中 国 气 象 局
China Meteorological Administration

国家卫星气象中心
National Satellite Meteorological Centre

Commissioning test results of FY-3E early morning satellite

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Contributions from C. L. Qi, J. Shang, J.Y. Hu, Y. Guo, L. H. Xu, J. Qi, G. L. Yang, T. Mao, C. Huang, J. P. Dun, L. Wang, C. Q. Wu, H. Qiu, F. L. Dou, S. L. Wu, J. W. sLi, et al.

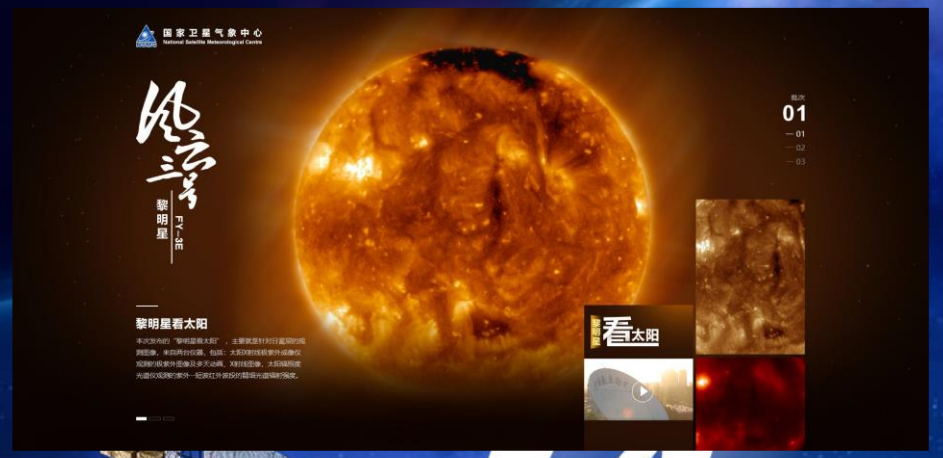
National Satellite Meteorological Center, CMA

GSICS Annual Meeting, March 14-18, 2022

Outline

PART 01

FY-3E overview

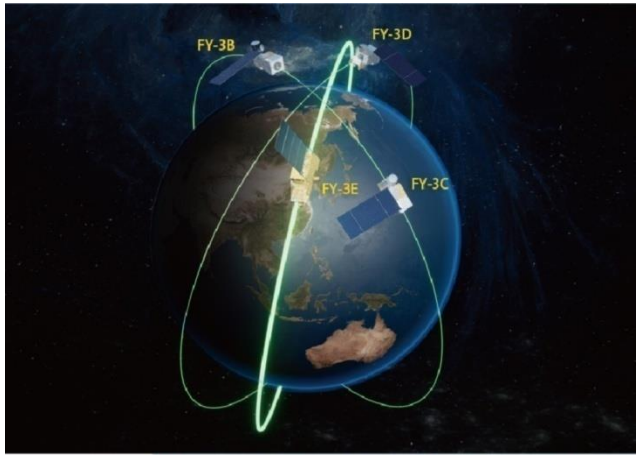


First operational meteorological satellite in an early morning orbit for civil use.

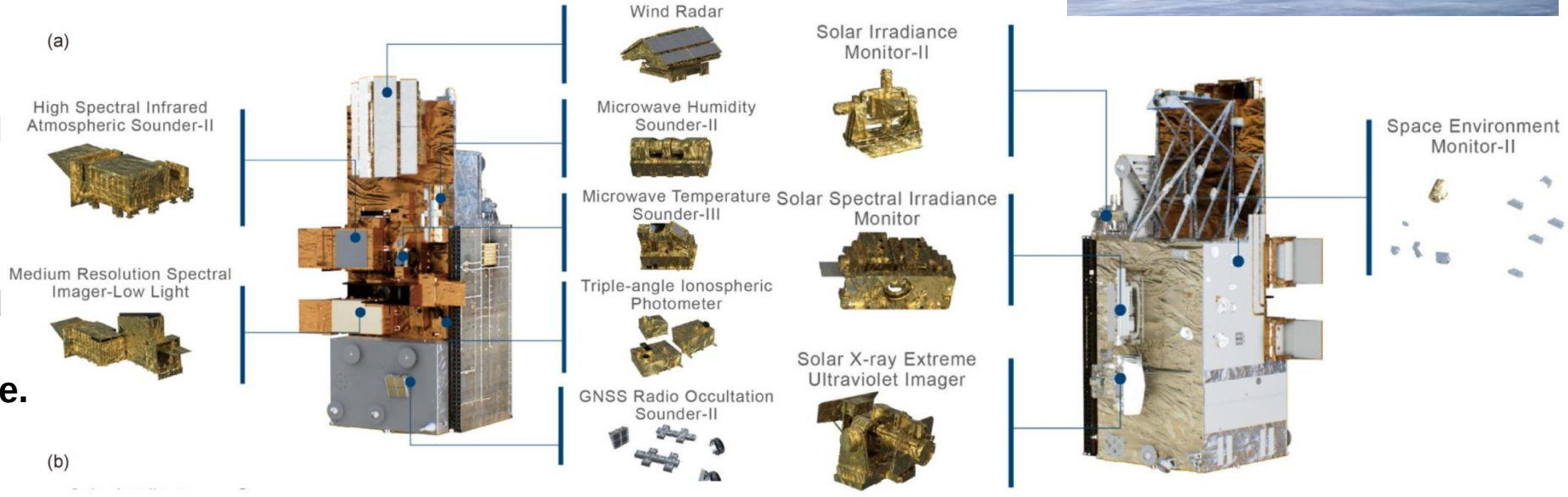
launched time: July 5, 2021

Local equator crossing time: 5:40 AM

No.	Group	Instrument
1	Optical Imager	Medium Resolution Spectral Imager-Low Light (MERSI-LL)
2	Passive Microwave Sounder	Microwave Temperature Sounder-III (MWTS-III)
		Microwave Humidity Sounder-II (MWHS-II)
3	GNSS Occultation & Reflection	GNSS Radio Occultation Sounder(GNOS-II)
4	Active Microwave	Wind Radar (WindRAD)
5	Hyperspectral Sounder	High Spectral Infrared Atmospheric Sounder-II (HIRAS-II)
6	Solar Irradiance Observation	Solar Irradiance Monitor-II (SIM-II)
		Solar Spectral Irradiance Monitor (SSIM)
7	Space Weather Sensor	Space Environment Monitor-II (SEM-II)
		Triple-angle Ionospheric Photometer (Tri-IPM)
		Solar X-ray and Ultraviolet Imager (X-EUVI)

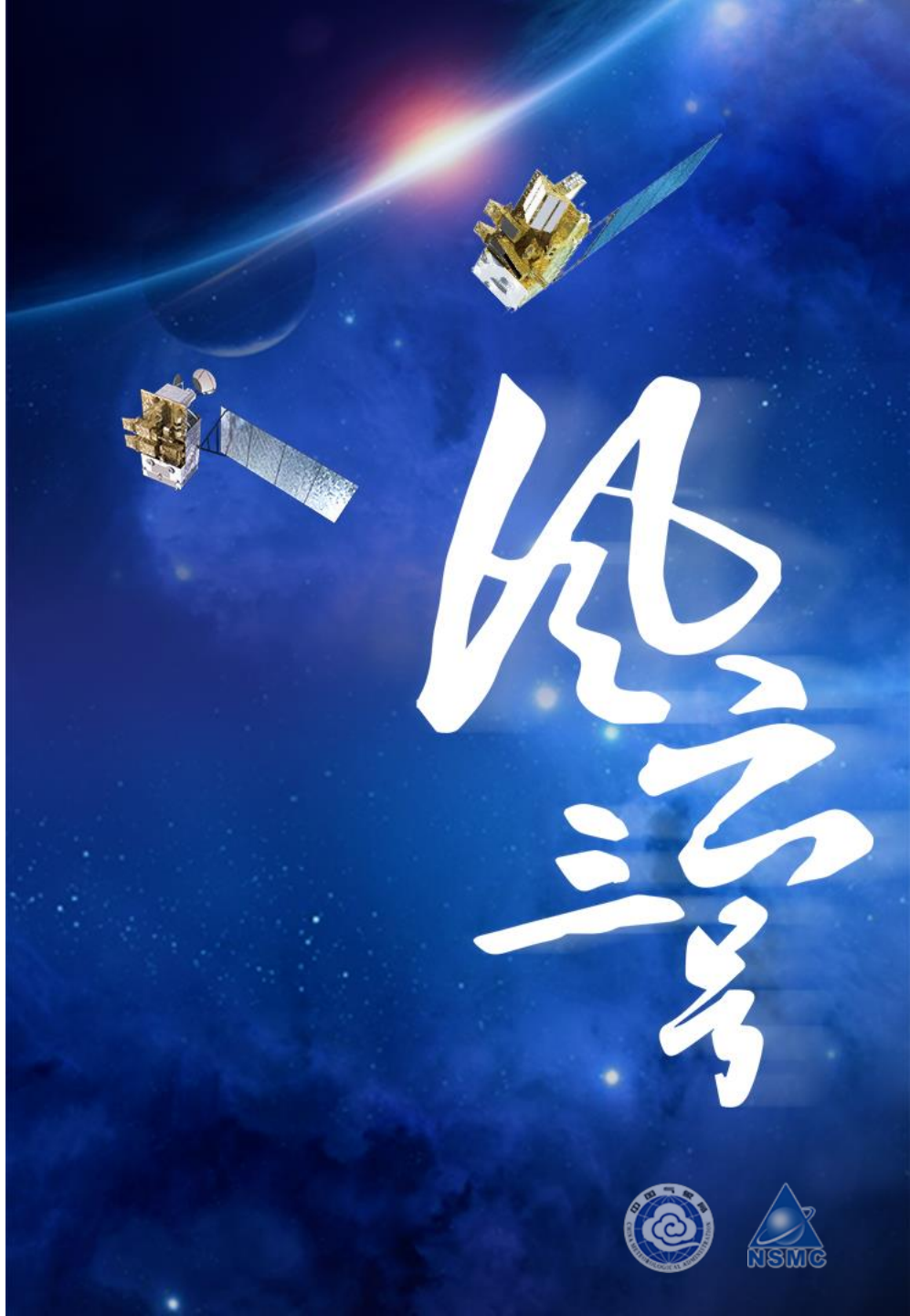


- FY-3E together with the mid-morning and afternoon satellites provides an optimal temporal distribution.
- NWP communities will significantly benefit.
- Further benefits are expected in severe weather/climate events monitoring and climate.



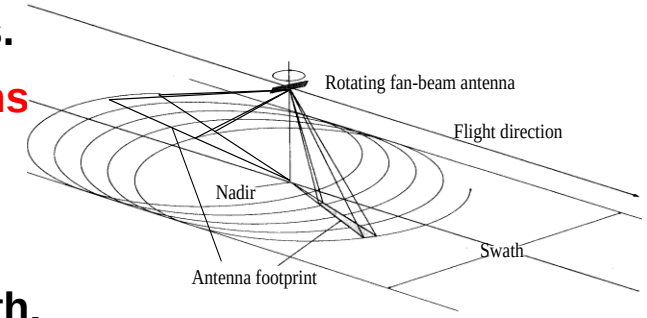
PART 02

Instrument performance



Wind Radar (WindRAD)

- The first active remote sensing instrument of Fengyun series.
- Dual-frequency: C & Ku band, both with VV & HH polarizations
- Advanced rotating fan-beam.

