A Summary on NPP CrIS SDR Post-launch Calibration/Validation Activities and Preliminary Results

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NOAA/Center for Satellite Applications and Research

AMS Annual Meeting
January 22-26, 2012
New Orleans, LA
(8:30 Room 257, 1/24/12)

JPSS CrIS SDR Team Members

The CrIS Sensor Data Record (SDR) calibration and validation (Cal/Val) team is made up of investigators and subject matter experts from

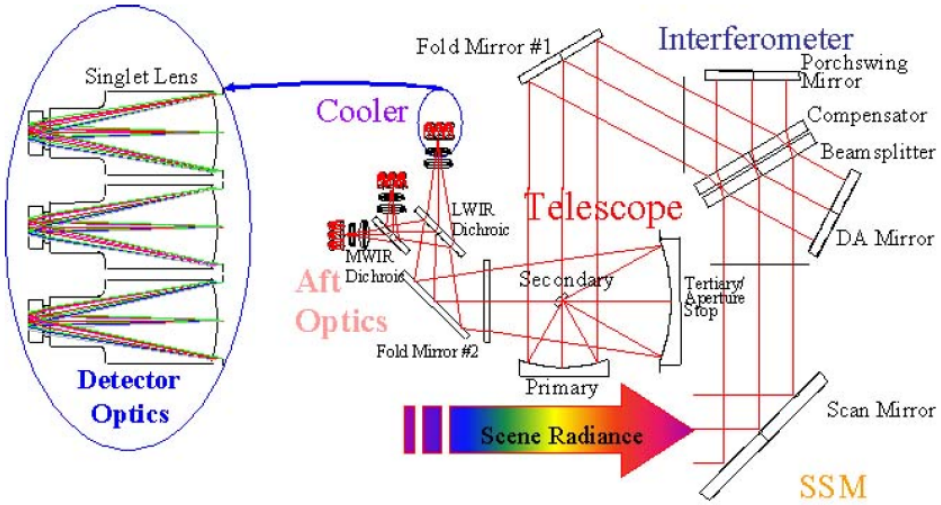
- NOAA Center for Satellite Applications & Research (STAR)
- University of Wisconsin (UW)
- University of Maryland Baltimore County (UMBC)
- Space Dynamics Laboratory/Utah State University (SDL/USU)
- Massachusetts Institute of Technology/Lincoln Labs (MIT/LL)
- Exelis-ITT
- Northrop Grumman Aerospace Systems (NGAS)
- Raytheon
- NASA Langley Research Center

NPP CrIS Current Status

- NPP was launched on October 28th, 2011
- CrIS was originally scheduled to be powered up on Dec 10th. Unfortunately, the activation process was postponed until January 18th, 2012

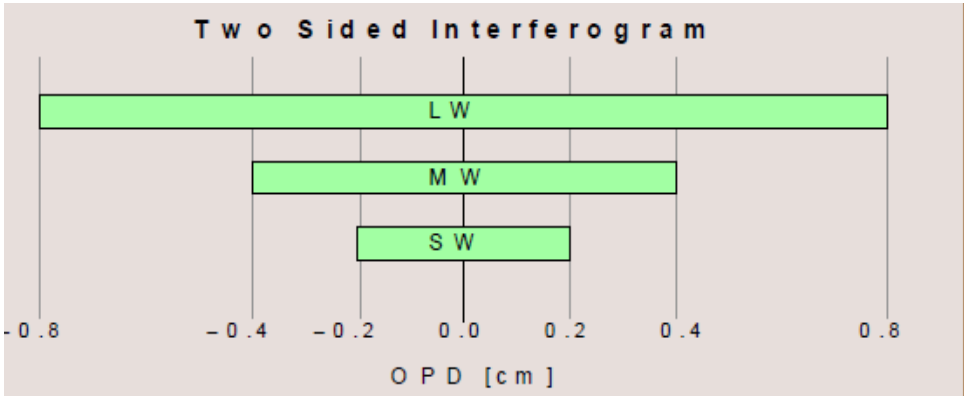
This presentation will provide an overview of the CrIS instrument, SDR algorithm and post-launch Cal/Val activities and CrIS firstlight data acquired on January 20th 2012 or after.

