Chinese Meteorological Satellite and its Applications

Xiang FANG

National Satellite Meteorological Center,

China Meteorological Administration

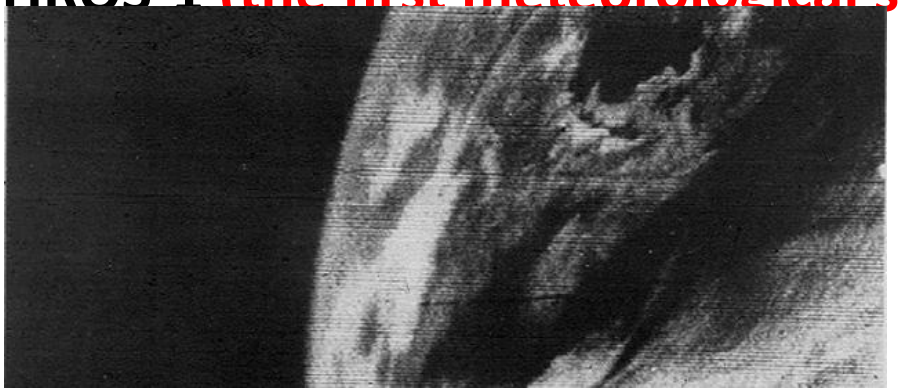
(NSMC/CMA)

Outline

- **Overview of Meteorological Satellites**
- **Current FY satellite Status and furture programs**
- **FY Satellite Data Service**
- **FY satellite data Applications**

Overview of Meteorological Satellites

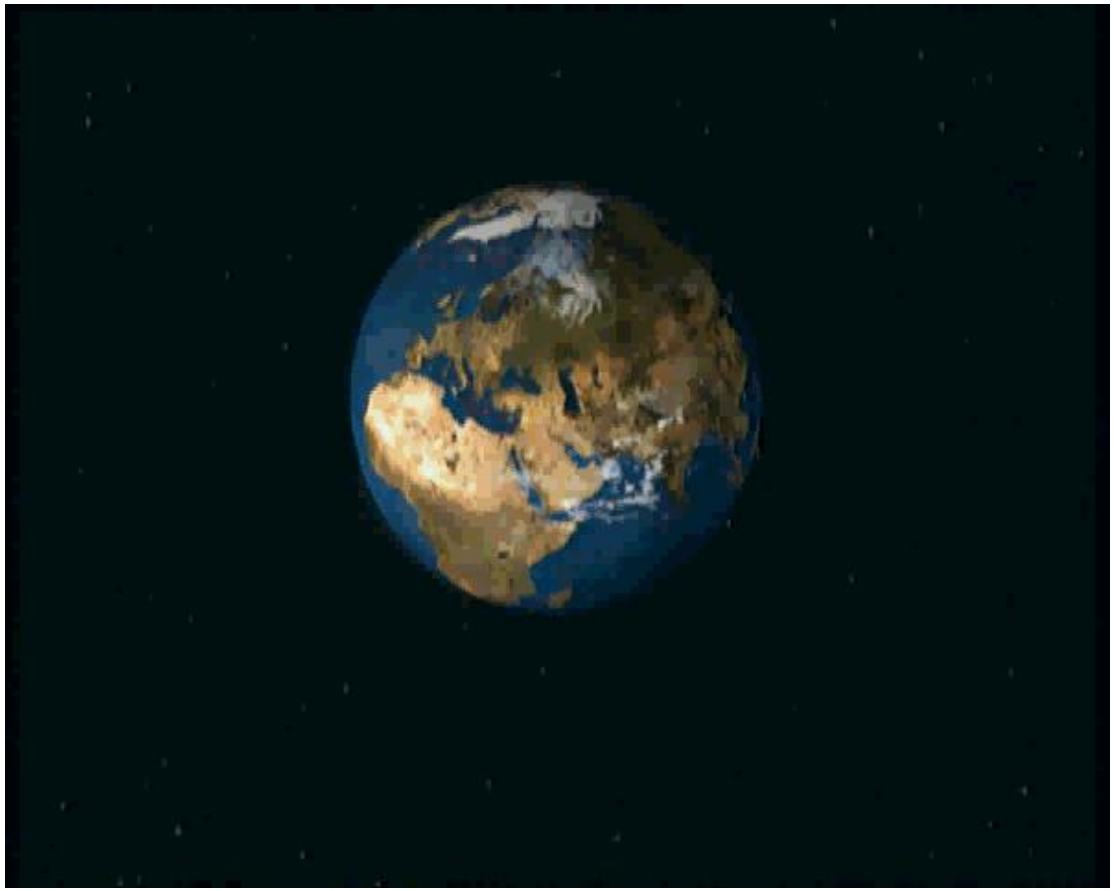
- 1940s, Rocket with camera (the first image from space)
- 1957, Sputnik (the first man-made satellite, former Soviet Union)
- 1959, Vanguard 2 (the first meteorological instrument, US)
- 1959, Explorer 7 (the first successful meteorological instrument, US)
- 1960, TIROS-1 (the first meteorological satellite, US)



The first image from TIROS-1

Geostationary orbits

The Geostationary satellites are used for observing the development and evolution of weather phenomena. Especially to the short time scales: their data are used mainly for nowcasting and the determination of satellite derived wind.



- Advantage： temporal frequency
- Disadvantage: part of the Earth, single instrument, bad spatial resolution, bad spectral resolution

located in the fixed point above the Earth's equator. Altitude is near 36,000 km. It can observe the earth more frequently in once per half hour, even fifteen minutes or less.

Sun synchronous orbits (Polar orbiting)

- Advantage: global coverage, multiple instruments, good spatial resolution, good spectral resolution
- Disadvantage: bad temporal frequency

The polar orbiting satellites means the satellite rotates around the earth bypass the pole. Their orbital altitudes near 850 km and their **orbital** periods is around 101 minutes, The polar orbiting satellites provide **global coverage** twice-a-day. That means every where can be observed twice a day. The polar orbiting satellites have the high spatial resolution, so it can be used to monitor land surface and atmospheric structure in more detail.

Imaging Mode for Geo and Leo Satellite

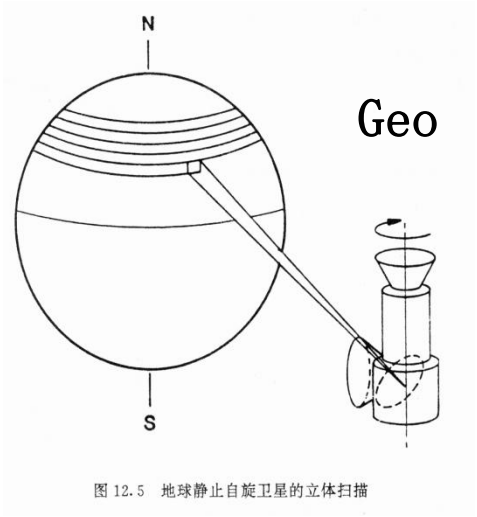
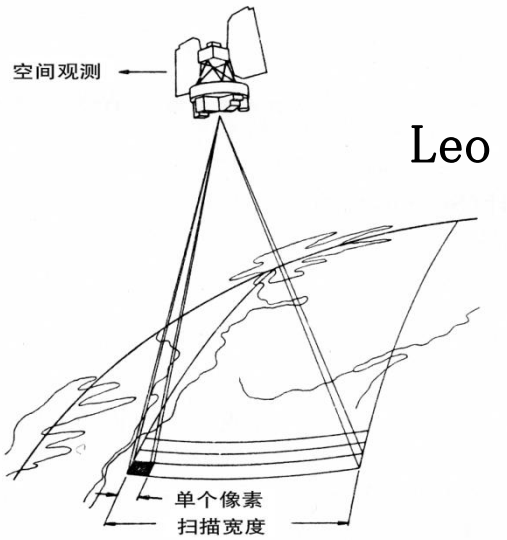
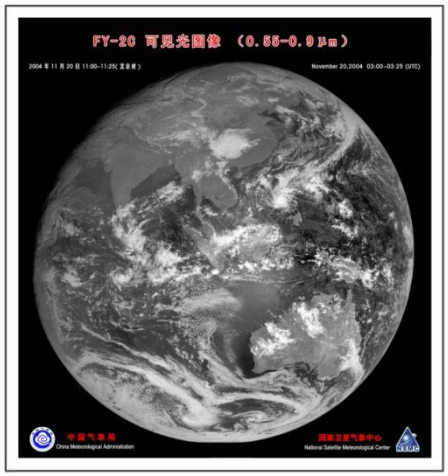
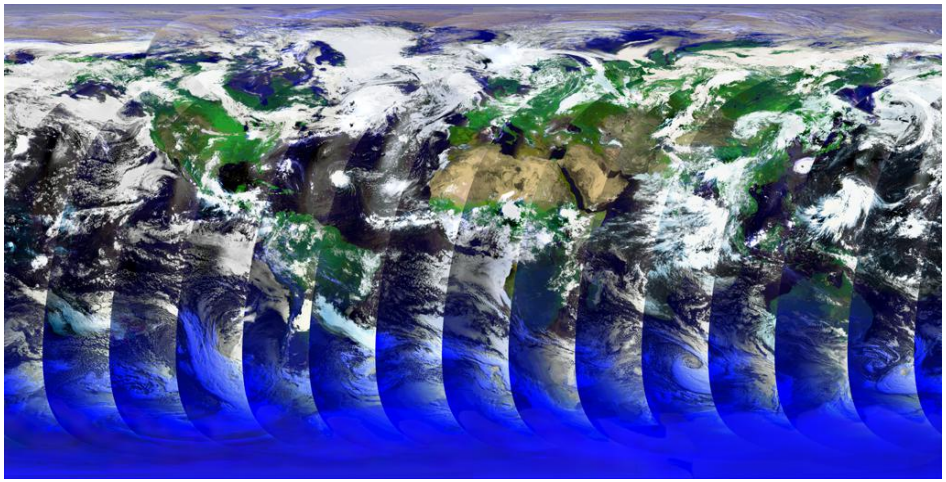


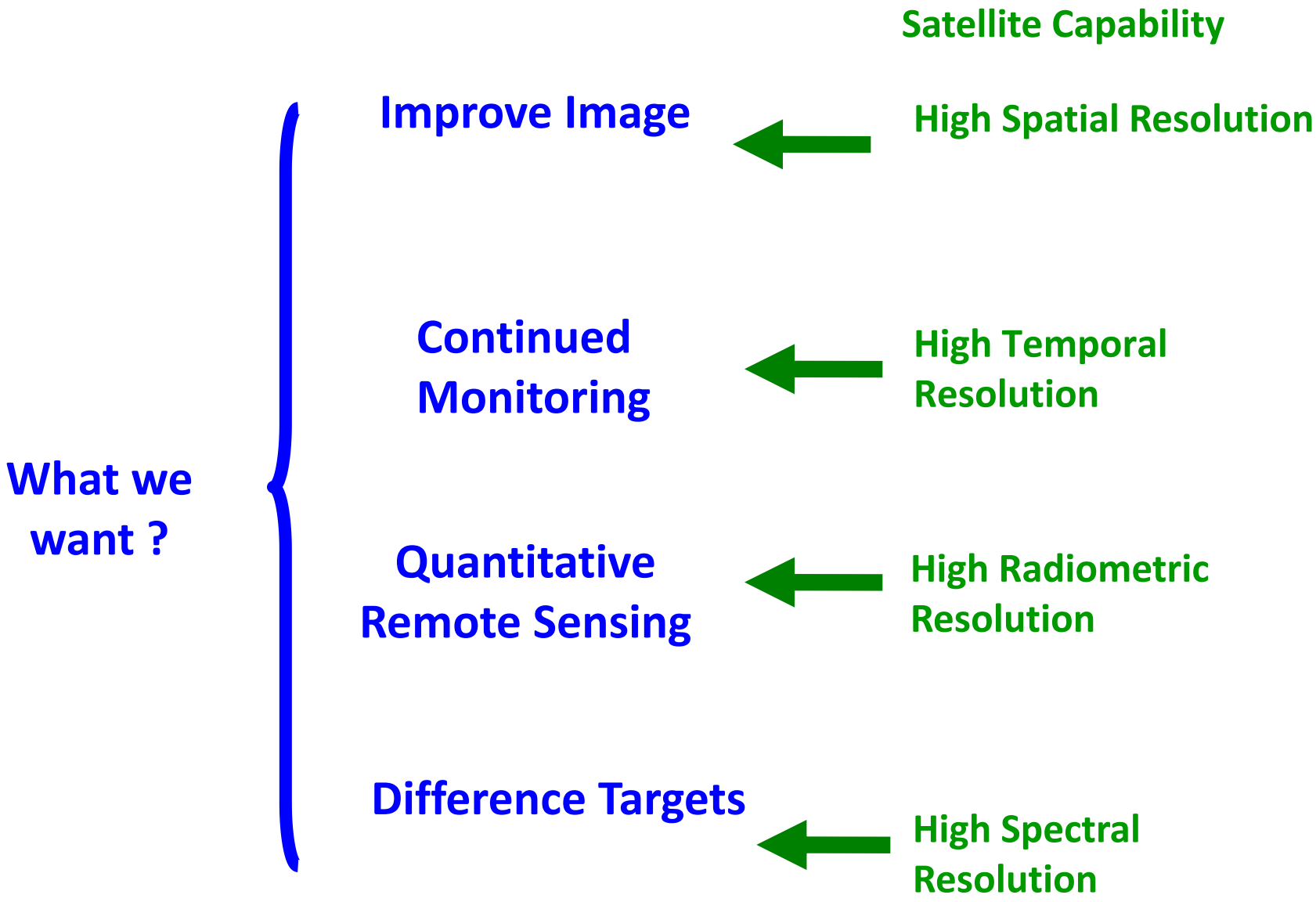
图 12.5　地球静止自旋卫星的立体扫描



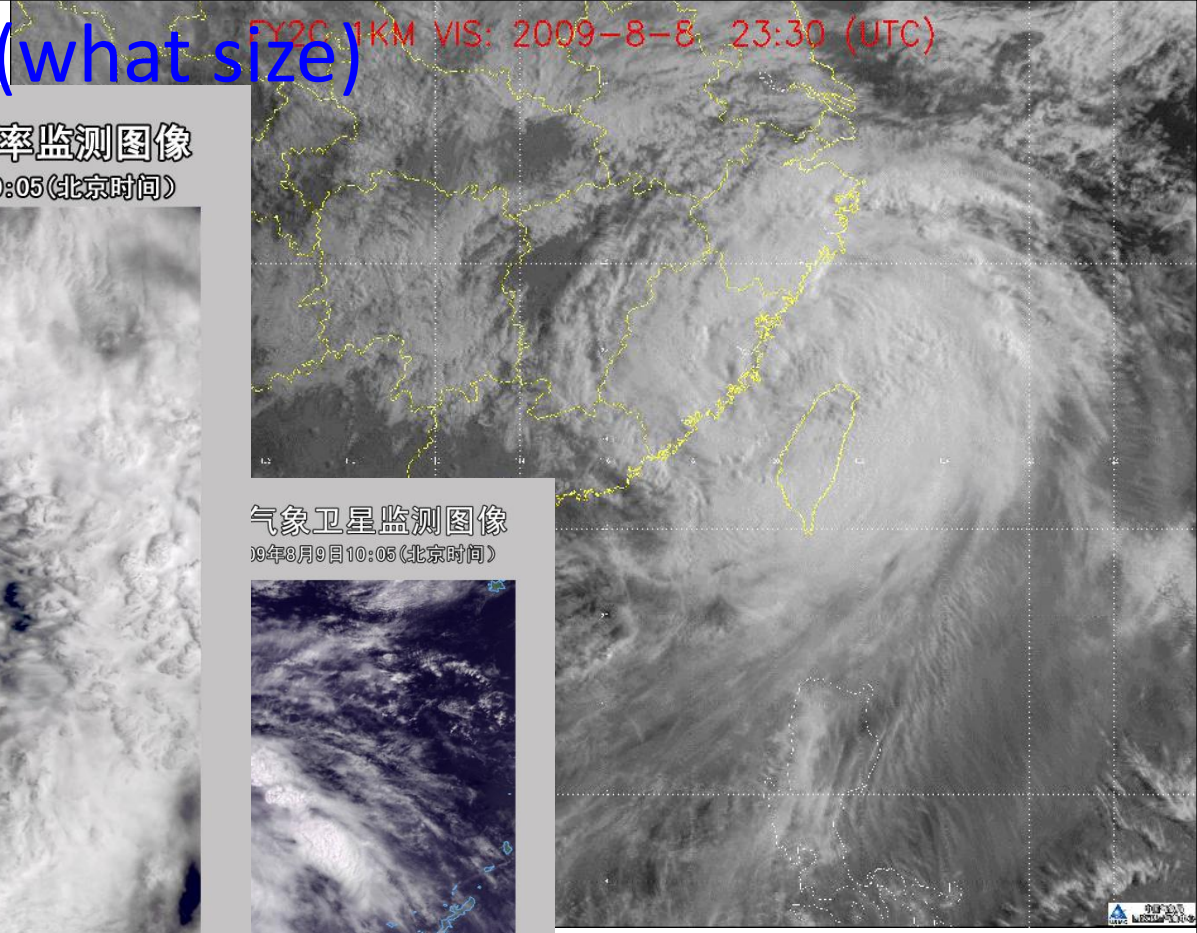


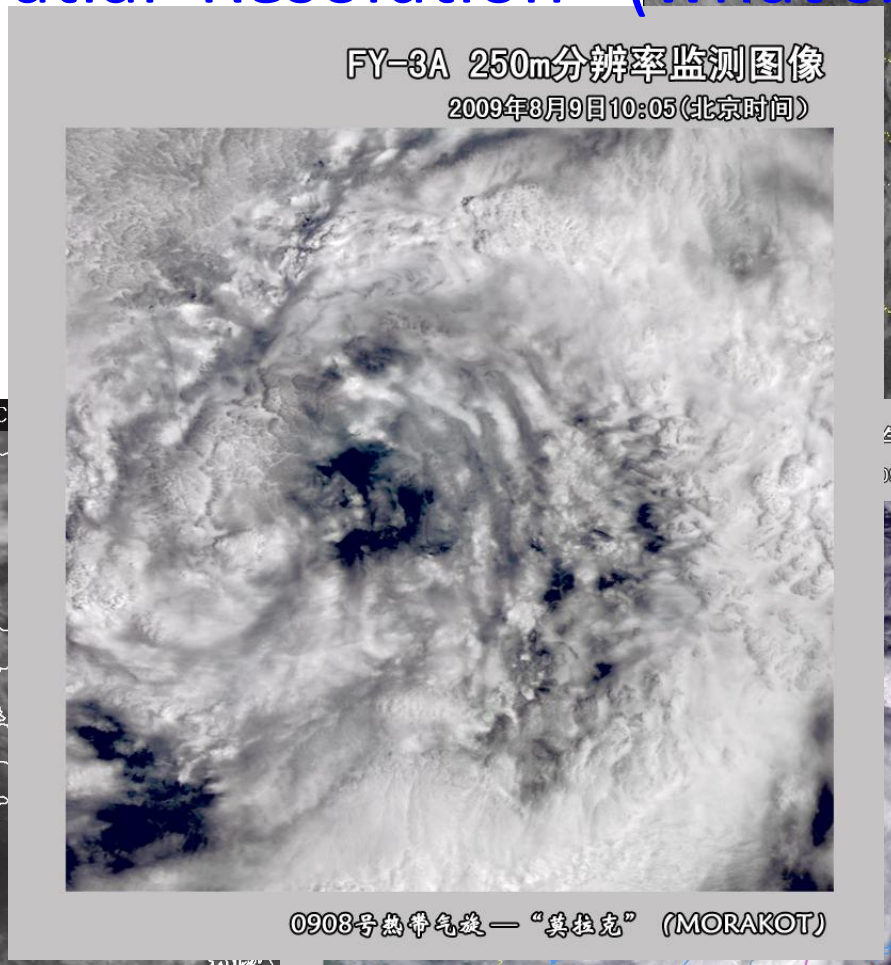


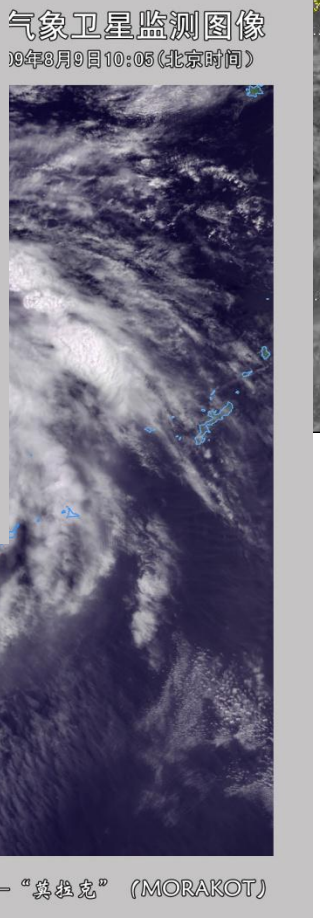
Observation Resolution

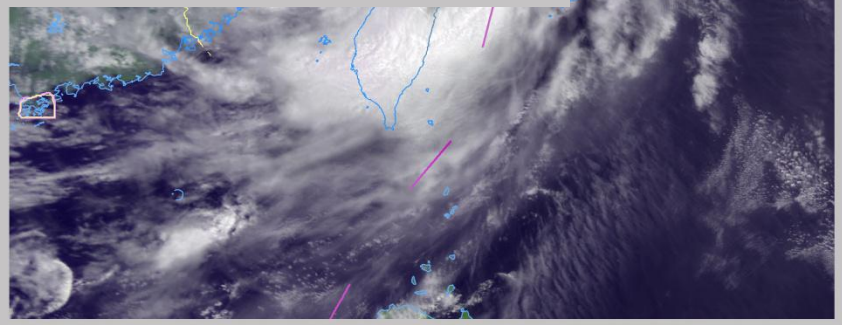


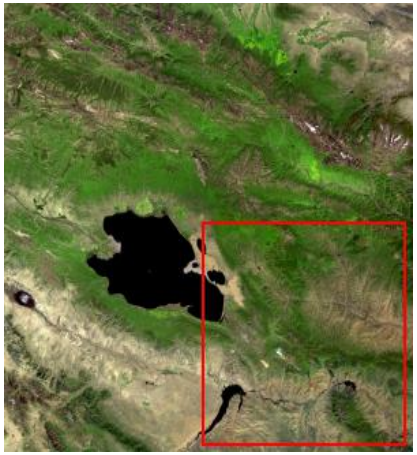
Spatial Resolution (what size)





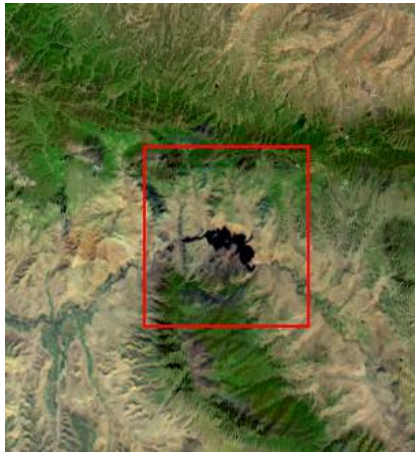




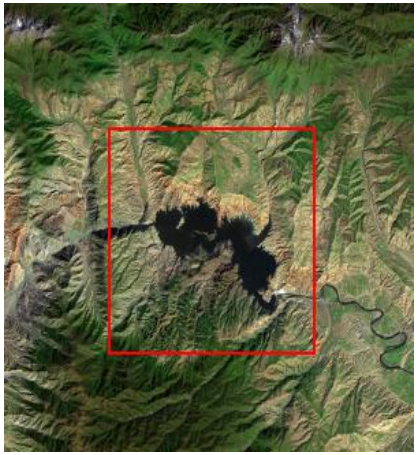


1 km

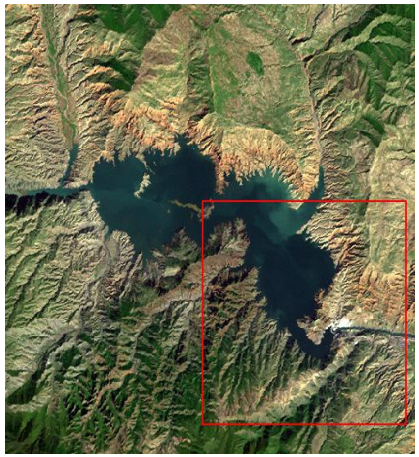
500 m



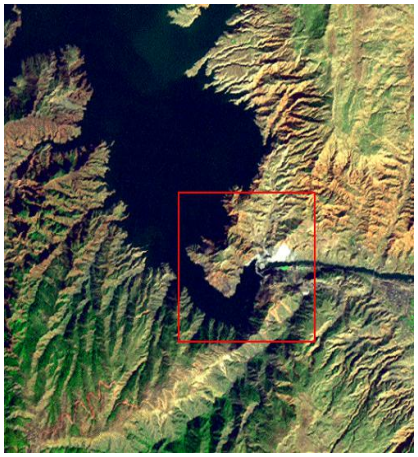
250 m



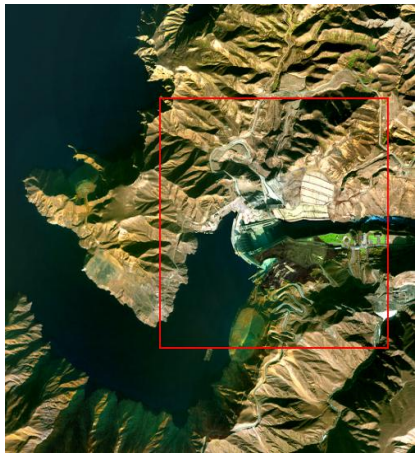
100 m



30 m

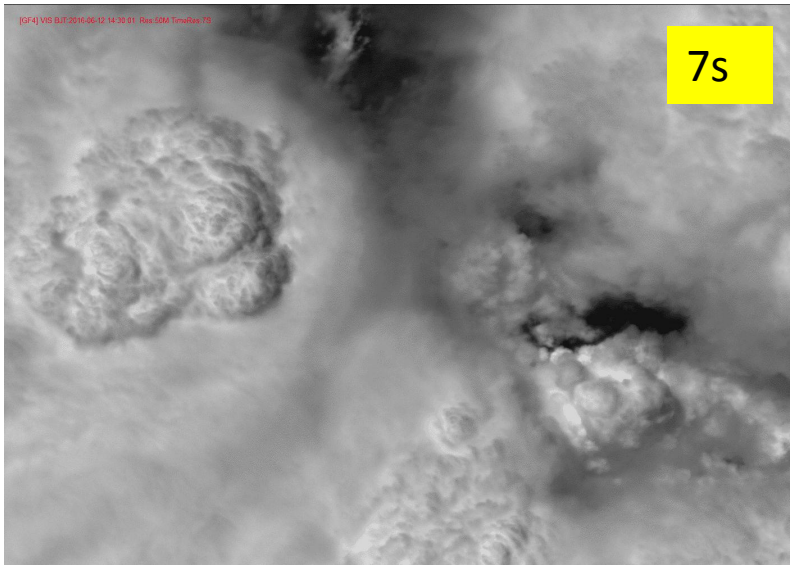


15 m

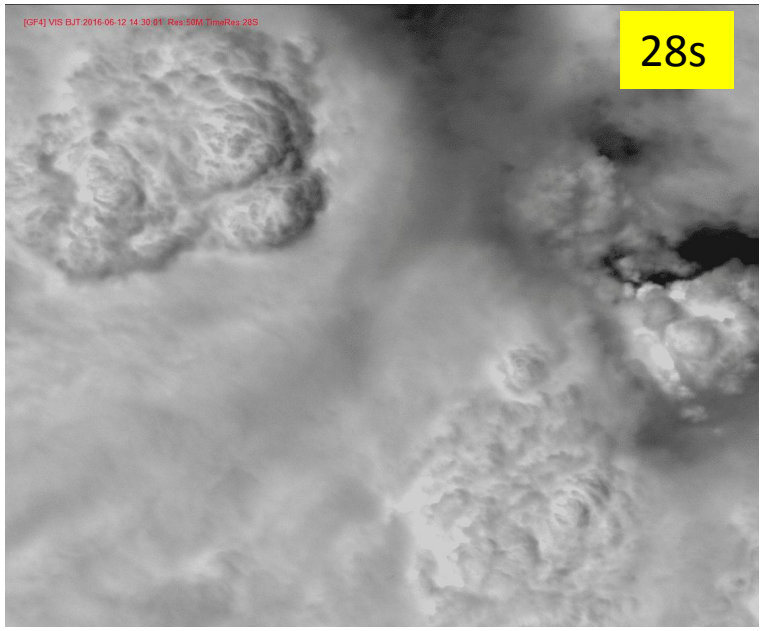


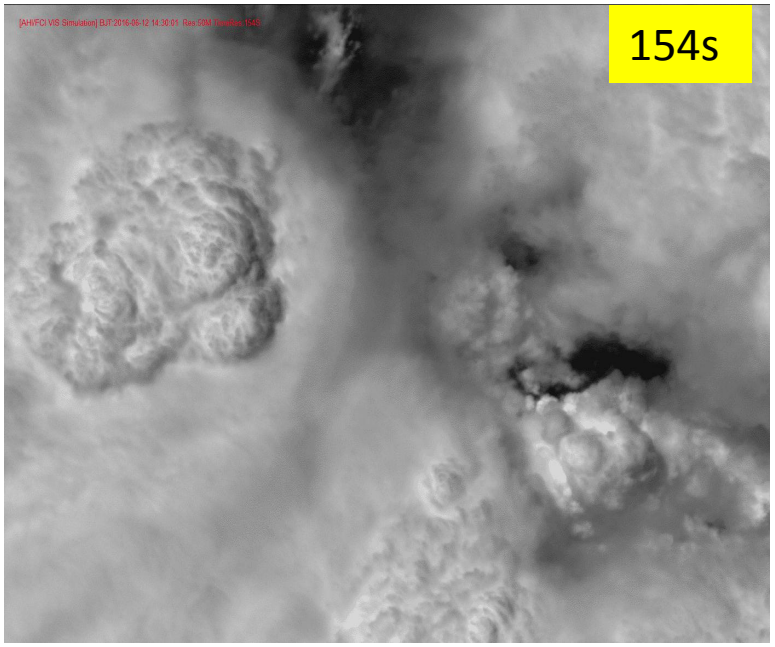
5 m

2.8 m

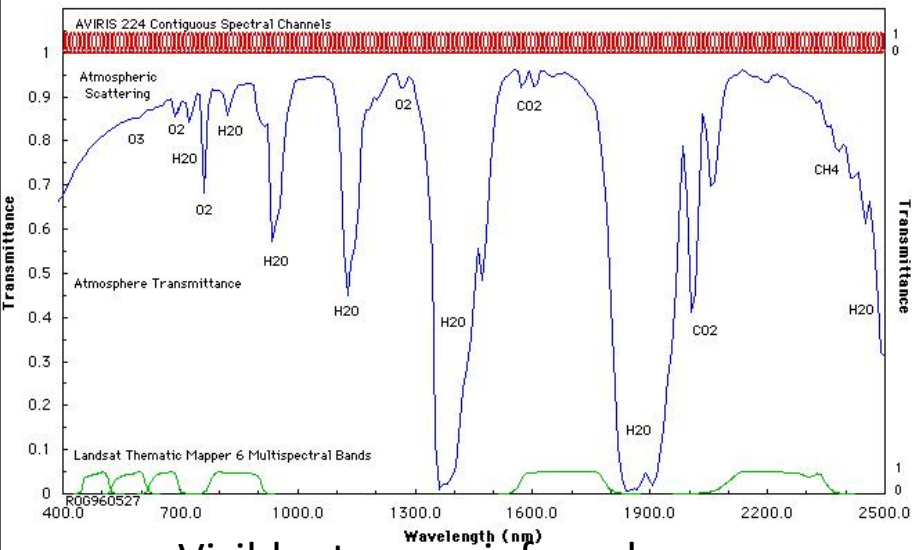


Temporal Resolution (How often)

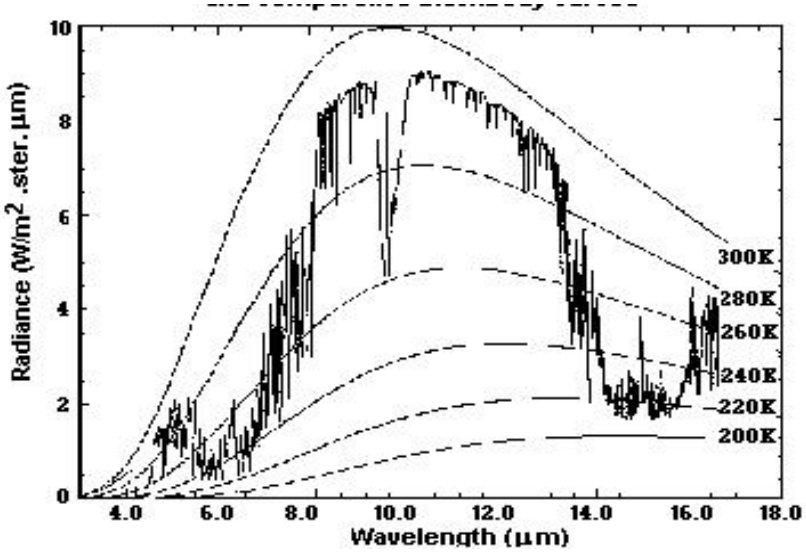




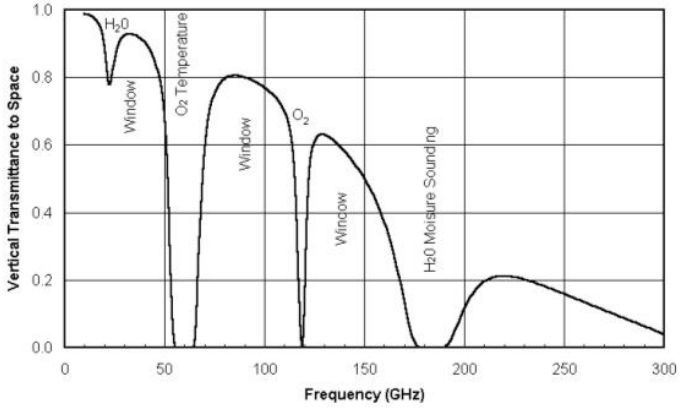
Spectral Resolution
(visible to near infrared, infrared and microwave)



Visible- to near infrared



infrared



microwave

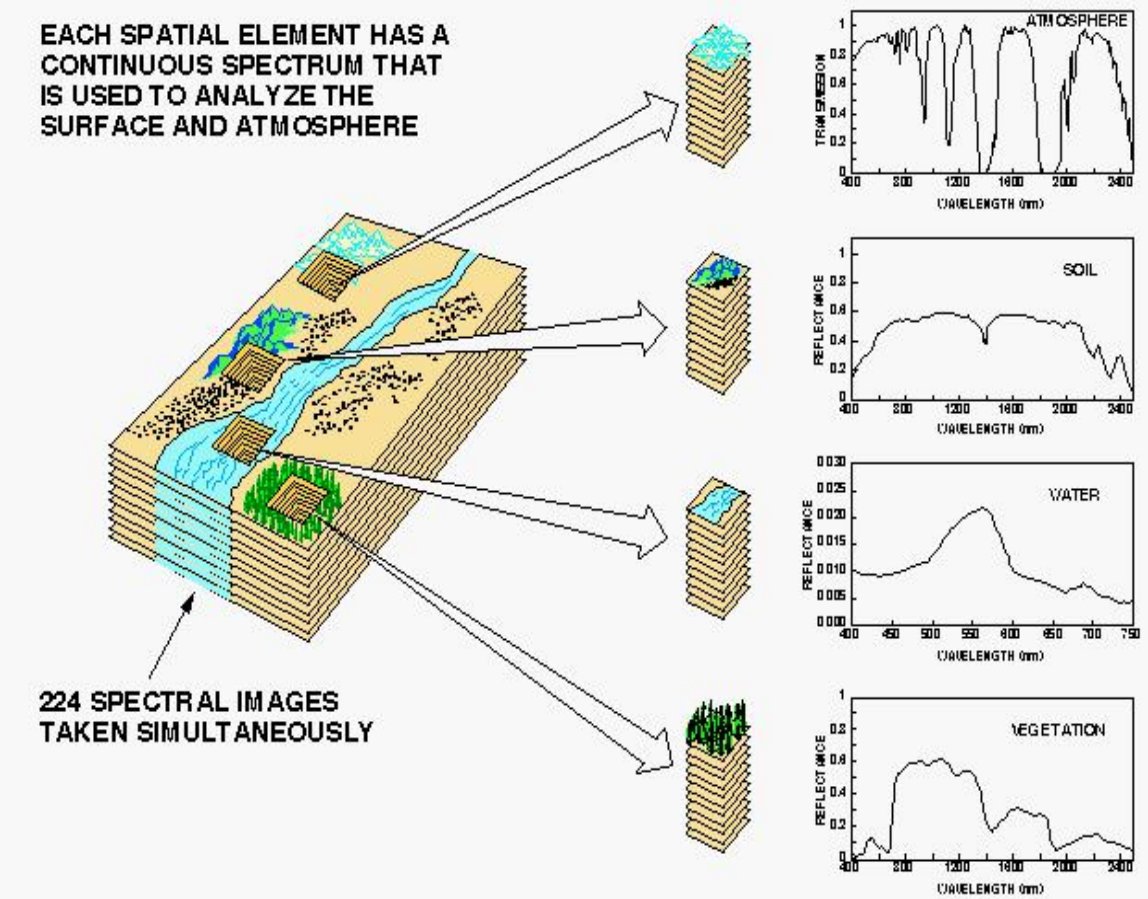
Each channel has its specific wavelength range and in the certain spectral band. the same target has different features in different channel, from this, we can discern a target, like cloud, snow, fog and dust storm. The more narrow the wavelength is the more accurate spectrum features we can get from the target.

