Validated Maturity Science Review
For Suomi-NPP CrIS SDR Side-2 Data

POC: Flavio Iturbide-Sanchez
Date: 2020/02/06

JPSS

Long-term Performance of the SNPP/CrIS SDR Product After the Switch to Side-2 Electronics

Flavio Iturbide-Sanchez
On behalf of the **CrIS SDR Science Team**

Outline

- CrIS SDR Algorithm Cal/Val Team Members
- CrIS SDR Specifications
- Evaluation of the SNPP CrIS SDR Performance
  - Noise (NEdN)
  - Radiometric Calibration Uncertainty
  - Spectral Calibration Uncertainty
  - Geolocation Uncertainty
- User Feedback
- Error Budget
- Risks, Actions, and Mitigations
- Documentation
- Conclusion
- Path Forward

Summary from Provisional Review

- The SNPP CrIS Side-2 SDR data product met the Provisional maturity requirements effective with EP v40 implementation (completed on Aug 1st 2019, at 16:49:40 UTC/12:49:40EST)

JPSS Data Products Maturity Definition

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.

CrIS Cal/Val Science Team Members

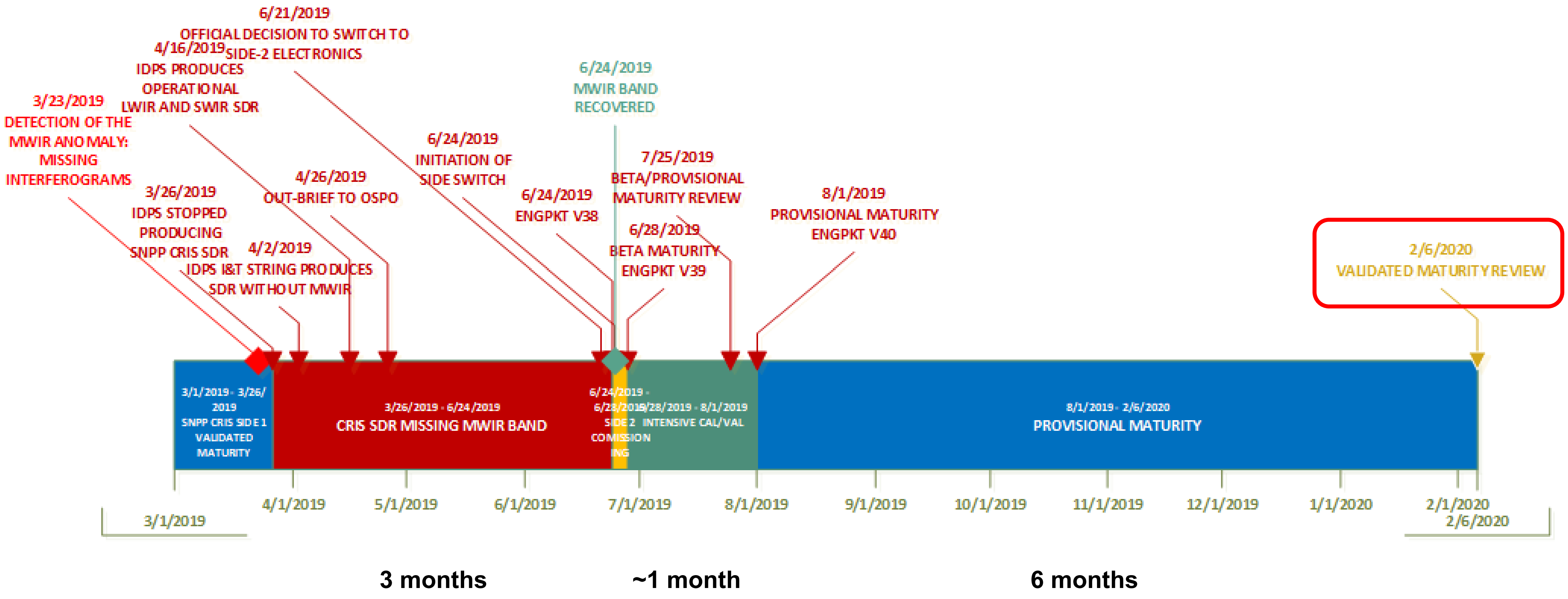
Name	Organization	Team	Major Task
Flavio Iturbide-Sanchez	NOAA/STAR	Yong Chen, Denis Tremblay, Erin Lynch, Peter Beierle, Kun Zhang	Project management, SDR team coordination and algorithm test in IDPS, calibration and geolocation science support, inter-comparison, CrIS SDR data quality and monitoring
Dave Tobin	U. of Wisconsin (UW)	Hank Revercomb, Joe Taylor, Bob Knuteson, Lori Borg, Michelle Feltz, Dan Desolver	Radiometric calibration, non-linearity coefficients, polarization, inter-comparison, simulation
Larrabee Strow	U. of Maryland Baltimore County (UMBC)	Howard Motteler, Sergio de Souza-Machado, Chris Hepplewhite, Steven Buczkowski	Spectral calibration, ILS parameters, inter-comparison, simulation
Dan Mooney	MIT/LL	Mark Tolman	Correlated and uncorrelated noise characterization, residual analysis and ringing, simulation
Dave Johnson	NASA Langley	Yana Williams	NASA flight support, instrument science
Clayton Buttles	Harris	Lawrence Suwinski, Don Ripplinger, Sara Glass, Jeff Garr, and Rebecca Malloy.	PLT tests, on-orbit instrument performance
Joe Predina	Logistikos	Richard Hertel, James Isaacs, Shankar Atre	Optimal laser wavelength setting, noise, calibration algorithm
Deirdre Bolen	JPSS/JAM		DR support
Bruce Guenther	JPSS/AMP	Susan Venter	Coordination with JPSS Flight Project
Banghua Yan	NOAA/STAR	Xin Jin, Warren Porter, Ninghai Sun	CrIS SDR data quality and monitoring

The Loss of the Midwave-IR (MWIR) Band

- **Loss of the MWIR Band:**
  - On March 23, 2019, missing SNPP/CrIS MWIR Interferograms were detected. IDPS stopped producing SNPP/CrIS SDR data since 18:27 UTC on March 26.
- **Root Source:**
  - Mid-wave (MW) IR Signal Processor Field Programmable Gate Array (FPGA) and associated support circuitry.
- **Option to Rectify the Anomaly:**
  - Switch to Side-2 Electronics: Very High Probability of Success.
- **Impacted Users:**
  - Weather Forecast centers, Environmental data record developers and users, Participants of field campaign experiments.
- **Impacted Operational Products in IDPS:**
  - Thermodynamic profiles, Outgoing Longwave Radiation, Trace Gases, MWIR Radiances.

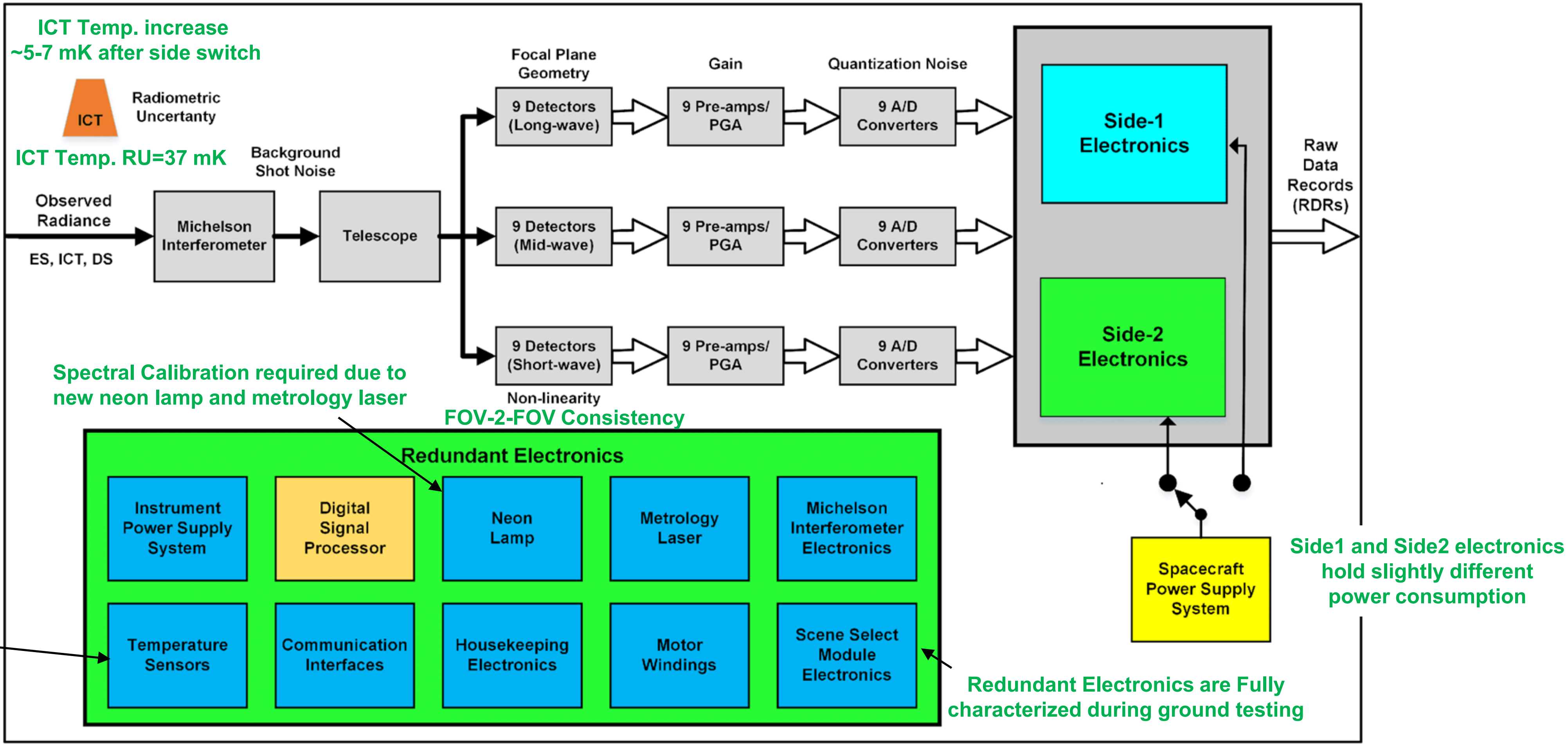
SNPP/CrIS Major Events and Milestones: Recovery Timeline

1 Day to Recover the MWIR Band
5 Days for Instrument Tuning
15 Days for Demonstrating Beta Level
15 Days for Demonstrating Provisional Level
6 months for Demonstrating Validated Level



- **Date of Side-2 Meetings:** 2019-03-29, 2019-04-12, 2019-05-01, 2019-05-15, 2019-05-29, 2019-06-26, 2019-07-03, 2019-07-17, 2019-07-25.
- **Delivered daily reports to the JPSS Managers after side switch.**

SNPP/CrIS Operating Under the Side-2 Electronics Configuration



Switching to Side-2 electronics:

- Spectral calibration was required due to new Side-2 metrology laser, Neon lamp and changes in the instrument temperature. Optimization of the focal plane characterization was needed to account for shifts occurring over the lifetime of the mission.
- No major impact on the Instrument Noise and Gain (Bit Trim Mask definition) was observed.
- Low impact on the Radiometric Uncertainty was observed due to minor changes in the ICT temperature, no changes in the detector's nonlinearity, and the use of well-characterized Side-2 temperature sensors.

SNPP/CrIS Side-2 Calibration Table Timeline

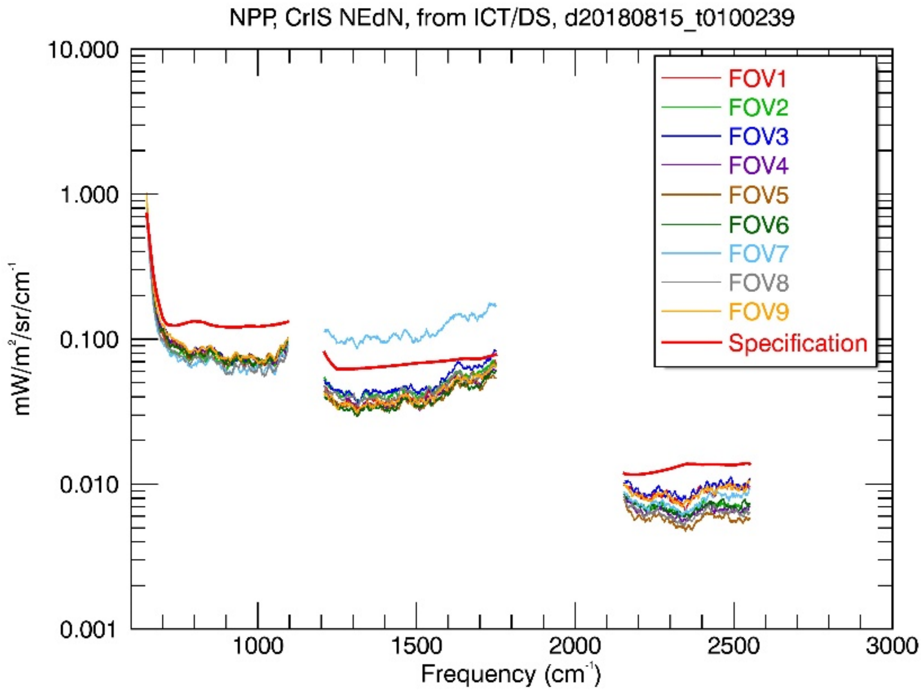
- **Engineering Packet v38**. **Initial calibration table after Side Switch.**
  - Based on Engineering Packet v37 (from Validated Side-1) and uploaded on June, 24 2019.
- **Engineering Packet v39**.
  - Upload completed on June 28, 2019 at about uploaded around 19:00UTC. Included mapping angles (in-track torque null position) and Vinst values (needed for non-linearity correction), for the all detectors and over the three spectral bands (9 FOVs x 3 bands). The SDR product demonstrated **Beta Maturity Level**.
- **Engineering Packet 40**. Three major calibration changes were proposed:
  1) Update the effective Neon wavelength, by adjusting it 0.4 ppm.
  2) Use new optimized focal plane parameters (Instrument Line Shape fit parameters).
  3) Use improved mapping in-track and cross-track angle parameters.

