Validated Maturity Science Review
For NOAA-21 OMPS NM and NP SDR Algorithm

Presented by

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Date: 03/28/2024

JPSS Data Product Validation Maturity Stages - COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Maturity Review - Entry Criteria (Provided by JSTAR)

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- NOAA-21 PLT Timeline
- Validated Maturity Performance Validation
  - On-orbit instrument performance assessment
    - Identify all of the instrument and product characteristics you have verified/validated as individual bullets
    - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data
- Users/Downstream-Products feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
  - Mitigations
- Path forward
- Summary

Maturity Review - Exit Criteria (Provided by JSTAR)

- Validated Maturity Performance is well characterized:
  - On-orbit instrument performance assessment
    - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria
    - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk.
- Updated Maturity Review Slide Package addressing review committee’s comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Validated Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward

NOAA-21 Ozone Mapping and Profiler Suite (OMPS) OMPS Nadir Mapper (NM) and Nadir Profiler (NP) Sensor Data Record

VALIDATED MATURITY REVIEW MATERIAL

Outline*

- **Algorithm Cal/Val Team Members**
- **Introduction to the Instrument, Requirements, Calibration Key Components**
  - **Instrument Overview**
  - **Product Requirements**
  - **OMPS PLT Timeline**
  - **OMPD SDR Key Calibration Components**
- Pre-launch/Post-launch Performance Matrix/Waivers (Starry)
- Evaluation of NOAA-21 OMPS NM and NP Instrument and Algorithm Performance to Specification Requirements
  - OMPS NM and NP ADR Review after Provisional Review (Trevor)
  - OMPS NM and NP instrument performance assessment (Dark, Non-linearity, Gain, and SNR)
  - OMPS NM and NP Wavelength Registration, Day-1 and Stray Light Performance Assessment
  - OMPS NM and NP Post-launch data quality assessment
    - OMPS SDR inter-sensor comparison analysis (Sirish)
    - RTM O-B and RTM-DD analysis
    - OMPS NM and NP Geolocation Accuracy Assessment
    - OMPS NM and NP data quality long-term monitoring from ICVS
- User Feedback Summary (Larry)
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

* All sections without presenter assignment will be presented by Banghua

STAR NOAA-21 OMPS SDR Algorithm Cal/Val Team

Name	Organization	Major Task
Banghua Yan (Project team lead)	NOAA/STAR/SCB	Project task plan and performance monitoring; OMPS instrument SDR cal/val science development and plan; OMP SDR validation science oversight; monthly/quarterly/annual/review reports; ATBD support
Trevor Beck (Team co-lead)	NOAA/STAR/SCB	Operational OMPS ADL code update and delivery with updated LUTs; OMPS RDR reader development; offline OMPS ADL code development; Dark correction improvement; Reprocessing of SDR data; OMPS TomRad validation support; ATBD update
Junye Chen	GST	NOAA-21 OMPS wavelength registration; NOAA-21 NM SDR SL calibration algorithm development and improvements; SNPP/NOAA-21 OMPS NP bi-weekly solar LUT derivation; solar radiometric cal.
Sirish Uprety	UMD/CISESS	NOAA-21 OMPS NP SL algorithm improvements; OMPS NM wavelength shift algorithm improvements; NOAA-21 OMPS inter-sensor radiometric calibration bias analysis against SNPP, NOAA-20, and GEMS
Xin Jin (50%)	GST/SSAI	SNPP/NOAA-20/NOAA-21 OMPS dark, gain and nonlinearity calibration algorithm and code development; dark LUT derivation; OMPS SDR validation support; inter-sensor comparison with NASA SDR data sets
Steven Buckner	GST/SSAI	OMPS data noise characterization analysis; Solar flux inter-sensor bias analysis; N20 OMPS solar LUTs; SNPP OMPS sensor degradation; Inter-sensor comparison with Tropomi; JSTAR weekly reports
Jingfeng Huang (50%)	GST/SSAI	CRTM interface development for OMPS NM/NP radiance simulations; validations of NOAA-21 OMPS SDR using RTMs (CRTM and TomRad)
Ding Liang (ICVS)	GST	OMPS data long-term monitoring via ICVS website system; Long-term inter-sensor comparison among 3 NPs and NMs; LT stability analysis of OMPS NM SDR data quality via DCC; OMPS RTM support

Other Contributors to NOAA-21 OMPS SDR Work

Name	Organization	Major Task
Lawrence Flynn	NOAA/STAR/SCB	OMPS EDR user feedback; share OMPS SDR acknowledge/skills in support of the OMPS SDR work
Glen Jaross/Thomas Kelly	NASA	OMPS instrument pre-launch SCDB data set support; OMPS instrument operating maintenance support; NOAA and NASA data comparison support
Vanistarry Manoharan	IDPS (associated with KBR)	SNPP/NOAA-20/NOAA-21 OMPS NM and NP SDR DRs/CCRs support
Bigyani Das	JPSS ASSISTT	SNPP/NOAA-20/NOAA-21 OMPS NM and NP SDR DRs/CCRs delivery support
Quanhua Liu	NOAA/STAR/APDB	Lead CRTM-OMPS capability development in support of NOAA-21 OMPS SDR reviews

Acknowledge L. Wang, C. Pan, W. Porter, C. Seftor, STAR OMPS EDR team (Z. Zhang and E. Beach), STAR CRTM team (M. Chen, P. Liang, Y. Ma), and JSTAR team for their valuable support in different aspects or stages.

OMPS Nadir Sensors: Nadir Mapper (NM) and Nadir Profiler (NP)

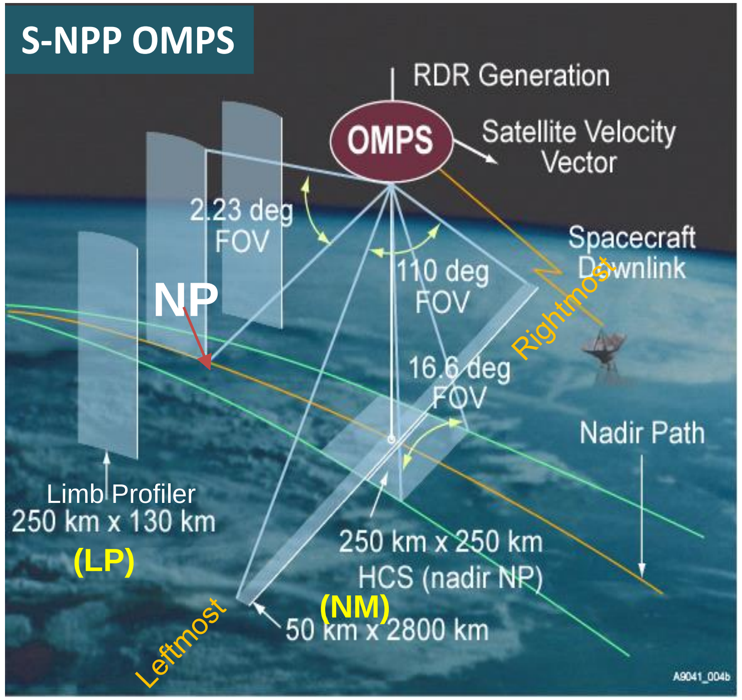
- **OMPS NM and NP sensors** are flying on the Suomi National Polar-orbiting Partnership (SNPP) launched on 28 Oct. 2011 and Joint Polar Satellite Systems (JPSS)-1 (alias NOAA-20) launched on18 Nov. 2017, JPSS-2 (alias NOAA-21) launched on 9 Nov. 2022.
- **The OMPS NM and NP sensors** provide ozone total column and vertical ozone profile records respectively.

- **Sensor Configuration**
  - 110° cross-track FOV telescope
  - Two grating spectrometers
    - » **Nadir Mapper covers 300 nm to 380 nm (196 channels)**
    - » **Nadir Profiler (NP) covers 250 nm to 310 nm**
    - » **2-D CCD optical detector for each spectrometer**

Overlapped wavelengths (300-310nm)

- **OMPS SDR Data Spatial Resolutions**
  - OMPS-NM:
    - » **SNPP: 35Cross-Track (CT) x 5Along-Track (AT) (50km x 50km @nadir)**
    - » **NOAA-20: 35CT x 15AT (50km x 17km @nadir)**
    - » **NOAA-21: 177CT x 30AT (12km x 10km @nadir)**
  - **OMPS-NP:**
    - » **SNPP: 1CT x 1AT (250 km x 250 km @nadir)**
    - » **NOAA-20 and NOAA-21: 5CT x 5AT (50 km x 50 km @nadir)**

SNPP OMPS Cross-Track Geometry



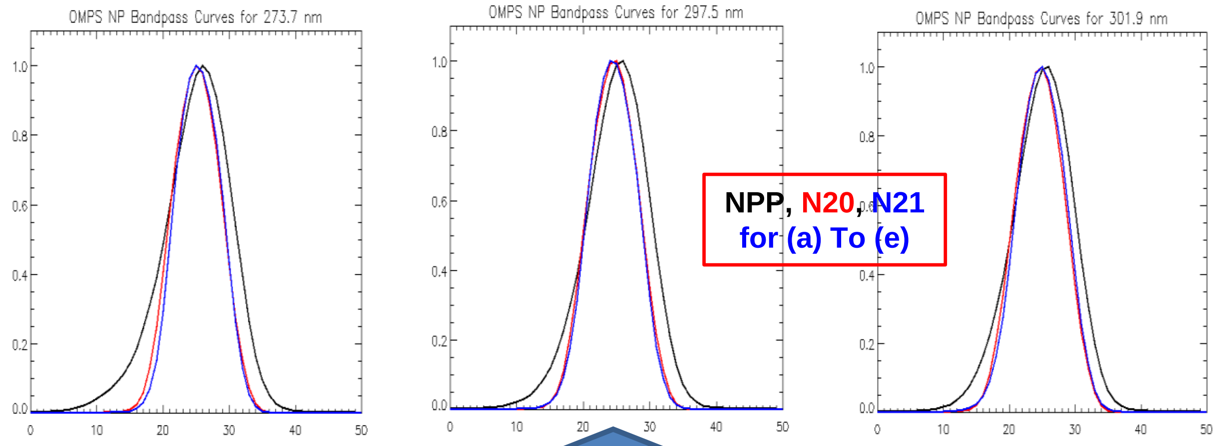
(Courtesy of Ball C.)

- ❑ SDRs: NOAA's Comprehensive Large Array-data Stewardship System www.class.noaa.gov
- ❑ SDRs Data Maturity Matrix: https://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php

OMPS Spectral Response Function Comparisons and Impact: Not identical, with an impact on NR up to 2.5%

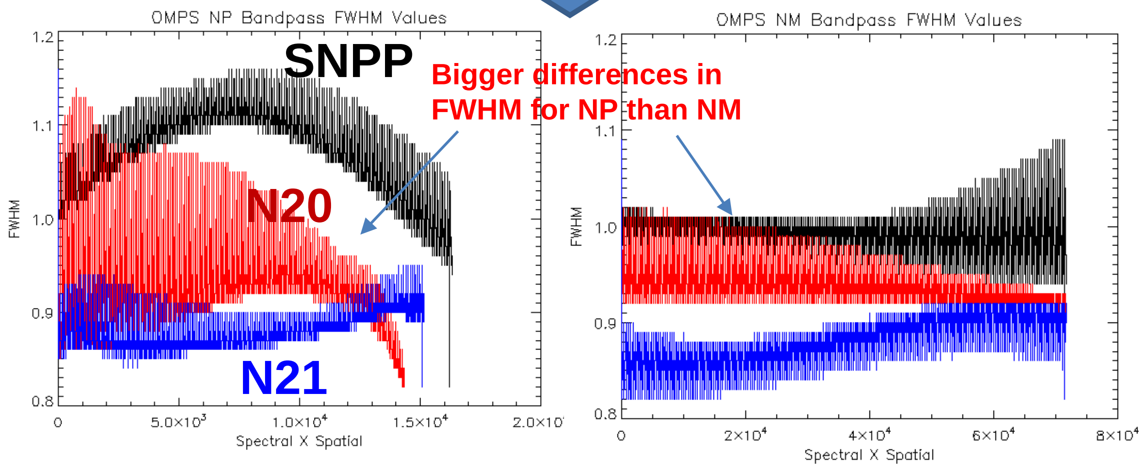
- Spectral channel information of OMPS NM and NP instruments
- Three NMs and NPs exhibit different spectral features.
  - Examples of BPS functions for 3 NPs: Figs. (a) ~ (c)
  - Full Width at Half Maximum (FWHW) are also different, seeing Fig. (d) and (e).
- The dissimilarity in BPS (FWHW) can cause differences in NR within ±1% for N21 and SNPP NM, and have the differences within ±1% for wavelengths below 300nm for N21 and SNPP NP, by using SNPP as a reference [see Figs. (f) and (g)]

(a) BPS @273.7nm **(b) BPS @297.5nm** **(c) BPS @301.9nm**

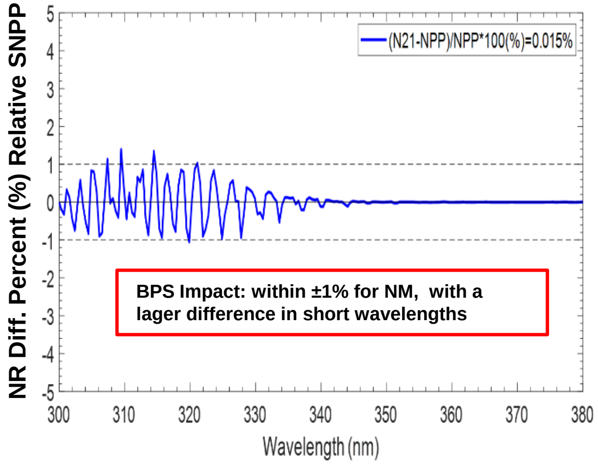


N21 OMPS instrument has a narrower bandwidth than both SNPP and N20

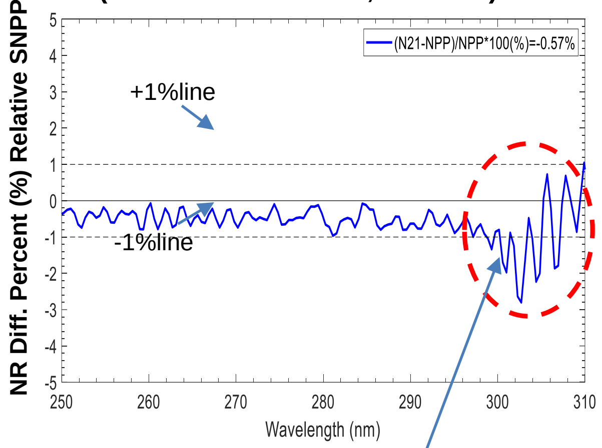
(d) FWHMs for 3NPs **(e) FWHMs for 3NMs**



(f) Simulated NR differences in NM Due to BPS Dif. (%) (SNPP as a reference; TomRad)



(g) Simulated NR differences in NP Due to BPS Dif. (%) (SNPP as a reference; TomRad)



BPS Impact: within ±1% for NP, with a lager differences up to 2.5% in the range from 300 to 310nm

Three OMPSs are not identical, with the largest difference between N21 and SNPP/N20!

NOAA-21 NM SDR Requirements

Budget Term	Requirement/Allocation
Wavelength range	300-380
Horizontal cell size	≤ 17 km @ nadir
SNR radiance @17 x17km^2	>300* (195 for NOAA-21 NM 10 x12km^2)
Irradiance uncertainty	*< 7%*
Wavelength registration accuracy	*<0.01 nm*
Intra-orbital wavelength variation	*<0.01 nm*
Radiance uncertainty	*< 8%*
OOB Stray Light	≤10%
Maximum Albedo Calibration	<2%
Geolocation Error	≤ 8.5 km @nadir (AT)

*305 - 380 nm according to L1RD doc

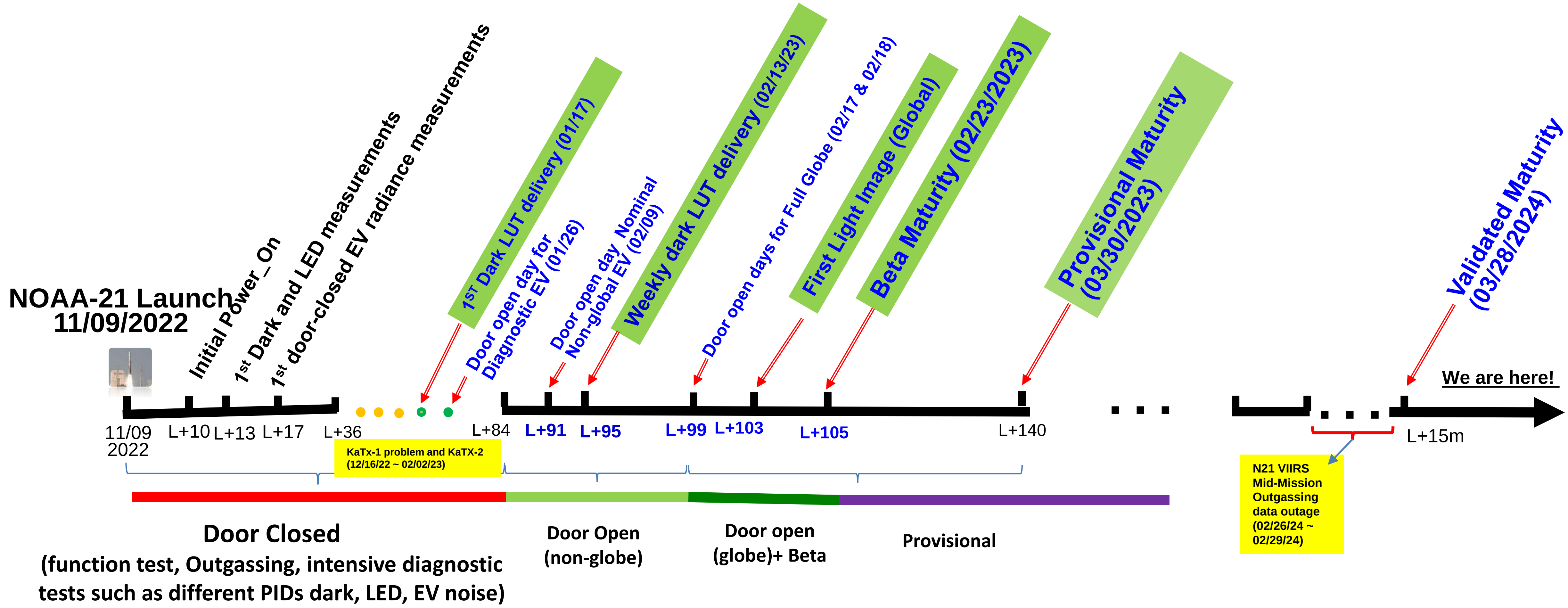
NOAA-21 NP SDR Requirements

Budget Term	Requirement/Allocation
Wavelength range	250-310
Horizontal cell size	≤ 50 km @ nadir
SNR radiance@50x50km^2	varies with wavelength λ
*Irradiance uncertainty**	*< 7%*
*Wavelength calibration**	*<0.01 nm*
*Intra-orbital wavelength variation**	*<0.01 nm*
*Radiance uncertainty**	*< 8%*
Maximum Albedo Calibration	<2%
OOB Stray Light	< 5%
Geolocation Error	≤ 25 km @nadir (AT)

*Follow NOAA-20 NP SDR requirement

Wavelength nm	SNR
250 - 273.6	7
273.6 - 283.1	20
283.1 -287.7	40
287.7-292	52
292-310	80

NOAA-21 OMPS Nadir Mapper and Nadir Profiler PLT Timeline[1,2]



[1] Courtesy of NASA OMPS Group for sharing the NOAA-21 OMPS PLT Activity Schedule

[2] Timeline is not shown on scale

Post-Launch Calibration Chart of NOAA-21 OMPS NM and NP SDR

Inputs:
OMPS RDR&SDR Science Data; VIIRS M1 band Data

2 Sensors (Spectrometers)

OMPS NM and NP SDR Algorithms Key Calibration Components

Outcomes:
Ensuring the SDR product can meet the specification requirements via improved OMPS SDR calibration coefficients

Dark Cal.

- Dark Calibration and Correction
  - One-time adjusted scale correction (ADR10682)
  - Weekly dark table (Fast Track)

Geo. Cal.

- Geolocation Registration (NM against VIIRS & NP against NM) — Prelaunch LUTs

NM and NP Consistency

- **NM and NP** Rad. (NR) Consistency (300-310nm)

Wavelength Registration and Update with Time

- One-time Wavelength Registration from ground to Orbit
  - SRF-convolved Solar Flux (Synthetic)
    - Hyperspectral Solar reference
    - OMPS SRF data (pre-launch)
  - On-orbit Solar Flux (Courtesy of NASA SIPS)
- Day-1 Solar Spectrum (ADR10281/303/308)
  - Solar Bias Error Correction (ADR10825)
  - Intra-Orbit Wavelength Registration Update for **NM** (Fast Track)
  - Bi-weekly Wavelength Registration Update for **NP** (Fast Track)

Stray Light Calibration

- Out-of-Field Stray Light Calibration for NM & NP (ADR10685 etc.)
- Out-of-Range (Band) Stray Light Calibration for **NM** (ADR10686)
- Solar Intrusion Correction for **NP** (≤300nm, SZA≥58° NH) (ADR10552/550)

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NOAA-21 OMPS NM and NP SDR Waivers (Presenter: Starry)

CCR	Title	Description
19-4768	OMPS Nadir Stray Light GSegDPS Waiver at 252nm	Waiver requesting relaxation of stray light requirement for NOAA-21 OMPS Nadir Profiler for 252nm from 5% to 7.3%. Rationale: The Nadir Profiler passes the stray light requirement of 5% at all wavelengths channel except for the shortest wavelength channel at 252nm.
19-1799	OMPS Nadir Stray Light PRD Waiver at 252 NM	Waiver requesting relaxation of stray light requirement O_PRD-11438 from 5% to 7.3% at 252nm only. Rationale: The Nadir Profiler passes the stray light requirement of 5% at all wavelength channels except for the shortest wavelength channel at 252nm.
19-0292	OMPS Nadir Stray Light MMSS and FSRD Waiver at 252nm	Waiver requesting relaxation of stray light requirement for NOAA-21 OMPS Nadir Profiler for 252nm from 5% to 7.3%. Artifacts regarding comparative performance to J1 and NOAA-21 OMPS instrument and relevant science impact are attached to 472-CCR-19-1799.
18-0246	Flow-Down of Approved NOAA-21 OMPS Nadir Resolution/SNR Requirements to the FSRD	The Flight Segment Requirements Document (FSRD) Rev B CCR (470-CCR-17-0195) included incorporation of approved mission-level changes to OMPS Nadir Mapper horizontal resolution (approved as NJO-2016-014 Rev C) and OMPS Nadir wavelength coverage requirement specifications (approved as NJO-2017-008 Rev B). This CCR has no impacts to Level 3 OMPS PRD requirements or to NOAA-21 SRD requirements.

NOAA-21 OMPS NM/NP Pre-launch Performance Matrix (Presenter: Starry)

ADR	CCR	Title	Description	Projected Build	Status
9633	5577	NOAA-21 OMPS Nadir Mapper (NM) geolocation code change for off-nadir geolocation error correction	Correct the mistake in the formula for calculating the OMPS geolocation unit vectors	Mx7	In Operation 7/18/22
9905	5513	NOAA-21 OMPS Mounting Matrix Updates (pre-dynamic)	Update the J02 OMPS Mounting Matrix using NOAA-21 satellite pre-dynamic data	Mx7	In Operation 7/18/22
9908	5926	NOAA-21 OMPS Nadir Version Table Update N_TIM_PAT_VER Value	An update to the Nadir Version Table for OMPS-TBL-VERS-GND-PI_j02 is required to account for raw data record (RDR) from the redundant side of the instrument.	Mx7	In Operation 7/18/22
9959	5997	NOAA-21 OMPS Nadir Mapper (NM) operational sample table includes 3 additional CCD spectral-columns that have no valid irradiance coefficients	1) NOAA-21 OMPS-NM operational sample table includes 3 additional CCD spectral-columns that have no valid irradiance coefficients. 2) NASA delivered new coefficients to NOAA STAR in January 2023	Mx7	In Operation (03/09/2023)
9960	5997	NOAA-21 OMPS Nadir Mapper (NM) and NOAA-21 Nadir Profiler (NP) show significant/unacceptable discrepancies in albedo coefficients	1) NOAA-21 OMPS-NM and NOAA-21 OMPS-NP show significant/unacceptable discrepancies in albedo coefficients between 300-310 nm. 2) NASA delivered the updated NOAA-21 NM radiance coefficients in February 2023	Mx7	In Operation (03/09/2023)
10037	6101	NOAA-21 OMPS pre-launch LUTs update	10 OMPS LUTs needed to be updated pre-launch	At NOAA-21 launch	In Operation
10039	6112	NOAA-21 OMPS Total Column code change and OMPS-TC MACROPIX and EV-SAMPLE tables update	An incorrect table was used for the OMPS-TC MACROPIX and EV-SAMPLE tables for J02 TC-OMPS.	Mx8	In Operation 07/23/2023
10044	6135	NOAA-21 OMPS Mounting Matrix Coefficients Update (post dynamic)	NOAA-21 OMPS post TVAC sensor mounting matrix coefficients update	At NOAA-21 launch	In Operation

NOAA-21 OMPS NM/NP Post-launch Performance Matrix (Presenter: Starry)

ADR	CCR	Title	Description	Projected Build	Status
10281	6439	Fix a 3-pixel-wavelength shift error in the NOAA-21 OMPS TC wavelength table	The NOAA-21 OMPS NM radiance shows a large discrepancy with NOAA-21 OMPS NP in the range from 300 to 310 nm due to an about 3-pixel-wavelength shift error. This issue was caused by mismatched OMPS NM wavelength table	Mx7	In Operation 03/09/2023
10281	6439	NOAA-21 OMPS NM and NP wavelength scale registration	Update the NOAA-21 OMPS nadir sensor wavelength tables due to the wavelength shift from ground to orbit	Mx7	In Operation 03/09/2023
10303	6463	NP Wavelength & OSOL Update	An update to the NOAA-21 NP wavelength and solar OSOL tables to capture the wavelength shift of the NP since 9 February. In the meantime, the updated OSOL table also fixed the 12-pixel shift error detected in the NOAA-21 NP solar flux SDR data (see the analysis later)	Mx7	In Operation 03/23/2023
10308	6475	NOAA-21 OMPS NM OSOL and wavelength LUT update	Incorrect value of QC used in the NOAA-21 OMPS algorithm for the nadir sensor has led to discontinuity of the NM SDR data at 84-86 cross track pixels. This will be fixed with the updated OMPS NM OSOL and wavelength LUTs.	Mx7	In Operation 03/13/2023

NOAA-21 OMPS NM/NP Post-launch Performance Matrix (Presenter: Starry)

ADR	CCR	Title	Description	Projected Build	Status
10360	6548	Fixing Straylight deficiency in N21 OMPS NM	The OMPS NM SDR data quality show a strong latitude dependency at short wavelengths. This problem gradually increase the inter-sensor radiance biases at short wavelengths. The root cause is from SL table being initialized at N20 NM cross-track resolution (35 pixels) instead of N21 NM resolution (177 pixels).	Mx8	In Operation 6/23/2023
10550	6767	Solar intrusion OMPS NP straylight correction	The preliminary analysis of NOAA-21 OMPS shows solar intrusion in the NP radiance. This straylight effect needs to be corrected.	Mx8	In Operation 11/09/2023
10552	6773	Solar Intrusion straylight correction for OMPS NP – code change	This stray-light effect needs to be corrected across NOAA-21, NOAA-20, and SNPP. This requires code change.	Mx10	TTO 5/16/2024
10682	NA	OMPS NP Dark Overcorrection	Updated via weekly fast track updates.	Mx8	In Operation 02/01/2024
10685	6951	N21 OMPS NP Straylight Correctio	Performance of NOAA-21 OMPS NP straylight LUT currently used in IDPS operations is not optimal and needs improvement for better calibrated SDR that leads to higher quality EDR products. To address this, the SDR team has developed a new straylight LUT that suggests improved calibration performance.	Mx9	In Operation 03/01/2024
10686	6956	N21 OMPS NM out-of-band straylight correction	This stray light calibration table is to correct stray light effects from wavelengths above 380nm on short wavelengths for NOAA-21 OMPS NM SDR data.	Mx9	In Operation 03/21/2024

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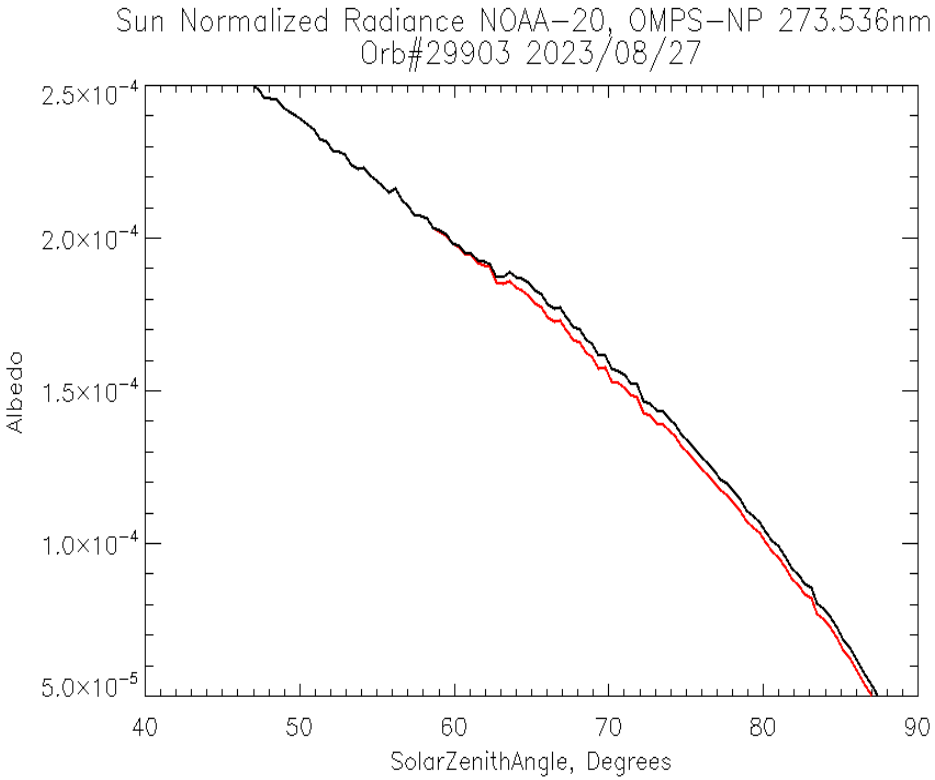
ADR Changes since Provisional Review

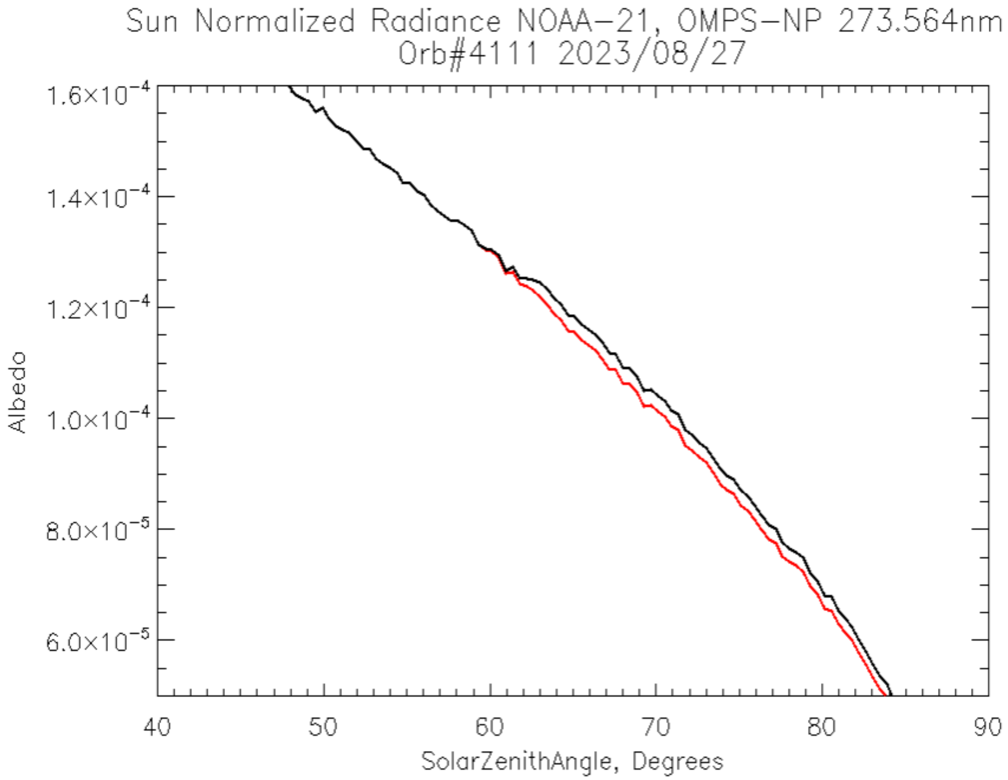
ADR	CCR	Title	Description	Build	Status
10360	**6548**	Fixing Straylight deficiency in N21 OMPS NM	The OMPS NM SDR data quality show a strong latitude dependency at short wavelengths. This problem gradually increase the inter-sensor radiance biases at short wavelengths. The root cause is from SL table being initialized at N20 NM cross-track resolution (35 pixels) instead of N21 NM resolution (177 pixels).	Mx8	In Operation 6/23/2023
10365	**NA**	Investigate 0.03 nm difference in EV and Solar Irradiance wavelength scale	Use the solar Mg-II 280nm absorption feature. This method is consistent with the earth viewradiance approach and the SNPP and NOAA-20 solar approaches. Updated via weekly fast track updates.		In Operation 11/06/2023
10553	**6799**	OMPS-NP Hot pixel/ Transient Pixel	One single CCD pixel began to exhibit unstable dark current background signal several months in to the mission. A flight table and ground table updates effectively disabled the transient pixel.	MX8	In Operation 01/26/2024
10550	**6767**	Solar intrusion OMPS NP straylight correction	The preliminary analysis of NOAA-21 OMPS shows solar intrusion in the NP radiance. This straylight effect needs to be corrected.	Mx8	In Operation 11/09/2023
	6773	Solar Intrusion for OMPS NP – code change	This stray-light effect needs to be corrected across NOAA-21, NOAA-20, and SNPP. This requires code change.	Mx10	TTO 5/16/2024
	NA	OMPS NP Dark Overcorrection	Updated via weekly fast track updates.		In Operation
10685	**6951**	N21 OMPS NP Straylight Correction	Performance of NOAA-21 OMPS NP straylight LUT currently used in IDPS operations is not optimal and needs improvement for better calibrated SDR that leads to higher quality EDR products.	Mx9	In Operation 03/01/2024
	6956	N21 OMPS NM out-of-band straylight correction	This stray light calibration table is to correct stray light effects from wavelengths above 380nm on short wavelengths for NOAA-21 OMPS NM SDR data.	Mx9	In Operations on 03/21/2024
10825	**TBD**	Assess calibration errors in NOAA-21 OMPS NM and NP solar flux relative to S-NPP	The solar flux differences in NOAA-21 OMPS NM and NP have been identified by comparing S-NPP day-1 and synthetic spectra		Further Study

ADR 10552 – NOAA-21 OMPS-NP Solar Intrusion

A recent orbit shows the solar intrusion as a function of solar zenith angle.
The portion in red as after correction.

Left: NOAA-20 **Right:** NOAA-21



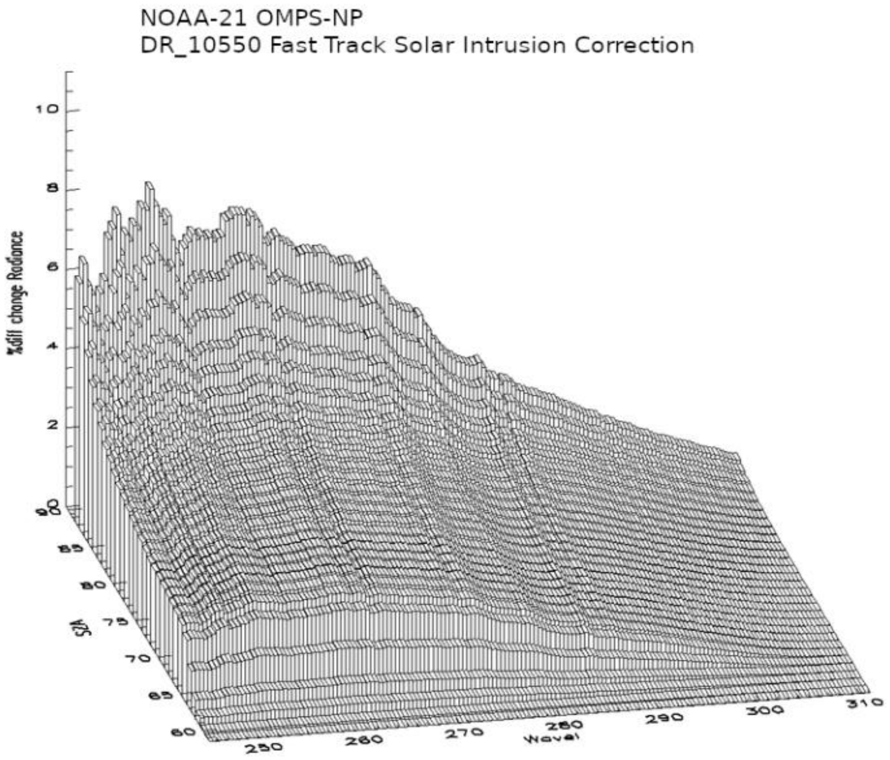


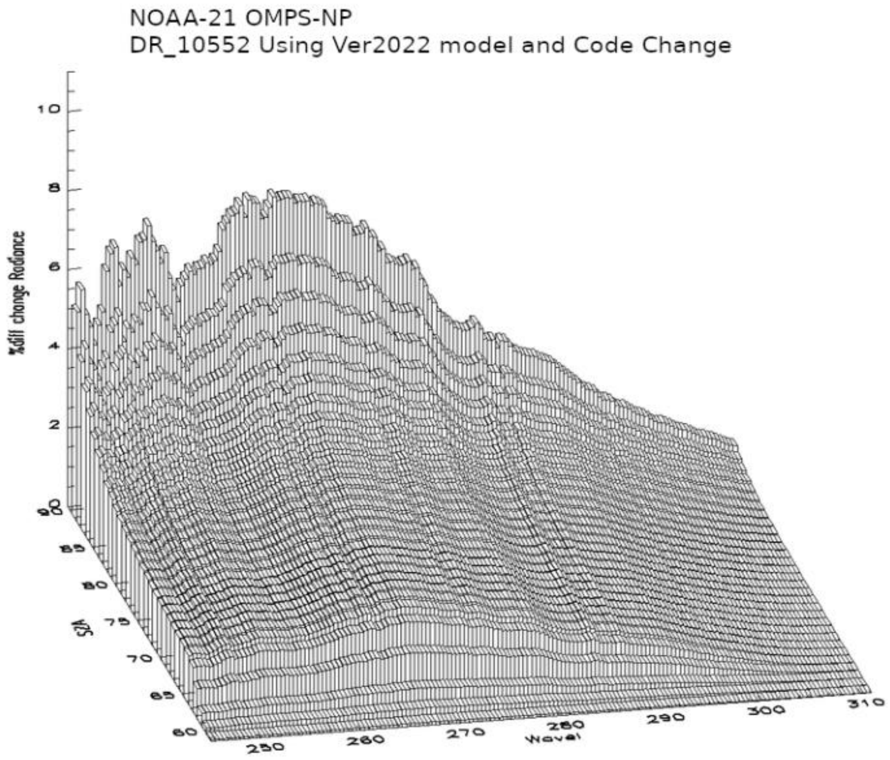
ADR 10550, 10552 – NOAA-21 OMPS-NP Solar Intrusion

Two ADR have been opened for the solar intrusion correction.

<u>Left:</u> The fast-track LUT correction, in IDPS since Nov. 9, 2023

<u>Right:</u> The code change ADR with more comprehensive model, MX10, TTO April 18, 2024





<u>Acknowledgement:</u> The Solar Intrusion correction algorithms were developed by L.K. Huang and NASA OMPS Team.

ADR 10682 Dark Current Scale Factor

It was found the OMPS-NP Dark current LUTs were over-correcting for all three OMPS-NP instruments. Earthview 360 measurements showed that NOAA-21 was the most over-corrected. A simple scale factor correction was applied.

