CERES Instrument Status
Flight Models 1 -6 (FM1 – FM6)

Susan Thomas
CERES Instrument Working Group Team

CERES Fall Science Team Meeting
September 15 - 17, 2020

Instrument Working Group

WG Chair/PS: Kory Priestley
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Instrument Operations

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Robert Wilson

CERES Instrument Operations: FM1 - 6

- **Flight Models (FM) 1 -4 and FM6: Normal Crosstrack operation.**

- **Flight Model 5 (FM5): Full Biaxial mode (azimuth rotation from 115 - 259 degree) since March 23, 2020.**

- **Aqua spacecraft anomaly with the Formatter Multiplexer Unit (FMU) of Solid State Recorder: August 16 – Sept 2, 2020.**
  - **CERES instruments (FM3 & FM4) in Crosstrack through August 19.**
  - **CERES instruments in SAFE mode: Aug 20 – Sept 2**
  - **Anomaly resolved with a soft reset of the FMU.**
  - **CERES commanded to Crosstrack : Sept 2, 19:40z (FM3) & 19:42z (FM4)**
  - **Calibration results do not show any issue with instrument performance**

CERES Instrument Operations: FM1 - 6

- **Intercomparison Operation in overpass region of 70 deg N**

  Terra/FM1 – S-NPP/FM5: May to July 2020

  Terra/FM1 – N20/FM6 : May to July 2020

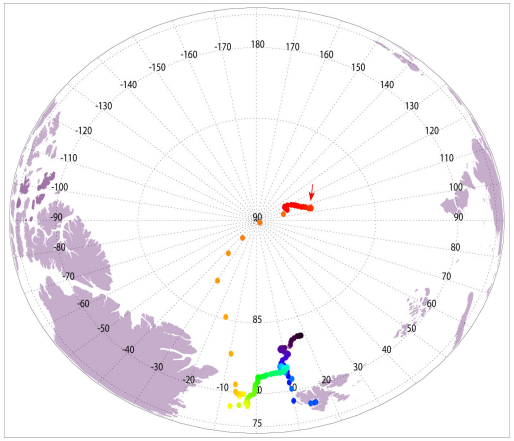
  Terra/FM1 – Aqua/FM3: June 1- 30, 2020

- **CERES (Terra/FM2) – GERB Operation: June 1 - 30, 2020**

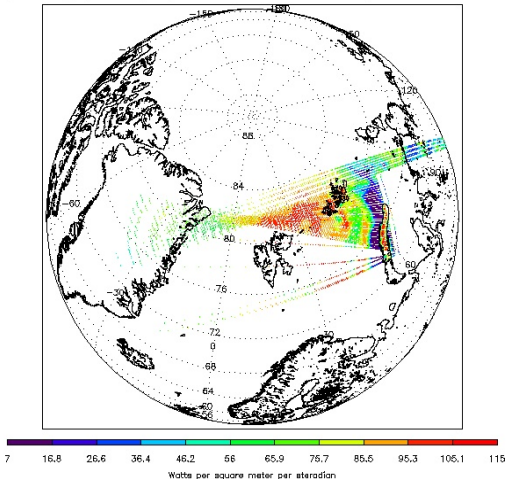
- **Terra/FM2 PAP for MOSAIC Campaign: May 1 – Sept 10, 2020.**

  Daily commanding to target the Ship Location in Artic Sea Ice.

Polarstern Location: 5/1 – 9/10/2020



CERES PAP Measurement: 6/27/2020



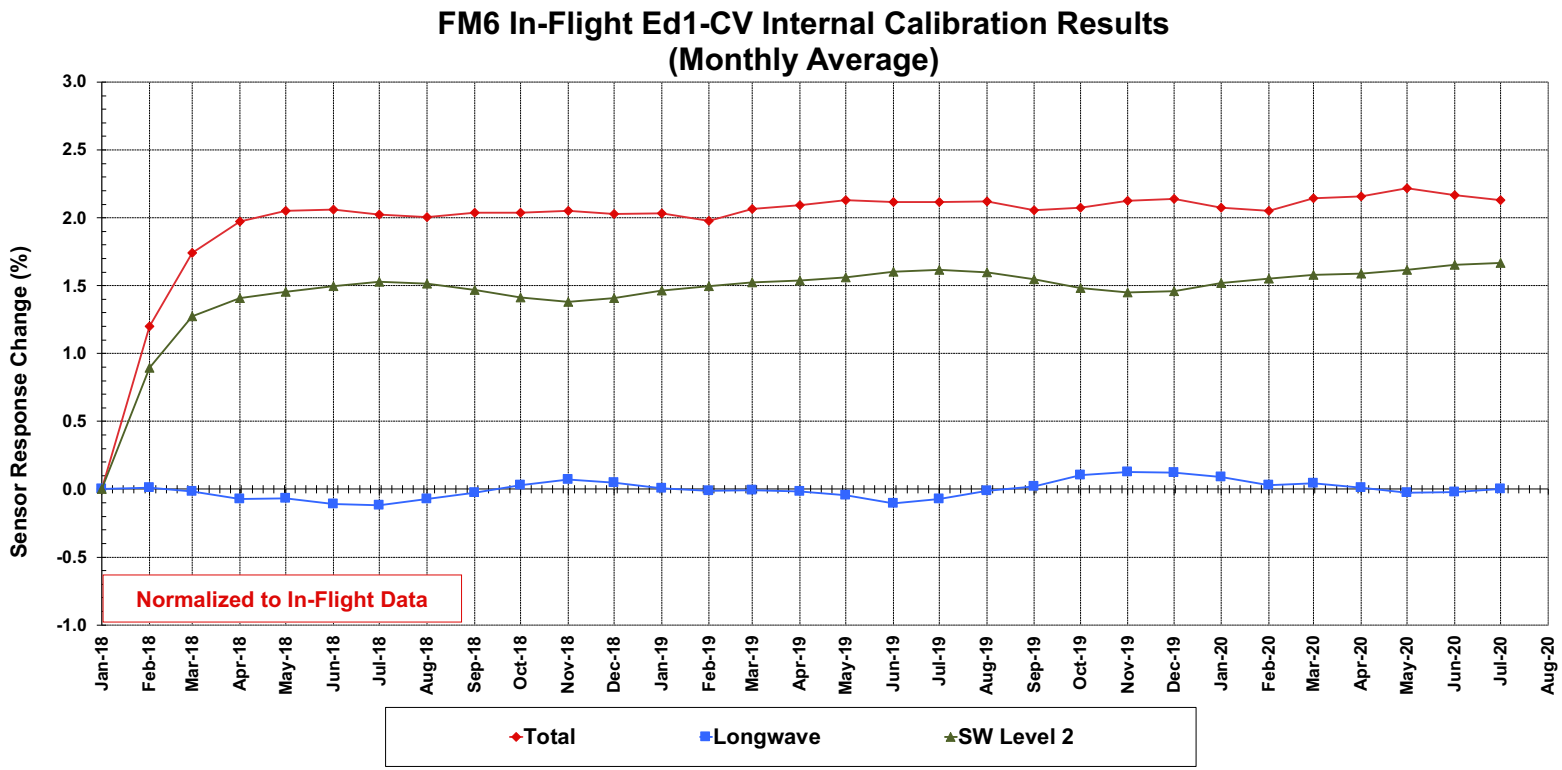
Ship Loc: 81.95N 9.78E
Predict: 81.74N 10.19E

