SATELLITE-BASED VERSUS GROUND-BASED RADIATION FLUXES UNDER ALL-SKY AND CLEAR-SKY CONDITIONS: The GEWEX SRB GSW(Rel. 3.0/4.0-IP) Results versus Their BSRN and RadFlux Counterparts

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Outline of the Presentation …

- The characteristics of the GEWEX SRB data
- Changes in Rel. 4.0-IP (V4.0) algorithm and inputs as compared to Rel. 3.0 (V3.0)
- Surface-based measurements
- Comparisons with surface-based measurements: Rel. 3.0 and preliminary Rel. 4.0-IP
- Summary and conclusions

GEWEX SRB Shortwave/Longwave Products Overview

- Time Span:
  - SW Rel. 3.0/LW Rel. 3.1: 1983-07 ~ 2007-12 (24.5 years; Released in 2011)
  - SW Rel. 4.0-IP: 1998-01 ~ 2009-12, progressing to cover more years
- Coverage and Resolution:
  - SW Rel. 3.0/LW Rel. 3.1: Global, quasi-equal-area grid boxes ranging from 1°x1° (equator) to 1°x120° (poles)
  - Rel. 4.0-IP: Global, currently 1°x1° quasi-equal-area
- Broadband Spectral Ranges:
  - Shortwave (SW): 0.3 μm - 5.0 μm
  - Photosynthetically Active Radiation (PAR): 0.4 - 0.7 μm
  - Longwave (LW): 0 cm^{-1} - 2200 cm^{-1} (~4.5 μm - ∞ μm)
- Levels:
  - Surface
  - Top-of-Atmosphere (TOA)
- Temporal Averages:
  - 3-Hourly, 3-Hourly-Monthly, Daily and Monthly

GEWEX SRB Data Set Characteristics

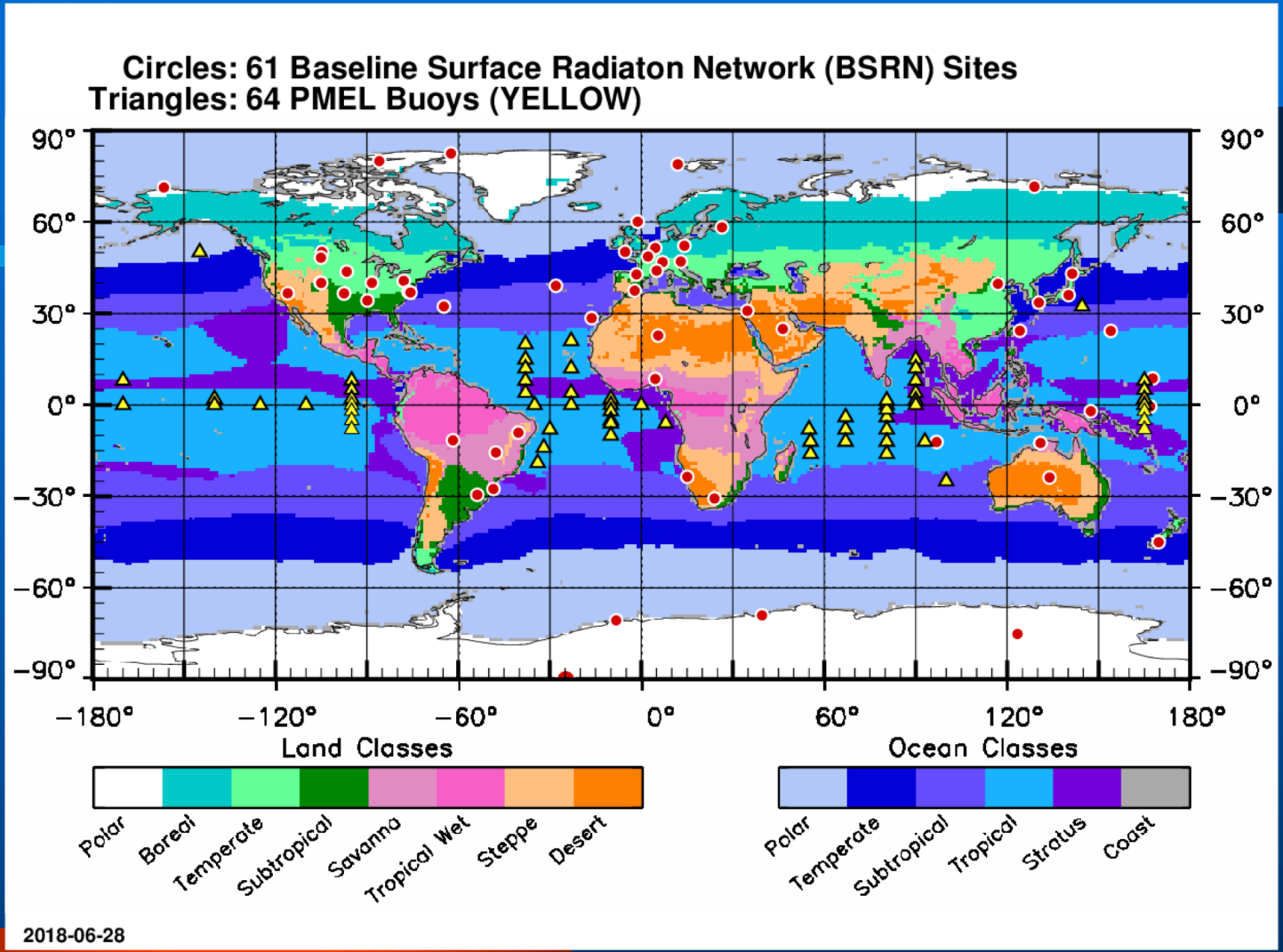
Main GEWEX SRB Flux Parameters

- Rel. 3.0/3.1: GSW-Pinker/Laszlo, LPSA-Gupta, GLW-Fu/Stackhouse, LPLA-Gupta
- Rel. 4.0-IP: GSW-Pinker/Laszlo, GLW-Fu/Stackhouse (boldface only)