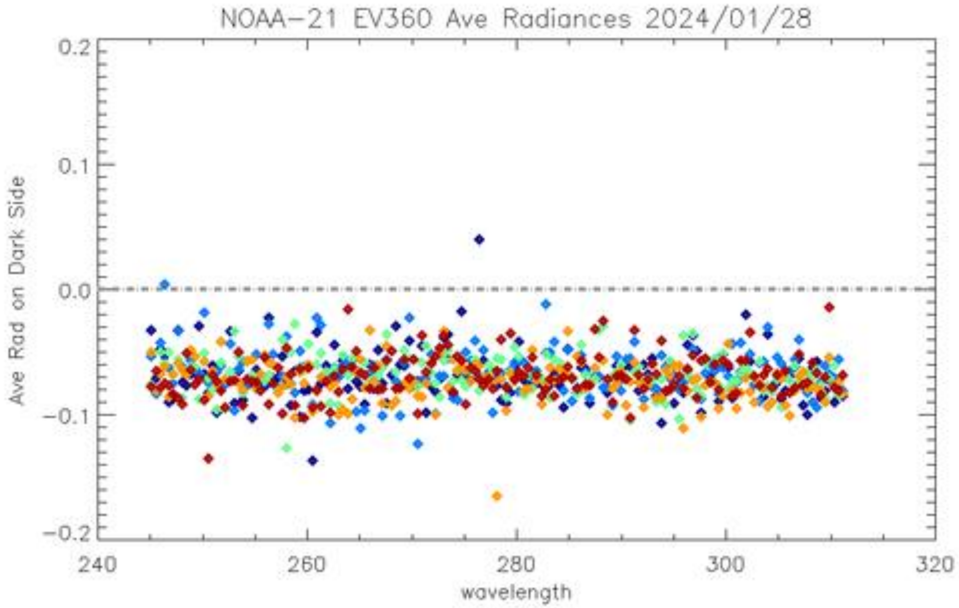
Sat Name	Dark Expose	Adjusted Dark Expose	Multiplier	Dark Reduction
NPP OMPS-NP	124.792	130.0	0.960	4%
NOAA-20	74.872	79.0	0.948	5.2%
NOAA-21	74.872	85.0	0.88	12.0%

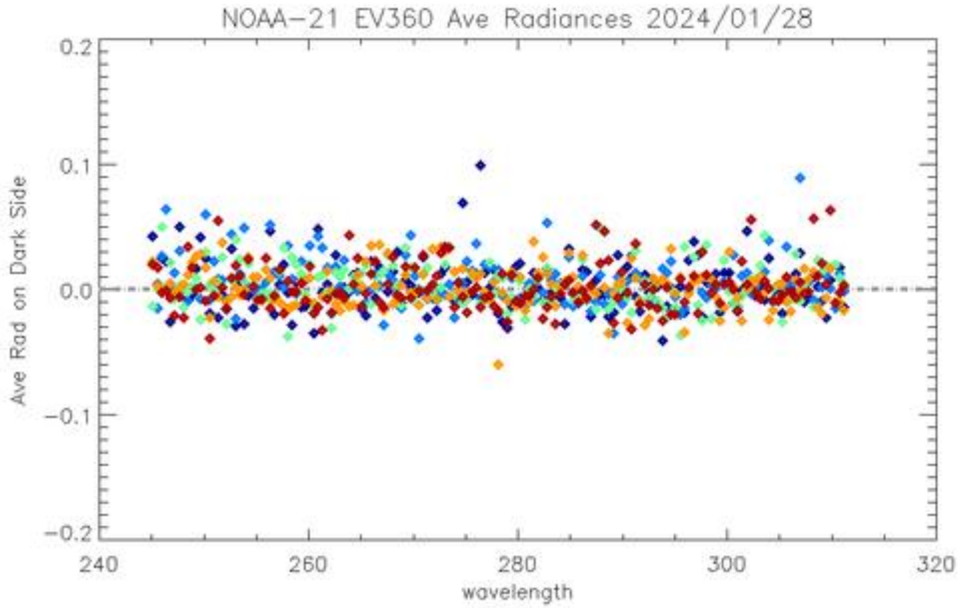
Summary of the Modified Dark LUTs

Dark Expose: The default value in the IDPS LUT. IDPS divides the dark counts to scale by time.
Adj Dark Expose: The number of seconds in the modified table. An increase scales the dark correction downward.
Multiplier: The equivalent multiplier to the dark counts. The scale factor to dark counts.
Dark Reduction: The Percent reduction that increasing the exposure time has on dark correction.

Based on one day of data, 2023/11/19 for both N20 and N21, and 2023/11/15 for S-NPP.

N21 2024/01/28 EV360 without/with Scaling



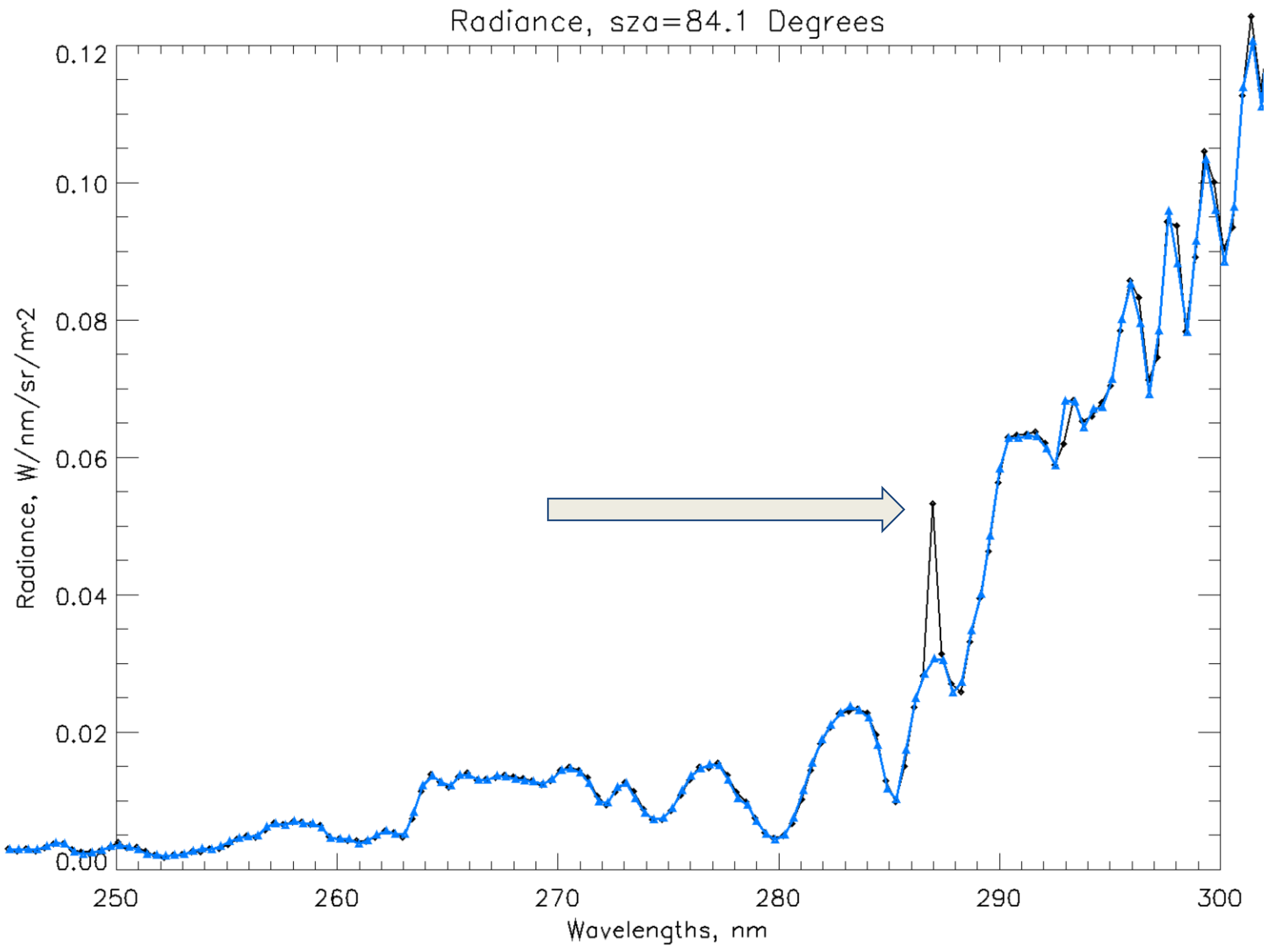


The 12% reduction in dark(for every pixel) leads to a solar zenith angle dependent change in radiances. The plot above illustrates that the negative radiances have been reduced.

ADR 10553 – NOAA-21 OMPS-NP Hot Transient Pixel

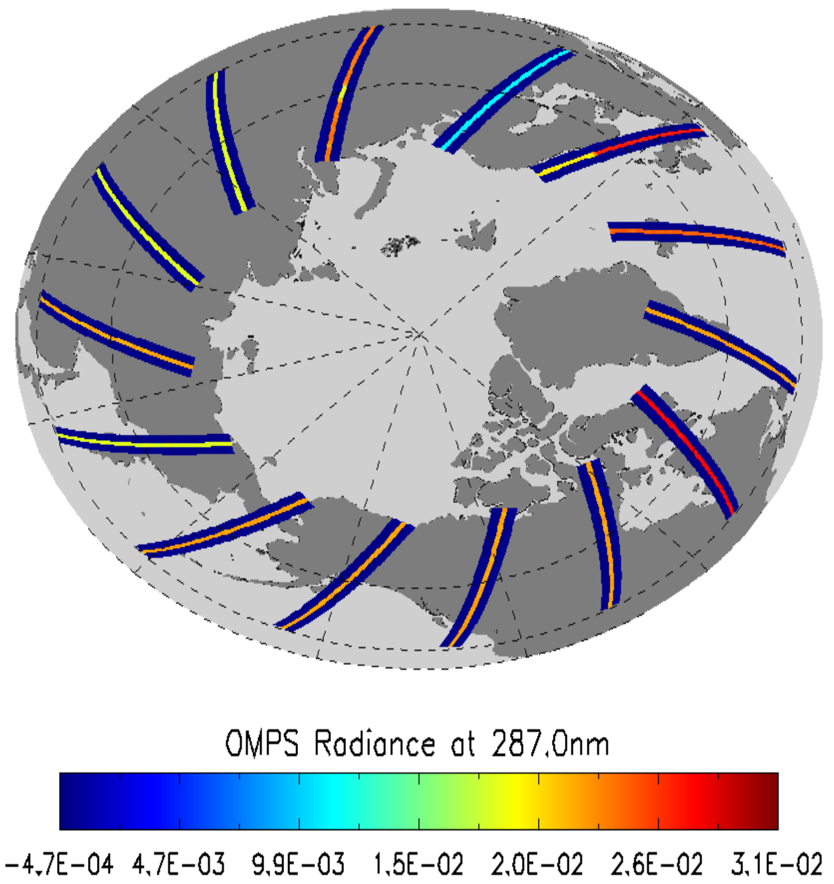
- The NP-SDR SOMPS product is affected. As an example one spectrum is plotted at SZA=84.1.
- In blue, crosstrack=1 spectrum is plotted.
- Nadir pixel CT=2 is in black, behind the blue curve.
- At iwlen=100 the radiance is 75% higher than the adjacent cross track pixel.

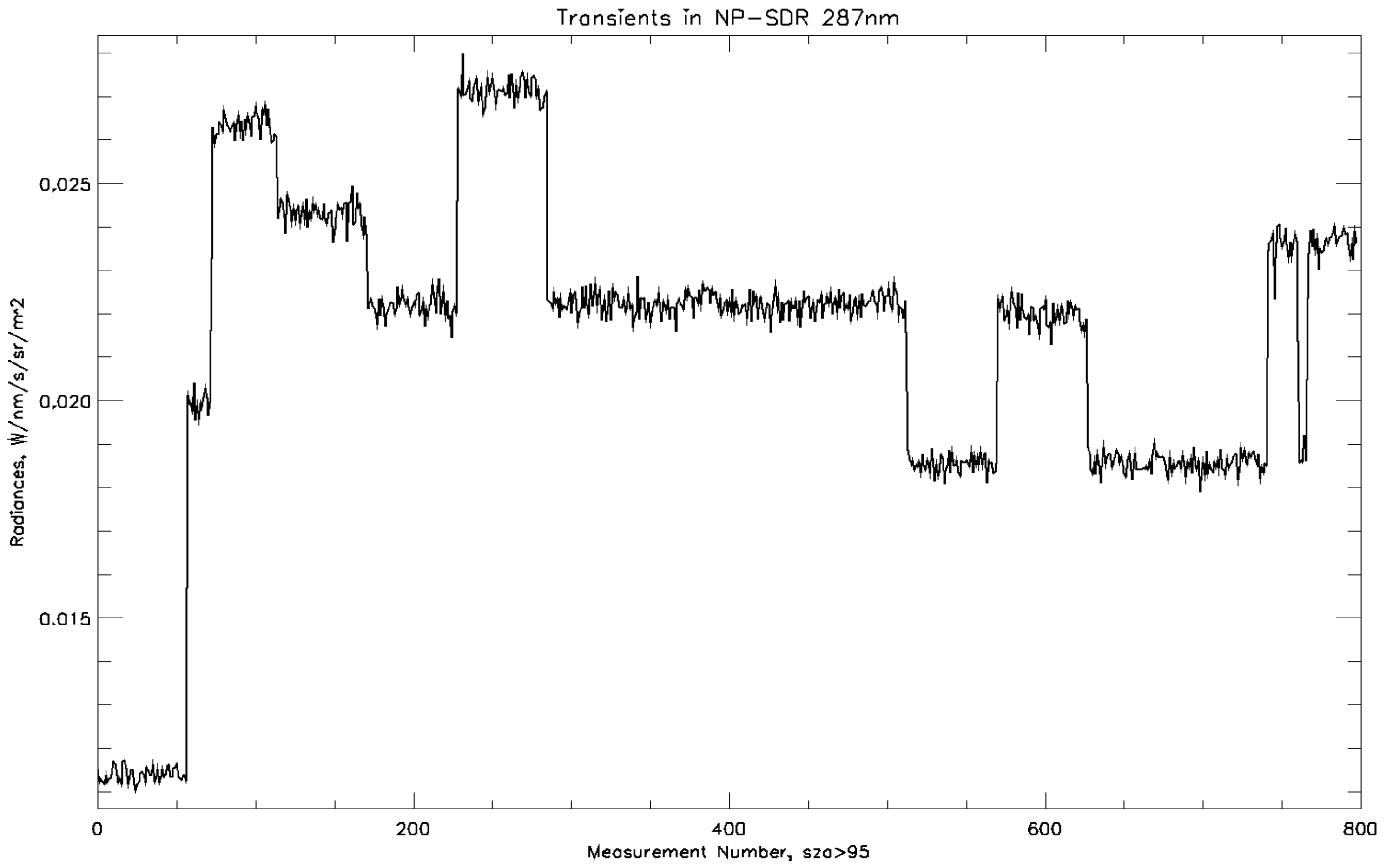
Nadir Pixel at wavelength index 100, 287.0nm



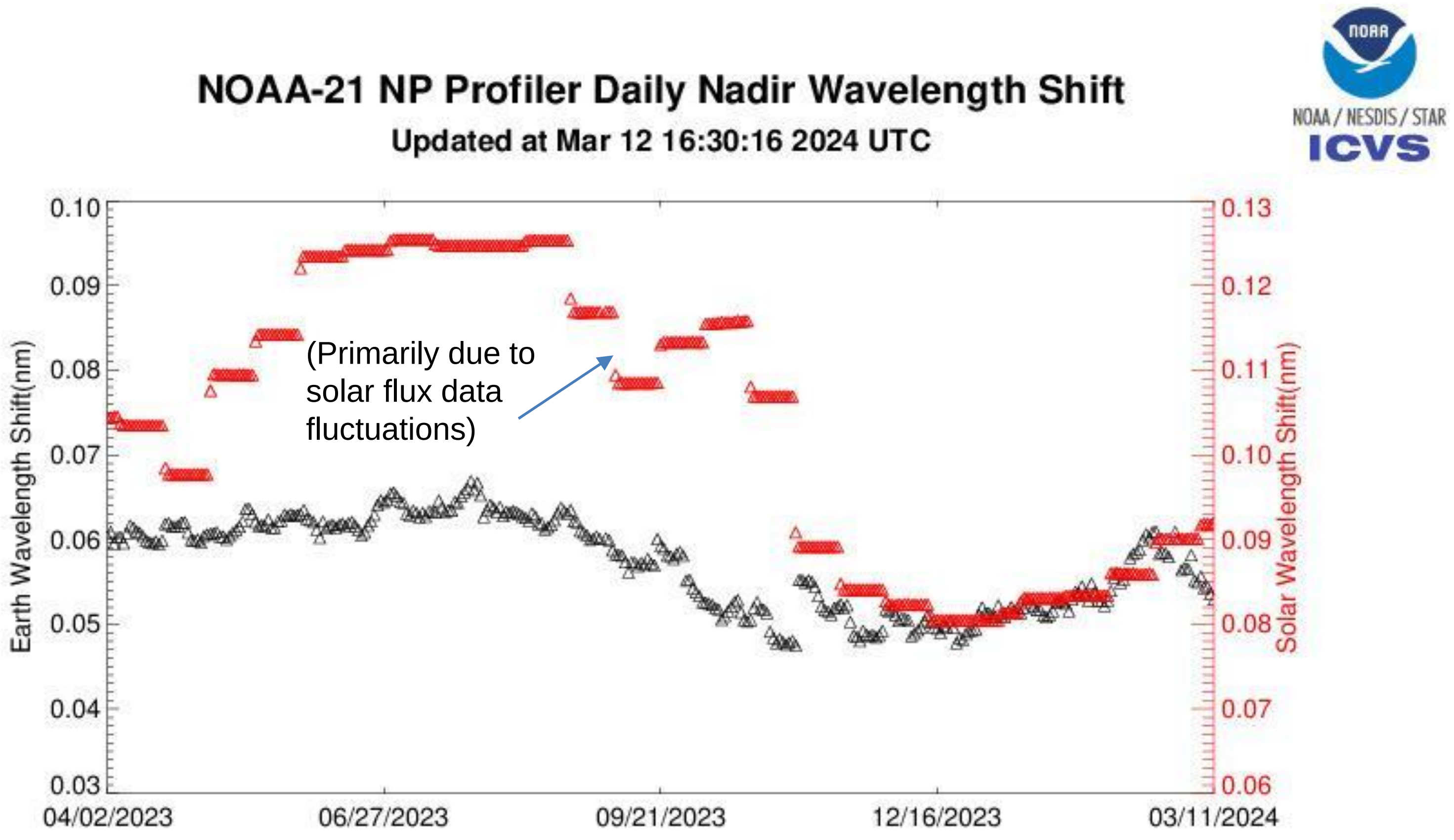
ADR 10553 – NOAA-21 OMPS-NP Hot Pixel

The map shows all scans where the solar zenith angle is > 95 degrees. The reflected UV radiance at this SZA should be very close to zero. The map shows 14 orbits. The variation in colors a show the transient nature. The image on the right shows the nadir macropixel for the same scans on the map.





ADR 10365 NP Time dependent 0.03nm Solar Spectrum Shift



- To reduce the solar activity impact the wavelength scale will be determined by the position of the minimum in the solar Mg-II 280nm absorption feature. This is consistent with the earthview radiance approach used for SNPP and NOAA-20.
- An off-line algorithm update for the OMPS-NP biweekly Solar delivery was made beginning on Nov. 6, 2023.
- The tables are fast-track and delivered bi-weekly.

OMPS Straylight DR

- DR 10360 OMPS-NM Straylight, In Operations 6/23/2023
- DR 10685 OMPS-NP Straylight, In Operations 03/01/2024
- DR 10686 OMPS-TC OOR, In Operations 03/21/2024

Straylight Correction Results are discussed in following Slides

ADR 10825 Assessing Calibration Errors in NOAA-21 Solar Flux

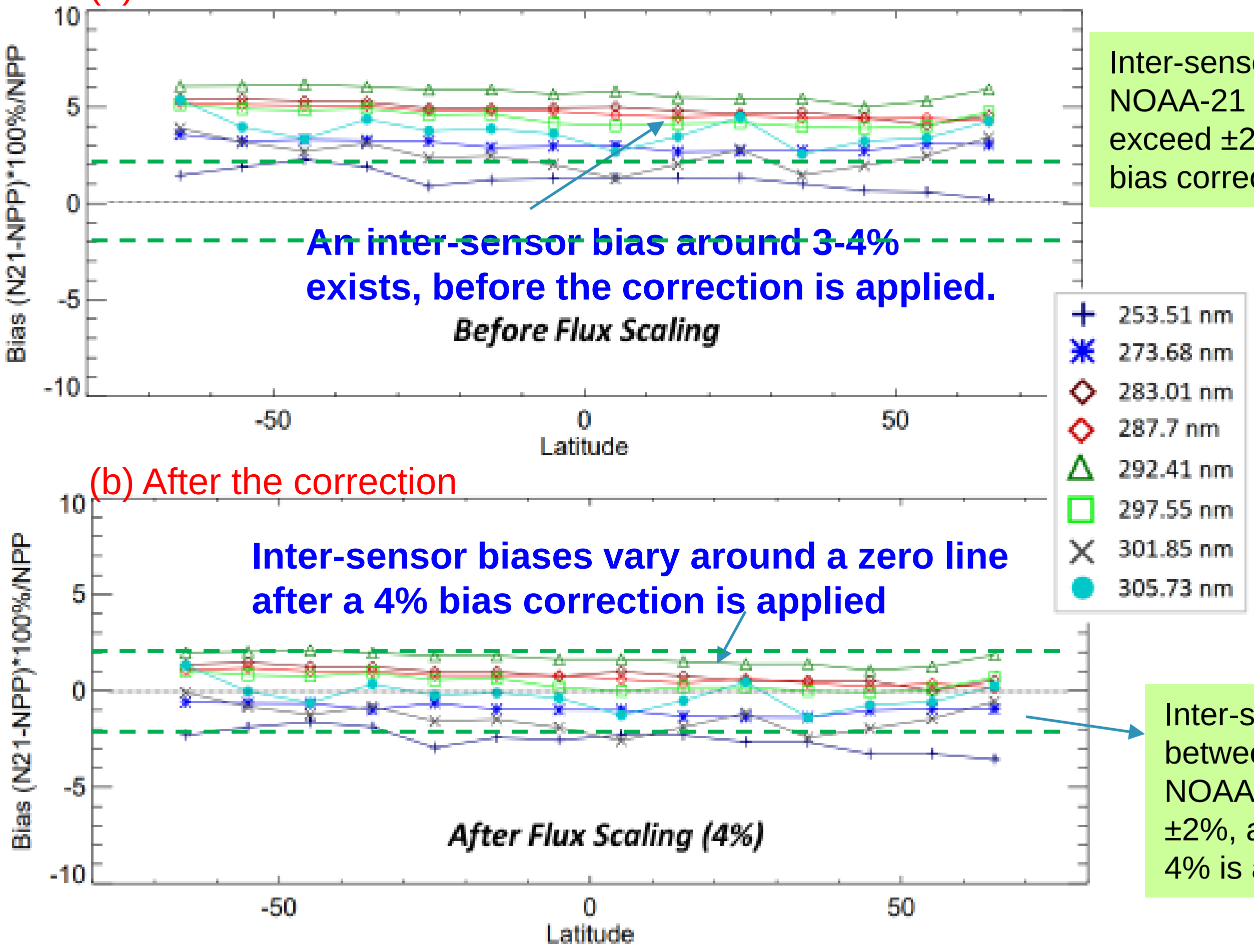
- The solar flux error problem in NOAA-21 OMPS NM and NP have been identified by comparing N21 day-1 and synthetic spectra
- The major N21 solar errors are quantified against S-NPP.
- A wavelength independent 4% correction for NP and 2% for NM can mitigate the deviation of NOAA-21 solar flux from S-NPP to meet requirements.

- ***Bias change can be on the order of 5% or more***

Datasets:

- *Oct. 10 to Nov. 10, 2023*
- *N21: Dark Scaled and Updated SL*
- *NPP: Dark Scaled*

(a) Before the correction



Inter-sensor biases between NOAA-21 and NOAA-20 mostly exceed ±2%, before the mean bias correction is applied.

Inter-sensor biases between NOAA-21 and NOAA-20 are mostly within ±2%, after the mean bias of 4% is applied.

Summary for DRs/CCRs After Provisional Review

- There have been 9 major ADRs for OMPS since the provisional review held one year ago on March 30,2023.
- The OMPS NP solar intrusion code change will be coming in MX10, expected in April, 2024

  -- Currently using the older fast-track LUT solar intrusion correction.
- A reprocessing for OMPS-NP-SDR has been completed for all data in 2023 SDR using the most recent updates to form a consistent set with the LUTs in IDPS.
- A reprocessing is being conducted for OMPS-TC/NM but will take much time. So far 2.0 months have been reprocessed.
- There is one major DR still in process, DR-10825 NM and NP Solar Flux Error.
  - A new CCR will be delivered by April to mitigate the solar flux error

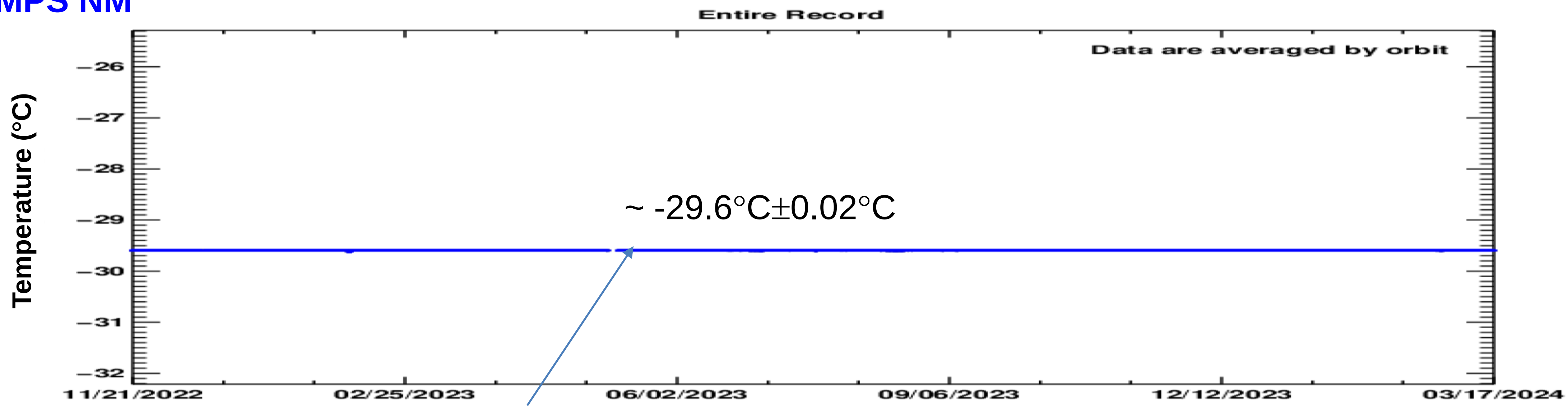
Outline*

- Algorithm Cal/Val Team Members
- Introduction to the Instrument, Requirements, and Calibration Key Components
- Pre-launch/Post-launch Performance Matrix/Waivers (Starry)
- Evaluation of NOAA-21 OMPS NM and NP Instrument and Algorithm Performance to Specification Requirements
  - OMPS NM and NP ADR Review after Provisional Review (Trevor)
  - **OMPS NM and NP instrument performance assessment (Dark, Non-linearity, Gain, and SNR)**
  - **OMPS NM and NP Wavelength Registration, Day-1 and Stray Light Performance Assessment**
  - OMPS NM and NP Post-launch data quality assessment
- User Feedback Summary (Larry)
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

* All sections without presenter assignment will be presented by Banghua

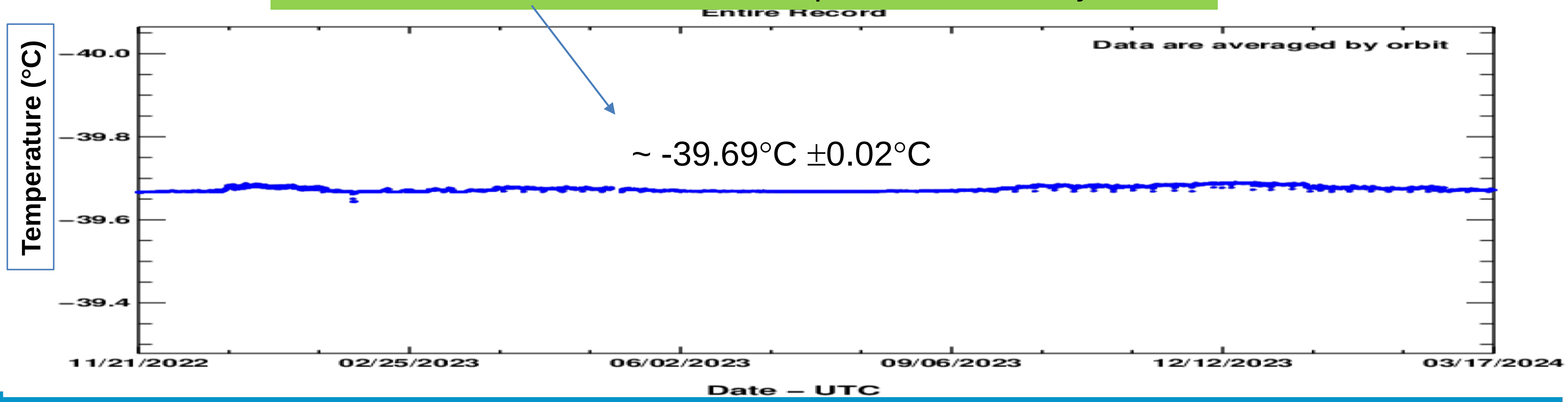
NOAA-21 OMPS NM and NP CCD Temperature Monitoring from ICVS (as of 03/17/2024)

(a) OMPS NM

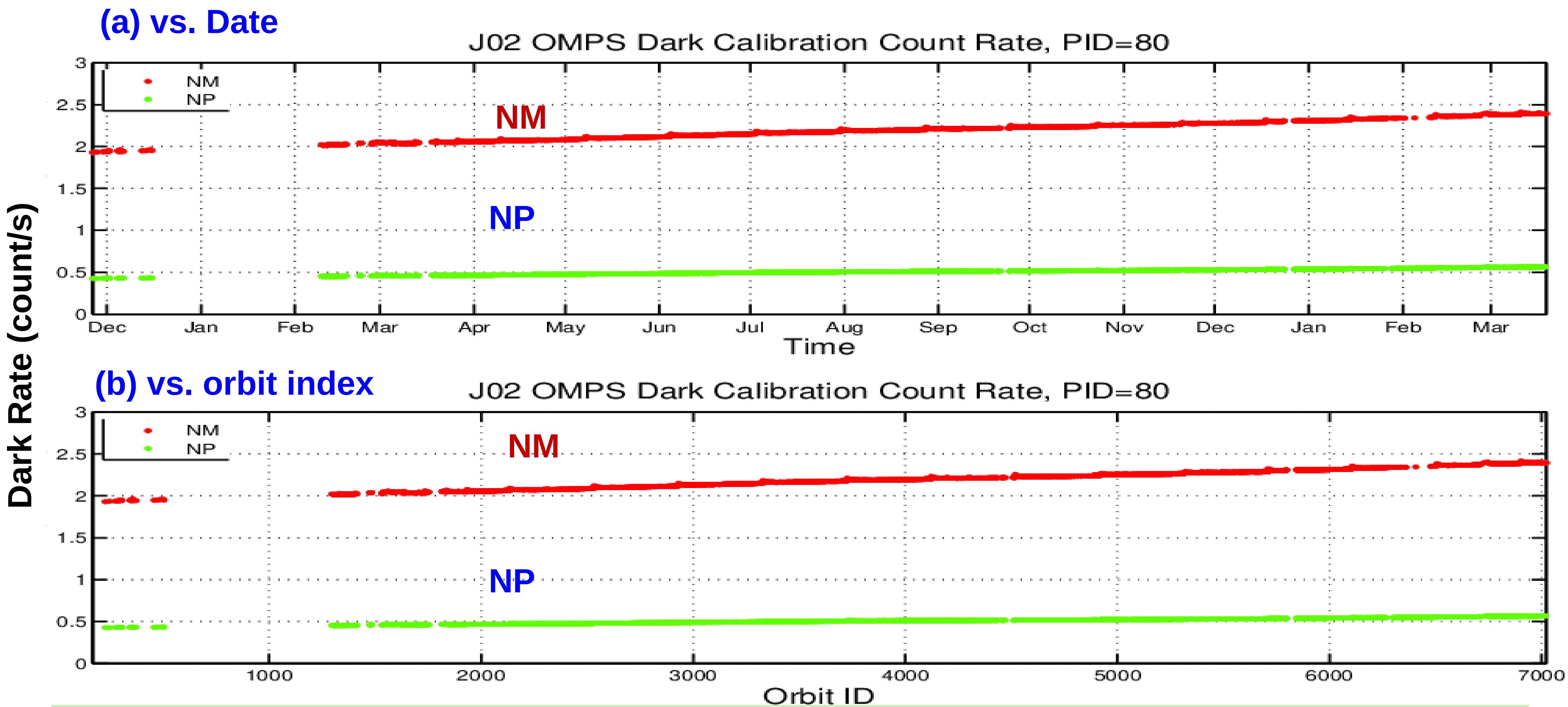


NOAA-21 OMPS NM/NP CCD temperatures are very stable

(b) OMPS NP



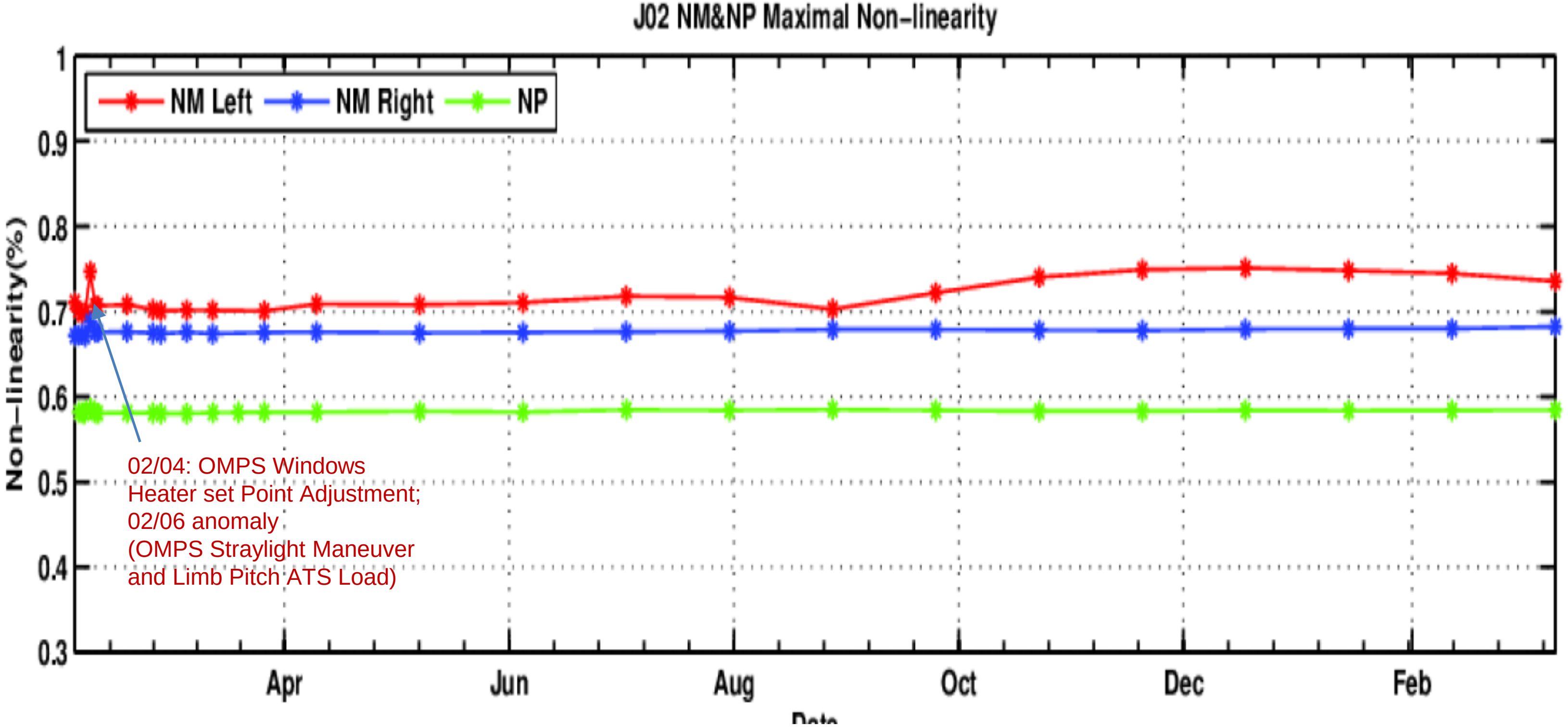
NOAA-21 OMPS NM and NP Dark Rate Calibration and Monitoring



- The first delivery for the dark LUT started on 01/17/2023;
- The weekly dark LUT delivery started on 02/13/2023;
- The OMPS NM/NP CCD dark rate shows certain degradation with time, which is considered by delivering a weekly dark table

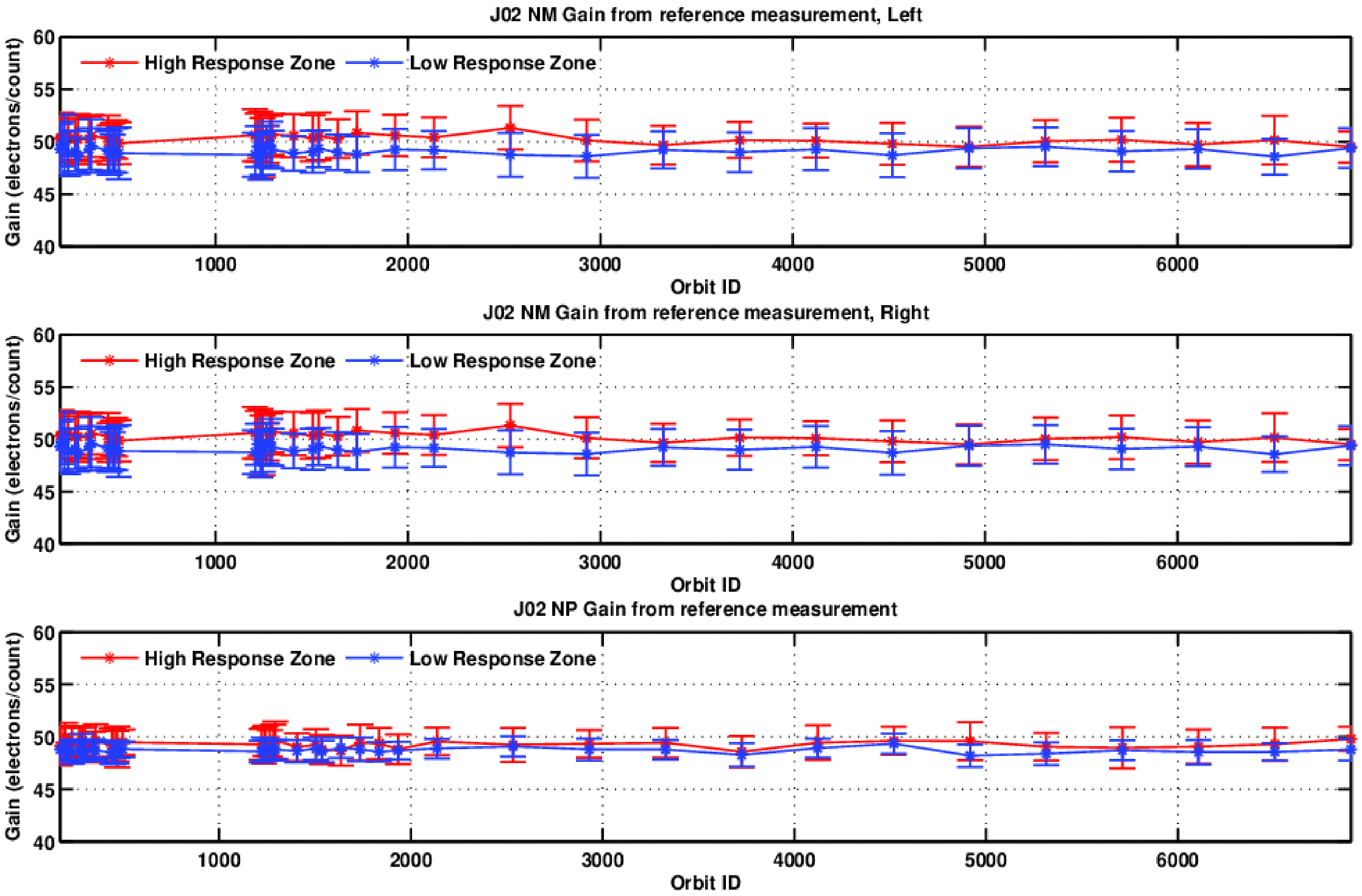
OMPS On-Orbit Nonlinearity Performance: Meet Requirement

- NOAA-21 OMPS NM and NP on-orbit nonlinearity performs stably: the system nonlinearity is less than 0.75%
  - Time series of maximum nonlinearity for the NOAA-21 OMPS NM (left and right CCD) and NP is shown in the figure.
  - The maximum nonlinearity is constantly smaller than 0.75%, within the requirement of 2%



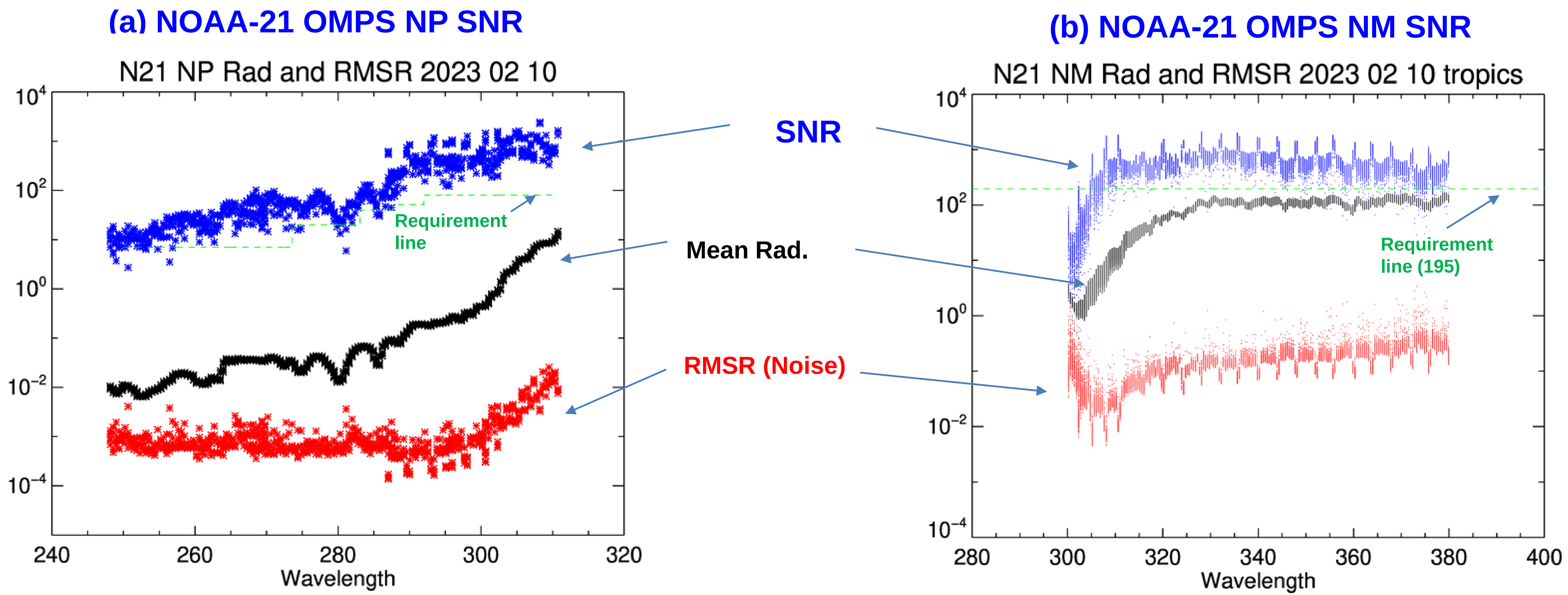
OMPS Gain Performance: Stable

- The NOAA-21 OMPS NM and NP system gains (electron#/count) are assessed based on the LED data by using the mean variance method that was used in the SNPP and NOAA-20 OMPS (Kowalewski et al., 2012)
- Time series of the NOAA-21 NM and NP gains are showed in the figure, demonstrating a relatively stable gain with small offsets relative to the pre-launch TVAC values.