NOAA-20/CERES FM6 INSTRUMENT STATUS

1. Calibration: ICM and Solar
2. Validation: Tropical Mean
3. Intercomparisons

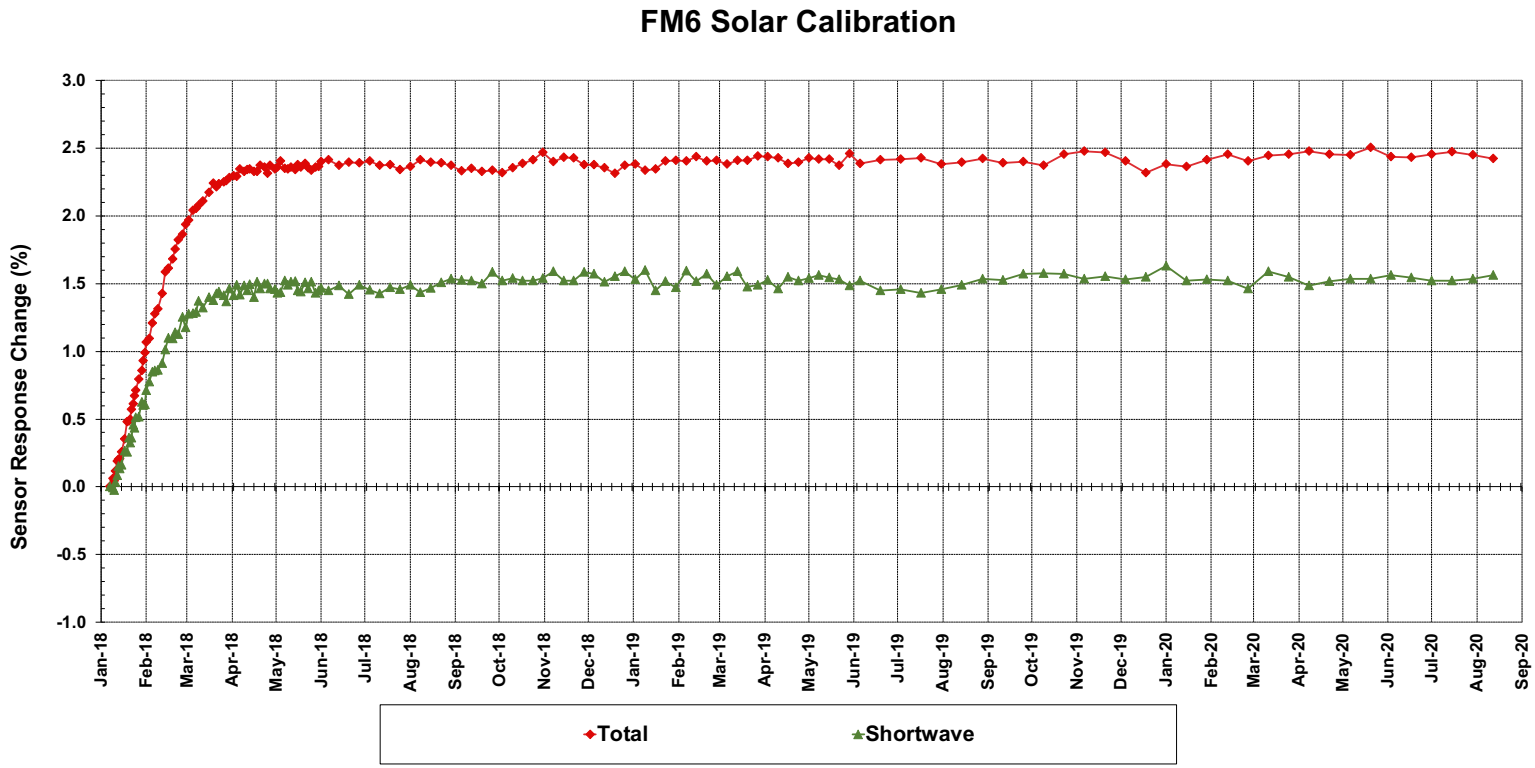
NOAA-20/CERES FM6 Calibration - ICM

Calibration results using on-board sources (Blackbodies and SW Lamp) show a stable sensor performance within 0.15% , after the initial response increase of 2.0% on Total and 1.5% on Shortwave sensors.



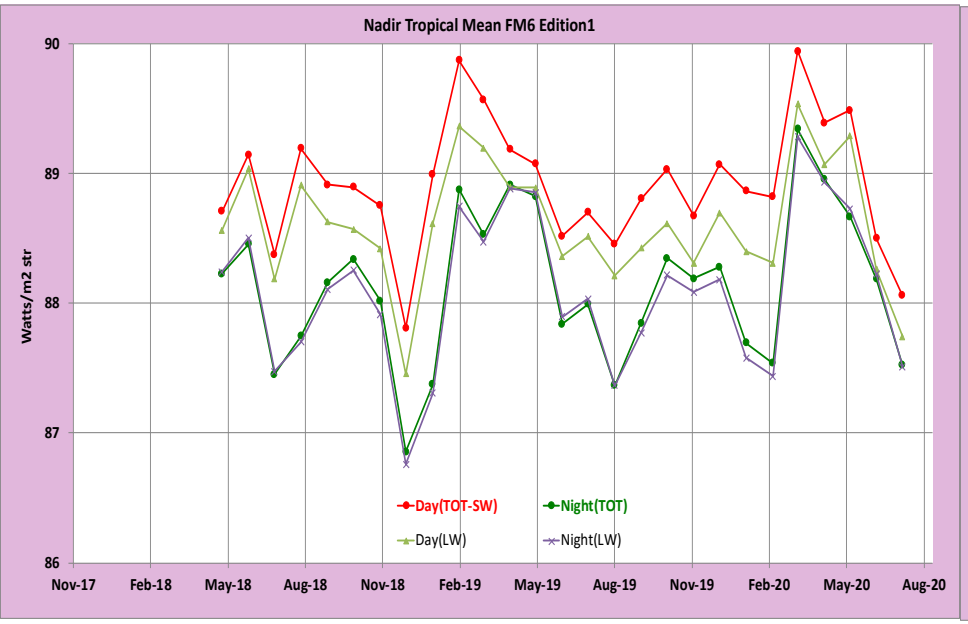
NOAA-20/CERES FM6 Calibration - Solar

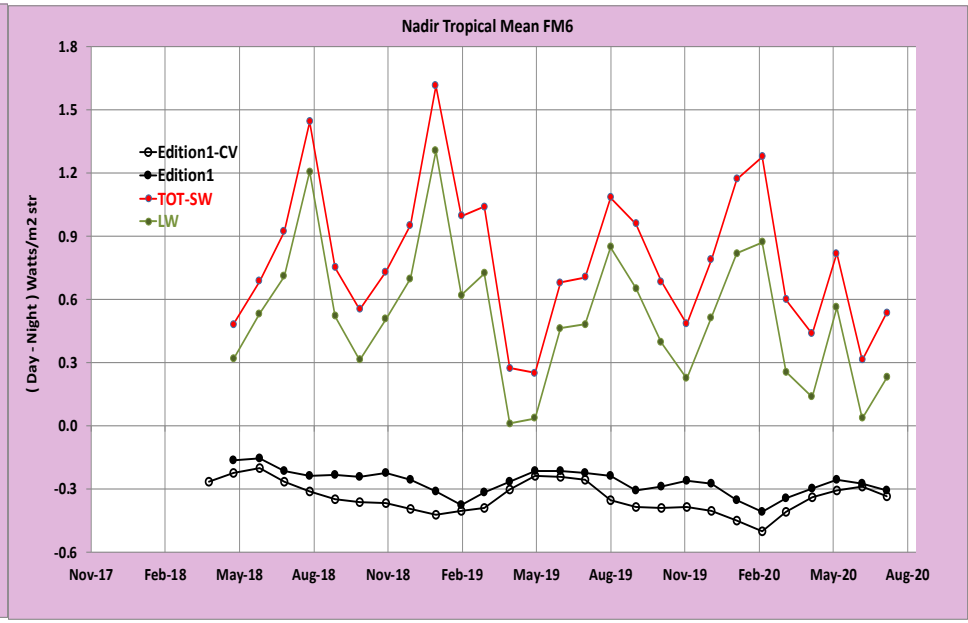
Solar calibration results with Mirror Attenuator Mosaic (MAM) show similar response trend as ICM results. After the initial response increase of 2.4% for Total and 1.5% for SW, the sensors are stable within 0.1 percent.



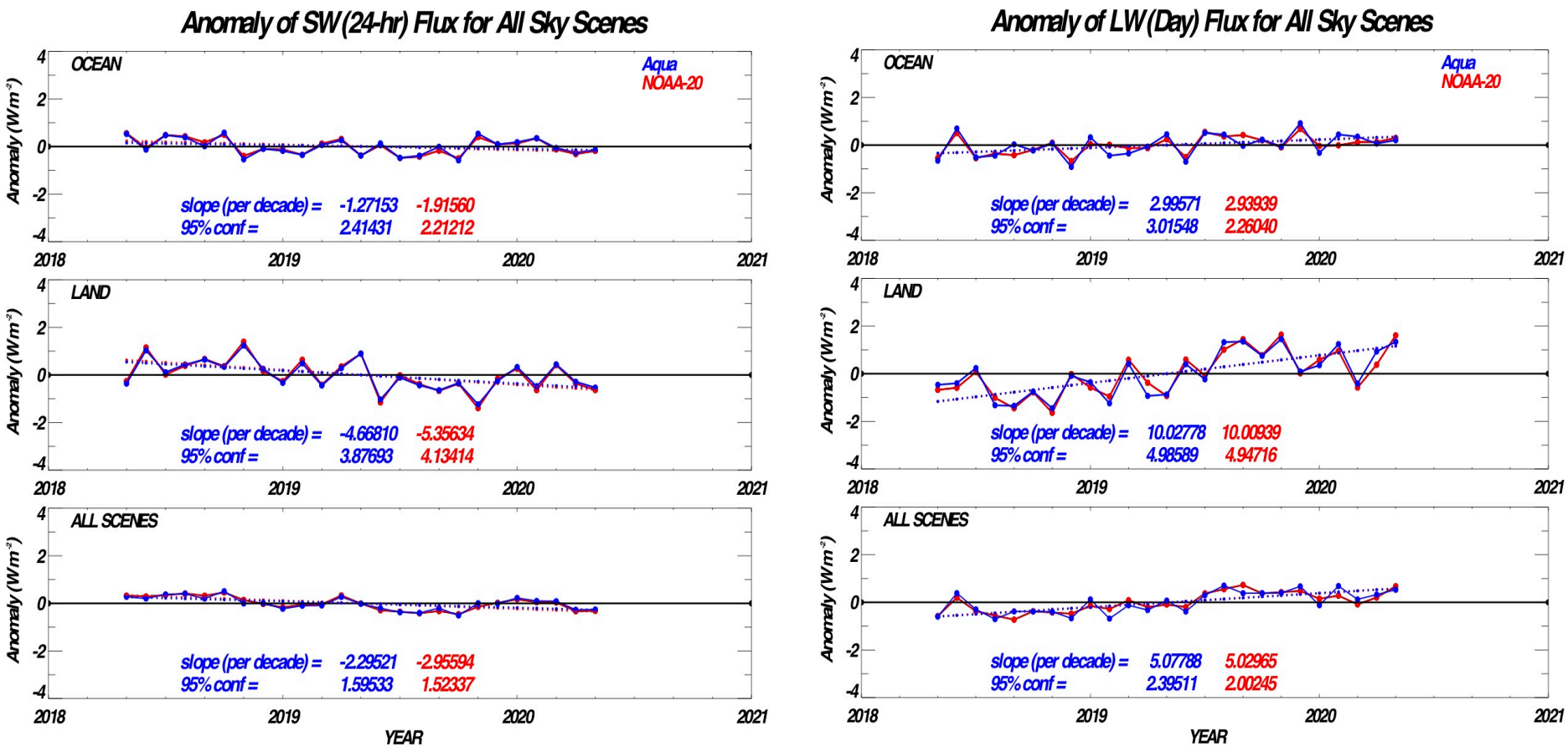
Validation Results – Tropical Mean (TM)

- **Nadir LW radiance for All-sky Ocean in ± 20 deg Latitude.**
- **Day and Night TM values from both Total and Longwave channels are trended.**
- **Changes in SW/TOT channel is monitored through Day-Night (DN) Difference comparison between LW measurements from Total sensor and LW sensor.**