  Expected to be delivered on the week of July 22, 2019, and uploaded during the week of July 29. This calibration coefficients are proposed to reach the **Provisional Maturity Level**.

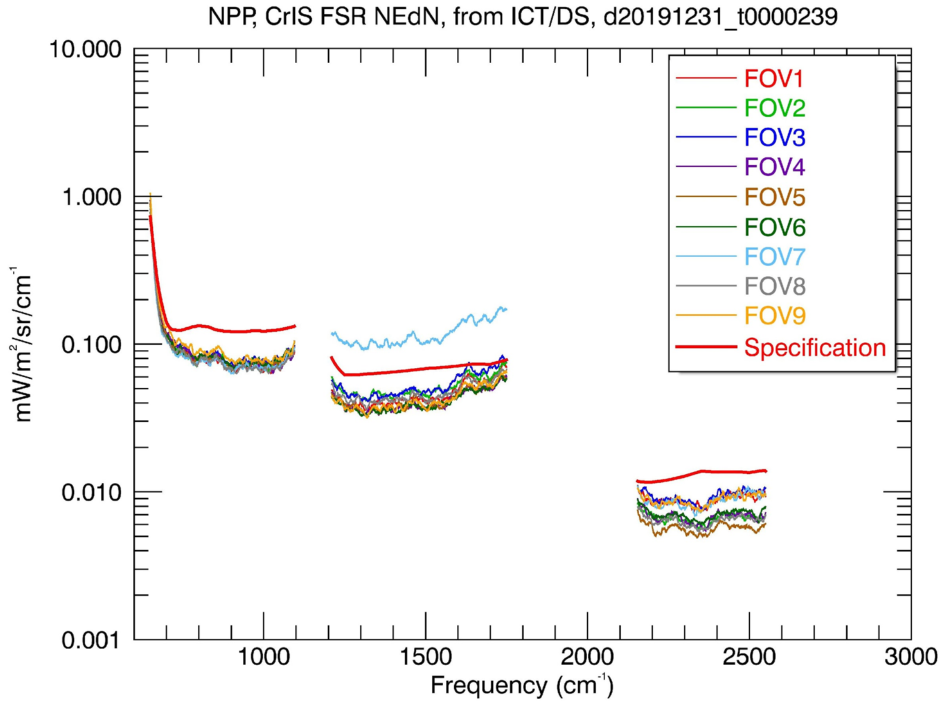
"*Calibration parameters were adjusted to maintain SDR data continuity between Side-1 and Side-2 rather than to minimize calibration errors*".

SNPP/CrIS NEdN: Comparison of Side-1 vs Side-2 (ICT/DS Method)

08/15/2018
(EPv37, Side-1)



12/31/2019
(EPv40, Side-2)

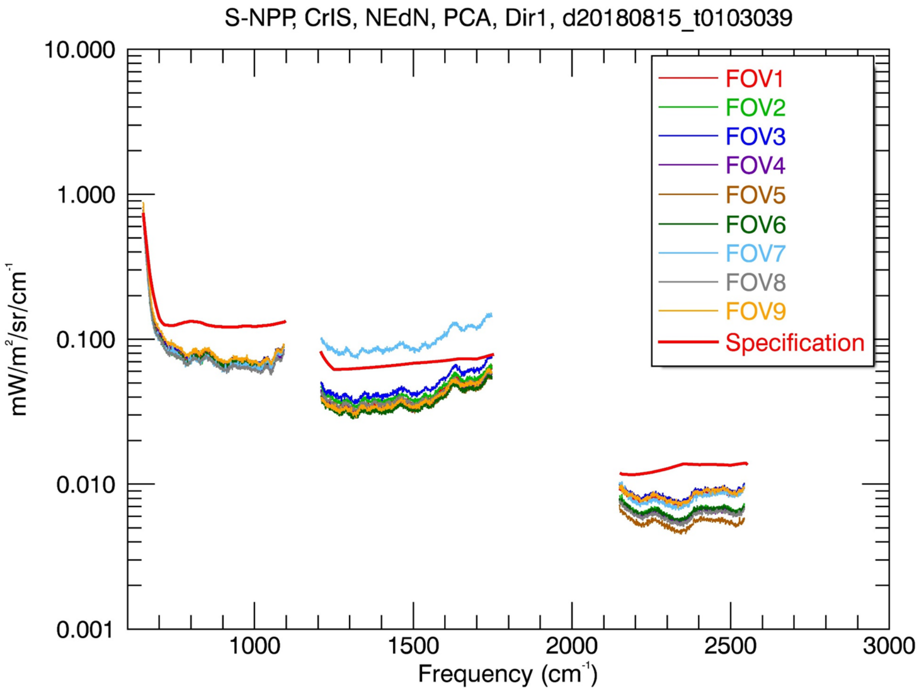


Side-1 and Side-2 NEdN are consistent

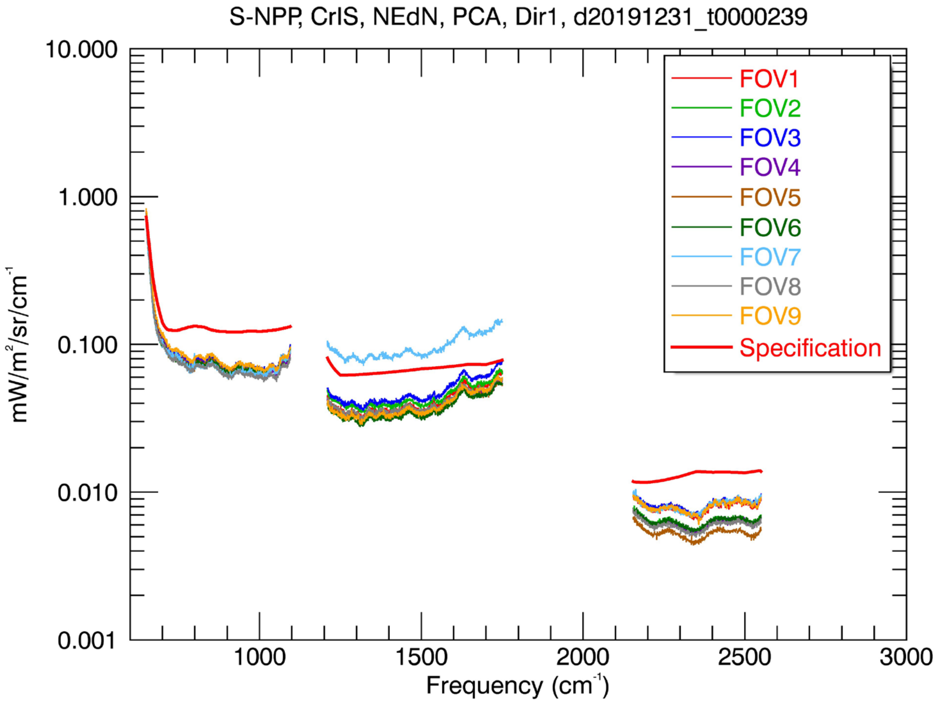
Provided by Denis Tremblay

SNPP/CrIS NEdN: Comparison of Side-1 vs Side-2 (PCA Method)

08/15/2018
(EPv37, Side-1)



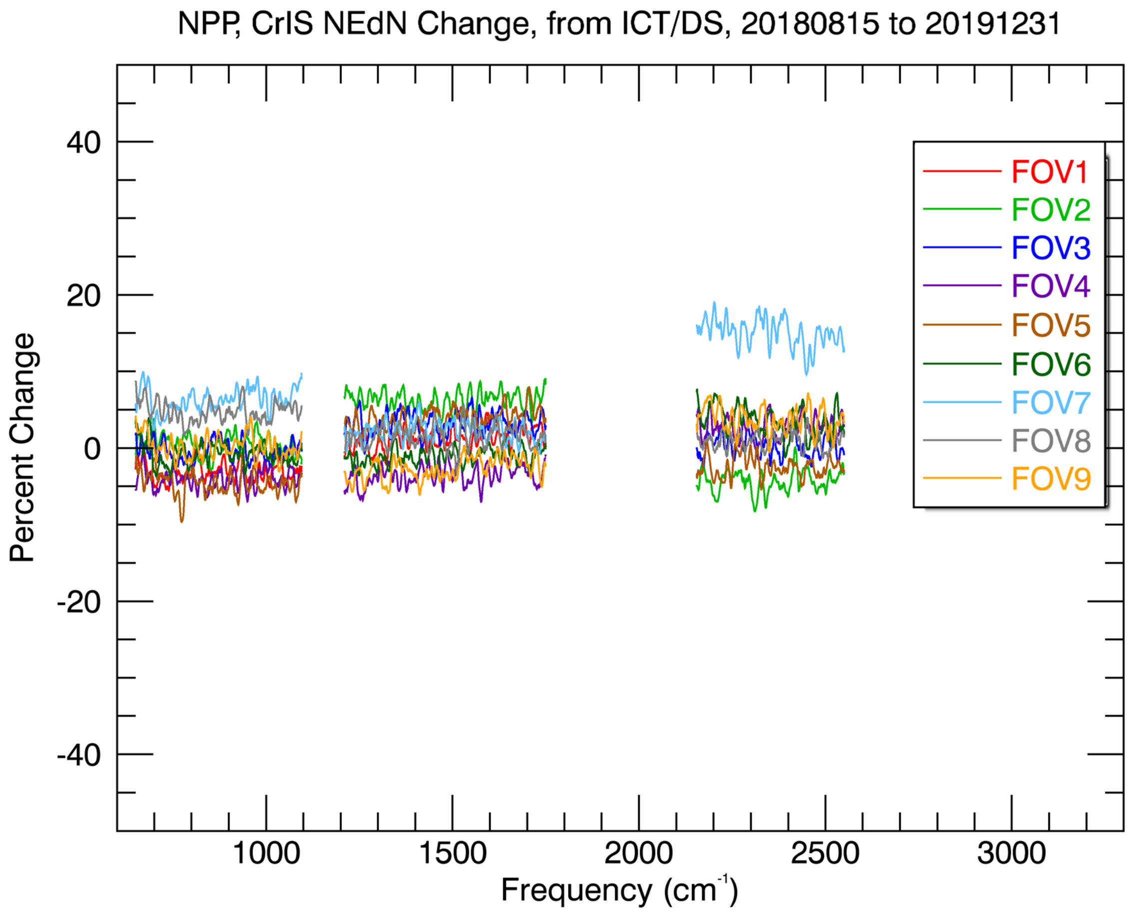
12/31/2019
(EPv40, Side-2)



Side-1 and Side-2 NEdN are consistent

Provided by Denis Tremblay

SNPP/CrIS NEdN: Comparison of Side-1 vs Side-2 (ICT/DS Method)



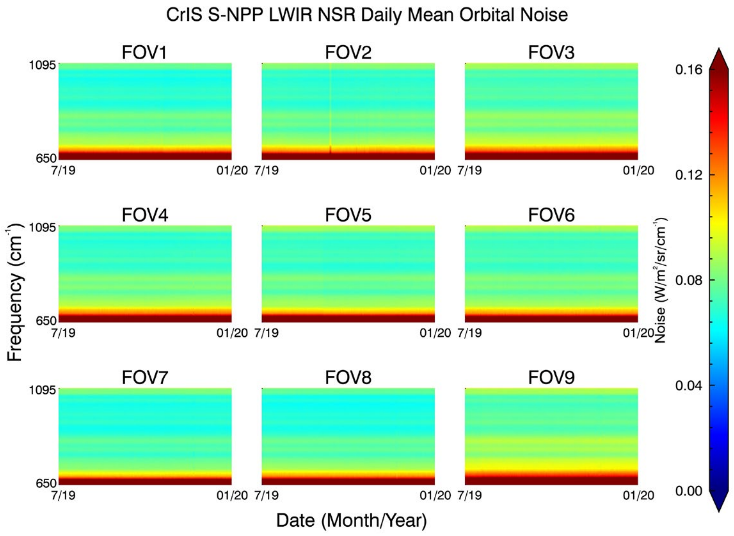
SWIR FOV7 Side 2
Is 15% higher than Side 1.

