Overview of the NASA CrIS Level 1B Version 3 Data Product and Product Assessment

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ITSC-23
25 June 2021

Overview of the CrIS L1B project

- Funded by NASA to create a climate quality CrIS L1B product spanning the SNPP, and J1 through J4 missions
- L1B consists of calibrated radiances, geolocation information and accompanying metadata
- Requires using a single software version that can process data from throughout the mission, handling mission events and anomalies and applying the optimal calibration throughout
- Underlying calibration equation and theory for NASA CrIS L1b Version 3 processing and current IDPS SDR processing are similar but may diverge for future releases.
- Primary considerations are
  - Stability and consistency of the product over large time scales
  - Traceability to TVAC and instrument design
  - Transparency of methods and software

CrIS L1B team

The team is responsible for developing and maintaining software that is used periodically to regenerate mission datasets

Joe Taylor – PI	UW-Madison
Larrabee Strow – PI	UMBC
Jessica Braun	UW-Madison
Michelle Feltz	UW-Madison
Ray Garcia	UW-Madison
Robert Knuteson	UW-Madison
Graeme Martin	UW-Madison
Howard Motteler	UMBC
Greg Quinn	UW-Madison
Hank Revercomb	UW-Madison
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Dave Tobin	UW-Madison

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SSEC

UMBC
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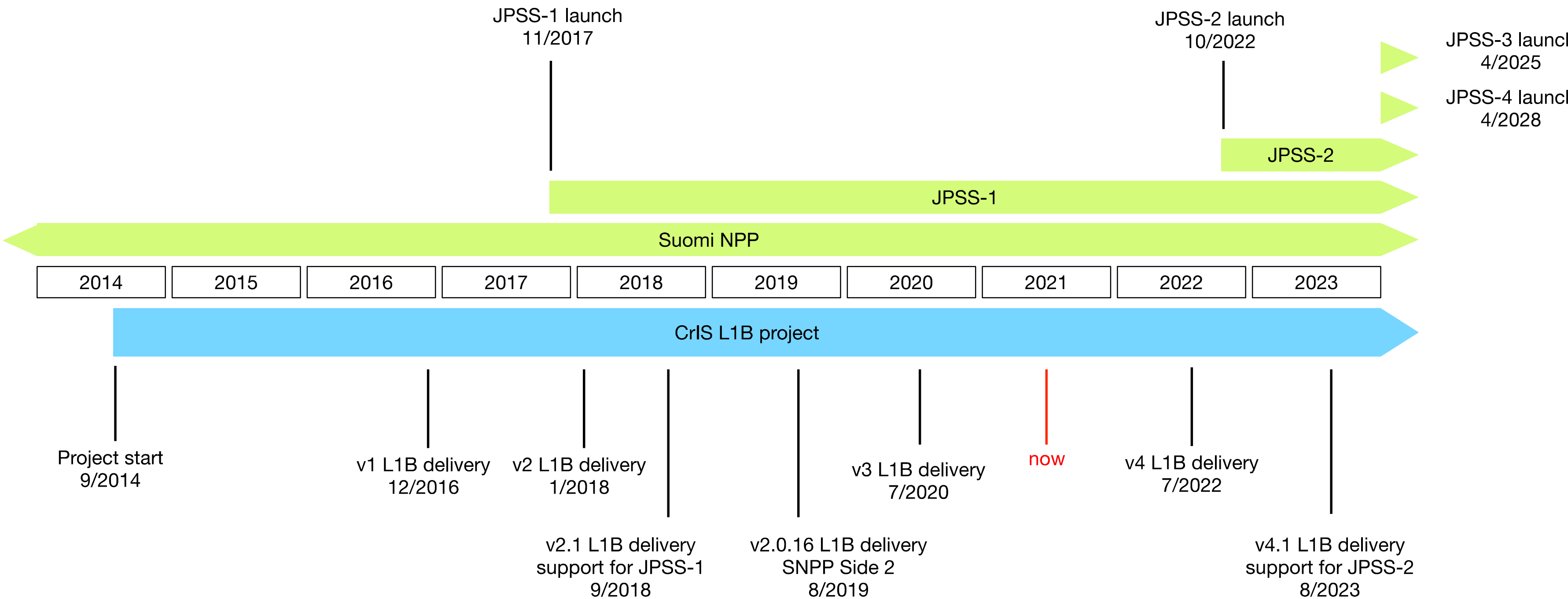
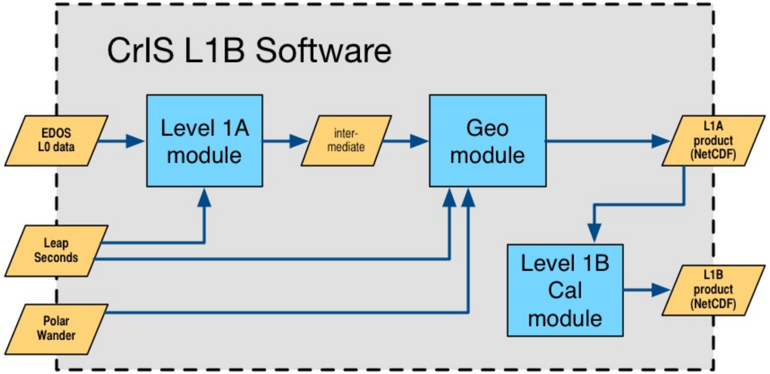
UMBC JCET NASA-GSFC

