RADIOMETRIC PERFORMANCE OF THE CRIS INSTRUMENT FOR JPSS-1

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Agenda

CrIS Overview

SNPP On-Orbit Performance Update

J1 Design Improvements

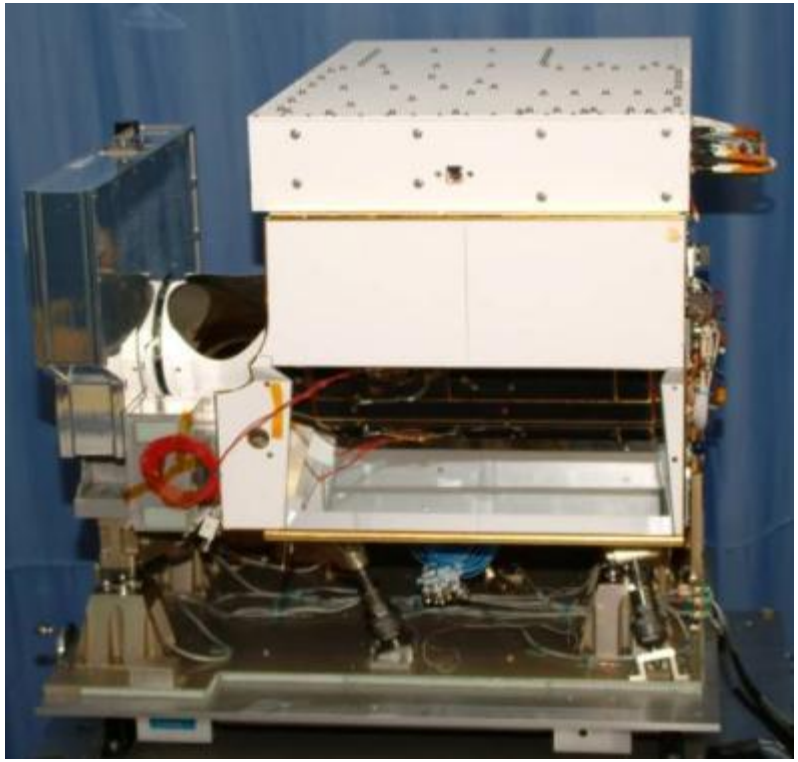
J1 Radiometric Performance

J1 Full Resolution Operating Mode

J2, J3, J4 Production Status

CRIS OVERVIEW

First CrIS Instrument Was Launched on Suomi NPP, October 2011

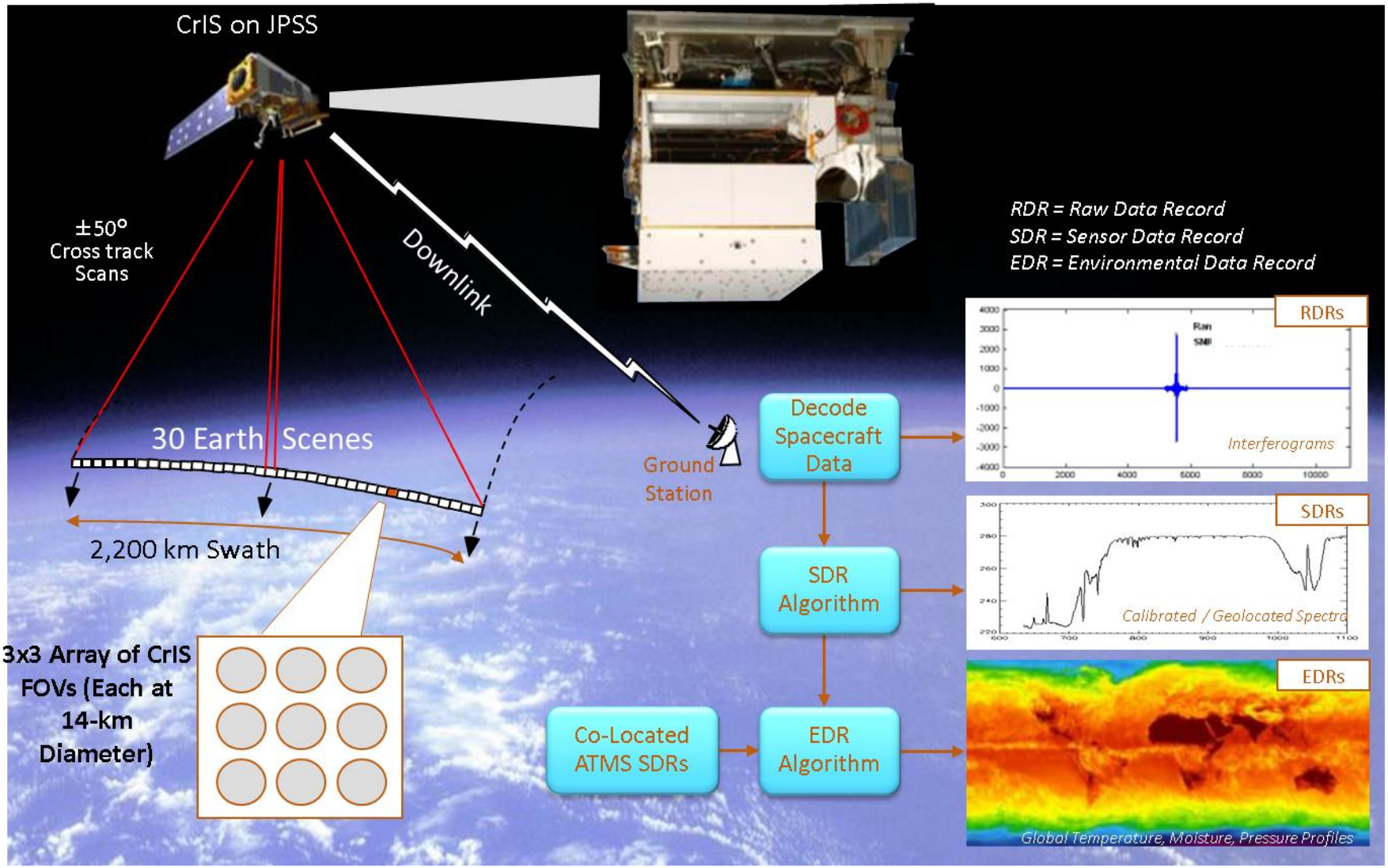


Band	Wavelength Range (cm^{-1})	(μm)	Sampling (cm^{-1})	No. Chan.
SWIR	2155-2550	4.64-3.92	0.625	633
MWIR	1210-1750	8.26-5.71	0.625	865
LWIR	650-1095	15.38-9.14	0.625	713

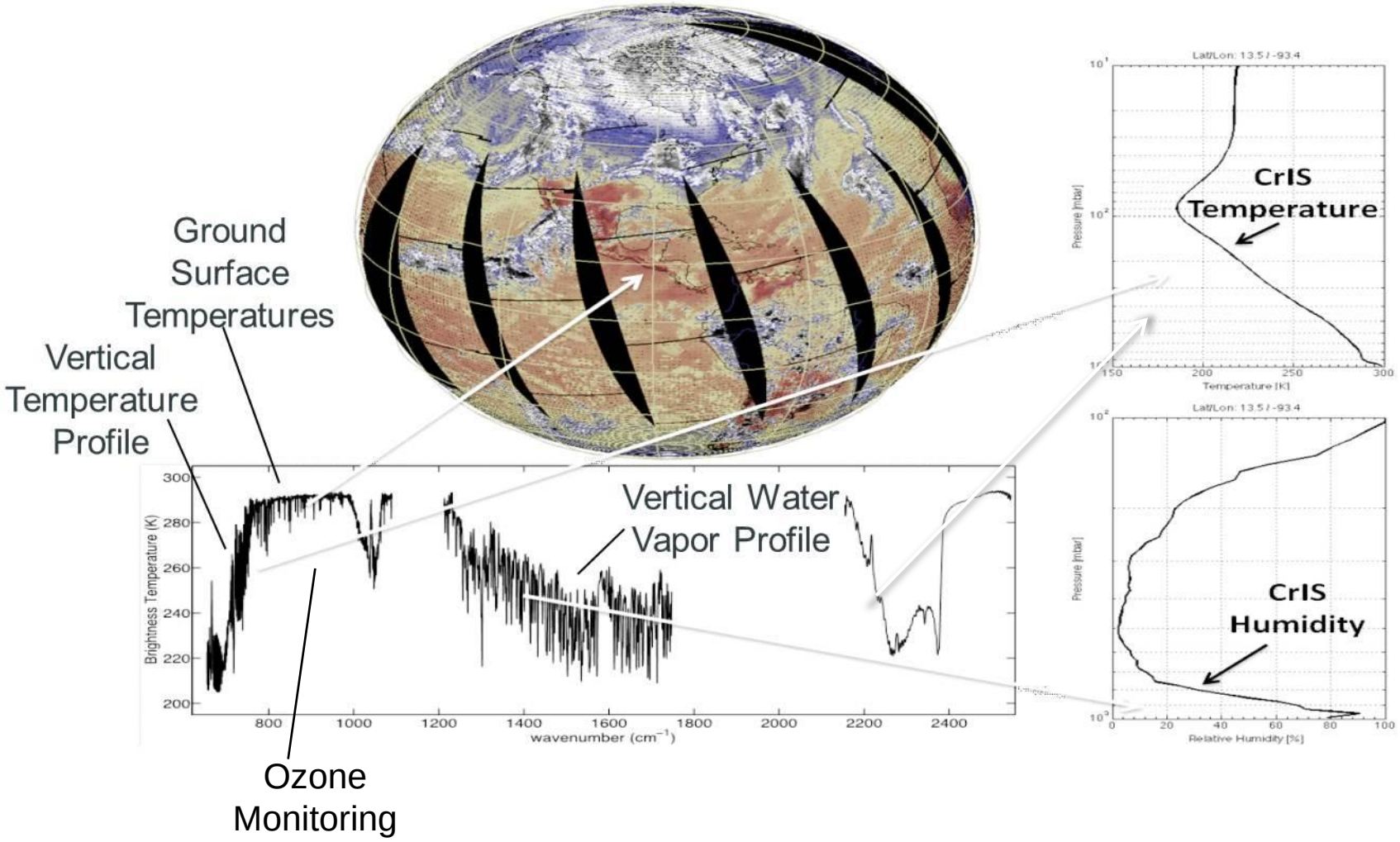
- CrIS measures upwelling infrared radiance at very high spectral resolution
  - 2211 spectral channels compared to 18 channels on HIRS sounders (NOAA-KLM); similar number as on AIRS (EOS-Aqua)
  - Low noise levels (NEdN) enabled by 8cm aperture and low-noise FPAs / electronics
  - Precise radiometric and spectral accuracy
  - Vertical profiles of the temperature, moisture, and pressure produced when CrIS and ATMS data are combined
  - Temperature retrieval accuracy well below 1K
- CrIS data is used to support:
  - Global weather forecasts
  - Accurate hurricane track and intensity forecasts
  - Severe weather predictions
  - Trace gas monitoring (CO_2, Ozone, CO)

