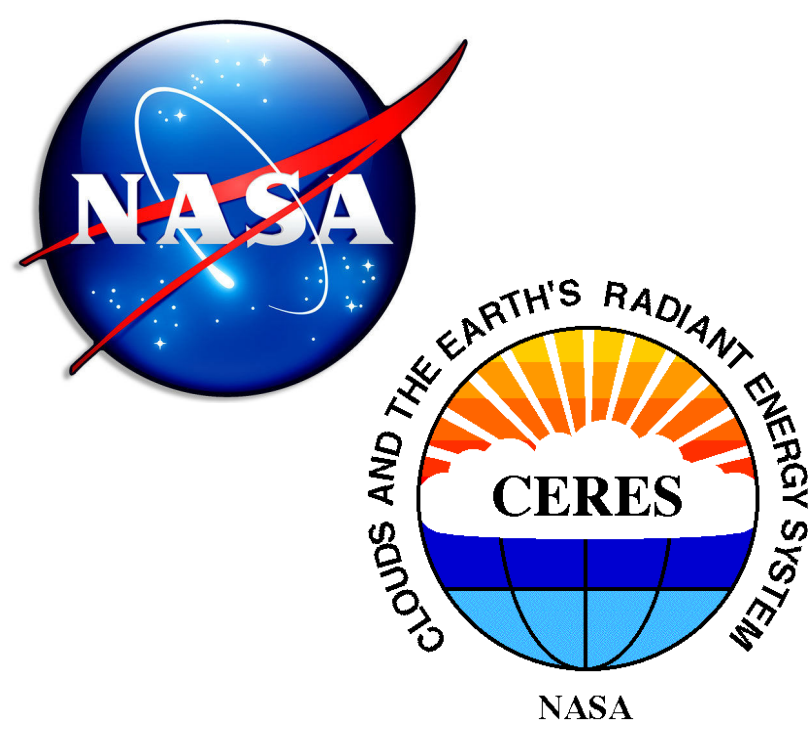




Performance Stability Evaluation of Clouds and the Earth's Radiant Energy System (CERES) Flight Model 5 (FM5) Instrument on S-NPP

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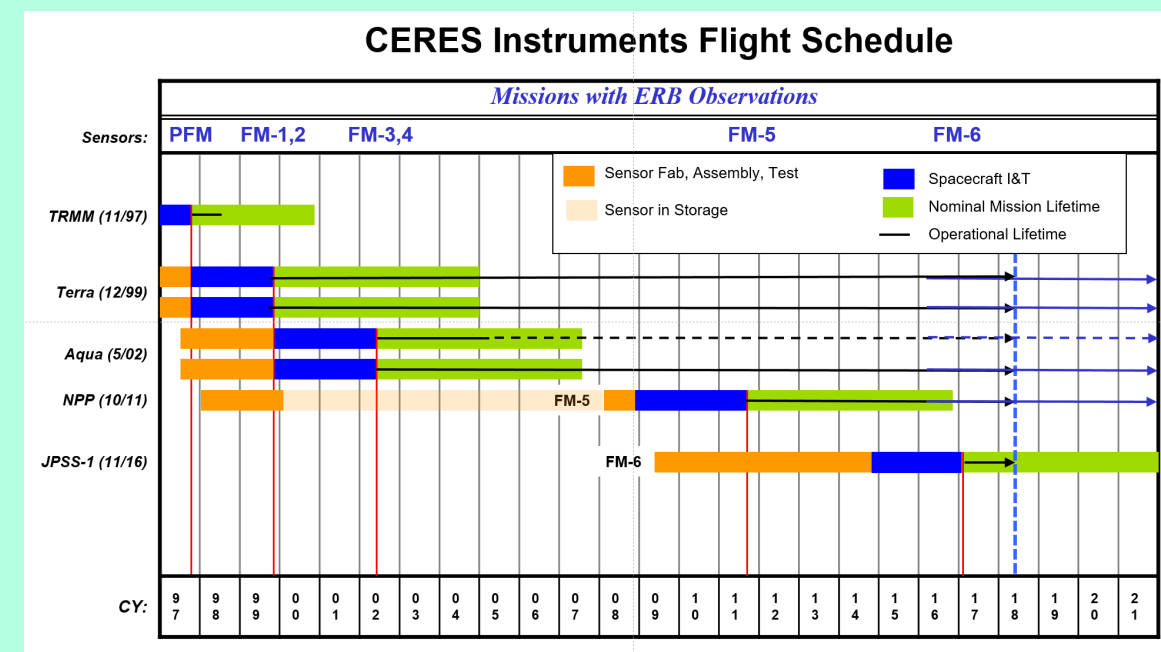
1) Science Systems and Applications, Inc.2) NASA Langley Research Center



