中国气象局

The FengYun Mission Recent Progress on FY3E and FY3G

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FY3 Team
NSMC/CMA

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国家卫星气象中心
（空间天气监测预警中心）

Fengyun constellation

9 Satellites in orbit

- **5 LEO (FY-3C, FY-3D, FY-3E, FY-3F, FY-3G)**
- **4 GEO (79E, 86.5E, 99.5E, 105E)**

GEO

FY-2G, -2H

FY-2G (99.5°E) and FY-2H (79°E)
Full disk every 30 min
FY-2H, last flight unit of FY-2 series.

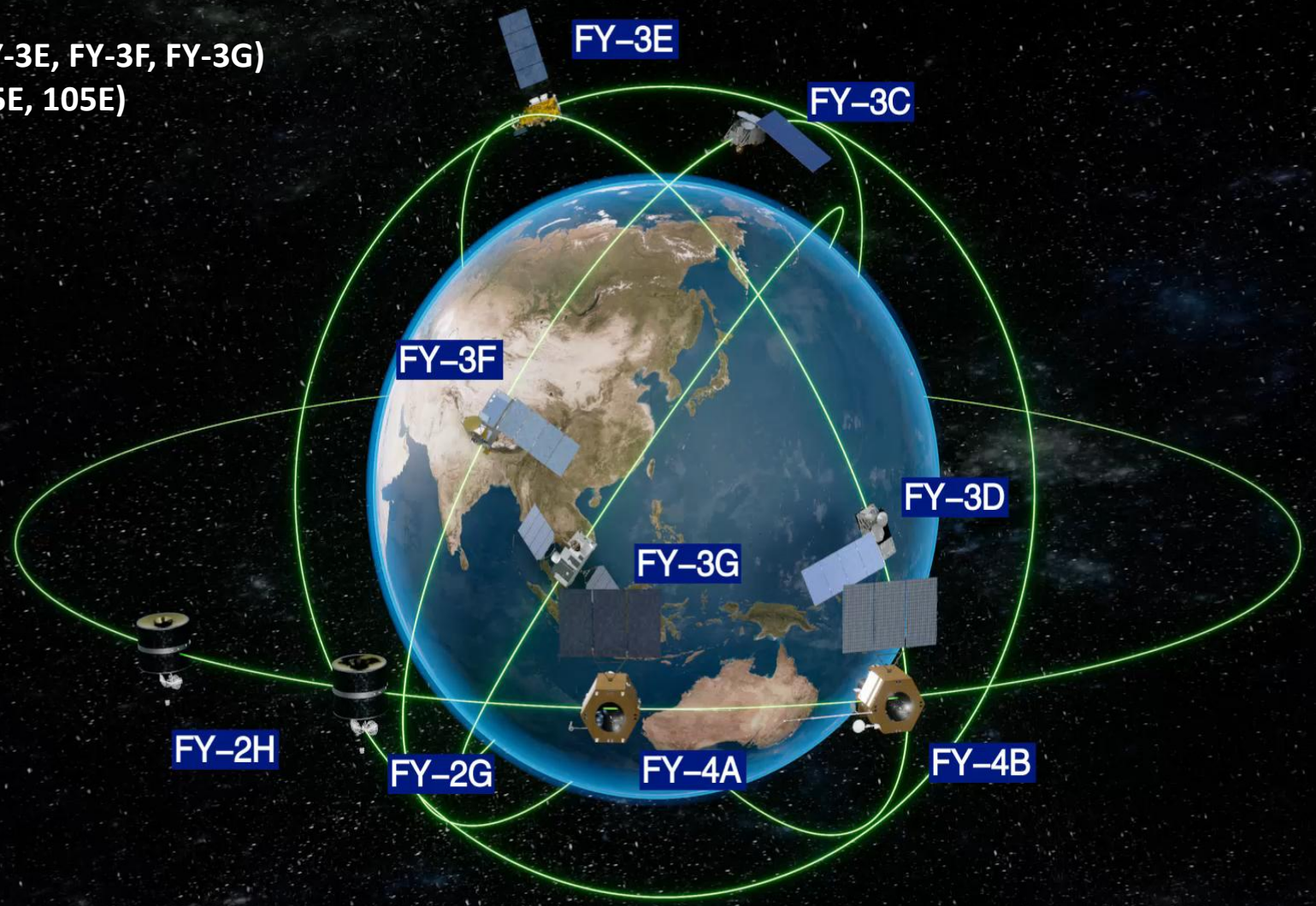
FY-4A

First of China's second-generation GEO meteorological satellites.

FY-4A (86.5°E) , Full disk every 15 min.

FY-4B

FY-4B (104.7°E), Full disk every 15 min, partial areas rapid scanning at 1 min.
Operational since 1st December 2022



LEO

FY-3C

Mid-morning orbit
Operational with degraded performance

FY-3D

Afternoon orbit, ECT 13:45 local time
10 EO instruments

FY-3E

Early-morning orbit, ECT 5:41 local time
11 EO instruments
Operational since 1 Dec. 2022

FY-3F

Mid-morning orbit
10 EO instruments
Launched 3 Aug. 2023

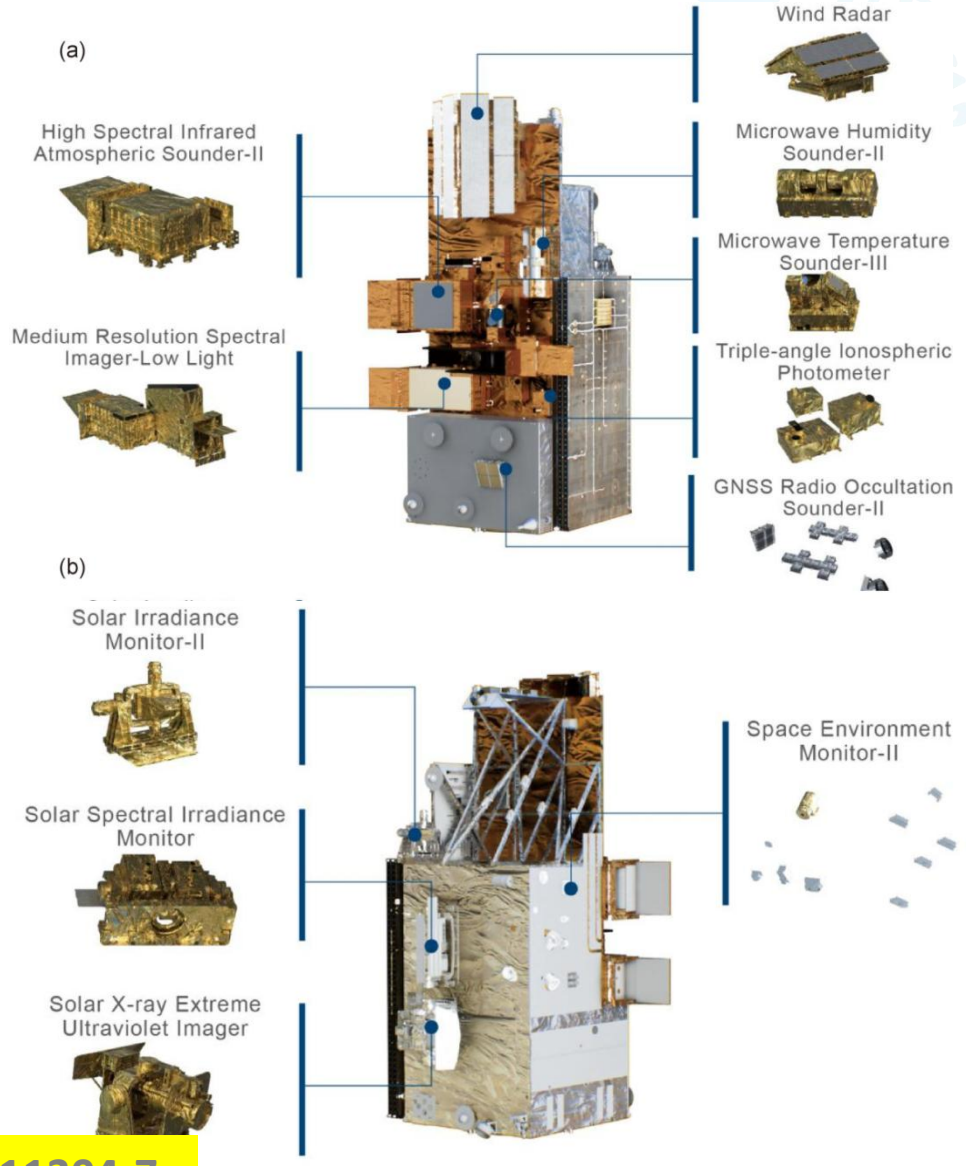
FY-3G

Incline orbit
6 EO instruments
Launched 16 Apr. 2023
In-orbit testing data released

Successful launch of FY-3E on 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)

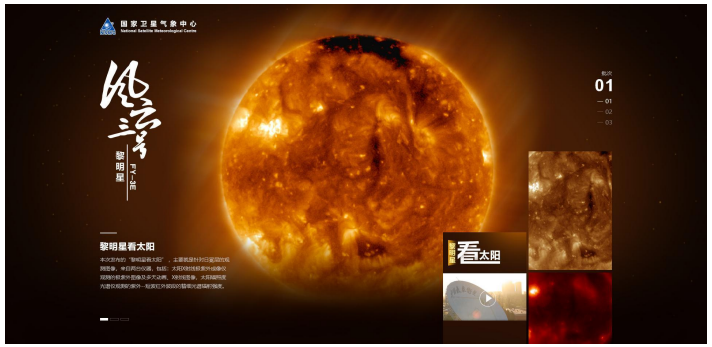


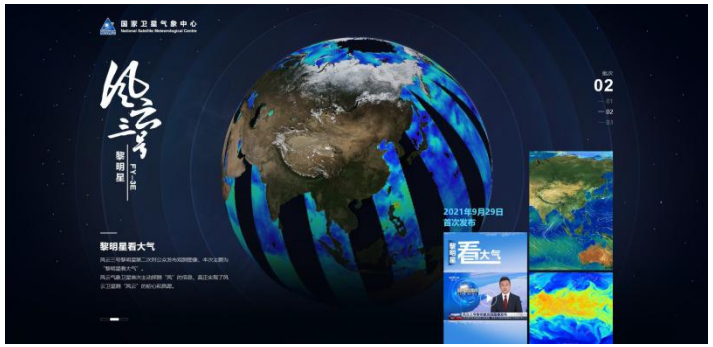
- FY-3E together with the mid-morning and afternoon satellites provides an optimal temporal distribution.
- NWP communities will significantly benefit.
- Further benefits are expected in severe weather/climate events monitoring

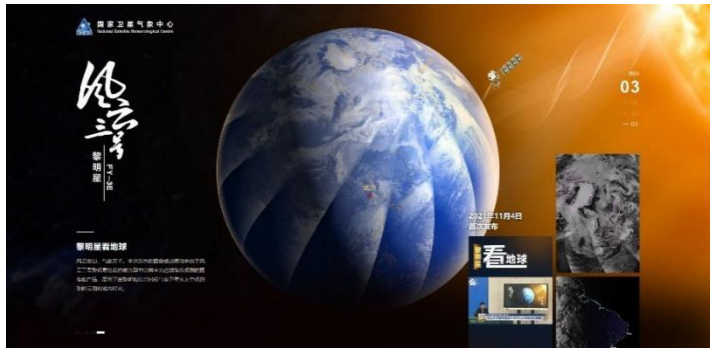
Zhang, P., et al., 2021: Adv. Atmos. Sci., https://doi.org/10.1007/s00376-0211304-7;
Zhang P., et al., 2023 BAMS.DOI: 10.1175/BAMS-D-22-0045.1

Schedule of FY-3E in-orbit testing after the launch

The first picture of the third phase was released at a press conference of the CMA







- ☐ Use requirements
- ☐ Test outline
- ☐ Test rules
- ☐ Scoring & evaluation criteria

July 5, 2021 — lunched successfully

※

Oct. 15, 2021 — Complete Satellite Platform check out

※

Dec. 31 ※ 2021 — Complete Instruments Test and Satellite delivery

March 2022 — Review of L1/L2 provision for trial operation

June 2022 — Turn into formal operation and data release

FY-3E quantitative products

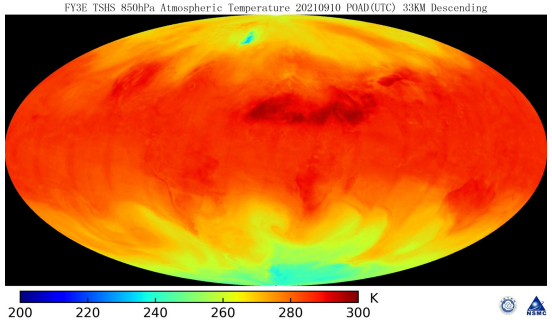
Types	Name
Image	Quasi constant contrast image
	City lights
	Global IR mosaic
	Vertical sound image
Cloud and Radiation	Cloud type
	,Outgoing long-wave radiation
Atmospheric parameter	Atmospheric temperature and humidity profile
	Atmospheric temperature and humidity profile—Microwave
	GNOS-II Atmospheric temperature and humidity profile
	MWHS-II rainfall
Sea and Land	LST
	WindRAD Sea wind field
	GNOS-II SWS
Space weather	GNOS-II Atmospheric Density profiles
	Tri-IPM Total Electron Content
	SEM products
	X-EUVI image
Cryosphere	WindRAD Sea ice

Six categories and eighteen types

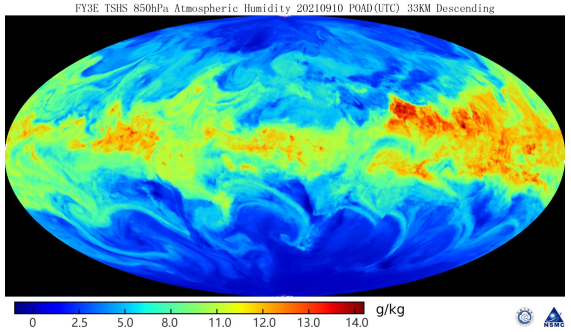
Demonstration of atmospheric, Marine and land surface products