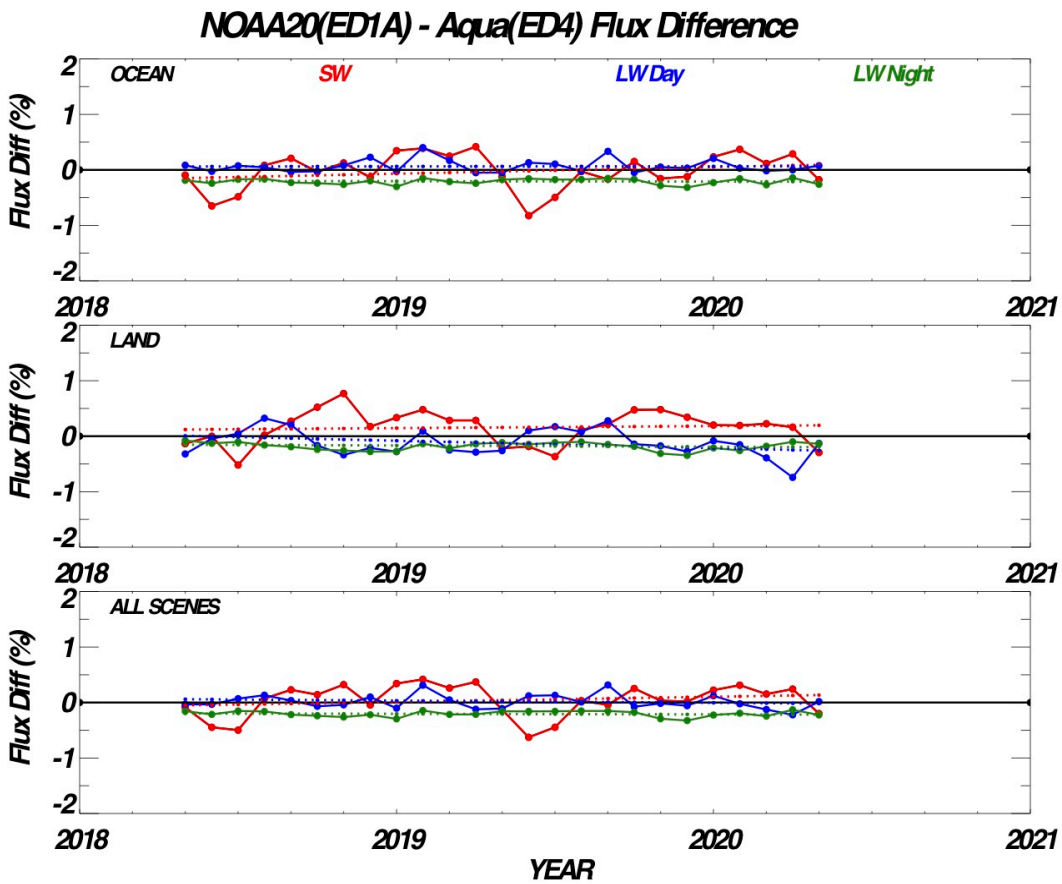
N20/FM6 Validation: Comparison with Aqua/FM3



- SW and LW_Day comparisons with Aqua/FM3 show similar anomaly trends for all scenes.

N20/FM6 Validation: Comparison with Aqua/FM3

- **N20/FM6 and Aqua/FM3 flux difference remain consistent over 2-year period.**



Flux Difference (%)

Ocean	Mean	STDEV
SW	-0.021	0.329
LW Day	0.070	0.120
LW Night	-0.211	0.052

Land	Mean	STDEV
SW	0.153	0.307
LW Day	-0.118	0.241
LW Night	-0.183	0.074

All Scenes	Mean	STDEV
SW	0.036	0.292
LW Day	0.015	0.128
LW Night	-0.203	0.053

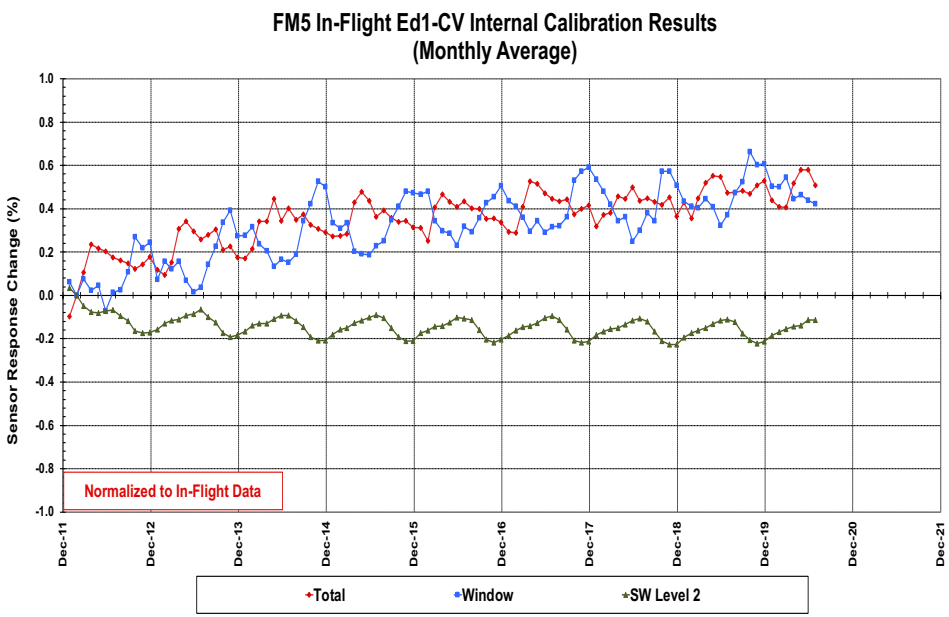
S-NPP/ CERES FM5 INSTRUMENT STATUS

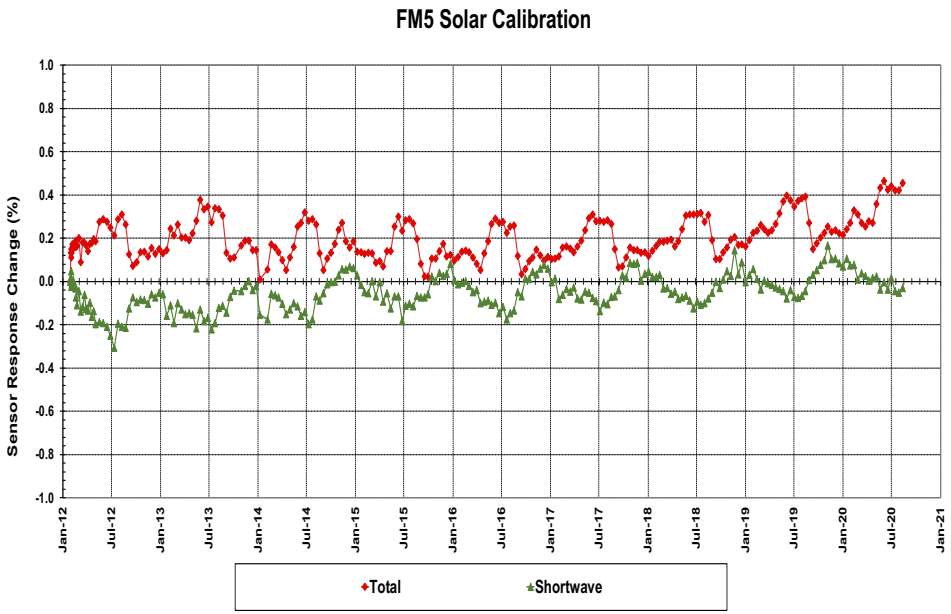
1. Calibration: ICM and Solar
2. Validation Results
3. Intercomparison Results
4. RAP Operation

S-NPP CERES FM5 Instrument Calibration

ICM calibration: Increase in response of 0.6% for Total and Window sensors. SW sensor shows a drop of 0.2 percent.

Solar calibration: Total and SW sensor responses show increase in trend.

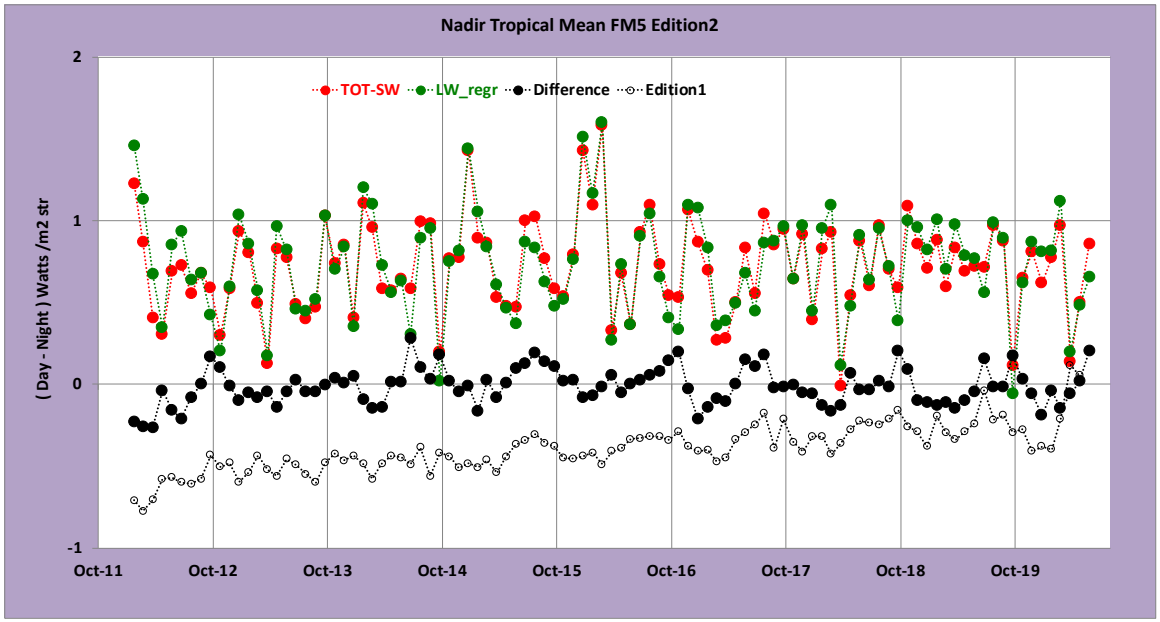




Sensor gain corrections based on ICM calibrations are applied to Edition2 data products.