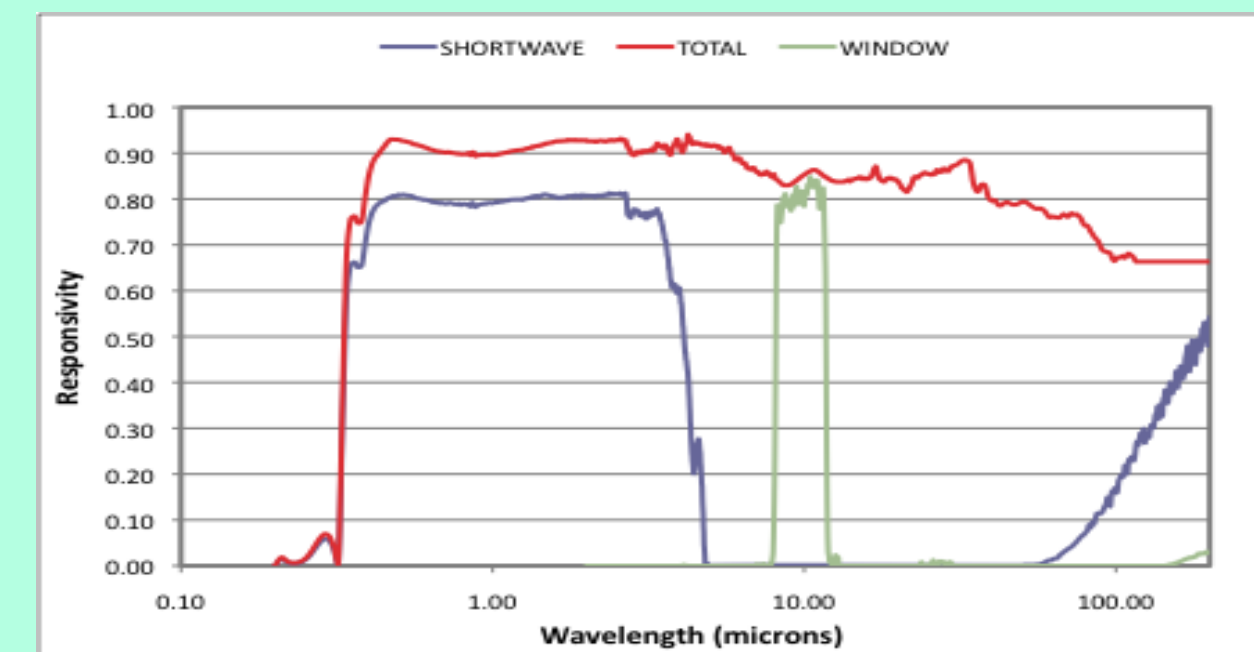
FLIGHT MODEL 5 (FM5): S-NPP Spacecraft
Launch Date: October 2011
Orbit Type: Polar Sun-synchronous
Orbit Ascent: 1:30 PM equatorial crossing
Altitude: 825 KM

Instrument Overview

- Broadband scanning Radiometers designed for long-term monitoring of Earth's Radiation Energy Budget. Two components of Earth Radiation Budget - Reflected Solar and Emitted Longwave Radiation – are measured by CERES sensors.
- Six CERES Instruments built by Northrop Grumman Aerospace Systems (NGAS) at Redondo Beach, CA.
- Three sensor assemblies with cassegrain optics and thermistor bolometer detectors
Total: 0.3 – >100 micron, Shortwave: 0.3 – 5.0 micron, Window: 8.0 – 12.0 micron
- Pre-launch Calibration Accuracy Requirements
+/- 0.5% Longwave, +/- 1.0% Shortwave



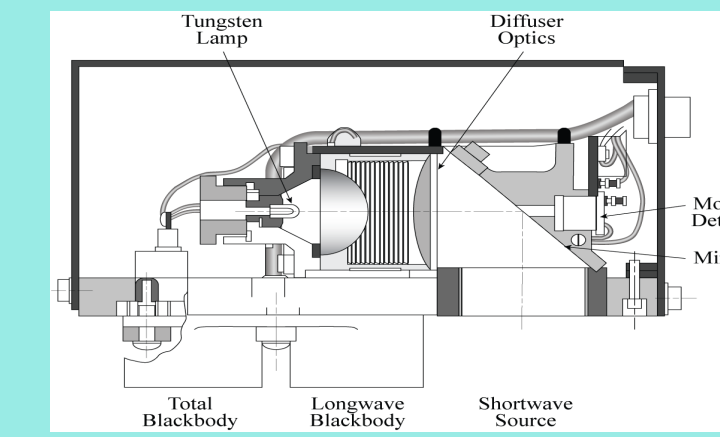
Over 75 years of CERES instrument flight experience



Spectral Response Function of CERES Sensors

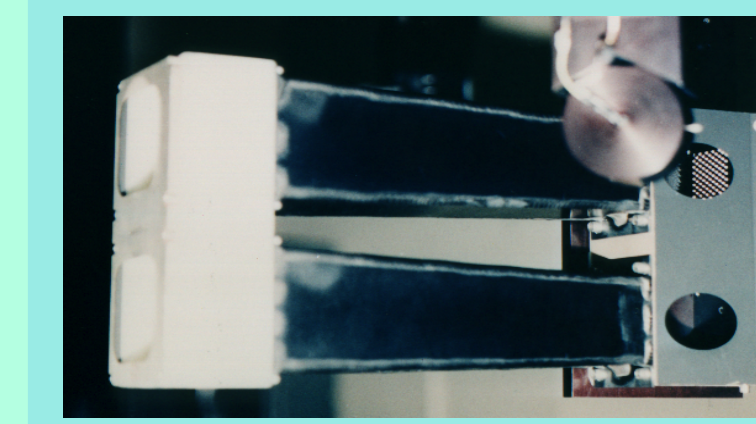
CERES Flight Calibration Systems

Internal Calibration Module (ICM)