1

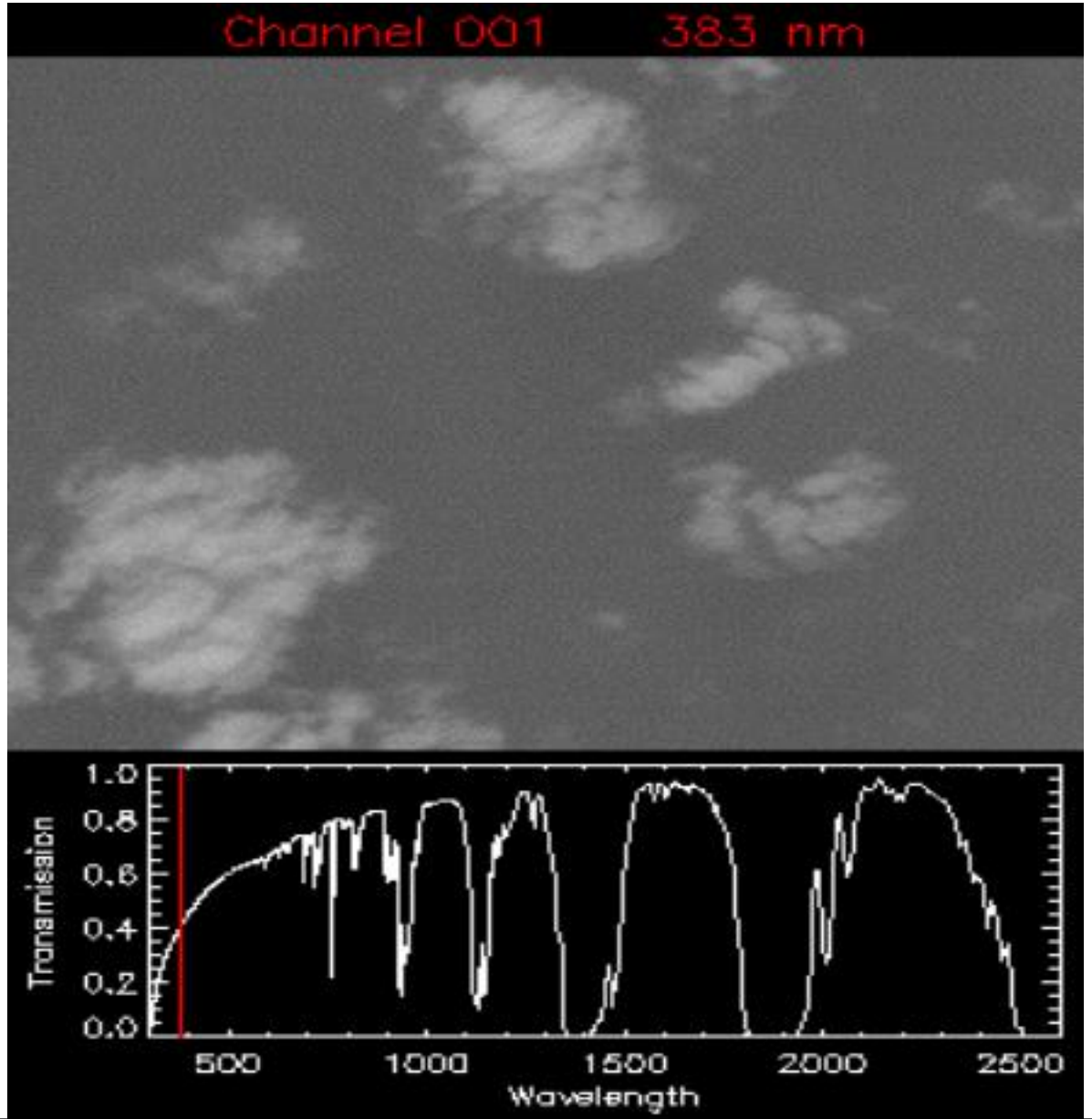
Spectral Resolution

Each target has its specific properties in spectrum. We can identify different targets on the Earth from the spectrum.

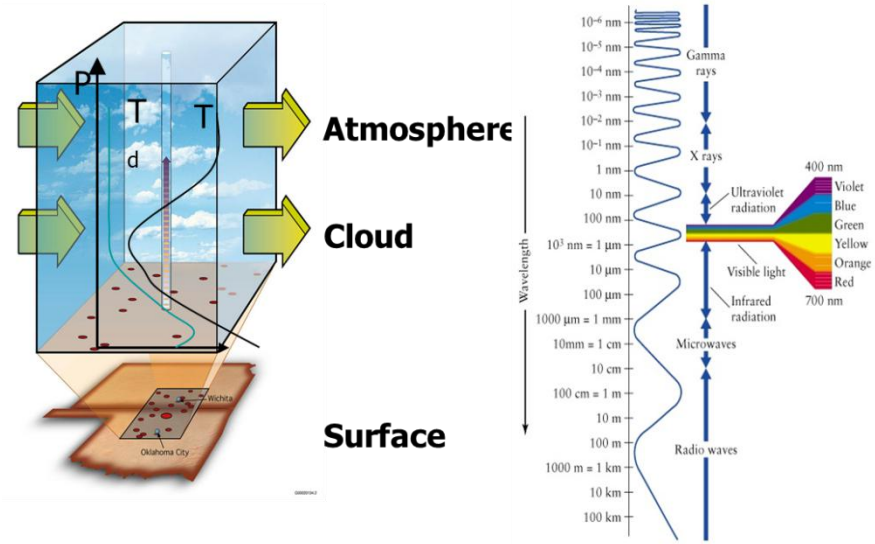
Each channel has its specific wavelength range and in the certain spectral band. the same target has different features in different channel, from this, we can discern a target, like cloud, snow, fog and dust storm. The more narrow the wavelength is the more accurate spectrum features we can get from the target.

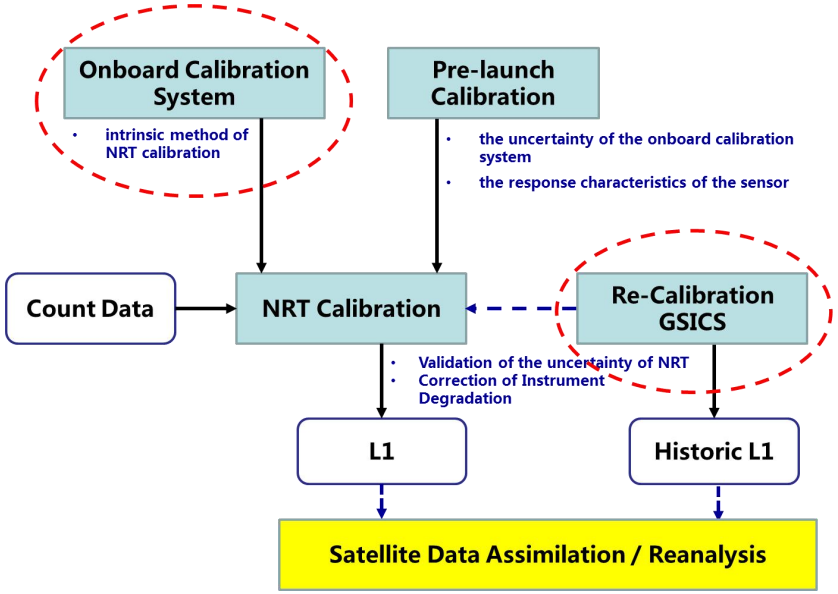


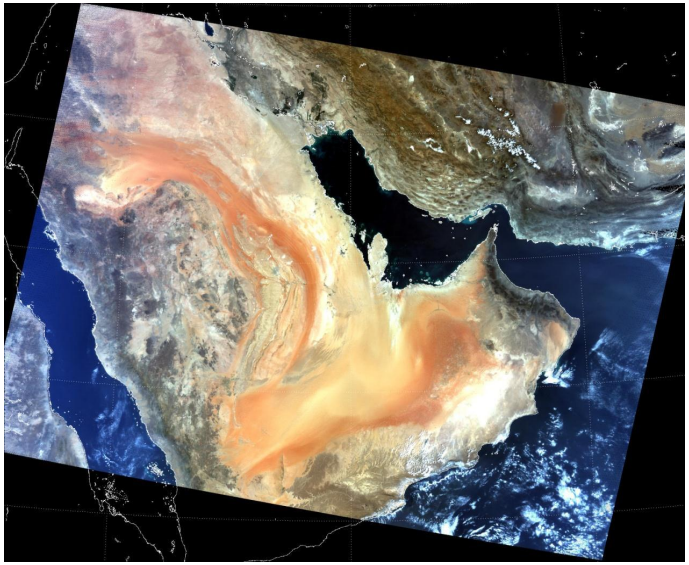
High Spectral Resolution



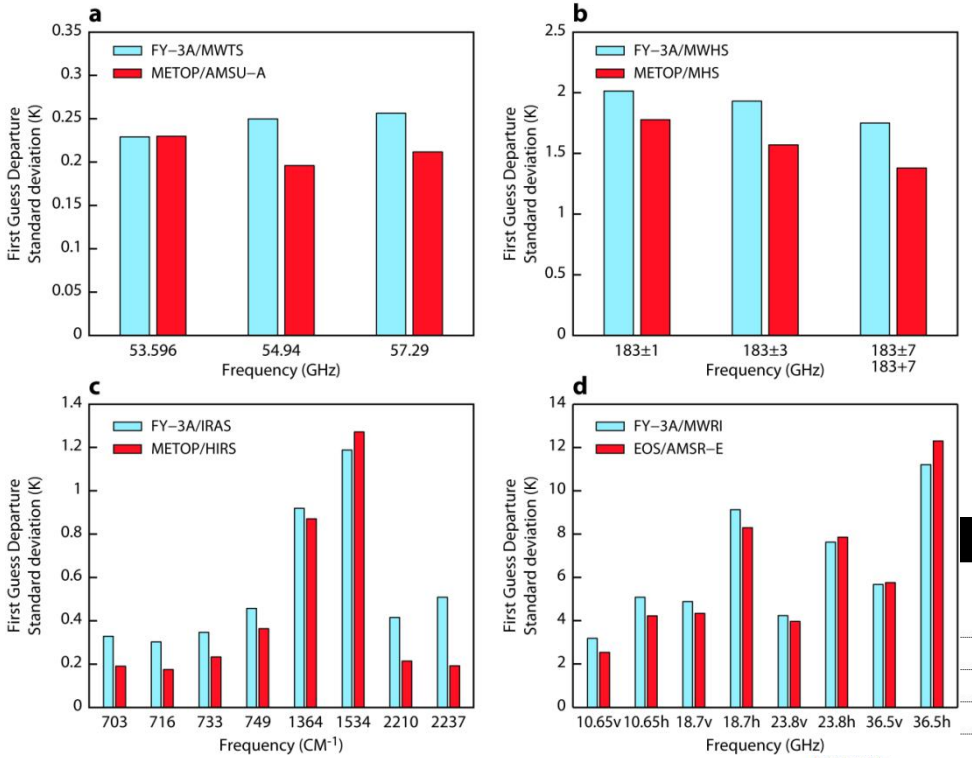
High Radiometric Resolution







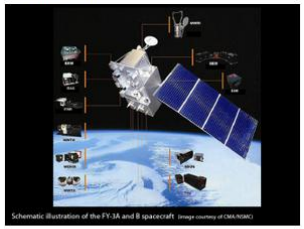
Data Quality with NWP



Suppliers
Contact us

ECMWF starts using Chinese satellite data

29 September 2014



On 24 September 2014, ECMWF actively used Chinese satellite data for the first time in the operational forecasting system. This marks a milestone in ECMWF's fruitful cooperation with the Chinese Meteorological Administration (CMA) and the Chinese Institute of Atmospheric Physics (IAP) in the area of characterisation and use of Chinese satellite data. China is expected to play a leading role in providing meteorological satellite data in the near future, alongside Europe and the US, currently the main providers of satellite sounding data used operationally. Activating the first Chinese satellite data in the ECMWF system is therefore an important step towards a much greater use of Chinese satellite data in the future.

The new data originates from the Microwave Humidity Sounder (MWHS) on-board the Fengyun-3B (FY-3B) satellite. It contributes to an improved analysis of mid- to upper-tropospheric humidity, and adds robustness to the satellite observing system. Although FY-3B is an experimental satellite, the data has been found to be of sufficient quality to further improve ECMWF's atmospheric analysis. Keyi Chen, visiting scientist from IAP, explains: "Our work has shown the data is of reliable quality, and it has an impact comparable to similar European or US satellite instruments that have been used operationally for a long time."

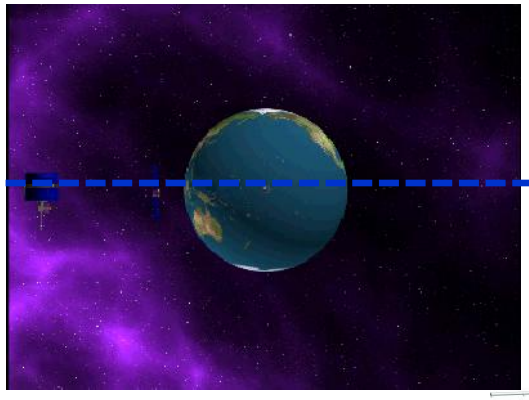
The development is the result of a very constructive partnership with CMA and IAP to characterise Chinese satellite data. During regular visits to ECMWF, Qifeng Lu from CMA has significantly advanced our understanding of the performance of the instruments on the experimental FY-3A and B satellites. This work continues with the analysis of data from the latest Chinese satellite, FY-3C, performed together with CMA, ECMWF, and the UK Met Office. FY-3C is China's first operational meteorological polar-orbiting satellite, and it carries much improved instruments compared to the earlier FY-3A and B satellites. It was launched in September last year and Qifeng Lu is currently visiting ECMWF again. He notes: "The cooperation between CMA, ECMWF and the Met Office is very important to help us evaluate the data and improve its performance. This is also of benefit to the wider community. We very much hope that more Chinese data will be actively assimilated at ECMWF and elsewhere in the future."

2. Current FY Status and future programs

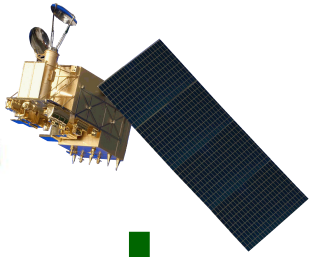
Overview of Chinese FENGYUN Meteorological Satellites

Polar System

First Generation
FY-1 A, B, C, D

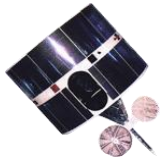


Second Generation
FY-3 A, B, C, D

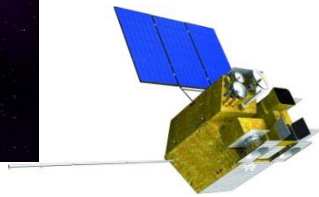


FY-3E,F, G planned until 2025

Geostationary System



First Generation
FY-2 A, B, C, D,
E, F, G, H



Second Generation
FY-4 A

FY-4B,C,D planned until 2025

Launched Satellites

Since Jan. 1969, China began to develop his own meteorological Satellite				
Leo	Launch Data		Geo	Launch Data
FY-1A	Sept. 7, 1988		FY-2A	Jun. 10, 1997
FY-1B	Sept. 3, 1990		FY-2B	Jun. 25, 2000
FY-1C	May 10, 1999		FY-2C	Oct. 18, 2004
FY-1D	May 15, 2002		FY-2D	Dec. 8, 2006
FY-3A	May 27, 2008		FY-2E	Dec. 23, 2008
FY-3B	Nov 5, 2010		FY-2F	Jan. 13, 2012
FY-3C	Sept 23, 2013		FY-2G	Dec. 31, 2014
FY-3D	Nov 15, 2017		FY-4A	Dec. 11, 2016
			FY-2H	June 5, 2018

Overall Development Strategy (4 stages):

1) 1970 - 1990: Conducting satellite research and development

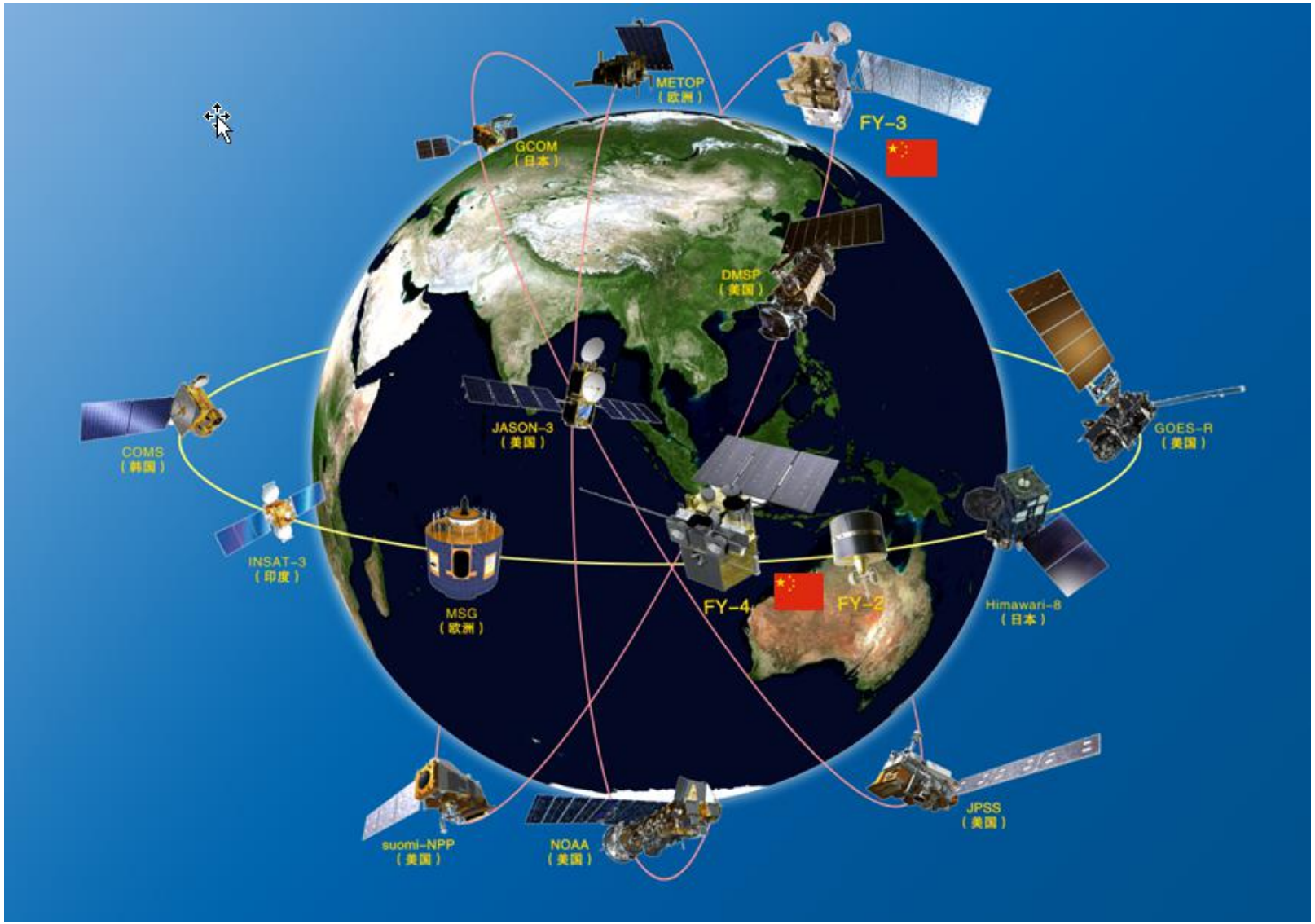
2) 1990 - 2000: Implementing transition from R&D to operational

3) 2000 - 2010: Implementing transition from 1st generation to 2nd generation

4) 2010 - 2020: Pursuing accuracy and precision of satellite measurements

Important Component of WMO Space Program

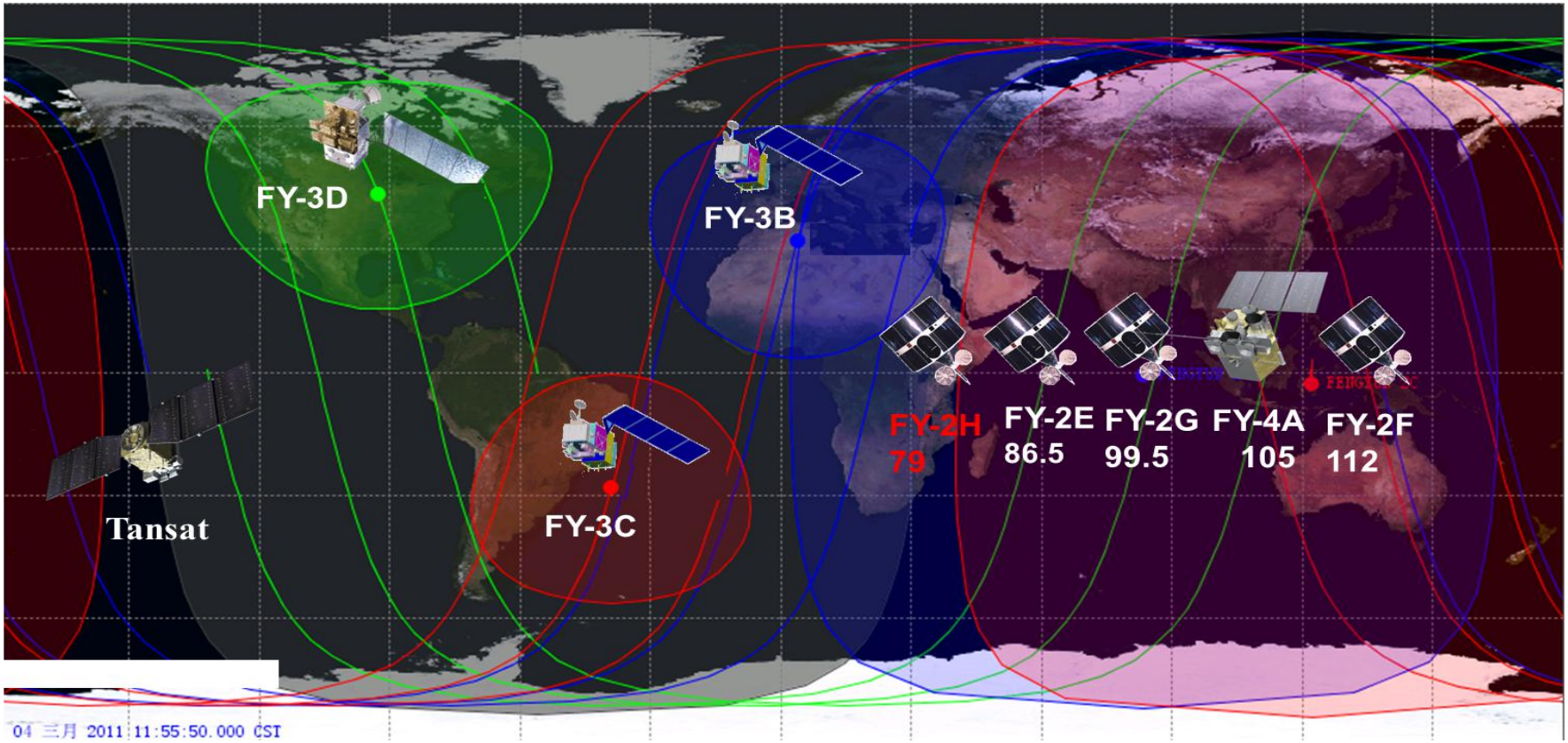
- reliable and sustained observation in operation
- open data policy to free access



On Orbit Satellite

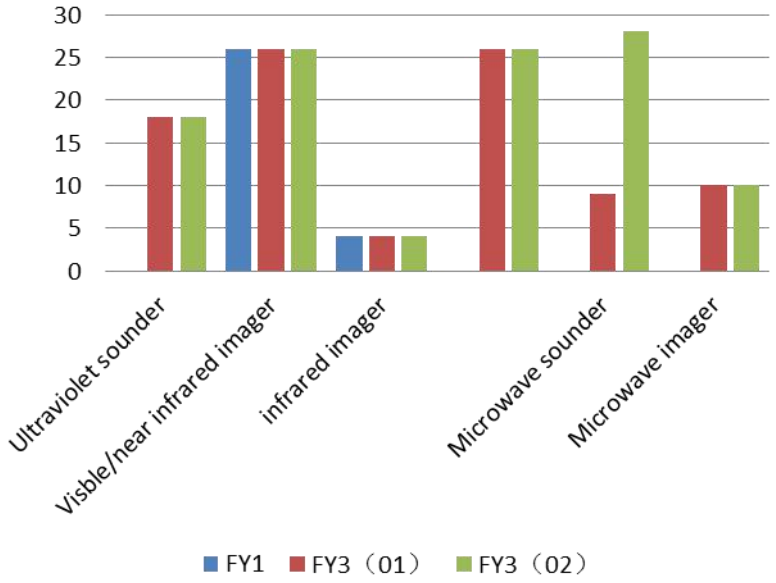
FY Program: 8 on the orbit, 7 in operation, 1 in on-orbit test

Joint program: TanSat ,GF-4



Current Instruments for EO

Satellite		No. of Instruments	Name in Abbrev.
FY-1	FY-1 A/B	2	5-channel VIRR
	FY-1 C/D	2	10-channel VIRR
FY-2	FY-2 A/B	1	3-channel VISSR
	FY-2 C/D/E	1	5-channel VISSR
FY-3	FY-3 A/B	10	10-channel VIRR
			MERSI
			IRAS
			MWTS
			MWHS
			MWRI
			SBUS
			TOU
			ERM
			SIM
	FY-3C	11	GNOSS
	FY-3D	10	HIRAS
			GAS
FY-4	FY-4A	3	AGRI
			GIIRS
			LMI



Optical Imager

Atmospheric Sounder

Microwave Imager

Atmospheric Composition Detector

Radiation Budget Monitor

Future CMA satellite programs by year 2025

LEO

- FY-3E(operational) Early Morning
- FY-3F/G (operational)
- FY-3 RM, Rainfall Measurement

GEO

- FY-4B/C (operational), with improvements on FY-4A!
- FY-4 MW (R&D), GEO microwave

Others

- GF-5 (R&D) Atmospheric Composition
- GF-follow on (op,) Atmospheric Environment

Fengyun GEO Constellation

4 in operation

FY-2E: Full Disk (86.5° E)

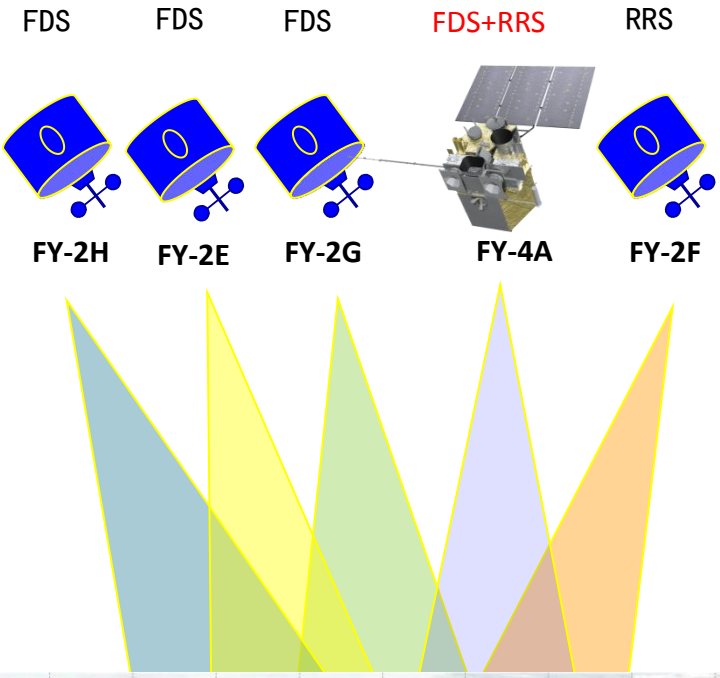
FY-2G: Full Disk (99.5° E)

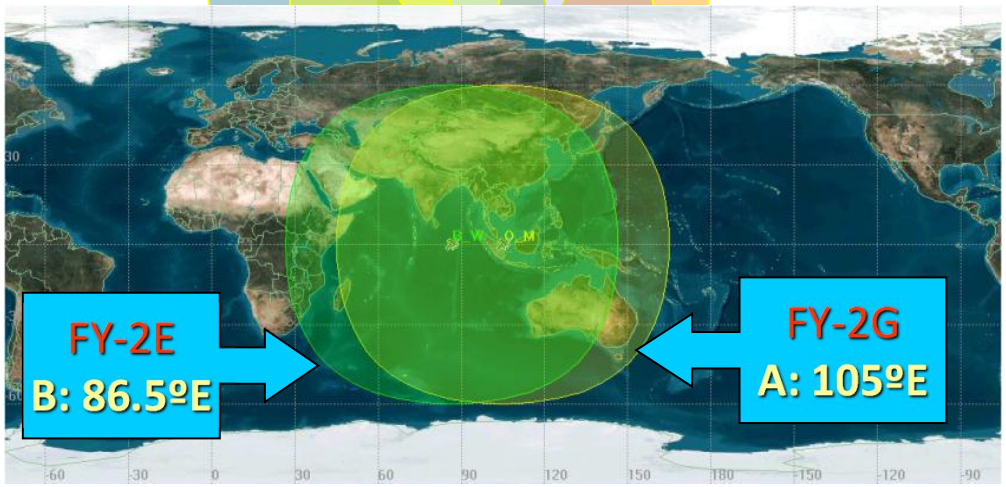
FY-4A: Full Disk + Regional Rapid (105° E)

FY-2F: Regional (112° E)

1 in orbit test

FY-2H (79° E)



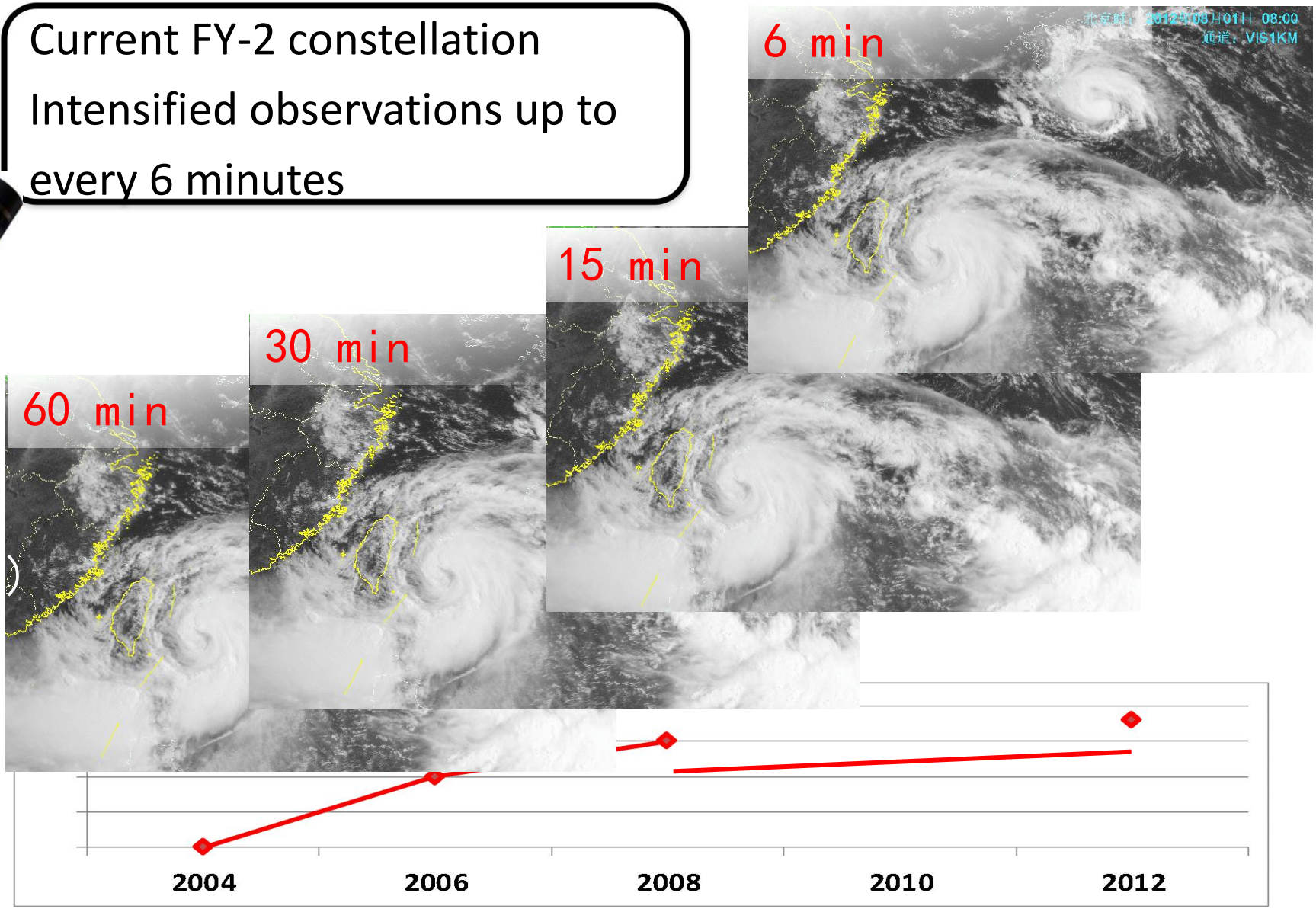


FY-2F/G/H

S-VISSR --- 5 channel visible and infrared spin scan radiometer		
VIS	0.50-0.75 μm	Changed! FY-C/D/E 0.50-0.9 μm
IR	6.3-7.6 μm	
WV	0.62-0.76 μm	
IR(Split windows)	10.3-11.3 μm、11.5-12.5 μm	
Space Environment Monitoring – solar particle in immediate vicinity of satellite		
SEM	Space Environment Monitor	
DCPS – data collection service for 4,000 platforms at present capability		
Domestic	401.1-401.4 MHz	
International	402.0-402.1 MHz	

Current FY-2 constellation

Intensified observations up to every 6 minutes

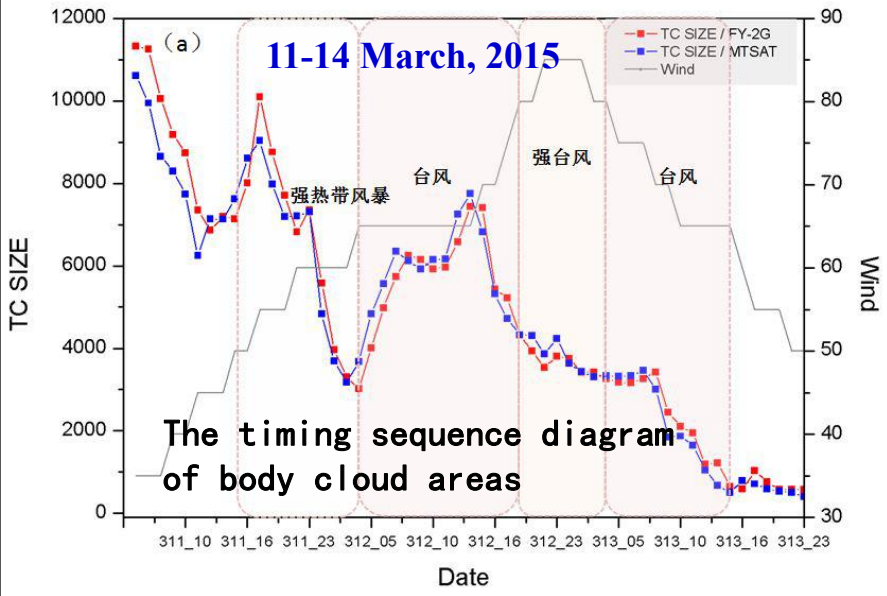


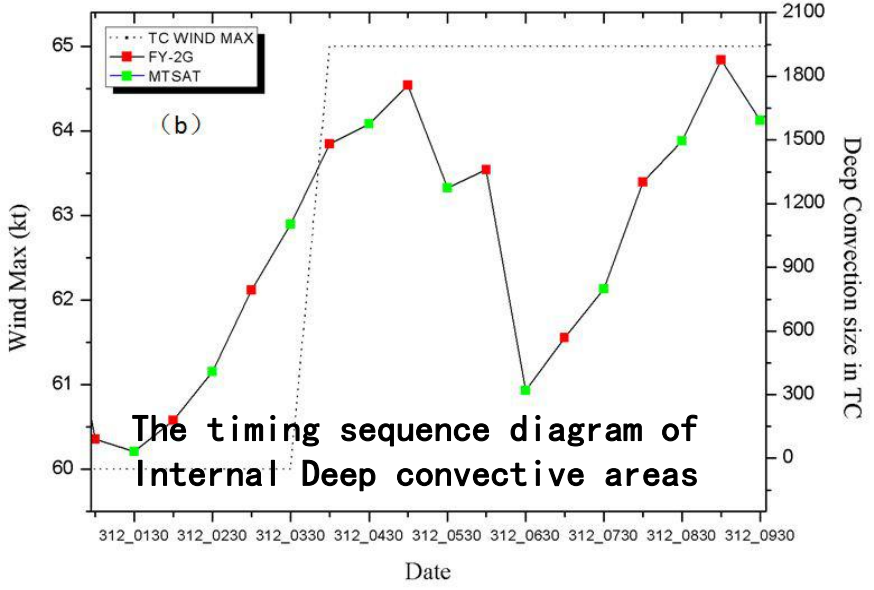
FY-2 Operational Products

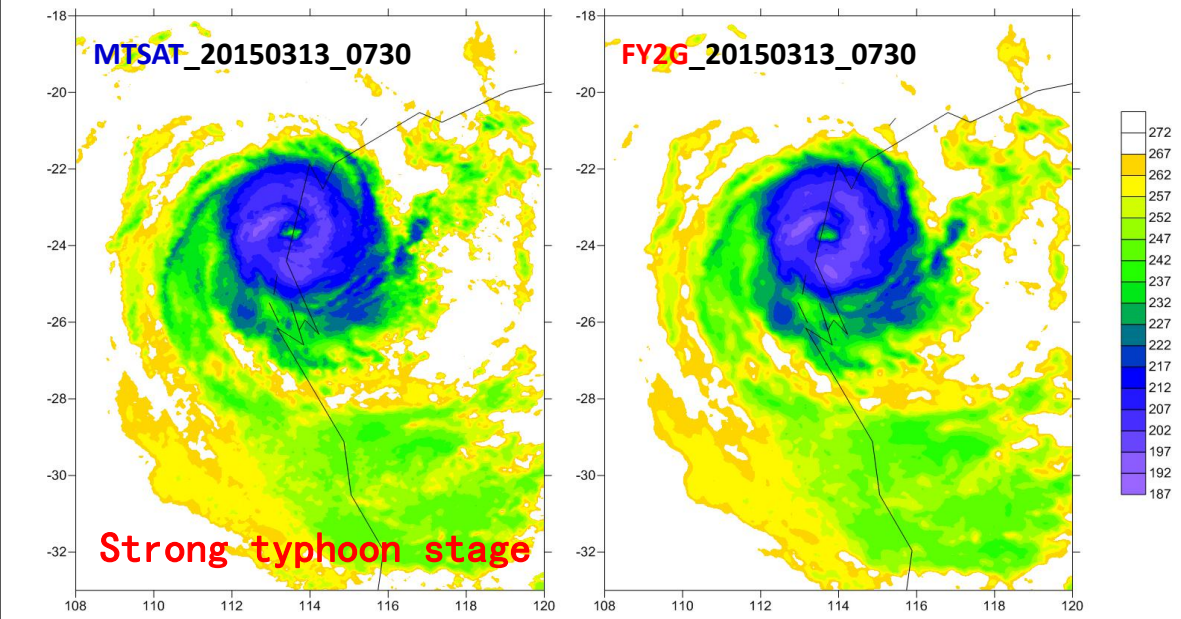
No.	Products	No.	Products	No.	Products
1	Raw image	10	OLR	19	ISCCP dataset
2	Normalized image	11	SST	20	Heavy fog monitor
3	Projected image	12	TBB	21	Sea ice monitor
4	Mosaic image	13	Upper troposphere humidity	22	Fire spots
5	Cloud classification	14	Cloud water profile	23	Water bodies
6	Total cloud amount	15	Precipitable water	24	Soil humidity
7	AMV	16	Solar irradiance		
8	Rainfall estimation	17	Sand storm detection		
9	Precipitation index	18	Snow cover		

