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

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CERES Instrument Working Group

CERES Spring Science Team Meeting
April 28, 2020

Instrument Working Group

Chair/PS: Kory Priestley
DPS: Mohan Shankar

Instrument Operations	**Data Management**	**Cal/Val**
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John Butler	Mark Timcoe	Nathaniel Smith
Cian Branco	Dianne Snyder	Nitchie Smith
Adam Horn		Z. Peter Szewczyk
Carol Kelly		Robert Wilson
William Edmonds		

CERES Instrument Operations

- **Flight Models (FM) 1-4, FM6 are in nominal mode of operation- Crosstrack.**
- **FM5 is operating in 'normal' Biaxial mode since Mar 23, 2020.**
- **FM2 PAP scans of the MOSAiC Expedition:**
  - Conducted PAP scan test on Apr 23, 2020; Successfully targeted the location of the Polarstern.
  - Plan is to conduct PAP scans of the location of the ship starting May 1, 2020.
- **Planned Inter-comparison Operations during summer 2020**
  - Terra/FM1 – S-NPP/FM5: May 1 – Jul 31, 2020
  - Terra/FM1 – NOAA-20/FM6: May 1 – Jul 31, 2020
  - Terra/FM1 – Aqua/FM3: Jun 1 – 30, 2020
  - Terra/FM2 – GERB: Jun 1 – 30, 2020

Overpass region around 70^0 N

Instrument Product-line definitions

- **NOAA-20**
  - *Edition1-CV*: Products without any on-orbit instrument calibration corrections applied.
  - *Edition 1*: Incorporates the most up-to-date calibration corrections, radiometric scaling to Aqua.

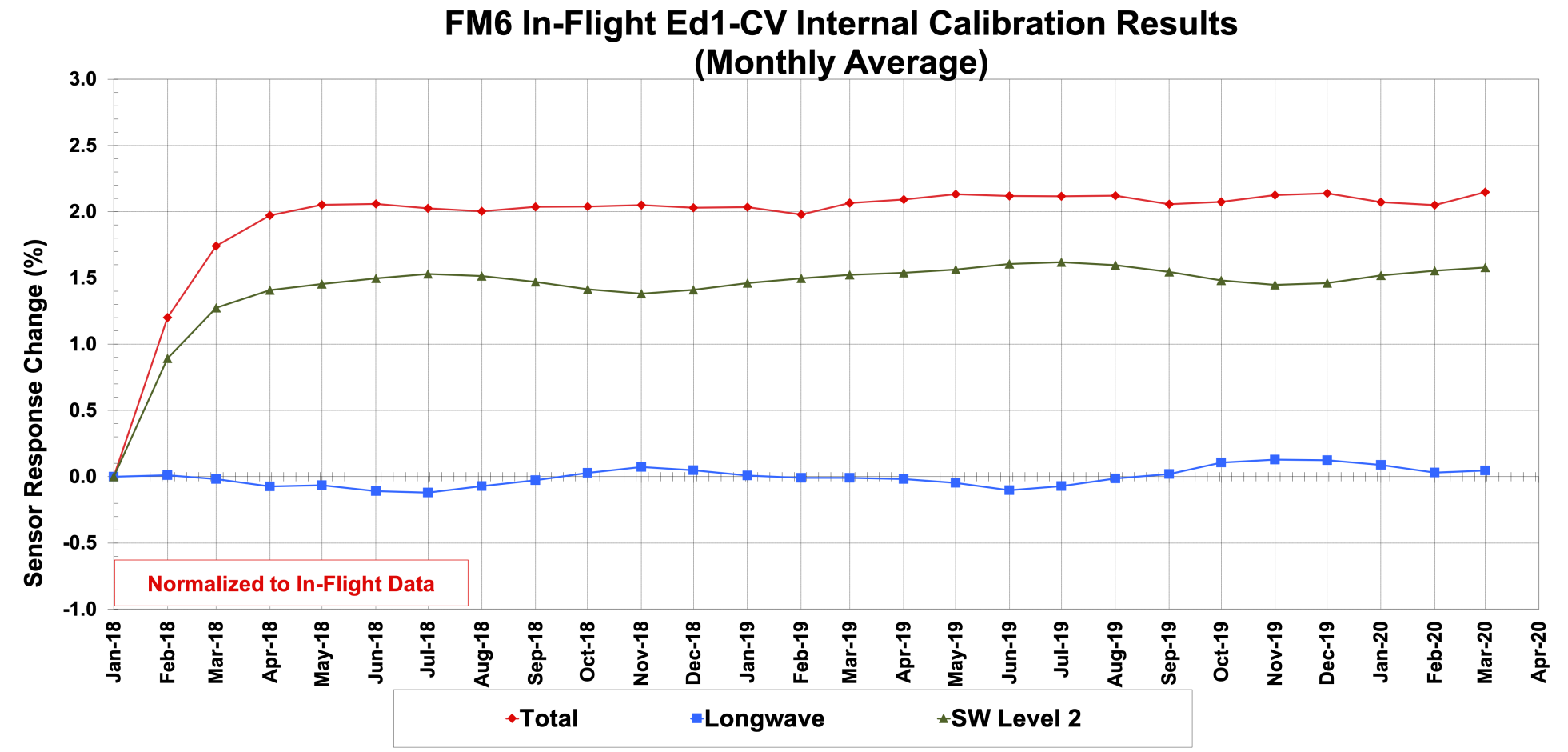
- **S-NPP**:
  - *Edition 1-CV*: Products without any on-orbit instrument calibration corrections applied.
  - *Edition 2*: Incorporates the most up-to-date calibration corrections, radiometric scaling to Aqua, and time varying SRF adjustments to TOT channel.

- **Terra/Aqua**:
  - *Edition 1-CV*: Products without any on-orbit instrument calibration corrections applied.
  - *Edition 4*: Incorporates the most up-to-date calibration corrections, radiometric scaling and time varying SRF adjustments to SW and TOT channels.

NOAA-20/FM6 Instrument Status

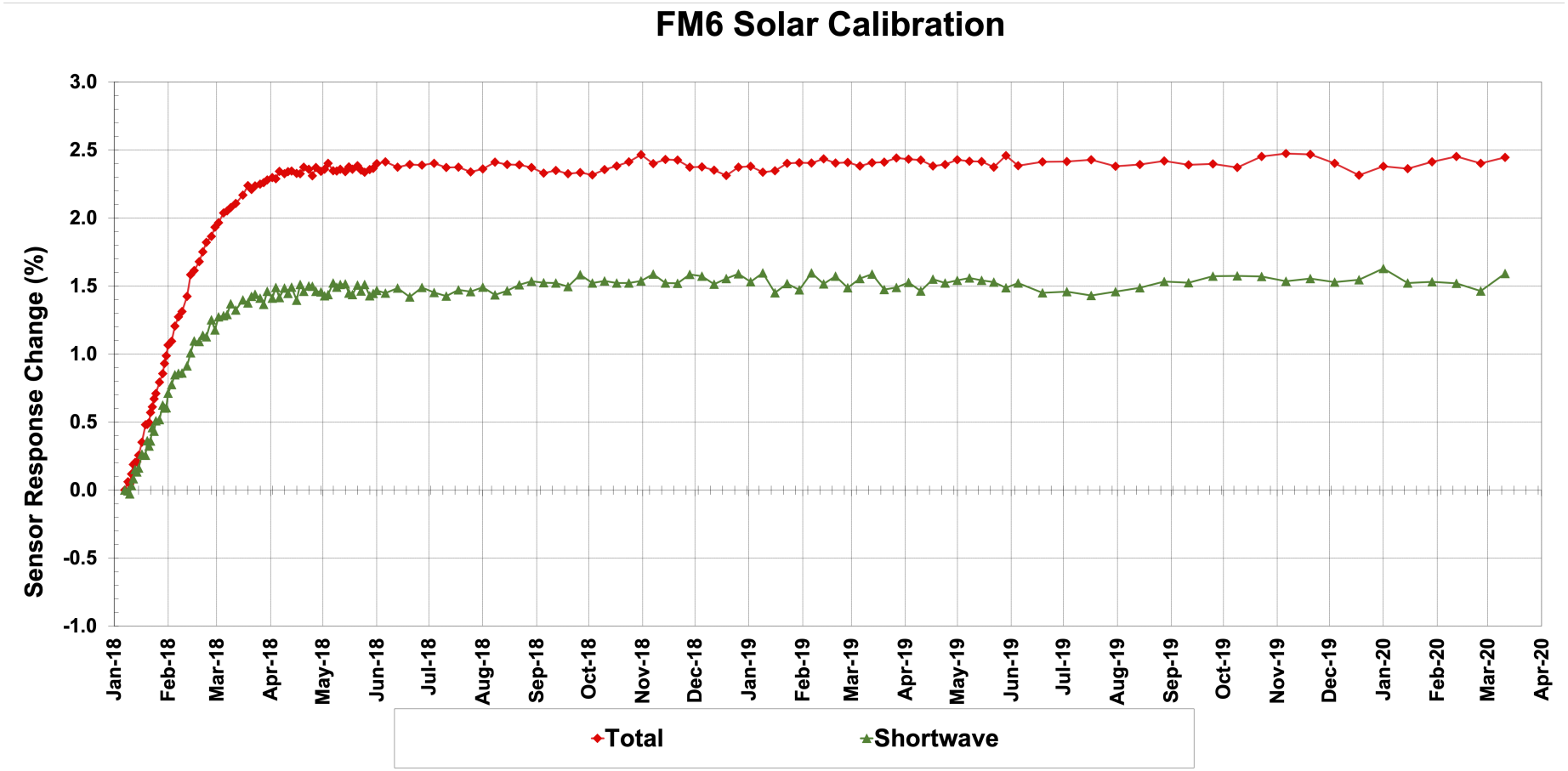
FM6 Internal Calibration

- For SW and TOT channels, the responses to the on-board sources (SWICS lamp and Blackbodies) continue to be stable after the initial rise of ~1.5% (SW) and ~2% (TOT) since start of mission.
- LW Channel (calibrated using blackbody) continues to show very little variation.



FM6 Solar Calibration

- **Response of the SW and TOT channels while viewing the MAM that is illuminated by the sun.**
- **After the initial rise of ~1.5% for SW, and ~2.5% for TOT, the response is very stable.**



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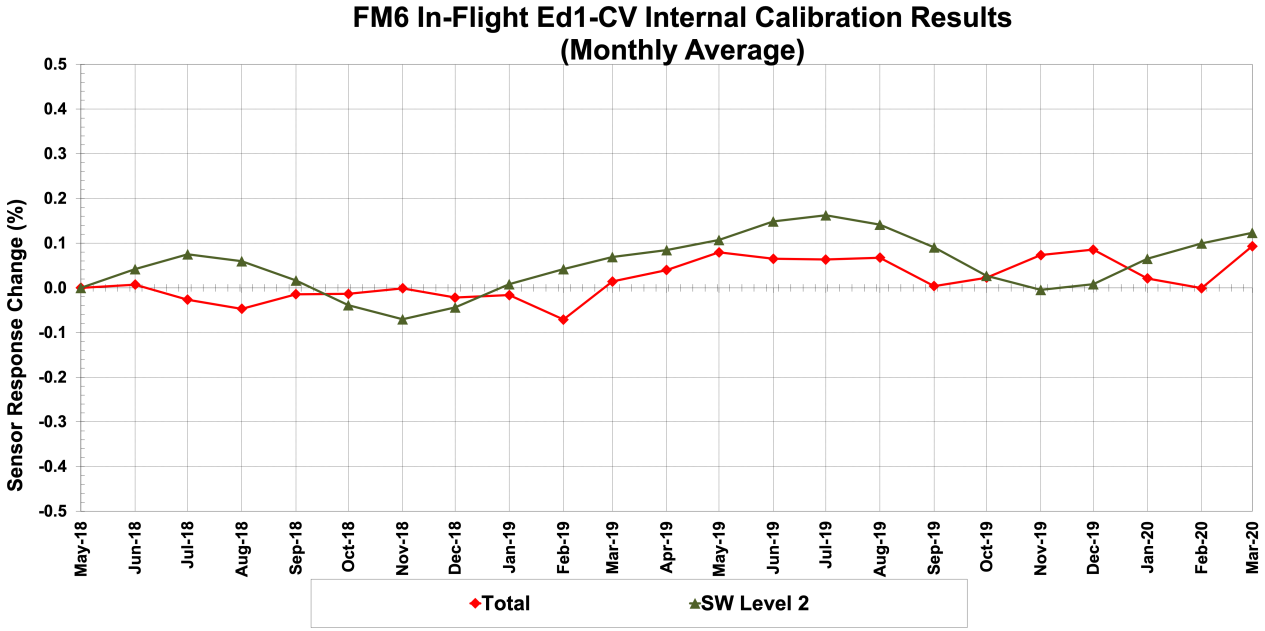
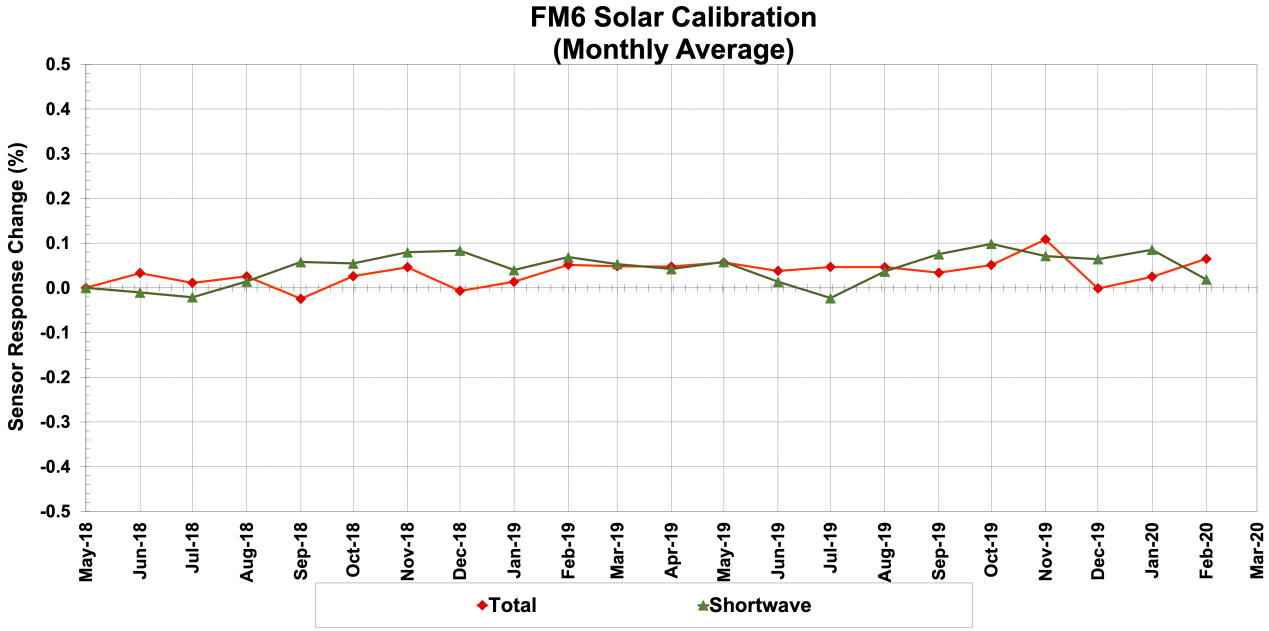
FM6 Calibration- Since May 2018

FM6 Internal and solar calibration results show consistently very little change (~0.1%) since May 2018.