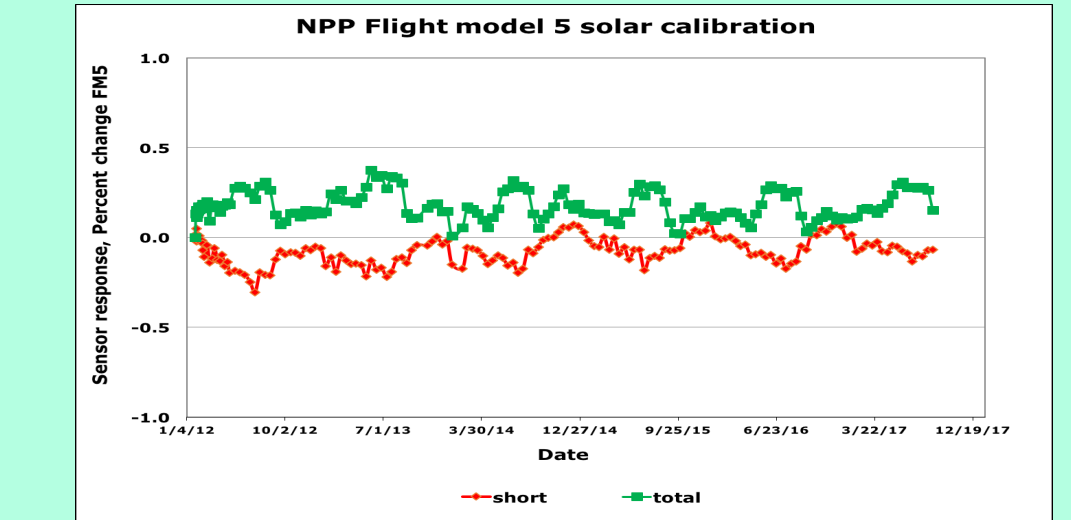
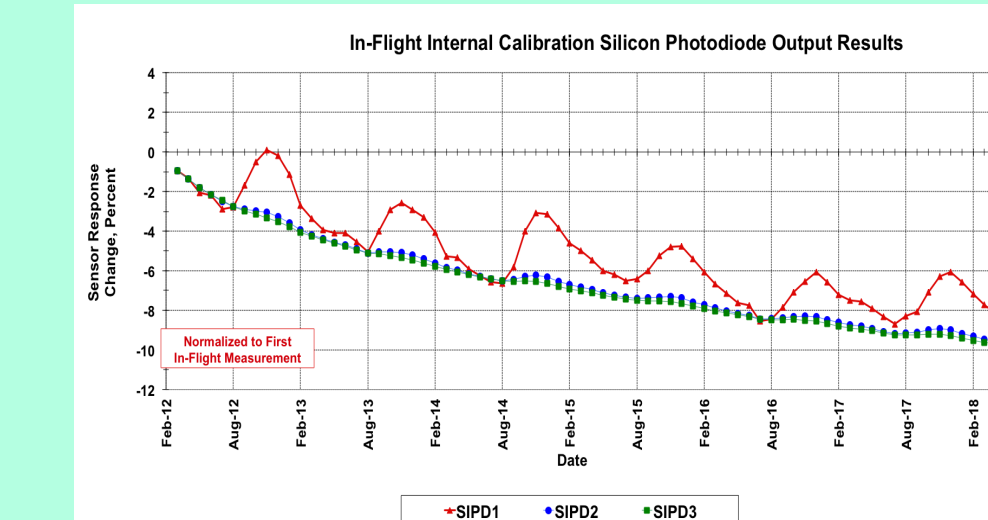
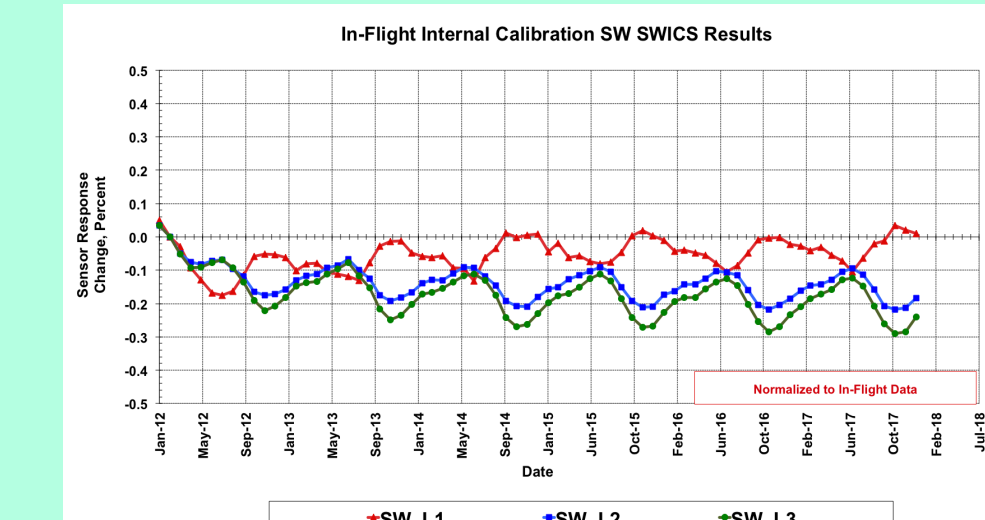
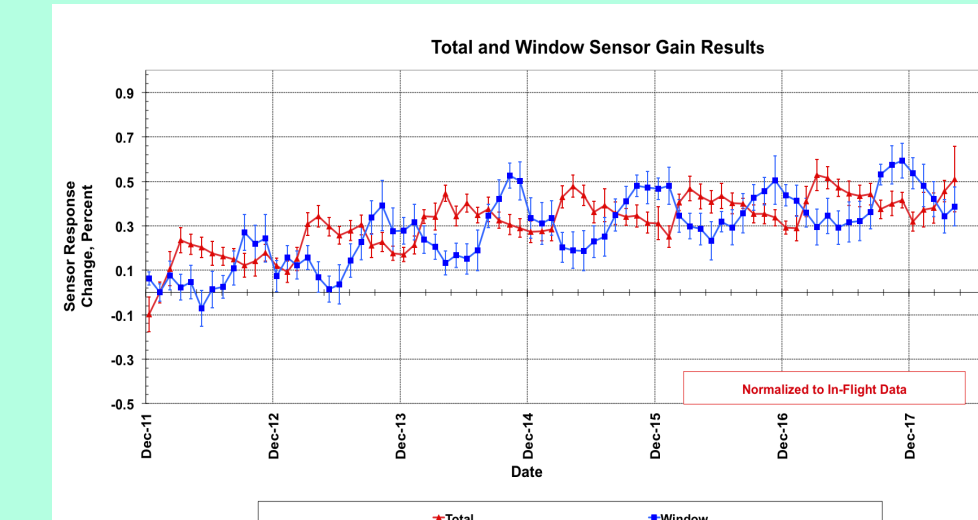
Total & Window: Anodized Aluminum Blackbody
Shortwave: Shortwave Internal Calibration Source (SWICS) Evacuated Tungsten Lamp
SWICS Monitor: Silicon Photodiode

Mirror Attenuator Mosaic (MAM)



