CrIS SDR LongTerm Monitoring, High Resolution Processing, and Data Analysis of FM2 Bench Data Set

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and

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Outline

- CrIS Long Term Monitoring
- CrIS High Resolution SDR product (radiance) and CO retrieval.
- Processing of FM2 Bench Test
- Summary

Related Presentations

- Comparison of Full-resolution S-NPP CrIS Radiance with Radiative Transfer Calculations – Xu Liu
- Radiometric and Spectral Consistency of Hyperspectral Infrared Sounders– Likun Wang
- Assessment of CrIS Full Resolution SDR Radiometric ans Spectral Accuracy Using Community Radiative Transfer Model – Yong Chen

S-NPP CrIS Overall Status

- Radiometric, spectral, and noise performances meet specification with margin.
- Very low noise due to a combination of the dynamic alignment, on-board digital filter, optical design
- Excellent spectral calibration (< 2ppm) due to the presence of the on-board neon lamp. Spectral calibration stability also due to the CrIS structural frame (Be-Al alloy).
- Impulse noise is very rare event.
- No FCE due to the presence of a lock-in mechanism.
- No ice contamination.

NPP CrIS Sensor Data Record (SDR) Requirements

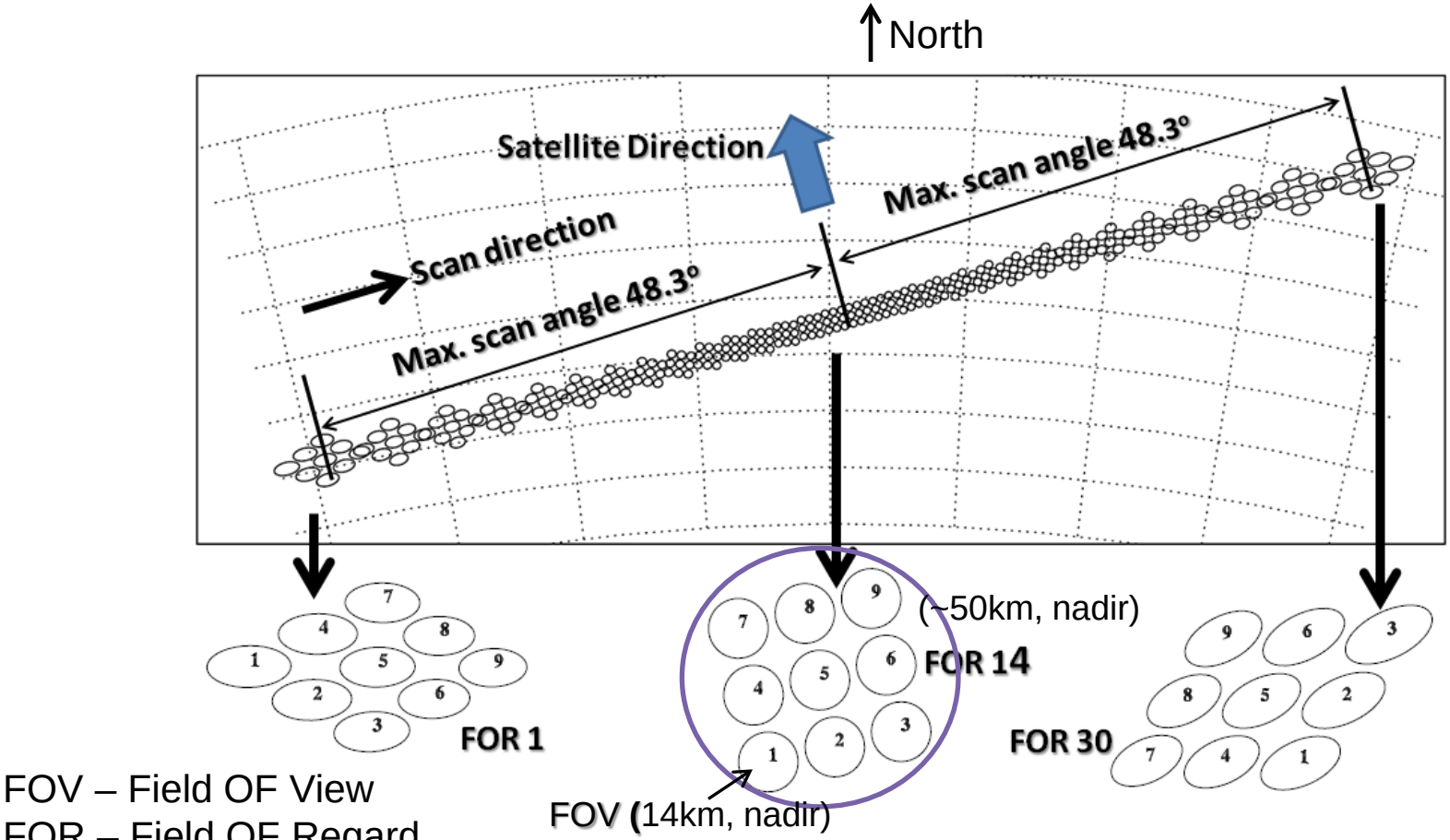
Band	Spectral range (cm^{-1})	N. of chan.	Resolution (cm^{-1})	FORs per Scan	FOVs per FOR	NEdN@287K $mW/m^2/sr/cm^{-1}$	Radiance Uncertainty (%)	Spectral uncertainty ppm	Geolocation uncertainty km
LW	650-1095	713	0.625	30	9	0.14	0.45	10	1.5
MW	1210-1750	433	1.25	30	9	0.06	0.58	10	1.5
SW	2155-2550	159	2.5	30	9	0.007	0.77	10	1.5

ppm – part per million

FOV – Field OF View
FOR – Field OF Regard

CrIS SDR spectra are un-apodized

Scan, FOR & FOV Position

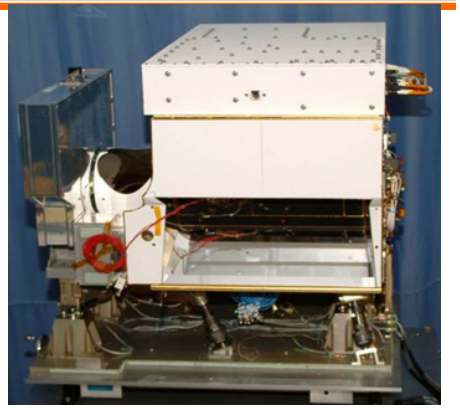


FOV – Field OF View
FOR – Field OF Regard

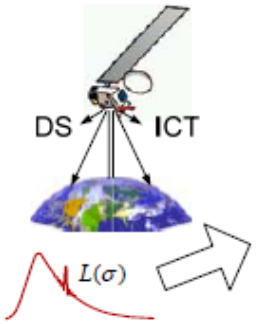
- 2200 Km Swath (FOR1 to FOR 30).
- CrIS surveys 1 scan line every 8 seconds.
- CrIS acquires 8.7 million spectra per day.

