Clouds and the Earth's Radiant Energy System

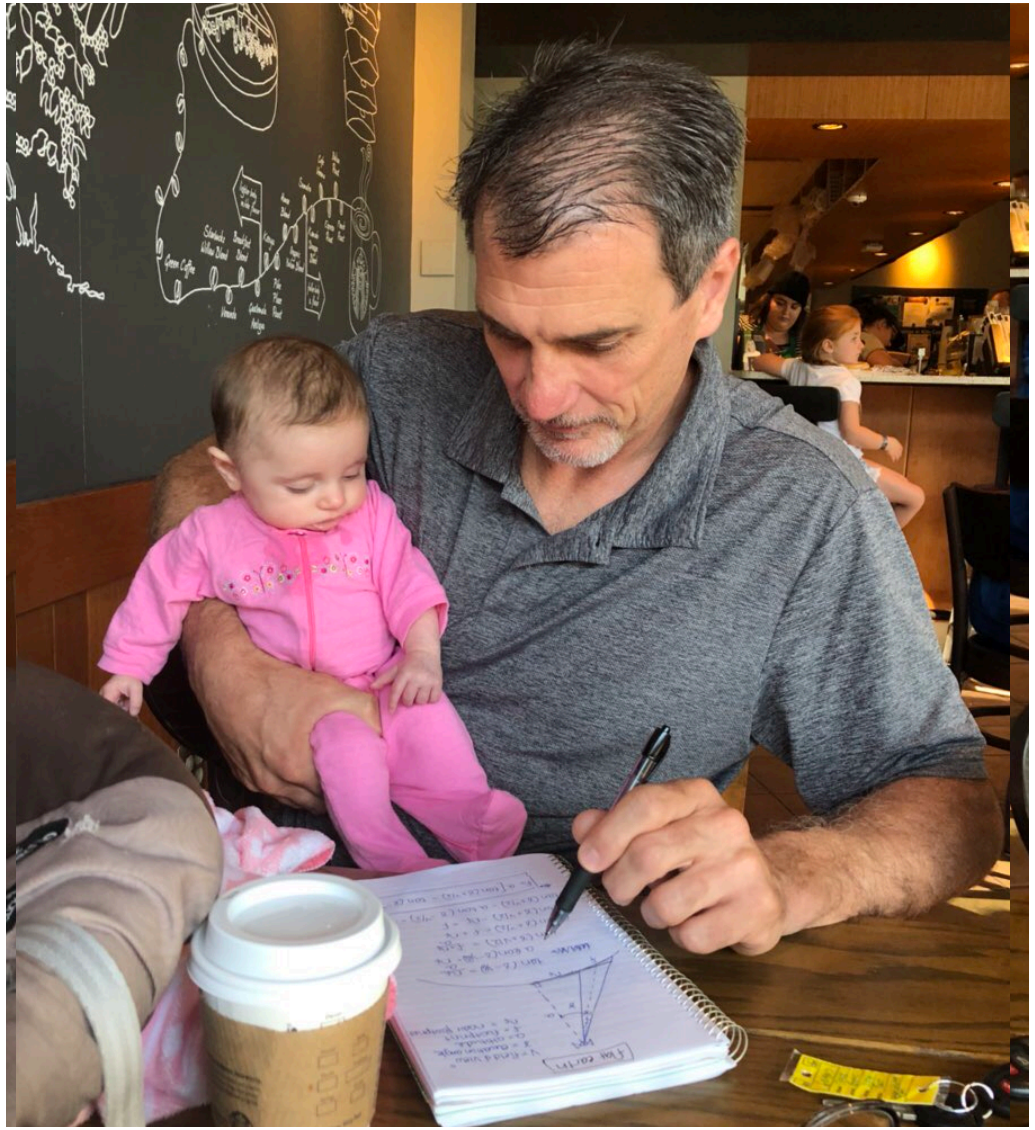
FM-6 Radiometric Performance : Initial Results

Instrument Working Group

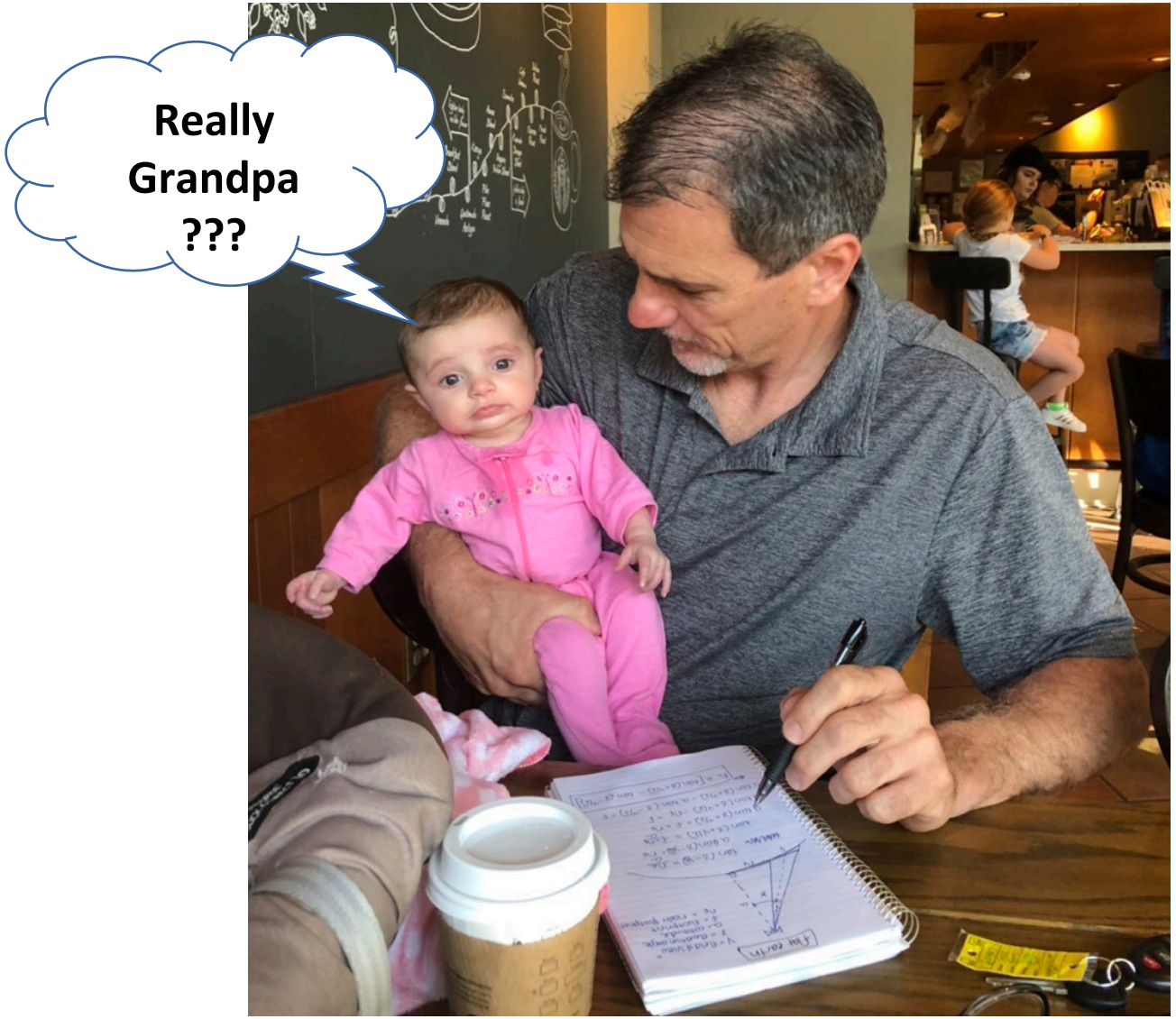
Kory Priestley, presenting

Earth Radiation Budget Science Team Meeting
NASA Langley Research Center
May 15, 2018

Newest Team Member



Newest Team Member



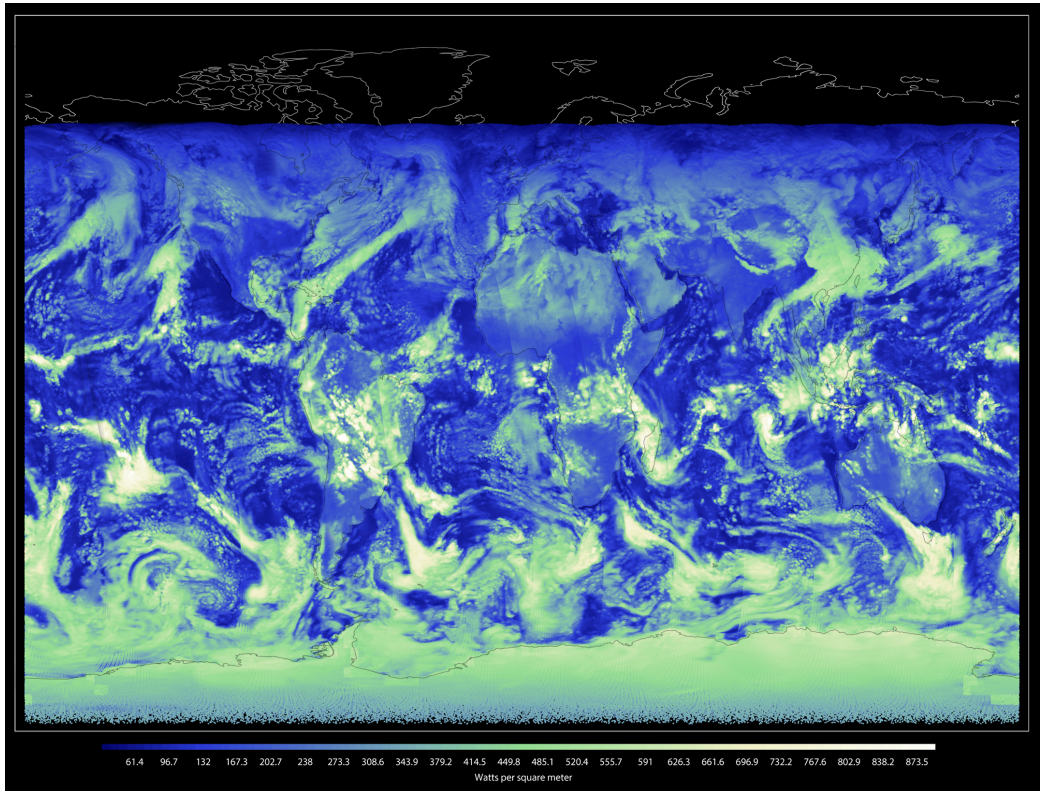
Executive Summary

- **NOAA-20 Launched on 11/18/17**
- **CERES operational power applied 11/29/17**
- **CERES opened covers on 1/5/18 and began Earth observations**
- **CERES has *successfully* completed all commissioning activities**
- **All aspects of performance are as expected and acceptable**
- **LaRC processing system fully operational - No SDR products for CERES**
- **We are thankful for the close and collaborative coordination with the JPSS team**

