State of CERES

Norman G. Loeb
NASA Langley Research Center, Hampton, VA

CERES Science Team Meeting, September 26-28, 2017
NASA GSFC, Greenbelt, MD

CERES Meeting

Review status of CERES Instruments and Data Products:

- Status of CERES
- CERES Terra, Aqua, S-NPP SW/LW/TOTAL Channel Calibration Update
- CERES FM6 and RBI Update
- MODIS & VIIRS Cloud Algorithm & Validation Status
- ADM, SOFA, SARB and TISA Working Group Reports
- EBAF-TOA & EBAF-SFC Edition 4 Updates
- FLASHFLUX Update
- Data Management Team Update: Terra/Aqua/S-NPP
- Atmospheric Sciences Data Center (ASDC) Update
- CERES Communication Activities

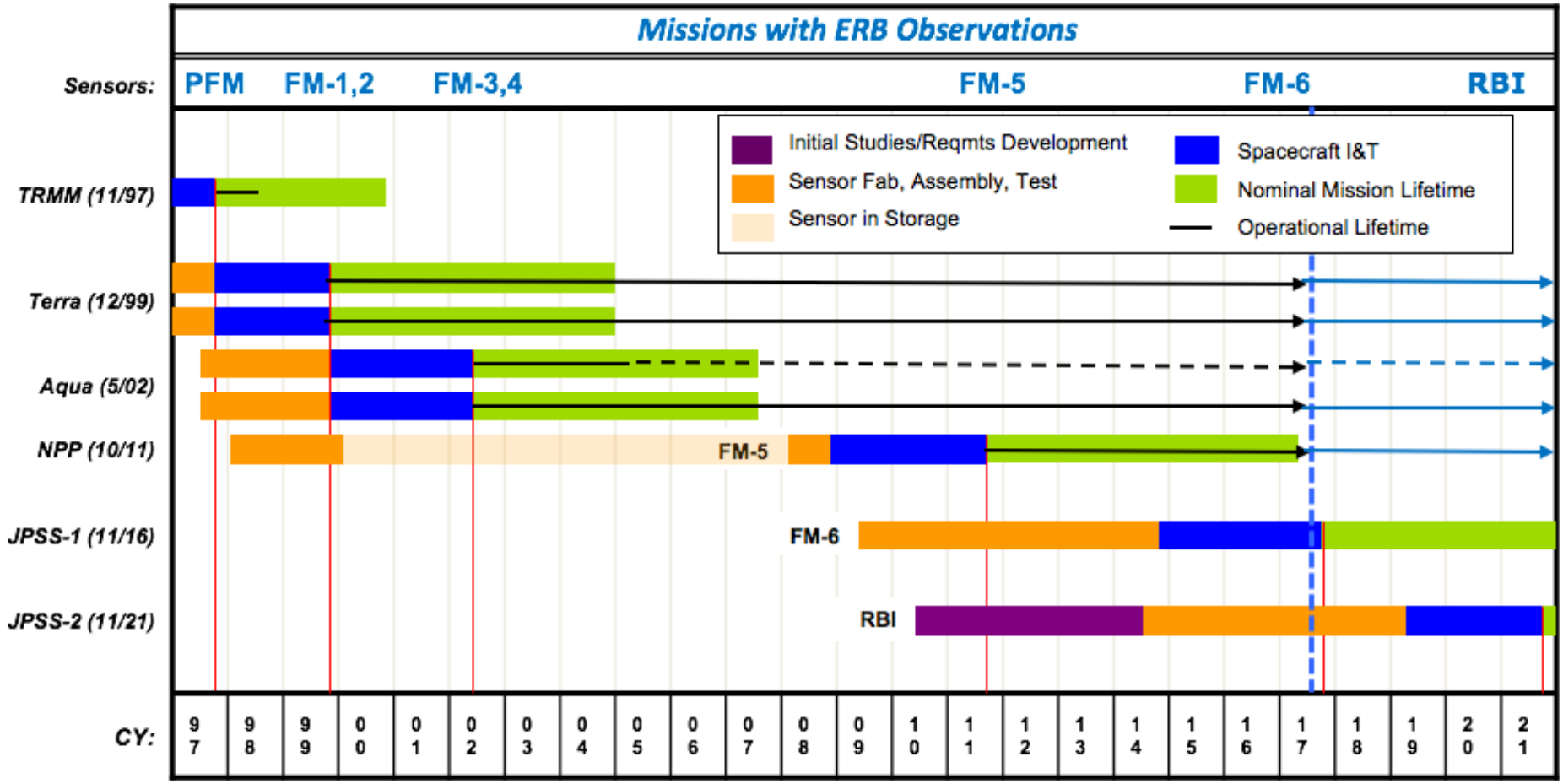
CERES Team Leads

- Principal Investigator: Norman Loeb
- Project Scientist: Kory Priestley

<u>CERES Working Groups:</u>

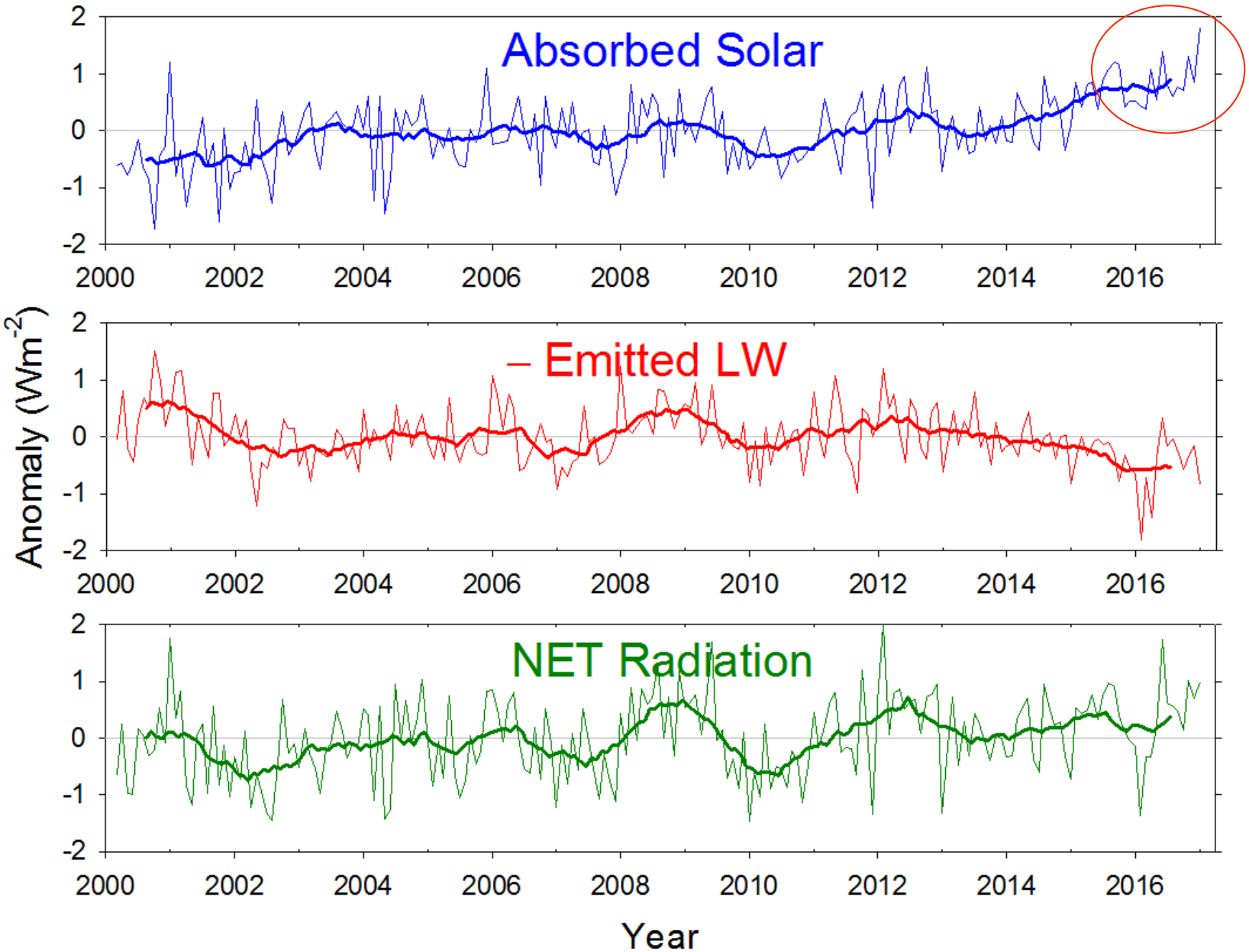
- Instrument: Kory Priestley
- Clouds: Bill Smith Jr.
- Inversion: Wenying Su
- SOFA: David Kratz
- SARB: Seiji Kato
- TISA: David Doelling
- ERBElike: Takmeng Wong
- FLASHFlux: Paul Stackhouse & David Kratz
- Data Management: Jonathan Gleason & Katie Moore
- ASDC: John Kusterer

