Assessment of CrIS Full Resolution SDR Radiometric and Spectral Accuracy

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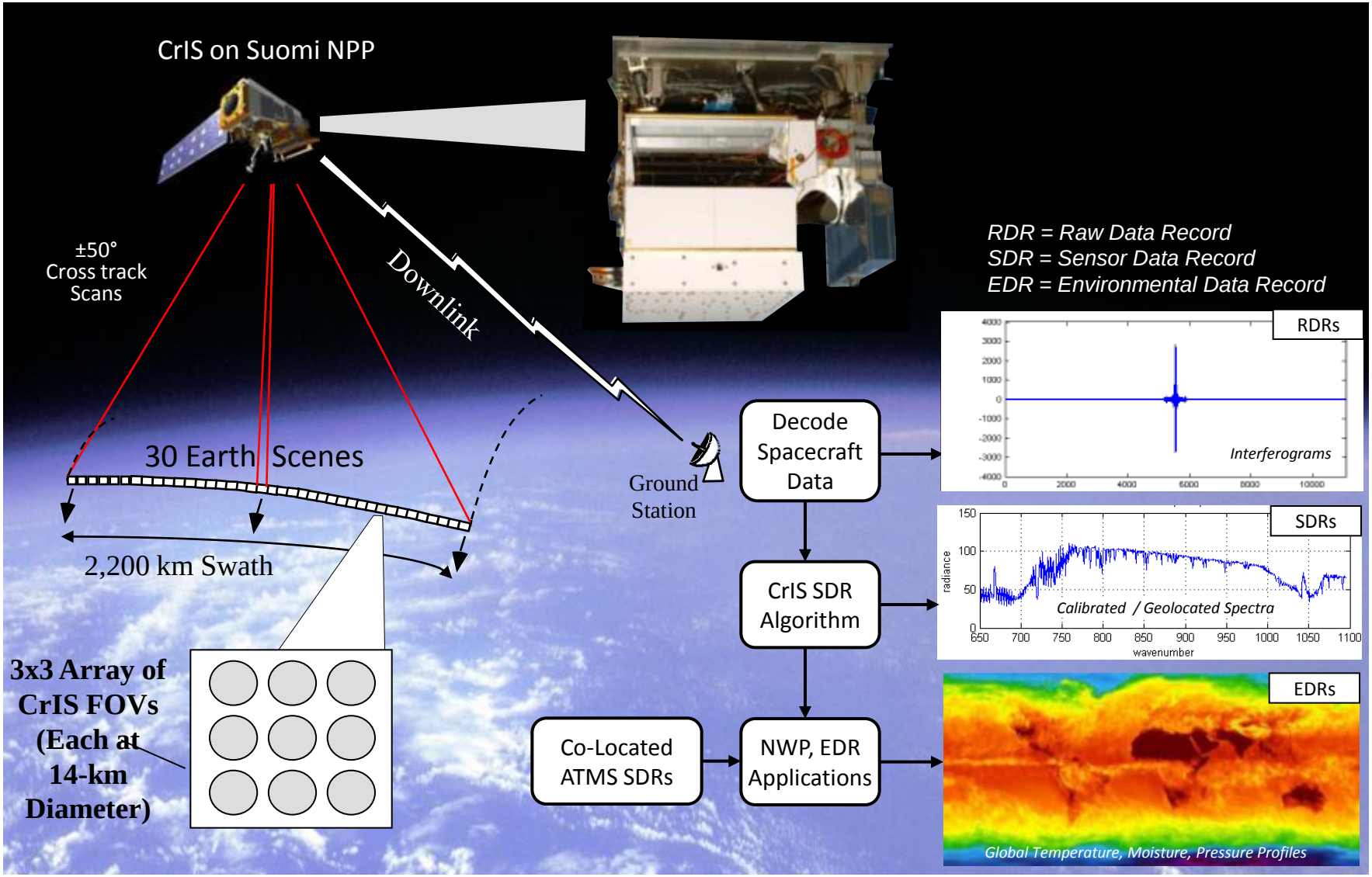
CrIS Operational Concept



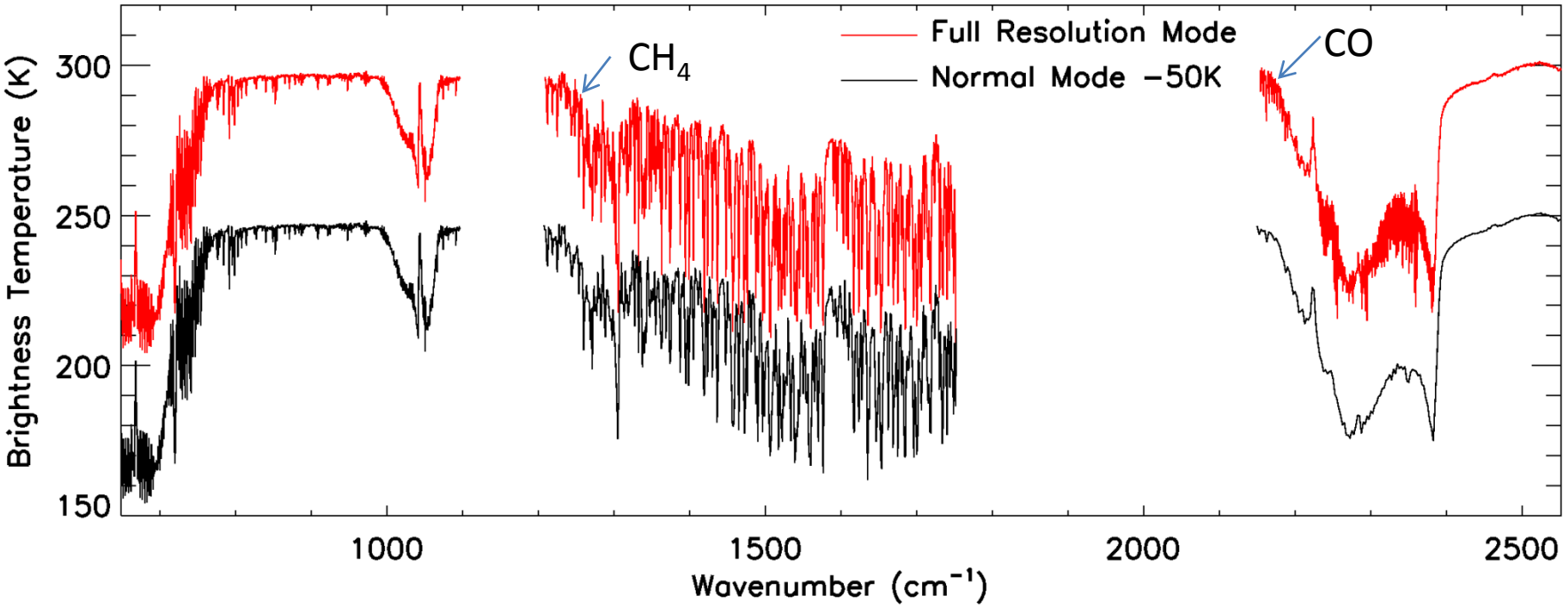
CrIS Normal Resolution and Full Resolution SDR

- CrIS can be operated in the full spectral resolution (FSR) mode with 0.625 cm^{-1} for all three bands, total 2211 channels.
- To Improve the retrieval of atmospheric greenhouse gases CO, CO_2, and CH_4.
- NOAA intends to operate CrIS in FSR mode in the near future.
- Up to date, the FSR mode has been commanded two times in-orbit (02/23/2012, 03/12/2013), and plans on 08/27/2013.

