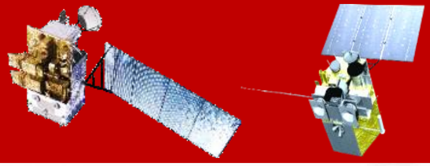

Performance Status of FY-3E/HIRAS-II and FY-4B/GIIRS

Lu “Richard” Lee, Chengli Qi, Chunqiang Wu, Xiuqing Hu, Feng Lu, Lei Yang, Zhuoya Ni

National Satellite Meteorological Center (NSMC), CMA

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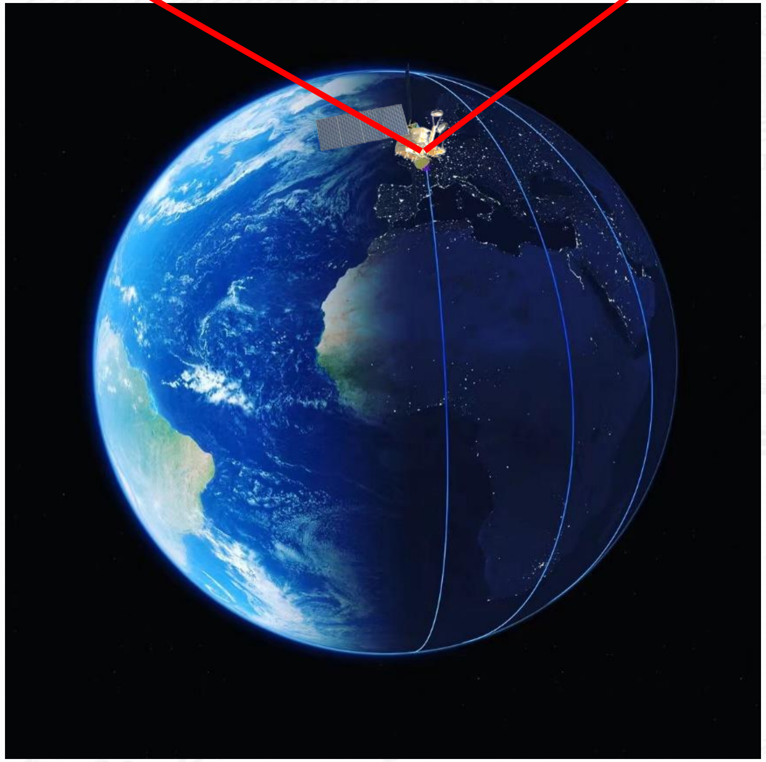
Shanghai Institute of Technical Physics (SITP), CAS

ITWG Advanced Sounder WG Meeting

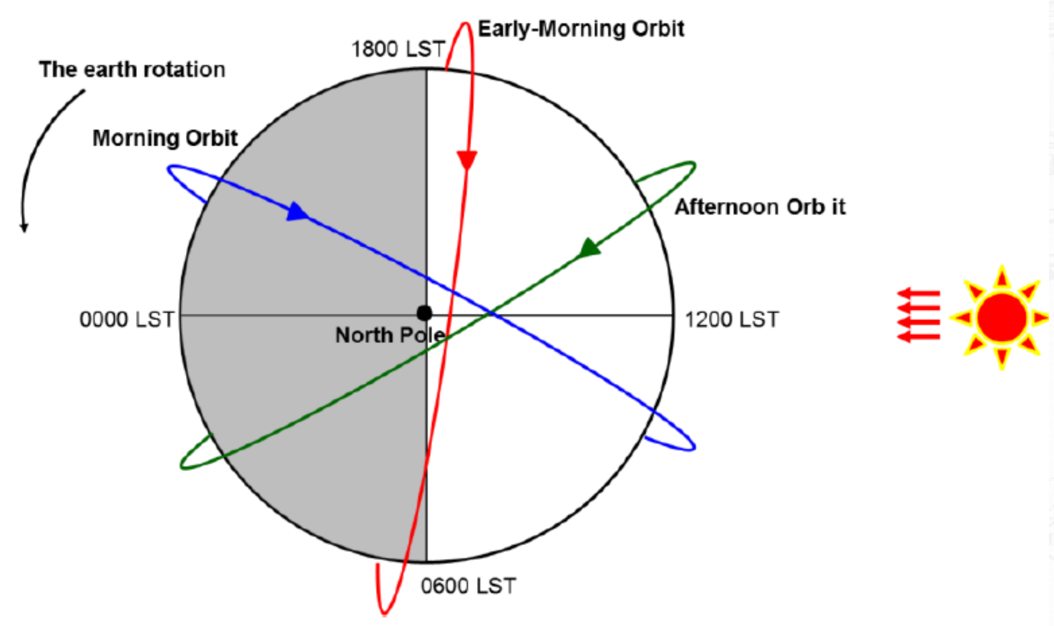
Outline

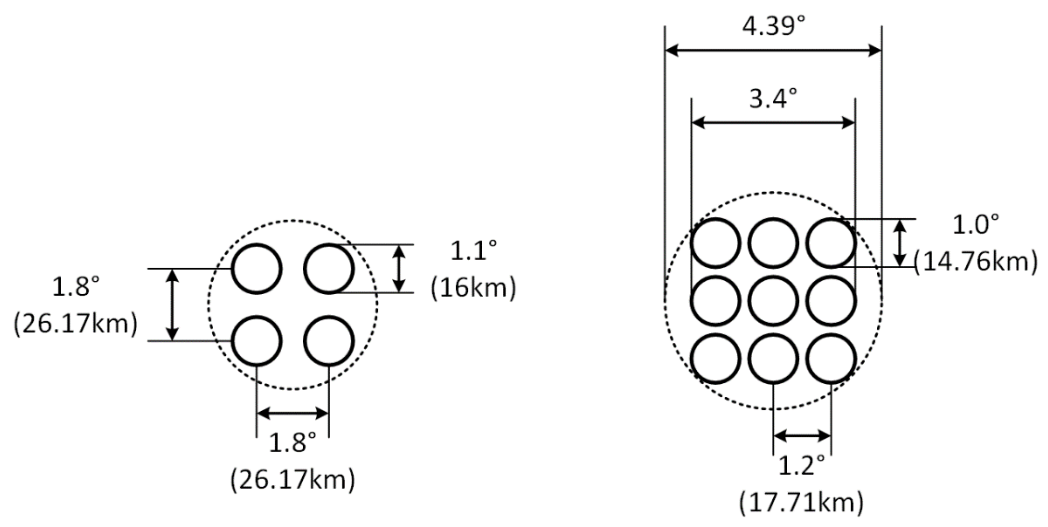
- FY-3E/HIRAS-II Introduction
- FY-3E/HIRAS-II On-board Performance Status
- FY-4B/GIIRS Introduction
- FY-4B/GIIRS On-board Performance Status
- Summary

The first IR sounder on the early-morning-orbit

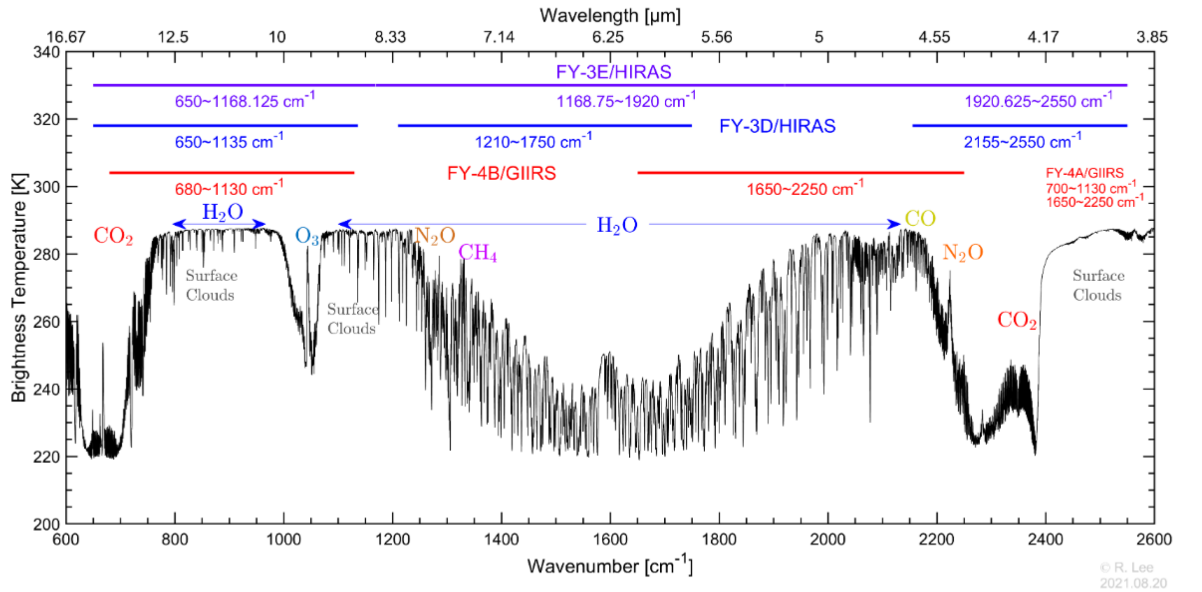


- FY-3E was launched successfully on July 5, 2021.
- FY-3E is the world's first early-morning-orbit meteorological satellite for civil use.
- HIRAS-II is the second hyperspectral IR sounder onboard FY-3 series satellites.





(a) FY-3D/HIRAS Detector Layout (b) FY-3E/HIRAS Detector Layout



Band	Spectral Range (cm^{-1})	Spectral Resolution (cm^{-1})	Sensitivity (NEΔT@280K) FY-3D	Sensitivity FY-3E		Radiometric Accuracy FY-3D	Radiometric Accuracy FY-3E	Spectral Uncertainty FY-3D	Spectral Uncertainty FY-3E
LWIR	650～1168.125 （15.38 μm～8.56 μm）	0.625	0.4 K	650 ～667 cm^{-1}	0.8 K	0.7 K	1.0 K	10 ppm	7 ppm
				667～689 cm^{-1}	0.4 K		0.5 K		
				689～1000 cm^{-1}	0.2 K		0.4 K		
				1000～1136 cm^{-1}	0.4 K		0.5 K		
MWIR	1168.75～1920 （8.55 μm～5.21 μm）	0.625	0.7K	1210～1538 cm^{-1}	0.2 K	0.7 K	0.4 K		
				1538～1750 cm^{-1}	0.3 K		0.5 K		
SWIR	1920.625～2550 （5.21 μm～3.92 μm）	0.625	1.2 K	2155～2300 cm^{-1}	0.3 K	0.7 K	0.5 K		
				2300～2550 cm^{-1}	0.5 K		0.6 K		

Outline

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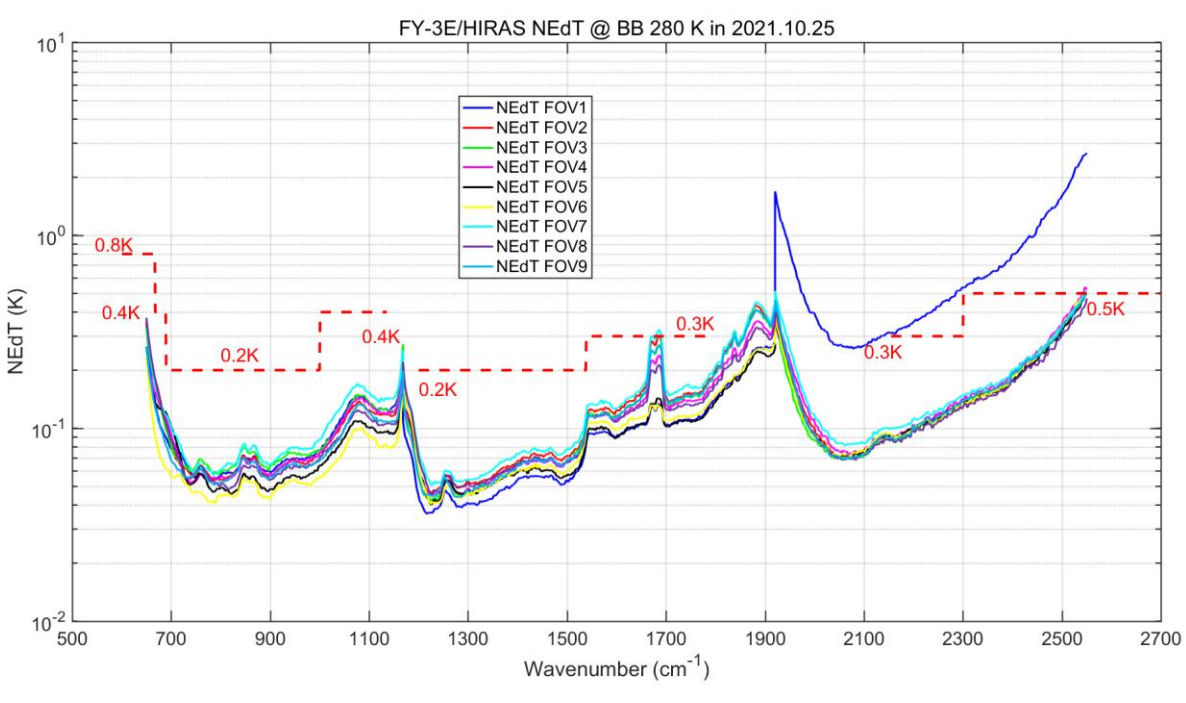
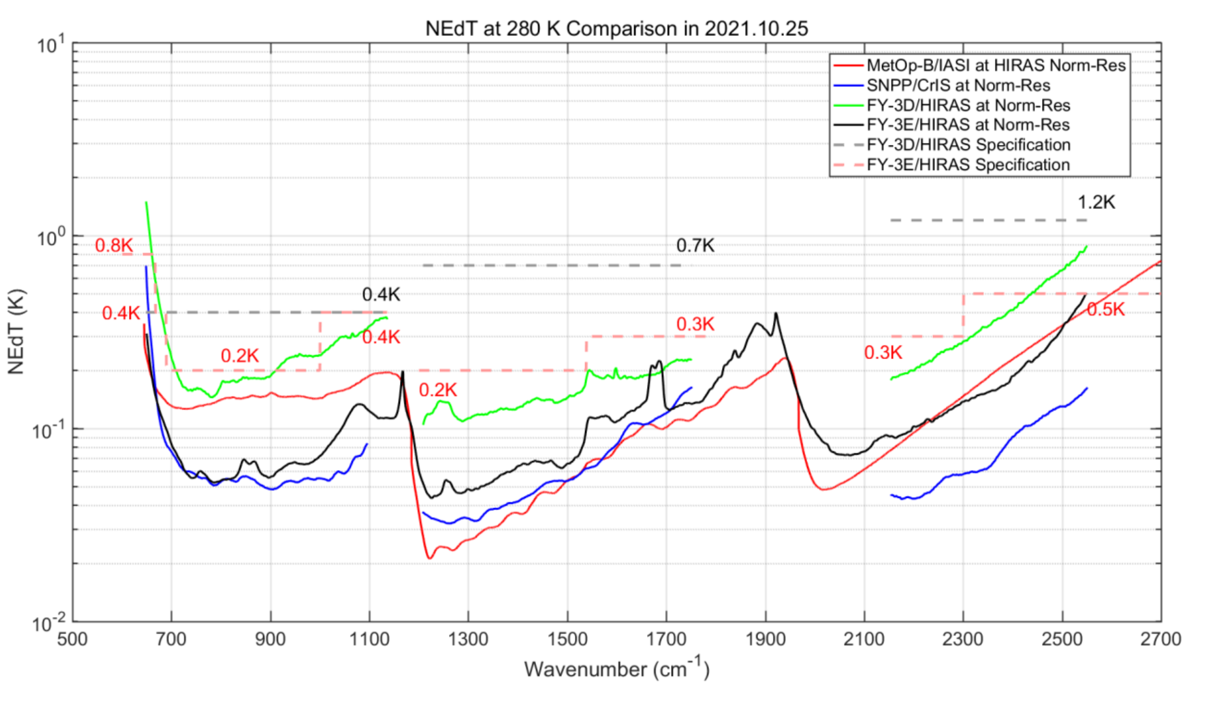
HIRAS-II NEdT Performance