Side-1 and Side-2 NEdN Change in Percentage

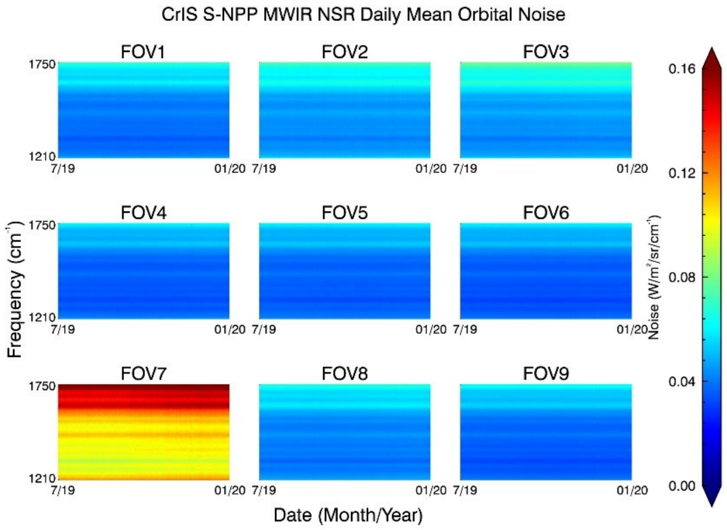
Provided by Denis Tremblay

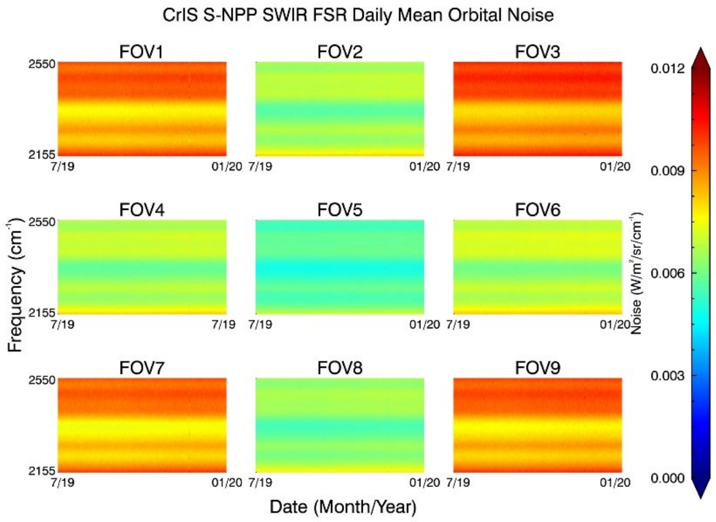
S-NPP Side 2 NEdN Time Series 7/1/209 to 12/31/2019

LWIR



MWIR

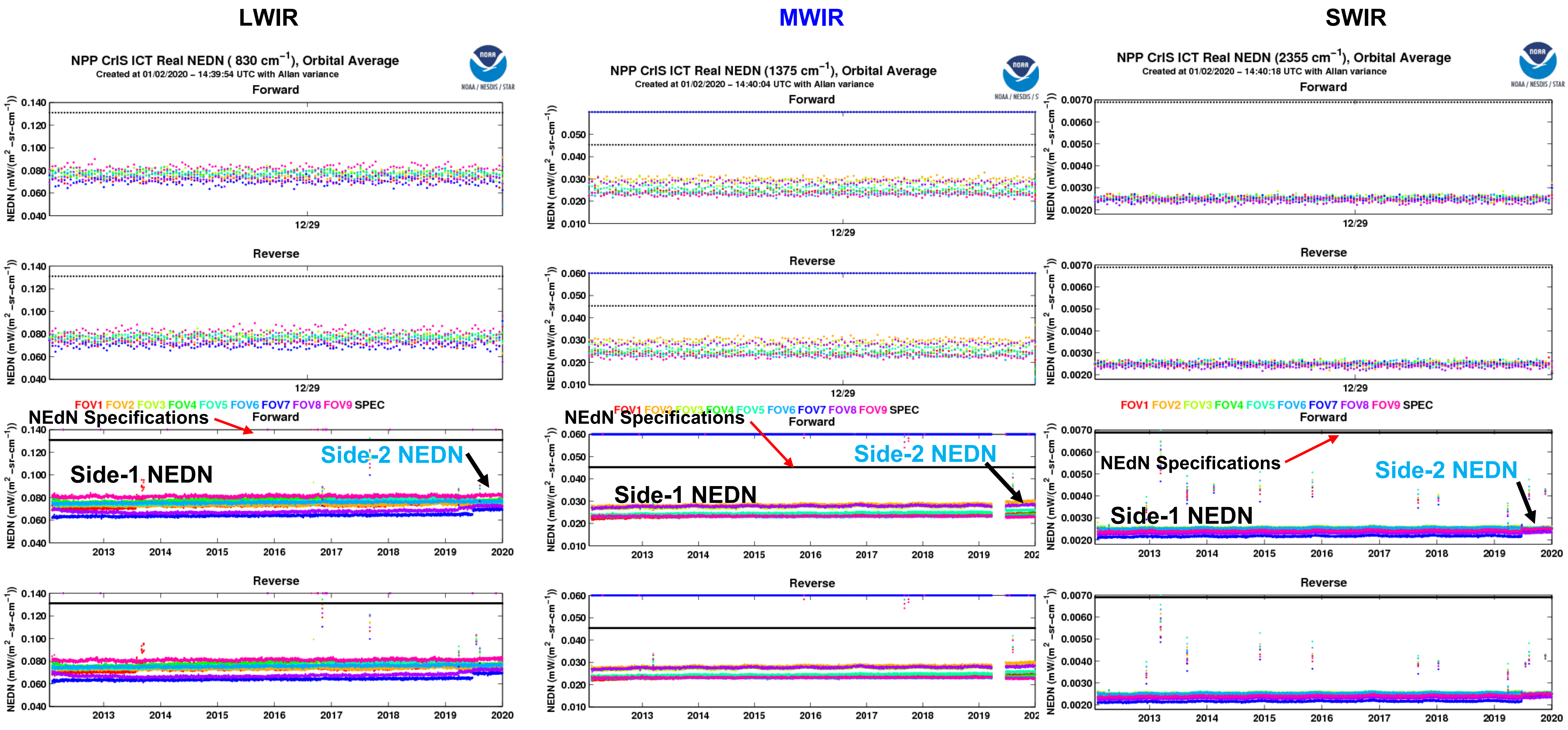




- FSR NEdN is very stable July to December 2019
- Noise burst seen on September 8th and 9th for LWIR FOV2 only (see next slide).

Provided by Denis Tremblay

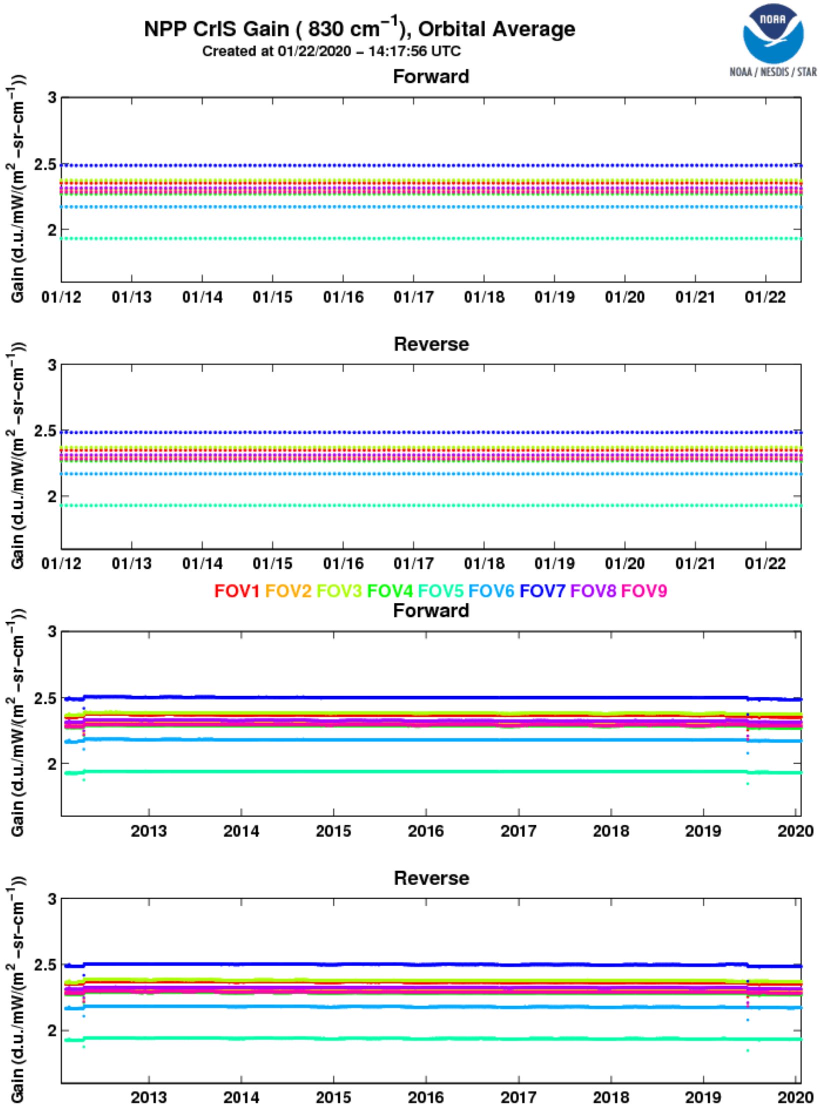
SNPP/CrIS NEdN Consistency Between Side-1 and Side-2