Frequency Band	Spectral Range (cm^{-1})	Number of Channel (unapodized channel)	Spectral Resolution (cm^{-1})	Effective MPD (cm)
LWIR	650 to 1095	713* (717)	0.625	0.8
MWIR	1210 to 1750	433* (437)	1.25	0.4
		865* (869)	0.625	0.8
SWIR	2155 to 2550	159* (163)	2.5	0.2
		633* (637)	0.625	0.8

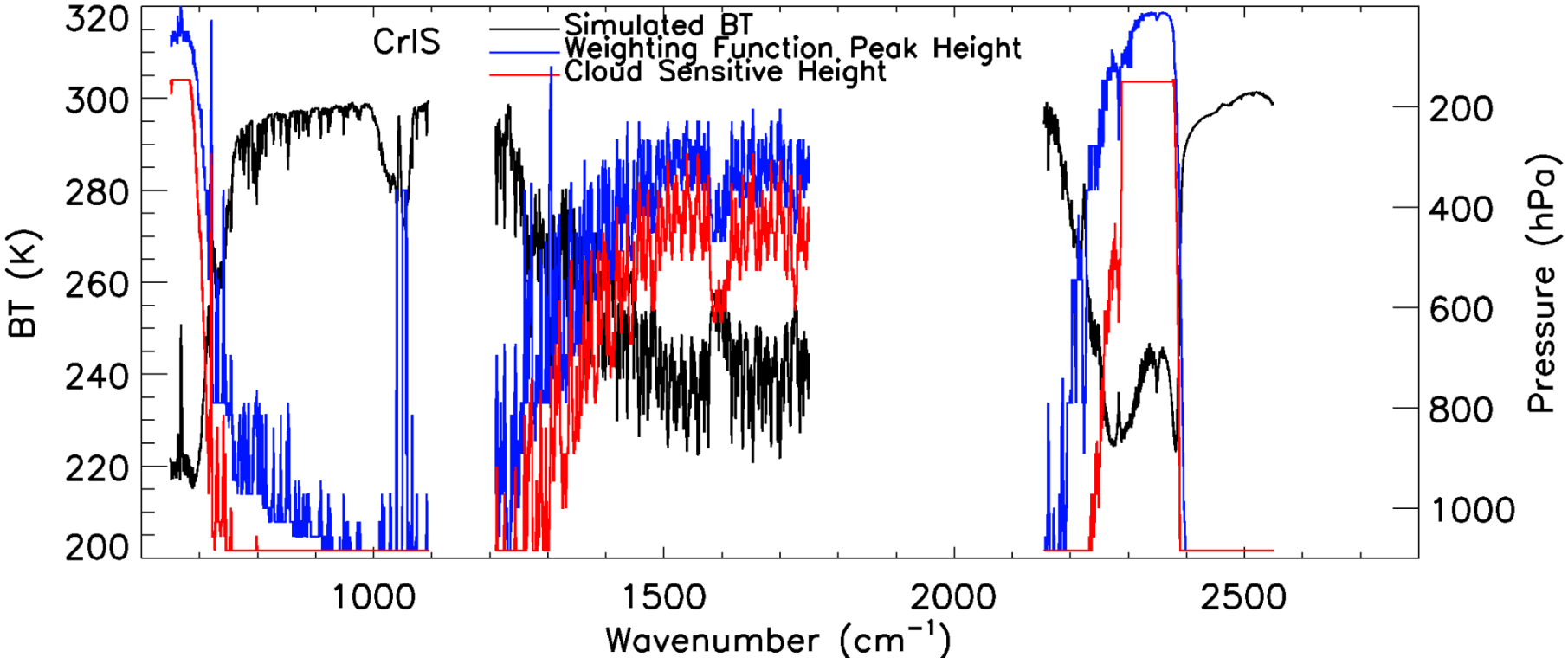
Red: Full resolution

CrIS Normal Mode and Full Resolution Mode Spectra



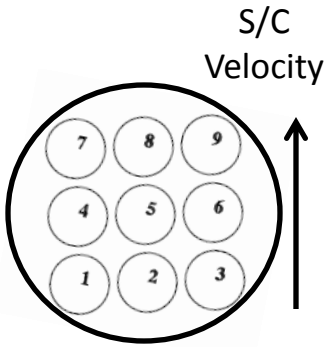
- An example of CrIS SDR LWIR, MWIR, and SWIR normal spectra produced by IDPS.
- The full resolution spectra were produced with a modified ADL code from full spectral resolution RDRs, collected when the CrIS was operated in the full spectral resolution mode on 03/12/2013.
- CH_4 absorption band (1210 – 1400 cm^{-1}), and CO absorption band (2155-2190 cm^{-1})

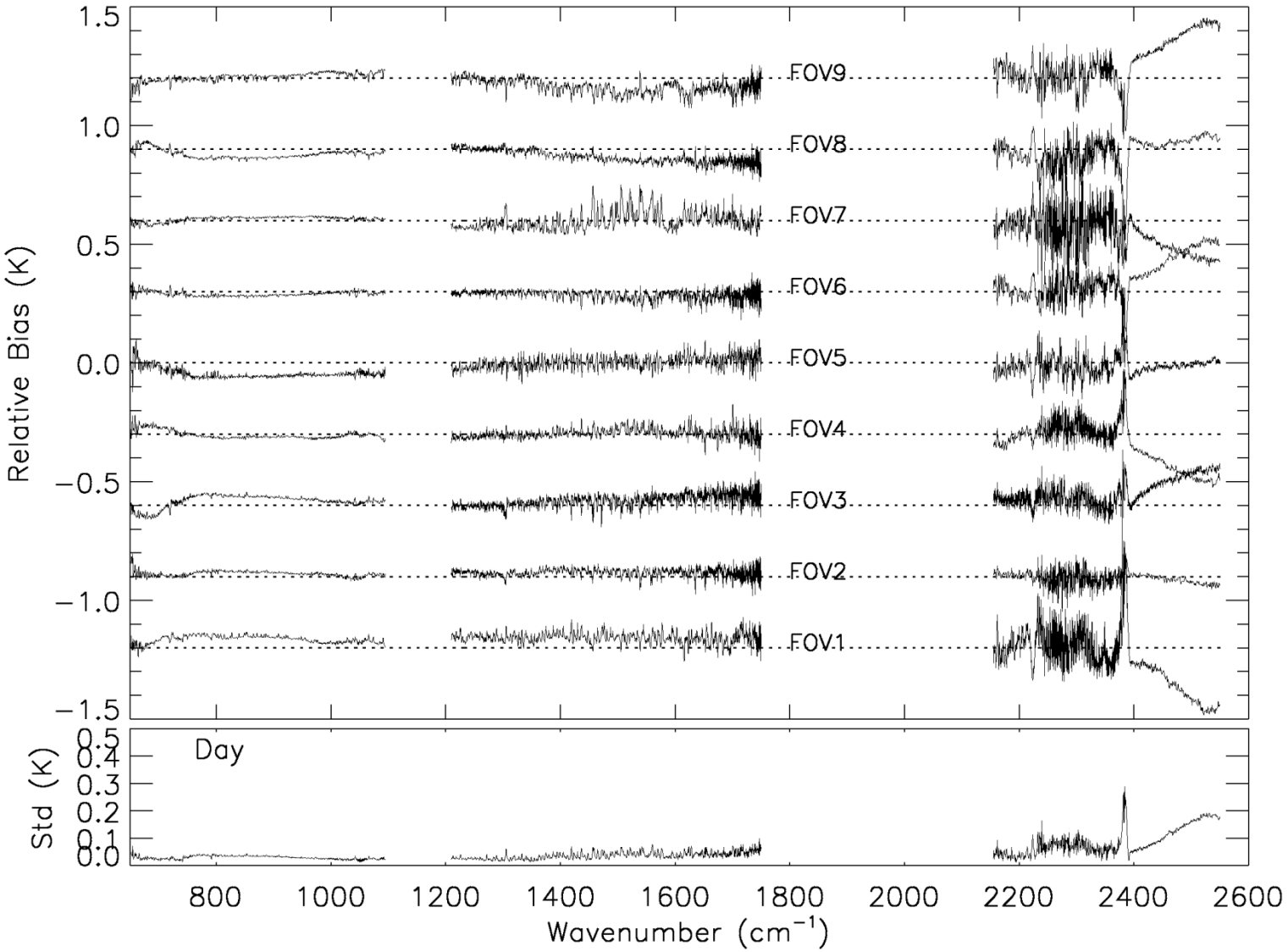
CrIS Channel Cloud Sensitivity Height and Weighting Function Peak Height



The Community Radiative Transfer Model (CRTM), a fast RT model, has the capability to simulate the CrIS full resolution mode SDR, with up to 6 input variable gases (H_2O, CO_2, O_3, N_2O, CO, and CH_4).

