Inter-Comparison of Suomi NPP CrIS Radiances with AIRS and IASI Toward Infared Hyperspectral Benchmark Measurements

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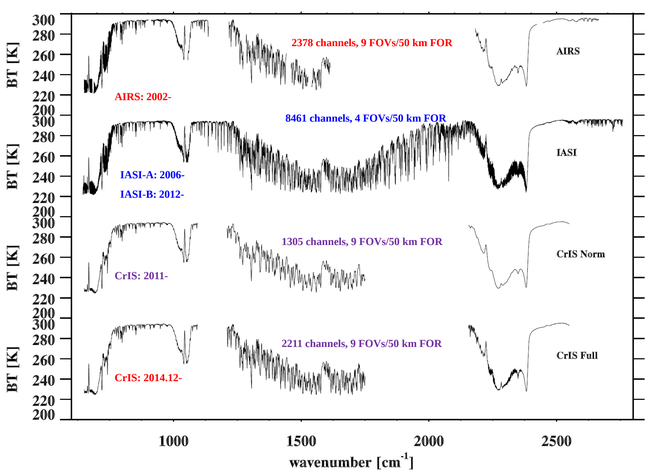
Abstract:

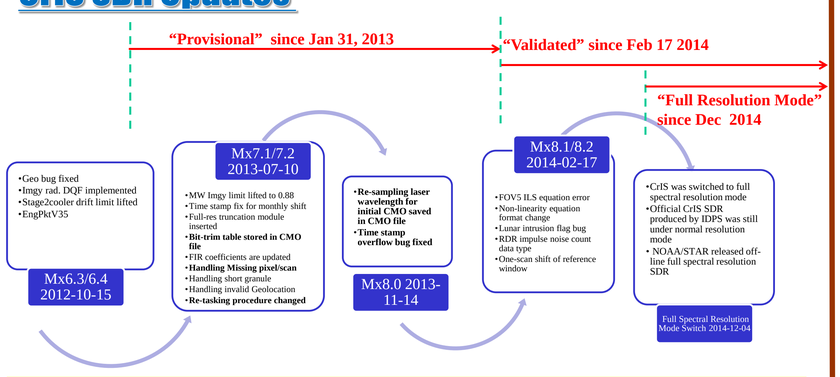
The radiometric and spectral consistency among the Atmospheric Infrared Sounder (AIRS), the Infrared Atmospheric Sounding Interferometer (IASI), and the Cross-track Infrared Sounder (CrIS) is fundamental for the creation of long-term infrared (IR) hyperspectral radiance benchmark datasets for both inter-calibration and climate-related studies. In this study, the CrIS radiance measurements on Suomi National Polar-orbiting Partnership (*SNPP*) satellite are directly compared with IASI on *MetOp-A* and *-B* at the finest spectral scale and with AIRS on *Aqua* in 25 selected spectral regions through one year of simultaneous nadir overpass (SNO) observations to evaluate radiometric consistency of these four hyperspectral IR sounders. The spectra from different sounders are paired together through strict spatial and temporal collocation. The uniform scenes are selected by examining the collocated Visible Infrared Imaging Radiometer Suite (VIIRS) pixels. Their brightness temperature (BT) differences are then calculated by converting the spectra onto common spectral grids. Finally, recently-released full spectral resolution SDR product is also compared with IASI on MetOp-B during recent SNO event. Several similar studies have been presented recently, including those by D. Jouglet from Centre national d'études spatiales (CNES) (Jouglet et al. 2014), D. Tobin from University of Wisconsin (Tobin et al, 2013), and L. Strow from University of Maryland, Baltimore County (Strow et al 2013). All studies suggest that the CrIS radiance measurements agree well with these instruments.

Spectral Coverage of CrIS, IASI, and AIRS



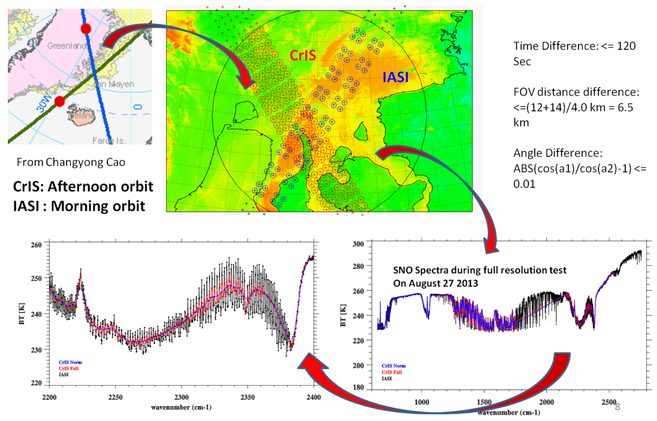
AIRS on Aqua is a grating infrared sounder with 2378 spectral channels with an ascending node at 1330 local solar time. CrIS on Suomi NPP and IASI on MetOp-A and -B are Michelson Interferometers. IASI measures the 3.5-16.4 μm spectrum in 8461 spectral channels with a spectral sampling interval of 0.25 cm^{-1}. CrIS spectrum (without apodization) covers three IR bands with spectral resolutions of 0.625 cm^{-1}, 1.25 cm^{-1}, and 2.5 cm^{-1} at the normal operational mode (a total of 1305 spectral channels) and with an identical spectral resolution of 0.625 cm^{-1} in all three bands at the full spectral resolution mode (a total of 2211 channels).

