

Suomi NPP CrIS SDR Provisional Product Highlight

Yong Han, CrIS SDR Team Lead

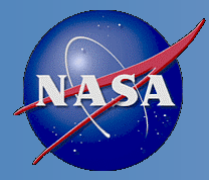
Suomi NPP SDR Product Review

NOAA Center for Weather and Climate Prediction (NCWCP)

5830 University Research Park, College Park, Maryland

October 23 - 24, 2012

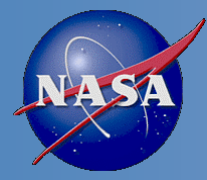




Outlines



- Team Membership
- CrIS operational concept
- Beta product and issues
- SDR specifications
- Highlights and caveats of the current product (Provisional)
- Lessons learned
- Summary



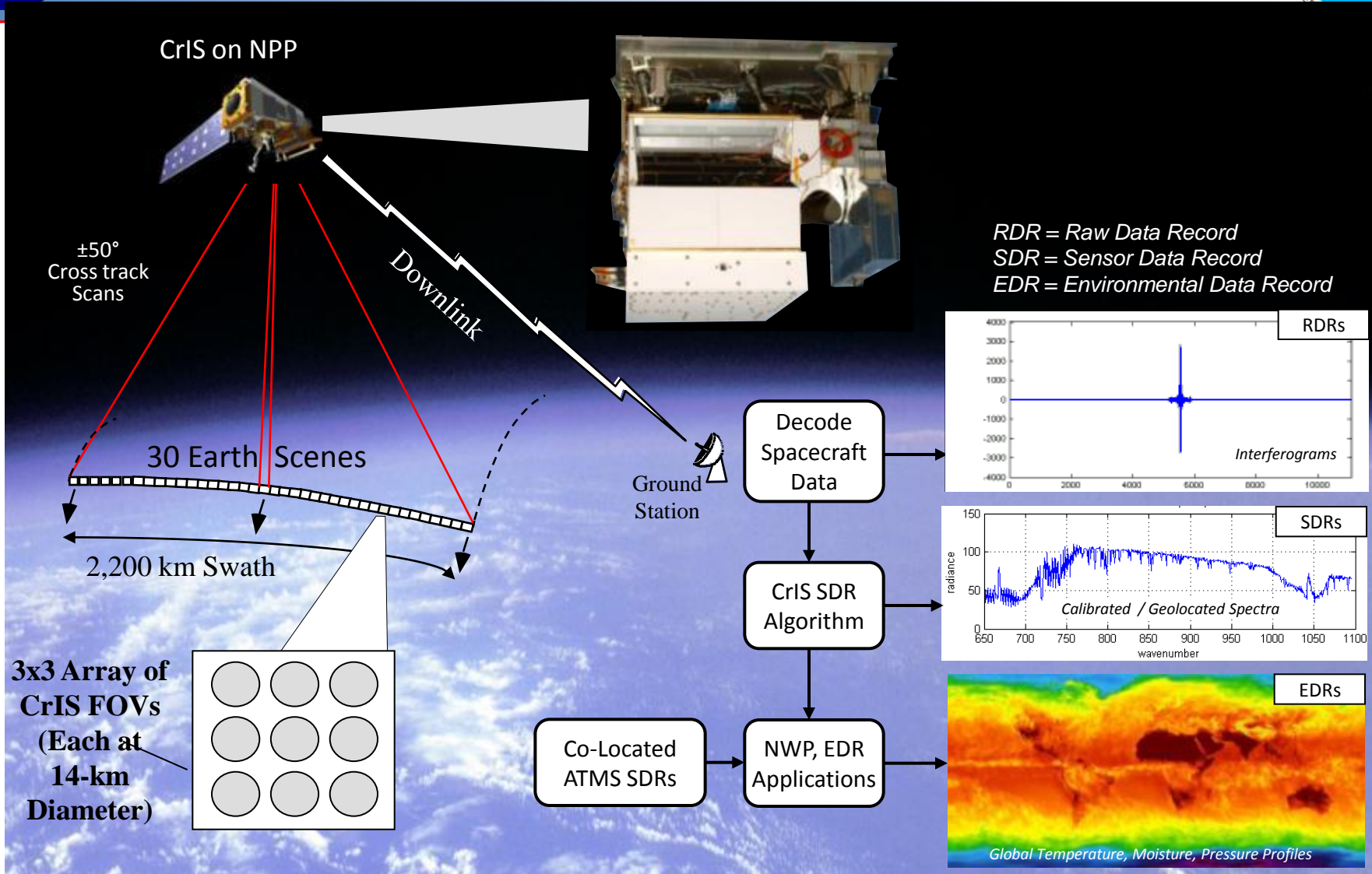
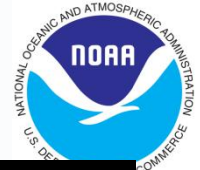
CrIS SDR Team

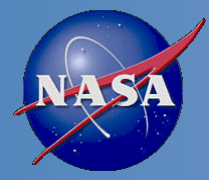


PI Name	Organization	Funding Agency	FY13 Task
Yong Han	NOAA/STAR	NJO	Support NPP/J1 Calval
Deron Scott	SDL	NJO	Support NPP/J1 Calval
Hank Revercomb	UW	NJO	Support NPP/J1 Calval
Larrabee Strow	UMBC	NJO	Support NPP/J1 Calval
Dan Mooney	MIT/LL	NJO	Support NPP/J1 Calval
Neal Baker	DPA	NJO	Support NPP/J1 Calval
Dave Johnson	NASA	NASA	Support NPP/J1 Calval
Joe Predina	Exelis	NASA/NJO	Support NPP/J1 Calval
Degui Gu	NGAS	NASA	Support NPP/J1 Calval & transition
Wael Ibrahim	Raytheon	NASA	Support NPP/J1 Calval



CrIS Operational Concept

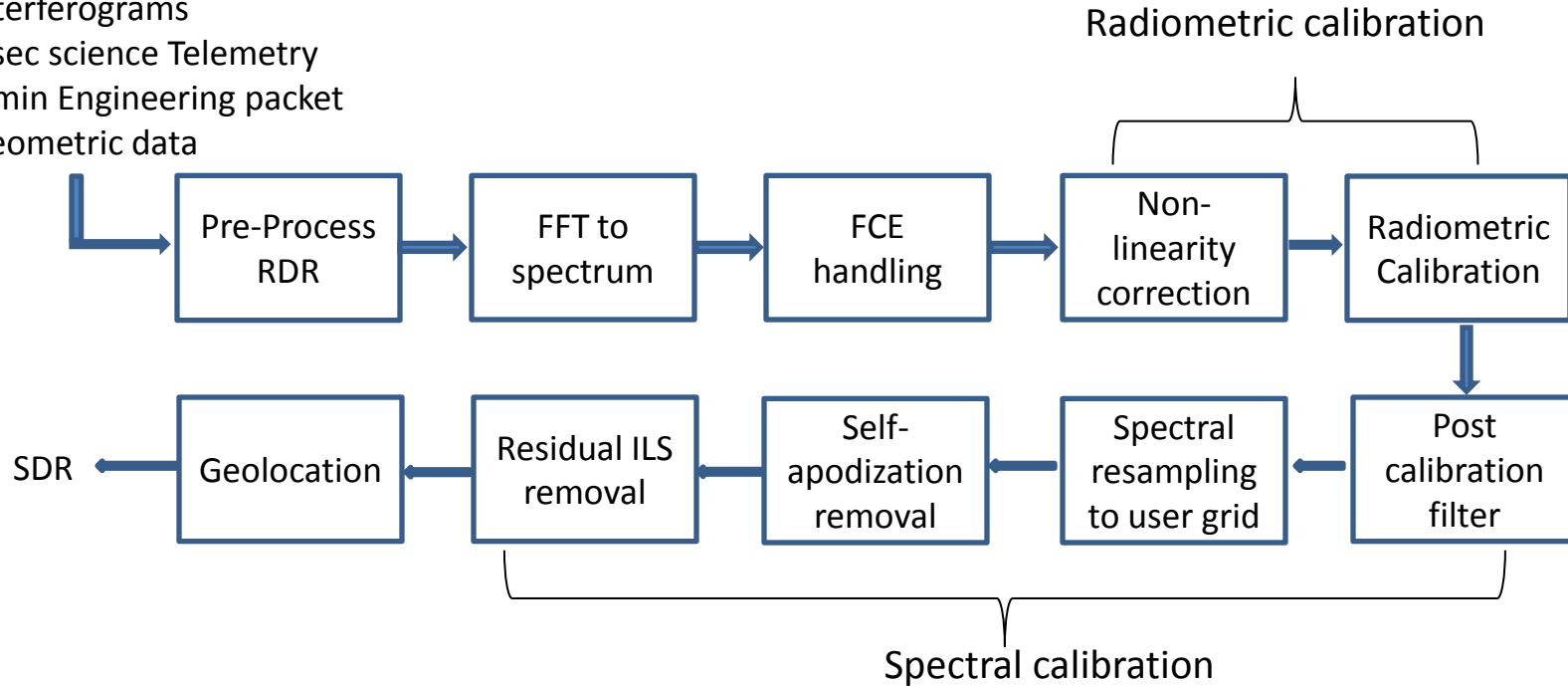




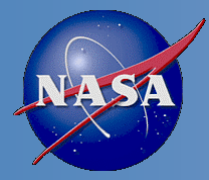
CrIS SDR Algorithm



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



All calibration coefficients and parameters are included in the Engineering packet



