$A = USV^T$

JPSS-1 CrIS Bench Test Data and Preliminary Assessment of the Instrument Stability

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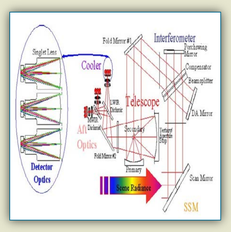
Abstract

The JPSS-1 (or J1) satellite is scheduled for launch in late 2017. One of the instrument on-board this satellite is the CrIS flight module 2 (FM2) which is a Fourier Transform Spectrometer. This CrIS FM2 is a near-clone of the CrIS FM1 that is currently flying on-board the S-NPP satellite. The J1 CrIS underwent a series of tests on the bench which consists in operating the instrument at room temperature with normal atmospheric pressure. This presentation presents analysis results performed on the operational mode at full resolution and the gas cell data. Principle component analysis of the operational full resolution data set shows that the instrument is very stable and no instrumental artifacts (anomalies) were found. Bench test analysis is essential in characterizing the CrIS instrument.

Instrument Characteristics and Attributes

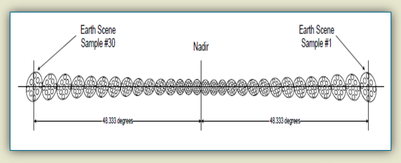
CrIS Optical Schematic

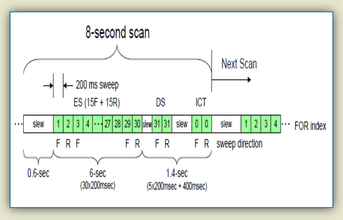


Normal Acquisition Mode

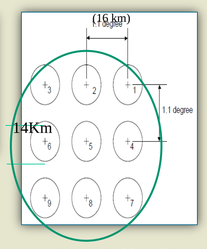
Number of FOV	9
Number of FOR per Scan Line	30
Scan line Acquisition Period	8 seconds
Number of Scan line per day	10800
Number of Frequency Band	3
Total number of Spectra per Day	8.7 Million

Scan Line (2200 Km Swath)





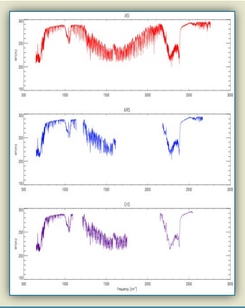
Field Of Regard



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

Spectral Characteristics

Band	Spectral Range (cm-1)	Spectral Range (μm)	Bandwidth (cm-1)	Resolution (cm-1)	Max OPD (cm)
LWIR	650-1095	15.4-9.1	445	0.625	0.8
MWIR	1210-1750	8.3-5.7	540	0.625	0.8
SWIR	2155-2550	4.6-3.9	395	0.625	0.8



- IASI has full spectral coverage from 645 cm-1 to 2760 cm-1.
- AIRS and CrIS have 3 frequency bands as shown.
- CrIS has coarser spectral resolution in MW and SW. JPSS-1 is expected to download full spectral resolution (0.625 cm-1 all 3 bands). JPSS-1 launch is planned for 2017.

CrIS acquires 8.7 million spectra per day covering over 95% of the Earth surface.

Motivation

The JPSS-1 CrIS instrument will undergo a series of test prior to its delivery. The tests includes: (1) bench , (2) EMI, (3) Vibration, (4) TVAC. After delivery, the CrIS instrument will be subject to additional testing such as satellite integration, geolocation accuracy, additional electro-magnetic susceptibility and many more.

The JPSS-1 CrIS (or Flight Module 2) instrument was put together for the first time in Mid-2013. The first of a series of tests is the so-called 'bench' testing. The instrument is operated on the bench at room temperature and normal atmospheric condition. The goal of the bench test is to assess the interferometer. Bench testing includes Laser ILS, gas cell, normal mode of operation at full spectral resolution, noise (or NEdN), and many others.

JPSS-1 CrIS Pre-launch Testing

CPT Bench Test
-Laser ILS
-NEdN (low res.)
-NEdN (full res.)
-Gas cell
-Normal mode (full res.)

