Suomi NPP CrIS SDR Task Overview

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Suomi NPP SDR Product Review
NOAA Center for Weather and Climate Prediction (NCWCP)
5830 University Research Park, College Park, Maryland
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Outlines

- Team Membership
- CalVal activities & results since Provisional review meeting
- DR Status
- CrIS SDR has reached Validated maturity level
- Path forward
- Summary

CrIS SDR Team

PI Name	Organization	Funding Agency
Yong Han	NOAA/STAR	NJO
Deron Scott	SDL	NJO
Hank Revercomb	UW	NJO
Larrabee Strow	UMBC	NJO
Dan Mooney	MIT/LL	NJO
Degui Gu	NGAS	NASA
Mike Cromp	Exelis	NASA/NJO
Dave Johnson	NASA	NASA
Wael Ibrahim	Raytheon	NASA
Carrie Root	JPSS/DPA	NASA

Findings at Provisional Review Meeting (10/23/2013)

- Outstanding – significant amount of work since beta
- No major issues
- Instrument well within specification
- Team should analyze trends very carefully to assess stability
- Need to ensure data quality flags are working
- Need to assess CrIS saturation at the cold end – important for climate
- Continue to assess stability, study M15/CrIS scene dependent bias, and CrIS/AIRS cold end issue

CrIS CalVal Tasks Performed Since Provisional Review Meeting

- SDR algorithm and software improvement
- CrIS performance characterization
- Radiometric CalVal
- Spectral CalVal
- Geolocation CalVal
- CrIS instrument and SDR trending and monitoring
- Development of full spectral resolution data processing capability
- Documentation

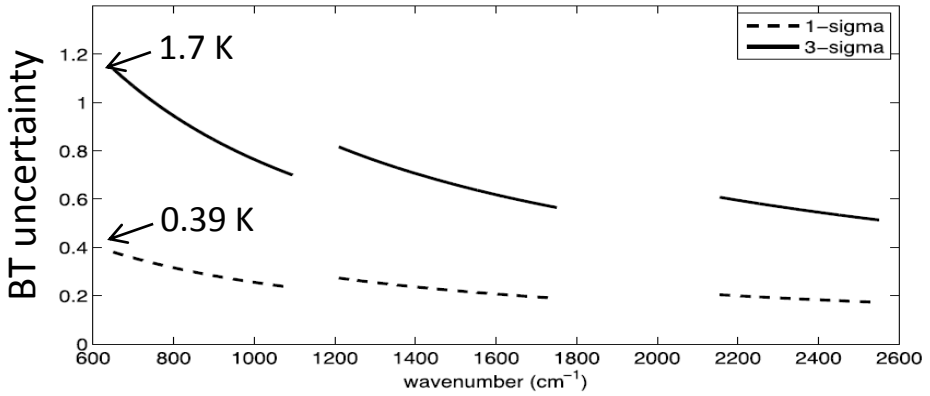
SDR Data Sets

- IDPS
  - SDRs produced by IDPS with versions up to Mx8.0
  - Calibration data: EngPkt-v35
- ADL
  - Reprocessed SDRs (UW 18 months; STAR 10 months)
  - Code updated to match Mx8.1 (become operational on 2/20/2014)
  - Calibration data: EngPkt v36 (become operational on 2/20/2014)

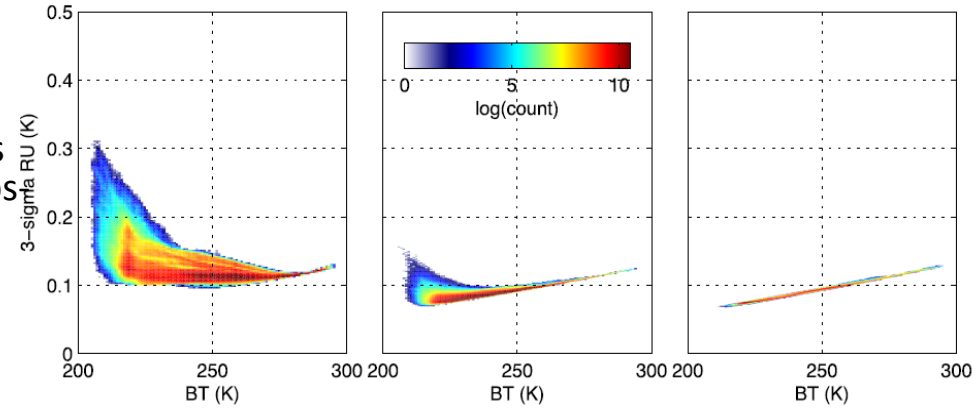
Radiometric CalVal

- Activities
  - Radiometric Uncertainty (RU) estimates & evaluations
  - CrIS vs. AIRS/IASI/VIIRS comparisons
  - CrIS vs. RT model comparisons
  - FOV-to-FOV & F-to-R comparisons
  - Nonlinearity (NL) correction algorithm improvement
  - NL a2 coefficient adjustments
  - SSM polarization investigation
  - 14 telecon meeting presentations
- Results
  - RU estimates & error budget
  - Consistency between RU estimates and results obtained from cross-sensor comparisons & Obs calc analysis
  - Improved NL correction algorithm/code in Mx8.1
  - Updated a2s in EngPkt v36
  - Issue of CrIS/VIIR-M15 cold scene difference addressed
  - Polarization effect significant but small compared to RU spec. (preliminary)