Relatively stable with time: within ±1%

Earth View Noise Meets Requirements
(NP: 250 ~ 310nm; NM:305~380nm)

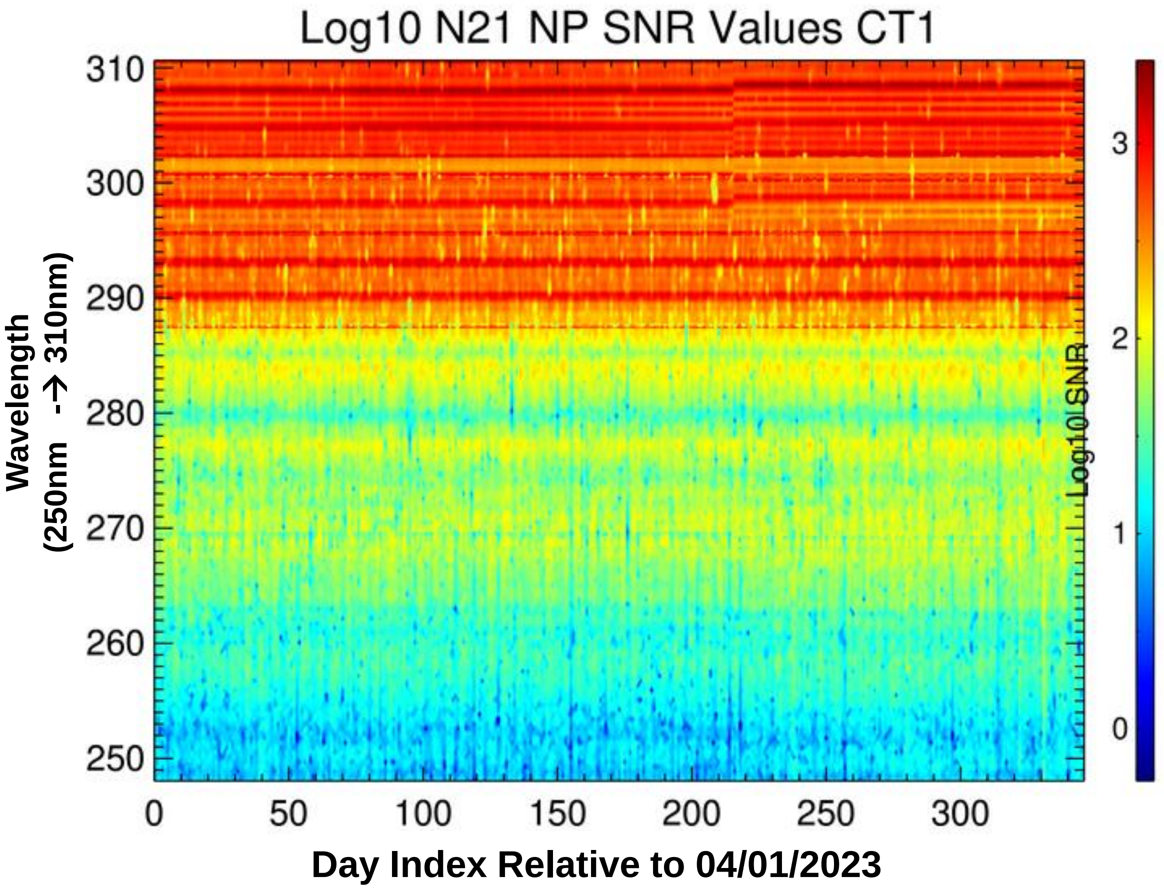


(A PCA-based empirical algorithm initialized by L. Fylnn was used to compute the mean radiance and residual component based on daily SDR data)

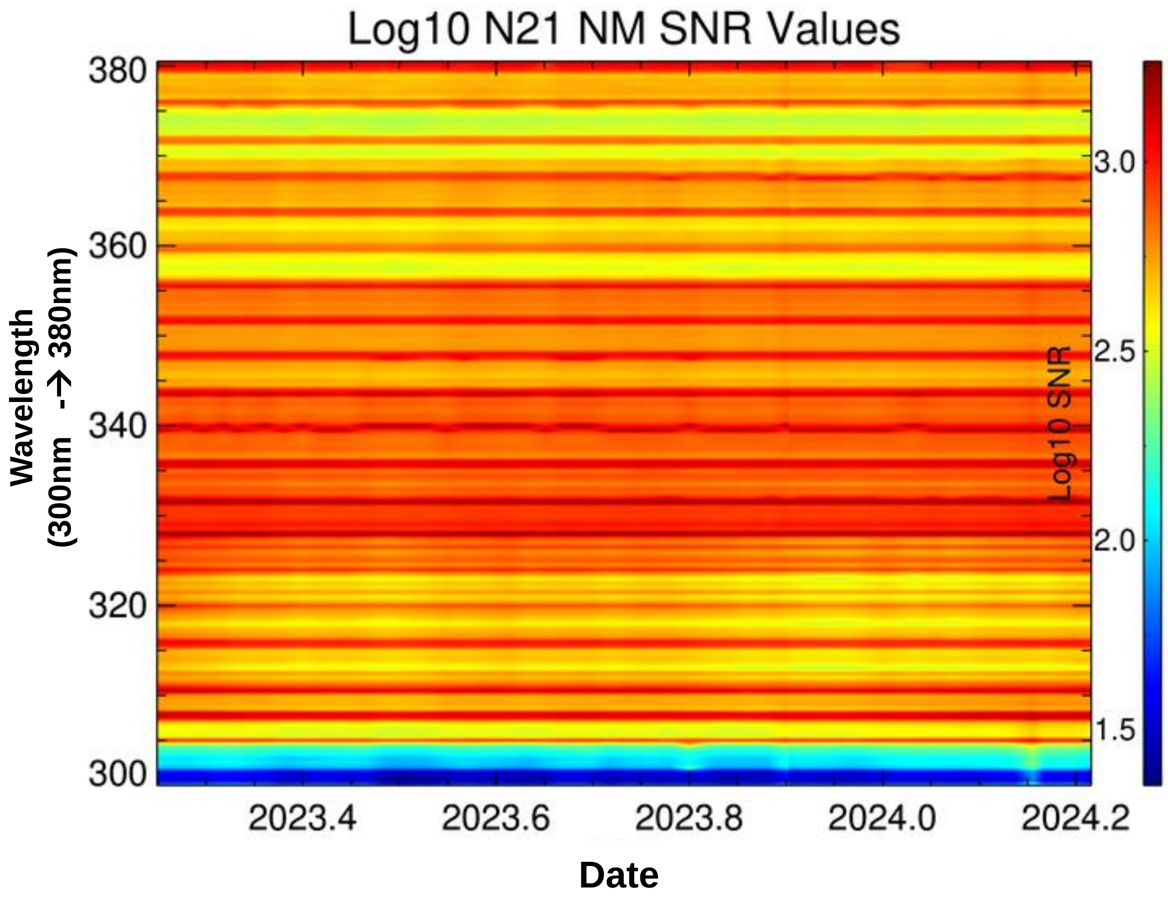
Both NOAA-21 OMPS NM (≥305nm) and NP meet the SNR requirements, while the NM data below 305 nm is a little noisy as expected (As L1RD doc defined, the SNR accuracy is defined primarily for 305 - 380 nm).

NOAA-21 OMPS NP and NM SNR Time Series: Stability Check

OMPS NP



OMPS NM

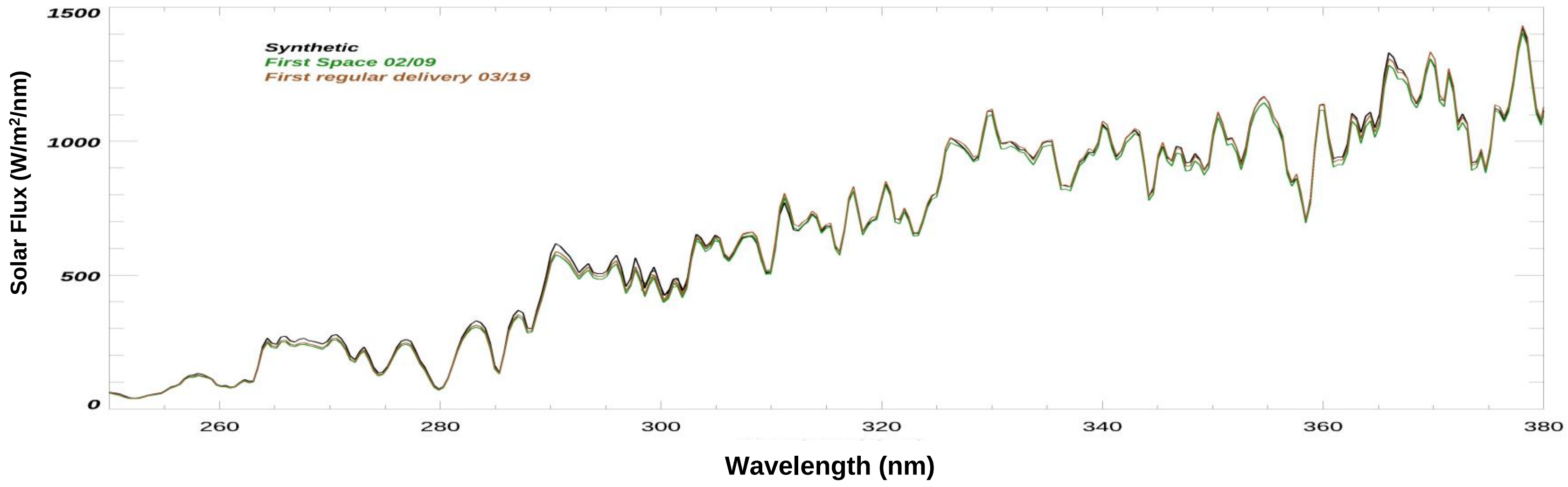


Both NOAA-21 OMPS NM and NP show a stable SNR performance so far. They meet the SNR requirements in the range from 305 ~ 380nm for NM and NP for the whole wavelength range

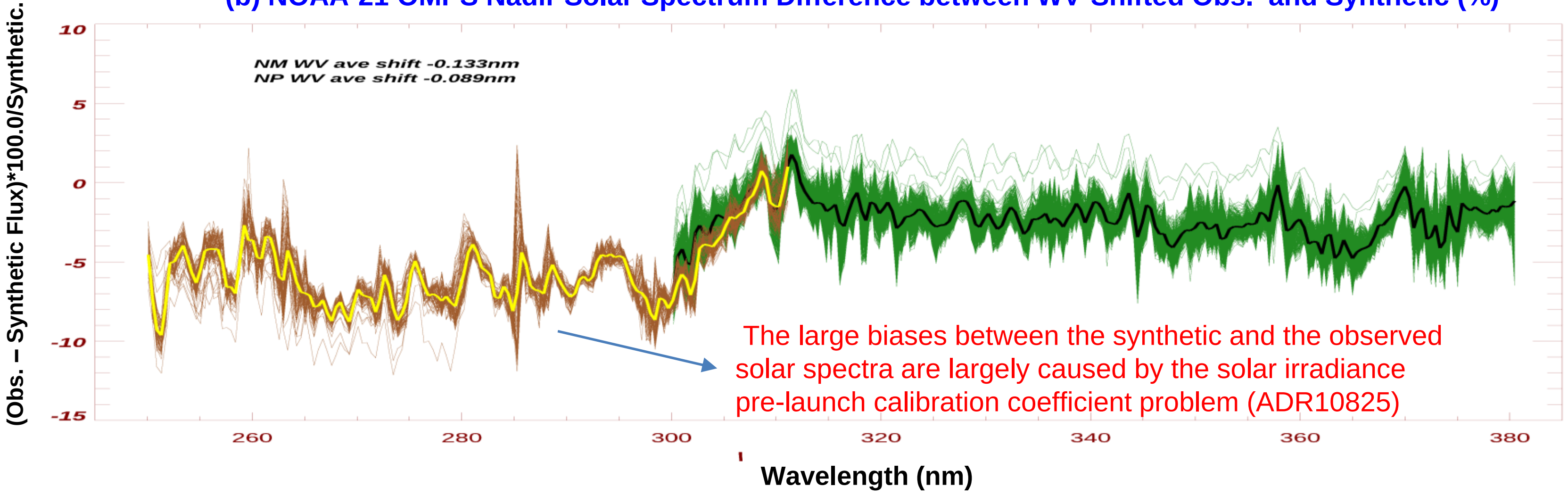
Wavelength Registration Changes from Ground to On-Orbit

- The J2 OMPS NM and NP wavelength registration is changed due to the instrumental thermal temperature change from ground to orbit.
- The NM/NP wavelength changes relative to the pre-launch (a synthetic solar spectrum) are determined based on the first solar diffusor measurement data. The methodology is similar to the OMPS ATBD methodology).
- The results show that the wavelength mean changes are **-0.133 nm for NM and**
- **-0.09 nm for NP.**

(a) NOAA-21 OMPS NM and NP Synthetic and On-Orbit Solar Spectrum Comparison

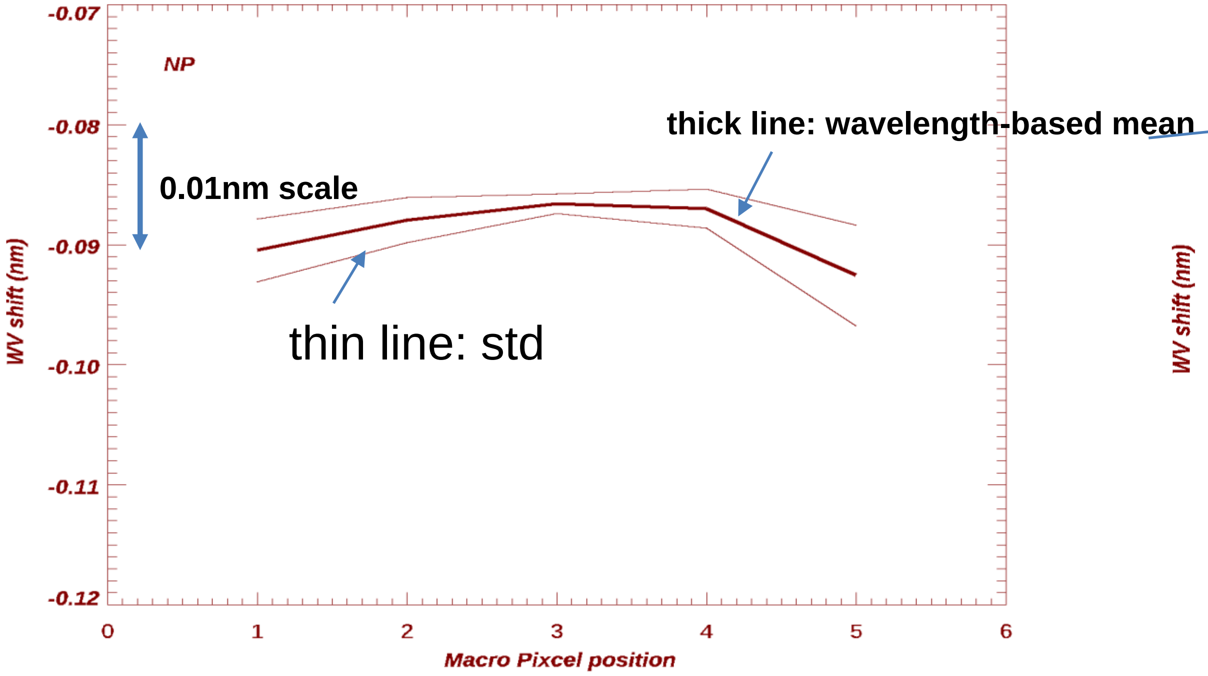


(b) NOAA-21 OMPS Nadir Solar Spectrum Difference between WV-Shifted Obs. and Synthetic (%)

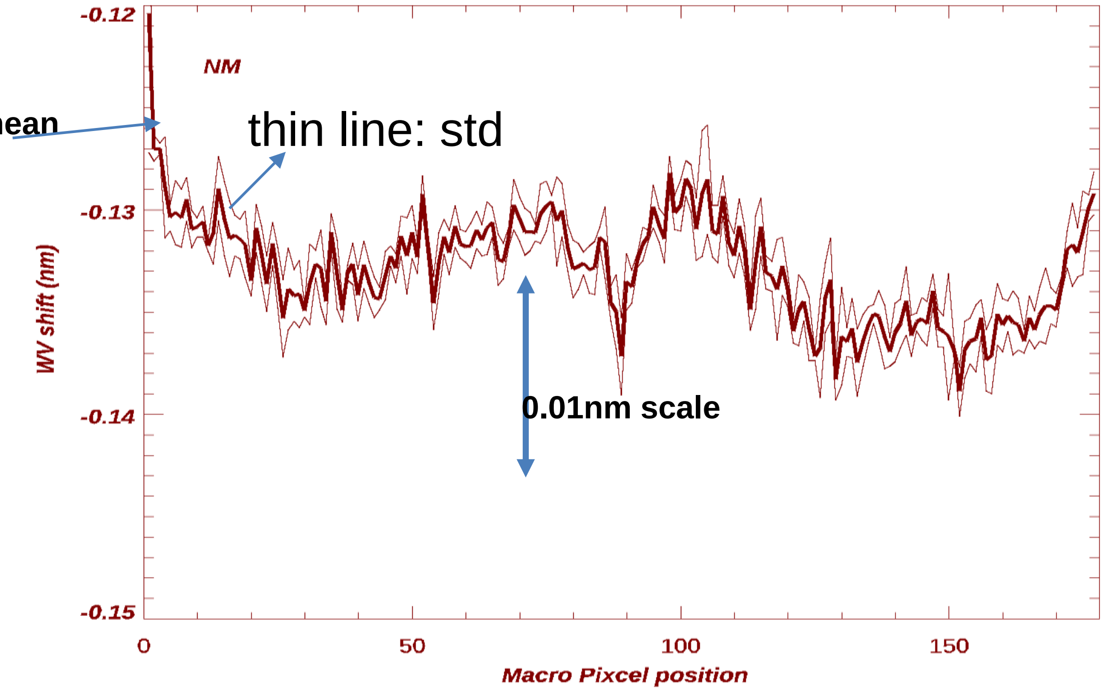


Assessment of NOAA-21 OMPS NM and NP Wavelength Registration Accuracy

(a) OMPS NP Wavelength Shift from Ground to On-Orbit vs. FOV



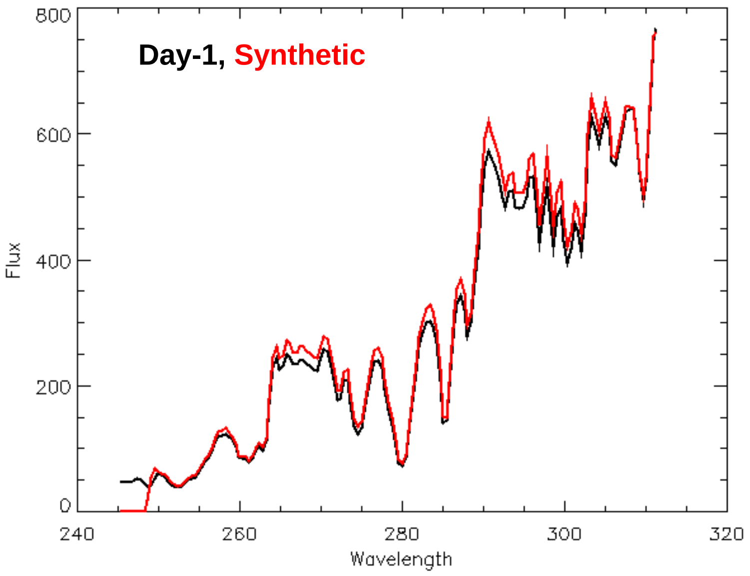
(b) OMPS NM Wavelength Shift from Ground to On-Orbit vs. FOV



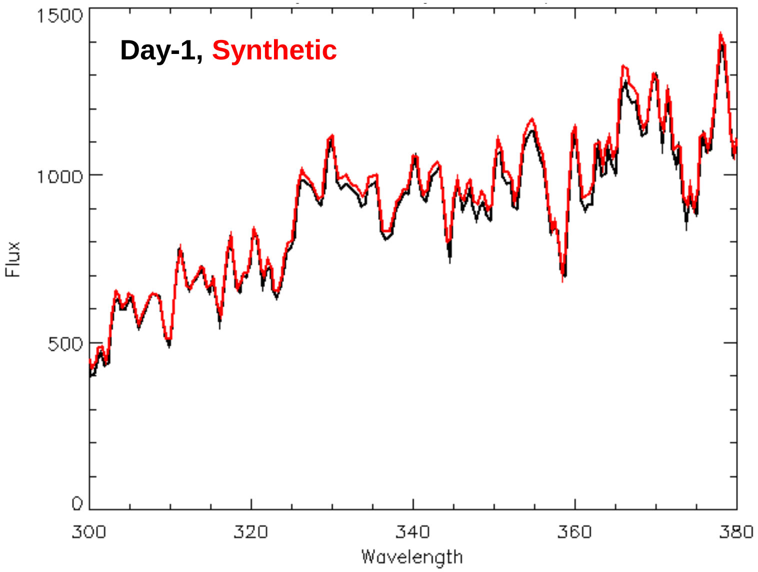
NOAA-21 OMPS NM and NP wavelength registration from ground to on-orbit has an uncertainty (standard deviation or std.) much less than 0.01nm.

NOAA-21 NP and NM Synthetic and Day-1 Comparisons

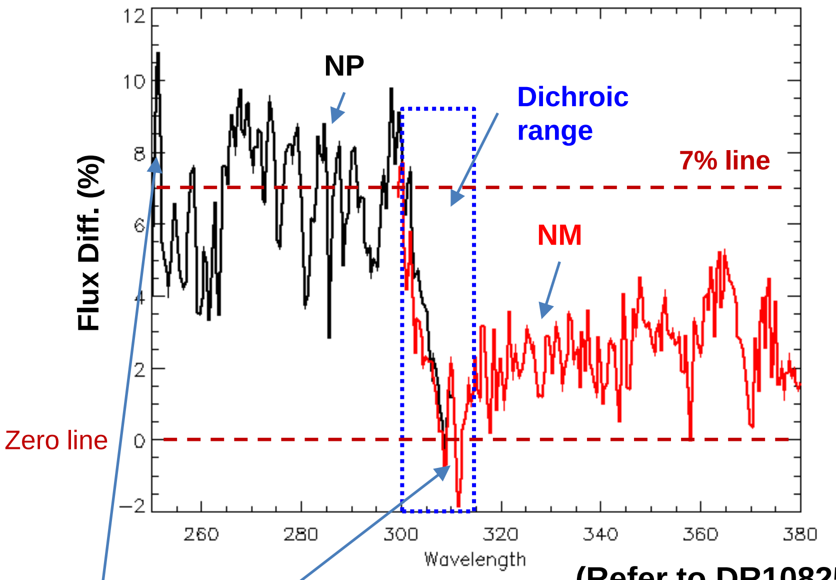
(a) N21 NP Day-1 - Synthetic



(b) N21 NM Day-1 - Synthetic



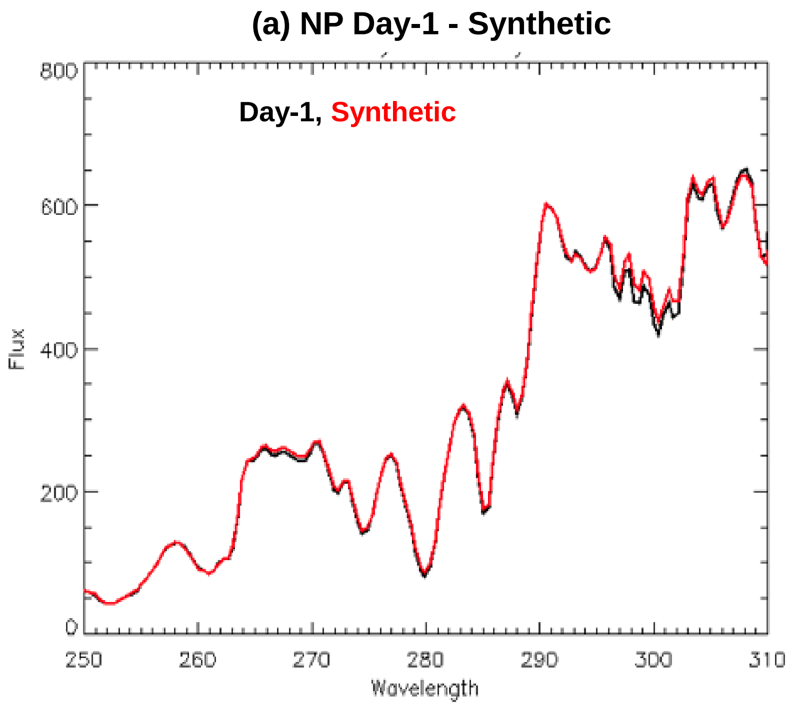
(b) N21 NM and NP Day-1 Difference
Percent relative to Synthetic

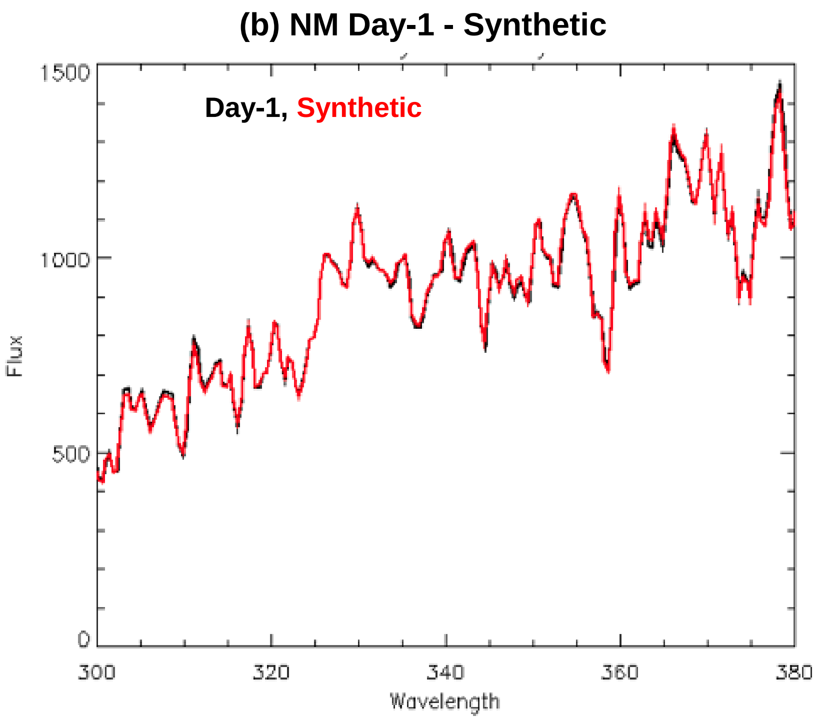


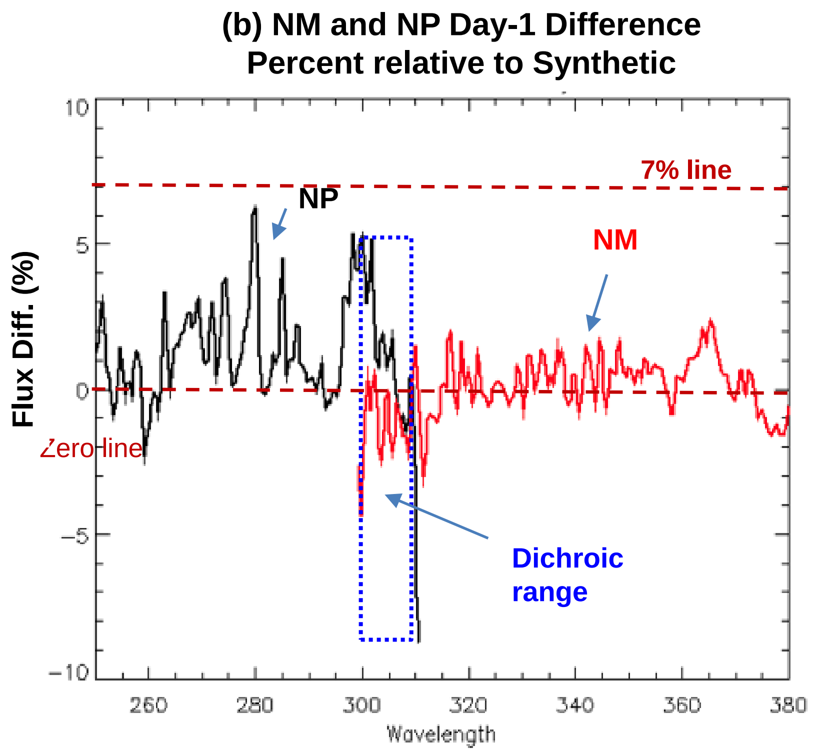
(Refer to DR10825)

(1) The N21 day-1 solar flux is lower than the synthetic solar flux by less than 7% for most of the wavelengths, with exceptions at very short NP wavelengths and some of the dichroic range.
(2) Discrepancies up to 2% occur in the dichroic range from 300 to 310 nm between NM and NP.

SNPP NP and NM Synthetic and Day-1 Comparisons







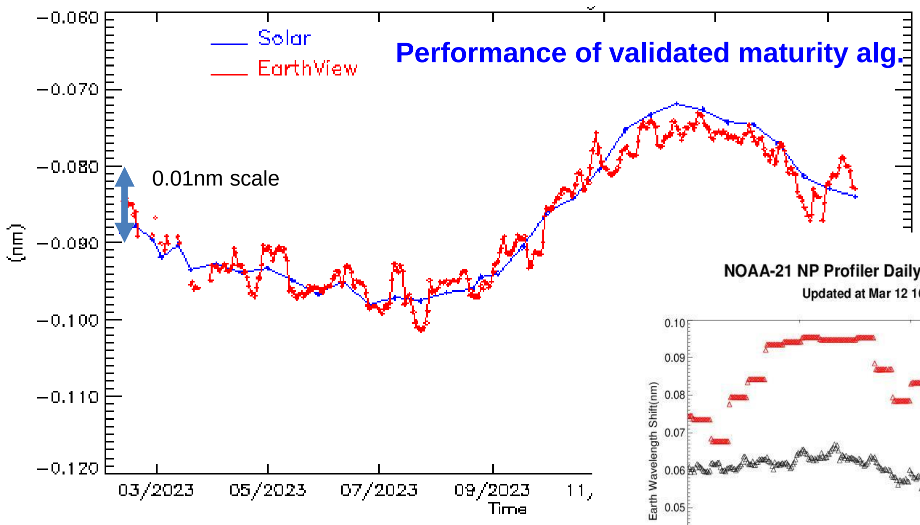
(1) The SNPP day-1 solar flux is more comparable with the synthetic solar flux than NOAA-21, with the differences mostly within 3% (absolute value).

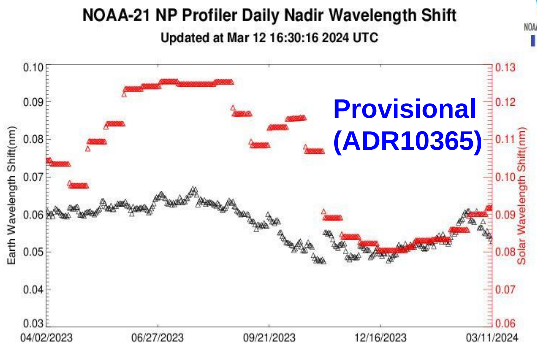
(2) Discrepancies up to 2% also occur in the dichroic range from 300 to 310 nm between NM and NP.

Assessment of NOAA-21 OMPS NP Wavelength Shift Accuracy with Time (Using Validated Maturity Algorithm)

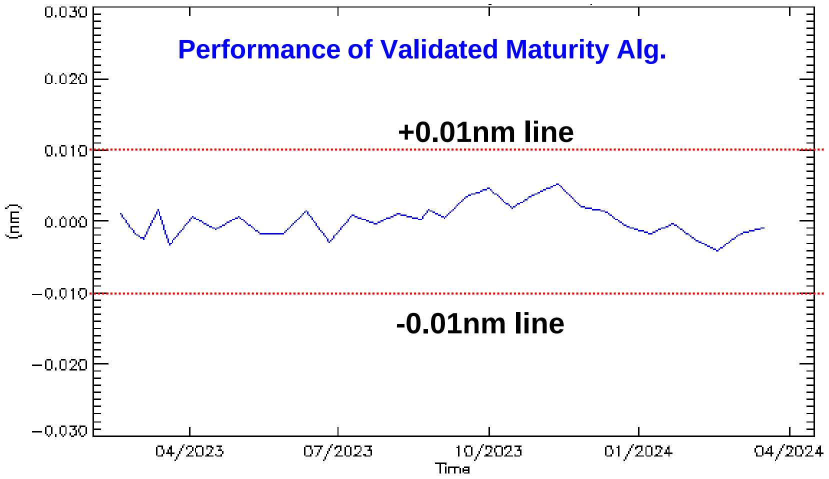
- Started a weekly update of the wavelength shift for NOAA-21 NP after 03/01/2023 to capture impact of the instrument temperature with time.
  - Use the Mg-II 280 absorption feature in measured working diffusor solar flux measurement data to determine wavelength shift relative to the day-1 wavelength scale
  - ADR 10365 fixed the inconsistency in the delivered NP wavelength shifts from EV-based values
  - The figures used the corrected wavelength shift algorithm (ADR10365) for the data prior to the implementation of the DR

(b) Comparison of Solar-delivered and EV Radiance-Derived Relative Wavelength Shifts



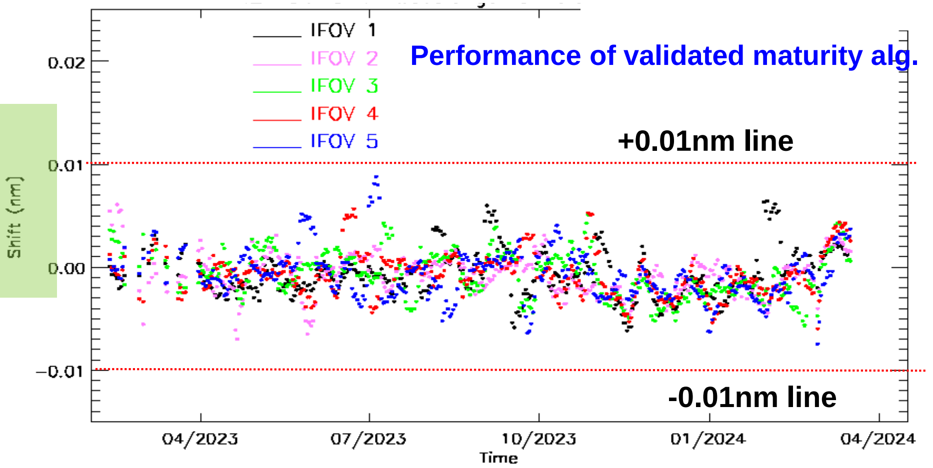


(a) Time Series of Deviations of 'Delivered' from Actual Relative Wavelength Shifts (Real Solar Data)



Meet the requirement with 0.01nm

(c) Wavelength Shift Differen delivered and Earth Rad

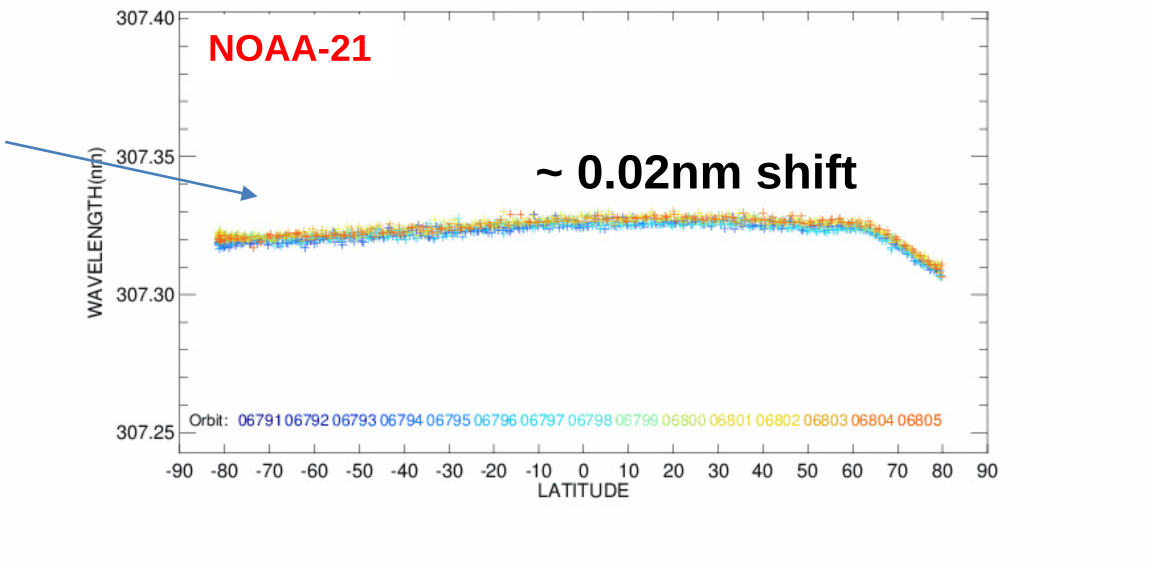


NOAA-21 OMPS NM Intra-Orbit Wavelength Shift Calibration and Monitoring

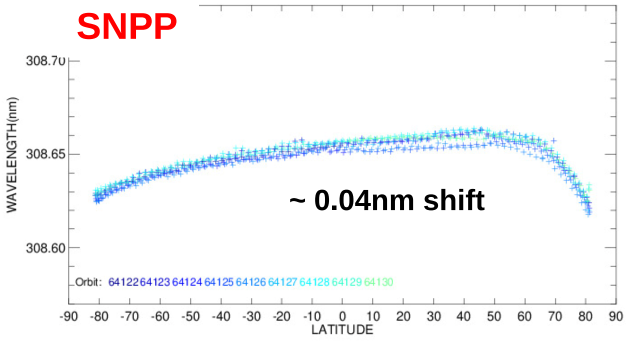
- The NOAA-21 OMPS NM Earth-view radiance measurements show intra-orbital shift in the wavelength scales.
  - The root cause is variations in the instrument temperatures along an orbit.
  - The shifts are correlated with some specific temperature variations, e.g., temperature differences between the OMPS NM housing and nadir calibration housing sensors.
- An empirical algorithm (Flynn et. al., 2013), by using a multiple regression fit of the radiance /irradiance ratios over 345 nm to 380nm, is employed to predict the relative wavelength shift with latitude in the NOAA-21 OMPS SDR operational processing.
- The NOAA-21 NM shows a stable intra-orbit wavelength shift pattern with a variation of 0.02nm, which is smaller than that for either NOAA-20 (~0.03nm) or SNPP (~0.04nm).