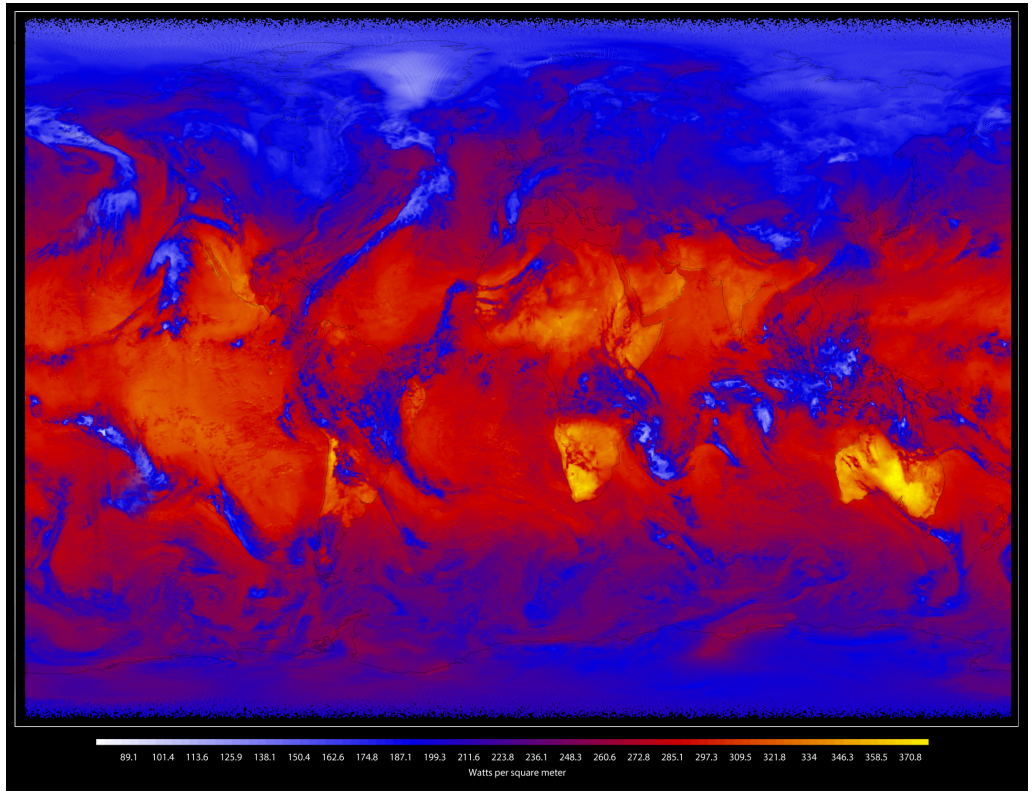
CERES on NOAA-20 First Light Images

Clouds and the Earth's Radiant Energy System

TOA Reflected Solar Flux



TOA Emitted Thermal Flux

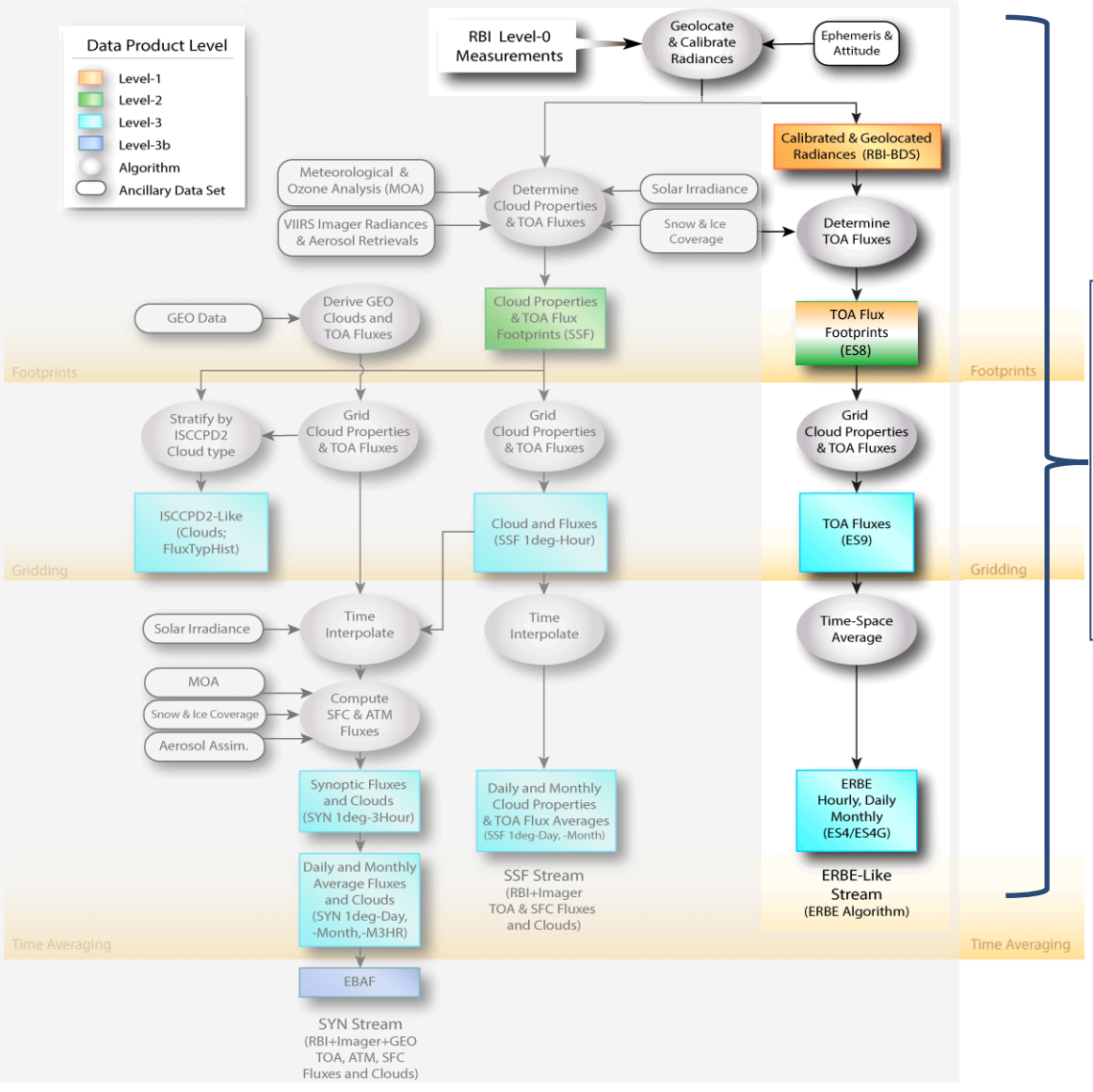


- Contamination covers completed opening at 12:57AM ET January 5th.
- Global maps of the instantaneous Reflected Solar and Emitted Thermal TOA Fluxes.
- The data time period spans 24 hours from about 1:50PM ET Friday January 5th.
- Timing was perfect to capture the tail-end of the 'Bomb Cyclone' Snow event which moved through the Mid-Atlantic Region January 3rd.

Earth Radiation Budget Science Processing

Clouds and the Earth's Radiant Energy System

Leveraging NASA's 2+ decade Investment in The Earth Radiation Budget Science Team



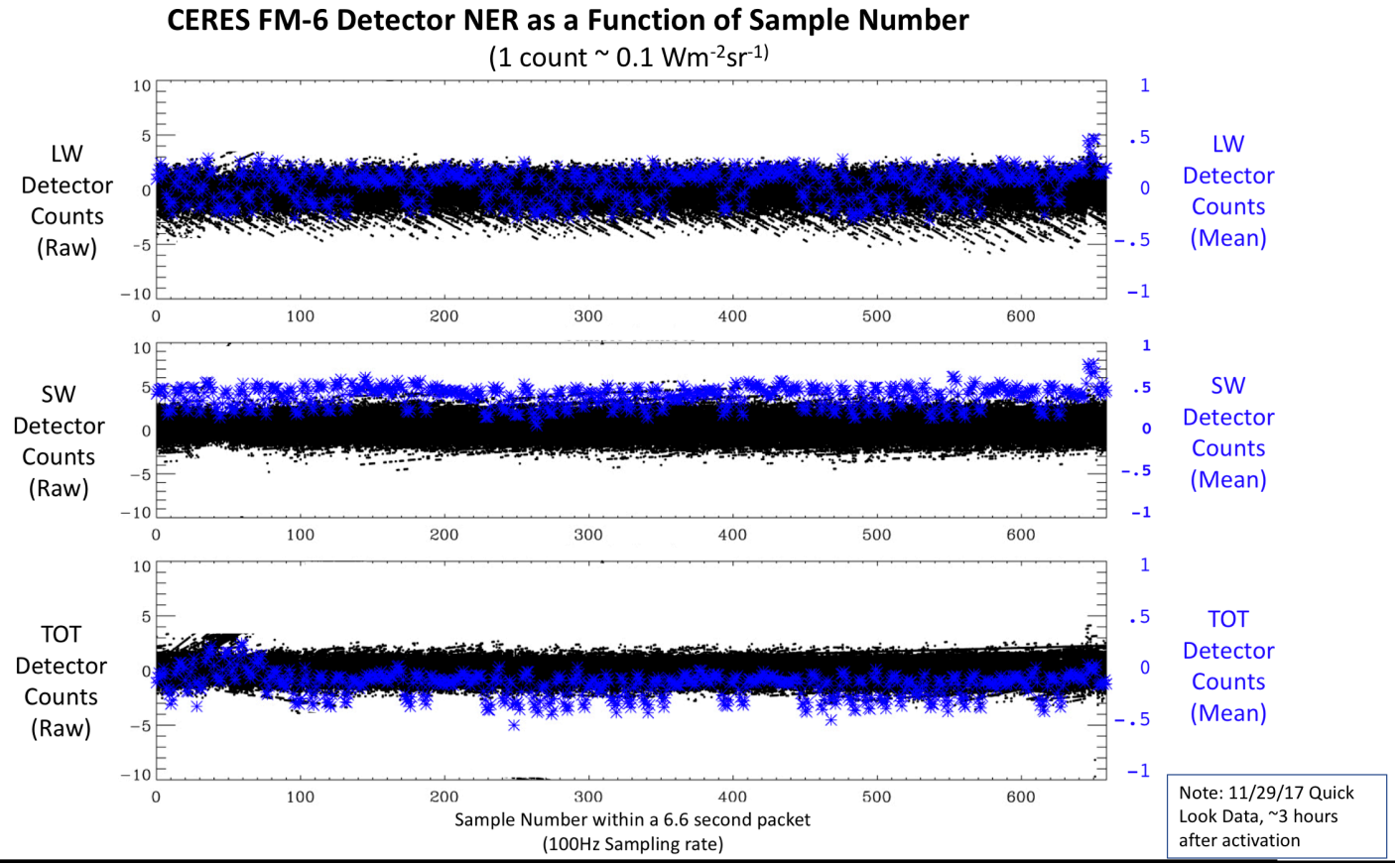
'Autonomous' processing stream necessary for characterizing instrument performance

CERES Flight Radiometric Validation Activities

Clouds and the Earth's Radiant Energy System

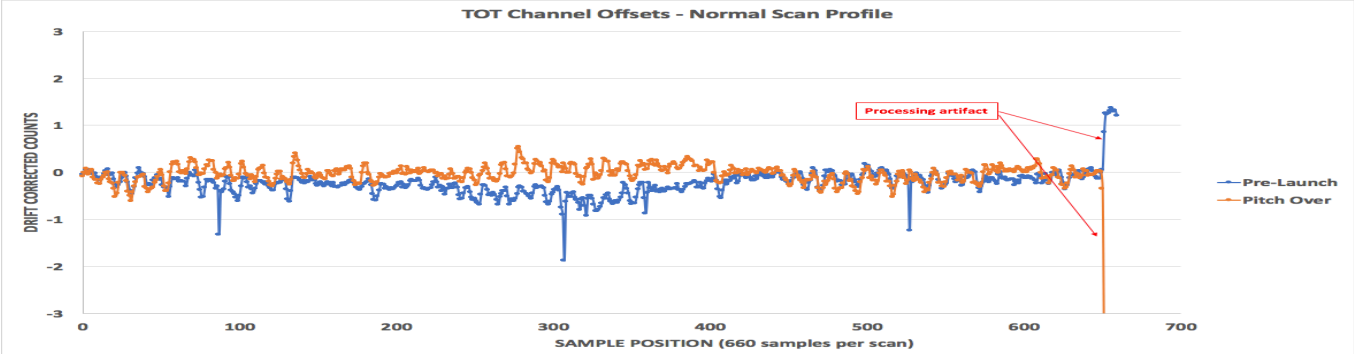
		Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	Theoretical Line-by-Line	Filtered Radiance	> 20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Globally Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N – 20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel consistency, stability	TOT, SW
	TIme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW
	Lunar Radiance Measurements	Filtered Radiance	Sub Pixel	Quarterly	Inter-Instrument Agreement	LW, SW, WN

Noise Equivalent Radiance (NER)

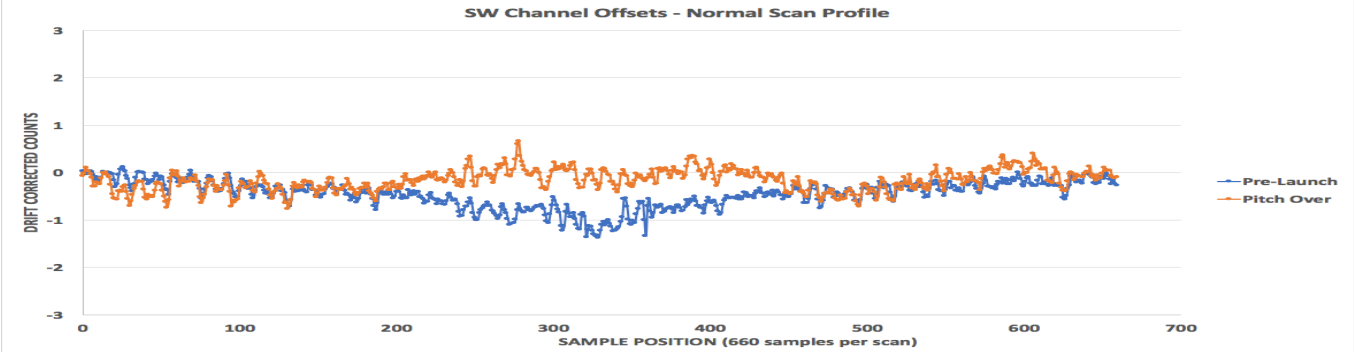


- Noise Equivalent Radiance is statistically indistinguishable from that measured during the pre-launch radiometric Calibration in 2014.

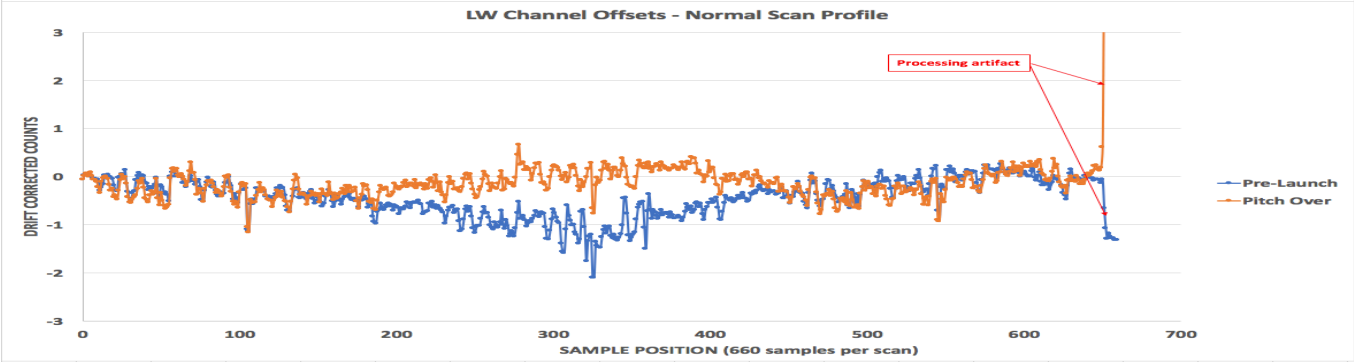
Scan Angle Dependent Bias Values



TOT Channel



SW Channel



LW Channel

Calibrations

- 3.4.1 CERES On-Orbit Calibration
  - CERES shall perform on-orbit calibration for all channels.
- 3.4.3 CERES Solar Calibration
  - CERES shall be capable of performing bi-weekly radiometric calibrations using the Sun as a calibration source.
- 3.4.4 CERES Lunar Calibration
  - CERES shall be capable of performing periodic radiometric calibrations using the Moon as a calibration source.