Uncertainty specification @287K blackbody



Distribution of 3-sigma RU for on orbit of data

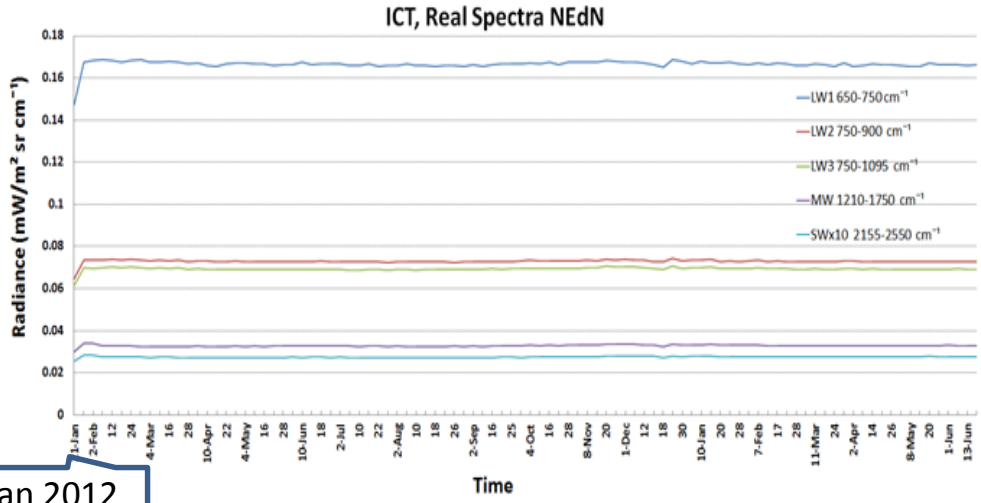


See presentation Tobin et al.

Instrument Performance Characterization

- Activities
  - NEdN and responsivity evaluation & trending
  - RDR data quality assessment & trending
  - Instrument event investigation (e.g. CREEBIT error impact on SDR)
  - 14 telecon meeting presentations
- Results
  - Stable instrument performance
  - Low and stable NEdN
  - Excellent dynamic range: no signal saturation in LW & MW bands; 0.2% of SW data saturated in sun-glint areas.
  - No Fringe Count Error (FCE) so far
  - No ice contamination so far
  - RDR flags working as expected
  - small increase of DS imaginary NEdN since Oct 2013 – no impact to the real radiance spectra
  - LW FOV1 NEdN variations of ~(25-50)% observed in July-Sep. 2013; back to normal since

Stable real spectra NEdN



NEdN significantly lower than spec

	LW	MW	SW
Specification	0.14	0.05	0.007
Actual	0.098	0.036	0.003

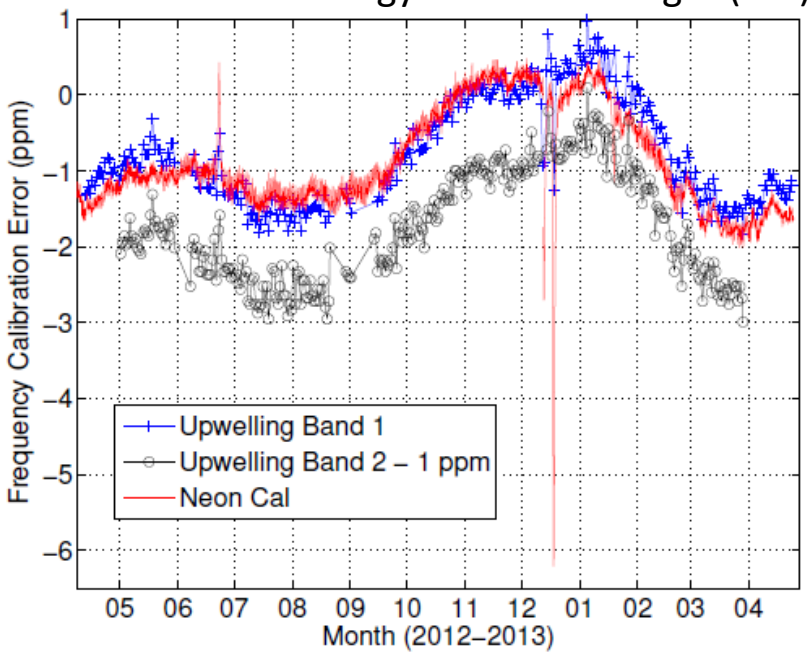
NEdN units: $mW/m^2/sr/cm^{-1}$

See presentation Zavyalov et al.

