FY-4C MISSION STATUS

Present by Dr.Feng LU
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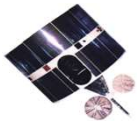
Many thanks to Chengli Qi ,Xiaohu Zhang, Lan Wei,Lu Li, Zhiwei Wang, Anqing Chen, Fuxiang Huang, Lei Ding,Changpei Han, KefeiSong,Xin Zhang,LipinFu, WeiguoZong , and other contributors

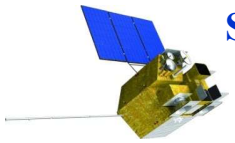
Outline

- Current status
- FY-4C mission
- Progress on Instrument Trade-off Studies
- Summary



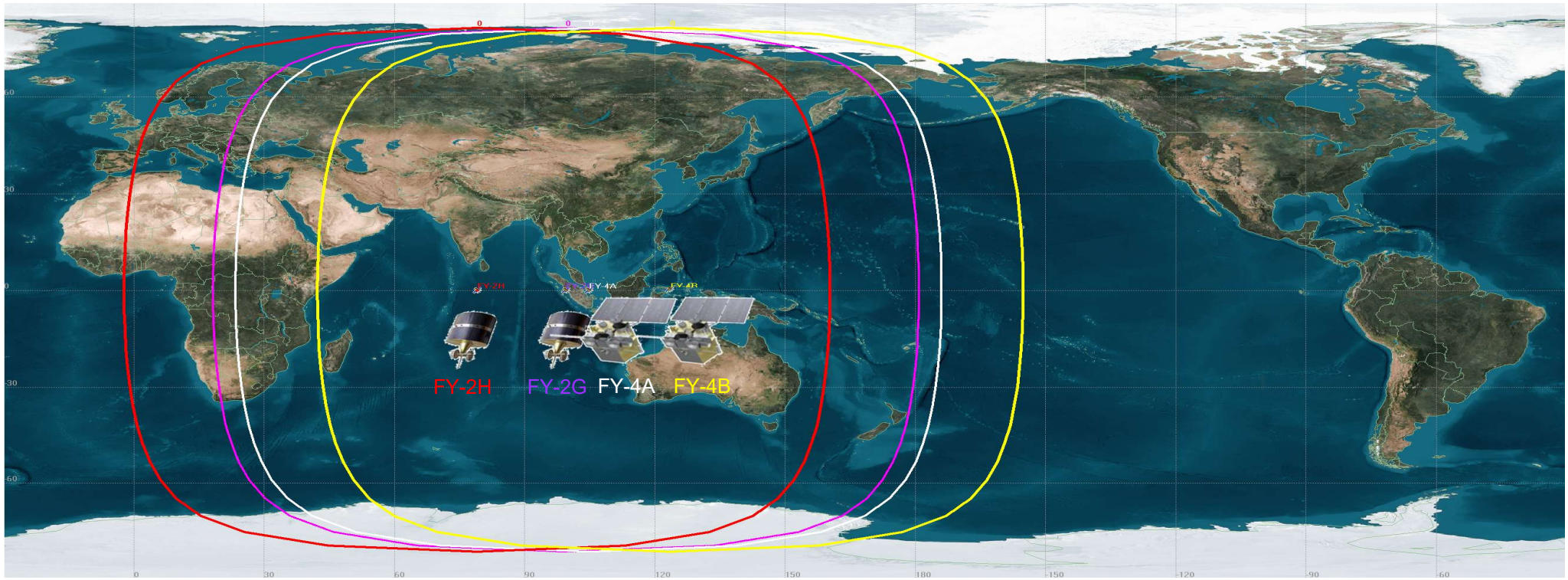
First Generation

FY-2H 79.0E
FY-2G 99.0E

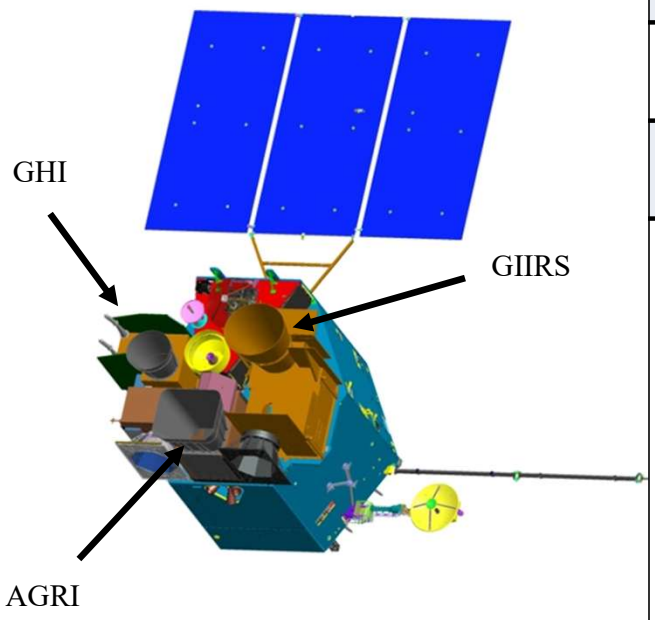


Second Generation

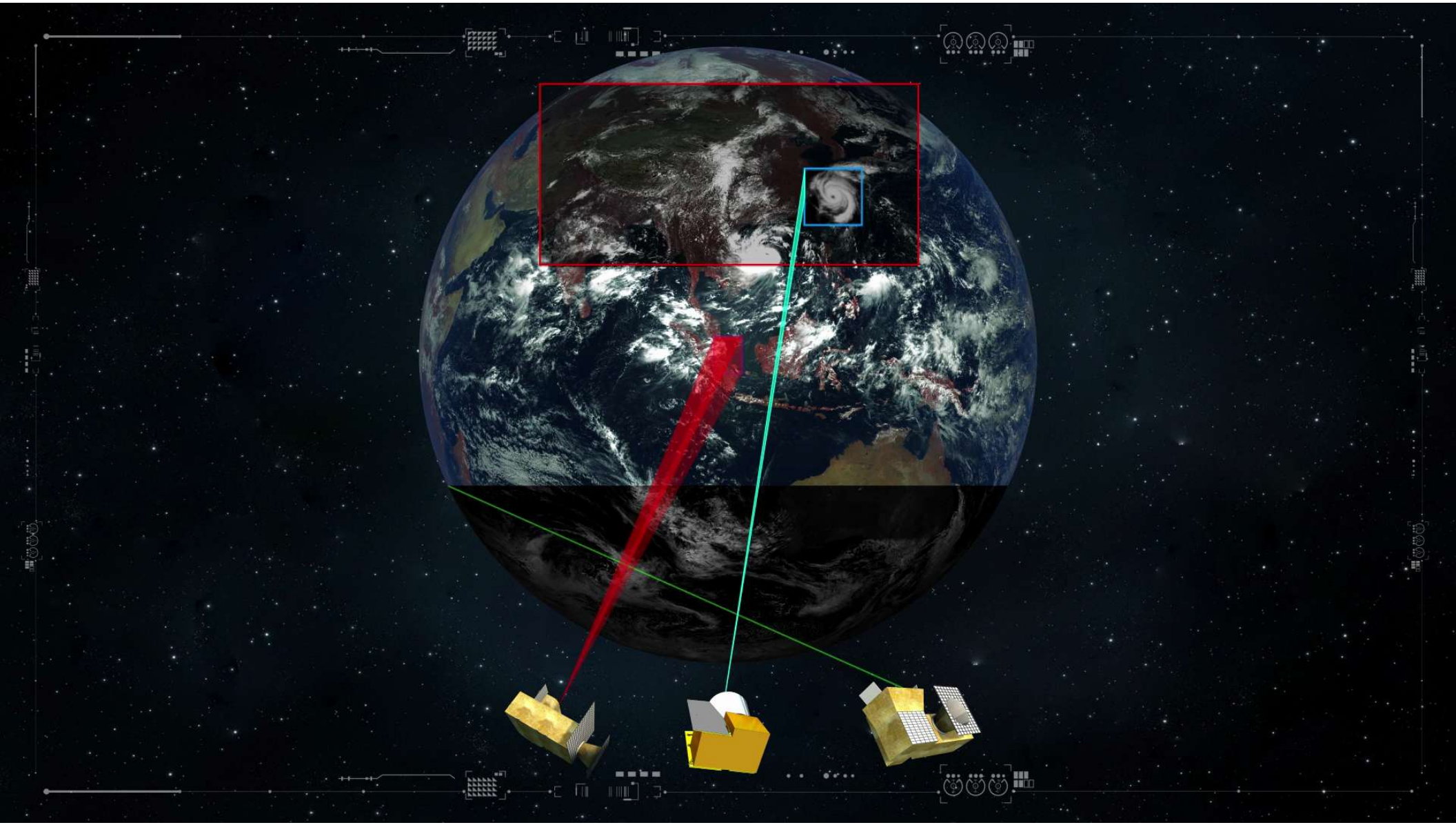
FY-4A 123.5E 2025.2
FY-4B 105E 2024.5.1



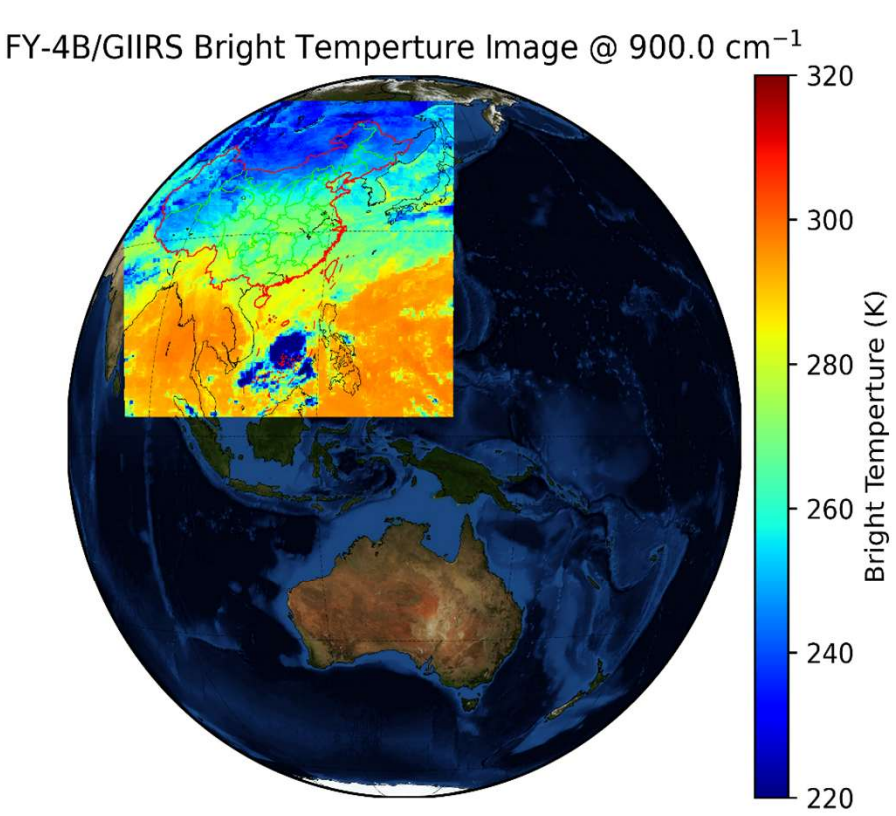
Current FY-4 payload

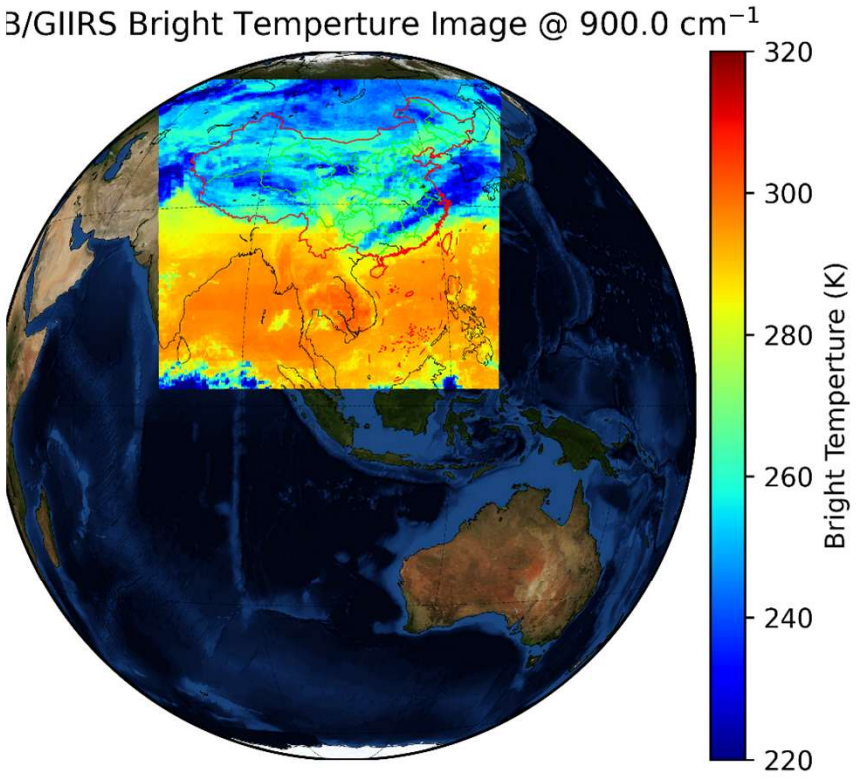


	FY-4A(EXP)	FY-4B(OP)
Stabilization	Three-axis	Three-axis
Designed Life	5~7 Years	7-10 Years
Observation efficiency	85%	85%
Observation Mode	Imaging +Sounding + Lightning Mapping	Imaging +Sounding
Main Instruments	AGRI :14 channels SSP Resolution：0.5~4Km Fulldisk imaging：15min Flexible imaging ： 2D	AGRI :15 channels SSP Resolution：0.5~4Km fulldiskimaging：15min Flexible imaging ： 2D
	GIIRS: SSP Resolution:16Km Spectral Resolution: 0.625cm-1	GIIRS: SSP Resolution:12Km Spectral Resolution: 0.625cm-1
	LMI： SSP Resolution:7.8Km	GHI：7 channels SSP Resolution0.25-2Km
	SEP High energy particles	SEP High energy particles Magnetic field



