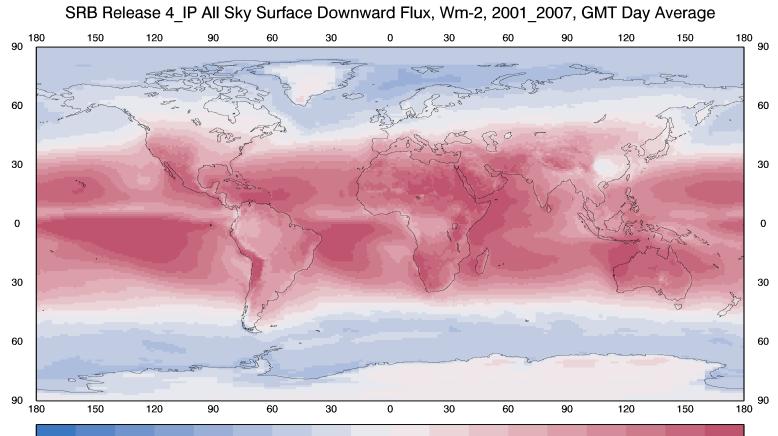
*Global  
annual  
averaged  
fluxes for  
2001-2007*

Flux Component	Rel 3.0 (2001-2007)	Rel 4_IP (NEW algorithm, NEW inputs nnHIRS, HXS V01)	CERES Syn1Deg (Ed. 4A)	CERES EBAF (Ed 4.0)
Surface total down	187.8	185.8	185.4	187.1
Surface down diffuse	104.4	99.7	102.0	--
Surface clear-sky down	248.0	240.9	242.9	243.9
Surface pristine-sky down	258.5	252.8	253.1	256.3
Surface albedo	0.127	0.130	0.134	0.142
Surface net	165.7	163.7	164.1	166.1
Surface Cloud Radiative Effect	-60.2	-55.2	-58.6	-56.8
TOA Up	102.4	100.2	101.0	99.3



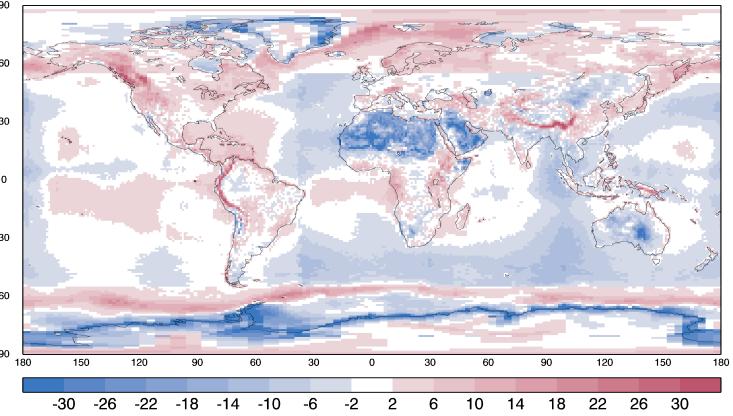
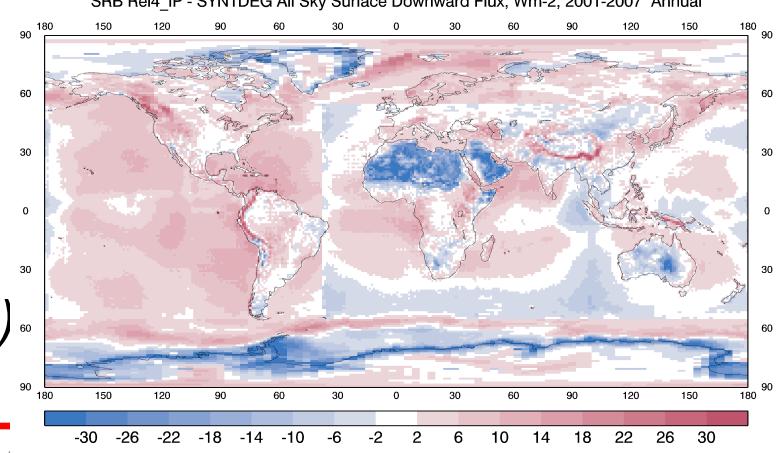
# Global Mean Surface SW Down Flux for 2001-2007

Mean  
SW  
Down



R4-IP  
-  
GSW  
R3

R4-IP  
-  
SYN1-  
Deg  
(Ed 4.0)

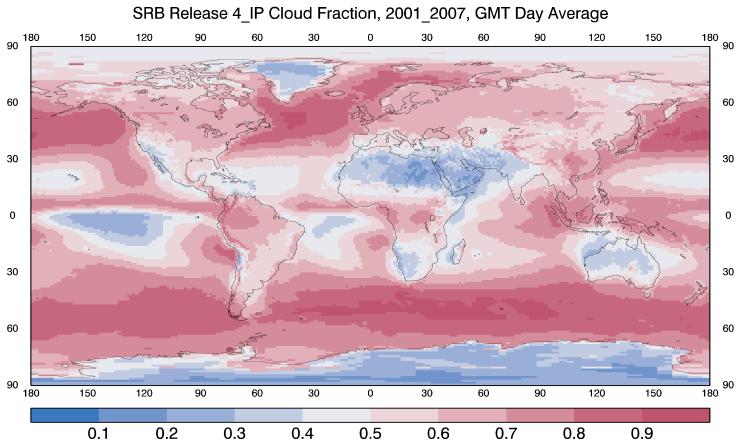


R4-IP  
-  
Surf.  
EBAF  
(Ed  
4.0)



# Global Mean Cloud Fractions for 2001-2007

Mean  
CF



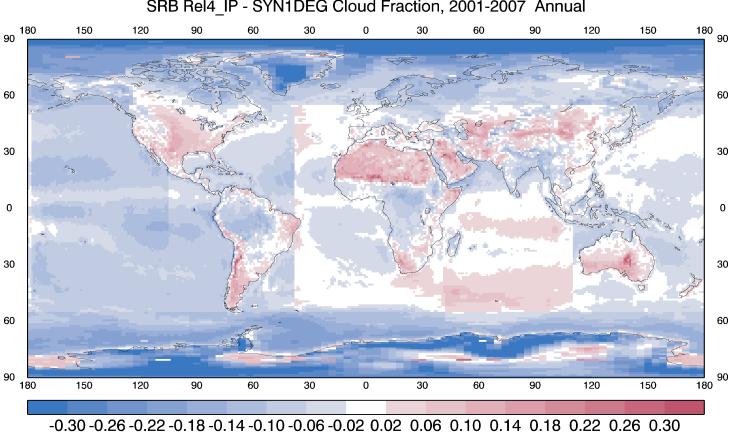
R4-IP

-

GSW

R3

R4-IP  
-  
SYN1-  
Deg  
(Ed 4.0)



