2014 STAR JPSS Science Teams Annual Meeting

ATMS/CRIS SDR Team Leads

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CrIS SDR Team

May 16, 2014

Team Activities during This Annual Meeting

- Team Lead report
- ATM/CrIS SDR Breakout Session
  - 8 CrIS SDR presentations and discussions
- 1 hour CrIS SDR Team Discussion
  - J1 test schedule and status overview – Dave Johnson
  - CrIS SDR algorithm/software improvement discussions
- Team member side meetings - lots of discussions
- STAR CrIS SDR group side meetings with other CrIS SDR groups

Last Year's Major Accomplishments

- Successfully completed the CrIS SDR ICV process: achieved the Validated status for the S-NPP CrIS SDR product
- CrIS noise performance and accuracies of radiometric and spectral calibrations exceed specifications with large margins
- Rate of GOOD SDRs is better than 99.98%
- All significant DRs have been processed and issues addressed
- Good progress was made in improving calibration algorithms and software
- Preliminary analysis of the bench test data was performed and the results are within the expectation
- Preparation for the IDPS CrIS SDR code to handle full resolution RDRs was completed
- Program was made in generating a comprehensive proxy data set for J1 algorithm and code testing

Important Coming Events

- J1 SDR code and cal. LUTs delivery, Jan. 15, 2015
- S-NPP CrIS will be switched to full spectral resolution mode, Dec 2014
- J1 TVAC tests, June – Oct., 2014

Work Plan
(coming program year)

- SDR calibration algorithm/software improvements
  - Formulate the best radiometric and spectral calibration equation
  - Improve self-apodization correction algorithm
  - Optimize FIR filter and post calibration filter
  - New FCE correction module
  - Algorithm implementation and CMO computation efficiency improvement
- J1 pre-launch CalVal work
  - Test data analysis
  - Instrument performance evaluation
  - Deriving calibration coefficients (LUTs)
- Proxy data sets for J1 algorithm/code test
  - Data source: S-NPP data, J1 TVAC data and RT simulations
- Full spectral resolution work
  - Validate IDPS SDR product when S-NPP CrIS is switched to FSR mode in Dec, 2014
  - Prepare for FSR SDR offline processing

Summary of Algorithm Improvement Discussions during this Annual Meeting

- To meet the SDR software delivery date on Jan. 15, 2015, the team is organized to work in three areas in parallel: calibration algorithms, proxy data sets and software changes
- Algorithm improvements to remove ringing artifacts
  - Need to define truth spectra with channel response functions the user can simulate
  - Determine the best calibration equation through simulations and real data analysis (actions planned)
  - The team agreed to change CMO computation scheme (actions planned)
- Software work
  - Before the team's decision on the algorithm changes, work will be done to modularize calibration code so that once the decision is reached, the algorithms can be quickly implemented into the software (actions planned)
  - Useful discussions with STAR AIT team and Raytheon team for code change collaborations

The following slides are more detailed summary of the results of CrIS SDR team activities during this annual meeting