CrIS CalVal Activity Category



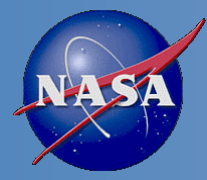
- Early sensor checkout and optimization (EOC, completed)
- CrIS performance characterization (EOC, ICV)
- SDR software update and algorithm improvement (EOC, ICV, LTM)
- Radiometric calval – NEdN, nonlinearity, ICT model and etc (EOC, ICV, LTM)
- Spectral calibration calval (EOC, ICV, LTM)
- Geolocation calval (EOC, ICV, LTM)
- CrIS performance trending and monitoring (EOC, ICV, LTM)

EOC – Early Orbit Checkout (completed)

ICV – Intensive Calibration and Validation

LTM – Long Term Monitoring

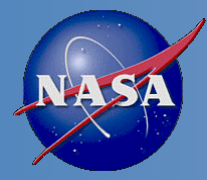
46 CalVal tasks are detailed in the CalVal plan



Beta Product Declared on May 15



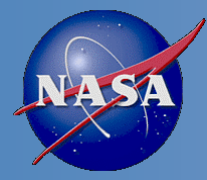
- Major Efforts resulted in CrIS SDR Beta product
 - Instrument checkout: PGA setting and bit trim mask updates (Engineering packet v32, uploaded on Feb. 8)
 - Spectral and Radiometric CalVal: ILS parameters, nonlinearity coefficients and ICT emissivity table updates (Engineering packet v33, uploaded on April 11)
 - Data quality assessment and data analysis: new onboard FIR filter (uploaded on April 18) to remove sweep direction dependent radiance bias
 - Critical SDR software bug fixes
- Issues
 - Data quality flag errors: ~60% of good SDRs are flagged as Degraded
 - Missing and corrupted RDR packets are not handled appropriately under certain conditions
 - The fringe count error (FCE) detection and correction code module is defective and has been turned off, as the FCE is currently a rare event
- Caveats described in the Beta Readme file
 - The data quality flags are defective
 - The fringe count error (FCE) detection and correction module was turned off
 - Monitored laser wavelength is set to zero
 - Some scans are incorrectly wrapped into granules whose time stamps don't match



CalVal Activities since Beta Review Meeting



- Spectral and radiometric uncertainty characterization
 - Inter-satellite/sensor comparisons
 - Observation vs. radiative transfer model comparisons
 - Gain analysis: orbital dependence, channeling, stability
 - Internal consistency check: FOV-2-FOV comparisons, FOR-2-FOR comparisons, component correlation analysis and PCA
 - Calibration algorithm analysis: spectral ringing and proposal for improvement
 - Full resolution data analysis for SW spectral calibration
- Geolocation validation
 - Uncertainty estimated using VIIRS data and near coastline CrIS data; 4.5 km error was found and fixed
- Algorithm improvement and code fix
 - New data quality flag based on imaginary part of radiances
 - New algorithm for checking temperature limits
 - Engineering packet updates from v33 to v34 and v35
 - Code fixes for geolocation and handling missing packets

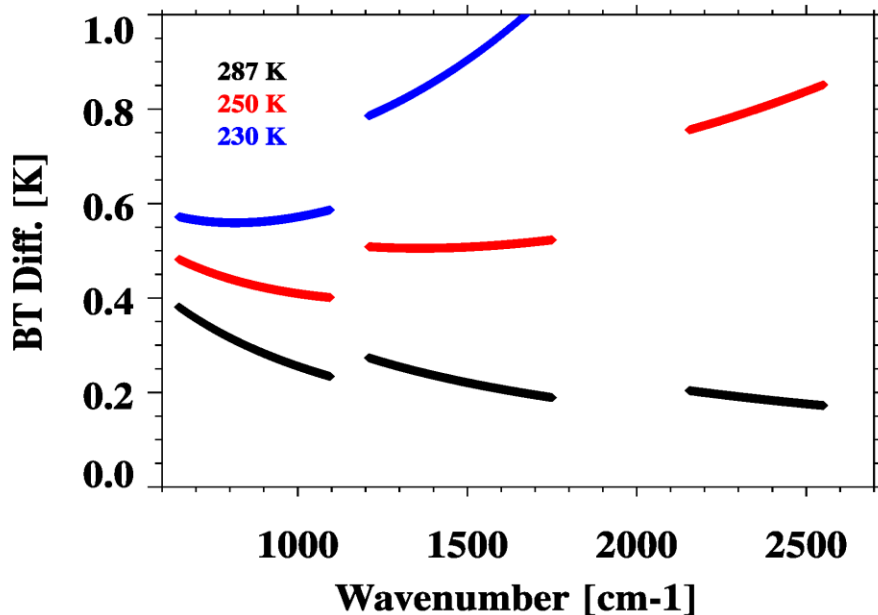


NPP CrIS Sensor Data Record Calibration Uncertainty Specifications

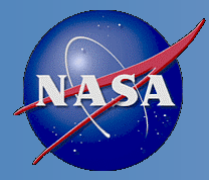


SDR Calibration Uncertainty

Band	Spectral range (cm ⁻¹)	N. of chan.	Resolution (cm ⁻¹)	FORs per Scan	FOVs per FOR	NEdN @287K BB mW/m ² /sr/cm ⁻¹	Radiometric Uncertainty @287K BB (%)	Spectral (chan center) 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

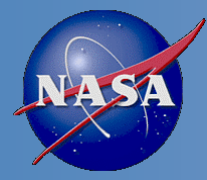


Radiometric uncertainty specification converted to that expressed in brightness temperature

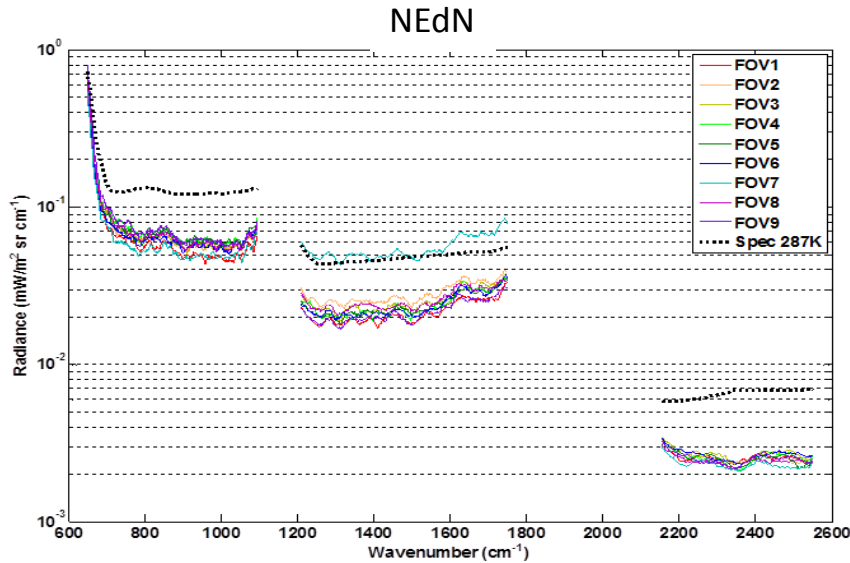


Highlights of the Current CrIS SDRs (Provisional)