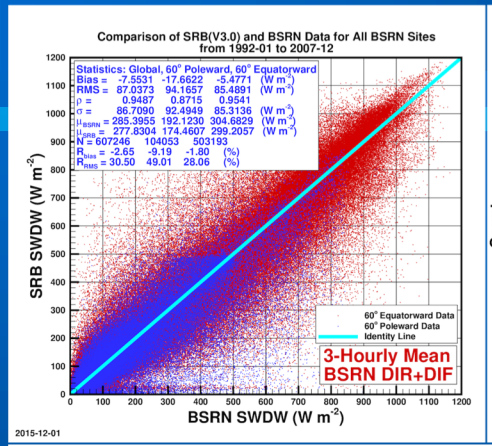
Parameter	Surface Fluxes (W m^{-2})		TOA Fluxes (W m^{-2})	
	Upward	Downward	Upward	Downward
SW All-Sky Flux	**GSW**, LPSA	**GSW**, LPSA	**GSW**	**GSW**, LPSA
SW Clear-Sky Flux	**GSW**, LPSA	**GSW**, LPSA	**GSW**	**GSW,** LPSA
PAR All-Sky Flux	--	**GSW**	--	**GSW**
LW All-Sky Flux	**GLW**, LPLA	**GLW**, LPLA	**GLW**	--
LW Clear-Sky Flux	**GLW**, LPLA	**GLW,** LPLA	**GLW**	--
Day/Night Flag	**GLW**	--	--	--
Sun & View Angles	**GSW**	--	--	--

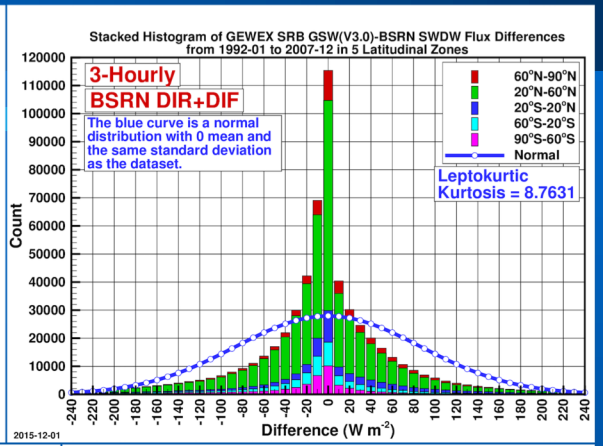
Metadata of Surface-Based Measurements

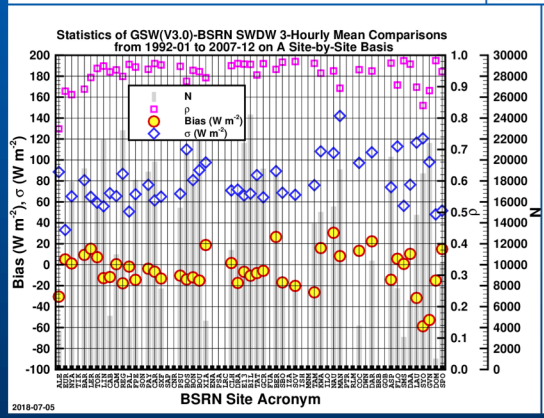
Dateset	Number of Sites	Site-Months	Period
BSRN	61	9800	1992 ~ 2007
RadFlux	42	7119	1992 ~ 2017
PMEL	64	4389	2000 ~ 2017
GEBA	2261	321,942	1901 ~ 2015
WRDC	1259	23,016	1964 ~ 2013

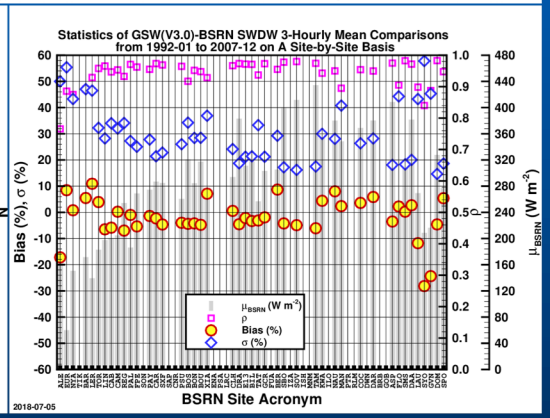

Circles: 61 Baseline Surface Radiaton Network (BSRN) Sites
Triangles: 64 PMEL Buoys (YELLOW)
90°
60°
30°
0°
−30°
−60°
−90°
−180°
−120°
−60°
0°
60°
120°
180°
Land Classes
Polar
Boreal
Temperate
Subtropical
Savanna
Tropical Wet
Steppe
Desert
Ocean Classes
Polar
Temperate
Subtropical
Tropical
Stratus
Coast
2018-06-28

GEWEX SRB GSW(V3.0)-BSRN *3-Hourly* Mean All-Sky SW Downward Flux Comparison for the 16-Year Period from 1992 - 2007