Since May,1st 2024, The FY-4B operation over 105E

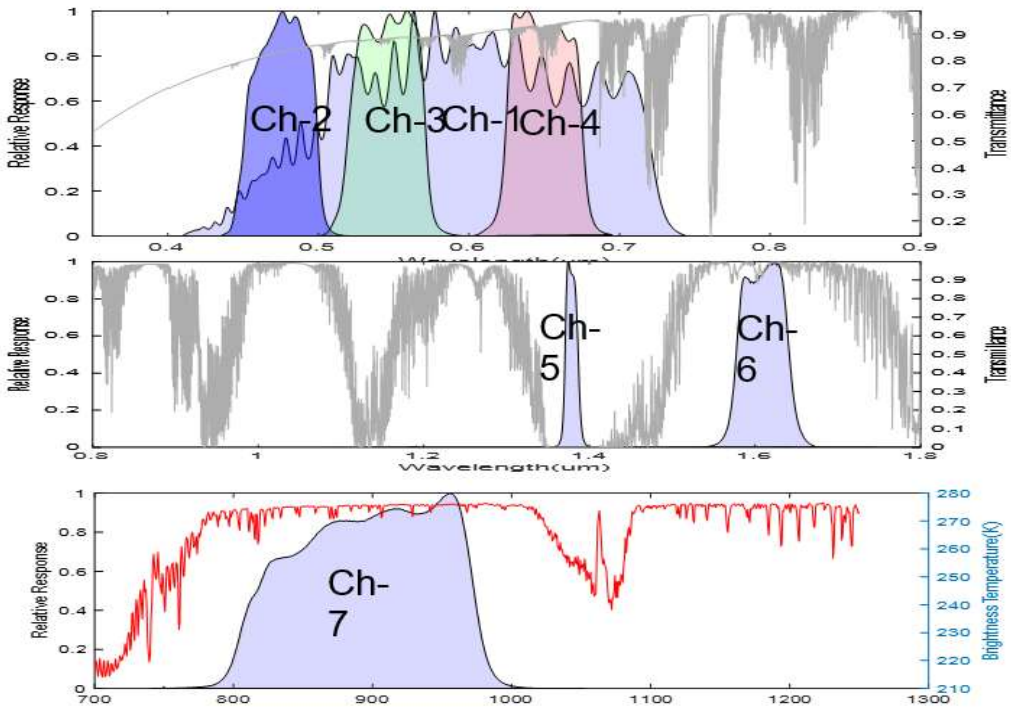




Rapid imaging: GHI

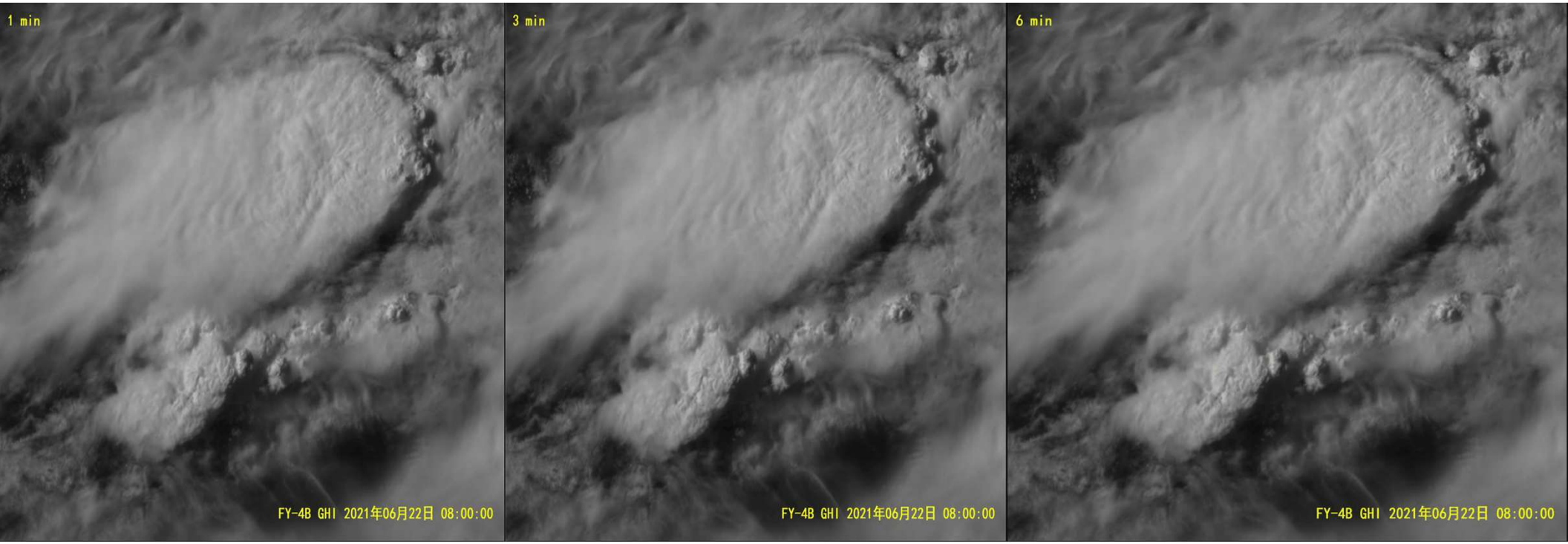
Geosynchronous High-speed Imager (GHI)

Central wavelength	Spectral interval	SNR or NEΔT @ specified input	IFOV at s.s.p.
0.675 μm	0.45-0.9	> 300 @ 100 % albedo	0.25 km
0.470 μm	0.445-0.495	> 300 @ 100 % albedo	0.5 km
0.545 μm	0.52-0.57	> 300 @ 100 % albedo	0.5 km
0.645 μm	0.62-0.67	> 300 @ 100 % albedo	0.5 km
1.378 μm	1.371-1.386	> 300 @ 100 % albedo	0.5 km
1.61 μm	1.58-1.64	> 300 @ 100 % albedo	0.5 km
11.4 μm	10.3-12.5	0.2 K @ 300 K	2.0 km



Rapid imaging： GHI

Geosynchronous High-speed Imager (GHI)



1min

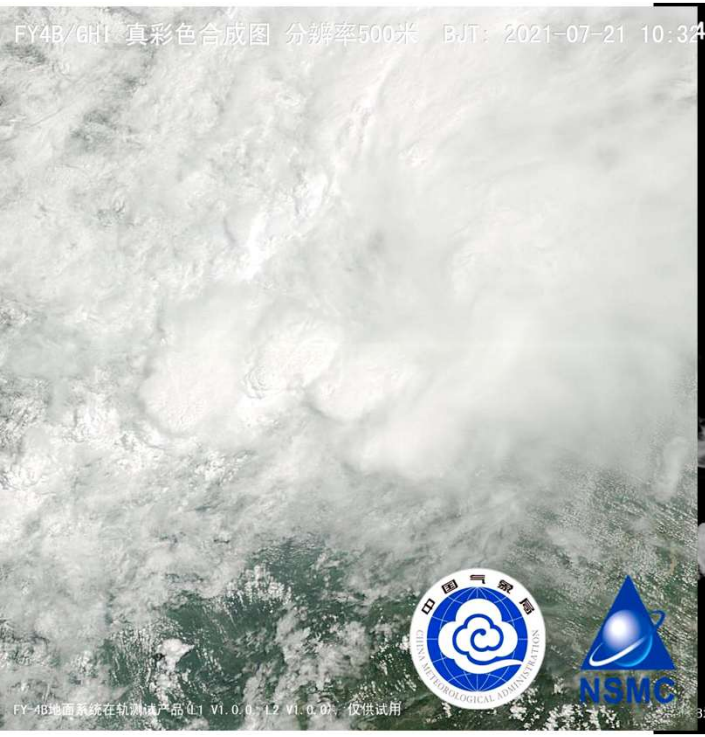
3min

6min

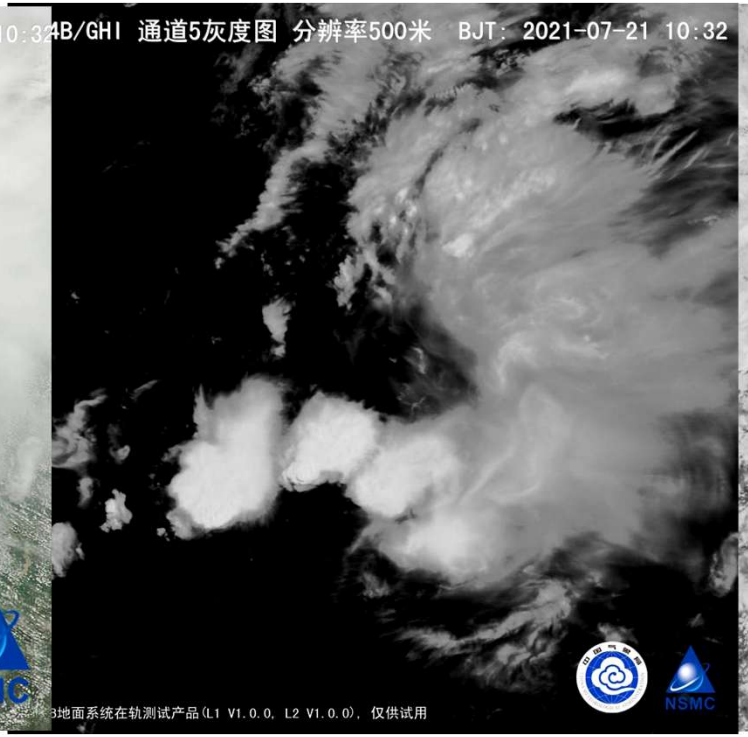
Rapid imaging： GHI

Geosynchronous High-speed Imager (GHI)

