The GEWEX Radiative Flux Assessment Project: Status

CERES Scicence Team Meeting

2-5 November 2009

Paul Stackhouse (NASA LaRC)

Oversite Committee: Atsumu Ohmura (ETH), Ehrhard Raschke (U. of Hamburg), William Rossow (NASA GISS), Paul Stackhouse (NASA LaRC) and Bruce Wielicki (NASA LaRC)

~75 assessment participants (TOA, surface, and both)

Local Contributors: Lin Chambers (LaRC), Takmeng Wong (LaRC), Laura Hinkelman (NIA), J. Colleen Mikovitz (SSAI), Taiping Zhang (SSAI), Atmospheric Science Data Center

GEWEX-RFA: Status Overview

- Purpose and Introduction
- Review web site status
- Review data set inventory
- Preliminary Results
- Next Steps

Radiative Flux Assessment Overview

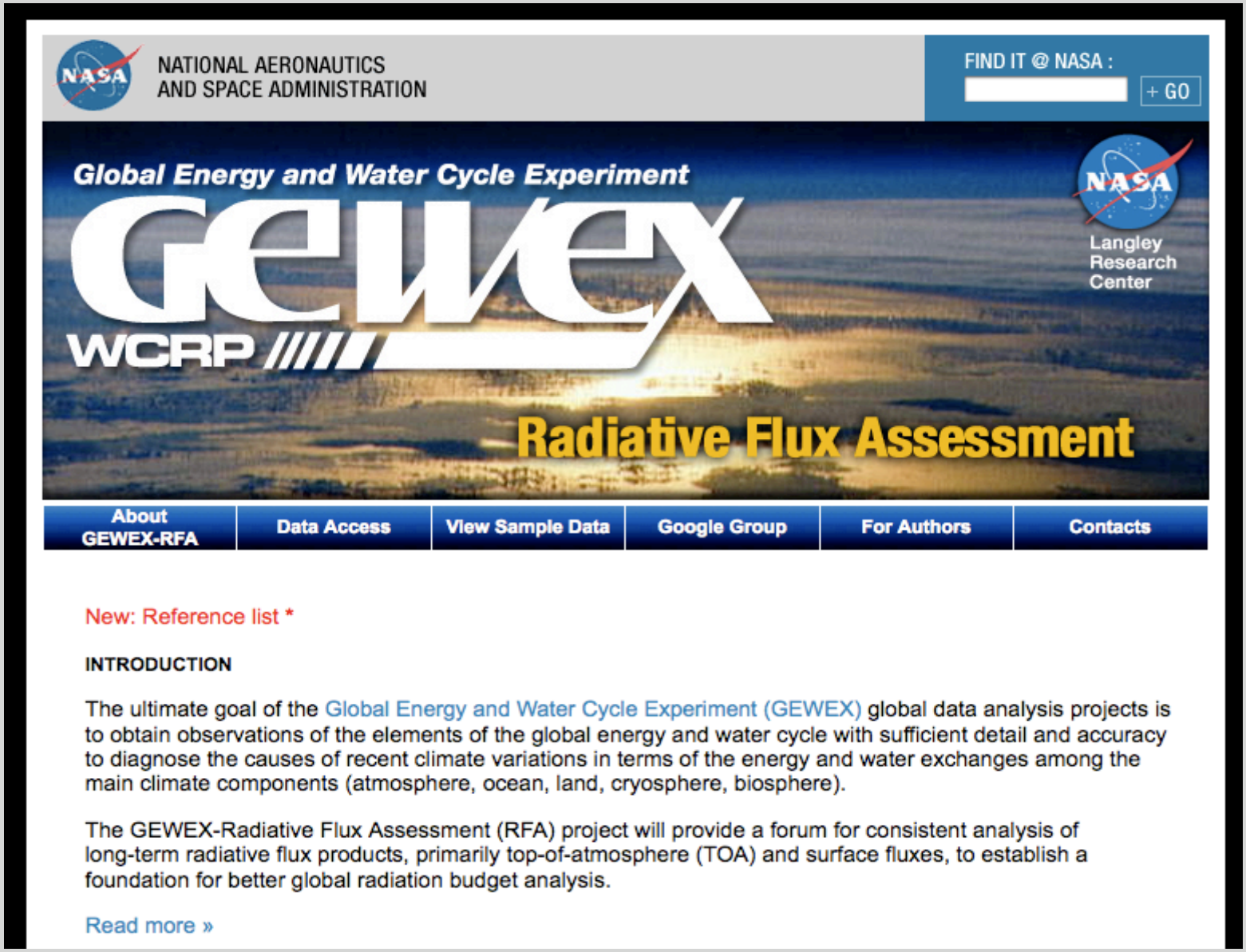
- **Purposes:**
  - **Assess our current understanding and capability to**
    - ***derive TOA and surface radiative fluxes from analysis of satellite observations***
    - ***validate these fluxes with surface observations***
    - ***simulate these fluxes with models and assimilation***
  - **Assess uncertainties and outstanding issues in flux estimation, particularly long-term variability**
    - ***sources include satellite calibration, input data sources, and assumptions (particularly in regards to spatial and temporal gap filling)***
    - ***Compare surface fluxes to surface based measurements***
    - ***intercompare existing data products***
    - ***identify largest uncertainties and needs***
  - **Report methods and uncertainties to be useful for future IPCC reports on long-term data uncertainty.**
  - **Develop climate system observation requirements for radiative fluxes and compare to current product accuracies.**
  - **Assess GCM and reanalysis products.**

GEWEX RFA Activities to Date

- 1st Workshop held (Oct. 2004 - Zurich, Switzerland)
  - Discussed issues & developed pieces of draft document
  - Assigned TOA and surface groups
- Draft Document Outline
  - Proposed intercomparison activities
- 2nd Workshop held (Feb. 2006 - Williamsburg, VA)
  - Refined document outline & surface/TOA actions and goals
  - Assigned authors
- Web Site (Rel. 1.2) Now Operational
  - Includes document framework
  - Datasets ingested and ready for analysis
- 3rd Workshop held (June 2007 - New York City, NY)
  - Results discussed
  - Preliminary conclusions discussed relevant to document
- Collecting and Editing Document Chapter/Sections
  - Most chapters/sections submitted; editing beginning
  - Work continuing for analysis/writing/assembly of report

GEWEX-RFA Site

(http://gewex-rfa.larc.nasa.gov/)



Data Access Web Page

(http://eosweb.larc.nasa.gov/GEWEX-RFA/)

ATMOSPHERIC SCIENCE DATA CENTER

GEWEX Radiative Flux Assessment

NOTICE: Our systems recently underwent significant changes. Please report any problems you encounter to larc@eos.nasa.gov.

The ultimate goal of the Global Energy and Water Cycle Experiment (GEWEX) global data analysis projects is to obtain observations of the elements of the global energy and water cycle with sufficient detail and accuracy to diagnose the causes of recent climate variations in terms of the energy and water exchanges among the main climate components (atmosphere, ocean, land, cryosphere, biosphere). The GEWEX Radiative Flux Assessment (RFA) project will provide a forum for consistent analysis of long-term radiative flux products, primarily top-of-atmosphere (TOA) and surface fluxes, to establish a foundation for better global radiation budget analysis.

Data access is restricted to assessment participants until the data are made publicly available (currently anticipated to be May 2007). To access the interim data you need an ASDC user account and approval from the LaRC GEWEX-RFA organizing committee. Join the assessment team.

GEWEX-RFA Home Page | Data Provider Instructions | File Conventions | List of Participants

Top of Atmosphere (TOA) Data Products	Surface Data Products	Ground-Based Measurements
• Maps • Time Series • Hovmöller Diagrams • High Time/Space Resolution	• Maps • Time Series • Hovmöller Diagrams • High Time/Space Resolution	• Time Series • Chuck Long's Derived Parameters (RFA FTP site)

Note: The data files provided here are subsets of larger data sets. Links to the full data archive for each product can be found in the corresponding product description files.

Acknowledgement

The GEWEX-RFA data products should not be used in publications while the assessment is underway. After the assessment has been completed, when data from the GEWEX Radiative Flux Assessment are used in a publication, we request the following acknowledgment be included: "*The GEWEX Radiative Flux Assessment data were obtained from the NASA Langley Research Center Atmospheric Science Data Center.*" In addition, the provider of each data set used should be specifically acknowledged. See the product description file(s) for details.

View Cart | ASDC Home Page | Join GEWEX-RFA News List | Questions/Feedback

Responsible NASA Official: John M. Kusterer
Site Administration/Help: NASA Langley ASDC User Services (larc@eos.nasa.gov)
[Privacy Policy and Important Notices]
Last Updated: Fri Aug 17 2007 12:11:19 GMT-0400 (EDT)

GEWEX-RFA Data Archive

To date, data have been submitted from:

- ASRB (Swiss surface radiation measurements)
- U. Oregon Surface Sites (>20 years)
- BSRN (Baseline Surface Radiation Network)
- CAVE (CERES-ARM Validation Experiment web site)

Also non-standard surface data from Chuck Long.

- CERES (ERBE-like, SRBAVG, SRBAVG-GEO and EBAF)
- DLR ISIS (ISCCP based SW TOA and Surface fluxes)
- ERBE (ERBES - TOA SW, LW and Net Fluxes)
- FORTH (TOA, Surface SW, LW from ISCCP D1)
- HIRS IR (OLR only)
- ISCCP-FD (TOA, Surface, SW and LW fluxes)
- ScaRaB (TOA SW and LW fluxes)
- NASA/GEWEX SRB (ISCCP TOA, Surface SW and LW fluxes)
- U. Maryland SRB (Z. Li and R. Pinker - ISCCP/MODIS SW)
- GFDL CM 2.1 (Surface, SW and LW fluxes)
- NCEP R2 and ERA-40 (TOA, Surface, SW and LW fluxes)
- AR4 models runs for IPCC

GEWEX-RFA Results To Date

- Smith et al., 2006: ERB calibration intercomparison
- Raschke et al., 2006, GRL: SRB, ISCCP TOA comparison
- Zhang et al., 2006a,b: Near-surface meteorological and radiative properties
- Wong et al, 2006 => ERBE, HIRS, ISSCP-FD time series
- Loeb et al. (JClim, 2007): CERES/Terra vs. ISCCP-FD, CERES/Terra vs. SeaWiFS PAR, and CERES/Terra vs. CERES/Aqua; CERES EBAF (Loeb et al., 2008)
- SRB/CERES/ISCCP teams: Various intercomparisons
- Roesch et al. (not published): Sensitivity of monthly averages to treatment of data gaps
- Hinkelman et al.: Preliminary time series analysis
- Freidenreich: GFDL model results vs. ISCCP-FD/SRB
- Schaaf: Surface albedo studies
- Kinne and Raschke: comparisons to AMIP runs;

GEWEX-RFA Draft Report Website

No.	Section	Responsible Author	Report Status	Dataset Status
1.0	Executive Summary	Assessment leads	At end	
2.0	Introduction	Chapter Lead: Rossow		
2.1	Assessment Objectives	Rossow (with Wielicki, Stackhouse, Raschke, Ohmura)		
2.2	Observation System Requirements	Rossow (with Wielicki/Stackhouse)		
3.0	Incoming Solar Radiation at TOA	Chapter Leads: Raschke with Kopp	V002 Draft	
4.0	Long-Term TOA Flux Data Product Comparisons	Chapter Leads: Wielicki and Rossow		
4.1	Spatial Climatological Averages (Maps)	Wong		
4.1.1	Long-Term Averages	Wong	Draft	
4.1.2	Long-Term Seasonal Averages	Wong		
4.2	Temporal Variability	Hinkelman		
4.2.1	Monthly Time Series Variability: Global Land/Ocean, Zonal Land/Ocean	Wong & Hinkelman		
4.2.2	Annual Cycle Variability: Global Land/Ocean, Zonal Land/Ocean	Wong & Hinkelman	Draft	
4.2.3	Time Series at Selected Surface Sites	Rossow (ISCCP), Rutan (CERES), Stackhouse (SRB)		
4.3	High Time/Space Resolution Comparisons: June and July 2004	Richard Bantges	Draft	
4.4	Error Budget at Varying Time and Space Scales	Loeb	Draft	
5.0	Long-Term In-Situ Surface Flux Data Product Comparisons	Chapter leads: Dutton		
5.1	Measurement Uncertainty Estimates	Dutton	Draft	
5.2	Summary of In Situ Surface Flux Derived Products	Long	Draft	
5.3	Long-Term Surface In Situ Time Series Analysis	Liepert, Wild(?)	Wild Partial Draft (Ohmura, solar irradiance)	
5.4	Surface in-situ measurement needs and issues	Rutan, Dutton	Partial Draft (Ohmura, single site)	

Listing of all sections

Name of each section

Responsible authors

Status of each section

Color coded for easy reading

Archive of all old draft versions

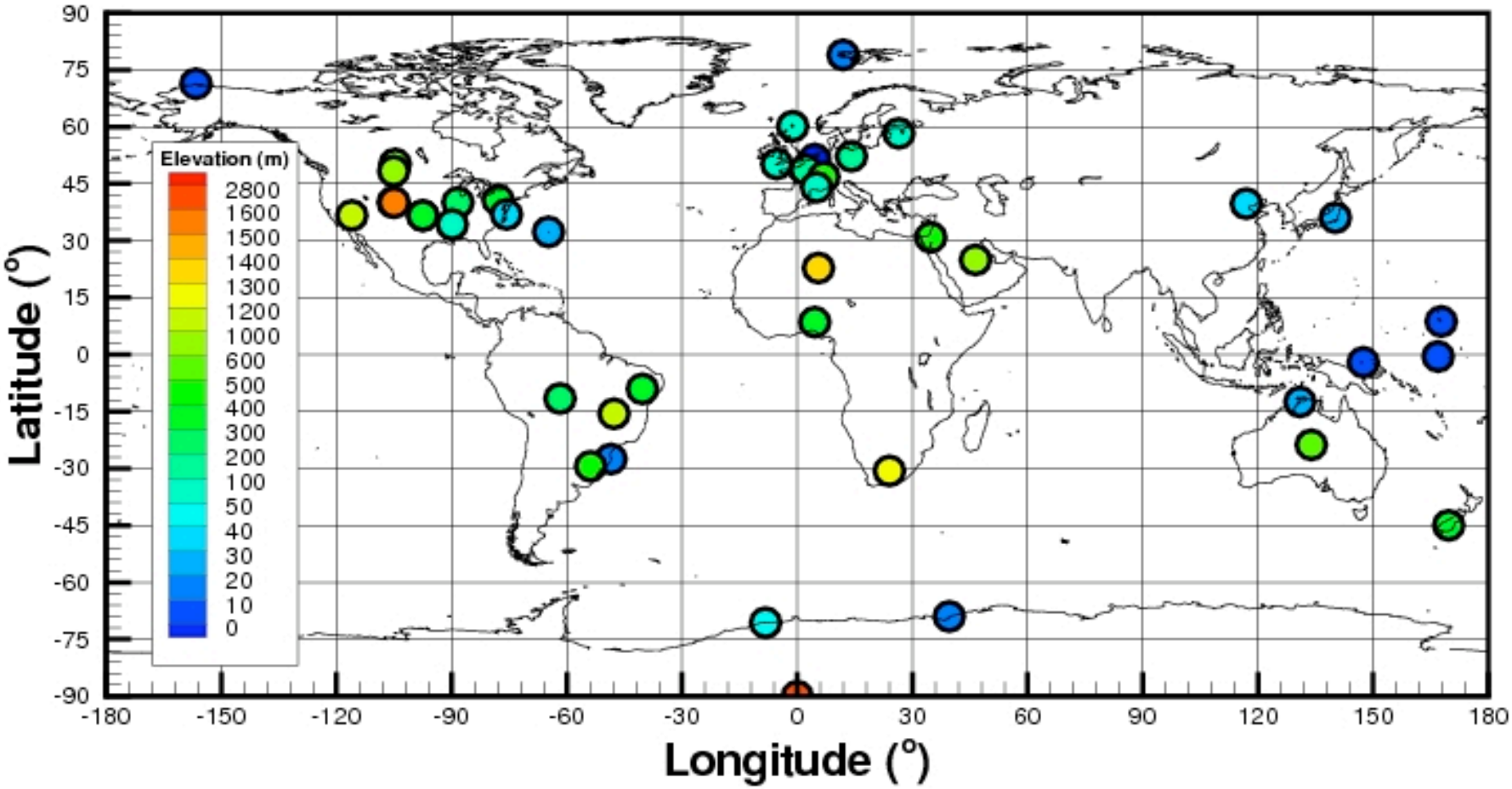
RFA Report Status

Section	Title	Responsible Author(s)	Status
1.0	Executive Summary	TBD	Last
2.0	Introduction	Rossow	Last
3.0	Incoming Solar Irradiance	Raschke and Kopp	V2 Draft
4.0	Long-Term TOA Flux Data Product Comparisons	Wong and Rossow	6 of 9 draft sections
5.0	Long-Term In-Situ Surface Flux Data Product Comparisons	Dutton, Long	4 of 4 draft sections
6.0	Long-Term Satellite Based Surface Flux Product Comparisons	Stackhouse, Wild and Ohmura	5 of 9 draft sections
7.0	Satellite-Estimate Surface vs. In-Situ Measurement Comparisons	Wild	3 of 3 draft sections
8.0	Vertical Column Flux Divergence	Raschke	Draft
9.0	Global Radiation Budget Diagram	Loeb	Draft 100%
10.0	Global Model Comparisons	Raschke, Kinne, Friedenreich	16 of 30 draft sections
A	Data Sets and Uncertainties	Pinker and Dutton	16 of 30 draft sections
B	Radiative Transfer Model Comparisons	Kato	Draft
C	Contributed Papers	Various	4 drafts
D	Lessons Learned	Co-Chairs	draft

Radiative Flux Assessment Next Steps

- Data Analysis
  - Continue analysis of submitted datasets for TOA and Surface fluxes to complete sections
  - Continue evaluation of ingested datasets against surface site data; cross comparisons; different time and space scales - long-time scales emphasized
  - Collection, posting, discussion of analysis results
- Assembly of Radiative Flux Assessment Draft
  - Raschke visited LaRC (9/23 – 10/3)
  - Request participant results and analysis for posting
  - Chapter leads; coordinate analysis; assemble chapters with submitted results
  - Begin cross editing assignments
- Collaborative draft assessment document (Jan, 2010)
- Final document (to follow, 3-4 months?) - meetings and/or teleconferences to be scheduled

43 Baseline Surface Radiation Network (BSRN) Sites with Data Starting from 1992



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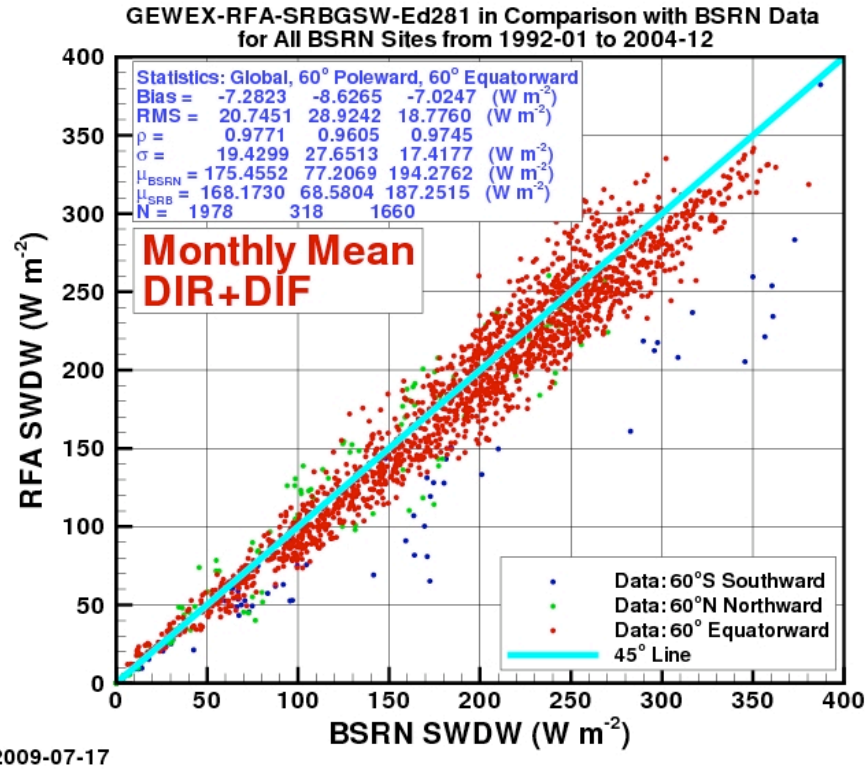
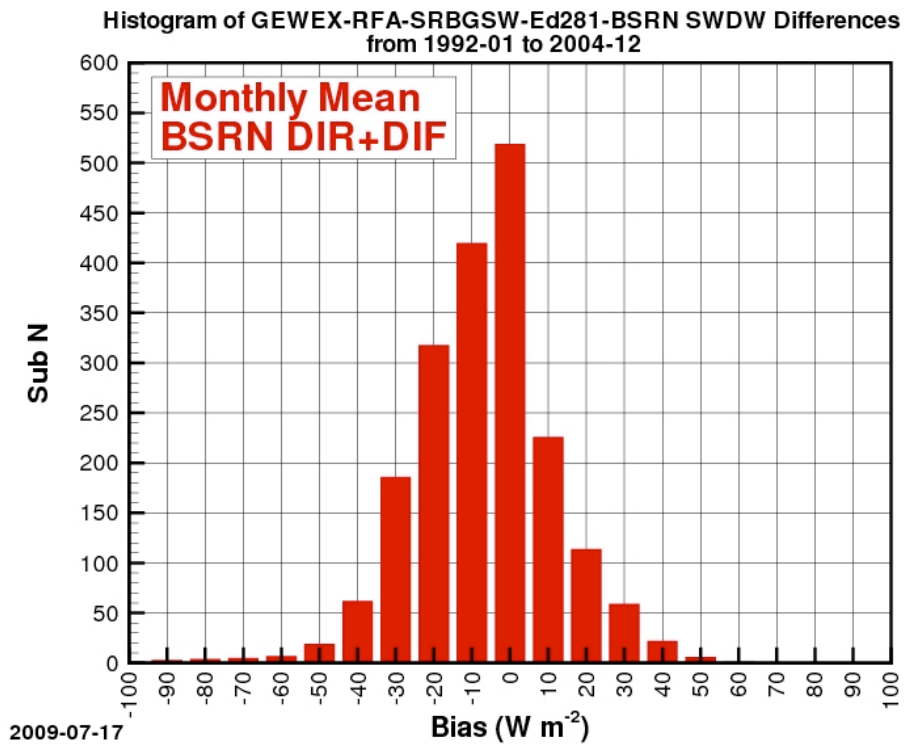
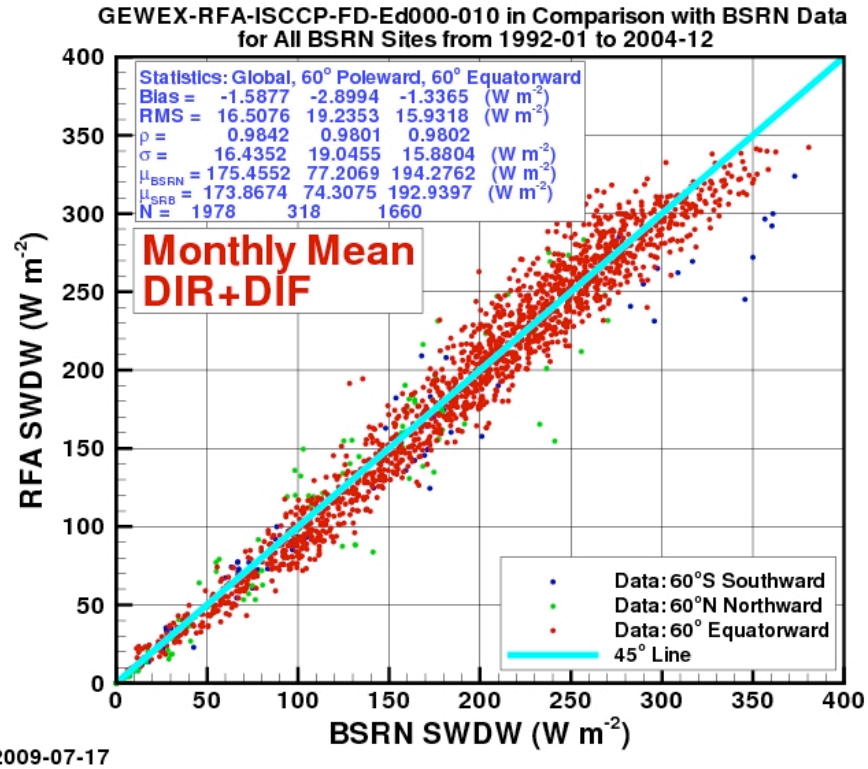


