S-NPP CrIS Full Spectral Resolution SDR Processing and Quality Assessment

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JPSS CrIS SDR Science Team

Acknowledgement to the contributions of JPSS CrIS SDR Science Team

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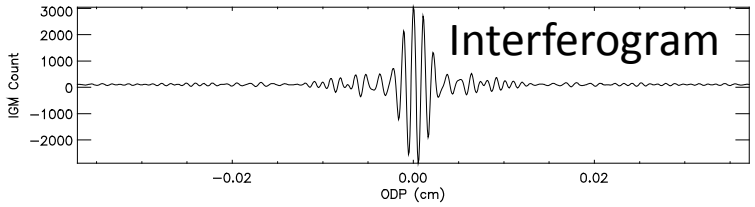
Raytheon	Wael Ibrahim

Outline

- S-NPP CrIS normal and full spectral resolution (FSR) mode measurements
- FSR SDR processing and data accessibility
- Preliminary assessment of FSR SDR data quality
- Summary and future work

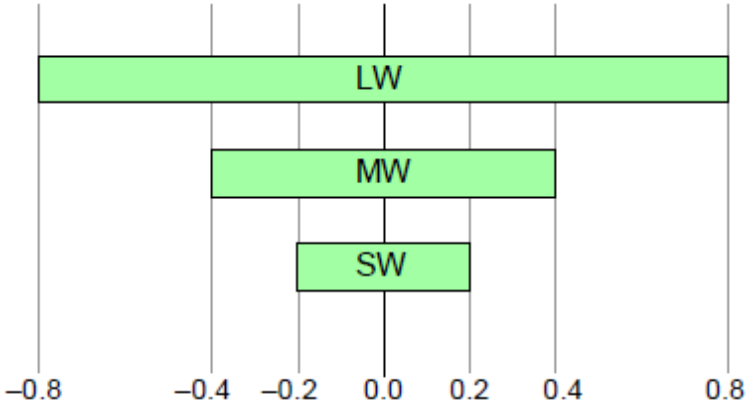
Normal and FSR Mode Measurements

CrIS instrument provides interferograms & calibration data

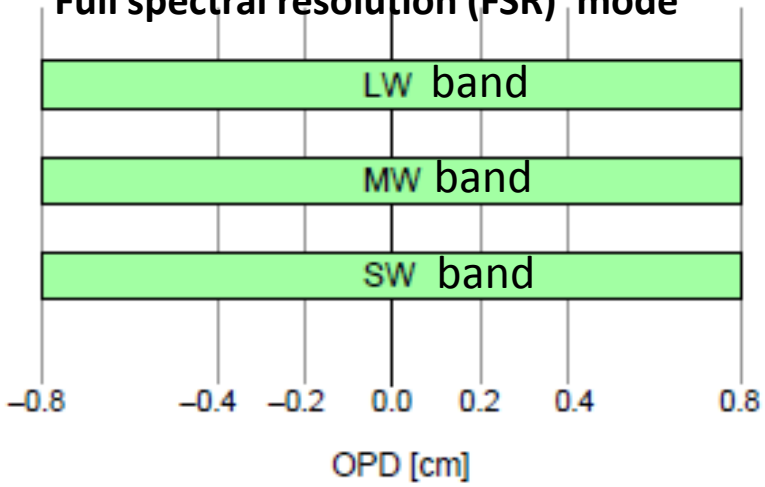


Interferogram length

Normal mode



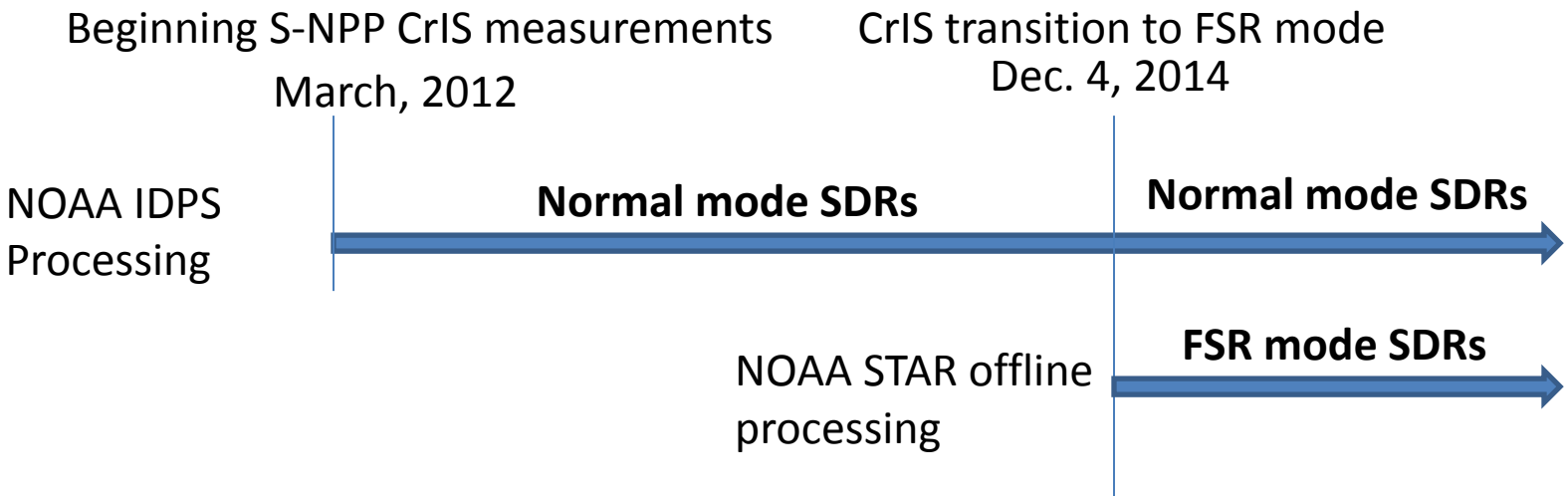
Full spectral resolution (FSR) mode



- Ground SDR processing software converts the interferograms to calibrated spectra
- Spectral resolution defined as $1/(2 \cdot \mathrm{Max\_OPD})$

SDR Processing before and after S-NPP CrIS Transition to FSR Mode

- S-NPP CrIS turned to FSR mode on Dec 4, 2014
- The NOAA operational SDR processing system (IDPS) continues to produce normal mode SDRs by truncating the MW and SW interferograms
- An offline processing system provides FSR SDRs



JPSS/NPP CrIS SDR Processing Software & Data

- (Official) Interface Data Processing Segment (IDPS):

  normal resolution SDRs archived on CLASS

- NOAA/STAR modified Algorithm Development Library (ADL), based on IDPS code of version Mx8.5, Block2.0:

  full spectral resolution SDRs available to the public at ftp://ftp2.star.nesdis.noaa.gov/smcd/xxiong/

