Updates on Suomi NPP and NOAA-20 OMPS Sensor Data Records (SDRs)

**C. Pan[a], F. Weng[b], T. Beck[c], L. Flynn[c], Z. Zhang[d] and L. Zhou[c]*

[a] ESSIC, University of Maryland, College Park, MD 20740
[b] Environmental Model and Data Optima Inc., Laurel, MD 20707
[c] NOAA NESDIS/STAR, College Park, MD 20740
[d] I M Systems Group Inc., Rockville, MD 20852

98th American Meteorological Society Annual Meeting
7-11 January 2018
Austin, US

Supported by NOAA grant NA09NES4400006 (Cooperative Institute for Climate and Satellites) at the University of Maryland/ESSIC

Topics and Scopes

- Introduction
  - Instrument overview
  - OMPS Sensor Data Records (SDRs)
  - SDR science applications
- From Suomi-NPP to JPSS-1 (NOAA-20)
  - Suomi-NPP OMPS SDR reprocessing
  - Status of NOAA-20 OMPS operation
  - NOAA-20 OMPS SDR Pre-operational performance
  - Schedules and Milestones
  - Long Term Monitoring
- Summary

Introduction

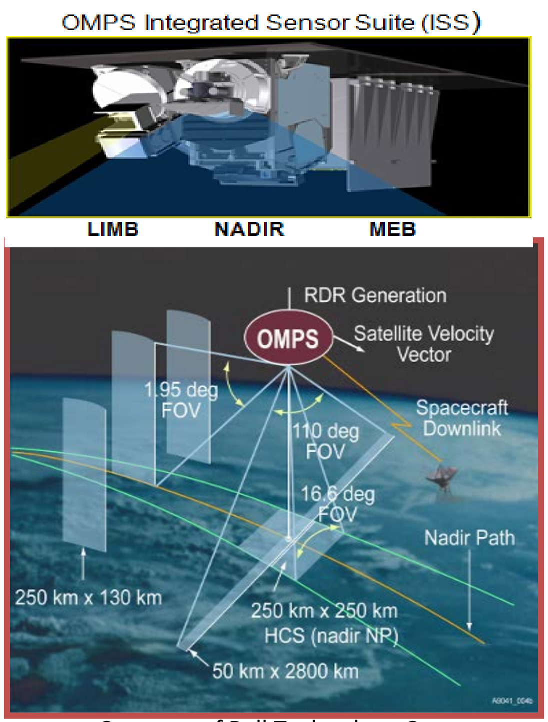
- The Joint Polar Satellite System (JPSS) satellites provides continuity of global environmental data. The Suomi National Polar-Orbiting Partnership (S-NPP) Satellite is the first Satellite in the JPSS constellation of satellites.
- OMPS is one of five instruments flying on JPSS-1 satellite on Nov. 18th 2017. The first OMPS is on board the Suomi-NPP satellite launched in Oct. 2011.
- OMPS heritage sensors are SBUV/2 and TOMS, providing ozone total column and vertical profile data that continues ozone daily global data with higher calibration accuracy and higher spatial and spectral resolution.

OMPS: Ozone Mapping Profiler Suite

JPSS-1 reached polar orbit on Saturday, November 18; it officially became known as NOAA-20.