CrIS Space Segment Processing

Cross-track Infrared Sounder (CrIS)

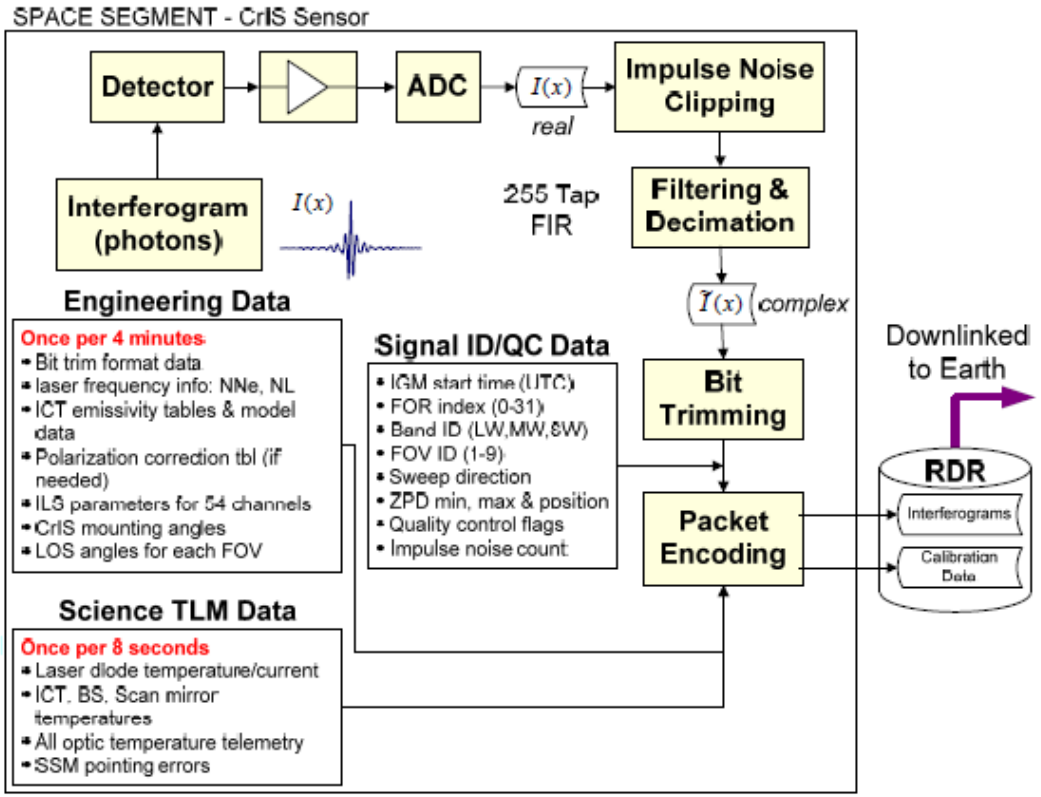


Volume: < 71x80x95 cm
Mass: 146 kg
Power: < 110 W



Observed scene
(three different types)

ES: Earth Scene
DS: Deep Space
ICT: Internal Calibration Target

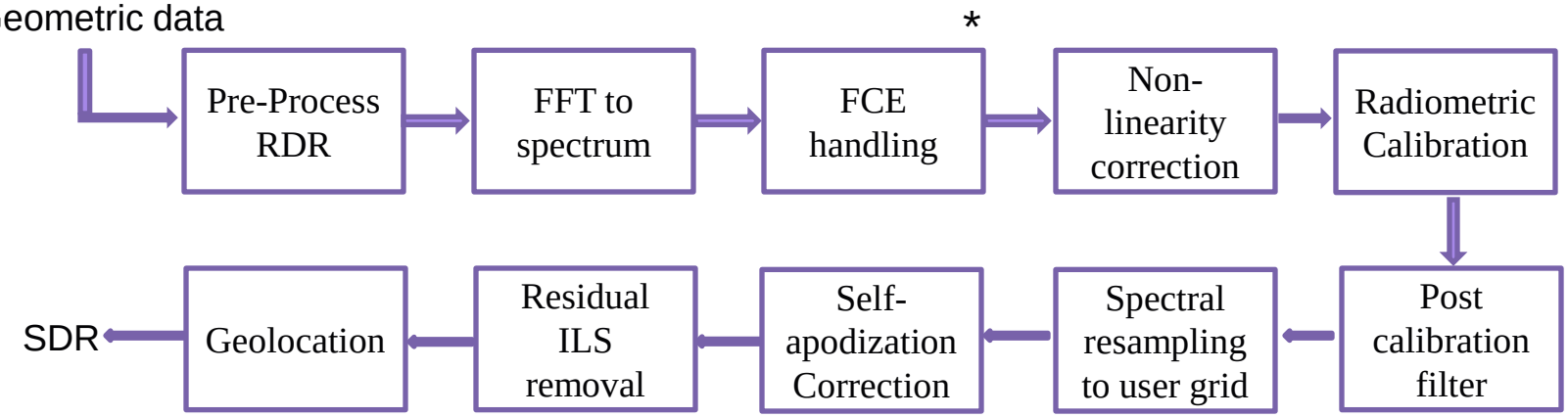


RDR - Raw Data Record

All calibration parameters are included in Engineering packet embedded in downlink data streams to the exception of the digital FIR filter which is in the PCT file.

CrIS SDR Algorithm Data Flow

RDRs:
Science Interferograms (APID 1315 to 1395)
8 sec science Telemetry (APID 1289)
4 minutes Engineering packet (APID 1290)
Geometric data



CrIS SDR Processing Softwares

- Interface Data Processing Segment (IDPS) - operational code
- Algorithm Development Area (ADA) - an offline IDPS code
- Algorithm Development Library (ADL) - Linux version IDPS code
- Team member science codes:
  - Exelis SDR PC code
  - UW/UMBC CCAST (CrIS Calibration Algorithm & Sensor Testbed)
  - MIT/LL SDR code

} For development and CalVal

* FCE Detection and Correction Algorithm disabled.