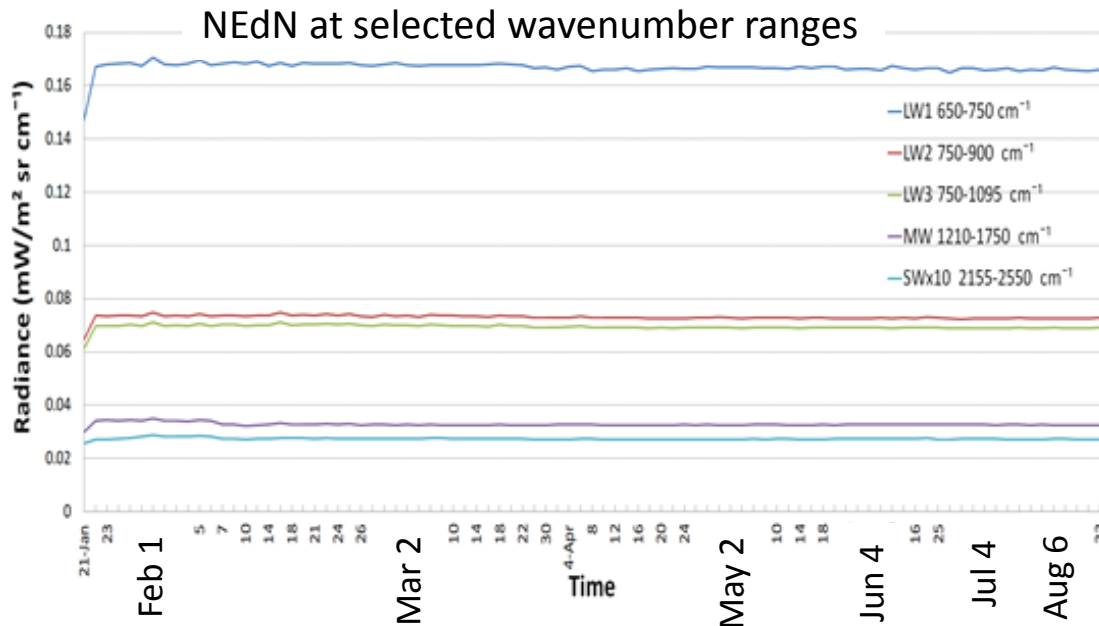


NEdN



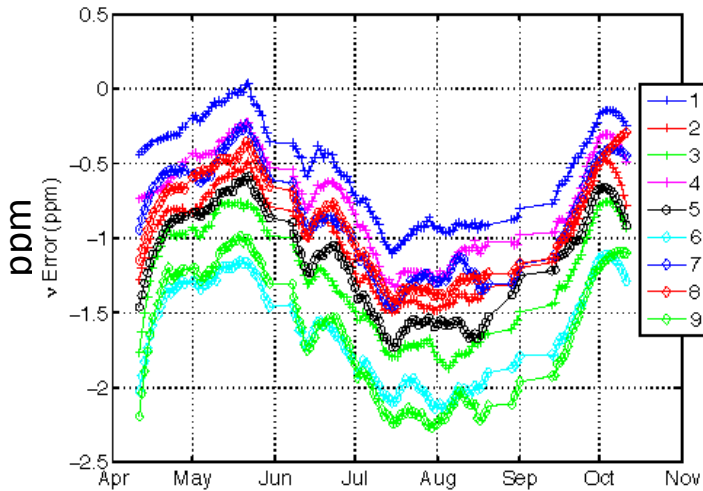
The noise levels are much better than the specification

The large NEdN at MW FOV 7 is a known issue before NPP launch

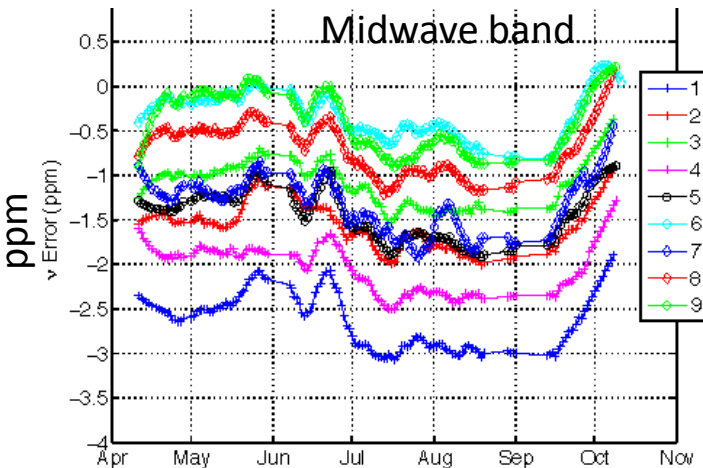


Stable NEdN over 8 months

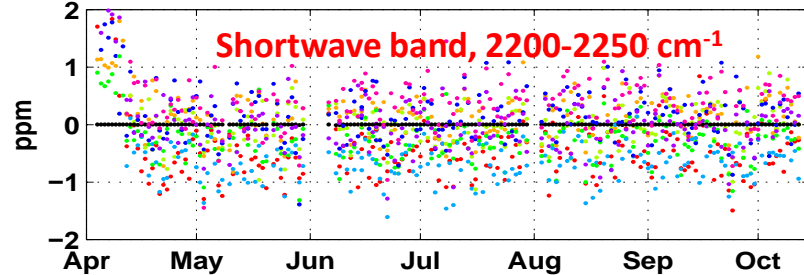
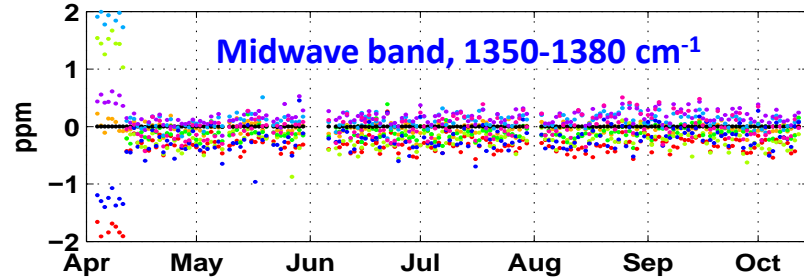
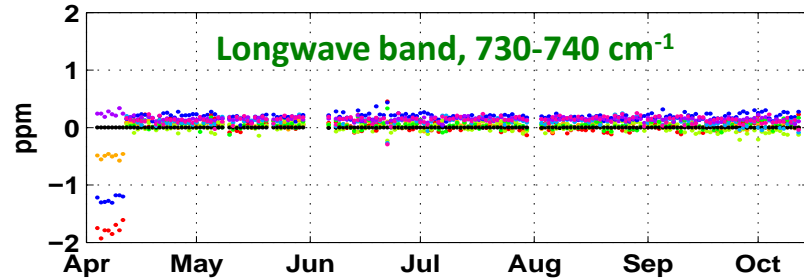
Spectral shifts assessed with RTM



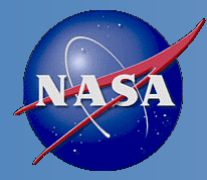
Midwave band



Inter-FOV spectral shifts relative to FOV5 derived from correlation analysis

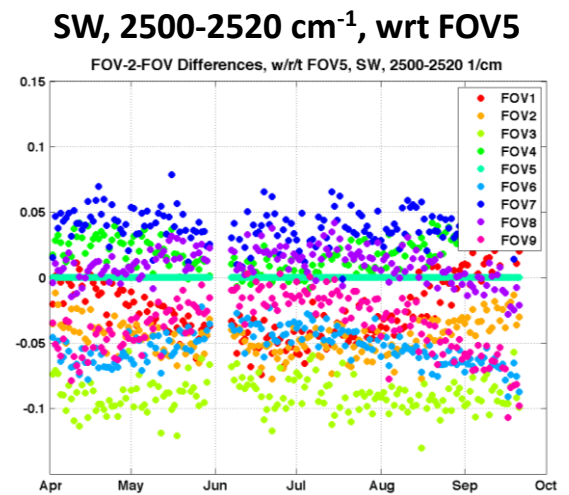
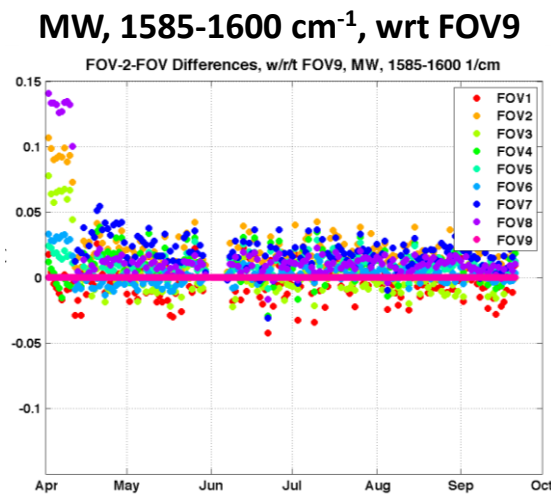
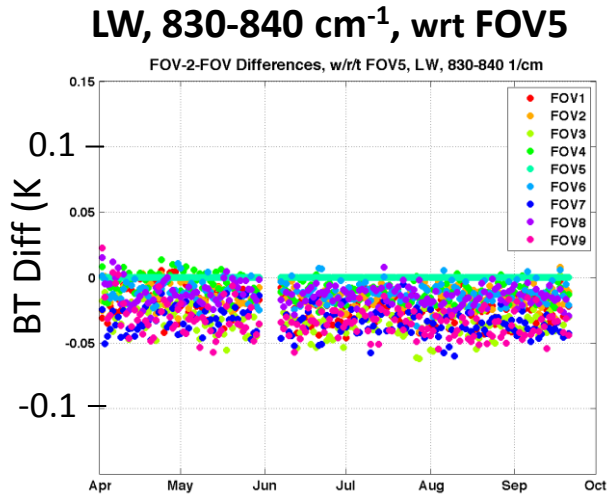
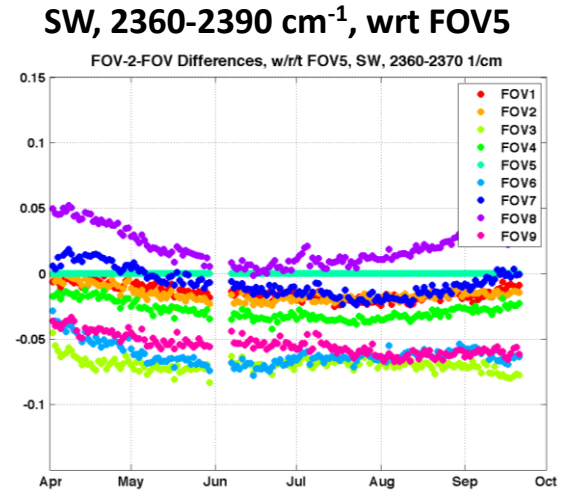
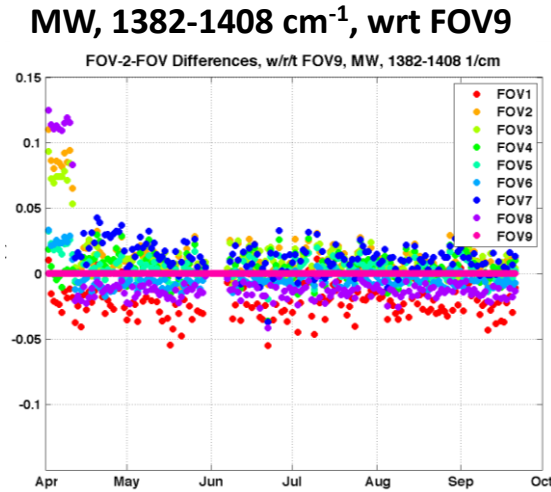
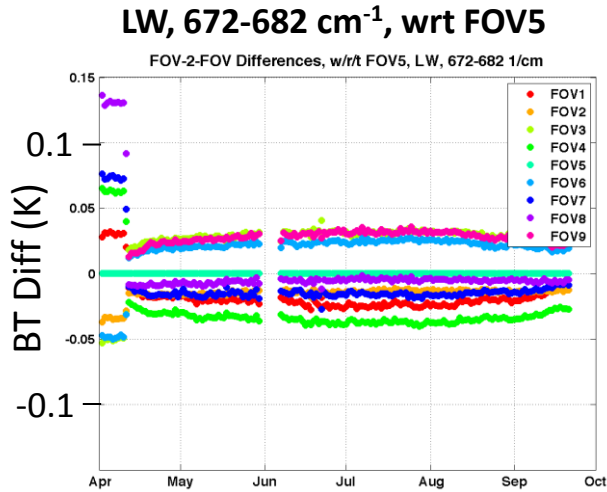


