Sumi-NPP OMPS Calibration and Characterization from Early Orbit Images

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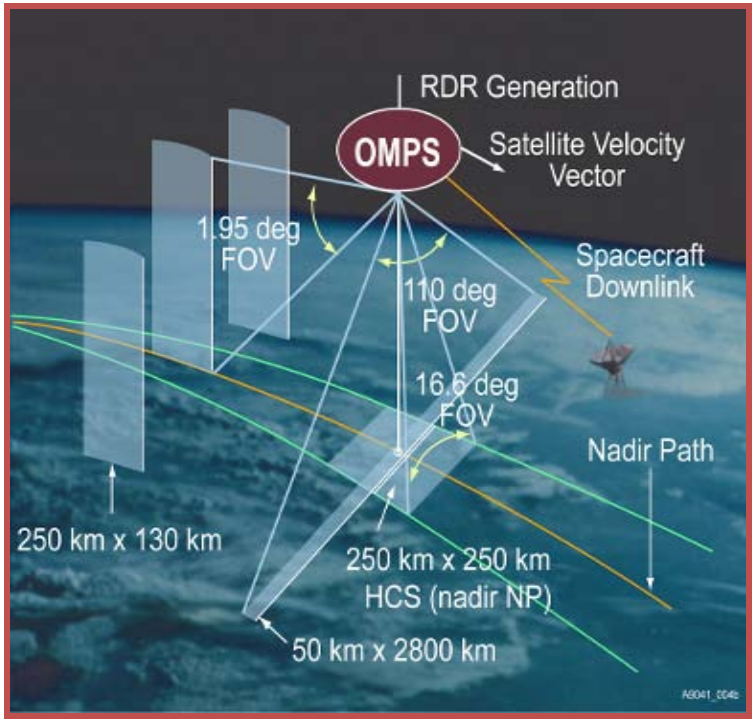
Outline

- Ozone Mapper Profiler Suite (OMPS) Instrument Overview
- Sensor Data Record (SDR) Statue
- On-orbit Performance and Calibration
  - Dark and bias
  - South Atlanta Anomaly (SAA) influences
  - Linearity performance and LUT
  - Solar calibration: Observed solar irradiance and wavelength change
- Summary

Sensor Overview

	Nadir Technical Specification
Telescope	One telescope w/ two separate grating CCD spectrometers Nair Profiler (NP) and Nadir Mapper (NM)
Swath Width	NM: 2800 km (35 cells, 50 km) NP: 250 km (single cell)
Field of View (FOV)	NM: 110 x 0.27 deg NP: 16.7 x 0.25 deg
Spectral Range	NM: 300 to 380 nm NP: 250 to 310 nm
Spectral Sampling Interval	NM: 2.4 pixels per FWHM NP: 2.4 pixels per FWHM
Spectral Resolution	NM: 1.0 nm NP: 1.0 nm
CCD Detector Cooling Operational set point	Thermo-Electric Coolers (TECs) NM: -45.0 C NP: -30.0 C
Calibration	• On-board light-emitting diodes (LEDs) and dual Solar diffusers. • Dark, bias, linearity and gain correction, data binning, hot pixel removal. • Stability maintained by periodic solar observations with reflective diffusers



OMPS Calibration Database (DB)/LUTs

- LUTs are nominally updated weekly on-orbit.
- Nadir has 30 LUTs that have/will be generated by human-in-loop process by NASA

  Science Operation Center (SOC)
  - Ground SDR Algorithm: Sample Tables, Channel Band Centers, Dark Current, Bias
  - Sensor Table Uploads: Sample Tables, Pixel Gain (part of Radiance), LED/Linearity
  - Other Calibration LUTs are Bandpass, Spatial Registration, Radiance, Irradiance, Goniometric

DB Catalog	Data in DB	Frequency of Updates
STB	Sample tables and Bad pixel	As needed
DCT	Detector dark signal in counts	Weekly/Daily
ZIO	Zero input detector electronic offset	Weekly
LED	Lamp signals and linearity LUT	Weekly/Monthly
GON	Goniometry coefficients	Not required
RAD	Radiometric cal. coef. and gain coef.	Weekly for gain coef.
IRD	solar irradiance calibration coefficient	Not required
BPS	Band pass	Not required
SRG	Spatial registration	Not required
CBC	Channel band center wavelength	weekly
SLT	Stray light correction coefficients	as needed
WAVMON	Parameters related to wavelength cal.	weekly
RAWFLUX	Normalized solar signal	weekly
FLUX	spectral shift corrected RAWFLX	weekly
FLATFIELD	localized relative pixel responses	weekly
WAVELENGTH	wavelength cal. Trending	weekly

OMPS SDR Products (SDRs)

NPP Interface Data Processing Segment (*IDPS*) produces Raw Data Records (RDRs), Temperature Data Records, (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs), as well as Intermediate Products (IPs). Data are available via NOAA CLASS http://www.class.ncdc.noaa.gov

Science SDR	
SOMTC_NPP	OMPS Nadir Total Column Science SDR
SOMPS_NPP	OMPS Nadir Profile Science SDR
Calibration SDR	
SOMSC_NPP	OMPS Nadir Total Column Calibration SDR
SOMNC_NPP	OMPS Nadir Profile Calibration SDR

- Earth View SDR and Calibration SDR are produced by separate SDR Algorithm processes in HDF5 format, includes Calibrated sensor data, Geolocation data, Quality flags, Metadata at the granule and aggregation level.
- The basic SDR processing includes signal correction, calibration analysis, and calibration application. Intervention is required only for approving upload tables and the synchronized configuration tables used in the ground system.
- The OMPS EV SDR has been in Beta status since early March, 2012. It is expected to be in provision status within one year.

Calibration Status

- OMPS Suite has undergone EOC checkout:
  - provided a baseline for sensor health, status telemetry and detector characteristics – response, dark, noise, smear, bias, detector gain and linearity.
  - Results indicate that OMPS on-orbit performance is stable and meets the expectation.
- OMPS is currently in the (Intensive Calval) ICV stage (~L+18 months):
  - Verified initial CCD corrections and begin the on-orbit sensor nominal calibration
  - Updated wavelength and solar irradiance with on-orbit results.
  - Radiometric and spectral calibration with solar observations are undergoing.
  - Begin data product validation, examine the Earth radiances and wavelengths to evaluate the calibrations.