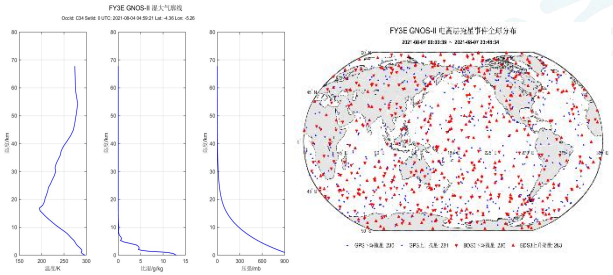
atmosphere

heat



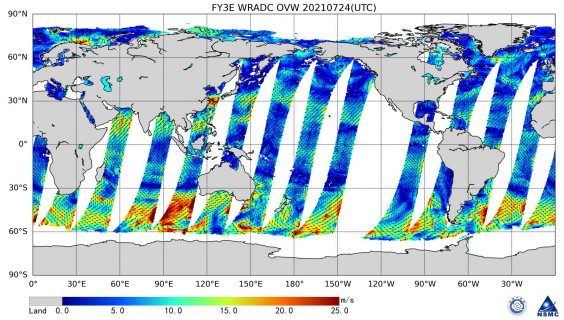
humidity

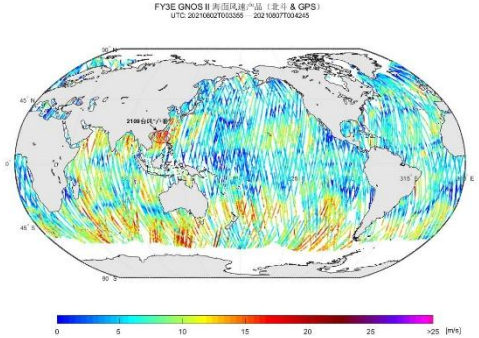




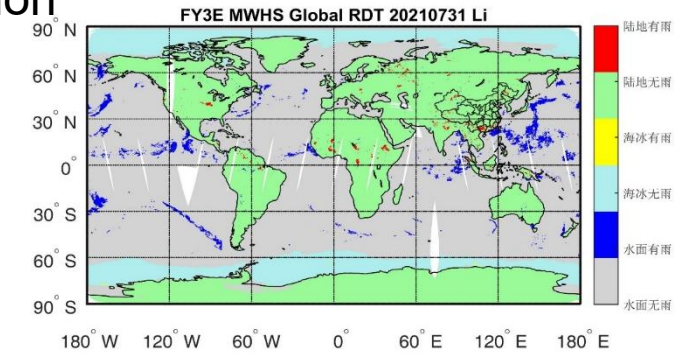
Land and sea surface

motion



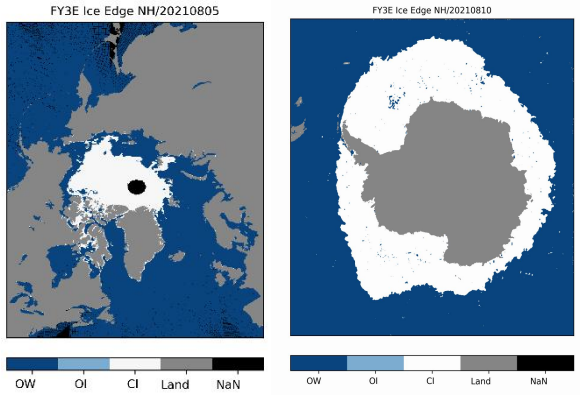


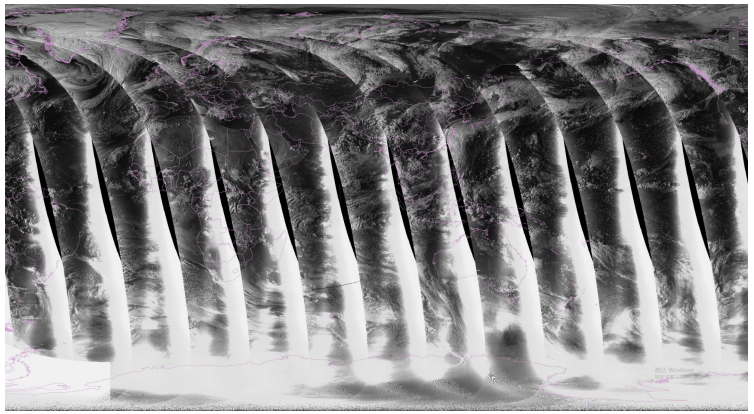
precipitation



Cryosphere

Polar ice



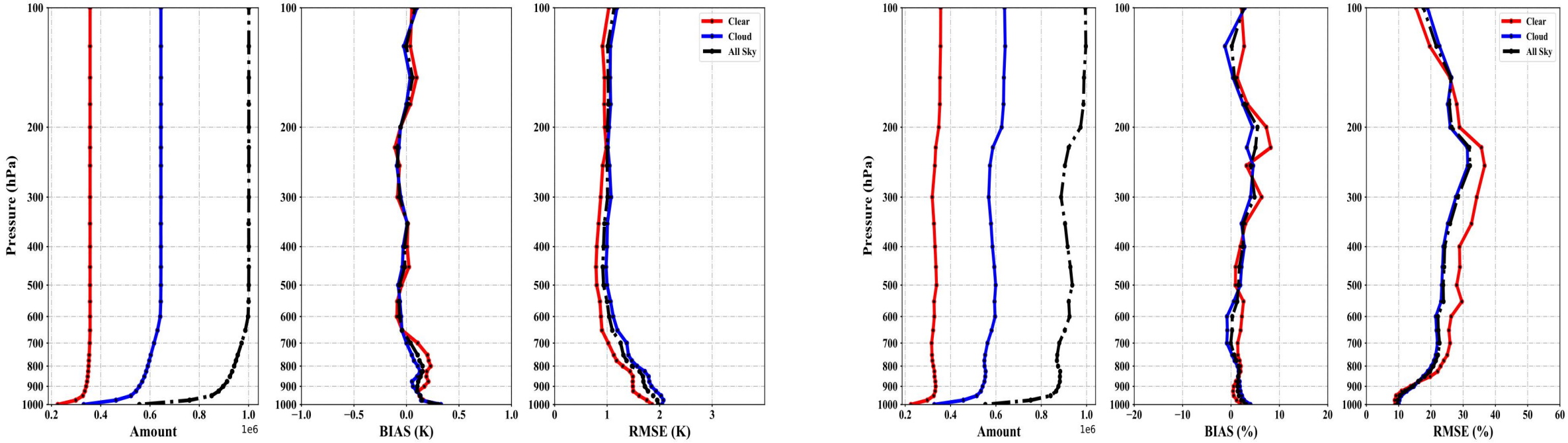


Low light/Infrared images

Atmospheric parameters——Temperature and Humidity

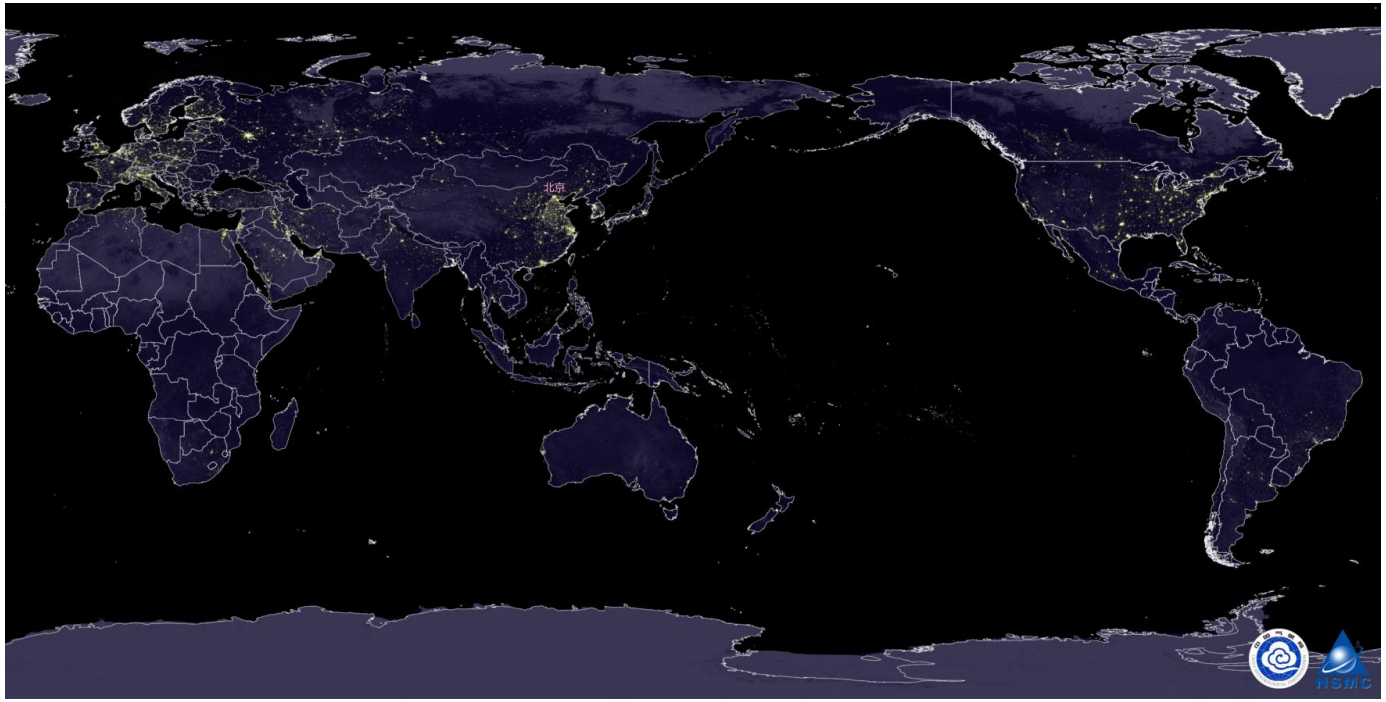
Quality evaluation：

- Compared with ERA5 reanalysis field, the preliminary test conclusion: the precision of clear sky ocean temperature profile & relative humidity is better than 1.5K, and 15%, respectively.



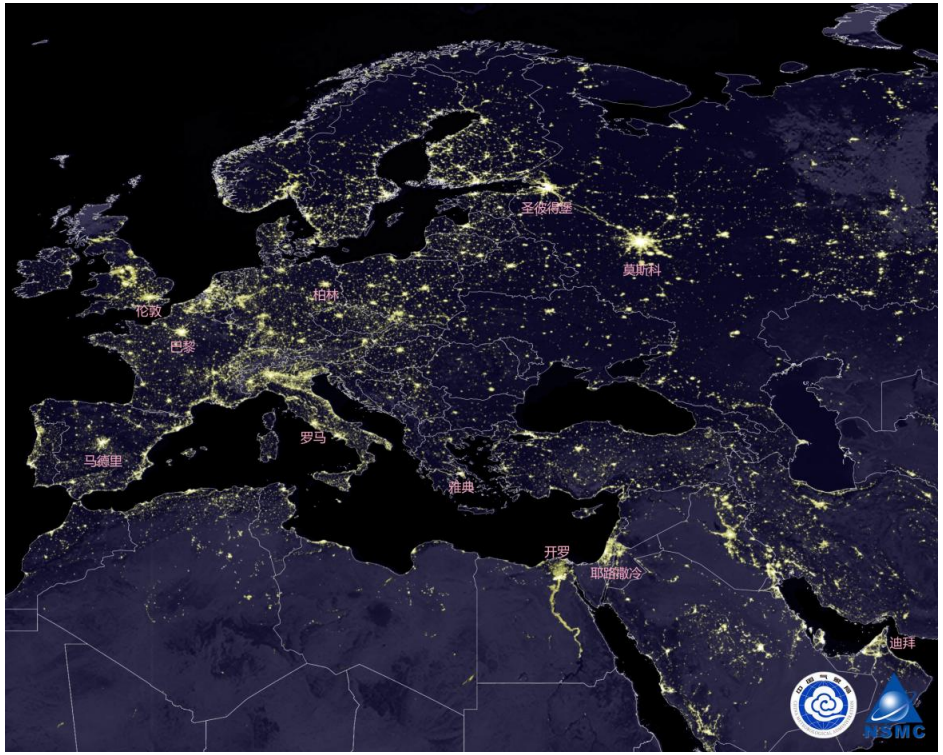
Comparison and verification of FY-3E/VASS temperature and relative humidity profiles with ERA5 reanalysis data

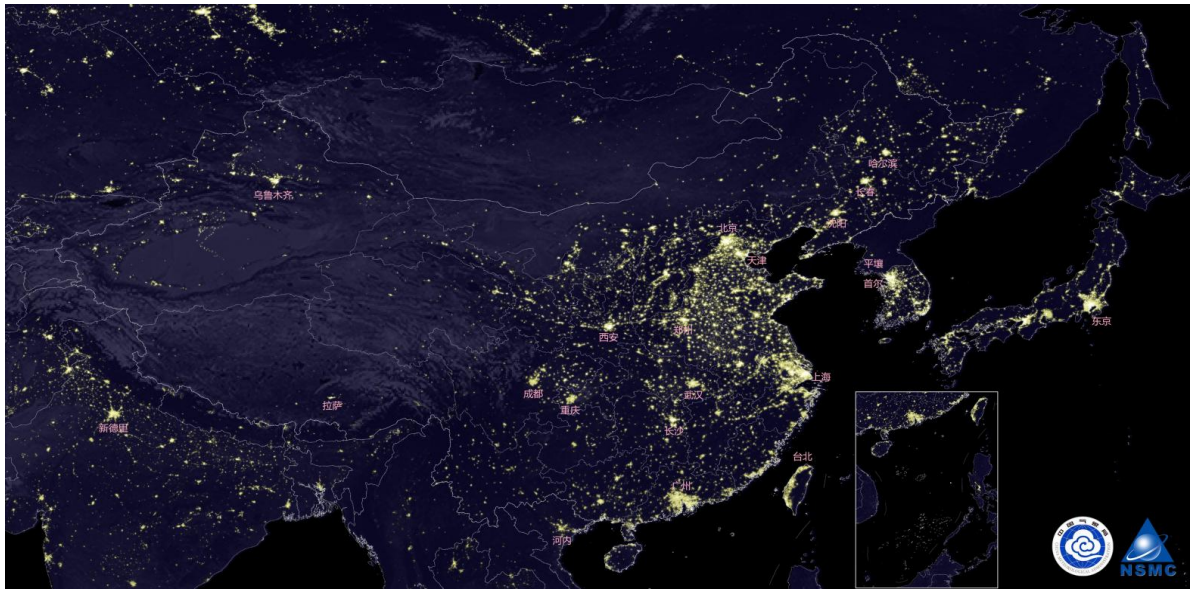
Nighttime Light of FY-3E



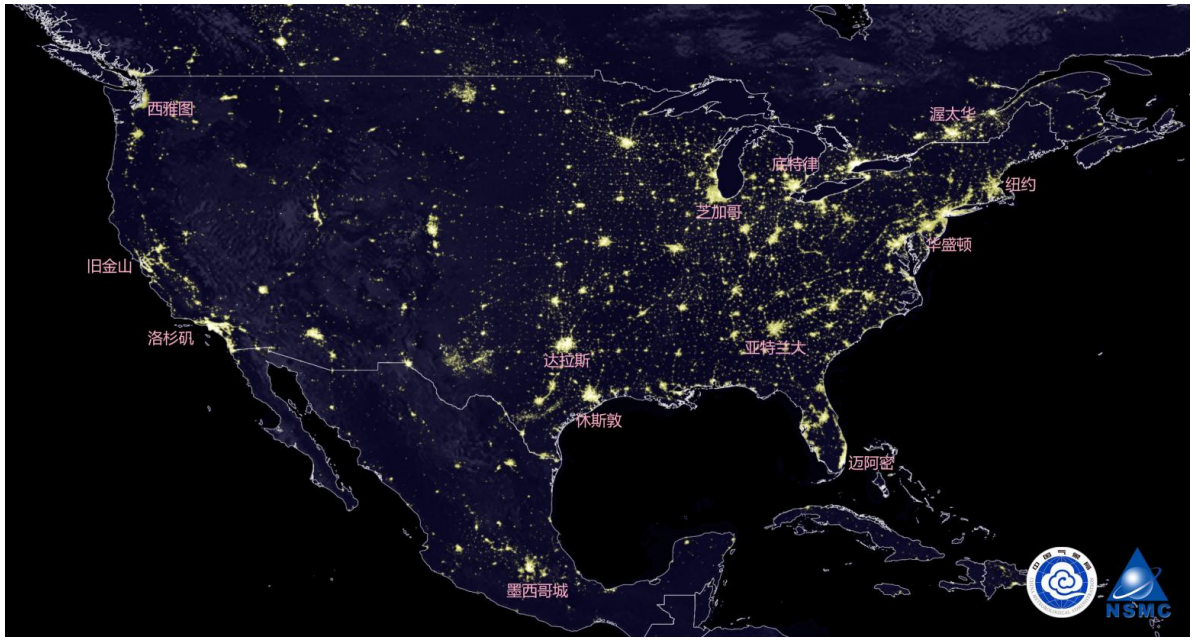
FY3E is equipped with a low light channel, which can detect weak visible light sources at night, greatly improving China's ability to monitor weather and climate conditions and human activities. City lights can reflect the infrastructure construction level and energy consumption, as well as the economic development level and population. Its changes can be used to assess the impact of urban development, natural disasters and war. The city light thematic map of FY-3E shows China, USA and Europe are obviously regions.

City lights in Europe are very dense, especially in the area from Western Europe to Central Europe. Moscow and St. Petersburg are particularly dazzling in Eastern Europe. In addition, Nile Valley in Egypt along the river has high dense lights.



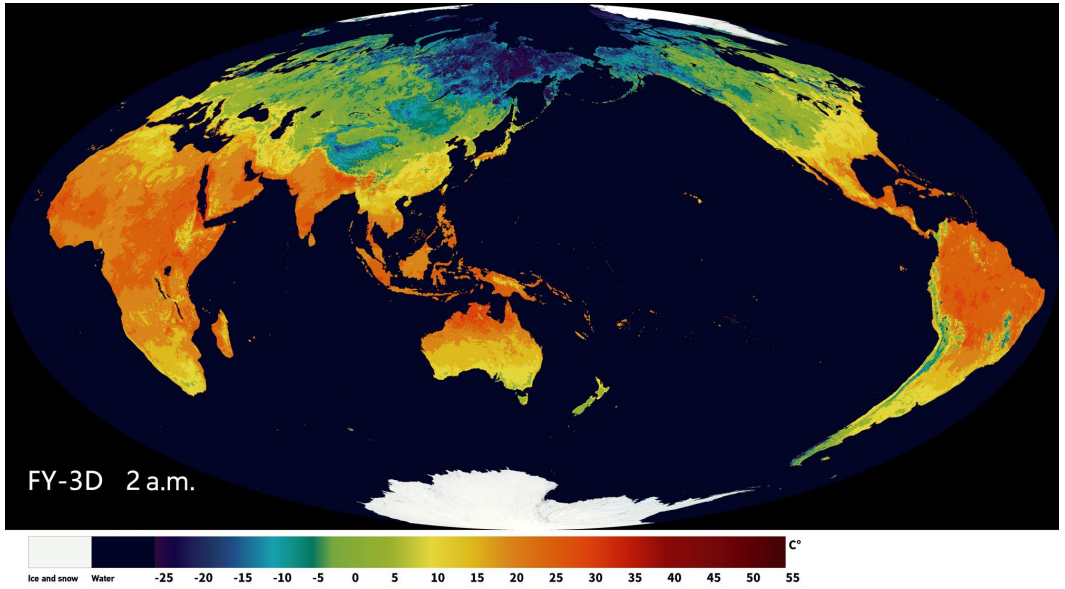


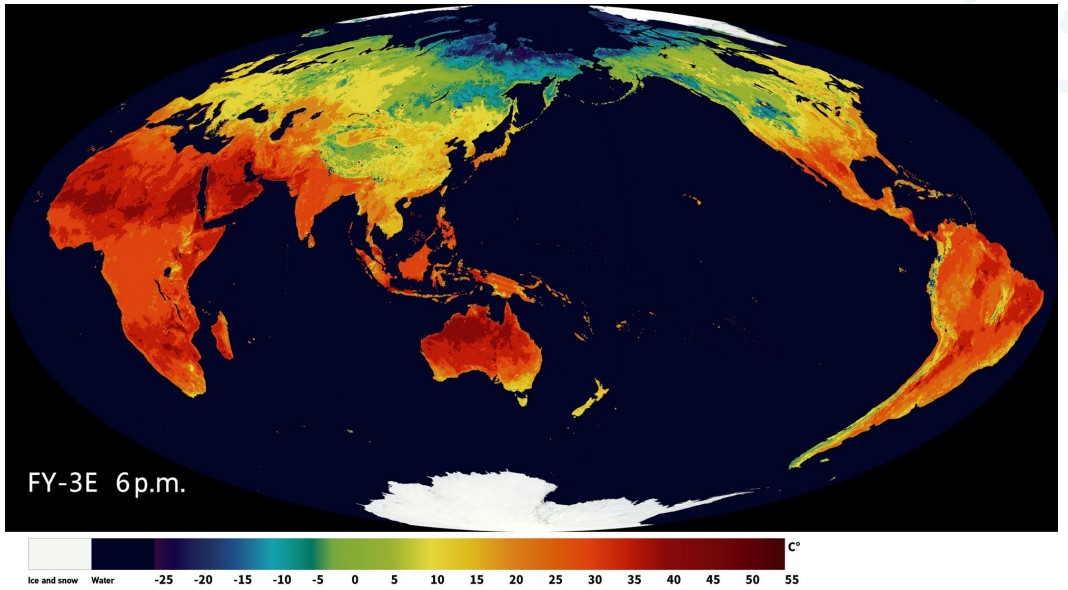
City lights in China are mainly distributed in the east, especially in the Beijing Tianjin Hebei, Yangtze River Delta and Pearl River Delta regions. Provincial capitals are outstanding in the central and western regions. Strong contrast between South Korea and North Korea on the Korean Peninsula.