FM6 Edition-1

- **FM6 Edition-1 record starts from May 2018**
  - After the settling out of the large initial change in gain.
- **Incorporated the gain change from start of mission to May 2018**
- **Performed radiometric scaling to Aqua/FM3 in May 2018**
  - Used SSF-1deg product to determine required scaling for SW, TOT and LW channels based on observed differences with FM3.
  - Scaling was incorporated into the FM6 SRFs.

FM6 Edition 1- Radiometric Scaling to Aqua

Scaling applied to FM6 SRF (May 2018):
SW: -0.40%
TOT: -0.08%
LW: -0.45%

Pre- Radiometric scaling

SSF- 1deg Global avg. All-sky Flux Difference		
FM6-FM3%	**May 2018**	**Jun 2018**
SW	-0.287	-0.431
LW (TOT-SW)	-0.005	0.062
LW Channel	-0.482	-0.418

Post Radiometric scaling

SSF- 1deg Global avg. All-sky Flux Difference		
FM6-FM3%	**May 2018**	**Jun 2018**
SW	0.087	-0.057
LW (TOT-SW)	-0.025	0.044
LW Channel	-0.063	0.001

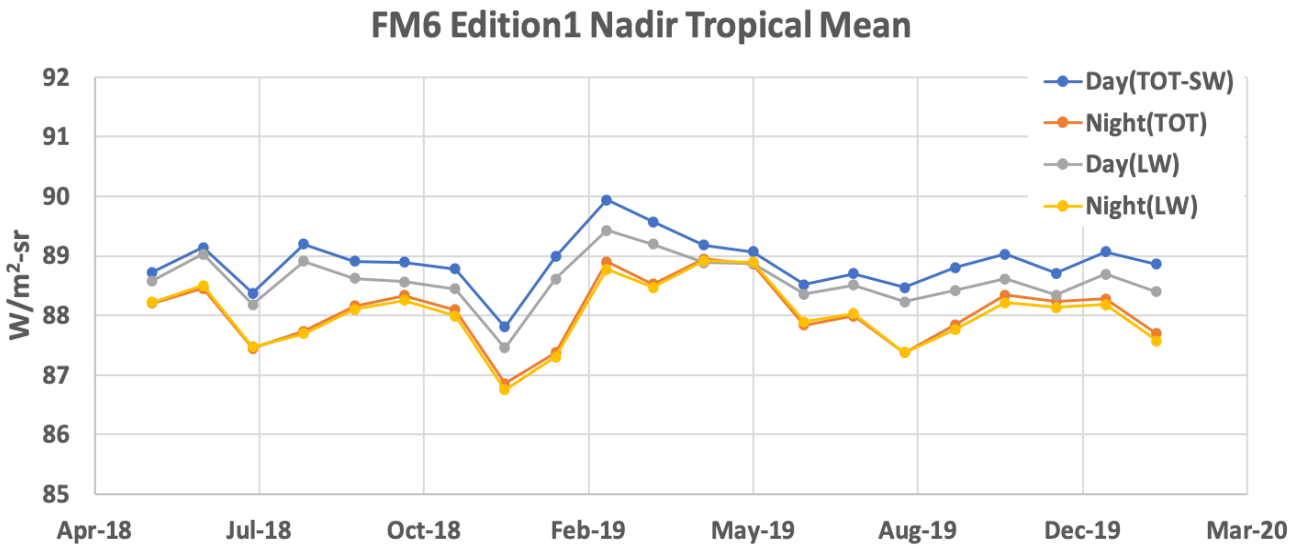
Validation – Tropical Mean

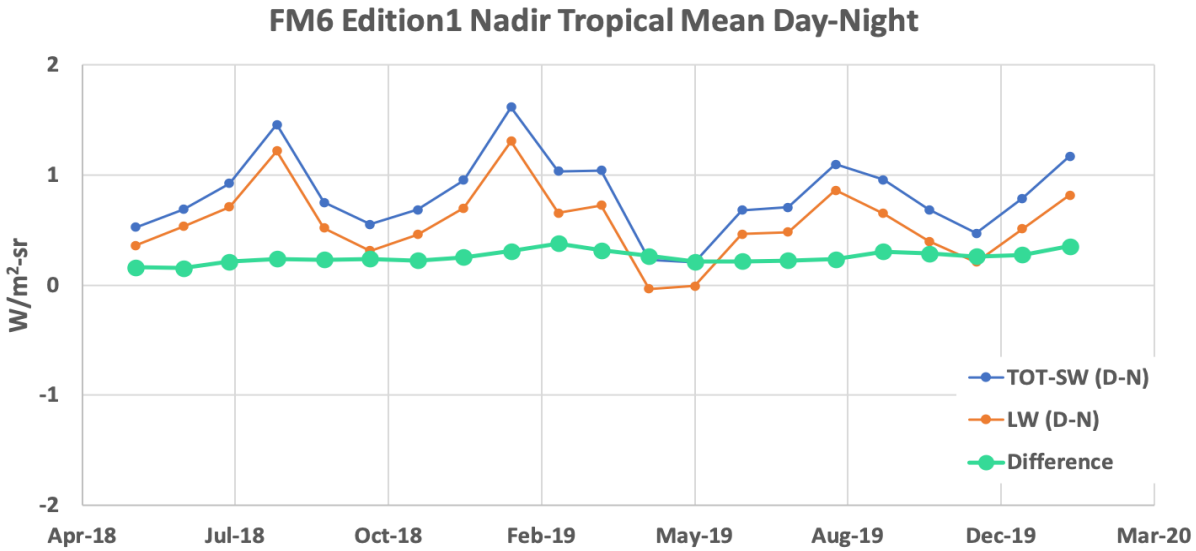
- Average of the ES-8 Nadir radiances over Tropical ocean (20^0N-20^0S) scenes under All-sky conditions.
- TM Day-Night Difference (DN) is calculated:
  - TOT and SW sensors

    $DN = TM_D(TOT\text{-}SW) - TM_N(TOT)$
  - LW sensor

    $DN = TM_D(LW) - TM_N(LW)$
- Difference in the two DN values point to an anomaly in the shortwave regions of the sensors.

Validation- FM6 Tropical mean

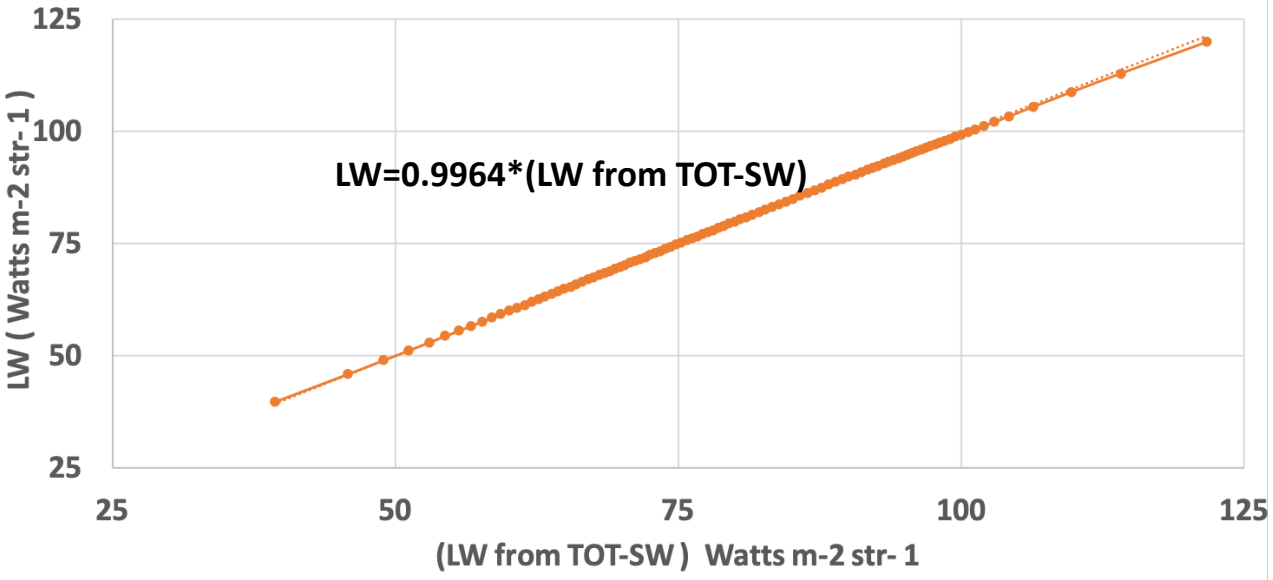




FM6 3-channel Consistency check- Global LW Day and Night

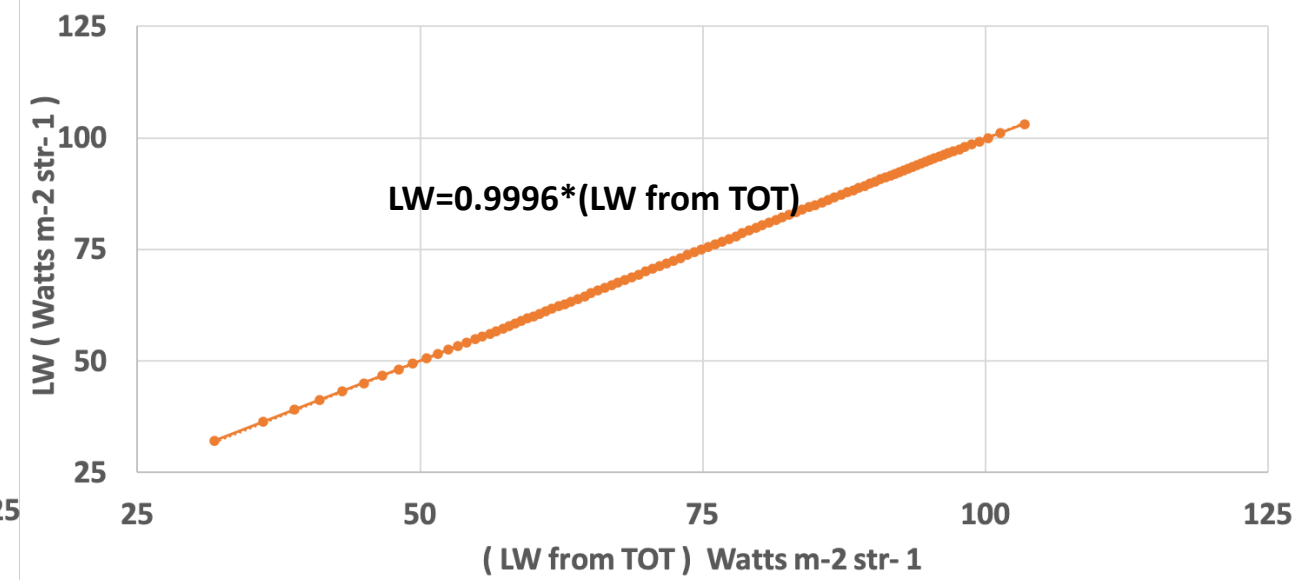
Uses ES-8 Nadir
May 2018 - Jan 2020

Day Global Edition 1
TOT- SW vs. LW sensor



Daytime
LW_{TOT-SW} - LW_{LWc}= 0.36%

Night Global Edition 1
LW from TOT vs. LW sensor



Nighttime
LW_{TOT} - LW_{LWc}= 0.04%

S-NPP/FM5 Instrument Status

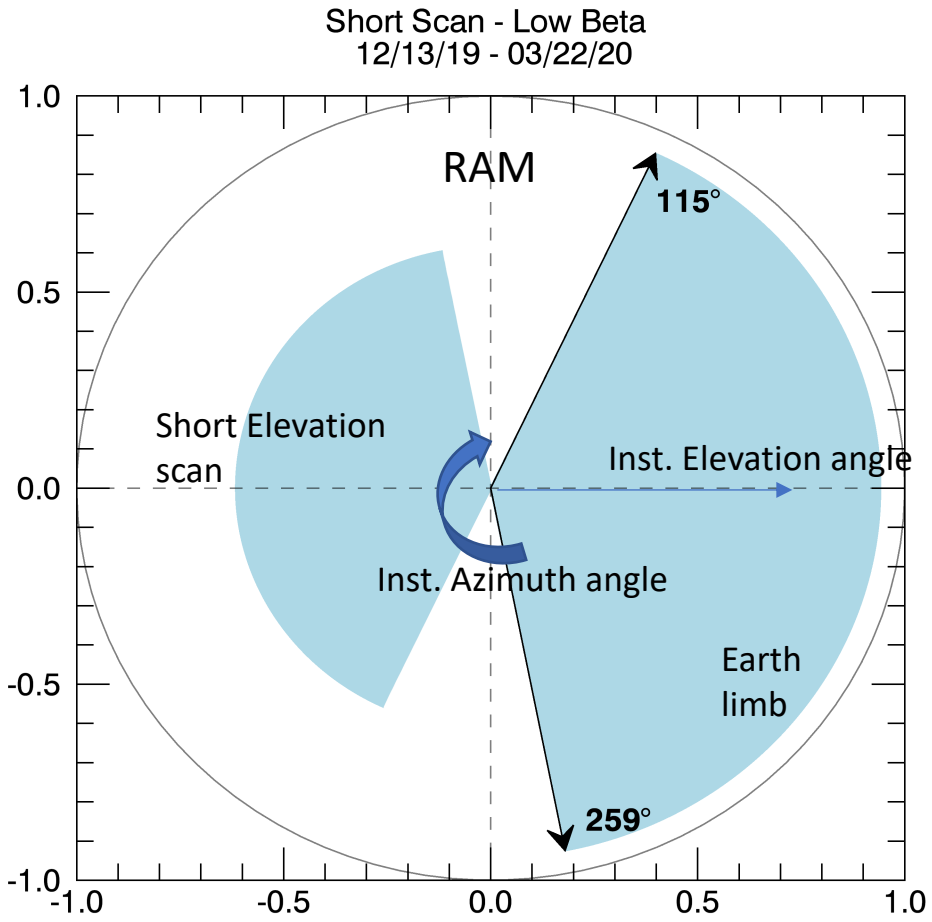
FM5 Biaxial mode

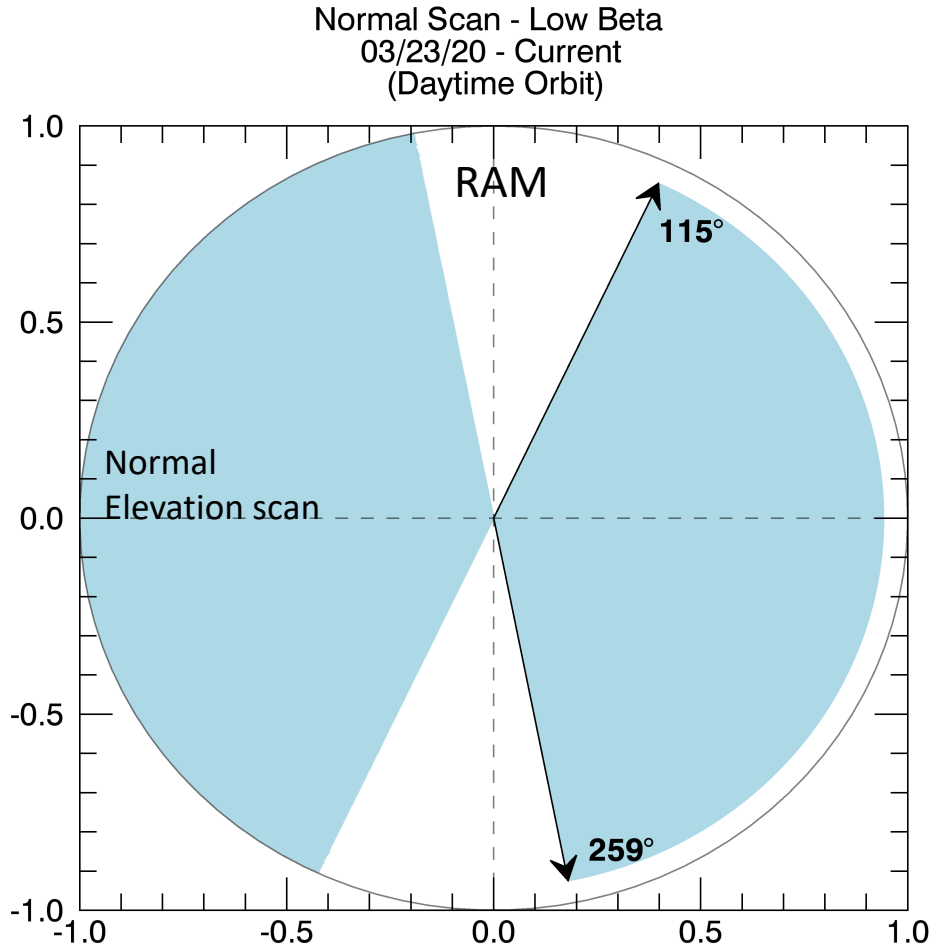
- **FM5 was operated in restricted biaxial mode between Oct 1, 2019 through Mar 22, 2020.**

- **FM5 was transitioned into a 'normal' biaxial mode starting Mar 23, 2020 (for the daytime orbit)**
  - Some saturations observed in the SW sensor outputs in certain azimuth angles (in the unused space look positions).
  - Likely cause is glint from antenna on spacecraft.
  - Does not impact the ADM data collects.

