FY3E HIRAS-II and its pre-launch performance evaluation

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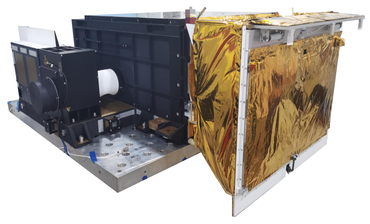
Introduction

FY-3E/HIRAS-II is the second infrared hyperspectral instrument in the FY-3 series of China's polar orbit meteorological satellite system. It will be carried on the early-morning orbit and provide the first infrared vertical sounding data of the early-morning orbit to the numerical prediction centers for global data assimilation application. The data will be used together with morning and afternoon orbit observation and will make new contribution to the accuracy improvement of numerical prediction.

FY-3E HIRAS-II pre-launch test was fulfilled and the instrument performance was evaluated, and the following conclusions are obtained: the sensitivity is significantly improved compared with FY-3D, meet the requirements. The scanning mirror is gold-plated, which greatly reduces the polarization effect. In the MW band, the linearity is obviously improved compared with FY-3D. Spectral calibration accuracy meet the requirement of 7ppm, most of which are better than 5ppm, and spectral resolution and Full Width at Half Maximum(FWHW) of ILS also meet the requirements. FY-3E will be launched at the end of June this year. At present, all the preparations for the satellite instruments and ground processing system have been completed. It is expected that the launch of FY3E will bring more benefits to satellite applications.

High Spectral Infrared Atmospheric Sounder

Based on the development of FY-3D satellite, HIRAS-II focuses on improving the detection sensitivity, spectral and radiative accuracy and service life of the instrument. The improvement of performance is conducive to the further improvement of temperature and humidity profile inversion accuracy. Compared with the FY-3D/HIRAS instrument, the observation time of each scan line of HIRAS-II is changed from 10 to 8 seconds, the view angle is changed from 1.1 to 1 degree and the corresponding nadir spatial resolution improved from 16 to 14 km, and the field of regards (FORs) of earth observation in each scan line are reduced from 29 to 28. In addition, the detector array is changed from 2×2 to 3×3. The observed spectra of the instrument are divided into three infrared bands: long wave (LW), medium wave (MW) and short wave (SW). The maximum optical path difference of the interferometer is 0.8cm, which will produce a basic resolution of 0.625cm-1.



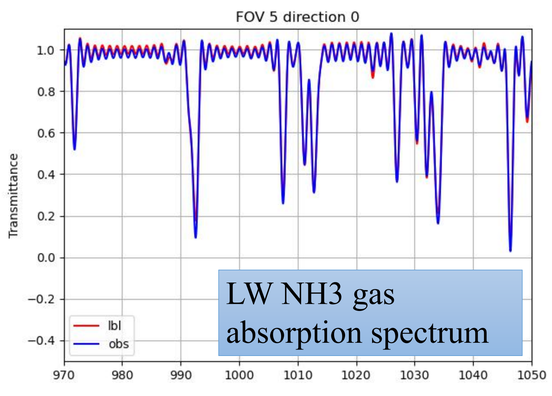
FY-3E/HIRAS-II

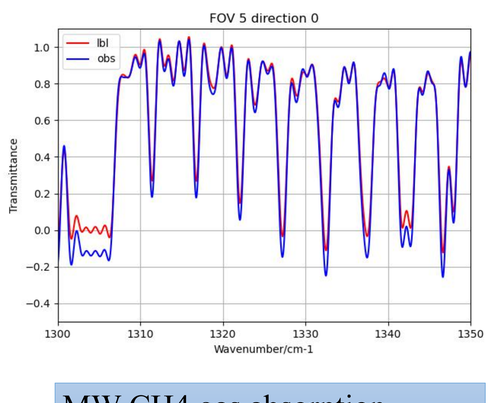
Instrument： Specification

Parameters	Specification(FY-3D)	Specification(FY-3E/F/H)
Scan angle	50.4 Deg	50.4 Deg
Pixels per scan line	29*4	28*9
view angle	1.1 Deg	1 Deg
Nadiv spatial resolutinon	16 Km	14 Km
Scan period	10 s	8 s
Detectors arrangement	2 × 2	3 × 3
Pointing precision	0.1 Deg	0.06 Deg
Pointing stability	/	0.45 Mrad

