

# Spectral and Radiometric Calibration of HIRS Using IASI on MetOp

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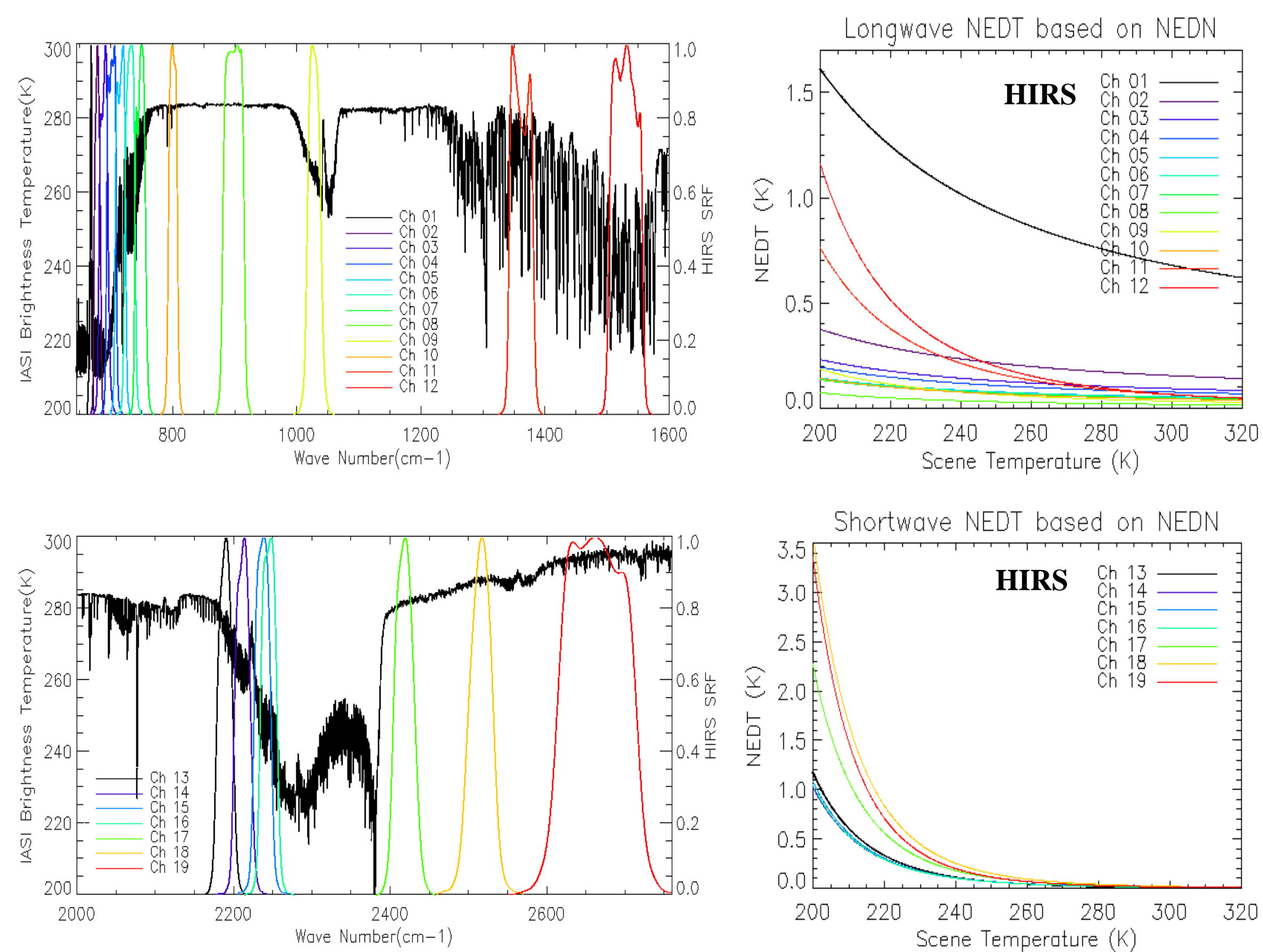
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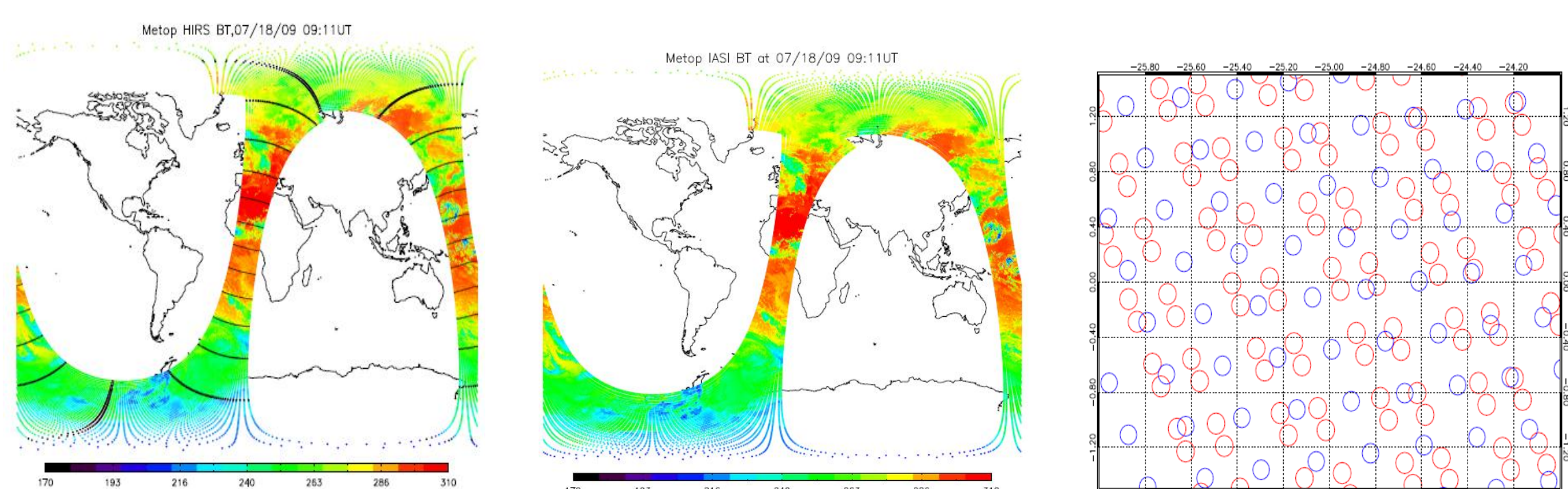
## Abstract