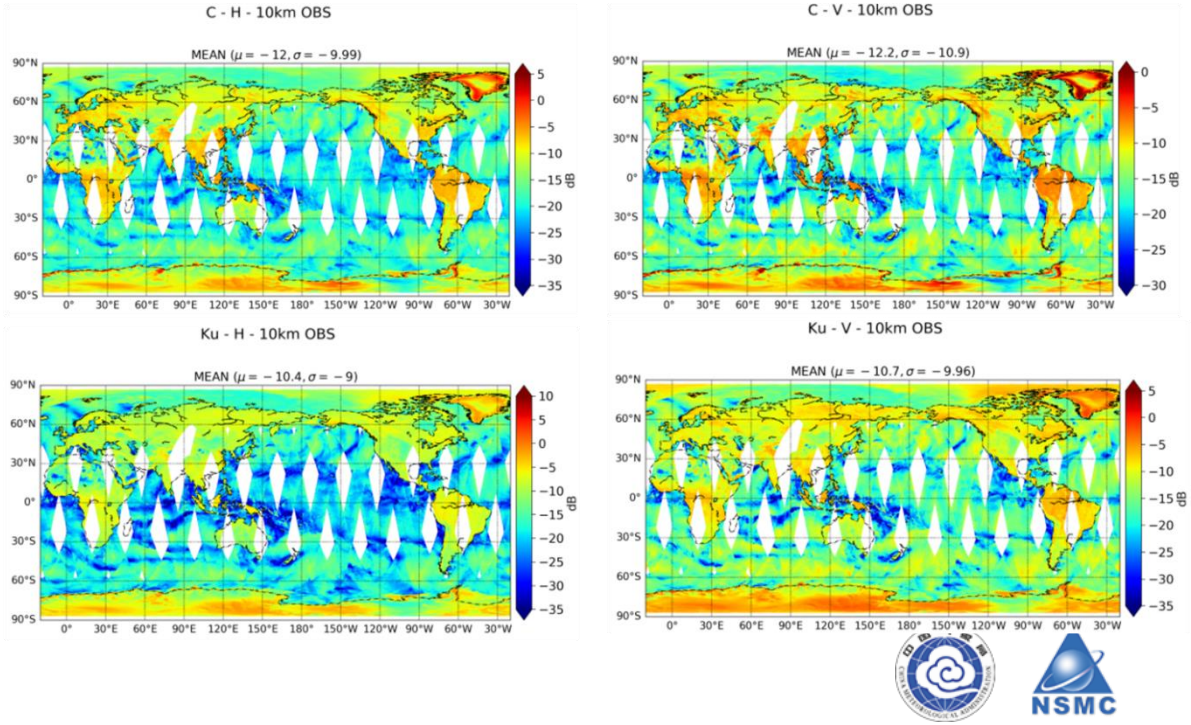


- Powered on time: July 9, 2021
- 10 items were tested including spatial resolution, swath width, minimum detectable wind speed, radiometric resolution, internal calibration accuracy, observation accuracy and important telemetry parameters.
- Instrument status is quite stable.

Instrument specification

Parameter	Metric	
Frequency	5.4 GHz （C band）	13.256 GHz （Ku band）
Polarization	VV、HH	VV、HH
Spatial resolution (azimuth×range)	25 ×0.5km	10 ×0.5km
Swath	> 1200km	
Scanning mode	360° conical scanning	
Minimum detectable wind speed	3 m/s(-26.2dB)	3 m/s(-30.8dB)
Radiometric resolution	0.5dB （wind speed≥5 m/s） 1.0dB （wind speed = 3 m/s）	
Radiometric accuracy	≤ 0.6dB	

Earth surface backscattering products (20220303)



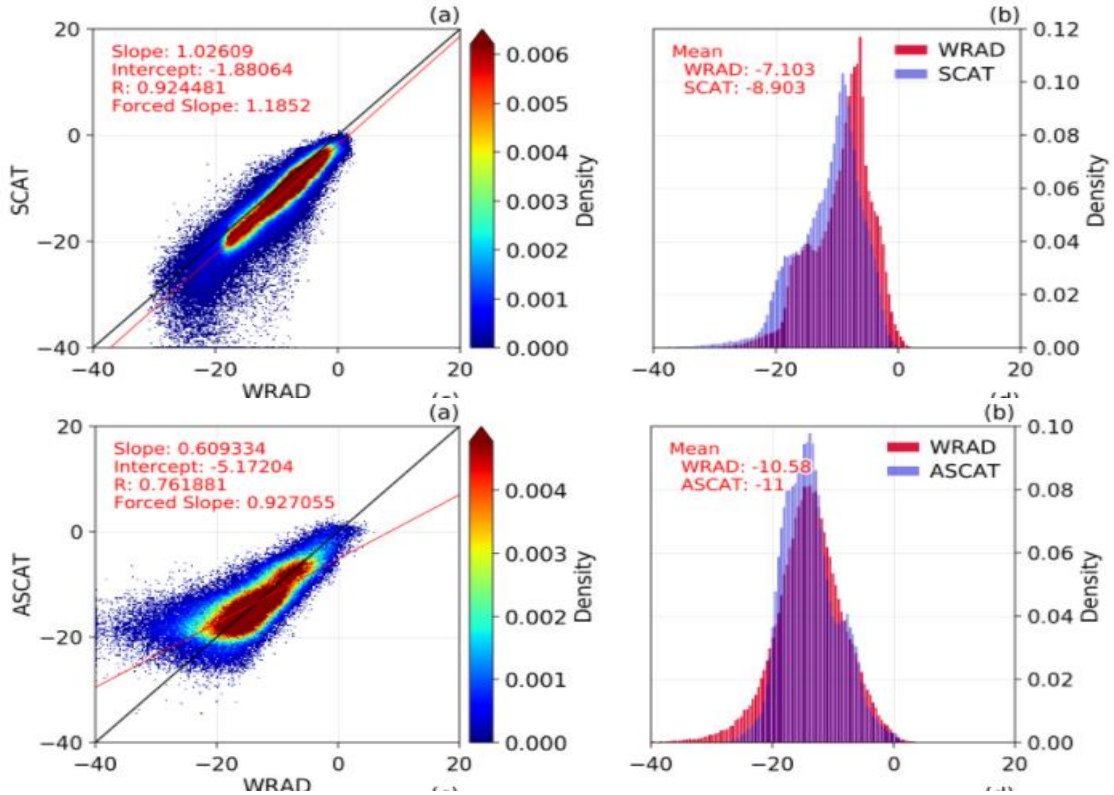
NSMC

Wind Radar (WindRAD)

Internal calibration: better than 0.3 dB.

Frequency	Accuracy of internal calibration (dB)	Specification (dB)
C	0.2399	≤ 0.6
Ku	0.1937	≤ 0.6

SNO: preliminary results



	Correlation coefficient	Bias / dB
Ku HH	0.92	1.80
Ku VV	0.91	1.65
C VV	0.76	0.41

- **Sigma0 bias of C band is smaller than Ku. Sigma0 of Ku band is relatively large.**
- **Further improvement is under investigation, and external calibration will be carried out.**
- **Detailed SNO and NOC will be carried out.**

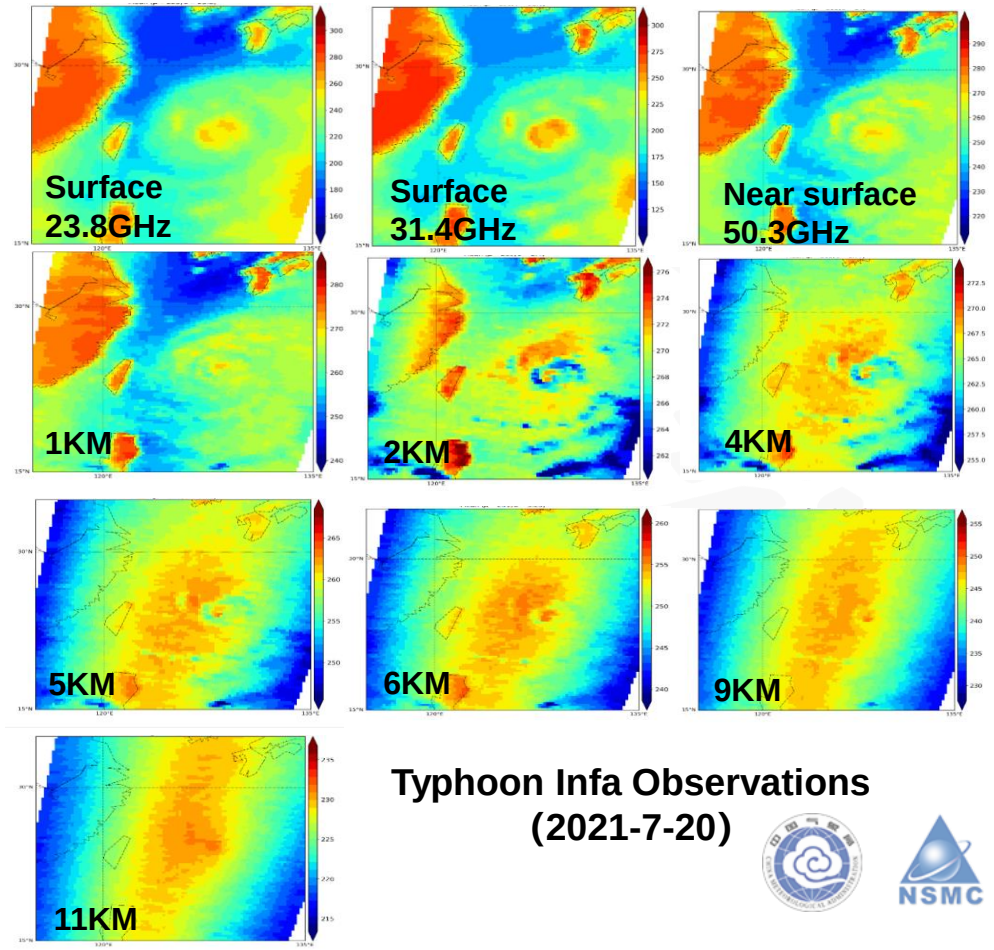
Microwave Temperature Sounder-III (MWTS-III)

- The third generation MWTS with 4 more channels (23.8 GHz, 31.4 GHz, 53.246±0.08 GHz and 53.948±0.081 GHz) and better NEdT requirement.
- Powered on time: July 9, 2021.
- Instrument status is stable.

Instrument specification

CH	Center Frequency (GHz)	Bandpass width (MHz)	NEdT (K)	Polarization	Accuracy* (K)
1	23.8	270	0.3	QH	1.2/0.8
2	31.4	180	0.35	QH	1.2/0.8
3	50.3	180	0.35	QV	1.2/0.8
4	51.76	400	0.3	QV	1.2/0.8
5	52.8	400	0.3	QV	1.2/0.8
6	53.246±0.08	2*140	0.35	QV	1.2/0.8
7	53.596±0.115	2*170	0.3	QV	1.2/0.8
8	53.948±0.081	2*142	0.35	QV	1.2/0.8
9	54.40	400	0.3	QV	1.2/0.8
10	54.94	400	0.3	QV	1.2/0.8
11	55.50	330	0.3	QV	1.2/0.8
12	57.290344(fo)	330	0.6	QV	1.5/1.2
13	fo±0.217	2*78	0.7	QV	1.5/1.2
14	fo±0.3222±0.048	4*36	0.8	QV	1.5/1.2
15	fo±0.3222±0.022	4*16	1.0	QV	1.5/1.2
16	fo±0.3222±0.010	4*8	1.2	QV	1.5/1.2
17	fo±0.3222±0.0045	4*3	2.1	QV	2.5/1.5

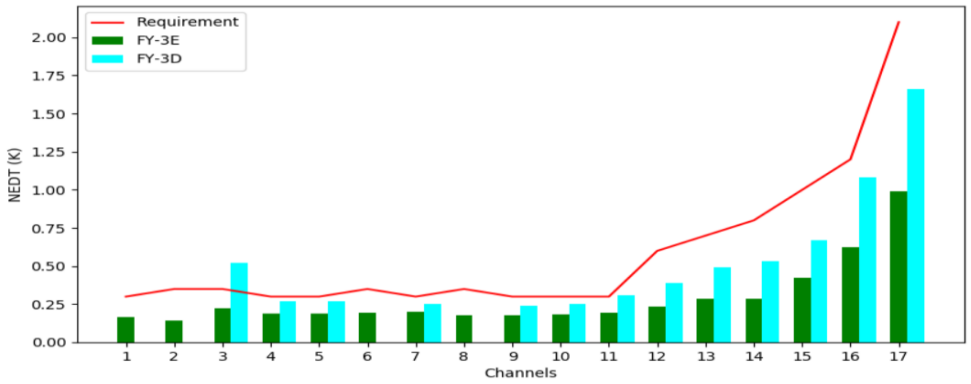
*: Requirements/Expectation



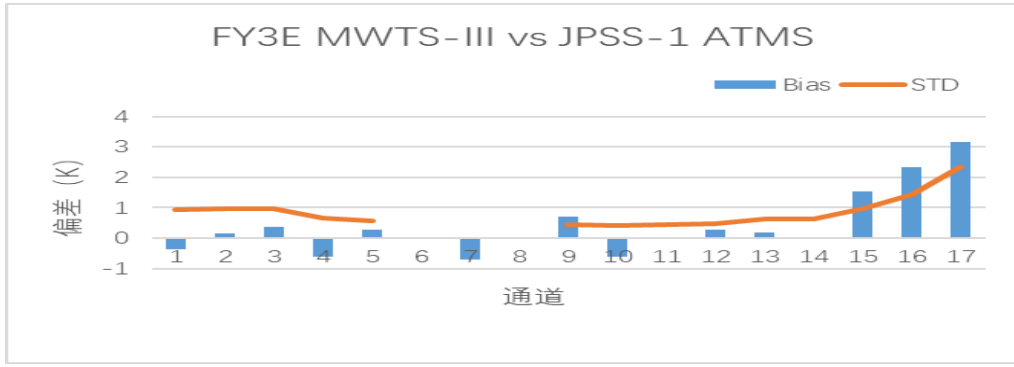
Typhoon Infa Observations (2021-7-20)