NEdT@280 K inter-comparison with several IR sounders



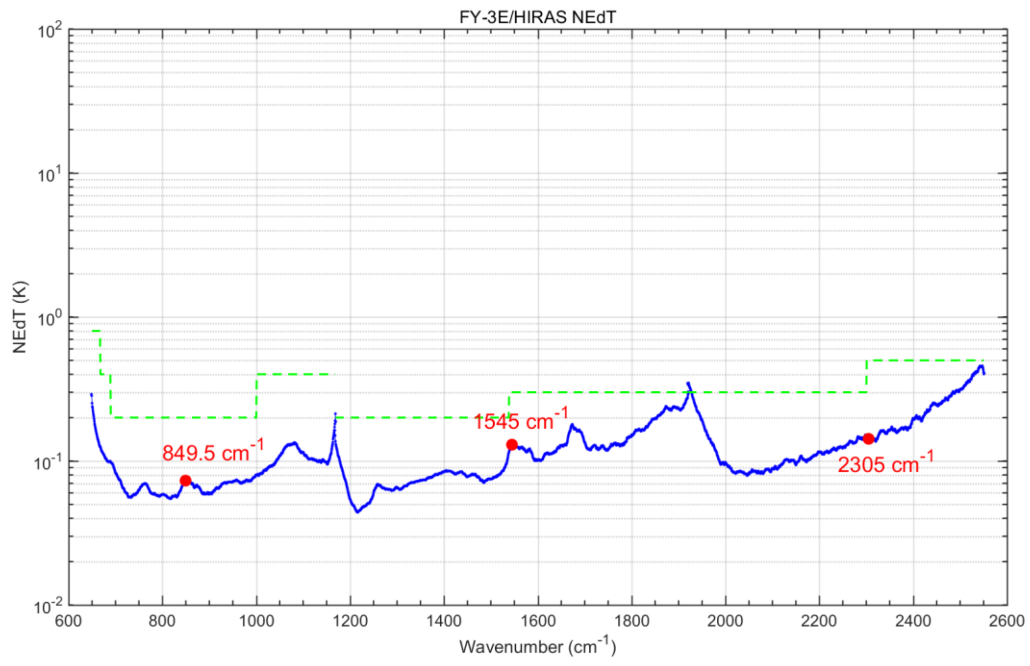


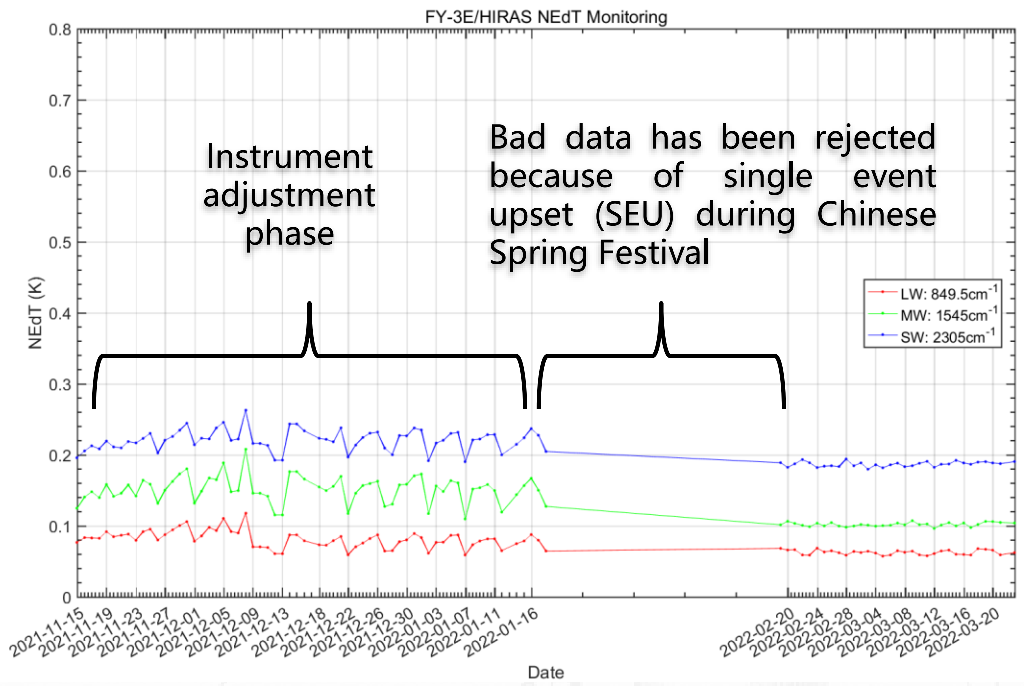
FY-3E/HIRAS-II LWIR and MWIR have good noise performance

SWIR FOV-1 is out of family and larger than the specification

FY-3E/HIRAS-II noise performance is better than FY-3D/HIRAS except for the FOV-1 in SWIR.

NEdT Stability



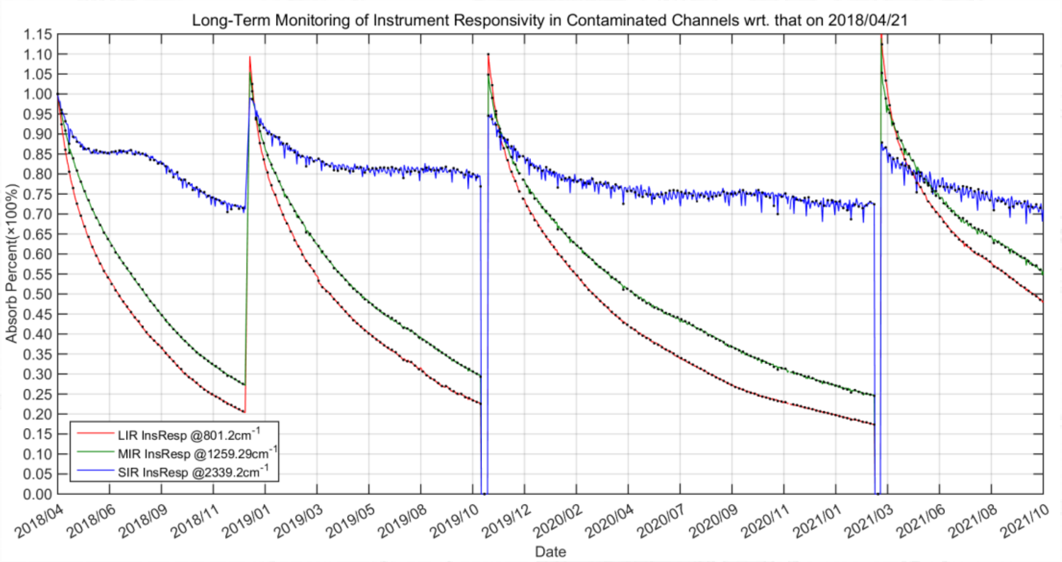


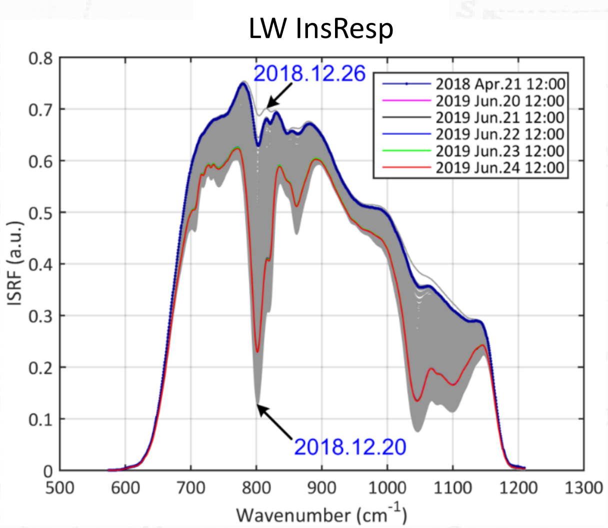
FY-3E/HIRAS-II mean NEdT of 9 FOVs
(SW FOV-1 being rejected)

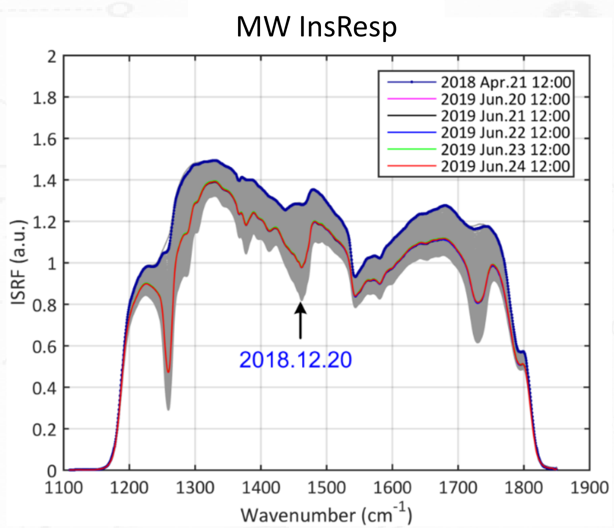
FY-3E/HIRAS-II noise performance is stable.

HIRAS-II Instrument Responsivity

InsResp Stability





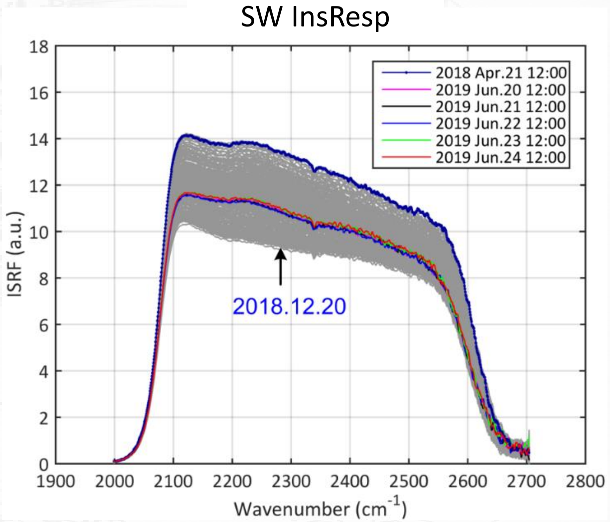


FY-3D/HIRAS InsResp Monitoring

$$InsResp(\sigma) = \frac{|C_{ICT}(\sigma) - C_{DS}(\sigma)|}{B_{ICT}(\sigma)}$$

C_{ICT}: HIRAS ICT FFT raw spectra
C_{DS}: HIRAS ICT FFT raw spectra
B_{ICT}: ICT radiance on sensor resolution

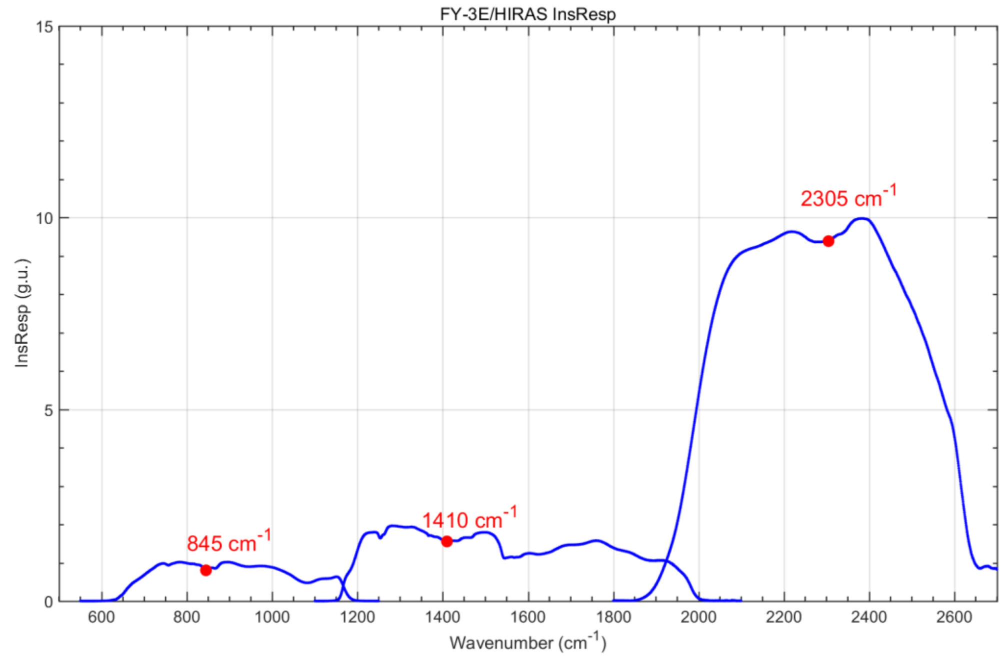
In 2018, it had been found that the instrument responsivity (InsResp), and also the measured signal in each band of FY-3D/HIRAS would decrease with time. The signal attenuation could attribute to the silica gel gas absorption that appears in the interferometer optical path. The absorption affects almost the whole spectral range of the three bands. There are some strong absorbing channels in LW and MW bands, such as 801.2 cm^{-1} and 1259.3 cm^{-1}. From 2018 to 2021, HIRAS has undergone three on-orbit operations of warming maintenance in 2018-12-21, 2019-10-30, and 2021-03-21, respectively.

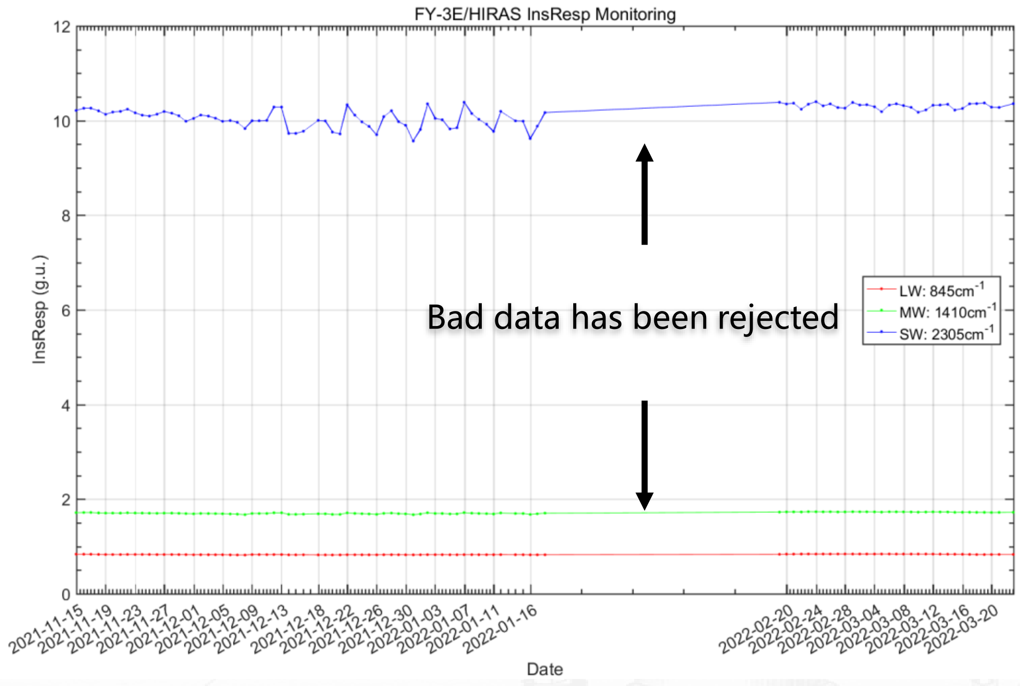


Ref:

Han Y., Chen Y. 2018, IEEE Trans. Geosci. Remote Sens. 56(2):1008-1016.