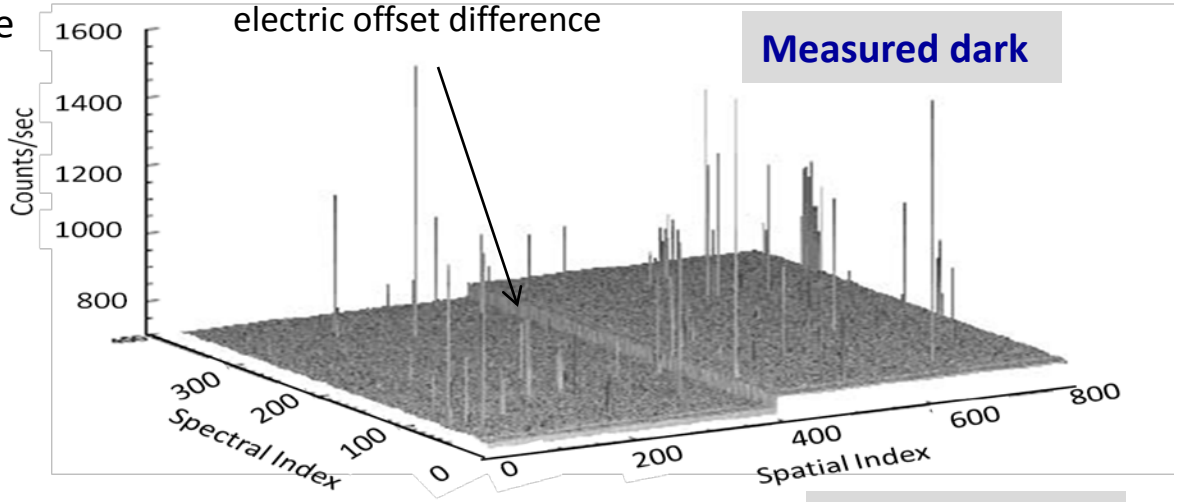
OMPS Dark Calibration

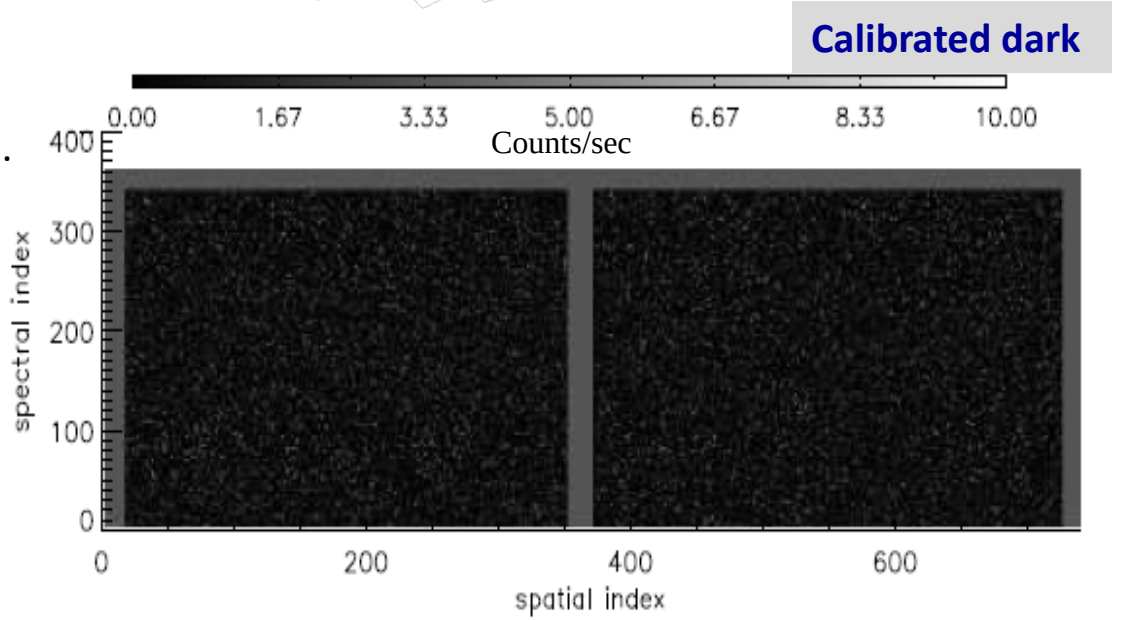
- OMPS dark calibration defines the average dark current for each pixel in both the image and storage regions on a CCD Focal plane Array (FPA).

- Dark Current performance is consistent with pre-launch characterization and within the expectations.

- The challenge in the calibration is how to remove transients influence.

- Integration time has been optimized to efficiently capture and isolate transients. A sequence of single-frame images with 72 seconds now are used as a default measurement.