Microwave Temperature Sounder-III (MWTS-III)

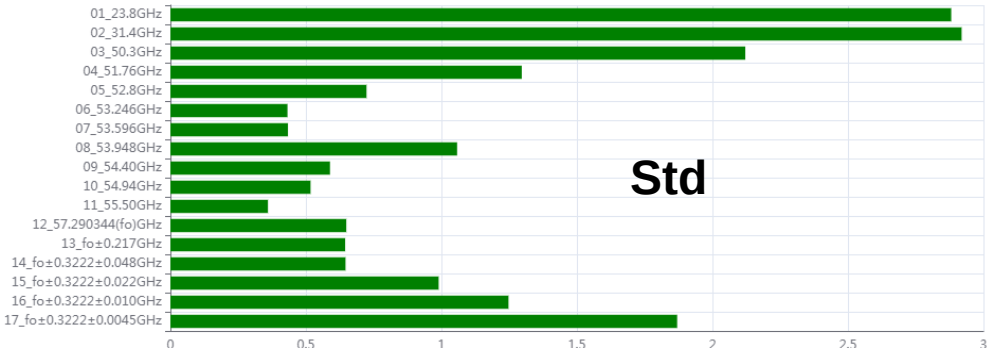
NEdT: better than FY-3D MWTS-II.

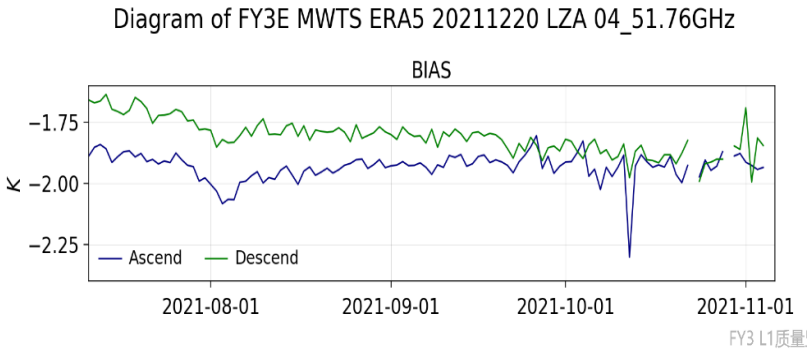


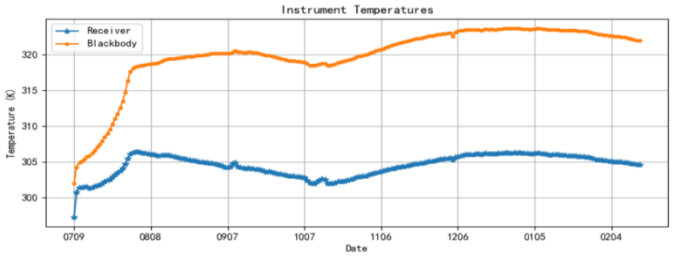
SNO: Std <1K



OMB :





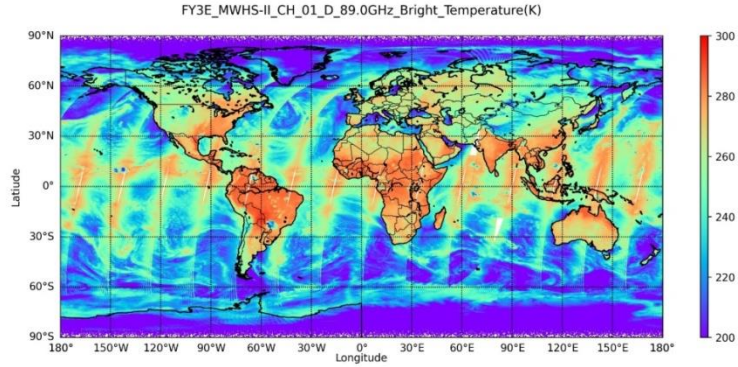


Microwave Humidity Sounder-II (MWHS-II)

- Inherited MWTS with 15 channels with better requirements.

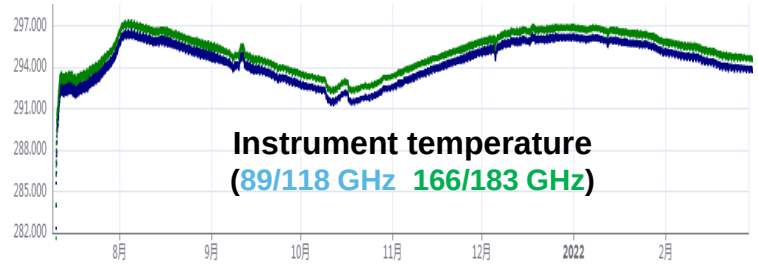
Window channel at 166 GHz instead of 150 GHz.

- Powered on time: July 9, 2021.
- Instrument status is stable.



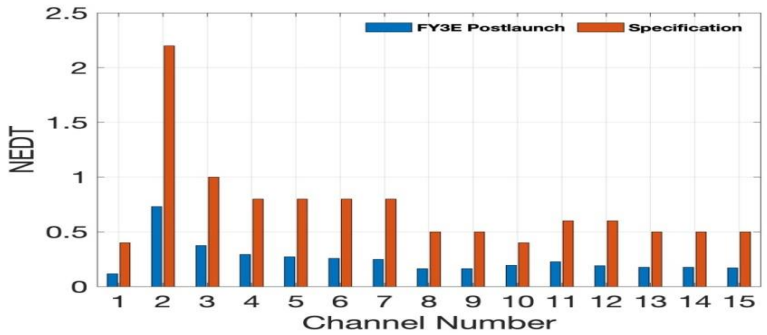
Instrument specification

CH	Center Frequency (GHz)	Polarization	Bandpass Width(MHz)	NEdT (K)	Accuracy (K)
1	89.0	QV	1500	0.4	0.8
2	118.75±0.08	QH	20	2.2	2.2
3	118.75±0.2	QH	100	1.0	1.0
4	118.75±0.3	QH	165	0.8	1.0
5	118.75±0.8	QH	200	0.8	1.0
6	118.75±1.1	QH	200	0.8	0.8
7	118.75±2.5	QH	200	0.8	0.8
8	118.75±3.0	QH	1000	0.5	0.8
9	118.75±5.0	QH	2000	0.5	0.8
10	166.0	QV	1500	0.4	0.8
11	183.31±1	QH	500	0.6	0.8
12	183.31±1.8	QH	700	0.6	0.8
13	183.31±3	QH	1000	0.5	0.8
14	183.31±4.5	QH	2000	0.5	0.8
15	183.31±7	QH	2000	0.5	0.8

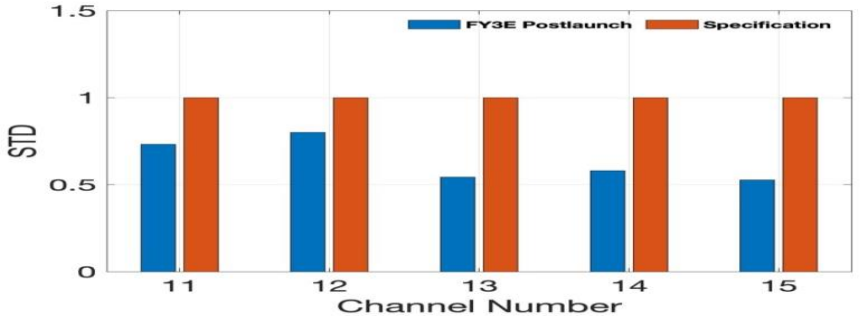


Instrument temperature
(89/118 GHz 166/183 GHz)

NEdT: better than specification

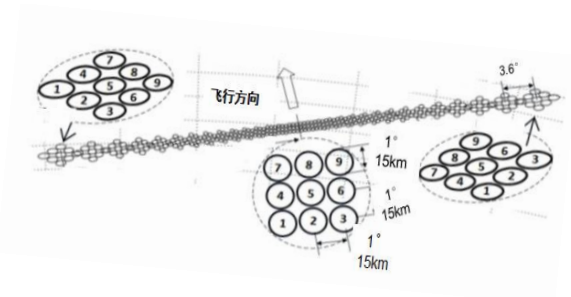


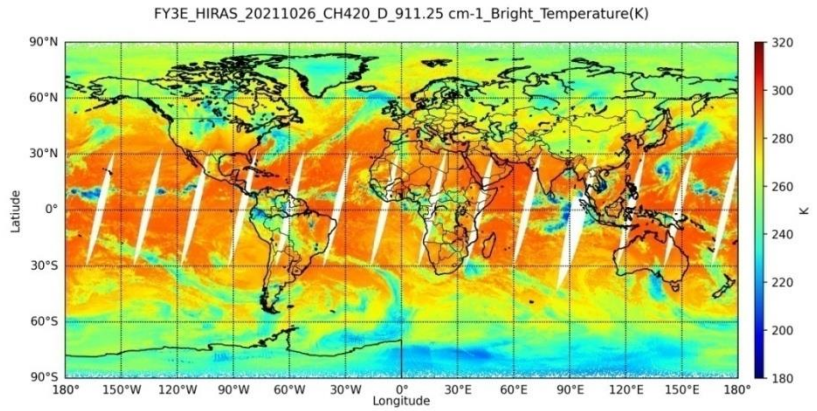
SNO: std <1K for 5 humidity channels



High Spectral Infrared Atmospheric Sounder-II (HIRAS-II)

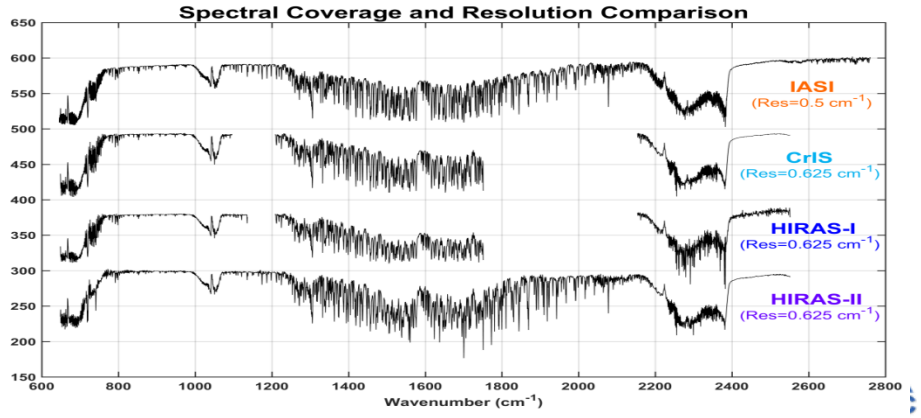
- The second generation HIRAS
- Detectors: 3*3
- NEdT well improved, especially MW/SW
- Full spectral coverage from 650 to 2550 cm^{-1} without gaps between 3 spectral bands.
- Detectors and interferometer powered on time: Oct. 12, 2021
- Instrument status is stable.