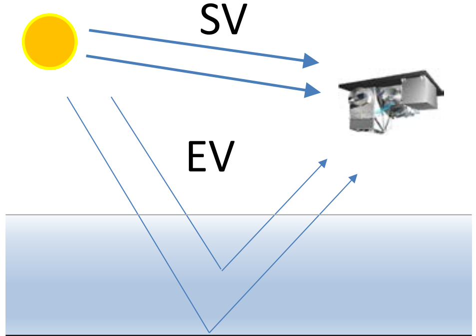
Instrument Configuration

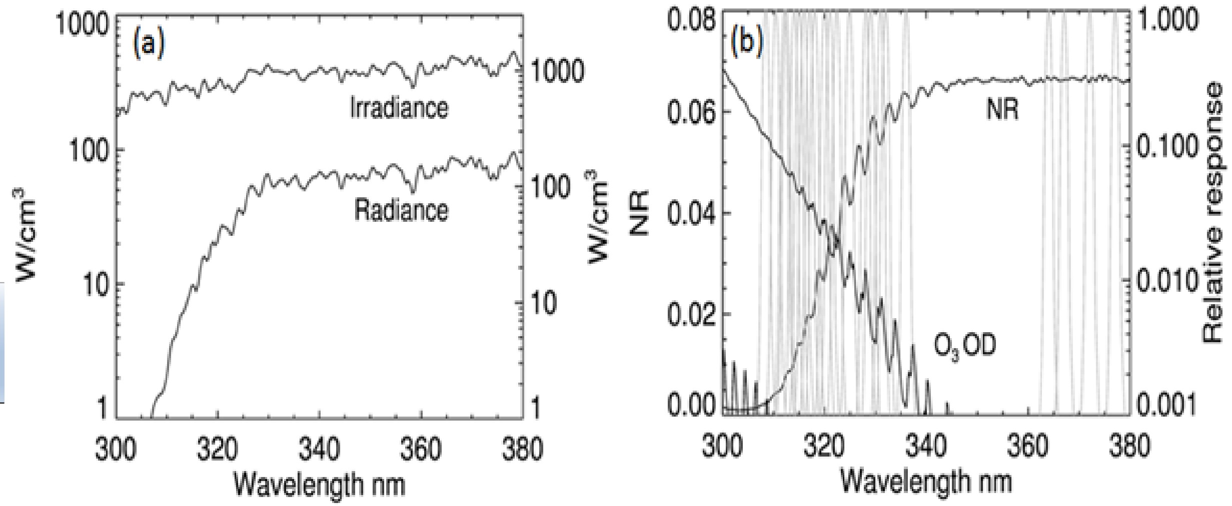
	Nadir Technical Specification
Telescope	One telescope w/ two grating CCD spectrometers Nair Profiler NP and Nadir Mapper (NM)
Swath Width	NM: 2800 x 50 km^2; NP: 250 x 250 km^2
Field of View (FOV)	NM: 110^o; NP: 16.7^o (square)
Spectral Range	NM: 300 to 380 nm; NP: 250 to 310 nm
Spectral Sampling Interval	2.4 pixels per FWHM
Spectral Resolution	1.0 nm
CCD Detector Cooling Operational set point	Thermo-Electric Coolers (TECs) NM: -45.0 ^oC; NP: -30.0 ^oC
Calibration	On-board light-emitting diodes (LEDs) and dual Solar diffusers
Products	Provide globe maps every 24 hours of amount of ozone and volumetric concentration in a vertical column of atmosphere with a 4- days revisit



Courtesy of Ball Technology Corp.

OMPS Measurement Technique





EV radiance
$$I_{jk}^{m}(t)=\frac{C_{jk}^{r}k_{jk}^{r}}{\tau_{jk}(t)}$$

SV irradiance
$$F_{jk}^{m}(t)=\frac{C_{jk}^{i}k_{jk}^{i}}{g\,\rho(t)\tau_{jk}(t)}$$

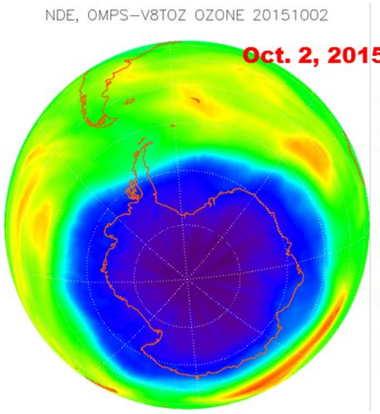
Normalized radiance
$$\frac{I_{jk}^{m}}{F_{jk}^{m}}=K_{jk}\frac{C_{jk}^{r}}{C_{jk}^{i}}g\,\rho(t)$$

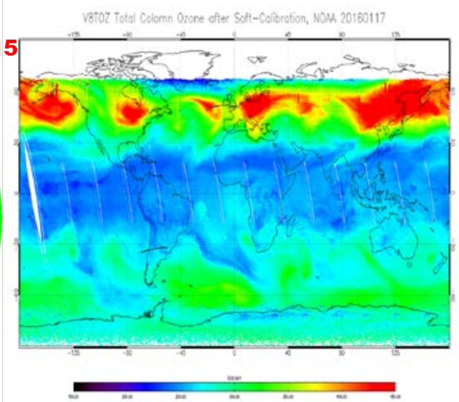
$C_{jk}(t)$: initially calibrated radiance counts
k_{jk}: radiance calibration constant
$\tau_{jk}(t)$: pixel response changes
$\rho(t)$: solar diffuser plate reflectivity
g: relative angular irradiance response

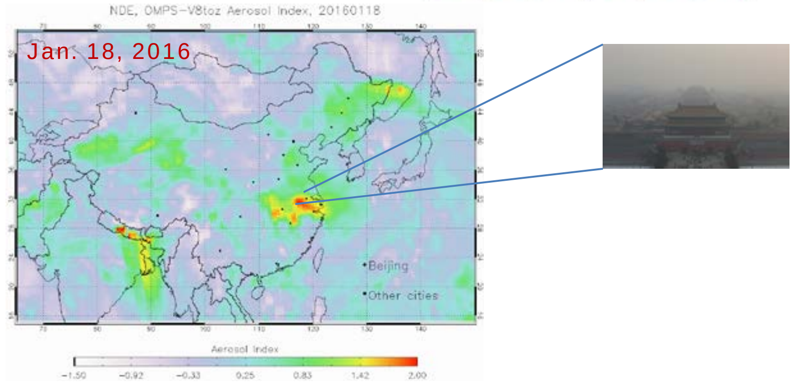
CCD detector performance, stray light, wavelength registration are the primary factors

