S-NPP Ozone Mapping Profiler Suite Nadir Sensor Performance Monitoring

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NOAA Center for Weather and Climate
Prediction (NCWCP) in College Park, MD
20740

Topics

- ➤ Dark current
  - Dark distribution
  - Dark generate rates
  - Electronic bias
  - Hot pixels
  - Dark Signal Non-uniformity (DSNU)
  - Readout noise

- ➤ Solar observation
  - Spectral smile
  - Wavelength variation
    - from ground to orbit
    - Intra-orbit variation
    - trending
  - Noise
  - Degradation

- ➤ Linearity
  - System non-linearity
  - LED data noise
  - LED output drifts
  - Dynamic range of detector response
  - Calibrated accuracy
  - LED lamp warm up behavior
  - LED illumination uniformity
  - CCD gain

- ➤ Sensor noise from EV observation
- ➤ Telemetry
- ➤ Stray light
- ➤ Cross-sensor stability comparison
- ➤ Calibration table evaluation and trending

In-flight data collection

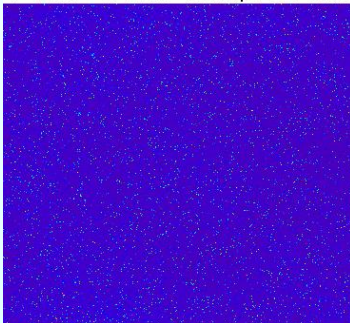NP Dark Calibration   NM Linearity Calibration   Solar Calibration   Earth radiance
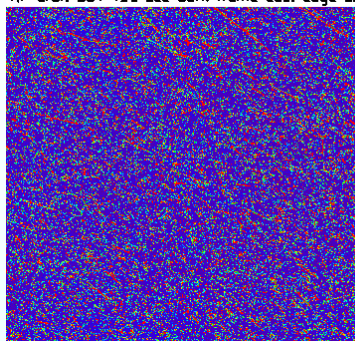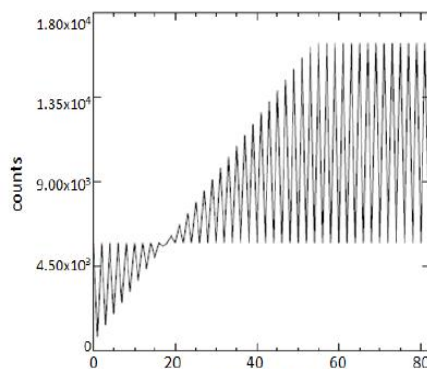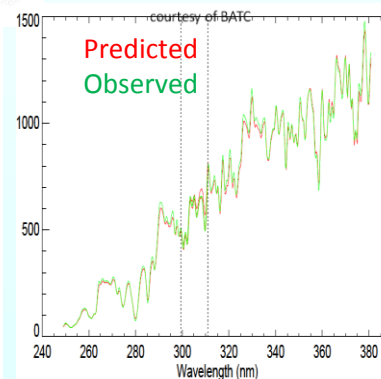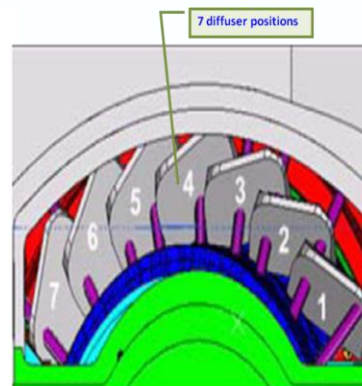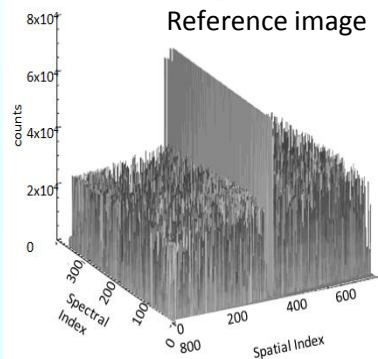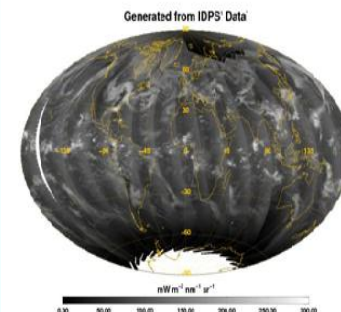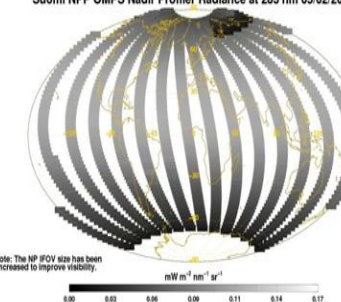
- Independently perform sensor data end-to-end analysis
- Trend and validate calibrated LUTs
- Evaluate a LUT via. ADL test prior to uploading to IDPS
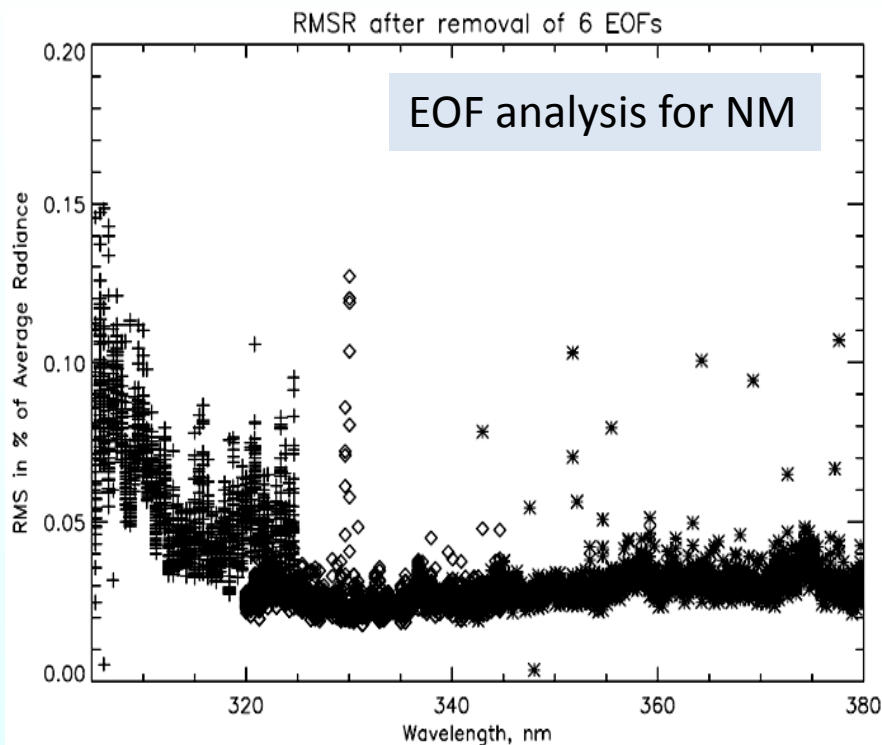- Earth radiance trend and validation via. Cross-sensor comparison

Negative Smear in NP SDR

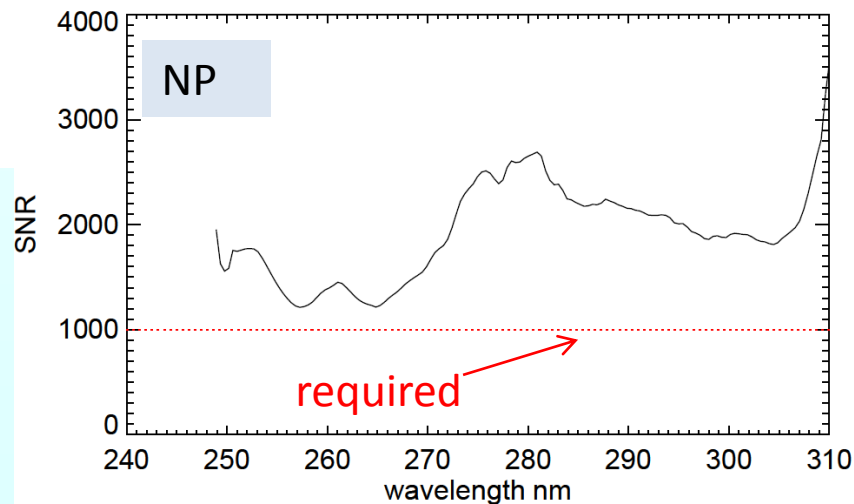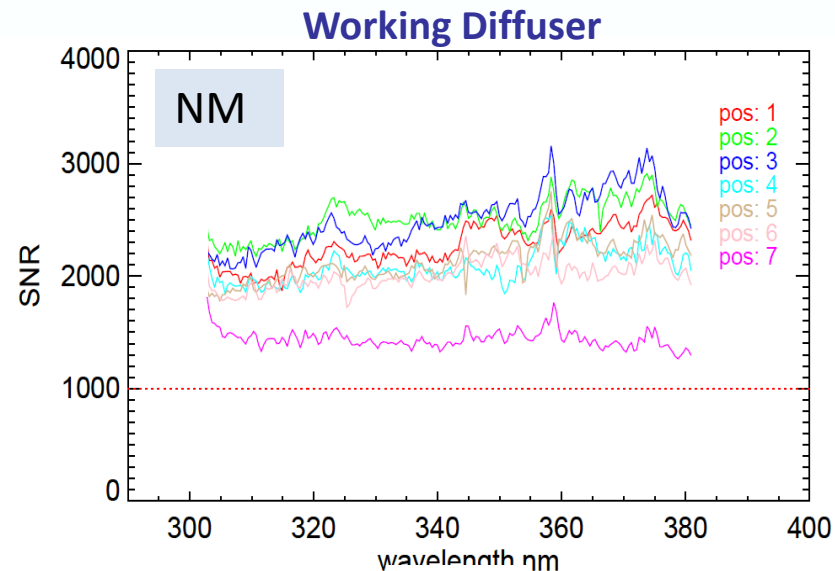Histogram of NP smears from Feb. 5, 2014 to Mar.3, 2014
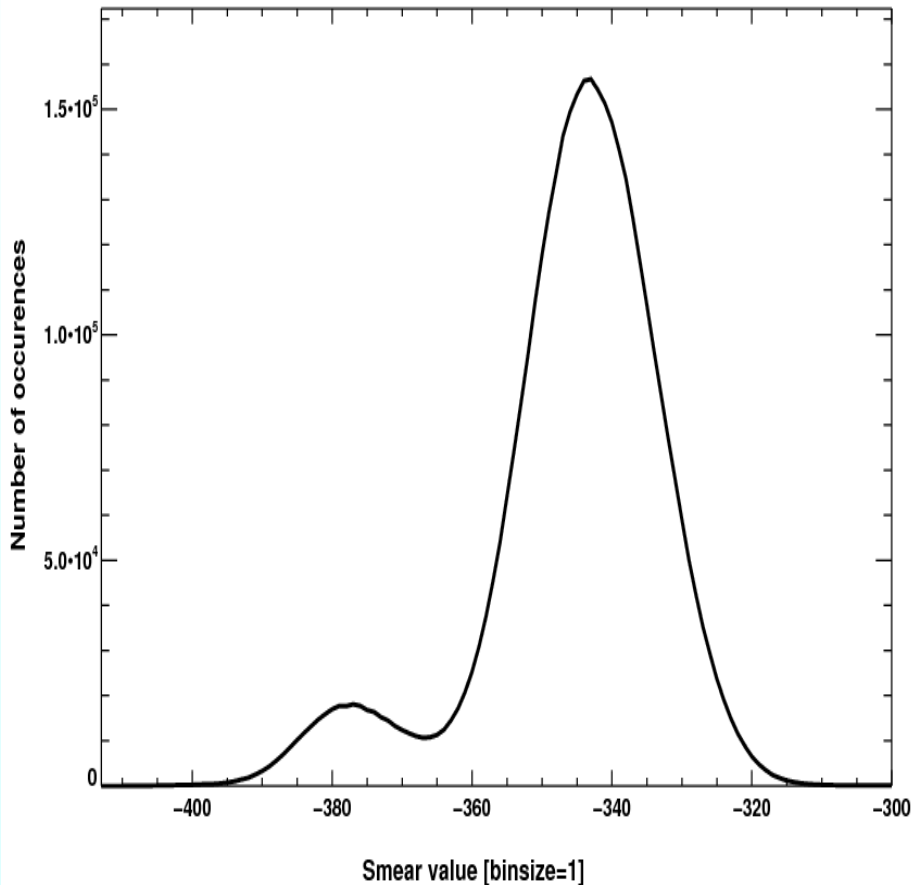
Nearly all NP smear data in the EV SDR are negative. An investigation led to the discovery of an error in the ground software related to the NP smear/bias correction

Sensor noise meets requirement

RMSR after removal of 6 EOFs

EOF analysis for NM

Working Diffuser

NM

pos: 1
pos: 2
pos: 3
pos: 4
pos: 5
pos: 6
pos: 7

NP

required

- Earth view noise < 0.01 % RMSR
   -Noise in the SAA has an influence for NP @ wavelength < 290 nm
- Solar view SNR > 1000
   - SNR from reference diffuser has a similar pattern and also meets the requirement.