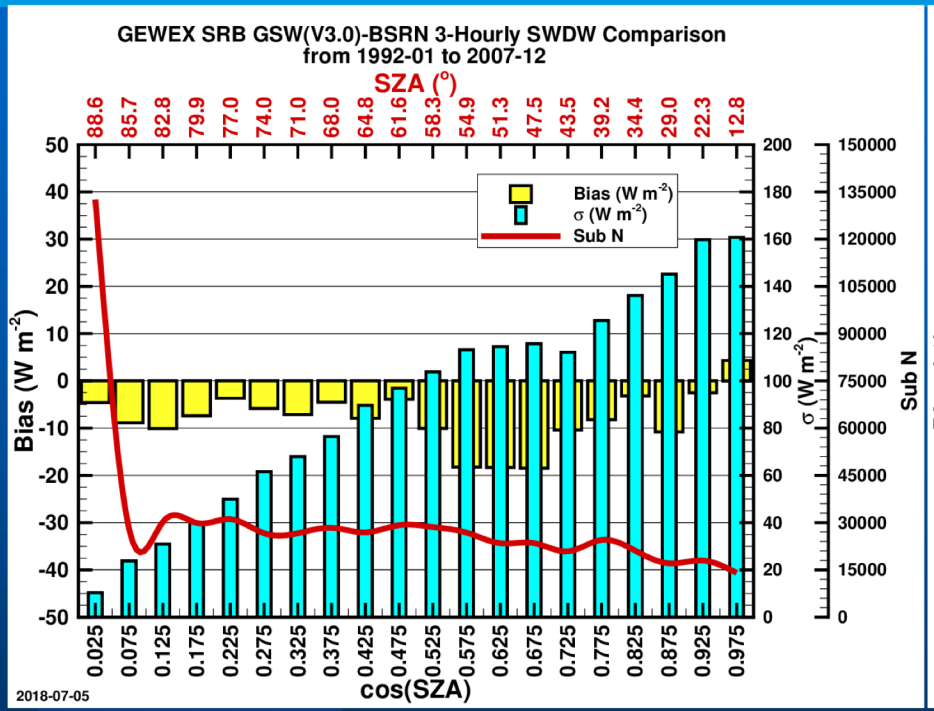


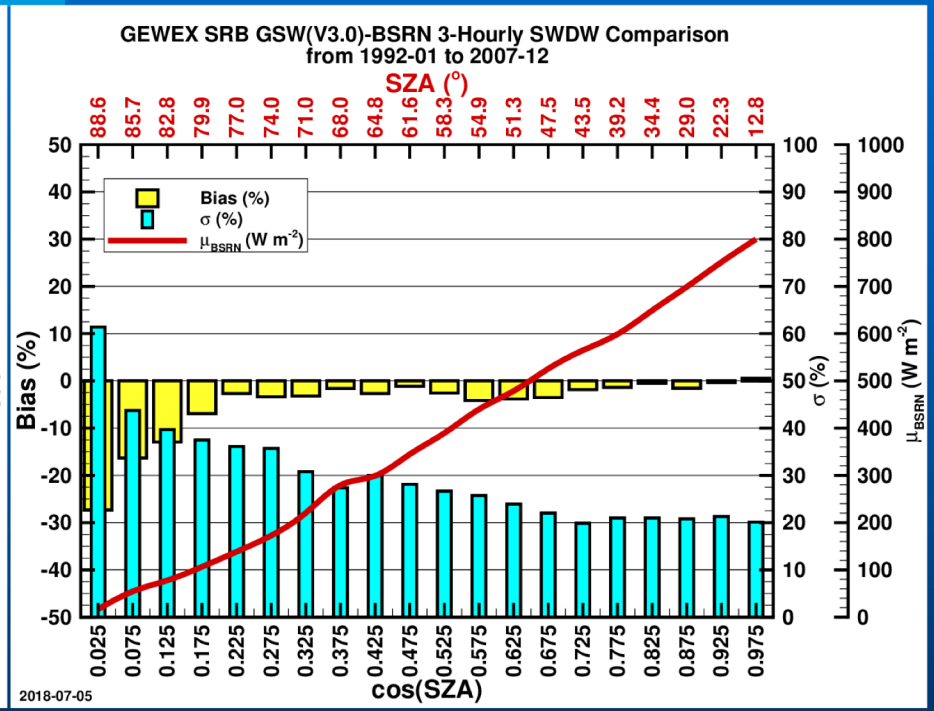




- BSRN data begin in 1992.

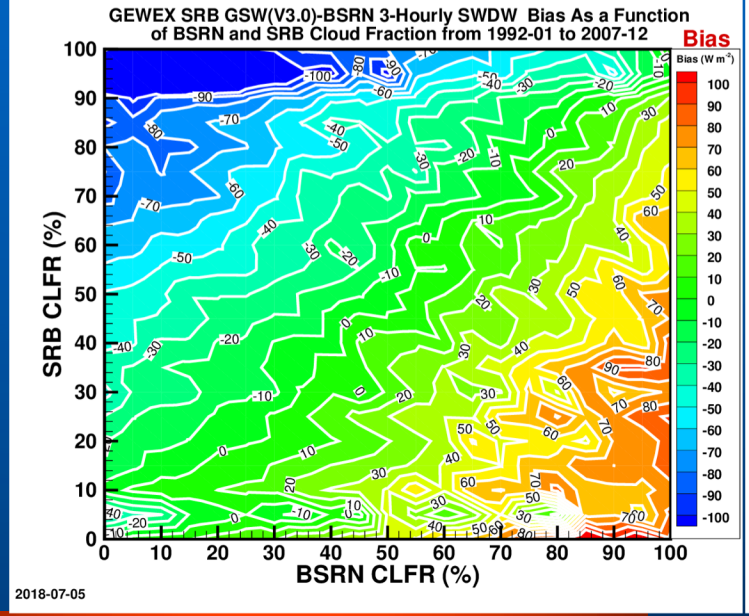
GEWEX SRB GSW(V3.0)-BSRN *3-Hourly* Mean All-Sky SW Downward Flux Comparison for the 16-Year Period from 1992 - 2007 in 0.05-Sized Bins of cos(SZA)



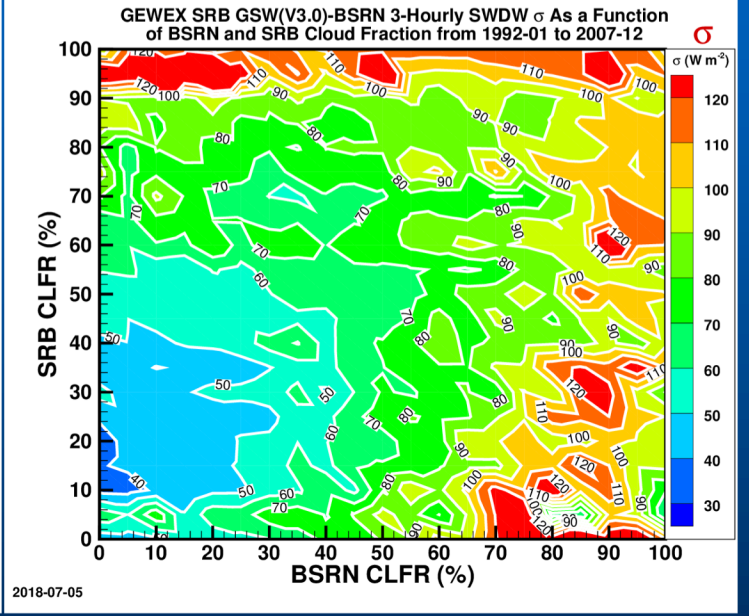


The Effect of SRB-BSRN CLFR Difference in the GSW(V3.0)-BSRN *3-Hourly* All-Sky SW Downward Flux Comparison (1992-2007)

Bias (W m^{-2})



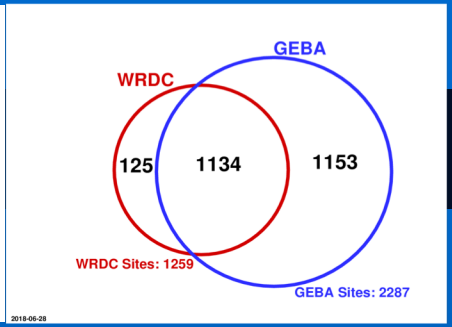
σ (W m^{-2})