Solar Diffuser Plate
Nickel substrate with Aluminum coated spherical cavities or divots
Provides relative calibration for the SW sensor and SW portion of the Total sensor

Sensor Response Results

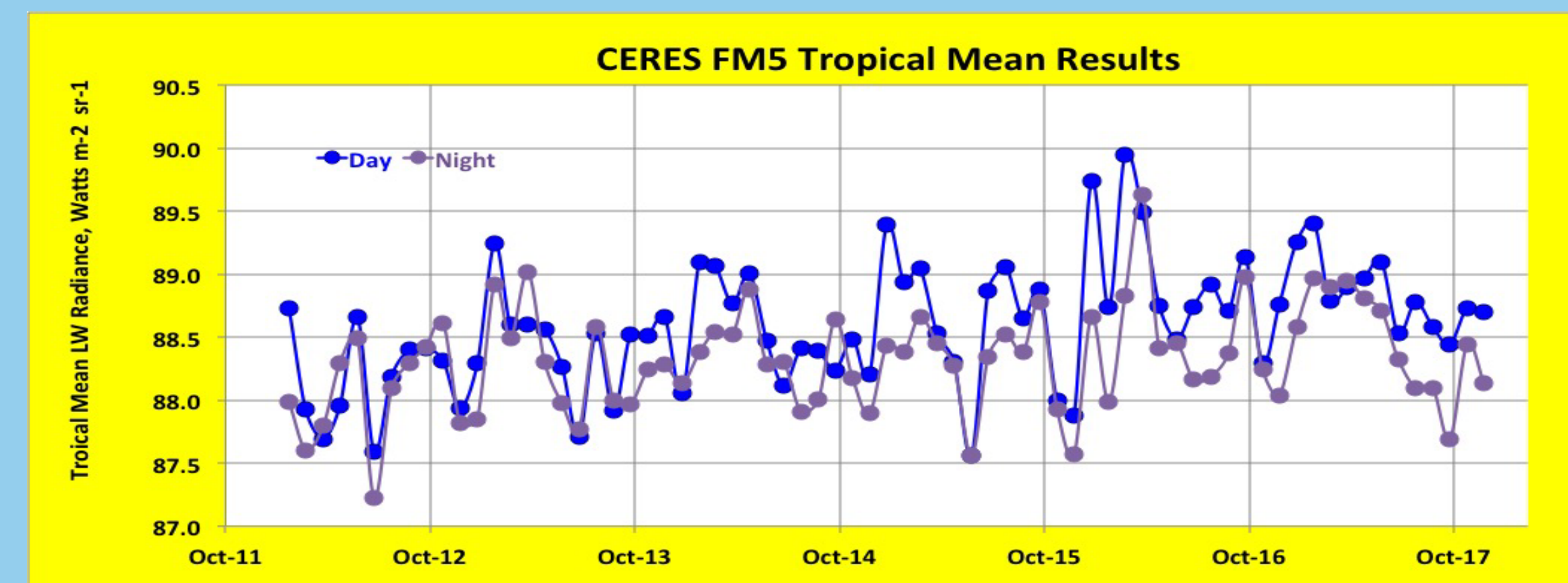


- The performance of CERES sensors are within the expected range of +/- 0.5%
- The Silicon photodiode (SiPD) monitor for the shortwave tungsten lamp source has shown a drop on-orbit which is due to radiation and is observed in all CERES instruments.

Tropical Mean (TM) Study

TARGET: Tropical Ocean (20°N - 20°S)

- Monthly Average of All-sky Tropical Ocean Longwave Radiance measurements.
- Tropical Mean Day and Night Trends highlight the total sensor performance.

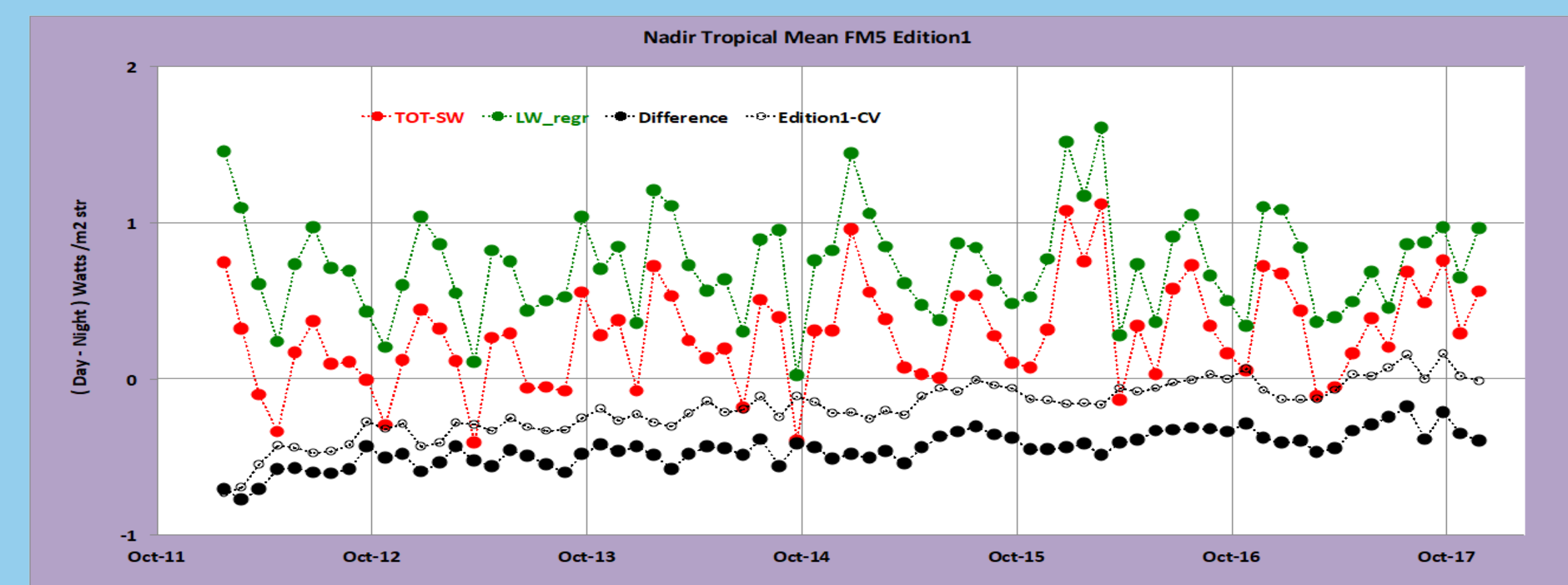


TM DAY-NIGHT DIFFERENCE (DN) evaluation is performed to determine changes in the shortwave spectral region of sensors.