CrIS SDR Updates

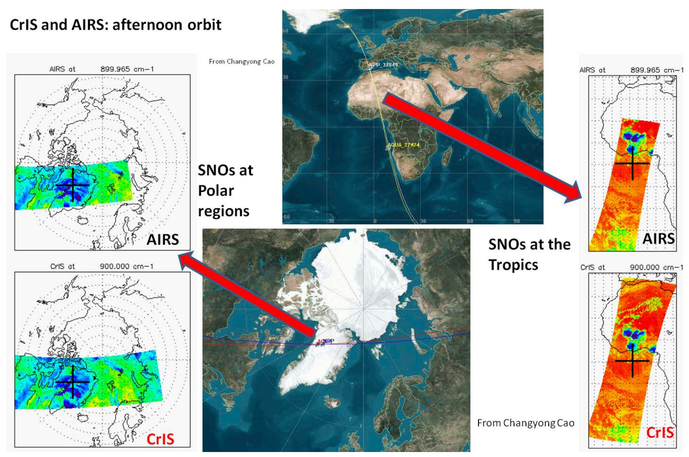


- New version of CrIS SDR processing software Mx8.1/8.2 was released on Feb. 17 2014, including changes on non-linearity correction equations and spectral calibration of FOV5. Engineering Packets V36 was uploaded simultaneously, including new non-linear correction coefficients and instrument line shape (ILS) parameters.
- Using the off-line processing software and new calibration parameters, NOAA/STAR CrIS SDR team has re-processed CrIS SDR back to Jan 01 2013.
- After CrIS was switched to the full spectral resolution mode, the official CrIS SDR was still released as the normal resolution. NOAA/STAR CrIS SDR team off-line processed full spectral resolution SDR that was released for public.

Simultaneous Nadir Overpass (SNOs)

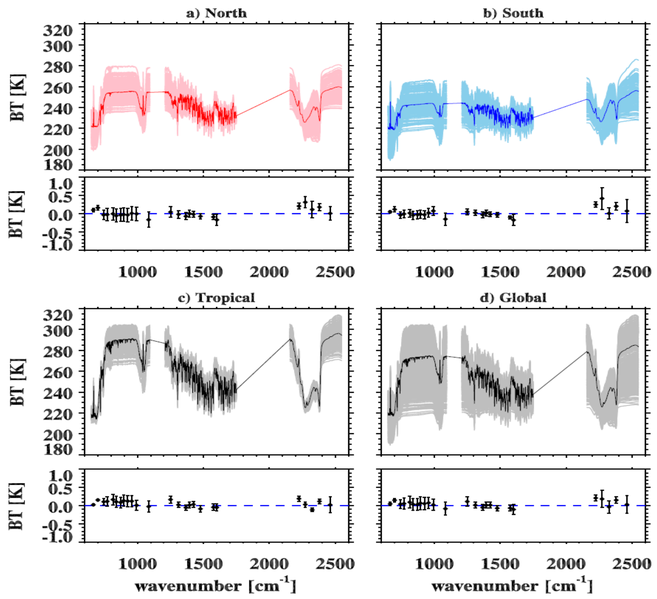


Polar orbiting satellites intersect each other at high latitudes, so called SNOs. This occurs for satellites even in very different orbits. When the SNO occurs, the radiometers from both satellites view the Earth and the atmosphere at the same place and same time but from different altitudes. This greatly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



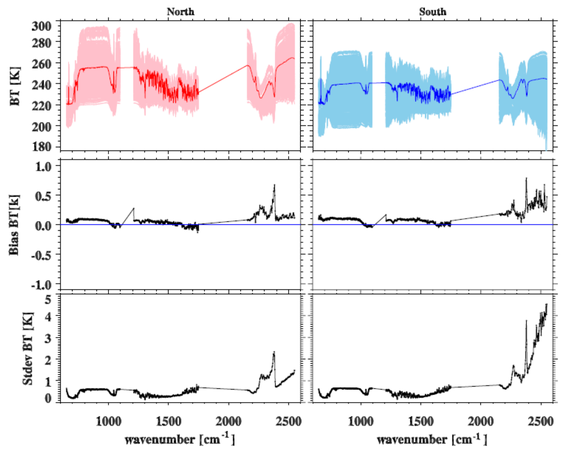
Aqua and SNPP satellites basically have the same equatorial crossing time (~1330 LST) but different altitude. Consequently, they have the SNOs in the Polar Regions and SNOs in the Tropics, providing ample opportunities to compare *SNPP* CrIS measurements with Aqua AIRS at different latitudes with relatively large dynamic range.