OMPS SDRs and Applications

- GEOs: Earth geo-location information of measurements
- Calibration SDRs (offline): ancillary information, including radiometric and geometric calibration coefficients.
- EV SDRs: calibrated radiance and key parameters such as wavelength, solar flux, dark, smear, electronic bias etc.
- SDR algorithm was developed to function on the processing hardware to meet product requirements.
- Primary application: continue three decades of total ozone and ozone profile records; measure other atmospheric particles like sulfur dioxide and ash that result from volcanic eruptions.







https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/D0001-M01-S01-006_JPSS_ATBD_OMPS-TC-Ozone_C.pdf
https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/D0001-M01-S01-005_JPSS_ATBD_OMPS-NP-Ozone_A.pdf

Reprocessing of Suomi NPP SDR

Beta - Mar. 05, 2012

Provisional - Mar. 01, 2013

Validated - Sept. 2015

- Calibration and EV SDR separation
- Wavelength, solar day one and dark update
- Earth view sample table update
- RDR truncation correction

IDPS Mx6.2 - 2012-08-10

IDPS Mx7.1-Mx7.2 Feb. 28 2013

- SAA dark LUT update Mx7.1, May 20, 2013
- Error in Scene ascending/descending condition Flag Mx7.1, May 20, 2013
- TC SL correction was resumed -Mx7.2, Aug. 21, 2013

- TC Wavelength ajustement - Mx8.2
- NP SL LUT - Mx8.3 Mar. 18, 2014
- OMPS Bias LUT correction for negative smears in TC SDR – Mx8.5 July 22, 2014
- TC SL LUT update – Mx8.6, Nov. 21, 2014
- NP wavelength LUT update