Mass	Power	Volume
146 kg	105 W	~0.4 m^3

CrIS Operational Concept

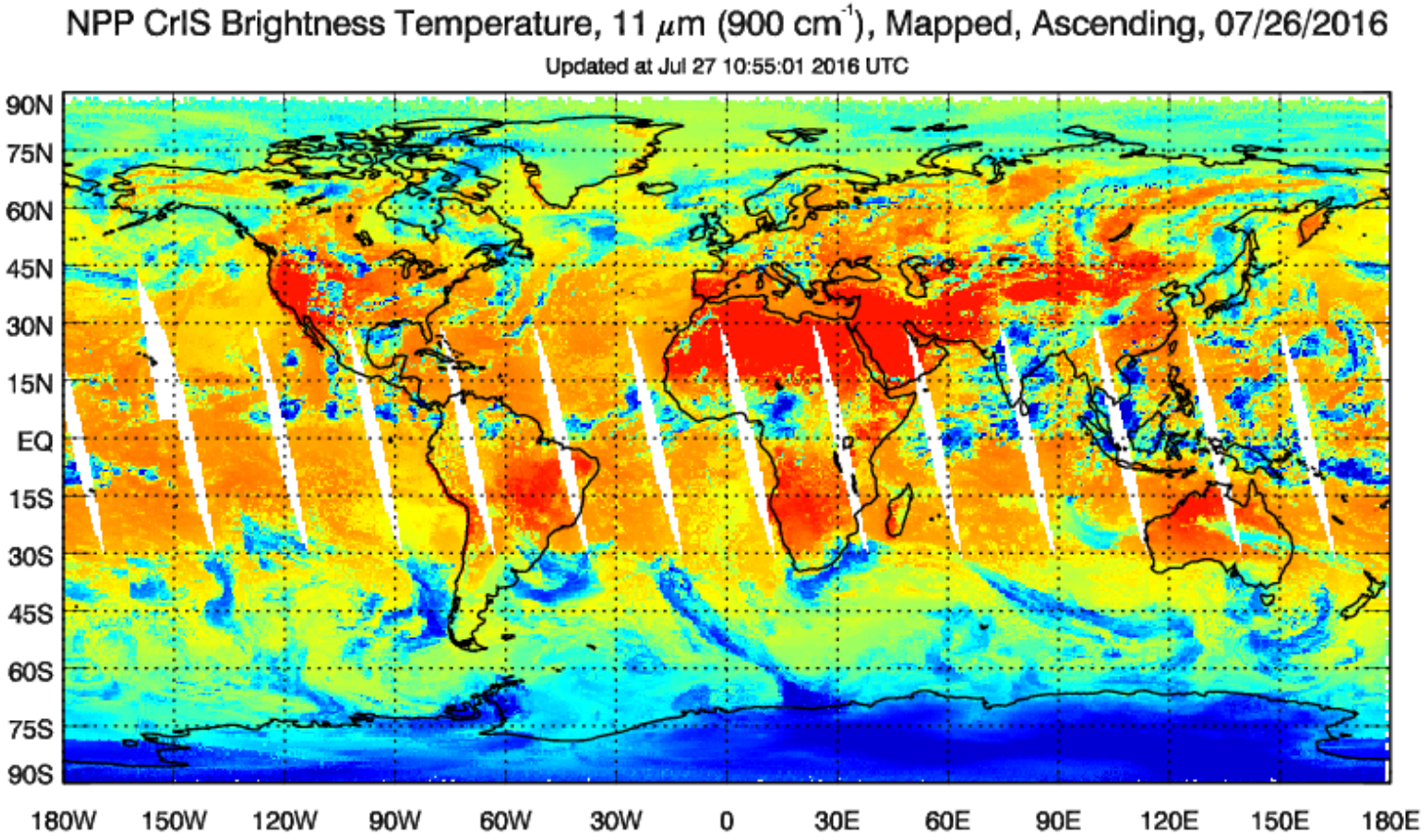


CrIS Data Products Provide Critical Inputs to Global Weather Predictions



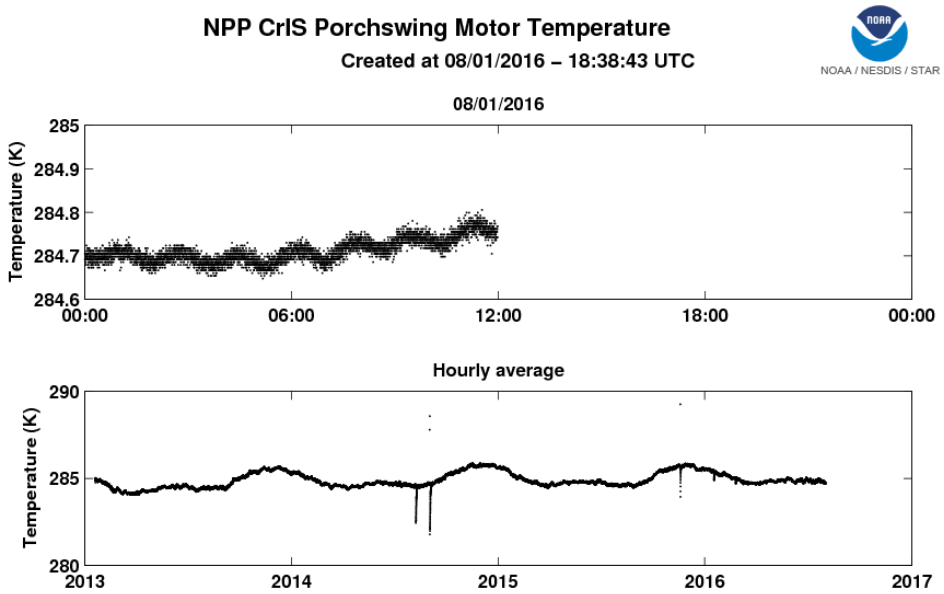
SNPP ON-ORBIT PERFORMANCE UPDATE

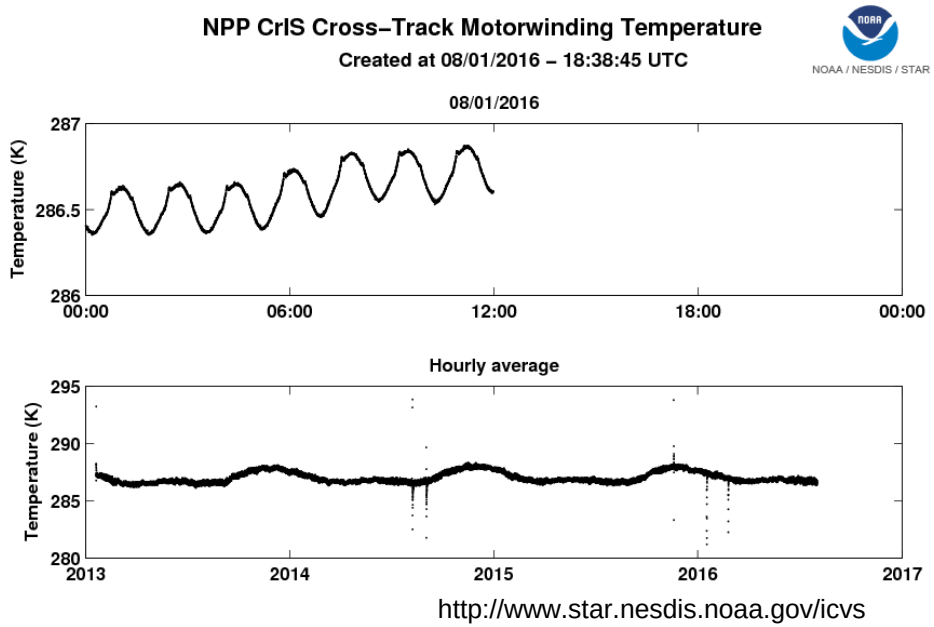
SNPP CrIS Continues to Provide Worldwide Coverage of Upwelling Radiance