Satellite

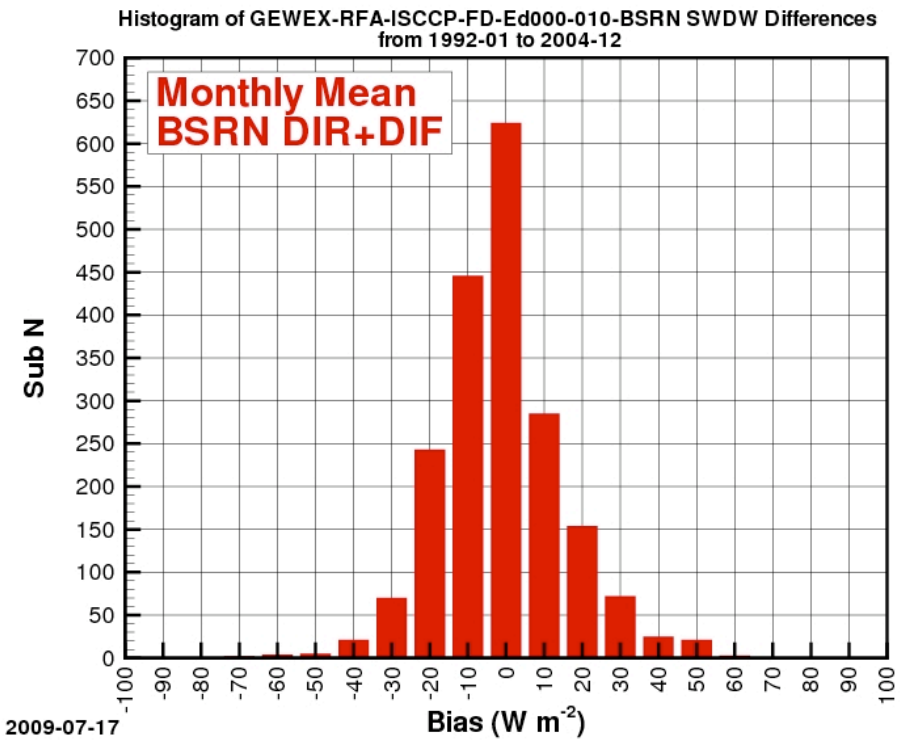
SRBGSW-ED281





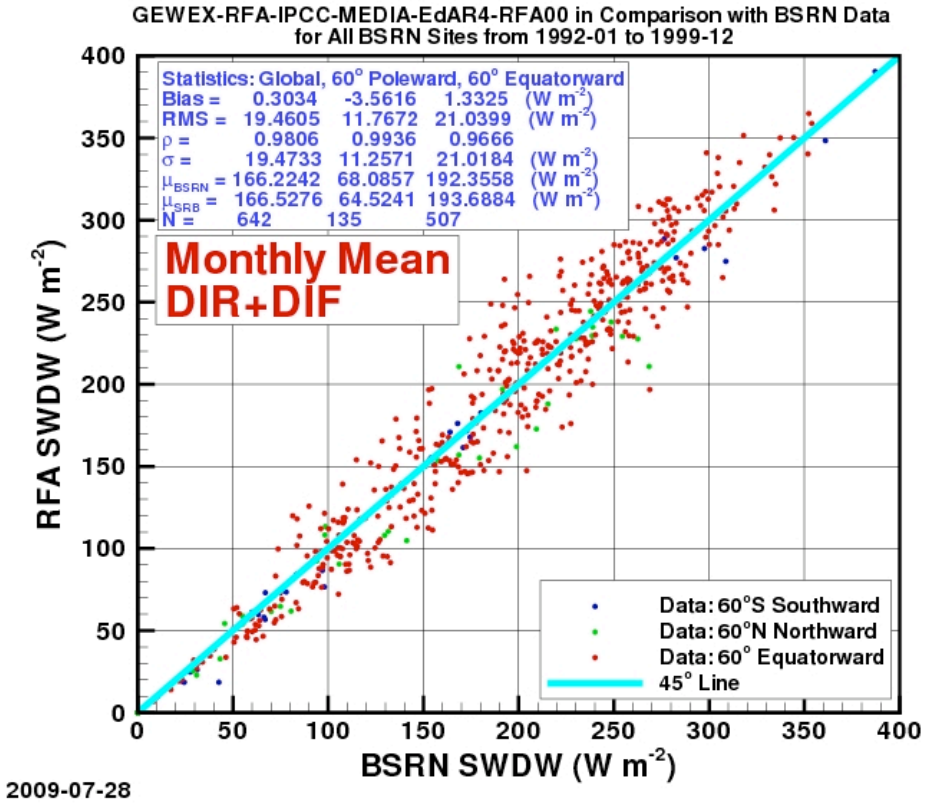
Satellite

ISCCP-FD-Ed000-010

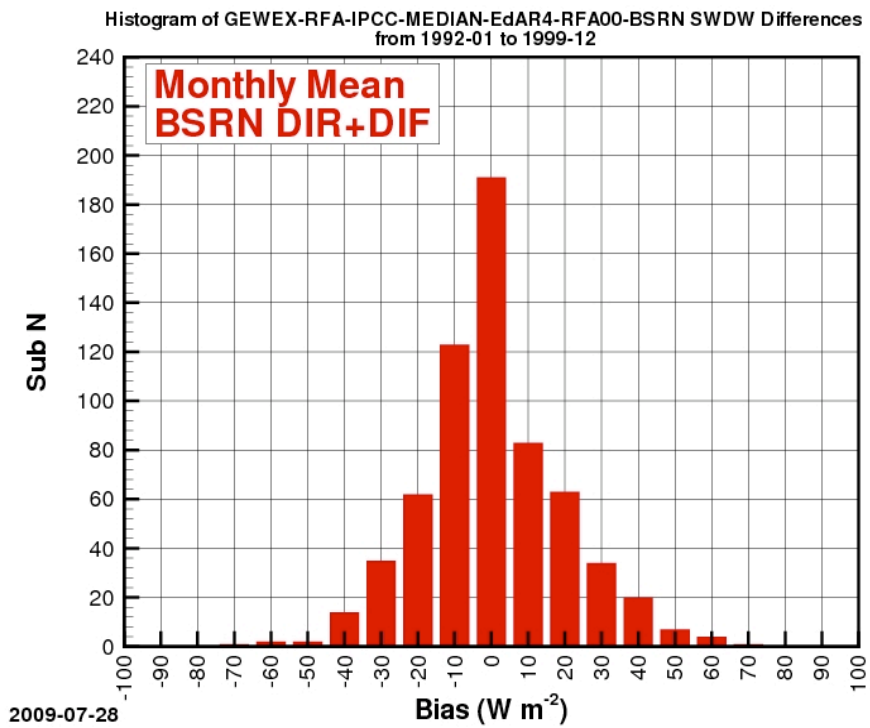


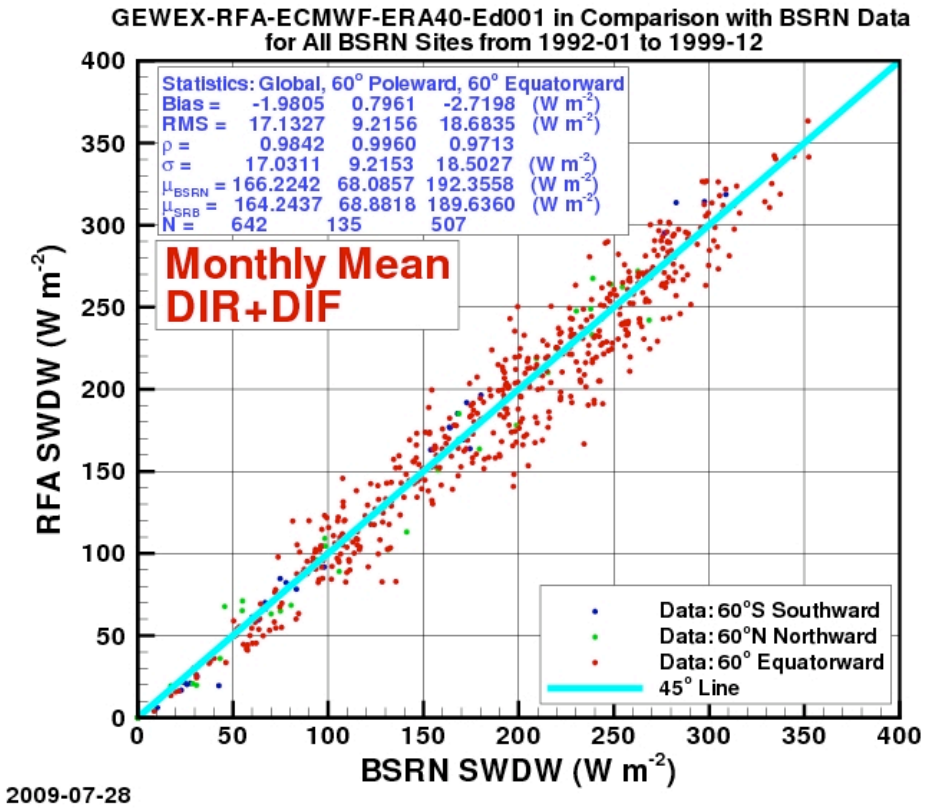
Statistics of GEWEX RFA *Satellite* Data Comparison with BSRN Data

Data Set	Bias (Wm^{-2})	RMS (Wm^{-2})	ρ	σ (Wm^{-2})	N
Sat_DLR_ISIS_Ed001	-1.9211	15.7730	0.9859	15.6596	1978
Sat_FORTH_Ed01a	-14.1678	24.2317	0.9703	19.6637	1811
Sat_GEWEX_SRBGSW_Ed281	-7.2823	20.7451	0.9771	19.4299	1978
Sat_GEWEX_SRBQSW_Ed025	-0.7686	16.8880	0.9830	16.8747	1978
Sat_ISCCP_FD_Ed000_010	-1.5877	16.5076	0.9842	16.4352	1978
Sat_UMD_SRB_Ed033	7.6642	21.6148	0.9791	20.2155	1978

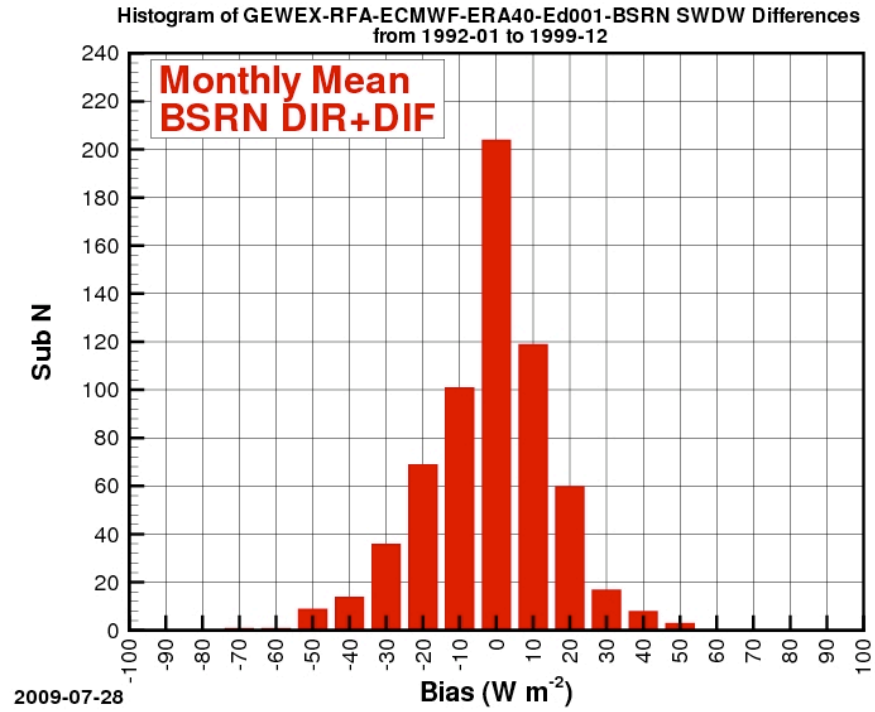


IPCC MEDIAN EdAR4





ECMWF-ERA40-Ed001



Statistics of GEWEX RFA *Reanalysis* Data Comparison with BSRN Data

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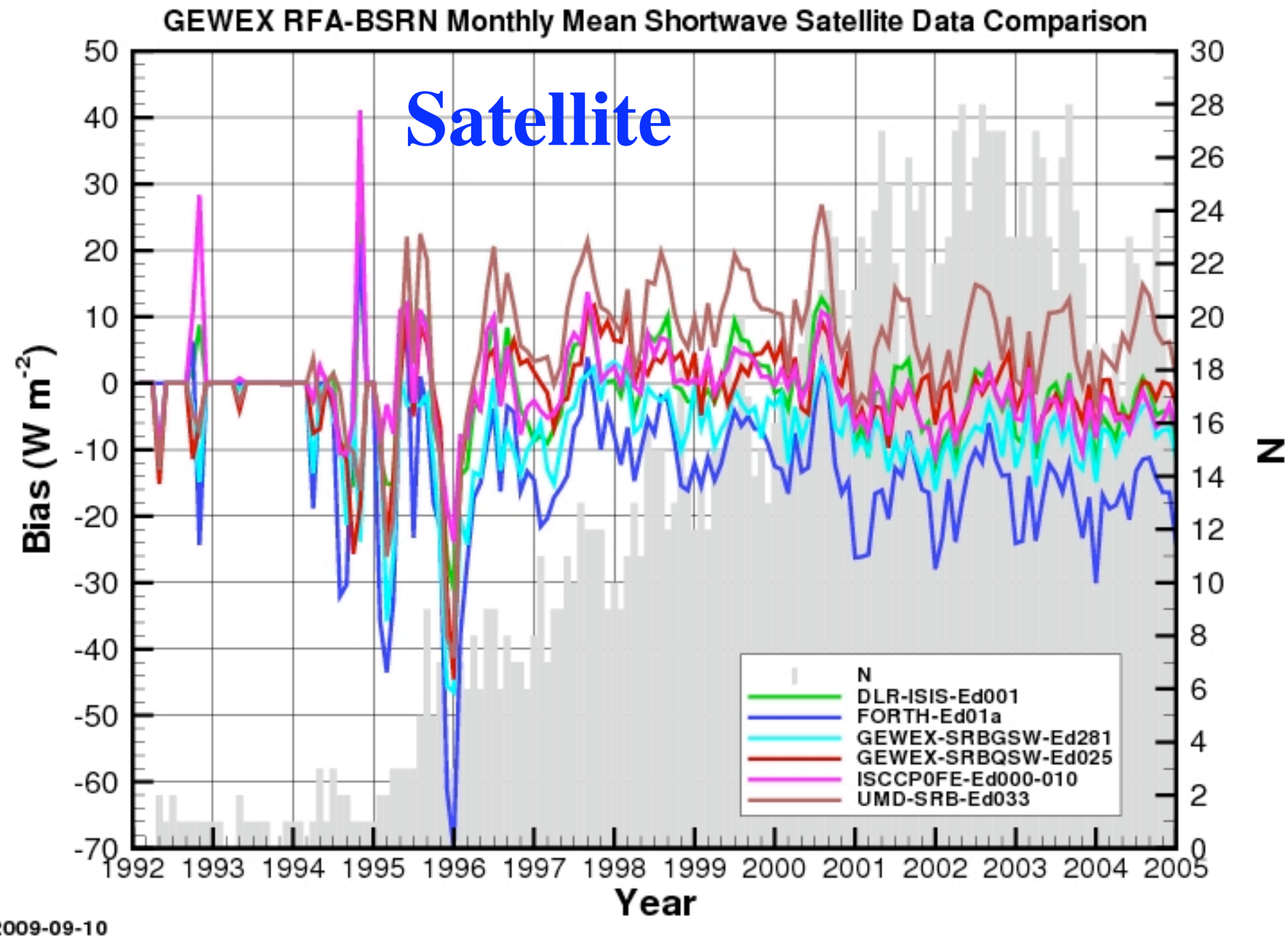
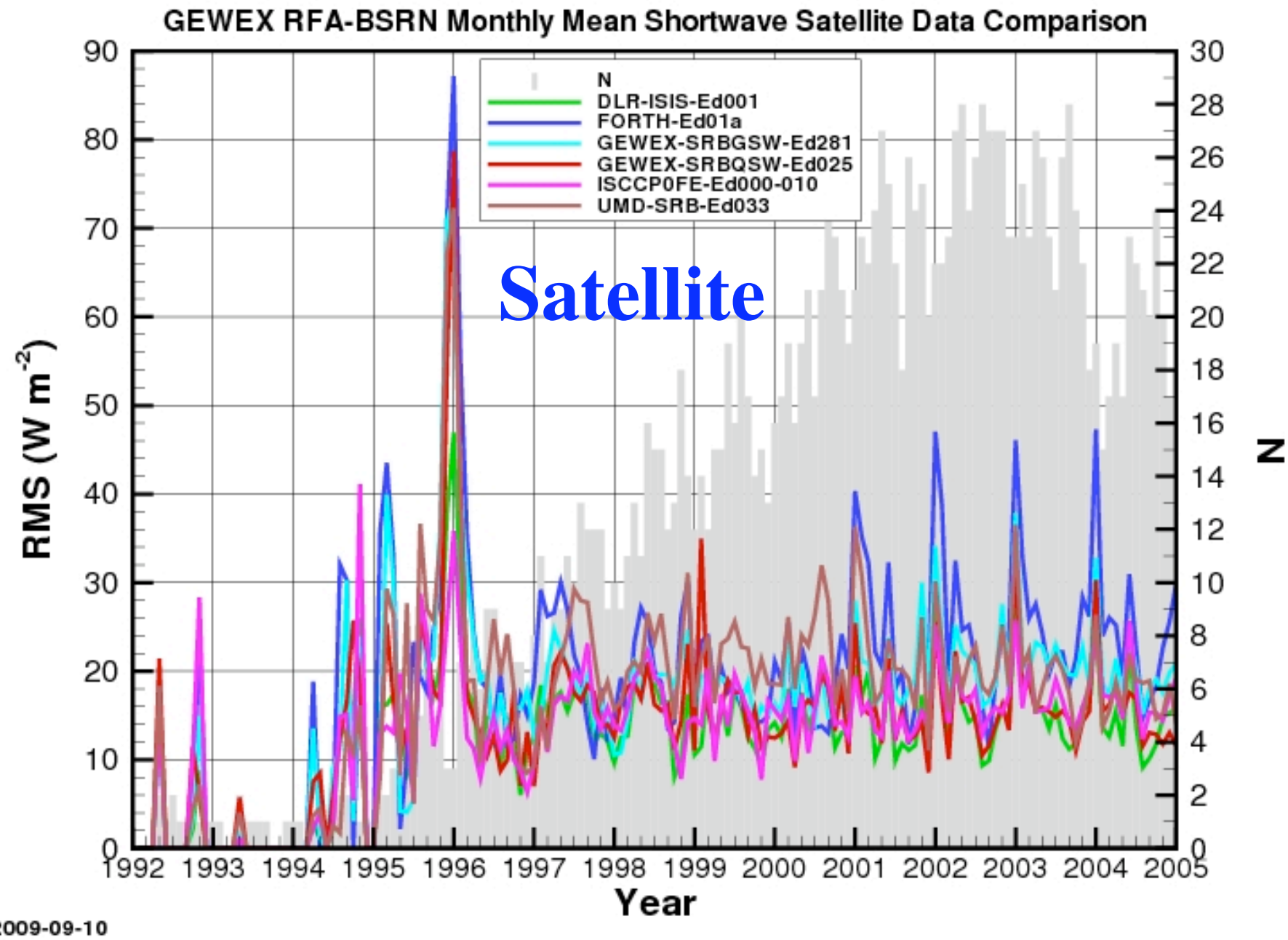
Rea_ECMWF_ERA40_Ed001	-1.9805	17.1327	0.9842	17.0311	642
Rea_GFDLCM2.1_Ed001	-10.8181	26.5905	0.9672	24.3093	642
Rea_IPCC_AVERAGE_EdAR4	-16.3822	25.2508	0.9810	19.2302	642
Rea_IPCC_MEDIAN_EdAR4	0.3034	19.4605	0.9806	19.4733	642
Rea_NCEP_DOE_R2_Ed002	19.1322	33.9217	0.9631	28.0333	642


GEWEX RFA-BSRN Monthly Mean Shortwave Satellite Data Comparison
Satellite
Bias (W m-2)
N
Year
N
DLR-ISIS-Ed001
FORTH-Ed01a
GEWEX-SRBGSW-Ed281
GEWEX-SRBQSW-Ed025
ISCCP0FE-Ed000-010
UMD-SRB-Ed033
2009-09-10


GEWEX RFA-BSRN Monthly Mean Shortwave Satellite Data Comparison
N
DLR-ISIS-Ed001
FORTH-Ed01a
GEWEX-SRBGSW-Ed281
GEWEX-SRBQSW-Ed025
ISCCP0FE-Ed000-010
UMD-SRB-Ed033
Satellite
RMS (W m-2)
N
Year
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16
18
20
22
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26
28
30
1992
1993
1994
1995
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1997
1998
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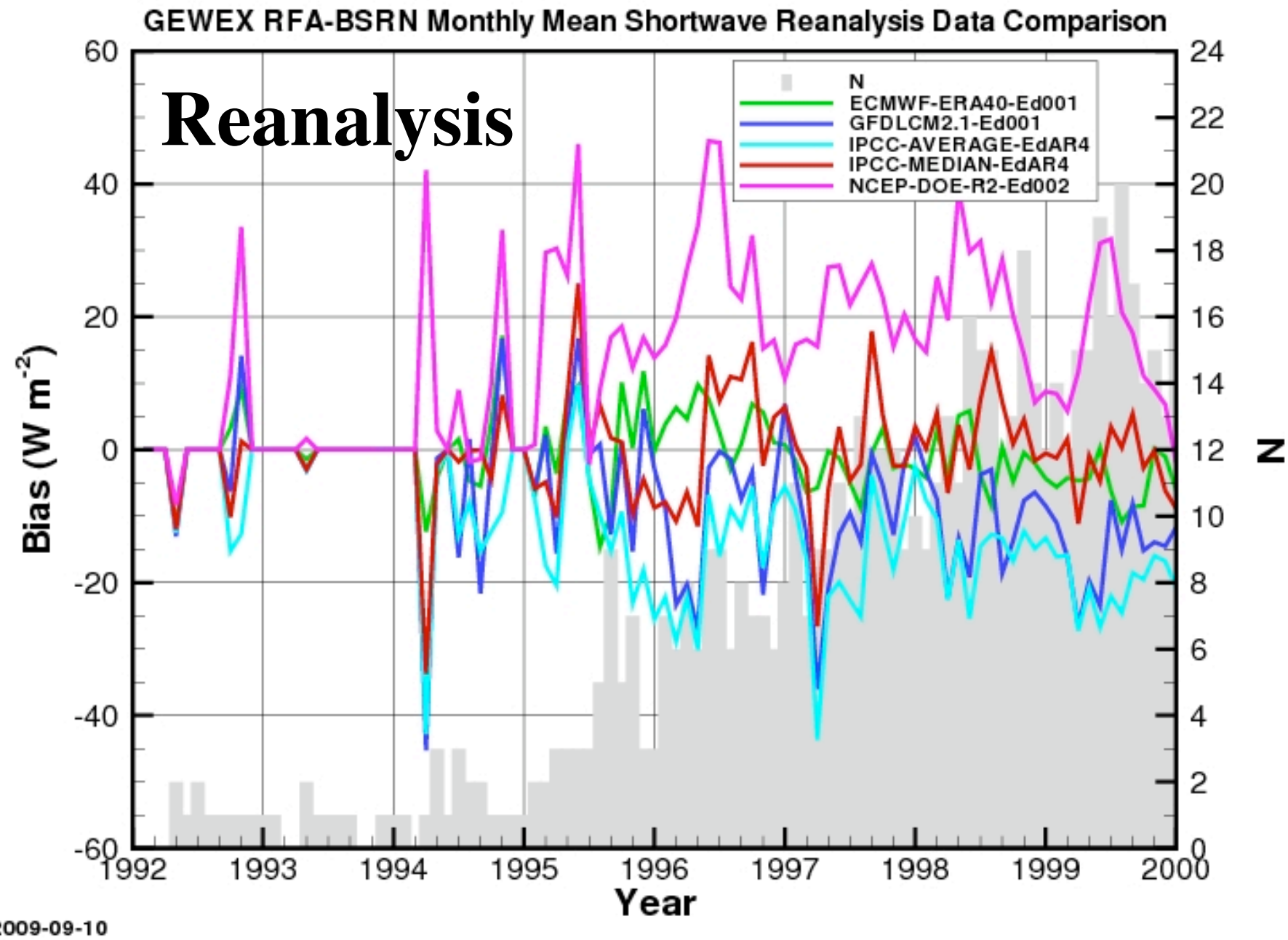
2004
2005
2009-09-10


GEWEX RFA-BSRN Monthly Mean Shortwave Reanalysis Data Comparison
Reanalysis
N
ECMWF-ERA40-Ed001
GFDLCM2.1-Ed001
IPCC-AVERAGE-EdAR4
IPCC-MEDIAN-EdAR4
NCEP-DOE-R2-Ed002
Bias (W m-2)
N
Year
60
40
20
0
-20
-40
-60
24
22
20
18
16
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1999
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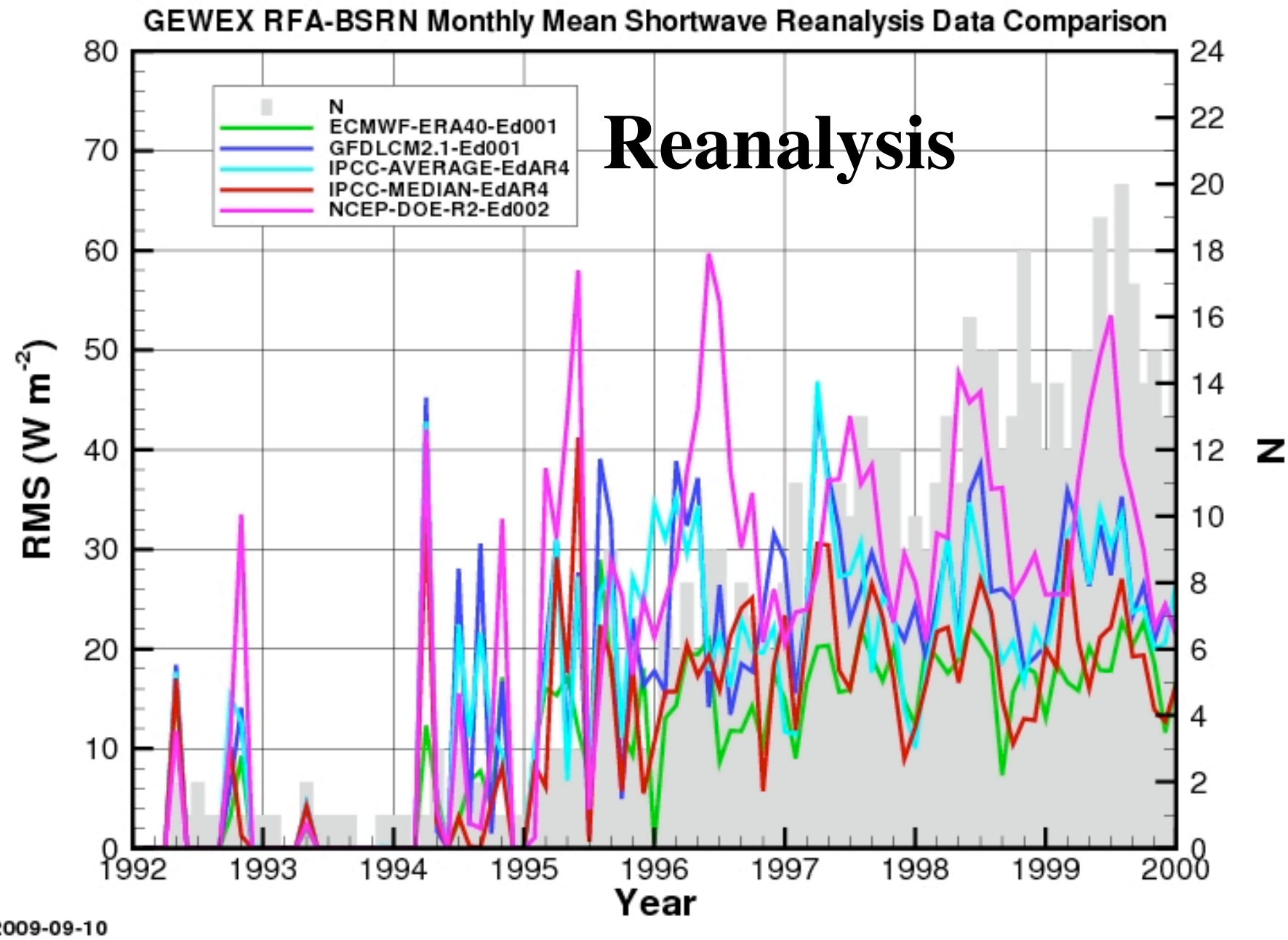
GEWEX RFA-BSRN Monthly Mean Shortwave Reanalysis Data Comparison
Reanalysis
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ECMWF-ERA40-Ed001
GFDLCM2.1-Ed001
IPCC-AVERAGE-EdAR4
IPCC-MEDIAN-EdAR4
NCEP-DOE-R2-Ed002
RMS (W m-2)
N
Year
0
10
20
30
40
50
60
70
80
0
2
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12
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1992
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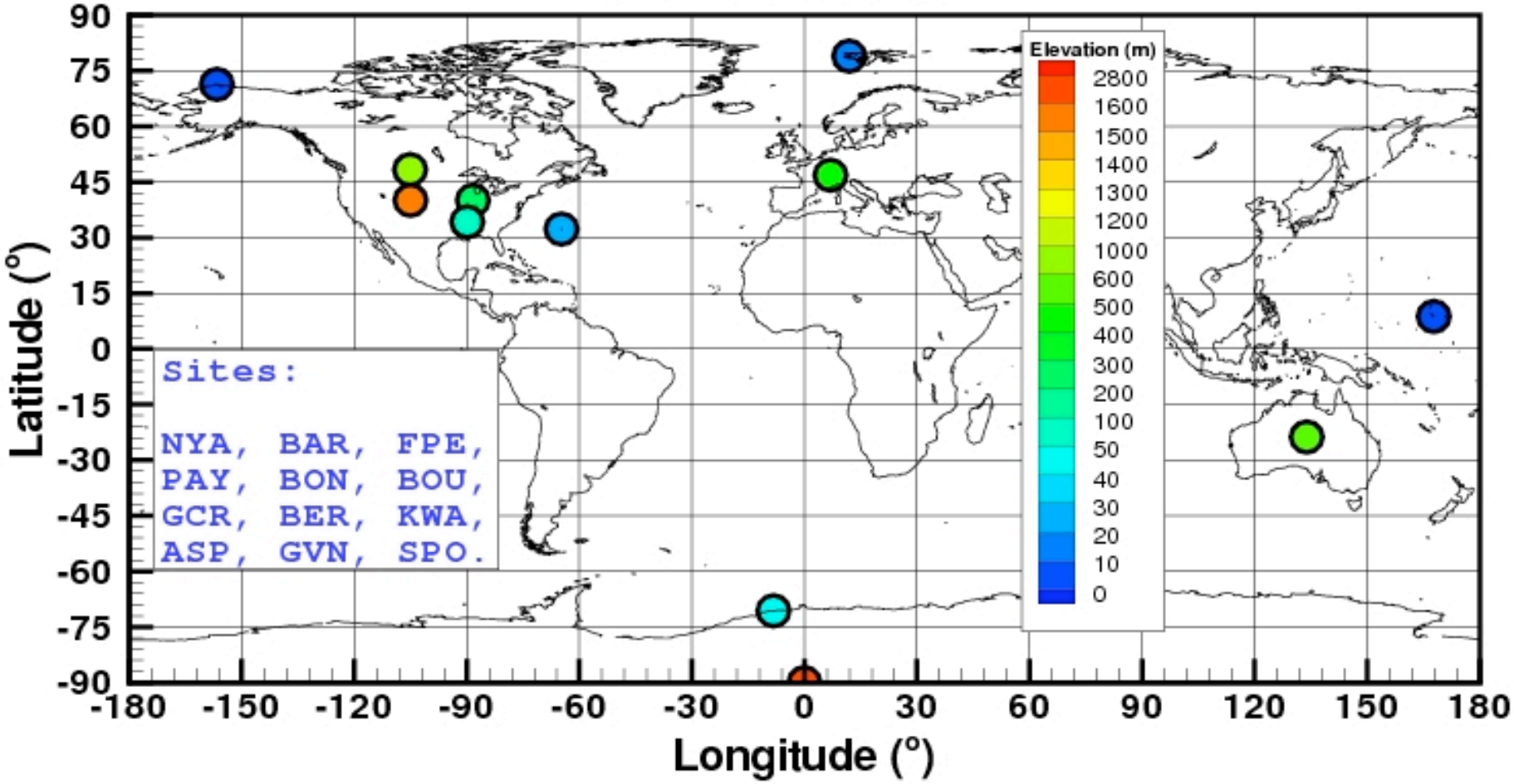
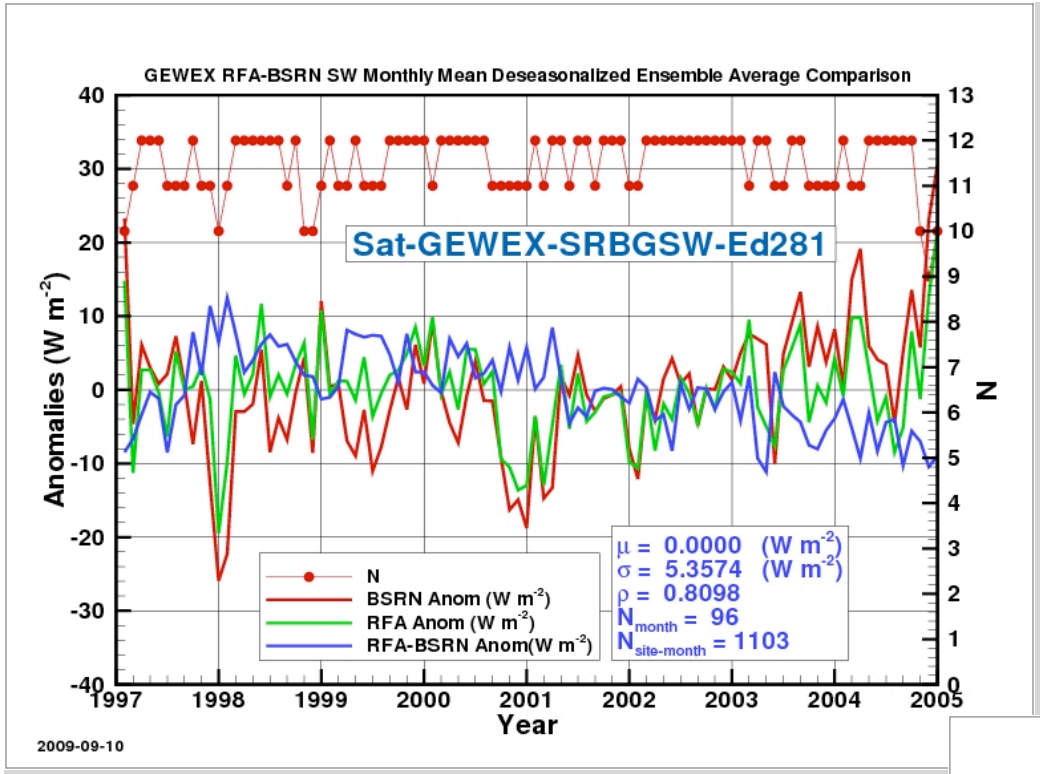
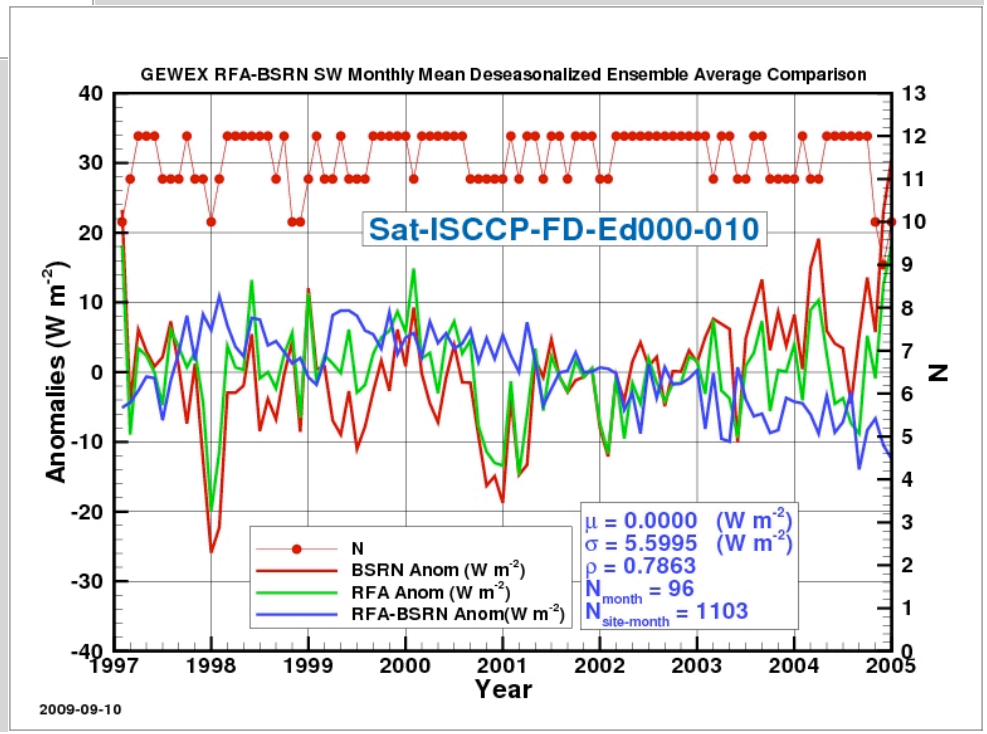
1999
2000
2009-09-10