IDPS Mx8.2- Feb. 20 , 2014

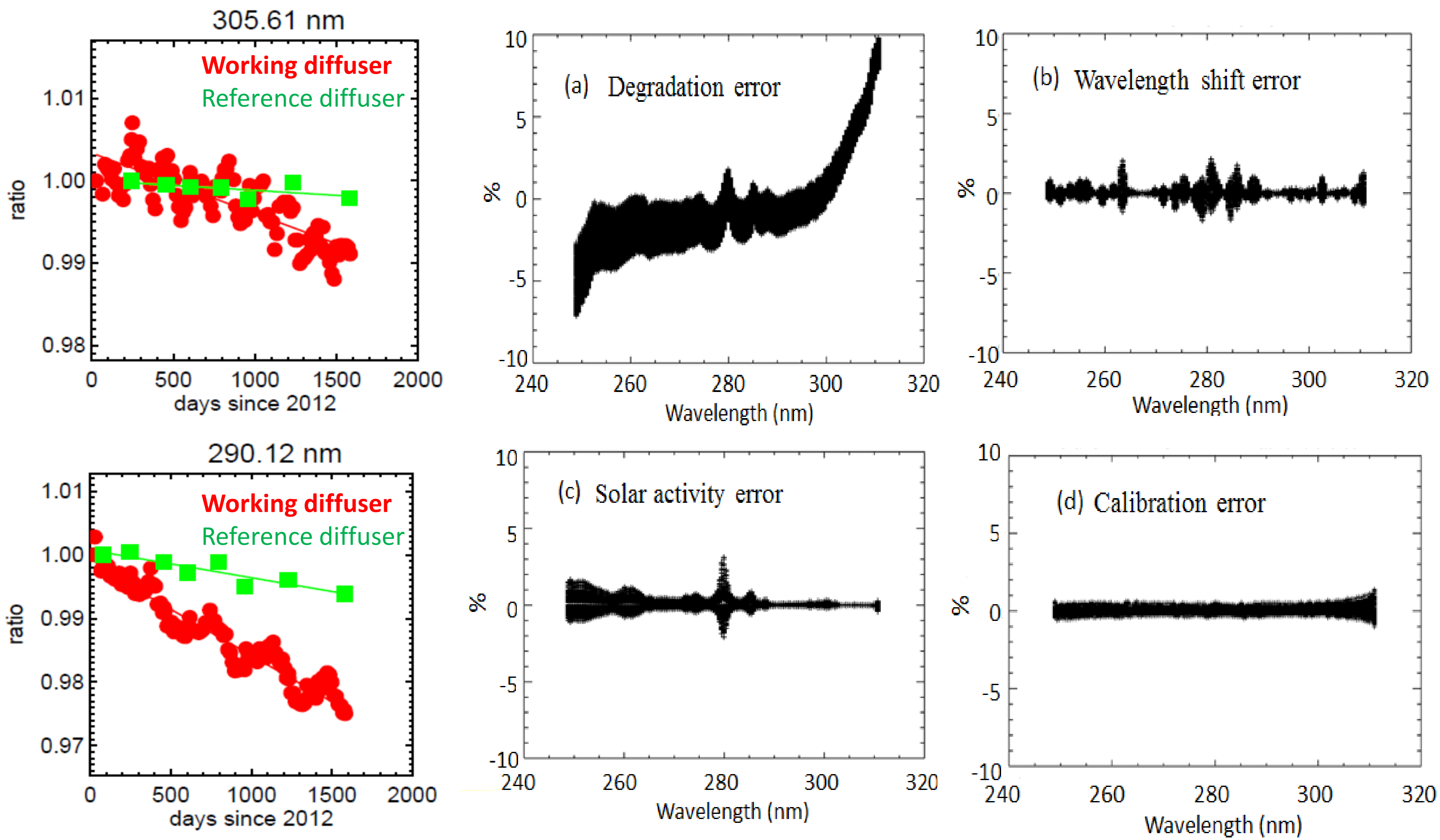
IDPS Mx8.11 2015-09-09

- TC Wavelength ajustement
- NP Wavelength ajustement
- TC and NP Solar day one LUTs update
- TC and NP radiance constants update
- TC wavelength LUT format change to include wavelength shift component
- SDR code change to process the changed wavelength format.

IDPS: ground Interface Data Processing Segment

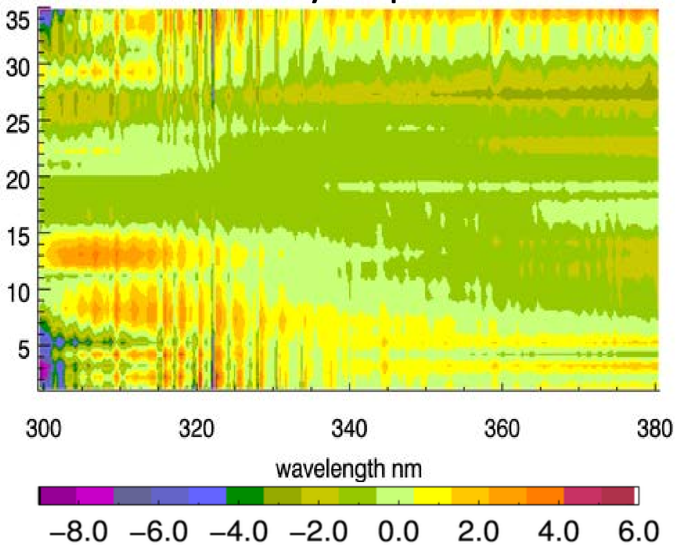
- SDR quality chronologically improved since Suomi NPP launch
- Use up-to-dated calibration LUTs and algorithm in OMPS SDR life-cycle reprocessing
- Produce consistent SDRs at the attainable quality level.

