Inter-Comparison of NPP/CrIS Radiances with AIRS and IASI

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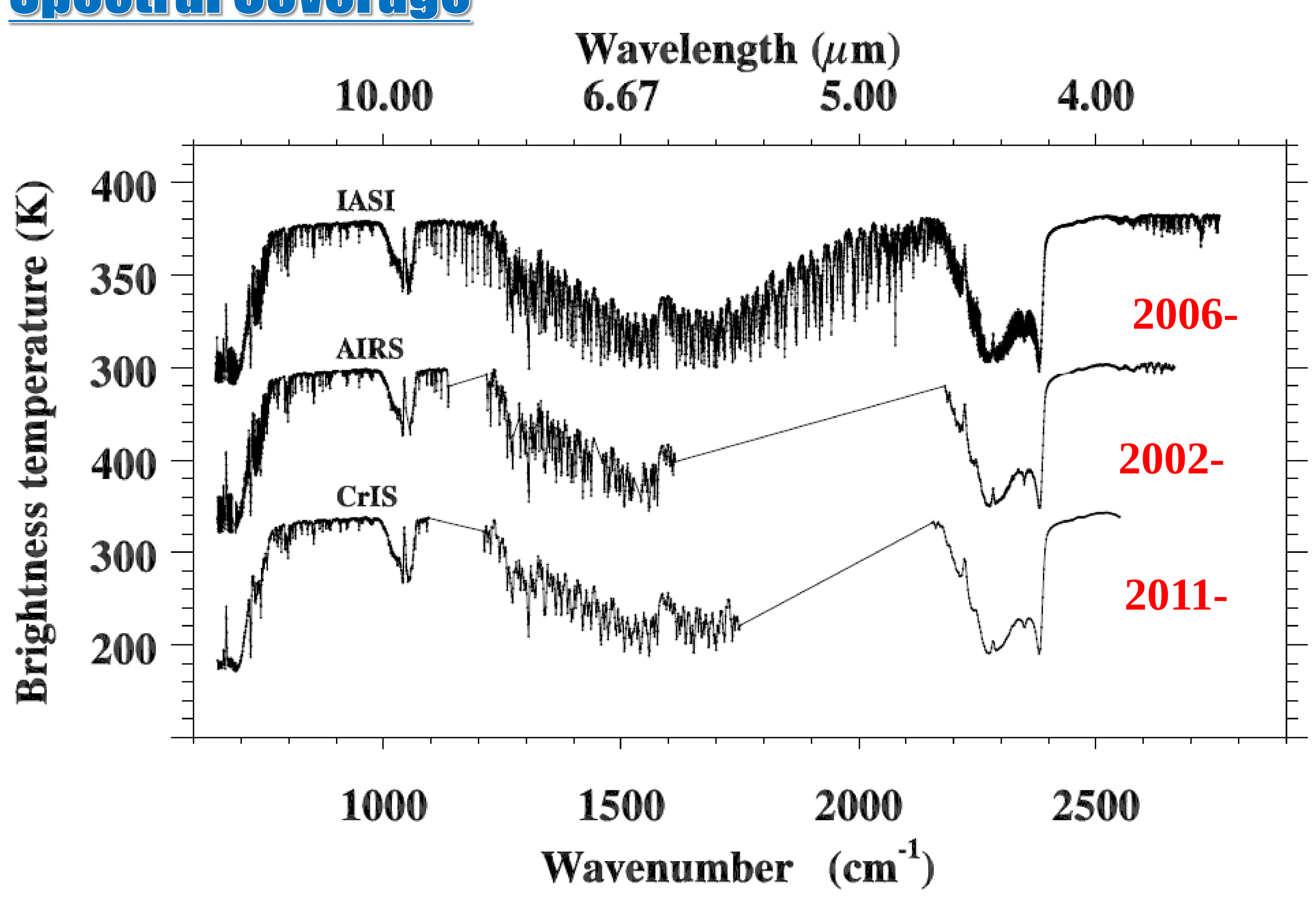
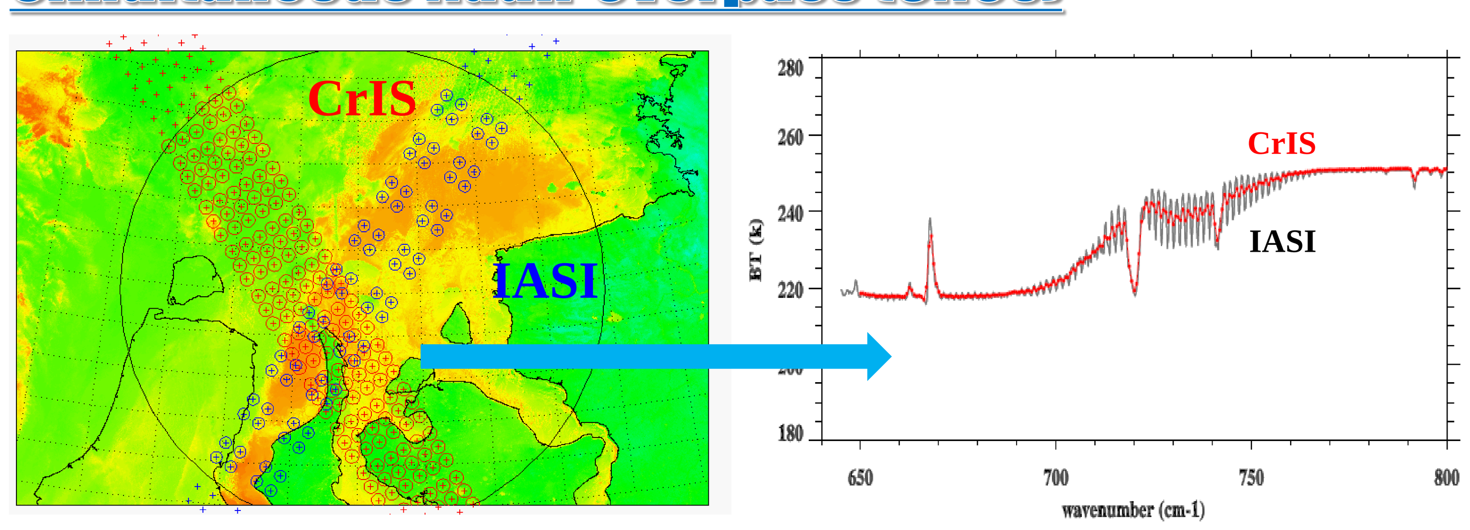
Abstract: The Cross-track Infrared Sounder (CrIS) on the newly-launched Suomi National Polar-orbiting Partnership (Suomi NPP) and future Joint Polar Satellite System (JPSS) is a Fourier transform spectrometer that provides soundings of the atmosphere with 1305 spectral channels, over 3 wavelength ranges: LWIR (9.14 - 15.38 µm); MWIR (5.71 - 8.26 µm); and SWIR (3.92 - 4.64 µm). An accurate spectral and radiometric calibration as well as geolocation is fundamental for CrIS radiance Sensor Data Records (SDRs). In this study, through inter- and intra-satellite calibration efforts, we focus on assessment of NPP/CrIS post-launch radiometric and spectral calibration. Specifically, we compare CrIS hyperspectral radiance measurements with the Atmospheric Infrared Sounder (AIRS) on NASA Earth Observing System (EOS) *Aqua* and Infrared Atmospheric Sounding Interferometer (IASI) on *Metop-A* to examine spectral and radiometric consistence and difference among three hyperspectral IR sounders using simultaneous overpass observations (SNO) observations. The purpose of this study is to use inter-calibration technologies to quantify the CrIS calibration bias and uncertainties.