NOAA-21 OMPS NM Intra-Orbit Wavelength Shift at 307.32nm (03/4 ~ 03/17/2024, available nominal data) (Animated)

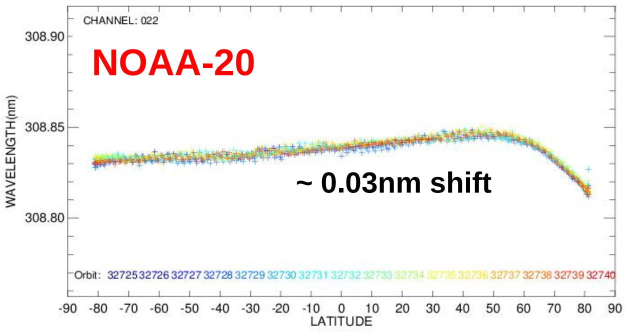
The NOAA-21 OMPS NM shows a stable intra-orbit wavelength shift pattern with time, with a shifted range within 0.02nm that is slightly smaller than either SNPP or NOAA-20 (~ 0.03 or 0.04 nm)



S-NPP NM Daily Wavelength Scale on 2024/03/13
Updated at Mar 14 20:04:08 2024 UTC

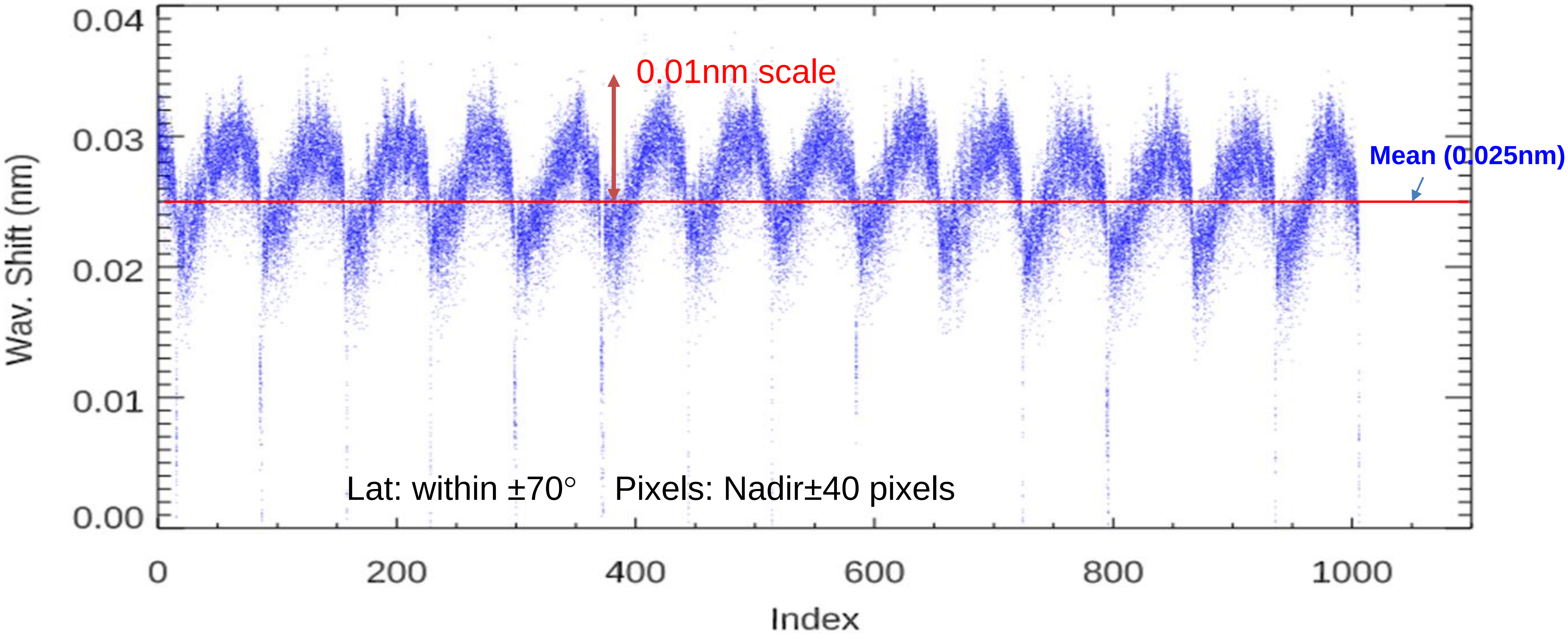


NOAA-20 NM Daily Wavelength Scale on 2024/03/13
Updated at Mar 14 21:12:28 2024 UTC



Reference: https://www.star.nesdis.noaa.gov/icvs/ for more days of the results

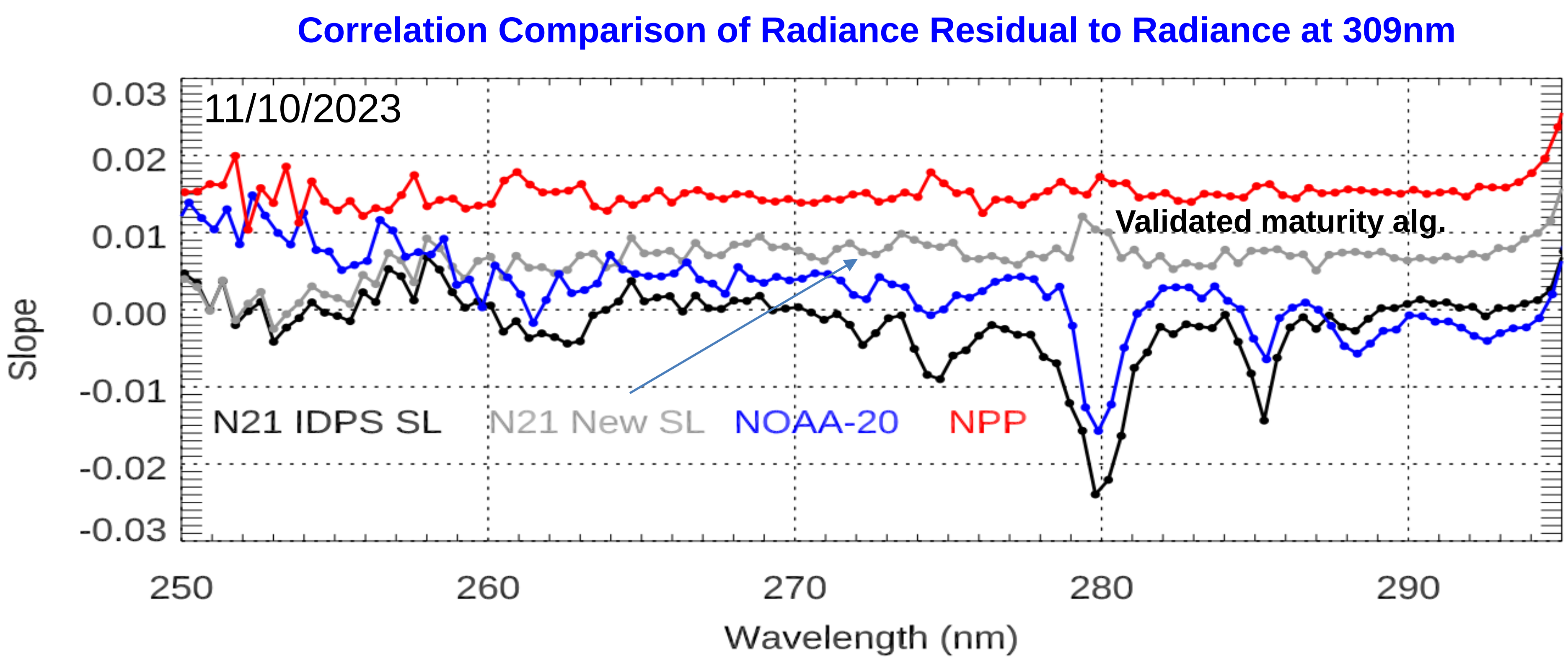
Assessment of NOAA-21 OMPS NM Intra-Orbit Wavelength Scale Accuracy



On average, the NOAA-21 OMP NM intra-orbit wavelength shift accuracy meet the requirement with 0.01nm.

Courtesy of L. Flynn of the wavelength shift algorithm

Assessment of NOAA-21 NP Stray Light (SL) Correction Performance (1/4)



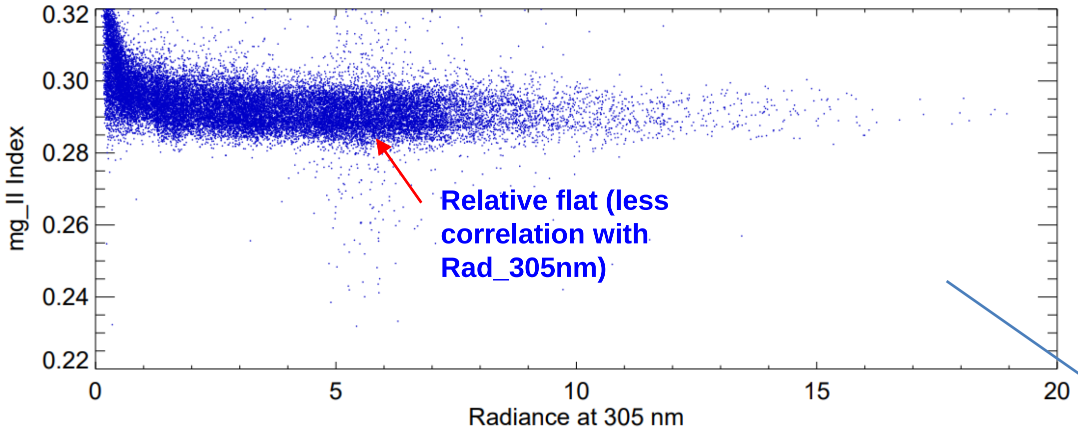
- The NOAA-21 NP SL coefficients were derived using the **point spread function (PSF) data** from BallC vendor via NASA OMPS group.
- Due to lack of truth, the performance of NOAA-21 OMPS NP SL is assessed by analyzing the correlation of the data with longer wavelength (~309nm) in comparison with SNPP and NOAA-20 SL performance.
- For each channel, the latitude dependency of data (± 40 degrees lat.) are corrected by fitting
- The residuals (%) for each channel are correlated with longer wavelength
- **The NOAA-21 NP (new SL table; validated maturity) shows better performance: SNPP indicates underestimated SL and NOAA-20 suggests stronger correlation.**

Assessment of NOAA-21 OMPS NP Stray Light Correction Performance (2/4)

- An empirical algorithm based on Magnesium (mg)-II index (core to wing ratio at 280nm) (courtesy of L. Fylnn) is used to assess the performance of the NP SL.
- mg II index correlation with 305 nm: For SL correction working well, ideally expect to be flat with no correlation
- N21: suggests less variability with nearly flat trend
- N20: Suggests larger variability (cross track pixel dependency) and stronger correlation (larger SL residual)

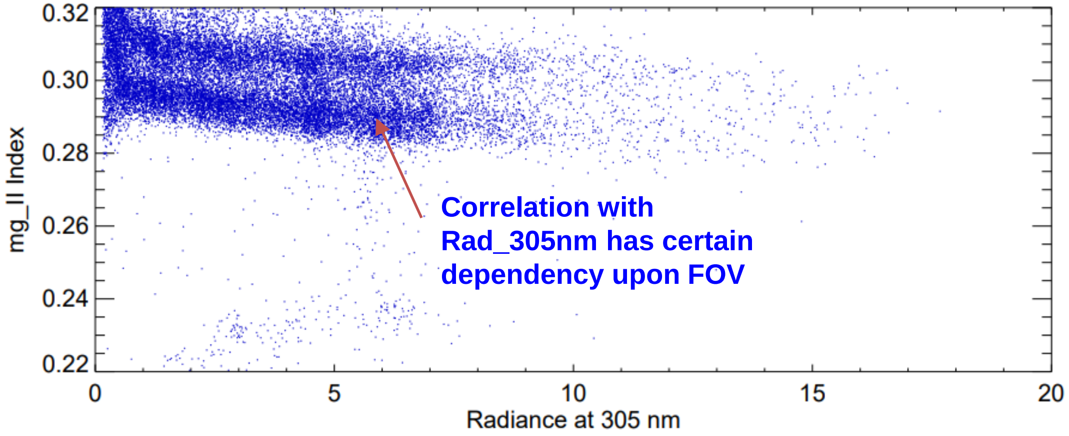
Comparison of mg-II Correction Index between NOAA-21 and NOAA-20 NP (Data: 11/10/2023)

N21 Updated SL and Scaled Dark



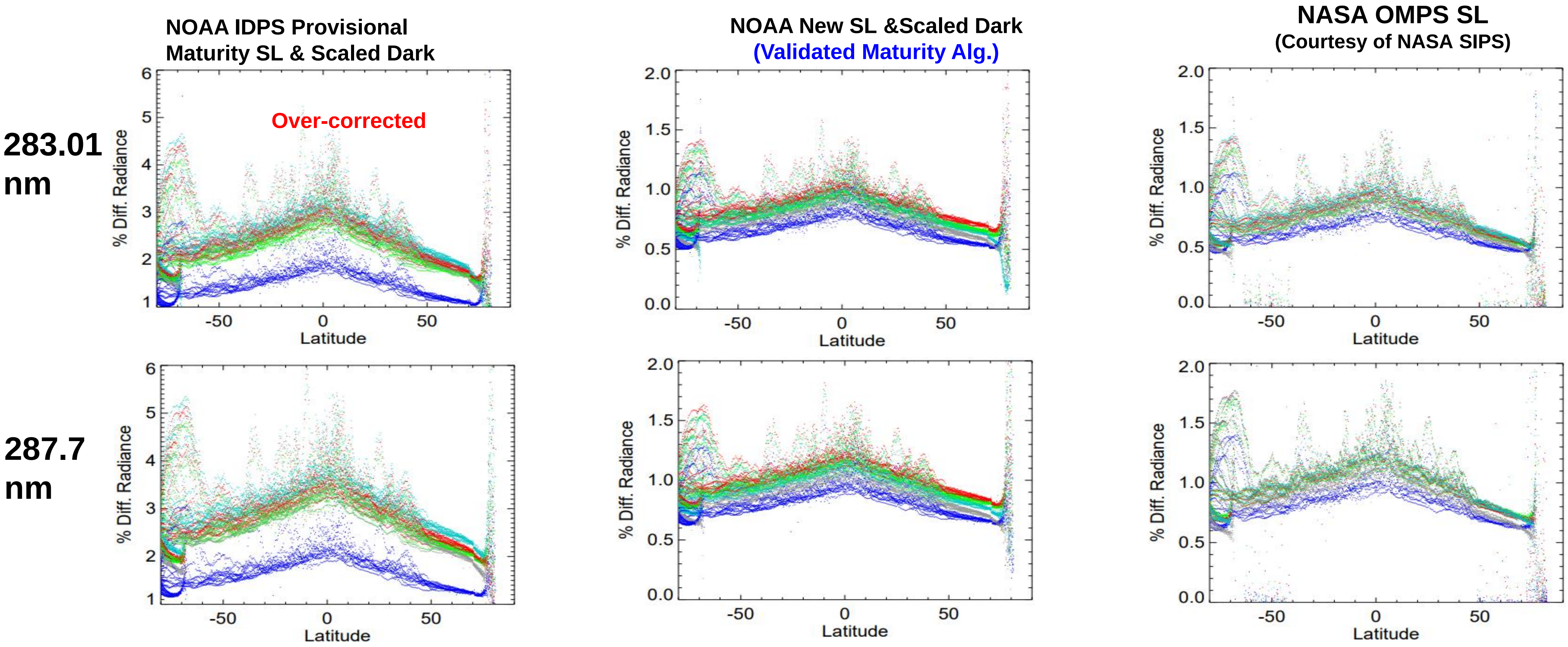
NOAA-21 NP SL shows a better performance than N20

N20 IDPS



Assessment of NOAA-21 OMOS NP Stray Light Correction Performance (3/4)

Comparison of SL Correction Impact vs. Latitude among 3 SL Algs.



Cross Track Pixels: Pixel 1 (Leftmost pixel) Pixel 2 Pixel 3 Pixel 4 Pixel 5 (Rightmost pixel)

The NOAA new SL table has a more comparable performance to NASA SL table.

Assessment of NOAA-21 OMOS NP Stray Light Correction Performance (4/4)

Comparison of SL Correction Impact on Radiance between NOAA and NASA

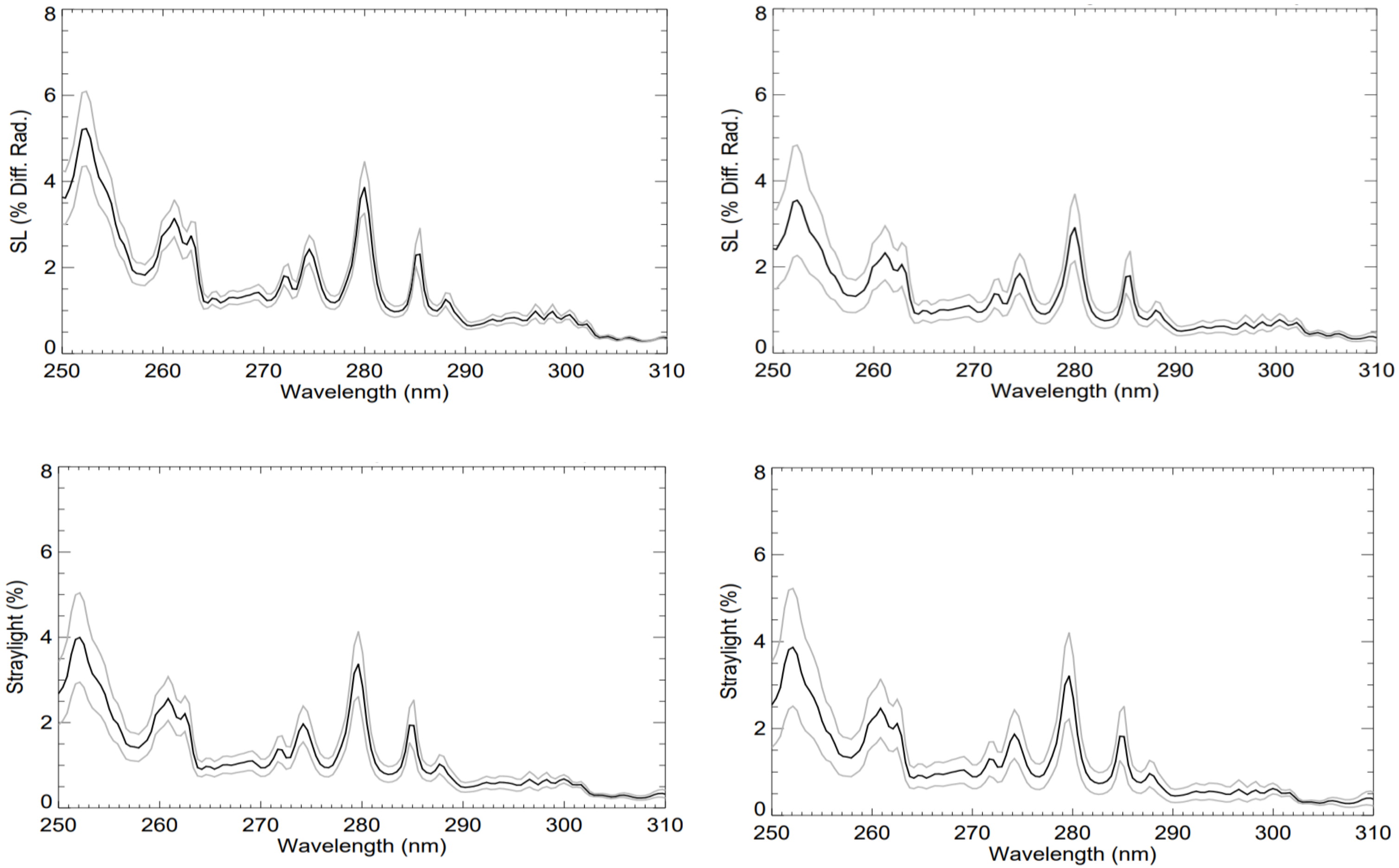
(a) Rad Diff. Percent due to SL Correction

±10°Lat

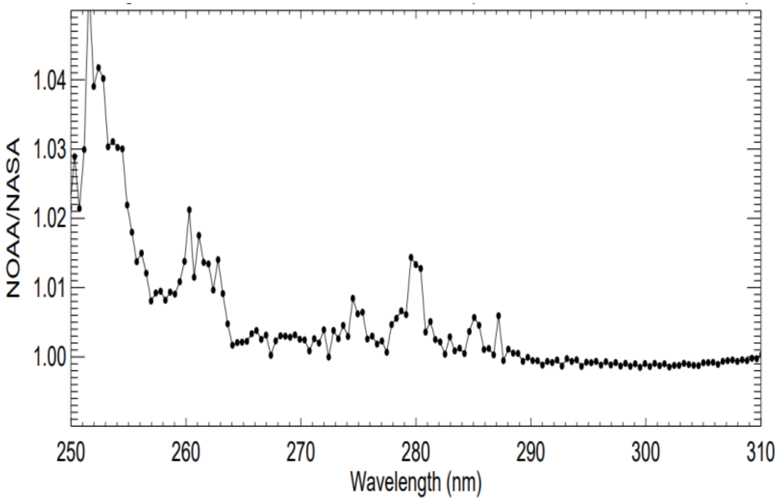
≥70°Lat

NOAA

NASA



(b) Rad(SL) Ratio (NOAA/NASA)



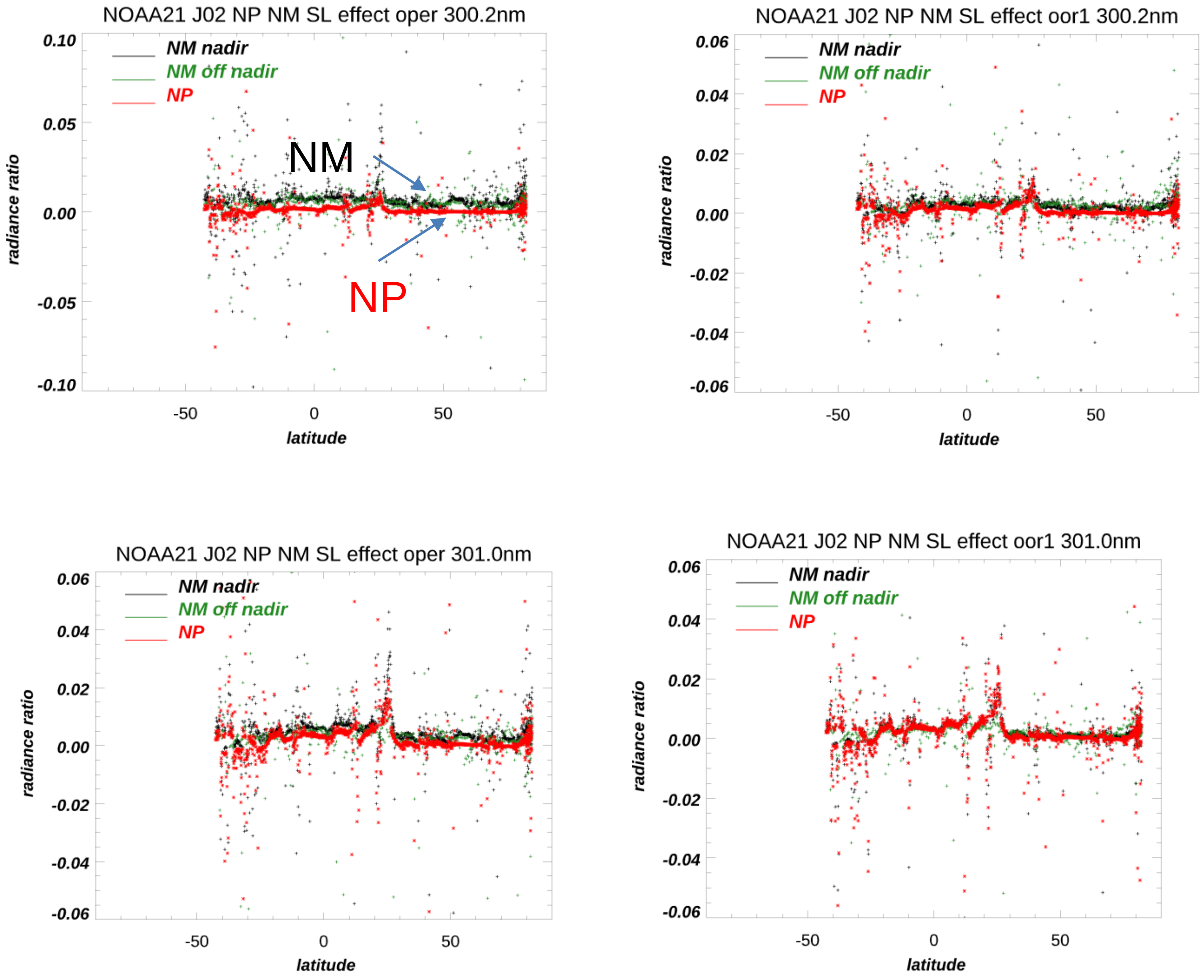
NOAA and NASA SL agrees well, with the differences less than 1% for wavelengths above 255nm.

Meet the requirement with 5%.

Assessment of NOAA-21 OMPS NM OOR Stray Light Performance

- An empirical algorithm with predicting the sum of NM radiance **above 380nm** (**to 421nm**) is developed to account for contribution of SL from wavelengths above 380nm to short wavelengths, so named as **out-of-range (OOR) SL**.
- Performance of the OOR SL alg. is assessed through the ratio of radiance variation between short wavelength range (300 – 308nm) and a long wavelength channel (379nm). Then, compare it with corresponding NP value. If the two are close, it means the OOR SL correction is good.
- The OOR SL table improves the performance of the NOAA-21 OMPS NM in the short wavelengths.

Without OOR SL | **With OOR SL**



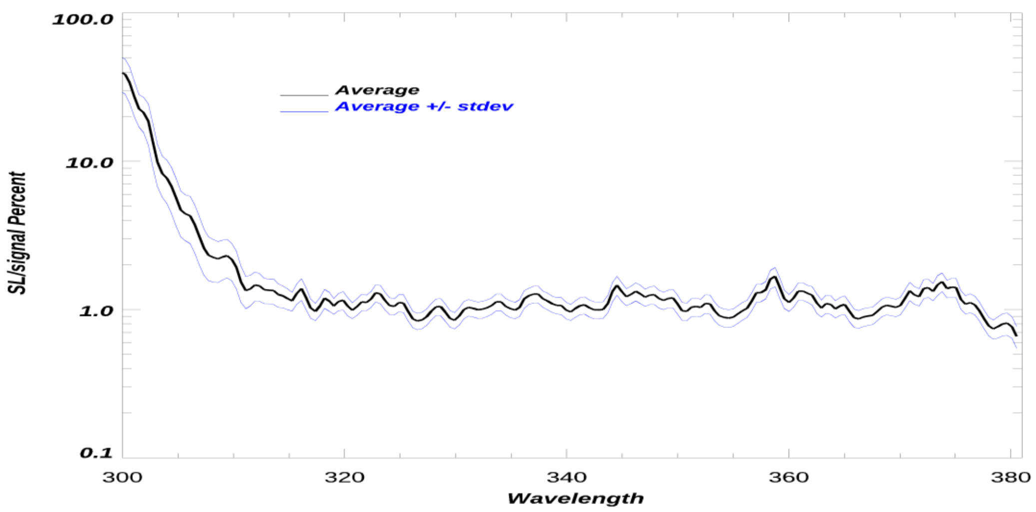
(Refer to ADR 10686 for details)

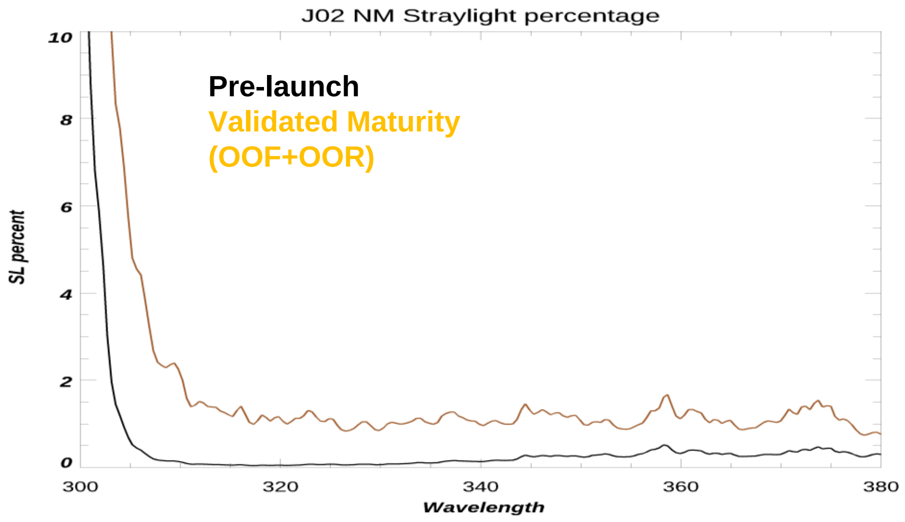
(Courtesy of NASA OMPS Group for sharing the SIPS Data (300nm~421nm)

Assessment of NOAA-21 OMPS NM Total (OOR+OOF) SL Performance

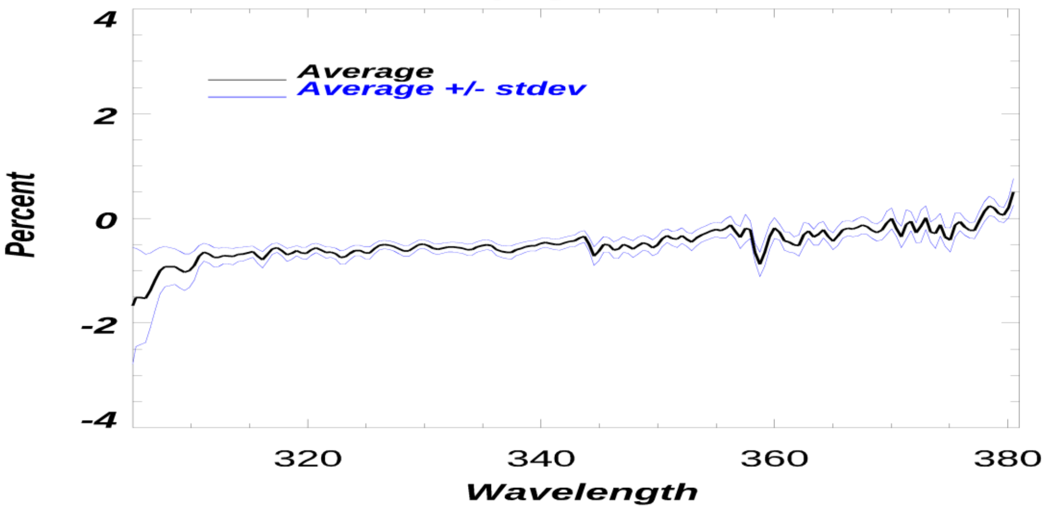
- The N21 NM out-of-field (OOF) SL covers internally scattered SL signals (spectrally and spatially) from the used CCD area in which wavelengths are below 380nm.
- The SL coefficients were derived using the point spread function (PSF) data.
- The NOAA-20 OSMP NM SL correction performance agrees well with NASA with the differences within 1% for most of wavelengths.

(b) N21 NM (OOR+OOF) SL Percent





(c) N21 NM (OOR+OOF) SL Difference Percent (NOAA and NASA)



Meet the requirement with 10%.

Assessment of NOAA-21 OMPS SDR Data Calibration Accuracy

- Challenges:
  - Certain discrepancies in spectral BPS, wavelength scale and pre-launch calibration accuracy among 3 OMPS nadir (NM and NP) instruments (SNPP, NOAA-20, NOAA-21)
  - Lack of truth or perfect tools for validation of the OMPS SDR data accuracy
  - 5 Different spatial resolutions among 3NMs and 3 NPs, leading to different viewing conditions
  - Lack of accurate Inputs (e.g., surface reflectivity, ozone profile) to RTM
- Mitigation: Use Multiple Methods
  - Inter-sensor comparison analysis
    - 32-day averaged differences for both NM and NP
    - Comparison of NOAA-21 OMPS SDR between NOAA and NASA Data Sources
    - Deep convective cloud (DCC) targets for OMPS NM
    - NOAA-21 OMPS NM and NP consistency analysis
  - Double differences of (O-B) via CRTM as a bridge

Table Comparison of Spatial Resolution for 3NPs and 3 NMs

Name	NOAA-21	NOAA-20	SNPP
NP (250-310nm)			
Granule size	5 x 5	5 x 5	1 x 1
Spatial	50x50 km^2	50x50 km^2	250x250 km^2
NM (300 – 380nm)			
Granule size	177x30	35x15	35x5
Spatial	12x10 km^2	50x17 km^2	50x50 km^2
NM and NP Consistency (300 – 310nm) (Focus on NM pixels within NP nadir pixel)			

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  - OMPS NM and NP ADR Review after Provisional Review (Trevor)
  - OMPS NM and NP instrument performance assessment (Dark, Non-linearity, Gain, and SNR)
  - OMPS NM and NP Wavelength Registration, Day-1 and Stray Light Performance Assessment
  - OMPS NM and NP Post-launch data quality assessment
    - **OMPS SDR inter-sensor comparison analysis (Sirish)**
    - RTM O-B and RTM-DD analysis
    - OMPS NM and NP Geolocation Accuracy Assessment
    - OMPS NM and NP data quality long-term monitoring from ICVS
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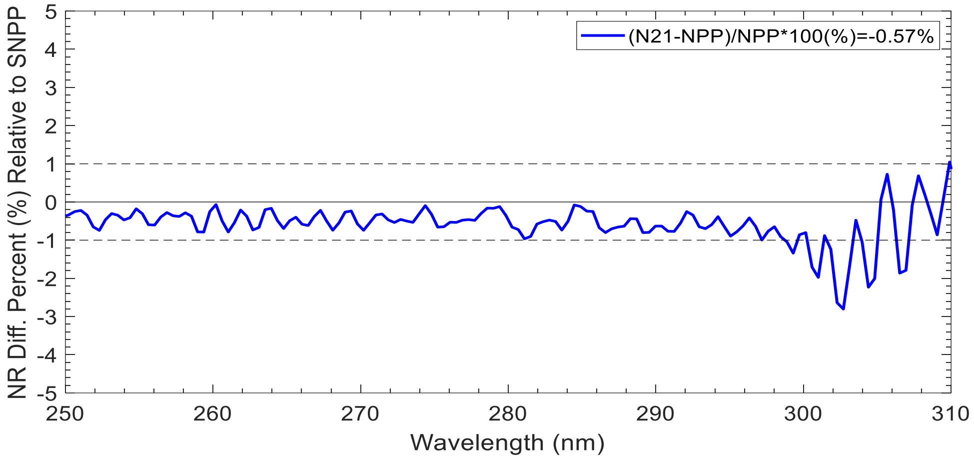
Validating N21 OMPS Calibration Through Intercomparison

- NOAA-21 OMPS radiometric performance needs to be continuously analyzed, monitored, and independently validated to ensure that the calibration quality is well within the specification.
- This study evaluates NOAA-21 radiometric consistency with S-NPP and NOAA-20 OMPS, using TOA radiance and reflectance comparison, including DCC.
- Major sources of uncertainties are from uncertainty in sensor calibration, time differences in observation, BRDF, registration errors.
- N21 Radiometric performance evaluation:
  - **N21 OMPS NM/NP comparison with SNPP and NOAA-20**
    - Compare 32-day Global Mean Radiance/Reflectance
  - **N21 and SNPP NM consistency using DCC**
    - Global DCC (+/-40) reflectance comparison between NOAA-21 and SNPP OMPS NM
  - **N21 OMPS NM and NP consistency**
    - NM and NP radiometric consistency over dichroic region (~300-310 nm) by comparing collocated radiance and reflectance
  - **N21 OMPS comparison with NASA**

Impact on intercalibration due to Spectral Response Function differences

- SNPP and N20 RSRs are not identical and can have minor differences.
- Impact evaluated using TomRAD Model Simulations.

NP spectral bias

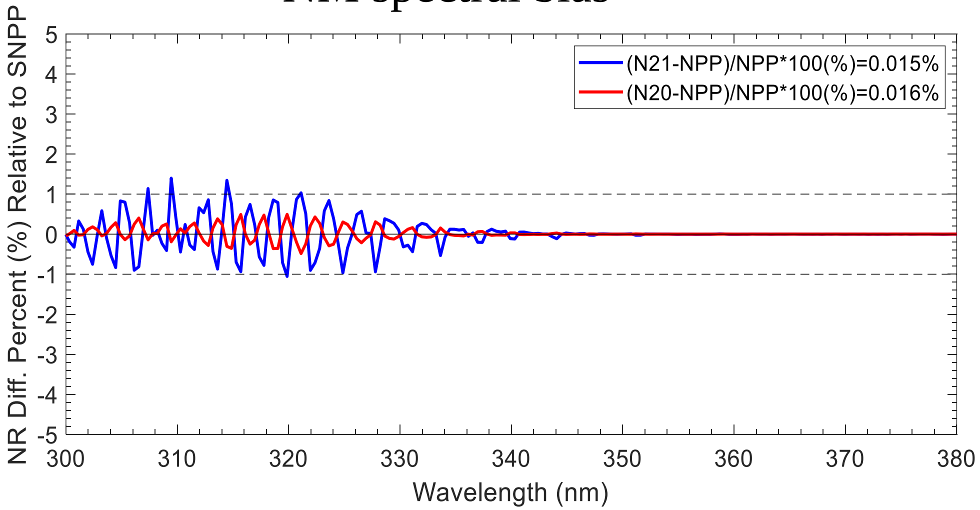


Spectral bias:

NP: Less than 1% below 300 and up to ***3% (absolute value) at 300-310nm***

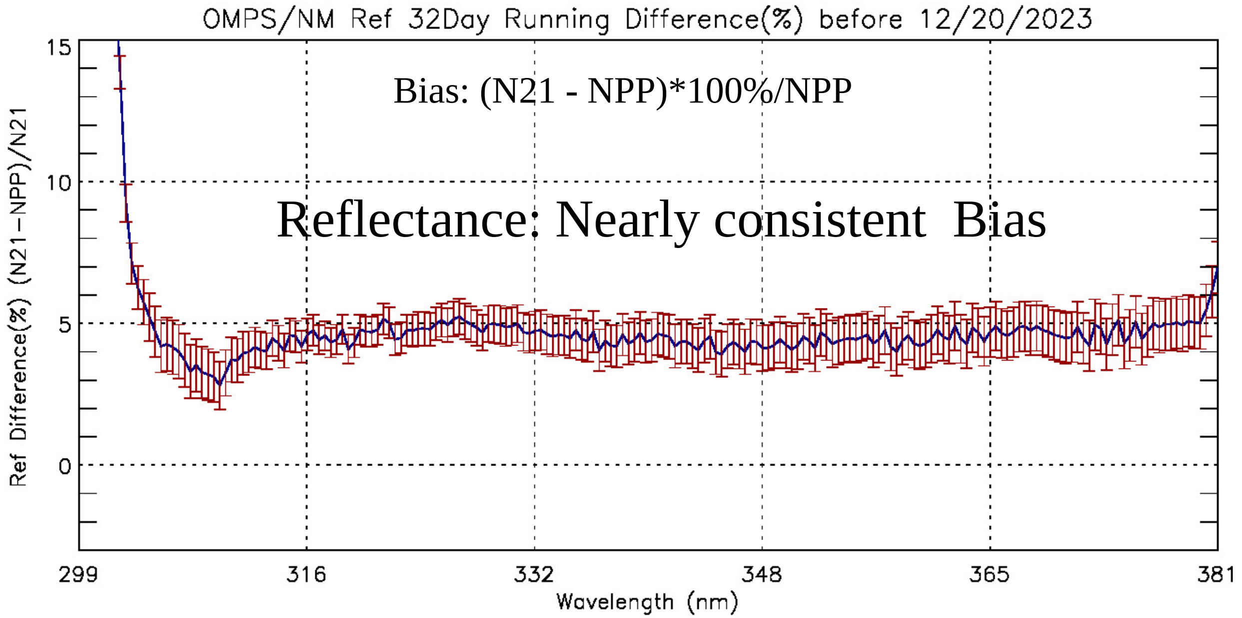
NM: 1% or less

NM spectral bias

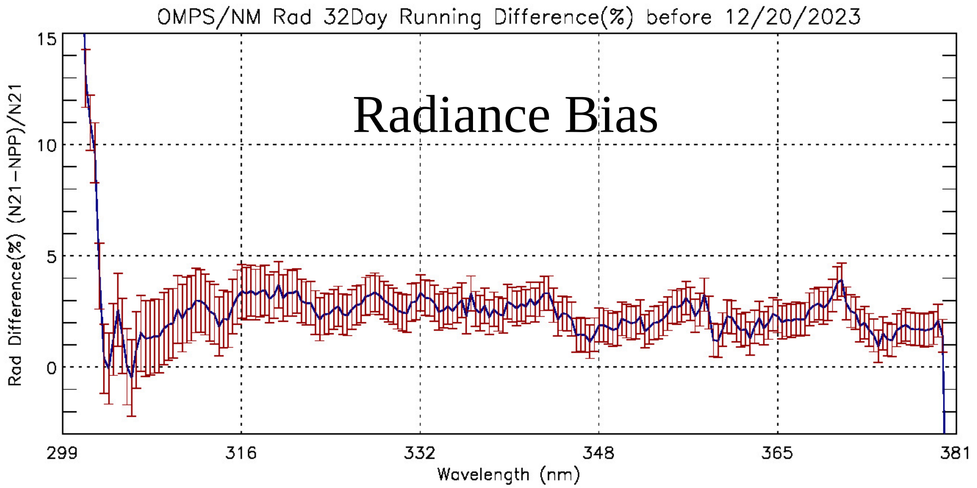


N21 NM Radiometric Consistency with SNPP

- NOAA-21 and S-NPP OMPS-NM reflectance difference calculated from 32-days global mean reflectance
- Reflectance comparison indicates larger (~5% ± 1%) and nearly consistent bias
- Radiance comparison indicates smaller bias, 2-3% for majority of channels



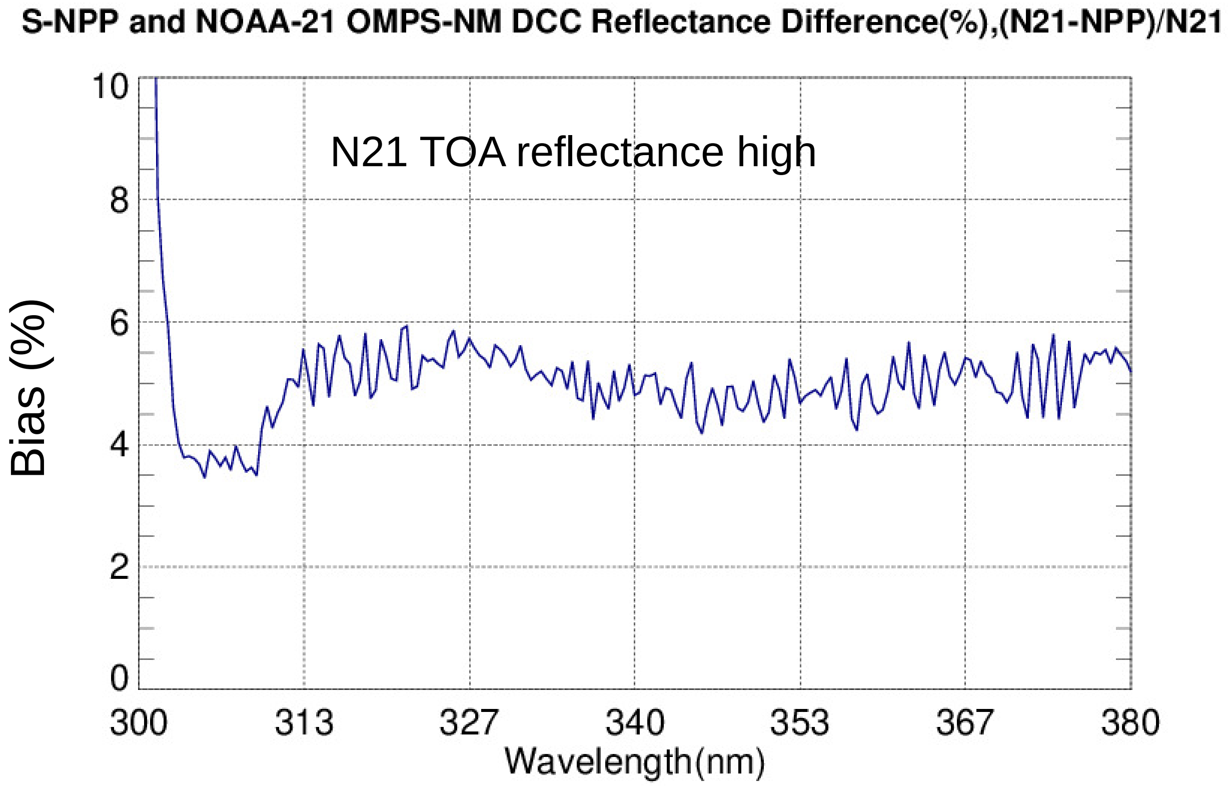
- **Radiance meets requirement**
- **Reflectance can meet the 2% requirement after applying 2% bias correction for solar flux (DR10825)**



Comparing N21 and SNPP OMPS NM over DCC

- N21 NP observed TOA reflectance larger than SPP by ~5% ± 1%, similar to earlier results

- NOAA-21 and S-NPP OMPS-NM reflectance difference calculated from **32-days global mean reflectance agrees within 1% with DCC result**.