CrIS 9 FOVs Nadir Observation Variability (FOR 15 and 16) for Clear Sky over Oceans





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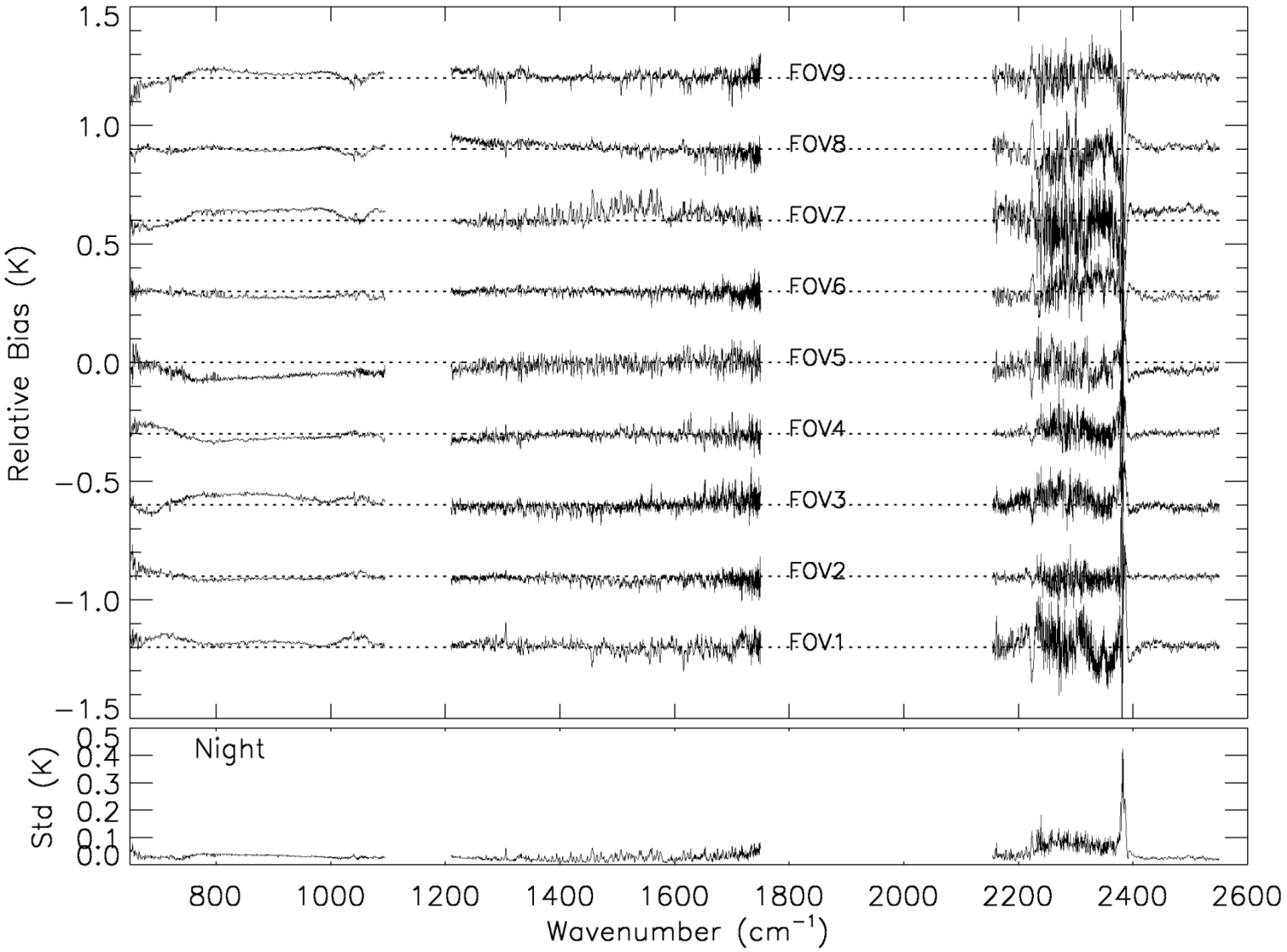
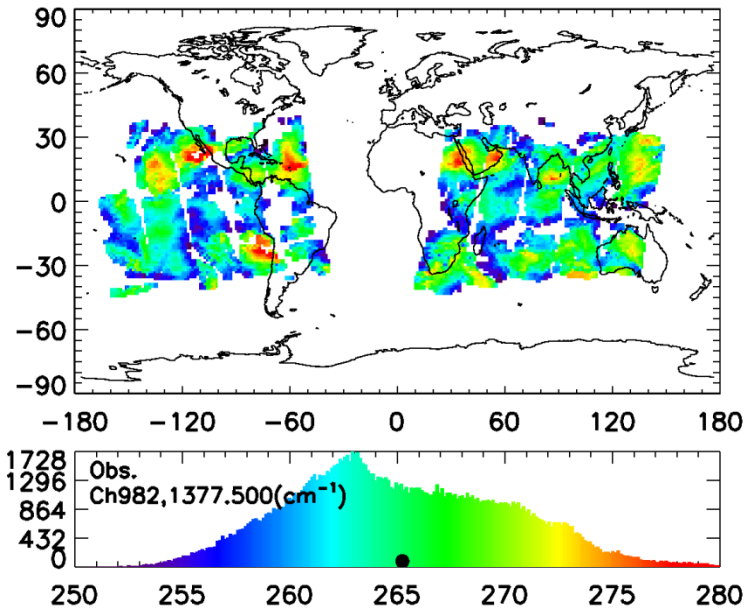
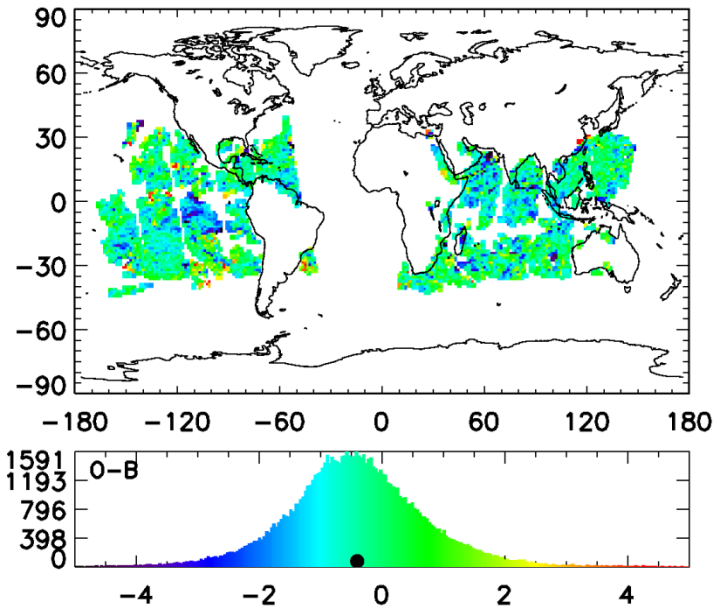


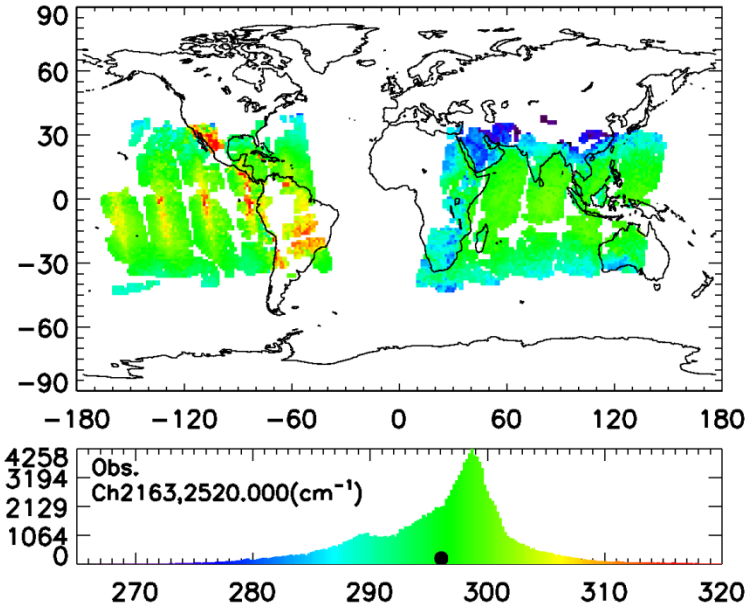
Observation BT and O-B Global Distribution