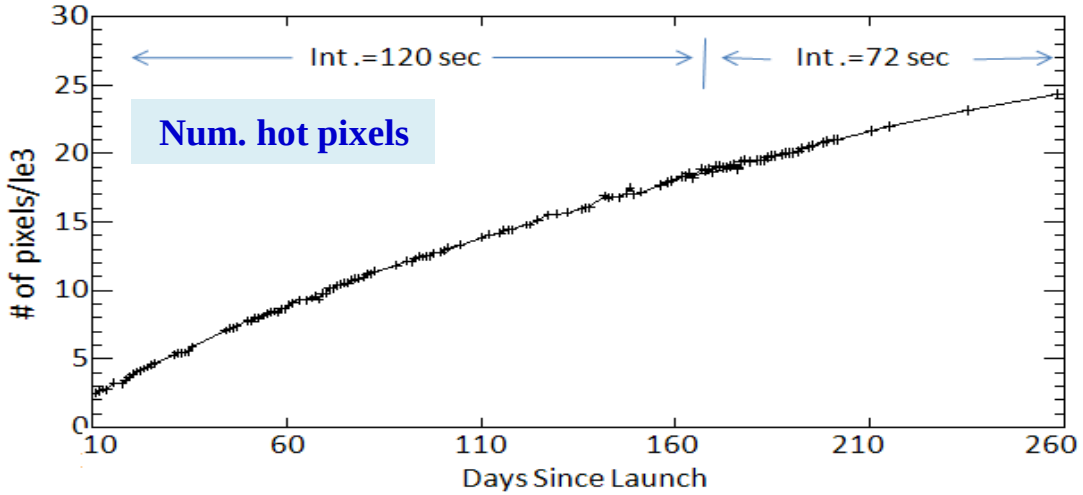


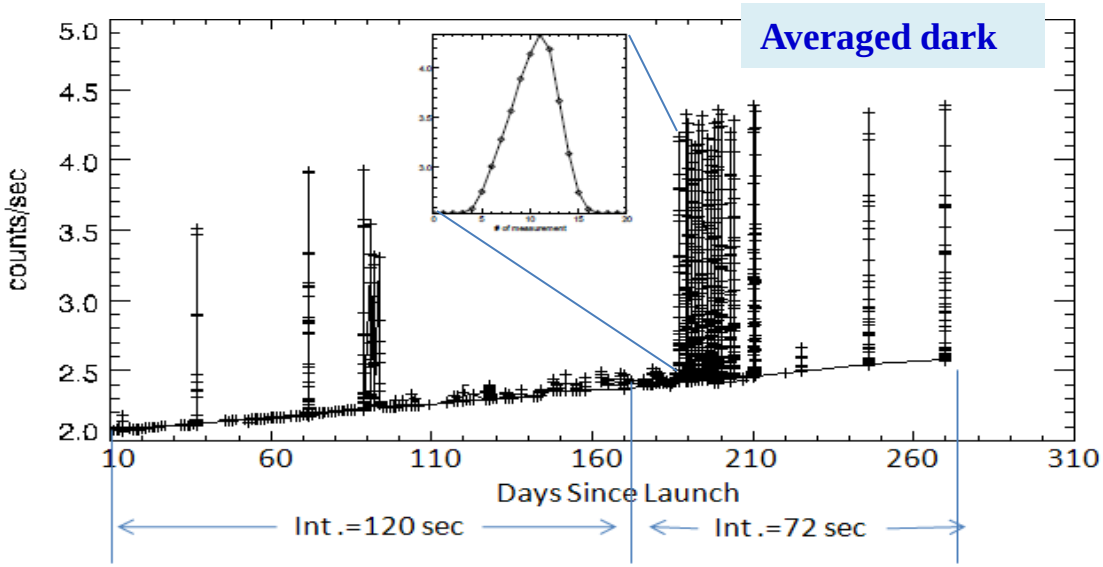
On-orbit CCD Detector Performance

- Senor on-orbit behavior are monitored through NOAA STAR Integrated Calibration and Validation Systems (ICVS).

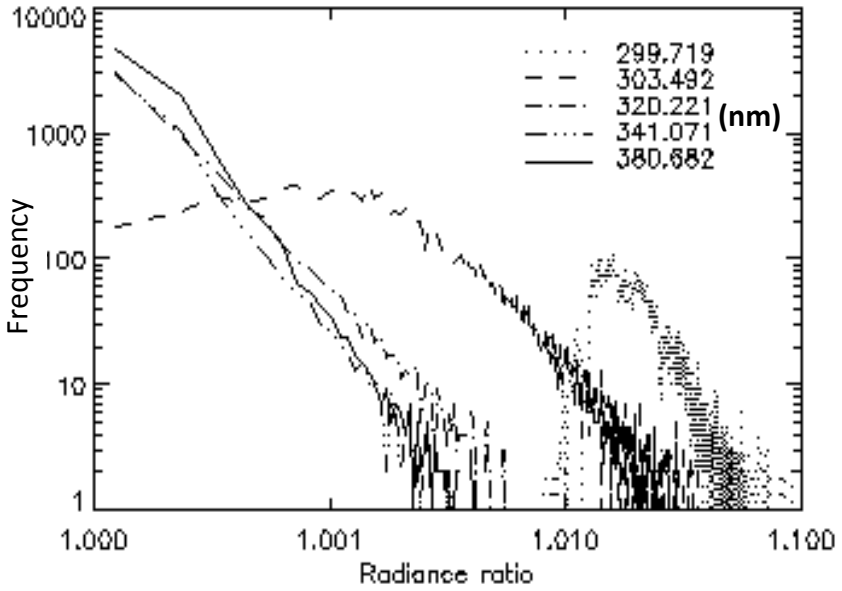
- Influenced by the hot pixels, the orbit dark images exhibit a higher signals level.

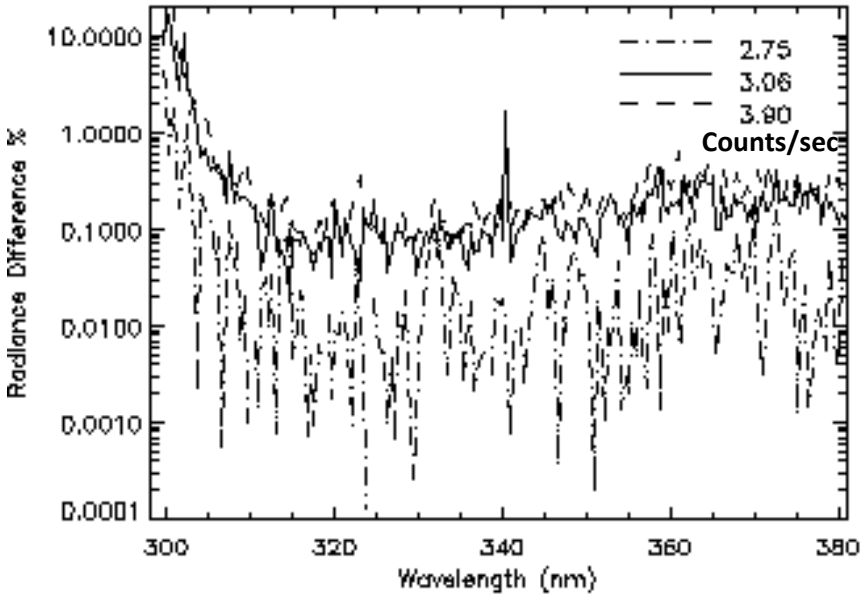
- Averaged dark signals constantly increase nearly 0.1% daily, indicating a slowly degraded CCD performance. Daily updates of dark LUT is necessary.