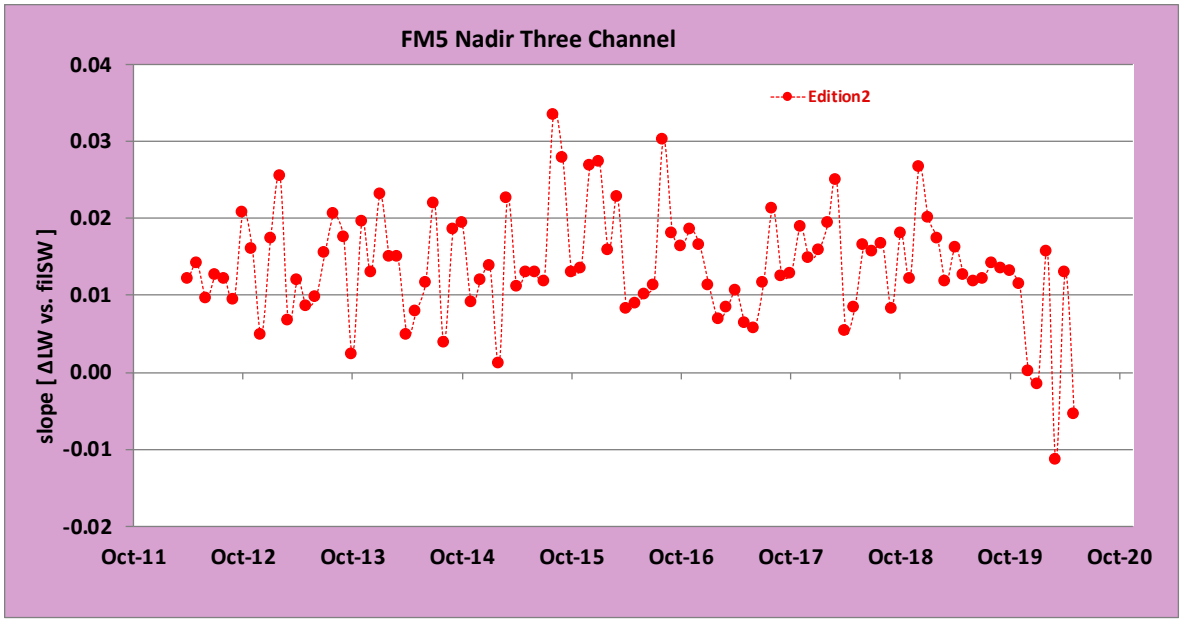
FM5 Validation: Tropical Mean

- **Nadir LW radiance for All-sky Ocean in ± 20 deg Latitude.**
- **Day-Night (DN) Difference comparison between LW and Simulated LW from Window measurements highlight the changes in SW/TOT sensor.**
- **DN Difference on Edition2 data show a stable trend. SW/TOT SRF correction removed the positive trend of < 0.01 W/m^{2}sr /year observed in Edition1 data.**



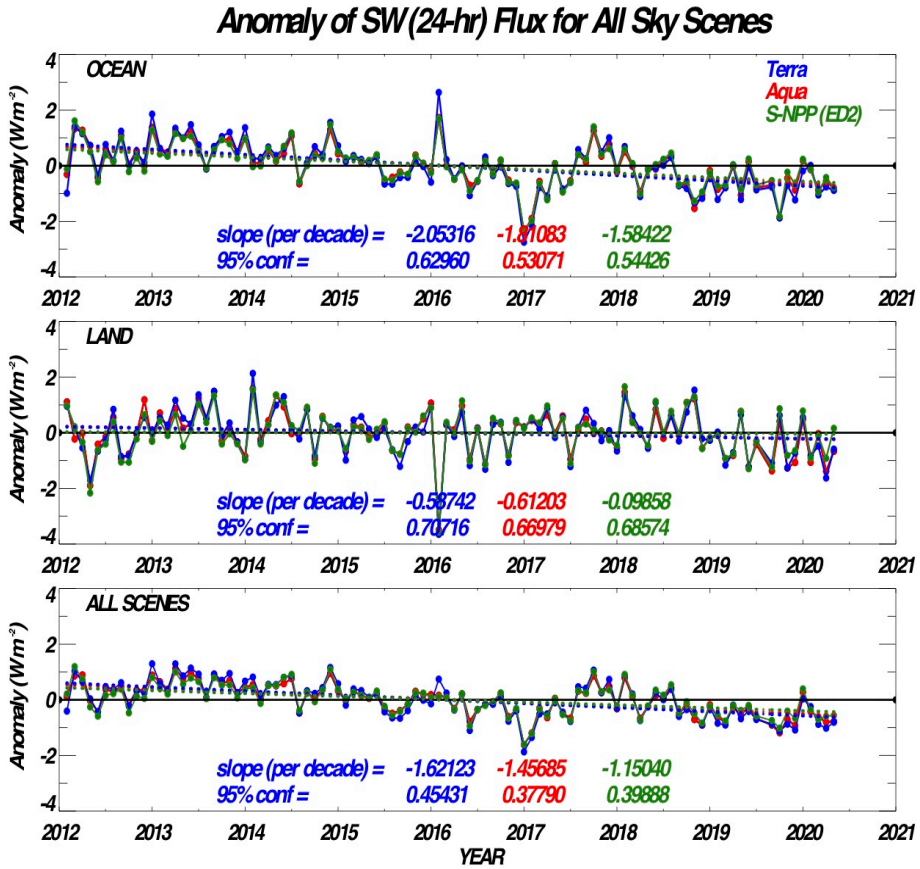
FM5 Validation: DCC 3-Channel Comparison

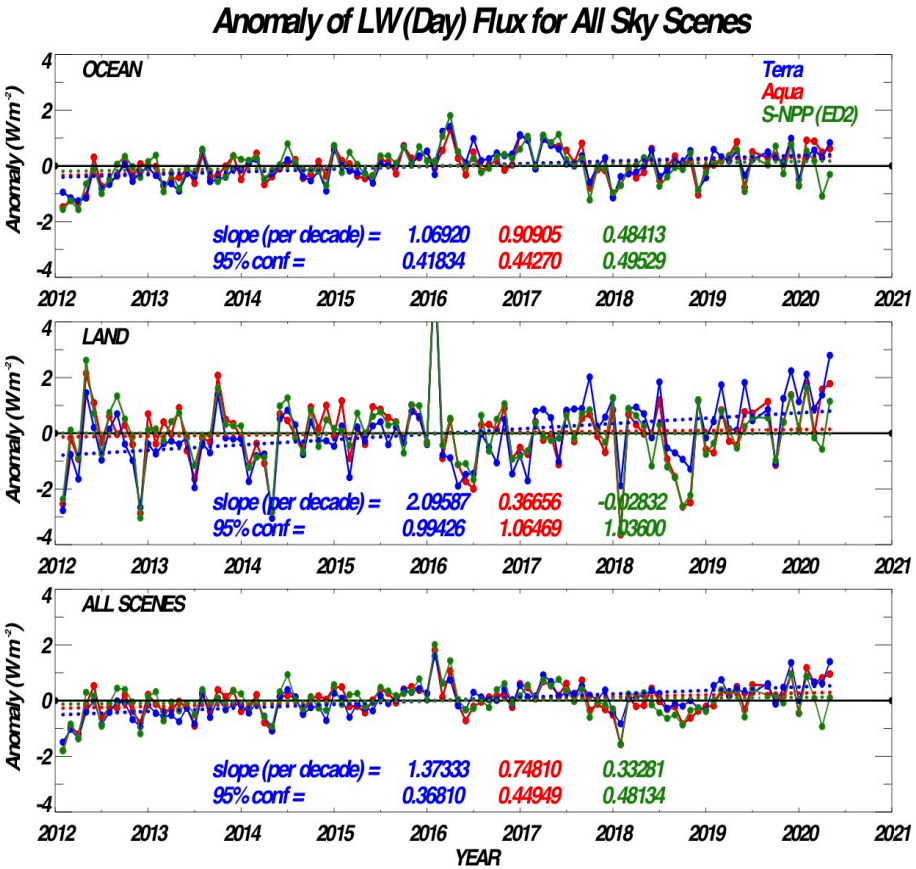
- **Deep Convective Cloud used as target to conduct consistency check between the 3 sensors.**
- **The slope in monthly trend of LW and Simulated LW (Window) difference with SW measurement is monitored over time.**
- **Highlights the variation in the relationship between response functions of SW sensor and SW portion of Total sensor.**



