Provisional Maturity Science Review
For NOAA-21 CrIS SDR

Presented by Flavio Iturbide-Sanchez and
the CrIS SDR Cal/Val Science Team
Date: 03/30/2023

Outline

- Executive Summary for Provisional Review
- Product Overview and Requirements
- Quality flag analysis and validation
- 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)
  - Radiometric Nonlinearity Verification
  - NEdN/radiometric noise performance
  - Radiometric performance (from CrIS SDR team, UW and UMBC)
  - Spectral performance (from CrIS SDR team, UW and UMBC)
  - Geolocation Accuracy
  - Analysis of Imaginary and Real Radiances
  - Downstream User Feedback (NUCAPS)
- Risks, actions, mitigations, waivers
- Documentation locations, check-list and requirements met
- Justification, Caveats and Path Forward

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 **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.

Executive Summary for Provisional Review

- From assessments, the CrIS cal/val team has shown that the NOAA-21 CrIS SDR data meets the Provisional 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 v211 for all FORs. The total geolocation uncertainty is 250 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 associate with the CrIS SDR Algorithm.

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

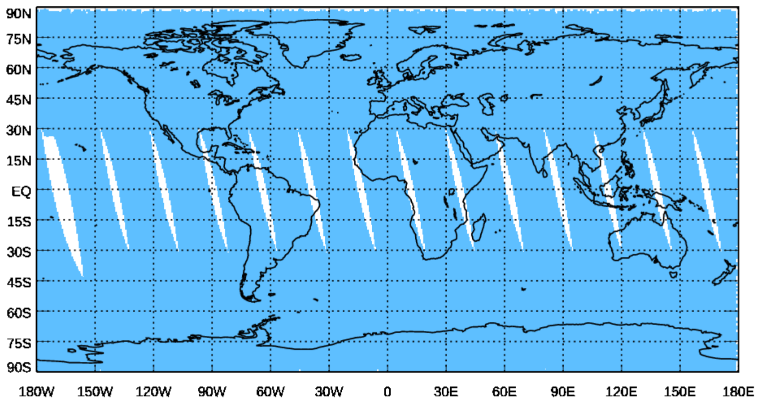
[1]JPSS Algorithm Specification Volume I: Software Requirement Specification (SRS) for the CrIS RDR/SDR, 474-00448-01-03, Revision I, October 24, 2019.
[2]JPSS Level 1 Requirements Document Supplement (L1RDS) – Final, JPSS-REQ-1002/470-00032, Revision 2.11, Rev. 2.1, 02/07/2019. The NEdN Maximum values 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.

Overall Data Quality Flag (3/24/2023)

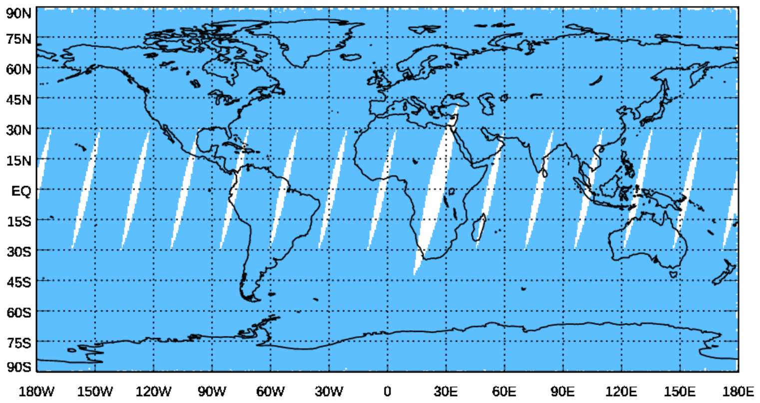
Long-Wave

NOAA-21 CrIS Long Wave SDR Overall Quality Flag, Mapped, Ascending, 03/24/2023

(Sky Blue: Good; Green: Degraded; Red: Invalid)



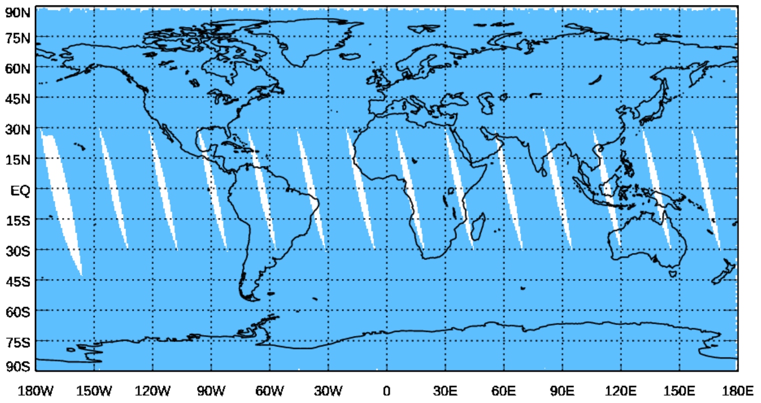
NOAA-21 CrIS Long Wave SDR Overall Quality Flag, Mapped, Descending, 03/24/2023



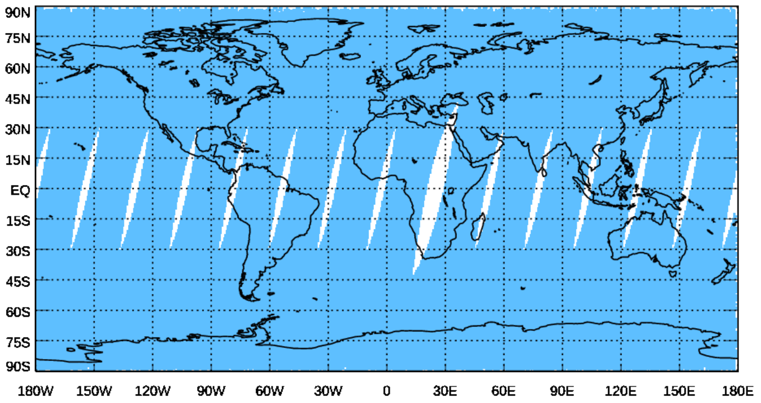
Mid-Wave

NOAA-21 CrIS Mid Wave SDR Overall Quality Flag, Mapped, Ascending, 03/24/2023

(Sky Blue: Good; Green: Degraded; Red: Invalid)



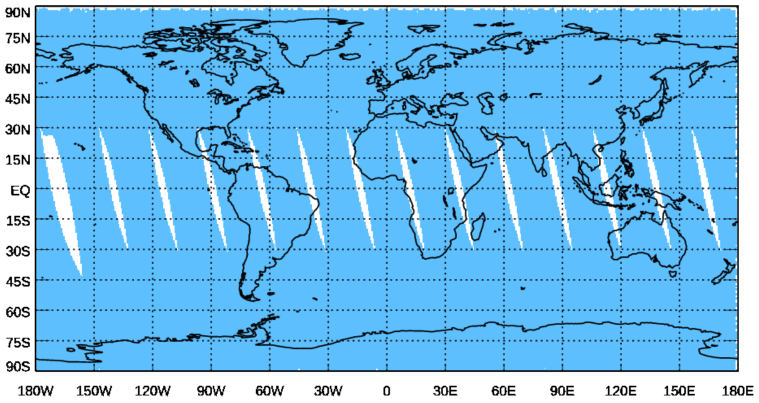
NOAA-21 CrIS Mid Wave SDR Overall Quality Flag, Mapped, Descending, 03/24/2023



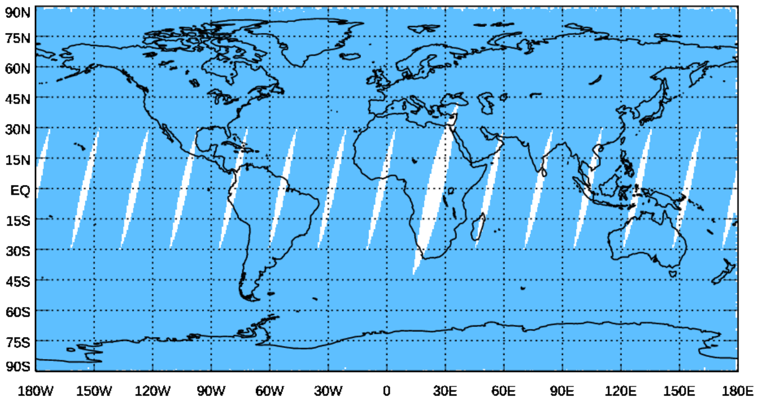
Short-Wave

NOAA-21 CrIS Short Wave SDR Overall Quality Flag, Mapped, Ascending, 03/24/2023

(Sky Blue: Good; Green: Degraded; Red: Invalid)

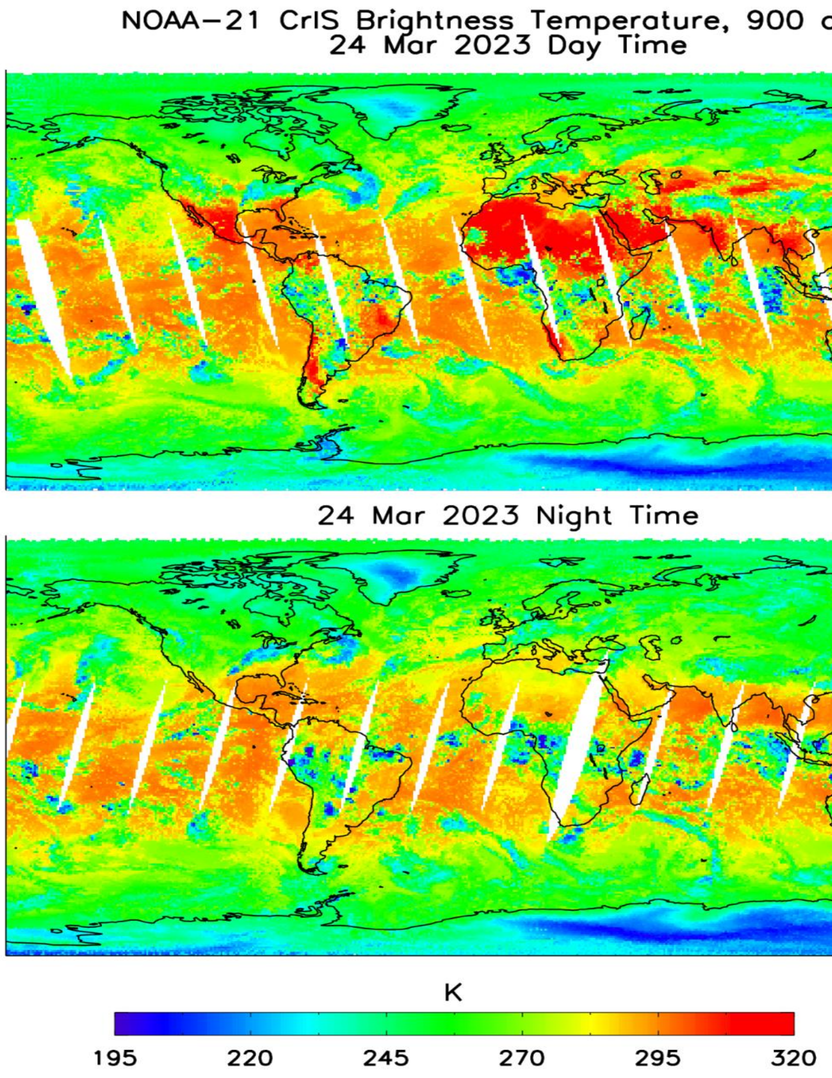


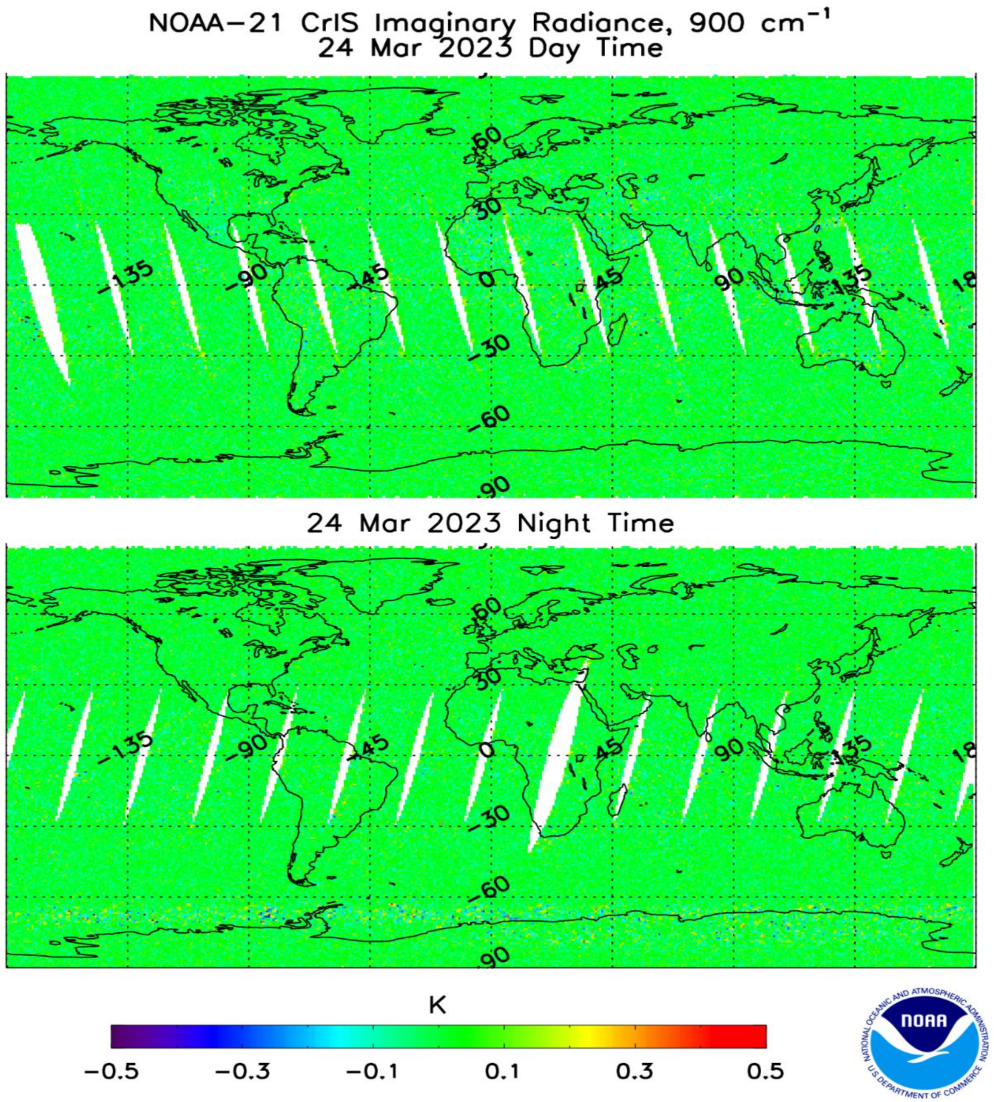
NOAA-21 CrIS Short Wave SDR Overall Quality Flag, Mapped, Descending, 03/24/2023



After the Upload of EP v211 on March 23, 2023, there has not been major Data gaps and signs or consistent Degraded or Invalid Spectra (Quality Flags indicate good data)

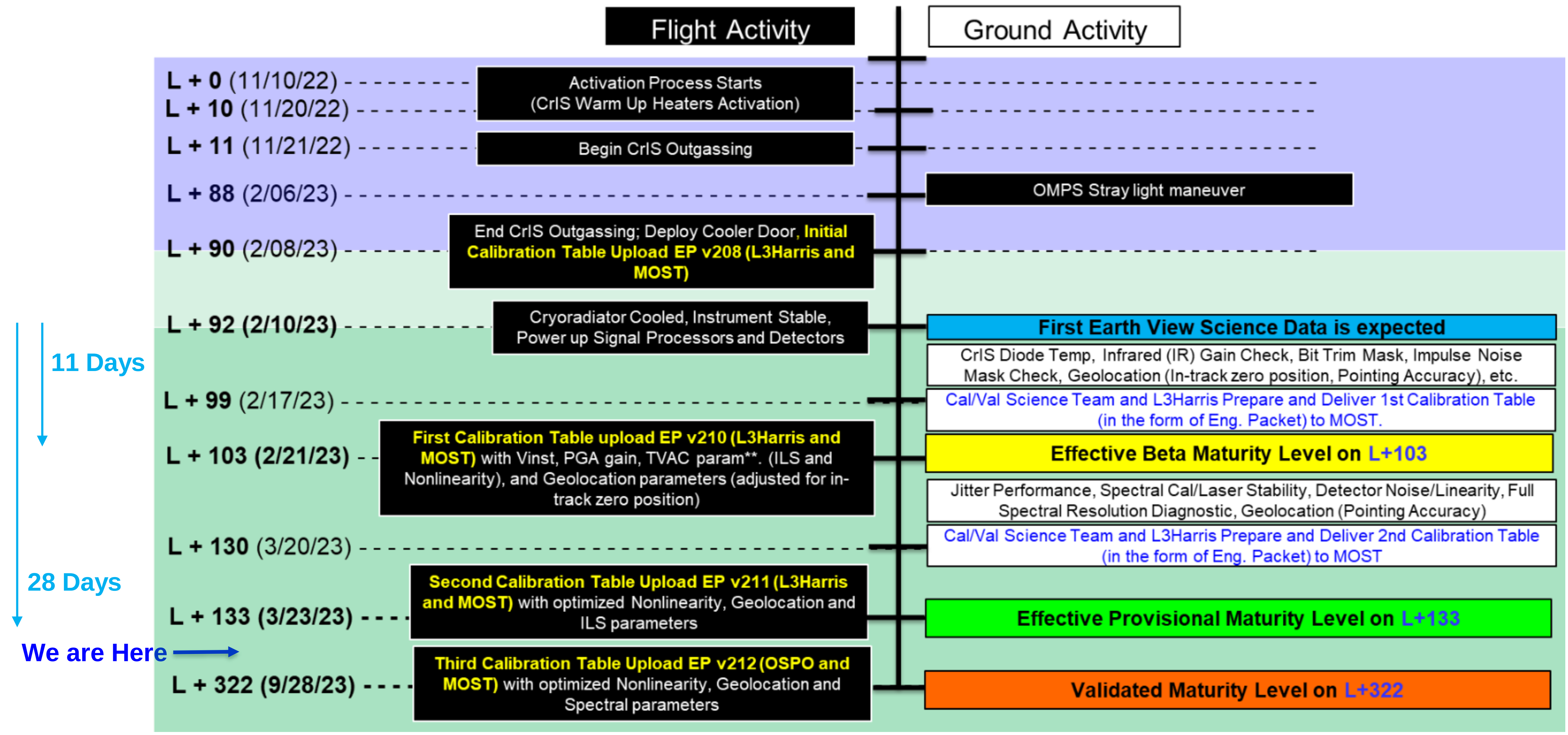
NOAA-21 CrIS Observation Map (24 March 2023)





NOAA-21 CrIS observed brightness temperatures and imaginary radiances are nominal.

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



- **New Improvements for NOAA-21 CrIS**
  - An algorithm update (CCR 6287) has been submitted **for quality control** where **the neon-calibrated laser wavelength** must be between 1540 nm and 1560 nm, or it will be rejected and replaced with the previously valid wavelength value.
  - This update was successfully tested and implemented into the new **IDPS Block 2.3 Mx8 Build.**
  - **Thus far, no invalid neon calibrations have occured.**

Upload of the NOAA-21 CrIS EP v211 on March 23, 2023

The Calibration Table for NOAA-21 CrIS was successfully uploaded on March 23, 2023 at 19:09:30Z (EP v211). A summary of the major updates include:

a) Optimized geolocation mapping parameters

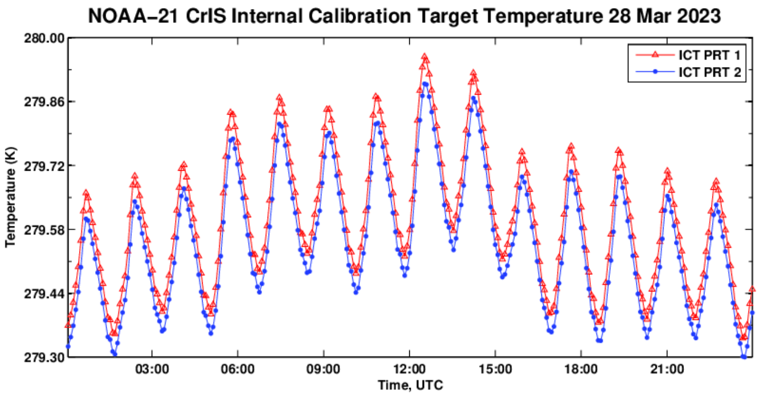
b) Optimized spectral parameters (Instrument Line Shape and Neon Wavelength)

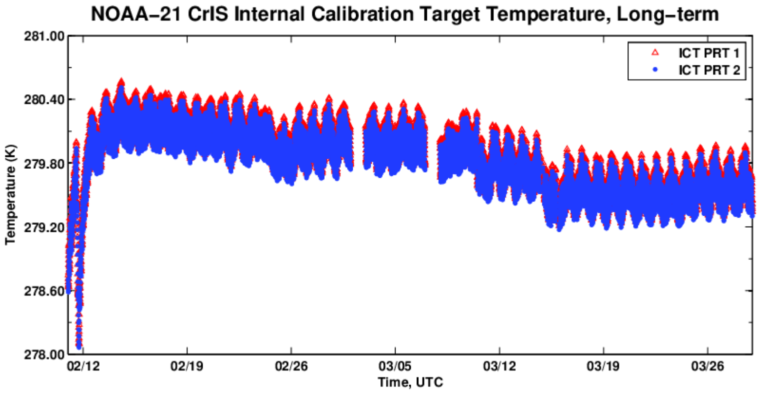
c) Optimized radiometric nonlinearity a2 values

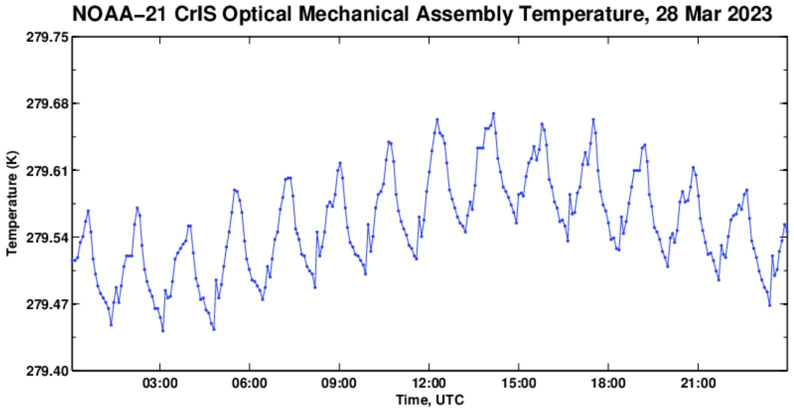
Optimized parameters were derived using the NOAA-21 CrIS on-orbit observations.

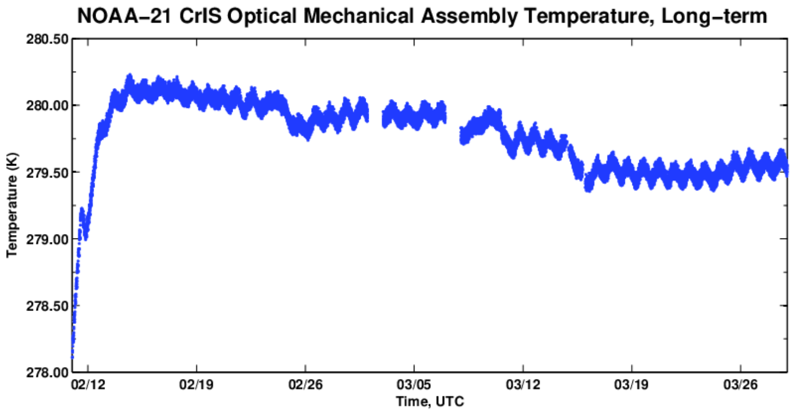
NOAA-21 CrIS Science Telemetry: ICT, OMA & Scan Baffle Temperatures

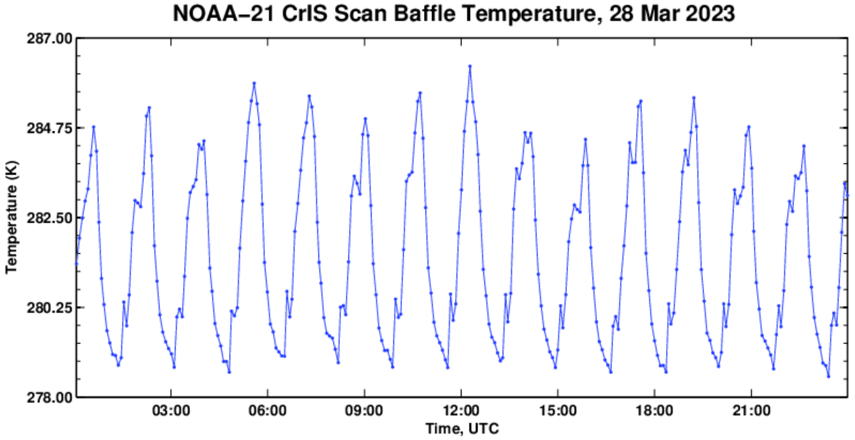
- **Critical CrIS modules are at nominal temperatures, and are stable**
- Includes Internal Calibration Target, Optical Mechanical Assembly, and Scan Baffle/SSM Mirror Temperatures

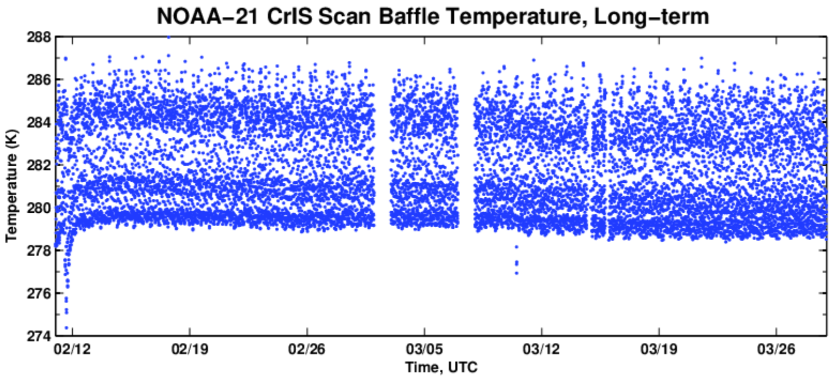








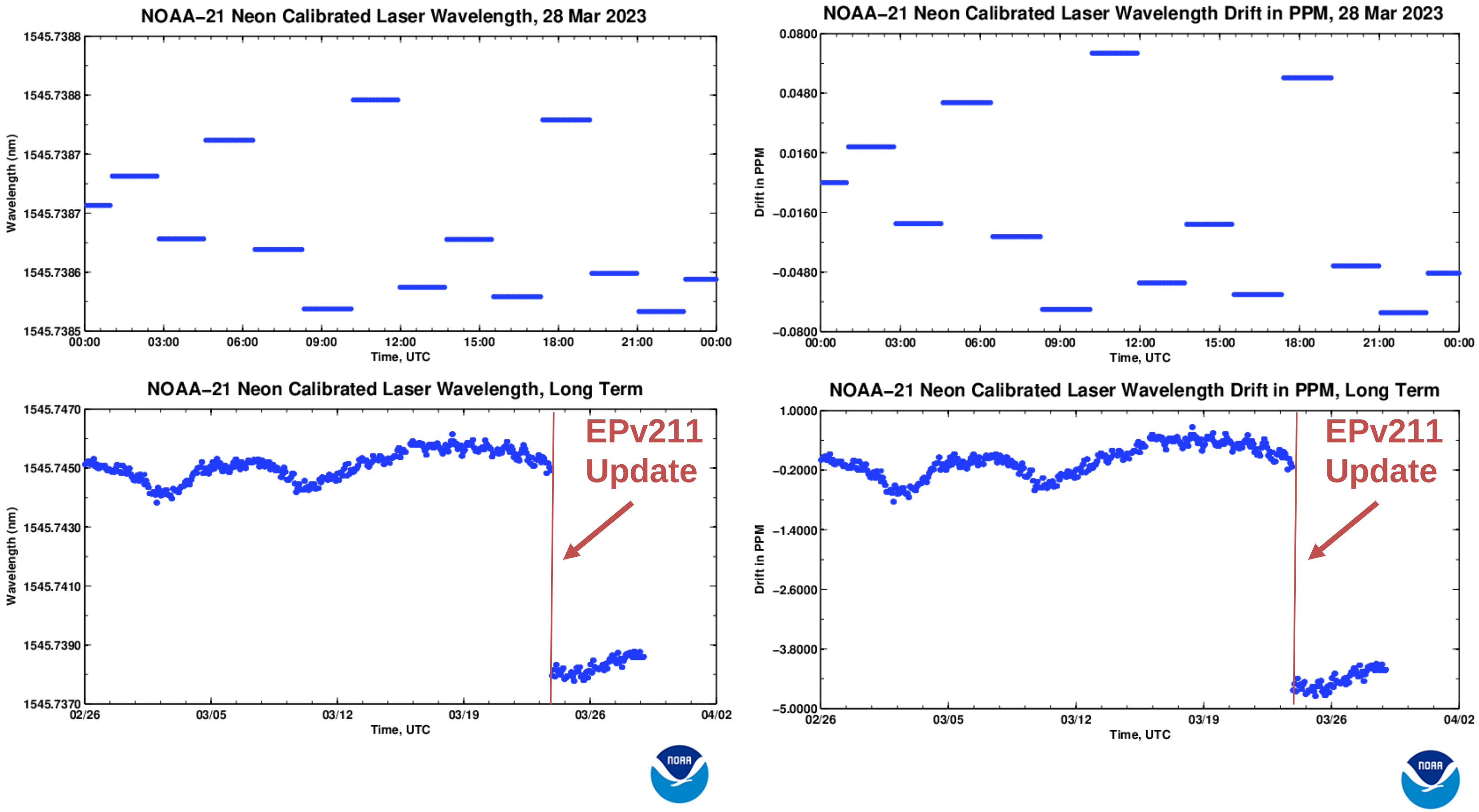




Provided by Peter Beierle

NOAA-21 CrIS Science Telemetry: Laser Wavelength

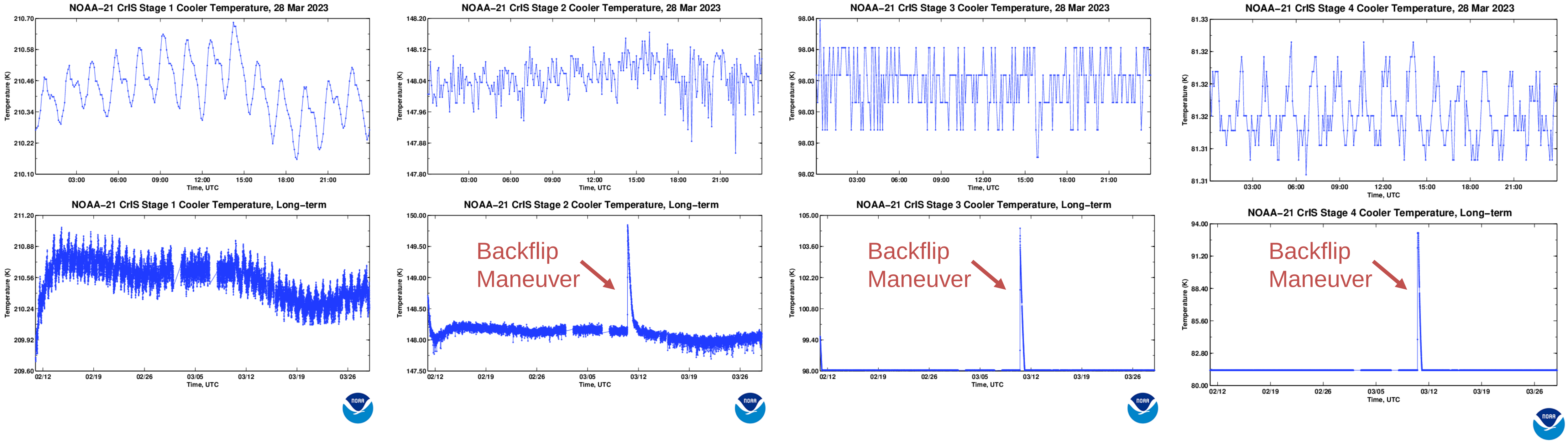
- **Neon Calibrated Laser Wavelength is Stable and at a nominal level**
- **Value updated slightly (by ~4.5 ppm) after Engineering Packet v211 Update**



Provided by Peter Beierle

NOAA-21 Detector Cooler System Telemetry

- **Detector Stage Coolers are at nominal temperatures, and stable**
- 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

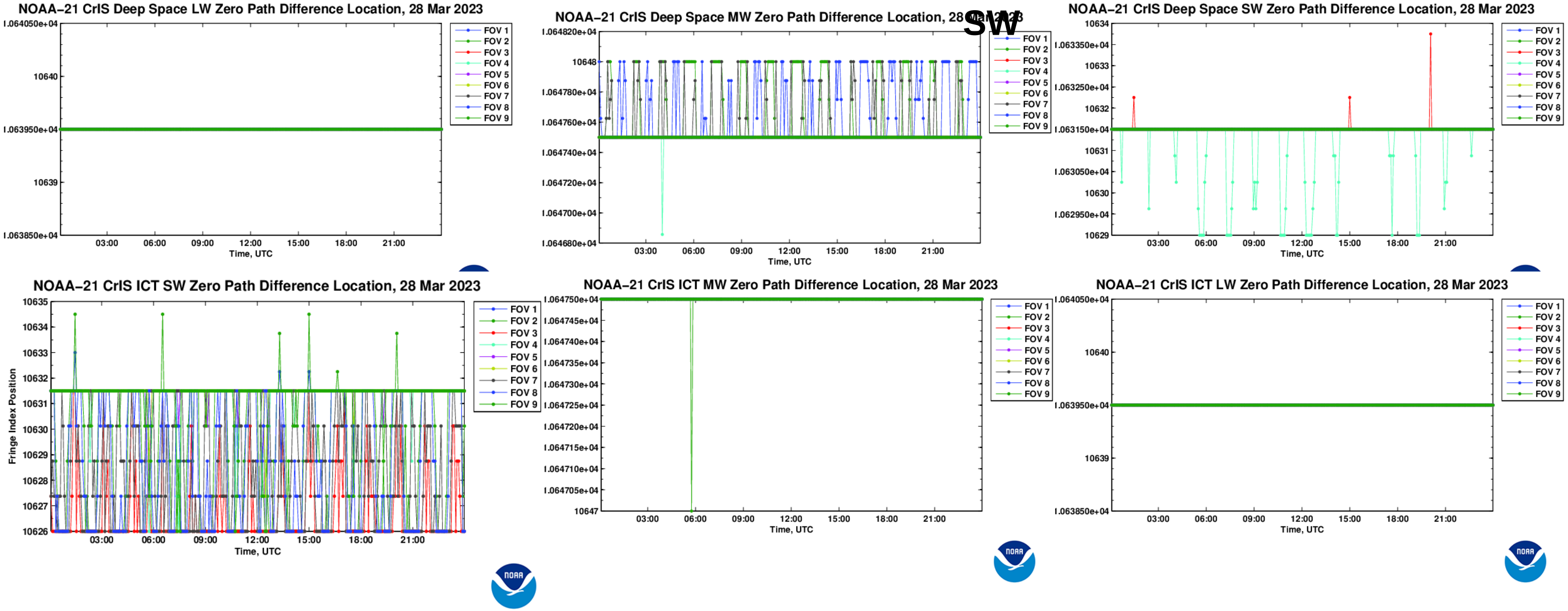
NOAA-21 Zero Path Difference (ZPD) Location

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

LW **SW** **MW**

Deep Space

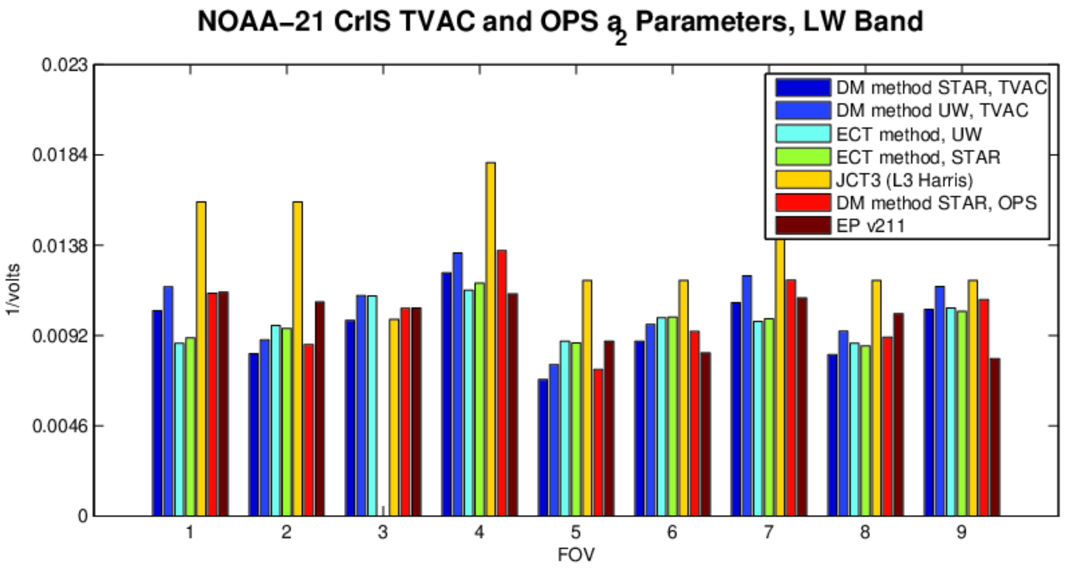
ICT

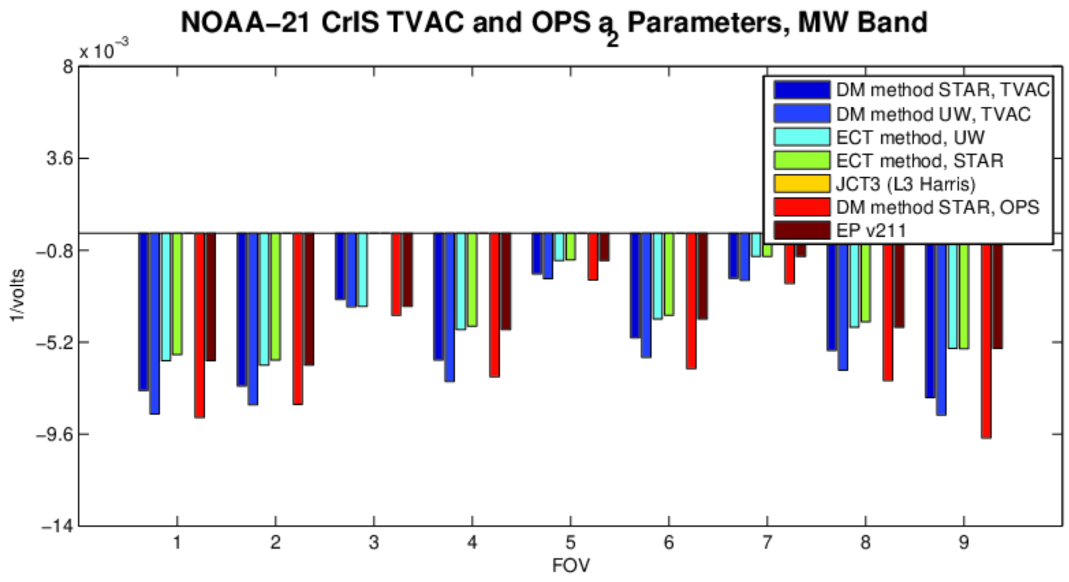


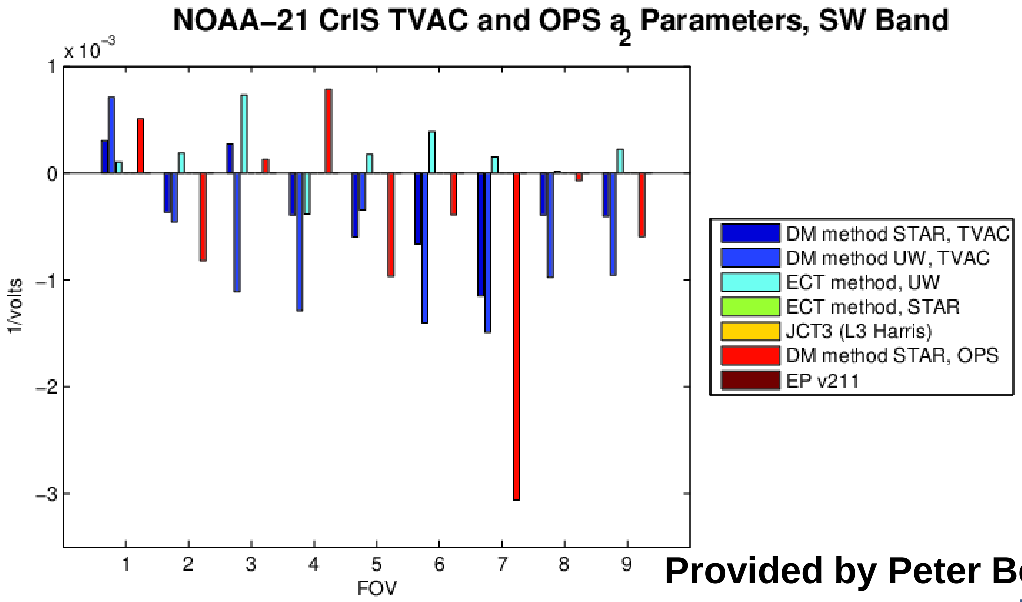
Provided by Peter Beierle

NOAA-21 On-orbit Nonlinearity Verification

- Diagnostic Mode Data from February 24 and 25, 2023.
- **Good agreement between TVAC DM method, ECT method, and on-orbit calculation of nonlinearity**
- **Further Refinement Was made using Fov2Fov Radiometric comparisons on-orbit, used for EPv211 update (see UW slides)**