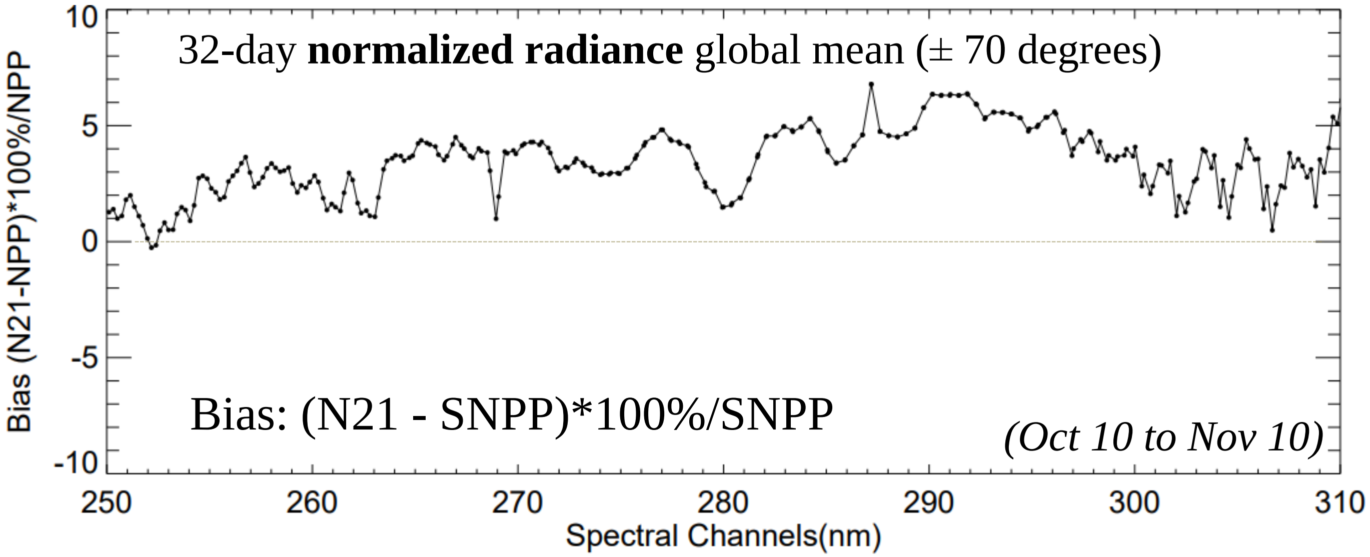


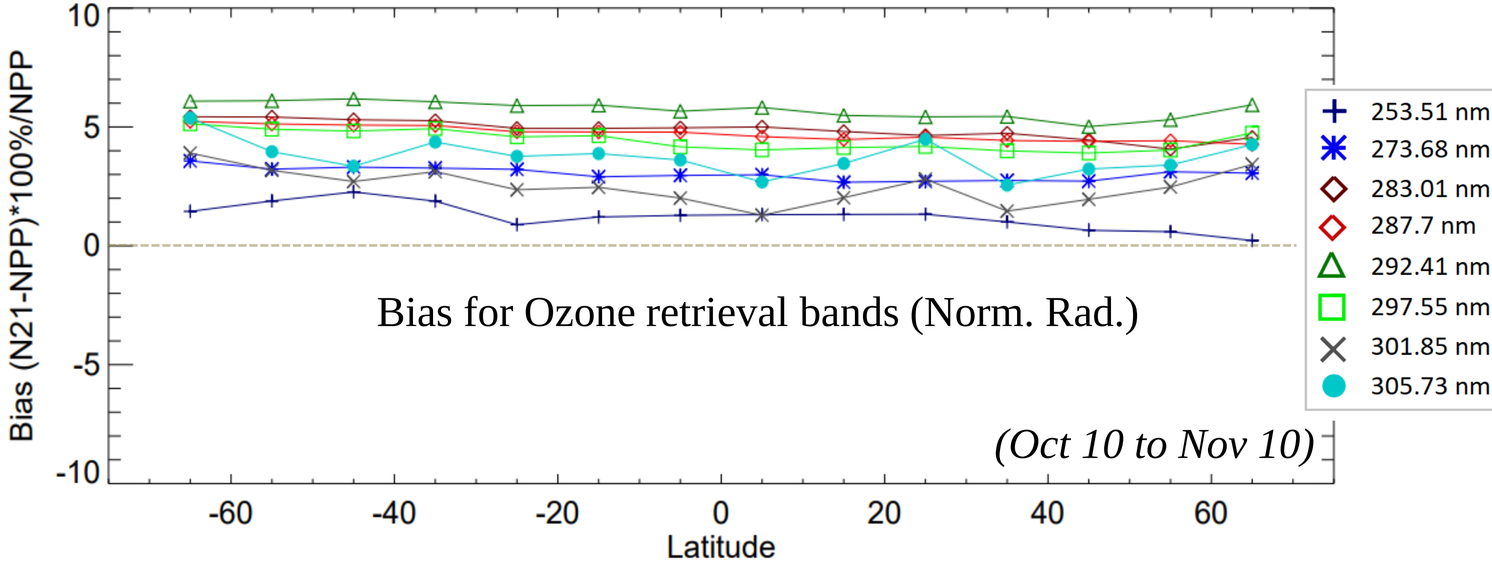
NOAA-21 DCC reflectance: 7 days mean from 12/1-12/7
S-NPP DCC reflectance: 30 days mean from 11/18-12/18

N21 and SNPP NP Radiometric Consistency

- Compared N21 NP reflectance with SNPP

- Wavelength dependent biases are **less** than 5% for majority of channels (DR10825)
    - A system bias in 4% will be removed (**a new CCR is needed**) to meet the requirement within ±2%
    - Systematic bias in the SDR are corrected by EDR team for O3 retrieval.

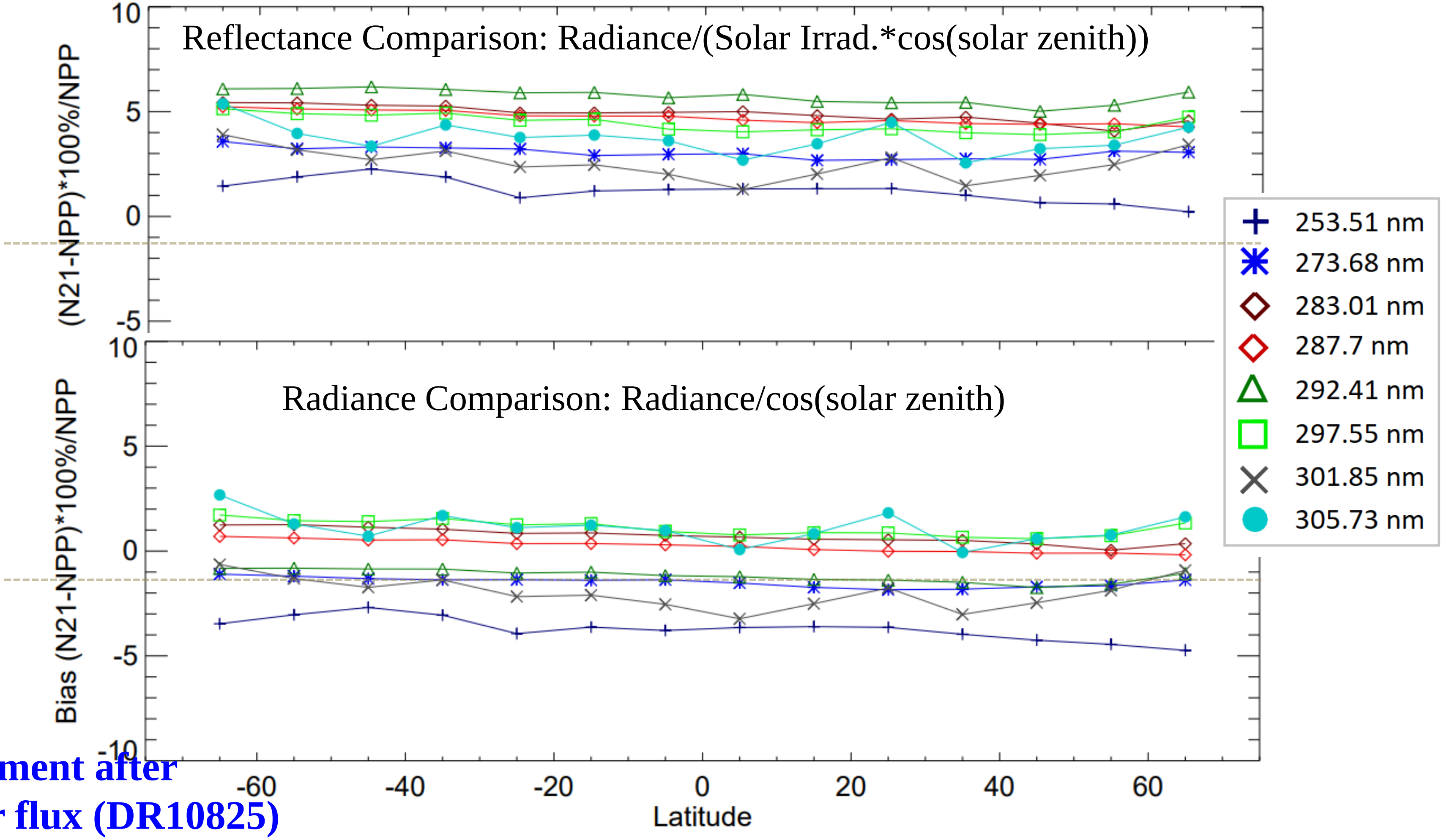




Norm. Rad: Radiance/(Solar Irrad.*cos(solar zenith))

N21 NP Radiometric Consistency with SNPP for Ozone Retrieval Channels

- *Bias can change by more than 5% for some bands with/without using solar irrad.*
- *With soft. Cal. Near equator, the bias is nearly 0 for all bands*
- *Calibration improvements since provisional, SH Latitude dependency is significantly reduced and comparable to N20 (Ref: Communication with EDR team)*

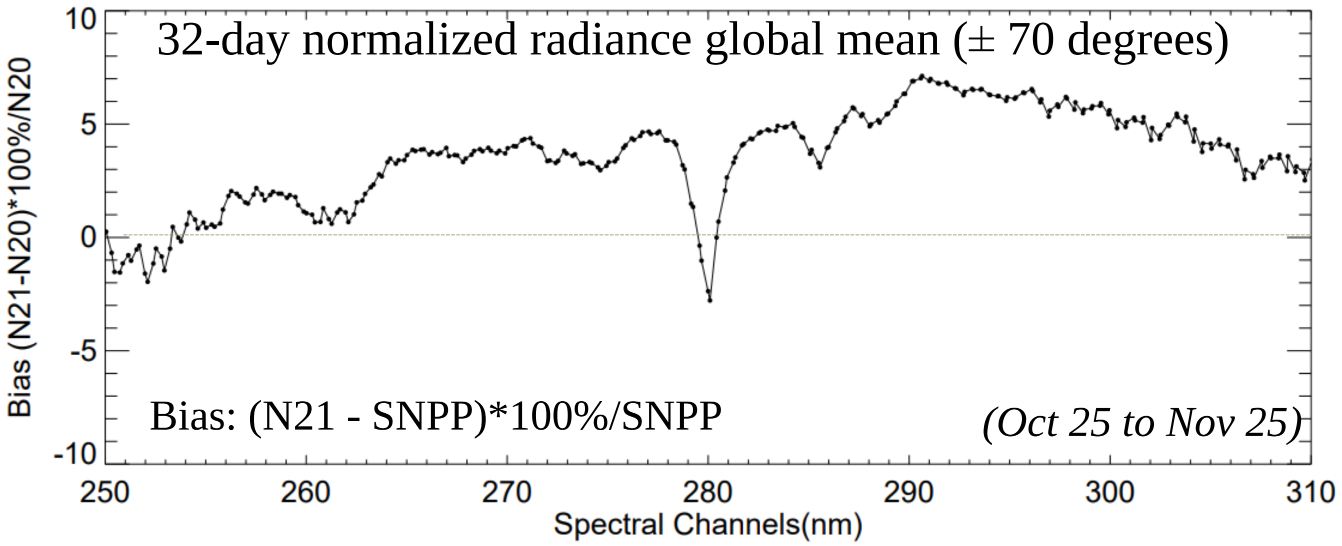


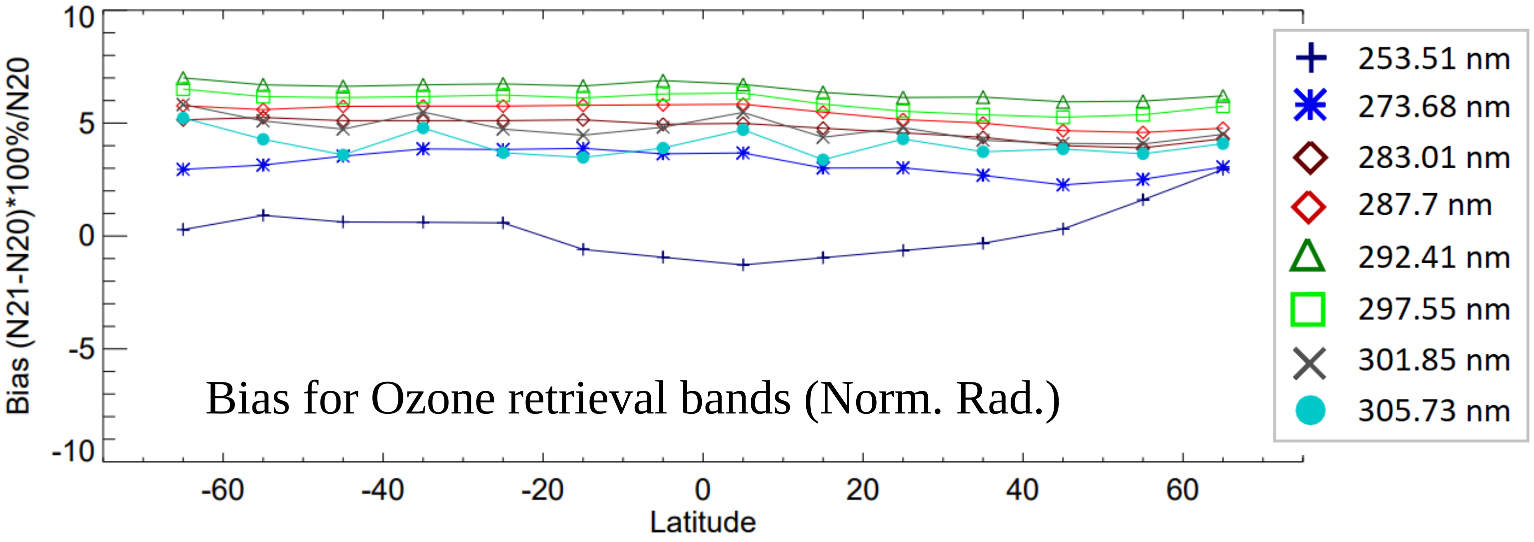
- **Radiance meets requirement**
- **Reflectance can meet the 2% requirement after applying 4% bias correction for solar flux (DR10825)**

N21 NP Radiometric Consistency with NOAA-20

- As observed in earlier slide, all the N21 bands are biased high relative to N20 by up to 6% ± 1%
  - Will be decreased to ±2% applying 4% bias correction for solar flux (DR10825)
- O3 retrieval bands indicate nearly flat bias except for 253.5 nm.
- Consistent bias is corrected through softcal by EDR alg.

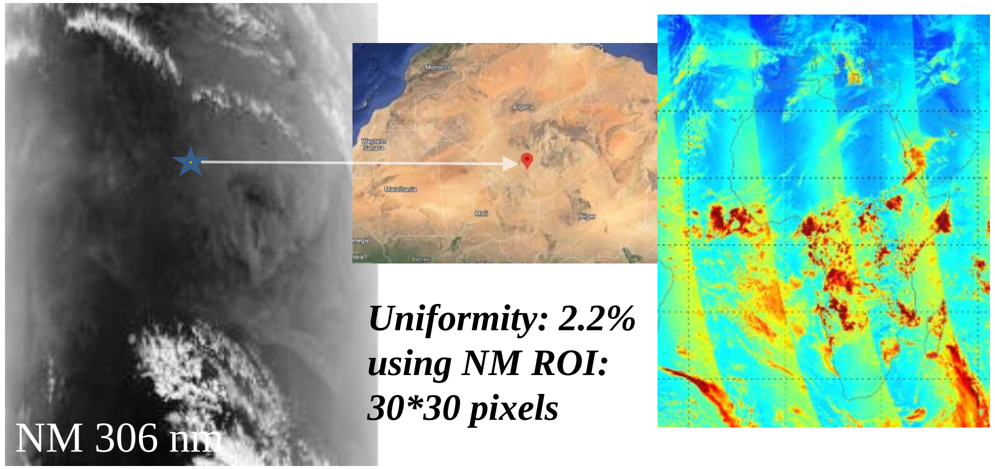
N21 and N20 NP



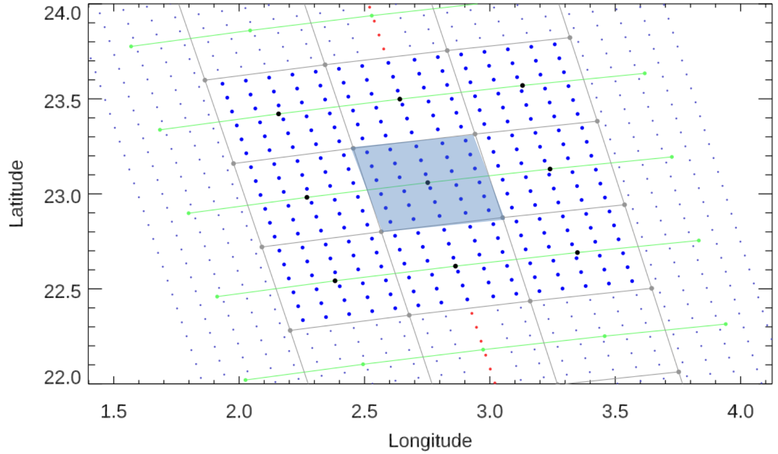


N21 NP and NM Comparison

- NM and NP spectral channels match from 300-310 nm (dichroic region)
- Radiometric consistency in the dichroic region can be helpful for more accurate O3 profile retrieval that uses both NP and some NM bands
- For N21, 1) NP nadir pixel and 2) 3*3 NP pixels from nadir, are compared with collocated NM
  - Barely noticeable bias differences
- A homogenous area in the Saharan Desert region used (best spatial uniformity)
  - reduces the uncertainty due to registration errors
- **Radiometric bias is well within 2%** above 302 nm

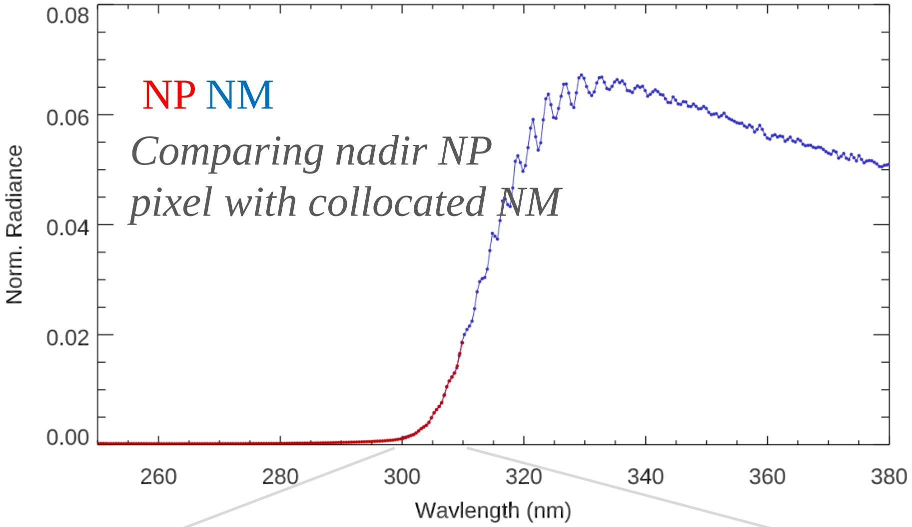


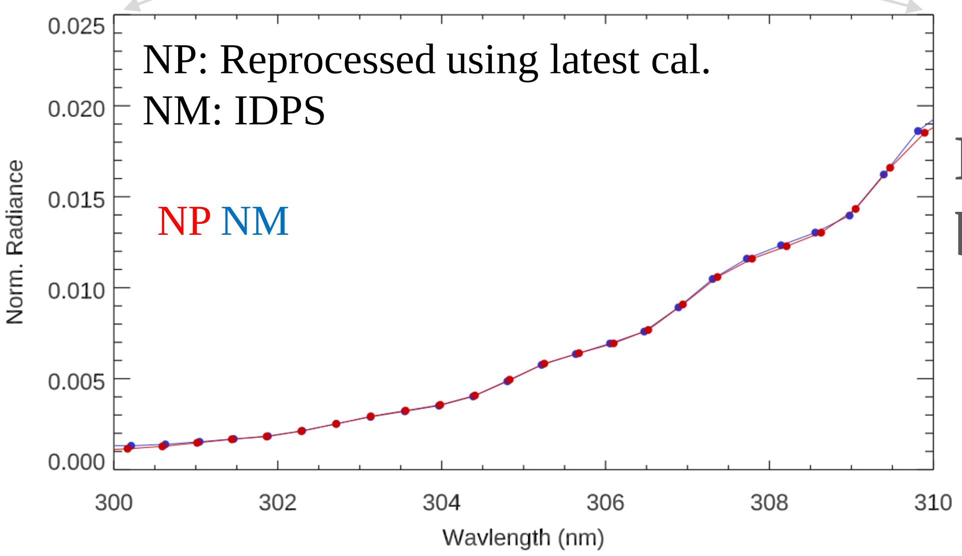
NP and NM collocation

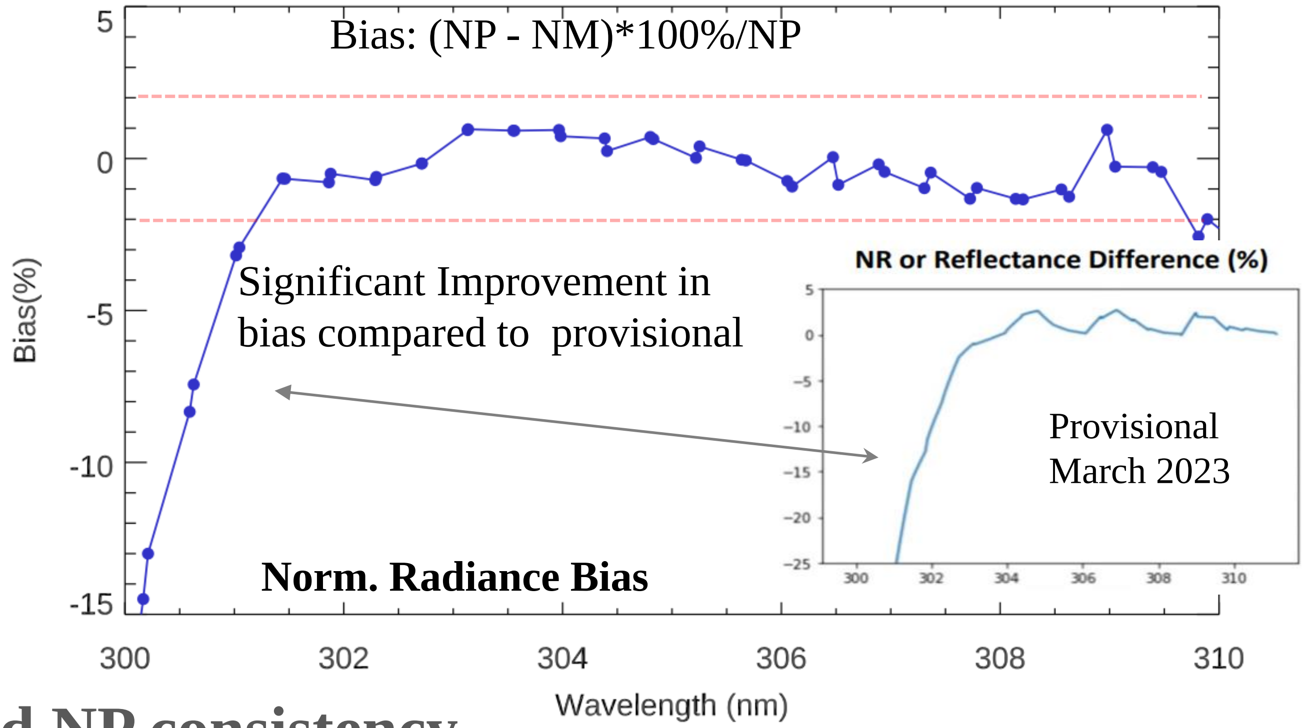


N21 NP and NM Comparison

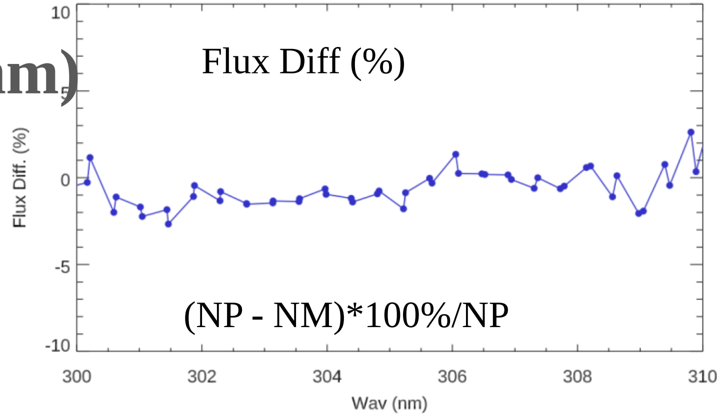
(11/10/2023)



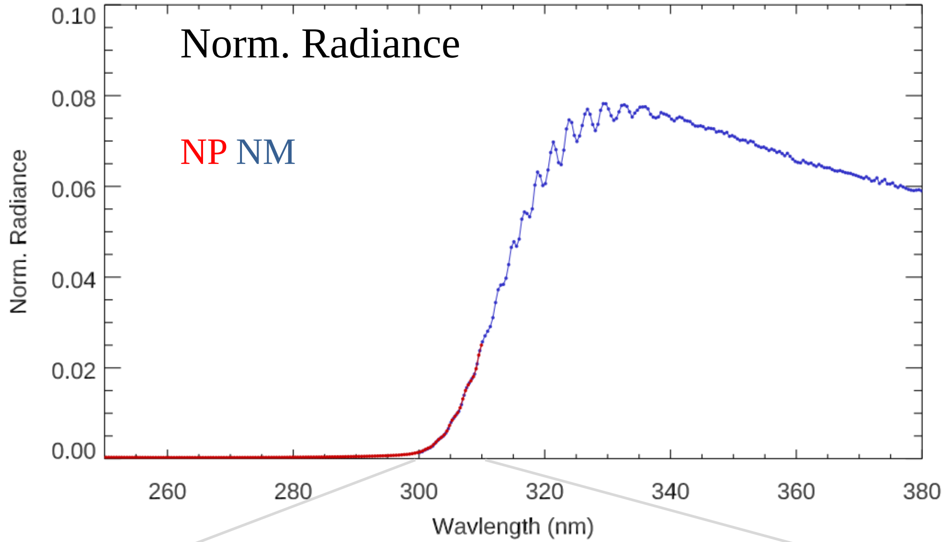


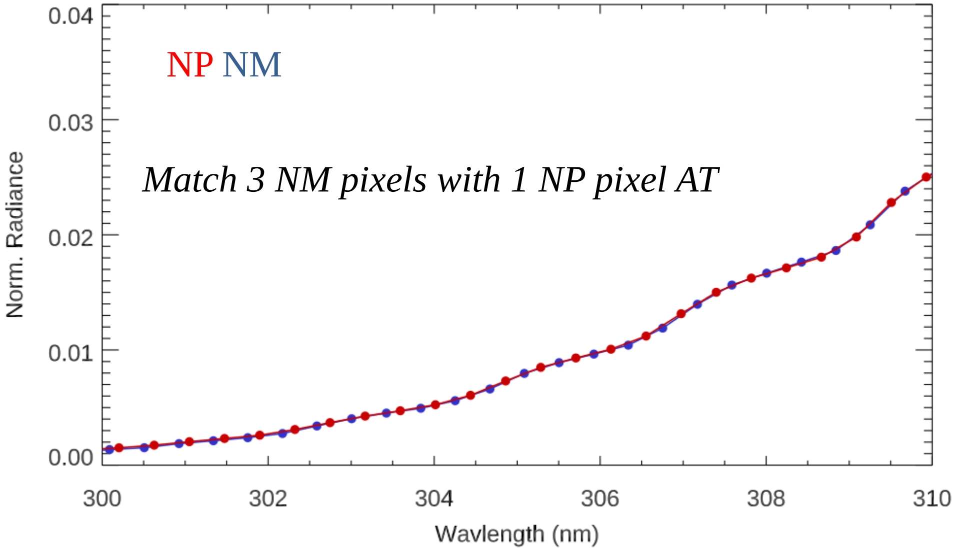


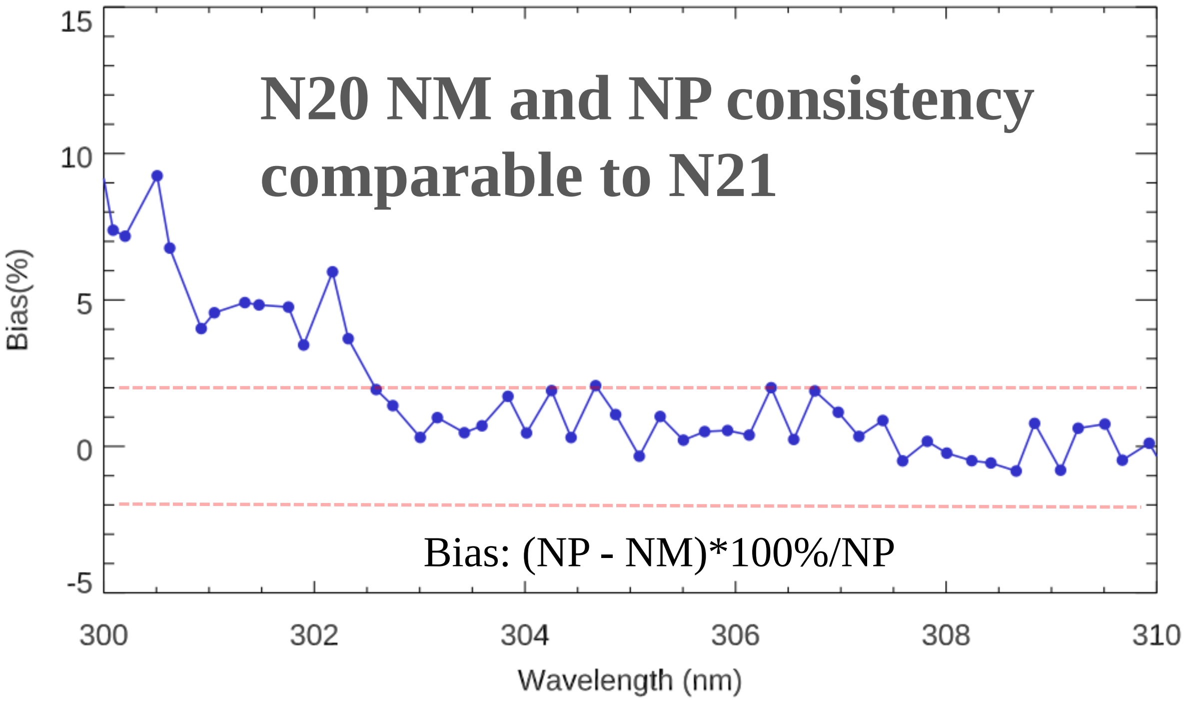
NM and NP consistency better than 2% (>301.5 nm)

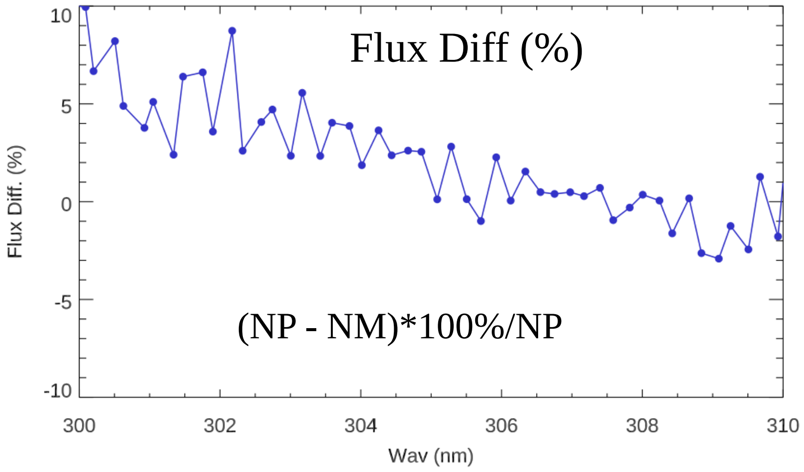


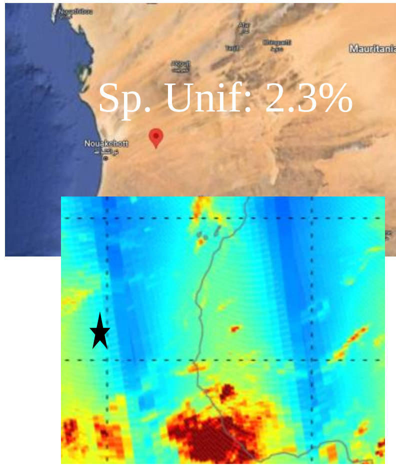
N20 NM and NP Comparison (Saharan Desert)







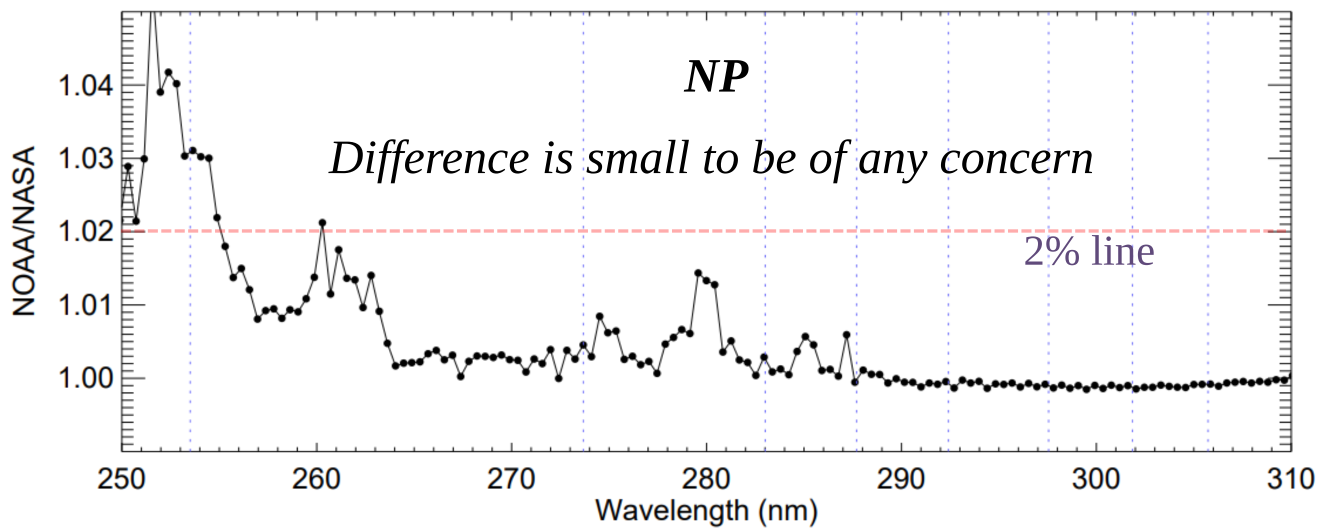


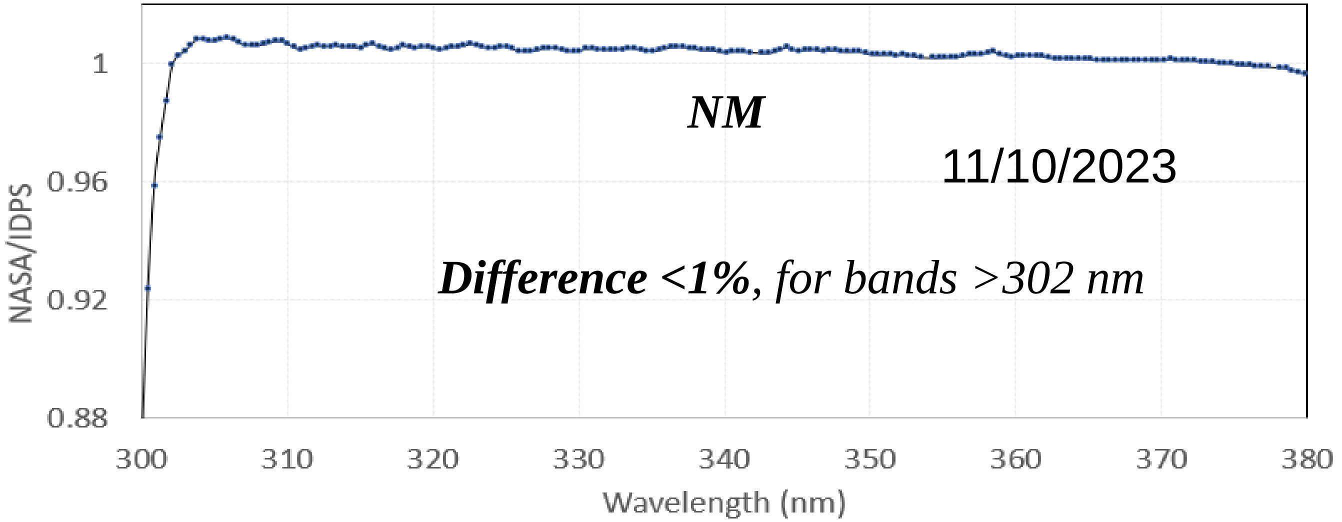


NASA and NOAA Radiance Comparison for NM and NP

➢ NOAA and NASA global radiance comparison suggests good agreement:

- **NP radiance agrees well within 2% for majority of bands** except shorter wavelengths which can be up to 5%
- **NM agrees to within 1% or less** for bands > 301 nm





Summary on Inter-Sensor Comparison Analysis Results

- By using the SNPP SDR as reference, NOAA-21 OMPS NM and NP SDR data demonstrates a very good performance in agreement with SNPP (N20) within the requirement, with an exception in reflectance.
  - **N21 NP and NM radiance meets requirement: <8%**
  - **N21 NP and NM solar irradiance meets requirement: <7%**
  - **Normalized radiance or Reflectance can meet the requirement, after a wavelength independent bias correction is applied to each of NOAA-21 NM and NP (ADR10825).**
    - For ozone retrieval, EDR team performs soft calibration to correct bias, meets the reflectance requirement well

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    - **RTM-DD analysis (RTM simulation as a bridge)**
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    - **OMPS NM and NP data quality long-term monitoring from ICVS**
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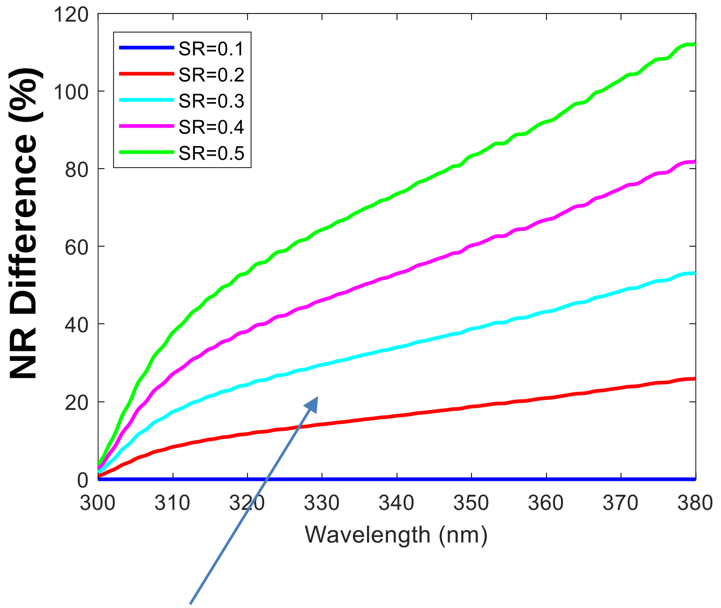
Introduction to Two Radiative Transfer Models (RTM)s

- Two RTMs
  - TomRad (Courtesy of NASA OMPS Group; Eck F., P. K. Bhartia, and J. B. Kerr, 1995)
    - The Model has been widely used in the OMPS SDR and EDR fields
    - Challenge: a very slow computation efficiency (e.g., months for one day of NM data simulation)
  - **CRTM for OMPS** (Courtesy of STAR CRTM Team; Liu et al. 2022)
    - Interface package development (Input Pro-Processing and Output Post-Processing (J. Huang & X. Jin)
    - CRTM-OMPS key Features
      - Under Lambertian surface assumption
      - Deriving surface reflectance from observations at window channels with weak O3 absorption
      - Pseudo-spherical approximation
    - Having much improved computation efficiency
- Common Challenges
  - Lack in accurate surface reflectivity and ozone profile information for accurate simulations
  - RTM-DD is expected to provide more accurate validations results

Normalized radiance (NR) sensitivity to surface reflectivity



Inaccurate surface refl. can cause large impact on simulated radiance above 300nm

Assessment Method Using CRTM: RTM-DD

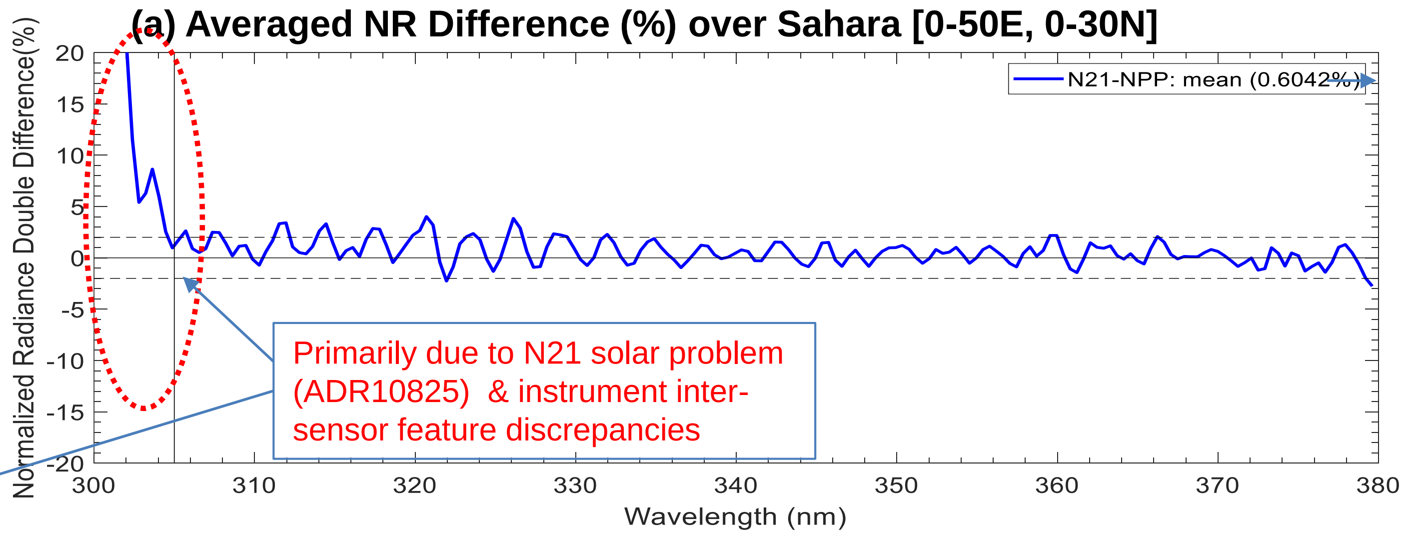
- Double Difference via RTM (DD-RTM):
- DD-RTM = (O – B)_N21 – (O-B)_SNPP

where O: satellite observations; B: RTM simulations

  - O – B = **Instrument calibration errors (e.g., BPS difference, solar cal. error, cal. algorithm error)**
    + RTM modeling errors (e.g., solar reference data set difference)
    + Simulation errors due to inaccurate inputs (surface reflectivity or/and ozone profile)
  - Approximately, DD-RTM represents the instrument calibration errors
    (last two items of errors should be mostly canalled)
- Data Sets: multiple days of the data sets
  - N21 NP SDR: used the reprocessed data sets to reflect the validated maturity level of the data
  - N21 NM SDR: IDPS operational data
  - SNPP and NOAA-20 NM and NP: operational data
  - Under clear skies
  - Inputs to the RTM simulations:
    - CRTM simulations:
      - Temperature and ozone profiles are provided in ECMWF analysis data
      - CRTM-derived surface reflectivity at two or three window channels in OMPS observations
      - NASA SNPP EDR surface reflectivity and profiles

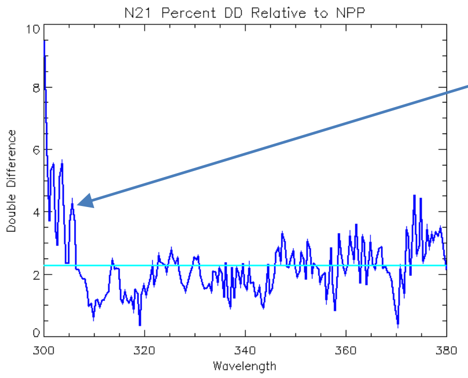
Method # 1: NM Average Normalized Radiance Double Differences between NOAA-21 and SNPP, CRTM-Derived Surface Reflectivity

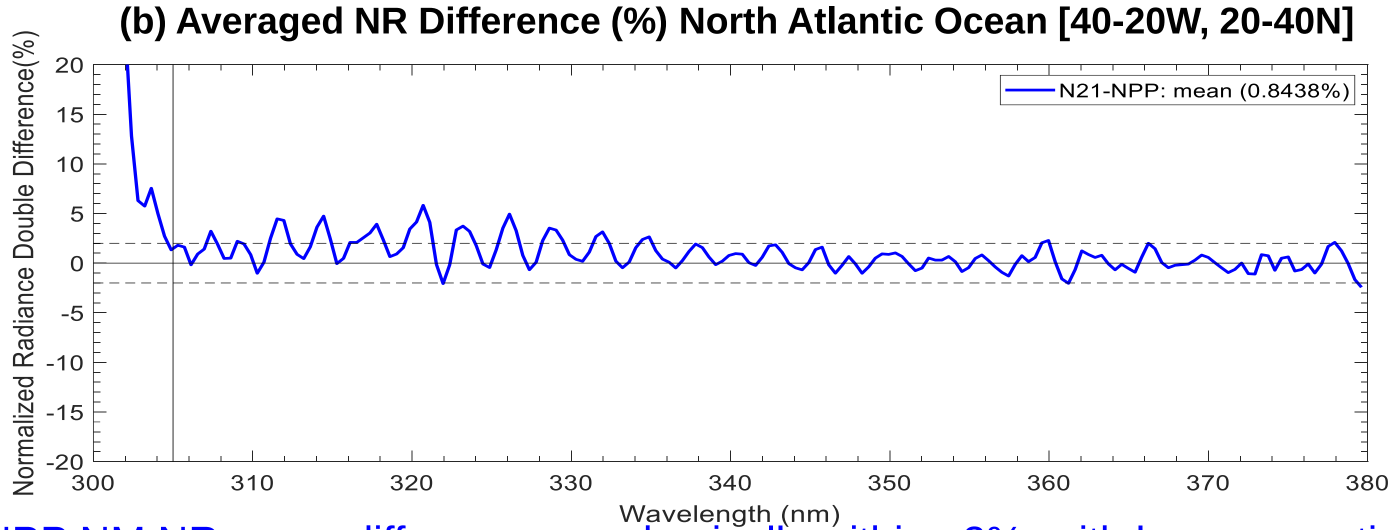
Date: 2024-03-01



The mean values are calculated for [305-380nm]

N21 NM Day1/Syn. Diff. percent to SNPP

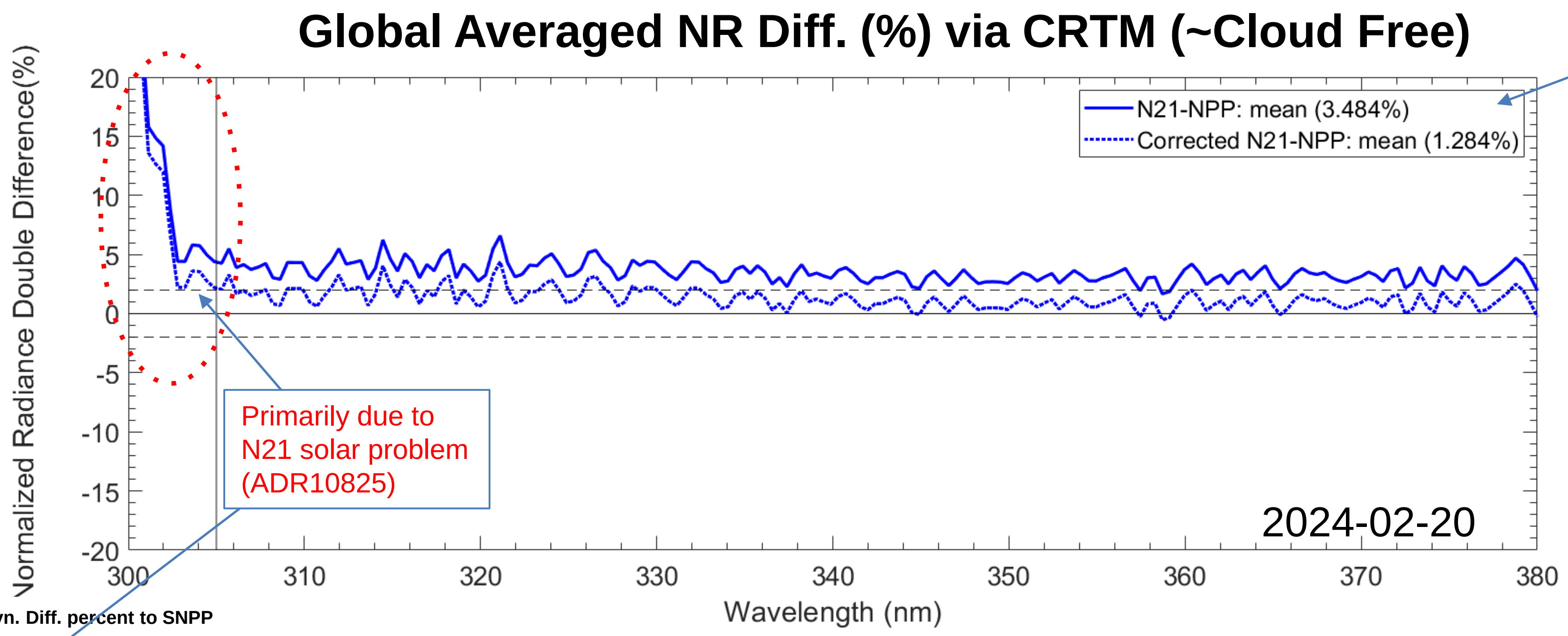




Note:
More O-B analysis results are referred to in backup side, including independent analysis from the NASA PCRTM group

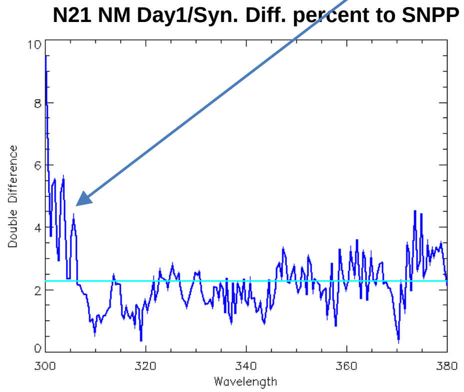
- N21 and SNPP NM NR mean differences are basically within ±2%, with large exceptions below 305nm.
  - The simulations used the CRTM-derived reflectivity that absorbed the biases in the SDR solar flux.

Method # 2: NM Average Normalized Radiance Double Differences between NOAA-21 and SNPP, EDR Reflectivity



The mean values are calculated for [305-380nm]

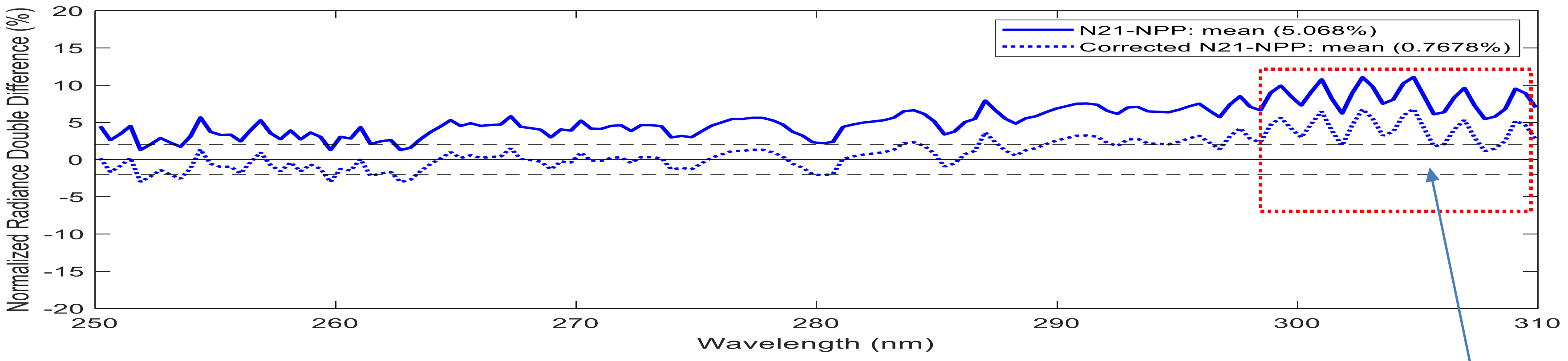
Sold line: no bias correction due to solar cal. Error
Dash line: the mean bias (2%) bias correction is applied



- N21 and SNPP NP NR mean differences are basically within ±2%, with some margins below 305nm, partially due to inaccurate surface reflectivity, solar errors, and BPS differences.

NP Average Normalized Radiance Double Differences between NOAA-21 and SNPP, EDR Reflectivity

(a) 16-Day Average over Sahara [0-50E, 0-30N]

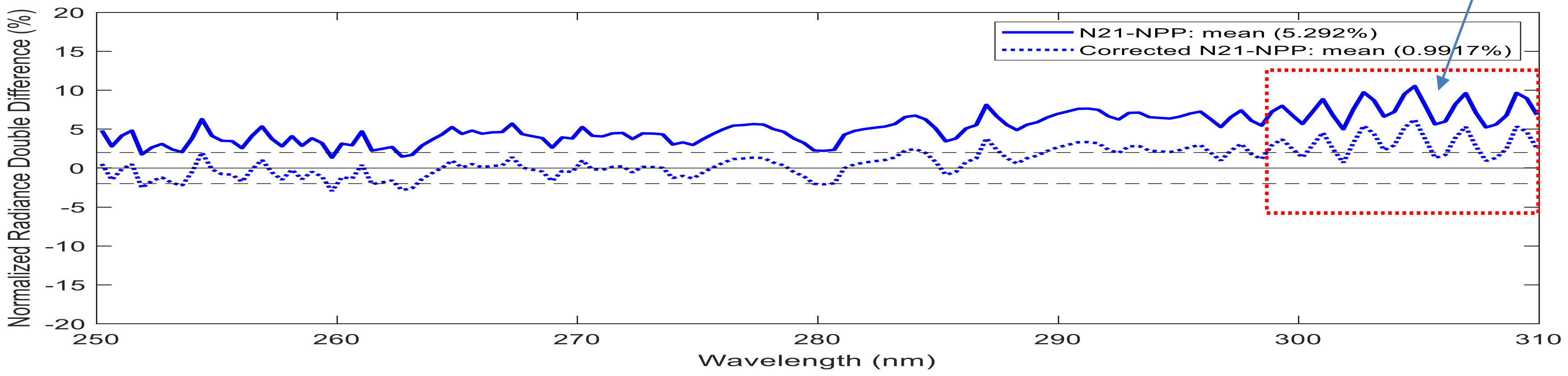


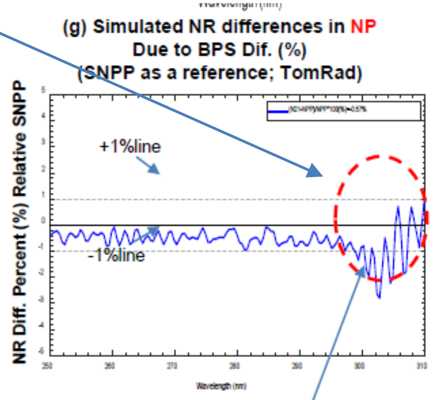
Sold line: no bias correction due to solar cal. Error
Dash line: the mean bias (~4%) bias correction is applied

Dates: 2023/04/01-2023/04/16

BPS impact too

(a) 16-Day Average North Atlantic Ocean [40-20W, 20-40N]





nd SNPP/N20!

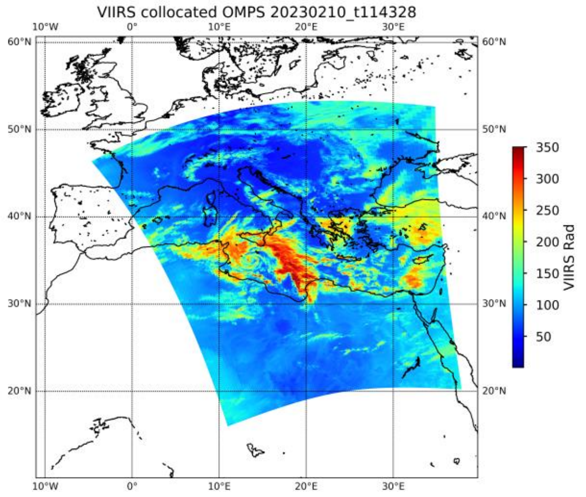
BPS Impact: within ±1% for NP, with a lager difference in the range from 300 to 310nm

N21 and SNPP NP NR mean differences with the mean bias correction (see dash lines) are basically within ±2%, with some margins above 300nm, partially due to inaccurate surface reflectivity.

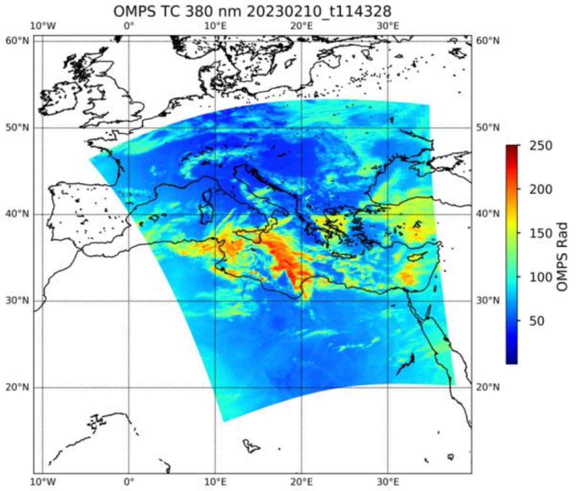
NOAA-21 OMPS NM Geolocation Assessment (1/3): Geolocation Accuracy Relative to VIIRS*

- Geolocation registration is an important calibration work, which contains CCD pixel look angles for the Field Angle Map (FAM) LUT and is used to compute the pointing direction (unit vectors) of each individual CCD pixel in the OMPS SDR operational processing.
- An algorithm was developed to estimate the geolocation accuracy of the OMPS NM SDR data from SNPP to NOAA-21 (Wang et al. 2022).
- The algorithm was applied to the NOAA-21 OMPS NM SDR data.
  - VIIRS M1 band data on 02/10 collocated with the OMPS 380nm data.
  - A high correlation is observed between the OMPS 380nm and VIIRS M1 band radiance data.
  - A small perturbation is applied to the OMPS SDR data to have the best correlation between the two data sources.

(a) Collocated VIIRS M1 Band (750m nadir, 3200 pixel per scan)



(b) OMPS 380nm (12x10km nadir, 177 pixel per scan)



(c) OMPS 380nm vs. VIIRS M1

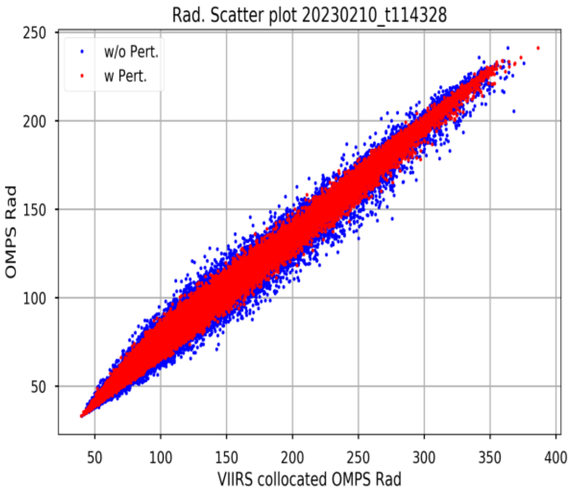
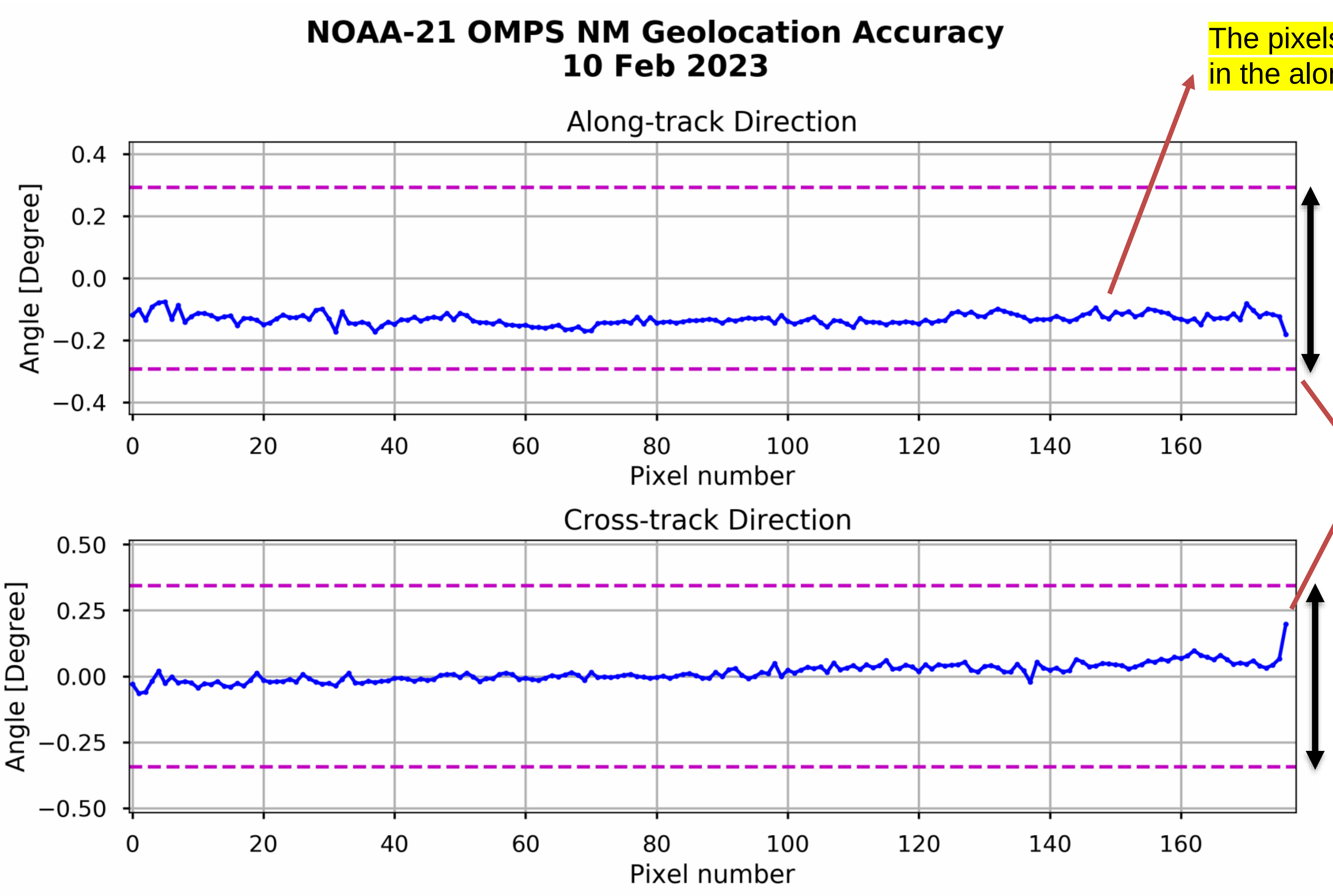


Figure (a) VIIRS band 1 image. (b) OMPS NM 380 nm. (c) Scattering plot of OMPS radiance at 380 nm and VIIRS radiance at 410 nm with (red dots) /without (blue dots) the perturbation.

NOAA-21 OMPS NM Geolocation Assessment (2/3): Geolocation Accuracy Relative to VIIRS*



The pixels were shifted ~0.1 degree (1.5 km at nadir) in the along-track direction

Corresponding to 8.5 km at nadir

The worst performance is at the edge pixel 176 (DR10039 code error)

Corresponding to 10.0 km at nadir

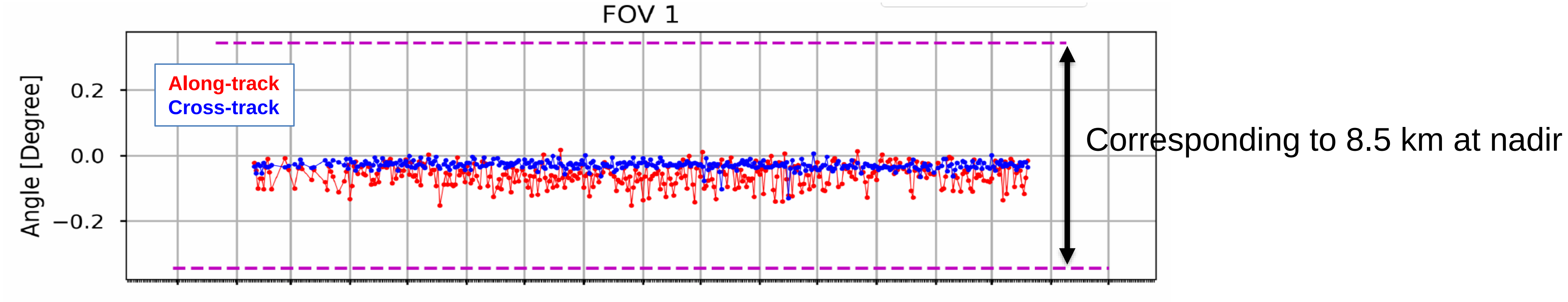
*Further assessment is needed in the future.

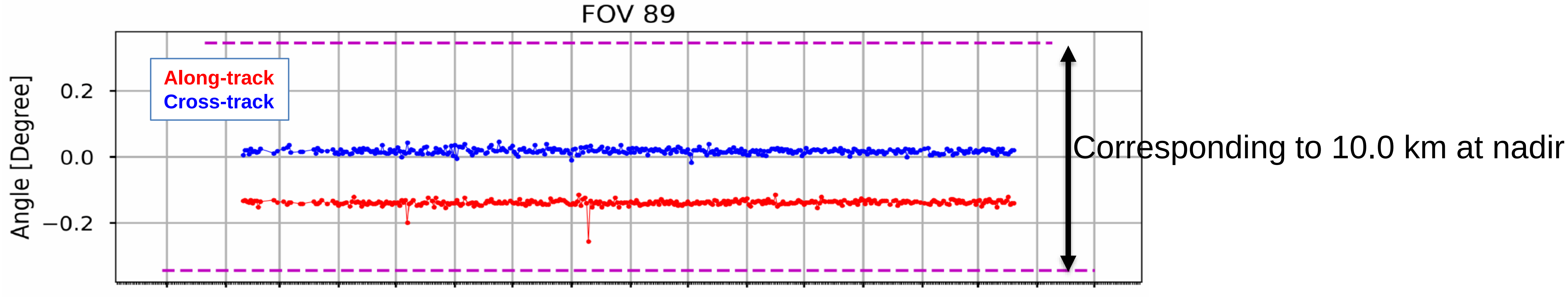
- Instruments are in the orbit test stage
- OMPS NM spectral calibration is not done yet.
- VIIRS geolocation evaluation is still undergoing.

Geolocoation accuracy relative to VIIRS within the subpixel level (~ less than half of pixel size)

(Alg. Reference: Wang et al. 2022)

NOAA-21 OMPS NM Geolocation Assessment (3/3): Geolocation Accuracy Time Series Relative to VIIRS*



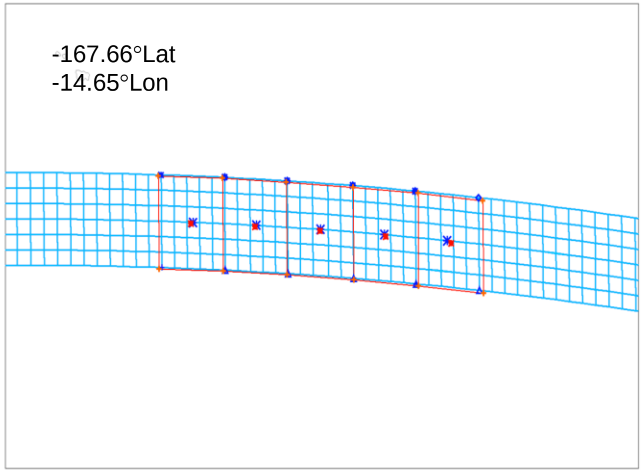


The geolocation relative to VIIRS is well within subpixel level (~1/2 pixel level), meeting requirement.

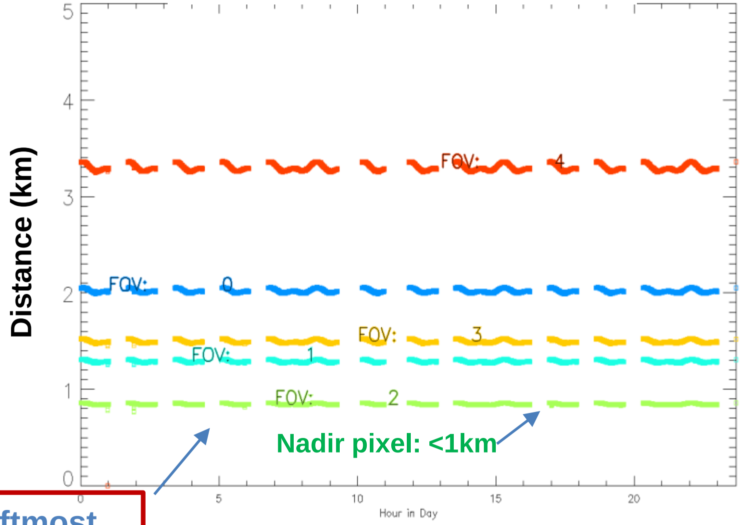
NOAA-21 OMPS NP Geolocation Accuracy Assessment Relative to OMPS NM Nadir

- The geolocation accuracy of OMPS NP pixels is determined by using the difference of nadir pixel between OMPS-NP and OMPS-NM
  - 6 (AT) X 5 (CT) N21 NP ground pixels (marked in blue) coincident to each OMPS-NM (marked in red) ground pixel.
  - The center of the aggregated set OMPS-TC pixels is also marked with a blue asterisk
- The distance between the OMPS-NP center point and the OMP-TC aggregated pixel center point is plotted.
- There are five lines for each across track pixel. The inter-pixel distance between each is within the requirements.
- The NOAA-21 OMPS NP pixels meet the requirement (less than ½ pixel resolution ~ 25km@nadir), which have a better performance than NOAA-20

(a) NOAA-21 NM and NP Ground Pixel Map?

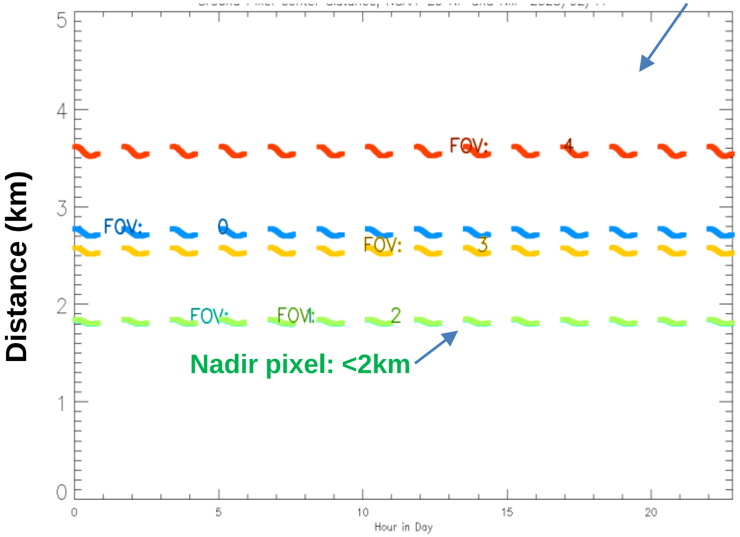


(a) NOAA-21, 2023/02/17

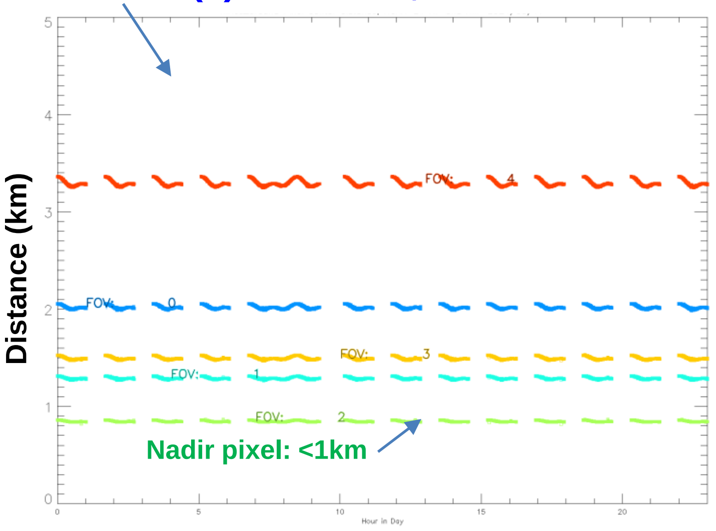


FOV0: leftmost
FOV2: nadir
FOV4: rightmost

(b) NOAA-20, 2023/02/17



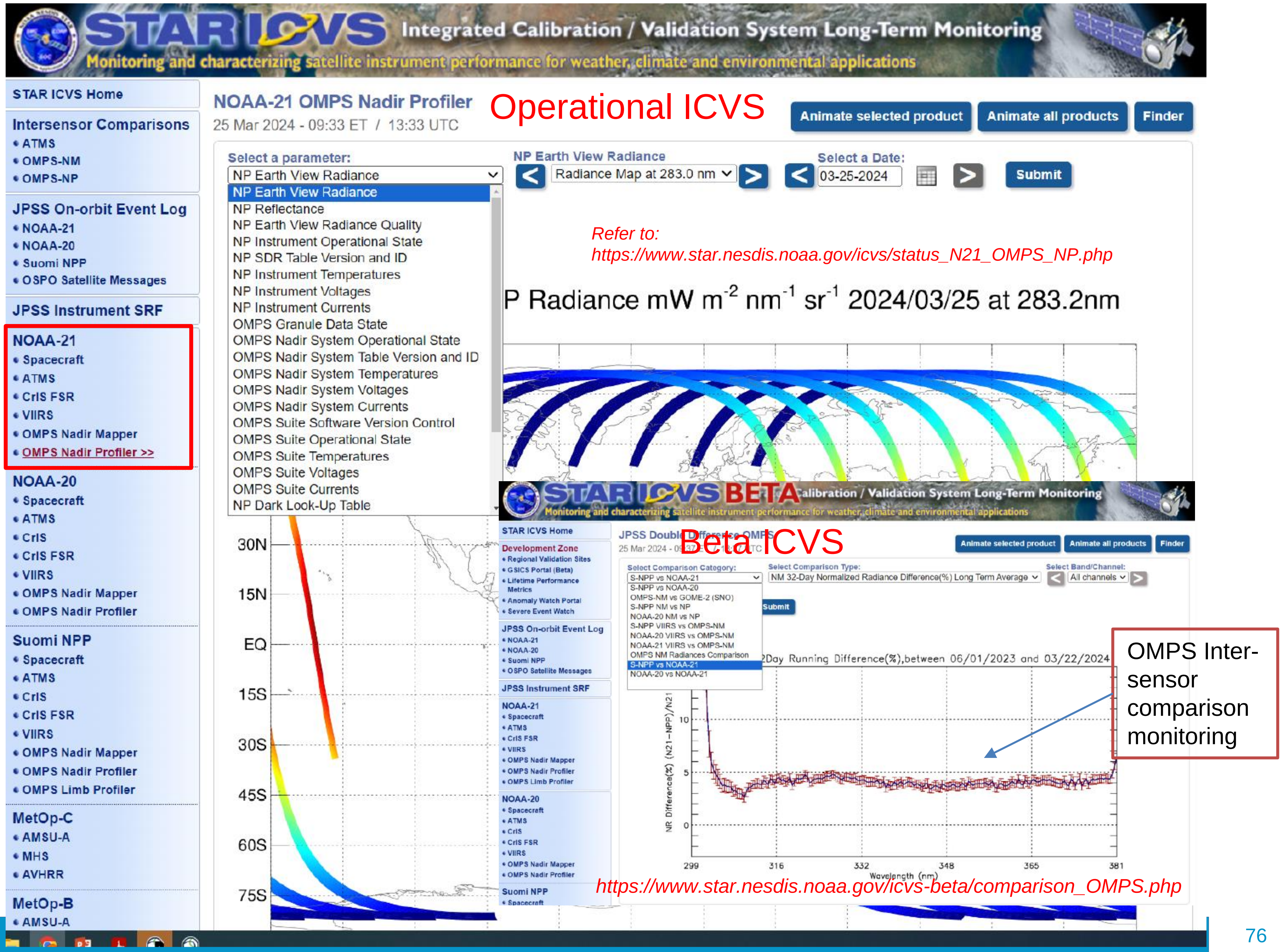
(c) NOAA-21, 2024/03/17.



Meeting the requirement!