4 image products, 16 weather products and 5 environmental products

Typical application: Quantitative Analysis （strong Typhoon Olwyn）





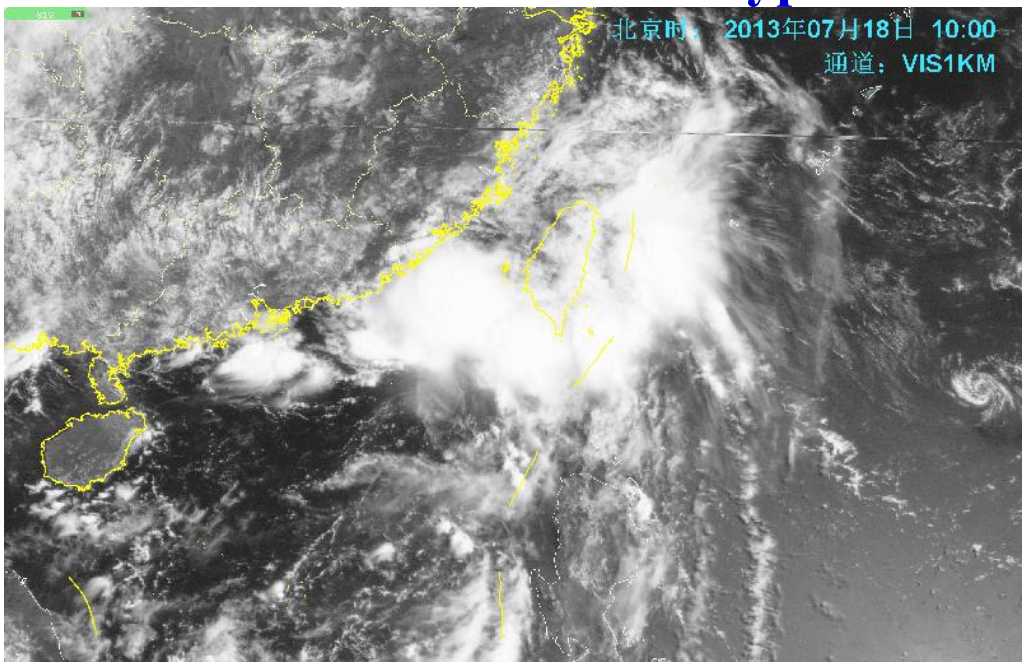


Important results:

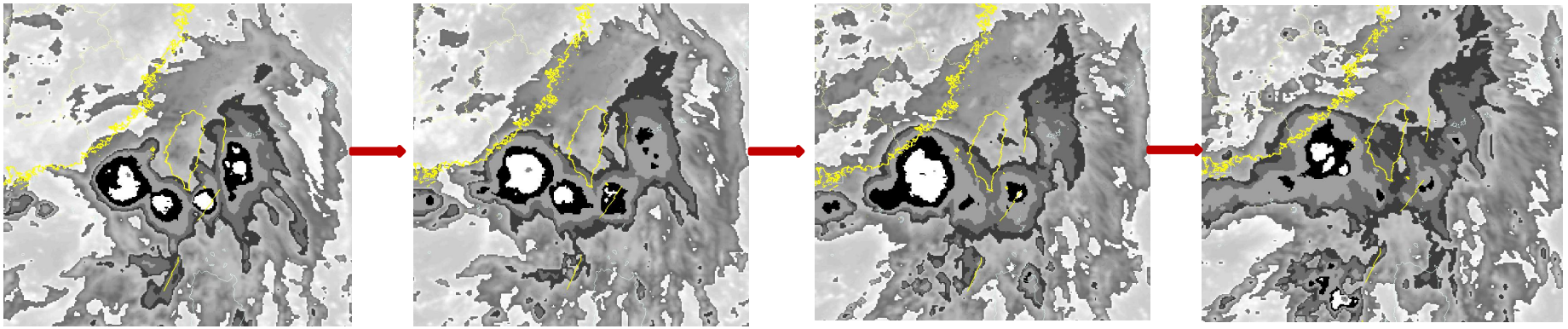
■ The performance of radiation measurement between FY-2G and MTSAT-2 is similar. They can be alternatively used;

■ The deviation average brightness temperature between FY-2G and MTSAT-2 less than -1.0K@200K。

FY-2 regional-scan observation: monitoring the development of meso- or micro- cloud clusters in inner typhoon

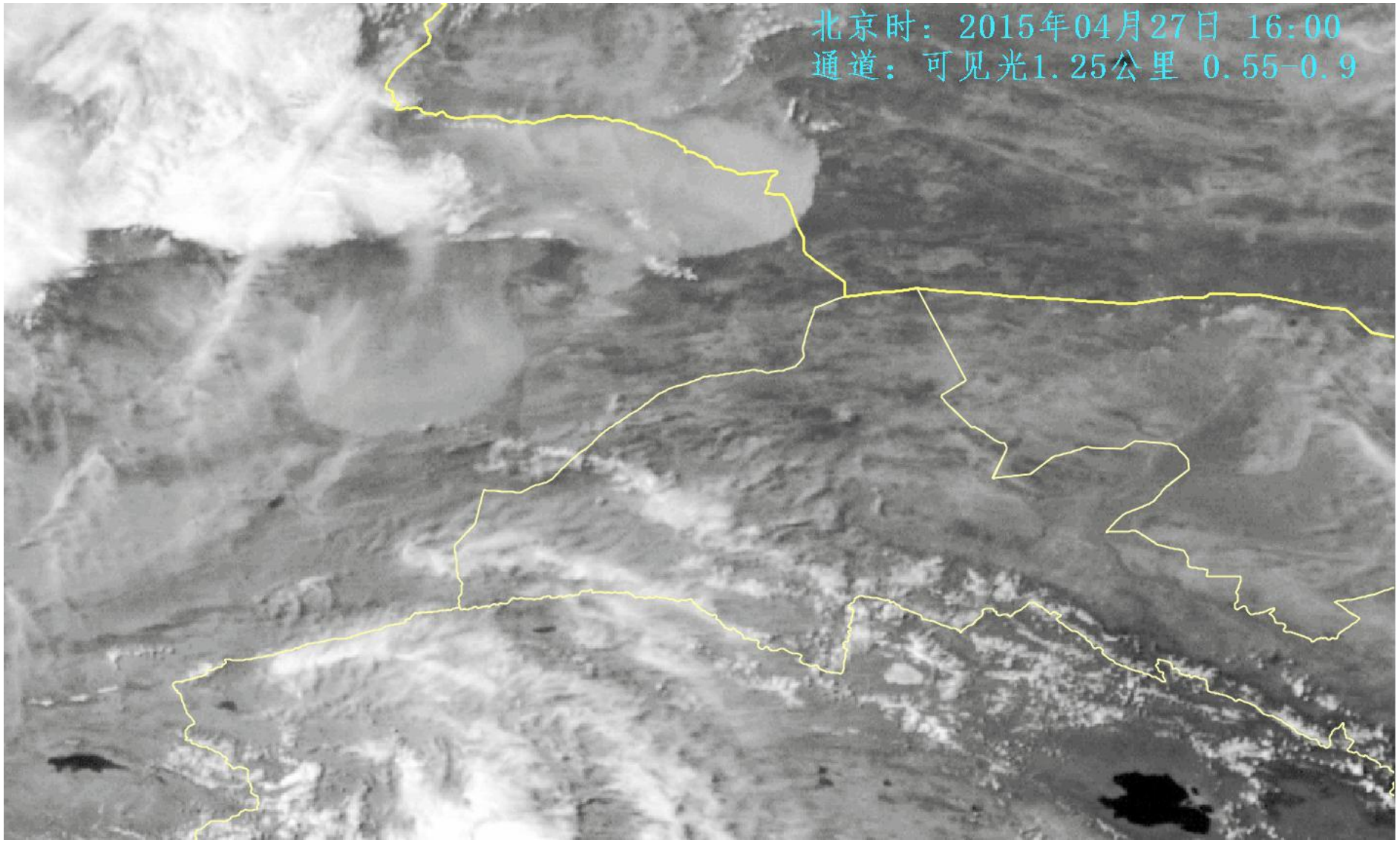


Base on the FY-2 regional-scan observation per 6min., using the method of tracing cloud cluster, the evolution of the internal typhoon cloud can be monitored quantitatively.



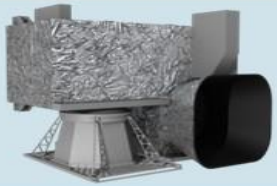
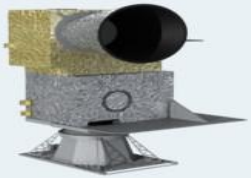
Dust storm monitoring using FY-2G data (3 minutes interval)

2015/4/27 16:00-17:57 FY2G



FY-4A

---- Post launch test has been finished and is providing operational service since May 8, 2018

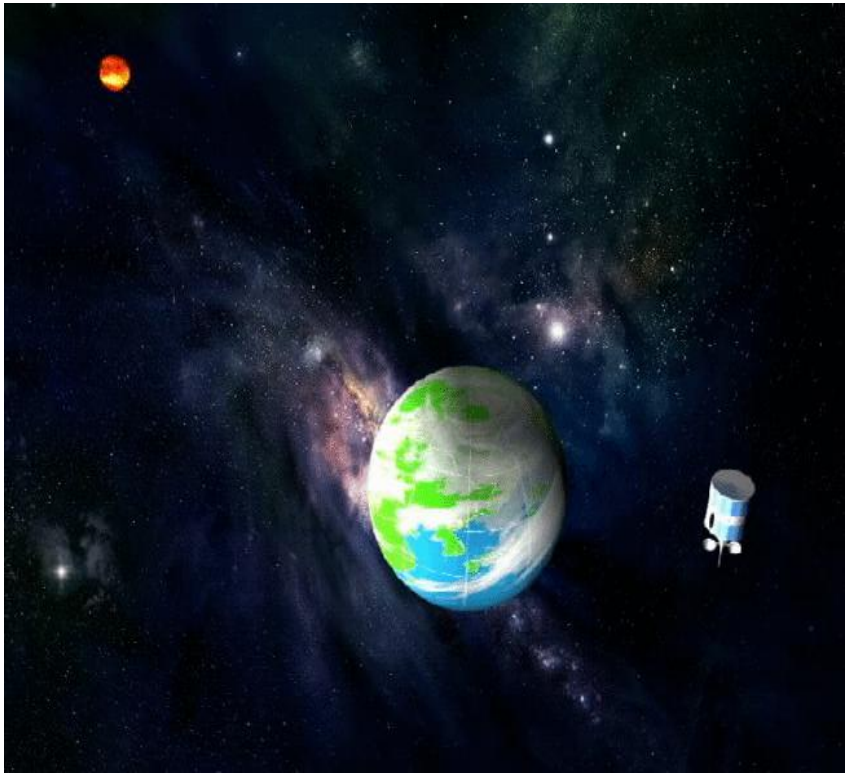
Instrument		Purposes
	***AGRI: Advanced Geosynchronous Radiation Imager***	14 -channel Earth images
	***GIIRS : Geostationary Interferometric InfraRed Sounder***	Clear-sky atmospheric temperature and humidity profiles
	***LMI : Lightning Mapping Imager***	Lightning distribution map in China area
	***SEP: Space Environment Package***	Space electric and magnetic environment information

For the first time, imager, sounder and lightning mapper instruments are carried on the same geostationary platform.

Advancement of FY-4A compared with FY-2

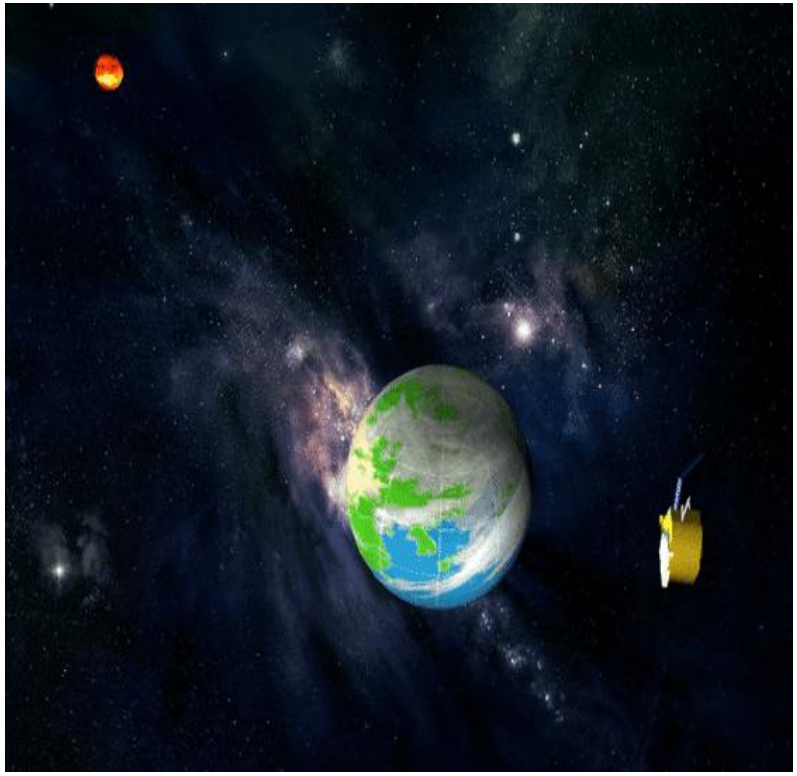
	FY-4A	FY-2
Stabilization	**Three-axis**	**Spin**
Designed Life	**5~7 Years**	**4 Years**
Observation Efficiency	**85%**	**5%**
Observation Mode	**Imaging +Sounding + Lightning Mapping**	**Imaging Only**
Main Instruments	**AGRI :14 channels** SSP Resolution：0.5~4Km Global imaging：15min Flexible imaging ： 2D	**VISSR: 5 channels** SSP Resolution：1.25~5Km Global imaging：30min Flexible imaging ： 1D
	GIIRS:1635 channels Spectral Resolution: 0.8,1.6cm-1 SSP Resolution:16Km	**N/A**
	LMI SSP Resolution:7.8Km	**N/A**
	SEMS High energy particles Magnetic field	**SEM** High energy particles Solar X ray fluxes

Three-axis Stabilization Platform



FY-2

- Spin stable, high stability
- Low observation efficiency 5%
- Atmospheric vertical detection and lightning detection cannot be achieved



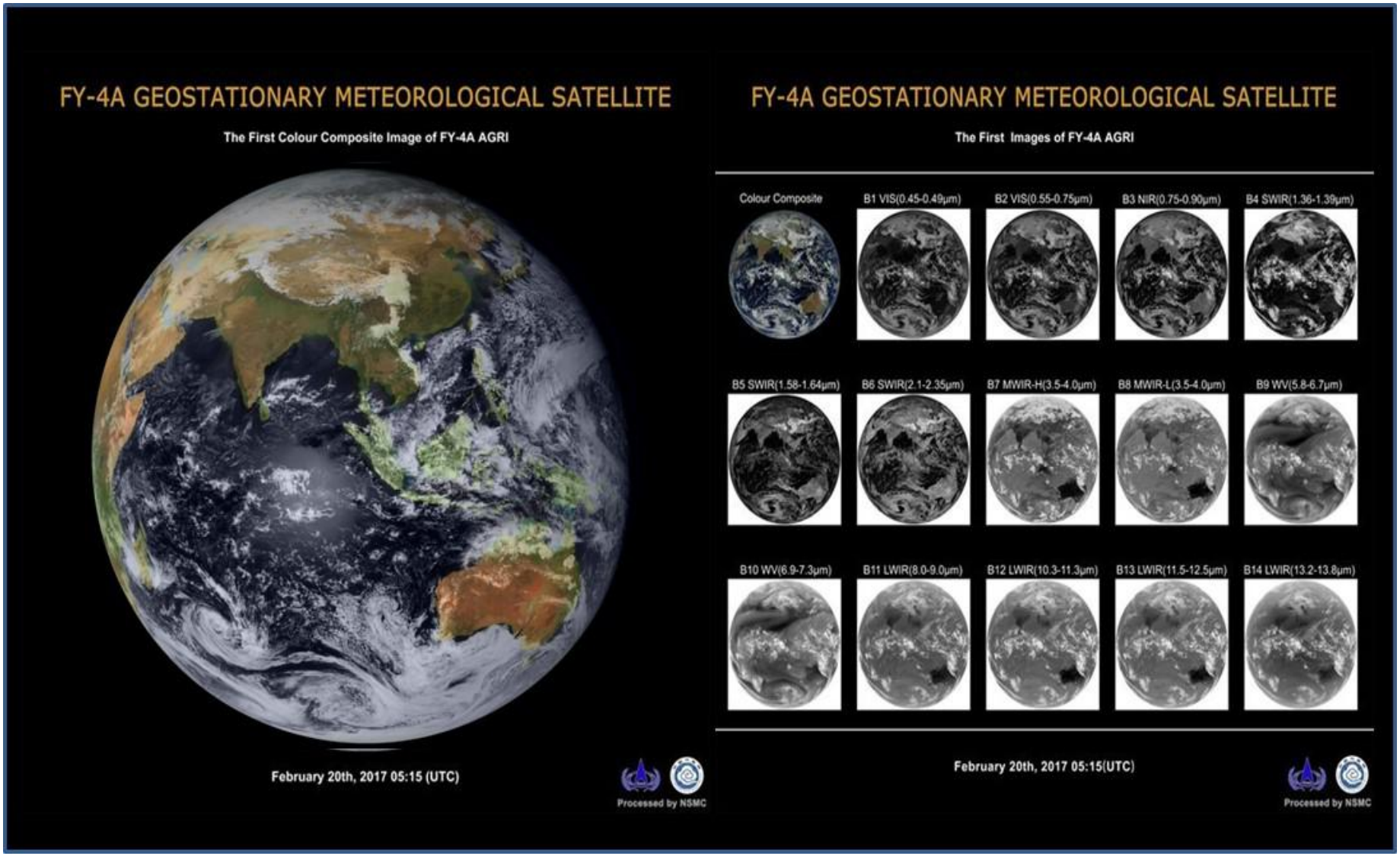
FY-4

- Three-axis stability, active attitude control, low stability
- High observation efficiency, can always face the earth
- Atmospheric vertical detection and lightning detection
- Technical implementation is difficult: pointing accuracy, stability

FengYun-4 Technical Properties

Detect ability		FY-4A (China)	GOES-16/17 (USA)	Himawari-8/9 (Japan)
Imager	Spatial resolution	Visible/Near Infrared: 0.5-1Km Infrared： 2-4Km	Visible/Near Infrared: 0.5-1Km Infrared： 2Km	Visible/Near Infrared: 0.5-1Km Infrared： 2Km
	Temporal resolution	15m（Later 10m）	5m	10m
	Band Amount	14（Later 16）	16	16
	Precision	**0.2K（Actual <0.1K）**	0.1K	0.1K
Sounder	Spectral Range	Long wave：8.85-14.29μm Middle wave：4.44-6.06μm		
	Band Amount	1650		
	Spectral resolution	0.625cm-1		
	Spatial resolution	16Km		
lightning mapping imager	Center wavelenght\	777.4nm	777.4nm	
	Temporal resolution	2ms	2ms	
	Spatial resolution	7.8km	7.8km	
Space	target	Particle/magnetic field /X ray	Particle/magnetic field /Imaging of the sun	

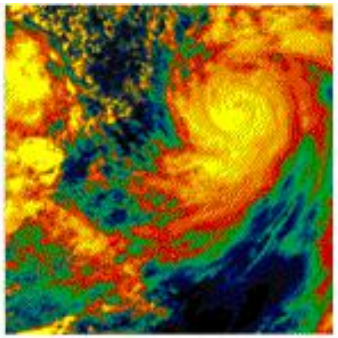
AGRI: Advance Geo. Radiation Imager



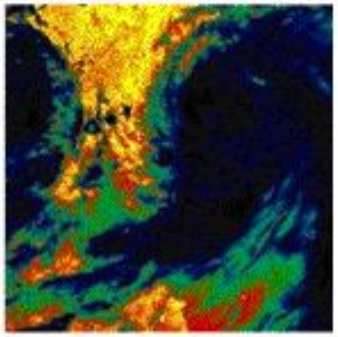
Chinese FengYun Geo. imaging capability

	FY-2 F/G/H VISSR			FY-4A AGRI			
Channel	Band	Spatial Resolution	Sensitivity	Band	Spatial Resolution	Sensitivity	Main Application
Visible & Near-Infrared				0.45～0.49	1	S/N≥90 (ρ=100%)	Aerosol
	0.55～0.75	1.25	2.3 @ρ=1%	0.55～0.75	0.5～1	S/N≥200 (ρ=100%)	Fog, Clound
				0.75～0.90	1	S/N≥5(ρ=1%)@0.5Km	Vegetation
Short-wave Infrared				1.36～1.39	2	S/N≥200 (ρ=100%)	Cirrus
				1.58～1.64	2	S/N≥200 (ρ=100%)	Cloud,Snow
				2.1～2.35	2～4		Cirrus,Aerosol
Mid-wave Infrared				3.5～4.0(High)	2	NEΔT≤0.7K(300K)	Fire
	3.5～4.0	5	0.22K@300K	3.5～4.0(Low) *	4	NEΔT≤0.2K(300K)	Land surface
Water Vapor				5.8～6.7	4	NEΔT≤0.3K(260K)	WV
	6.3～7.6	5	0.30K@260K	6.9～7.3	4	NEΔT≤0.3K(260K)	WV
Long-wave Infrared				8.0～9.0*	4	NEΔT≤0.2K(300K)	WV,Cloud
	10.3～11.3	5	0.12K@300K	10.3～11.3*	4	NEΔT≤0.2K(300K)	SST
	11.5～12.5	5	0.16K@300K	11.5～12.5*	4	NEΔT≤0.2K(300K)	SST
				13.2～13.8*	4	NEΔT≤0.5K(300K)	Clound,WV

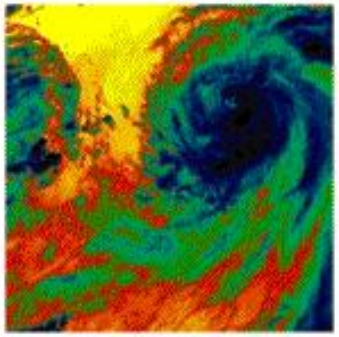
FY-2 、 FY-4 Advanced Geo.Radiation Imager



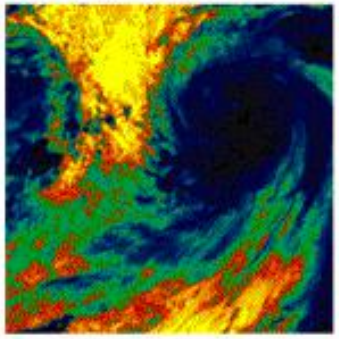
0.64um



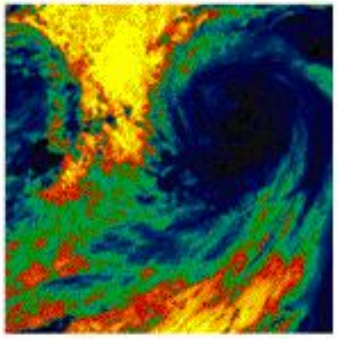
3.8um



6.3um



10.5um

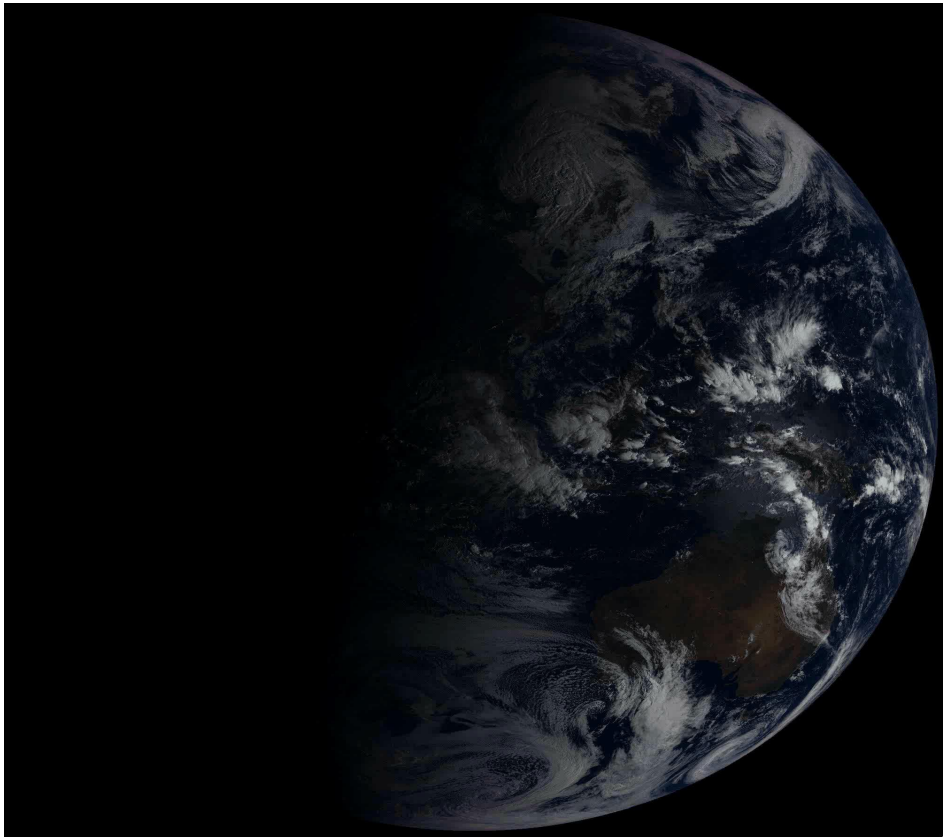


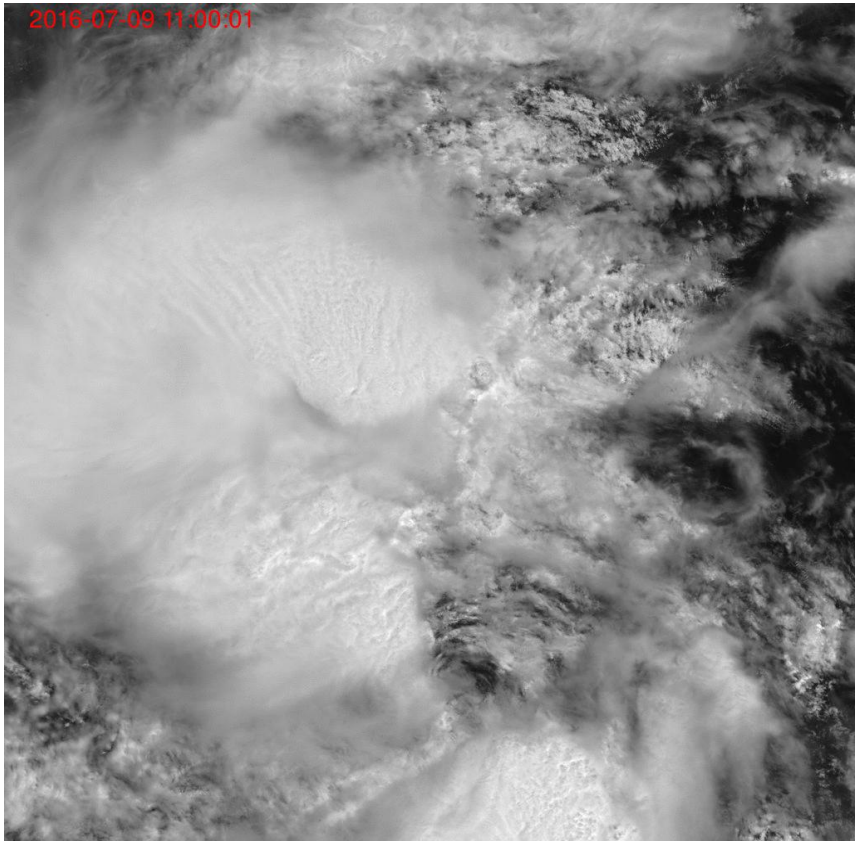
12.3um

0

1024

FY-4： 15 min. interval Full Disc Obs. + 1-5 min. Regional Rapid Scan

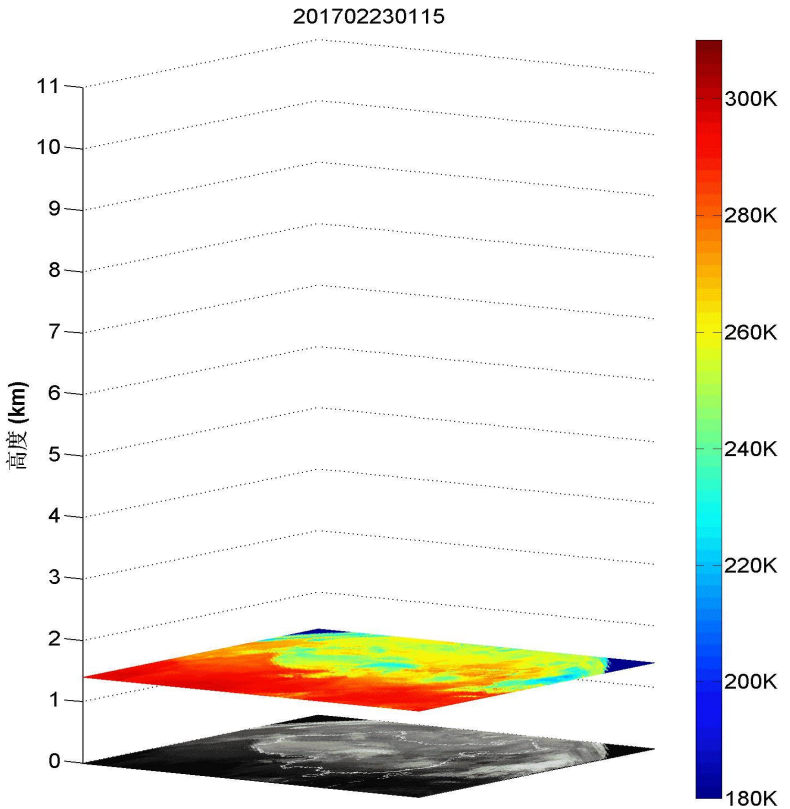




GIIRS: Geo. Interferometric Infrared Sounder

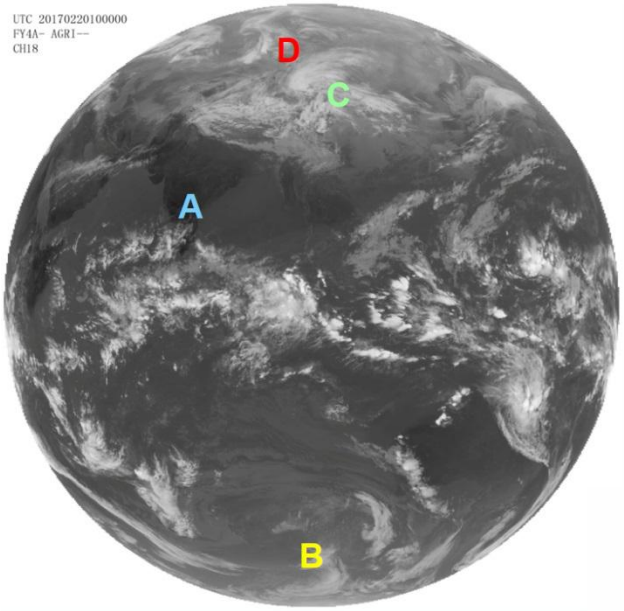
	FY-4A (designed)	FY-4A (actual)
Spectral range (cm^{-1})	700 – 1130	700 – 1130
	1650 –2250	1650 –2250
Spectral resolution (cm^{-1})	0.8	0.625
	1.6	0.625
Sensitivity@280K (K)	0.4-0.8	0.4
	0.8-1.2	0.8
Spatial resolution (Km)	16	16
Temporal resolution (min)	67(China area)	45(China area)

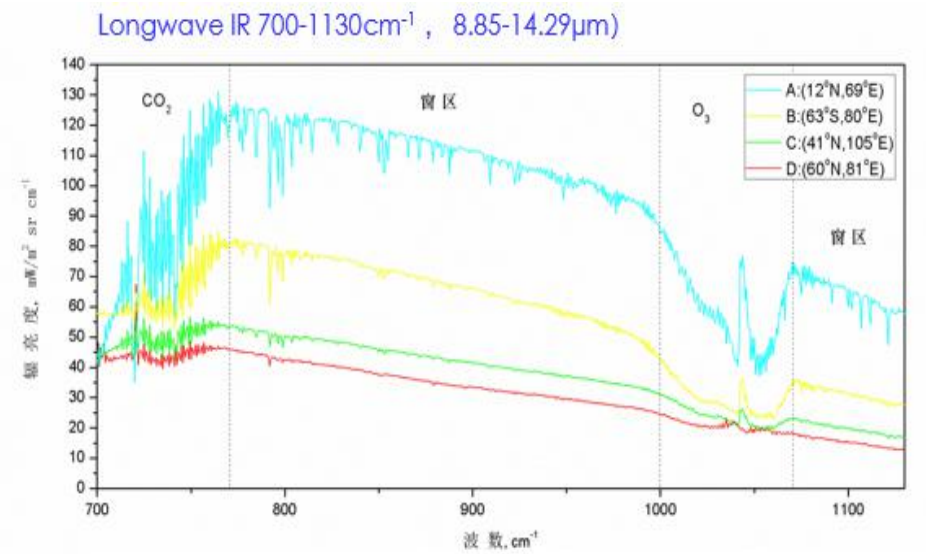
Full Disc Scan: the GIIRS is able to scan the full earth disc within about **3** hours, and a total of about 1530 views are needed. The full disc is revisited every 6 hours, and Level 1 data can be provided.