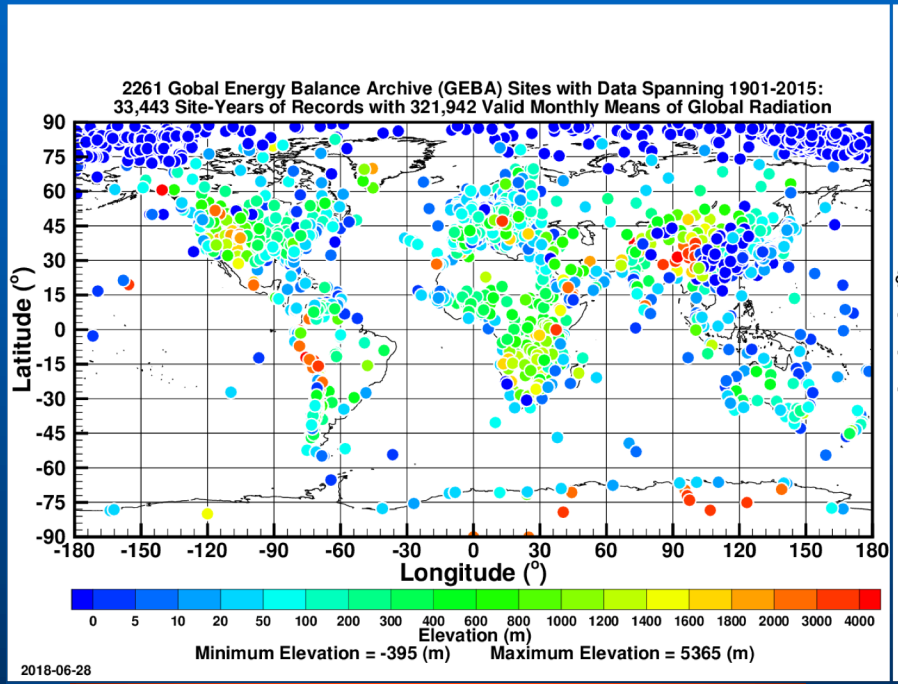


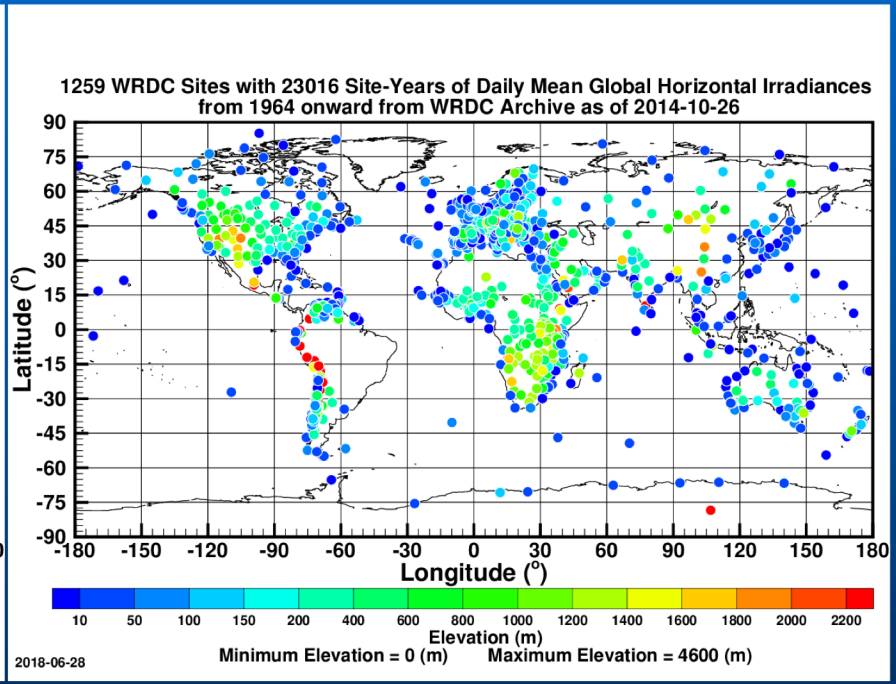
GEBA (Global Energy Balance Archive) and WRDC (World Radiation Data Centre) Radiation Data Site Maps

About 90% of WRDC sites and 50% of GEBA sites are the same sites.

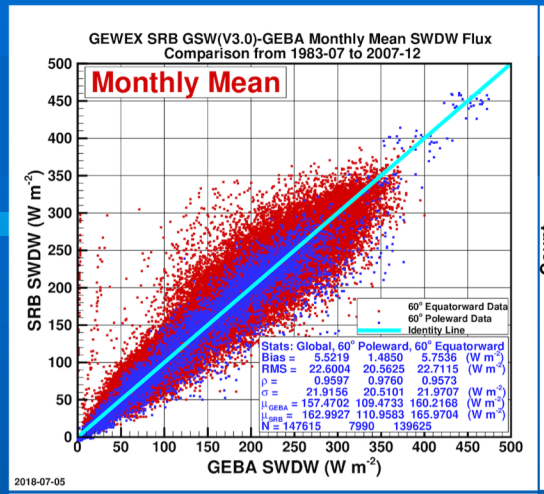
- **WRDC has *daily* means**
- **GEBA has only *monthly* means**

