Introduction and preliminary result of FY4B/GIIRS on-orbit test

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2021-11-03

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1、 Background

- ☐ The collection and completeness of observational data affect the accuracy of numerical weather forecasting.

  Satellite observations can obtain：

- ✓ Global observation data
- ✓ Three-dimensional vertical structure information of the atmosphere and its components
- ☐ Fine calibration is the prerequisite for its quantitative application

WMO proposes that the NWP goal in 2040 is to achieve a horizontal resolution of 1km, a vertical stratification of 180 layers, and a time resolution of 0.5 minutes. To meet the requirements of refined numerical weather prediction, the accuracy of satellite data calibration is critical.

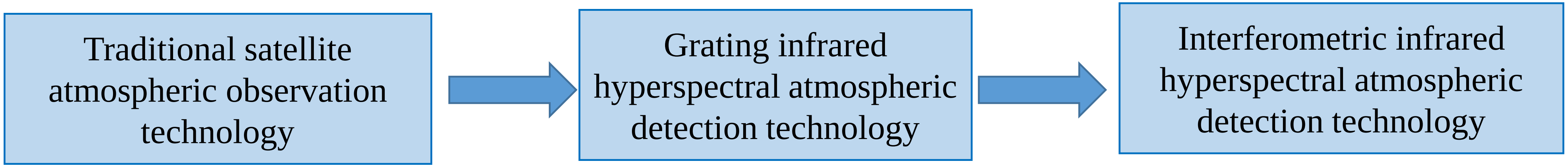
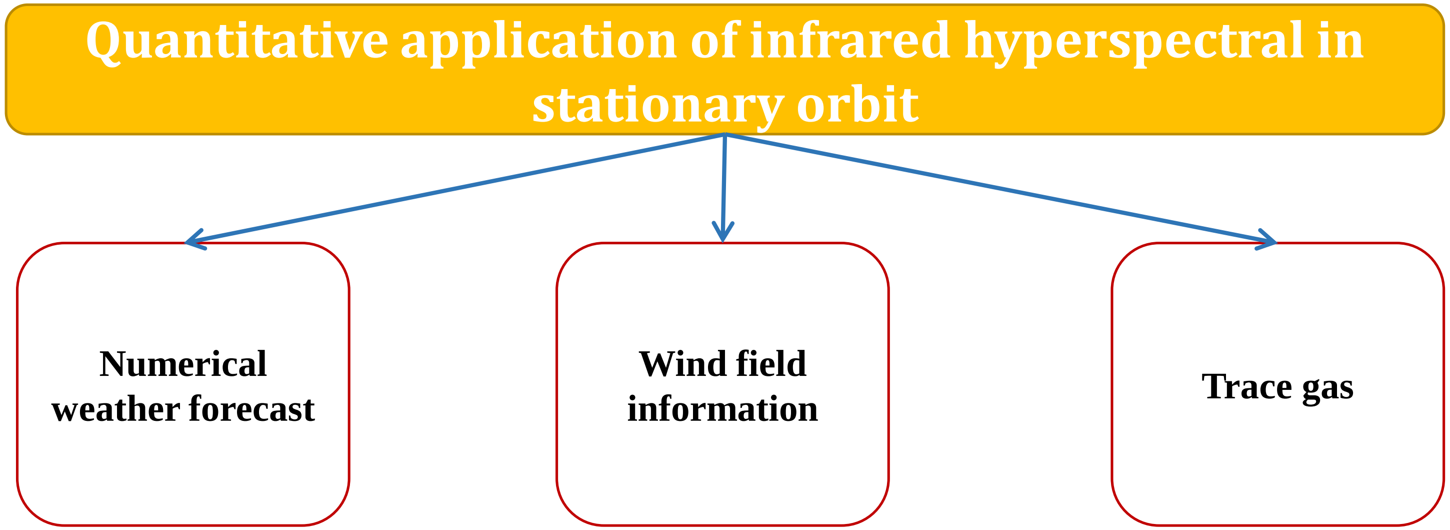


Figure 1 the development of infrared hyperspectral atmospheric detection technology

Features and advantages of infrared hyperspectral instruments for geostationary satellites

- Polar orbit infrared hyperspectrometer: global coverage, used for global numerical weather prediction and climate research, limitation is low time resolution
- Geostationary orbit infrared hyperspectrometer: small and medium-scale coverage of high-frequency observations, used for regional numerical forecasts and short-term forecasts, with the advantage of high time resolution



2、 Introduction of FY-4B/GIIRS

- The FengYun 02 satellite was successfully launched on June 3, 2021, and was successfully fixed on the equator at E123.5 degree on June 10, then officially names FY-4B.

- FY-4B/GIIRS is the first operational Geostationary instrument. It is a Michelson interferometric infrared hyperspectrometer, and is designed by Shanghai institute of technical physics Chinese academy of sciences.