CERES & RBI Flight Schedules

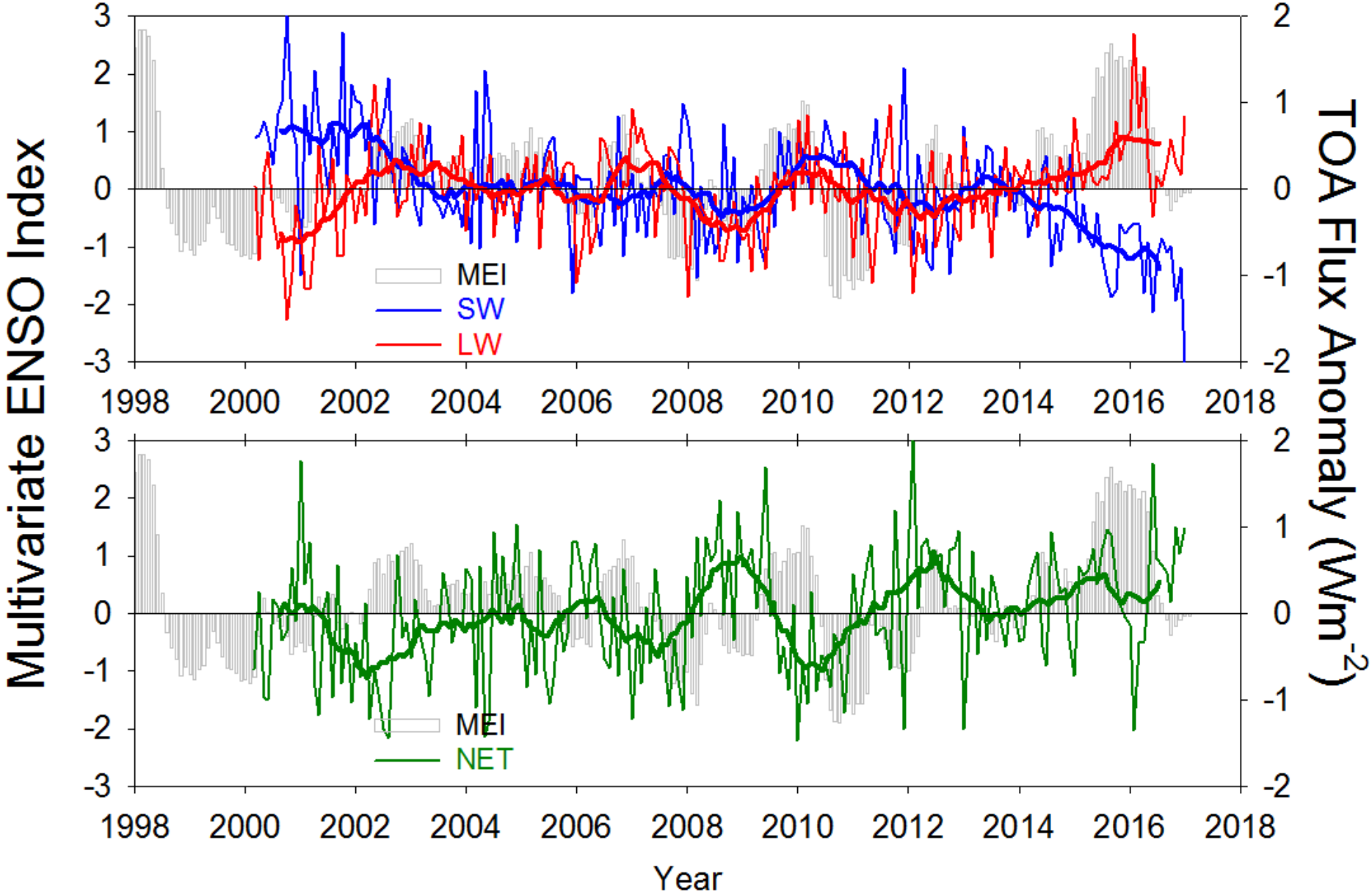


- Currently, 5 CERES instruments fly on 3 satellites: Terra (L1999), Aqua (L2002) and S-NPP (L2011).
- CERES FM6 will fly on JPSS-1 (**November 10, 2017**). The CERES follow-on instrument (Radiation Budget Instrument, or RBI) will fly on JPSS-2 in FY21 (4th Qtr).

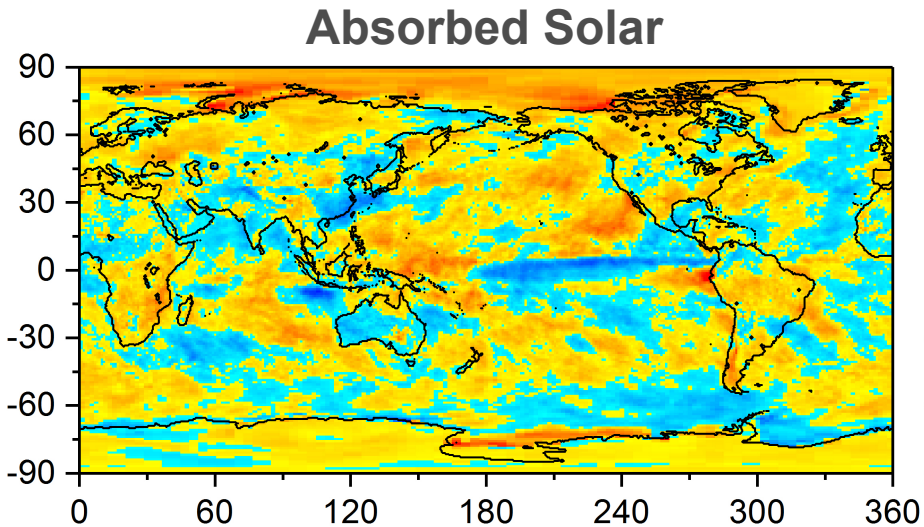
Global TOA **All-Sky** Radiation Anomalies
(CERES_EBAF_Ed4.0; 03/2000 – 01/2017)