Improvement of Solar Calibration



Improvement of Data Accuracy

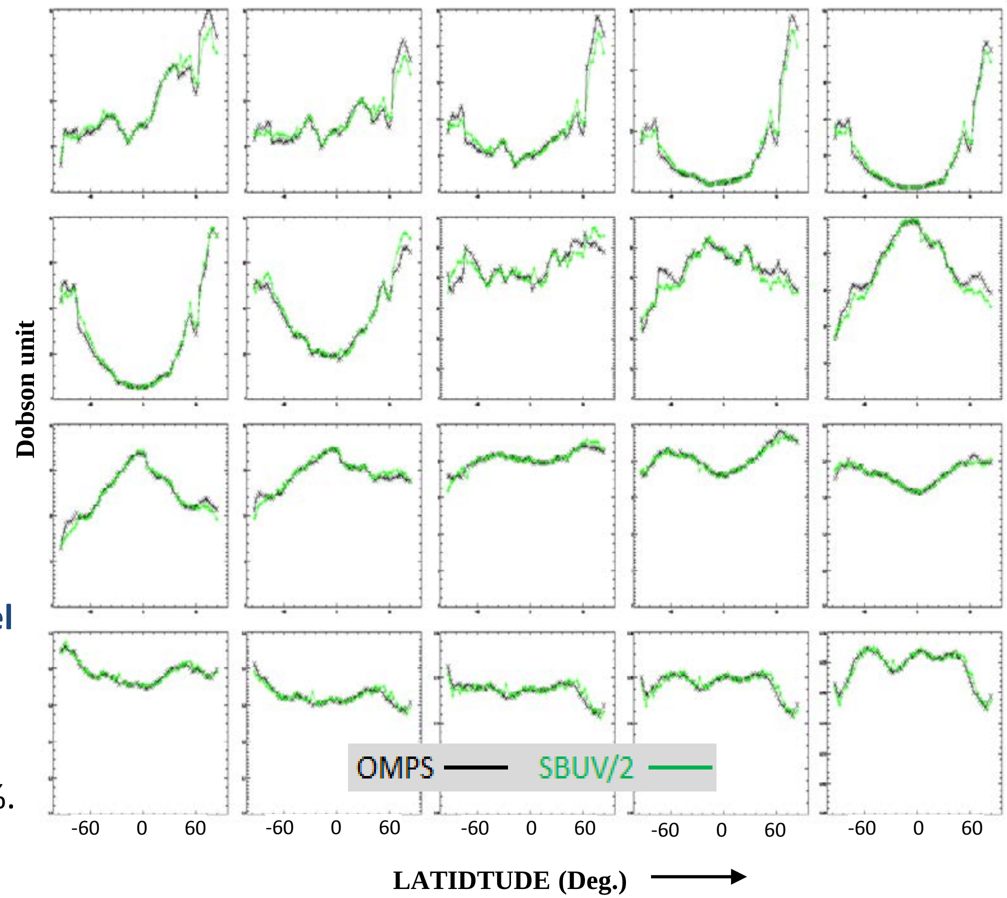
Albedo accuracy improvement %



Evaluated by comparison w/ MLS on the SDR level and NOAA 19 SBUV/2 on EDR level

- No long term time-dependent change relative to NOAA-19 SBUV/2.
- OMPS Nadir Mapper bias is near zero on average and a profiler bias of about 0.5%.

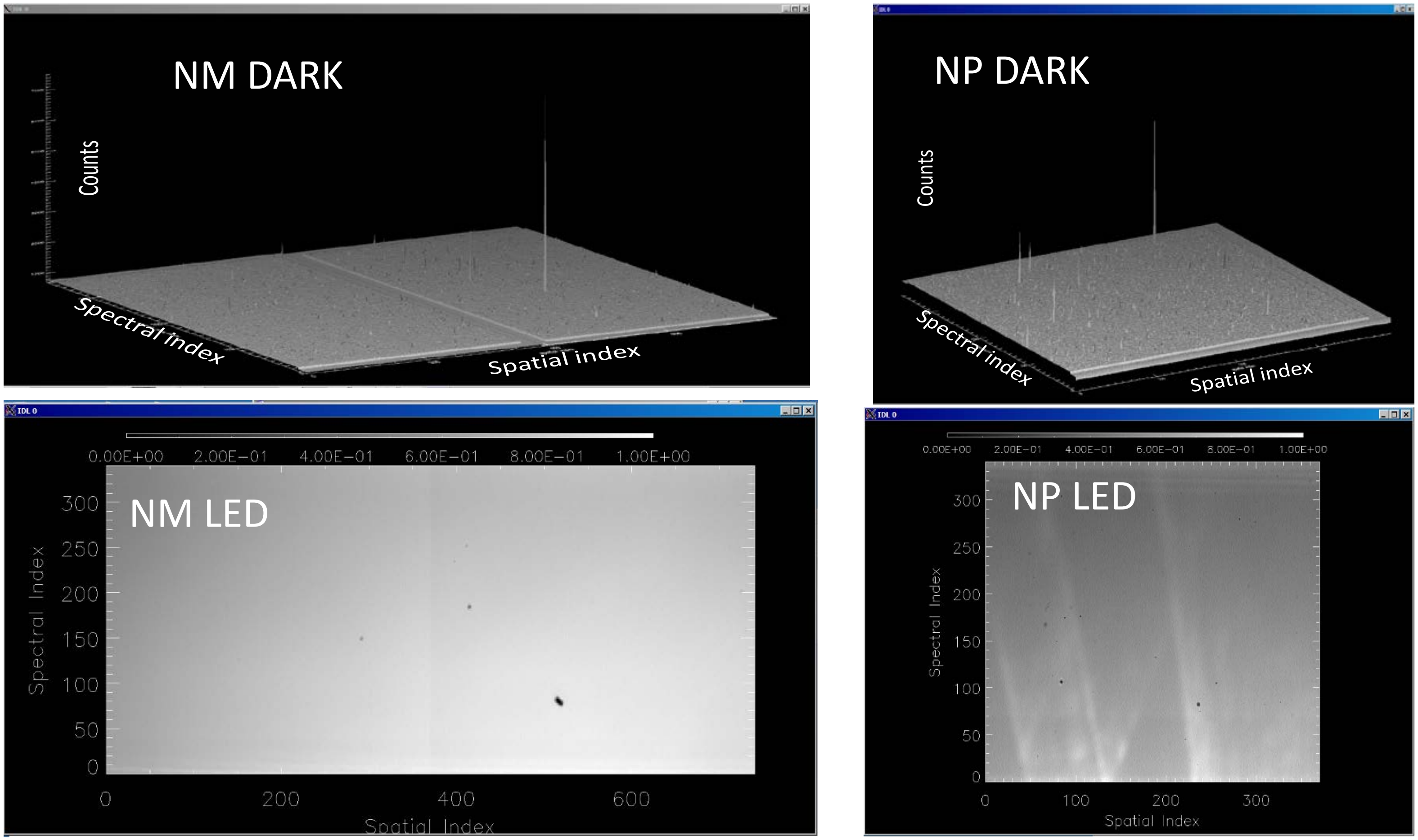
Ozone layer comparison w/ NOAA-19 SBUV/2 (green)



