Validated Maturity Science Review
For NOAA-21 CrIS SDR

Presented by Flavio Iturbide-Sanchez and the CrIS SDR Cal/Val Science Team

Date: 09/28/2023

Outline

- Executive Summary for Validated Review
- Product Overview and Requirements
- Cal/Val Timeline
- EP Update
- Evaluation of the NOAA-21 CrIS SDR Performance
  - NOAA-21 Telemetry Analysis (Module and detector cooler temperatures, Laser Wavelength, and ZPD location)
  - NEdN/radiometric noise performance
  - Radiometric performance (from CrIS SDR team, UW and UMBC)
  - Spectral performance (from CrIS SDR team, UW and UMBC)
  - Radiometric Nonlinearity Verification (UW)
  - Radiometric Intercomparisons with other IR Sensors (from CrIS SDR team, UW and UMBC)
  - Geolocation Accuracy
  - Analysis of Imaginary and Real Radiances
  - Downstream User Feedback (NCEP, ECMWF, NUCAPS, OSPO)
- Risks, actions, mitigations, waivers
- Documentation locations, check-list and requirements met
- Justification, Caveats and Path Forward

See Supplementary Slides in the Back of the Presentation for Additional Assessment

Validated Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- 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/EDRs feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward
- Summary

The CrIS SDR Cal/Val Science Team and Collaborators

Team Lead	Organization	Team	Major Tasks
Flavio Iturbide-Sanchez (Science Team Lead)	**NOAA/STAR** Cal/Val Team	**GST:** Kun Zhang, Denis Tremblay, Arun Ravindranath, Wayne McCullough **UMD:** Peter Beierle	Science Lead and Project Management; SDR Team Coordination and Algorithm Test in IDPS; Algorithm/Software Sustainment and Maintenance; Noise, Geolocation, Radiometric and Spectral Characterization; Inter-comparison; Long-term SDR Data Quality and Monitoring; Science Support
Dave Tobin	**U. of Wisconsin (UW)** Cal/Val Team	Hank Revercomb, Joe Taylor, Bob Knuteson, Lori Borg, Michelle Loveless, Dan Desolver	Radiometric Calibration; Radiometric Error Budget and Uncertainty; Noise Characterization; Non-linearity Correction; Polarization Correction; Inter-comparison; Science Support
Larrabee Strow	**U. of Maryland Baltimore County (UMBC)** Cal/Val Team	Howard Motteler, Sergio de Souza-Machado, Chris Hepplewhite, Steven Buczkowski	Spectral Calibration; Neon Calibration System; Self-Apodization Correction (e.g. ILS parameters); Inter-FOV Variability; Inter-comparison; Radiometric Stability; Science Support
Dave Johnson	**NASA Langley**	Yana Williams	NASA Flight Support; Instrument Science
Joe Predina	**Logistikos**	Richard Hertel, James Isaacs, Glen White, Mark Searfoss, Perry Falk & Fred Williams	Anomaly Resolution and Instrument Science
Sara Glass	**L3Harris**	Lawrence Suwinski, Jeff Garr, Rebecca Malloy, Mike Pries, Brian Case, Chad Eviston, Kris Kombrink	Instrument Manufacturer; On-ground and On-orbit Instrument Characterization and Support
Deirdre Bolen	**NOAA/JPSS**		Algorithm Manager; Discrepancy Report Support

JPSS/GOES-R 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.

NOAA-21 CrIS Post-Launch Commissioning and Cal/Val Timeline

Launch + day (date)	Flight Activity	Ground Activity
L + 0 (11/10/22)	Activation Process Starts (CrIS Warm Up Heaters Activation)	
L + 10 (11/20/22)		
L + 11 (11/21/22)	Begin CrIS Outgassing	
L + 88 (2/06/23)		OMPS Stray light maneuver
L + 90 (2/08/23)	End CrIS Outgassing; Deploy Cooler Door, **Initial Calibration Table Upload EP v208 (L3Harris and MOST)**	
L + 92 (2/10/23)	Cryoradiator Cooled, Instrument Stable, Power up Signal Processors and Detectors	**First Earth View Science Data is expected** CrIS Diode Temp, Infrared (IR) Gain Check, Bit Trim Mask, Impulse Noise Mask Check, Geolocation (In-track zero position, Pointing Accuracy), etc.
L + 99 (2/17/23)		Cal/Val Science Team and L3Harris Prepare and Deliver 1st Calibration Table (in the form of Eng. Packet) to MOST.
L + 103 (2/21/23)	**First Calibration Table upload EP v210 (L3Harris and MOST)** with Vinst, PGA gain, TVAC param**. (ILS and Nonlinearity), and Geolocation parameters (adjusted for in-track zero position)	**Effective Beta Maturity Level on L+103** Jitter Performance, Spectral Cal/Laser Stability, Detector Noise/Linearity, Full Spectral Resolution Diagnostic, Geolocation (Pointing Accuracy)
L + 130 (3/20/23)		Cal/Val Science Team and L3Harris Prepare and Deliver 2nd Calibration Table (in the form of Eng. Packet) to MOST
L + 133 (3/23/23)	**Second Calibration Table Upload EP v211 (L3Harris and MOST)** with optimized Nonlinearity, Geolocation and ILS parameters	**Effective Provisional Maturity Level on L+133**
L + 314 (9/20/23)	**Third Calibration Table Upload EP v212 (OSPO and MOST)** with optimized Nonlinearity, Geolocation and Spectral parameters	
L + 320 (9/26/23)	**PCT Update CCR 6761 (OSPO and MOST)** with optimized Polarization Correction	**Effective Validated Maturity Level on L+320**
L + 322 (9/28/23) ← We are Here		**Validated Maturity Review on L+322**

Executive Summary for Validated Review

- From assessments, the CrIS cal/val team has shown that the NOAA-21 CrIS SDR data meets the Validated Maturity Requirements in terms of:
  - Noise (NEdN) performance: All FOVs and bands within the specification, compares well to S-NPP and NOAA-20, no out-of-family detectors showing high NEdN values.
  - Radiometric performance: radiometric FOV2FOV consistency is within 0.1 K.
  - Spectral performance: absolute (and relative) spectral offsets for all three bands are all within ±2 ppm (and ±1 ppm).
  - Geolocation performance: Geolocation meets the requirements using EP v212 for all FORs. The total geolocation uncertainty is 253 meters 1-sigma where the specification is 1.5 Km. Current uncertainty is comparable to S-NPP and NOAA-20.
  - Intercomparisons between GOES-16/18 ABI and NOAA-21 CrIS, demonstrate consistent results across all bands over the assessment time period (bias within 0.2K).
- NOAA-21 CrIS SDR products have been reliably produced by IDPS since first science data on February 10, 2023. No Discrepancy or Risk Reports have been submitted during this period associated with the CrIS SDR Algorithm.

Requirement Check List – CrIS SDR

DPS	Requirement	Performance
DPS-357	The CrIS SDR product shall provide complex spectral radiances, calibrated from CrIS interferogram RDRs, for all CrIS earth scene measurements, at the refresh rates of the instrument.	Yes
DPS-798	The CrIS BUFR product shall provide geolocated complex spectral radiances, converted from CrIS SDRs, in the BUFR format.	Yes
DPS-359	The CrIS SDR product shall provide complex spectral radiances binned into three bands denoted SW (short wave), MW (mid wave), and LW (long wave).	Yes
DPS-791	The CrIS SDR product shall conform with the CrIS instrument requirement MMSS-235 of the Multi-Mission Systems Specification, reproduced below for reference (***see next slide***).	Yes
DPS-364	The CrIS Geolocation Data product shall provide WGS84 ellipsoid-referenced geolocation data for all fields of view, calibrated from CrIS instrument and spacecraft RDRs, for all CrIS earth scene measurements, at the refresh rates of the instrument.	Yes
DPS-366	The CrIS Geolocation Data product shall have a 3-sigma geolocation uncertainty in the along-scan direction, over all scan angles, not to exceed 1/4 the along-scan footprint size of the 3 dB (FWHM) beam of each FOV.	Yes
DPS-367	The CrIS Geolocation Data product shall have a 3-sigma geolocation uncertainty in the along-track direction, over all scan angles, not to exceed 1/4 the along-track footprint size of the 3 dB (FWHM) beam of each FOV.	Yes

CrIS SDR JPSS L1-Requirements

Product Requirements from JPSS L1RD

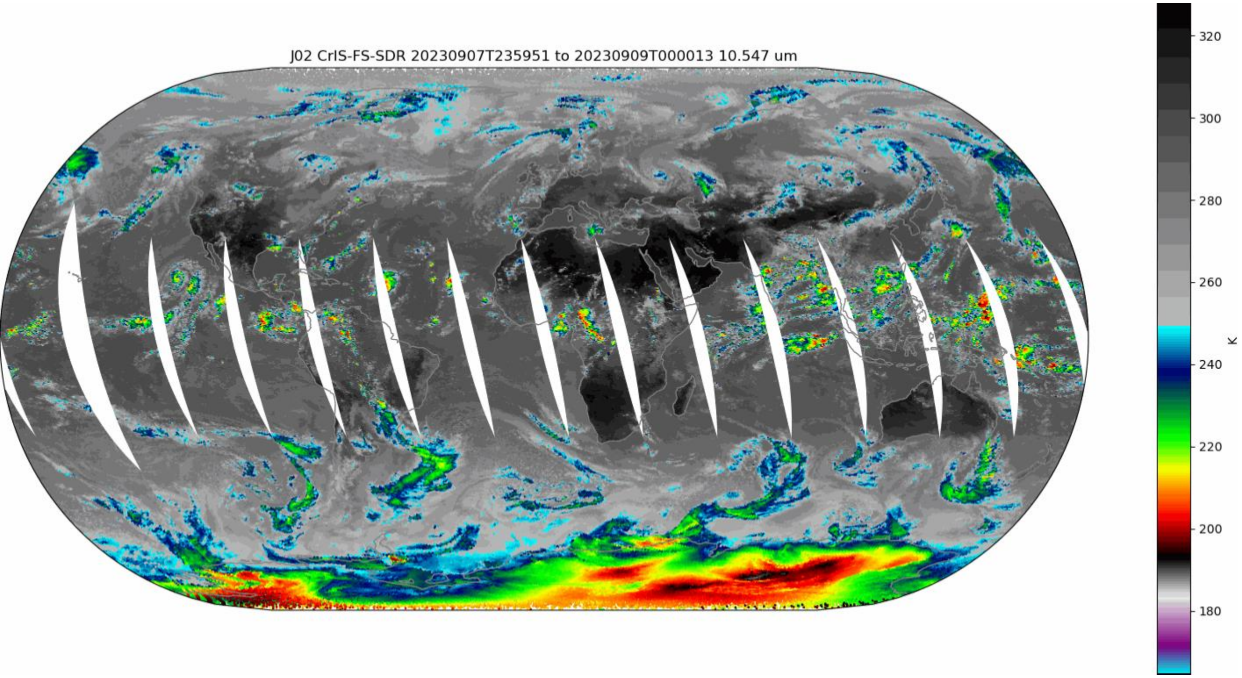
Band	Minimum Wavenumber Range[1] (cm^{-1})	# of Channels[4]	Spectral Resolution (cm^{-1})[1,3]	Maximum NEdN @287K BB[2] ($mW/m^2/sr/cm^{-1}$)	Radiometric Accuracy @287K[1,2] (%)	Maximum FOV Footprint at Nadir FOV (km)	Maximum Spectral Uncertainty[1] (ppm)	Geolocation Mapping Uncertainty (3σ)[1] (km)
LWIR	650-1095	713	0.625	0.45 @ 670 cm-1, 0.15 @ 700 cm-1, 0.15 @ 850 cm-1, 0.15 @ 1050 cm-1	0.45	15	10	5
MWIR	1210-1750	865	0.625	0.078 @ 1225 cm-1 0.064 @ 1250 cm-1 0.069 @ 1500 cm-1 0.075 @ 1700 cm-1	0.58	15	10	5
SWIR	2155-2550	633	0.625	0.013 @ 2200 cm-1 0.014 @ 2350 cm-1 0.014 @ 2550 cm-1	0.77	15	10	5

[1]JPSS Algorithm Specification Volume I: Software Requirement Specification (SRS) for the CrIS RDR/SDR, 474-00448-01-03, Revision I, October 24, 2019.
[2]JPSS Level 1 Requirements Document Supplement (L1RDS) – Final, JPSS-REQ-1002/470-00032, Revision 2.11, Rev. 2.1, 02/07/2019. The NEdN Maximum values for the MWIR and SWIR are the result of scaling the NEDN values, defined in Table 4.3, by a factor of $\sqrt{2}$ and 2, respectively.
[3]JPSS-2 CrIS Performance Requirements Document (PRD), 472-00346, Revision B, 03/10/2016.
[4]JPSS CrIS SDR ATBD) for Full Spectral Resolution, June 14, 2018.

NOAA-21 CrIS Observations is Coverage, One vs Two CrISs

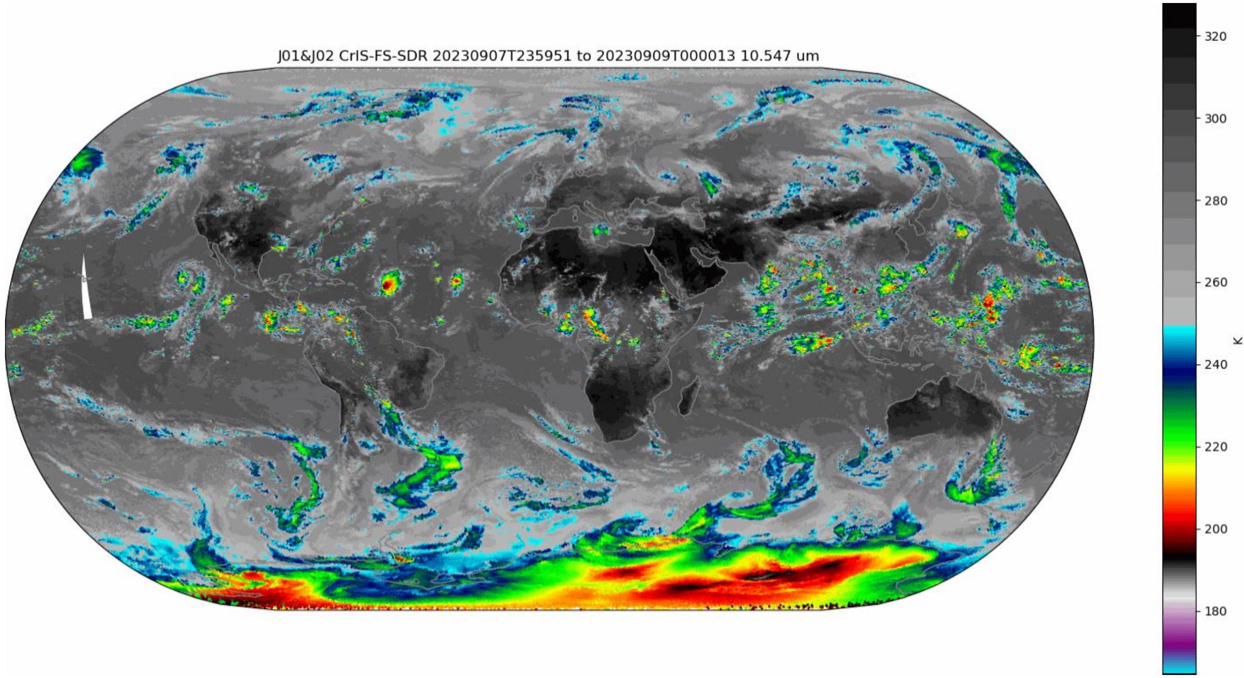
The NOAA-21 CrIS Sensors is providing a continuous stream of data used mainly for numerical weather forecasting

NOAA-21 CrIS (Ascending)



2023-09-08 through 2023-09-15, 947 cm^{-1} (10.55 μm)

NOAA-21 and NOAA-20 CrIS (Ascending)



2023-09-08 through 2023-09-15, 947 cm^{-1} (10.55 μm)

Upload of the NOAA-21 CrIS EP v212 on September 20, 2023

- The NOAA-21 CrIS onboard Calibration Table requires update to enhance the performance of the NOAA-21 CrIS calibrated radiances, in support to the transition to the Validated Maturity level.

- The Calibration Table for NOAA-21 CrIS was successfully uploaded on September 20, 2023.

- The update includes **radiometric and geolocation calibration parameters**.
  - Radiometric: nonlinearity coefficient for LW FOV9
  - Geolocation: enhanced mapping parameters

- There was **no update on spectral calibration parameters** in the EP v212, since the NOAA-21 CrIS relative spectral calibration is within +/- 1 ppm for each band and is comparable or better than NOAA-20 and SNPP.

Deployment of NOAA-21 CrIS PCT CCR 6761 for Enabling Polarization Correction Algorithm

- **The polarization correction** was incorporated into the NOAA-21 CrIS calibration **to remove relatively small by important calibration biases** which are currently present in the NOAA-21 CrIS data without the polarization correction in place.

- The NOAA-21 CrIS polarization correction has **an average radiometric impact is ~0.05 K, ~0.1 K, and ~0.2 K for LWIR, MWIR, and SWIR band**, respectively. The performance is consistent with the impact found in SNPP and NOAA-20 CrIS.

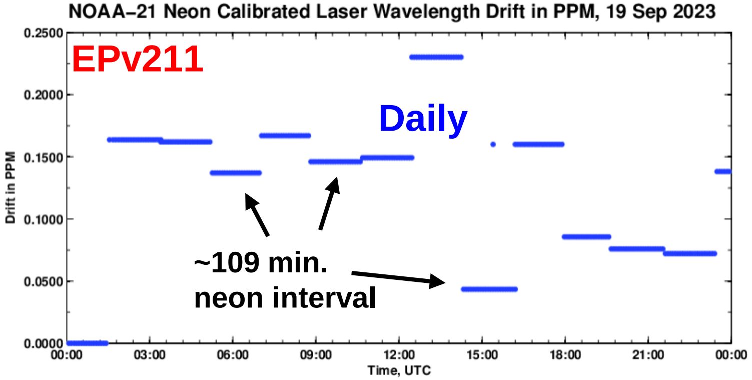
- The NOAA-21 CrIS polarization correction was enabled via a PCT update in the DP-TE environment on September 22, 2023.

- Upon the checkout by CrIS science team, **the PCT update was deployed in the operational (DP-OE) environment on September 26, 2023 at 20:10 UTC.**

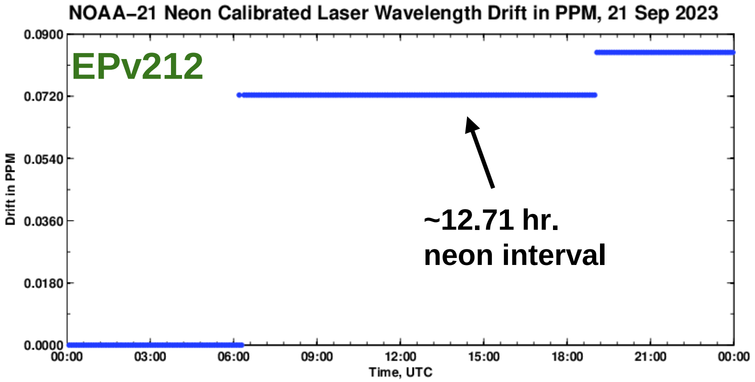
NOAA-21 CrIS Science Telemetry: Laser Wavelength

- **With the update of EPv212, the increase in interval between neon calibration measurements (now ~12.71 hours) has been implemented (was originally ~109 minutes).**
- The small (pk2pk<1.2 ppm) periodic oscillation of the laser wavelength has been observed (period ~ 14 days)
  - Seems to depend on the how long the neon lamp is turned on for, and is related to the neon fringe partial start/stop counts
- **Neon Calibrated Laser Wavelength is Stable and at a nominal level**

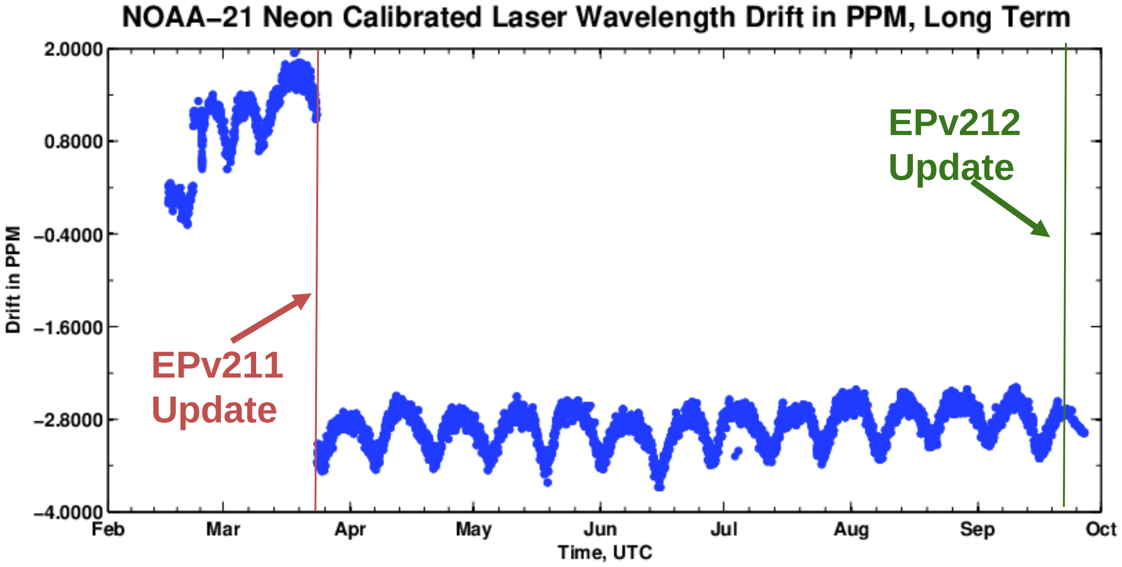
Sep 19



Sep 21



Long-Term: ~7 months



Additional studies on this impact and the oscillations can be found here:
[ppt1:Neon Turn-on time] [ppt2:Neon Fringes] [ppt3:Spectral and Radiometric Impact]

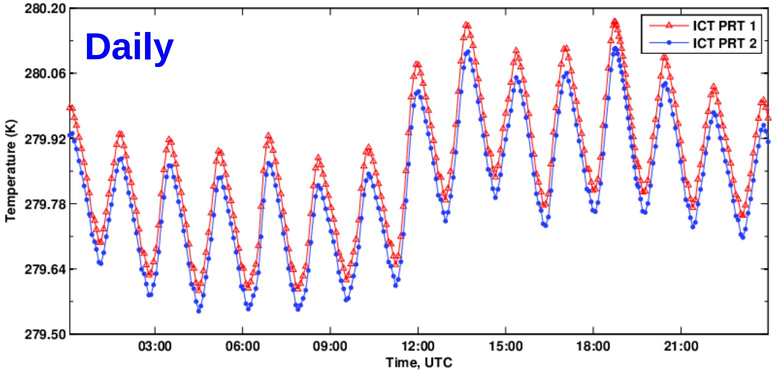
Provided by Peter Beierle

NOAA-21 CrIS Science Telemetry: ICT, OMA & Scan Baffle Temperatures

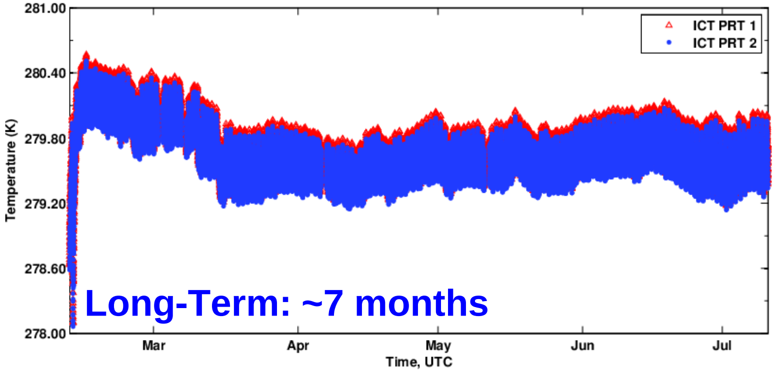
- **Critical CrIS modules are at nominal temperatures, and have been stable for more than 7 months**
- Includes Internal Calibration Target, Optical Mechanical Assembly, and Scan Baffle/SSM Mirror Temperatures

Internal Calibration Target

NOAA−21 CrIS Internal Calibration Target Temperature 27 Sep 2023

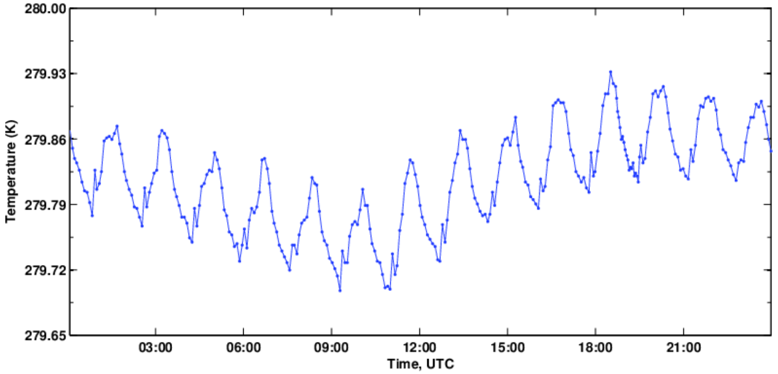


NOAA−21 CrIS Internal Calibration Target Temperature, Long−term

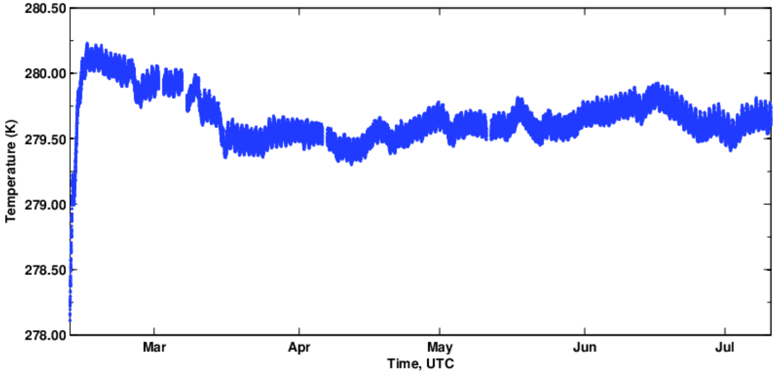


Optical Mechanical Assembly

NOAA−21 CrIS Optical Mechanical Assembly Temperature, 27 Sep 2023

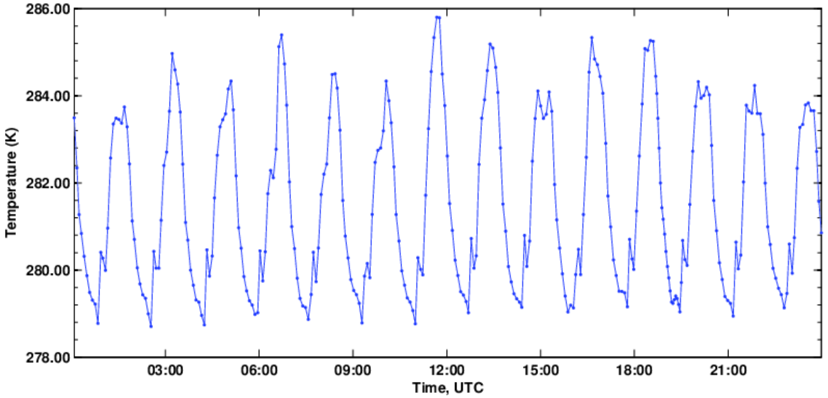


NOAA−21 CrIS Optical Mechanical Assembly Temperature, Long−term

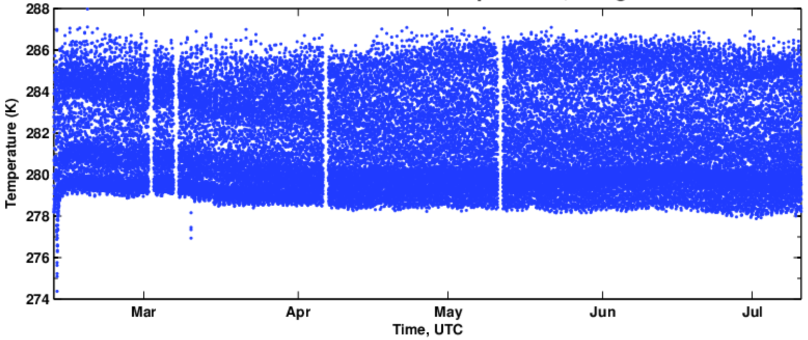


Scan Baffle

NOAA−21 CrIS Scan Baffle Temperature, 27 Sep 2023



NOAA−21 CrIS Scan Baffle Temperature, Long−term

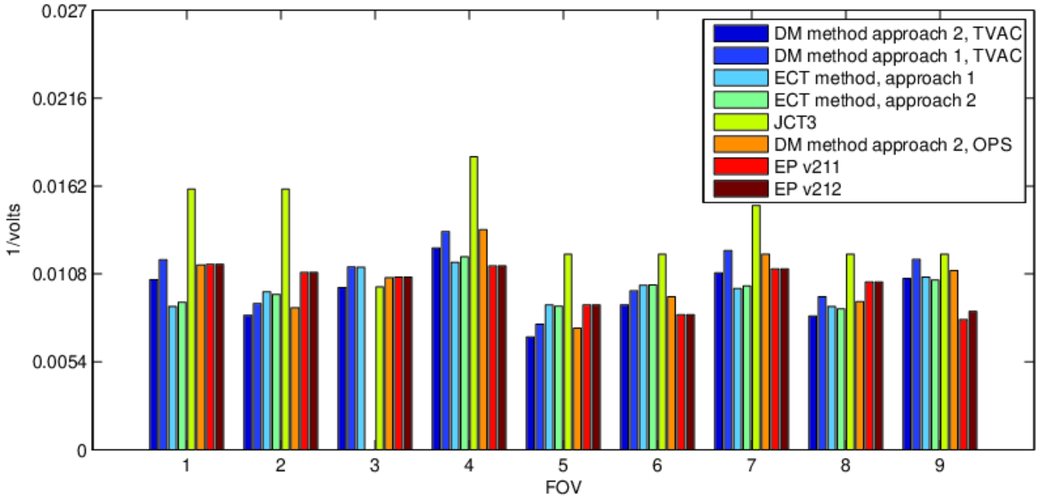


Provided by Peter Beierle

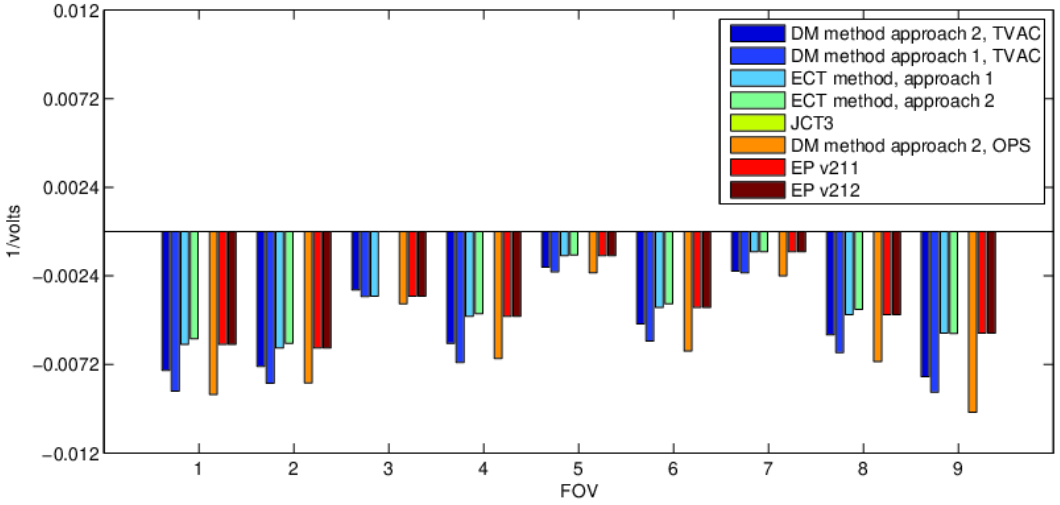
NOAA-21 On-orbit Nonlinearity

- **Good consistency between TVAC Diagnostic Mode method (ground), External Calibration Target method (ground), and the On-orbit calculation of nonlinearity**
- **From EPv211 to EPv212, a minor adjustment was applied in order to improve the FOV-2-FOV Radiometric consistency.** (see UW slides)