Qi C., Wu C., Hu X. et al. 2020, IEEE Trans. Geosci. Remote Sens. 58(6):4335-4352.



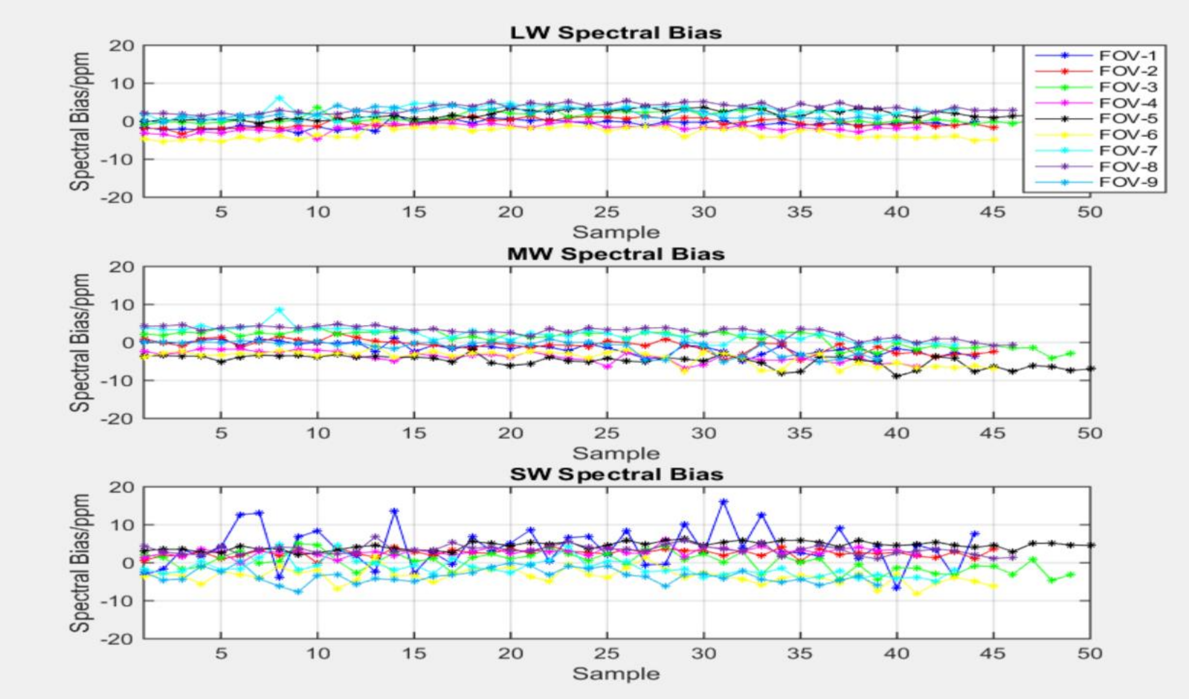


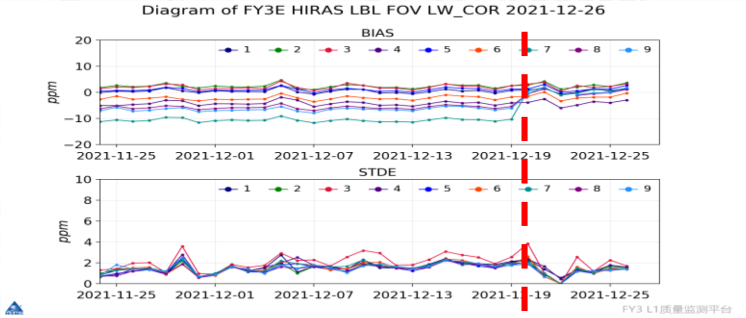
FY-3E/HIRAS-II mean InsResp of 9 FOVs

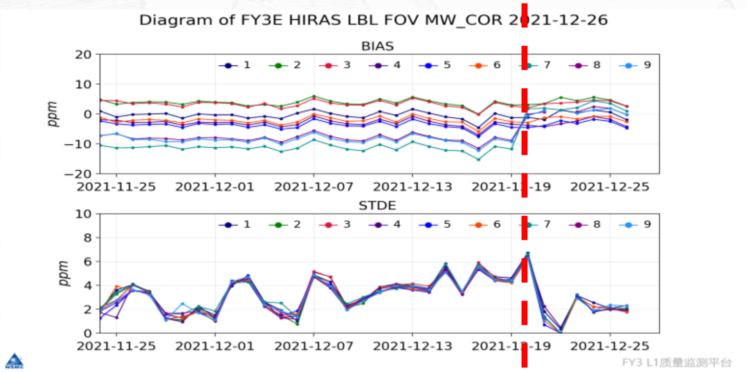
Up to now, FY-3E/HIRAS-II instrument responsivity is stable.

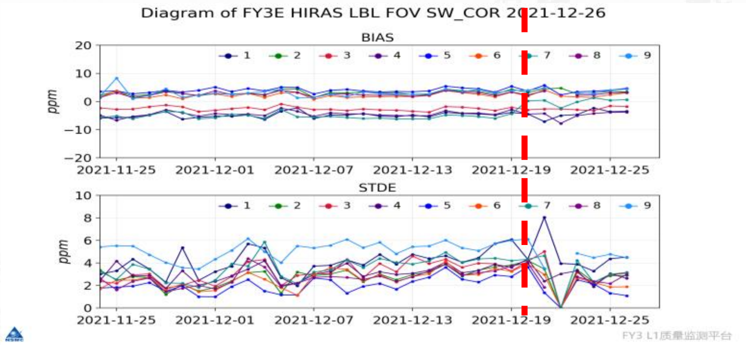
HIRAS-II on-board spectral calibration

based on LBL simulated spectra





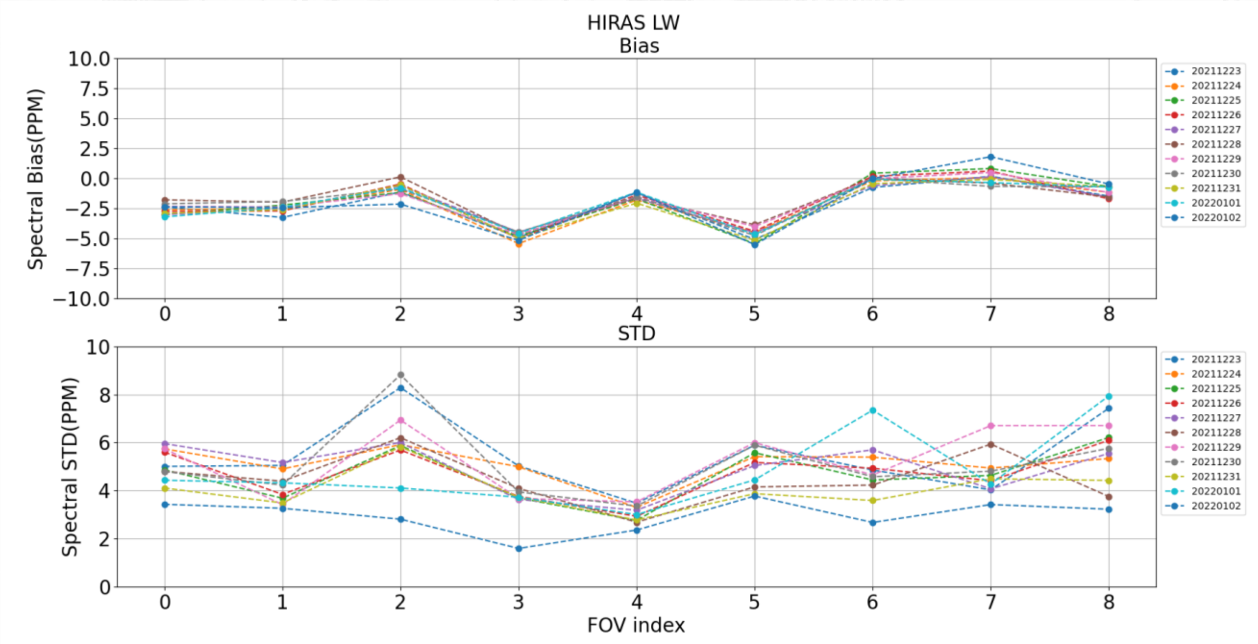


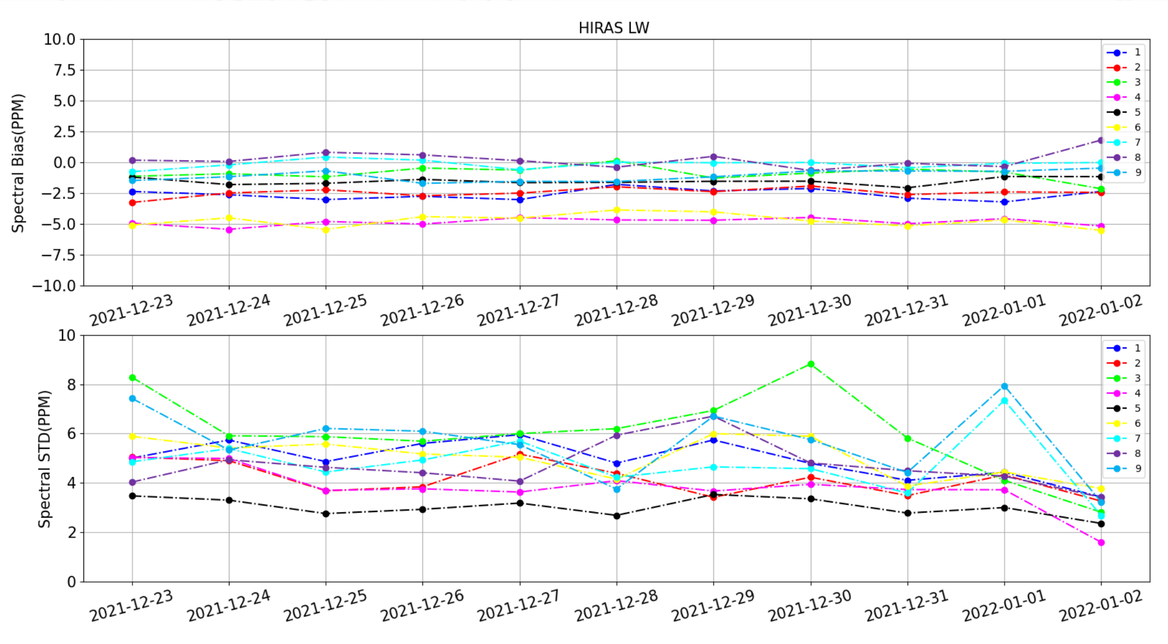


The spectral offsets for all three bands are within ±5 ppm after the spectral calibration parameter updated on Dec. 20, 2021.