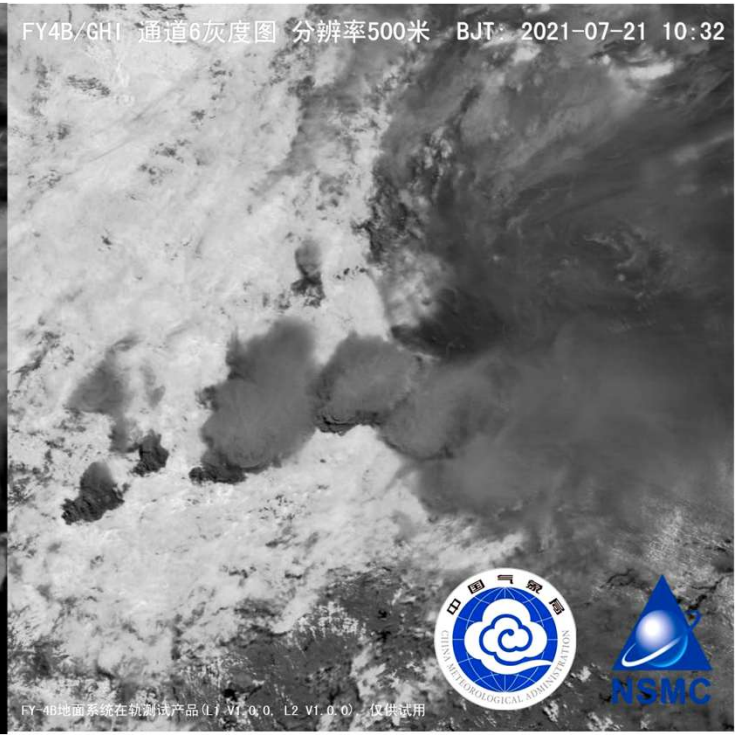
Jul 21,2021 Henan China



True Color
cloud

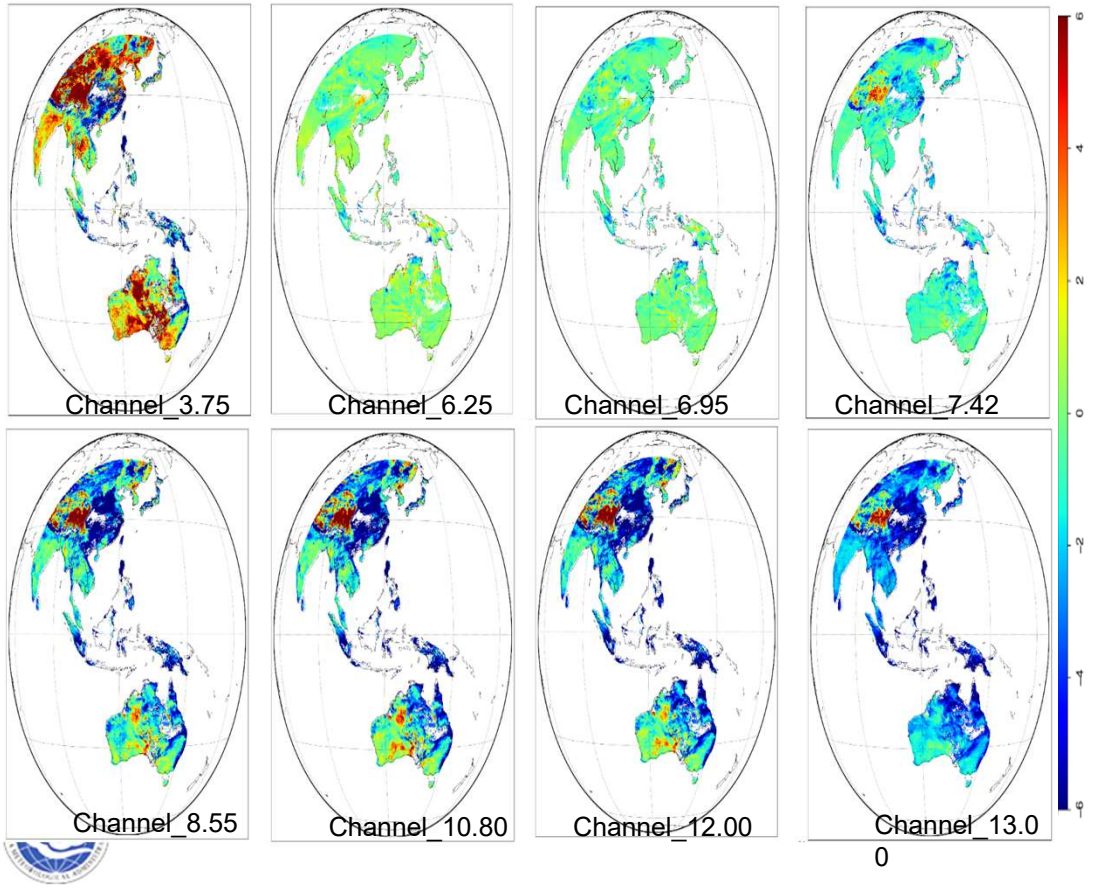


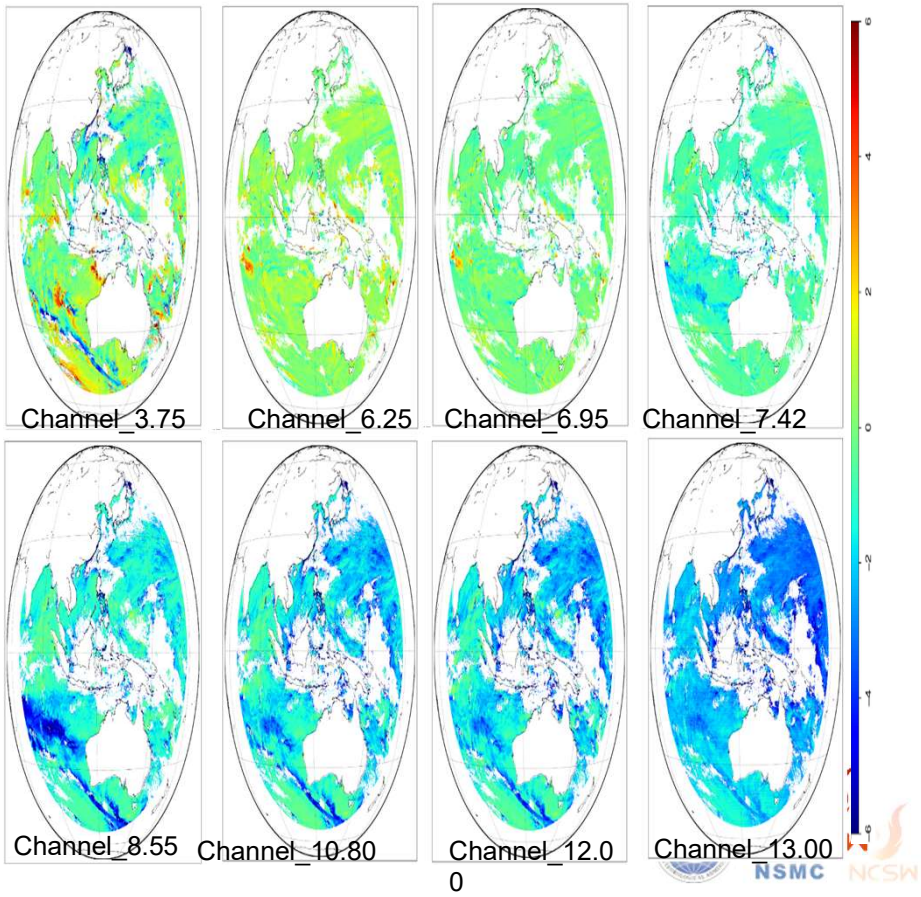
Ch-5 cirrus channel



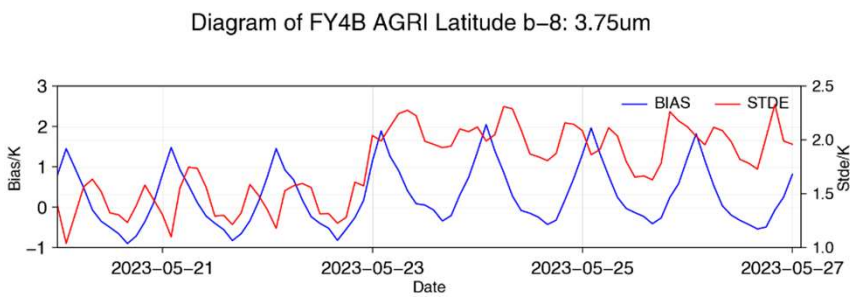
Ch-6 ice/water

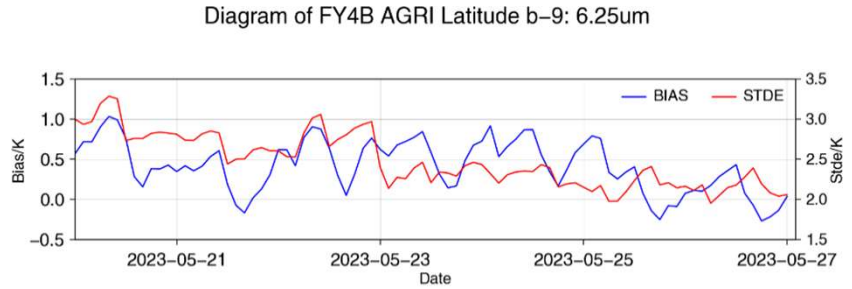
AGRI channel simulation is operational in NSMC

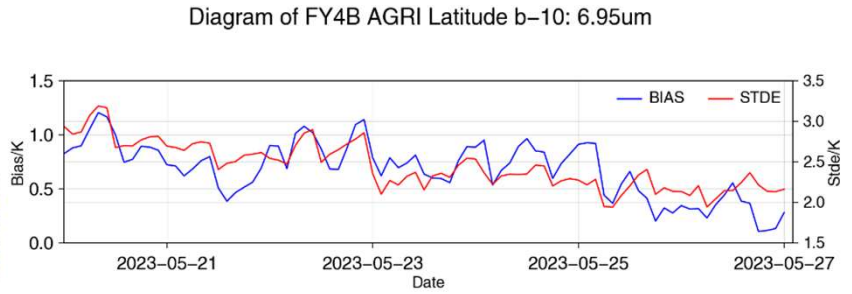


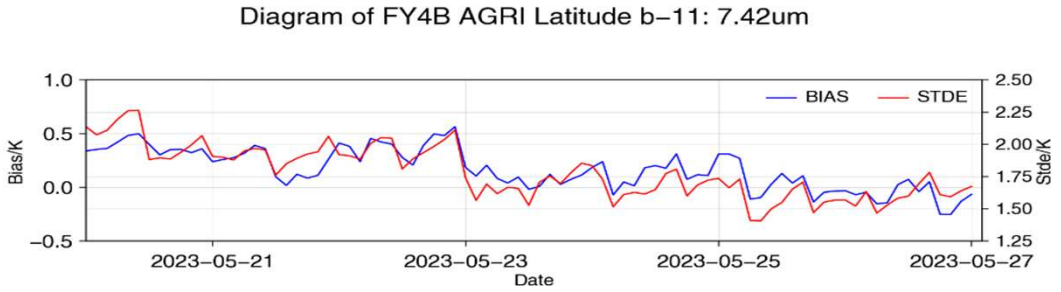


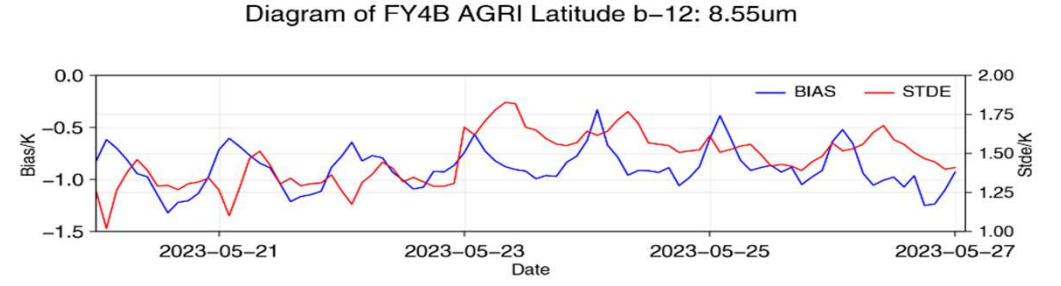
AGRI performance montorning is operational in NSMC

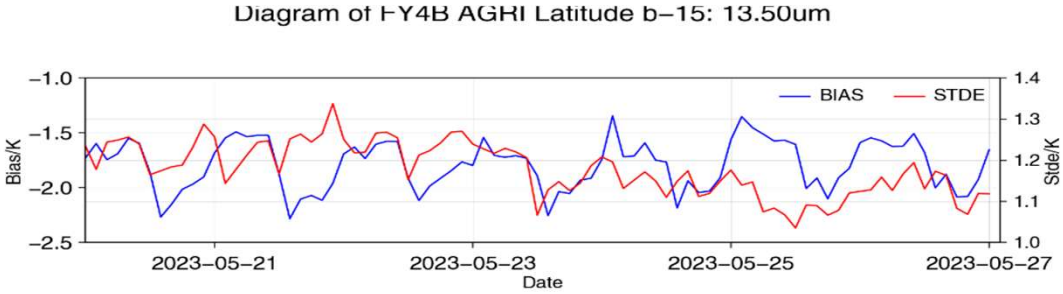




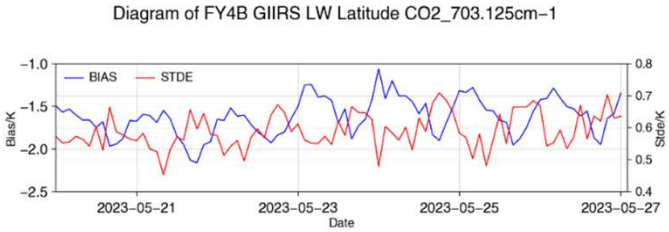


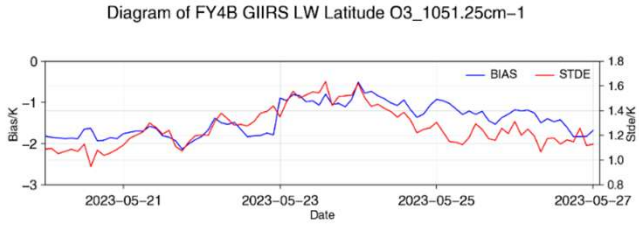


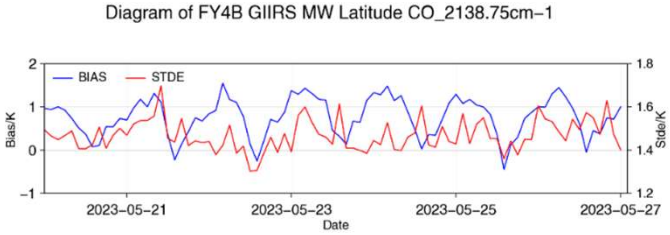


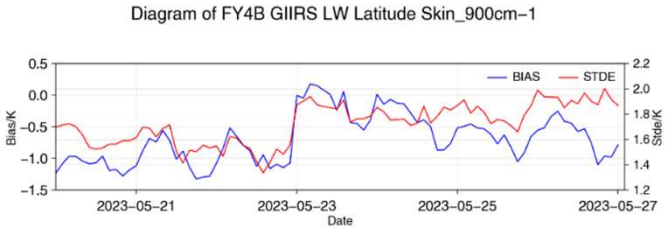


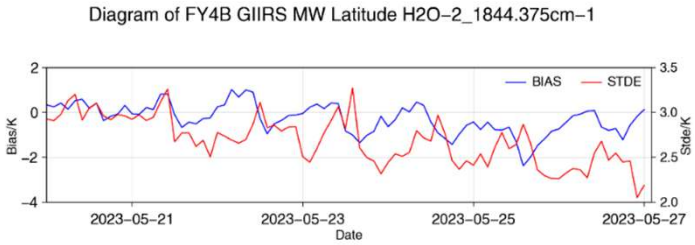
GIIRS performance montorning is operational in NSMC