Project timeline



Software

- The CrIS L1B software is based on calibration code that was developed at UMBC and UW (CCAST), with new modules developed for L1A and geolocation
- Matlab + Python + bash
- Self-contained binary packages are delivered to JPL, who develops a production wrapper
- The science code is then run operationally at GES DISC, to reprocess the mission data and in forward processing



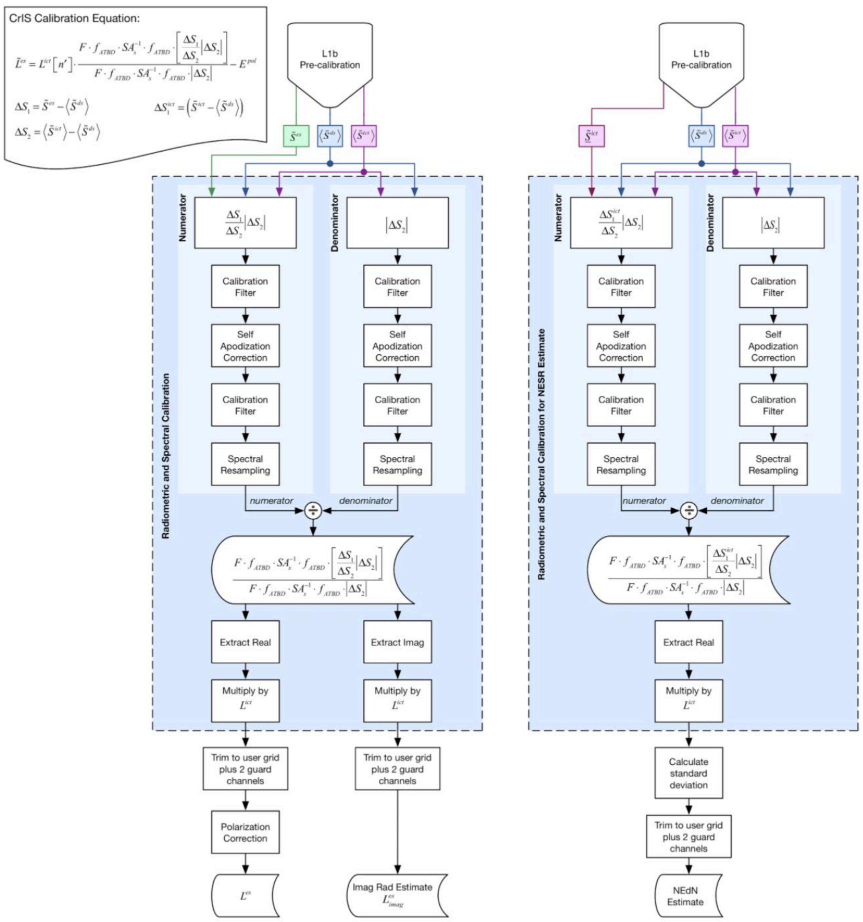
- Other software / products developed under the L1B project (not covered by this talk)
  - CHIRP (UMBC): produces a consistent AIRS/CrIS product by converting to a common SRF and removing biases
  - IMG (UW): VIIRS radiance and cloud information aggregated to the CrIS footprints

L1B product

- NetCDF4, CF compliant
- Separate files for L1A and L1B products (currently only L1B is distributed)
- 6-minute granulation
- Extensive per-observation quality information and summaries at the granule level
- File format was developed with JPL and is common to the CrIS and ATMS L1B files
- The product is used in Level 2 product generation (eg, retrievals, VIIRS/CrIS fusion), and is intended for use in future climate studies

Calibration

- Complex calibration method (Revercomb, 1988) used for radiometric calibration
- Full calibration is applied to **complex** spectra (real and imag output)
- Onboard neon source for spectral calibration
- Instrument self-apodization correction via inverse self apodization operator (Genest and Tremblay, 1999; Desbiens et al., 2006)
- Full calibration (without Doppler or polarization correction) is used to produce NEdN estimate
- The calibration and other algorithm sub-modules are described in the CrIS L1B ATBD



CrIS L1B Version 3 product

Improvements in the v3 product include:

- Polarization correction
- Correction of Doppler shift due to the Earth's rotation
- Fringe count error detection and correction
  - First (& only) event on 10 Aug 2019 (SNPP)
- Earth Scene interferogram spike detection
- Improved detection and removal of calibration reference outliers
  - Improved lunar intrusion detection
  - ICT outlier detection
- Radiometric uncertainty estimate tool
- Further reduction in point-to-point spectral ringing (useful for those that use unapodized radiances)
- Common software package for SNPP and JPSS-1
  - SNPP Side 1 and Side 2 support
  - Configuration file driven
  - Instrument and epoch dependent parameter files
- L1A refinements
  - Added provenance, addition of raw telemetry values
- GEO refinements
  - geospatial bounds attribute, WGS84 ellipsoid for sun glint calculation, Doppler velocity calculation
- Other minor improvements and bug fixes