HIRAS-II on-board spectral calibration

based on SNO IASI-C spectra

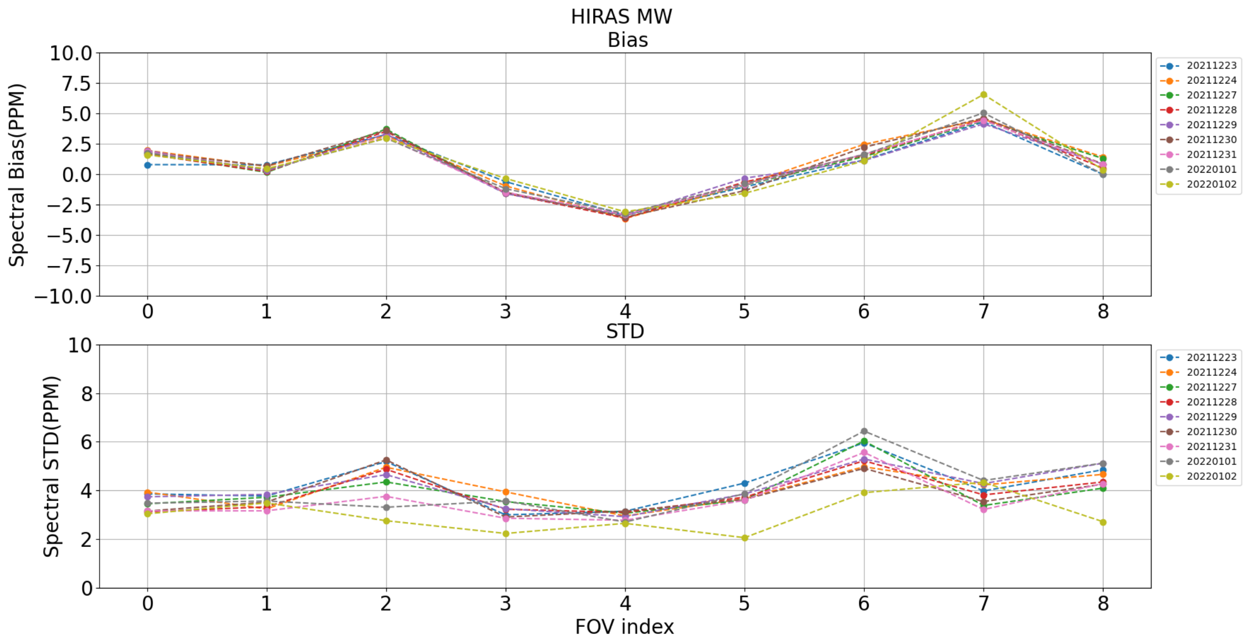


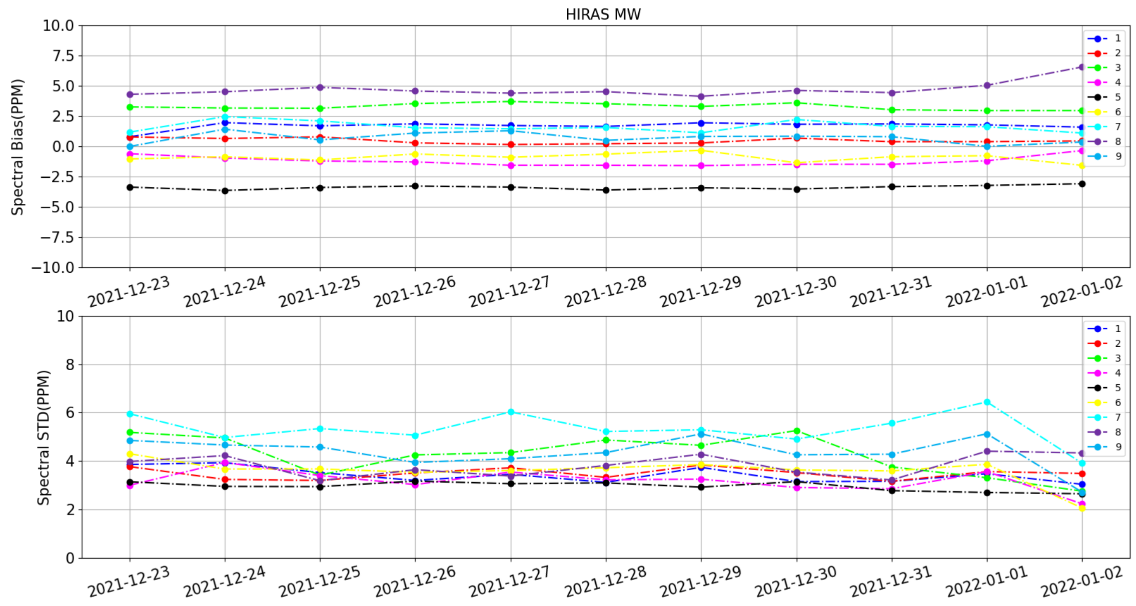


LWIR spectral offsets are within ±5 ppm

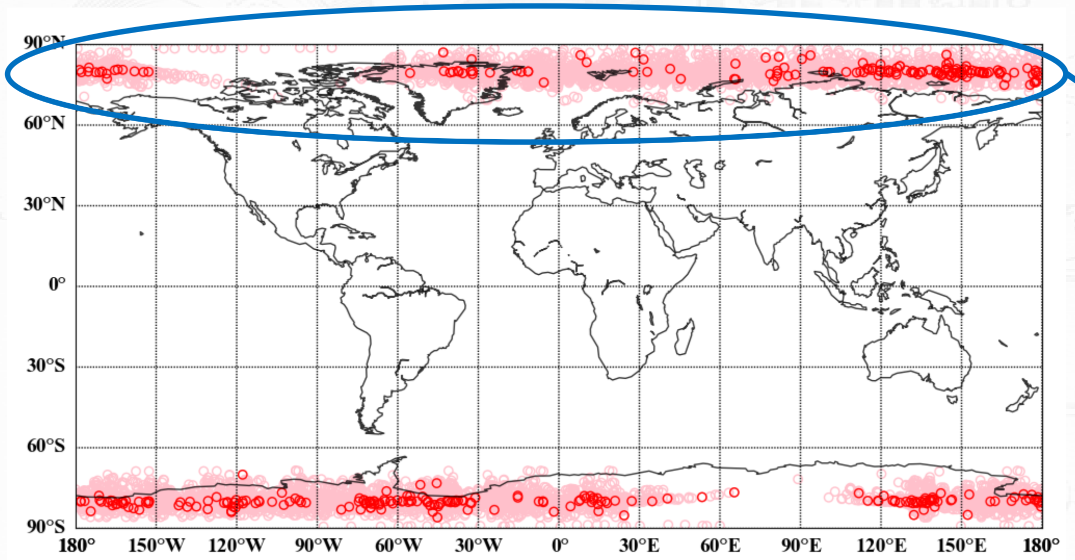
HIRAS-II on-board spectral calibration

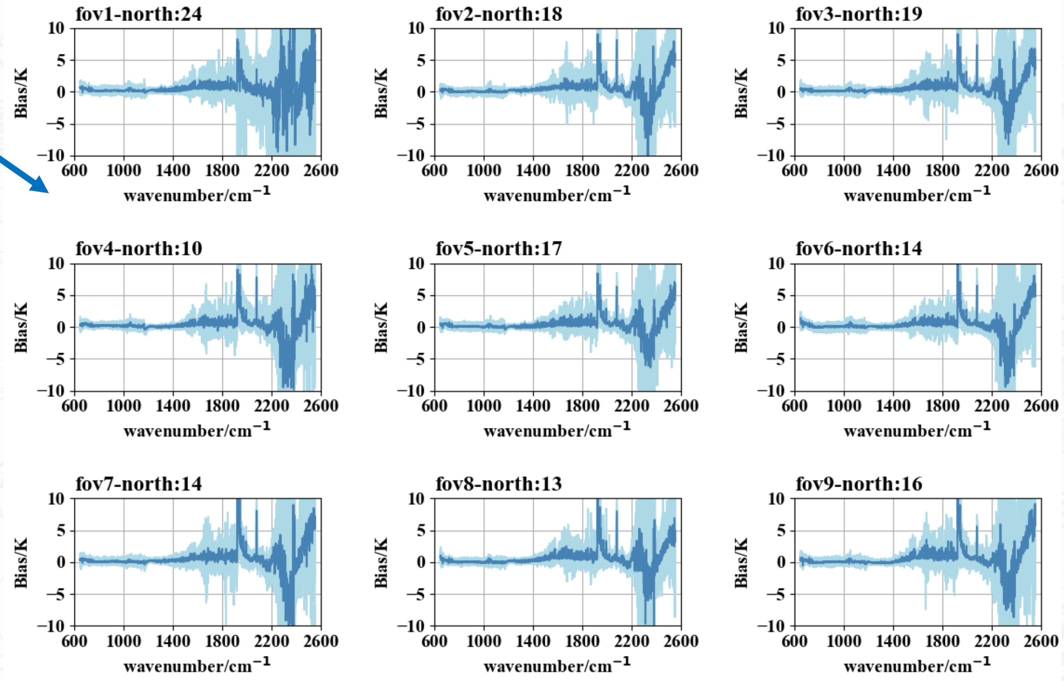
based on SNO IASI-C spectra





MWIR spectral offsets are within ±5 ppm





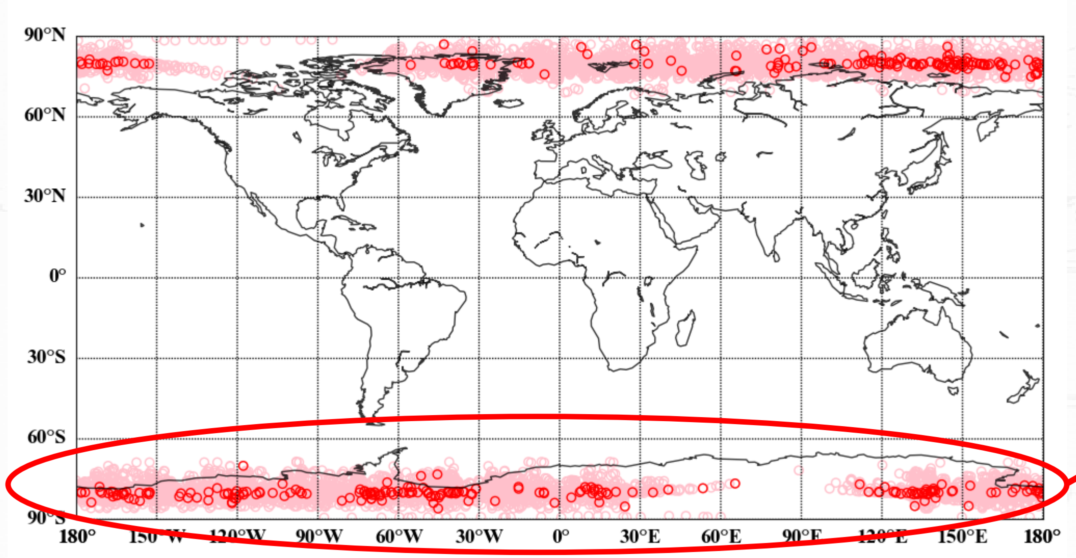
HIRAS-II to IASI-B SNOs in the polar regions (from Nov.14 to Dec.01 2021)

The BT differences in LWIR and MWIR are less than 1.0 K (std. dev. < 1K).

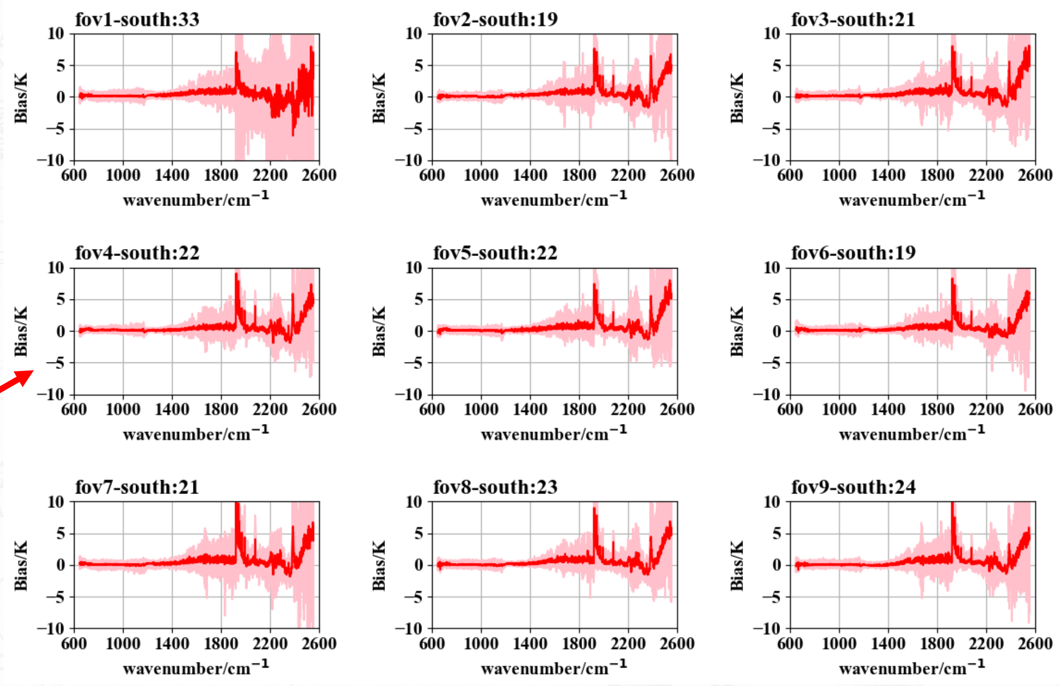
The SWIR BT differences are larger than that in LWIR and MWIR, because of the cold scenes in Arctic regions.

HIRAS-II on-board radiometric calibration

Based on SNO inter-comparison with IASI-B



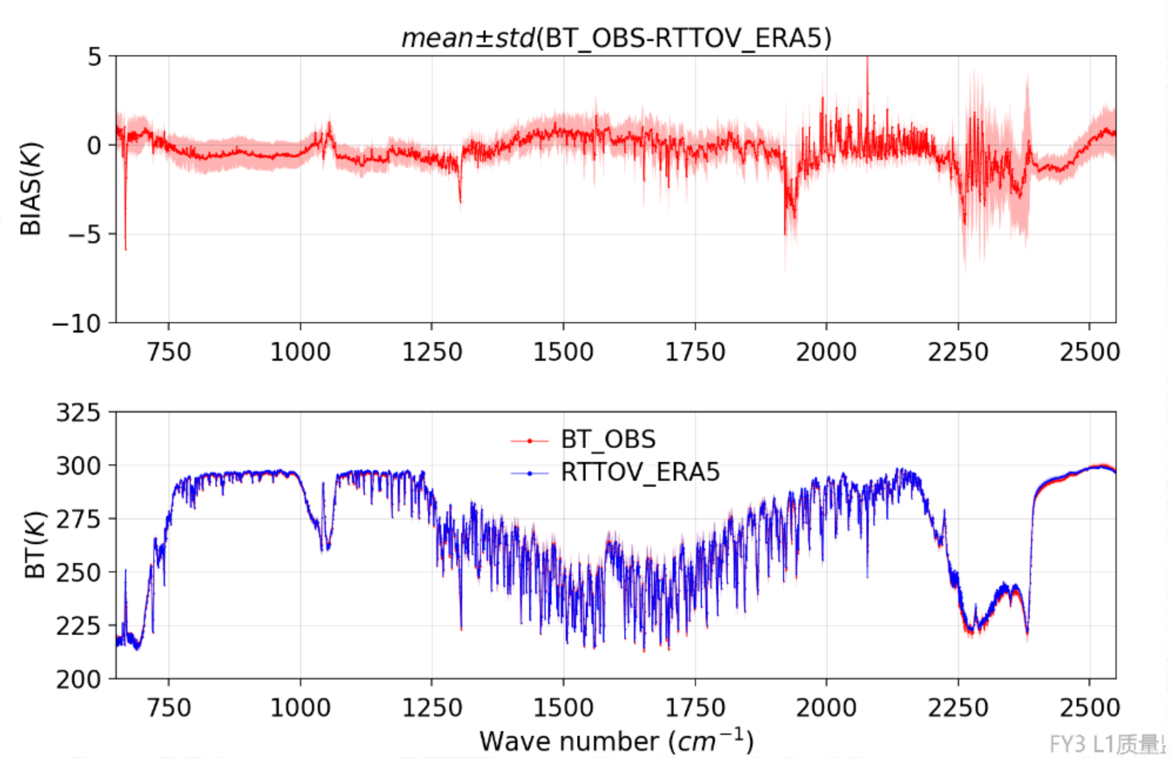
HIRAS-II to IASI-B SNOs in the polar regions (from Nov.14 to Dec.01 2021)

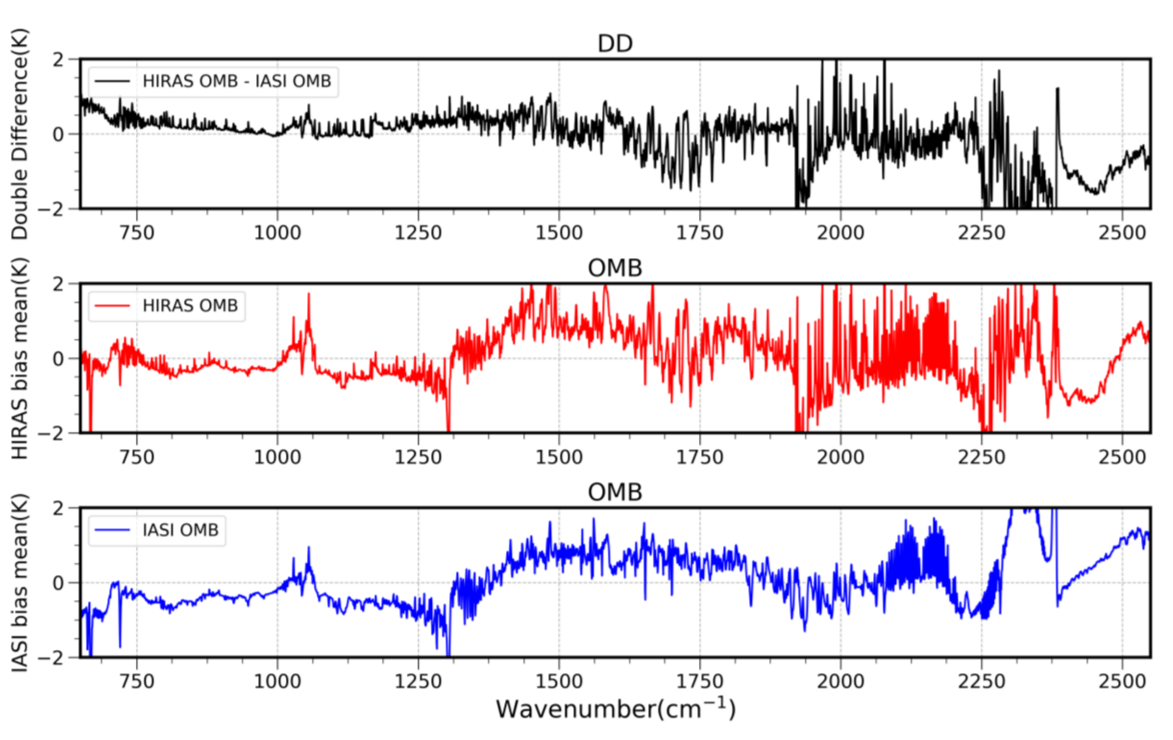


Since the SNO scenes in Antarctic are warmer than Arctic, the SWIR BT dev. has been reduced considerably.