➢ FY-4A/B GIIRS instrument details

	FY-4A/GIIRS	FY-4B/GIIRS
Spectral Range	LWIR:700cm^{-1}-1130cm^{-1} S/MIR:1650cm^{-1}-2250cm^{-1}	LWIR:680cm^{-1}-1130cm^{-1} S/MIR:1650cm^{-1}-2250cm^{-1}
Spectral resolution	0.625cm^{-1}	0.625cm^{-1}
Temporal Resolution	35min（1000*1000） 67min（5000*5000）	45min（5000*5000）
Sensitivity(mW/ m^{2}sr cm^{-1})	LWIR:0.5-1.1 S/MIR:0.1-0.14 S/N≥200 (ρ=100%)	LWIR:≤0.5 S/MIR:≤0.1 S/N≥200 (ρ=100%)
Calibration accuracy (radiation)	1.5K	0.7K
Calibration accuracy (spectrum)	10ppm	<10ppm
Spatial Resolution	L/S/MIR:16km VIS:2km	L/S/MIR:12km VIS:1km

FY-4B/GIIRS instrument characteristics has improved compared with that of FY-4B/GIIRS.

Spectral range

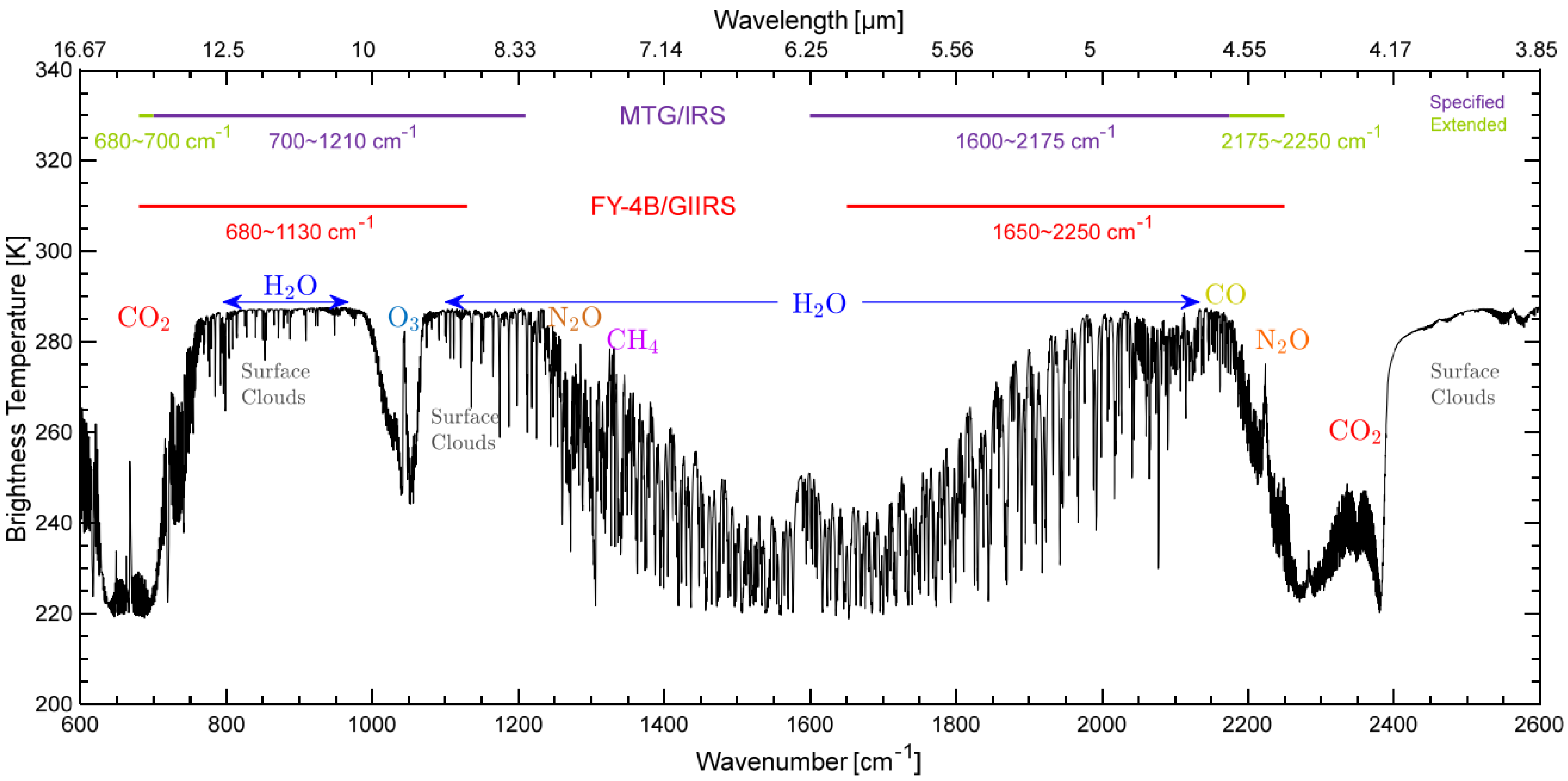


Figure 2 The spectral coverage of infrared hyperspectrometer

From Lu LEE et al. (2021) Prefight assessment of the FY-4B Geostationary Interferometric Infrared Sounder (GIIRS) Radiaometric Performance