1. TOTAL and SHORTWAVE SENSOR
 $DN_{TS} = TM(day, TOT-SW) - TM(night, TOT)$

2. LONGWAVE/WINDOW SENSOR
 $DN_L = TM(day, LW) - TM(night, LW)$

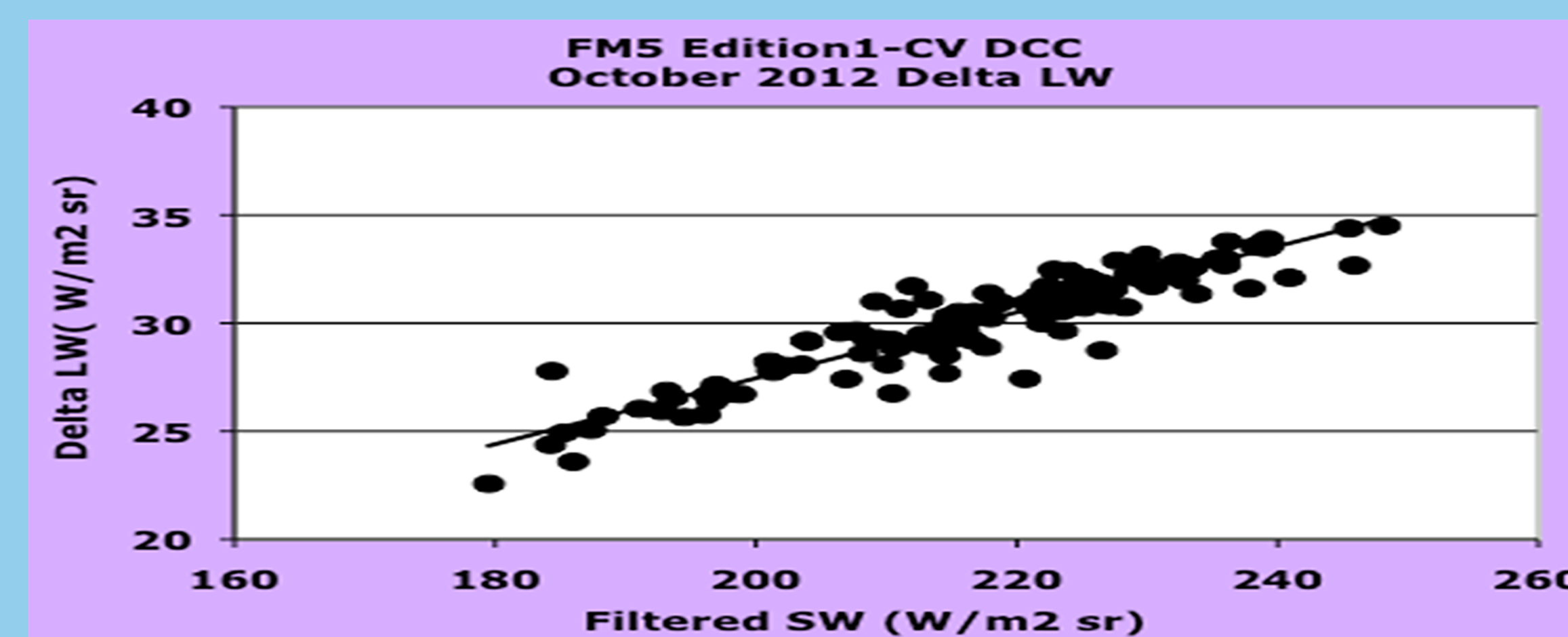
3. $(DN_{TS} - DN_L)$ highlights any trends occurring in the Shortwave region of the Total sensor