S-NPP CrIS CalVal Upcoming Activities

- Radiometric performance: New non-linearity (NL) coefficients (a2) and new NL formulation.
- Spectral calibration: New ILS parameters along with new ILS formulation for FOV5.
- New bit trim mask adapted for high resolution data. One day of high resolution RDR will be acquired on August 27/28 2013.
- CrIS assessment of geolocation, noise, stability for Validated maturity level product.
- Validated Maturity product level review planned for November 2013 where the assessment will rely on off-line processing (e.g. ADA, ADL, CCAST). Production software at IDPS will be updated in January 2014.
- CrIS performance trending and monitoring (mission life).

New Non-linearity Formulation

- Change from :

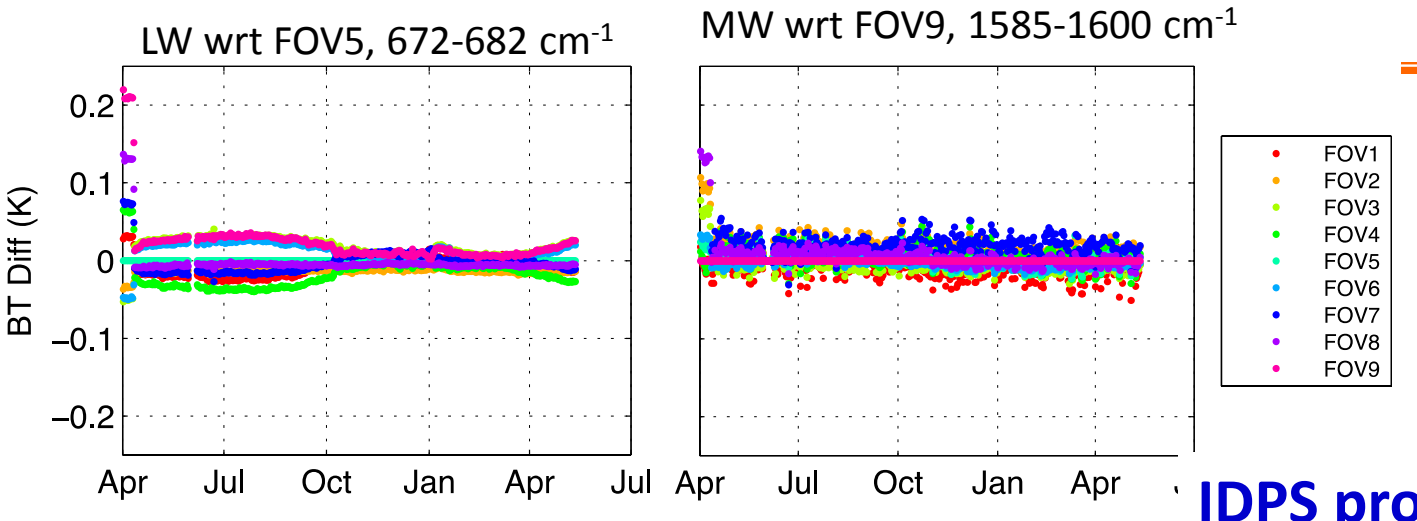
$$C' = C / (1 - 2a_2V)$$

to

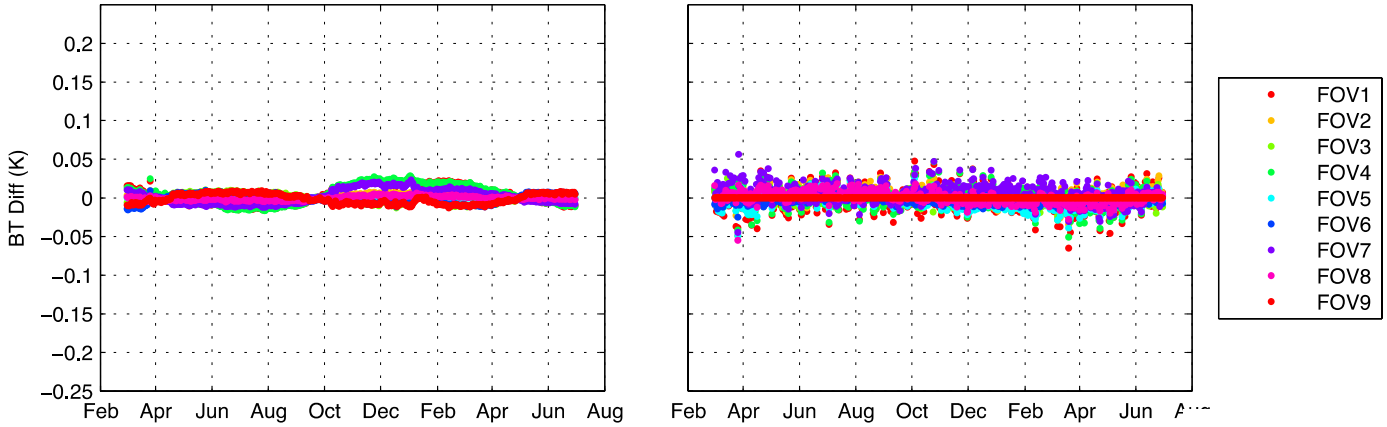
$$C' = C * (1 + 2a_2V)$$

- New a2 coefficients estimated along with the new ILS FOV5 formulation