➢ The change of the infrared detector array

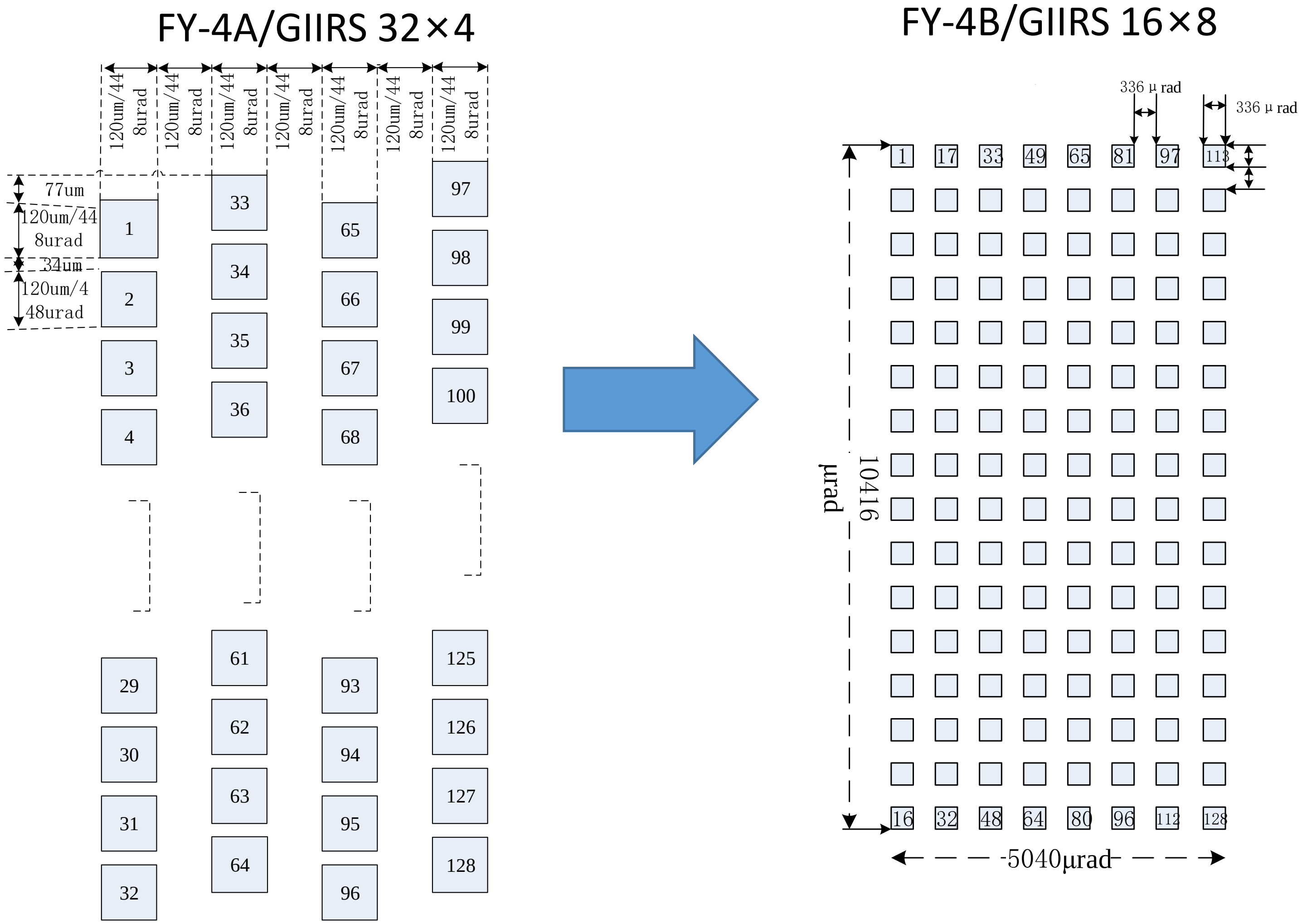


Figure 3 The change of the infrared detector array

The change of the infrared detector array has two advantages:

- ✓ Make full use of the field of view, and the field of view is more uniform
- ✓ Balance between the detection efficiency and spatial resolution

3、 Pre-launch calibration and TVAC data analysis

The pre-launch TVAC test aims to check the instrument performance, including NEdN, radiation calibration accuracy, spectral calibration accuracy.

TVAC test is includes two parts: the radiation calibration test and spectral calibration test.

- Radiation calibration test is carried in vacuum environment, and the Blackboard is a target.
- Spectral calibration test is in the gas pool (CO and NH3) and empty pool with gas.

The pre-launch test aims to check the instrument performance, including NEdN, radiantion calibration accuracy, spectral calibration accuracy.