LW & MW band frequency uncertainty < 3 ppm (specification 10 ppm)
 SW band frequency uncertainty relative to FOV5 < 3 ppm

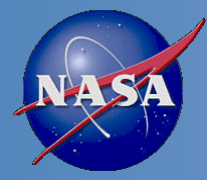


Radiometric Uncertainty Assessment

Inter-FOV difference

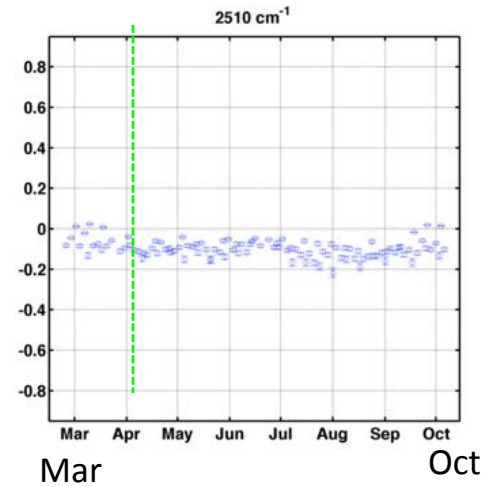
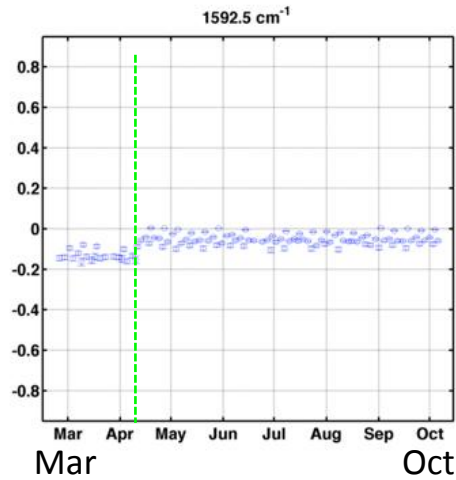
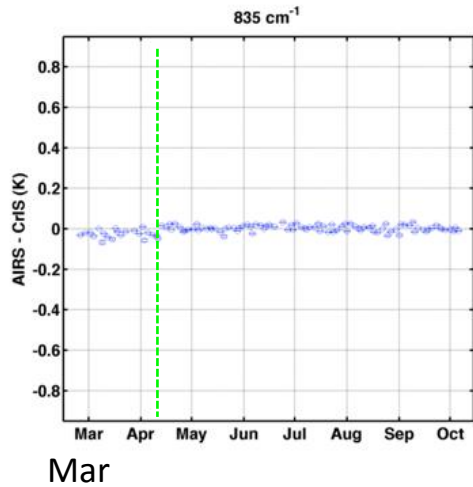
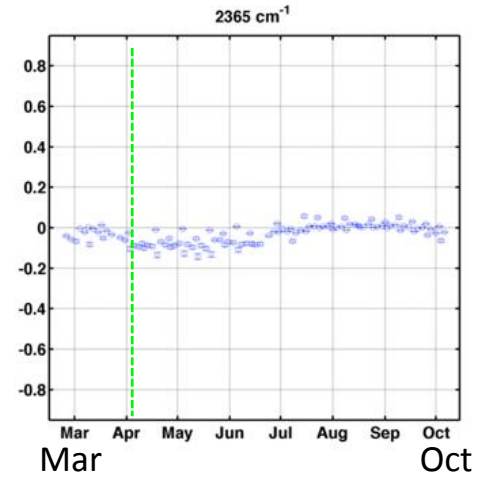
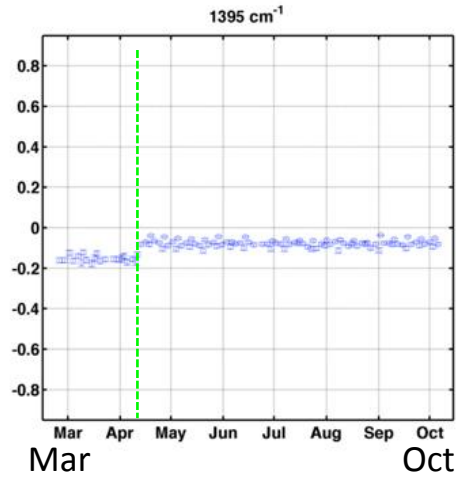
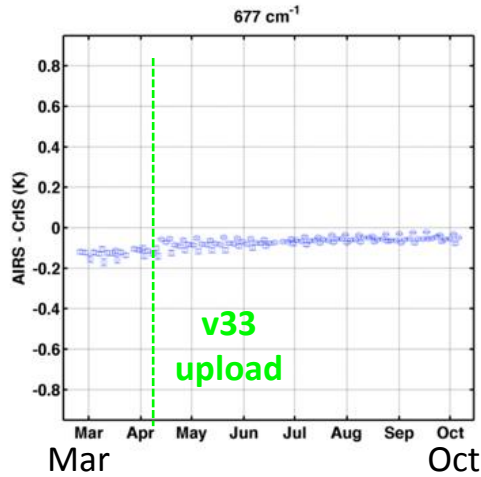


FOV-2-FOV differences are less than 0.04 K for LW and MW and less than 0.1 K for SW

