CrIS as a GSICS Reference and recent Intercalibration examples

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Topics:

- ***Report: "The Cross-track Infrared Sounder (CrIS) as a Reference for the Global Space-based Inter-Calibration System (GSICS)", Version 2, 04 April 2020***
    - *Pre-launch calibration traceability*
    - *Radiometric Uncertainty*

- ***Recent Intercalibration examples***
    - *AIRS/IASI/CrIS SNOs*
    - *Scene Temperature Dependence*
    - *SNPP CrIS / NOAA-20 CrIS Double Differences*
    - *SNPP CrIS/VIIRS*

The Cross-track Infrared Sounder (CrIS) as a Reference for the Global Space-based Inter-Calibration System (GSICS)

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04 April 2020
Version 2

The Cross-track Infrared Sounder (CrIS) sensors on the S-NPP and NOAA-20 satellites have the required characteristics to provide reference measurements of Top-of-atmosphere infrared radiance spectra for the Global Space-based Inter-Calibration System (GSICS). This report documents those characteristics, including pre-launch sensor characterization, calibration traceability to on-orbit performance, and on-orbit radiometric calibration accuracy. Example on-orbit intercalibration results with other candidate reference sensors are presented. This report will be updated as needed to document the CrIS sensor characteristics in this context, such as the documentation of the JPSS-2/NOAA-21 CrIS.

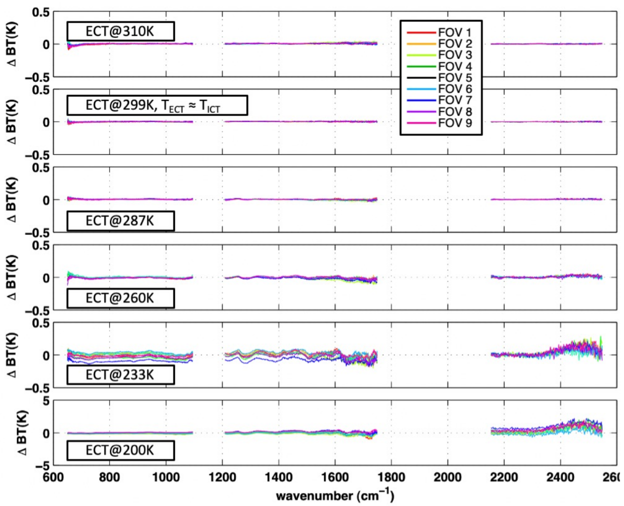
1. Introduction

The goal of GSICS [1] is to create a consistent and more accurate set of satellite data using approaches that tie data from less accurate and less consistent sensors to more accurate "reference sensors." For infrared radiance data, GSICS has implemented a successful GEO/LEO intercalibration system in which the array of global Geostationary infrared sensors is re-calibrated based on inter-comparison and inter-calibration with reference Low-earth-orbit

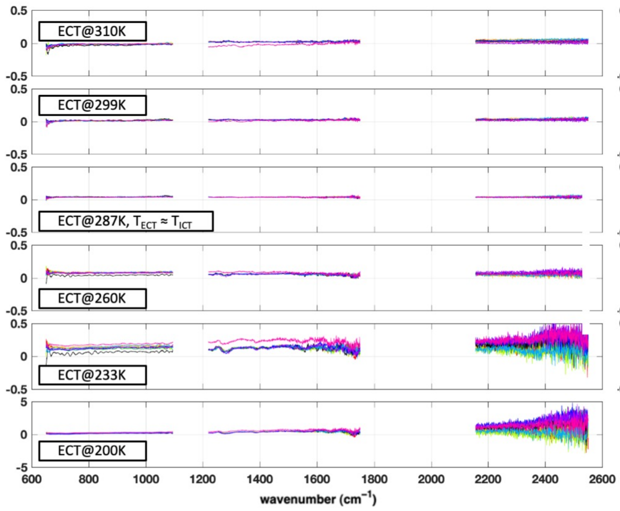
Pre-launch calibration traceability of CrIS using SI-traceable External Calibration Target (ECT) views

ECT view calibrated BT spectra minus ECT predicted BT, for ECT at 200K, 233K, 260K, 287K, 299K, 310K

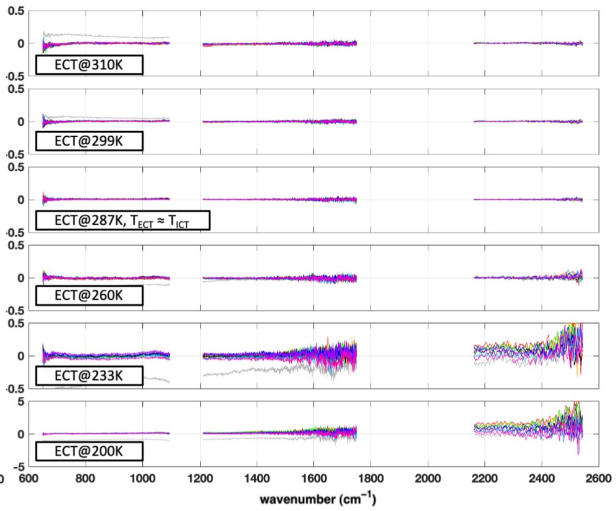
S-NPP CrIS, 2008



NOAA-20 CrIS, 2014



JPSS-2 CrIS, 2020



(JPSS-3 CrIS testing on-going now)

FOV3 (grey line) had Space Target view misalignment for the JPSS-2 data acquisition and analysis shown here. FOV3 is in family for TVAC testing in which the Space Target to FOV3 misalignment was remedied.