Effect of Changes: Long term FOV-2-FOV differences



IDPS processing



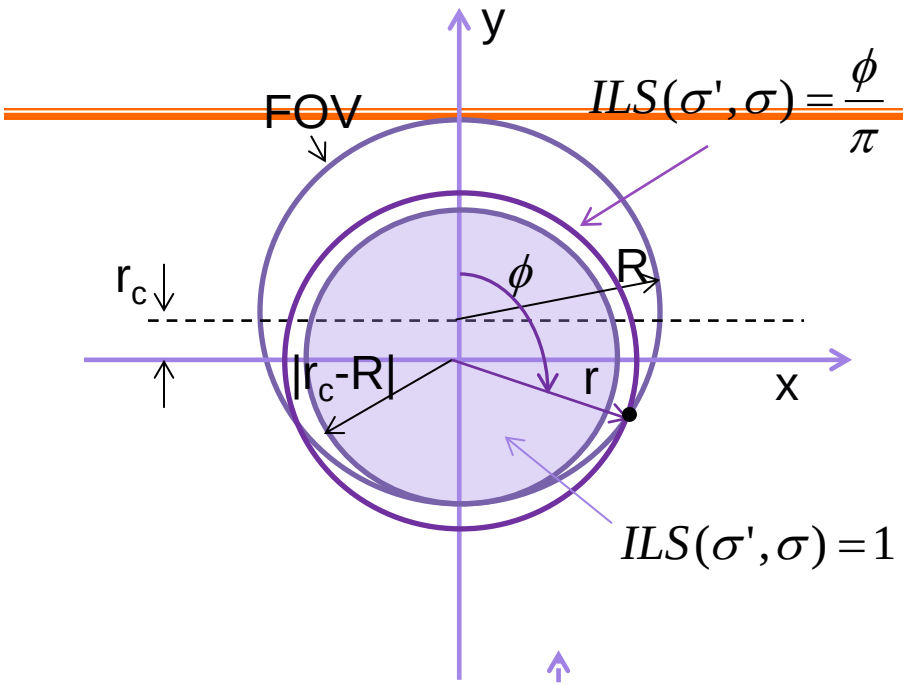
Reprocessed

(Courtesy of UW)

Mean FOV-2-FOV BT diffs over the full time period are (mK):

LW:	3.7	1.3	-0.5	4.0	0	-1.1	1.6	-0.5	-1.7
MW:	-1.3	2.3	-0.7	0.0	-3.5	-3.6	6.6	0.7	0

FOV 5 ILS Equation Derivation

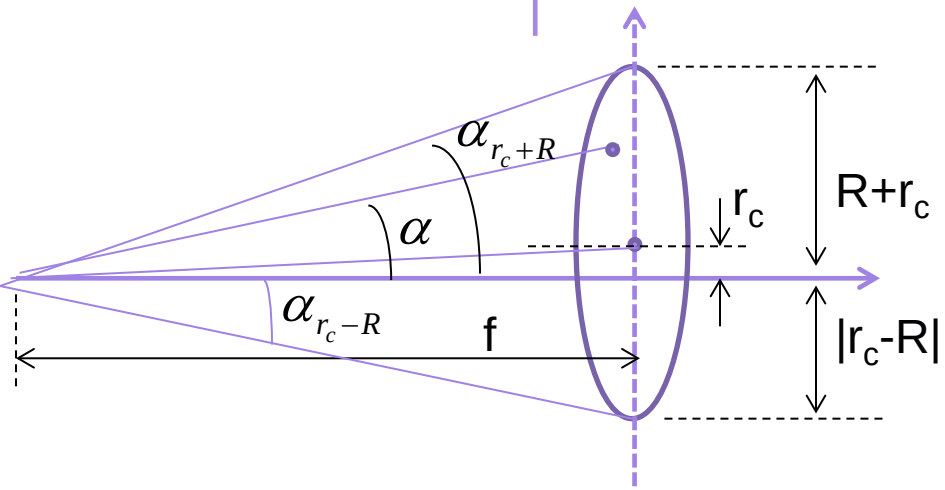


$$\Rightarrow \begin{cases} x^2+y^2=r^2 \\ x^2+(y-r_c)^2=R^2 \end{cases} \Rightarrow$$

$$y=\frac{r^2+(r_c-R)(r_c+R)}{2r_c}$$

$$r=f\sqrt{\frac{\sigma^2}{\sigma'^2}-1} \qquad \begin{aligned} r_c-R &= f\tan(\alpha_{r_c-R}) \\ r_c+R &= f\tan(\alpha_{r_c+R}) \end{aligned}$$

$$if\ r_c<R,\quad \alpha_{r_c-R}<0$$



$$y=\frac{f^2}{2r_c}[(\frac{\sigma^2}{\sigma'^2}-1)+\tan(\alpha_{r_c-R})\tan(\alpha_{r_c+R})]$$

$$\phi=\arccos(\frac{y}{r})$$

$$=\arccos(\frac{(\frac{\sigma^2}{\sigma'^2}-1)+\tan(\alpha_{r_c-R})\tan(\alpha_{r_c+R})}{[\tan(\alpha_{r_c-R})+\tan(\alpha_{r_c+R})]\sqrt{\frac{\sigma^2}{\sigma'^2}-1}})$$