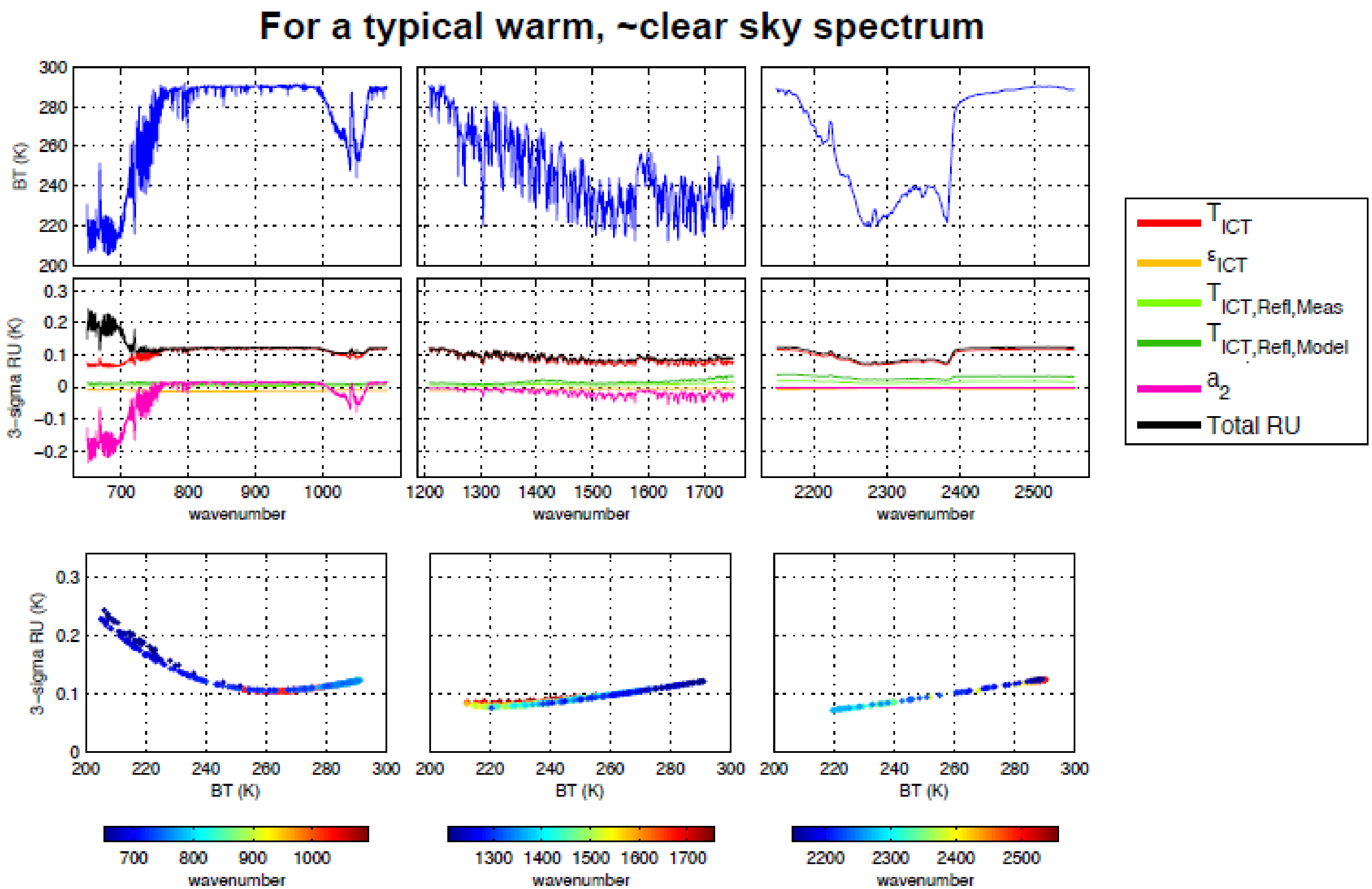
Summary and Highlights

- There are 8 presentations from the CrIS SDR Cal/Val team
- Team activities focused on
  - Continue to improve S-NPP algorithm software performance and robustness (two updates since SDR review)
  - Continue to evaluate and characterize CrIS SDR data accuracy and stability
    - Radiometric calibration performance
    - Spectral calibration performance
  - Prepare for full resolution SDR generation
    - Baseline algorithm developed based on ADL version of the SNPP code
    - Evaluation of different calibration approaches
  - Assessment of full resolution SDR data quality by comparison with AIRs/IASI
    - Global comparison
    - SNOs
  - Support to JPSS-1 sensor testing and performance assessment
- Open discussion session of instrument test status and J-1 SDR algorithm development plan after the presentations

CrIS Radiometric Calibration

- Major contributors to CrIS Radiometric Uncertainty (RU):
  - ICT emissivity/reflectivity
  - ICT temperature (driver at 112mk for NPP)
  - Residual Nonlinearity (LW band more significant)
  - Polarization (not yet included due to lack of characterization, but estimated up to 50mk)
- Performance Issues: shortwave band biases
  - FOV2FOV comparison
  - Comparison with other instrument (IASI/AIRS?)
- J-1 RU expected to be similar to SNPP
- Recommended changes for future CrIS sensors:
  - Remove spectral gaps between LW-MW and MW-SW gaps
  - Smaller and more FOVs
- Discussion
  - Q: Are there any seasonal change in the RU ?
  - A: No changes are seen due to ICT

S-NPP CrIS, example 3-sigma RU estimates

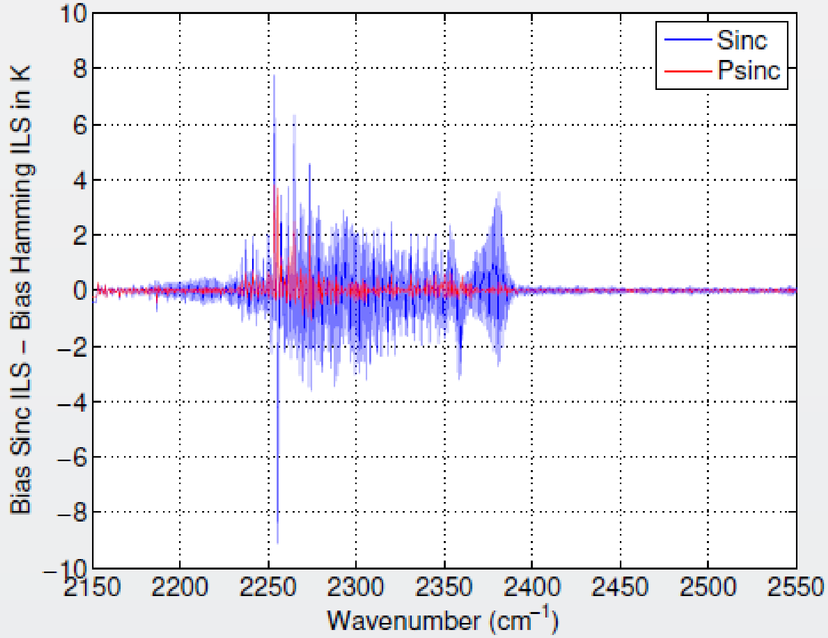


CrIS Spectral Calibration

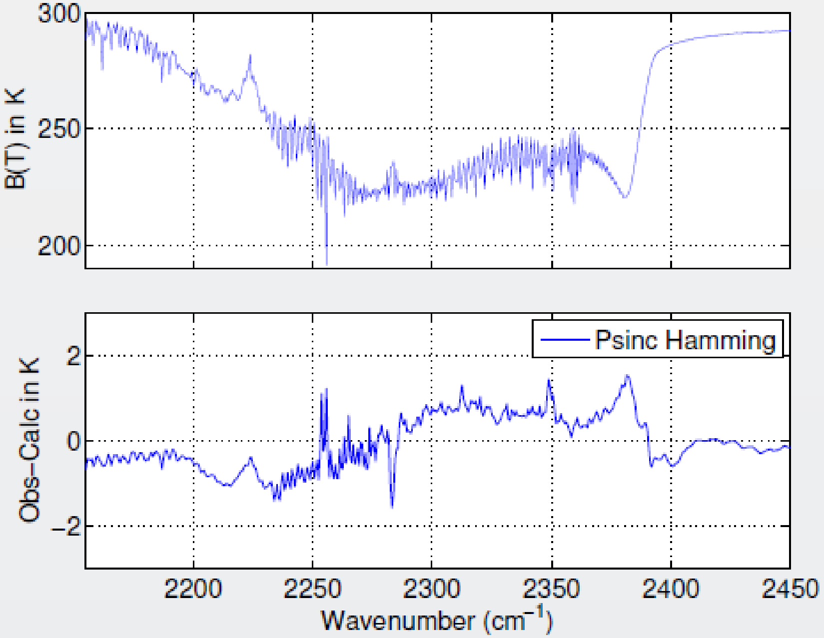
- Assessment of CrIS Spectral calibration
  - stable and accurate based on partially completed analysis
- Selection of ILS basis (Sinc vs Periodic Sinc)
  - Short-wave SDR ringing vastly improved for high-resolution; less significant for normal mode data
  - FOV-7 improvements needed for high-spectral resolution mode
- Comparison of CrIS high resolution mode data and AIRS SNOs
  - 0.1K agreement on a channel-by-channel basis
  - 0.2K ringing in AIRs data is due to lack of spectral calibration
- Discussion
  - Q : Is there a neon lamp drift?
  - A: Found a -0.07 ppm trend since the beginning of the mission (so very stable).