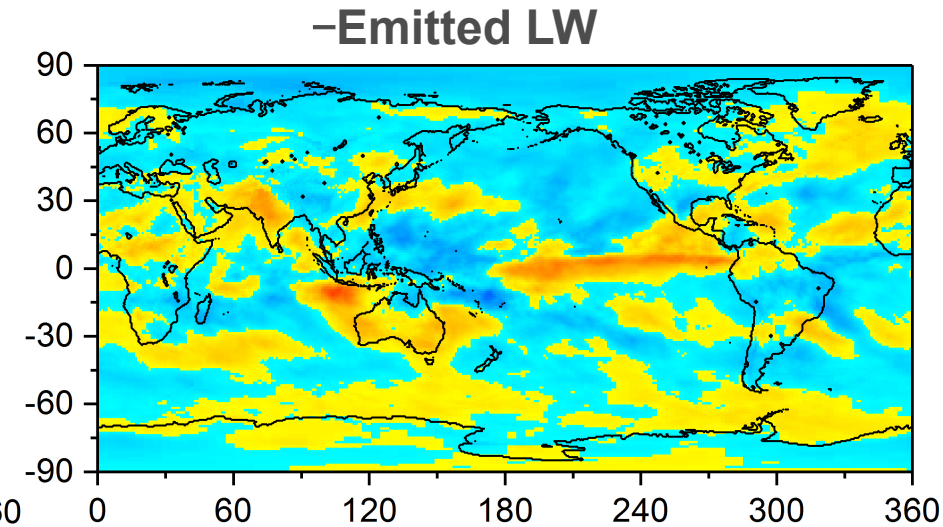


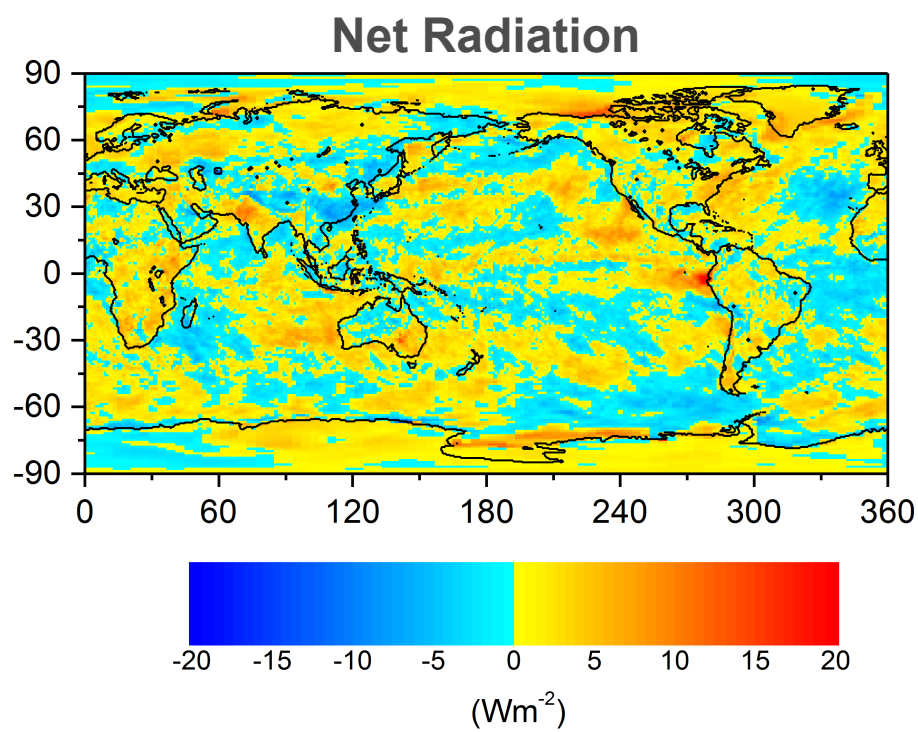
Global Mean TOA Flux Anomalies & Multivariate ENSO Index

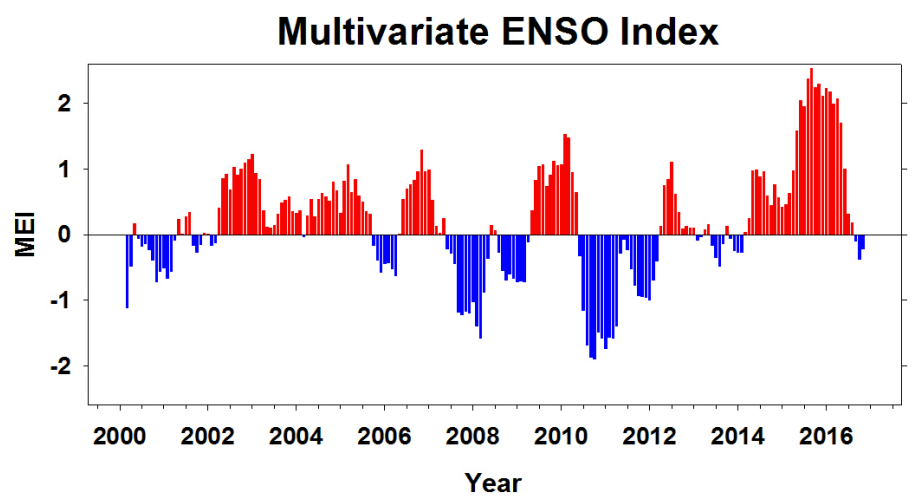


TOA Radiation Changes (March 2000 – January 2017)

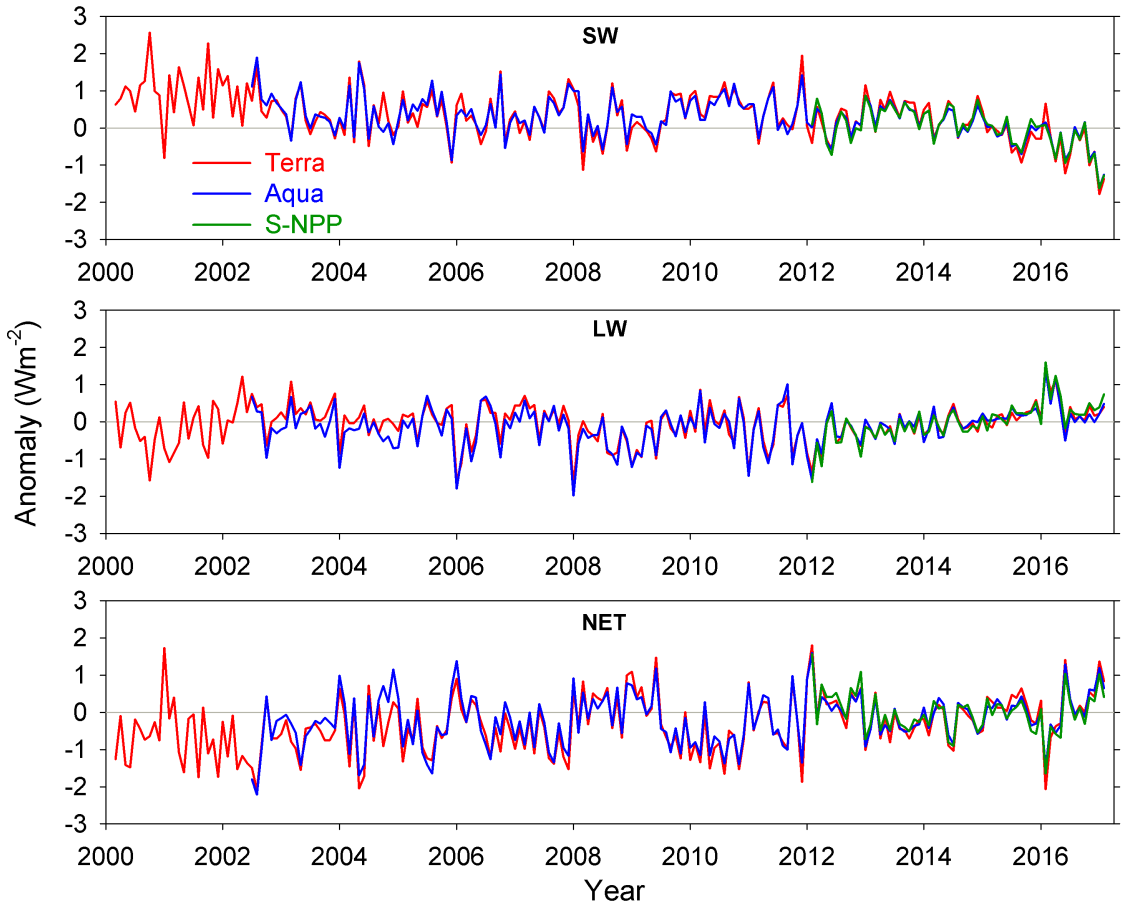








Global Deseasonalized Monthly Anomalies in TOA Flux from SSF1deg Product (Relative to Climatological Means for 02/2012 - 02/2017)