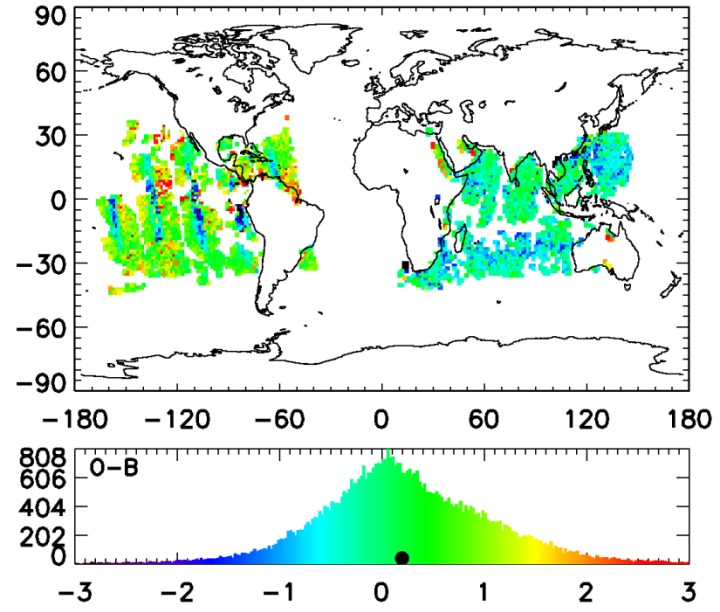
Ch 982
water vapor channel





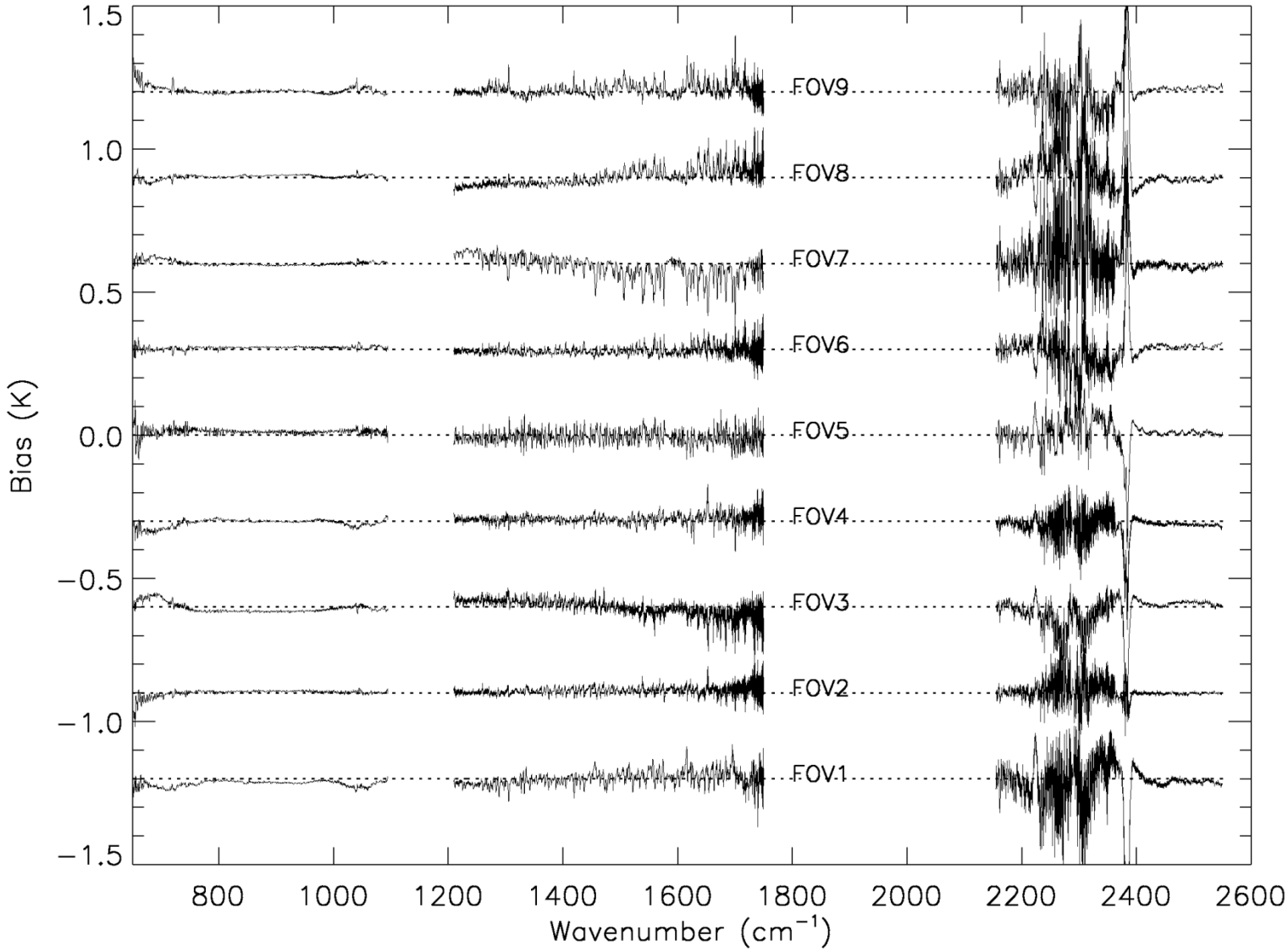
Ch 2163
window channel





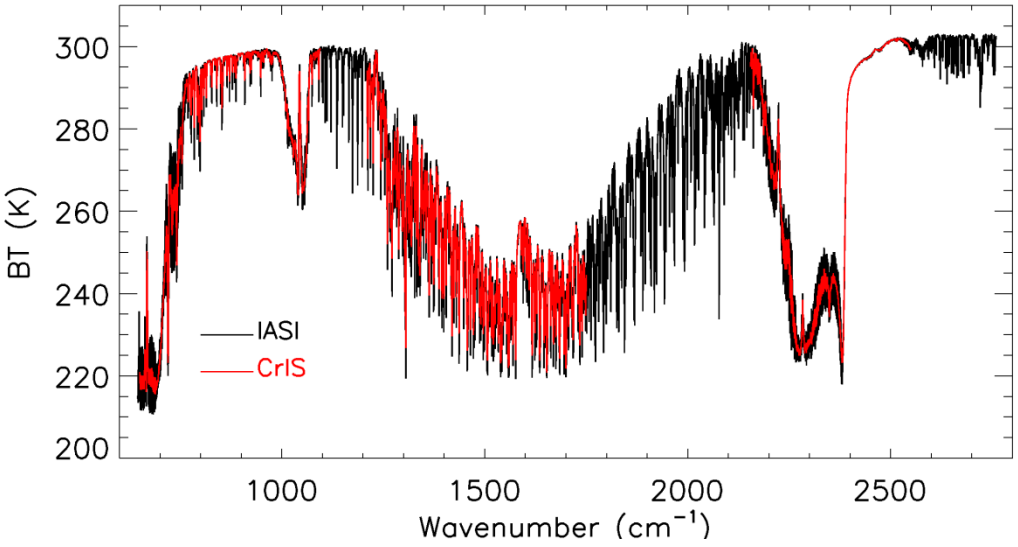
FOV-2-FOV Variability

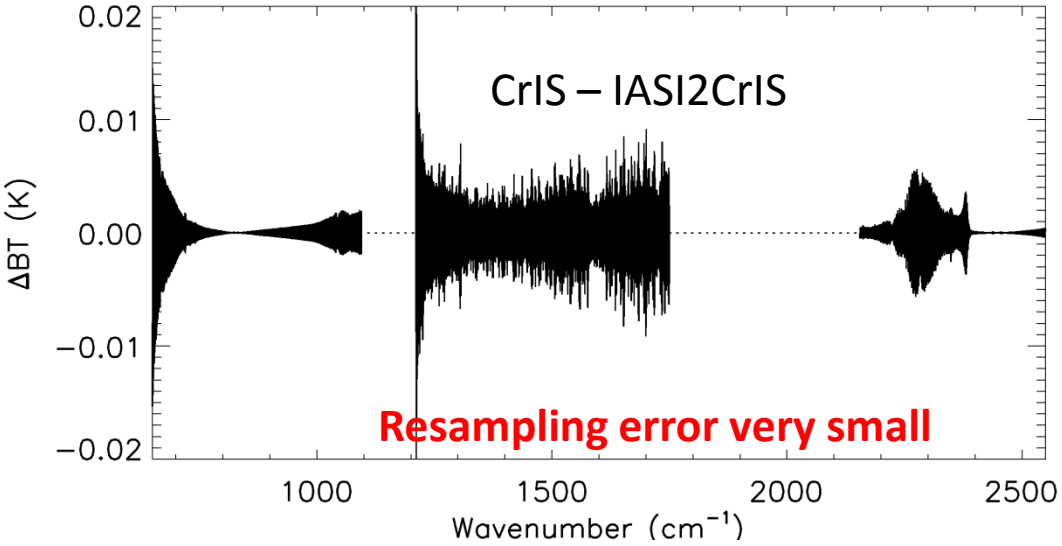
$$BIAS_{FOVi} = \overline{(Obs - CRTM)_{FOV_i}} - \overline{(Obs - CRTM)_{all}}$$