LT Maintenance of NOAA-21 OMPS Instrument & Data Performance

- The ICVS monitors long-term (LT) performance of the NOAA-21 OMPS NM/NP instrument, calibration/telemetry RDR and SDR data quality in a near-real time mode (https://www.star.nesdis.noaa.gov/icvs/status_N21_OMPS_NP.php;).
- The monitoring parameters include the instrument performance (temperature, CCD dark, smear, hot pixel, etc.), EV-radiance, reflectance, data quality flag, and other calibration parameters.
- Examples are given on the right panel for the NOAA-21 OMPS NP global image (operational) and inter-sensor comparison monitoring (beta ICVS)



Outline*

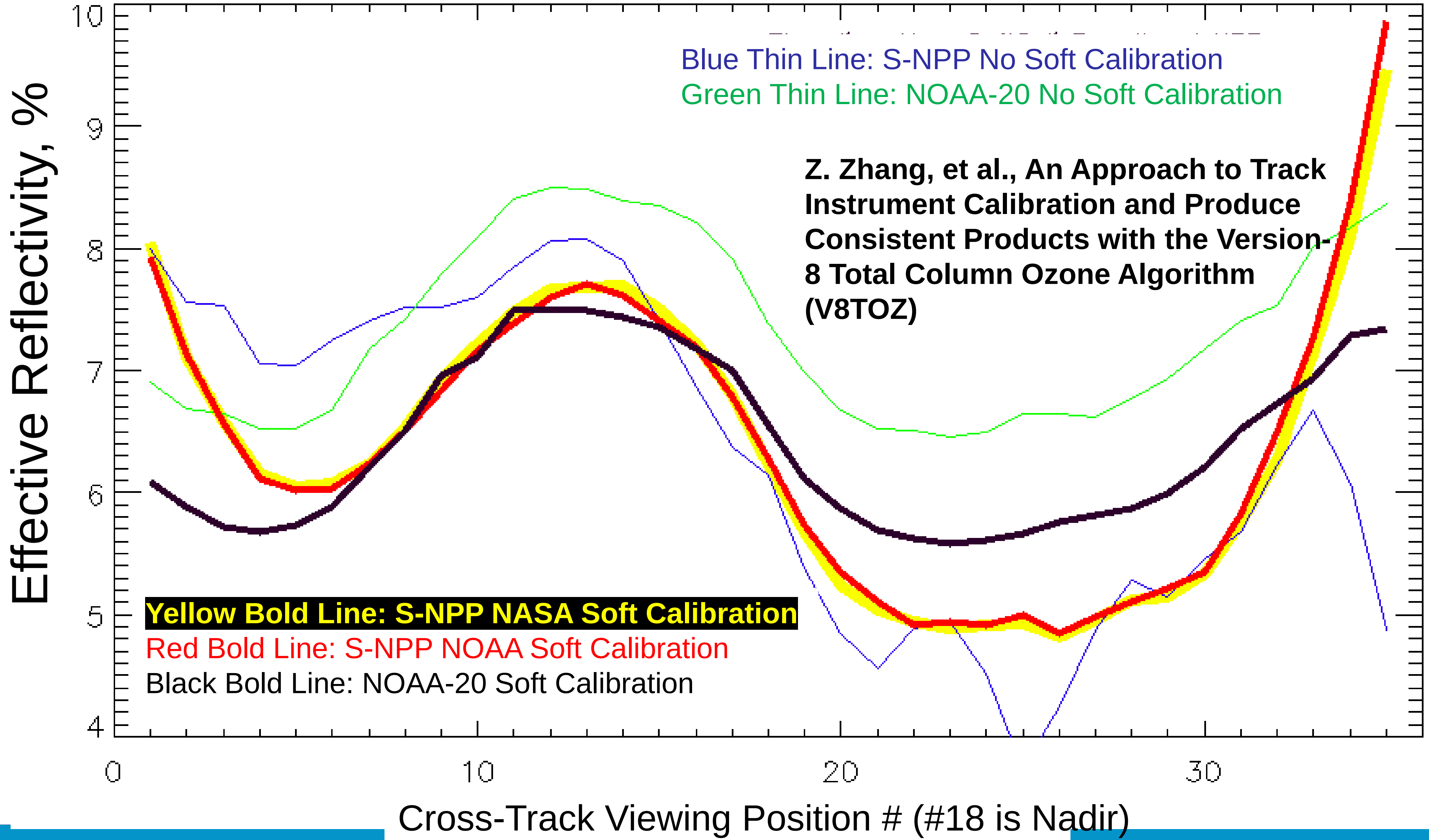
- Algorithm Cal/Val Team Members
- Introduction to the Instrument, Requirements, and Calibration Key Components
- Pre-launch/Post-launch Performance Matrix/Waivers (Starry)
- Evaluation of NOAA-21 OMPS NM and NP Instrument and Algorithm Performance to Specification Requirements
  - OMPS NM and NP ADR Review after Provisional Review (Trevor)
  - OMPS NM and NP instrument performance assessment (Dark, Non-linearity, Gain, and SNR)
  - OMPS NM and NP Wavelength Registration, Day-1 and Stray Light Performance Assessment
  - OMPS NM and NP Post-launch data quality assessment
- **User Feedback Summary (Larry)**
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

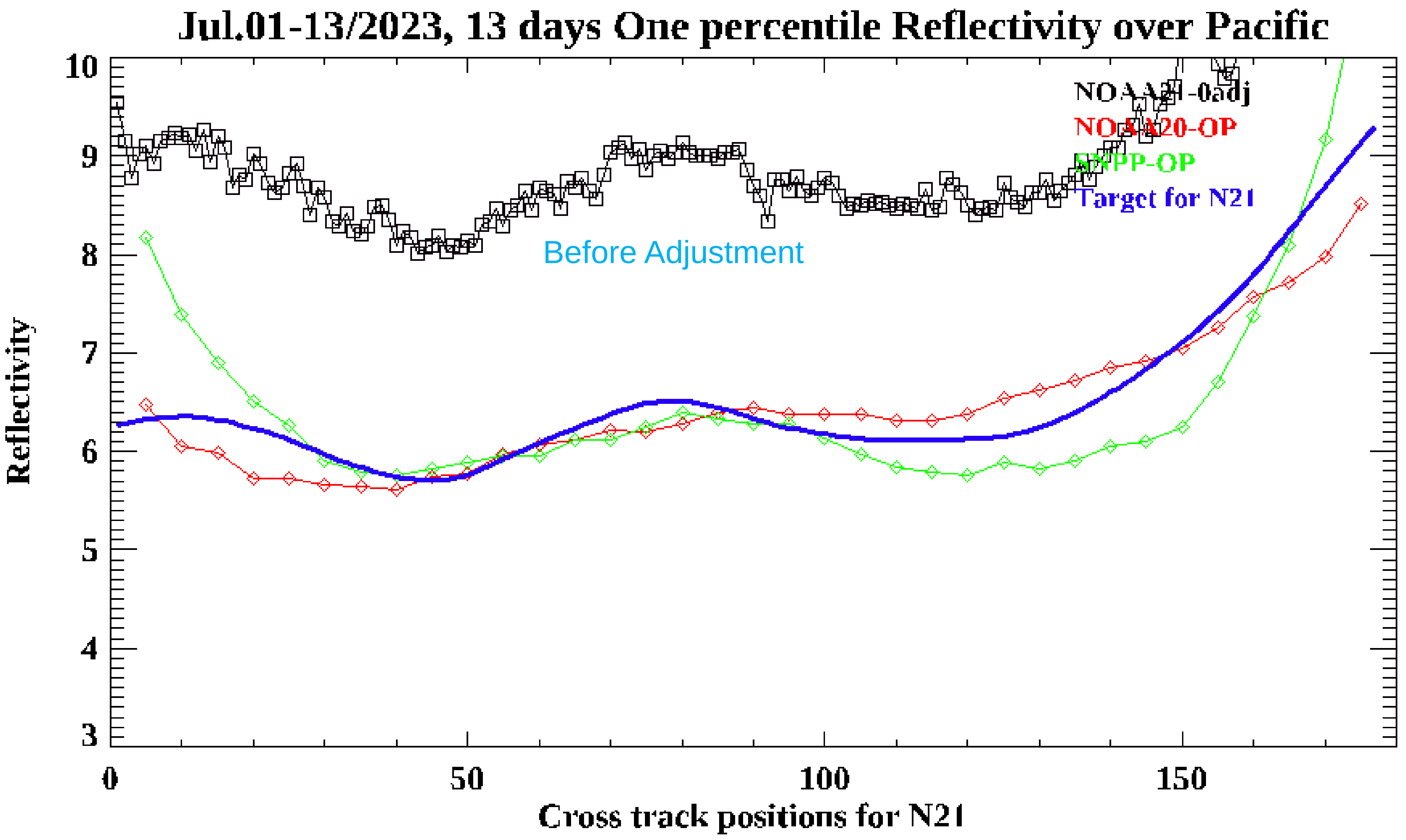
* All sections without presenter assignment will be presented by Banghua

NOAA-21 OMPS V8TPRO & V8TOZ EDR INPUT FOR OMPS NM & NP SDR REVIEW

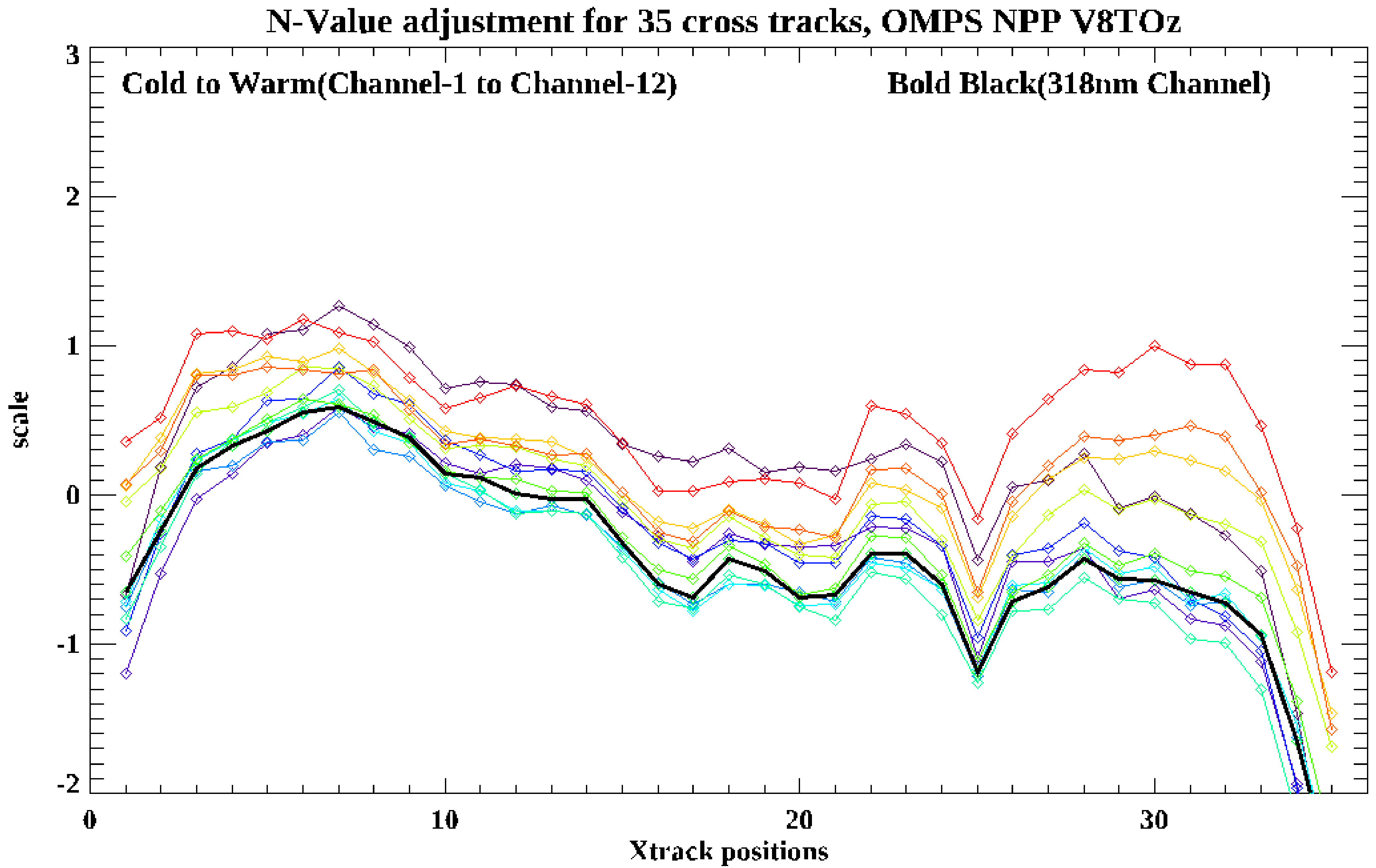
Larry Flynn (NOAA) with support from Zhihua Zhang (IMSG)

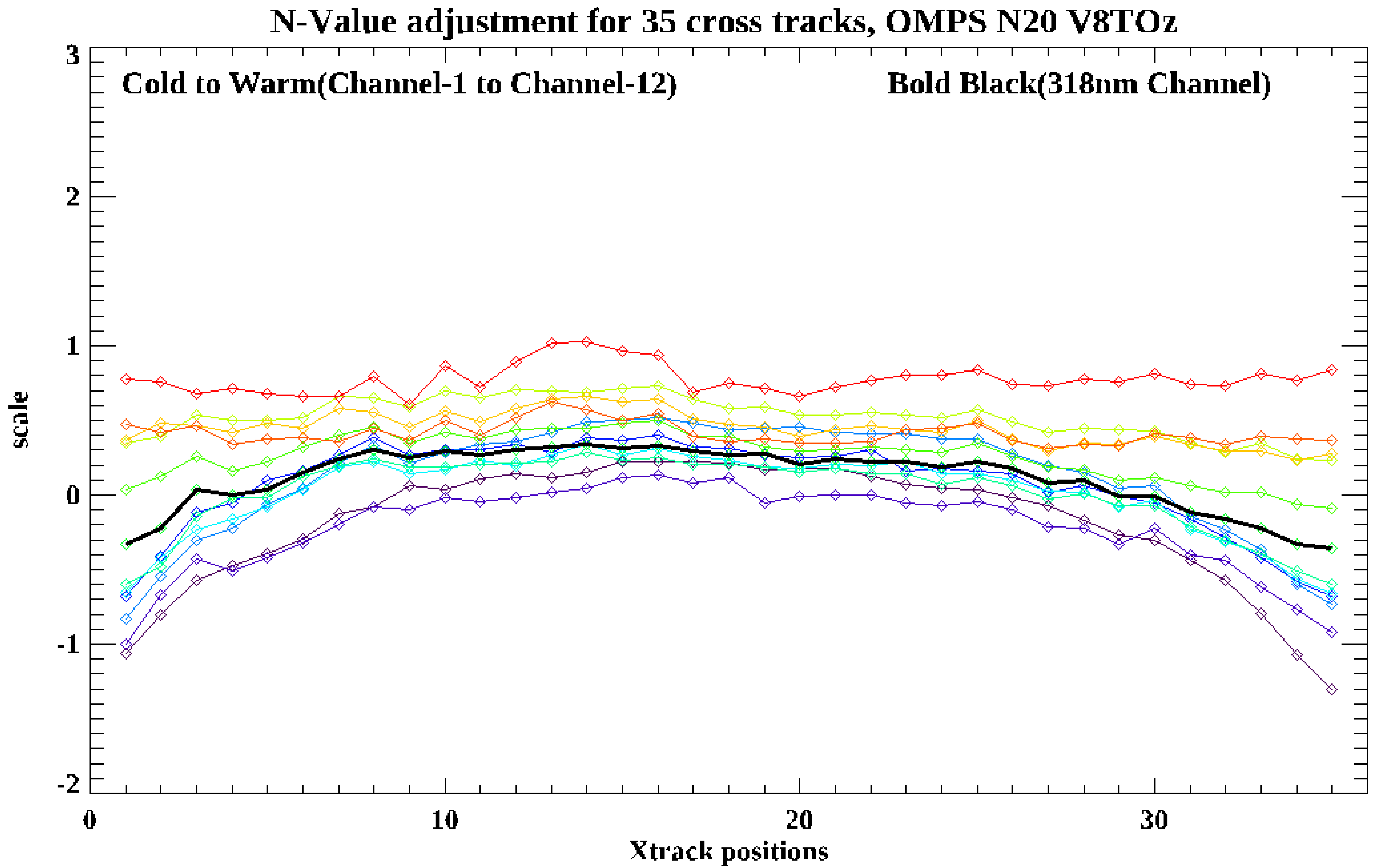
Cross-track Dependence of the One-Percentile Effective Reflectivity from the 331 nm Channel for September 2020 over a Latitude / Longitude Box in the Equatorial Pacific



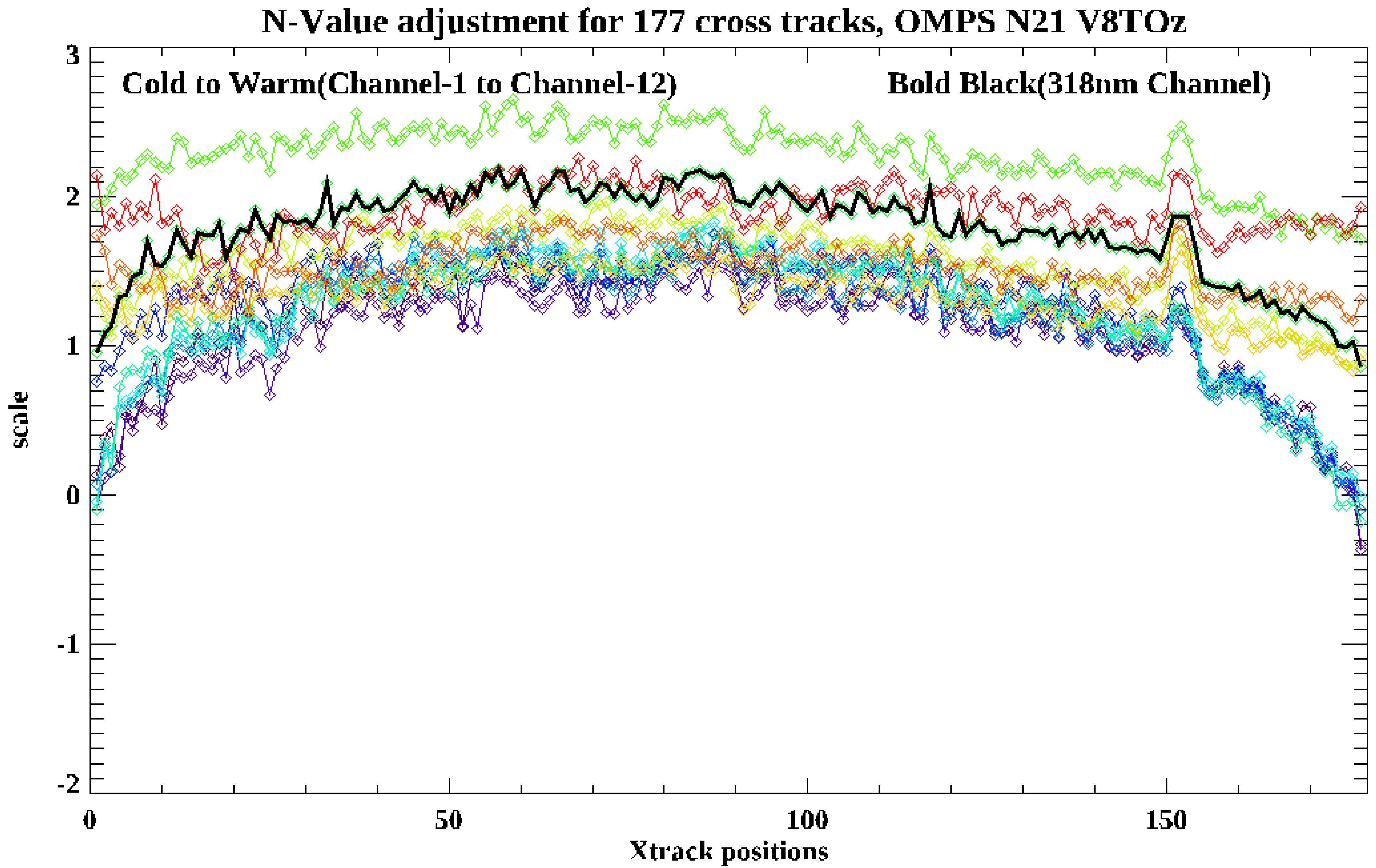


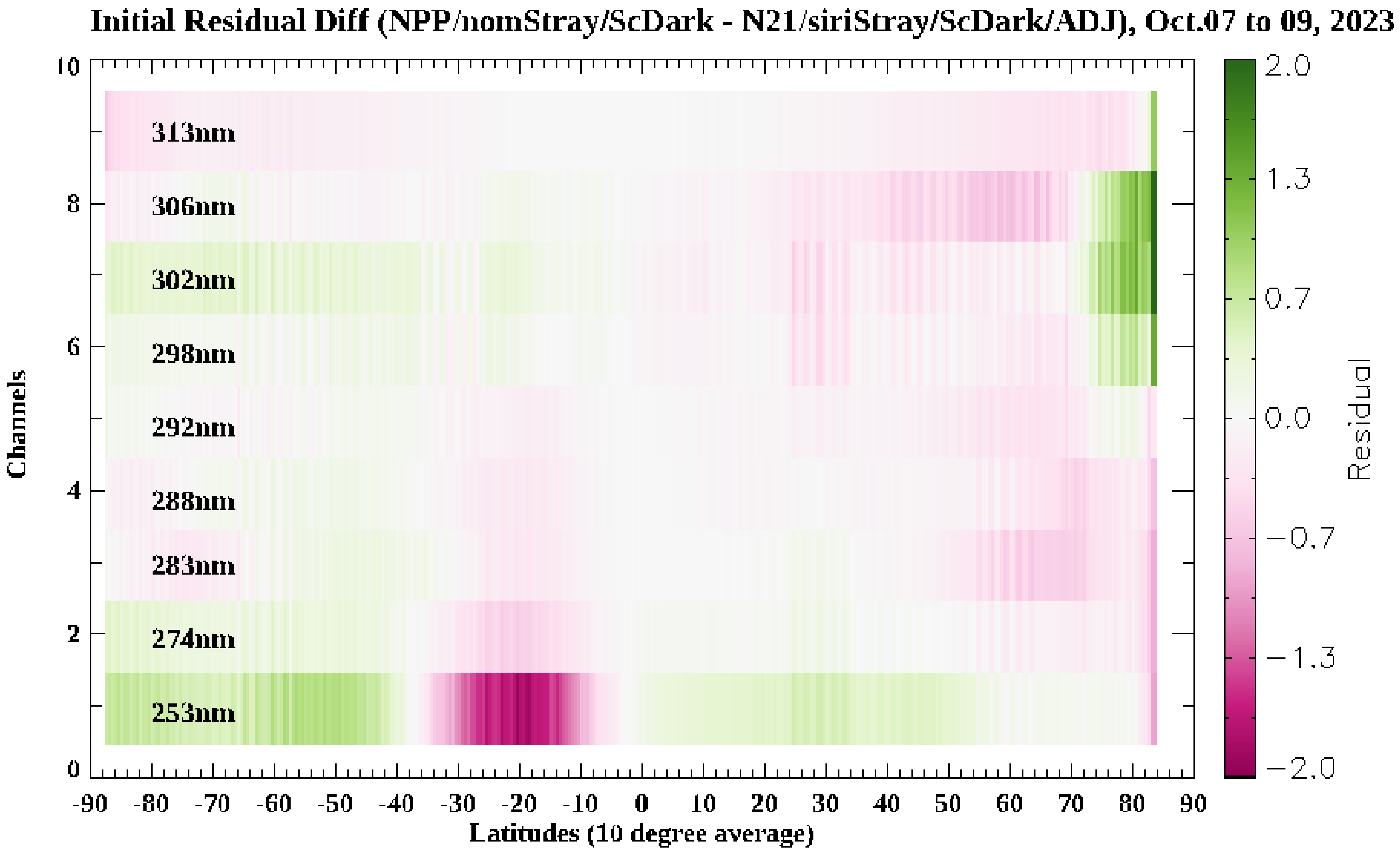
Jul.01-13/2023, 13 days One percentile Reflectivity over Pacific
NOAA21-0adj
NOAA20-OP
SNPP-OP
Target for N21
Before Adjustment
Reflectivity
Cross track positions for N21
10
9
8
7
6
5
4
3
0
50
100
150


N-Value adjustment for 35 cross tracks, OMPS NPP V8TOz
Cold to Warm(Channel-1 to Channel-12)
Bold Black(318nm Channel)
scale
Xtrack positions
3
2
1
0
-1
-2
0
10
20
30



N-Value adjustment for 35 cross tracks, OMPS N20 V8TOz
Cold to Warm(Channel-1 to Channel-12)
Bold Black(318nm Channel)
scale
Xtrack positions
3
2
1
0
-1
-2
0
10
20
30


N-Value adjustment for 177 cross tracks, OMPS N21 V8TOz
Cold to Warm(Channel-1 to Channel-12)
Bold Black(318nm Channel)
3
2
1
0
-1
-2
scale
0
50
100
150
Xtrack positions


Initial Residual Diff (NPP/nomStray/ScDark - N21/siriStray/ScDark/ADJ), Oct.07 to 09, 2023
Channels
Latitudes (10 degree average)
Residual
313nm
306nm
302nm
298nm
292nm
288nm
283nm
274nm
253nm
0
2
4
6
8
10
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0

Summary & Messages

- The EDR team considers the current OMPS NM and NP SDR quality and validation as sufficient to allow the V8TOz (Total Column Ozone) and V8PRo (Vertical Ozone Profile) EDRs to reach validated maturity.
- There are some concerns regarding the calibration, bandpasses and wavelength scales in the 300-310 nm region.
- The SDR team has also uncovered a possible deficiency in the NOAA-20 OMPS NP stray light correction.
- The EDR Team would also like to see development of solar activity and instrument degradation terms in the biweekly OMPS NP solar updates for all three sensors.

User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Larry Flynn	NOAA/STAR/SMCD	OMPS Ozone retrieval	• The EDR team considers the current OMPS NM and NP SDR quality and validation as sufficient to allow the V8TOz (Total Column Ozone) and V8PRo (Vertical Ozone Profile) EDRs to reach validated maturity. • There are some concerns regarding the calibration, bandpasses and wavelength scales in the 300-310 nm region. • The SDR team has also uncovered a possible deficiency in the NOAA-20 OMPS NP stray light correction. • The EDR Team would also like to see development of solar activity and instrument degradation terms in the biweekly OMPS NP solar updates for all three sensors.

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- **Path Forward**

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Risks, Actions, and Mitigations

- Provide updates for the status of the risks/actions identified during the previous maturity review(s); add new ones as needed

Identified Risk/Issue	Description	Impact	Action/Mitigation and Schedule
Issue # 1	NOAA-21 OMPS NM and NP solar pre-launch calibration errors	NOAA-21 OMPS SDR normalized radiance or reflectance quality	Will deliver the updated NOAA-21 OMPS NM and NP solar flux tables by applying the mean bias corrections (~4% for NP and ~2% for NM); April 2024

Documentations (Check List, 1 slide)

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	The OMPS (SDR&EDR) ATBD exits but its update is in progress (Target: by April 2024)
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	N/A
System Maintenance Manual (for ESPC products)	N/A
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	In plan
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

Check List - Validated Maturity

Validated Maturity End State	
Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).	Yes, it is. The performance of the data at different seasons and locations were assessed, with the reprocessed one-year N21 NP SDR data.
Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.	Yes, it is. 9 new DRs documented the anomalies in both calibration algorithms and products. All DRs have been closed except for one (DR10825) per the user's request. In addition, the OMPS SDR ATBD update is in progress
Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.	Yes, it is. The root cause and solution per DR have been well analyzed to have full qualitative and quantitative determination of product fitness.
Product is ready for operational use based on documented validation findings and user feedback.	Yes.
Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument	Yes, with an action that will be taken in April 2024. The action will mitigate the mean bias in NOAA-21 OMPS NM and NP solar flux.

Conclusion (1/2)

- The accuracy and performance of the calibration algorithms about NOAA-21 OMPS NM and NP SDR have been comprehensively assessed to meet the requirement specifications, except for solar calibration problem.
  - The assessed calibration algorithms include the NOAA-21 NM and NP wavelength scale registration, Day-1, wavelength shift alg. for NM and NP, 3 SL algs.
  - For the solar flux calibration problem, the error features and solutions have been investigated (ADR10825).
    - By applying the averaged bias correction (wavelength independent bias correction), the NOAA-21 OMPS NM and NP albedo or reflectance can meet the requirement (Target: April 2024).
- The long-term performance of the NOAA-21 OMPS NM and NP instrument has been assessed, e.g., dark rate, nonlinearity, gain, SNR, meeting the requirements.
  - The ICVS provides a LT monitoring of the instrument and data performance in coordination with the OMPS SDR team

Conclusion (2/2)

- The quality of NOAA-21 OMPS NM and NP SDR data have been comprehensively assessed over a large and wide range of representative conditions (i.e., global, seasonal), by using multiple methods, e.g. inter-sensor comparison, DCC target, comparison with NASA data set, CRTM-DD.
  - NM and NP SNR meet the requirements
  - NM and NP Geolocation accuracy meets the requirement
  - NM and NP radiance meets the requirement, with margins below 302nm for NM and below 253nm for NP due to the BPS differences as expected.
  - NM and NP solar flux meets the requirement, with margins below 305nm for NM and some wavelengths for NP due to the solar pre-launch cal. error and BPS differences
  - In the range from 302 to 310 nm, the NM and NP data consistencies are mostly within ±2%.
  - OMPS NM SDR albedo (reflectance or normalized radiance) data agree with both SNPP and NOAA-20 typically with margins.
    - With the averaged bias correction (wavelength independent bias correction), the albedo or reflectance can on average meet the requirement with ±2%.
    - Action will be taken in April 2024.

NOAA-21 OMPS SDR are in a family with SNPP and NOAA-21

NOAA-21 NM SDR Requirement Check

Budget Term	Requirement/Allocation	Meet Spec.
SNR radiance @17 x17km^2	>300* (195 for NOAA-21 NM 10 x12km^2)	Yes.
Irradiance uncertainty	*< 7%*	Yes.
Wavelength registration accuracy	*<0.01 nm*	Yes.
Intra-orbital wavelength variation	*<0.01 nm*	Yes.
Radiance uncertainty	*< 8%*	Yes.
OOB Stray Light	≤10%	Yes.
Maximum Albedo Calibration	<2%	Yes, by applying a mean bias correction in April
Geolocation Error	≤ 8.5 km @nadir (AT)	Yes.

*305 - 380 nm according to L1RD doc

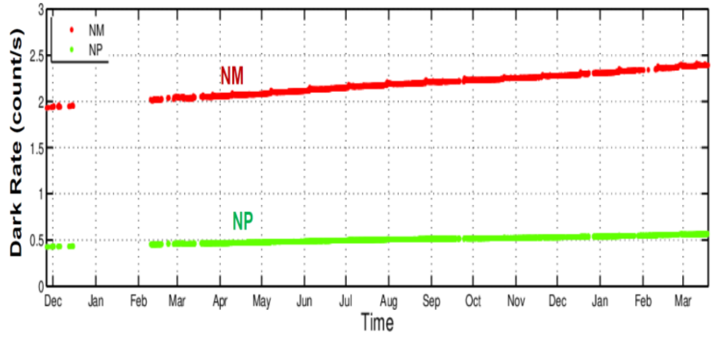
NOAA-21 NP SDR Requirement Check

Budget Term	Requirement/Allocation	Meet Spec.
SNR radiance@50x50km^2	varies with wavelength λ	Yes.
*Irradiance uncertainty**	*< 7%*	Yes.
*Wavelength calibration**	*<0.01 nm*	Yes.
*Intra-orbital wavelength variation**	*<0.01 nm*	Yes.
*Radiance uncertainty**	*< 8%*	Yes.
Maximum Albedo Calibration	<2%	Yes, by applying a mean bias correction in April
OOB Stray Light	< 5%	Yes.
Geolocation Error	≤ 25 km @nadir (AT)	Yes.

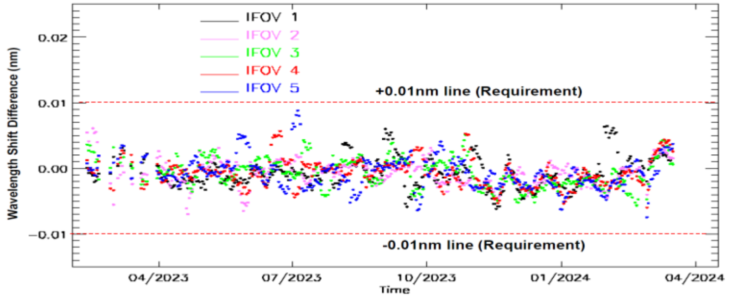
NOAA-21 OMPS NM and NP Validated Maturity Highlights

Dark, Wavelength shift and SNR performance

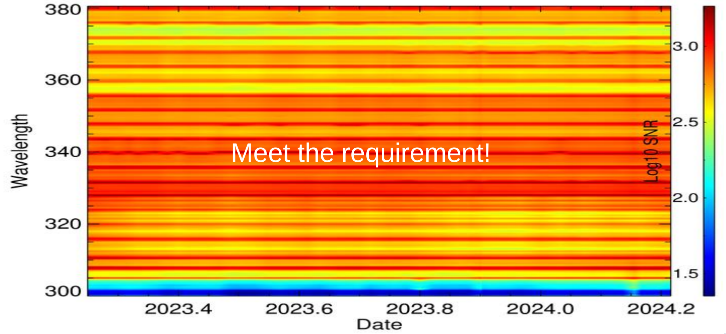
(a) NM and NP dark rate time series



(b) Diff Percent between Solar Flux- and Radiance Relative Wavelength Shifts

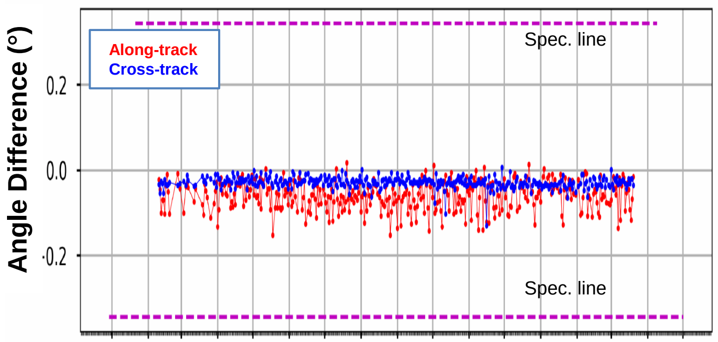


(c) NM Log10 SNR Time Series

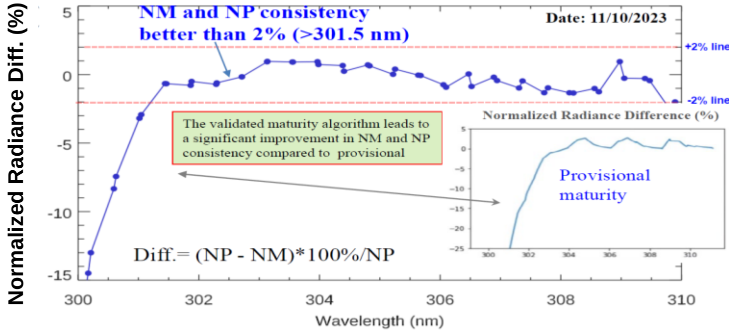


Geolocation and Radiance (& NR) Performance

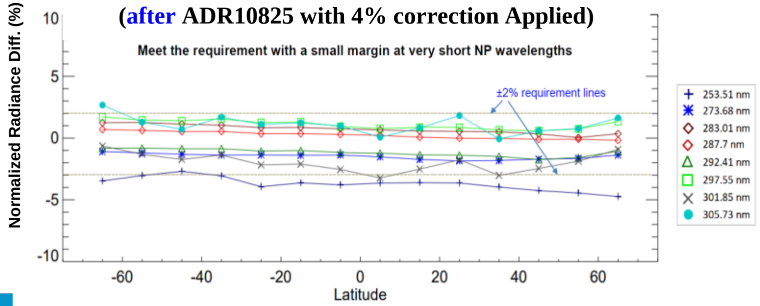
(a) NM Geolocation Error Time Series (against VIIRS)



(b) NOAA-21 NP and NM NR Consistency (Validated Maturity)

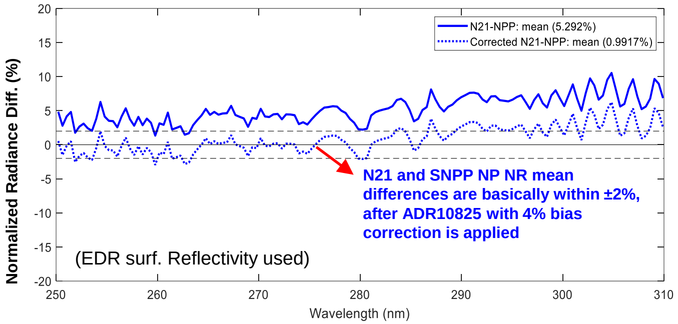


(c) 32-Day Averaged NP NR Diff. (%) between NOAA-21 and SNPP (after ADR10825 with 4% correction Applied)

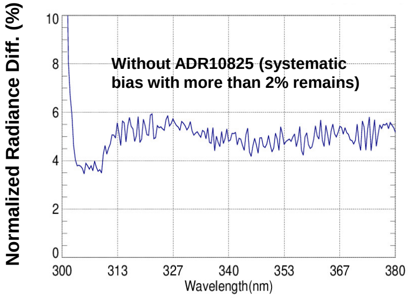


NR Performance Cont. & User Feedback

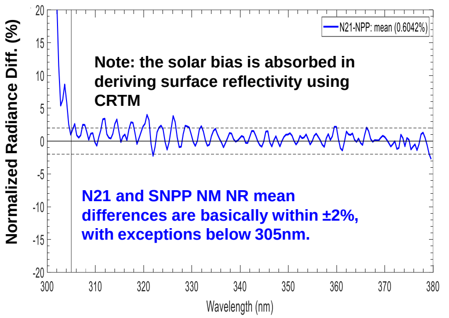
(a) 16-Day Averaged OMPS-NP NR Diff. (%) between NOAA-21 and SNPP via CRTM



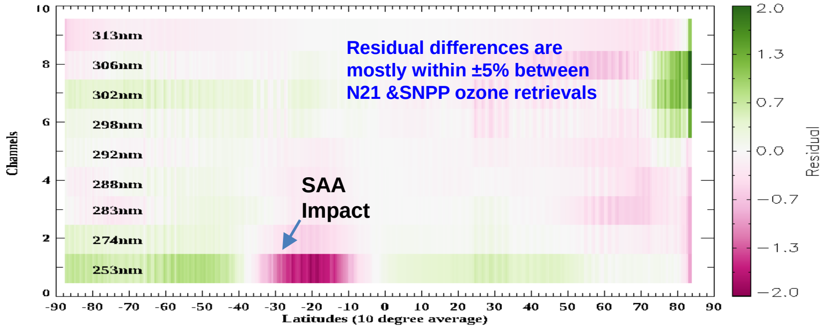
(b) Averaged NM NR Diff. (%) between NOAA-21 and SNPP via DCC



c) 16-Day Average OMPS-NM NR Diff. (%) between NOAA-21 and SNPP via CRTM



(d) Residual Difference (%) in OMPS Ozone Retrieval(%) between NOAA-21 and SNPP



Path Forward: Planned Improvements

- Deliver the updated NOAA-21 OMPS NM and NP solar flux tables by applying the mean bias correction (~4% for NP and ~2% for NM) to mitigate the NOAA-21 OMPS solar pre-launch calibration error problem
- Extend the inter-sensor comparison analysis to other sensor observations such as Tempo, TropOMI, GEMS
- Improve the simulation accuracy and efficiency of the CRTM for OMPS NP and NM in coordination with the STAR CRTM team
- Assess impact of a different solar reference spectrum (e.g., GSICS-recommended TSIS) on NOAA-21 SDR data quality
- Continue to update the OMPS SDR ATBD

Path Forward: Future Cal/Val activities / milestones

- **Apr 2024**: Deliver the updated NOAA-21 OMPS NM and NP solar flux tables by applying the mean bias correction (~4% for NP and ~2% for NM) to mitigate the NOAA-21 OMPS solar pre-launch calibration error problem
- **Jun 2024**: Assess impact of a different solar reference spectrum (e.g., GSICS-recommended one) on NOAA-21 SDR data quality
- **Jul 2024**: Derive the instrument degradation rate for mission-long SNPP and NOAA-20 NM and NP SDR datasets
- **Aug 2024**: Address the user's request about development of solar activity and instrument degradation terms in the biweekly OMPS NP solar updates for all three sensors.
- **Sept 2024**: Improve the inter-sensor comparison method, by adding the inter-sensor comparison with TEMPO, TropOMI, GEMS
- **Sept 2024**: Improve the simulation accuracy of the CRTM for OMPS NP and NM in coordination with the STAR CRTM team
- **Sept 2024**: Continue to update the OMPS SDR ATBD

Path Forward: Lessons learned

- Establish an accurate RTM simulation tool, with/without the convolution with instrument BPS spectral features
  - A good validation tool can significantly speed up improvements of the OMPS calibration algorithms towards meeting requirements
  - Assist in capturing/quantifying instrument SDR calibration problems, especially for J4 polarization problem analysis
  - Good candidates:
    - CRTM in convolution with instrument BPS
    - PCRTM without convolution with instrument BPS
- Develop more objective validation methods about OMPS NM and NP SL and wavelength shift accuracy assessment
  - Validations of the OMPS SL and NM instar-orbit wavelength shift with time are still dependent upon empirical algorithms
  - It is challenging to accurately quantify the errors in the SL and wavelength shift algorithms
- Establish the OMPS solar flux calibration algorithm and processing code
  - Currently, the on-board OMPS solar flux data are provided by the NASA OMPS group. So, we lack in understanding of detailed calibration from radiometric count to solar flux, including stray light correction.
  - This deficiency could lead to a delay of early-orbit OMPS SDR calibration in NOAA side
- Build a direct communication vehicle from with the instrument vendor
  - A direct communication with the vendor can help us understand the problem at an earlier time and in depth, including getting the analysis report of the problem from vendor
    - We appreciated the NASA OMPS group for sharing the message about NOAA-21 OMPS nadir instrument solar pre-launch calibration problem via email in January 2024.
  - This is especially important for us to conduct **timely** calibration analyses for the J4 OMPS nadir polarization problem, impact and mitigation.