σ – true frequency

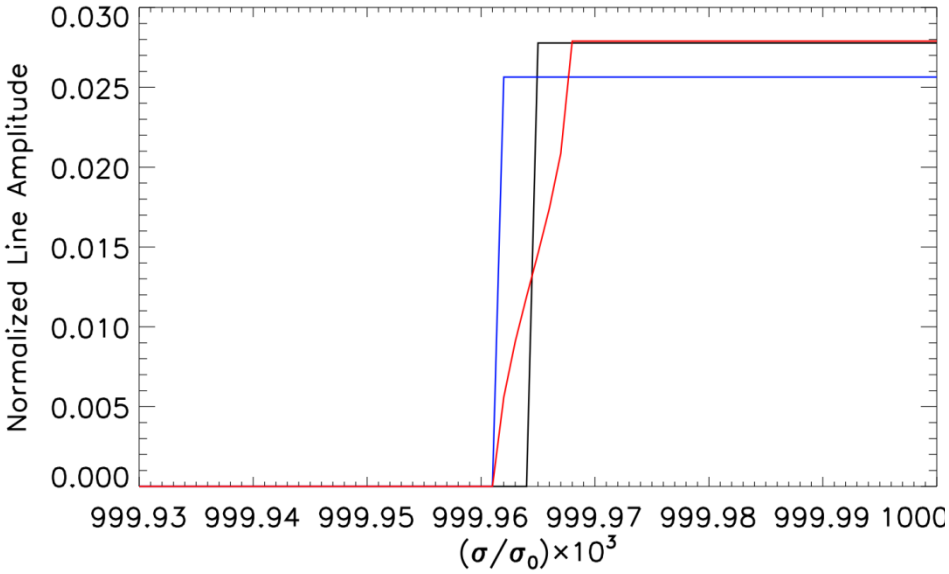
σ’ – shifted frequency

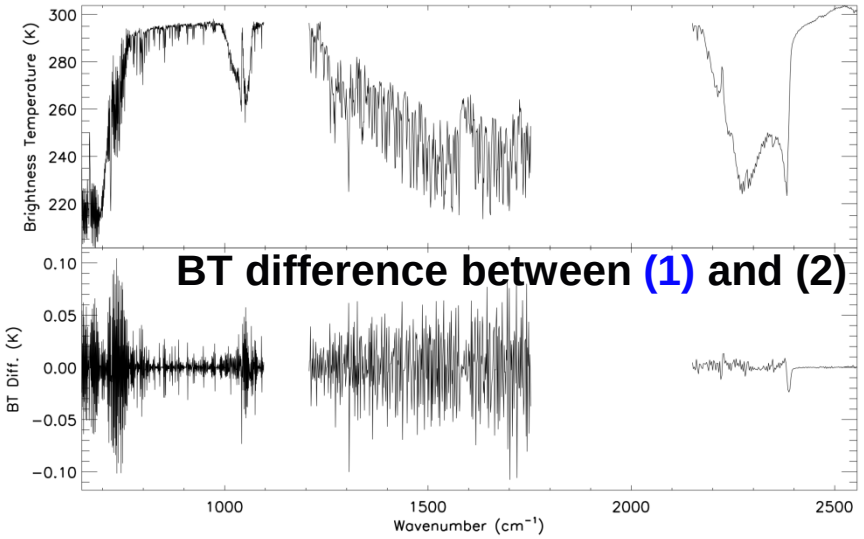
FOV5 Self-apodization Function and Impact on Brightness Temperature

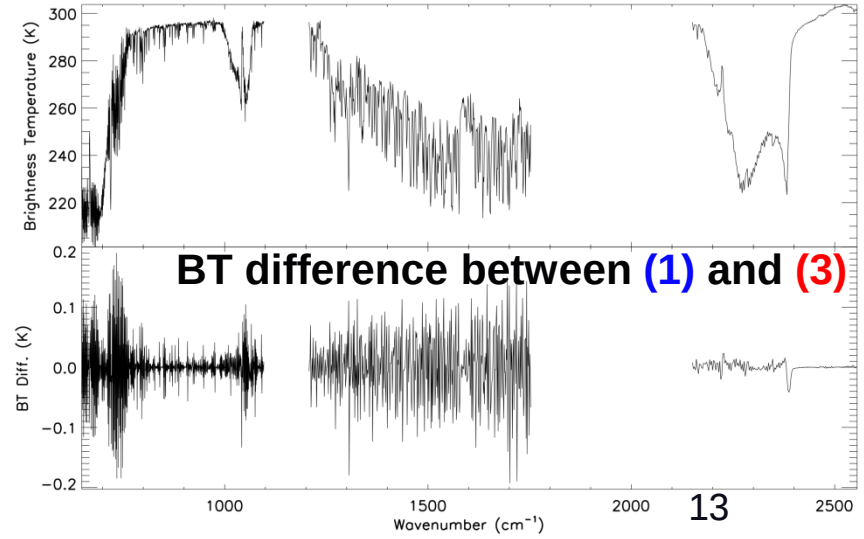
Currently used in IDPS (1)

Assuming center on Axis (2)

After correction (3)