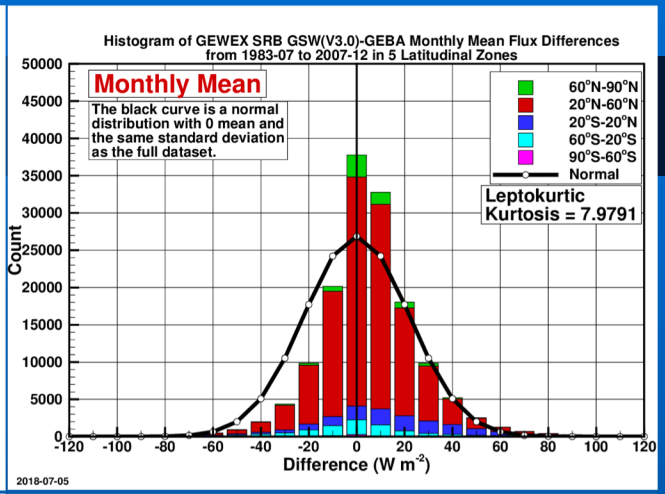




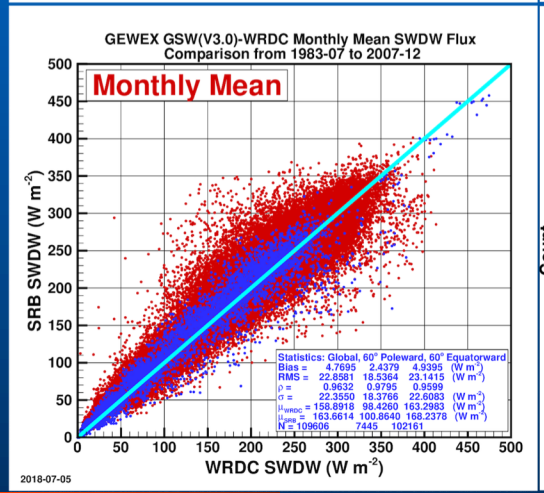


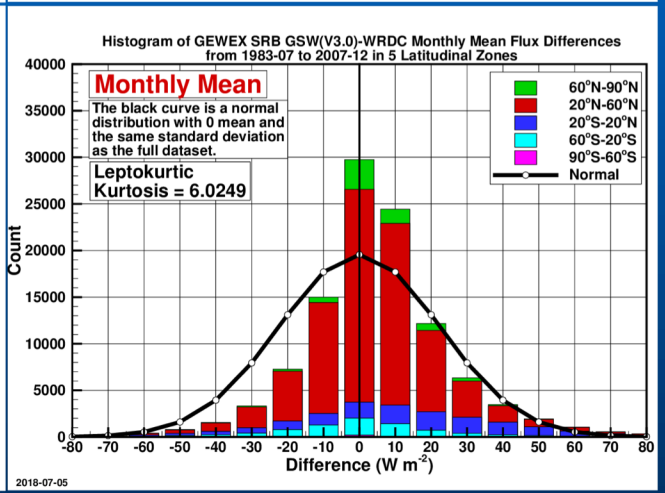
GEWEX SRB GSW(V3.0)-GEBA Monthly Mean Comparison from 1983-07 to 2007-12





GEWEX SRB GSW(V3.0)-WRDC Monthly Mean Comparison from 1983-07 to 2007-12





GEWEX SRB GSW(V3.0) All-Sky Overall Monthly Mean Comparison Statistics

Comparison	Bias	RMS	ρ	σ	μ_{OBS}	N	Period
GSW-BSRN	-5.58	22.72	0.9730	22.02	170.19	4625	**1992-2007**
GSW-GEBA	5.52	22.60	0.9597	21.91	157.47	130809	**1983-2007**
GSW-WRDC	4.76	22.85	0.9632	22.35	158.89	109606	**1983-2007**
GSW-PMEL	11.07	19.00	0.9074	15.44	238.21	1644	**2000-2007**

ρ: correlation coefficient;
σ: standard deviation of differences;
μ_{OBS}: mean of surface-based observations;
N: number of data points.

*Units of Bias, RMS, σ and μ: W m^{-2}

The Ground-Based RadFlux Clear-Sky Data Derived from BSRN Data

The RadFlux algorithm subjects high temporal resolution (1- to 5-minute data) regularly observed data to 4 tests to identify clear-sky episodes which are then fit to exponential functions of cosine of the Solar Zenith Angle:

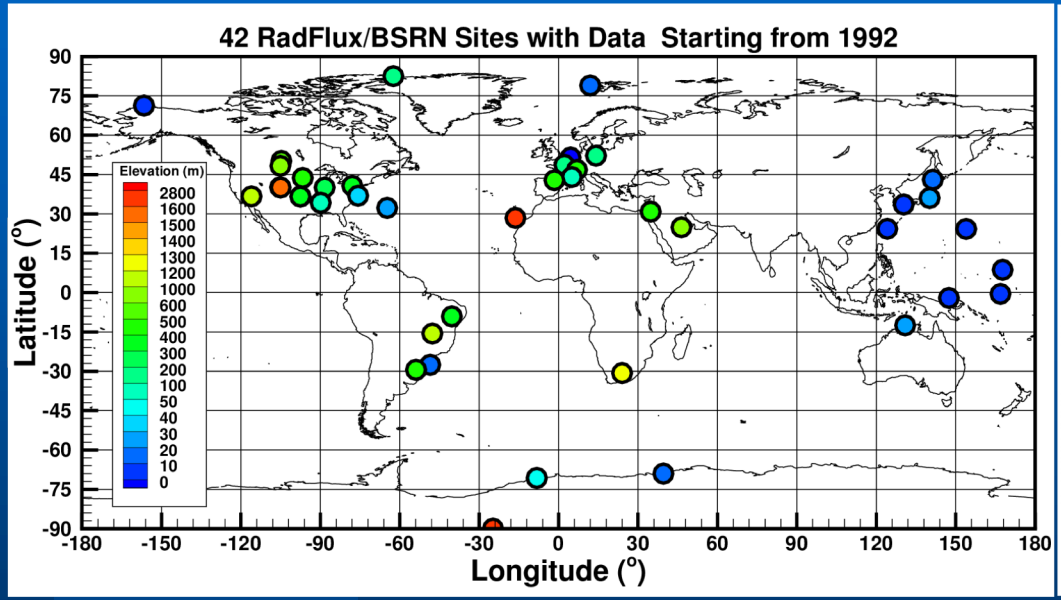
1. A normalized total shortwave magnitude test;
2. A maximum diffuse shortwave test;
3. A rate of change of magnitude test; and
4. A normalized diffuse ratio variability test.

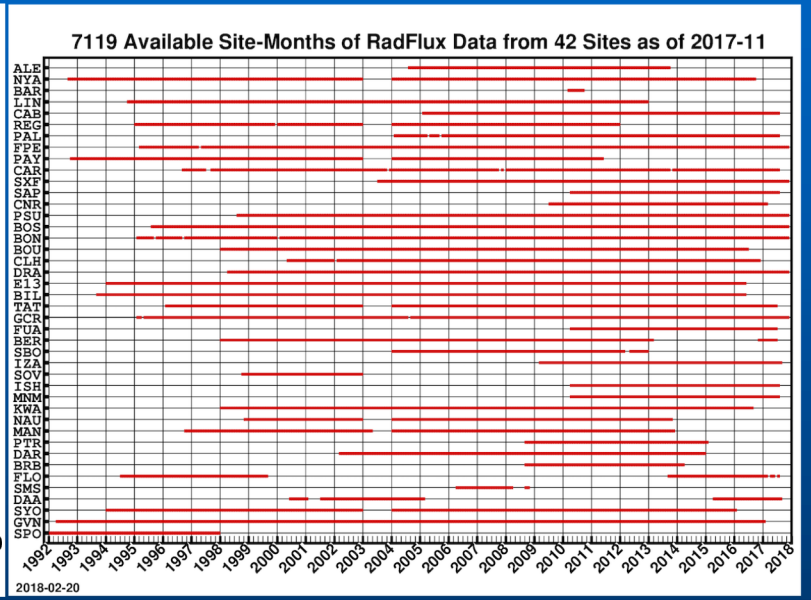
References

Long C.N., Ackerman T.P. Identification of clear skies from broadband pyranometer measurements and calculation of downwelling shortwave cloud effects. J Geophys Res 2000; 105(D12): 15609-26.