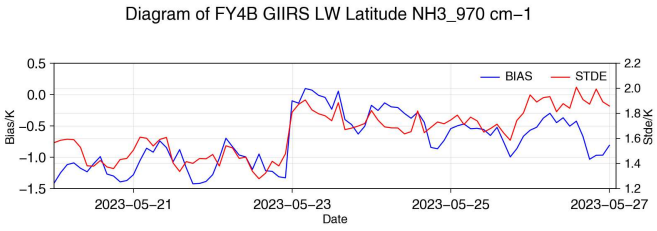


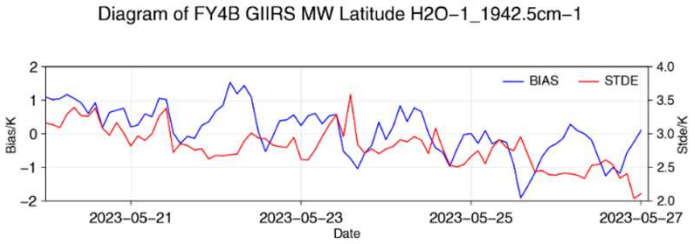




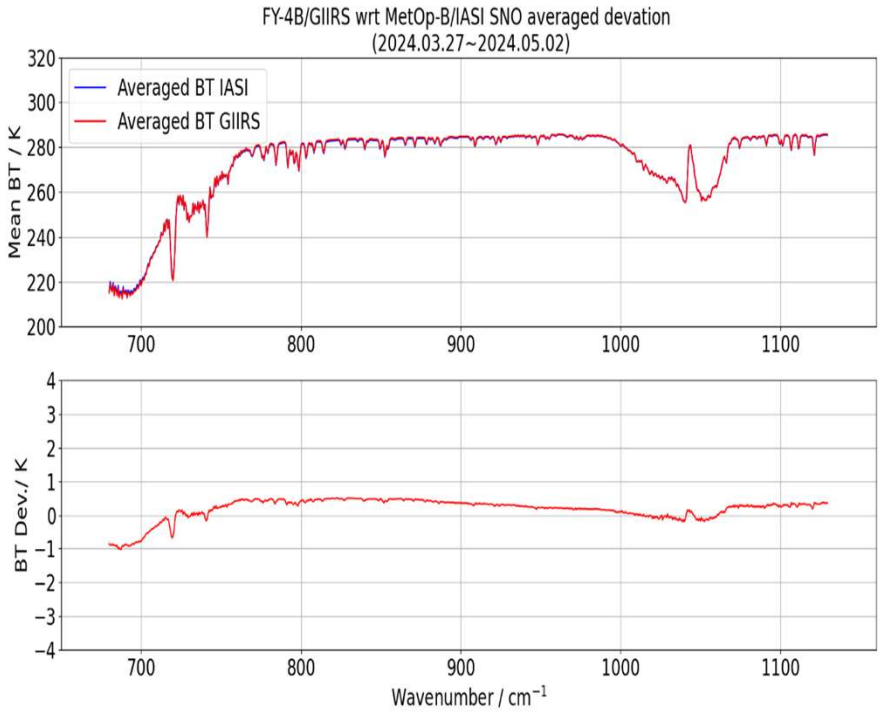




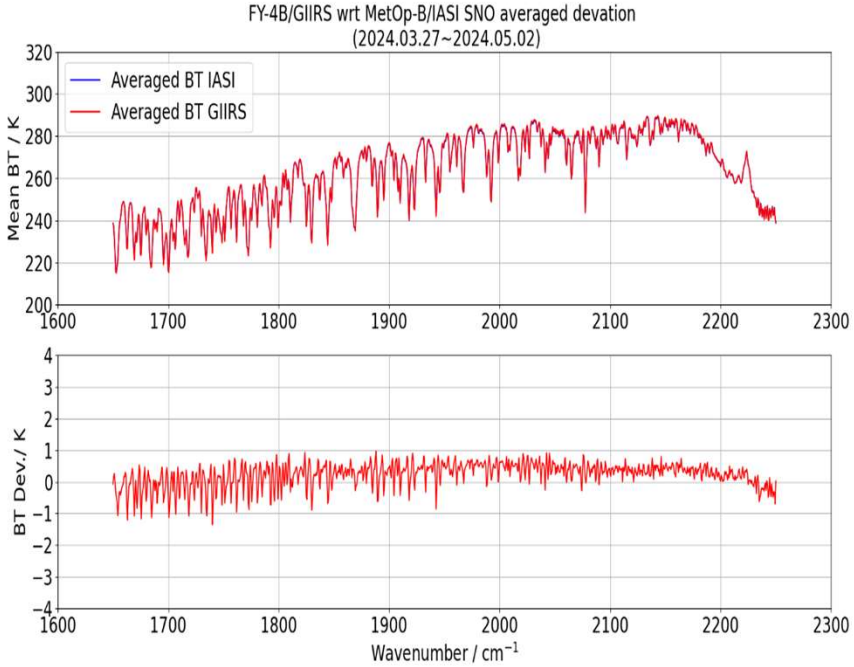




FY-4B GIIRS-II calibration accuracy 0.5~1K



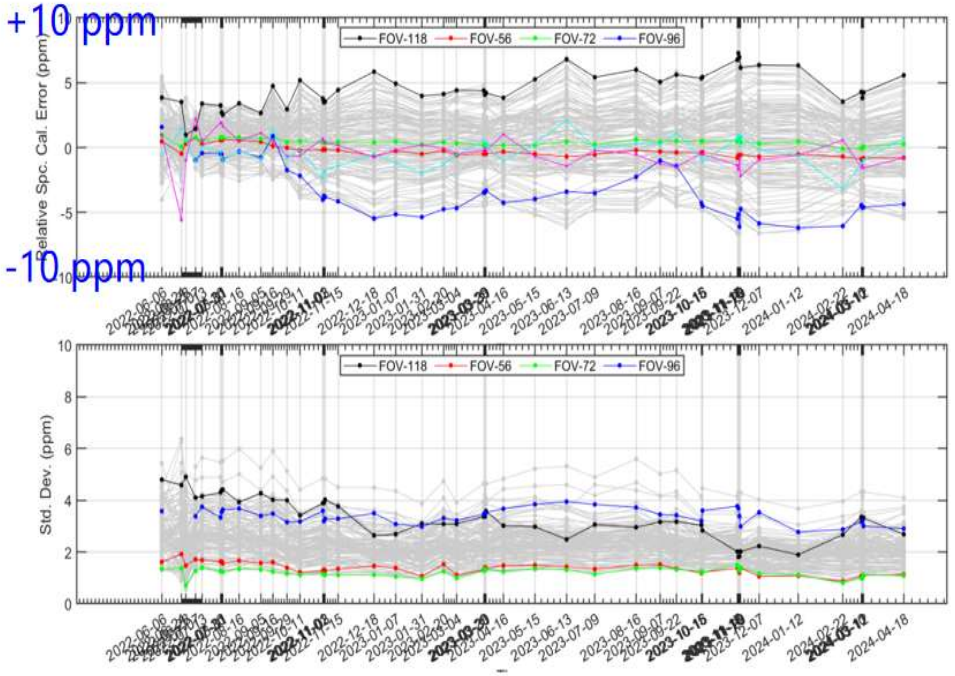
FY-4B/GIIRS LWIR
(2024.3.~2024.05)



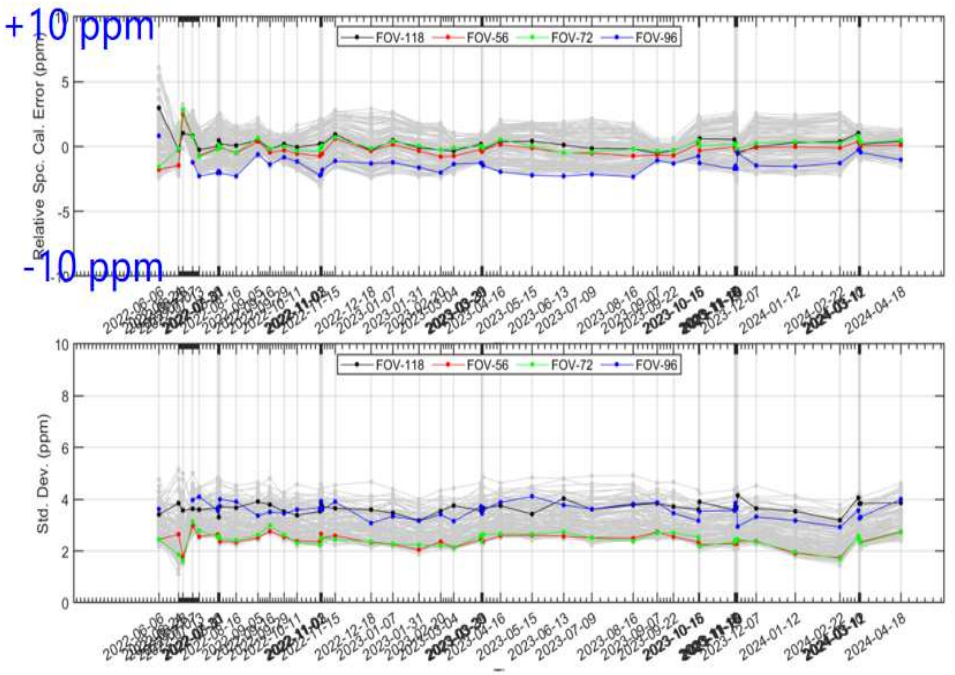
FY-4B/GIIRS MWIR
(2024.3.~2024.05)

FY-4B/GIIRS辐射定标精度主要采用与GSICS框架参考仪器MetOP/IASI开展星下点交叉定标（SNO）的方式进行评估， 李路等，国家卫星气象中心分析报告

FY-4B GIIRS-II calibration performance diagnosis



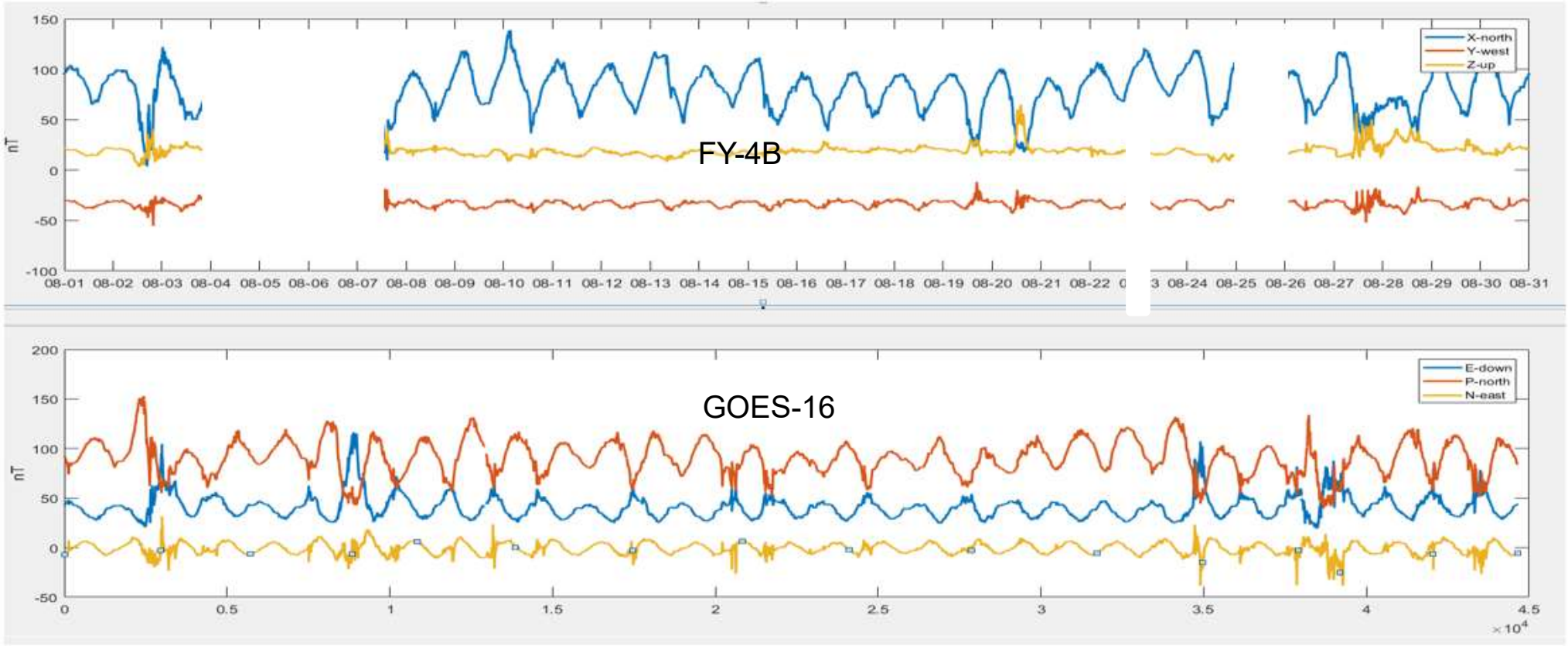
FY-4B/GIIRS LWIR 全部128探元光
谱定标精度时间序列
(2022.6.~2024.05)



FY-4B/GIIRS MWIR 全部128探元光
谱定标精度时间序列
(2022.6.~2024.05)

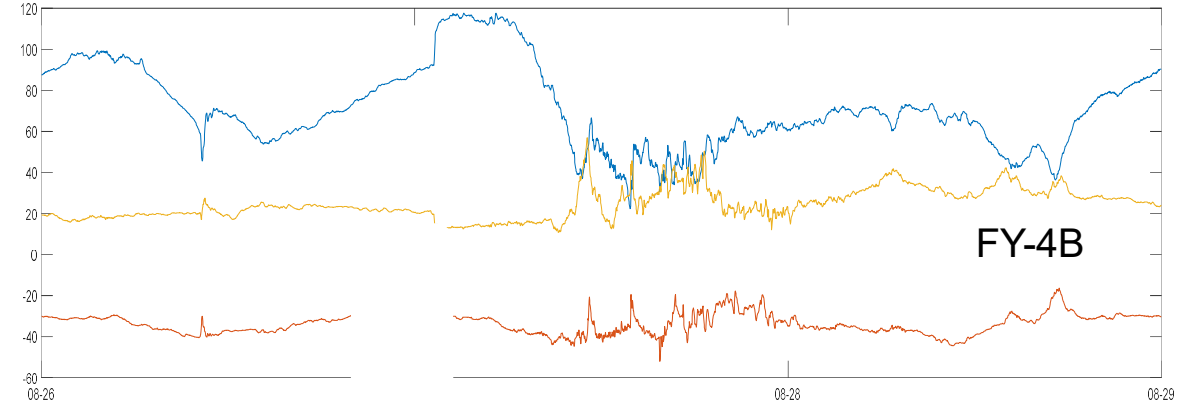
courtesy of Lu Li

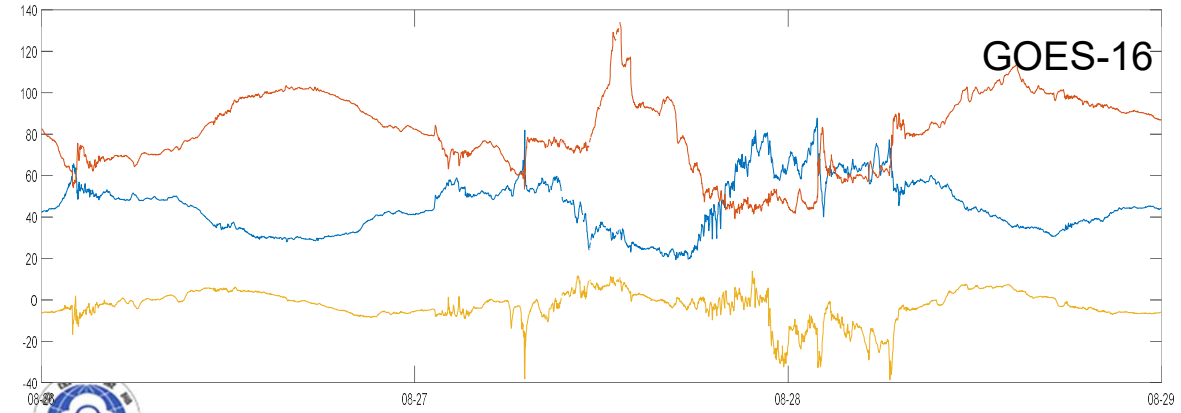
FY-4B Space Environment Package(SEP)