Spectral CalVal

- Activities
  - Spectral uncertainty estimates & evaluations with RT model, cross-sensor comparisons and FOV to FOV-5 comparisons
  - ILS correction algorithm improvement
  - ILS parameter adjustments for spectral calibration
  - Neon calibration monitoring/trending
  - CMO matrix monitoring
  - 13 telecon meeting presentations
- Results
  - Absolute and relative spectral calibration uncertainty estimates
  - Improved ILS correction algorithm/code in Mx8.1
  - Updated ILS parameters in EngPkt v36
  - Metrology laser variations and Neon calibration well characterized

Observed frequency calibration error vs variation of metrology laser wavelength (red)



frequency calibration uncertainty for all three bands:

Absolute: < 3 ppm

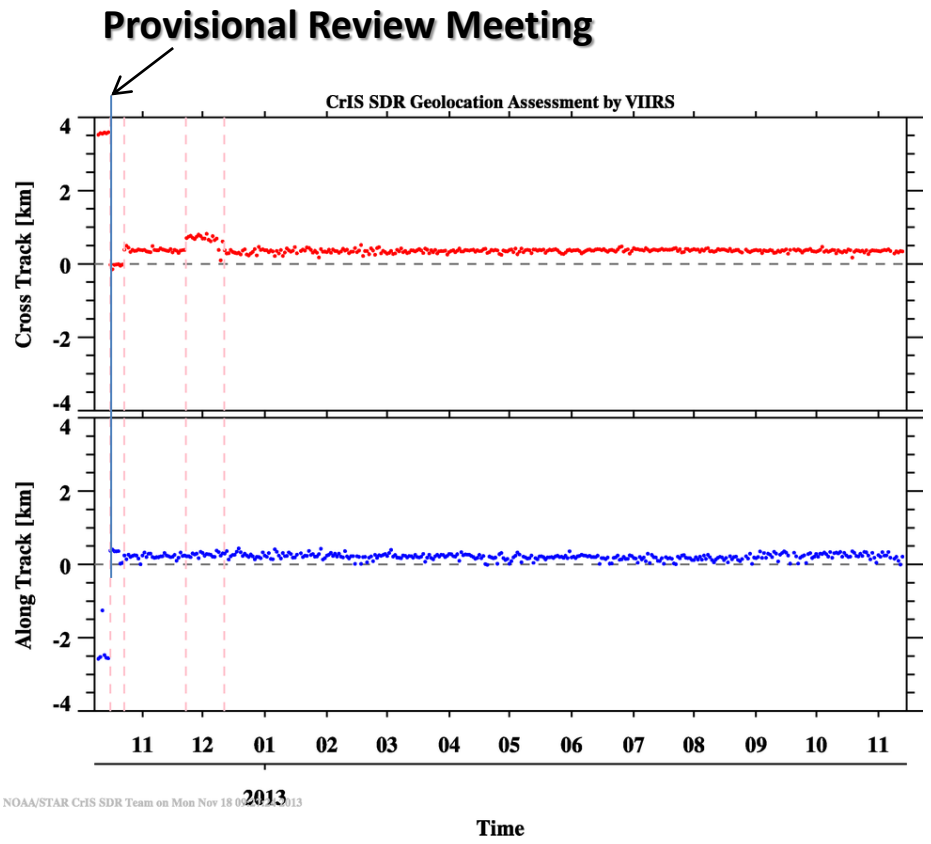
Relative: < 0.6 ppm (relative to FOV-5)

Spec: 10 ppm

See presentation Strow et al.

Geolocation CalVal

- Activities
  - Off-nadir geolocation assessment
  - Band-to-band co-registration evaluation
  - Assessment of ILS update (v35 to v36) on geolocation accuracy
  - Trending and monitoring
- Results
  - Meet spec (scan angle < 30 degree)
  - Band-to-band co-registration meets spec (benefit from spectral cal.)
  - ILS updates do not significantly change geolocation: < 100 m

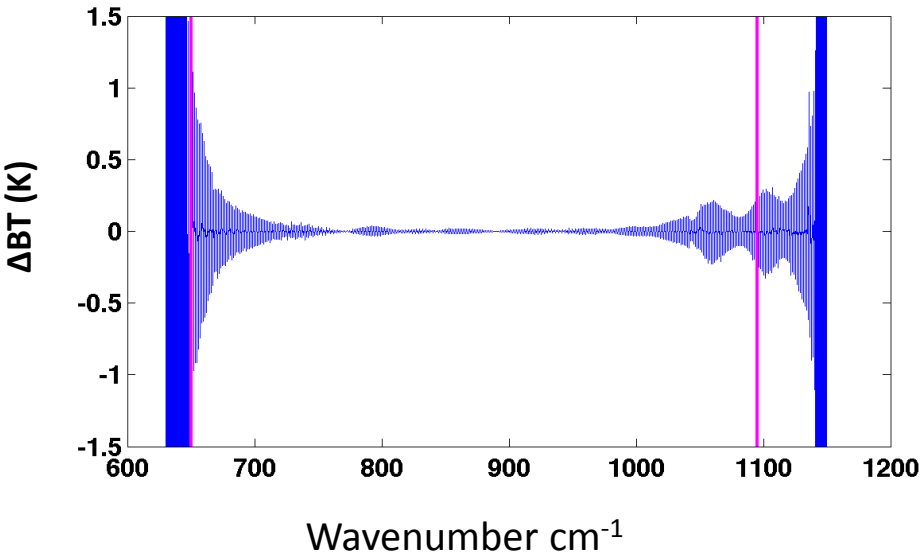


See presentation Wang et al.