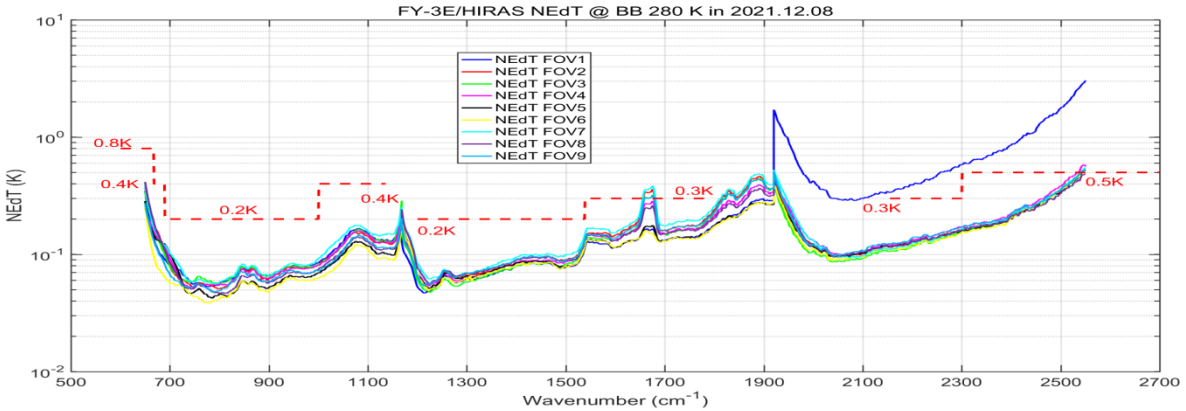
Instrument specification

Band	Spectral range (cm^{-1})	Spectral resolution (cm^{-1})	NEΔT@280K		Radiometric accuracy(K)	Spectral accuracy (ppm)
LWIR	650 ~ 1168.125 (15.38 ~ 8.56 μm)	0.625	650 ~ 667 cm^{-1}	0.8K	1K/0.8K	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	1168.75 ~ 1920 (8.55 ~ 5.21 μm)	0.625	1210 ~ 1538 cm^{-1}	0.2K	0.4K/0.3K	
			1538 ~ 1750 cm^{-1}	0.3K	0.5K/0.4K	
SWIR	1920.625 ~ 2550 (5.21 ~ 3.92 μm)	0.625	2155 ~ 2300 cm^{-1}	0.3	0.5K/0.4K	
			2300 ~ 2550 cm^{-1}	0.5	0.6K/0.5K	

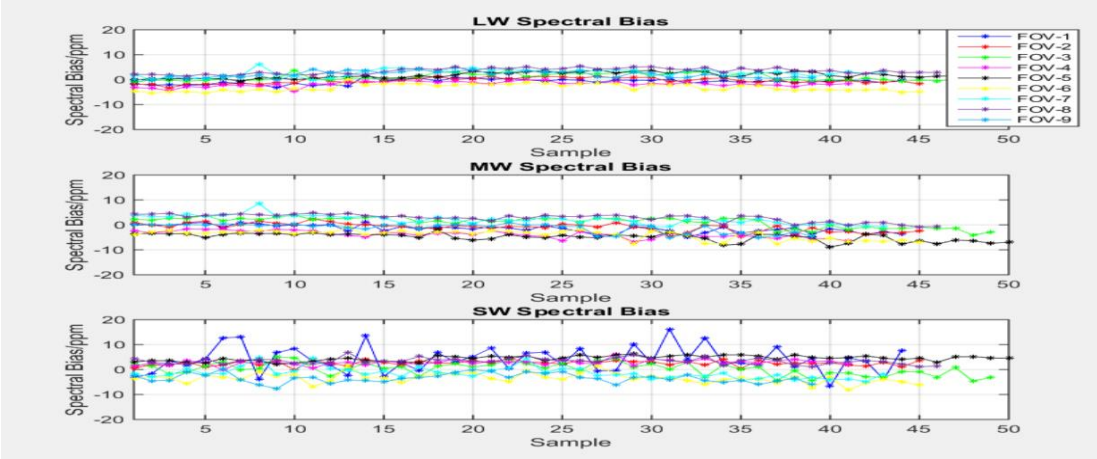


High Spectral Infrared Atmospheric Sounder-II (HIRAS-II)

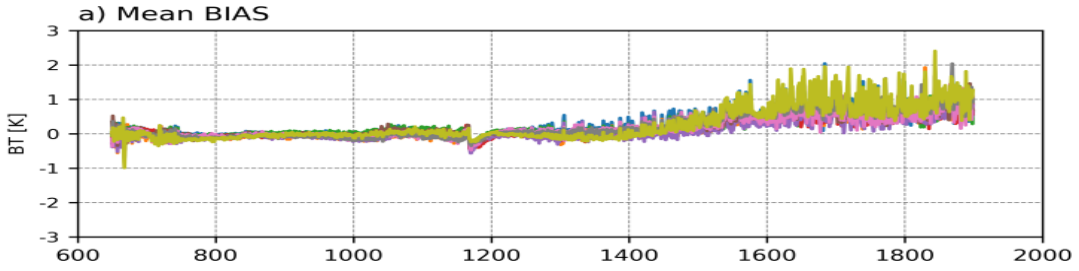
NEdT: Good noise performance in LWIR & MWIR, comparable to CrIS and IASI in LWIR. SWIR FOV-1 out of family & larger than specification. Channels around 1700 cm-1 slightly higher.



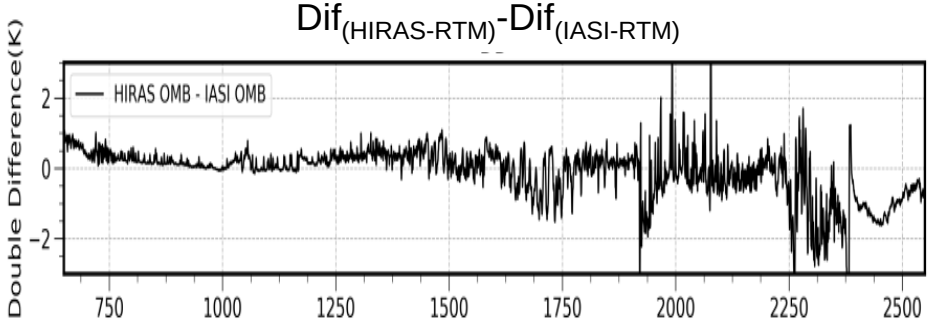
Spectral bias: all within ±5 ppm.



SNO: BT bias in LWIR < 0.3K and most MWIR channels < 0.5 K .



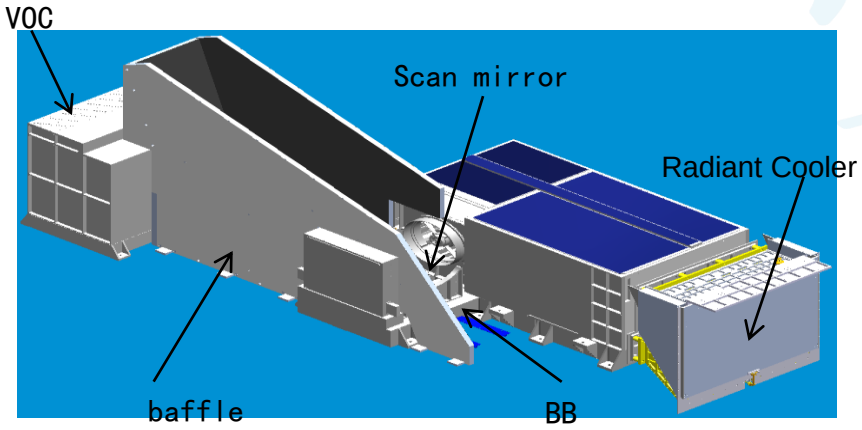
OMB DD: BT bias in LWIR <0.5K, 0.5 to 1.0 K in MWIR.



NSMC

Medium Resolution Spectral Imager-Low Light (MERSI-LL)

- Optical imager with 6 infrared channels inherited from FY-3D and 1 panchromatic low-light band (500-900nm).
- RBS powered on time: July 9, 2021
- TEB powered on time: Sept. 7, 2021
- Onboard Solar Diffused Transmission Board (SDTB) is used for RSB degradation monitoring.
- Instrument status is stable.



Instrument specification

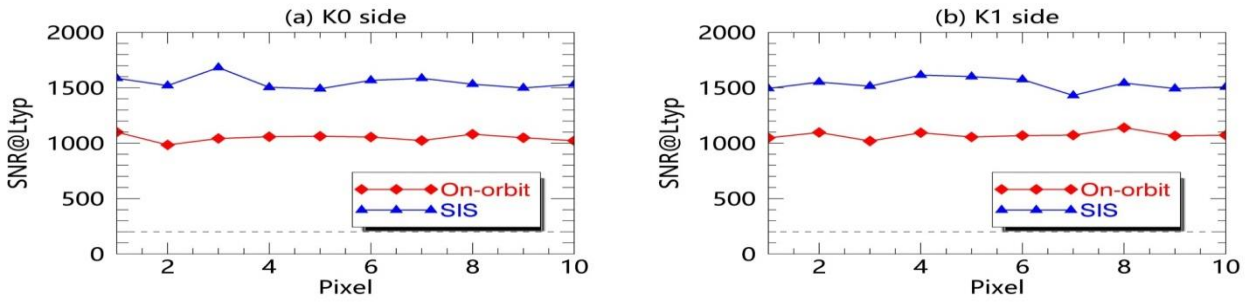
CH	CW (μm)	L_{max}/T_{max} W/m²/sr	L_{min}/T_{min} W/m²/sr	L_{typ}/T_{typ} W/m²/sr	SNR/ NEΔT @L_{typ}/T_{typ}	Accuracy*
1	0.70	90	3e-5	4e-5(night)	7	50%/10%
				50(day)	200	10%/5%
2	3.8	350K	186K	300K	0.25K	0.4K/0.2K
3	4.05	380K	185K	300/380K	0.25K	0.4K/0.2K
4	7.2	270K	186K	270K	0.30K	0.4K/0.2K
5	8.55	330K	185K	270K	0.25K	0.4K/0.2K
6	10.8	345K	185K	300K	0.30K	0.4K/0.2K
7	12.0	345K	185K	300K	0.30K	0.4K/0.2K

*: Requirements/Expectation
250m: 10.8 and 12 um

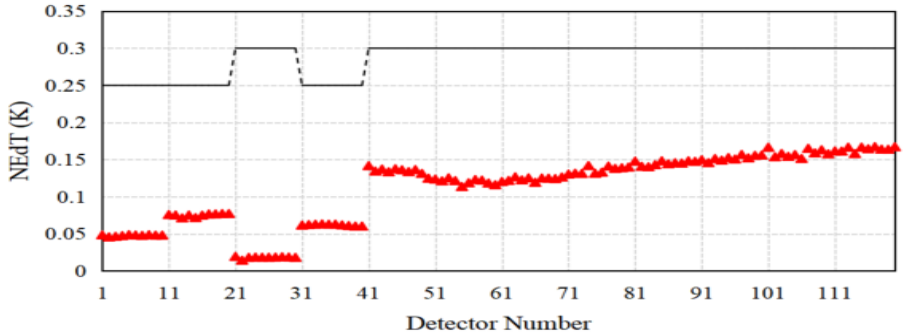
LLB Image Aug. 2, 2021

Medium Resolution Spectral Imager-Low Light (MERSI-LL)