R4-IP

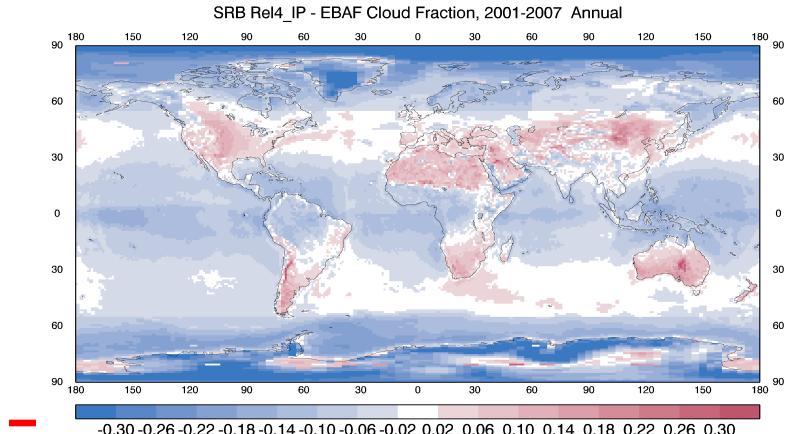
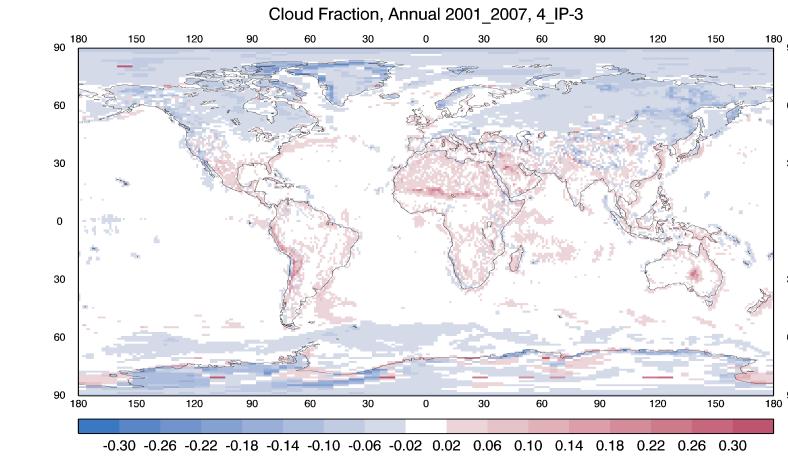
-

Surf.

EBAF

(Ed

4.0)





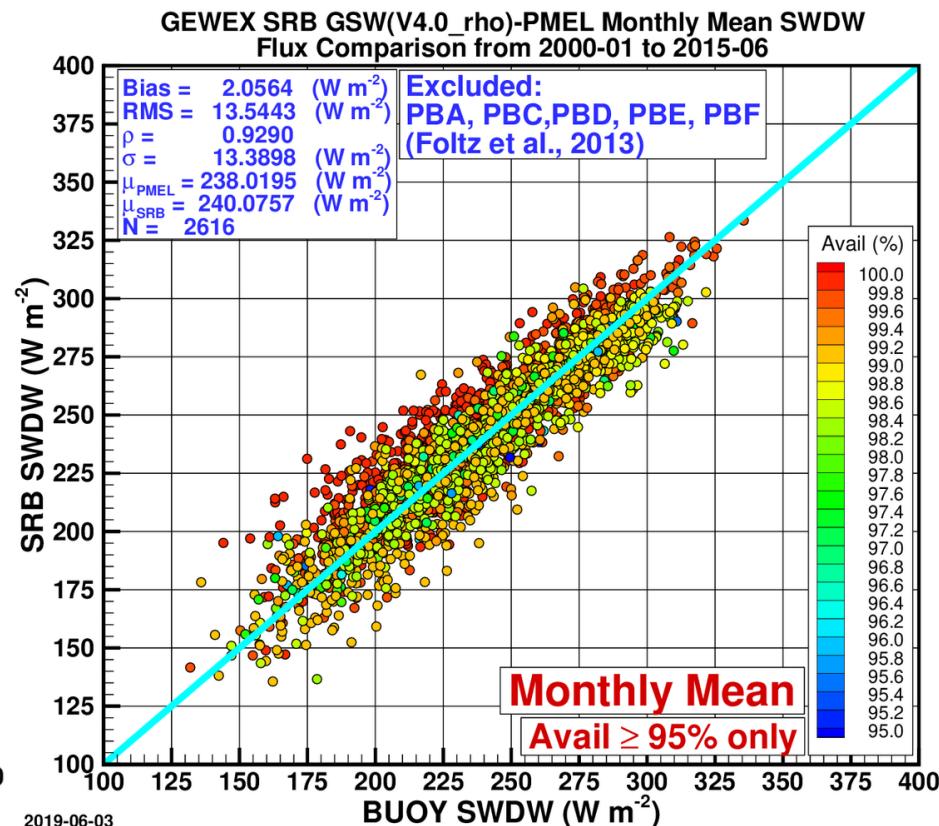
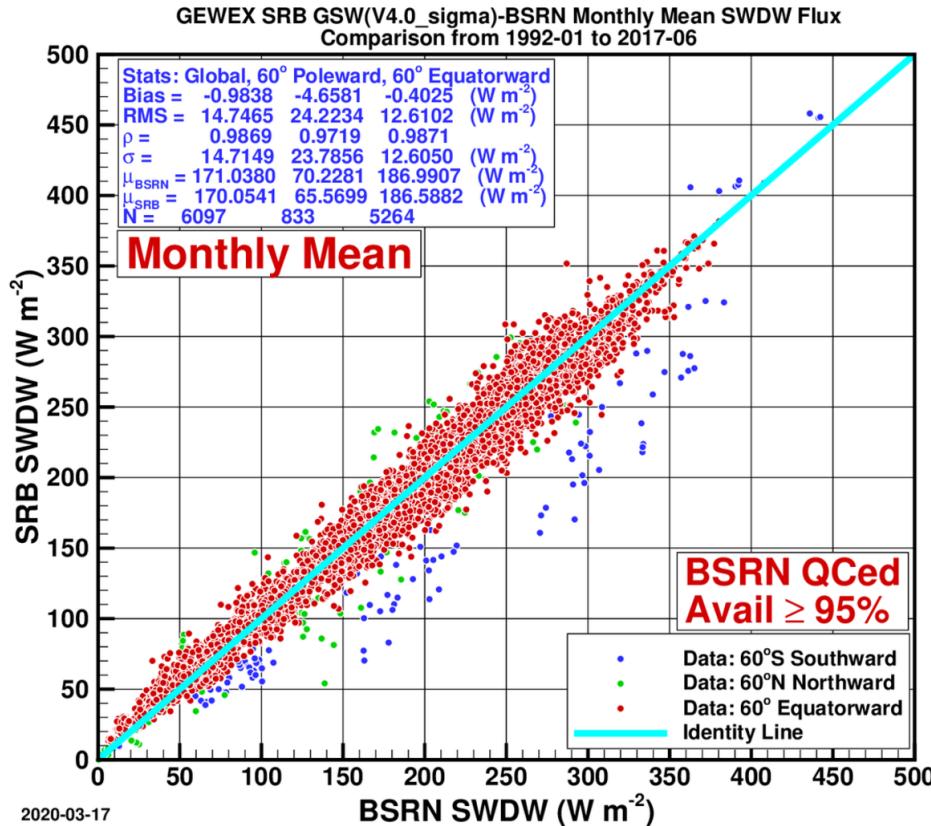
# GSW Validation vs BSRN and PMEL Buoy Observations