Sinc vs. Periodic Sinc

Bias Psinc/sinc - Bias Hamming
A clean metric for excess ringing



Observed - Computed (NWP)
Psinc apodized to Hamming



- This is a major improvement to the high-resolution short-wave data
- Periodic sinc mostly improves corner FOVS, where the self-apodization correction is largest, SA matrix is more poorly conditioned.
- Should help improve absolute spectral calibration once CrIS is in high-resolution mode

CrIS Calibration Equation

- Evaluated 11 different calibration approaches
- Order of CMO (self-apodization removal) has caused the most significant differences
- Spectral interpolation before or after radiometric calibration also makes a (small) difference
- Relative differences only, not absolute ranking of performance due to lack of truth (objective criteria)

Calibration options

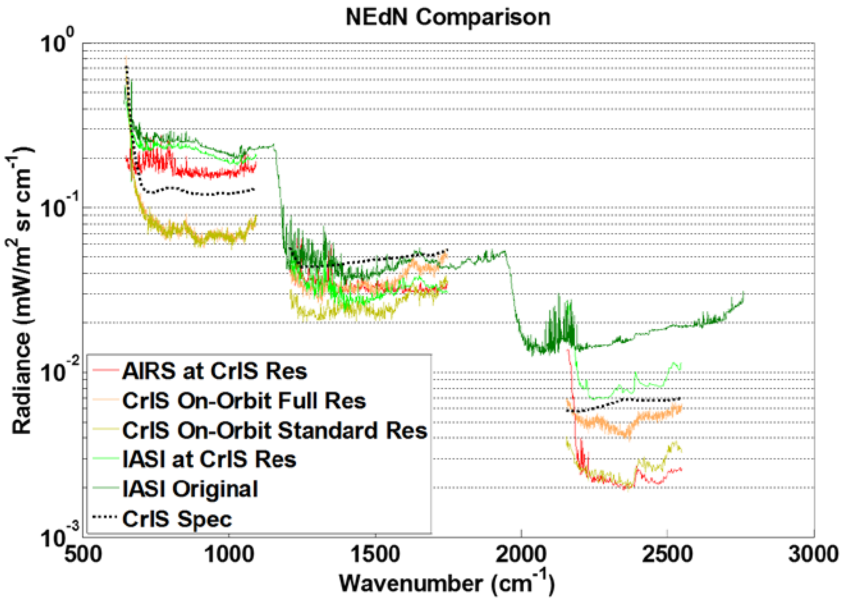
Item	Member	Calibration	CMO Principals	Calibration Order
1	IDPS	$N=(SA_u^{-1}\cdot F_{s\to u}\cdot f_{ATBD})\cdot\left\{\frac{S_E-S_{SP}}{S_{ICT}-S_{SP}}\cdot ICT(T,u_{sensor*(1+delta)})\right\}$		
2	ADL/CSPP	$N=(SA_u^{-1}\cdot F_{s\to u}\cdot f_{ATBD})\cdot\left\{\frac{S_E-S_{SP}}{S_{ICT}-S_{SP}}\cdot ICT(T,u_{sensor*(1+delta)})\right\}$	$SA_u^{-1}\cdot F_{s\to u}$	
3	Exelis (old)	$N=\left(SA_u^{-1}\cdot F_{s\to u}\cdot f_{ATBD}\right)\cdot\left\{\frac{S_E-S_{SP}}{S_{ICT}-S_{SP}}f_{BH}\cdot\left[SA_u^{-1}\cdot F_{s\to u}\right]^{-1}\cdot ICT(T,u_{sensor})\right\}$		
4	UMBC/UW** option A	$N=F_{s\to u}\cdot f\cdot SA_s^{-1}\cdot\left\{f\cdot\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\cdot ICT(T,u_{sensor\_off\_axis})\right\}$		**Calibration first, then CMO**
5	CCAST Cal mode 1	$N=F_{s\to u}\cdot f\cdot SA_s^{-1}\cdot\left\{\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\cdot ICT(T,u_{sensor\_off\_axis})\right\}$		
6	UMBC/UW** option B	$N=F_{s\to u}\cdot\left\{ICT(T,u_{sensor})\cdot f\cdot SA_s^{-1}\cdot\left\{f\cdot\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\right\}\right\}$		
7	CCAST Cal mode 2	$N=F_{s\to u}\cdot f\cdot\left\{ICT(T,u_{sensor})\cdot SA_s^{-1}\cdot\left\{\mathrm{Re}\left[\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\right]\right\}\right\}$	$F_{s\to u}\cdot SA_s^{-1}$	
8	LL(old)*	$N=\left\{\frac{M\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{M\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\right\}\cdot ICT(T,u_{user})$		
9	LL(new)	$N=\left\{\frac{F_{s\to u}\cdot SA_s^{-1}\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{F_{s\to u}\cdot SA_s^{-1}\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\right\}\cdot ICT(T,u_{user})$		
10	Proposed(1)	$N=F_{s\to u}\cdot f_{ATBD}\cdot\left\{\frac{SA_s^{-1}\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{SA_s^{-1}\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\cdot ICT(T,u_{sensor})\right\}$		**CMO first, then Calibration**
11	Proposed(2)	$N=ICT(T,u_{user})\cdot\left\{\frac{F_{s\to u}\cdot SA_s^{-1}\cdot f_{ATBD}\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{F_{s\to u}\cdot SA_s^{-1}\cdot f_{ATBD}\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\right\}$		
12	Exelis(new)	$N=\left\{\frac{\left(SA_u^{-1}\cdot F_{s\to u}\cdot(S_E-S_{SP})\right)}{\left(SA_u^{-1}\cdot F_{s\to u}\cdot(S_{ICT}-S_{SP})\right)}\right\}\cdot ICT(T,u_{user})$	$SA_u^{-1}\cdot F_{s\to u}$	