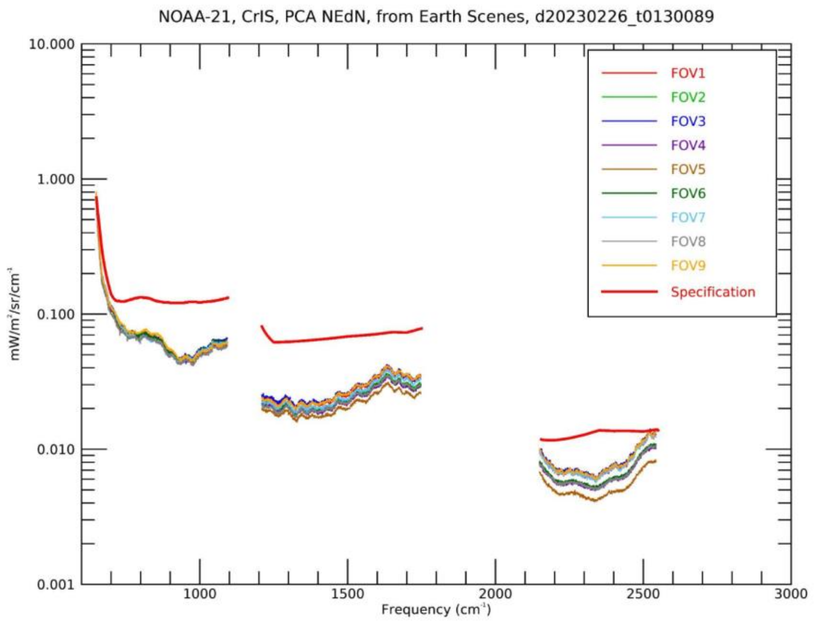




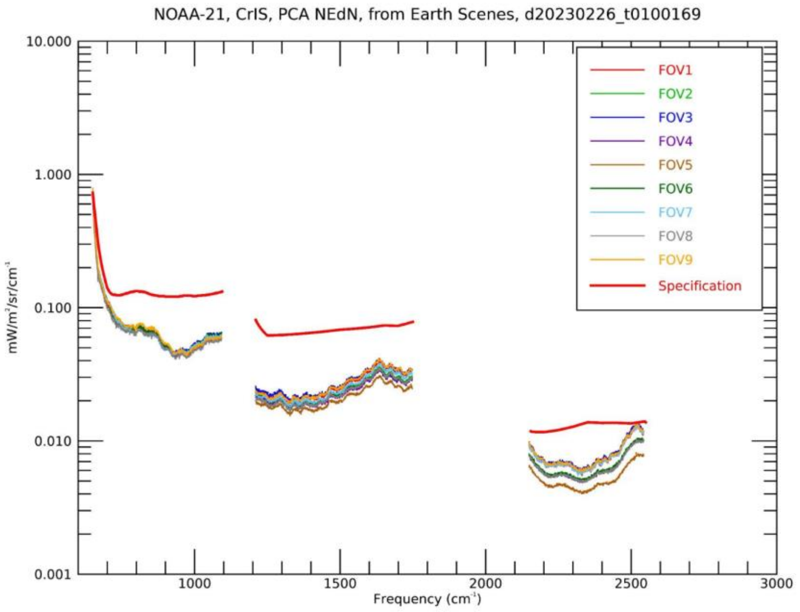
Provided by Peter Beierle

NOAA-21 CrIS On-orbit Performance: Radiometric Noise

NOAA-21 EP 210, 5/26/2022



NOAA-21 EP 211, 2/26/2023



PCA NEdN (Turner Method) on 2/26/2023 from SDR on-orbit Earth Scenes for EP 210 and EP 211.

NEdN meets the requirements.

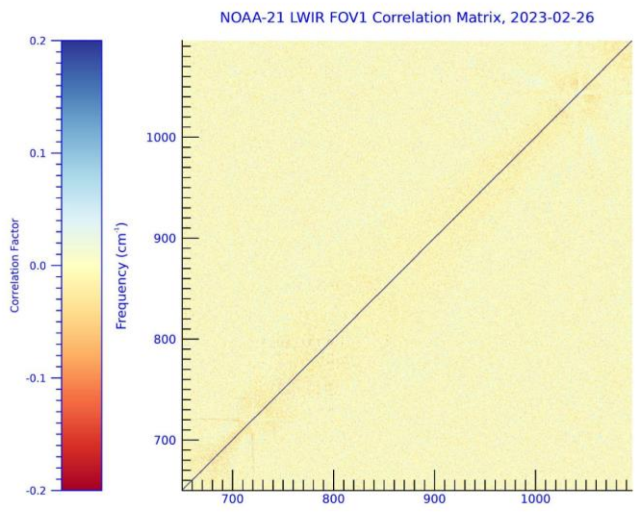
- EP 210 and EP 211 NEdN are consistent, and **on-orbit NEdN already meets the requirements.**
- **NOAA-21 CrIS shows high consistency noise performance between FOVs.**
- FOV spread in SW is a known effect of the algorithm (ISA correction) when applied to full resolution spectra.
- Specification line (bold red) does not include the self-apodization (or ILS) effects whereas the radiometric noise includes these effects (see slide 17).

Provided by Denis Tremblay

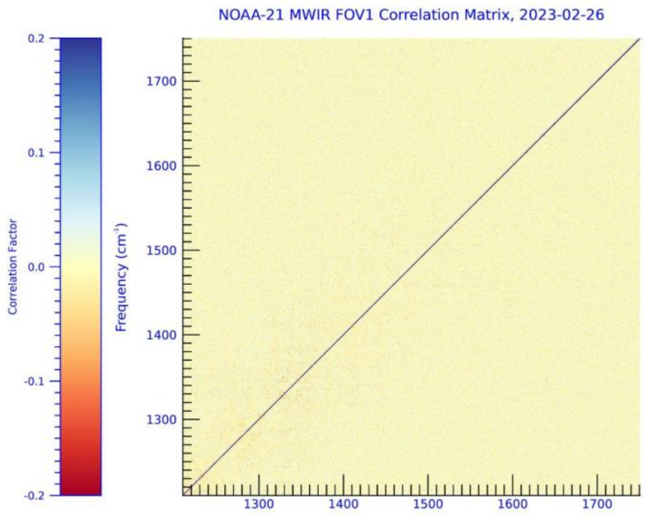
NOAA-21 CrIS on-orbit performance: Full Correlation Matrix for EP 211

NOAA-21 on-orbit Full Correlation Matrices for FOV 1 (LWIR, MWIR, SWIR) on 2/126/2023 for EP 211

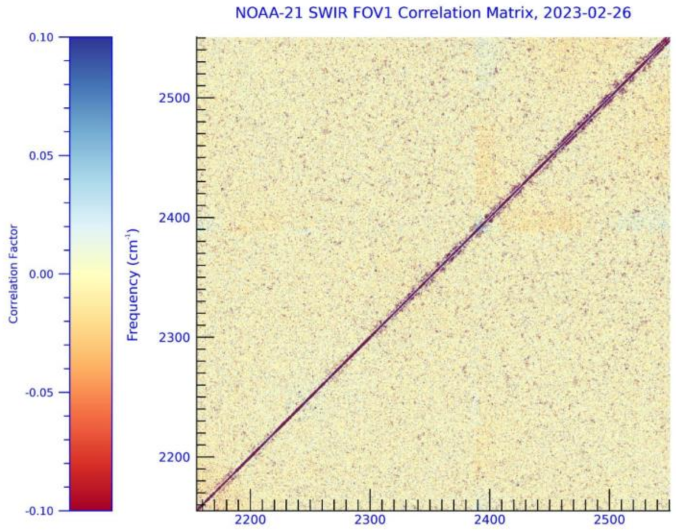
LWIR



MWIR



SWIR



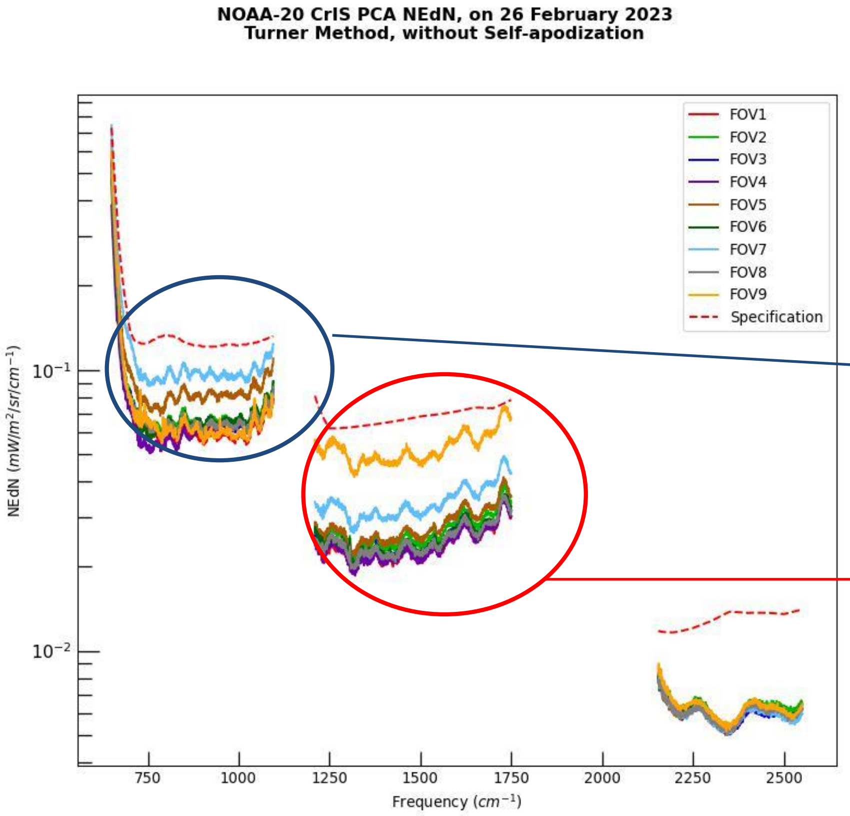
- SWIR near off-diagonal high values are due to SA effect (most for side FOVs, less for side FOVs, lesser for center FOV). **This is similar to SNPP and NOAA-20 CrIS as expected.**
- **There is no sign of high cross correlation in noise between the channels.**

Provided by Denis Tremblay

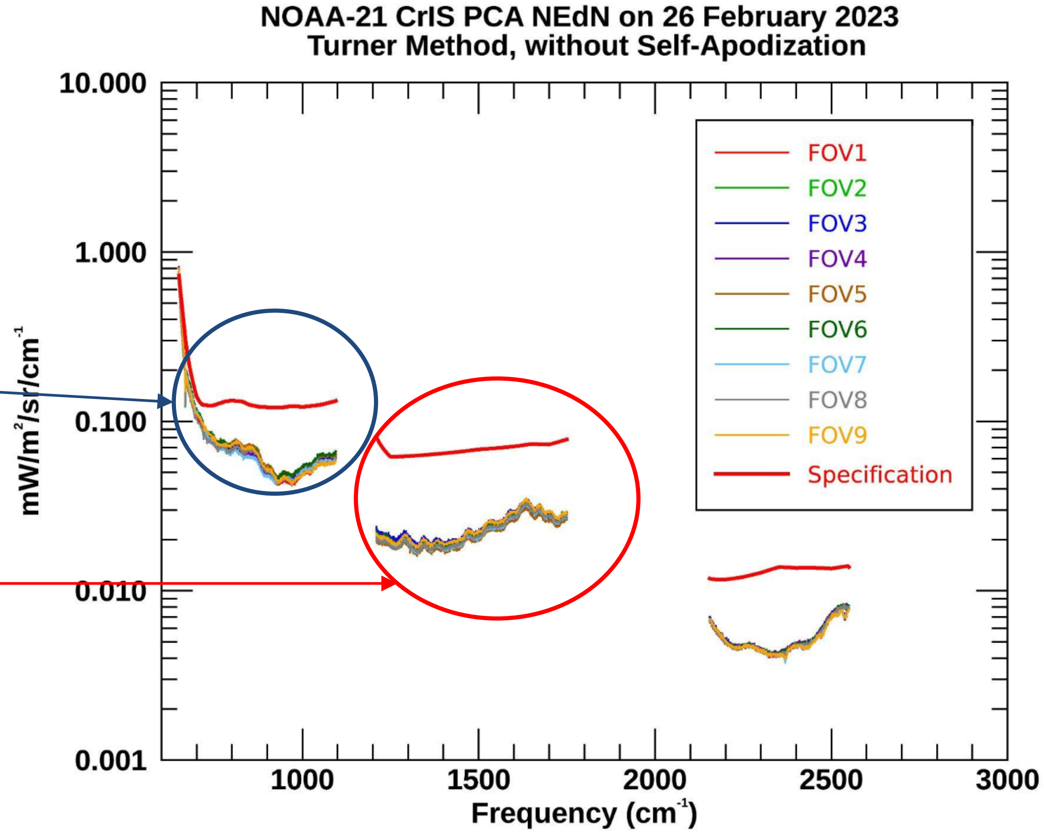
NOAA-21 CrIS EP 211 On-orbit Noise Performance vs NOAA-20

PCA NEdN Turner Method on 2/26/2023 (Without Self-Apodization effect)

NOAA-20



NOAA-21



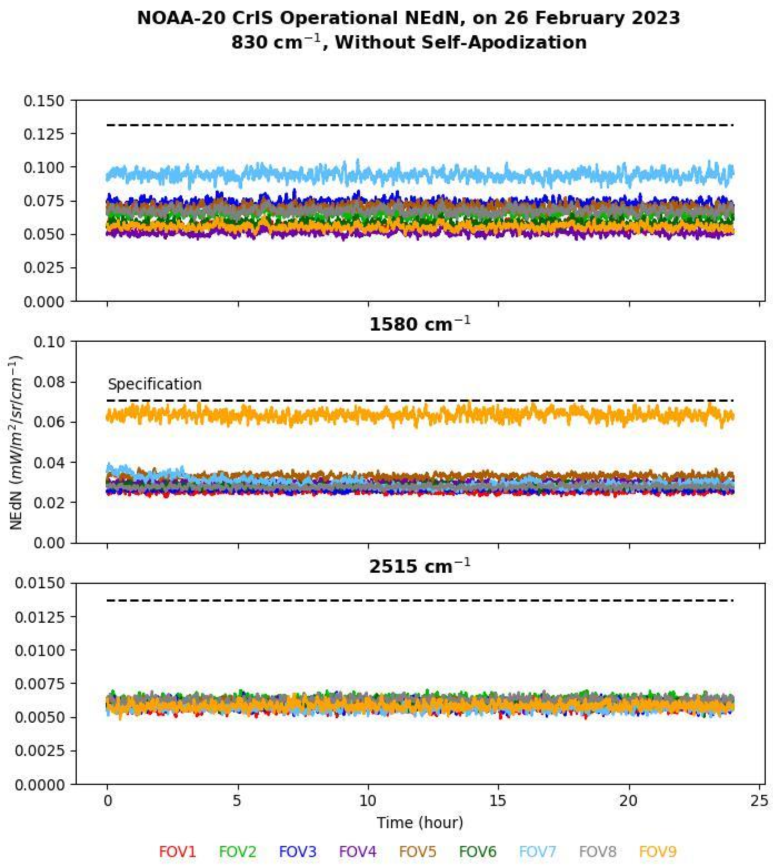
NOAA-21 has **no outliers in the MWIR** and has **much less variance/spread in the LWIR and MWIR** bands for NEdN (noise). **Improved consistency in noise levels between the FOVs.**

Provided by Denis Tremblay

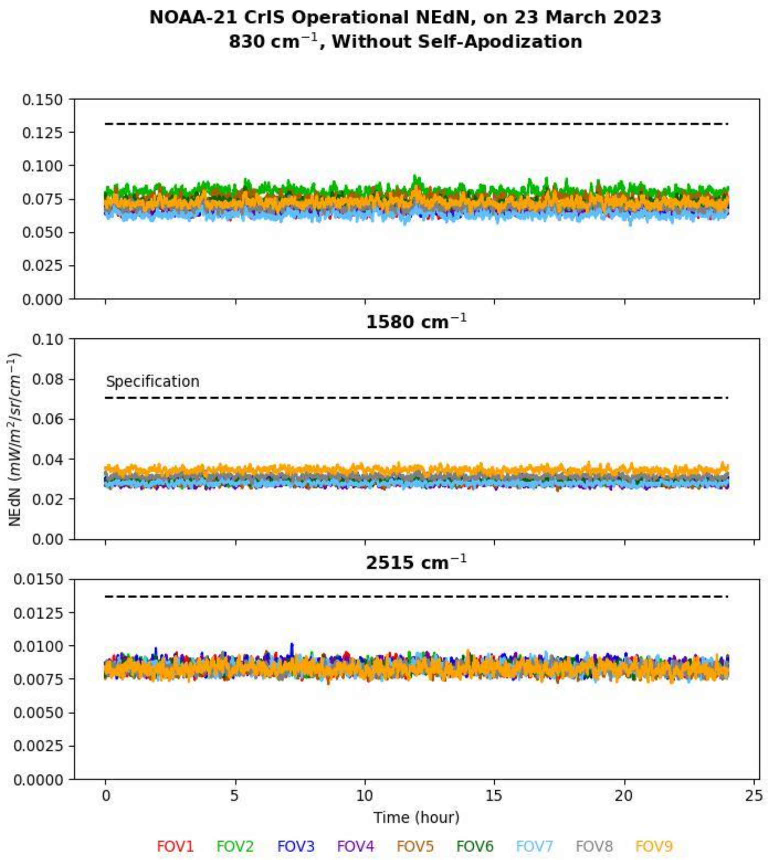
NOAA-21 CrIS on-orbit performance: Radiometric Noise Stability

NEdN at Scan Level

NOAA-20



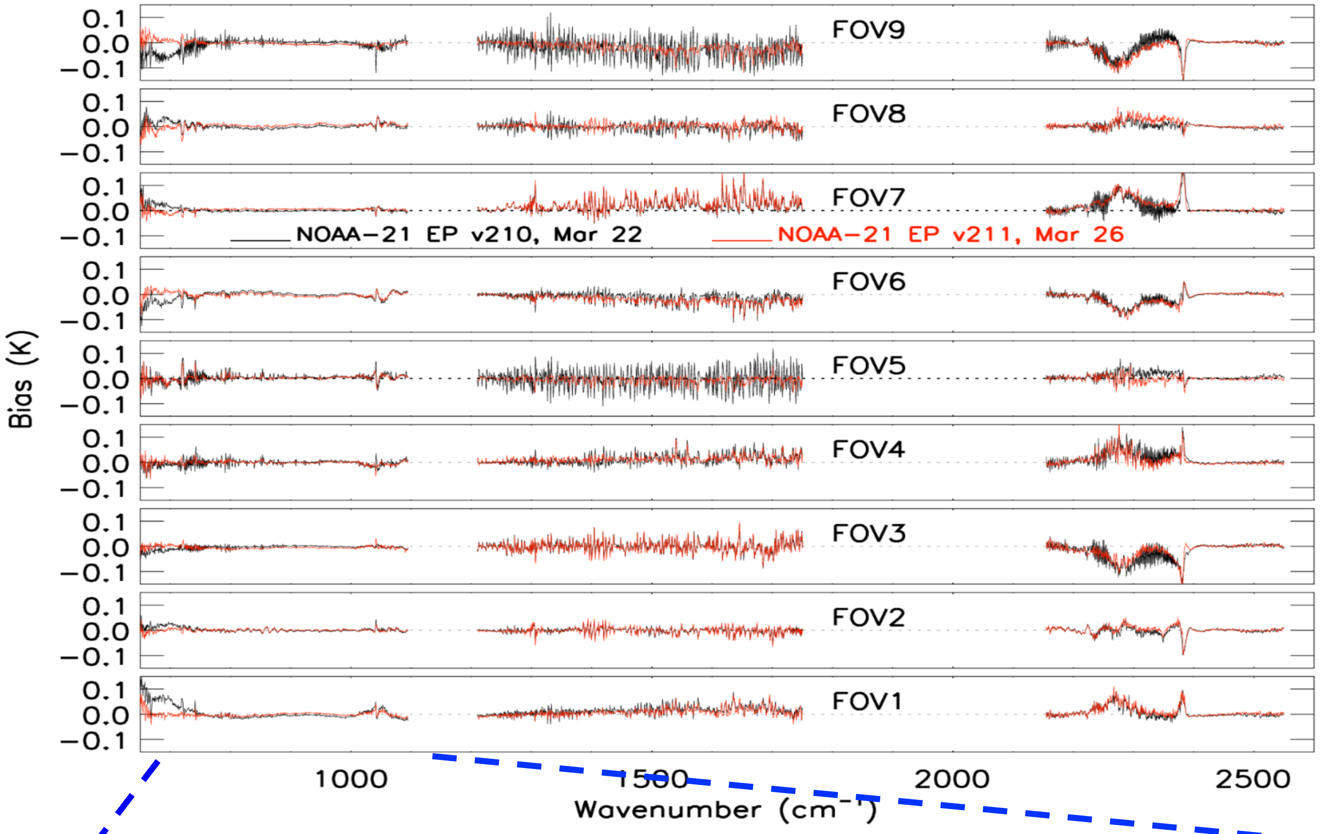
NOAA-21



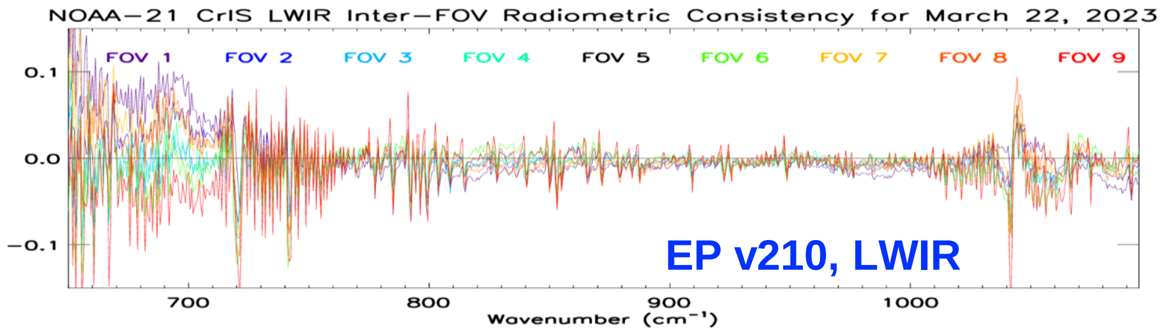
NOAA-21 CrIS Radiometric noise (NEdN) has shown stability and consistency for all detectors.

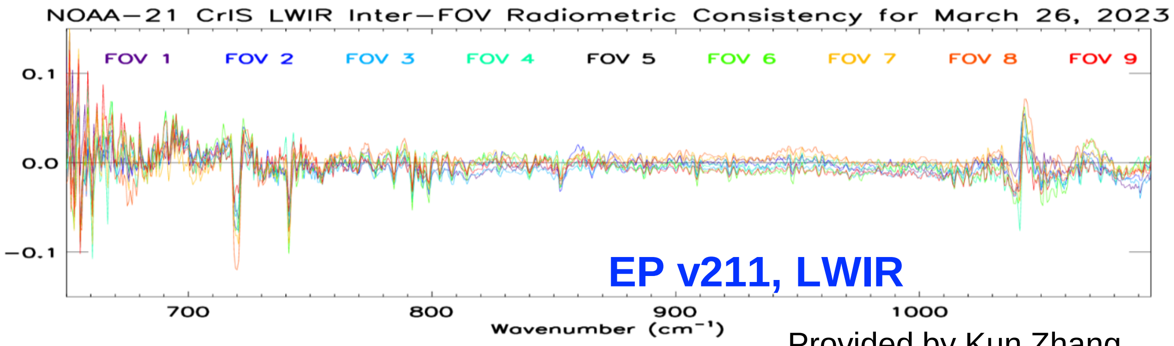
Provided by Denis Tremblay

NOAA-21 CrIS FOV-2-FOV Variability with EP v211 Update



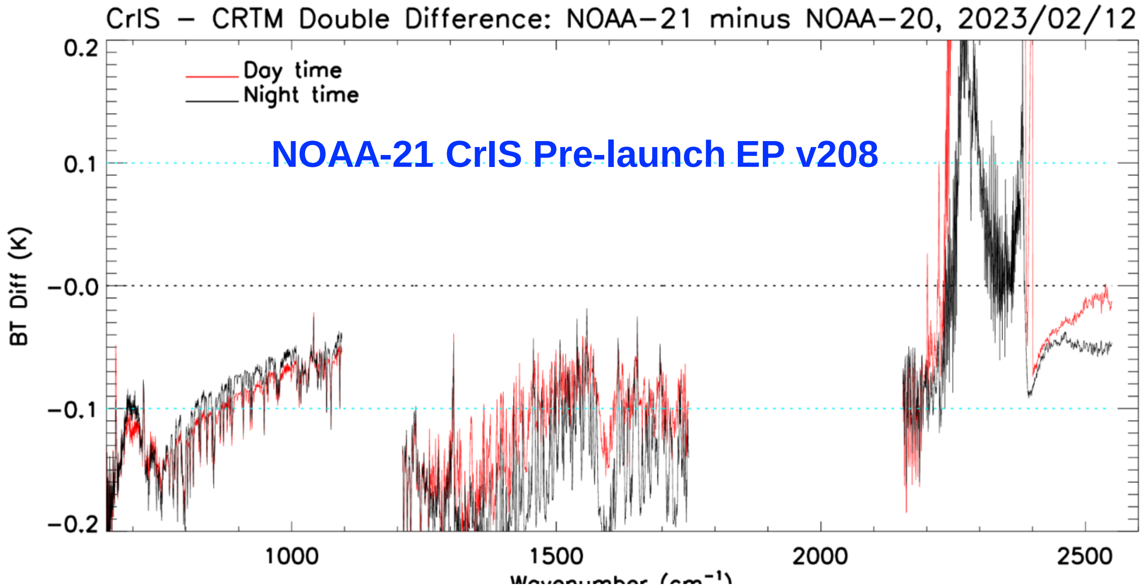
- Intercomparison of FOV-2-FOV variability before (March 22) and after (March 26) the EP v211 update.
- The NOAA-21 CrIS FOV-2-FOV relative radiometric variability is **within +/- 0.1 K for all three bands after the Engineering Packet v211 update.**
- **The radiometric consistency improvement at MWIR** is related to the optimized spectral parameters.
- **Improved FOV-2-FOV radiometric consistency at LWIR** as a result of optimized nonlinearity a2 values.

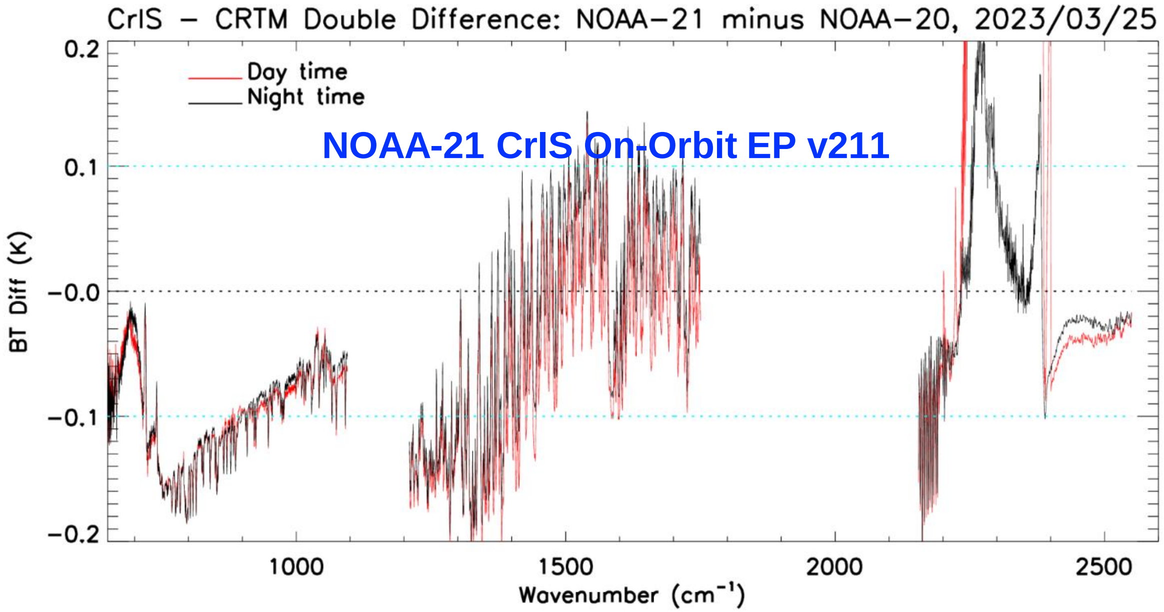


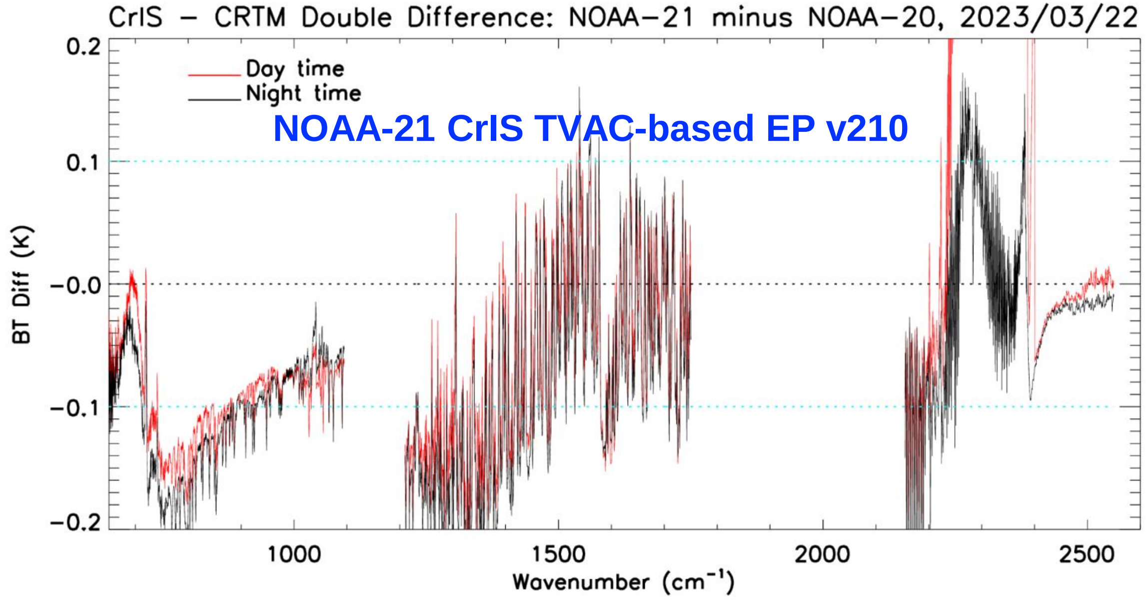


Provided by Kun Zhang

NOAA-21 CrIS Radiometric Comparison with NOAA-20 CrIS







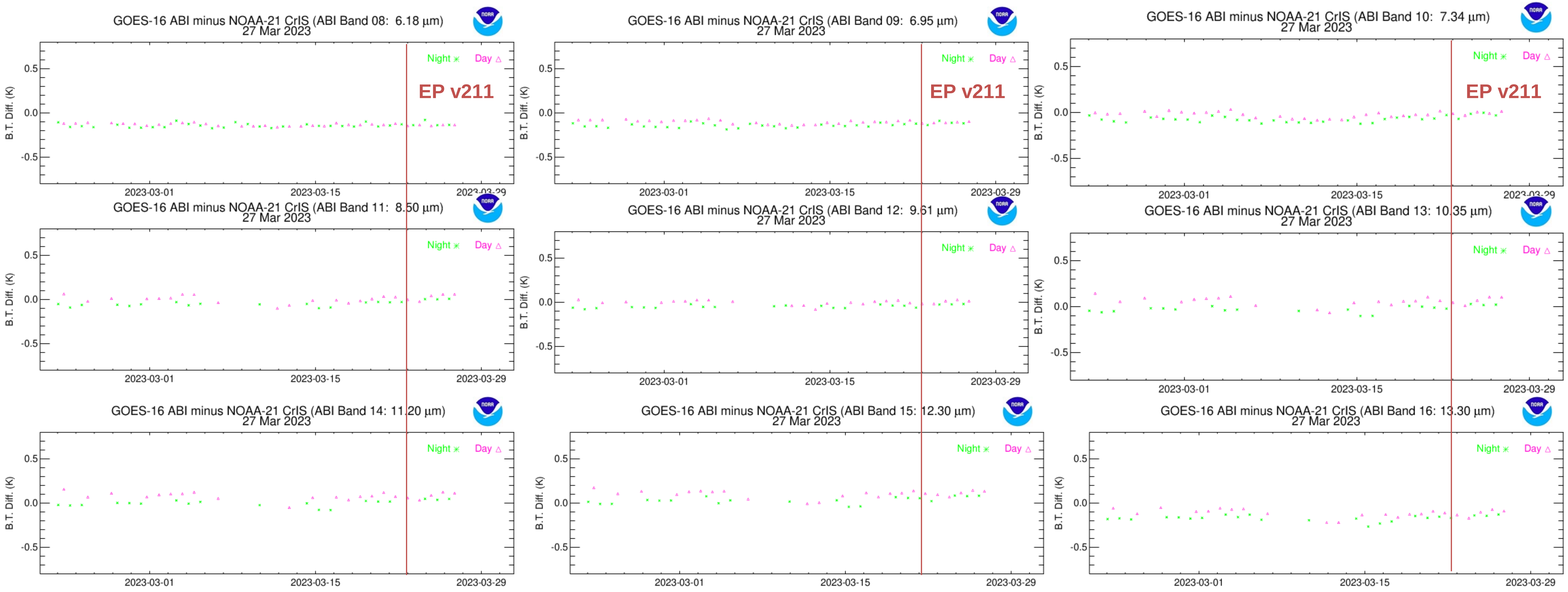
- **Radiometric differences with the latest calibration table update (EP v211) are within +/- 0.2 K for most of channels in three bands.**
- **The non-linearity calibration update reduced the radiometric difference at LWIR.**
- All FOVs and FORs for clear-sky observations over ocean between +/- 65 deg latitude were selected for March 25, 2023.
- NOAA-21 CrIS Calibration Table v211 in operation.