MLS: Microwave Limb Sounder

BSUV/2: Solar Backscatter Ultraviolet Radiometer -2

NOAA-20 OMPS Aliveness Test



NOAA-20 OMPS instrument was activated on11/28/2017.
The Aliveness Test took dark and LED images, followed by a Self-Compatibility test.

NOAA-20 OMPS Dark Calibration

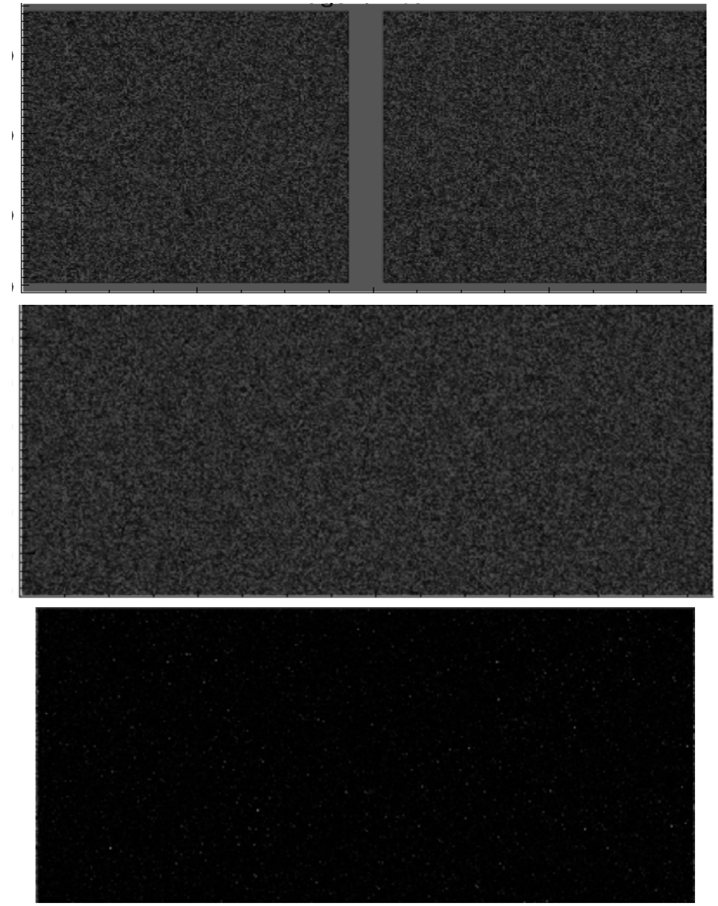
Rates calculated from mean of only non-transient pixel values in sequence.

Storage region rates are measured with a similar but shorter sequence.

Dark current correction:

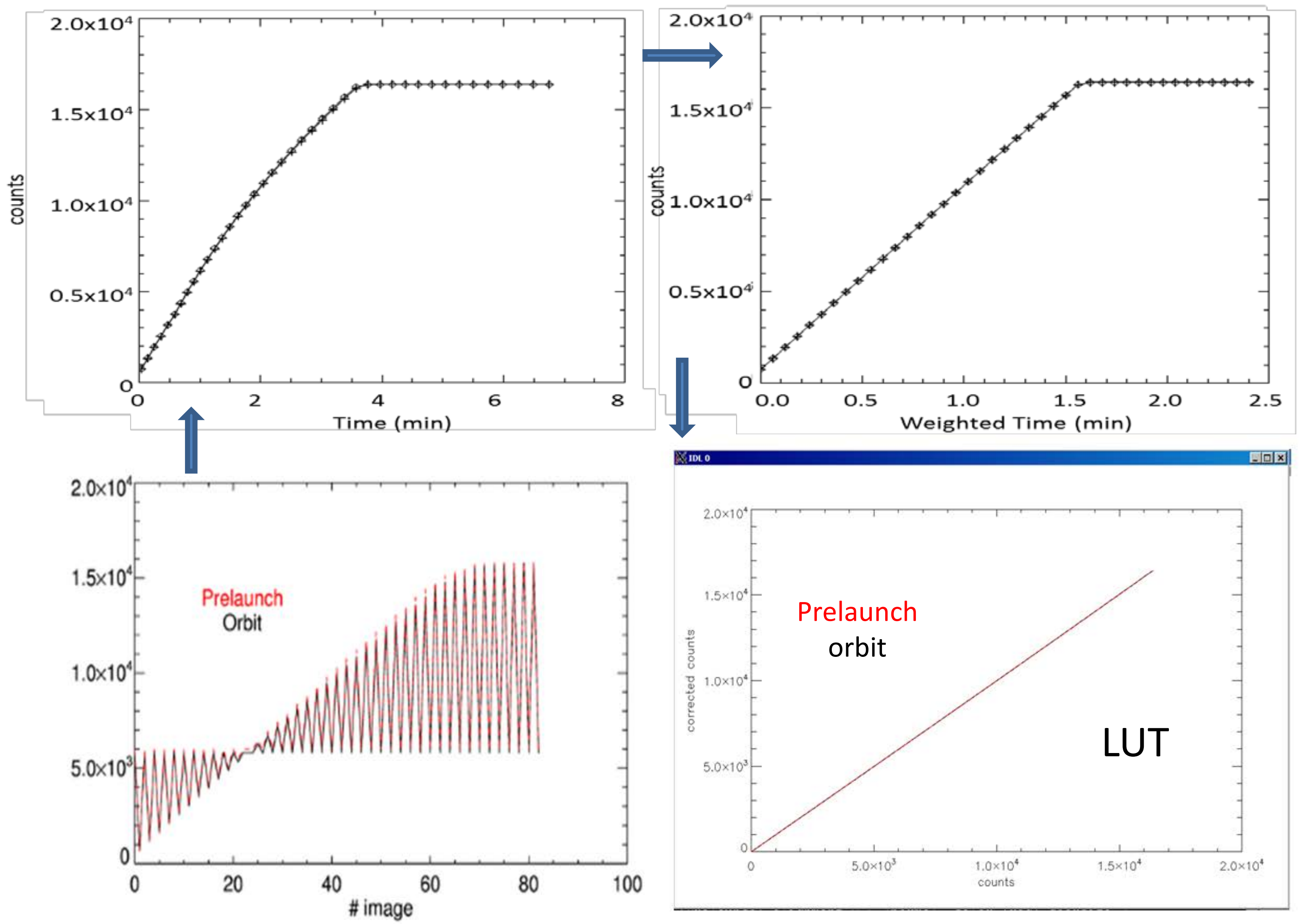
$$im(i, j) = im_i(i, j) * t_i - im_s(i, j)$$

Rates x integration time - dark current accumulated in storage region during CCD readout.