Version 3 product assessment

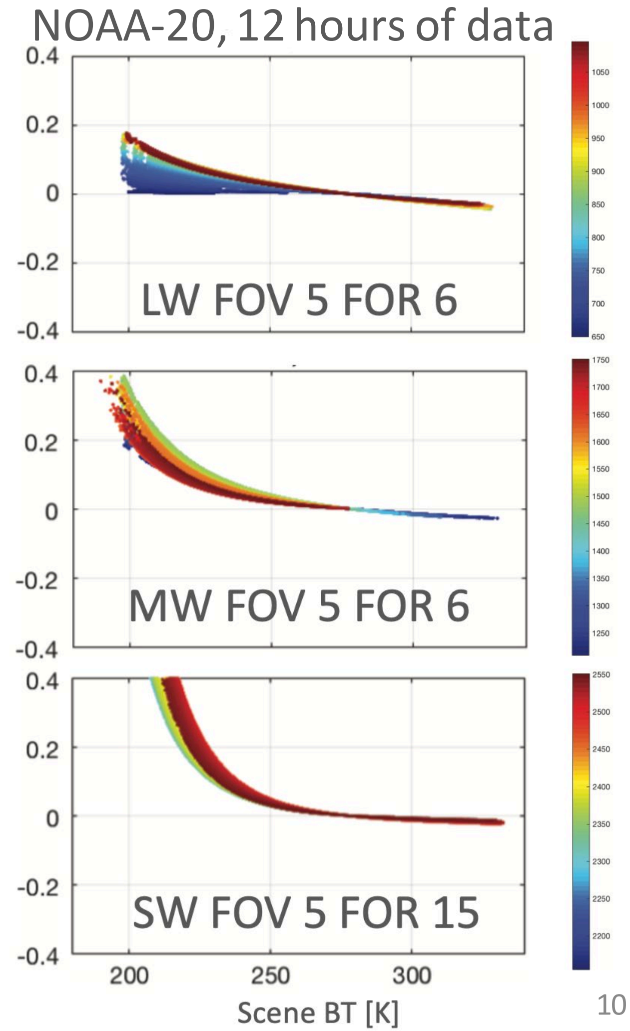
- FOV-2-FOV consistency (spectral and radiometric)
- Clear sky Obs-Calc
- CrIS to VIIRS comparisons
- SNOs and SONOs
  - AIRS, IASI-A, IASI-B, IASI-C
- SNPP CrIS to JPSS-1 CrIS
  - Via calculation as intermediate measurement (Obs – Calc double difference)
  - Via AIRS or IASI as intermediate measurement (SNO double difference)
- Current version to prior versions
- Geolocation evaluation
- Quality flag assessment
  - Lunar intrusion
  - Spike detection
  - Imaginary radiance threshold
- Mission length metrics

Polarization correction

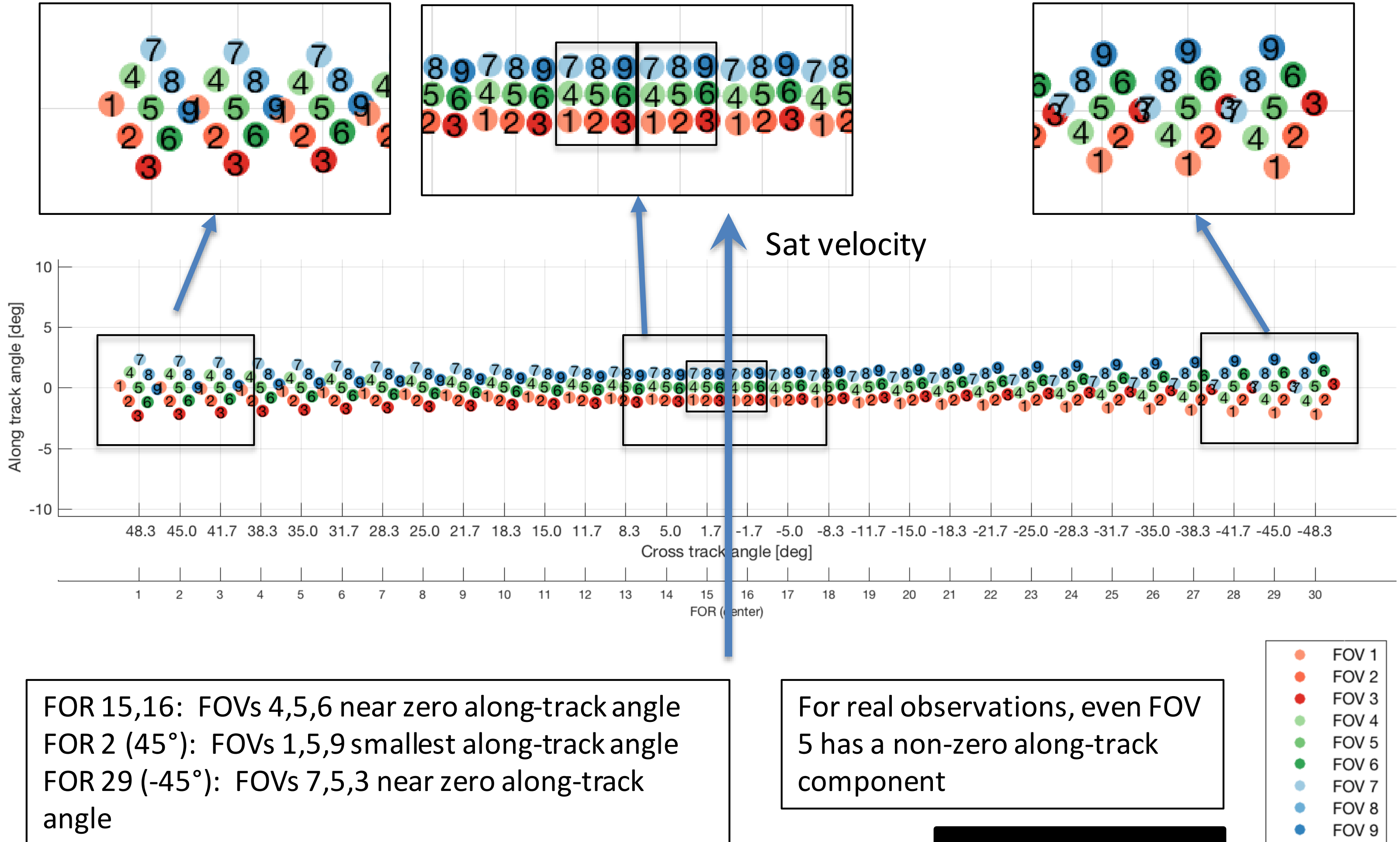
- Polarization correction parameters were derived independently for SNPP and NOAA-20 using pitch maneuver data
- The SNPP correction is slightly larger than the correction for NOAA-20
  - slightly different optical coatings for the two sensors
- The correction is scan angle dependent
  - The LW and MW correction is largest near FOR 10
  - The SW correction is largest near nadir (FOR 15, 16)
- The correction is scene temperature dependent
  - Correction increases with decreasing scene temperature
  - Correction is largest in SW when expressed as brightness temperature
  - Correction in LW and MW are relatively small, but not insignificant for cold scenes
- The correction has a small FOV dependence