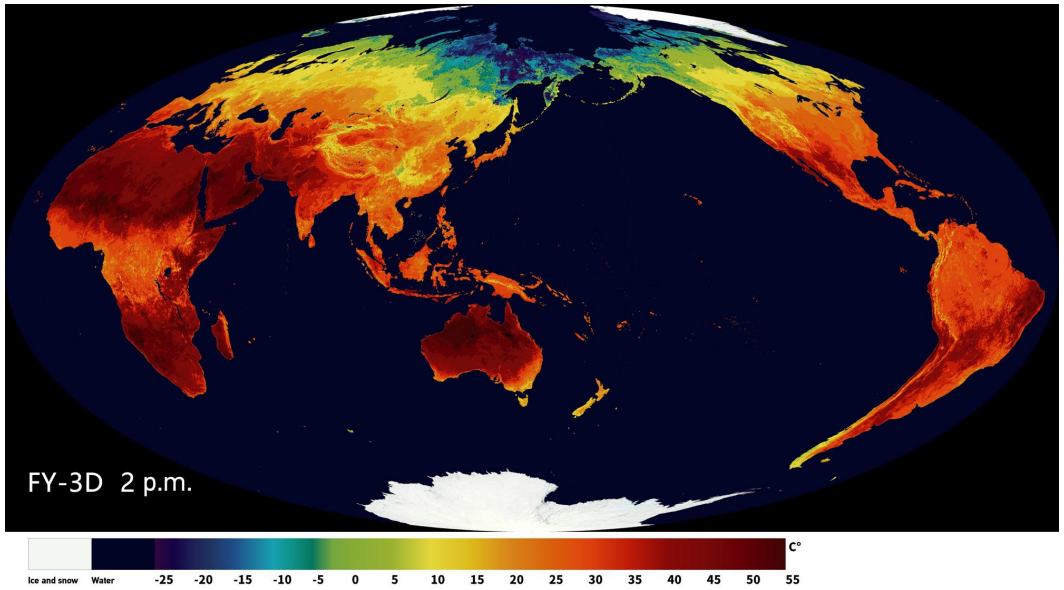


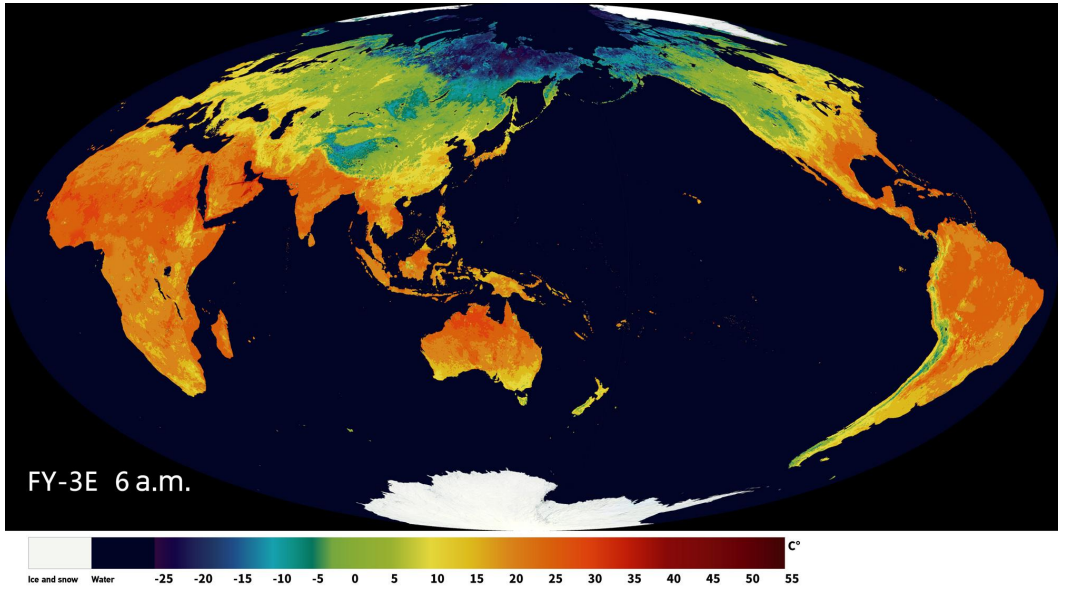
Lighting areas on the east coast and the Great Lakes region of USA. Several major cities in the central and western regions have extended traffic routes, small cities regularly distributed, forming into a city network. In contrast, there is little light in the west, especially in several large cities such as Los Angeles, San Francisco, Seattle, etc.

Land surface Daily variation from FY-3E and FY-3D (2021.10)

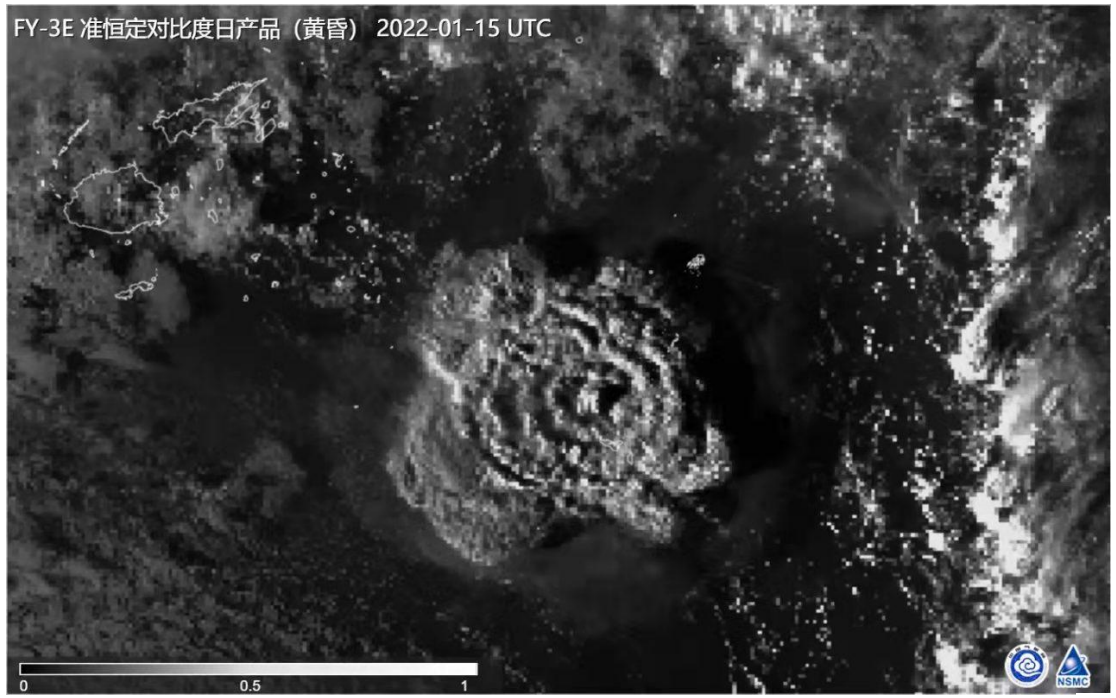


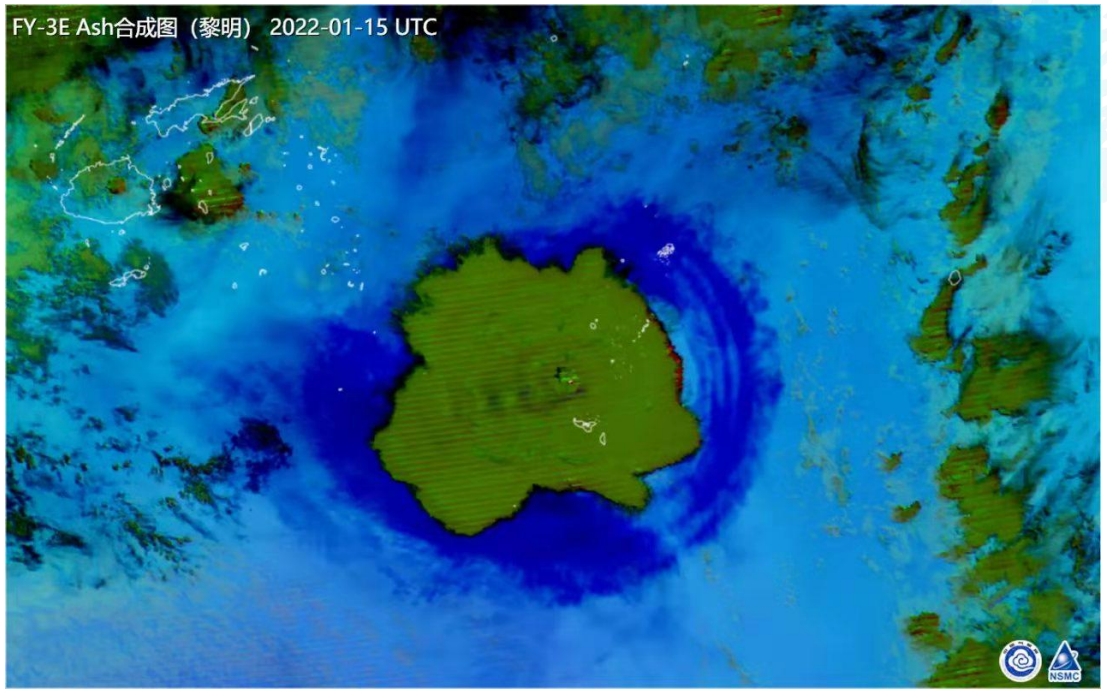


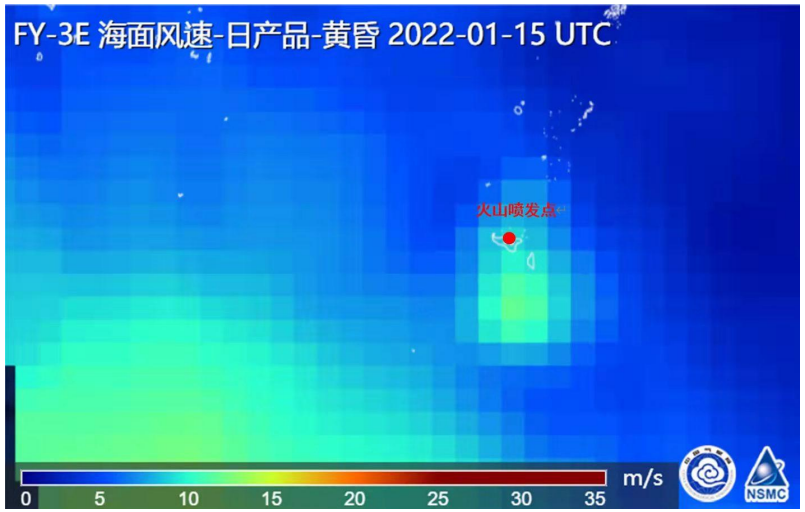


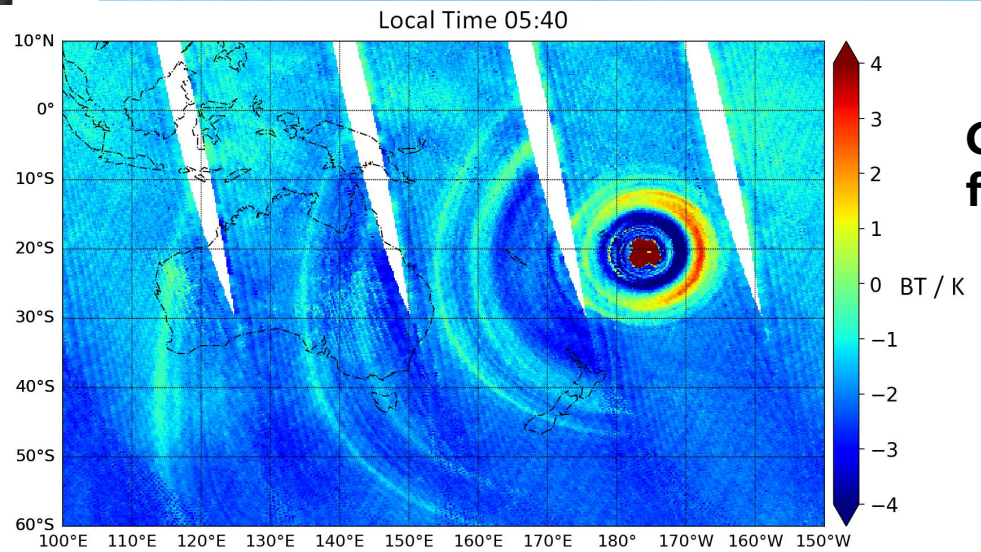


FY-3E Tonga Volcano monitoring









Gravity wave from HIRAS-II

FY-3G

- FY-3G, was successfully launched on 16 April 2023 and became the world’s third satellite to measure precipitation with space-borne radar after the TRMM in 1997 and GPM in 2014

Distinguishing Feature

- **FY-20, 20 satellites in FY family**
- **First satellite in China to measure precipitation**
- **China has become the only country in the world which operates meteorological satellites in four near-earth orbits (EM, AM, PM, Low Inc.)**

Scientific Goal

- **3D structure of precipitation in high accuracy**
- **Global distribution characteristics of precipitation, especially over the ocean and in the mountain areas**
- **Enhance understanding on extreme precipitation, energy and water cycle, etc.**

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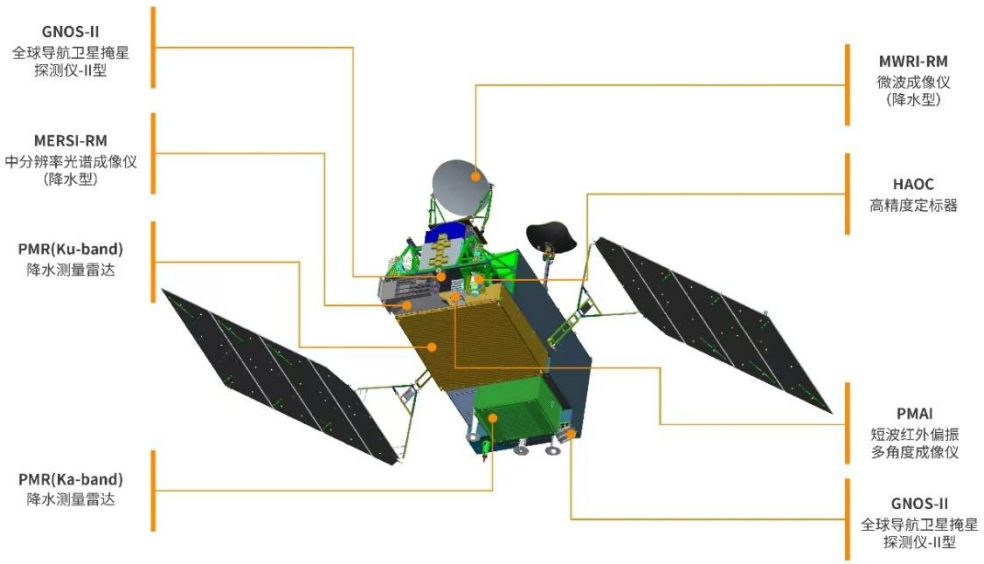
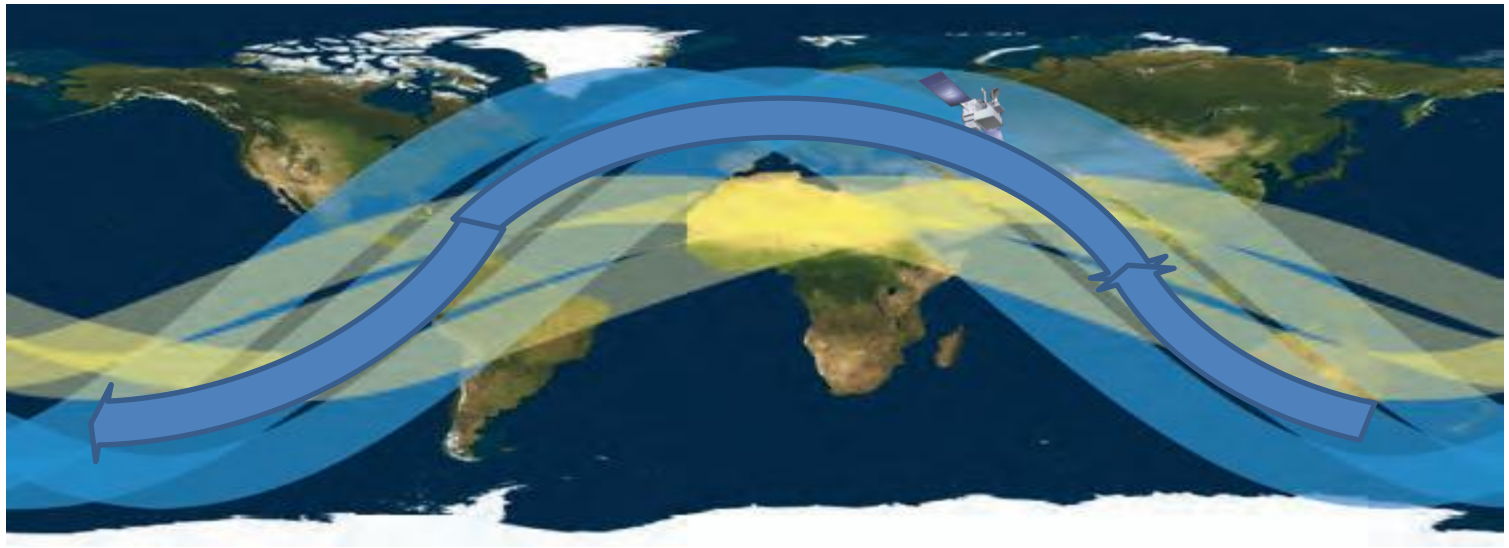
Payloads Configuration