- Same SDR format

CrIS Full Resolution SDR Spectral Parameters

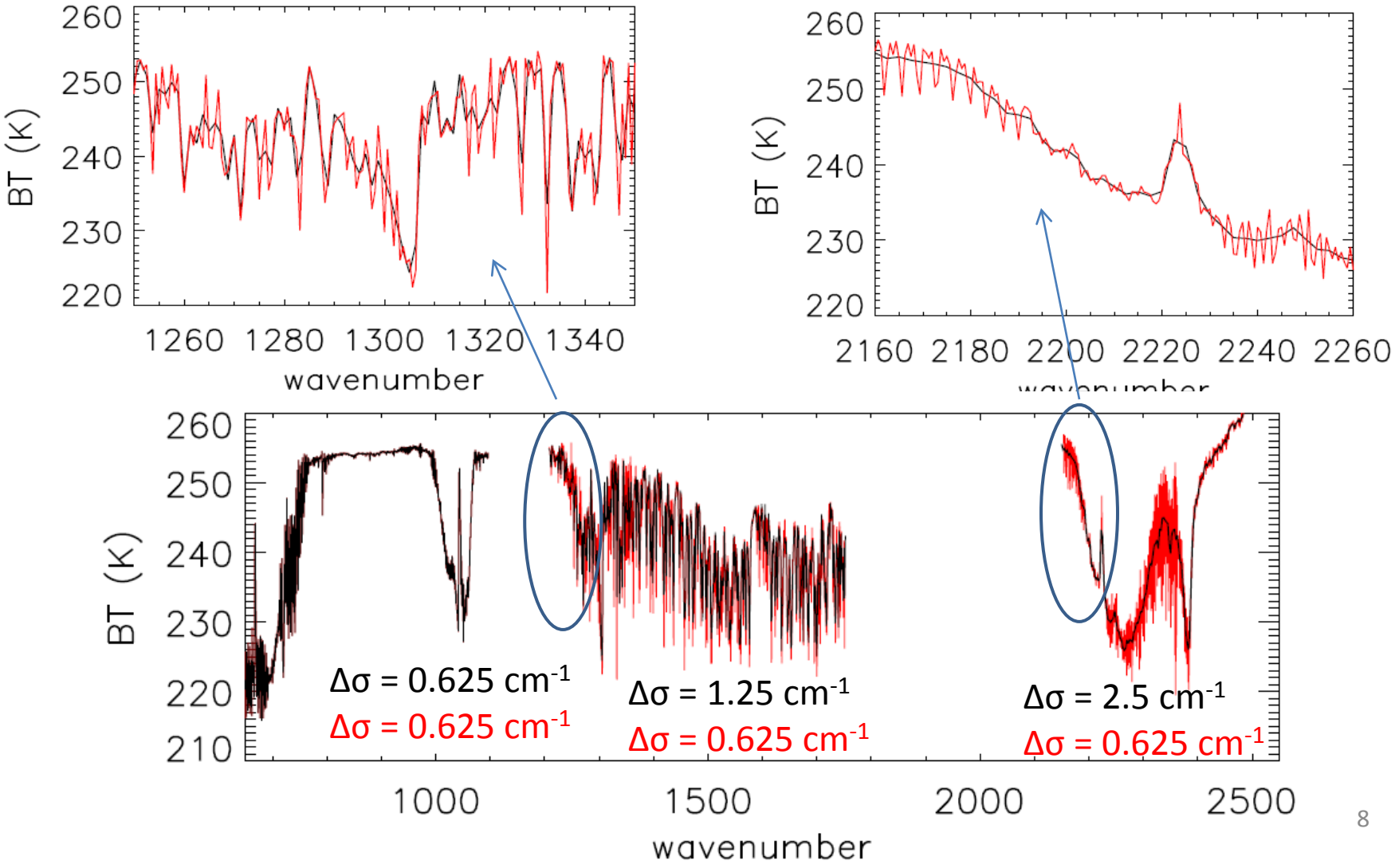
Blue: normal resolution

Frequency Band	Spectral Range (cm^{-1})	Number of Channel	Spectral Resolution (cm^{-1})
LWIR	**650 to 1095**	**713 (713)**	**0.625 (0.625)**
MWIR	**1210 to 1750**	**865 (433)**	**0.625 (1.25)**
SWIR	**2155 to 2550**	**633 (159)**	**0.625 (2.5)**

Number of FSR channels: 2211
Number of normal resolution channels: 1305

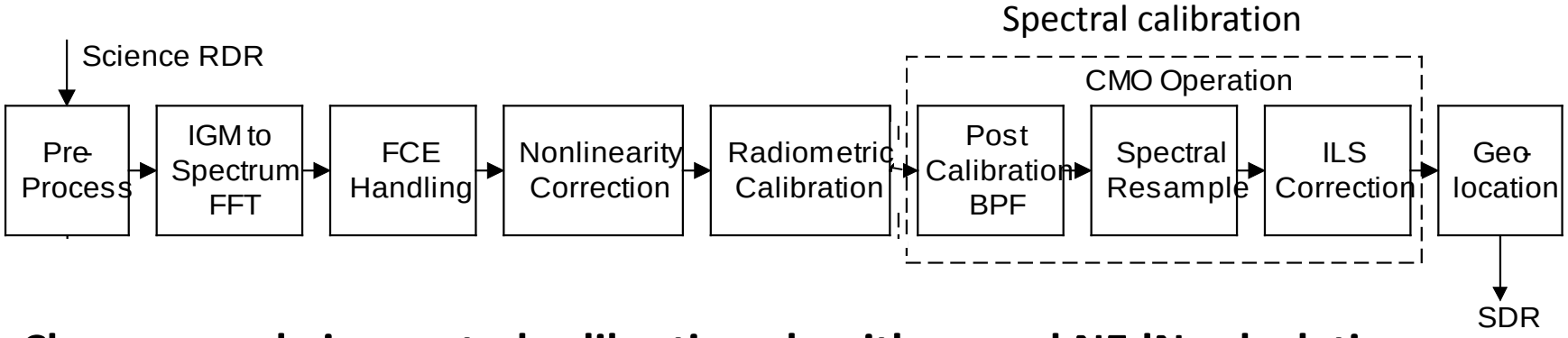
Examples of Measured Spectra

Red lines – full resolution; black lines – normal resolution



Algorithm Updates for FSR Processing

The processing flow (unchanged):