- *ECT view data used to characterize the sensor radiometric nonlinearity and provide end-to-end calibration traceability to NIST via temperature sensor calibrations and NIST TXR measurements*
- *BT residuals are sub 0.1K for ECT temperatures of >260K, and larger as expected for 233 and 200K plateaus due to TVAC Space Target uncertainties; residuals are well within pre-launch RU*
- *TVAC data and analysis results to be archived and documented as part of the L1B record for traceability and on-going, future evaluations*

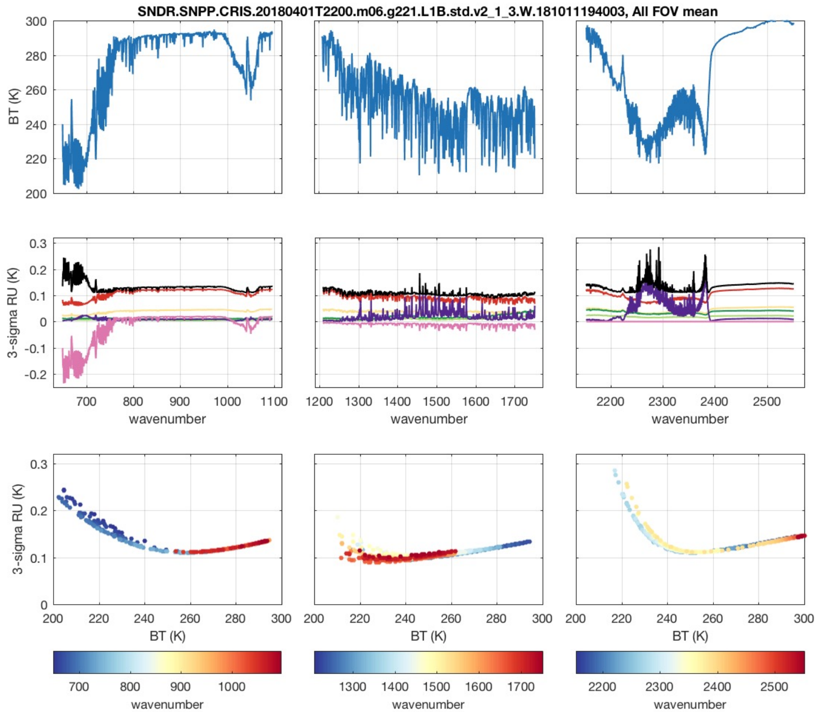


Figure 5. *SNPP CrIS Radiometric Uncertainty estimate for a typical warm tropical spectrum, expressed as a 3-sigma (not to exceed) brightness temperature uncertainty. Uncertainties due to the ICT temperature, ICT emissivity, ICT reflected temperatures, polarization coefficients, and radiometric nonlinearity coefficients are included.*