Insturment	Abbr.	Chan No.	Swath Width（km）
Precipitation Measurement Radar	PMR	2	300
Microwave Radiation Imager	MWRI-RM	26	800
Medium Resolution Spectral Imager	MERSI-RM	8	1000
Global Navigation Satellite System Occultation Sounder	GNOS-R	4	--
High Accuracy On-board Calibrator	HAOC	440/220	50
Short-wave Infrared Polarized Multi-Angle Imager	PMAR	12	700

Inclination

TRMM	35°
GPM	65 °
FY-3G	50 °



☐ Operation

☐ R & D

Parameters of FY-3G PMR, TRMM PR and GPM DPR

☐ Comparison of the main parameters of PMR with TRMM PR and GPM DPR

Radar Systems	FY-3G PMR	TRMM PR	GPM DPR
Frequency band	dual-frequency (Ku, Ka)	single-frequency (Ku)	dual-frequency (Ku, Ka)
Swath width(km)	>300	215 (@350 km orbit altitude)	245(Ku), 125(Ka)
Horizontal resolution (km)(Naidr)	5	4.3(@350 km orbit altitude)	5.2
Range resolution(m)	250	250	250(Ku), 250/500(Ka)
Observation range(km)	18～－5 ASL	15～－5ASL	18～－5ASL(Ku) 18～－3ASL(Ka)
Minimum detectable precipitation rate(mm/h)	0.5(18 dBZ, Ku), 0.2(12 dBZ, Ka)	0.7(@350 km orbit altitude)	0.5(Ku), 0.2(Ka)
Dynamic range(dB)	≥70	≥70	≥70
Measurement accuracy(dB)	≤ ±1	≤ ±1	≤ ±1
Beam-matching accuracy(°)	≤0.1	/	≤0.14
Antenna peak sidelobe(dB)	≤ 30	≤ 25	≤ 25

Zhang, P., et al., 2023: FY-3G satellite instruments and precipitation products: first report of China's Fengyun rainfall mission in-orbit. Journal of Remote Sensing, Article ID: 0097. DOI: 10.34133/remotesensing.0097

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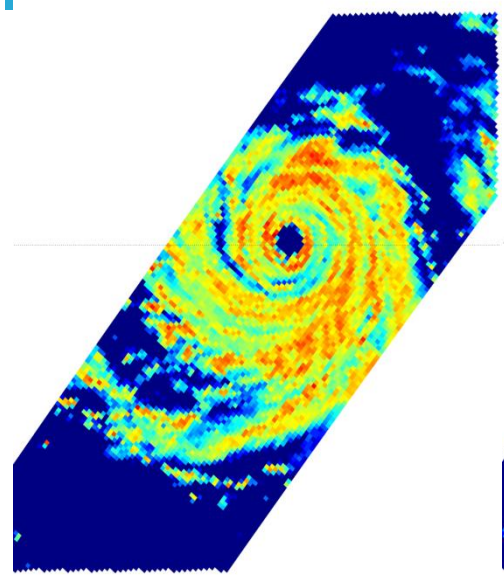
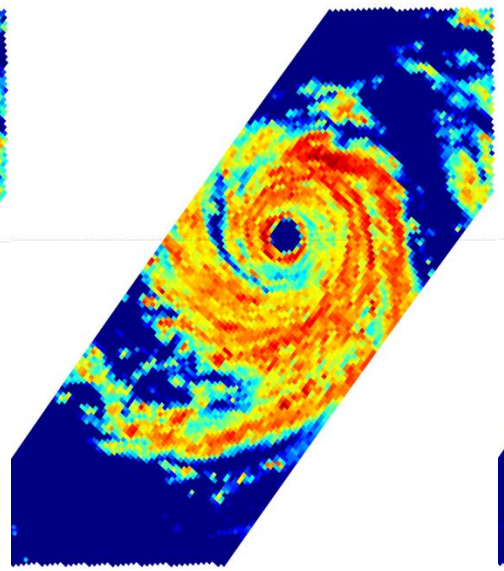
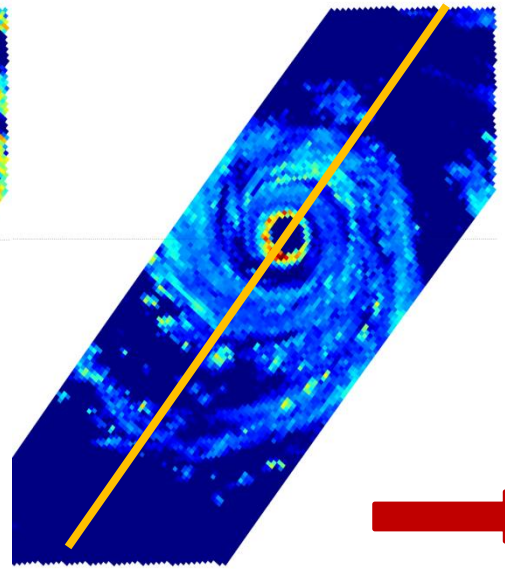
FY-3G PMR VS GPM DPR (2302 Typhoon Mawar on May 25) --- Ku Band



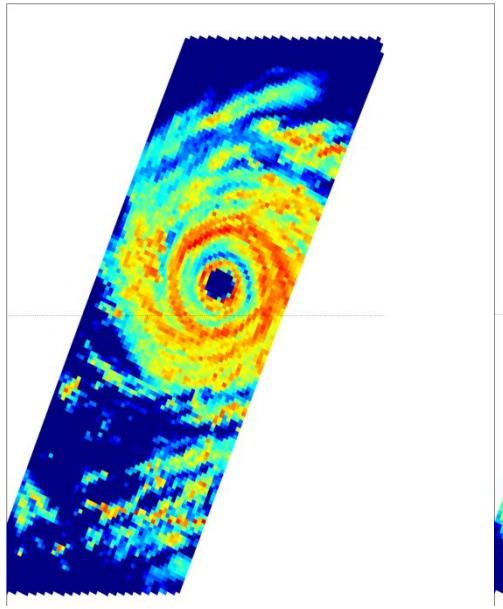
3km Alt.

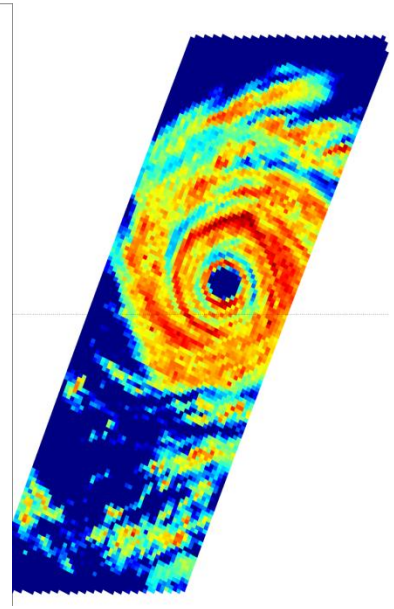


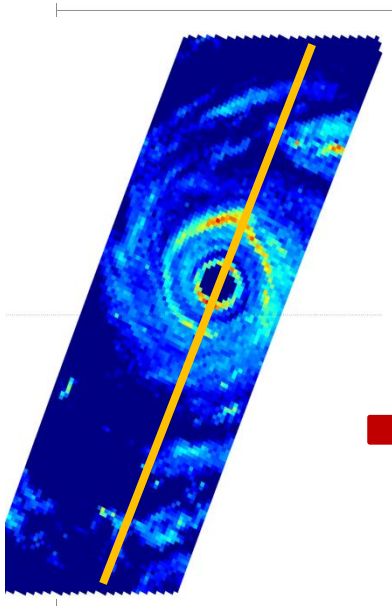
5km Alt.



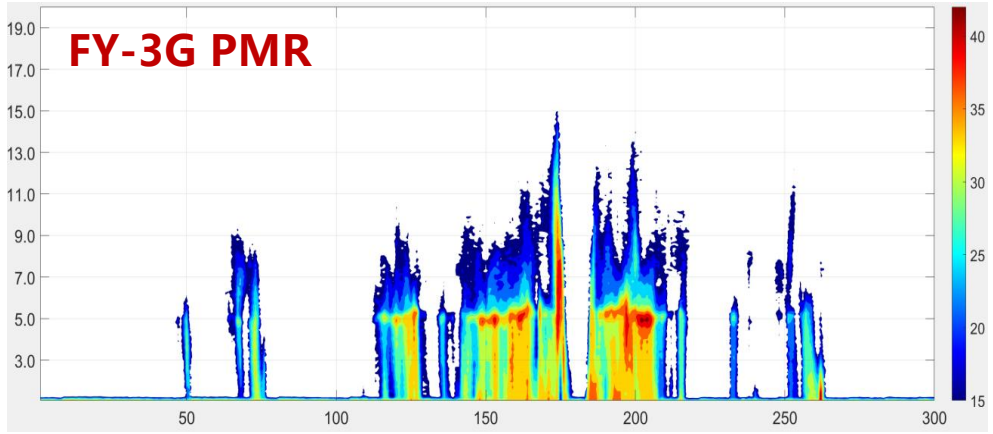
7km Alt.

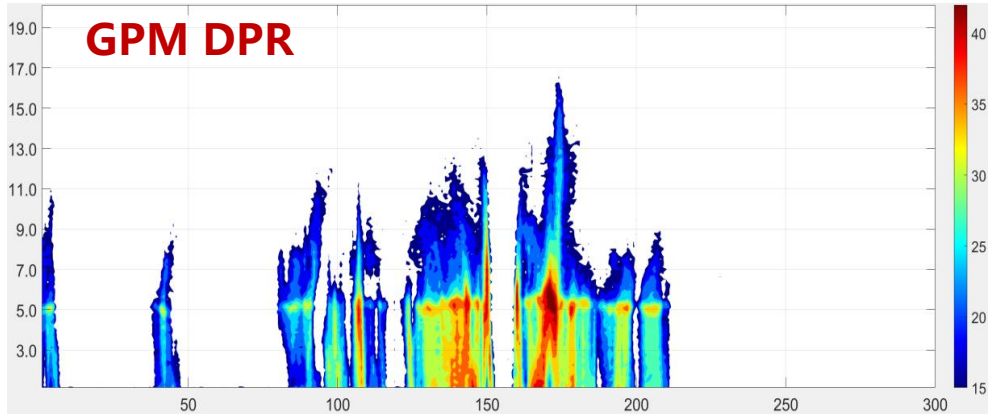




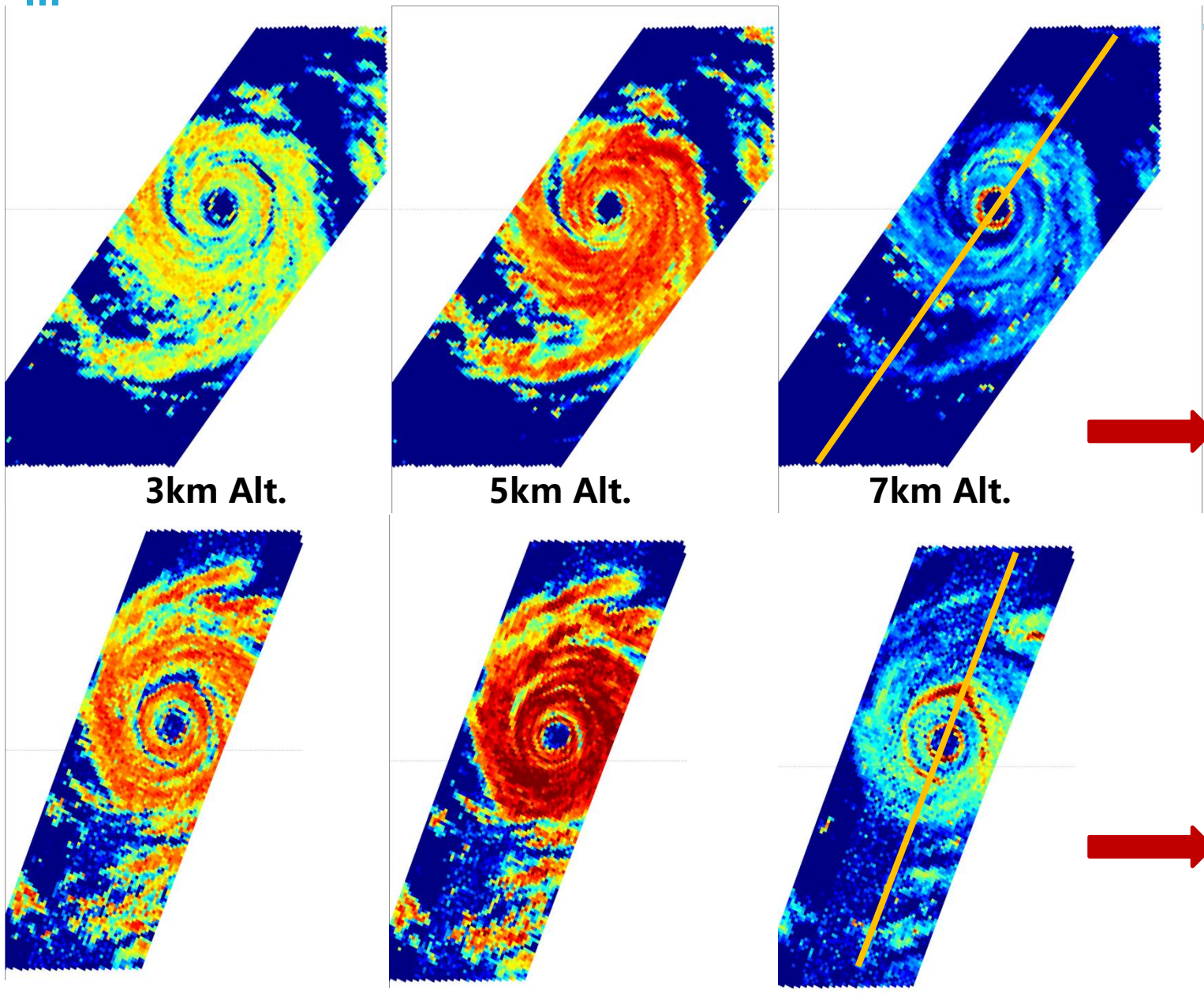


- The structure and value are similar
- Swath is wider
- Minimum detectable precipitation intensity is 15 dbZ (better than the nominal parameter 18 dbZ)