http://www.star.nesdis.noaa.gov/icvs

Performance Is Stable with No Unexpected Changes Observed

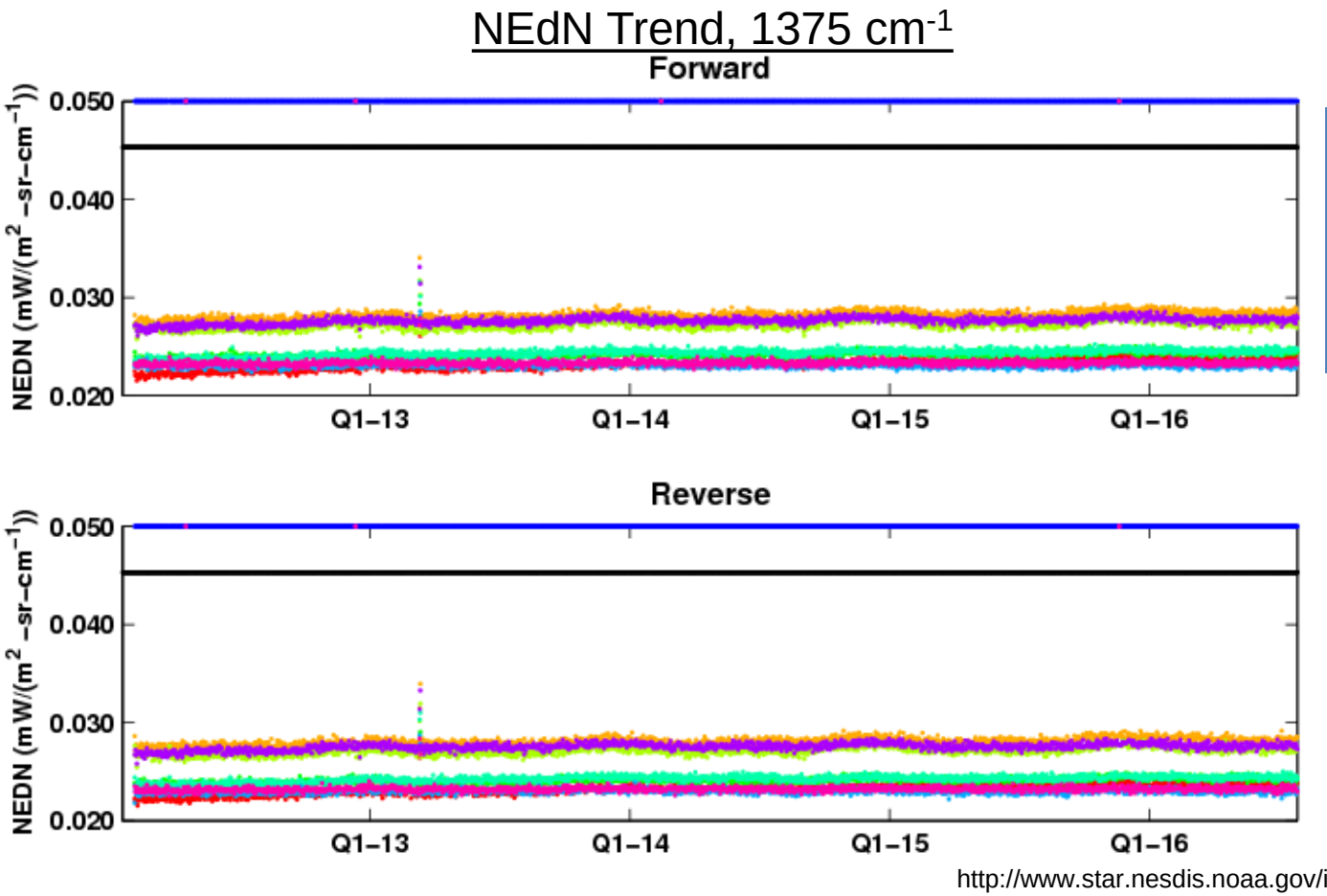




http://www.star.nesdis.noaa.gov/icvs

No Hardware Issues or Degradation Observed for Any SNPP CrIS Modules

NEdN Performance Has Remained Stable Over Mission Life



SNPP CrIS Has Been On-Orbit for Five Years vs. Required Mission Life of Seven

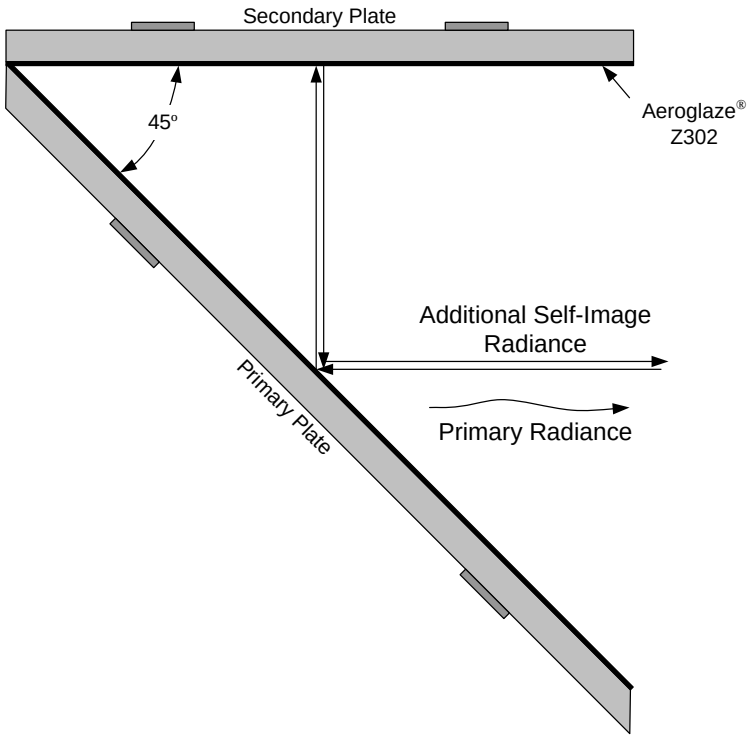
http://www.star.nesdis.noaa.gov/icvs

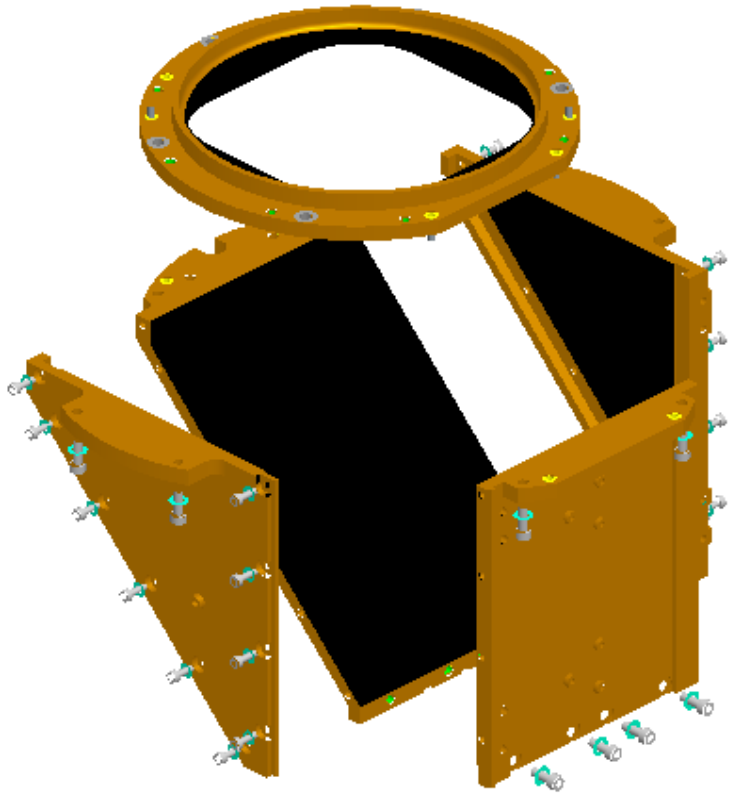
SNPP CrIS Continues to Deliver Stable, Low-Noise Spectra for Science Users

J1 DESIGN IMPROVEMENTS

Internal Calibration Target (ICT) Design Improved for J1

- **Specular three-bounce trap design**
- **Very low view of stray environmental energy**
- **ICT emissivity and temperature uncertainty greatly improved from SNPP**





Additional J1 Design Improvements

NPP brazed frame replaced by single piece machined chassis

- Improved manufacturability

Signal processor and scene select mirror (SSM) CCAs redesigned

- Improved robustness of CCAs

Several minor enhancements to the Vibration Isolation System (VIS)