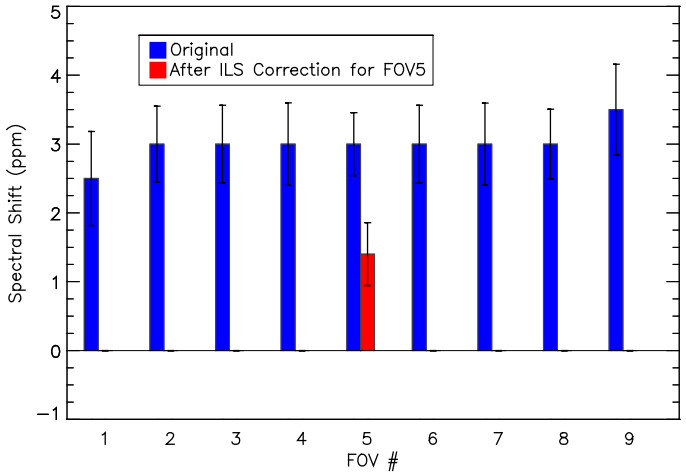




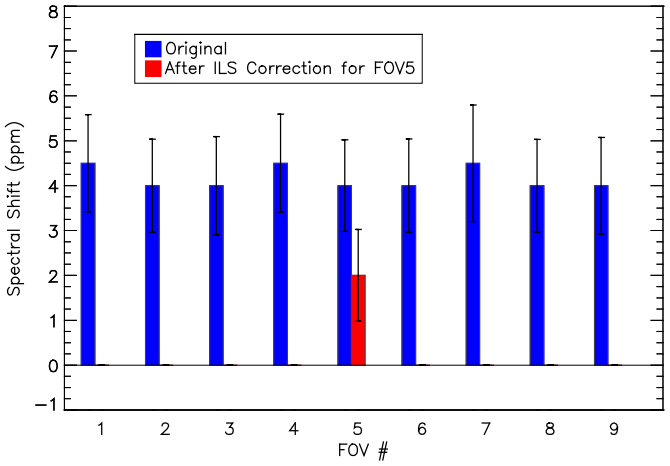


Cross-Correlation of CrIS Spectral between Observations and CRTM Simulations

LWIR



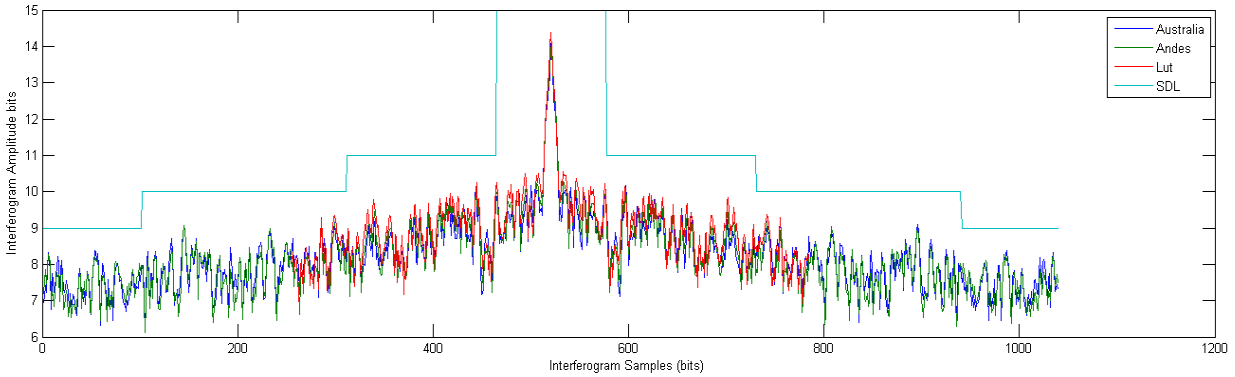
MWIR



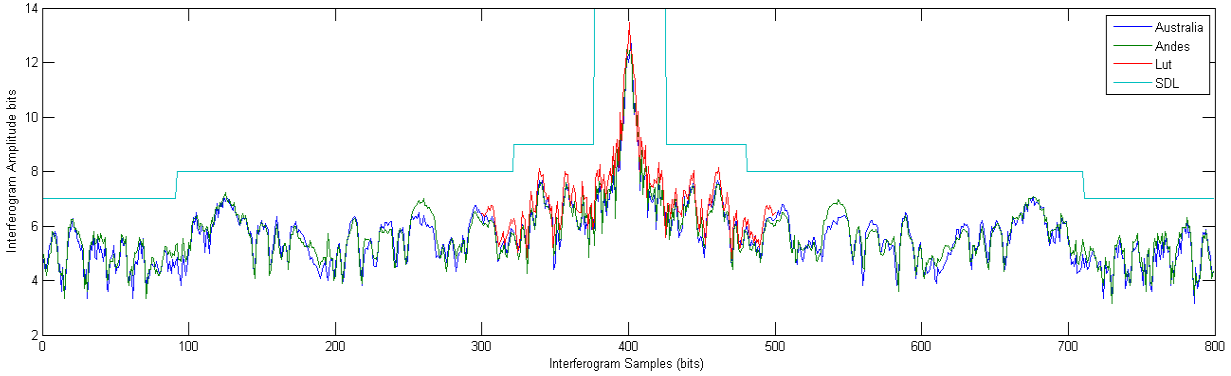
- Cross-correlation method between CrIS observations and CRTM simulations under clear sky over ocean to detect the spectral shift.
- New FOV5 ILS correction reduced the spectral shift for both LWIR and MWIR bands to 1.6 and 2.0 ppm respectively.
- The better fit will help the assimilation of the CrIS radiance into NWP weather forecasting model.

Cross-Correlation of CrIS Spectral between Observations and CRTM Simulations

MWIR



SWIR



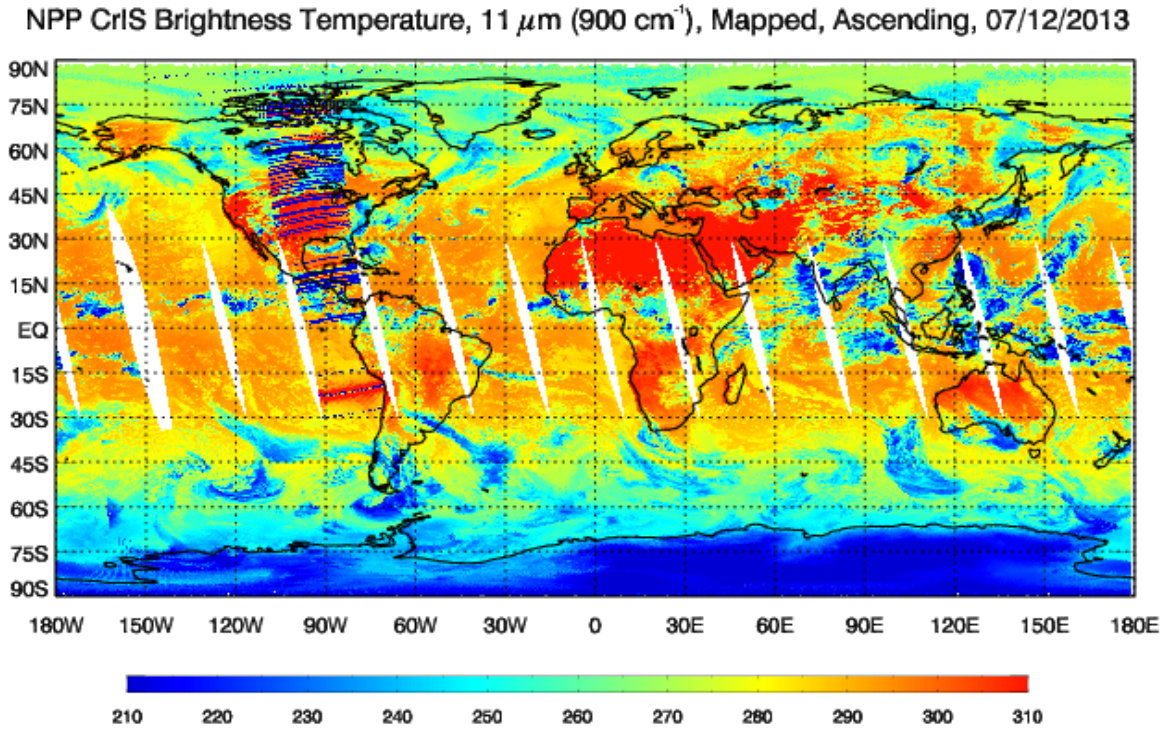
- New Bit trim mask for high resolution will reduce the data rate to 2.713 Mbps which is below the required 2.73 Mbps.

Long Term monitoring.

- LTM system continuously monitors over 120 parameters for anomaly detection, instrument stability, instrument health.
- Several radiance anomalies were detected
  - manual retasking of repaired granules,.
  - Instrument placed in safe mode.