CERES Internal Calibration Module

ICM contains 2 subassemblies

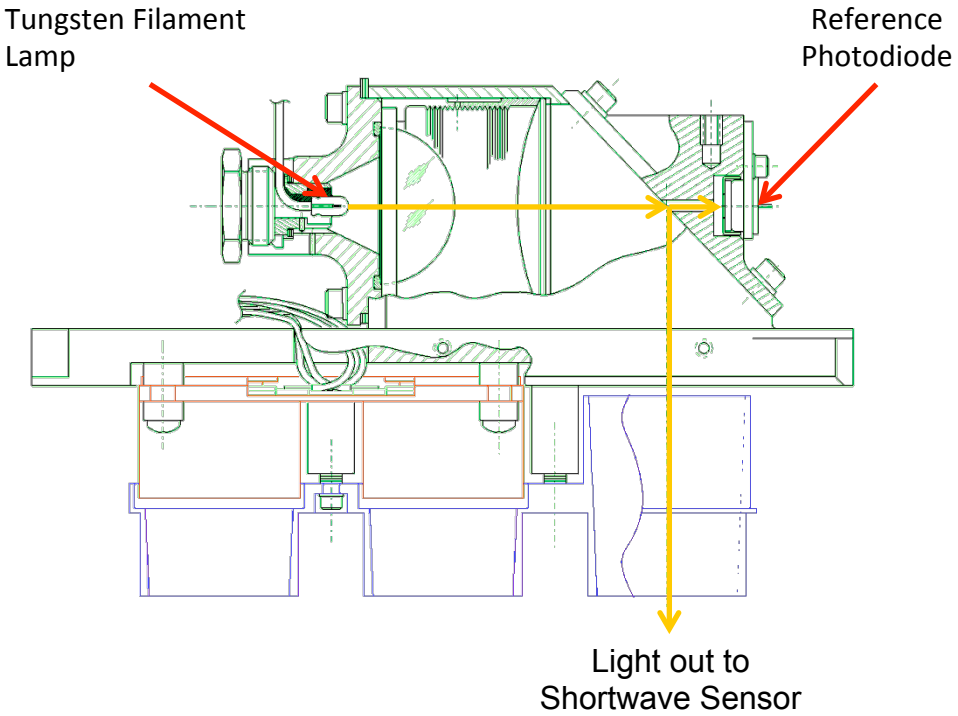
Shortwave Internal Calibration Source (SWICS):

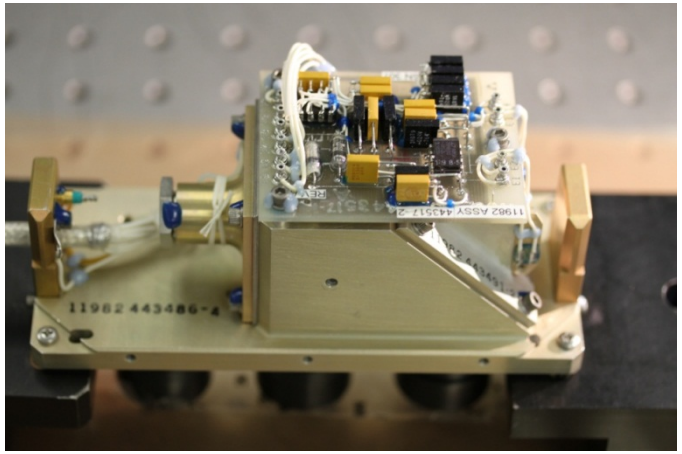
- Lamp and focusing optics
- Reference Detector
- Folding Mirror

Internal BlackBody (IBB):

- Concentric grooved blackbodies
- Heaters and PRTs

During Calibration we view the SWICS lamp with two independent detectors
CERES SW sensor and Reference Photodiode

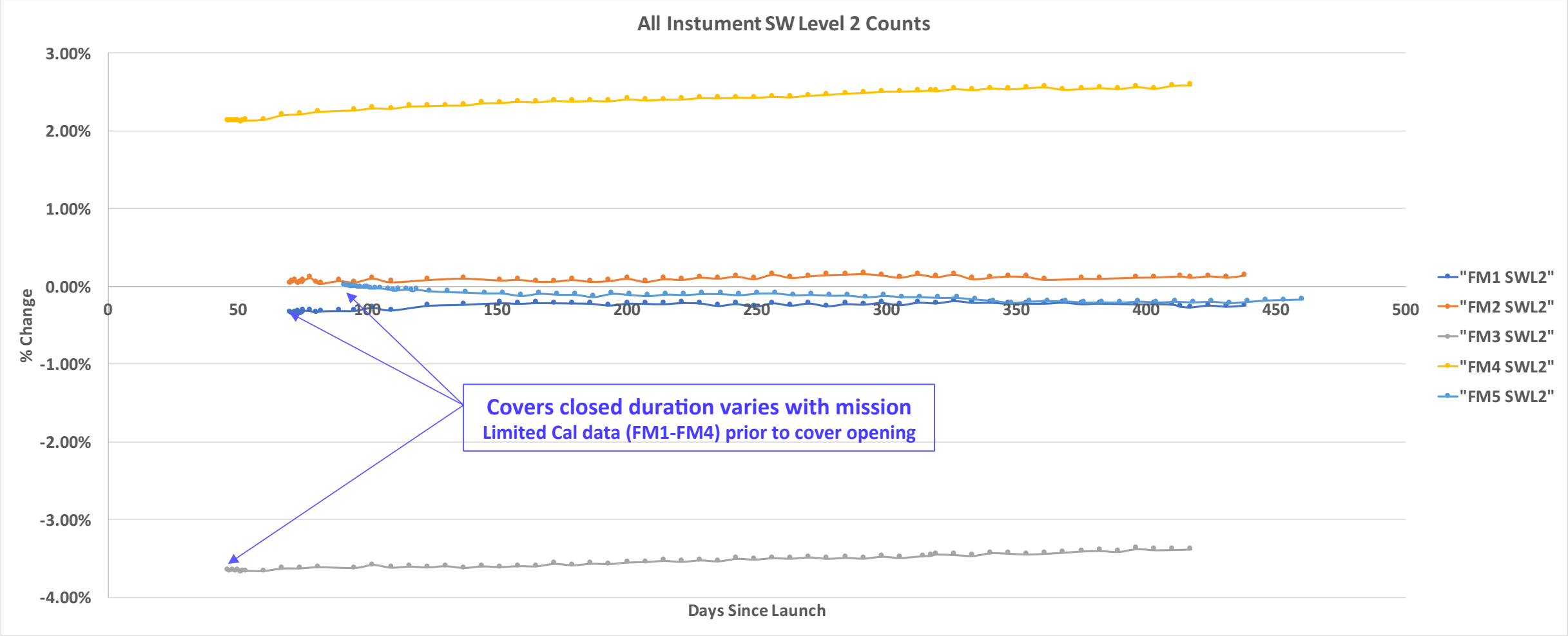




FM1-FM5 Instruments Shortwave Channel Gain Stability

First 365 days post cover opening

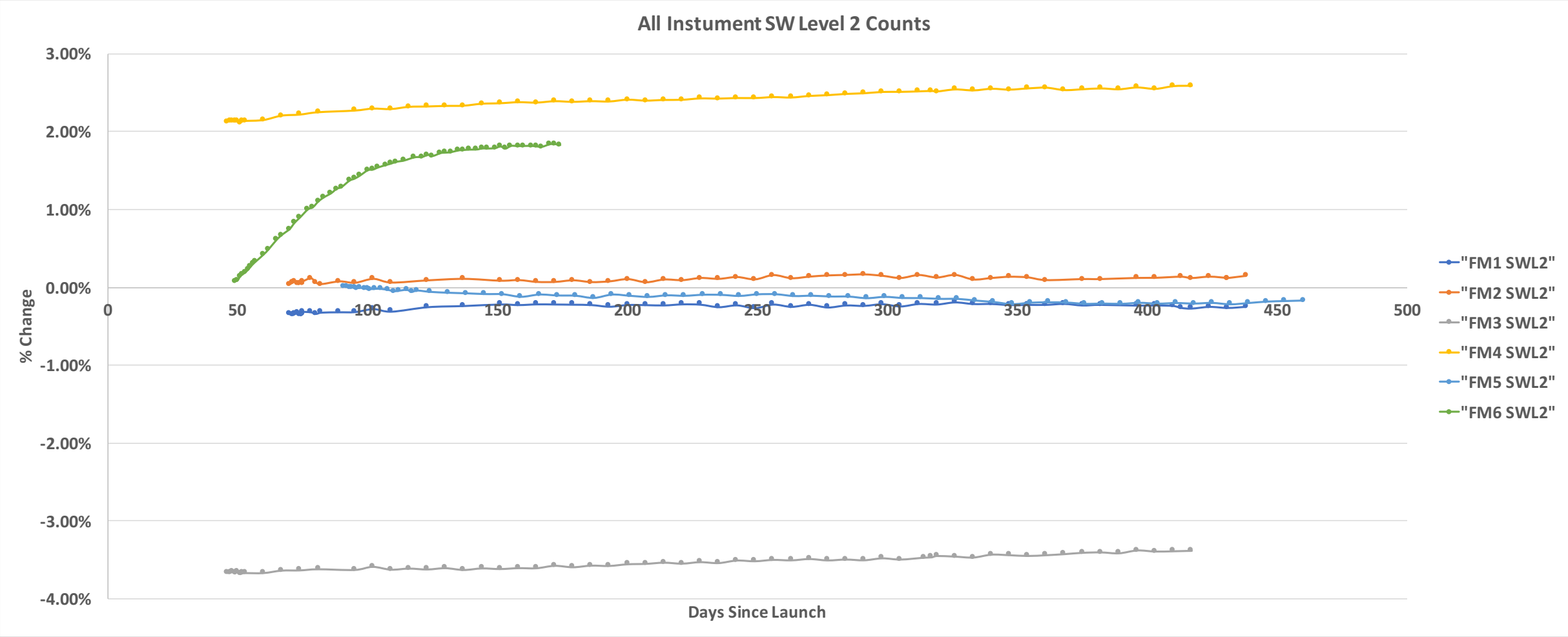
Clouds and the Earth's Radiant Energy System



All Instruments Shortwave Channel Gain Stability

First 365 days post cover opening

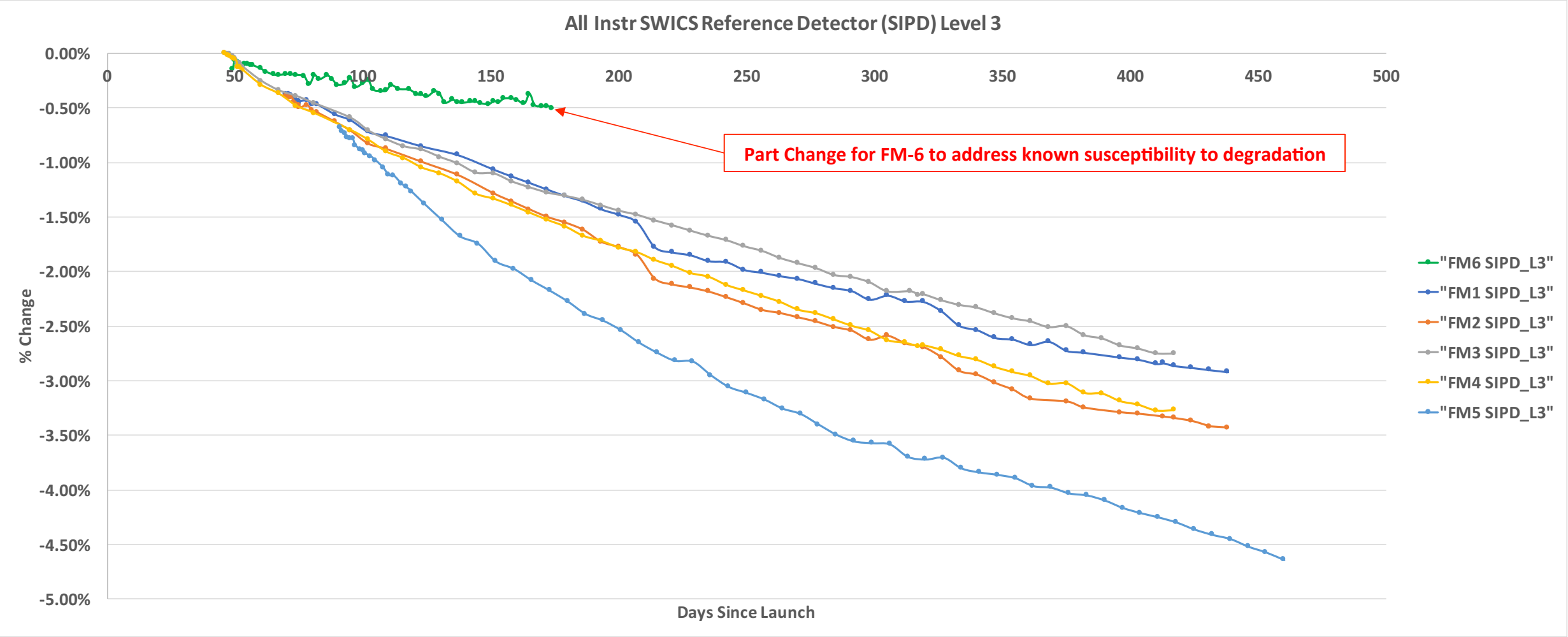
Clouds and the Earth's Radiant Energy System



All Instrument SW SWICS Level 3 SiPD Reference Detector

First 365 days post cover opening

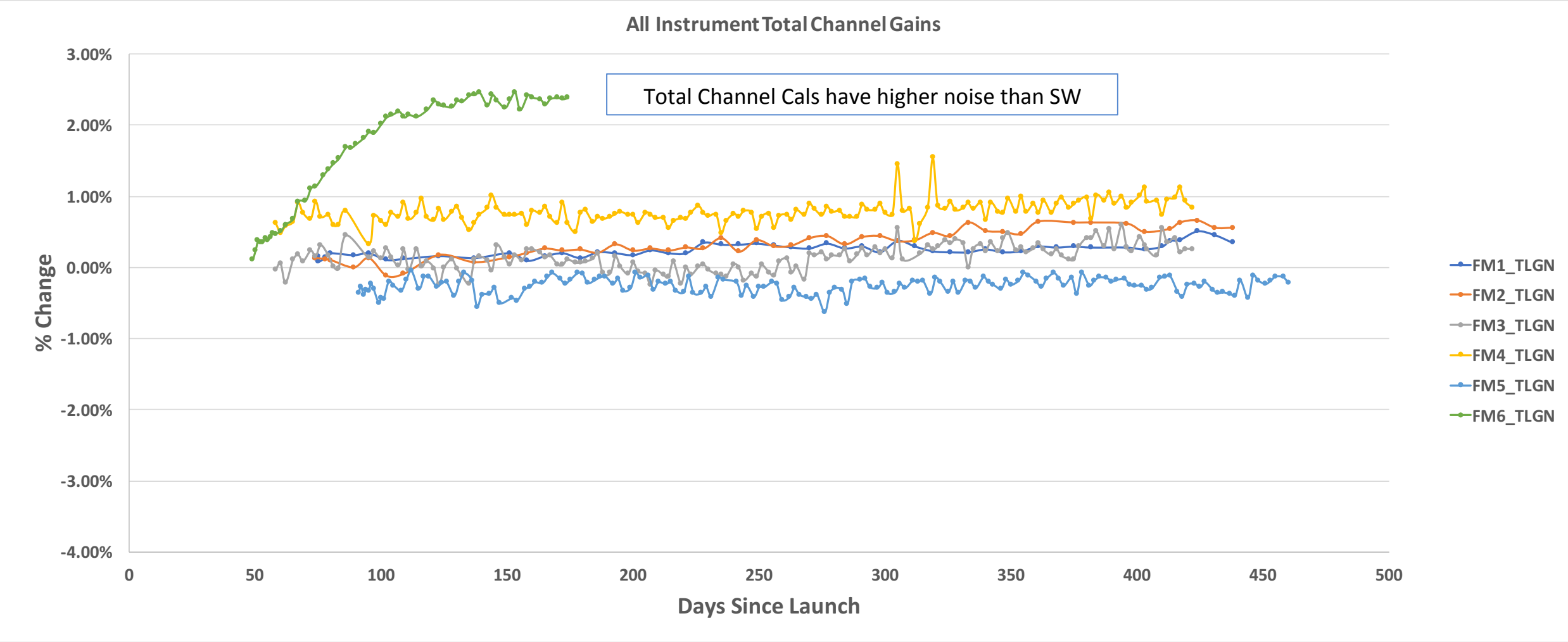
Clouds and the Earth's Radiant Energy System