Spectral Ringing Investigation

- Activities
  - Diagnostic and normal mode data analysis
  - Ringing simulations
  - Ringing categorization
  - 12 telecon meeting presentations
- Results
  - Major sources of ringing are categorized and understood
  - 99% of ringing artifacts are below RU spec. (converted to 287K BB)
  - Hamming Apodization reduces ringing to noise level

Simulated ringing (difference from “truth”)

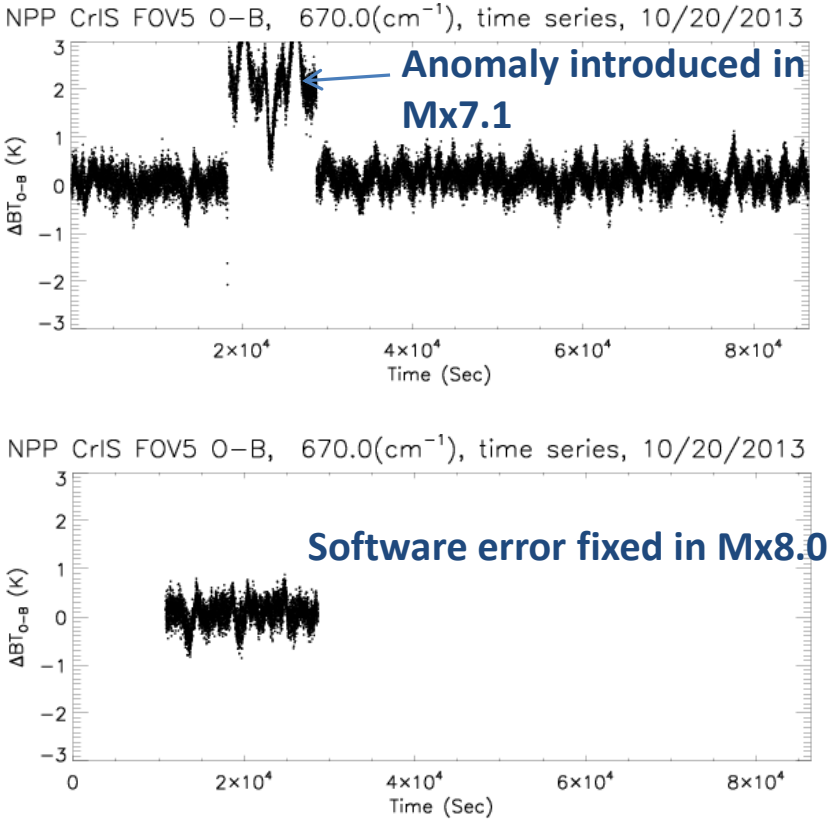


See presentation Mooney et al.

SDR Software Improvement

- Activities
  - SDR quality monitoring and evaluation on a daily basis
  - IDPS and ADL/G-ADA SDR comparisons
  - Software DR investigations and code fixes
  - SDR anomaly event investigations (4 events since Oct. 2012)
  - 29 telecon meeting reports
- Results
  - Discovered and addressed 22 code bugs and issues
  - Eliminated root causes of the anomaly events occurred so far
  - Software is stabilized: expect no significant error with an impact on data quality after 11/14/2013 (Mx8.0)
  - Imaginary QF implemented to invalidate data if FCE occurs

Observation – Simulation



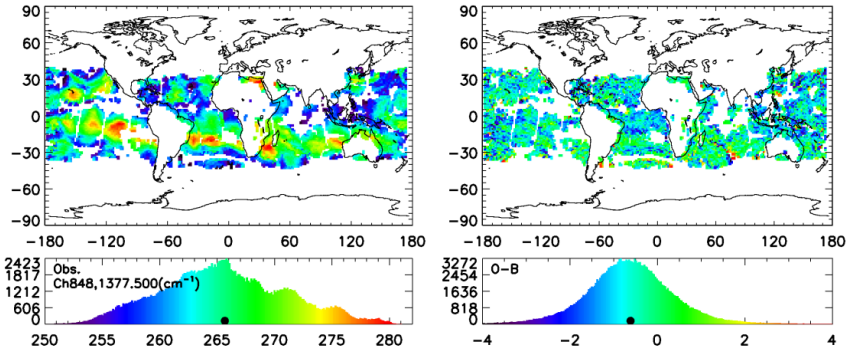
See presentation Jin et al.

Preparation for Full Spectral Resolution Operation

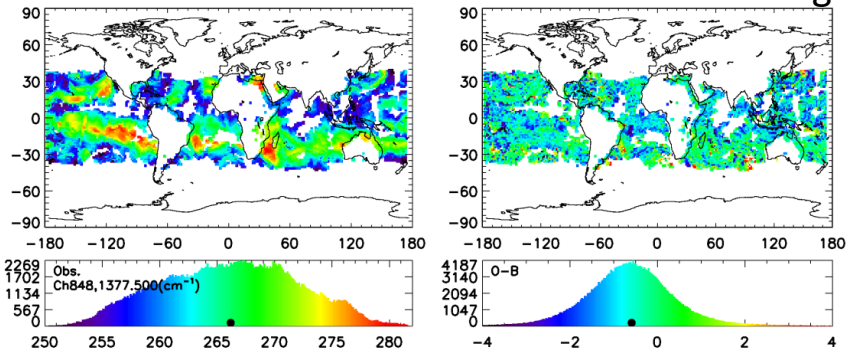
- Activities
  - IDPS RDR truncation module development
  - IDPS SDR evaluation/validation for 2 on-orbit full resolution tests
  - Bit trim mask evaluation/adjustment to meet data rate
  - Full resolution SDR processing experiments
  - 25 telecon meeting presentations
- Results
  - IDPS RDR truncation module was implemented & validated (Mx7.1)
  - Proposed Bit trim mask meets the data rate requirement
  - The noise impulse masks need to be lifted by 1 bit (no impact to the data rate)