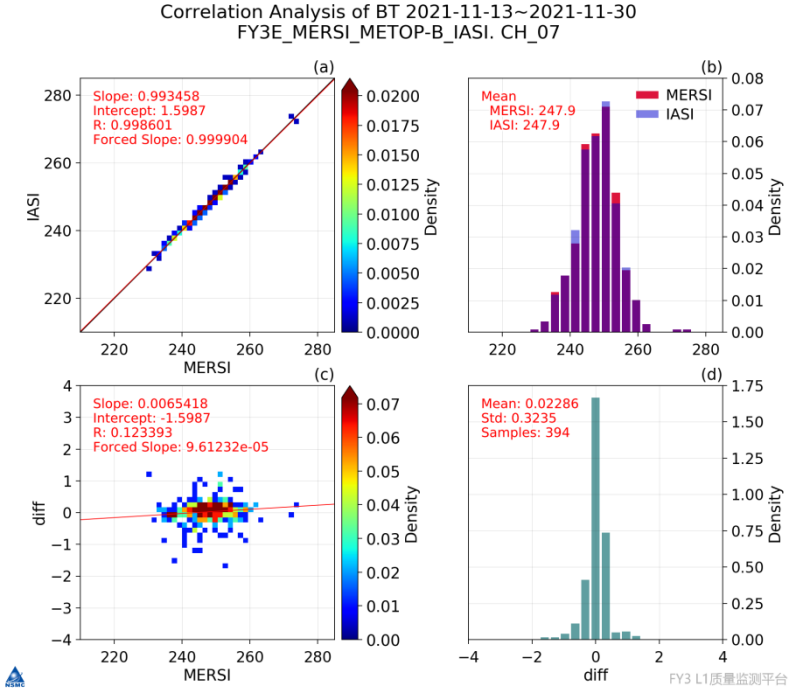
SNR: LL band low gain



NEdT: 1km-channels <0.1K, 250m-channels<0.18K



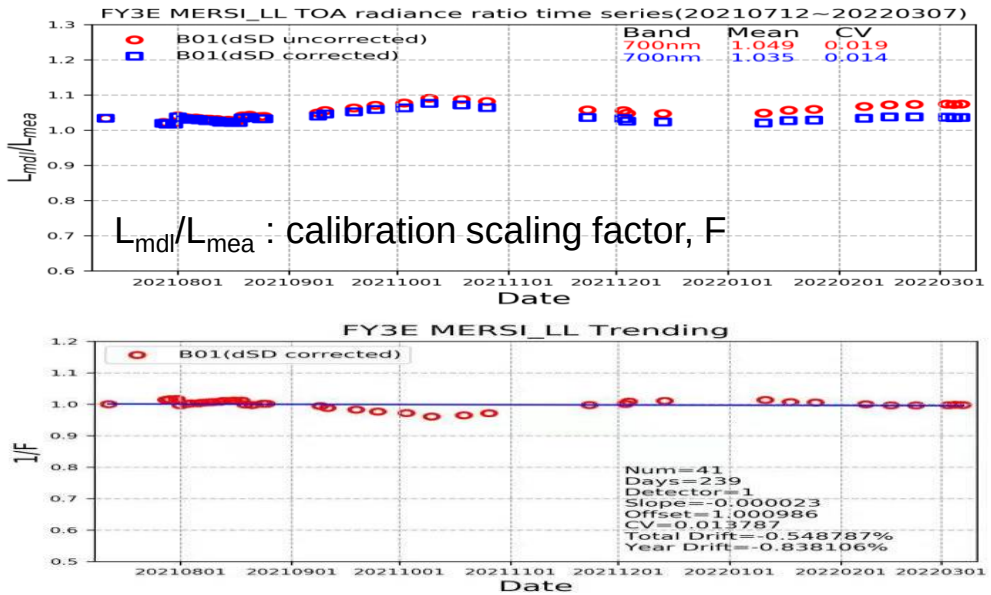
SNO: IR biases within 0.3 K.



IASI-B	Bias
CH2_3.8	-0.394
CH3_4.05	-0.116
CH4_7.2	-0.127
CH5_8.5	0.032
CH6_10.8	-0.039
CH7_12.0	0.023

LLB low gain:

F factor (L_{mdl}/L_{mea}) is around 1.035. 1/F factor trending shows that radiometric response of LLB is stable with total drift <1%.

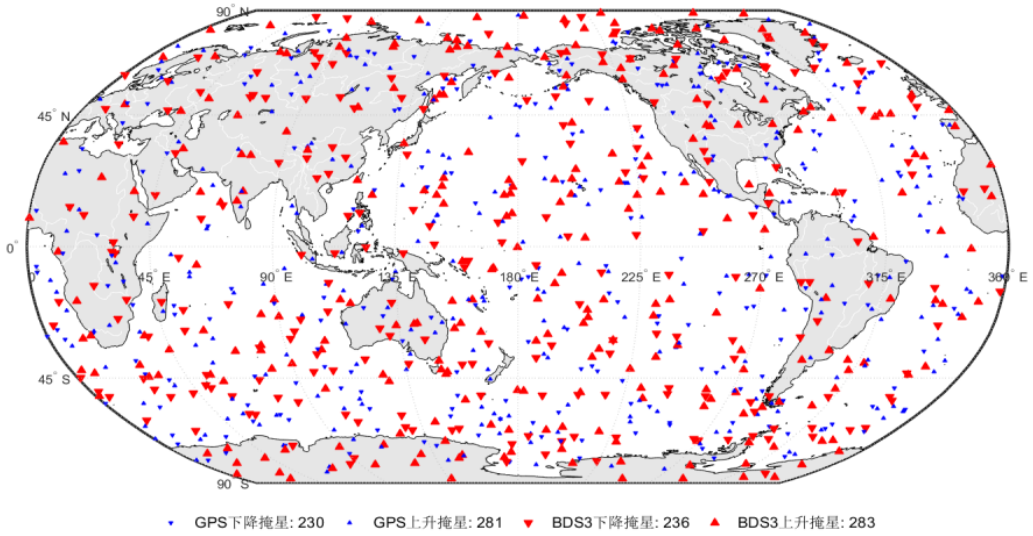


L_{mdl}/L_{mea} : calibration scaling factor, F

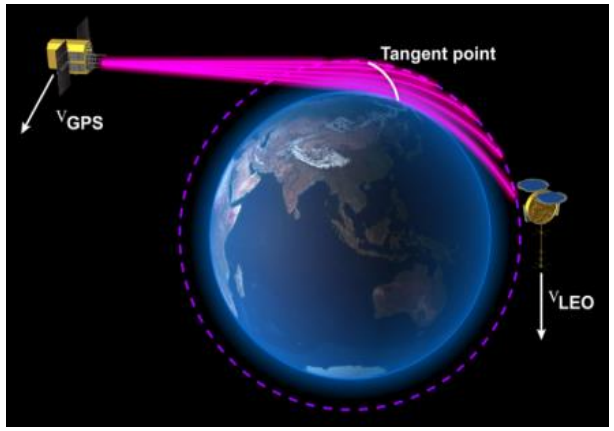
GNSS Radio Occultation Sounder-II (GNOS-II)

- **GNSS Reflectometry (GNSS-R) module added.**
- **GNSS Radio Occultation (GNSS-RO) module including GPS and BeiDou system.**

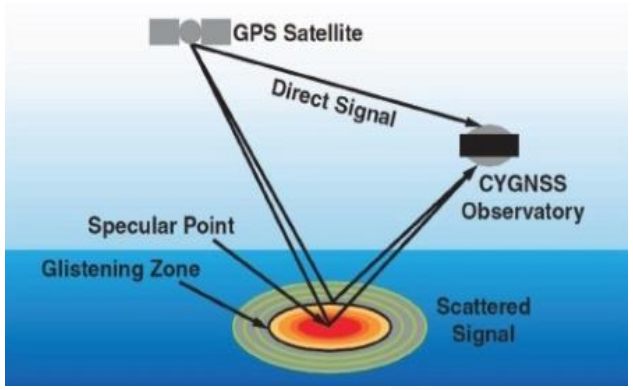
Ionospheric RO distribution



Total number of occultation: more than two times of FY-3D. GPS/BDS atmospheric occultations ＞1000 GPS/BDS ionospheric occultations ＞1200.

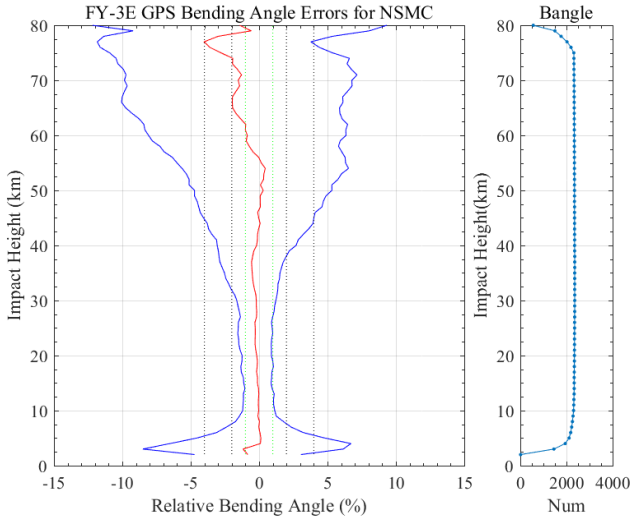


GNSS-RO

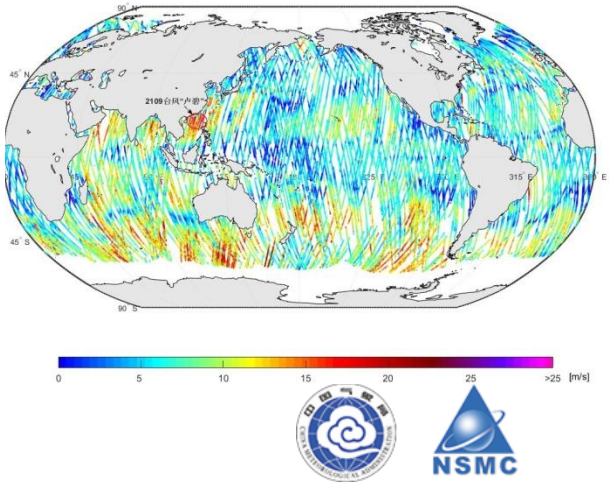


GNSS-R

Bending angle accuracy: std <2 % (10~35km) for atmospheric occultations



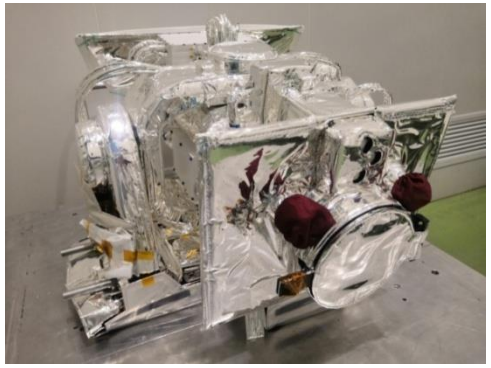
Sea surface wind (20210802-0807)

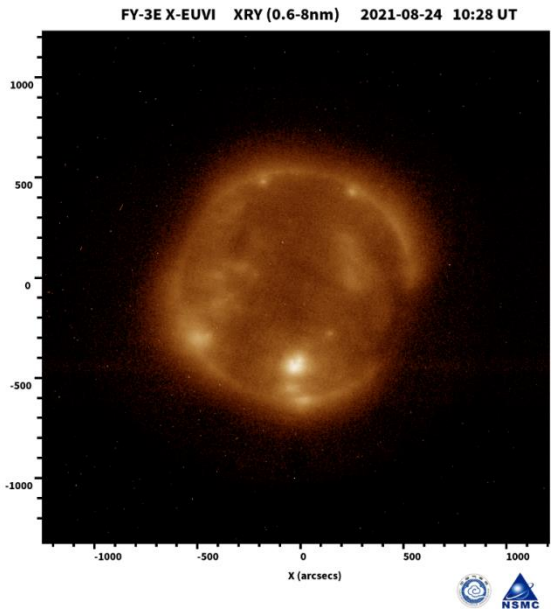


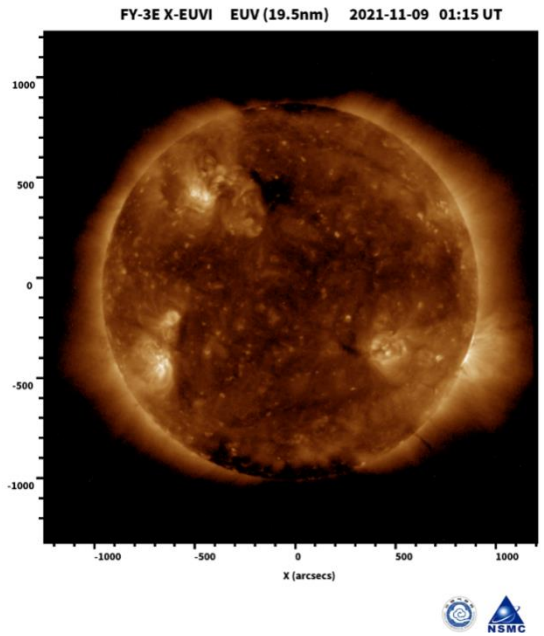
Solar Observation Instruments

Solar X-ray and Ultraviolet Imager (X-EUVI)

- 2 spectral bands:
  X(0.6-8nm), EUV(19.5nm)
- 8 channels:
  X1:0.6-8.0 nm X2:0.6-6.0
  X3:0.6-5.0 nm X4:0.6-2.0 nm
  X5:0.6-1.6 nm X6:0.6-1.2 nm
  EUV1(thin) EUV2(thick)