V3 product assessment:

- Polarization correction reduces CrIS inter-FOV variability for NOAA-20 and SNPP
- Polarization correction improves the symmetry of the CrIS observations with respect to nadir
- Polarization correction of both CrIS sensors results in better agreement between the two sensors (using AIRS or IASI as the intermediate reference)



Doppler correction: Footprint Angles, CrIS FOV rotation illustration

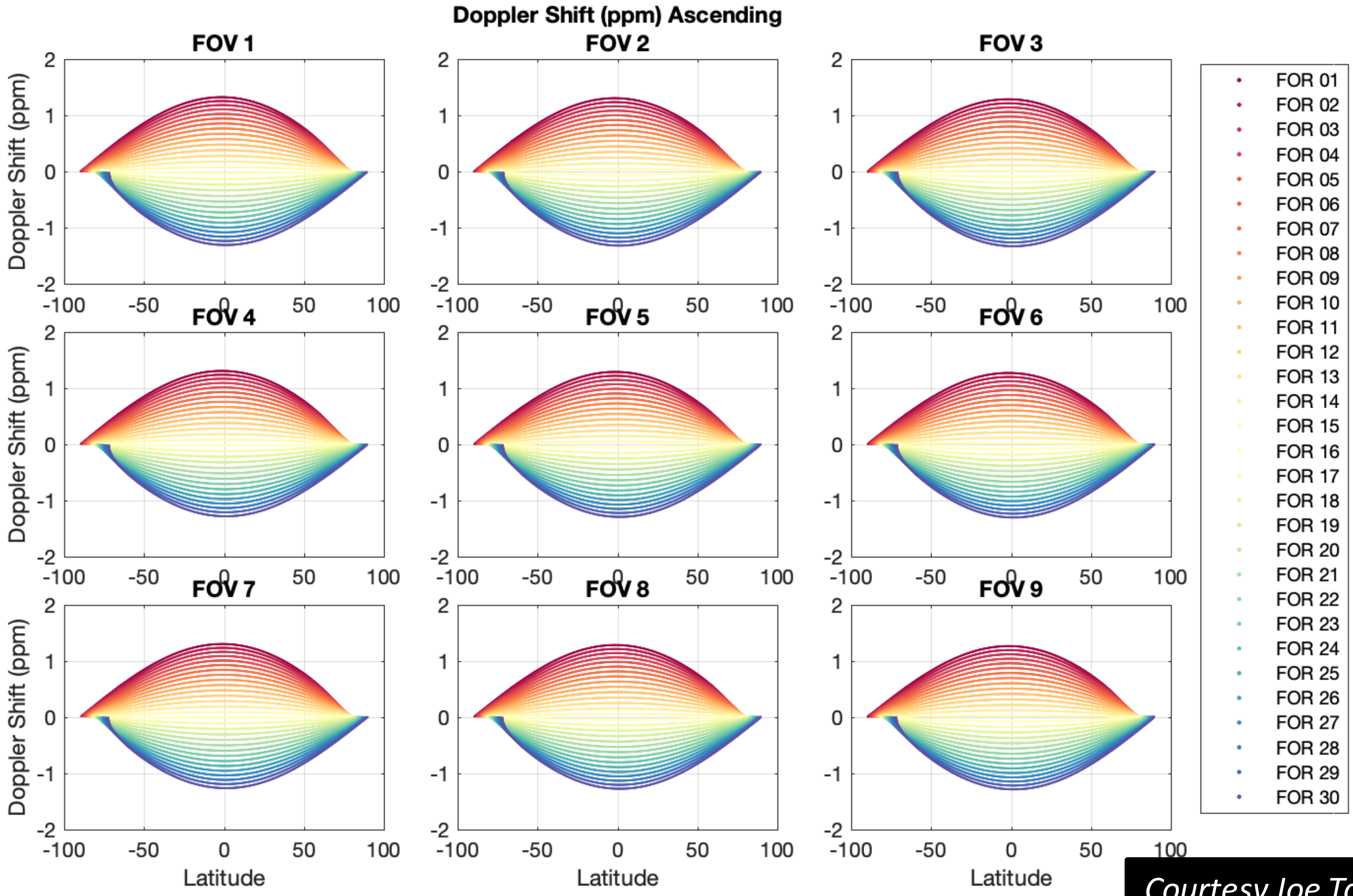


FOR 15,16: FOVs 4,5,6 near zero along-track angle