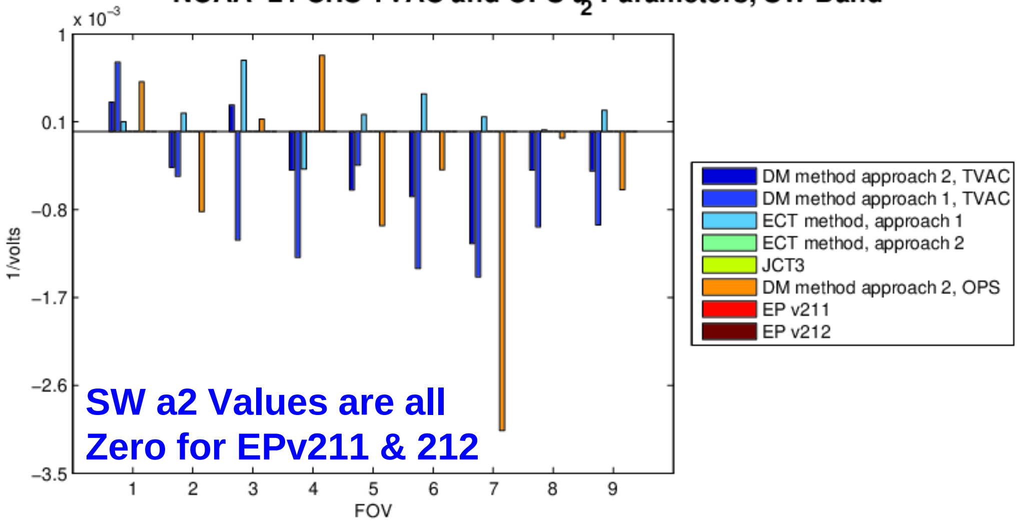
NOAA–21 CrIS TVAC and OPS a_2 Parameters, LW Band



NOAA–21 CrIS TVAC and OPS a_2 Parameters, MW Band

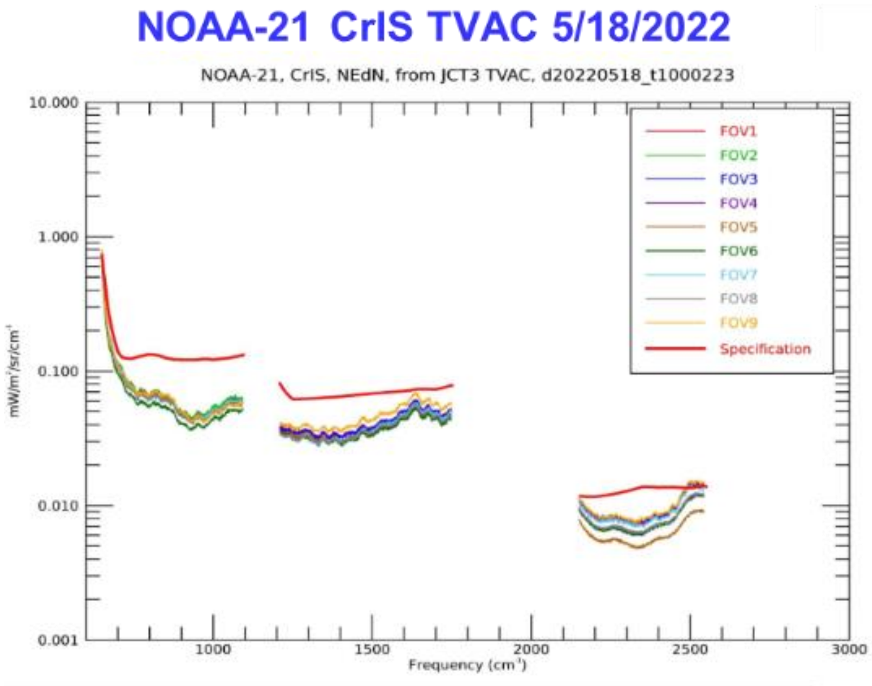


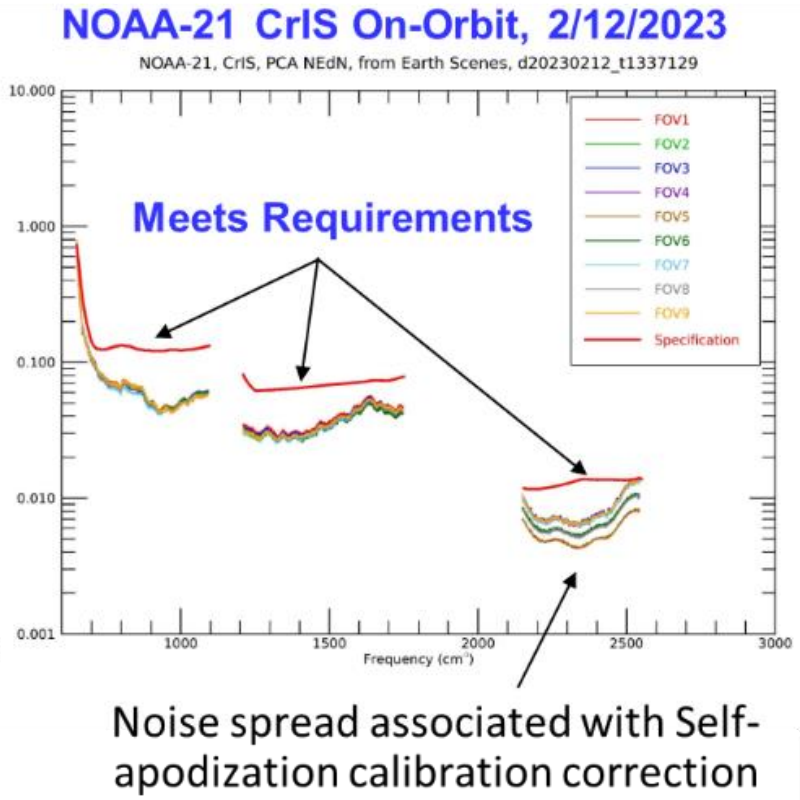
NOAA–21 CrIS TVAC and OPS a_2 Parameters, SW Band

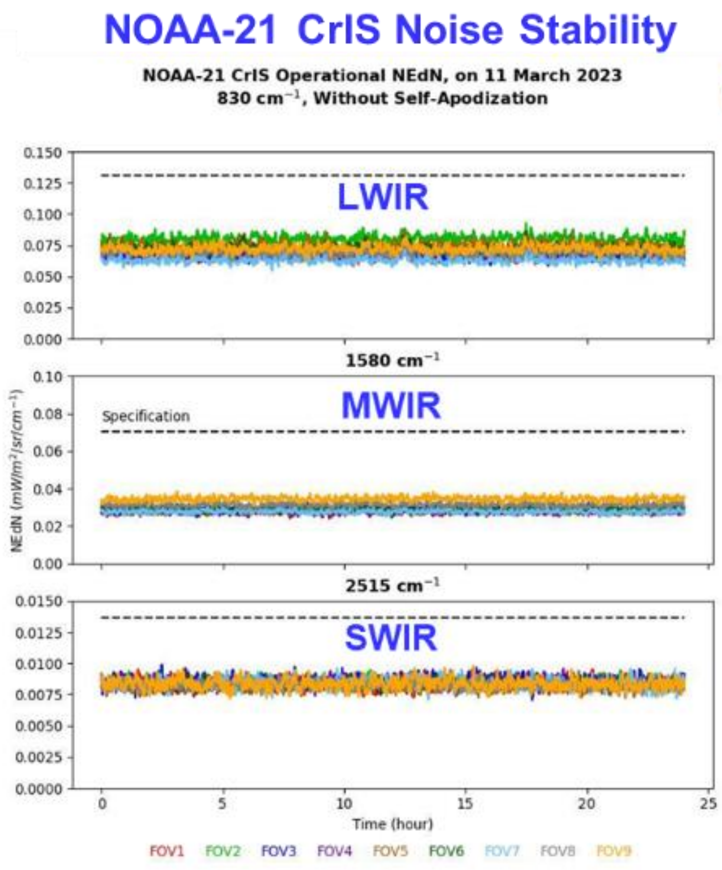


Provided by Peter Beierle

NOAA-21 CrIS Noise: Pre-launch and On-orbit Performance



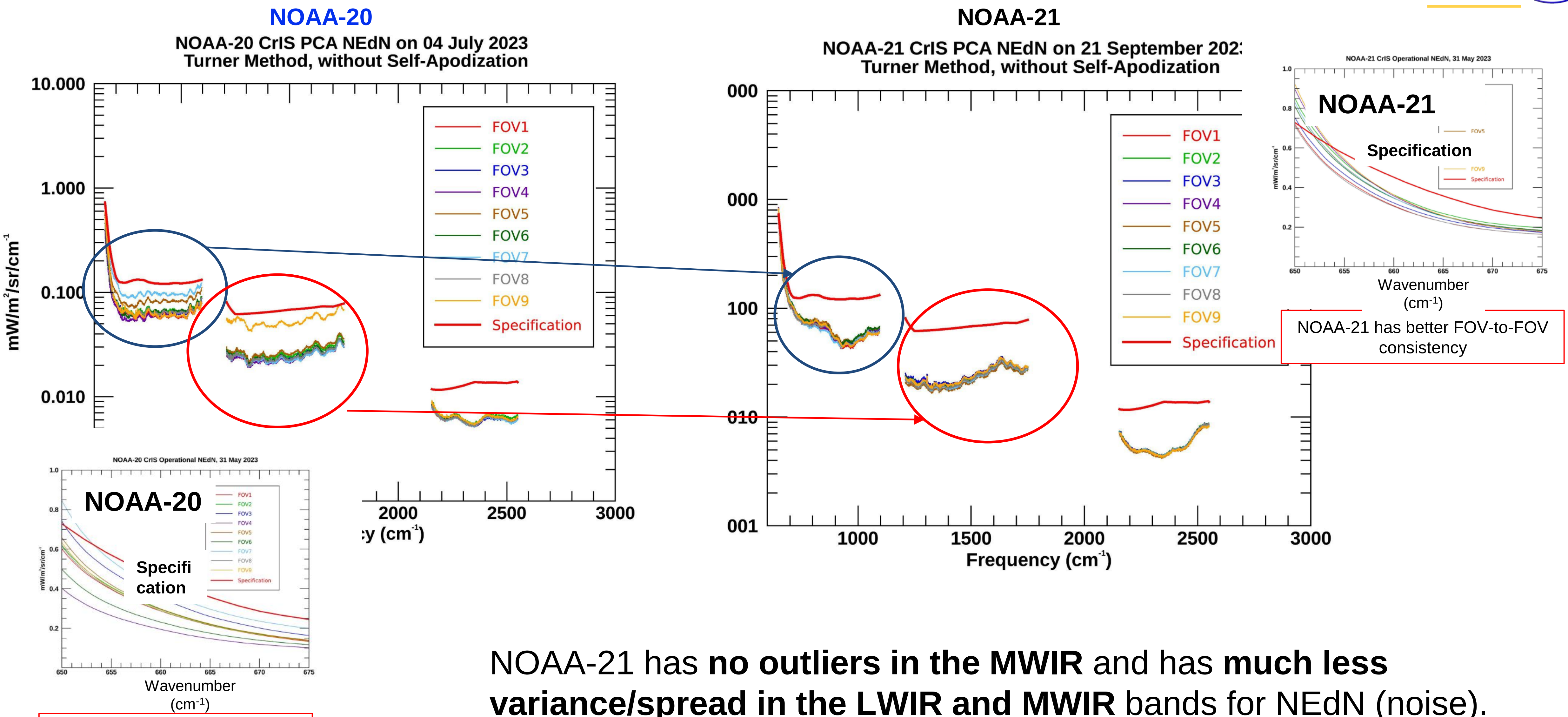




The On-orbit NOAA-21 CrIS Noise performance is comparable to pre-launch performance, consistent and stable among FOVs.

The Inter-channel noise correlation is low and similar to SNPP and NOAA-20, expecting to facilitate the assimilation of the data in NWP.

NOAA-21 CrIS EP 212 On-orbit Noise Performance vs NOAA-20



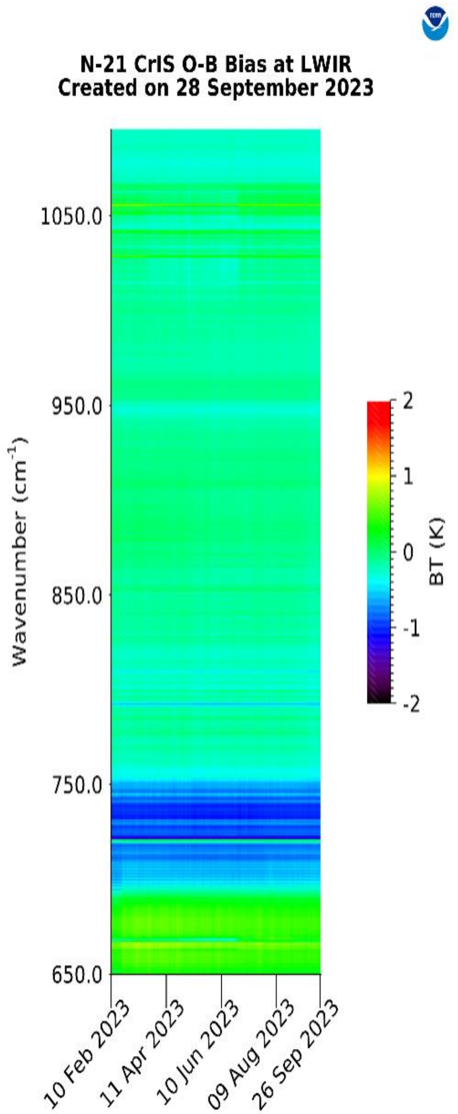
NOAA-21 has better FOV-to-FOV consistency

NOAA-20 CrIS has, in general, lower noise than NOAA-21 near the Longwave IR edge

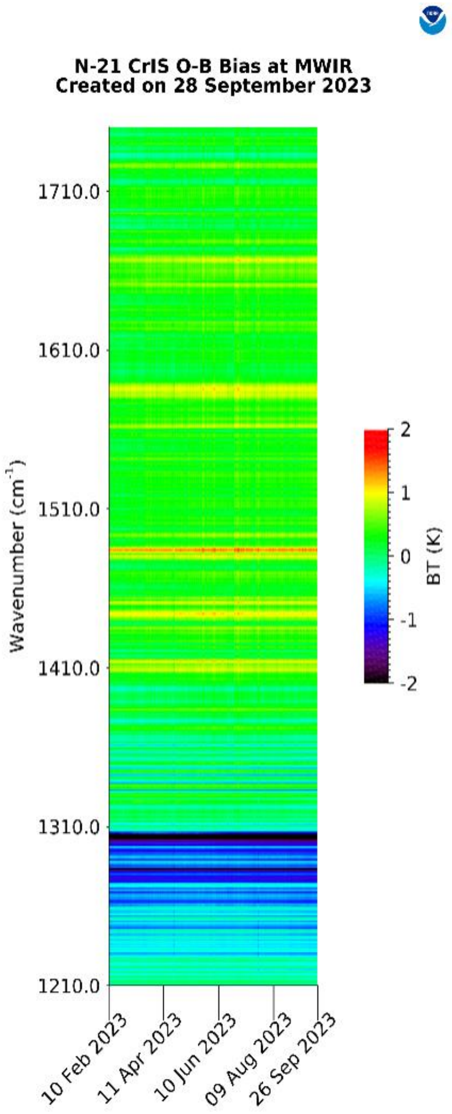
NOAA-21 has **no outliers in the MWIR** and has **much less variance/spread in the LWIR and MWIR** bands for NEdN (noise). **Improved consistency in noise levels between the FOVs.**

Provided by Denis Tremblay

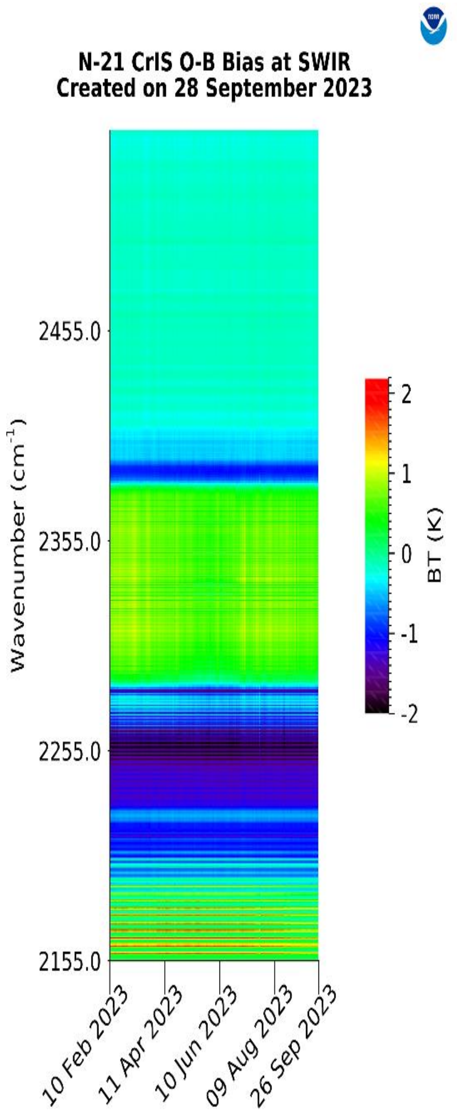
Seasonal Trending of Radiometric Accuracy for NOAA-21 CrIS Observations-minus-Simulations (O-B)



LWIR



MWIR

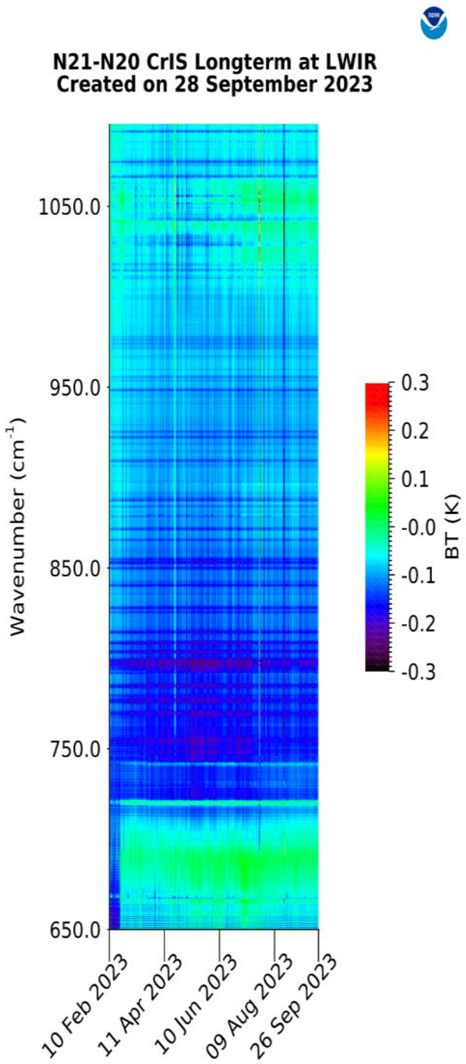


SWIR

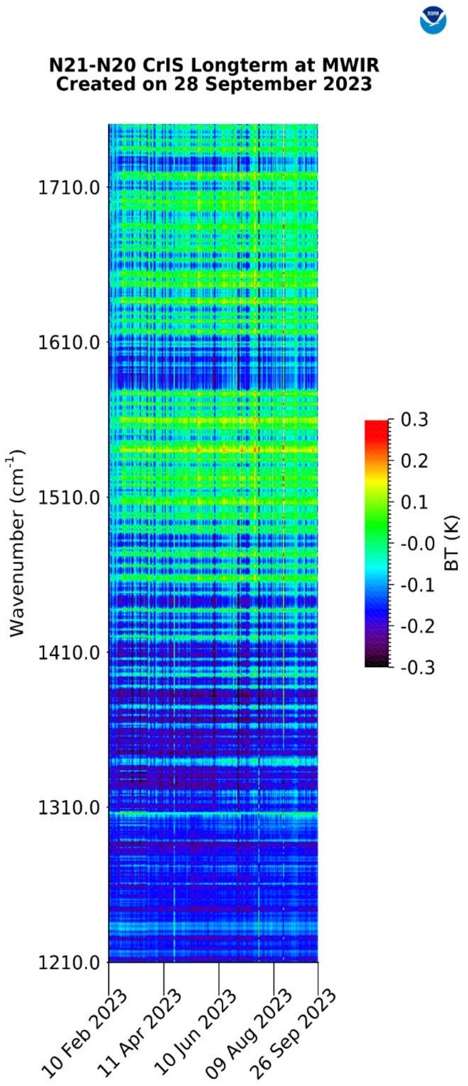
- Mean O-B bias over clear-sky CRTM simulations remains consistent **within +/- 2.0 Kelvin** for LWIR, MWIR, and SWIR band since the beginning of the NOAA-21 CrIS mission (~7 months).
- This accounts for the systematic biases between CRTM and Observation (which has been seen with SNPP and NOAA-20 CrIS).

Provided by Kun Zhang

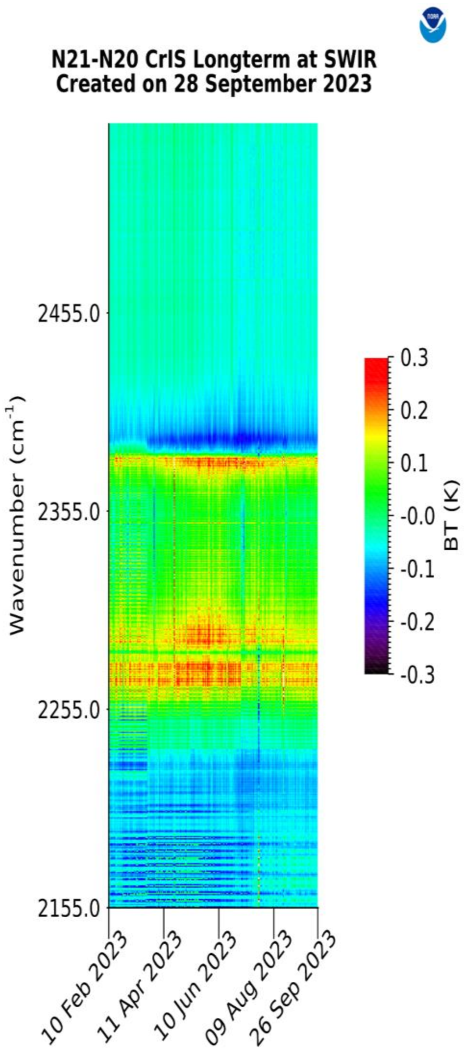
Seasonal Trending of Radiometric Consistency Between NOAA-21 and NOAA-20 CrIS



LWIR



MWIR

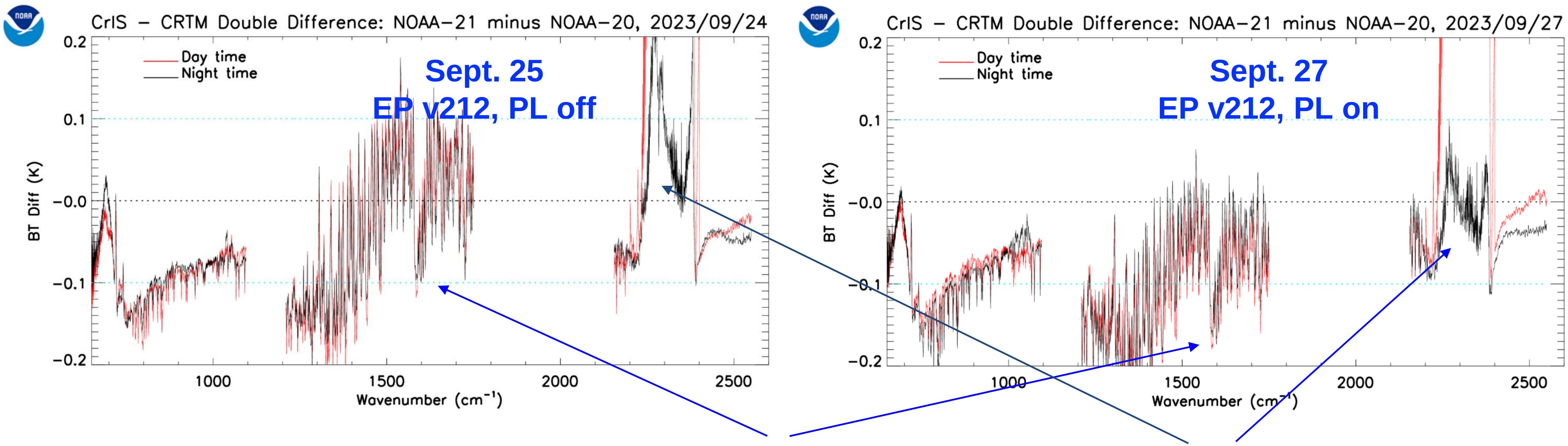


SWIR

- NOAA-21 CrIS shows radiometric consistency with NOAA-20 CrIS at LWIR, MWIR, and SWIR band.
- **Majority of channels show radiometric differences within +/- 0.2 K**.
- Radiometric improvement around 700 cm^{-1} channels at LWIR band is due to the nonlinearity correction update in the Calibration Table.