- Improved robustness of module

J1 RADIOMETRIC PERFORMANCE

J1 CrIS Successfully Completed Comprehensive Test Program

EMI testing

Vibration testing

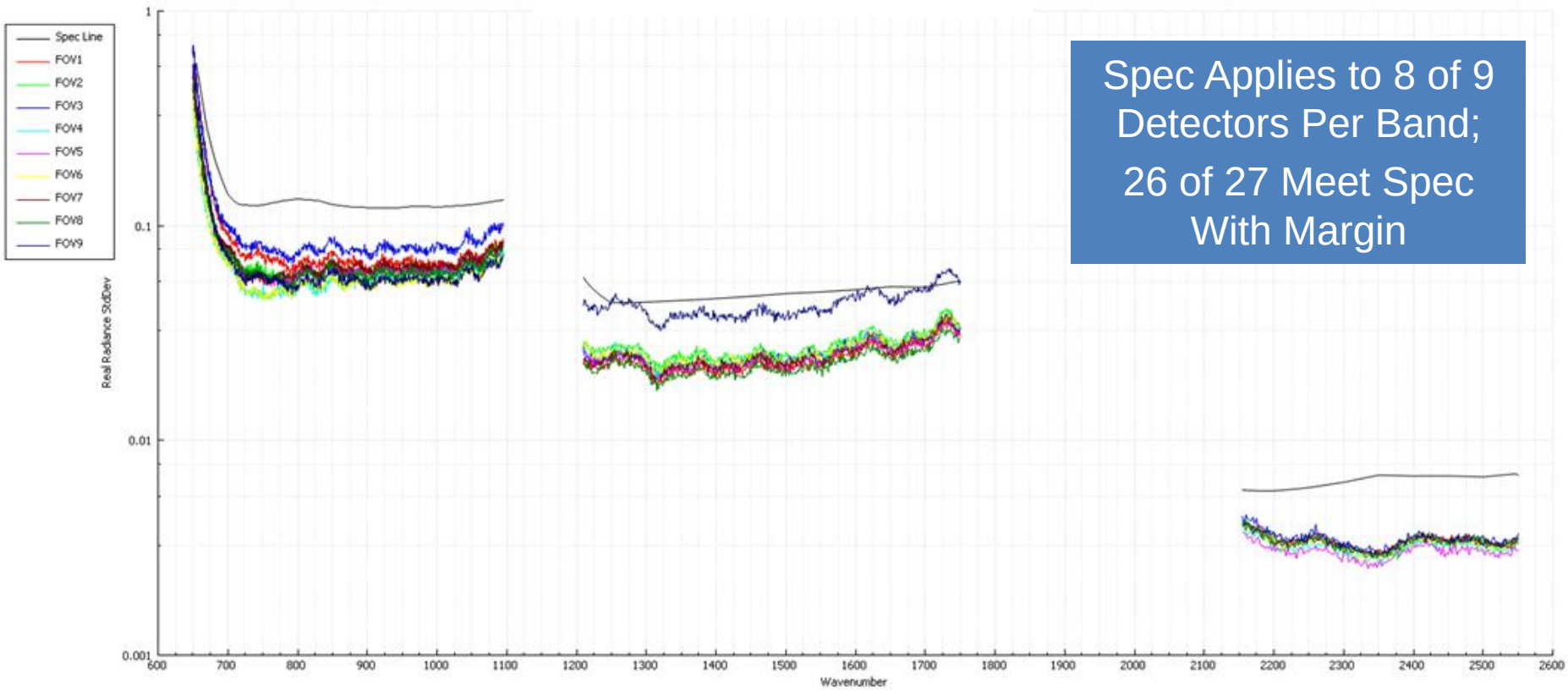
TVAC testing

- Noise Equivalent Spectral Radiance (NEdN)
- Radiometric Performance
  - Radiometric Uncertainty
  - Repeatability
  - Detector Linearity
- Instrument Line Shape (ILS) / Spectral Accuracy
- Day in the Life
- Field of View (FOV) Shape / Coregistration
- Dynamic Interaction
- Electrical Performance

J1 Meets All Radiometric Requirements With Margin

Results Discussed in Following Slides

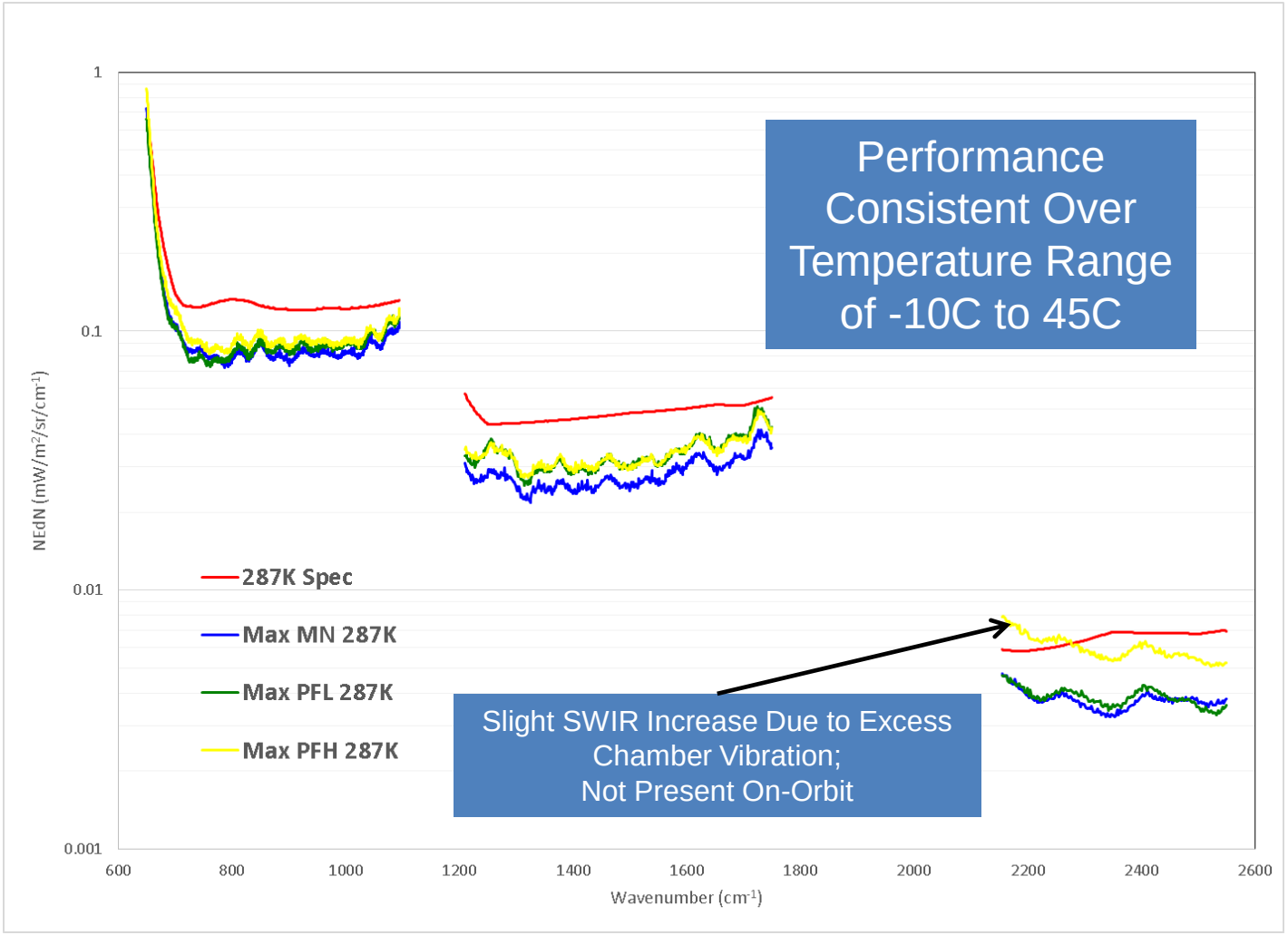
Typical J1 NEdN Meets Specification With Margin



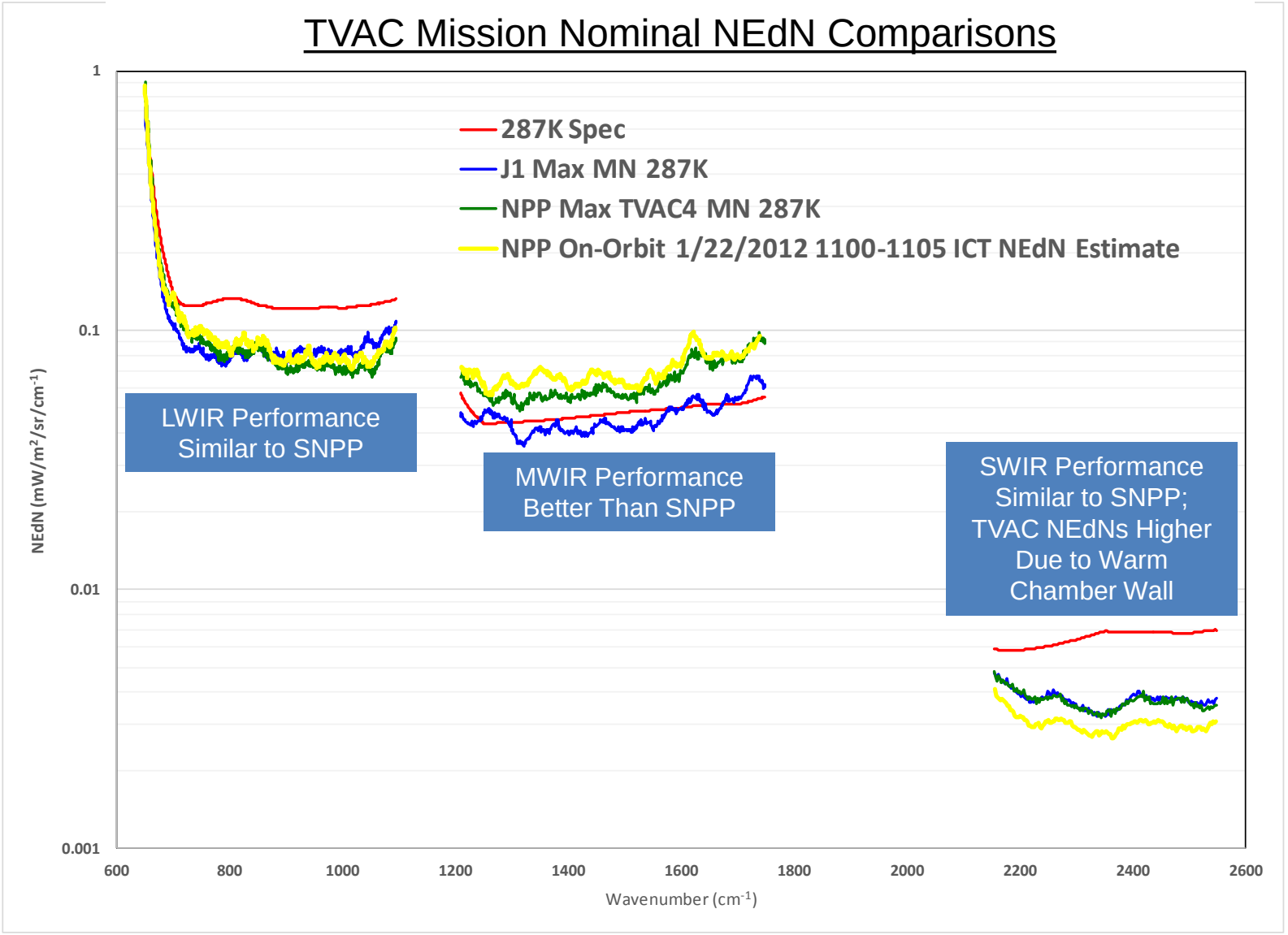
Spec Applies to 8 of 9 Detectors Per Band;