HIRAS-II on-board radiometric calibration

based on IASI SNO comparison & double-difference



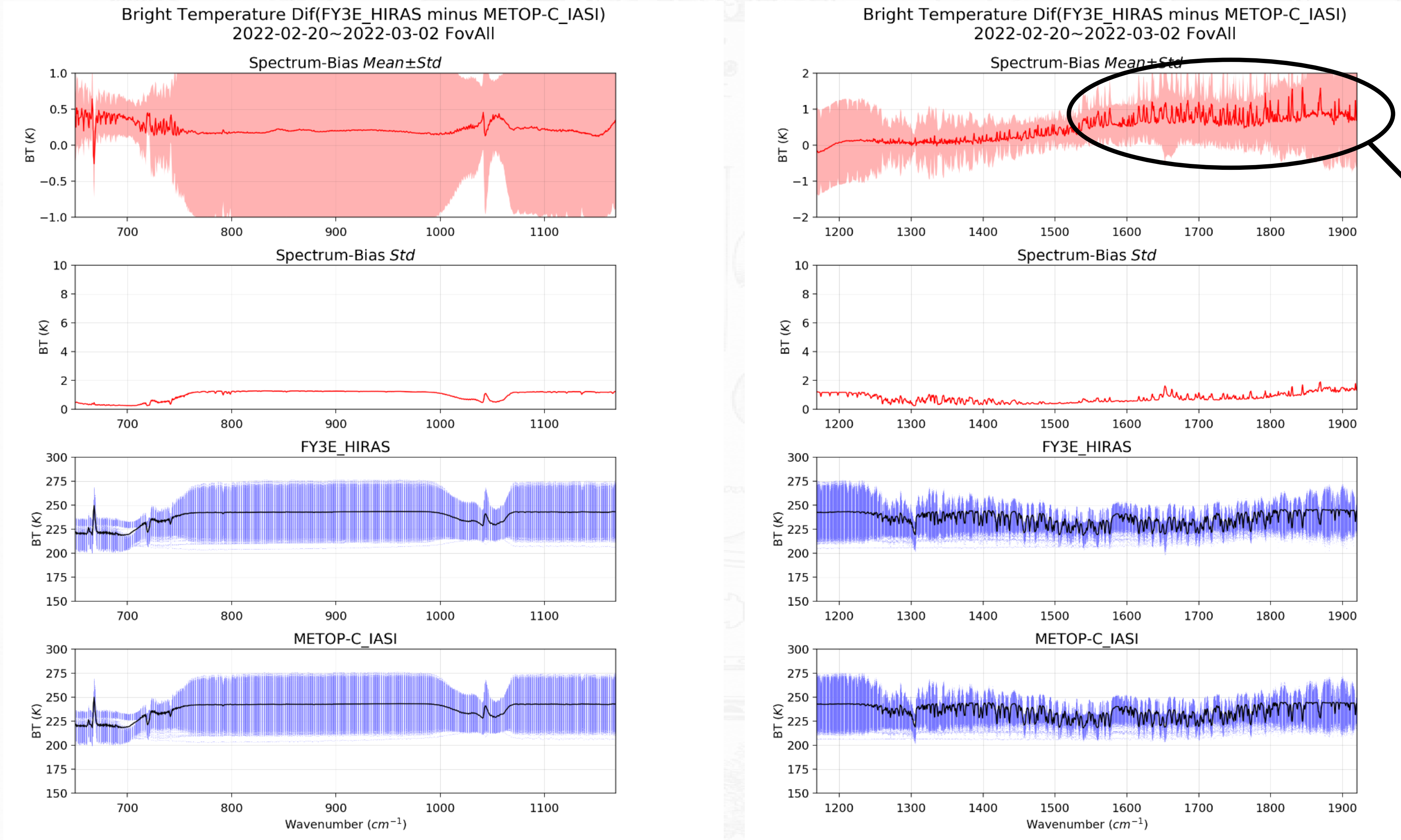


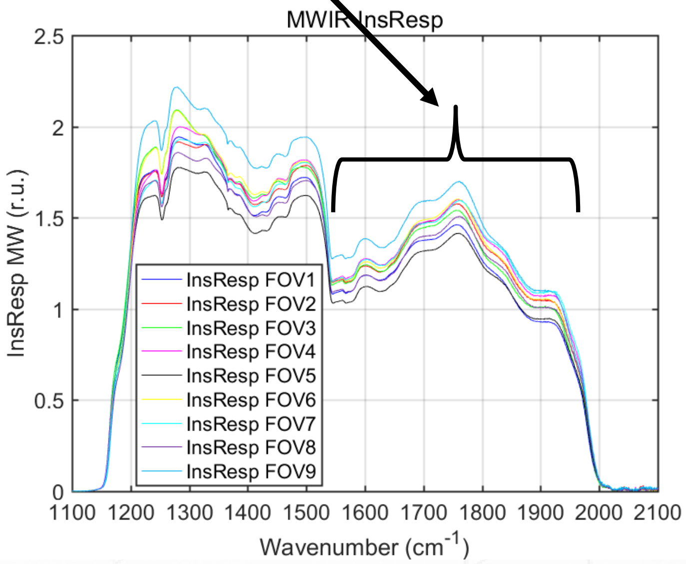
The RTTOV spectra are calculated for clear scenes using ERA5.

LWIR radiometric accuracy is better than 0.5 K, and MWIR is about 0.5 to 1.0 K.

SWIR is larger than specification, and is need improved.

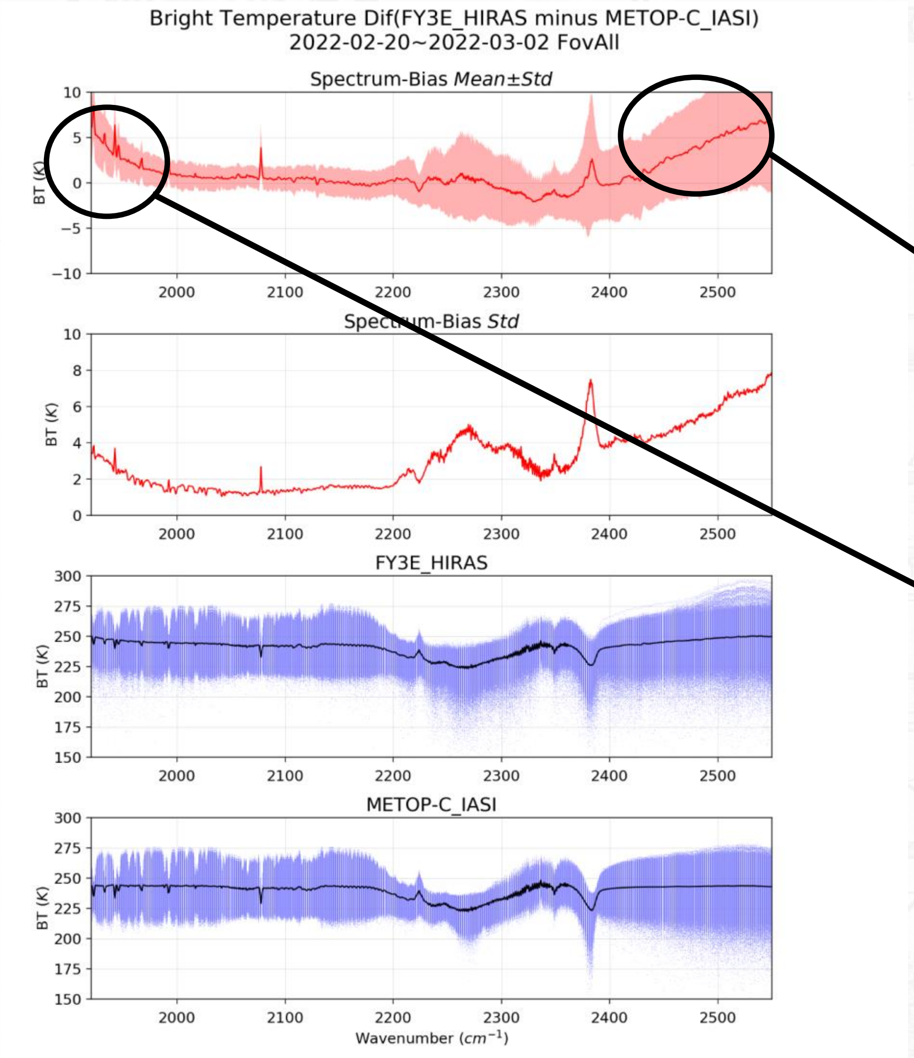
HIRAS-II on-board radiometric calibration



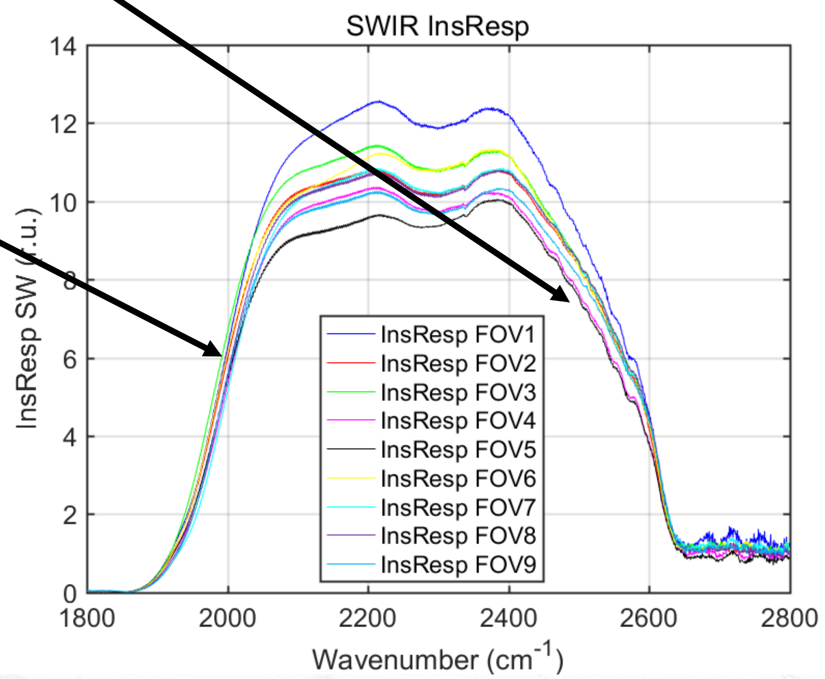


LWIR radiometric accuracy is better than 0.5 K,
MWIR is about 0.5 to 1.0 K.

HIRAS-II on-board radiometric calibration



SW calibration issue may be related with the instrument responsivity variation within the domain of the spectral response function, especially in the band edges.



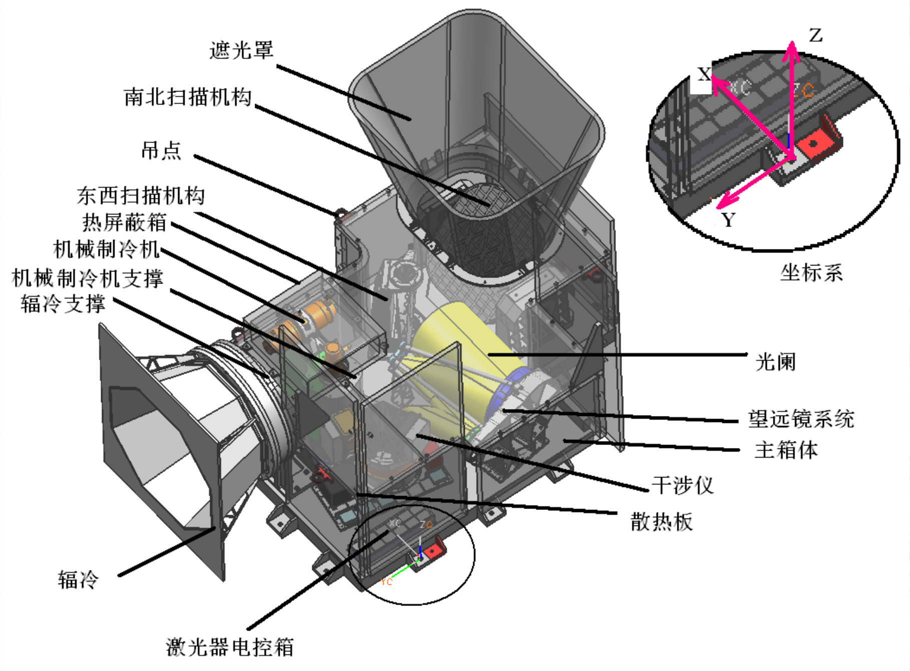
Ref:

D. Pierre, T. Bertrand, C. Dorothee, et. al. Introduction to the ringing effect in satellite hyperspectral atmospheric spectrometry. AMT, 2021, (discussions).

D. Pierre, T. Bertrand, C. Dorothee, et. al. Correction of calibration ringing in the context of the MTG-S IRS instruments. arXiv, 2022.

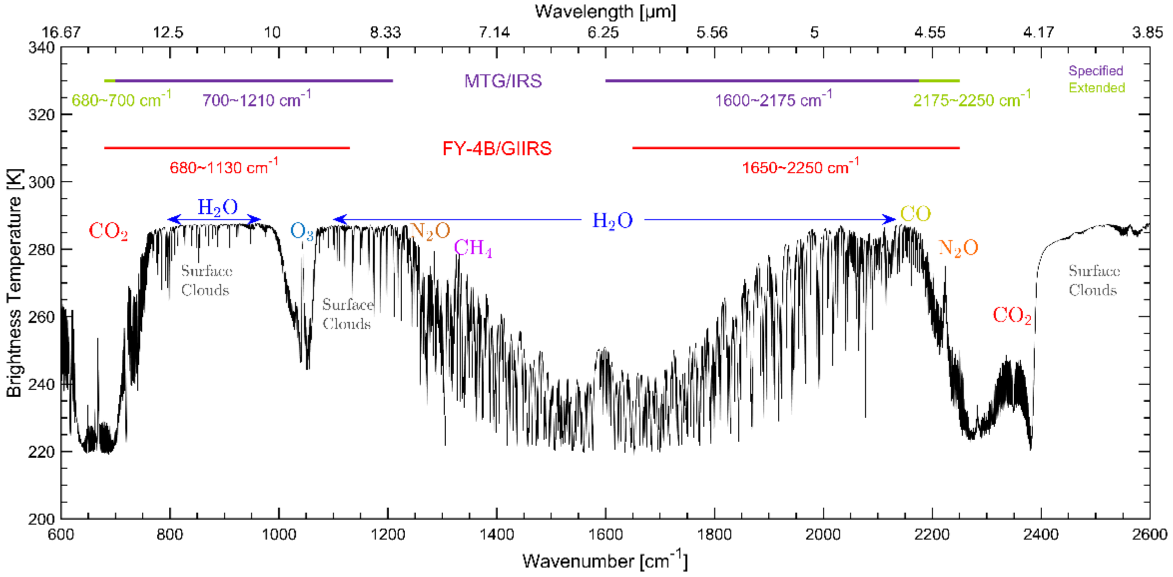
Outline

- FY-3E/HIRAS-II Introduction
- FY-3E/HIRAS On-board Performance Status
- **FY-4B/GIIRS Introduction**
- FY-4B/GIIRS On-board Performance Status
- Summary



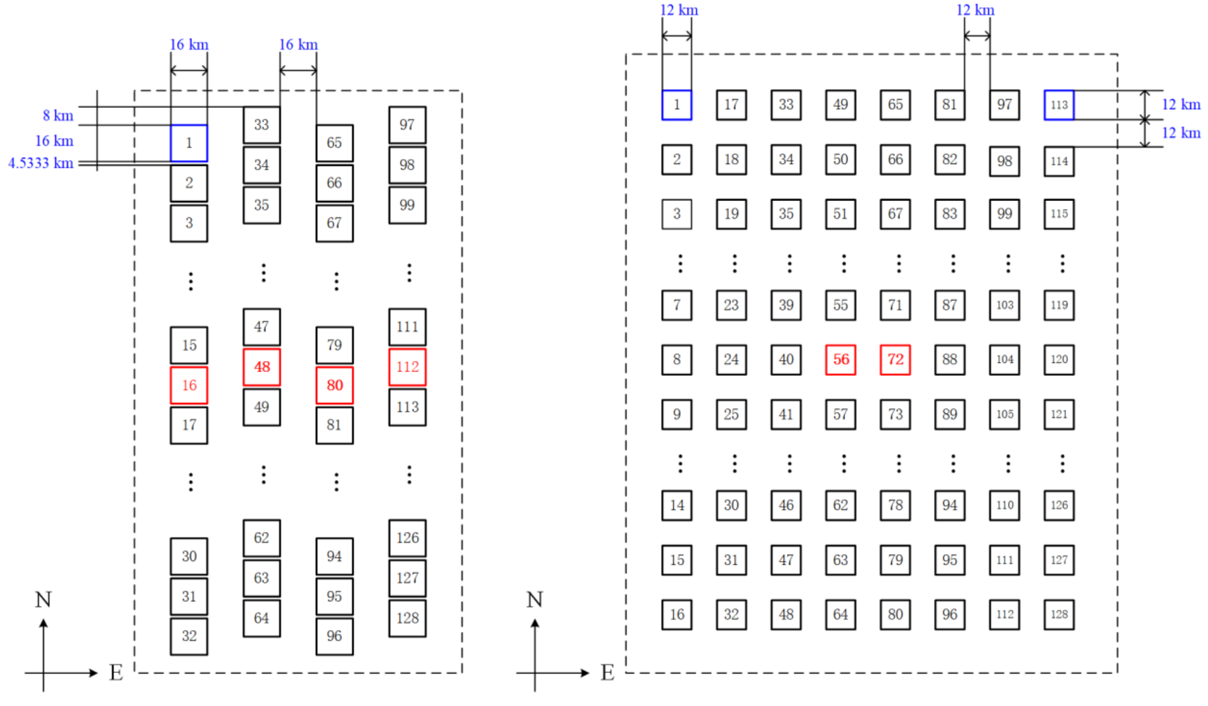
GIIRS Model

- FY-4B/GIIRS was launched successfully on June 3, 2021, which is China's second hyperspectral IR sounder on the GEO satellite.
- Unlike the demonstration of FY-4A/GIIRS, this sounder is expected to be used for NWP operational model.



