CERES FM1 – FM6 Instrument Update

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CERES Instrument Working Group Team

CERES Science Team Meeting
NASA Langley Research Center
April 22 – 24, 2014

Instrument Working Group

Mission Operations/I&T

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- James Bailey -

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- Denise Cooper -

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-Susan Thomas–

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Nathaniel Smith

Nitchie Smith

Z. Peter Szewczyk

Robert Wilson

RBI and CERES FM6 Status

Kory Priestley

Radiation Budget Instrument : Status

RBI is intended to be a continuity measurement for the CERES observations

Request For Proposal (RFP) may be found at : https://www.fbo.gov , keyword is RBI.

- Final RFP released in June 2012
- Proposals received September 2013
- Evaluation of proposals underway
- Contract award anticipated Spring 2014

Radiometric Accuracy	CERES (k = 1)	RBI (k = 1)
Total Channel	Larger of 0.575 W/m^2-sr or 0.5%	Larger of 0.575 W/m^2-sr or 0.5%
Shortwave Channel	Larger of 0.75 W/m^2-sr or 1.0-%	Larger of .75 W/m^2-sr or 1.0%
Longwave Channel	Larger of 0.75 W/m^2-sr or 0.5%	Larger of 0.75 W/m^2-sr or 0.5%

CERES FM6 Instrument Performance Issues

- The CERES FM6 Team continues to pursue resolution of three issues:

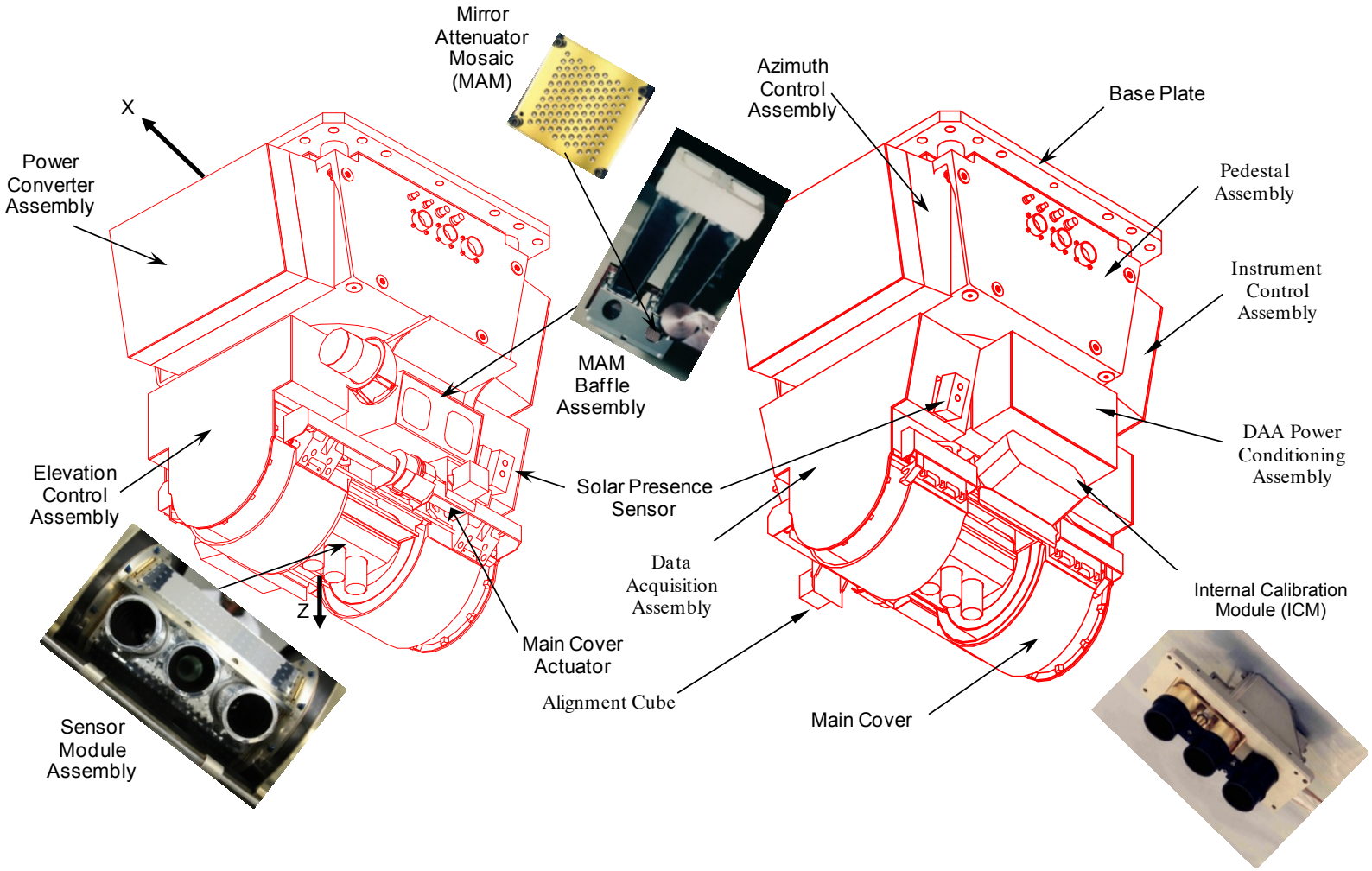
  1. Solar Diffuser Mirror Attenuator Mosaic (MAM) scatter non-uniformity
  2. Internal Calibration Module (ICM) lamp brightening
  3. Internal Calibration Module (ICM) reference detector photodiode (PD) response decrease

- In May of 2012, FM6 had completed its baseline calibration with the following open issues:
  - SWICS lamp appears to have increased in brightness throughout the calibration campaign whereas the source monitor photodiode indicated a decrease in source output throughout the calibration campaign
  - Data from MAM scatter testing indicate spatial non-uniformity of >4.5% vs. 1.5% measured at component level.
  - If not resolved, CERES FM-6 will not meet its on-orbit SW channel performance accuracy requirements

Root cause has been identified for all items, workarounds complete, instrument completing Assembly and integration

CERES Instrument Description

Clouds and the Earth's Radiant Energy System



Performance Resolution Approach

ICM Resolution (Complete)

- Isolate Performance Problems
  - ICM Vacuum Test determined the Lamp and PD performance issues are confined to the ICM
  - ICM Diagnostic Test to further isolate performance issues
- Select replacement flight Lamp and PD from CERES parts

MAM Resolution (Complete)

- Isolate Performance Problem
  - Diamond-Turned Tooling marks have been identified as the source of MAM performance issue
- Select replacement flight MAM from CERES heritage MAMs
  - Pre-condition MAM using AO asher from GRC

- Verify ICM performance in vacuum **(Complete)**
- Verify Instrument Performance (January 2013) **(Complete)**
- Conduct SAR/PSRR (April 2013) **(Complete)**

JPSS-1 Satellite I&T Overview

- Ball Aerospace & Technologies Corporation (BATC) in Boulder, CO is the JPSS-1 spacecraft provider and satellite integrator
  - BATC was also NPP S/C provider and integrator
- NGST will run first Bench Acceptance Test at BATC
- NASA LaRC personnel will perform CERES I&T activities at BATC
- JPSS will coordinate launch operations through NASA KSC
  - Launch will be from Vandenberg Air Force Base, CA (same as NPP)
  - Launch vehicle provider has not been selected yet
- I&T will heavily leverage success accomplished on NPP
  - Reuse NPP I&T flow & procedures minimizing changes
  - Integrate lessons learned from NPP for JPSS-1 I&T

JPSS-1 Satellite I&T Schedule

- CERES Delivery to BATC — June 2014
- CERES Bench Acceptance Test — June 2014
- First Instrument Integrated (CERES): — October 2014
- Last Instrument Integrated: — May 2015
- Satellite Pre-Environmental Review: — August 2015
  - Dynamics Testing Complete — November 2015
  - EMI – EMC Complete — February 2016
  - TVAC Complete — March 2016
- Satellite I&T Complete: — May 2016
- Ship to Launch Site: — September 2016
- Launch Readiness Date: — October 2016

CERES – JPSS-1 I&T Summary

- **CERES I&T Activities for integration to JPSS-1 are being planned**
  - **Activities and documents are being coordinated with BATC**
- **CERES Project expects to retain most key I&T personnel from CERES FM5 on NPP**
  - **Some new personnel will be added and young team members to be mentored to gain experience for longevity**
- **I&T staffing levels are planned and conflicts with other LaRC Projects seems manageable**
- **CERES Team personnel have already been participating in I&T discussions with JPSS and BATC**

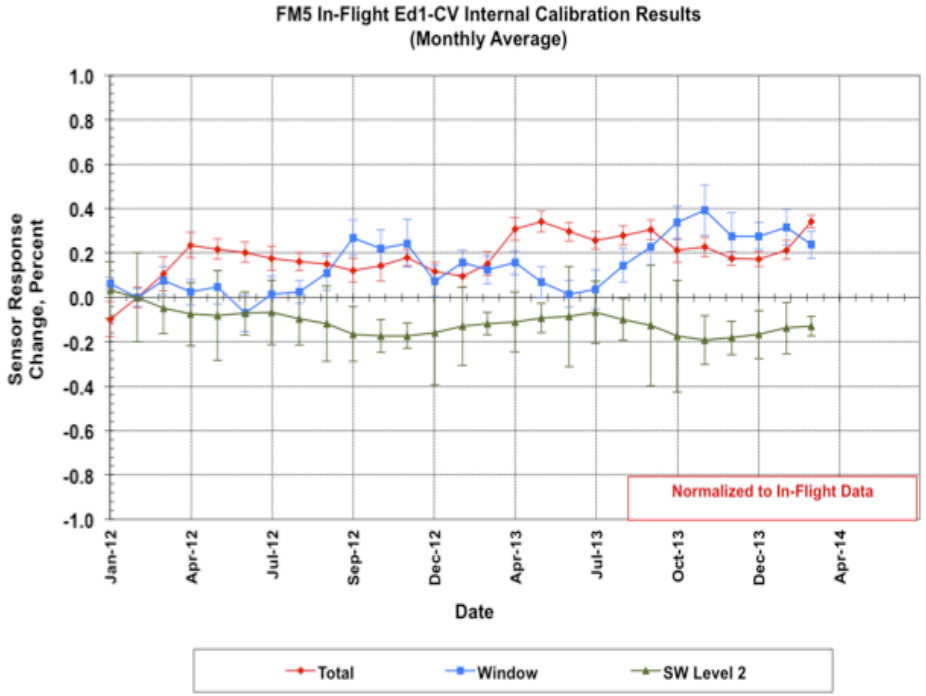
CERES Team will be ready to support JPSS-1 Satellite I&T

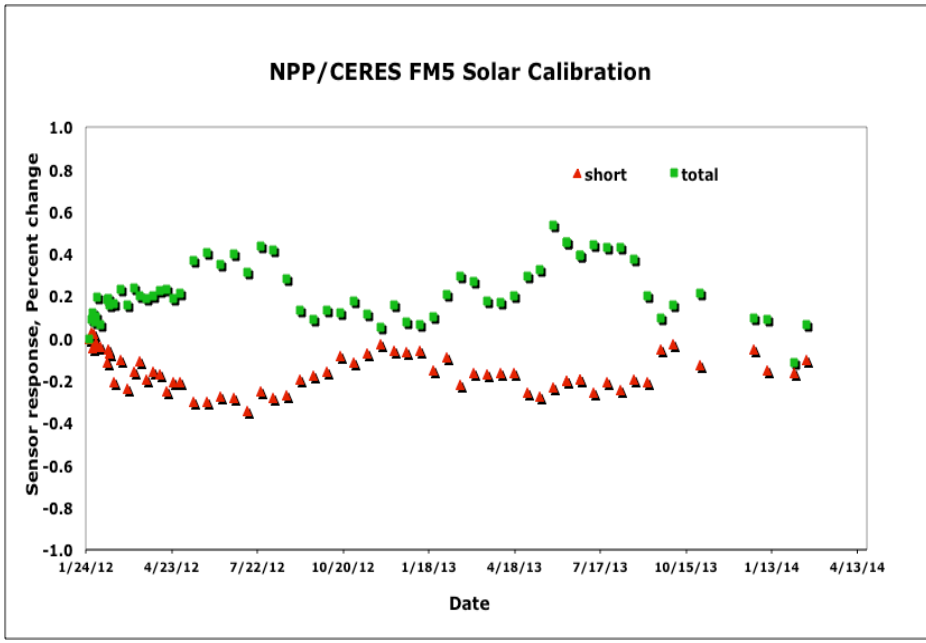
Suomi-NPP/ CERES FM5 Instrument Status

Suomi NPP/CERES FM5 Instrument Status

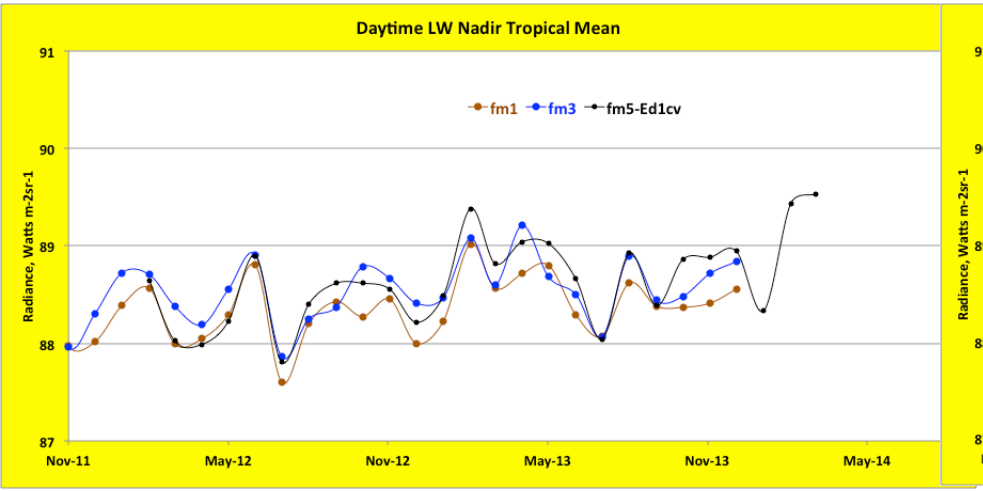
CERES FM5 has completed 2 years on-orbit operations.