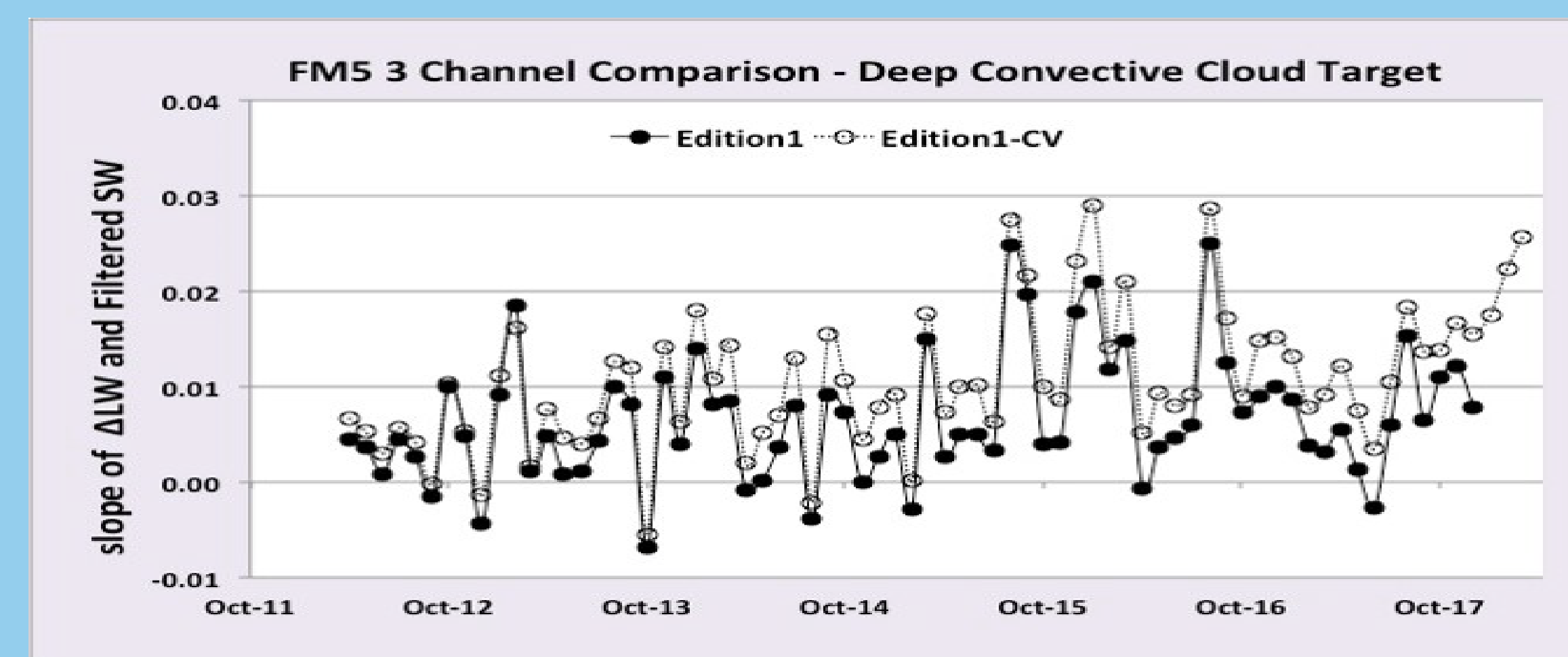
CERES 3-Channel Comparison

TARGET: Deep Convective Clouds

- Nadir measurement comparison of the three CERES sensors viewing the Deep Convective Clouds (DCC).
- In addition to measured LW radiance, LW radiance