FM5 Validation - Terra and Aqua Comparison

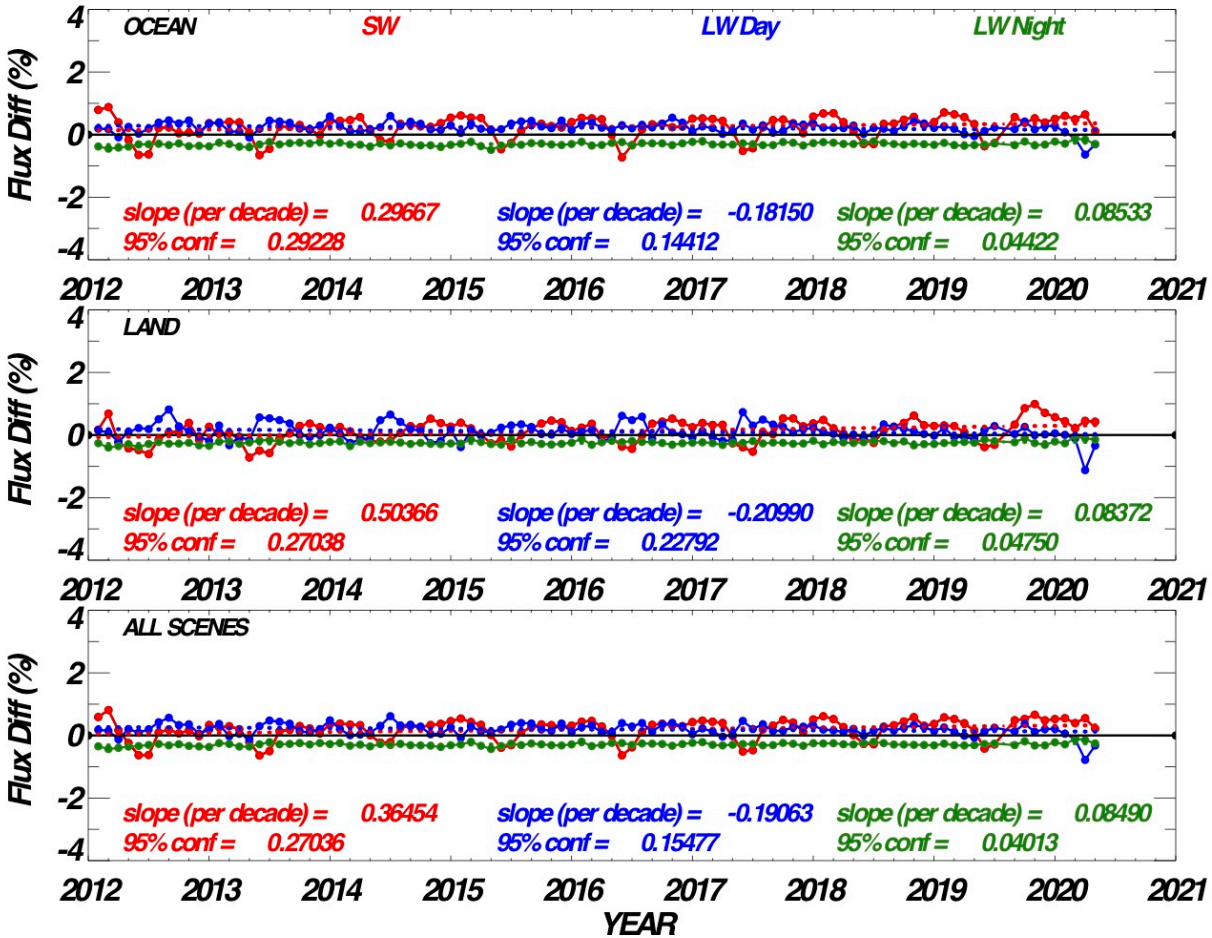
- FM5 SW and LW-Day Flux Anomalies show consistent trend as Terra/FM1 and Aqua/FM3 data for 2012 - 2020





FM5 Validation: Comparison with Aqua/FM3

S-NPP/FM5 (ED2) – Aqua/FM3 (ED4) Fluxes

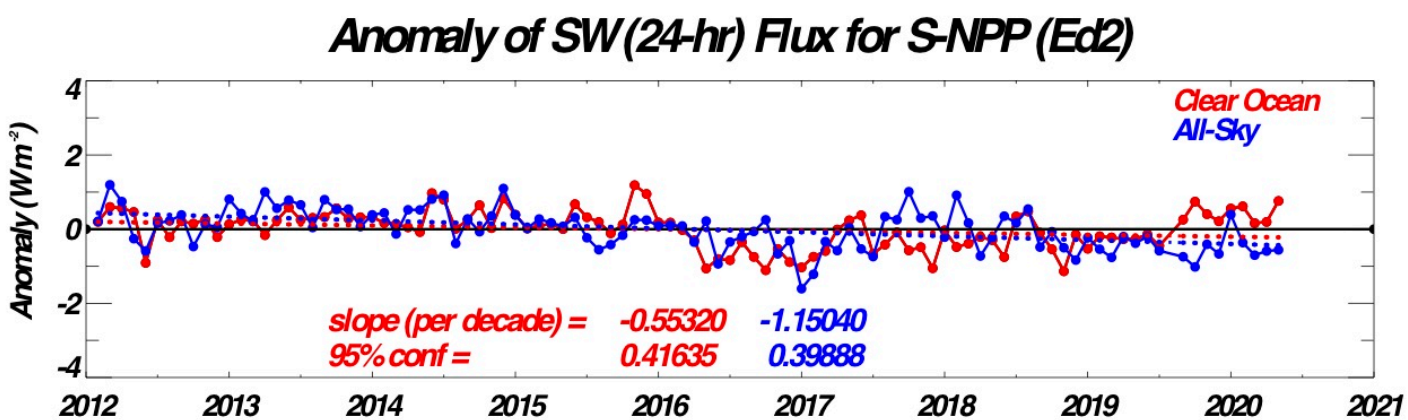


FM5 Biaxial Operation

- **FM5 instrument is operating in Biaxial mode since October 1, 2019**

  - Restricted Biaxial mode: Oct 1, 2019 – March 22, 2020
  - Normal Biaxial mode since March 23, 2020

- **SW Flux anomaly comparison for All-Sky and Clear Ocean scenes do not show any drop in the Clear Ocean SW data.**



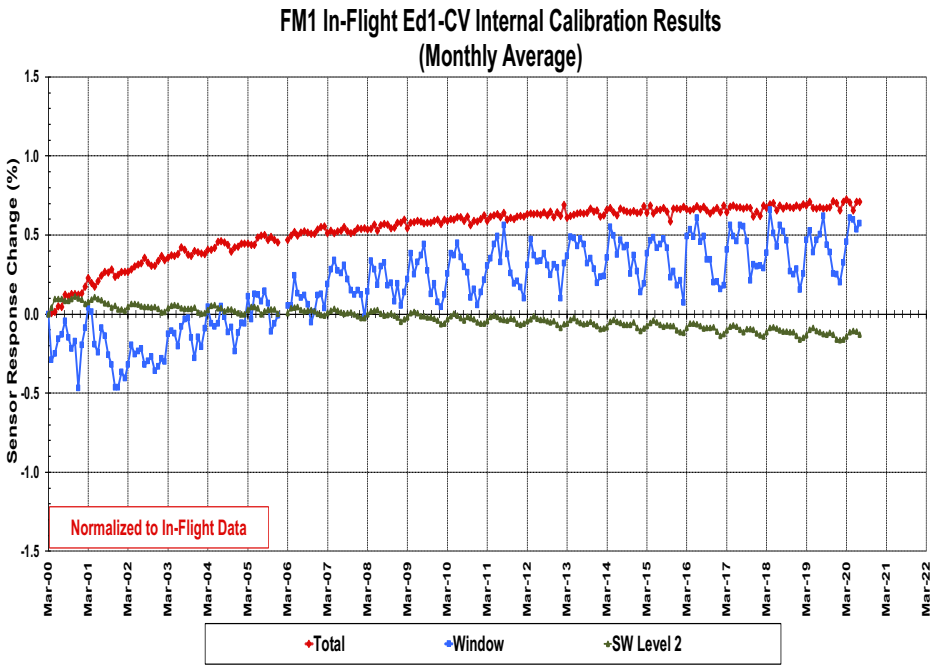
TERRA & AQUA INSTRUMENT STATUS

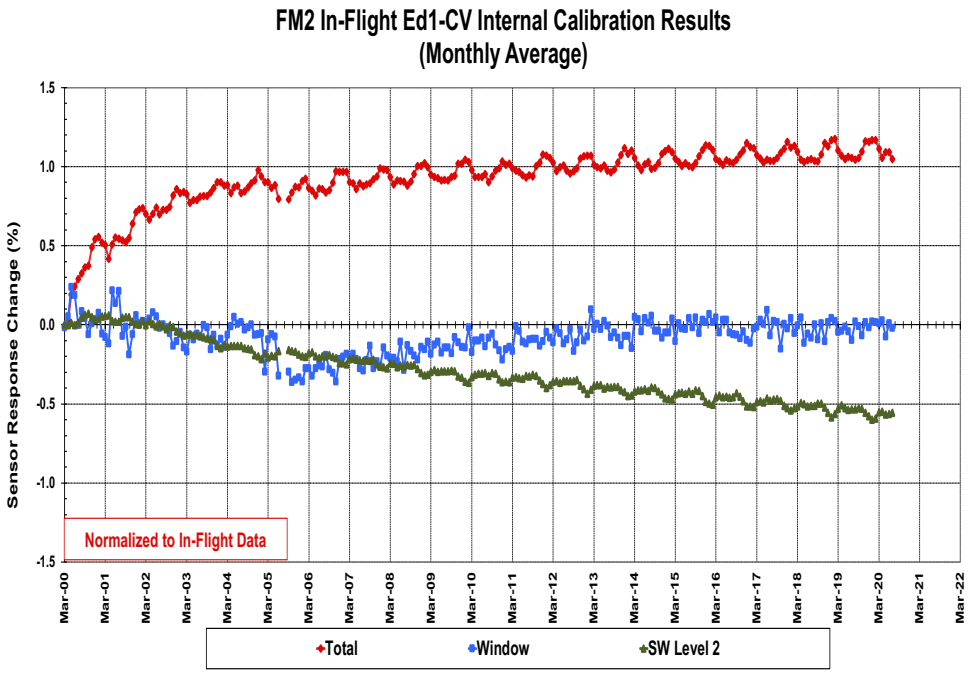
[CERES FM1 – FM4]