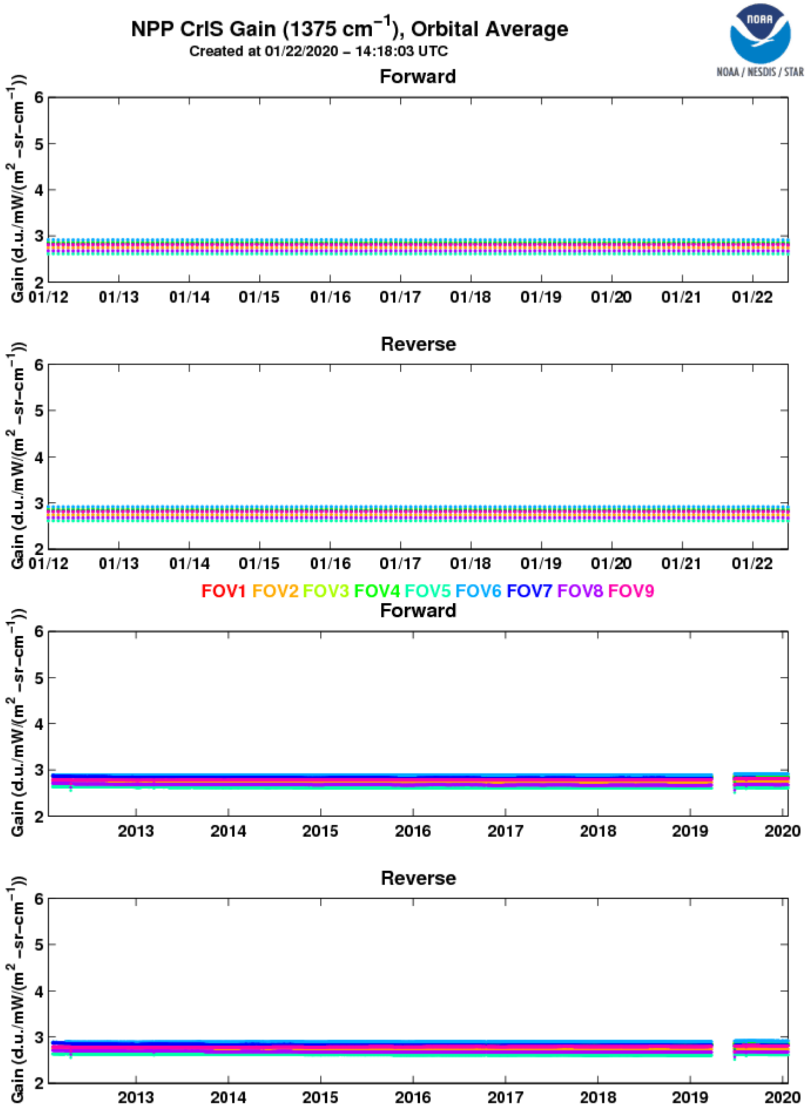
From the STAR ICVS website

SNPP CrIS Gain, Orbital Average

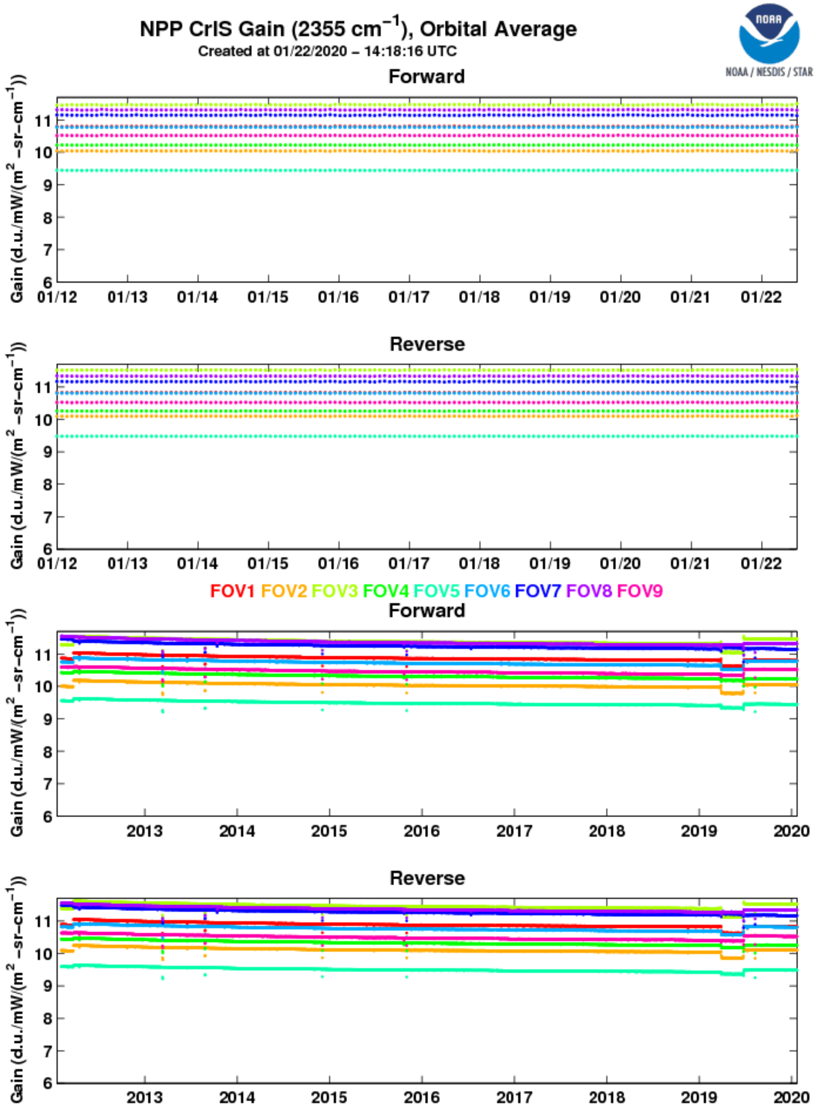
LWIR



MWIR



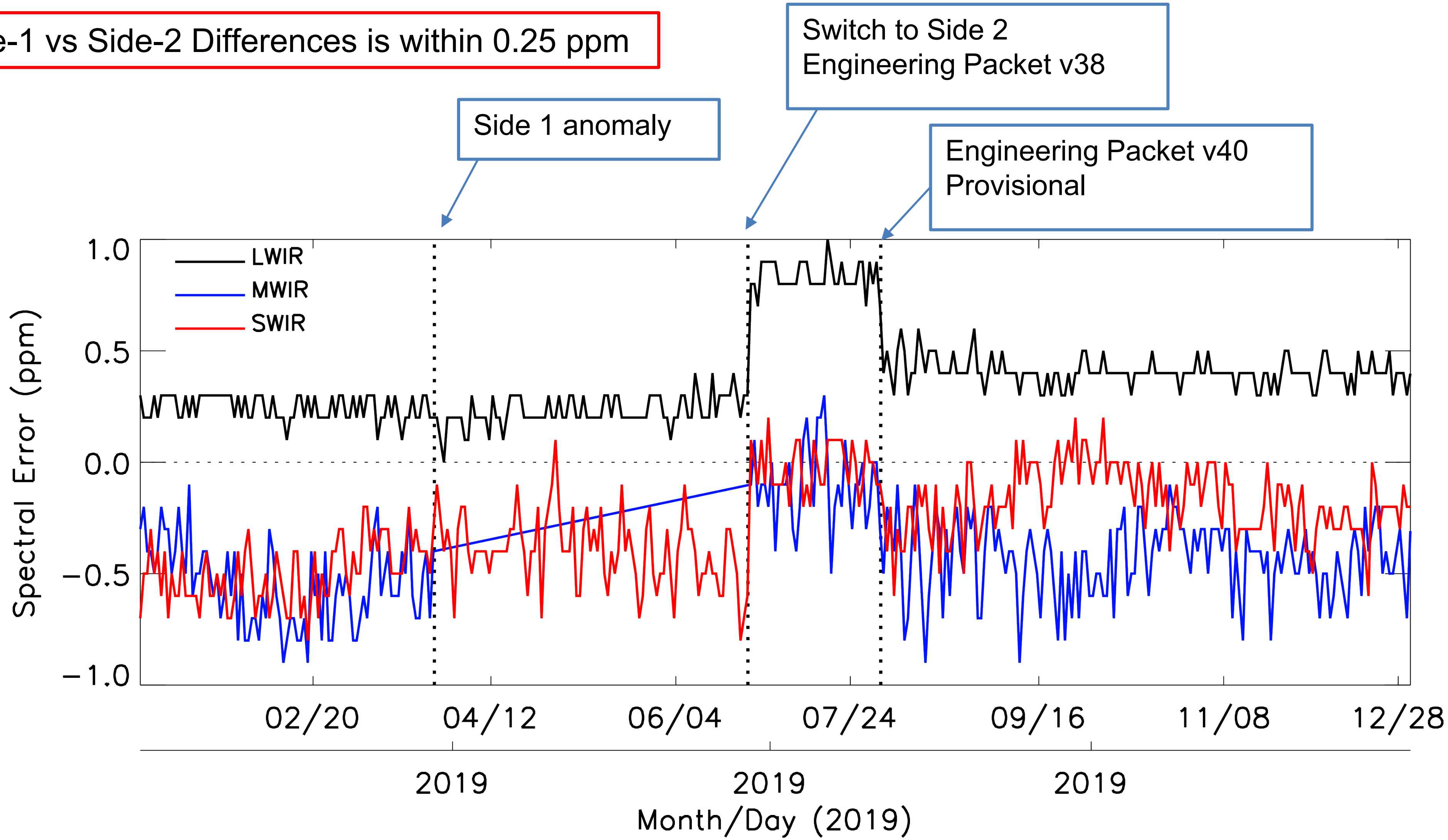
SWIR



From the STAR ICVS website

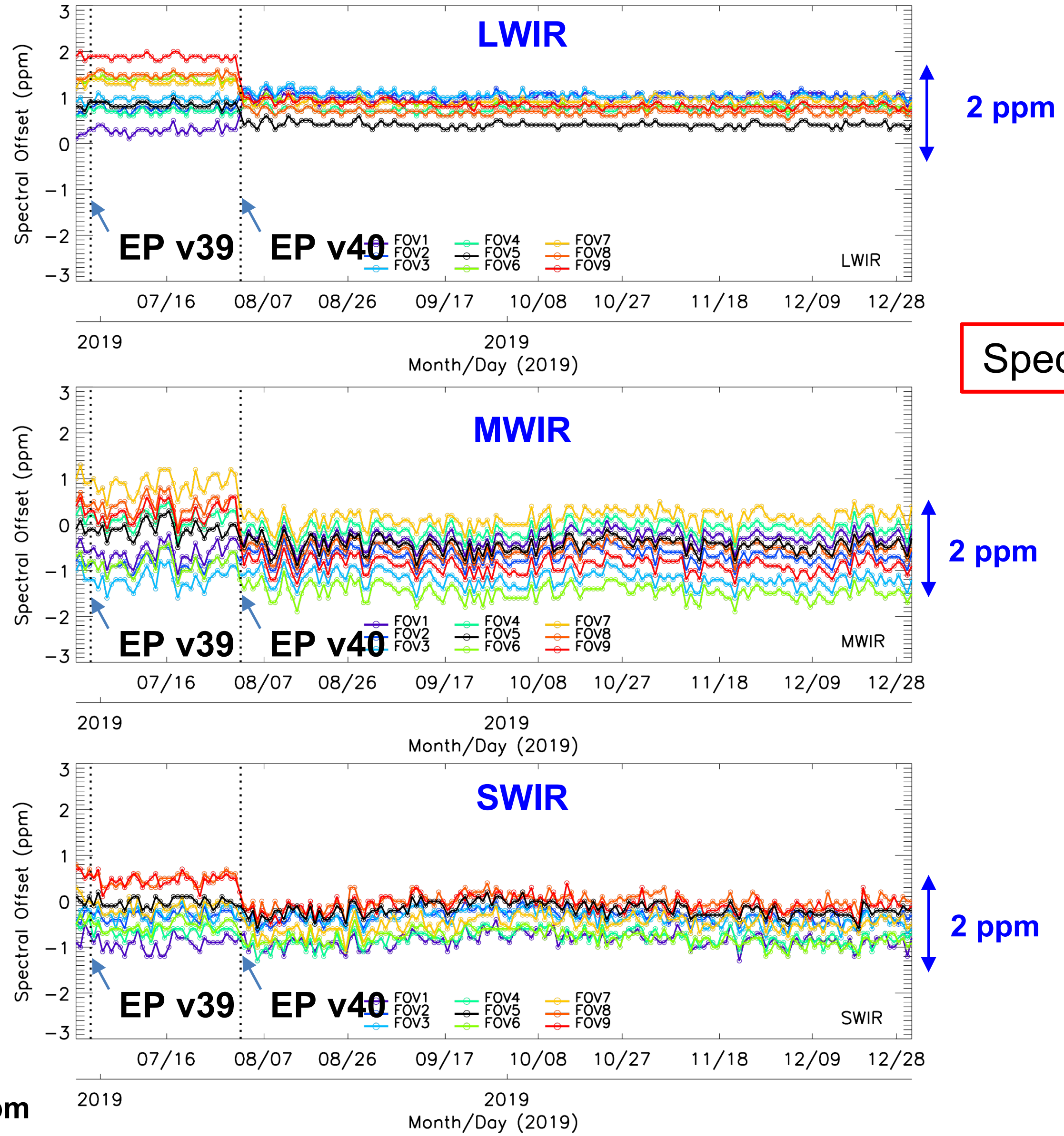
Center FOV5 Absolute Spectral Accuracy

Side-1 vs Side-2 Differences is within 0.25 ppm



Provided by Yong Chen

Long-term Absolute Spectral Uncertanty Trending After Side Switch



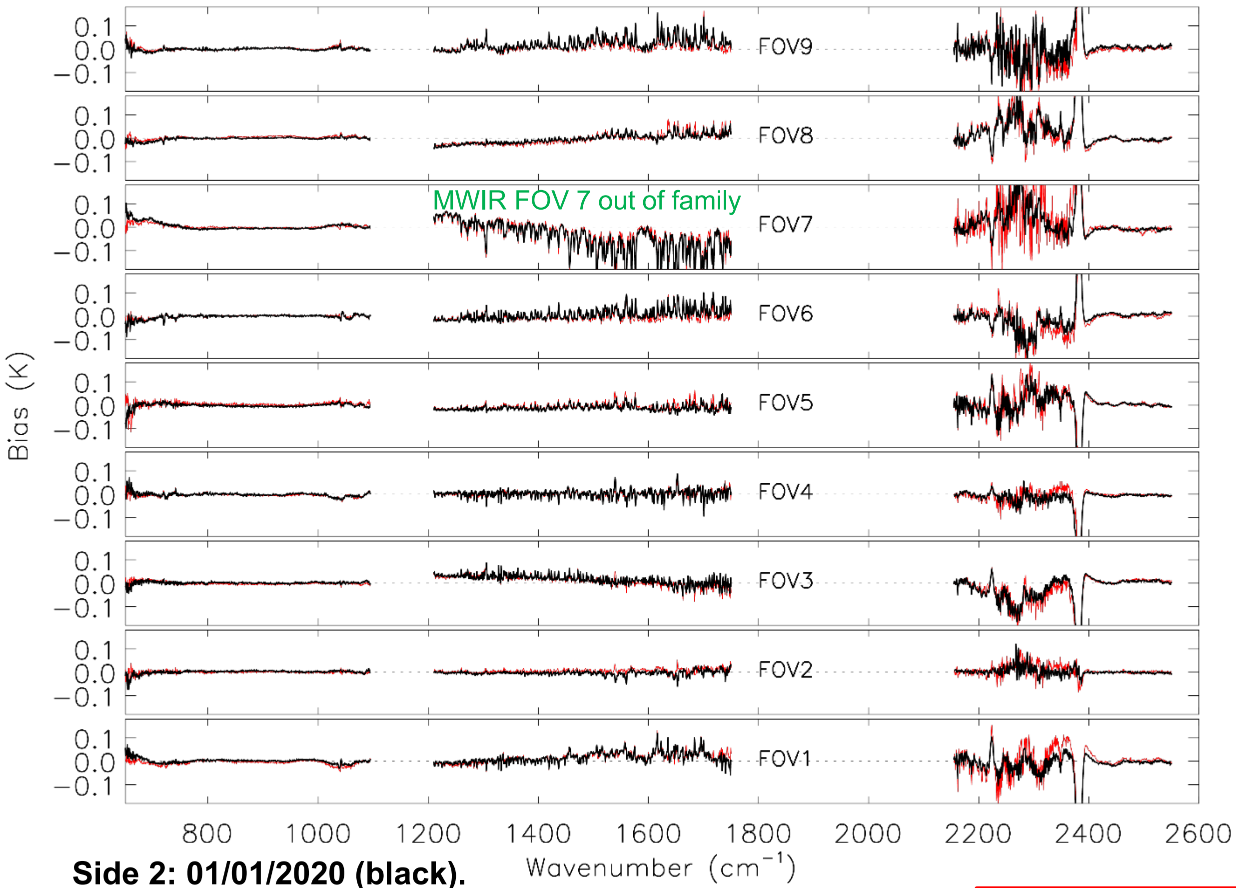
Spectral uncertainty is within 2 ppm

Spectral Accuracy requirement is 10 ppm

Provided by Yong Chen

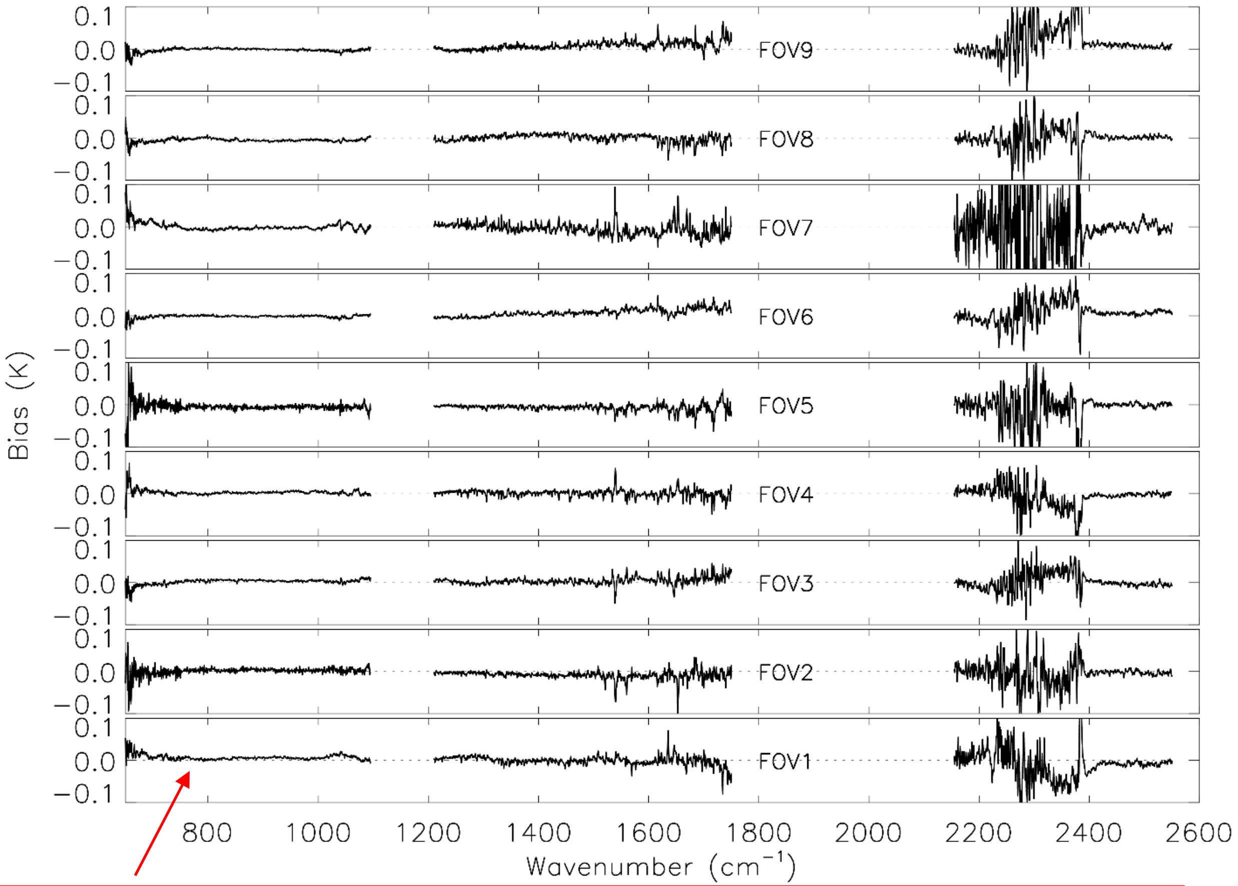
FOV-2-FOV Radiometric Consistency: SNPP Side-2 vs Side-1

S-NPP/CrIS Side-2 vs Side-1 FOV-2-FOV Consistency



Side 2: 01/01/2020 (black).
Side 1: 08/17/2018 (red).

Brightness Temperature Differences Between Side-2 and Side-1



- Differences are within 0.1 K. This demonstrates that the nonlinearity is consistent between Side 1 and Side 2.