- The FY-4B/GIIRS L1 science team was set up in October 2020, with two HIRAS scientists joining in. The two scientists are Chengli Qi and Lu "Richard" Lee.
- The new team redesigned the L1 calibration algorithm which is based on Revercomb et al (1988).

Specifications



(a) FY-4A/GIIRS Detector Layout

(b) FY-4B/GIIRS Detector Layout

Item	Band	
	LWIR	MWIR
Spectral range/cm^{-1}	680~1130	1650~2250
MPD/cm	0.8	0.8
Resolution/cm^{-1}	0.625	0.625
Number of Channels	721	961
NEdR/[mW/(m^2·sr·cm^{-1})]	< 0.5	< 0.1
Spatial resolution (s.s.p)/km	12×12	12×12
Frequency uncertainty/ppm	10	10
Radiometric CAL. accuracy/K	0.7	0.7

- The detector layout has been updated from 32×4 to 16×8, with spatial sampling from 16×16 km to 12×12 km at Nadir.

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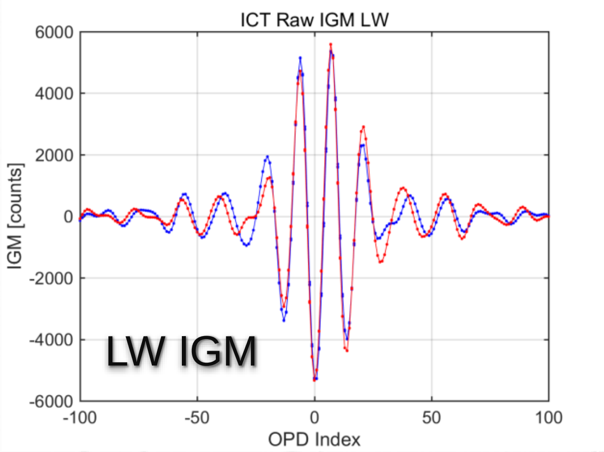
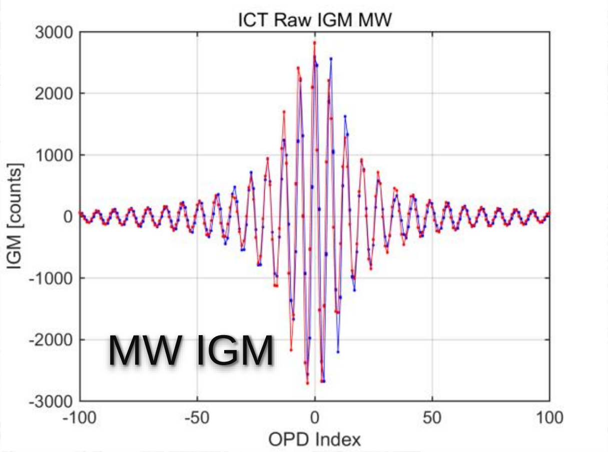
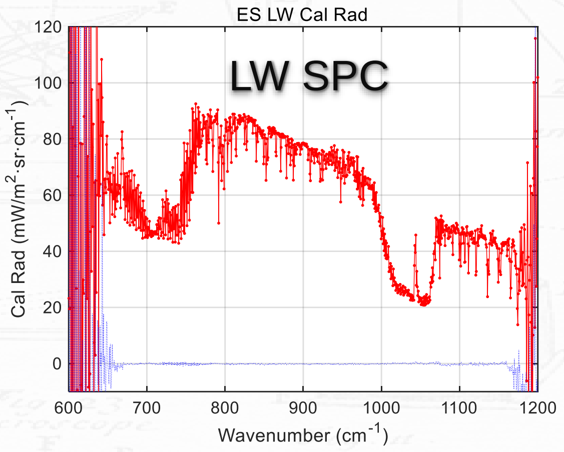
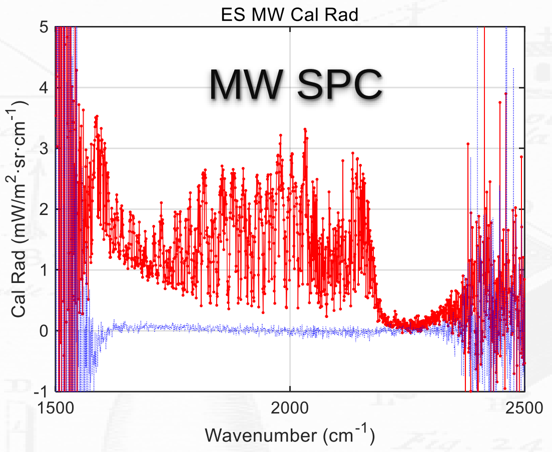
FY-4B/GIIRS Day-1 data check