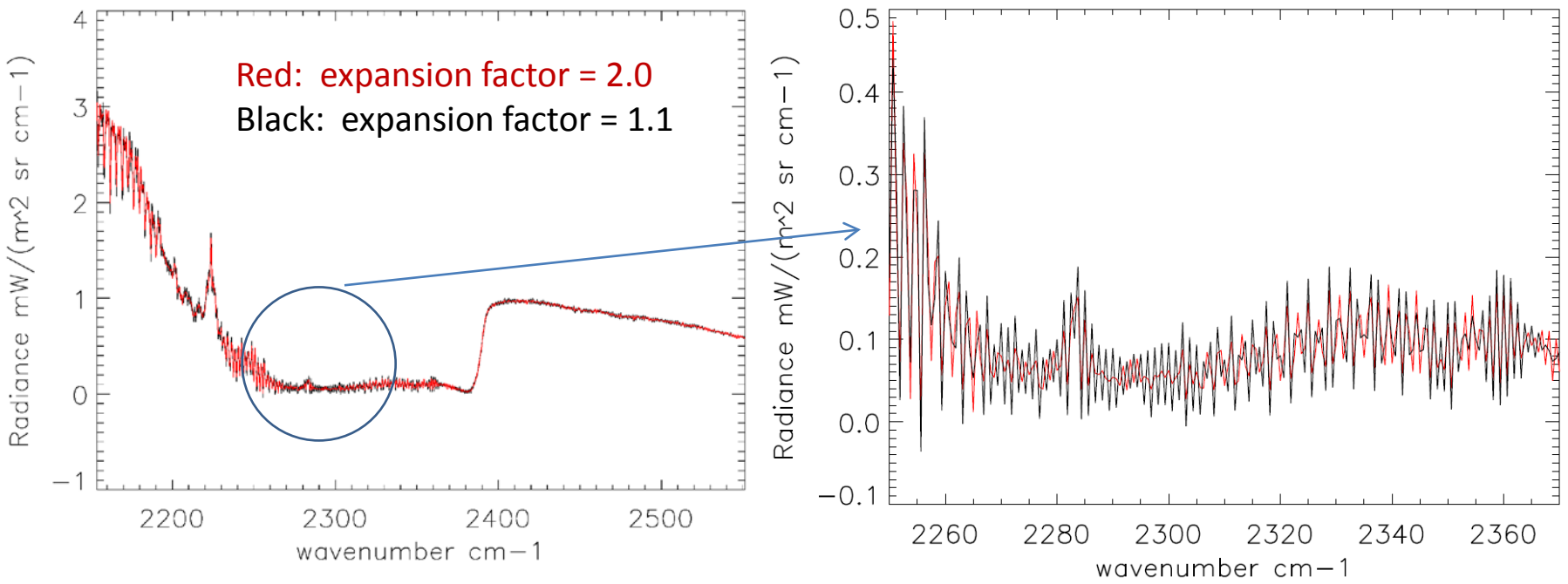


Changes made in spectral calibration algorithms and NEdN calculation

- Spectral calibration algorithm changes:
  - The resampling matrices now always follow the laser metrology wavelength λ measurements, in stead of being updated when λ varies by more than 2 ppm
  - The resampling and self-apodization matrix calculation algorithms are modified to reduce spectral ringing artifacts
- NEdN algorithm change:
  - Spectral calibration (CMO operation) is applied to radiance noise (NEdN) calculation

Self-Apodization Correction Algorithm Update for FSR Processing

FSR SW band spectra calibrated with expansion factors 1.1 (black) and 2.0 (red)

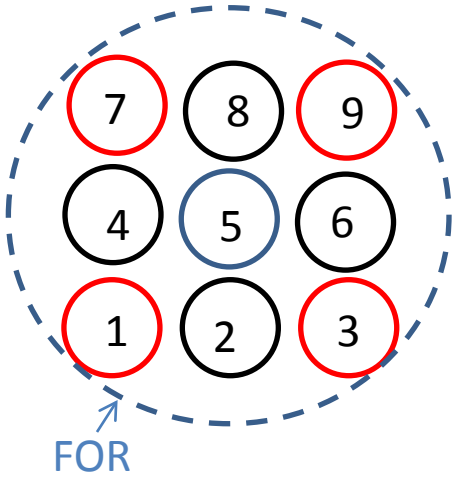


The self-apodization (SA) matrix expansion factor is increased from 1.1 to 2.0 for the MW and SW bands to reduce ringing artifacts