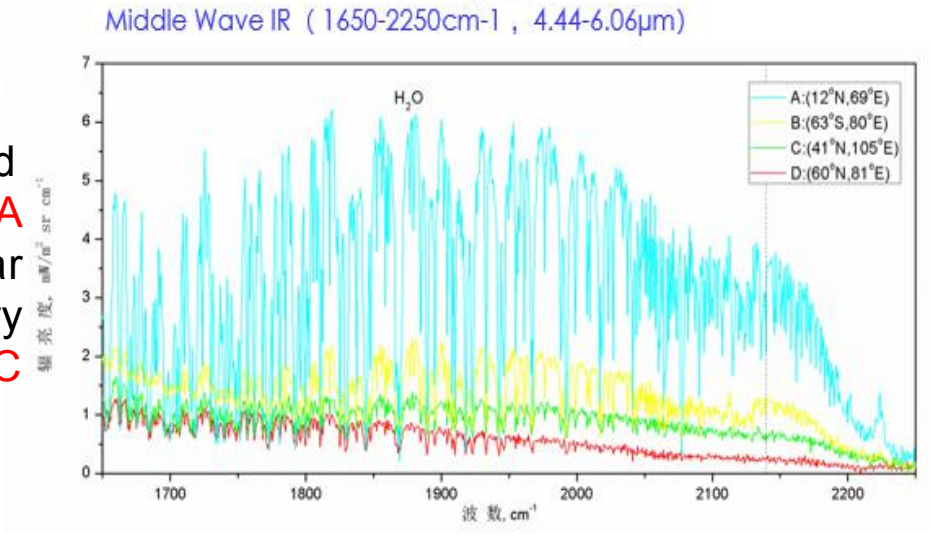


BT animation of different layers in troposphere for China area

GIIRS: Geo. Interferometric Infrared Sounder





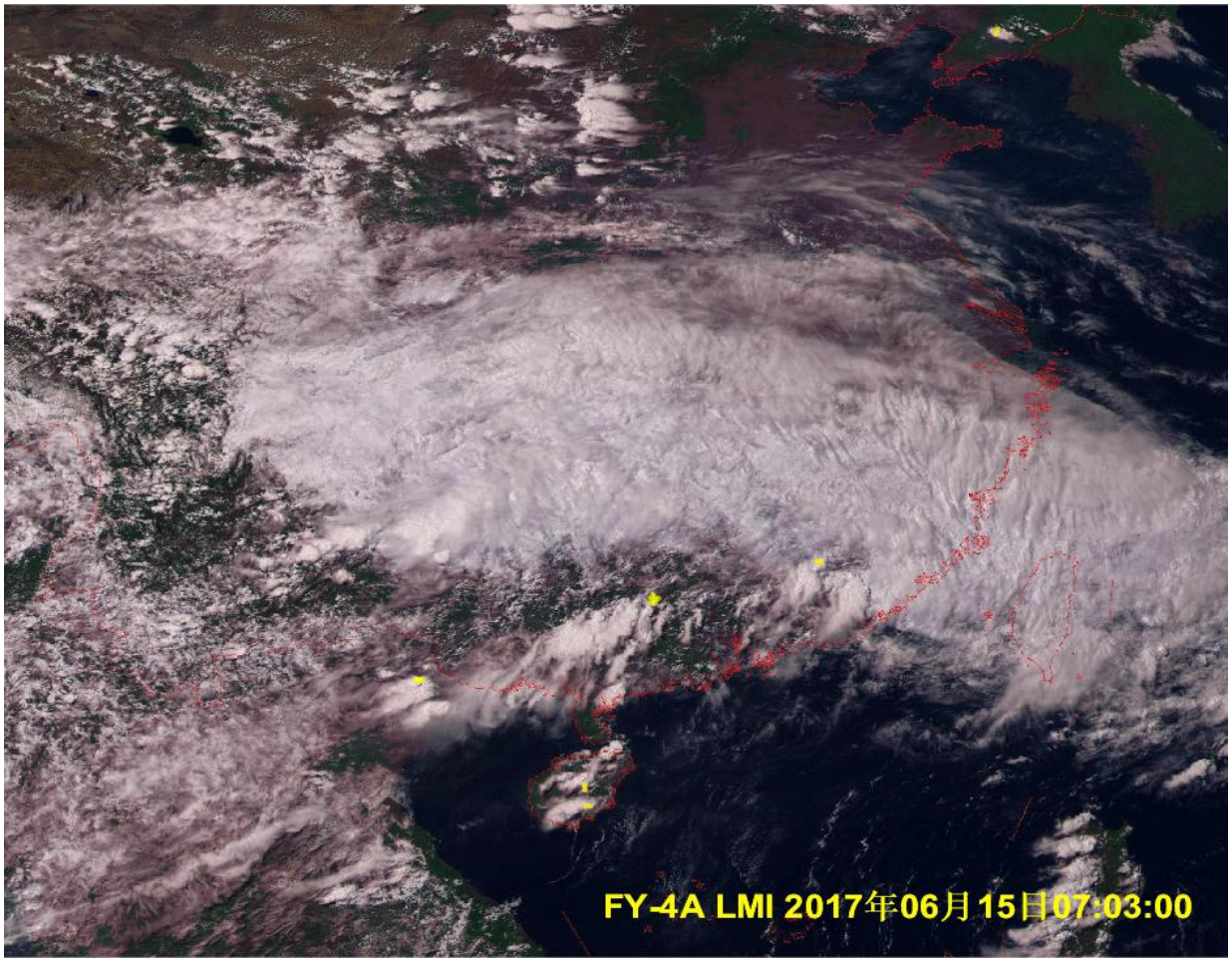


The GIIRS radiance measurements in LWIR and MWIR at four samples are shown. Sample A indicates the relatively warm and humid clear atmosphere. Sample B and D represent the dry and cold atmosphere at high latitudes. Sample C shows the typical cloudy sky.

LMI: Lightning Mapping Imager

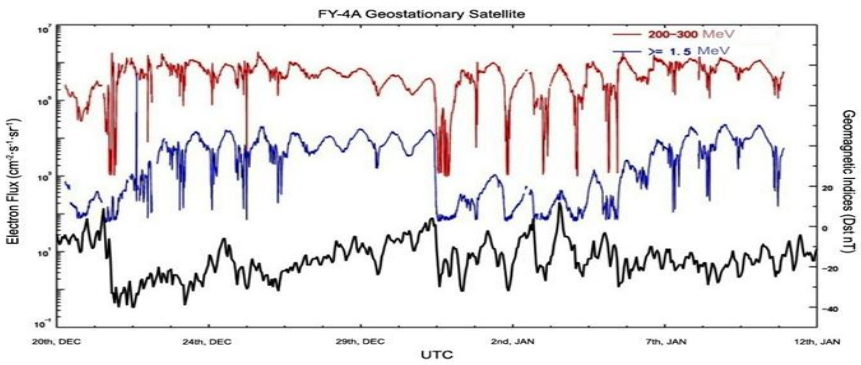
Acquire lightning distribution maps over specific region

Spatial resolution	about 7.8Km at SSP
Sensor size	400×300 ×2
Wave-length at center	777.4nm
Band-width	1nm±0.1nm
Detection efficiency	>90%
False-alarm ratio	<10%
Dynamic range	>100
SNR	>6
Frequency of frames	2ms
Quantization	12 bits
Measurement Error	10%

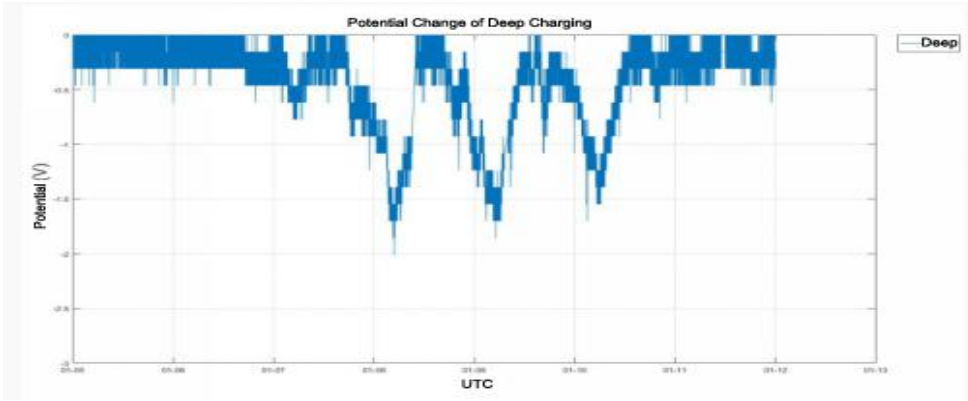


SEP: Space Environment Package

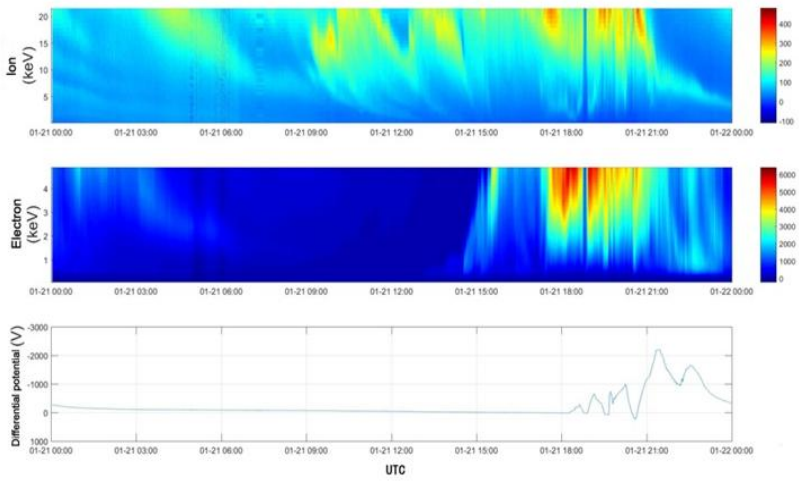
Electron Flux



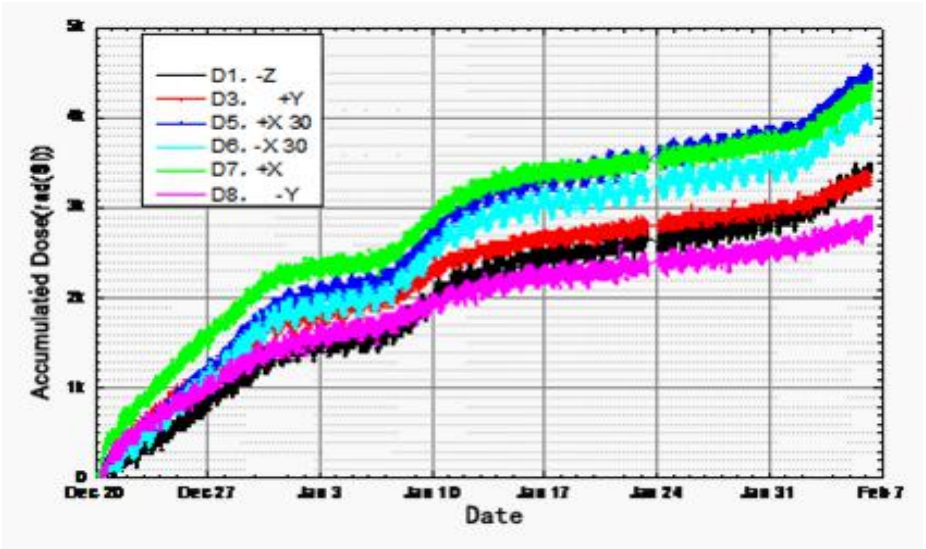
Surface Charging



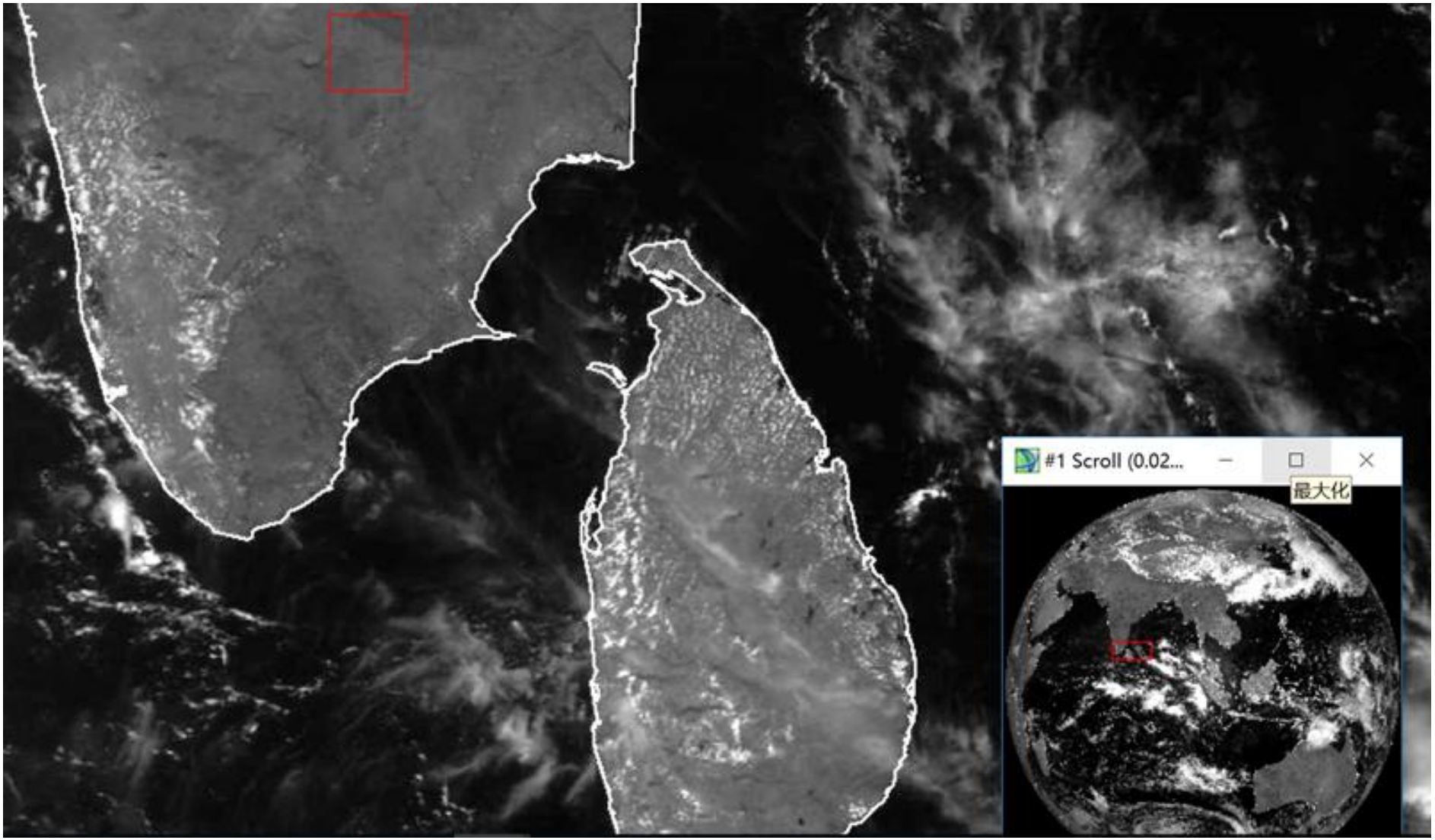
Deep Charging



Radiation Dose

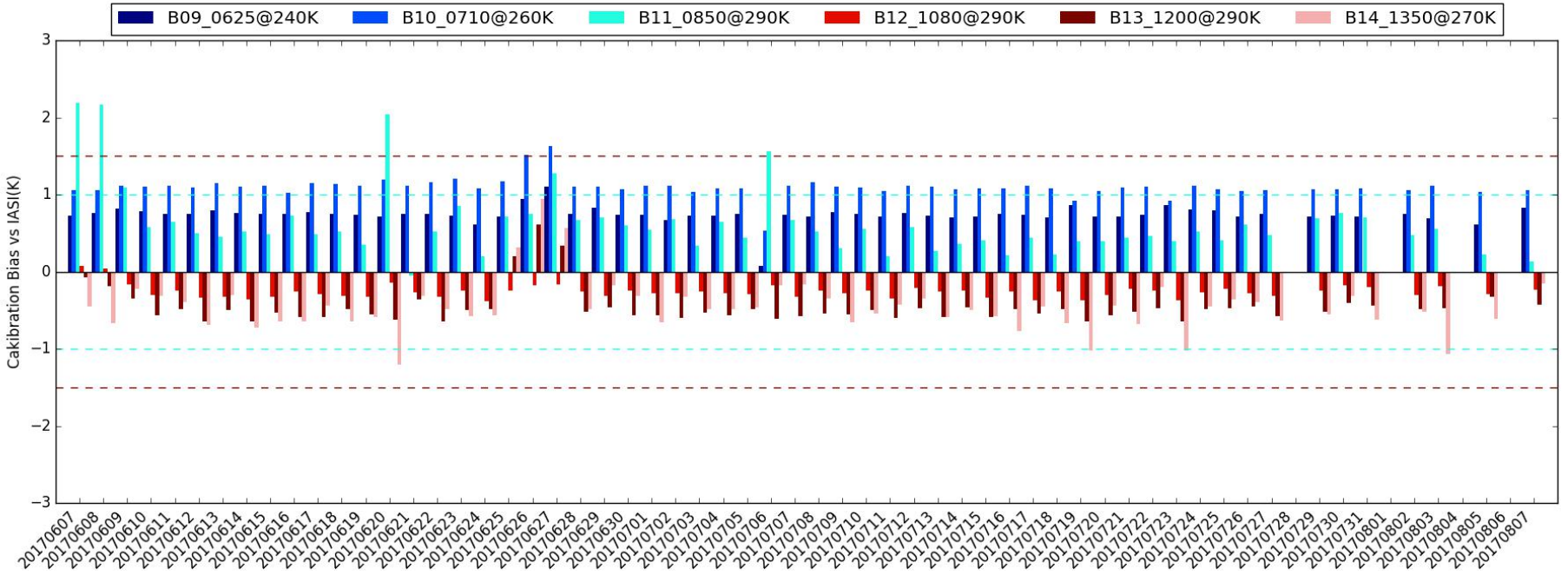


Some of IOT results: 1) accuracy of AGRI INR (<1 IR pixel)



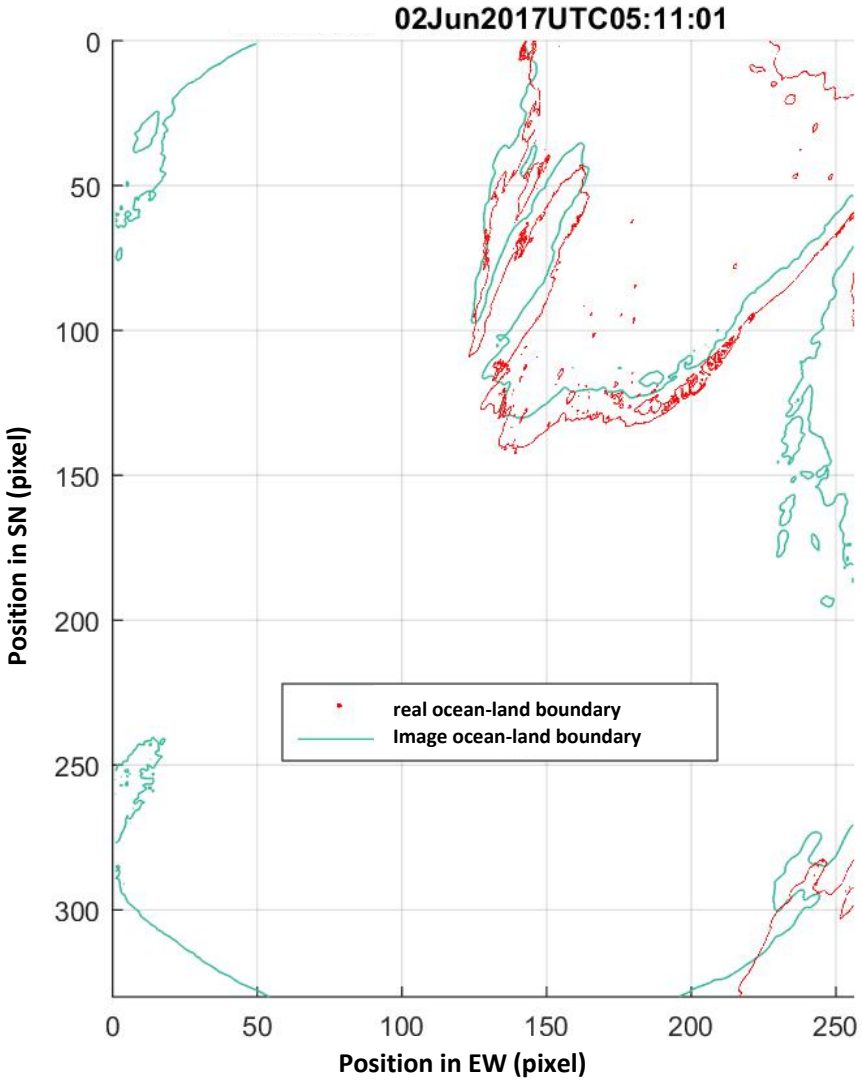
201704110500 UTC 0.75~0.90um 1km

2) CAL bias monitoring for AGRI (IR)

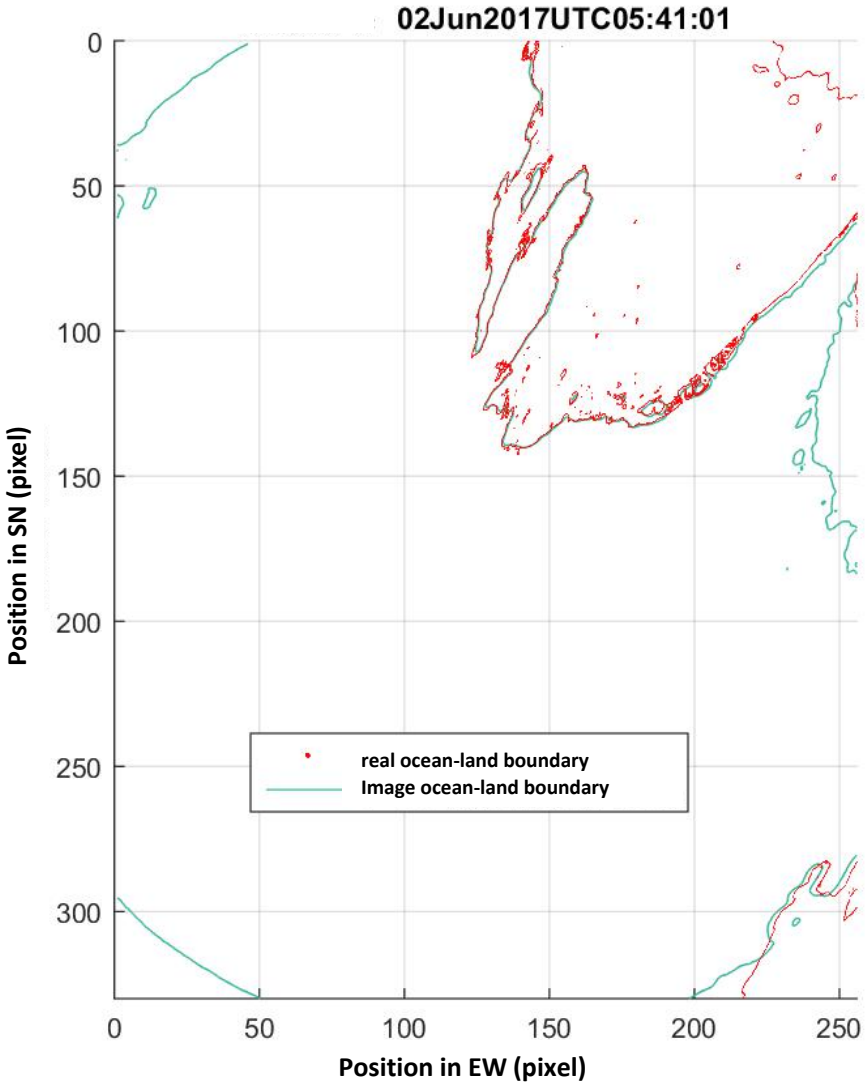


- **Full optical-path & aperture blackbody with a space-ground combined calibration method is adopted;**
- **Under the complex thermal environment of GEO orbit, the daily calibration biases for all TEBs are less than 1K;**
- **The daily calibration bias of 10.3μm band is perfect (<0.3K).**

3) Accuracy of GIIRS INR (<1 IR pixel)

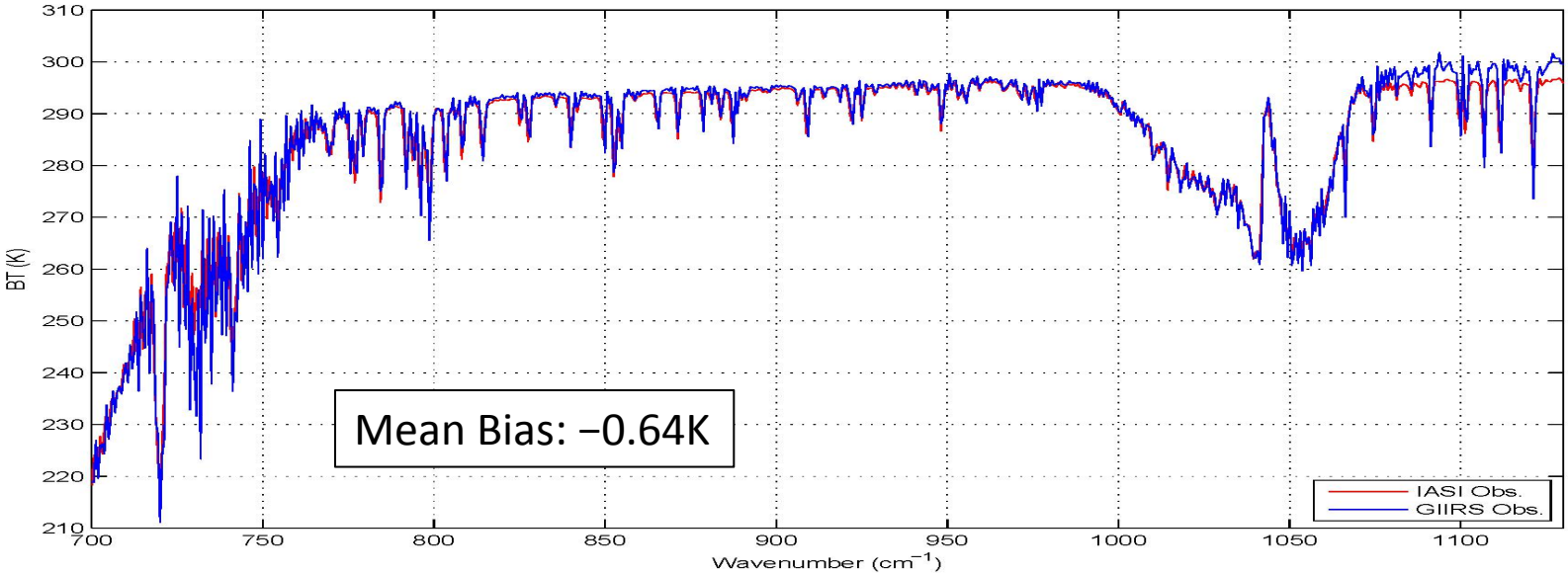


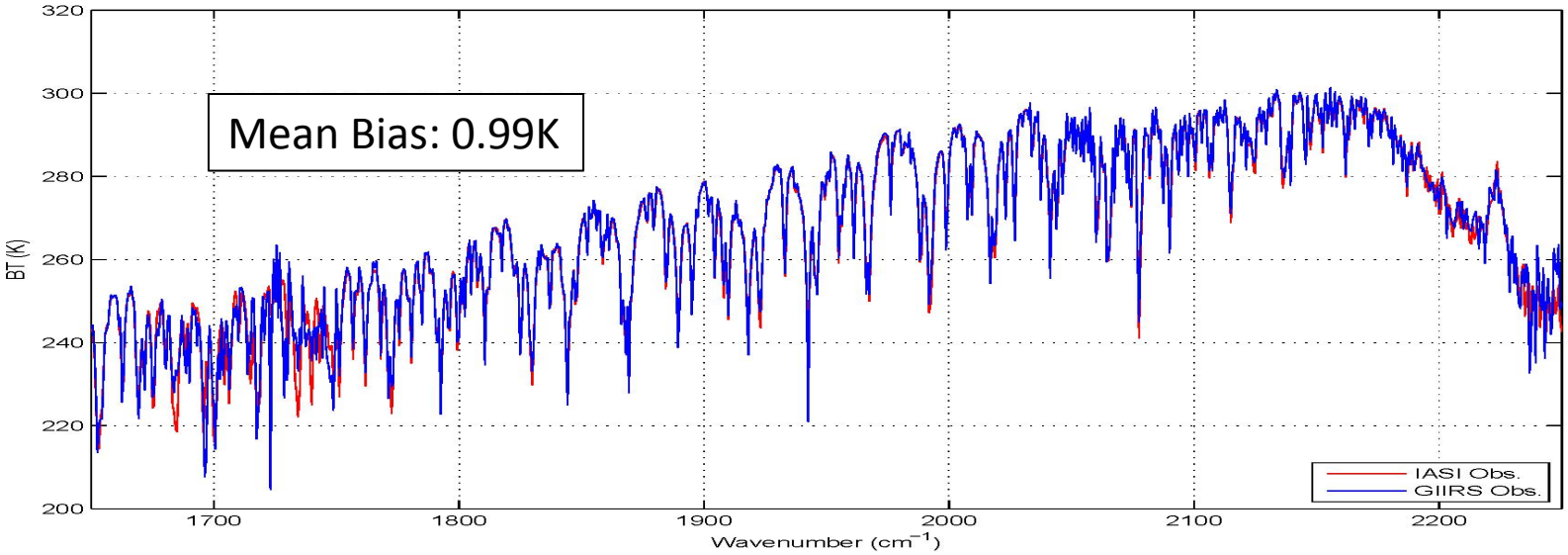
without thermal distortion compensation



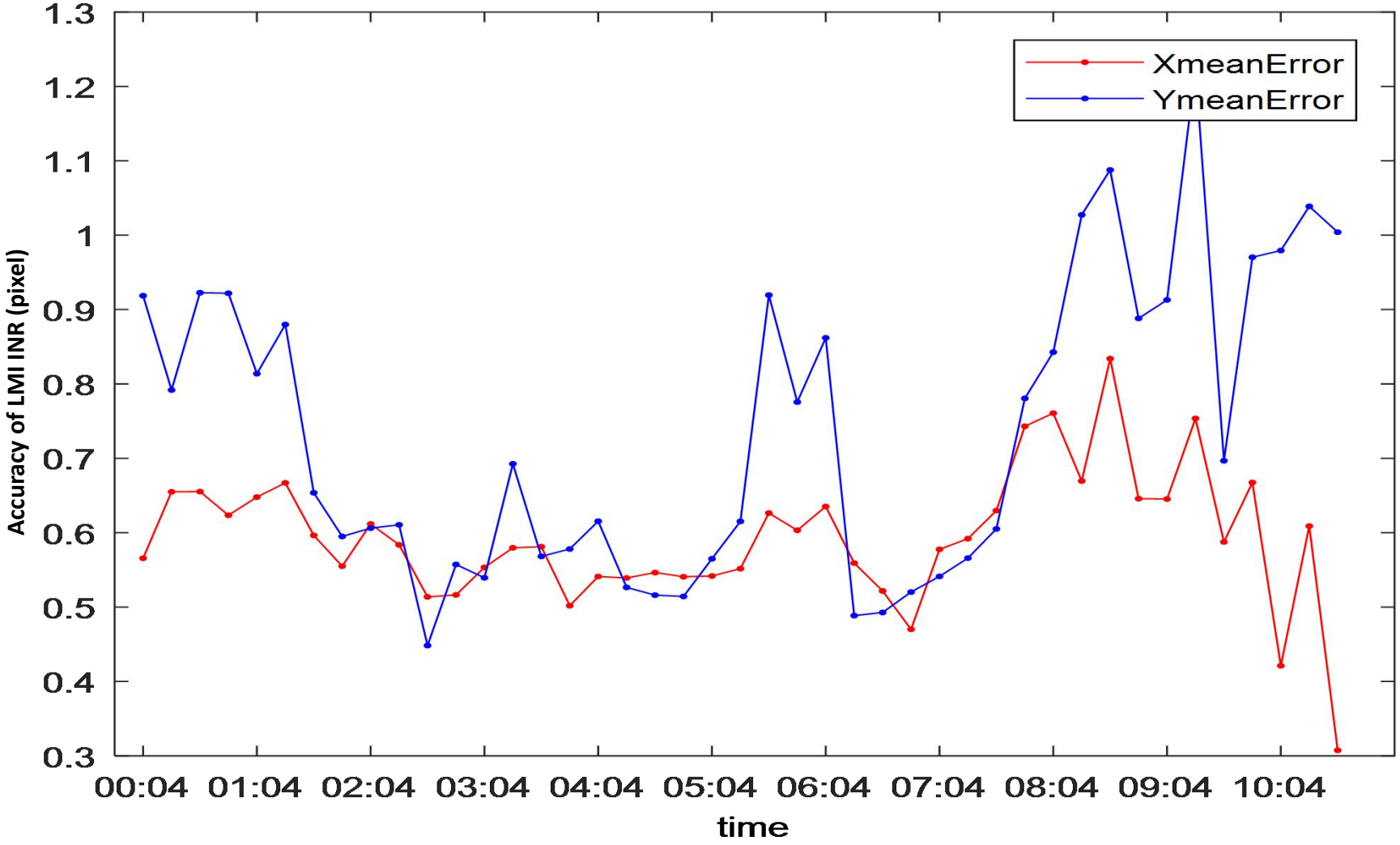
with thermal distortion compensation

4) Radiometric CAL bias monitoring for GIIRS





4) accuracy of LMI INR (<1 pixel) during Daytime



FY-4A observation mode

AGRI:

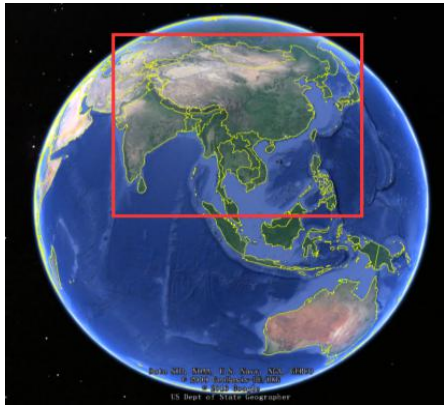
- Every hour: Full disk (00:00/01:00/02:00…23:00）
- Every 3 hour: 3 continuously Full disk(Eg.23:45-00:00-00:15)
- Rest: China area, (every 5 minutes)

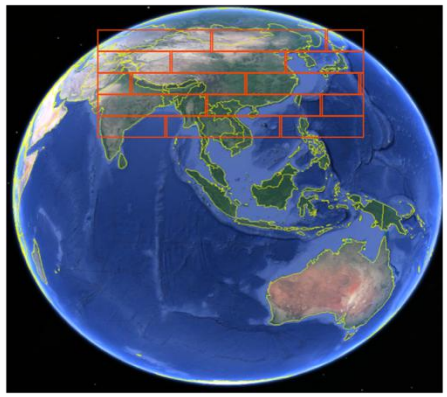
GIIRS:

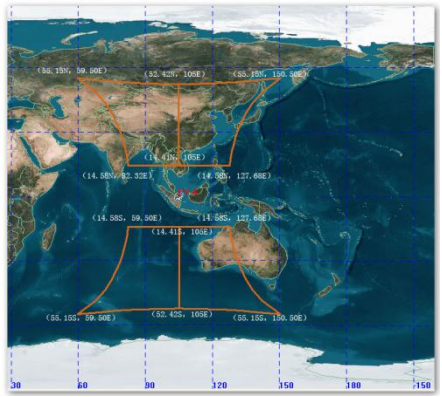
- Every 3 hour: Full disk clear sky observation
- Every 15 minutes: China area clear sky observation

LMI:

- 500 frames per second
- 21 Mar.-22 Sep: Northern Hemisphere
- 22.Sep-Next 21 Mar: Southern Hemisphere



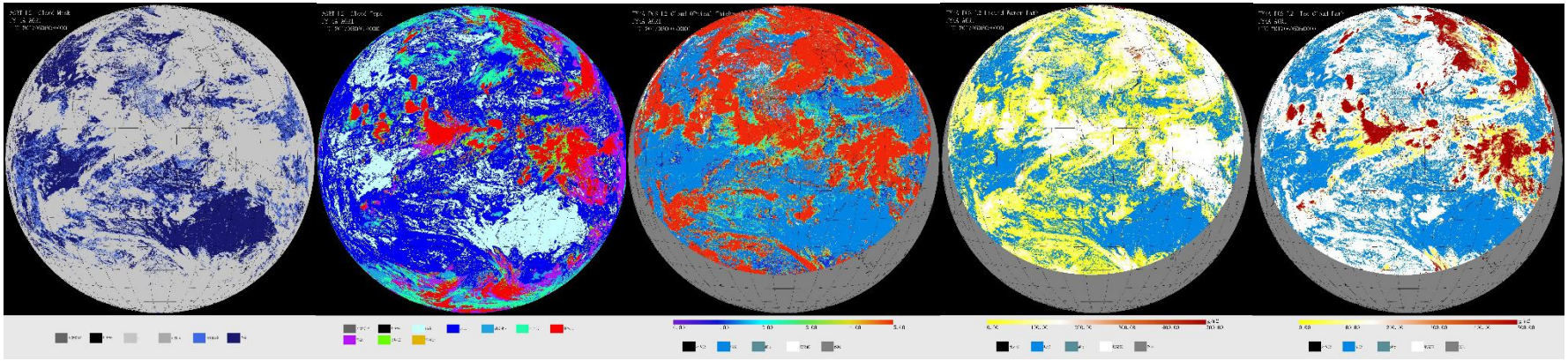




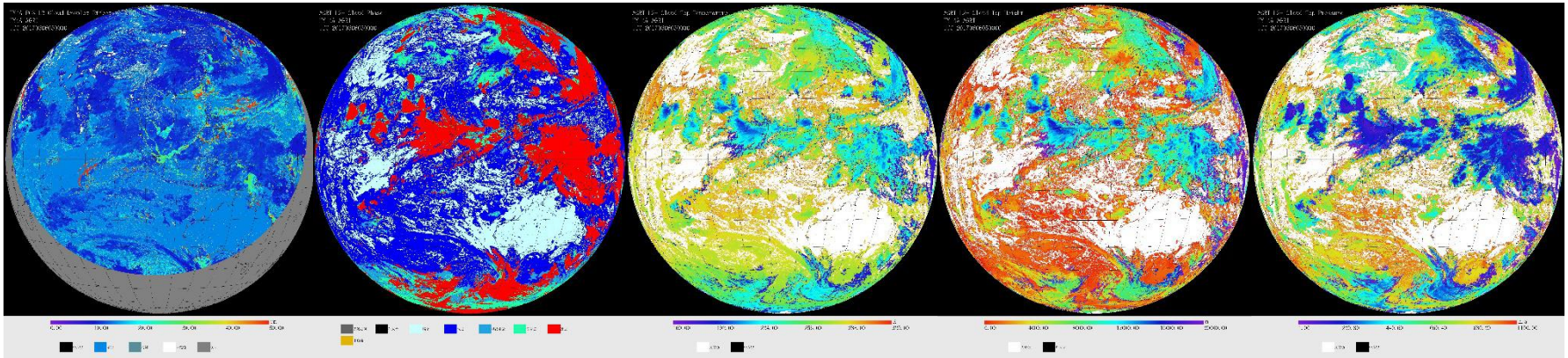
FY-4A Baseline products * CSR will online in 4Q 2018