FM5- Biaxial operation

FM5 is now operating in 'Normal' Biaxial mode since 03/23/2020 (daytime orbit).

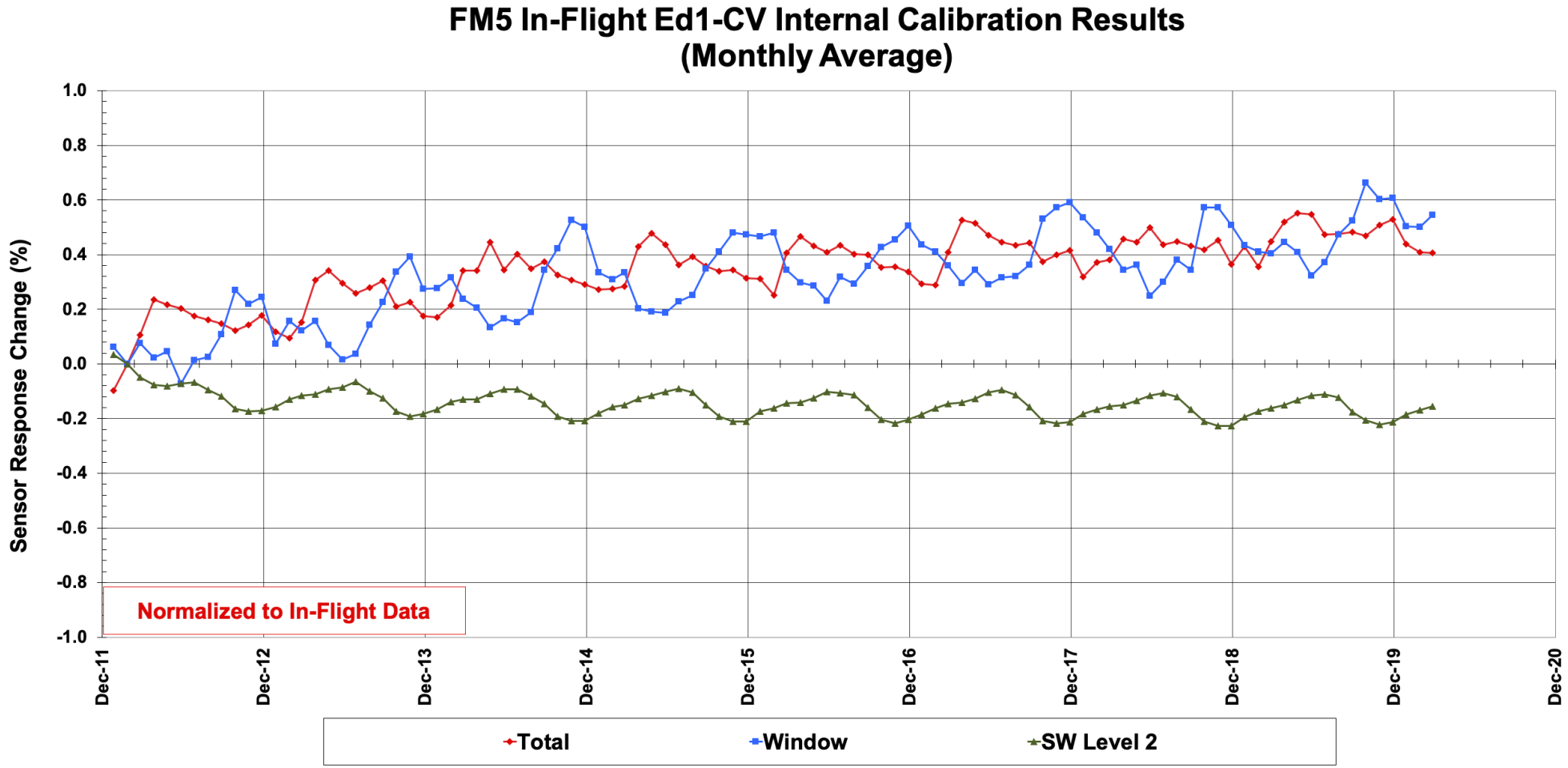




FM5 Internal Calibration

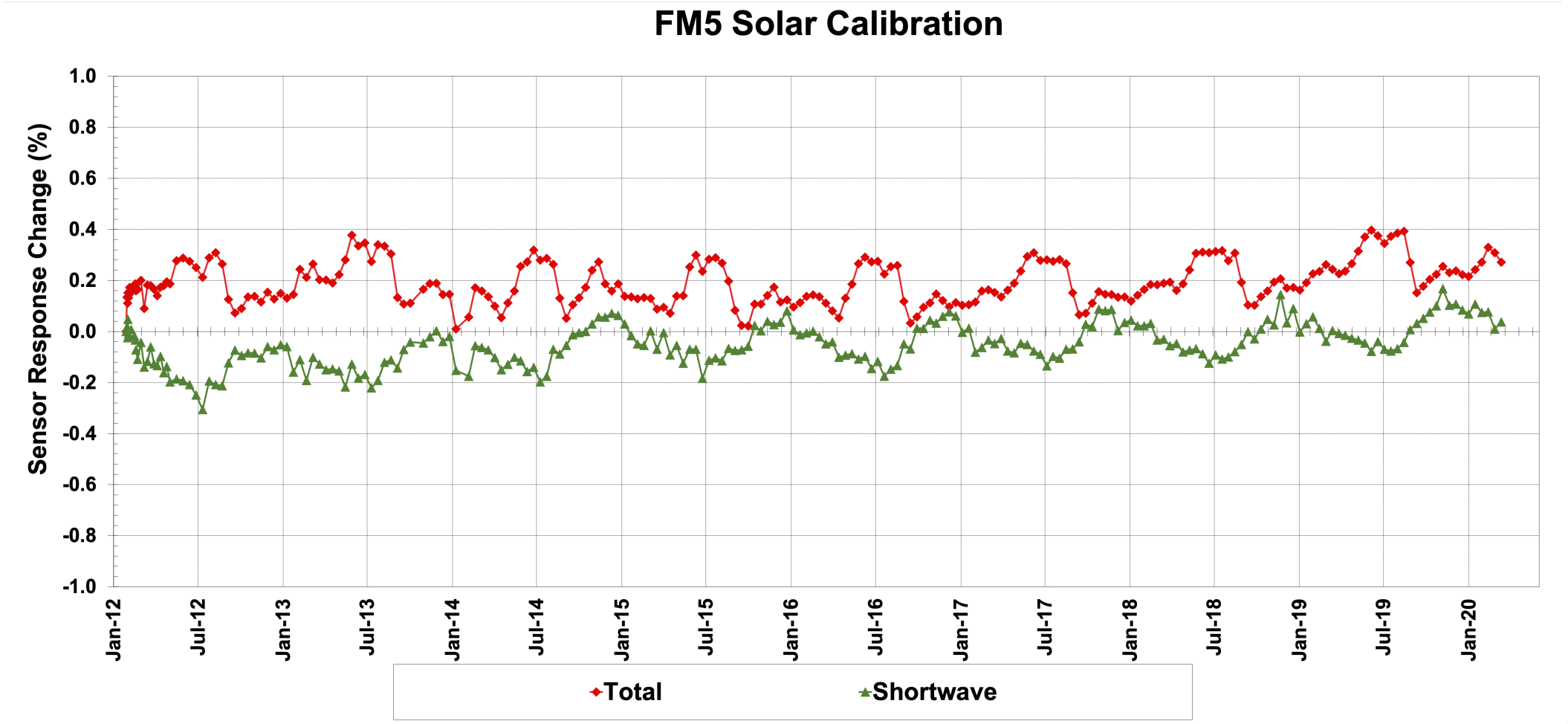
In response to the blackbodies, the FM5 TOT and WN sensors show a ~0.5% rise since start of mission.

SW channel's response to the SWICS has settled at ~-0.2% since start of mission.



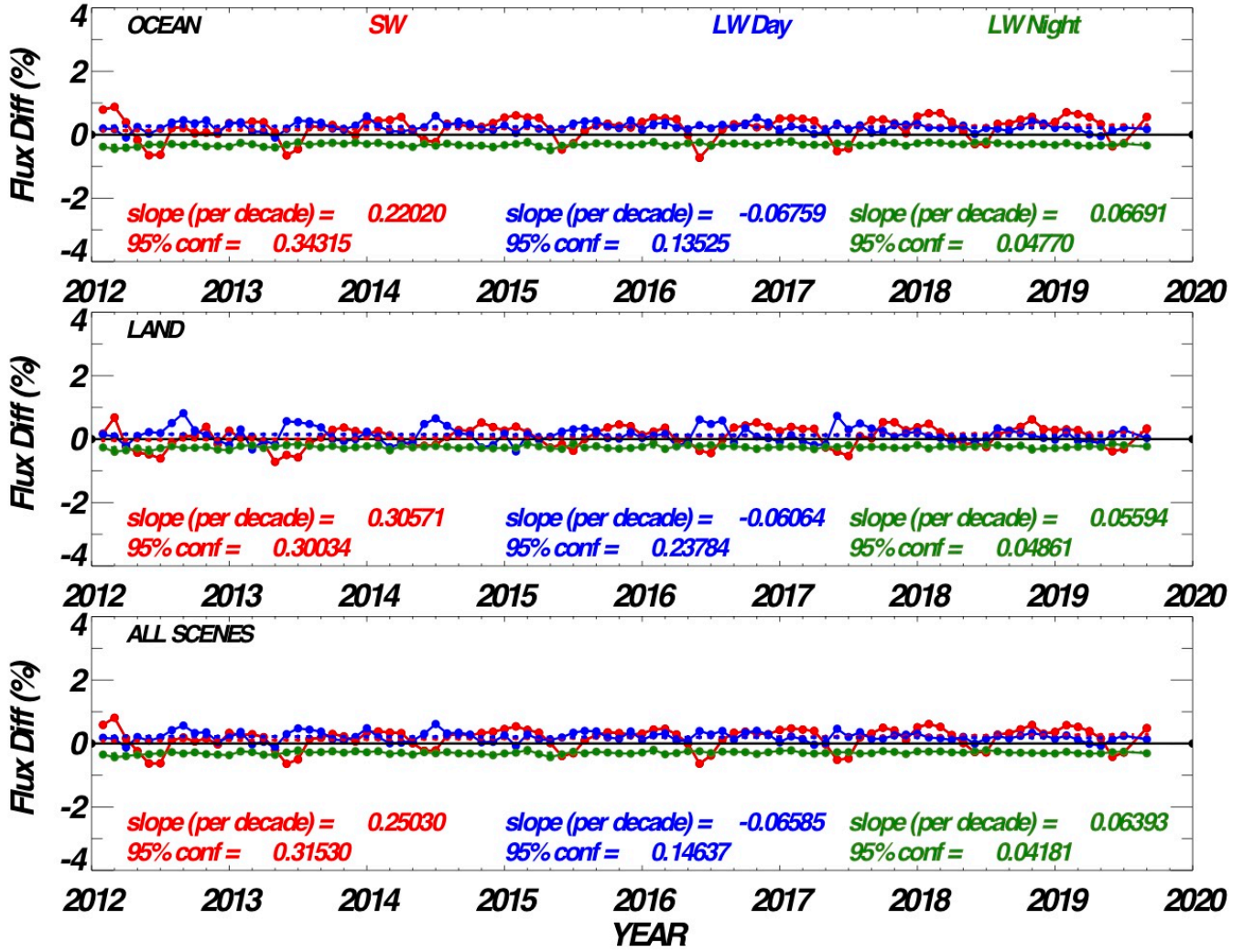
FM5 Solar Calibration

- **FM5 Solar calibration results show the MAMs are very stable.**
- **TOT and SW responses show a slight upward trend in latter part of mission.**



Validation: S-NPP (Ed2) – Aqua (Ed4) Flux difference

S-NPP/FM5 shows consistency with the Aqua/FM3 instrument (Ed4) at BOM as well as long term.