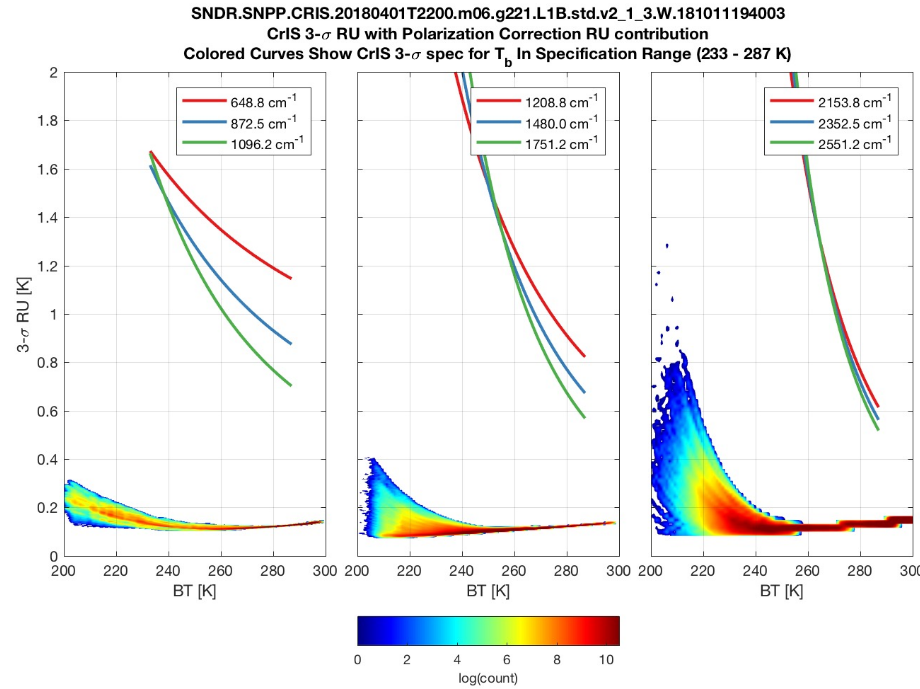


Figure 6. *SNPP CrIS Radiometric Uncertainty estimate for granule (6 minutes) of warm tropical spectra, expressed as a 3-sigma (not to exceed) brightness temperature uncertainty. The graphs show density plots of the RU for the (left to right) Longwave, Midwave, and Shortwave band measurements, as well as the sensor specification values expressed as 3-sigma brightness temperature.*