- It is identified that Side 2 show slightly smaller variations at SWIR band.

Based on Observations and Simulated (CRTM) Radiances over Clear Sky and Ocean Surfaces.

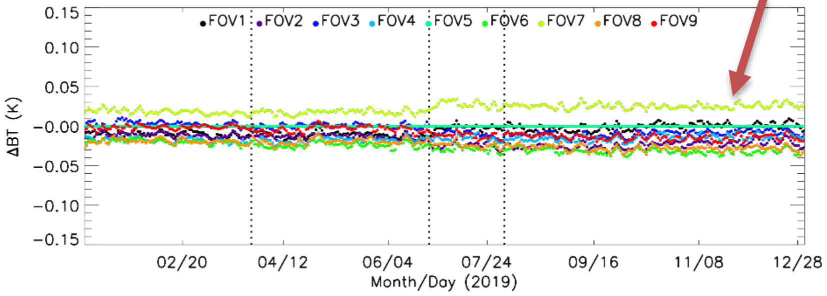
Provided by Yong Chen

S-NPP Long-term Trending of FOV-2-FOV Radiometric Consistency: Side-1 vs Side-2

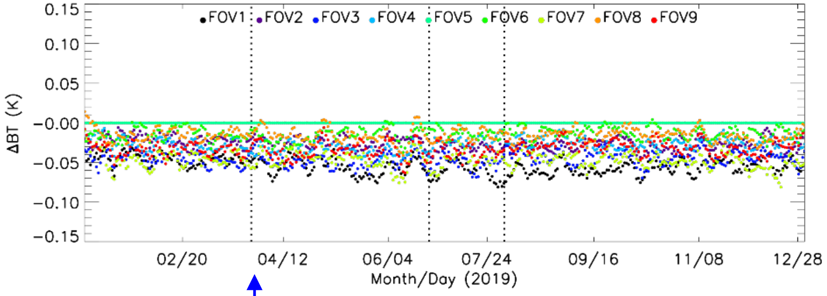
LWIR Band

Side1/Side 2 Difference ~0.02 K

672-682 cm^{-1}



830-840 cm^{-1}

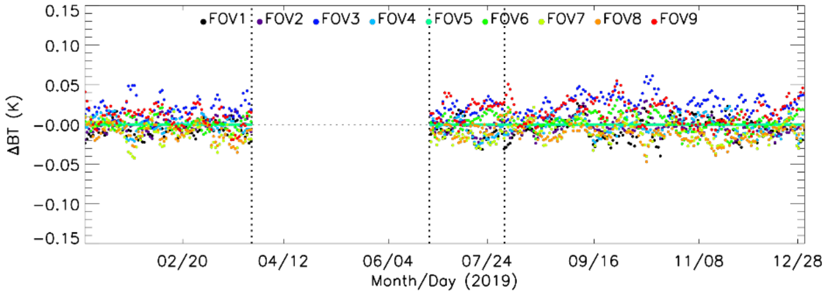


Anomaly

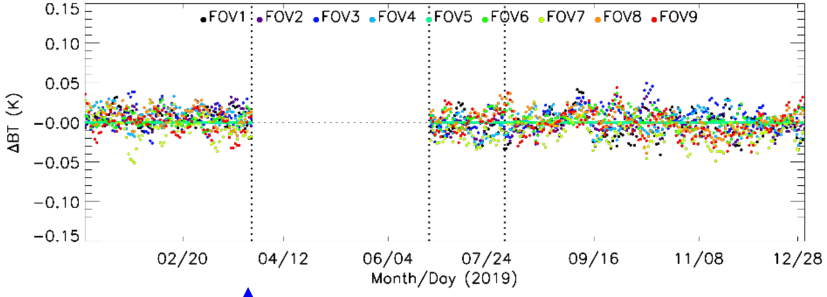
End of Side Switch

MWIR band

1382-1408 cm^{-1}



1585-1600 cm^{-1}

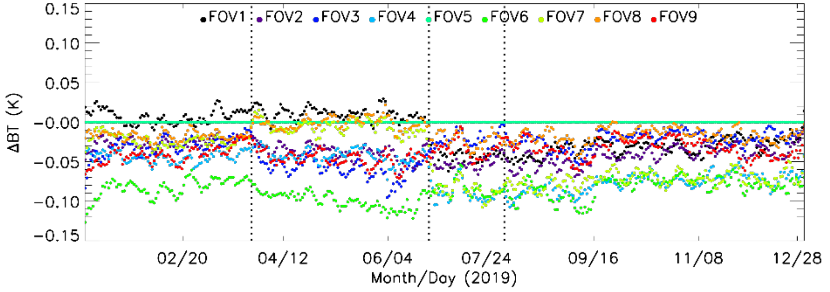


Anomaly

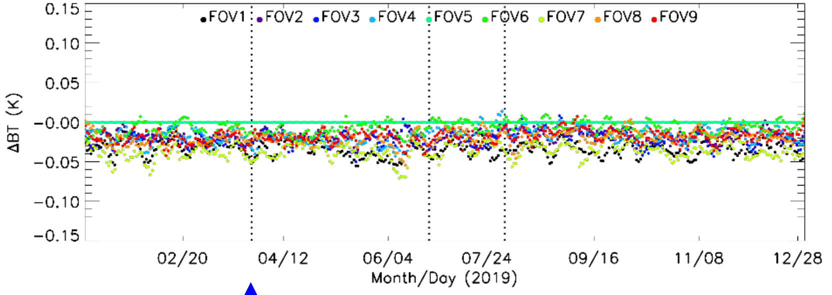
End of Side Switch

SWIR band

2350-2370 cm^{-1}



2500-2520 cm^{-1}



Anomaly

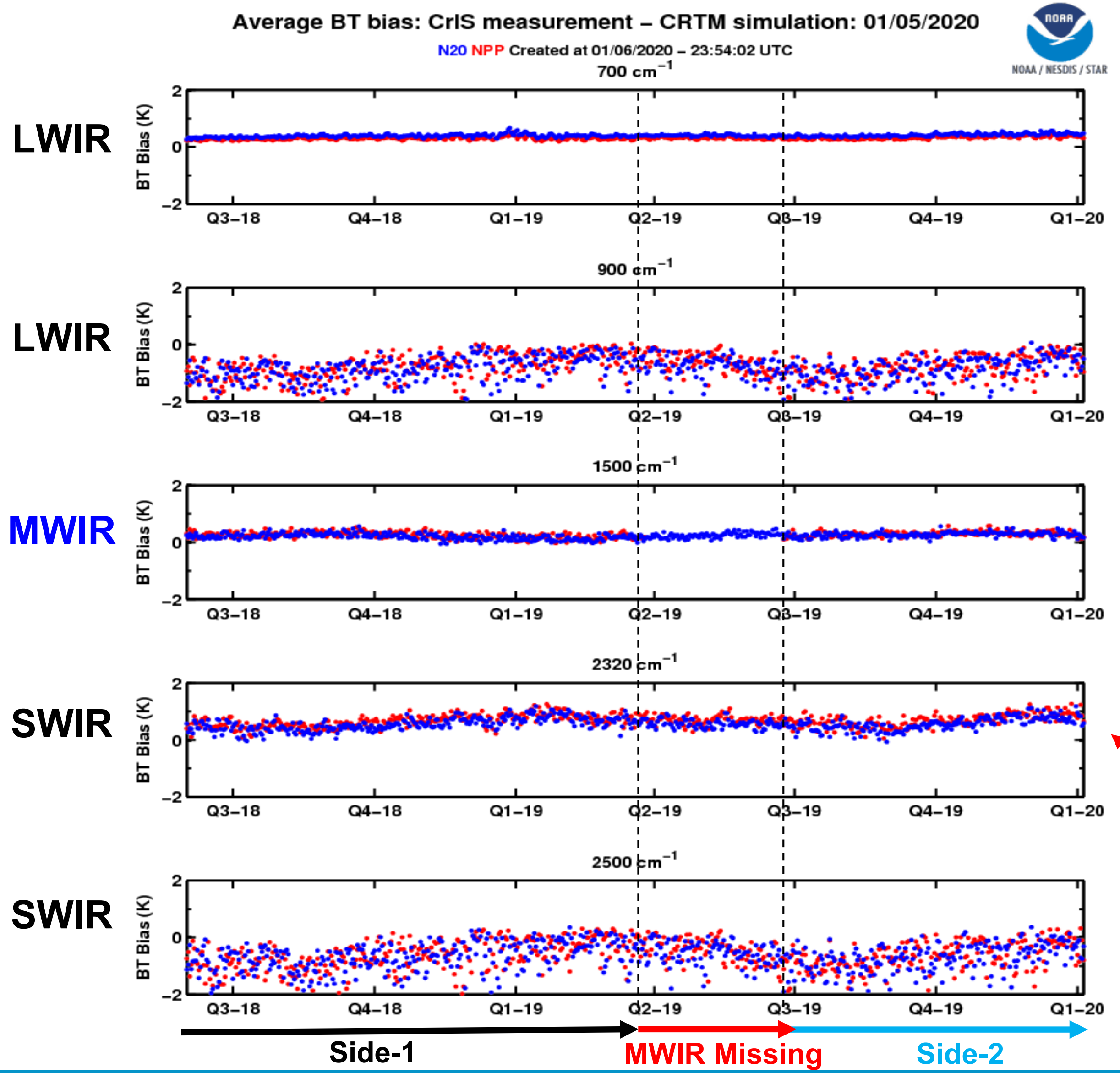
End of Side Switch

FOV-to-FOV consistency between Side-1 and Side-2 over the 3-spectral Bands. All are within 0.1 K.