FOR 2 (45°): FOVs 1,5,9 smallest along-track angle
FOR 29 (-45°): FOVs 7,5,3 near zero along-track angle

For real observations, even FOV 5 has a non-zero along-track component

Courtesy Joe Taylor

Calculated Doppler Shift Due to Earth Rotation Only Versus Latitude, Ascending, All FOVs and FORs

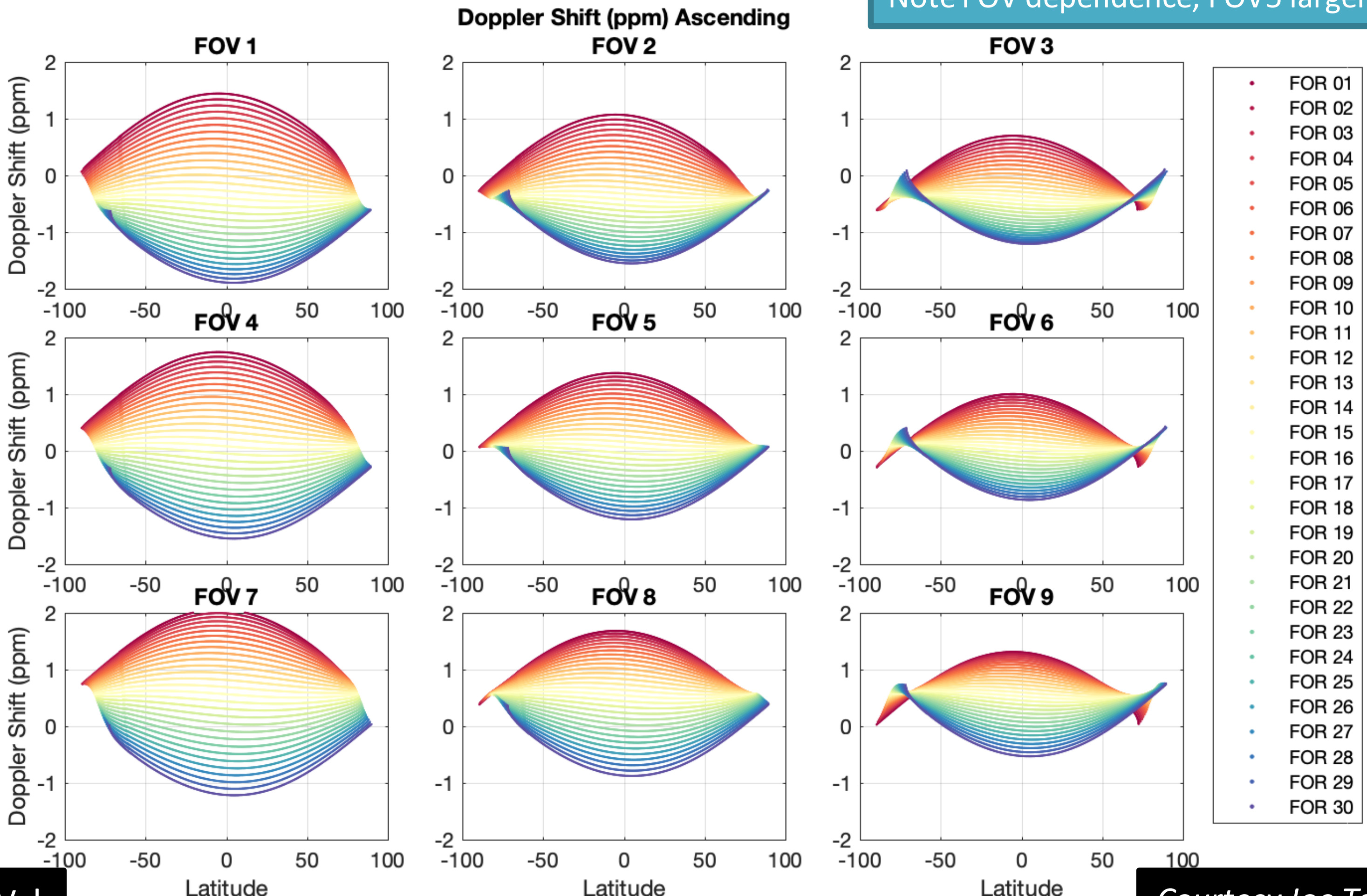


Earth Only

Courtesy Joe Taylor

Calculated Doppler Shift Due to Earth and Satellite Velocities Versus Latitude, Ascending, All FOVs and FORs