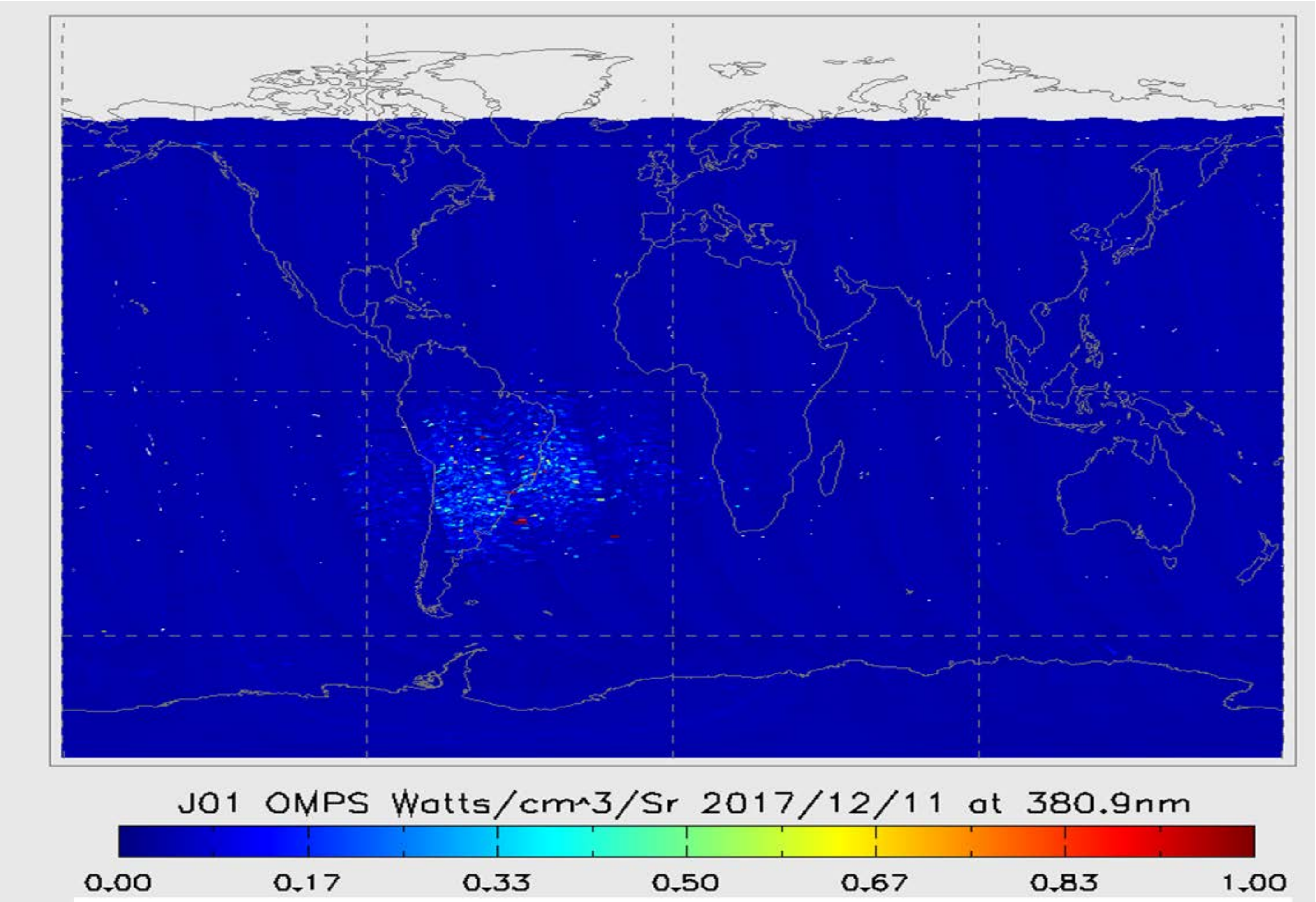
NOAA-20 OMPS weekly dark current calibration starts on 1/18/2018

NOAA-20 OMPS Nonlinearity Calibration



NOAA-20 OMPS system linearity is nearly identical before and after launch

NOAA-20 OMPS NM SAA Impact



Similar impact of South Atlantic Anomaly (SAA) region has been observed in S-NPP OMPS.

NOAA-20 OMPS SDR Milestone

Launch	Post-launch Testing (PLT)			Operations				
	2-months	2-months	2-months	2-months	2-months	2-months	2-months	2-months

L + 1 m | L + 3 m | L + 9 m

L+68 days | L+90 days | L+270 days

SDRs

Beta

Initial calibration is applied. Rapid modification is expected. For users to familiar with data. Not ready for scientific publication

Provisional

SDR may not be optimal, but are ready for operational evaluation. Users feed back are encouraged to participate in the data quality QA.

Validated **LTM**

Sensor performance has characterized and calibration meets sensor design criteria. Ready for scientific publication.

Phases of Post Launch SDR Cal/Val:

1. **Early Orbit Check-out (L + 90 days) – System Calibration & Characterization**
2. **Intensive Cal/Val (L + 270 days); SDR Validation**
3. **Long-Term Monitoring (LTM); through life of sensor mission**

Expected NOAA-20 Performance

Source of Uncertainty	Pre-launch Error Budget	Pre-launch Performance	Post-launch Performance
Irradiance Absolute 1σ Fractional Uncertainty (%)	≤ 7.0	≤ 3.194	≤ 7.0
Intro-orbital wavelength drift(nm)	≤ 0.01	≤ 0.01	≤ 0.016
Wavelength Registration(nm)	≤ 0.02	≤ 0.018	≤ 0.01
Stary Light (%)	≤ 2.0	≤ 0.5	≤ 2.0*
Nonlinearity (%)	≤ 2.0	≤2	≤ 0.5
radiance SNR	≥ 1000	≥ 3547	≥ 1000-2000
λ - independent Albedo 1σ Fractional Uncertainty (%)	≤ 2.0	≤ 1.717	≤ 2.0*
λ - dependent Albedo 1σ Fractional Uncertainty (%)	≤ 0.5	≤ 0.497	≤ 0.5

Summary

- Suomi-NPP OMPS NM and NP EV SDRs have life-cycle data reprocessed.
  - Maintain the stability of the SDRs at the already established attainable quality level
  - Provide experience for NOAA-20 OMPS SDR calibration

- NOAA-20 OMPS sensor performs well
  - A successful sensor orbital decontamination calibration leads to Beta maturity SDRs.
  - SDR quality level is expected to be comparable to the SNPP OMPS SDRs