NEdN

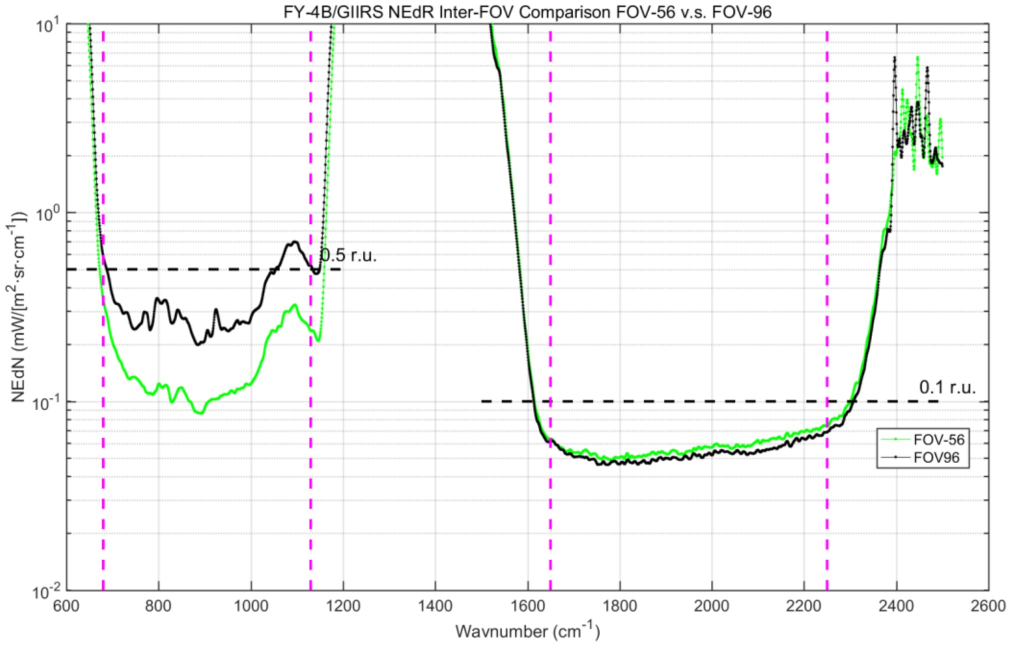


Figure 4 Sensitivity of long-wave and medium-wave detectors

The sensitivity of FOVs meet the requirement, except the sensitivity of FOV 96 exceed the requirements after 1100 cm-1

Radiation calibration accuracy

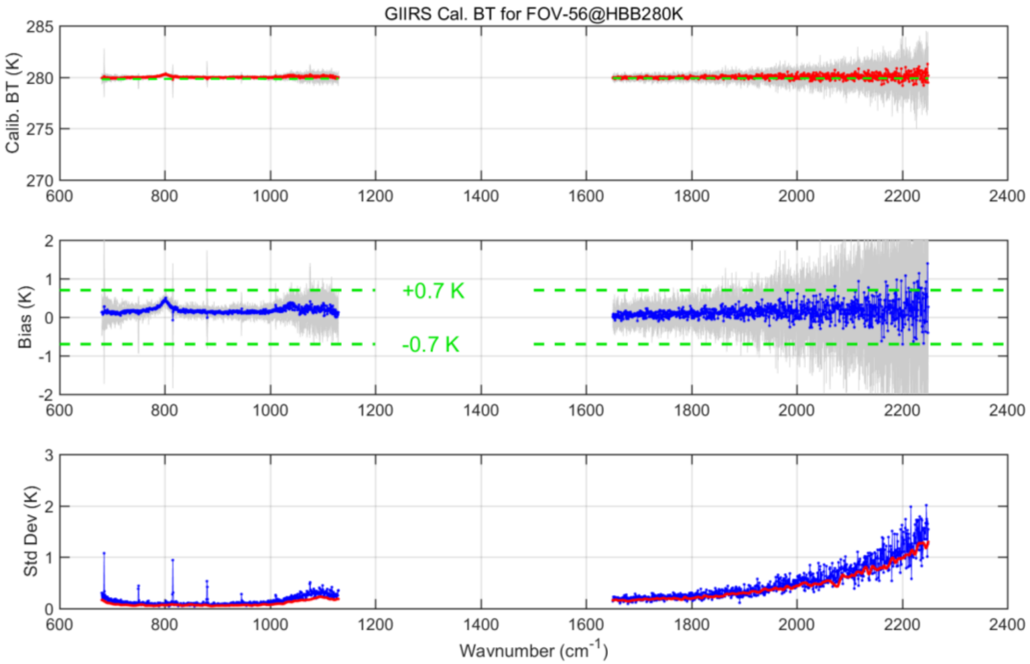


Figure 5 Radiation calibration accuracy

The radiation calibration accuracy of medium wave and long wave meets the index requirements (0.7K)

Spectral calibration accuracy

Comparison among the fine spectrum of observation transmittance before and after spectral calibration and IBL simulated fine spectrum at 0.001cm-1 spectral resolution.