Dark changes as expected

OMPS Nadir Mapper Dark Current Histogram — NM

OMPS Nadir Profiler Dark Current Histogram — NP

NM / NP count/s vs orbit num.

Hot pixel — $(1 - a*e^{-bx})$ — After ~7 year, 99% pixels will become hot.

NM / NP Closed Darks	21 images
NM / NP Storage Darks	9 images

• Weekly increase in mean: ~0.6% for NM and 0.8% for NP, resulting in uncertainties ~0.03% for NM and 0.1-0.5 % for NP.

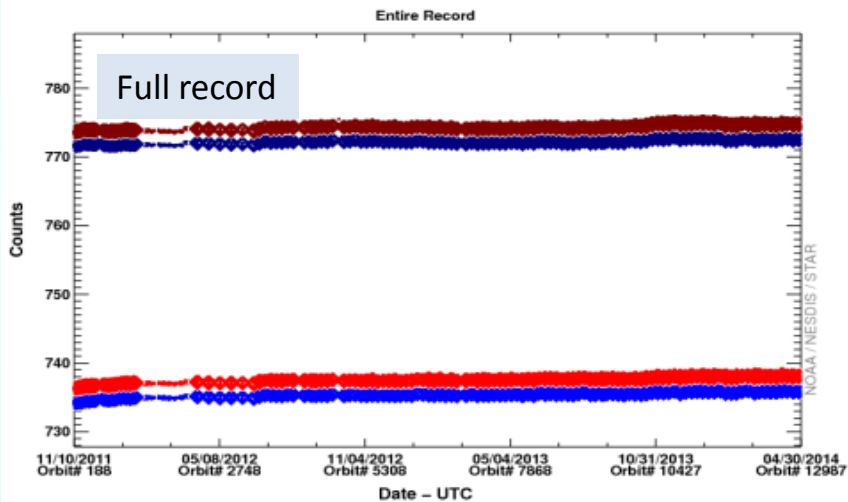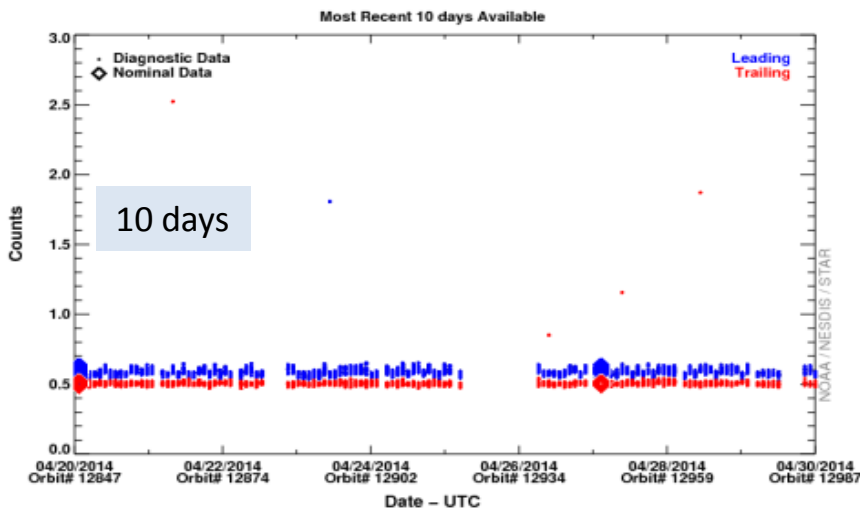• The change in dark has negligible impact on the dynamic range of the sensor response for at least 7 years.
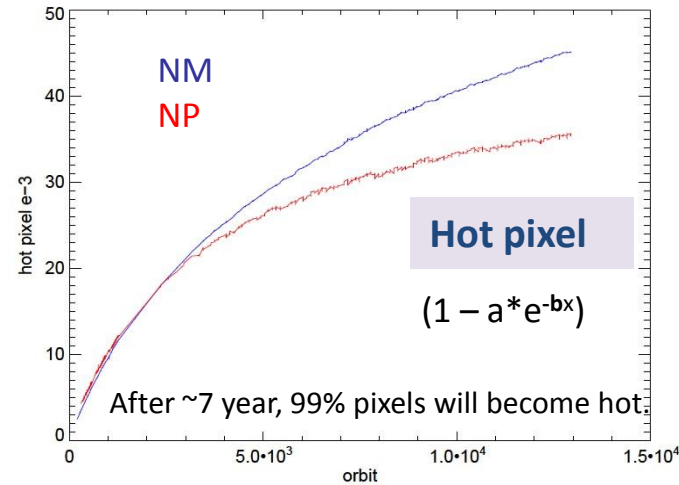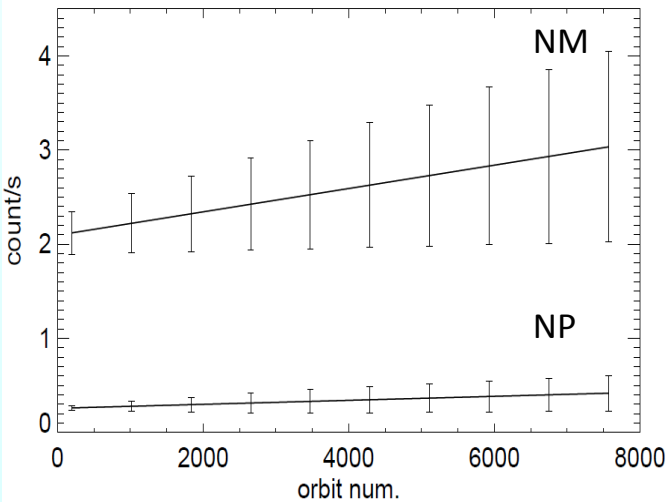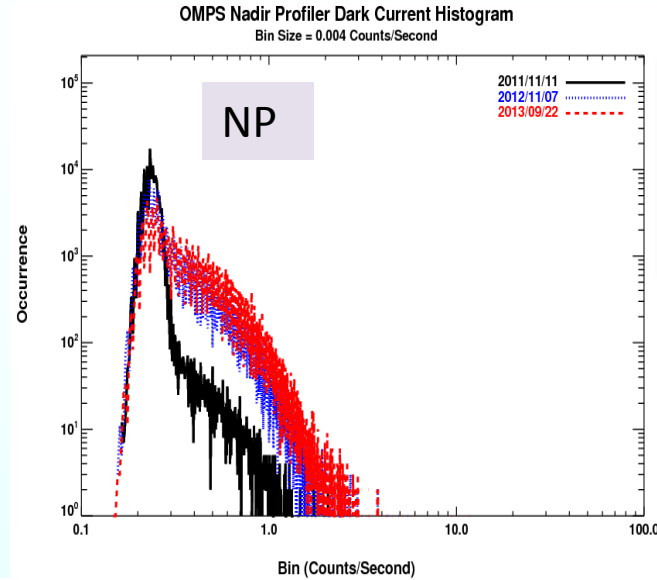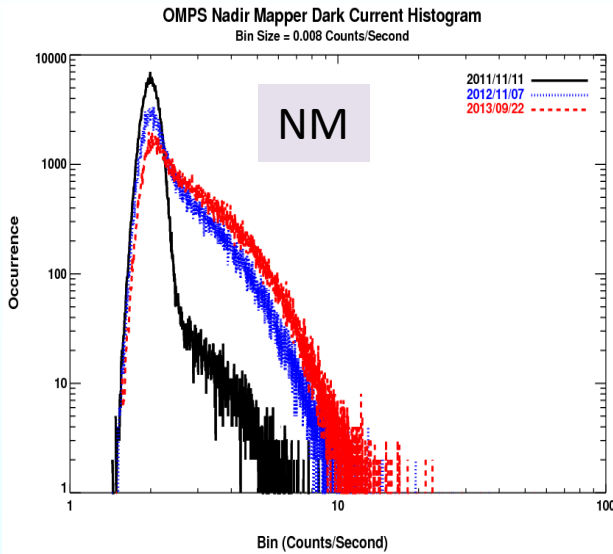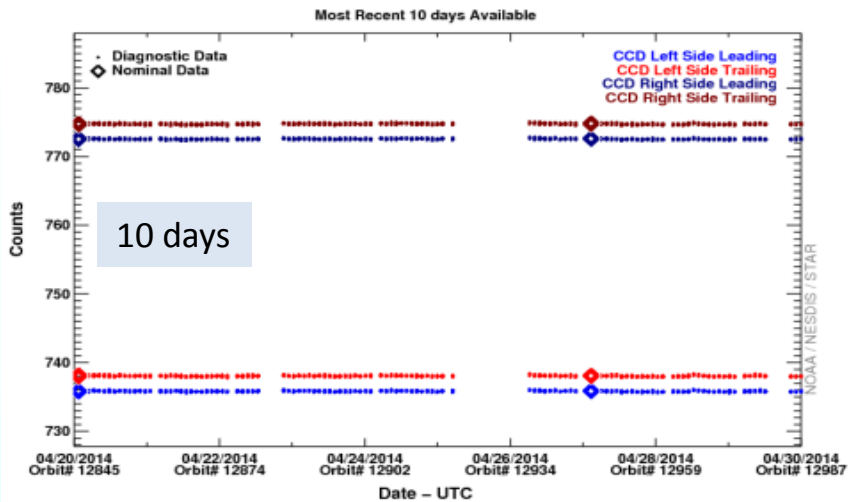
NM bias and dark readout noise