Uses SSF data products

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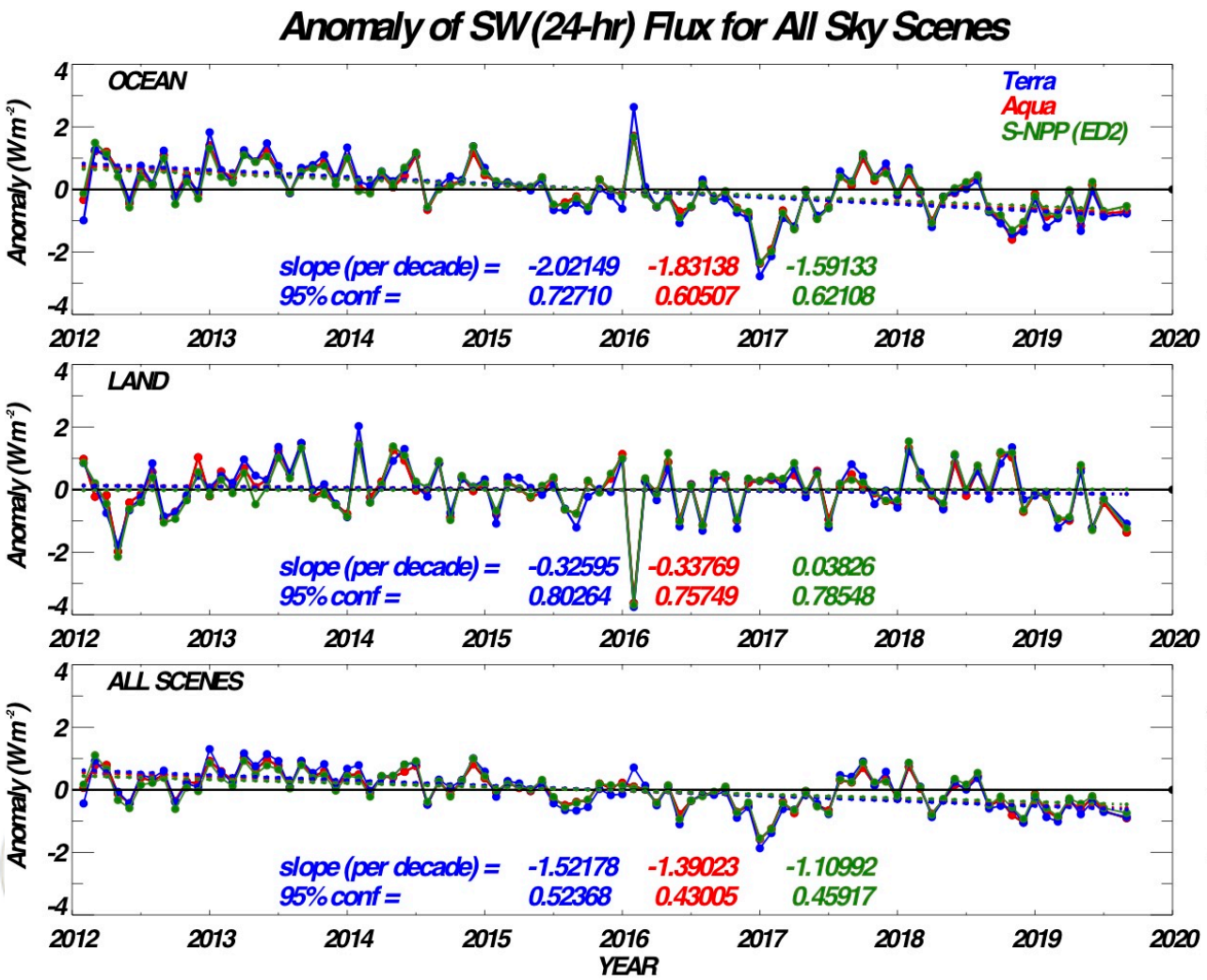
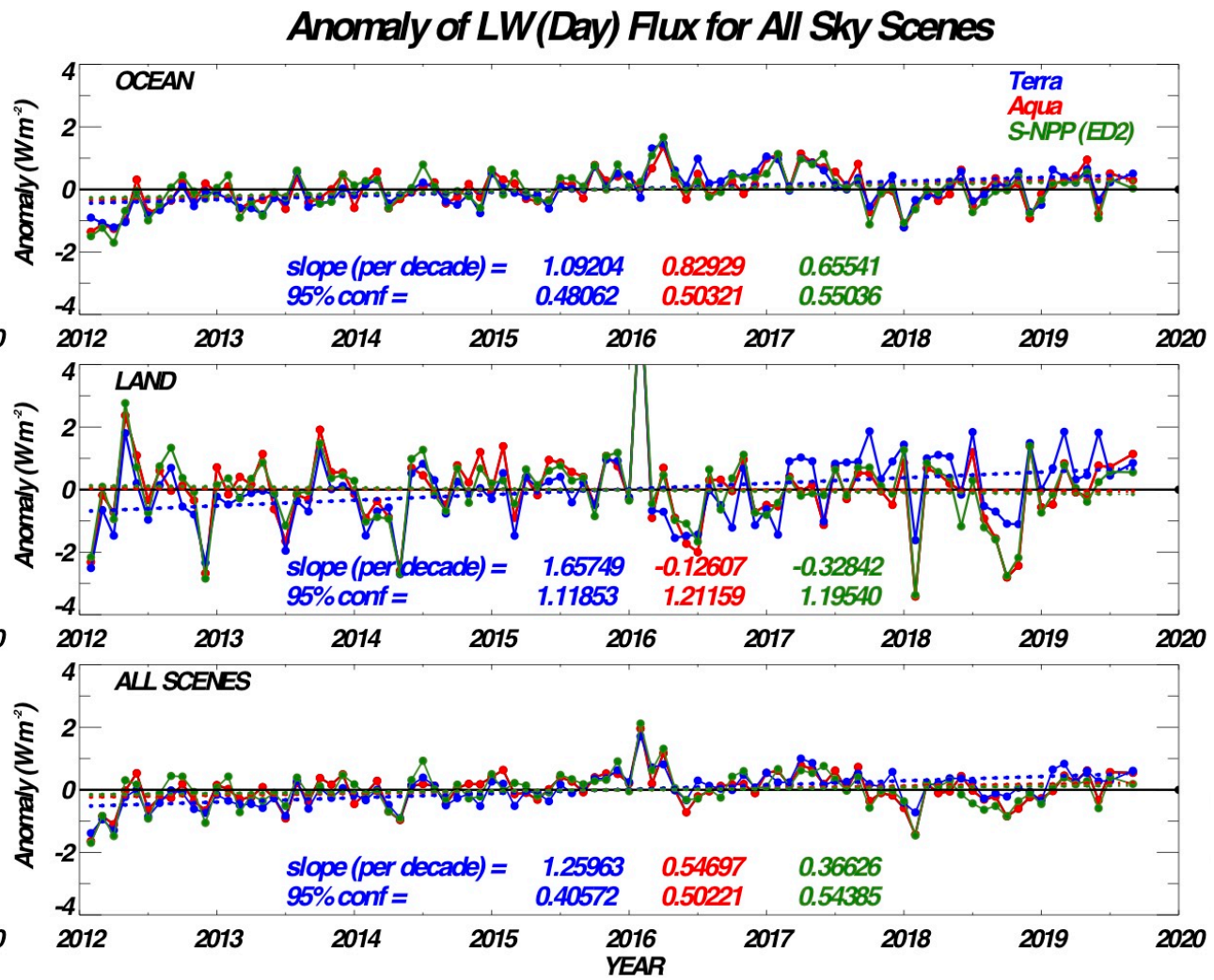
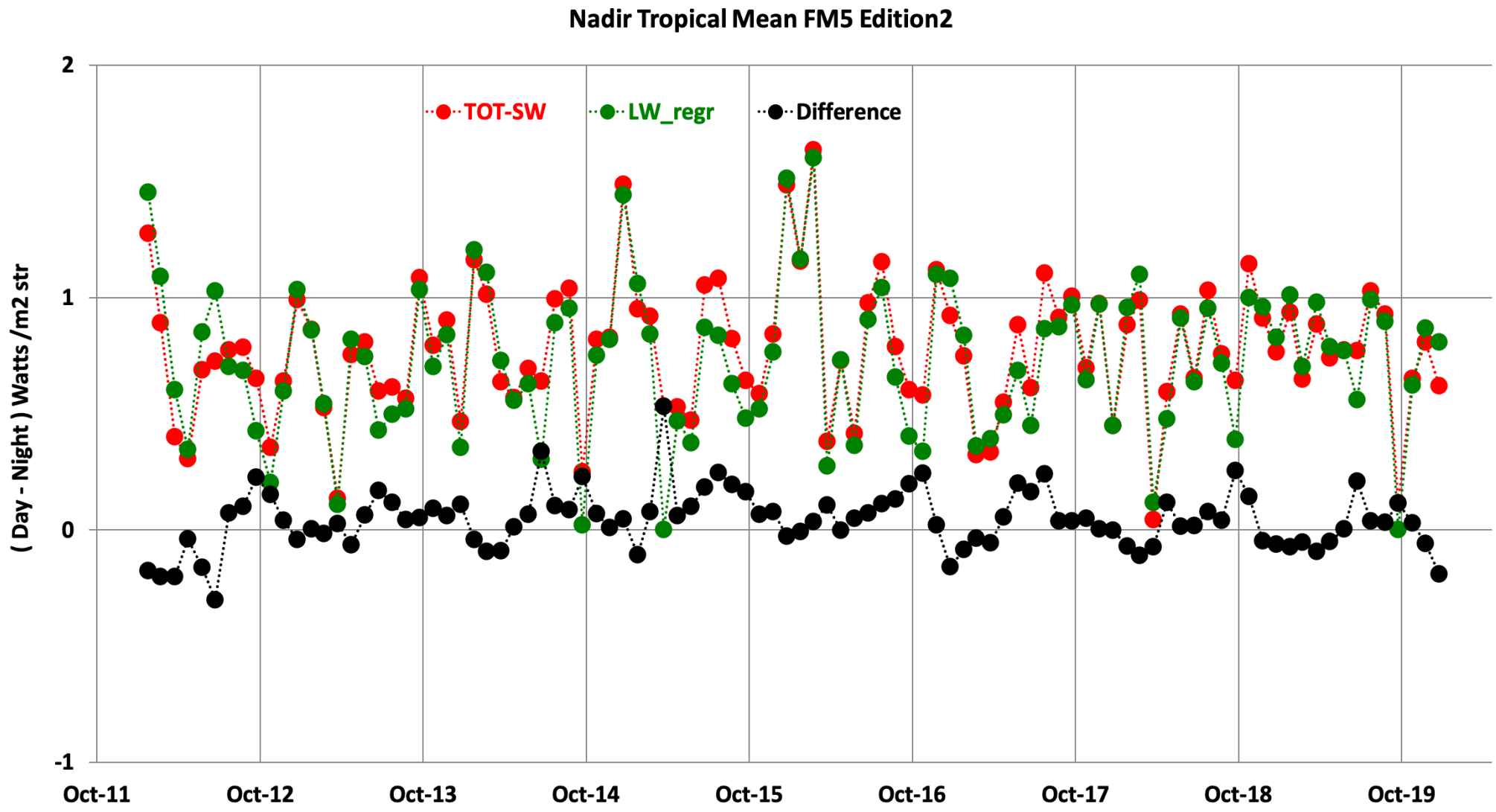
Validation: FM5 SW and LW day Anomalies

- Uses SSF data products
- S-NPP/FM5 shows consistency with the trends for Terra and Aqua instruments for the period 2012-2019.





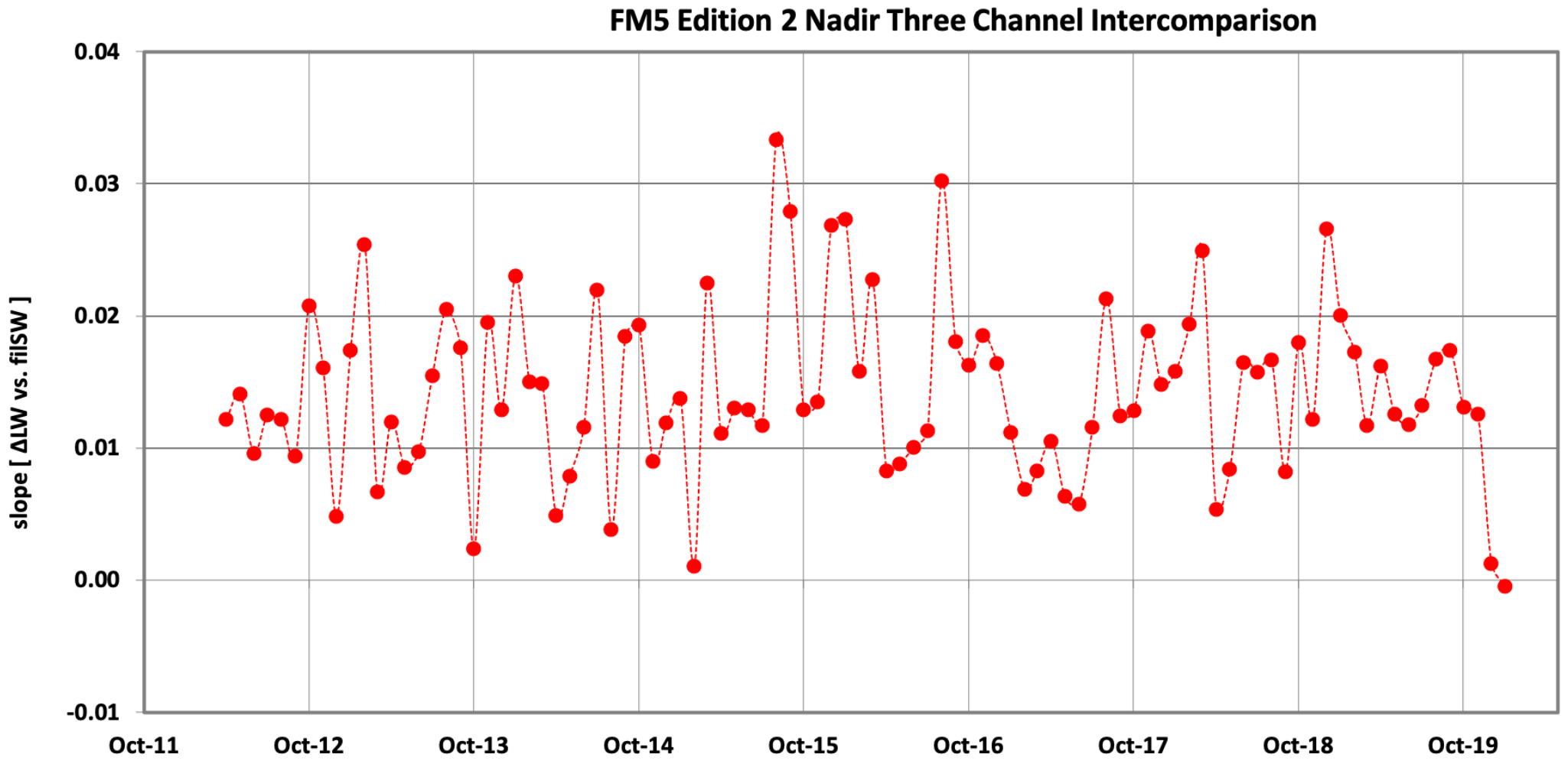
Validation- FM5 Tropical Mean



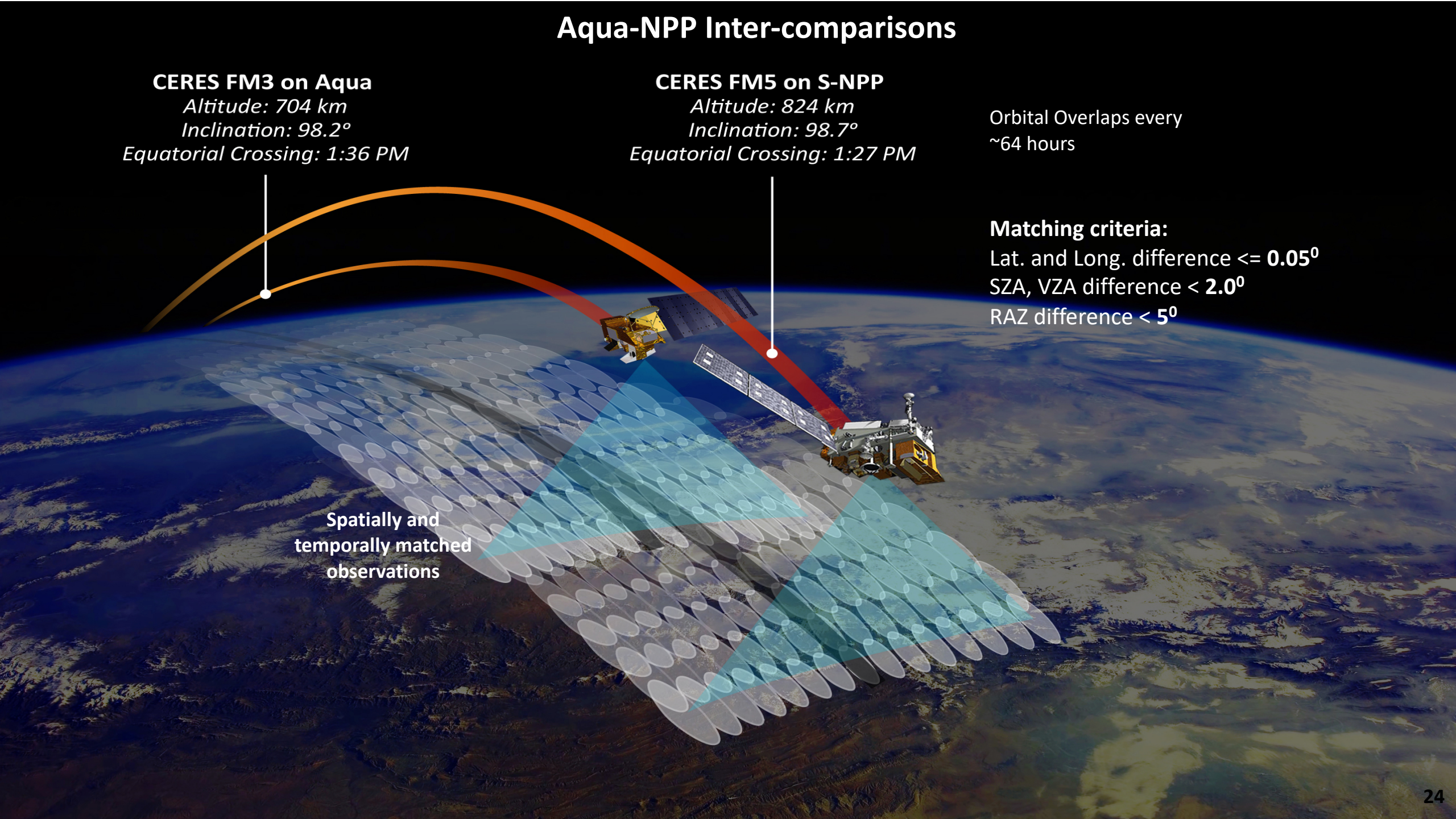
Validation: DCC 3-Channel Inter-comparison

- Compare the radiances from the three sensors of the instrument when viewing Deep Convective Clouds (DCC).
- Two sets of longwave (LW) radiances obtained:
  - TOT and SW sensors
  - Trained WN sensor
- The trend between the difference of the two LW radiances and the SW radiance is monitored over time.
- Highlights inconsistencies in the relationship in the response functions of the SW sensor and the shortwave part of the TOT sensor.