CrIS: A Fourier Transform Spectrometer



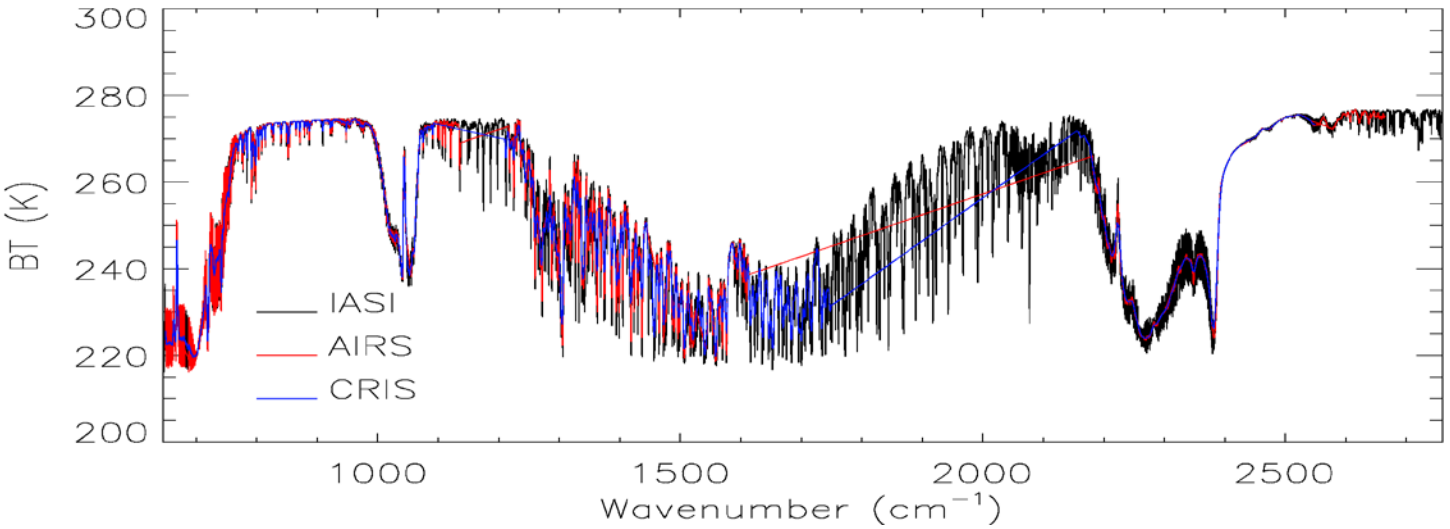
CrIS Optical system

CrIS optical path difference (OPD)



CrIS Spectral Parameters

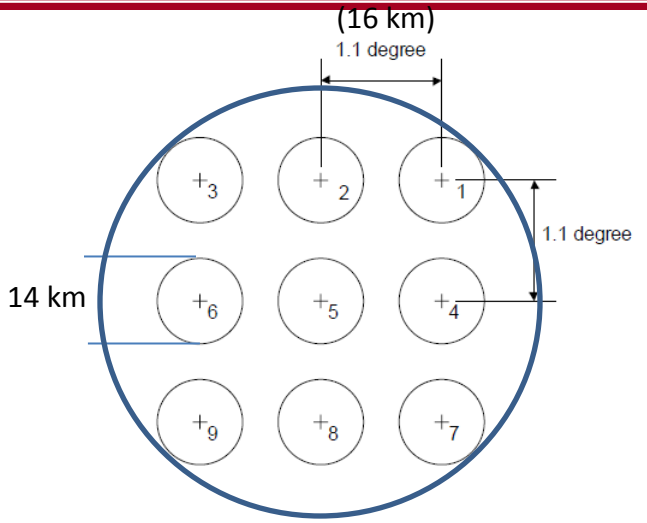
Band	Spectral range [cm^{-1}]	Spectral range [μm]	Band width [cm^{-1}]	Resolution $\Delta\sigma$ [cm^{-1}]	MPD [cm]
LW	650 – 1095	15.4 – 9.1	445	0.625	0.8
MW	1210 – 1750	8.3 – 5.7	540	1.25	0.4
SW	2155 – 2550	4.6 – 3.9	395	2.5	0.2



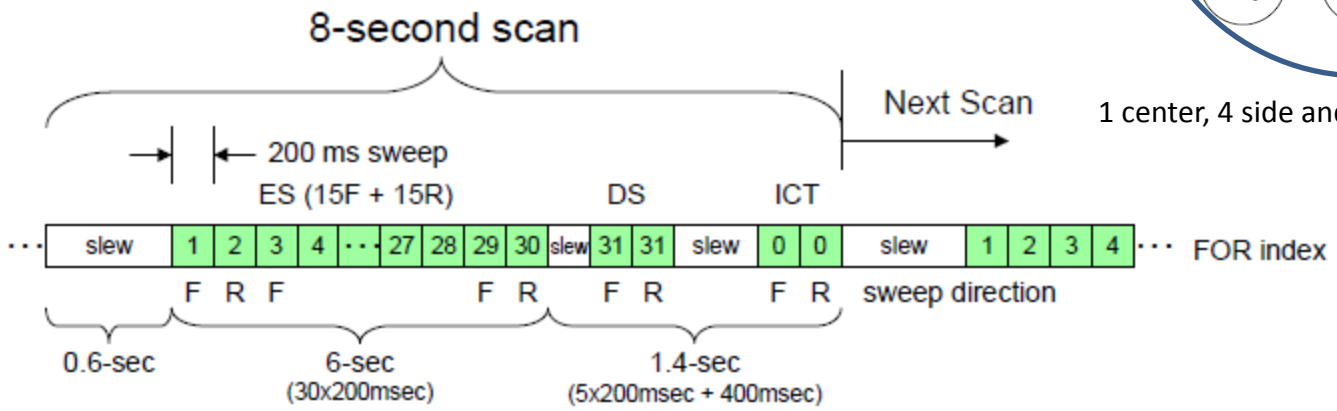
Simulated CrIS spectrum overlaid with IASI and AIRS spectra

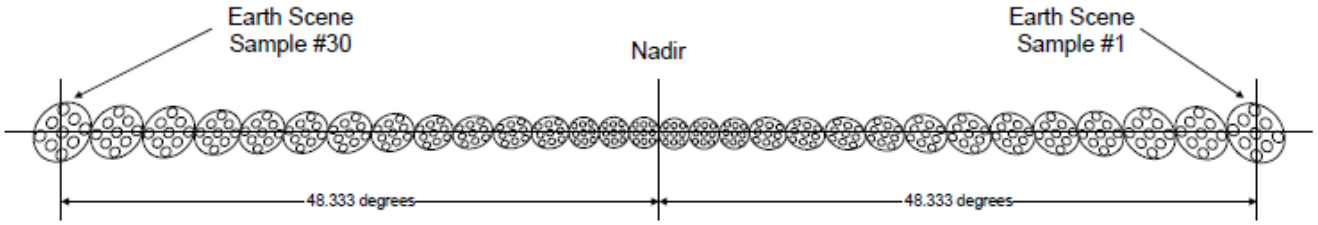
CrIS FOVs and Measurement Sequence

- Each Field of Regard (FOR) has 9 Fields of View (FOVs)
- Each cross-track scan has 30 FOVs of Earth scene (ES), 2 deep space (DS) views and 2 Internal Calibration Target (ICT) views