The Software truncation module works as expected: Obs – Calc results showing no difference before and during 8/27 FSR test

Before



During



BT (K) ΔBT (K)

IDPS CrIS SDR code is ready to process full resolution RDRs

DR Status

Total 34 DRs

	Closed	To be closed	Mx8.1/8.2 20 Feb 2014	Mx8.3 21 April 2014	On-going
Software	4878, 4963, 4964, 5010, 5011, 7009, 7019, 7133, 7261	5043, 7072,7073, 7130, 7131, 7187, 7188, 7281, 7295	7201, 7204, 7239, 7273, 7365	7363, 7383, 7445	7230, 7279, 7361
CMO, PCT, EngPkt	4941, 4994, 7025	4976	7418		
Document		7247 (ATBD)			

ILS & NL correction improvements

Lunar Intrusion flag fix; no impact on data quality

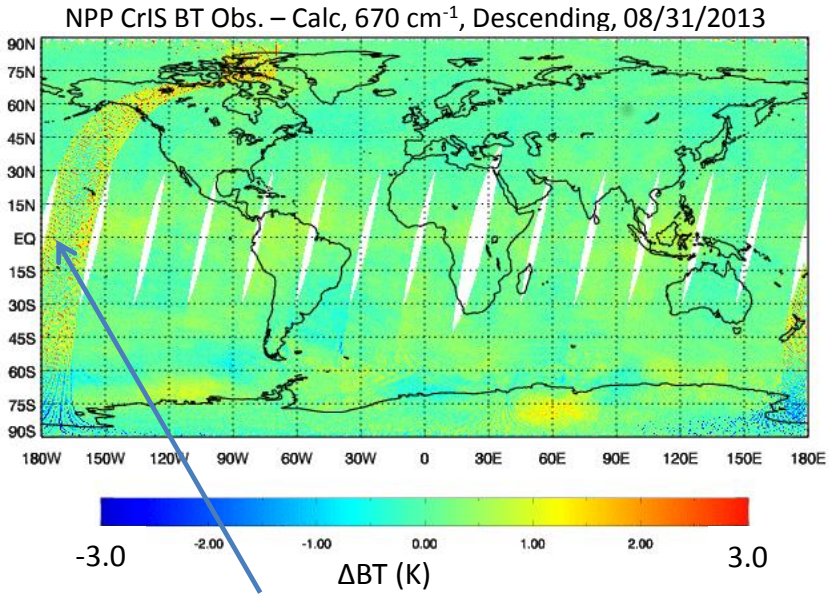
- DR7230: Time stamp gives filename with 1985 (three granules so far, no impact on users)
- DR7279: Large number of CMO files (occurred only once, no impact on SDR product)
- DR7361: Discrepancy in CMO file – incorrect time stamp bias (the time stamp bias currently not used in the code)

All DRs with impacts on data quality have been addressed

Web-based CrIS Monitoring System

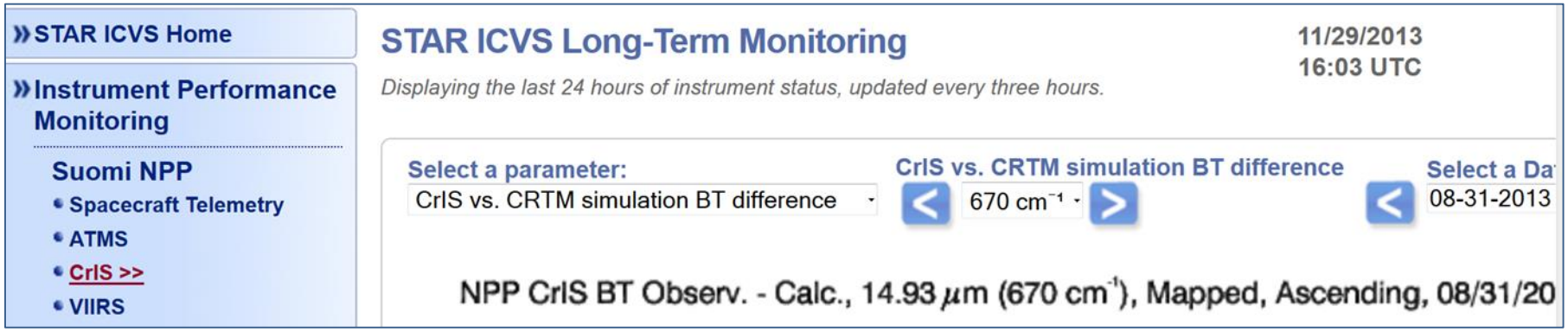
- Activities
  - Added new monitoring/trending capabilities to the STAR CrIS ICVS system
- Results
  - 29 new items added to the system
  - Global images and time series of CrIS radiance bias against CRTM/NWP simulations
  - Geolocation error (against VIIRS) time series