	FY-4A	FY-2
Cloud	Cloud Mask Cloud Top Temperature Cloud Top Height Cloud Top Pressure Cloud Type Cloud Phase Daytime cloud optical and microphysical properties Nighttime cloud optical and microphysical properties	Cloud Mask Cloud Top Temperature Cloud Classification Cloud Cover Ratio Cloud Total Amount
Atmosphere	Quantitative Precipitation Estimate Layer Precipitable Water Atmosphere Motion Vector Atmospheric Temperature Profile Atmospheric Humidity Profile Cloudy Vertical Temperature Profile Cloudy Vertical Moisture Profile Aerosol Detection Atmosphere Instability Index Convective Initiation Tropopause Folding Turbulence Prediction Total Ozone Amout Ozone Profile	Precipitation Index Quantitative Precipitation Estimate Clear sky Total Precipitable Water Atmosphere Motion Vector Cloudy Vertical Moisture Profile Upper Tropopause Humidity
Radiance	Outgoing Long wave Radiation Surface Solar Irradiance Downward Longwave Radiation Upward Longwave Radiation Reflected Shortwave Radiation	Outgoing Long wave Radiation Surface Solar Irradiance
Surface	Sea Surface Temperature (Skin) Land Surface Temperature Snow Cover Land Surface Albedo Land Surface Emissivity Evapotranspiration products	Sea Surface Temperature (Skin) Land Surface Temperature Snow Cover
Environment	Dust Smoke Detection Fire/Hot Spot Characterization Fog Detection	Dust Index Fire/Hot Spot Characterization Heavy Fog Detection
Lightning	One Minute Lightning Quantitative Product (including flash group event) Lightning Jump Identification Product Flash Daily Density	
Space	High-energy particle distribution Magnetic Field Intensity Space Environment Effect	

FY-4A Baseline Products

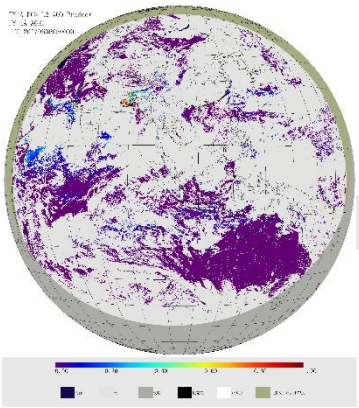


Clear Sky Masks | Cloud Type | Cloud Optical Depth | Cloud Liquid Water Path | Cloud Ice Water Path

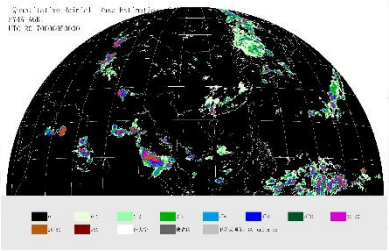


Cloud Particle Size Distribution | Cloud Phase | Cloud Top Temperature | Cloud Top Height | Cloud Top Pressure

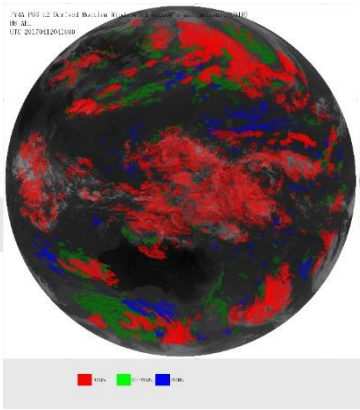
FY-4A Baseline Products



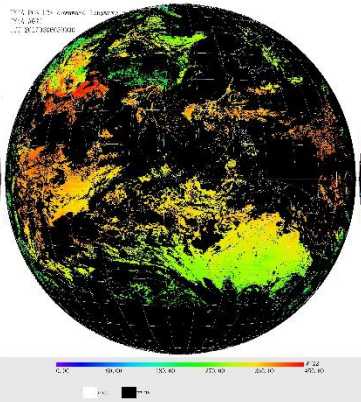
Aerosol Detection



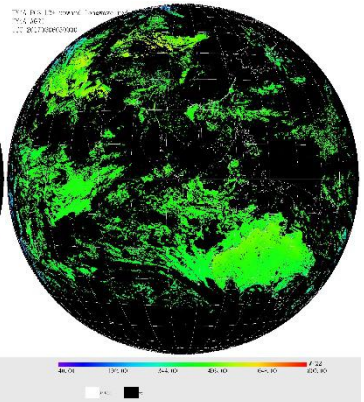
Rainfall Rate/QPE



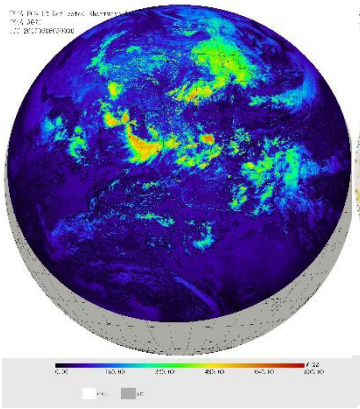
Atmospheric Motion Vector



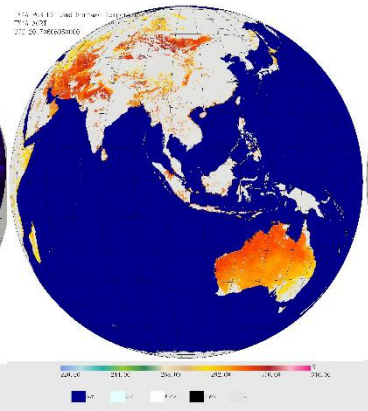
Downward Long wave Radiation:Surface



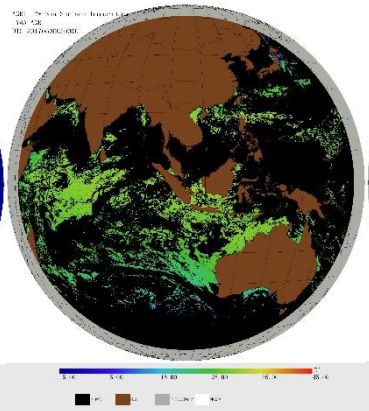
Upward Long wave Radiation: Surface



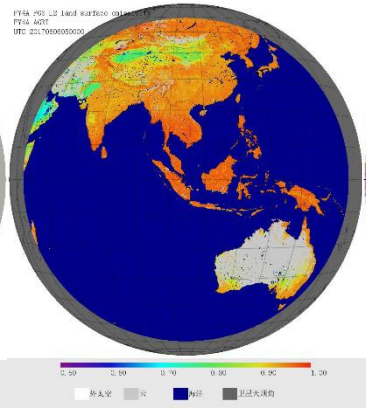
Reflected Shortwave Radiation



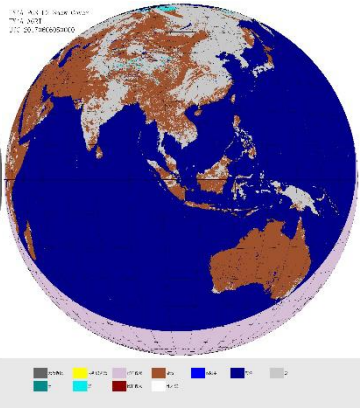
Land Surface (Skin) Temperature



Sea Surface (Skin) Temperature



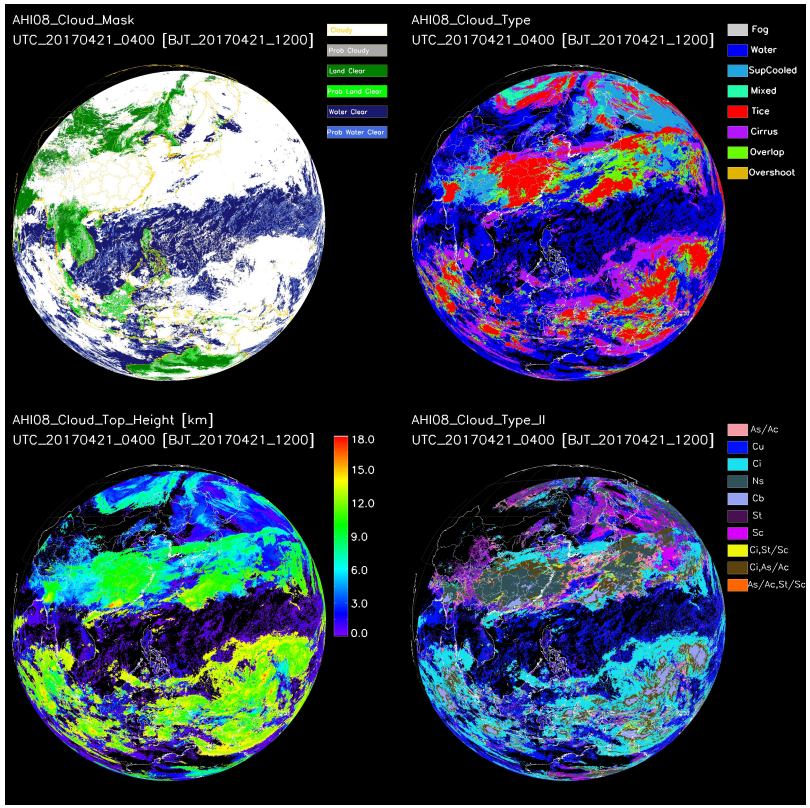
Land Surface Emissivity



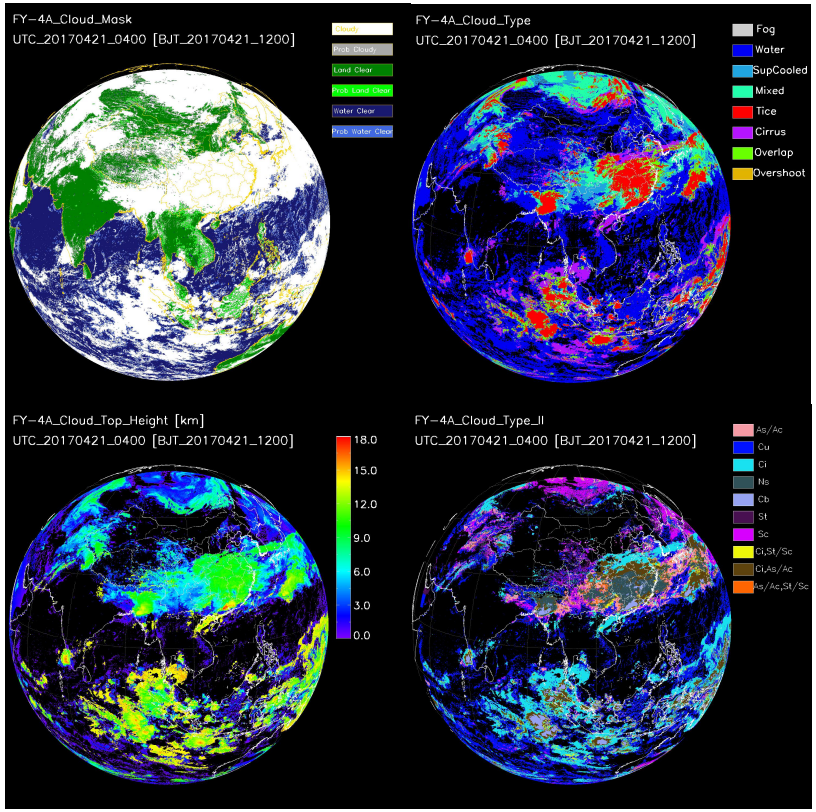
Land Surface Emissivity

Inter-comparing of FY-4 algorithm sensitivity to different sensors

（Cloud Mask, Cloud type， Cloud top Height etc）

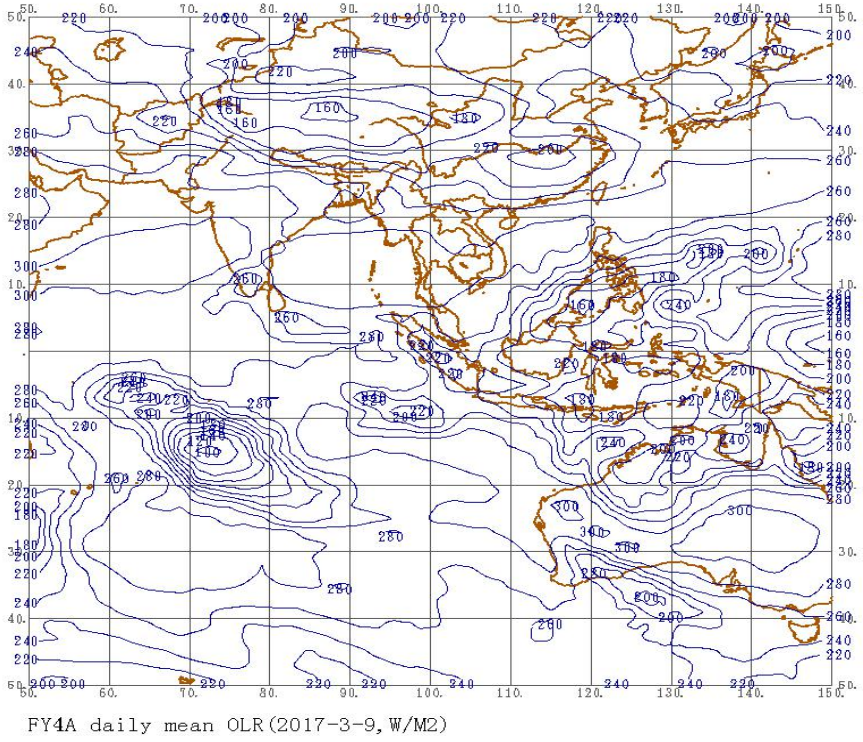


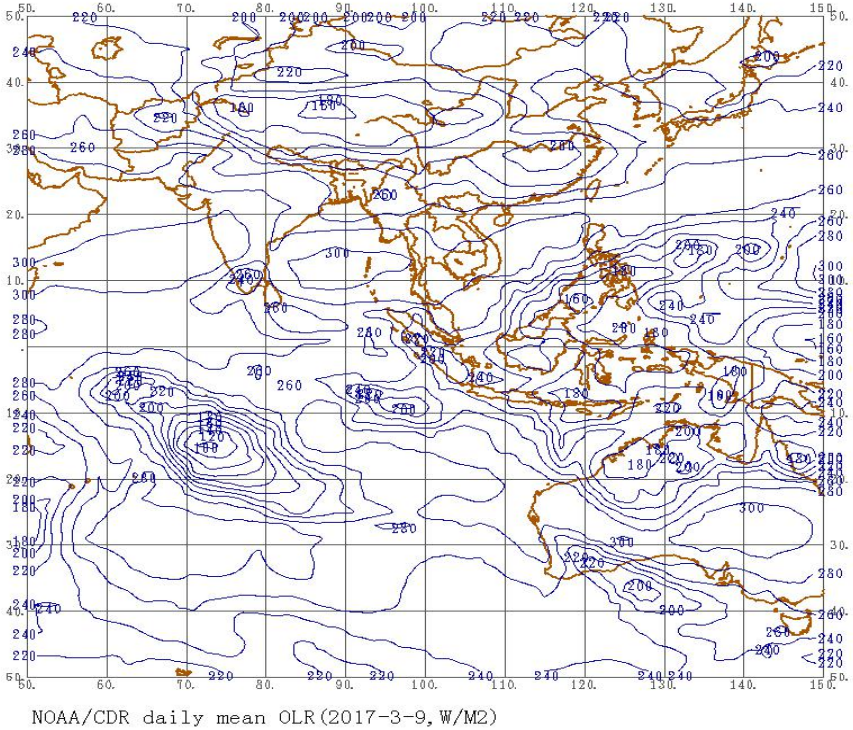
Himawari-8 AHI



FY-4A AGRI

Intercomparing of FY-4 products





FY-4A OLR

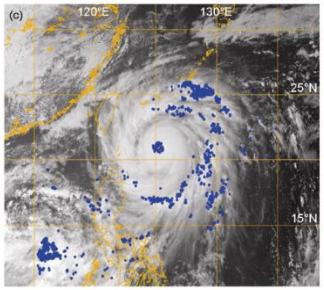
Preliminary result:
RMSE=6.26W/M2,
R=0.9892,
BIAS=3.0W/M2

NOAA/CDR OLR

OLR sample L2 data were kindly provided by NOAA/NESDIS

Some Highlight Application Aspects

New Application 1: Lightning in Tropical Cyclone & Strong Convection



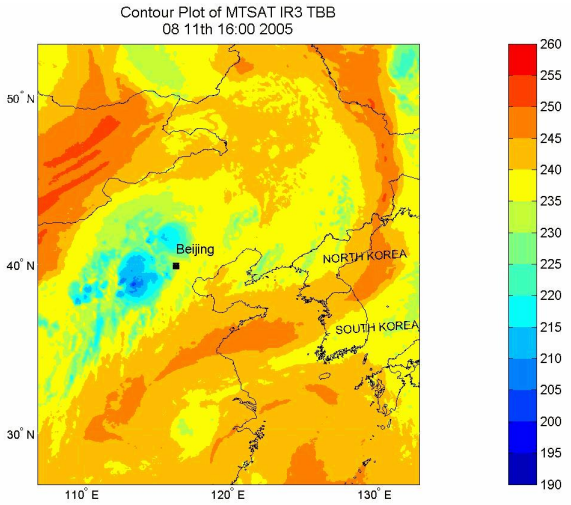
Eyewall

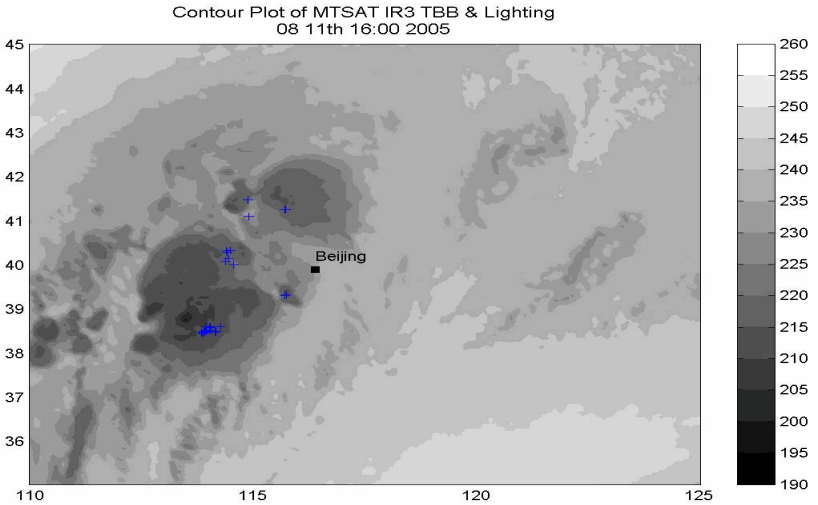
Inner Core

Inner Rainband

Outer Rainband

- Lighting distribution characteristics
  - Lighting density
  - Lighting evolution
- Correlation between lighting frequency and TC intensity level
  - Lighting density ratio of eyewall to outer rainbands
  - Inner core lighting periodic outbreaks
  - Lighting change in landing TC
- Lighting indicate TC forecasting
  - TC Rapidly Intensification TC Rapidly Weaken
  - TC track tendency

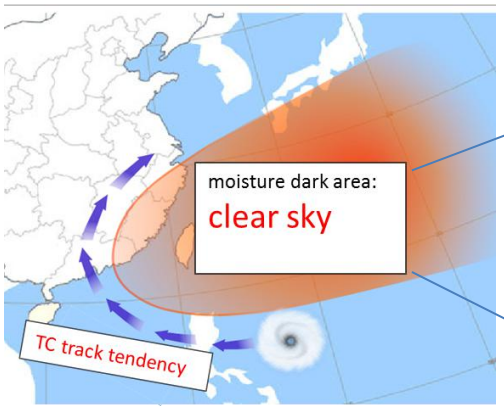




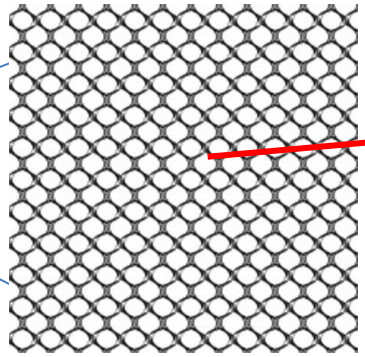
- **Combined with satellite images and lightning distribution maps, the variation tendencies of cloud cluster, e.g. movement and intensity, and the focused convection can be extracted directly**

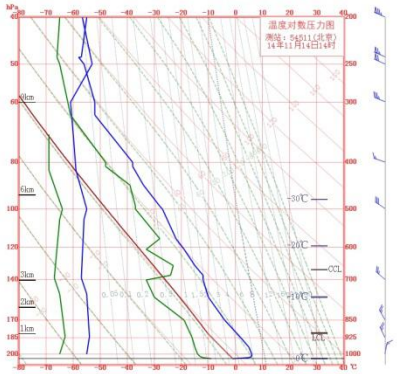
New Application 2: GIIRS in Surrounding Field Analysis around TC

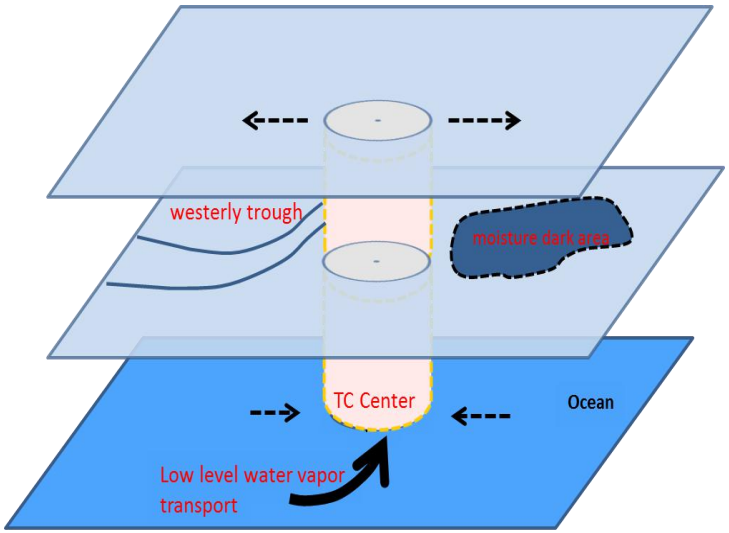
GIIRS's observation provides a satisfied T&H profiles at each grid especially in ocean area



GIIRS Obs.

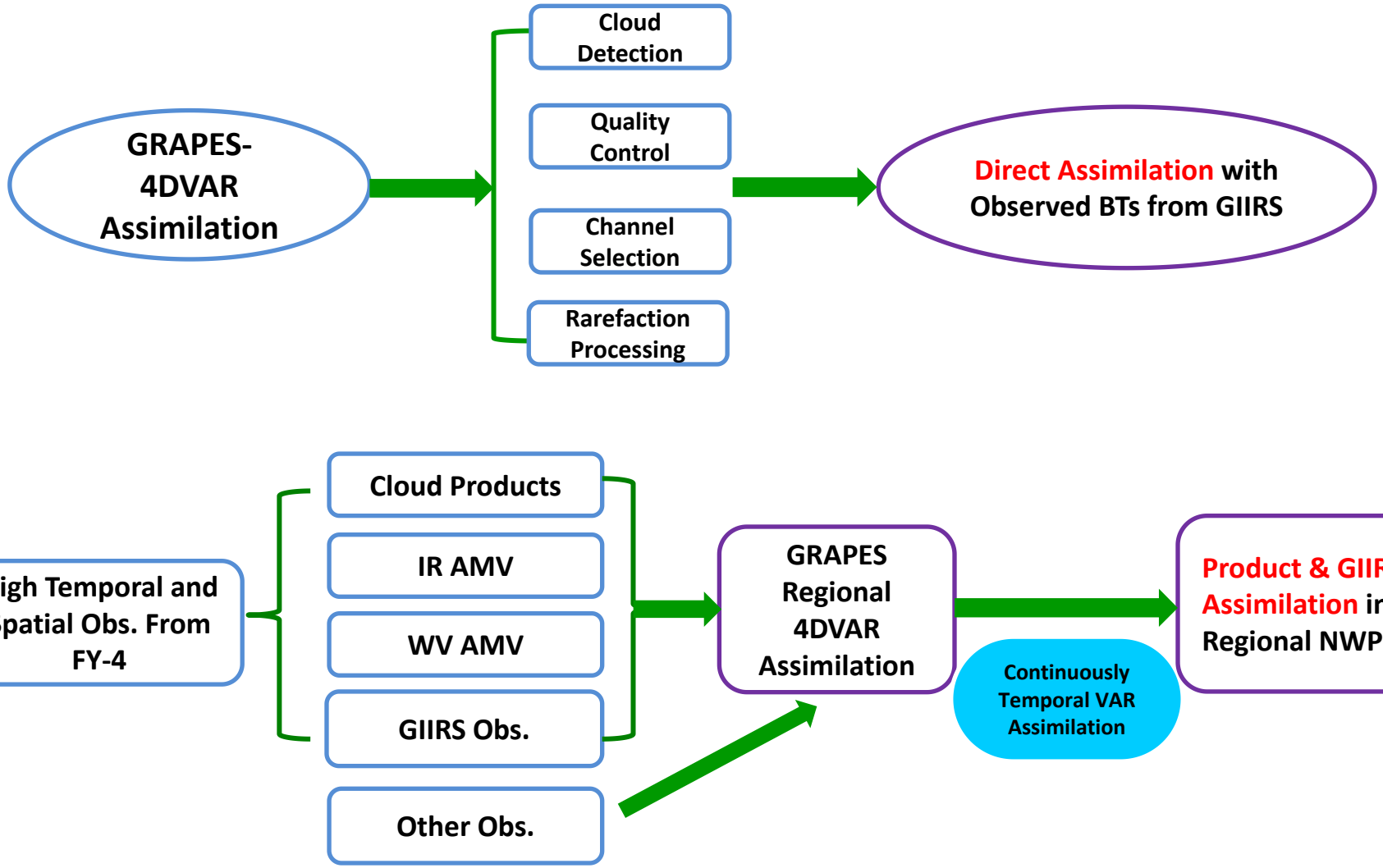






TC's track and intensity are closely related with the large-scale atmospheric circulation changes, for example, the subtropical high which is TC's guiding airflow and determines TC's track tendency.

New Application 3: GIIRS & Products in Assimilation of NWP

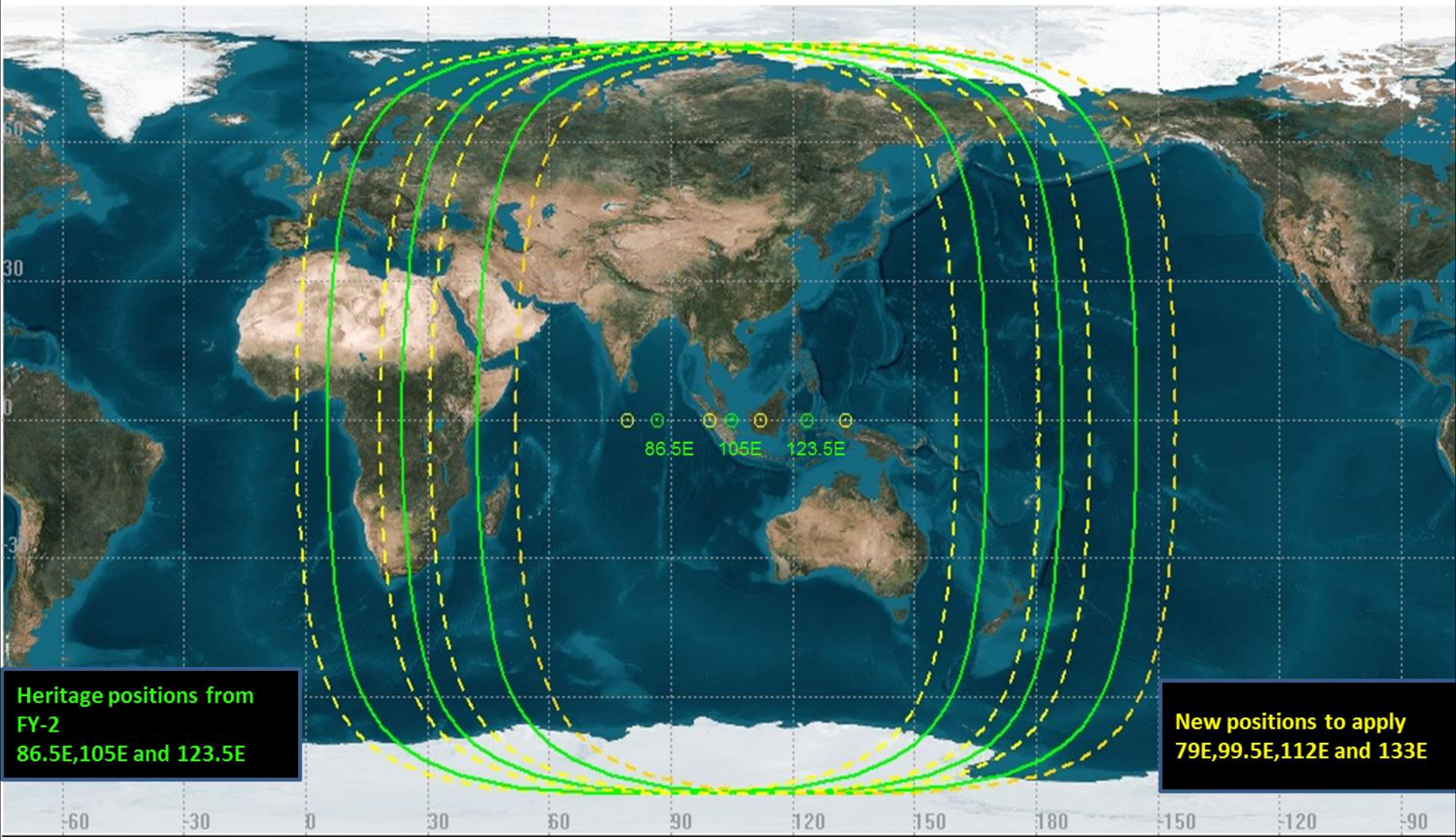


FOLLOW-UP PLAN OF FY-4

FengYun GEO Satellites Launch Plan by 2025

No.	Orbit	Status	Launch
FY-4B	Geo	Op, planned	2019
FY-4C	Geo	Op, planned	2021
FY-4MW	Geo	R&D, planned	TBD

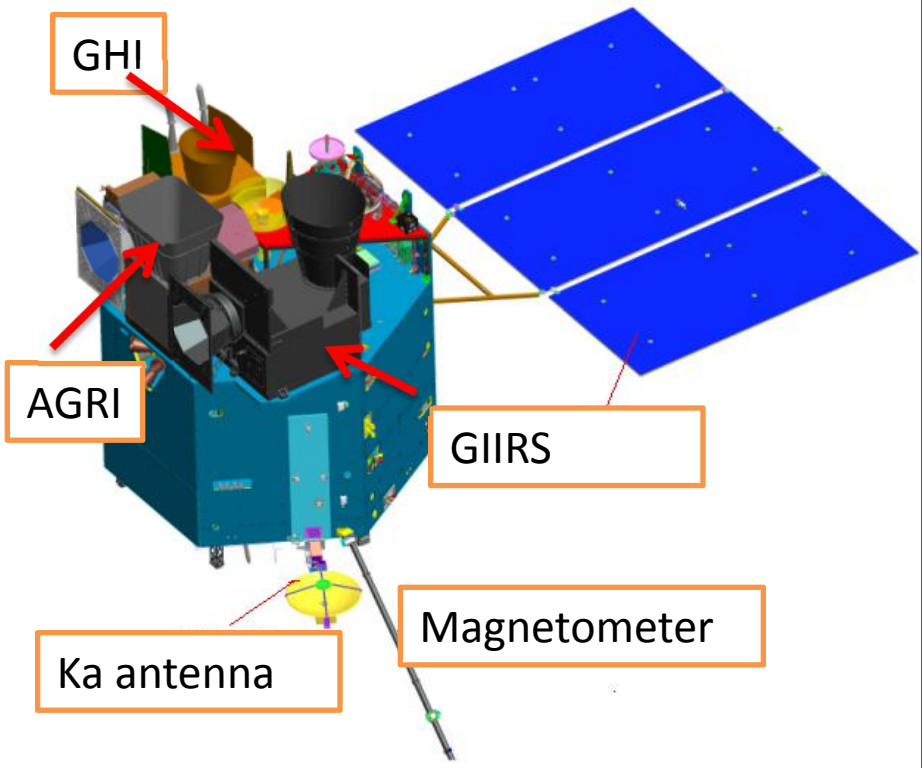
FY-4 Orbital Positions



FOLLOW-UP PLAN OF FY-4

FY-4B is the first operational satellite, it will inherit FY-4A technology. Geo High-speed Imager(GHI) will be the new payload, with regional high-speed high-resolution continuous observation capability.

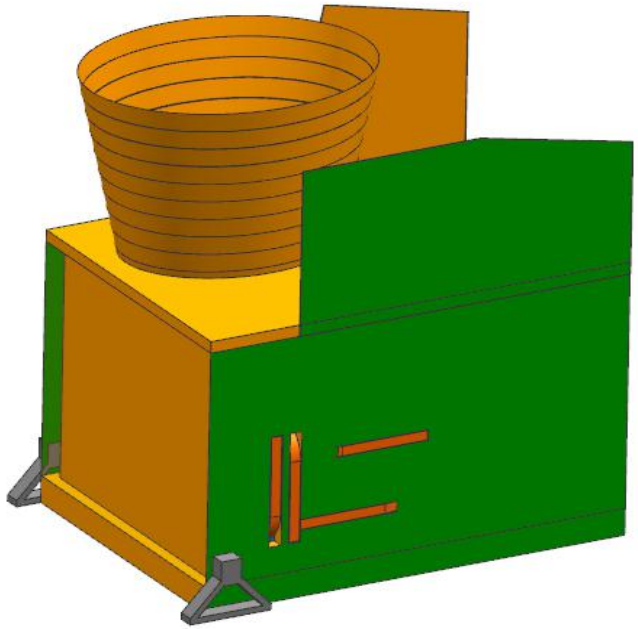
Payload	Upgrade
AGRI+	**Add 7.24-7.60μm**
	2.1**μm and 3.5μm spatial resolution upgrade to 2km**
GIIRS+	**Wavelength range is extended to 680～1130cm^{-1}**
	Spatial resolution of visible channel upgrade to 1km



FOLLOW-UP PLAN OF FY-4

Geo High-speed Imager(GHI)

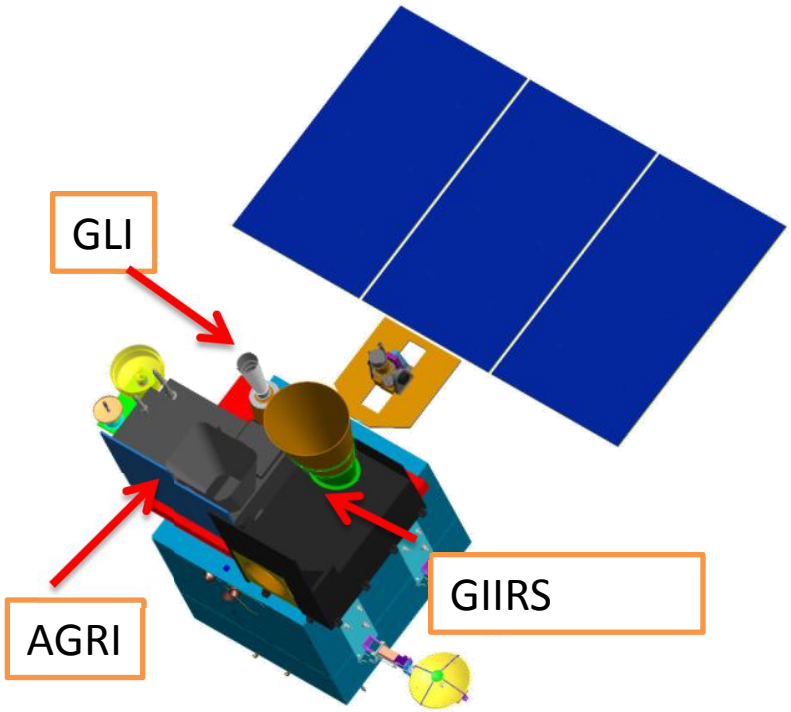
No.	Bandwidth （μm）	Spatial Resolution（km）
1	Panchromatic	0.25
2	0.445~0.495	0.5
3	0.52~0.57	0.5
4	0.62~0.67	0.5
5	1.36~1.39	0.5
6	1.58~1.64	0.5
7	10.5~12.5	2



FOLLOW-UP PLAN OF FY-4

The performance of payload and platform on FY-4C will be substantially optimization and upgrade.