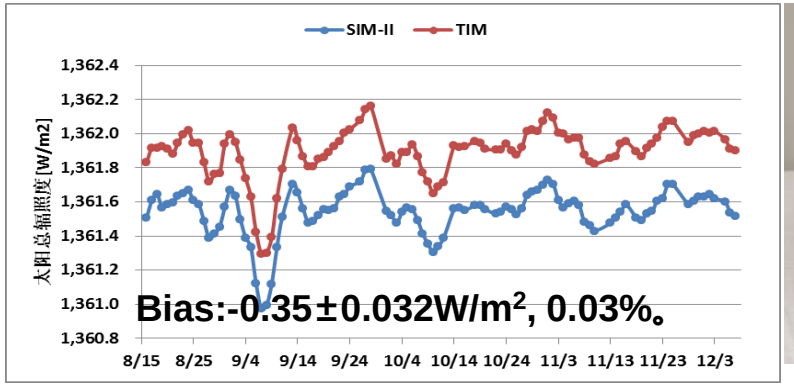


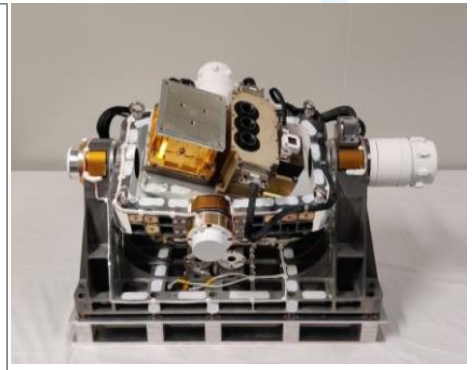




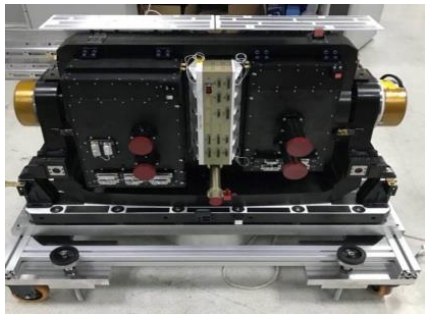
Solar Irradiance Monitor-II (SIM-II)

Total solar irradiance (TSI)

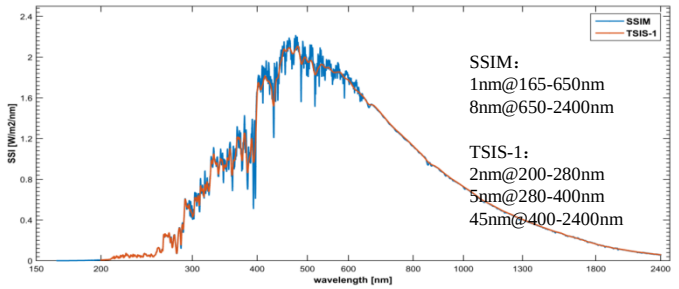




Solar Spectral Irradiance Monitor (SSIM)



Solar spectral irradiance from 165 to 1650nm



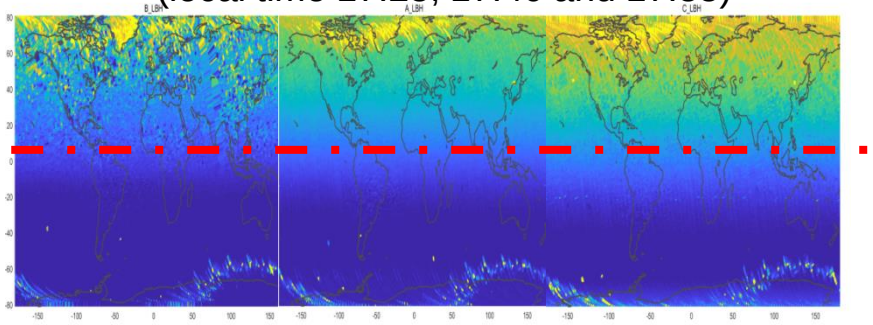
- 3 spectral bands: UV(165-320nm), VIS(285-700nm), NIR(650-1650nm)
- Spectral resolution: UV&VIR:1 nm, NIR <8nm.

Space Weather Instruments

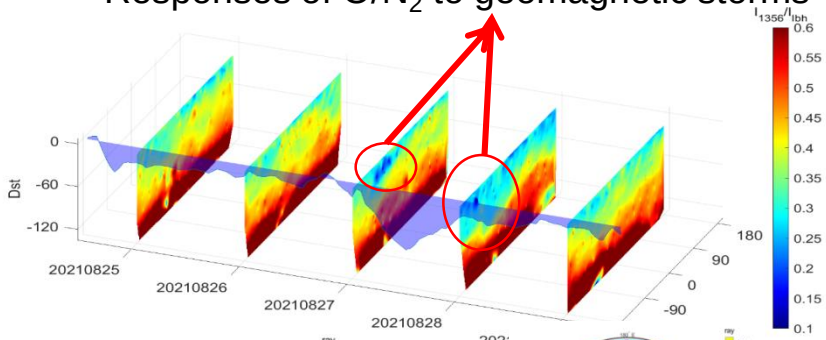
Triple-angle Ionospheric Photometer (Tri-IPM)

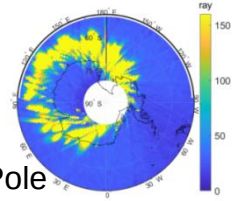
Measuring airglow radiation intensity of oxygen atoms and nitrogen molecules with 3 probes, which can inverse the variation of ionosphere/middle and upper atmosphere.

Airglow map with 3 sensors
(local time 17:25, 17:40 and 17:55)



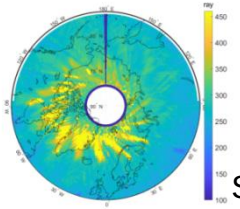
Responses of O/N_2 to geomagnetic storms





North Pole

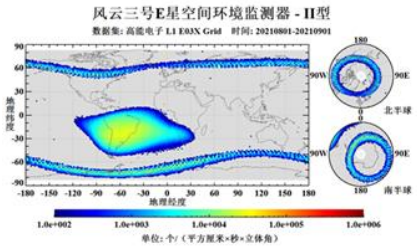
Aurora



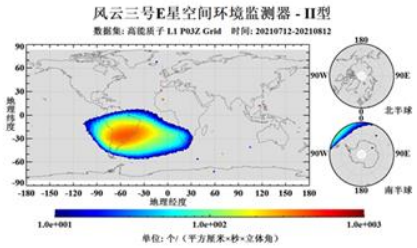
South Pole

Space Environment Monitor-II (SEM-II)

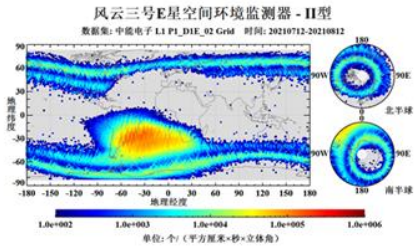
Measuring the space factors (particles, radiation dose, surface potential, magnetic field vectors, etc.) in situ.



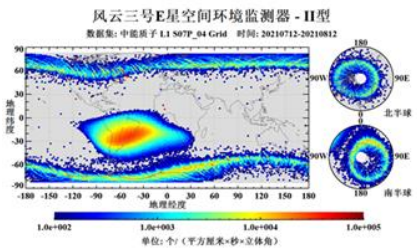
高能电子E3通道
(0.65 MeV ~ 1.20 MeV)



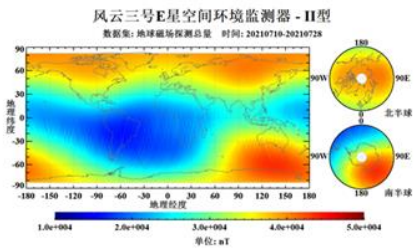
高能质子P3通道
(10 MeV ~ 26 MeV)



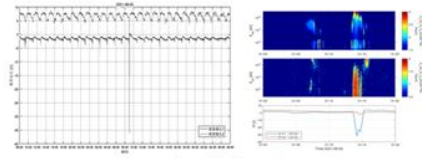
中能电子D1方向E2通道
(40 keV ~ 60 keV)



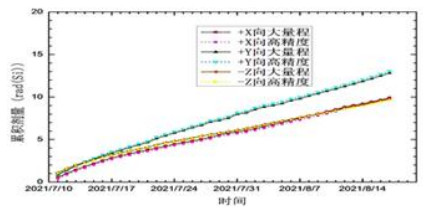
中能质子S7方向P4通道
(120 keV ~ 170 keV)