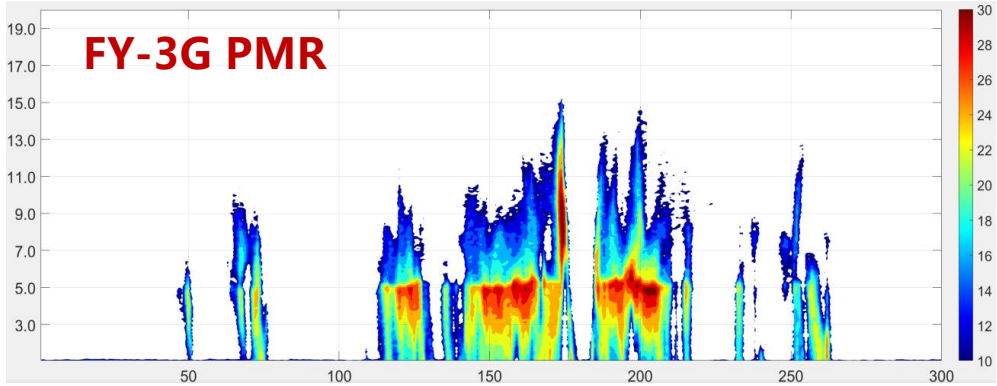


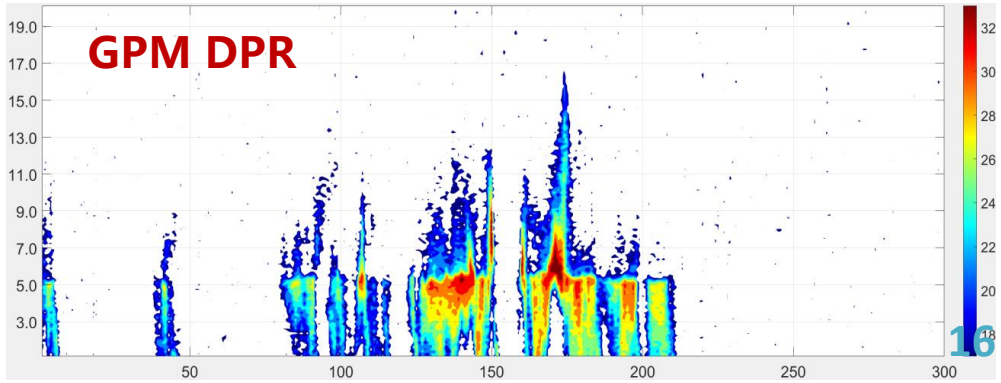


FY-3G PMR VS GPM DPR (2302 Typhoon Mawar on May 25) --- Ka Band

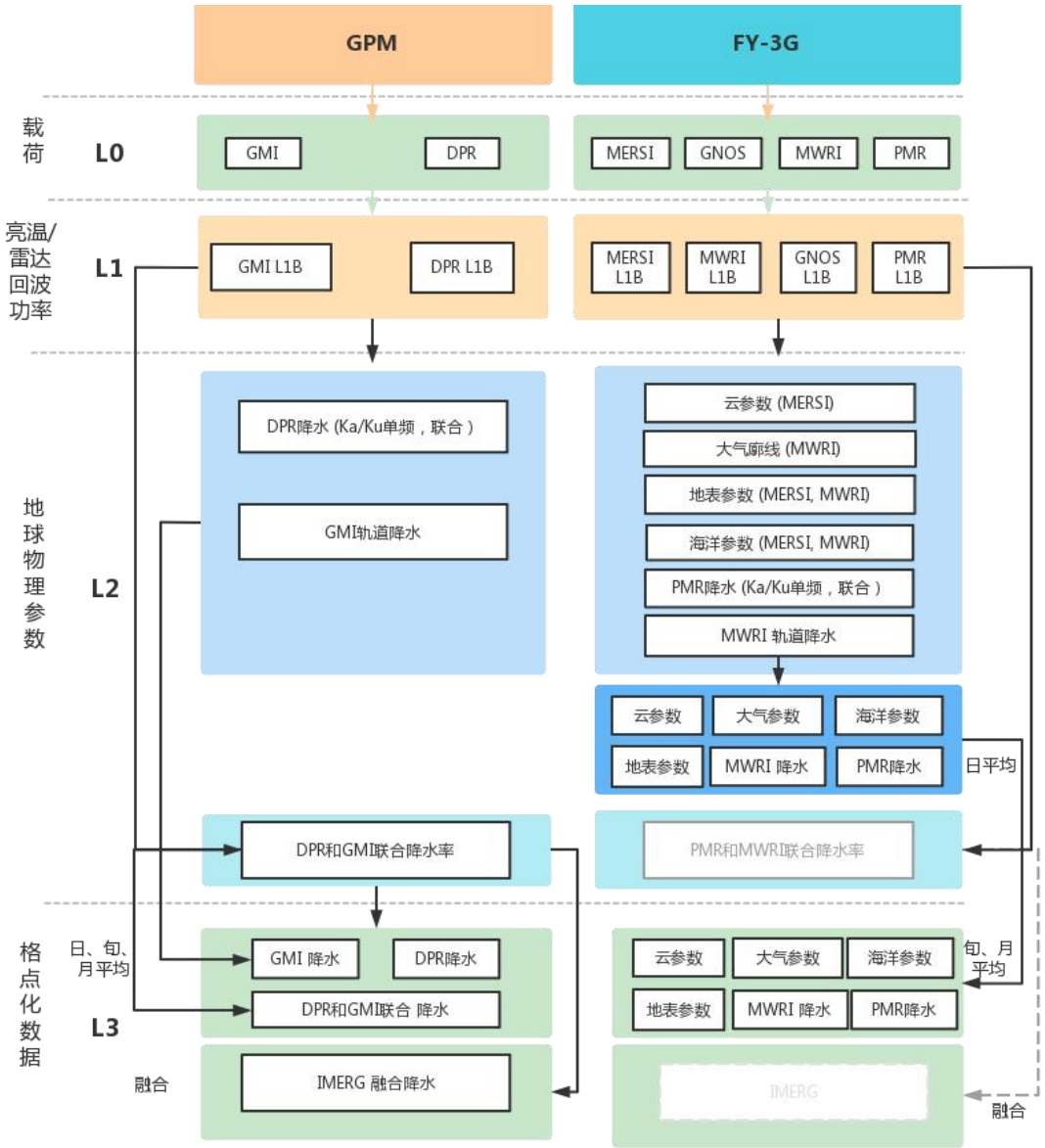


- Minimum detectable precipitation intensity is 10 dbZ (better than the nominal parameter 12 dbZ)
- The overall performance is equivalent to GPM DPR





FY-3G Satellite Product System Design



DPR

1. Ka/Ku 亮带检测
2. Ka/Ku 降水相态
3. Ka/Ku 降水分类
4. Ka/Ku 降水率
5. 双频降水率
6. 潜热

PMR

1. Ka/Ku 亮带检测
2. Ka/Ku 降水相态
3. Ka/Ku 降水分类
4. Ka/Ku 降水率
5. 双频降水率
6. 潜热

GMI

1. 水凝物廓线
2. 降水

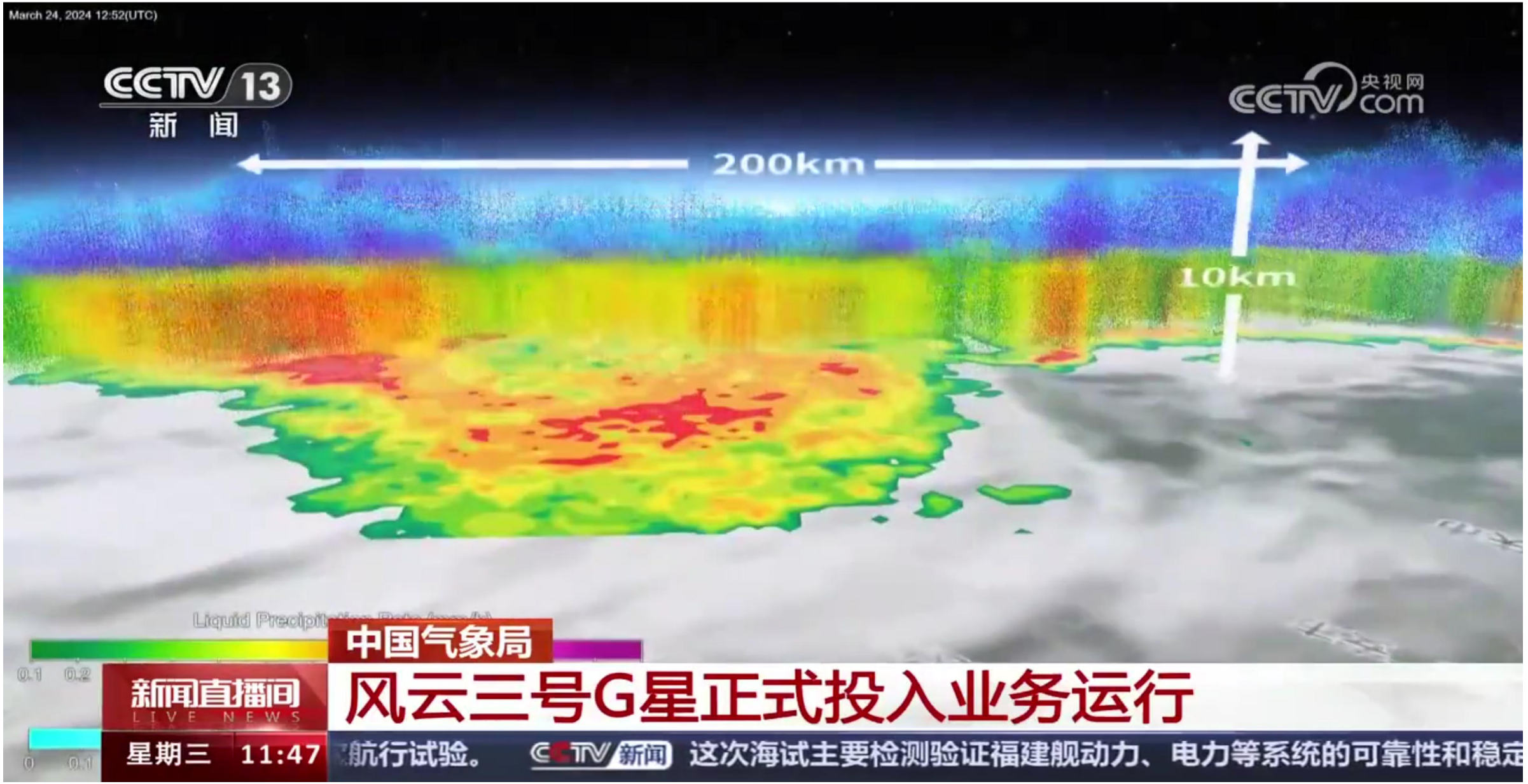
MWRI

1. 水凝物廓线
2. 降水
3. 大气可降水（洋面）
4. 大气温度廓线
5. 云水含量
6. 地表发射率
7. 雪深/雪水当量
8. 陆表温度
9. 土壤水分
10. 土壤冻融

FY-3G Satellite Product System Design

- Totally 28 products,34 geophysical parameters, including Cloud（3）、Land（7）、Ocean（3）、Atmosphere（9）、Space weather（1）、Data assimilation support（2）, Data fusion（3).

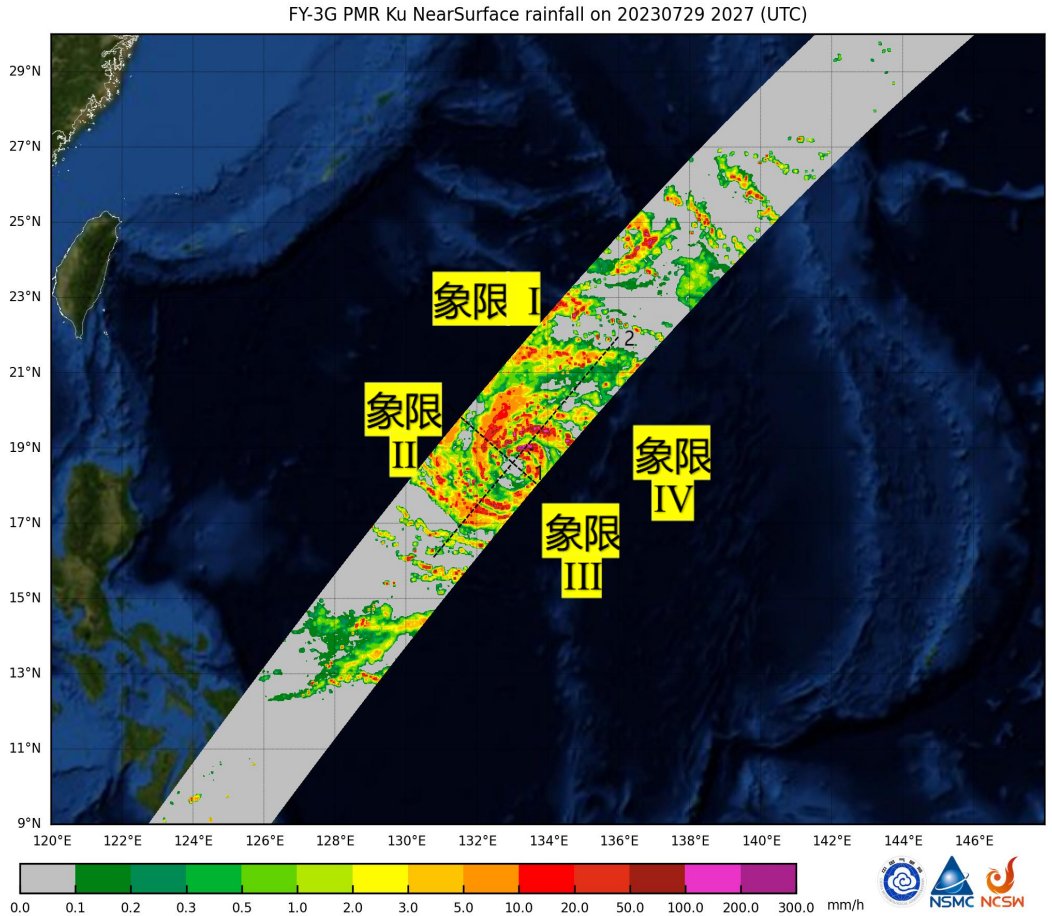
No.	Group	Products	Parameters	Payloads
1	Cloud & Radiation	cloud mask	clouds, clear sky mask	MERSI-RM
2		cloud amounts	total cloud amounts, effective cloud amounts	
3		cloud phase	cloud phase, cloud classification	
4	Land	land surface temperature	land surface temperature	MERSI-RM
5		snow cover	snow cover	MERSI-RM
6		snow depth/snow water equivalent	snow depth, snow water equivalent	MWRI-RM
7/8		soil moisture	soil moisture	MWRI-RM, GNOS-II
9		soil feeze thaw	soil freeze thaw	MWRI-RM
10		surface emissivity	surface emissivity	MWRI-RM
11	Ocean	sea surface temperature	sea surface temperature	MWRI-RM MERSI-RM
12/13		sea wind speed	sea wind speed	MWRI-RM, GNOS-II
14	Atmosphere	rain rate	rain rate	MWRI-RM
15		hydrometeor profile	cloud water profile, cloud ice profile, rain water profile, temperature, moisture, rain rate,cloud water contents,cloud ice contents	MWRI-RM
16		precipitable water	preicipitable water over sea	MWRI-RM
17		dry atmospheric profile	refractivity, density, pressure profiles	GNOS-II
18		moist atmospheric profile	banding angle, temperature, mositure , pressure profiles	GNOS-II
19		Ku-band radar product	bright band、precipitation type、precipitation phase、rain rate	PMR
20		Ka-band radar product	bright band、precipitation type、precipitation phase、rain rate	PMR
21		Dual-band radar product	bright band、precipitation type、precipitation phase、rain rate	PMR
22		latent heating	latent heating	PMR
23	Space weather	electric density profile	electric density profile	GNOS-II
24	Data assimilation surpport	MWRI-RM data assimilation support	MWRI-RM data assimilation support	MWRI-RM
25		GNOS-II data assimilation support	banding angle、refractivity（thining）	GNOS-II
26	Data fusion (scientific experimental products)	MWRI-RM/PMR joint retrieved rain rate	rain rate	PMR+MWRI-RM
27		Integrated Multi-satellitE Retrievals for FY-3	rain rate	FY-3D,G,F MWRI
28		Integrated Multi-satellitE Retrievals for Fengyun geostationary and polar orbits	rain rate	FY-3+FY-4



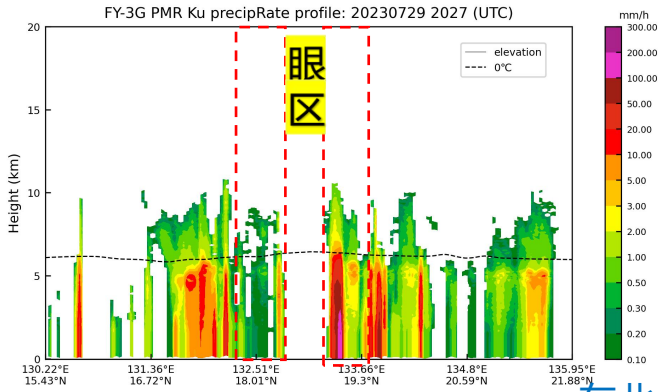
On May 1st, FY-3G satellite officially run into operational service.