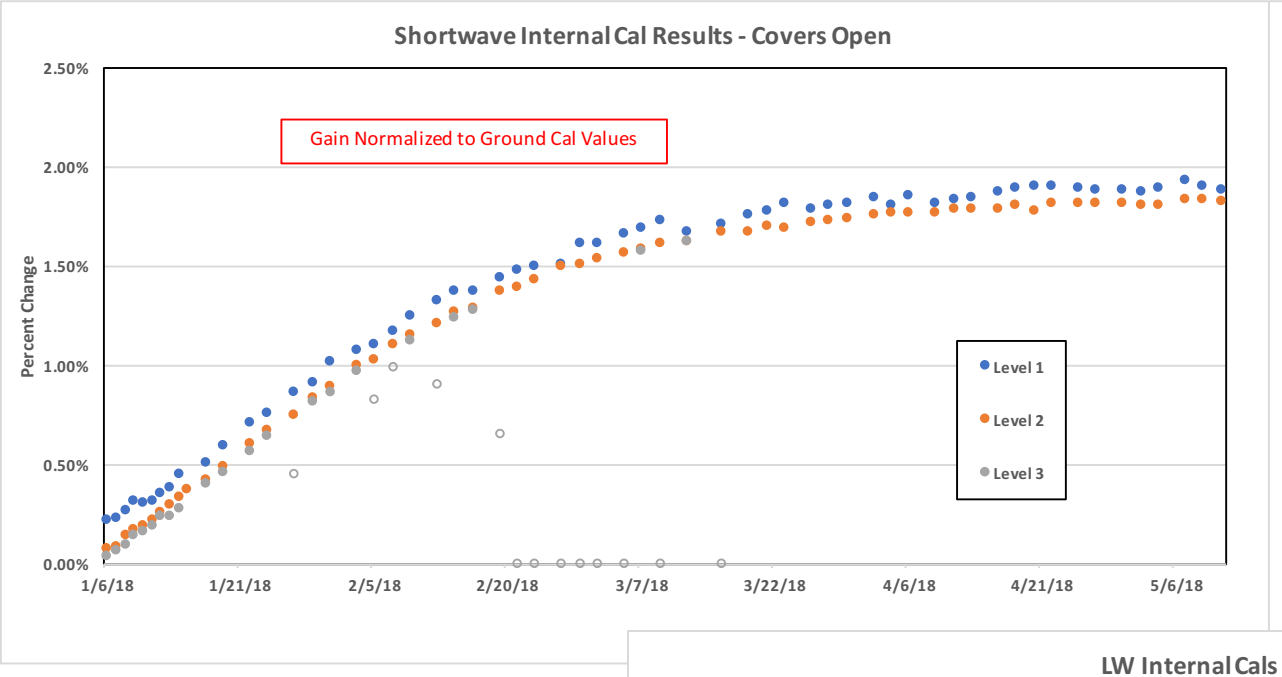
All Instruments Total Channel Gain stability

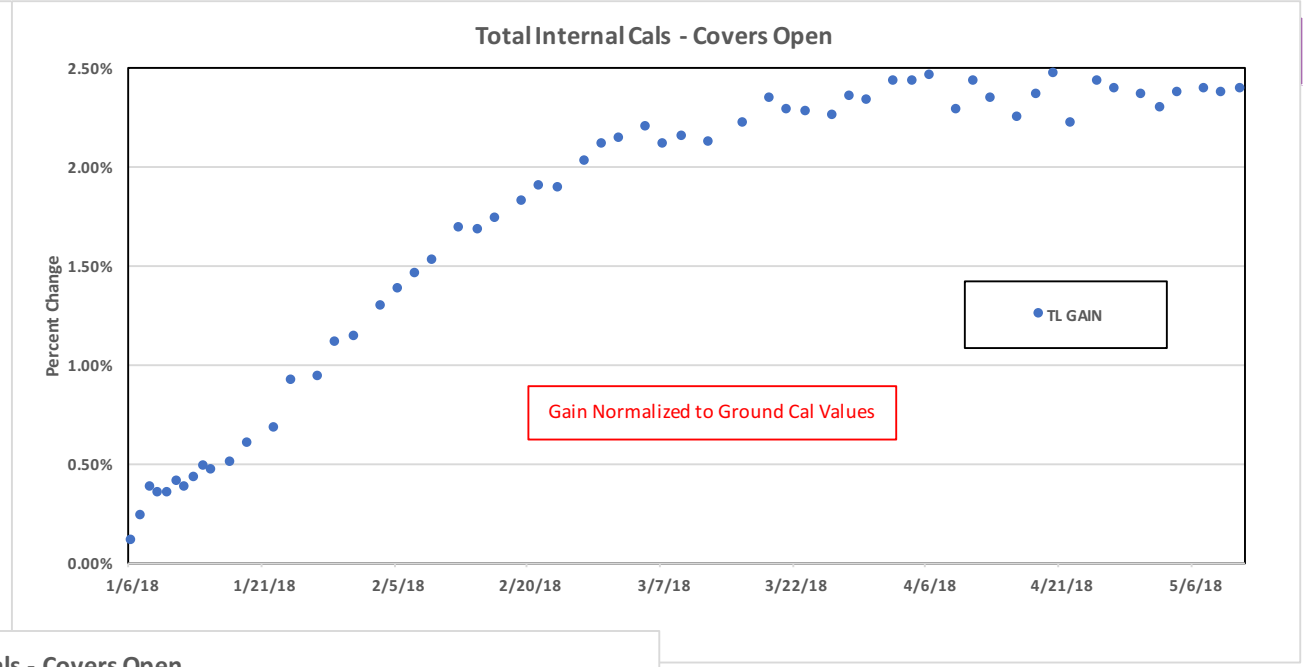
First 365 days post cover opening

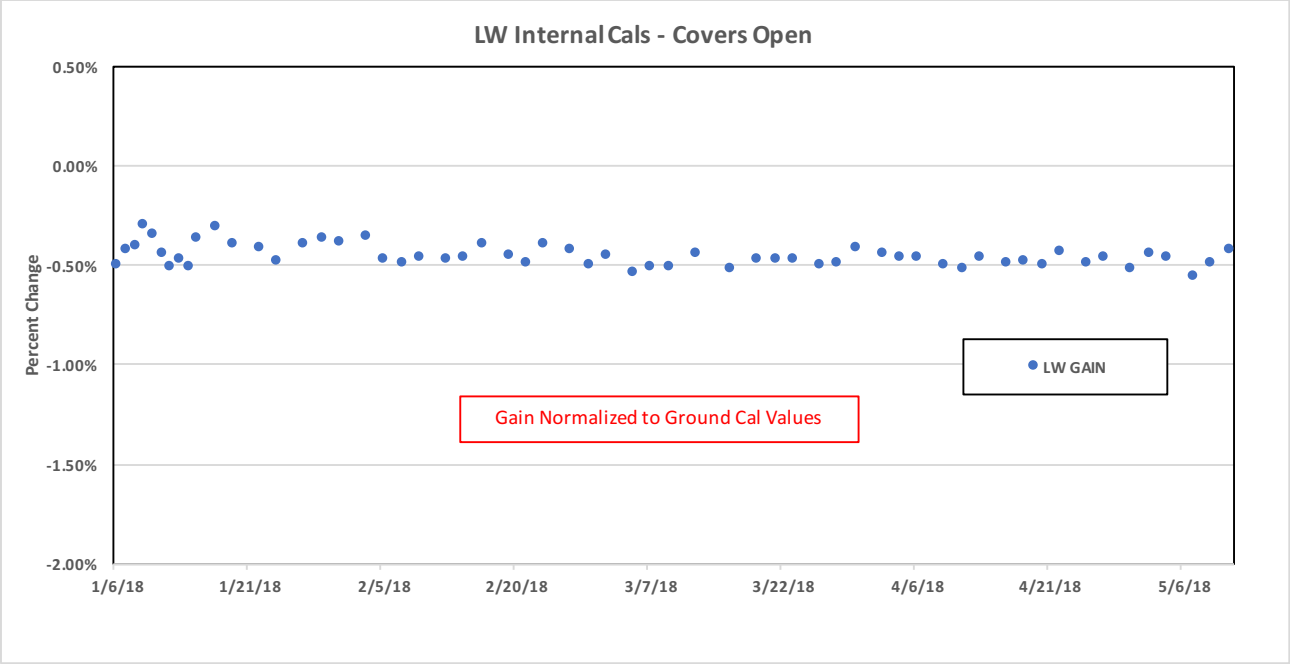
Clouds and the Earth's Radiant Energy System



Internal Cal Results – Covers Opened

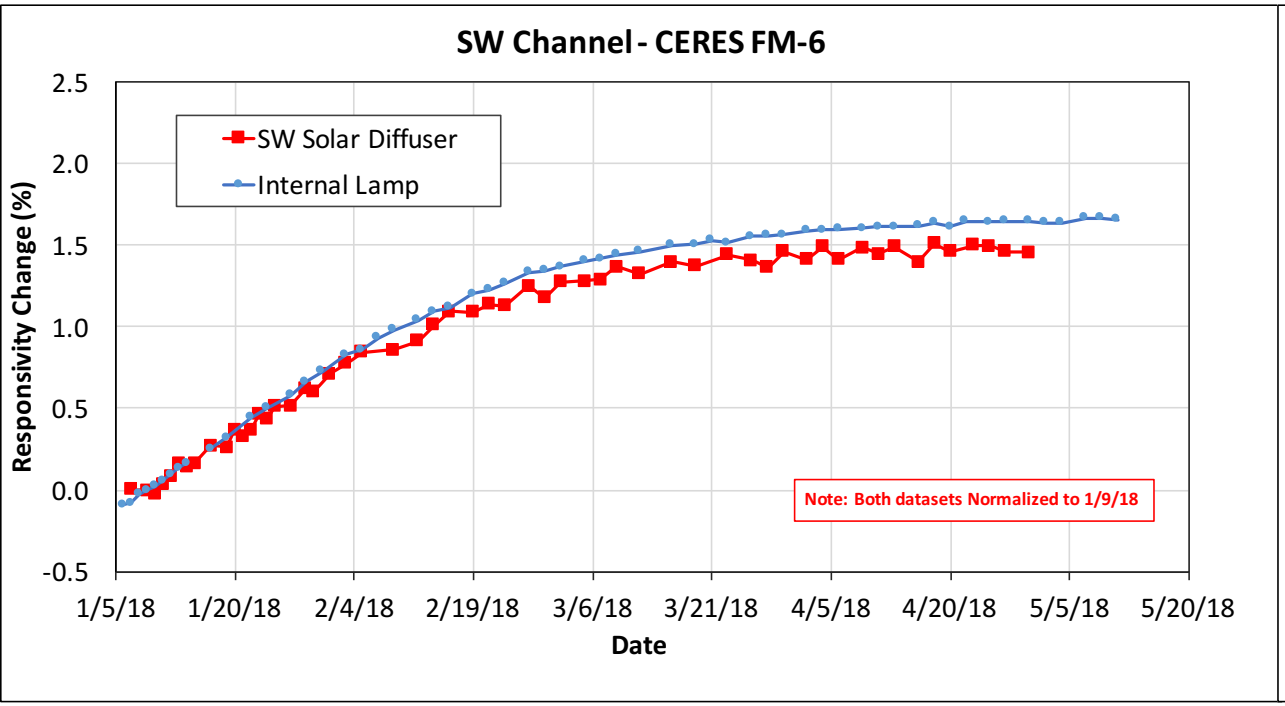


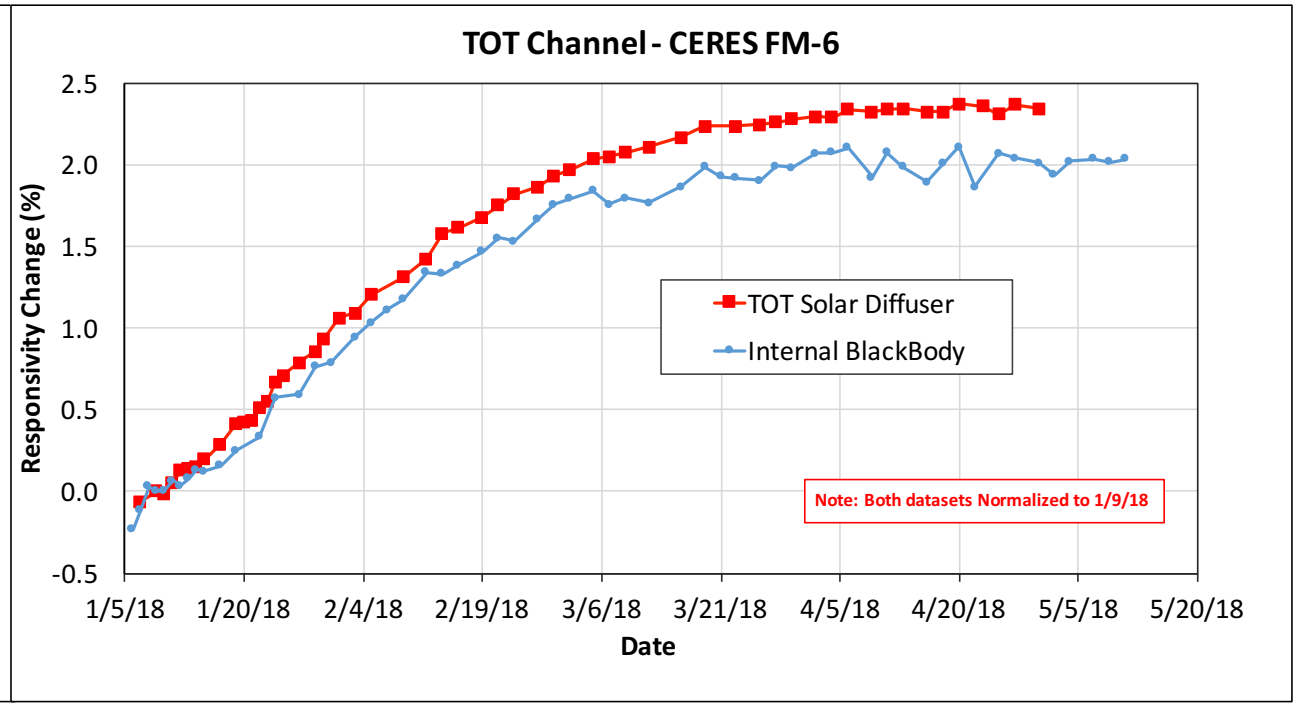




Note: All Axes 2.5% full scale

Solar and Internal Cal Comparison





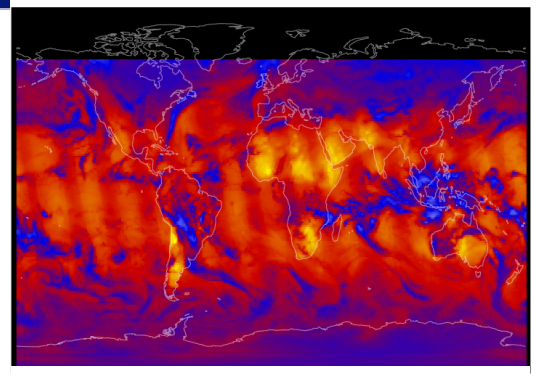
Note: All Axes 3.0% full scale

Daytime OLR FM-6 Intra-Channel Comparison (LW minus LW channel)