1. Calibration: ICM and Solar
2. Validation Results
3. Edition4 Gain/SRF Strategy

Terra CERES FM1 & FM2 Instrument Calibration

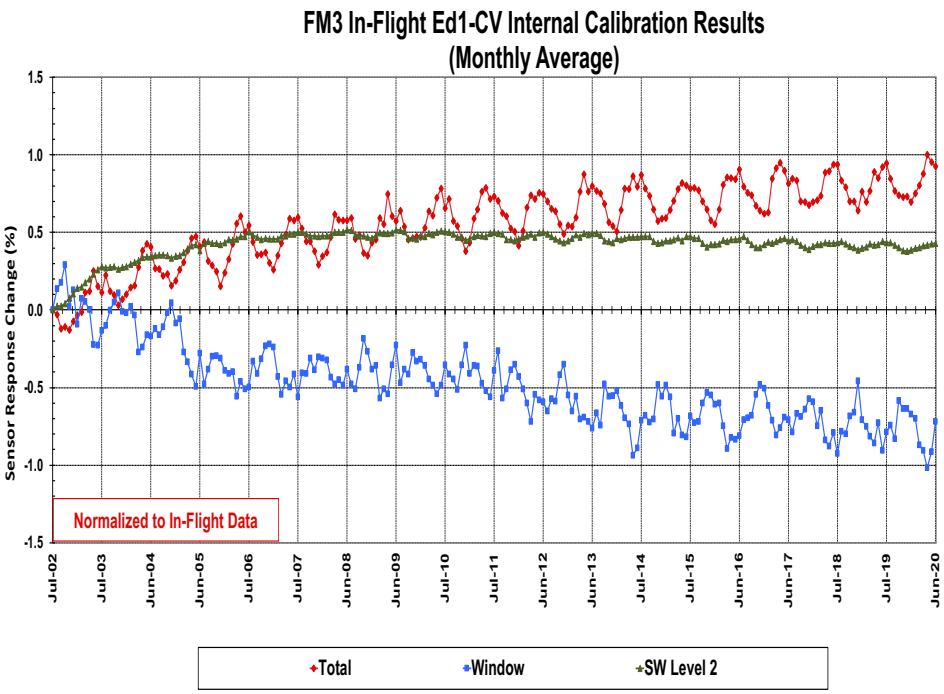
- **Increase in response for Total and Window sensors**
- **Drop in response for SW sensors.**

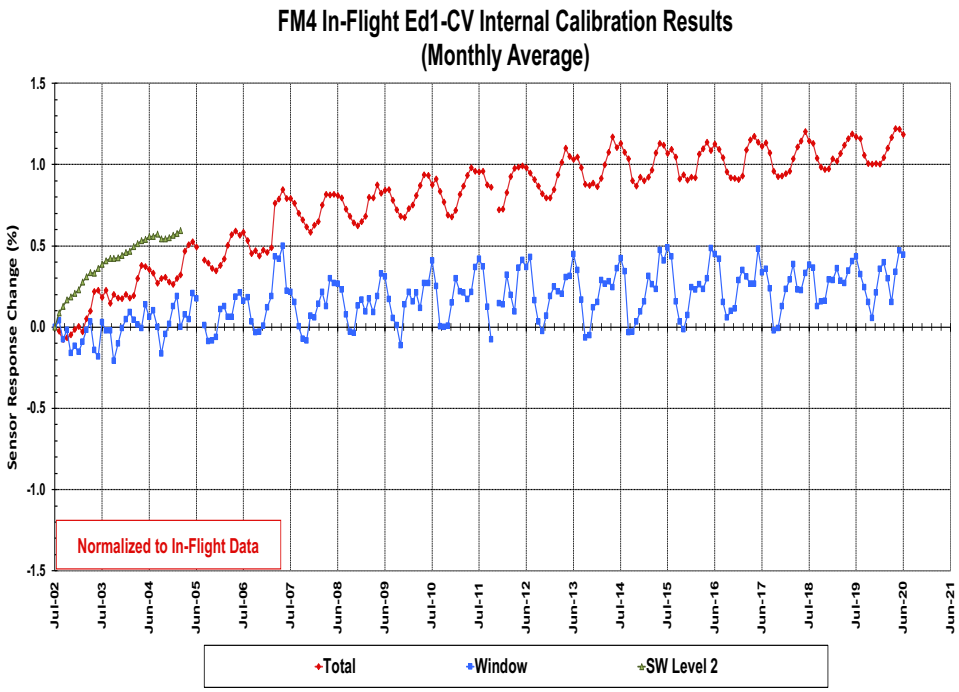




Aqua CERES FM3 & FM4 Instrument Calibration

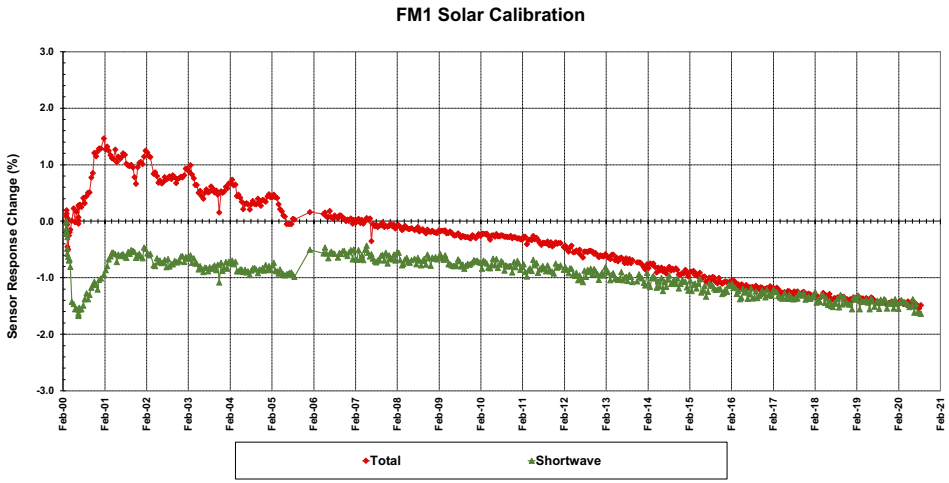
- **Increase in response for Total and SW sensors.**
- **Window sensor on FM3 showed a drop where as FM4 response show slight upward trend.**

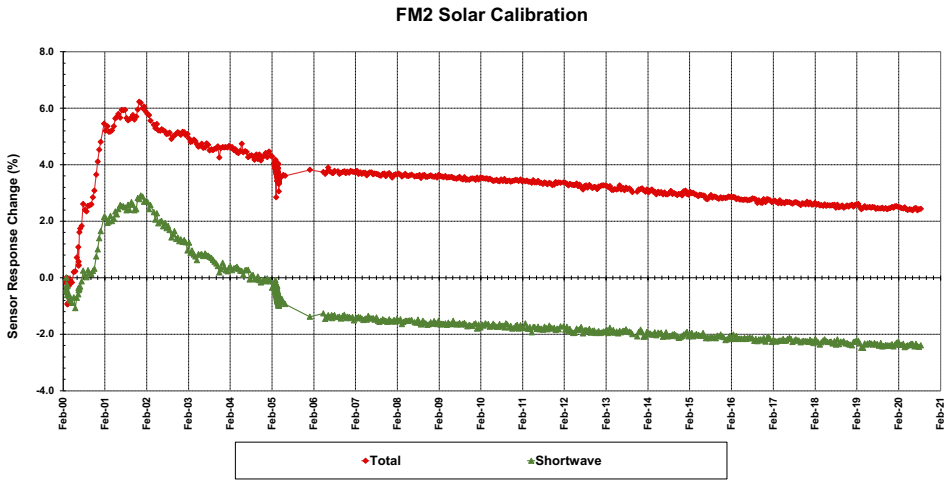


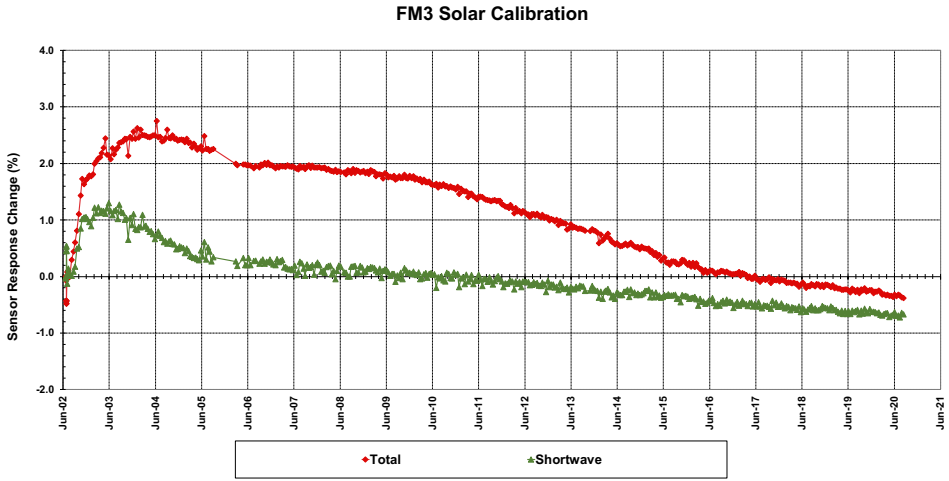


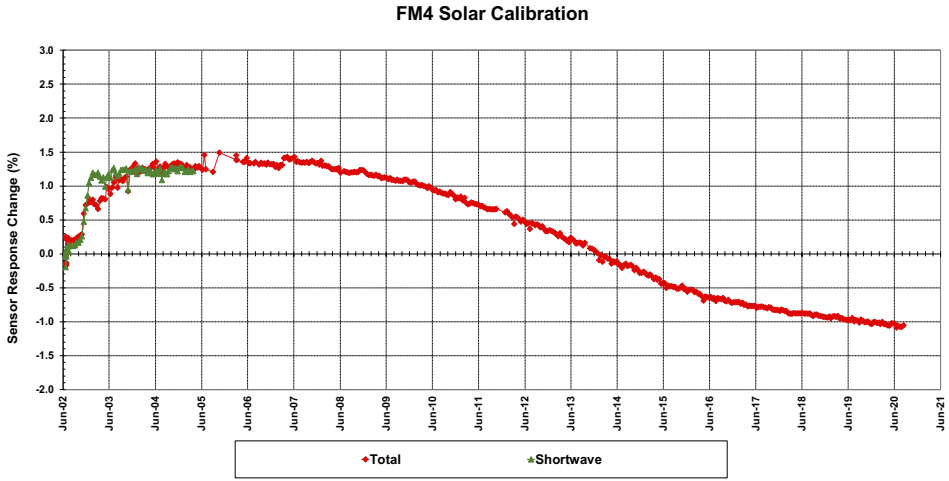
Terra & Aqua Solar Calibration Results

- **After the new solar raster scan calibration sequence starting April 2006, the MAMs showed similar rate of change – 1% for SW sensors and 1.5 to 2.5 % for Total sensors.**