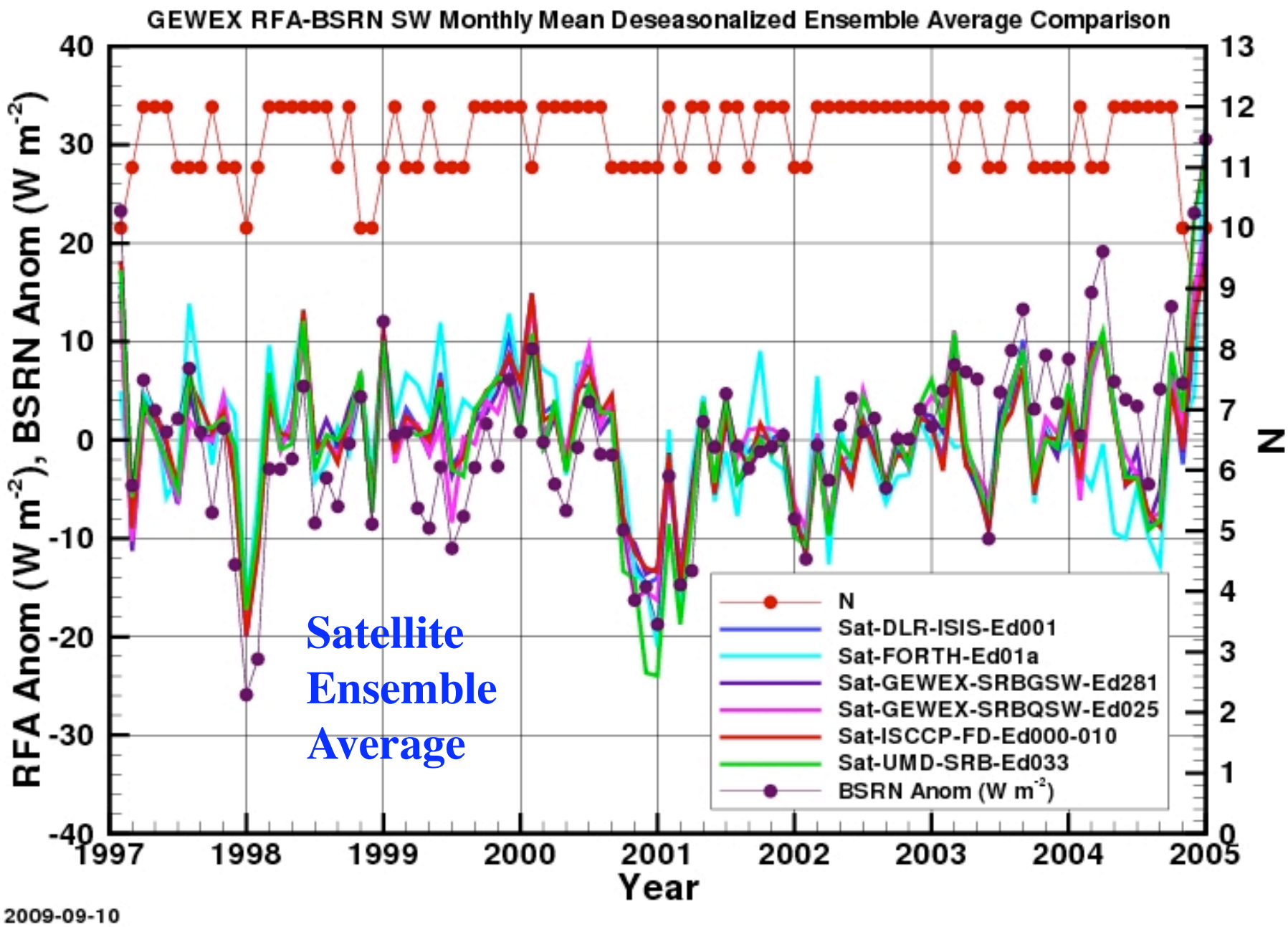
12 Baseline Surface Radiation Network (BSRN) Sites with Nearly Continuous Records Since 1995

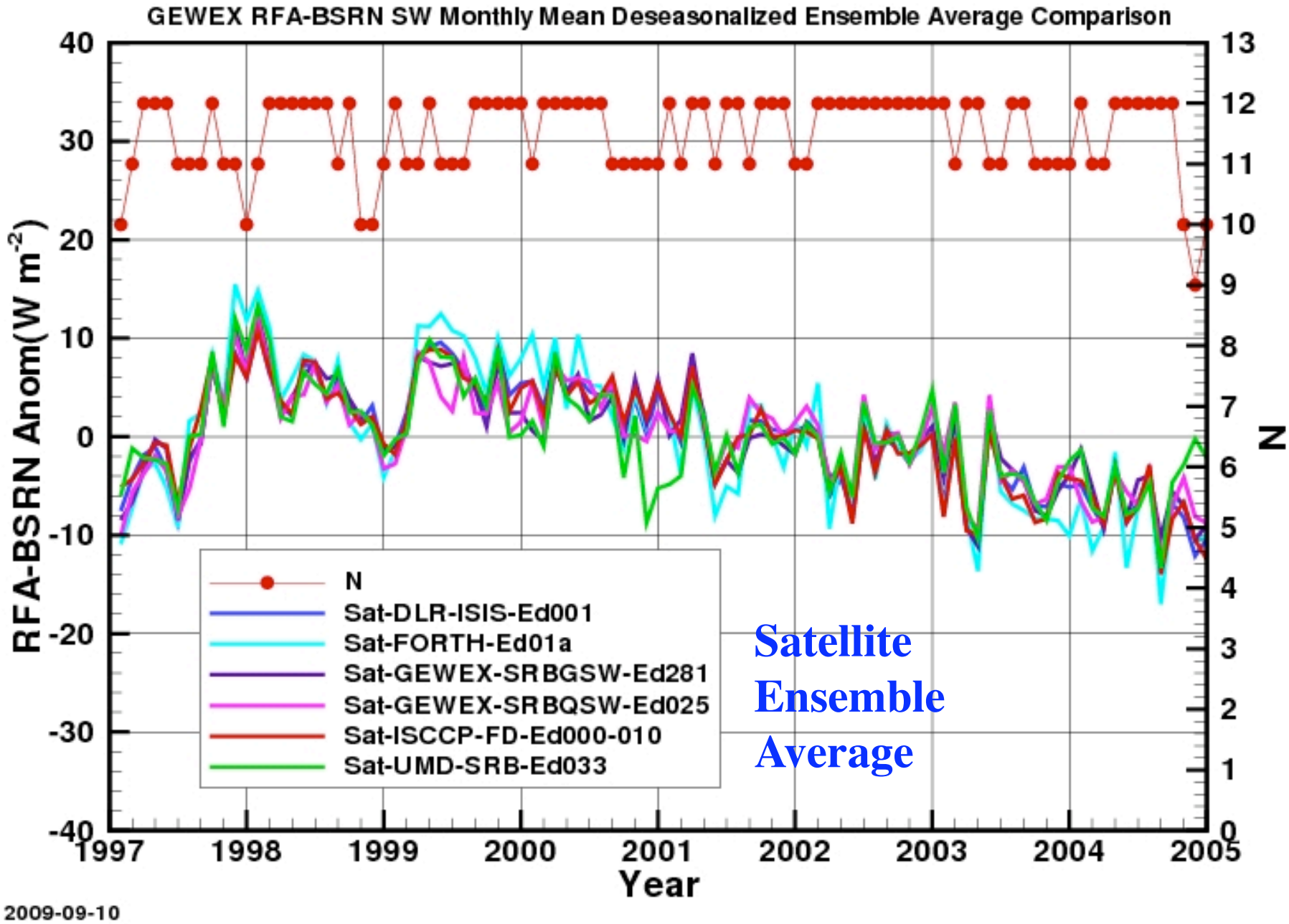




Ensemble Average Deseasonalized Anomalies

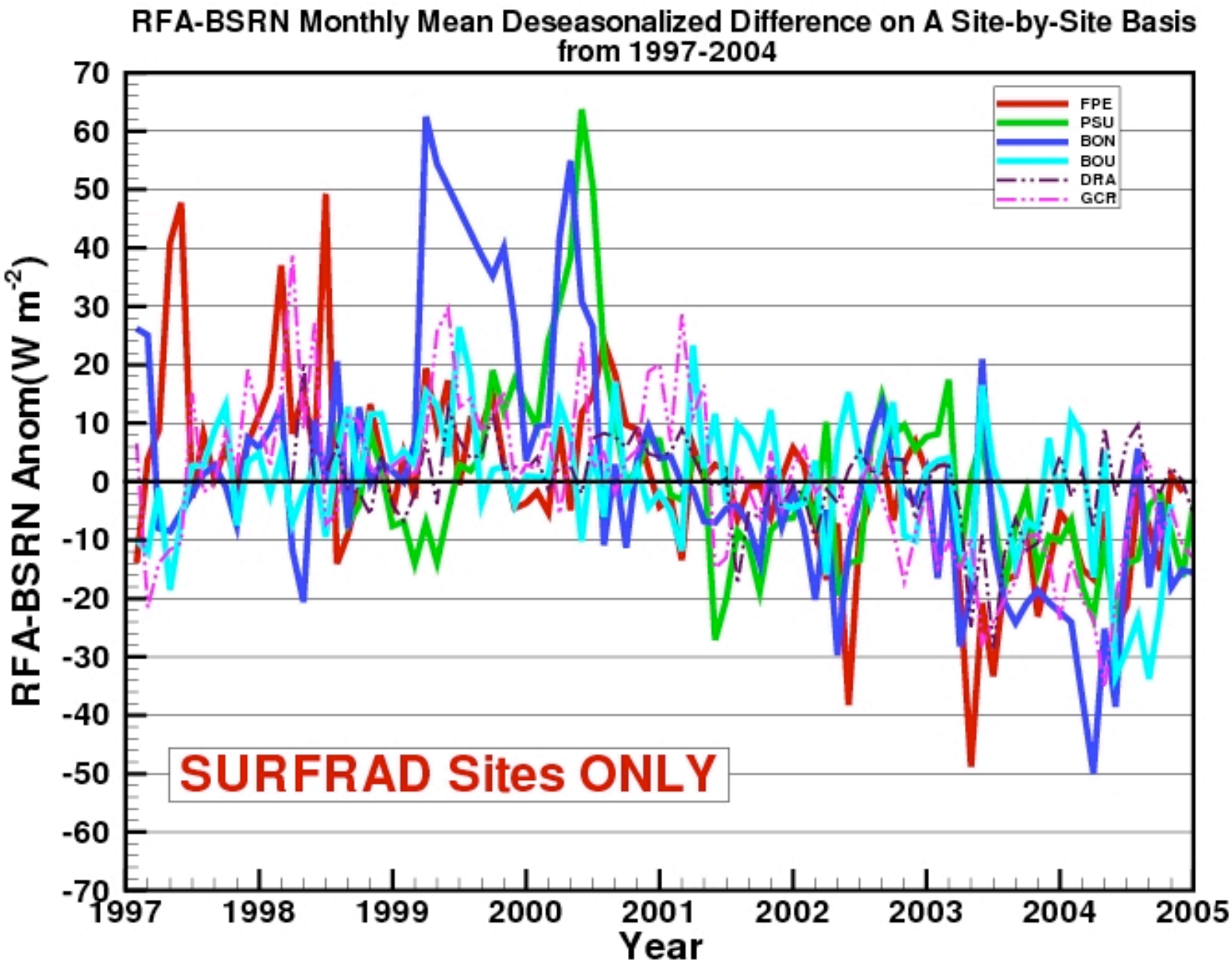



GEWEX RFA-BSRN SW Monthly Mean Deseasonalized Ensemble Average Comparison
RFA Anom (W m-2), BSRN Anom (W m-2)
N
Year
Satellite Ensemble Average
N
Sat-DLR-ISIS-Ed001
Sat-FORTH-Ed01a
Sat-GEWEX-SRBGSW-Ed281
Sat-GEWEX-SRBQSW-Ed025
Sat-ISCCP-FD-Ed000-010
Sat-UMD-SRB-Ed033
BSRN Anom (W m-2)
2009-09-10


GEWEX RFA-BSRN SW Monthly Mean Deseasonalized Ensemble Average Comparison
RFA-BSRN Anom(W m-2)
N
Year
N
Sat-DLR-ISIS-Ed001
Sat-FORTH-Ed01a
Sat-GEWEX-SRBGSW-Ed281
Sat-GEWEX-SRBQSW-Ed025
Sat-ISCCP-FD-Ed000-010
Sat-UMD-SRB-Ed033
Satellite Ensemble Average
2009-09-10

Statistics of GEWEX-RFA *Ensemble* Average Validation against the BSRN Data

Satellite Data Set	μ (W m^{-2})	σ (W m^{-2})	ρ	Months	Sit-Mon
DLR_ISIS_Ed001	0.00	5.63	0.7828	96	1103
FORTH_Ed01a	0.00	7.27	0.6480	96	939
GEWEX_SRBGSW_Ed281	0.00	5.36	0.8098	96	1103
GEWEX_SRBQSW_Ed025	0.00	5.15	0.8246	96	1103
ISCCP_FD_Ed000_010	0.00	5.60	0.7863	96	1103
UMD_SRB_Ed033	0.00	5.24	0.8187	96	1103


RFA-BSRN Monthly Mean Deseasonalized Difference on A Site-by-Site Basis
from 1997-2004
RFA-BSRN Anom(W m-2)
Year
FPE
PSU
BON
BOU
DRA
GCR
SURFRAD Sites ONLY
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
1997
1998
1999
2000
2001
2002
2003
2004
2005

2009-11-03

GEWEX RFA Status Summary

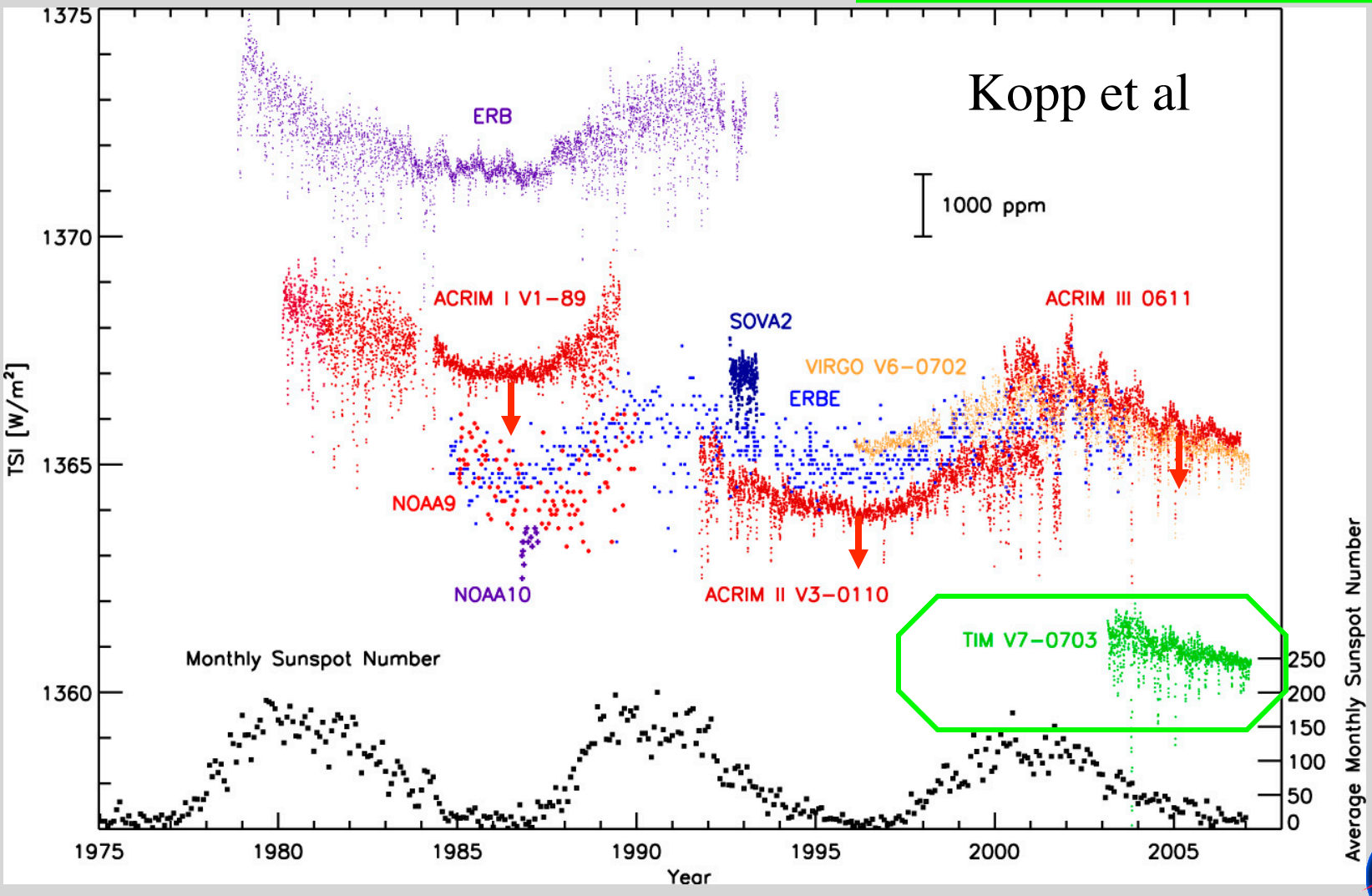
- **Results to date**
  - Providing broad assessment global products relative to surface and TOA measurements
  - Comparisons showing importance of input data sets and resulting uncertainties in flux products
- **Report document update**
  - Document has been reorganized
  - Chapters being assembled and assessed
  - Editing of submitted sections has been begun
  - Editing will be expanded to chapter leads and to all participants in the next 3 months
- **Goals:**
  - Rough draft to participants in Jan
  - Higher quality draft in April
  - Sessions at EGU and AMS

Backup slides

Radiative Flux: SORCE TIM Indicates Lower TSI Value

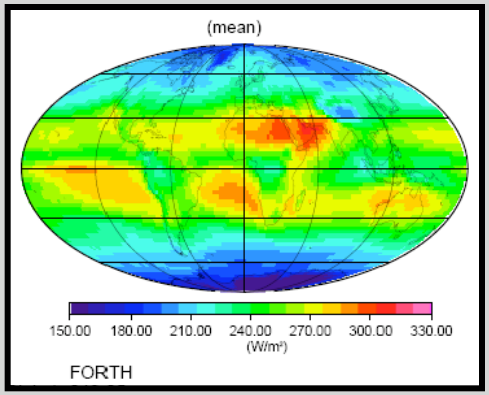
Fundamental discovery that the TSI is ~1361 W/m², not 1366 W/m² (TIM).

SORCE/TIM result motivated detailed examination by NIST and TSI community.