Note FOV dependence, FOV5 largely unchanged



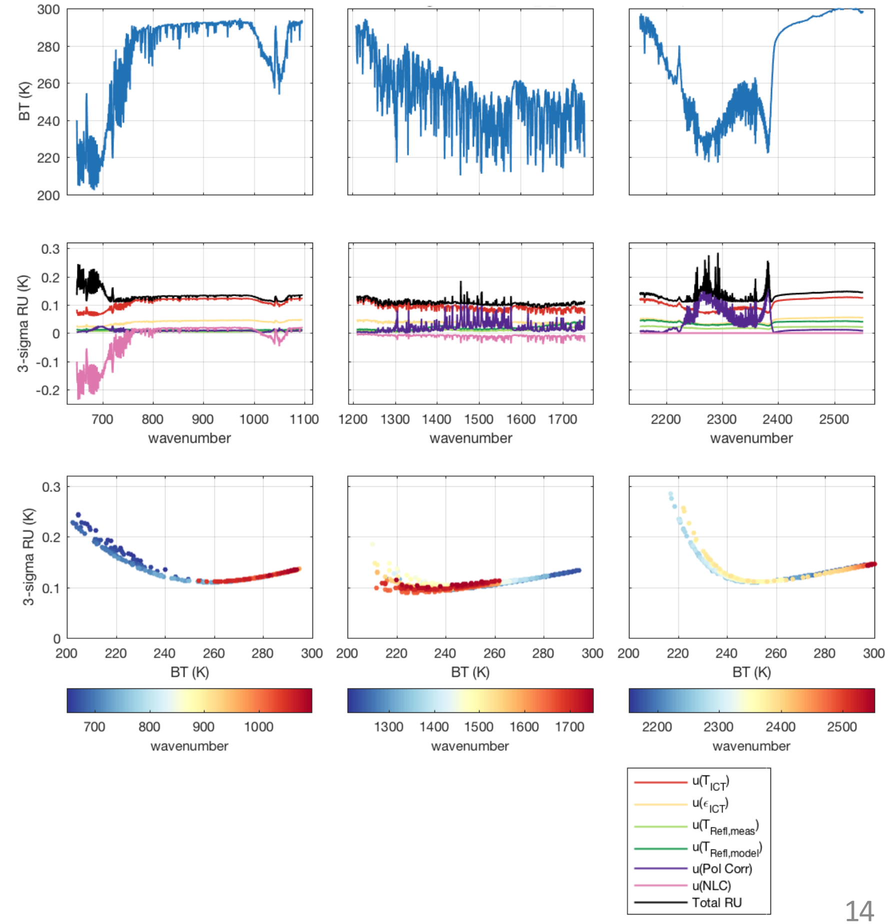
Earth and Sat Vel

Courtesy Joe Taylor

Radiometric Uncertainty Estimation

- A critical aspect of a reference sensor and climate quality measurement record is the documentation of and ability to calculate the uncertainty in the sensor measurements
- The radiometric uncertainty (RU) in the calibrated radiance can be determined via a perturbation analysis of the calibration equation
  - Equivalent to a differential error analysis described in the GUM (Guide to Uncertainty in Measurements)
- SNPP CrIS: Tobin, D., et al. (2013), Suomi-NPP CrIS radiometric calibration uncertainty, *J. Geophys. Res. Atmos.*, 118, 10,589–10,600, doi: 10.1002/jgrd.50809.
- The CrIS NASA L1b V3 product contains the information needed to accurately calculate the radiometric uncertainty for **any** CrIS NASA L1b calibrated radiance
- Radiometric Uncertainty Tool documentation, sample code, and static RU parameters will be made available shortly