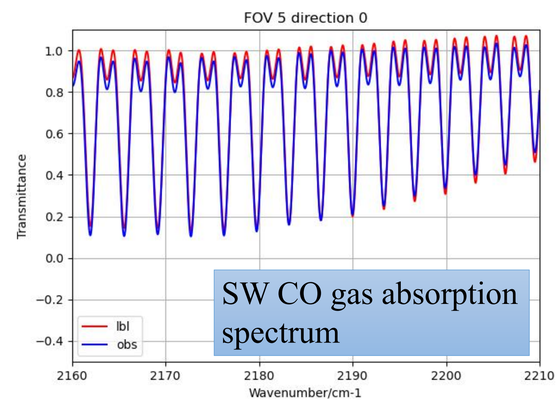
Band	Spectral range(cm^{-1}) (FY-3D/E/F/H)	Spectral relolution(cm^{-1}) (FY-3D/E/F/H)	(NEΔT@280K) FY-3E/F/H		FY-3D	Calibration accuracy Minimum/Expected FY-3E/F/H	FY-3D	Spectral accuracy （ppm） Minimum/Expected FY-3E/F/H	FY-3D
LWIR	650 ~ 1135 (15.38μm ~ 8.8 μm)	0.625(DR) 0.625(FR)	650 ~ 667 cm^{-1}	0.8K	0.4K	1K/0.8K	1K/0.7K	10 ppm	7 ppm /5 ppm
			667 ~ 689 cm^{-1}	0.4K		0.5K/0.4K			
			689 ~ 1000 cm^{-1}	0.2K		0.4K/0.3K			
			1000 ~ 1136 cm^{-1}	0.4K		0.5K/0.4K			
MWIR	1210 ~ 1750 (8.26μm ~ 5.71 μm)	1.25(DR) 0.625(FR)	1210 ~ 1538 cm^{-1}	0.2K	0.7K	0.4K/0.3K			
			1538 ~ 1750 cm^{-1}	0.3K		0.5K/0.4K			
SWIR	2155 ~ 2550 (4.64μm ~ 3.92 μm)	2.5(DR) 0.625(FR)	2155 ~ 2300 cm^{-1}	0.3	1.2K	0.5K/0.4K			
			2300 ~ 2550 cm^{-1}	0.5		0.6K/0.5K			

HIRAS-II Spectral calibration





MW CH4 gas absorption spectrum

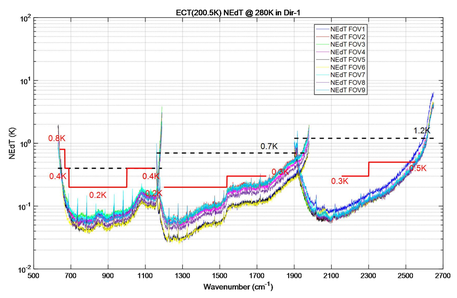


- LBL calculated transmittances are consistent with measurement transmittance.
- Generate the spectral correction parameters that will be used in orbit based on pre-launch gas pool test data.

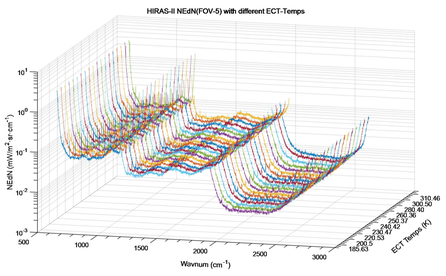
Detector		FOV1 (ppm)	FOV2 (ppm)	FOV3 (ppm)	FOV4 (ppm)	FOV5 (ppm)	FOV6 (ppm)	FOV7 (ppm)	FOV8 (ppm)	FOV9 (ppm)
LW	gas pool observation	0.43	3.01	1.70	0.98	1.58	0.72	0.44	0.79	0.89
	laser observation	-2.7	1.8	2.03	2.47	4.73	1.88	3.41	6.8	4.3
MW	gas pool observation	1.16	1.03	5.54	2.13	0.73	1.19	2.36	2.20	2.10
	laser observation	-1.32	-1.68	-6.10	-5.74	-2.56	-2.56	-6.95	-4.22	-6.26
SW	gas pool observation	1.75	1.18	4.8	1.3	1.14	2.99	-6.24	0.64	-5.07
	/	/	/	/	/	/	/	/	/	/

- Adjust off-axis parameters and verify spectral bias using gas pool and laser observation.
- Spectral frequency bias are within 7 ppm after off-axis parameters adjustment in LW, MW and SW bands.

NEdT of HIRAS-II

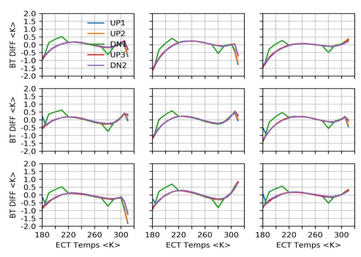


- NEdTs of all channels for 3 bands get great improvement from 3D HIRAS and meet specification.

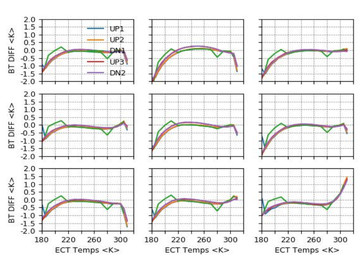


- NEdTs for different ECT temperature.
- NEdTs are stable and without obvious dependency on object temperature.

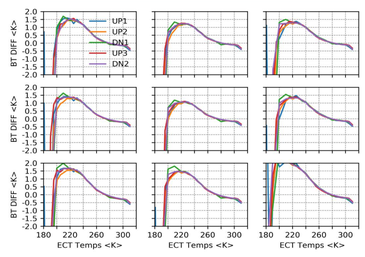
LW channel calibration bias / K



MW channel calibration bias / K



SW channel calibration bias / K



- LW and MW exhibit obvious Non-Linerity characteristics.
- After NL correction, LW and MW channels calibration biases are within 0.5 K.
- SW without NL correction, but displays abnormal large bias structure due to weak sigal and large noise for object temperature of less than 260 K.

Conclusions

- ❖ Sensitivity of HIRAS-II for 3 bands get great improvement from 3D HIRAS.
- ❖ Spectral calibration bias are within 7ppm, most detectors are better than 5ppm and meet requirement.
- ❖ LW and MW bands still exbihit strong NL characteristics.
- ❖ Polarization effects are evaluated based on TVAC test, calibrated brightness temperature biases varies with the scanning Angle within 0.1K for 290 K blackbody object, need more verification work using on-orbit data.