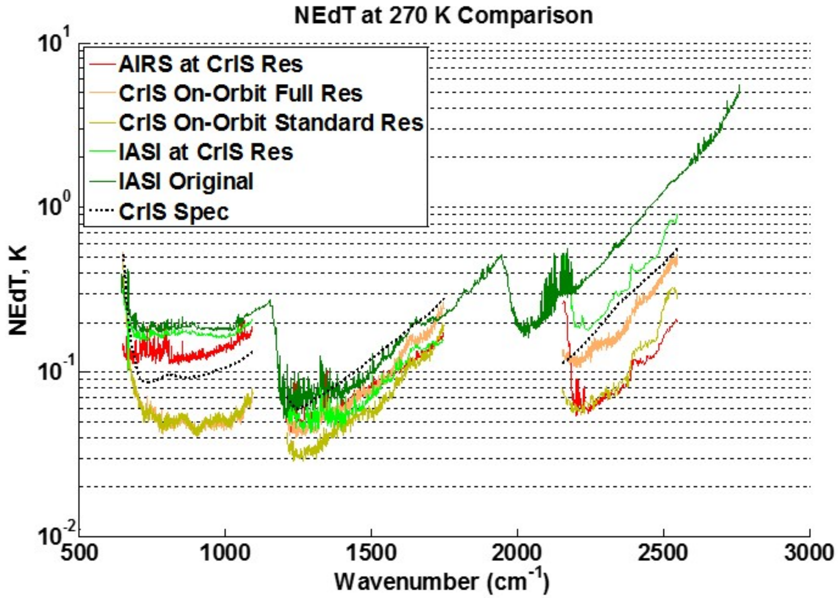
Ref

CrIS Noise Performance

- NEdN level meets mission requirements for both NPP and J1 instruments with a margin of typically 100% (except MWIR FOV 7 NPP instrument).
- The intrinsic detector noise randomly distributed in spectral domain dominates total instrument NEdN
  - Negligible contribution of correlated noise is observed.
- CrIS has comparable or smaller noise levels than AIRS and IASI heritage instruments (~2-3 times smaller in LWIR spectral band)
- NEdN has remained extremely stable during on-orbit operations. Only small seasonal, orbital and spatial NEdN variations (<10%) are observe on-orbit.
- Small anomaly (50%) in LWIR FOR1 NEdN was observed on July 07 and September 10 and 12,2013. Remains stable on slightly elevated level (<10%)
- Discussion
  - Q: What is the noise increase of LW FOV1 root cause?
  - A: Root cause is not known

NPP: NEdN and NEdT (at 270^0K) comparison with AIRS and IASI



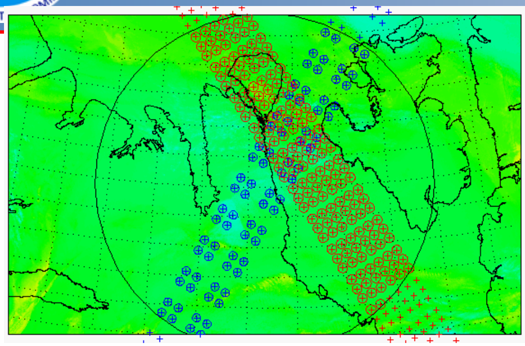


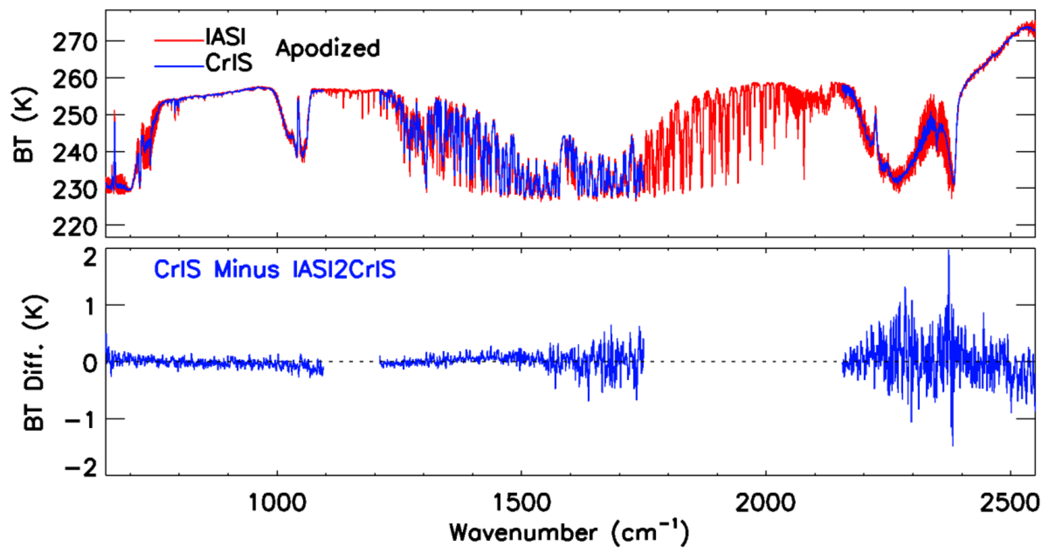
- NEdN is estimated from Earth scene radiances using SDL PCA approach (60 PCs retained)
- CrIS exhibits smaller noise level in LWIR (~x3) and SWIR (~x3) spectral bands than noise estimated from IASI observations reduced to CrIS spectral resolution
- As expected, CrIS full spectral resolution noise in MWIR and SWIR bands is higher by ~x1.4 and ~x2, respectively, as compared to the CrIS standard spectral resolution