DCC 3-Channel Intercomparison



Aqua-NPP Inter-comparisons



Orbital Overlaps every ~64 hours

Matching criteria:

Lat. and Long. difference <= **0.05^0**

SZA, VZA difference < **2.0^0**

RAZ difference < **5^0**

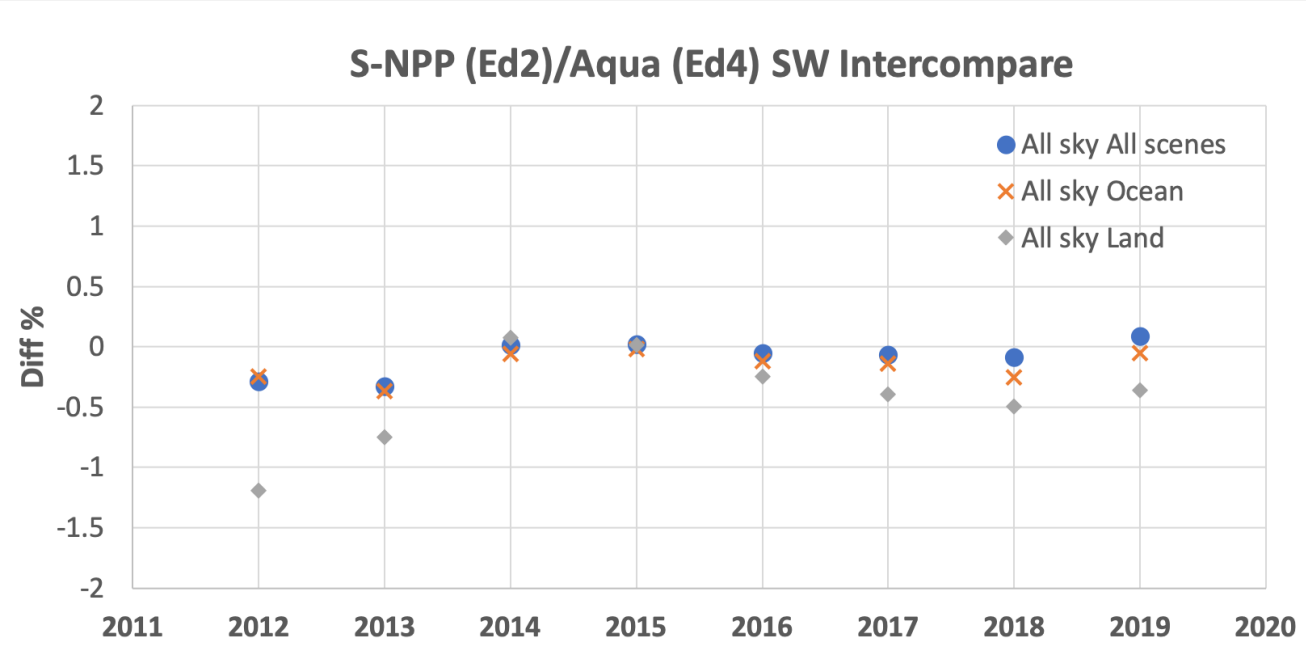
FM5/FM3 Inter-comparisons: 2012-2019

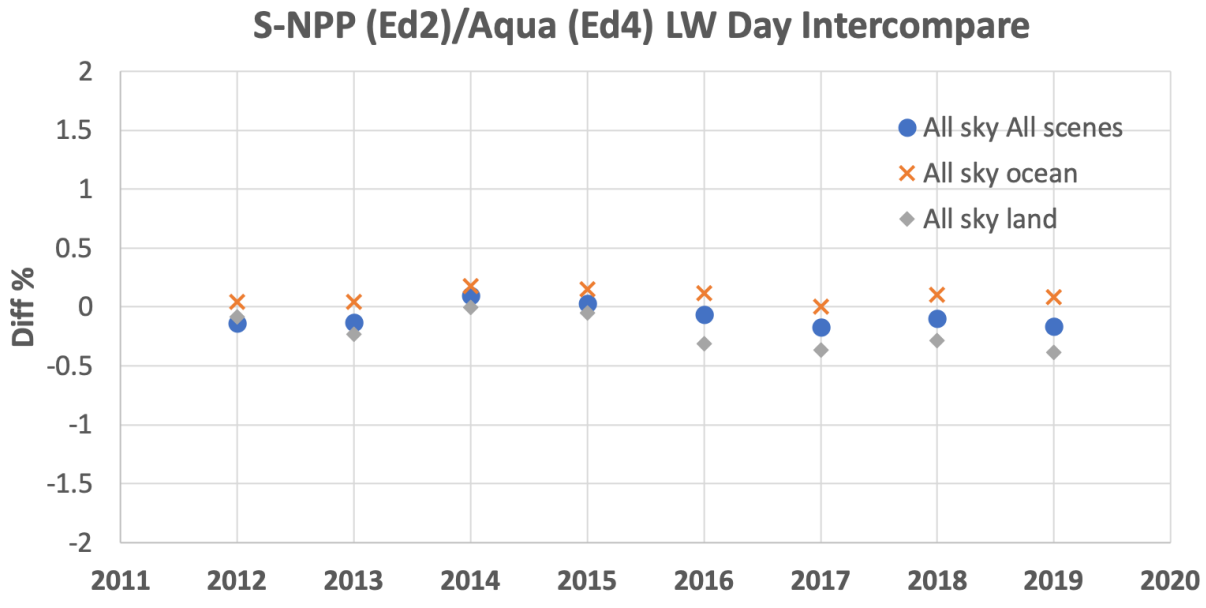
Difference of Reflectance: FM5-FM3 %

Uses SSF data

Difference of Radiance: FM5-FM3 %

$$Reflectance = \frac{SW_{rad} * \pi}{F * \cos(SZA)}$$ F=1361 W/m^2



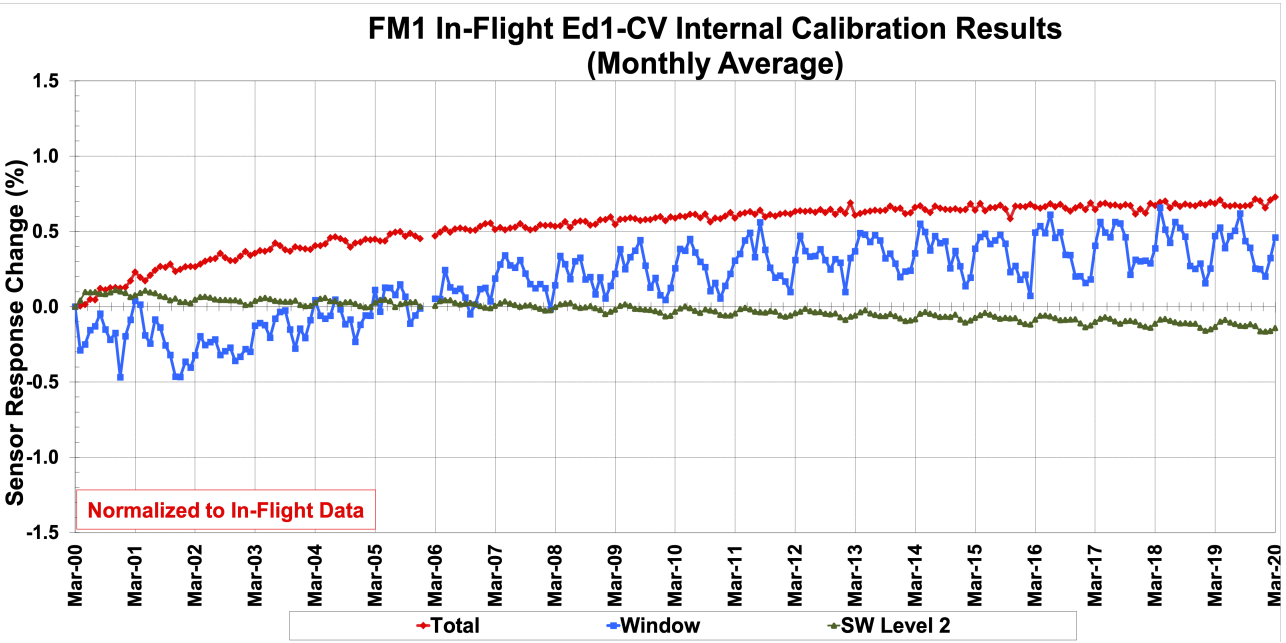


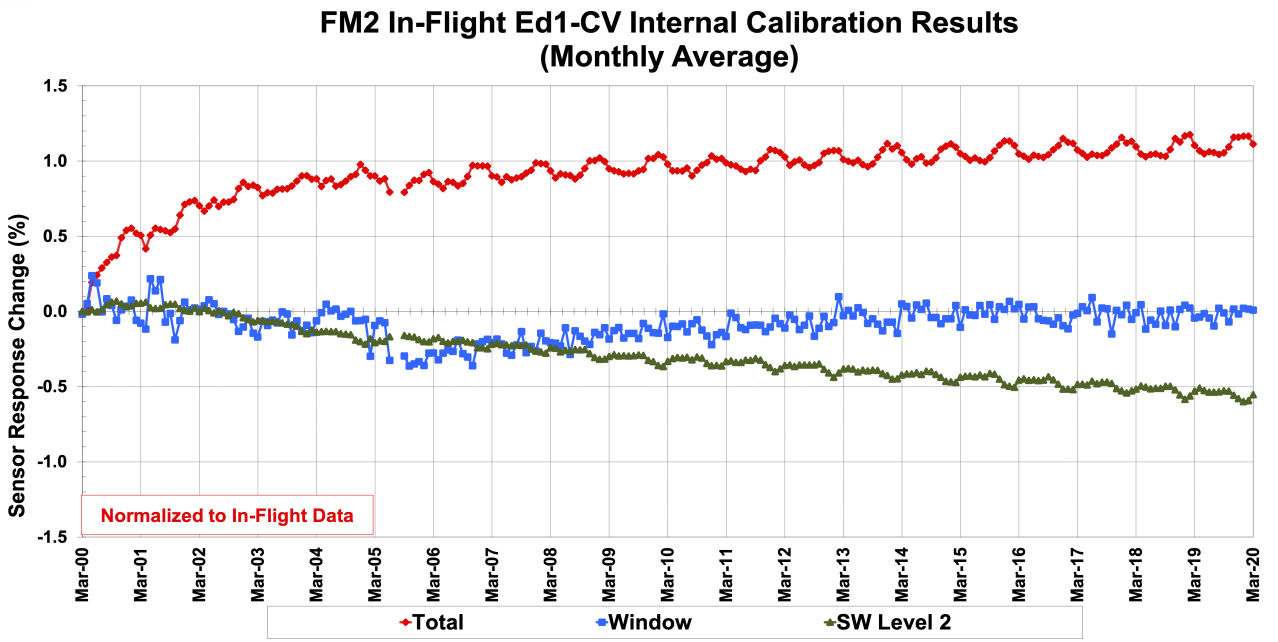
2014 data used for the radiometric scaling FM5 to FM3.

Terra & Aqua Instruments' Status
CERES FM1-FM4

Terra- FM1 & FM2 Internal Calibration

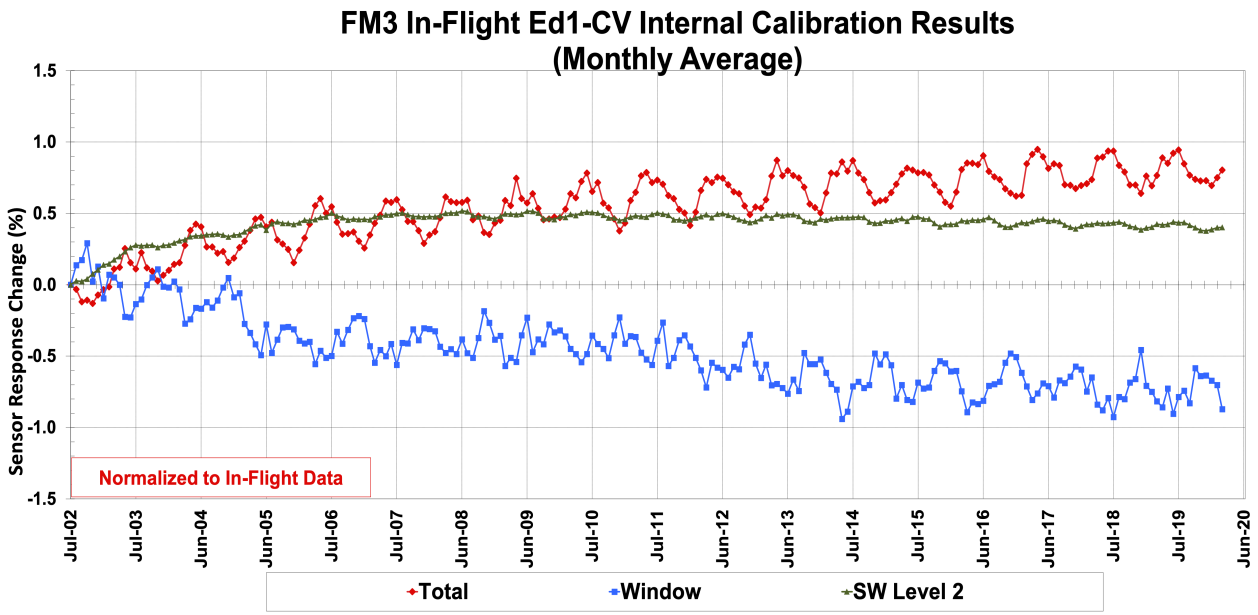
- **For FM1, TOT channel shows ~0.7% rise, SW channel shows ~0.1% drop, and WN channel shows ~0.5% rise after initial drop.**
- **For FM2, TOT channel shows ~1.2% rise, SW channel shows ~0.6% drop, while WN channel shows ~0% change since start of mission.**