Daily radiance bias image



Anomaly clearly seen in the bias image, but very hard to be seen in the radiance image

CrIS ICVS site:
http://www.star.nesdis.noaa.gov/icvs/status_NPP_CrIS.php



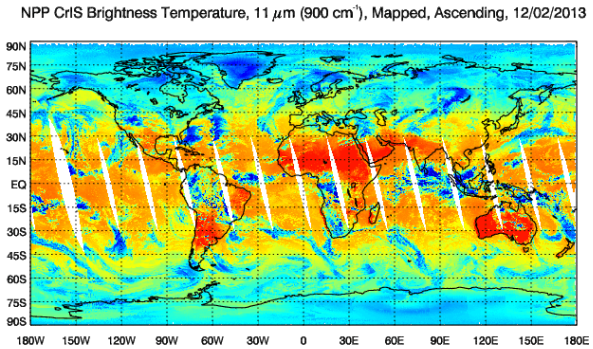
Typical Global Maps of Real & Imaginary spectra and Overall Quality Flag

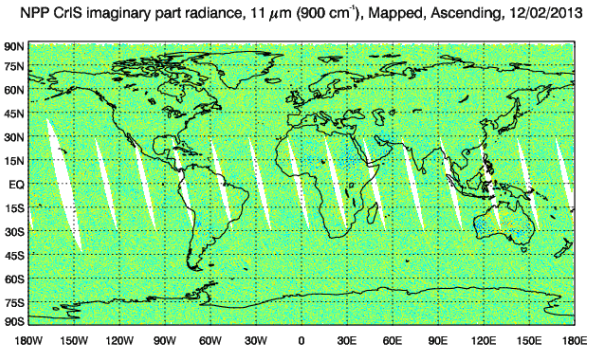
Example of data quality after Mx8.0

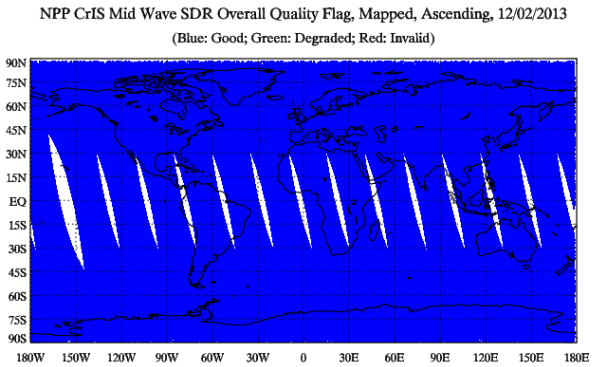
Real radiance

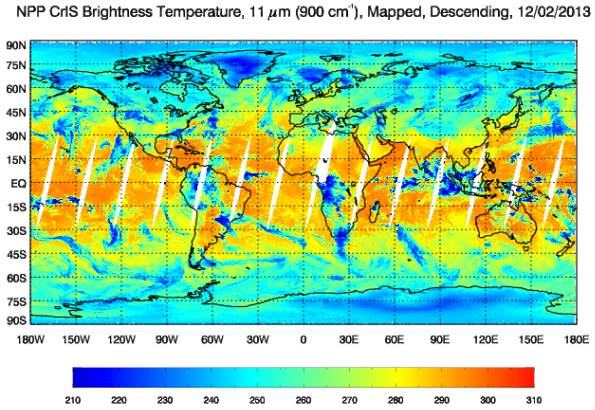
Near zero Imaginary radiance indicates good real radiance

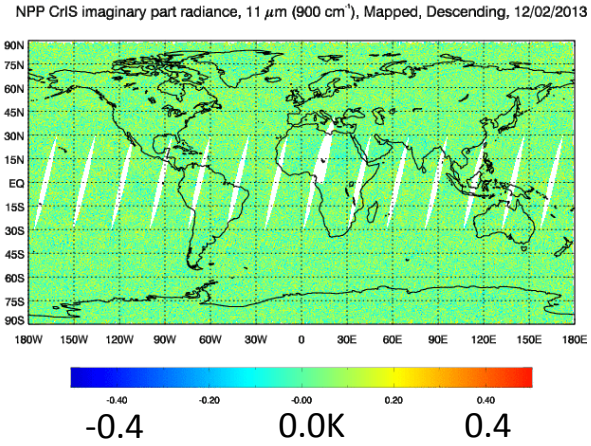
Overall SDR quality flag
Blue - good

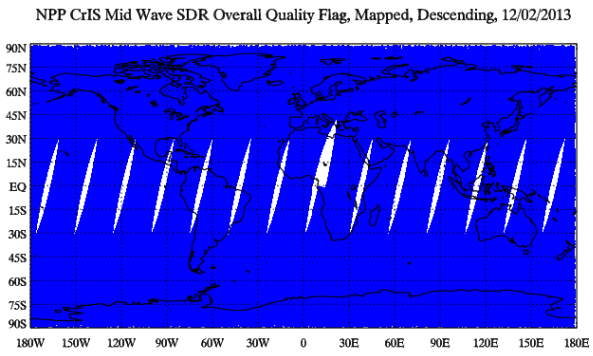












900 cm^{-1} channel

Documentation (1/2)