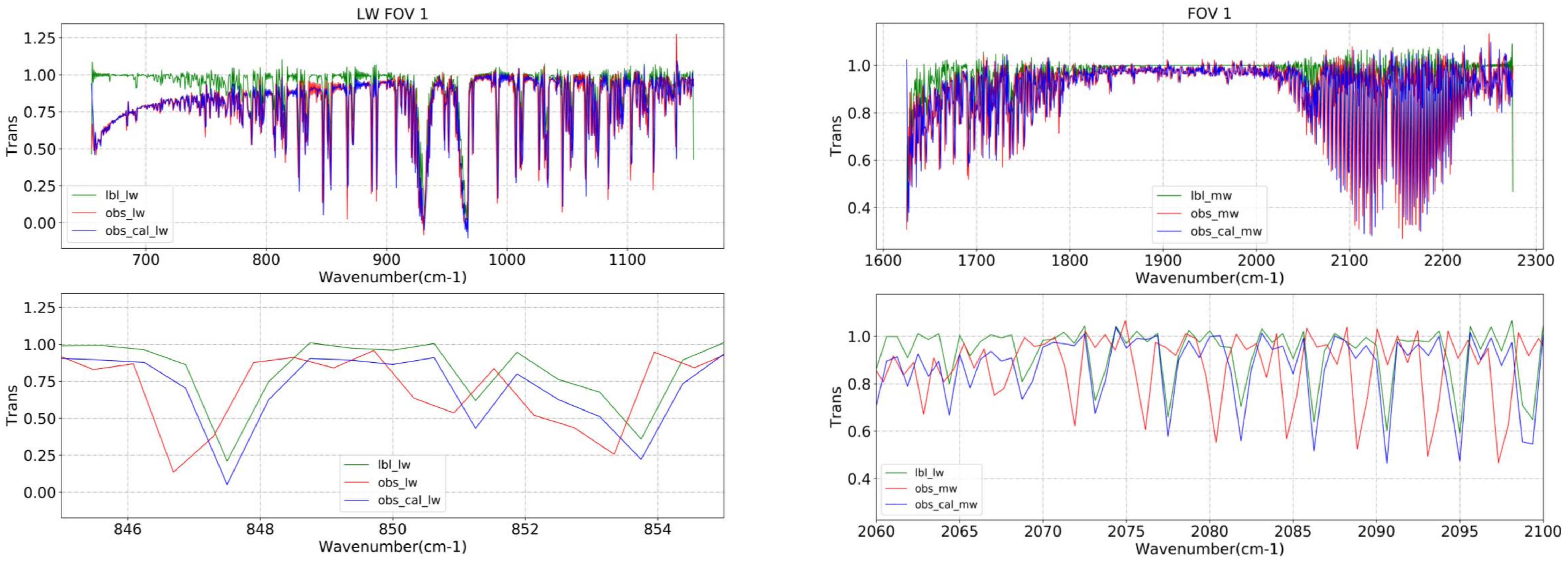


Figure 6 Comparison among the observation and simulated transmittance

The channel of the spectral calibration spectrum (blue line) is much closer to the IBL spectrum (green line) than original spectrum (red line).