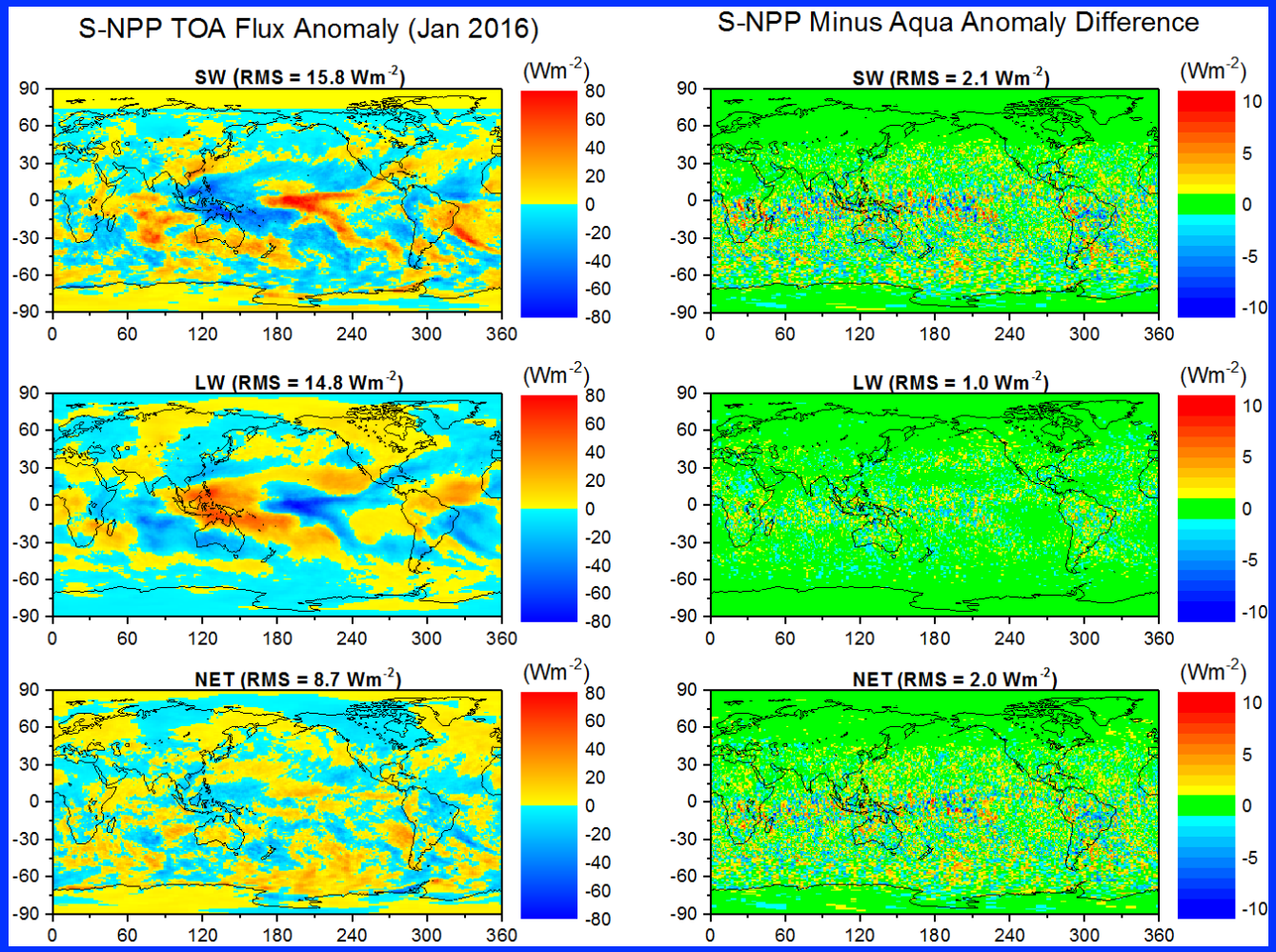


Stdev in Monthly Anomaly Differences (02/2012 – 02/2017)

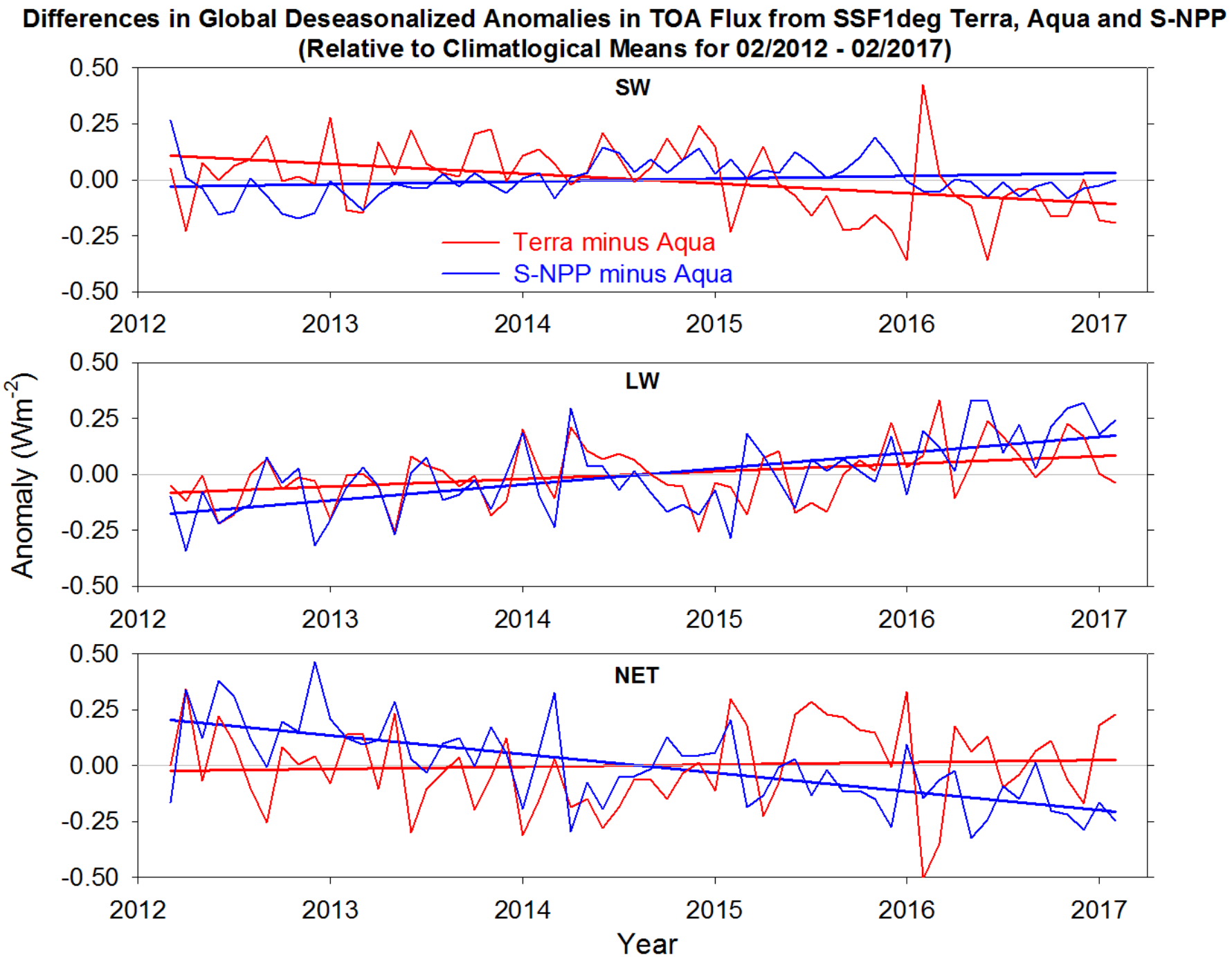
(Wm^{-2})	Terra - Aqua	S-NPP - Aqua
SW	0.17	0.085
LW	0.13	0.17
NET	0.19	0.18

- Excellent agreement in month-to-month variability for Terra, Aqua and S-NPP.

S-NPP (Edition1) vs Aqua (Edition 4) Regional TOA Flux Comparison



- CERES S-NPP regional TOA flux anomalies clearly show an eastward shift in convection from the Maritime Continent to the central Pacific Ocean during the strong 2016 El Niño event.
- CERES SNPP & Aqua regional anomalies show consistent pattern during the El Niño event.
    - Further study is needed to assess impact of VIIRS-MODIS cloud retrieval differences and how these impact TOA flux anomaly differences shown in right column.


Differences in Global Deseasonalized Anomalies in TOA Flux from SSF1deg Terra, Aqua and S-NPP
(Relative to Climatlogical Means for 02/2012 - 02/2017)
SW
LW
NET
Terra minus Aqua
S-NPP minus Aqua
Anomaly (Wm-2)
Year
0.50
0.25
0.00
-0.25
-0.50
2012
2013
2014
2015
2016
2017

Trend Differences & 95% Conf. Intvls.

	March 2012 – February 2017 (Wm^{-2} per decade)	
	Terra - Aqua	S-NPP - Aqua
SW	-0.44 ± 0.30	0.12 ± 0.32
LW	0.34 ± 0.24	0.71 ± 0.25
NET	0.10 ± 0.38	-0.84 ± 0.25
	July 2002 – February 2017 (Wm^{-2} per decade)	
	Terra - Aqua	S-NPP - Aqua
SW	0.032 ± 0.083	-
LW	-0.19 ± 0.07	-
NET	0.16 ± 0.11	-

- Expect significant reduction in S-NPP vs Aqua LW trend for S-NPP Edition 2.0.
  - S-NPP Ed 2.0 will account for changes in SW part of TOT channel SRF.