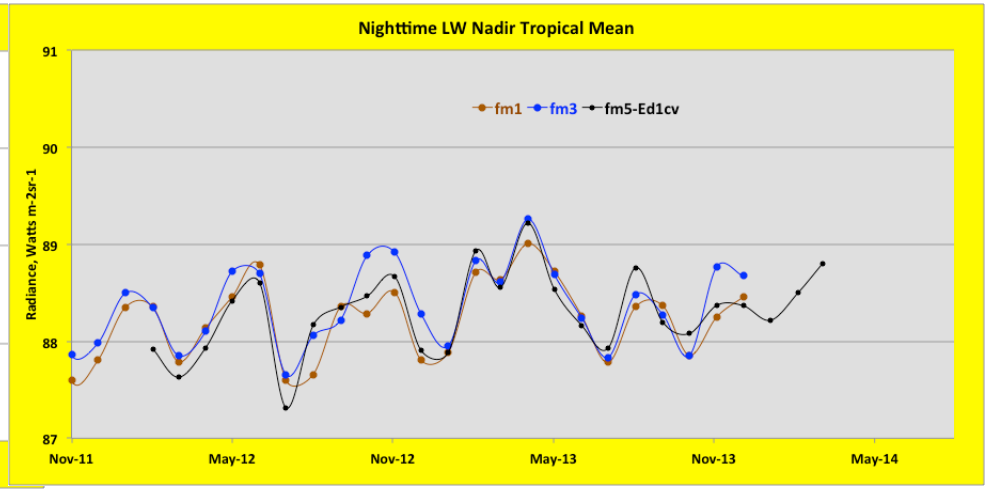
The calibration and validation results show the instrument on-orbit performance are within the expected range during this period.

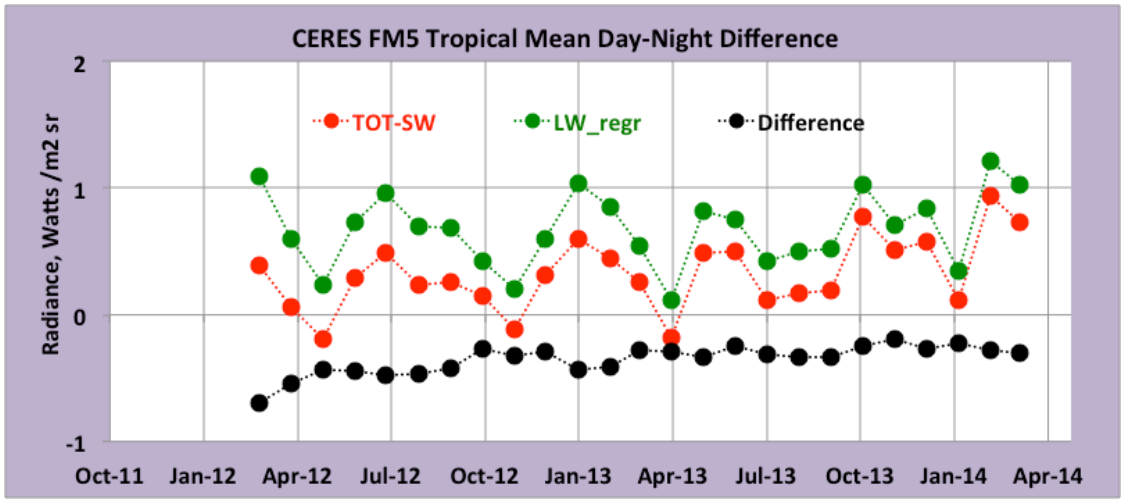




Suomi NPP/CERES FM5 Validation: Tropical Mean

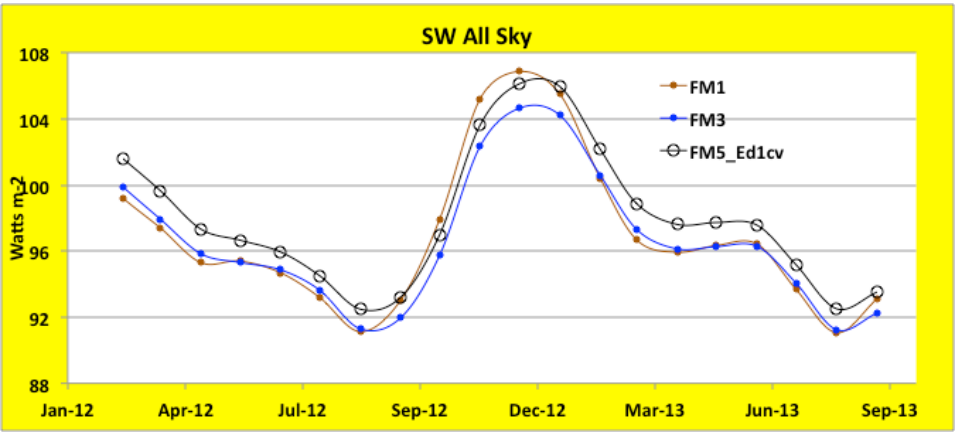


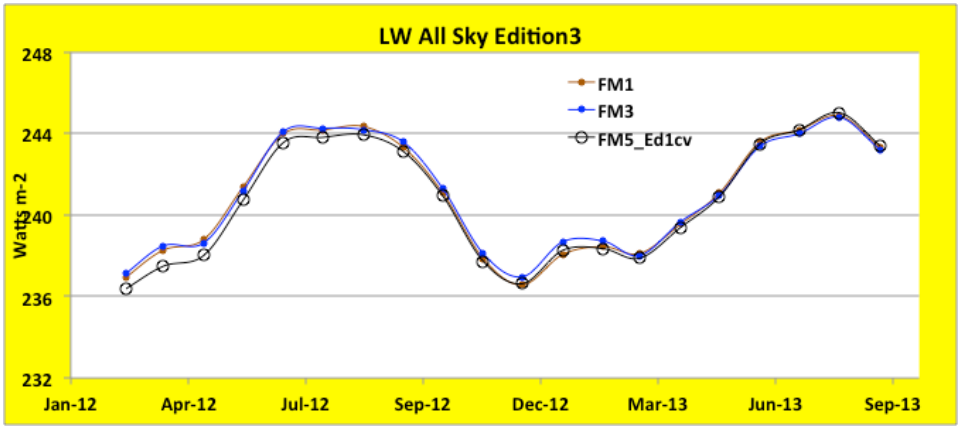


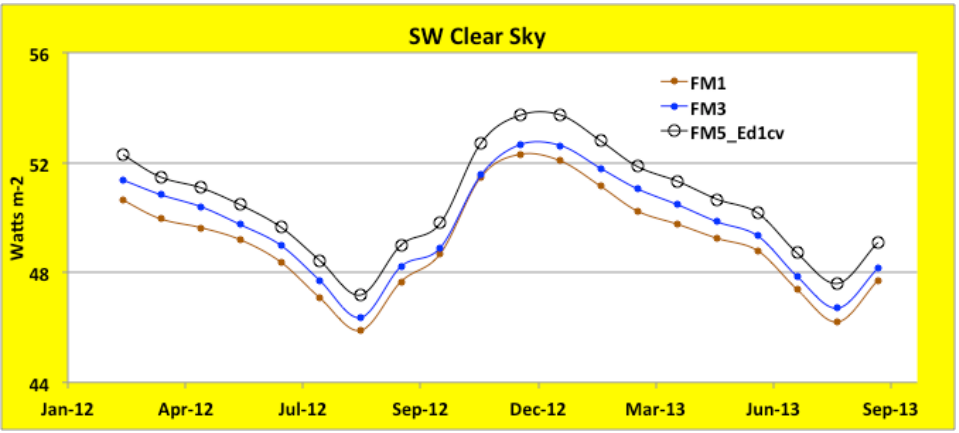


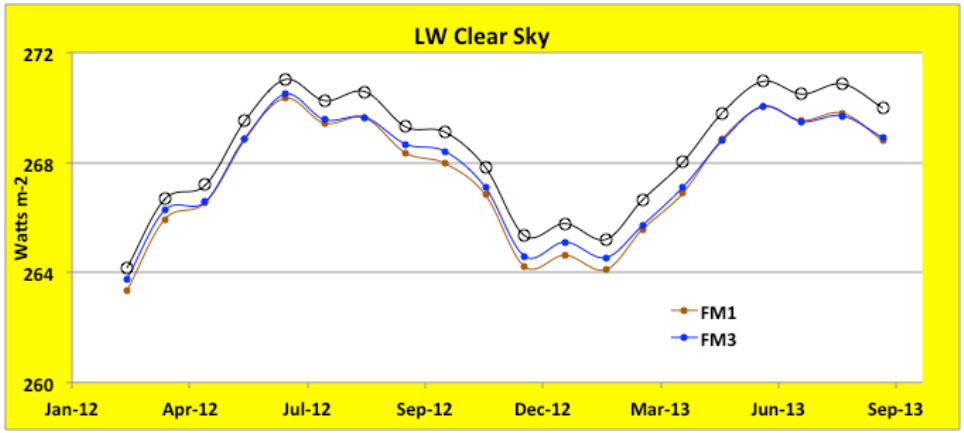
CERES FM5 – Global Flux Comparison (ES4)

Comparison with CERES FM1 and FM3[Feb 12 – Sept 13]









CERES FM5/FM3/FM1 Inter-Comparisons

Three strategies in place for matched footprint comparisons

- NPP and Aqua Simultaneous Observation occur every 64 hours and last ~20 minutes with views < 1 minute apart. Comparison based on 1^o x1^o grid averages with relative VZA <15 deg and RAZ < 10 deg.
- NPP/ Aqua Nadir Dwell Scan profile for Targeted sites. Ground-track match is within 0.5 deg on Latitude and 0.25 deg for Longitude with views < 5 minutes.
- NPP (FM5)/Aqua(FM3)/Terra (FM1) Measurements in the minor plane: Targeted region is 68^o N and the observation duration is ~ 2.5 minutes. The campaign spans from May – July.

SW measurements on FM5 is greater than FM3 and FM1 in all three methods.

LW Day measurements on FM5 is lower than FM3 and FM1 in all cases.

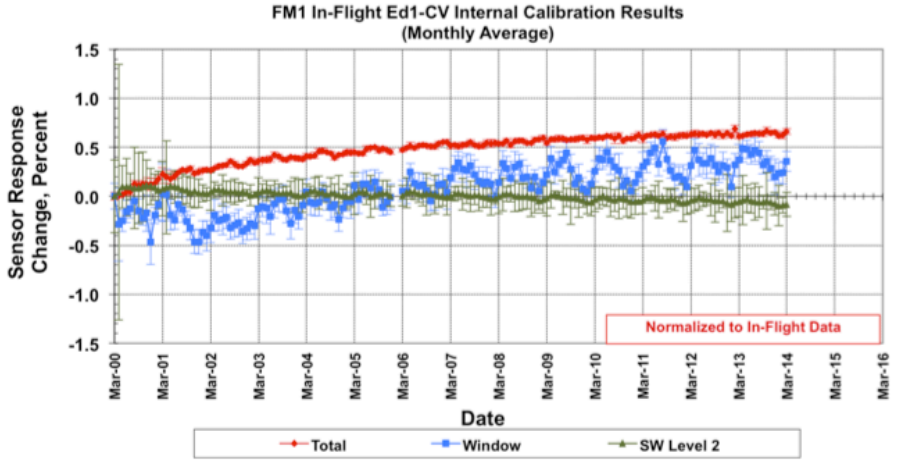
LW night measurements are within 1% for all instruments.