Dark Current Influences on Radiance



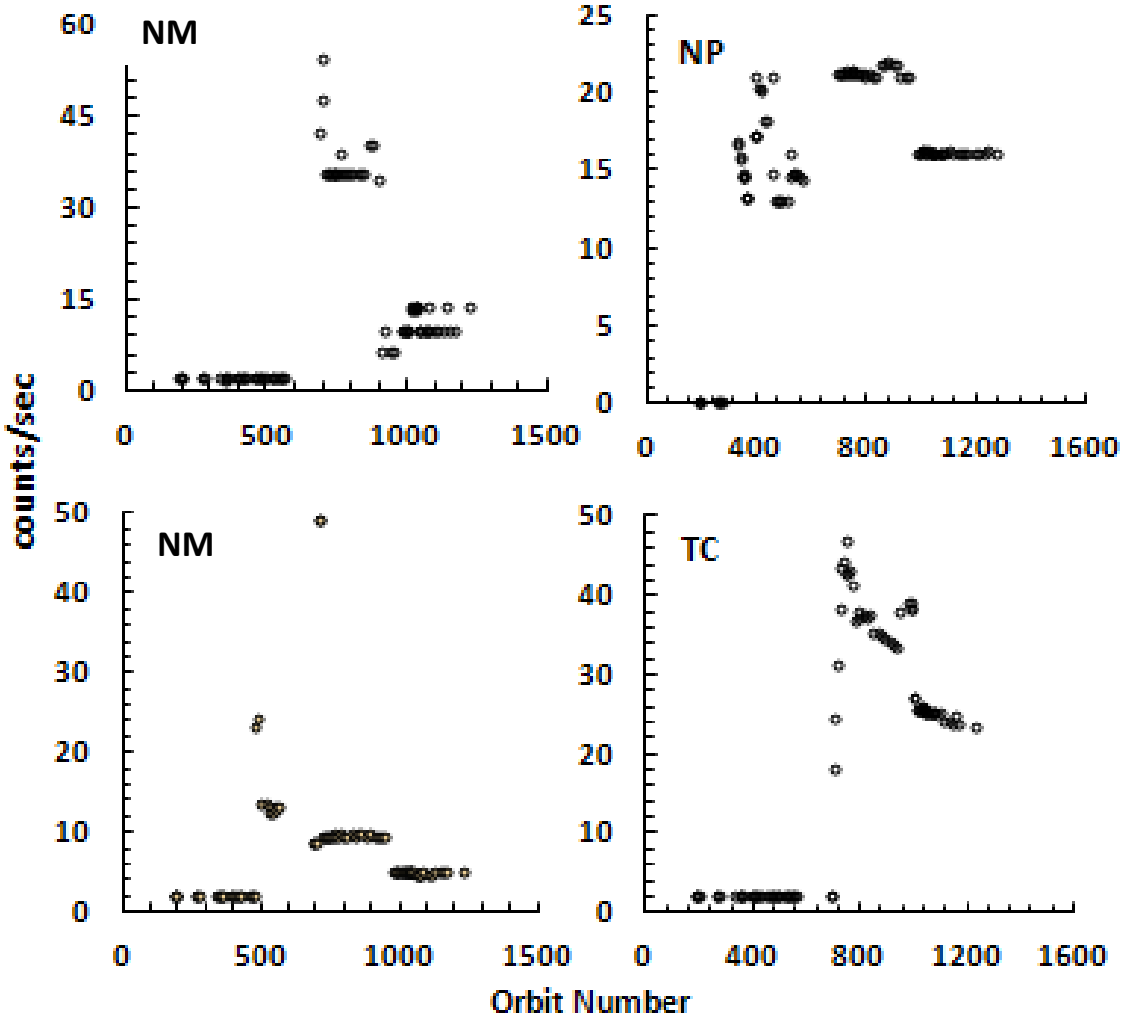


Dark current impact on radiance change between Nov.11, 2011 to April 06, 2012 is wavelength and earth scene dependent. if the dark table remains un-updated for the first 150 days, the radiance error could be up to 10%.

Different South Atlantic anomaly (SAA) level shows different impact on earth view radiance retrieval . Short wavelengths less than 300 nm has a relative large error.

Random Telegraph Signals

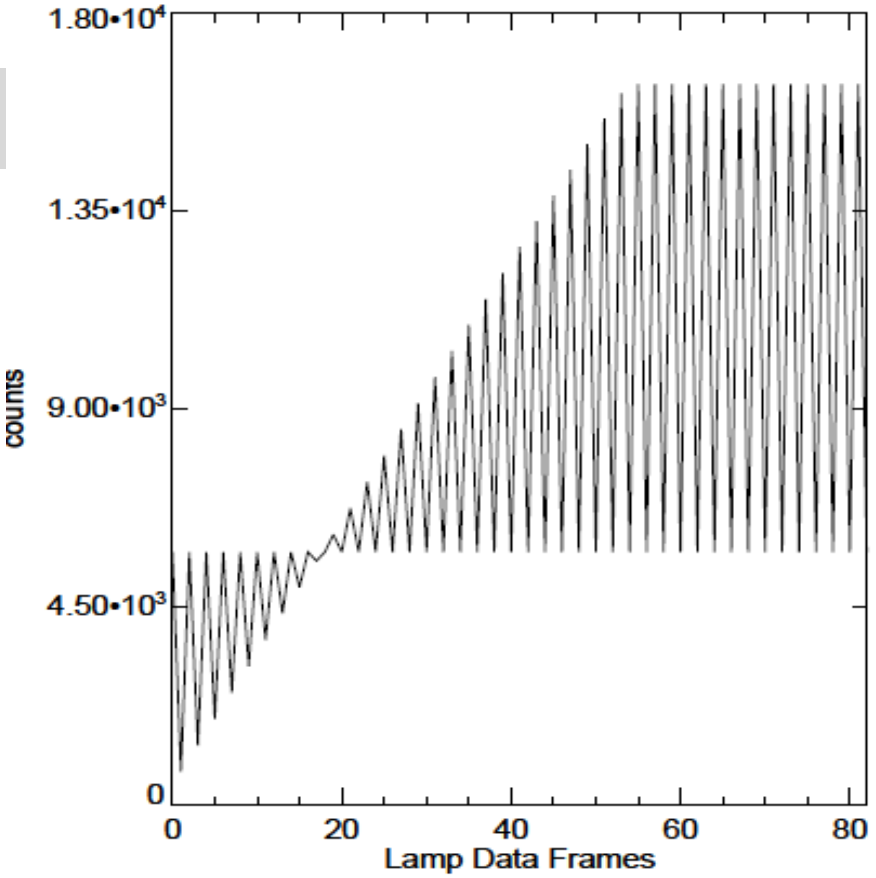
- Some of OMPS CCD pixels exhibit a type of behavior known as Random Telegraph Signals (RTS) fluctuations.
- Examples of four individual pixels from Nadir CCDs that have a dark signal as a function of time; the signal of each pixel is unstable.
- It is estimated that at the early orbit calibration phase, less than one tenth to several tenth percent pixels in NP and NM are manifesting itself with the RTS behavior.
- These RTS pixels can be still used in the earth view measurement due to its small population.