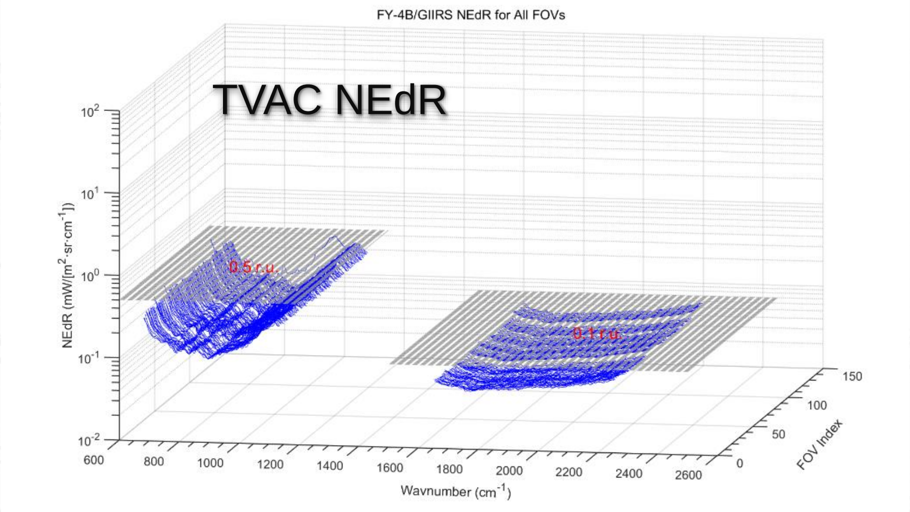
Day-One Data Check

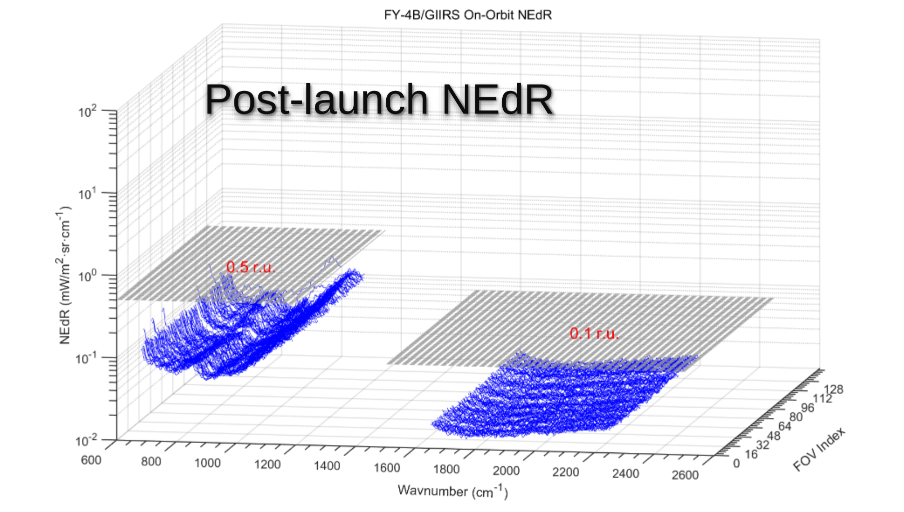






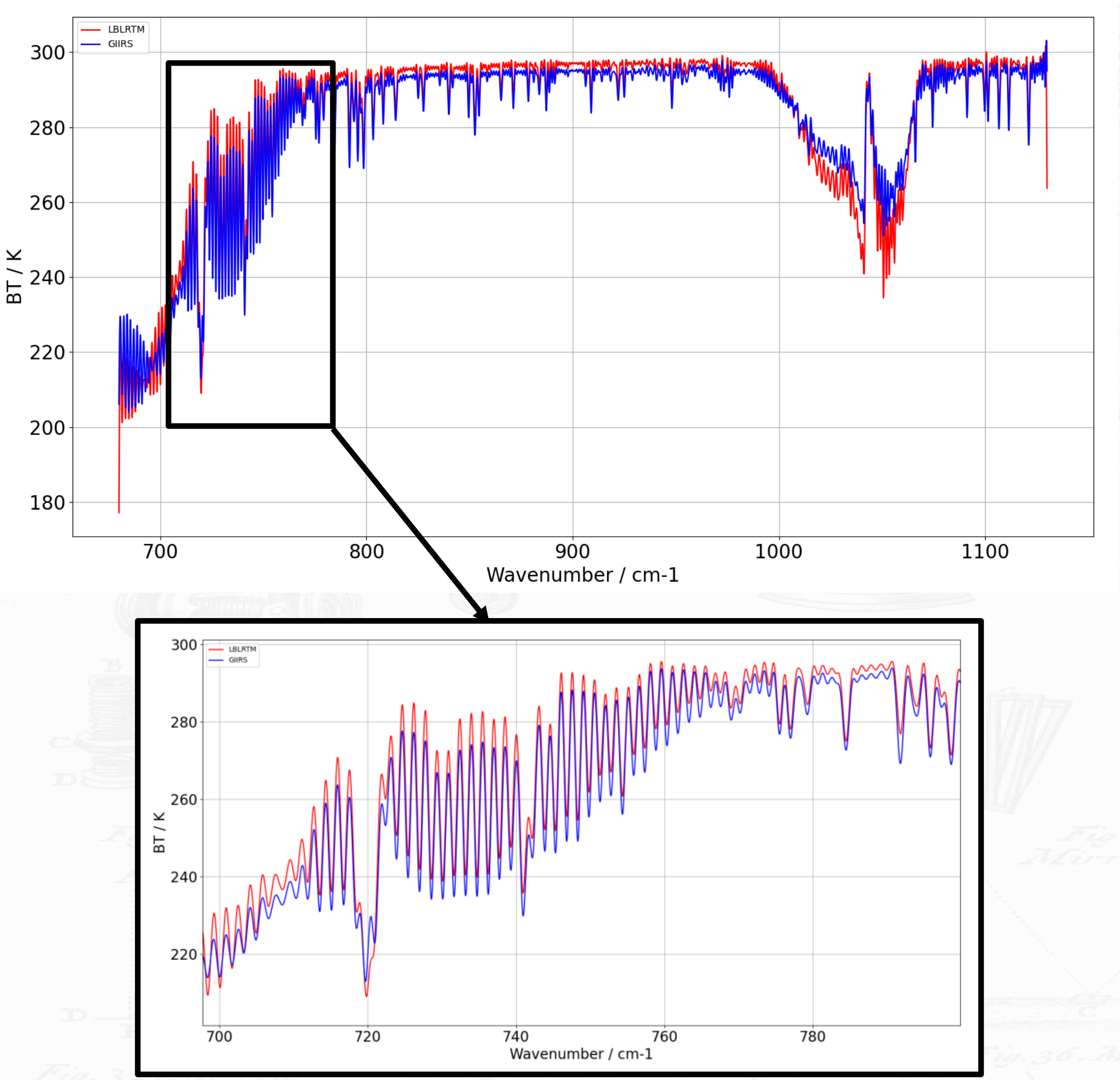




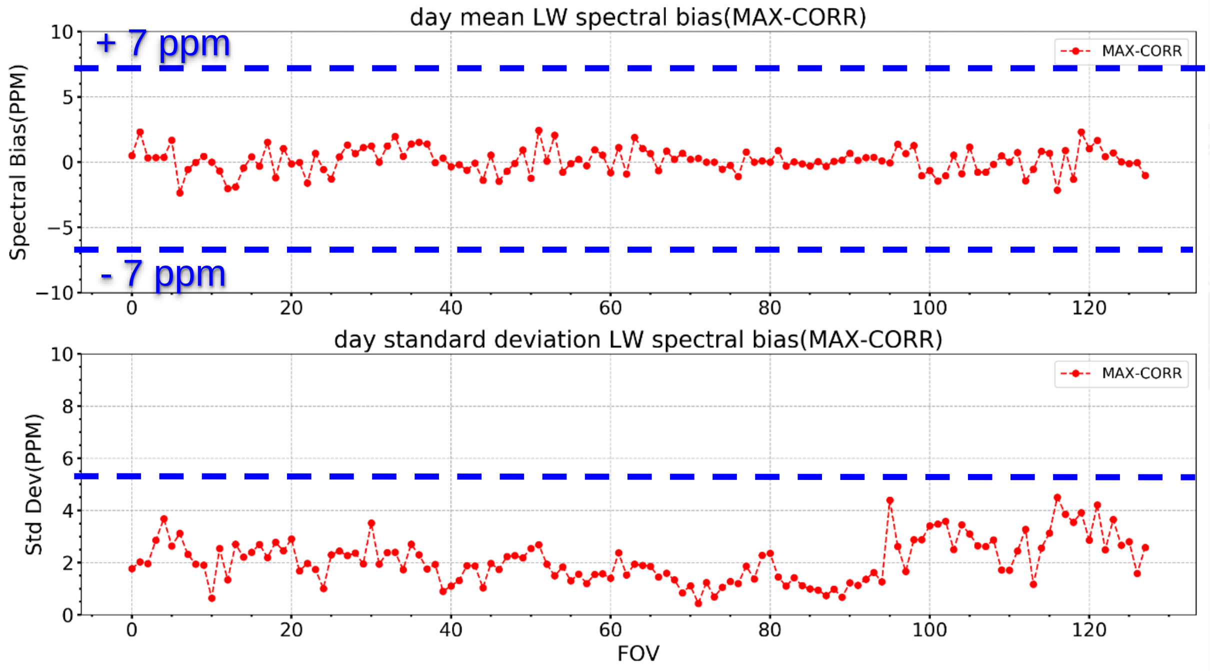


GIIRS on-board spectral calibration

based on LBL simulated spectra



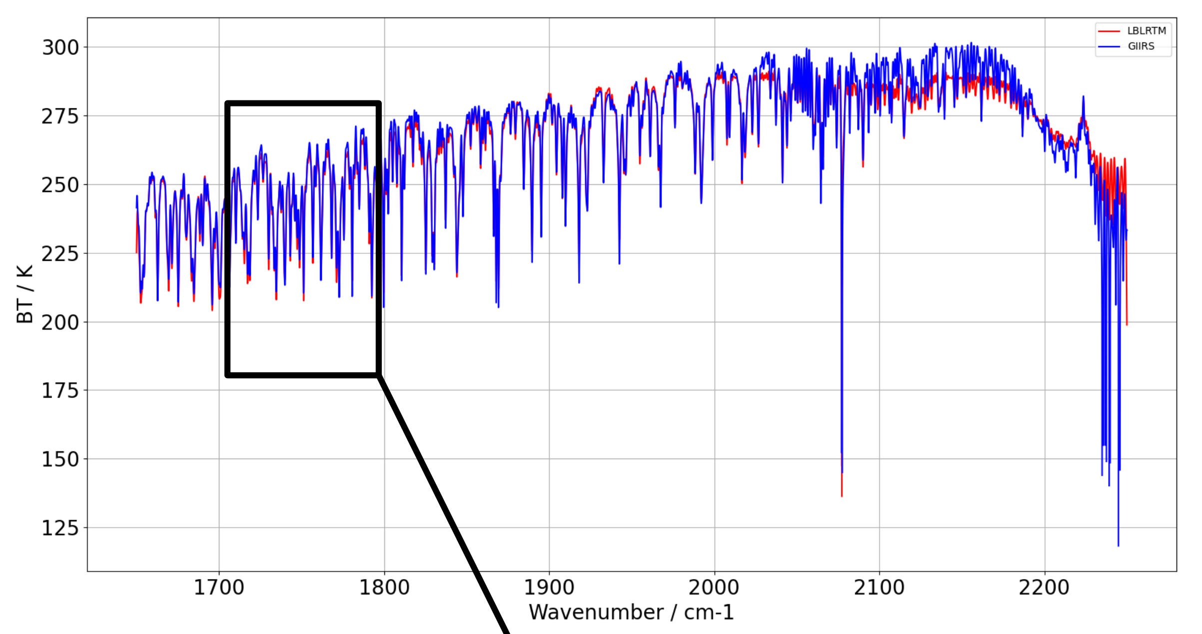
Take 2022.01.11 data for example

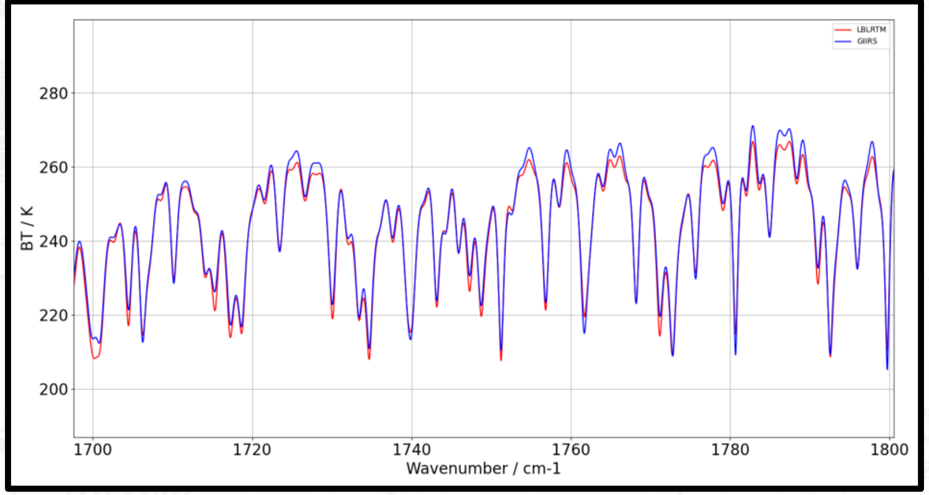


- FY-4B/GIIRS LWIR spectral calibration accuracy : within ±7 ppm (std. < 5ppm)

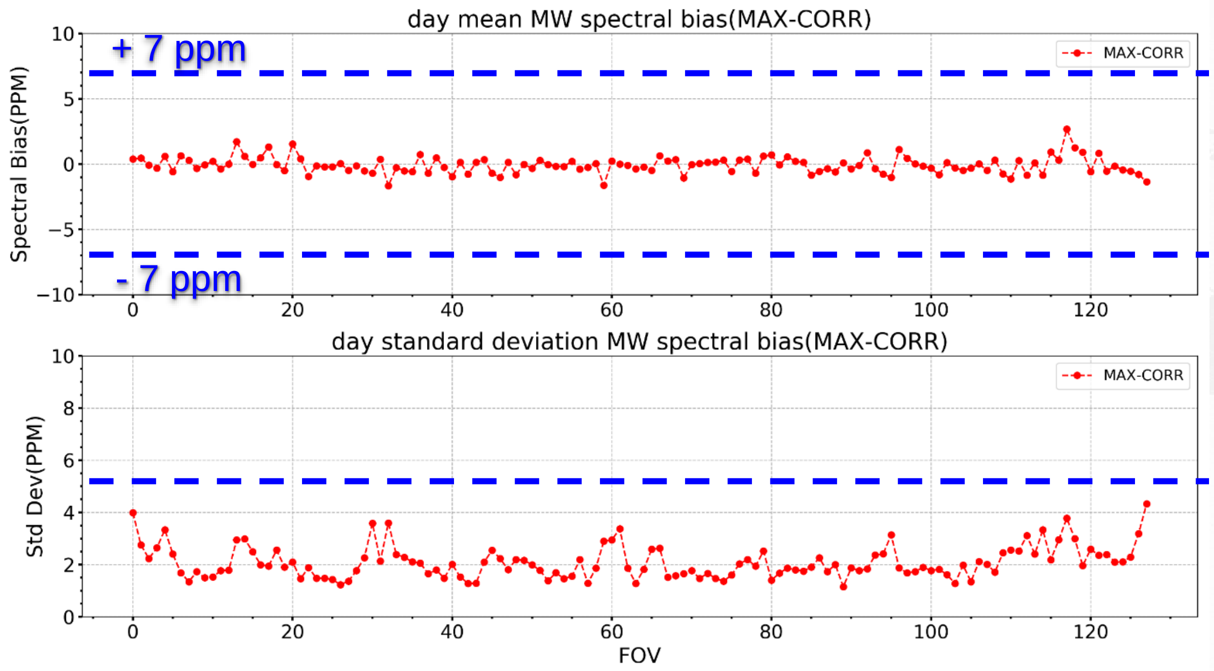
GIIRS on-board spectral calibration

based on LBL simulated spectra





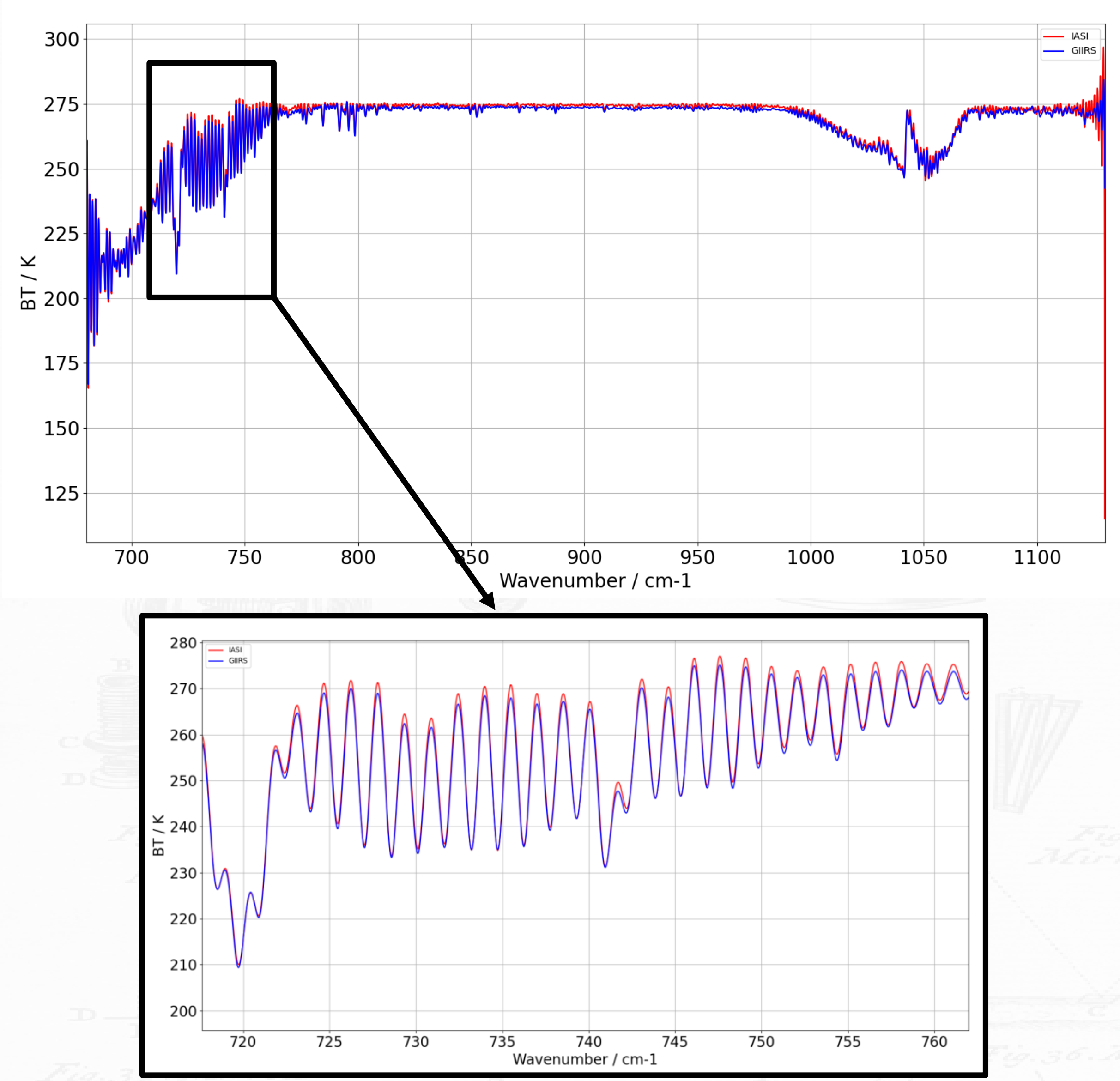
Take 2022.01.11 data for example



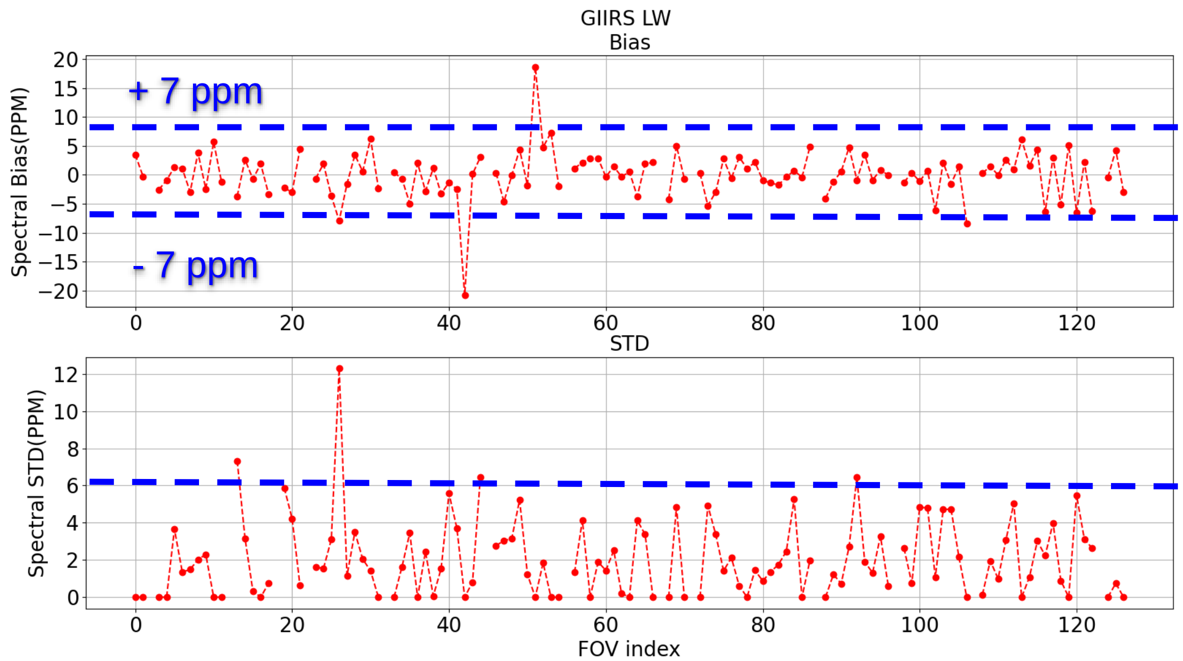
- FY-4B/GIIRS MWIR spectral calibration accuracy : within ±7 ppm (std. < 5ppm)