Spectral calibration accuracy

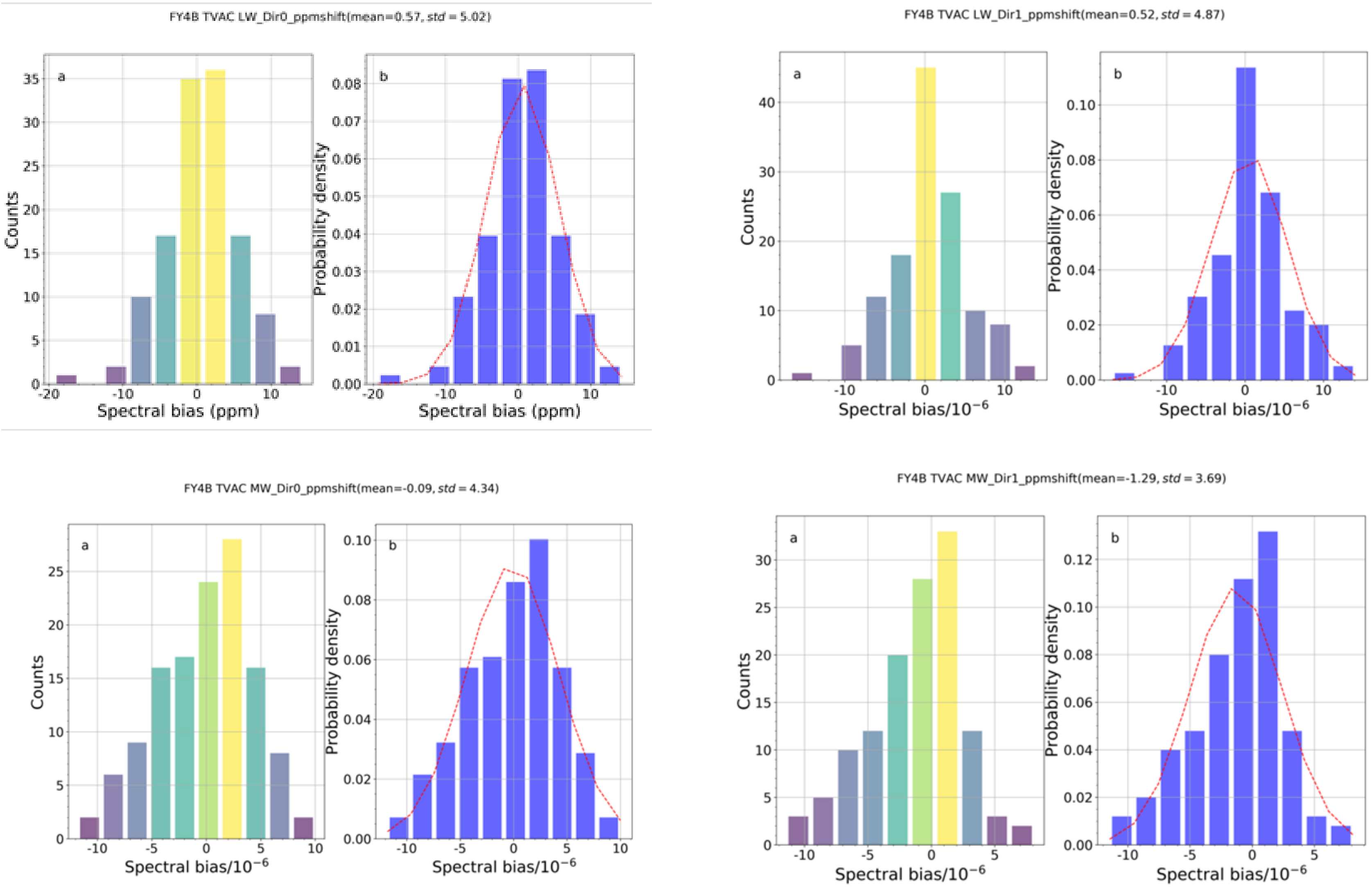


Figure 7 Spectral calibration accuracy

Evaluate the spectral calibration accuracy of LWDir0, LWDir1, MWDir0, MWDir1 using the observation data the LBL simulated data.

- ✓ The 96% of 128 detectors of LW and MW meet the index requirements (better than 10ppm)
- ✓ The first of each column has the bad performance.

▢ The non-linearity

Figure 8 Non-linear effects

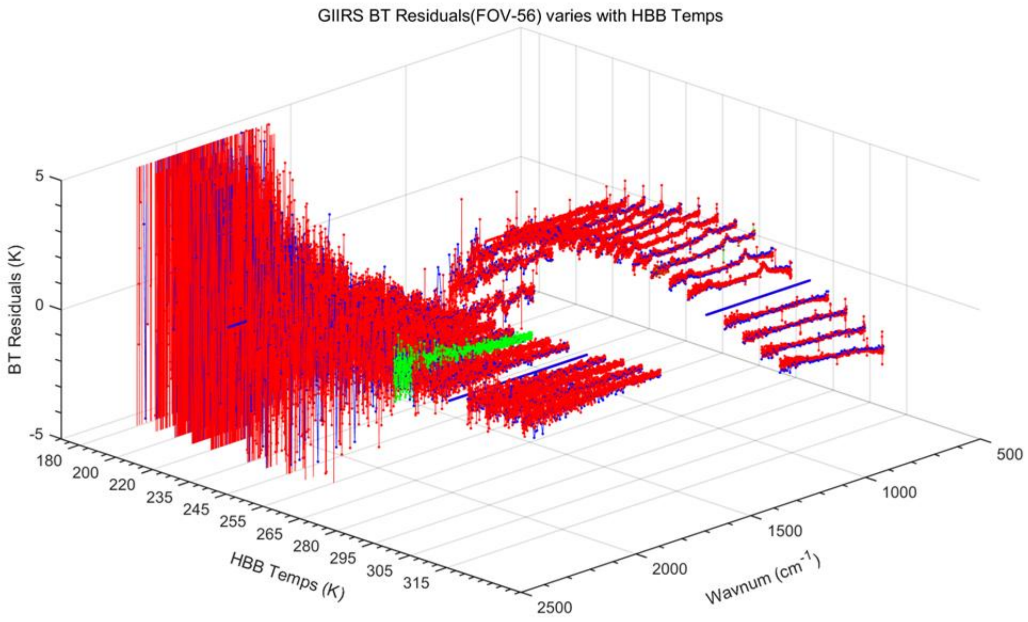
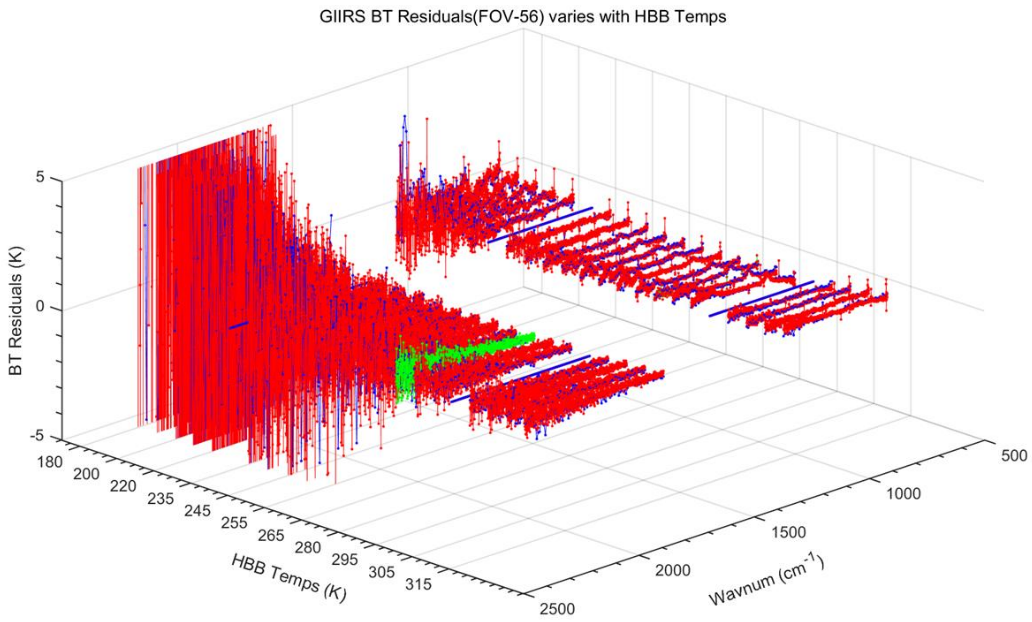