http://www.star.nesdis.noaa.gov/icvs-draft/status_NPP_CrIS.php

Radiance Anomaly due to Manual Retasking of Repaired Granules

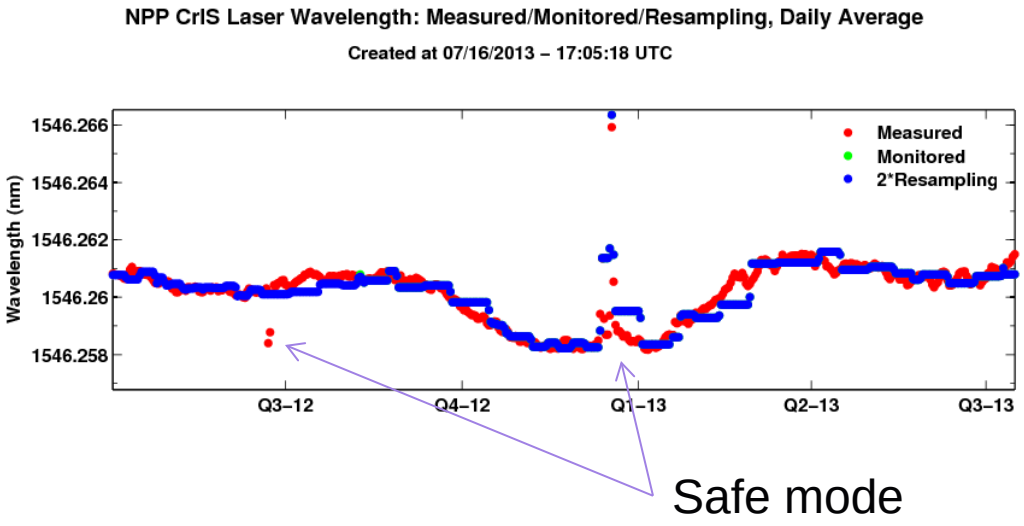


-Example of radiance anomaly on July 12th 2013.

- Repaired granules are made available, then the operator launches a secondary process (executable) that appears to disrupt the main CrIS SDR processing.

- Mitigation is to have the secondary process (manual retasking) to be perform in the back orbit (at later time).

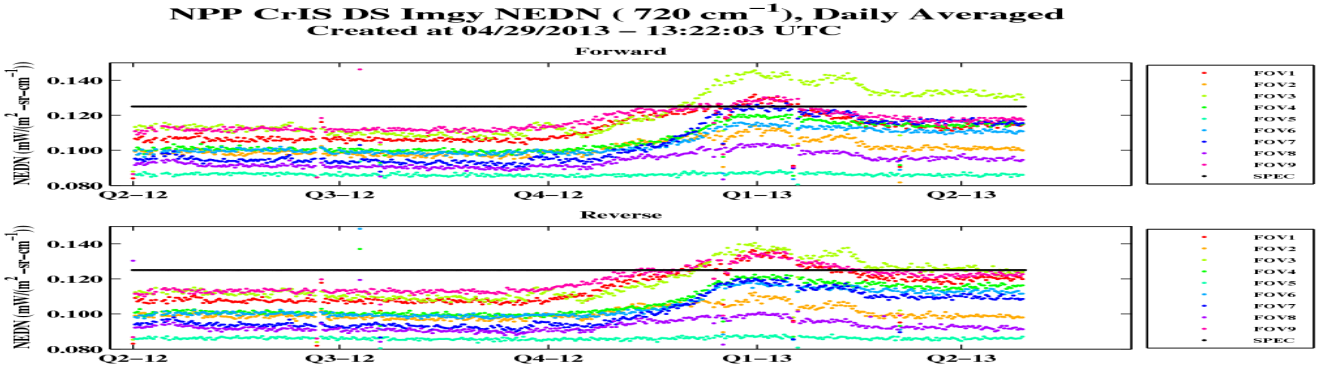
Laser Wavelength

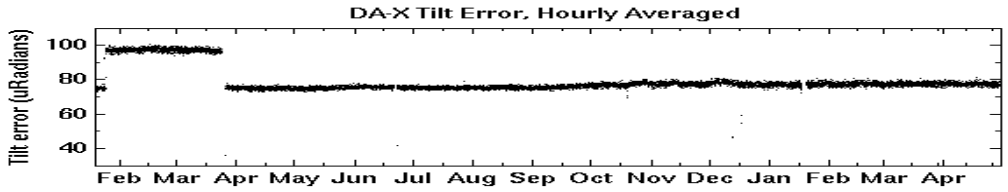


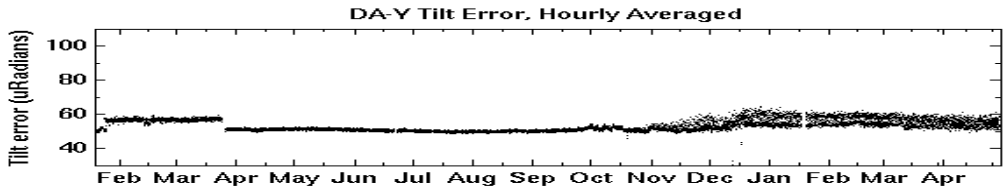
- When in safe mode, CrIS laser wavelength changes.
- 2* Resampling value is incorrect (blue). Code fix effective on 7/10/13
- Overall, the laser wavelength is very stable (< 2 ppm).

CrIS laser metrology subsystem is very stable.

Deep Space Noise





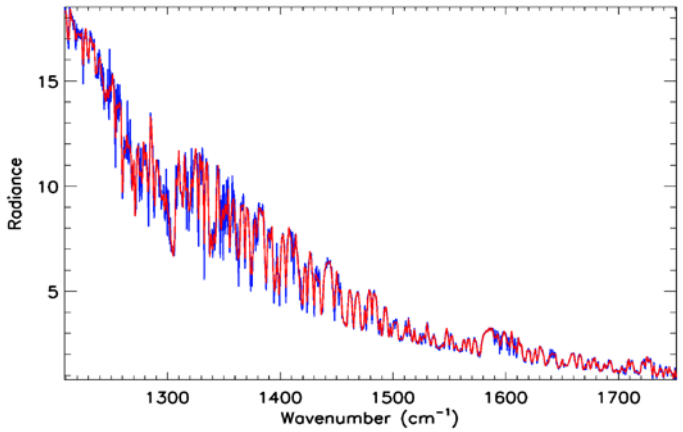


High Resolution CrIS Data

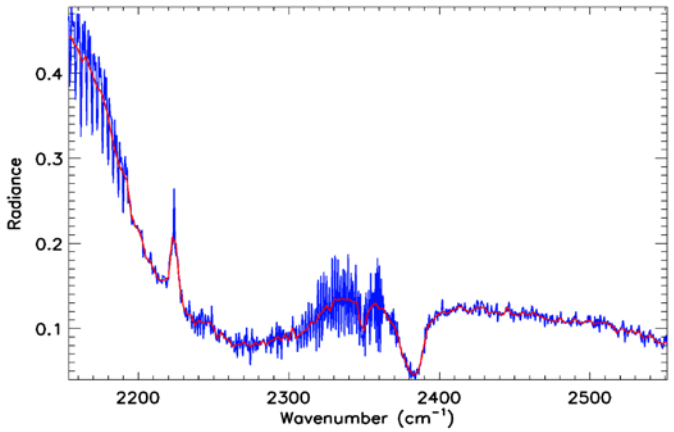
- Goal is to acquire high resolution RDR data for NPP (0.625 cm-1 all 3 bands).
- Motivation:
  - Allows spectral calibration for SWIR and MWIR.
  - Trace gas retrieval (CO, CO_2, CH_4, O_3). These 4 gas are planned to be EDR products for J1.
- Spectral resolution change:
  - MWIR : from 1.25 to 0.625 cm-1
  - SWIR : from 2.5 to 0.625 cm-1
- Data set acquisition:
  - 2/23/2012 during the commissioning phase
  - 3/12/2013 for S/C and ground data processing.
  - August 27th 2013 (planned).