CERES & RBI Reviews

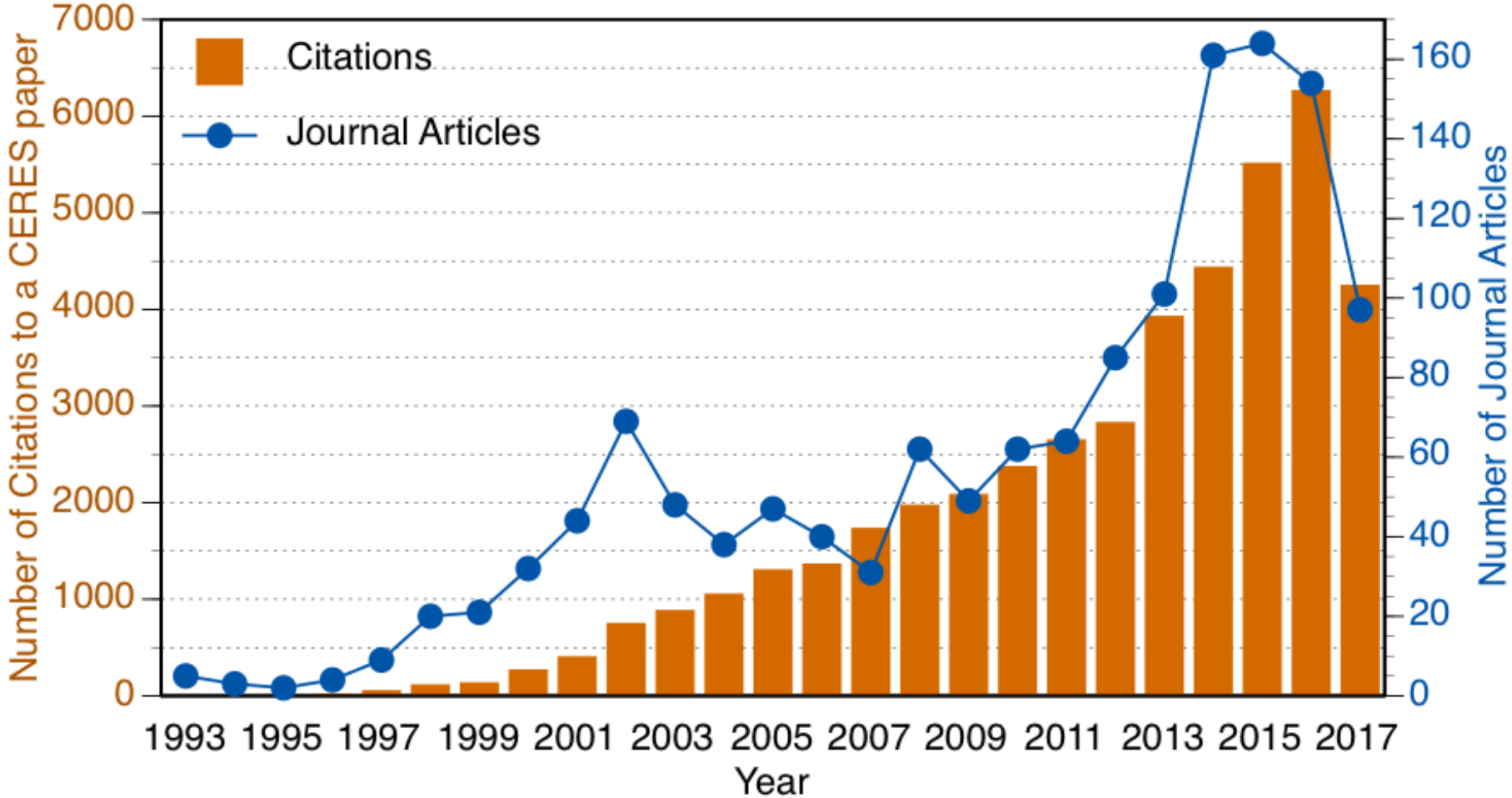
1) Earth Radiation Budget Science Team Review (May 30).

2) S-NPP End of Prime Mission Review (October 4).

3) RBI Critical Design Review (This week).

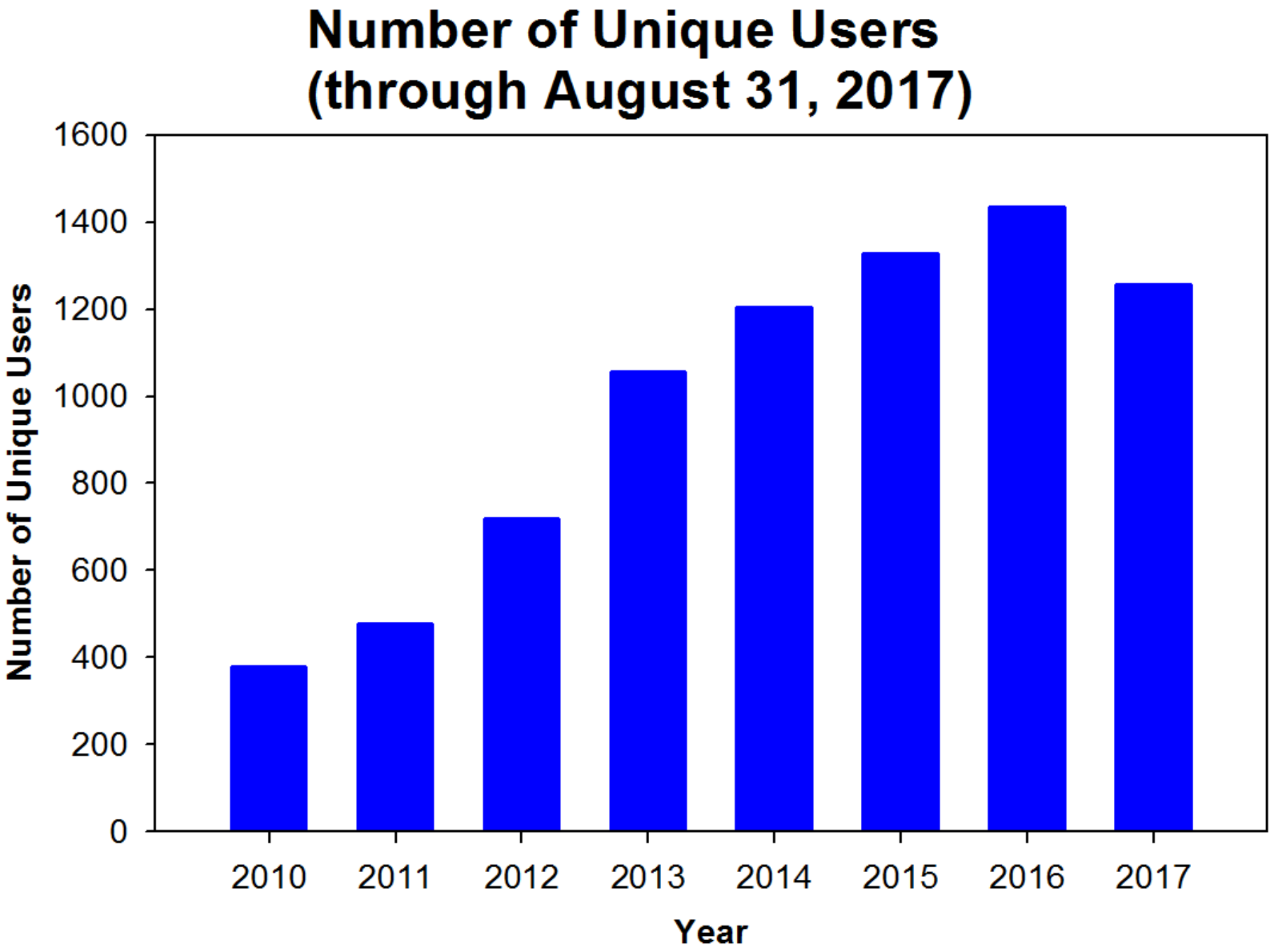
4) RBI Continuation Review (NASA HQ, 2017)

CERES Journal Publications and Citation Counts
(For Papers Between 1993-2017; Updated August 30, 2017)



- Total number of peer-reviewed journal articles: 1,412
- Total number of citations to CERES papers: 44,533

(Compiled by Anne Wilber & Dave Kratz)


Number of Unique Users
(through August 31, 2017)
Number of Unique Users
1600
1400
1200
1000
800
600
400
200
0
2010
2011
2012
2013
2014
2015
2016
2017
Year

Number of Unique Users by CERES Data Product
(through August 31, 2017)

Level	Product	2010	2011	2012	2013	2014	2015	2016	2017
1b	BDS	11	9	14	19	14	11	13	11
2	SSF	84	77	138	223	247	253	278	244
	FLASH_SSF	25	8	15	23	30	61	41	46
	C3M	31	32	33	37	28	55	54	34
	ES8	22	20	18	31	16	21	15	12
	SSF-MISR	9	4	2	5	4	2	1	0
3, 3b	EBAF-TOA	72	160	346	484	579	580	540	497
	EBAF-Surface			147	289	375	424	464	378
	SYN1deg	70	139	188	331	375	431	483	421
	SSF1deg	77	126	107	157	166	160	194	150
	ISCCP-D2like	17	12	37	57	41	40	47	76
	ES4	59	36	11	27	19	13	12	11
	ES9	21	12	5	13	9	5	5	8
	FLASH_TISA	17	18	20	17	15	15	36	39

CERES Terra and Aqua Data Product Availability

Data Product	Level	Ed2.8	Ed3.0	Ed4.0
BDS	1	-	02/2017	03/2017
SSF	2	-	02/2017	03/2017
SSF1deg	3	-	02/2017	02/2017
SYN1deg	3	-	02/2017	01/2017
CldTypHist	3	-	01/2017	01/2017
EBAF-TOA	3b	02/2017	-	01/2017
EBAF-SFC	3b	12/2016	-	08/2016

Note: 02/2017 will be last data month of Edition 3.0 and EBAF Ed2.8 production.