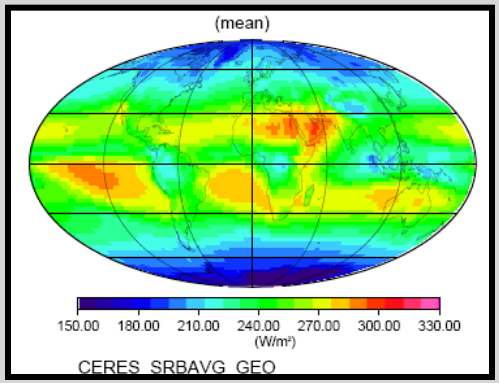


Annual Mean LW Fluxes

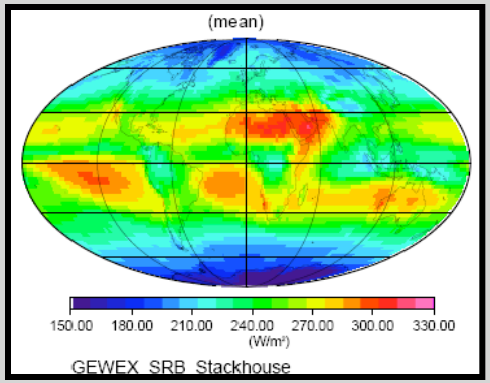
FORTH



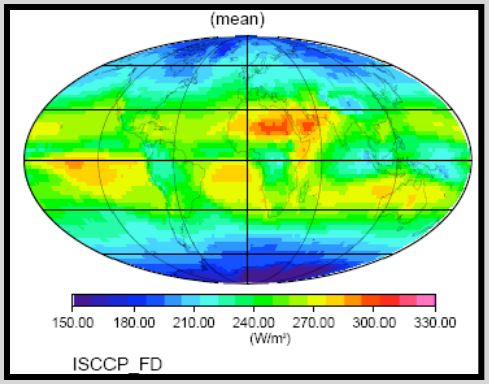
CERES SRBAVG GEO



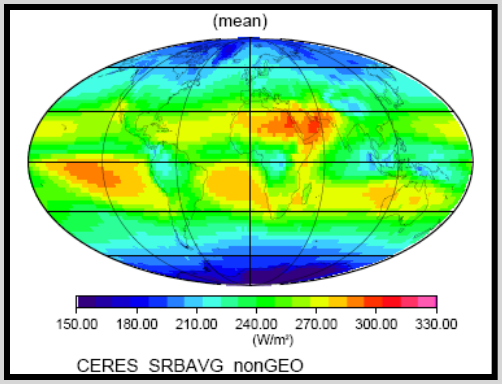
GEWEX SRB/LaRC



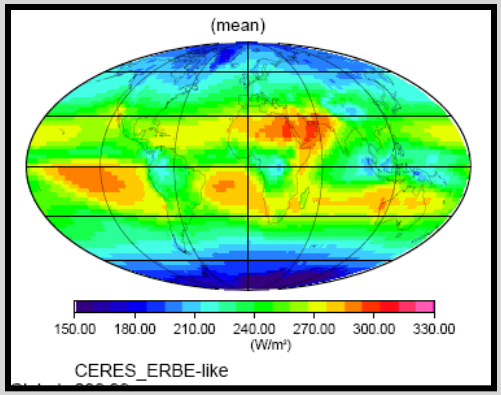
ISCCP-FD



CERES SRBAVG NONGEO



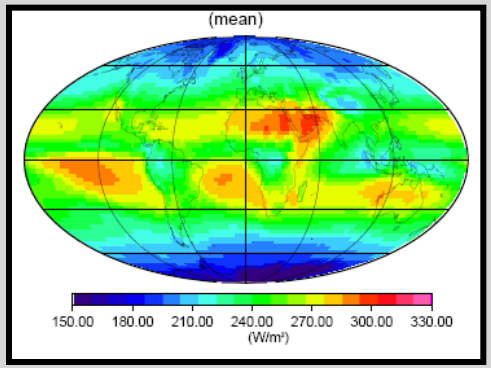
CERES ERBE-LIKE



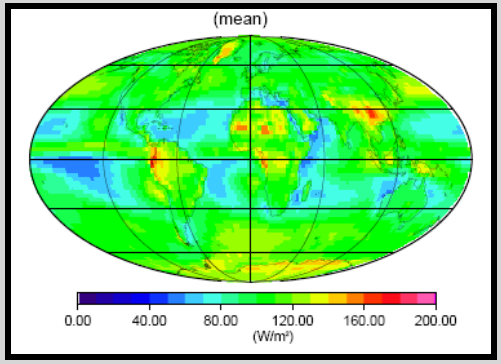
Data Period: 3/2000 to 10/2005

Multi-Dataset Ensemble Mean

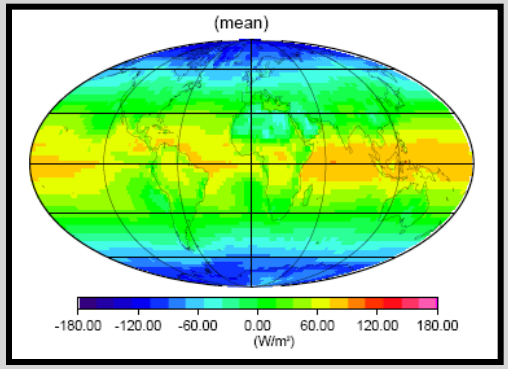
LW



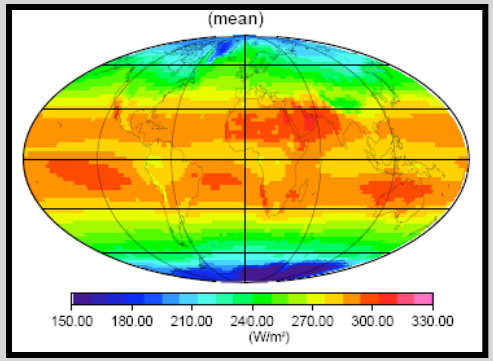
SW



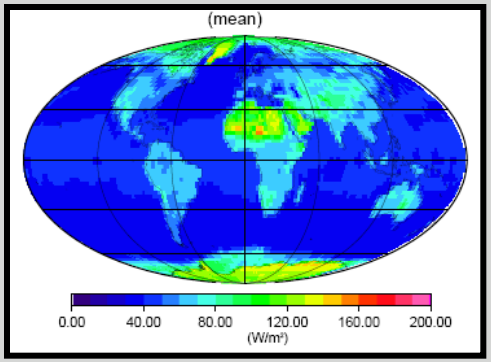
Net



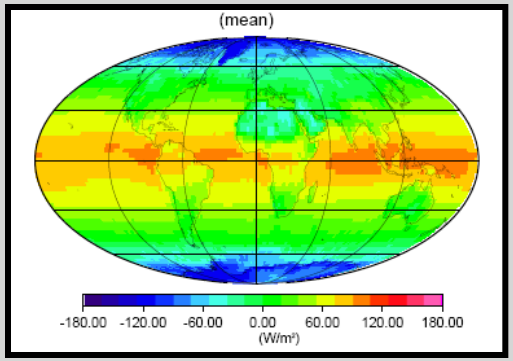
Clear LW



Clear SW



Clear Net



Data Period: 3/2000 to 10/2005

Annual Global Mean TOA Budget

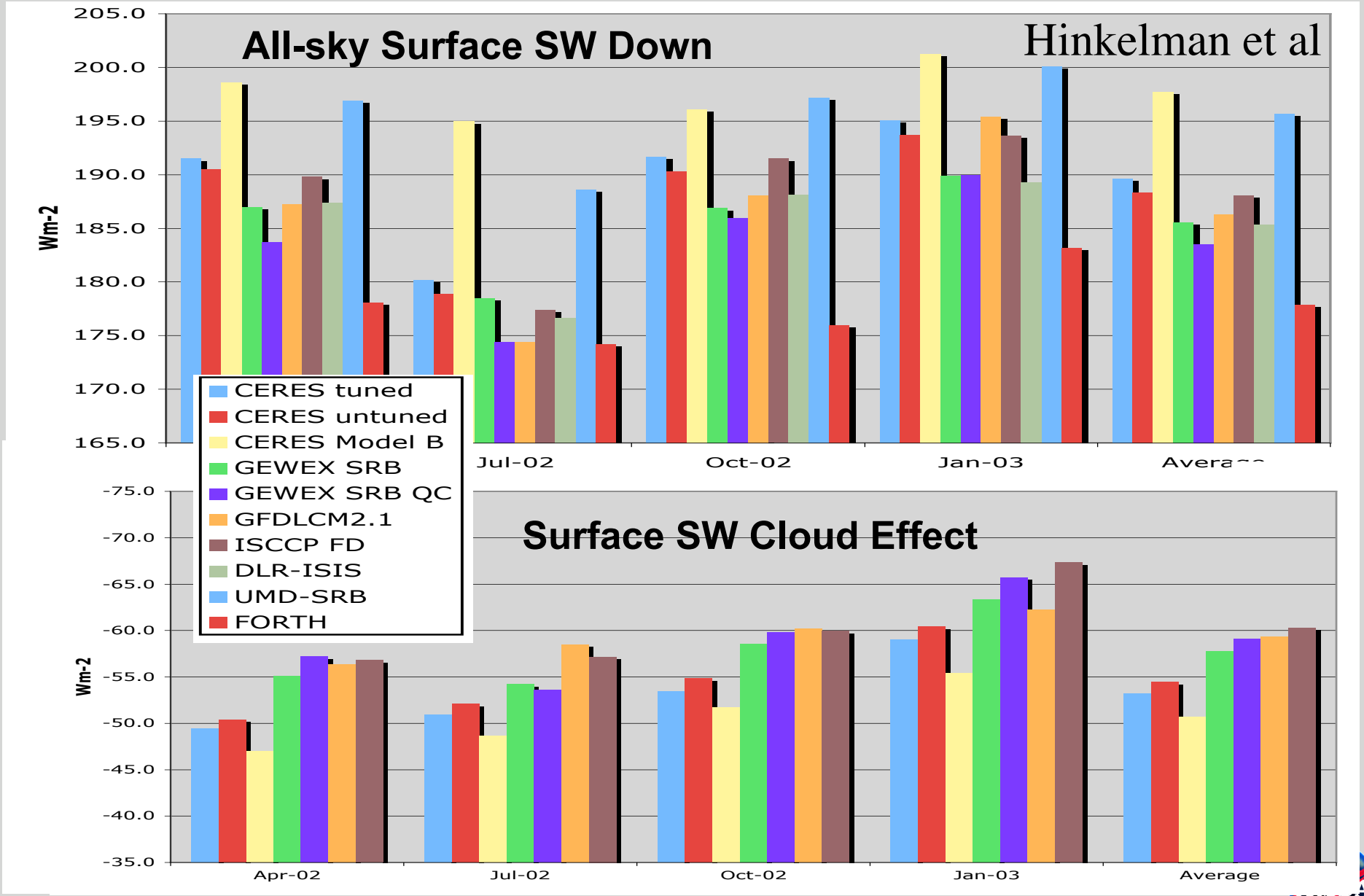
	Mean	Range
Solar In.	341.0	339.5, 341.8
LW	238.8	236.2, 240.6
SW	99.8	96.8,107.0
Net	4.4	-0.9, 8.3
CLW	266.2	263.3, 266.9
CSW	51.8	49.3, 54.3
CNet	24.9	19.9, 28.6

Data Period: 3/2000 to 10/2005

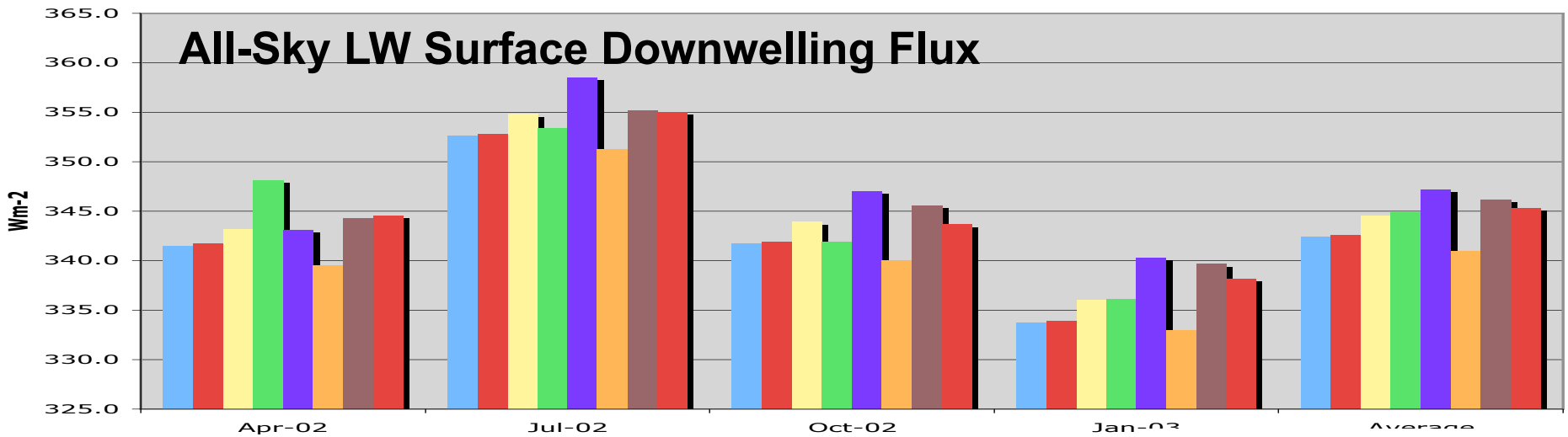
GEWEX-RFA TOA Global Mean Comparison (Relative to CERES SRBAVG GEO)

	CERES SRBAVG GEO	CERES SRBAVG NonGEO	CERES ERBE-like	GEWEX SRB LaRC	ISCCP FD	FORTH	GEWEX SRB UMC	CERES EBAF
LW	237.2	0.6	1.8	3.4	-1.0	2.9	N/A	2.5
SW	97.9	-1.1	0.9	3.9	7.8	9.1	0.0	1.6
Net	6.5	0.5	-2.3	-7.4	-6.5	1.9	N/A	-5.7
CLW	264.2	2.3	2.7	3.9	-0.9	N/A	N/A	5.3
CSW	51.6	0.0	-2.4	1.9	2.7	N/A	N/A	0.8
CNet	27.7	-2.7	0.9	-7.8	-3.5	N/A	N/A	-9.6

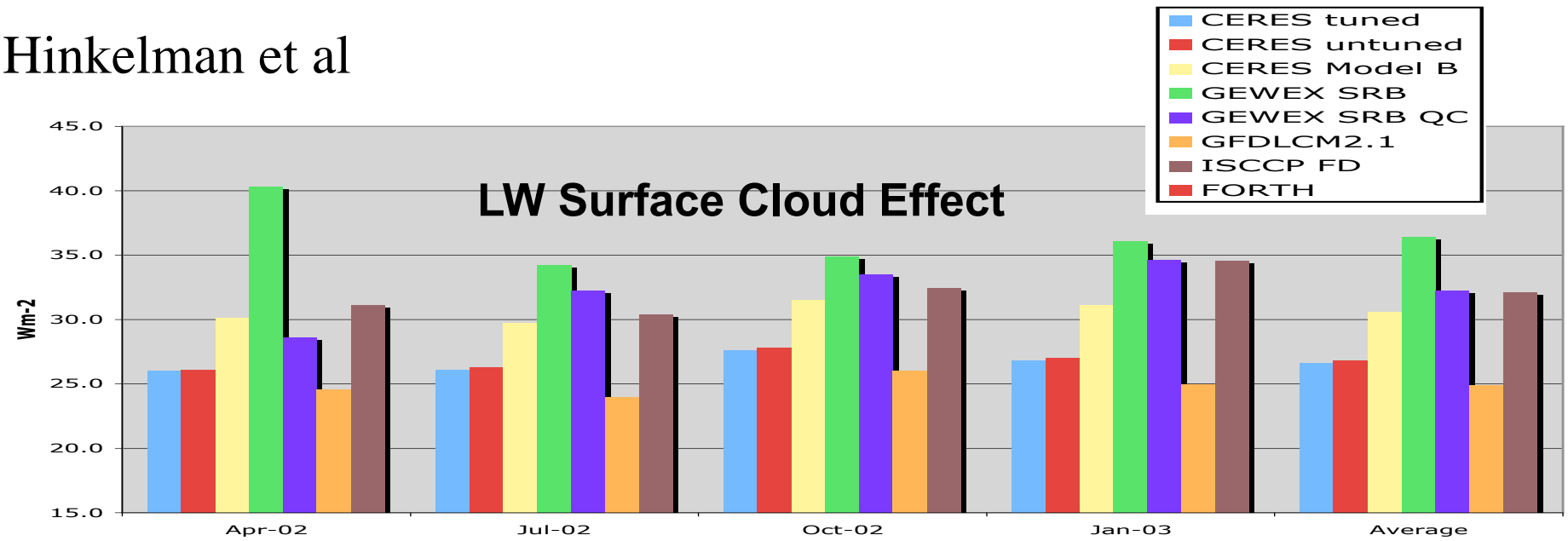
Multi-data Set Comparisons



Multi-data Set Comparisons



Hinkelman et al



Surface Radiative Budget 2002

	K&T	Mean
SW Down:	198	178 – 198
SW Up:	30	21 – 24
SW CRF	–	-60 – -51
LW Down:	324	341 – 346
LW Up:	390	392 – 399
LW CRF	46	25 – 36
SW albedo	0.15	0.11 – 0.125

Hinkelman et al

Surface Measurement Example Uncertainty Matrix:

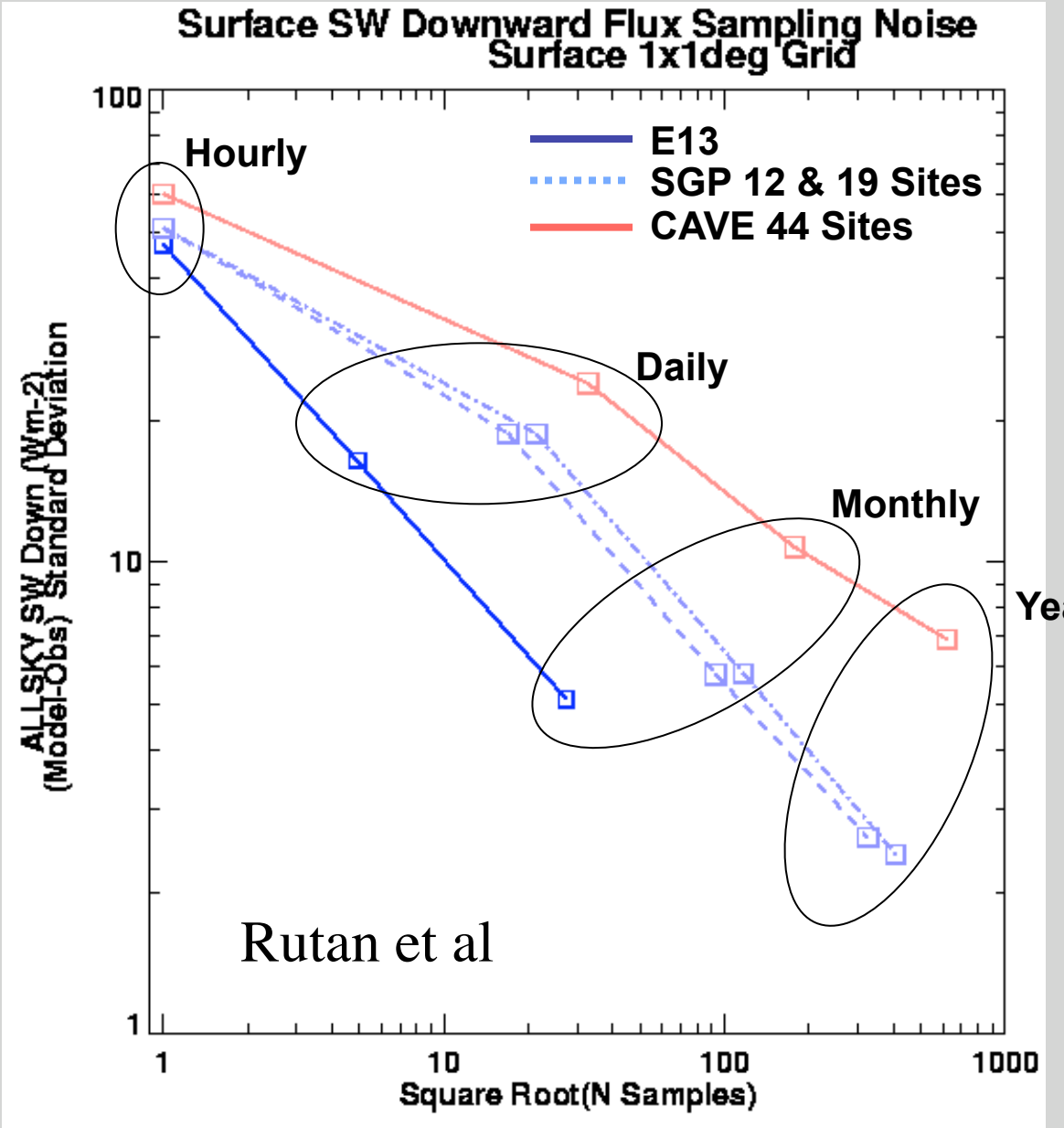
BSRN Operational Measurement Quality

RMS Uncertainties for Radiative Measurements (Ohmura et al, 1998, BAMS; Michalsky et al., 1998; Shi and Long, 2002, Dutton et al., 2001; Ells Dutton personal comm.)

Quantity (Instrument)	1 Minute Avg. (1 Hz sampling) (W m^{-2})	1 Hour (W m^{-2})	1 Day (W m^{-2})	1 Month (W m^{-2})	1 Year (W m^{-2})	10 Years	Thermal Offset
LW Broadband (pyrgeometer)	5 - 7 (2%)	5	3 -- 5	3 -- 5	3 -- 5	??	---
SW Broadband Global (direct+diffuse, pyranometer)	25+ (4-5%)	8 -- 20	5 -- 15	5 -- 15	5 -- 15	??	up to -3%
SW Broadband Direct (NIP)	5 - 15 (1.5%)	1% or 2	1% or 2	1% or 2	1% or 2	??	---
SW Broadband Diffuse (shaded pyranometer)	5 -- 7 (3-4%)	5 -- 15	5 -- 15	5 -- 12	5 -- 12	??	up to -10
SW Broadband Total (shaded pyranometer + NIP)	10 -- 15 (3.0%)	5 -- 15	5 -- 15	5 -- 12	5 -- 12	??	up to -10

Challenge: Derive similar tables for each network; survey and classify measurements (i.e., land, ocean)

SW Down: Noise from Multiple Sites

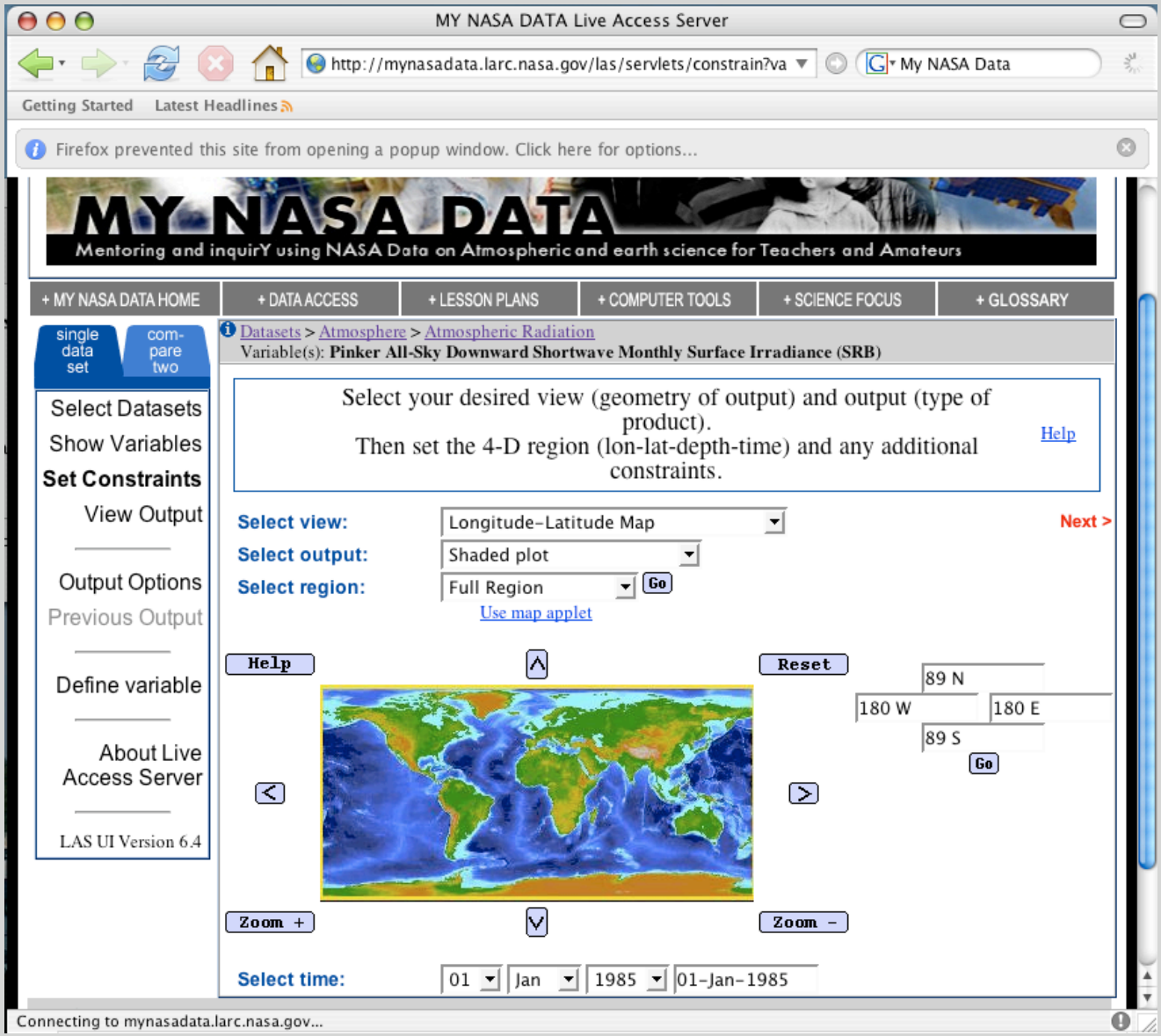


GEWEX RFA Web Tools

Starting address: http://gewex-rfa.larc.nasa.gov/

- About: Purpose, draft document
- Data Access (eosweb.larc.nasa.gov/GEWEX-RFA)
  - "Data Provider Instructions" document gives step by step instructions to prepare and submit data sets
  - Data ordering currently limited to assessment participants
- View Sample Data
  - Limited data visualization tools (access restricted)
- FTP site
  - Exchange repository for talks and report writing (access restricted)
  - Submit name, institution, e-mail address, and IP address to rfa_admin@larc.nasa.gov
- E-mail list(s)
  - TOA and surface (some are on both)
  - Submit name, institution, and e-mail address to rfa_admin@larc.nasa.gov
- GEWEX-RFA Google groups
  - Capability for archived discussion and document exchange

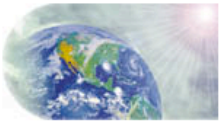
Data Availability: Live Access Server



GEWEX RFA Web Site

ATMOSPHERIC SCIENCE DATA CENTER

GEWEX Radiative Flux Assessment



The ultimate goal of the Global Energy and Water Cycle Experiment (GEWEX) global data analysis projects is to obtain observations of the elements of the global energy and water cycle with sufficient detail and accuracy to diagnose the causes of recent climate variations in terms of the energy and water exchanges among the main climate components (atmosphere, ocean, land, cryosphere, biosphere). The GEWEX Radiative Flux Assessment (RFA) project will provide a forum for consistent analysis of long-term radiative flux products, primarily top-of-atmosphere (TOA) and surface fluxes, to establish a foundation for better global radiation budget analysis.

Data access is restricted to assessment participants until the data are made publicly available (currently anticipated to be May 2007). To access the interim data you need an ASDC user account and approval from the LaRC GEWEX-RFA organizing committee. Join the assessment team.

Assessment Activity Summary | How to Participate | File Conventions | News and Discussion | List of Participants | Acknowledgement

Top of Atmosphere (TOA) Data Products	Surface Data Products	Ground-Based Measurements
• Maps • Time Series • Hovmöller Diagrams • High Time/Space Resolution	• Maps • Time Series • Hovmöller Diagrams • High Time/Space Resolution	• Time Series

Note: The data files provided here are subsets of larger data sets. Links to the full data archive for each product can be found in the corresponding product description files.

Acknowledgement

When data from the GEWEX Radiative Flux Assessment are used in a publication, we request the following acknowledgment be included: "*The GEWEX Radiative Flux Assessment data were obtained from the NASA Langley Research Center Atmospheric Science Data Center.*" In addition, the provider of each data set used should be specifically acknowledged. See the product description file(s) for details.

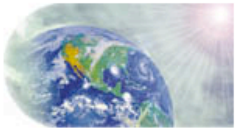
View Cart | ASDC Home Page | Join GEWEX-RFA News List | Questions/Feedback

Responsible NASA Official: Michelle T. Ferebee
Site Administration/Help: NASA Langley ASDC User Services (larc@eos.nasa.gov)
[Privacy Policy and Important Notices]
Last Updated: Tue Apr 25 2006 11:52:54 GMT-0400 (EDT)

GEWEX RFA Web Site

ATMOSPHERIC SCIENCE DATA CENTER

GEWEX Ground-based Measurements: Time Series



Select categories to view and order data.
JavaScript must be enabled for optimal performance.

Temporal Resolution	(•) All available temporal resolutions ( ) Monthly (UTC) ( ) Monthly (LST) ( ) Monthly mean of diurnal cycle (15 minute resolution) ( ) Daily (UTC) ( ) Daily (LST) ( ) Hourly ( ) 15 minute
Site	All available sites
Sky condition	(•) All available sky conditions Clear sky: ( ) Type 1 (measured) ( ) Type 2 (computed) ( ) Both ( ) All sky
Parameter	(•) All available parameters ( ) Shortwave (SW) direct (horizontal) downward flux ( ) SW diffuse downward flux ( ) SW total (direct + diffuse) downward flux ( ) SW hemispheric downward flux * ( ) SW upward flux ( ) SW net (total down + up) flux ( ) SW broadband albedo ( ) Longwave (LW) downward flux ( ) LW upward flux ( ) LW net (down + up) flux ( ) Total (SW + LW) net flux
View Files	Reset

* Single instrument measurement of broadband SW downward flux including both direct and diffuse components.

Data access is currently restricted to assessment participants. Join the assessment team. All data will be made available to the public upon completion of the assessment (anticipated date: May 2007).

Flux Assessment Draft Plan: TOA

- **Provide overview of current TOA flux estimation products including: ERBE (Scanner/Nonscanner), CERES, SCARAB, ISCCP FD, GEWEX SRB, NOAA Pathfinder and reanalysis**
- **Intercompare SWup, LWup, net; all-sky and clear-sky:**
  - **Monthly gridded product maps**
  - **Monthly time series (global and zonal; land and ocean; Hovmeuller)**
  - **Seasonal gridded maps of diurnal cycle**
  - **Characterize variability at various time and space scales**
    - ***Observation products***
    - ***Model products***
  - **Compare Meteorological Regimes and Cloud Systems**
    - ***Tropical Convection and mid-latitude stratocumulus regions defined***
  - **Time series at selected surface sites (collaborate w/ surface)**
  - **High Space and Time Intercomparison: GERB area, for June – July 2004**
  - **Error budget intercomparison**
- **Provide web-based data portal for data producers and users**

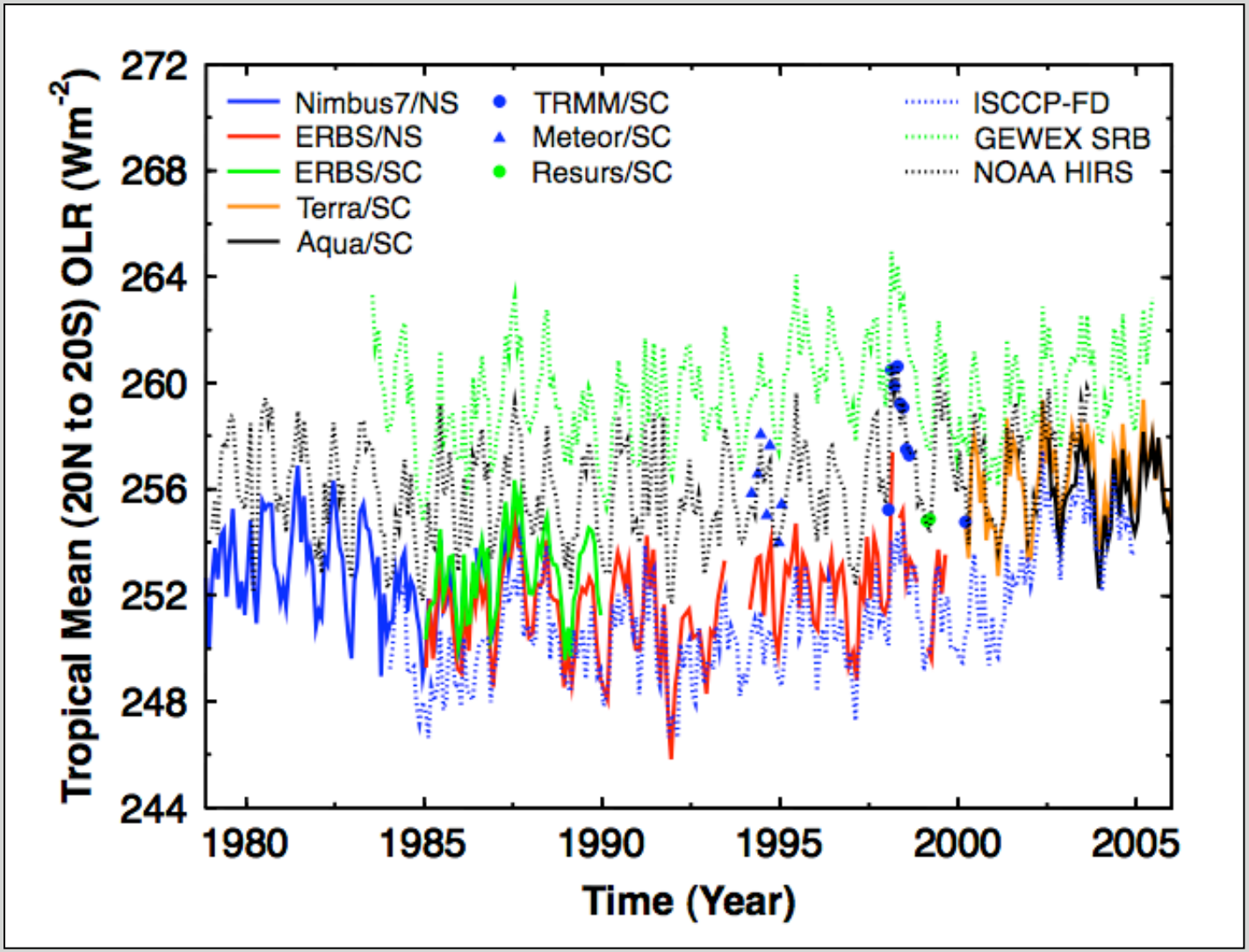
Flux Assessment Draft Plan: Surface

- **Provide overview of surface measurements networks**
  - **Poll existing data sets: spatial and temporal extent; calibration**
  - **Select long and short-term datasets**
  - **Summarize surface measurement needs and issues**
- **Provide overview of current surface flux estimation products including:**
  - **Global: GEWEX SRB, ISCCP FD, ESRB, CERES SARB and SOFA, UMD ISCCP and MODIS based (Pinker), SWnet (Li), ERA 40, NCEP R2, GEOS-4**
  - **Regional: GEWEX CSE's, Tropical Pacific (Chou), MSG (2-3), Polar Fluxes (Key), Brazilian products, UMD GOES and ISCCP DX, SUNY-Albany**
- **Satellite-surface Intercomparisons for: SW down (total, direct, diffuse), LW down; all-sky and clear-sky**
  - **Statistical Intercomparisons: various space and time scales**
  - **Time series intercomparisons: variability, systematic**
  - **Summarized satellite-surface issues**