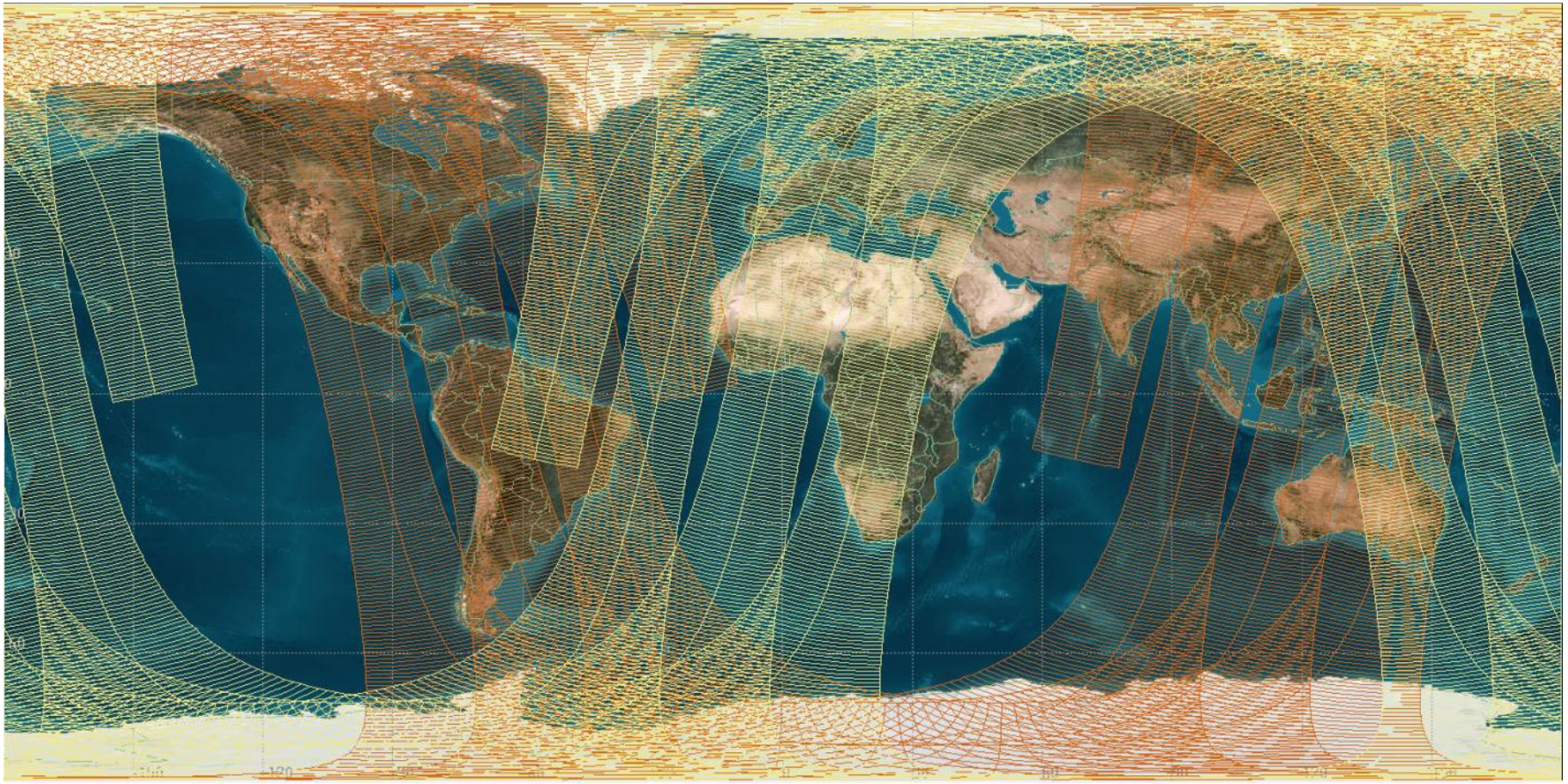
Payload	Upgrade
AGRI++	**18 channels including true color channel of 500m resolution**
	5min full disc
	IR 2km
GIIRS++	**Wavelength range is extended to 650～1130cm^{-1}**
	Spatial resolution of visible channel upgrade to 0.5km and IR channel upgrade to 8km
GLI+	**Full disc lightning detection**



Fengyun LEO

Fengyun Polar Constellation

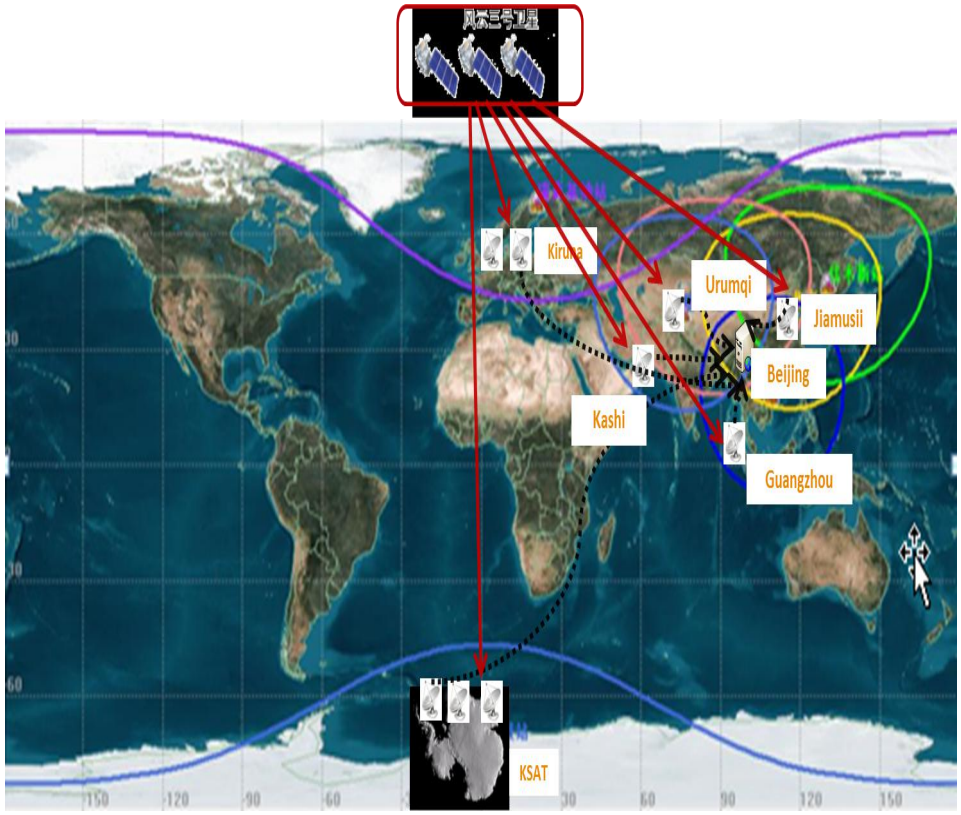
- In full Operation (Global) : FY-3B （FY-3D）+ FY-3C, global coverage 4 times per day



FY-3C LTC 10:30 AM　　FY-3D LTC 13:40 PM

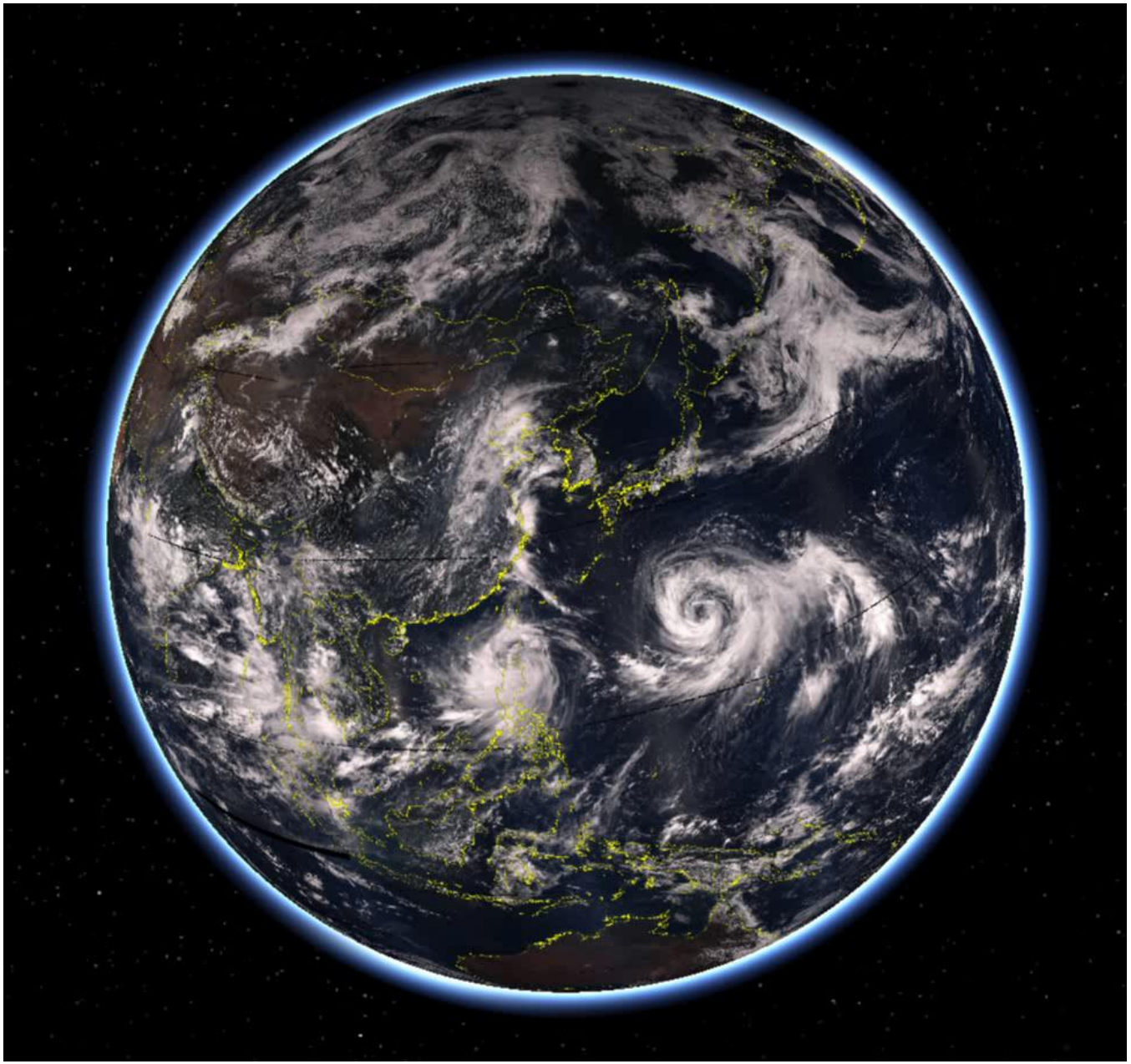
Observation capability from FY-3

- Global data acquiring latency within 1 hours (80%)
- Global data coverage with 2800 Km swath with per day, 250m spatial resolution in maximum



Ground Station Name	Longitude	Latitude
Beijing Station	116.28E	40.05N
Guangzhou Station	113.34E	23.16N
Wulumuqi Station	87.57E	43.86N
Kashi Station	75.94E	39.52N
Jiamusi Station	130.36E	46.90N
Kirunna Station	21.00E	68.00N
Troll Station	2.50E	72.00S

FY-3：Seamless global observation with data latency less than 1 hours.



FY-3D: Launched on 15 Nov, 2017

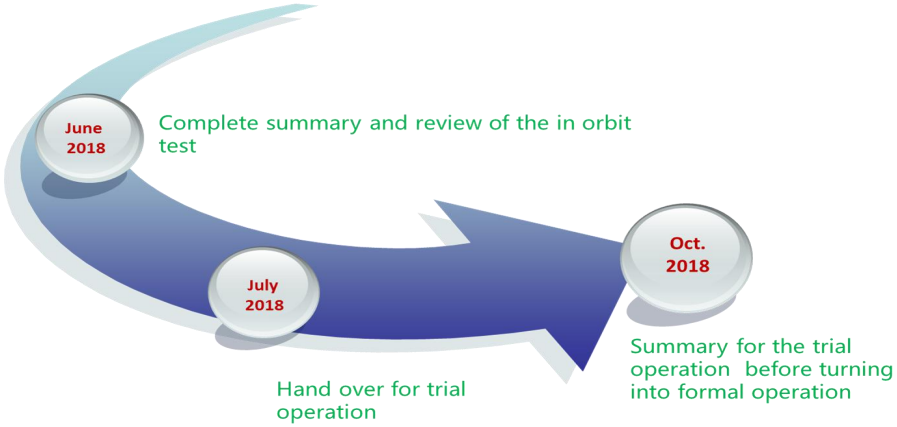
Parameters	Satellit
Orbit type	Near-pol
Orbital altitude	836 Km
Orbital inclination	98.75°
Precision orbit	Semi-maj
	Orbital in
	Orbital ec
Repeat cycle	5.5d (Des
Eccentricity	≤0.0025
Local time drift at ascending node	15 min w
Launch window	local tim 14:00
Design lifetime	5 yrs for

- 4 new instruments (HIRAS, GAS, WAI, IPM)
- 1 important improved instruments (MERSI-2)
- 5 successive Instruments

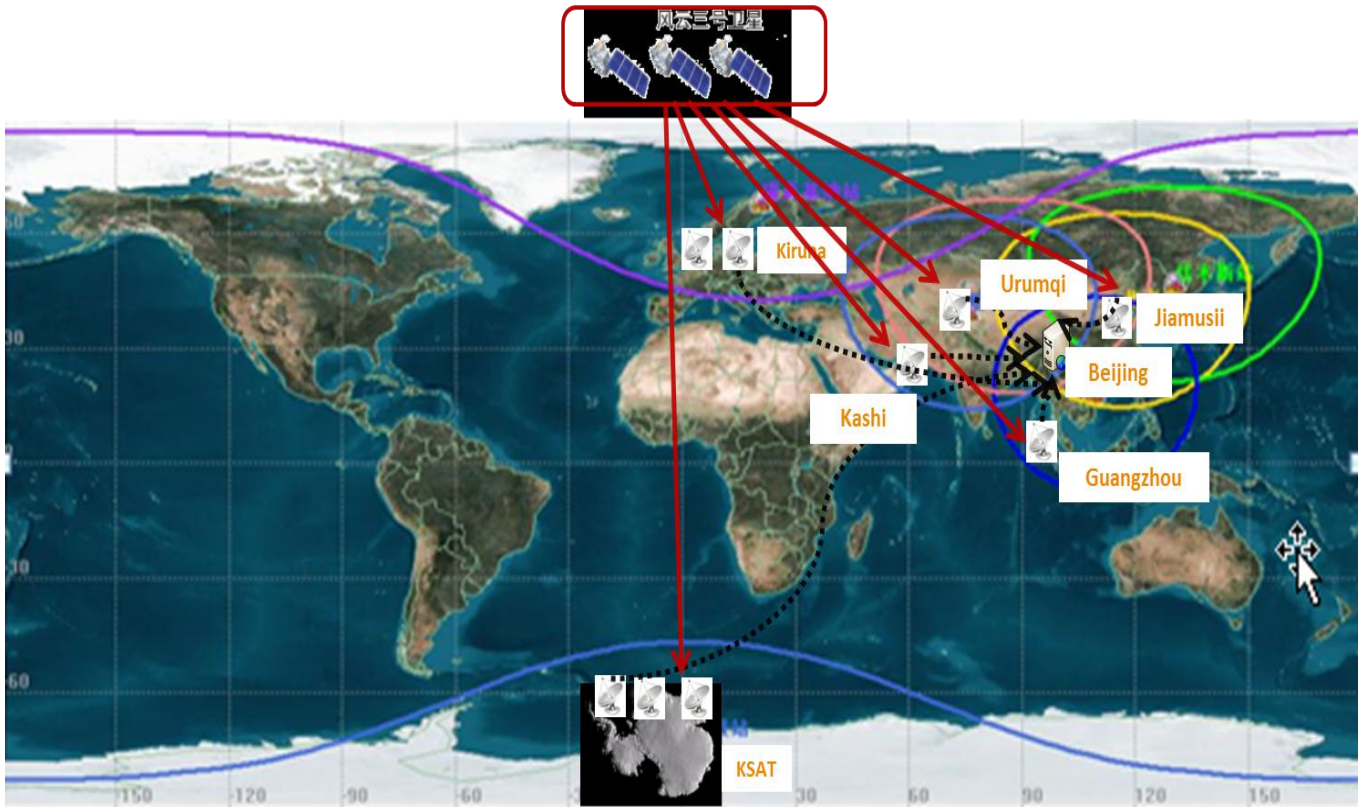
Payload Name	Channel Numbers with Spectral Coverage
MEdium Resolution Spectral Imager (MERSI-2)	25 (0.413 – 12 μm)
Hyperspectral InfraRed Atmospheric Sounder (HIRAS)	1370 (3.92 – 15.38 μm)
MicroWave Radiation Imager (MWRI)	10 (10.65 – 89 GHz)
MicroWave Temperature Sounder (MWTS-2)	13 (50.3 – 57.29 GHz)
MicroWave Humidity Sounder (MWHS-2)	15 (89.0 – 183.31 GHz)
GNSS Occultation Sounder (GNOS)	29 (--)
Greenhouse-gases Absorption Spectrometer (GAS)	5540 (0.75 – 2.38 μm)
Wide angle Aurora Imager (WAI)	1 (140 – 180 nm)
Ionospheric PhotoMeter (IPM)	3 (130 – 180 nm)
Space Environment Monitor (SEM)	25 (--)

- Performance are improved significantly for the key characteristics, such as S/N, calibration accuracy, etc.

- ✓ In Orbit testing began on December 12th， 2017;
- ✓ the in orbital testing has been finished. The results show that the satellite platform and main payloads functions well，and meets the requirements;



Global data latency within 2 hours (80%) less than 1 hour



Comparison with missions on JPSS-1

	FY-3D	Number of Channels	Band	JPSS-1	Number of channels	Band
1.	Medium Resolution Spectral Imager	25	0.413-12μm	VIIRS	22	0.413-12μm
2.	Microwave temperature sounder	13	50.3-57.29GHz	ATMS	22	23-183GHz
3	Microwave humidity sounder	15	89-183.31 GHz			No 118GHz
4	Microwave imager	10	10.65-89 GHz	--		
5	GNSS radio occulatation Sounder	29	29	--		
6	Hyperspectral Infrared Atmospheric Sounder	1370	3.92 - 15.38μm	CrIS	2211	3.92 - 15.4μm
7	Greenhouse-gases Absorption Spectrometer	5540	0.75-2.38μm	--		
8	Wide-field Auroral Imager	1	140-180 nm	--		
9	Ionospheric PhotoMeter	3	130-180 nm	--		
10	Space Environment Monitor	29	29	--		
				OMPS	NM,NP	250-1000nm
				CERES	3	0.3-100μm

- FY-3D was launched in the same week as JPSS-1, which are all Polar-orbiting meteorological satellite in the afternoon orbit.
- The number of instruments carried on FY-3D is twice that of JPSS. In addition to covering most observation functions of JPSS-1, FY-3D also has the GNSS radio occultation and greenhouse gas detection, as well as powerful space environment monitoring.
- FY-3D is one of the most complete operational satellite systems in the world.

MERSI→MERSI-II
continuity and Evolution

MERSI-2 Improvement:

- Cover all bands in FY-3A/B/C MERSI
- Five more IR bands
- Circurrus cloud band 1.38um
- Water vapor bands In NIR and 7.2um
- Two IR split windows with 250m spatial resolution
- Higher accuracy from onboard calibration
- Lunar Calibration capability

Band	SNPP VIIRS	FY-3D MERSI-II	FY-3A/B/C MERSI
1	DNB	0.470	0.470
2	√	0.550	0.550
3	√	0.650	0.650
4	√	0.865	0.865
5	×	1.03	11.25
6	√	1.64	1.640
7	√	2.13	2.130
8	√	0.412	0.412
9	√	0.443	0.443
10	√	0.490	0.490
11	√	0.555	0.520
12	√	0.670	0.565
13	√	0.709	0.650
14	√	0.746	0.685
15	√	0.865	0.765
16	×	0.905	0.865
17	×	0.936	0.905
18	×	0.940	0.940
19	√	1.38	0.980
20	√	3.8	1.030
21	√	4.05	
22	×	7.2	
23	√	8.550	
24	√	10.8	
25	√	12.0	

250 m
1000 m

Typical Products:

Image: RGB image, target classification

Land Surface: LST, NDVI, etc.

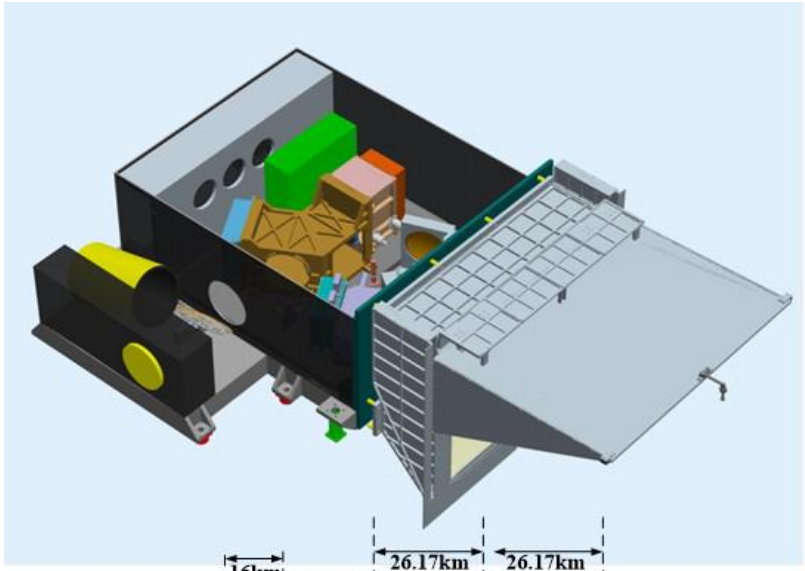
Ocean Surface: SST, ocean color, etc

Atmosphere: aerosol, water vapor, etc

Cloud: cloud top, cloud microphysics

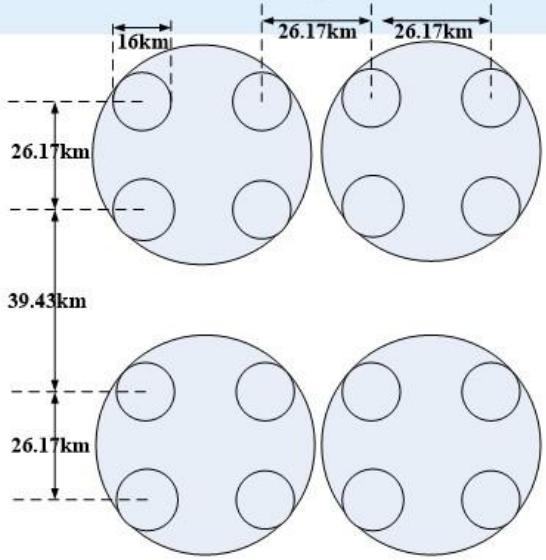
HIRAS Hyperspectral sounder

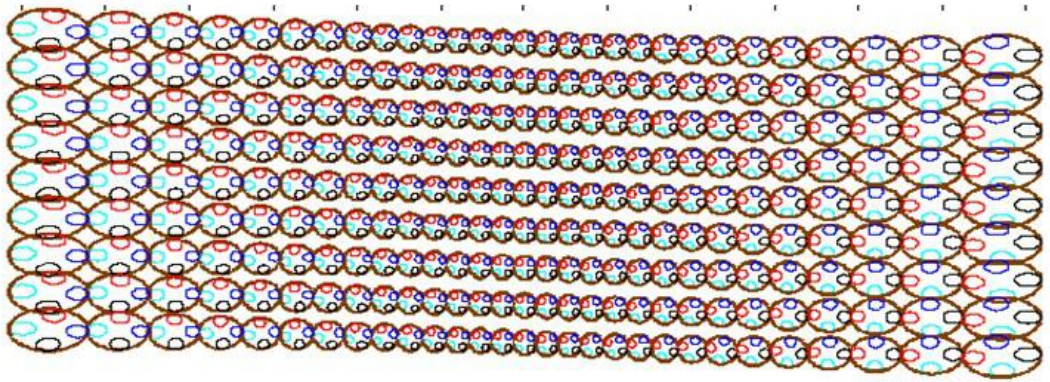
-- comparable with CrIS & IASI



Items	Specification
Scanning cycle	10 s (33 FORs)
FOV	1.1° (16Km)
Scanning Line	29*4 FORs
Max Scanning Range	± 50.4°

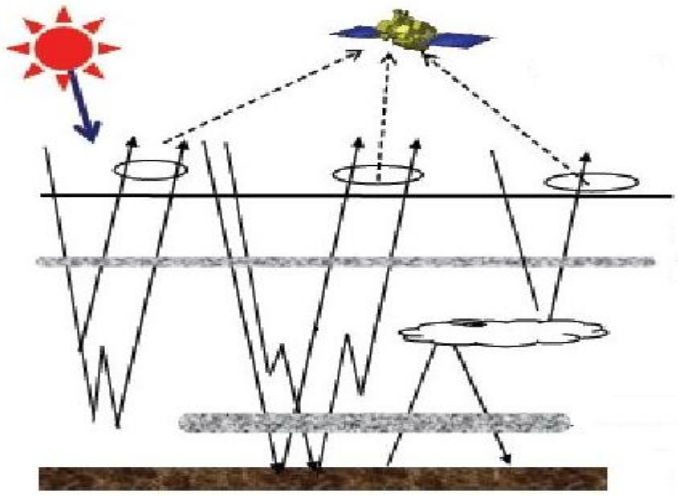
Band	Spectral range (cm-1)	Resolution (cm-1)	NEΔT @250K	chs
Longwave	650 *– 1136 (15.38 μm-8.8 μm)	0.625	0.15K	778
Midwave1	1210 – 1750 (8.26μm-5.71 μm)	1.25	0.1K	433
Midwave2	2155-2550 (4.64μm-3.92 μm)	2.5	0.3K	159





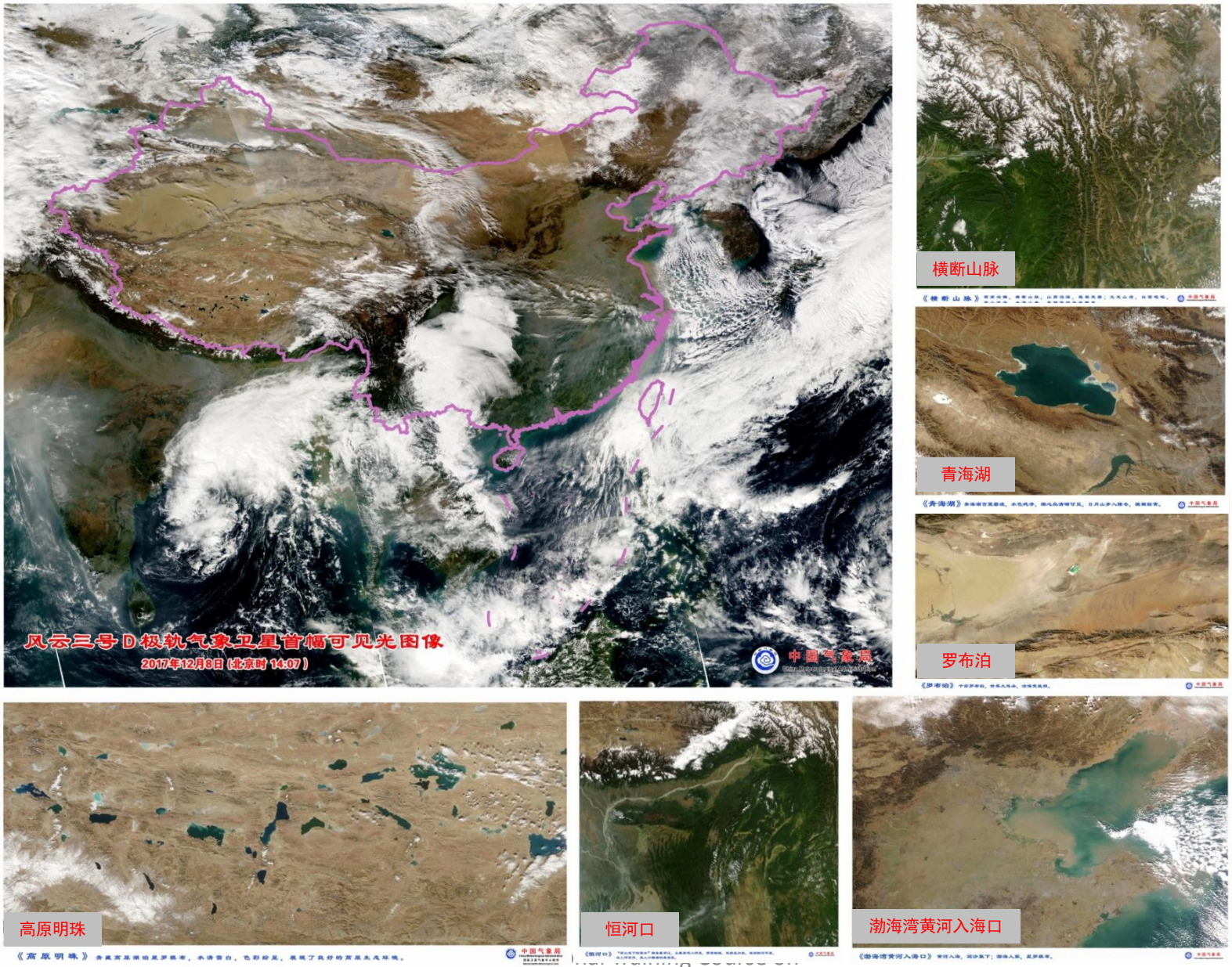
GAS: Greenhouse gases Absorption Spectrometer

- **Objectives:** to measure golbal CO_2 and CH_4 column density by using a SWIR Interferometer
- **Spectral res.:** 0.2 cm^{-1}
- **Spatial res.:** 13km
- **Number of Bands:** 4



Specification		FY-3D GAS	FY-3G GAS-II	TanSat	OCO
Spectral bands (μm)	0.76	√	√	√	√
	1.6	√	√	√	√
	2.0	√	√	√	√
	2.3	√	√	—	—
Spectral Resolution (nm) @1.6μm		0.073	0.07	0.12	0.0757
Spatial Resolution (km)		13.2	< 3	2	1
Swath(km)		----	>100	20	10
Sample points		7	----	9	8
Sample interval (S)		2.2	----	0.3	0.333

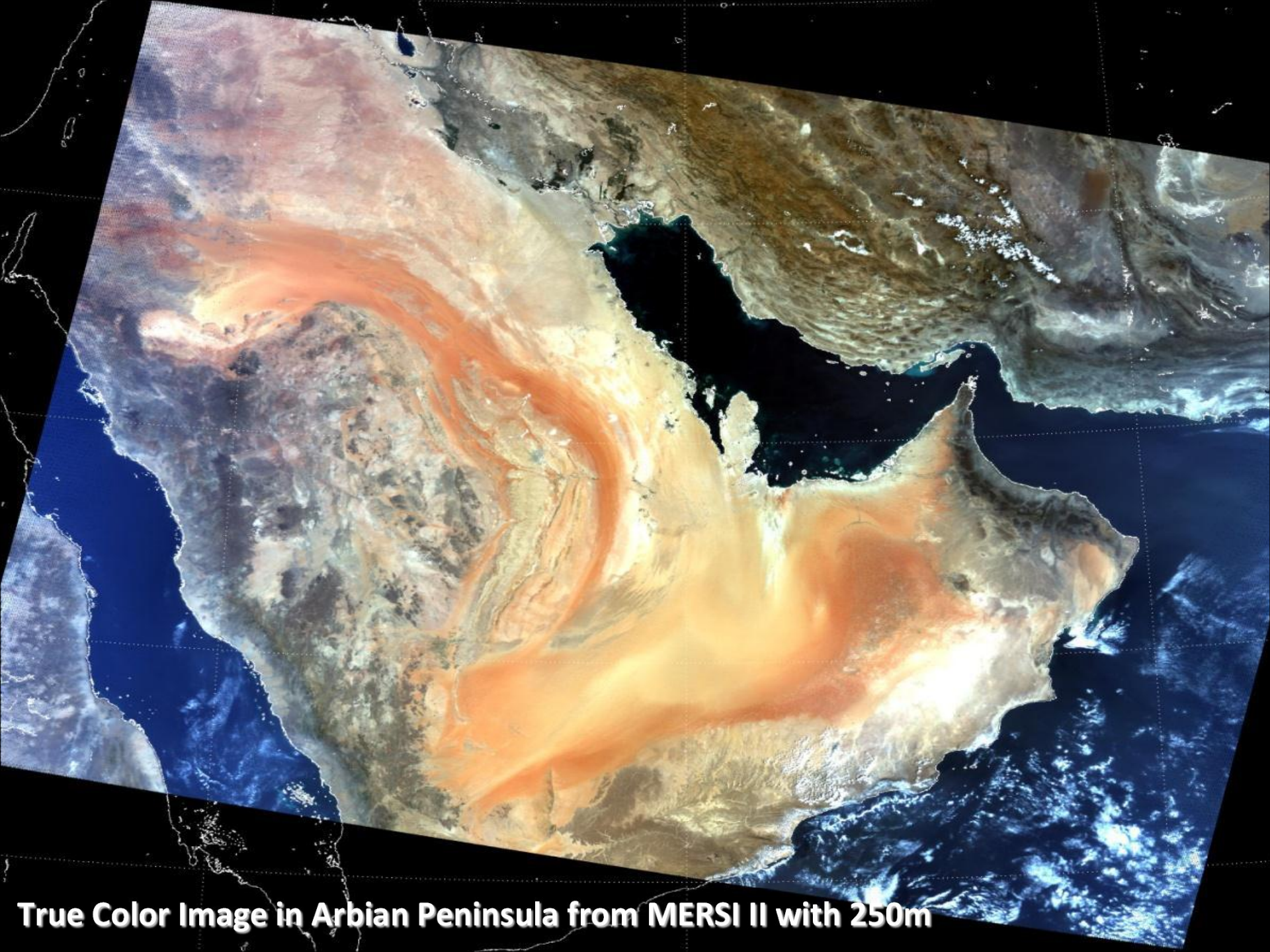
The first image from MERSI



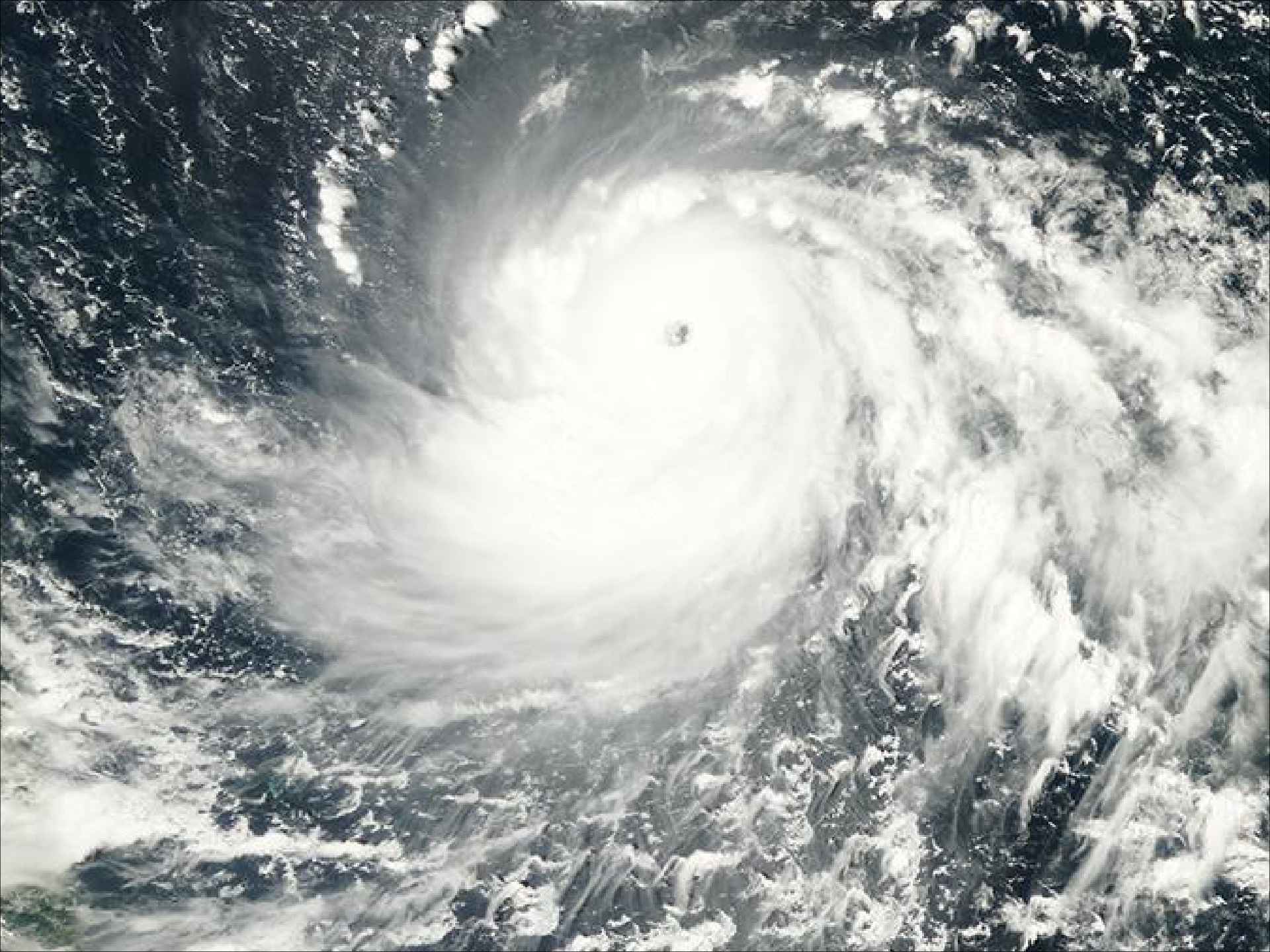
FY-3D Baseline products

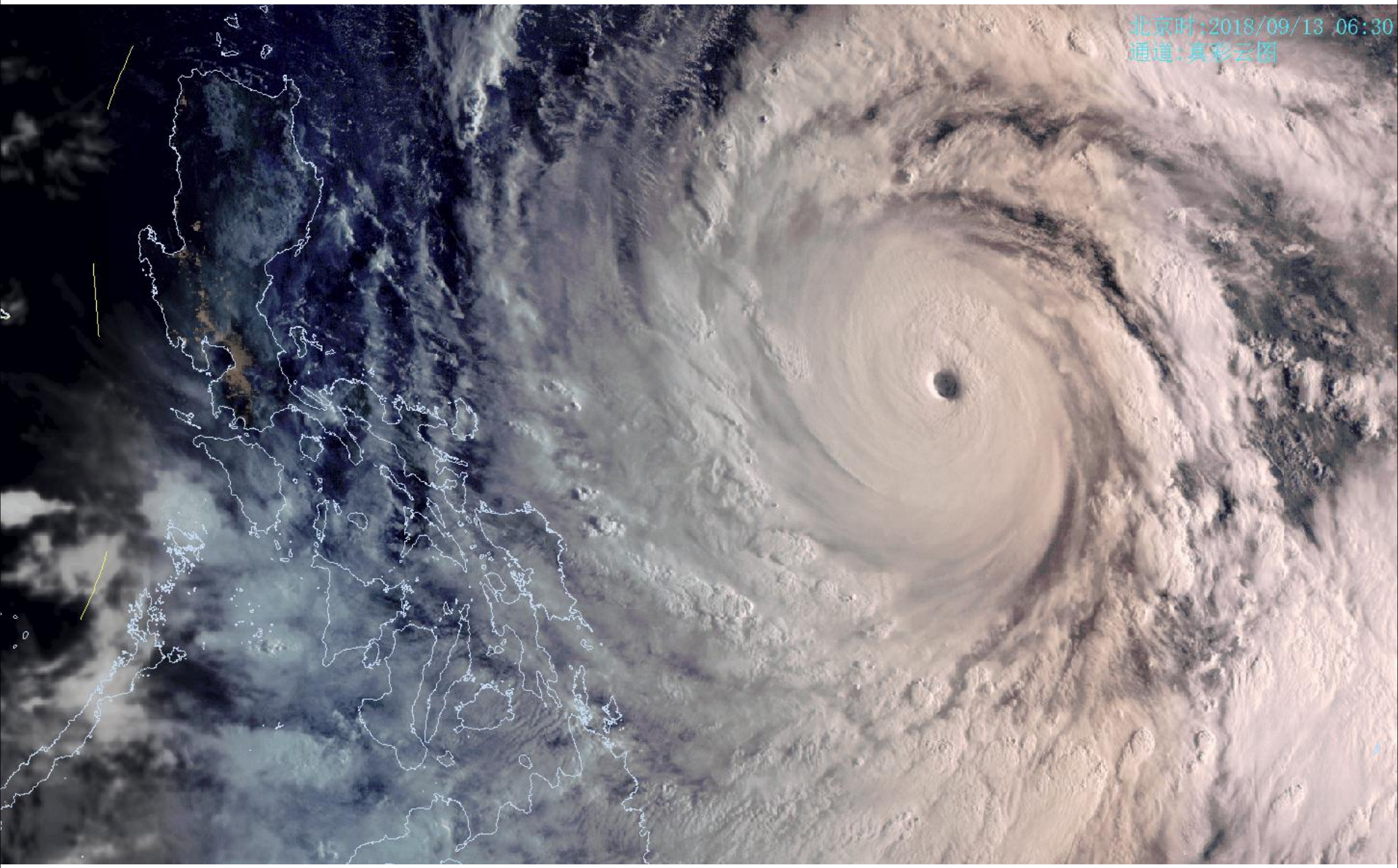
Cloud & Radiation	Atmosphere	Land Surface	Sea Surface	Space Weather
Cloud mask, Cloud amount, Cloud type, Cloud phase, Cloud top temperature, Cloud top height, Cloud optical depth, Cloud physical parameters, Cloud water content, Cloud liquid water, Ice water path, Outgoing longwave radiation	Atmospheric total precipitable water, Dust storm index, Aerosol optical depth, Rain detection, Atmospheric humidity profile (GNOS,VASS), Atmospheric temperature profile (GNOS,VASS), Precipitation, Microwave rain rate, Fog detection	Global fire detection, Land cover, Land surface reflectance, Land surface temperature, Soil moisture, NDVI, Snow cover, Snow cover fraction, LAI, FPAR, NPP, Albedo, Snow depth, Snow water equivalent	SST, Sea-Ice cover, Ocean color, Chlorophyll, Sea surface wind speed	radiation flux of high energy particles, surface electric potential radiation dose, GNOS Electron Density Profile, Ionospheric O/N2 Column Ratio, Aurora Mapping Products