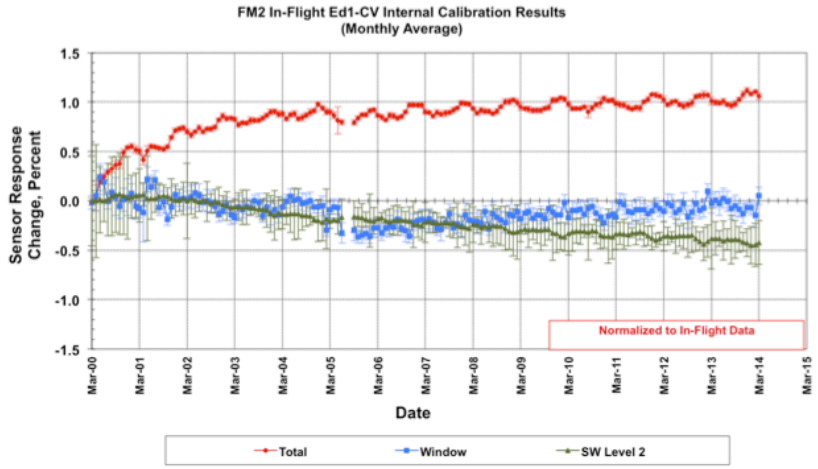
Z. P. Szewczyk will give detailed discussion on the methodology in Co-I report.

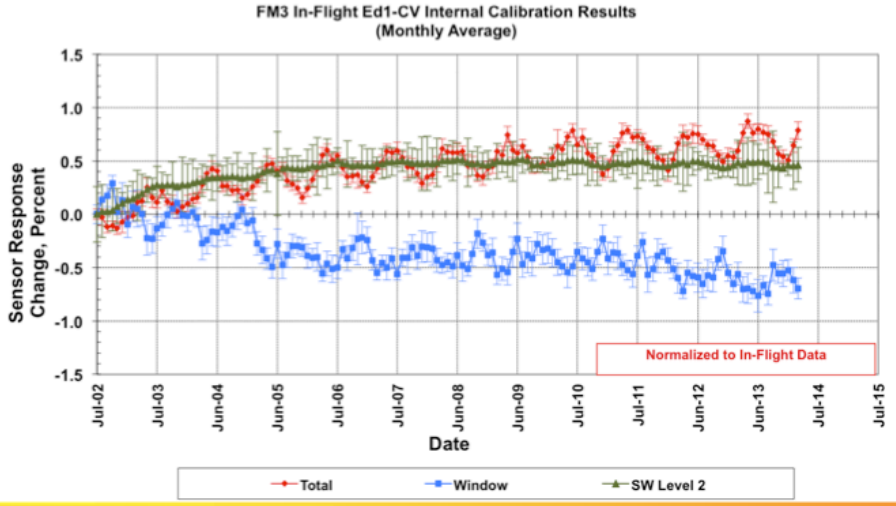
TERRA & AQUA INSTRUMENT STATUS

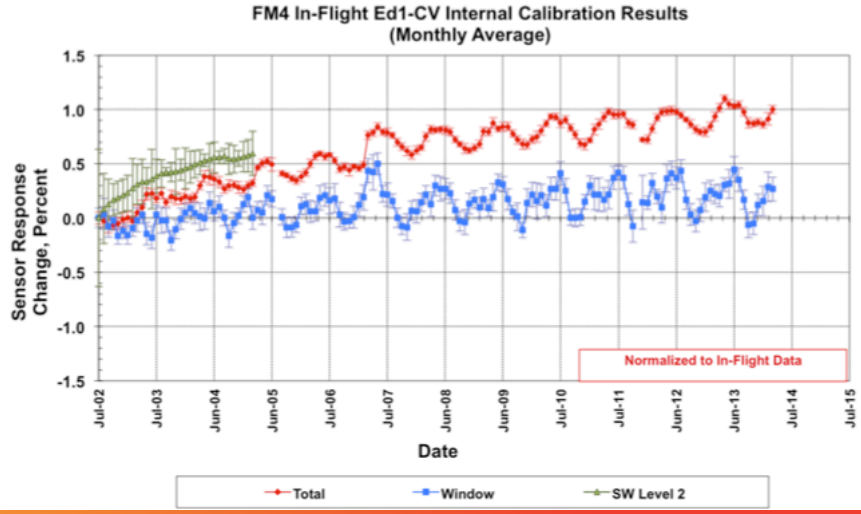
[CERES FM1 – FM4]

Terra – Aqua Sensor Performance









TERRA/AQUA EDITION-4 Updates

Start of Mission: Terra/Aqua Gain same as Edition3

Terra SRF same as Edition3

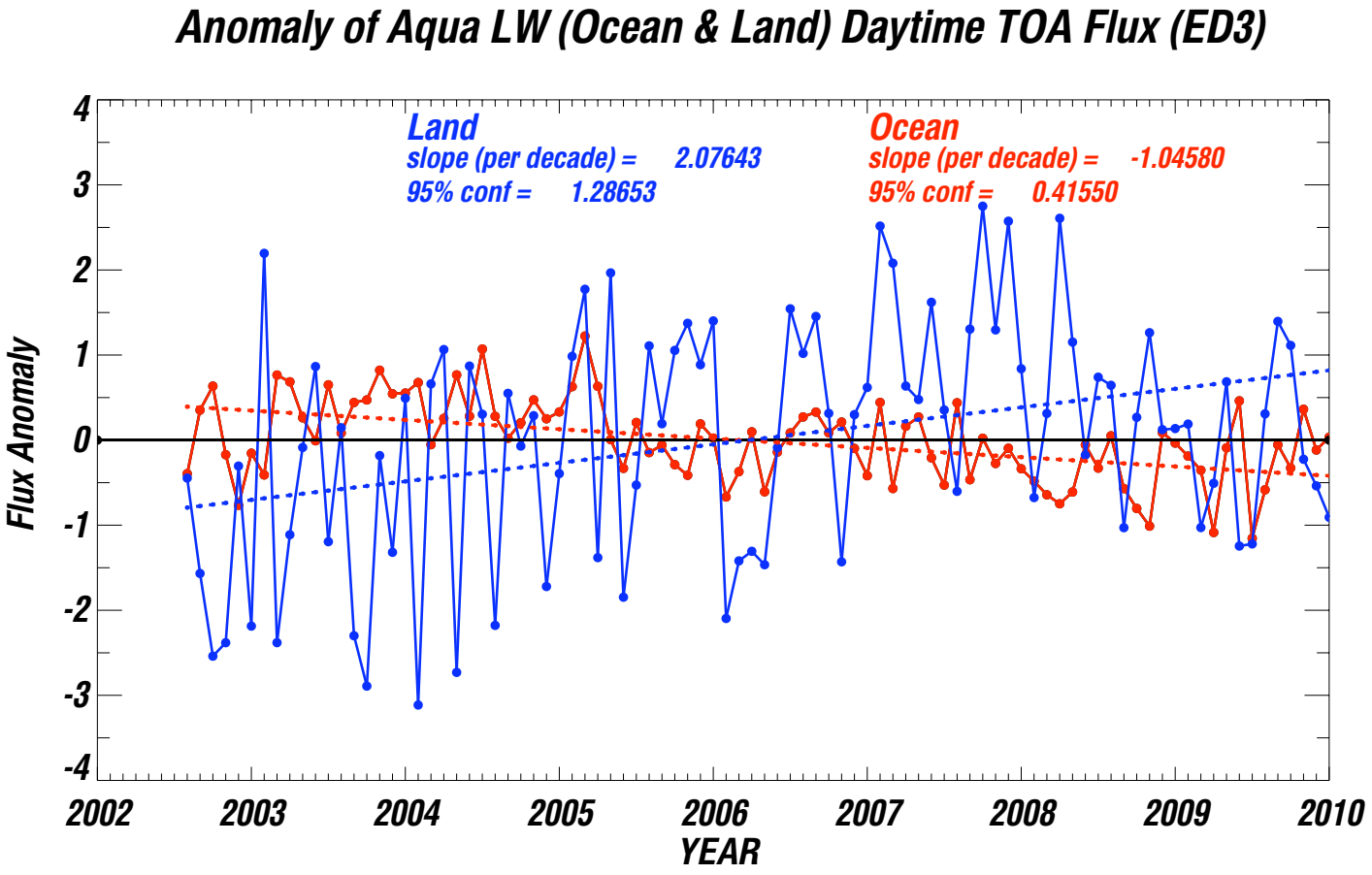
Aqua SRF: SW and SW/TOT update on FM3

The monthly Gain values for the Total, Window and Shortwave sensors are based on the in-flight ICM calibrations.

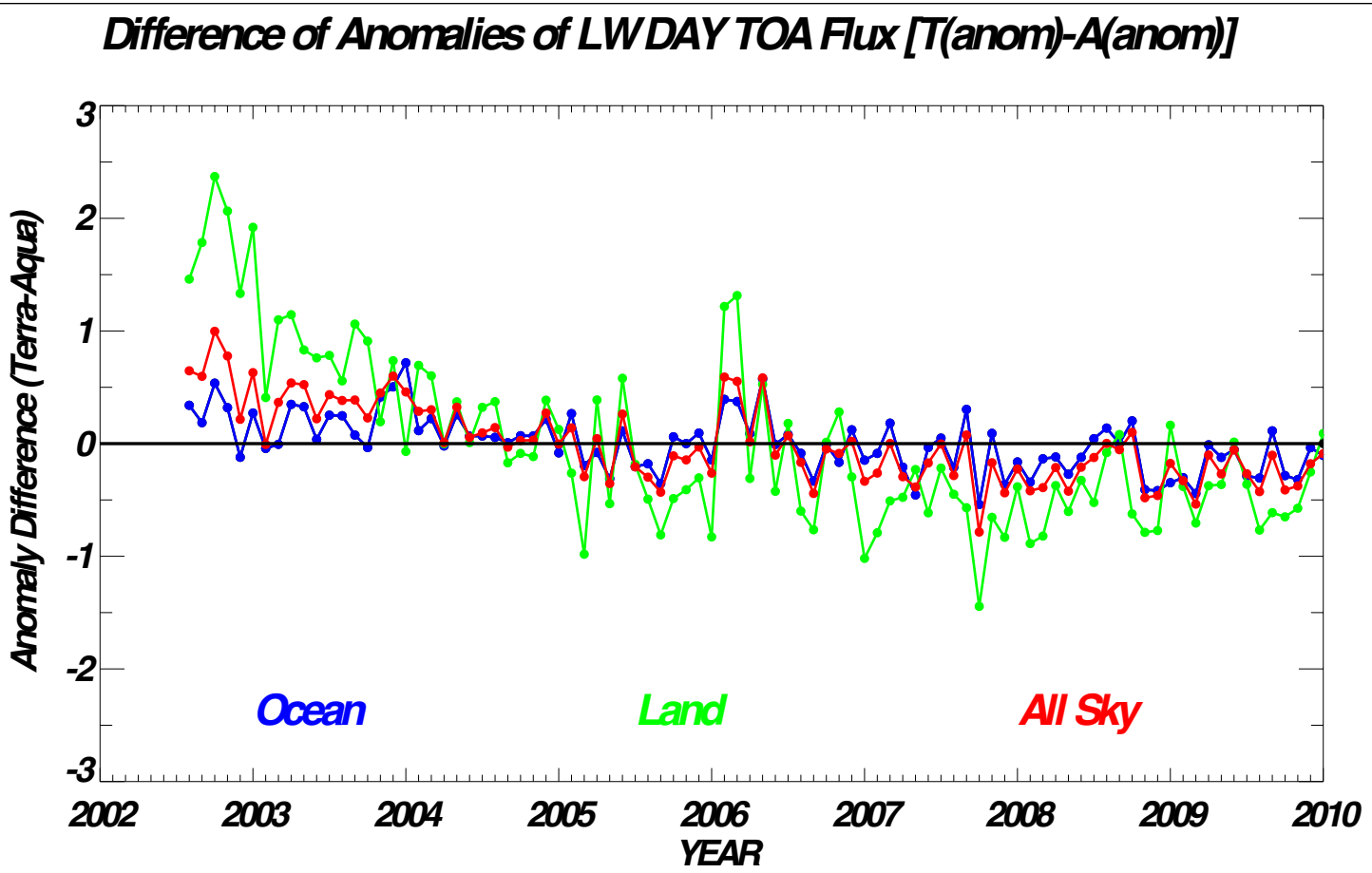
The monthly SRF corrections for spectral degradation are applied to SW sensor. (same approach as Edition3)

Revised methodology to derive the monthly SRF correction in SW/TOT sensor. All-sky Ocean and Land measurements are used in determining the spectral changes.