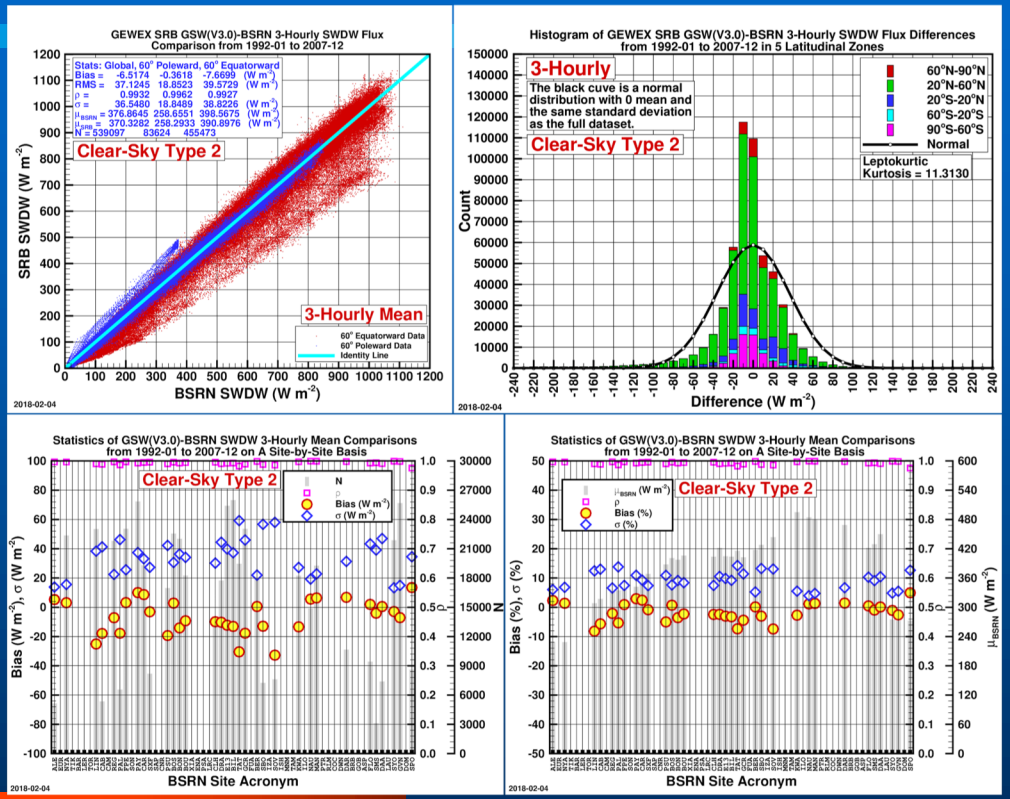
Long C.N., Gaustad K.L. The shortwave (SW) clear-sky detection and fitting algorithm: Algorithm operational details and expressions 2004; DOE/SC-ARM/TR-004.1.

The 42 RadFlux Clear-Sky Data Sites and Available Site-Months as of 2017-11

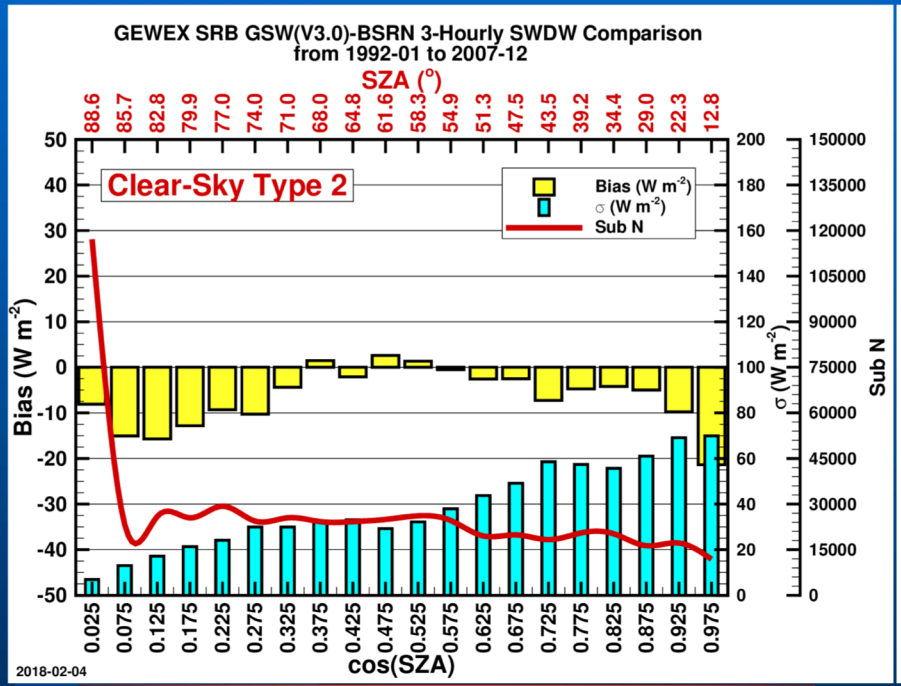


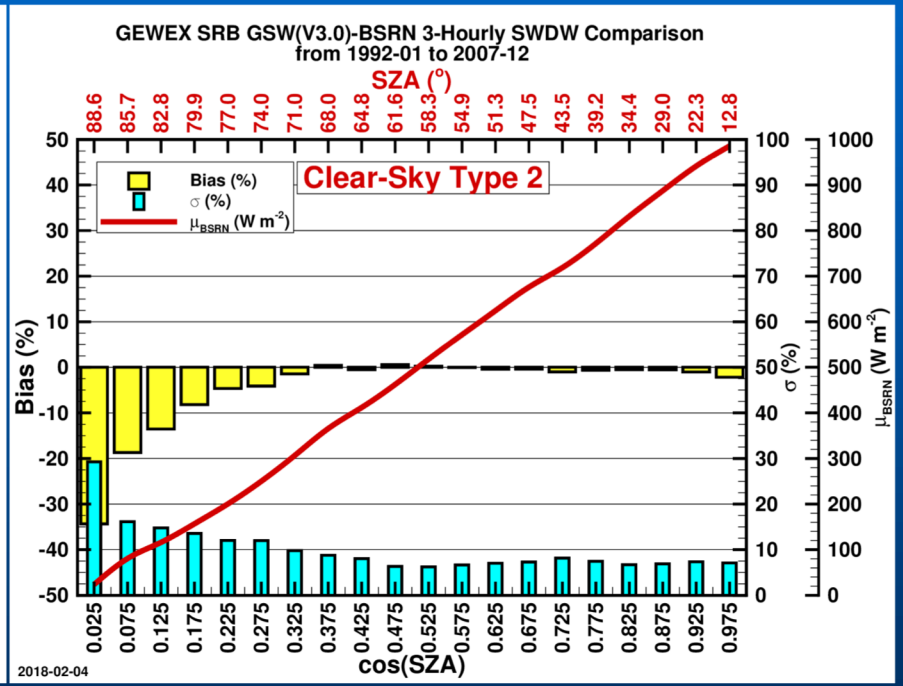


GEWEX SRB GSW(V3.0)-RadFlux *3-Hourly* Mean Clear-Sky SW Downward Flux Comparison for the Period 1992-2007