High Resolution Data 3/12/2013

MWIR



SWIR



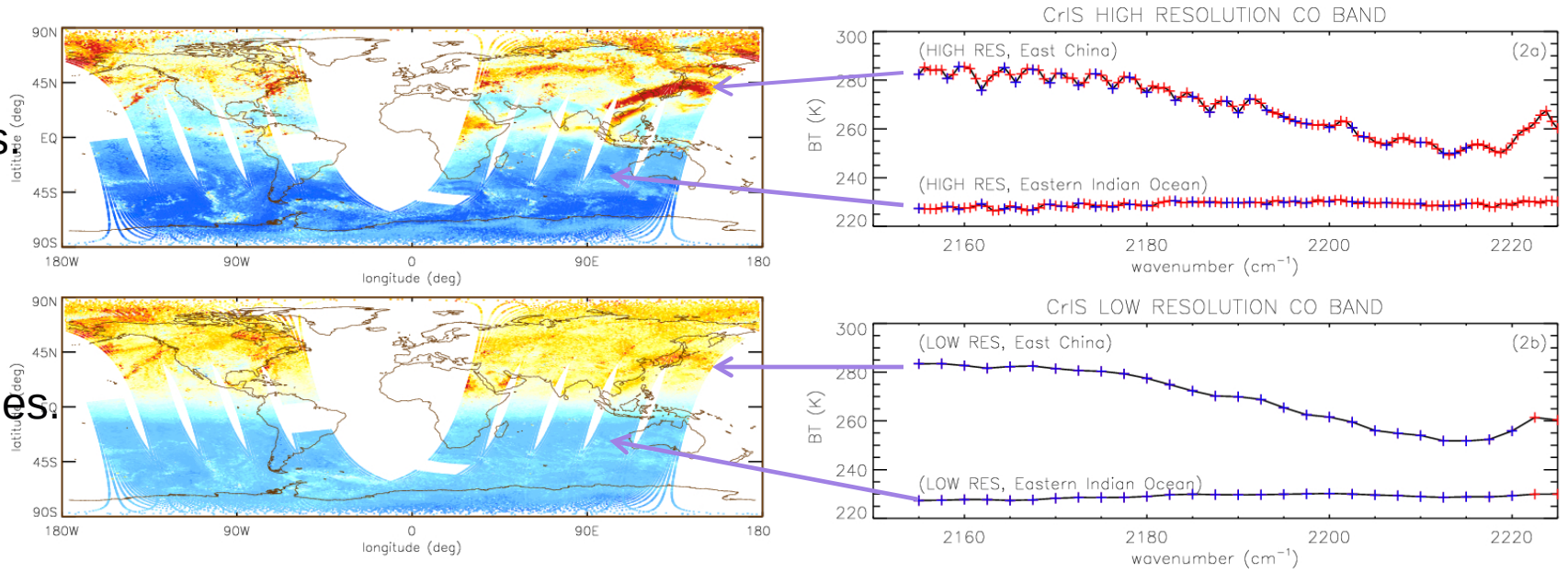
- Low Res.
- High Res.

- 5 Orbits of data collection.
- Issue : Too high data rate (3.52 Mbps) caused loss of data downloaded form the S/C; need to reduce to 2.73 Mbps.
- Can achieve the 2.73 Mbps by changing the bit trim mask.

CrIS CO Retrieval on March 12th 2013

Hi Res.

Low Res.



Courtesy of A. Gambacorta, NOAA-STAR

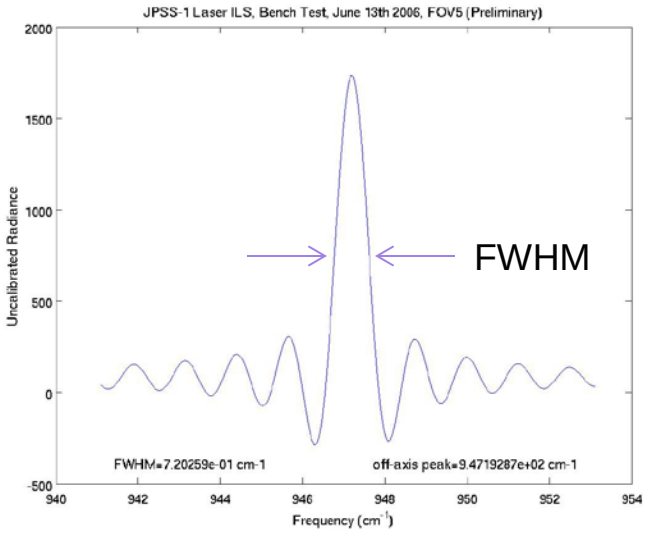
- CrIS high resolution RDR (raw) processed offline giving the high SDR (0.625 cm-1 all 3 band).
- CrIS radiance processed by NUCAPS to retrieve CO for both low and high resolution cases.

CrIS Flight Module 2 for J1: Bench Test

Laser ILS Data (June 13th 2013).

Spectral line at 948 cm^{-1}.

Processed with CrIS SDR PC From Exelis



FWHM = 0.722 cm^{-1}

- The FM2 CrIS instrument was put together for the very first time.
- Bench testing has the goal to evaluate the instrument health and to look at the firstlight data.
- Issue: Cooler module not working properly.
- Data processing: New Housekeeping packets (need to update the RDR reader).
- FM2 TVAC schedule for Q1 2014.

JPSS-1 Launch scheduled for Q2 2017

Summary

- S-NPP CrIS is working fine and is very stable.
- The CrIS SDR product is expected to reach the Validated maturity level in early 2014.
- High resolution data will allow CO retrieval.
- CrIS flight module 2 (J1) is currently being testing. The formal TVAC is planned for early 2014.