26 of 27 Meet Spec With Margin

NEdNs Are Stable Over Large Thermal Variations



J1 NEdN Performance Equal to or Better Than SNPP



CrIS Radiometric Uncertainty Assessed by Analysis and Verified by Test

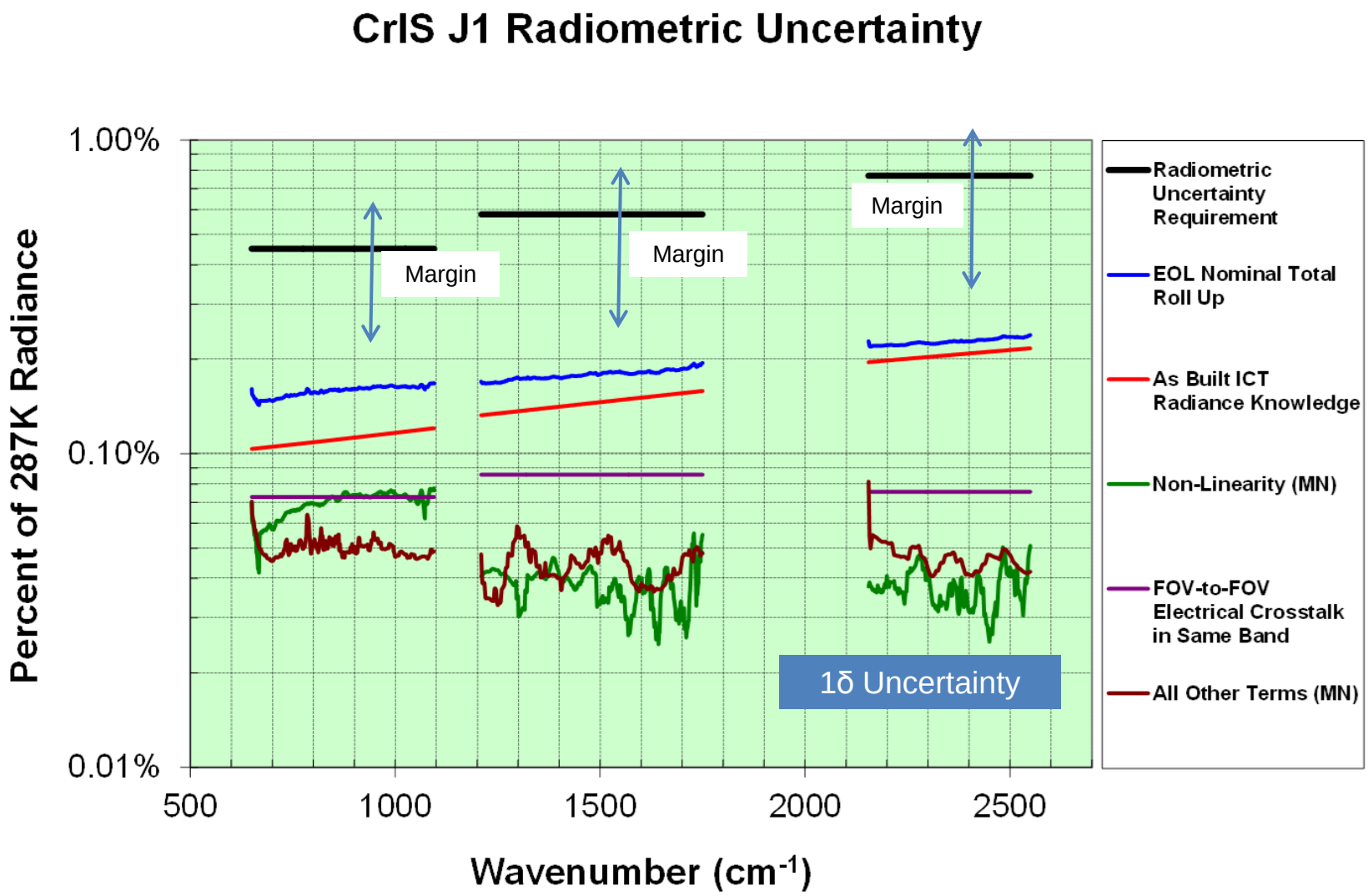
HARRIS

1. **Analysis, using an error budget roll-up**
   - Includes all known error terms and end of life (EOL) effects
   - Eliminates inclusion of excess error due to test equipment and measurement method

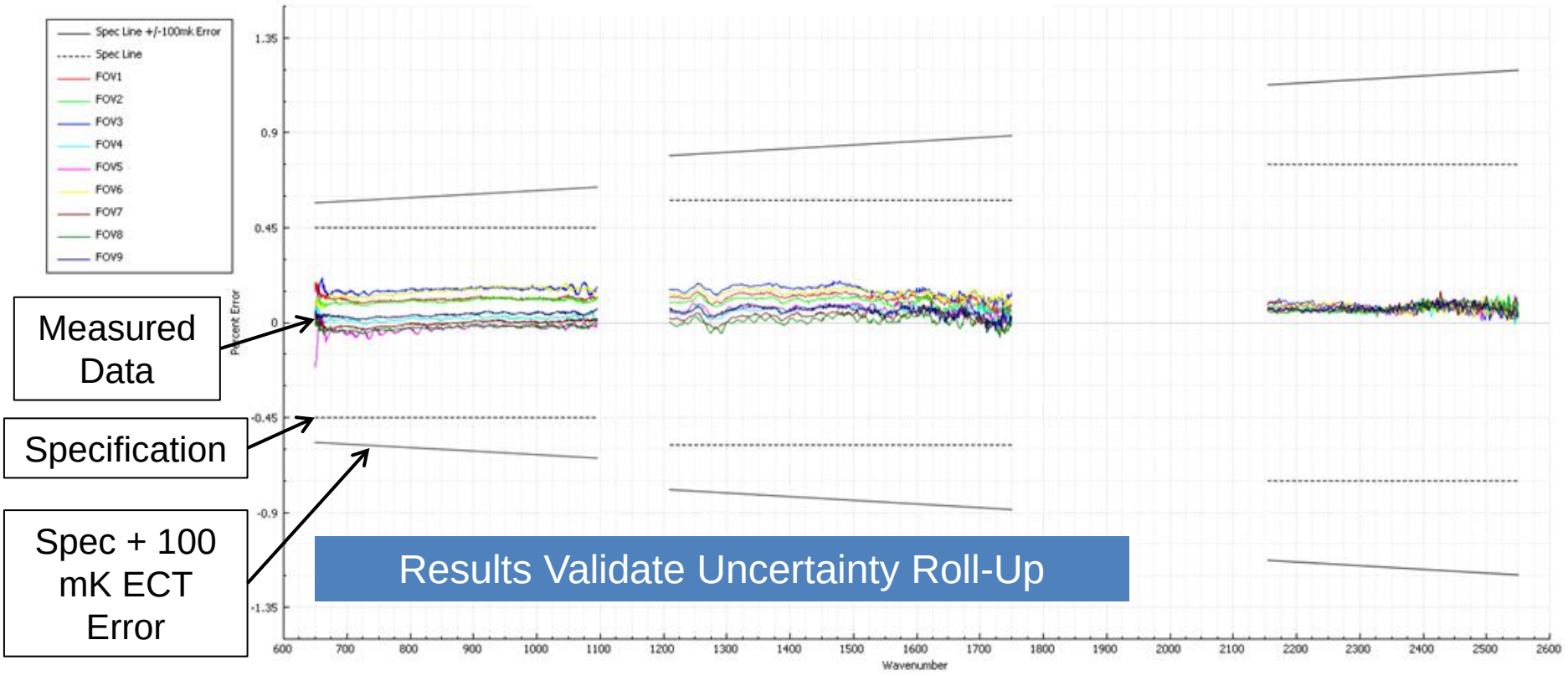
2. **Direct measurement using a blackbody target**
   - Uses reported temperature of External Calibration Target (ECT) as truth
   - Validates roll-up using CrIS radiometric accuracy assessed relative to reported ECT temperature
   - Does not contain EOL effects but includes ECT temperature knowledge error in assessment
   - ECT and space calibration target (SCT) performance verified by NIST following TVAC