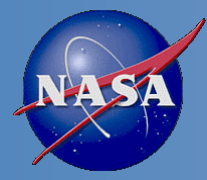


Radiometric Uncertainty Assessment

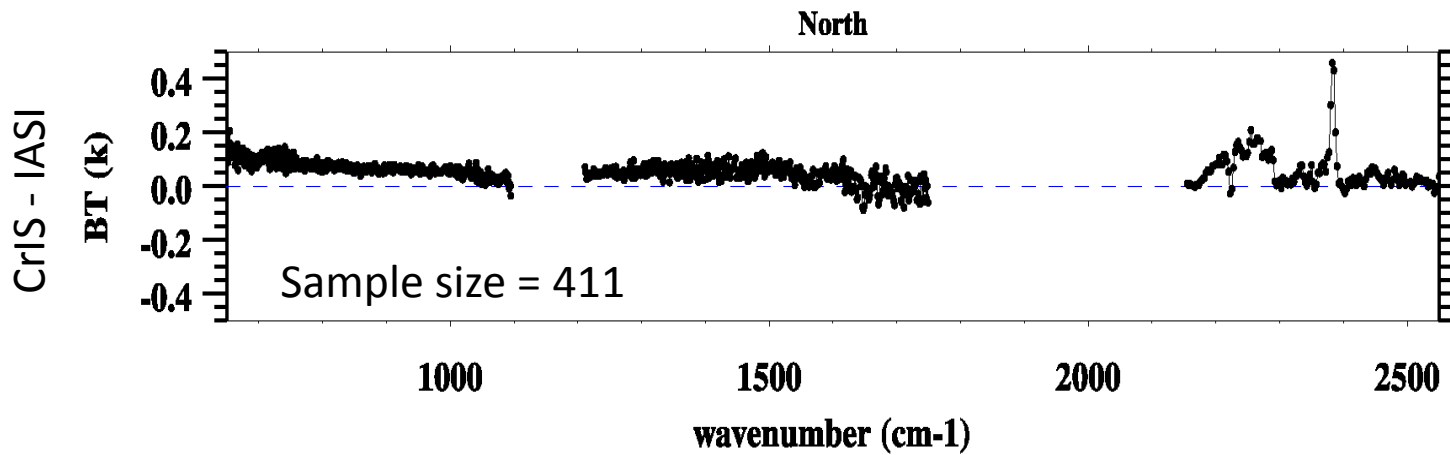
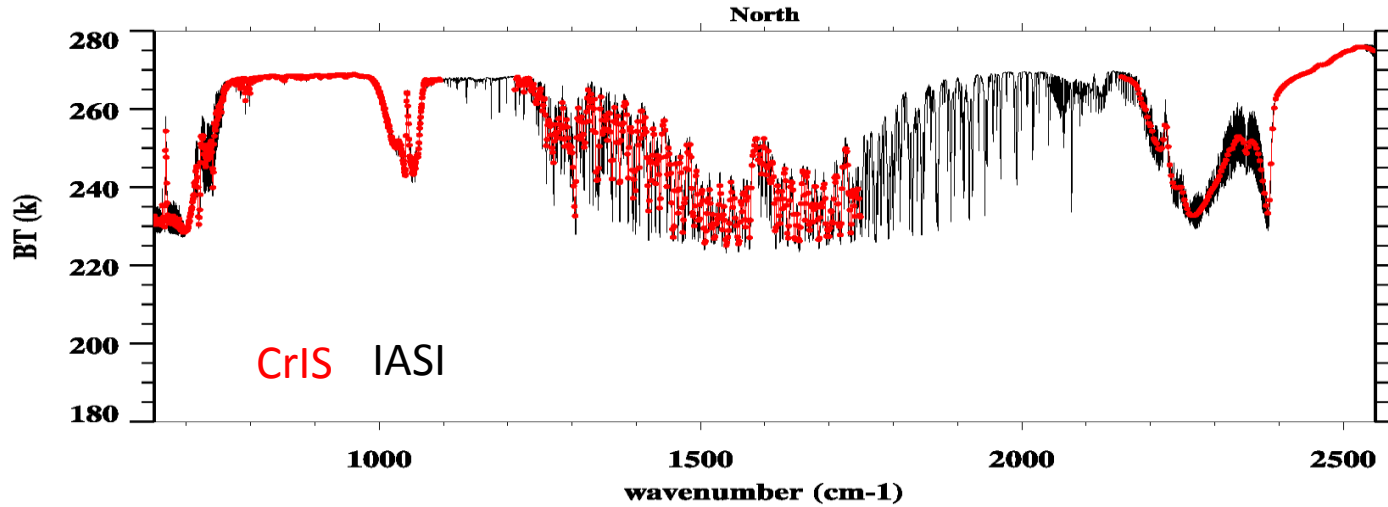
Daily Mean CrIS-AIRS Differences



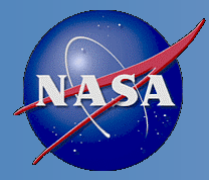
Stable difference ~ 0.1 K



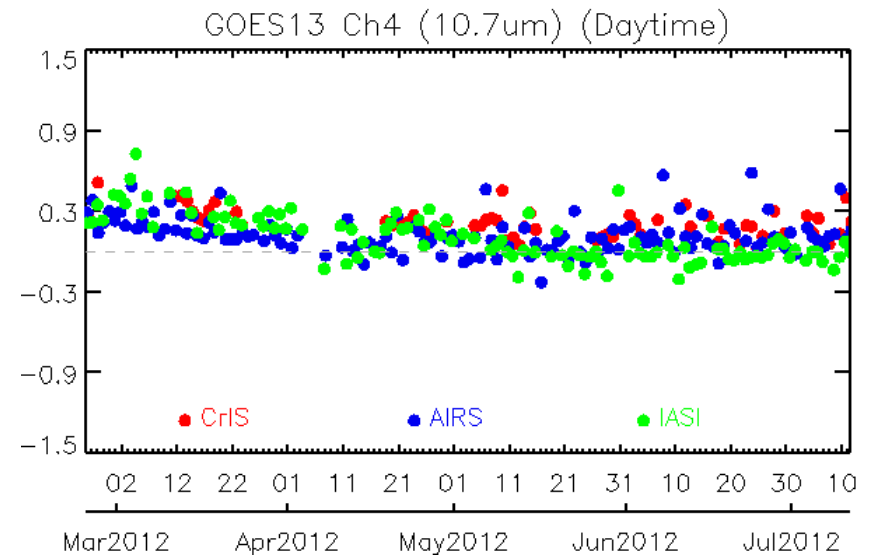
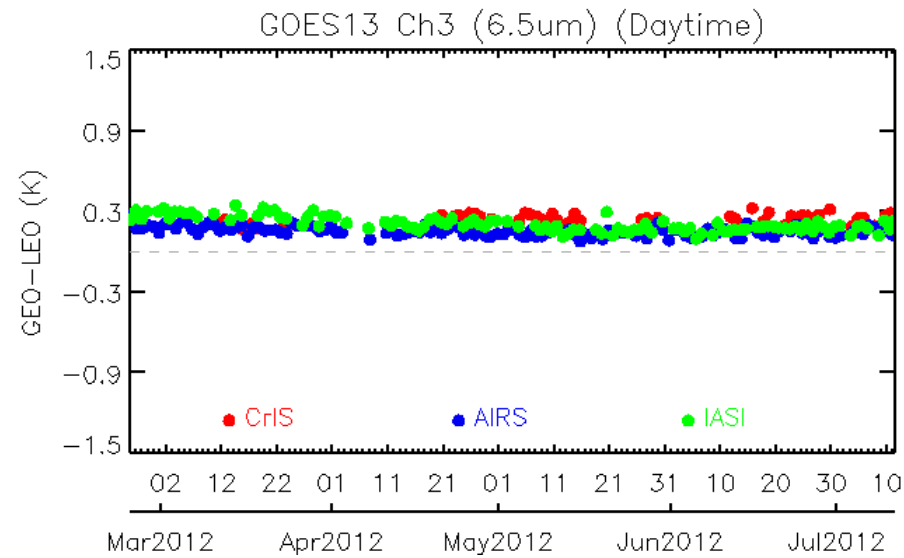
Radiometric Uncertainty Assessment CrIS-IASI SNO (North Pole)



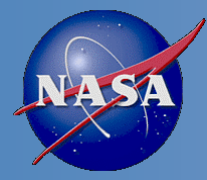
The CrIS IASI difference is ~ 0.2 K



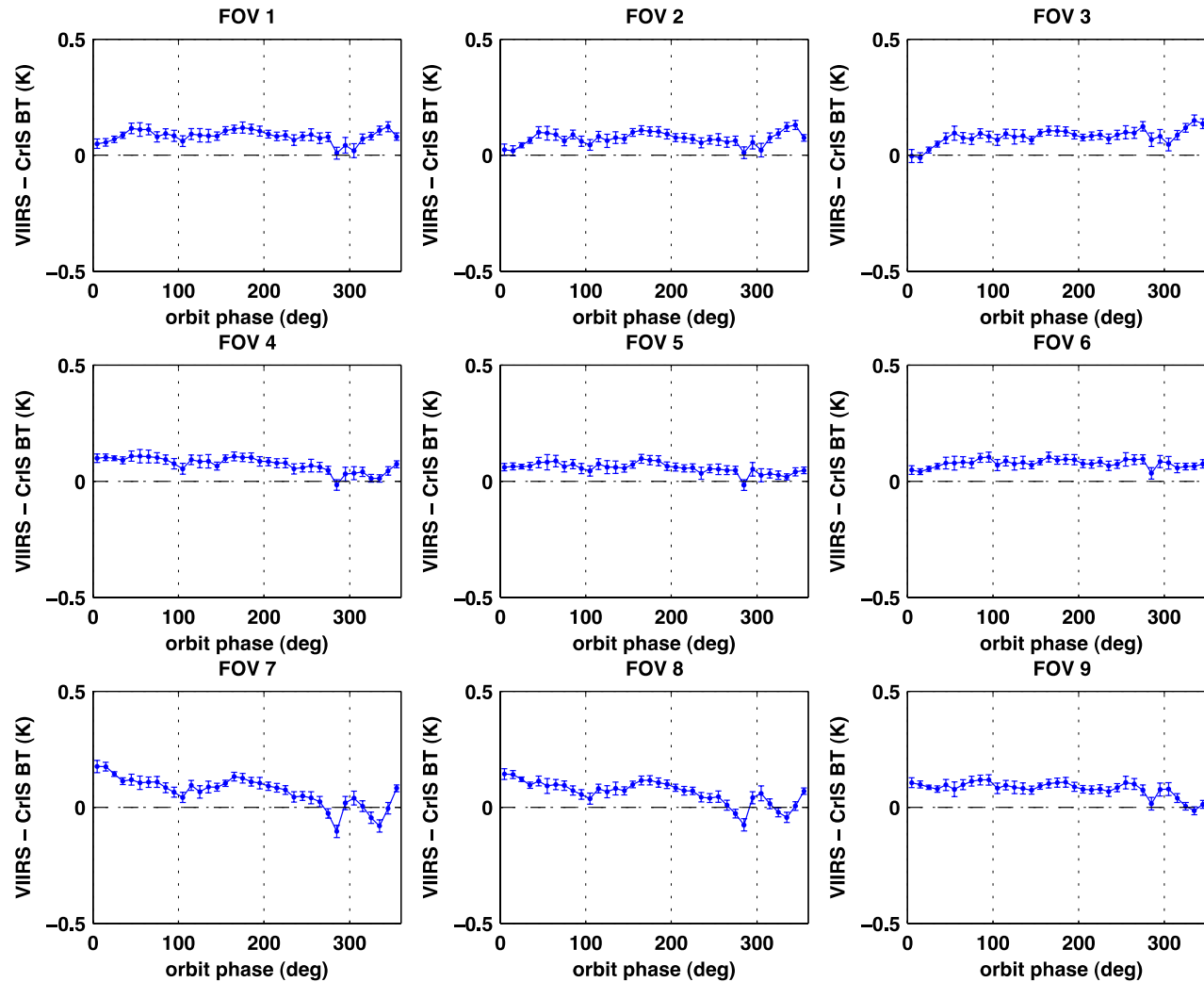
Radiometric Uncertainty Assessment Time-Series of GEO-LEO Tb Difference