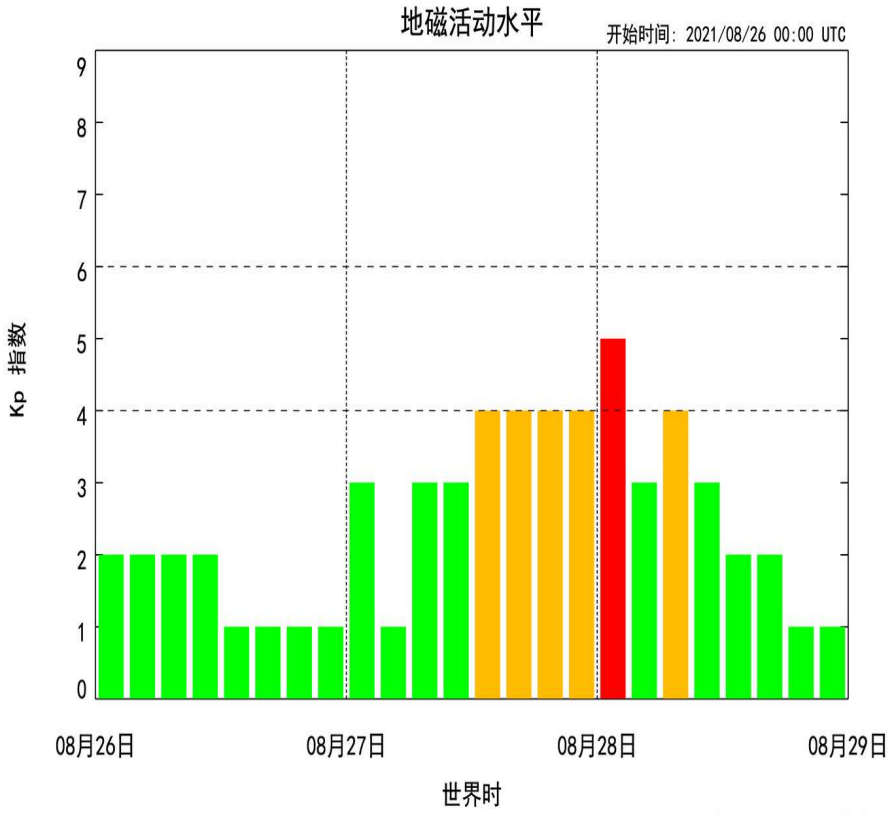
courtesy of Lu Li

FY-4B Flux Gate Magnetometer (FGM)





geomagnetic storm: Kp=5



courtesy of Lu Li

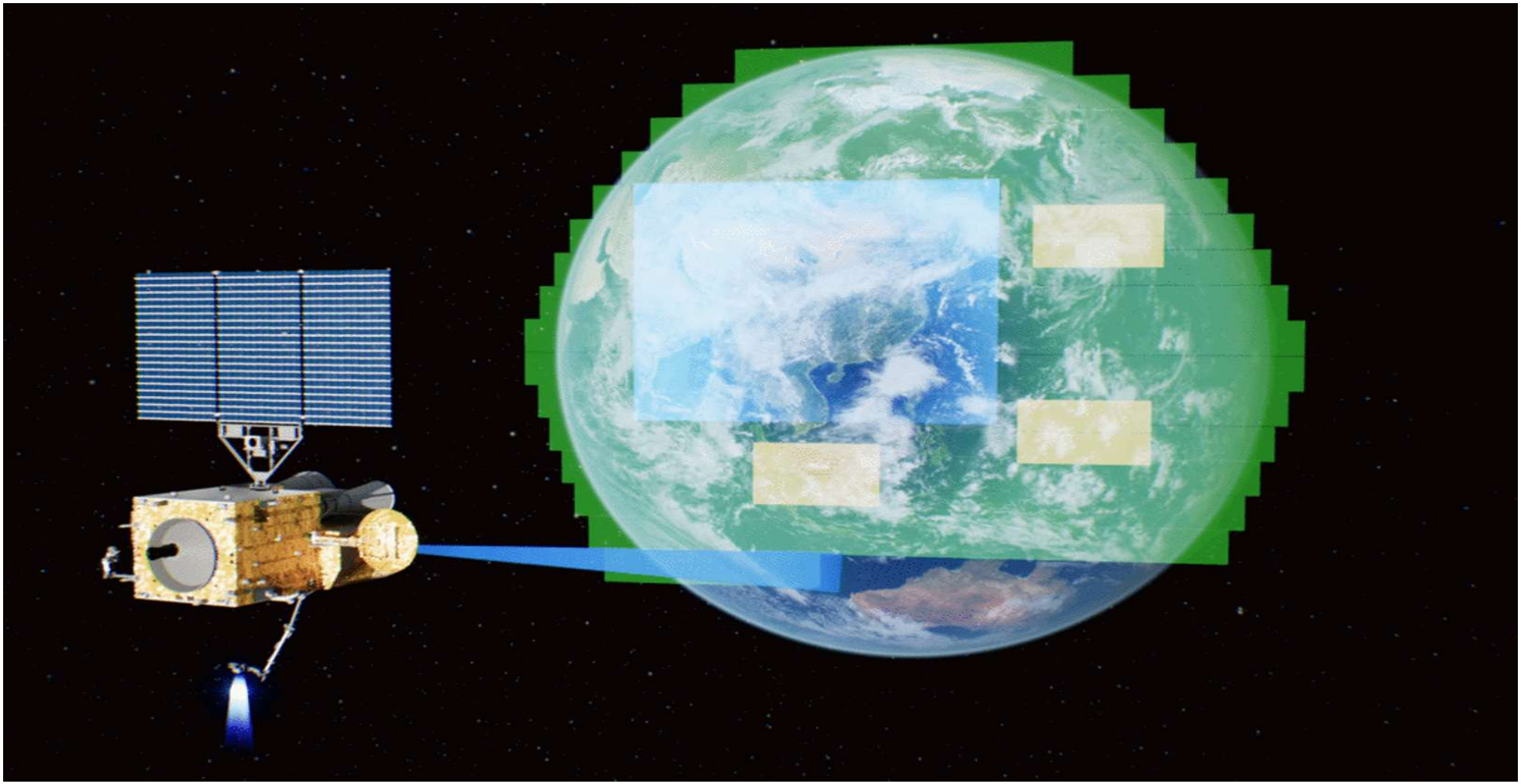
Outline

- Current status
- FY-4C mission
- Progress on Instrument Trade-off Studies
- Summary

WMO Vision for WIGOS in 2040 for GEO

	Application	Satellite/Instrument
VIS/IR Imager w/ rapid repeat cycles	Cloud amount/type/top height/temperature, wind, sea/land surface temperature, precipitation, aerosols, snow cover, vegetation cover, albedo, atmospheric stability, fires, volcanic ash, sand/dust storm, convective initiation	• NOAA: GOES-16,17/ABI • JMA: Himawari-8,9/AHI • KMA: GK-2A/AMI • CMA: FY-4A,4B/AGRI • EUMETSAT: MTG-I1/FCI (2022)
Hyperspectral IR Sounder	Atmospheric temperature/humidity, wind, rapidly evolving mesoscale features, sea/land surface temperature, cloud amount/top height/temperature, atmospheric composition	• NOAA: under consideration • JMA: under consideration • KMA: under consideration • CMA: FY-4A,4B/GIIRS • EUMETSAT: MTG-S1/IRS (2024)
Lightning Mapper	Lightning, location of intense convection, life cycle of convective systems	• NOAA: GOES-16,17/GLM • JMA: under consideration • KMA: under consideration • CMA: FY-4A/LMI • EUMETSAT: MTG-I1/LI (2022)
UV/VNIR Sounder	Ozone, trace gases, aerosol, humidity, cloud top height	• NASA: TEMPO (2022) • JMA: N/A • KMA: GK-2B/GEMS • CMA: N/A • EUMETSAT: MTG-S1/UVN (2024)

➢ CGMS will strive to advance the new generation of GEO satellites, including advanced imaging, IR sounding and lightning mapping for the whole **geostationary ring**. It is also agreed that CGMS will strive to work towards operational hourly daytime UV/VIS mapping of air quality from geostationary orbit.



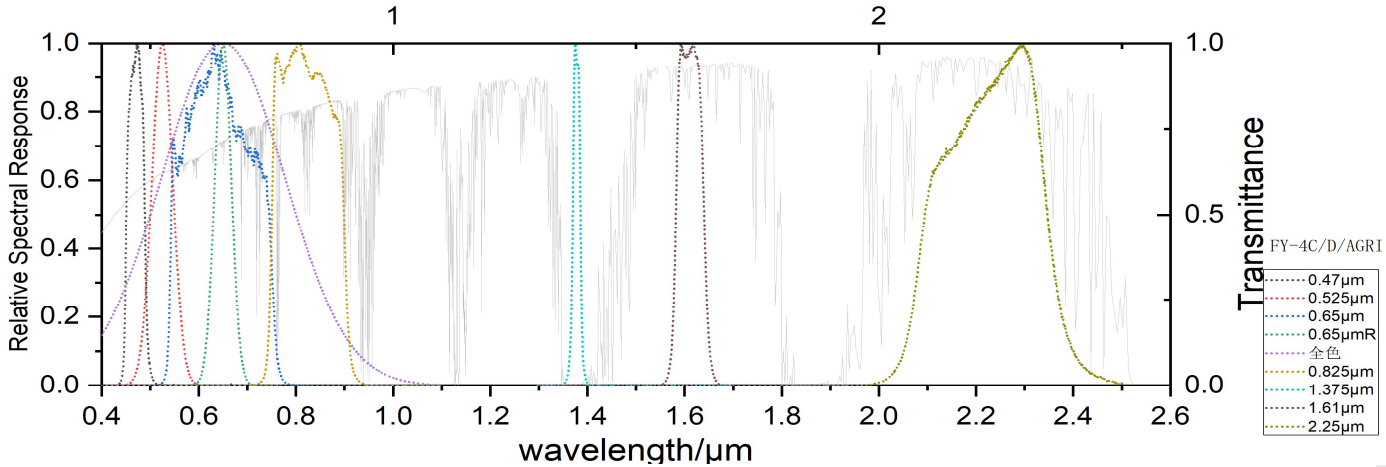
Major Meteorological payload onboard FY-4C

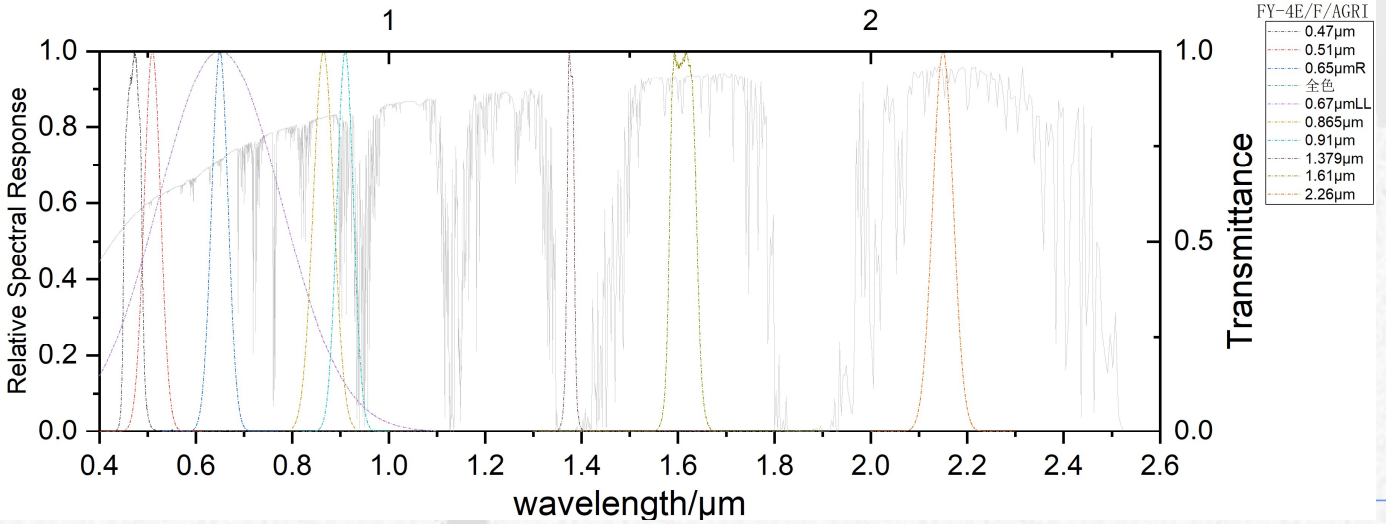
	FY-4A(EXP)	FY-4B(OP)	
Observation Mode	**Imaging +Sounding + Lightning Mapping**	**Imaging +Sounding**	**Imaging +Sounding + Lightning Mapping+Solar Imaging**
Main Instruments	**AGRI :14 channels** SSP Resolution：0.5~4Km Fulldisk imaging：15min	**AGRI :15 channels** SSP Resolution：0.5~4Km Fulldisk imaging：15min	**AGRI :19channels** SSP Resolution：0.25~2Km 10min：one Fulldisk+10regional
		GHI：7 channels SSP Resolution0.25-2Km,Regional imaging :1min	
	GIIRS: SSP Resolution:16Km Spectral Resolution: 0.625cm-1	**GIIRS:** SSP Resolution:12Km Spectral Resolution: 0.625cm-1	**GIIRS:** SSP Resolution:8Km Spectral Resolution: 0.625cm-1
	LMI： SSP Resolution:7.8Km,regional imaging		**LMI：** SSP Resolution:7.8Km,Fulldisk imaging
	SEP High energy particles	**SEP** High energy particles,Magnetic field	
			SUVI Solar-Extreme Ultraviolet imager
			SXUS Solar X-EUV Irradiance Sensor
			MUSI Multiband Ionospheric Ultra-Violet Spectrum Imager