Preparation of CrIS Full Resolution Processing

- Full resolution SDR algorithm is under development
  - Prototype code development is based on MX 8.3 and ADL 4.2
  - The prototype has now options for different calibration approaches (spectral cal/radiometric cal ordering)
- CrIS full resolution SDR radiometric uncertainty:
  - FOV-2-FOV radiometric differences are small, within ±0.3 K for all the channels
  - Double difference with IASI are within ±0.3K for most of channels
  - SNO results versus IASI show that agreement is very good for band 1 and band 2, but large BT differences in cold channels for band 3
- CrIS full resolution SDR spectral uncertainty:
  - Spectral shift relative to FOV5 are within 1 ppm
  - Absolute spectral shift relative to CRTM simulation are within 3 ppm
- Discussion
  - Q :With the acquisition of full resolution on NPP, will we drop FOV 7 ?
  - A: Yes FOV7 in the direct broadcast will drop as reported by DPE/DPA.
  - Q: SNO CrIS IASI difference in SW appears big?
  - A: yes it is somewhat high.
  - Q: Can the code perform a dynamic switch between low and full resolution?
  - A: No. the code needs to recompile in order to switch resolution.

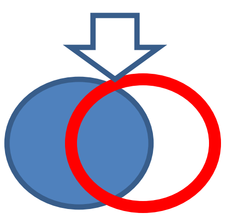
SNOs between CrIS and IASI

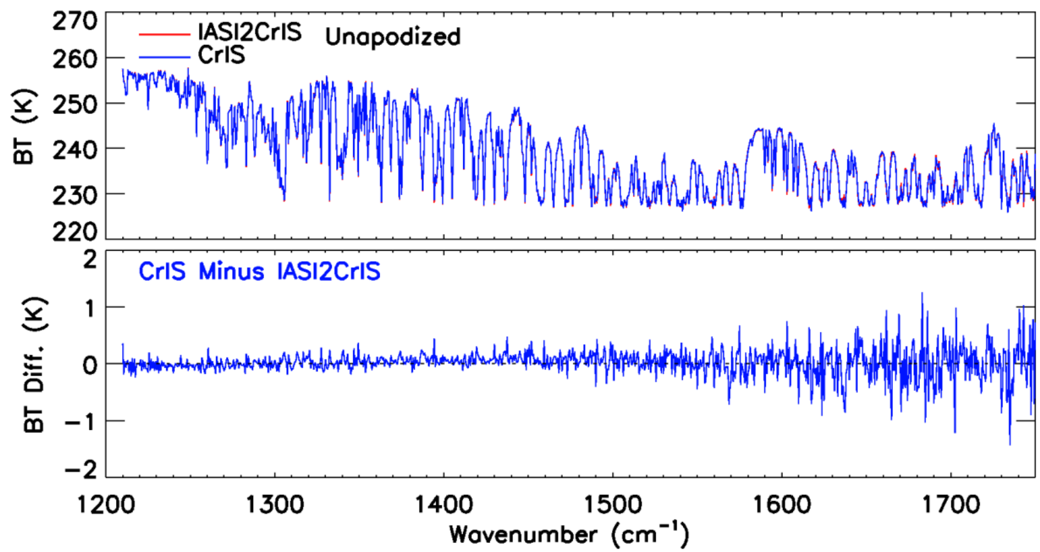




SNO Criteria

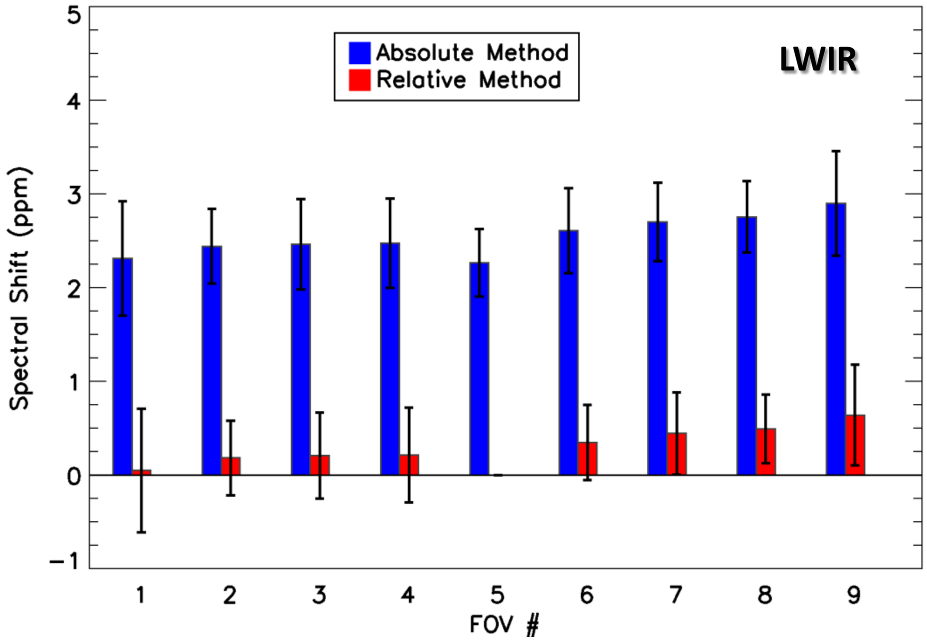
- Time difference:
  <= 120 seconds
- Pixel distance:
  <=(12+14)/4.0 km = 6.5 km
- Zenith angle difference:
  ABS(cos(a1)/cos(a2)-1) <= 0.01