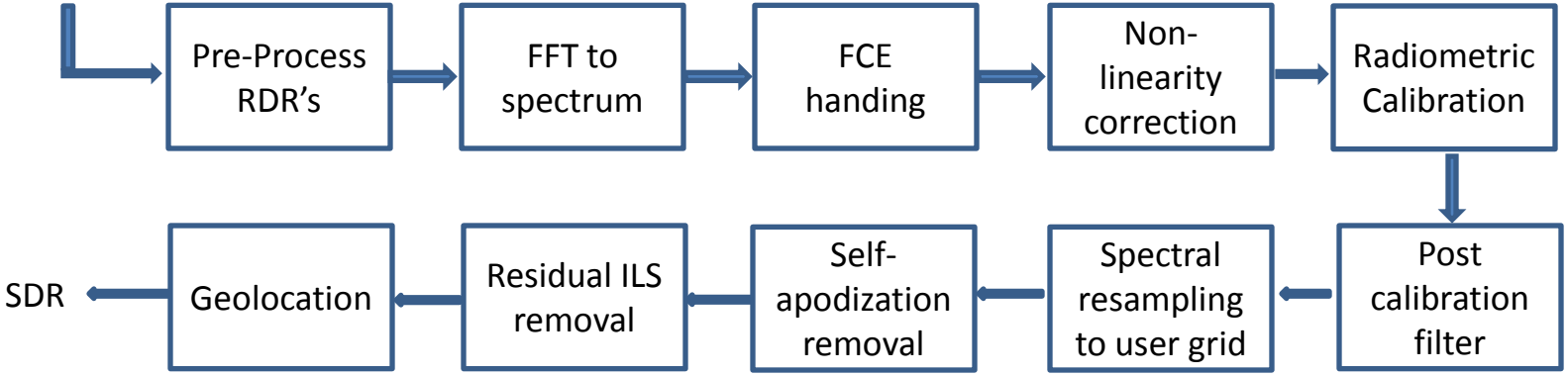
1 center, 4 side and 4 corner FOVs in each FOR





CrIS SDR Algorithm Flow Diagram

RDRs:
Interferograms
8 sec science Telemetry
4 min Engineering packet



- The SDR algorithm: remove instrument effects and produce calibrated Earth scene spectra
- All calibration coefficients are included in the Engineering packets
- The raw data, SDR algorithm and calibration coefficients will be validated and adjusted during the post-launch CalVal process

CrIS SDR Algorithm: Non-linearity Correction

- Detector non-linearity:

$$Interferogram_{non-linear} = (Interferogram_{ideal} + V) - a_2 (Interferogram_{ideal} + V)^2 + \ldots$$

a2 – Non-linearity coefficient
V – DC voltage at the detector/preamp output

$$Spectrum_{non-linear} = (1 - 2a_2 V) Spectrum_{ideal} - a_2 (spectrum_{ideal} \otimes spectrum_{ideal})$$

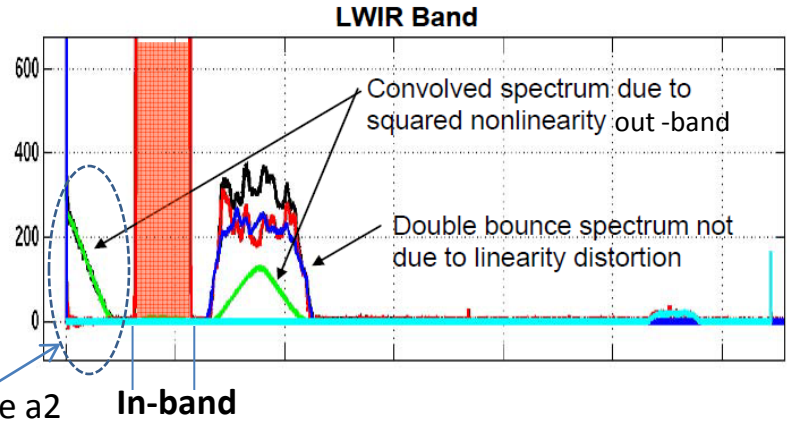
In-band signal

- Out of band
- Does not overlap with the in-band signal
- Can be used to estimate a_2

- Corrected spectrum:

$$Spectrum_{ideal} = Spectrum_{non-linear} / (1 - 2a_2 V)$$

The a2 coefficients will be validated/adjusted in the post-launch Cal/Val process



Post-launch Cal/Val Phases and SDR Product

- Calval Phases:
  - **EOC**: Early Orbit Checkout, ~20 days, starting from January 18th. Perform interferometer optimization.
  - **ICV**: Intensive Calibration/Validation, 6 months, starting from the end of EOC, from February to August 2012.
  - **LTM**: Long-term Monitoring, from the end of ICV to the end of mission, starting in August 2012.
- SDR Product Maturity level
  - **Beta**:CrIS SDR available on March 3rd 2012 (Engineering Packet V33).
  - **Provisional:** CrIS SDR (initial calibration applied; product may not be optimal), ready August 30th 2012 (Engineering Packet V34)
  - **Validated**: CrIS SDR, available on November 30th 2012.