- GEWEX GSW-BSRN monthly mean shortwave downward flux comparison statistics for the 7-year period from 2000-03 to 2007-02.
- CERES Edition 4 SYN1deg-BSRN and EBAF-BSRN are added

Version	Bias	RMS	$\rho$	$\sigma$	$\mu_{\text{DATA}}$	N
GEWEX GSW-BSRN Monthly Mean (BSRN avail $\geq 95\%$ )						
GSW(V3.0)	-4.28	18.39	0.9805	17.89	167.18	1907
GSW(V4.0_IP)	-1.75	15.03	0.9865	14.93	169.71	1907
CERES SYN1deg(Ed4A)	-1.92	9.51	0.9948	9.31	169.54	1907
CERES EBAF(Ed4.0)	-1.82	10.07	0.9941	9.90	169.64	1907
GEWEX GSW-PMEL Monthly Mean (BSRN avail $\geq 95\%$ )						
GSW(V3.1)	9.38	15.53	0.9368	12.37	250.21	1238
GSW(V4.0_IP)	0.80	12.55	0.9345	12.52	241.63	1238

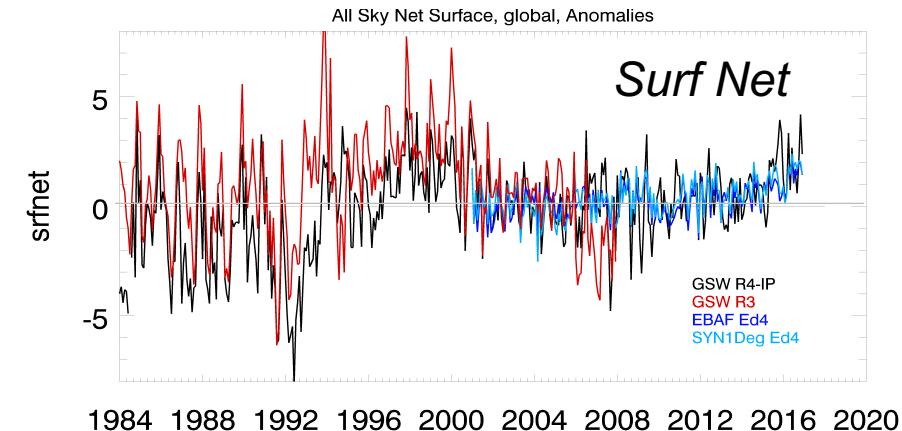
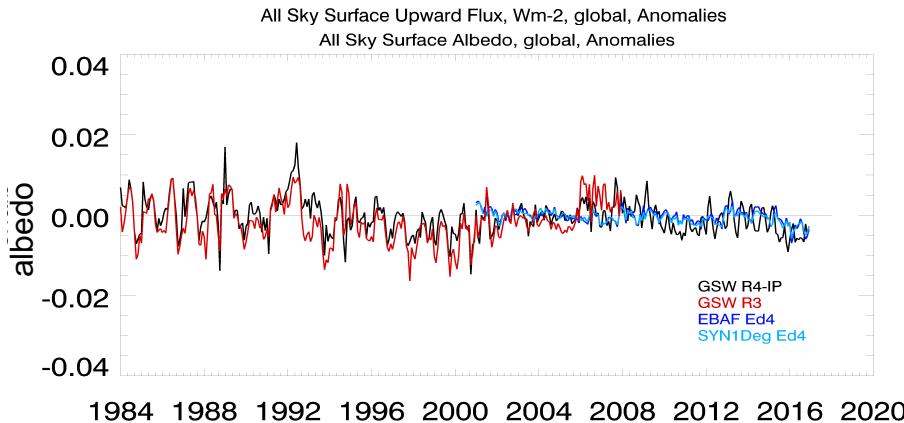
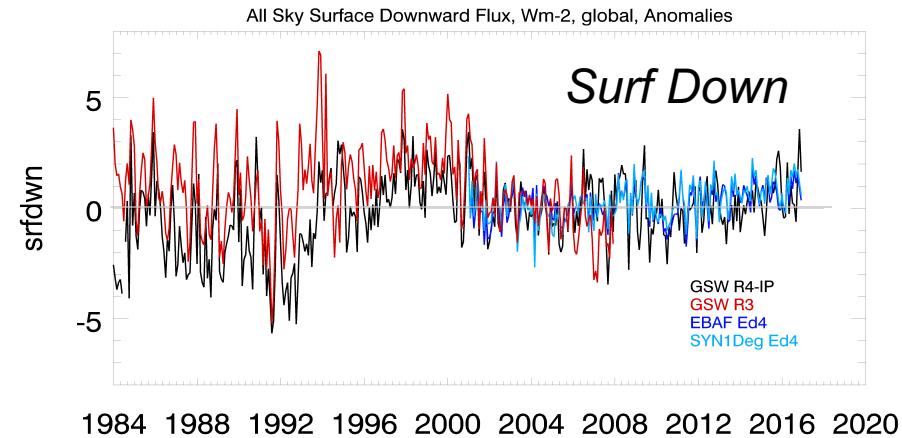
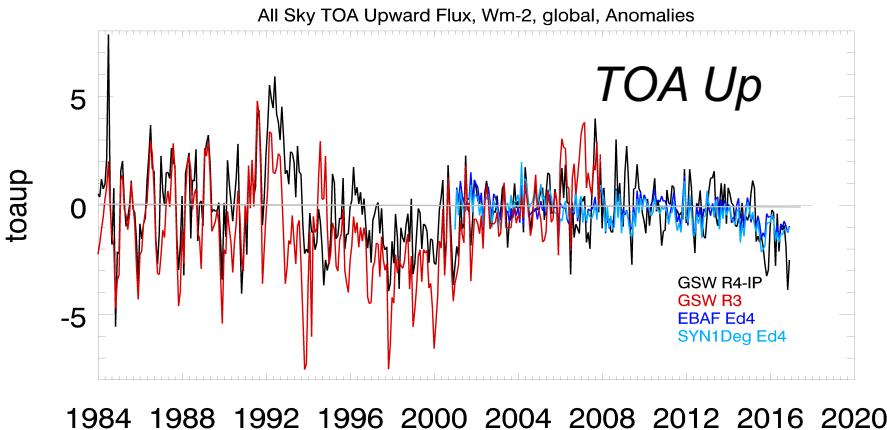