The High-Resolution Infrared Radiation Sounder (HIRS) has been widely used in numerical weather prediction and climate studies. Accurate radiance measurements from HIRS are critical for all related applications because of its impact on products at all-levels. A few studies comparing HIRS with other instruments reported small biases in several HIRS channels, especially the channels that are sensitive to the spectral response functions (SRF). The MetOp satellite carries both the HIRS and Infrared Atmospheric Sounding Interferometer (IASI), and previous studies have showed that the IASI is well calibrated and have accurate spectral and radiometric calibration. In this study, the hyper-spectral IASI measurements in the same spectral region as that of the 19 HIRS bands are used to simulate HIRS measurements. The IASI-simulated HIRS radiance measurements are compared with co-located HIRS radiance measurements on the same spacecraft to quantify the biases at the 19 HIRS bands. A detailed analysis of the bias patterns is performed. The root causes of the biases are analyzed with recommendations in resolving these biases.

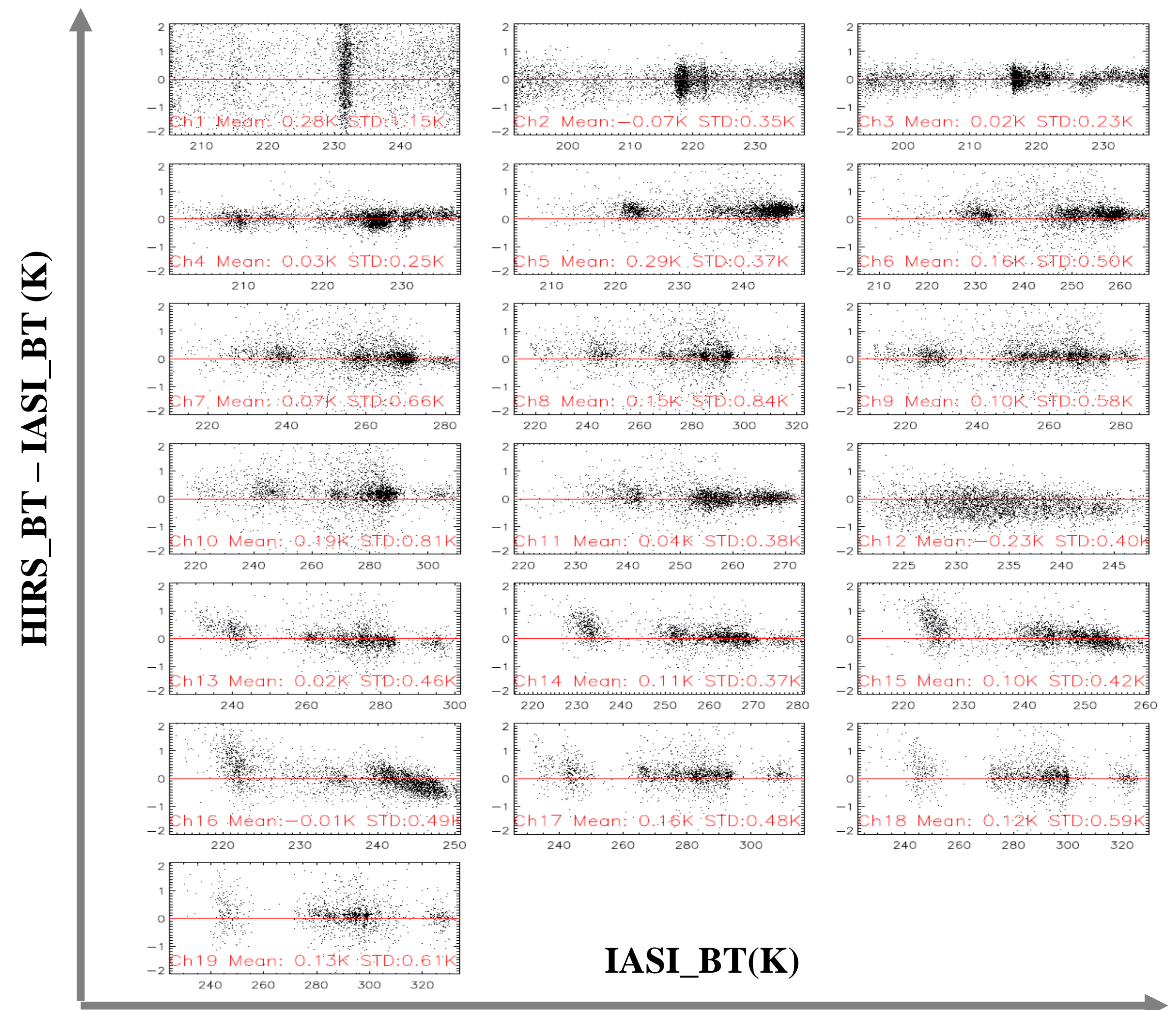
## Data and Methods



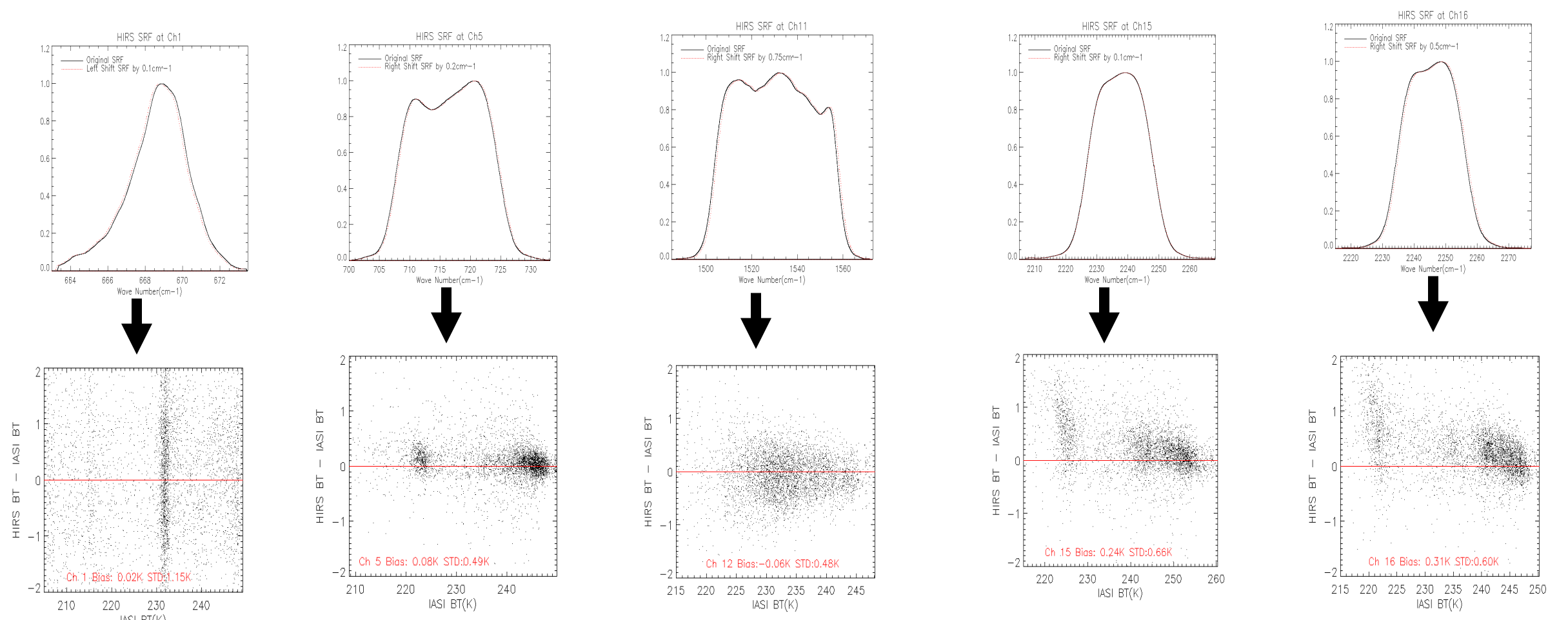
- IASI: scan rate: 8s, IFOV @ Nadir: 12km, with 8461 spectral samples between 645.0 cm<sup>-1</sup> and 2760 cm<sup>-1</sup> (15.5 μm and 3.63 μm), and sampling interval of 0.25 cm<sup>-1</sup>.
- HIRS: scan rate: 6.4s, IFOV@ Nadir: 10km, with 19 channels from short wave to long wave.