Results From Two Methods Demonstrate J1 Uncertainty is Very Low

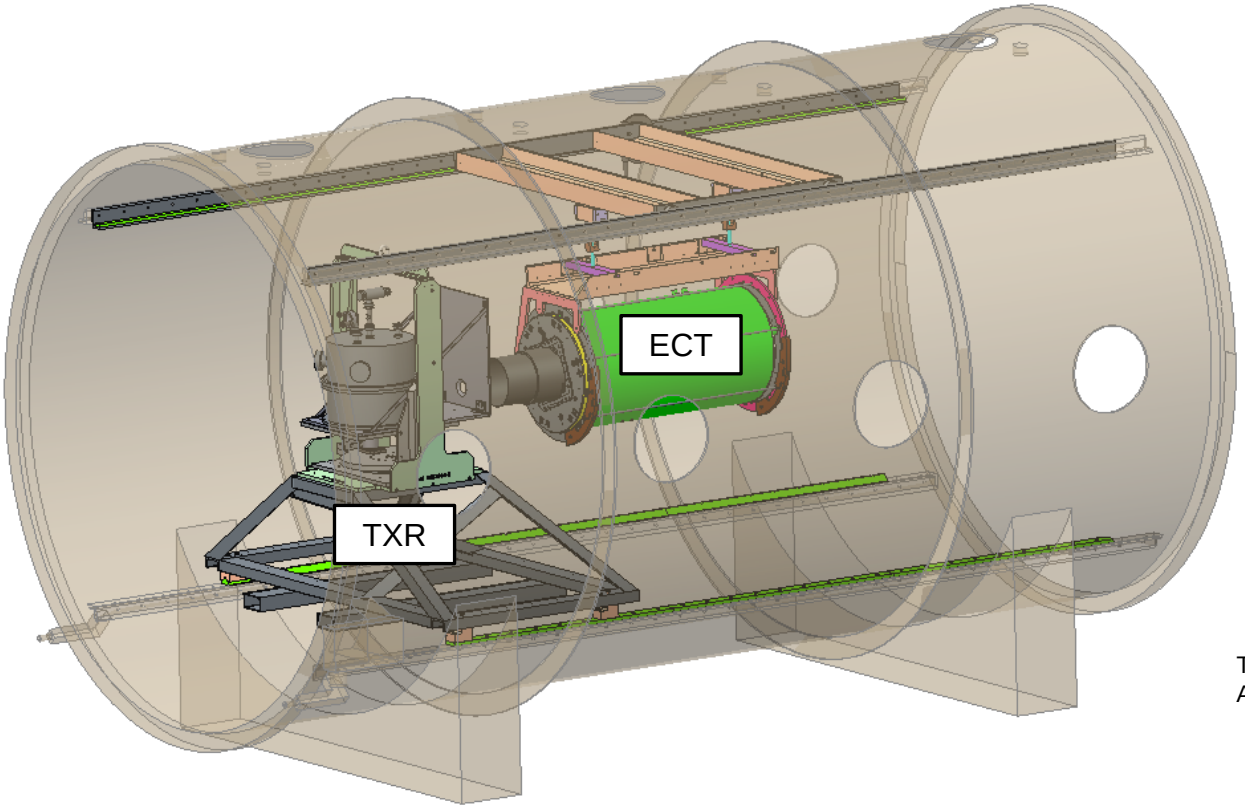
Roll-up Analysis Shows J1 Radiometric Uncertainty Performance Is Excellent

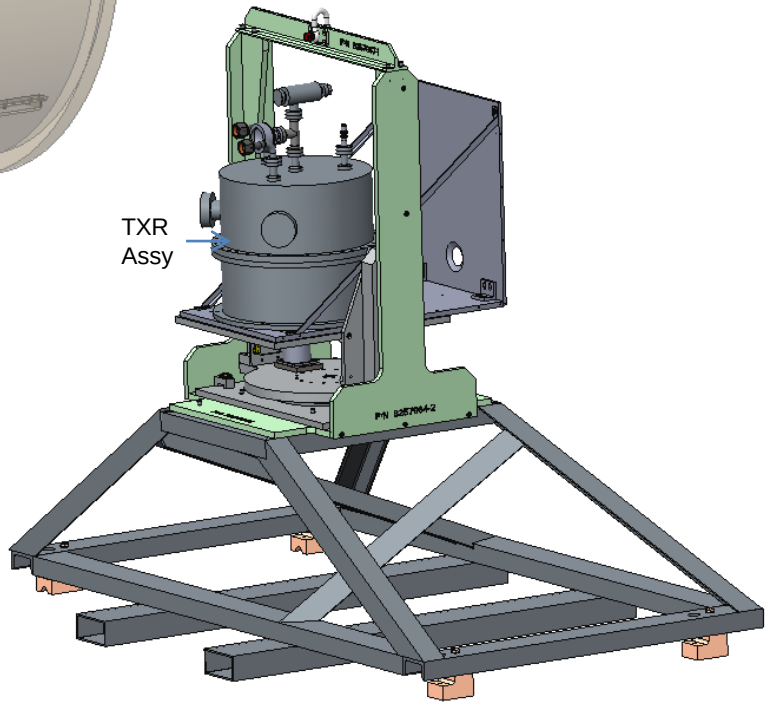


Uncertainty Roll-up Confirmed With Measured ECT/SCT Data



Calibration Target Performance Verified by NIST Following TVAC Testing

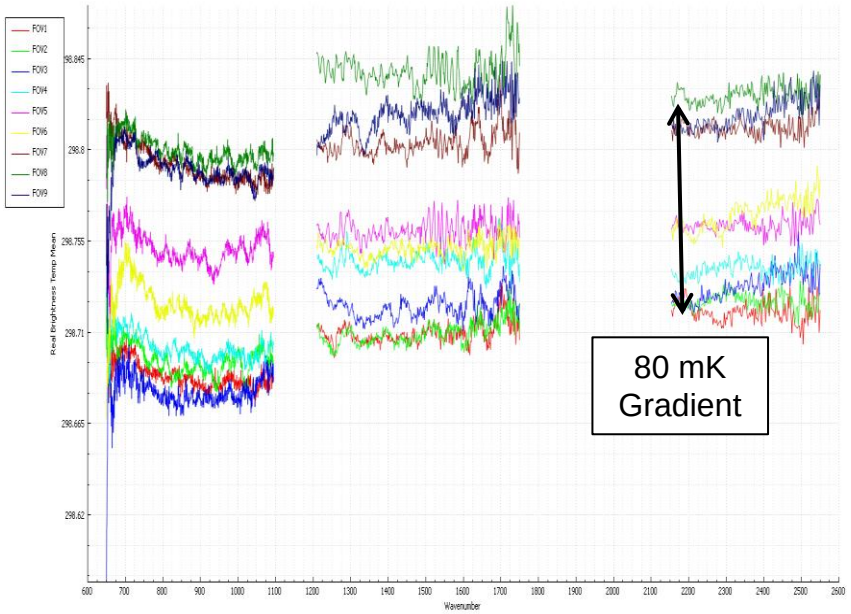




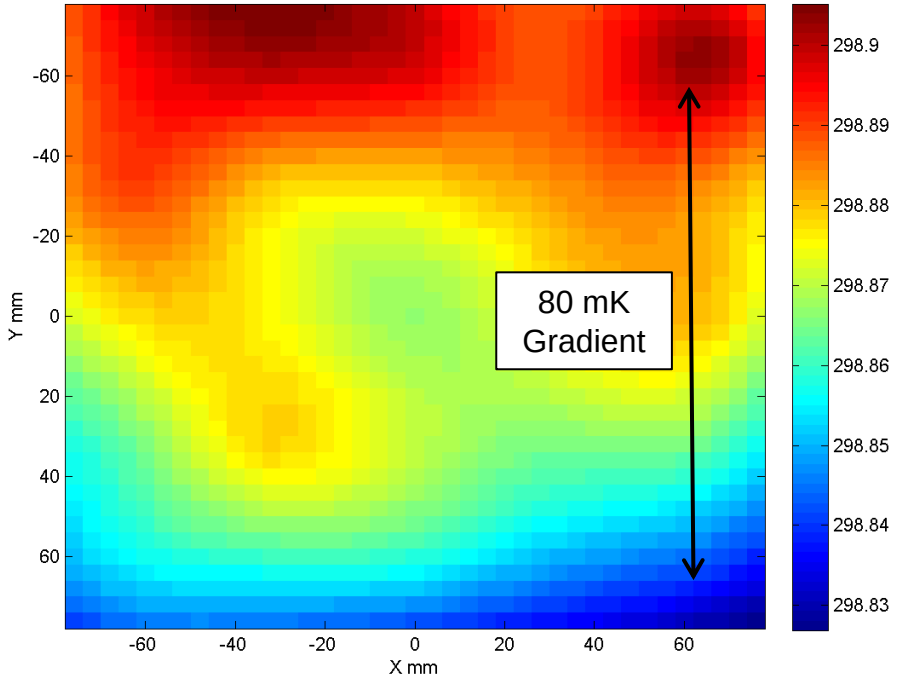
NIST TXR Used to Verify Actual ECT/SCT Temperatures and Measure Thermal Gradients