# GSW R4-IP Validation vs BSRN, PMEL





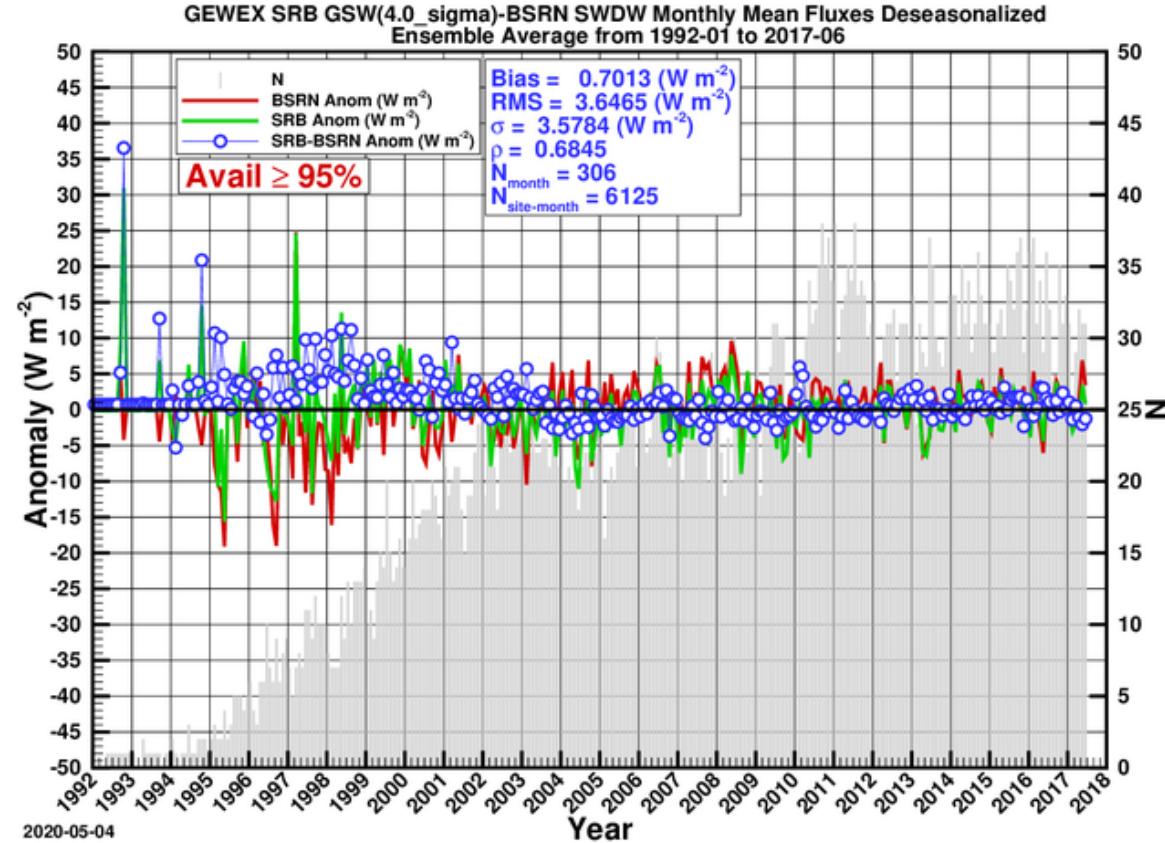
# Global SW Component Anomalies (2001-2007 Base)





# GSW-BSRN Global Ensemble Anomaly Time Series

- Mean by month created for each site for that site time series record.
- Anomaly time series determined for each site
- Averaged to find mean anomaly
- GSW anomaly time series matching surface site extent are computed
- Time series of ensemble averaged site anomalies compared to that of GSW
- Large differences early in the time series fade with number of sites
- Overall anomaly difference sigma is  $3.6 \text{ W m}^{-2}$  with a correlation 0.68
- Systematic +bias from 1996 through about 2001 under investigation





# LW Algorithm/Input Updates for Release 4.0

	Release 3.0	Rel. 4.0
Aerosol Inputs	None	MAC v1 Aerosols (Kinne et al., 2013)
Ice Cloud Properties	Original ice cloud radiative properties	Updated ice cloud radiative properties (Rose et al. 2015); scaled to ISCCP Tau VIS/IR
Water Cloud Properties	Assumed no water clouds above 440 mb	Add high water cloud; modified cloud overlap to treat high water clouds; scaled to ISCCP Tau VIS/IR
T, q profile	GEOS-4	ISCCP nnHIRS (Shi et al); MERRA-2 based oceanic inversion layer correction
Tskin	GEOS-4/ISCCP Ts blend	Blend SeaFlux SST (CDR R2) / LandFlux Ts (Coccia et al) /ISCCP HX Ts; emissivity correction to desert/sparsely vegetated surface types
Data Product Changes	TOA and surface flux only; UT; Clear and all-sky	Pristine-sky (no aerosols), local time, atmospheric levels.
Years Run	1983-2007	1998 - 2009