is also derived from trained Window sensor.



The slope of the difference in derived and measured daytime LW radiances and the SW radiance is monitored over time.

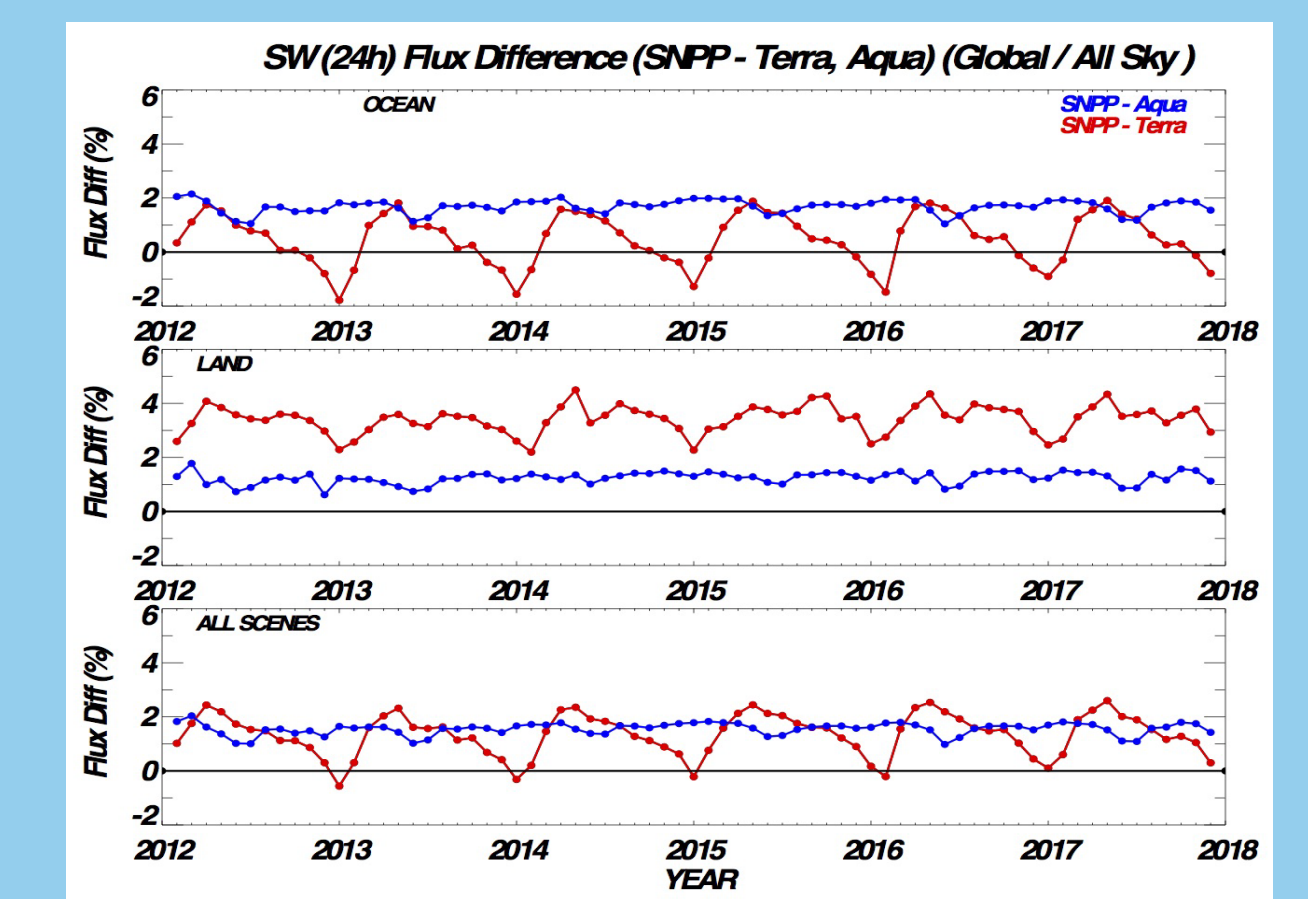
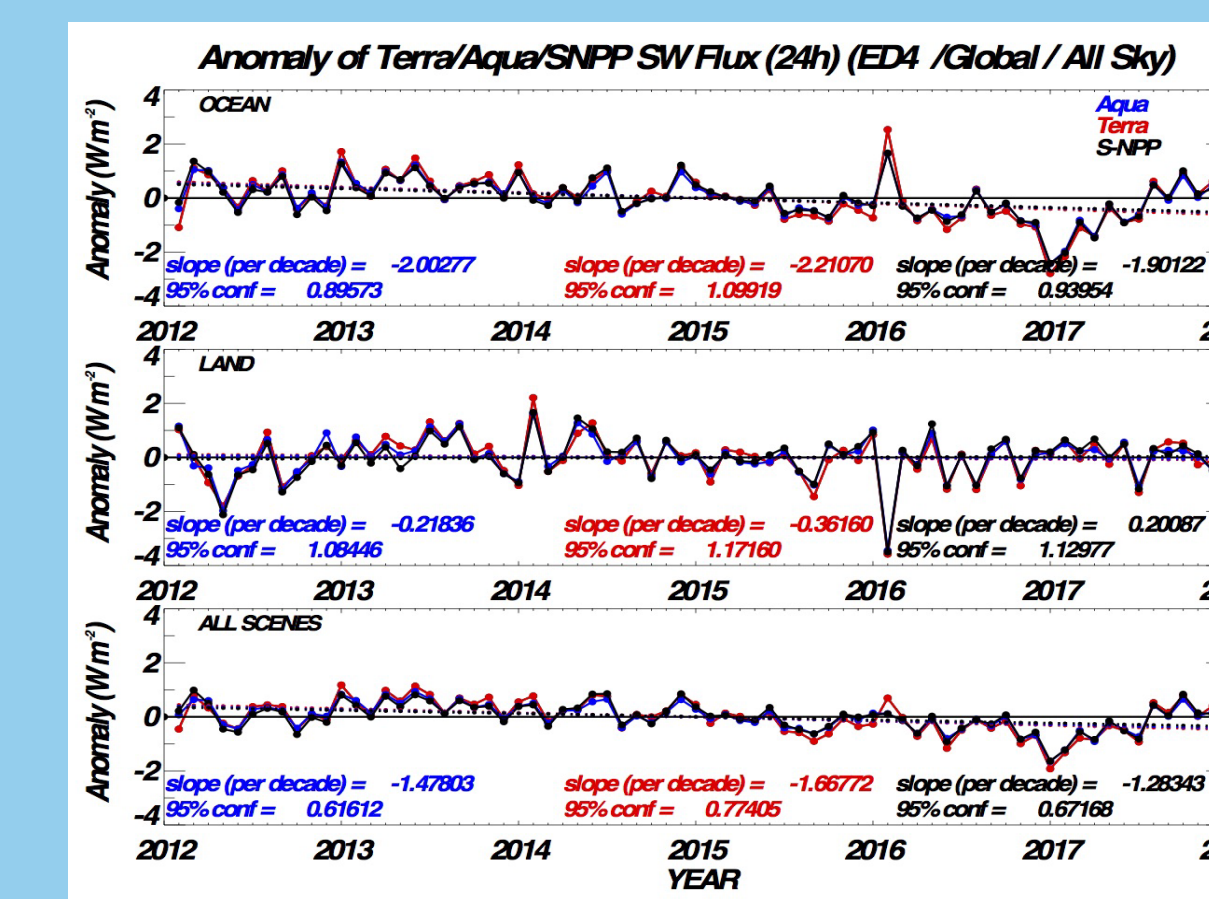