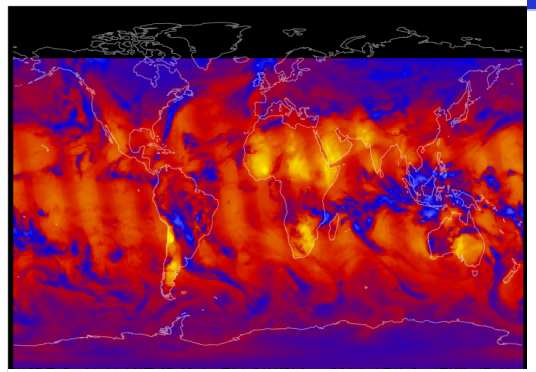
Clouds and the Earth's Radiant Energy System

New Broadband LW channel enables many new Validation capabilities

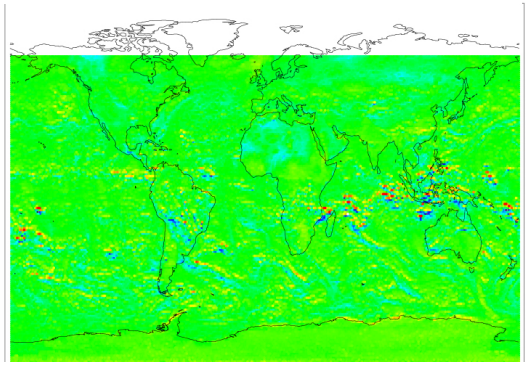
FM6 LW 01/14/2018



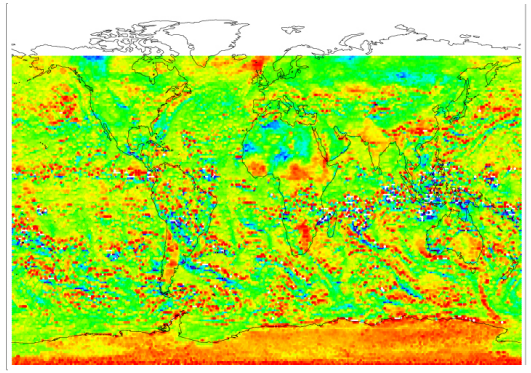
FM6 LW Channel 01/14/2018



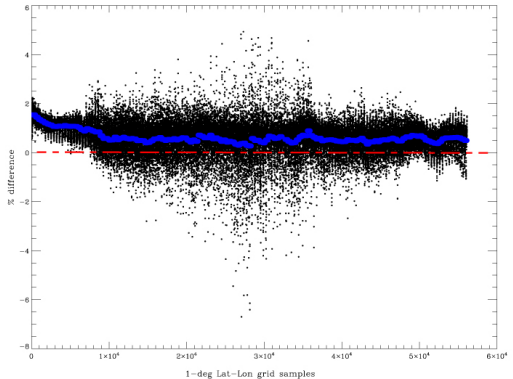
Differences between -5 to 5%



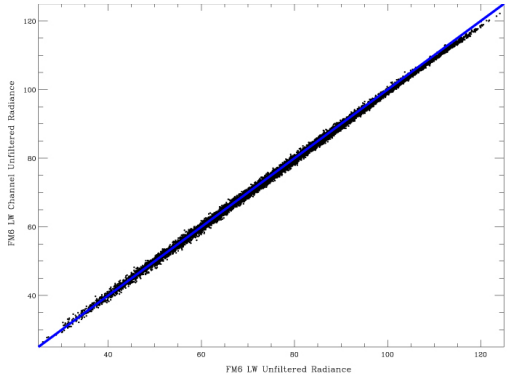
Differences between -2 to 2%



LW – LW Channel difference

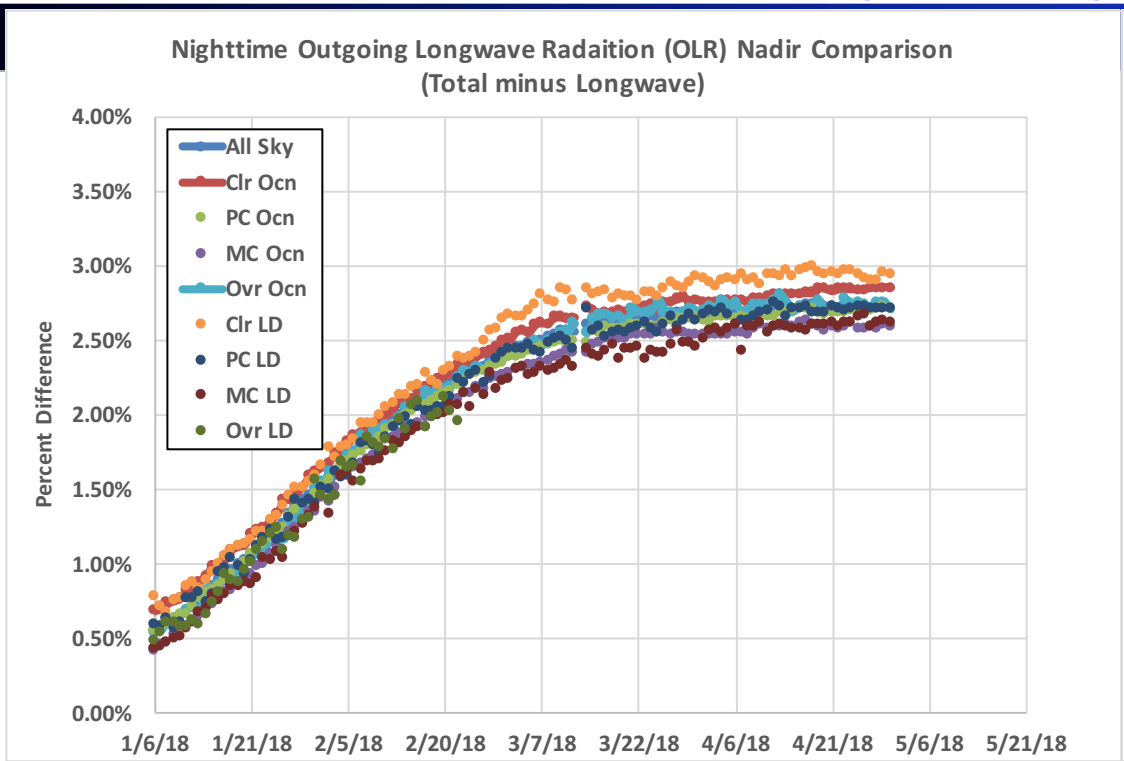


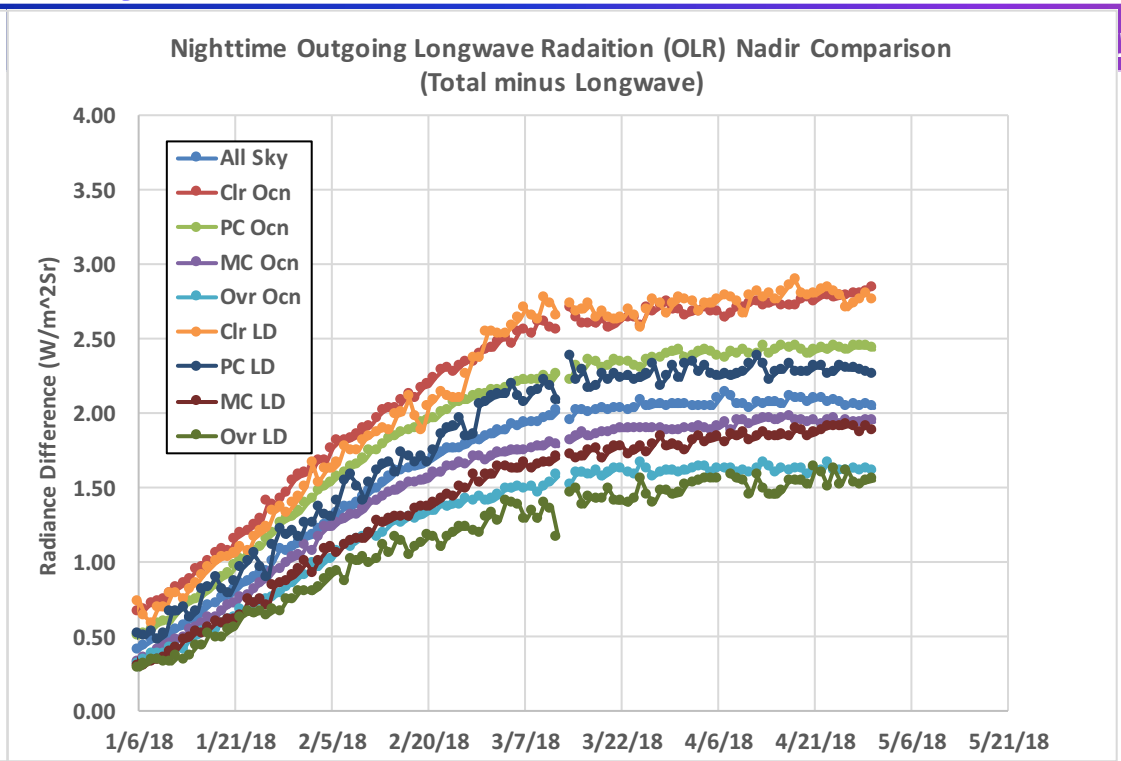
LW vs LW channel



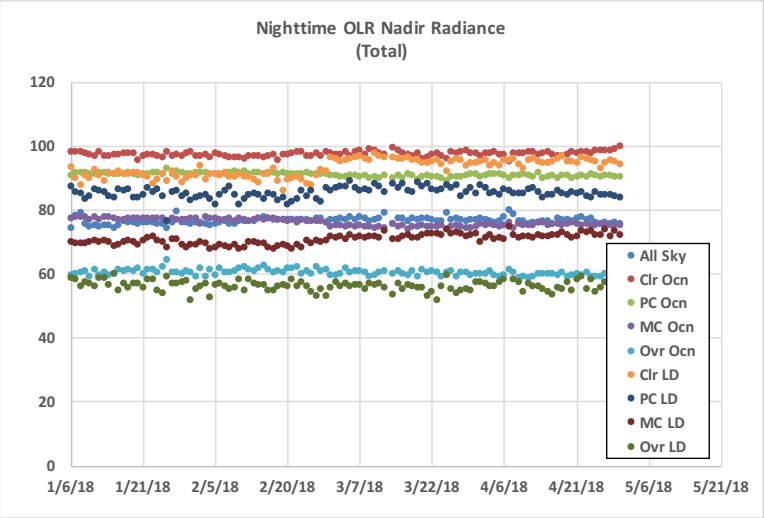
Note: At-Launch Production strategy
Earth Viewing Data