Spectral Coverage



AIRS: Grating spectrometer; **IASI and CrIS**: Interferometer

Simultaneous Nadir Overpass (SNOs)



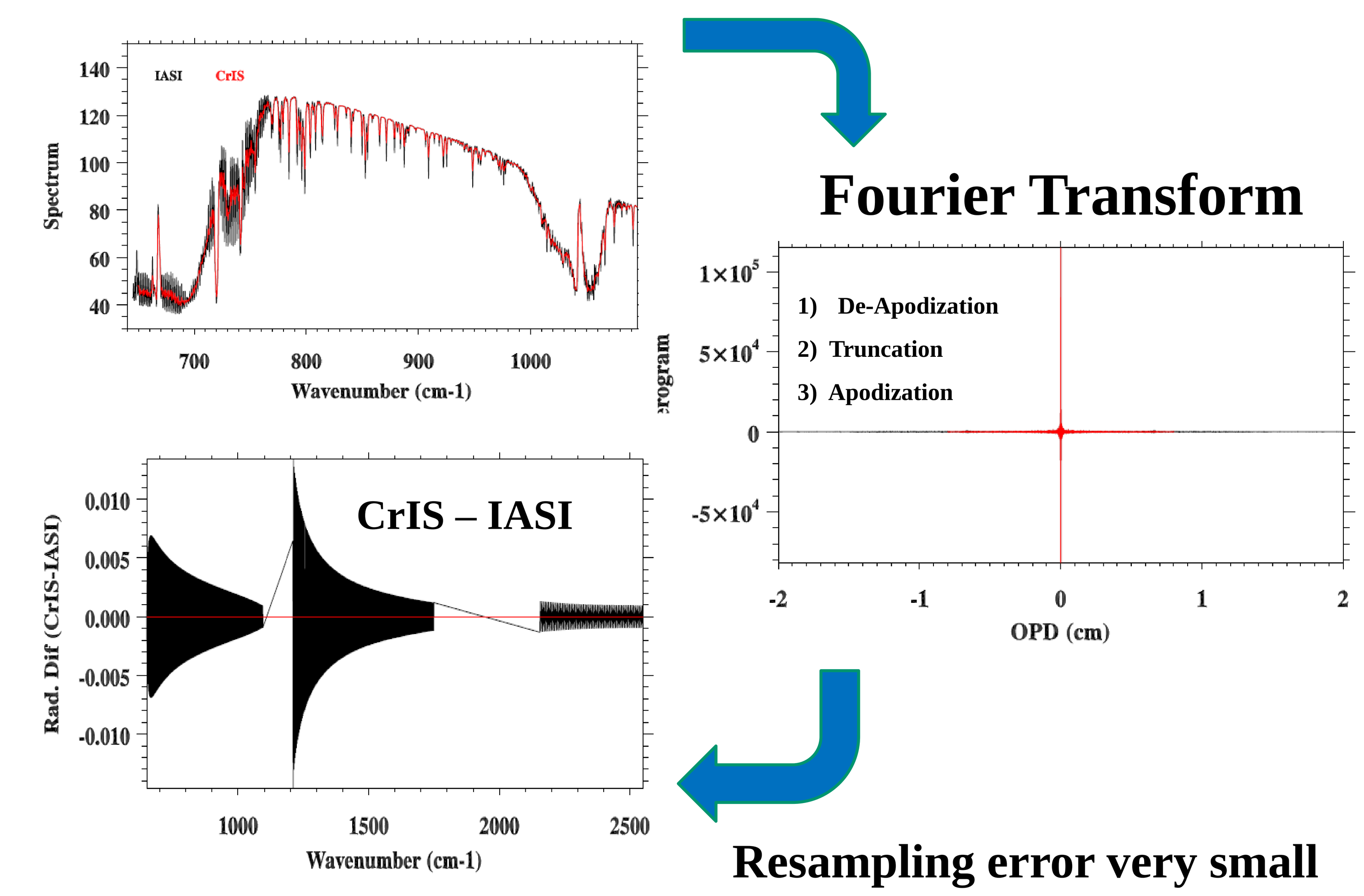
Polar orbiting satellites intersect each other at high latitudes, so called SNOs. This occurs for satellites even in very different orbits. When the SNO occurs, the radiometers from both satellites view the Earth and the atmosphere at the same place and same time but from different altitudes. This greatly reduced the uncertainties caused by collocation.