# Annual Average LW Fluxes for 2001-2007

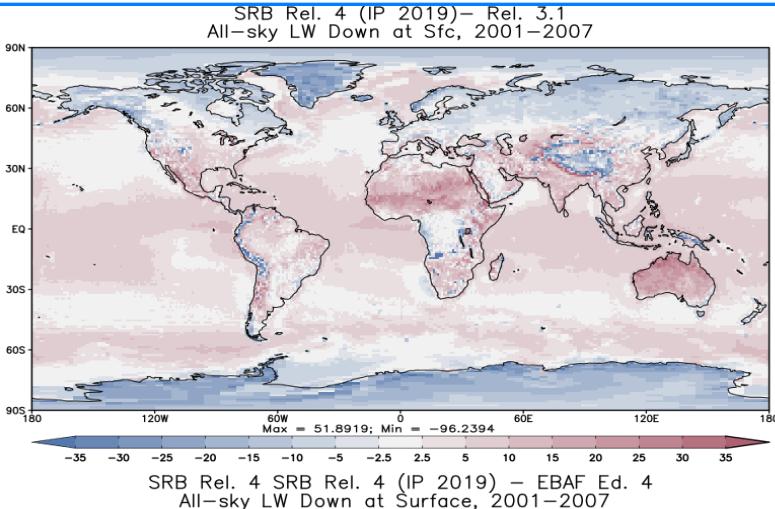
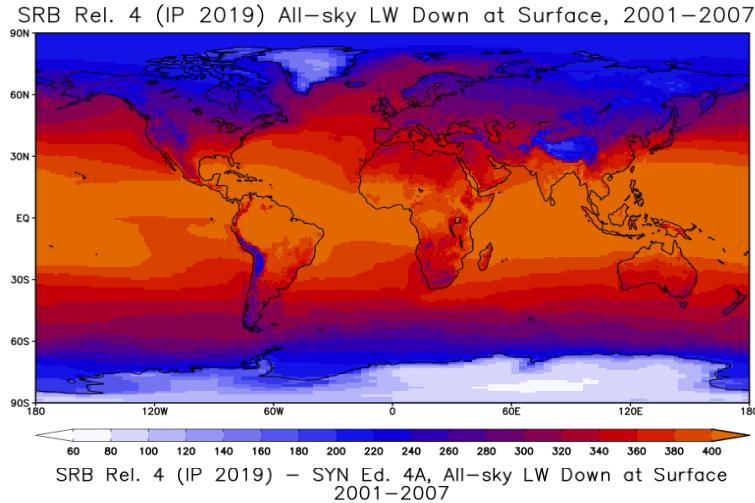
*Global  
annual  
averaged  
fluxes for  
2001-2007*

	Rel 3.1	Rel 4-IP	EBAF 4	SYN 1 Deg
All-sky TOA Up	238.0	239.6	240.3	238.2
Clr-sky TOA Up	265.2	262.6	266.3	262.5
Pristine TOA Up	265.2	263.8		262.9
All-sky Sfc Down	344.3	347.3	345.4	347.6
Clr-sky Sfc Down	311.0	316.5	317.5	317.9
Pristine Sfc Down	311.0	315.0		316.1
Surface Up	398.0	399.3	398.7	398.1
All-sky Sfc Net	-53.7	-52.1	-53.2	-50.5
Sfc CRE	33.2	30.8	27.9	29.7
TOA CRE	27.2	23.0	26.0	24.3
Sfc ARE		1.4		1.7
TOA ARE		1.3		0.46



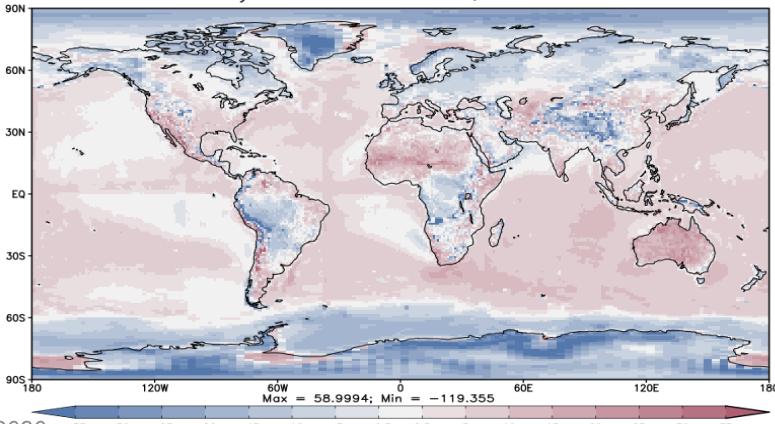
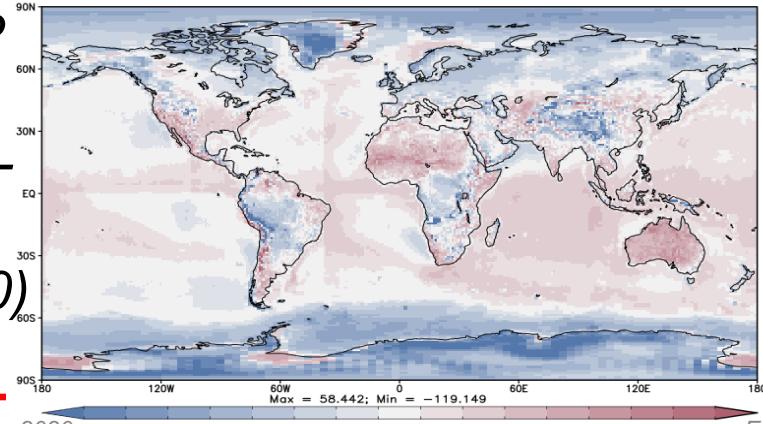
# GLW 4-IP Surface Down Annual Fluxes (2001-2007)

Mean  
LW  
Down



R4-IP  
-  
GLW  
R3

R4-IP  
-  
SYN1-  
Deg  
(Ed 4.0)



R4-IP  
-  
Surf.  
EBAF  
(Ed  
4.0)