True Color Image in Caribbean Sea from MERSI II with 250m



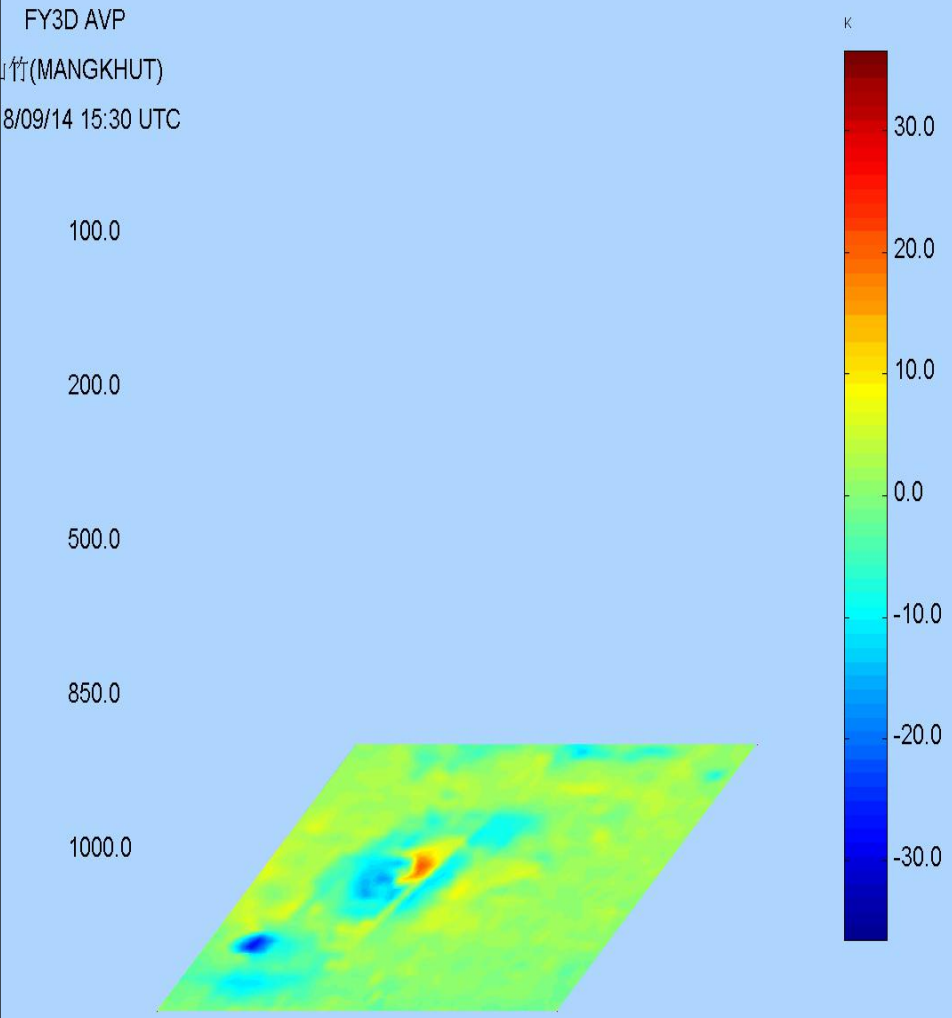
True Color Image in Arbian Peninsula from MERSI II with 250m



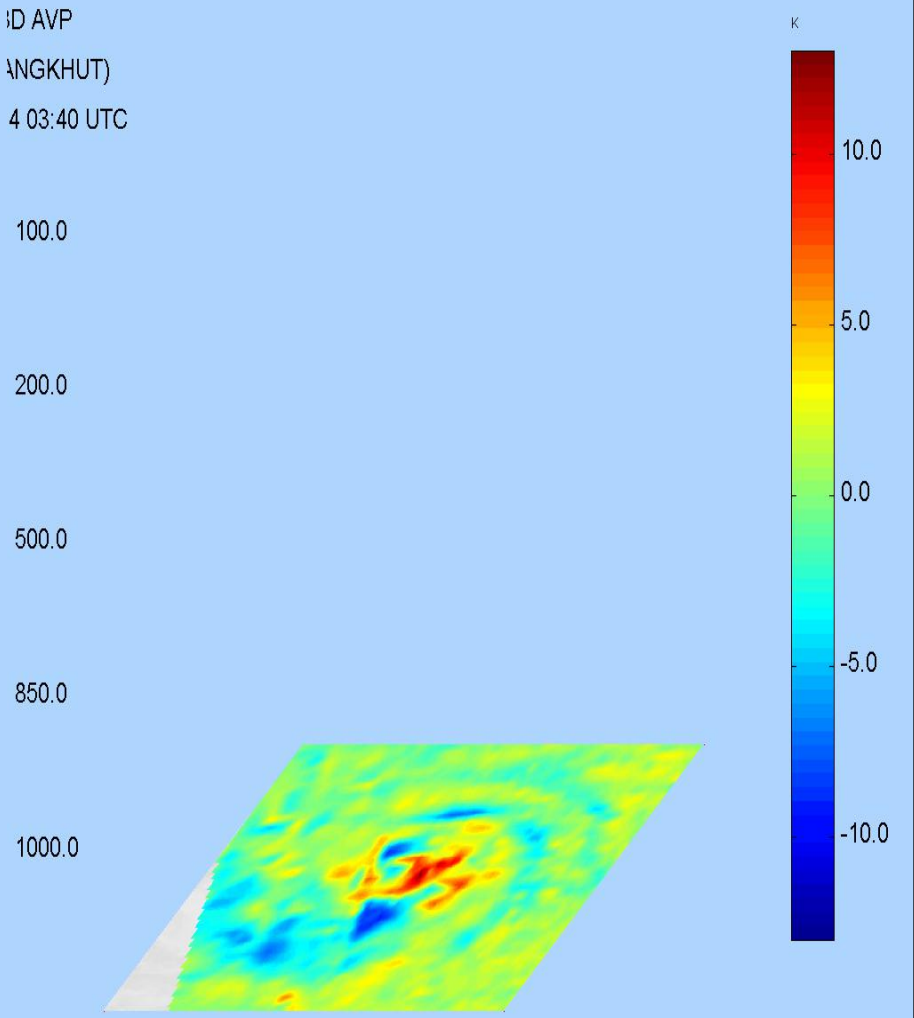

北京时:2018/09/13 06:30
通道:真彩云图

Temperature Profile from HIRAS-MWTS-WMHS

9月14日23:30

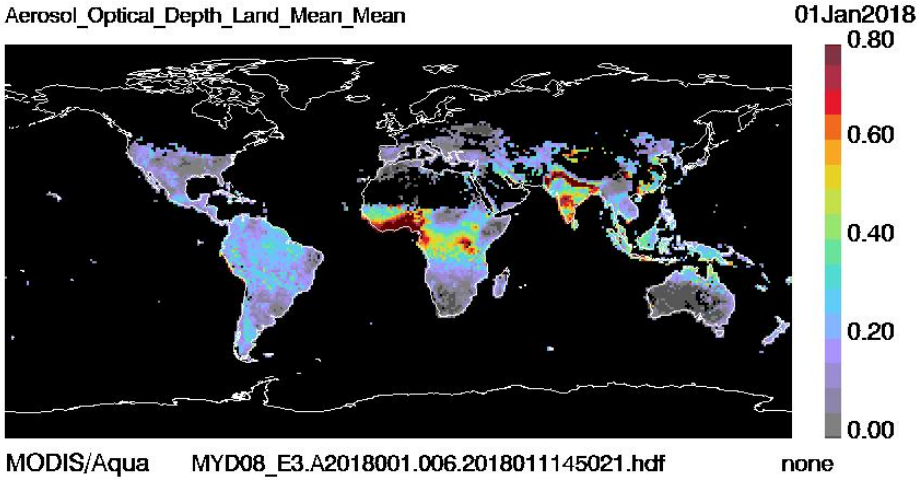


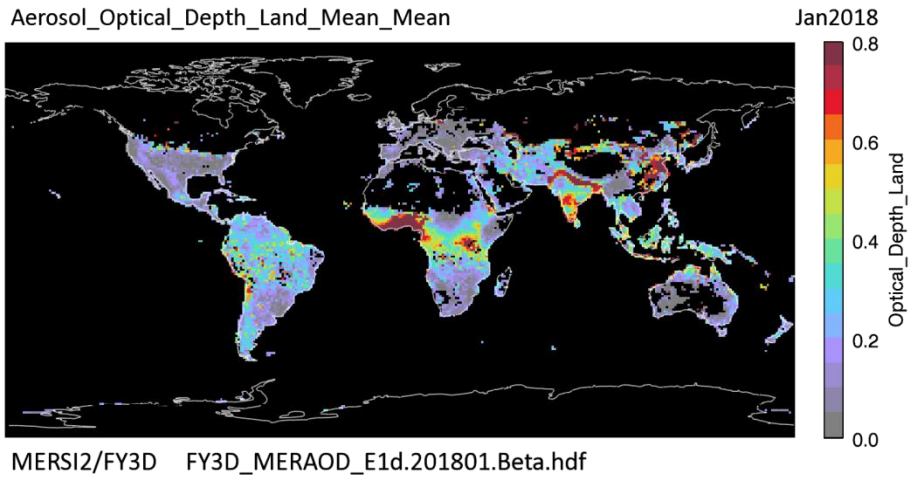
9月14日11:40



Typhoon Mangkhut (1822) 2 hour before landing

Global 8-day-mean product : MERSI II and MODIS land aerosols

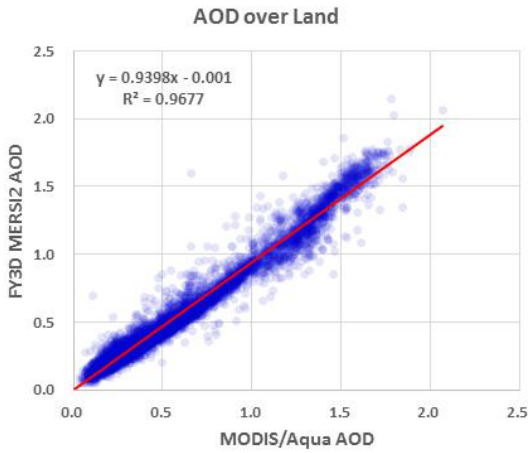




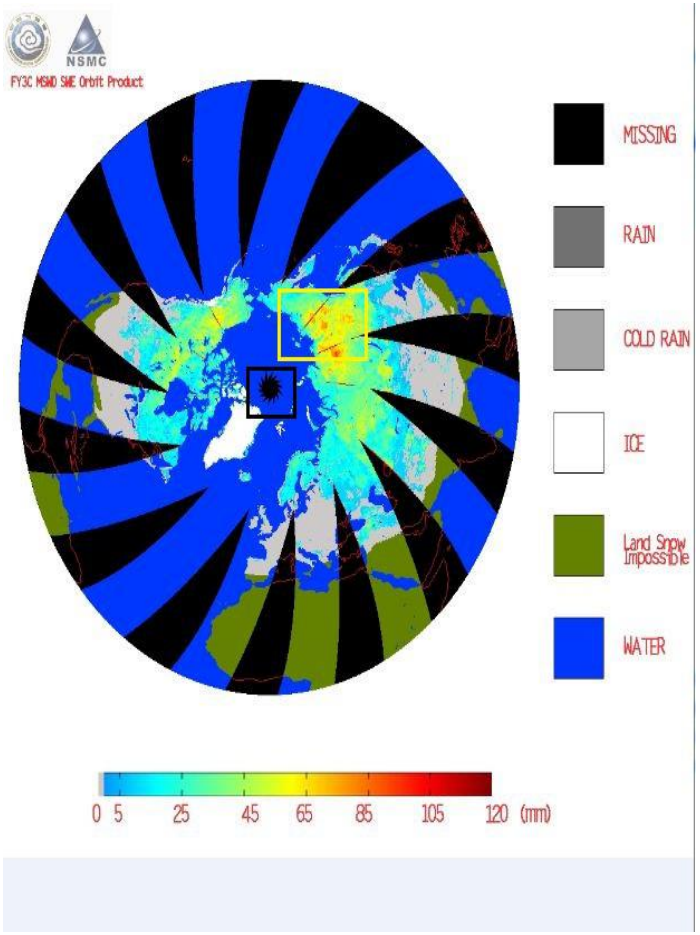
MODIS/Aqua

MERSI2/FY3D

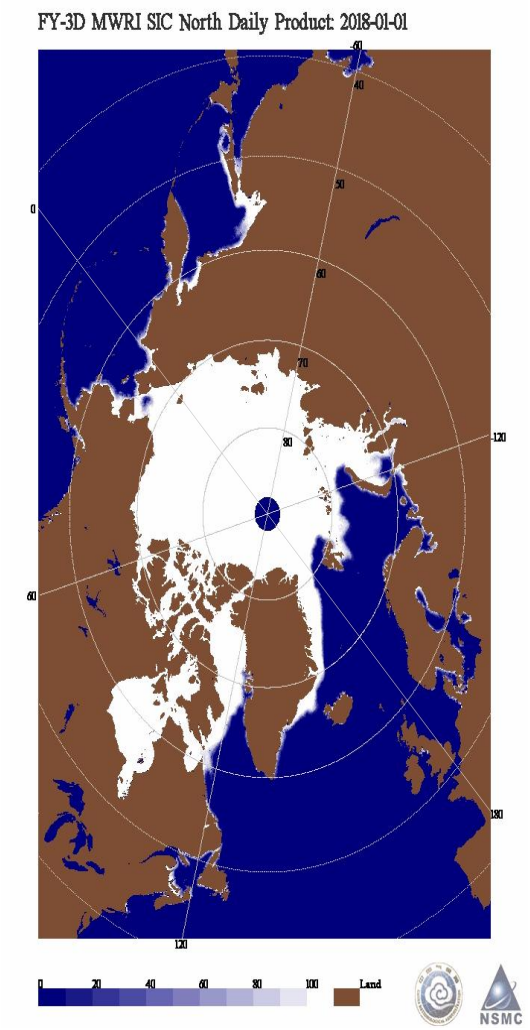
Good consistency in global distribution and AOD of pollution sources.

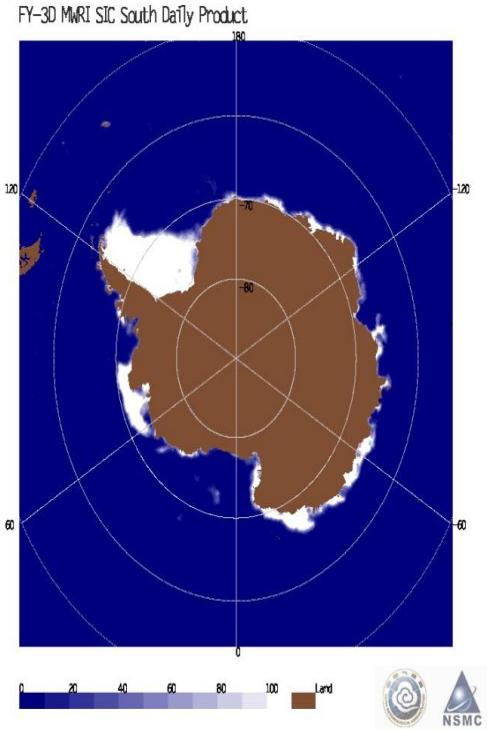


Snow depth/SEW

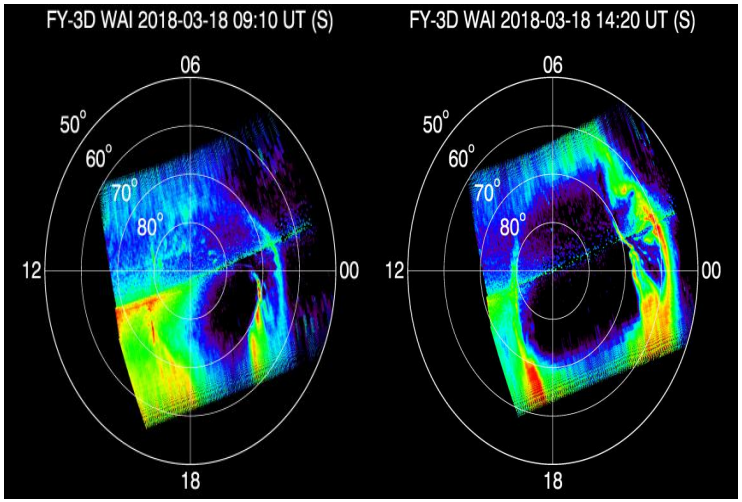


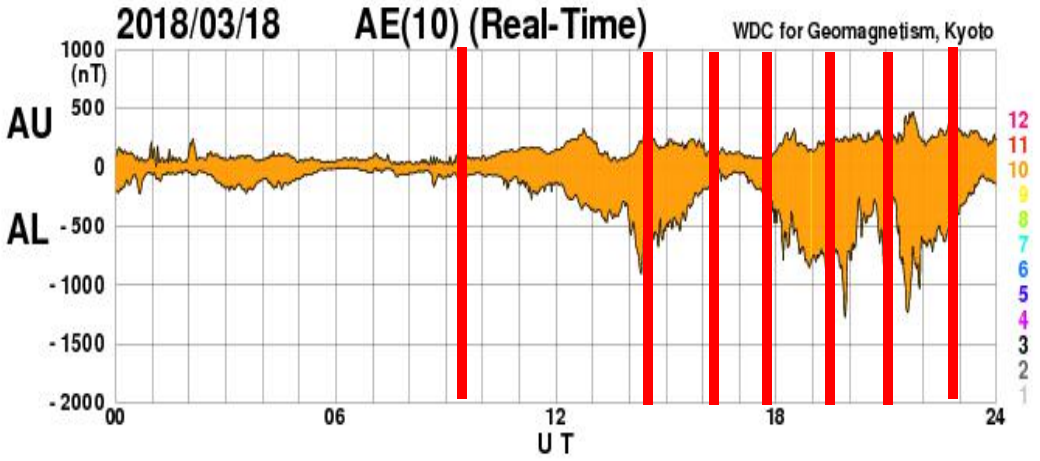
MWRI Sea ice

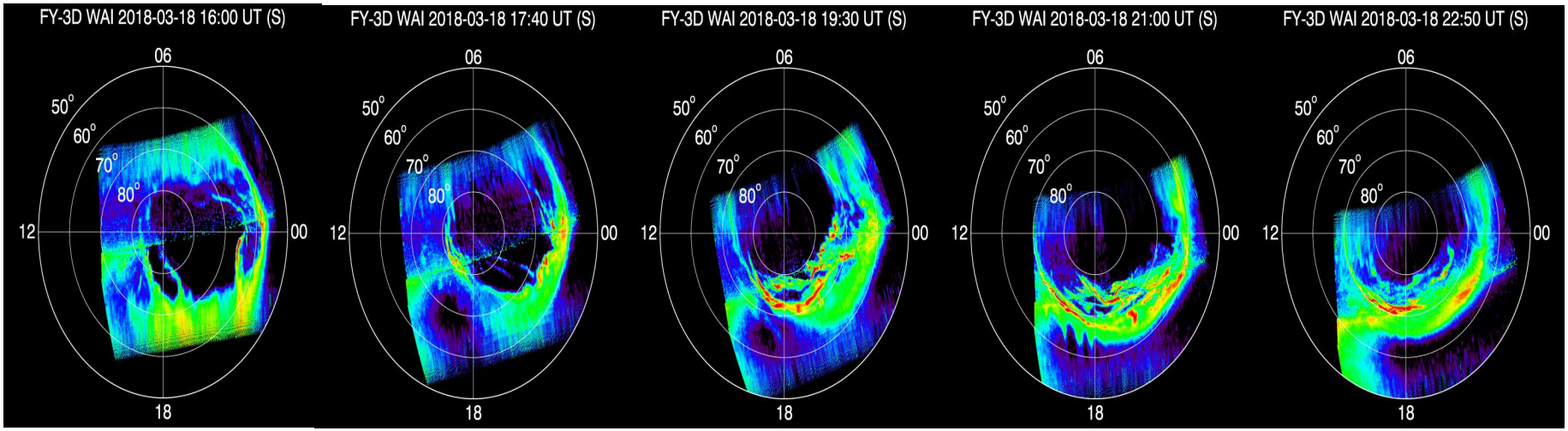




Aurora in the North Polar from WAI







FOLLOW-UP PLAN OF FY-3

No.	Orbit	Status	Launch
FY-3E	Early Morning	Op, planned	2019
FY-3F	PM	Op, planned	2021
FY-3G	AM	Op, planned	2021+(TBD)
FY-3 RM	Inclined	R&D, Planned	2021+(TBD)

Payloads Configuration for FY-3E/F/G and Rainfall Mission

N0.	Sensor Siute	Satellite / Sensor	FY-3E (05) EM Satellite	FY-3F (06) AM Satellite	FY-3G (07) PM Satellite	FY-3R (08) Rainfall Satellite
		Scheduled Launch Date	2018	2019	2021	2020
1	Optical Imagers	MERSI	√（III-Low Light）	√（III）	√（III）	√（III-Simplified）
2	Passive Microwave Sensors	MWTS	√	√	√	√
		MWHS	√	√	√	√
		MWRI		√	√	√
3	Occultation Sounder	GNOS	√	√	√	√
4	Active Microwave Sensors	WindRAD	√	√		
		Rainfall RAD				√
5	Hyperspectral Sounding Sensors	HIRAS	√	√	√	
		GAS (Greenhouse Gases Absorption Spectrometer)			√	
		OMS (Ozone Mapping Spectrometer)		√		
6	Radiance Observation Sensor Suite	ERM		√		
		SIM	√	√		
		SSIM (Solar Spectral Irradiation Monitor)	√			
7	Space Weather Sensor Suite	SEM		√	√	
		Wide Angle Aurora Imager		√	√	
		Ionosphere photometer	√(Multi-angle)	√	√	
		Solar X-EUV Imager	√			

- Improved Medium Resolution Spectrum Imager (MERSI II) in FY-3D, 3E, 3F
- Greenhouse Gases Absorption Spectrometer (GAS) in FY-3D,3F
- Hyper-Spectral Infrared Sounder (HIRAS) will take replace of current IRAS in FY-3D,F
- Sea Surface Wind Radar (WindRAD) in FY-3E

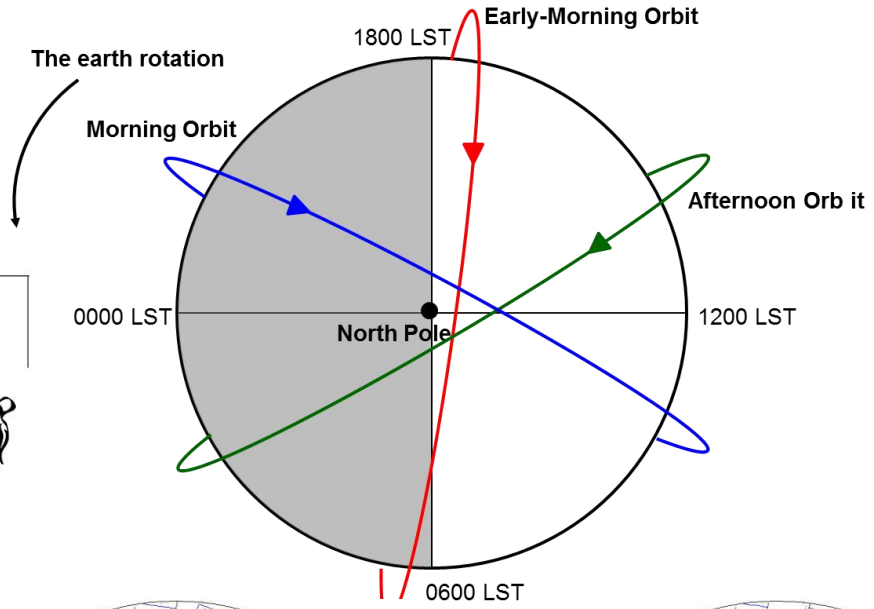
Early-morning orbit satellite is under development

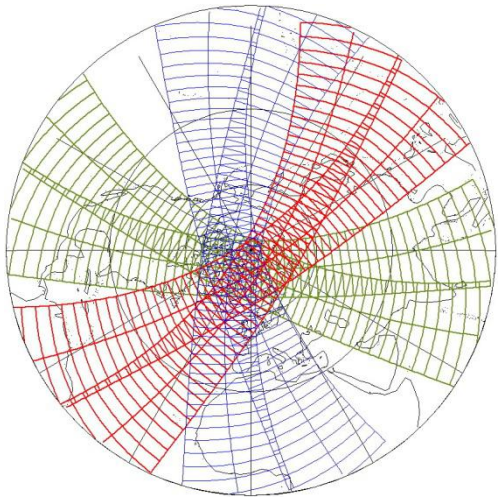
Virtual Constellation for Three Polar Orbits

Assessment of the benefits of a satellite mission in an early morning orbit

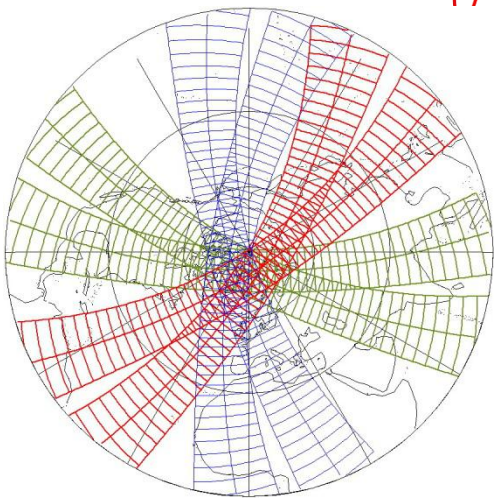
Report from the WMO-CGMS Tiger Team

April 2013

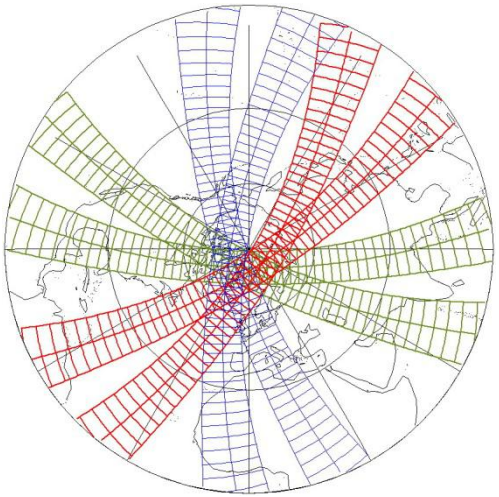




VIS/IR imagery with cross-track scanning - swath 2900 km



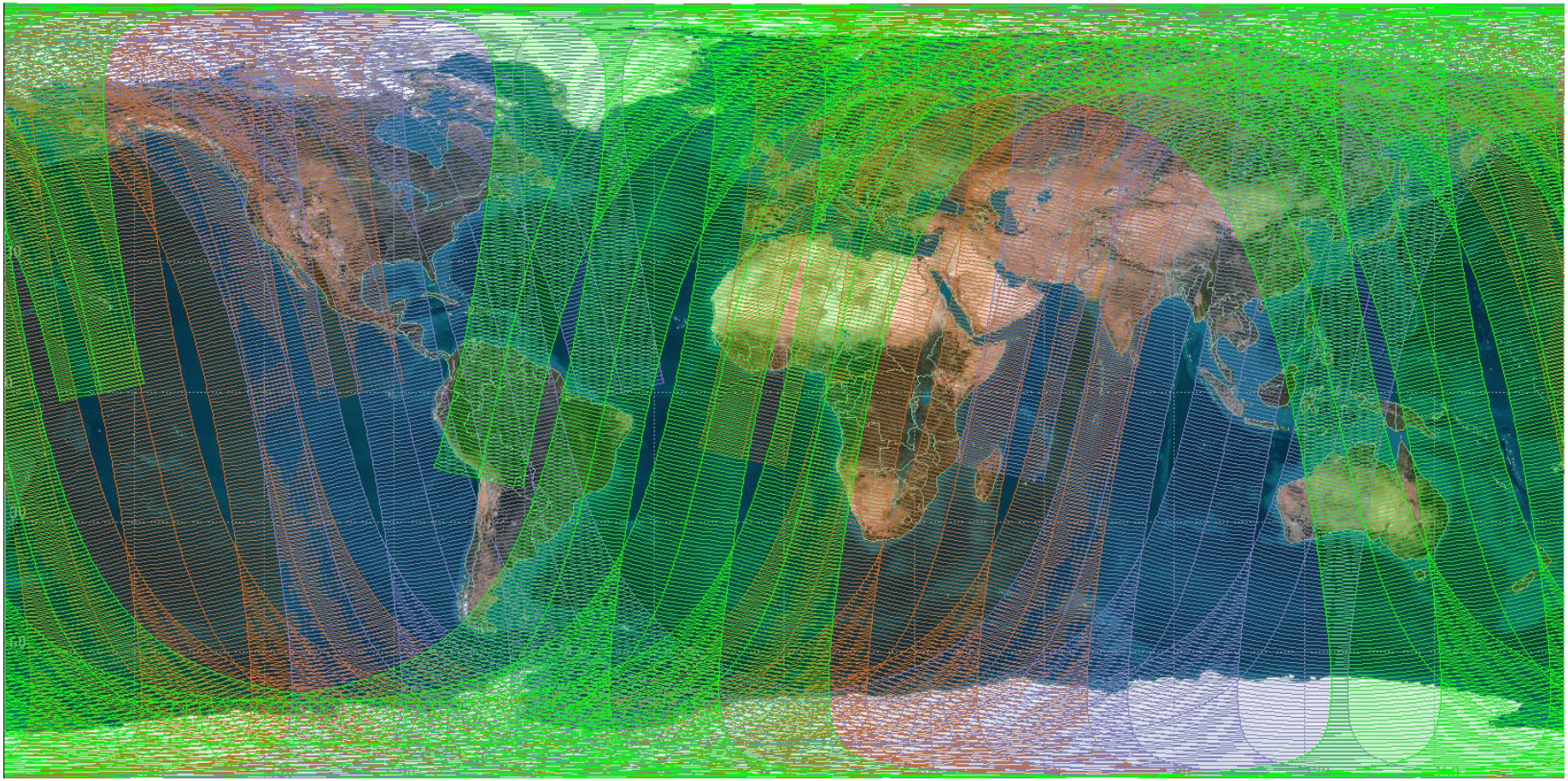
IR/MW sounding with cross-track scanning - swath 2200 km



Microwave radiometer with conical scanning - swath 1700 km

Orbit Option: FY-3 Early Morning + NPP + Metop

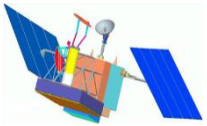
Recognizing that global even distribution of sounding data is of great significance for the 6 hour NWP assimilation window, one approach is to constitute a three orbital fleet including **Metop** (Mid. Morning) **+ NPP** (Afternoon) **+ FY-3** (Early Morning).