2、Introduction to FY3G Key Products

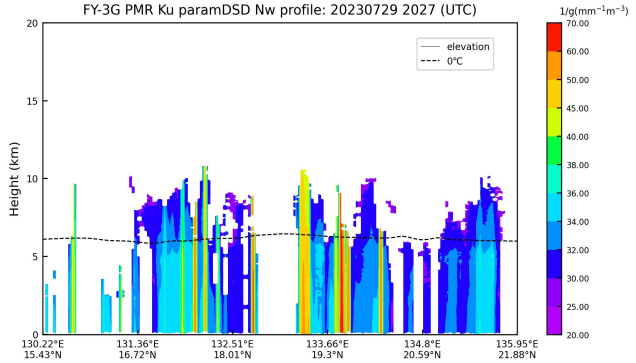
PMR Ku-Band Radar Product



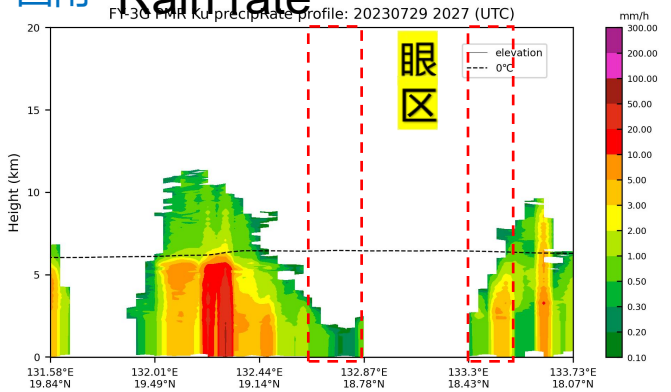
Equivalent reflectivity factor



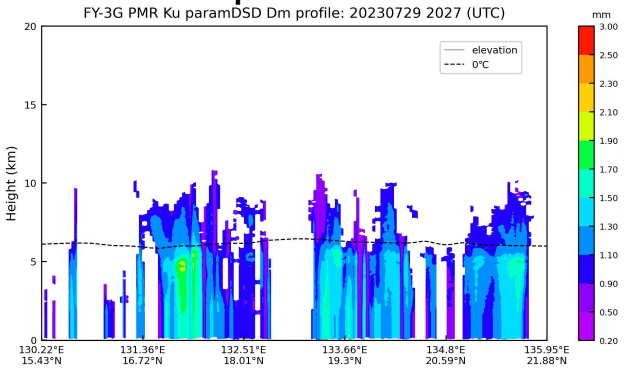
number concentration



Rain rate

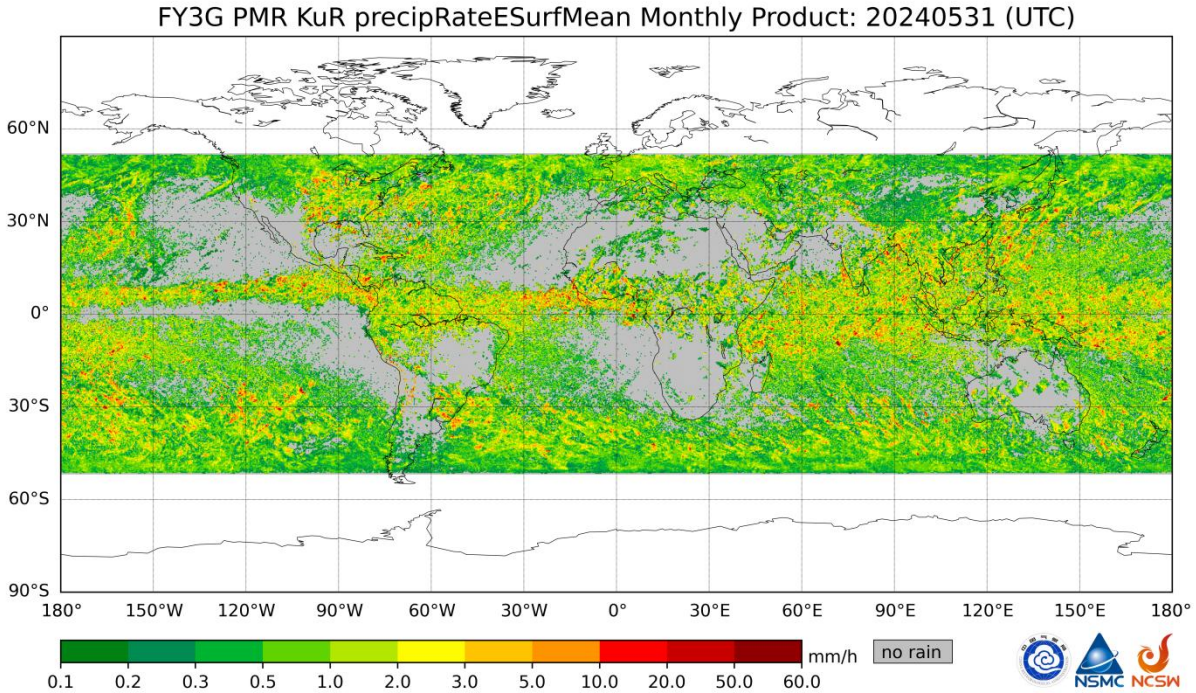


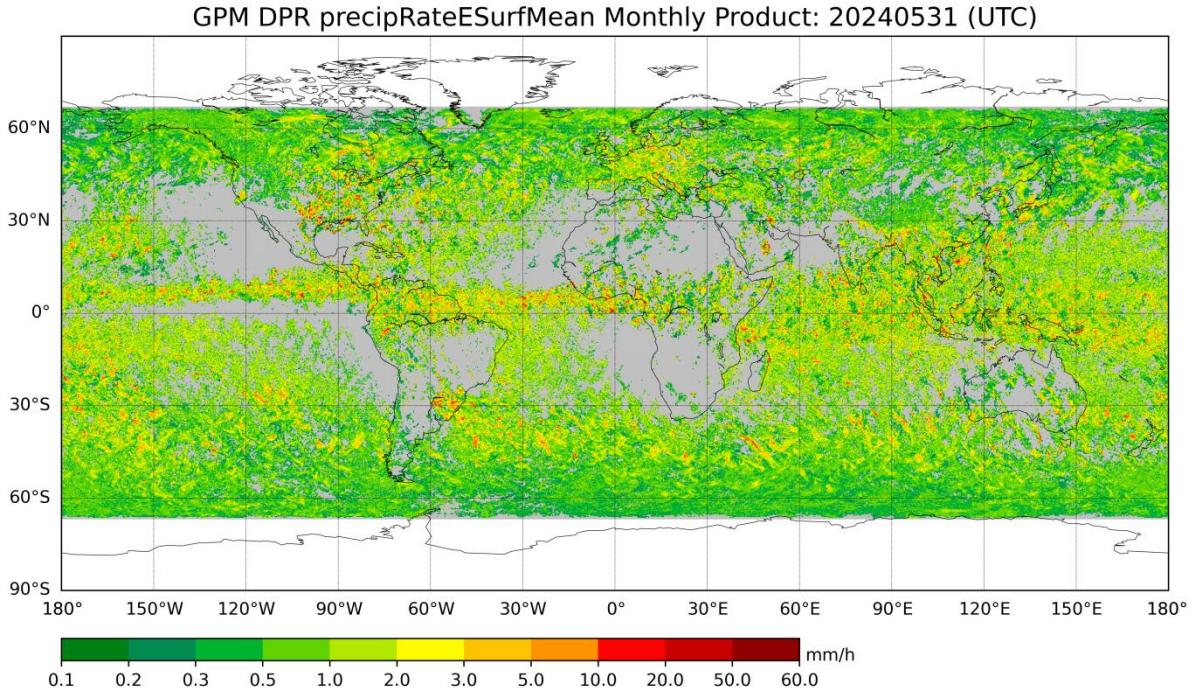
raindrop diameter



Product	Spatial Resolution (highest)	Coverage	Precision
Ku-band radar product	5 Km(horizontal) 250m (vertical)	55S-55N	Bias<40% (as compared to surface rain observations)

PMR & DPR Monthly Product Comparison

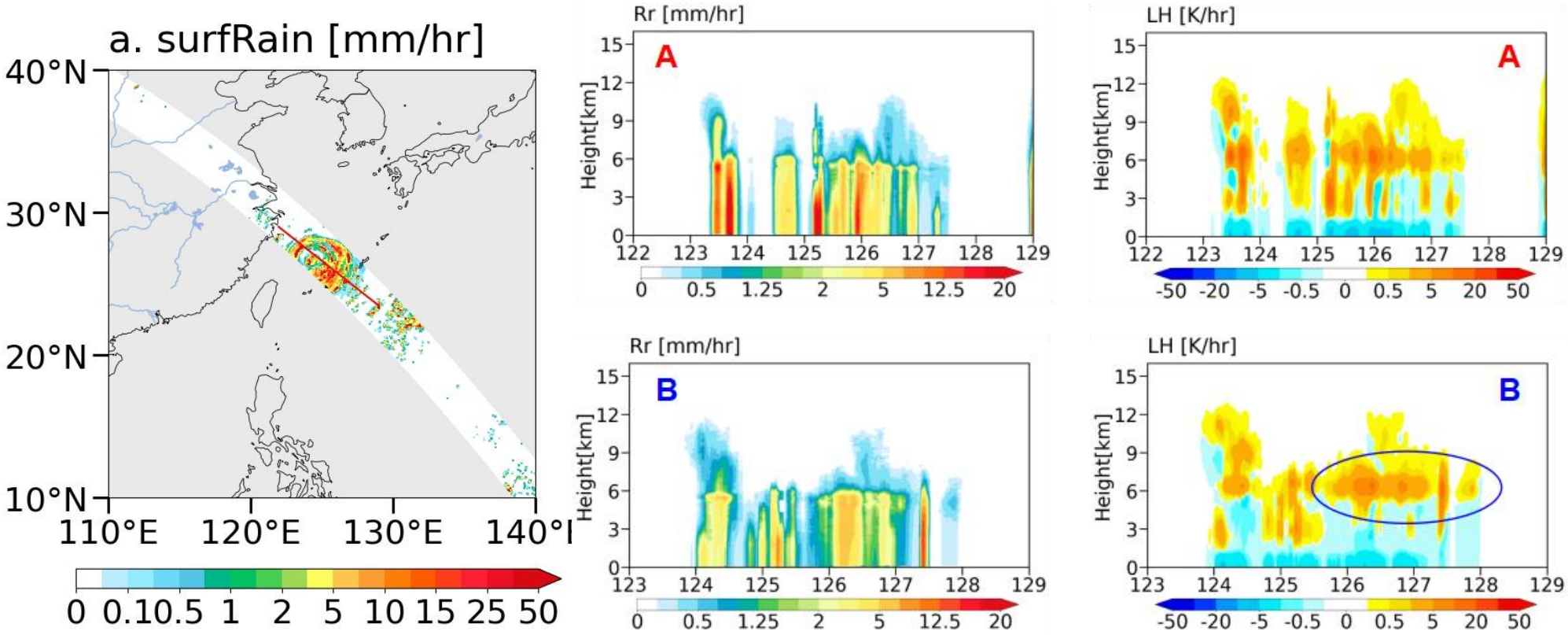




1、The minimum GPM Ze is around 12dBZ, and the minimum PMR Ze is around 10dBZ. The improvement in radar sensitivity results in PMR seeing more weak precipitation.

2、The near surface layer of PMR is about 500 meters higher than that of GPM, and there is more extrapolation of the profile.

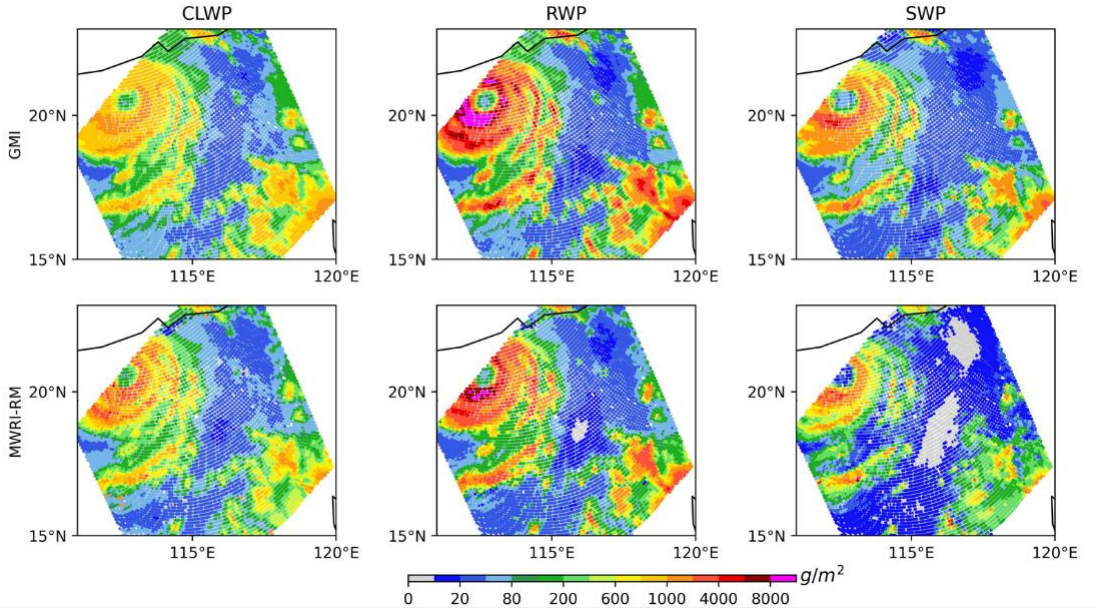
PMR Latent heating



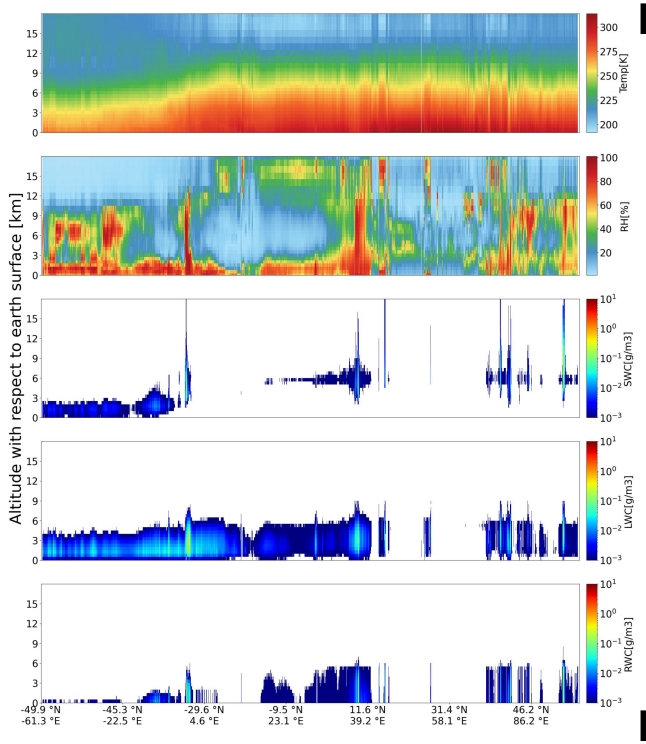
FY-3G PMR Ku band retrieved latent heating for the Super Typhoon Khanun in 2023

Product	Spatial Resolution （highest）	Coverage	Precision
latent heating	5 Km(horizontal) 250m (vertical)	55S-55N	bias: -0.06K/hr

MWRI-RM Hydrometeor profile



FY-3G microwave-retrieved hydrometeor contents (surface rain, ice water, cloud water ,liquid water) for the Super Typhoon Khanun in 2023

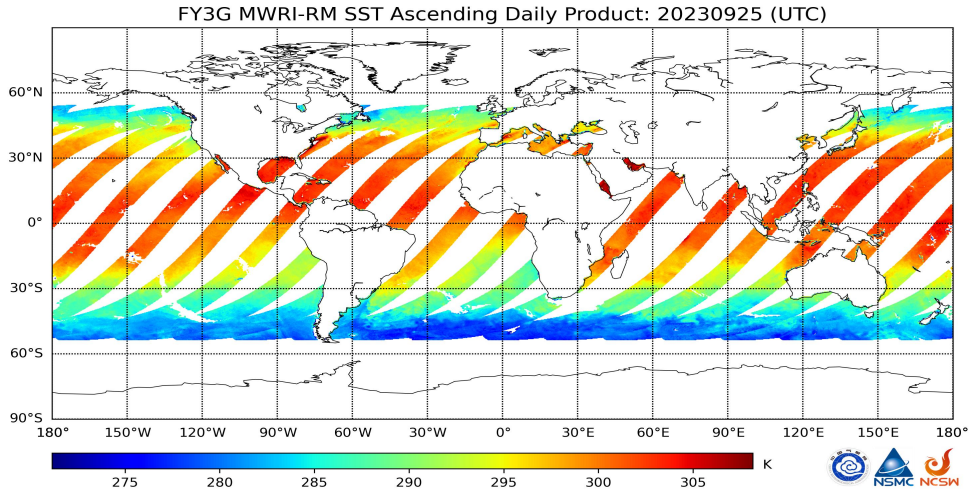


FY-3G microwave hydrometeor profiles (surface rain, ice water, cloud water ,liquid water)

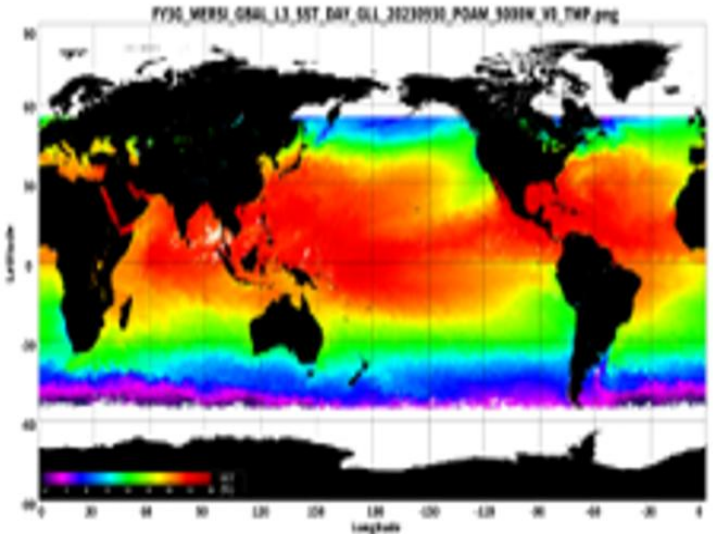
- The microwave imager (WMRI-RM) onboard the FY3G satellite has 17 channels ranging from 10.65GHz to 183.31 GHz, which can be used to retrieve multiple hydrometeors including ice water, cloud water , liquid water, temperature and moisture profile as well as the hydrometeors contents.
- The hydrometeor profiles can be applied in understanding the radiative properties and forcing effects of clouds.