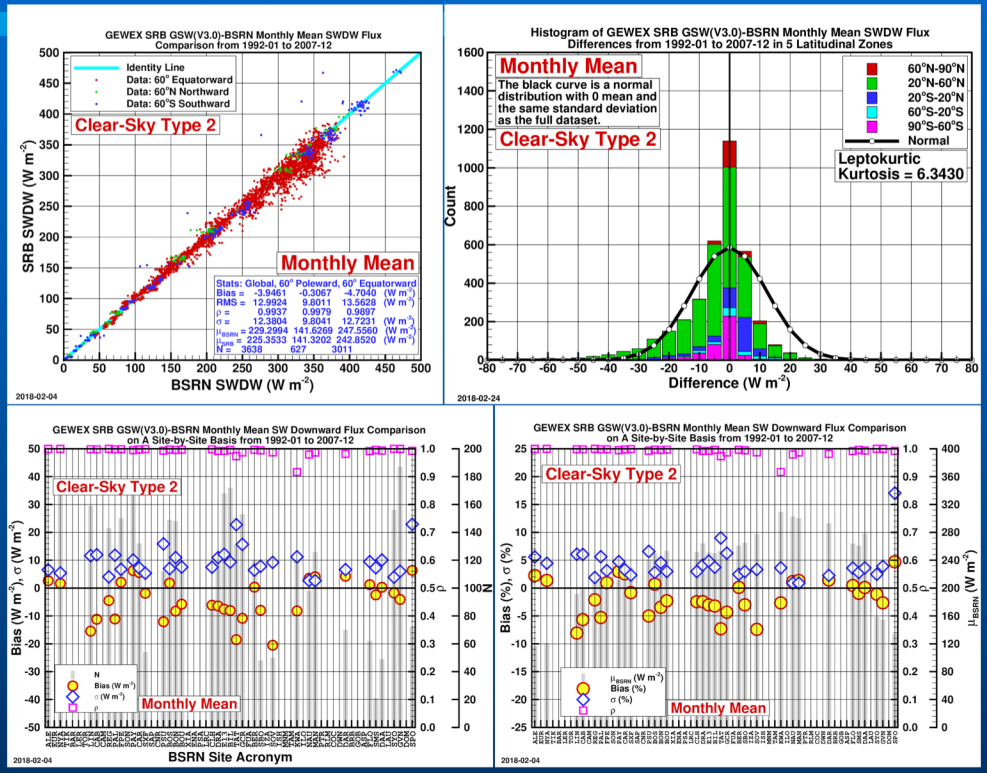


GEWEX SRB GSW(V3.0)-RadFlux *3-Hourly* Mean Clear-Sky SW Downward Flux Comparison for the Period 1992-2007 in 0.05-Sized Bins of cos(SZA)





GEWEX SRB GSW(V3.0)-RadFlux *Monthly* Mean Clear-Sky SW Downward Flux Comparison for the Period 1992-2007