Provided by Yong Chen

Long-term Trending of Radiometric Accuracy (O-B) for NOAA-20 and SNPP/CrIS

Time series of O-B for SNPP (Red) and NOAA-20 (Blue) from June 2018 to January 5, 2020 for several channels.



Data selection criteria:
FSR, Oceanic, nighttime, cloudless, and nadir FOVs
Time series of O-B of five selected channels:
700cm^{-1}, 900cm^{-1}, 1500cm^{-1}, 2320cm^{-1}, and 2500cm^{-1}

CRTM simulation using ECMWF forecast as input
Data time range: 2018-06-01 and 2020-01-05

For NPP, select two temporal ranges:
Range1: 07/01/2019 ~ 12/31/2019
Range2: 07/01/2018 ~ 12/31/2018

Mean O-B difference between two ranges (K):

0.0256 0.0609 0.0211 0.0740 0.0873

Std. Dev. difference between two ranges (K):

0.0044 -0.0314 -0.0146 0.0185 -0.0479

Consistency between Side-1 and Side-2

Provided by Xin Jin

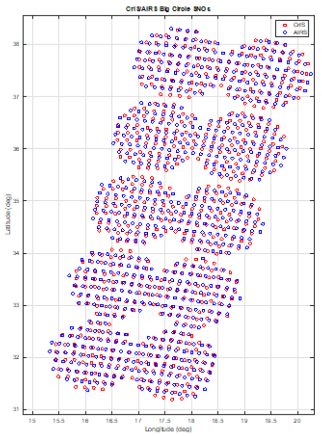
Inter-comparison SNPP/CrIS and AIRS Simultaneous Nadir Observations

CrIS/AIRS Big Circle SNOs Definition:

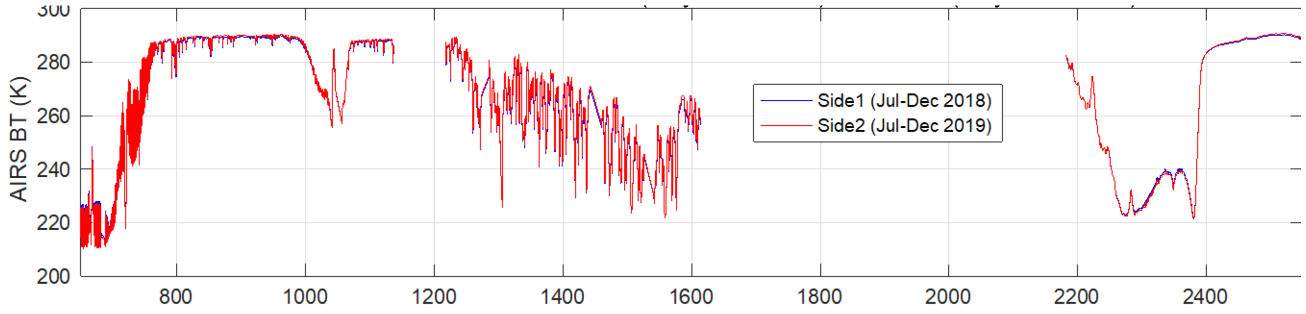
- Big Circle diameter approximately 150 km.
  (ellipse with minor axis of 75 km projected x-track)
- CrIS fields of view lat/lon retained within ellipse.
- AIRS fields of view lat/lon retained within ellipse.

Matchup Criteria Used In This Study:

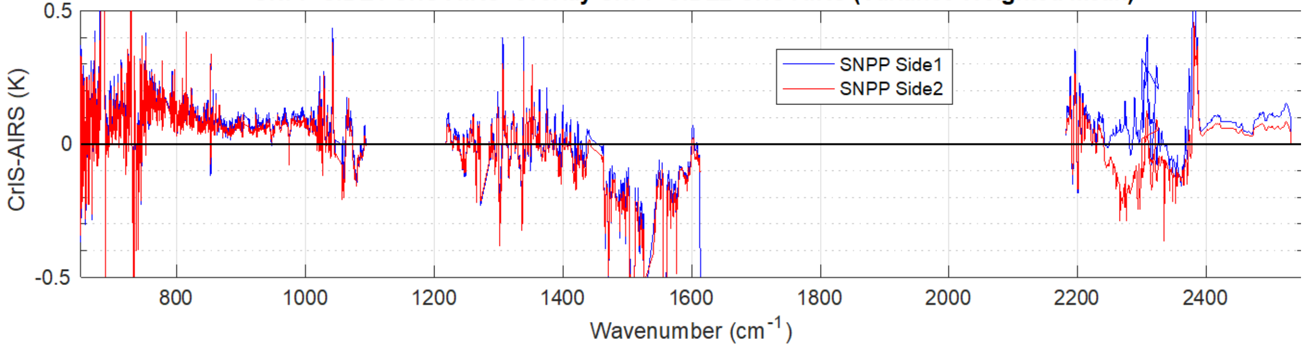
- CrIS and AIRS View Angle wrt Nadir < 10 deg
- For this study CrIS restricted to near nadir FORs 13, 14, 15 and 16, 17, 18.
- AIRS scan angles within 3 deg of CrIS mean SNO angle
- Latitude Range: [-40 deg <= Latitude <= 40 deg]
- Land/Ocean: Both included
- Day/Night: Night (Solar Zenith Angle > 95 deg)
- Time difference |CrIS-AIRS| < 12 minutes.
- Big Circle Scene Uniformity:
  AIRS radiance std dev 900 cm^{-1} < 1 $mW/(m^2\ sr\ cm^{-1})$



AIRS Mean BT: Side-1 (Jul-Dec 2018) vs Side-2 (Jul-Dec 2019)



CrIS BT – AIRS BT (smoothed)



Uncertainty in difference assumes that observations are independent. Sigma_SPACE is derived from the standard deviation of the AIRS FOVs within a Big Circle SNO.

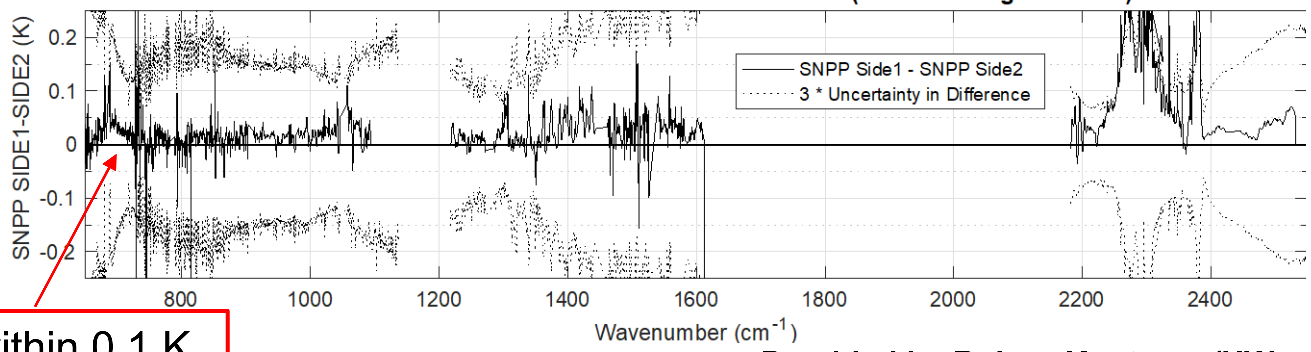
Note: This does not account for the overlap of observations within the Big Circle that can reduce the uncertainty of the difference.

$$\Delta = \sigma_\Delta^2 [\Sigma_{i=1:N} \omega_i \delta_i],$$

$$\sigma_\Delta = [\Sigma_{i=1:N} \omega_i]^{-1/2},$$

$$\omega_i = 1/(\sigma_{SPACEi}^2)$$

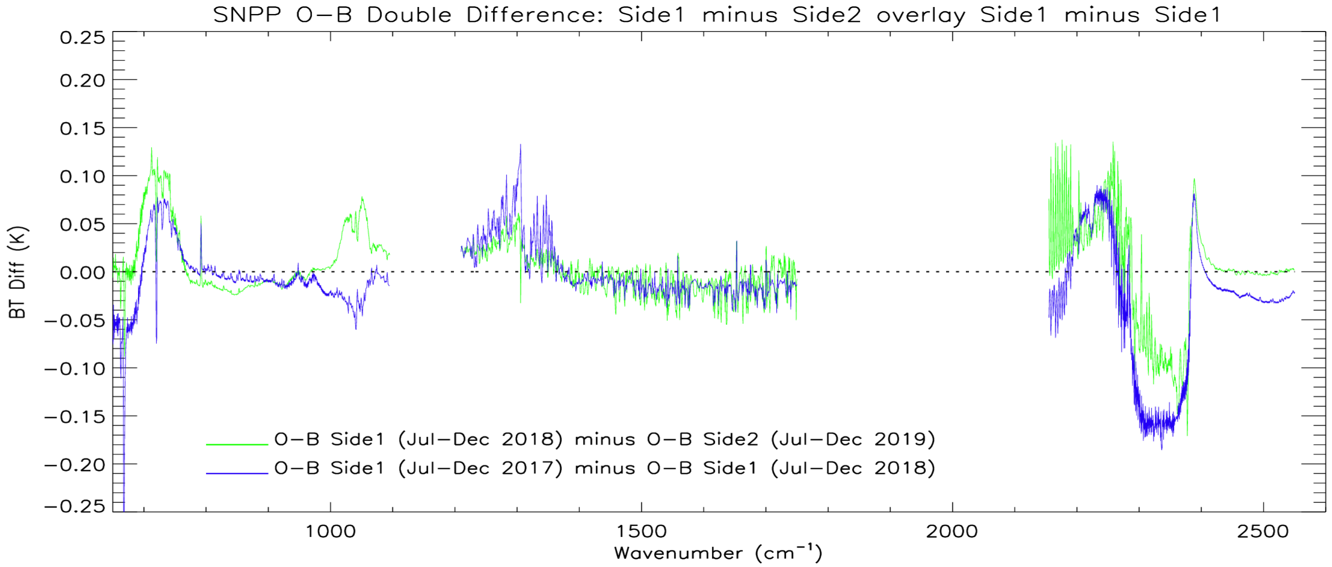
SNPP SIDE1 minus SNPP SIDE2



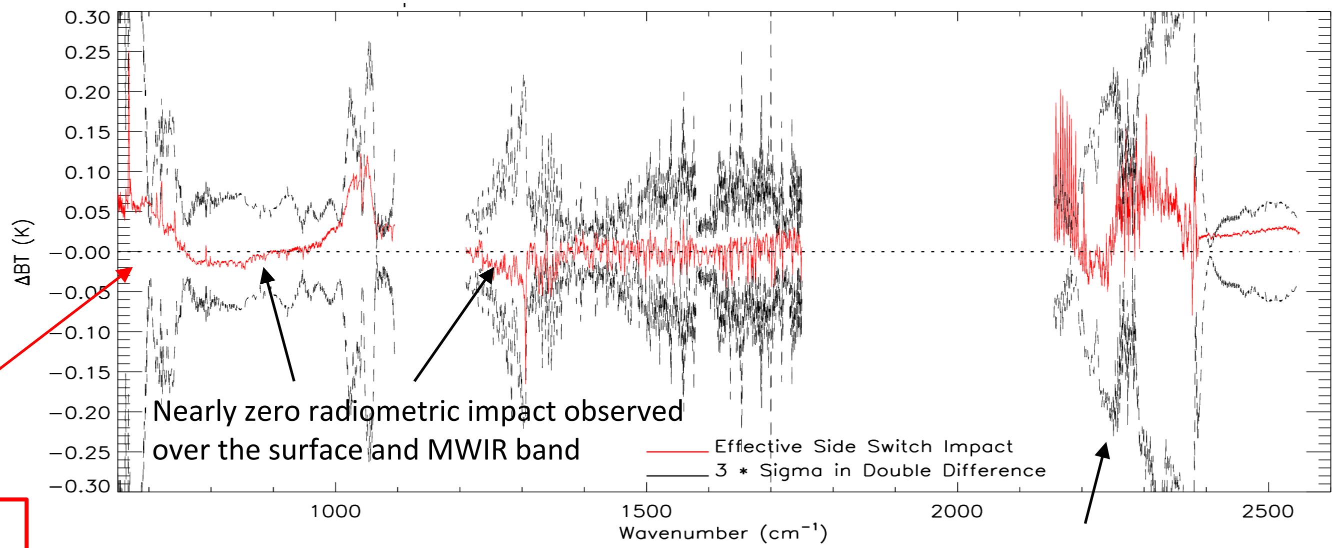
Differences are within 0.1 K

Provided by Robert Knuteson/UW

Radiometric Impact of Side Switch Based on Comparisons Between Observations and Simulations



Latitude: <|65| deg.
Scan angles: All scan angles.
FOVs: All FOVs.
Sky conditions: Clear.
Surfaces: Ocean.
Number of points: ~15 Million points during the Jul-Dec period.



Differences are within 0.1 K

Double difference is within the statistical uncertainty

Potential effect associated to variability of surface solar reflection in daytime.