The following criteria are used to pair CrIS and IASI/AIRS nadir FOVs, i.e., 1) their observational time difference is less than 120 seconds, 2) the FOV distance is less than 6.5 km, and 3) $|cos(a1)/cos(a2)-1.0|$ is less than 0.01 where a1 and a2 are zenith angels from CrIS and IASI/AIRS FOVs. In addition, only homogeneous were selected for comparison in order to reduce uncertainties caused by the collocation by checking the radiance standard deviation within each CrIS/AIRS/IASI FOVs. The above figures gives an example of the CrIS and IASI spectra that meet the above criteria (only CrIS longwave region shown).

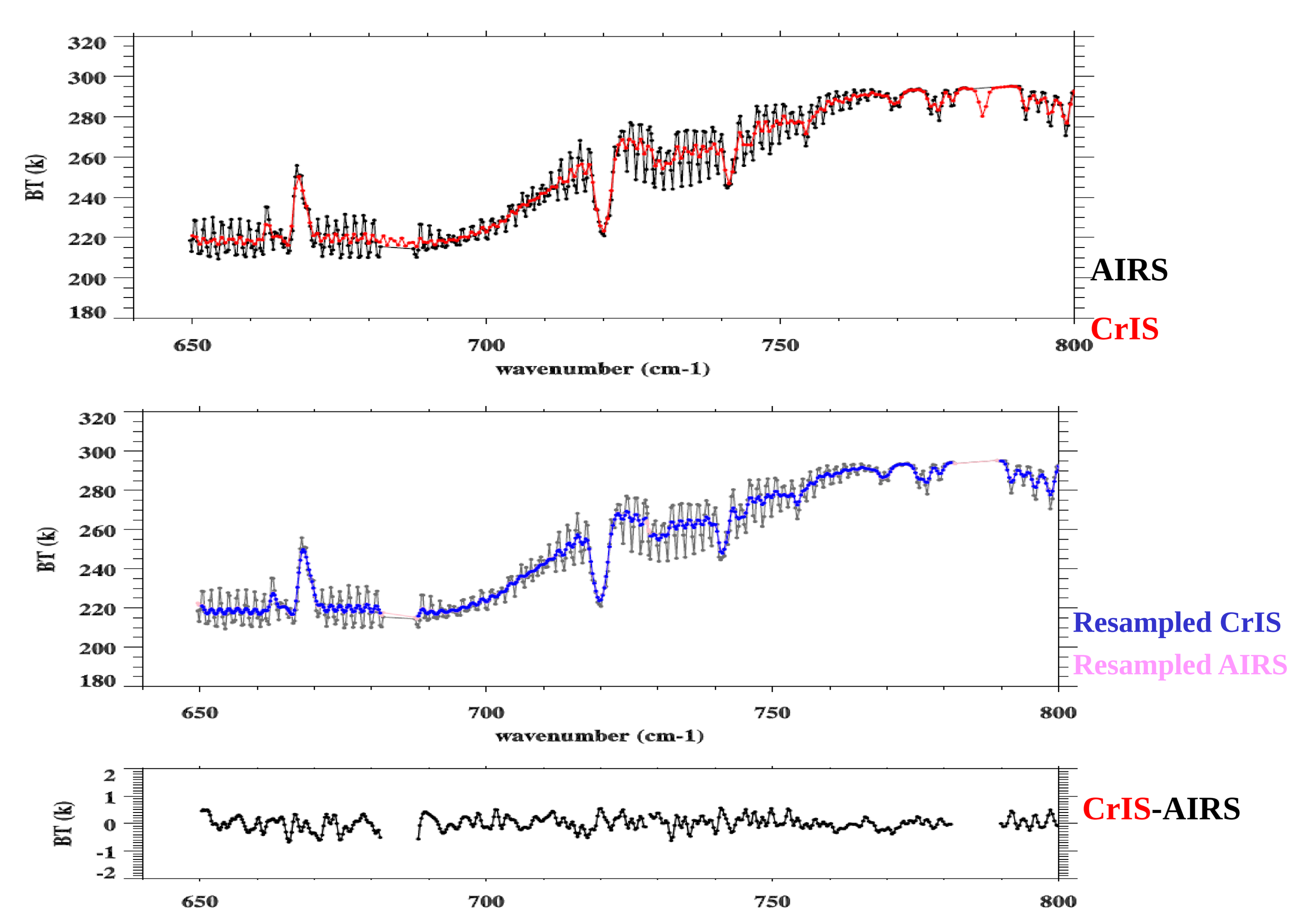
Data processing procedures

- Obtain SNO prediction from STAR Website
- Identify SDR file list
- Collocate CrIS (FOR 14 &15) with AIRS/IASI
- Match spectral grids
- Average the spectra (all, FOV or Scan)
- Make a comparison
- Monitor BT differences