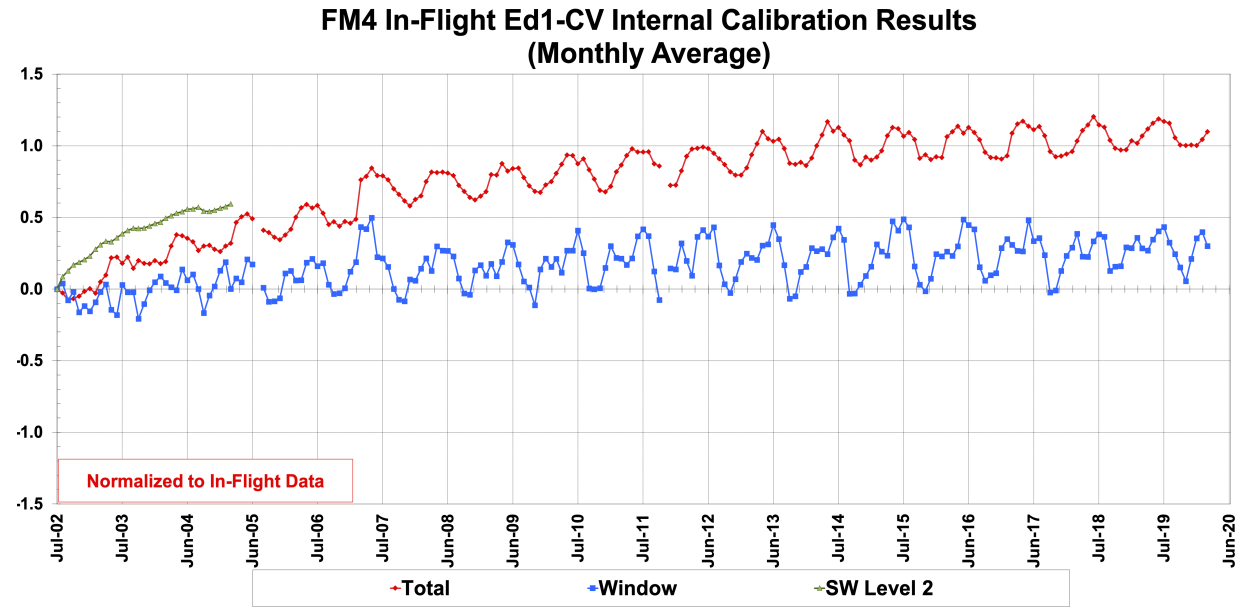




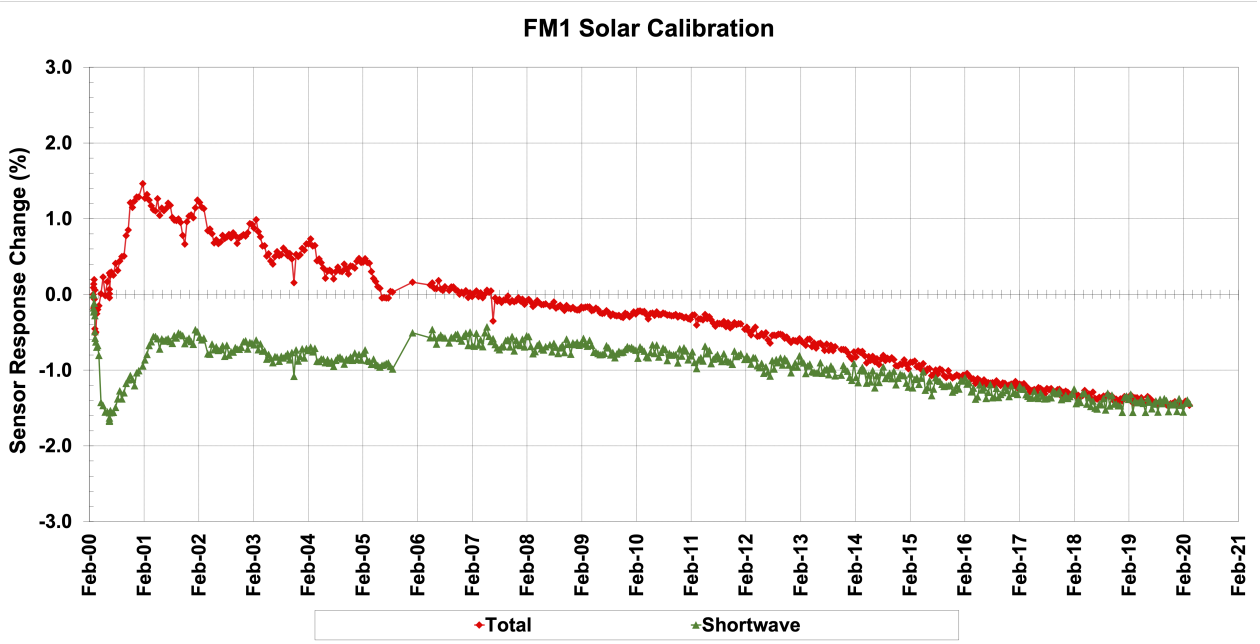
Aqua- FM3 and FM4 Internal Calibration

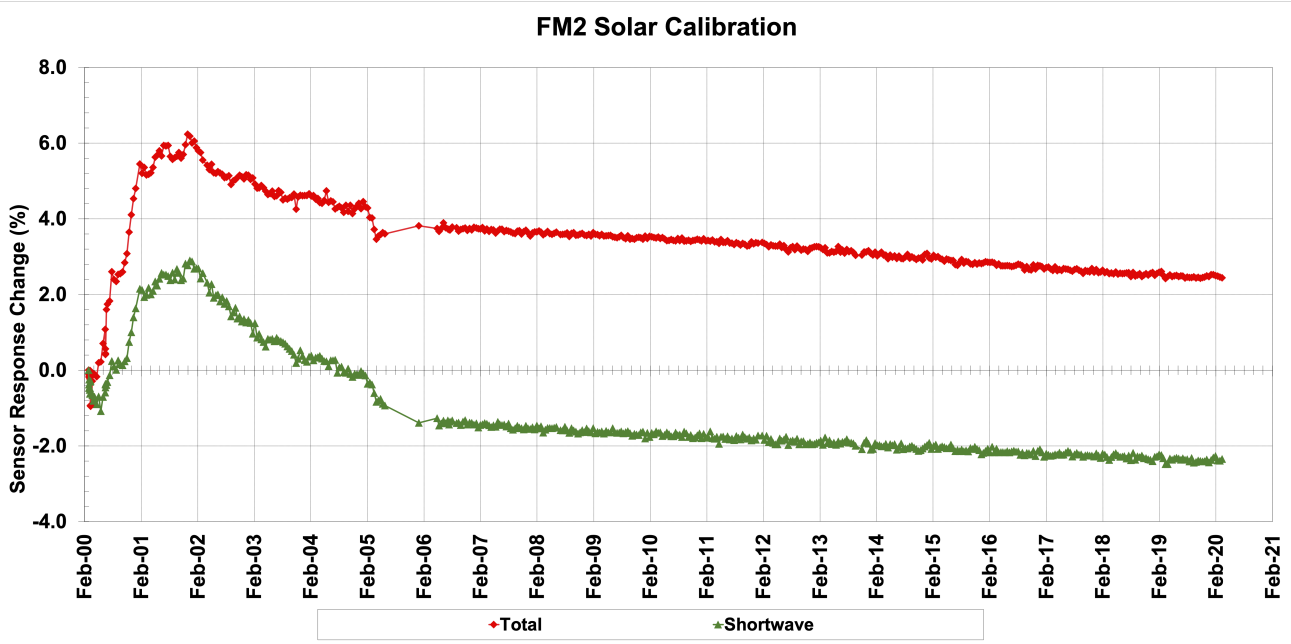
- **For FM3, TOT channel shows ~0.8% rise, SW channel shows ~0.5% rise, and WN channel shows ~0.8% drop.**
- **For FM4, TOT channel shows ~1% rise, while WN channel shows ~0.25% rise.**





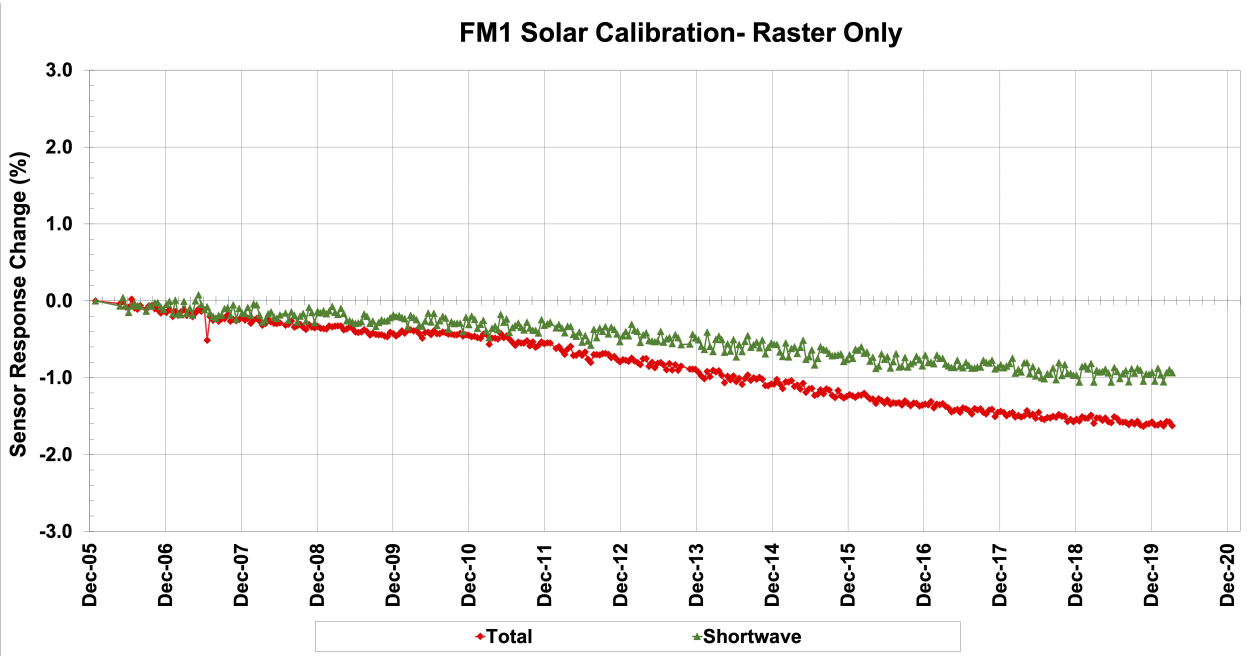
Terra- FM1 & FM2 Solar Calibration

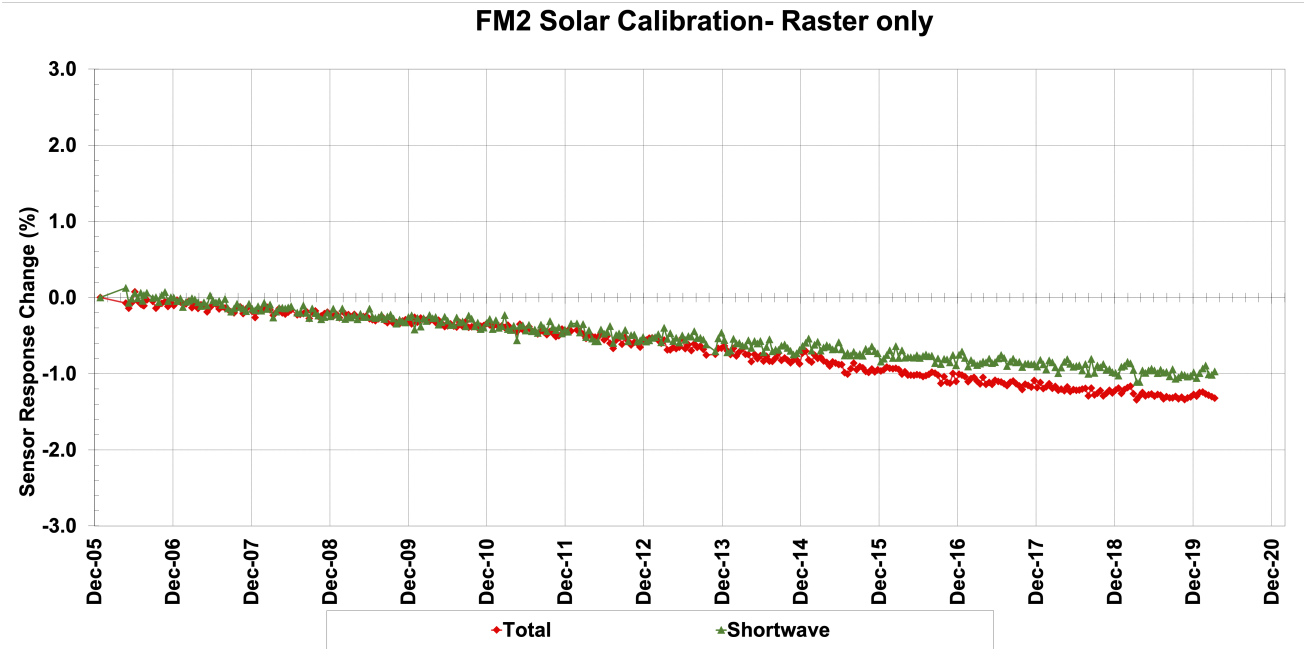




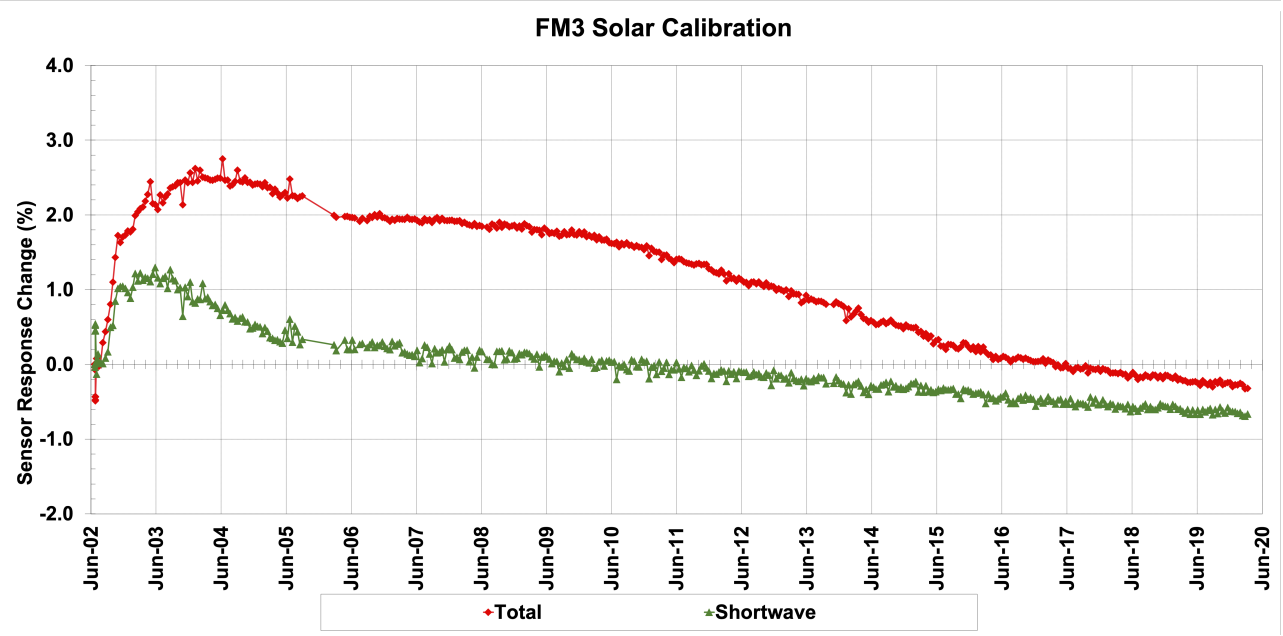
Terra- Solar Calibration, Raster Scan only