Linearity Calibration

Table Key Criteria of Nadir System Linearity

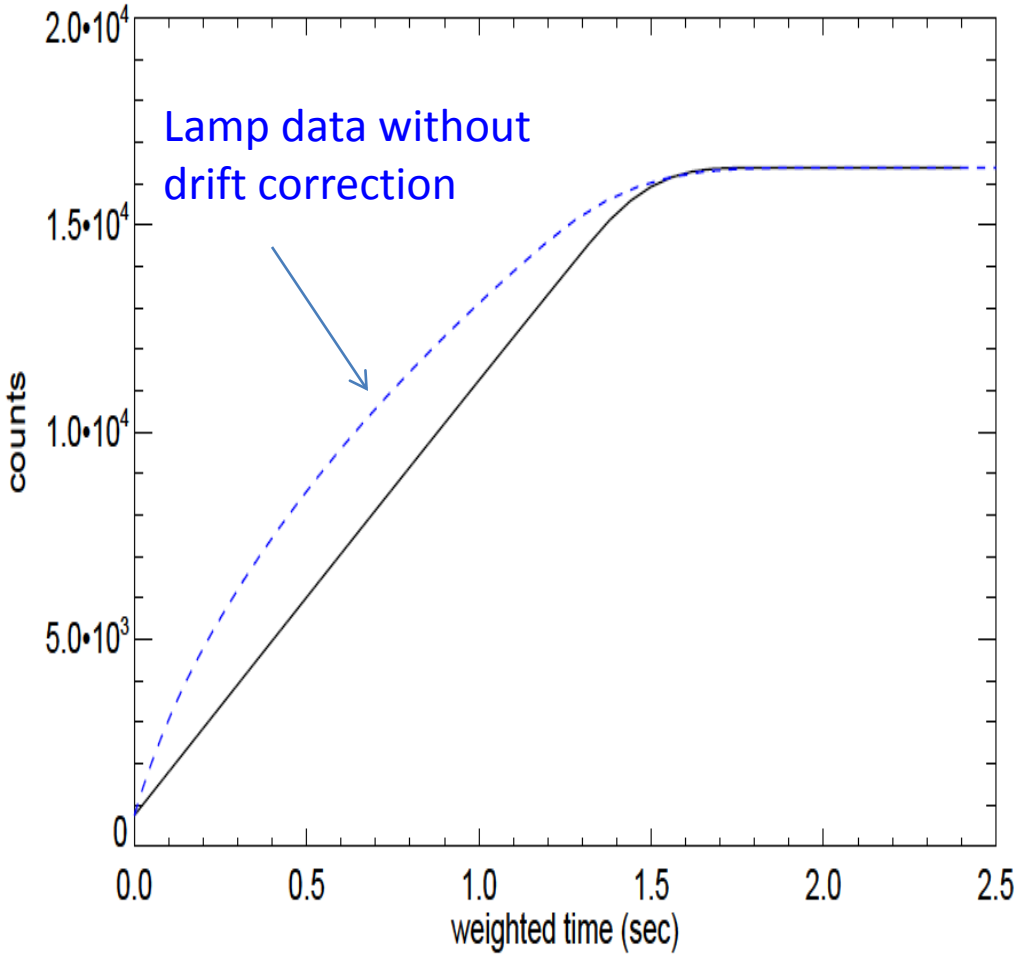
Catalog	Requirement	Note
Full well	>12000	Saturation
Nonlinearity	2%	Shall be no more than 2% of full well
Offset	780- 800 counts	Offset due to amplifier biases.
Max. stepped int.	0.5 sec	
LED drift	1% per minute	Degradation rate of LED output.
LED noise	0.1% over 5 minutes	1-sigma random variability of LED output



- 83 images are collected with a series of fixed stepped integration times (INT). The stepped INT are selected in an increasing sequence to well present for fixed charge levels.
- 41 references images are interleaved with the measured images to compensate LED output signal variation.

Linearity Calibration Coefficients

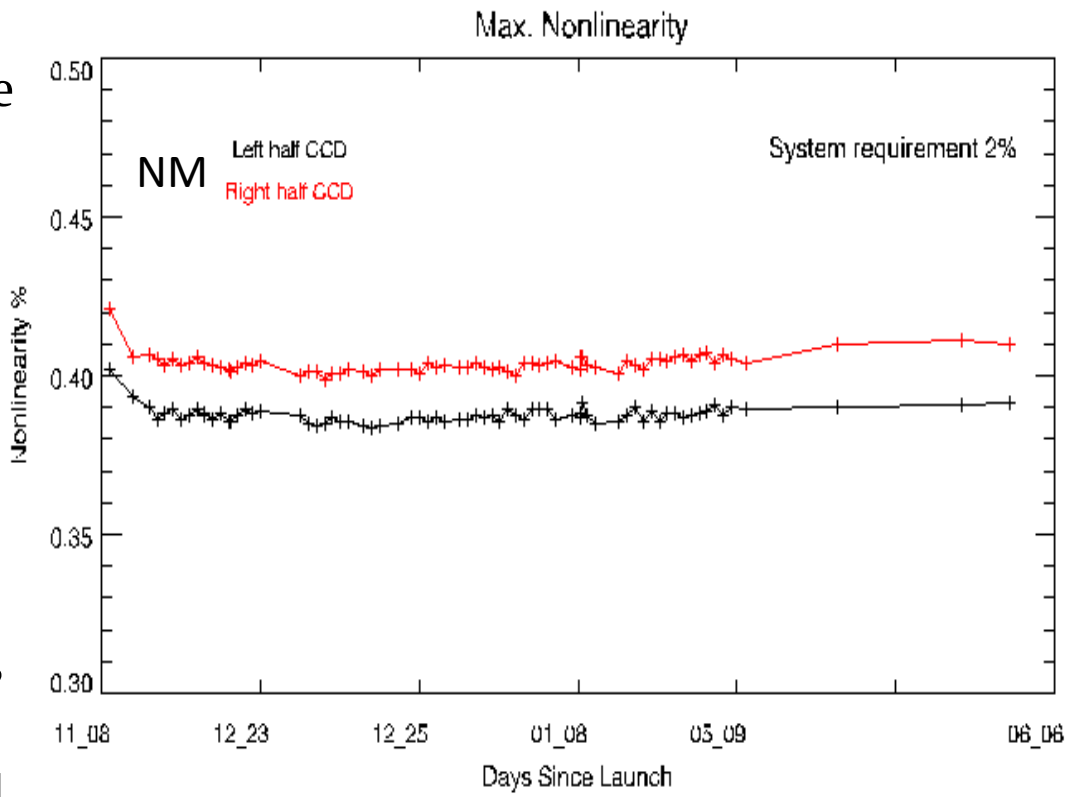
- Lamp drifting is removed prior to Linearity LUT derivation
- Linearity coefficients are used to compute the ideal counts
- The linearity LUTs are created by interpolating between measured count levels and ideal count levels with 16384 entries
- Each CCD halves is characterized separately to generate its own set of linearity calibration coefficients