Provided by Kun Zhang

NOAA-21 CrIS SDR/GOES-16 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), <u>indicating the highly stable calibration of NOAA-21 CrIS Radiances</u>.**

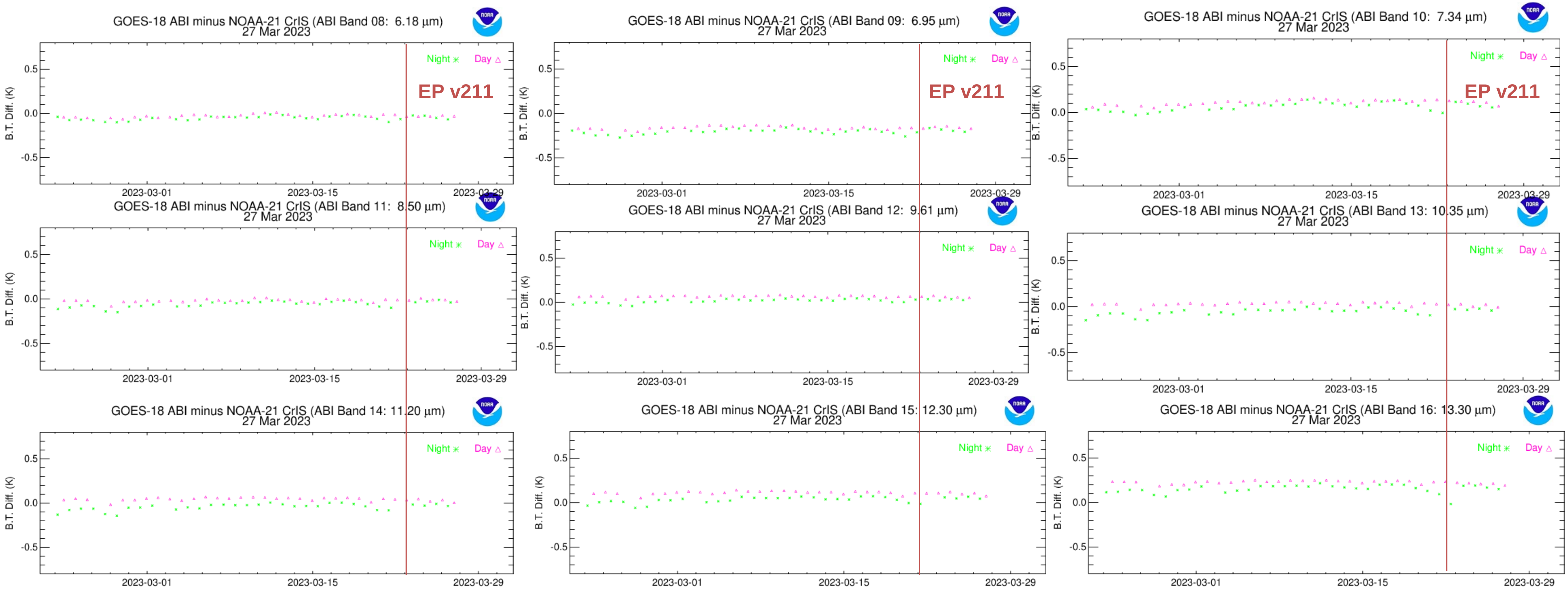
Provided by Peter Beierle



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

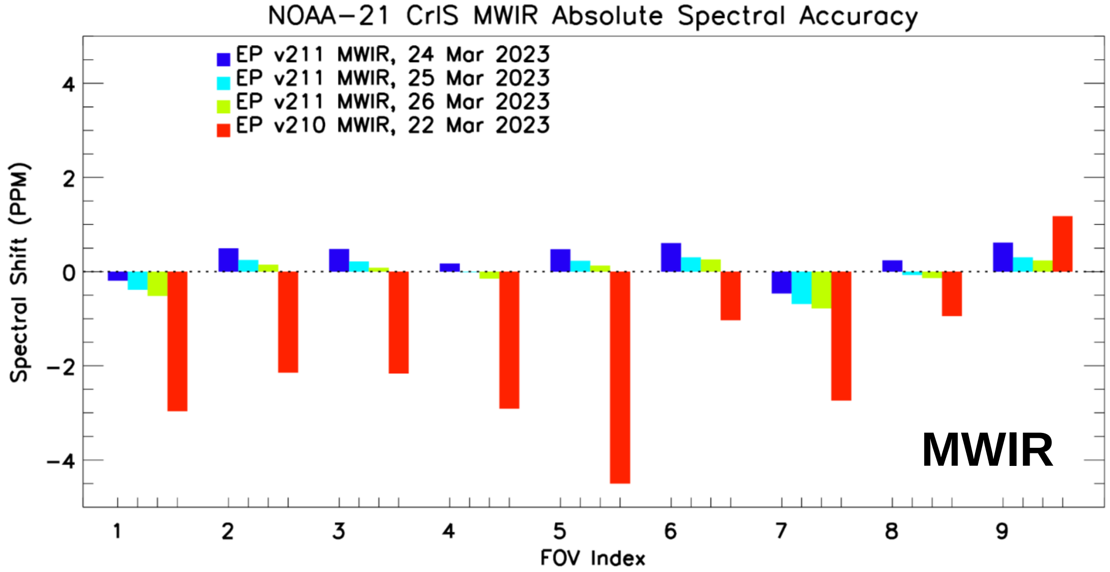
- ABI bands 8-11 correspond to CrIS MWIR band and bands 12-16 correspond to CrIS LWIR band.
- **The comparison of the two instruments shows temporally stable brightness temperature biases (within 0.2K), <u>indicating the highly stable calibration of NOAA-21 CrIS Radiances</u>.**

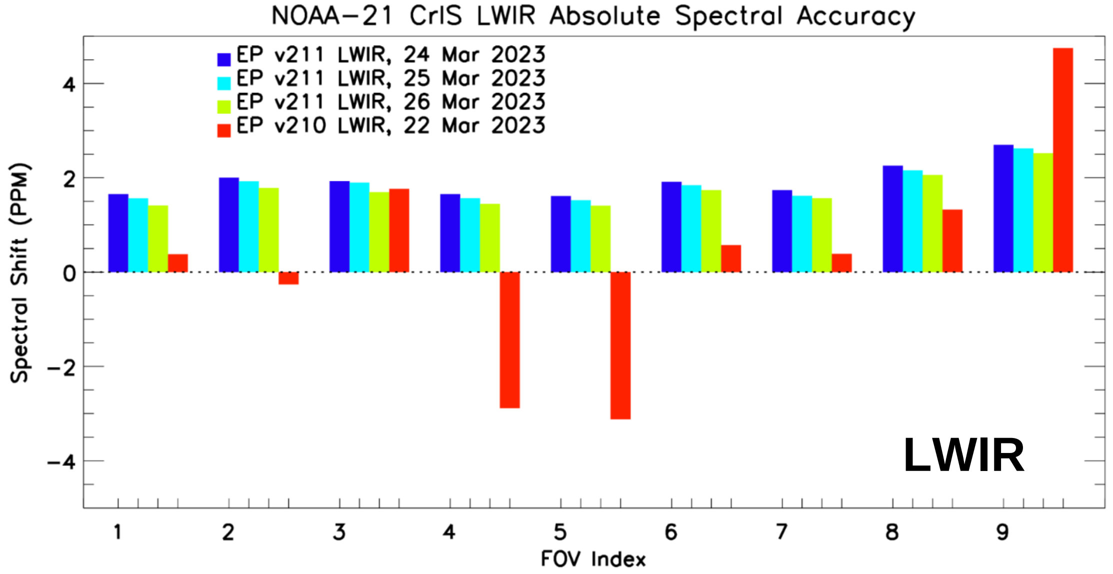
Provided by Peter Beierle

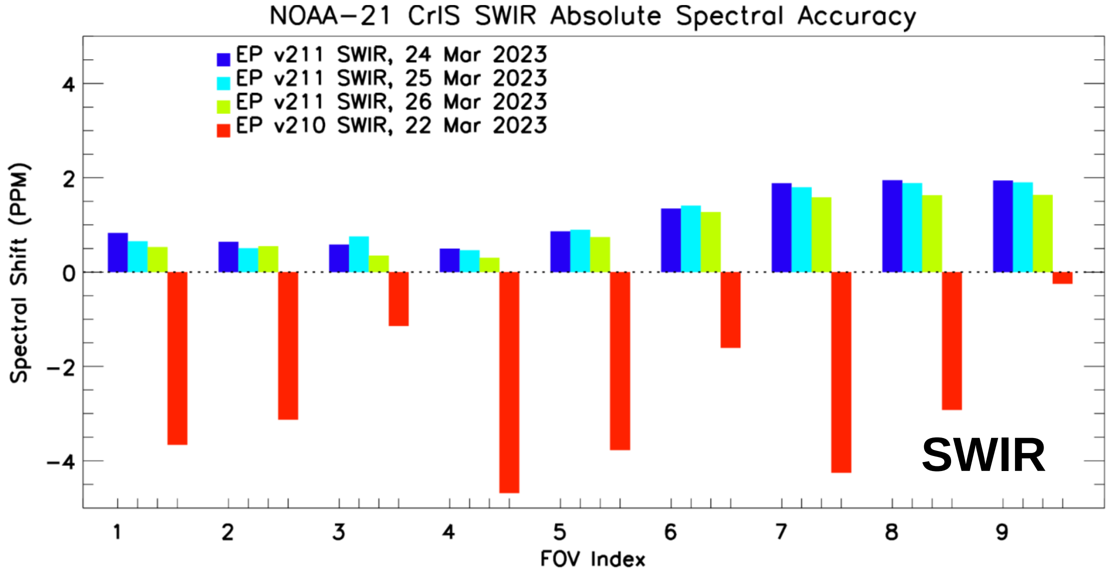


NOAA-21 CrIS Absolute Spectral Accuracy with EP v211 Update

- The NOAA-21 CrIS shows **consistent absolute spectral shift for all three bands** on March 24, 25, and 26 after EP v211 update.
- **Significant spectral performance improvement** compared to the Beta maturity EP v210.
- Absolute spectral shift **within 2 ppm for LWIR, MWIR, and SWIR band**.



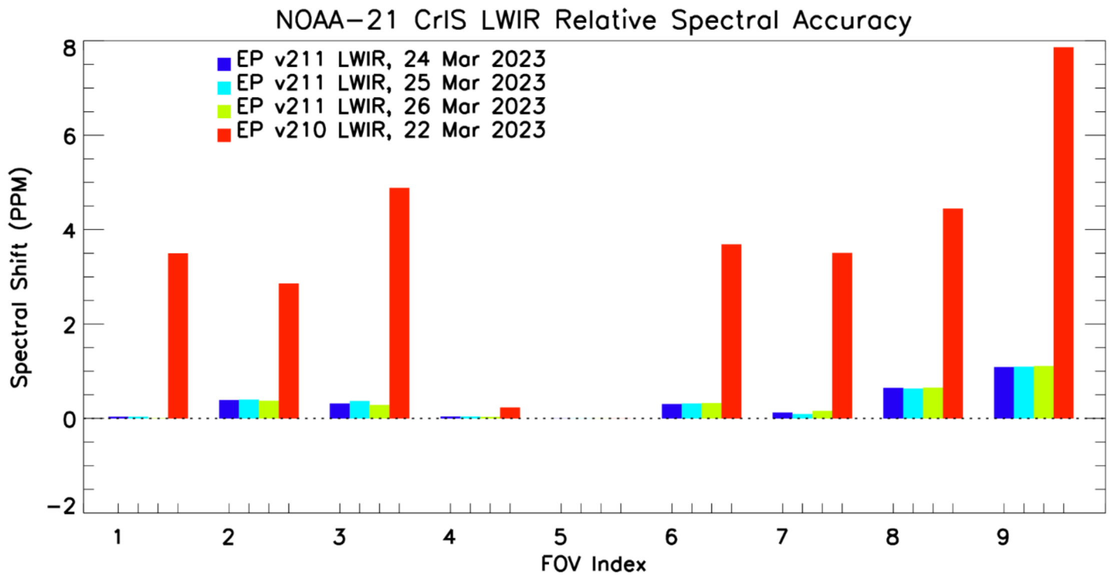


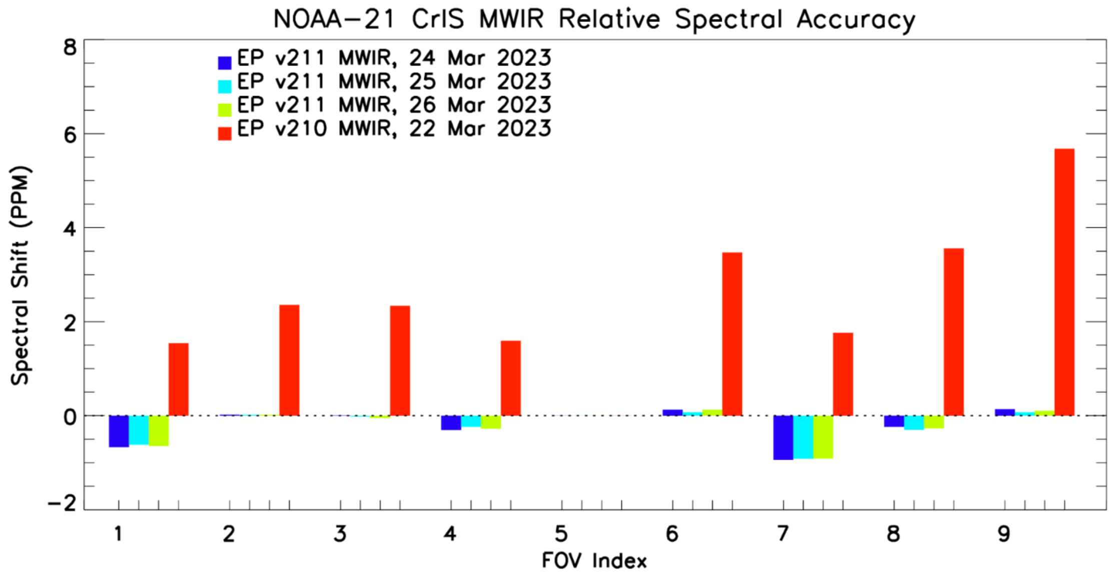


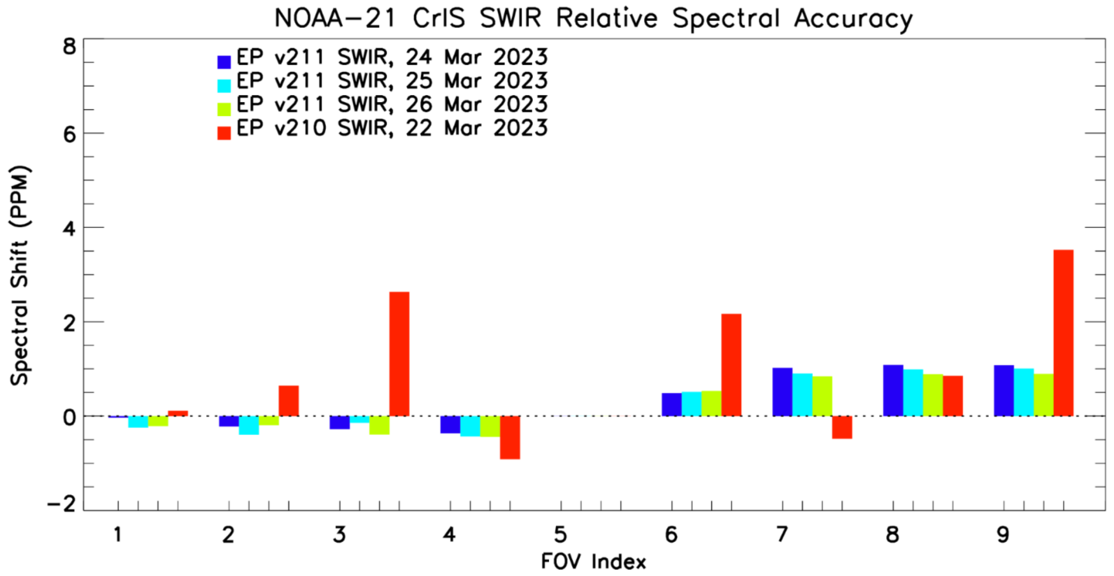
Provided by Kun Zhang

NOAA-21 CrIS FOV-2-FOV Spectral Shift with EP v211 Update

- The NOAA-21 CrIS shows **FOV-2-FOV spectral shift within 1 ppm for all three bands** after EP v211 update.
- **Significant spectral performance improvement** compared to the Beta maturity EP v210.

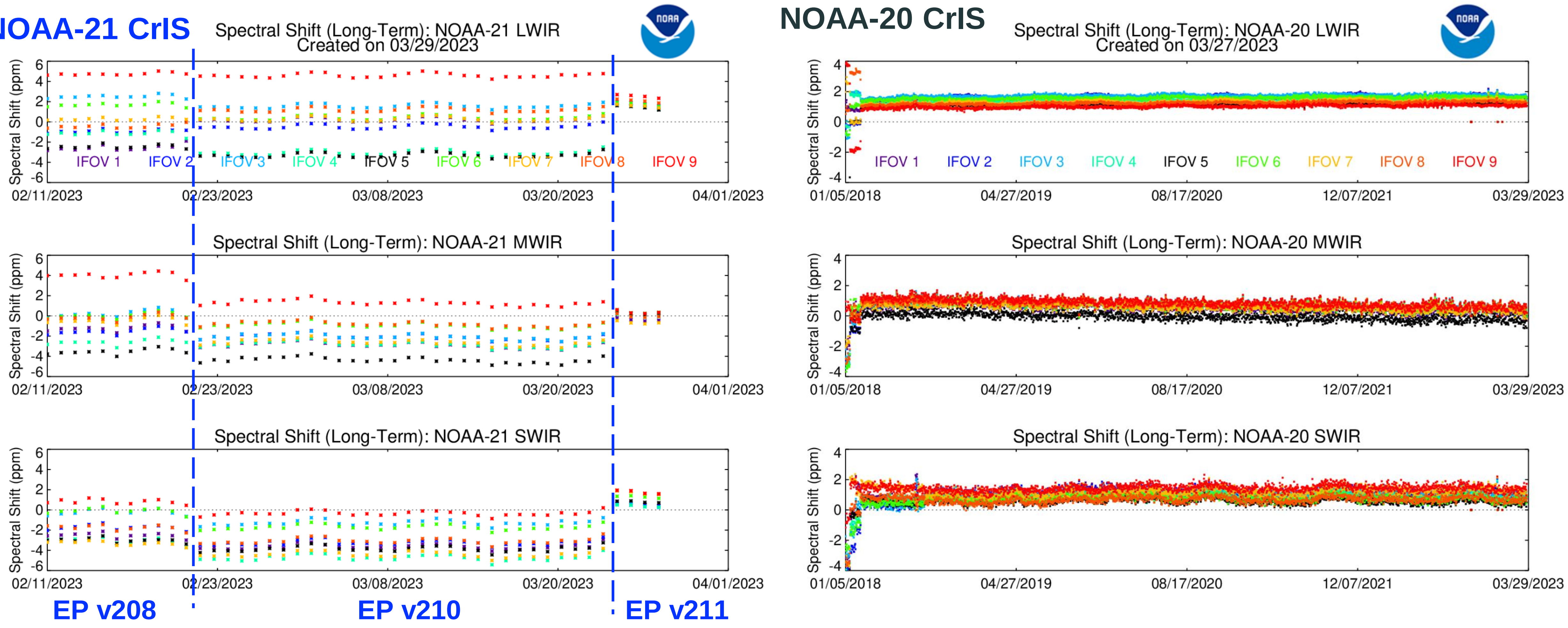






Provided by Kun Zhang

NOAA-21 CrIS Spectral Accuracy Comparisons with NOAA-20

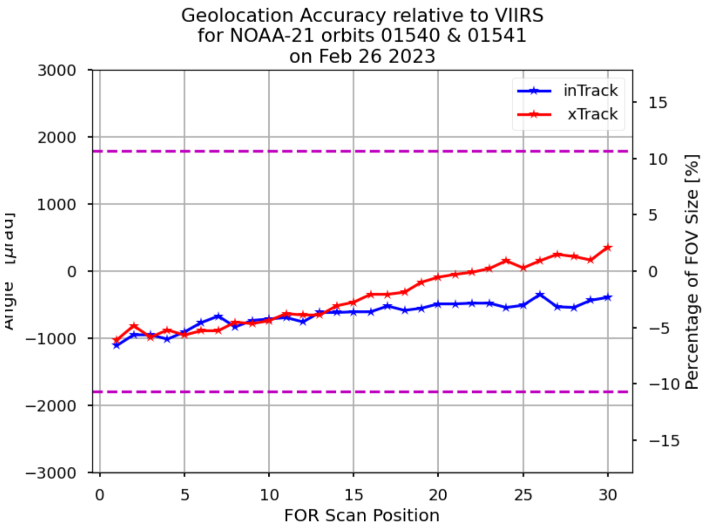


- **The NOAA-21 CrIS shows significant improvement of spectral accuracy after EP v211 update.**
- **The absolute spectral accuracy is reduced to within +/- 2 ppm for all three bands and has consistent performance as the operational NOAA-20 CrIS.**

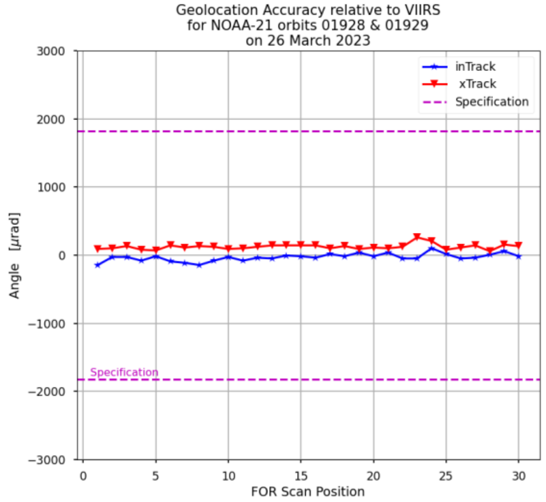
Provided by Kun Zhang

Geolocation Accuracy: NOAA-21 EP 210 vs EP 211 and Time Series

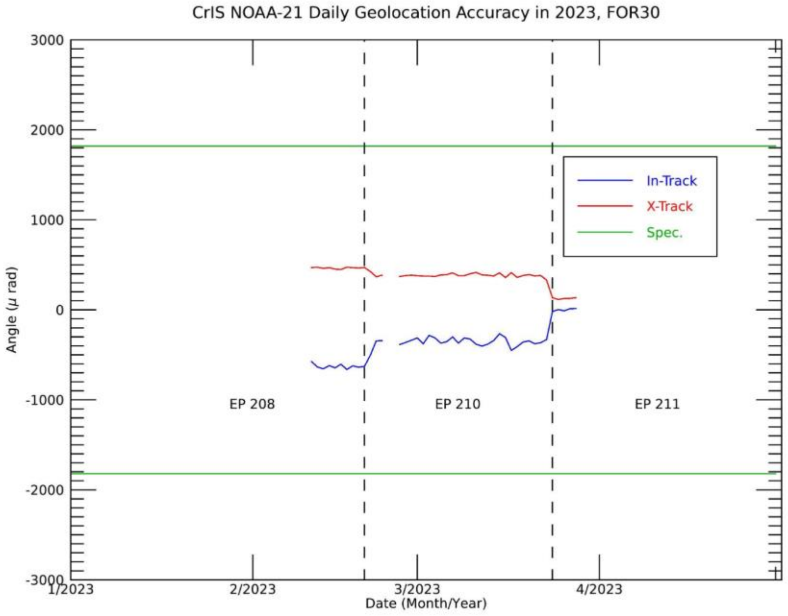
EP 210



EP 211



Time Series



- **Geolocation meets the requirements for EP 211.**
- Worst case performance: **Geolocation uncertainty amounts to about 250 m. at nadir** with EP V211.
- **Future geolocation adjustment will consider adjustment of the VIIRS geolocation and potential annual/semi-annual variation.**

Geolocation accuracy is excellent for EP 211.

Provided by Denis Tremblay

Imaginary Radiance Observation

- What: **Slightly elevated imaginary radiance levels have been observed between 45-60 deg. S Latitude Region.**
- Why: Results from **heating of the SSM baffle** when illuminated by the Sun at high latitudes **when leaving satellite eclipse**, **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 quality of the NOAA-21 CrIS SDR data.**

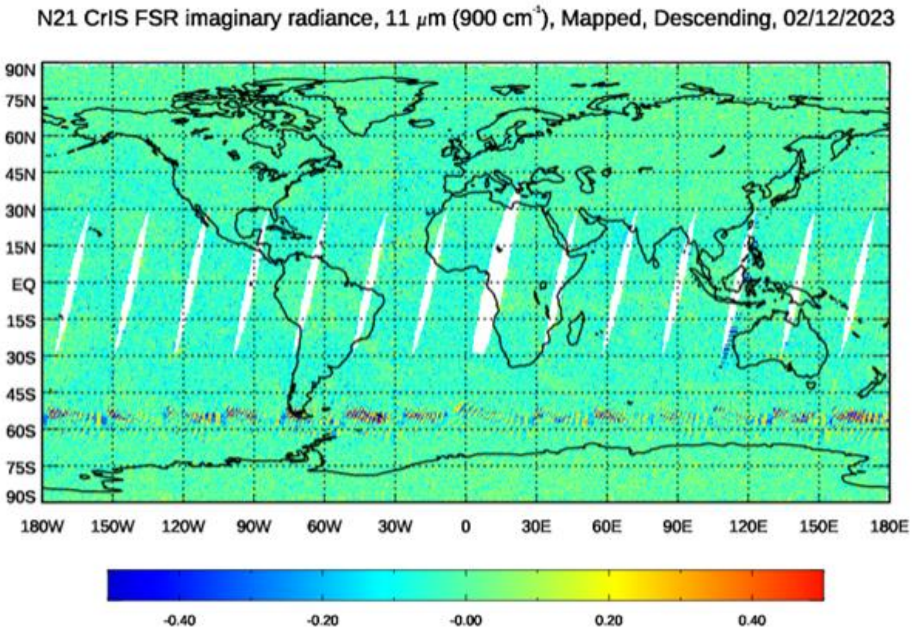
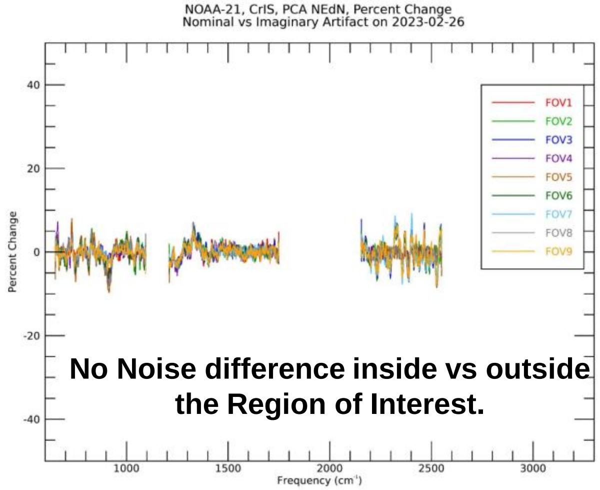
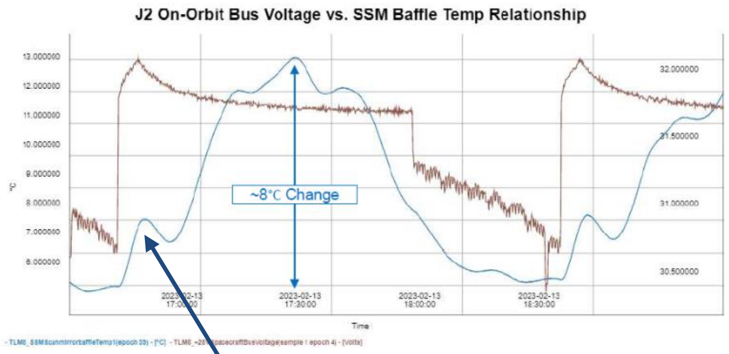


Figure Courtesy of ICVS





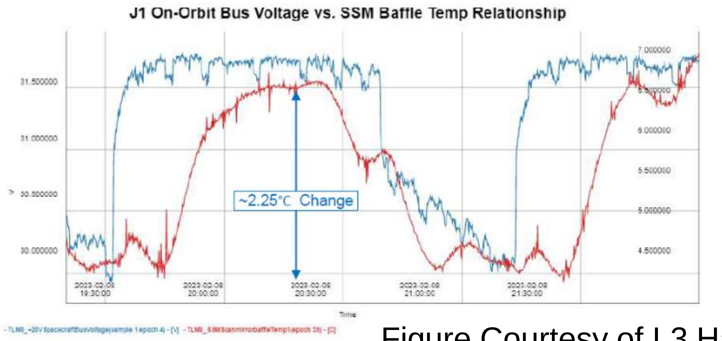
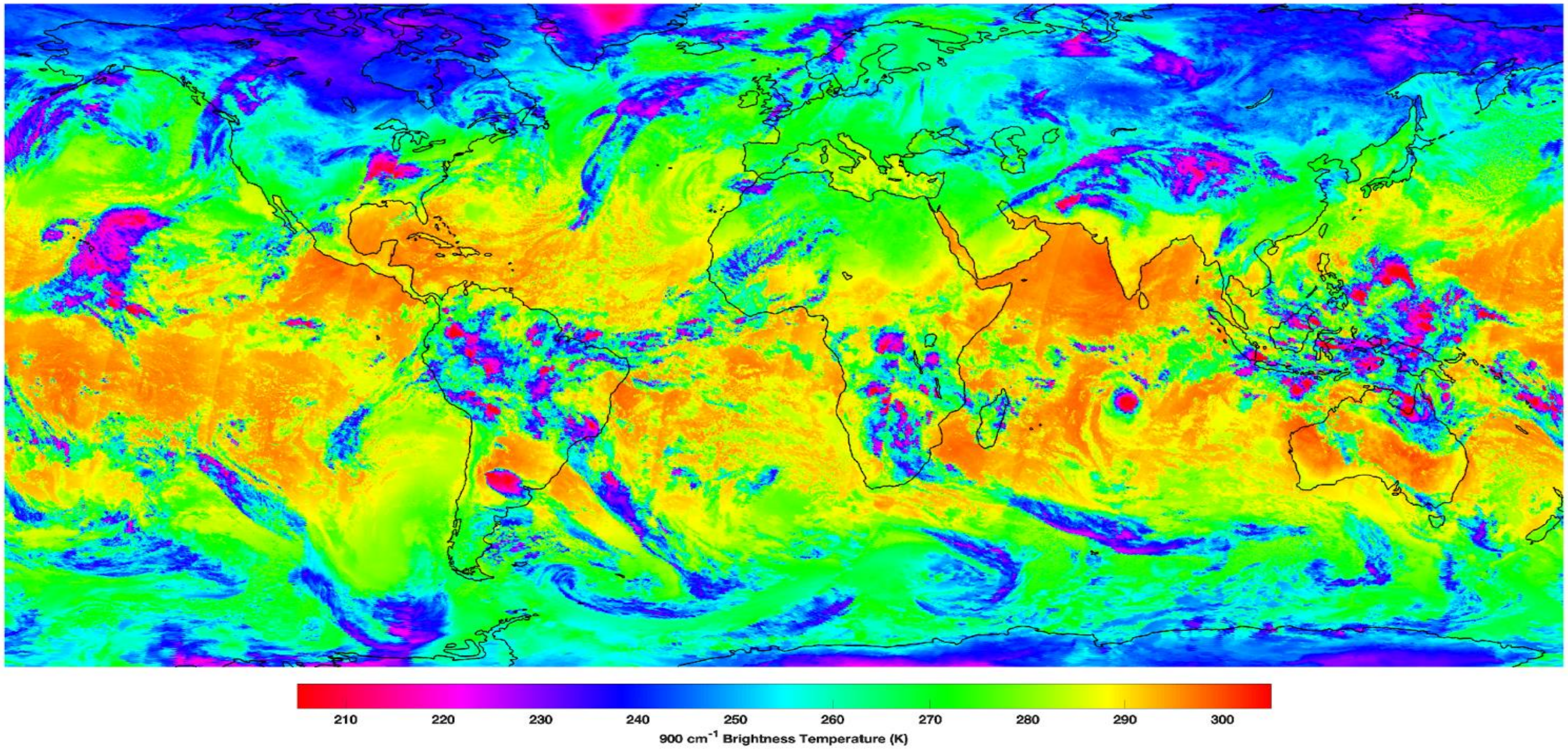


Figure Courtesy of L3 Harris

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

NOAA-21 CrIS SDR Calibration and Validation Efforts from University of Wisconsin/SSEC Cal/Val Science Team



JPSS-2/NOAA-21 Nonlinearity coefficient determination progression

1. Pre-launch Ground Testing:

Stepped ECT NM data and DM data collections in MN TVAC (in 2020)

1.1. NM a_2 estimates

1.2. TVAC V_{INST}

1.3. DM a_2 estimates

in EPv210, uploaded 21 Feb

2. In-Orbit assessments & refinements:

Comparison of TVAC and In-orbit DM a_2 values suggests no changes from TVAC to In-orbit.

2.1. In-orbit DM ROP and in-orbit DM a_2 estimates (24-25 Feb 2023)

2.2. In-orbit ILS refinements (from LLS on 3/1) and In-orbit V_{INST}

2.3. In-orbit a_2 refinements based on NM Earth view FOV-2-FOV analysis

in EPv211, uploaded 24 Mar

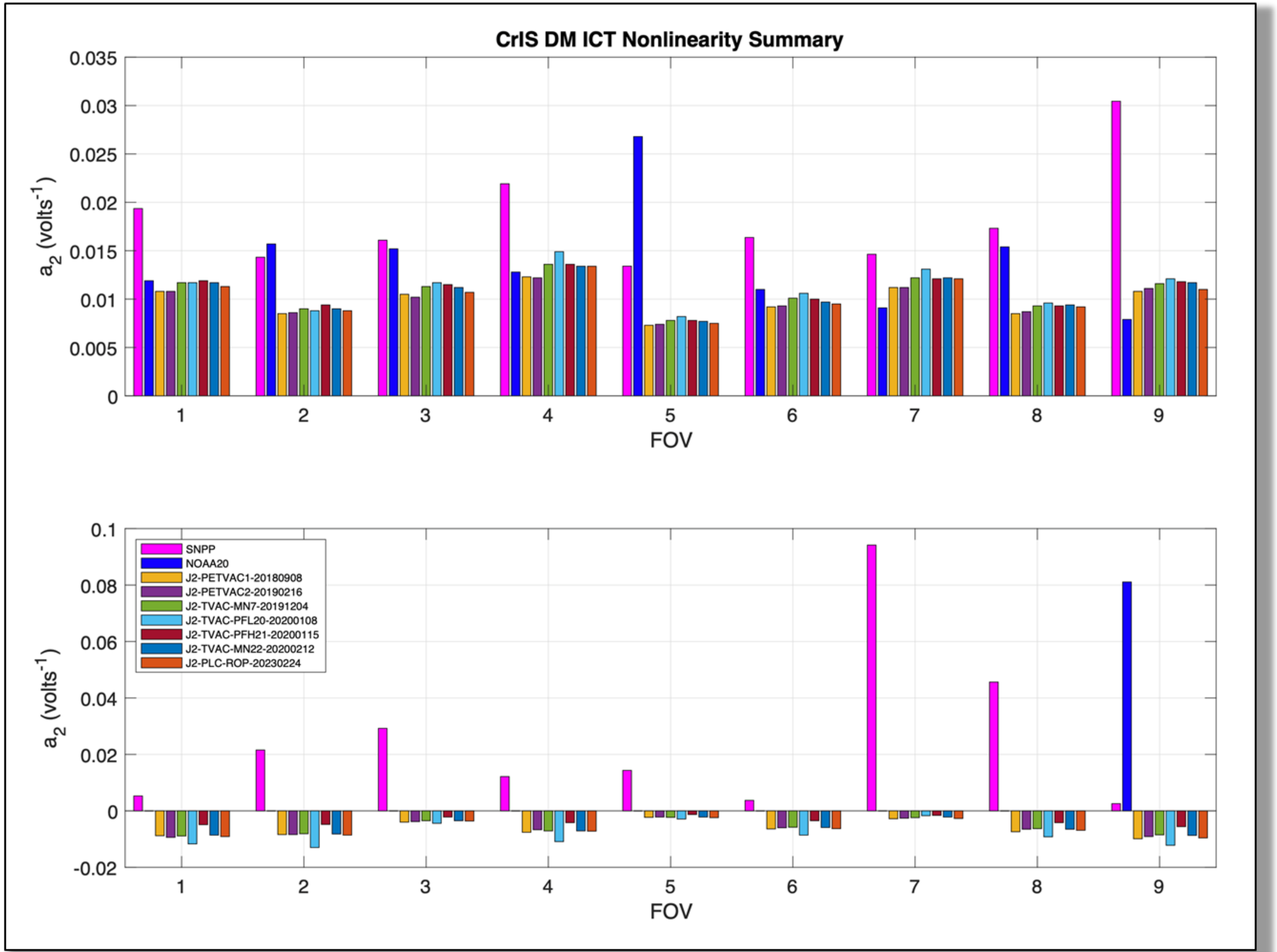
2.4. Assessment/closure studies using resulting a_2 values

* Note agreement between subsequent CrISes or other sensors is not considered in this process

DM Nonlinearity Estimates

DM a_2 estimates

- SNPP
- NOAA20
- J2-PETVAC1-20180908
- J2-PETVAC2-20190216
- TVAC→ J2-TVAC-MN7-20191204
- J2-TVAC-PFL20-20200108
- In-Orbit→ J2-TVAC-PFH21-20200115
- J2-TVAC-MN22-20200212
- J2-PLC-ROP-20230224



a_2 value refinements to minimize Earth view FOV-2-FOV differences

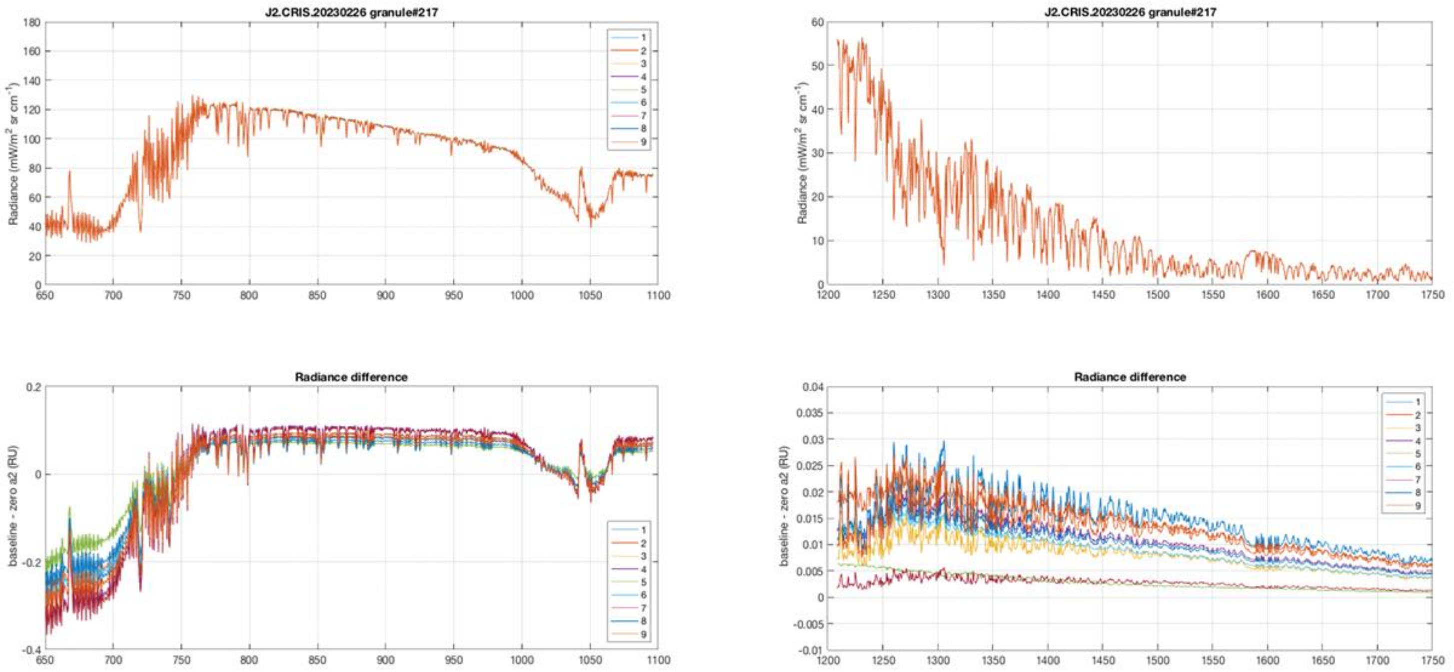
Results follow the same methodology as for SNPP and NOAA20, and are median a_2 multipliers for Midlatitude spatially uniform FOR data.