FY-4C: AGRI

F E N G Y U N

band	center wavelength(μm)	bandwidth（μm）	resolution(Km)	sensitivity	band
1	0.47	0.45~0.49	0.5	S/N≥150(ρ=100%)	S/N≥3(ρ=1%)
2	0.525	0.50~0.55	0.5	S/N≥200(ρ=100%)	S/N≥5(ρ=1%)
3		0.4~0.9	0.25	S/N≥200(ρ=100%)	S/N≥5(ρ=1%)
4	0.65	0.55~0.75	0.5	S/N≥150（ρ=100%）	S/N≥3（ρ=1%）
5	0.65	0.63~0.67	0.5	S/N≥200(ρ=100%)	S/N≥5(ρ=1%)
6	0.825	0.75~0.90	0.5	S/N≥200(ρ=100%)	S/N≥5(ρ=1%)
7	1.379	1.371~1.386	0.5	S/N≥70(ρ=60%)	S/N≥2(ρ=1%)
8	1.61	1.58~1.64	0.5	S/N≥200(ρ=100%)	S/N≥5(ρ=1%)
9	2．225	2.10~2.35	1	S/N≥200(ρ=100%)	S/N≥5(ρ=1%)
10	3.75	3.50~4.00	1	≤0.35K(300K)	≤2.5K（240K）
11	4.05	3.972~4.127	1	≤0.8K（300K）	≤2.4K（270K）
12	6.25	5.80~6.70	2	0.1～0.2K(300K)	0.4～0.9K(240K)
13	6.95	6.75~7.15	2	0.1～0.25K(300K)	0.4～1.2K(240K)
14	7.42	7.24~7.60	2	0.1～0.25K(300K)	0.4～1.2K(240K)
15	8.55	8.3~8.8	2	0.1～0.25K(300K)	0.4～1.2K(240K)
16	9.61	9.42~9.80	2	0.1～0.2K(300K)	0.4～0.9K(240K)
17	10.80	10.30~11.30	2	0.1～0.2K(300K)	0.4～0.9K(240K)
18	12.00	11.50~12.50	2	0.1～0.2K(300K)	0.4～0.9K(240K)
19	13.3	13.00~13.60	2	0.3～0.5K(300K)	0.8～2.0K(240K)





new channels need fast RTM for trade off studies balance the S/N ratio and SRF

0.525μm :
green band

0.65μm:
for high resolution apps

FY-4C：GIIRS

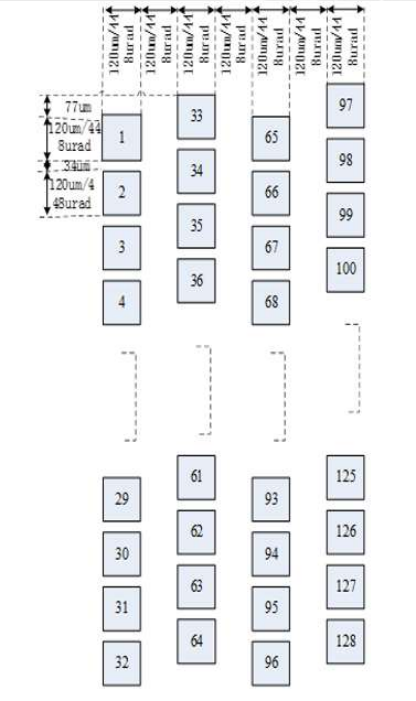
F E N G Y U N

	FY-4A/GIIRS	FY-4B/GIIRS	FY-4C/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}		
Temporal Resolution	35min（1000*1000）67min（5000*5000）	45min（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	0.5K
Calibration accuracy (spectrum)	10ppm	7ppm	5ppm
Spatial Resolution	L/S/MIR:16km VIS:2km	**L/S/MIR:12km** **VIS:1km**	**L/S/MIR:8km** **VIS:0.5km**

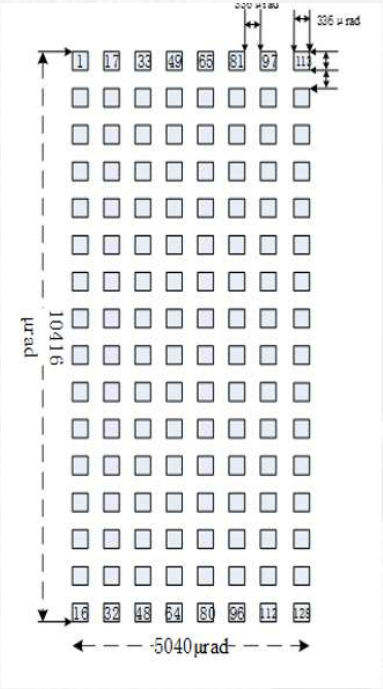
Evolution of FY-4 GIIRS

FENG YUN

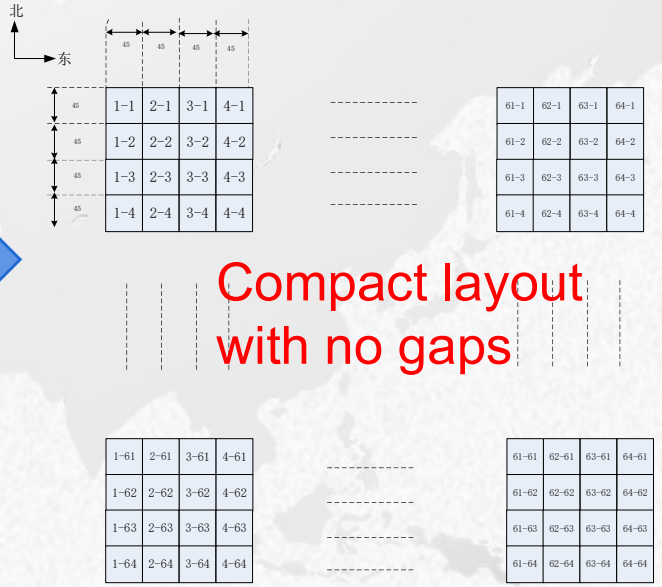
FY-4A 32X4



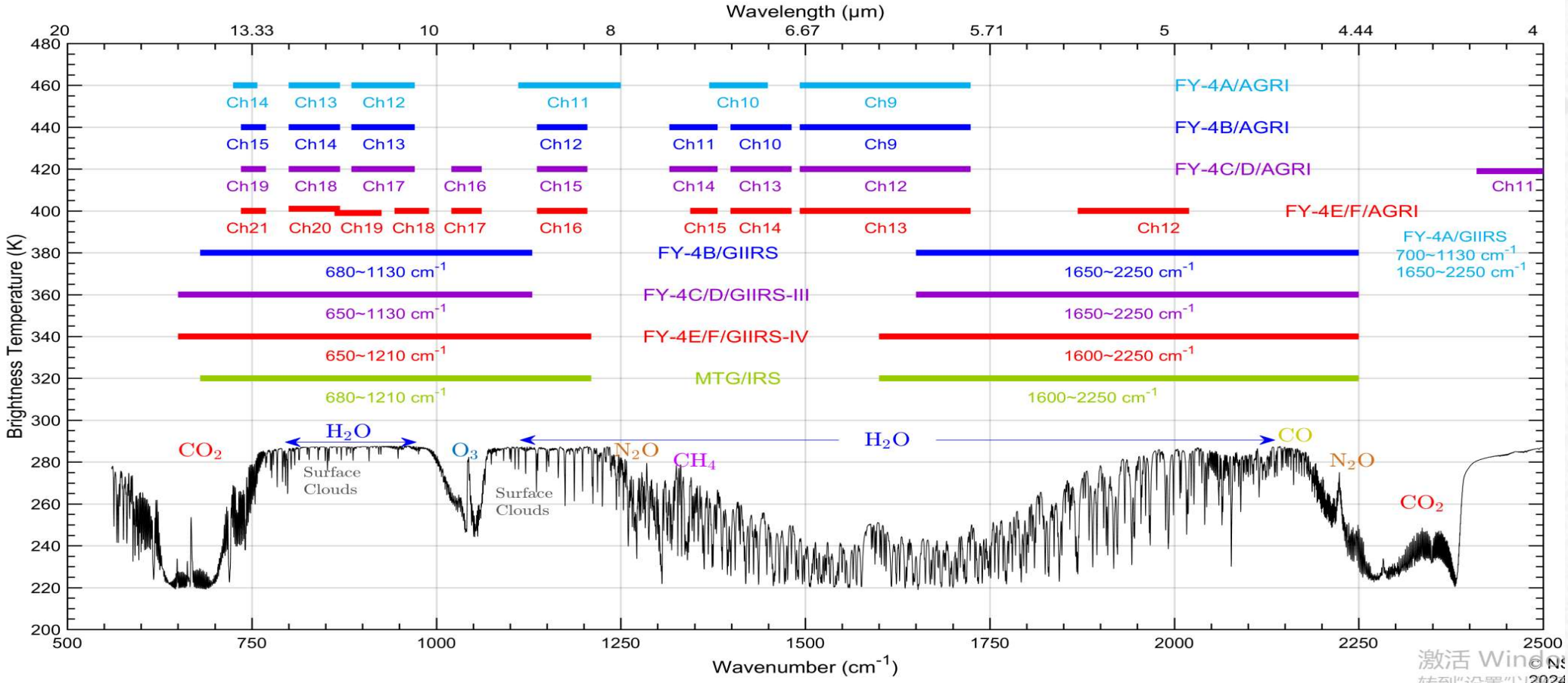
FY-4B 16X8



FY-4C 64X64



Evolution of FY-4 GIIRS

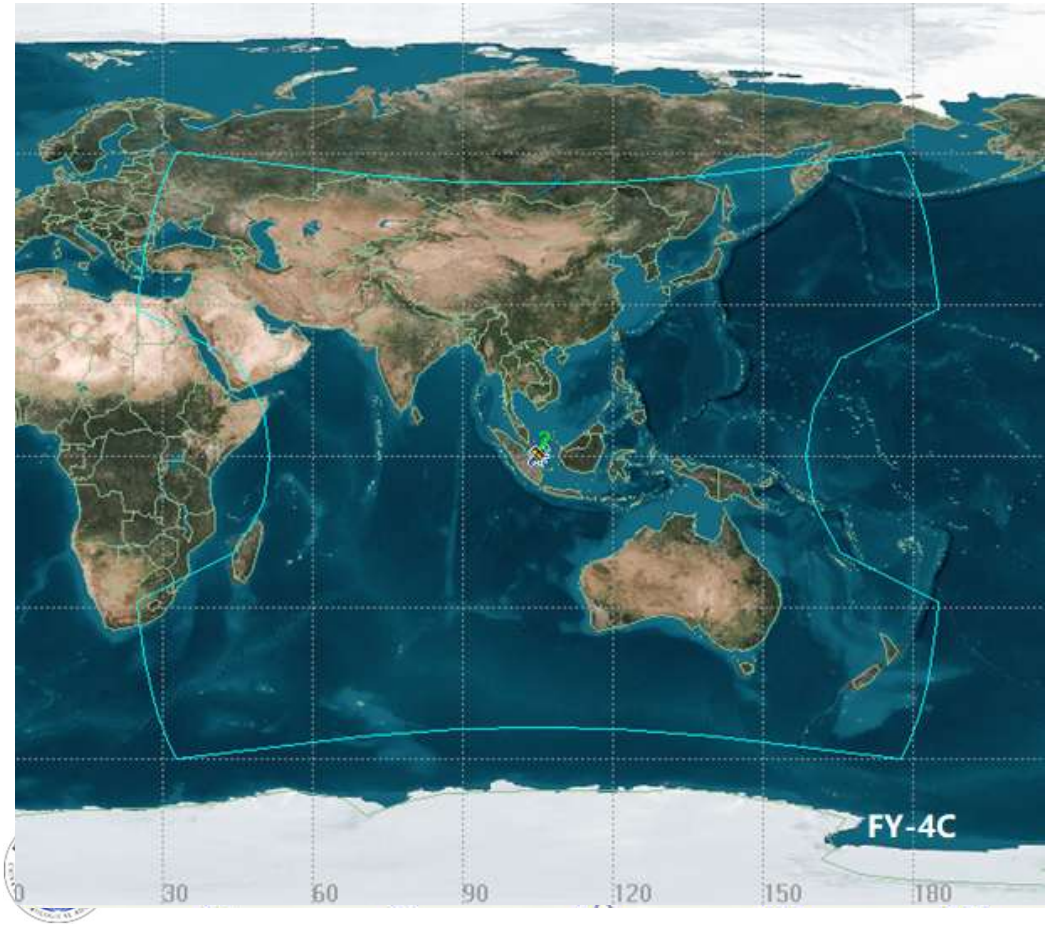


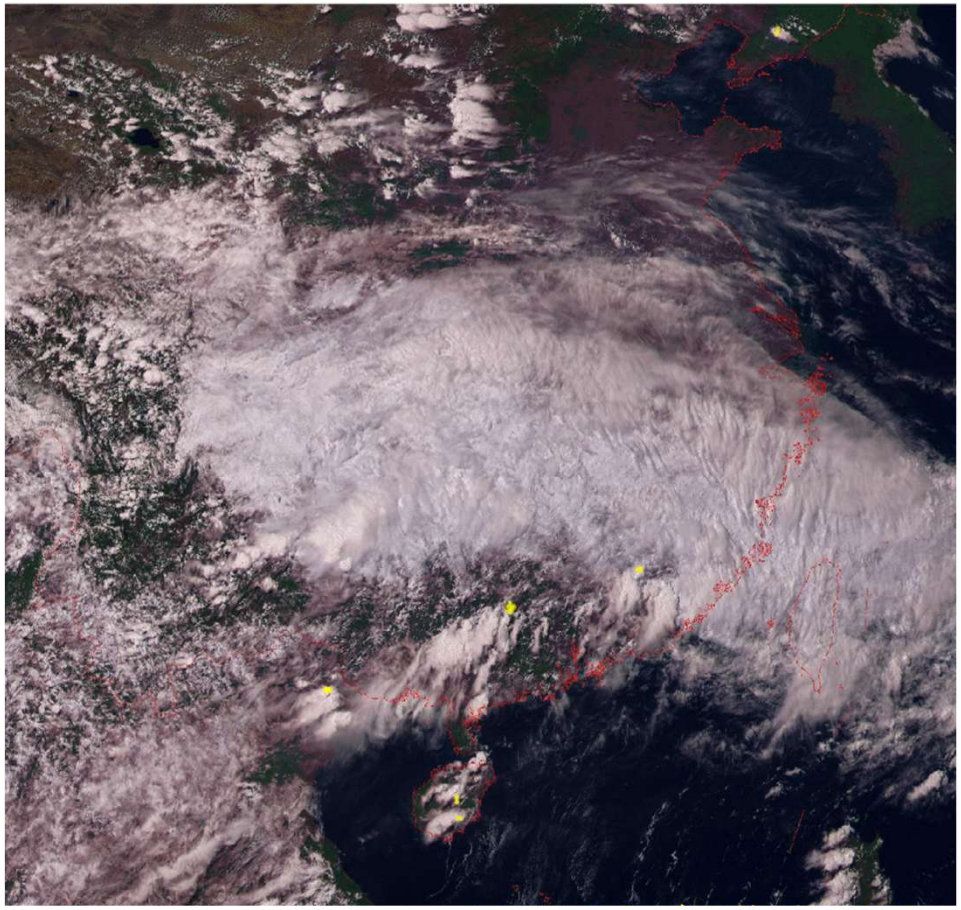
Evolution of FY-4 LMI

FENG YUN

	LMI-I (FY-4A)	LMI-II (FY-4C)	LMI-III (FY-4D/E)
sensor	CCD	CCD	CCD
resolution	8km	4-8km	**4km**
center wavelength	777.4nm	777.4nm	777.4nm
bandwidth	1nm *	2nm *	2nm *
detection rate	90%	≥70%@daytime ≥90%@night	≥70%@daytime ≥90%@night
虚警率	10%	≤30%@@daytime ≤10%@nighttime	≤30%@@daytime ≤10%@nighttime
S/N	>6	>6	>6
frame rate	500帧/s	500帧/s	500帧/s
量化等级	12bit	12bit	12bit
INR accuracy	1 pixel	1 pixel	1 pixel

