Assessment of S-NPP CrIS Radiometric and Spectral Accuracy using Community Radiative Transfer Model

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Abstract

The Cross-track infrared Sounder (CrIS) on Suomi National Polar-orbiting Partnership Satellite (S-NPP), is a very important Fourier transform interferometer and provides soundings of the atmosphere with 1305 channels. The sounding information will be used to enhance weather forecast and help improve understanding of climate change. Quantifying the CrIS radiometric and spectral accuracy, and bias with other hyper-spectral infrared sensors such as Infrared Atmospheric Sounding Interferometer (IASI) on MetOp are crucial for creating fundamental climate data records and intercalibrating other infrared sensors.

The CrIS Sensor Data Record (SDR) data sets were assessed by using Community Radiative Transfer Model (CRTM) and ECMWF forecast data for clear sky and over ocean and compared with IASI data. The CRIS SDR data sets were evaluated to estimate the FOV-2-FOV variability and sweep direction bias. Results show that FOV-2-FOV variability is small; The sweep direction bias among FORs is also small. Results from the double difference with IASI show that the differences are within ±0.2 K for most of channels.

The CrIS spectral accuracy is also assessed by using the cross-correlation method to compare the CrIS fine grid spectral between observations and CRTM simulations. About 3 ppm and 4 ppm uncertainty are found in CrIS SDR data in band 1 (LWIR), and band 2 (MWIR), respectively.

Overall, CrIS SDR meets the high quality standard for the usage by NWP and the scientific community.

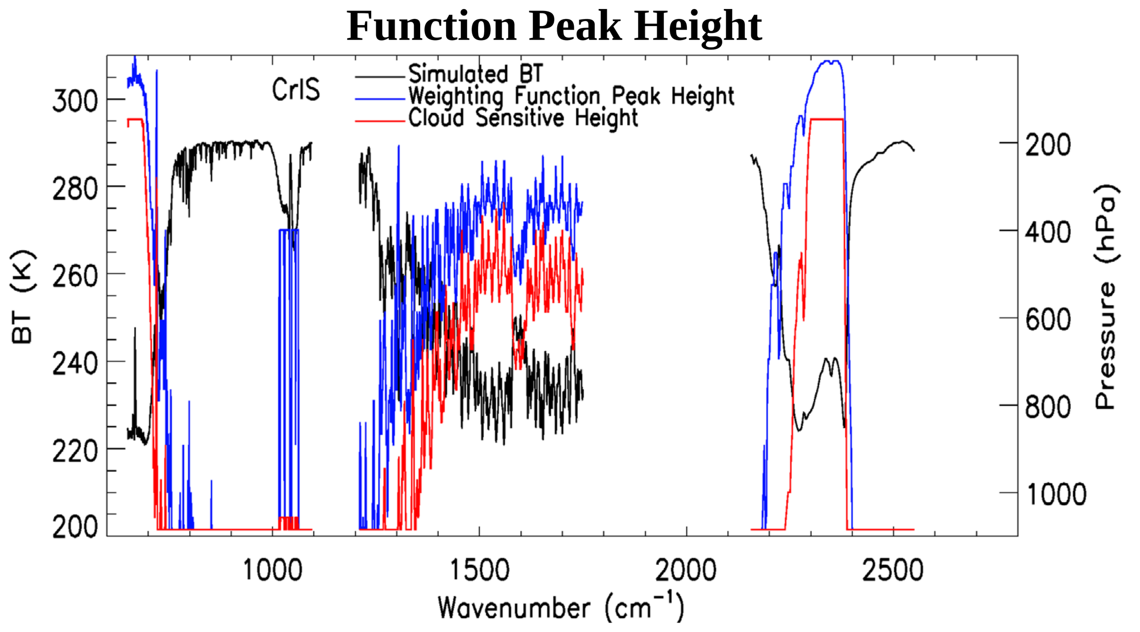
IR Cloud Detection Algorithm

- The channels are first ordered according to their cloud sensitivity (with the highest channels first and the channels closest to the surface last) (McNally and Watts, 2003)
- The overcast variable contains overcast radiances assuming the presence of a black cloud at each of CRTM levels. The height for a particular channel is assigned by finding the level where the difference between the overcast and clear radiances is less than 1%.