Terra+Aqua Edition 4 Plans

- The CERES Terra & Aqua Edition 4 reprocessing relies upon MODIS Collection 5 radiances and aerosols through February 2017.
- Starting in March 2017, MODIS Collection 6 imager data will be used, as MODIS Collection 5 processing at GSFC will be terminated.
- MODIS Collection 6 production at GSFC will continue through December 2017, and then be superseded by MODIS Collection 6.1.
- MODIS Collection 6.1 is a major calibration upgrade for select Terra (6.72 and 8.6 μm) and Aqua (visible) channels.
  - Will significantly improve the quality of the MODIS Terra water vapor channel (6.72 μm), which is used in the CERES cloud mask.
  - Entire MODIS record should be available by spring 2018.
- Once MODIS C6.1 is available, CERES Team will reprocess with MODIS C6.1 starting in March 2016, when the MODIS Terra water vapor channel showed a large spurious loss of sensitivity.
  - To mark the change, Edition 4.0 will be renamed to Edition 4.1.
  - CERES data through February 2016 will not be reprocessed until Edition 5.

S-NPP Edition1 Product Availability

Product	Platform	Processed through	Current	Publically Available
BDS	S-NPP	07/2017	Yes	Yes
SSF	S-NPP	03/2017	Yes	Yes
SSF1deg-Hour	S-NPP	02/2017	Yes	Yes
SSF1deg-Day/Month	S-NPP	02/2017	Yes	Yes
SYN1deg	Terra+S-NPP		12/2013	No

- SYN1deg-Terra_SNPP being reviewed for public release.
- Will be updated to 02/2017 by end of October.

S-NPP Edition 2 Plans

- In Edition 1, instrument gains (from onboard calibration) were taken into account. No attempt was made to place FM5 on same radiometric scale as FM3 or correct for spectral response function changes with time.
- Cloud retrieval, ADMs, TISA & SARB algorithms were based upon those from Aqua.
  - Some changes to VIIRS cloud mask since water vapor and CO_2 bands are unavailable.
  - Cloud retrieval look-up tables were recomputed for VIIRS bands.
- S-NPP Edition 2:
  - Will place FM5 on same radiometric scale as FM3.
  - Will correct for FM5 spectral response function changes with time (LW daytime only).
  - Will place VIIRS on same radiometric scale as MODIS Aqua and use the latest version of VIIRS level 1b.
  - Will defer any other major algorithm changes to Edition 3 (e.g., Clouds, ADMs, TISA, SARB).
  - Goal is to have all required Edition 2 deliveries in by the next CERES science team meeting.

Terra Lunar Deep Space Calibration (LDSC) Maneuver

- A DSC maneuver is an accelerated 240 degree pitch-over (360 relative to local horizon) during S/C night that provides observations of the cold background of deep space and an option for a lunar viewing.

- Two previous DSC maneuvers were executed in 2003:
  - March 26 was a deep space calibration (DSC).
  - April 14 was both deep space and a lunar calibration (LDSC).

- A LDSC provides the Terra instrument teams observations that can be compared against the LDSC in 2003.

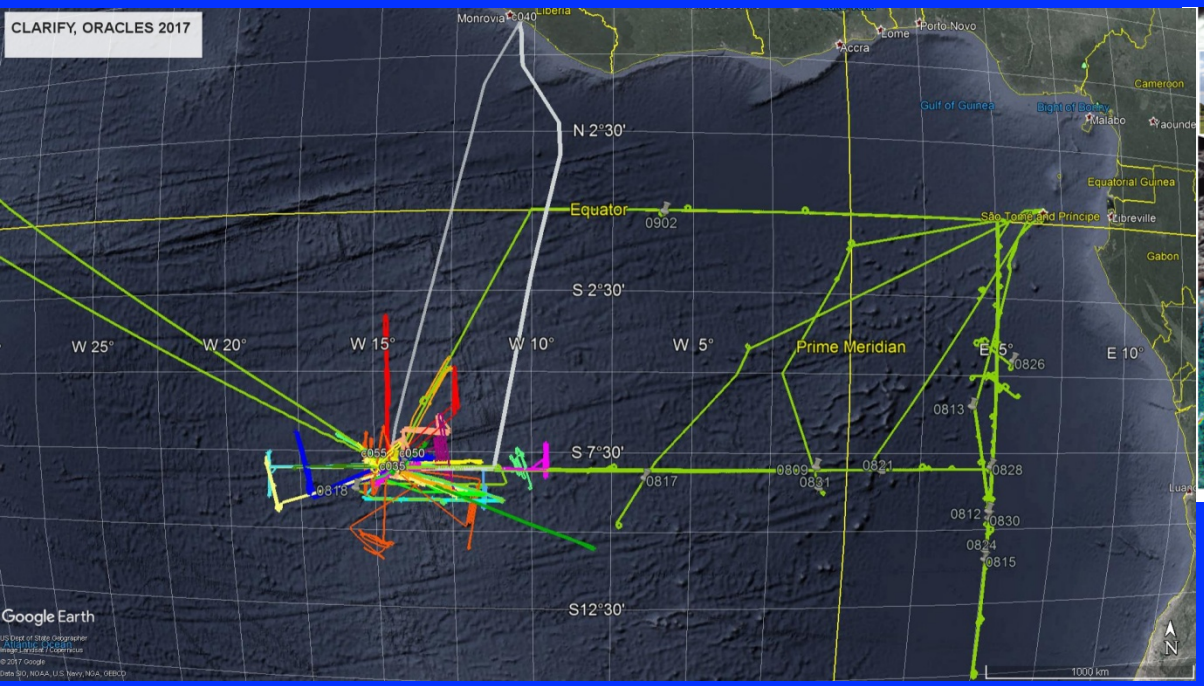
- Can be used to verify calibration changes from onboard calibration sources over the lifetime of the mission.

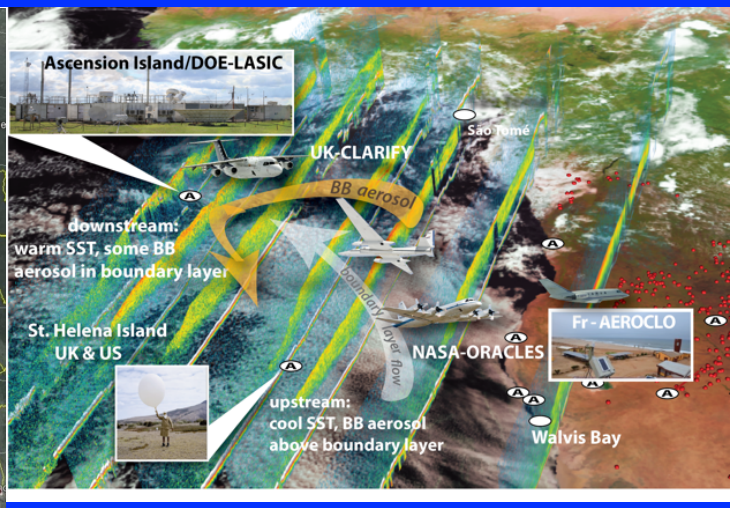
- Terra successfully performed a LDSC maneuver on August 5, 2017.

- CERES collected measurements in 5 elevation scan profiles that are normally used in Earth observations.
- The sensor offset counts show similar trends as the ones measured in April 2003.