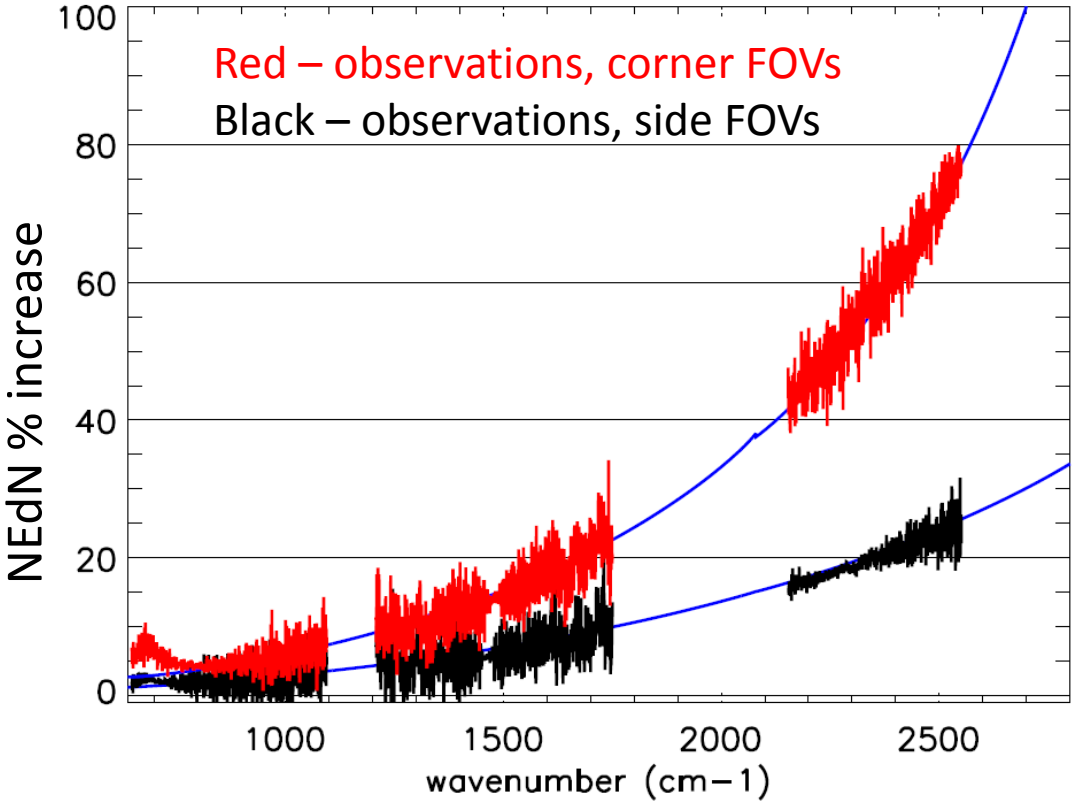
NEdN Algorithm Update

Unlike the normal resolution SDRs, noise levels of FSR spectra in MW and SW bands are significantly increased by self-apodization (SA) correction:

Corner FOVs (red)
Side FOVs (black)



Field Of Regard (FOR)
Field Of View (FOV)

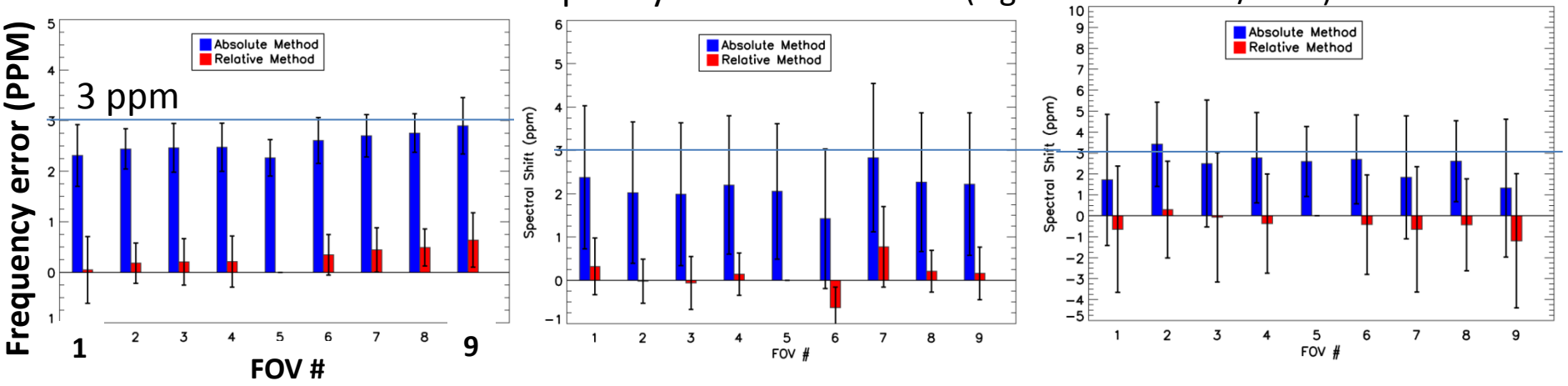


The FSR processing code includes SA correction in the NEdN calculation
(the noise increase is first noticed by Lawrence Suwinski of Exelis)

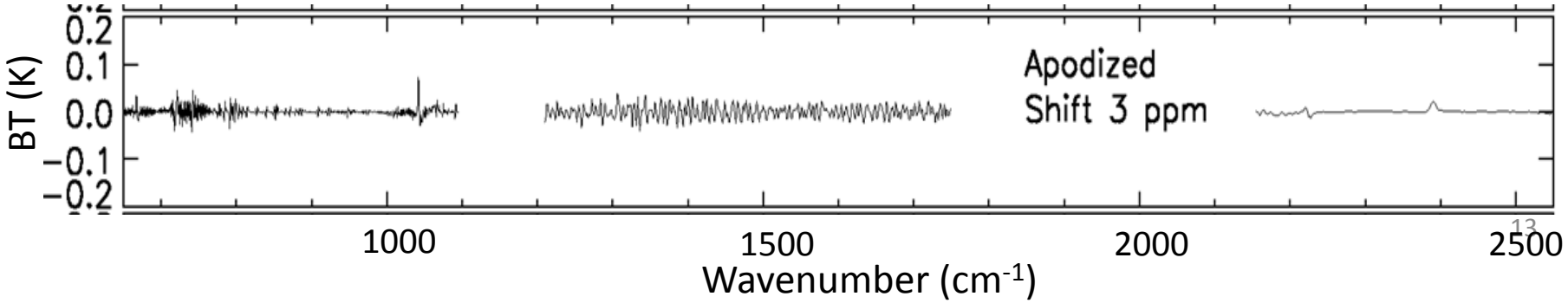
Preliminary Data Quality Assessment

FSR Spectral Calibration Accuracy

Frequency calibration error (Figure from NOAA/STAR)



Radiance error caused by 3 ppm frequency error



Spectral calibration uncertainty (all FOVs & all bands):