Uses data for 26 Feb to 2 Mar 2023 (5 full days)

LW:
uses 680-690 cm^{-1} radiance means,
FOV5 as reference FOV, and
4 sets of data: EPv210 a_2 x [0.0 0.75 1.0 1.25]

MW:
uses 1580-1600 cm^{-1} radiance means,
FOV5 as reference FOV, and
4 sets of data: EPv210 a_2 x [0.0 0.50 1.0 2.0]

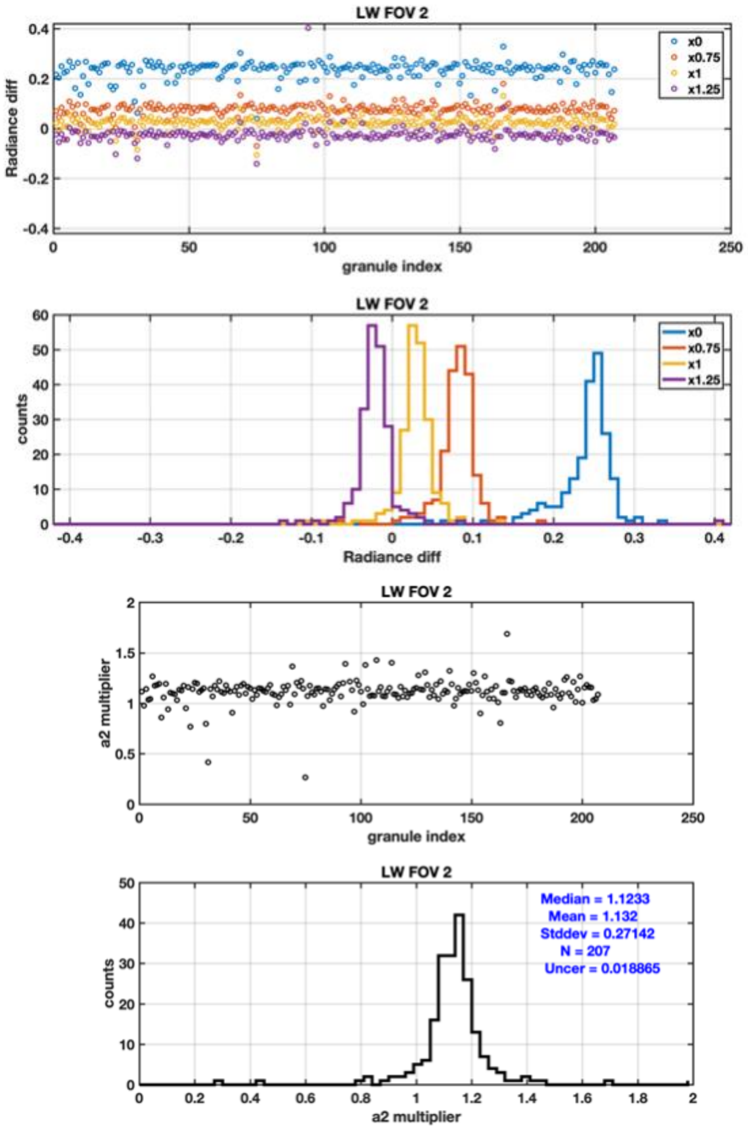
Example ES NLC, for NOAA-21 using EPv210



Example results: FOV-2-FOV Differences and a2 Fits

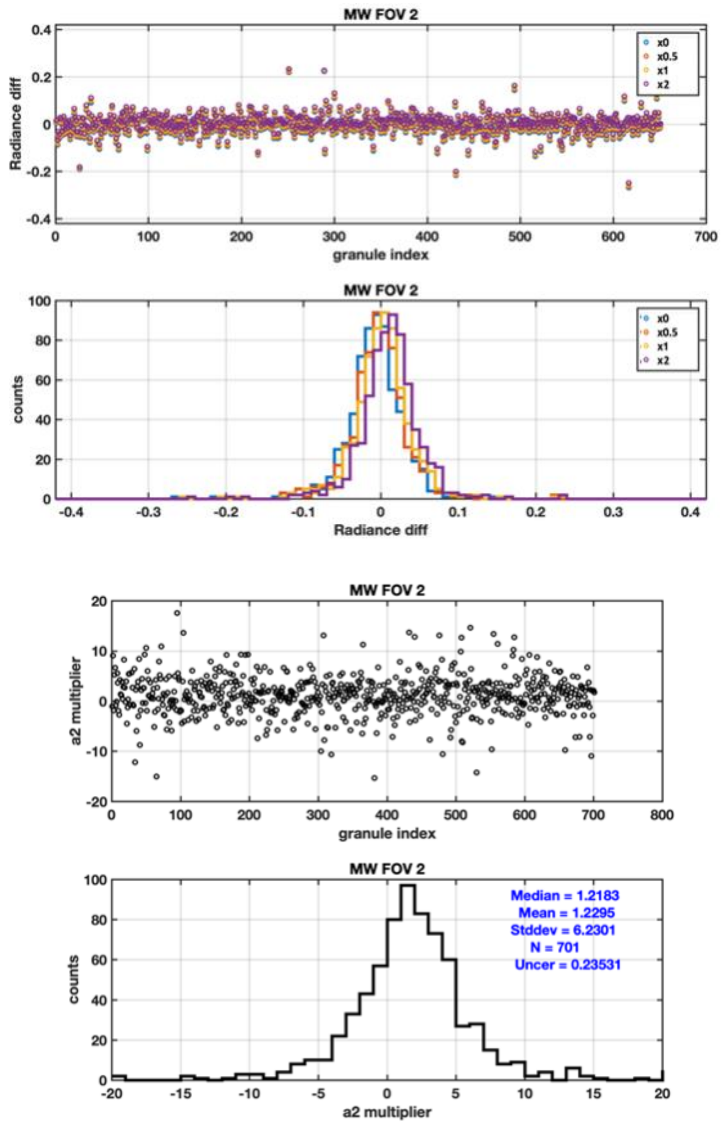
LW FOV2

a_2 x 0
a_2 x 0.75
a_2 x 1
a_2 x 1.25



MW FOV2

a_2 x 0
a_2 x 0.5
a_2 x 1
a_2 x 2



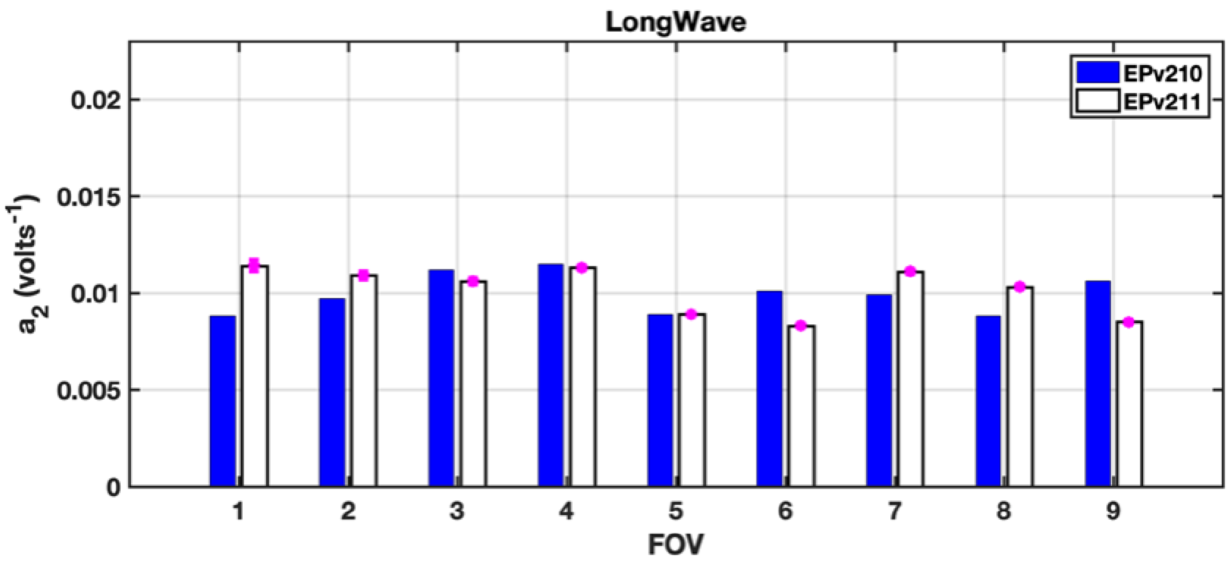
Summary of FOV-2-FOV analysis and a2 values for EPv211

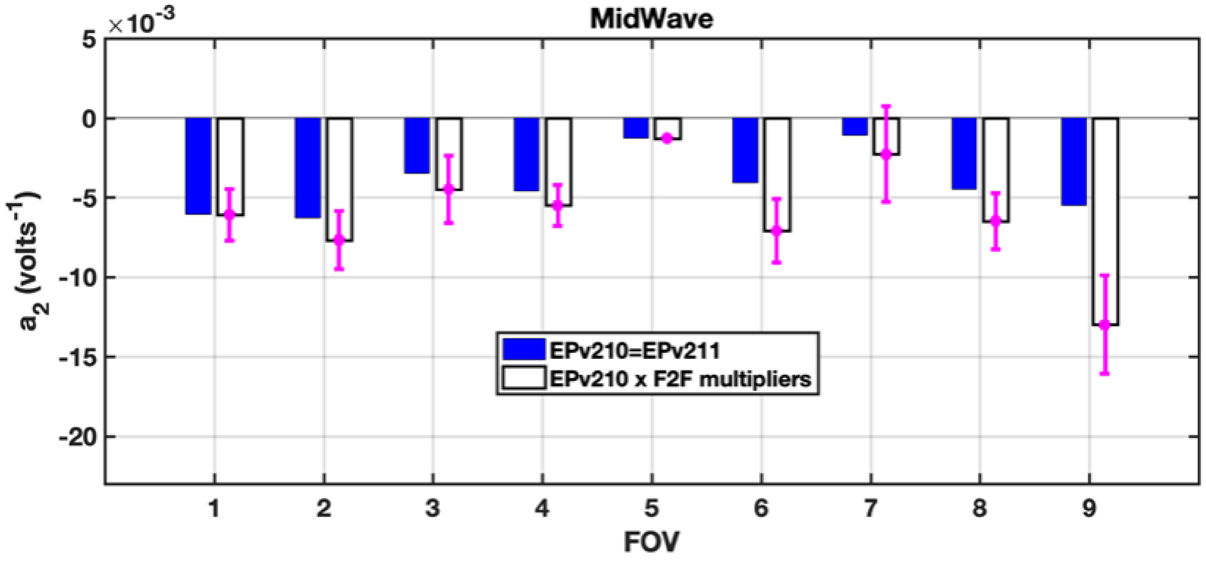
Feb 14

- LW band: FOV-2-FOV adjustments are straightforward and nice closure with various assessments
- MW band NL is very small (slightly negative) and FOV-2-FOV adjustment spread and uncertainty is significantly larger, and some closure assessments are inconclusive, with some possible degradation, at this point.

➢ **For EPv211 and Provisional review, recommended FOV-2-FOV refinements for LW a_2 values, but leave MW at pre-launch TVAC values**

- Continue to assess MW band with refinements possible for Validated stage review/EP.





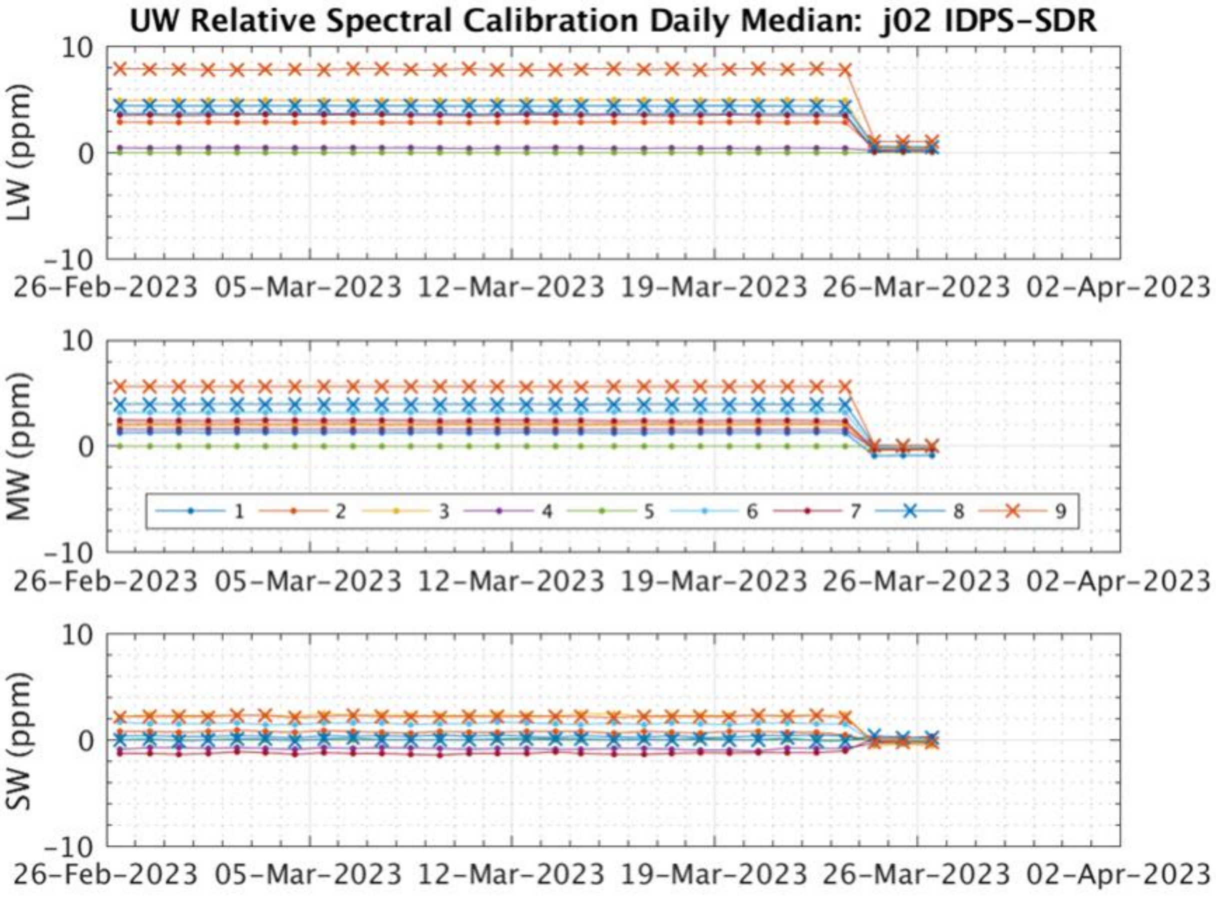
Assessments of EPv211 Calibrated Radiances

- FOV-2-FOV spectral
- FOV-2-FOV radiometric
- CrIS/VIIRS
- Clear sky Obs-Calcs and Double Diffs
- IASI SNOs, AIRS SNOs and Double Diffs

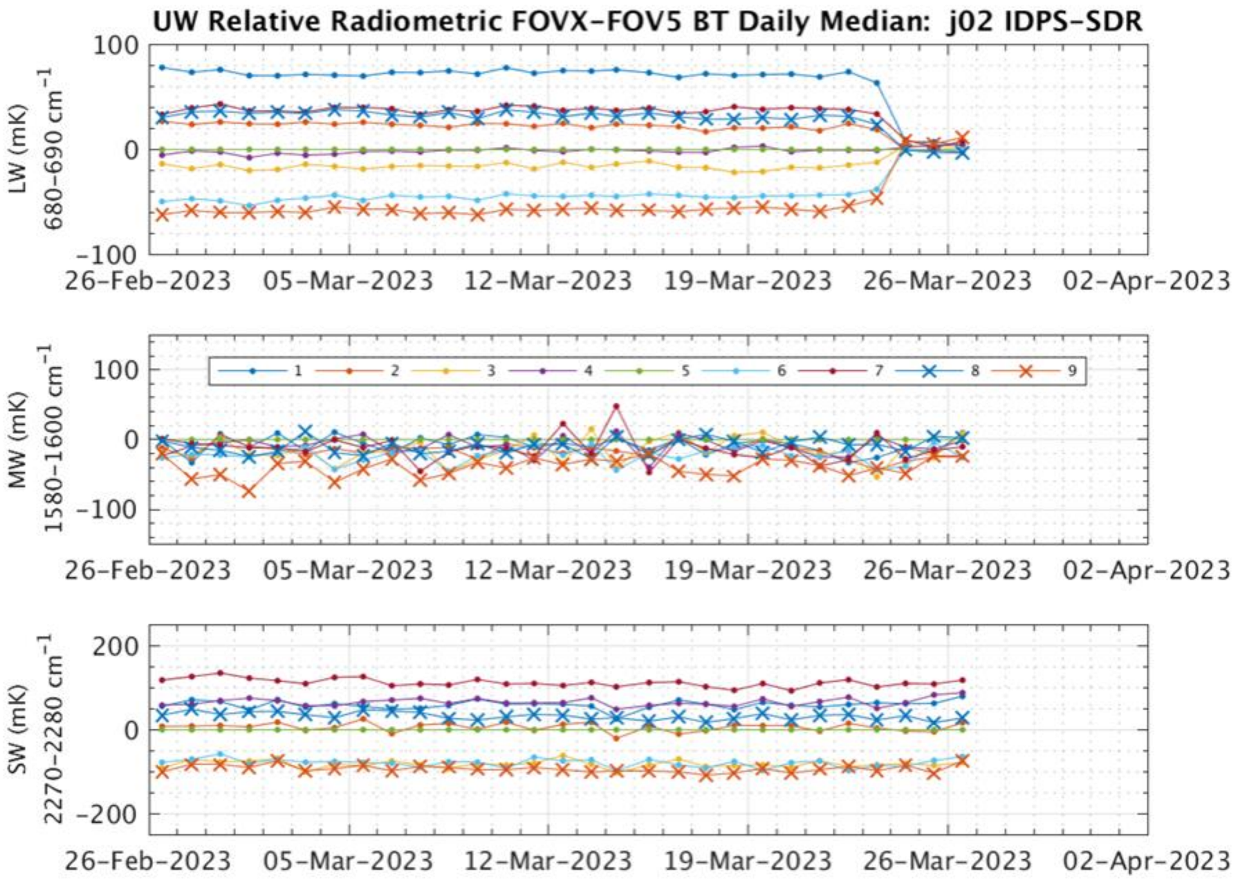
➢ **All show very good spectral and radiometric calibration and support use of EPv211**

UW FOV-2-FOV Time Series Using IDPS SDR

NOAA-21 CrIS Relative Spectral Calibration



NOAA-21 CrIS Relative Radiometric Calibration



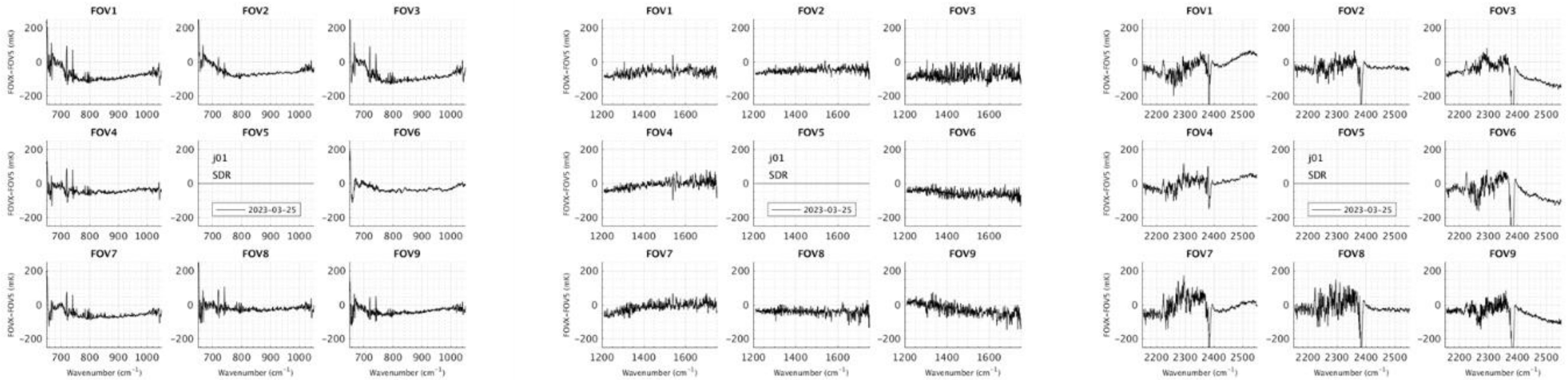
- NOAA21 CrIS Engineering Packet v211 uploaded on 23 March 2023 19:09:30Z
- LW, MW, and SW FOV-2-FOV spectral calibration is better than 2ppm and similar to SNPP/NOAA-20 performance
- LW, MW, and SW FOV-2-FOV radiometric calibration is very good and similar to SNPP/NOAA-20 performance

UW FOV-2-FOV Radiometric Using IDPS SDR (with EPv211 for NOAA-21)

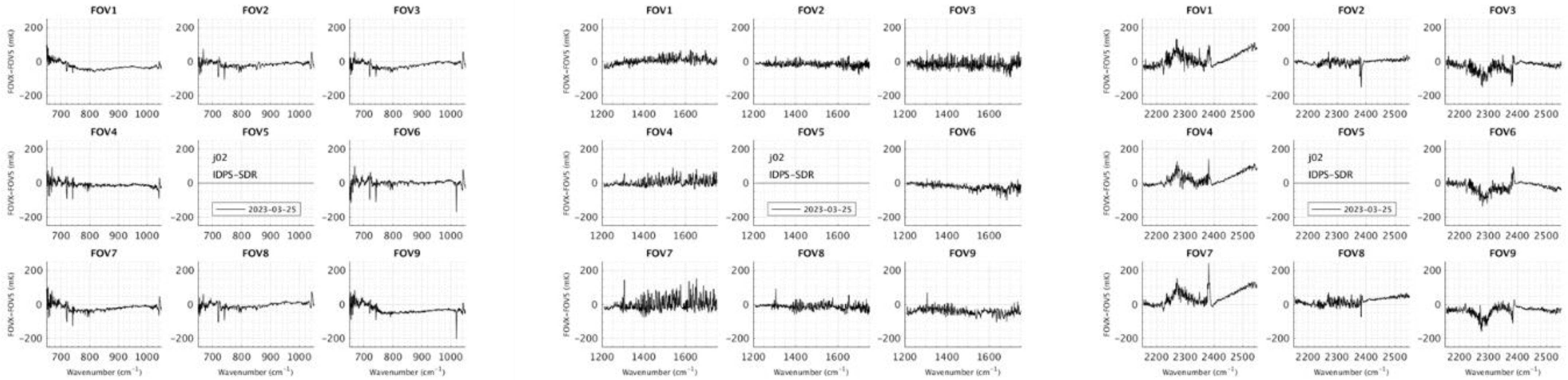
Daily Mean 60S-60N
25 March 2023

Longwave | **Midwave** | **Shortwave**

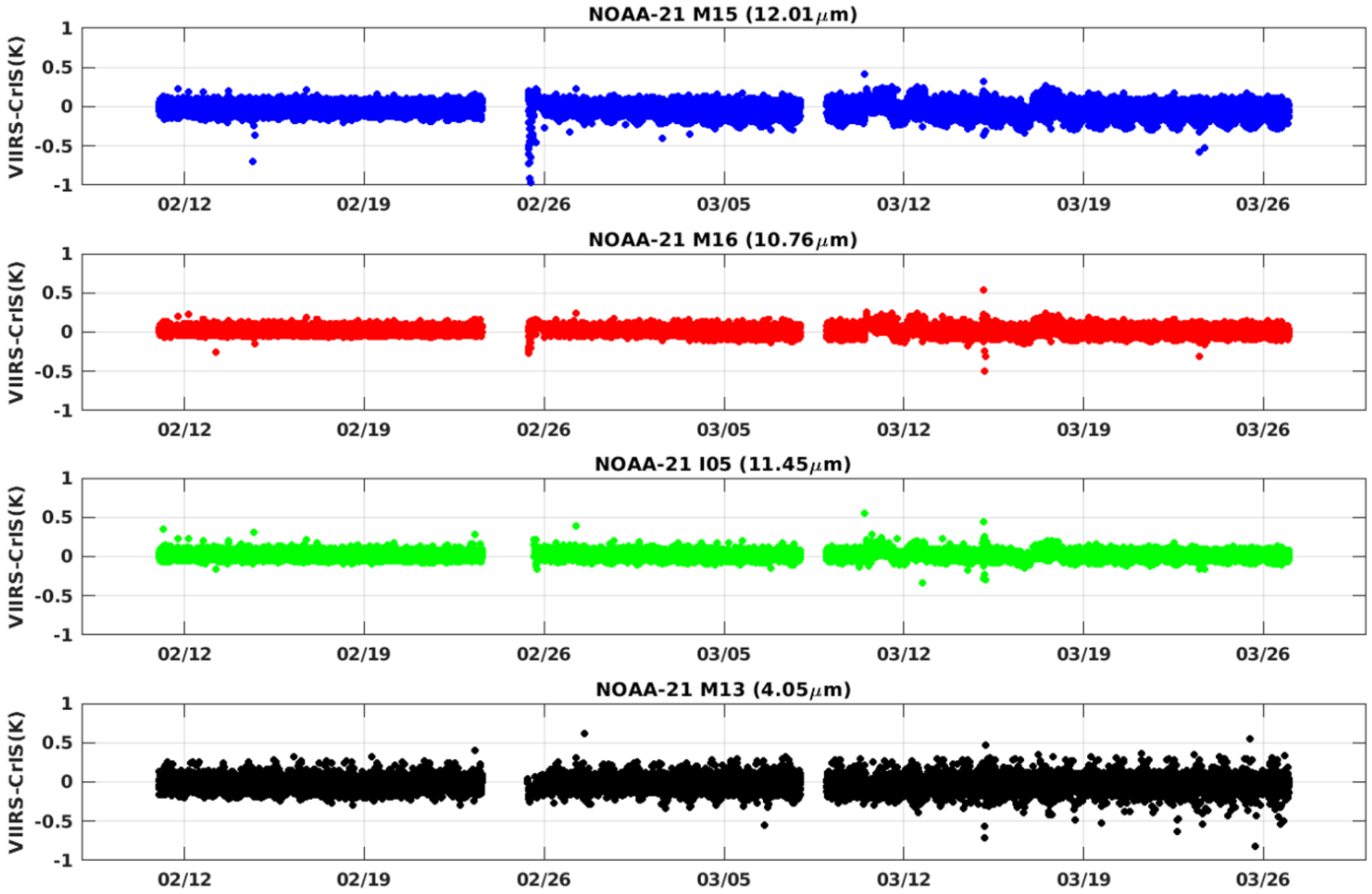
NOAA20



NOAA21
[EP v211]

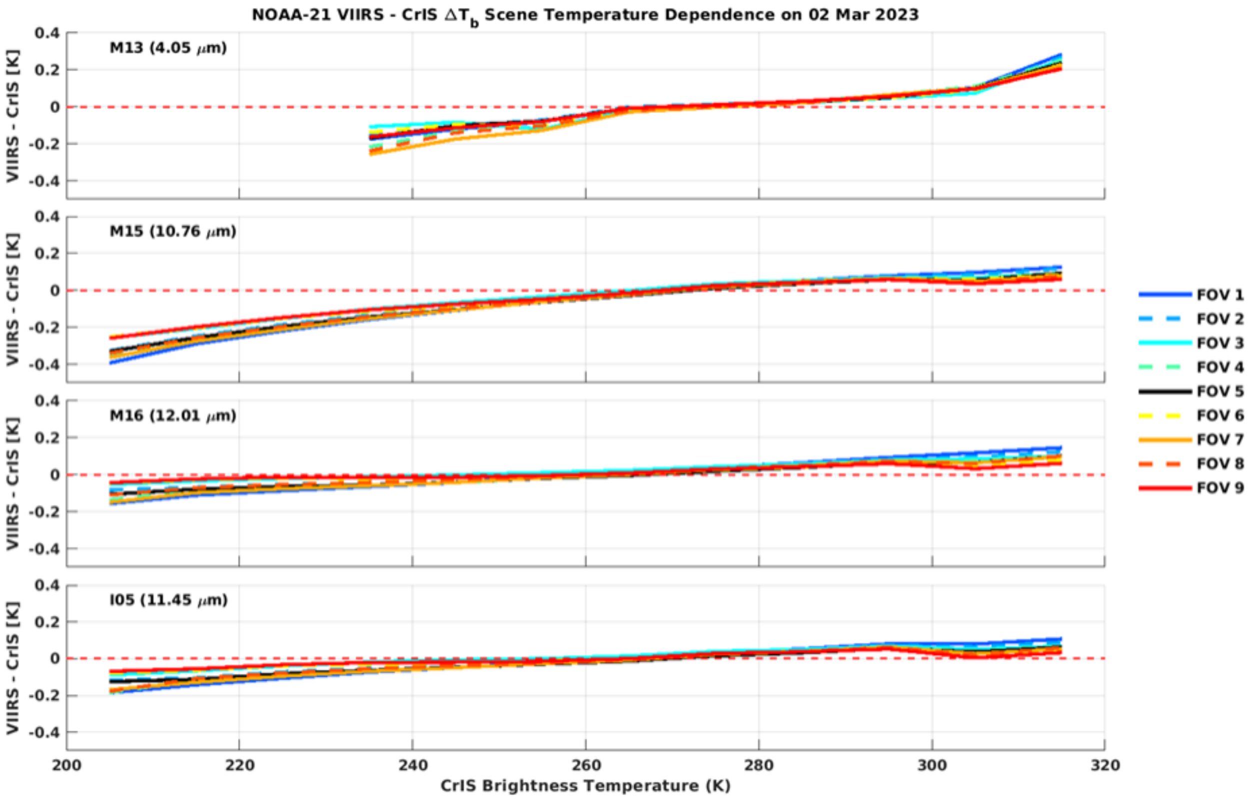


CrIS/VIIRS Comparison Timeline, since Feb 10

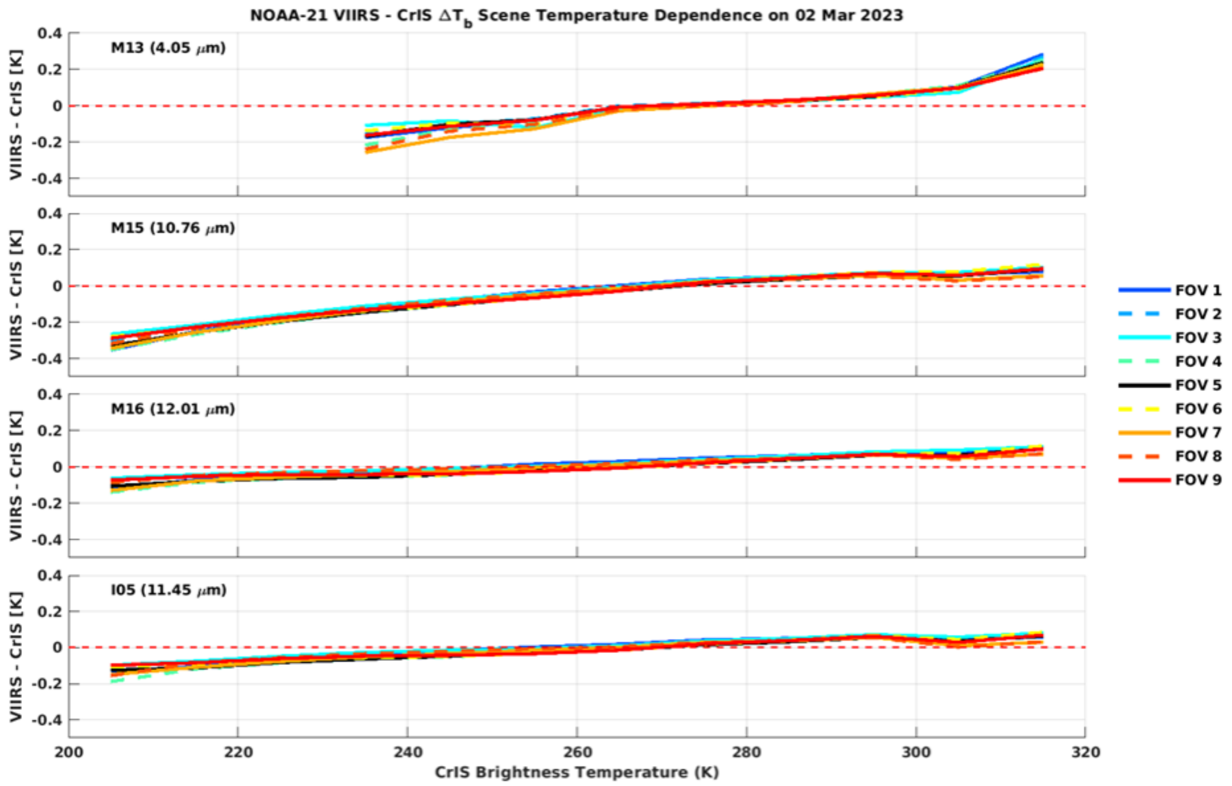


CrIS/VIIRS Comparisons as a function of Scene BT, by FOV

CrIS with EPv210



CrIS with EPv211

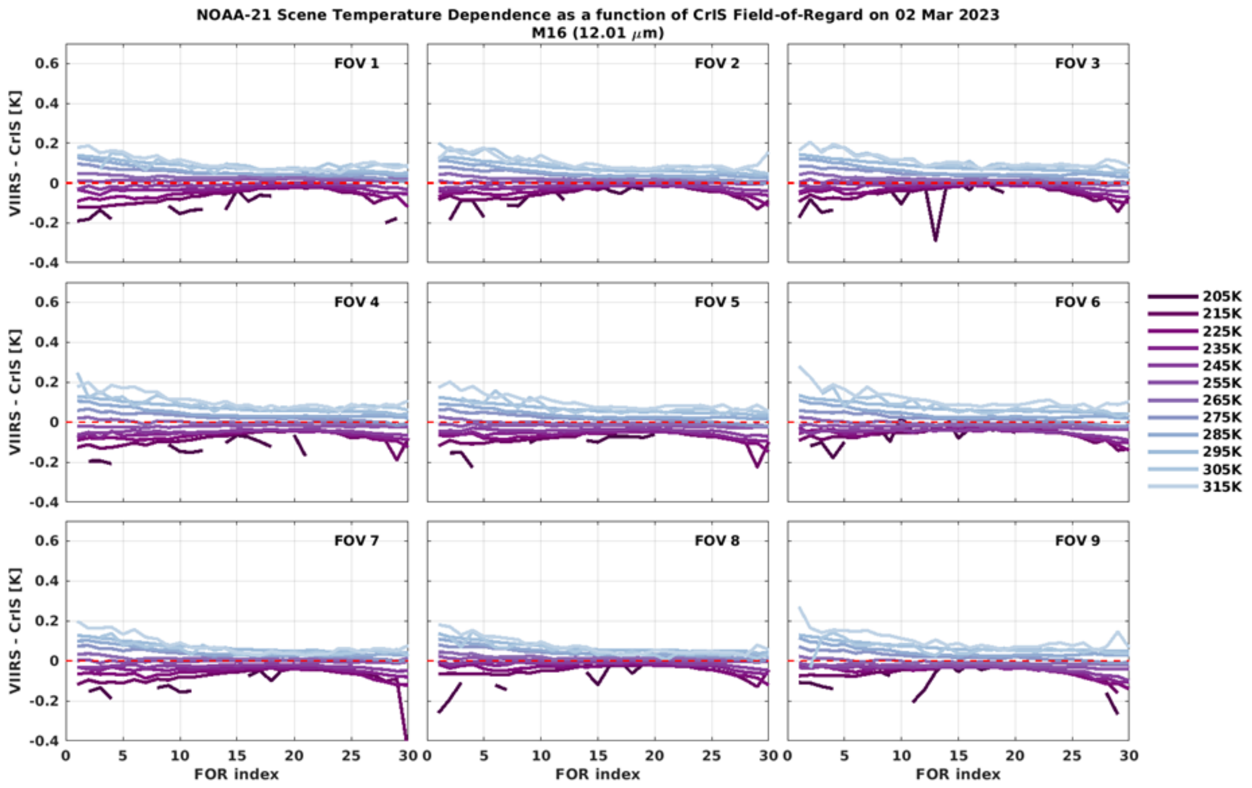


- Overall behavior is very similar to SNPP and NOAA-20 comparisons
- Better agreement among FOVs for EPv211 compared to EPv210

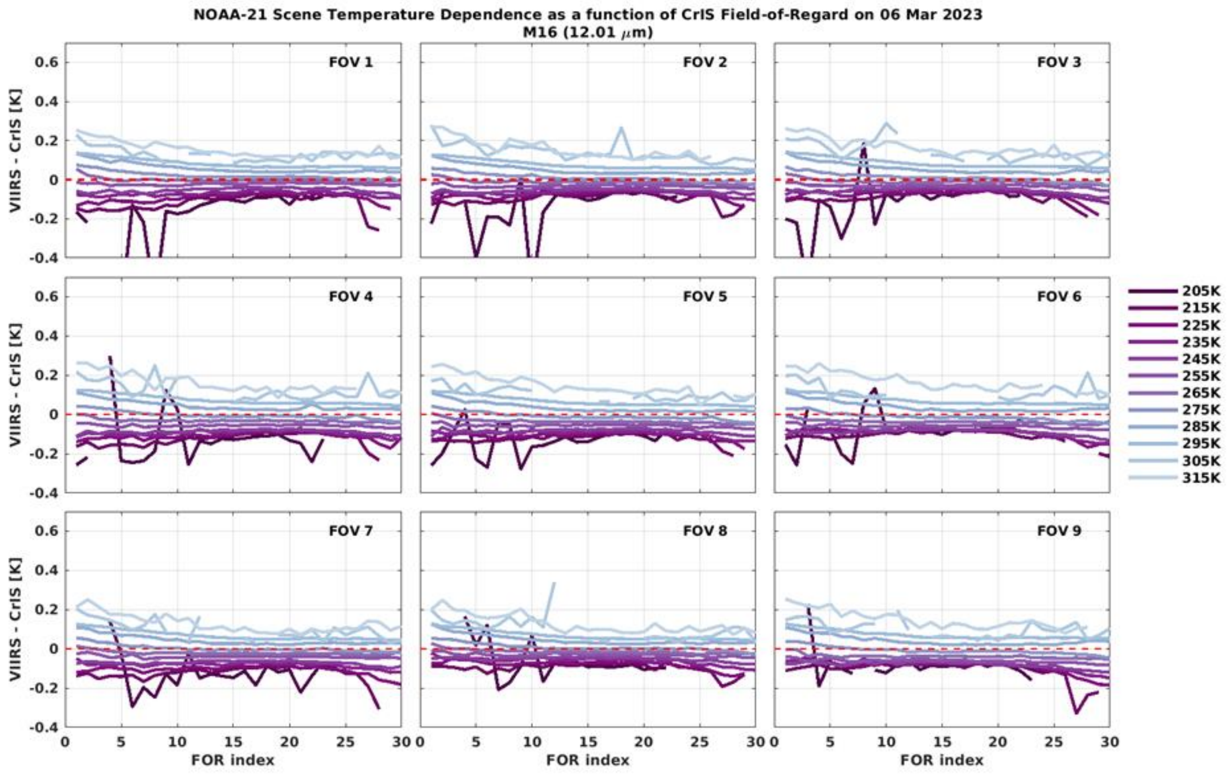
CrIS/VIIRS Comparisons as a function of FOR Index (Scan Position), by scene BT