S-NPP, Terra & Aqua Compare

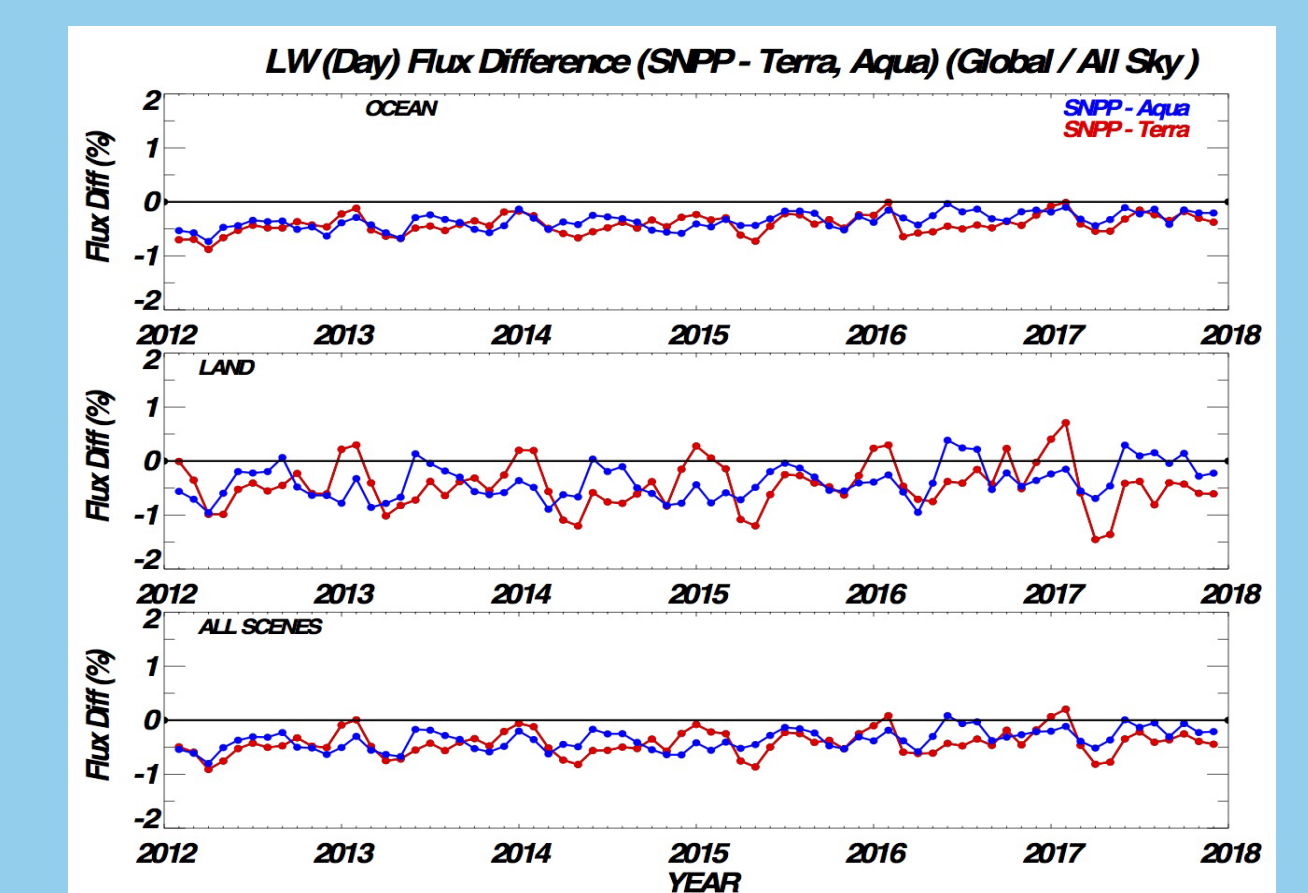
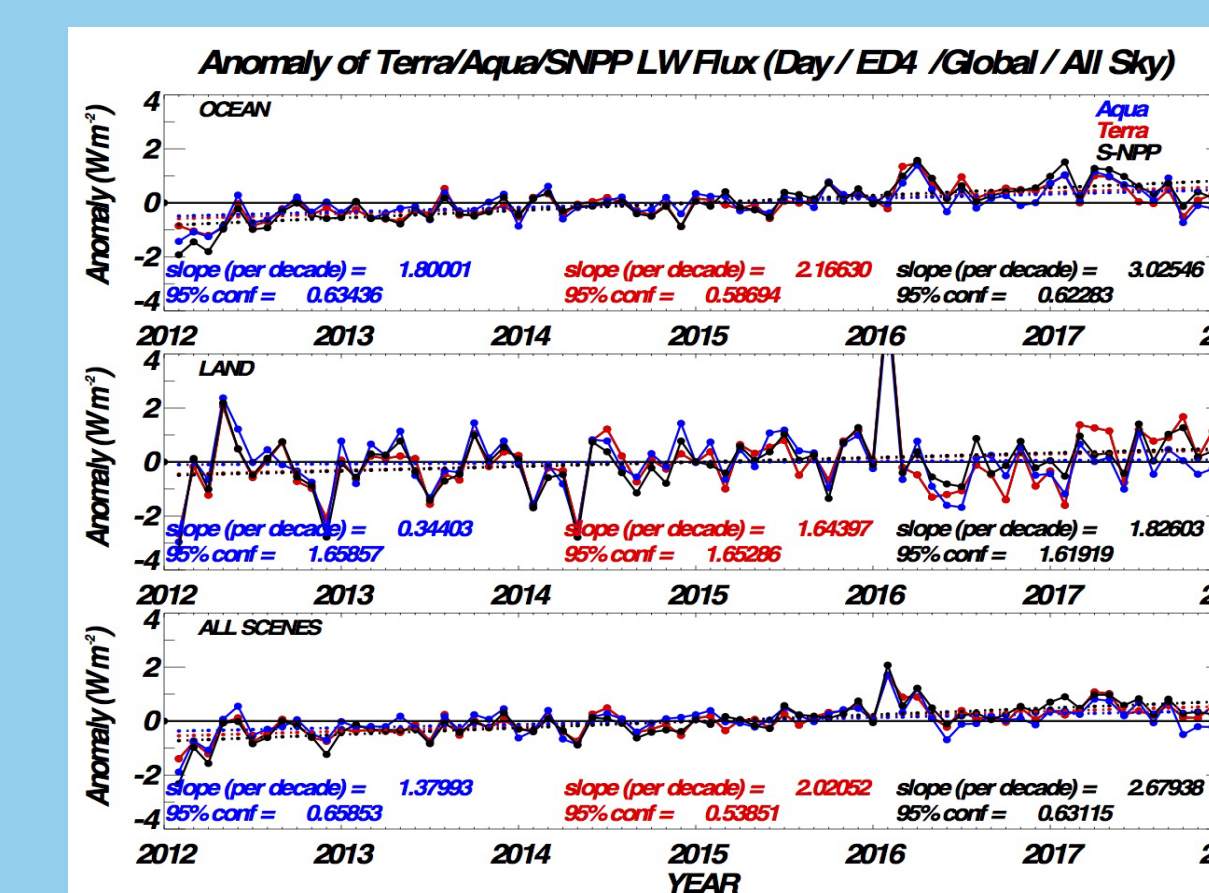
TARGET: Flux Differences between instruments

- SW and LW-Day Flux anomalies from the 3 instruments show similar trends.
- Flux differences between the instruments on different spacecraft were trended to evaluate the variations over time. SW Flux difference is stable through the period. LW-Day Flux difference between instruments show slight rising trend for ocean scenes in FM5 instrument.

SW Comparison



LW Day Comparison



Summary

- S-NPP/ CERES FM5 sensor performances based on in-flight calibration results with on-board targets (ICM and solar) show sensor stability is within the pre-launch accuracy goals.
- Validation results with Tropical Ocean and Deep Convective Clouds have shown that SW portion of Total sensor is relatively stable over time.
- Shortwave (SW) and Longwave (LW) measurements from the 3 CERES spacecraft show similar trends over mission period.
- CERES FM5 Edition1 data products are released through NASA Langley Distributed Active Archive Center (DAAC). The data period cover from March 2012 - April 2018.

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