TXR Testing Verified Target Performance Seen By Sensor During TVAC

Measured CrIS Data



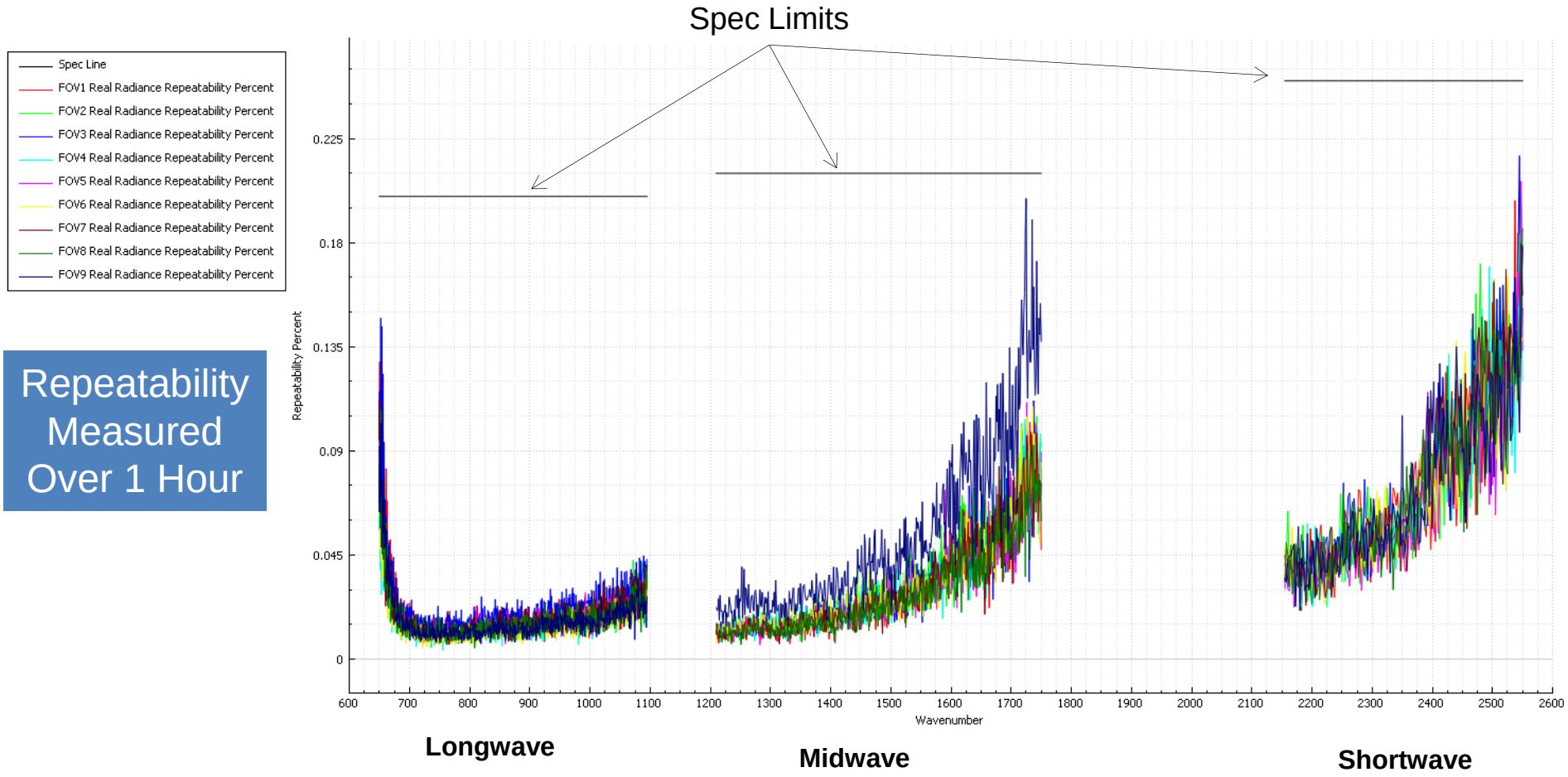
TXR Results



Testing Verified ECT Performance as Seen By Sensor During TVAC;
~80 mK Gradient Matches That Seen By CrIS

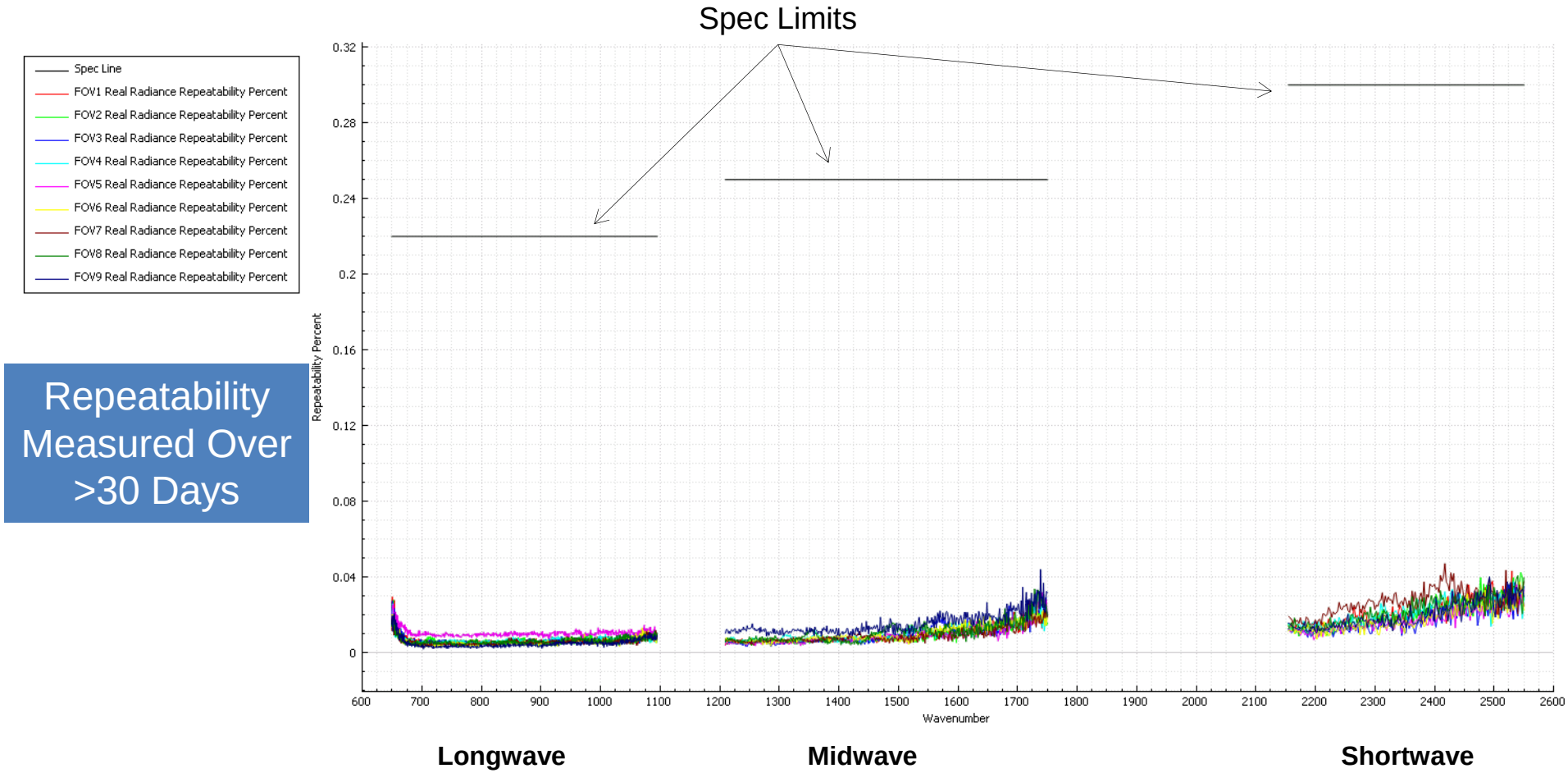
see Rice, et.al., '*Measurements of the Harris J1 CrIS ECT and SCT Calibration Sources Using the NIST TXR*' for further detail