地球磁场探测总量



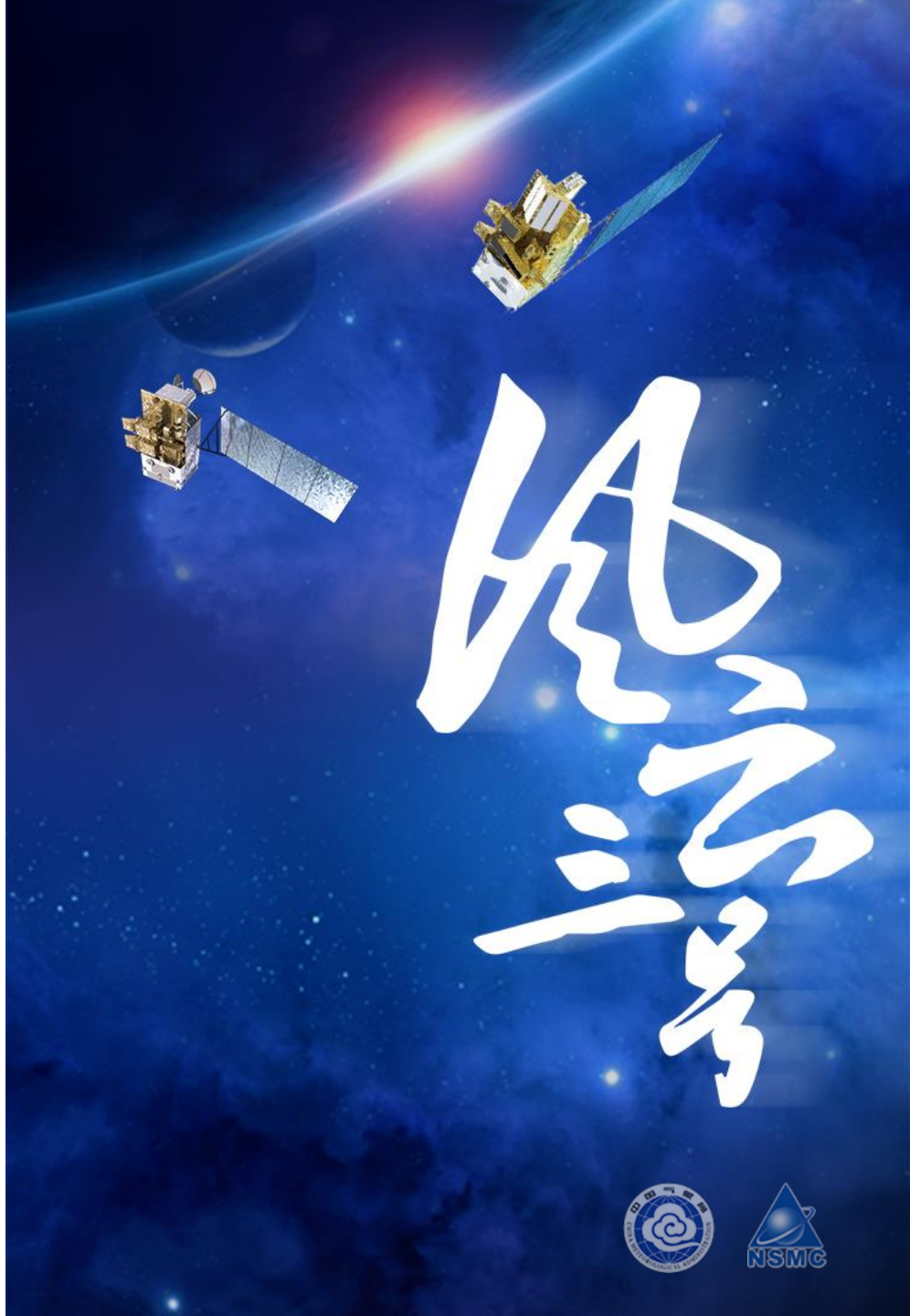
电位探测



辐射剂量探测

PART 03

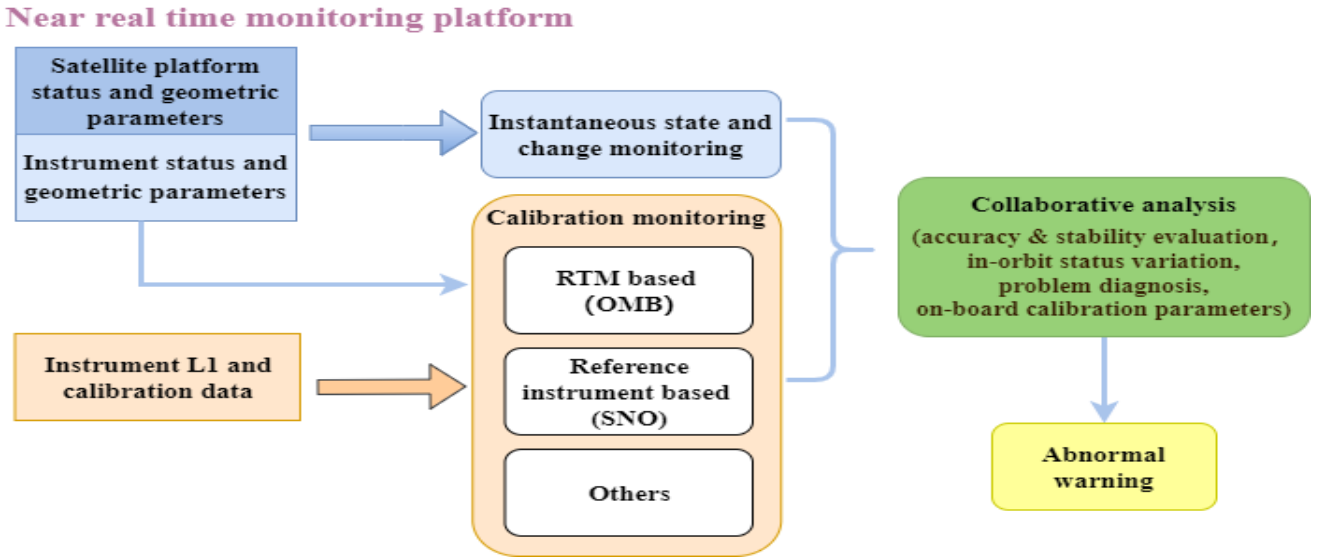
Instrument & SDR monitoring

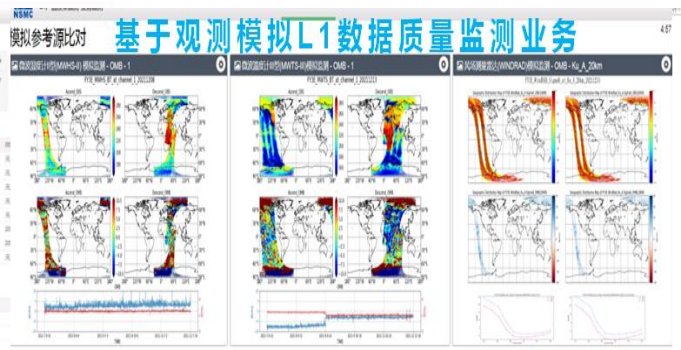


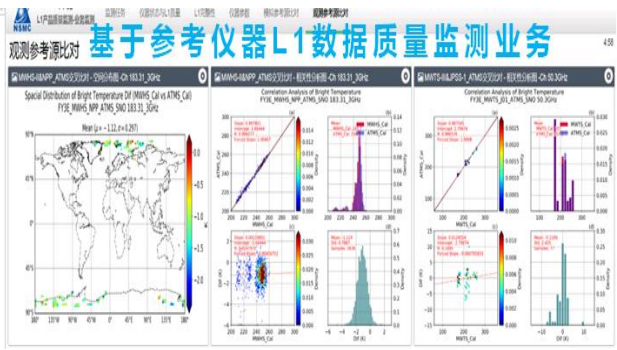
Instrument status and L1 quality monitoring system

Operational monitoring/alarming:

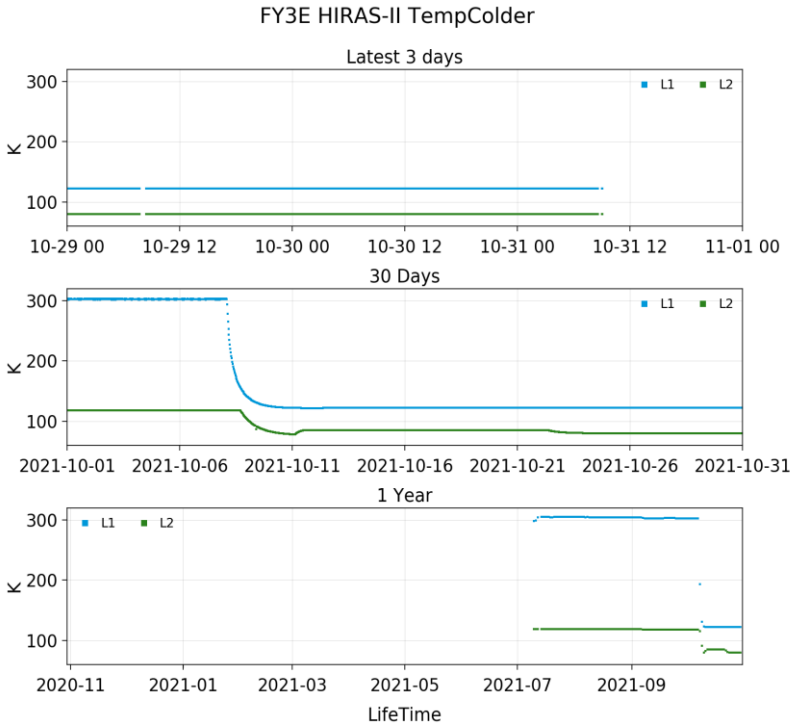
- **Platform monitoring: GPS and IOE**
- **Instrument parameter monitoring: 11 instruments**
- **L1 calibration accuracy monitoring: based on RTM simulation and reference instruments**
- **Other calibration analysis**

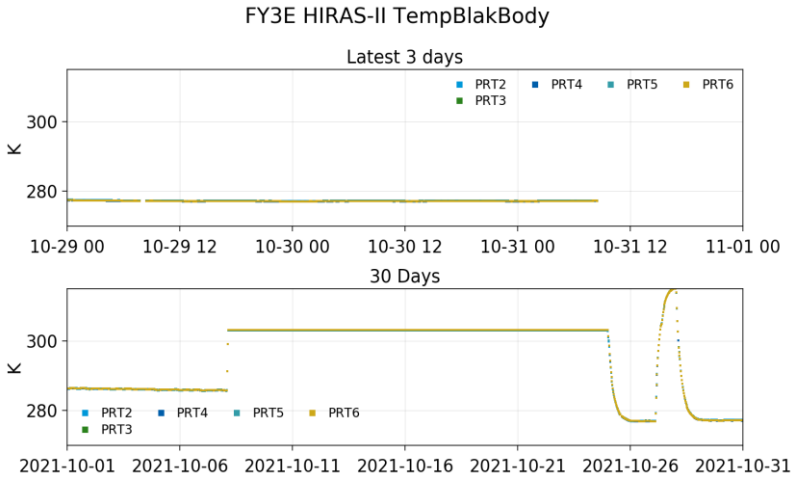


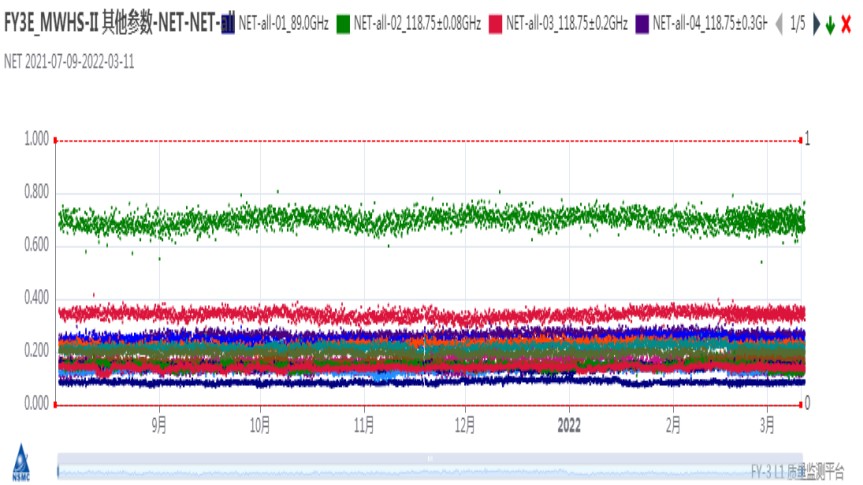




Key instrument telemetry monitoring



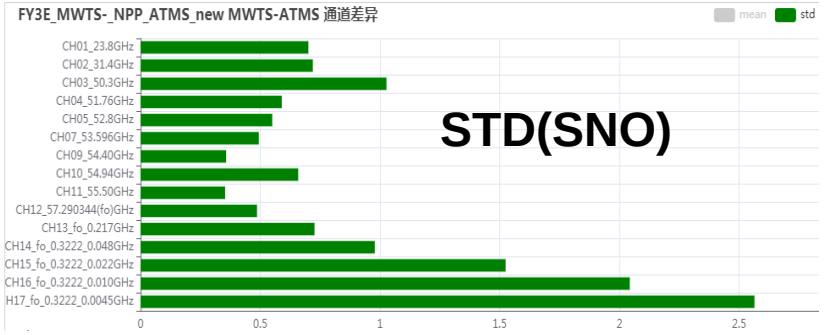




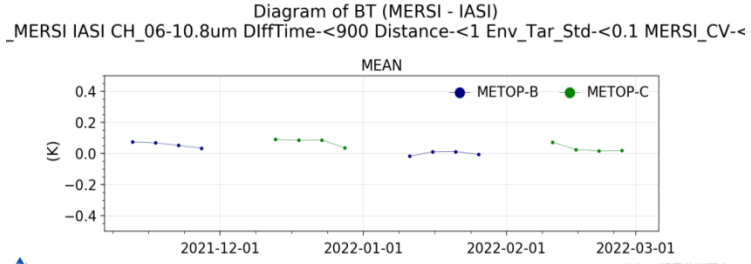
No.	Instrument	Par Num
1	MERSI-LL	30
2	MWHS-II	22
3	MWTS-III	25
4	HIRAS-II	53
5	WindRAD	72
6	GNOS-II	43
7	SIM-II	22
8	SSIM	25
9	SEM-II	34
10	Tri-IPM	18
11	X-EUVI	18

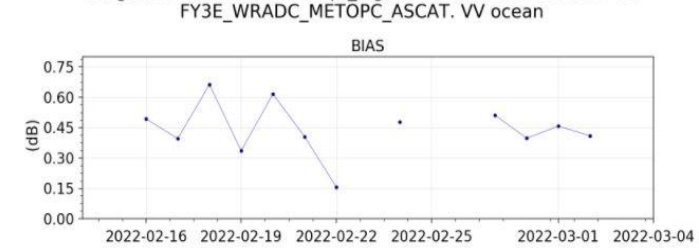
L1 quality monitoring using reference instrument

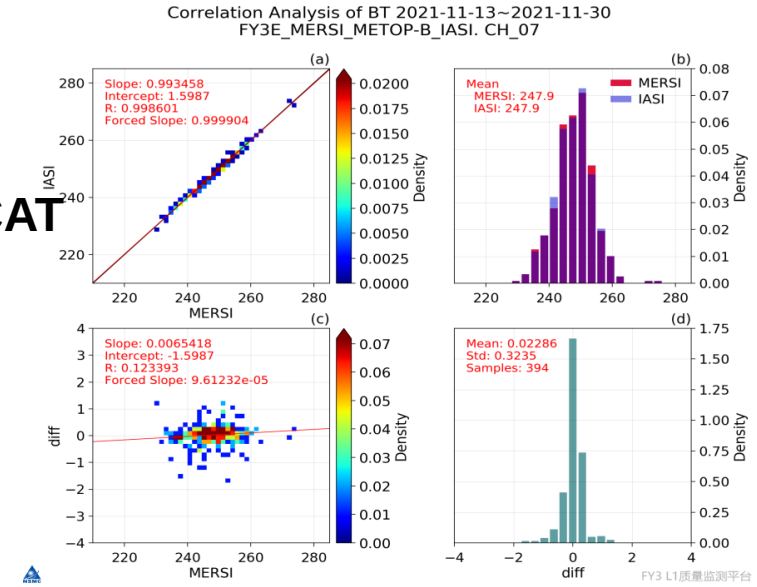
- **MERSI**: vs. IASI
- **HIRAS**: vs. IASI
- **MWTS&MWHS**: vs. ATMS
- **WindRAD**: vs. CFOSAT/SCAT&HY-2/SCAT &Metop/ASCAT