Aqua EDITION-3 LW Flux: Ocean and Land



Terra -Aqua EDITION-3 LW Flux Anomaly



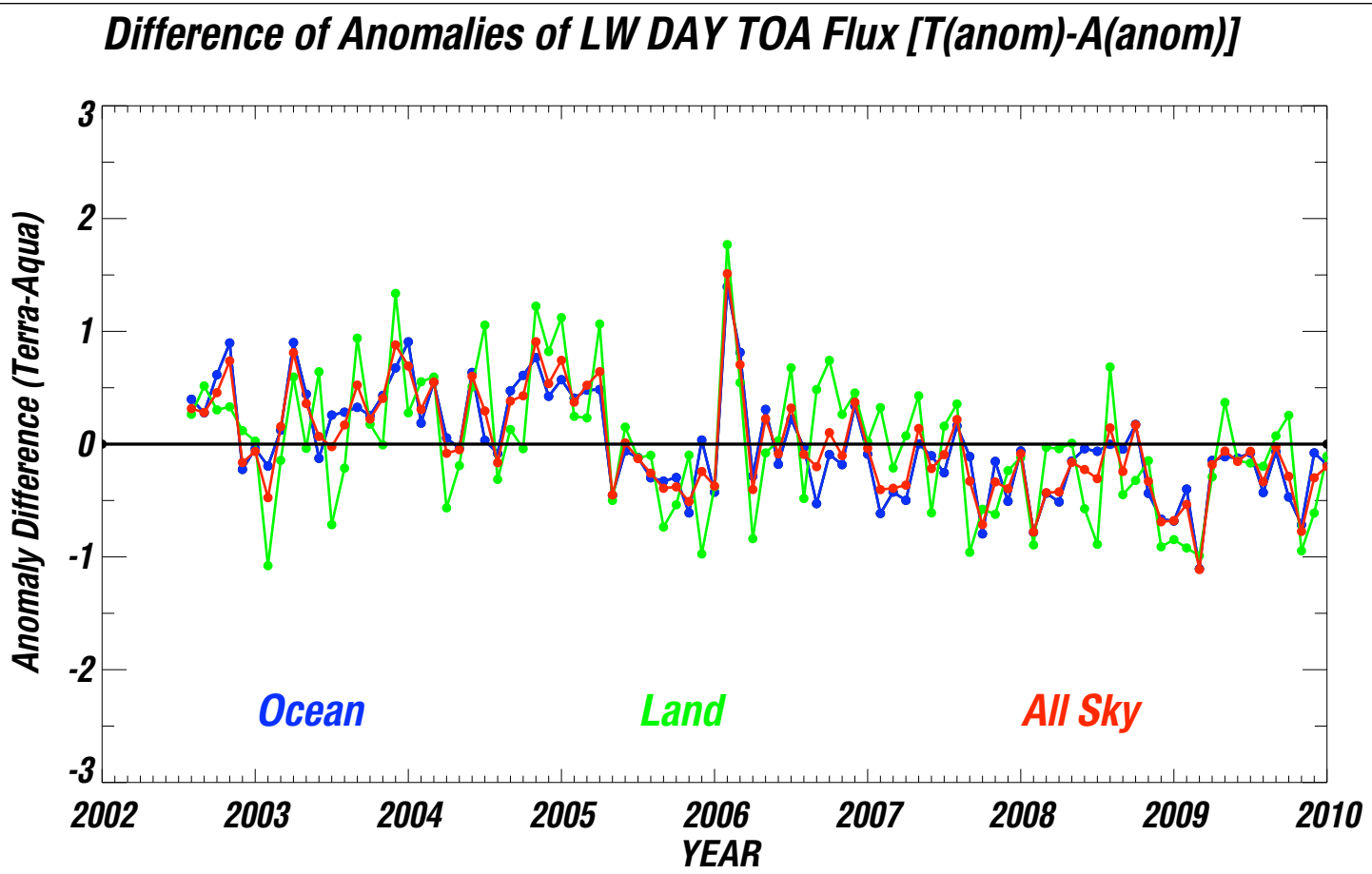
TERRA/AQUA SW/TOT Spectral Response

- **The corrections applied to SW/TOT SRF is of the functional form:**

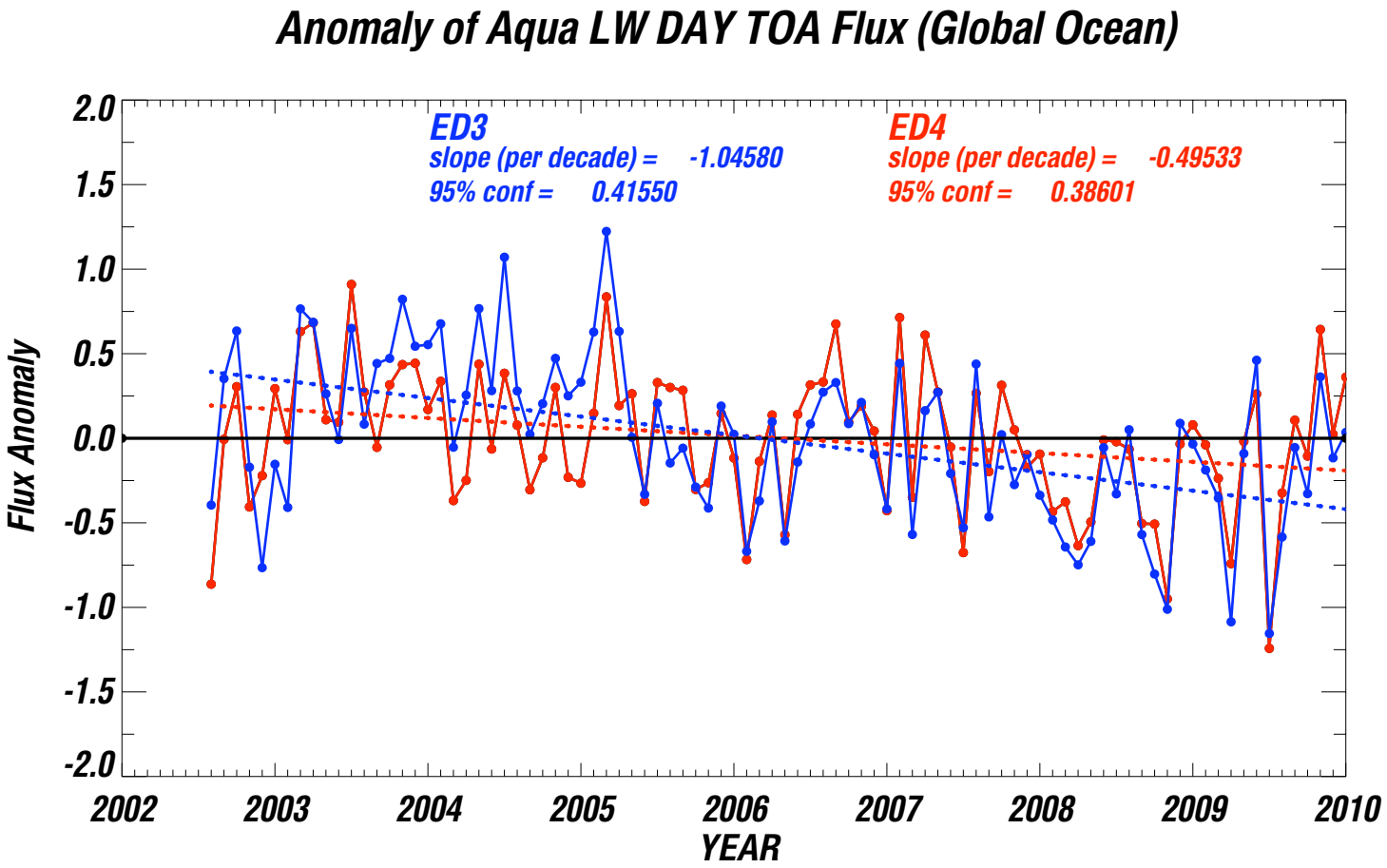
$$D(\lambda) = [1 - e^{-\alpha\lambda}] + \beta$$

- **A Database of candidate SRFs is created for all possible Alpha and Beta combinations, corresponding to each corrected SW SRF.**
- **Monthly LW-day measurements are calculated for All-sky Ocean and All-sky Land scenes in Tropics (30N – 30S) for each candidate SRF.**
- **Regression between LW(Day-Night) and WN (Day-Night) for each candidate SRF for both Ocean and Land scenes.**
- **The solution is determined from candidate SRFs that show the best fit for ocean and land scenes and provide the least bias with the first month in mission.**