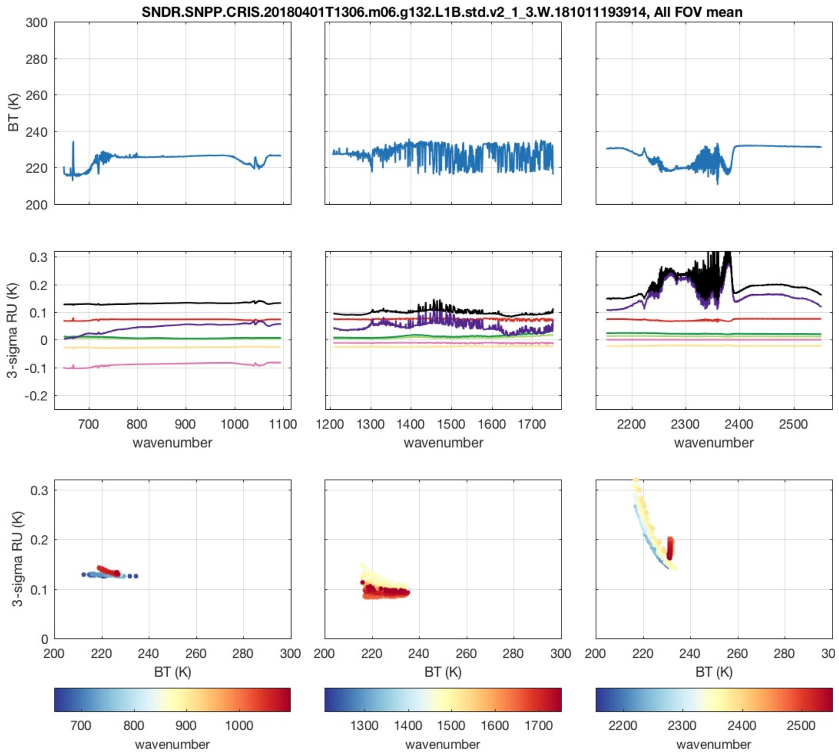


Figure 7. *Same as Figure 5 but for a cold Antarctic spectrum.*

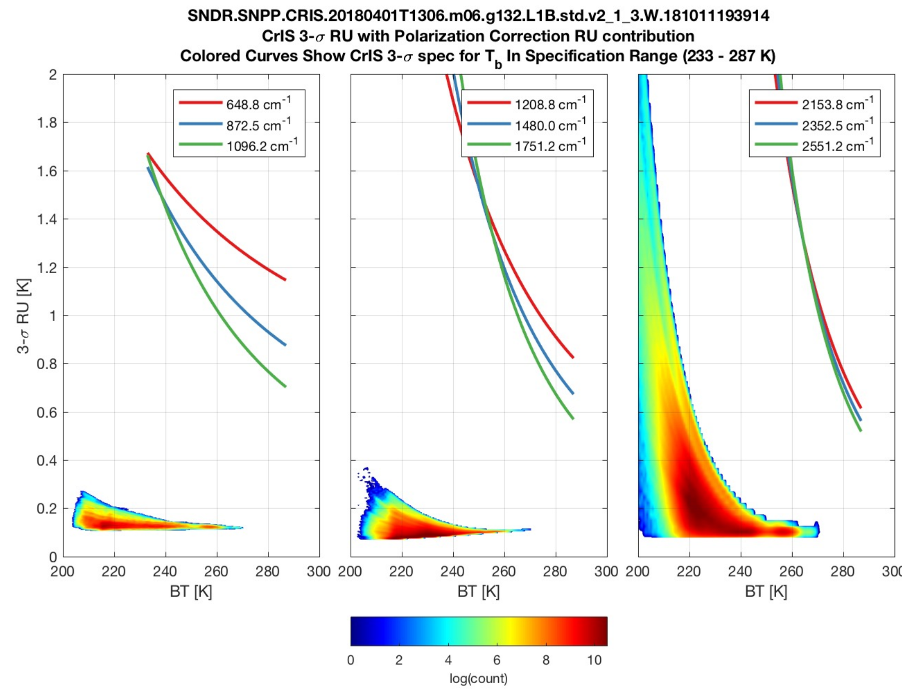


Figure 8. *Same as Figure 6 but for a cold Antarctic spectrum.*

Example Comparison of IASI, AIRS, and CrIS using Simultaneous Nadir Overpasses

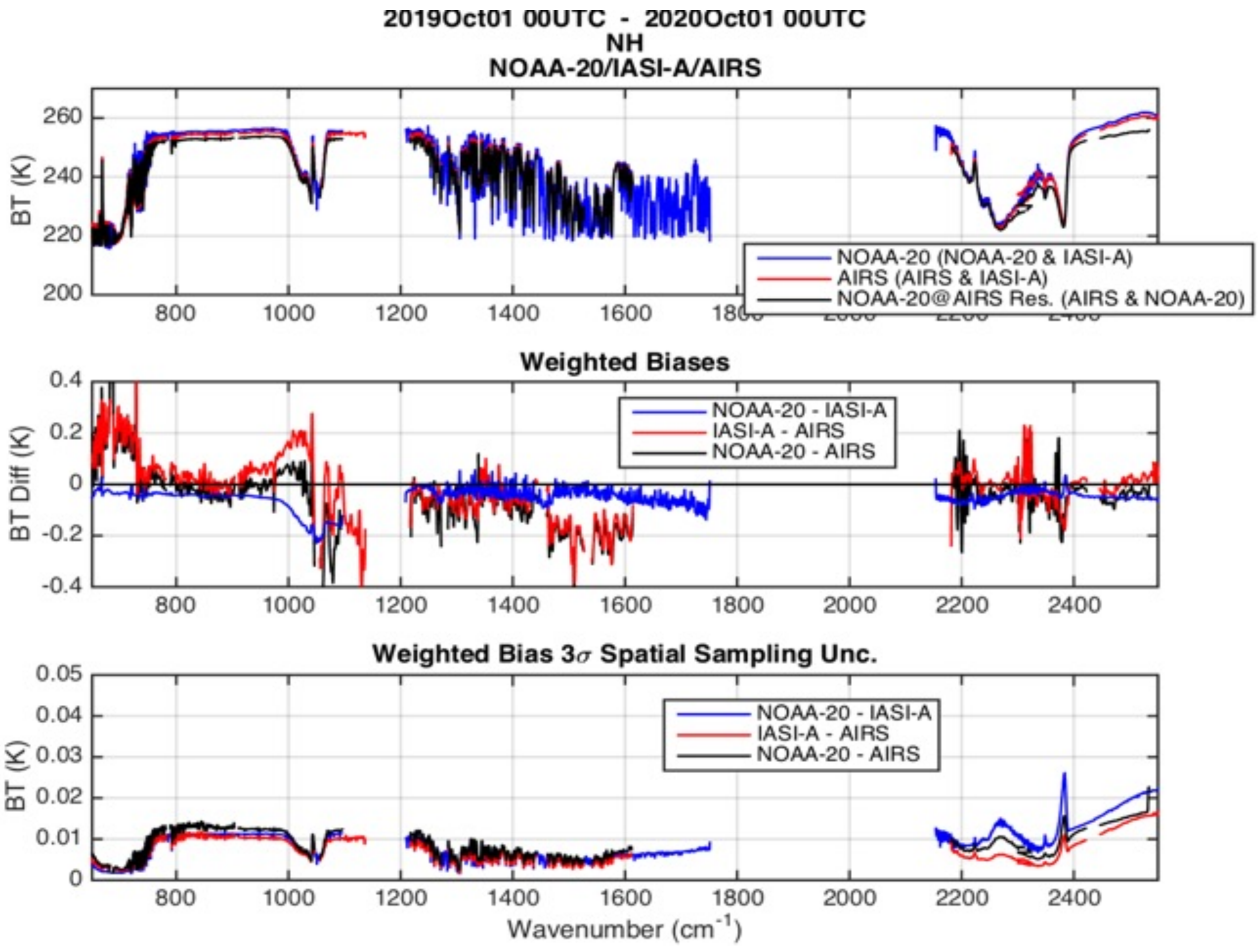
Northern Hemisphere SNOs for Oct 2019 to Oct 2020

Mean differences and uncertainties for:

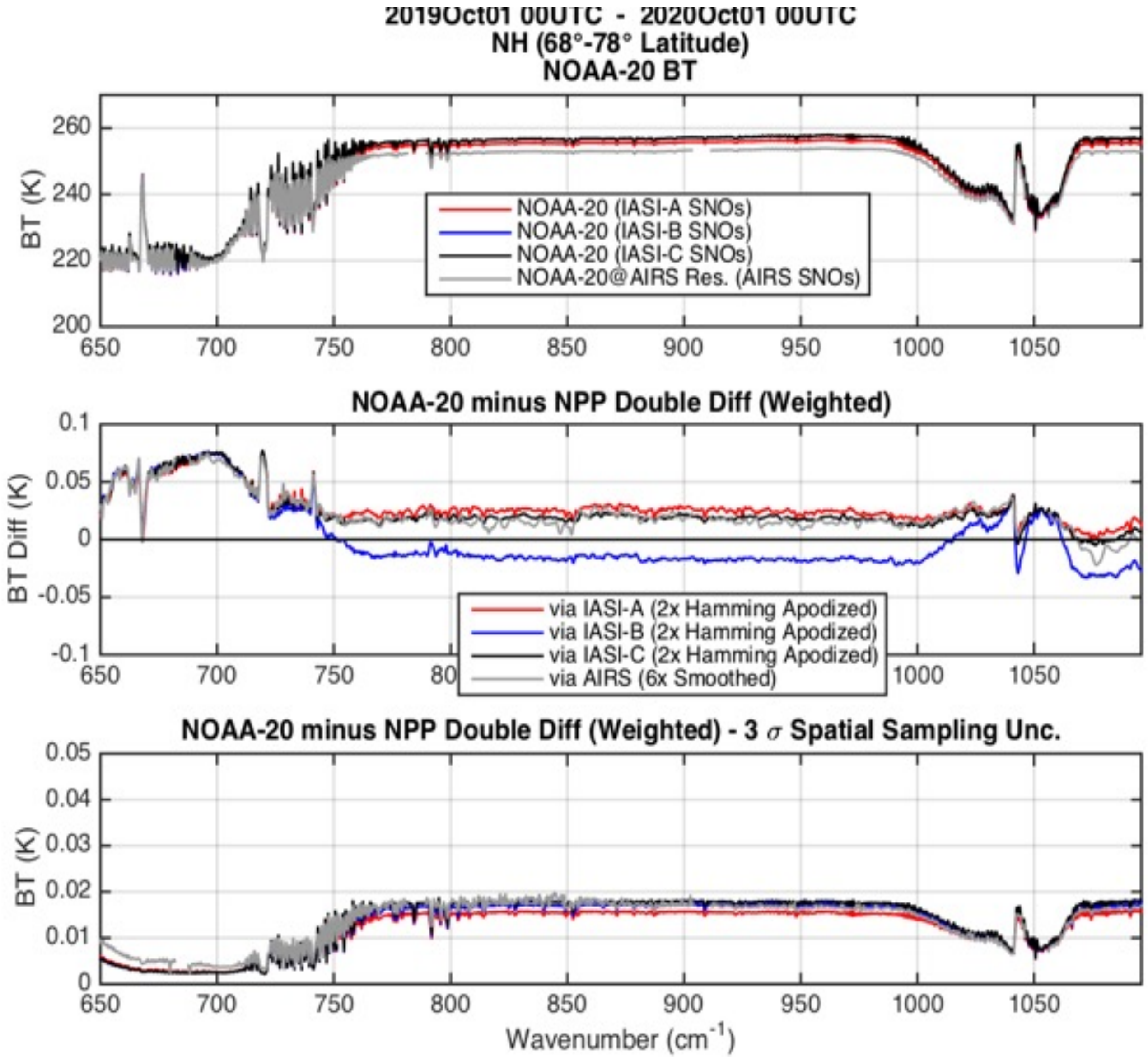
- NOAA-20 CrIS minus METOP-A IASI
- METOP-A IASI minus AIRS
- NOAA-20 CrIS minus AIRS