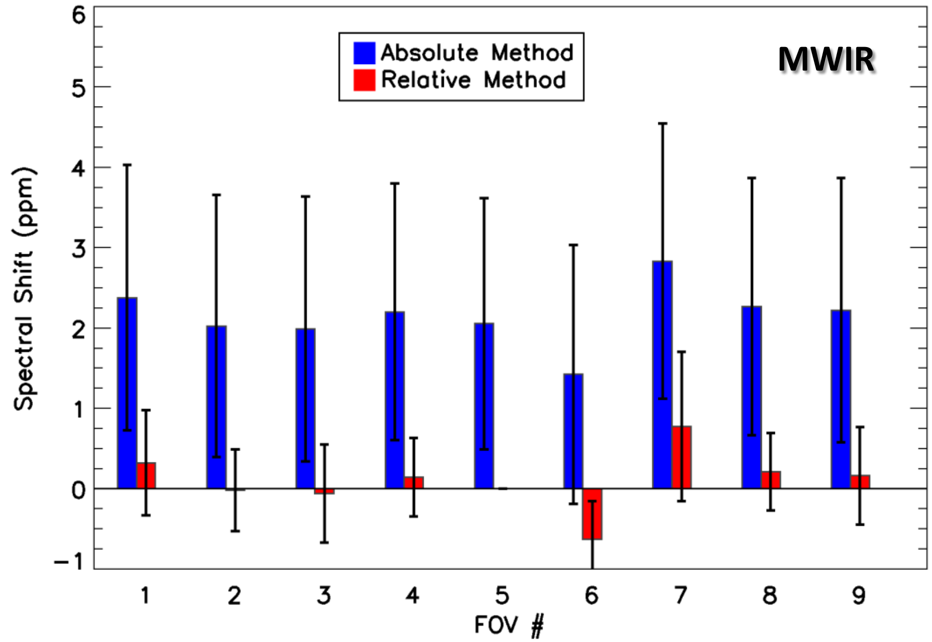


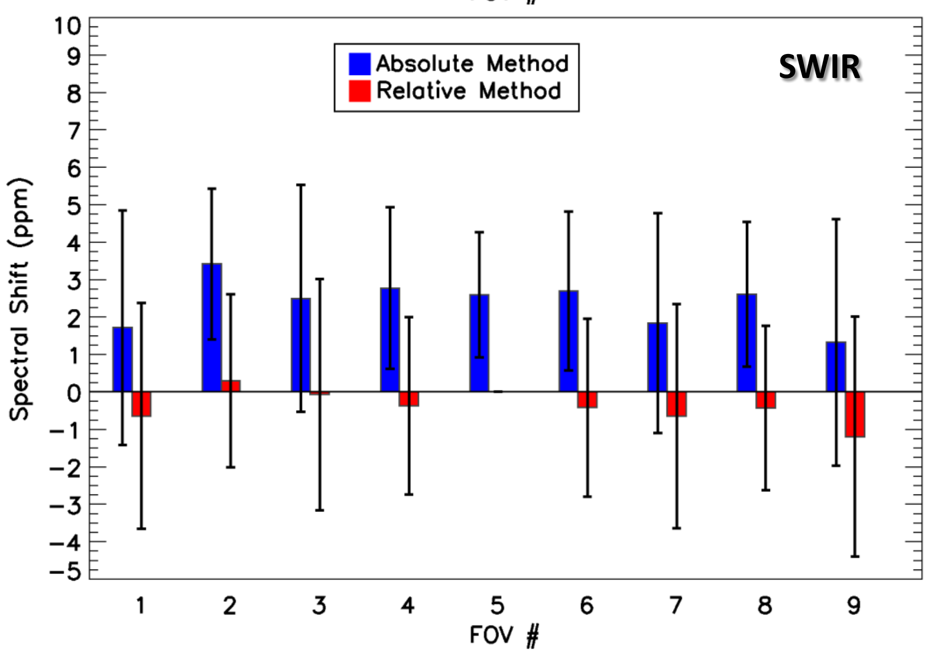


- SNO agreement is very good for band 1. Also good for band 2, but larger BT difference toward the end of band edge
- Large BT differences in cold channels for band 3