Resampling IASI/AIRS with CrIS

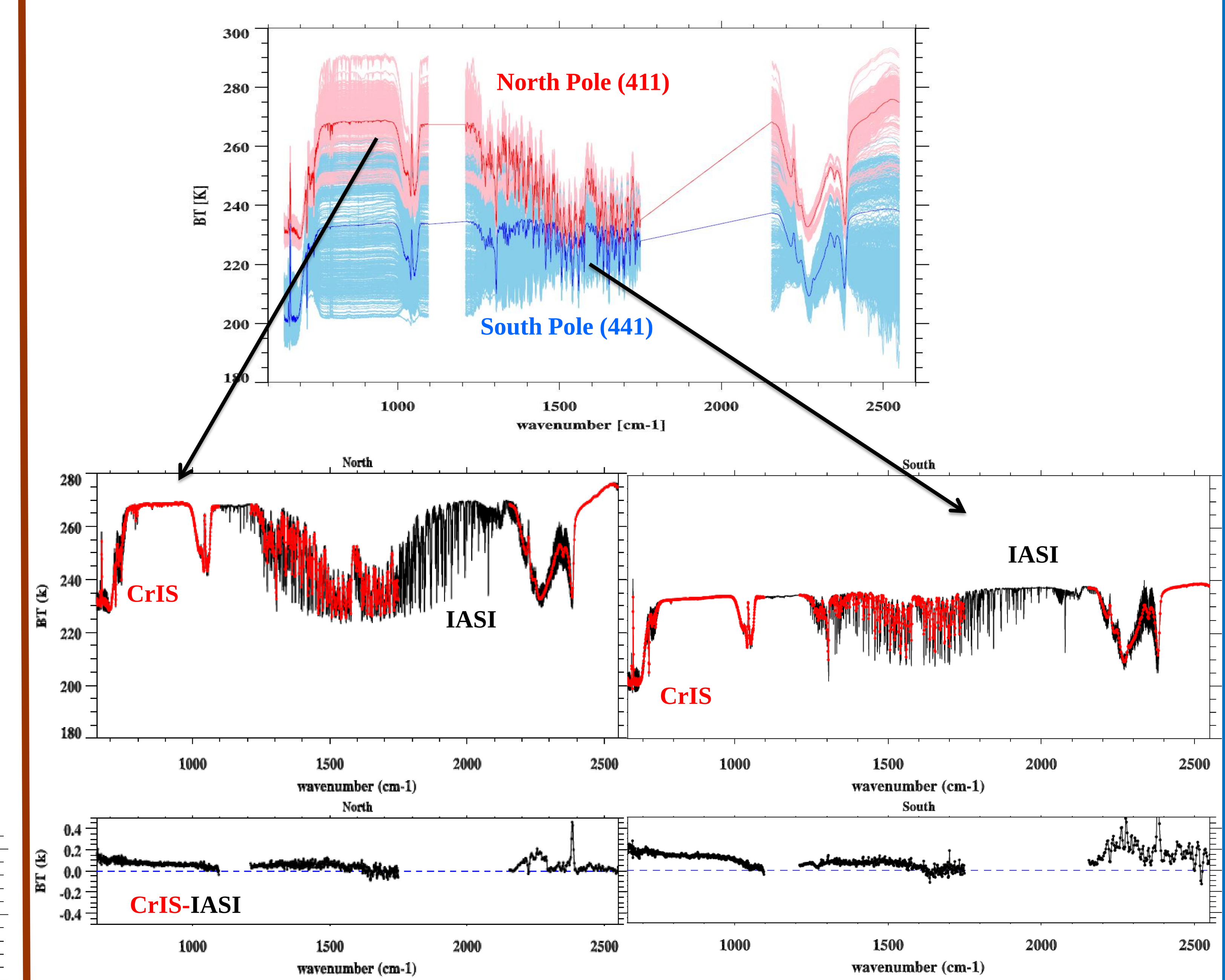


Since both CrIS and IASI are interferometers and IASI has a longer optical path difference (OPD) it is straightforward to convert IASI spectra into CrIS spectral.Five steps are performed, including: 1) converting IASI spectra to interferograms using Fourier transform; 2) de-apodizing IASI interferograms using IASI apodization functions; 3) truncating the IASI interferograms based on CrIS OPDs; 4) apodizing truncated interferograms using CrIS Hanning apodization functions; and 5) transforming interferograms into spectra using inverse Fourier transform. Theoretical study indicates that the above method is very accurate and re-sampling error is less than 0.02K for typical CrIS and IASI spectra.