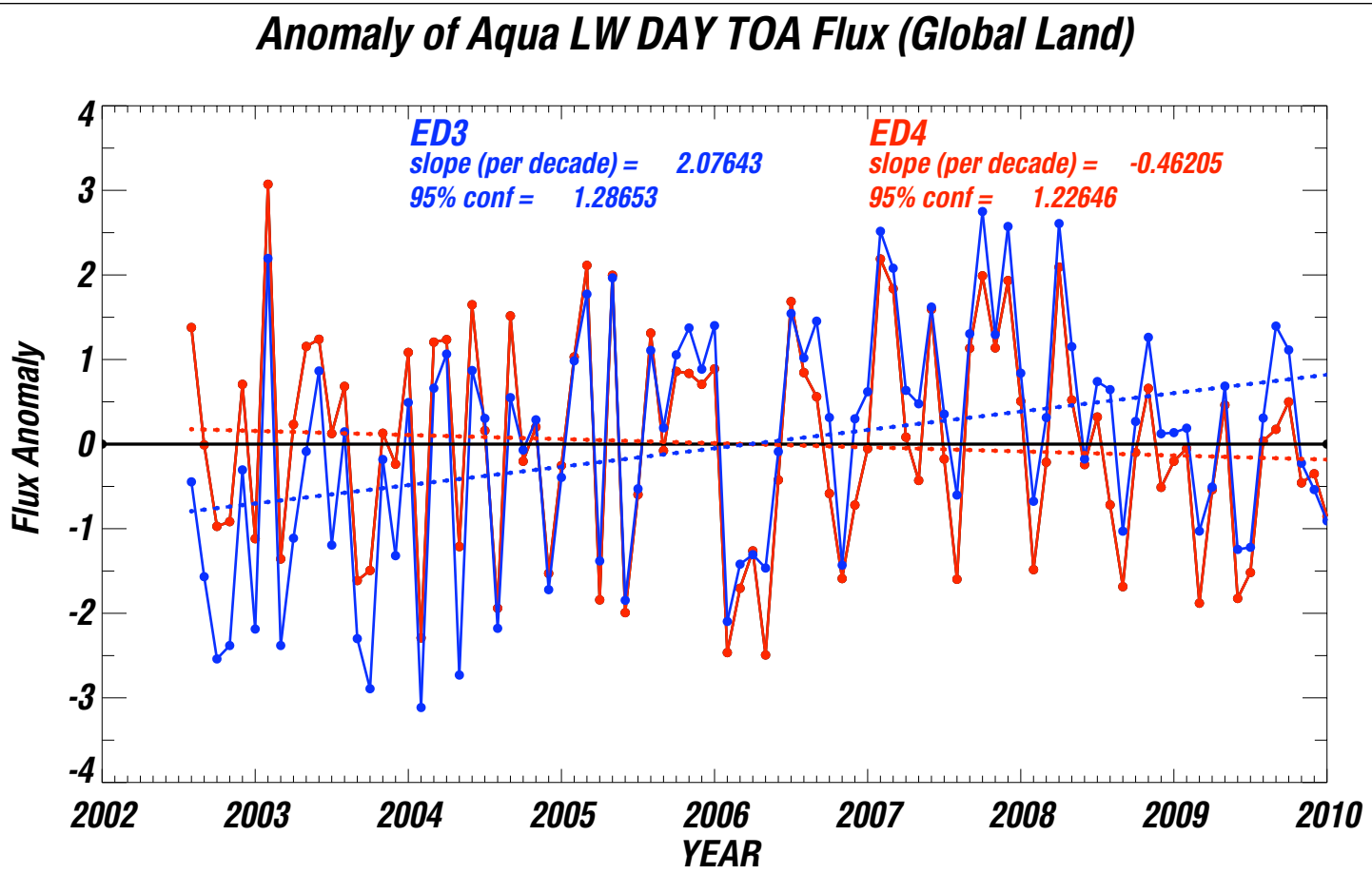
Terra -Aqua EDITION-4 LW Flux Anomaly



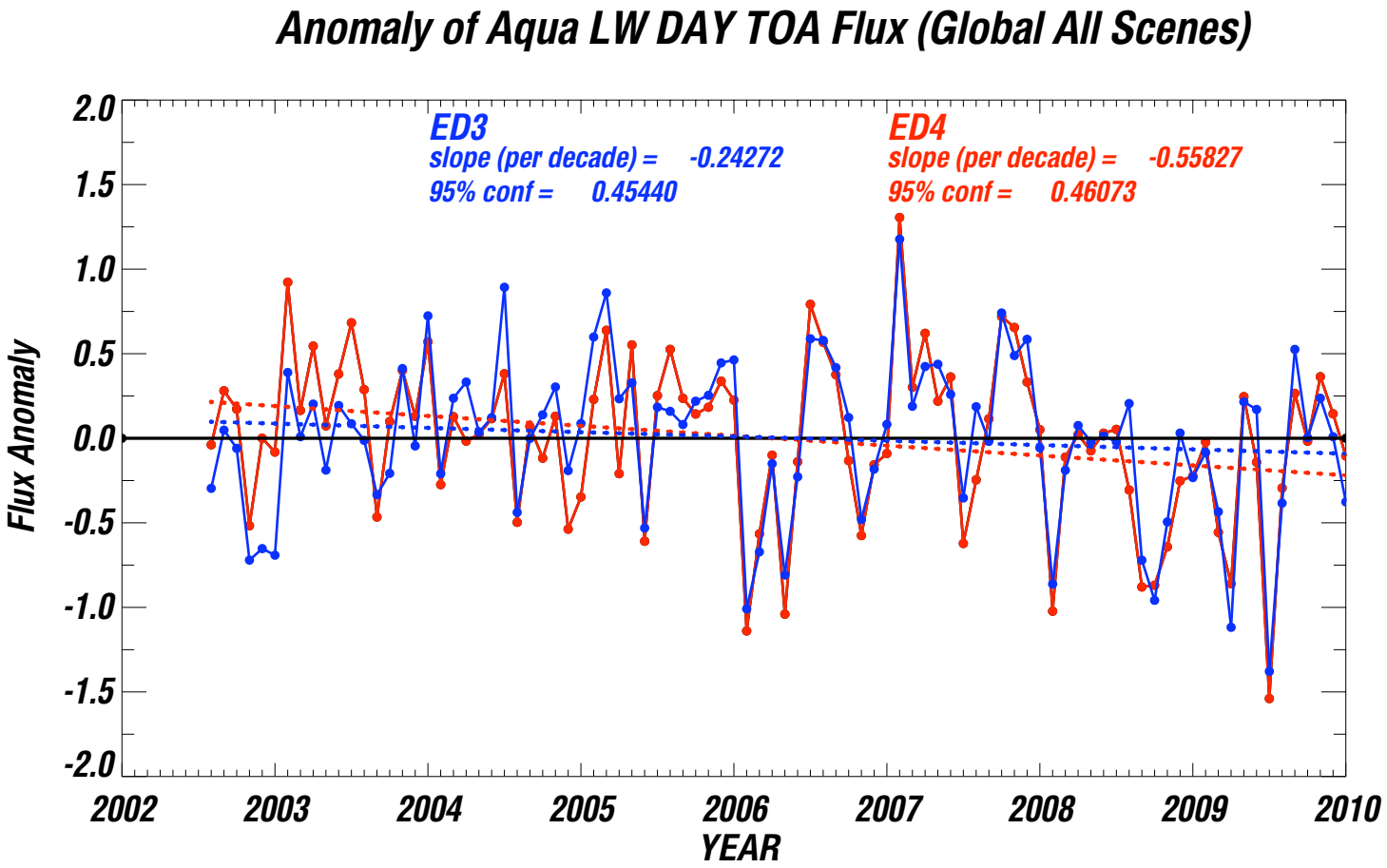
Aqua EDITION Compare: All-sky Ocean LW Day Flux



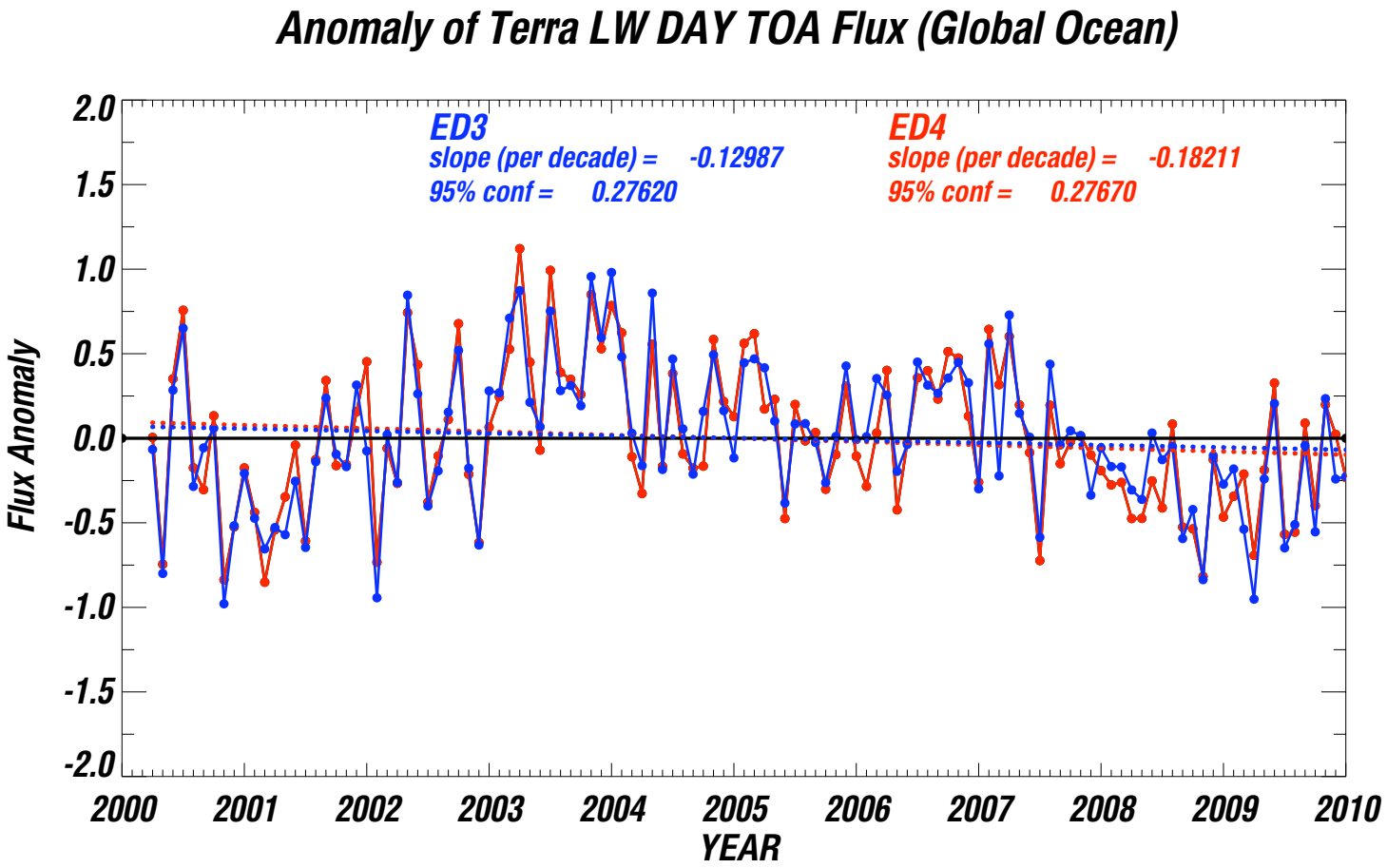
Aqua EDITION Compare: All-sky Land LW Day Flux



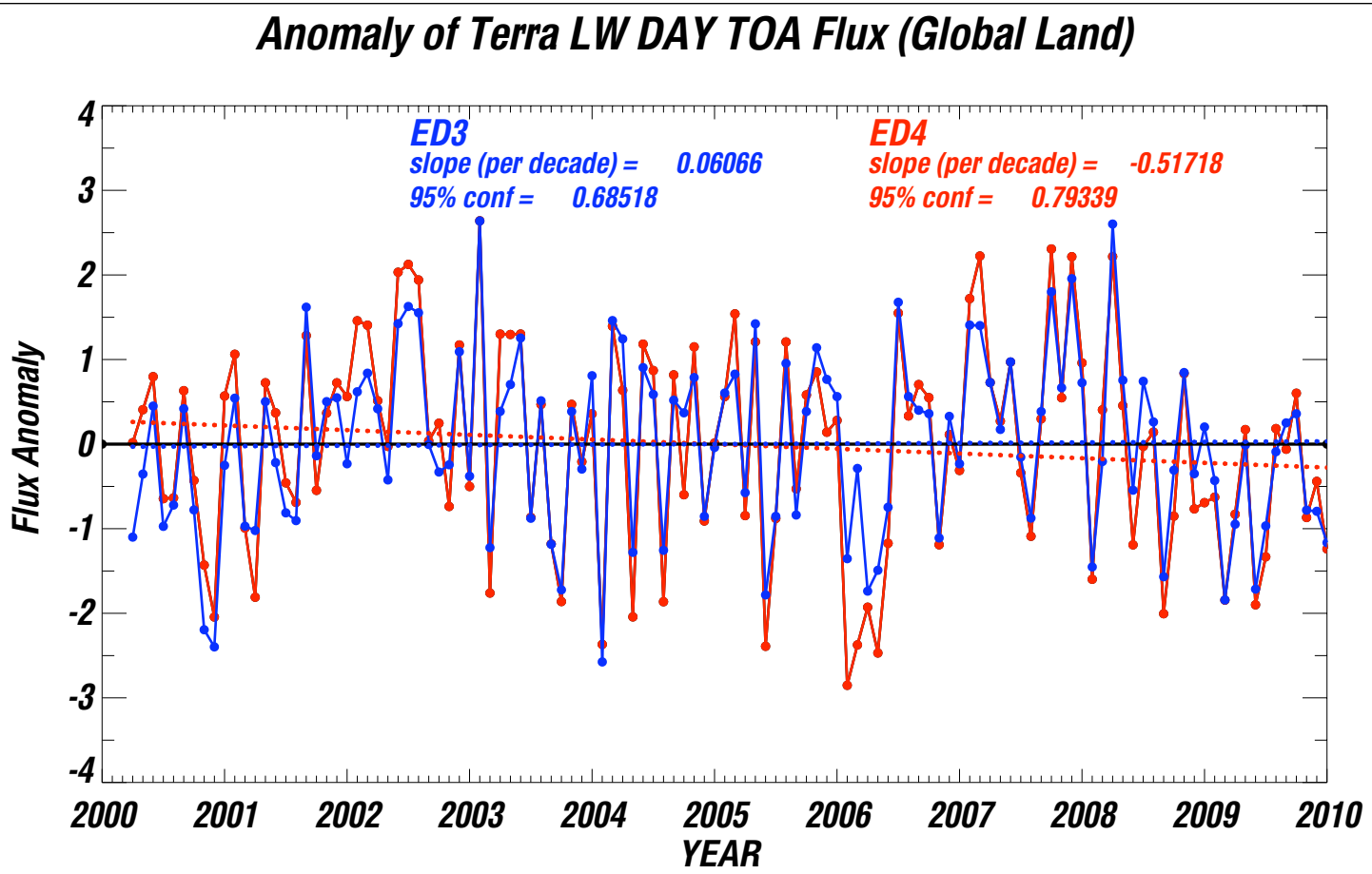
Aqua EDITION Compare: LW Day Flux All Scenes



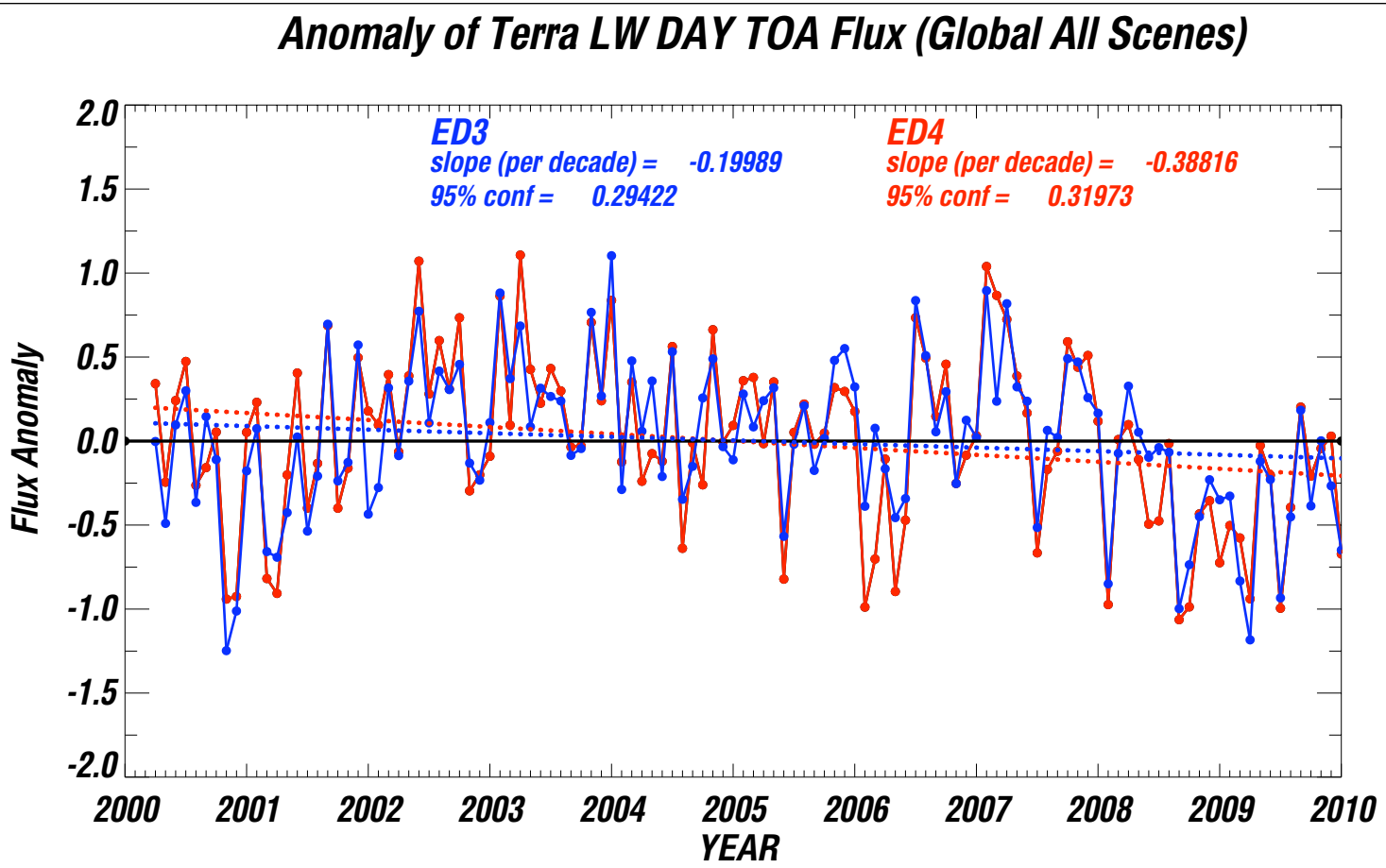
Terra EDITION Compare: All-sky Ocean LW Day Flux