GIIRS on-board spectral calibration

based on SNOs spectra with IASI-C



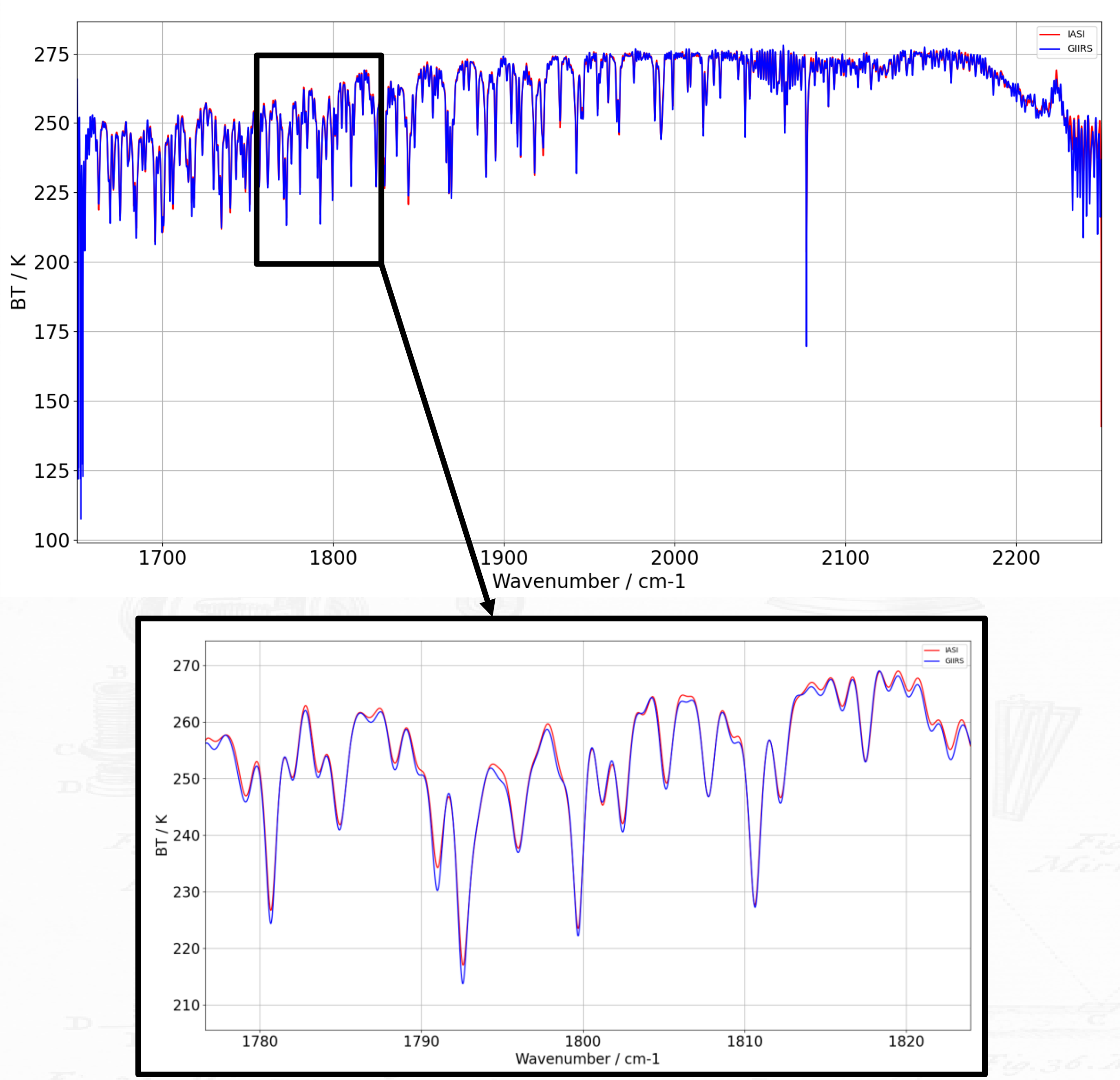
SNOs data 2022.02.22-24



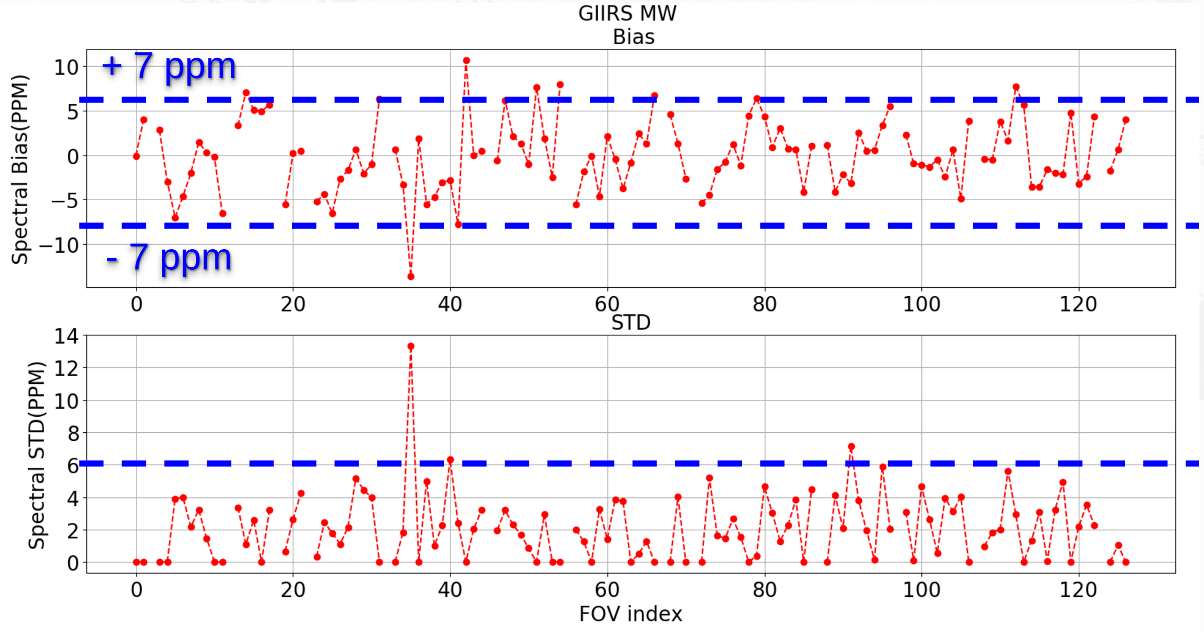
- FY-4B/GIIRS LWIR spectral calibration accuracy : most FOVs within ±7 ppm (std. < 6ppm)

GIIRS on-board spectral calibration

based on SNOs spectra with IASI-C

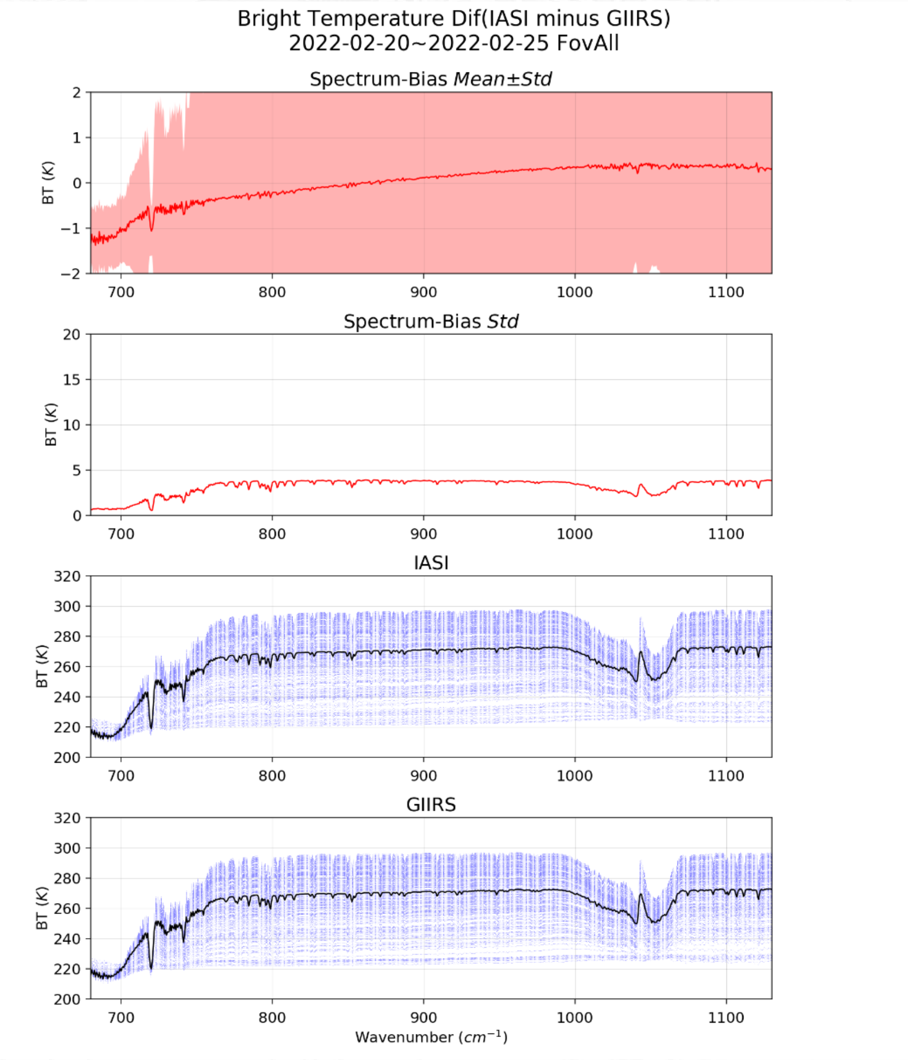


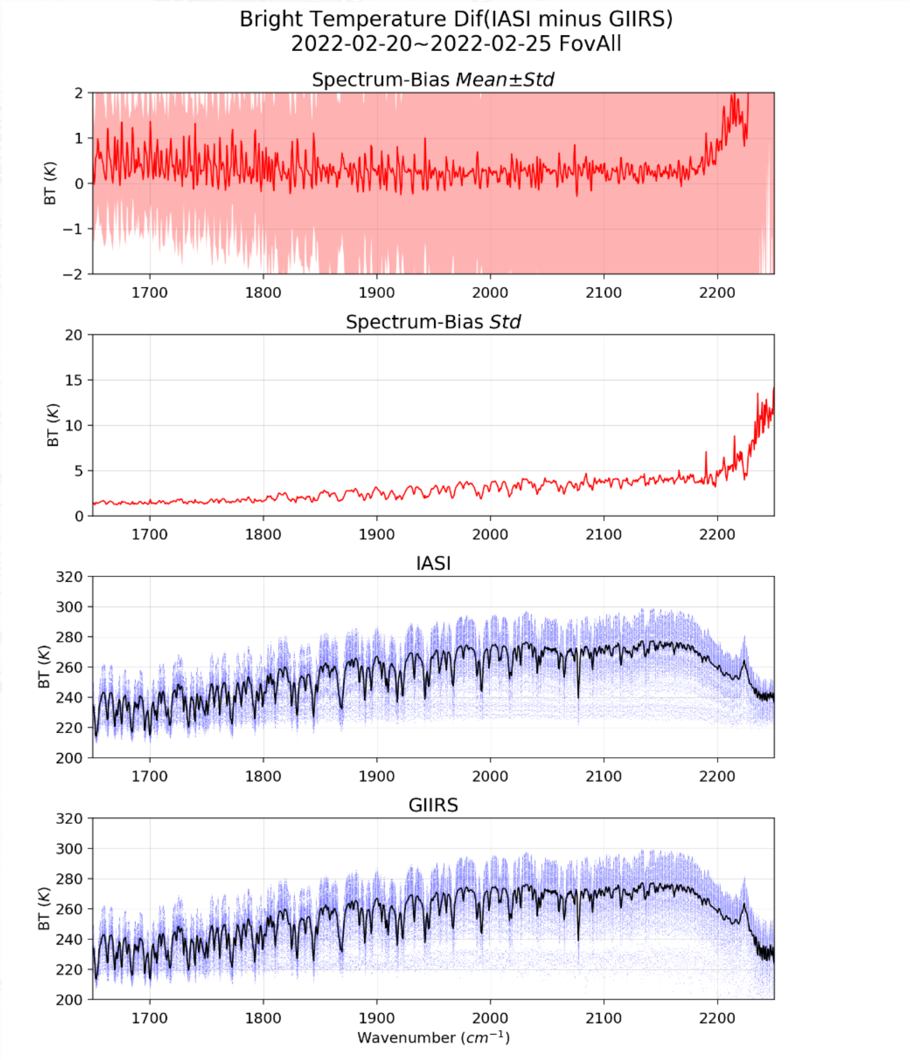
SNOs data 2022.02.22-24



- FY-4B/GIIRS MWIR spectral calibration accuracy : most within ±7 ppm (std. < 6ppm)

GIIRS on-board radiometric calibration

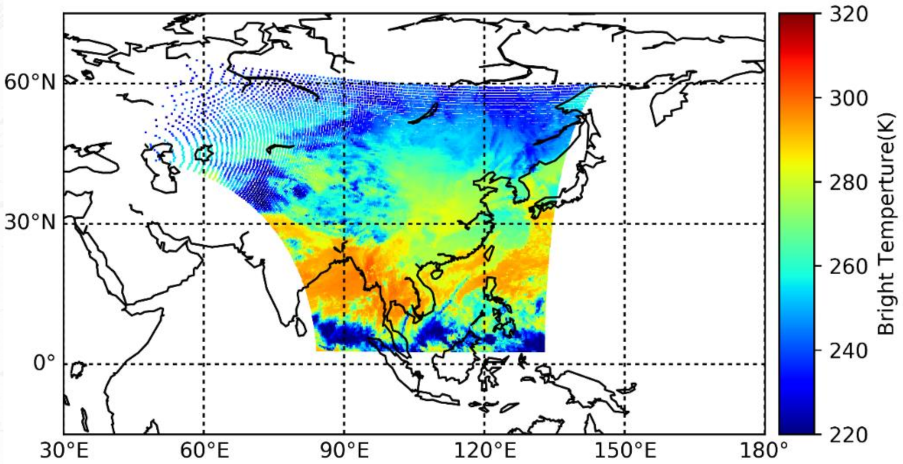




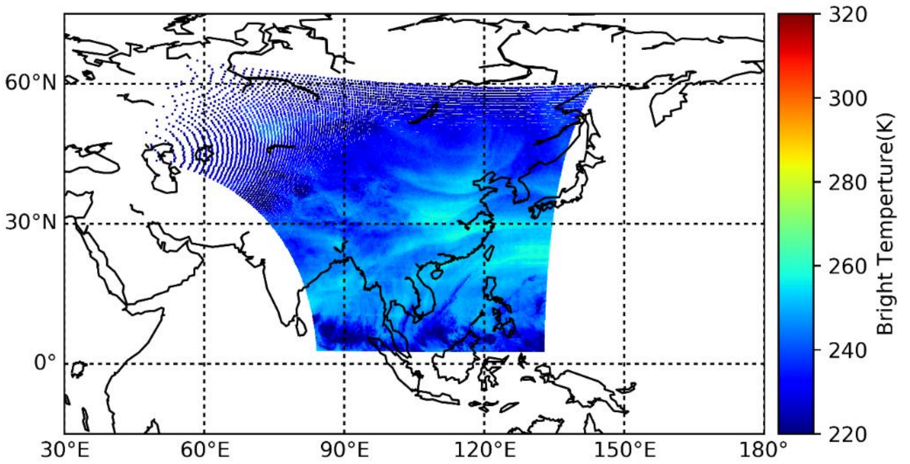
Just preliminaries, fine tuning is still under going.

GIIRS Brightness Temperature

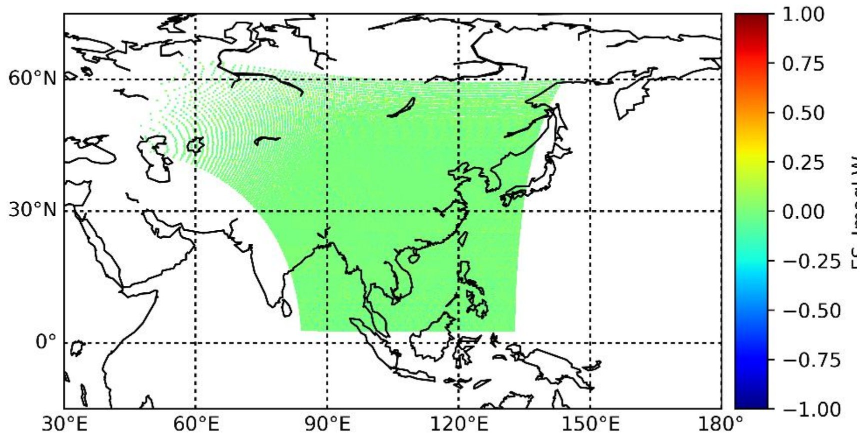
BT images in some channels



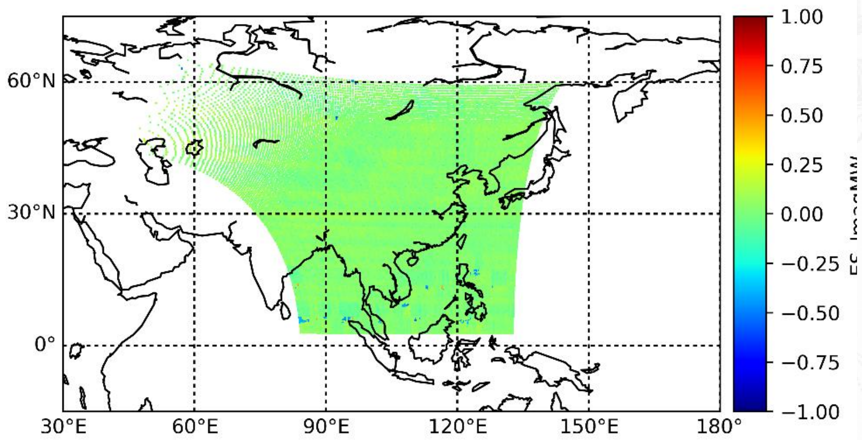
LW in 900 cm^{-1} channel



MW in 1870 cm^{-1} channel



Imag. Part



Imag. Part

Summary

All the results are the preliminaries in this phase

- **FY-3E/HIRAS-II**
  - — The spectral and radiometric calibration accuracy and stability need to be improved
  - — The long-term monitoring of sensor sensitivity and spectral responsivity (InsResp) are under going
- **FY-4B/GIIRS**
  - — The radiometric accuracy will be improved by adjusting the algorithm (such as LW nonlinearity correction)
  - — Spectral offset stability requires long-term monitoring (MW spectral calibration parameters need fine tuned)
  - — The long-term monitoring of sensor sensitivity and spectral responsivity (InsResp) are under going

Fin

Thank you for your time !

If you have any queries, please contact us at the address below.

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