CrIS *versus* AIRS on Aqua

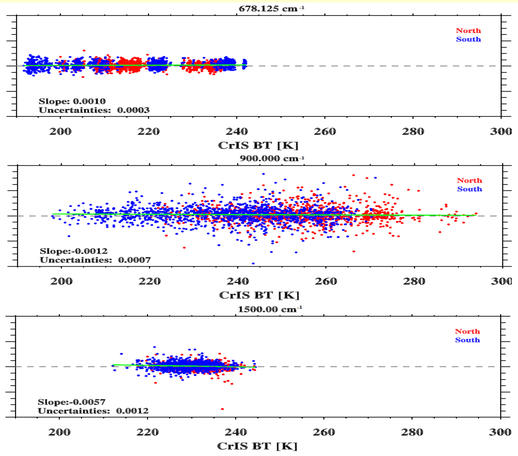


As a grating spectrometer, AIRS spectral resolution varies with different bands, and spectral gap exists due to the design. Moreover, the observations from some channels are not in good quality due to the bad or degraded detectors. CrIS and AIRS are compared at the 25 spectral regions for both Polar and Tropical SNOs. The CrIS-AIRS BT differences are less than or around 0.1 K among 21 of 25 comparison spectral regions and they range from 0.15 K to 0.22 K in the remaining 4 spectral regions.

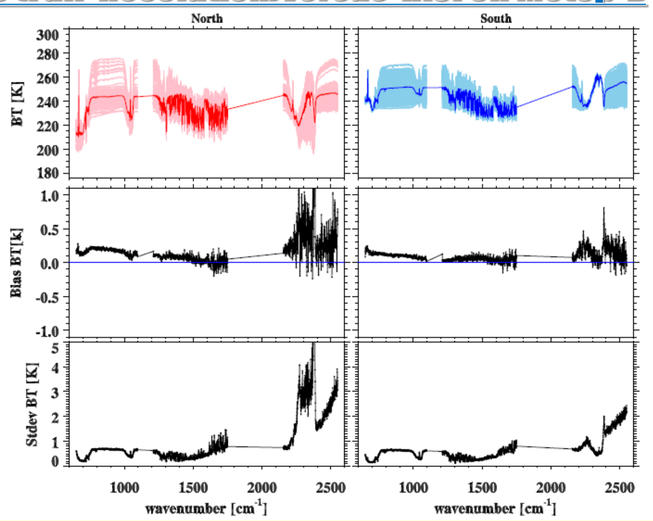
CrIS *versus* IASI on Metop-A



CrIS agrees well with Metop-A/IASI at LW and MW band. CrIS is slightly warmer than IASI/Metop-A at the SW band. There is no scene-dependent patterns for CrIS-IASI BT differences at the individual channels shown below. The results are similar for CrIS and IASI on MetOp-B.



CrIS (Full Resolution) *versus* IASI on Metop-B



CrIS full spectral resolution SDR products (2211 channels) are now off-line processed by NOAA/STAR CrIS SDR team since December 4 2014, which can be downloaded from ftp://ftp2.star.nesdis.noaa.gov/smcd/xxiong/. During December 26-28 2014, three days' SNO event occurred between CrIS and IASI on MetOp-B, including 144 spectra in North Polar Region and 187 spectra in South Polar Region. The preliminary results indicate that CrIS full spectral resolution SDR products agree well with IASI in the longwave and middle-wave bands and the BT differences are around 0.1-0.2 K. A ringing pattern can be found in the shortwave band probably due to cold scenes.

Reference

Jouglet, D., J. Chinaud, and X. Lenot, 2014: Radiometric inter-comparison of IASI :IASI-A /IASI-B, IASI / AIRS, IASI / CrIS. *the 2014 EUMETSAT Meteorological Satellite Conference*, Geneva, Switzerland.

Tobin, D., and Coauthors, 2013: Soumi NPP/JPSS Cross-Track Infrared Sounder (CrIS): Intercalibration with AIRS, IASI, and VIIRS. *the 93rd AMS Annual Meeting*, Austin,.

Strow, L., H. Motteler, P. Schou, and S. E. Hannon, 2013: Intercalibration of IASI with AIRS and CrIS. *the Third Infrared Atmospheric Sounding Interferometer conference, Hyères, France.*