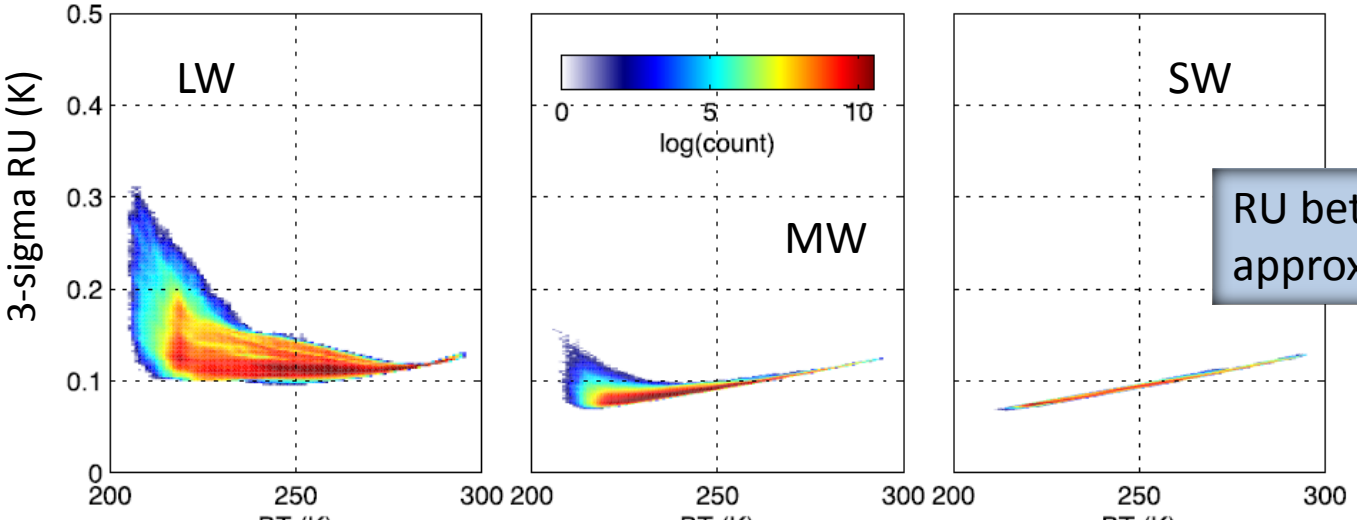
< 3 ppm

Strow et al. 2013, JGR

Radiometric Uncertainty (RU)

Radiometric calibration algorithms and coefficients have not been changed in the normal resolution to FSR SDR software development

Normal resolution SDR RU was evaluated during the CrIS SDR Cal/Val process:

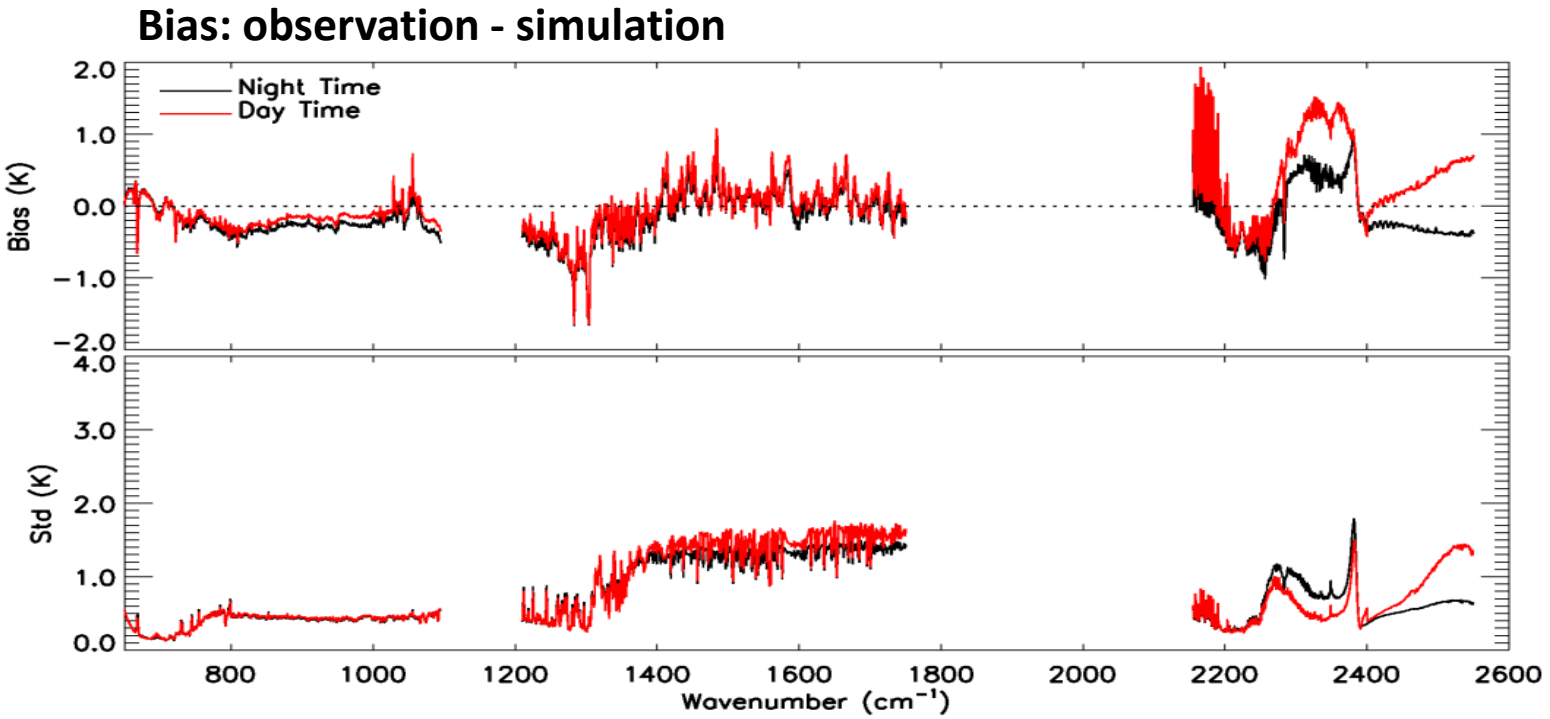


RU better than spec by approximately a factor 4

Tobin et al. 2013, JGR

Distribution of 3-sigma RU for one orbit of data, including RU for all spectral channels and FOVs

FSR Radiance Bias

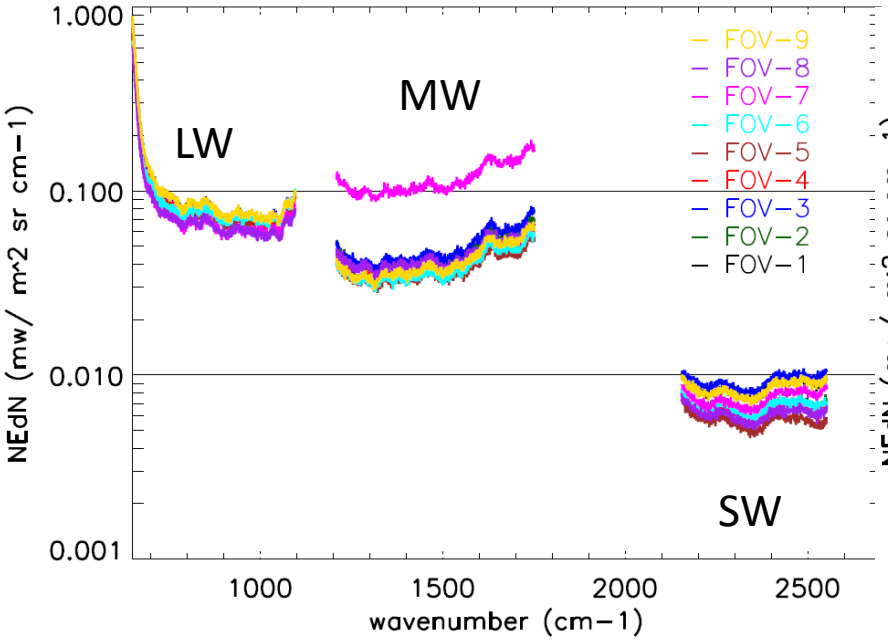


- Clear-sky spectra over ocean