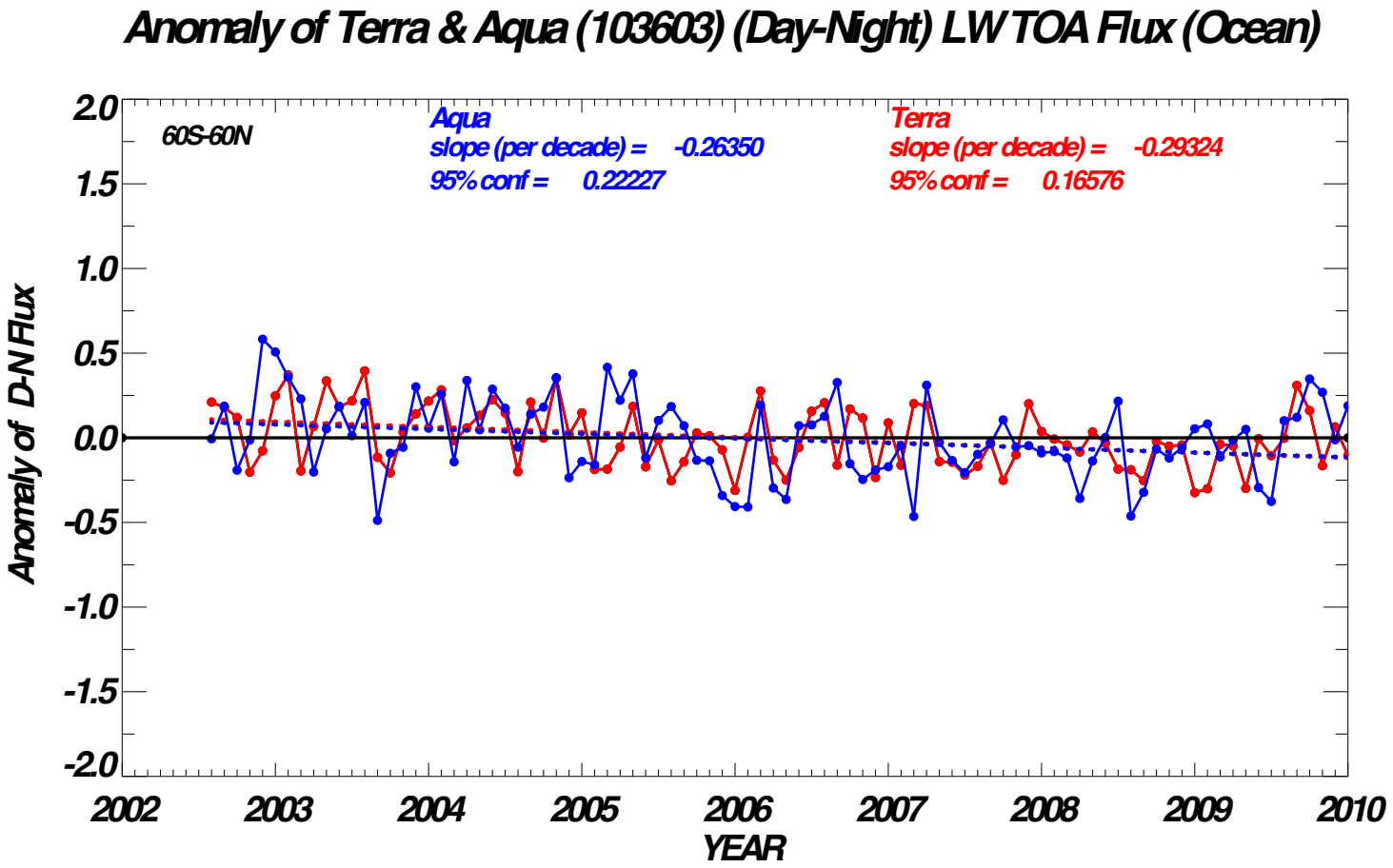
Terra EDITION Compare: All-sky Land LW Day Flux



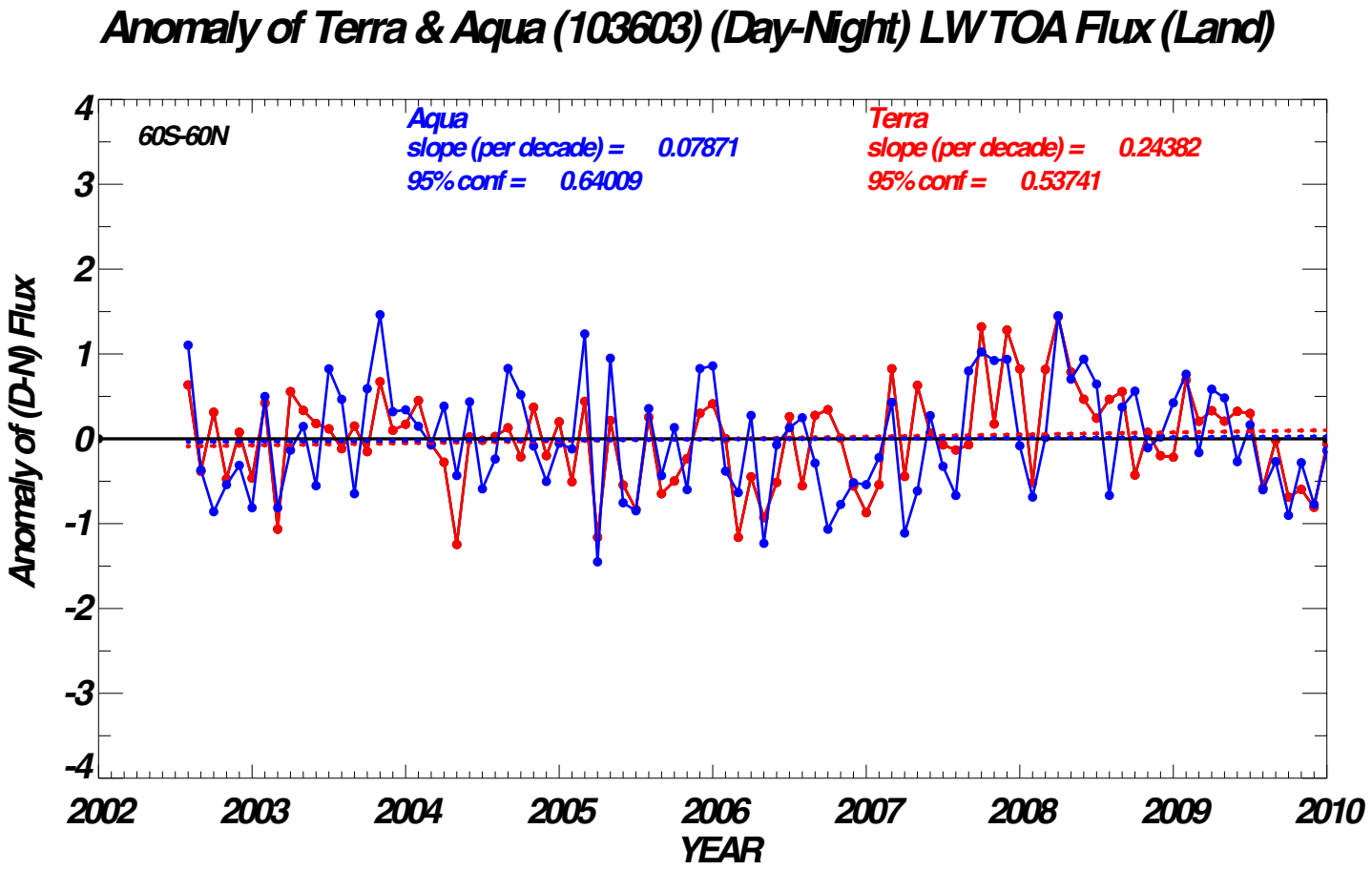
Terra EDITION Compare: LW Day Flux All Scenes



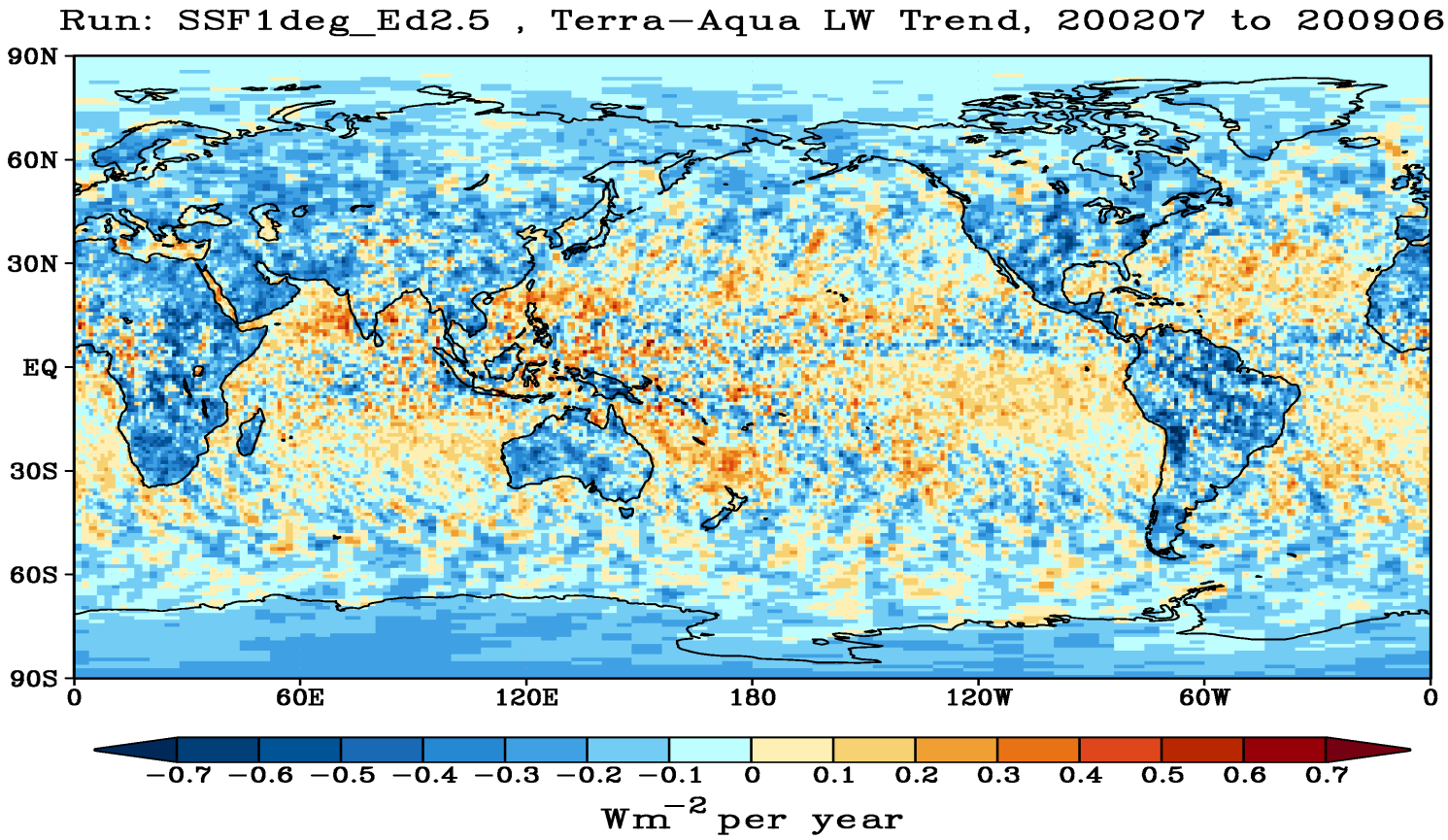
EDITION-4: LW Day – Night Flux Difference: Ocean