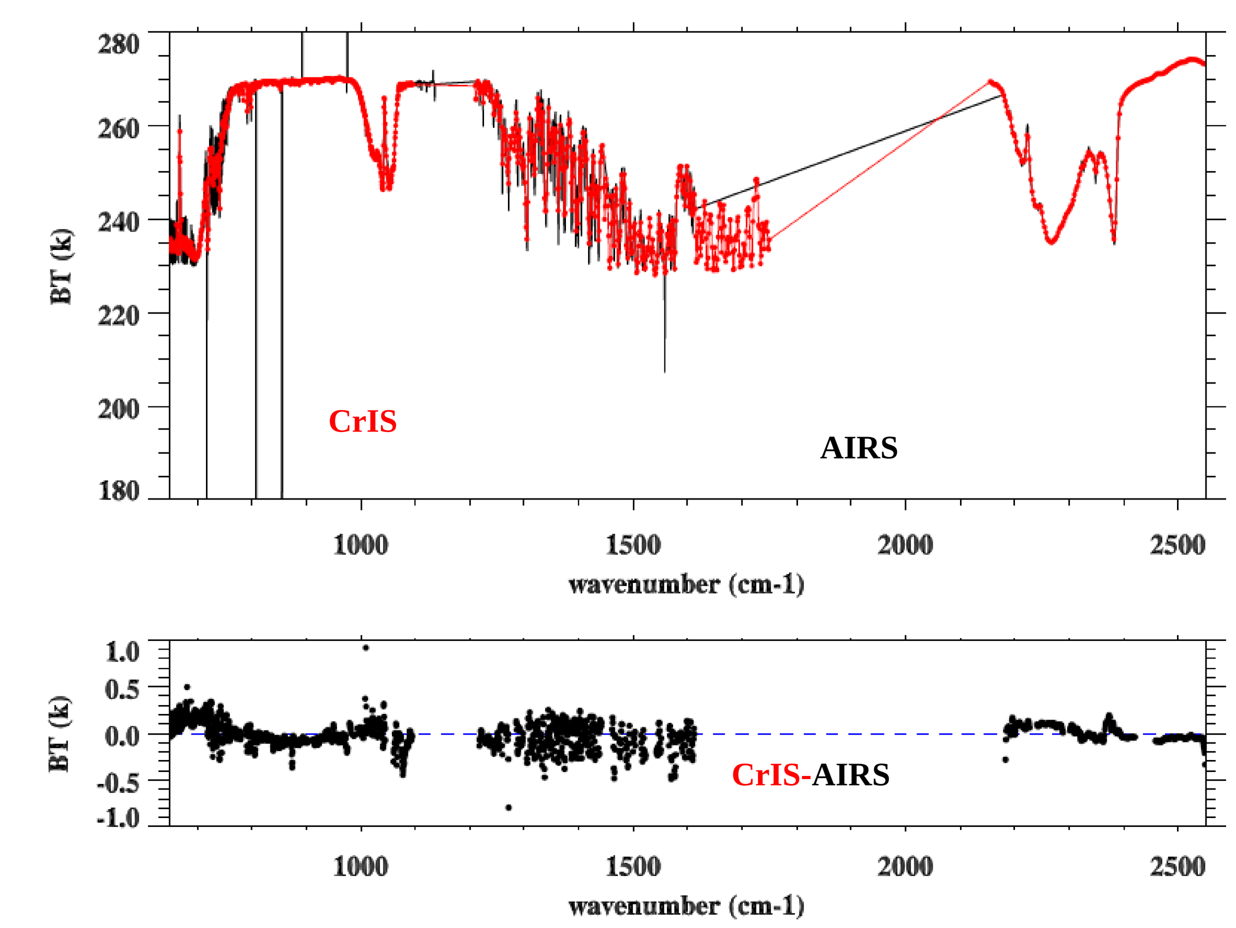


For AIRS and CrIS, a cross-convolution method is used to covert CrIS spectra into AIRS spectral domain. The reason is that AIRS is a grating spectrometer, spectral resolution varies with different bands, and spectral gap exists due to the design, and some channels are missed caused by bad or degraded detectors. The first step is to convolve AIRS spectra with the CrIS spectral response function (SRF). In the second step, CrIS spectra are resampled to high-resolution spectrum and then convolved with AIRS SRFs. After that, AIRS and CrIS spectra are processed at AIRS spectral grids.

CrIS *versus* IASI



CrIS *versus* AIRS



Summary: CrIS on the newly-launched Suomi NPP is a Fourier transform spectrometer that provides soundings of the atmosphere with 1305 spectral channels. An accurate spectral and radiometric calibration as well as geolocation is fundamental for CrIS radiance SDR. In this study, through inter- and intra-satellite calibration efforts, we focus on assessment of NPP/CrIS post-launch performance.

1) For CrIS Band 1 (longwave), CrIS-IASI/AIRS BT difference is scene-dependent and the differences get large when scene temperatures are low. Specifically, CrIS is warmer than IASI around 0.1-0.2K, and CrIS agrees well with AIRS at window region for warm scene (>270K) but warmer than AIRS at the CO_2 region (0.2-0.3 K).

2) For CrIS band 2 (middle-wave), at water vapor absorption region, CrIS and are consistent to both IASI and AIRS.

3) For Band 3 (shortwave), at the South Pole, the noise is large at low temperatures, and the differences are less than 0.1 K in most regions at North Pole.

The comparison results indicate that CrIS meets the designed specification, but we still need to further investigate the root causes of BT difference between CrIS and AIRS/IASI and between CrIS and VIIRS.