CrIS with EPv211

02 March 2023



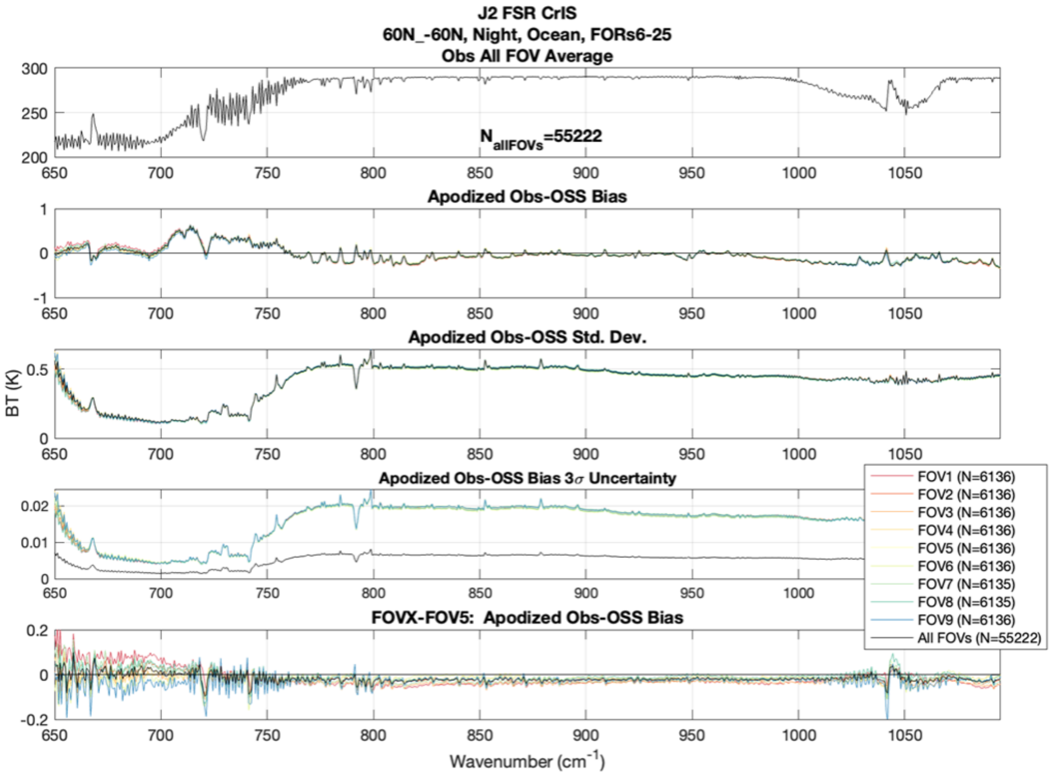
06 March 2023



- VIIRS cold focal planes temperature change on 3/3
- Slightly better agreement with CrIS prior to this change

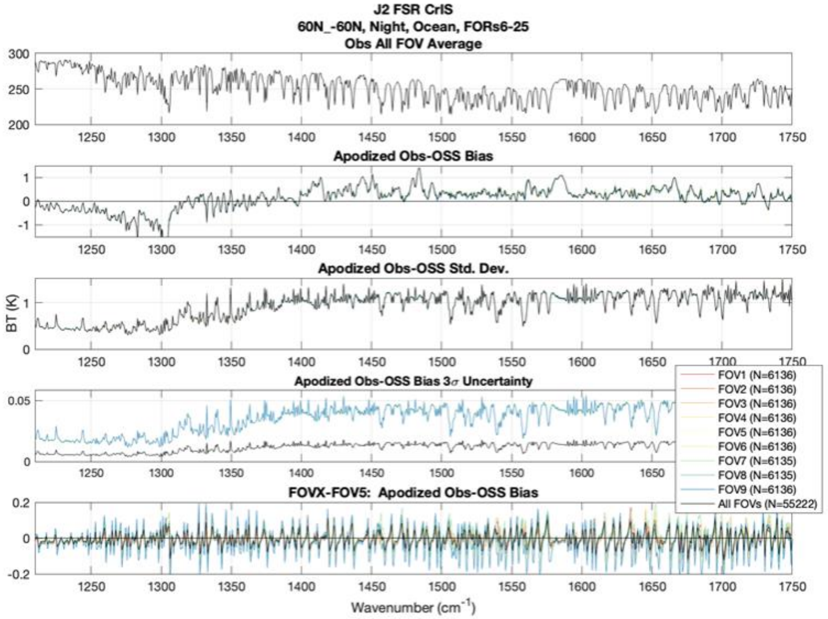
NOAA-21: IDPS EPv210

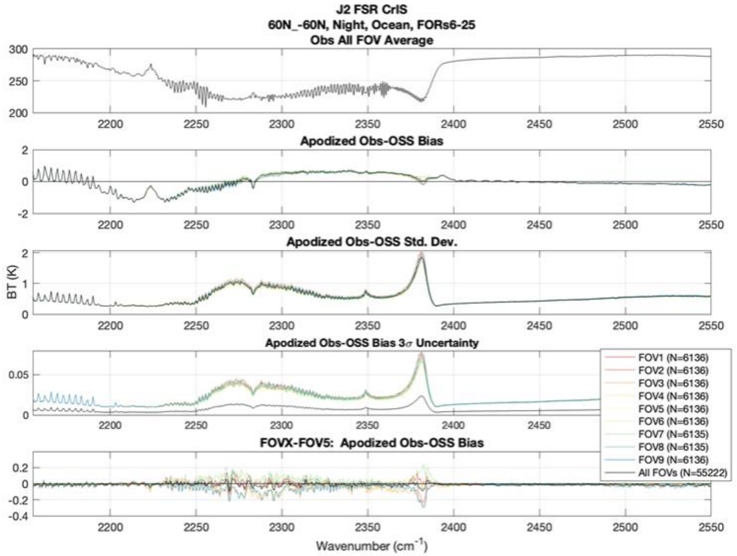
NOAA-21 Obs-Calcs



Clear Sky Obs-Calcs

Feb 26th-28th, 2023



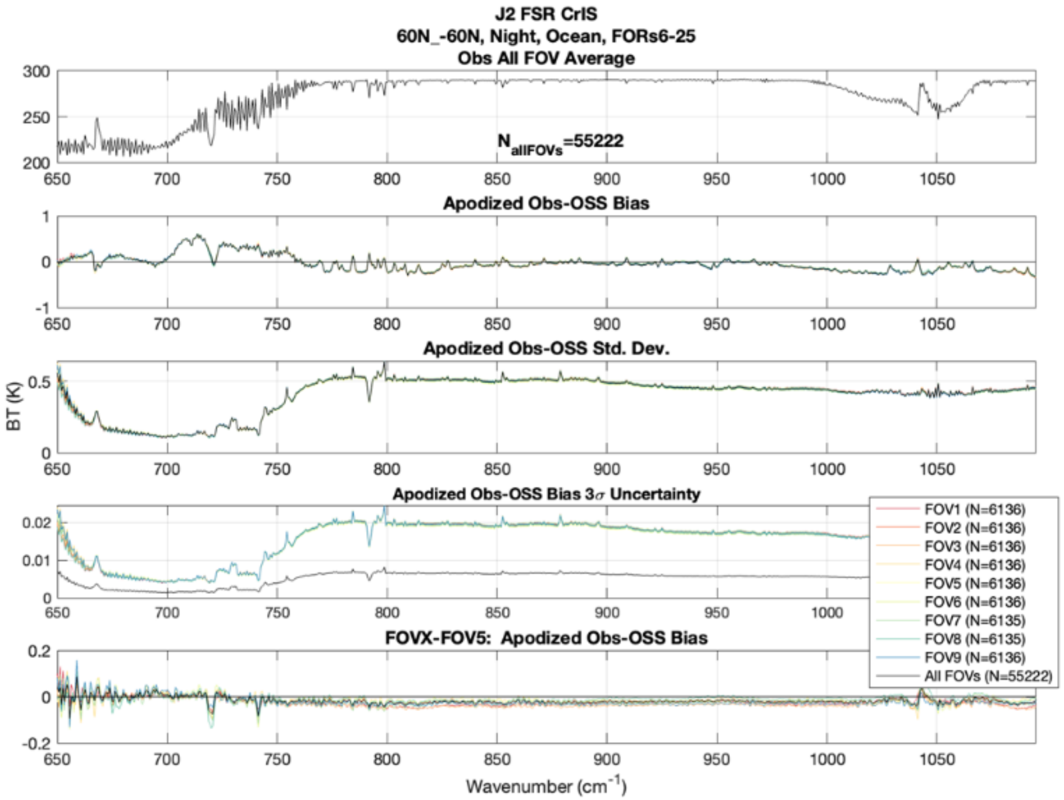


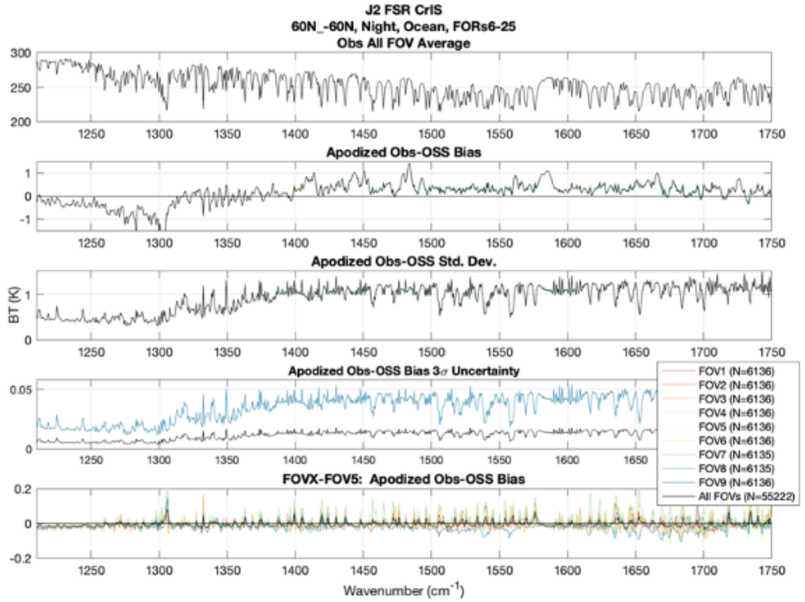
- LW spread due to NL and MW+SW "hash" due to ILS

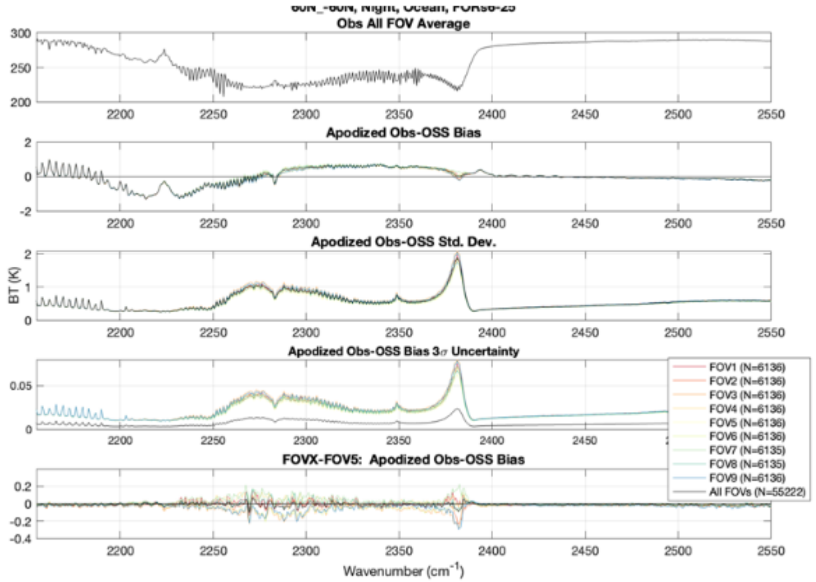
NOAA-21: ADL EP211

Clear Sky Obs-Calcs
Feb 26th-28th, 2023

NOAA-21 Obs-Calcs





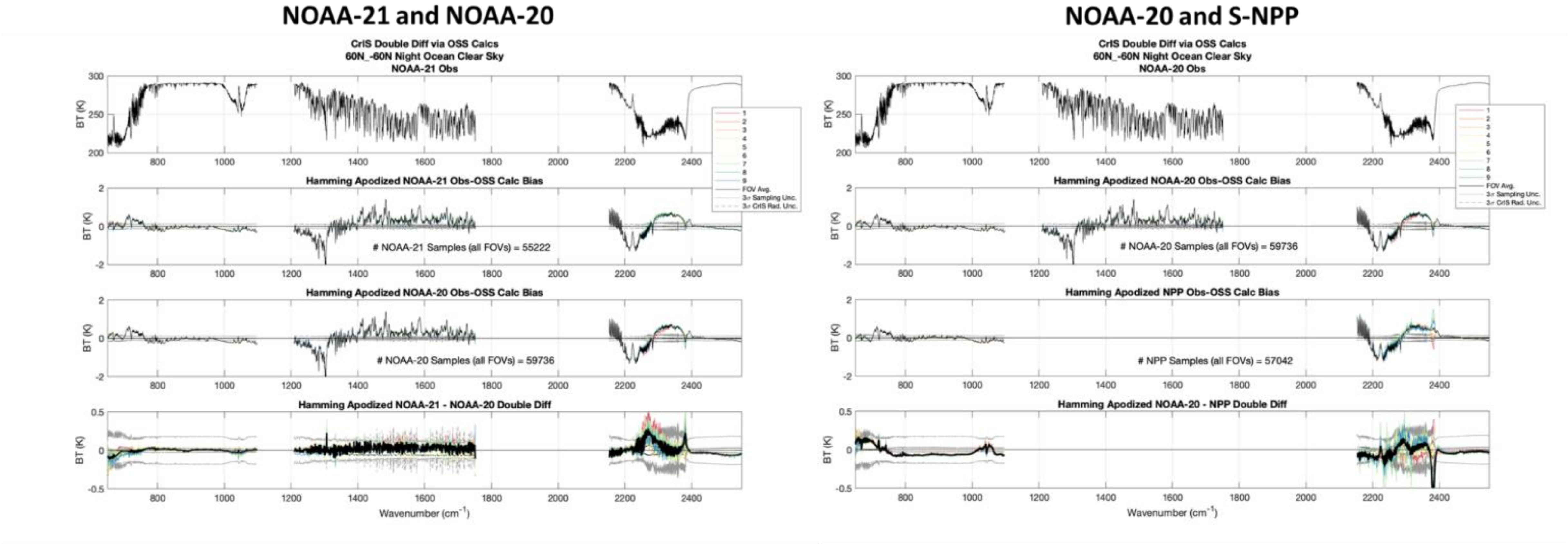


- EPv211 refinements in NL and ILS

Clear Sky Obs-Calcs and Double Differences

NOAA-21: IDPS EPv210
NOAA-20: IDPS
SNPP: IDPS

Feb 26th-28th, 2023



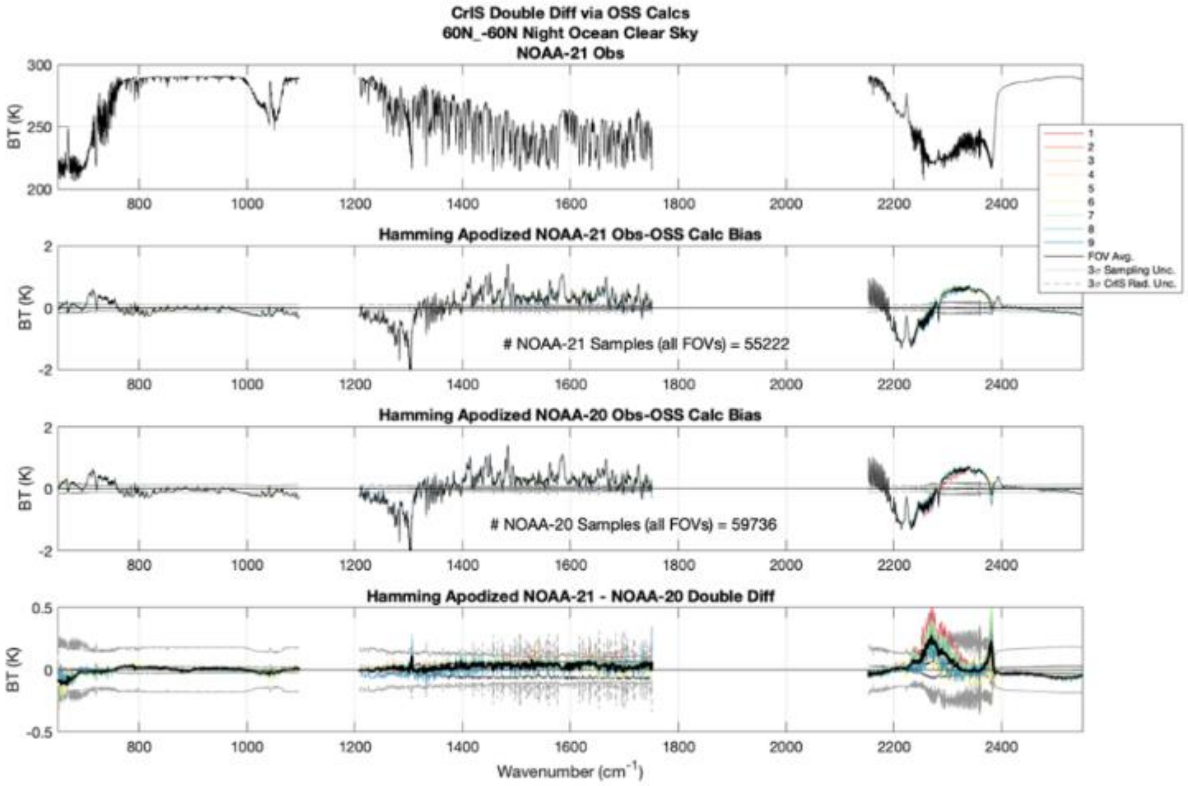
- Overall good performance for NOAA-21 but larger FOV spread in LW, and spectral "hash" in MW and SW

Clear Sky Obs-Calcs and Double Differences

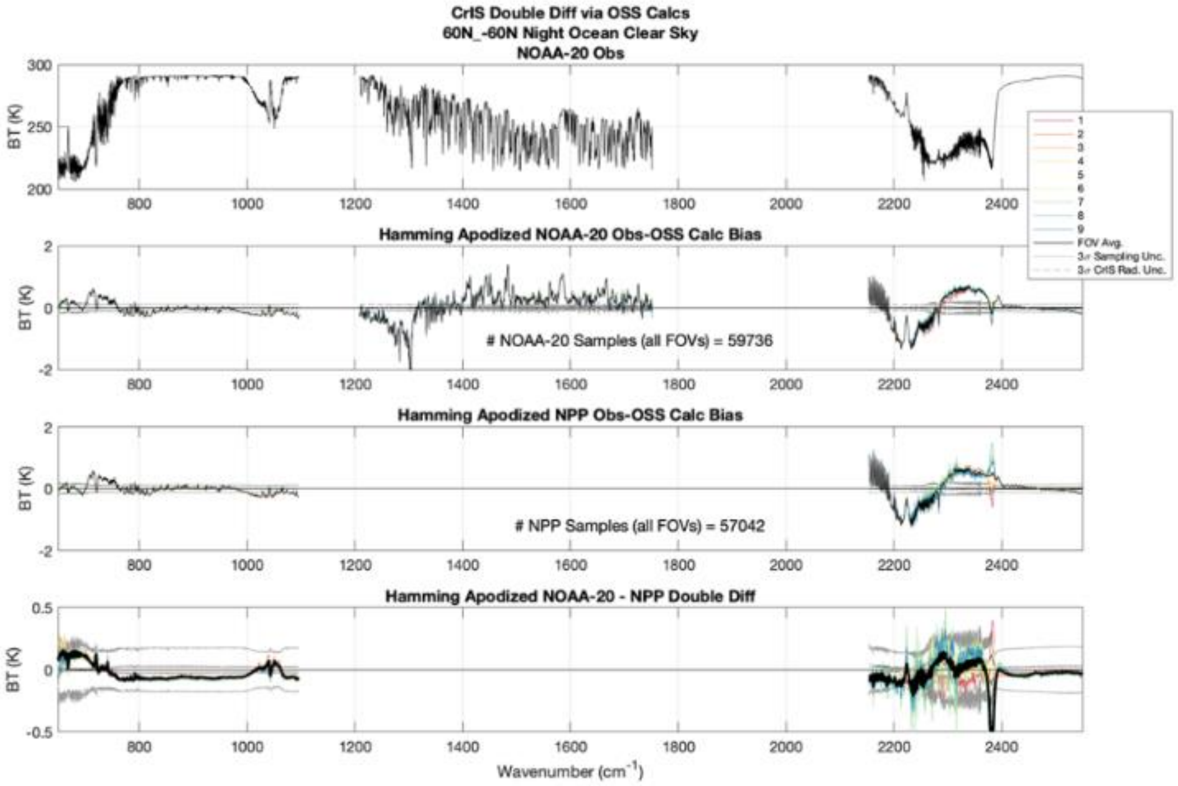
NOAA-21: ADL EPv211
NOAA-20: IDPS
SNPP: IDPS

Feb 26th-28th, 2023

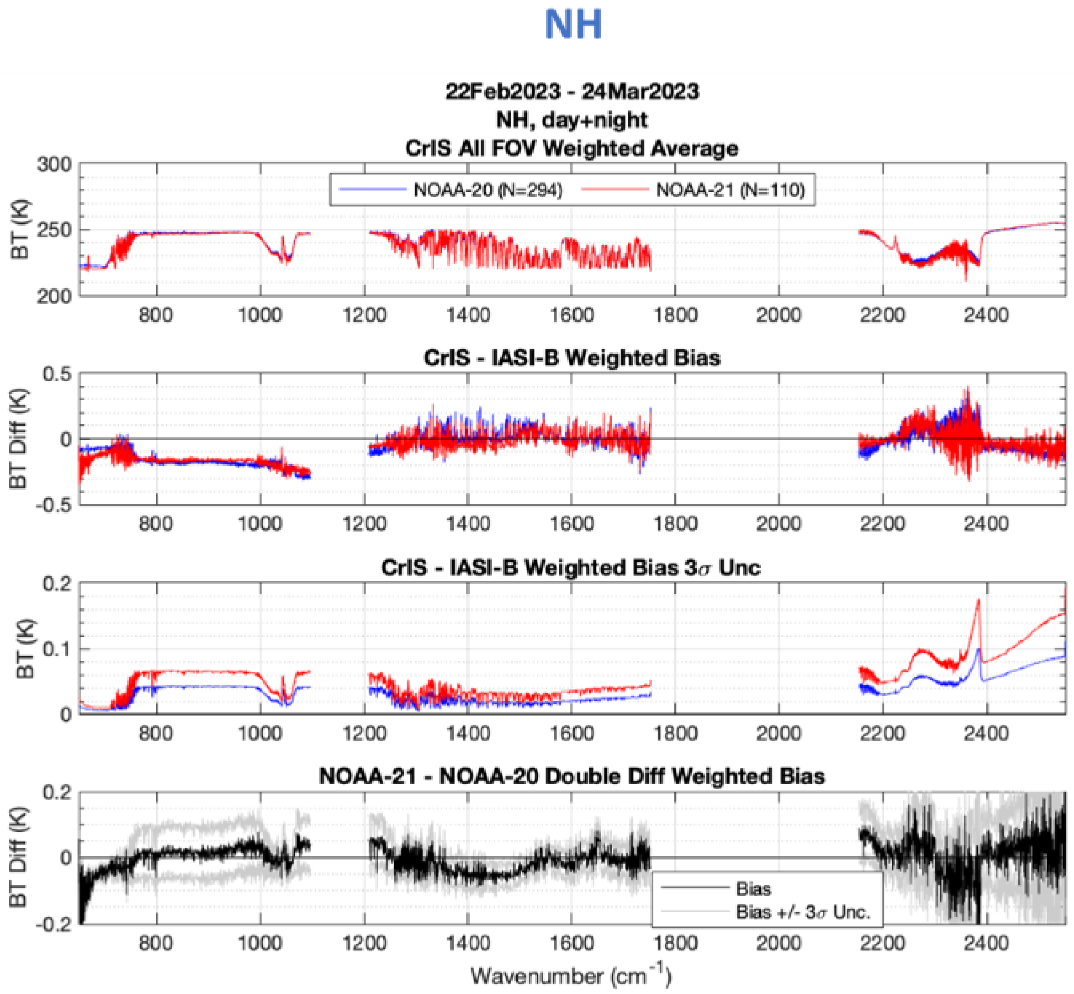
NOAA-21 and NOAA-20

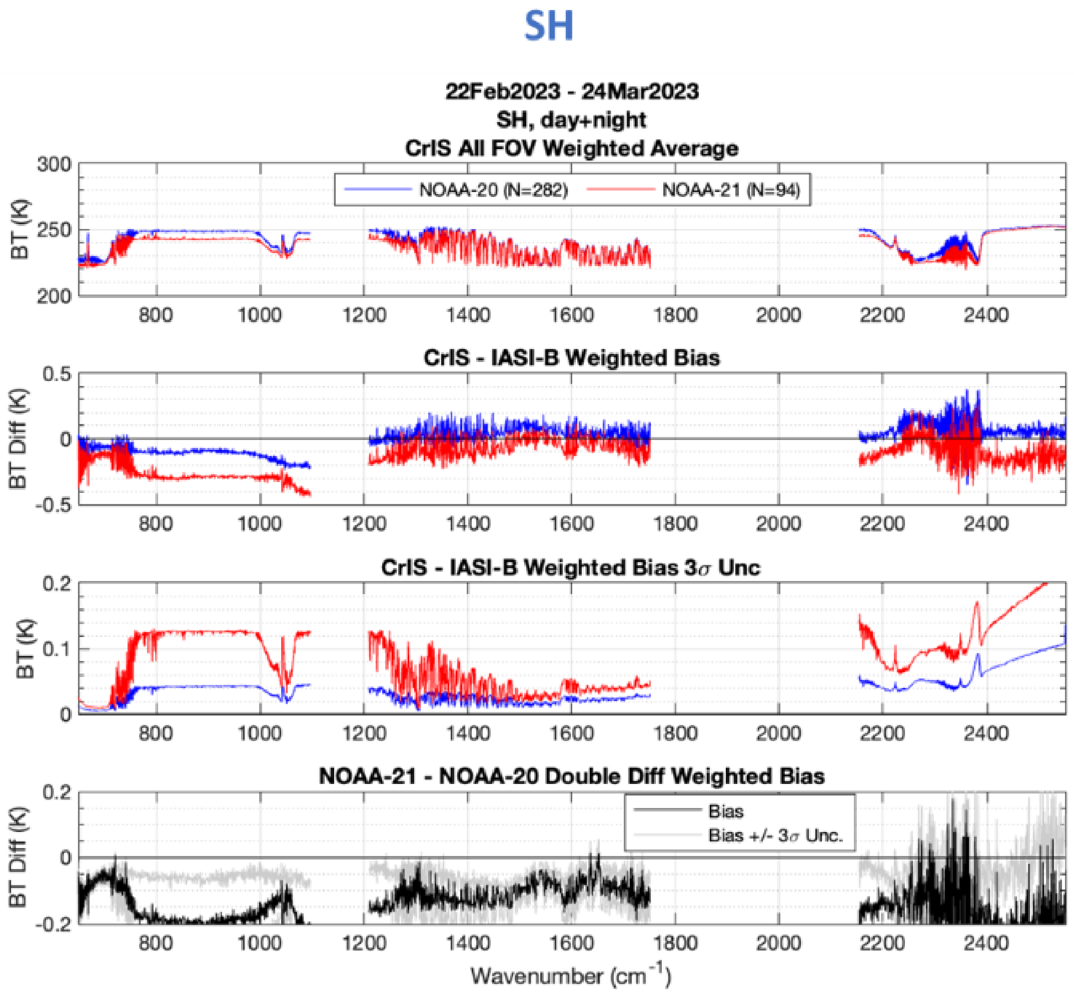


NOAA-20 and S-NPP



NOAA-21 - NOAA-20 via IASI-B SNOs



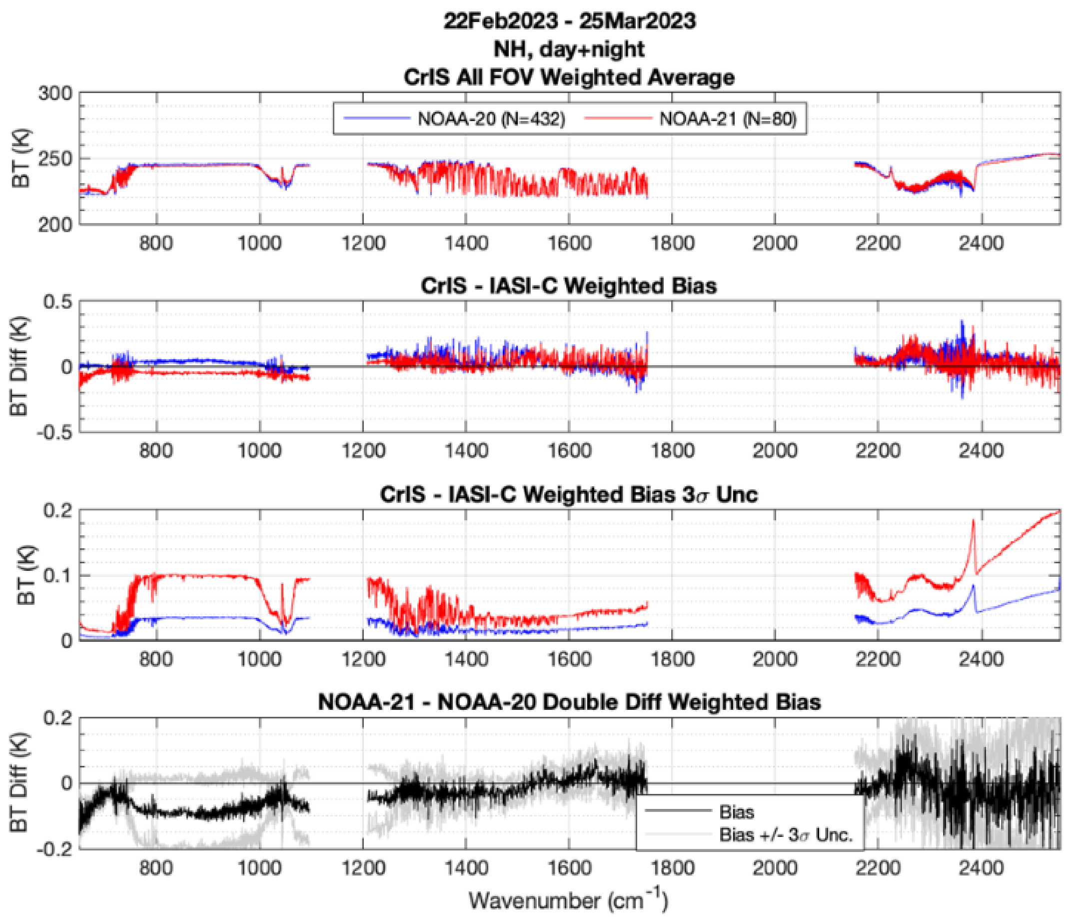


- **Good agreement between both CrISes and IASI-B**

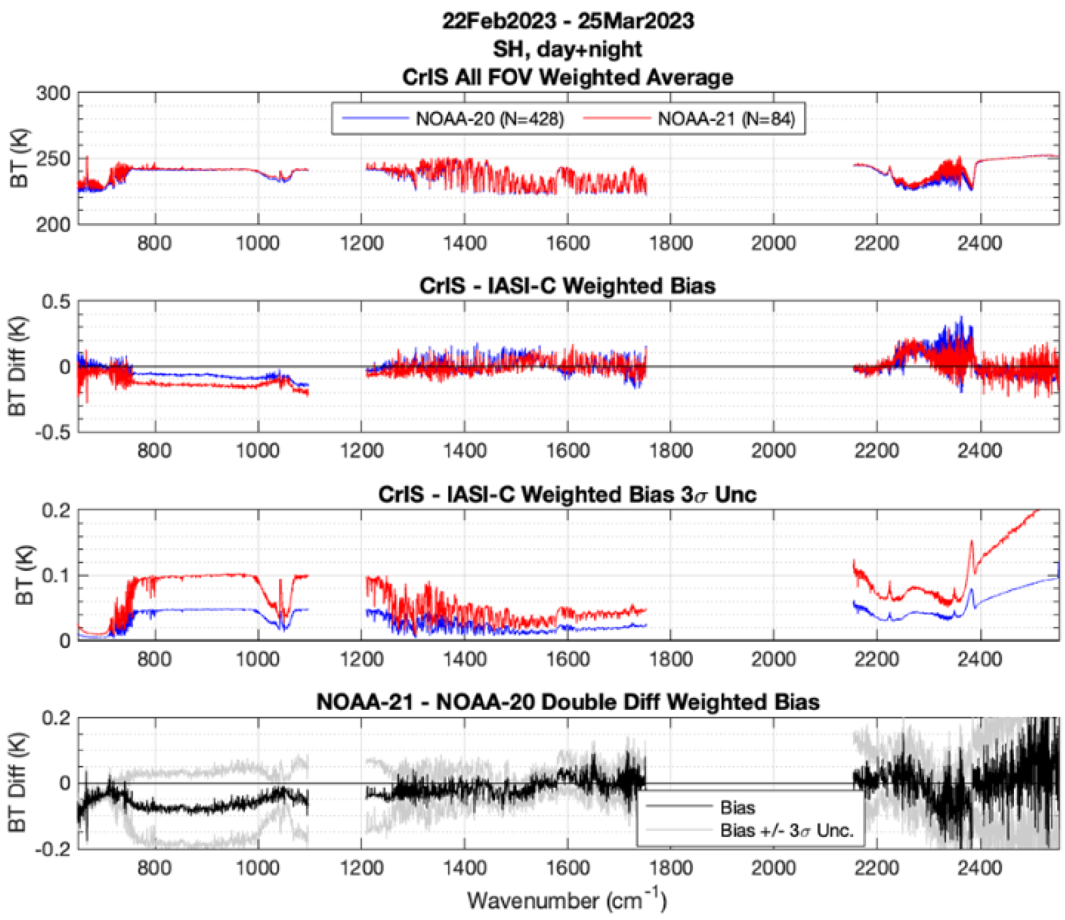
***Uncertainty shown in 2 bottom panels here is spatial sampling uncertainty – sqrt(1/sum of weights)*

NOAA-21 - NOAA-20 via IASI-C SNOs

NH



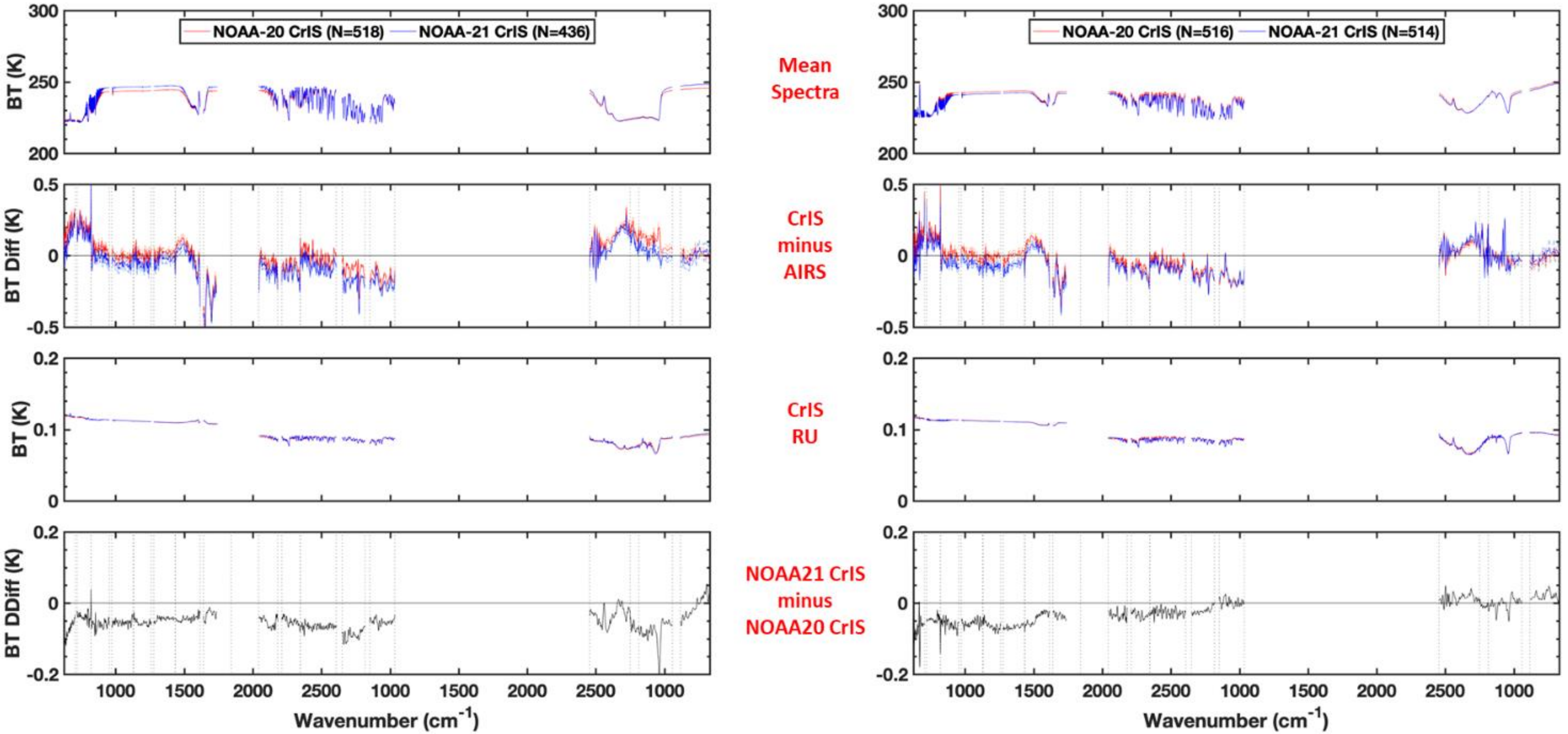
SH



- **Good agreement between both CrISes and IASI-C**

***Uncertainty shown in 2 bottom panels here is spatial sampling uncertainty – sqrt(1/sum of weights)*

NOAA-21 - NOAA-20 via AIRS SNOs (with analysis performed with spectral sampling similar to CrIS/IASI SNOs)



- ➢ **Double Differences show good agreement between NOAA-20 and NOAA-21 CrIS, and similar behavior/differences as IASI SNO results**

Next Steps

1. Derivation of PolCor calibration coefficients from the 3/10 Pitch maneuver data, and processing of data with PolCor turned on
2. Continue to study MW NLC and assess possible MW a_2 refinements
3. Assess FOV-2-FOV cross-talk
4. Assess interferometric/correlated noise
5. Provide Radiometric Uncertainty estimates
6. IASI and AIRS SNOs and Double Diffs
7. Assess artifacts via PCA

User/Downstream Product Feedback (NOAA-21)

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Ken Pryor ken.pryor@noaa.gov	NOAA/STAR NUCAPS Team	Atmospheric Sounding	March 29, 2023

NOAA-21 ATMS/CrIS show high quality with respect to NOAA-20, as demonstrated by no additional tuning needed for the NUCAPS algorithm to generate high quality NOAA-21 NUCAPS EDR products.