- Simulation calculated with CRTM and ECMWF profiles
- Large bias during daytime mainly due to CRTM errors in NLTE calculations

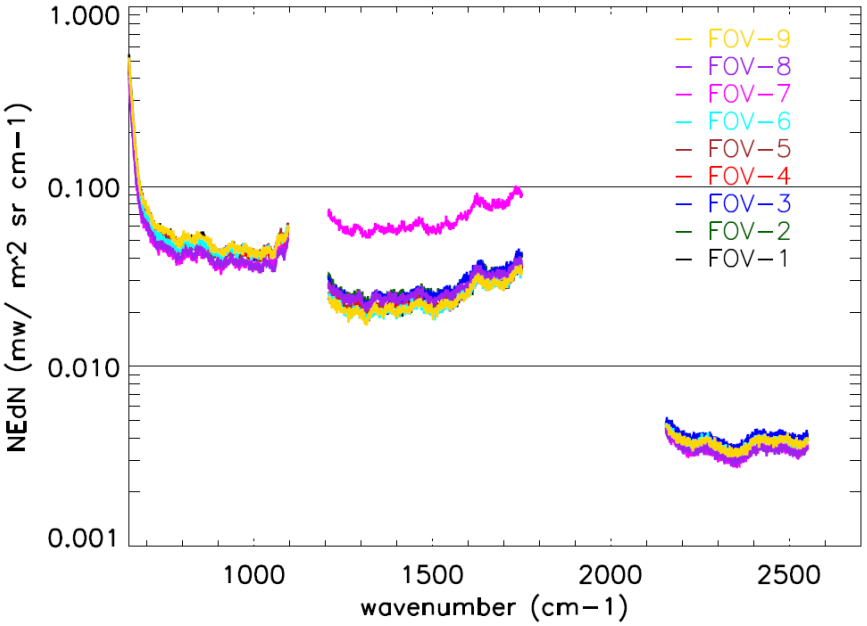
Reasonable agreement between CrIS observation and simulation, similar to that obtained from normal resolution data