Provided by Kun Zhang

NOAA-21 CrIS Radiometric Comparison with NOAA-20 CrIS Before and After the Polarization Correction PCT Update

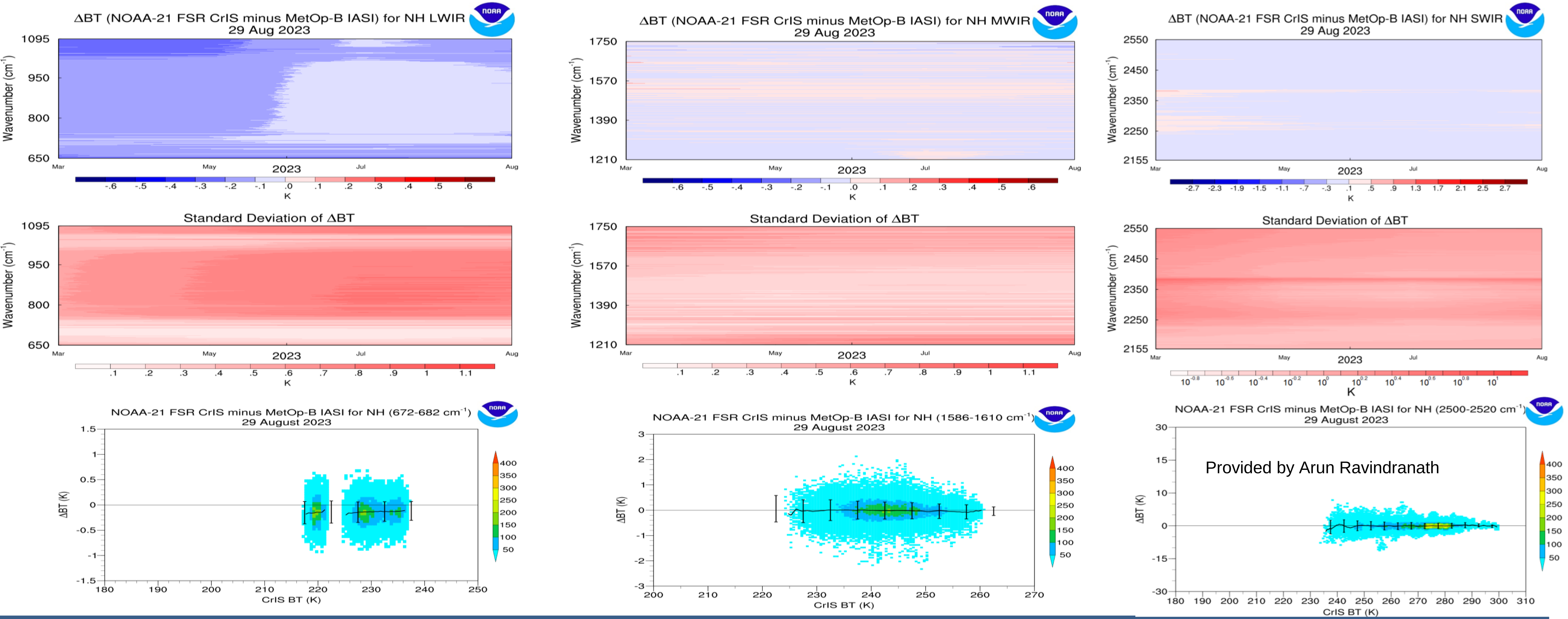


- **An average radiometric bias reduction of ~0.1 K for the MWIR band and ~0.2 K for the SWIR band was observed after the polarization correction enabled for September 27. It works as expected.**
- **Radiometric bias with EP v212 and Polarization Correction On for NOAA-21 CrIS are within +/- 0.1 K for most of channels in three bands.**
- All FOVs and FORs for clear-sky observations over ocean between +/- 65 deg latitude were selected for September 27, 2023.
- **See Backup Slides and CrIS SDR Website for More Radiometric Assessment Results**

Provided by Kun Zhang

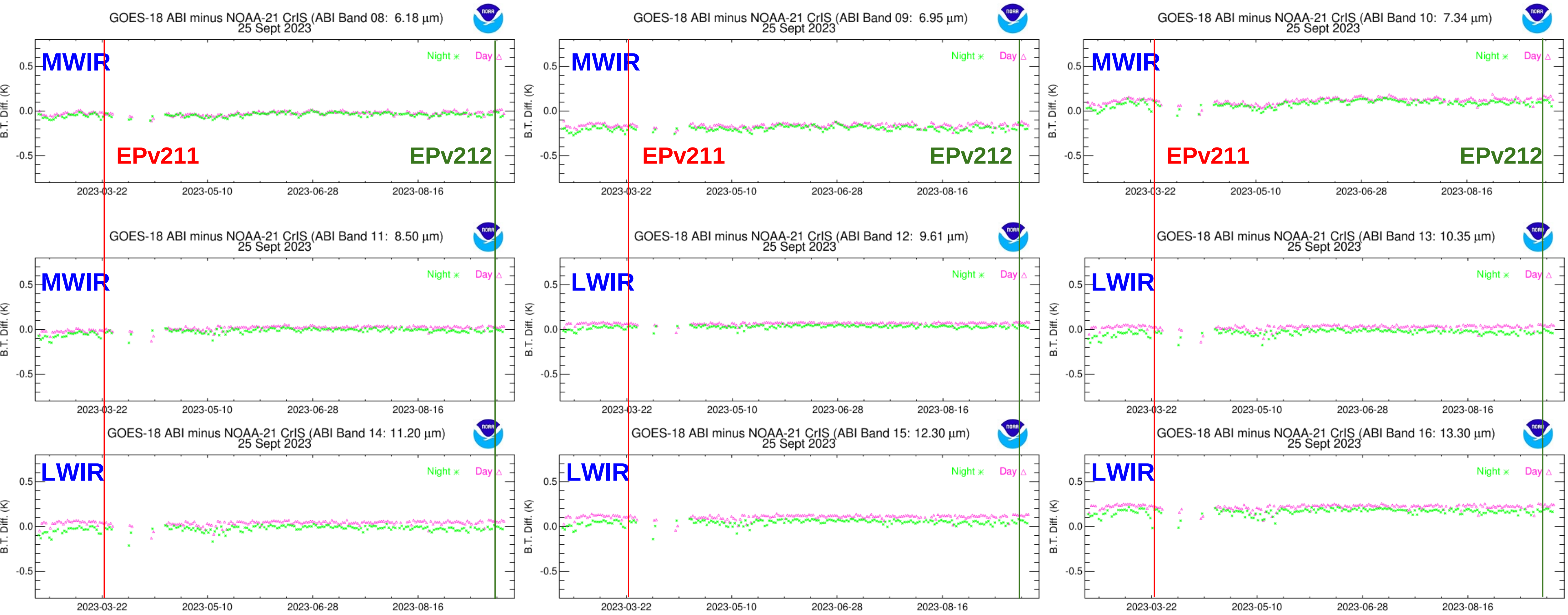
NOAA-21 CrIS minus MetOp-B IASI SNO Intercomparison Radiometric Biases

- **Top panel:** NOAA-21 CrIS - MetOpB IASI BT biases averaged over FOV in the LW, MW and SW bands, for northern hemisphere; **Mid panel:** The standard deviations of the BT values by FOV; **Bottom Panel:** scene temperature dependence scatterplots
- **Biases are within 0.2 K for LW, and within 0.1 K in the MW/SW**
- **Standard deviation values between 0.3 K to 0.9 K (LW), 0.1 K to 0.6 K (MW), and 0.5 K to 3 K (SW)**
- **No scene temperature dependence is observed**



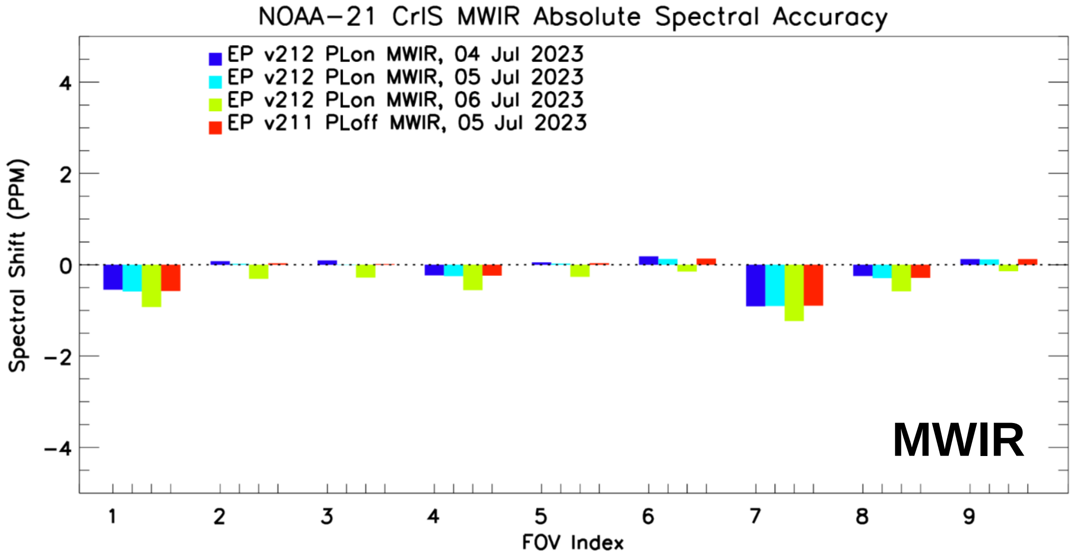
NOAA-21 CrIS SDR/GOES-18 ABI Radiometric Inter-comparisons

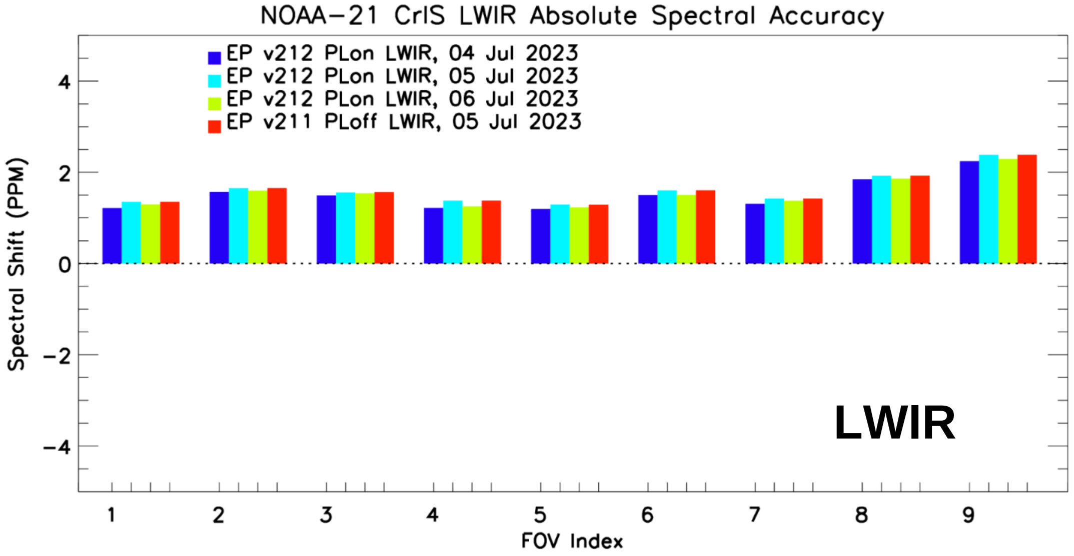
- ABI bands 8-11 correspond to CrIS MWIR band and bands 12-16 correspond to CrIS LWIR band.
- **The comparison of the two instruments shows temporally stable brightness temperature biases (within 0.2K), indicating the highly stable calibration of NOAA-21 CrIS Radiances.**

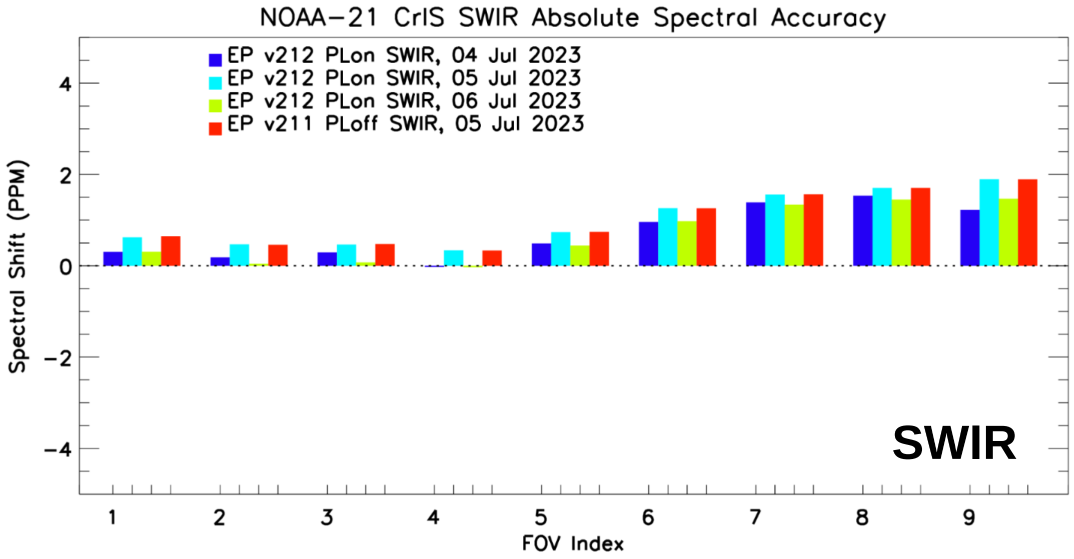


NOAA-21 CrIS Absolute Spectral Accuracy with EP v212 Update

- The NOAA-21 CrIS shows **consistent absolute spectral shift for all three bands** on July 4, 5, and 6 with EP v212 applied and **Polarization Correction** on using ADL.
- Absolute spectral shift **within 2 ppm for LWIR, MWIR, and SWIR band**.
- Spectral accuracy of the operational SDR data on July 5 with EP v211 as **reference**.

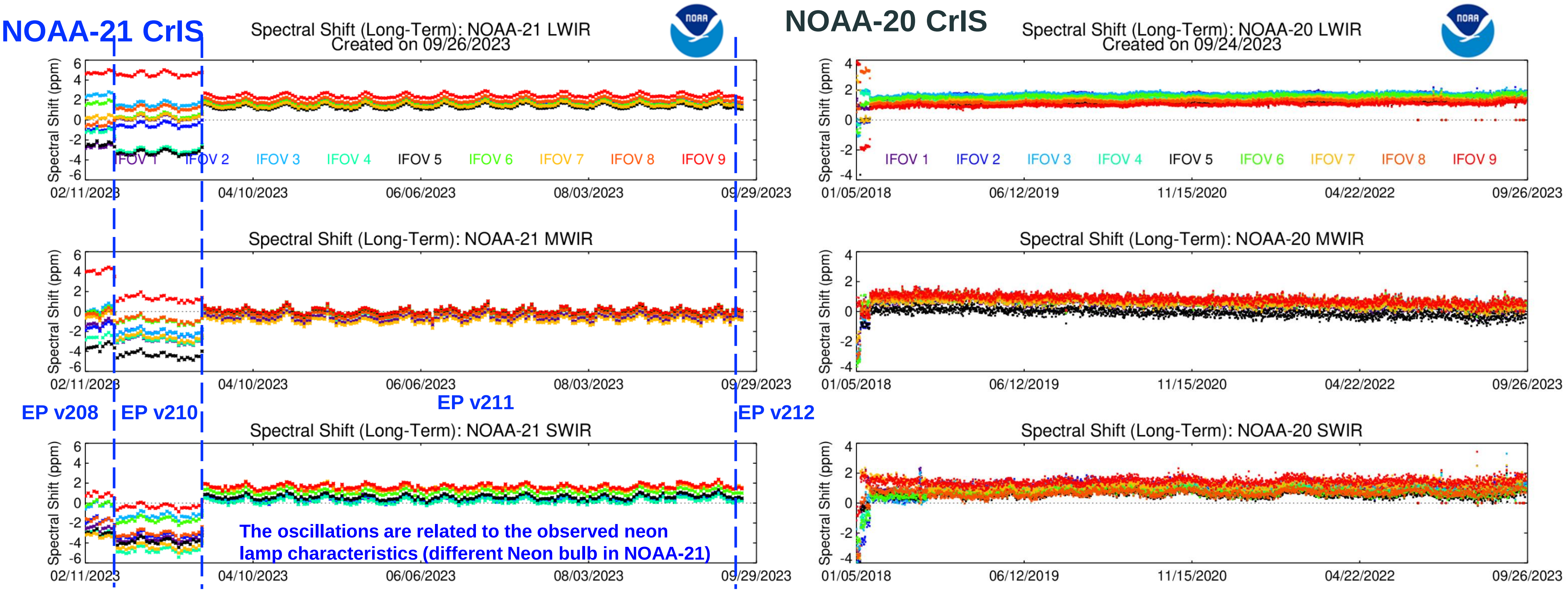






Provided by Kun Zhang

NOAA-21 CrIS Spectral Accuracy Comparisons with NOAA-20

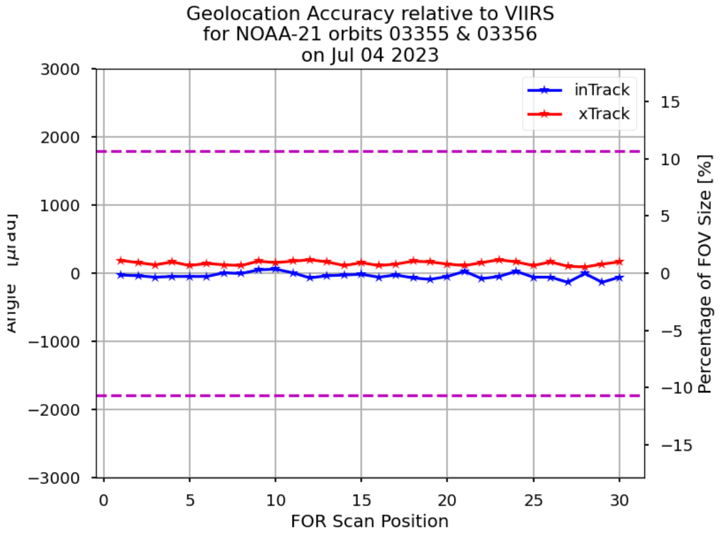


- **The NOAA-21 CrIS shows significant improvement of spectral accuracy after EP v211 update and maintains the same level of spectral accuracy after EP v212 update. NOAA-21 CrIS data provides accurate location of the rich absorption lines found in the infrared region.**
- **The absolute spectral accuracy is reduced to within +/- 2 ppm for all three bands and has consistent performance as the operational NOAA-20 CrIS.**

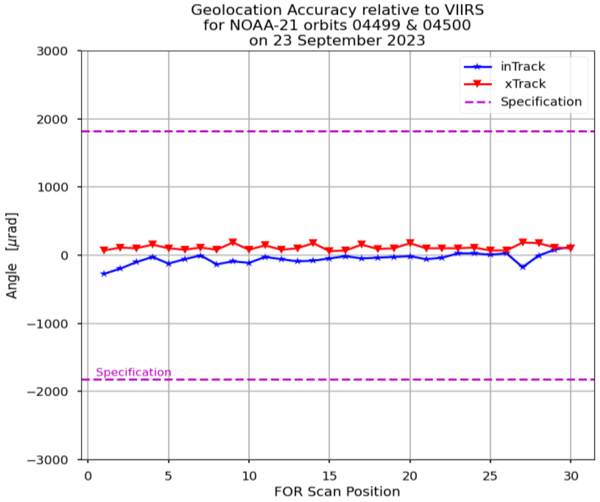
Provided by Kun Zhang

Geolocation Accuracy: NOAA-21 FOR 30, Time Series

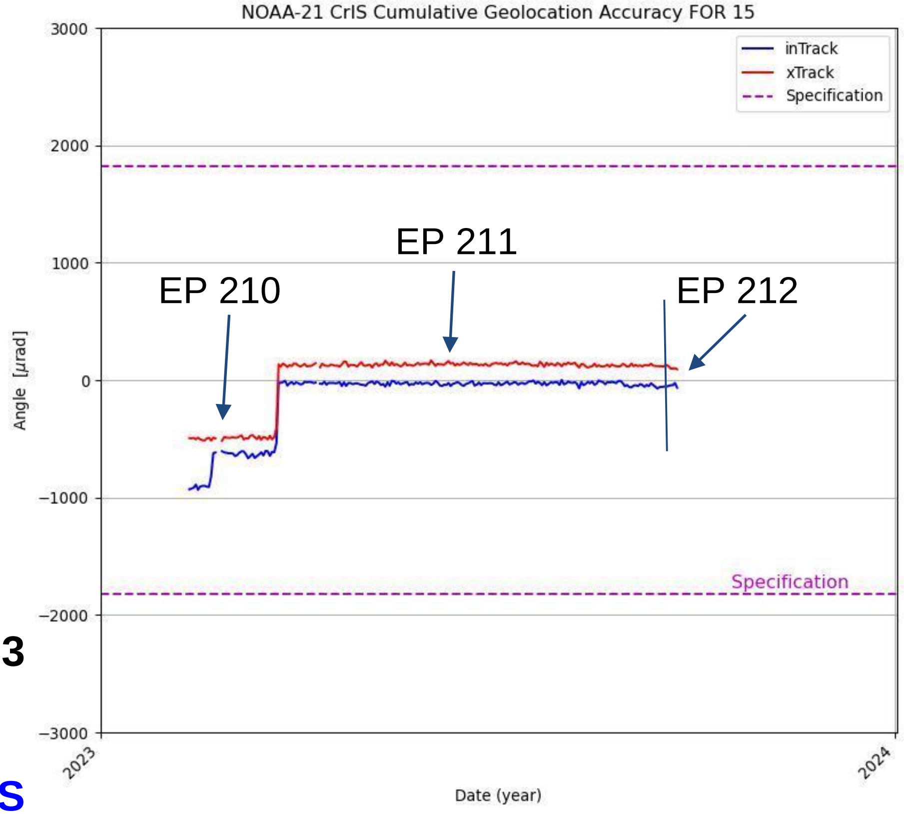
EP v211
(4 July 2023)



EP v212
(23 September 2023)



Time Series: On-Orbit Performance



- **Geolocation meets the requirements for EP212.**
- Worst case performance: **Geolocation uncertainty amounts to about 253 m. at nadir** with EP V212.
- **Future geolocation adjustment will consider adjustment of the VIIRS geolocation, potential annual/semi-annual variation.**

Accurate and precise geolocation is required to collocate CrIS with ATMS observations in order to combine them for retrievals or reduce representativeness errors in data assimilation applications.

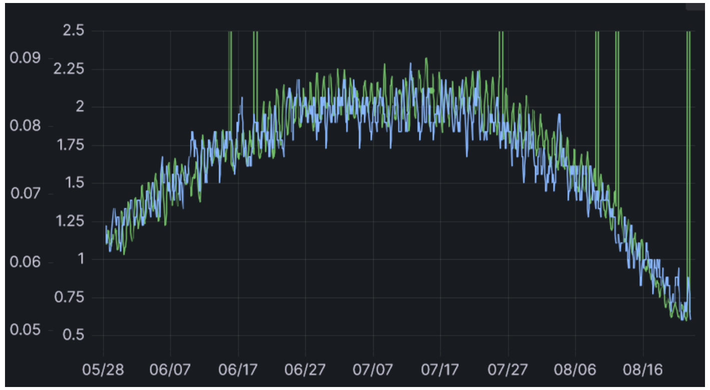
Geolocation accuracy is excellent for EP 212. Time series for EP212 is expected to improve after applying polarization correction.

Provided by Denis Tremblay

Caveats: Imaginary Radiance Observation

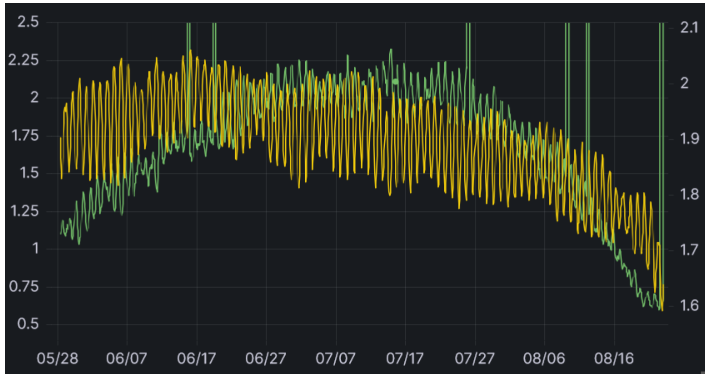
- What: **Slightly elevated imaginary radiance levels have been observed between 45-60 deg. S (Feb-Apr 2023) and 70-90 deg. S (after May 2023) Latitude Region.**
- Why: **Likely results from *increased heat flux in the instrument aperture* when exiting eclipse at high southern latitudes, causing a thermal transient seen in the Dynamic Alignment System response and Instrument temperatures.**
- **The impact of this feature has been quantified and does not impact the overall quality of the NOAA-21 CrIS SDR data.**
- **These affected scenes are captured by the Lunar Intrusion (marked as degraded) and Imaginary Radiance (marked as invalid) Quality Flags, helping to identify and reduce the impact on users.**

Long-Term Trend (May-August 2023)

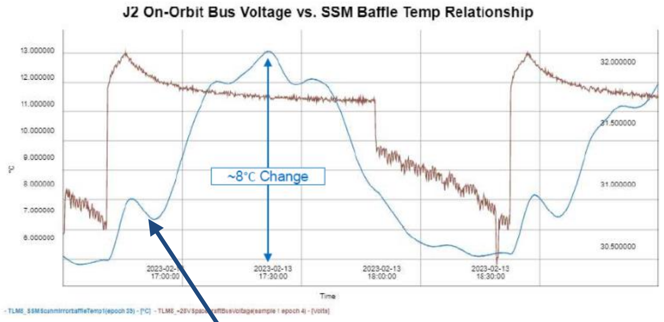


Near Shadow departure
Green: **peak Imaginary Radiance**
Blue: **local delta in Beam Splitter Temperature.**

STRONG seasonal correlation.



Near Shadow departure,
Green: **peak Imaginary Radiance**
Yellow: **delta in Scan Mirror Baffle Temperature.**



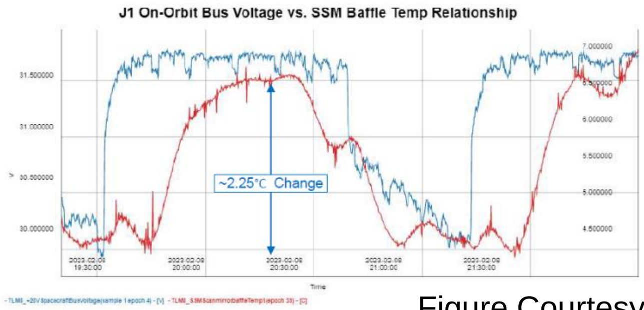


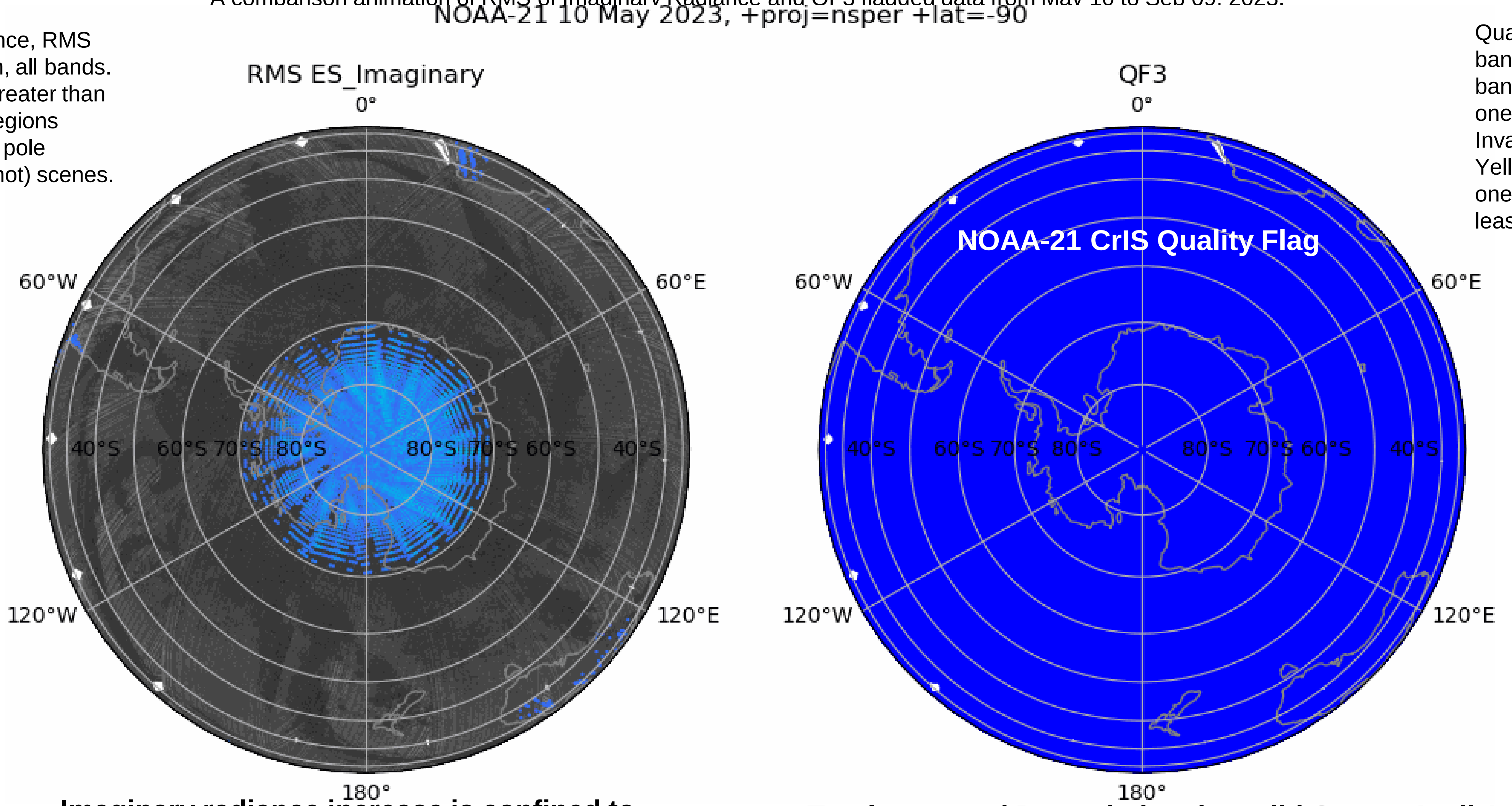
Figure Courtesy of L3 Harris

Heat pulse associated with the removal of a coating from the exterior of the baffle on J2 and forward

Comparison of Imaginary Radiance and Degraded/Invalid Flags

A comparison animation of RMS of Imaginary Radiance and QF3 flagged data from May 10 to Sep 09, 2023.

Imaginary radiance, RMS across spectrum, all bands. Blue indicates greater than 0.2. Dark blue regions outside of south pole indicate bright (hot) scenes.