FM-6 Nighttime OLR Intra-Channel Comparison - Nadir (LW-LWc) Daily ES-8



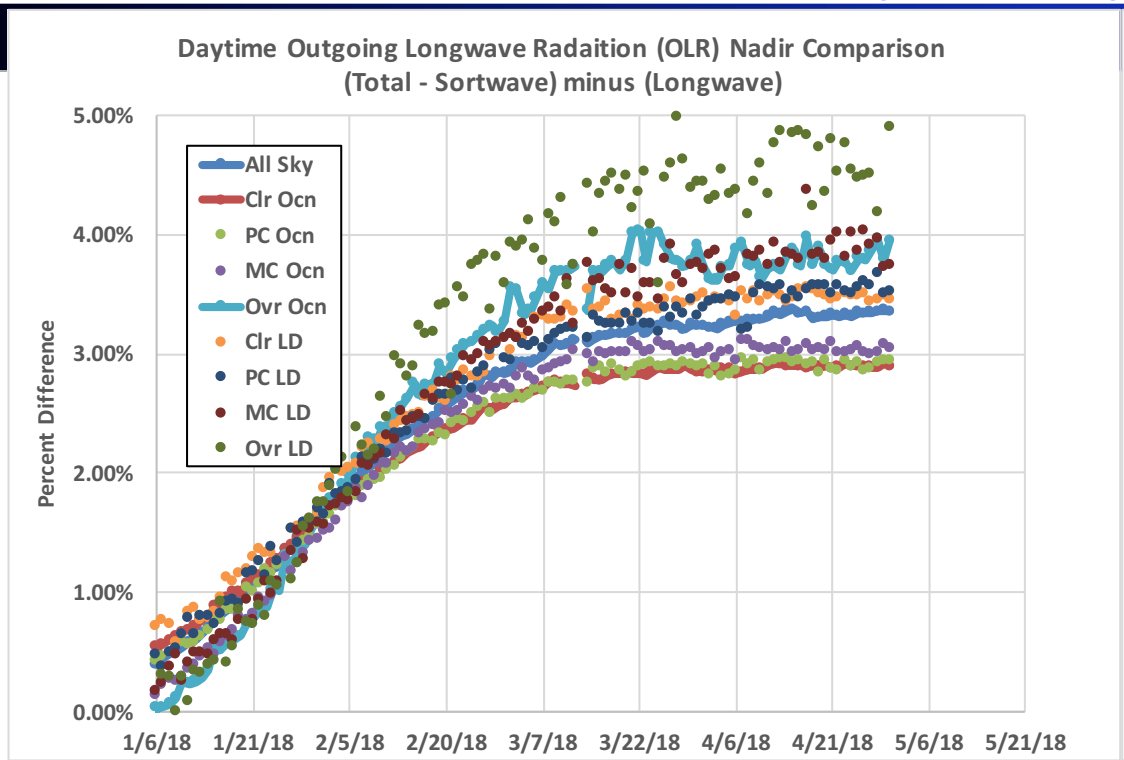


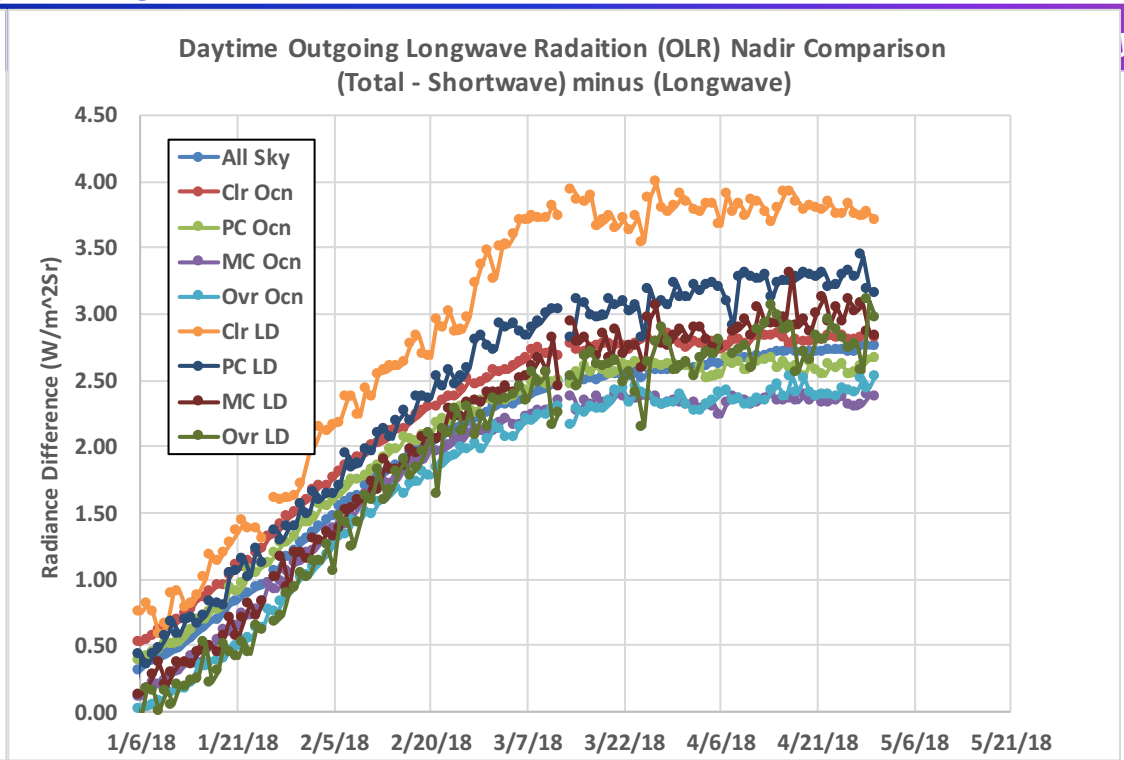
Nighttime

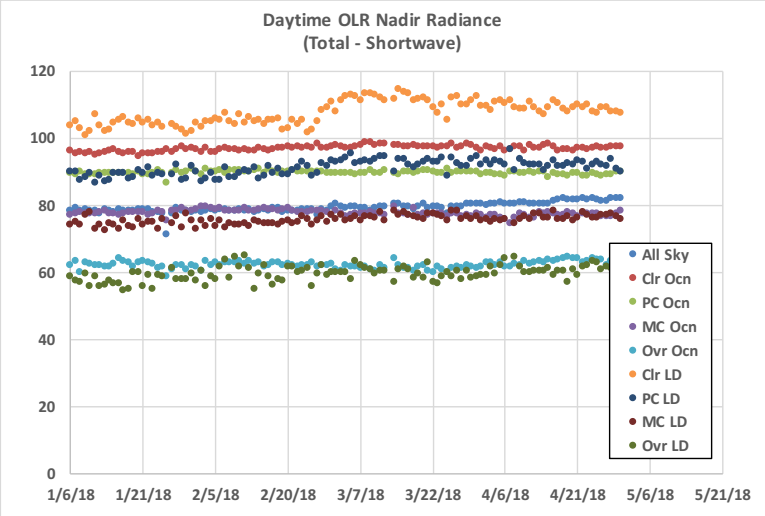


Note: At-Launch Production strategy
Earth Viewing Data
LWc implies Longwave Channel

FM-6 Daytime OLR Intra-Channel Comparison - Nadir (LW-LWc) Daily ES-8





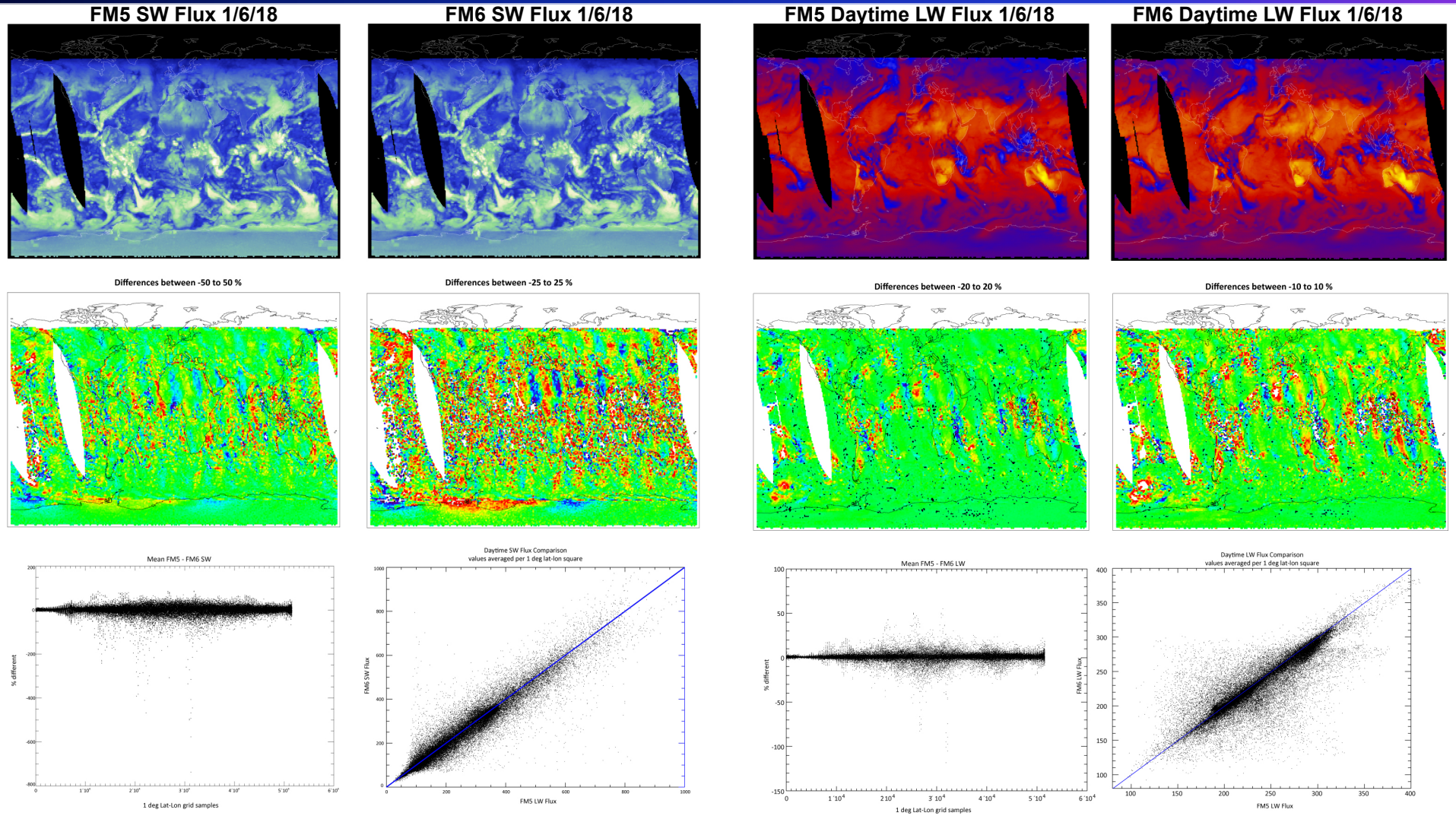


Daytime

Note: At-Launch Production strategy
Earth Viewing Data
LWc implies Longwave Channel

S-NPP to NOAA-20 TOA Flux Comparison

Clouds and the Earth's Radiant Energy System



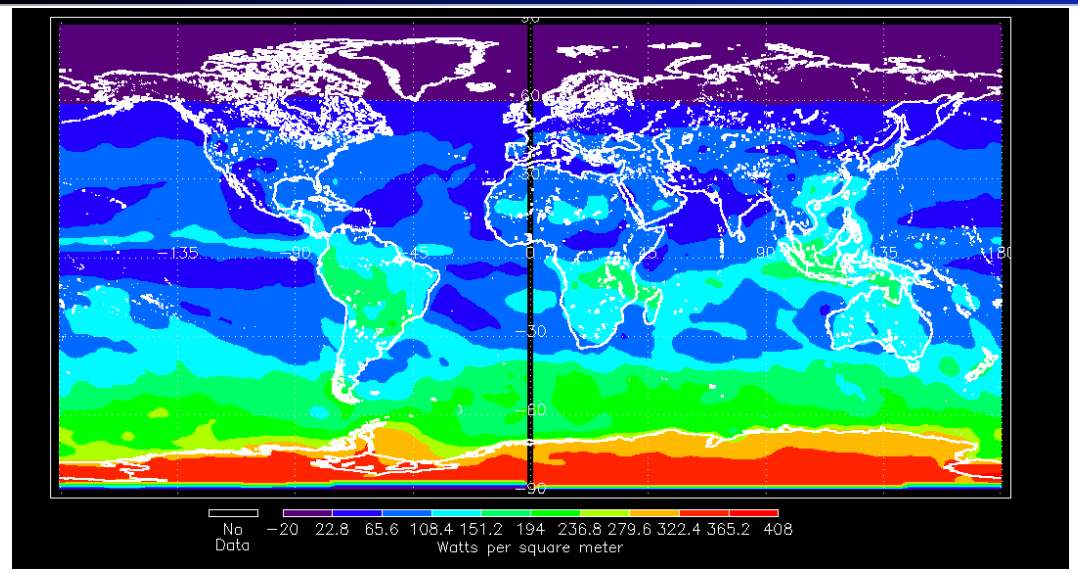
- CERES FM5 to FM6 Intercomparisons underway (Insufficient data collected to date)
- Diagnostic Tools developed
- Qualitative Analyses (ES-8 product) look very promising

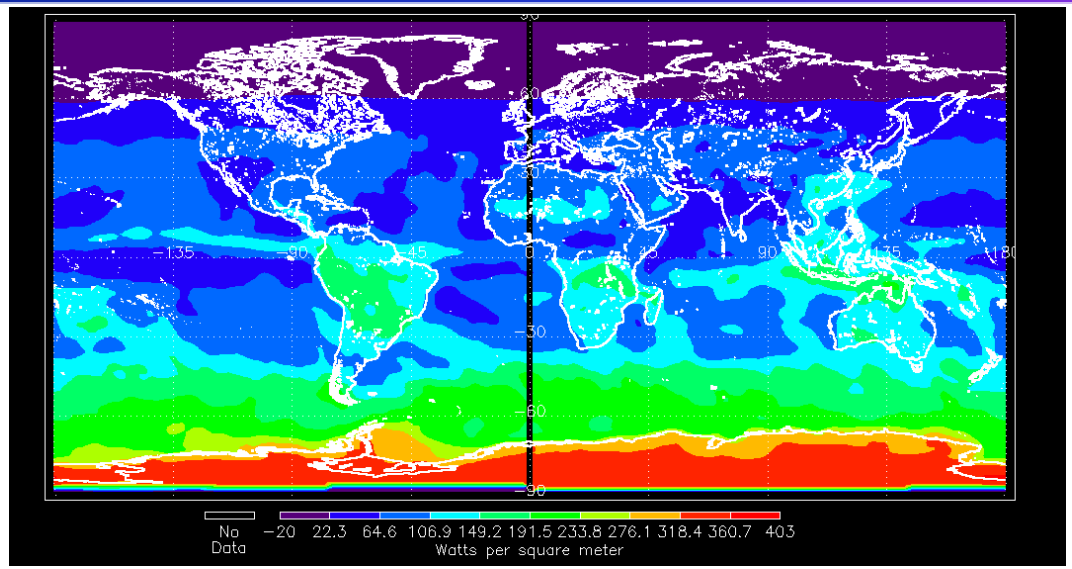
Note: At-Launch Production strategy (FM6)
Edition1-CV Production Strategy (FM5)
Earth Viewing Data

CERES FM5 to FM6 2.5-deg monthly average comparisons (ERBE-Like S4 product, January 2018)

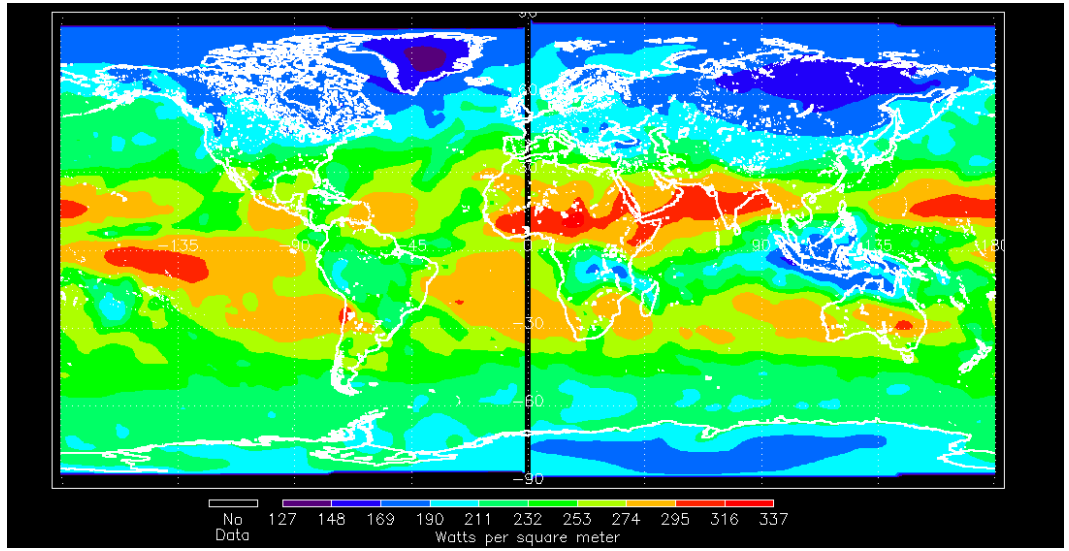
FM-5 (Jan 1-21)