Bias

Readout noise

10 days
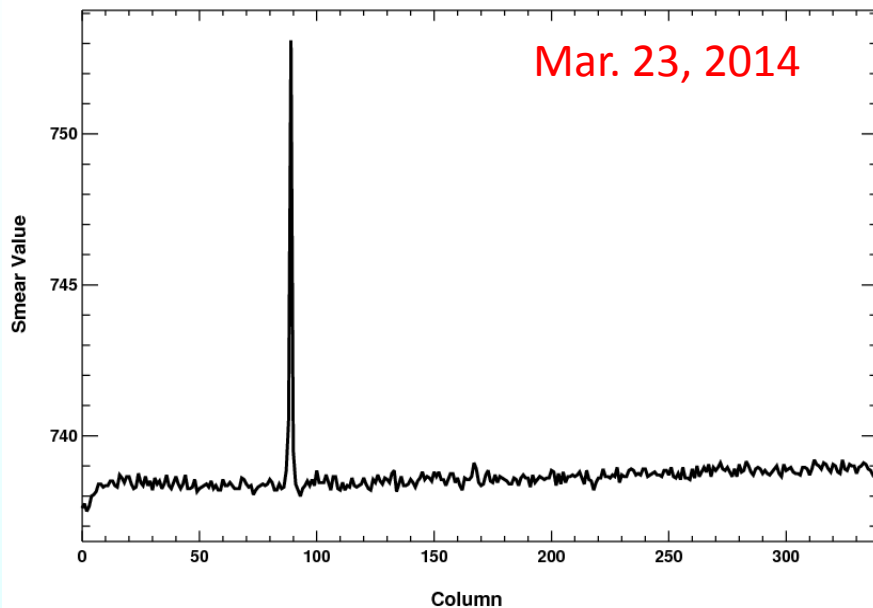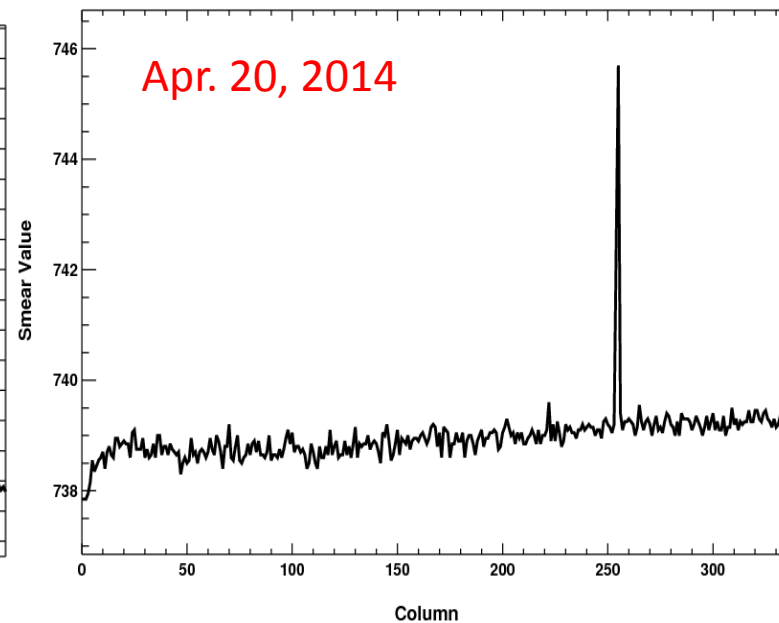
10 days

Full record

Full record
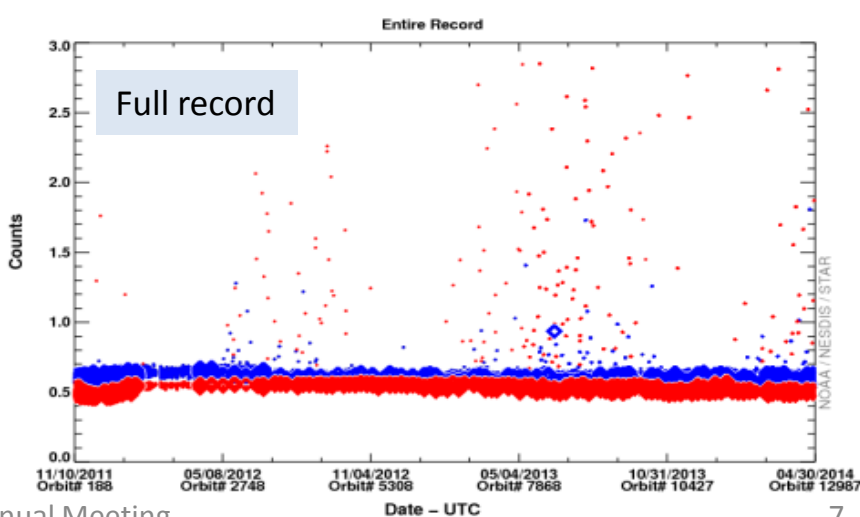
NM Anomalous Smear Values

CCD1 Smear Values for Nominal Dark on March 23, 2014

Mar. 23, 2014

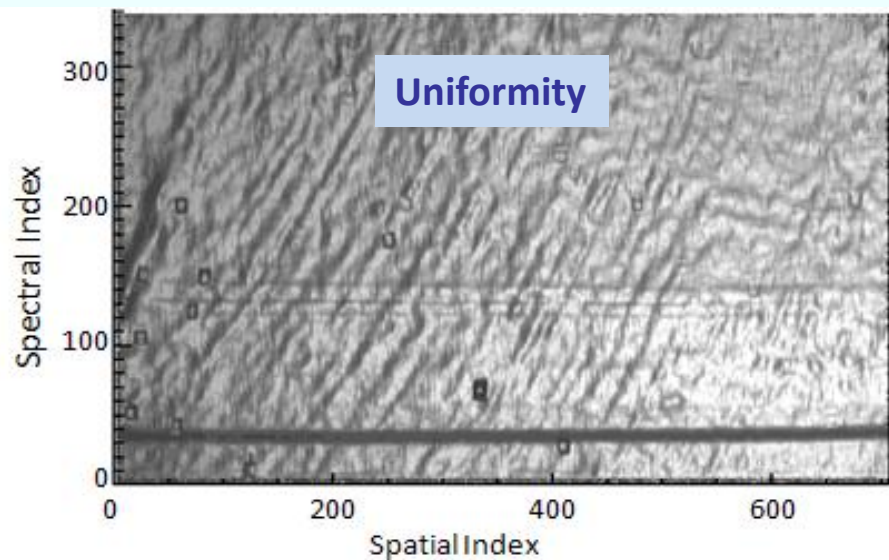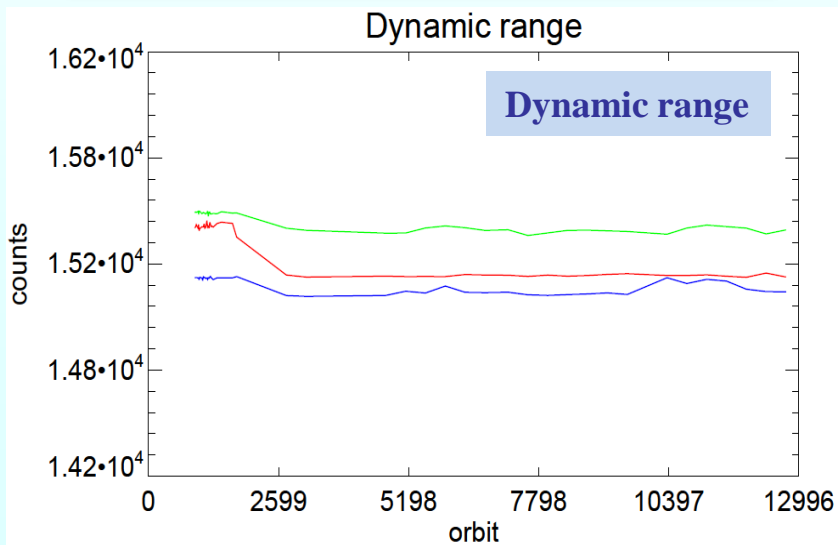CCD1 Smear Values for Nominal Dark on April 20, 2014
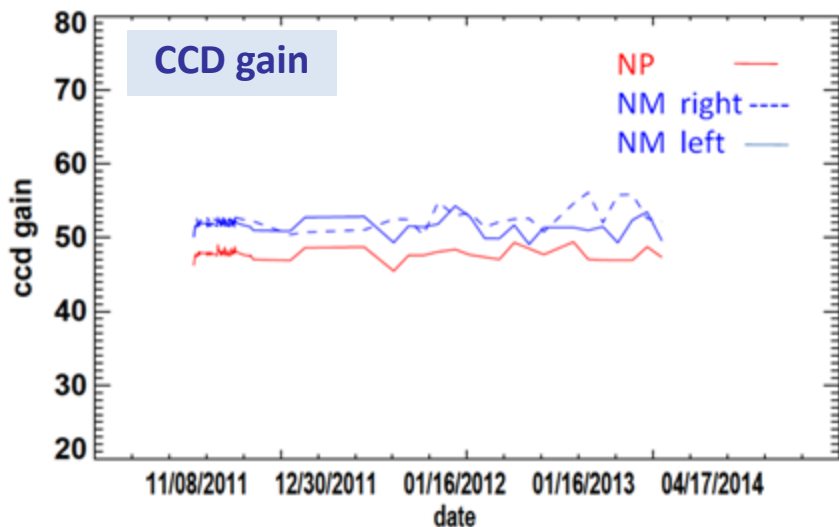
Apr. 20, 2014

Anomalies smear values were discovered from NM CCD1 storage region. These were automatically detected.