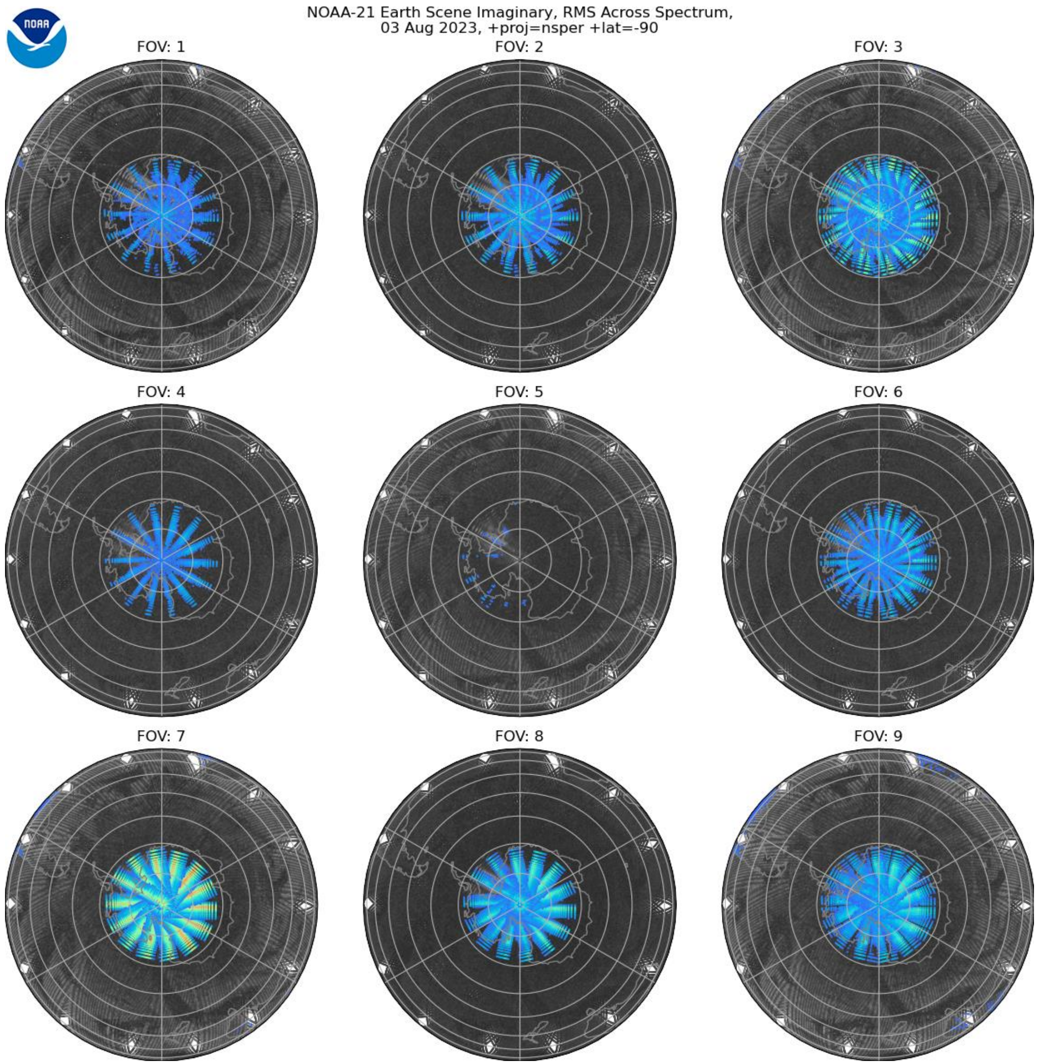


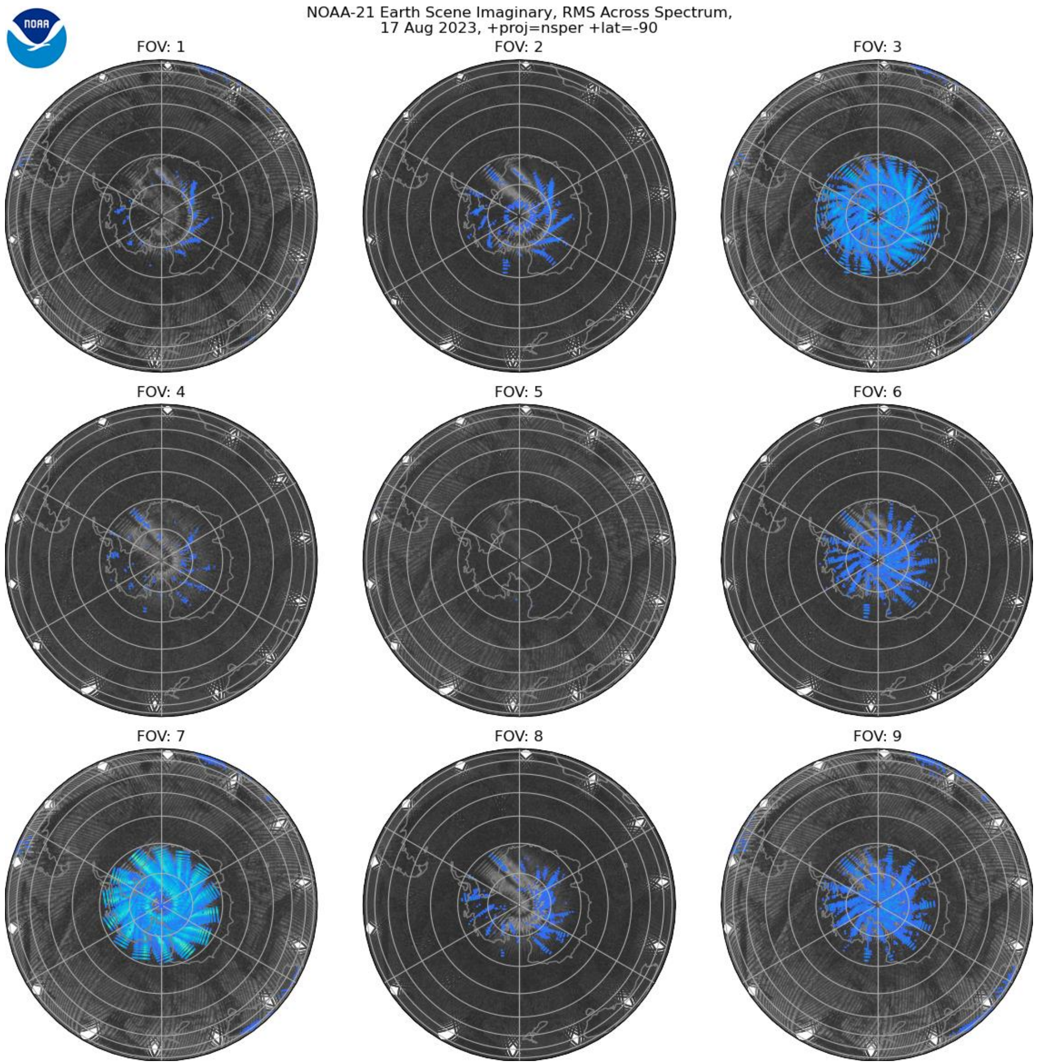
Quality Flag 3, all three bands. Blue: Good, all bands Green: Degraded, one of more bands, Red: Invalid, one or more bands. Yellow: Degraded in at least one band and Invalid in at least one other band.

Imaginary radiance increase is confined to within 70 degree South between May 10 to September 9.

Total Impacted Degraded and Invalid Cases, April 1 to August 31: 230,606 of 1,329,542,100 observations (**~0.02%**)
Worst Day: 2023-07-07 5,057 of 8,748,810 observations (**0.06%**)

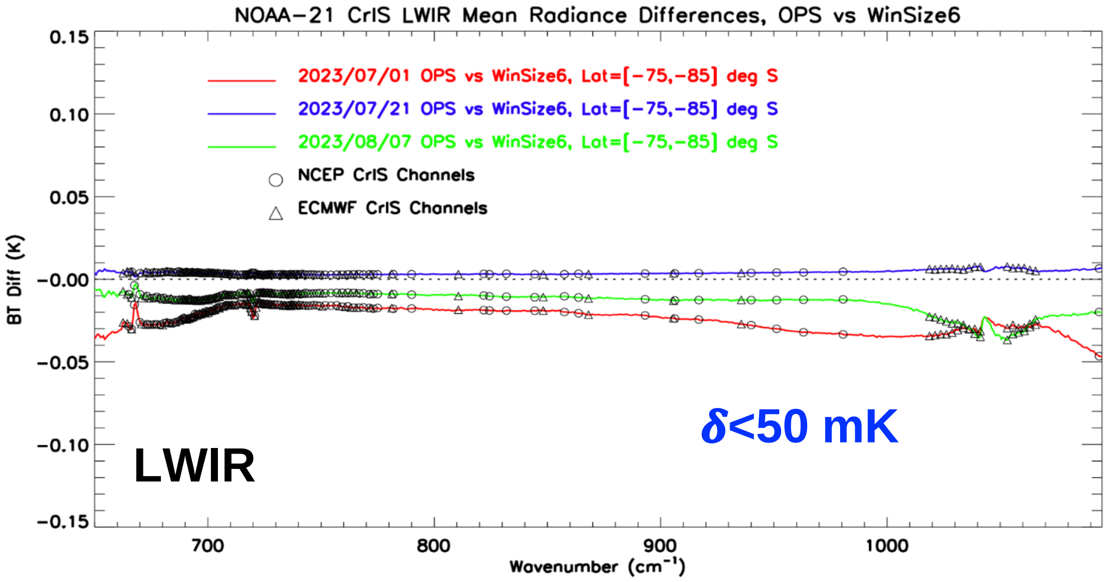
Imaginary Radiance as a function of FOV and Time

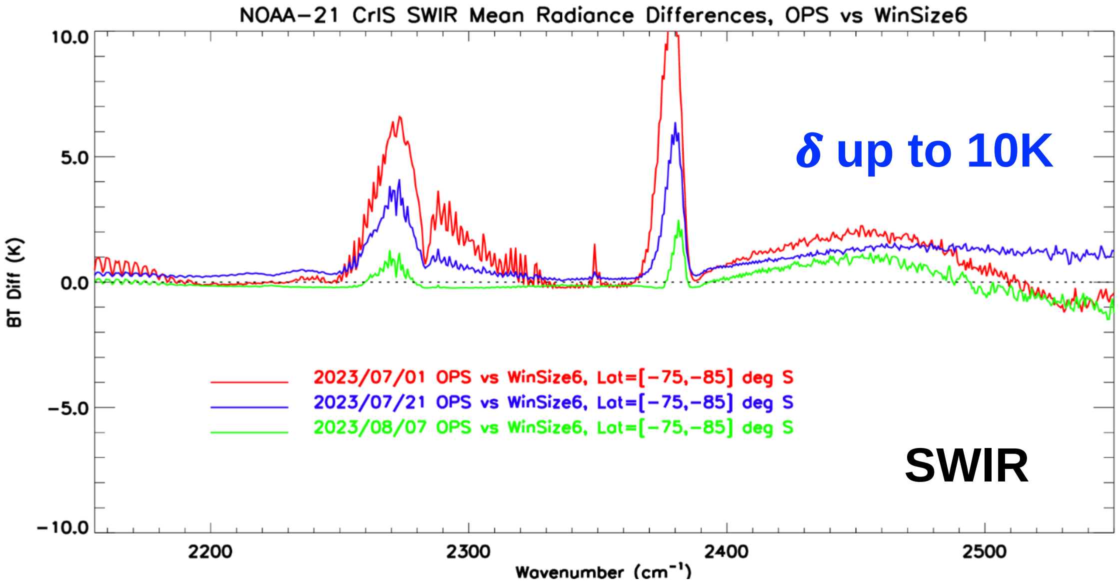


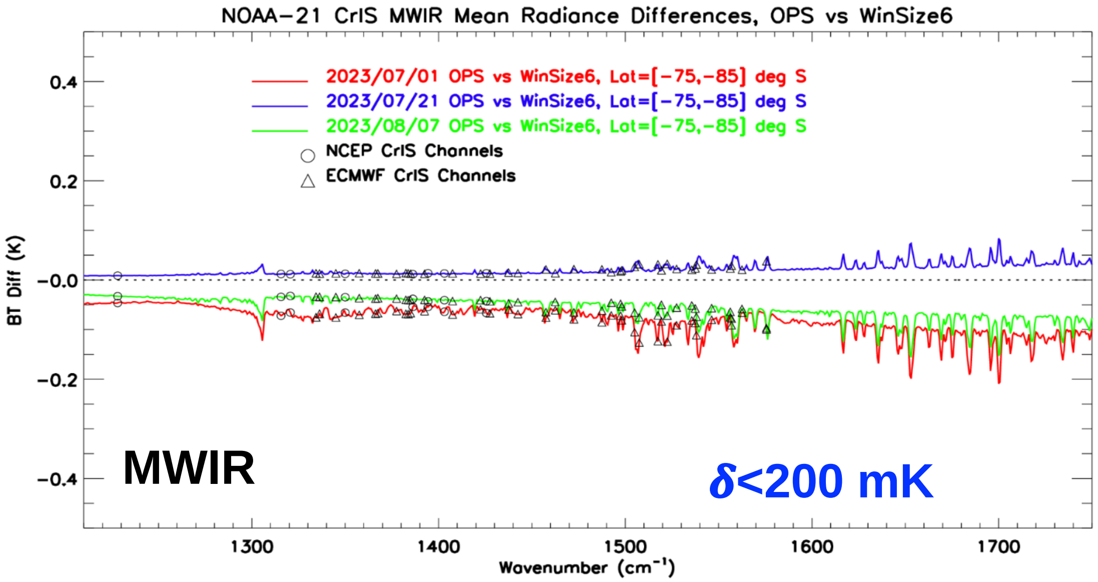


FOV 3 and FOV 7 are most impacted (Least impacted is FOV 5)

Radiometric Impact of NOAA-21 CrIS Elevated Imaginary Radiances







- **Between -75 and -85 degree latitude, a mean brightness temperature difference of ~50 mK for the LWIR band, ~200 mK for the MWIR band, and ~5.0 K for the SWIR band.**
- **The CrIS channels which are assimilated in NWP centers only consist of a subset of the LWIR and MWIR band.**
- **Radiometric impact was assessed using ADL with calication window size 6 as compared to the operational algorithm for three selected days when the impact reaches near maximum.**

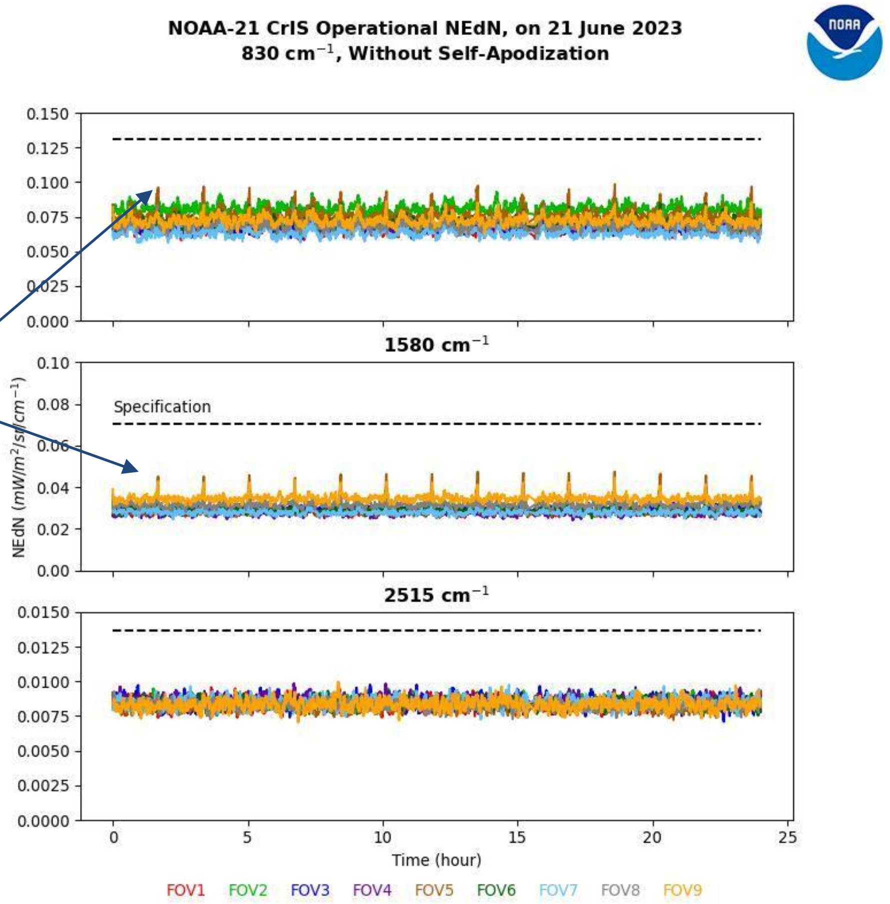
Provided by Kun Zhang

NOAA-21 CrIS on-orbit performance: Radiometric Noise Stability

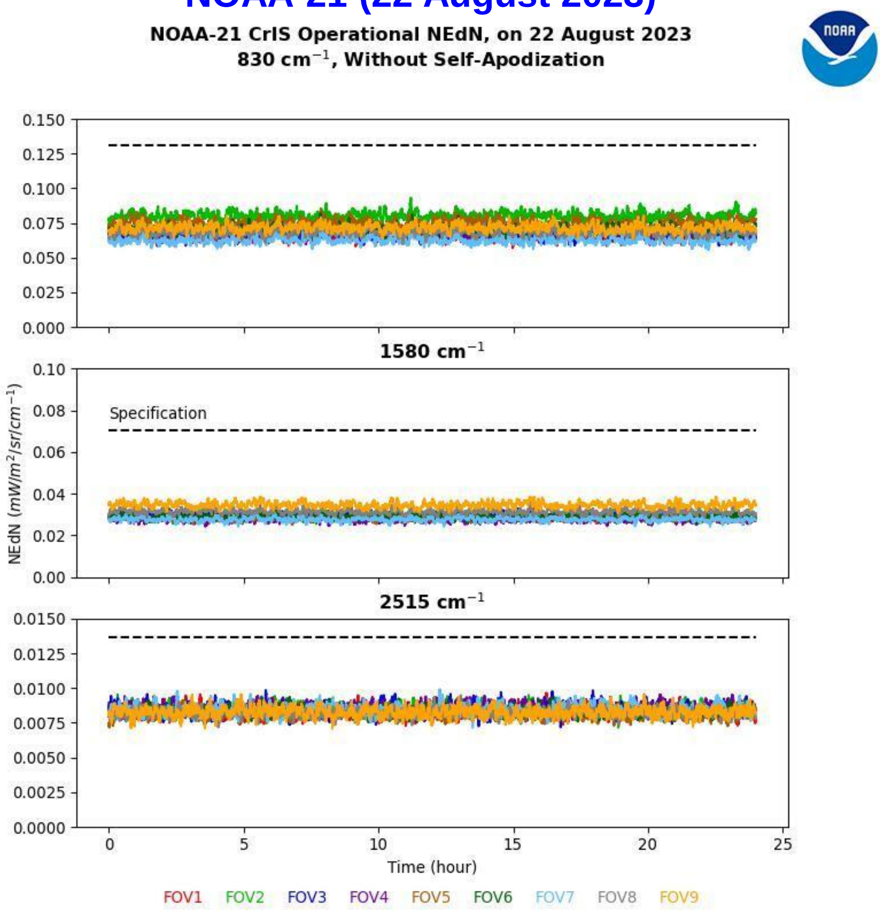
NEdN at Scan Level

Spikes appear from May to Mid-August

NOAA-21 (21 June 2023)



NOAA-21 (22 August 2023)



NOAA-21 CrIS Radiometric noise (NEdN) has shown stability and consistency for all detectors, and within Specification
There are Orbital-Periodic Noise Spikes Observed from May to Mid-August associated with the Imaginary Radiance Observation (Which peaked in the same time period)

User/Downstream Product Feedback (NOAA-21)

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Chris Burrows Chris.Burrows@ecmwf.int	ECMWF	Numerical Weather Prediction	"NOAA-21 CrIS looks to be very good quality. The standard deviations of O-Bs indicate that it is reasonable to assimilate this instrument with the same observation errors that we use for NOAA-20."
Andrew Collard andrew.collard@noaa.gov	NCEP	Global Environmental and Weather Prediction	"NOAA-21 CrIS performance is very similar to NOAA-20. We expect to be able to switch on this instrument in operations in the next month, although this may be delayed by any closure of the US government."
Haidao Lin haidao.lin@noaa.gov	CIRA/CSU and NOAA/OAR/GSL	Numerical Weather Prediction (regional)	"For the regional RRFS DA, the NOAA-21 CrIS-FSR data quality/impact look very good and comparable to NOAA-20."
Ken Pryor ken.pryor@noaa.gov	NOAA/STAR NUCAPS Team	Atmospheric Sounding	"Sounding products generated from NOAA-21 show consistency with the NOAA-20 sounding products. NUCAPS team is working on the NUCAPS algorithm optimization for NOAA-21 with updates to radiance tuning and first guess regression LUTs. Once implemented, these updates would further improve NOAA-21 sounding products."
Awdhesh Sharma awdhesh.sharma@noaa.gov	OSPO	Satellite and Product Operations	"we have been operationally running the NOAA-21 CrIS SDR and BUFR products. We expect to be able to generate J2 EDR sometime in November-December, 2023. Although this may be delayed by any closure of the US government"

Validated Maturity Review - Exit Criteria

- Validated Maturity Performance is well characterized and meets/exceeds the requirements:
  - 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 Validated Maturity Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Validated Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward

CrIS Validated Maturity Review - Exit Criteria

- Validated Maturity **Performance is well-characterized** and meets/exceeds the requirements based on a comprehensive assessment of on on-orbit NOAA-21 CrIS SDR data.

- **No data gaps** associated with the performance of the SDR calibration algorithm have been identified.

Check List - Validated Maturity

Validated Maturity End State	Assessment
Product performance has been demonstrated over a large and wide range of representative conditions (i.e. global, seasonal)	Yes
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
Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.	Yes
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

Product Requirements Met

Band	Longwave		Mid-wave		Shortwave	
Attribute	Requirement	Meet Req?	Requirement	Meet Req?	Requirement	Meet Req?
Wavenumber (cm^{-1})	650-1095	YES	1210-1750	YES	2155-2550	YES
Spectral Range (µm) (J1MSS-1586)	9.13-15.38	YES	5.71-8.26	YES	3.92-4.64	YES
Spectral Resolution (cm^{-1}) (J1MSS-2440)	0.625	YES	0.625	YES	0.625	YES
Polarization	NS	-	NS	-	NS	-
Radiometric Uncertainty @ 287K BB (%) (J1MSS-1584)	0.45	YES	0.58	YES	0.77	YES
Radiometric Stability @ 287K BB (%) (J1MSS-1592)	0.40	YES	0.50	YES	0.64	YES
Maximum NEdN ($mW/(m^2$-sr-$cm^{-1})$) (J1MSS-1583)	0.45 @ 670 cm^{-1} 0.15 @ 700 cm^{-1} 0.15 @ 850 cm^{-1} 0.15 @ 1050 cm^{-1}	YES	0.078 @ 1225 cm^{-1} 0.064 @ 1250 cm^{-1} 0.069 @ 1500 cm^{-1} 0.075 @ 1700 cm^{-1}	YES	0.013 @ 2200 cm^{-1} 0.014 @ 2350 cm^{-1} 0.014 @ 2550 cm^{-1}	YES
Nadir FOV (km) (J1MSS-1590)	15	YES	15	YES	15	YES
Spectral Uncertainty (ppm) (J1MSS-1587)	10	YES	10	YES	10	YES

NOAA-21 CrIS SDR Performance vs JPSS L1-Requirements

Band	Minimum Wavenumber Range[1] (cm^{-1})	# of Channels [4]	Spectral Resolution (cm^{-1})[1,3]	Maximum NEdN @287K BB[2] ($mW/m^2/sr/cm^{-1}$)	Radiometric Accuracy @287K[1,2] (%)	Maximum Spectral Uncertainty[1] (ppm)	Geolocation Mapping Uncertainty (3σ)[1] (km)
LWIR	650-1095	713	0.625	(0.2129) 0.45 @ 670 cm-1, (0.1204) 0.15 @ 700 cm-1, (0.0739) 0.15 @ 850 cm-1, (0.0679) 0.15 @ 1050 cm-1	(0.15) 0.45	(2) 10	(0.76) 5
MWIR	1210-1750	865	0.625	(0.02384) 0.078 @ 1225 cm-1 (0.02322) 0.064 @ 1250 cm-1 (0.02664) 0.069 @ 1500 cm-1 (0.03747) 0.075 @ 1700 cm-1	(0.18) 0.58	(2) 10	(0.76) 5
SWIR	2155-2550	633	0.625	(0.00791) 0.013 @ 2200 cm-1 (0.00689) 0.014 @ 2350 cm-1 (0.01575) 0.014 @ 2550 cm-1	(0.35) 0.77	(2) 10	(0.76) 5

[1]JPSS Algorithm Specification Volume I: Software Requirement Specification (SRS) for the CrIS RDR/SDR, 474-00448-01-03, Revision I, October 24, 2019.
[2]JPSS Level 1 Requirements Document Supplement (L1RDS) – Final, JPSS-REQ-1002/470-00032, Revision 2.11, Rev. 2.1, 02/07/2019. The NEdN Maximum values for the MWIR and SWIR are the result of scaling the NEDN values, defined in Table 4.3, by a factor of $\sqrt{2}$ and 2, respectively.
[3]JPSS-2 CrIS Performance Requirements Document (PRD), 472-00346, Revision B, 03/10/2016.
[4]JPSS CrIS SDR ATBD) for Full Spectral Resolution, June 14, 2018.

Risks, Actions, and Mitigations

Identified Risk	Description	Impact	Action/Mitigation and Schedule
None	**No major risks** have been identified for the NOAA-21 CrIS SDRs.	None	None

Recommendation

Based on the comprehensive assessment performed on the NOAA-21 CrIS SDR data after the upload of the EPv212 on Sep. 20 and PCT CCR 6761 implementation on Sep. 26, **the CrIS SDR Cal/Val Team recommends the transition of the NOAA-21 CrIS SDR data to the Validated Maturity Level.**

Justification (1/2)

After NOAA-21 CrIS SDR provisional maturity on March 23, 2023, CrIS SDR team members continued the assessment and analysis of both CrIS on-orbit data and special post-launch tasks (PLT) data, including CrIS science RDR, SDR, and GEO data products. This includes final refinements of the Radiometric Nonlinearity using FOV2FOV radiometric comparisons, verification of the ILS parameters; and the updates made with the upload of Engineering Packet version 212 and PCT update CCR 6761 further refinement of geolocation parameters, change in the interval between neon calibration reference measurements, and derivation of polarization correction. Based on the nearly one hundred ninety days of continuous intensive evaluation and monitoring of CrIS data, the following assessments of the CrIS instrument and data products are given:

1. On-orbit NEdN: all FOVs and bands are within the specification and are comparable to S-NPP and NOAA-20 CrIS
2. Radiometric uncertainty: The radiometric uncertainty expressed as a % of the 287 K blackbody radiance, in terms of the maximum 1-sigma radiometric uncertainty for each band, is 0.15%, 0.18%, and 0.35% for the Longwave, Midwave, and Shortwave respectively. This falls well within the specification for each band.
3. The mean O-B bias over clear-sky CRTM simulations remains consistent within ± 2.0 Kelvin for LWIR, MWIR, and SWIR band since the beginning of the NOAA-21 CrIS mission (~7 months). This accounts for the systematic biases between CRTM and Observation (which has been seen with SNPP and NOAA-20 CrIS).
4. With respect to the radiometric consistency between NOAA-20 and NOAA-21 CrIS (over the 3 spectral bands), the majority of channels show radiometric differences within ± 0.2 K.
5. The radiometric FOV2FOV relative consistency is within ±0.1K for all three bands.
6. Spectral uncertainty: absolute spectral offsets for all three bands are all within ±2 ppm, and relative spectral offsets for all three bands are within ±1 ppm. This assessment accounts for changing the interval between neon lamp spectral calibration measurements to 45,864 seconds (originally 6,552 seconds).

Justification (2/2)

7. Geolocation uncertainty: The total geolocation uncertainty is 760 meters 3-sigma where the specification is 5 km. Current uncertainty is comparable to S-NPP and NOAA-20 CrIS.
8. NOAA-21 CrIS SDR products have been reliably produced by IDPS since the first light data was produced on February 10, 2023.
9. Intercomparisons of NOAA-21 CrIS vs NOAA-21 VIIRS show very good agreement (mean of all scene temperature biases are within 50 mK).
10. Intercomparisons of NOAA-21 CrIS vs Metop-B IASI, Metop-C IASI, all show very good radiometric agreement (biases are within 0.5 K).
11. Double differences via calculated spectra and IASI and AIRS, show similar results and show very good agreement between NOAA-20 CrIS and NOAA-21 CrIS (double differences are within 0.5 K).
12. Intercomparisons between GOES-16 and GOES-18 ABI and NOAA-21 CrIS demonstrate consistent results across all bands over the assessment time period (bias within 0.2K).
13. NOAA NUCAPS team has generated and analyzed NOAA-21 trace gasses, temperature, water vapor and other EDR products and is comparable with operational NOAA-20 EDR's.
14. Feedback from NWP was provided by representatives of ECMWF, NCEP, OSPO, CIRA/CSU and NOAA/OAR/GSL Feedback. They provided agreement that the performance of the NOAA-21 CrIS SDR product is consistent with the NOAA-20 CrIS SDR product with respect to number of assimilated channels, as well as statistics including radiometric biases and variance.

Path Forward

The CrIS SDR team will work diligently as we transition to long term monitoring of the NOAA-21 CrIS SDR Product. Some highlights of the expected long-term objectives include:

- Perform long-term inter-comparison with other sensors, including RO products.
- Continue to monitor CrIS instrument stability and performance, as well as SDR data quality
- Continue to monitor and investigate the 40S-90S latitude imaginary radiance behavior in order to observe the annual variation of this phenomenon. A formulation of possible mitigation strategies will also be investigated.
- As part of continuing operations, potential anomalies that impact the calibration of the sensor that occur during the CrIS instrument’s mission will be addressed.

Documentations (Science Maturity Checklist)

Science Maturity Checklist	Yes ?	Where
ReadMe for Data Product Users	Yes	https://docs.google.com/document/d/1haqvdtuIZJDZzShT7nwjZ1ElKlr6rDFM/edit?usp=sharing&ouid=108646070675148611458&rtpof=true&sd=true
Algorithm Theoretical Basis Document (ATBD)	Yes	https://docs.google.com/document/d/14Nqk6b-Ay--dNywRZg8iWA_GZs8NvPyY/edit?usp=share_link&ouid=108646070675148611458&rtpof=true&sd=true
Algorithm Calibration/Validation Plan	Yes	https://docs.google.com/document/d/1Ce4FS8GTtkx-_E50efIRM1mWGxaPK-VX/edit?usp=share_link&ouid=108646070675148611458&rtpof=true&sd=true
(External/Internal) Users Manual	Yes	https://www.star.nesdis.noaa.gov/jpss/documents/UserGuides/CrIS_SDR_Users_Guide1p1_20180405.pdf
System Maintenance Manual (for ESPC products)	Not Applicable	Not Applicable
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	In Progress	In Progress
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	In Progress	In Progress

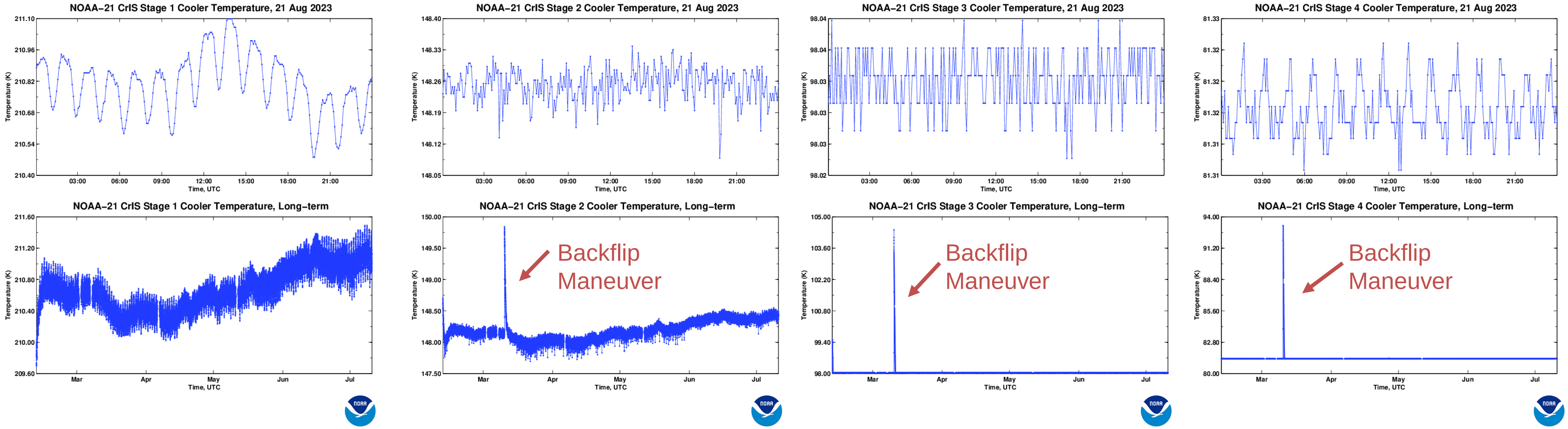
Acknowledgements (Toward NOAA-21 CrIS Validated Maturity)

Acknowledgement and thanks are extended to all individuals and organizations participating in the intensive NOAA-21 CrIS Pre-launch analysis, Early Checkout, and Intensive Cal/val toward Validated Maturity, an example of Team Effort, Hard Work, Dedication and Professionalism: **NOAA/STAR, NASA, University of Wisconsin, University of Maryland Baltimore County, L3Harris, Logistikos, Northrop Grumman, and MIT**.