Post-launch Cal/Val Tasks

CrIS SDR Team ICV Cal/Val Tasks	
Bit Trim and Impulse Mask Checks	Double-difference Cross Comparison with AIRS and IASI
Spike Analysis	SNO Cross Calibration with AIRS and IASI
Ice Contamination Analysis	Error Budget Assessment
Correlated/Uncorrelated noise characterization	Early Broadband Radiance Comparisons with GOES and Others
Detector Linearity Check and Adjustment	Responsivity and Sensitivity Characterization
Spectral Calibration	Artifact Analysis with Principle Component Analysis
ICT External Environmental Radiance Model Assessment and Tuning	Spectral correction & resampling consistency checks
Geolocation Calibration	Internal Consistency Checks on Radiometric Calibration
Radiance Residual Analysis	RDR and SDR Trending and Monitoring

Cal/Val Methods (1)

- Spectral calibration
  - Determine ILS spectral parameters from clear-scene, ocean, upwelling spectra, using a cross-correlation of observed to computed spectra
  - Inter-satellite/sensor comparisons (IASI, AIRS)
  - Compare center, side and corner FOVs
- Radiometric Calibration
  - Non-linearity check and correction
    - Perform analysis of out-of-band signals in complex spectra and self consistency in calibrated Earth view data
    - Perform analysis of Earth view data using MW FOVs 6 and 9 (with negligible nonlinearity effects) to determine refined nonlinearity coefficients for the other MW FOVs
    - Use AIRS/CrIS and IASI/CrIS SNO analyses and AIRS/CrIS and IASI/CrIS double difference analyses to refine nonlinearity coefficients for the LW FOVs
  - ICT Environmental check and adjustment
    - Compare CrIS and VIIRS radiances as a function of orbital position
    - Track CrIS measured ICT and DS radiances verses ICT PRT temperature
    - Compare channels with similar weighting functions but different ICT emissivities

Cal/Val Methods (2)

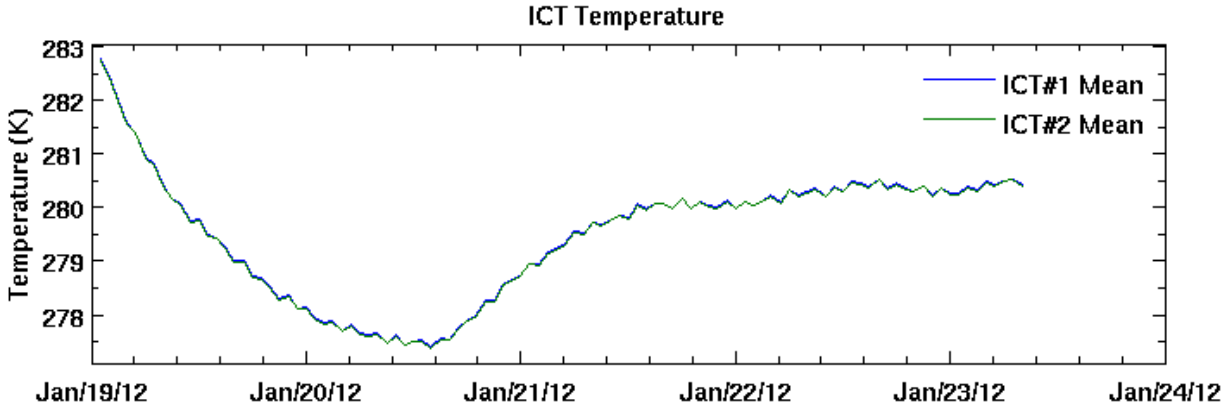
- Radiometric Calibration (continue)
  - FOV radiance intercomparison
  - Double Difference
  - Satellite radiance intercomparision: SNO ,CrIS vs IASI, CrIS vs AIRS
  - Observed minus Calculated (Obs-calc): CrIS vs NWP, CrIS vs Radiosonde, CrIS vs CRTM
- Correlated/Uncorrelated Noise Characterization
  - NEdN analysis
  - Using PCA approach perform estimation of random and spectrally correlated components of total NEdN using calibrated ICT and DS SDRs.
- Geolocation calibration
  - Direct geolocation calibration using coastal boundaries with large thermal gradient imploding CrIS window channels .
  - Geolocation calibration using CrIS versus VIIRS coastal boundaries crossing
  - CrIS geolocation calibration/validation with respect to VIIRS SDRs
- Long-term trending and monitoring
  - Telemetry parameter, noise and SDR status trending
  - Radiance and sensor performance monitoring
  - Anomaly detection.