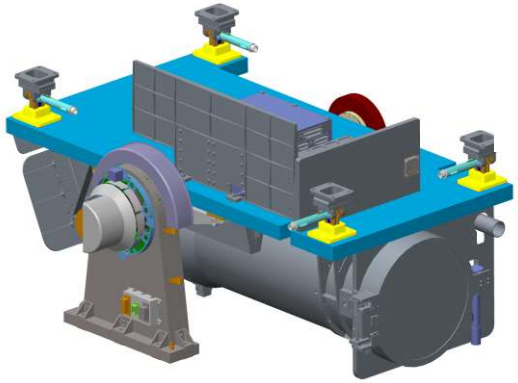
FY-4C: Lightning Imaging





FY-4C: Solar Extreme Ultraviolet imager (SUVI)

Title		
	FY-4	FY-3
Bandpass	**EUV1: Fe XVIII 9.4nm** **EUV2: Fe IX 17.1nm** **EUV3: Fe XIV 21.1nm** **EUV4: He II 30.4nm**	EUV: Fe XII 19.5nm X1：0.6-8.0 nm， X2：0.6-6.0 nm， X3：0.6-5.0 nm， X4：0.6-2.0 nm， X5：0.6-1.6 nm X6：0.6-1.2 nm
Field of view	**42×42 arcmin**	42×42 arcmin
Resolution	**3.5 arcsec**	EUV channe: 5 arcsec X channel: 10arcsec
Detector	**CMOS 2048×2048**	CCD 1024×1024



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Wavelength Log(Te)	94Å	171Å	211Å	304Å
Filaments				■
Coronal Holes			■	
Active region complexity		■	■	
CMEs(e.g. dimming)		■		
Flare Location and Morphology	■			
Quiet Regions		■		■

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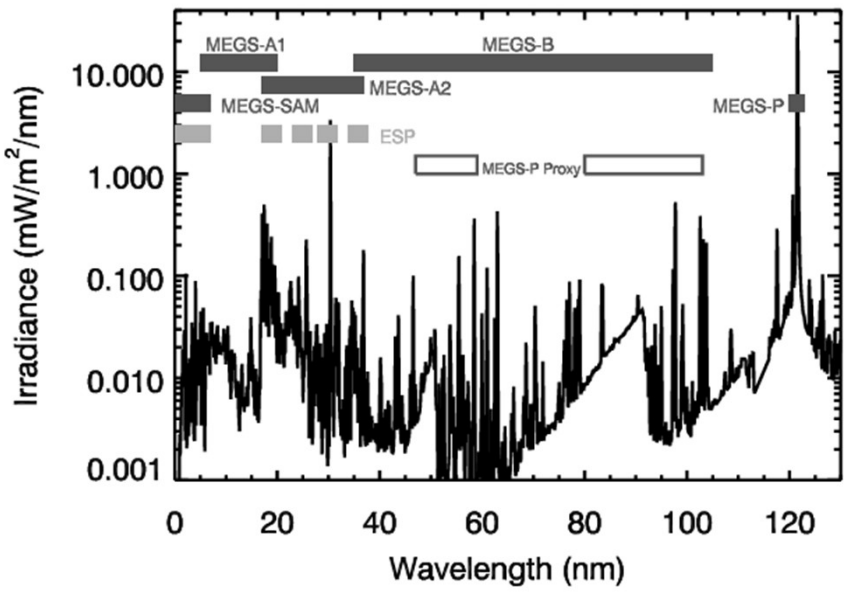
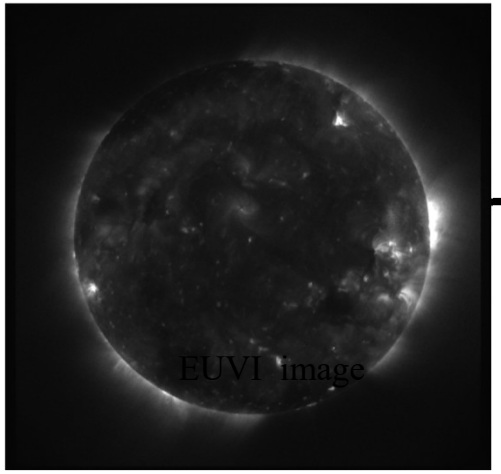
FY-4C: Solar Extreme Ultraviolet imager (SUVI)

SDO/EVE: solar spectral irradiance from **60 – 1050 Å** with ≈**1 Å** spectral resolution and a 10 s cadence.

After radiometric calibration in orbit, four channel of EUVI can be cross-calibration with SDO/EVE



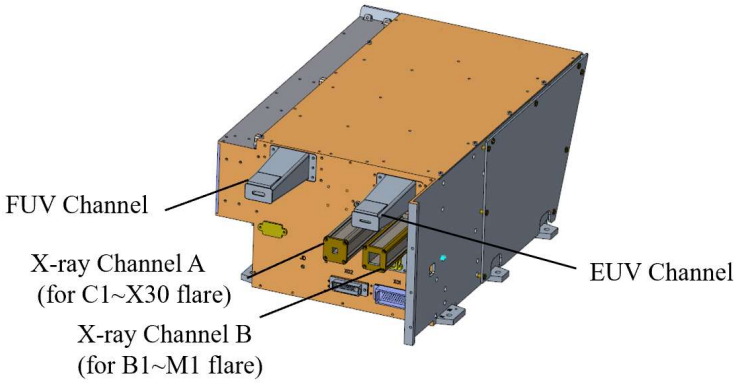


$$E = \frac{R \cdot \omega \cdot \sum DN}{t}$$

EUVI Total irradiance

FY-4C：SolarX-EUVIrradianceSensor(SXUS)

FY-4C SXUS VS GOES-R XRS and EUVS

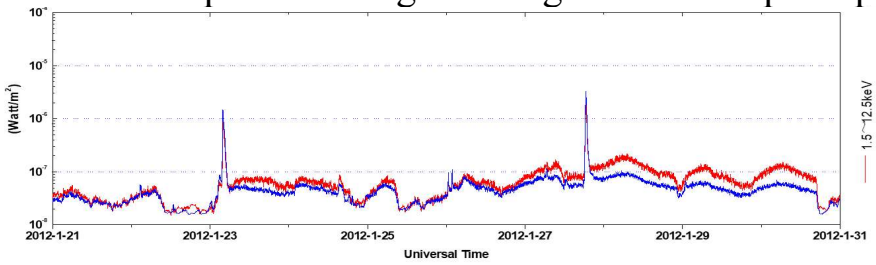


performance		FY-4C	FY-2	GOES-R
wavelength	X-ray Channel (A and B)	0.05~0.8nm	0.05~0.8nm	0.05nm-0.8nm
	EUV channel	5-35nm	/	25.6nm、28.4nm、30.4nm
	FUV channel	110-145nm	/	117.5nm、121.6nm、133.5nm、140.5nm
		275-285nm	/	275-285nm
Spectrum resolution		≤5%	≤5%	/
		0.5nm@5~35nm	/	0.6nm
		0.6nm@110~145nm	/	1nm
		0.1nm@275~285nm	/	0.1nm
Field of view (FOV)		84±2 arcminute	±25°	±70 arcminute
Integrate time		≤1s@Xray ≤5s@EUV-FUV	2.05s@Xray	≤1s@Xray ≤5s@EUV
Flare coverage		B1~X30	C5~X30	C2~X20
Irradiance Accuracy		≤20%	≤20%	≤20%

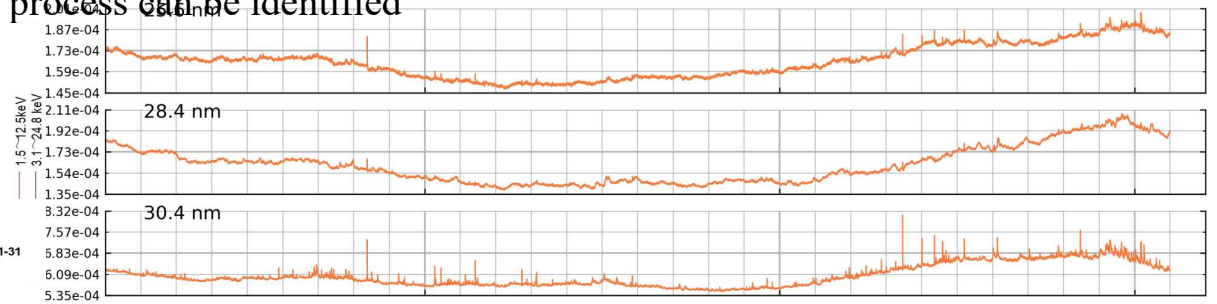
FY-4C：SolarX-EUVIrradianceSensor(SXUS)

FY-4C SXUS VS GOES-R XRS and EUVS

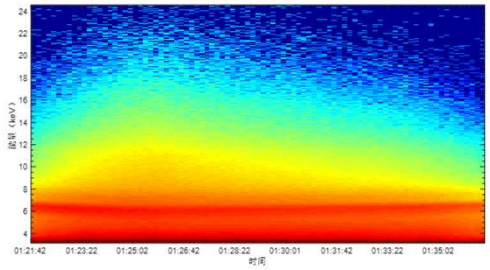
- High resolution （lar spectrum data from X-rays to FUV band can be measured by FY-4(03) satellite, generating X-ray flux, EUV flux, Mg-II index from FUV flux.
- The results can be verified and compared with instruments XRS and EUVS of GOES satellite
- The spectral changes during the flare eruption process can be identified



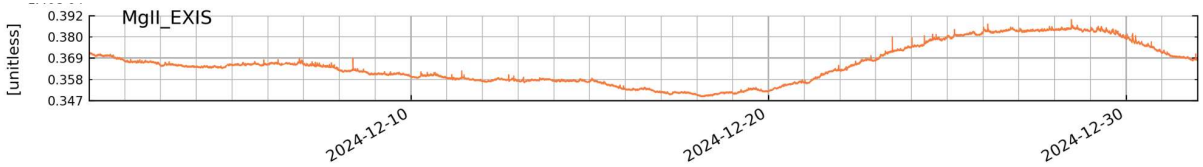
Example：X-ray flux and flare class (data from FY-2H)



Example：EUV Irradiance per minute (data from GOES)



Example：X-ray spectrum for M1 flare (data from China Space Station)

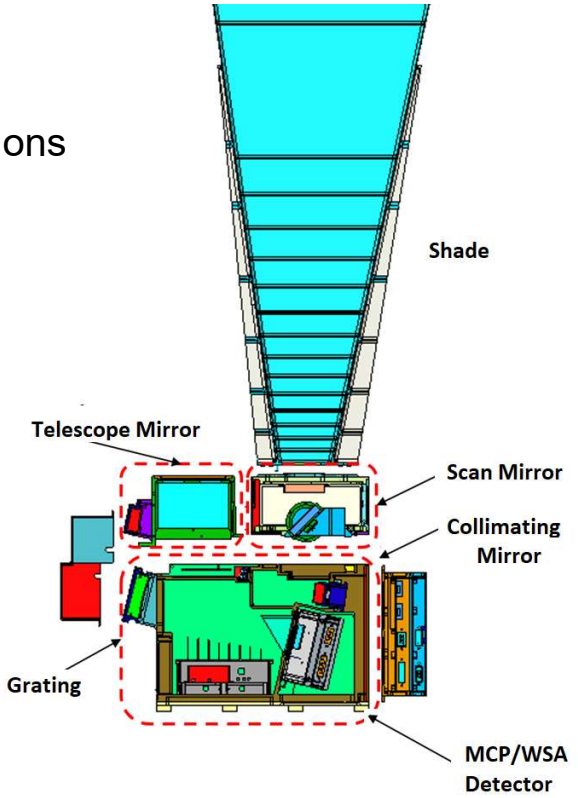


Example：Mg-II index (data from GOES)

FY-4C Capabilities: Multiband Ultraviolet Spectrum Imager(MUSI)

MUSI : A hyperspectral imager designed to observe the FUV airglow emissions between ~120 and 160 nm, which include the prominent HI 121.6 nm, OI 130.4 nm, OI 135.6 nm, and the N_2 Lyman-Birge-Hopfield (LBH) emission

FOV	**14°×16°**	
Wavelength(nm)	**120-160**	
Spectral Resolution	**< 0.4nm**	
Responsivity (counts·s-1·R-1·pixel-1)	**121.6nm**	**≥2.85E-3**
	130.4nm	**≥5.7E-3**
	135.6nm	**≥5.7E-3**
	140-160nm	**≥4.3E-3**
Spatial Resolution(km)	**< 50**	
Disk scans	**≤60min**	



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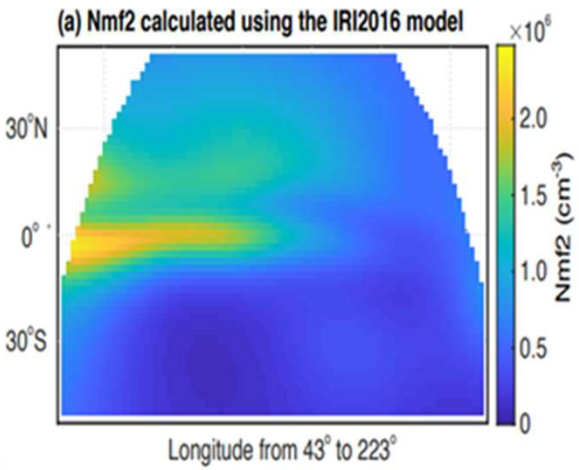
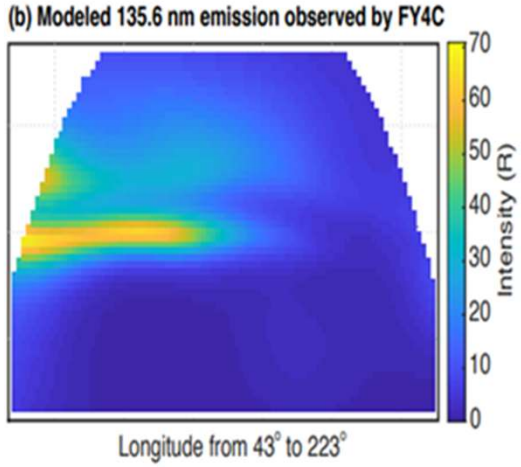
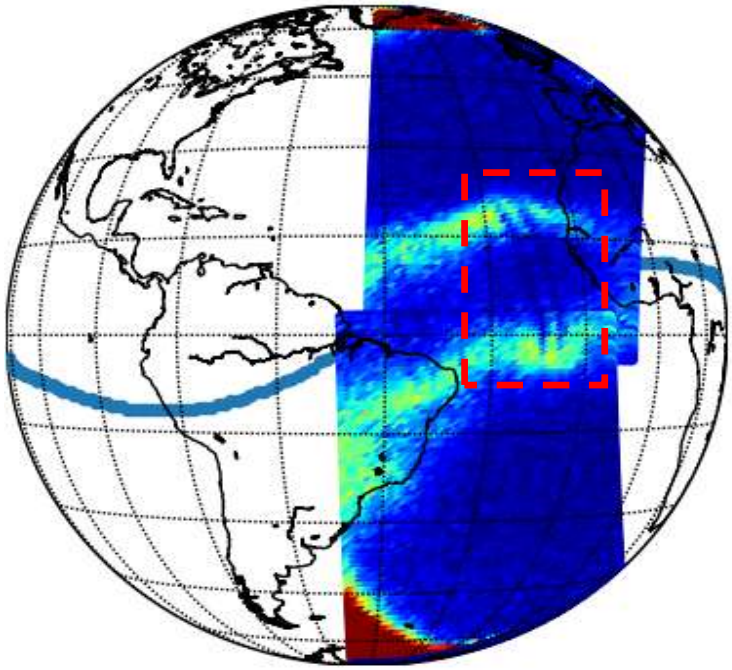
FY-4C Capabilities: Multiband Ultraviolet Spectrum Imager(MUSI)