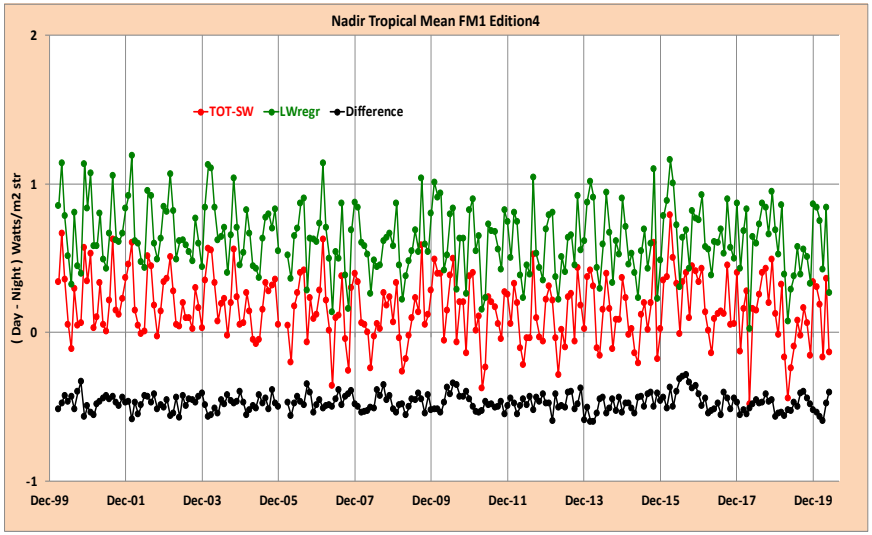


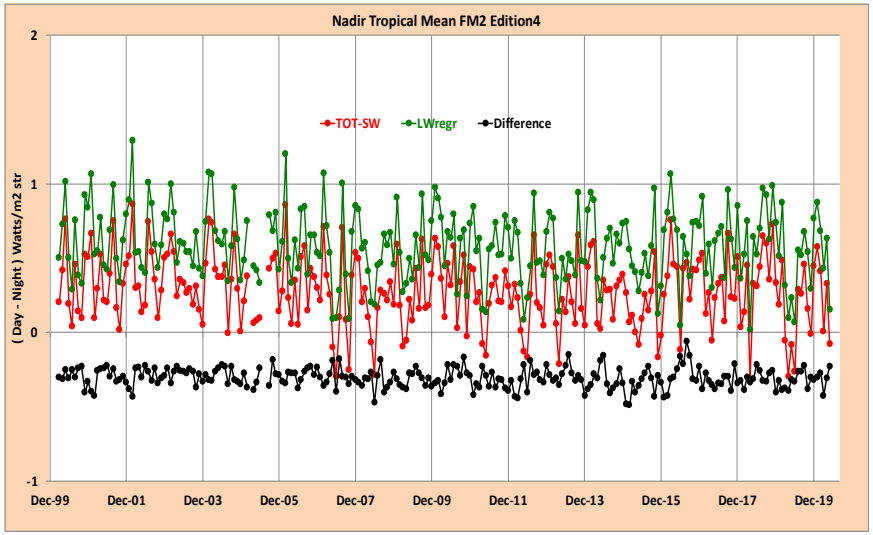


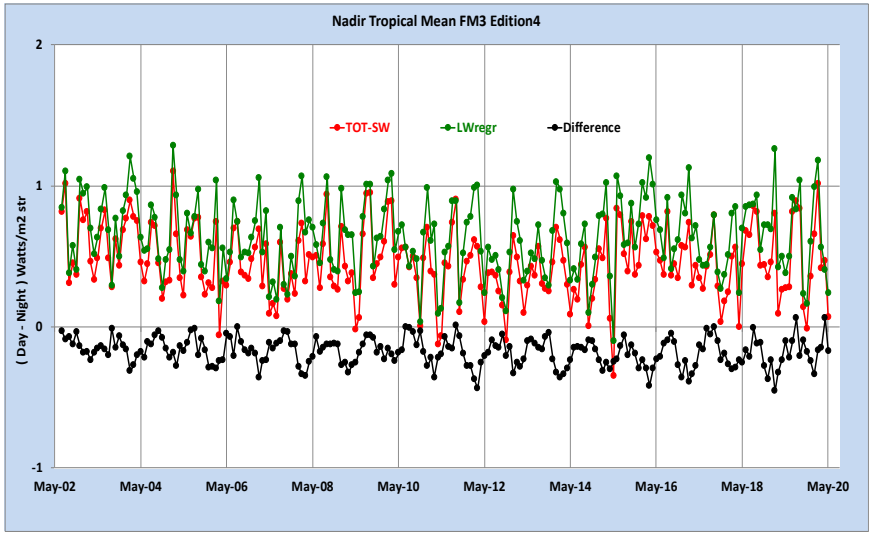




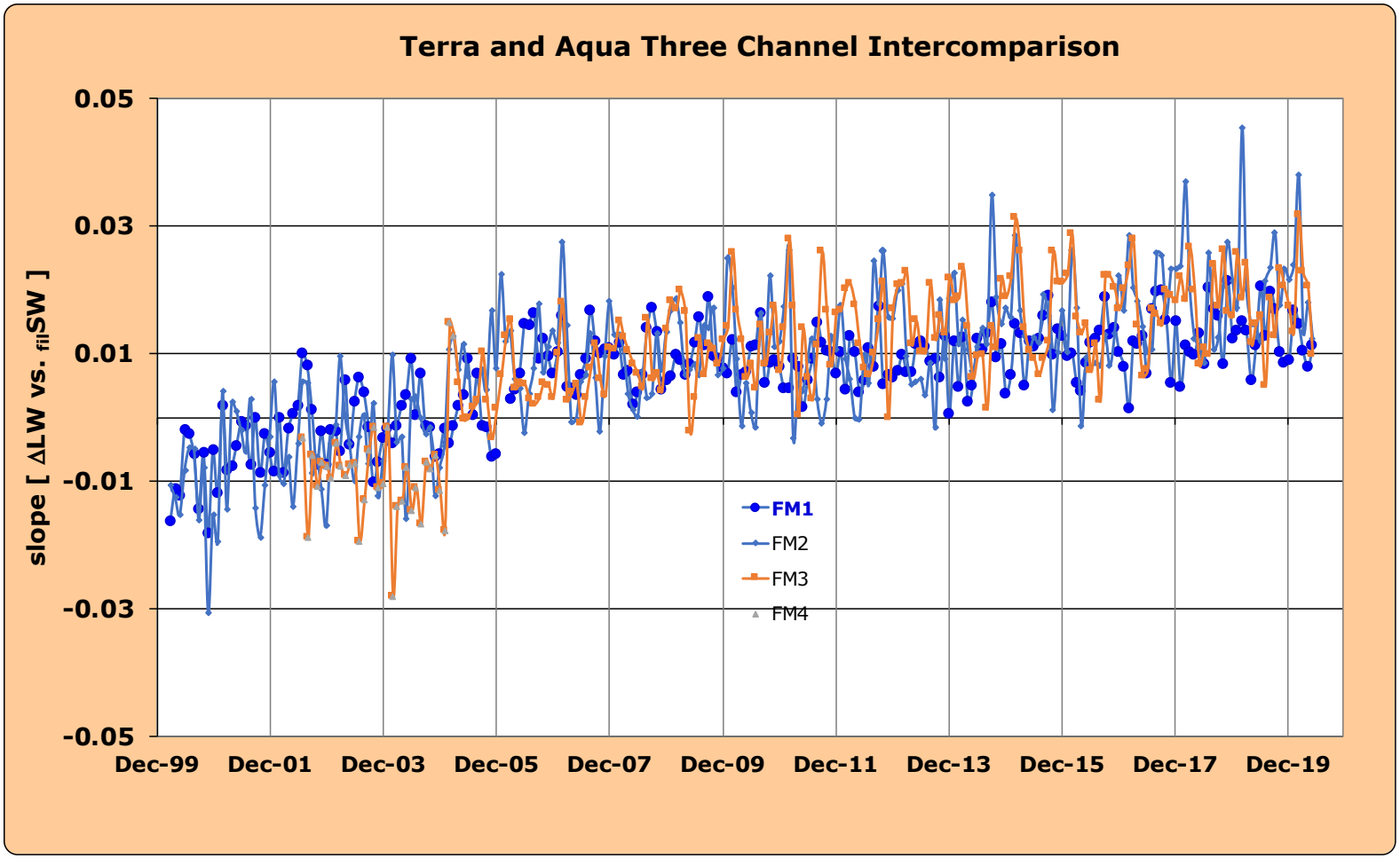
Validation – Tropical mean Results





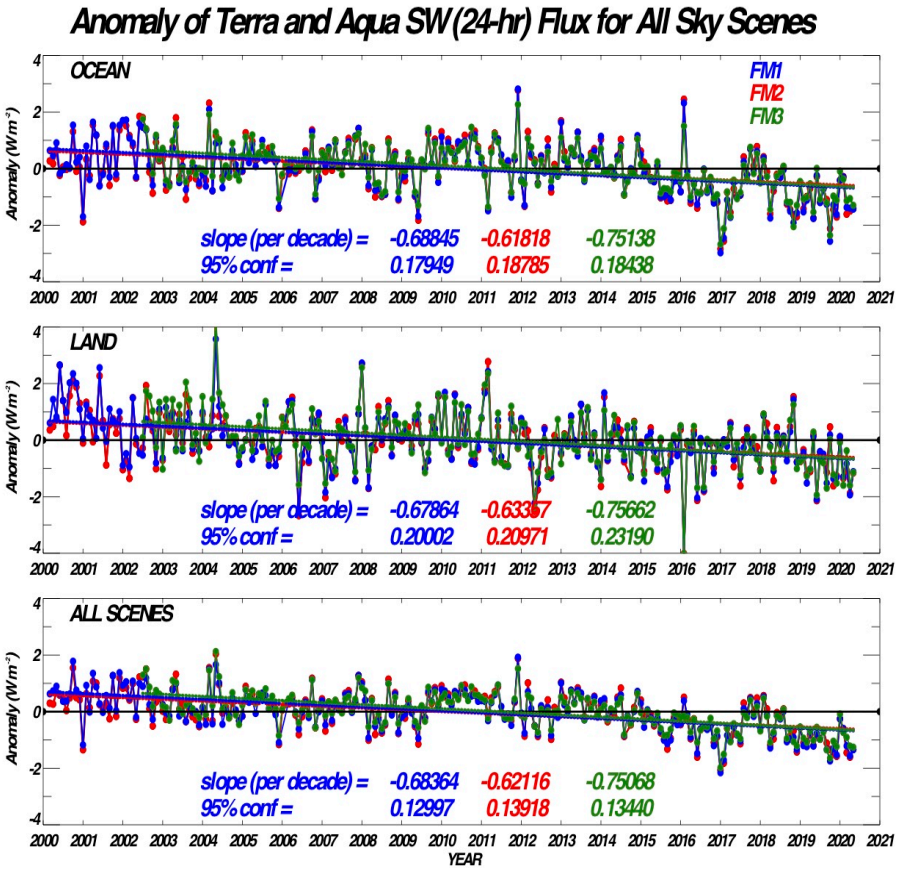


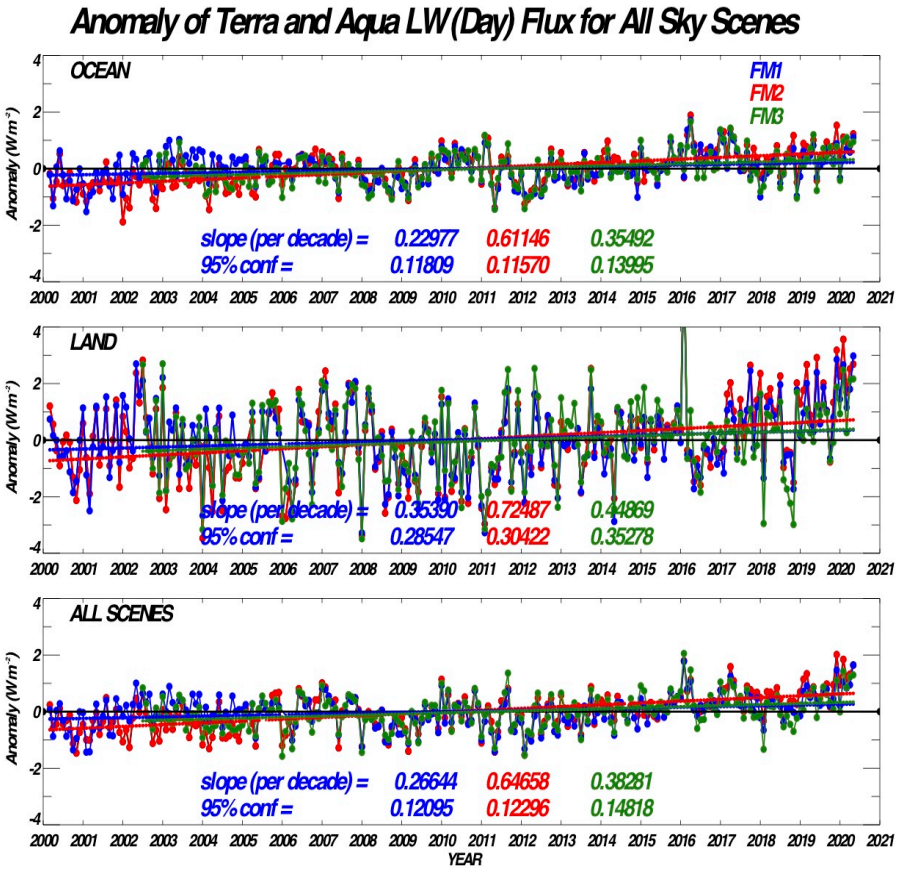
Validation – DCC 3-Channel Intercomparison



Validation: TERRA & AQUA Edition-4 Results

SW and LW-Day Flux Anomalies show similar trends for FM1, FM2 and FM3 instruments





TERRA/AQUA Edition4 GAIN & SRF Strategy

- **Current Gain corrections applied for Total and Window sensors are based on 5-month average of ICM Blackbody calibrations.**
- **The impact on LW Flux measurement with 3-month average for the gain correction was evaluated.**

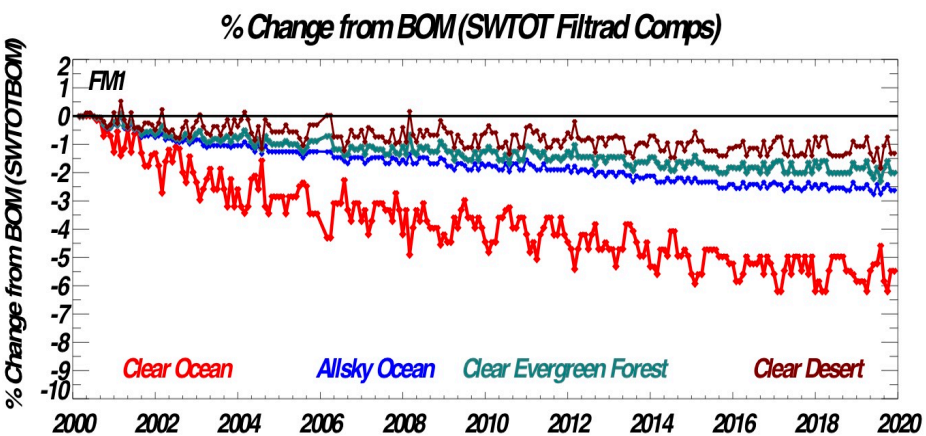
LW Flux Comparison for 5-mon vs 3-mon average Gain value

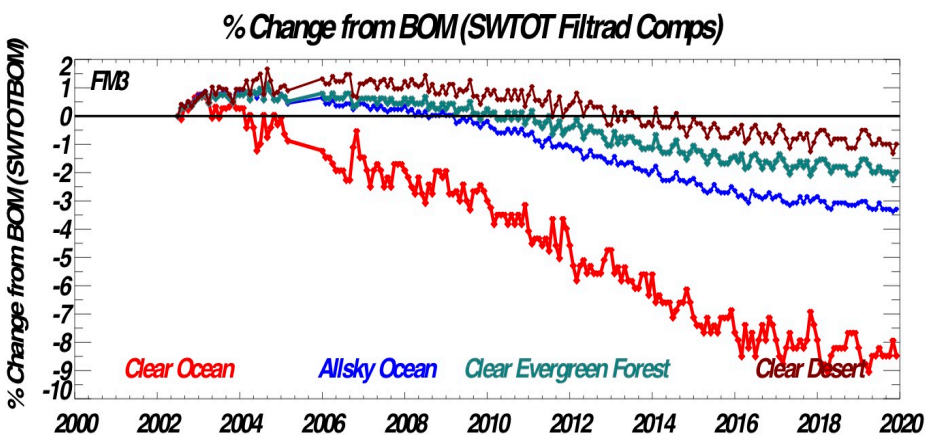
	FM1				FM3			
	Gain Diff % (Ed4 -3mon)	Flux Ed4 Gain W/m2	Flux 3-mon Gain W/m2	Flux Diff % (Ed4 – 3mon)	Gain Diff % (Ed4 - 3mon)	Flux Ed4 Gain W/m2	Flux 3-mon Gain W/m2	Flux Diff % (Ed4 – 3mon)
Jan 20	0.008	237.85	237.88	-0.013	0.051	237.92	238.15	-0.097
Feb 20	-0.002	239.22	239.22	0.00	0.057	239.42	239.67	-0.104
Mar 20	-0.027	239.39	239.22	0.071	0.050	239.27	239.5	-0.096

TERRA/AQUA Edition4 GAIN & SRF Strategy

- **The SW/TOT Spectral Response Function (SRF) changes for LW_Day is stable for most scenes in last 18 – 24 months.**
- **Constant SRF with 3-month average gain showed < 0.07% change [Jan-Mar 2020] in Edition4 LW Flux measurement.**
- **The new Gain/SRF approach will be used for Edition4 processing starting June 2020.**

SW/TOT Throughput Change for Terra and Aqua (SRF applied to SCIAMACHY Scene Spectra)





SUMMARY

- CERES FM6 instrument calibration and validation results show stable performance after the initial sensor response increase in Total and Shortwave sensor.
- Validation studies on CERES FM5 instrument do not show any change in the trends from the biaxial operations.
- A new approach to determine Terra and Aqua Instruments' Total and Window sensor gains is implemented for Edition4 processing starting June 2020. This will reduce the latency in generating CERES higher level data products.
- Validation results from Terra, Aqua and S-NPP show consistent trends among all CERES instruments.
- Gains and SRFs for Terra/Aqua Edition4 and S-NPP Edition2 were delivered through May 2020. Gains for NOAA20 Edition1 processing was delivered through July 2020.