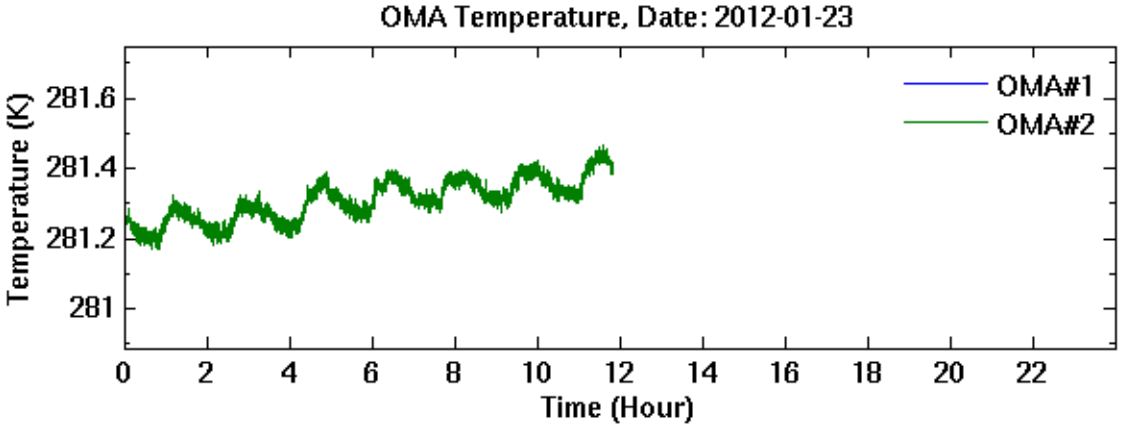
CrIS Firstlight

CrIS science data available since January 20th 2018 (normal mode of data acquisition).

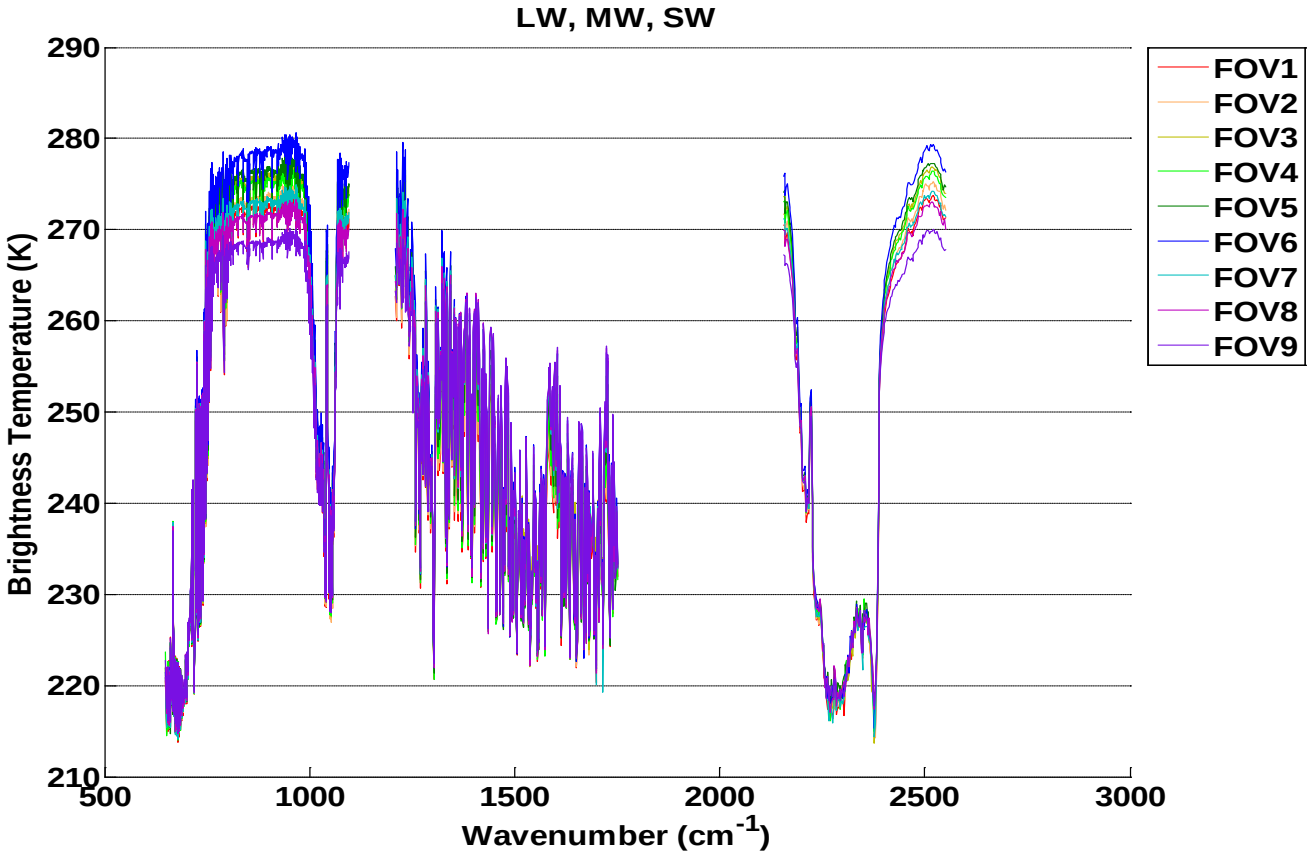
Uses TVAC calibration coefficient (Engineering packet version 31).