Production

- Nightside TEC and NmF2
- Plasma Bubble
- O/N2





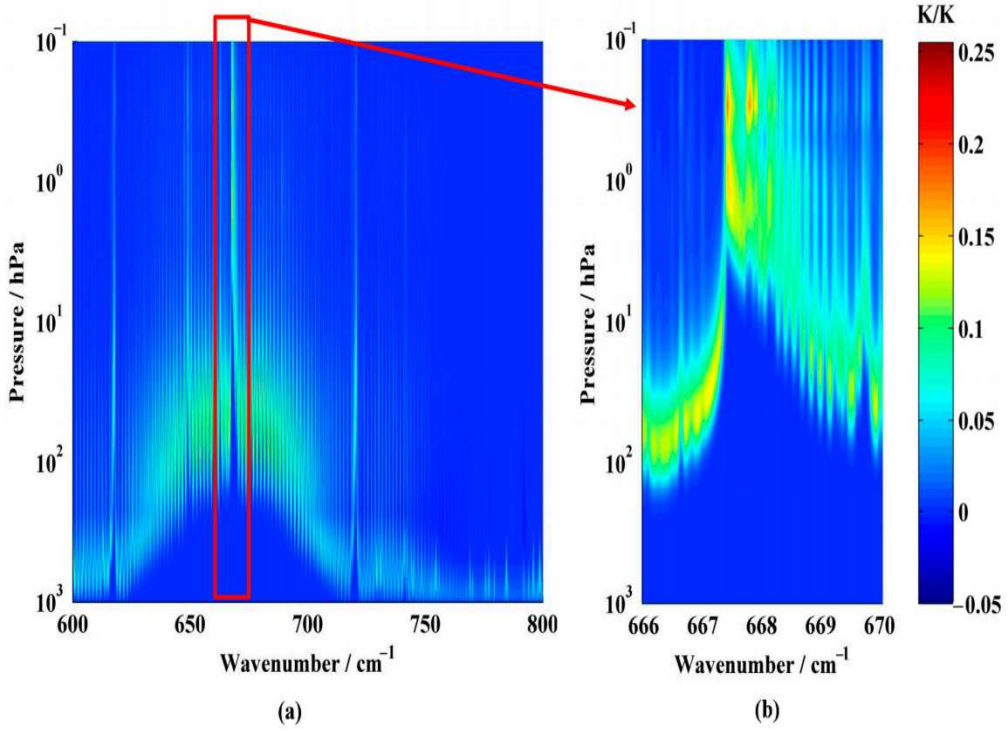


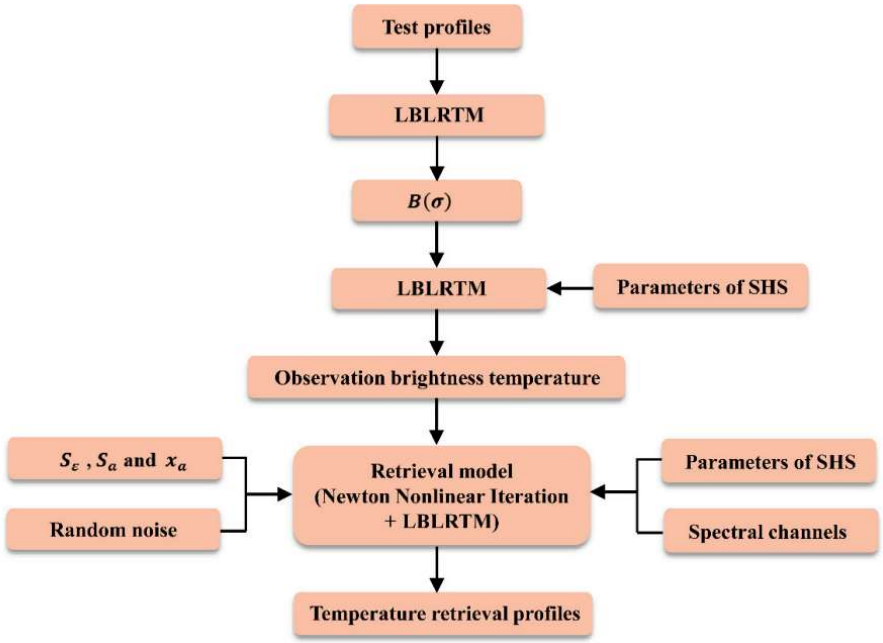
The radiation measured by **MUSI** can be compared with that of Special Sensor Ultraviolet Spectrographic Imager(**SSUSI**) onboard DMSP

Outline

- Current status
- FY-4C mission
- Progress on Instrument Trade-off Studies
- Summary

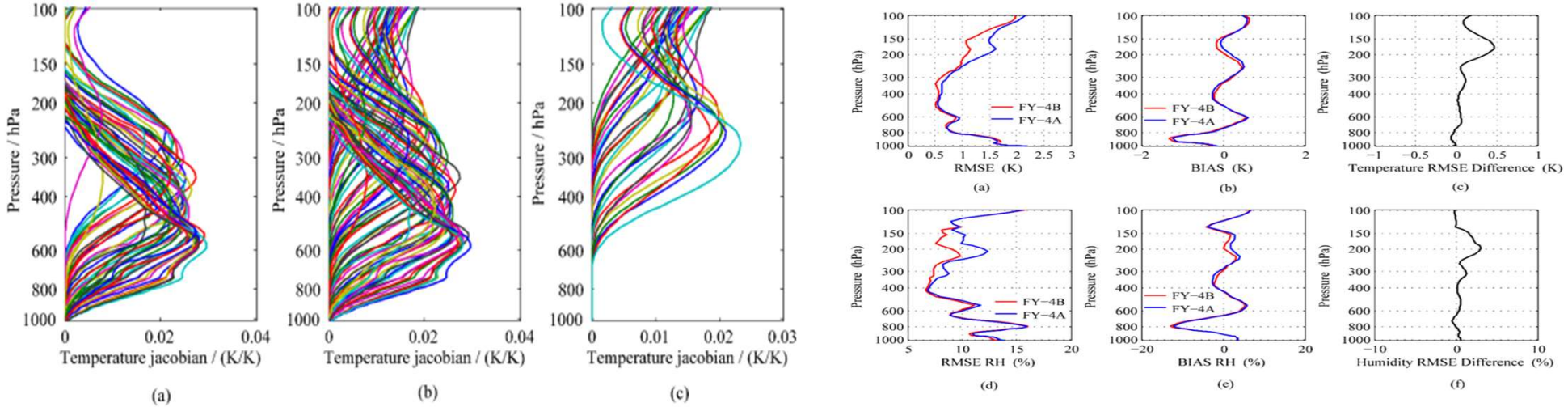
Can we using Ultra-High Spectral Resolution Sounder from Nadir-Viewing Satellites to improve Stratospheric Temperature sounding performance? a case study based on LBLRTM





Wang, Wang, S.; Feng, Y.; Fu, D.;Kong, L.; Li, H.; Han, B.; Lu, F. Stratospheric Temperature Observations by Narrow Bands Ultra-High Spectral Resolution Sounder from Nadir-Viewing Satellites. Remote Sens. 2023, 15, 1967.

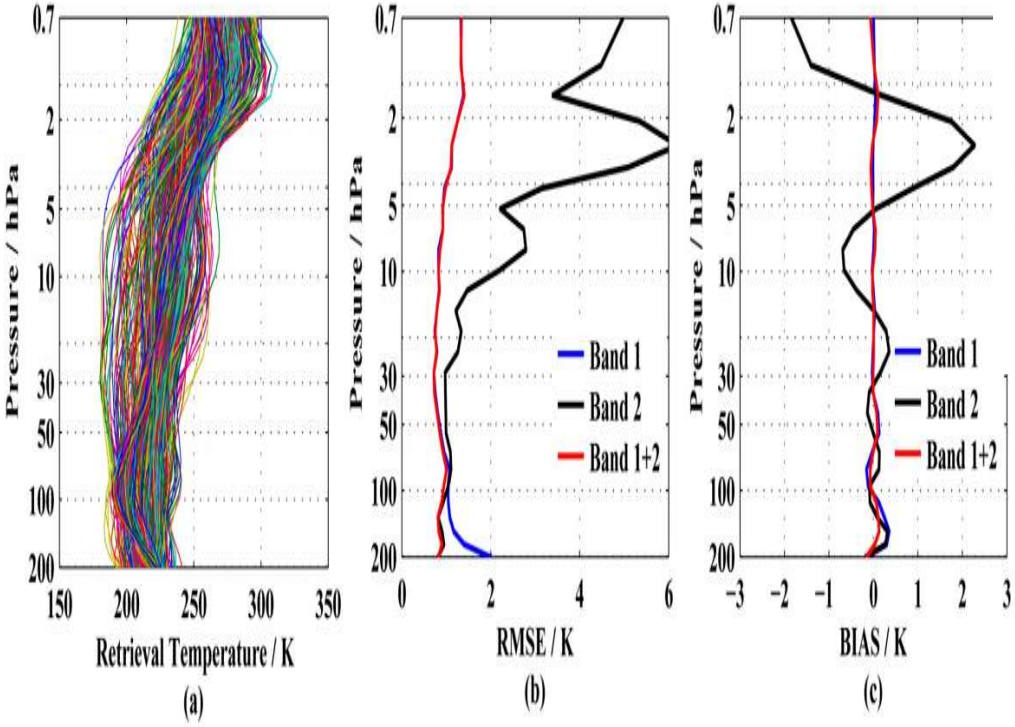
Investigation of the Fengyun-4A/B GIIRS Performance on Temperature and Humidity Retrievals using fast RTM

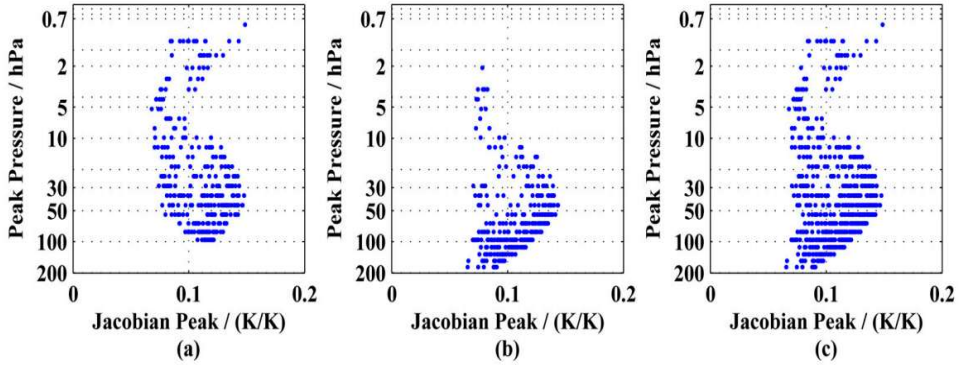


The temperature and humidity retrieval accuracy of FY-4B GIIRS is better than that of FY-4A GIIRS in 130–400 hPa, especially near 200 hPa, as the spectral range extends. The maximum difference of RMSE is about 0.5 K for temperature and 3.0% for humidity near 200 hPa. The average RMSE of temperature retrieval in 130–400 hPa is about 1.1 K for FY-4A and 0.9 K for FY-4B, while that of humidity retrieval is about 9.3% for FY-4A and 8.0% for FY-4B.

Wang, S.; Lu, F.; Feng, Y. An Investigation of the Fengyun-4A/B GIIRS Performance on Temperature and Humidity Retrievals. Atmosphere 2022, 13, 1830. https://doi.org/ 10.3390/atmos13111830

Can we using Ultra-High Spectral Resolution Sounder from Nadir-Viewing Satellites to improve Stratospheric Temperature sounding performance? Yes!!!





Parameters	Value
Spectral region	Band 1: 666.87–676.44 cm^{-1} Band 2: 683.58–693.15 cm^{-1}
Spectral resolution	0.03 cm^{-1}
Horizontal pixel number	640
Vertical pixel number	512
Pixel pitch	30 μm
NeDT	~0.1 K@ 226 K
Exposure time	1.15 s
F number	1.2
Transmittance	0.2
Detectivity	2.8×10^{11} $\sqrt{H}$cm/W

Wang, Wang, S.; Feng, Y.; Fu, D.;Kong, L.; Li, H.; Han, B.; Lu, F. Stratospheric Temperature Observations by Narrow Bands Ultra-High Spectral Resolution Sounder from Nadir-Viewing Satellites. Remote Sens. 2023, 15, 1967.

Summary

FY-4C will be launched in 2025，after post launch test，FY-4C will be operational in Q3 2026.

Calibration is Key steps for effective utilization of the benefits of satellite observations

International partnerships are essential. FY-4 Project welcome GSICS communty early engagement in following calibration issues:

1) Visible band：expecially ice cloud observation
2) Hyperspectral：(from UV to longwave infrared)
3) Space weather：Solar XEUV，...

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