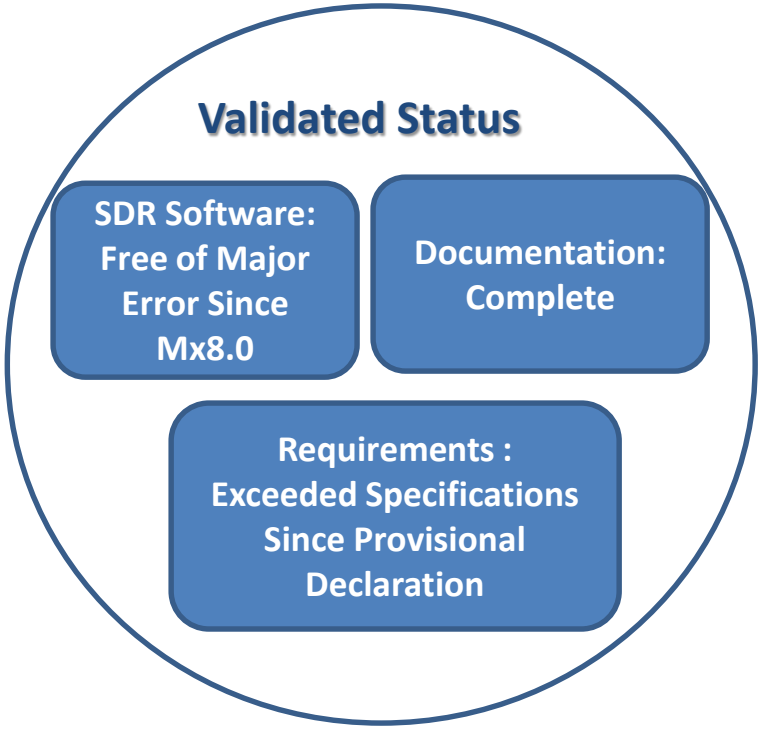
- CalVal results summarized in peer review papers
  - Han et al. (2013): Suomi NPP CrIS Measurements, Sensor Data Record Algorithm, Calibration and Validation Activities, and Record Data Quality, JGR
  - Zavyalov et al. (2013): Noise performance of the CrIS instrument, JGR
  - Tobin et al. (2013): Suomi-NPP CrIS Radiometric Calibration Uncertainty, JGR
  - Strow et al. (2013): Frequency Calibration and Validation of CrIS Satellite Sounder, JGR
  - Wang et al. (2013): Geolocation Assessment for CrIS Sensor Data Records, JGR
  - Chen et al. (2013): Detection of Earth-rotation Doppler Shift from Suomi National Polar-Orbiting Partnership Cross-track Infrared Sounder, Appl. Opt.

Documentation (2/2)

- Cal/Val results summarized in presentations given in this review meeting
  - Tobin et al.: Uncertainty Estimates and Evaluations
  - Zavyalov et al.: Noise Performance of the CrIS Instrument On-orbit
  - Strow et al.: CrIS Spectral Calibration and Trending
  - Wang et al.: CrIS SDR Geolocation Performance
  - Mooney et al.: Source and Effect of Ripple in CrIS Measurements
  - Jin et al.: CrIS SDR processing Quality
- CrIS SDR User's Guide version 1.0 (55 pages)
- Revised CrIS ATBD
- Error Budget (for the review panel)

CrIS SDR Reached Validated Maturity Level

- Requirements
  - Instrument & SDR performances exceeded requirements since Provisional status declaration 1/31/2013
- SDR software
  - Stable & free of errors that can impact data quality since 11/14/2013 (Mx8.0)
- Documentation
  - 5 presentations in this meeting
  - 6 Journal papers
  - SDR User's Guide & Revised ATBD
  - Error Budget table