Evaluation of NOAA-21 NUCAPS EDR Products in Support of CrIS SDR Provisional Maturity

Ken Pryor, Murty Divakarla, Tong Zhu, Juying Warner, Margarita Kulko, Nick Nalli, Mike Wilson, Changyi Tan and Zaizhong Ma

NOAA-21 NUCAPS Environmental Data Record (EDR) Products Evaluation

- **NOAA-20 NUCAPS v3.1** (v3.0 Operational version + updates)
- **NOAA-21 Ready NUCAPS v3.1** (Currently using NOAA-20 v3.1 LUTs)

Focus Days	CrIS Engr Pckg	Satellites & EDR Evaluations
02/16/2023 **02/20/2023**	EP v208 EP v210	NOAA-20 & NOAA-21 *T*(*p*), *q*(*p*), O3(*p*) *vs* ECMWF NOAA-20 *vs* NOAA-21 OLR NOAA-20 & NOAA-21 *vs* TROPOMI, OCO-2, TCCON
02/27/2023 **03/24/2023** IDPS	EP v211 (ADL) EP v211 (IDPS OPS)	NOAA-20 & NOAA-21 *T*(*p*), *q*(*p*), O3(*p*) vs. ECMWF NOAA-20 vs. NOAA-21 OLR NOAA-20 & NOAA-21 *vs* TROPOMI, OCO-2, TCCON

Focus Days	NOAA-20 (v3.1)	NOAA-21 (v3.1)	ECMWF	TROPOMI	OCO-2	TCCON	OLR
02/16/2023 02/20/2023*	✔ Yes	✔ Yes	✔ Yes	✔ Yes	✔ Yes	• Not Available	✔ Yes
02/27/2023 03/24/203	✔ Yes	✔ Yes	✔ Yes	✔ Yes	✔ Yes	• Not Available	✔ Yes

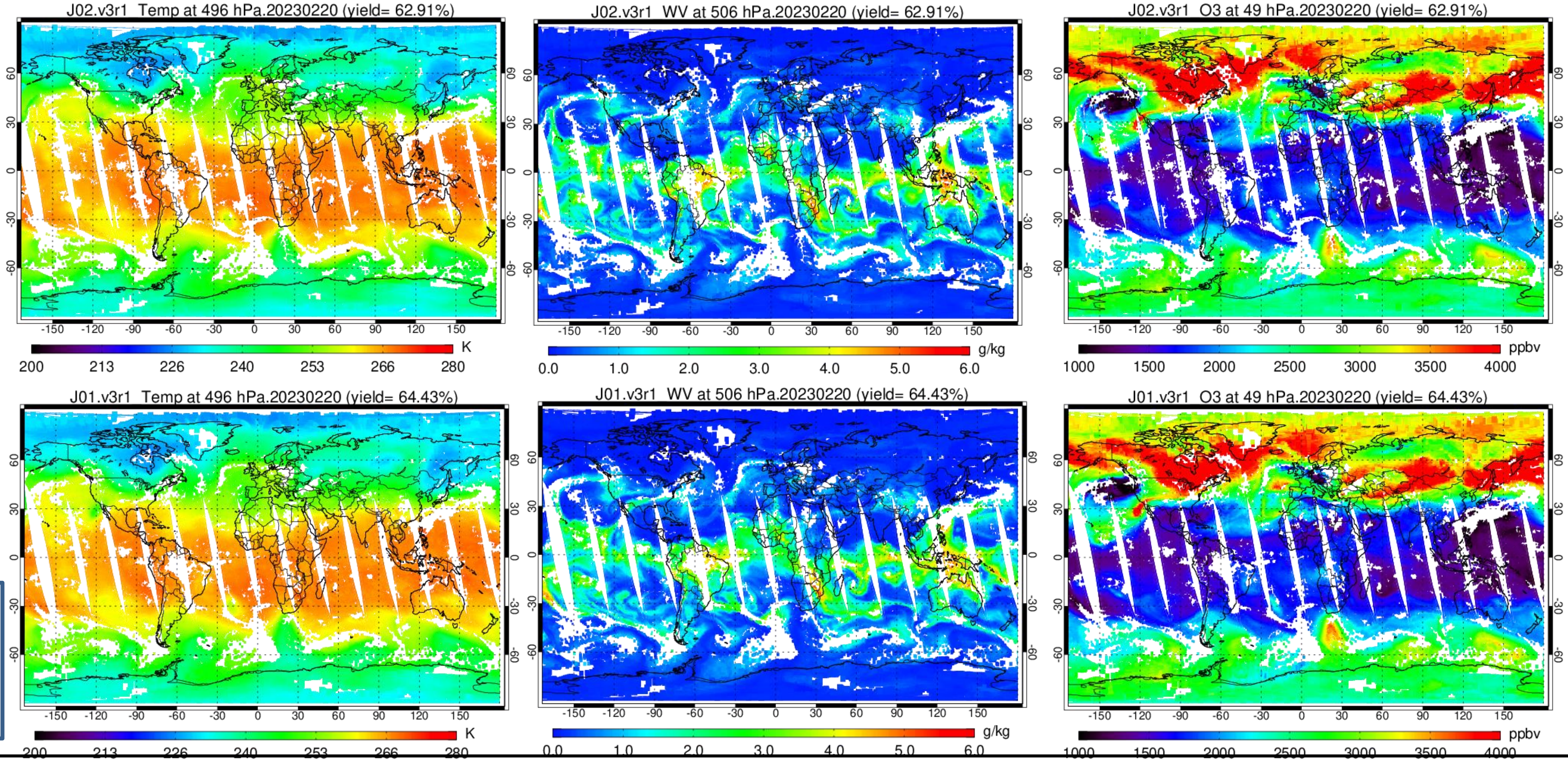
- Global maps and Statistical metrics (NOAA-20 & NOAA-21) *vs* ECMWF (*T*, *q*, O3)
- Global maps of CO, CH4, and CO2 (NOAA-20 & NOAA-21 *vs* TROPOMI CO, CH4, and OCO-2 v11
- OLR Plots: NOAA-21 *vs* NOAA-20 for 02/20, 03/24
- TCCON Measurement Matches: NOAA-20 & NOAA-21 *vs* TCCON (Currently Not Available)

NOAA-21 *vs* NOAA-20 NUCAPS EDR retrievals for 2023/02/20 (EP v210)

Temperature at 496 hPa | **Water Vapor at 506 hPa** | **Ozone at 49 hPa**

NOAA-21
Yield: 63%

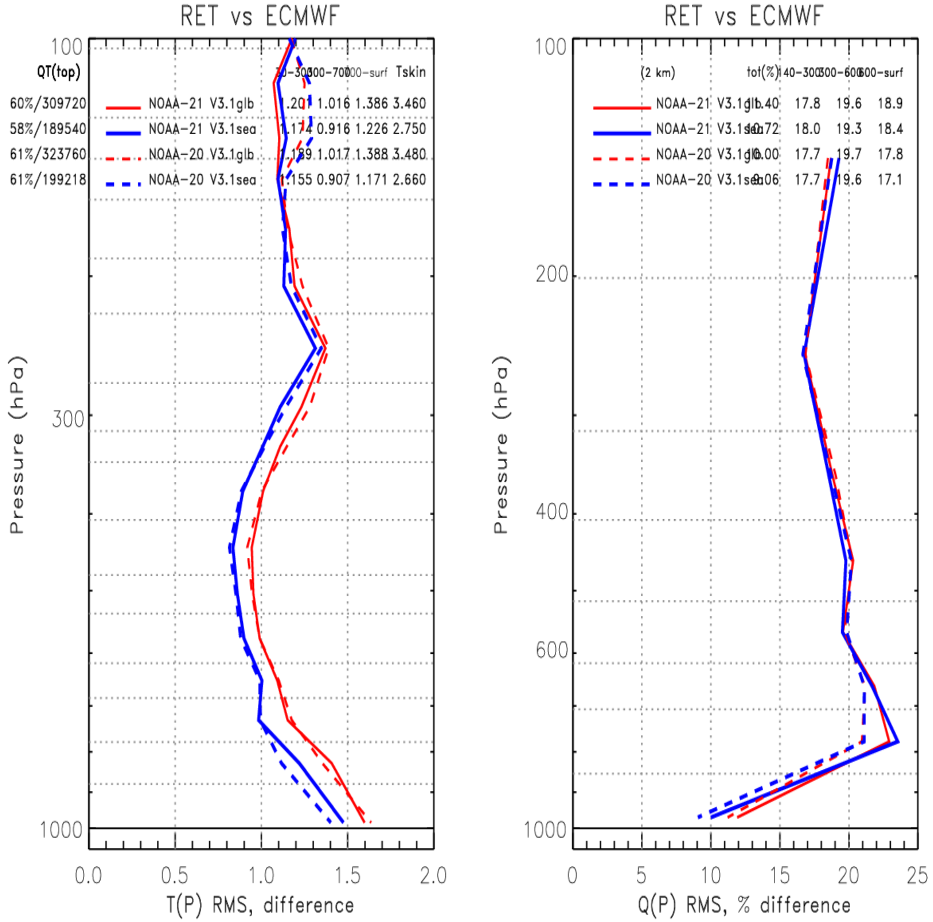
NOAA-20
Yield:65%



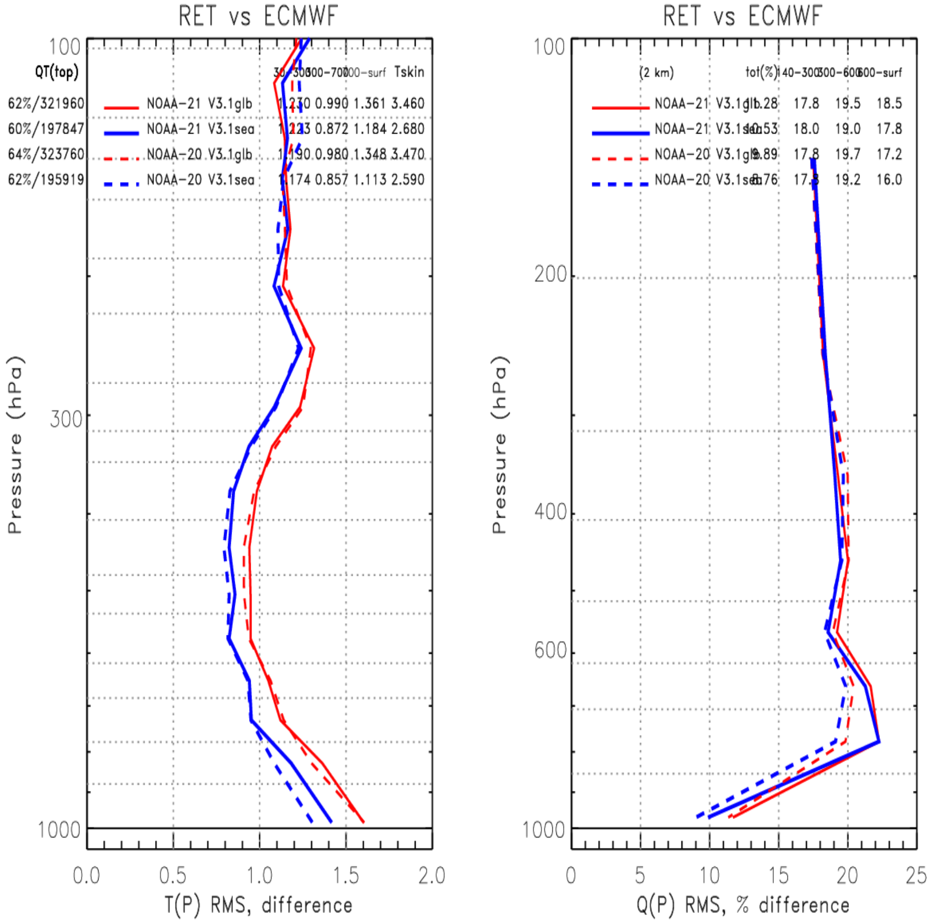
Figures Provided by Tong Zhu, Murty D, and NUCAPS Team Members

NOAA-21 NUCAPS EDR retrievals from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-21 operational NUCAPS EDRs. The algorithm produces vertical profiles of temperature, water vapor, ozone, CO, CH4, and CO2. Retrieved profiles (100 layers) span from surface to 0.01 hPa.

2023/02/16
RMS Differences with ECMWF
Temperature | Water Vapor



2023/02/20
RMS Differences with ECMWF
Temperature | Water Vapor



NOAA-21 Global
NOAA-21 Sea-only
NOAA-20 Global
NOAA-20 Sea-only

- NOAA-21 and NOAA-20 NUCAPS *T*(*p*), *q*(*p*) RMS differences with matched ECMWF show very similar characteristics.
- Demonstrates CrIS and ATMS SDRs/TDRs are performing as expected.

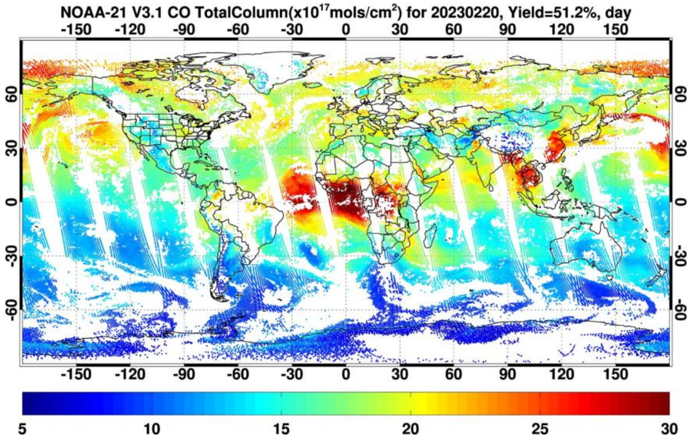
Figures Provided by Tong Zhu, Murty D., and NUCAPS Team Members

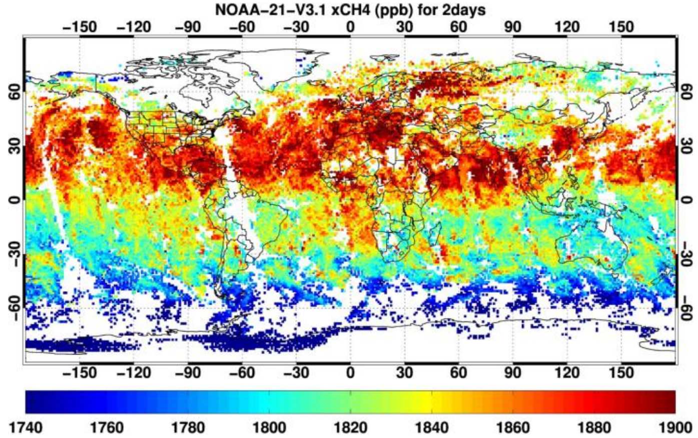
Total Column CO

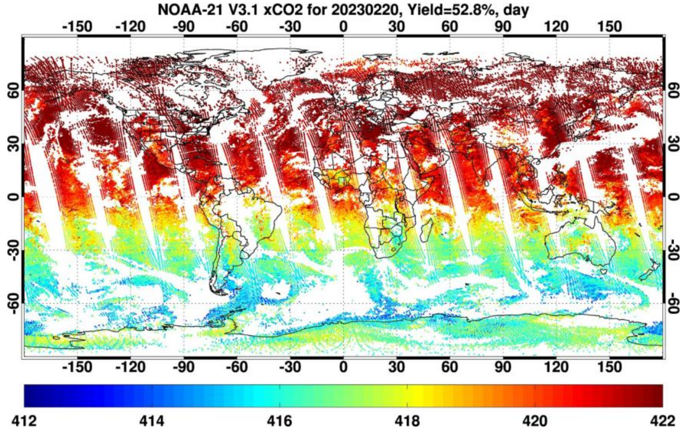
Total Column CH4

Total Column CO2

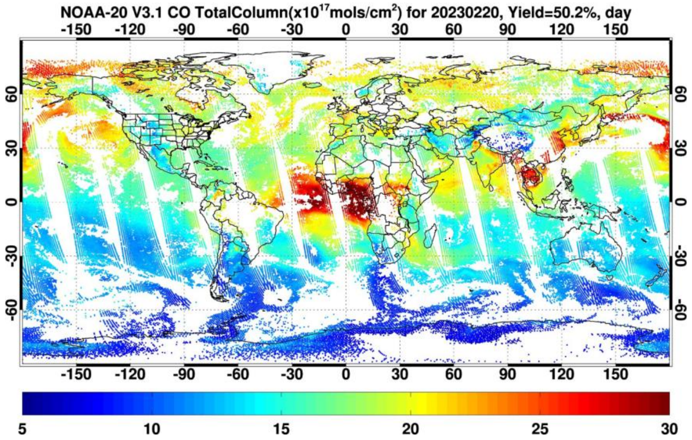
NOAA-21
Yield: 51%

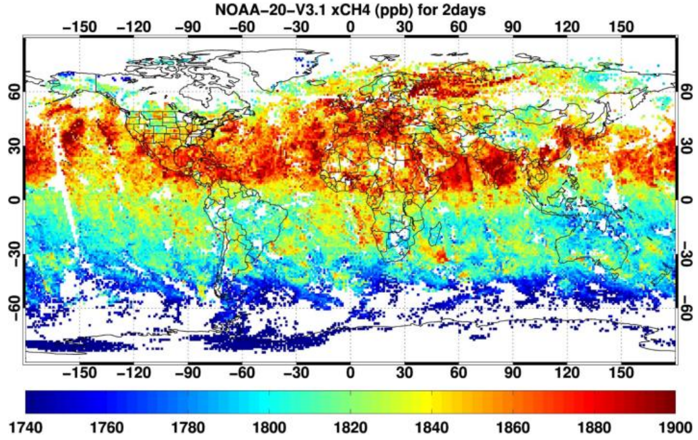


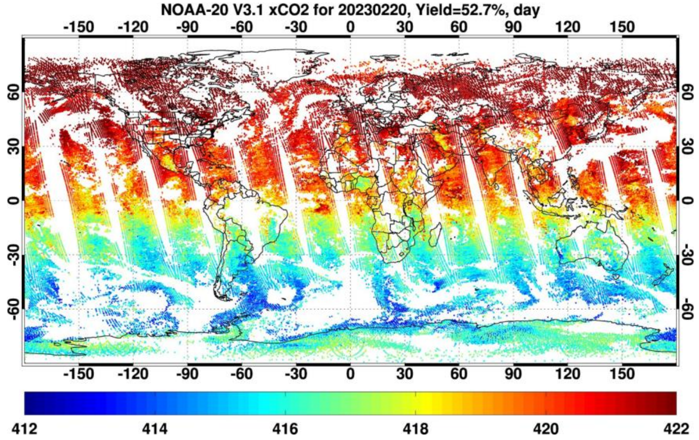




NOAA-20
Yield: 50%





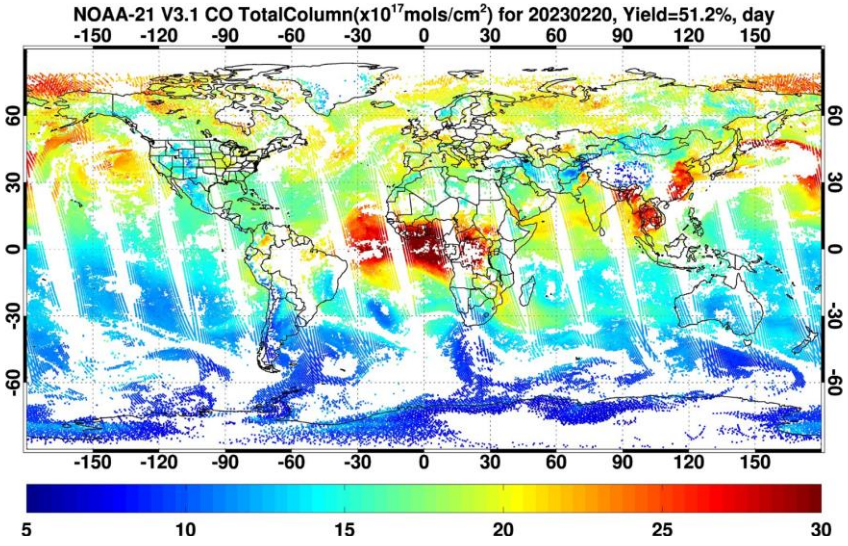


Figures Provided by Juying Warner, Tong Zhu, Murty D., and NUCAPS Team Members

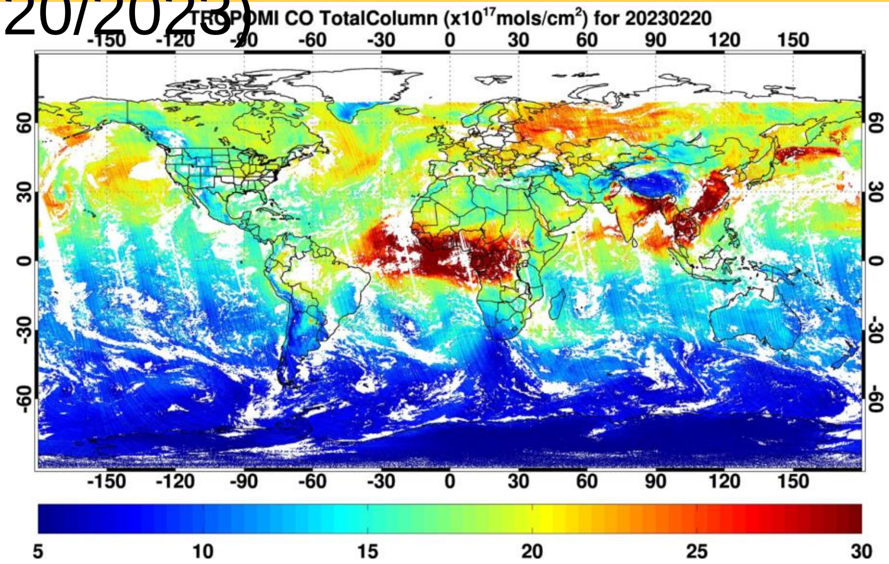
NOAA-21 NUCAPS trace gas EDR products from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-20 operational NUCAPS EDRs. Retrieved trace gas profiles (100 layers) span from surface to 0.01 hPa. Figures show Total Column CO, CH4, and CO2 EDRs. We are currently evaluating these EDRs with TROPOMI/OCO-2 products as well as TCCON in-situ Measurements.

Total Column CO NOAA-21 *vs* NOAA-20 NUCAPS 3.1 *vs* TROPOMI (2/20/2023)

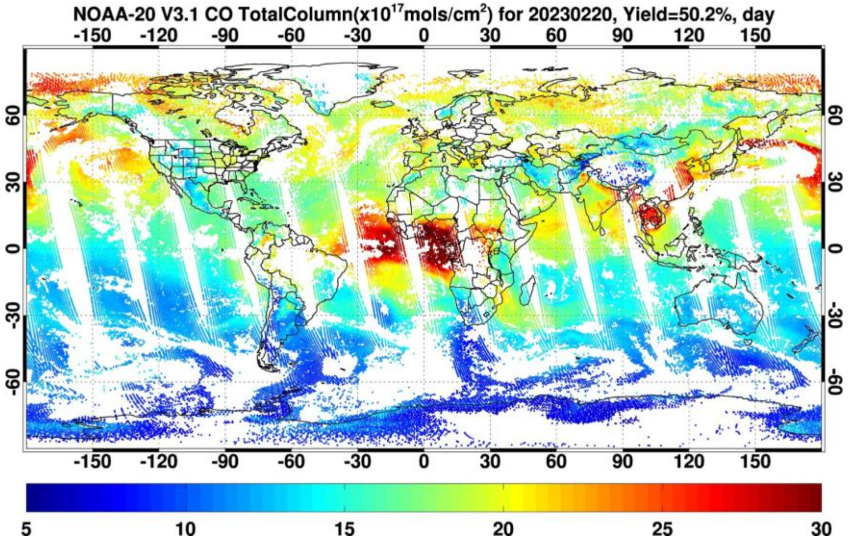
NOAA-21
Yield: 51%



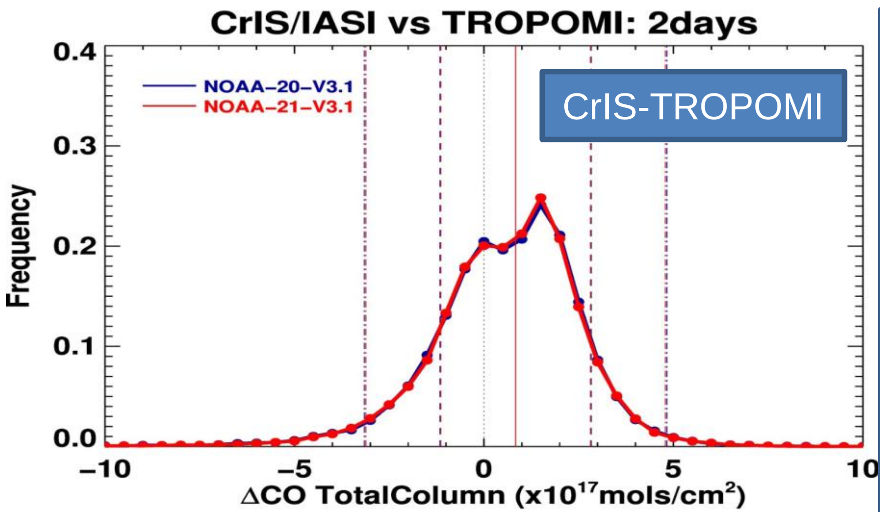
TROPOMI



NOAA-20
Yield: 50%



Figures Provided by Juying Warner, Tong Zhu, Murty D., and NUCAPS Team Members

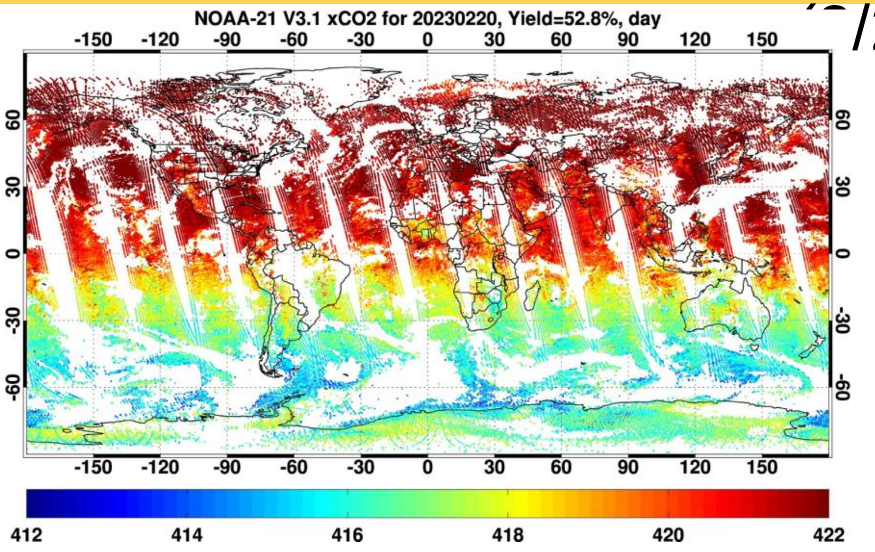


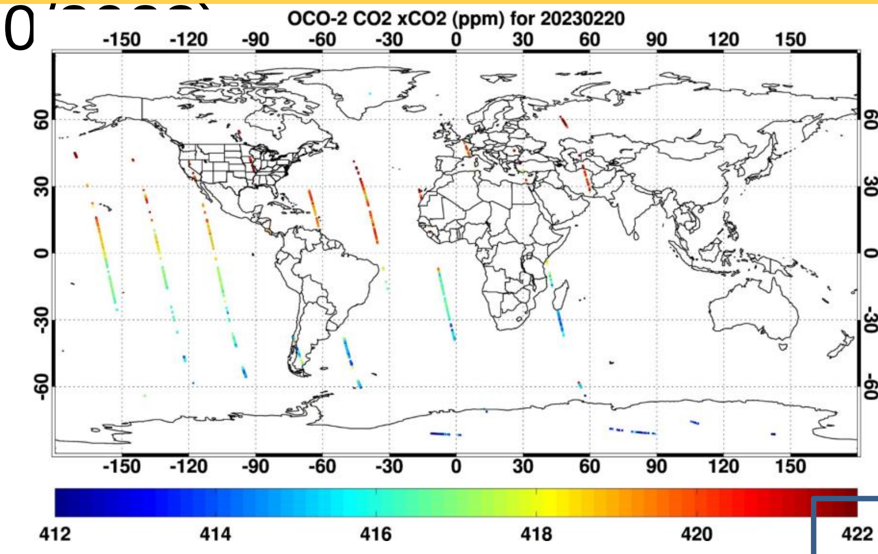
- NUCAPS EDRs are produced for both daytime and nighttime.
- TROPOMI uses solar measurements to retrieve CO and comparisons are possible for daytime only.

NOAA-21 NUCAPS CO EDR retrieval from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-20 operational NUCAPS EDRs. Retrieved CO profile (100 layers) span from surface to 0.01 hPa. Shown here is the total column CO *vs* TROPOMI.

Total Column CO_2 NOAA-21 *vs* NOAA-20 NUCAPS 3.1 *vs* OCO-2
/20

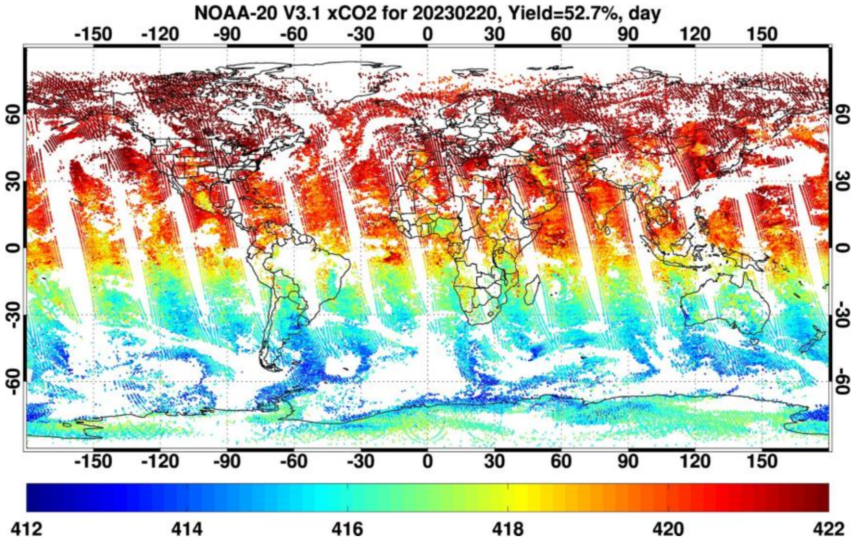
NOAA-21
Yield: 51%

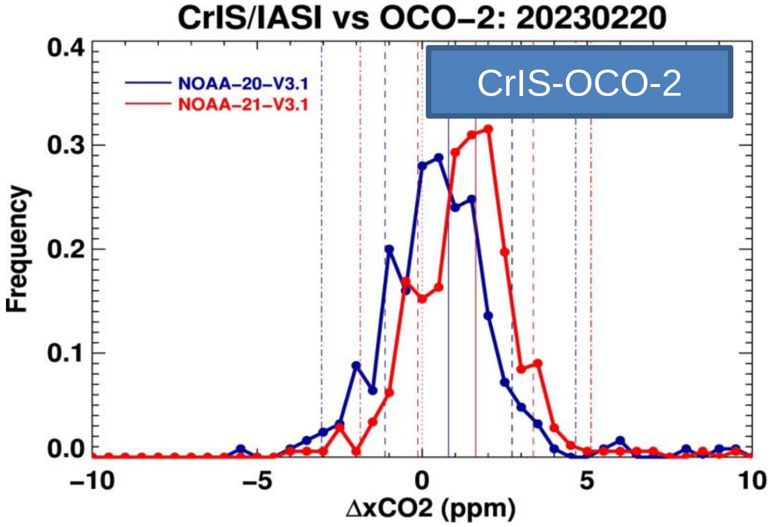




OCO-2
V11

NOAA-20
Yield: 50%





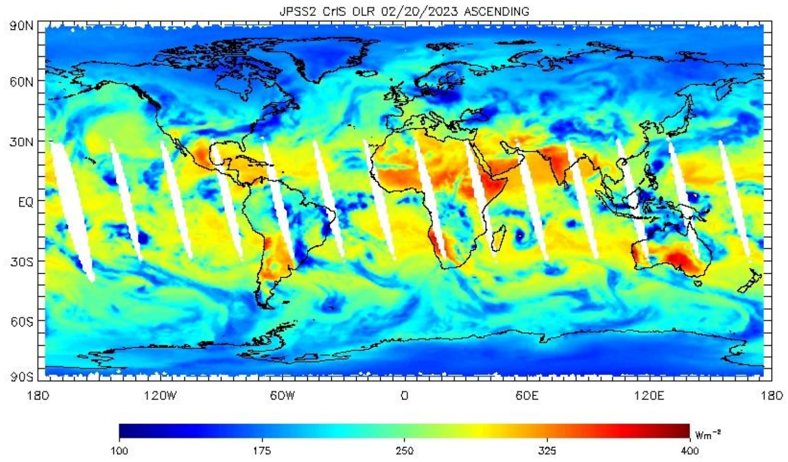
Figures Provided by Juying Warner, Tong Zhu, Murty D., and NUCAPS Team Members

- NUCAPS EDRs are produced for both daytime and nighttime
- OCO-2 Uses solar measurements to retrieve CO_2 and comparisons are possible for daytime only.
- NOAA-21 *vs* NOAA-20 differences suggest the need for NOAA-21 CrIS bias tuning.

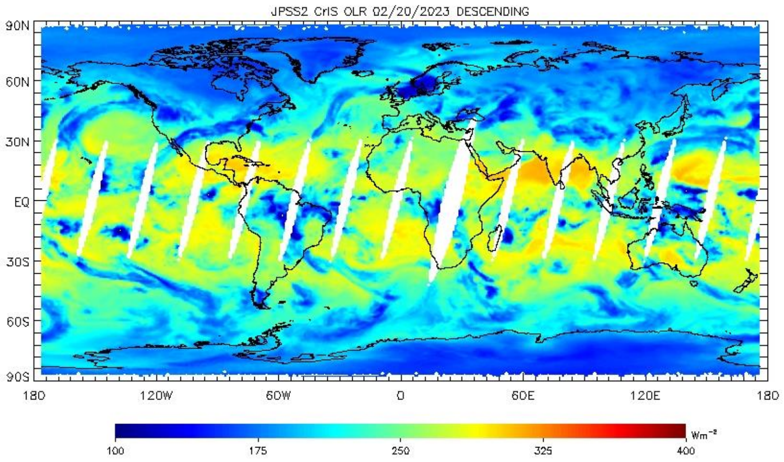
NOAA-21 NUCAPS EDR retrievals from J2-Ready algorithm matches very well both qualitatively and quantitatively with NOAA-20 operational NUCAPS EDRs. Retrieved trace gas profiles (100 layers) span from surface to 0.01 hPa. Shown here is the total column CO_2 *vs* OCO-2.