CERES FM2 PAP Support for CLoud-Aerosol-Radiation Interactions and Forcing (CLARIFY-2017)

- Field campaign over Ascension Island August 16 – September 7, 2017.
- Aircraft and surface observations of clouds and aerosols.
- Wide variety of aerosol conditions (clean marine, smoke in the boundary. layer and/or free-troposphere) and cloud conditions (clean, polluted, Sc, shallow Cu).
- Co-location of smoke and clouds provides a natural laboratory to study a wide range of aerosol-cloud-radiation interactions.





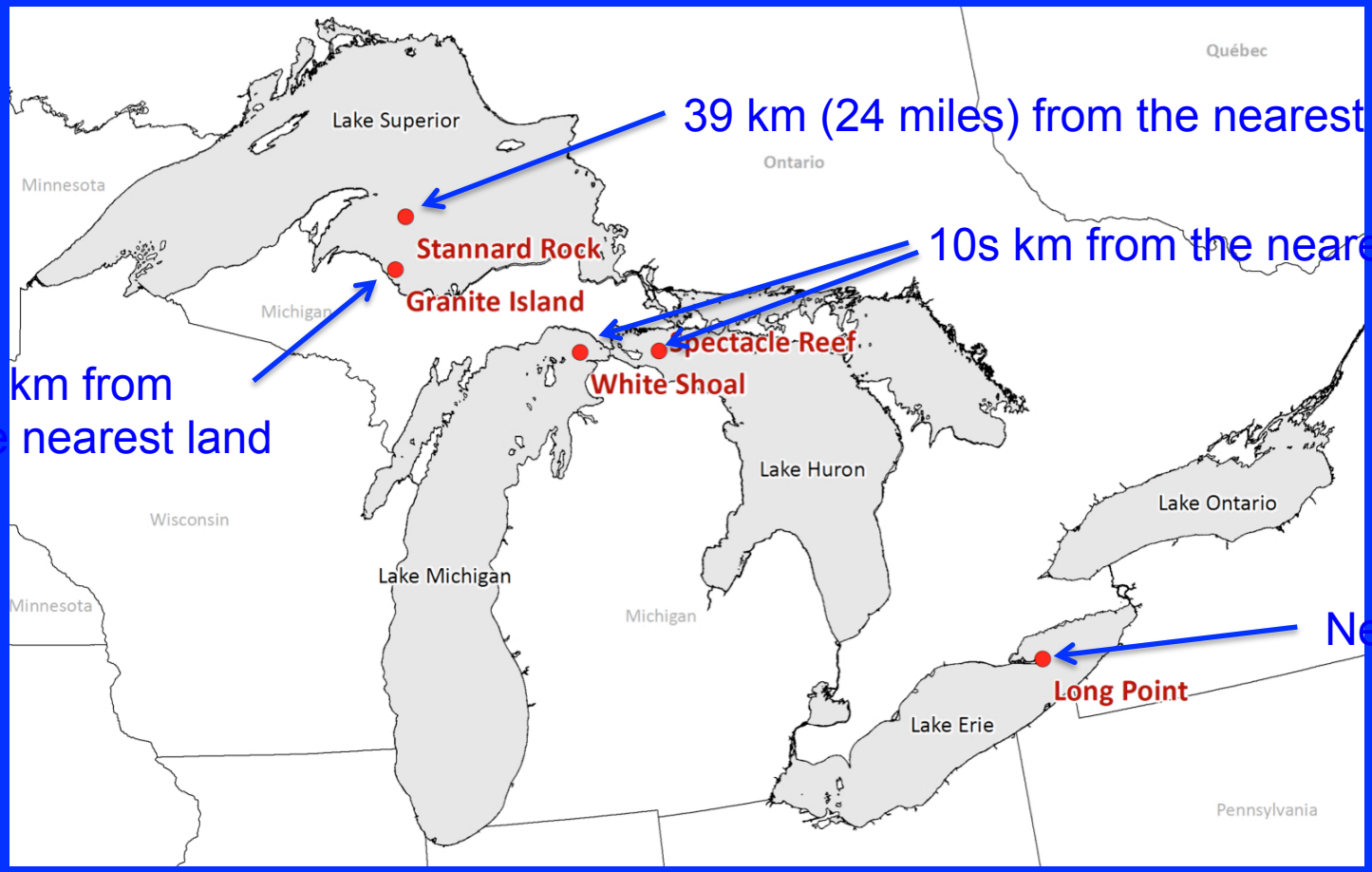
COVE

- DOE turned Chesapeake Light Tower (CLT) over to GSA for excess; GSA put CLT up for auction during spring 2015. Private new owners purchased CLT.
- We met the new owners. They were uncertain about how they would use the platform.
- We agreed to rent space on CLT to continue BSRN and AERONET operations.
- However, CLT did not pass NASA Safety inspection, so we cannot resume operations until new owners make needed repairs.
- All NASA equipment was removed from CLT.
- A 2nd BSRN instrument suite is operating at CAPABLE.
- A refurbished MPLNET instrument is expected to be operational at CAPABLE in June 2017.

Granite Island

- New location for COVE instrumentation.
- 2.5 acre island located about 5 miles offshore in Lake Superior.
- The island already hosts eddy covariance measurements for the Great Lakes Evaporation Network (GLEN).
- CERES radiation instruments and a GSFC AERONET will be located near the Bell Tower.
- Remote operation with occasional maintenance trips (summers only).

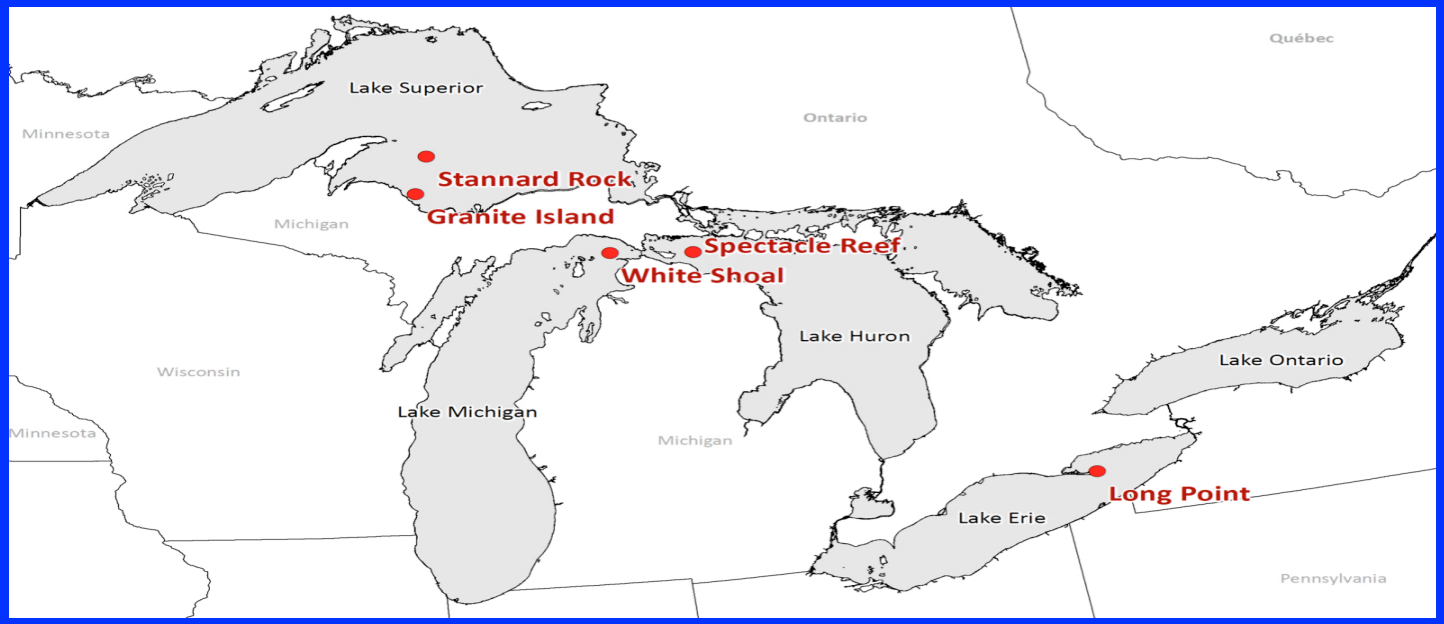
GLEN Stations



Instrumentations are installed on the lighthouses (most built in late 1800s) to measure evaporation and other meteorological parameters.