CrIS SDR Validated Science Review Supplemental Material

NOAA-21 Detector Cooler System Telemetry

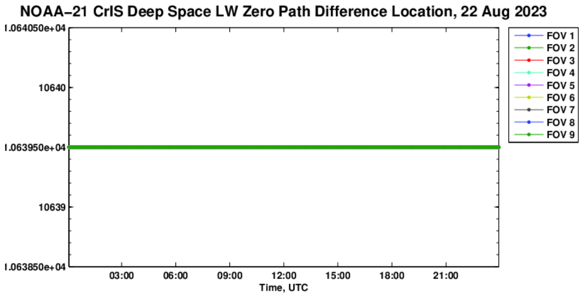
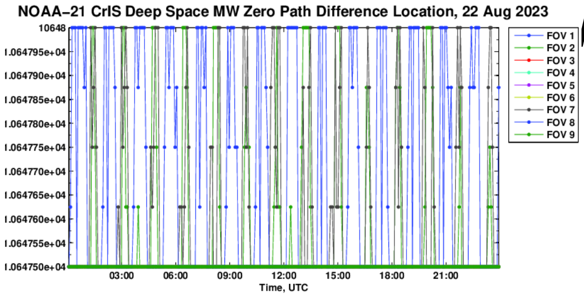
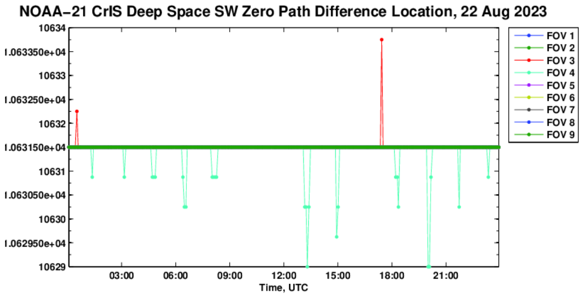
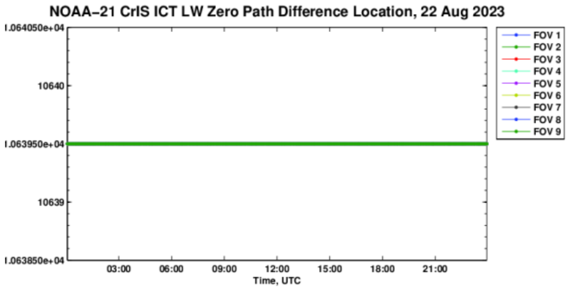
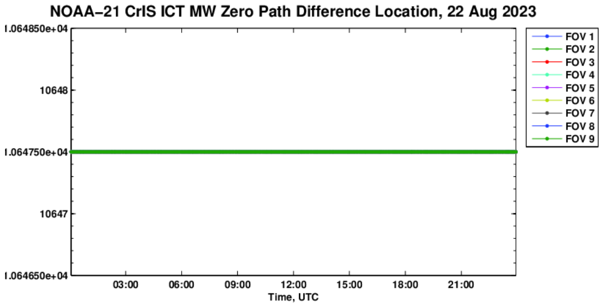
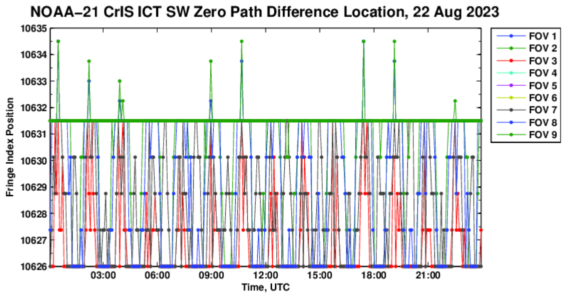
- **Detector Stage Coolers are at nominal temperatures, and stable since the Backflip Maneuver (~ 7 months)**
- Spike in temperature of coolers during **Spacecraft Backflip Maneuver on 3/10**, but temperatures have since **lowered down once more to nominal temperatures and stabilized**.



Provided by Peter Beierle

NOAA-21 Zero Path Difference (ZPD) Location

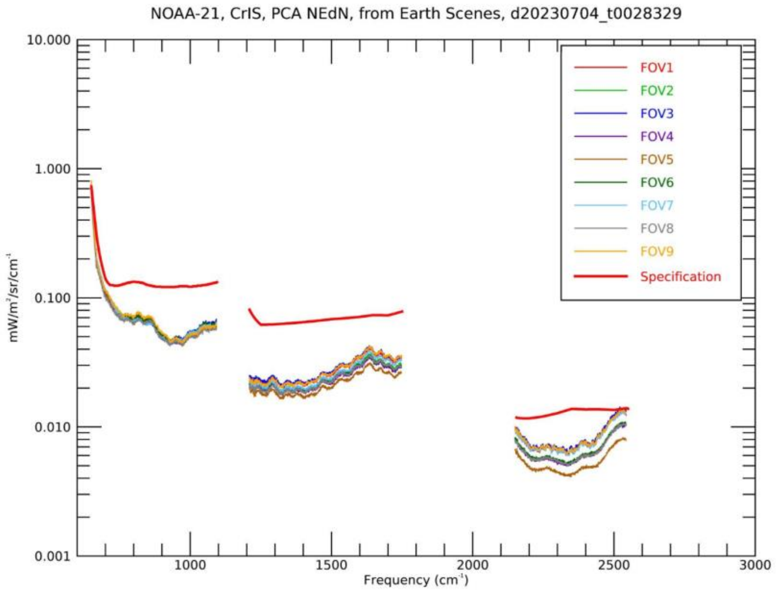
NOAA-21 CrIS Interferometer's Zero Path Difference (ZPD) locations are at a nominal value and are stable.

	LW		MW
Deep Space			
ICT			

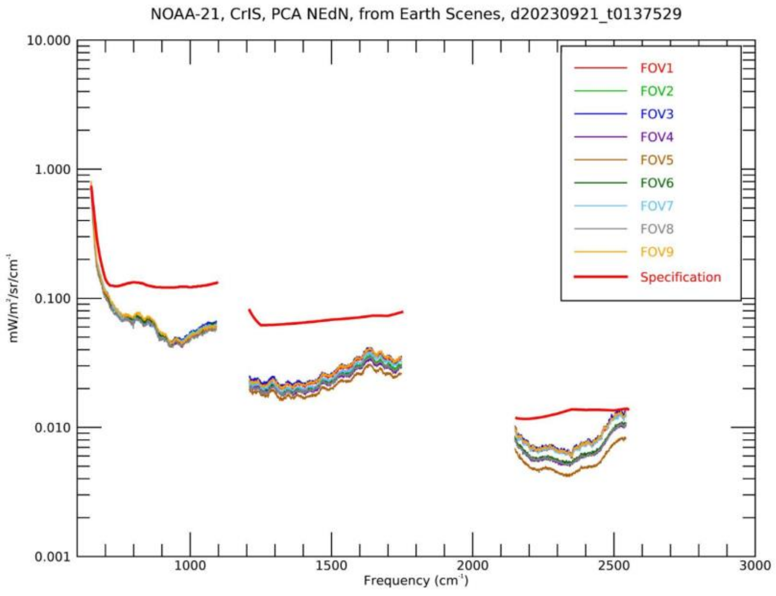
Provided by Peter Beierle

NOAA-21 CrIS On-orbit Performance: Radiometric Noise

NOAA-21 EP 211, 7/4/2023



NOAA-21 EP 212, 9/21/2023



PCA NEdN (Turner Method) on 9/21/2023 from SDR on-orbit Earth Scenes for EP 211 and EP 212.

NEdN meets the requirements.

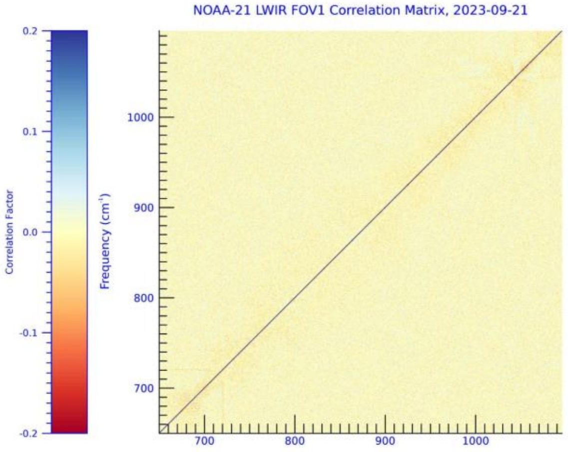
- EP 211 and EP 212 NEdN are consistent, and **on-orbit NEdN already meets the requirements.**
- **NOAA-21 CrIS shows high consistency noise performance between FOVs.**
- FOV spread in SW is a known effect of the algorithm (ISA correction) when applied to full resolution spectra.
- Specification line (bold red) does not include the self-apodization (or ILS) effects whereas the radiometric noise includes these effects (see slide 47).

Provided by Denis Tremblay

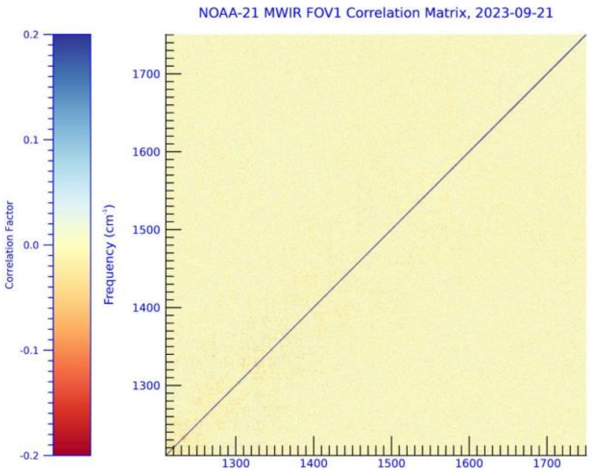
NOAA-21 CrIS on-orbit performance: Full Correlation Matrix for EP 212

NOAA-21 on-orbit Full Correlation Matrices for FOV 1 (LWIR, MWIR, SWIR) on 9/21/2023 for EP212

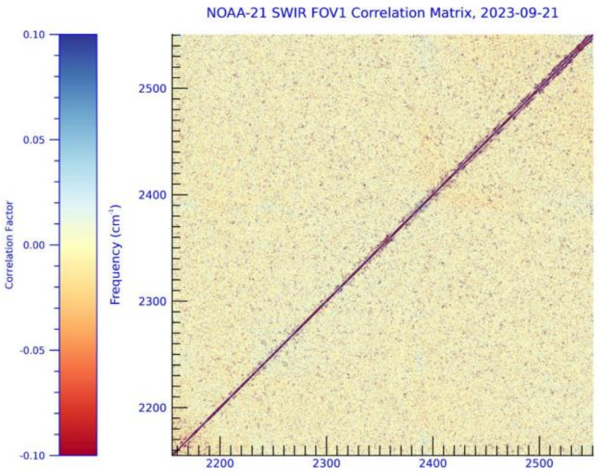
LWIR



MWIR



SWIR



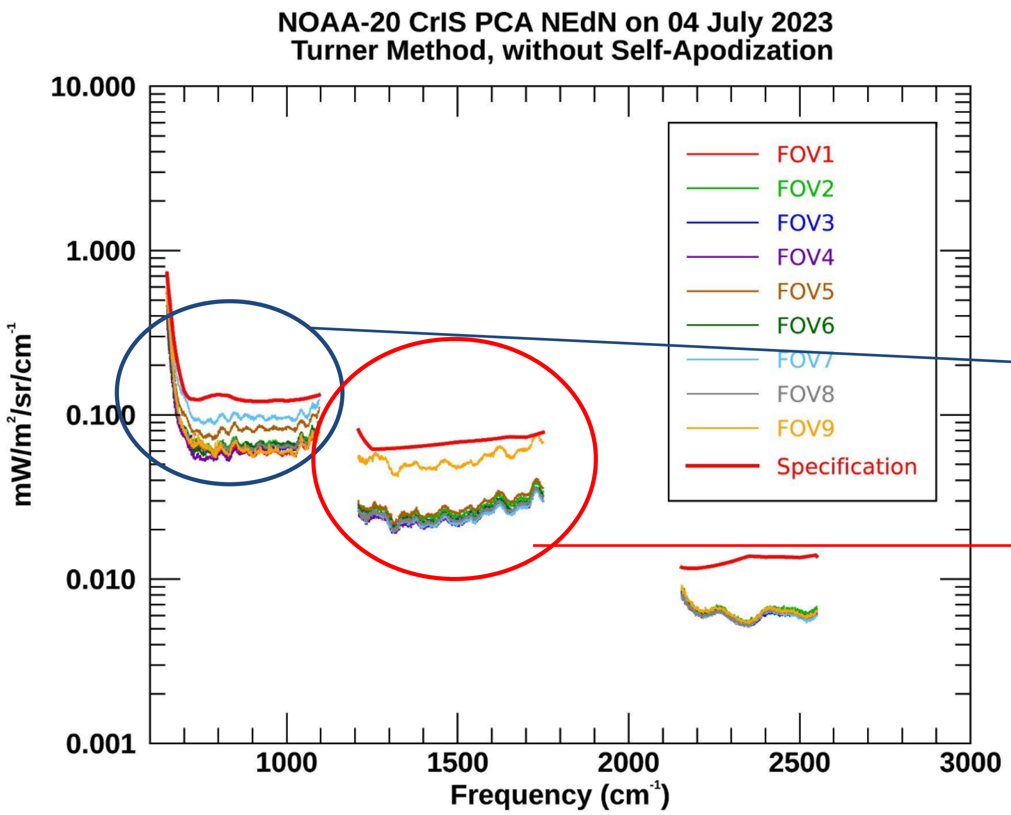
- SWIR near off-diagonal high values are due to SA effect (most for side FOVs, less for side FOVs, lesser for center FOV). **This is similar to SNPP and NOAA-20 CrIS as expected.**
- **There is no sign of high cross correlation in noise between the channels.**

Provided by Denis Tremblay

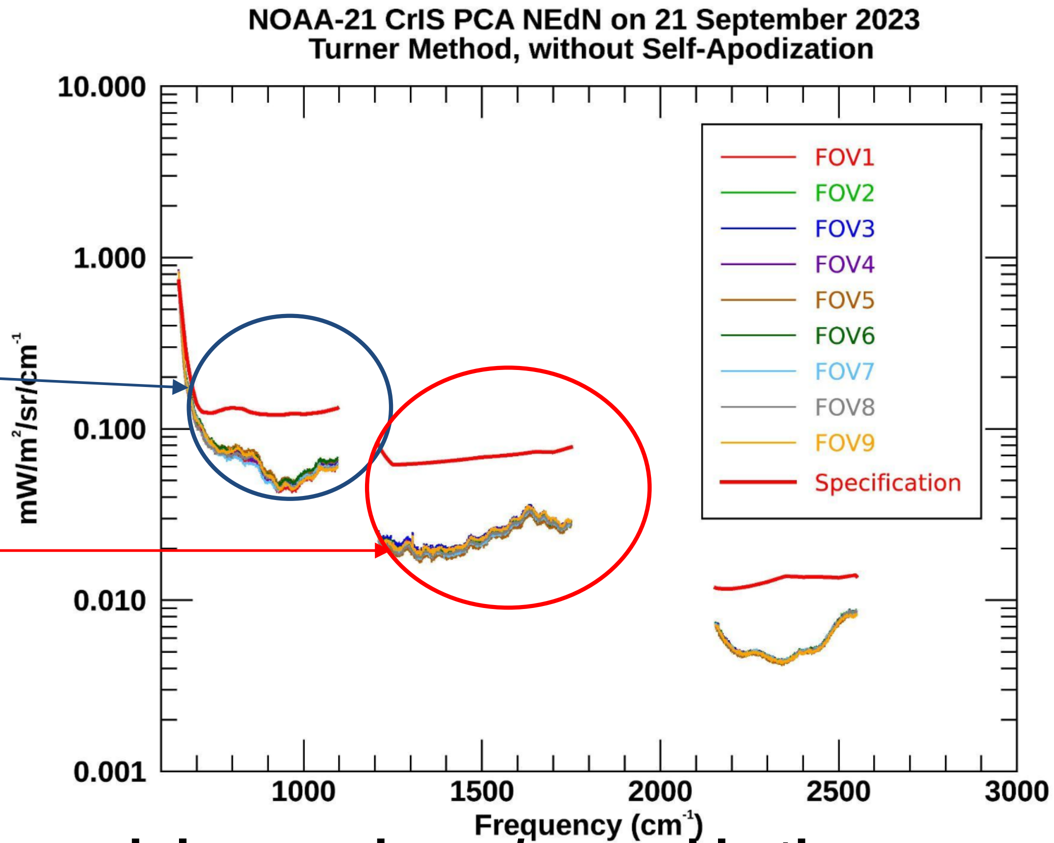
NOAA-21 CrIS EP 212 On-orbit Noise Performance vs NOAA-20

NOAA-21 PCA NEdN Turner Method on 9/21/2023 (Without Self-Apodization effect)

NOAA-20



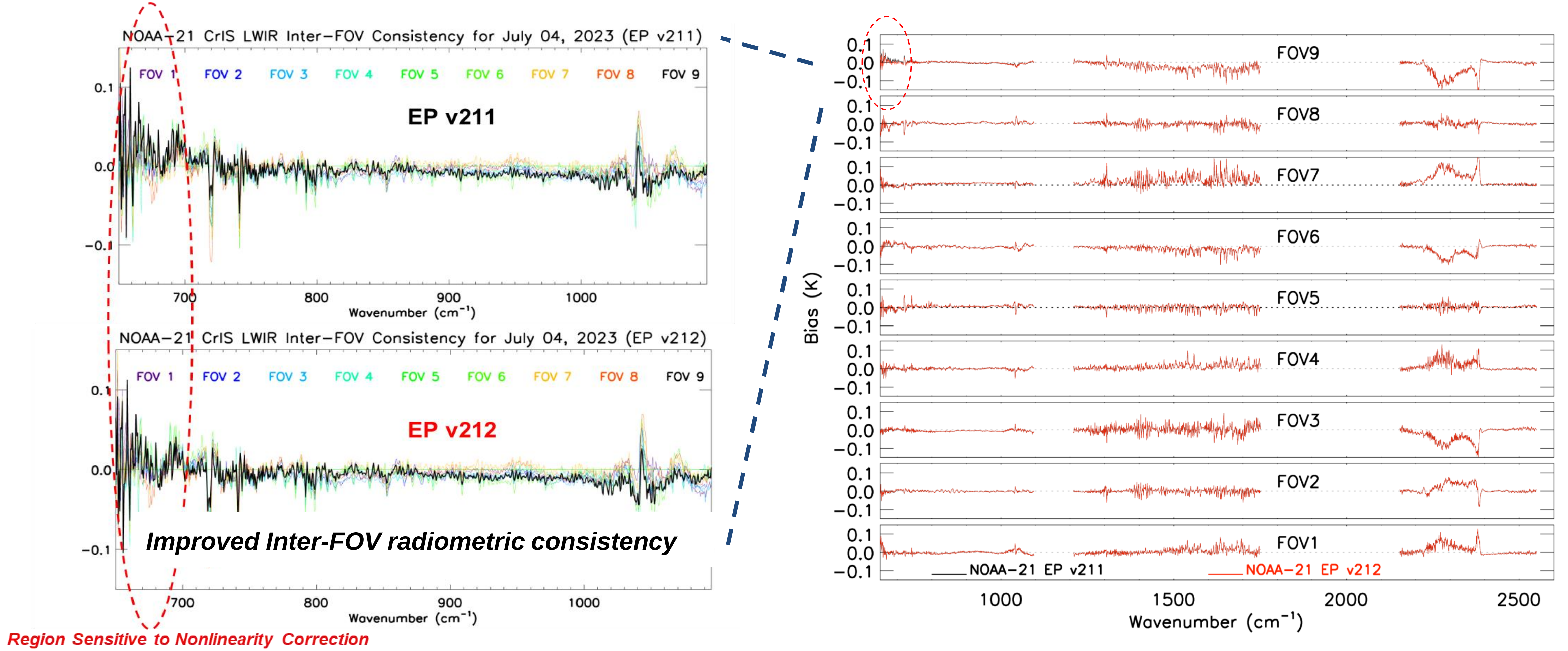
NOAA-21



NOAA-21 has **no outliers in the MWIR** and has **much less variance/spread in the LWIR and MWIR** bands for NEdN (noise). **Improved consistency in noise levels between the FOVs.**

Provided by Denis Tremblay

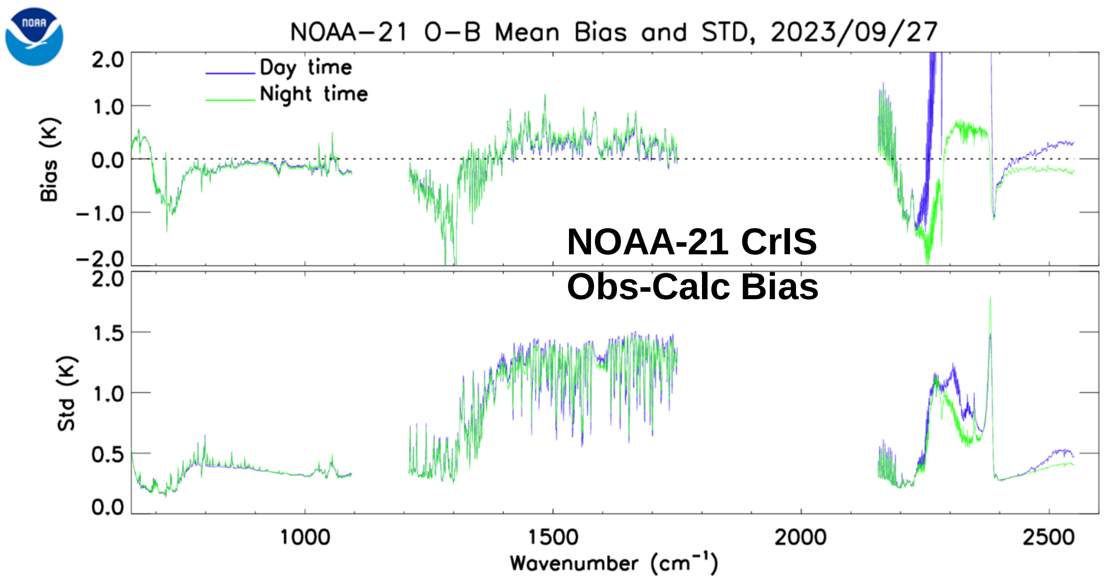
NOAA-21 CrIS FOV-2-FOV Variability with EP v212 Update

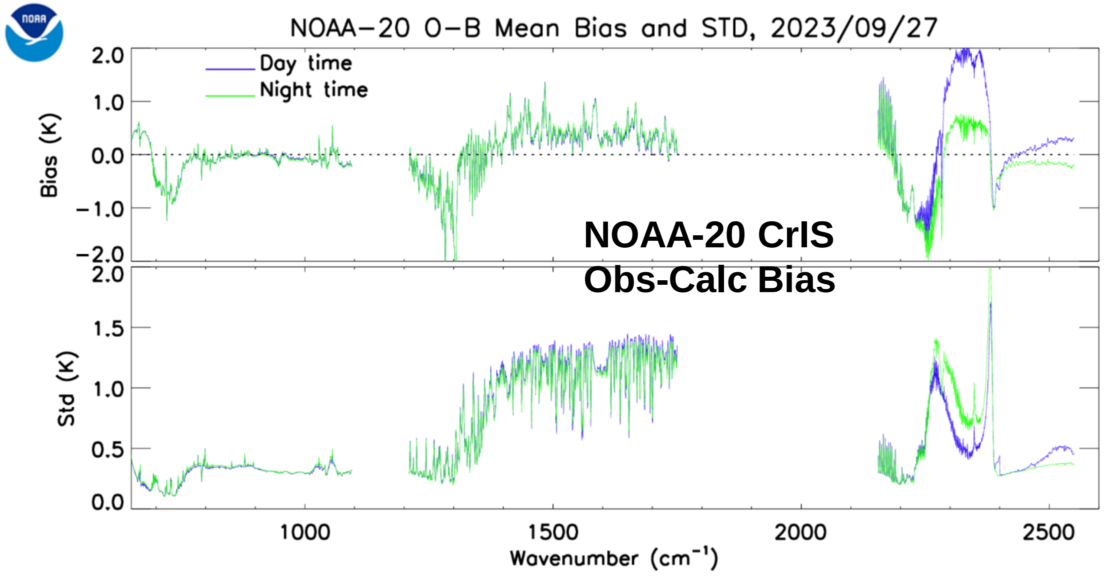


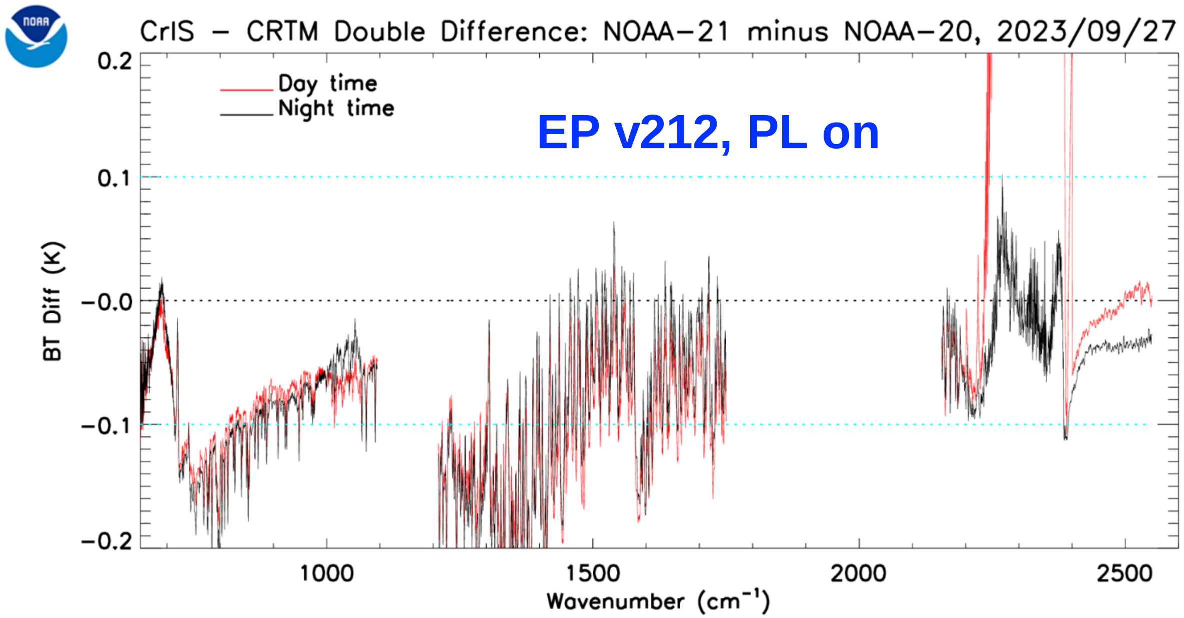
- The NOAA-21 CrIS FOV-2-FOV relative radiometric variability is **within +/- 0.1 K for all three bands with the Engineering Packet v212 update.**
- **Inter-FOV radiometric consistency shows small but observable improvement with the new EP v212 in the circled spectral range for LW FOV9.**

Provided by Kun Zhang

NOAA-21 CrIS Radiometric Comparison with NOAA-20 CrIS







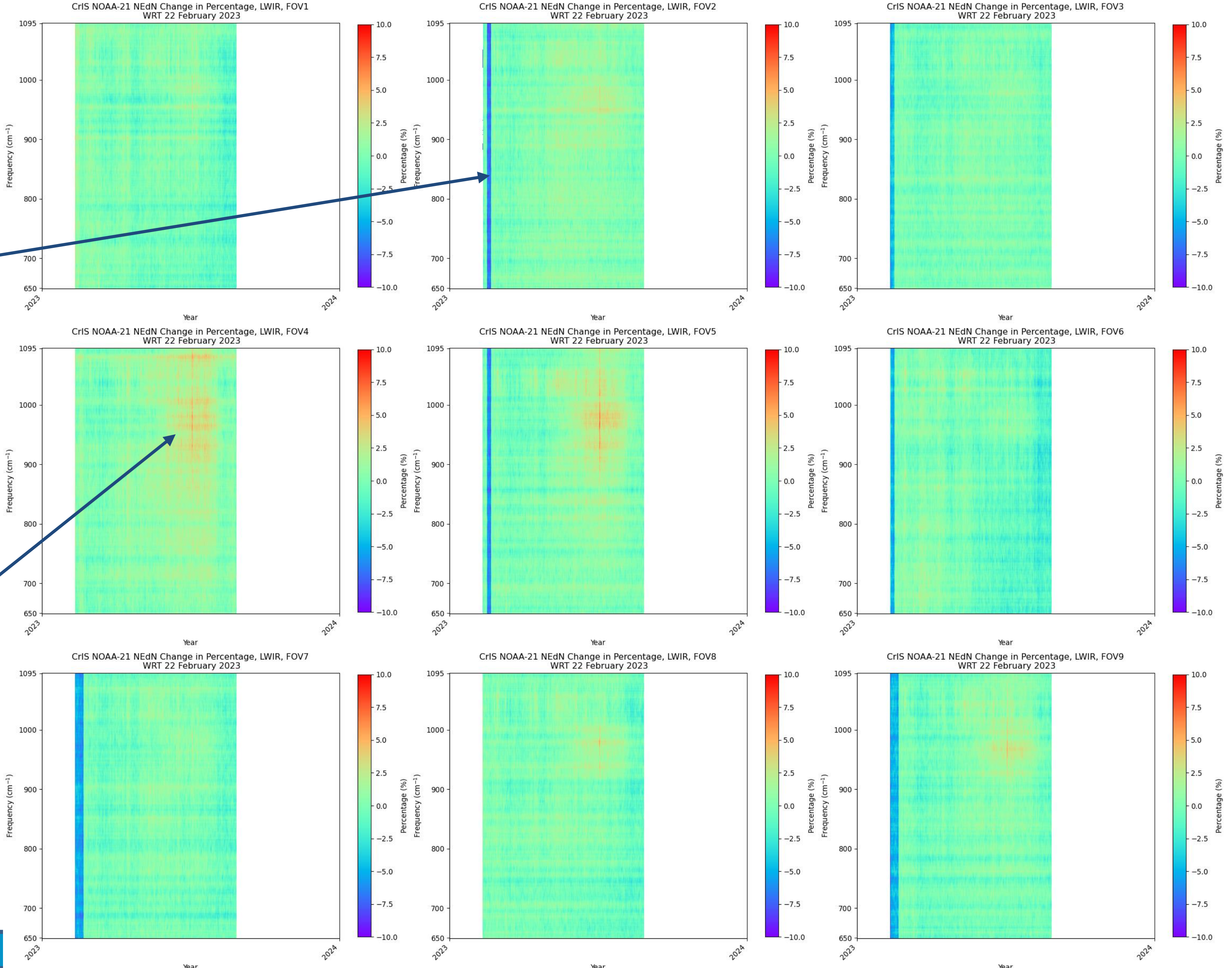
- **Radiometric differences with the latest calibration table update (EP v212) and the PCT update for NOAA-21 CrIS are within +/- 0.1 K for most of channels in three bands.**
- **The polarization correction was turned on for both NOAA-21 and NOAA-20 CrIS in this intercomparison.**
- All FOVs and FORs for clear-sky observations over ocean between +/- 65 deg latitude were selected for July 5, 2023.