→

EMI
-EP Qucik bode
-Conducted Susceptibility
-Conducted Emissivity
-Radiated Emission
-Raditated Susceptibility

→

Vibration (VIBE)
-Optical Boresight
-EP quick Bode
-Frangibolt Preload
-Launch vibe (X, Y, Z).
-Frangibolt Release
-Dynamic Interaction
-Optical Tilt Injection

↓

Post VIBE
-EP Qucik bode
-System Integration
-NEdN
-Bench Spectral (laser)
-FOV slit and Spot Scans.
-Spectral Measurement (4 gas)

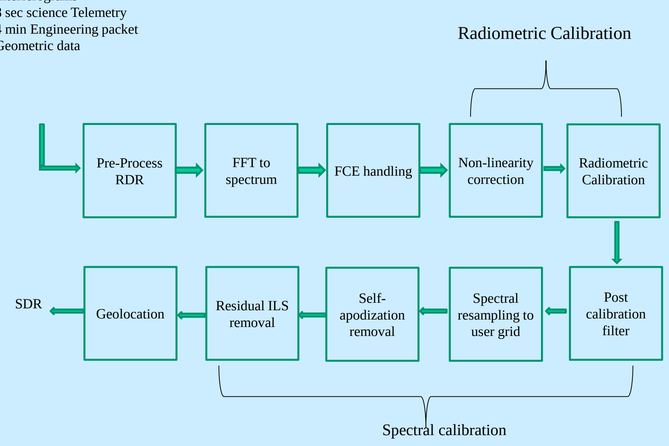
→

TVAC
-NEdN
-Crosstalk
-Spectral Measurement (gas cell).
-Scan Scenario
-Radiometric Calibration
-FOV Slit and Spot Scans

→ Pre-Shipment and Shipment

CrIS SDR Algorithm Data Flow

RDRs:
Interferograms
8 sec science Telemetry
4 min Engineering packet
Geometric data

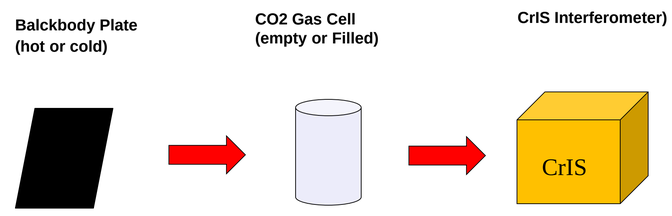


The CrIS SDR algorithm data flow is currently being updated. The modification with respect to S-NPP are: (1) Process the full resolution (0.625 cm-1 for all 3 bands), (2) The radiometric equation reordering where the spectral resampling (to user's grid) step is performed before the Instrument line shape (ILS) correction which comprises the self-apodization removal, (3) Change several input files content. One tentative change is to replace the inverse self-apodization matrix from dynamic computing to a fix regression table.

Pre-launch testing activities also includes the estimation of key calibration parameters such as the non-linearity and the ILS coefficients. From bench test results, non-linearity for the SWIR may be added (currently set to zero) according to UW.

CrIS SDR Algorithm product comprises the radiance, NEdN (noise), geolocation, and data quality flags.

Bench Gas Cell Measurements.



Bench gas cell test setup.

-A blackbody plate is place. This plate is temperature controlled allowing a cold and hot temperature.
-The gas cell is placed between the blackbody plate and CrIS interferometer. It is empty or filled with CO2 gas for LWIR measurements. The pressure of the CO2 gas is set to 40 Tor.

Data Processing

-Four data sets: (1) Empty-Cold, (2) Empty-Hot, (3) Filled-Cold, (4) Filled-Hot. A total of 320 spectra are averaged for each categories.
-The uncorrected transmittance T is

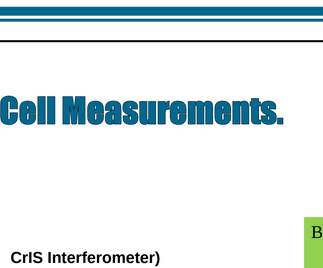
$$T = (FilledHot - FilledCold)/(EmptyHot - EmptyCold)$$

-First order corrected transmittance T* is filtered by the guard band (to dampen the spectrum edges), and multiplied by the inverse self-apodization (ISA) matrix taken from S-NPP TVAC4. The 9 FOVs are shifted to the 'right' . Here no resampling to the user's grid was applied.
-Gas cell measurements will be repeated in TVAC conditions and ILS will be derived. The expected spectral calibration accuracy shall be <10ppm.

$$T^* = ISA^* f^* T$$

Result : LWIR FOV overlay in CO_2 region.