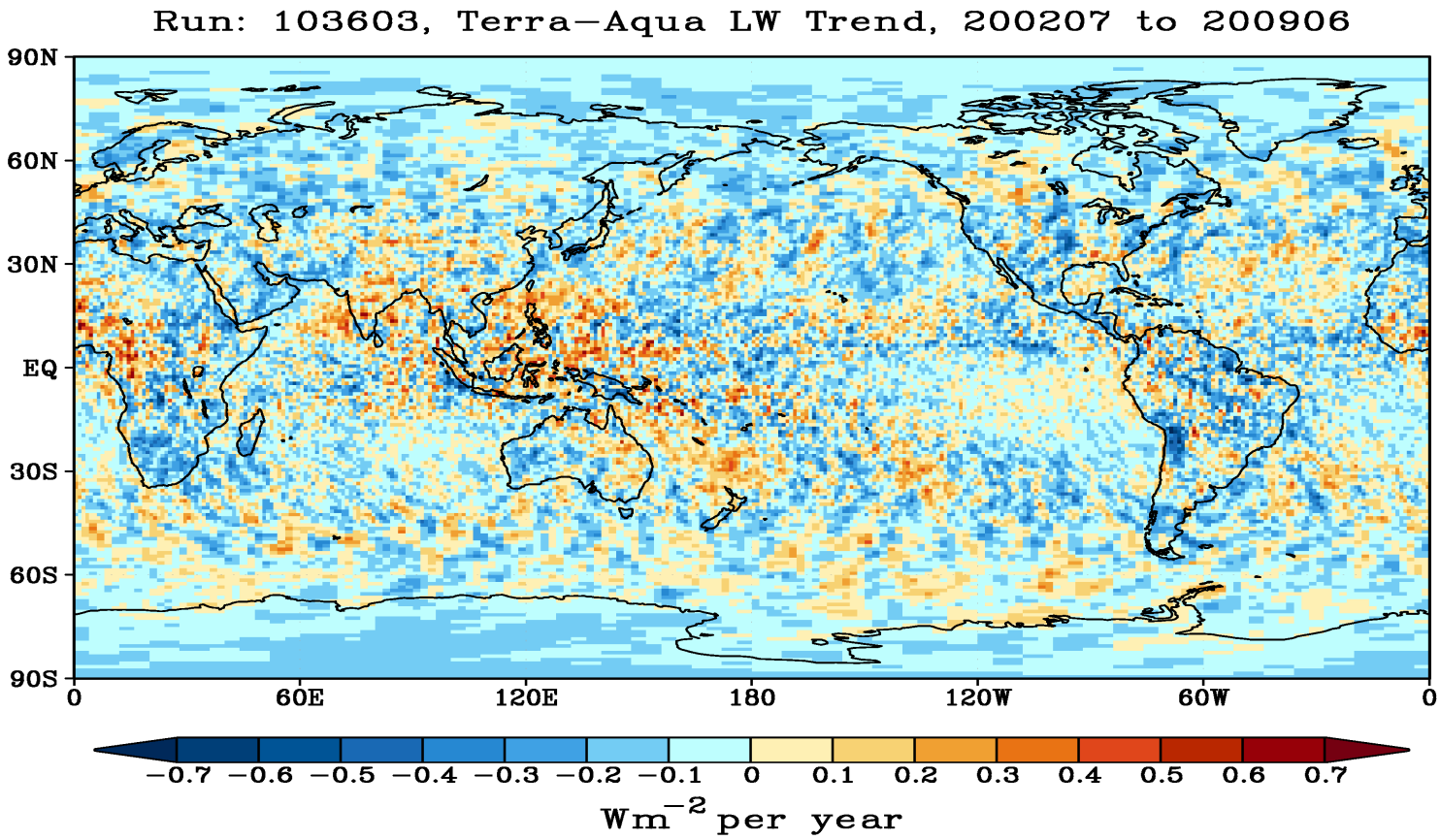
EDITION-4: LW Day – Night Flux Difference: Land



Terra-Aqua LW Difference Trend: Edition-3



Terra-Aqua LW Difference Trend: Edition-4



TERRA/AQUA DATA AVAILABILITY

Edition1-CV Data Products (Instrument & ERBE-like):

Start of Mission – March 2014

Edition3 Data Products (Instrument):

Start of Mission – December 2013

Edition4 Gains and Spectral Response Functions (SRF) :

Terra: Delivered - Start of Mission to Dec 2009

Aqua: Delivered - Start of Mission to Dec 2009

SUMMARY

- CERES FM6 Instrument has successfully completed the System Acceptance and Pre-Ship Readiness Review. The instrument will get shipped to Ball Aerospace in June 2014.
- Performance trends of S-NPP/CERES FM5 instrument are within the normal range. The sensor gains for Edition1 processing will be delivered in May 2014.
- New method was used to calculate the sensor response correction for SW/TOT region. Instrument Gains and SRFs for the Edition4 processing for Terra/ FM1 & FM2 and Aqua/FM3 & FM4 were delivered.

BACK UP SLIDES

TERRA/AQUA SW Spectral Response Correction

Assumption:

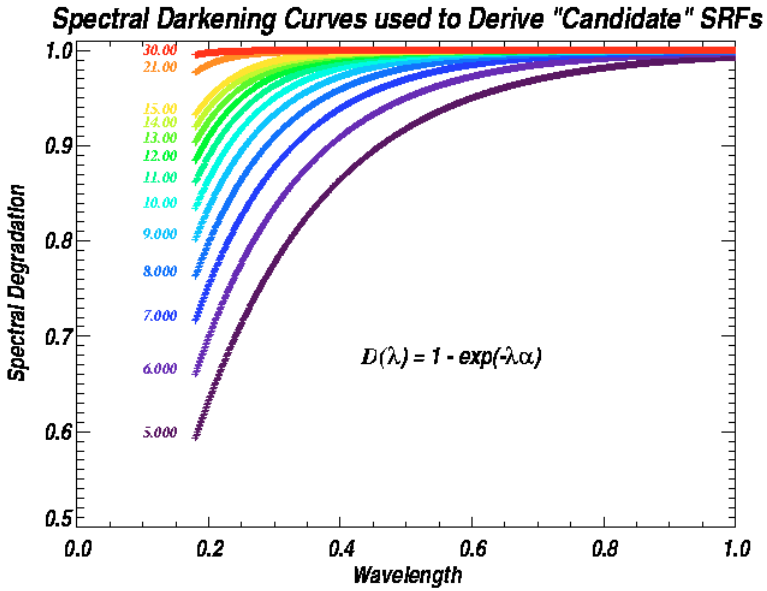
Temporal variation in the SW unfiltered radiance ratio is due to spectral degradation.

Spectral degradation occurs only on RAPS instrument

Approach:

The best SRF is selected from ‘candidate’ set of SRFs to correct spectral darkening for the instrument operating in RAPS mode, such that the monthly SW unfiltered radiance ratio remain constant throughout the mission.

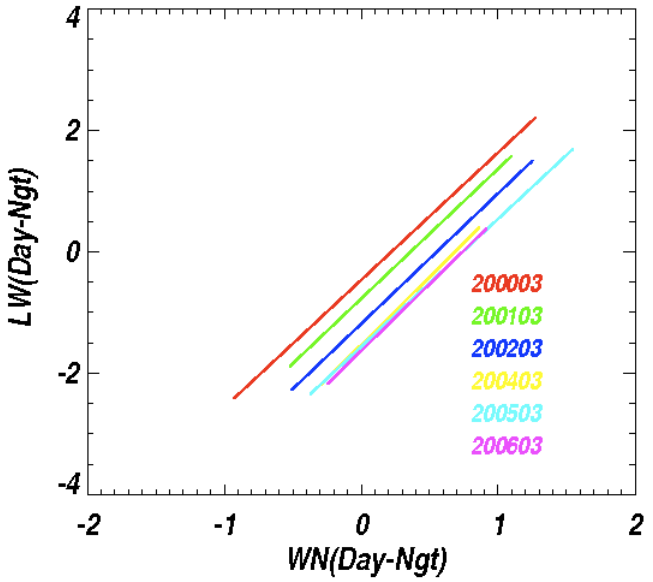
No correction is applied to the instrument in cross-track mode.



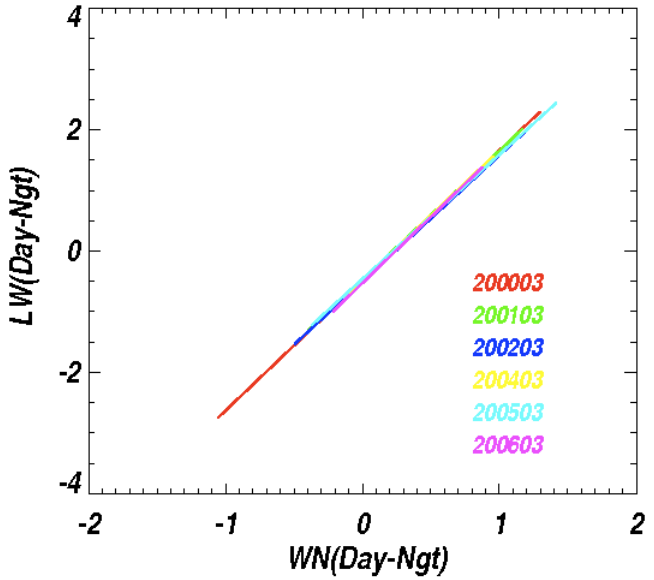
TERRA/AQUA SW/TOT Spectral Response

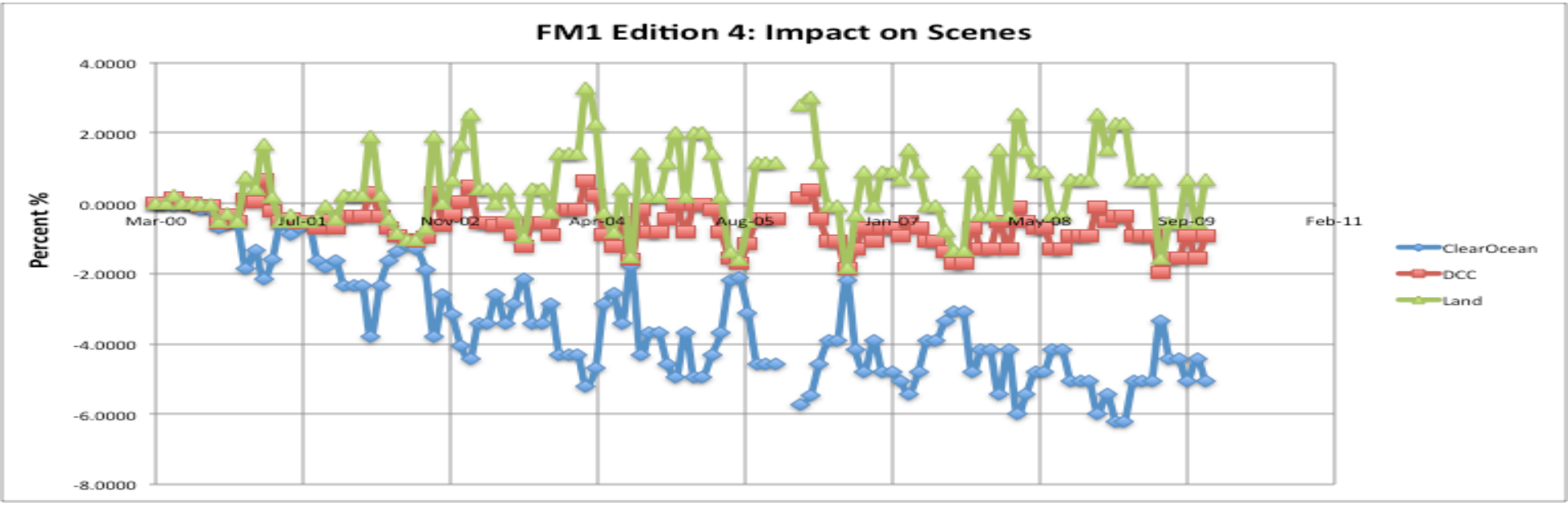
- All-Sky Ocean averages in the 30N – 30S region.
- Window and LW Day - Night difference regression.
- The best SRF is selected from 'candidate' set of SRFs with the spectral darkening correction, which will eliminate the monthly offset from Beginning of Mission (BOM).