The calibration team is working on an algorithm to improve transient detection.
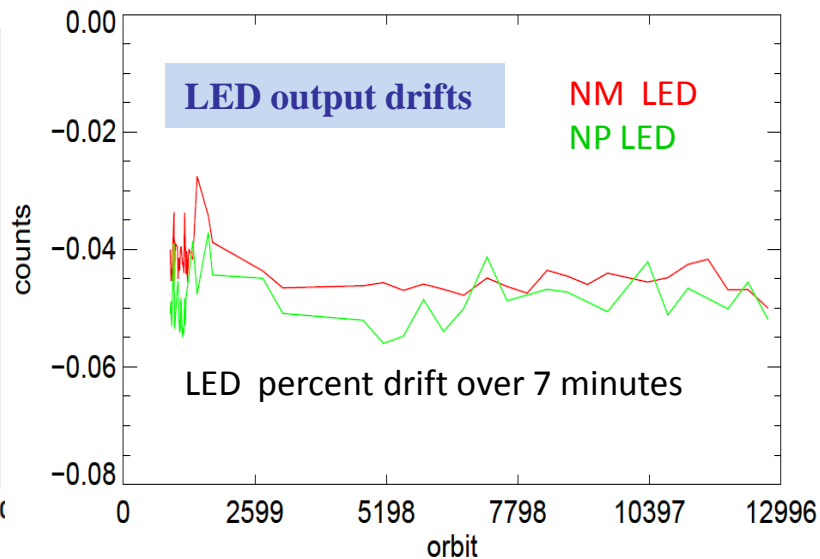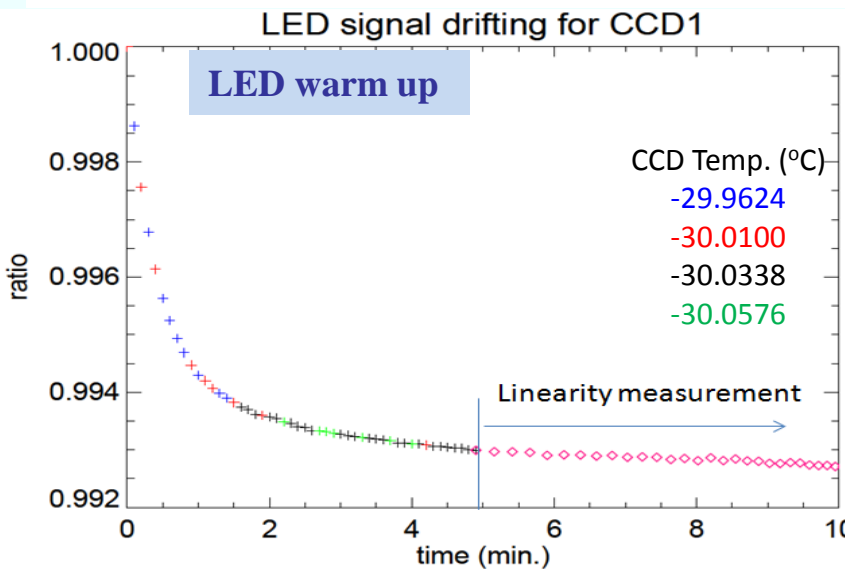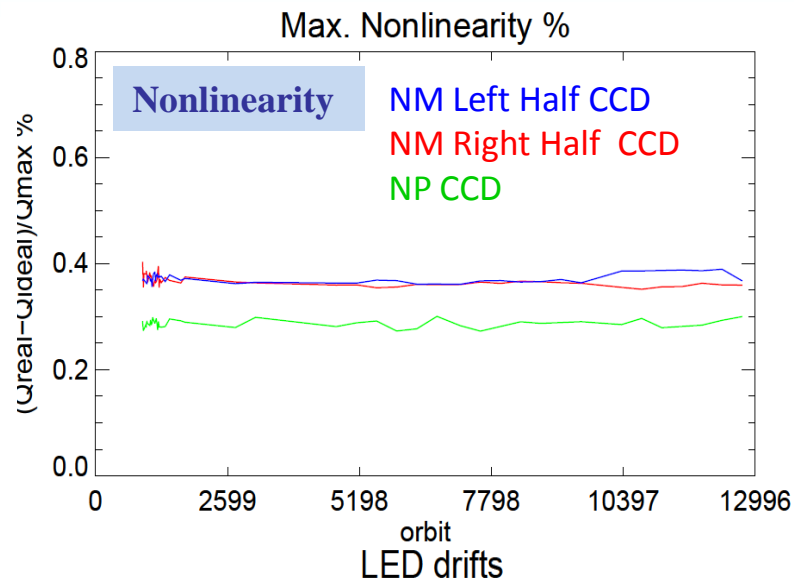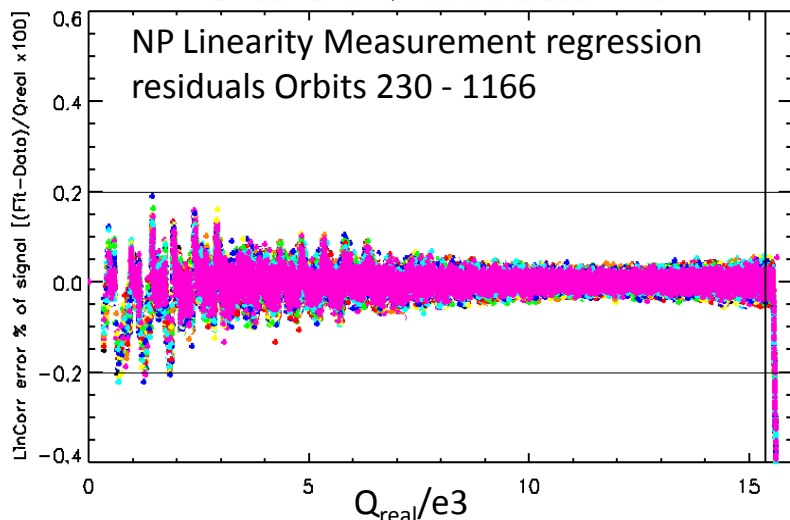
Linearity characterization

EVLED_Closed – 1 orbit Every 4th week

NP Lamp Warmup	50 images
NP Linearity	83 images
NP FF Lamp	1 image
NM Lamp Warmup	50 images
NM Linearity	83 images
NM FF Lamp	1 image

CCD gain

Dynamic range

Uniformity

System linearity meets requirement

NP Linearity Measurement regression residuals Orbits 230 - 1166

Max. Nonlinearity %

Nonlinearity
NM Left Half CCD
NM Right Half CCD
NP CCD

LED signal drifting for CCD1

LED warm up

CCD Temp. (°C)
-29.9624
-30.0100
-30.0338
-30.0576

Linearity measurement

LED drifts

LED output drifts
NM LED
NP LED

LED percent drift over 7 minutes

Modified solar measurement reduces view angle dependence

3orb Solar Every 2nd week

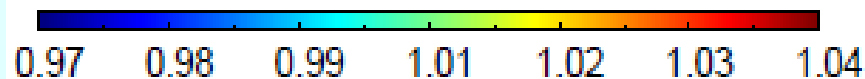|		
TC Solar (1,4,7)	57 images	Orbit 1
TC / NP Stor. Darks	37 images	
TC Solar 2	16 images	Orbit 2
NP Solar	16 images	
TC Solar 6	16 images	
TC / NP Open Darks	37 images	
TC Solar (1,3,5,7)	54 images	Orbit 3
TC / NP Closed Darks	37 images	
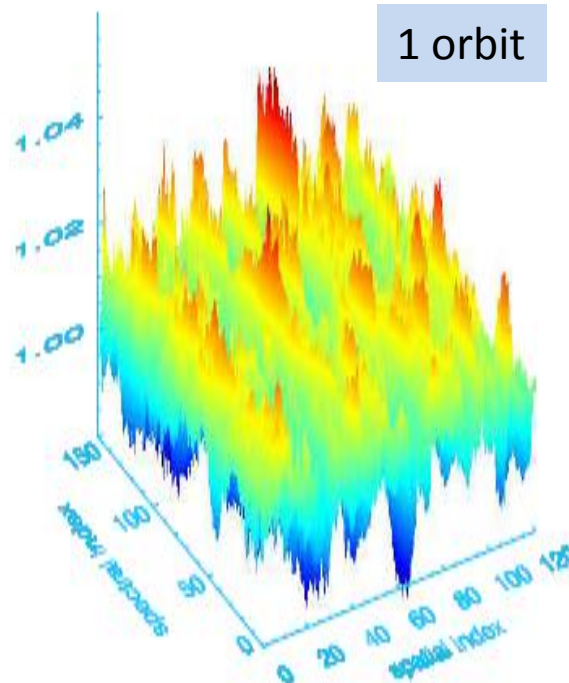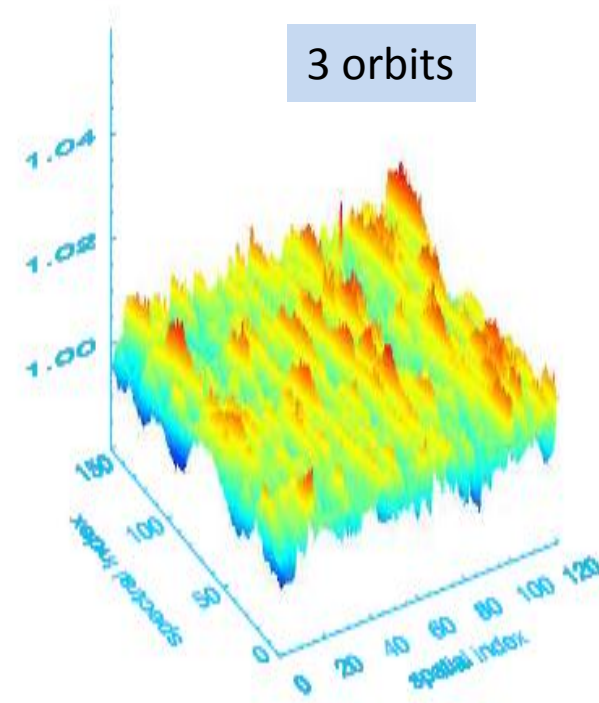
1 orbit

3 orbits

Ratio of solar data

Data is being used to study diffuser feature

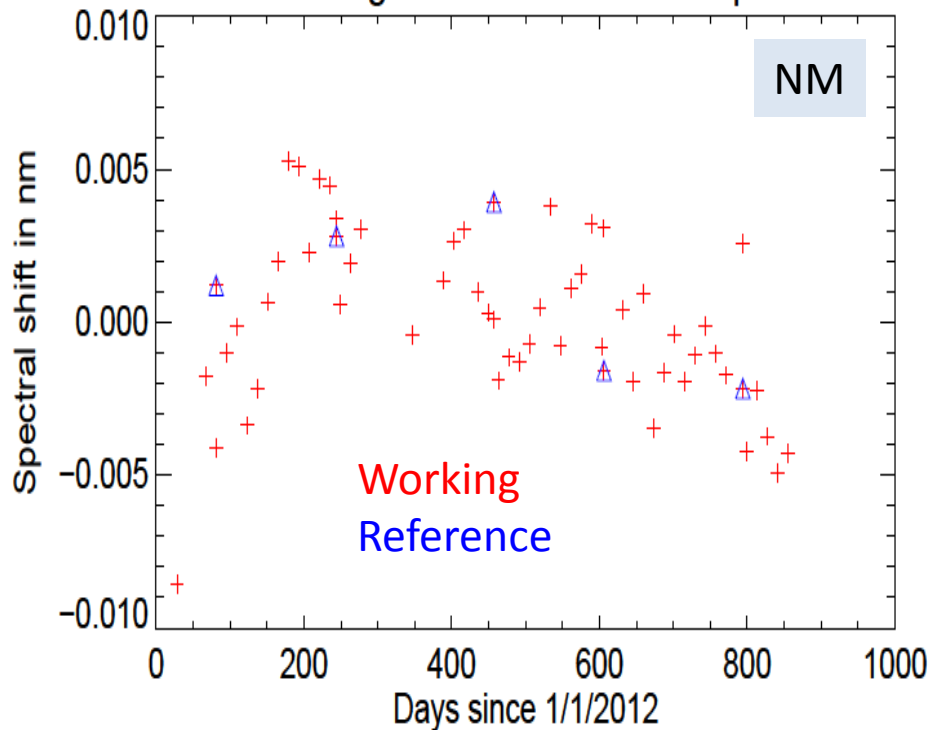# Wavelength shifted from ground to orbit
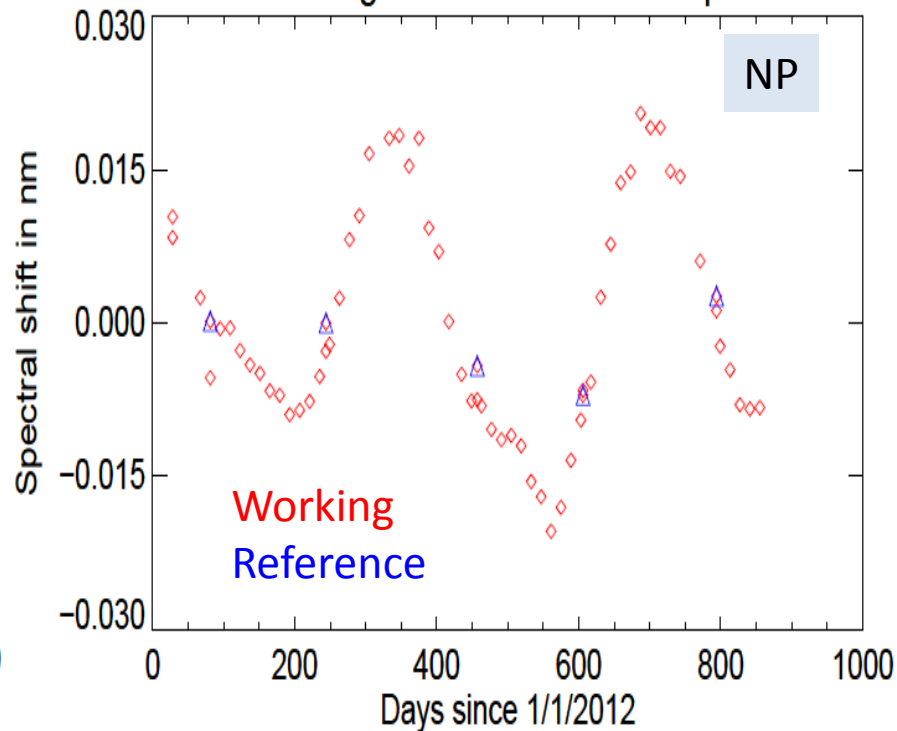
LUT comparison %