Flux Assessment Draft Plan: Surface

- **Satellite-based surface flux product intercomparisons for: SW down (total, direct, diffuse), SW up, albedo, LW down, LW up, emissivity; all-sky and clear-sky (for fluxes)**
  - **Monthly gridded product maps**
  - **Monthly time series (global and zonal; land and ocean)**
  - **Seasonal gridded maps of diurnal cycle**
  - **Characterize variability at various time and space scales**
    - ***Observation products***
    - ***Model products***
  - **Compare tropical convection and mid-latitude stratocumulus regions**
  - **Time series at selected surface sites (collaborate w/ surface)**
  - **High space and time intercomparison: GERB area, for June – July 2004**
  - **Error budget intercomparison**
- **Provide web-based data portal for data producers and users**

Tropical OLR Intercomparisons



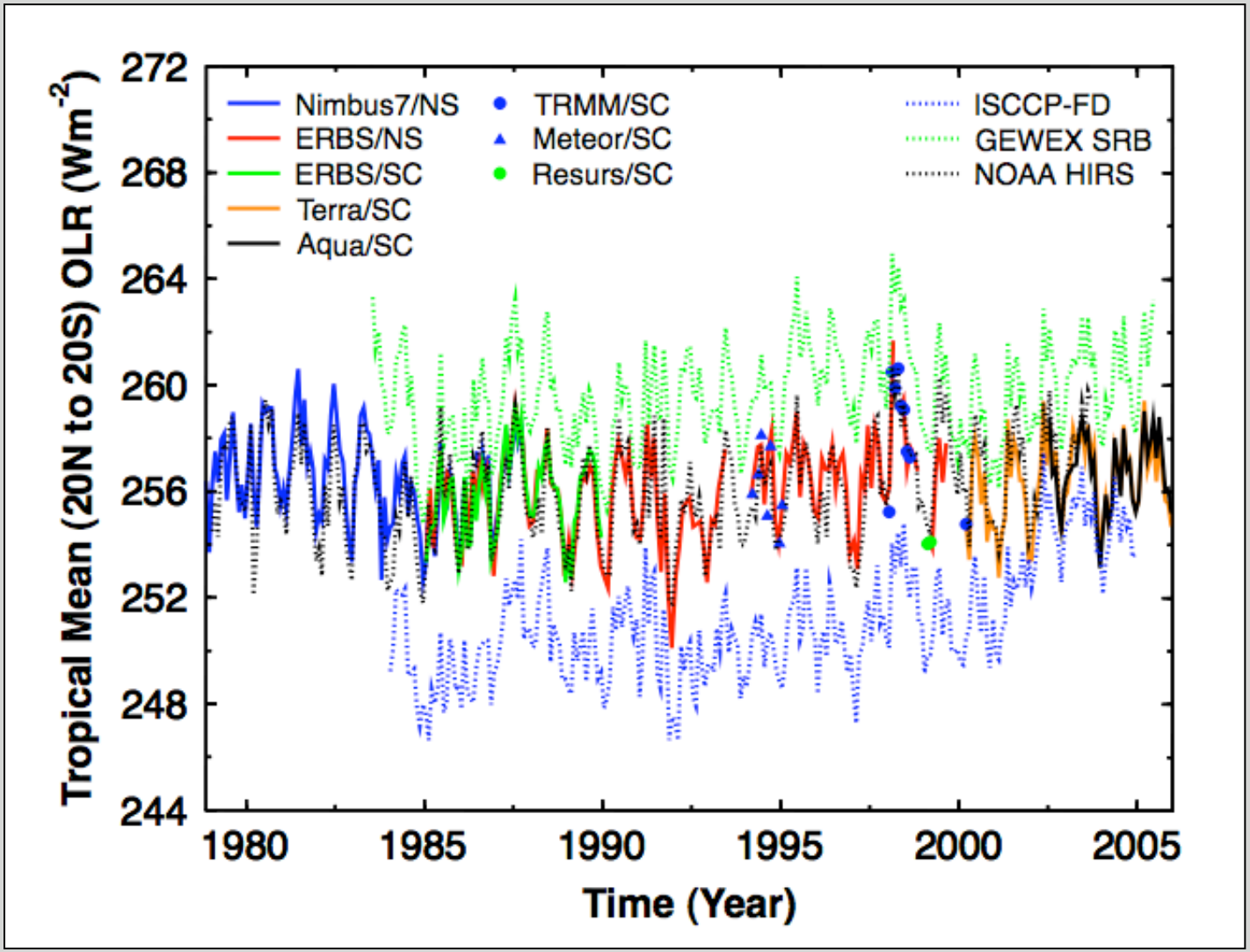
Anthropogenic radiative forcing of climate is ~ 0.6 Wm^{-2} per decade

Goal ~ 0.15 Wm^{-2} per decade

1.2 Wm^{-2} calibration accuracy: current best capability (e.g. CERES)

Current spread 5 - 10 Wm^{-2}; Narrows After 2001

Tropical OLR with ERBE Adjustment



Proposed adjustment uses overlap points from TRMM/Terra/Resurs, TRMM/ERBS-NS, ERBS-NS/SC, and Nimbus7-NS/ERBS

Total change to ERBS/Nimbus nearly 5 W m^{-2}

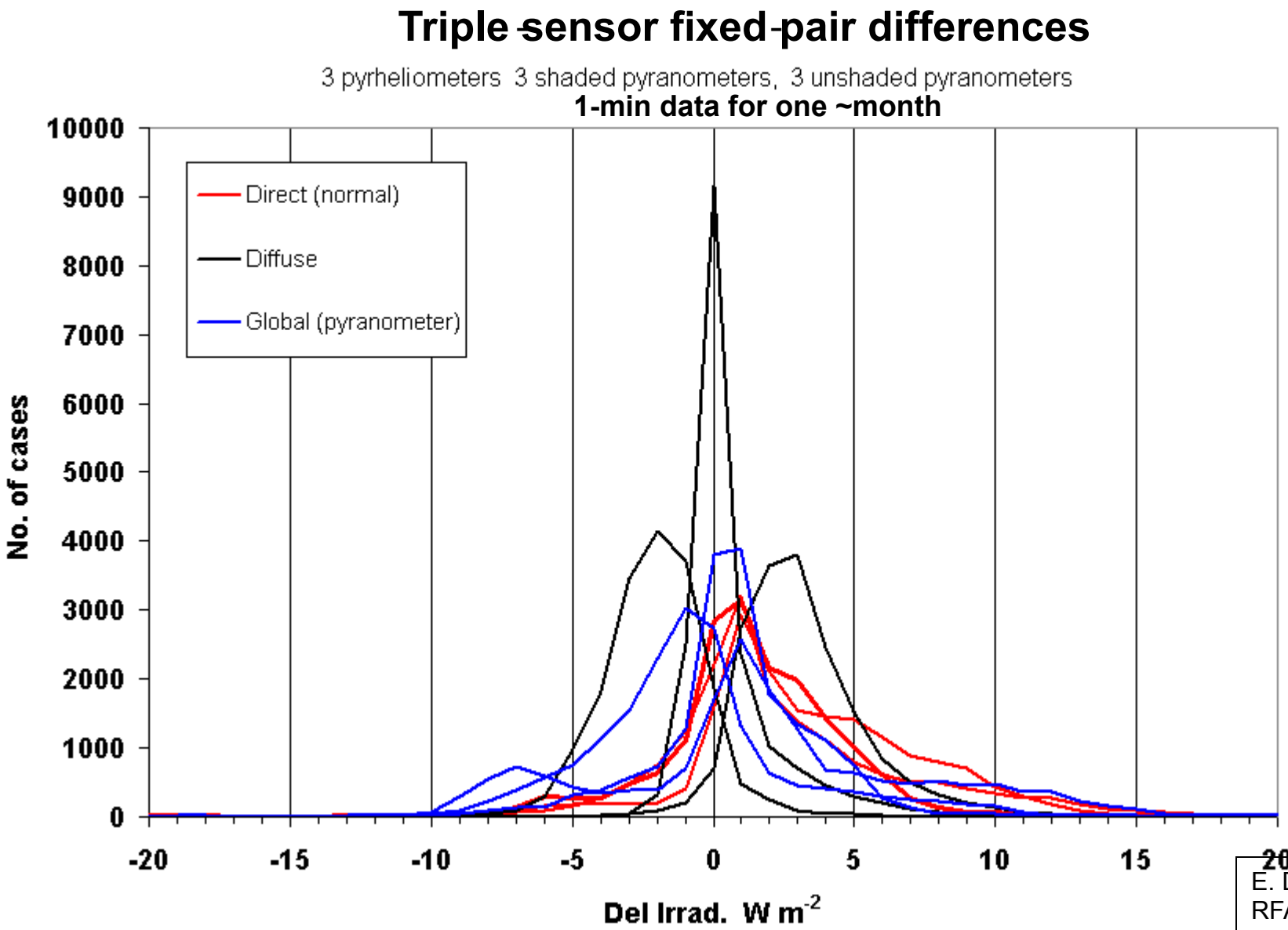
Dutton and Long

Operational Comparison

	Best	Typical	Worst
Diffuse SW	4.0 ± 1.4	8.9 ± 2.9	11.8 ± 3.7
Direct Normal SW	6.2 ± 3.2	13.6 ± 6.4	15.0 ± 6.8
Downwelling LW	3.3 ± 0.7	5.6 ± 1.4	7.7 ± 2.2
Downwelling SW	9.2 ± 4.0	16.1 ± 7.5	17.5 ± 7.2
Upwelling SW	11.1 ± 2.8		
Upwelling LW	9.6 ± 3.0		

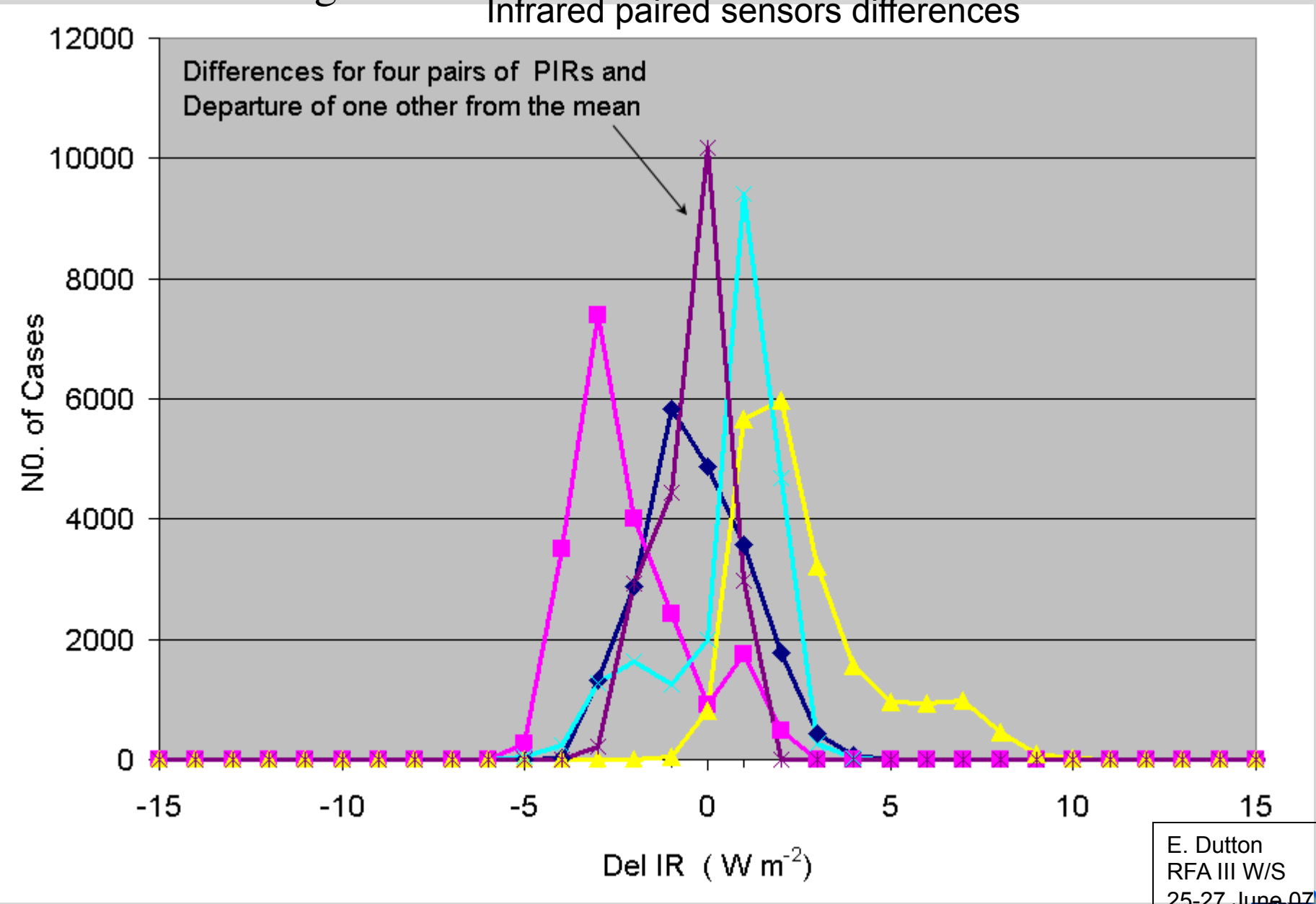
From "Best Estimate Radiation Flux Value-Added Product: Algorithm Operational Details and Explanations", Shi and Long (2002), ARM Tech Report ARM-TR-008

Dutton and Long



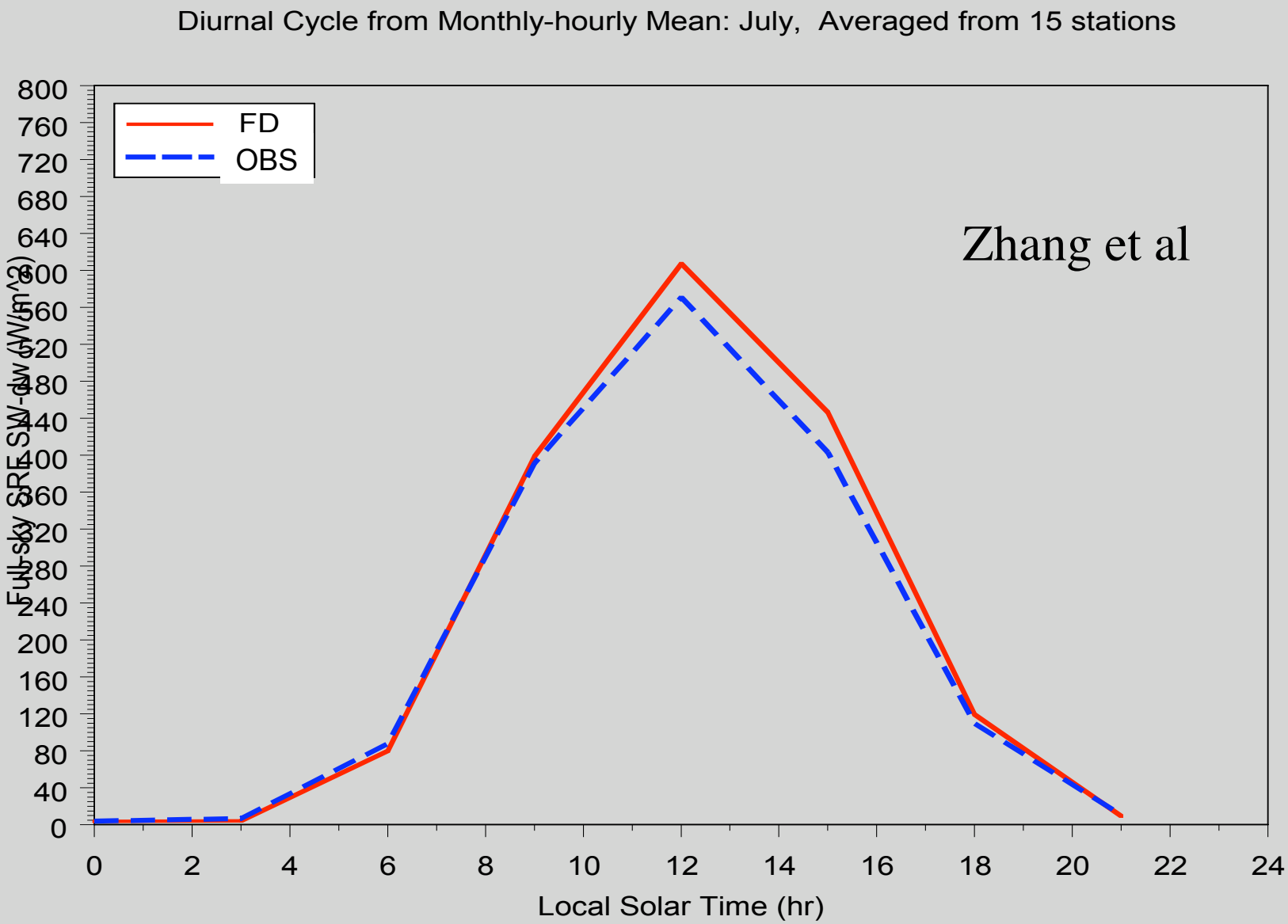
E. Dutton
RFA III W/S
25-27 June 07
New York

Dutton and Long



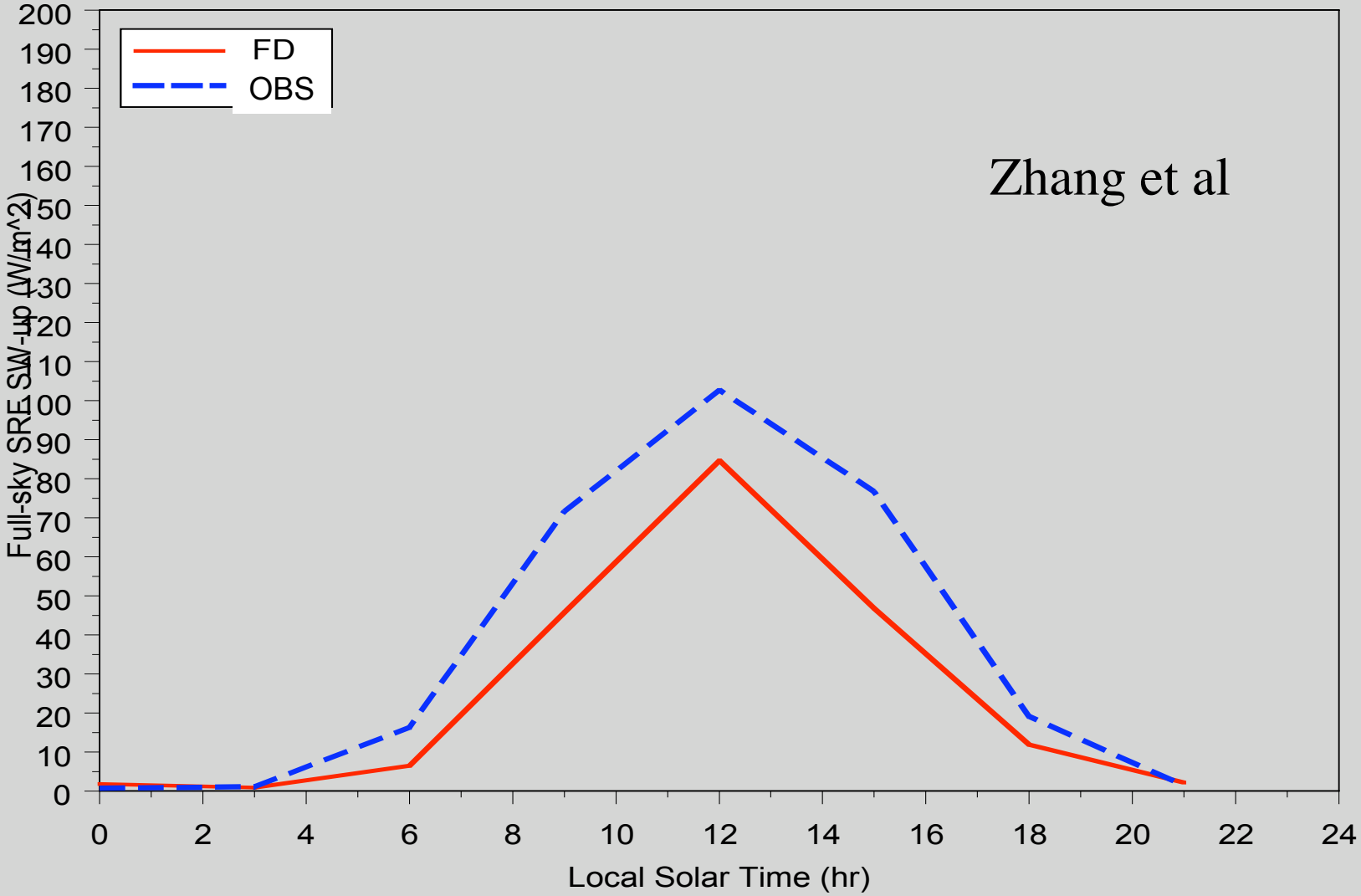
E. Dutton
RFA III W/S
25-27 June 07
New York

Full-sky SRF SW-dw (W/m^2) Diurnal Cycle Comparison: FD vs Observations

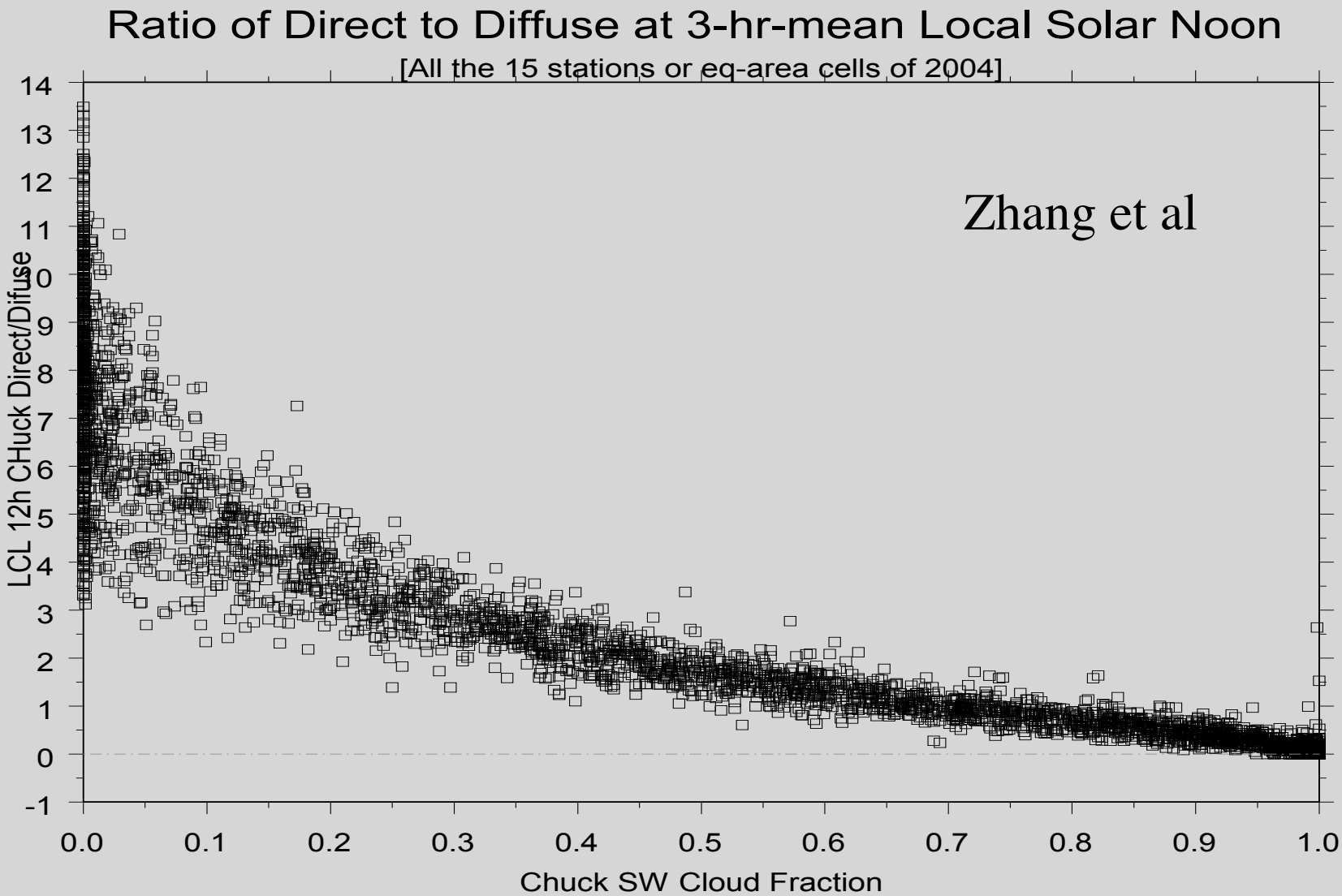


Full-sky SRF SW-up (W/m^2) Diurnal Cycle Comparison: FD vs Observations

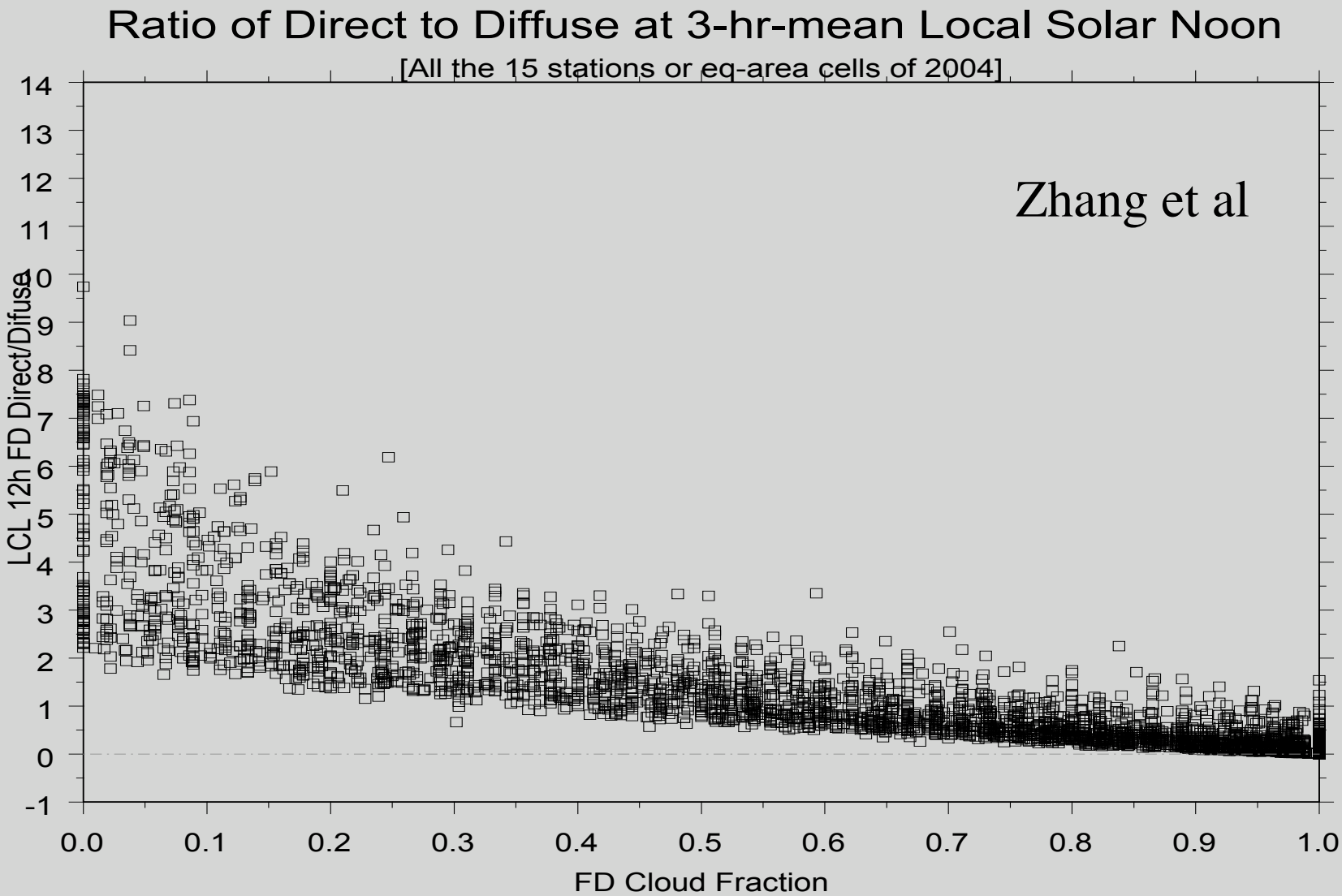
Diurnal Cycle from Monthly-hourly Mean: July, Averaged from 15 stations