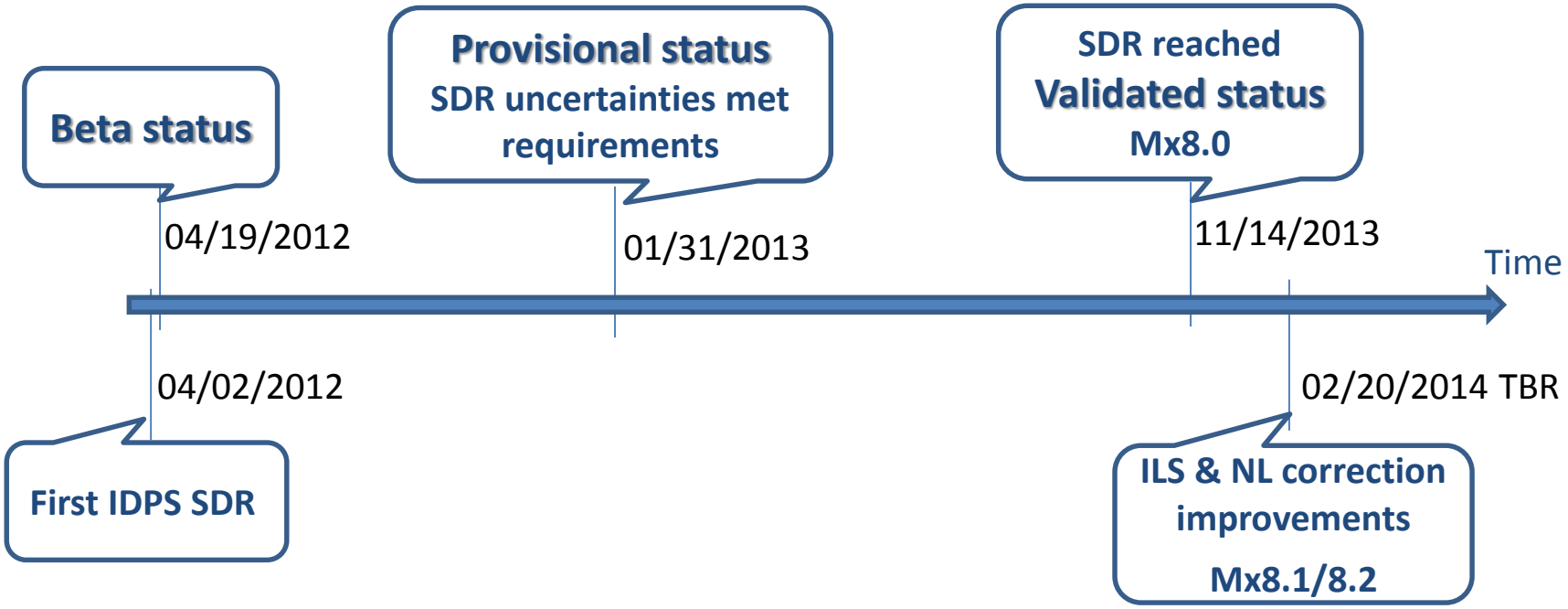


CrIS SDR uncertainties (**blue**) vs. specifications (black)

Band	NEdN @287K BB mW/m²/sr/cm⁻¹	Radiometric Uncertainty @287K BB (%)	Frequency Uncertainty (ppm)	Geolocation Uncertainty (km) *
LW	**0.098** (0.14)	**0.12** (0.45)	**3** (10)	**1.2** (1.5)
MW	**0.036** (0.06)	**0.15**(0.58)	**3** (10)	**1.2** (1.5)
SW	**0.003** (0.007)	**0.2** (0.77)	**3** (10)	**1.2** (1.5)

* Within 30° scan angles

IDPS CrIS SDR CalVal Milestones



Checklist for Validated Status

Validated Maturity Definition	Status	Explanation
On-orbit sensor performance characterized	✓	(1) Instrument performance and SDR uncertainties of spectral calibration, radiometric calibration and geolocation calculation have met requirements (2) SDR processing software has been stable and free of major errors (errors impact data quality) since 11/14/2013 (Mx8.0) (3) Instrument and SDR performances have been well characterized and documented in 6 published peer-review Journal papers, 5 presentations in this review meeting, SDR ATBD, SDR User Guide and error budget.
SDR product uncertainties well defined over a range of representative conditions	✓	
Calibration parameters adjusted accordingly	✓	Calibration parameters were updated with Engineering packet version 35 on 4/11/2012
There may be later improved version	✓	Both SDR software and calibration parameters will be updated on 20 February 2014 with Mx8.1 and Engineering packet v36, to improve the ILS and nonlinearity corrections
There will be strong versioning with documentation	✓	(1) Calibration parameters are in version control as part of the Engineering packet which has a version number. (2) Currently the SDR version number is identical with the IDPS build number. (3) Both updates are documented
Ready for use in applications and scientific publication	✓	(1) Both RDR and SDR data are available on CLASS for the public (2) NWP centers have been assimilating CrIS SDR data

Path Forward

- Suomi NPP
  - Continuation of RDR and SDR monitoring
  - Fine adjustment of spectral and radiometric calibration parameters and geolocation mapping parameters, if needed.
  - Continuation of Full Spectral Resolution work, if required.
  - SDR algorithm improvement to address the potential issues (e.g. FCE detection/correction, reduction of ringing artifacts and polarization effect correction)
  - Continuation of SDR software improvements to address the remaining and future issues
- JPSS J1
  - Support of and participation in pre-launch testing and instrument characterization
  - Calibration data (LUTs and coefficients) development
  - Algorithm/software development and improvements (full resolution SDR capability, calibration algorithms and FCE detection/correction module), delivering the SDR code in January 2015
  - Development of a comprehensive test data set derived from NPP observations and J1 TVAC tests for J1 algorithm and software development

Summary

- The team made great efforts to improve and characterize the product quality since the Provisional review meeting
- CrIS SDR product reached the Validated maturity level at Mx8.0 on 11/14/2013
- The improvements in spectral and radiometric calibration have been validated and will become operational at Mx8.1 on 2/20/2014
- The team has a clear path moving forward for both NPP and J1 missions