Dichroic filter shifts

Measured vs. Synthetic Solar Flux
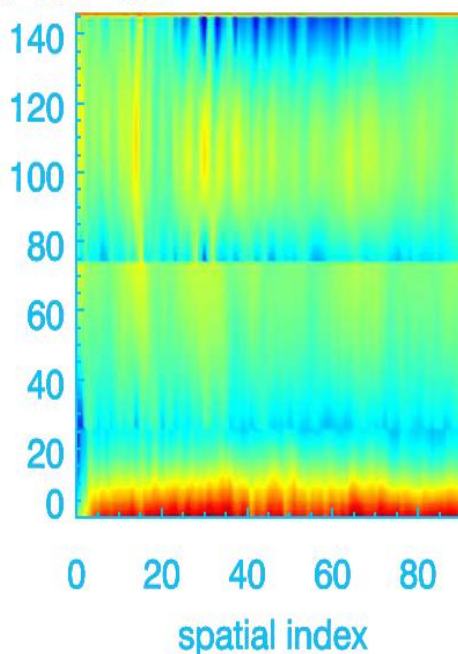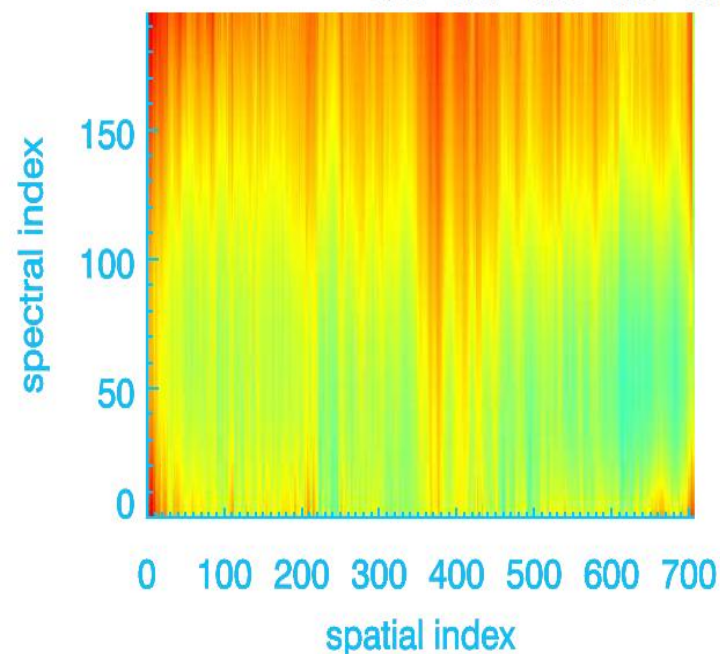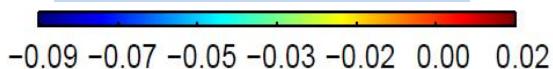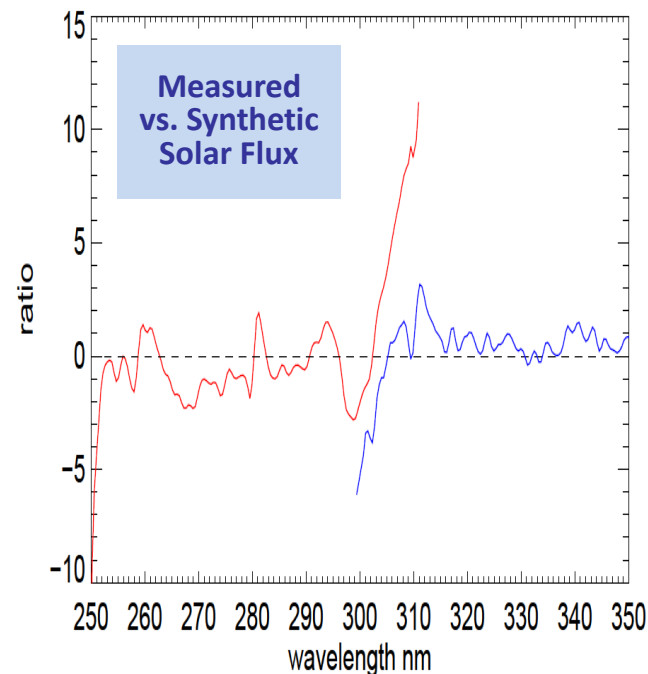
Orbital wavelength changes < ±0.02nm

NM intra-orbit wavelength variation <±0.025nm
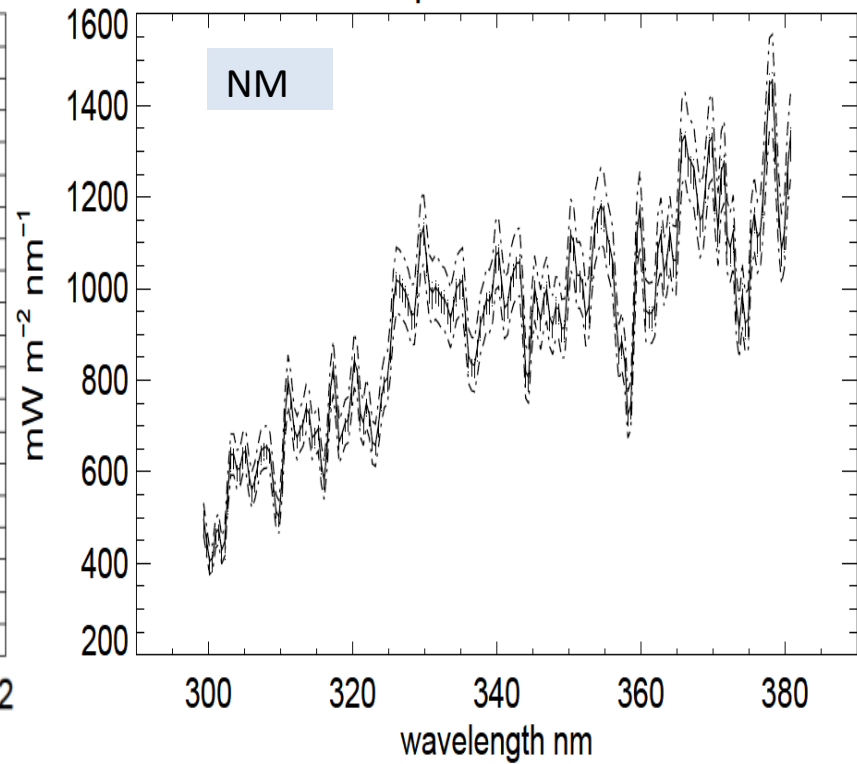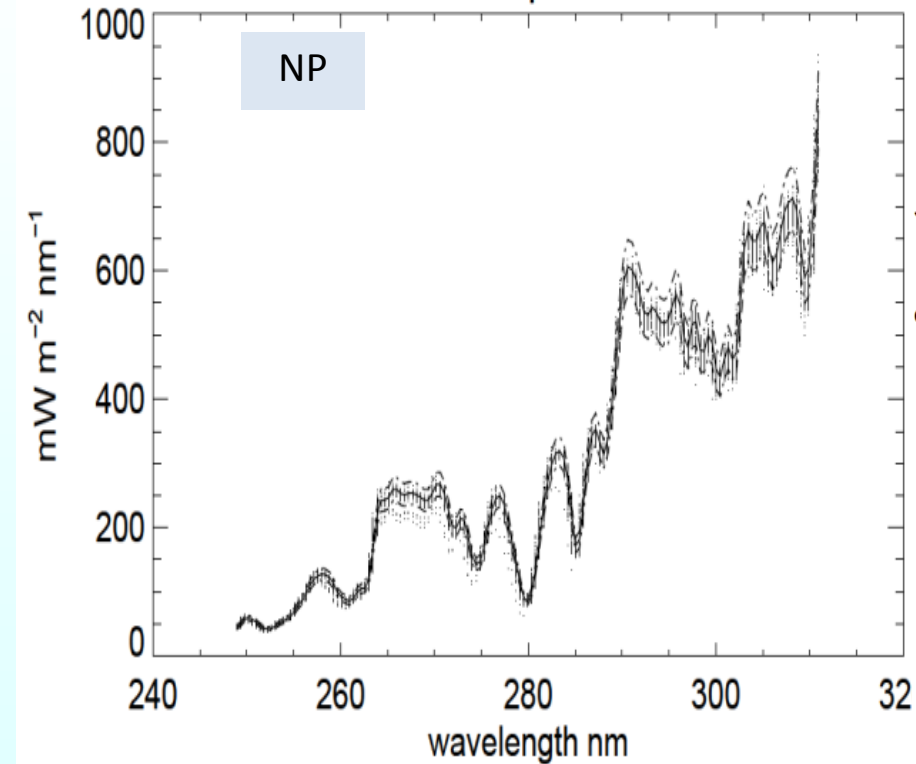
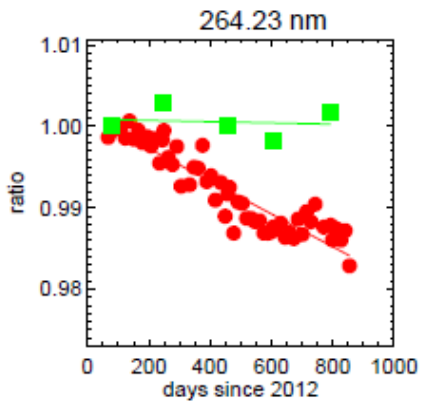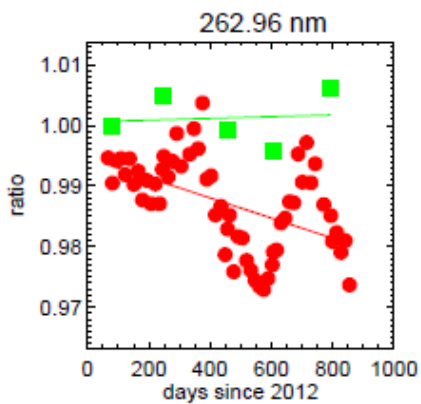NM housing temperature (°C)
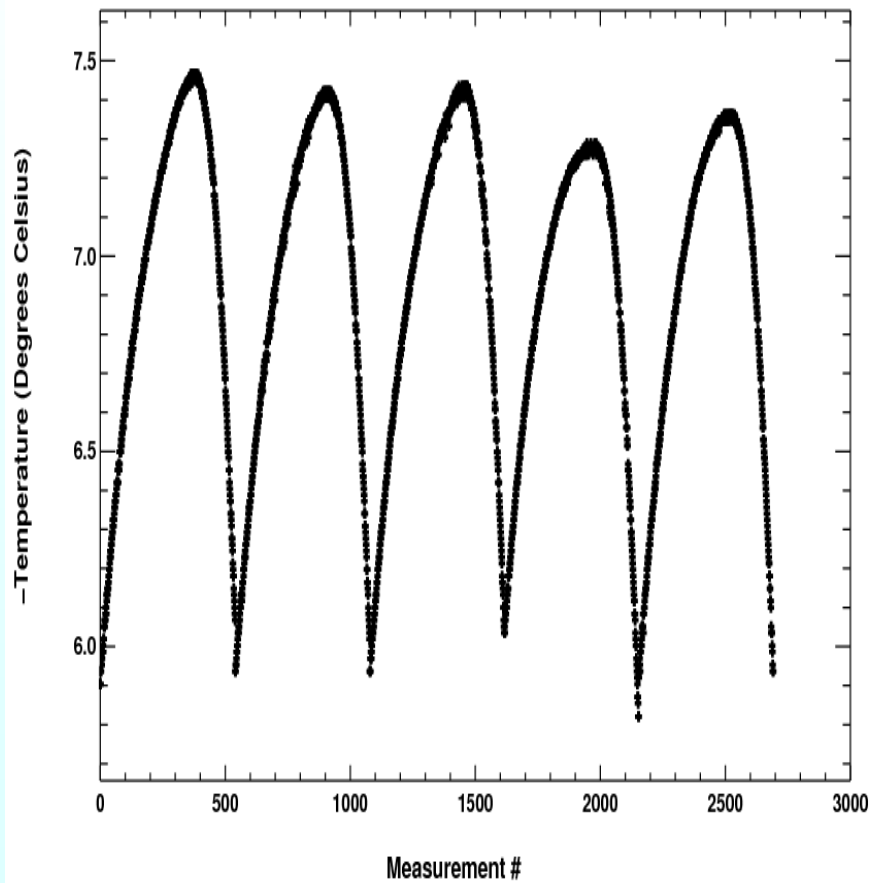
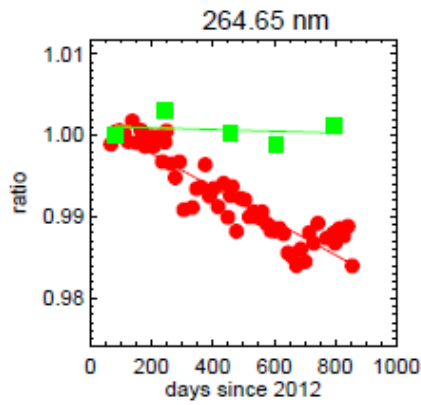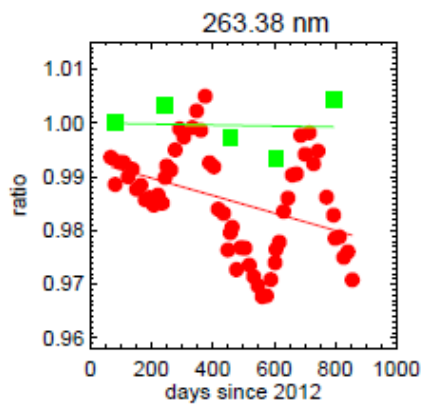Intra-orbital wavelength shift in pixel
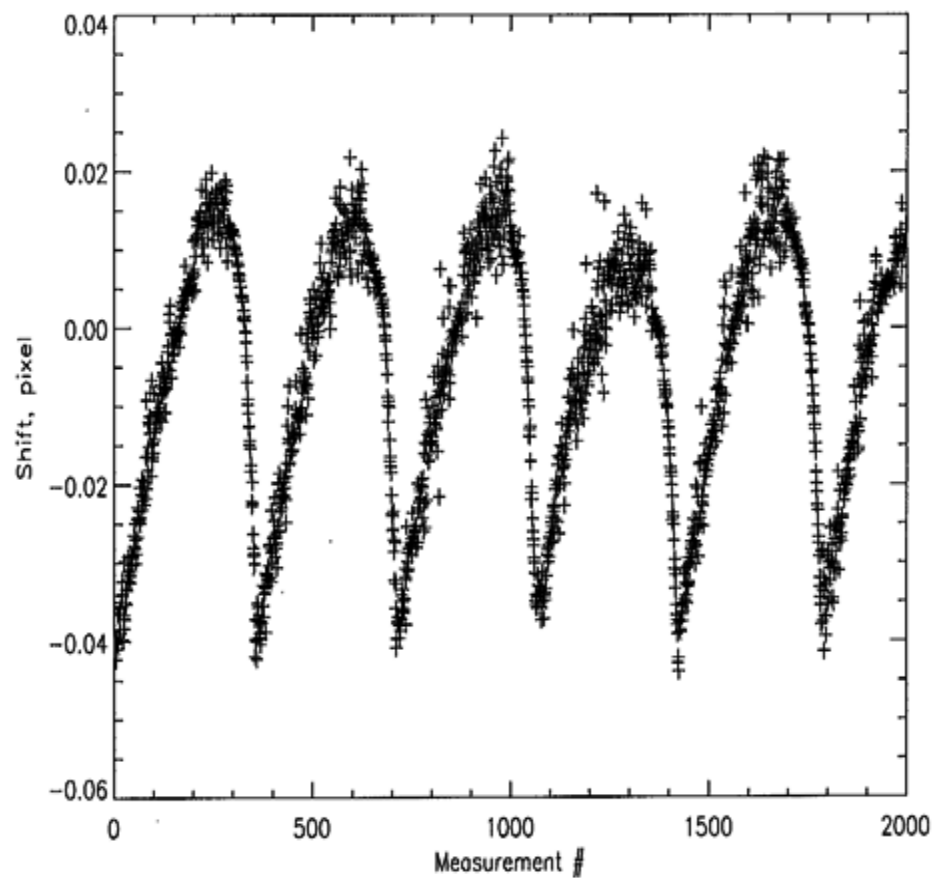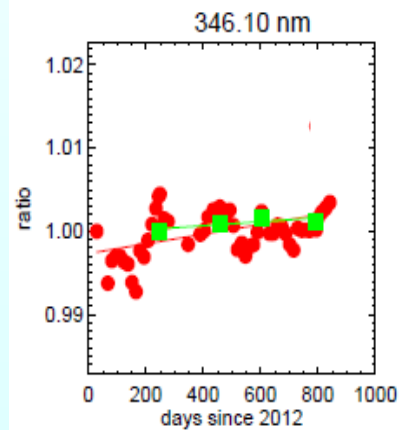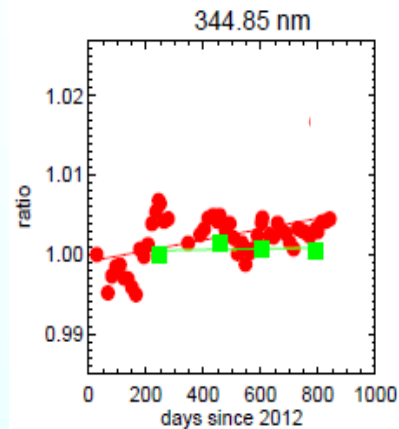
Solar irradiance uncertainty <7%