Provided by Kun Zhang

Time Series of Change in Radiometric NEdN Noise, LWIR, all FOVs

- **LWIR Noise remains stable and within Specifications over time across the LWIR Band, as indicated by the change in noise with respect to Feb 22, 2023**
- **High NEdN during the EOC.**
- **Noise relative increase from May to August 2023 across the bands (wrt 22 Feb. 2023) associated with the elevated imaginary part artifact (seasonal/annual effect).**
- ***The increase in noise is case by a rapid change in the instrument self emission and responsivity terms not captured by the mean of the sliding window.***

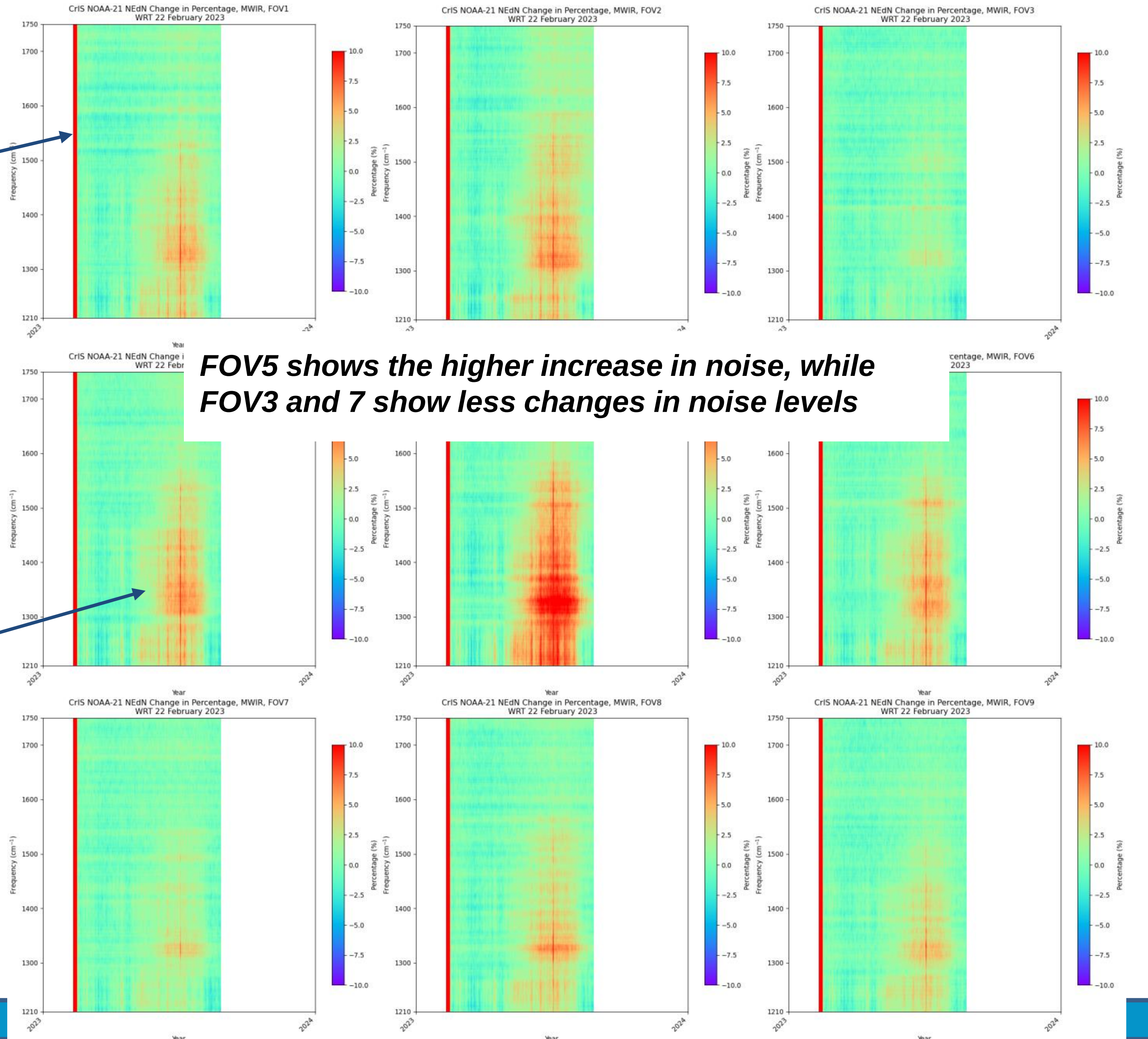
[Using PCA Method, February to August 2023, use 20 granules at the equator]



Time Series of Change in Radiometric NEdN Noise, MWIR, all FOVs

- **Noise is still within Specifications**
- **High NEdN during the EOC.**
- **Noise relative increase from May to August 2023 across the bands (wrt 22 Feb. 2023) associated with the elevated imaginary part artifact (seasonal/annual effect).**
- ***The increase in noise is case by a rapid change in the instrument self emission and responsivity terms not captured by the mean of the sliding window.***

[Using PCA Method, February to August 2023, uses 20 granules at the equator]

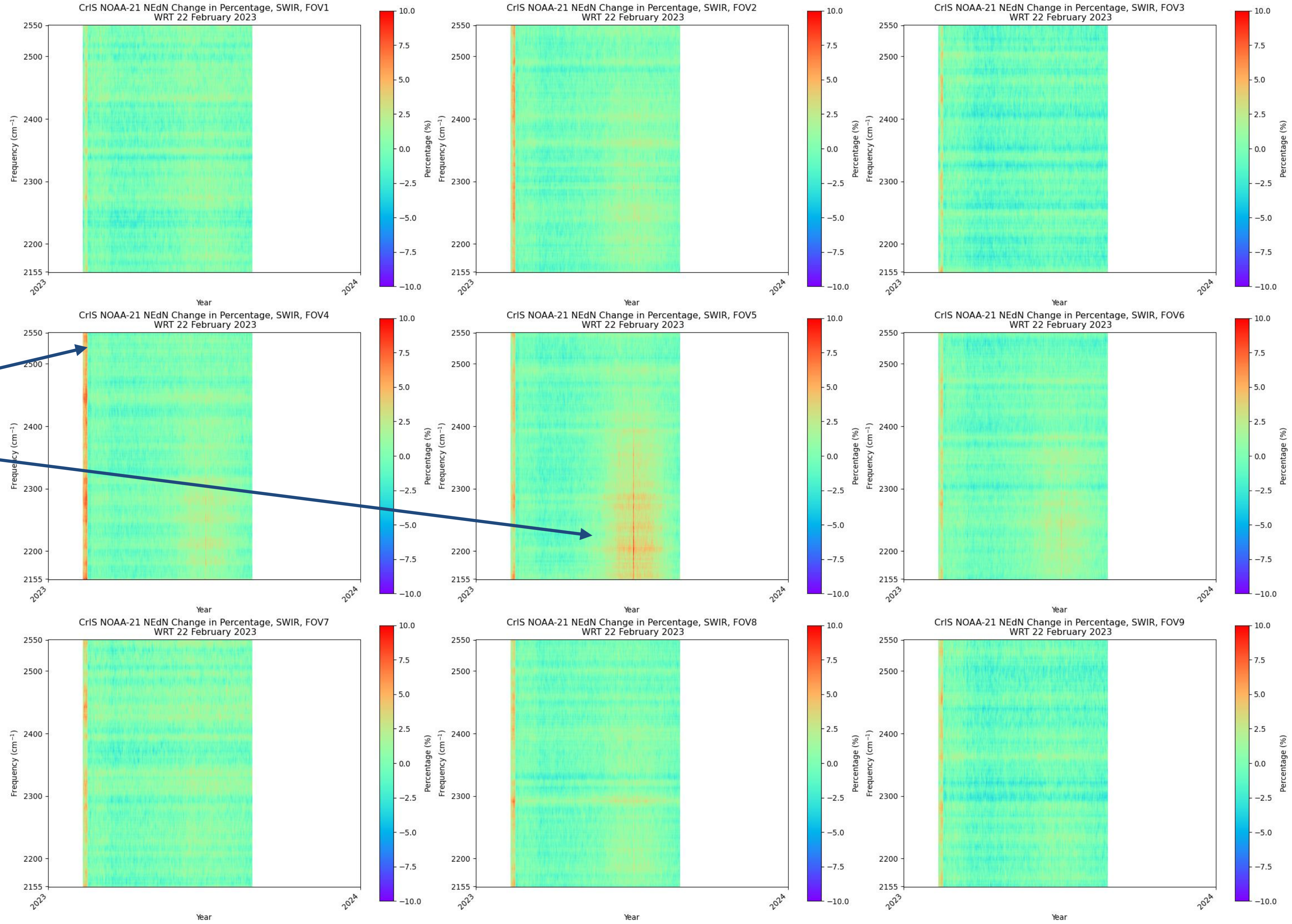


FOV5 shows the higher increase in noise, while FOV3 and 7 show less changes in noise levels

Time Series of Change in Radiometric NEdN Noise, SWIR, all FOVs

- **SWIR Noise remains stable and within specifications over time across the SWIR Band, as indicated by the change in noise with respect to Feb 22, 2023 (small seasonal/annual effect).**
- **High NEdN during the EOC.**
- **Elevated Imaginary Radiance also has an impact on the noise in the Earth Scenes**

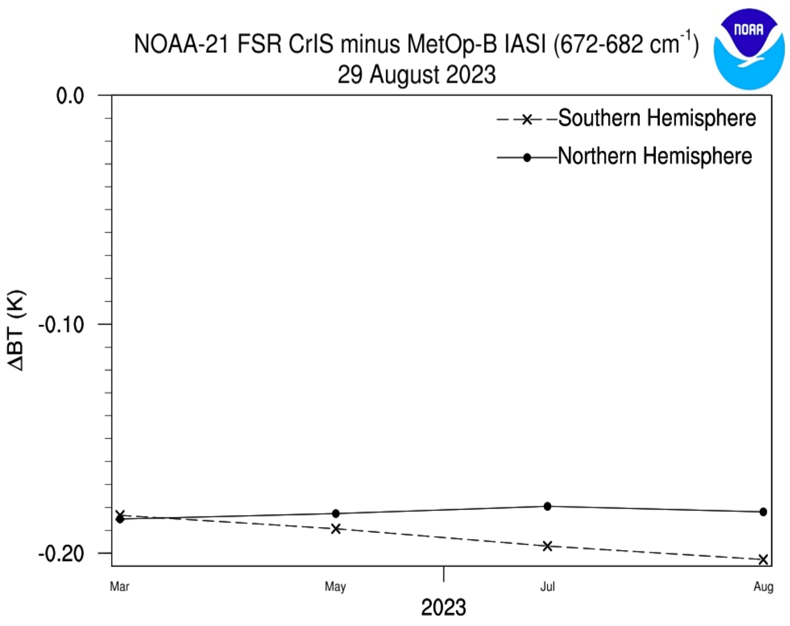
[Using PCA Method, February to August 2023, uses 20 granules at the equator]

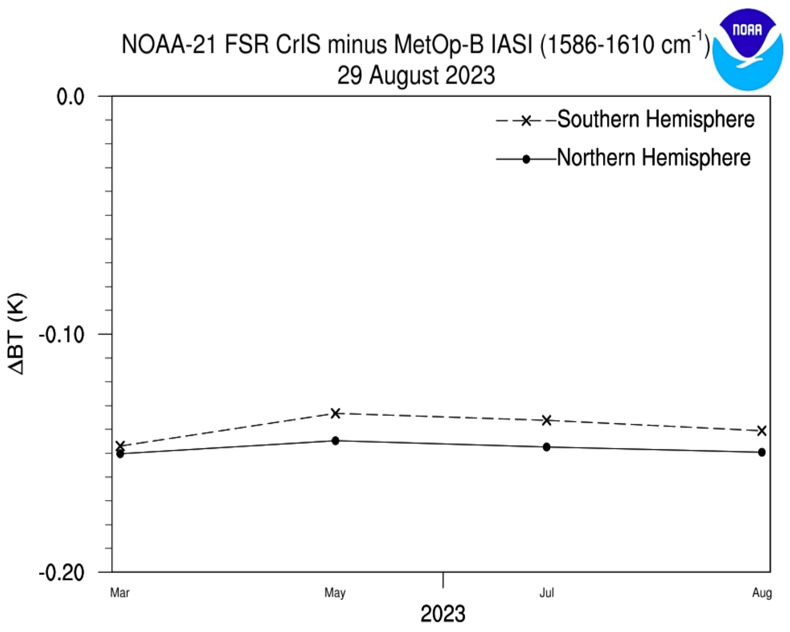


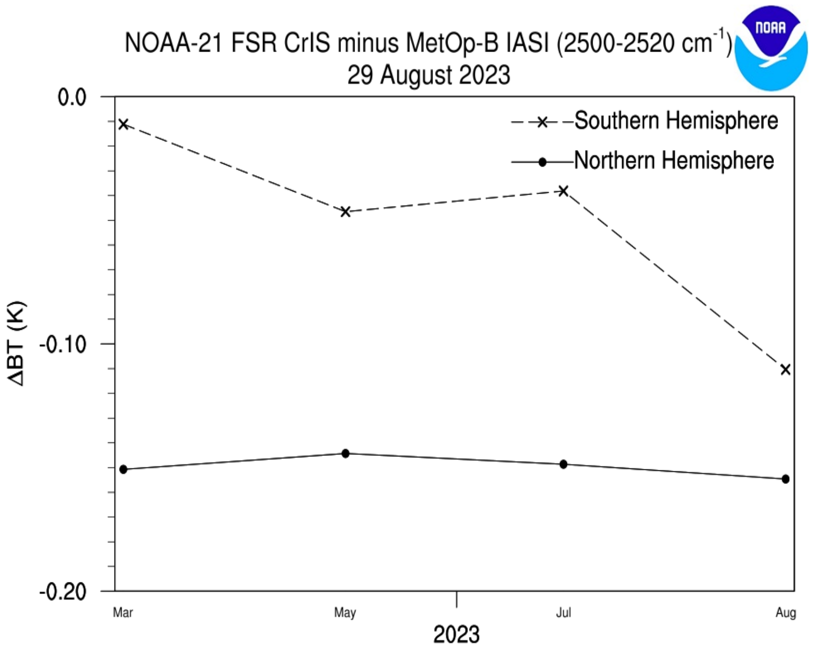
NOAA-21 CrIS minus MetOp-B IASI SNO Intercomparison Radiometric Biases

- **The BT differences between NOAA-21 CrIS and MetOp-B /ASI is consistently no greater than ~ 0.2 K in the 672 - 682 cm^{-1} in both hemispheres**
- IASI BT are consistently larger on average (hence negative bias values)
- **The BT differences between NOAA-21 CrIS and MetOp-B/IASI is no greater than ~ 0.15 K in the 1586 - 1610 cm^{-1} band for both hemispheres, and is consistently less than this for the SH.**
- **Biases in the 2500 - 2520 cm^{-1} band are consistently no greater than ~ 0.15 K in the NH, and are considerably lower in the SH, where it can be as low as ~ 0.01 K**

Provided by Arun Ravindranath

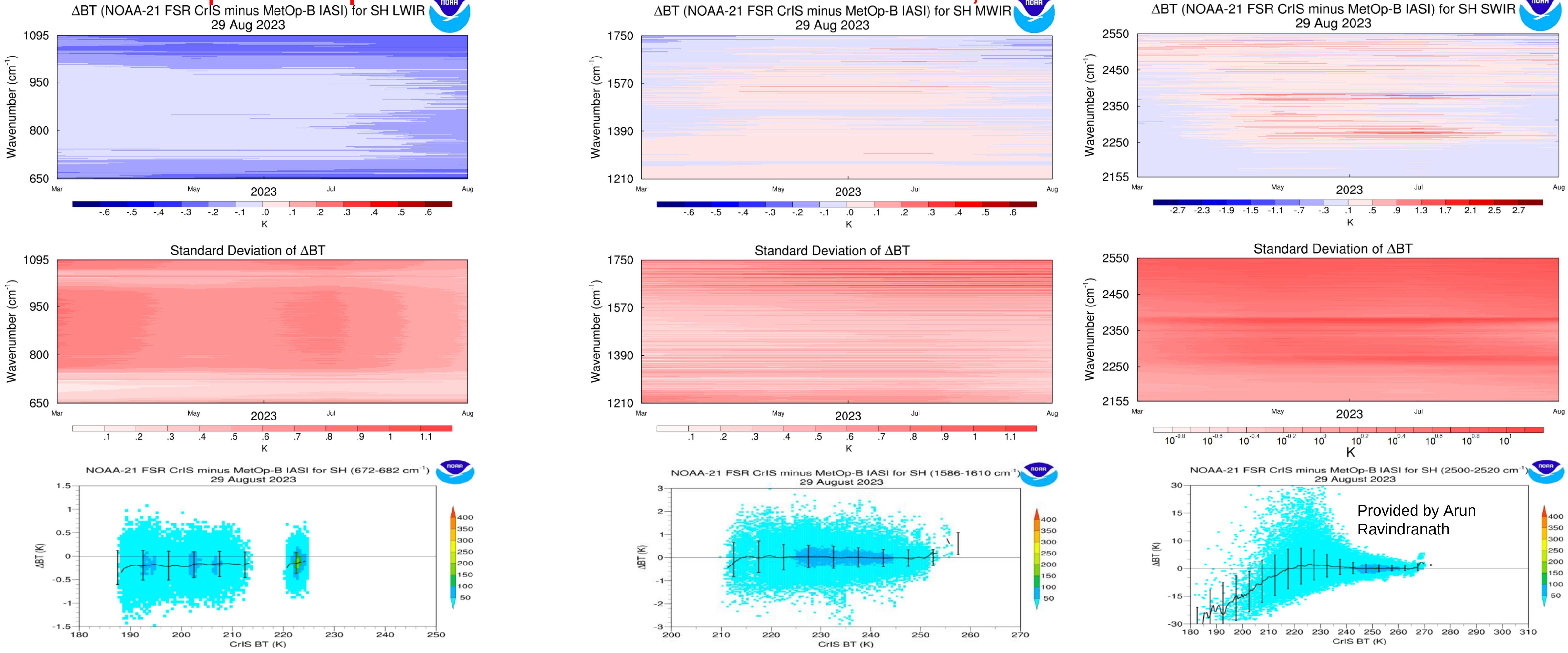






NOAA-21 CrIS minus MetOp-B IASI SNO Intercomparison Radiometric Biases

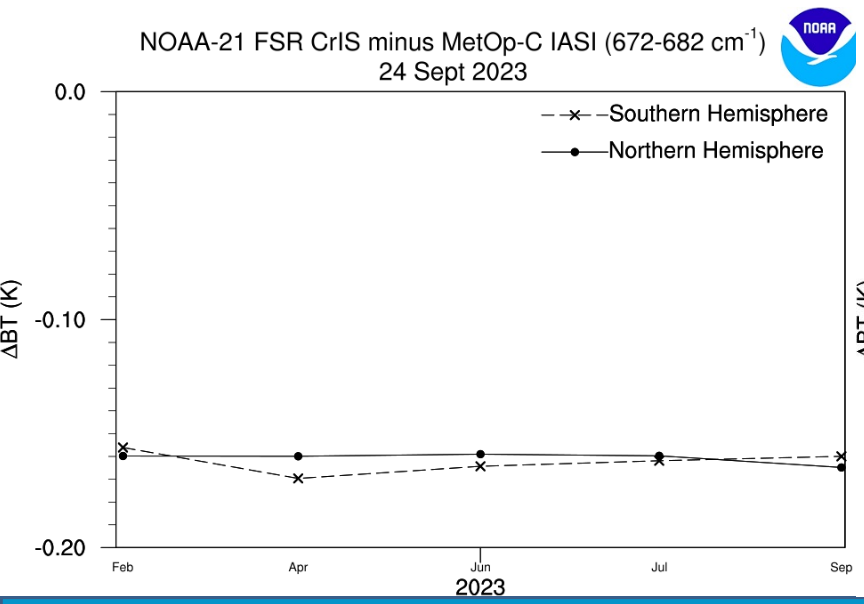
- These are the same type of plots as on slide 19, but for the southern hemisphere instead
- **Biases are within 0.2 K for LW, within 0.1 K in the MW, and within 3.6 K in the SW**
- **Standard deviation values are between 0.1 K to 0.9 K (LW), 0.1 K to 1.1 K (MW), and 0.7 K to 8 K (SW), with a few larger values**
- **Scene temperature dependence is not observed for the LW or MW bands, but is observed in the SW band**

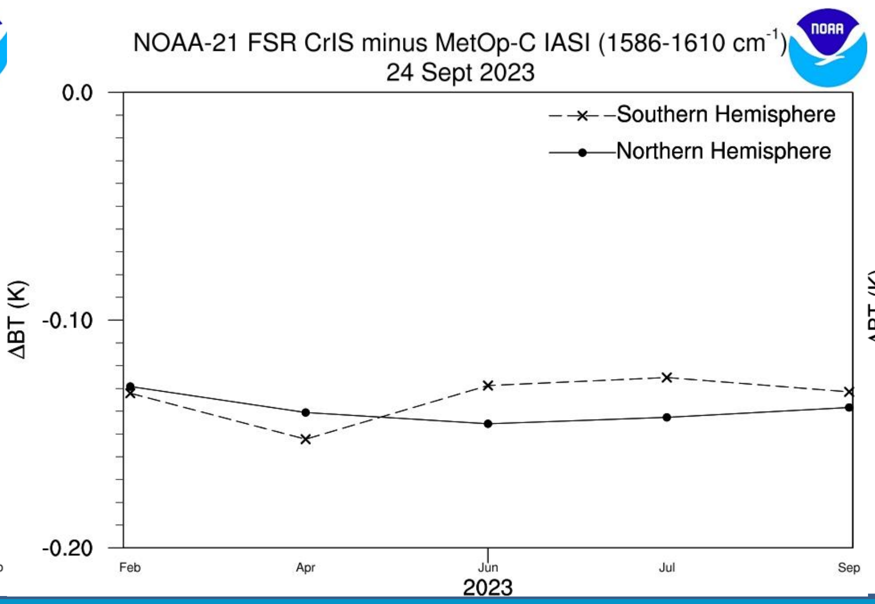


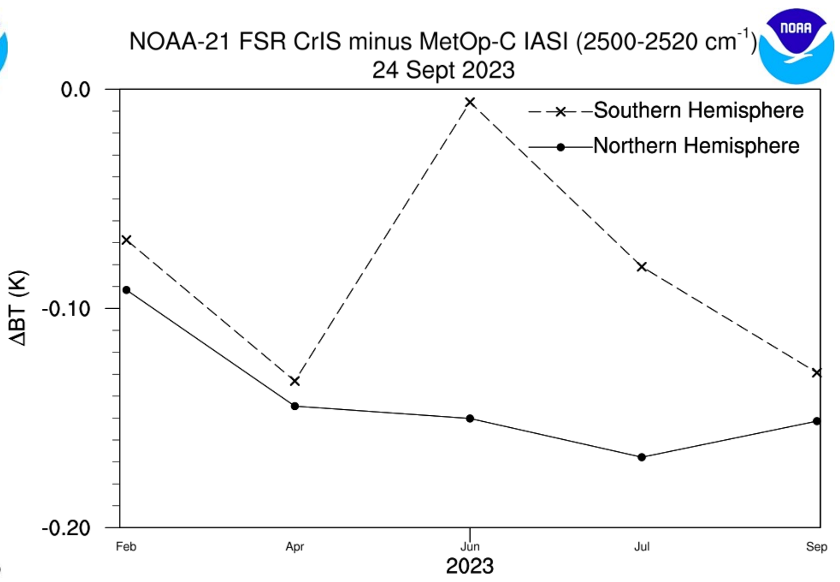
NOAA-21 CrIS minus MetOp-C IASI SNO Intercomparison Radiometric Biases

- **The BT differences between NOAA-21 CrIS and MetOp-C IASI is consistently no greater than ~ 0.17 K in the 672 - 682 cm^{-1} band**
- Very little variability is seen in the 672 - 682 cm^{-1} biases, especially for the NH
- **The BT biases are generally significantly lower for the SH in the 2500 - 2520 cm^{-1} band, ranging from -0.13 K to 0.05 K**
- **Biases for the 1586 - 1610 cm^{-1} band tend to be around -0.15 K to -0.12 K**

Provided by Arun Ravindranath



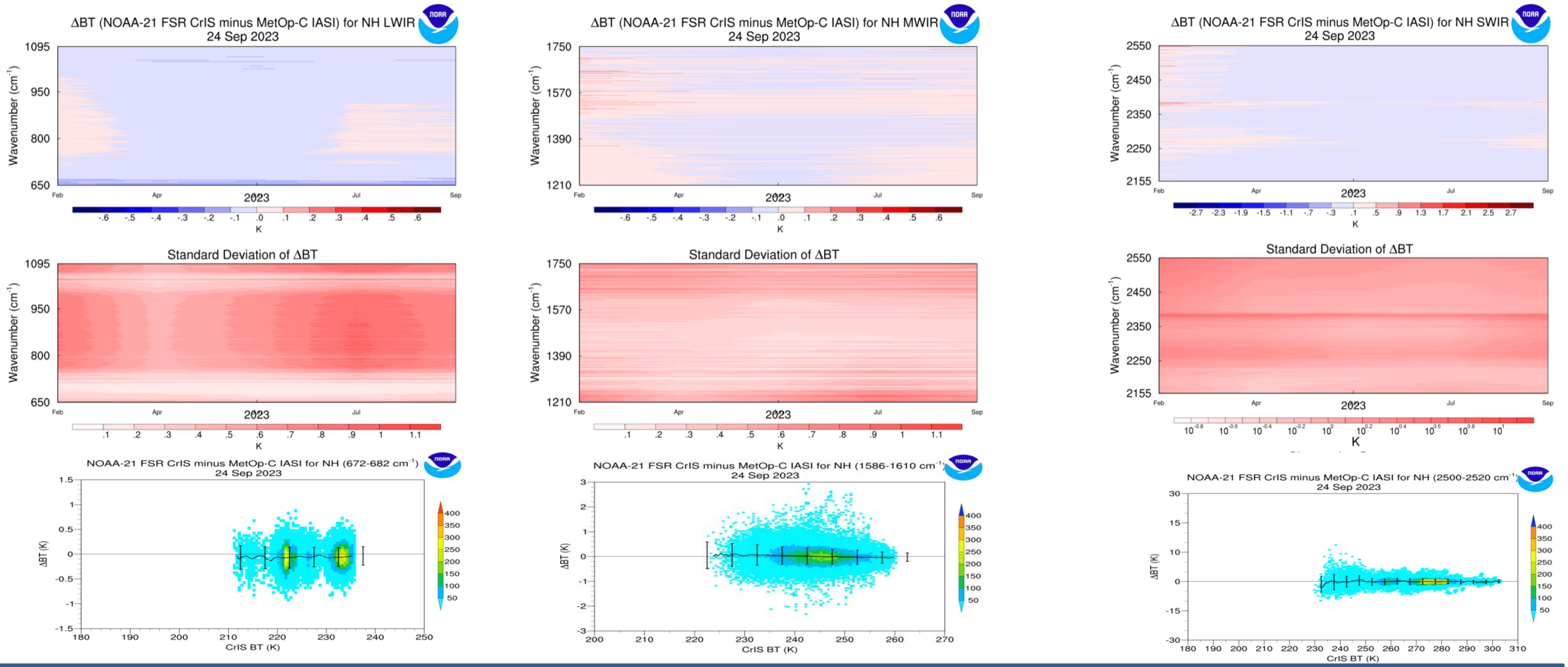




NOAA-21 CrIS minus MetOp-C IASI SNO Intercomparison Radiometric Biases

- These are the same type of plots as on the slide 19, but for the MetOp-C intercomparisons instead
- **Biases are within 0.2 K for LW, within 0.3 K in the MW, and within 0.8 K in the SW**
- **Standard deviation values are between 0.2 K to 0.9 K (LW), 0.2 K to 0.8 K (MW), and 0.5 K to 4 K (SW), with a few larger values**
- **Scene temperature dependence is not observed for any of the bands**