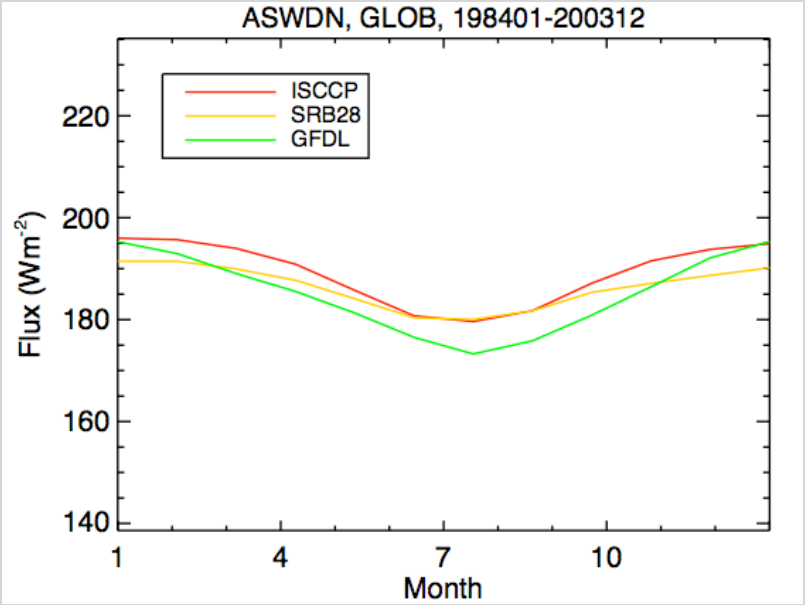
Cloud Fraction vs Direct/Diffuse Ratio : SOB (SW derived) From 15 BEST Stations Selected from BSRN, ARM and SURFRAD

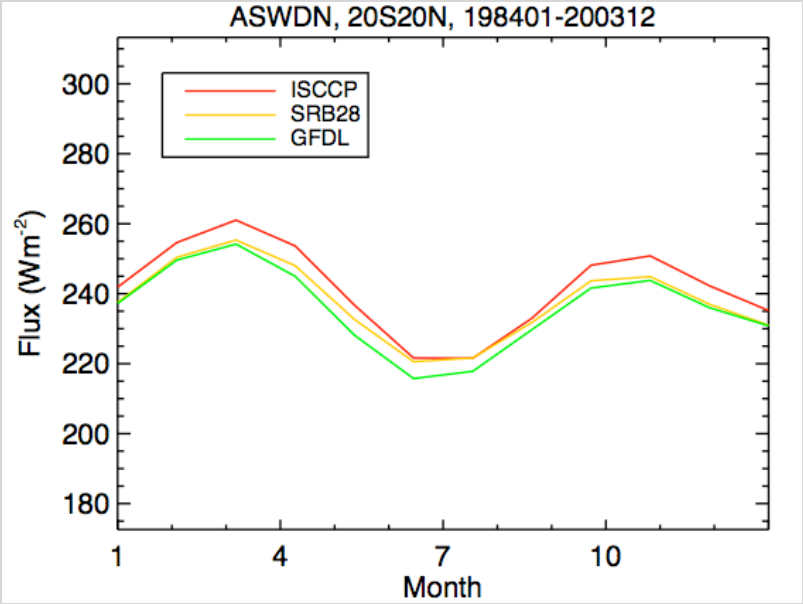


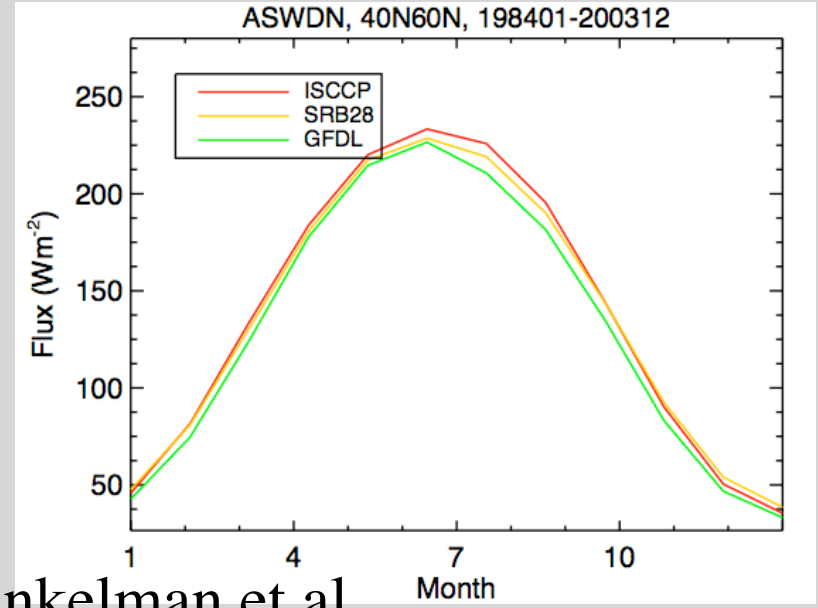
Cloud Fraction vs Direct/Diffuse Ratio: FD cell-mean Located to 15 BEST Stations Selected from BSRN, ARM and SURFRAD

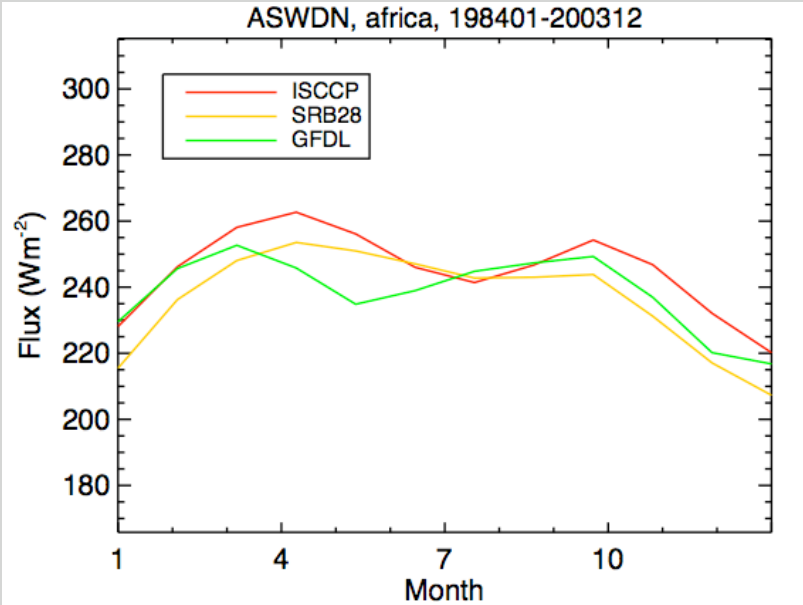


Seasonal Cycle Comparisons





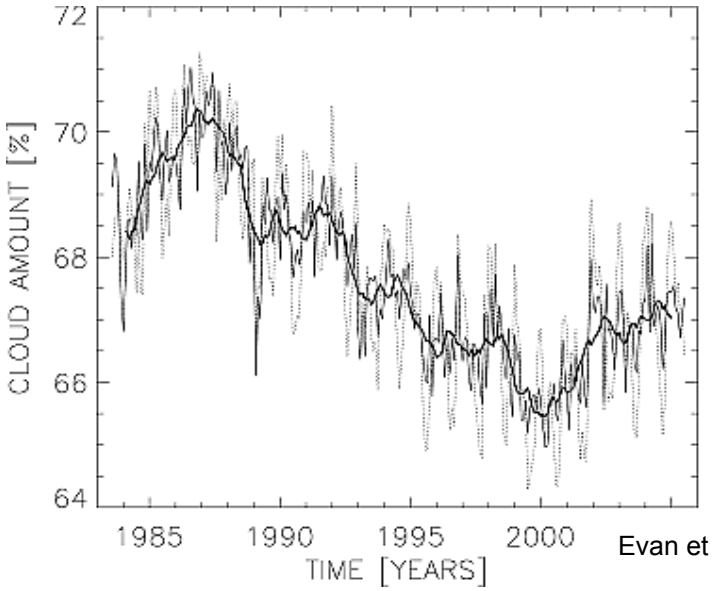




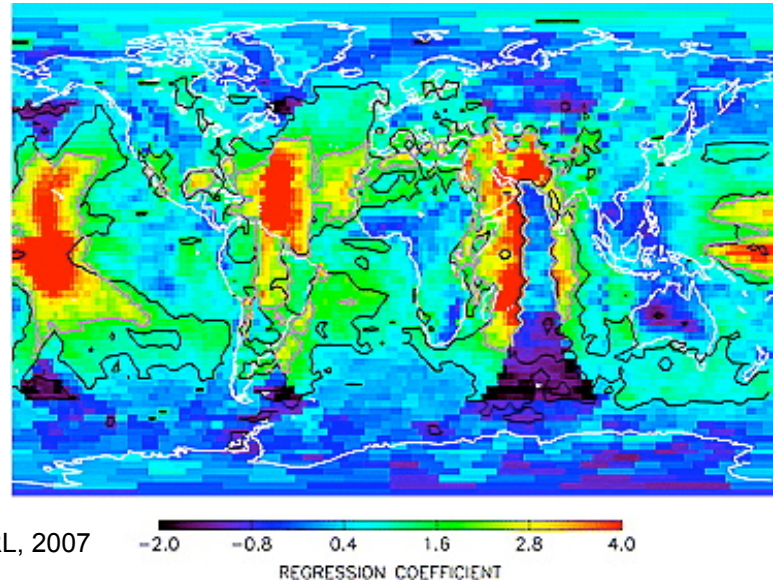
Hinkelman et al

ISCCP Cloud Cover Trend

ISCCP Mean Cloud Amount



Local Regression Coefficient



Evan et al., GRL, 2007

Possible causes:

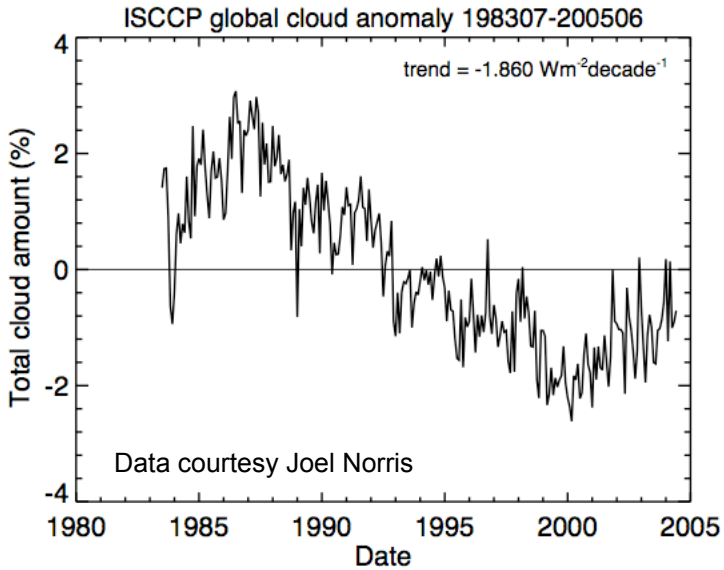
Addition/movement of geo. satellites
View zenith angle patterns of satellites
NOAA16 calibration problem

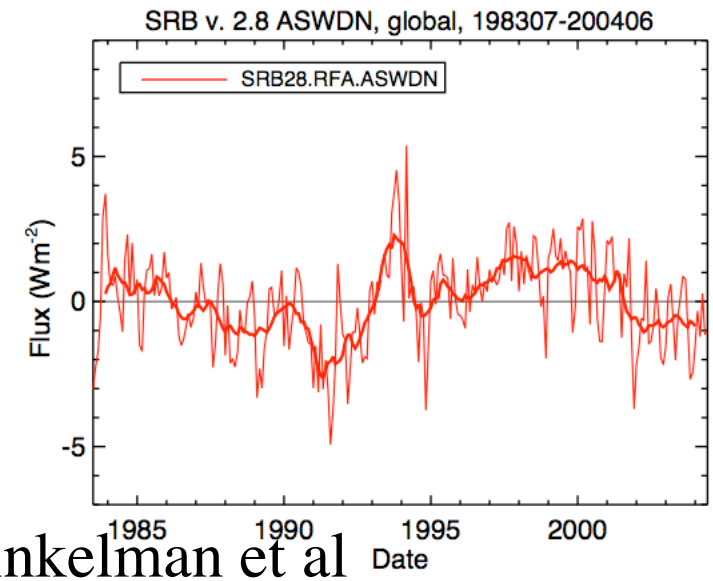
Q: How does this affect radiation products?

Hinkelman et al

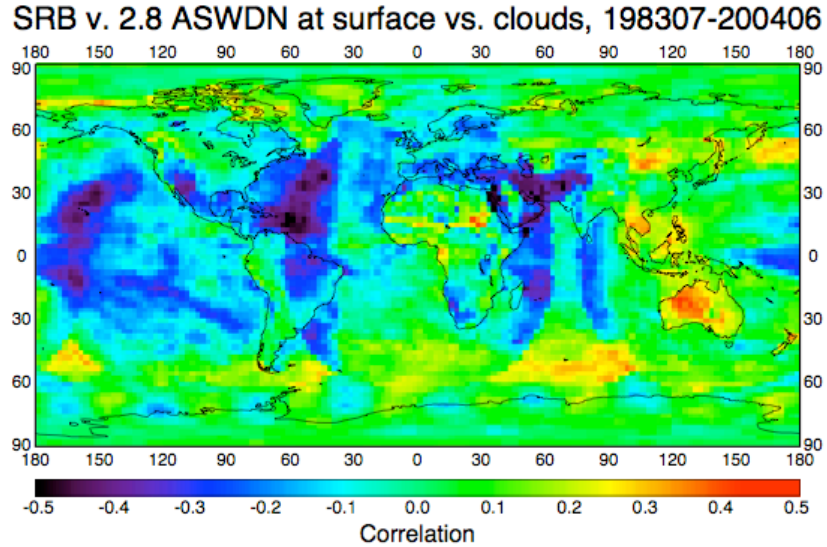
ISCCP Cloud Cover Artifact?

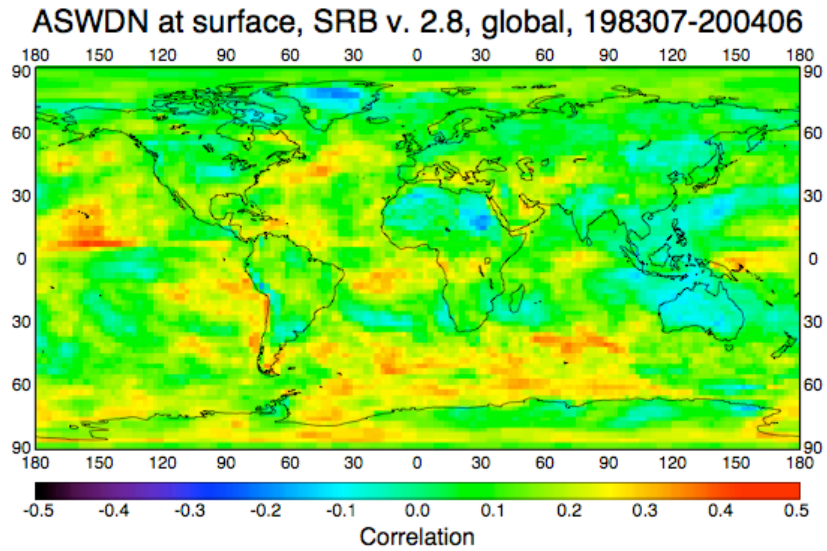
Global Mean Anomaly





Local Correlation to Mean

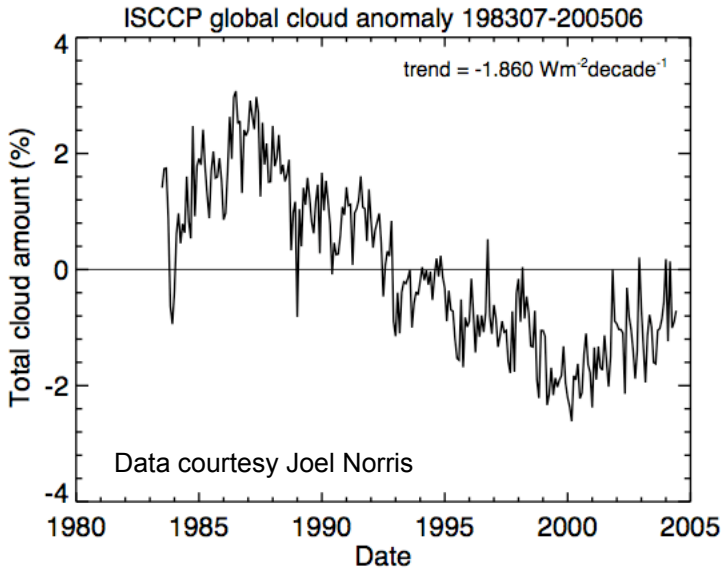


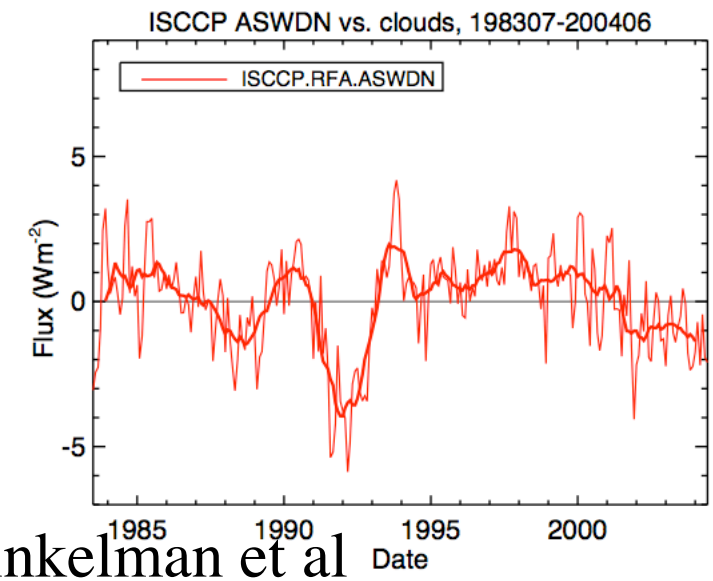


Hinkelman et al

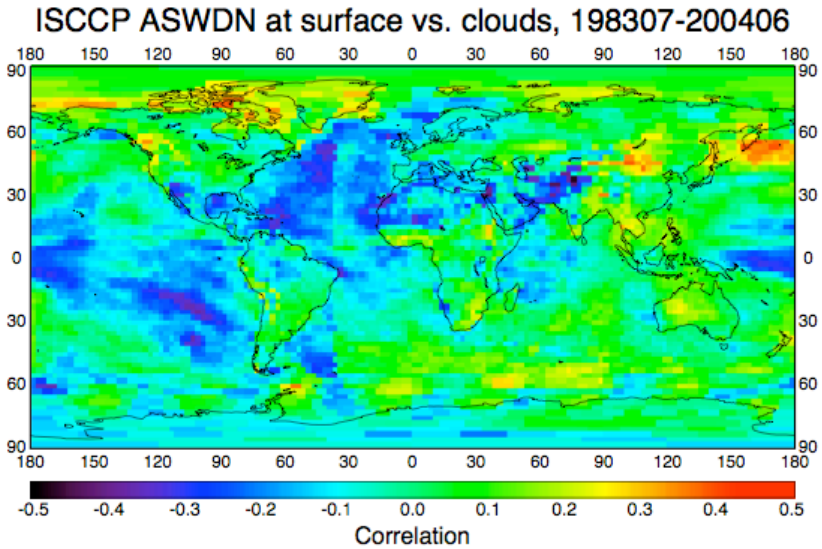
ISCCP Cloud Cover Artifact?

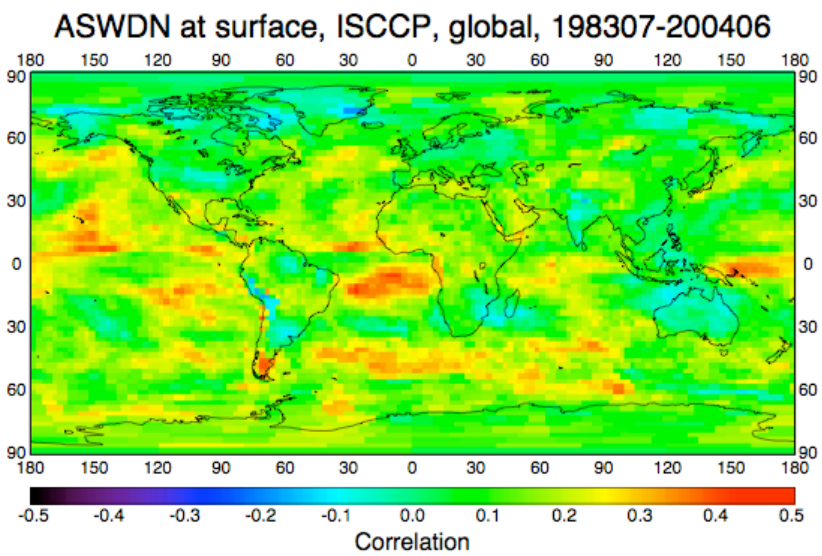
Global Mean Anomaly





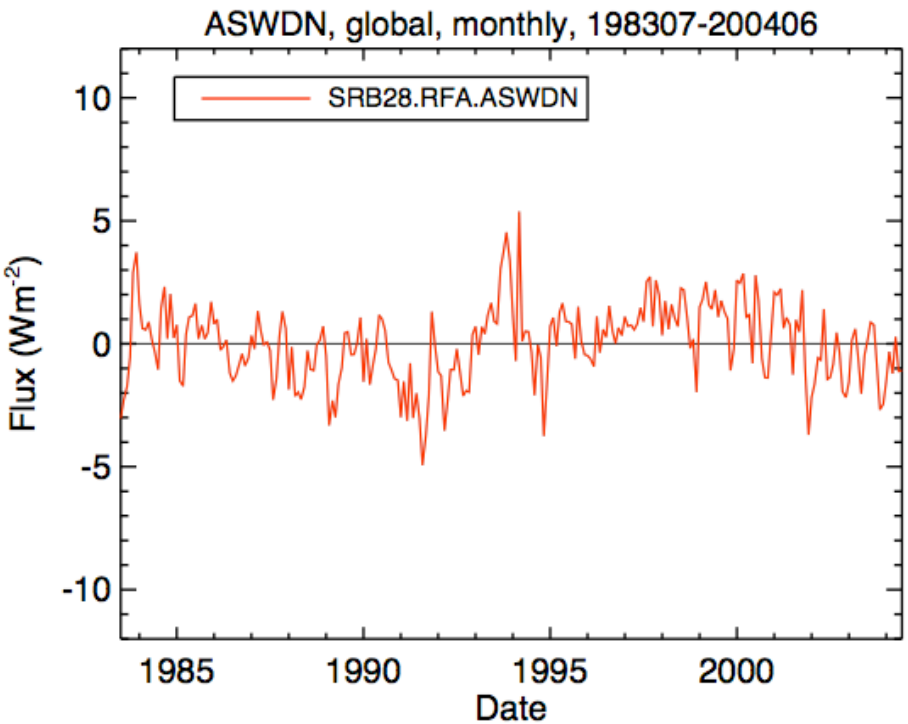
Local Correlation to Mean



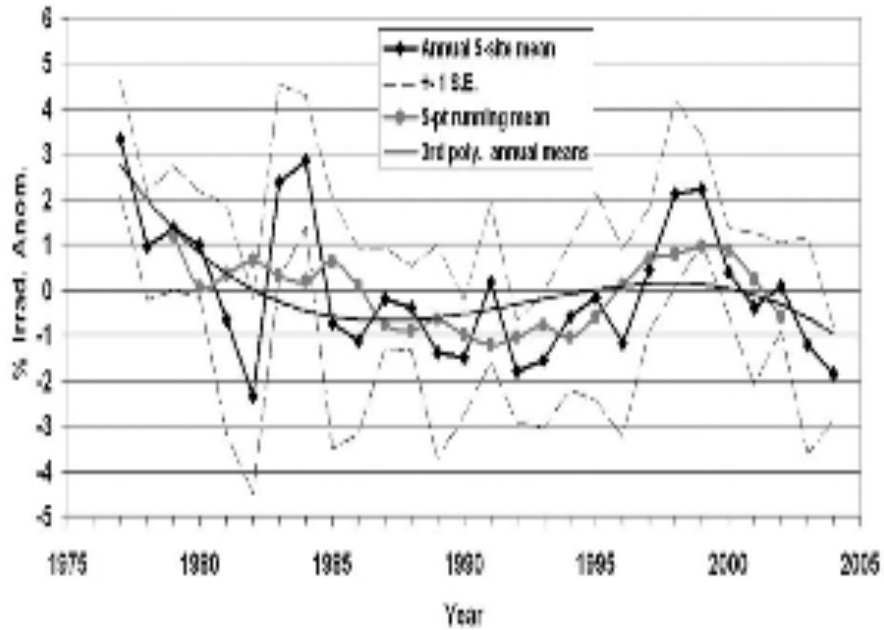


Hinkelman et al

Global “Dimming” and “Brightening”



GEWEX-SRB 2.8 Global Mean



Dutton et al. 2006 Surface Site Mean

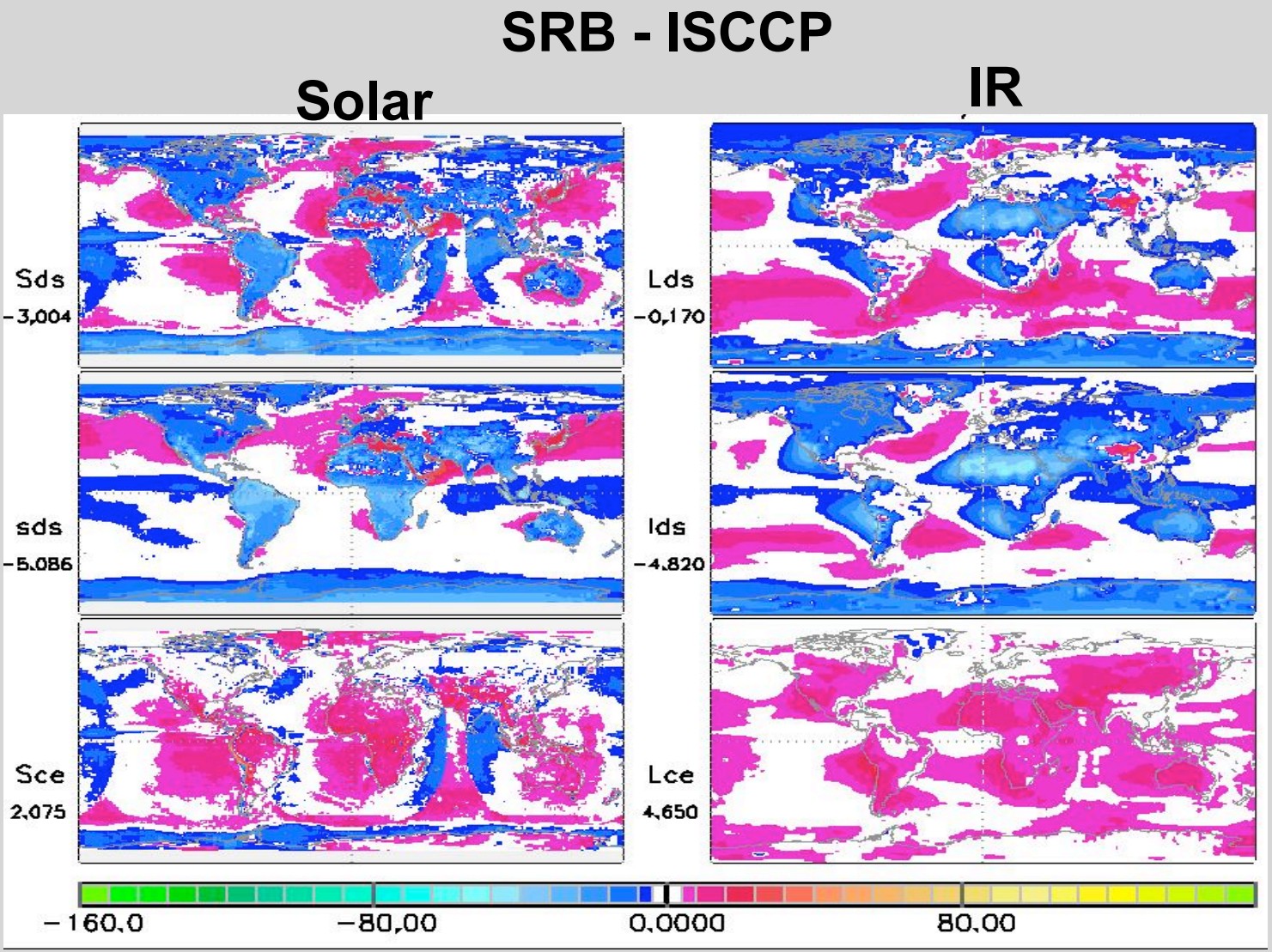
Are these trends significant?