- The IASI measurements are convolved with HIRS SRF to simulated HIRS measurements at all 19 channels. HIRS channel 19 is not fully covered by the IASI spectrum.
- IASI and HIRS measurements are collocated with navigation data, for which the distances between the nearest IASI/HIRS pairs are required to be less than 5km.
- The biases between IASI and HIRS are generally consistent for different orbits based on studies of many orbits. Example results for an MetOp orbit start from 09:11am at July 18, 2009 is presented here.



## Preliminary Results



- The brightness temperature differences (BTD) between HIRS and IASI can be due to radiometric calibration biases, instrument noise, spectral bias, and footprint mismatch. The mean BTD bias is typically caused by radiometric and spectral calibration, while the standard deviation of BTD is mainly due to footprint mismatch and instrument noise.
- The standard deviation of BTD is large at channel 1, channel 8, channel 10. Channel 1 has a large noise equivalent differential radiance (NEDN). Channel 8 and channel 10 are surface channels, which are significantly affected by surface inhomogeneity and footprint mismatch. Channels 2, 3, and 4 have small standard deviation of BTD because they are most sensitive to the upper atmosphere where the spatial uniformity is better than other channels. Channel 18 and channel 19 show larger standard deviations of BTD than other shortwave channels, probably because of solar contamination, and high noise at cold brightness temperatures for both IASI and HIRS.
- Channels 2, 3, and 8 are less affected by spectral biases because they are located in a relatively spectrally flat region. Therefore, the small bias at channel 2 and channel 3 suggests that the radiometric calibration biases are small. The bias for channel 8 is slightly larger, but the standard deviation of BTD is also large for this channel.
- The relatively large biases (> 0.2K) for channels 1, 5, and 12 are mostly caused by the spectral biases, or uncertainties in the spectral response functions (SRF). Preliminary study shows that correction of SRF can significantly reduce these biases.
- The cold biases over hot scene for channel 15 and channel 16 can be corrected by SRF spectral shift, but the overall biases in these two channels would also increased. Therefore, other factors need to be considered in further studies.



## Summary and Future Studies

- Measurements from HIRS on MetOp generally shows good agreements with that of IASI at better than 0.2K for most channels, although the biases could be larger for some channels.
- Spectral uncertainties appear to play a major role in channels with large biases, although not all biases can be explained by spectral shift in channels 15 and 16. Also, small nonlinearity correction will be needed for some of the longwave channels.
- We are collaborating with University of Wisconsin to re-calibrate the HIRS using a collection of new algorithms to make HIRS traceable to IASI for the longterm cloud series, in support of the science data stewardship program at NCDC.