GLEN Stations and Data Availability

	Stannard Rock	Granite Island	White Shoal	Spectacle Reef	Long Point
Years Available	2008-2014	2010-2014	2012-2014	2009-2014	2012-2014
Principle Investigator	C. Spence	J. Lenters	P. Blanken	P. Blanken	C. Spence
Data Level	1	1	1	1	1
Latent Heat	✔	✔	✔	✔	✔
Air Temperature	✔	✔	✔	✔	✔
Friction Velocity	✔	✔	✔	✔	✔
Momentum Flux	✔		✔	✔	✔
Wind Speed	✔	✔	✔	✔	✔
Wind Direction	✔	✔	✔	✔	✔
Relative Humidity	✔	✔	✔	✔	✔
Barometric Pressure	✔		✔		✔
Incoming Shortwave Radiation	✔		✔	✔	✔
Incoming Longwave Radiation	✔		✔	✔	✔



Upcoming Conferences & Meetings of Interest

American Geophysical Union Fall Meeting
- December 11-15, 2017, New Orleans, LA.

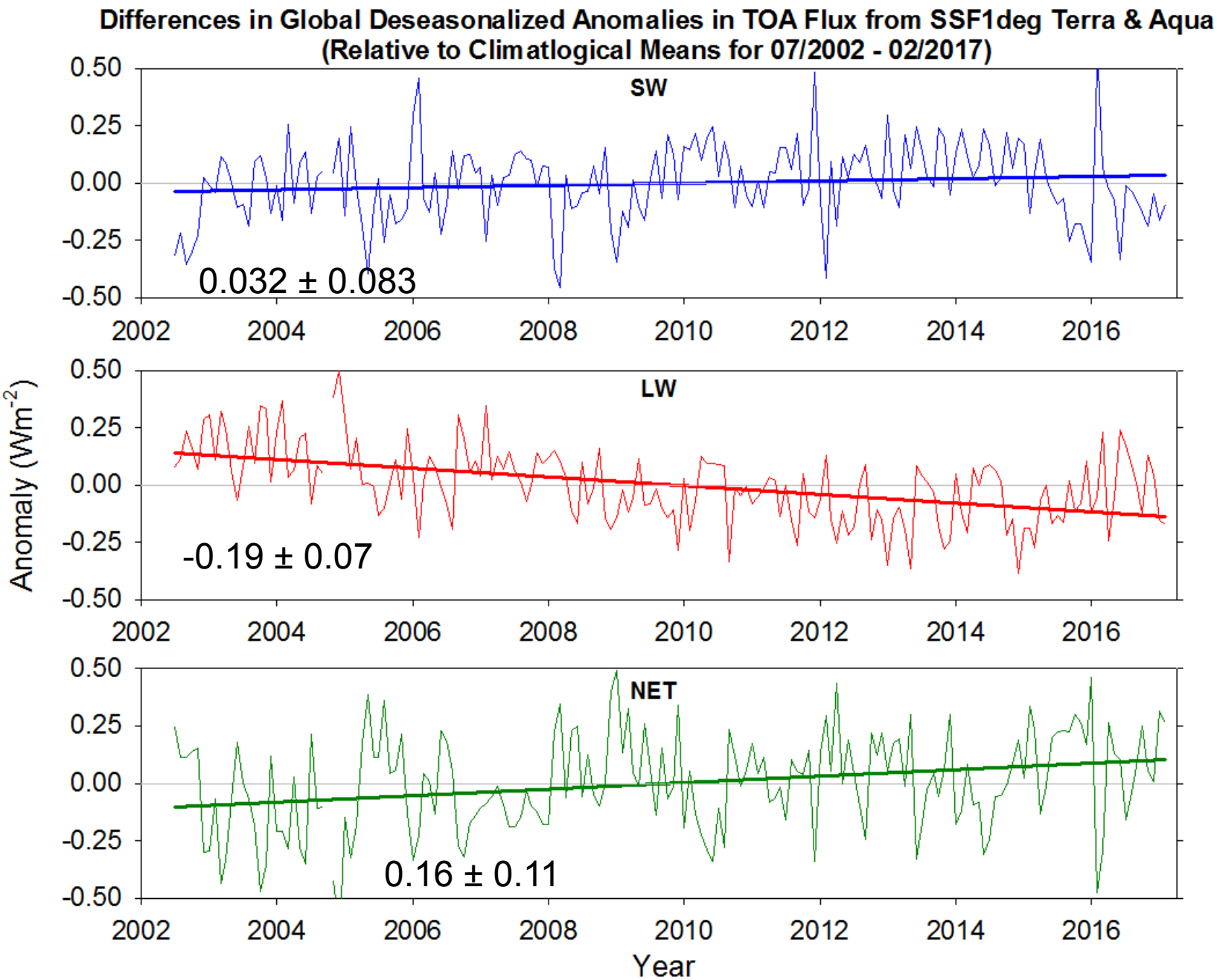
American Meteorological Society Annual Meeting
- January 7-11, 2018, Austin, TX.

8th GEWEX Science Conference
- May 6-11, 2018, Canmore, Alberta, Canada

Spring 2018 CERES Science Team Meeting
- May 15-17, 2018, NASA LaRC, Hampton, VA.

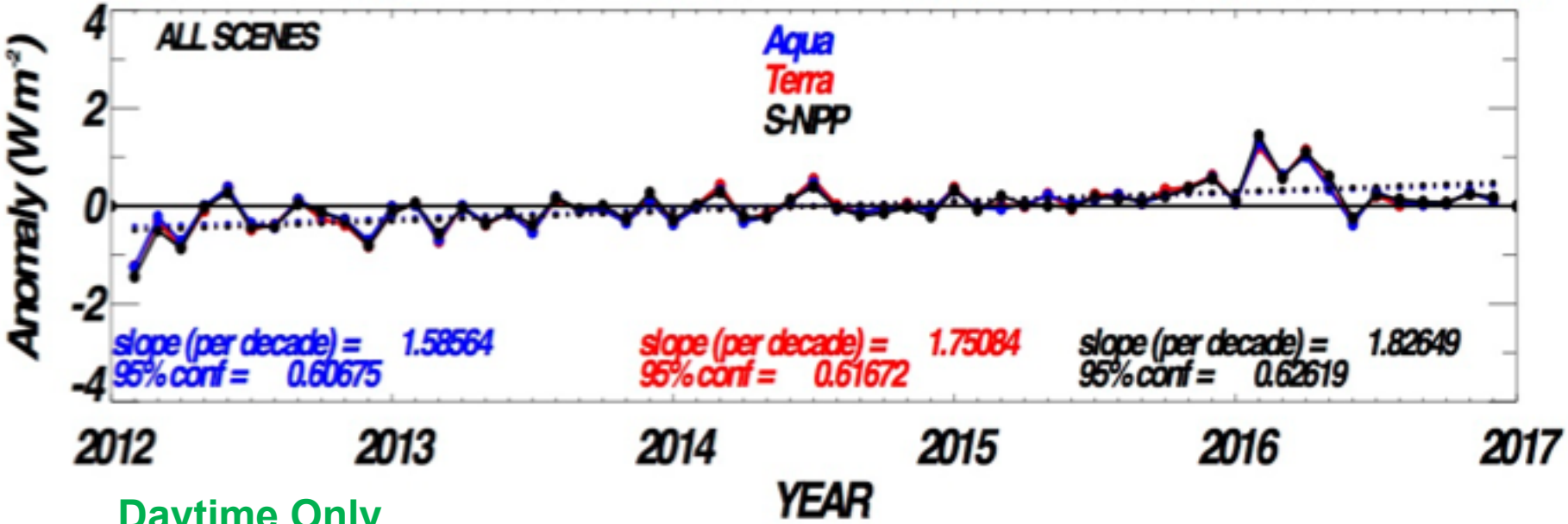
AMS Radiation/Cloud Physics Conference
- July 9-13, 2018, Vancouver, British Columbia, Canada.

End


Differences in Global Deseasonalized Anomalies in TOA Flux from SSF1deg Terra & Aqua
(Relative to Climatlogical Means for 07/2002 - 02/2017)
SW
0.032 ± 0.083
LW
-0.19 ± 0.07
NET
0.16 ± 0.11
0.50
0.25
0.00
-0.25
-0.50
2002
2004
2006
2008
2010
2012
2014
2016
Anomaly (Wm-2)
Year

LW TOA Flux Anomalies for Aqua, Terra & S-NPP

Nighttime Only



Daytime Only