# nnHIRS and GEOS-4 Temperature Differences

global = 0.371

60-90N = -0.711

60-90S = -1.004

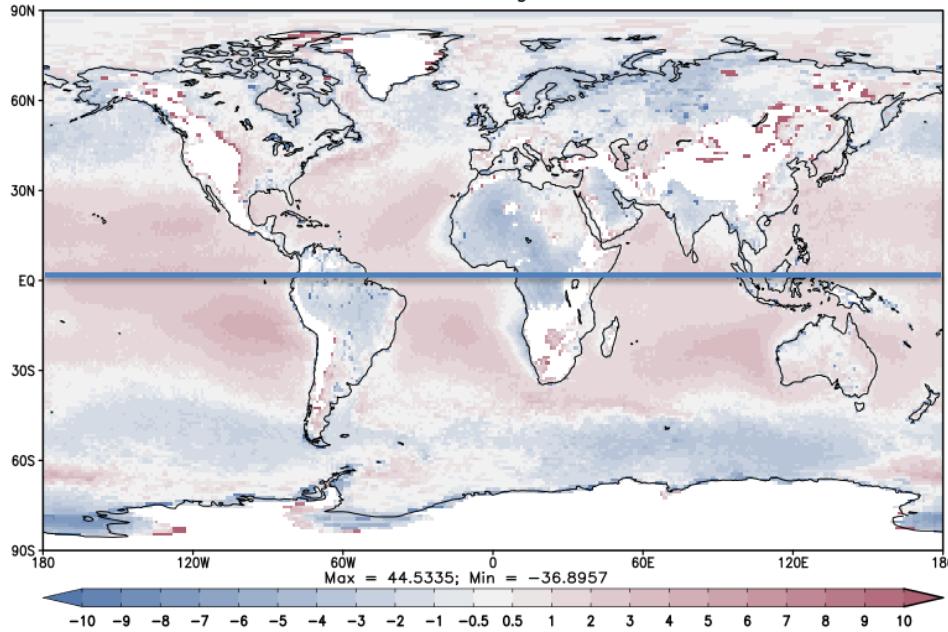
20N-20S = 0.972

20-60N = 0.230

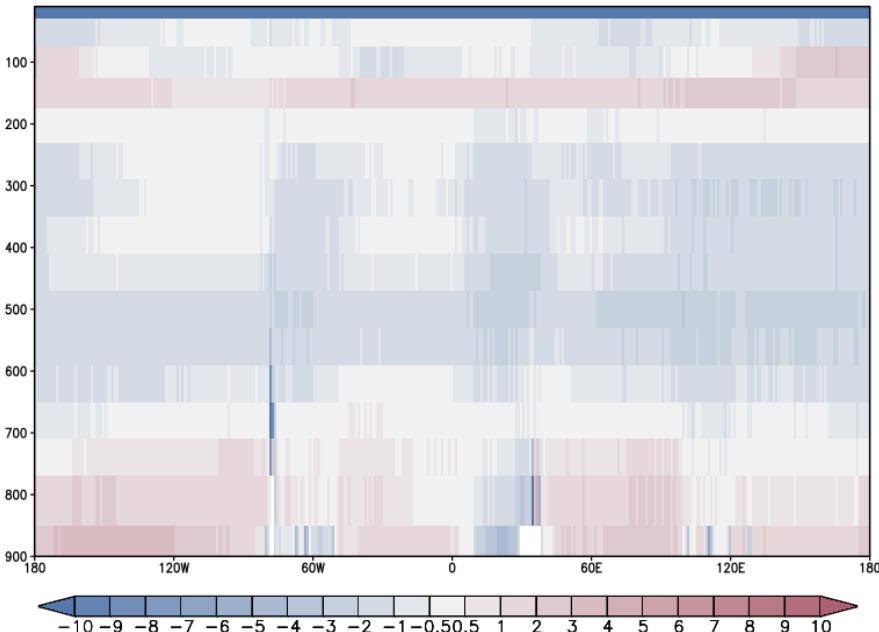
20-60S = 0.236

nnHIRS-GEOS4 900 hPa T

Annual average 2007



ISCCP nnHIRS Sep2015 (corr q) – GEOS-4 Profile Temp  
X-section for latitude 0.5 2007 annual ave





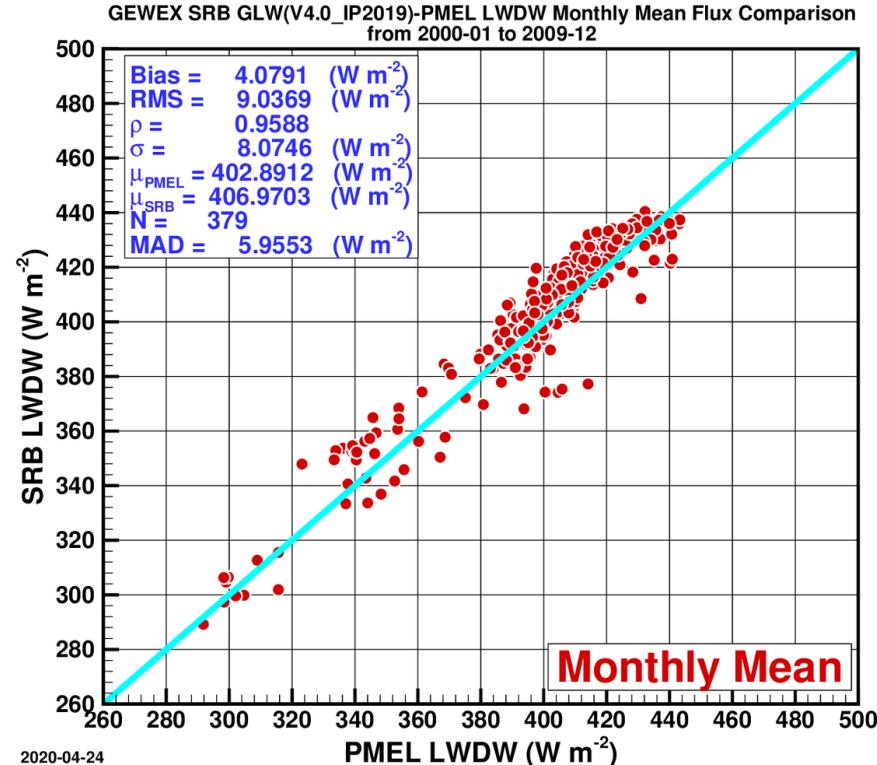
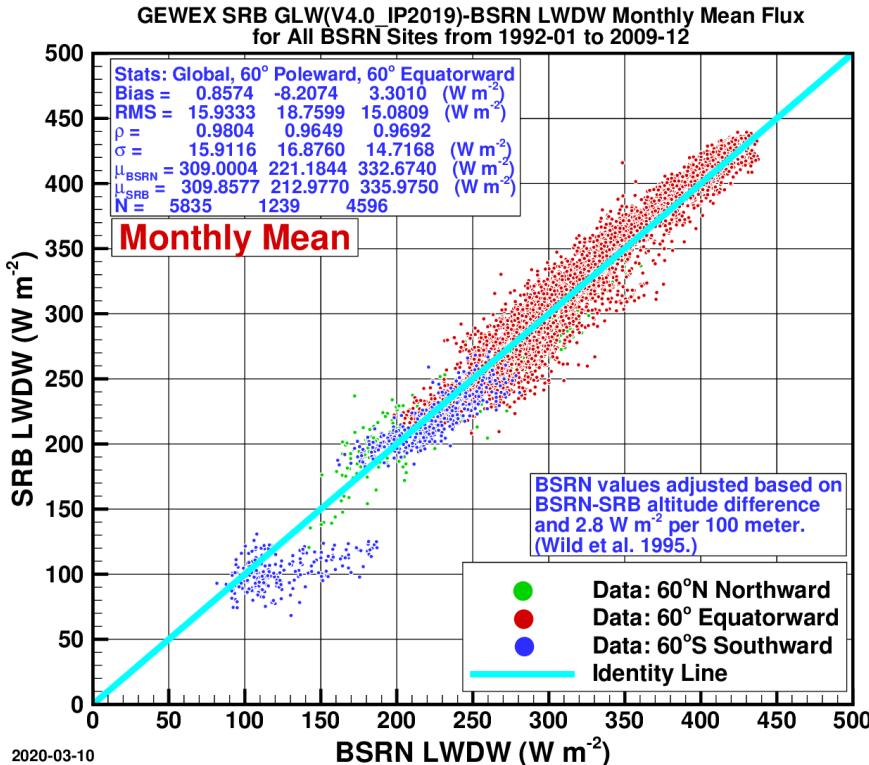
# GLW Validation vs BSRN and PMEL Buoy Observations