System Nonlinearity

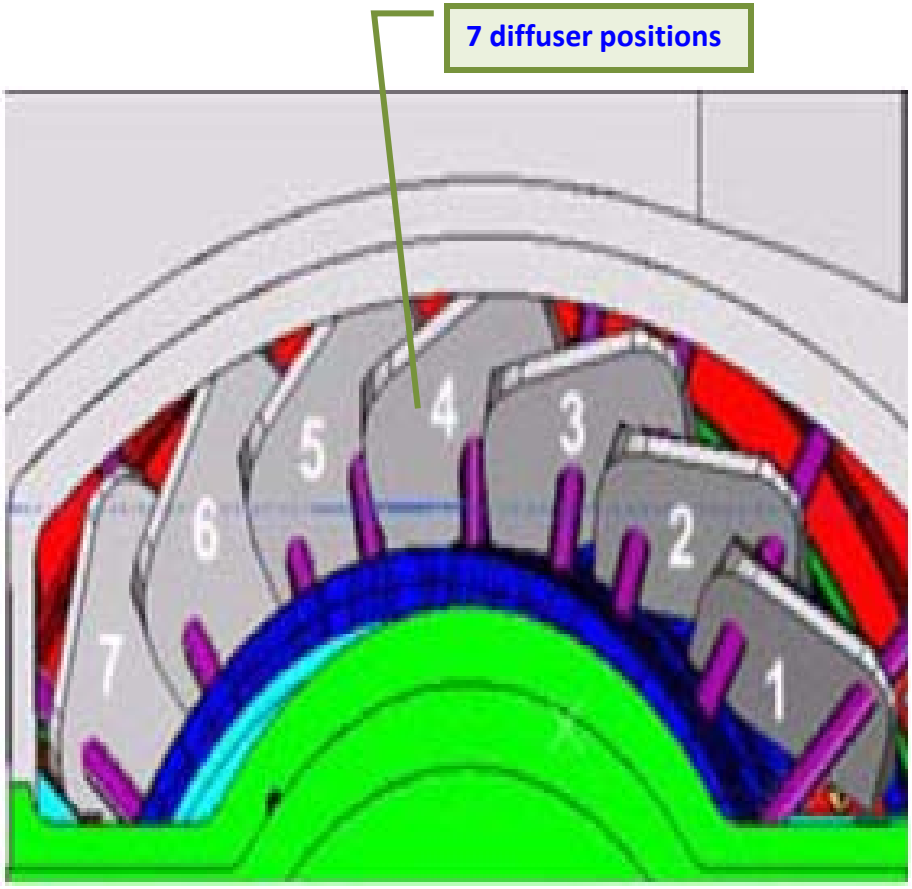
- The maxim non-linearity of the nadir sensor is no more than 0.42%, which meets the system requirement of 2% of full well

- The sensor non-linearity performance shows excellent stability. Given these stable results, the calibration team expects that the original plans to adjust this characterization weekly can be greatly relaxed.



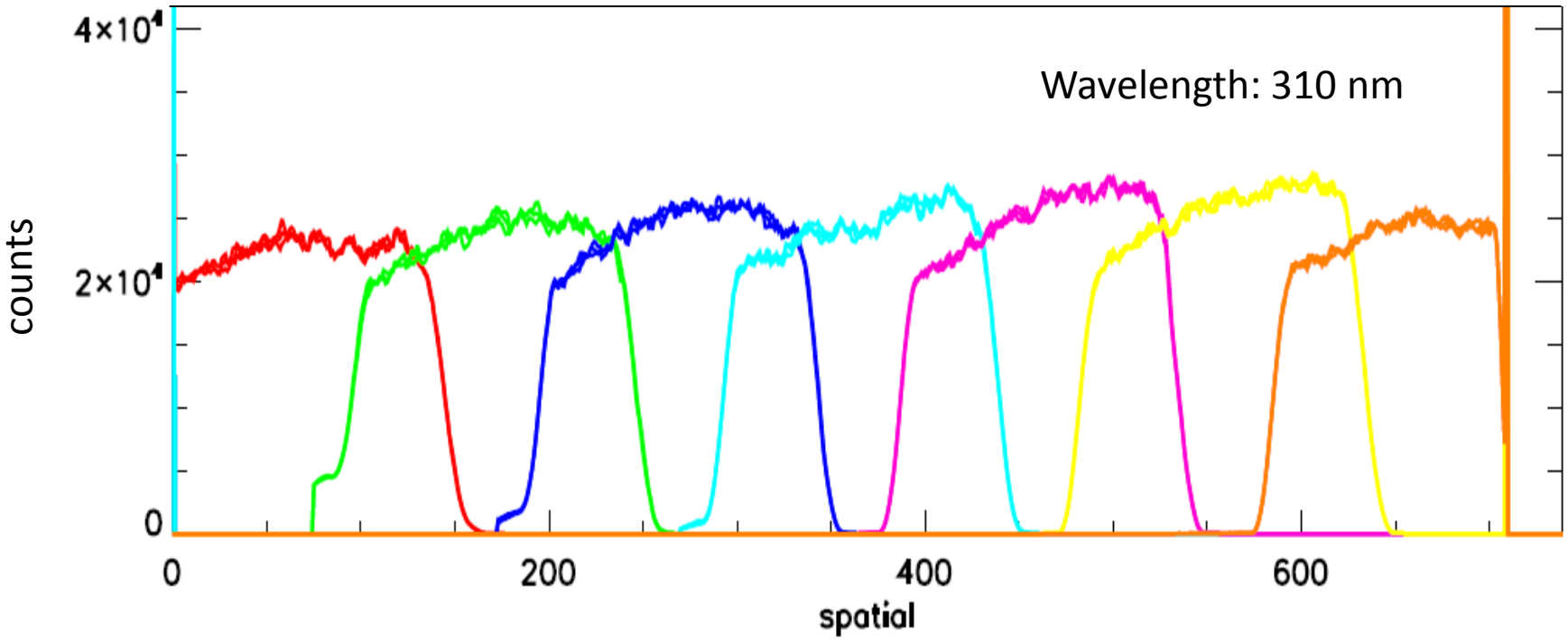
Solar Calibration

- The Nadir telescope diffuser has seven positions that cover the 110 deg FOV; position 4 illuminates the entire NP FOV.
- The diffuser response was mapped over a β_{AZ} range of 12 to 31.5 deg and a β_{EL} range of -10.4 to 10.4 deg.
- On orbit, the working diffuser is deployed once every week and the reference diffuser is nominally deployed every six months to monitor the degradation of the working diffuser.