FOV-2-FOV variability is small, within ±0.3 K for all the channels

Resample IASI to CrIS





IASI Observed Spectra

FFT

Fourier transform of the spectra to the interferogram space

Apodization Function

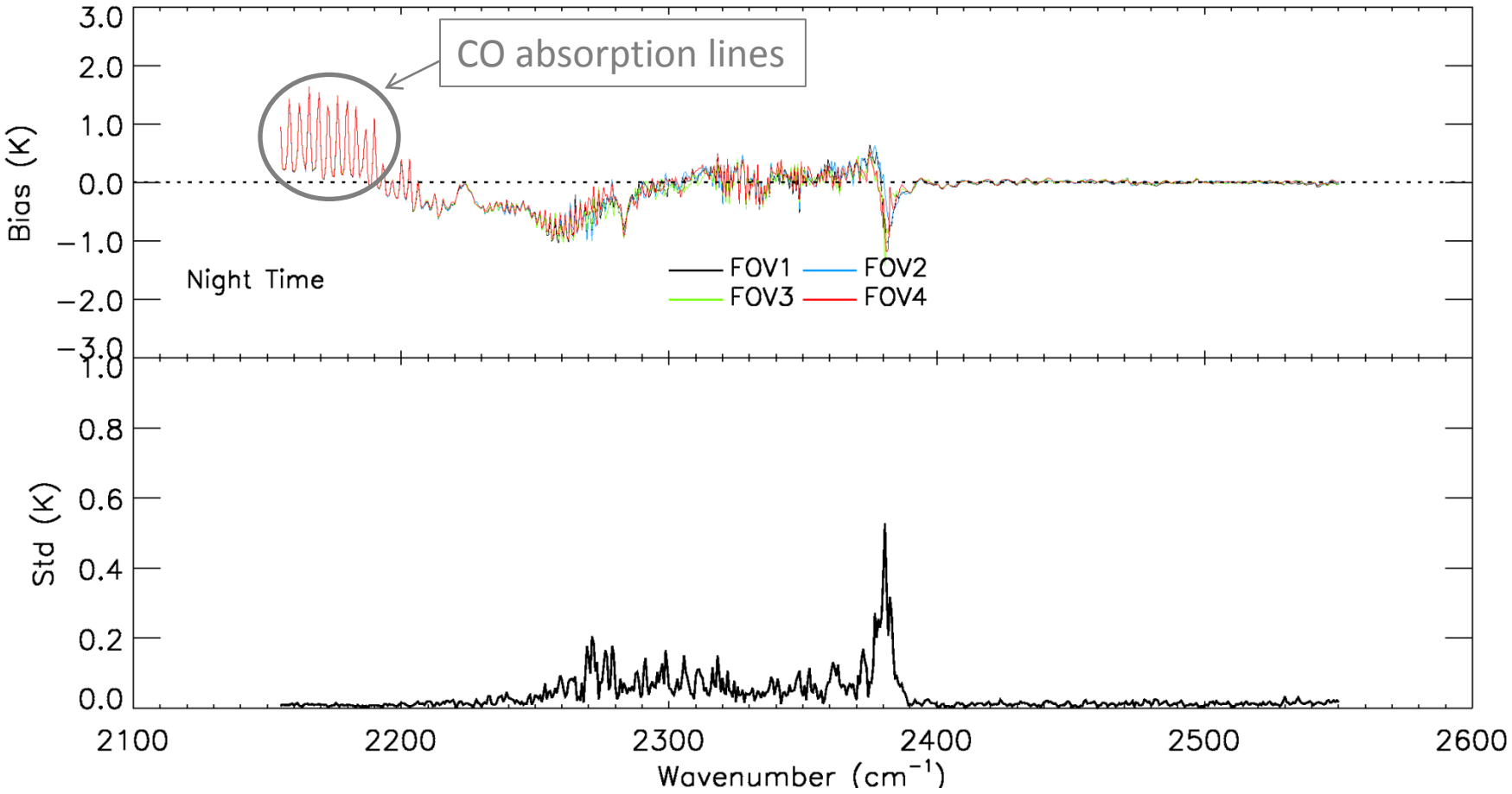
1) De-Apodization with IASI SRF
2) Truncation to CrIS OPD
3) Apodization with CrIS SRF

FFT^{-1}

Inverse Fourier transform of the products to spectra space, resampling the spectra on CrIS wavenumber basis.

IASI Nadir Bias for Shortwave

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



CrIS Nadir Bias for Shortwave

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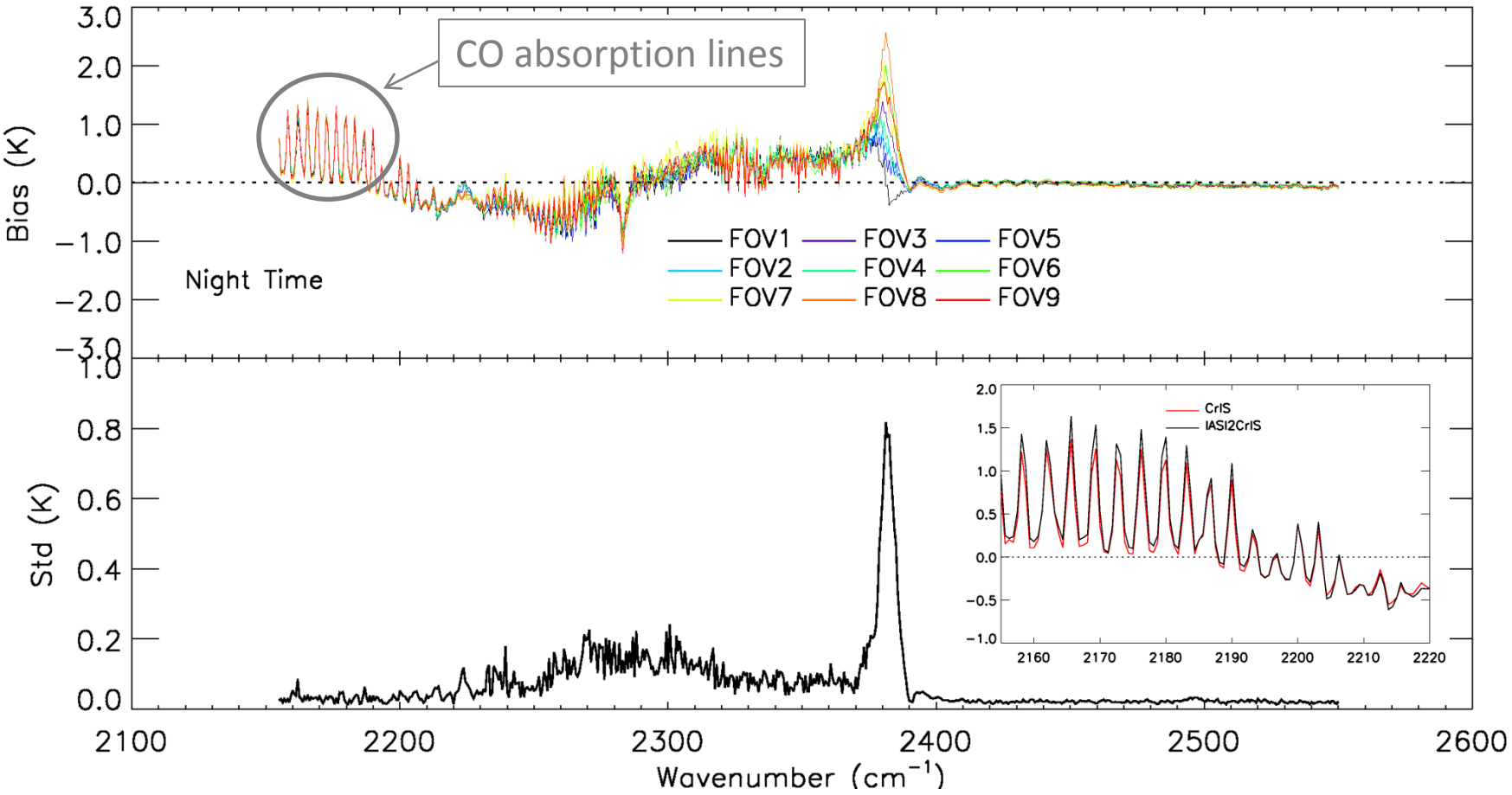
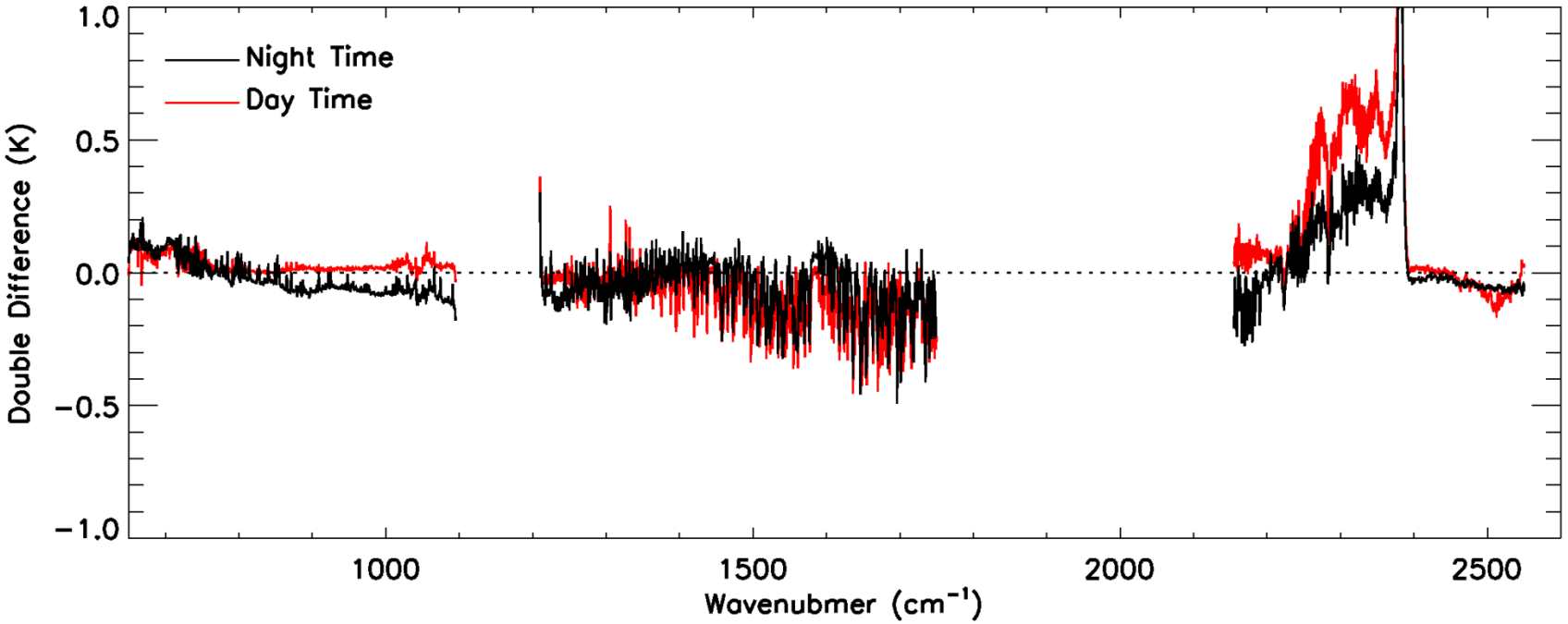