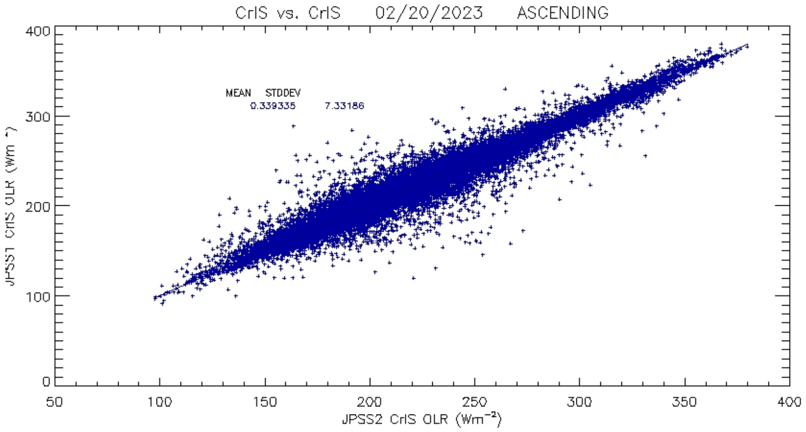
NUCAPS CrIS OLR NOAA-21 *vs* NOAA-20 (02/20/2023)

CrIS NOAA-21 Ascending

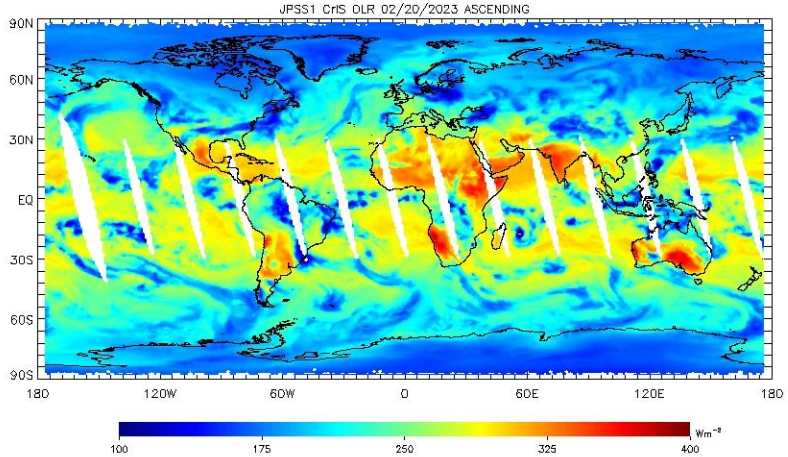


CrIS NOAA-21 Descending

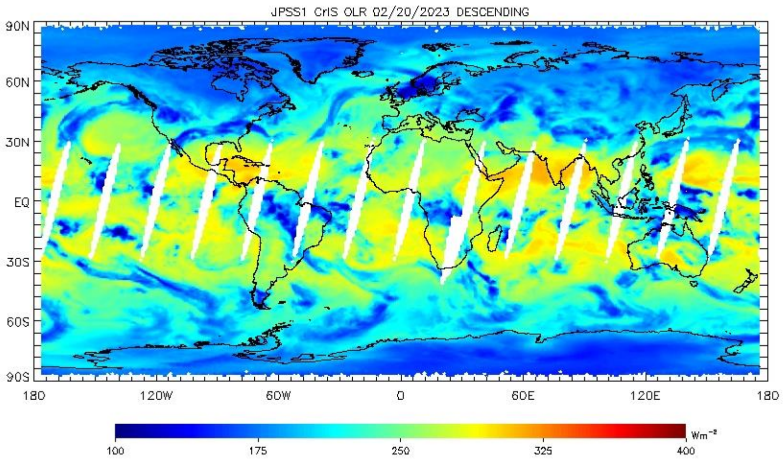


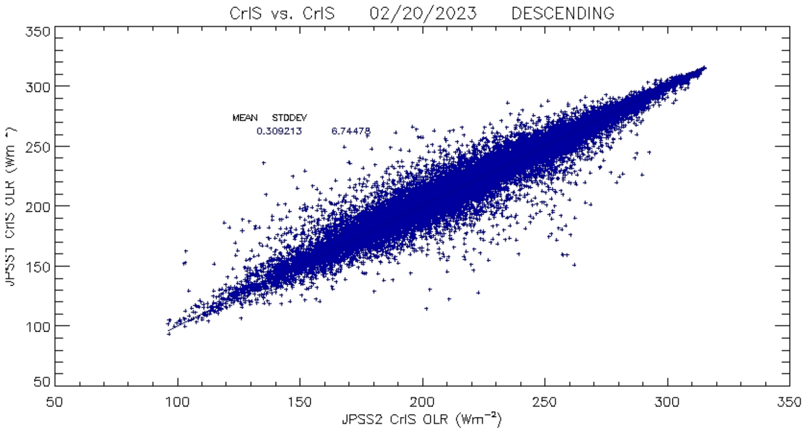


CrIS NOAA-20 Ascending



CrIS NOAA-20 Descending





CrIS NOAA-21 OLR agrees well with NOAA-20 for both ascending and descending nodes

Figure Credits: Margarita Kulko, Tong Zhu

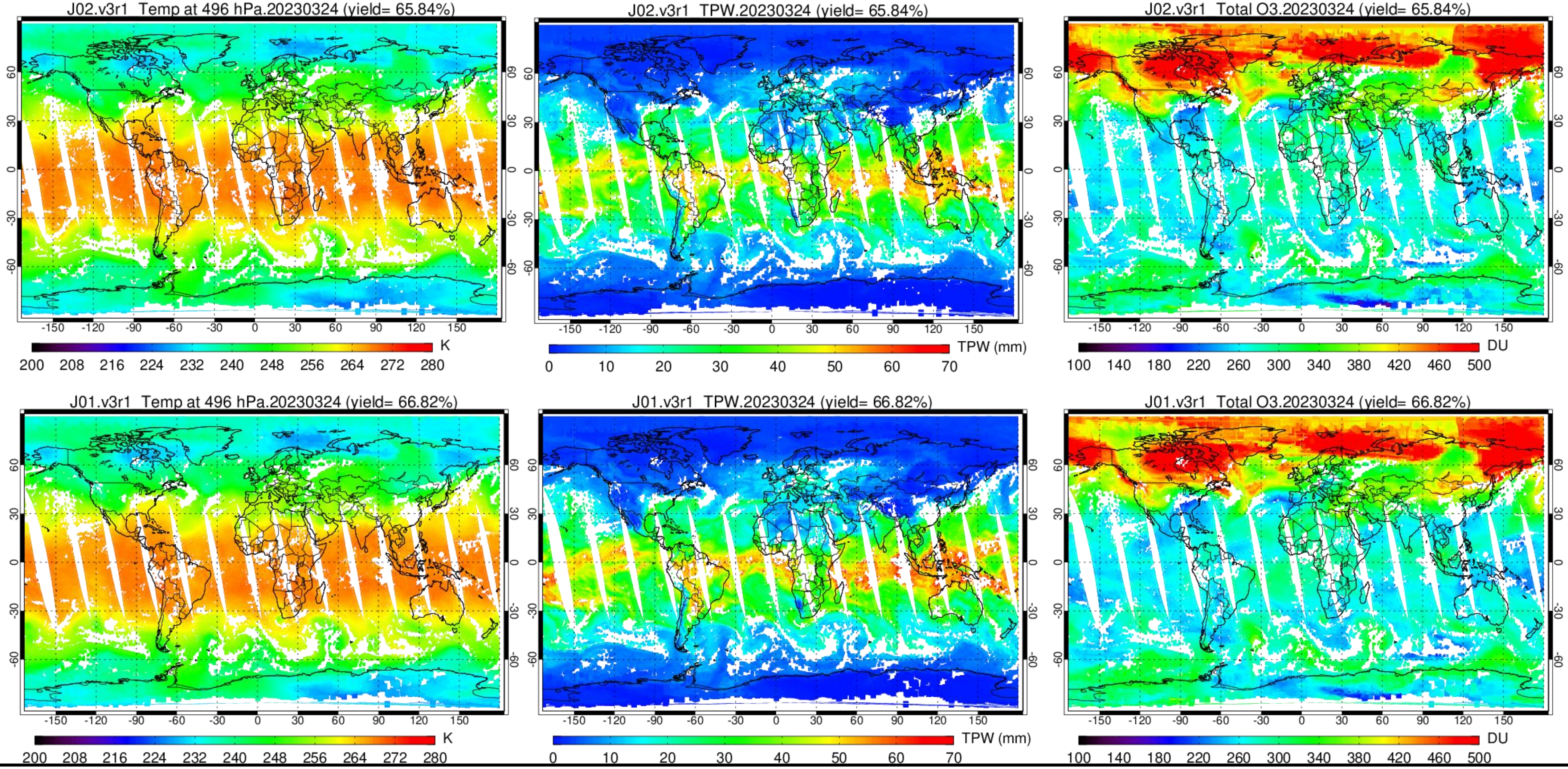
NOAA-21 *vs* NOAA-20 NUCAPS EDR Retrievals for 2023/03/24 (EP v211)

NOAA-21
Yield: 65%

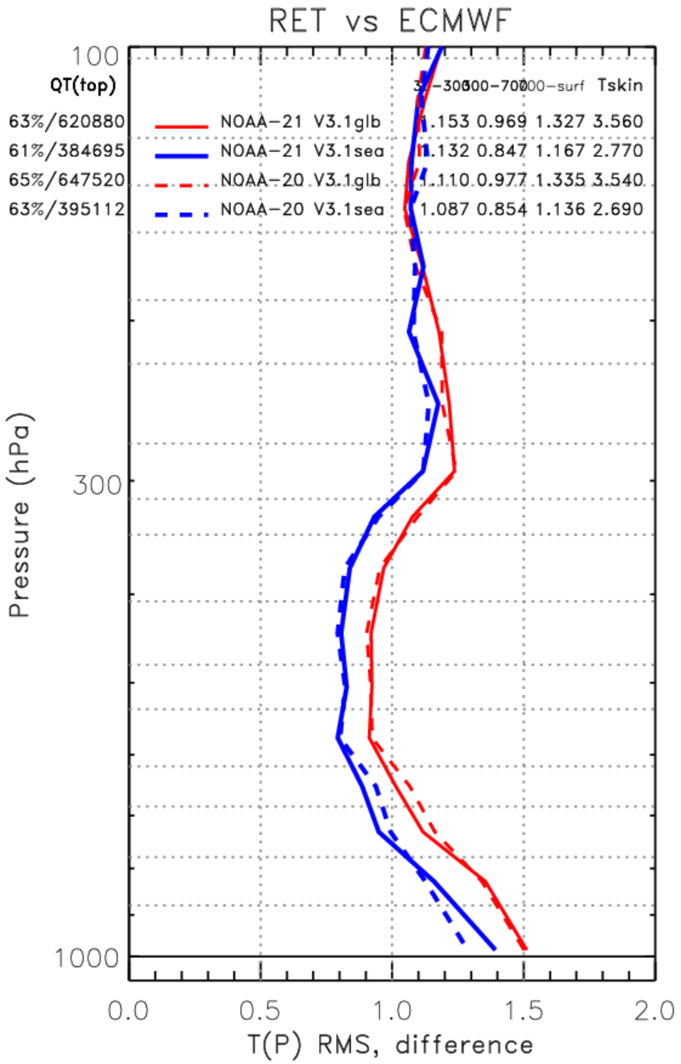
NOAA-20
Yield:66%

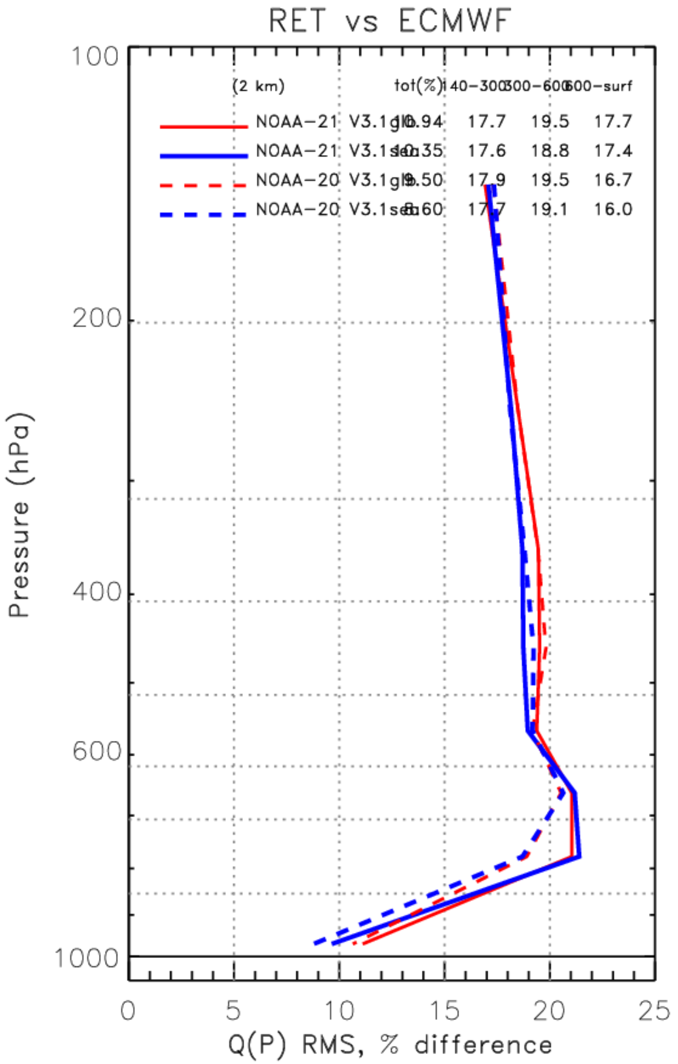
Figures Provided by Tong Zhu, Murty D., and NUCAPS Team Members

Temperature at 496 hPa | **TPW (mm)** | **Total Ozone (DU)**



NOAA-21 NUCAPS EDR retrievals from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-21 operational NUCAPS EDRs. The algorithm produces vertical profiles of temperature, water vapor, ozone, CO, CH4, and CO2. Retrieved profiles (100 layers) span from surface to 0.01 hPa.





NOAA-21 Global
NOAA-21 Sea-only
NOAA-20 Global
NOAA-20 Sea-only

- NOAA-21 and NOAA-20 NUCAPS *T*(*p*), *q*(*p*) RMS differences with matched ECMWF show very similar characteristics.
- RMS differences observed between 02/20 and 03/24 appears to be due to sample size, and day of the year
- Differences in engineering packets (cal/val) has no significant impact in the NUCAPS *T*(*p*), *q*(*p*) EDRs. Currently performing a detailed evaluation with trace gas EDRs.

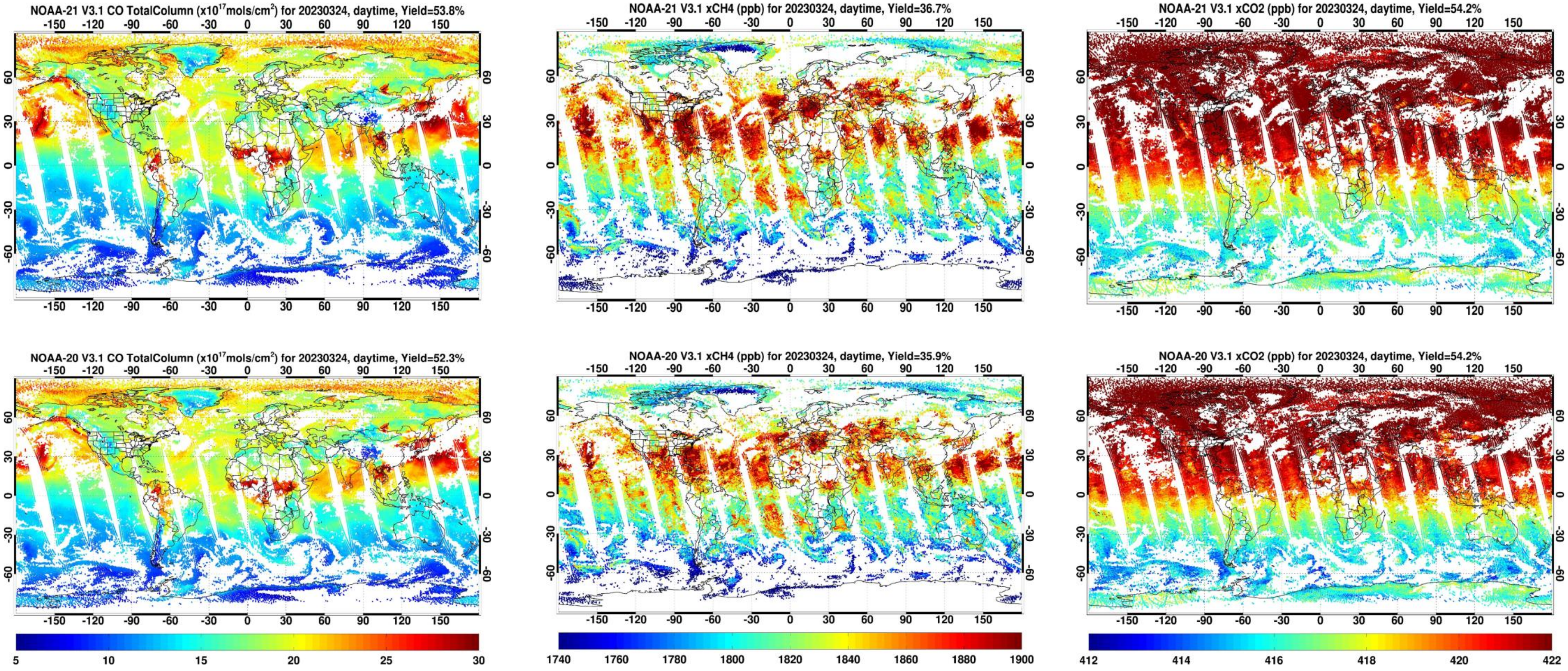
Figures Provided by Tong Zhu, Murty D., and NUCAPS Team Members

NOAA-21 *vs* NOAA-20 NUCAPS Trace Gas EDR Products (2023/03/24 Daytime; EP v211)

Total Column CO | **Total Column CH4** | **Total Column CO2**

NOAA-21
Yield: 51%

NOAA-20
Yield: 50%



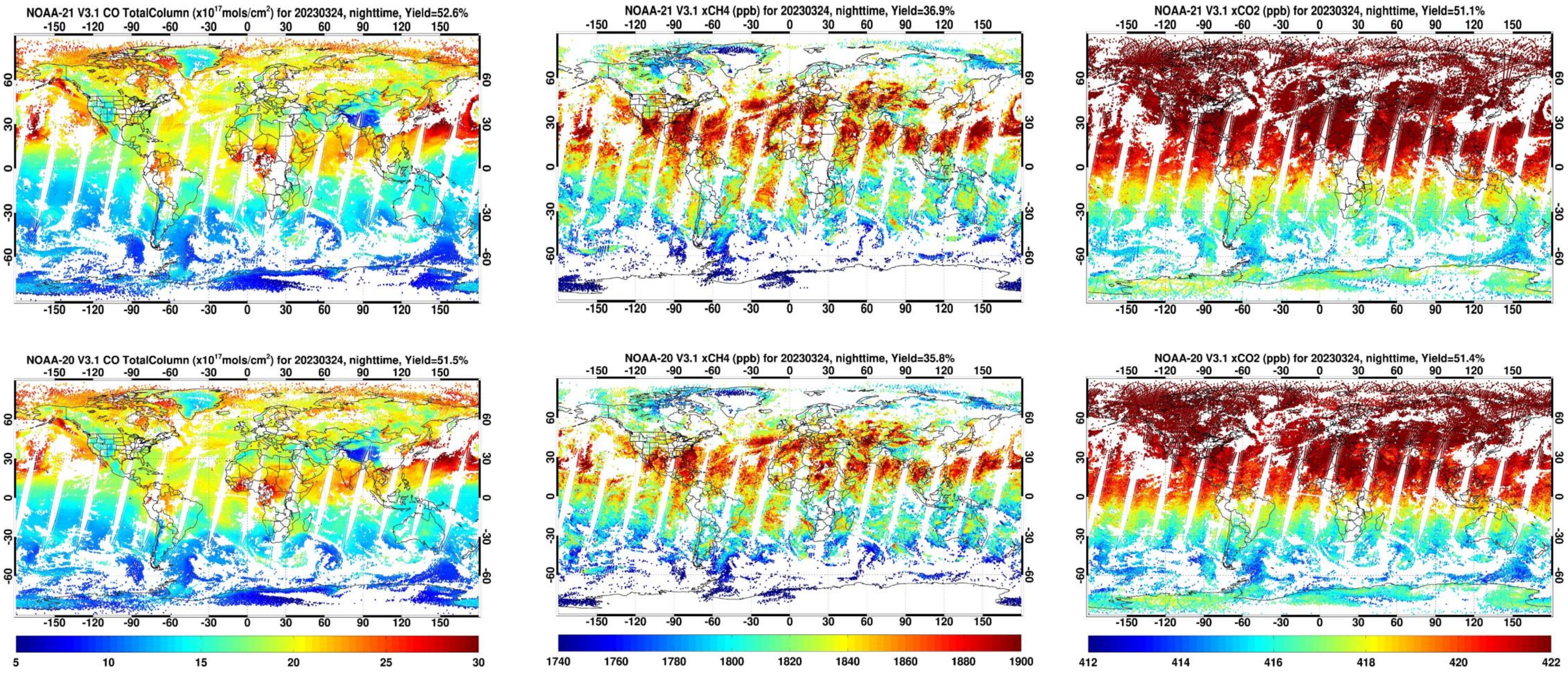
Figures Provided by Juying Warner, Tong Zhu, Murty D., **and NUCAPS Team Members**

NOAA-21 NUCAPS trace gas EDR products from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-20 operational NUCAPS products. Retrieved trace gas profiles (100 layers) span from surface to 0.01 hPa. Figures show Total Column CO, CH4, and CO2 Products. We are currently evaluating these products with TROPOMI/OCO-2 products as well as TCCON in-situ Measurements.

NOAA-21 *vs* NOAA-20 NUCAPS Trace Gas EDR Products (2023/03/24 Nighttime; EP v211)

Total Column CO | **Total Column CH4** | **Total Column CO2**

NOAA-21
Yield: 51%



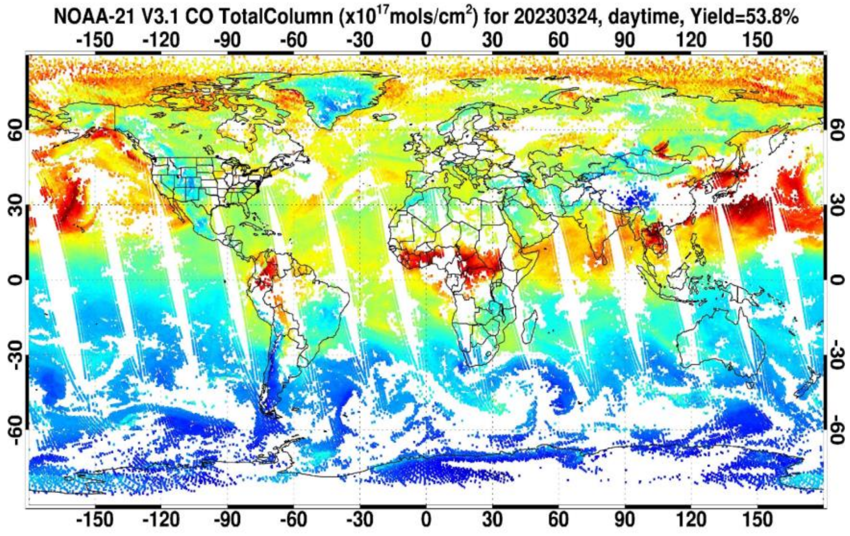
NOAA-20
Yield: 50%

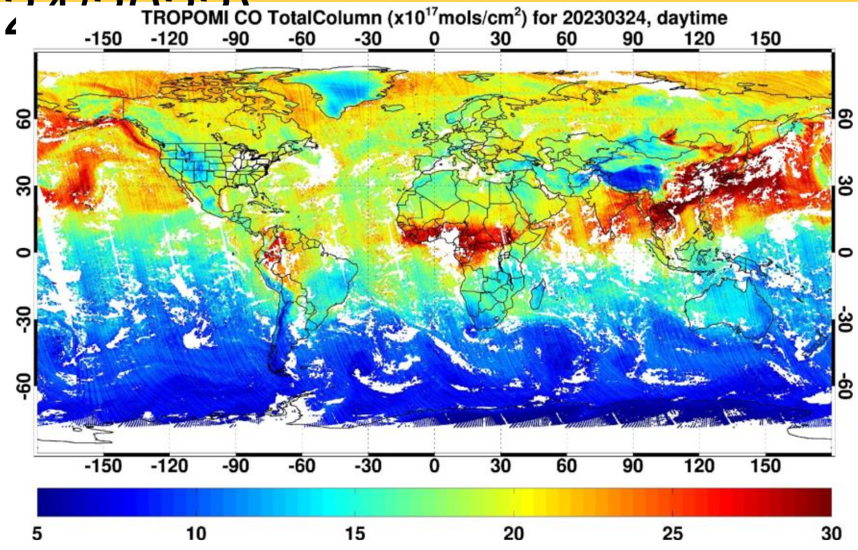
Figures Provided by Juying Warner, Tong Zhu, Murty D., **and NUCAPS Team Members**

NOAA-21 NUCAPS trace gas EDR products from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-20 operational NUCAPS products. Retrieved trace gas profiles (100 layers) span from surface to 0.01 hPa. Figures show Total Column CO, CH4, and CO2 Products. We are currently evaluating these products with TROPOMI/OCO-2 products as well TCCON in-situ Measurements.

Total Column CO NOAA-21 & NOAA-20 NUCAPS 3.1 *vs* TROPOMI (3/24/2023)

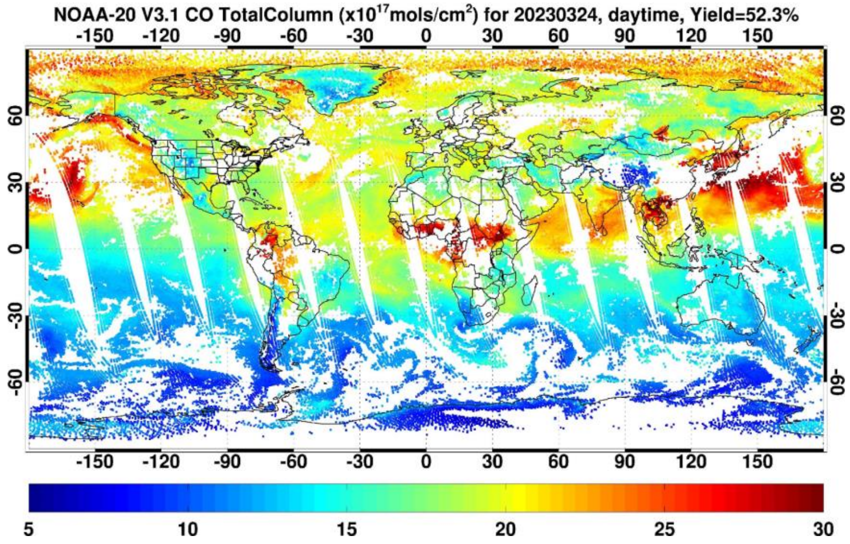
NOAA-21
Yield: 51%

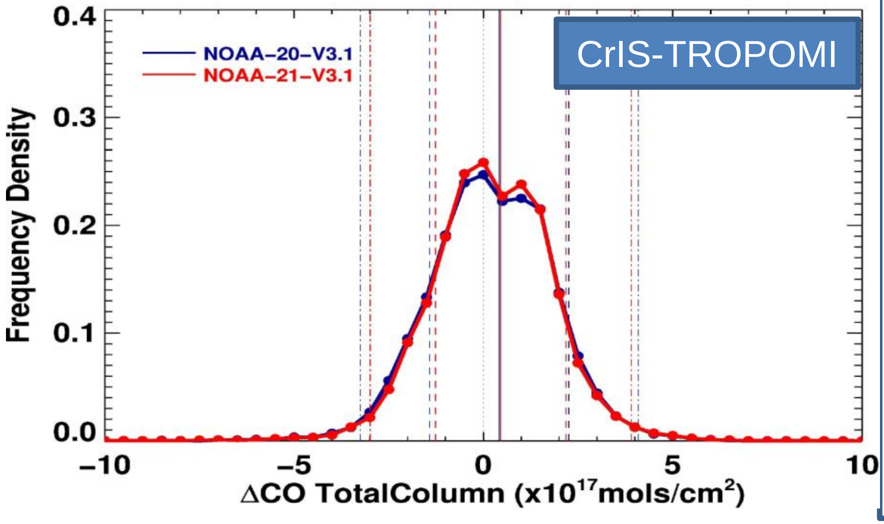




TROPOMI

NOAA-20
Yield: 50%





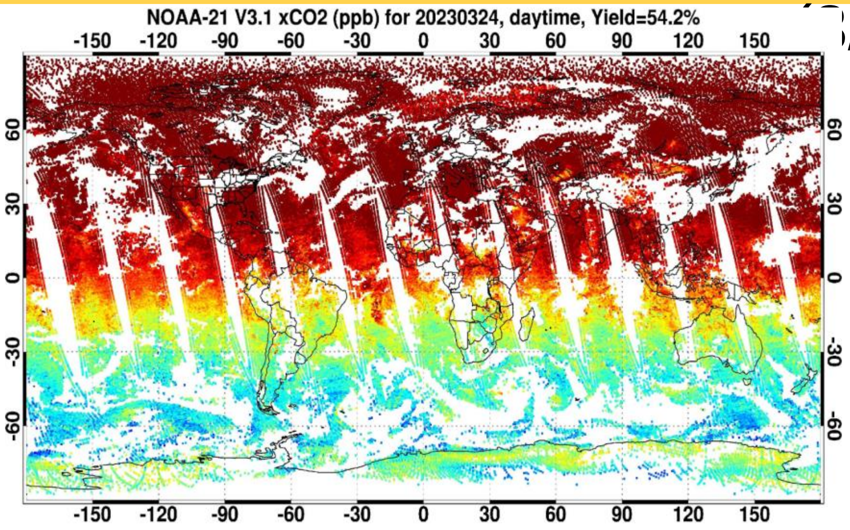
Figures Provided by Juying Warner, Tong Zhu, Murty D., and NUCAPS Team Members

- NUCAPS products are generated for both daytime and nighttime.
- TROPOMI uses solar measurements to retrieve CO and comparisons are possible for daytime only.

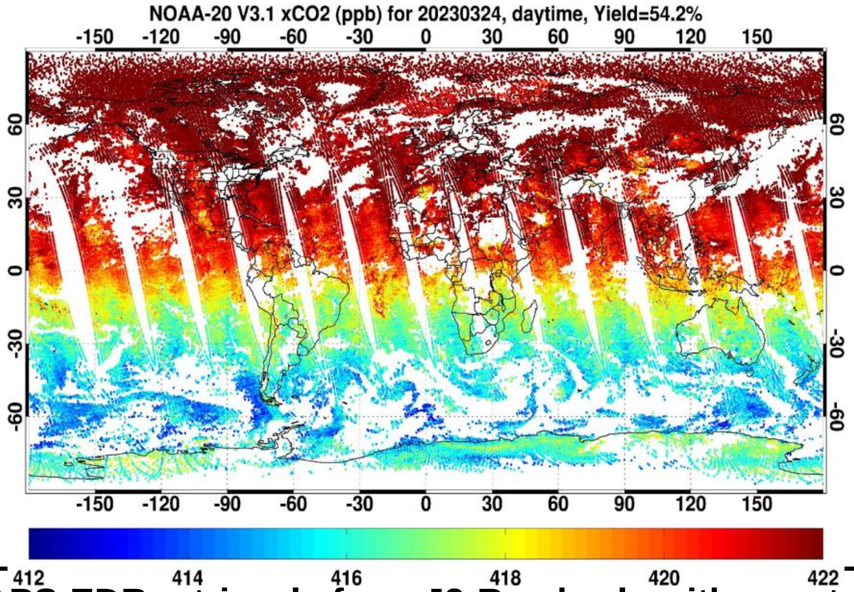
NOAA-21 NUCAPS CO product retrieval from J2-Ready algorithm matches very well both qualitatively and quantitatively with the NOAA-20 operational NUCAPS products. Retrieved CO profile (100 layers) span from surface to 0.01 hPa. Shown here is the total column CO *vs* TROPOMI.

Total Column CO_2 NOAA-21 & NOAA-20 NUCAPS 3.1 *vs* OCO-2 (3/24/2023)

NOAA-21
Yield: 54%

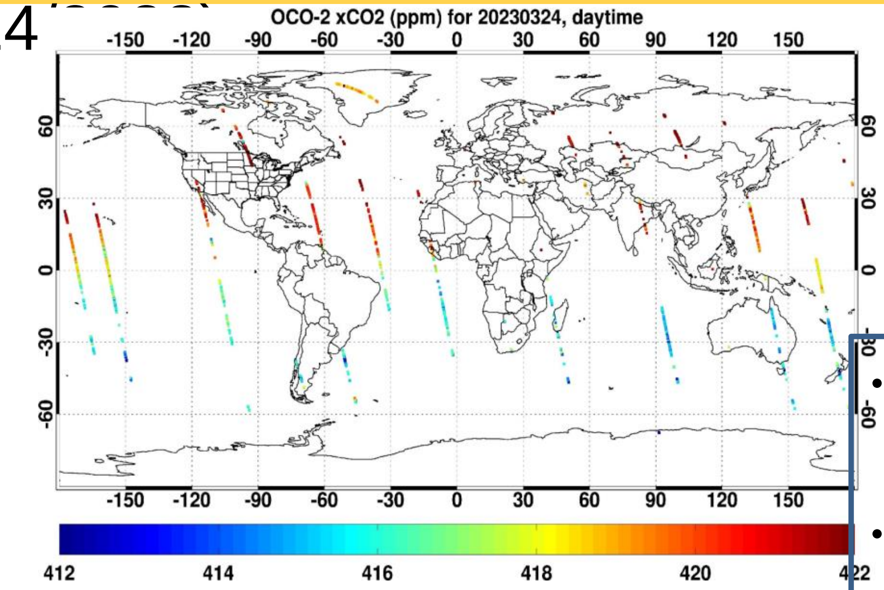


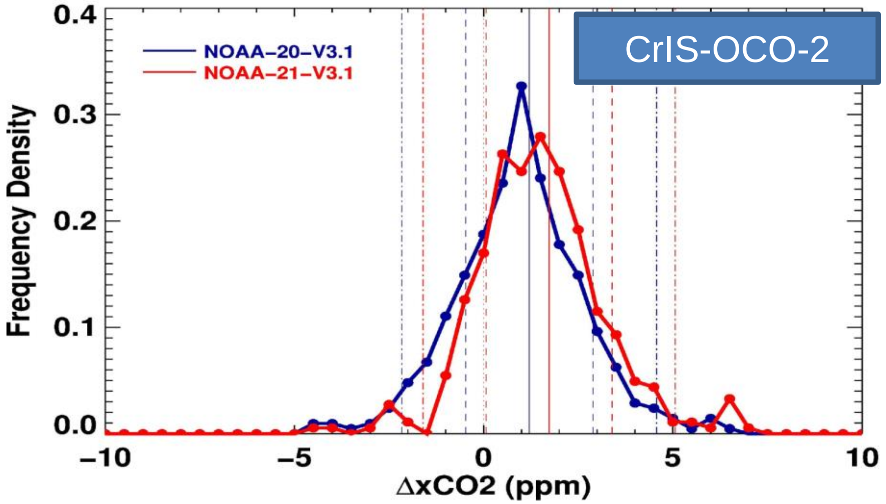
NOAA-20
Yield: 54%



Figures Provided by Juying Warner, Tong Zhu, Murty D., and NUCAPS Team Members

OCO-2
V11



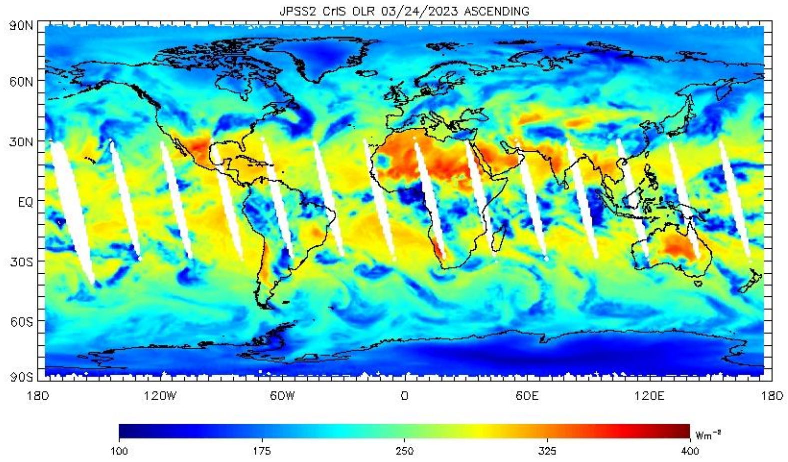


- NUCAPS products are generated for both daytime and nighttime.
- OCO-2 Uses solar measurements to retrieve CO_2 and comparisons are possible for daytime only.
- NOAA-21 *vs* NOAA-20 differences suggest the need for NOAA-21 CrIS bias tuning.
- **EP v211 improved CO_2 product matches between NOAA-20 and NOAA-21.**

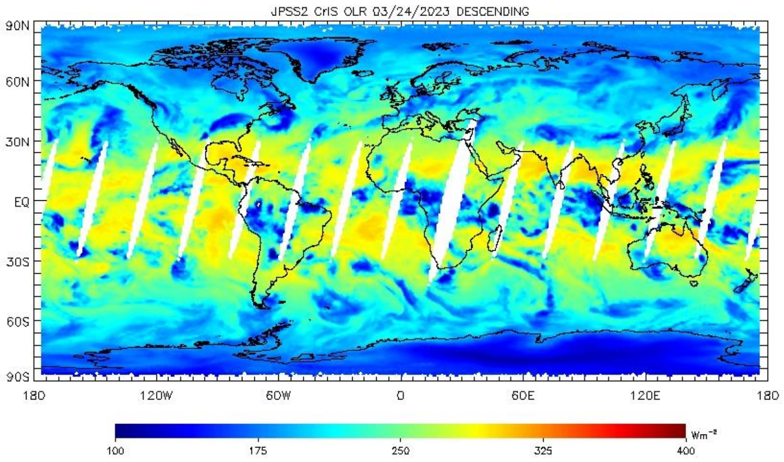
NOAA-21 NUCAPS EDR retrievals from J2-Ready algorithm matches very well both qualitatively and quantitatively with NOAA-20 operational NUCAPS products. Retrieved trace gas profiles (100 layers) span from surface to 0.01 hPa. Shown here is the total column CO_2 *vs* OCO-2. 64

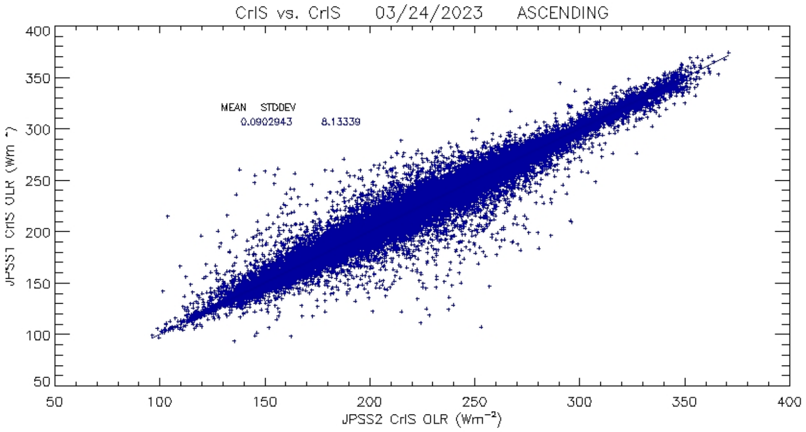
NUCAPS CrIS OLR NOAA-21 *vs* NOAA-20 (3/24/2023)

CrIS NOAA-21 Ascending

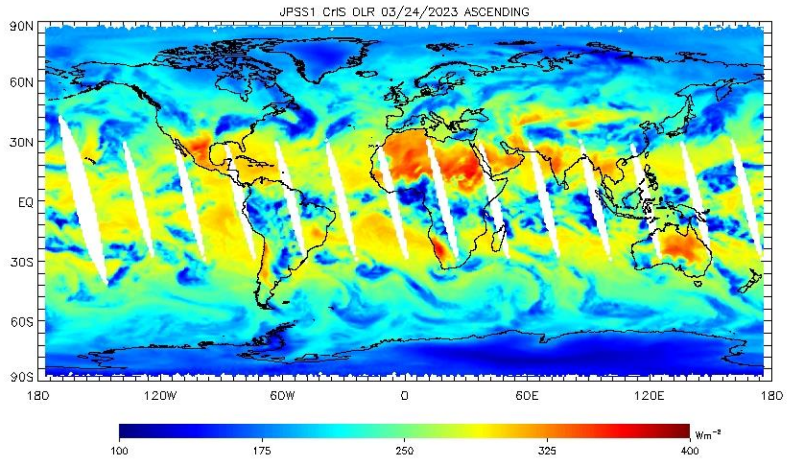


CrIS NOAA-21 Descending

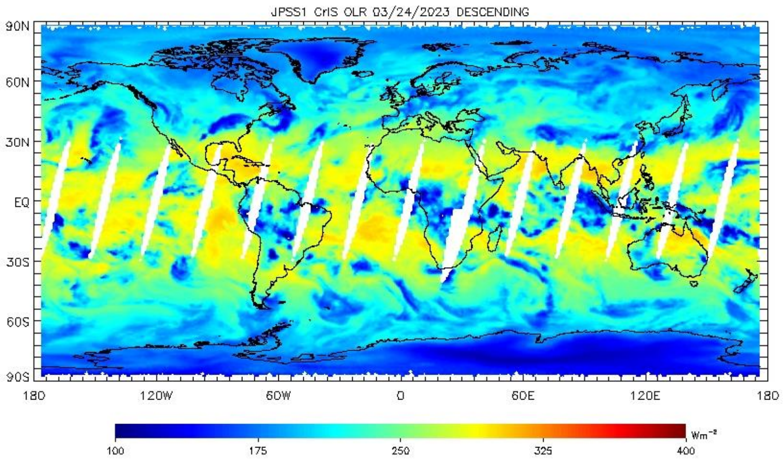


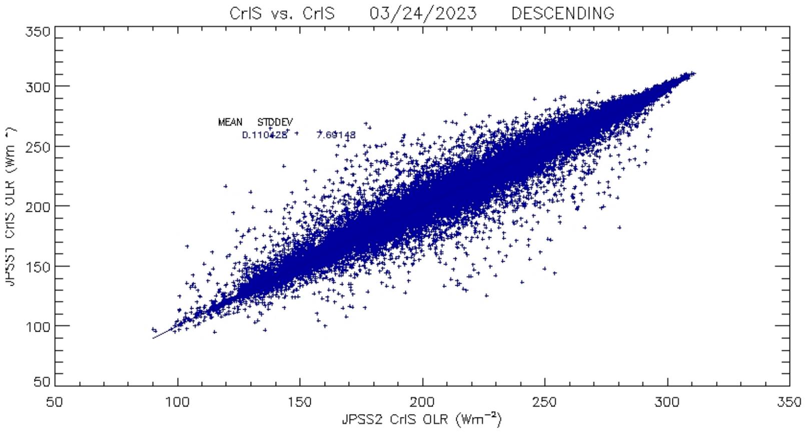


CrIS NOAA-20 Ascending



CrIS NOAA-20 Descending





CrIS NOAA-21 OLR agrees well with NOAA-20 for both ascending and descending nodes
Figure Credits: Margarita Kulko, Tong Zhu

NOAA-21 NUCAPS EDR Product Evaluation in Support of CrIS SDR Provisional Maturity
Downstream Product Summary

- Evaluated NUCAPS Environmental Data Records (EDRs) from a set of global Focus Days covering the CrIS SDR Engineering Packet (EP) updates
  - EP v208/210: 02/16, 02/20; EP v211 02/27 (ADL), 03/24 (IDPS)
  - Differences in EP versions (cal/val) had no significant impact on the NUCAPS *T*(*p*), *q*(*p*) EDRs. However, positively impacted the trace gas EDRs.
- NOAA-21 and NOAA-20 NUCAPS *T*(*p*), *q*(*p*), and O3(*p*) RMS differences with matched ECMWF show very similar characteristics.
- NOAA-21 and NOAA-20 trace gas EDR evaluations (CO, CH4 and CO2) with TROPOMI and OCO-2 observations show very similar patterns. EP v211 improved CH4 and CO2 matches between NOAA-20 and NOAA-21.
- NOAA-21 and NOAA-20 Outgoing Longwave Radiation (OLR) product agrees well for both ascending and descending orbital nodes.
- TCCON measurements have a lag between the measurements and data archive availability; TCCON data will be used for NUCAPS NOAA-21 Provisional and Validated Maturity assessments.
- Currently performing first guess cloudy and clear regression exercises to ascertain the need for seasonal focus days for optimized first guess.
- Evaluations performed so far may allow the NUCAPS products to be declared as Beta Maturity. A minimum of 12 focus days spanning the season cycle will be used to evaluate seasonal biases to meet NUCAPS EDR Provisional Maturity requirements.
- **NOAA-21 NUCAPS EDR product evaluation demonstrates that CrIS/ATMS SDRs/TDRs are performing as expected for meeting Provisional Maturity.**

NATIONAL WEATHER SERVICE

NCEP/EMC Readiness for NOAA-21

Andrew Collard[1]
Iliana Genkova[2]
James Jung[3]
Daryl Kleist[1]
Xu Li[2]
Emily Liu[1]
Haixia Liu[2]
Russ Treadon[1]

Contributors listed in alphabetical order

Polar Product Operations and Readiness Team Meeting

Tuesday March 14th 2023

[1]NOAA/NWS/NCEP/EMC
[2]Lynker@ NOAA/NWS/NCEP/EMC
[3]University of Wisconsin -Madison

Summary

- We expect to be able to implement NOAA-21 data in a timely manner based on current experience with the data.
- ATMS and CrIS will be the first to be operationally implemented with a target of Q3FY2023
- Other observations will be assimilated based on when data is available

NOAA-21 CrIS Pre-Launch Scientific Waivers

There are **no CrIS SDR Pre-Launch Scientific Waivers** for the NOAA-21 provisional maturity science review

CrIS Provisional Maturity Review - Exit Criteria

- Provisional 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.