- *GEWEX GLW-BSRN and GLW-PMEL monthly mean longwave downward flux comparison statistics for the 7-year period from 2001-01 to 2007-12.*
- *CERES SYN1deg(Ed4A)-BSRN and EBAF(Ed4.0)-BSRN are added.*

Version	Bias	RMS	$\rho$	$\sigma$	$\mu_{\text{DATA}}$	N
<b>GEWEX GLW-BSRN Monthly Mean (BSRN avail <math>\geq 95\%</math>)</b>						
GLW(V3.1)	1.79	10.92	0.9896	10.78	313.82	2324
GLW(V4.0_IP2019)	2.84	15.53	0.9804	15.27	314.86	2324
CERES SYN1deg(Ed4A)	4.18	10.00	0.9926	9.09	316.85	2324
CERES EBAF(Ed4.0)	2.16	9.27	0.9927	9.01	314.83	2324
<b>GEWEX GLW-PMEL Monthly Mean (BSRN avail <math>\geq 95\%</math>)</b>						
GLW(V3.1)	-2.06	7.03	0.8835	6.74	411.35	180
GLW(V4.0_IP)	4.03	7.70	0.8983	6.58	417.14	180
CERES SYN1deg(Ed4A)	1.12	6.12	0.9087	6.03	414.54	180
CERES EBAF(Ed4.0)	1.14	5.92	0.9131	5.83	414.56	180



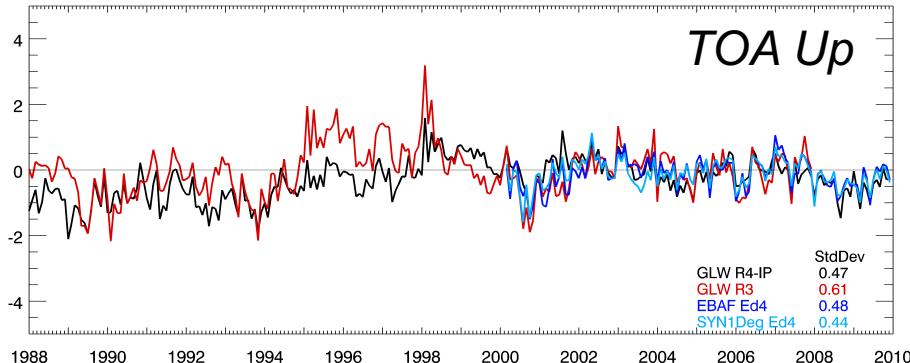
# GLW R4-IP Validation vs BSRN, PMEL



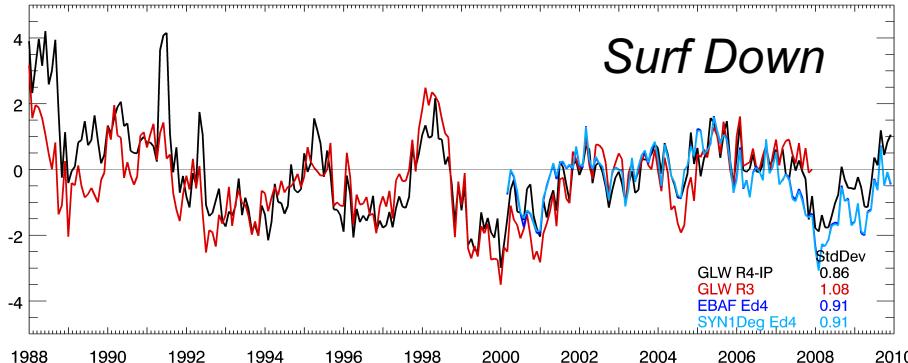


# Global LW Component Anomalies (2001-2007 Base)

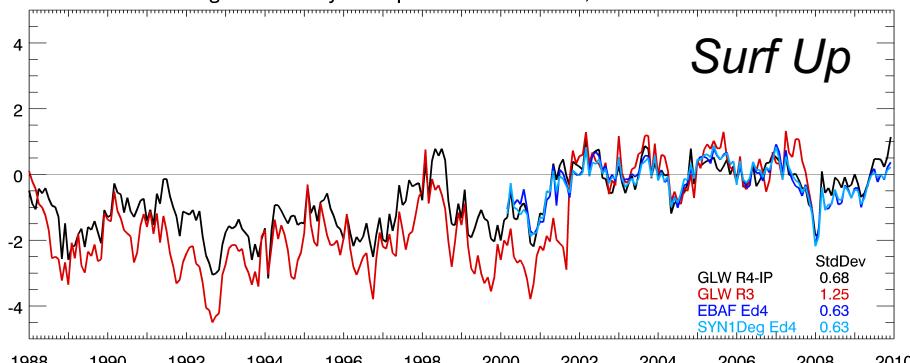
Longwave All-sky TOA Up Global Anomalies, Base 2001-2007