- Good agreement between IASI and CrIS, better than bias with CRTM.
- CrIS std. over FOVs is quite high near 2380 cm^{-1}, maybe focal plane geometry.

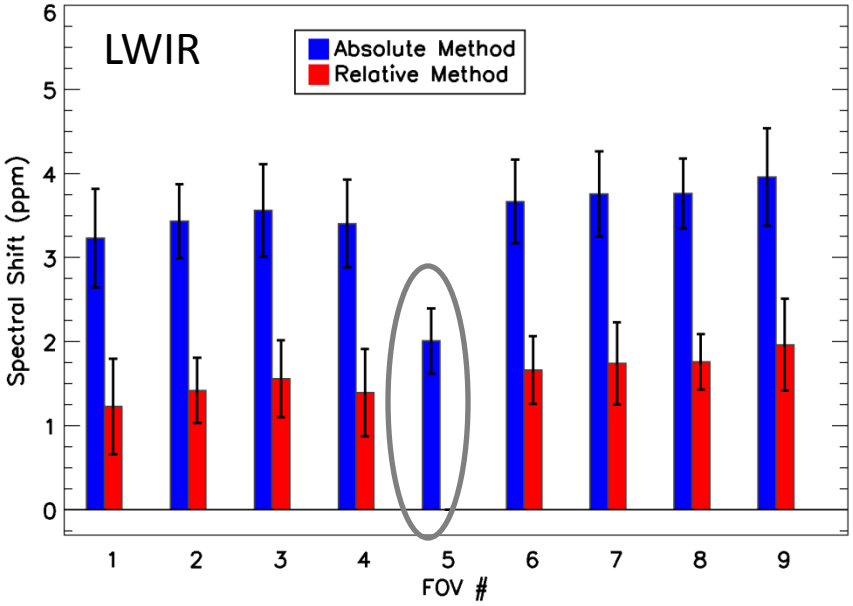
Double Difference between CrIS and IASI2CrIS

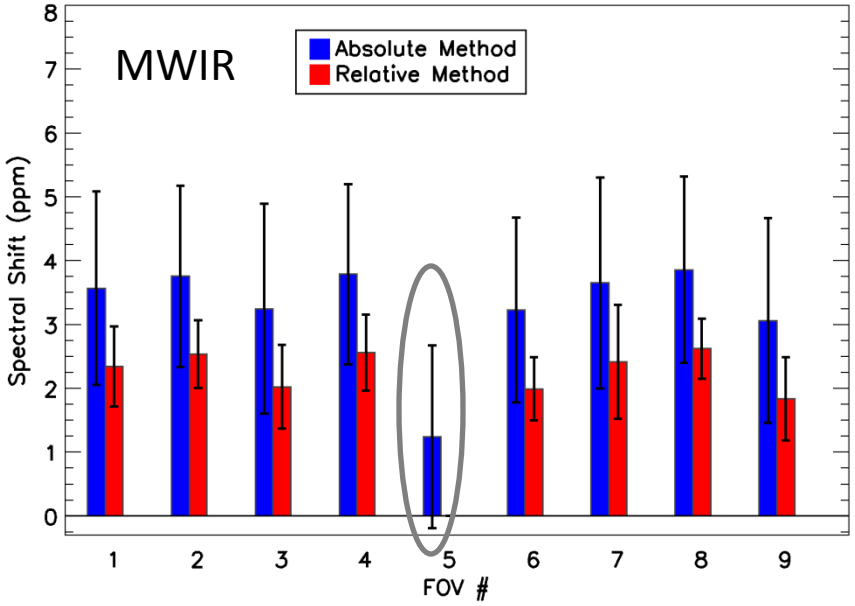
$$DD = \overline{(Obs - CRTM)_{CrIS}} - \overline{(Obs - CRTM)_{IASI\,2CrIS}}$$

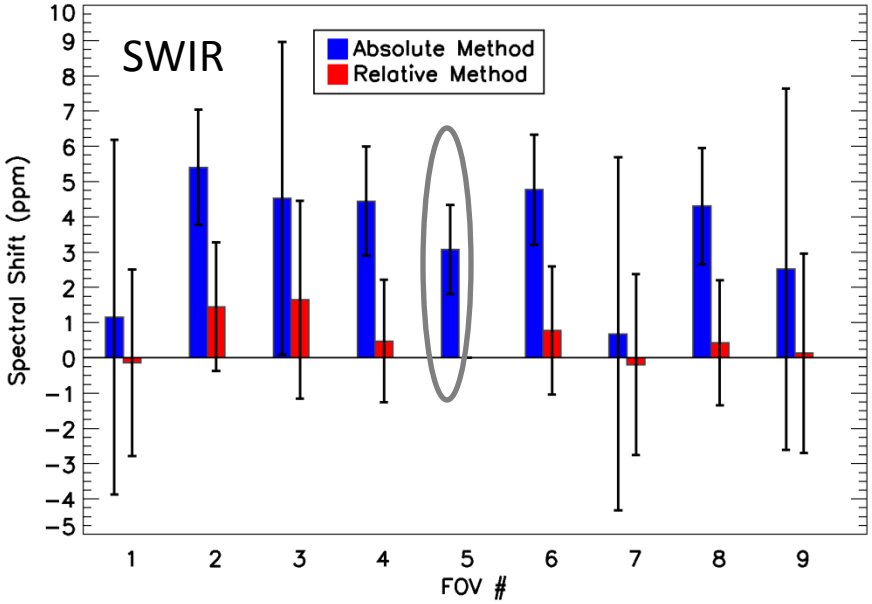


- Double differences of CrIS and IASI relative to CRTM calculated radiance are within ±0.3 K for most of channels.
- For 4.3 μm CO_2 strong absorption region, CrIS is warmer than IASI about 0.3-0.5 K.
- One expects CrIS and IASI window channels to differ by 0.1 K due to diurnal variation in the SST.