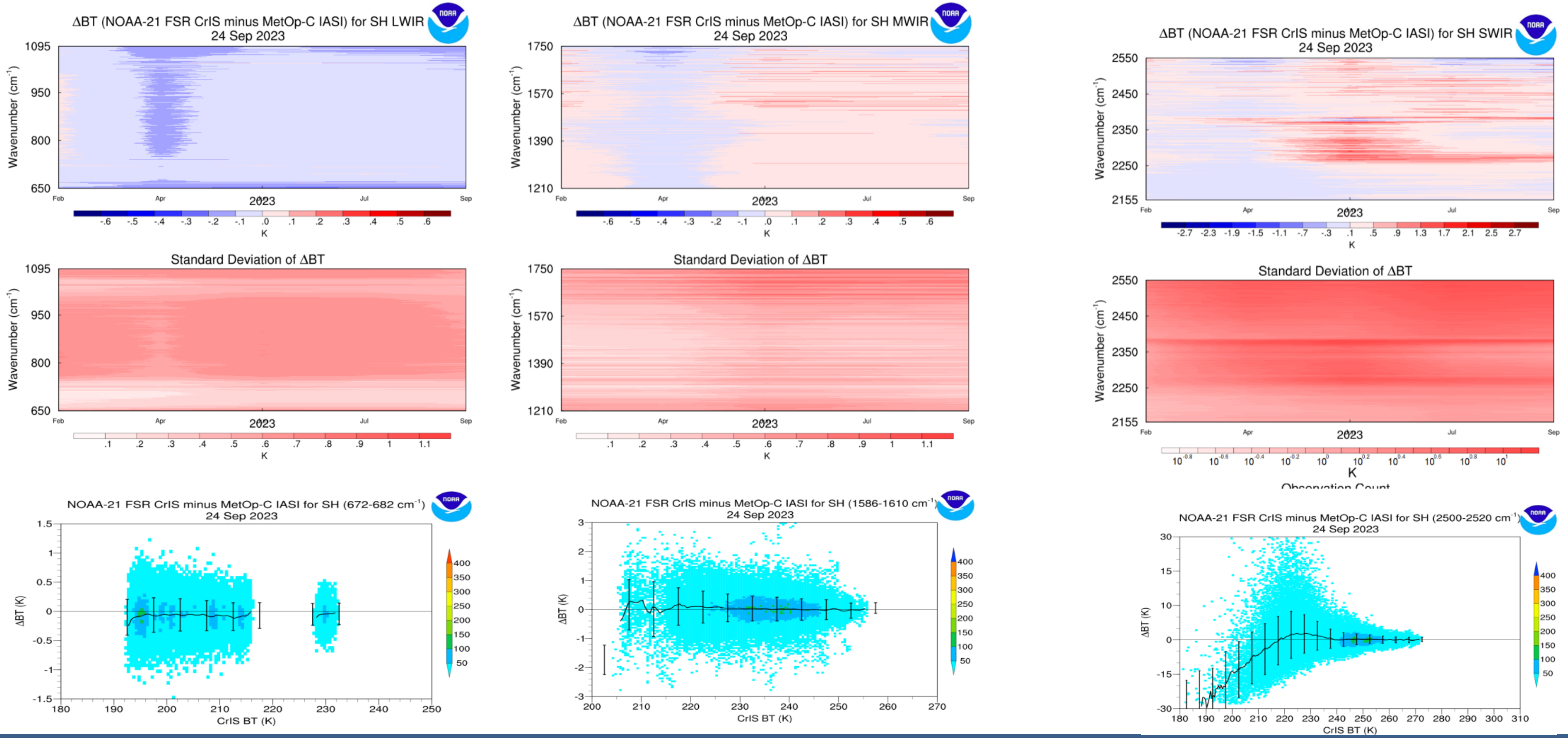
Provided by Arun Ravindranath



NOAA-21 CrIS minus MetOp-C IASI SNO Intercomparison Radiometric Biases

- These are the same type of plots as on the slide 31, but for the MetOp-C intercomparisons instead
- **Biases are within -0.3 K to -0.1 K (LWIR), -0.2 K to 0.4 K (SWIR), and -0.3 K to 3 K (SWIR)**
- **Standard deviation values are within 0.1 K to 0.8 K (LWIR), 0.1 K to 1 K (MWIR), and < 1 K to 11 K (SWIR)**
- **Scene temperature dependence is not observed for the LW or MW bands, but is observed in the SW band**

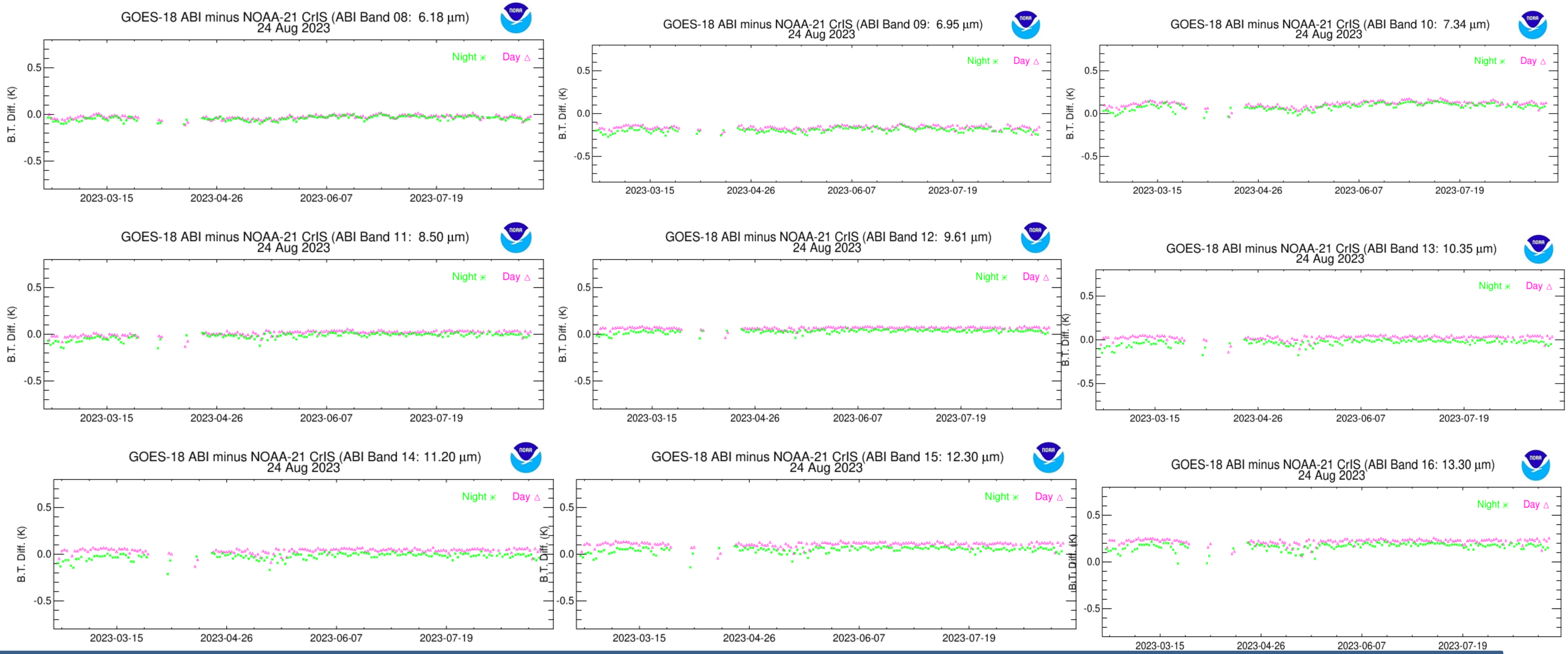
Provided by Arun Ravindranath



NOAA-21 CrIS SDR/GOES-18 ABI Radiometric Inter-comparisons

Add EPs timeline)!

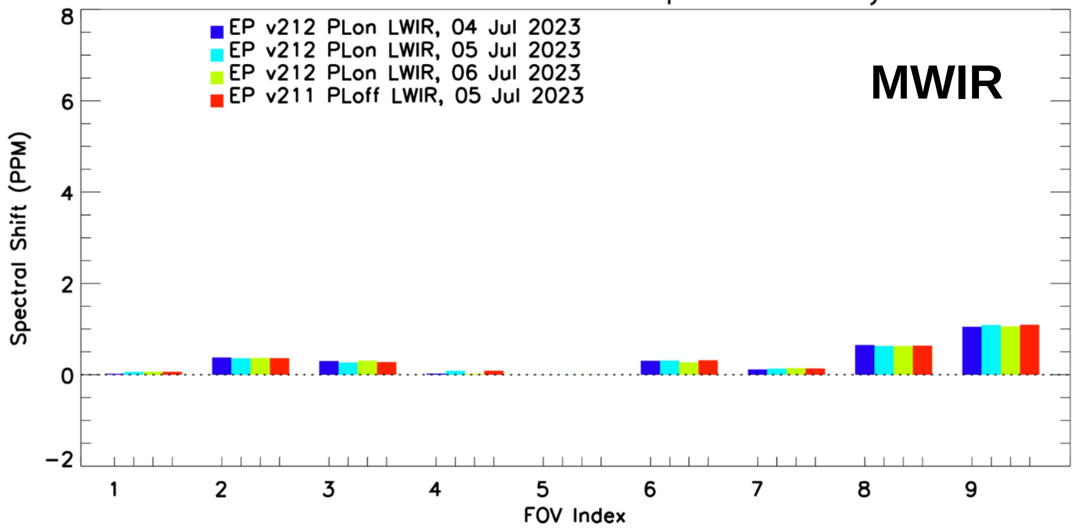
- ABI bands 8-11 correspond to CrIS MWIR band and bands 12-16 correspond to CrIS LWIR band.
- **The comparison of the two instruments shows temporally stable brightness temperature biases (within 0.2K), <u>indicating the highly stable calibration of NOAA-21 CrIS Radiances</u>.**



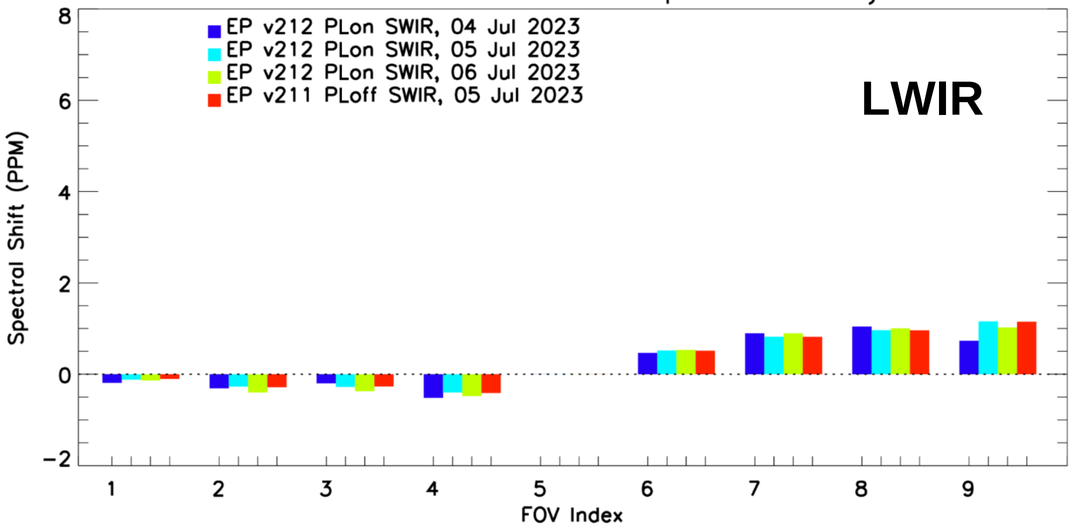
NOAA-21 CrIS FOV-2-FOV Spectral Shift with EP v212 Update

- The NOAA-21 CrIS shows **FOV-2-FOV spectral shift within 1 ppm for all three bands** with EP v212 applied and **Polarization Correction** on using ADL
- Relative spectral shift **within 1 ppm for LWIR, MWIR, and SWIR band**.
- Relative spectral accuracy of the operational SDR data on **July 5 with EP v211 as reference (operational)**.

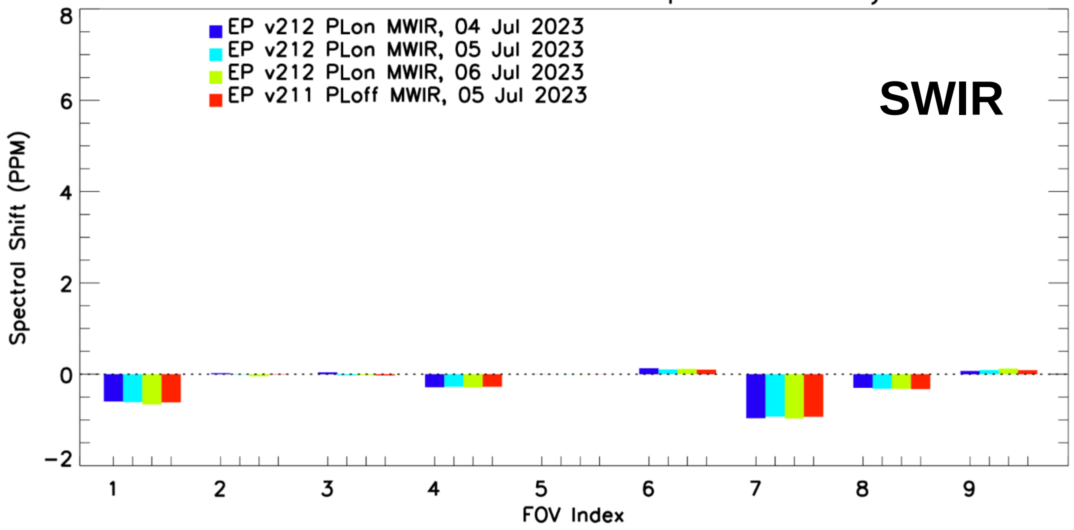
NOAA−21 CrIS LWIR Relative Spectral Accuracy



NOAA−21 CrIS SWIR Relative Spectral Accuracy

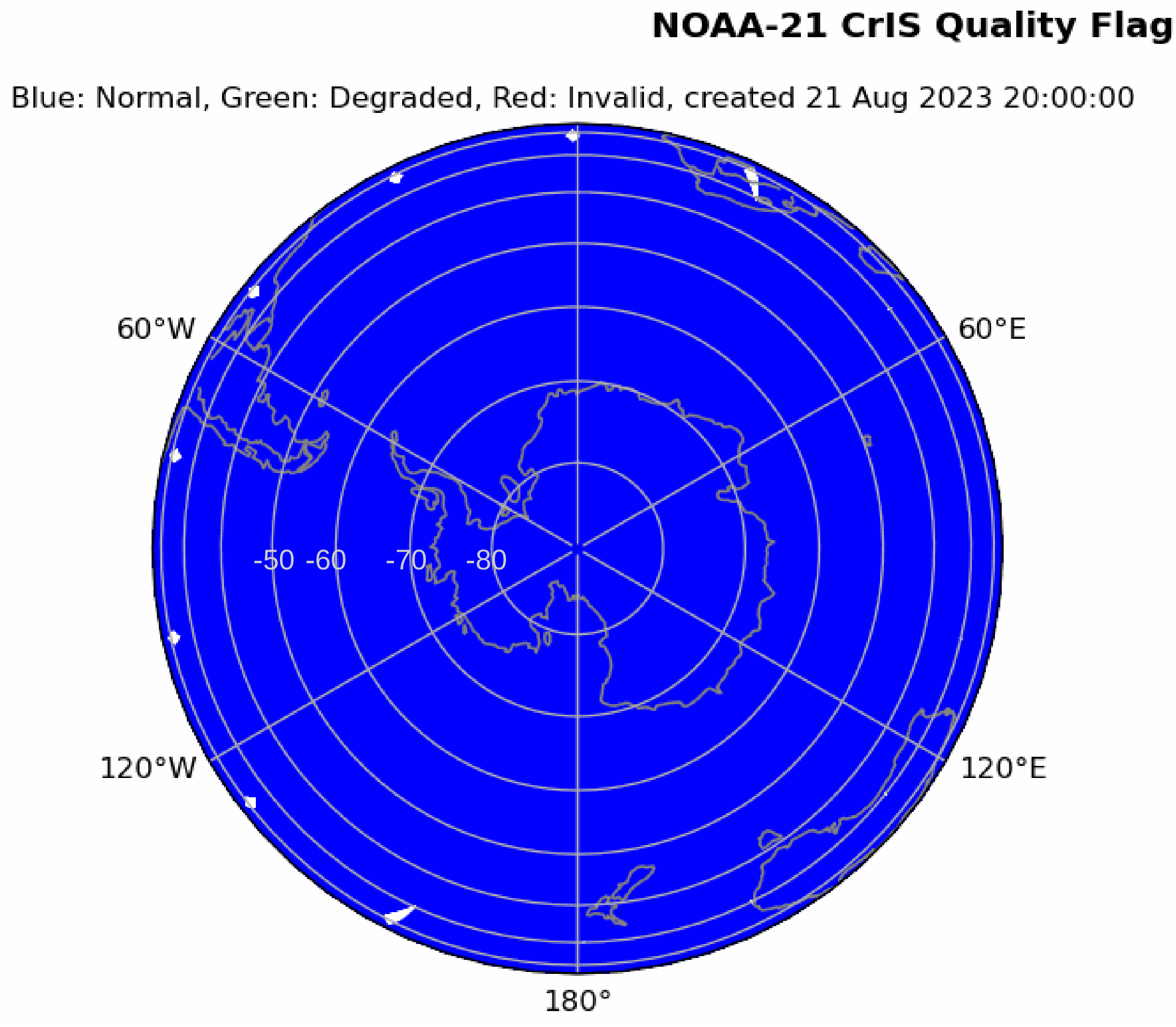


NOAA−21 CrIS MWIR Relative Spectral Accuracy



Provided by Kun Zhang

Progression of Overall Data Quality Flag 2023 Antarctic Winter



An animation showing location of Invalid and degraded observations from a southern hemisphere view.

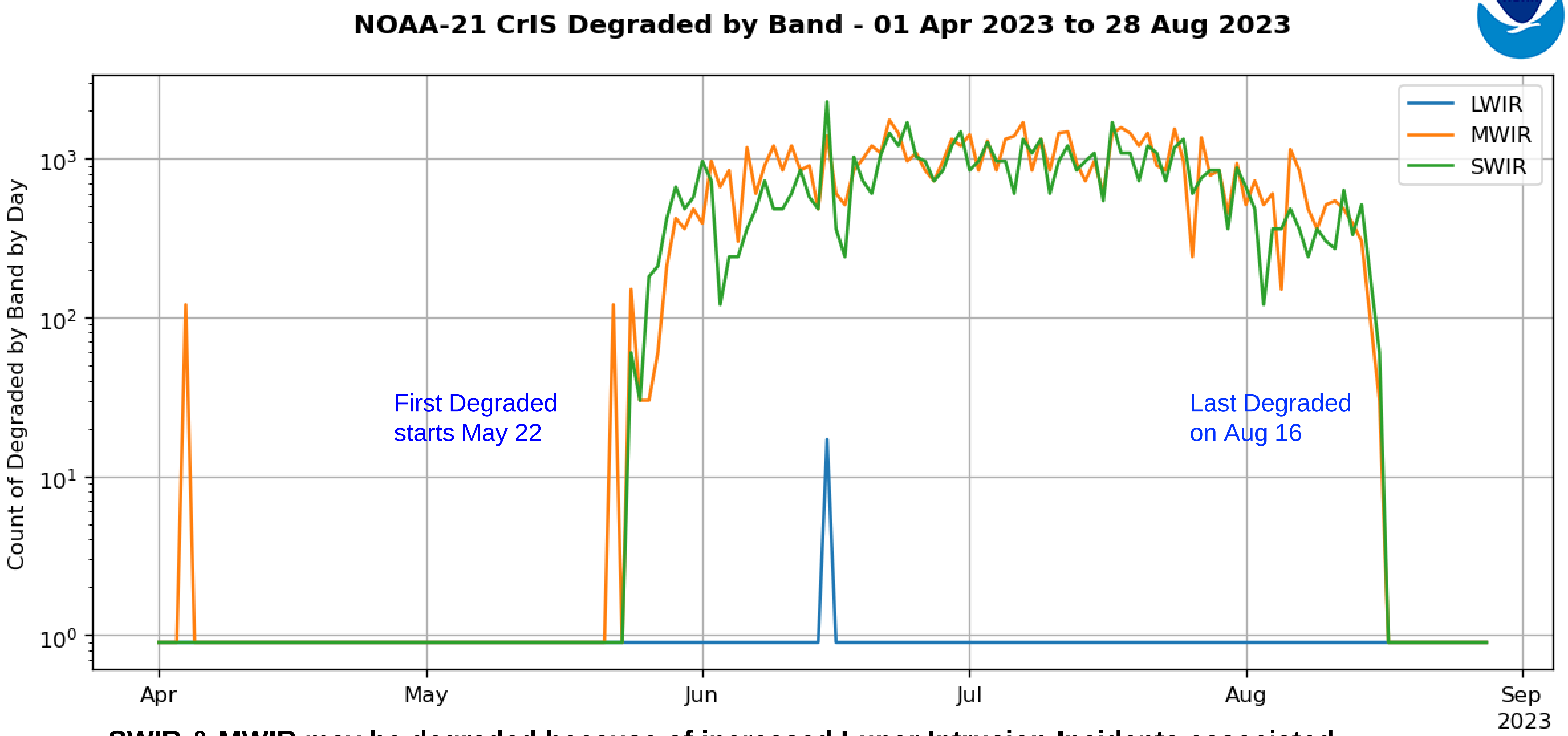
Incidents increase and decrease, and one can observe that they change position relative to south pole and orbit through the period.

Total Impacted Degraded and Invalid Cases, April 1 to August 31: 230,606 of 1,329,542,100 observations (**~0.02%**)

Worst Day: 2023-07-07
5,057 of 8,748,810 observations (**0.06%**)

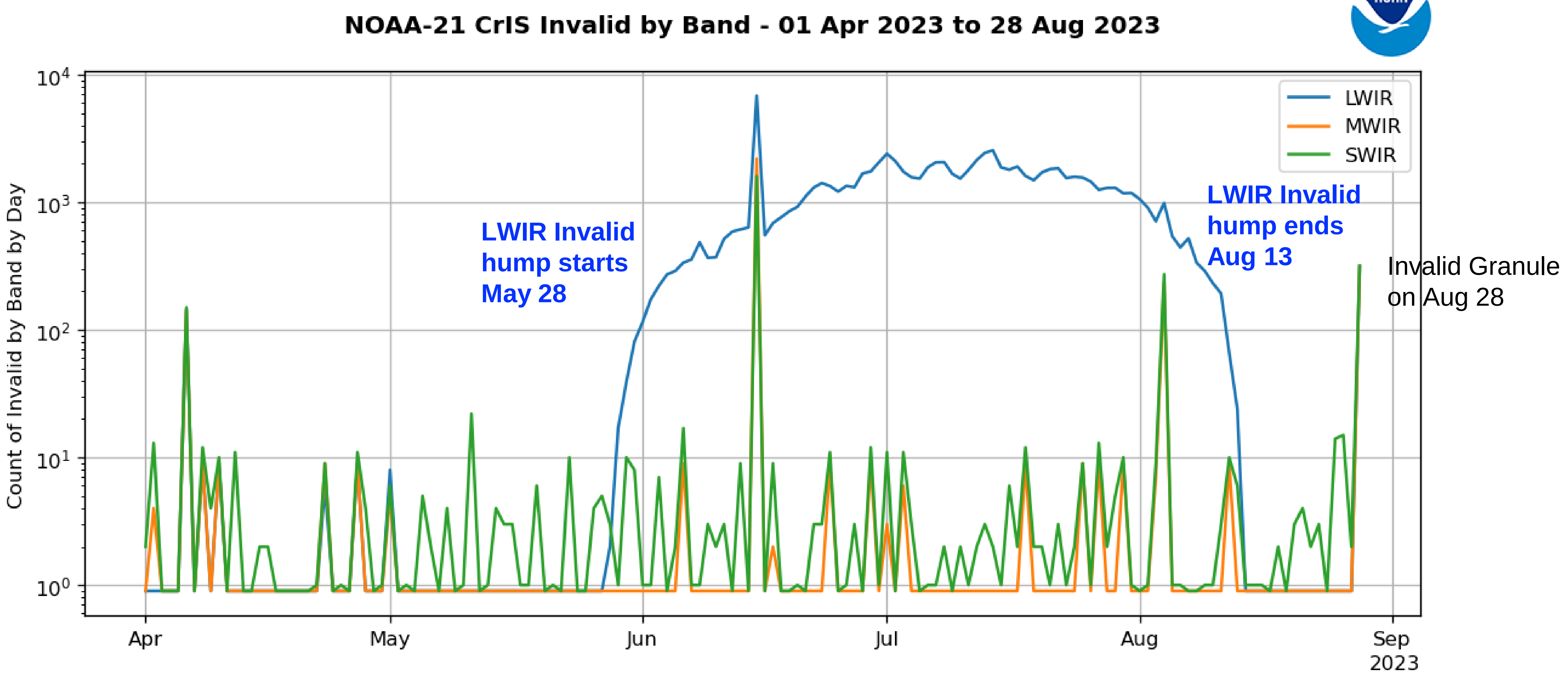
Cases confined to within ~70 degree South.

Degraded Data Quality Flag 2023-04-01 through 08-28



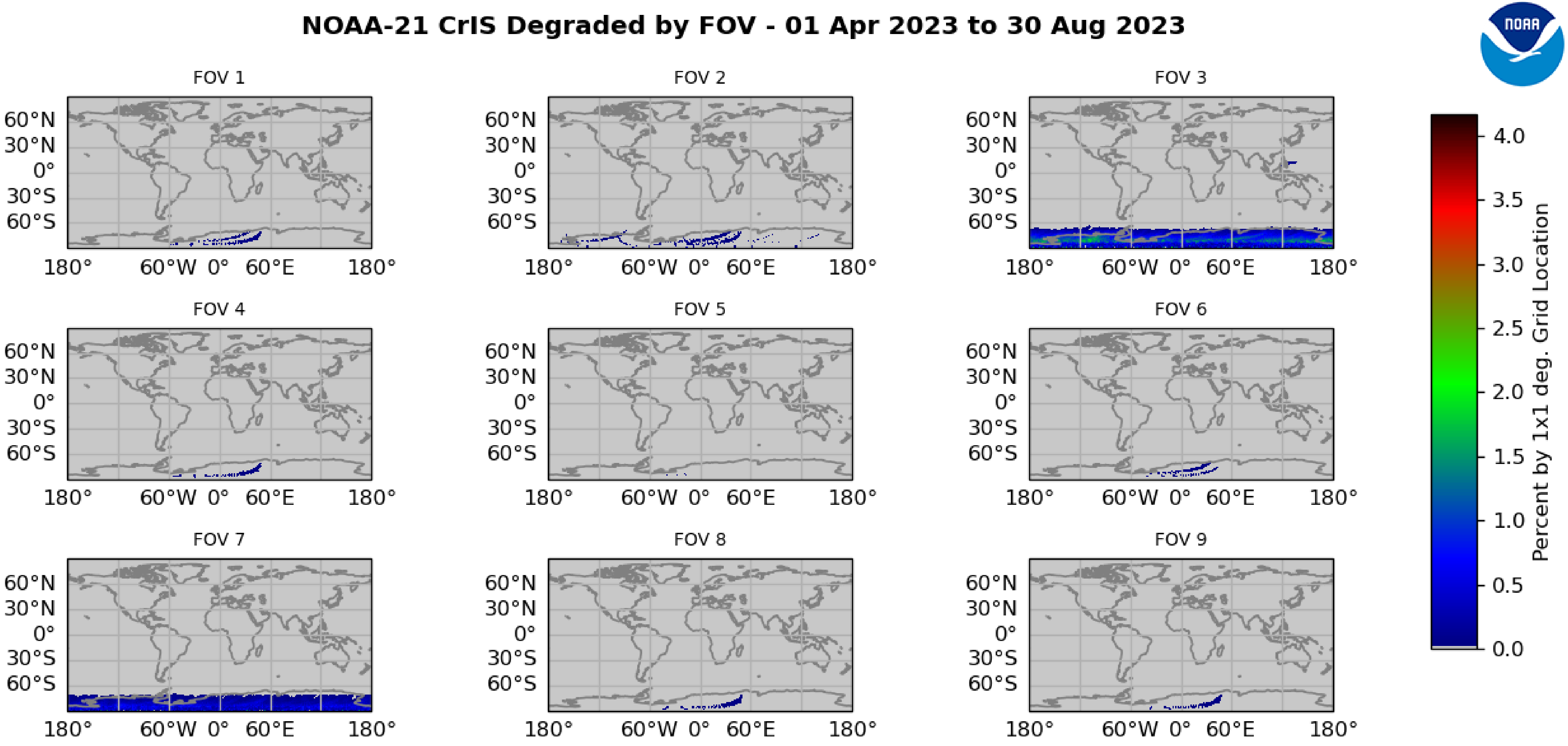
SWIR & MWIR may be degraded because of increased Lunar Intrusion Incidents associated with the increase in imaginary radiance

Invalid Data Quality Flag 2023-04-01 through 08-28



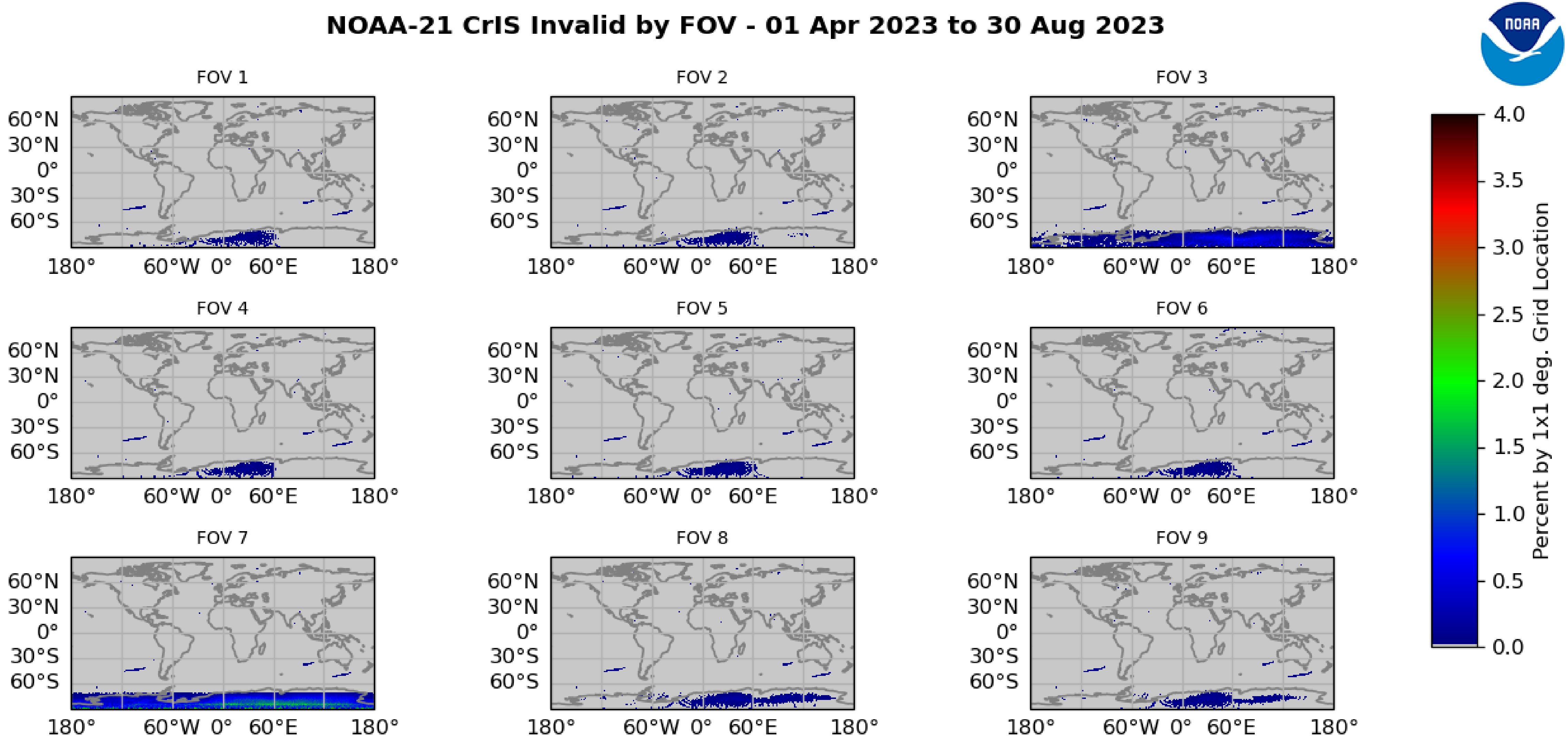
LWIR Band are invalid because of increased Imaginary Radiance is over its threshold

Cumulative Data Quality Degraded, Map by FOV



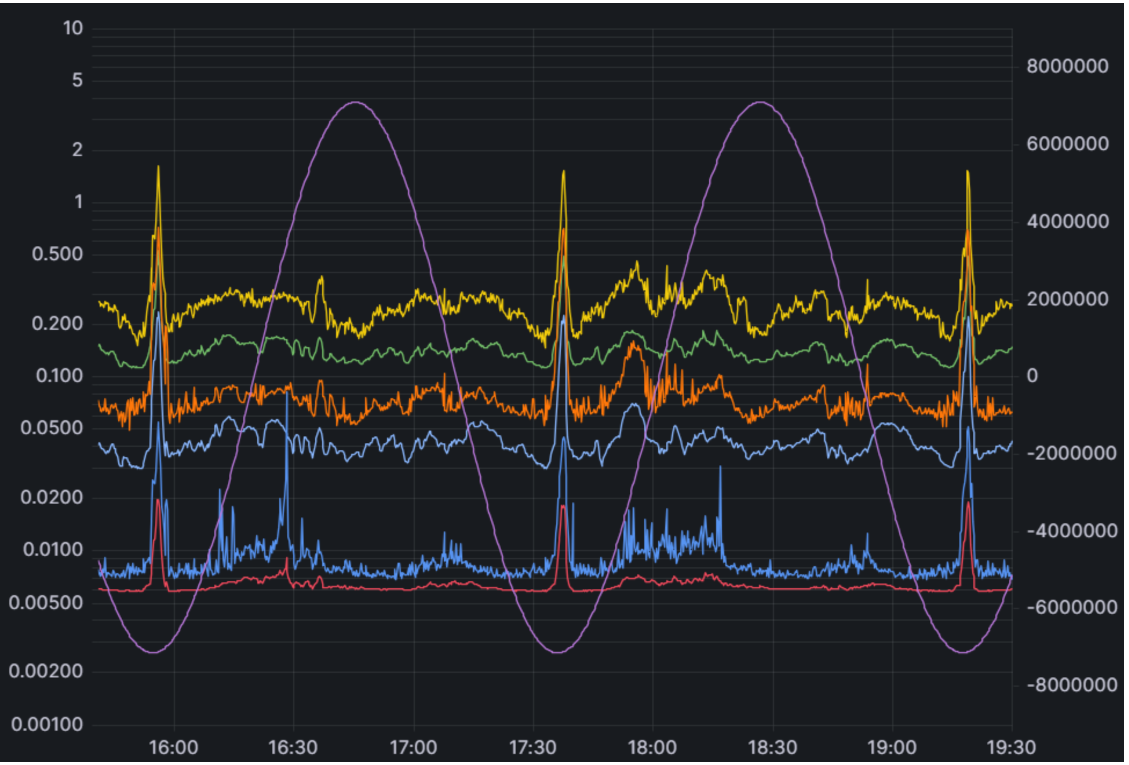
Most occurrences are in Antarctica in FOV 3 & 7, and represent less than 1 observation in 50 per location.