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

Documentations (Science Maturity Checklist)

Science Maturity Checklist	Yes ?	Where
ReadMe for Data Product Users	Yes	https://docs.google.com/document/d/10zFbY4psdp44A6bHcc3IBOMcRw3H-MVf/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

Check List - Provisional Maturity

Provisional Maturity End State	Assessment
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 select locations, periods, and associated ground truth or field campaign efforts.	Yes
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Yes
Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.	Yes
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	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	(0.203) 0.45 @ 670 cm-1, (0.115) 0.15 @ 700 cm-1, (0.0725) 0.15 @ 850 cm-1, (0.0647) 0.15 @ 1050 cm-1	(0.19) 0.45	(2) 10	(0.75) 5
MWIR	1210-1750	865	0.625	(0.02140) 0.078 @ 1225 cm-1 (0.02086) 0.064 @ 1250 cm-1 (0.02272) 0.069 @ 1500 cm-1 (0.02951) 0.075 @ 1700 cm-1	(0.21) 0.58	(2) 10	(0.75) 5
SWIR	2155-2550	633	0.625	(0.00513) 0.013 @ 2200 cm-1 (0.00434) 0.014 @ 2350 cm-1 (0.00801)0.014 @ 2550 cm-1	(0.37) 0.77	(2) 10	(0.75) 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.

Justification

After NOAA-20 CrIS SDR beta maturity on February 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, diagnostic RDR, SDR, and GEO data products. This includes verification of the Radiometric Nonlinearity using DM data and further refinements using FOV2FOV radiometric comparisons, further refinement of the ILS, neon lamp, and geolocation parameters. Based on the nearly thirty five 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: radiometric FOV2FOV relative consistency is within ±0.1K for all three bands.
3. Spectral uncertainty: absolute spectral offsets for all three bands are all within ±2ppm, and relative spectral offsets for all three bands are within ±1ppm.
4. Geolocation uncertainty: In-track geolocation accuracy significantly improved after updating mapping angles in v211 relative to VIIRS. The total geolocation uncertainty is 750 meters 3-sigma where the specification is 5 km. Current uncertainty is comparable to S-NPP and NOAA-20 CrIS.

1. NOAA-21 CrIS SDR products have been reliably produced by IDPS since the first light data was produced on February 10, 2023.
2. Intercomparisons of NOAA-21 CrIS with clear sky calculated spectra, NOAA-21 VIIRS, Metop-B IASI, Metop-C IASI, and Aqua AIRS all show very good agreement
3. Double differences via calculated spectra, IASI, and AIRS show similar results and show very good agreement between NOAA-20 CrIS and NOAA-21 CrIS
4. 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).
5. 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.

1. Assessed the effect of the permanent spacecraft pitch offset of -10 arc minutes, performed to optimize OMPS performance, and found that it will have minimal impact on the CrIS SDR Product.

Caveats

There are no caveats for the NOAA-21 CrIS SDR Calibration Algorithm.

Path Forward

The CrIS Team will work diligently to continue with the following planned Cal/Val tasks to promote the CrIS SDR data product to validated maturity by September 28, 2023 (L+322 days). The JPSS-2 Cal/Val plan provides details on all of the various planned efforts. Some highlights include:

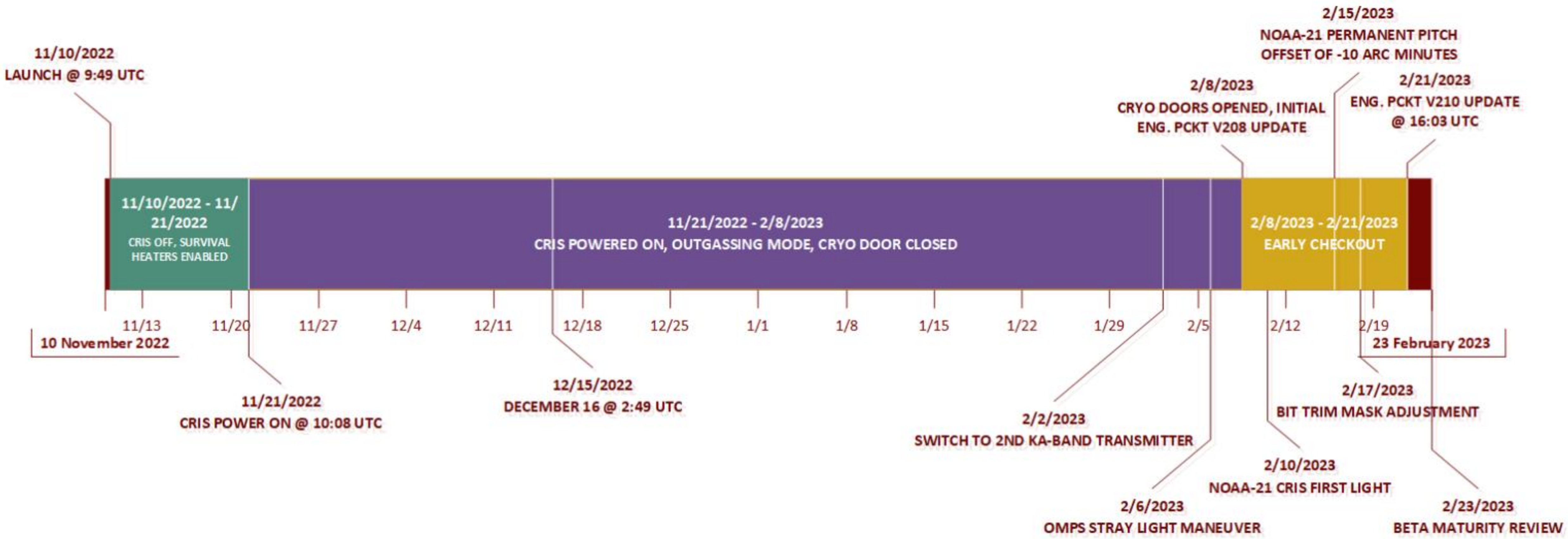
1. Perform long-term monitoring of the NOAA-21 CrIS SDR products and the NOAA-21 CrIS sensor.
2. Perform on-orbit radiometric error budget and provide the radiometric uncertainty
3. Perform long-term inter-comparison with other sensors, including METOP IASI and RO products.
4. Update the nonlinearity coefficients in the next Engineering Packet if needed.
5. Update the Instrument Line Shape (ILS) parameters in the next Engineering Packet if needed.
6. Update geolocation mapping angles in the next Engineering Packet if VIIRS geolocation is further updated, or if changes occur due to seasonal variation.
7. Continue to monitor CrIS instrument stability and performance, as well as SDR data quality
8. Analyze the pitch maneuver data to derive instrument polarization coefficients.
9. Continue to monitor and investigate the 40S-65S latitude imaginary radiance behavior.
10. Provide support to CrIS SDR data users to facilitate the assimilation of NOAA-21 CrIS calibrated radiances for weather forecasting and environmental monitoring. User's feedback on the quality of NOAA-21 CrIS SDR data is essential for the transition to the validate maturity level.

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 (Pre-Launch Testing)**

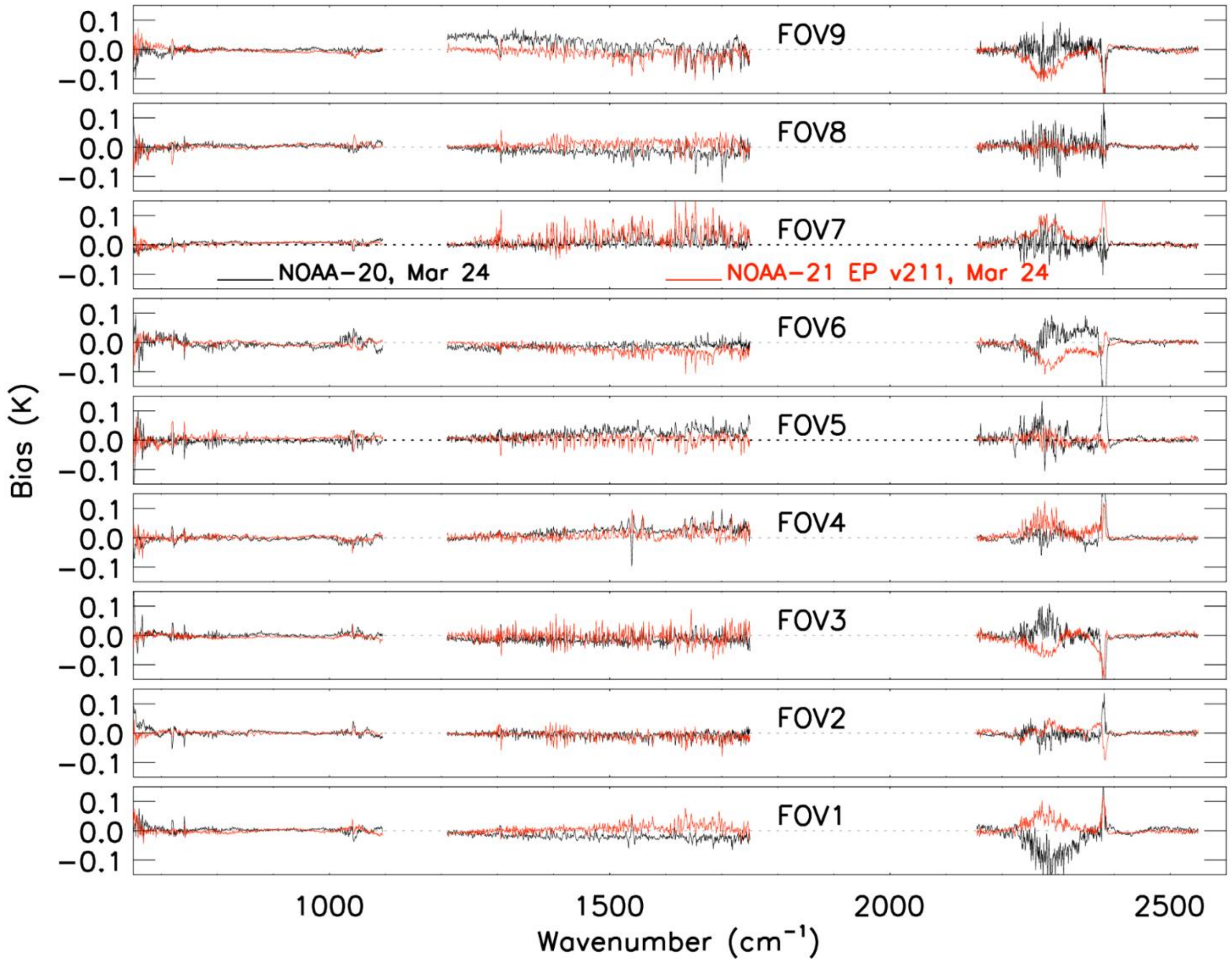
Backup Slides

NOAA-21 CrIS Post-Launch Timeline



NOAA-21 CrIS FOV-2-FOV Radiometric Consistency

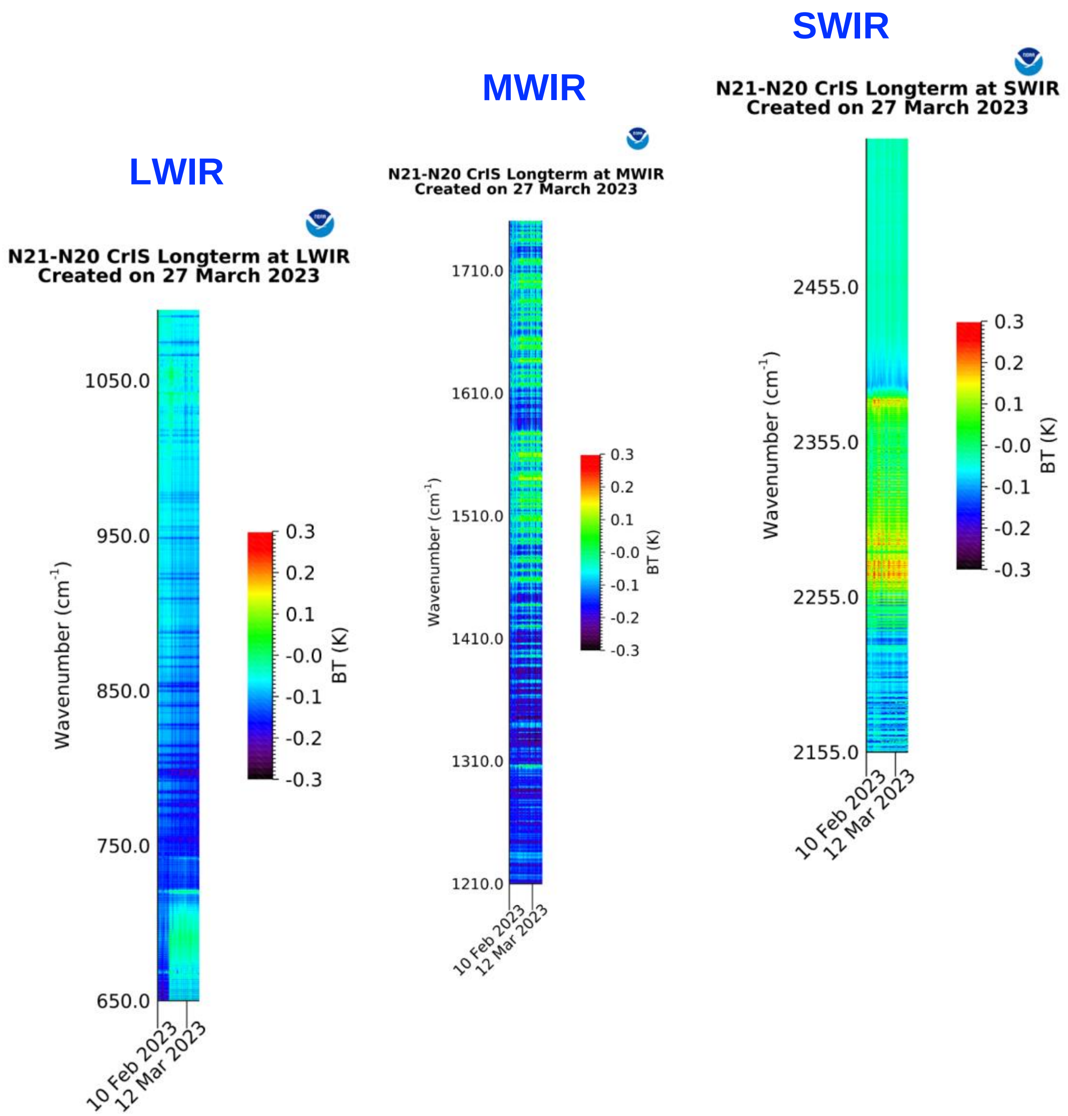
NOAA-21 vs NOAA-20 CrIS FOV-2-FOV Consistency



- **The NOAA-21 CrIS FOV-2-FOV relative radiometric variability is within +/- 0.1 K for all three bands after the Engineering Packet v211 update.**
- The FOV-2-FOV relative radiometric variability was assessed by mean difference of observed and simulated apodized spectra for each FOV relative to the overall mean bias.
- This result was derived using the NOAA-21 CrIS observations and collocated CRTM simulations over clear-sky and ocean surface for March 24, 2023.

Provided by Kun Zhang

Time Series of Radiometric Comparisons Between NOAA-21 and NOAA-20 CrIS

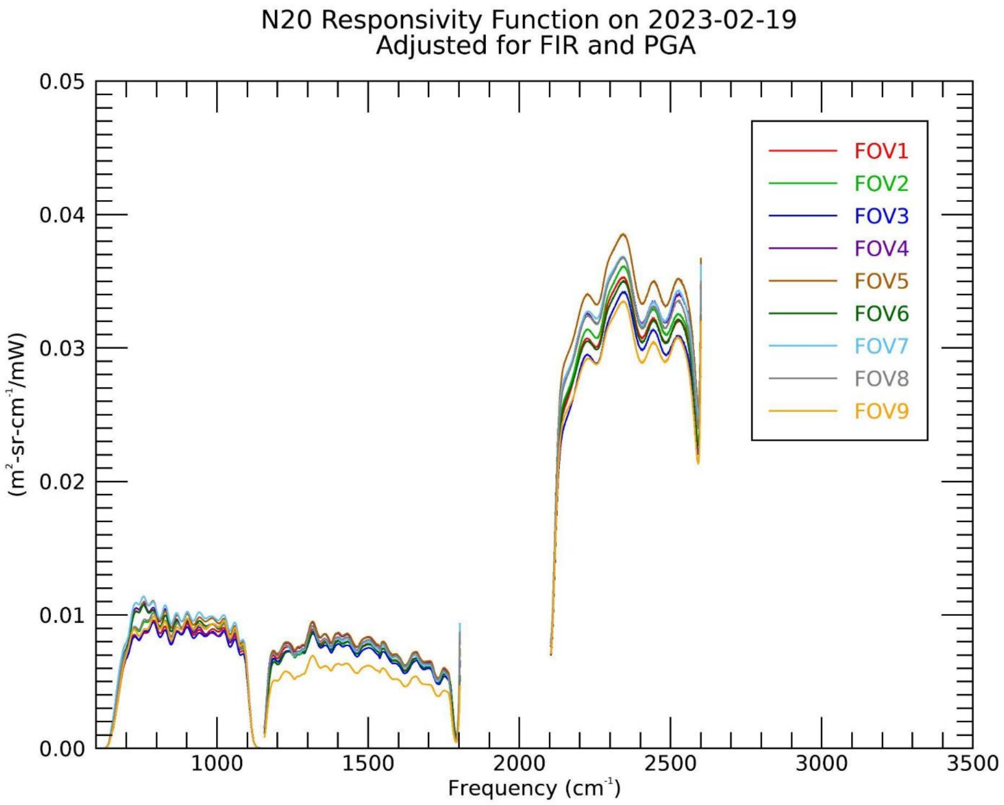


- NOAA-21 CrIS started to collect science data since February 10, 2023.
- A short time series of NOAA-21 CrIS radiometric comparisons with NOAA-20 CrIS show radiance differences are within 0.3 K for majority of channels since the first light observation.
- NOAA-21 CrIS Calibration Table v211 was uploaded in March 23, 2023.

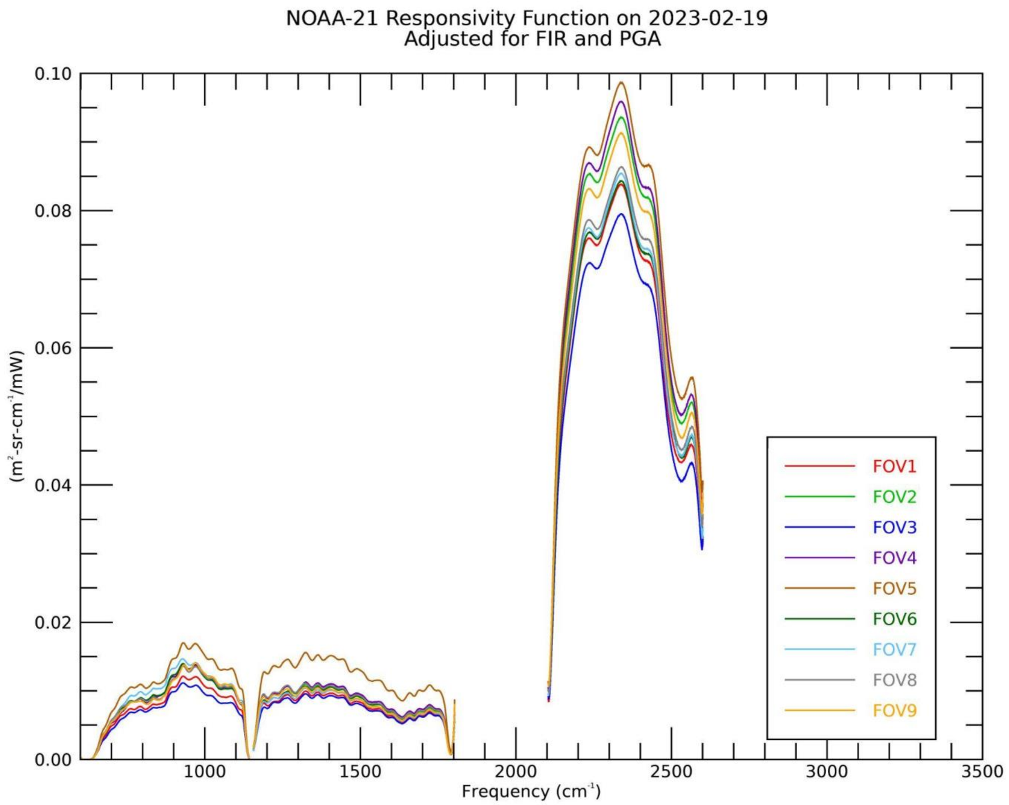
Provided by Kun Zhang

CrIS Responsivity: NOAA-21 relative to NOAA-20

NOAA-20



NOAA-21



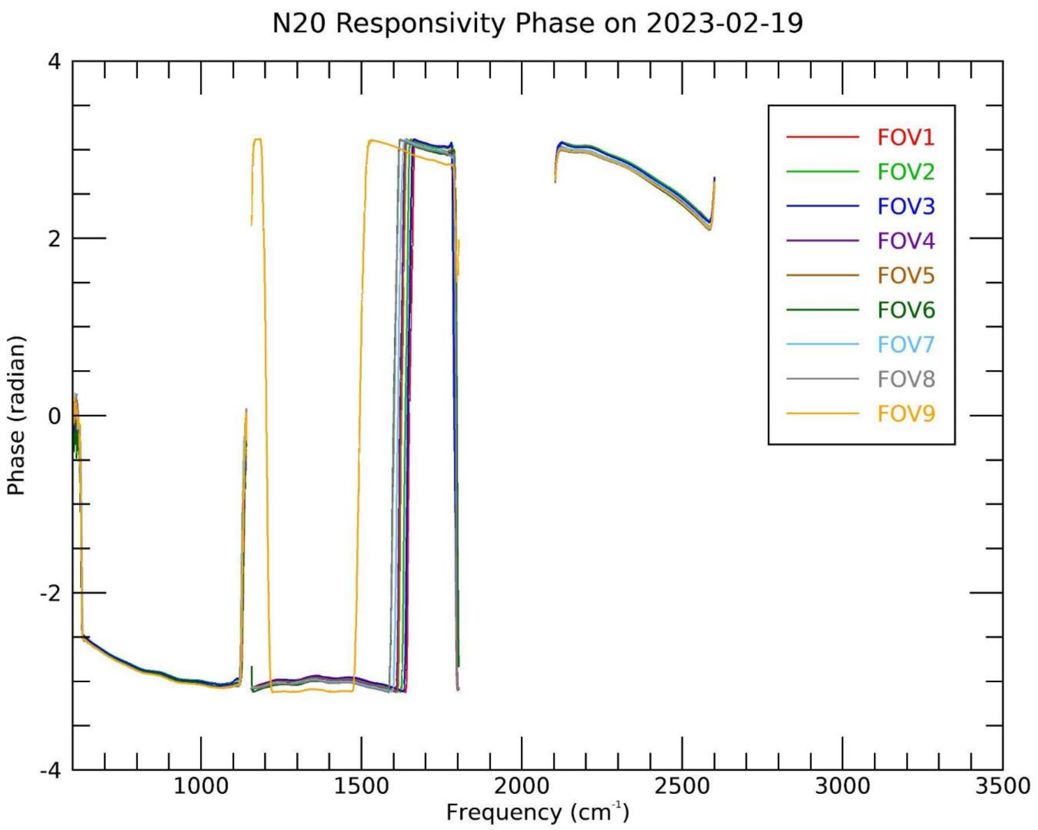
Main point: Responsivity is as high or higher for NOAA-21 than it was for NOAA-20 for all three bands (SWIR, LWIR, MWIR)

- These changes are calibrated out.
- Monitoring tool is developed to track possible degradation due to ice and/or chemical contamination.
- Possible responsivity degradation would increase the NEdN.

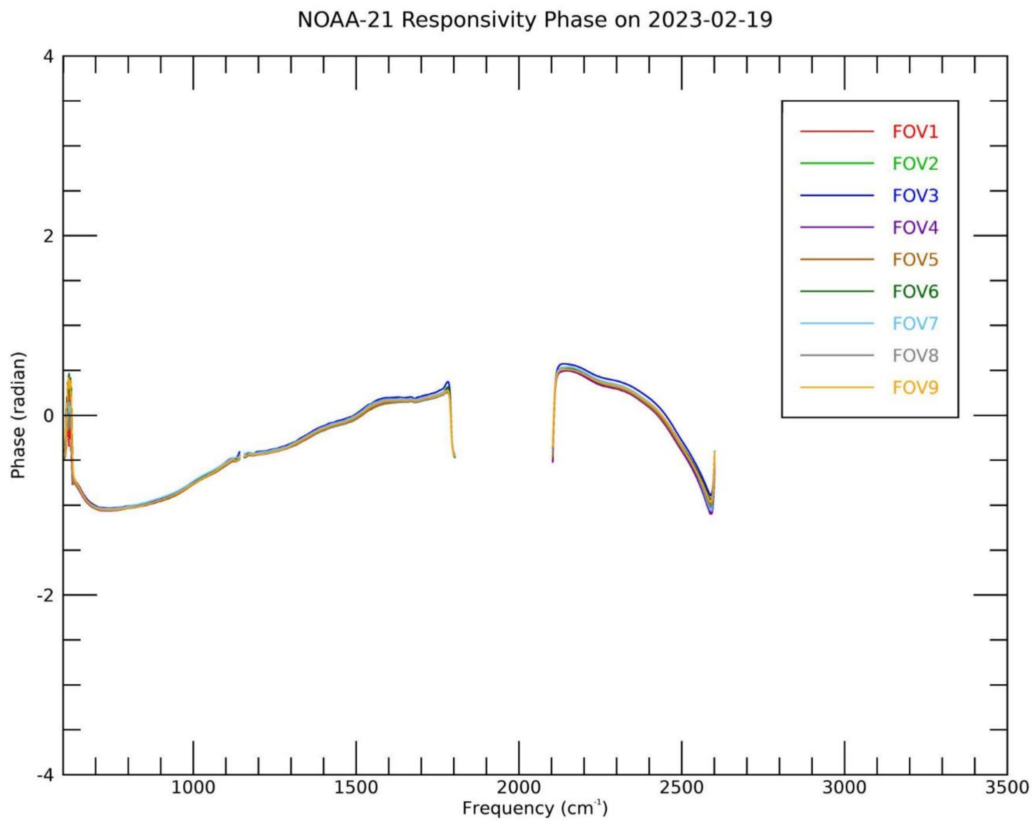
Provided by Denis Tremblay

CrIS Responsivity Phase: NOAA-21 relative to NOAA-20

NOAA-20



NOAA-21

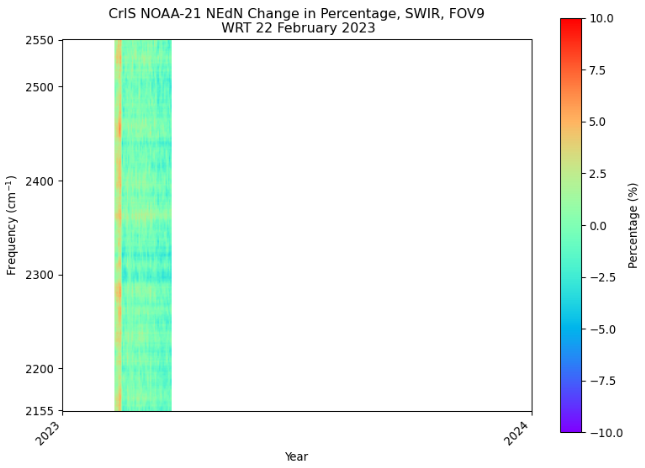


NOAA-21 responsivity phase has better FOV overlay than NOAA-20.

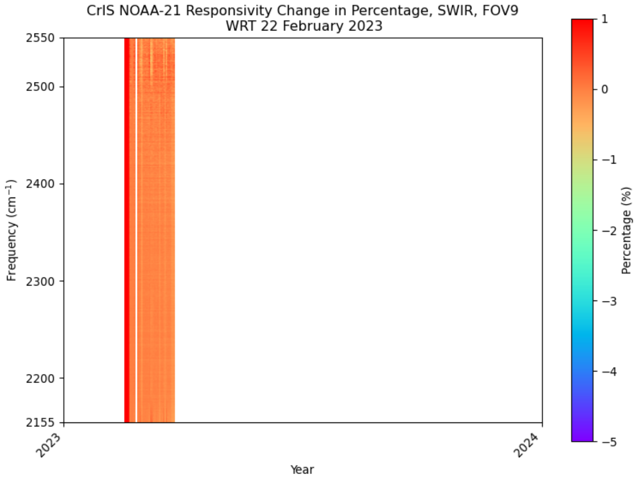
Provided by Denis Tremblay

Long Term Monitoring (Time Series)

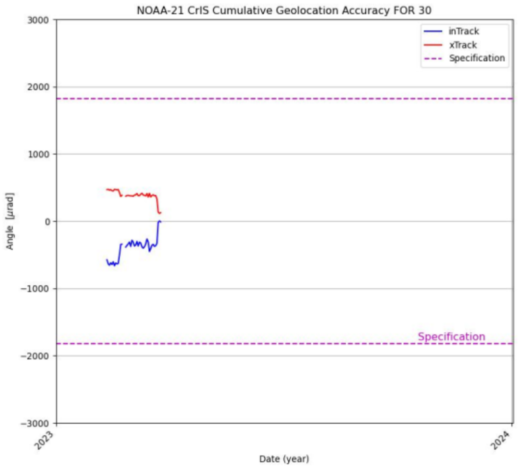
NEdN Change in %



Responsivity Change in %

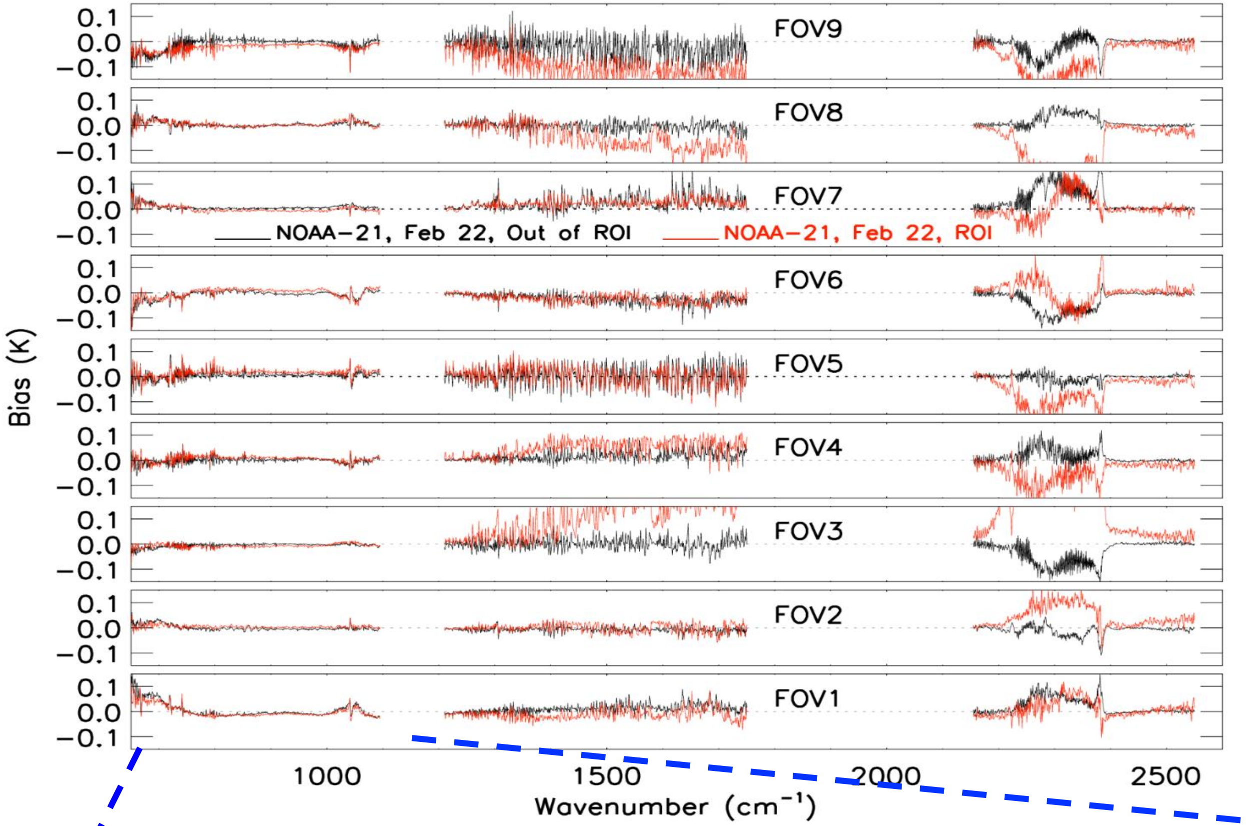


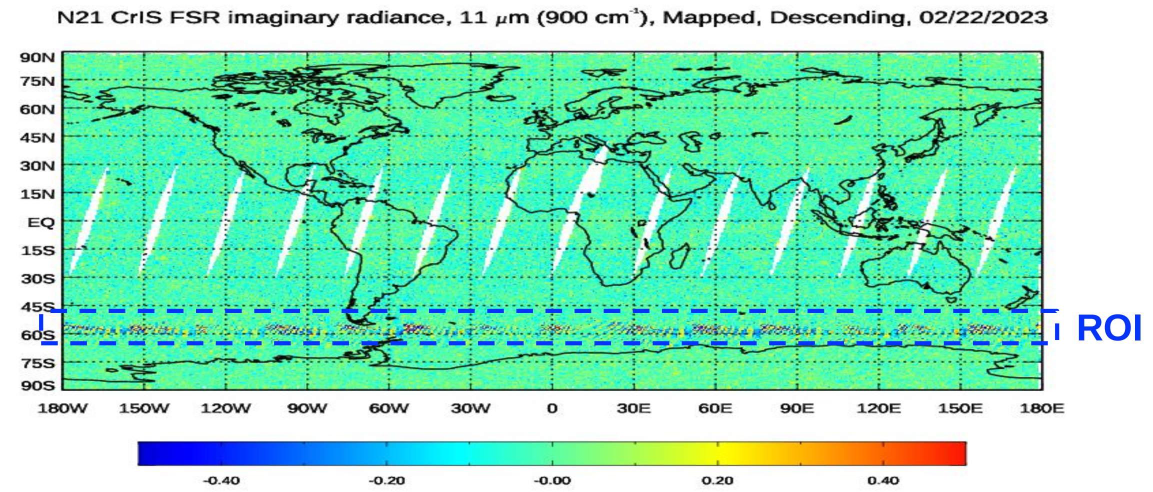
Geolocation accuracy



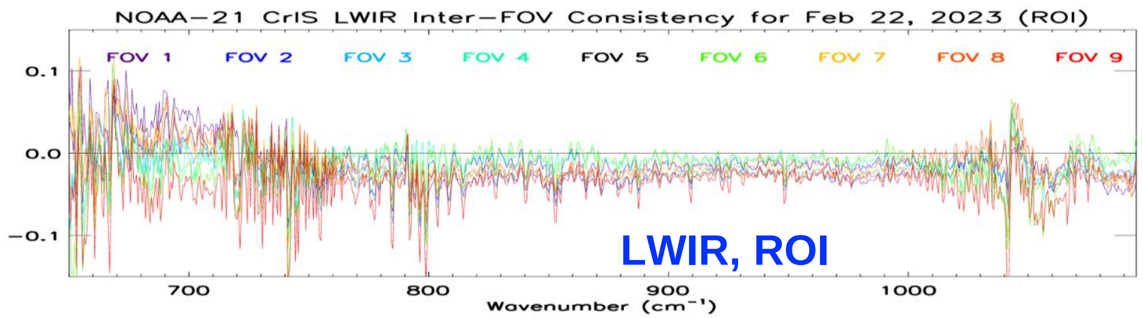
- Automated tools show the accumulated times series for NEdN, Responsivity, and Geolocation Accuracy.
- Too early in the mission to see any temporal trends at this time.

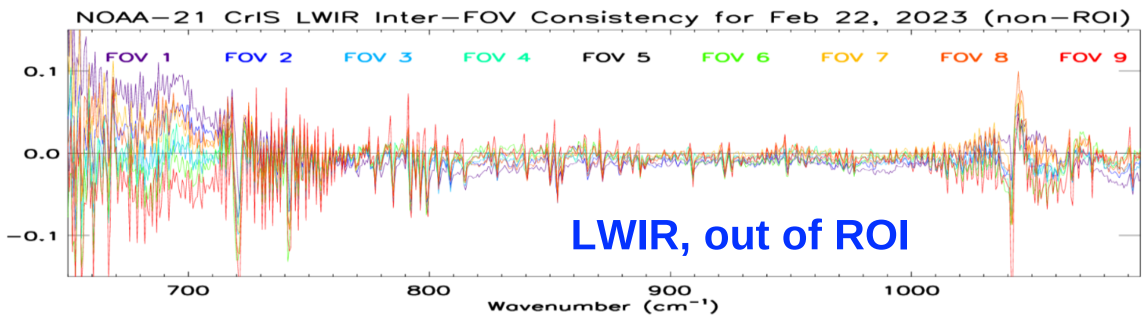
NOAA-21 CrIS FOV-2-FOV Analysis Over Different Regions





- FOV-2-FOV analysis shows **small differences resulted from ROI vs non-ROI area**. (large difference in the number of points for averaging may introduce bias in some FOVs in MWIR and SWIR band).
- Region of Interest (ROI): [-50, -60] latitude with slightly elevated imaginary radiance levels





Provided by Kun Zhang