Similar CrIS-GOES, AIRS-GOES and IASI-GOES differences



Radiometric Uncertainty Assessment CrIS/VIIRS (M13 4um) comparisons

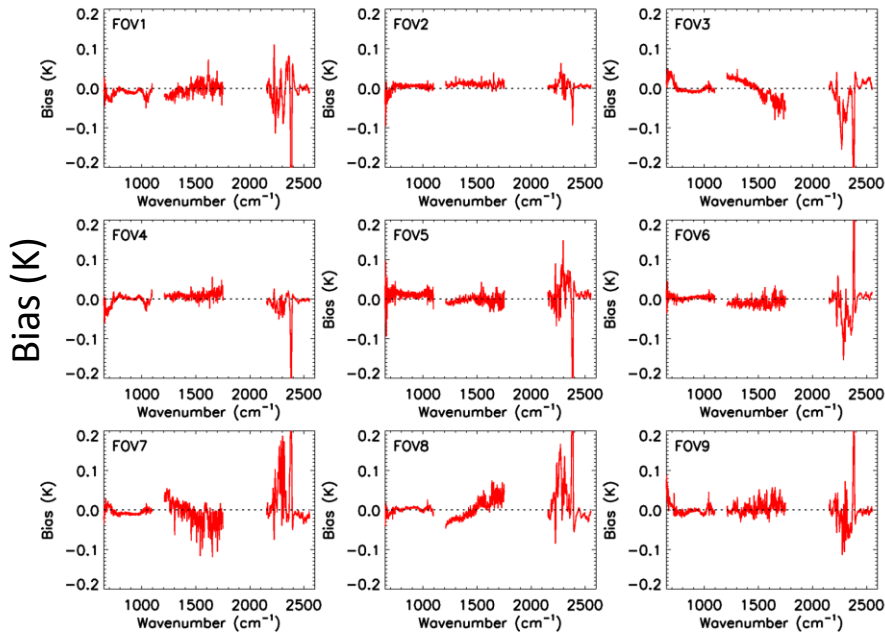


Difference is less than 0.2 K

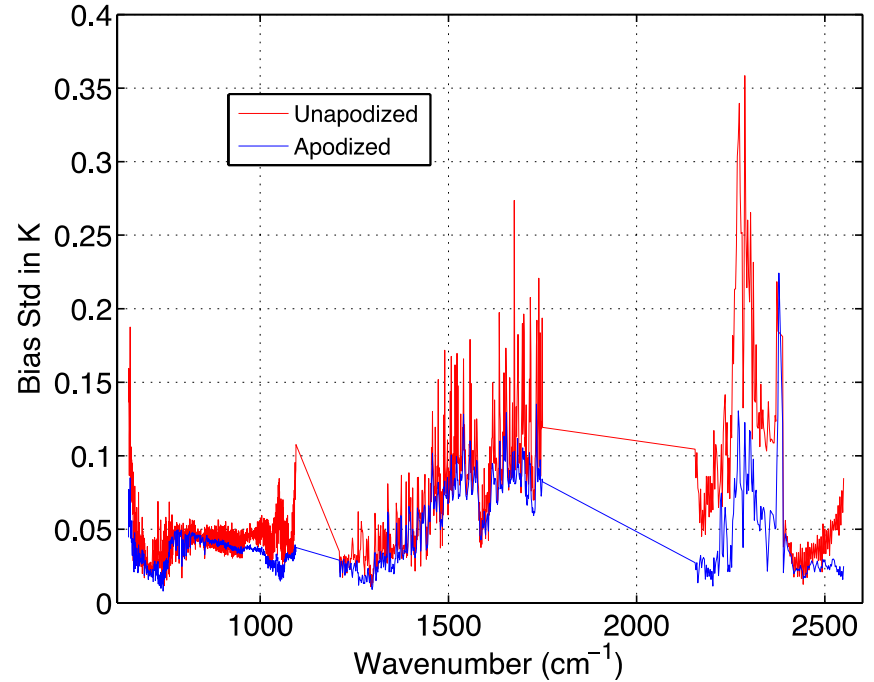
Radiometric Uncertainty Assessment

Radiance Bias Estimated with RTM

Standard deviations of Biases vs Radiative Transfer Model (RTM) simulated radiances



Standard deviation (over 9-FOVs) of Bias vs RTM simulated radiances



Overall bias < 0.2 K
FOV-2-FOV differences < 0.1 K

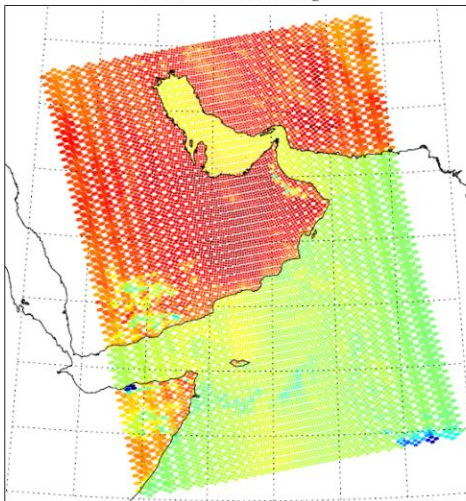
**Geolocation uncertainty within 30° scan angles < 1 km
(specification 1.5 km)**

VIIRS geolocation uncertainty

	Bias (m)	RMSE (m)
Track	-21	80
Scan	-8	64

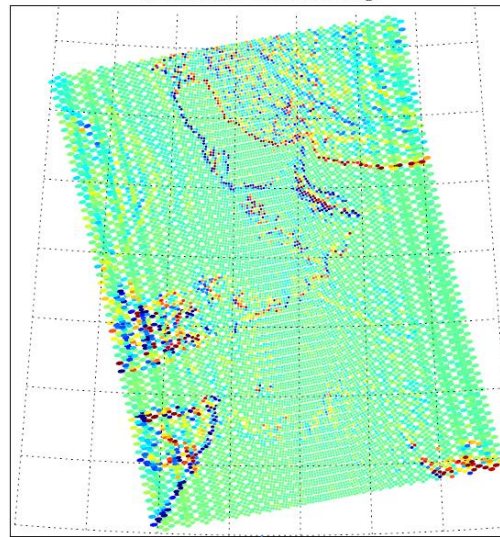
CrIS image

20120920.ADA CrIS Image



IDPS MX6.2
4.5 km geolocation error

20120920.IJPS CrIS-VIIRS Image



IDPS MX6.3

20120920.ADA CrIS-VIIRS Image

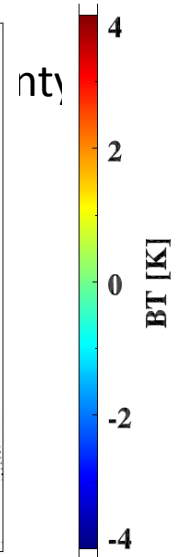
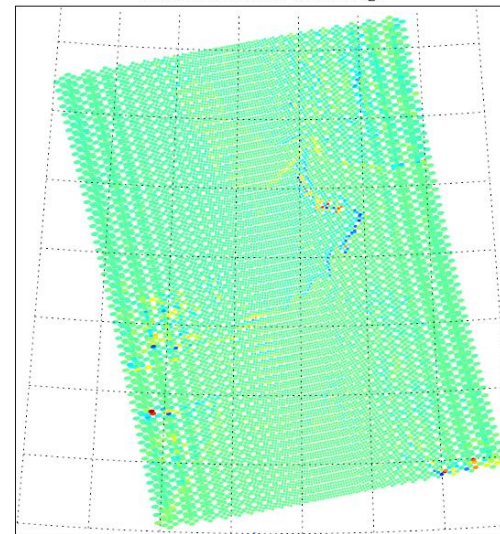
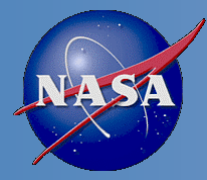