$$\frac{\left|R_{clear} - R_{cloudy}\right|}{R_{clear}} < 0.01$$

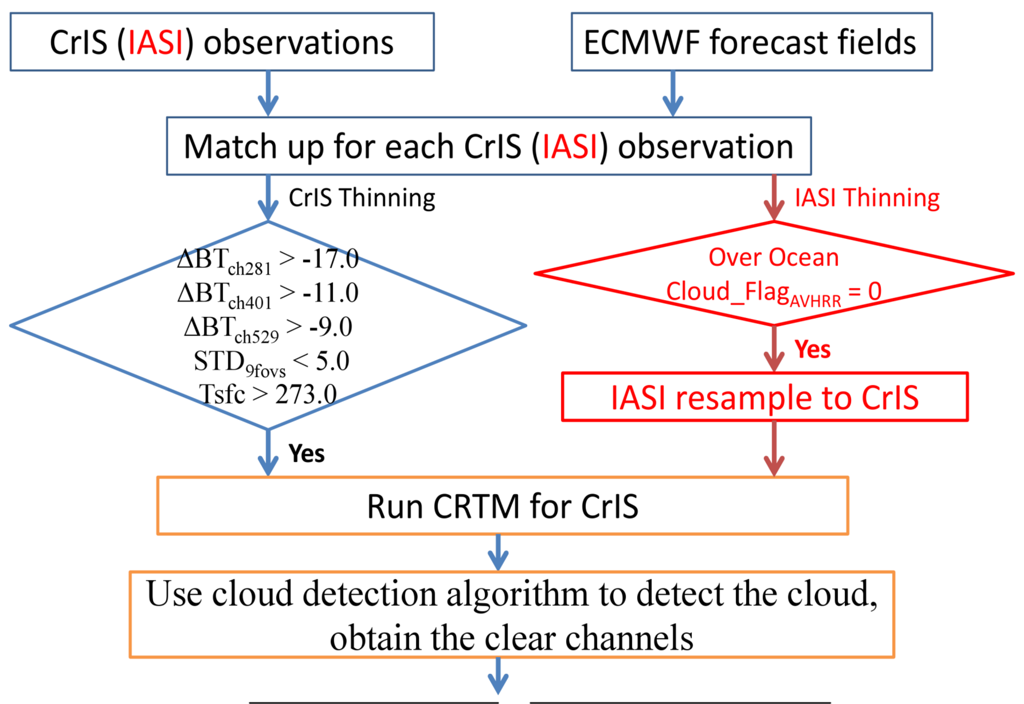
- The resulting ranked brightness temperature departures are smoothed with a moving-average filter in order to reduce the effect of instrument noise.