Acknowledgements

Thank Dr. Chunhui Pan for her long-term contributions to the OMPS SDR calibration and the pre-launch calibration preparation of the NOAA-21 OMPS; thank L. Wang for his support to the OMPS NM geolocation assessment algorithm; thank W. Porter for maintaining OMPS NM geolocation accuracy monitoring via ICVS, thank Glen Jaross and Colin Seftor, and Thomas Kelly for sharing pre-launch calibration data sets and early orbit diagnostic data analysis results with the STAR OMPS SDR Team. Thank Ninghai Sun for his support to the ICVS OMPS monitoring function development.

Acknowledge the support in different ways from Lihang Zhou and Manoharan Vani Starry, Ingrid Guch, Bigyani Das, Zhihua Zhang, and Eric Beach.

Disclaimer

The presentation contents are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA or the U. S. Government.

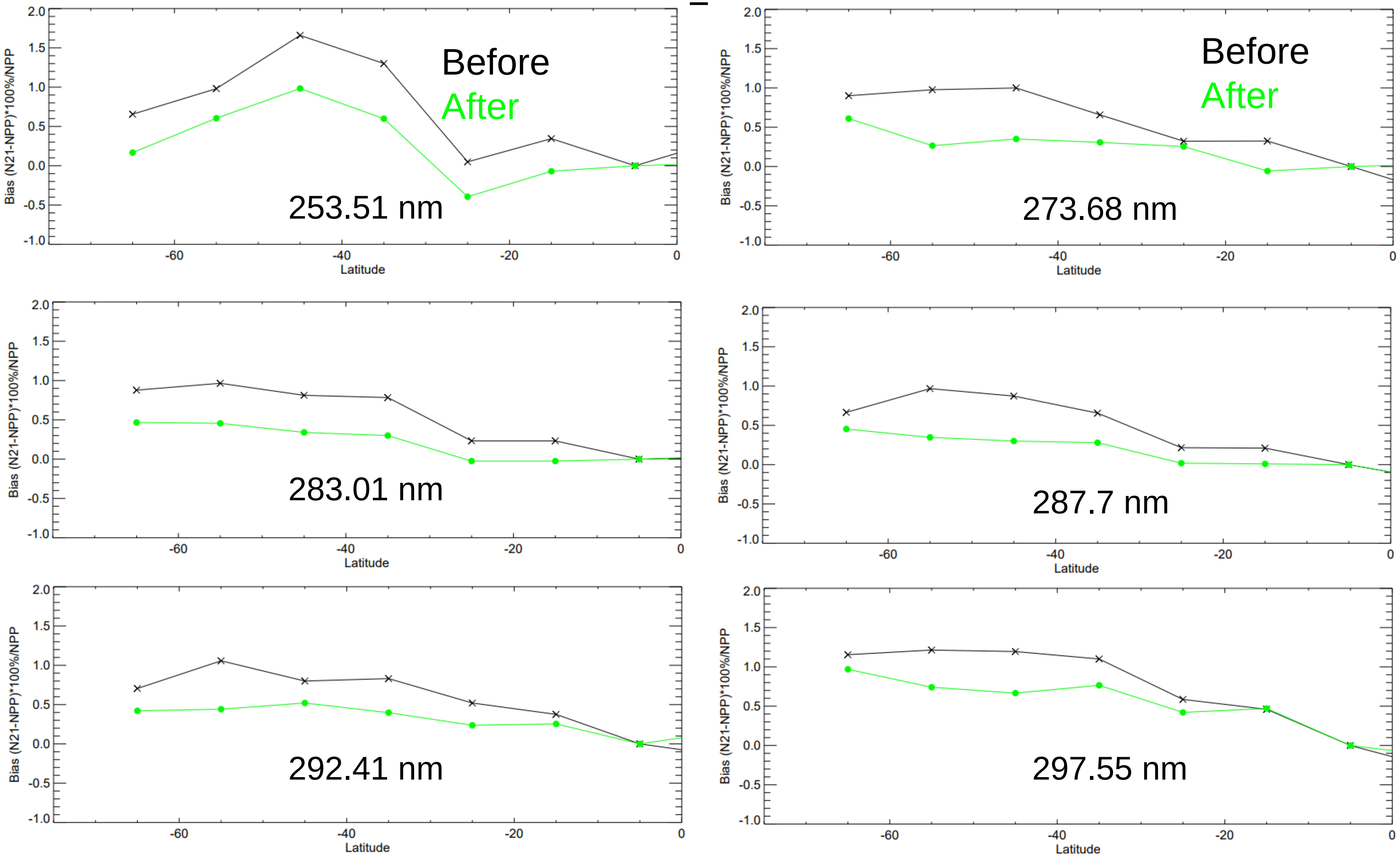
100

- backup

NP SH Latitude Dependency Improvement

- Major Improvement in N21 NP latitude dependency in SH after updating SL.

Green: Scaled_dark_Updated_SL
Black: newsol_solint



COMPARISON OF OMPS NP WITH SIMULATIONS (PCRTM, VLIDORT)

- **Input profiles of T, wv and Ozone are from the ERA5-matchup data. Other gases are from MERRA-2 climatology**

- **Using both PCRTM and VLIDORT_LBL calculation**

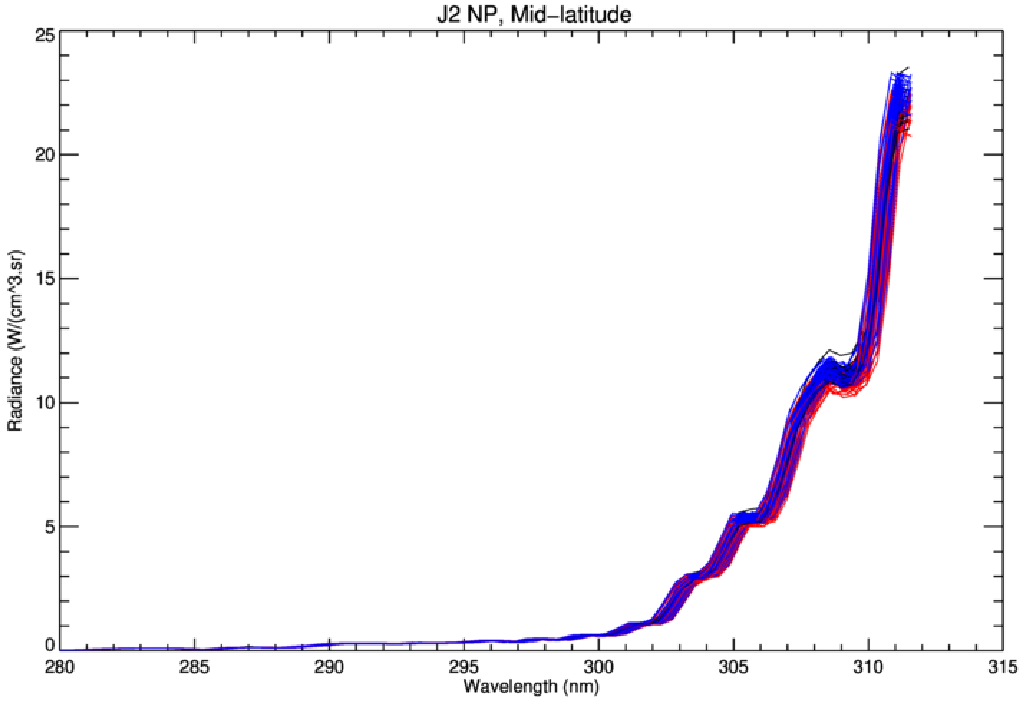
  (With and without Aerosol Tau = 0.2, 0)

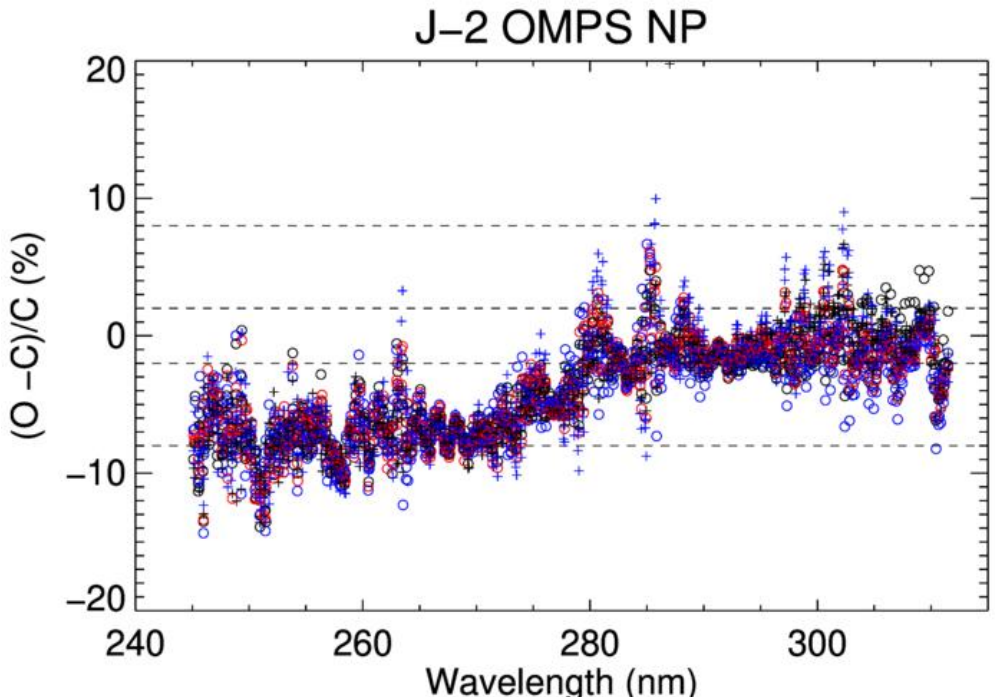
- **Convoluted using J-2 OMPS NP bandpass**

- **Ring Effect is not considered**

Courtesy of NASA Langley Research Center PCRTM Team

Comparison of Radiance for one granule





Radiance **Difference**

Courtesy of NASA Langley Research Center PCRTM Team

Comparing N21 and SNPP OMPS NM over DCC

- DCCs have been widely used in sensor intercalibration and temporal stability assessment.
- DCCs are the brightest tropical Earth targets with nearly a Lambertian reflectance
- OMPS-NM DCC pixels are identified by the following criteria:
    1. Solar zenith angles < 40 degrees;
    2. Sensor view zenith angles < 35 degrees;
    3. Latitude is between [30S,30N];
    4. 11-µm brightness temperature (TB11) < 210K based on sensitivity study
- OMPS-NM TB11 is from collocated VIIRS Moderate Resolution Band 15 (M15) SDR product.

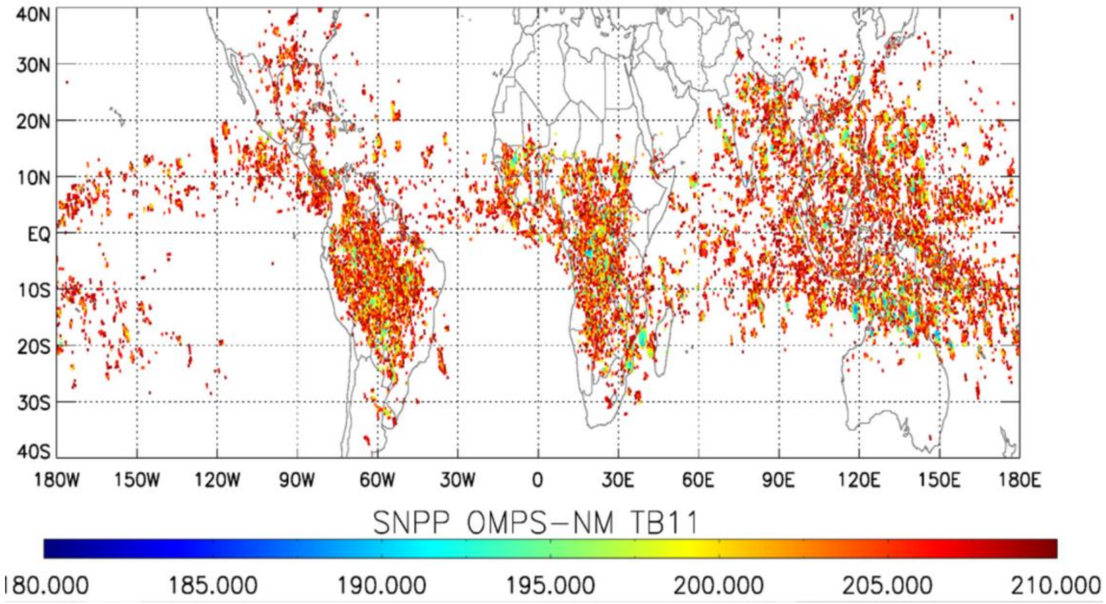
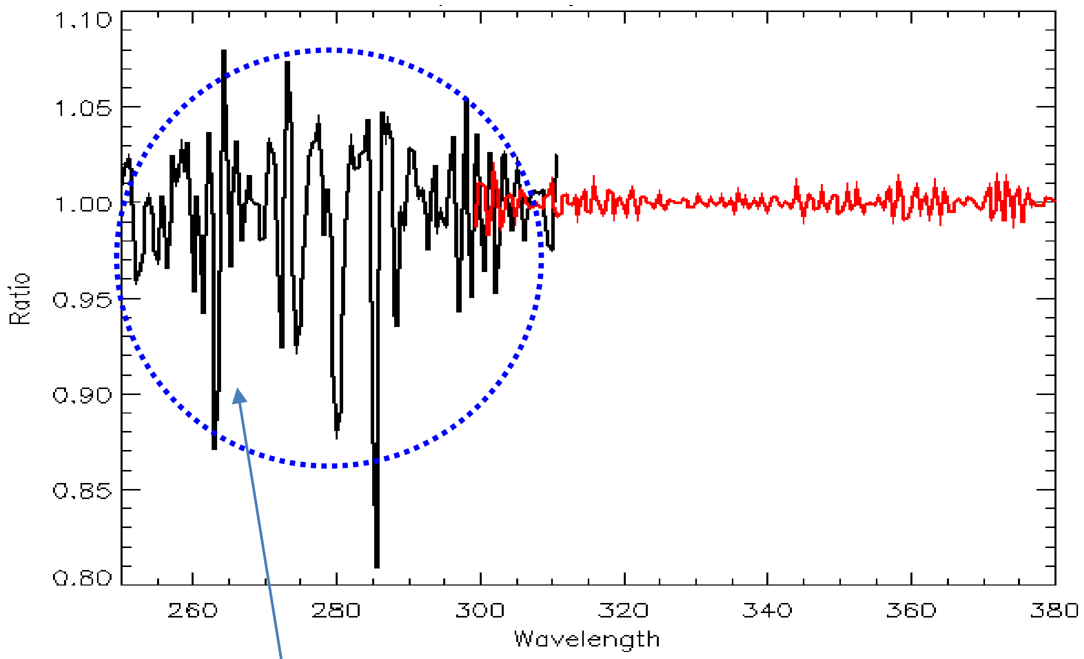


Figure. 4 S-NPP OMPS-NM DCC pixels

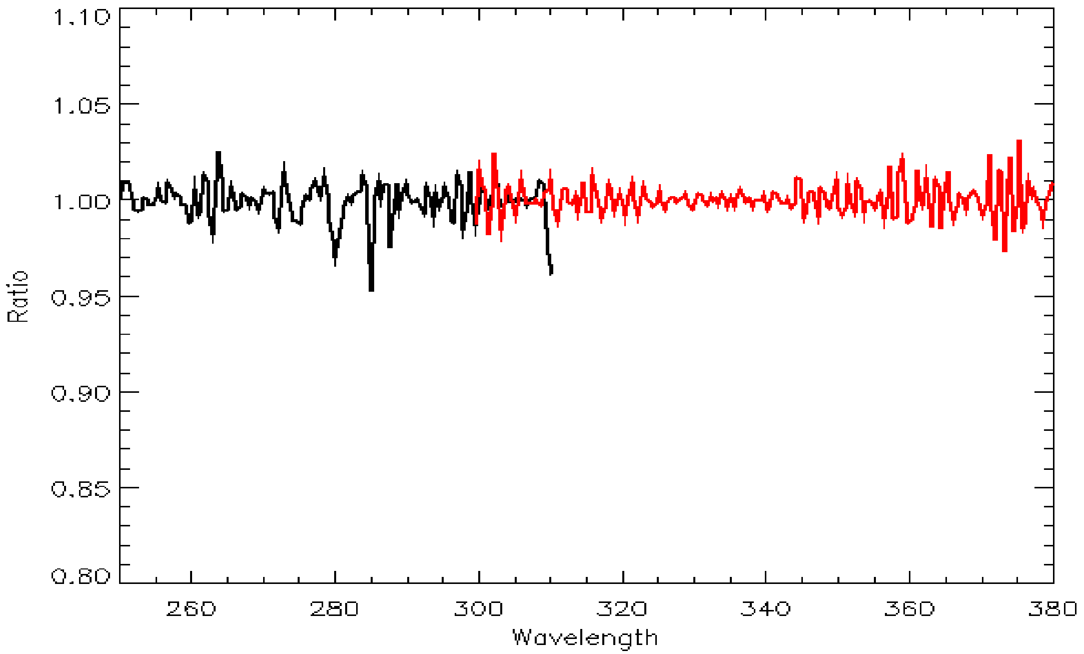
Synthetic Solar Spectrum Comparison among 3 OMPS Instruments

Ratio of NOAA-21 Synthetic Solar Flux to SNPP (NOAA-20)
(Assessing Impact of BPS/WV Scale Differences on Synthetic Solar Spectrum)

(a) NOAA-21/SNPP Ratio



(b) NOAA-21/NOAA-20 Ratio



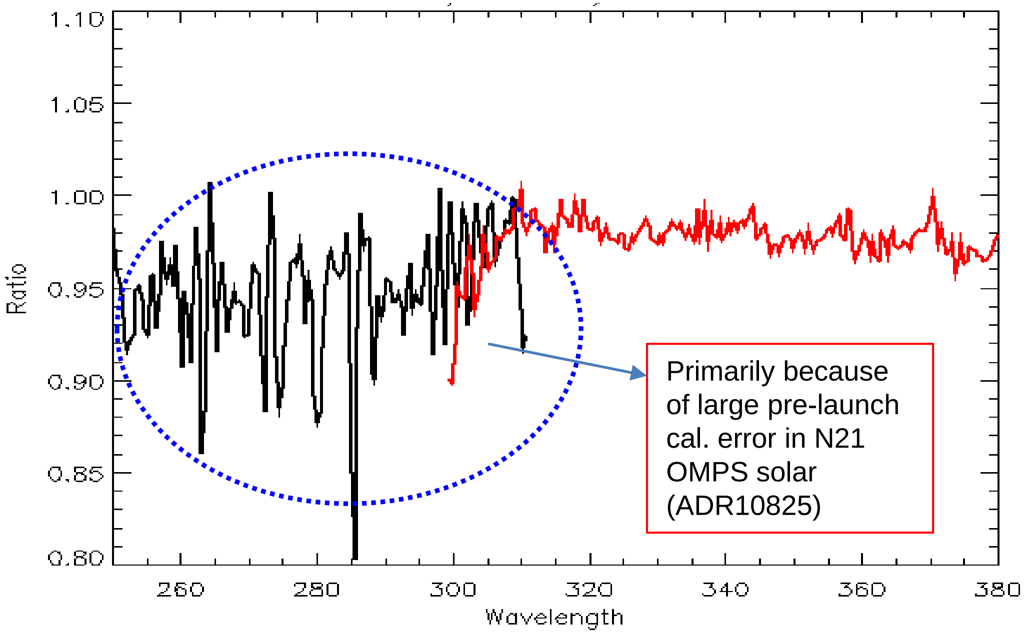
- **Synthetic solar flux is convolved by sensor band pass with solar reference spectrum.**
- **<u>Three sensors are different in spectral property</u>**
  - N21 NM and NP agrees with SNPP in differences typically less ±7%, with the largest in NP;
  - N21 NM and NP agrees with N20 in differences typically less ±3%, .

Day-1 Solar Spectrum Comparison among 3 OMPS Instruments

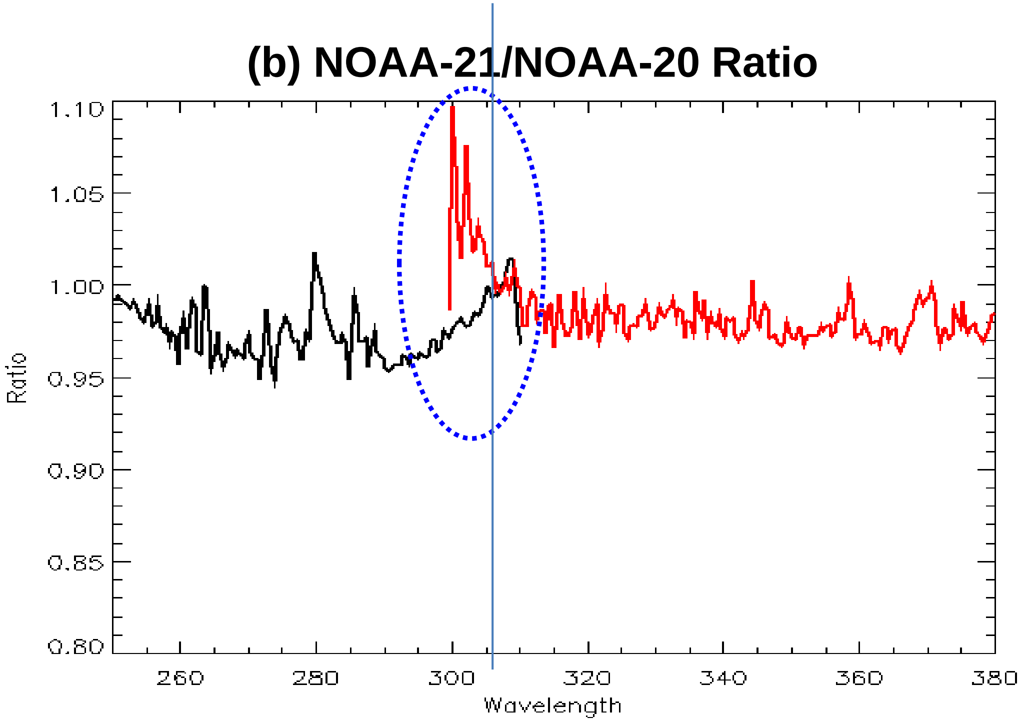
Ratio of NOAA-21 Day-1 Solar Flux to SNPP (NOAA-20)
(Assessing Impact of A few Factors* on Day-1 Solar Spectrum)

*A few factors include **solar cal. error, BPS diff.,** wavelength scale diff., solar activity, on-orbit mea. error, etc.

(a) NOAA-21/SNPP Ratio



(b) NOAA-21/NOAA-20 Ratio

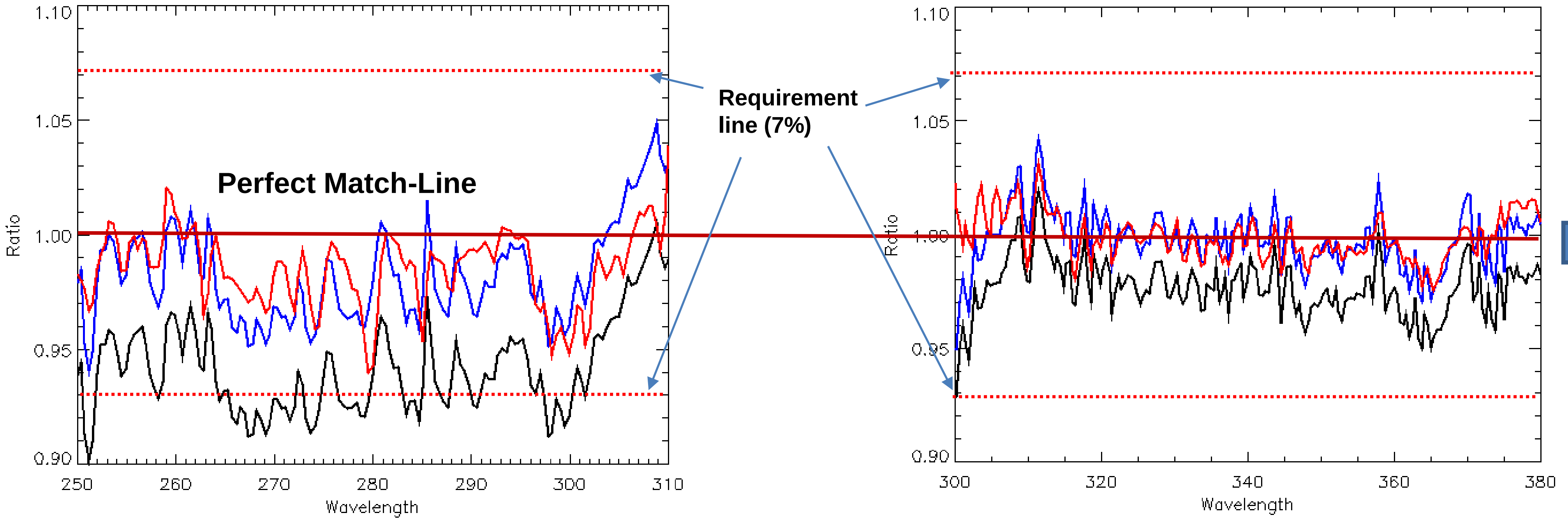


- **Three sensors are different in BPS spectral property, pre-launch cal. Features, wavelength scale and others, leading to the following conclusions:**
  - N21 NM and NP day-1 agrees with SNPP in differences (absolute value) up to 20%, with the largest in NP;
  - N21 NM and NP day-1 agrees with N20 in differences (absolute value) up to 10%, with the largest in NM dichroic range.

Assessment of the NOAA-21 OMPS Day1 Solar Flux Spectrum Relative to SNPP with/without Conceptual Bias Corrections

(a) N21 OMPS NP Day-1/Synthetic Difference (%) to SNPP

(b) N21 OMPS NM Day-1/Synthetic Difference (%) to SNPP



(Original Day-1; Day-1 Adjusted by Wavelength; Day-1 Adjusted by 4.3%)

(Original Day-1; Day-1 Adjusted by Wavelength; Day-1 Adjusted by 2.2%)

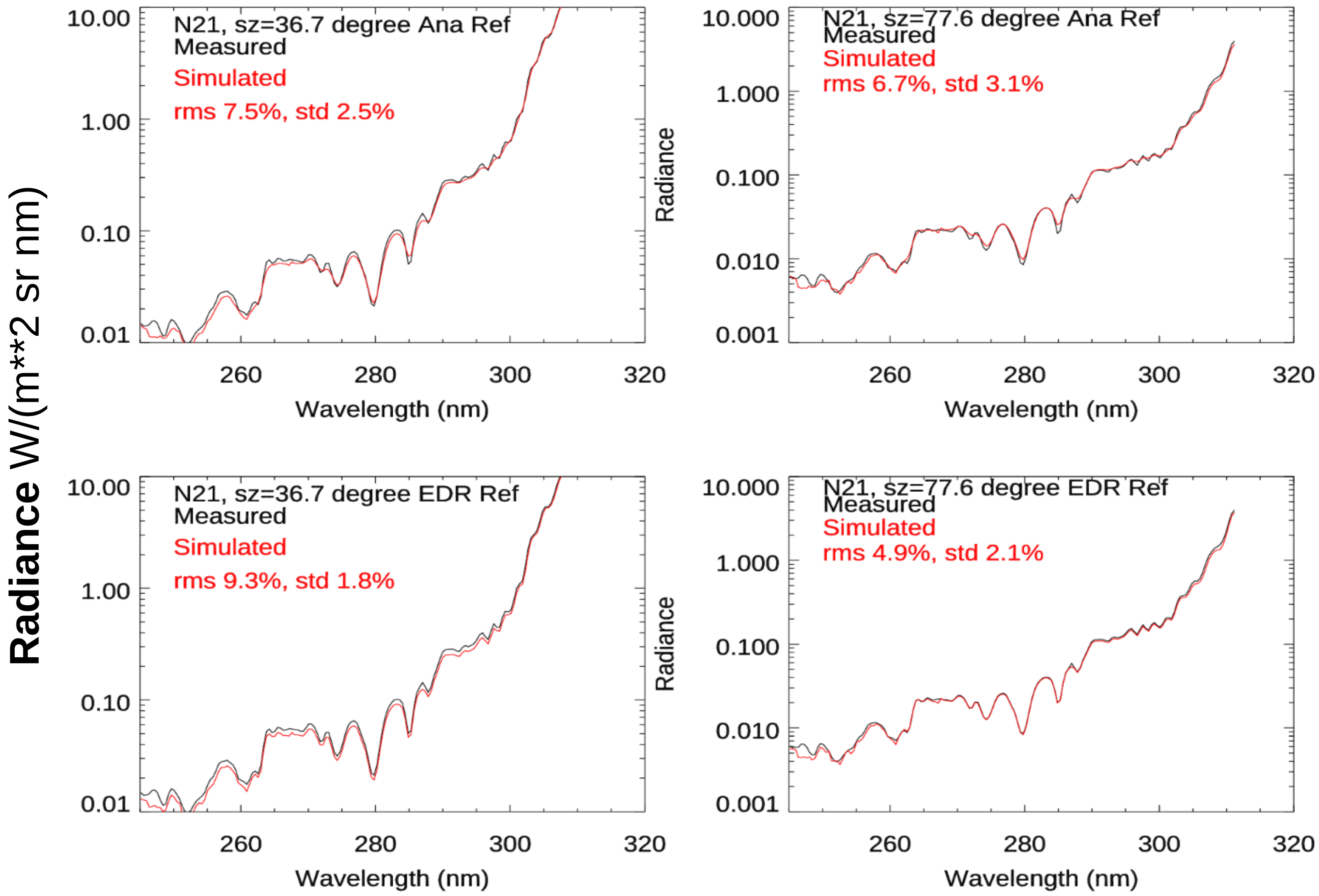
For the correction test, the detail is referred to the **ADR10825** (N21 OMPS Solar Pre-calibration Error Analysis)

By applying either wavelength independent (mean; blue color) or wavelength dependent (red color) bias correction, the NOAA-21 OMPS NM and NP solar flux (day-1) can agree **better** with SNPP and NOAA-20.

NOAA-21 OMPS NP Radiance Requirement Assessment Using CRTM Simulations

CRTM-Derived Surface Refl.

EDR-Derived Surface Refl.

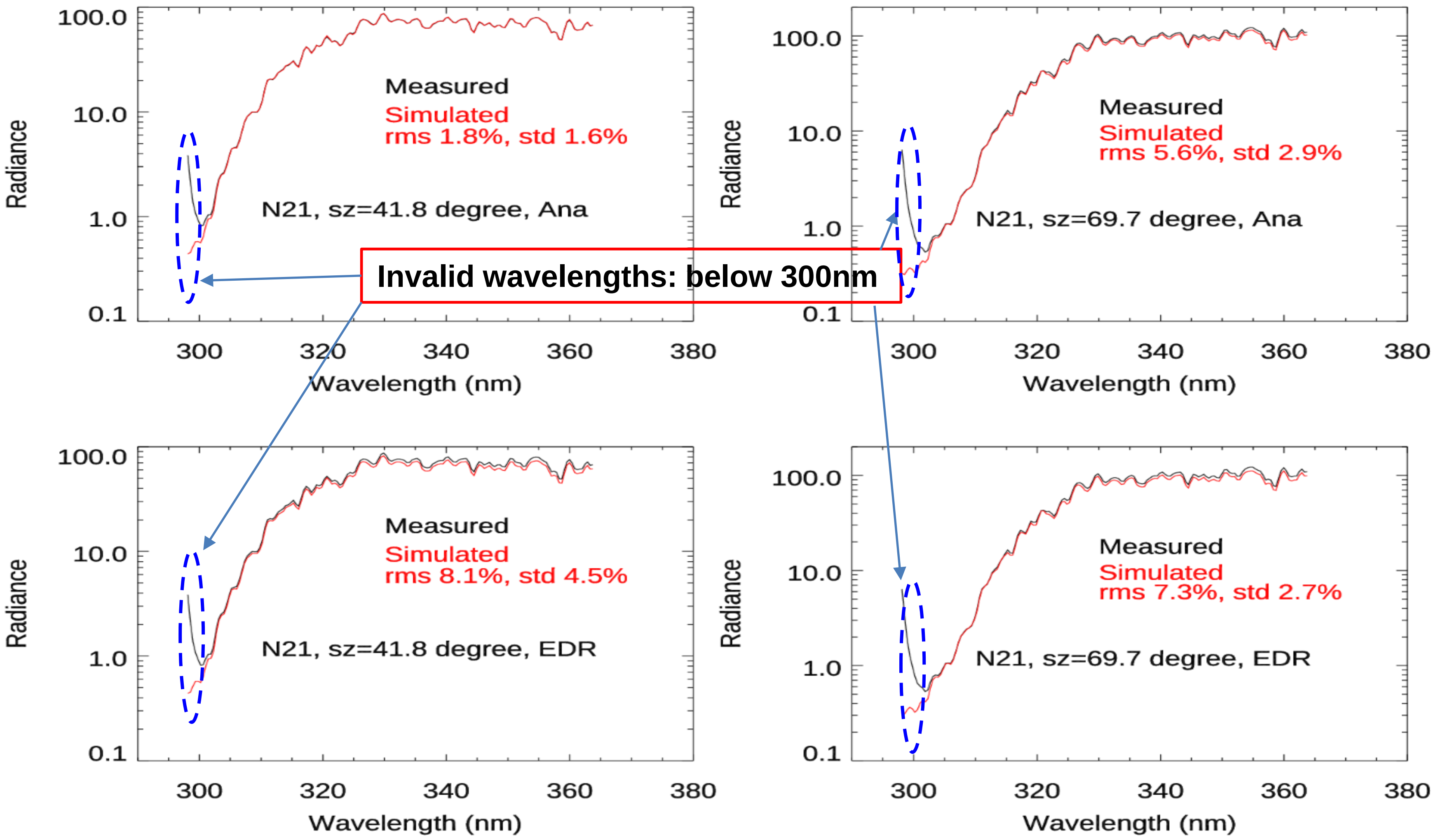


- On average, the NOAA-21 OMPS NP radiance deviation from the CRTM simulation is less than 8%, meeting the requirement with 8%

NOAA-21 OMPS NP Radiance Accuracy Assessment Using CRTM Simulation

CRTM-Derived Surface Refl.

EDR-Derived Surface Refl.



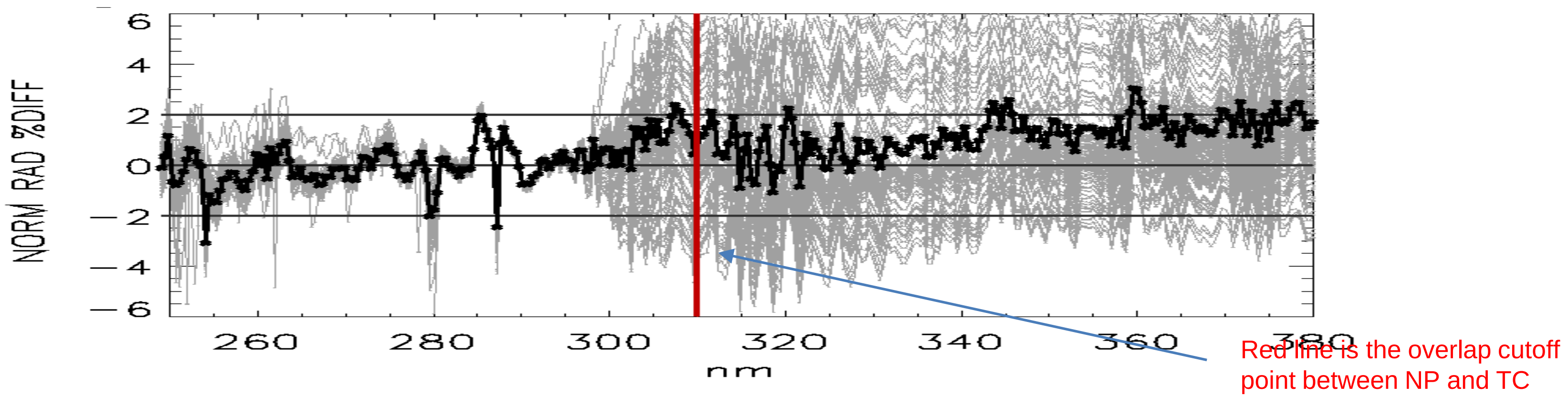
- On average, the NOAA-21 OMPS NM radiance deviation from the CRTM simulation is less than 8%, meeting the requirement with 8%

(Courtesy of Q. Liu and CRTM team)

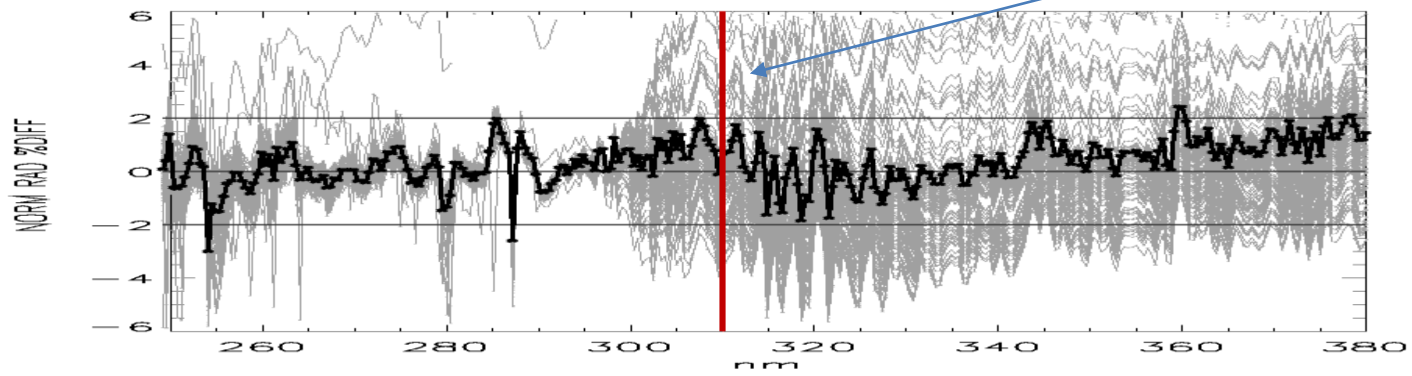
Daily-Averaged O- B Using TomRad and Observation-Derived Surface Reflectivity and Ozone Profiles: Data Quality Requirement Assessment

- TSIS solar reference in TomRad
- Data Source
  - 2023/10/06 Reprocessed data
- Regions: NH and SH (within±40°Lat)
- 13 EDR Channels are used to retrieve surface ‘reflectivity and ozone profiles

(a) Averaged NR Differences (%) over NH (O – B)



(b) Averaged NR Differences (%) over SH (O – B)

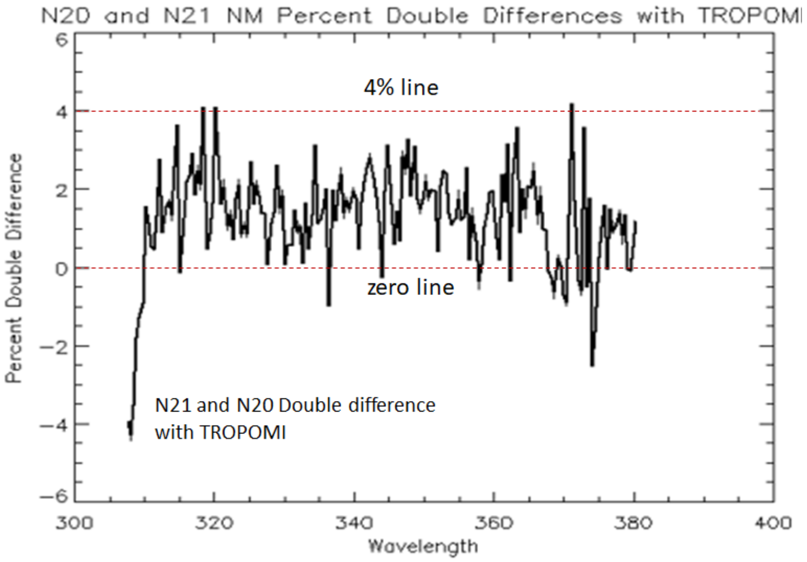


Just mean + std?

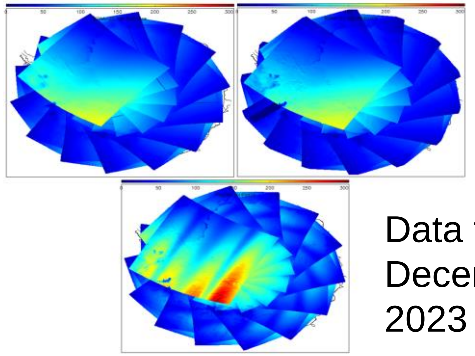
N21 and SNPP OMPS NM Bias using TROPOMI as a Double Difference

- Ray-Matching Approach
  - Similar sensor and solar geometry
  - Most of the comparisons in the polar region.

- ***N21 and N20 bias agrees with that derived from 32-days global reflectance bias to within 1%.***



NOAA-20 Rad: 373nm NOAA-21 Rad: 373nm



TROPOMI Band 3 Rad: 373nm

Data from December 21, 2023