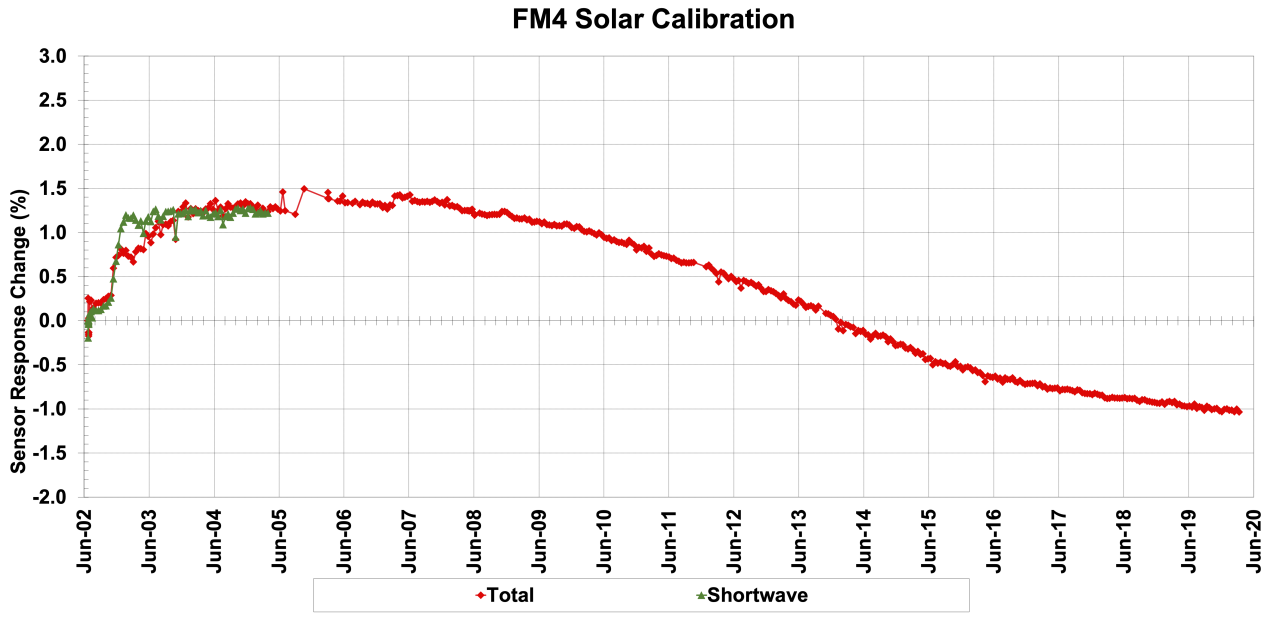
- **Since the transition over to raster scan for solar calibration, SW channel data shows a drop of response of ~1% and TOT channel shows a drop of ~1.5% for both FM1 and FM2 instruments.**





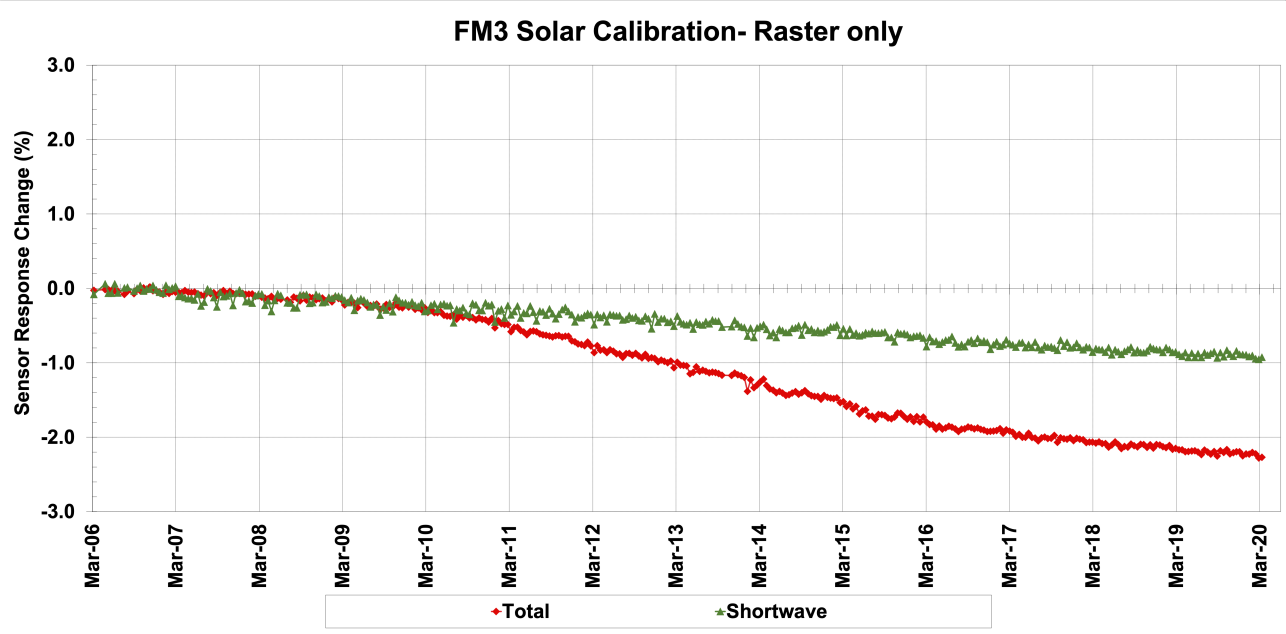
Aqua- FM3 & FM4 Solar Calibration

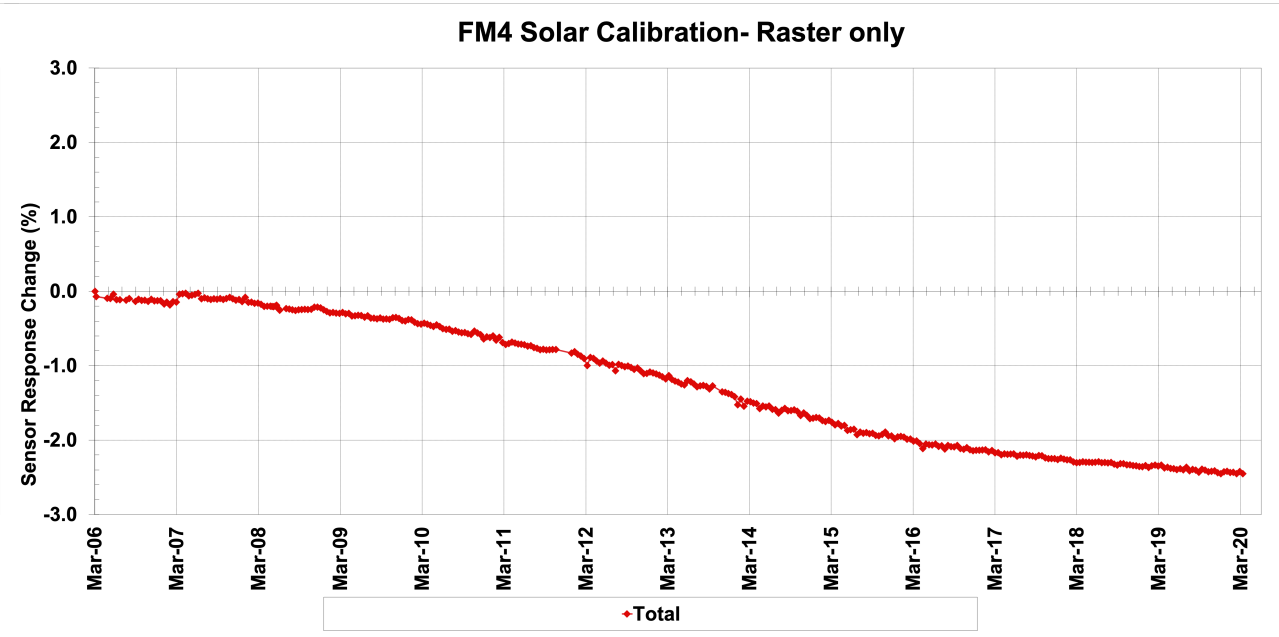




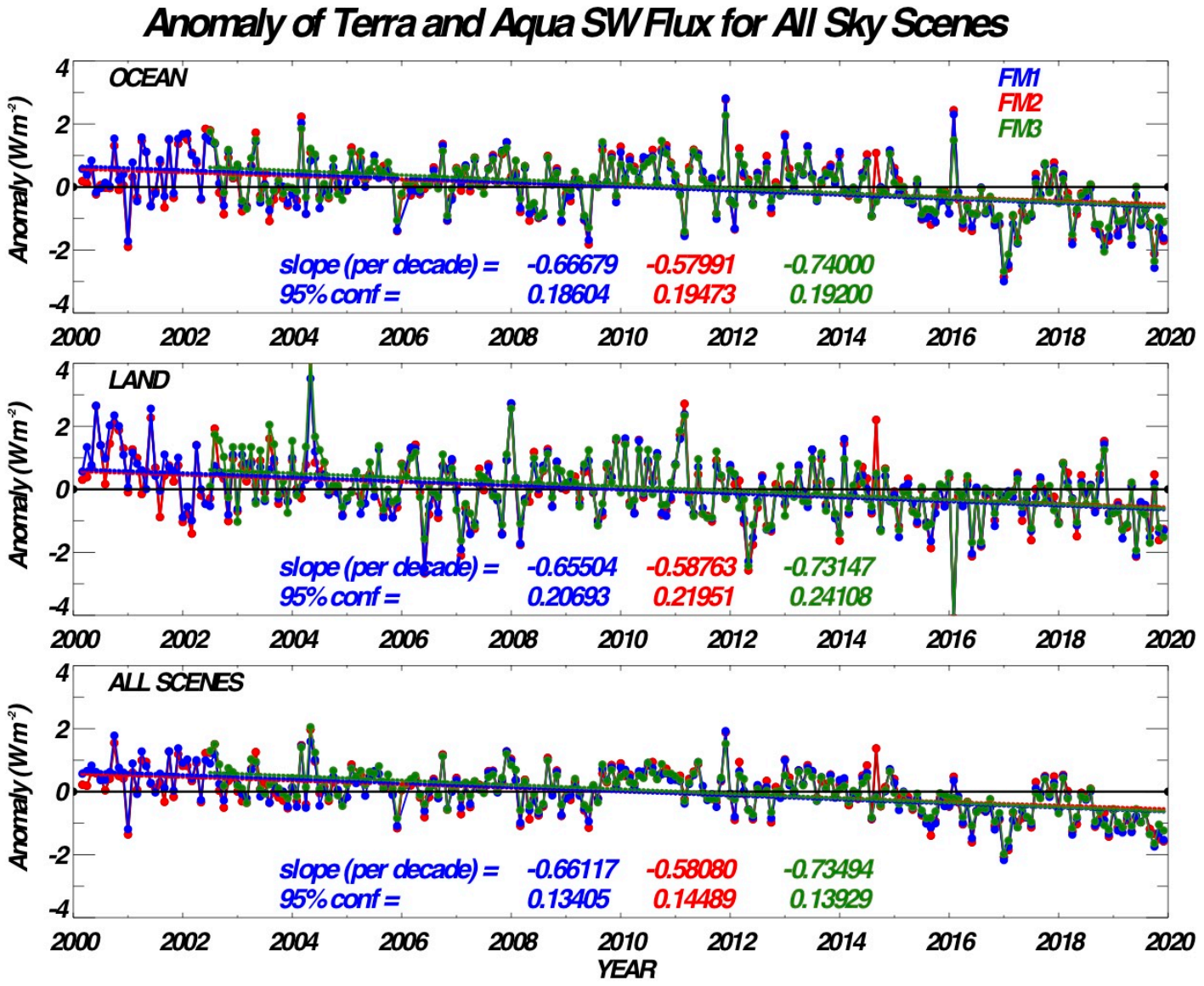
Aqua Solar Calibration, Raster Scan only

FM3 SW shows ~1% drop in response since start of raster scan.
TOT channel from both FM3 and FM4 show a similar >2% drop in response.





Validation: Terra and Aqua Ed-4 SW Flux Anomalies



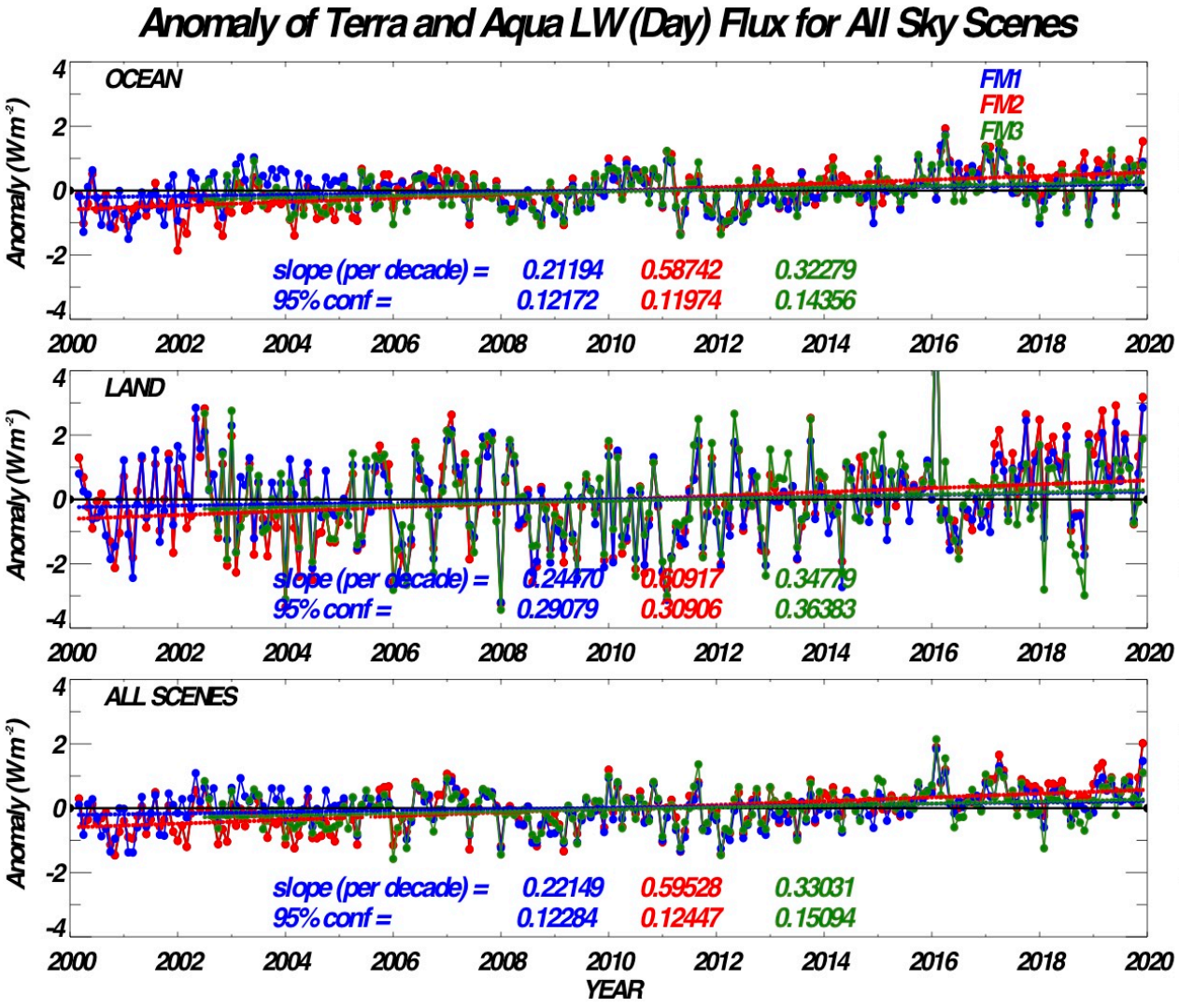
SW flux anomalies show similar trends for all three instruments