Figure 9 Nonlinear correction



The radiometric calibration results are as follows (take FOV-56 as an example):

- ✓ LW is affected by nonlinearity, and the calibration deviation shows a typical nonlinear deviation distribution with the HBB temperature;
- ✓ The overall linearity of the MW detector is good, but for the observation of low temperature targets below 220K, noise interference is great.

After the non-linear correction of the long-wave spectrum, the calibration deviation has been significantly improved.

4、The progress of FY-4B/GIIRS on-orbit test

The first stage of on-orbit test aim to debug the data processing system and evaluate instrument performance.

☐ Calibrated spectrum

The preprocessing algorithm can obtain the calibrated spectrum with the characteristics of the atmospheric spectrum

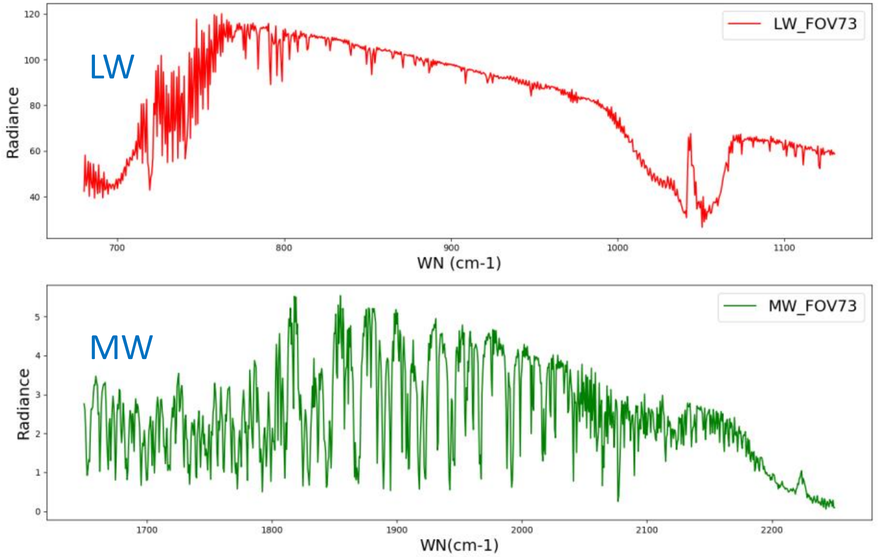


Figure 10 Calibrated spectrum of FY-4B/GIIRS

☐ Sensitivity

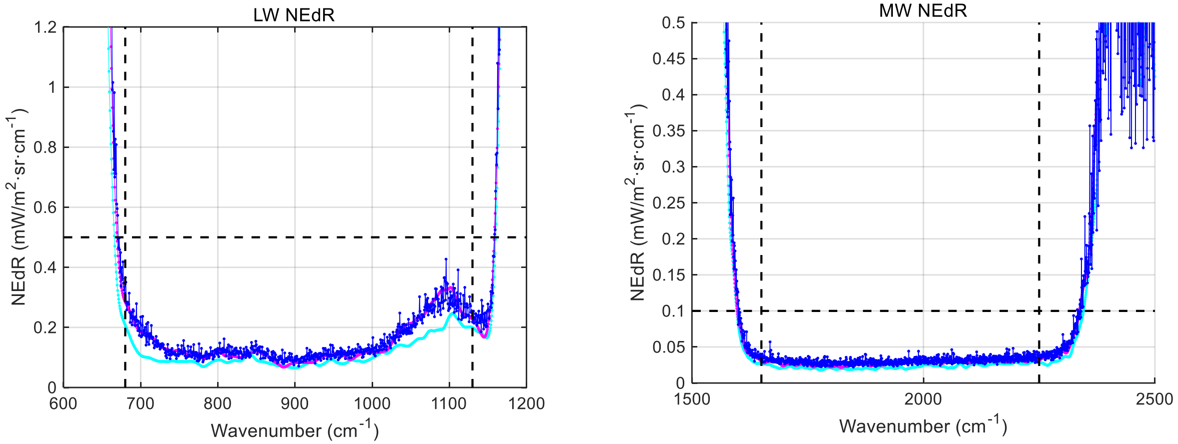


Figure 11 Sensitivity of FY-4B/GIIRS

The sensitivity of LW and MW on-orbit perform well, separately LWIR ≤0.5 mW/m^{2}sr cm^{-1} , NEdN for S/MIR ≤0.1 mW/m^{2}sr cm^{-1} , and is consistent with that pre-launch.