➢ Very good agreement between CrIS and IASI

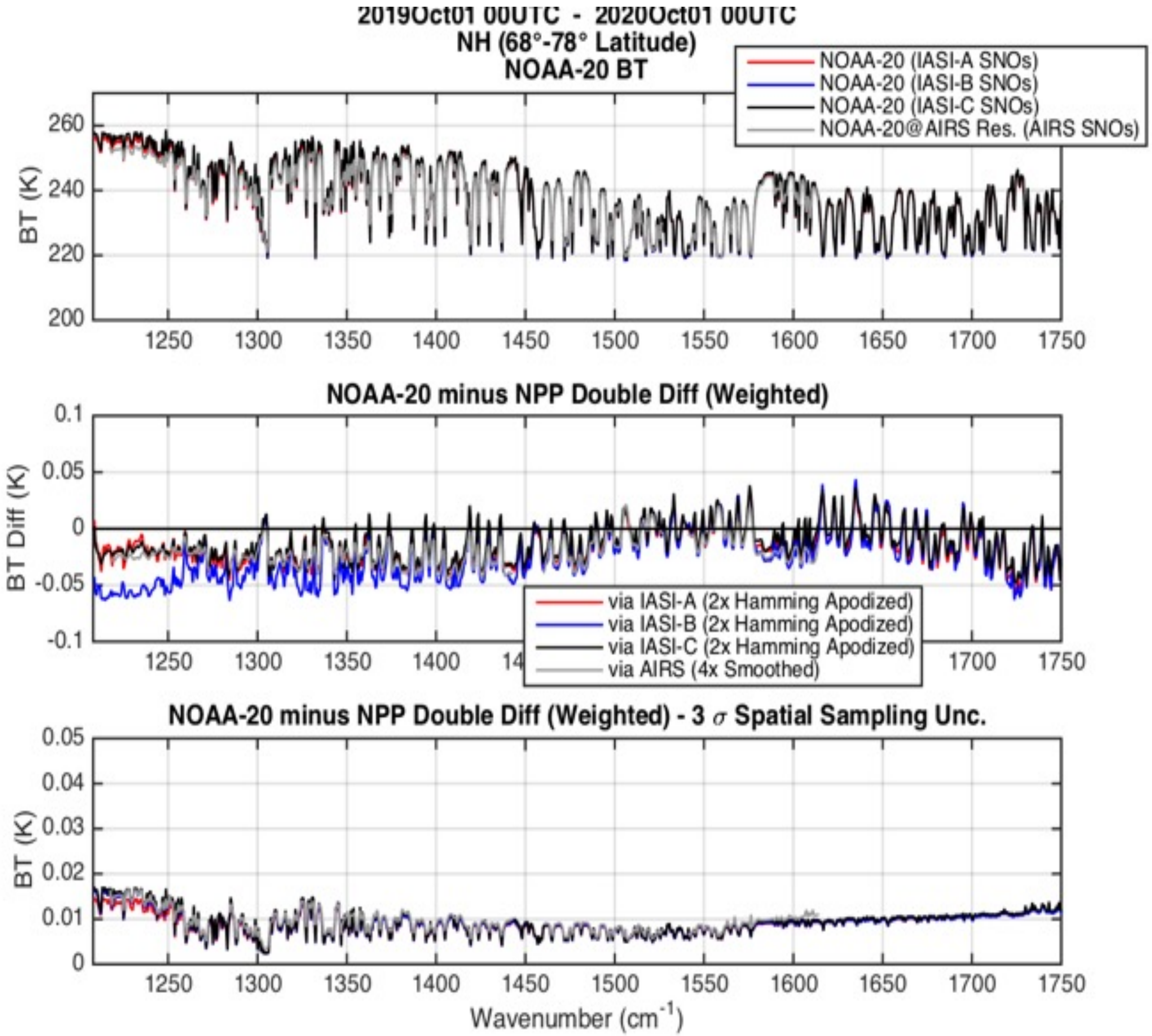
➢ Somewhat larger differences between AIRS and IASI, and between AIRS and CrIS



Comparisons of NOAA-20 CrIS and SNPP CrIS using SNO double differences, (NOAA20 - IASI)-(SNPP – IASI) demonstrates <0.1K agreement between the two CrISes



Comparisons of NOAA-20 CrIS and SNPP CrIS using SNO double differences, (NOAA20 - IASI)-(SNPP – IASI) demonstrates <0.1K agreement between the two CrISes

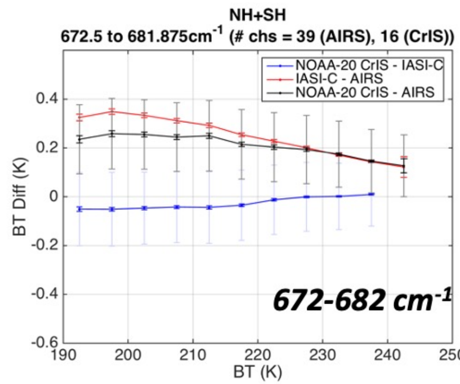


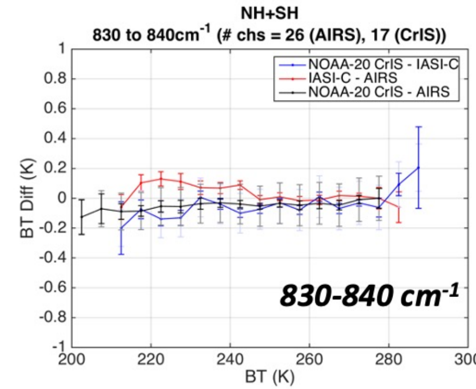
AIRS/IASI/CrIS Differences vs. Scene Temperature for selected wavenumber regions