CrIS Channel Cloud Sensitivity Height and Weighting Function Peak Height



CrIS Radiometric Accuracy

Clear Channel Simulation and Double Difference



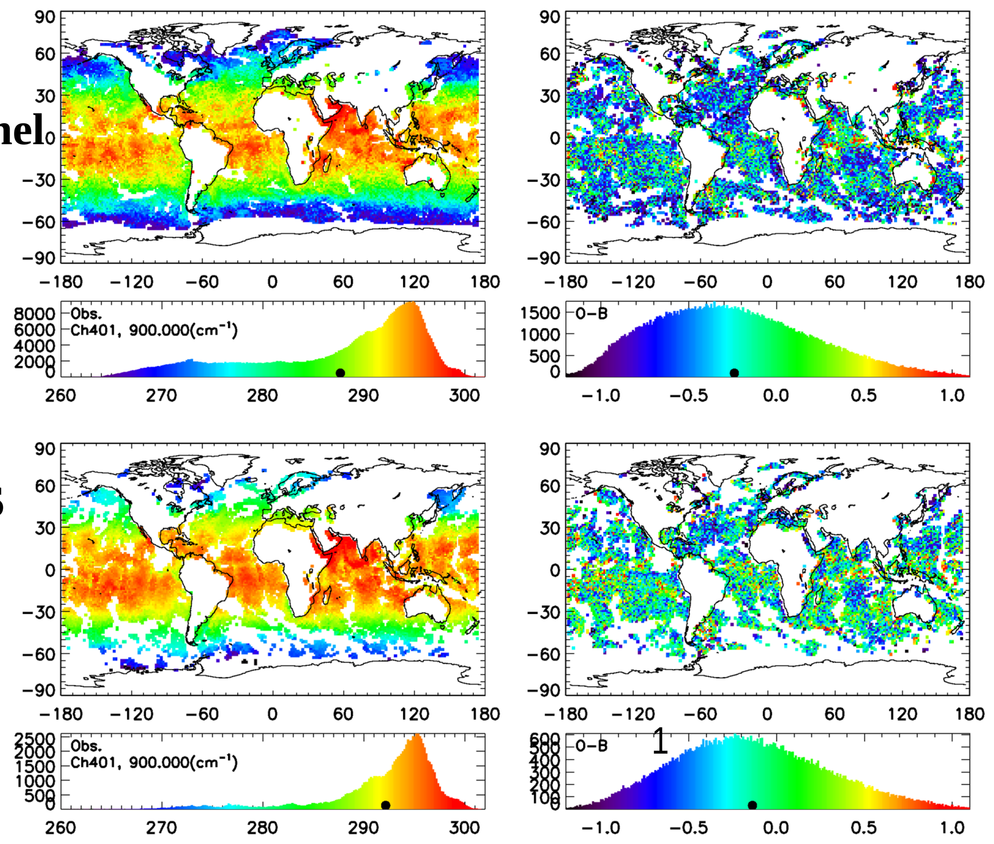
$$DD = \overline{(Obs - CRTM)}_{CrIS} - \overline{(Obs - CRTM)}_{IASI2CrIS}$$

Observation BT and O-B Global Distribution

05/15/12
Ch 401
Surface Channel

CrIS

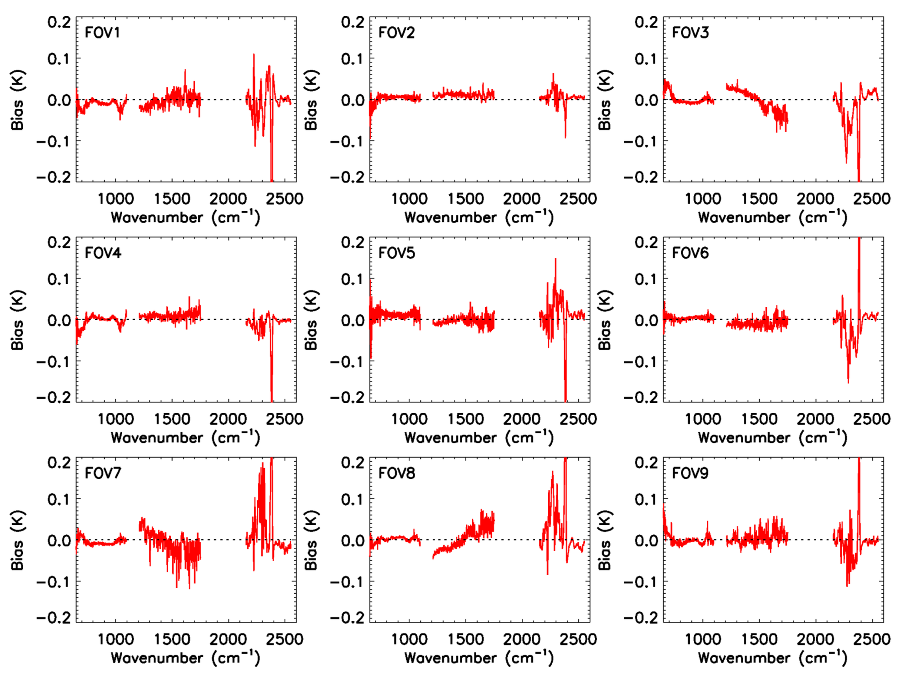
IASI2CrIS



FOV-2-FOV Variability
(remove the mean bias between observations and CRTM simulations)

$$BIAS_{FOV_i} = \overline{(Obs - CRTM)}_{FOV_i} - \overline{(Obs - CRTM)}_{all}$$