Image differences (CrIS – VIIRS) before and after a coding error fix

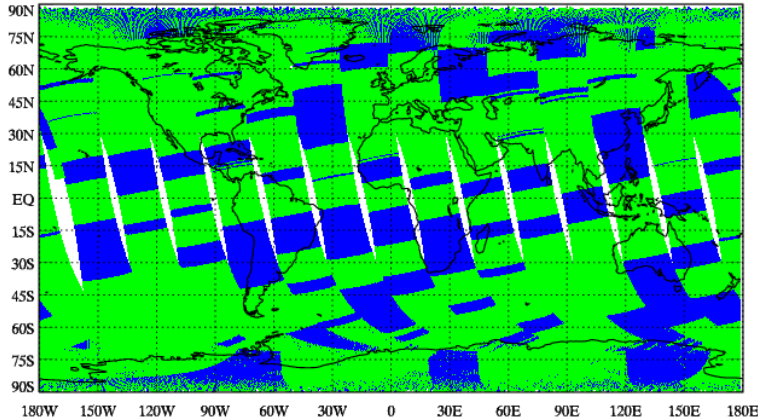


Overall Quality Flag Improvement



Beta product

Ascending_orbits: LW SDR_Quality Date: 2012-04-27
(Blue: Good; Green: Degraded; Red: Invalid)

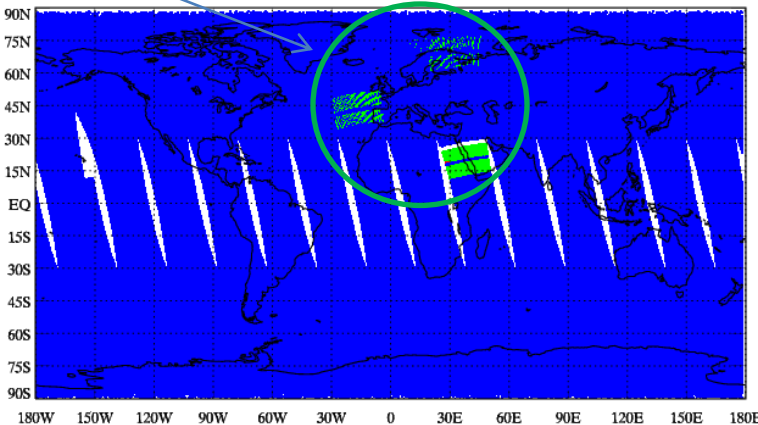


Quality flag:
Blue color – GOOD
Green color - DEGRADED

A false alarm (data labeled as Degraded) was fixed with code changes and parameter updates

Will be fixed with uploading Engpkt v35 on Oct. 22, 2012

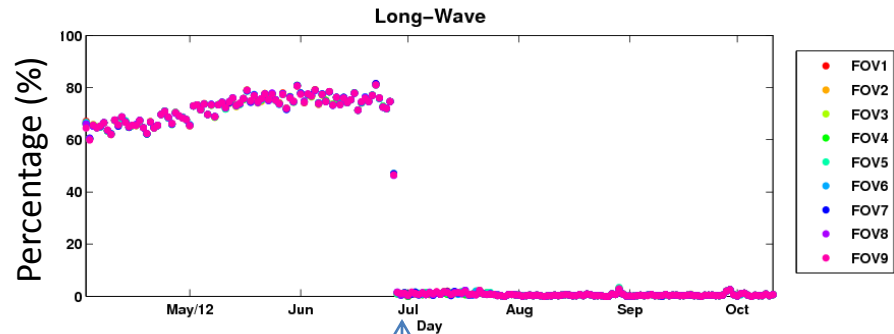
Ascending_orbits: LW SDR_Quality Date: 2012-06-29
(Blue: Good; Green: Degraded; Red: Invalid)



Current product

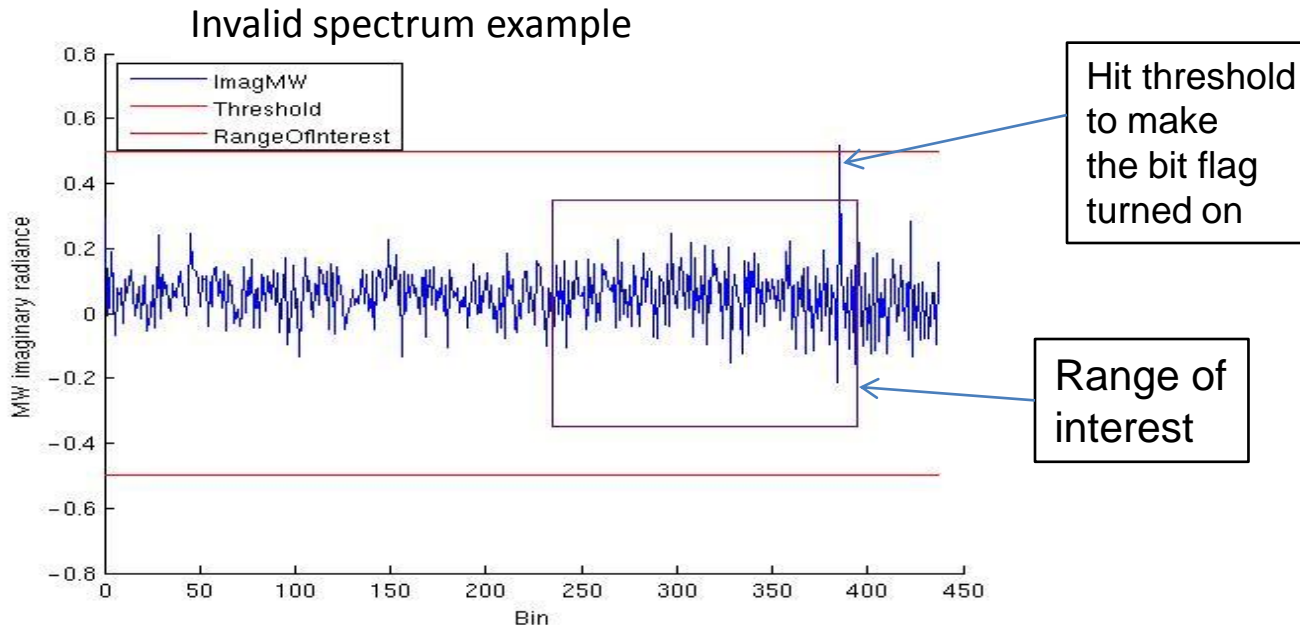
Daily Occurrence: Degraded SensorDataRecord

Created at 10/11/2012 – 15:18:34 UTC

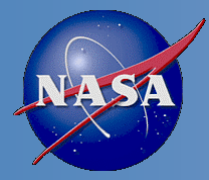


Engineering packet v34 uploaded

- Good radiance spectra have near zero imaginary radiances
- Add a bit flag to indicate the spectrum is Invalid if any imaginary channel in the range exceeds the thresholds:
 - LW: upper limit 1.5, lower limit -1.5, in the range 800 – 980 cm^{-1}
 - MW: upper limit 0.5, lower limit -0.5, in the range 1500 – 1700 cm^{-1}
 - SW: upper limit 0.05, lower limit -0.05, in the range 2250 – 2350 cm^{-1}



This is an important QC algorithm for detecting invalid SDR data caused by FCE events and many other RDR problems

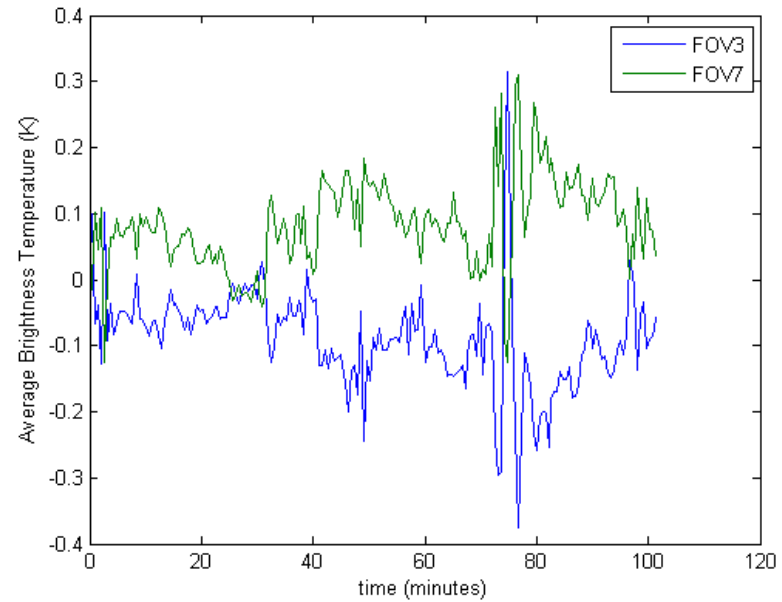
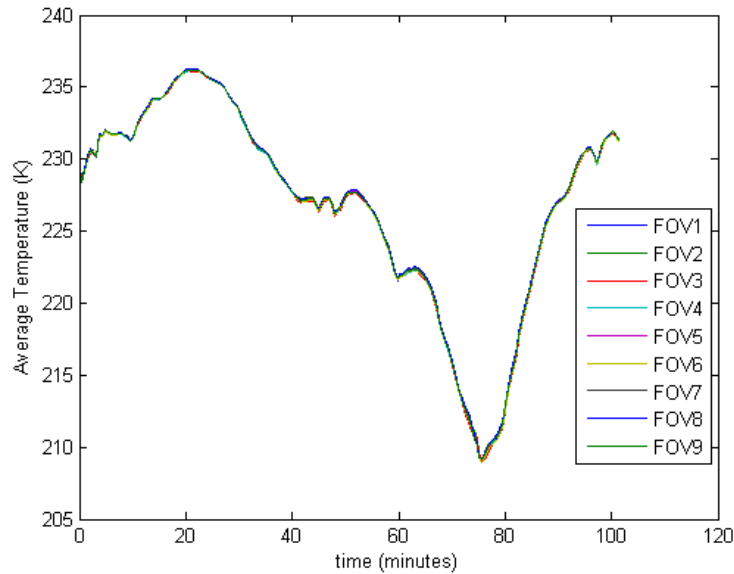