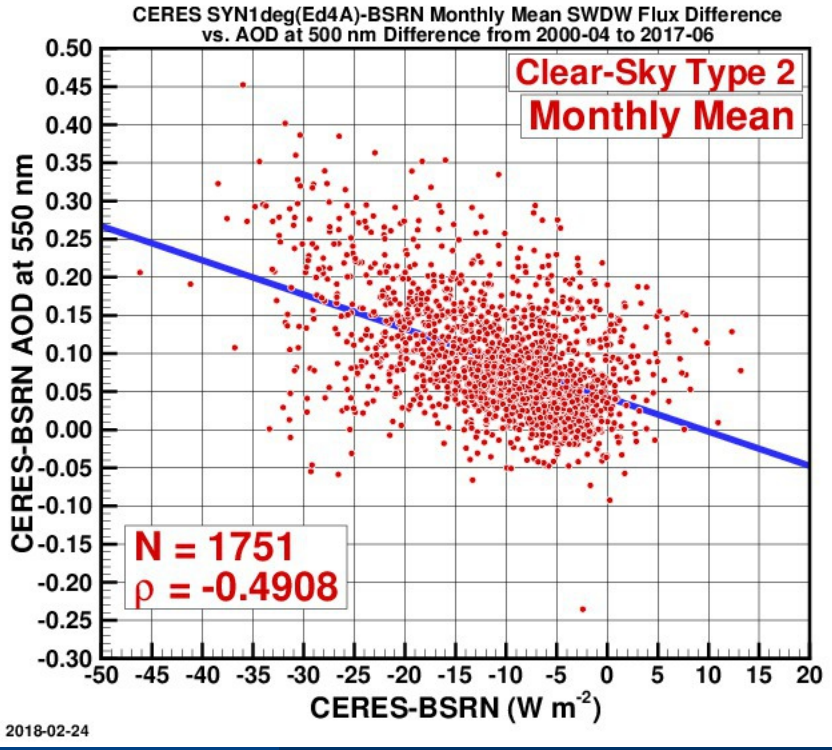


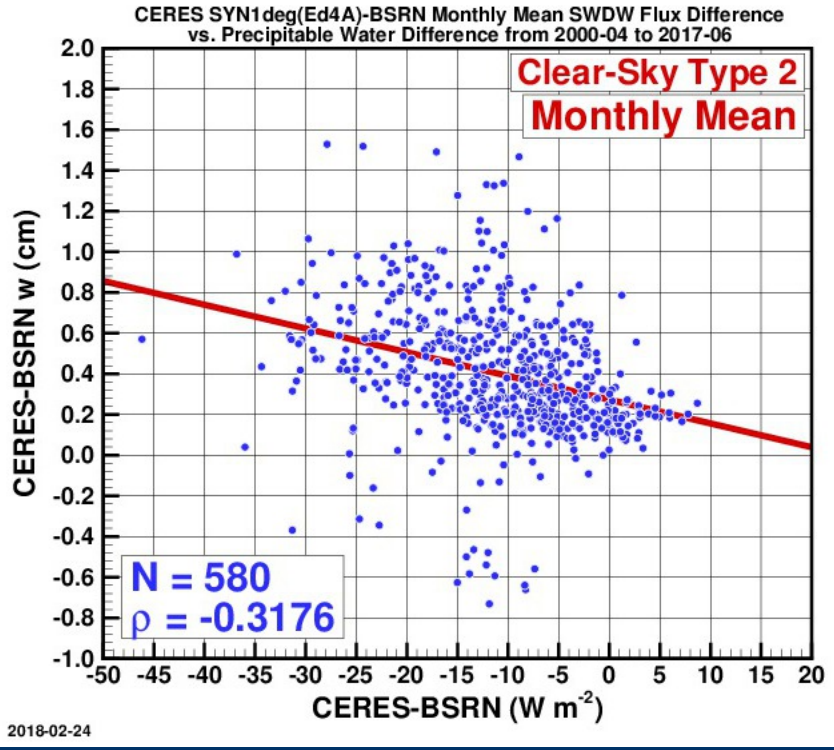
Intercomparison between GSW(V3.0), CERES SYN1deg(Ed4A) and CERES EBAF(Ed4.0) as against RadFlux Clear-Sky Fluxes from 2000-04 to 2007-12

Dataset	Bias	RMS	ρ	σ	μ_{DATA}	N
GSW(V3.0)	-5.29	12.59	0.9941	11.42	232.96	2347
SYN1deg(Ed4A)	-9.43	13.27	0.9966	9.33	228.82	2347
EBAF(Ed4.0)	-7.61	12.23	0.9963	9.57	230.65	2347

- Units of Bias, RMS, σ and μ_{DATA}: W m^{-2}

SYN1deg(Ed4A)-BSRN Clear-Sky SW Downward Flux Difference vs. Their AOD at 550 and Precipitable Water Counterparts





Changes in SW Algorithm from Rel. 3.0 to Rel. 4.0-IP

Rel. 3.0 Algorithm	Rel. 4.0-IP Algorithm
Shortwave bands: 5	Shortwave bands: 18
Assumed liquid clouds	Ice clouds added to look-up tables
Surface spectral albedo derived and incorporated into the surface albedo model of Briegleb et al. (1986) using 5 surface types from Mathews (1985)	First, new expanded albedo from MODIS and ASTER; later, plus spectral albedo of the ocean (Jin, 2004), and of snow and ice
Constant Aerosol compositions for land and ocean	Variable single-scattering albedo (SSA) and asymmetry (ASY)
2-stream Delta-Eddington based lookup tables for water clouds and assumed aerosol SSA and ASY	Lookup tables fully recalculated using the Fu-Liou radiative transfer code as used in CERES products

Changes in Inputs from Rel. 3.0 to Rel. 4.0-IP

Algorithm	Water Vapor	Aerosol	Cloud/Radiance	Solar Irradiance	Ozone
Rel. 3.0	GEOS-4	MATCH	ISCCP DX	1367 W m^{-2}	Blend of TOMS, TOVS, OMI and SMOBA
Rel. 4.0-IP	nnHIRS(201509)	• MAC-v1 Monthly • MAC-v1 Daily	ISCCP HXS(V1)	1361 W m^{-2} (SORCE/TIM v17; Kopp and Lean, 2011)	Blend of TOMS, TOVS, OMI and SMOBA

- GEOS: Goddard Earth Observing System;
- nnHIRS: neural network High resolution Infrared Radiation Sounder;
- MAC: Max-Planck Aerosol Climatology;
- ISCCP HXS: International Satellite Cloud Climatology Project High-resolution piXel-level Single-satellite;
- Preliminary GSW(V4.0-IP) spans the 12-year period 1998-2009.

Intercomparison between Preliminary GSW(V4.0-IP)-BSRN and GSW(V3.0)-BSRN Comparison Statistics from 1998-2007

	Bias	RMS	ρ	σ	μ_{SRB}	N
3-Hourly	-2.54	79.55	0.9576	79.51	286.11	524571
	-7.67	86.98	0.9499	86.64	281.55	522540
Daily	-1.61	31.49	0.9554	31.45	172.56	107252
	-4.55	34.72	0.9466	34.42	169.63	107252
Monthly	-1.36	14.86	0.9867	14.80	170.61	2494
	-3.74	17.72	0.9817	17.32	168.22	2494

RED: Preliminary GSW(V4.0-IP)
BLUE: GSW(V3.0)

- Units of Bias, RMS, σ and μ_{SRB}: W m^{-2}

Intercomparison between Preliminary GSW(V4.0-IP)-PMEL and GSW(V3.0)-PMEL Comparison Statistics from 2000-2007

	Bias	RMS	ρ	σ	μ_{SRB}	N
3-Hourly	1.76	94.95	0.9565	94.94	389.08	201514
	15.60	94.48	0.9601	93.18	403.10	201416
Daily	1.05	34.32	0.8366	34.30	241.71	39198
	9.66	34.47	0.8523	33.08	250.33	39198
Monthly	0.64	12.69	0.9329	12.68	241.47	1238
	9.38	15.53	0.9368	12.37	250.21	1238

RED: Preliminary GSW(V4.0-IP)
BLUE: GSW(V3.0)

- Units of Bias, RMS, σ and μ_{SRB}: W m^{-2}

Summary and Conclusions

- The GEWEX SRB Rel. 3.0 covers mid-1983 to 2007; with improved algorithm and newly available ISCCP and other inputs, Rel. 4.0-IP continues the temporal coverage with overlapping years; the preliminary GSW(V4.0-IP) results, the latest development of GEWEX SRB shortwave algorithm, spans 1998-2009;

- Compared with CERES SYN1deg(Ed4A) and EBAF(Ed4.0), GEWEX SRB GSW(V3.0) has the smallest bias against RadFlux clear-sky fluxes, but EBAF(Ed4.0) has the highest correlation and smallest standard deviation of error;

- The systematic negative bias of clear-sky SW downward fluxes could be partly explained by the systematically lower moisture and aerosol loads as observed at BSRN sites, although the observations are limited. CERES literature also indicates that satellite observations can sometimes miss the presence of clouds and misidentify slightly cloudy sky as clear;

- Over the land, the preliminary GSW(V4.0-IP) agree with BSRN appreciably better;

- Over the oceanic tropics, the magnitude of the preliminary GSW(V4.0-IP)-PMEL bias decreased significantly;

- FUTURE WORK: Assess cloud radiative effect using RadFlux data; compare CERES and SRB(Rel. 3.0, Rel. 4.0) data with RadFlux data.

Thank you!

For More Information about GEWEX SRB:

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

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Extras