ICT and OMA Temperature





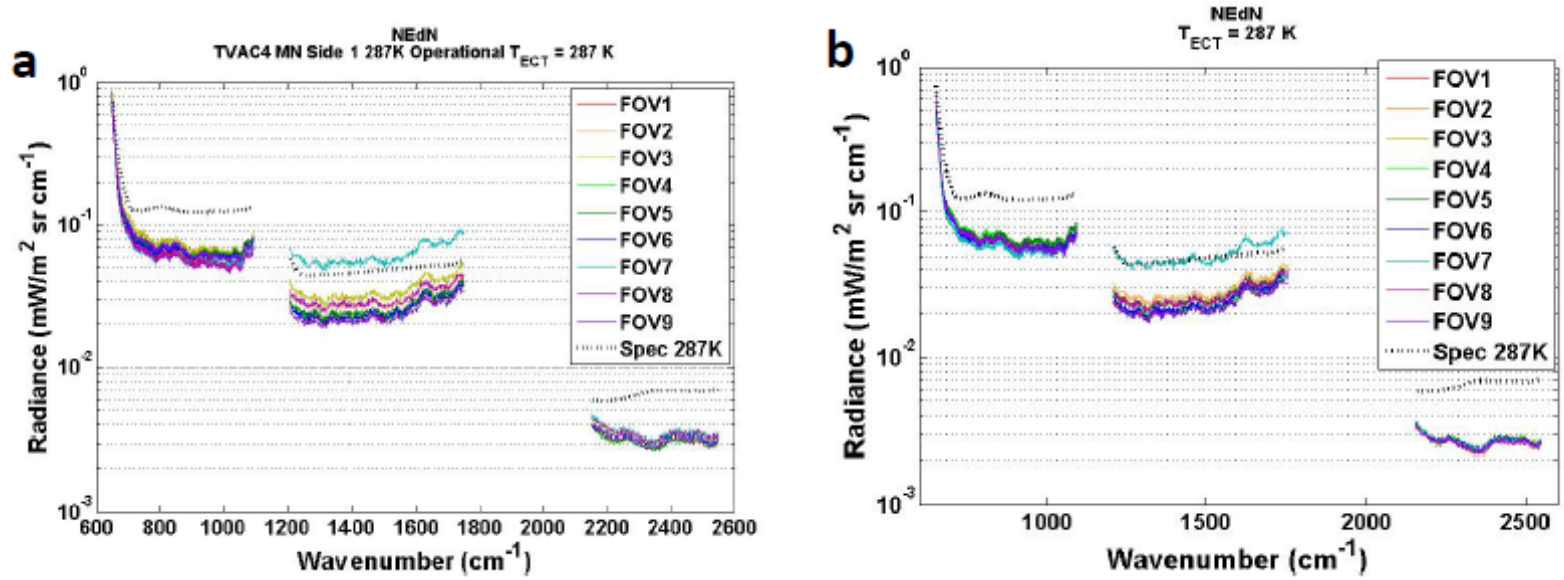
FOR1



Courtesy of SDL

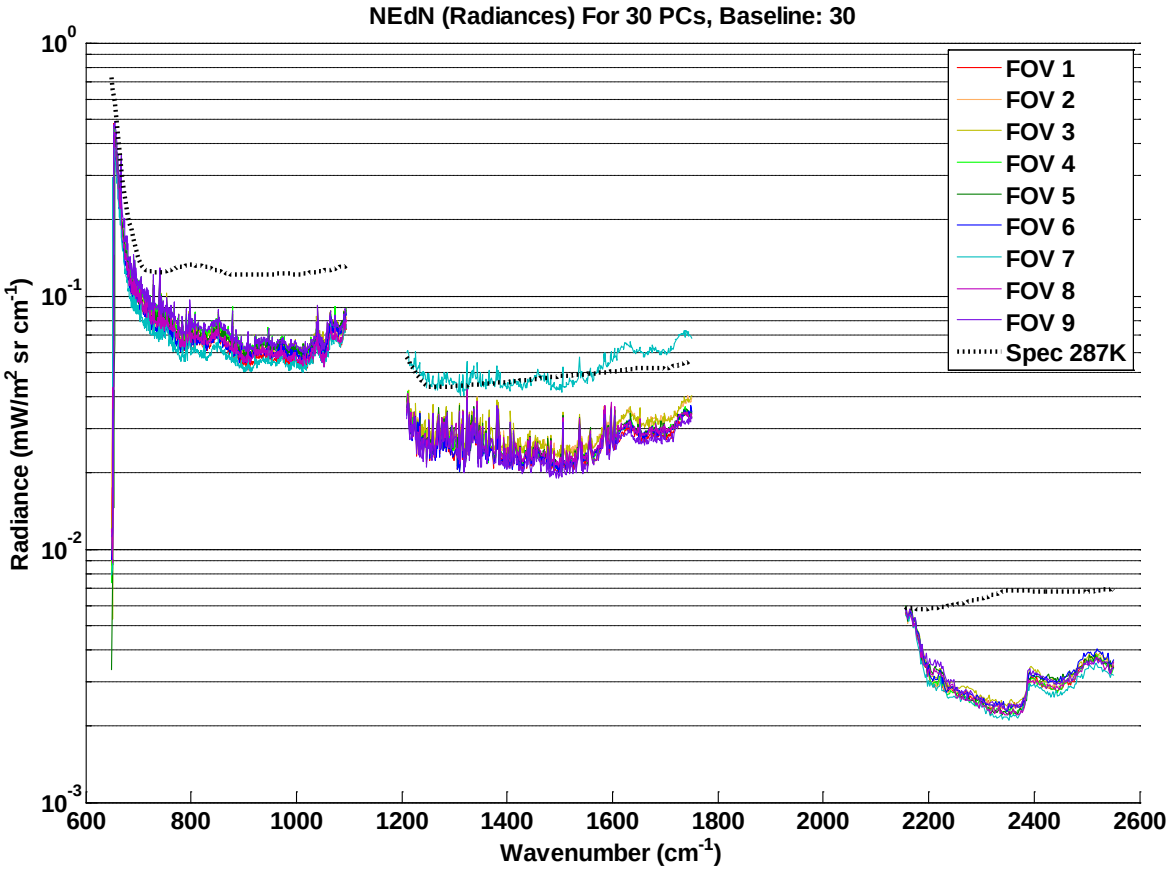
Processed with CrIS SDR PC V2.18.