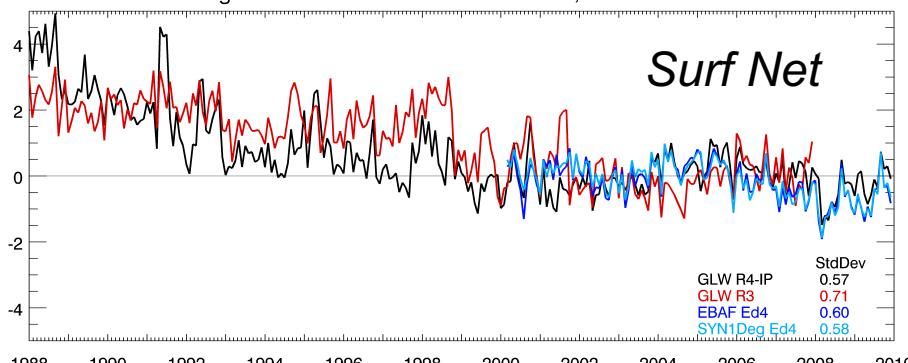
Longwave All-sky Sfc Down Global Anomalies, Base 2001-2007



Longwave All-sky Sfc Up Global Anomalies, Base 2001-2007

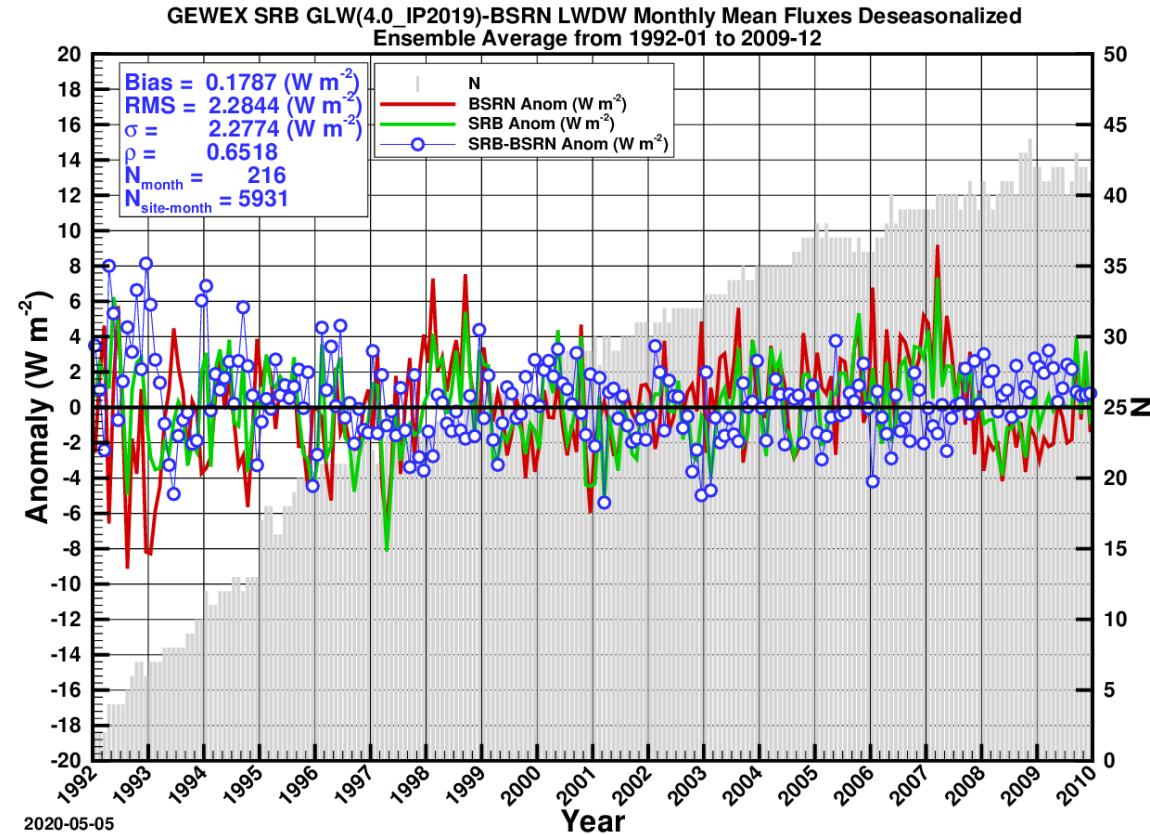


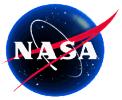
Longwave Surface Net Global Anomalies, Base 2001-2007



# GLW-BSRN Global Ensemble Anomaly Time Series

- Mean by month created for each site for that site time series record.
- Anomaly time series determined for each site
- Averaged to find mean anomaly
- GLW anomaly time series matching surface site extent are computed
- Time series of ensemble averaged site anomalies compared to that of GLW
- Large differences early in the time series fade with number of sites
- Overall anomaly difference sigma is  $2.3 \text{ W m}^{-2}$  with a correlation 0.65
- Time series alternates between + and – anomalies, but stays positive for 2008 and 2009.





# GEWEX SRB Rel 4-IP: Summary Status

- **GEWEX SRB Integrated Product Version**
  - GEWEX global data projects: ISCCP, SRB, LandFlux, SeaFlux, GPCP attempted joint product where key inputs used to tie energy and water cycle global data products; to be released within several months spanning 1998 to 2017
- **SW processed full length from July 1983 to June 2017**
  - Global annual averages consistent but regions of large differences; attributable to cloud fraction changes to first order
  - Reduction of polar clouds from new ISCCP HX significant
  - All-sky validation relative to BSRN and PMEL Buoys improved
  - Long-term variability and anomalies show good correspondence to ERBE and CERES data products



# GEWEX SRB: Summary Status

- **LW processed 1988 to 2009**
  - Annual average map differences show large changes
  - Attributable in part to new nnHIRS based T, q profiles
  - Surface validation good relative to BSRN, biased high over oceans
- **Continuing GEWEX SRB Rel 4-IP and 4+**
  - Continue validation and assessment; relative to CERES and surface observations; other satellite data sets
  - Review ocean correction procedure to nnHIRS; monthly variability corresponds well, but bias in oceanic tropical boundary layer evident
  - Develop/modify skin temperature to enable long-term production
  - Deliver, Document, Archive and Distribute and Publish new 1x1 version



# SRB Web Site and Data Sources

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

## 1. Atmospheric Science Data Center (main archive):

[https://eosweb.larc.nasa.gov/project/srb/srb\\_table](https://eosweb.larc.nasa.gov/project/srb/srb_table)

## 2. POWER Applied Science (climatological, monthly, daily; GIS formats)

<https://power.larc.nasa.gov>