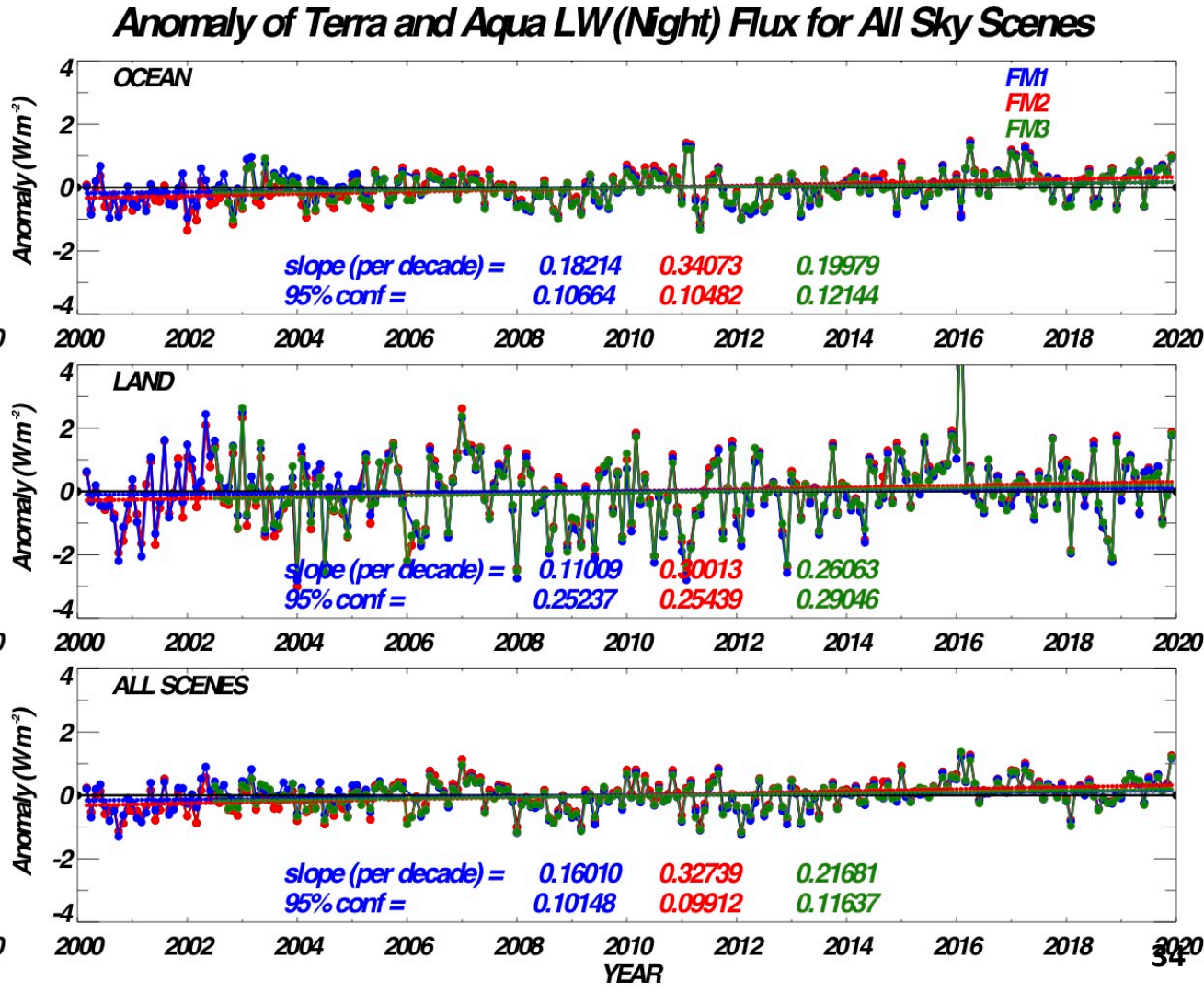
Uses SSF data products

Validation: Terra and Aqua Ed-4 LW Flux Anomalies

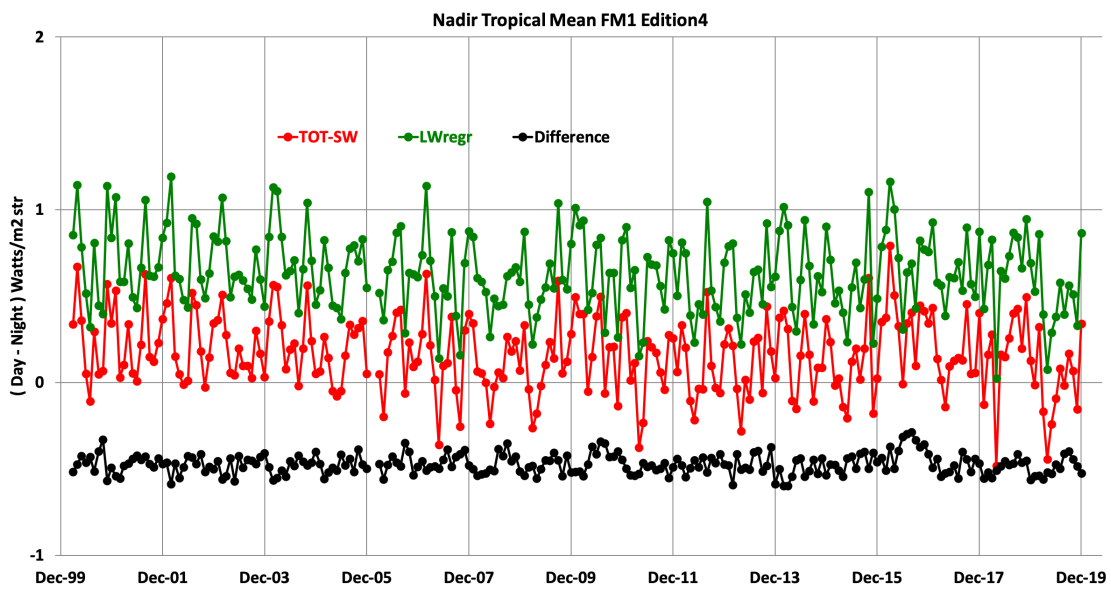
LW flux anomalies show similar trends for all three instruments

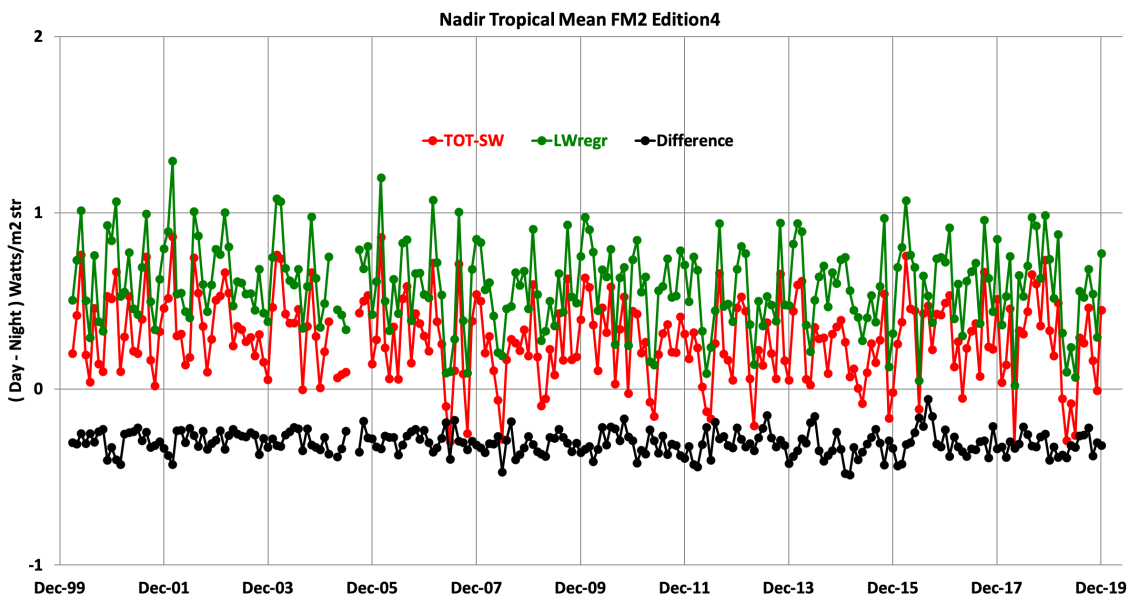
Uses SSF data products

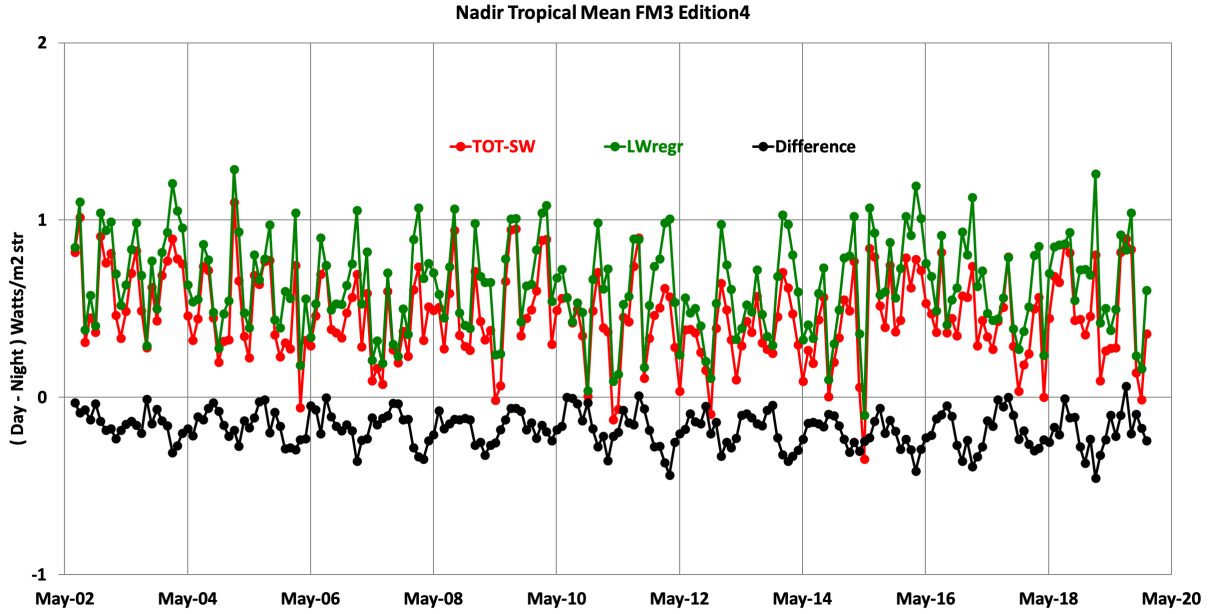




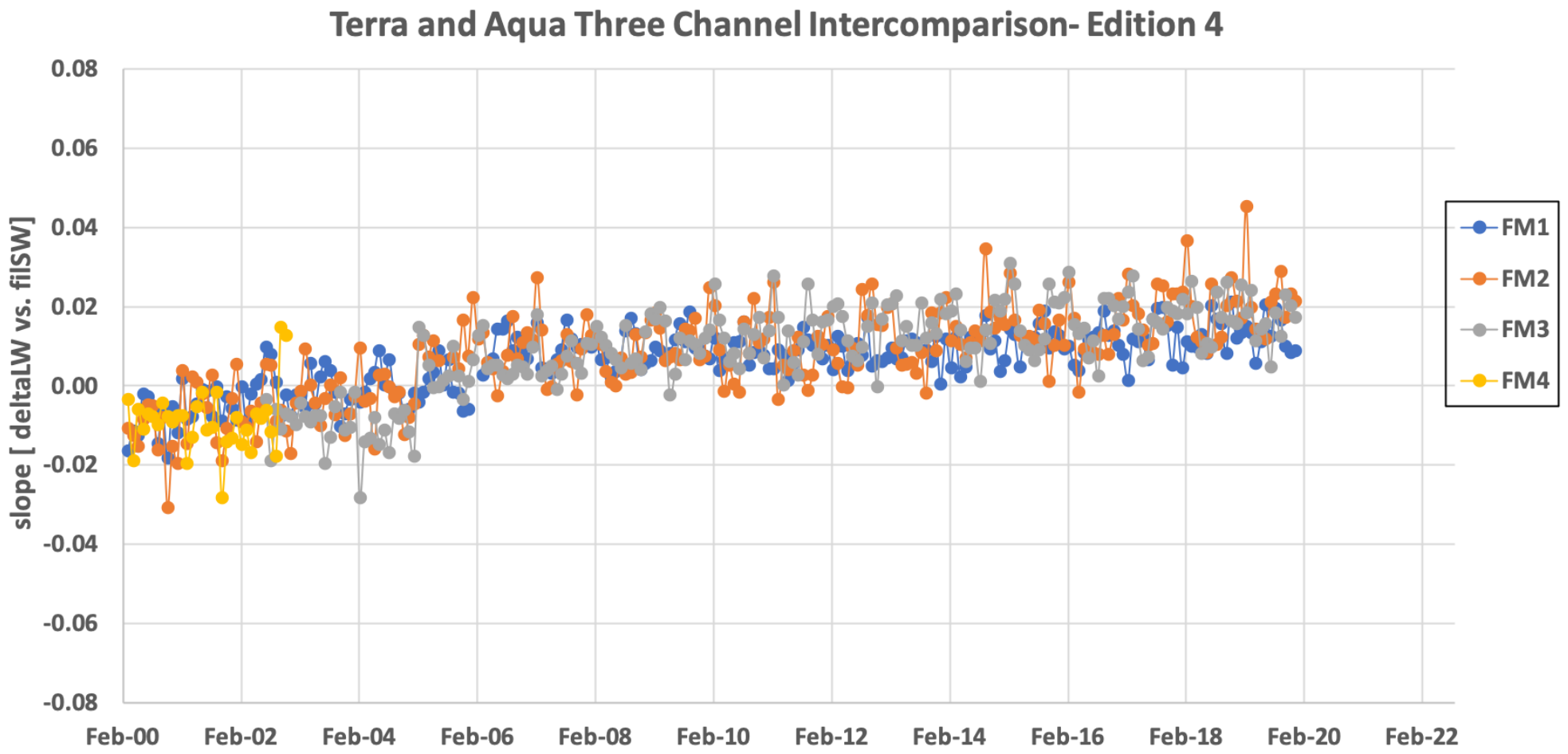
Validation- Terra and Aqua Tropical Mean







Validation- DCC 3-Channel Intercomparison



SUMMARY

- **All CERES instruments continue to perform nominally.**
  - **FM6 instrument continues to show stable performance after the initial sensor response rise.**
  - **FM5 is currently operating in biaxial mode, collecting ADM data.**
  - **FM1-FM4 continue to perform normally.**
  - **Validations show that all instruments are performing consistently.**
- **Data products**
  - **NOAA-20/FM6 Edition 1 gains and SRFs have been finalized and delivered through Jan 2020.**
  - **S-NPP/FM5 Edition 2 gains and SRFs have been delivered through Jan 2020.**
  - **Terra and Aqua instruments' Edition 4 gains and SRFs have been delivered through December 2019.**
- **We congratulate and look forward to working with the Libera team to continue the data record.**