Short Term Repeatability Performance Within Specification



Repeatability Measured Over 1 Hour

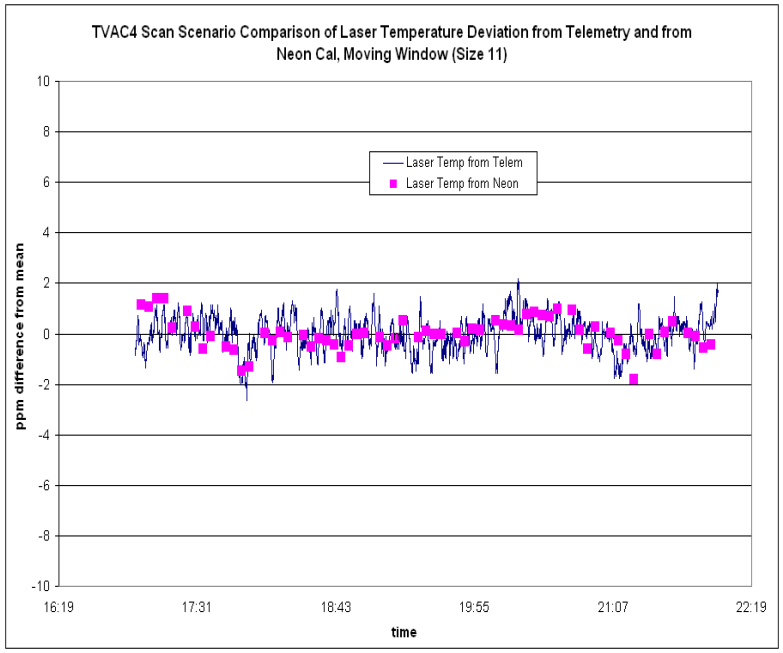
Long Term Repeatability Performance is Outstanding



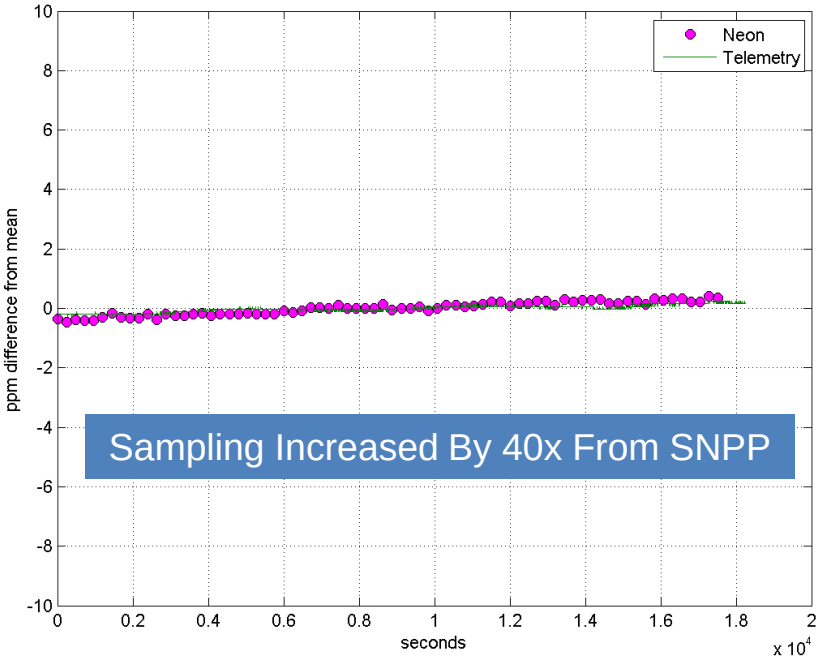
Repeatability Measured Over >30 Days

‘Day in the Life’ Test Demonstrates Even Better Spectral Stability Than SNPP

SNPP



J1



J1 Performance Improved by ~10x From SNPP;
Expected to Provide Improved Spectral Accuracy On-Orbit

J1 CrIS Ready for Launch

J1 CrIS completed comprehensive test program

- Excellent performance during all phases
- Performance as good or better than SNPP

Spacecraft testing underway

- CrIS integrated to J1 spacecraft in March 2015
- Successful Vibration and EMI test phases completed
- Spacecraft TVAC testing upcoming

JPSS currently scheduled for launch in January 2017

CrIS Sensor Ready to Support Successful JPSS-1 Mission

J1 FULL RESOLUTION OPERATING MODE

CrIS Baseline Operating Mode is Now 'Full' Spectral Resolution

SNPP began mission in 'nominal' resolution operation

- 'Nominal' = 0.625 cm^{-1} resolution for LWIR, 1.25 cm^{-1} for MWIR and 2.5 cm^{-1} for SWIR
- 'Full' = 0.625 cm^{-1} for all bands
- Original purpose was to reduce data rate to minimize spacecraft downlink
  - MWIR/SWIR interferograms simply truncated on-board prior to downlink

Science users expressed interest in full resolution data, especially for SWIR

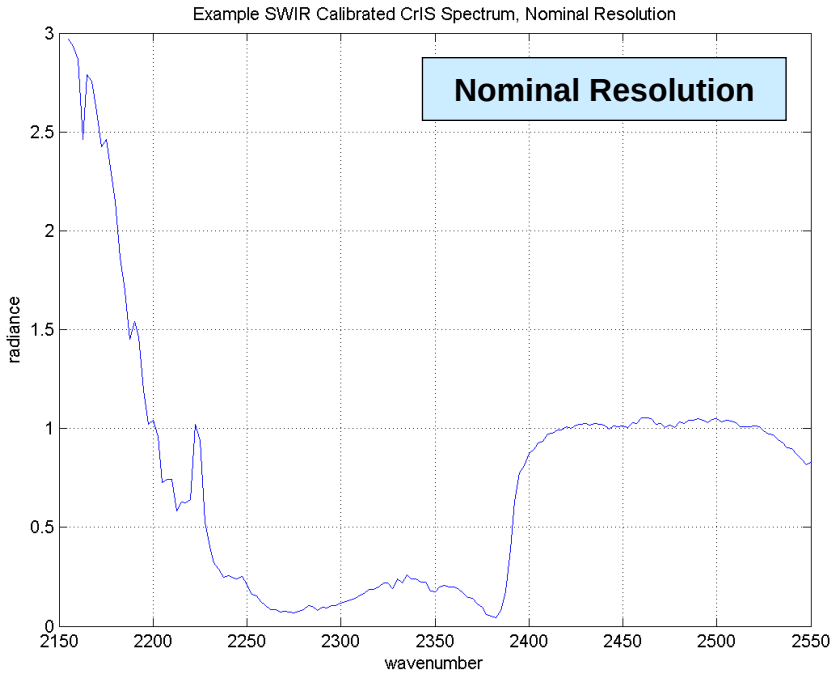
- Many trace gas lines be resolved with improved SWIR spectral resolution
- Spacecraft data rate could be met by removing two FOVs from direct broadcast

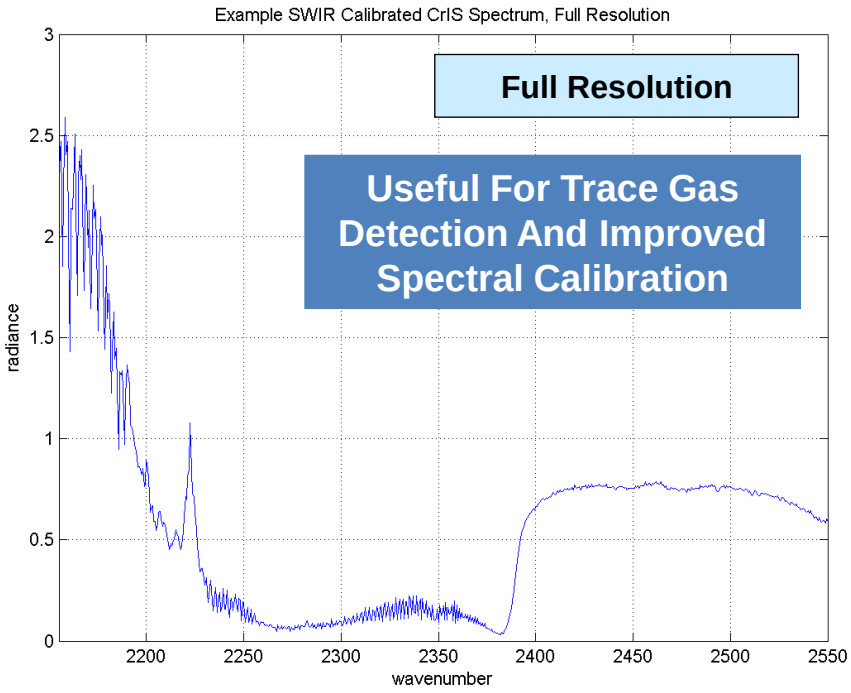
SNPP CrIS transitioned to full-resolution operations in December 2015

- Full resolution is now baseline operation for all CrIS sensors, including J1

Full Resolution Data Provides Much Improved Spectral Calibration

- **Full resolution allows for independent spectral calibration of SWIR band**
  - No scene content resolved in nominal resolution
  - Also allows improved spectral calibration of MWIR band
- **Data will be used to derive more accurate calibration parameters during J1 post-launch characterization tests**
  - MWIR/SWIR calibration expected to be more accurate with improved spectral resolution
  - Improved calibration demonstrated with SNPP data





J2-J4 PRODUCTION STATUS

J2-J4 Instrument Currently in Production

- J2 Status
  - Optics and interferometer currently under procurement
  - CCAs being built and tested
  - ICT PRTs under calibration
  - System test scheduled to start May 2017
  - Ship date currently set for May 2018

- J3-J4 Status
  - Procurements are underway to support J3-J4 builds
  - J3 expected ship date: 6/2020
  - J4 expected ship date: 1/2022

SUMMARY

CrIS Instruments Continue Excellent Performance

SNPP on-orbit performance is very stable

- No performance/hardware degradations observed

Full resolution operation implemented for SNPP forward

- Improves MWIR/SWIR spectral calibration

J1 noise and radiometric uncertainty performance equal to or better than SNPP

- New ICT design provides better calibration performance
- Ground calibration target performance validated by NIST testing

J2, J3 and J4 sensors currently in production