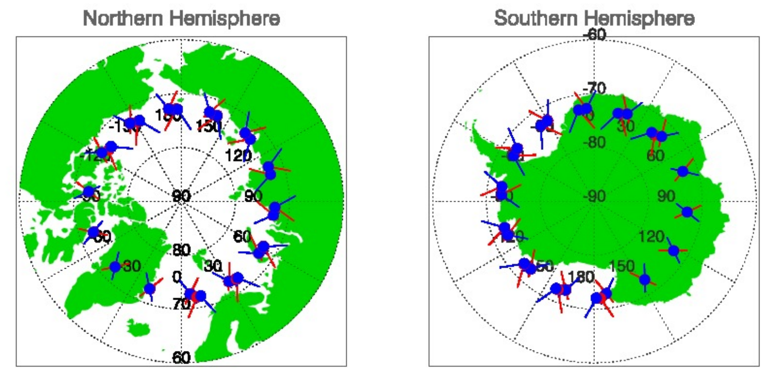
Provided by Kun Zhang

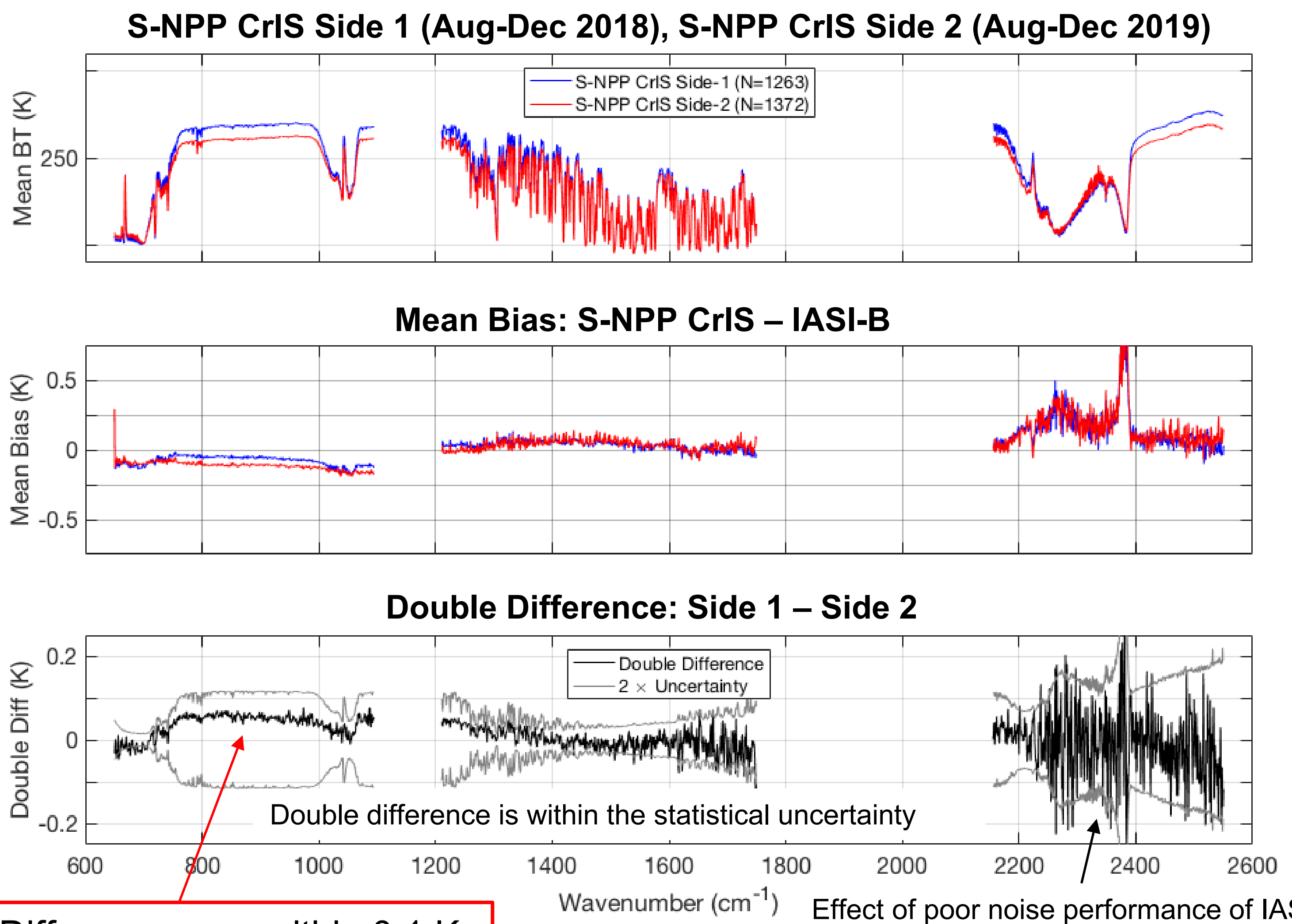
Inter-comparison of SNPP/CrIS and Metop-B/IASI Simultaneous Nadir Observations

Match up Criteria:

Condition	Criteria
FOV distance	≤ 13 km
Time difference	≤ 3 min
View angle difference	abs(cos(zen_cris)-cos(zen_iasi)) ≤ 0.01
Homogeneity	Mean(Stdev(CrIS FOVs in FOR)/Mean(CrIS FOVs in FOR)) < 50%
Day/Night	Day (Solar zenith angle < 95)
FORs	Off-nadir FORs 15 and 16

Nov. SNO Locations:





Differences are within 0.1 K

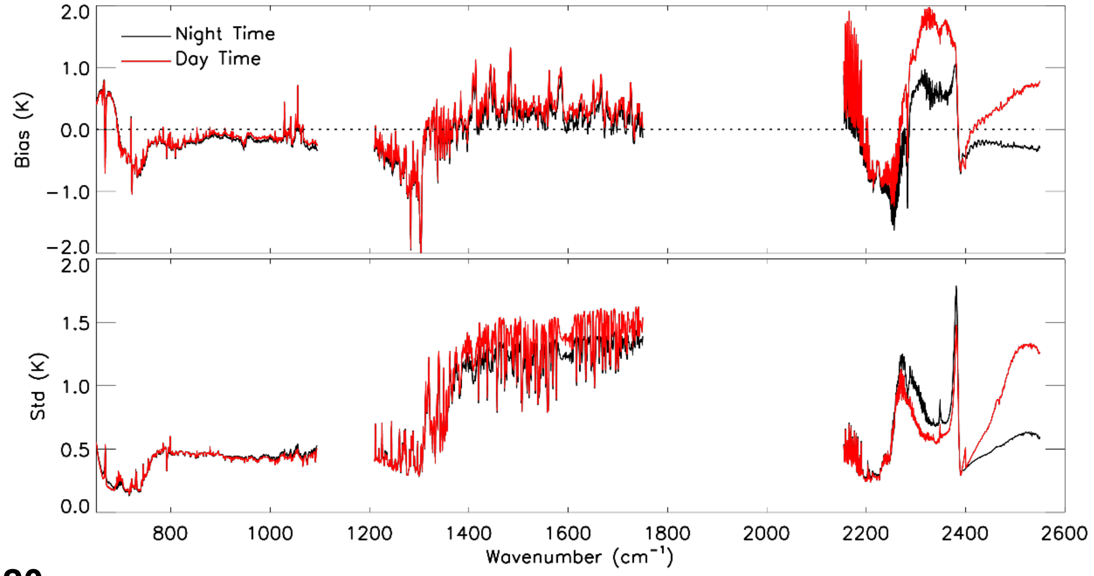
Effect of poor noise performance of IASI over SW and solar refection from solar.

Provided by Erin Lynch

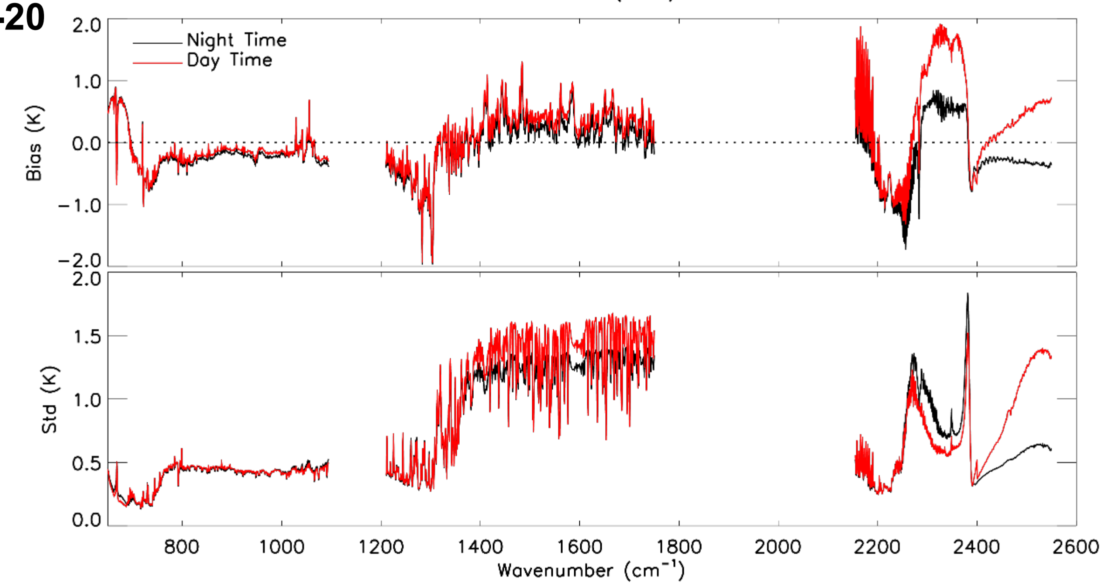
Radiometric Difference Between S-NPP/CrIS Side-2 and NOAA-20/CrIS

Bias/Stdev with respect to Simulated Observations, based on CRTM

S-NPP CrIS Side-2



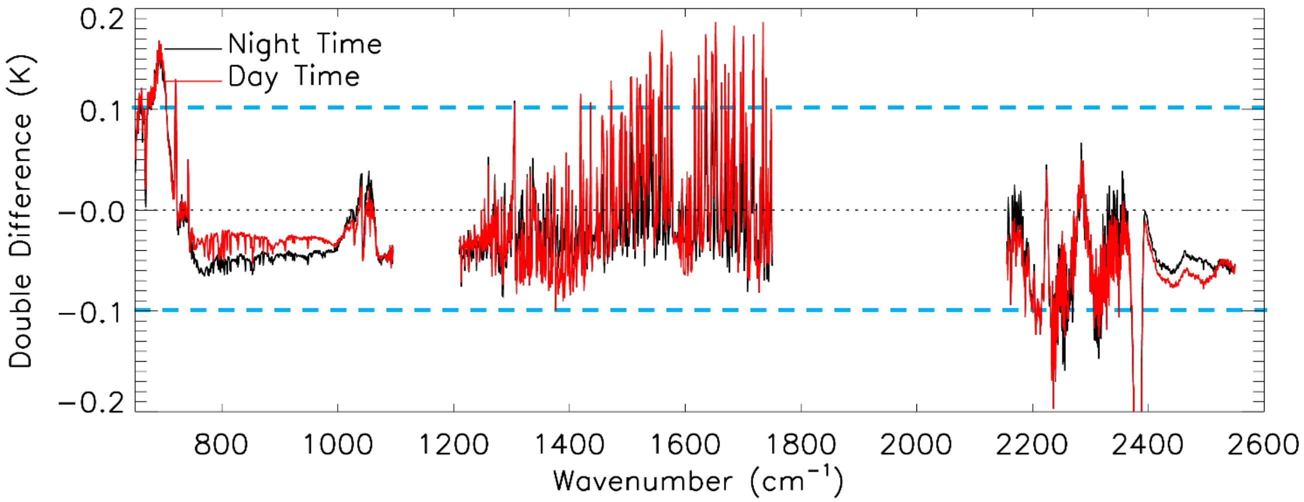
NOAA-20 CrIS



Double Difference:

NOAA-20 CrIS – S-NPP CrIS Side-2 using CRTM simulation as a transfer target

$$(BT - BT_{crtm})_{n20} - (BT - BT_{crtm})_{npp}$$

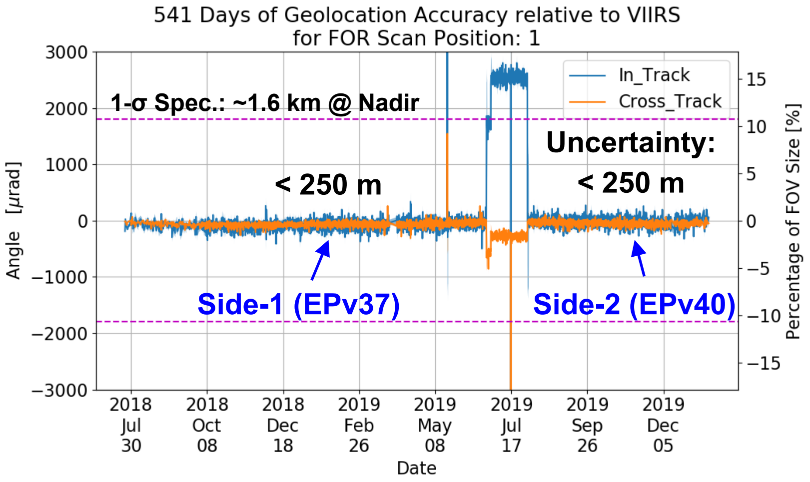


- Majority of channels are within ± 0.1 K.
- All FORs and FOVs for clear skies over oceans between ±65° on January 01, 2020.
- The effect of the CrIS instruments non-linearity is observed in the LWIR, where values above 0.1K are found.