☐ Instrument response

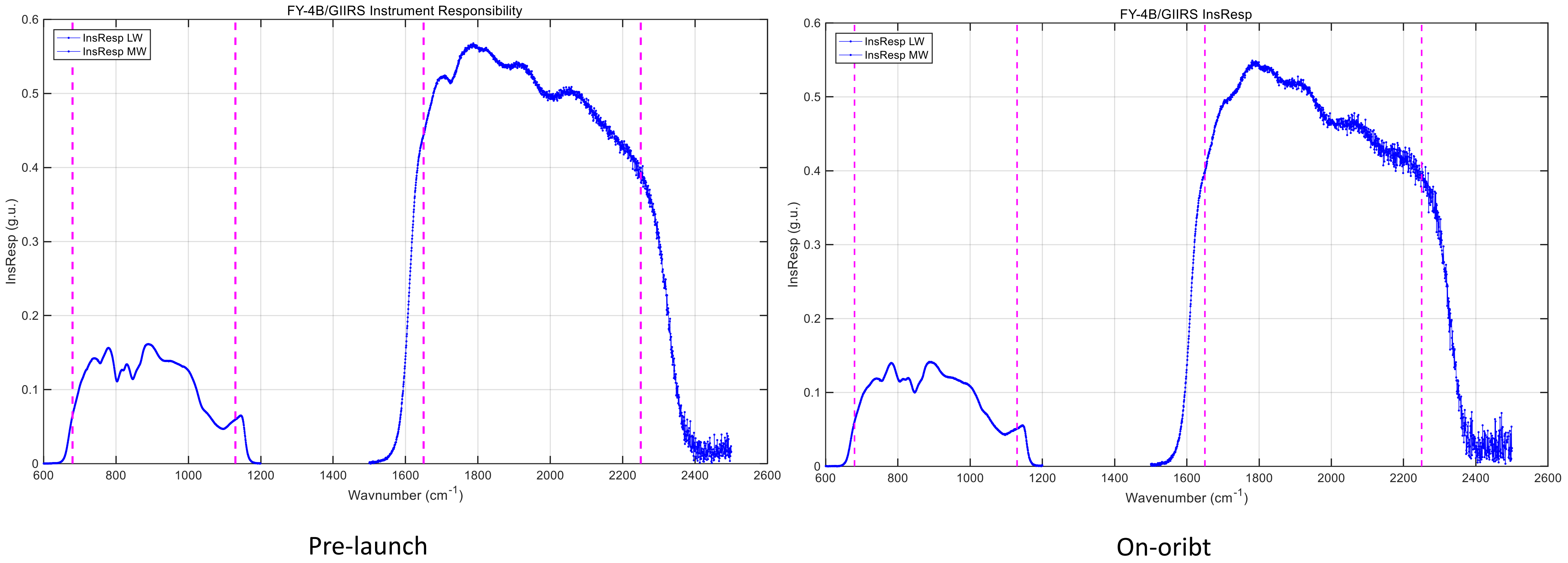


Figure 12 Comparison of Instrument response between pre-launch and on-oribt

The instrument response of LW and MW is consistent before and after launch

5、Summary

1、 **The FY-4B/GIIRS instrument performance is better than FY-4A/GIIRS, especially LWIR. NEdR, Calibration accuracy (radiation and spectral), spatial resolution, temporal resolution have improved significantly**. FY-4B/GIIRS is a operational instrument, and will play an important role in NWP and inversion of atmospheric temperature and humidity profile and so on .

2、 The pre-launch assessments of TVAC data exhibits that the instrument have good performance, including

- ✓ NEdN for LWIR ≤0.5 $mW/m^2 sr\ cm^{-1}$, NEdN for S/MIR ≤0.1 $mW/m^2 sr\ cm^{-1}$
- ✓ Radiation calibration accuracy <0.5k
- ✓ Spectral calibration accuracy is better than 10ppm

3、 The progress of FY-4B/GIIRS on-orbit test in the first stage

- ✓ Debug the data processing system, and obtain the calibration spectrum
- ✓ Preliminary assessment of instrument performance, and NEdN for LWIR ≤0.5 $mW/m^2 sr\ cm^{-1}$, NEdN for S/MIR ≤0.1 $mW/m^2 sr\ cm^{-1}$
- ✓ The instrument on-orbit performance has performed as well as that pre-launch

Thank you!