Cumulative Quality Flag, Invalid, Map by FOV



Most occurrences are in Antarctica in FOV 3 & 7, and represent less than 1 observation in 50 per location.

Imaginary Radiance and Invalid/Degraded Correlation Investigation

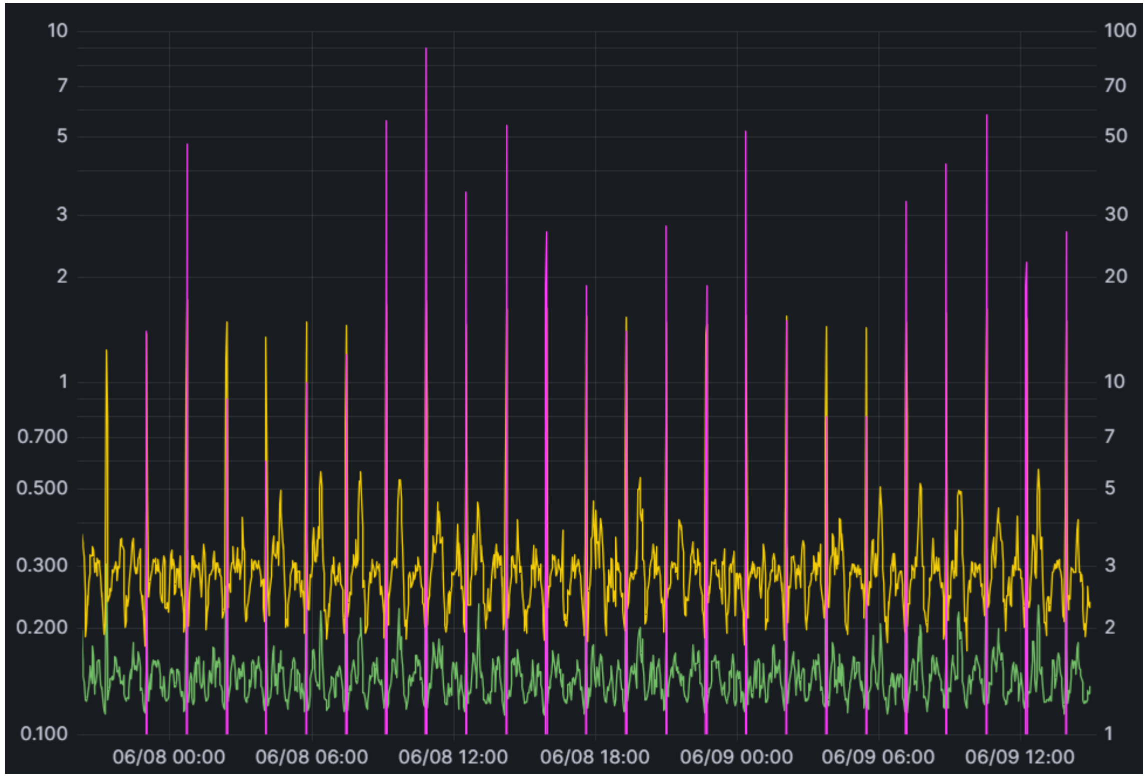


Purple: Satellite Z Position (J2000) right axis.

Avg over 20s bins: Green: RMS of ES_ImaginaryLW, Light Blue: RMS of ES_ImaginaryMW, Red: RMS of ES_ImaginarySW

Max over 20s bins: Yellow: RMS of ES_ImaginaryLW, Orange: RMS of ES_ImaginaryMW, Blue: RMS of ES_ImaginarySW

Conclusion: Strong correlation between satellite over Antarctic region and spike in RMS of Imaginary values, common across all bands.



Over 5 minute bins

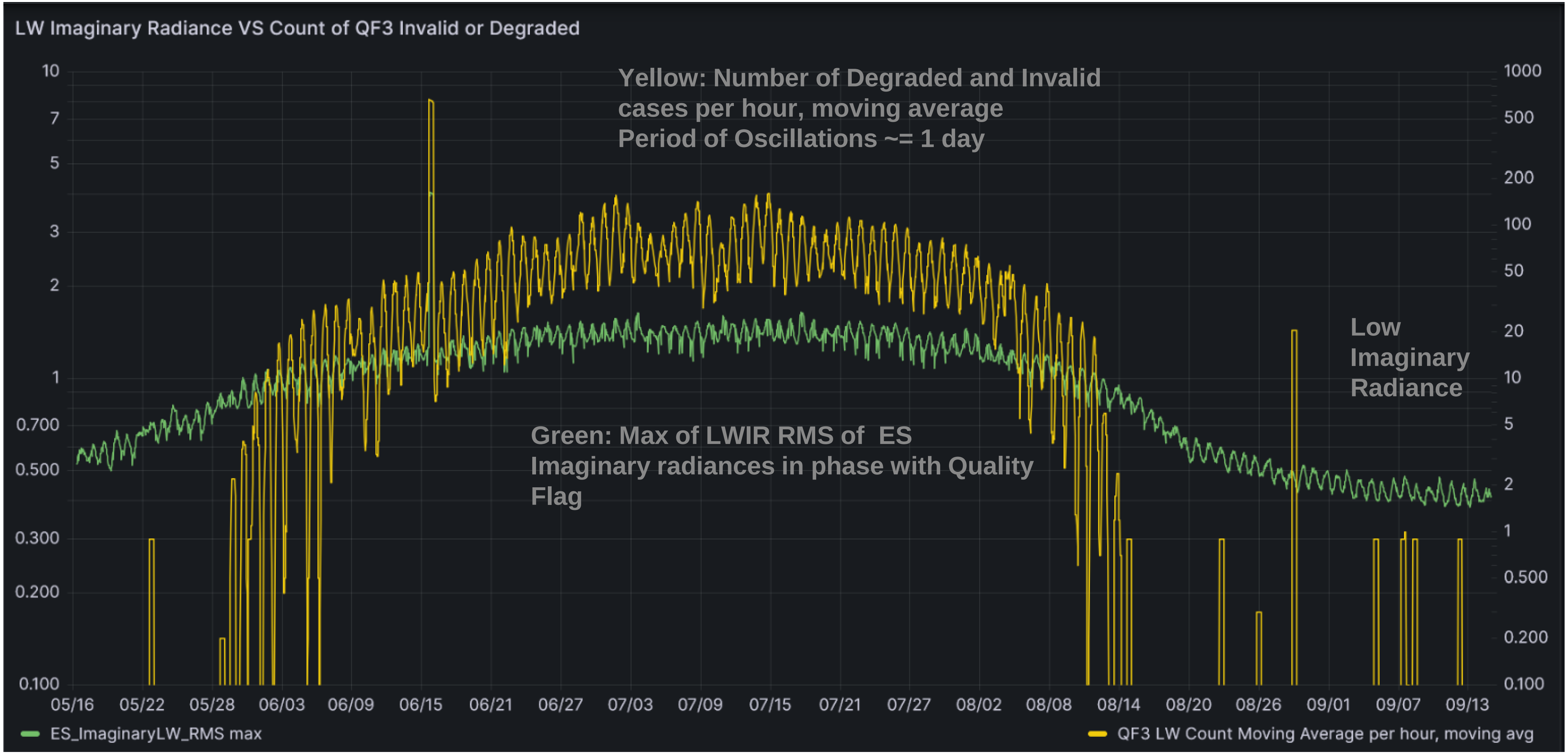
Green: Avg RMS of ES_ImaginaryLW

Yellow: Max RMS of ES_ImaginaryLW

Pink: Count of Invalid/degraded QF3 LW, right axis.

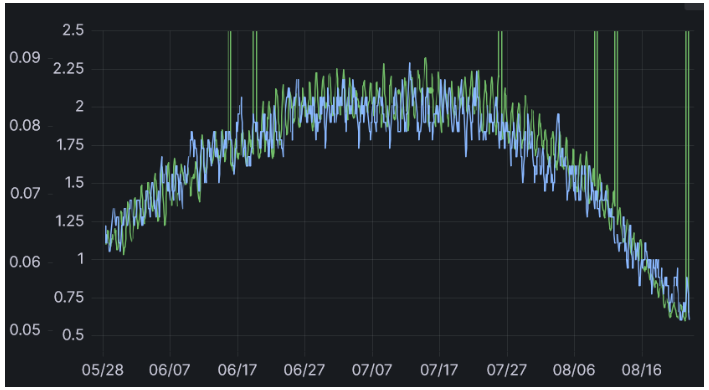
Conclusion: Strong correlation between Invalid/Degraded cases and higher RMS ES_Imaginary values.

LWIR RMS Imaginary Radiance vs Degraded & Invalid Observations

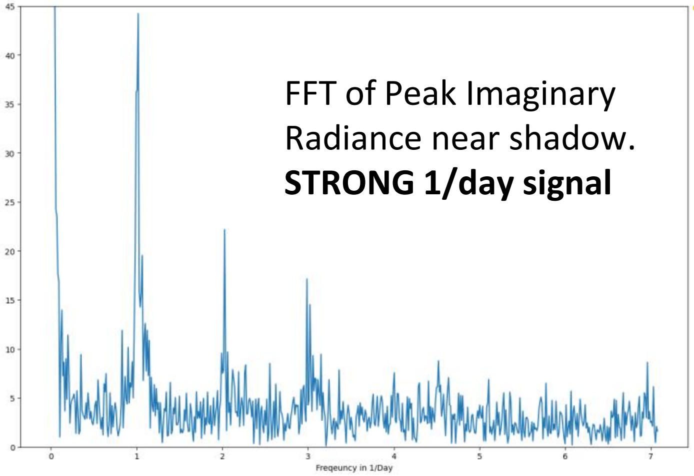


Shows correlation between increase of high imaginary radiances in Antarctica and increase in Invalid and Degraded LWIR flags

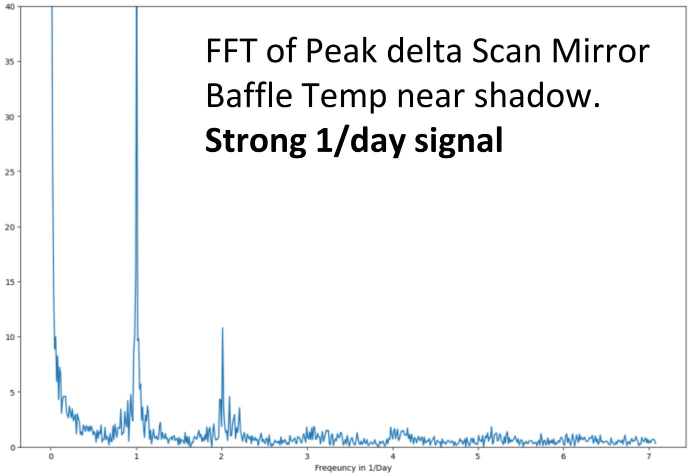
High Imaginary Radiance, High dTemp



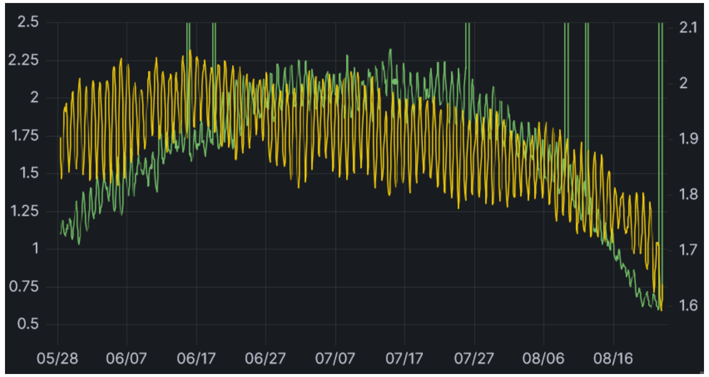
Near Shadow departure, peak Imaginary Radiance & local delta Beam Splitter Temperature. **STRONG seasonal correlation.**



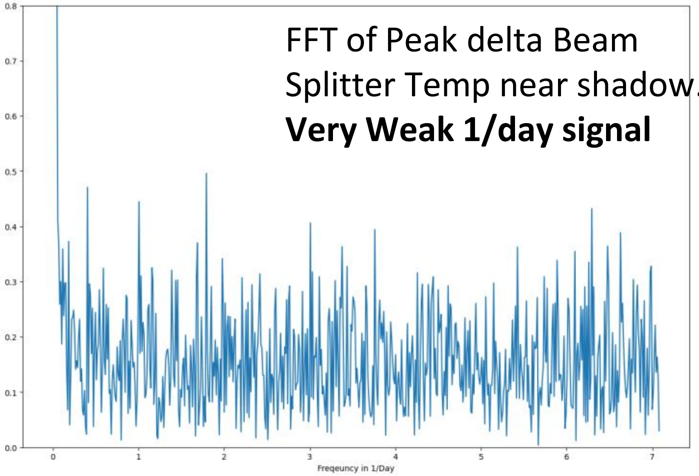
FFT of Peak Imaginary Radiance near shadow. **STRONG 1/day signal**



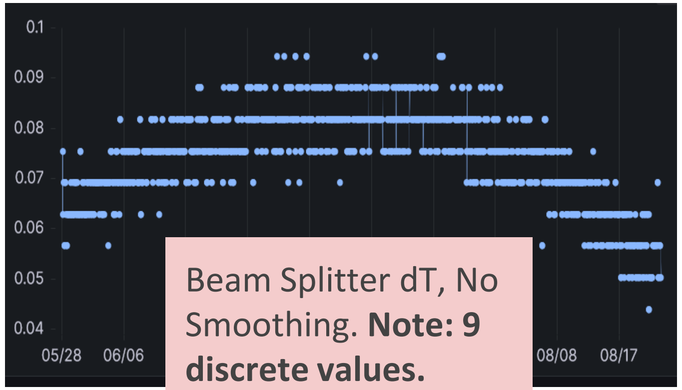
FFT of Peak delta Scan Mirror Baffle Temp near shadow. **Strong 1/day signal**



Near Shadow departure, peak Imaginary Radiance & local delta Scan Mirror Baffle Temperature. **Weak seasonal correlation.**



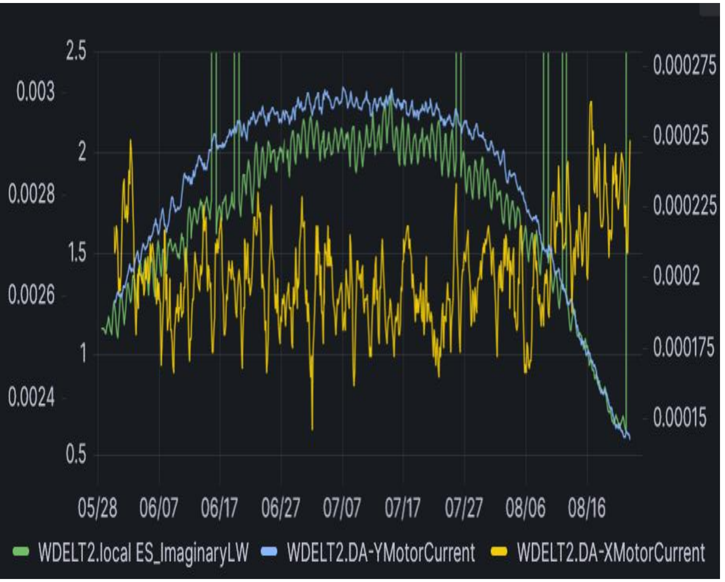
FFT of Peak delta Beam Splitter Temp near shadow. **Very Weak 1/day signal**



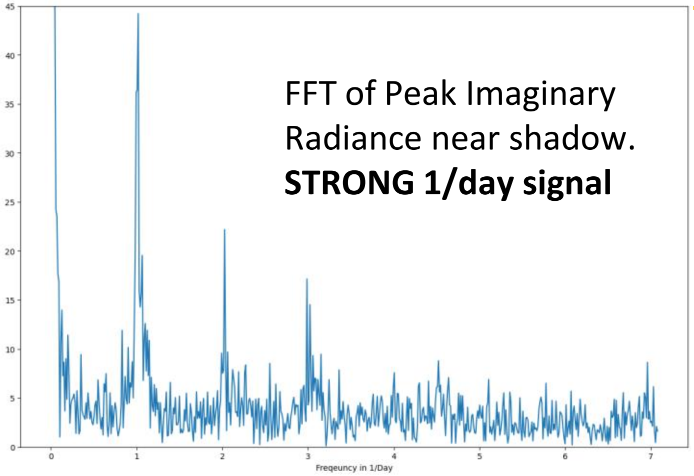
Beam Splitter dT, No Smoothing. **Note: 9 discrete values.**

Both delta Scan Mirror Baffle Temperature and delta Beam Splitter Temperature have been suggested as potential cause of higher imaginary radiances. Beam Splitter has a much better seasonal correlation, but may lack the 24 hour cycle correlation. However, this could be due to working at the very limits of temperature resolution.

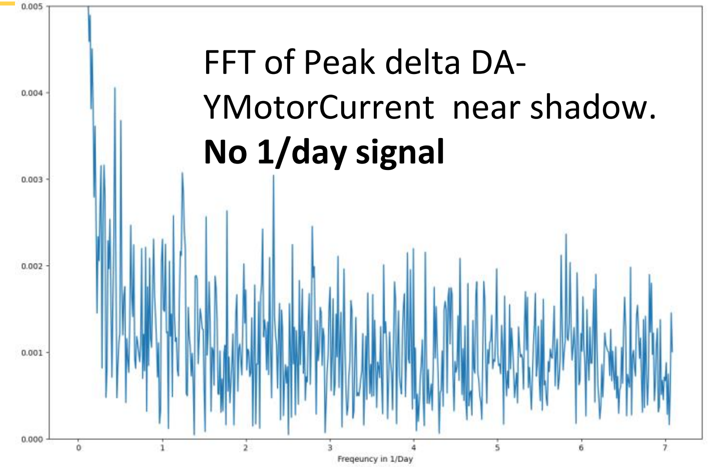
High Imaginary Radiance, High DA-Motor Current



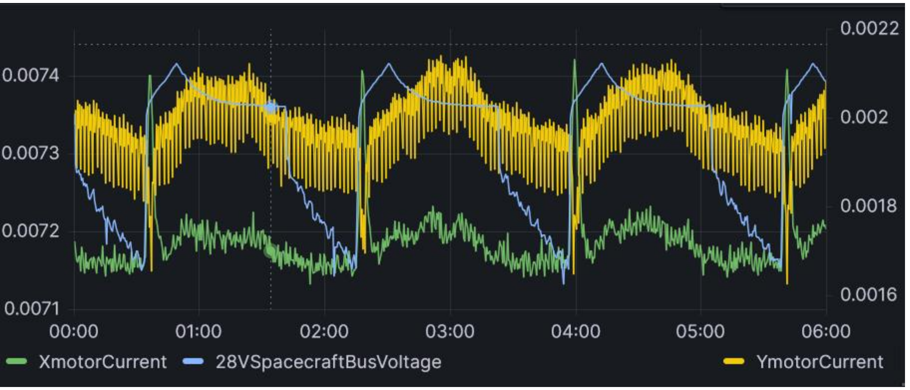
Near Shadow departure, peak Imaginary Radiance & local delta DA-YMotorCurrent (Blue), **STRONG seasonal correlation**. DA-XMotorCurrent (yellow) no correlation



FFT of Peak Imaginary Radiance near shadow. **STRONG 1/day signal**

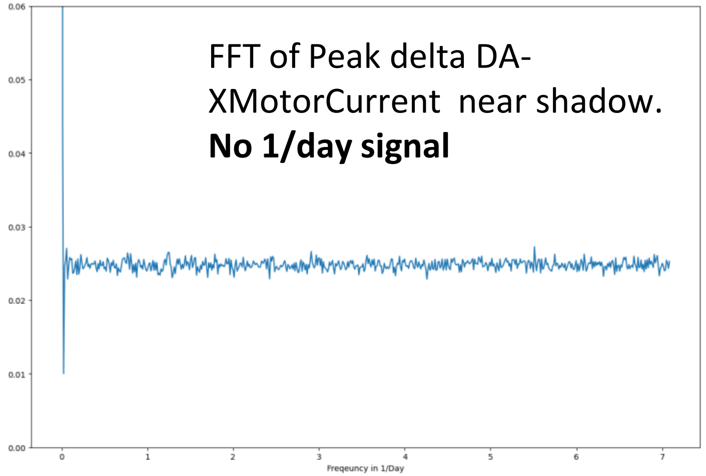


FFT of Peak delta DA-YMotorCurrent near shadow. **No 1/day signal**



+28VSpacecraftBusVoltage, DA-XMotorCurrent, DA-YMotorCurrent.

Shows spikes at shadow departure.



FFT of Peak delta DA-XMotorCurrent near shadow. **No 1/day signal**

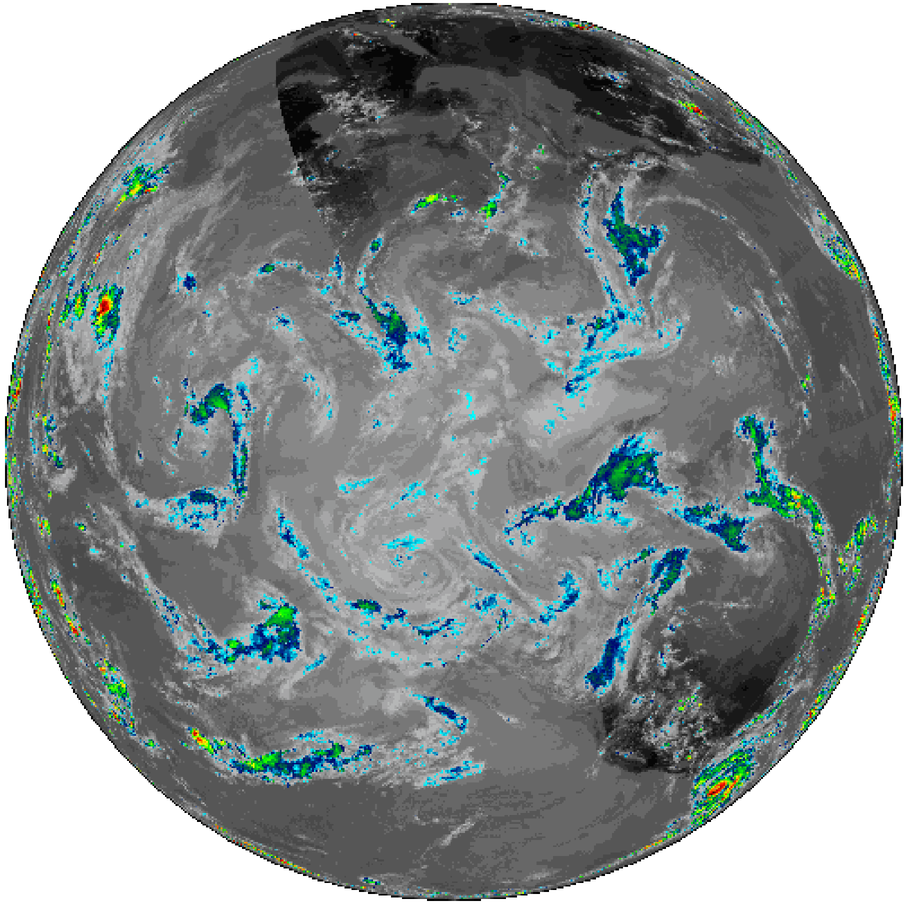
Delta DA-YMotorCurrent also has a strong seasonal similarity to the Imaginary radiance spike, but the DA-X MotorCurrent does not. Neither have a per day component, however.

NOAA-21 and NOAA-20/21 CrIS Images: Aug 18 09:30 - Aug 22 15:30

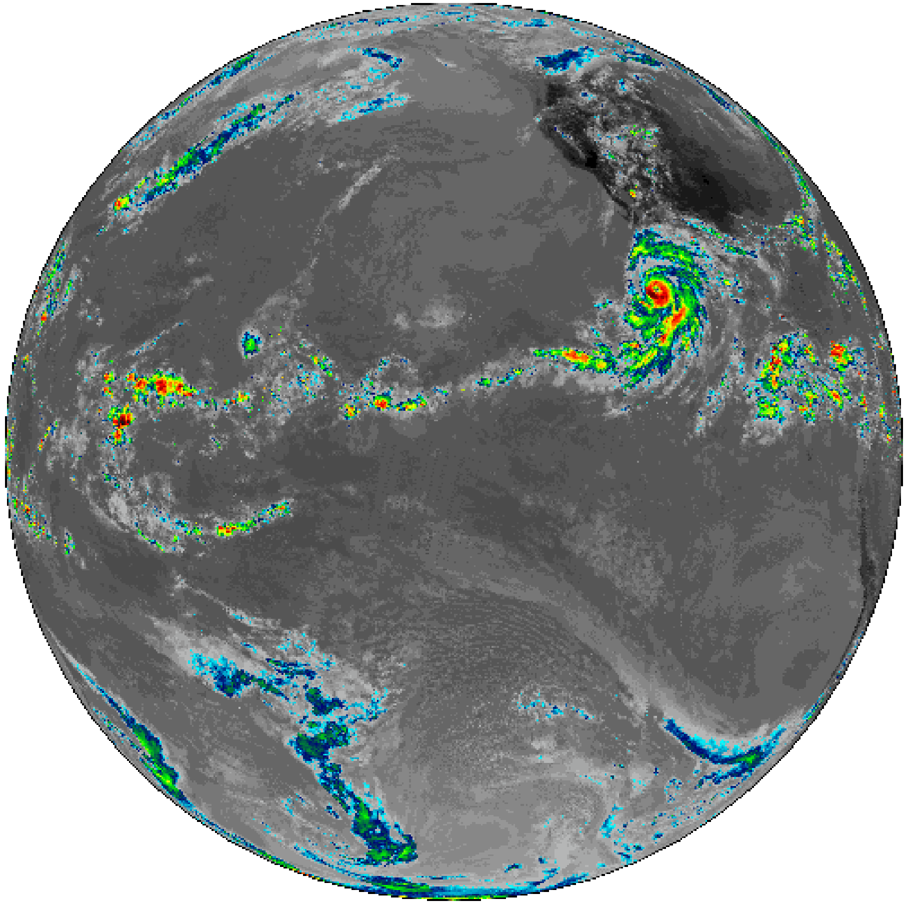
10.3 µm - Emulated GOES ABI 13

Note, Images combine NOAA-20 & NOAA-21 for better coverage.

Produced for CIRA RAMMB Slider by STAR CrIS Calibration Team



Northern Hemisphere View



GOES West View