Example Warm Scene: SNPP

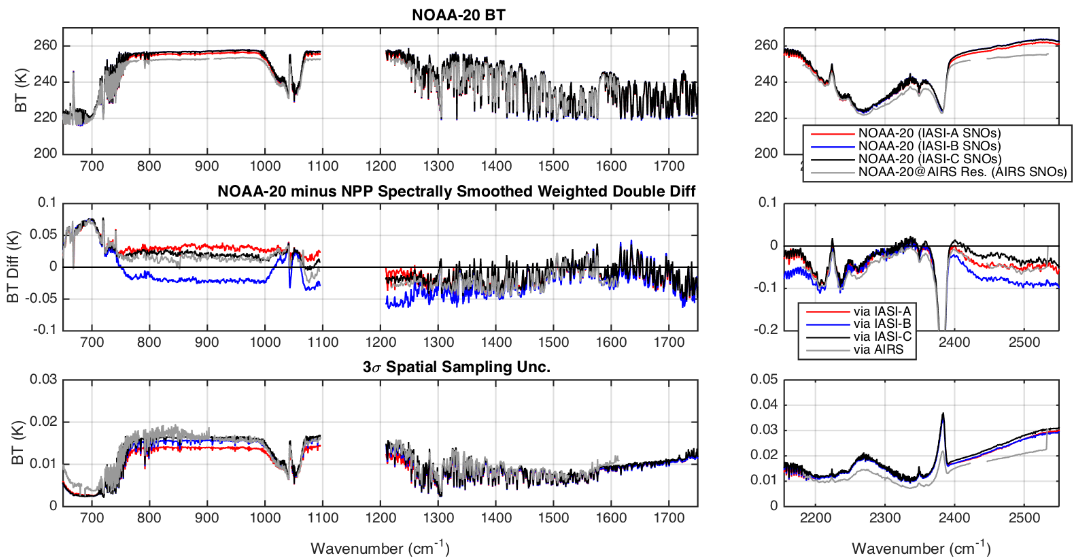


CrIS to CrIS double difference example
SNPP and NOAA-20 CrIS via SNOs with IASI and AIRS

- NOAA-20 minus NPP smoothed bias double diffs are computed using AIRS and each IASI as a reference
- NOAA-20 minus NPP biases are under 75 mK in LW/MW, 100 mK in SW (except for 2380cm^{-1} region)
- Sampling unc. <20 mK in LW/MW, <35 mK in SW → even at this level, the SNO methodology enables us to make claims about agreement between instruments (e.g. at 700cm^{-1})
- NOAA-20 and NPP agree well w/in the current radiometric uncertainty estimates (ignoring 2380cm^{-1} region which is prone to BT conversion issues)

NOAA20 – NPP Ddiff Smoothed
(Note Scale!)