courtesy of BATC

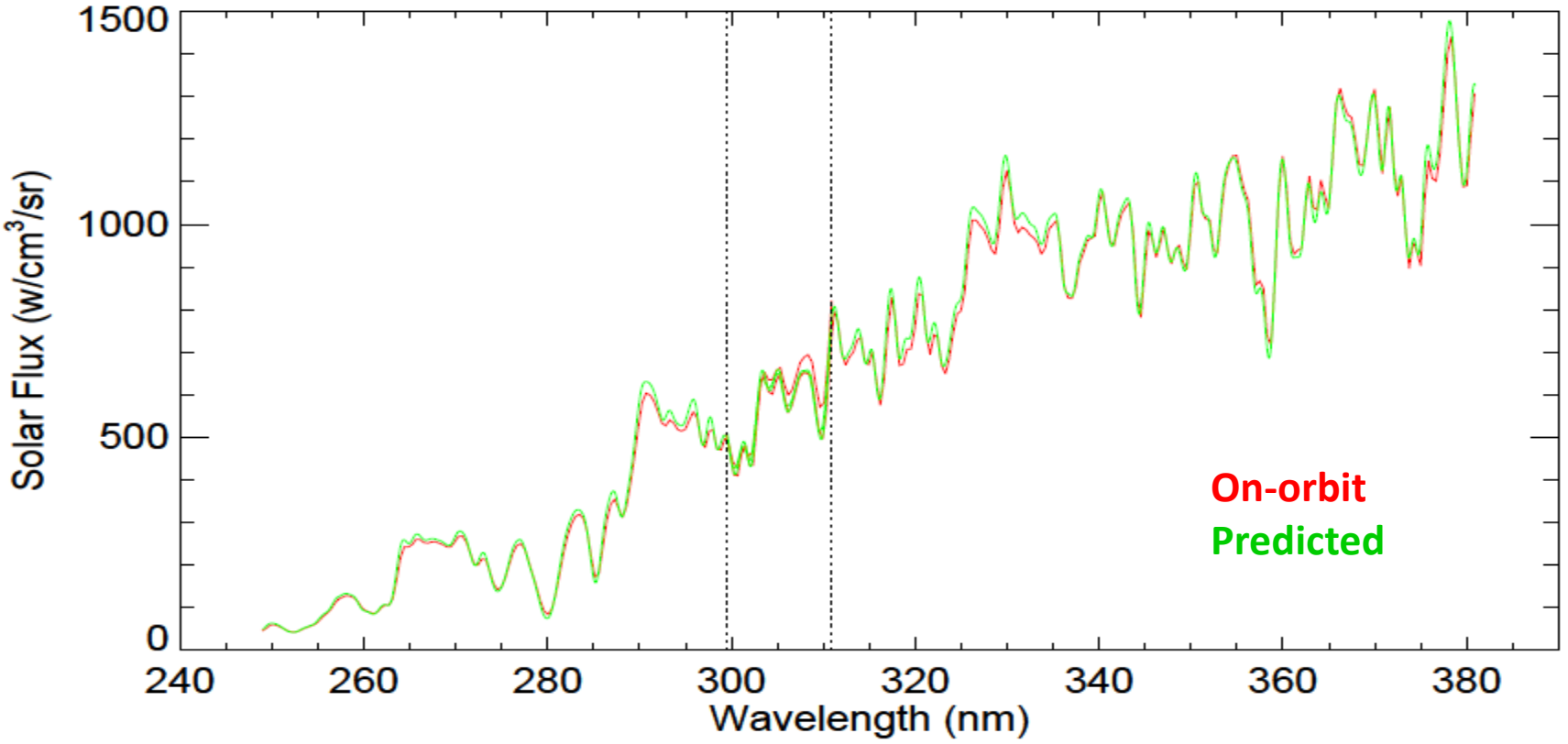
Solar Data from Initial Measurement



Improvement of the solar measurements is under testing

- The original measurement limited the angle range that would be seen by the diffuser over all 7 positions, causing signal rolls off on both edges
- New measurement changes the sequence of the calibration measurements (take place over 3 orbits) and extended the elevation angle range.