CrIS Spectral Uncertainty





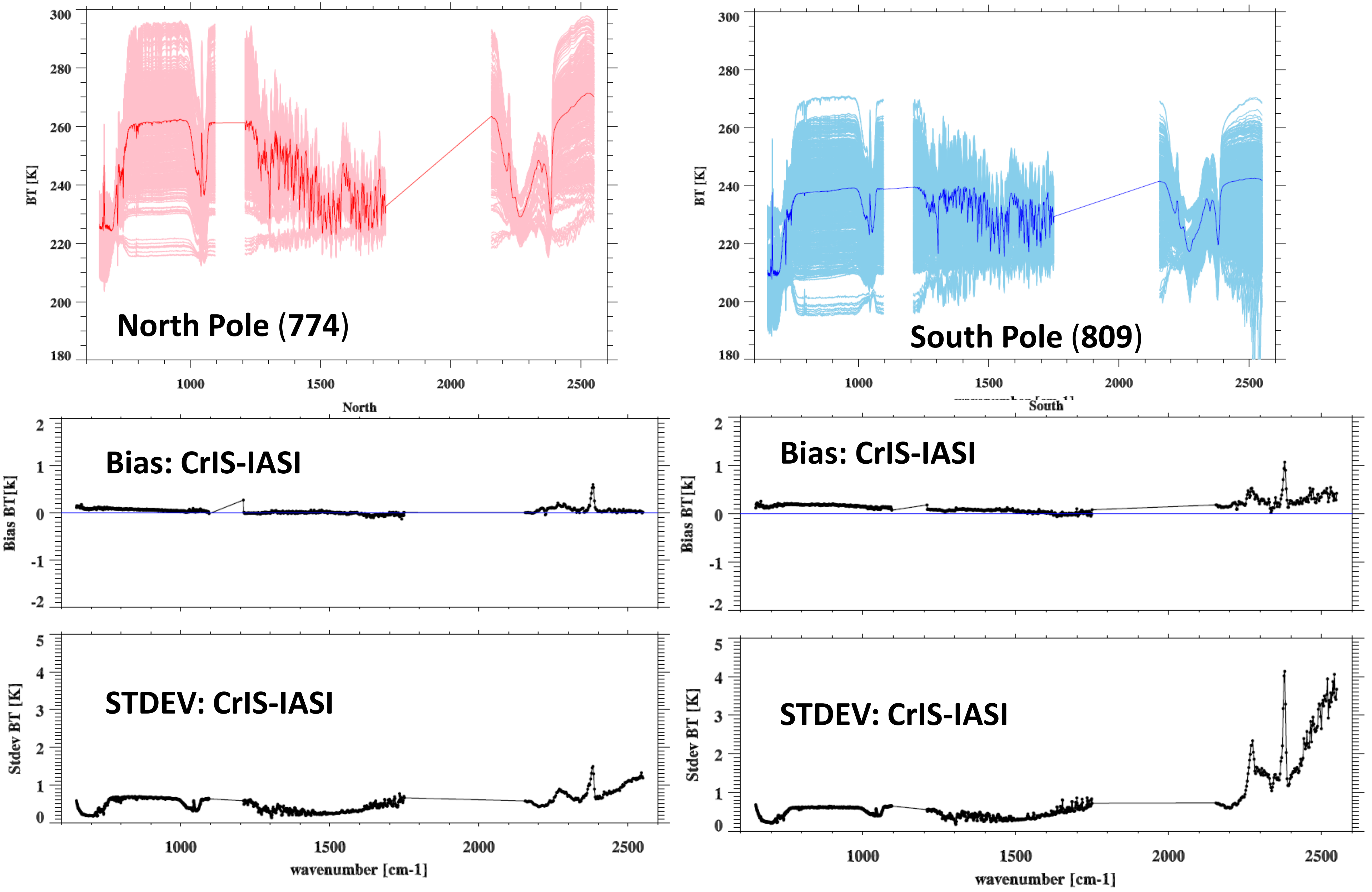


- Absolute cross-correlation method: between observations and CRTM simulations under clear sky over oceans to detect the spectral shift
- Relative method: observations from FOV 5 to other FOVs
- Frequency used: 710-760 cm^{-1} , 1340-1390 cm^{-1} , and 2310-2370 cm^{-1}
- **Spectral shift relative to FOV5 are within 1 ppm**
- **Absolute spectral shift relative to CRTM within 3 ppm**

Towards Establishing a Reference Instrument

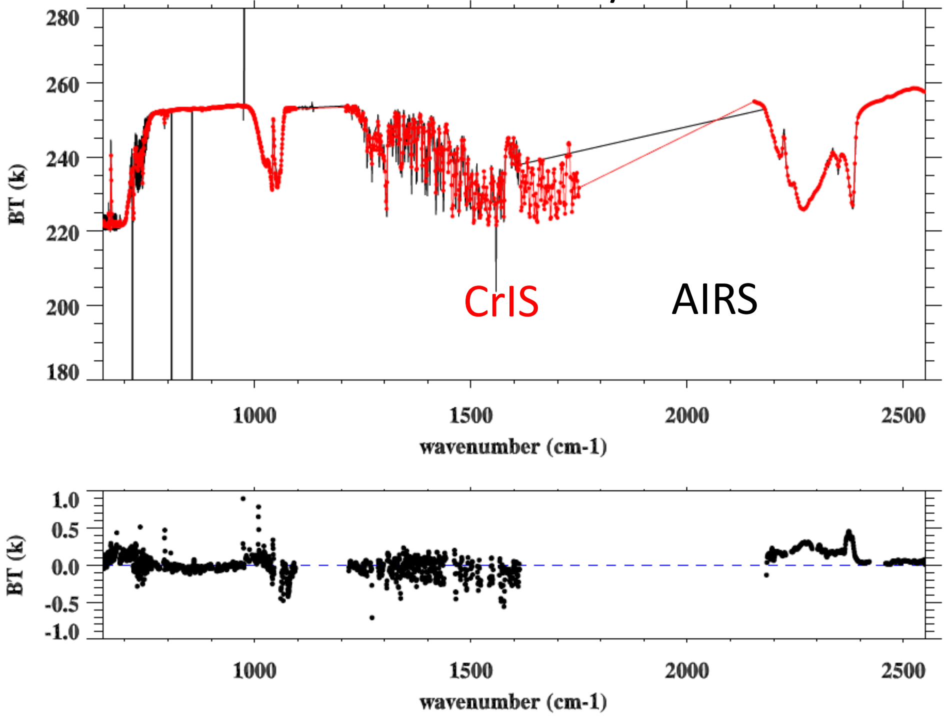
- Inter-comparison of CrIS with IASI/Metop-A, IASI-Metop-B, and AIRS have been made for one year's of SNO observations in 2013.
- CrIS vs. IASI
  - CrIS and IASI well agree each other at LWIR and MWIR bands with 0.1-0.2K differences
  - No apparent scene dependent bias
  - At SWIR band, a sharp increases can be clearly seen at spectral transition region. The reason is still under investigation.
- CrIS vs. AIRS
  - Resampling errors still remain when converting AIRS and CrIS onto common spectral grids.
  - CrIS and AIRS well agree each other at LWIR and MWIR bands within 0.4 K differences
  - At SWIR band, a sharp increases can be clearly seen at spectral transition region.
  - A weak seasonal variation can been seen for CrIS-AIRS at water vapor absorption region.
- Lessons learned for JPSS CrIS: Non-linearity play an important role for CrIS radiometric accuracy and should be carefully evaluated during the prelaunch test.
- Discussion:
  - Q What is the comparison between IASI A vs B (CrIS minus A or B)?
  - A: It shows a small difference, about 0.1 K.
  - C: We need to establish an absolute radiometric assessment.