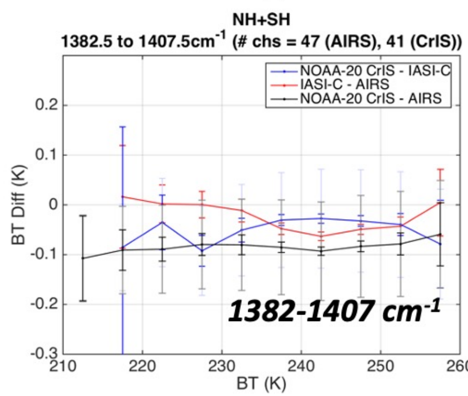
- The dependence of the BT differences on scene BT is shown for 4 wavenumber regions
- Both spatial sampling (dark colored) and CrIS radiometric (light colored) unc. are shown as error bars
- Biases are relatively independent of scene temperature

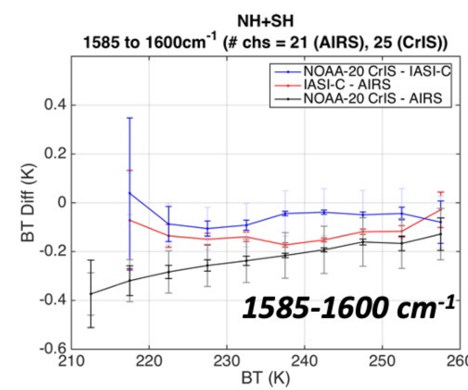
- At LW 670-680 cm^{-1}, diffs are likely explained by uncertainty in non-linearity corrections of CrIS, IASI, and AIRS
- At LW 835 cm^{-1} window region, agreement is better than 0.2 K down to 200 K
- At MW 1382-1407 cm^{-1} water vapor region, agreement better than 0.1 K down to 225K
- At MW 1585-1600 cm^{-1}, AIRS seems to be an outlier → consistent with the mean BT offset of AIRS relative to CrIS and IASI seen previously

Dark colored error bars: 3σ sampling unc.
Light colored error bars: 3σ CrIS radiometric unc.