Optical throughput trending

NP   **Reference**   **Working**   NM
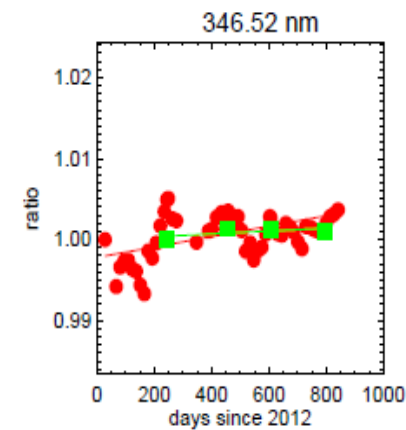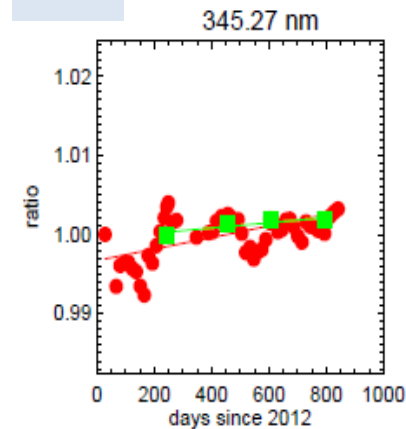
Sensor optic degradation < 0.5%
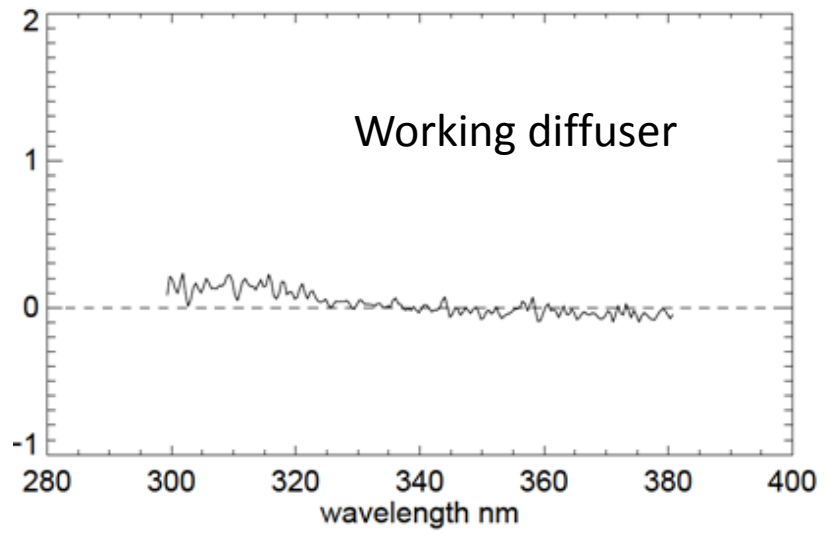
Cross-track position pattern in solar flux