Product	Spatial Resolution （highest）	Coverage	Precision
Hydrometeor profile	7 Km(horizontal) 0.5-1km (vertical)	55S-55N	<10%

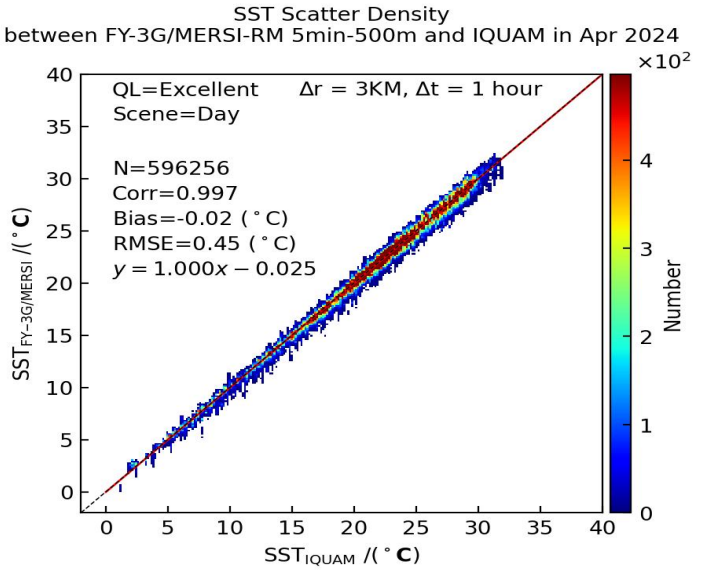
FY-3G sea surface temperature



MWRI SST



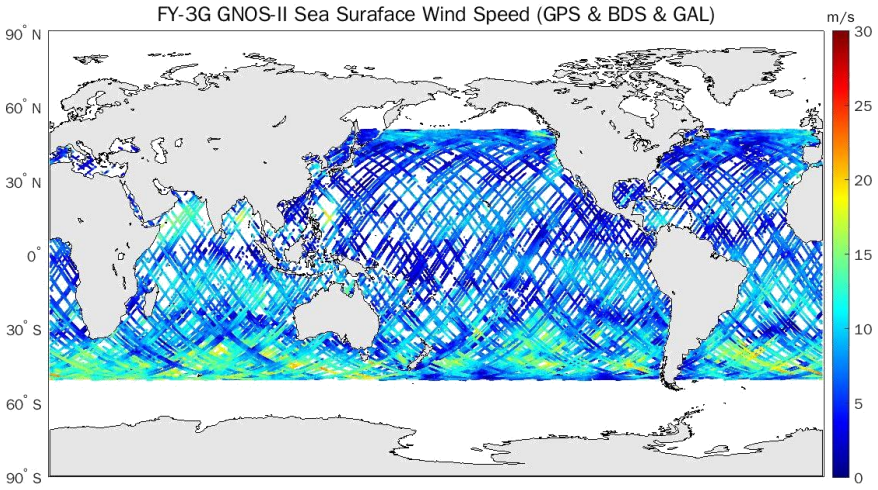
MERSI SST

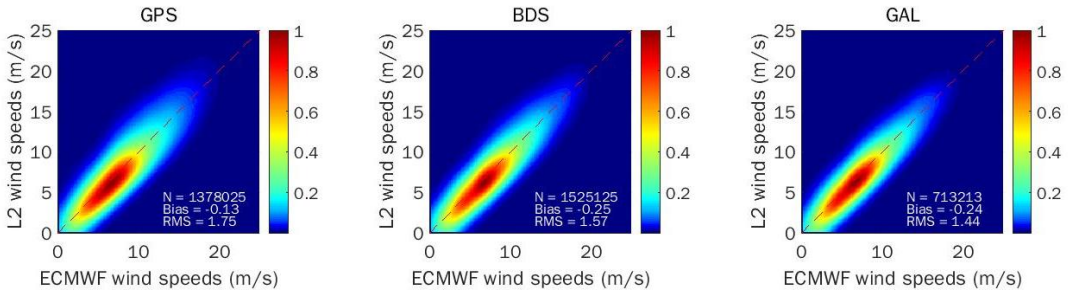


Product	Payloads	Spatial Resolution	Coverage	Precision
SST	MWRI-RM	21×35km	55S-55N	0.8K
	MERSI-RM	500m	55S-55N	0.5K

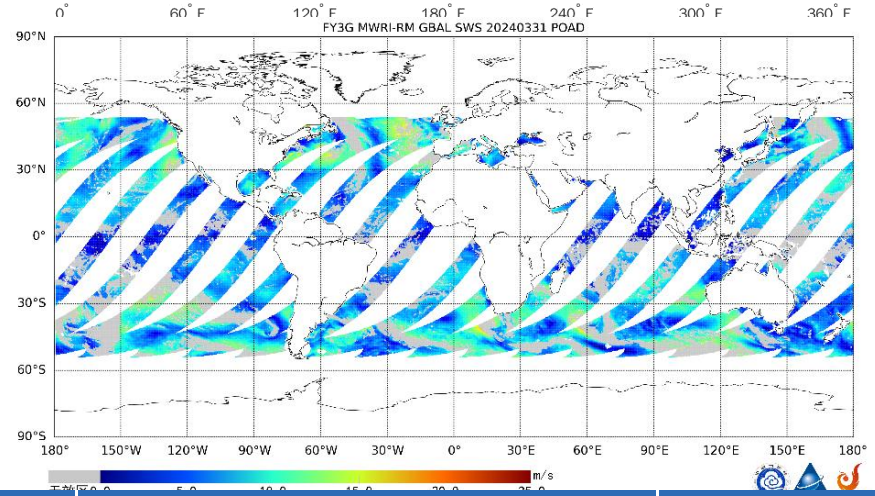
FY-3G Sea surface wind speed

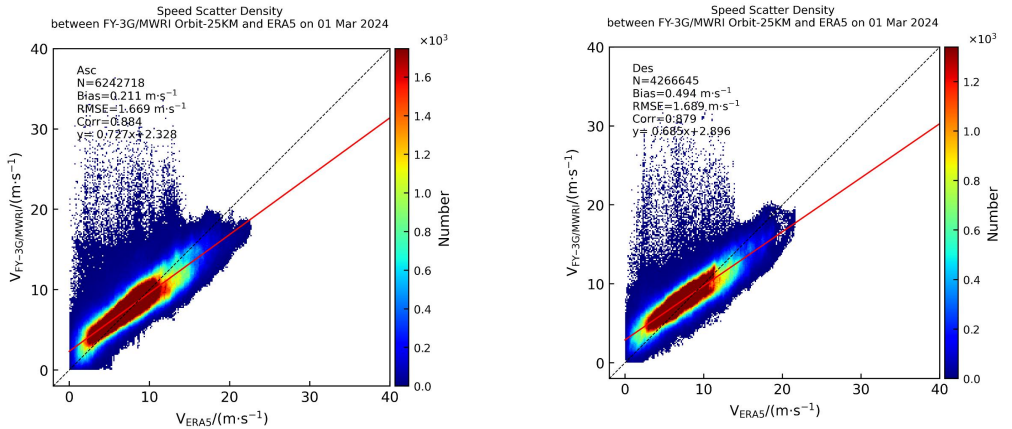
GNOS SSW





MWRI SSW

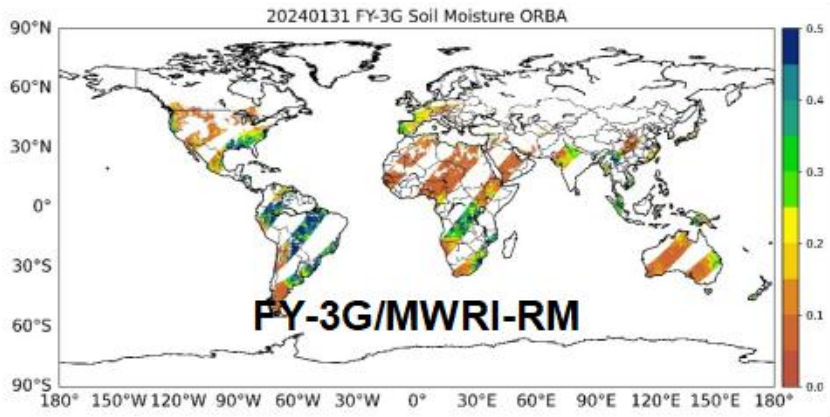


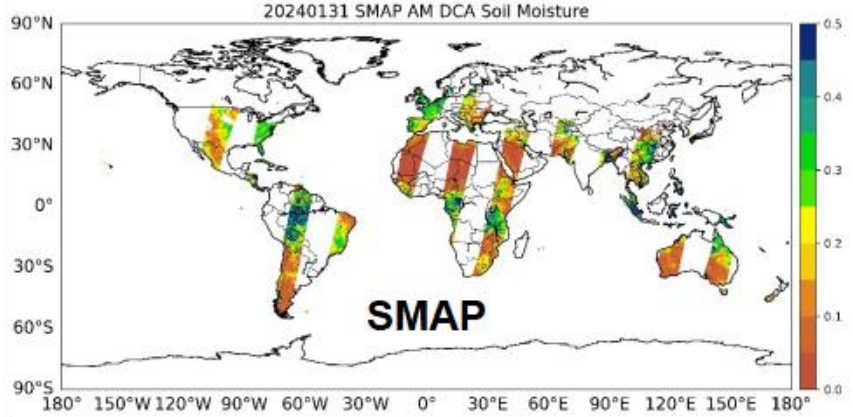


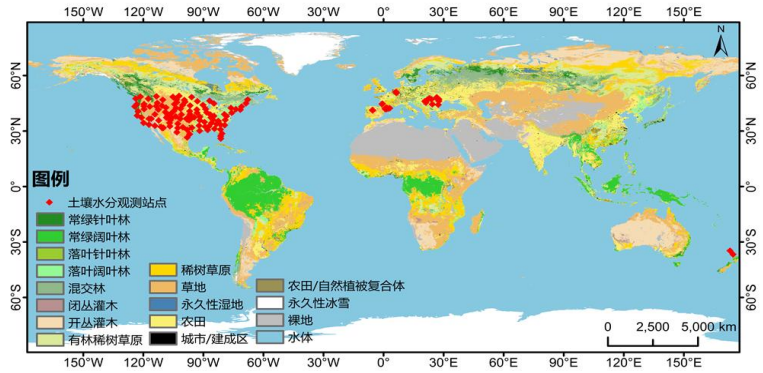
Product	Payloads	Spatial Resolution (highest)	Coverage	Precision
sea surface wind speed	GNOS-II	25km	55S-55N	GPS： 1.71m/s BDS : 1.91m/s GAL : 1.46m/s
	MWRI-RM	25km	55S-55N	Ascend: 1.832m/s Descend: 1.704m/s

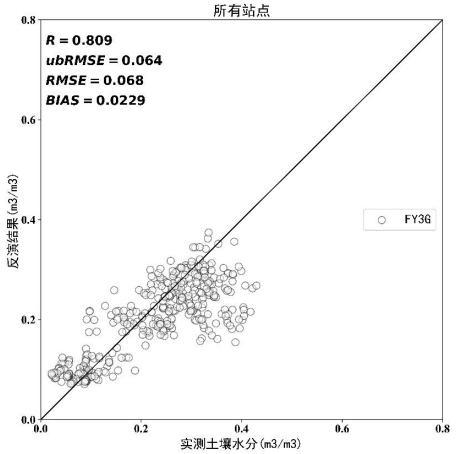
FY-3G Soil moisture

MWRI SVM



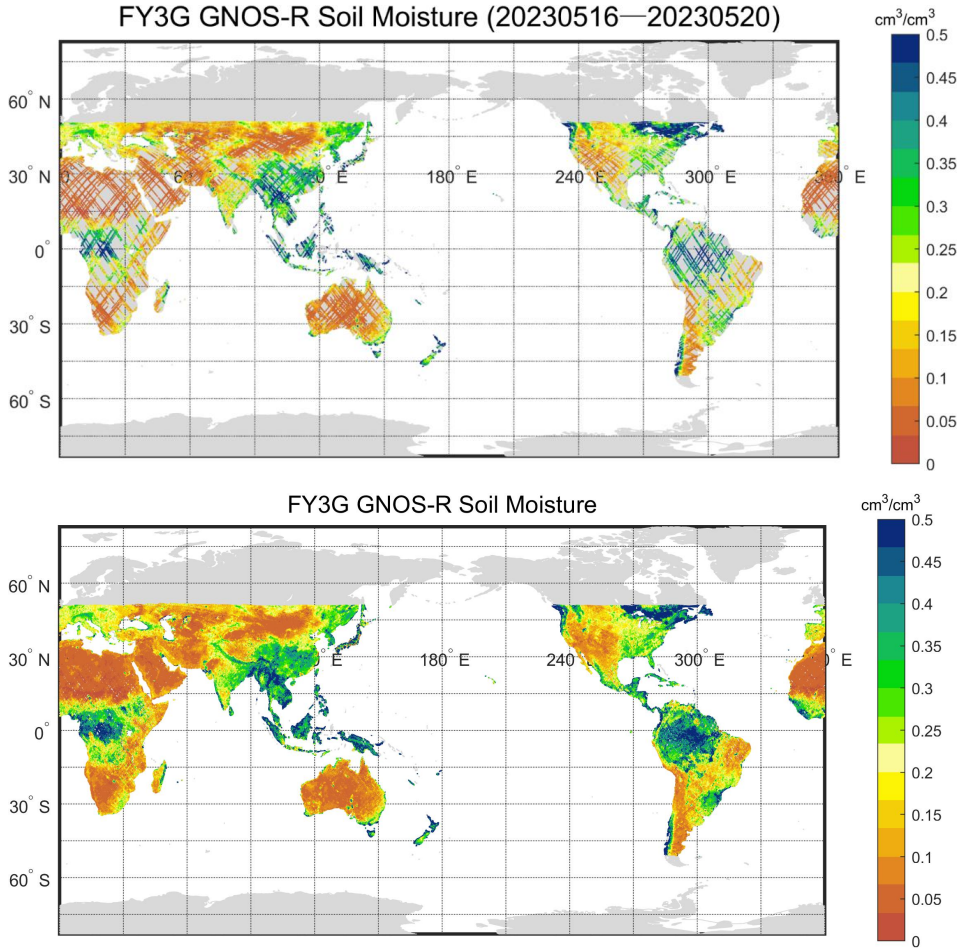




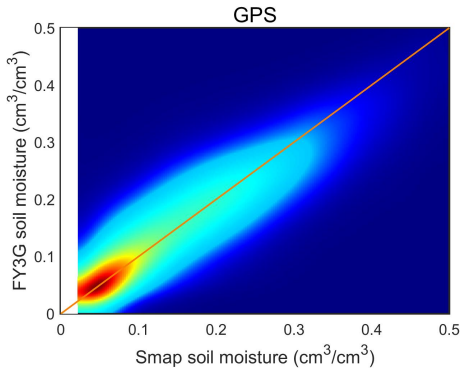


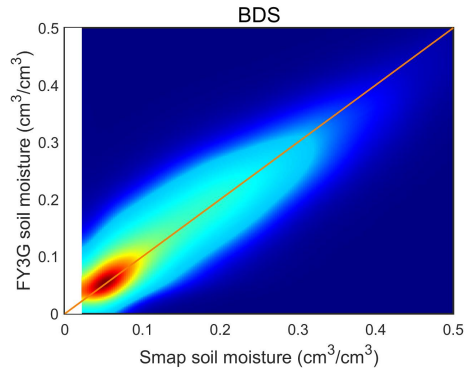
Product	Payloads	Spatial Resolution （highest）	Coverage	Precision
soil moisture	MWRI-RM	25km	55S-55N	0.06cm³/cm³
	GNOS	6km	55S-55N	0.05cm³/cm³