Hinkelman et al

Kinne et al

SRB, ISCCP Comparisons

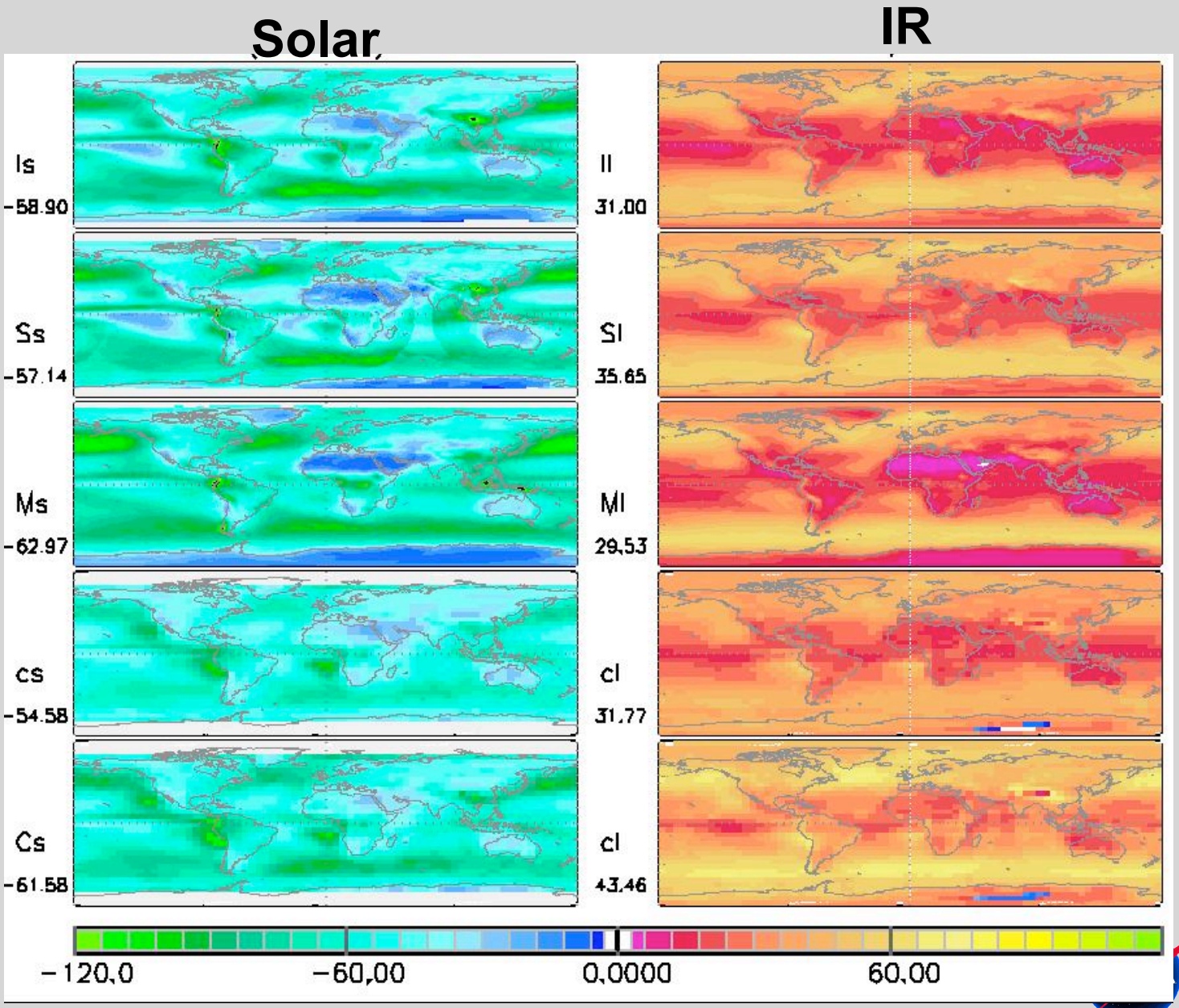
- down all-sky
- down clr-sky
- cloud-effect down



- SRB sol CE is less neg than ISCCP by 2W/m2 (opt. thinner clds)
- SRB IR CE is larger than ISCCP by 5W/m2 (lower altitude clds)

Cloud Effect (CE) Comparisons

- ISCCP
- SRB
- IPCC
- off-line
- off-line
  - scaled

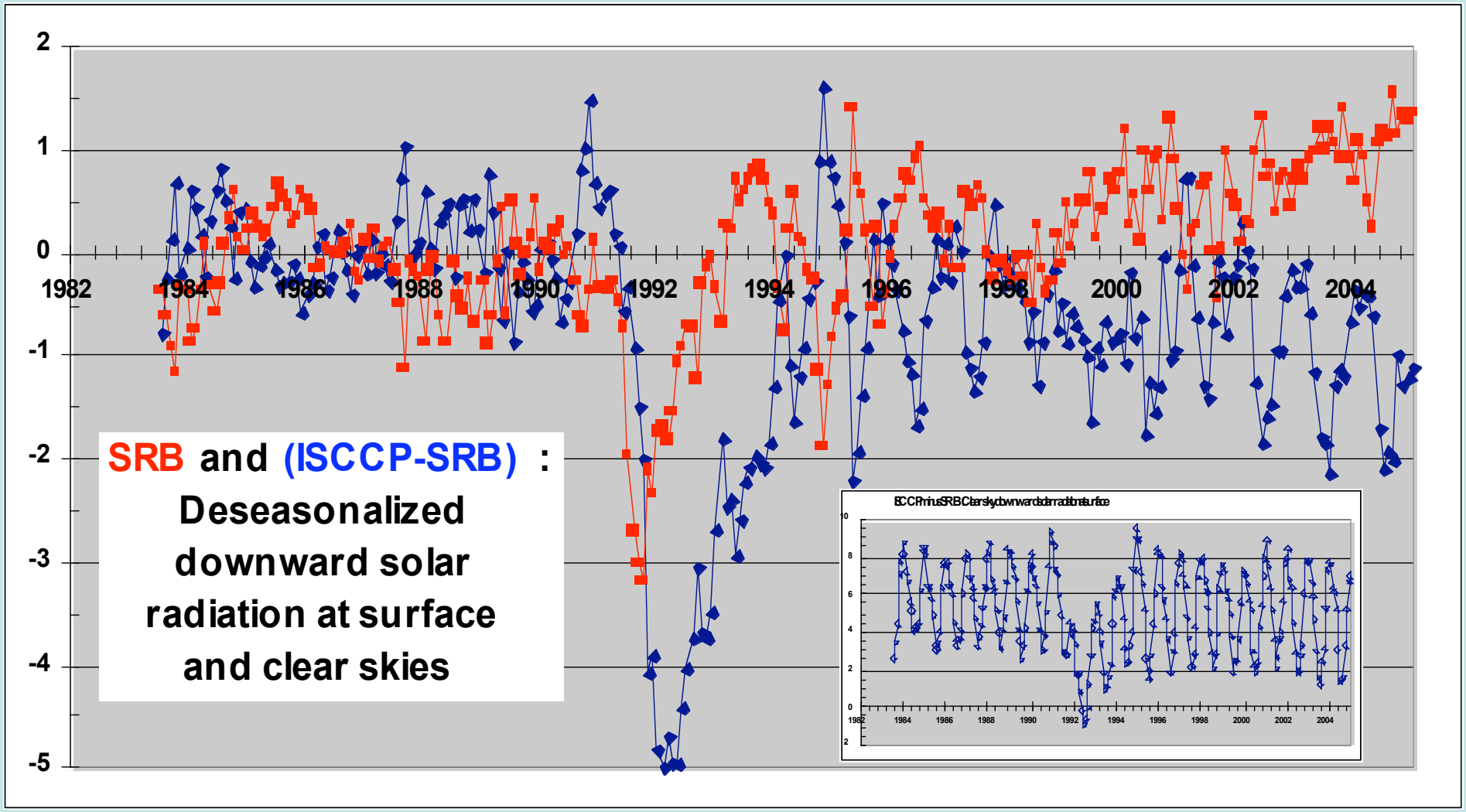


Kinne et al

Kinne et al Summary

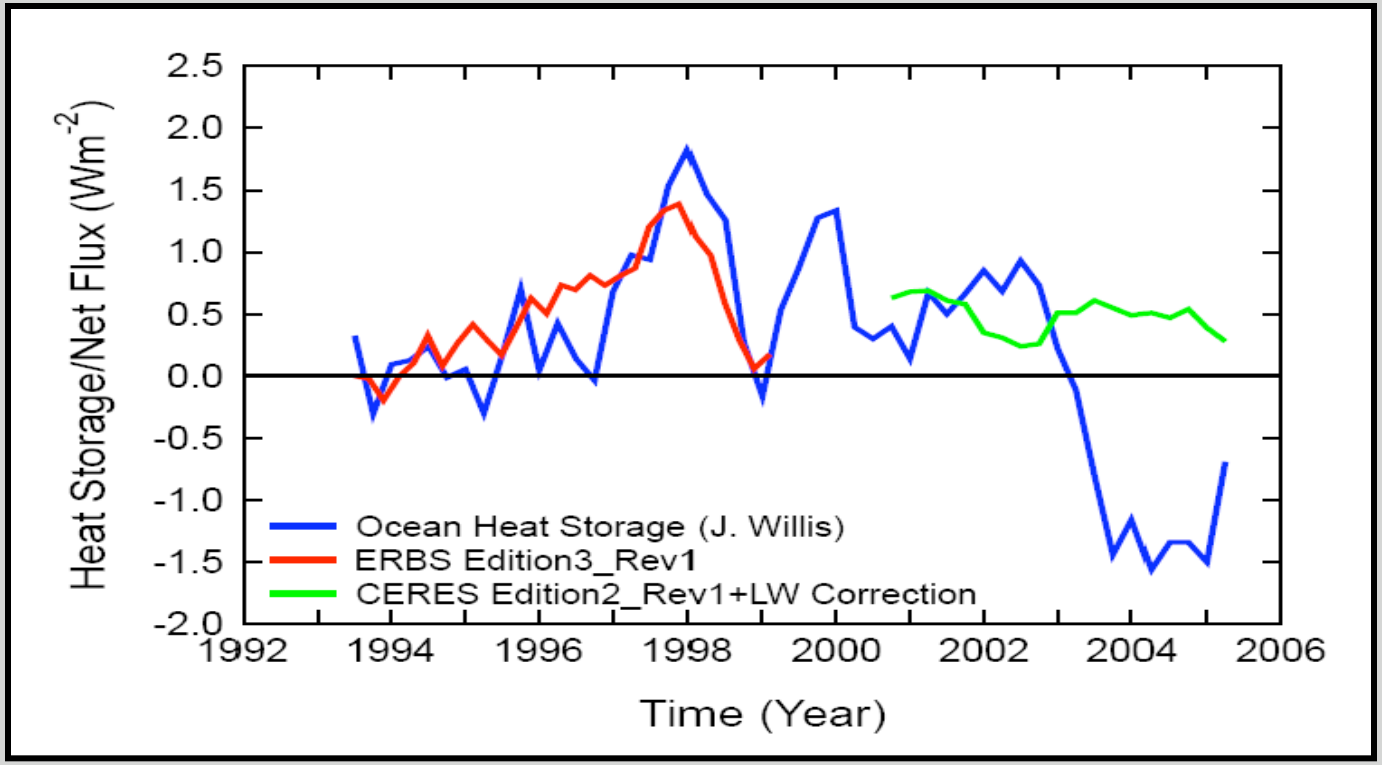
- **differences in SRB-ISCCP surface dn flux products are smaller in solar than IR**
  - ***alt. positioning and microphysics seem inconsist.***
- **SRB-ISCCP CE differences are smaller than potential uncertainties introduced by cloud climatology differences / implementations**
- **IPCC CE differences from 20 different global model are ~ 3 times larger than the climatology / implementation differences**

No solar “brightening” in ISCCP data?



Raschke et al

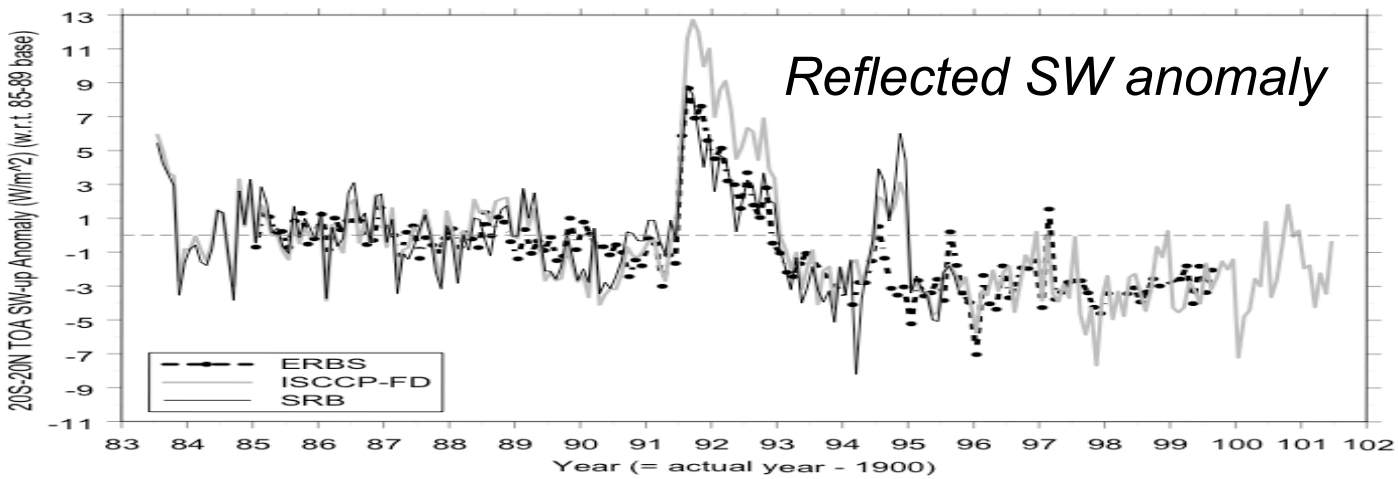
Does CERES Net Radiation Indicate New Ocean Cooling?

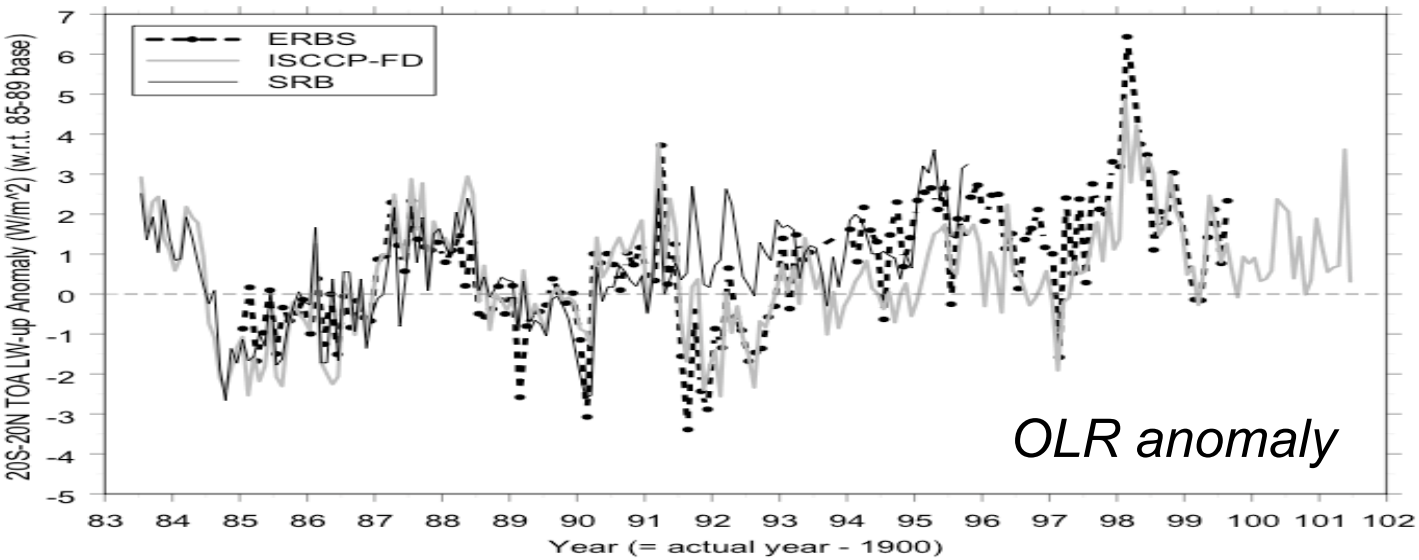


- *No!!* Net radiation changes in CERES (Ed3) are expected to show CERES at -0.1 Wm^{-2} vs. Ocean data of -1.7 Wm^{-2}
- No sign of ocean cooling (contraction) in the altimeter/ tide gauges data or accelerated glacial ice mass loss (GRACE);
- Willis et al will update showing that the cooling was in error and due to transition to new ARGO system

Wong et al; Willis et al (GRL, 2007)

TOA Time Series Intercomparison





SW TOA Flux Intercomparison

(Row - Column; Bold direct comparison; remainder inferred; Fluxes normalized relative to 240 W m^{-2})

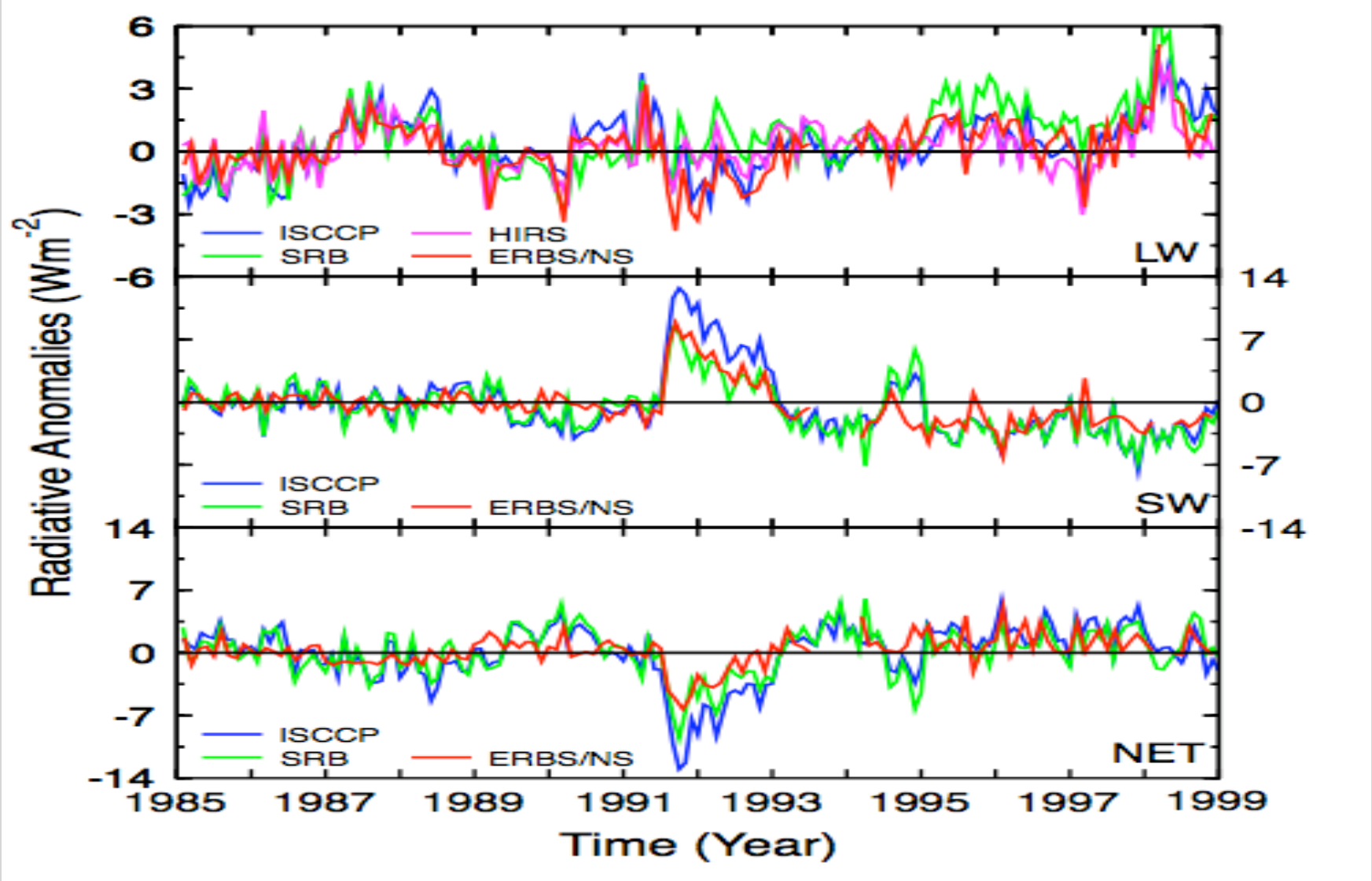
	ERBS Sc	ERBS NS	ScaRaB 1	CERES /TRMM	ScaRaB 2	CERES FM-1	CERES FM-2	CERES FM-3	CERES FM-4
ERBS Sc	-	**-5.4**	-4.5	-1.8	-5.2	-2.0	-1.7	-1.1	-1.2
ERBS NS	**0.3**	-	**0.9**	**3.6**	-0.2	3.4	3.7	4.3	4.2
ScaRaB 1	0.5	**0.4**	-	2.7	-0.7	2.5	2.8	3.4	3.3
CERES/ TRMM	0.9	**0.9**	1.0	-	**-3.4**	**-0.2**	0.1	0.9	0.6
ScaRaB 2	1.7	1.7	1.7	**1.4**	-	3.2	3.5	4.1	4.0
CERES FM-1	1.2	1.1	1.2	**0.7**	1.6	-	**0.3**	0.9	**0.8**
CERES FM-2	1.3	1.2	1.3	0.9	1.6	**0.5**	-	0.6	0.5
CERES FM-3	1.2	1.2	1.2	0.7	1.6	0.2	0.5	-	**-0.1**
CERES FM-4	1.2	1.1	1.2	0.7	1.6	**0.1**	0.5	**0.2**	-

Mean Differences

Standard Deviations

(Smith et al., 2006)

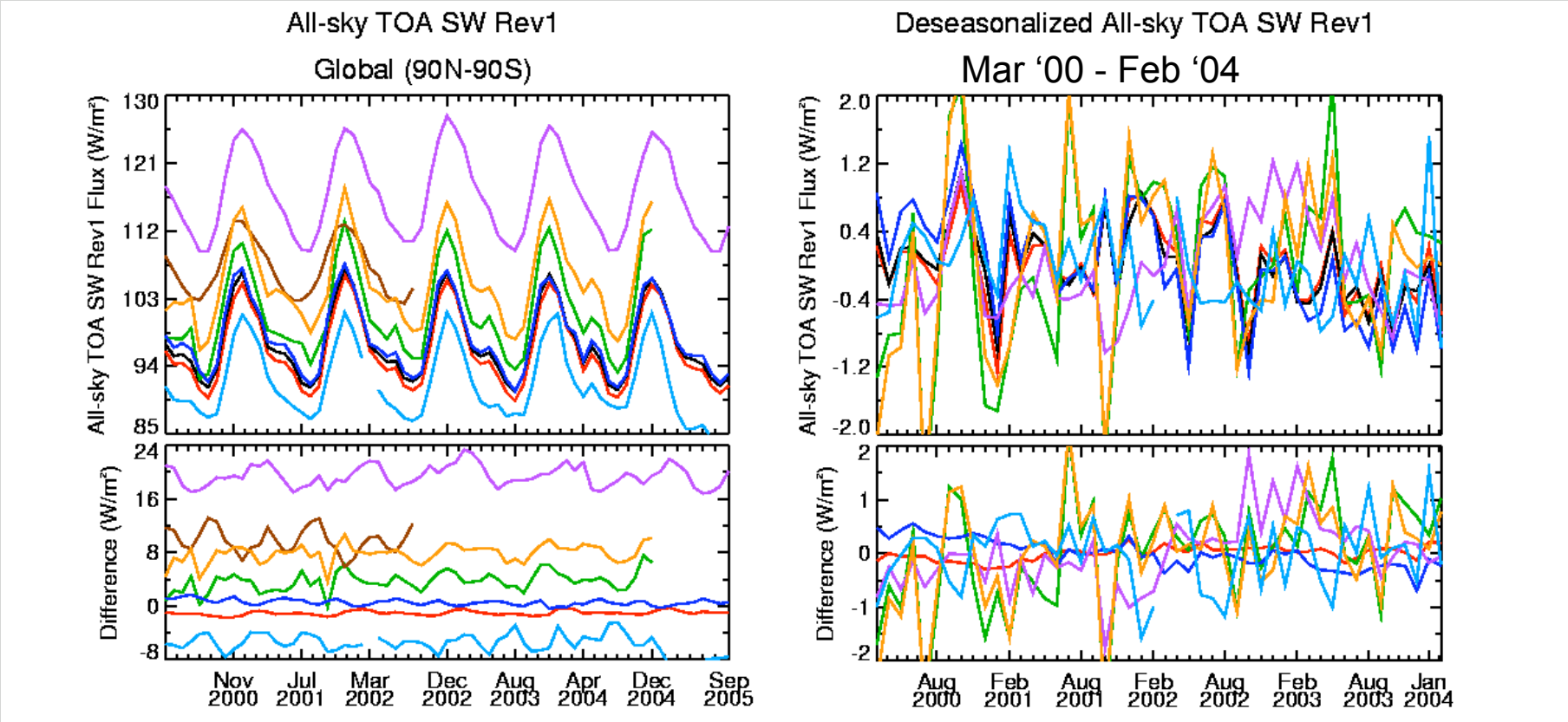
TOA Deseasonalized Anomalies



Courtesy Takmeng Wong, NASA LaRC

Global Monthly Averaged Time Series

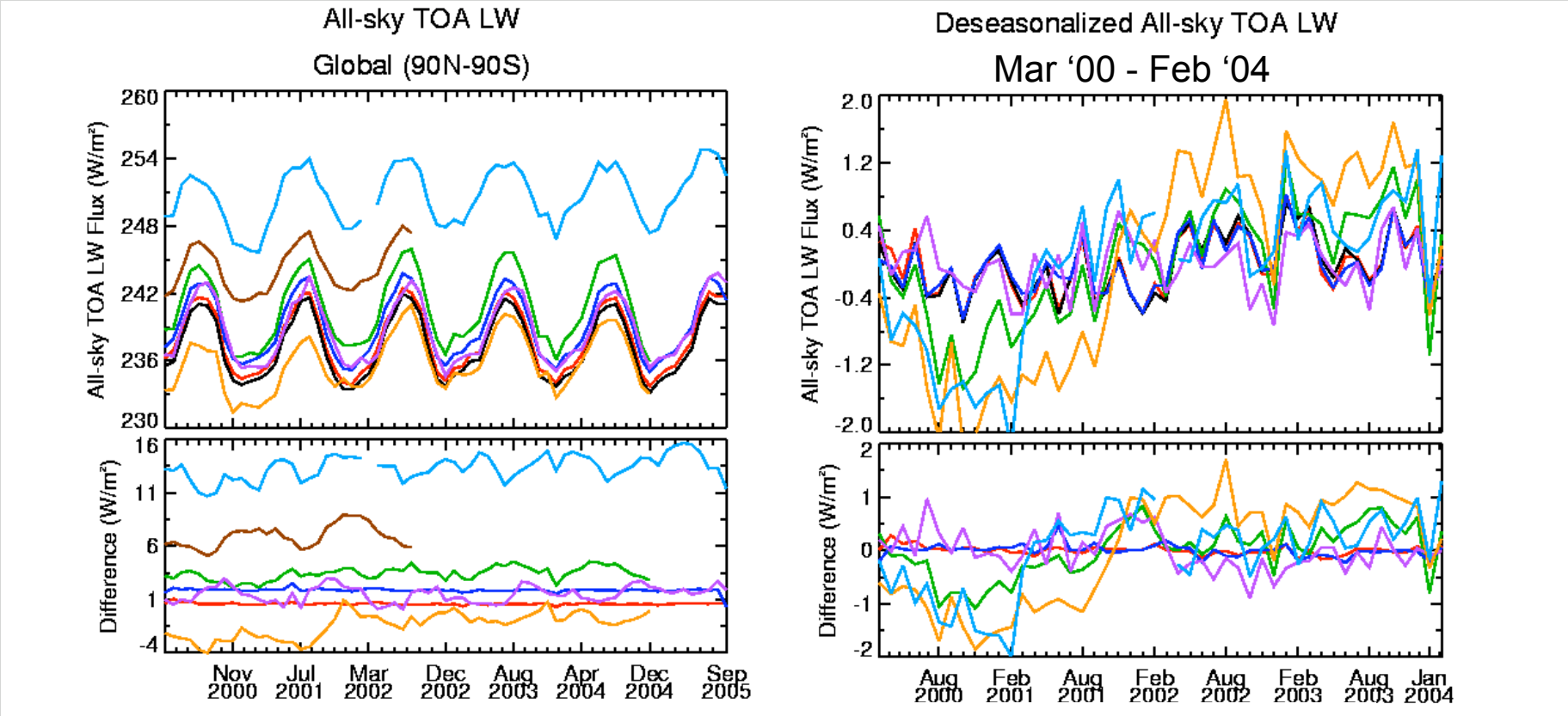
(courtesy Dave Doelling, CERES Team)