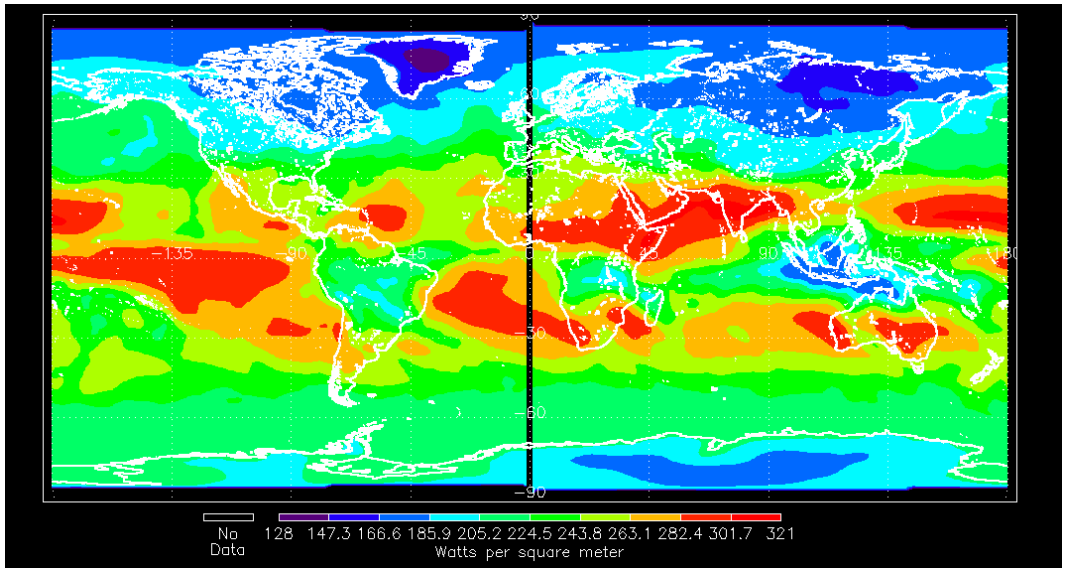
FM-6 (Jan 6-31)





Reflected solar



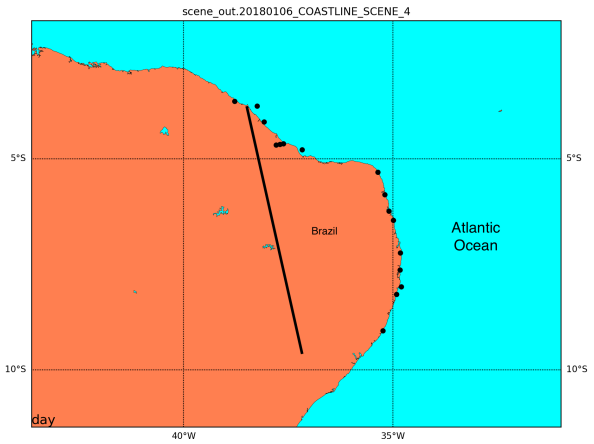


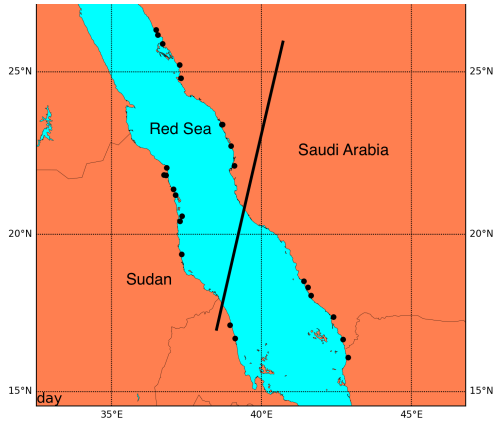
OLR Daytime

Note: At-Launch (FM6)
Edition1-CV (FM5)
Earth Viewing Data

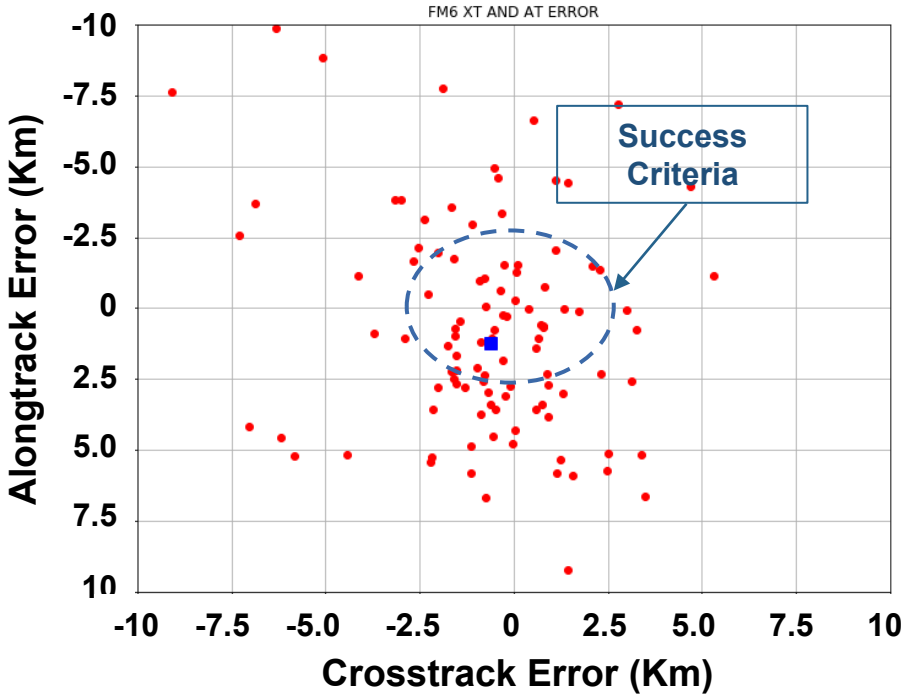
Geolocation and Pointing Accuracy – Coastline Detection

Clouds and the Earth's Radiant Energy System





January 6th – January 30th
Baseline1-QC BDS and ES8 files



Instrument	Detections	Mean Xt Error (km) 95% Confidence Interval	Mean At Error (km) 95% Confidence Interval
FM6	112	-0.60 +/- 0.53 km	-1.22 +/- 0.89 km

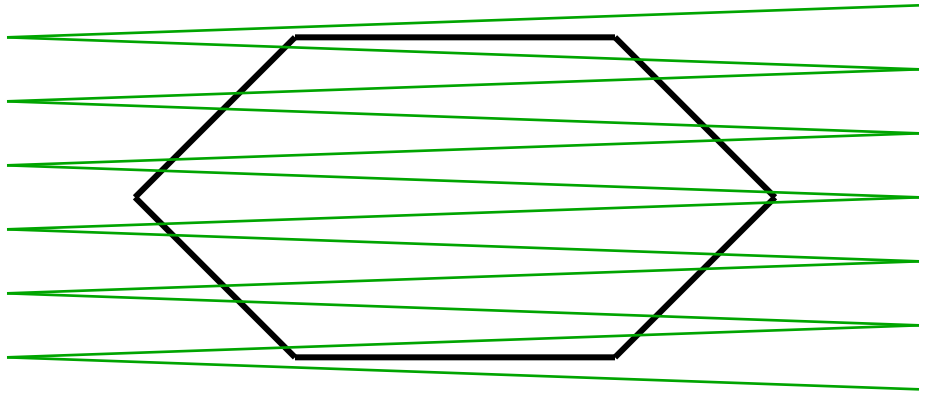
Validation of Pointing Knowledge Using Lunar Radiances

Objective: Utilize the full moon as a quasi-point source to complete a near steady-state raster scan across the CERES FOV.

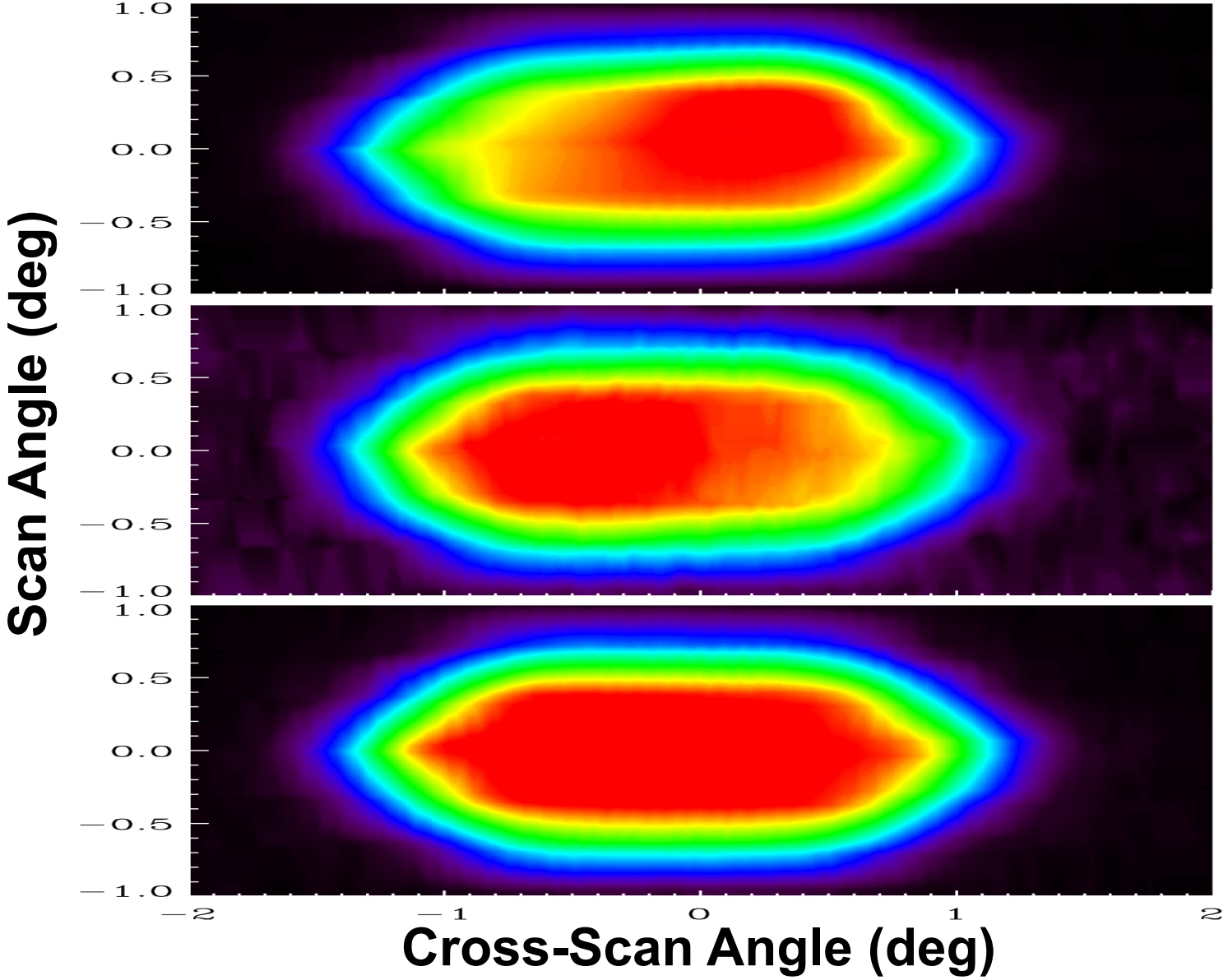
<u>Goals</u>

- **Validate pre-launch alignment measurements**
- **Measure inter-channel relative pointing accuracy**
- **Map out spatial non-uniformities in the CERES Optics/Detectors**
  - **This type of mapping is not performed *<u>under vacuum</u>* prior to launch.**
- **Measure Lunar Radiances for future instrument intercomparisons.**

~ By combining knowledge of the motion of the moon relative to the spacecraft and the programmability of the the CERES Instruments we obtain……..~