FSR Radiance Noise (NEdN)

Un-apodized spectra



Hamming apodized spectra



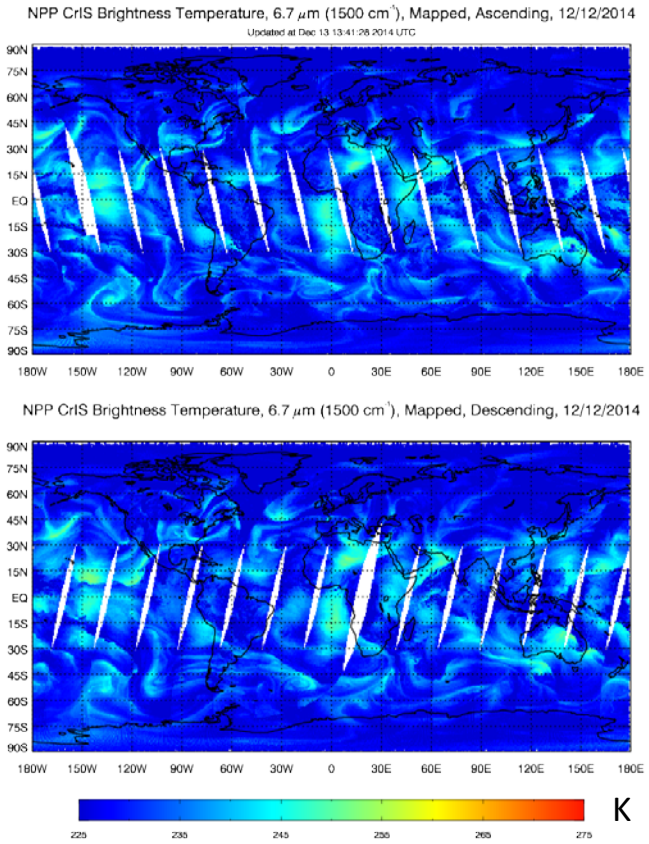
The spread of NEdN among FOVs on un-apodized spectra is due to SA correction (see also slide 11)

SA – self-apodiztion

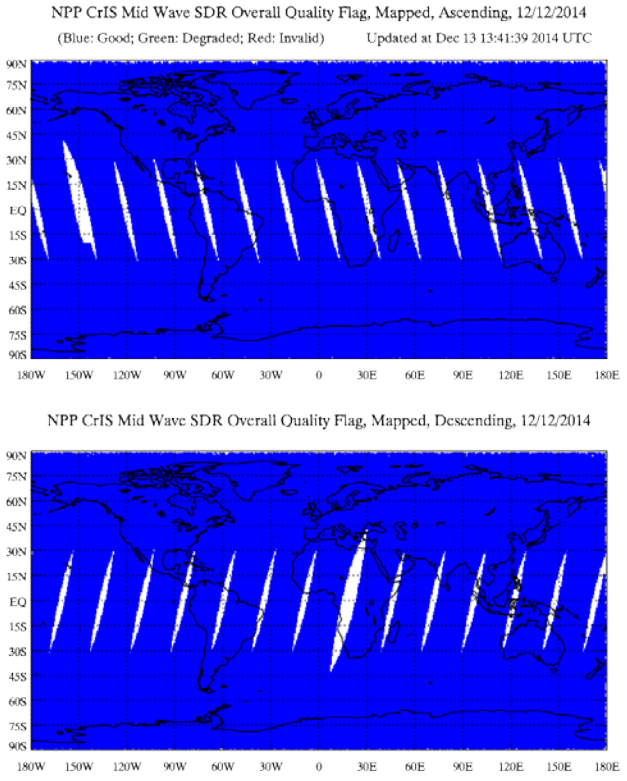
The portion of NEdN introduced by SA correction is almost completely removed with Hamming apodization

FSR SDR Processing Success Rate

1500 cm^{-1} channel radiance 12/12/2014



MW band overall quality flag:
Blue – Good, Green – Degraded,
Red: Invalid 12/12/2014



The success rate to produce valid SDRs is better than 99.9%

Summary & Future Work

- Since the CrIS transition to FSR mode on Dec 4, 2014, an offline ADL-based FSR SDR processing system has been processing the raw data into FSR SDRs available to the public
- Spectral calibration and NEdN algorithms were modified for FSR SDR processing
- Preliminary assessment shows expected SDR data quality
- We will work with JPSS managers to reduce SDR latency from the current 12-24 hours to 90 minutes
- We will continue working with the CrIS SDR Science team to improve the SDR algorithms and software