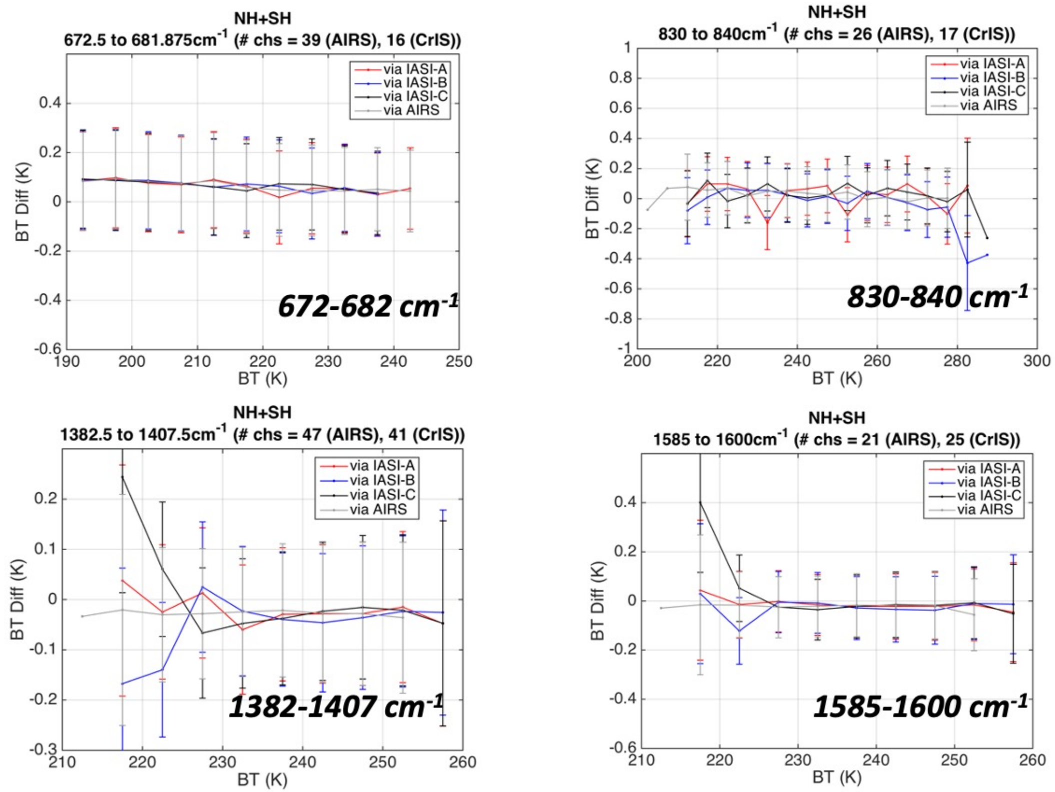






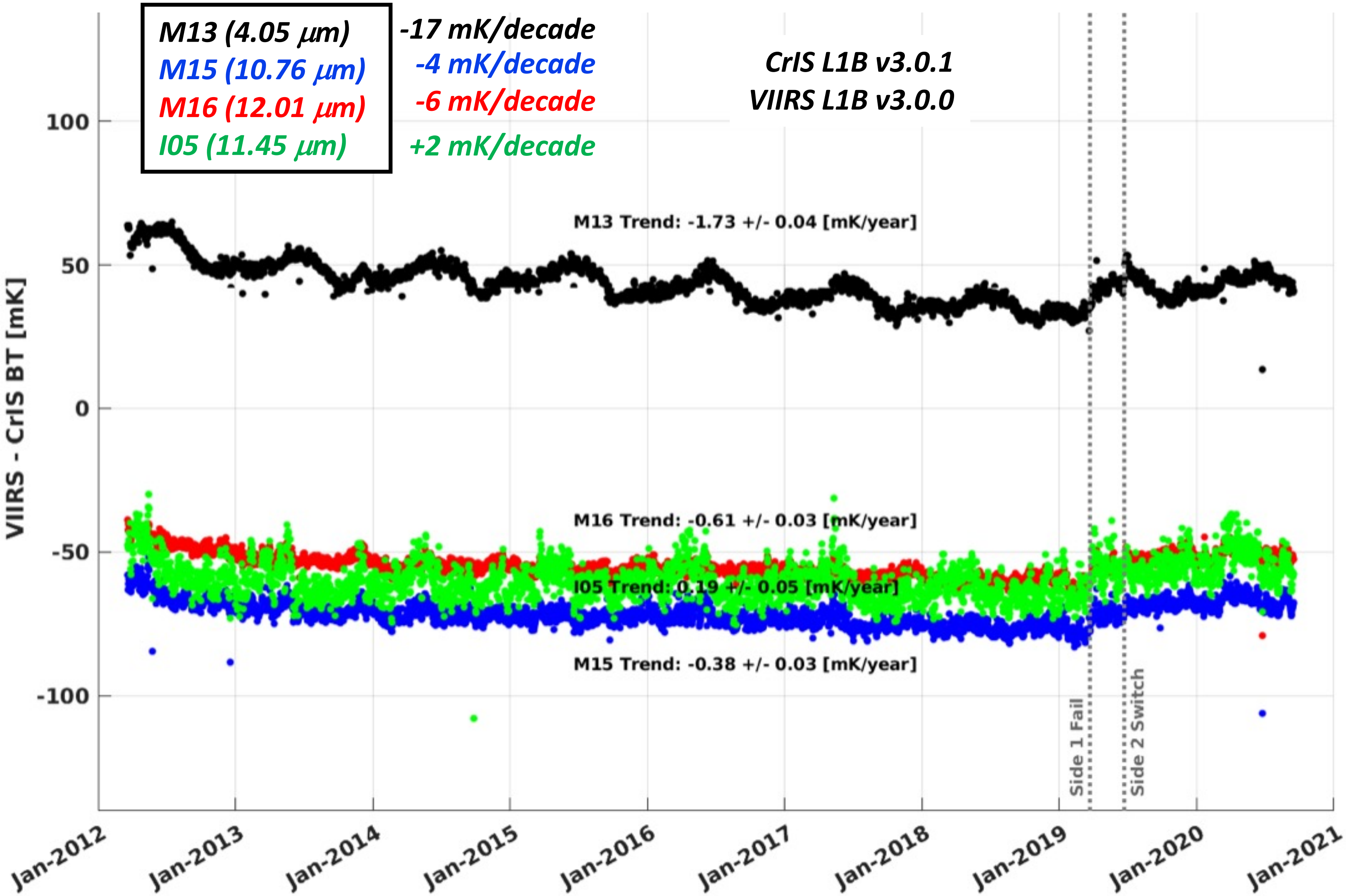
NOAA-20 CrIS minus SNPP CrIS Differences vs. Scene Temperature for selected wavenumber regions

- Again, the dependence of the BT differences on scene BT is shown – this time for NOAA-20 CrIS–NPP CrIS
- The 3σ sampling and 3σ CrIS radiometric uncertainty are combined via RSS and shown as error bars
- Within the statistical sampling uncertainty (not shown independently), NOAA-20 and NPP CrIS when compared using each IASI and AIRS, have very similar dependences on BT (very little if any)



Error bars: RSS(3σ CrIS radiometric unc & 3σ sampling uncertainty)

Mission length S-NPP CrIS/VIIRS Differences, Global Daily Means for 280-290K Scenes



- *Trends of +2, -4, -6, and -17 mK/decade*
- *Small discontinuities associated with 2019 CrIS electronics side switch*

Summary:

- ***CrISes are very good references for IR Intercalibration***
    - *Well-established calibration traceability*
    - *High accuracy, low noise*
    - *Well characterized uncertainties*

- ***Recent Intercalibration examples***
    - *Good agreement between AIRS/IASI/CrIS*
    - *Very good agreement between SNPP CrIS and NOAA-2 CrIS, but with room for improvement*
    - *Very good stability as demonstrated by mission length CrIS/VIIRS comparisons*