CrIS Spectral Uncertainty

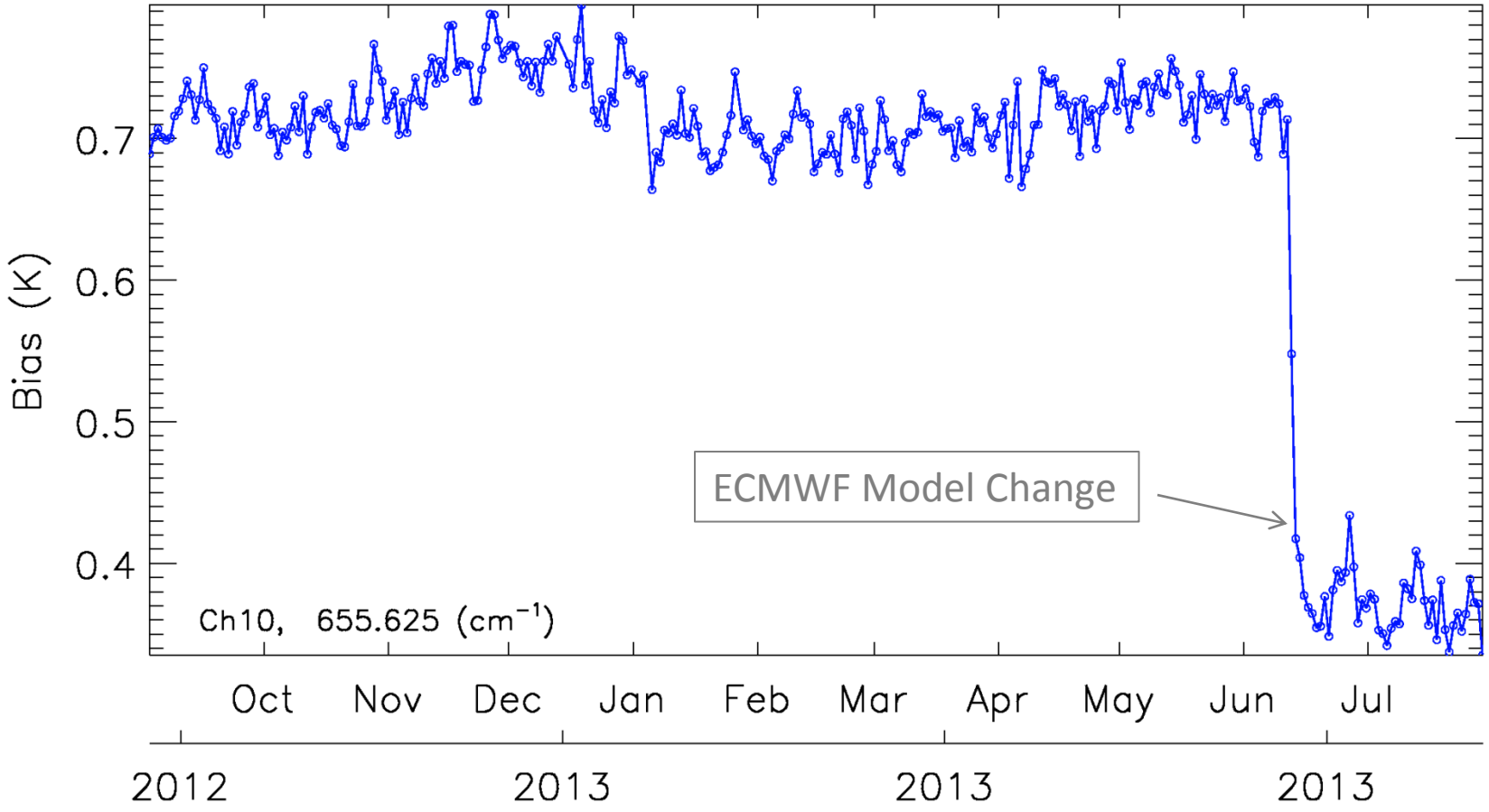






- Absolute Cross-correlation method between CrIS observations and CRTM simulations under clear sky over oceans to detect the spectral shift. Relative method only uses observations from FOV 5 to other FOVs.
- Note that FOV5 ILS correction code fix in ADL, which have impact about 1.6 ppm for FOV 5. That is shown in the relative spectral shift and absolute spectral shift.
- RT modeling is difficult in SWIR.

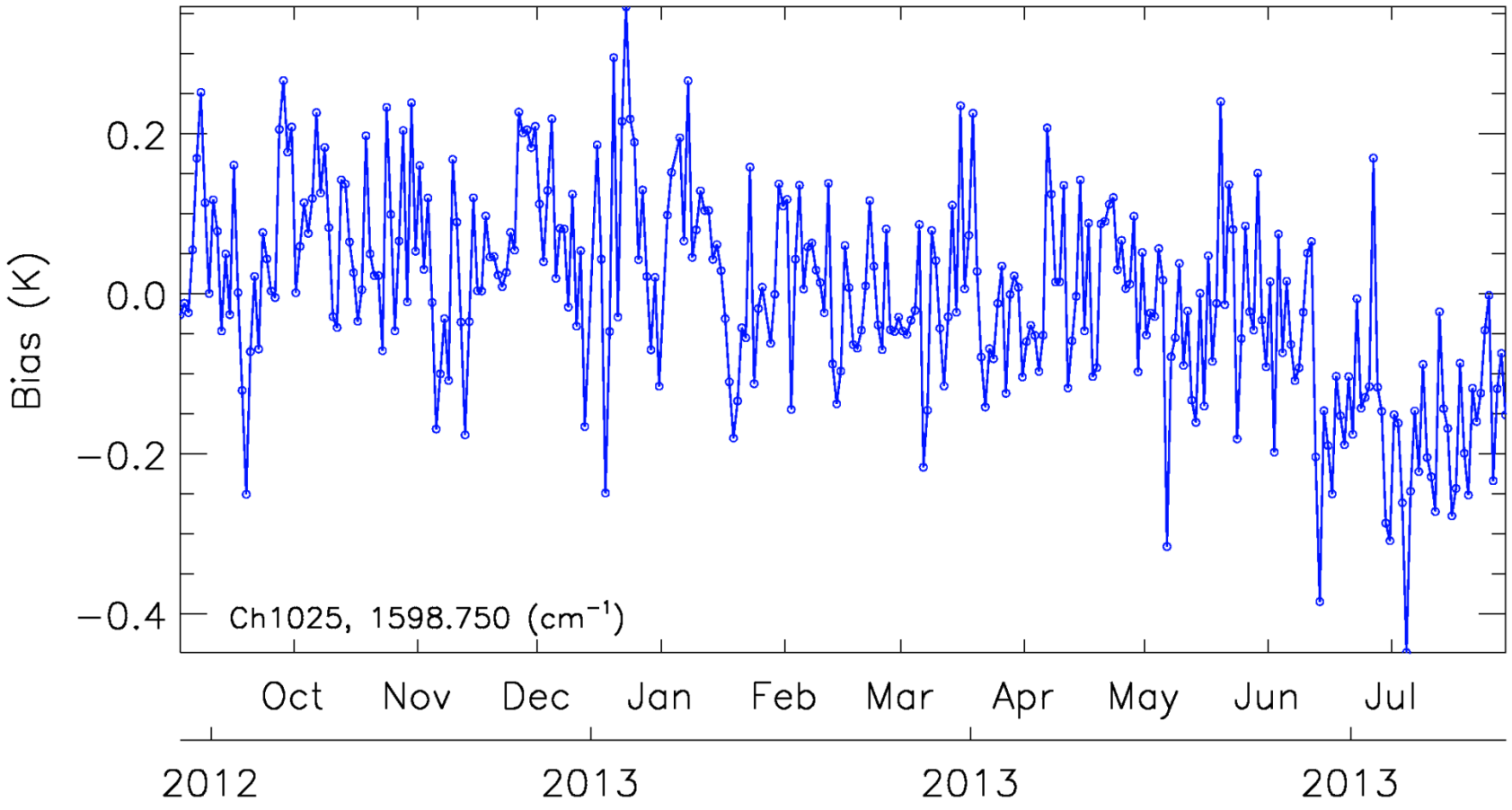
Long-Term Stability: Using CRTM and ECMWF



CrIS normal mode SDR biases relative to ECMWF. Bias is mostly stable, and improved at this stratospheric channel after ECMWF model change on June 25, 2013. ECMWF IFS cycle 38r2 increases the vertical resolution of the model throughout the troposphere and stratosphere (from 91 levels to 137 levels).