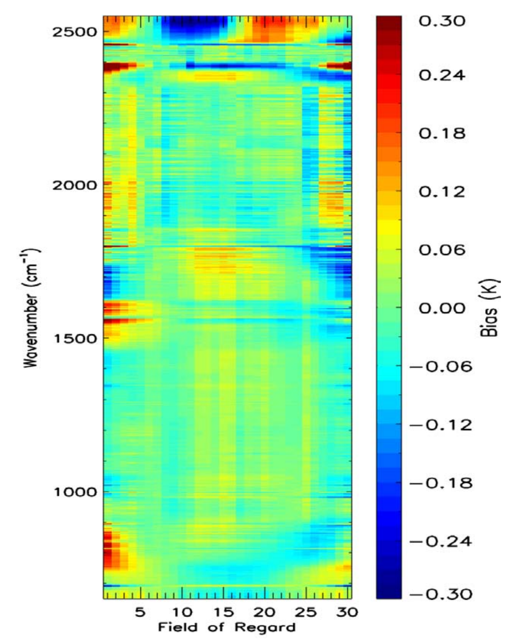
Total clear sky observation points ~300,000
Average all the FORs for each FOV



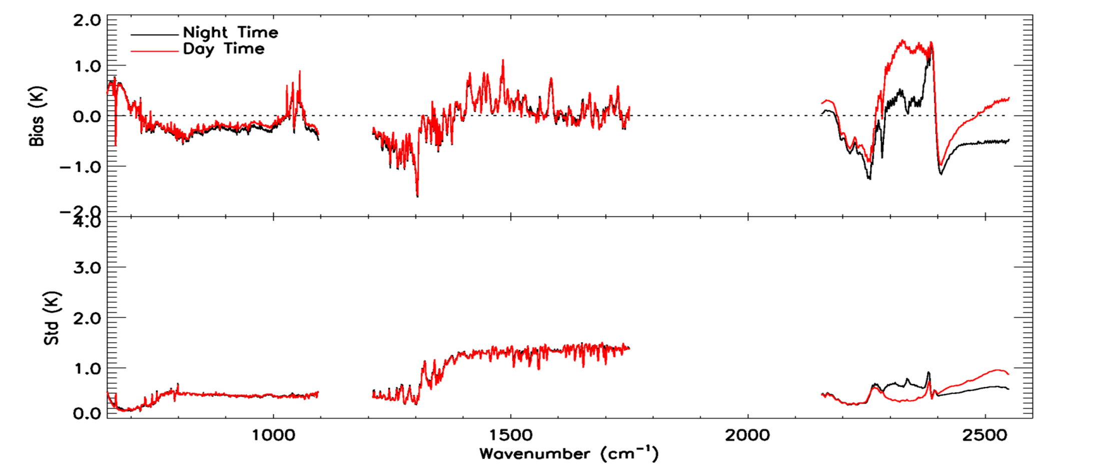
Sweep Direction Bias
CrIS Observations Compared with CRTM Calculations

$$\Delta BT_{FOR_i} = \overline{(Obs - CRTM)}_{FOR_i} - \overline{(Obs - CRTM)}_{all}$$