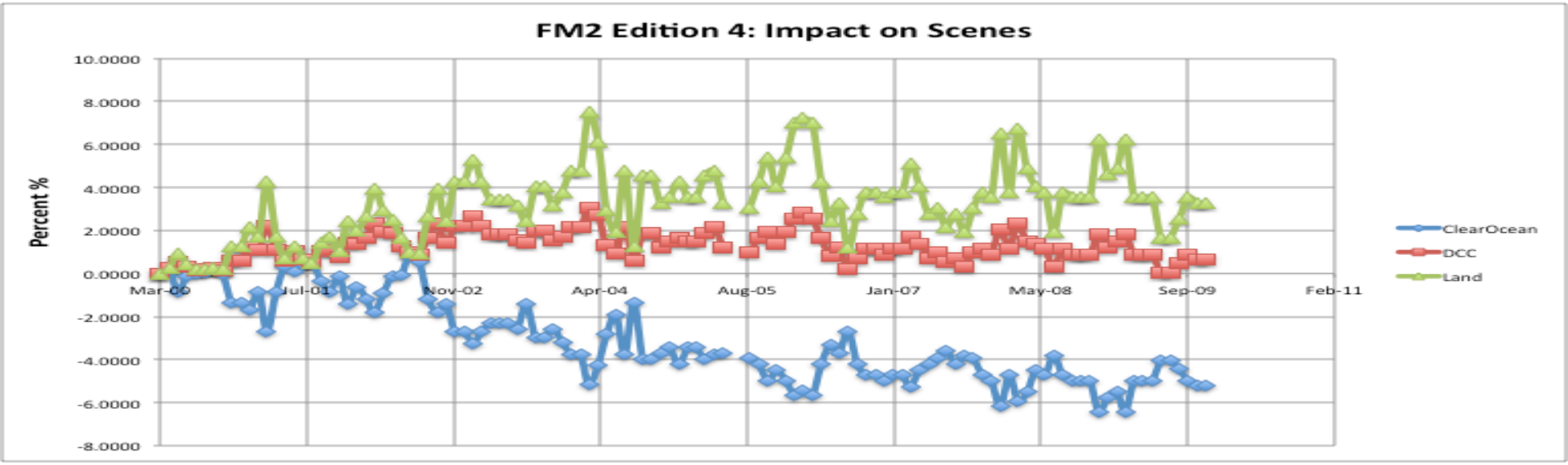
FM1 Zonal Average for Allsky Ocean (SW SRF only)

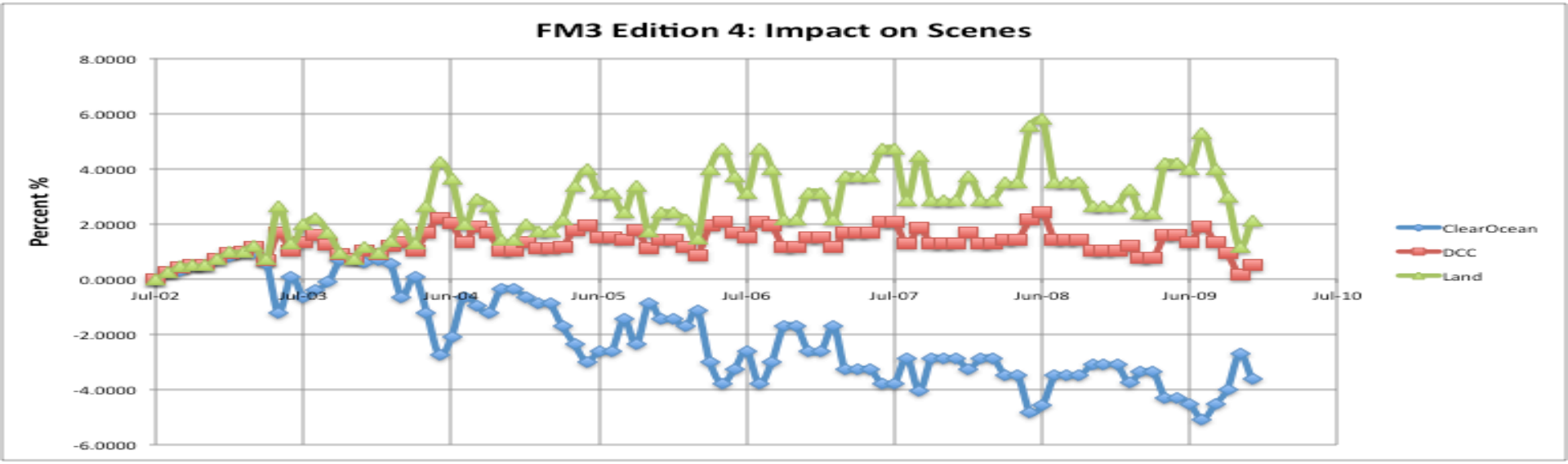


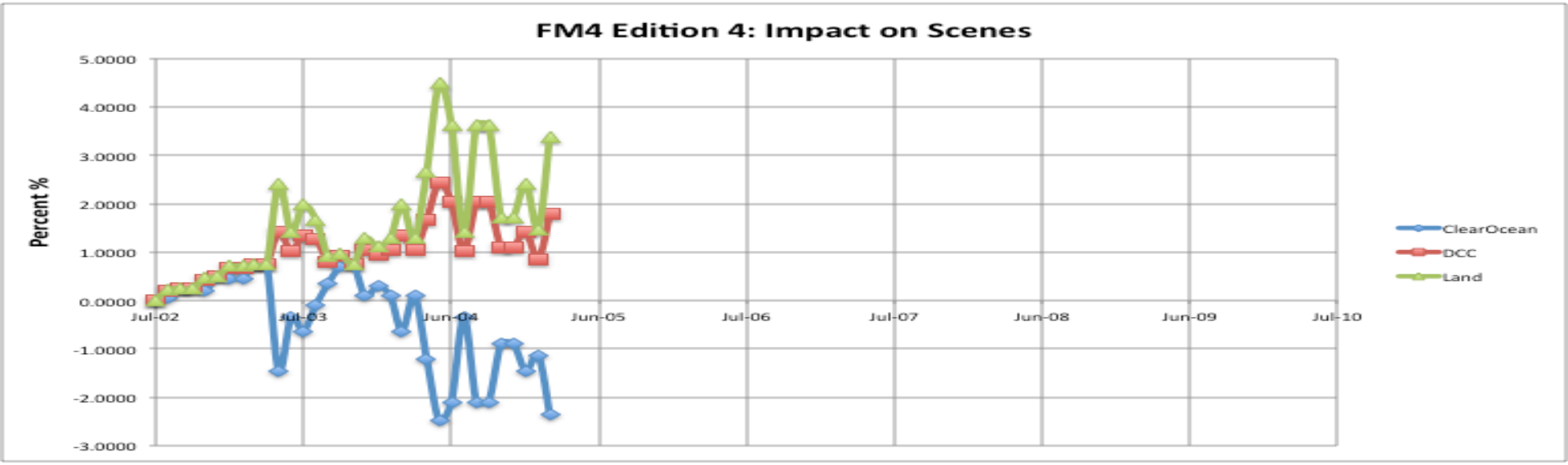
FM1 Zonal Average for Allsky Ocean (Ed3 SRFs)



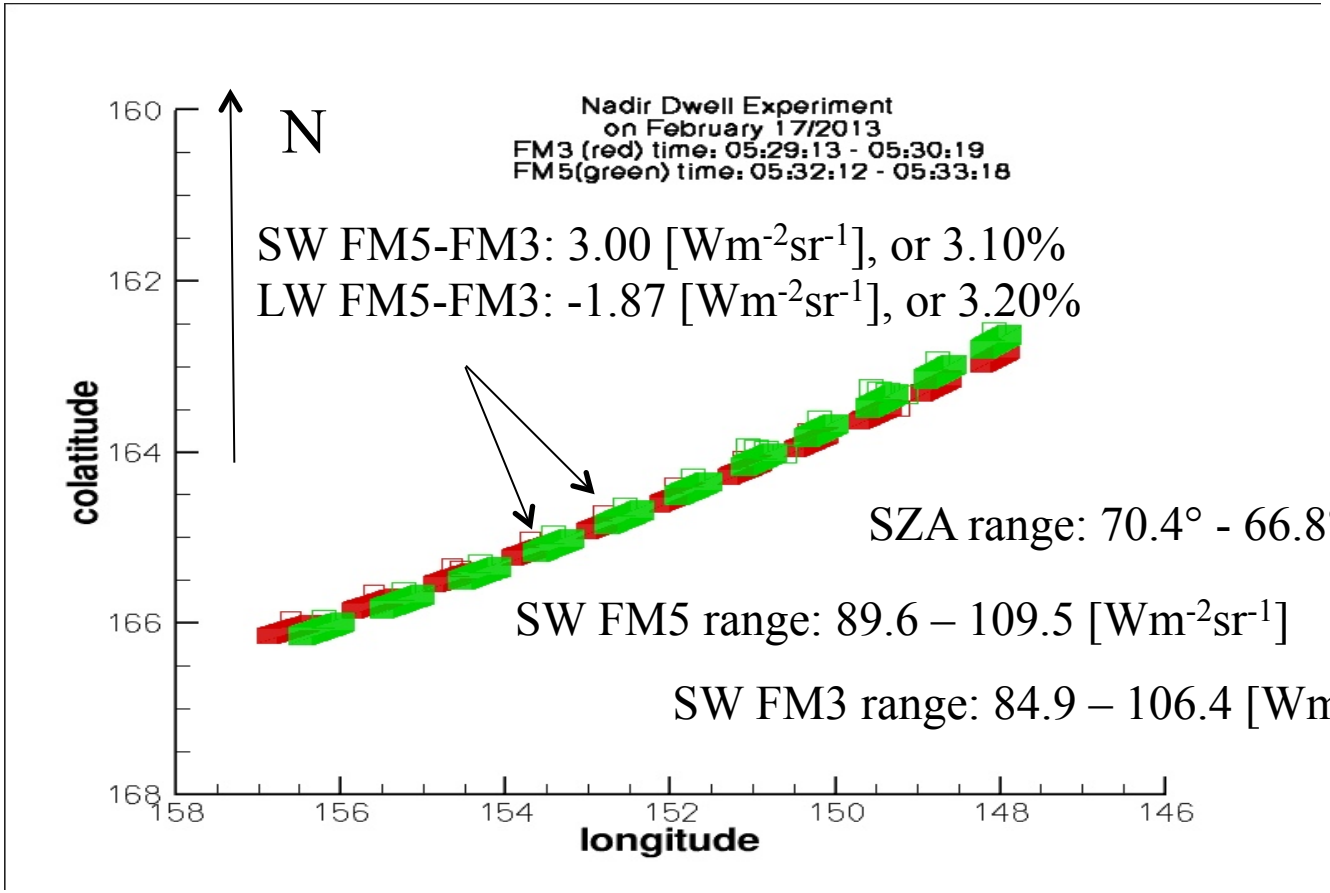

FM1 Edition 4: Impact on Scenes
Percent %
4.0000
2.0000
0.0000
-2.0000
-4.0000
-6.0000
-8.0000
Mar-00
Jul-01
Nov-02
Apr-04
Aug-05
Jan-07
May-08
Sep-09
Feb-11
ClearOcean
DCC
Land


FM2 Edition 4: Impact on Scenes
Percent %
10.0000
8.0000
6.0000
4.0000
2.0000
0.0000
-2.0000
-4.0000
-6.0000
-8.0000
Mar-00
Jul-01
Nov-02
Apr-04
Aug-05
Jan-07
May-08
Sep-09
Feb-11
ClearOcean
DCC
Land


FM3 Edition 4: Impact on Scenes
Percent %
8.0000
6.0000
4.0000
2.0000
0.0000
-2.0000
-4.0000
-6.0000
Jul-02
Jul-03
Jun-04
Jun-05
Jul-06
Jul-07
Jun-08
Jun-09
Jul-10
ClearOcean
DCC
Land


FM4 Edition 4: Impact on Scenes
Percent %
5.0000
4.0000
3.0000
2.0000
1.0000
0.0000
-1.0000
-2.0000
-3.0000
Jul-02
Jul-03
Jun-04
Jun-05
Jul-06
Jul-07
Jun-08
Jun-09
Jul-10
ClearOcean
DCC
Land

Nadir dwell scanning on 02/17 over Antarctica



CERES FM5 (NPP) –FM3 (Aqua) Comparisons

- NPP and Aqua Simultaneous Observation Opportunities occur every 64 hours and last ~20 minutes with views < 1 minute apart.
- Comparison based on gridded 1^o x1^o averages with relative VZA <15 deg and RAZ < 10 deg.

All-sky Results: Feb 2012– March 2013

(FM5-FM3)/ FM5	FM5 Radiance [W m^{-2} sr^{-1}]	Relative Difference [%]	α-confidence	Number of samples
Shortwave	**80.53**	**3.16**	**0.44**	**82**
LW day	**75.96**	**-1.39**	**0.13**	**84**
LW night	**67.79**	**-0.50**	**0.11**	**102**

- Additional scene comparisons – Clear Ocean, Clear Land, Overcast – showed FM5 SW is measuring higher (1.8 – 2.99 Wm-2sr-1.)