TVAC CrIS NEdN



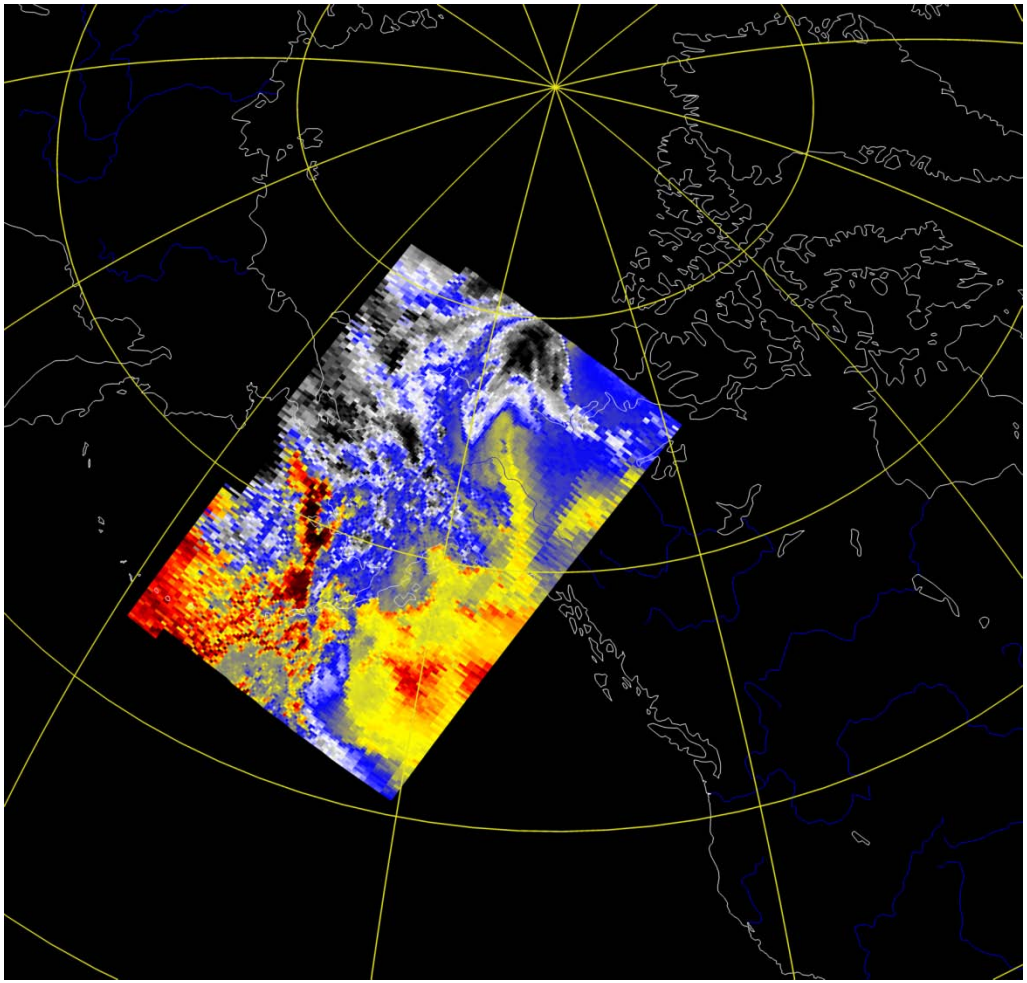
Nominal CrIS NEdN performance during TVAC4 (a) and S/C integration TVAC (b) tests (Vladimir et al., Proc. SPIE, September , 2011)