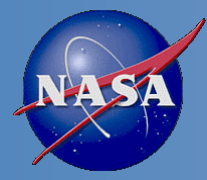
Issue under Investigation

SW Cold Scene FOV Differences



Brightness temperature averaged over the range from 2256 to 2302 cm^{-1} ; the scene is very cold



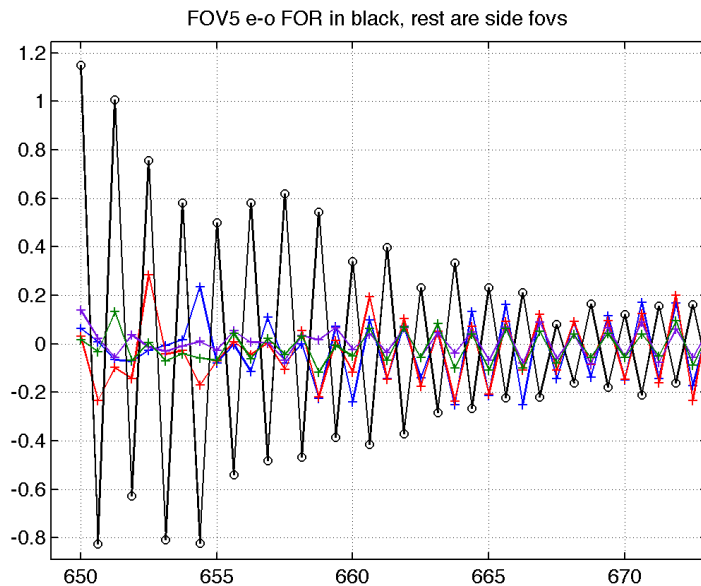


Issue under Investigation

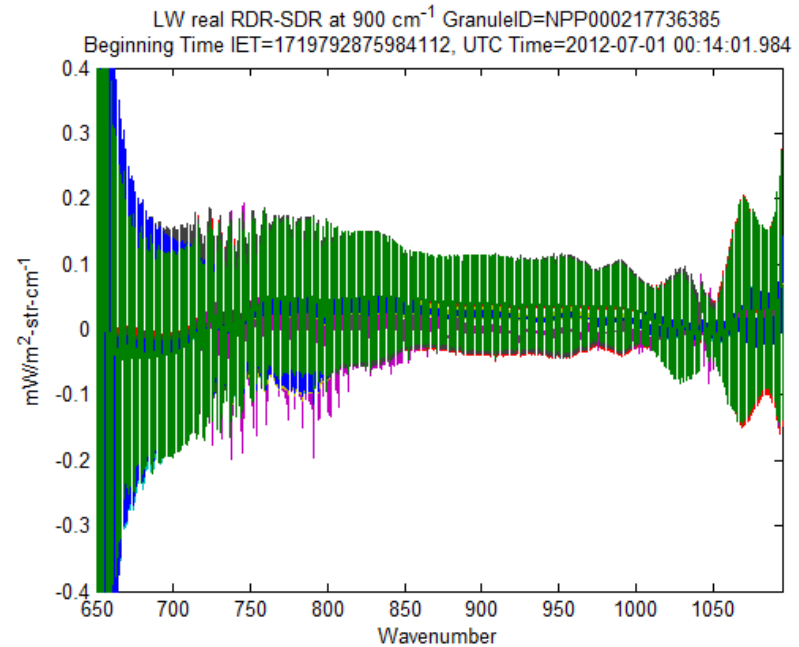
Ringling at the End of Un-apodized Spectra



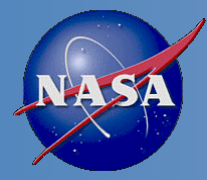
Differences in NWP biases with interferometer scan direction



Difference between IDPS and MIT/LL SDRs



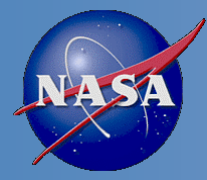
External apodization (e.g. Hamming) is recommended that can reduce the ringing to a level below 0.1 K



Status of Discrepancy Report (DR)



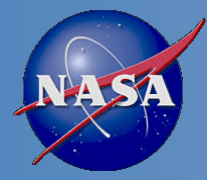
- Total 87 CrIS SDR DRs on CasoNOSA
- 72 DRs closed
- 16 DRs still open – none is critical for the Provisional
 - 4 DRs (#3563, #4937, #4661, #4232) are being closed
 - 2 FCE-related DRs (#4508, #4481) will be fixed in future together with the algorithm fix
 - FCE even has been rare so far
 - A new QC algorithm has been implemented, which is able to flag the data as Invalid If FCE happens
 - 5 DRs (#3081, #4198, #4253, #4774, #4812, #4407) will be handled in the future (DPA agrees)
 - No significant impact on the Provisional product users
 - 3 DRs (#4391, #4389) are minor code issues and will be fixed for Validated product
 - no significant impact on the Provisional product users
 - 2 DRs (#4868, #4090) will be fixed in Mx6.5 and Mx7.0
 - Once a month the IDPS will generate a bad scan of SDRs from a good scan of RDRs
 - Currently the data are correctly labeled as Invalid



Issues and Provisional Product Caveats



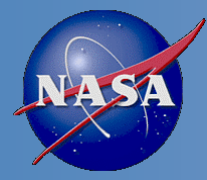
- Issues
 - Software issues are still appearing
 - Significant SW cold scene FOV differences
 - Spectral ringing
 - FCE module currently turned off
 - Several potential software components need to be checked out (e.g. the process of triggering CMO calculation by metrology laser variations has not been verified)
- Provisional product caveats
 - The value of the ESZPDMMagnitude field may not be corrected due to an inconsistency between the internal data types (DR 4389); the error will be fixed in the next build
 - The fourth scan of the SDR granule generated from a short RDR granule (3 scans) is not valid (filled with fillvalue), but labeled as Valid; will be fixed in Mx6.5



Path Forward



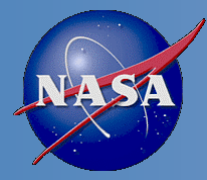
- Suomi NPP
 - Continuation of CalVal as planned for the remaining ICV and LTM
 - Fine adjustment of spectral and radiometric calibration parameters and geolocation mapping parameters
 - Algorithm and software quality control improvements (FCE detection/correction, self-apodization correction and code fix)
 - Close of all remaining and new DRs
 - Aircraft campaigns
 - Documentation, including SDR product user guide
 - Algorithm and code enhancement for handling full resolution RDRs
 - SDR Validated product: June 2013
- JPSS J1
 - Support of and participation in pre-launch testing and instrument characterization
 - Algorithm and software improvement (calibration algorithm, full resolution SDR and computation efficiency)



Lessons Learned



- Inadequate pre-launch software and algorithm testing resulted in a number of critical post-launch problems
- ADL is not fully compatible with IDPS, which caused delays of CalVal fixes, as the team had to wait for results from IDPS, which was not updated as often as the team wanted



Summary



- CrIS SDR has reached the Provisional maturity level
- All critical DRs and document issues have been addressed
- A number of CalVal and software issues have been identified and will be addressed for the Validated product
- The team has a clear path moving forward for both NPP and J1 missions

Calibration type	Meet Specification		
	LW band	MW band	SW band
NEdN	✓	✓	✓
Radiometric calibration	✓	✓	✓
Spectral calibration	✓	✓	✓*
Geolocation	✓**	✓**	✓**

* Relative to FOV5

** Within 30° scan angles

Provisional Maturity Level Definition	Status
Ready for operational evaluation	True
Product quality may not be optimal	True
Incremental product improvements are still occurring as calibration parameters are adjusted	True
Version control is in affect	True
General research community is encouraged to participate in the QA	True
Users are urged to consult the SDR product status documents prior to use of the data in publications	True