Stray light correction

No Stray light correction

NM

NM v1

NM v2

Spectral overlap

NM
NP

- No correction
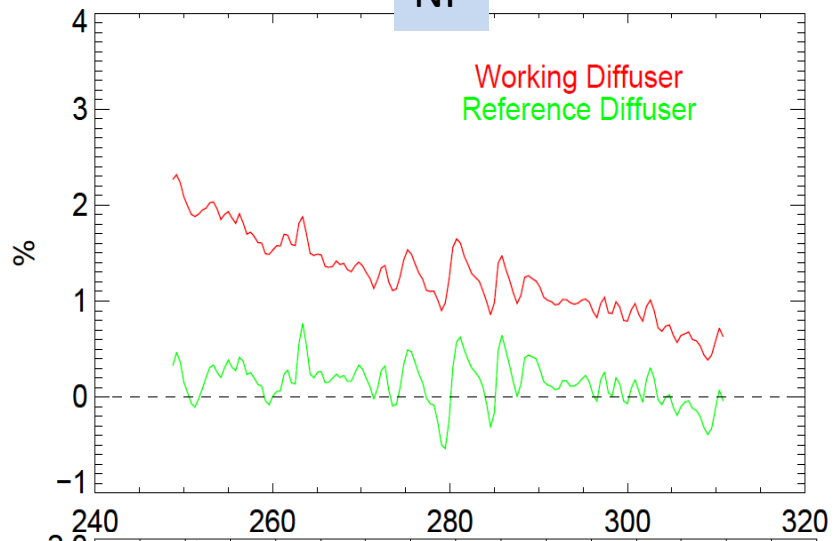- V1
- v2

NM

NP
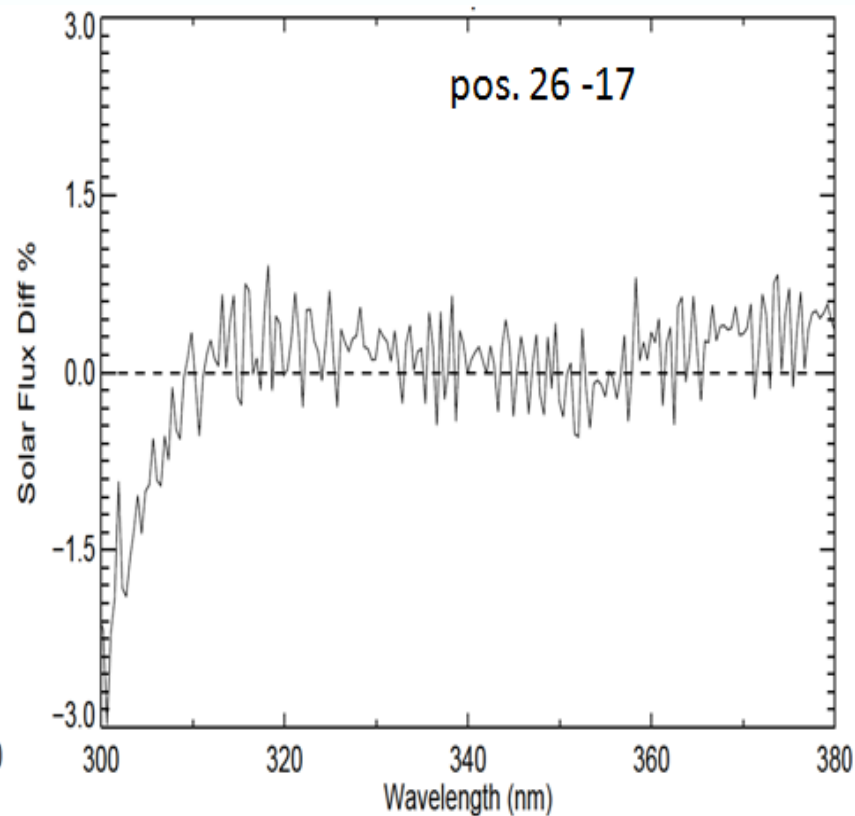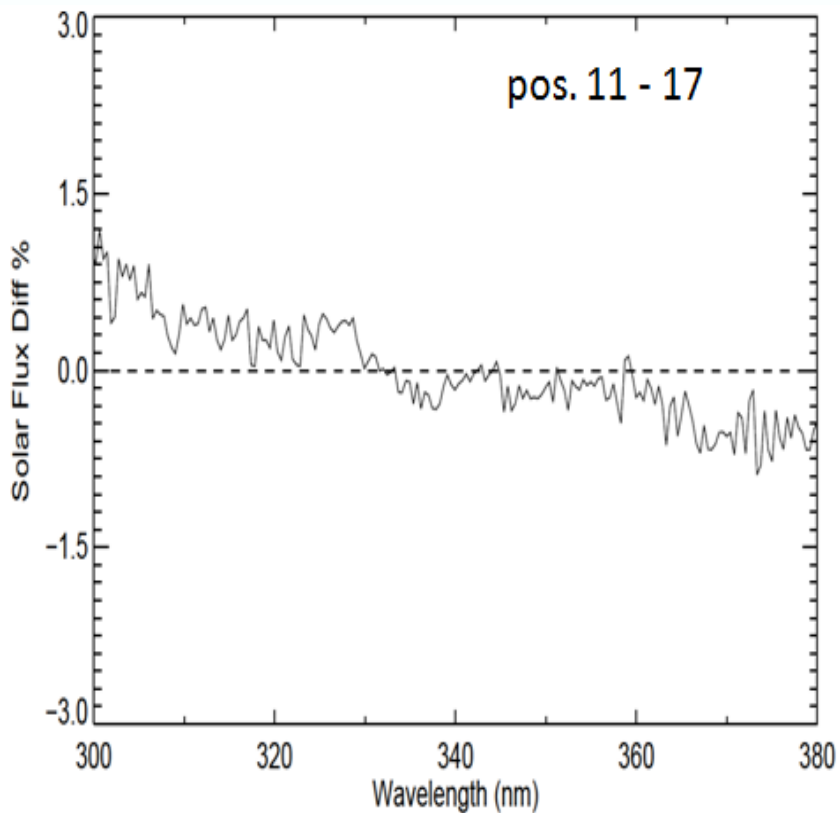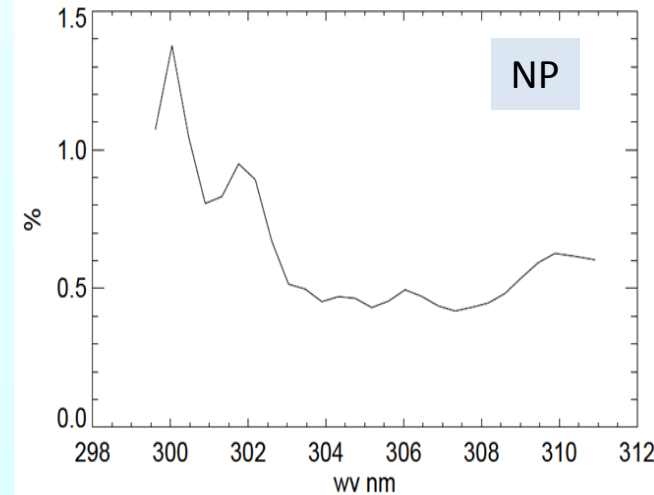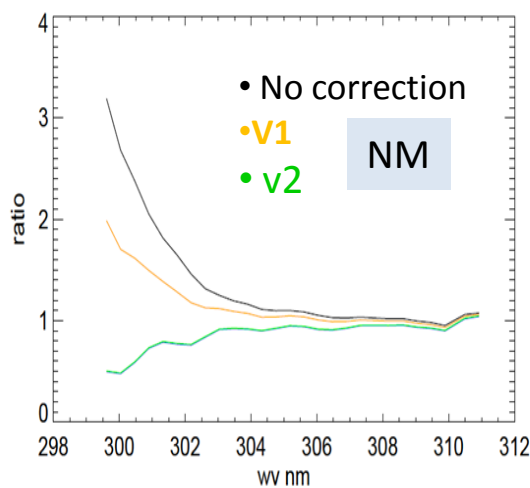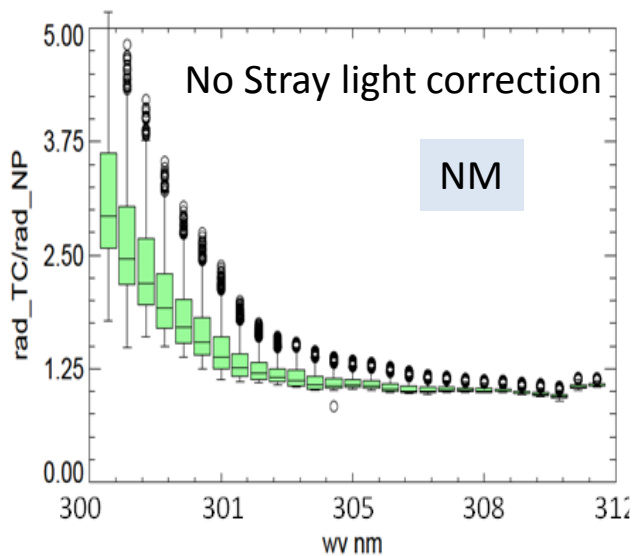
Summary

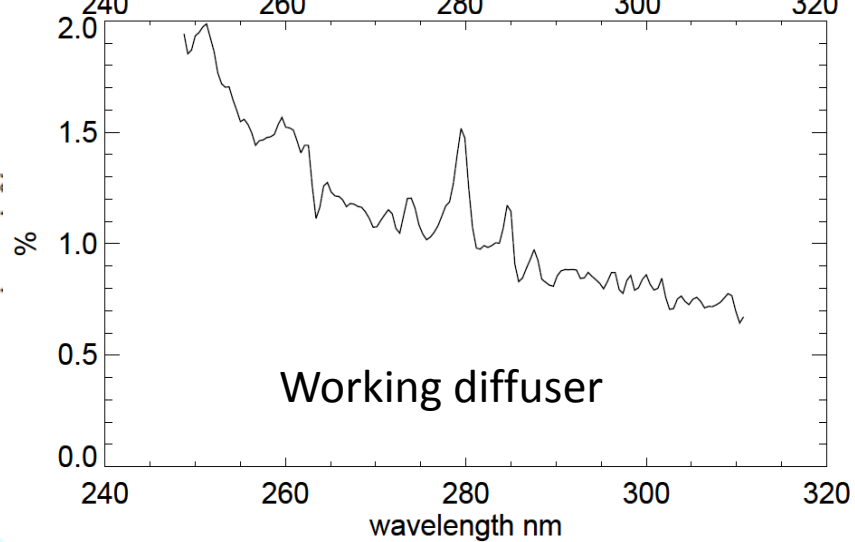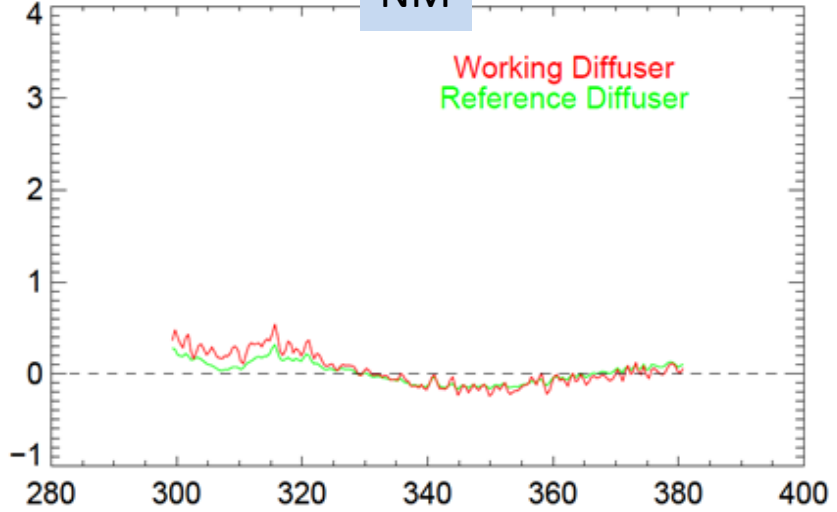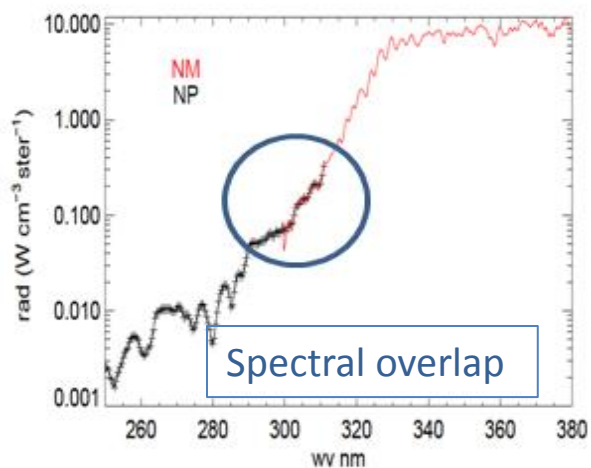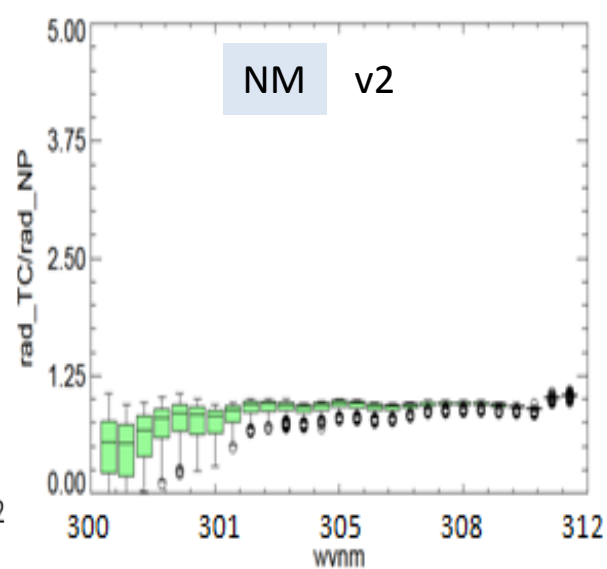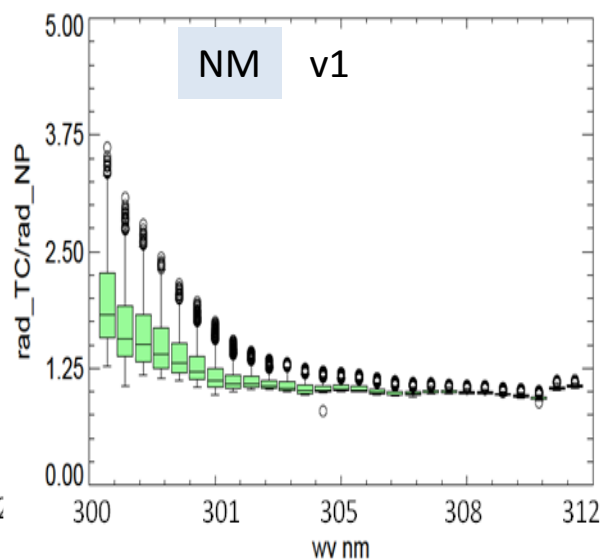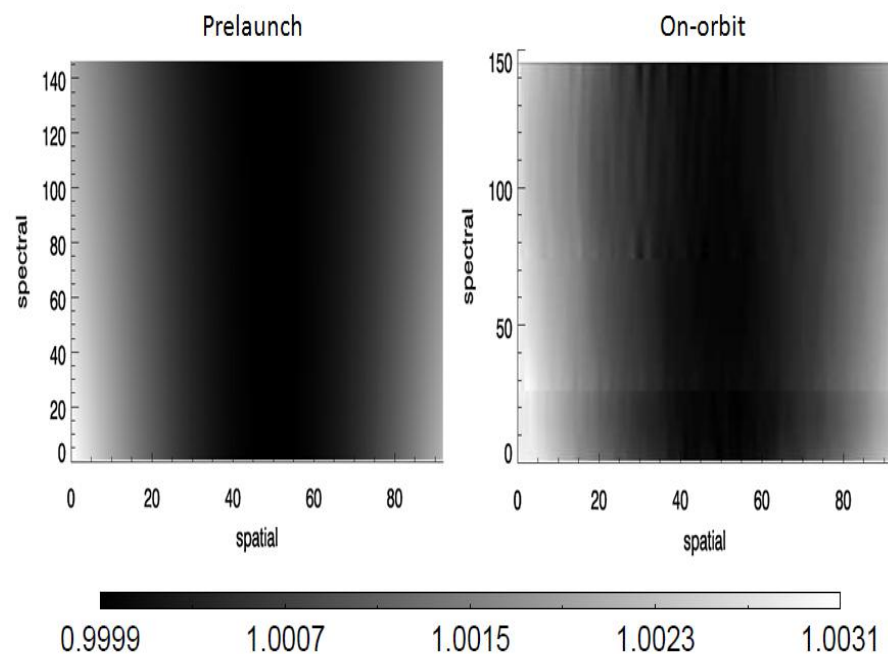| Parameters	Specification/Prediction Value	On-Orbit Performance
Non-linearity	< 2% full well	< 0.46%
Non-linearity Accuracy	< 0.2%	±0.2%
On-orbit Wavelength Calibration	< 0.01 nm	0.15-0.25 nm
Stray Light NM Out-of-Band + Out-of-Field Response	For NM ≤ 2	average < 2%
Intra-Orbit Wavelength Stability	Allocation (flow down from EDR error budget) = 0.02 nm	~ 0.02 nm
SNR	1000	> 1000
Inter-Orbital Thermal Wavelength Shift	Allocation (flow down from EDR error budget) = 0.02 nm	~0.02 nm
CCD Read Noise	60 –e RMS	< 25 –e RMS
Detector Gain	43 (for NP)	47 (for NP)
	46 (for NM)	51 (for NM)
Absolute Irradiance Calibration Accuracy	< 7%	< 3% in 300-310 nm: up to ~10 % for both NM and NP
Absolute Radiance Calibration Accuracy	< 8%	< 5% in 300-310 nm: up to ~6 % for NM and NP
Normalized radiance Calibration Accuracy	< 1%	< 1%