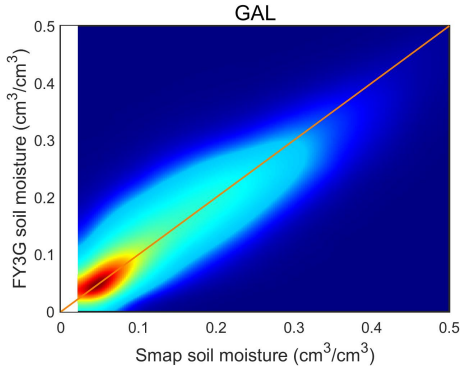
FY-3G Soil moisture

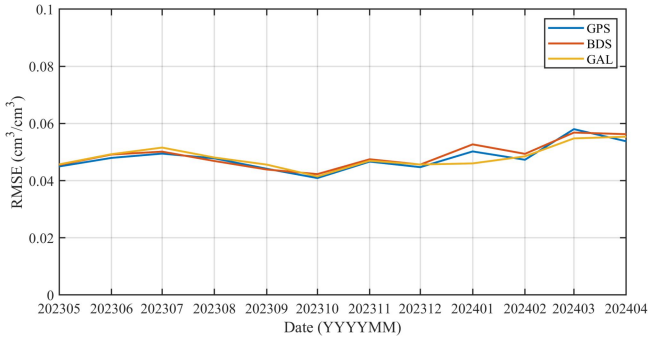


Monthly GNOS VSM

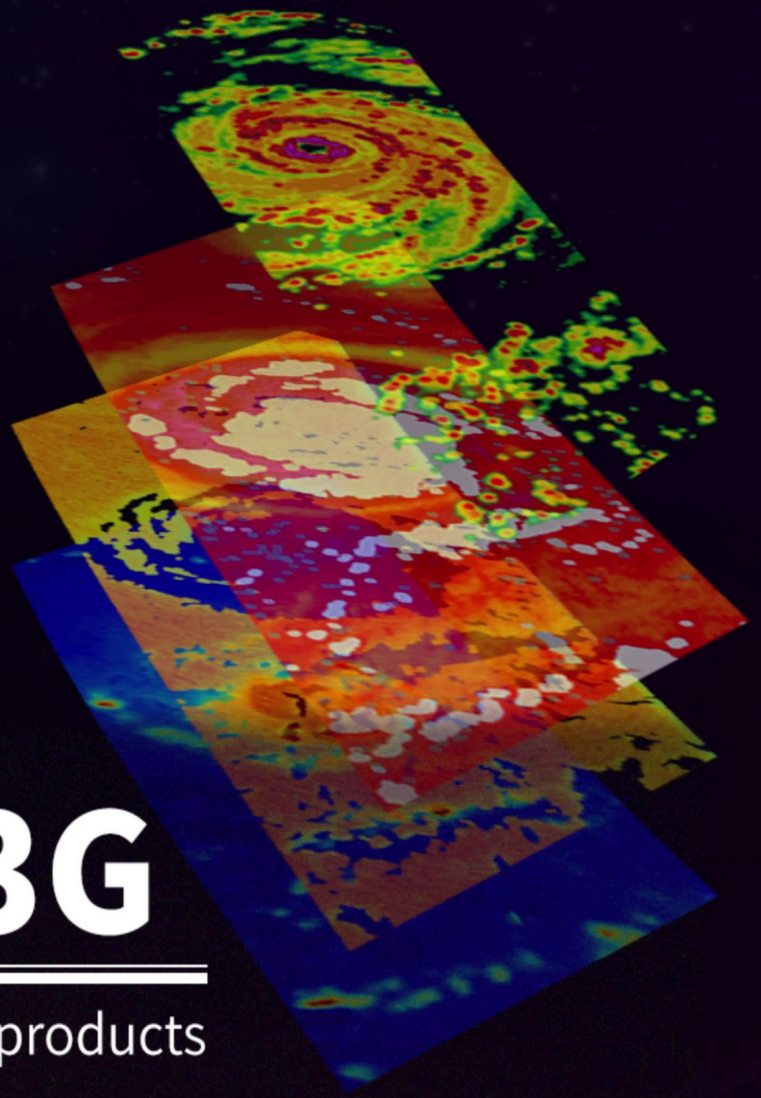








	GPS	BDS	GAL
RMSE(cm³/cm³)	0.049	0.049	0.048
Corr_Coeff	0.86	0.86	0.87



FY3G

Data and products

降水率

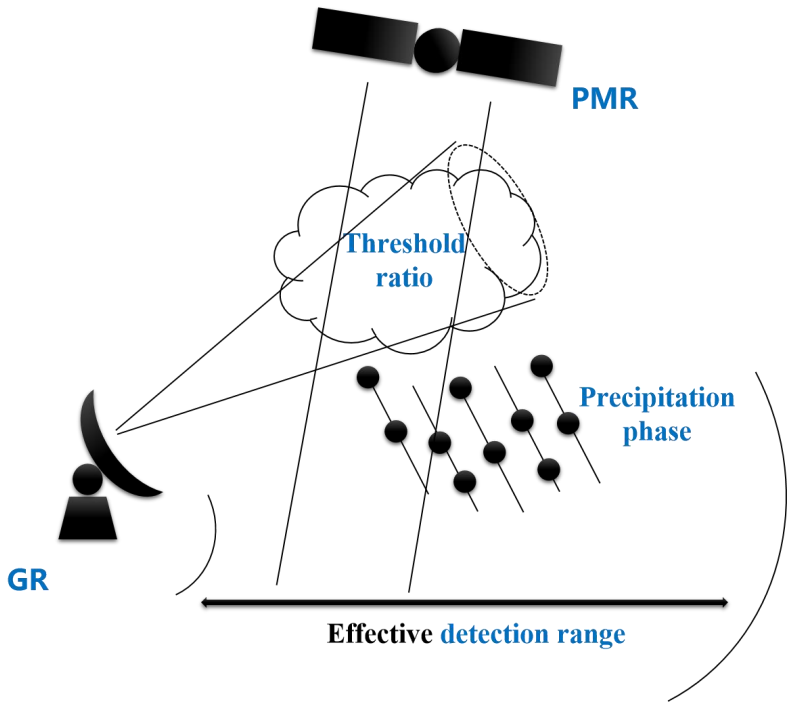
洋面大气可降水

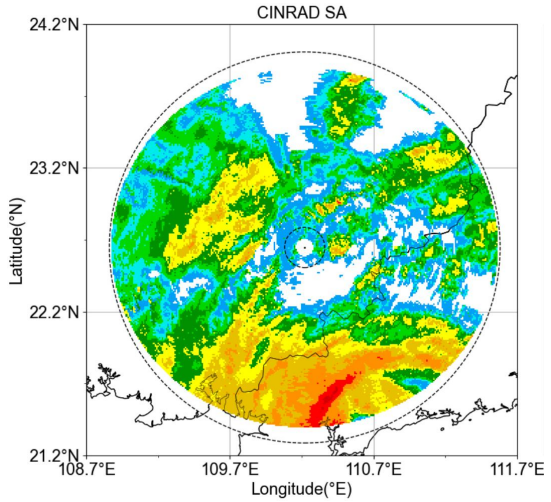
海面温度

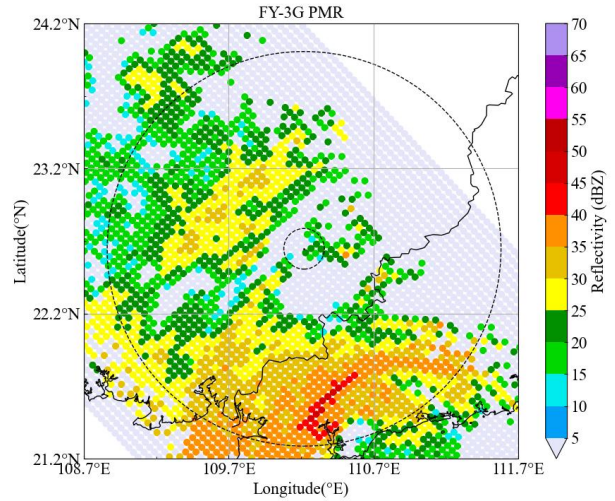
海面风速

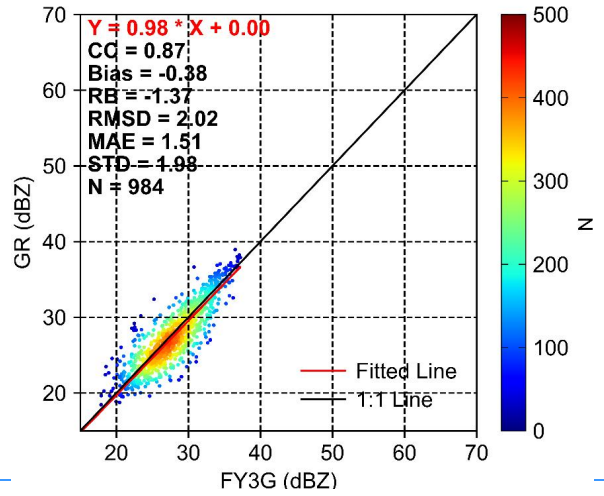
Consistency comparison of Satellite and Ground Radar

In the evaluation of the consistency of the FY-3G satellite with Ground Radar, we breaking through many key technologies such as radar frequency correction for all phases and precipitation types, pixel level matching within the effective irradiation volume of satellite and ground radar, and the impact of 3D field of view error correction, radar beam congestion factor and precipitation phase were also considered.









The deviation between FY-3G precipitation radar and ground radar (S band) is 1dB, with uncertainty within 2dB

Products service

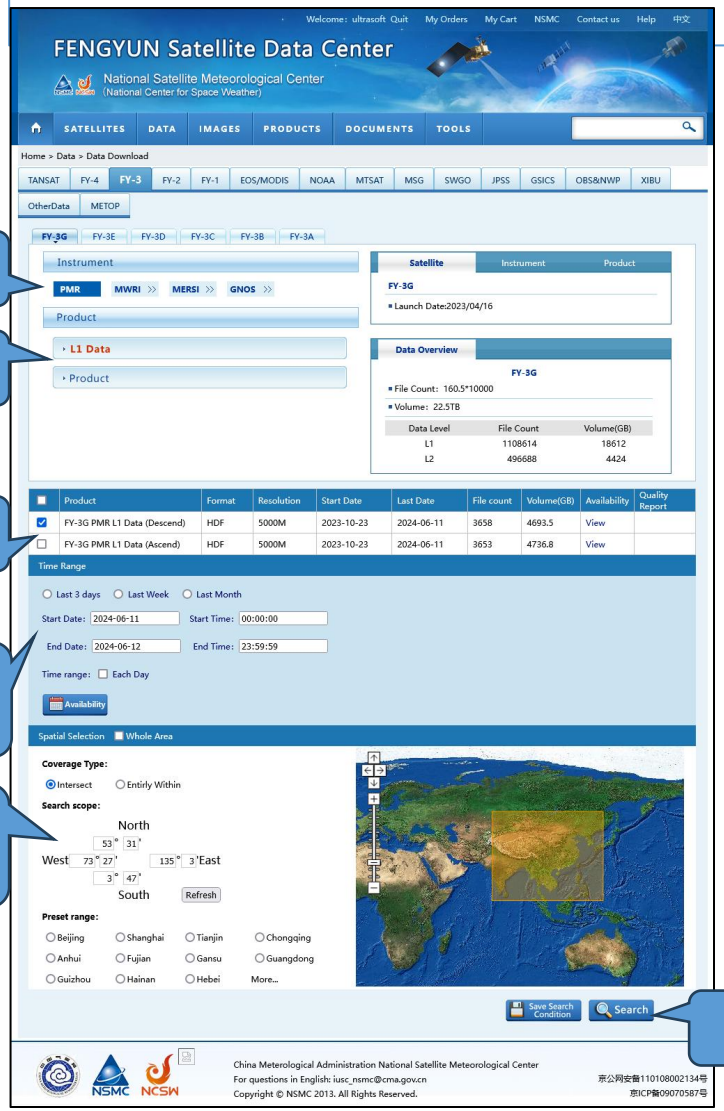
https://satellite.nsmc.org.cn

Products service

- How to get FY-3G Products

You should sign up to the web site first.

https://satellite.nsmc.org.cn/PortalSite/Data/Satellite.aspx?SatelliteCode=FY3G&SeriesCode=FY3X&currentculture=en-US



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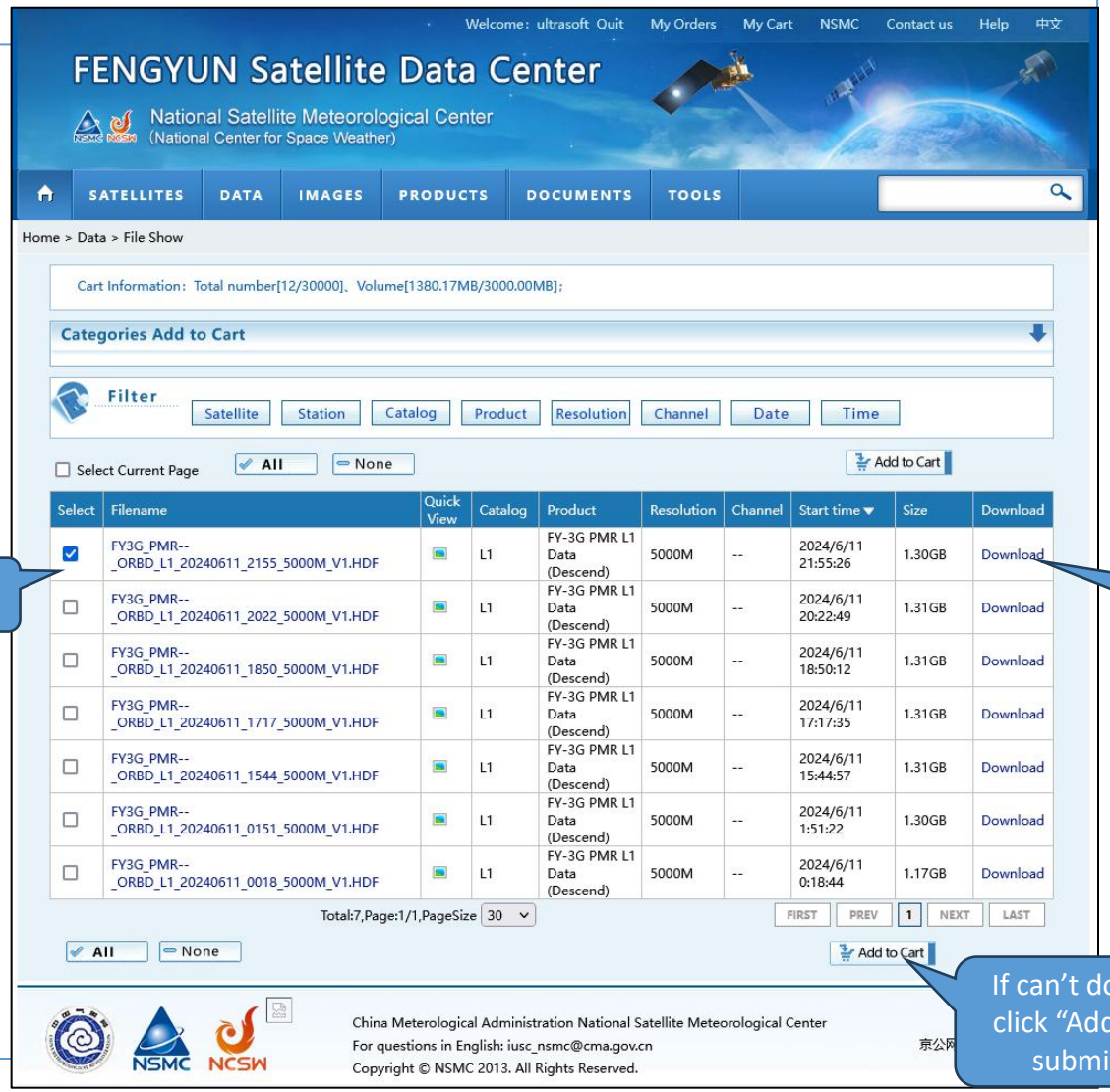
Choose type

Choose product

Choose date & time

Choose spatial coverage

Click to search



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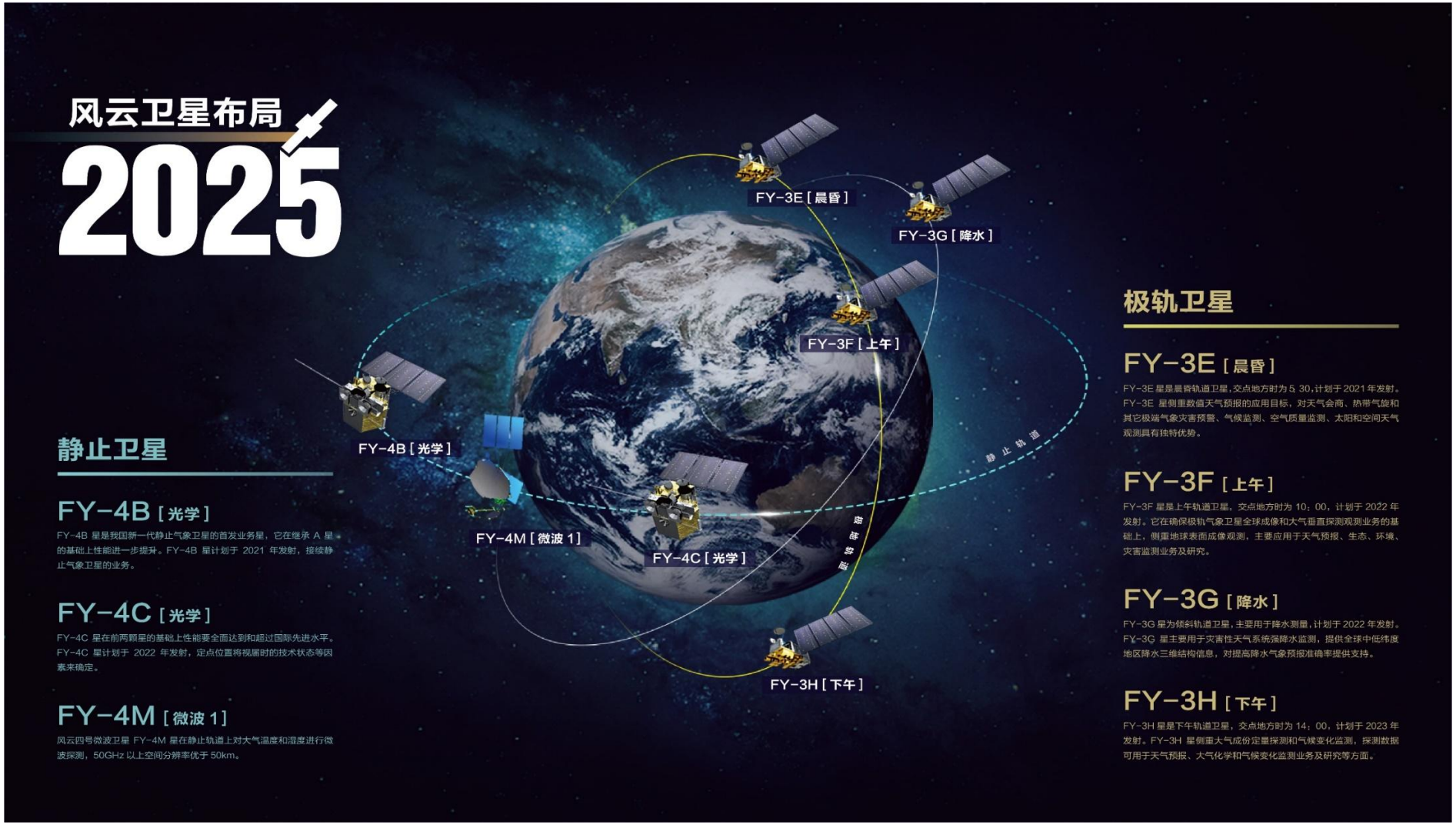
Future Plan



In the year of 2025, CMA will launch FY3H, FY4C(optical) and FY4M(micro wave)

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THANKS

感谢倾听