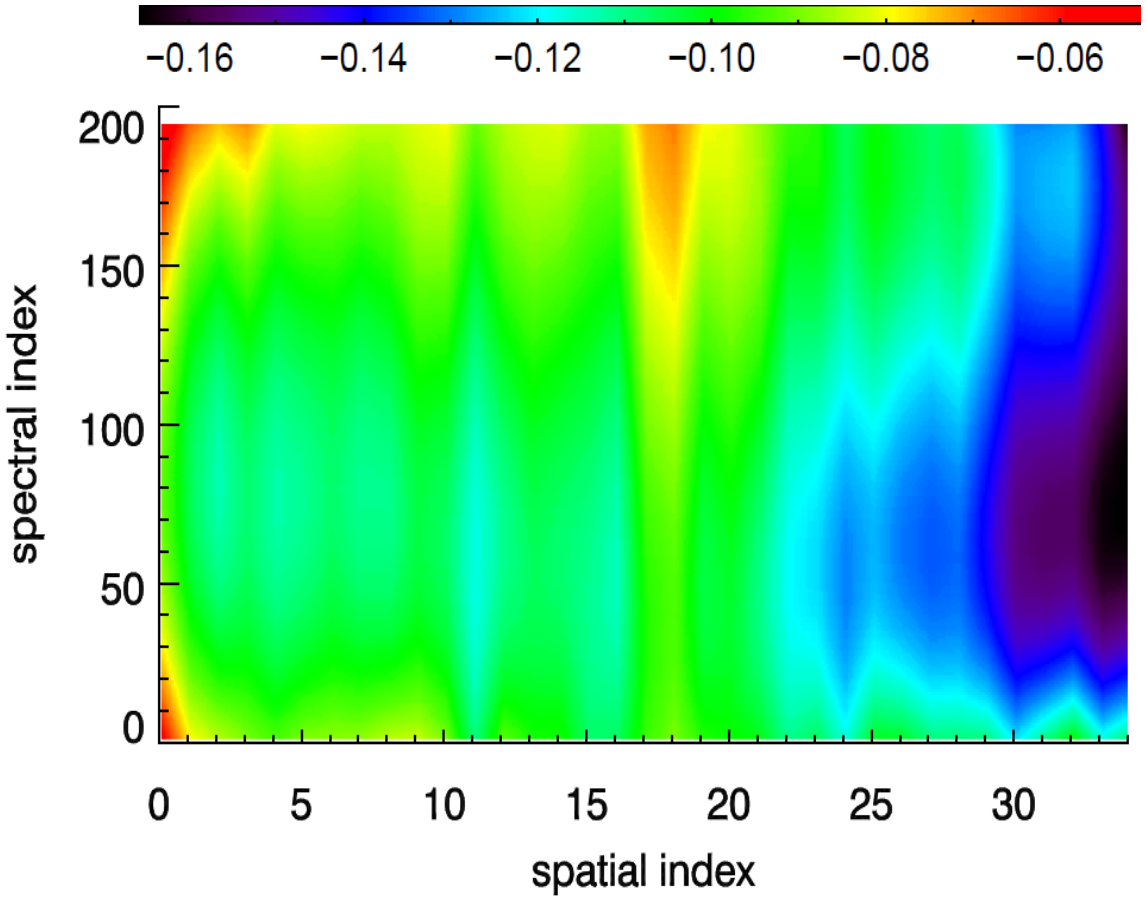
Solar Irradiance @OMPS Resolution



Observed solar irradiance is within an average of 2% of predicted synthetic solar spectra:

- NM is on average ±4% with small scale variations
- NP is less than 2% on average with several percent variations

Wavelength Shifts from Ground to Orbit

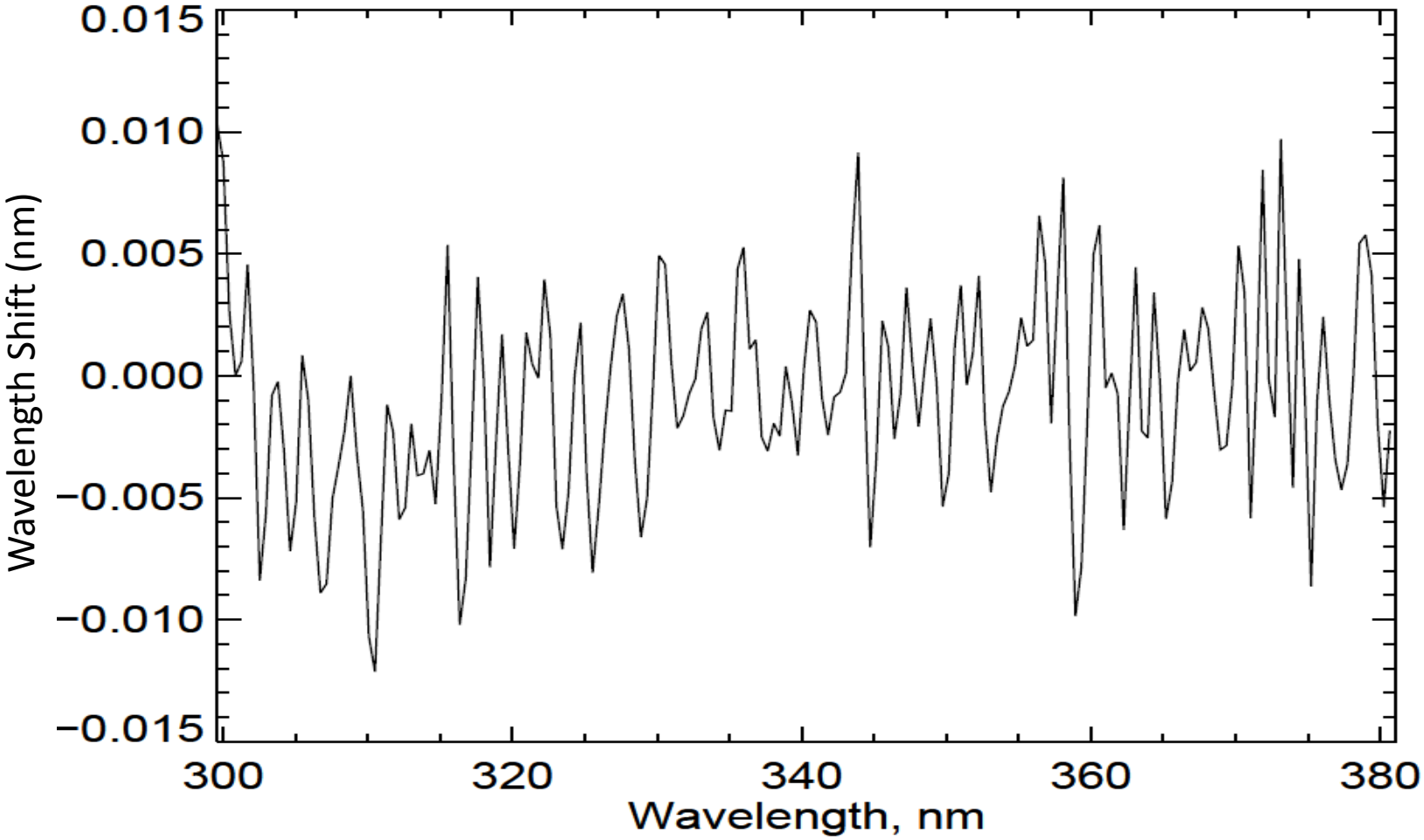


Ozone Channel Wavelength Shift

Wavelength (nm)	averaged_shift (nm)
253.092	-0.058
272.835	-0.092
283.021	-0.114
288.140	-0.092
291.989	-0.086
297.992	-0.094
301.862	-0.109
306.171	-0.136
312.838	-0.114
317.855	-0.117
330.795	-0.118
339.967	-0.115
380.024	-0.093

- Wavelength changed less than 0.16 nm from ground to orbit.

Wavelength Variation on Orbit



Summary

- OMPS Beta status was assigned on March 12, 2012 and will be in the provision status within one year.
- Instrument calibration baseline has been established,
  - Sensor key parameters: Dark Current, Electronic Bias, Hot Pixels, Non-linearity, Signal to Noise Ratio and Solar Spectral Response Function.
- Initial validation has been performed
  - Irradiance validation through Solar diffuser measurements.
  - IDPS SDR Radiance validation through Signal-to-Noise (SNR), Stray Light, Wavelength change, EDR products and compared with PEATE results.
  - IDPS Geolocation Registration through cross-sensor comparison with VIIRS and PEATE products.
- Numerous IDPS SDR processing anomalies are identified and solutions are proceeding through the system.