3σ Sampling Uncertainty



Courtesy Michelle Loveless

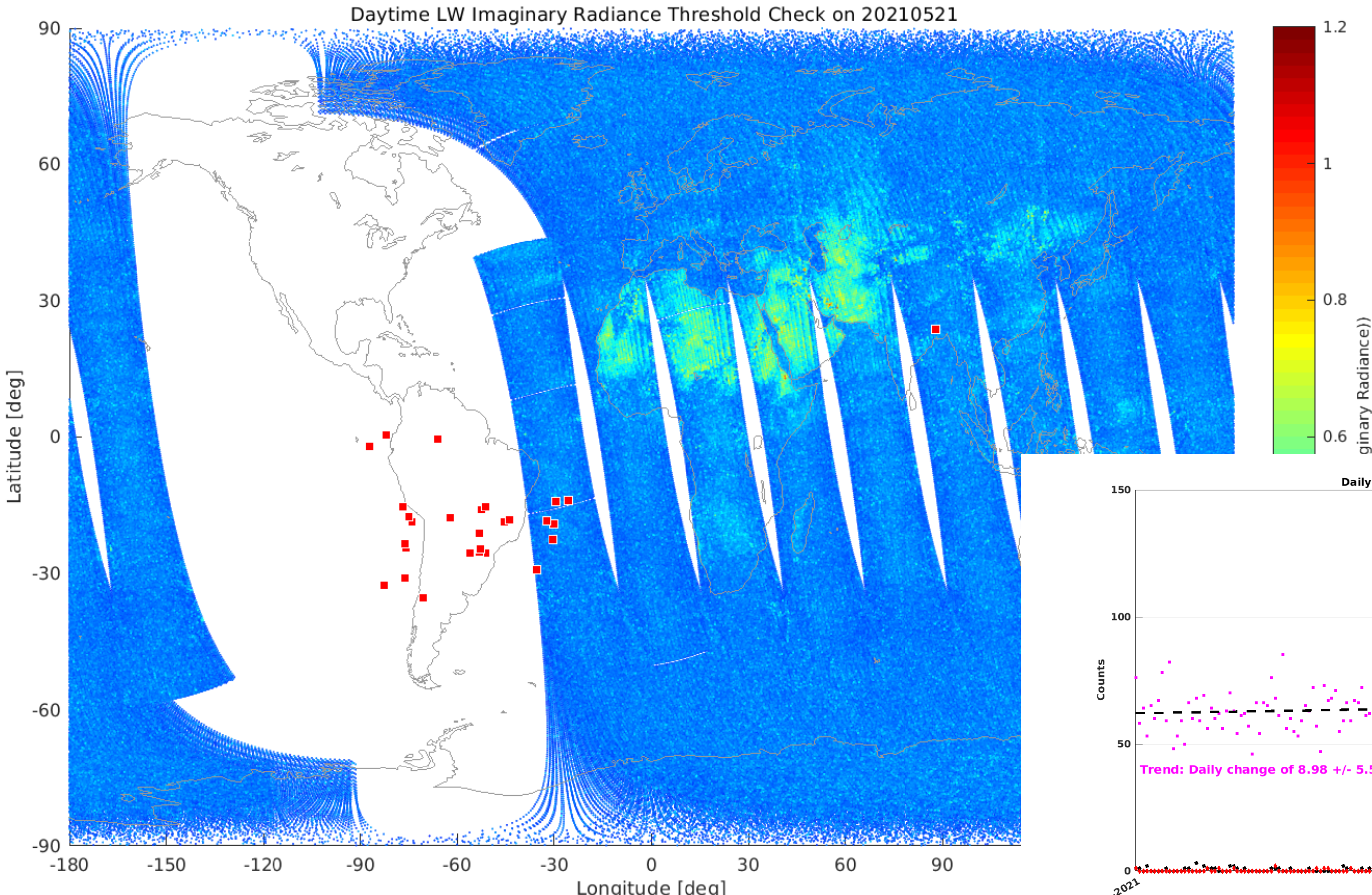
Current work

- V4 product development
- SNPP and JPSS-1 Intercomparisons
  - Potential SNPP CrIS Inter/Re-calibration using JPSS-1 CrIS
  - Quadratic nonlinearity a_2 and SNPP T_{refl} and/or e_{ICT} refinements
- CrIS Covariance Matrices
- Sensor Noise; Hamming apodization; Calibration Uncertainty JPSS-2 CrIS
  - Preparation for changes in telemetry
  - Incorporating TVAC analysis results
- Improved self-apodization correction
- Improved spectral calibration
- Mission survey and monitoring
- Website

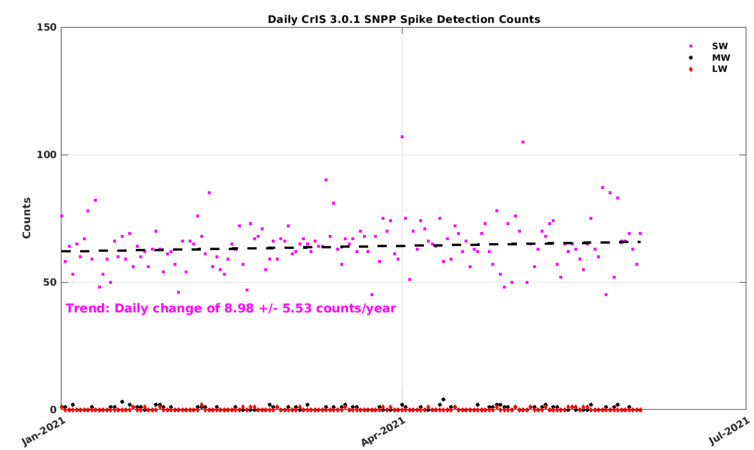
Plans for V4 product

- Full Doppler shift correction (in-track and cross-track)
- Neon lamp failure robustness
- Enhanced SEU spike detection
- SEU spike correction
- Lunar intrusion prediction model

Monitoring example: Suomi NPP Side 2 LW failure



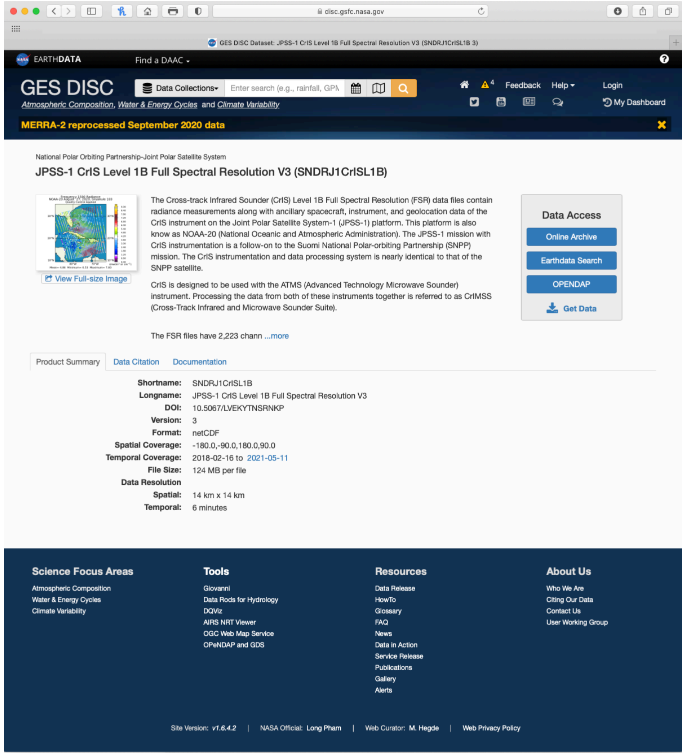
Red dots are spikes detected in SW band



Courtesy Dan Deslover

Products, Documentation, and Software

1. Visit GES DISC site: https://disc.gsfc.nasa.gov
2. Search "CrIS L1B v3"
3. Select the desired dataset
   - SNPP CrIS L1B NSR V3
   - SNPP CrIS L1B FSR V3
   - JPSS-1 CrIS L1B FSR V3
4. Dataset page has multiple methods of data access and links to documentation.



Direct links (V3):

- https://disc.gsfc.nasa.gov/datasets/SNPPCrISL1BNSR_3/summary
- https://disc.gsfc.nasa.gov/datasets/SNPPCrISL1B_3/summary
- https://disc.gsfc.nasa.gov/datasets/SNDRJ1CrISL1B_3/summary

Product contact info:

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