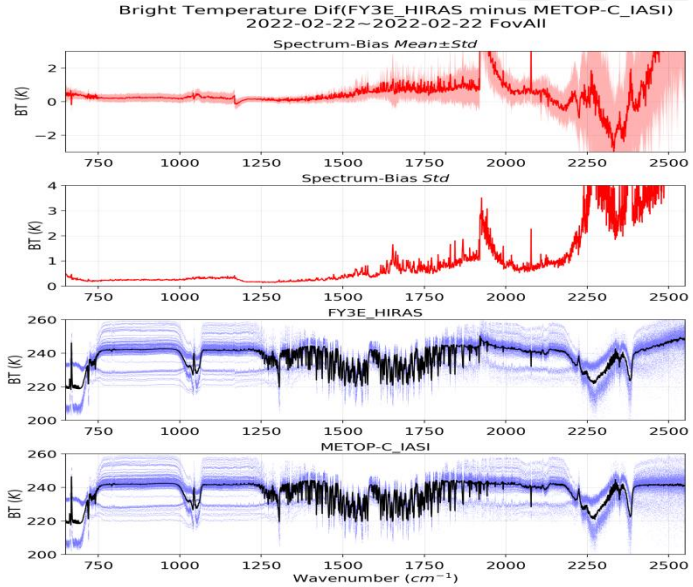


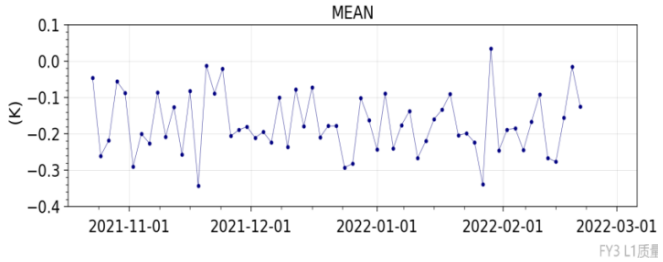
STD(SNO)

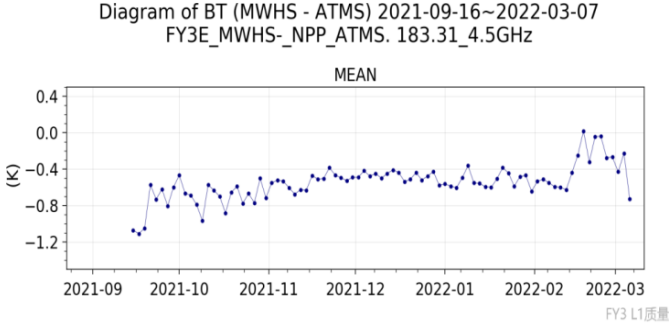


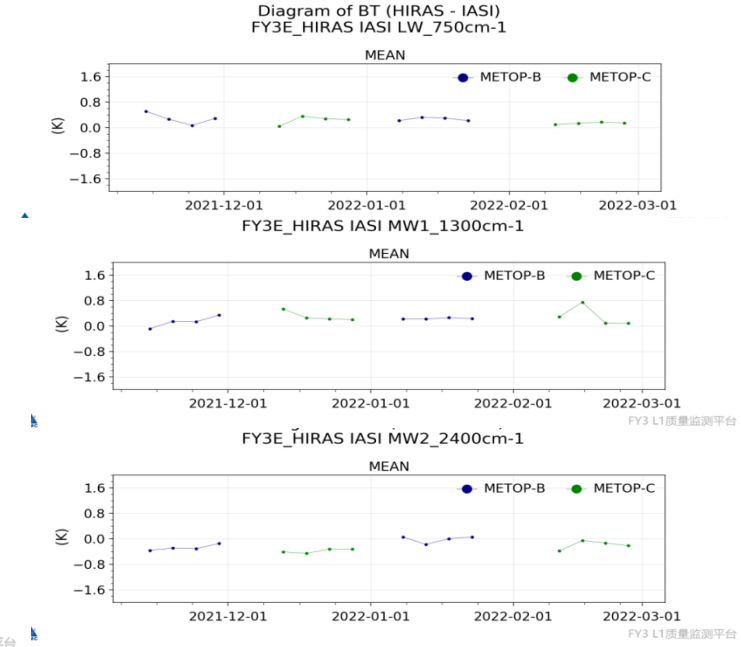






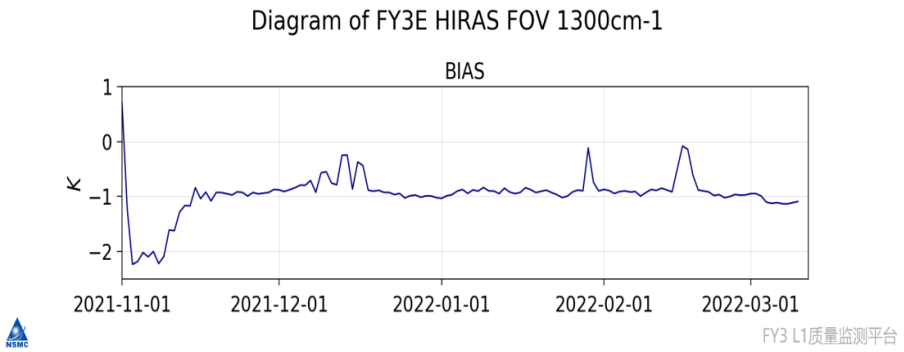


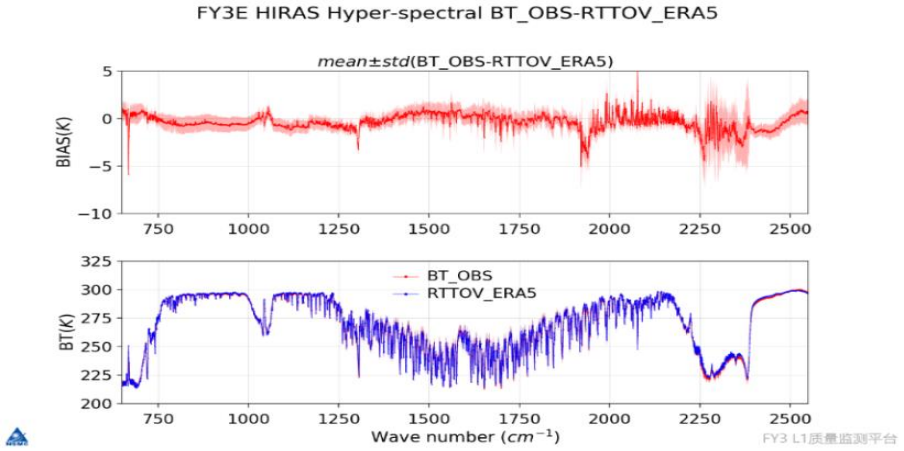


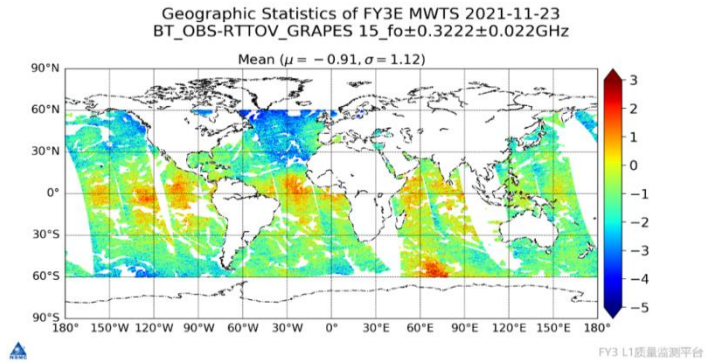


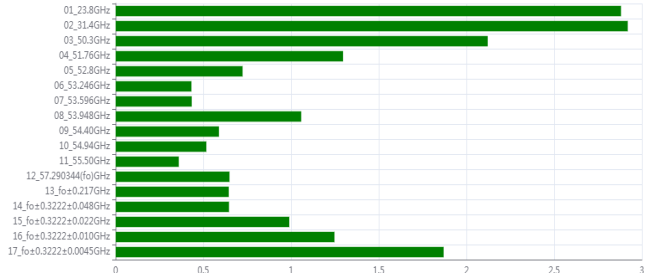
L1 quality monitoring using RTM+NWP

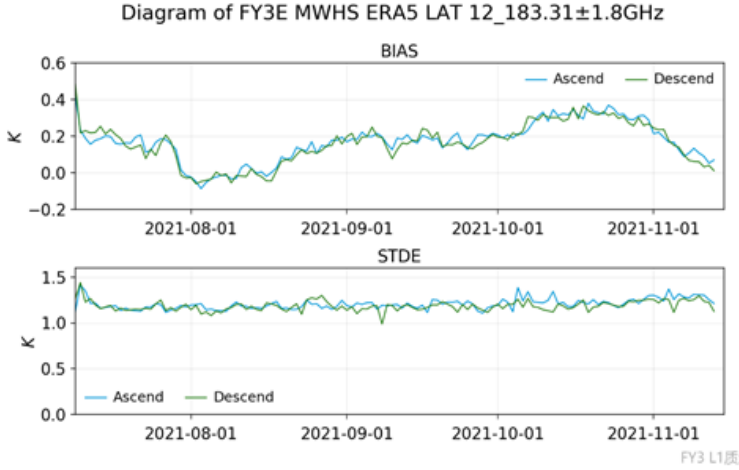
- **NWP data:** Grapes, ERA-5,…
- **RTM**: RTTOV, LBLRTM, GMF,…
- **Infrared:** MERSI, HIRAS
- **Passive MW:** MWTS, MWHS
- **Active MW:** WindRAD

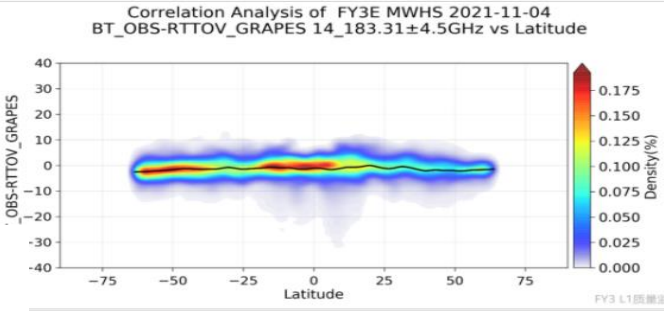


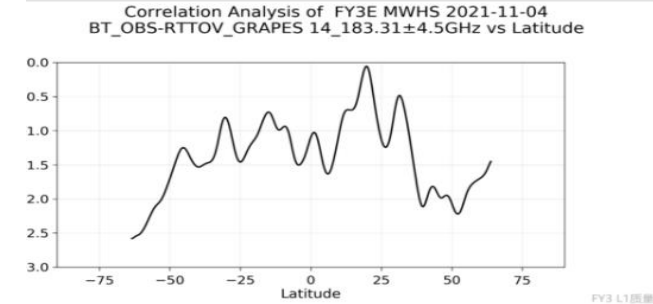








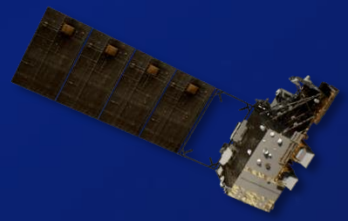




NSMC

Summary

- FY-3E platform and instrument tests are completed.
- L1 products will be available for trial use since Mar. 2022, and will be operationally released since June 2022.
- Instrument status and performance are monitored operationally.
- Detailed information will be provided in following CMA presentations for several instruments.



Thank you for your attention.

sunling@cma.gov.cn