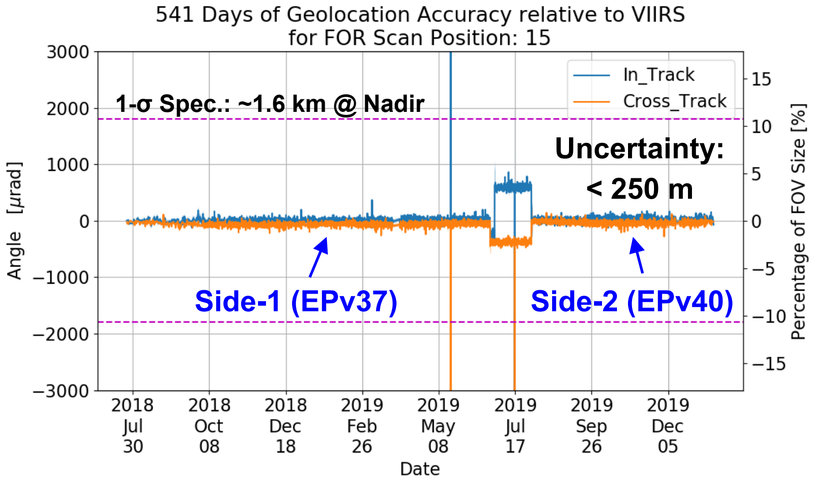
Provided by Yong Chen

Geolocation Uncertainty: Long-Term Trending

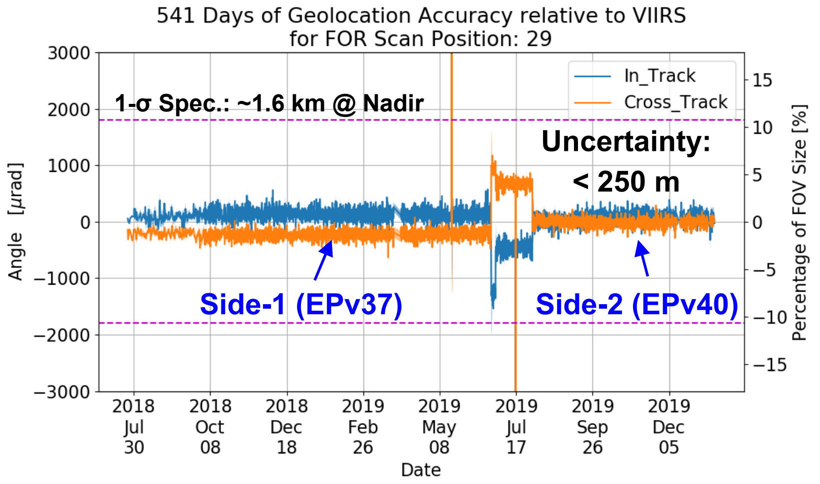
FOR1



FOR15



FOR30



Geolocation uncertainty is within 250 m for all Field-of-Regard (FOR)

Provided by Warren Porter

Anomaly and Events on SNPP CrIS SDR Side-2 Data

Date	Anomaly/Event	Description
7/10/2019	SNPP CrIS Missing Data Packect	Permanently missing S-NPP CrIS Science RDR data 158 pixels effected July 10; 3,166 pixels effected July 11; 414 pixels and engineering packet effected July 12; 29 pixels effected July 13; 82 pixels (~1 packet) effected July 14
7/18/2019	SNPP CrIS SSM Position Count Error	Number of scans of data lost unspecified
8/1/2019	Beta/Provisional Maturity Review: SNPP/CrIS SDR Side-2 data	No data packets lost
8/10/2019	CrIS Fringe Count Error	Both ICT and DS forward and reverse directions have 2 fringe counts shifts after scan 4029. ES at the same scan beginning with FOR 16 have 2 fringe counts too
8/28/2019	SNPP CrIS Calibration Table 40 Loaded to Side 2 Onboard EEPROM	No data packets lost
9/23/2019	SNPP CrIS SSM Position Count Error	A SSM position count error occurred this morning at around 08:37, resulting in loss of 36 scans of SDR data between 08:35 and 08:39. This event happened around the North Canda and has not been overlapped the following orbits of data. So we can see a big gap on the overall data quality map.
9/24/2019	SNPP CrIS Missing Data Packect	A missing data packets on 09/24, about 666 ES interferogram packets are missing over the Iceland. And the repaired granules are not available. It seems to be an accident during the satellite-ground contact.
9/26/2019	SNPP CrIS Missing Data Packect	A false lunar intrusion event today when NPP spacecraft had a spacecraft maneuver over the West Pacific Ocean. The deep space spectra were changed sharply during the event and triggered a false lunar intrusion event.
10/13/2019	SNPP CrIS SSM Position Count Error	A SSM position count error happened to NPP CrIS scan 7183 and 7184.As a result, part of ES pixels in scan 7183 are labeled as invalid and the whole scan of 7184 are labeled as invalid.
10/13/2019	Potential SNPP CrIS SSM Position Count Error	Another anomaly happened to FOR22 of scan 7168. All FOVs of all three bands in this FOR are labeled as invalid, including both the radiance parameters and the geo parameters.
10/19/2019	SNPP MW ES Bit Trim Table Memory Error Flag False Alarm	A bit-flip error happened to NPP CrIS MW over SAA on today. In this event, the MW bit trim table memory error flag was triggered as a false alarm. It has no impact on SDR data.
11/13/2019	SNPP CrIS SSM Position Count Error	A SSM position count error happened to NPP CrIS this early morning at 01:16 UTC. The data of scan#575 of all three bands/FOVs/FORs are labelled as invalid, as a result.
12/30/2019	SNPP CrIS SSM Position Count Error	A SSM position count error happened to NPP CrIS at around 15:32:42 on 2019/12/30. The location is near the South Pole. To continuous granules are impacted.
1/17/2020	Solar Vector Anomaly	Solar vector anomaly associated to an update needed in the JPL Planetary Ephemeris LUT in the Common GEO module of IDPS/ADL
1/17/2020	SNPP Drag Makeup Maneuver	On January 22, 2020, at 16:16:00Z, S-NPP will perform a 0.9-second propulsive Drag Makeup Maneuver (DMU) to maintain the Repeating Ground Track box. The impact of DMU on radiance data quality is reflected in the O-B. The DMU event is not reflected in the overall SDR data quality
1/29/2020	Operational Implementation of CrIS Polarization Correction	No data packets lost

16 anomaly and events. Only 8 instrument related. A few granules impacted. Similar instrument performance as Side-1

SNPP/CrIS Side-1 and Side-2 Overall Performance

SNPP/CrIS FSR SDR Side-2 uncertainties (blue) vs. specifications (black)

Band	Spectral Range (cm^{-1})	Resolution (cm^{-1})	Number of Channels	NEdN* ($mW/m^2/sr/cm^{-1}$)	Frequency Uncertainty (ppm)	Geolocation Uncertainty** (km)	Radiometric Uncertainty @287K BB¥ (%)	Radiometric Stability @287K BB (%)
LWIR	650-1095	0.625	713	0.099 (0.14)	2 (10)	0.25 (5)	0.16 (0.45)	0.17 (0.40)
MWIR	1210-1750	0.625	865	0.0536 (0.084)	2 (10)	0.25 (5)	0.19 (0.58)	0.21 (0.50)
SWIR	2155-2550	0.625	633	0.00752 (0.014)	2 (10)	0.25 (5)	0.40 (0.77)	0.28 (0.64)

SNPP/CrIS FSR SDR Side-1 uncertainties (blue) vs. specifications (black)

Band	Spectral Range (cm^{-1})	Resolution (cm^{-1})	Number of Channels	NEdN* ($mW/m^2/sr/cm^{-1}$)	Frequency Uncertainty (ppm)	Geolocation Uncertainty** (km)	Radiometric Uncertainty @287K BB¥ (%)	Radiometric Stability @287K BB (%)
LWIR	650-1095	0.625	713	0.101 (0.14)	2 (10)	0.25 (5)	0.16 (0.45)	0.17 (0.40)
MWIR	1210-1750	0.625	865	0.0522 (0.084)	2 (10)	0.25 (5)	0.19 (0.58)	0.21 (0.50)
SWIR	2155-2550	0.625	633	0.00741 (0.014)	2 (10)	0.25 (5)	0.40 (0.77)	0.28 (0.64)

* Mean value averaged over 9 FOVs and over entire band.

** Geolocation uncertainty is based on the largest 3-sigma value found over all scan angles (FORs). Accounts for in-track and cross-track errors. The specification is based on 3-sigma mapping uncertainty of 5 km (474-00448-01-03_JPSS-SRS-Vol-I-Part-3_0200G-2).

¥ S-NPP RU does not accounts for the polarization correction effect. RU values with polarization correction are expected to be lower than those reported in the table.

User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Andrew Collard andrew.collard@noaa.gov	NOAA/NCEP	NWP	Permanently in operations
Ben Ruston Ben.Ruston@nrlmry.navy.mil	NRL	NWP	Permanently in operations
Reima Eresmaa Reima.Eresmaa@ecmwf.int	ECMWF	NWP	September 10, 2019
Tony Reale tony.reale@noaa.gov	NOAA/STAR	Atmospheric Sounding/Validation	August 12, 2019
Ken Pryor ken.pryor@noaa.gov	NOAA/STAR	Atmospheric Sounding	August 12, 2019

- August 1st, 2019 is date for SNPP CrIS Side-2 reach the Provisional Maturity Level.
- On August 12, 2019 the SNPP EDR product became operational after SNPP CrIS anomaly.

Risks, Actions, and Mitigations

- No risks have been identified for the SNPP CrIS Side-2 SDRs.

SNPP CrIS Side-2 Provisional Maturity SDR Data Product Caveats

- No caveats have been identified for the SNPP CrIS Side-2 SDRs.
- No Discrepancy Reports have been entered for SNPP CrIS Side-2.

Requirement Check List – CrIS SDR (FSR)

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

JPSS GSRD Table B-3 + J1MSS (J1 Mission Systems Specification)   NS = Not Specified

Documentations (Check List, 1 slide)

Science Maturity Check List	Yes ?	Where
ReadMe for Data Product Users	Yes	Review Directory
Algorithm Theoretical Basis Document (ATBD)	Yes	https://www.star.nesdis.noaa.gov/jpss/Docs.php
Algorithm Calibration/Validation Plan	Yes	https://www.star.nesdis.noaa.gov/jpss/Docs.php
(External/Internal) Users Manual	Yes	https://www.star.nesdis.noaa.gov/jpss/Docs.php
Operational Algorithm Description Document (OAD)	Yes	https://jointmission.gsfc.nasa.gov/documents.html 474-00071
Peer-Reviewed Publications (Demonstrates algorithm is independently reviewed)	In Progress	
Regular Validation Reports (at least. annually) (Demonstrates long-term performance of the algorithm)	Yes	ICVS and CrIS weekly reports

Rationale for Validated

1. Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).

   SNPP CrIS SDR Side-2 performance has been demonstrated globally for more than six months.

2. 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.

   Comprehensive documentation of instrument status and product performance exists, including: presentations given during the Provisional and Validated Reviews from the science team and Users, ReadME file, and the reports generated during and after the side switch.

3. Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.

   SNPP CrIS SDR Side-2 data meets or exceeds specification requirements for radiometric, spectral, geolocation, and noise performance; comparable to NOAA-20 CrIS SDR data.

4. Product is ready for operational use based on documented validation findings and user feedback.

   The SNPP CrIS SDR data product has been permanently in operations at NOAA/NCEP. Operational at ECMWF on September 10, 2019. Operational in NUCAPS on August 12, 2019.

5. Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

   The CrIS SDR team maintains the algorithm and product validation to ensure the quality of the SNPP CrIS SDR data product.

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

Summary of SNPP/CrIS Performance and SDR Product Quality

1. **Recovered the Full Capabilities** of the First CrIS instrument on-orbit, after the successful switch to Side-2 electronics.
2. The quality of the SNPP/CrIS SDR **product is meeting the JPSS requirements and holds long-term stability**, and no major anomalies or caveats have been identified. The products holds Validated Level quality: noise, spectral (within 2 ppm), geolocation (within 250 m) and radiometric uncertainty for all three bands are all within the requirements.
3. Radiometric differences between **SNPP and NOAA-20 are within ±0.1 K** for the majority channels. The estimated differences were derived from the double-difference from radiative transfer calculations.
4. The **SNPP/CrIS SDR** data products has been assimilated monitored after reaching the Provisional Maturity Level **at NOAA/NCEP, ECMWF and NRL**. The rate of Good data quality after instrument side switch is greater than 99.7%, which is similar to Side-1 data quality rate.
5. The **assessment** of the SNPP/CrIS SDR Side-2 data in the **geophysical space** has carried out using comparisons between NUCAPS/SNPP Environmental Data Record (EDR) products and **Radiosonde Observations**.

Path Forward for the SNPP/CrIS Instrument

1. Continue monitoring the instrument long-term stability and performance, as well as the SDR data quality.
2. Continue to inter-compare the instrument against other sensors (including the NOAA-20/CrIS, IASI, VIIRS, and ABI), in order to further assess the radiometric calibration (uncertainty/stability).
3. Planning to Reprocess SNPP CrIS data around April 2020, using the same calibration coefficients and the latest IDPS software to improve the data consistency for the whole mission.

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