All-sky TOA SW Rev1		Difference		Avg
nonGEO	96.3	nonGEO - GEO		-1.0
GEO	97.3			
SRB	101.2	SRB - GEO		3.7
ERBE_like	97.9	ERBE_like - GEO		0.6
NCEP	116.7	NCEP - GEO		19.4
ECMWF	107.0	ECMWF - GEO		9.8
ISCCP FD	105.4	ISCCP FD - GEO		7.9
GEOS4	91.6	GEOS4 - GEO		-5.7

Global Monthly Averaged Time Series

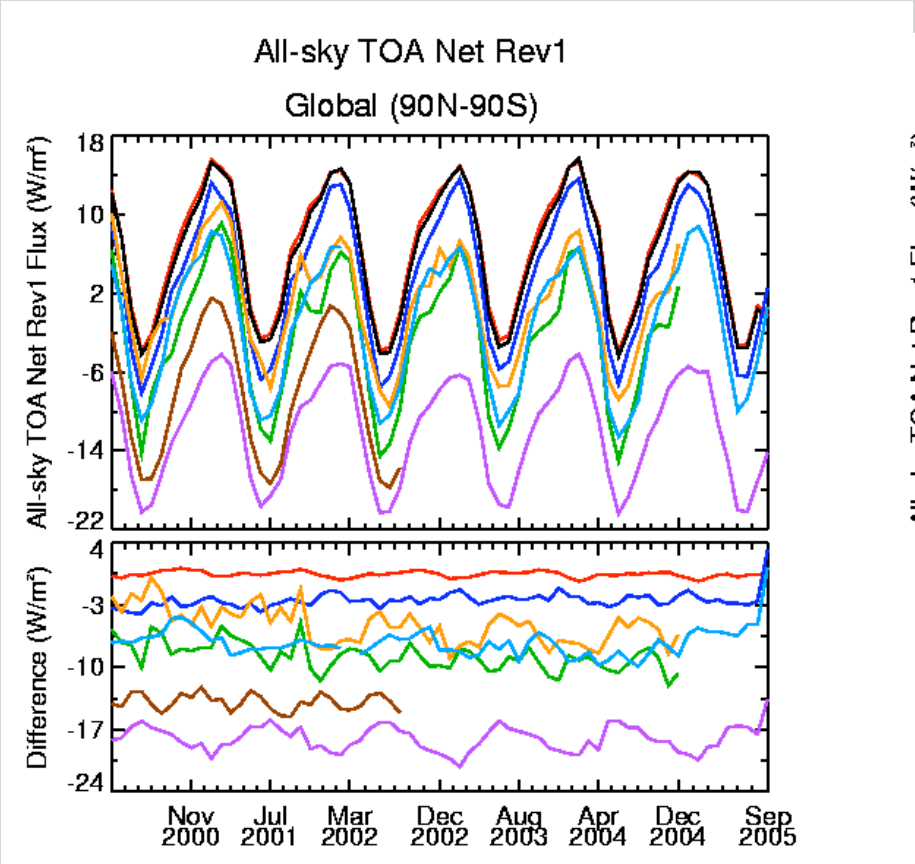
(courtesy Dave Doelling, CERES Team)

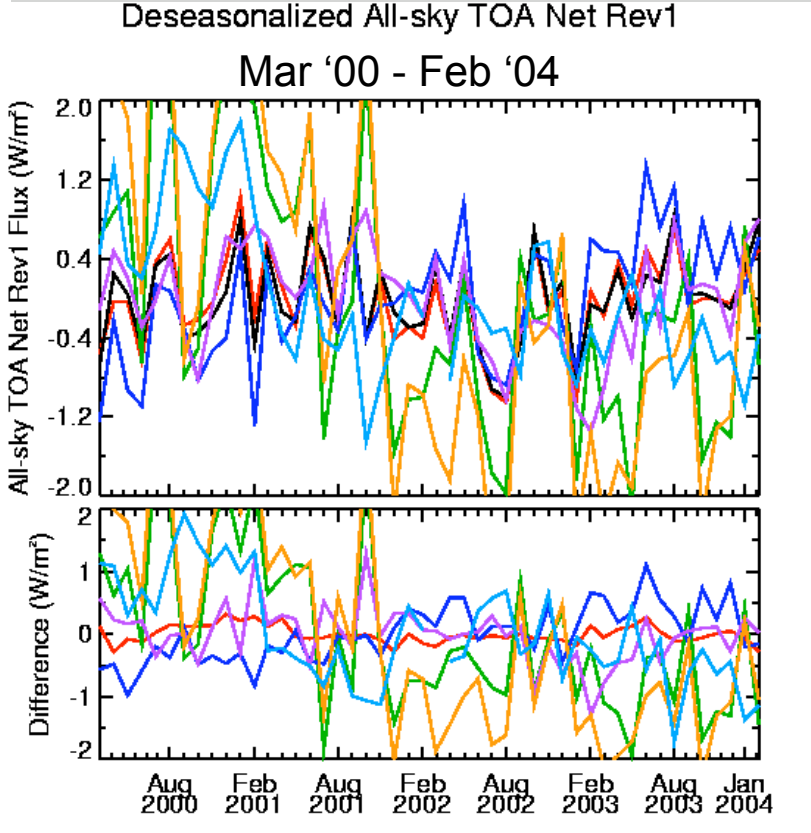


All-sky TOA LW		Difference		Avg
nonGEO	237.9	nonGEO - GEO		0.6
GEO	237.3			
SRB	240.6	SRB - GEO		3.4
ERBE_like	239.2	ERBE_like - GEO		1.9
NCEP	238.8	NCEP - GEO		1.5
ECMWF	244.3	ECMWF - GEO		6.9
ISCCP FD	235.8	ISCCP FD - GEO		-1.4
GEOS4	250.7	GEOS4 - GEO		13.4

Global Monthly Averaged Time Series

(courtesy Dave Doelling, CERES Team)



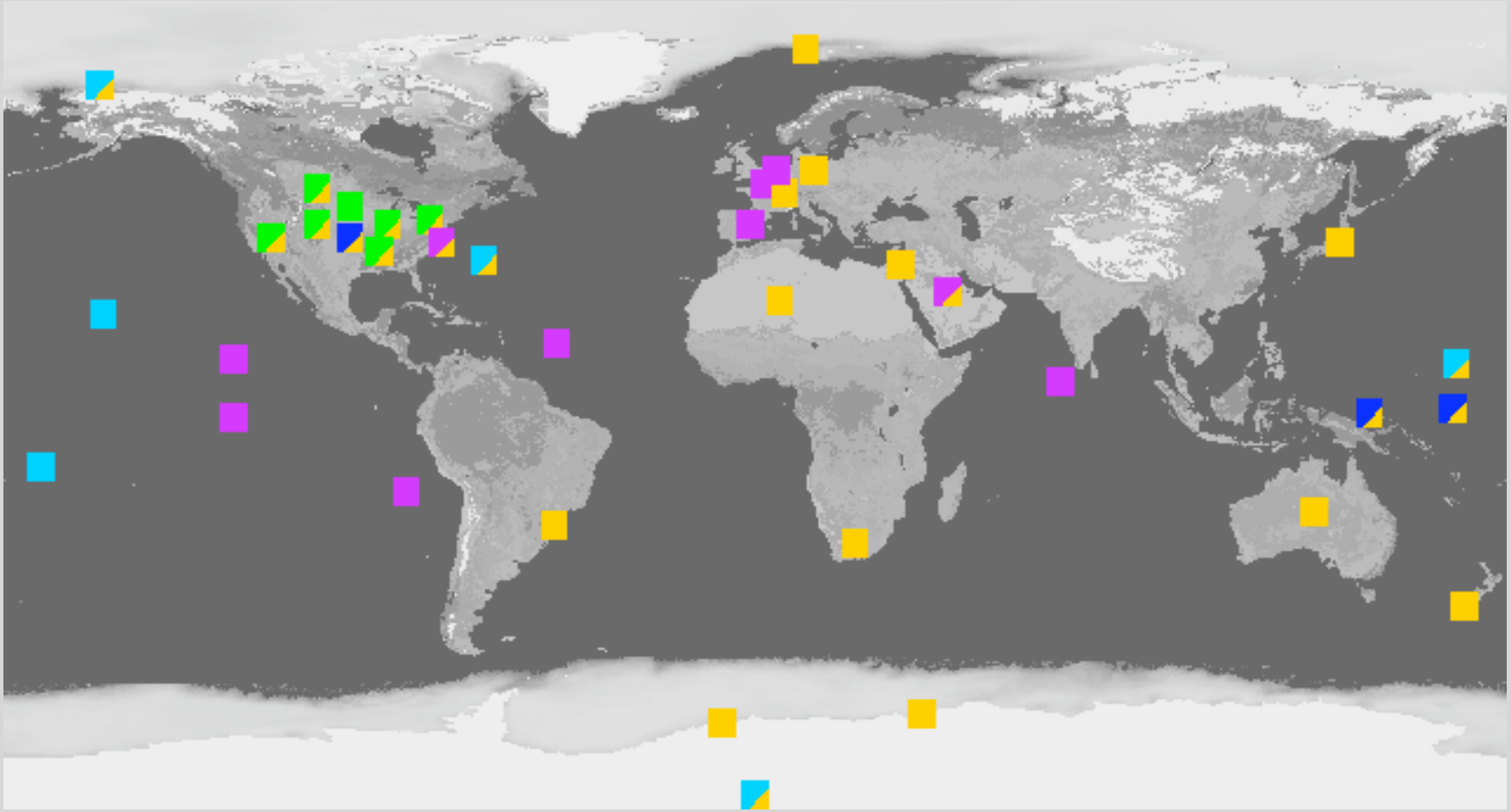


All-sky TOA Net Rev1		Difference		Avg
nonGEO	6.5	nonGEO - GEO		0.4
GEO	6.1			
SRB	-2.5	SRB - GEO		-8.8
ERBE_like	3.6	ERBE_like - GEO		-2.5
NCEP	-11.9	NCEP - GEO		-18.0
ECMWF	-8.3	ECMWF - GEO		-13.9
ISCCP FD	1.0	ISCCP FD - GEO		-5.3
GEOS4	-1.2	GEOS4 - GEO		-7.2

CERES TOA Flux Errors

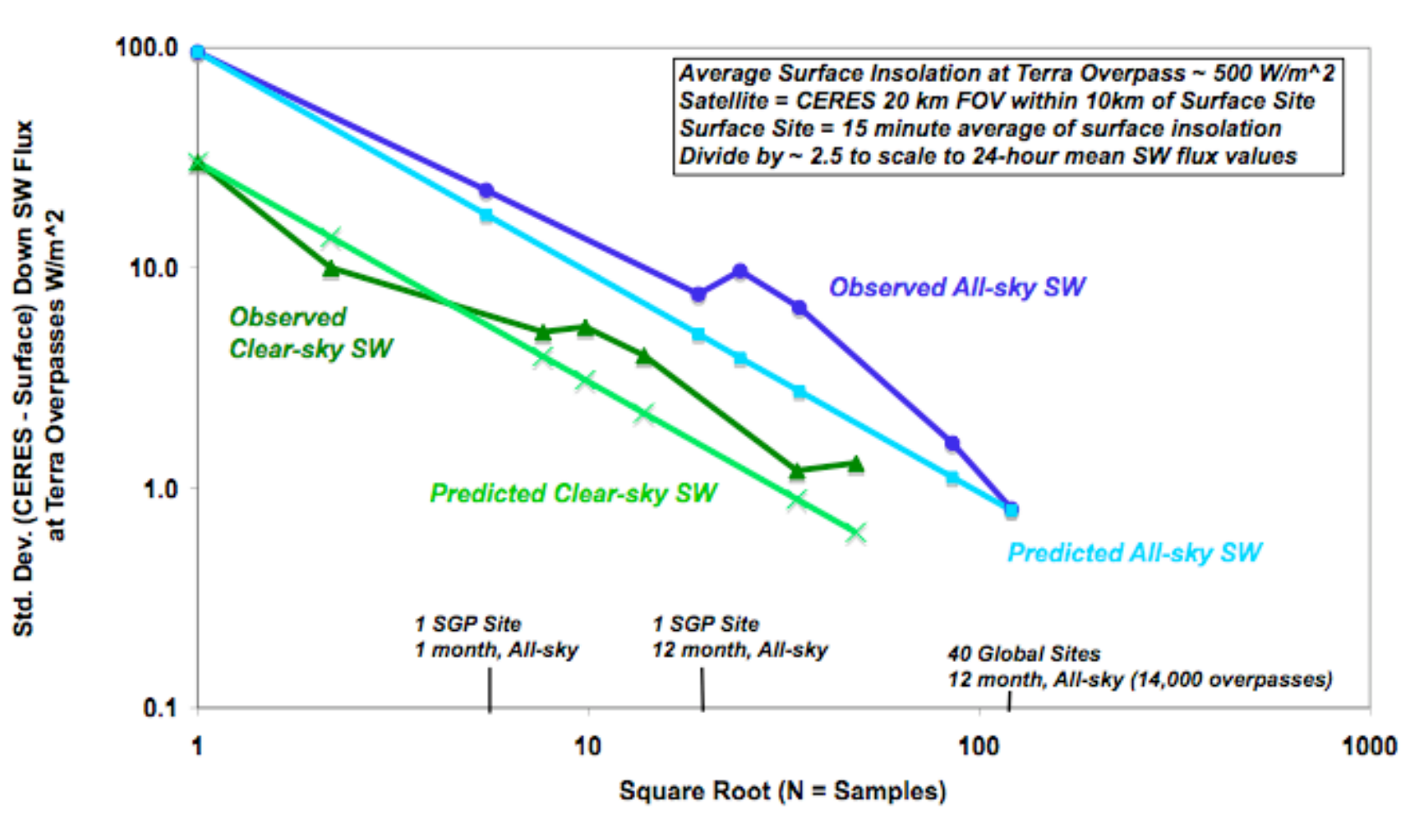
	Global Interannual Cld Rad Fcing Trend/decade	Zonal Eqtr - Pole Gradient Monthly	1 deg region Monthly (1 σ)	20km fov Instantaneous (1 σ) (S_o = 1000)
Dominant Error Sources	Calibration Stability	Angle Sampling Twilight	Calibration Time Sampling	Angle Sampling
TOA SW Flux	0.3 Wm^{-2} Terra Rev1	3.5 Wm^{-2}	3.0 Wm^{-2}	10 Wm^{-2}
TOA LW Flux	0.5 Wm^{-2} Terra Rev1	2.0 Wm^{-2}	1.5 Wm^{-2}	5 Wm^{-2}
TOA Net Flux	0.6 Wm^{-2} Terra Rev1	4.0 Wm^{-2}	3.5 Wm^{-2}	11 Wm^{-2}
Science Rqmt	0.15 Wm^{-2} 25% feedback	1 - 3 Wm^{-2}	2 - 5 Wm^{-2}	10 Wm^{-2}

ARM/BSRN/CMDL/Surfrad Surface Radiation Sites

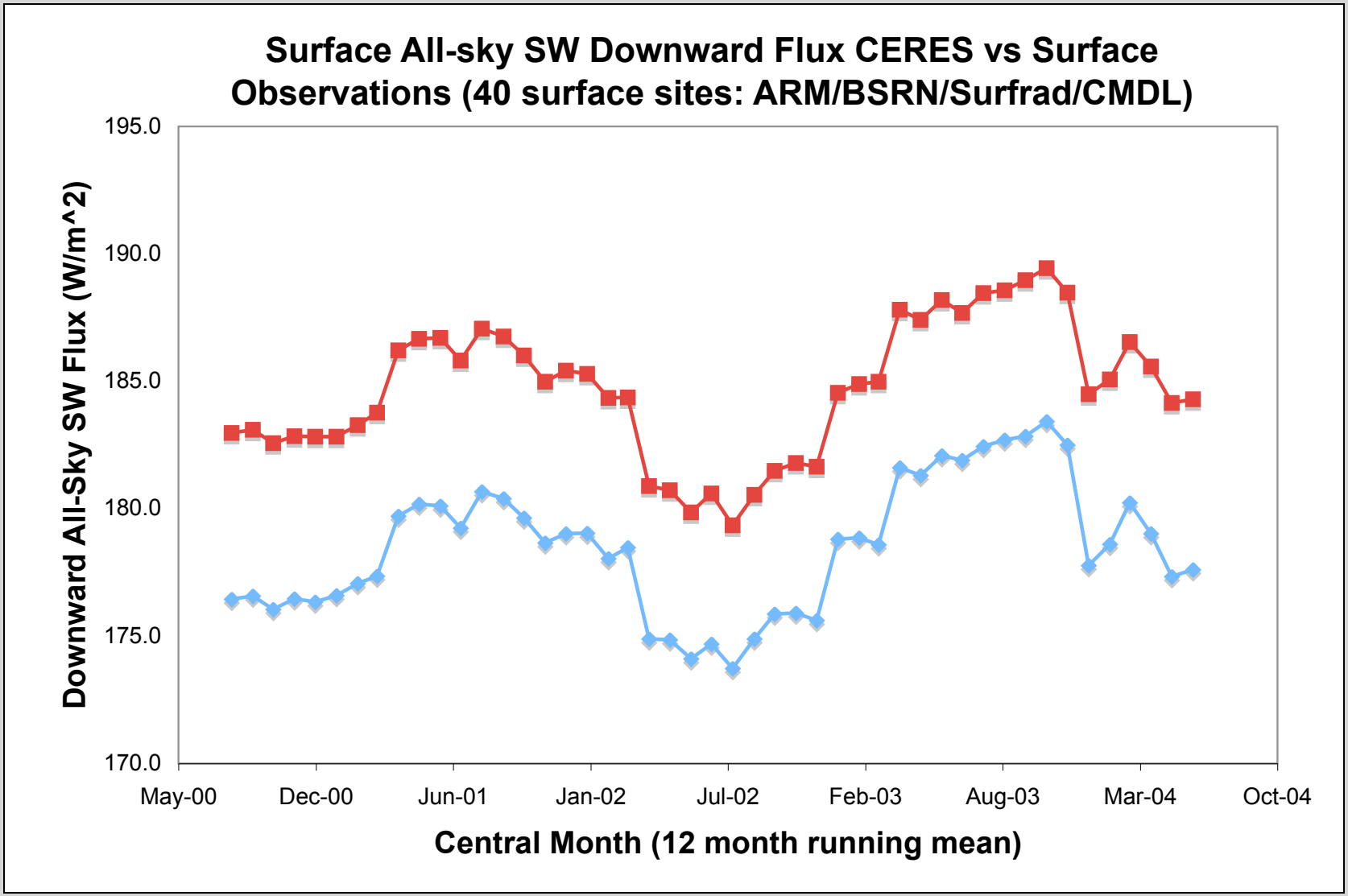


Surface SW Flux Validation Noise

Spatial mismatch of surface point to satellite area



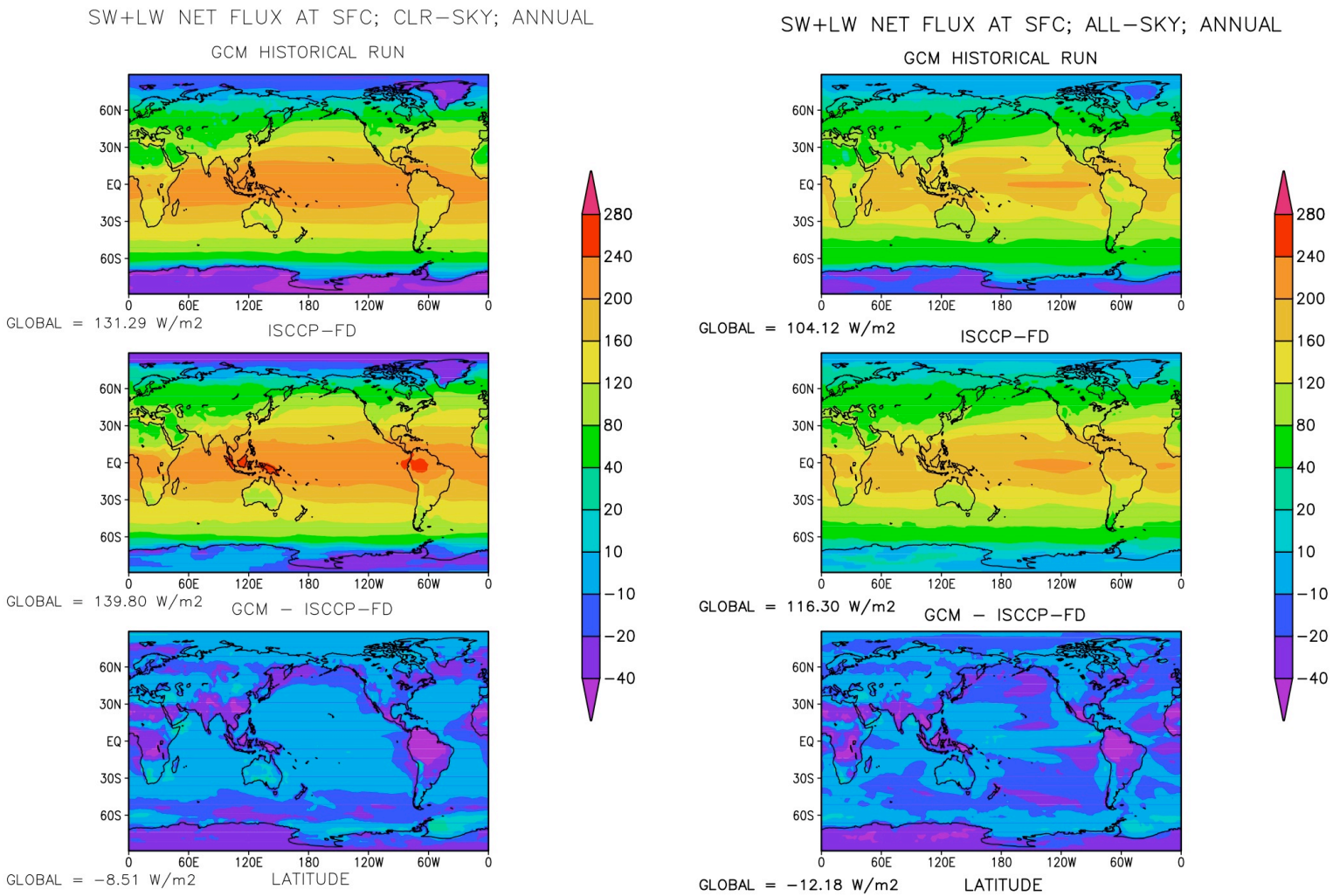
CERES CRS Surface Flux Anomalies vs Surface Radiometers



Surface Downward Flux Errors: 20 - 40 Surface Sites

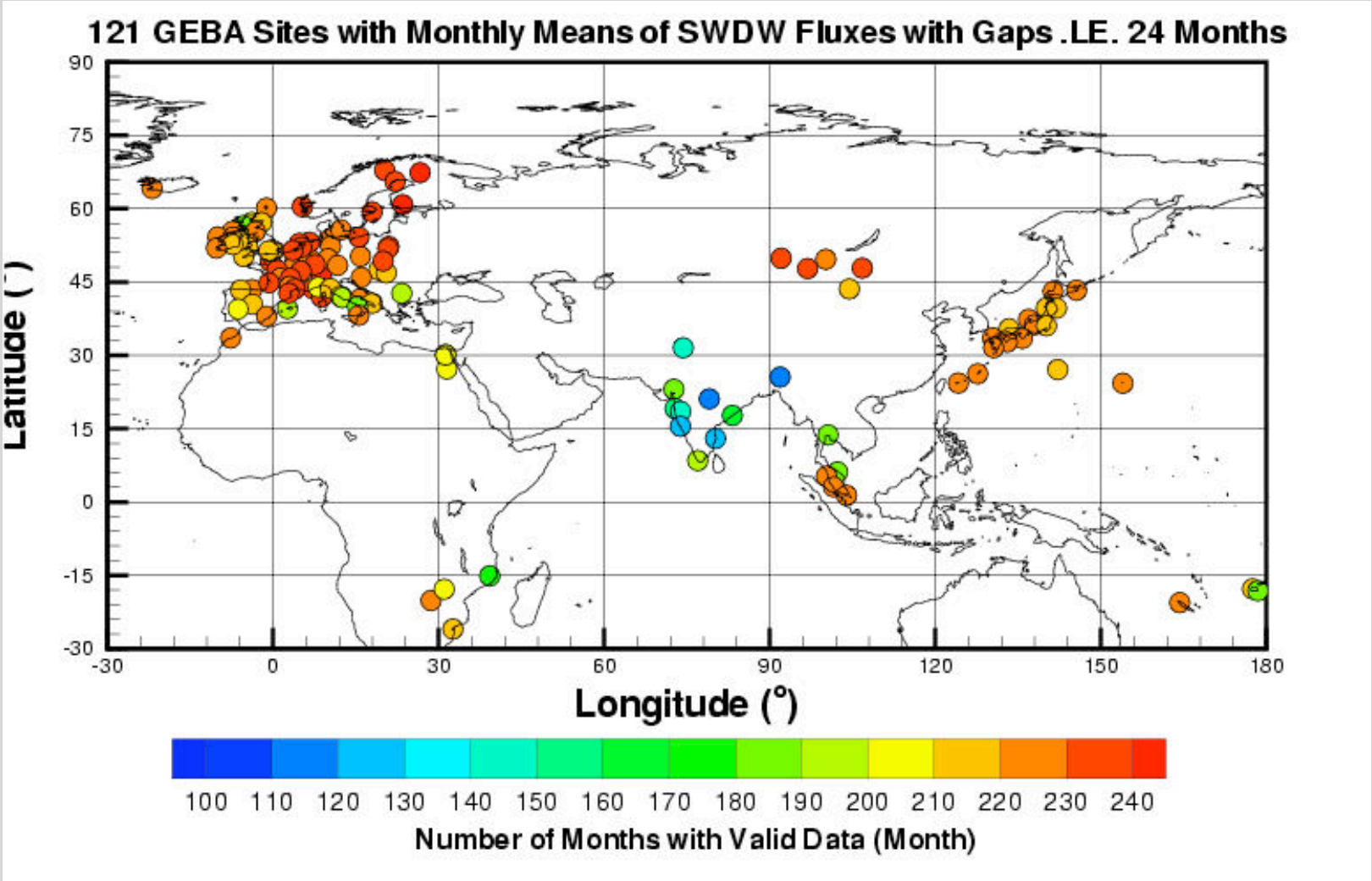
	Global Interannual Cld Rad Fcing Variability	SYN/AVG (est) Month, 1-deg Bias, Clr/All (1 σ)	SRBAVG Month, 1-deg Bias All (1σ)	CRS 20km fov Instantaneous 1 σ, Clr/All Sky (S_o = 900)
Dominant Error Sources	TBD	Aerosol, Tair, Polar sfc/cld Site Inhom.	Aerosol, Tair, Param. Site Inhom.	Angle Samp, Water Vapor Aerosol, Tair
Surface Down SW Flux	0.5 Wm^{-2} (40 sites)	0 / +5 Wm^{-2} (σ = 6)	3 Wm^{-2} (σ = 20)	23 / 20 Wm^{-2}
Surface Down LW Flux	1.0 Wm^{-2} (40 Sites)	-7 / -6 Wm^{-2} (σ = 8)	< 1 Wm^{-2} (σ = 10)	12 / 17 Wm^{-2}
Surface Down Total Net Flux	1.1 Wm^{-2} (40 Sites)	-7 / -1 Wm^{-2} (σ = 9)	4 Wm^{-2} (σ = 22)	26 / 26 Wm^{-2}
Science Rqmt	TBD	< 5-10 Wm^{-2}	< 5-10 Wm^{-2}	< 25 Wm^{-2}
BSRN Acc.	TBD	5 SW?, 10 LW?	5 SW, 10 LW	15 SW, 10 LW

GEWEX-RFA Sample Results: Global Annual Average



GEBA Data for 7/83-6/03

(courtesy Hans Gilgen, Atsumu Ohmura, Martin Wild)



19-year Trends from GEBA and SRB Data

	Fitted slope	95% Confidence Interval	95% Sig. Time	
GEBA data	**-0.952**	**[-2.479, 0.575]**	**35.2**	**36.3**
Matched SRB data	**-0.395**	**[-1.956, 1.166]**	**35.7**	**66.3**
SRB at GEBA sites	**0.671**	**[-0.466, 1.808]**	**28.9**	**37.7**
SRB global mean	**0.671**	**[-0.076, 1.419]**	**21.9**	**28.5**

Notes:

- Slopes and confidence intervals in Wm^{-2}/decade.
- First sampling time for 95% significance assumes a trend of 1.0 Wm^{-2}/decade. Second is for actual detected trend. Values given in years.
- Zero within every confidence level
- Confidence interval decreases with increasing samples
- Confidence tends toward more positive with increasing sample