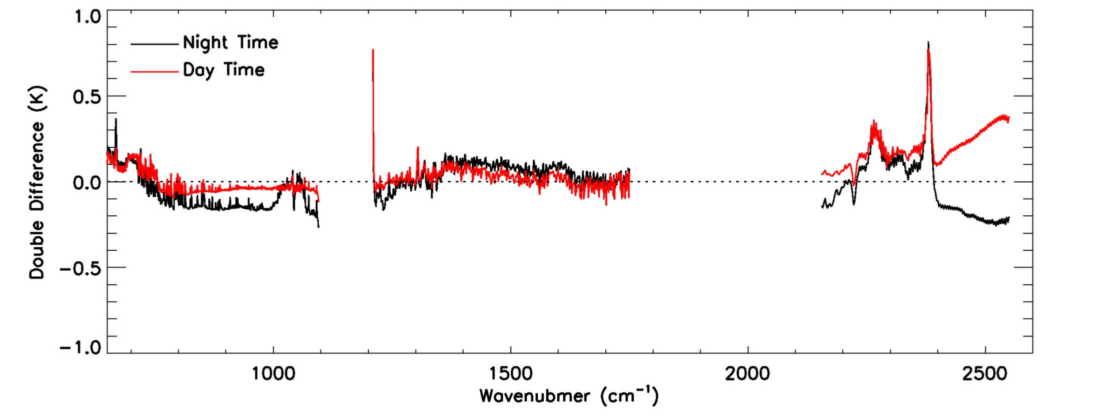
Total clear sky observation points ~300,000 within ±60 degree latitude over ocean