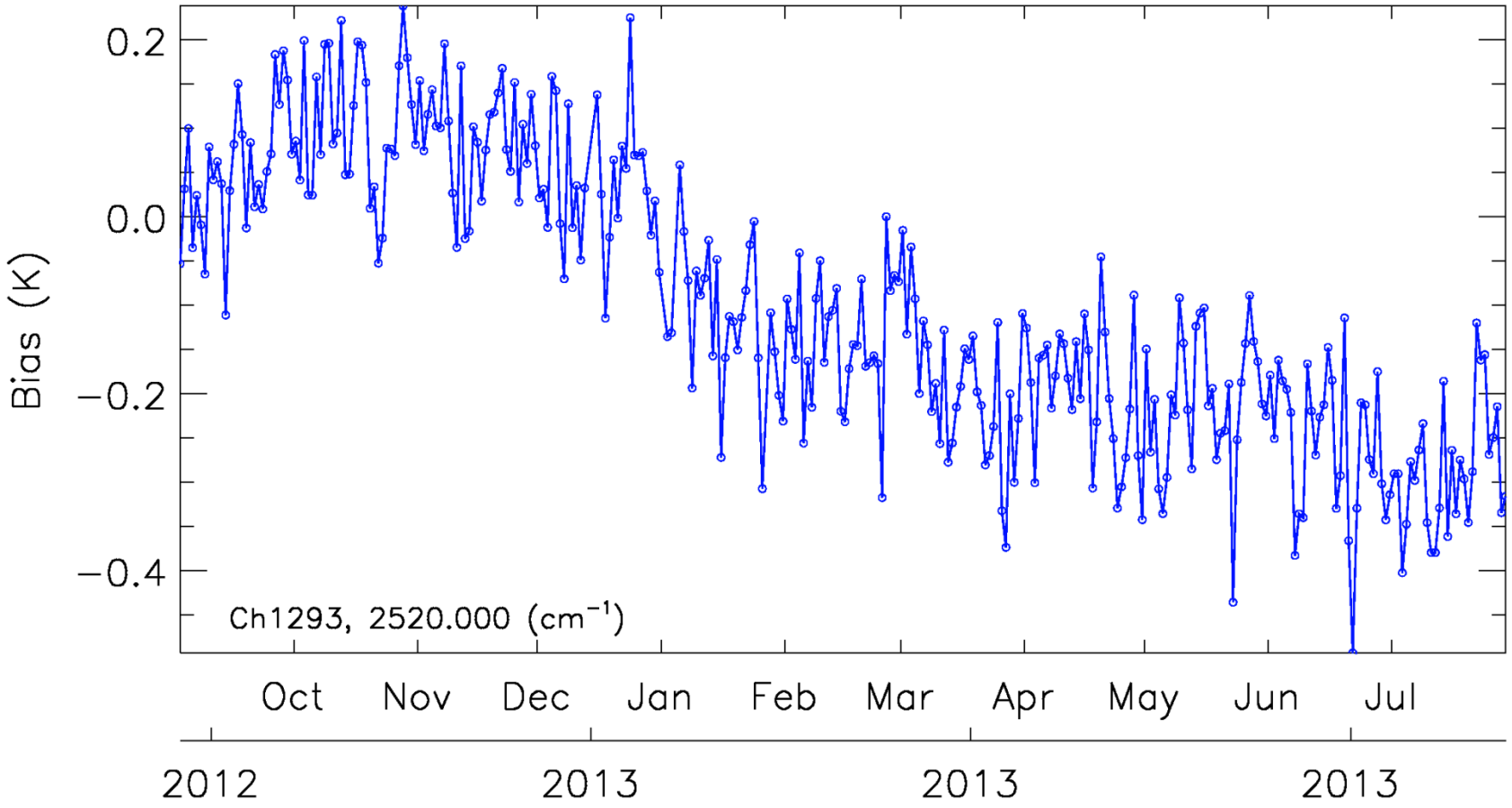
More detail see: http://www.ecmwf.int/products/changes/ifs_cycle_38r2

Long-Term Stability: Water Vapor Channel



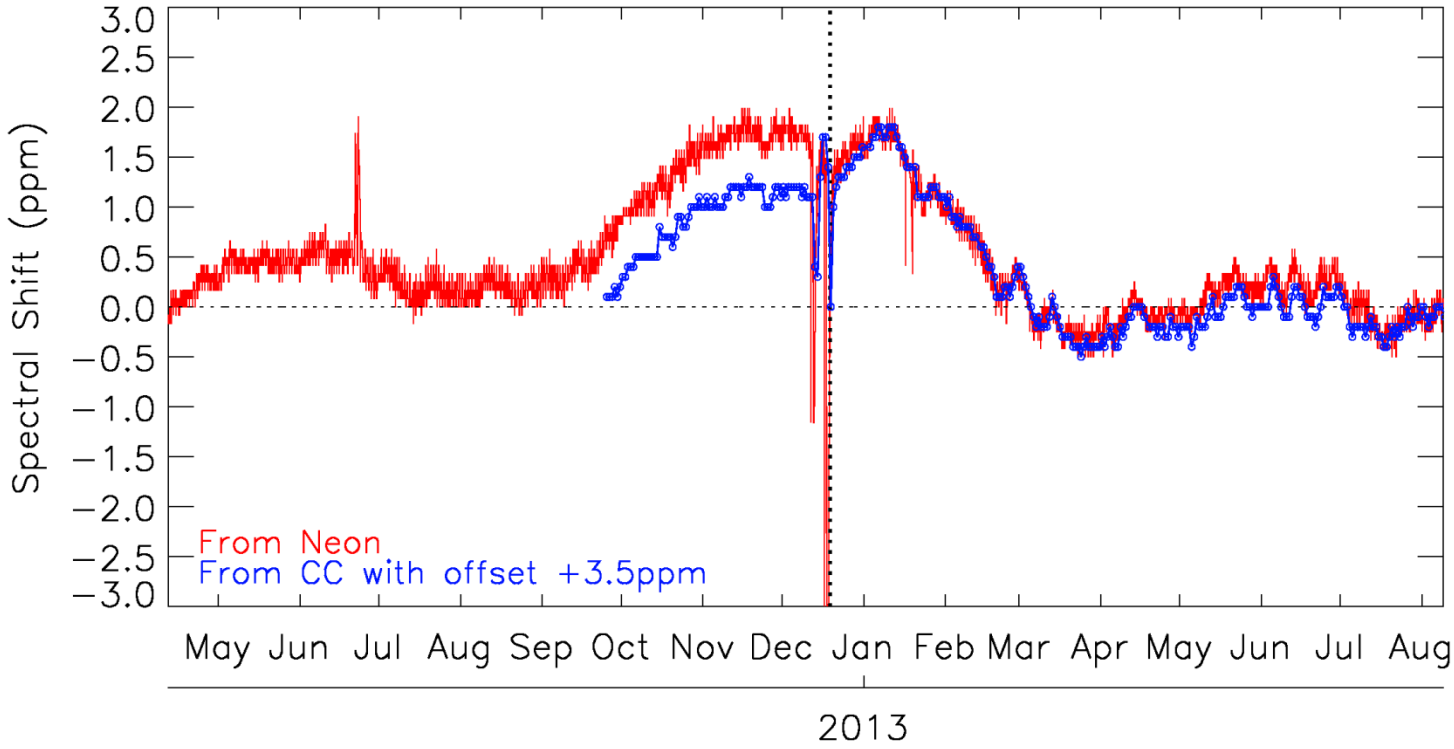
Bias is very stable and small through this monitoring period

Long-Term Stability: Relative to SST



- Use 2520 cm^{-1} for stability, there is almost no water vapor absorption in this channel, only affected by SST.
- Time period too small to draw a conclusion.

Spectral Uncertainty Long-term Monitoring



- The sharp spikes in late June and mid December 2012 are due to NPP spacecraft issues, not CrIS malfunctions.
- Band 1 FOV 5 spectral shift is determined by using cross-correlation (CC) method between CRTM simulations and observations.
- The Neon ZERO shift time is determined by the latest CMO update on Dec 19, 2012.
- An offset of +3.5 ppm from the CC results is used to match the Neon result.
- The relative spectral shift is perfectly following the Neon results after the latest CMO update.

Summary

- The CrIS full resolution SDRs generated from the modified ADL were assessed by using CRTM and ECMWF forecast data for clear sky and over oceans, and compared with IASI data.
- FOV-2-FOV radiometric and spectral differences are small.
- Results from the double difference with IASI show that the differences are within $\pm$0.3K for most of channels.
- CrIS normal mode SDRs long-term stability for radiometric and spectral is examined.