Post-Launch Lunar Calibrations
IFOV Uniformity Mapping & Coregistration

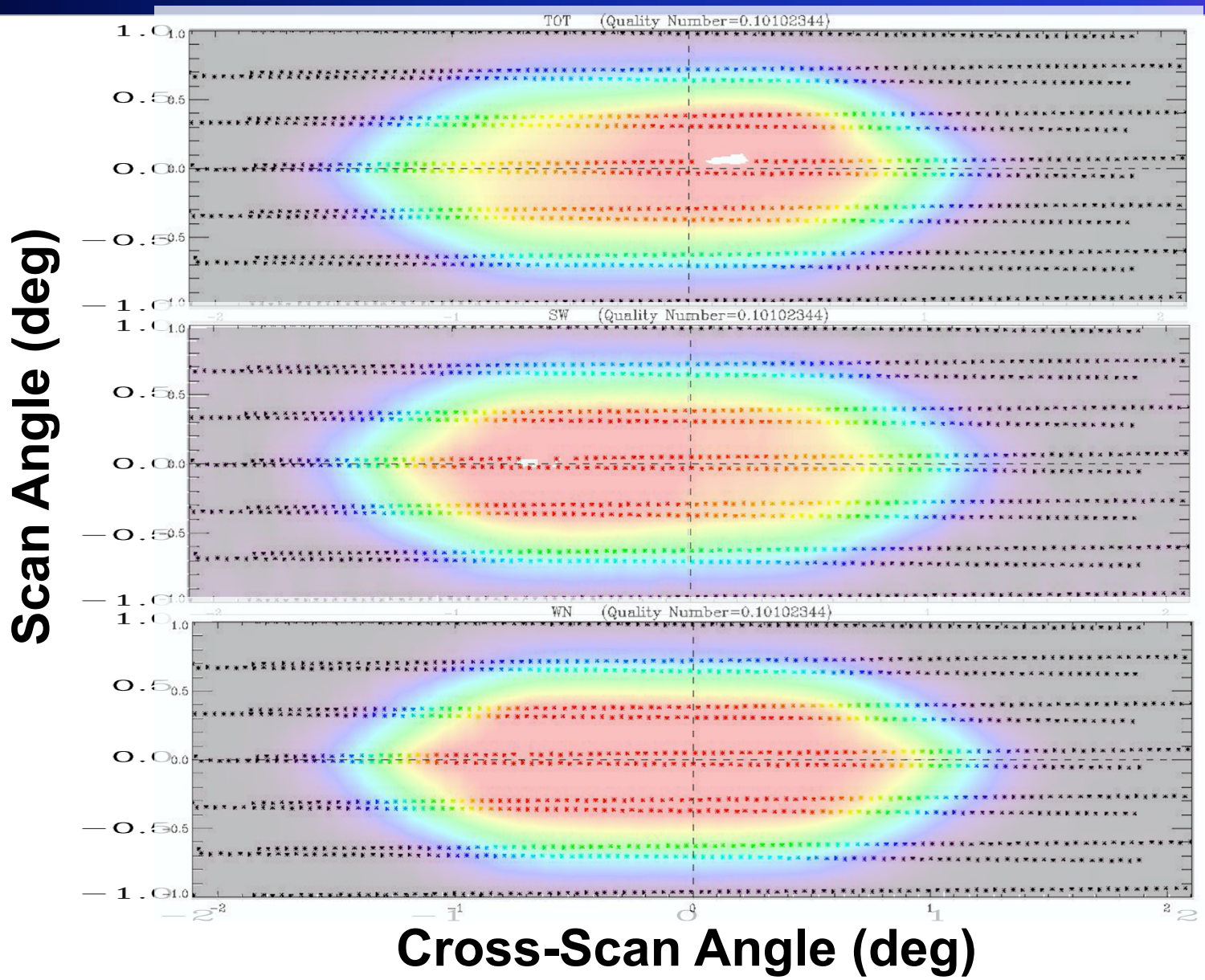


TOT Channel

SW Channel

LW Channel

Post-Launch Lunar Calibrations
IFOV Uniformity Mapping & Coregistration



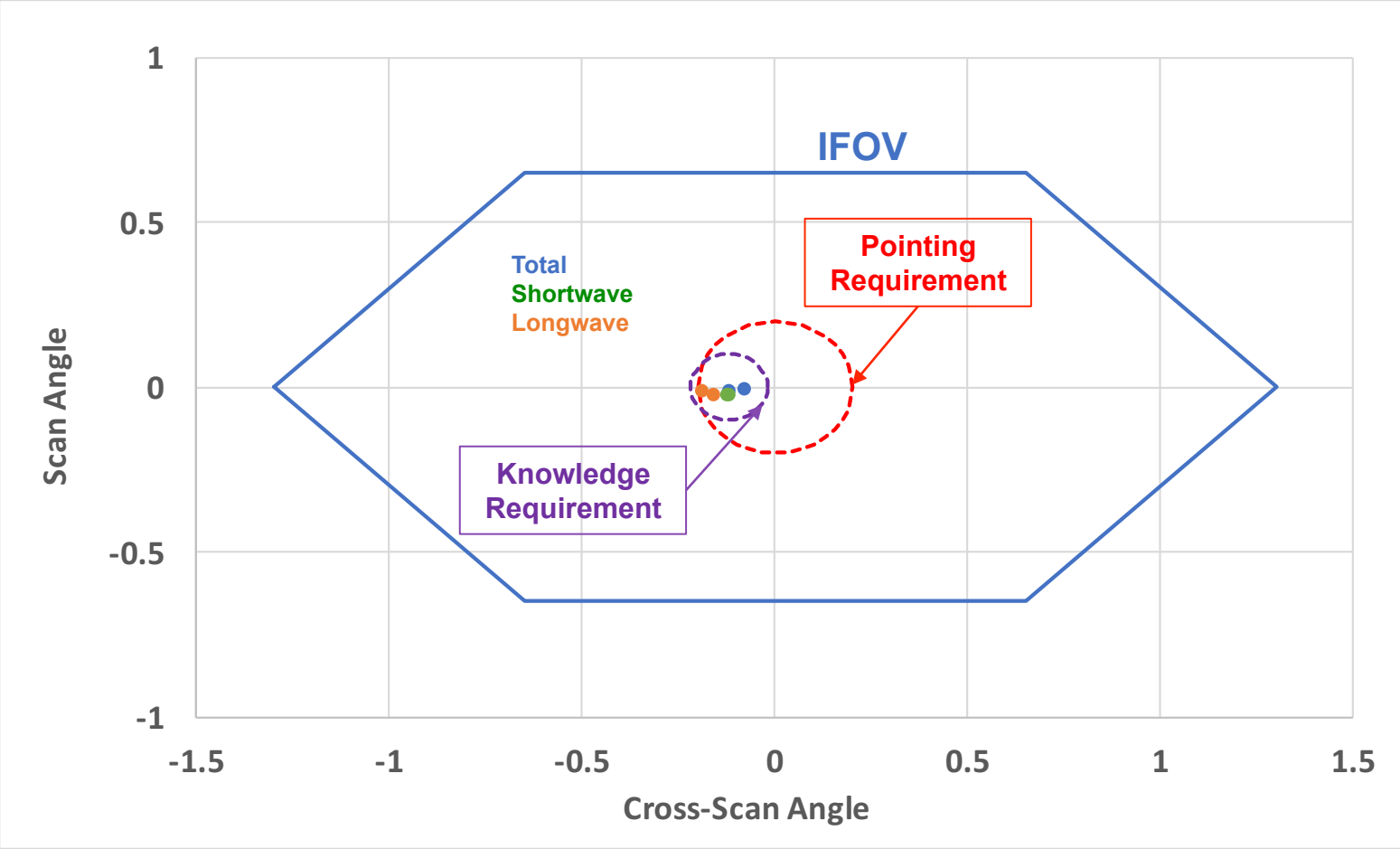
TOT Channel

SW Channel

LW Channel

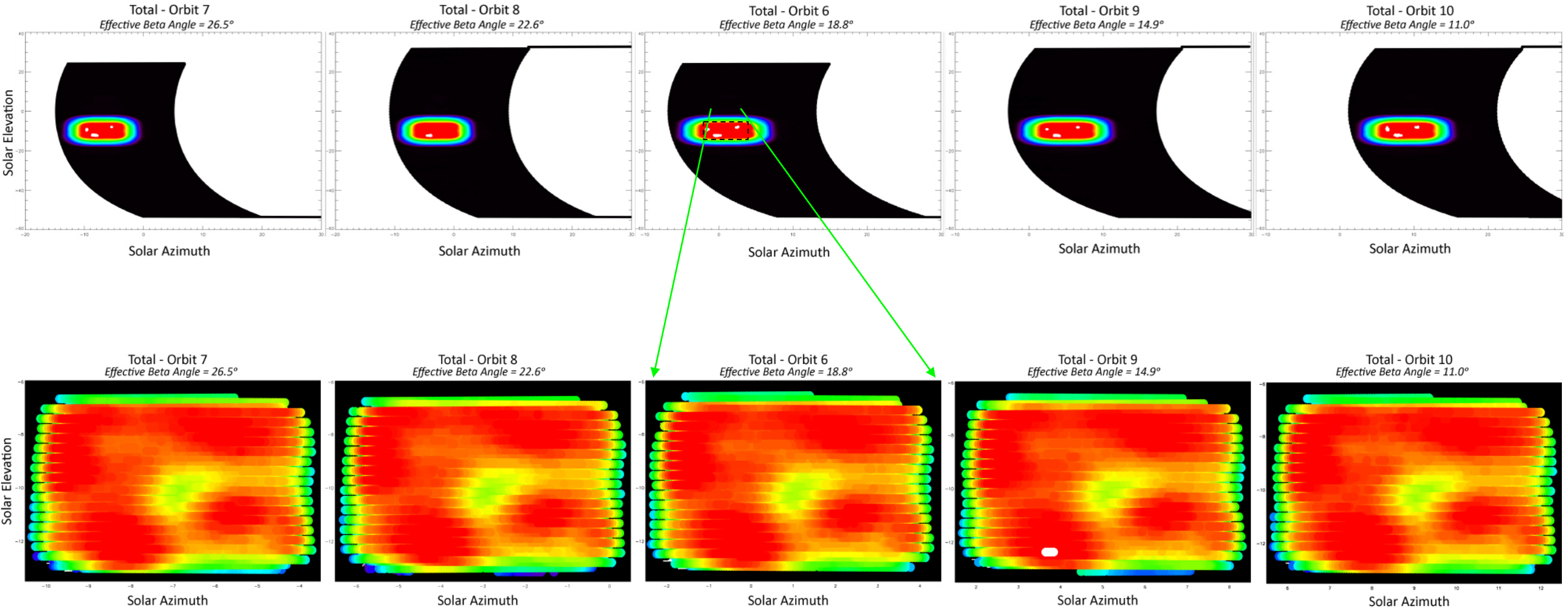
Lunar Cal Results – Covers Opened

Pointing Knowledge/Co-Registration



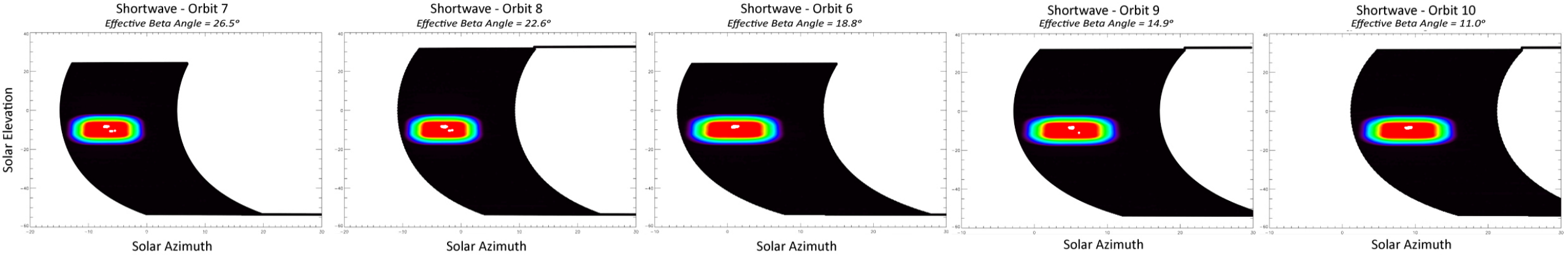
Yaw Maneuver Results– Total Channel

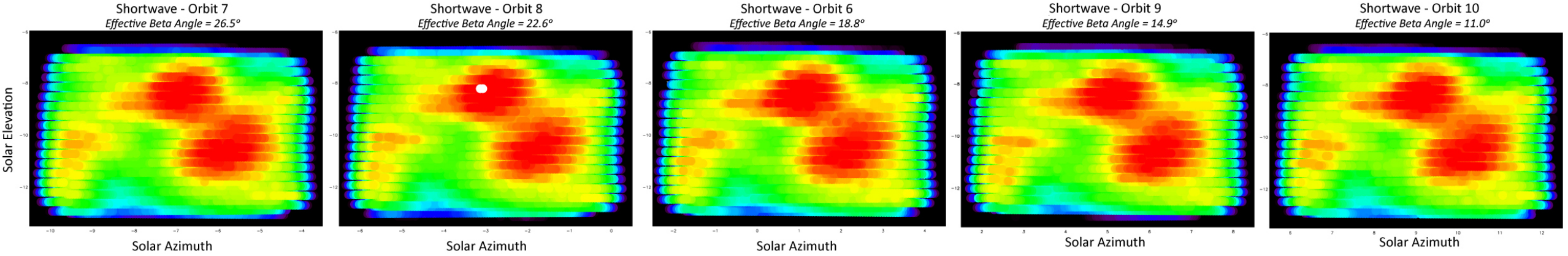
Lunar Cals Spanning Beta Angle Variation



Yaw Maneuver Results– Shortwave Channel

Lunar Cals Spanning Beta Angle Variation





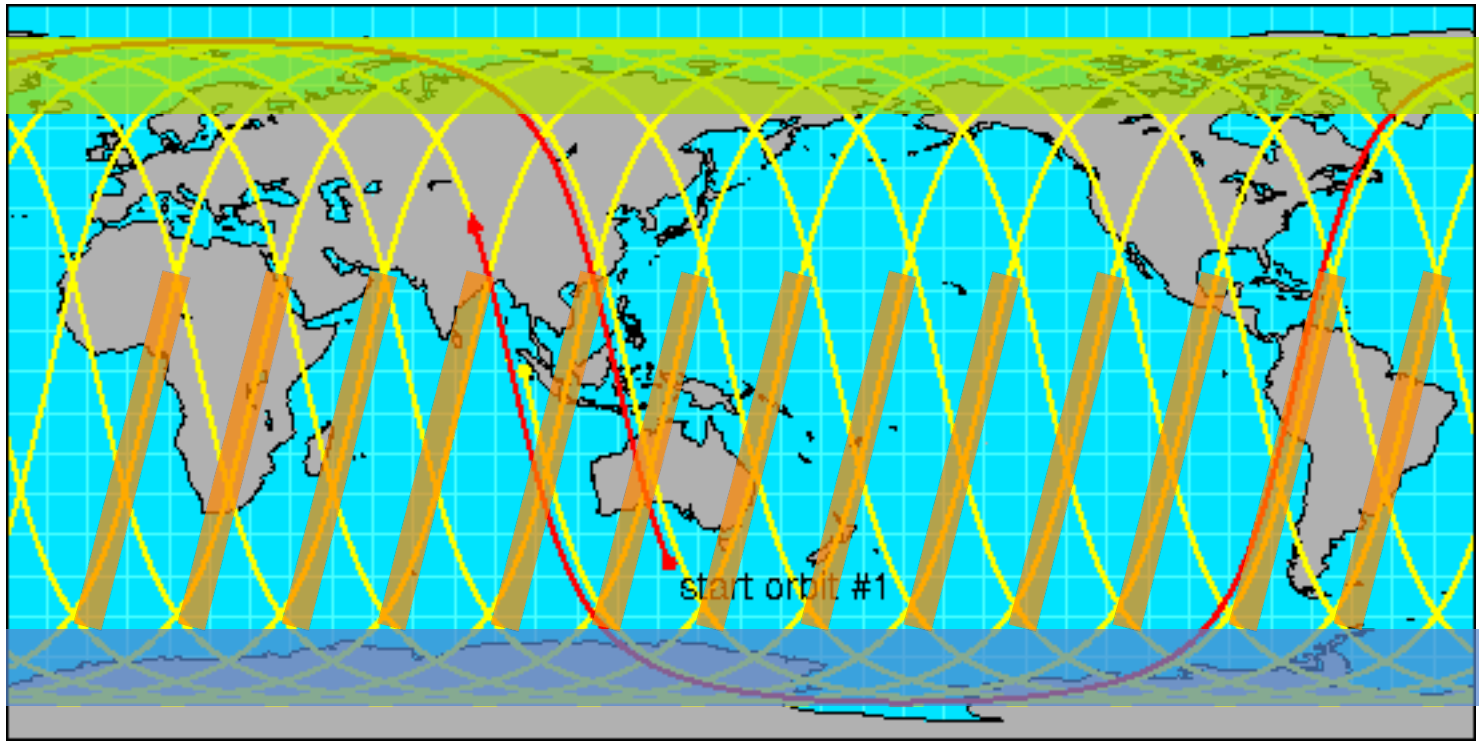
Executive Summary

- **CERES opened covers on 1/5/18 and began Earth observations**
- **CERES has *successfully* completed all commissioning activities**
- **All aspects of performance are as expected and acceptable**
- **LaRC processing system fully operational - No SDR products for CERES**
- **We are thankful for the close and collaborative coordination with the JPSS Team**

The Science Team is happy to inherit the CERES Instrument

Back-up

Aqua/NPP/NOAA-20 Flight Cal Locations



- Lunar Observations
- Solar Calibrations
- Internal Calibration Sequence

Geolocation and Pointing Accuracy

- Preliminary success will be analyzed after 60 days over all 5 criteria.
  - Absolute success will be measured longer term trending to maintain requirements throughout instrument life.
  - Acquire valid Lunar calibration measurements on each side of the full moon and one near full moon.
  - Perform crosstrack scanning for more than 60 days. (Currently ~35)
- Verify pointing accuracy to 746 (3σ) arcseconds and knowledge to 378 (3σ) arcseconds (Lunar)
- Verify footprint is geolocated within 10% of the footprint size with 95% confidence (Coastline)

Internal Cal Results – Covers Opened - Trend Evolution