CrIS versus IASI/MetOp-B

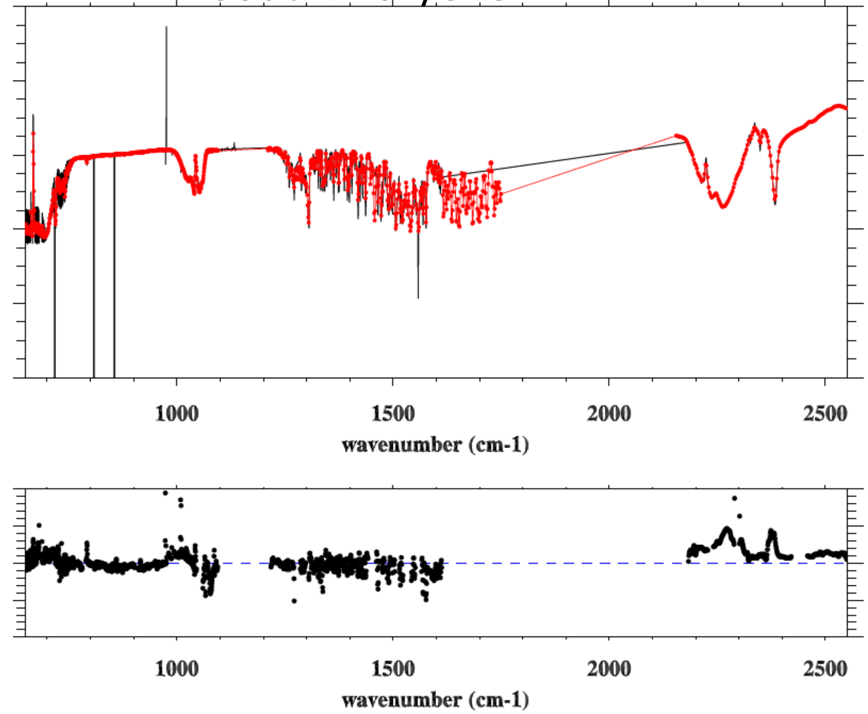


CrIS versus AIRS
Daily averaged SNO observations

North: 164/325



South: 161/325



Large spread could be due to the resampling uncertainties and AIRS band channels

Proxy dataset for Testing and Evaluating J1 CrIS SDR products

- There is a need to establish testing data for the algorithm due to software bugs, and missing observation among other reasons
- **We have so far collected 16 proxy datasets from SNPP CrIS trending/monitoring/debugging activitiesfor various tests:**
  - Functional test
  - Sensitivity test
  - Instrument anomaly
  - Engineering
  - Abnormal inputs
- **We have convenient tools to manipulate the dataset to create new cases for new requirement for J1**

NGAS Support for CrIS Cal/Val

- Twenty-seven DRs investigated, most related to SDR algorithm and data product quality issues, leading to eight CrIS SDR code update deliveries since launch
  - Two update deliveries since SDR validated maturity review to improve data anomaly handling
- Proposed an alternative spectral calibration approach to correct for sel-apodization and resample to user grid in one single step based on least square fit to the user desired (specified) ILS
  - Suggest to consider as an objective criterion when evaluating various viable approaches
- Use TVAC test data to evaluate different calibration approaches
- Discussion:
  - Q: Can CMO with LSE be available?
  - A: Yes, need to define laser wavelength

CrIS SDR Group Discussion

- J1 testing.
  - Window had leak. It has been resolved and now gives no tail end in LW. There is an obscuration cause by chip in the optics in FOV8.
  - RRTVAC (risk reduction) testing to check low frequency vibration due to communication gimbal.
  - Emi testing results are looking good. Current TVAC is from June to Oct 13 2014. This will include 8 thermal testing. Pre-ship review (PSR) is scheduled for the end of October. There is not enough time to do TVAC analysis (Oct 13) to be ready for the PSR. TVAC analysis should take about 2 months.
  - A request is made to have draft of sell-off memos (from D. Tobin).
- J-1 algorithm development.
  - Need to select the new algorithm (which candidate is the best) from a list of candidates
    - need to define the truth spectrum.
    - The selection of one of the 4 candidates will use simulation and also by looking at real data
  - Move CMO computation offline
    - It will be interpolated to the measured laser wavelength. (179 MB per laser wavelength). An advantage is to compute the CMO offline so we have visibility and there is no latency limitation. Also, we can select the best way to compute the CMO. As a disadvantage, if laser wavelength is way off the table range it would create an issue.
    - Also there is need to smooth the measured laser wavelength.
    - A suggestion is to interpolate the SA, then compute the inverse once per granule.
  - Need to address the non-cyclical effect s of the FIR application on-board the instrument.