On-orbit NEdN



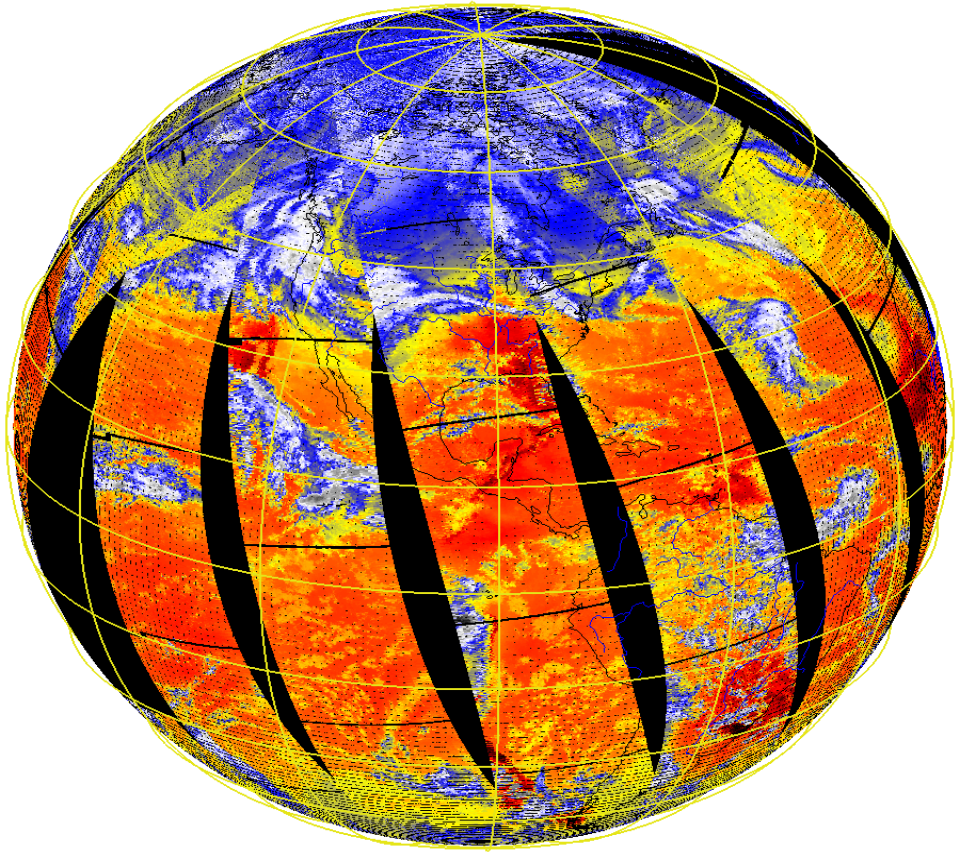
Courtesy of SDL

Brightness Temperature (900 cm^{-1})



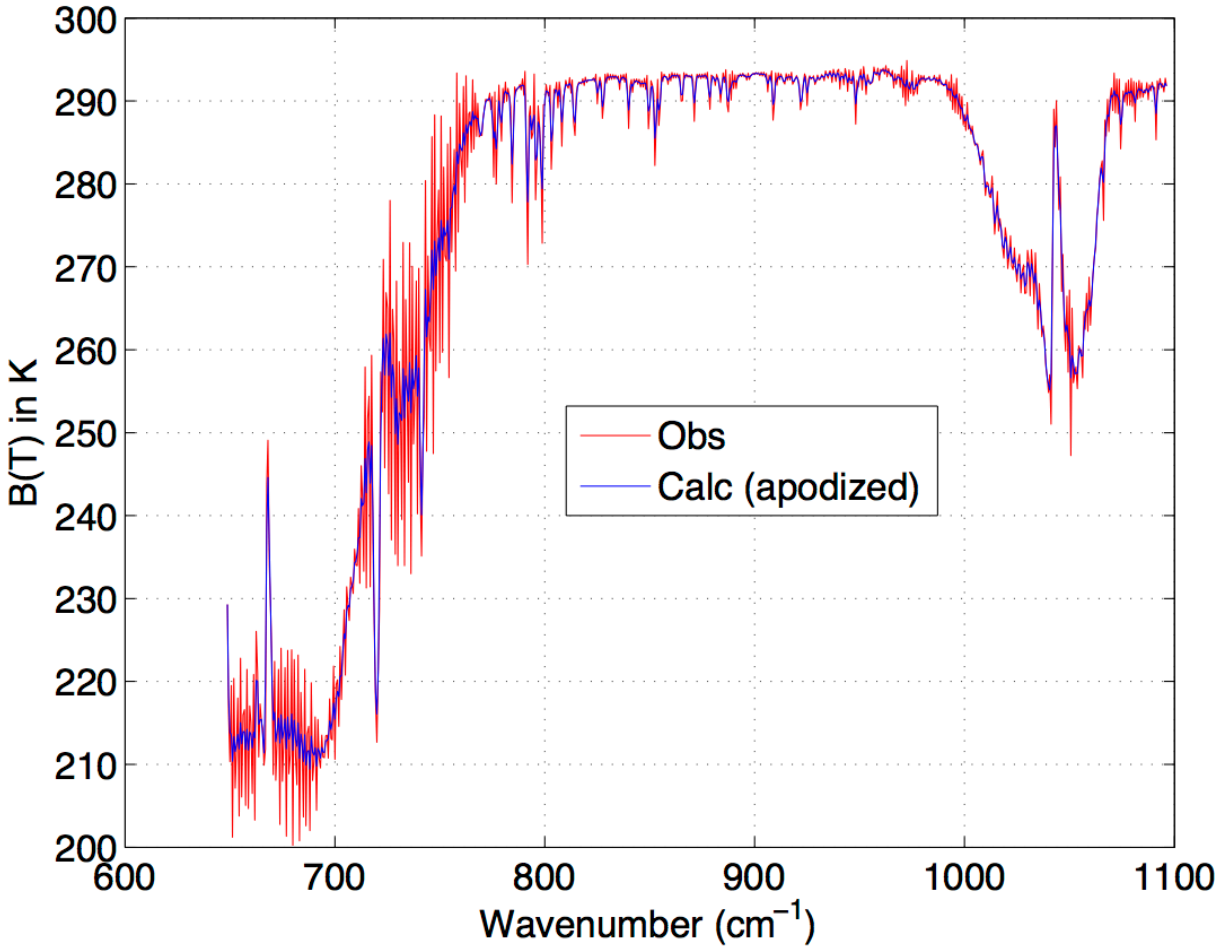
Courtesy University of Wisconsin

Brightness Temperature (900 cm^{-1})



Courtesy University of Wisconsin

CrIS minus ECMWF (obs-calc)



Courtesy of UW and UMBC, clear sky over ocean

Summary

- NPP CrIS was powered up on Jan. 18th, 2012. The CrIS SDR team is working on its calibration and validation.
- The goal of the planned post-launch Cal/Val activities is to provide well-calibrated CrIS SDR/EDR data for NWP models and climate studies.
- Cal/Val team is a unified group comprised of Subject Matter Experts from government, academia and industry.
- The team has developed and tested various Cal/Val tools and methods and is well prepare to perform various Cal/Val tasks in the three Cal/Val phases: EOC, ICV and LTM.
- Firstlight data have been acquired.

CrIS shall improve weather forecasting capability.