Bias and STD of CrIS O-S for Clear Sky over Ocean

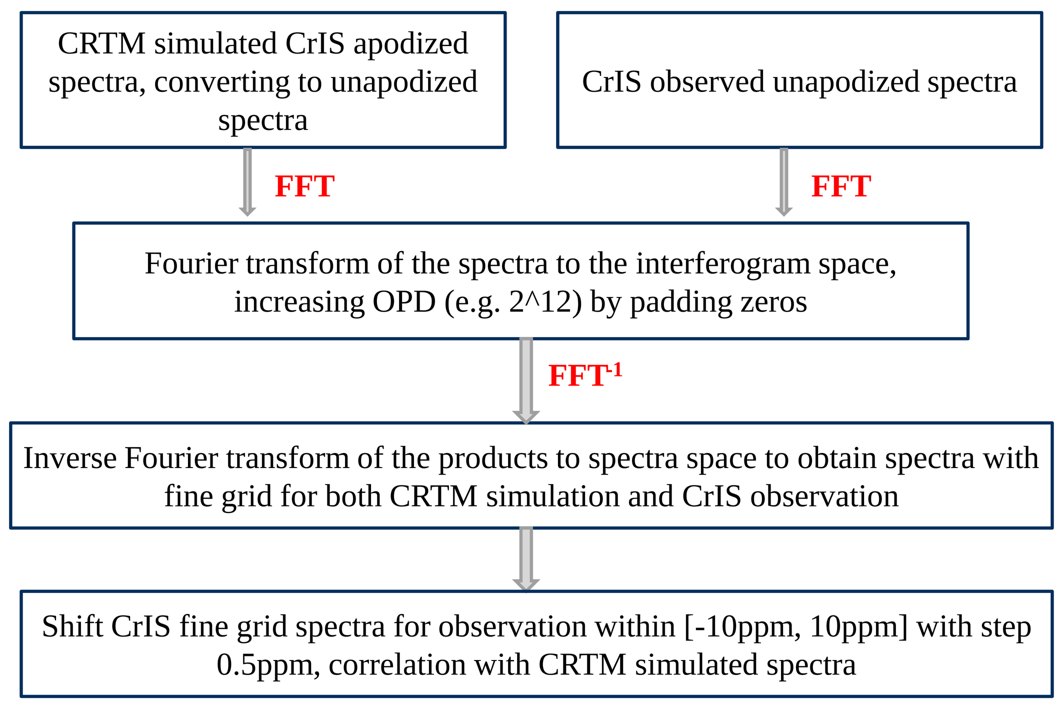


Double Difference between CrIS and IASI2CrIS

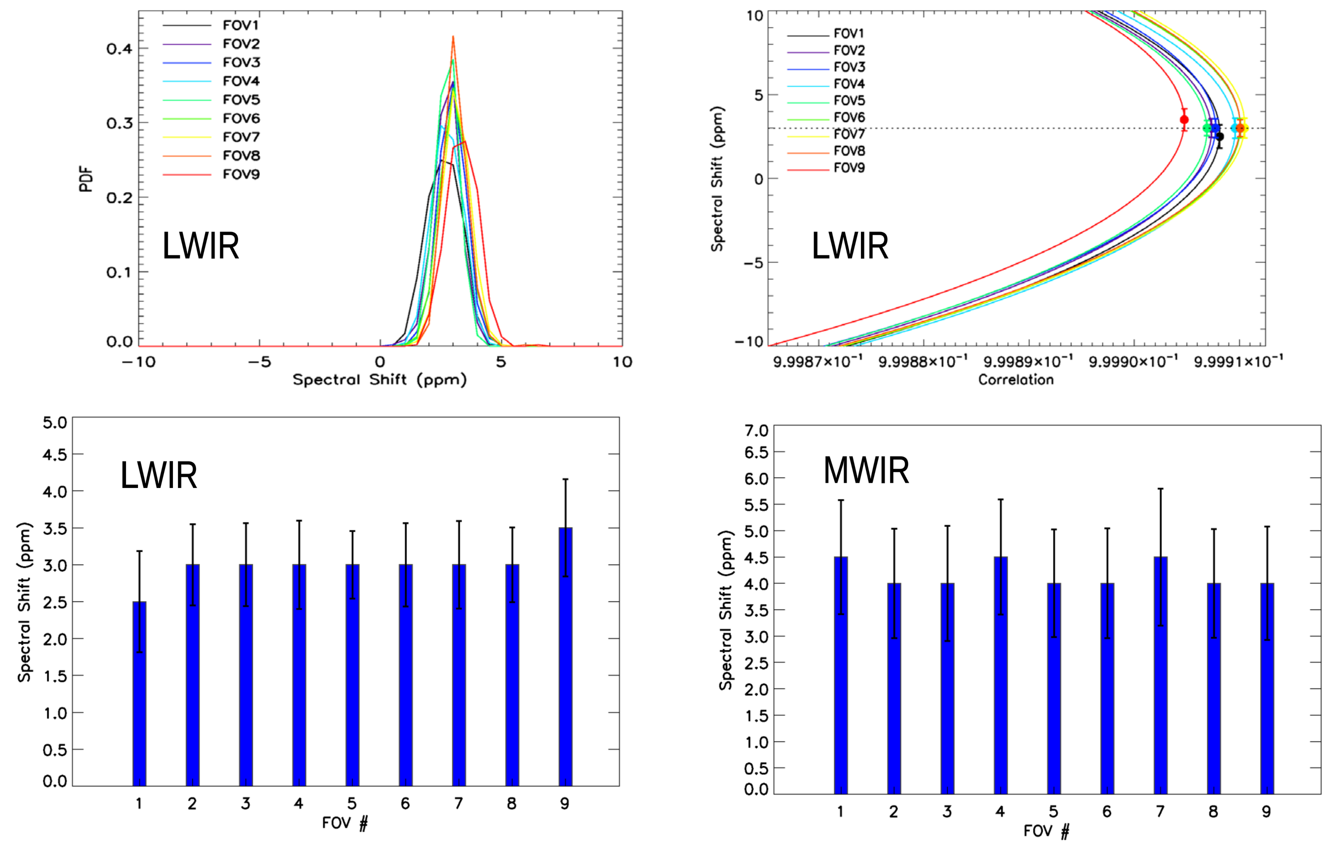


CrIS Spectral Uncertainty

Correlation of CrIS Spectral between Observations and Simulations



Spectral Shift Using Cross-correlation Method under Clear Sky between Observation and CRTM Simulation



Conclusion

This study shows the assessment of the CrIS radiometric and spectral uncertainty using CRTM. Double difference of CrIS and IASI relative to CRTM calculated radiance are within ±0.2 K for most of channels. CrIS FOV-2-FOV variability using NWP data is small, within ±0.2 K for all the channels. FOV spectral calibration is consistent within 1 ppm. Spectral calibration has 3 ppm offset wrt CRTM for LWIR, and 4 ppm offset for MWIR, and the spectral uncertainty at both bands meet requirement (10 ppm).