All FOV are shifted (no good overlay).



Apparent good FOV overlay

The bench gas cell measurements show a reasonable FOV overlay (Preliminary results).

PCA Analysis of Normal Mode Acquisition Target Data (full resolution)

Data Processing

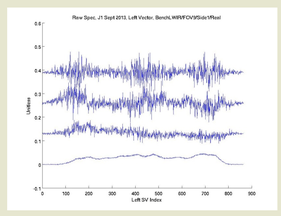
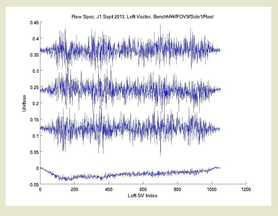
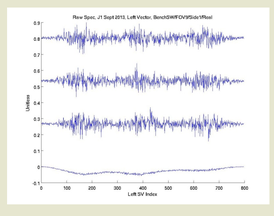
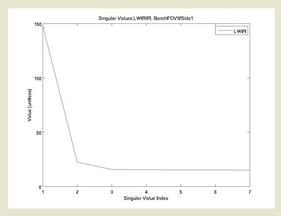
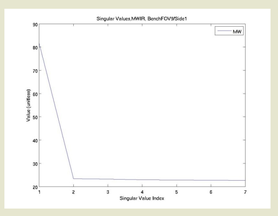
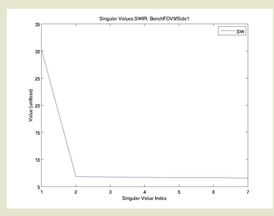
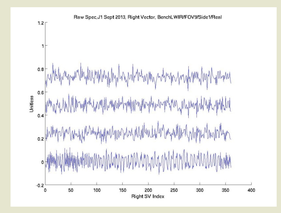
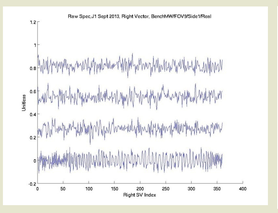
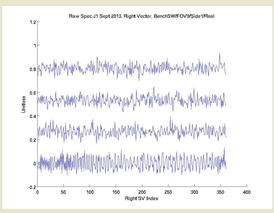
Normal mode target (hot blackbody plate) was acquired for a period of over 2 hours on 9/20/2013. In this analysis, 45 minutes of data were processed. First, the ensemble comprised the target views spectra for a given FOV and for the FOR 33 (target) only. This accounts for a total of 360 spectra (or one spectrum every 8 seconds). For LWIR, this forms the matrix A of dimension 864 by 360. the next step is to perform a PCA (or singular value decomposition) of the Matrix A. The results is:

$$A = USV^T$$

The orthogonal matrix U has the dimension 864 by 360 and forms the so-called 'left' eignvectors. These vectors shows any spectral signal. The diagonal matrix S contains the singular values in increasing order where its dimension is 360 by 360. The orthogonal matrix V has dimension 360 by 360. V has the right vectors which represent the temporal information.

The plots shown here are for FOV 9, all 3 bands, of the right vectors (U), singular values (diagonal of S), and the right vectors V.

Results from FOV5 show similar pattern as FOV9.

	LWIR FOV9	MWIR FOV9	SWIR FOV9
U			
S			
V			

PCA of JPSS-1 target view shows excellent stability with no sign of anomalies (no spectral spikes, no response fluctuation, no gain amplitude variability).

Summary

- **Bench testing of JPSS-1 CrIS shows good stability of the instrument.**
- **Full resolution data are acquired.**
- **Gas cell measurements show reasonable FOV overlay.**