"Spectral smile" is small
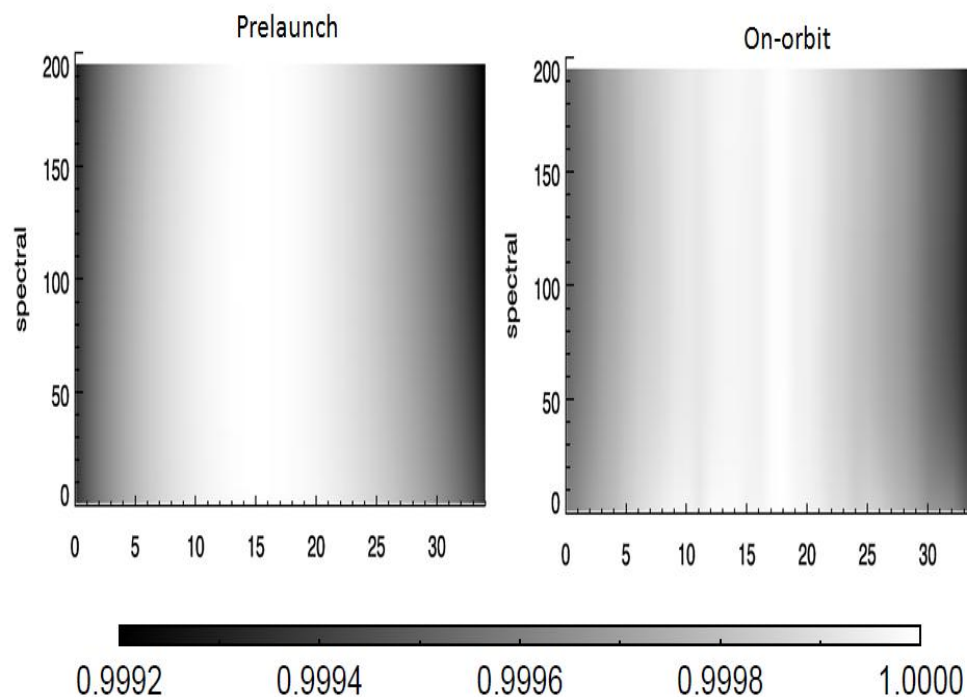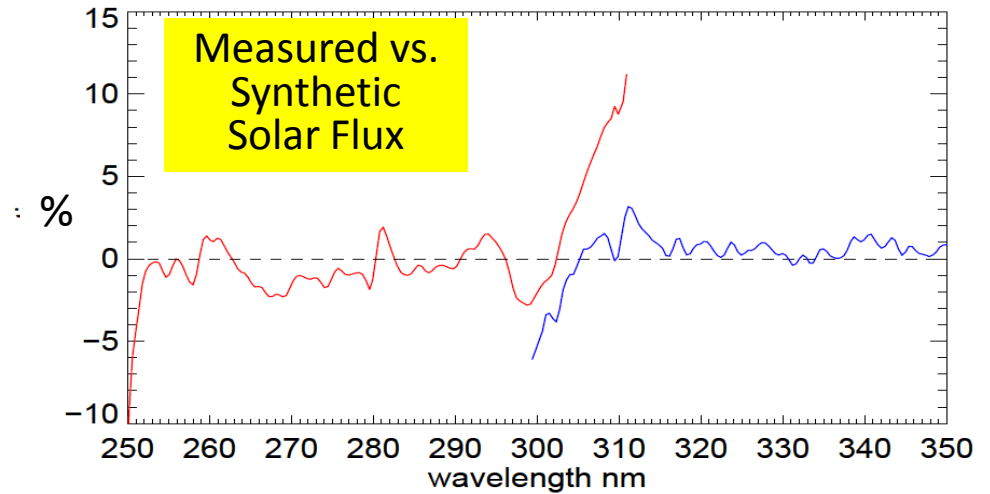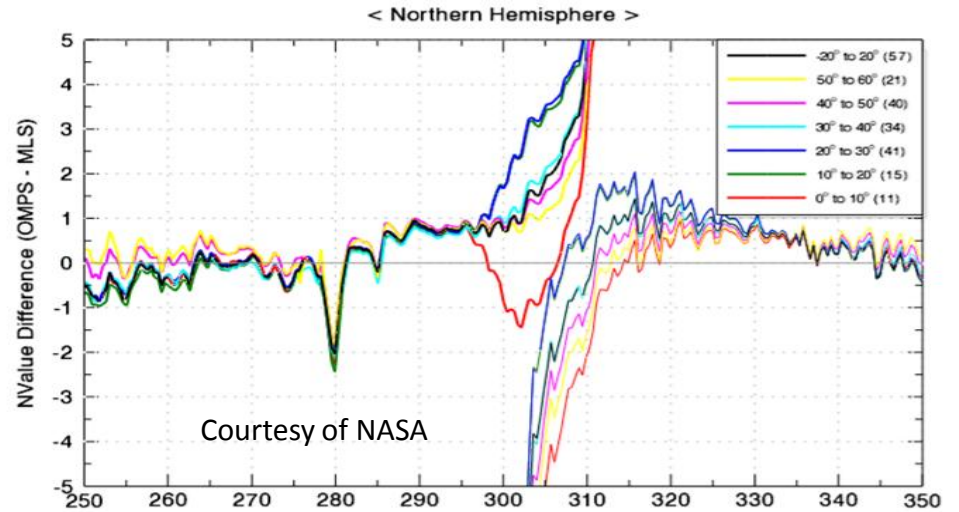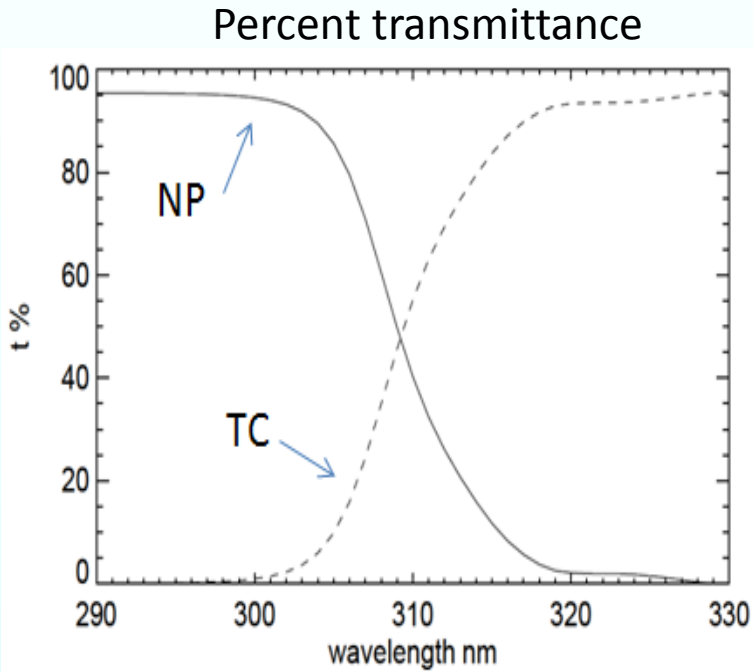
Dichroic shifted from ground to orbit

Percent transmittance

< Northern Hemisphere >

Courtesy of NASA

Measured vs. Synthetic Solar Flux

OMPS SDR calibration tables

Table Description	Table Type	Delivery Status
NM & NP Day 1 Solar	LUT	Once (will be repeat)
NM & NP Wavelength	GND-PI	Once(will be repeat)
NM & NP CF Earth	GND-PI	Monthly (ceased)
NM & NP Dark Tables	GND-PI	Weekly
Diagnostic Flight Sample Tables	SCT	When necessary
Earth-view Flight Sample Tables	SCT	Once
Earth-view Ground Sample Tables	GND-PI	Once
Calibration Flight Sample Tables	SCT	Once
NM & NP Radiometric Coefficients	LUT	TBD
NM Stray Light Coefficents	LUT	Once
NP Stray Light Coefficents	LUT	Once
NM & NP Linearity (Flight & Ground)	SCT/GND-PI	Not planned
NM & NP Flat Field	SCT	Not planned