FY-3 Early Morning 6:00 AM

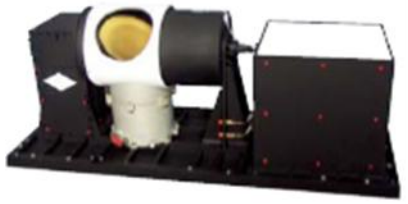
Metop-A 9:30 AM

NPP 13:30 PM

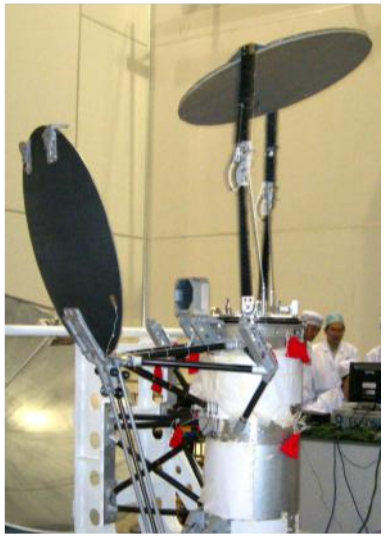


The main objectives of Rainfall Mission

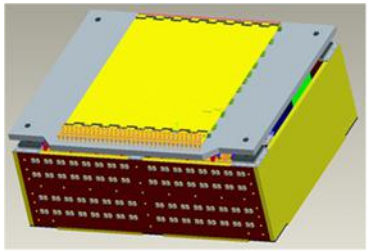
- Consist a Global observation constellation system with FY-3 satellites, as well as GPM satellite
- Improve the severe convective system monitoring ability in china together with GPM satellite
- Provide 3D precipitation structure over both ocean and land
- Improve the sensitivity and accuracy of precipitation measurement over china and surrounding area



MWTS

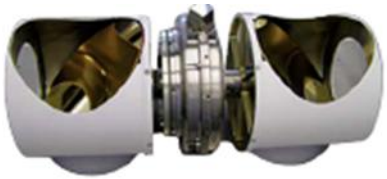


MWRI



KaPR

KuPR



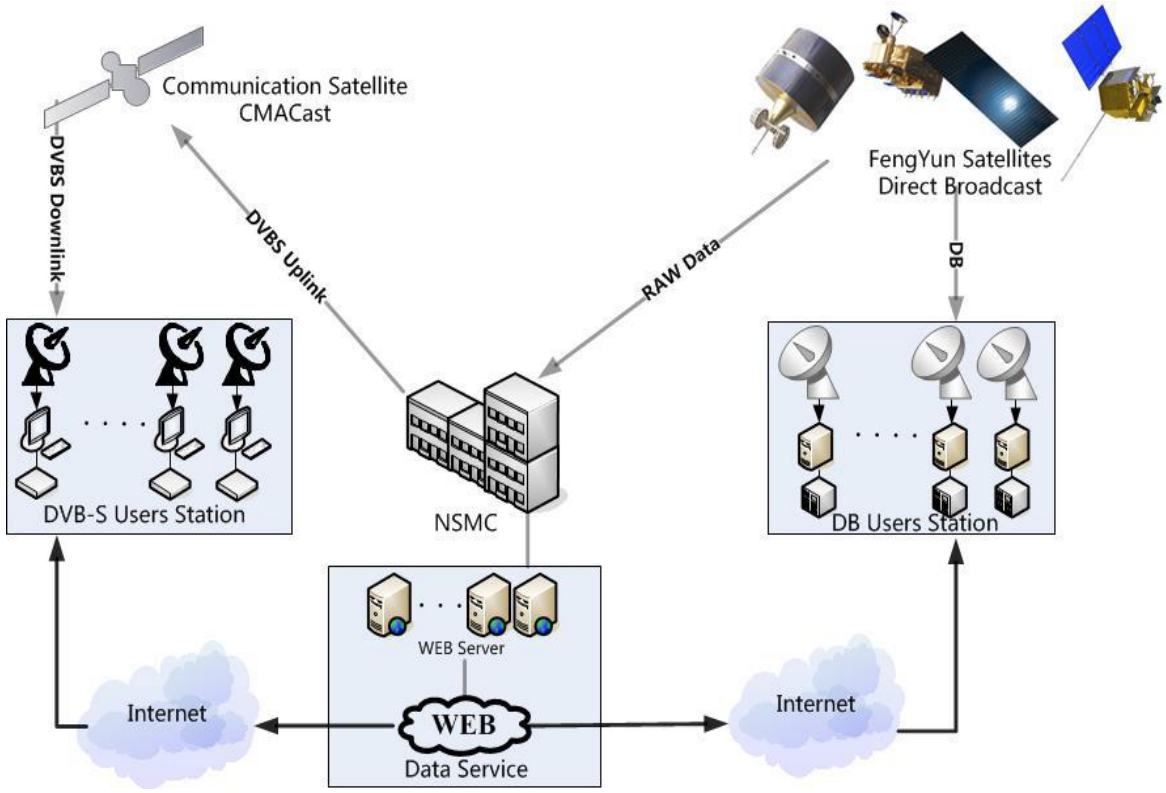
MWHS

FengYun Satellite Data Service

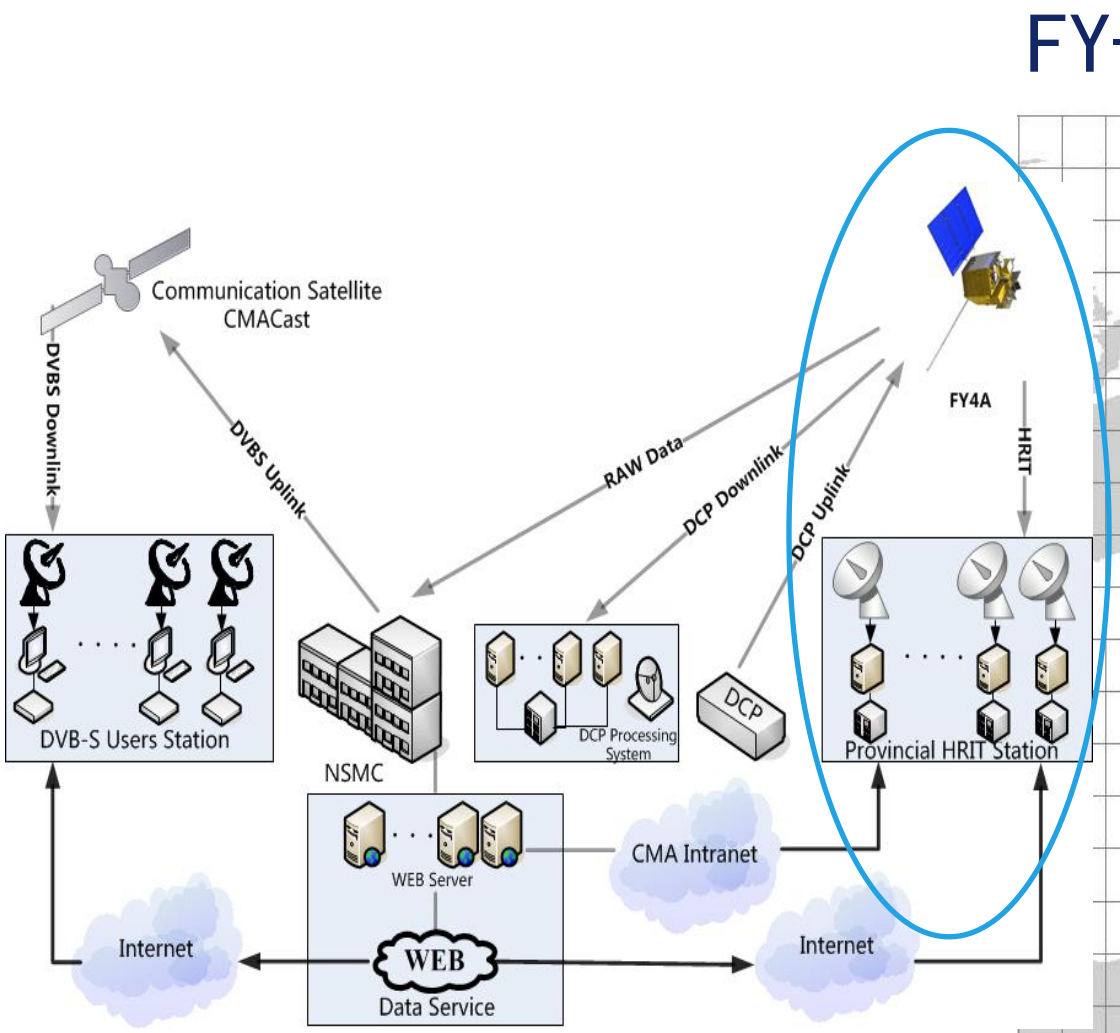
- Integrated Satellite Data Service System

❖ Real time
- Direct Broadcast
- CMACast

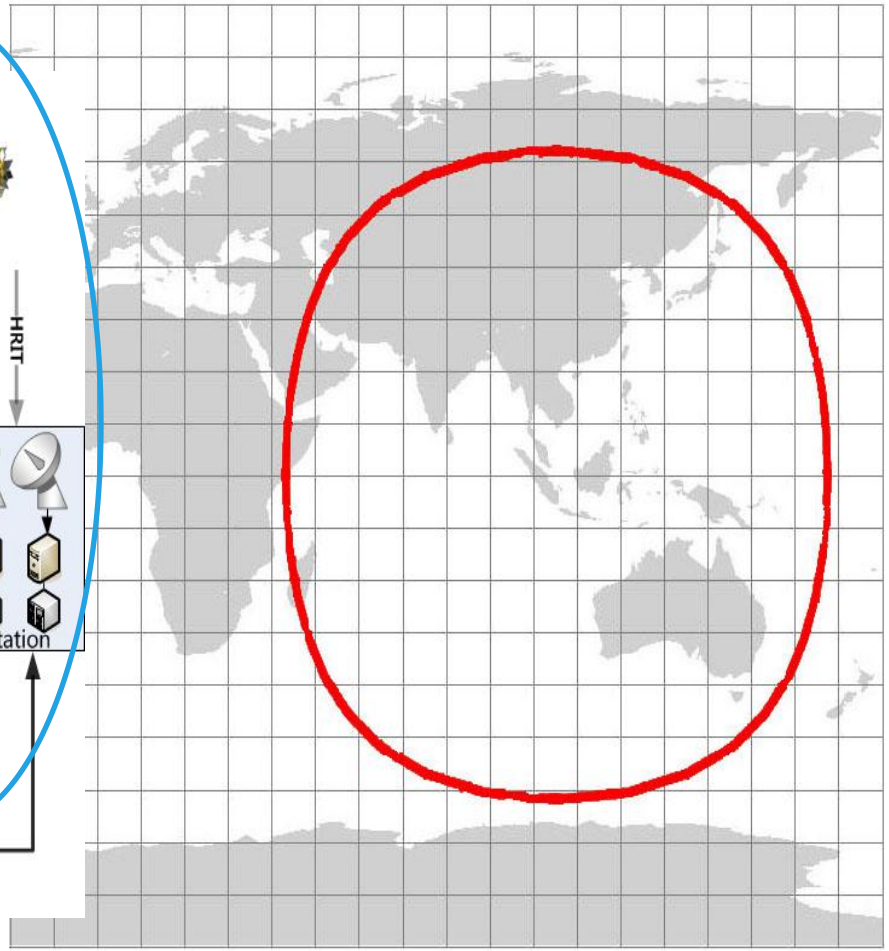
❖ Non-Real Time
- Website
- Cloud Service
- FTP Service
- Manual Service



FY-4A Direct Broadcasting

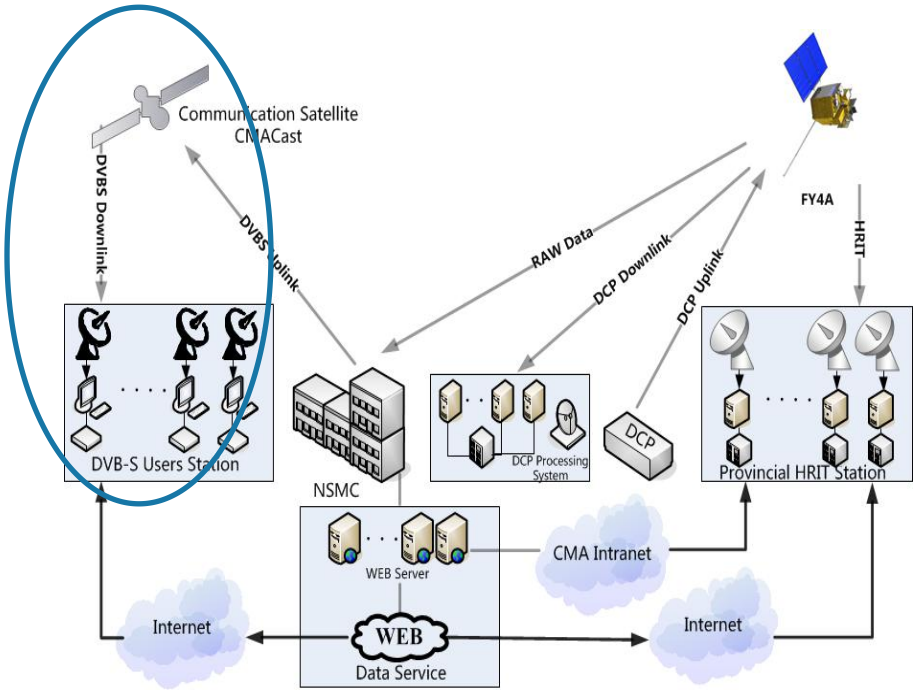


FY-4A DB Coverage



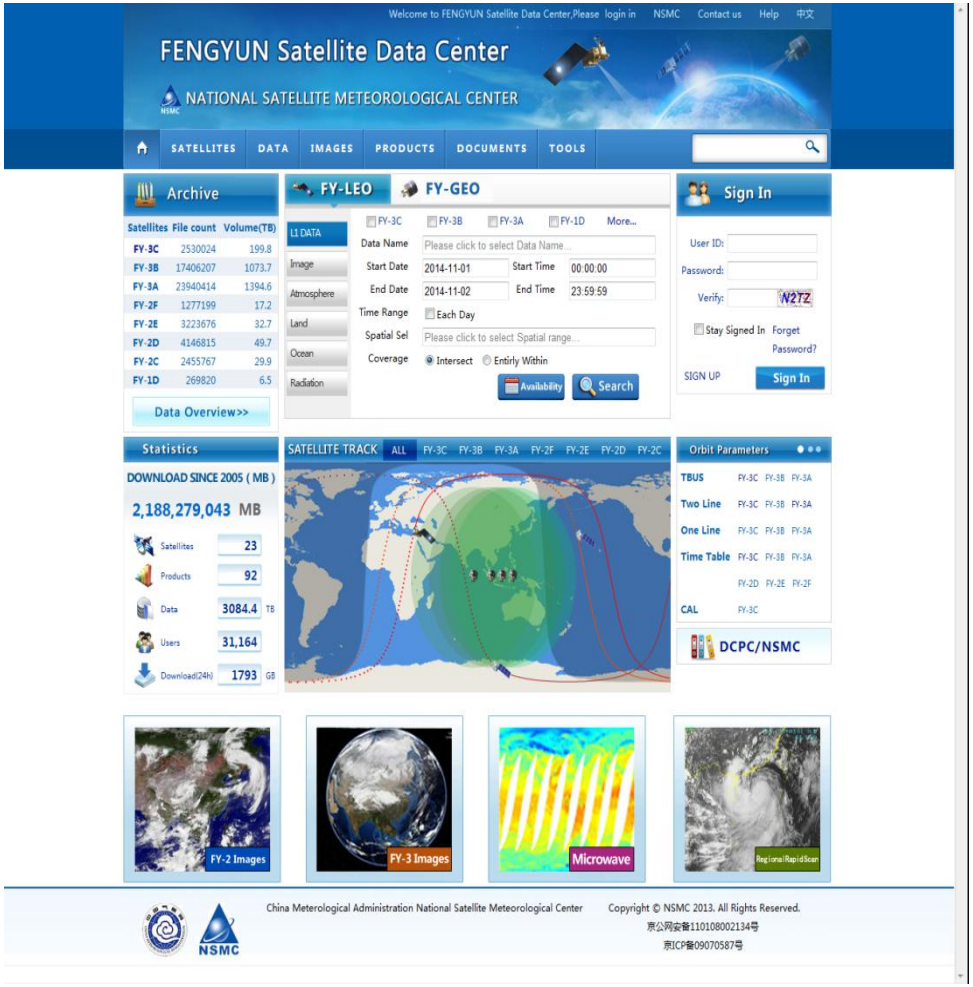
FY4A Data and Product Service via CMACast

- DVBS-2 broadcast system of CMA
- Operated by NMIC
- Meteorological data and Satellite data
- FY-4A datasets distributed by CMACast(1st Part)
- *Also available on NSMC NRT data pool (http://fy4.nsmc.org.cn/data/en/data/realtime.html)*



Satellite	Instrument	Level	Code	Name
FY-4A	AGRI	L1	FDI	AGRI L1 500m Data
		L1	FDI	AGRI L1 1km Data
		L1	FDI	AGRI L1 2km Data
		L1	FDI	AGRI L1 4km Data
		L1	GEO	AGRI 4km GEO data
		L2	ACI	Atmospheric Correction Image
		L2	CLM	Cloud Mask
		L2	CLT	Cloud Type
		L2	DSD	Dust Detection
		L2	OLR	Outgoing Longwave Radiation
		L2	QPE	Quantitative Precipitation Estimation
		L2	SSI	Surface Solar Irradiance
	GIIRS	L2	AII	Atmosphere Instability Index
			AVP	Atmosphere Vertical Profile
	LMI	L2	LIOE	LMI Events in One Minute

Data Service based on Web



http://satellite.nsmc.org.cn

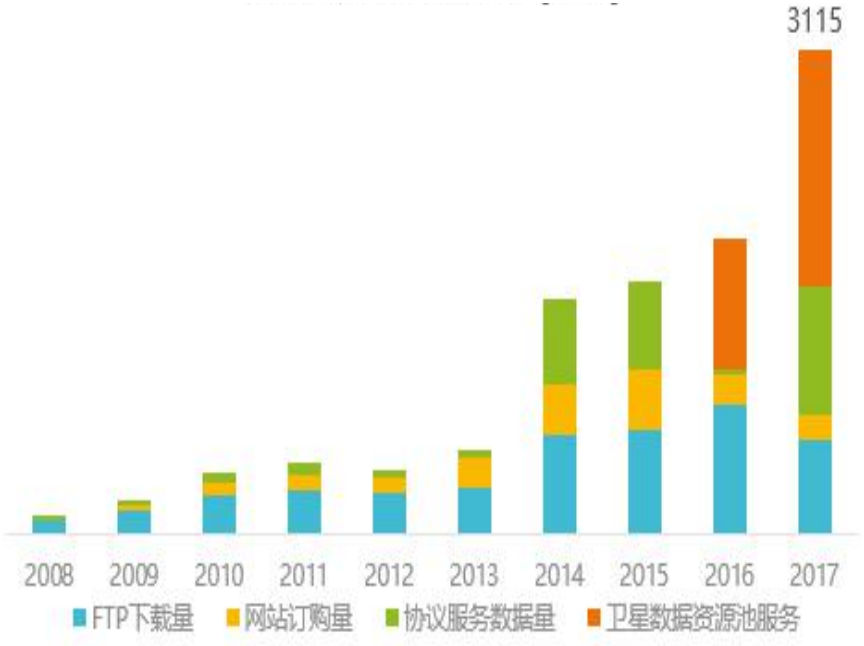
- All 10PB archived data (real time)
- Satellites' information
- Satellite images browse
- Documents and tools

User： freely register, update need authorized

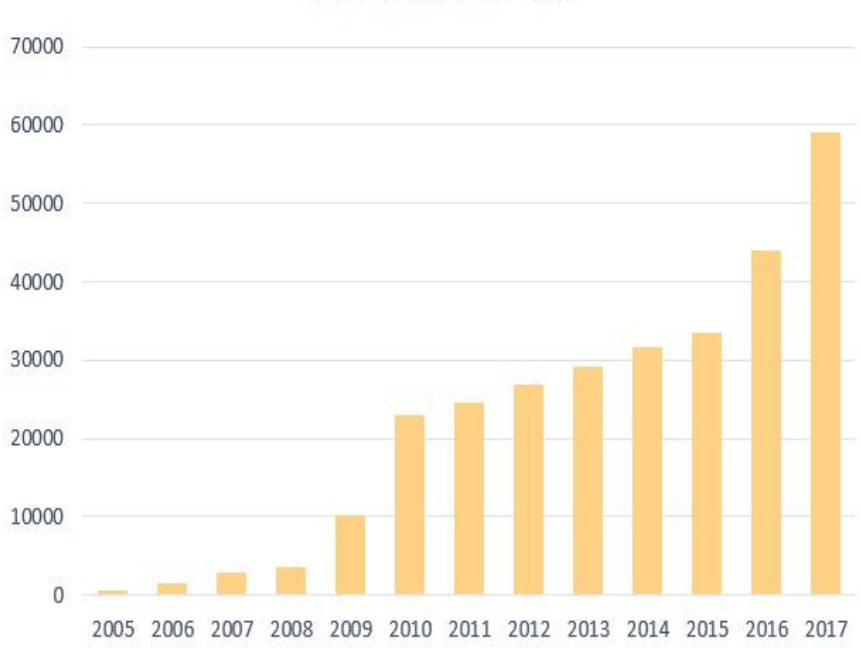
Data Service Web Portal Performance

- By the end of 3rd 2018:
  - Total register users: 67817
  - Total order amount: 55817
- In 2017: 3.1PB data downloaded, 90% FY data

Downloaded Data Amount



User Amount



Develop FY super User Application Station

The Fengyun super User Station will be composed of satellite data receiving facility, data processing platform, data application platform and mobile terminals. It provides direct and efficent approach to access Fengyun satellite data and products.

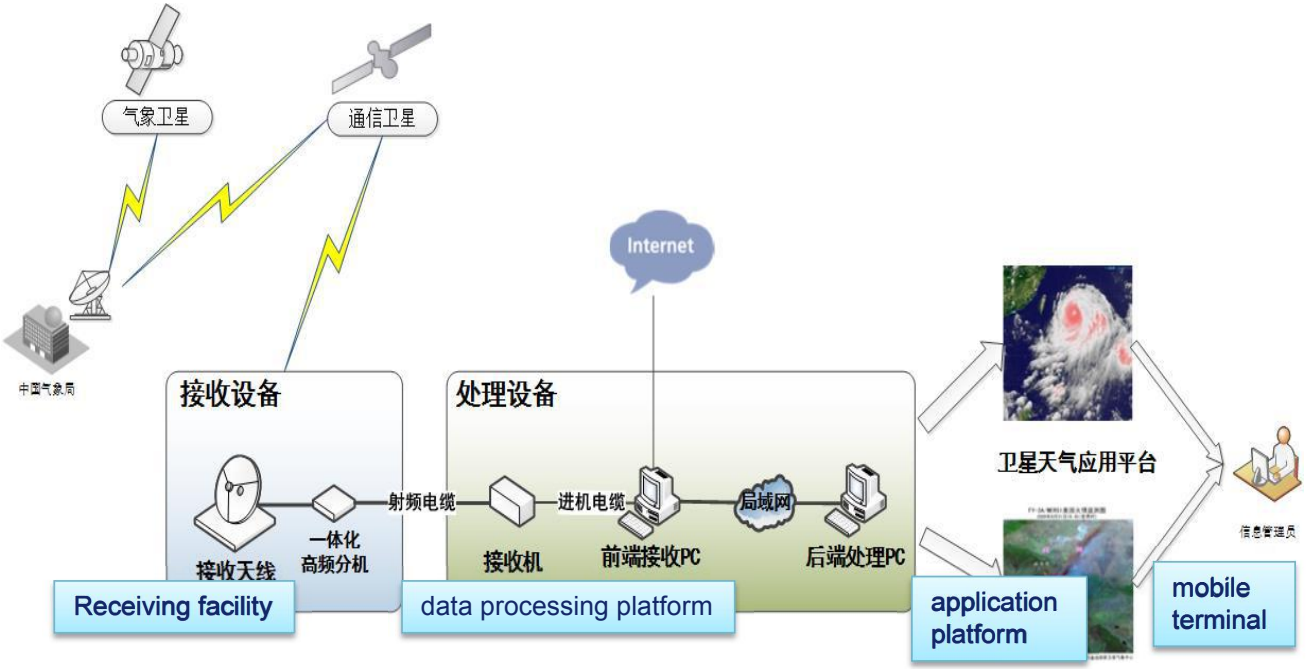


Diagram of FY super User Application Station

Tools - Support for Direct Broadcast

For DB data preprocessing

- FY-3 preprocessing software package is a software system for preprocessing direct broadcast (DB) data from FY-3 series satellites.
- It supports processing DB data of VIRR, MERSI, MWHS, MWTS, IRAS/HIRAS and MWRI from FY-3A, FY-3B , FY-3C, FY-3D.
- It consists of two software packages, FY-3 MPT/HRPT Level-0 data generation software package and FY-3 MPT/HRPT Level-1 data preprocessing software package.
- detail information can be found via http://satellite.nsmc.org.cn.

FY Satellite Application Platform

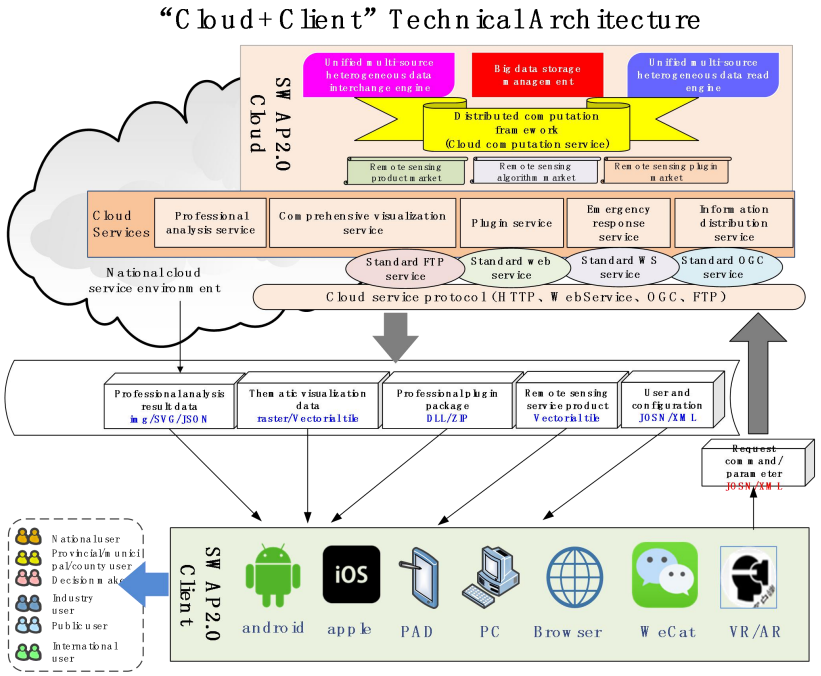
FY Satellite Weather Application Platform（SWAP2.0） is a comprehensive operational platform focusing on geostationary meteorological satellite application.

- It has the function of supporting comprehensive weather forecasting applications using FY-2 , FY-4 data and other multi-source observation data, providing thematic application plugins for typhoon, rain storm, strong convection, etc.

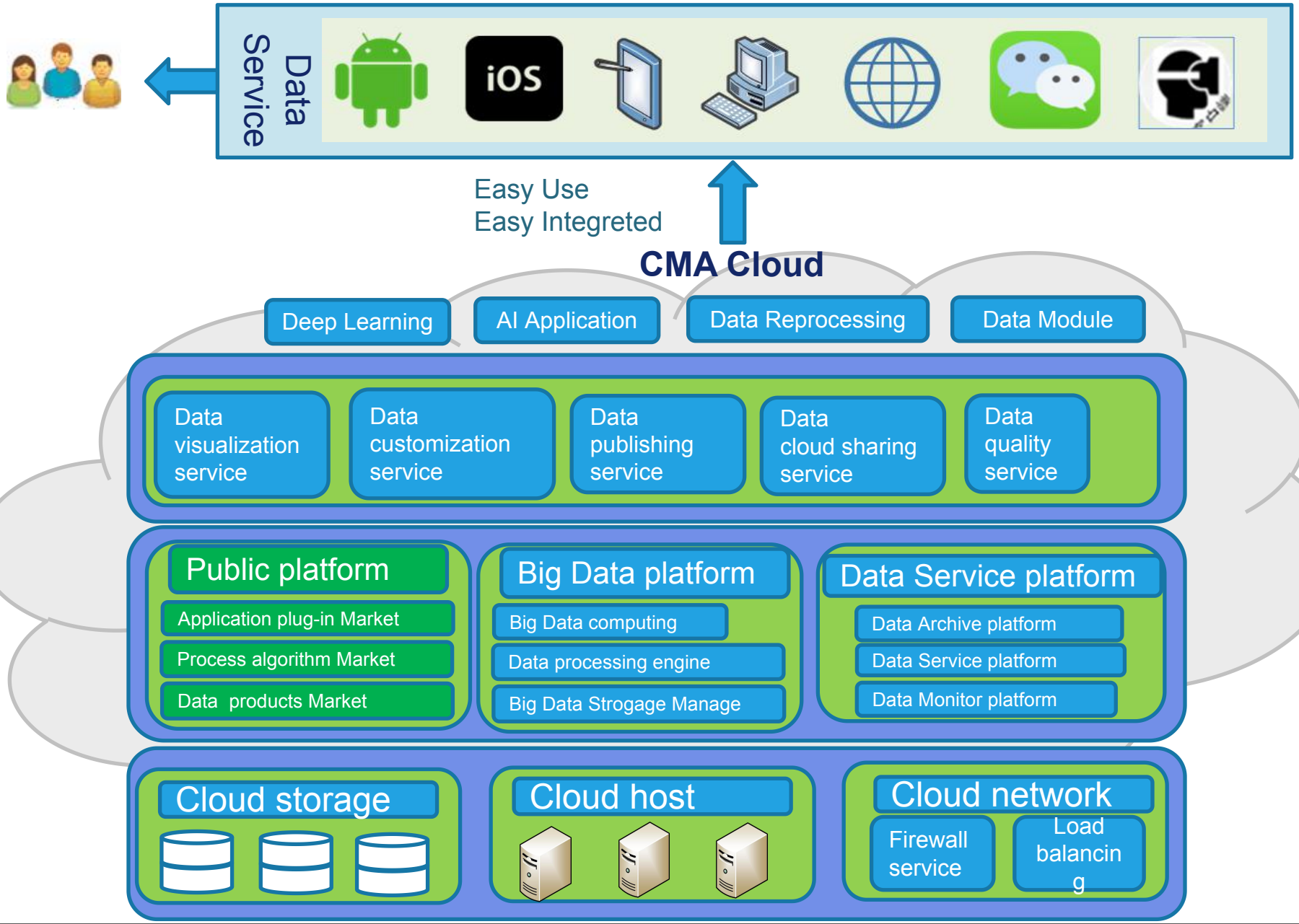
Satellite Monitoring Analysis Remote-sensing Toolkit（SMART 2.0）faces operators and researchers of disaster and environment monitoring. To comprehensive application platform of FY-3 and other polar orbit meteorological satellite data.

- They are based on “Cloud + Client” technical architecture, adopting open plugin concept, currently offering client edition and network edition beta testing software.

“Cloud+Client” TechnicalArchitecture

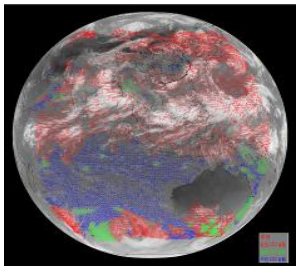


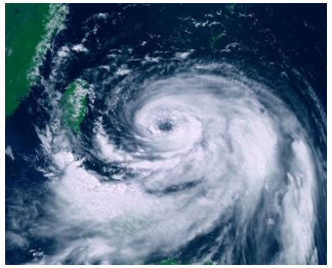
“Cloud + Client” Technology Architecture

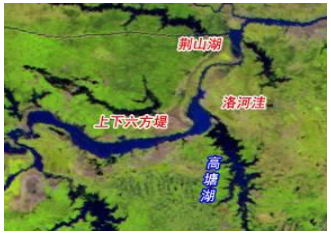


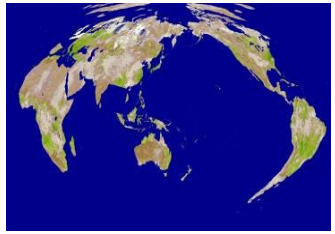
Applications

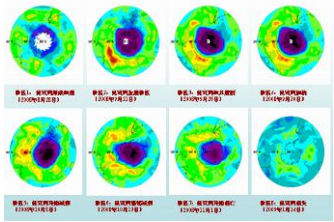
- **Weather Monitoring and Analysis**
  - Tropical Cyclone Monitoring
  - Heavy Rain Monitoring
  - Dust Storm Monitoring
  - Fog Monitoring
- **Natural Disaster Monitoring**
  - Flood Monitoring
  - Fire Monitoring
  - Snow Monitoring
  - Drought Monitoring
- **Environment Monitoring**
  - Vegetation Growth
  - Water Body Change
  - Blue Green Alga Monitoring
  - Sea Ice Monitoring
  - Sea Sedimentation
  - Heat Island Monitoring
  - Atmospheric Composition
- **Global Monitoring**



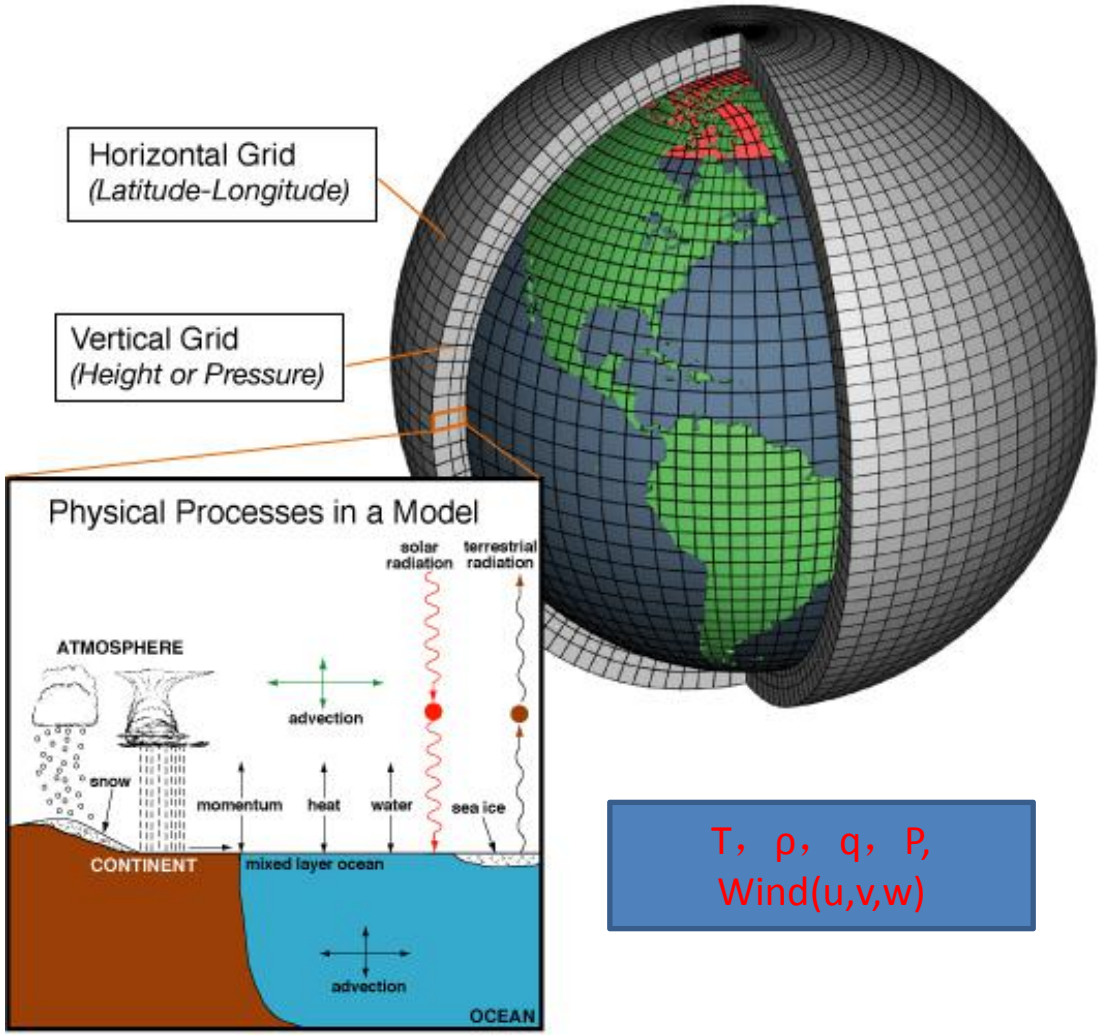








The cornerstone of modern weather prediction: Numerical weather prediction model

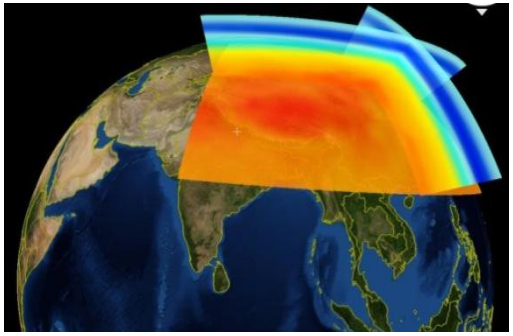


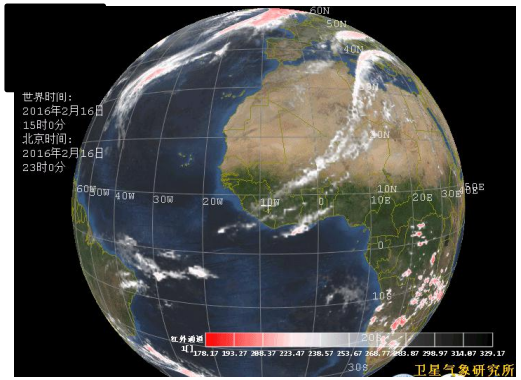
T, ρ, q, P,
Wind(u,v,w)

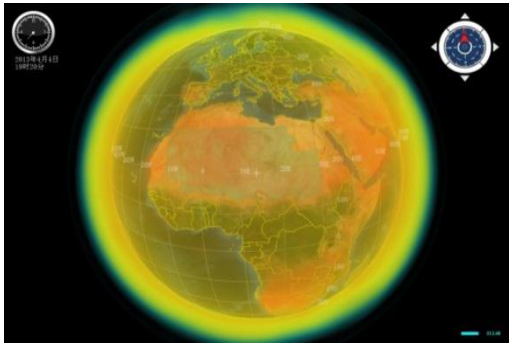
continuity equation
thermodynamic equation
water vapor equation
state equation
dynamic equation （U,V, W）

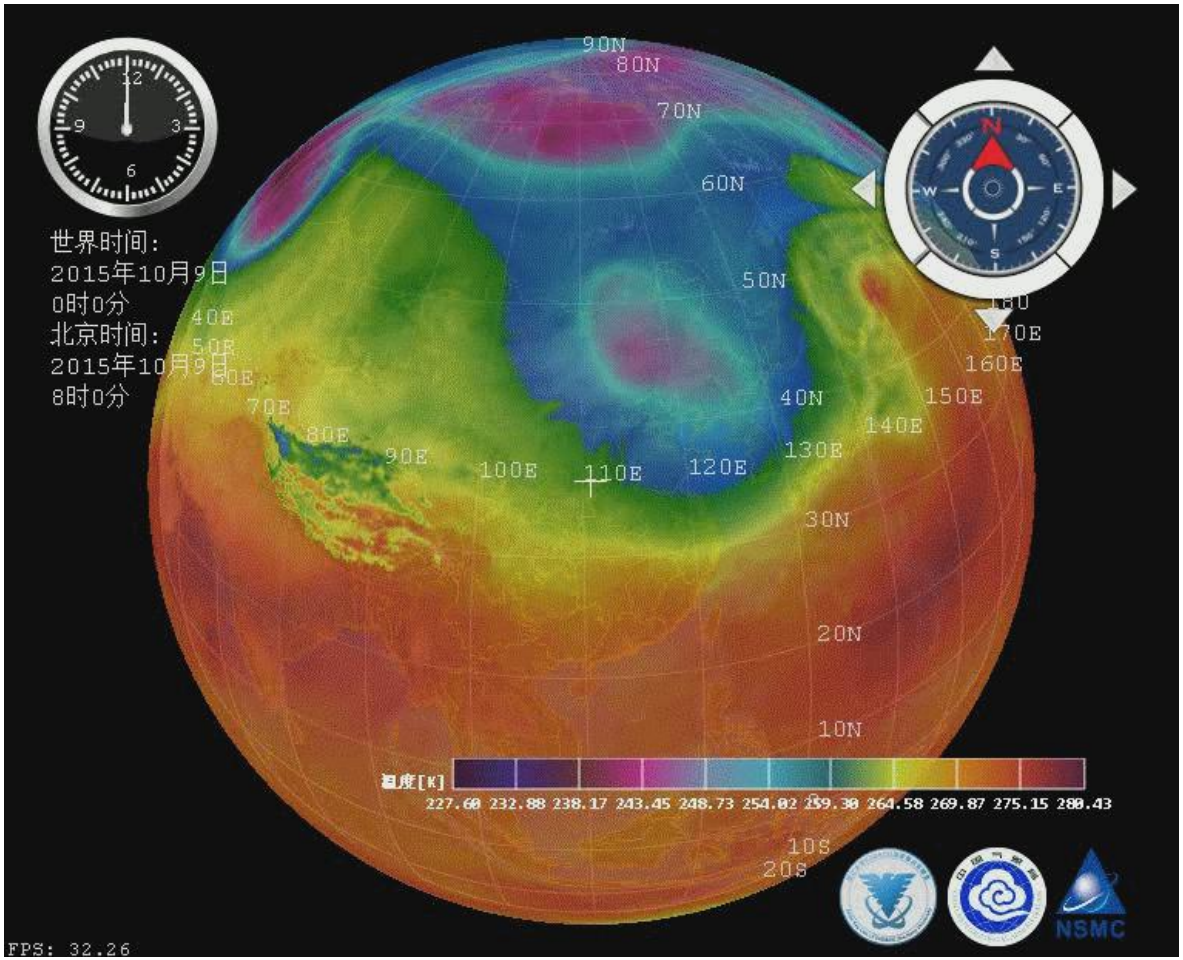
More than 90% initial field data of NWP are from satellites:
Atmospheric physical parameters: temperature, humidity
Atmospheric dynamic parameters: wind

The FY satellite can construct the global three-dimensional structure and dynamics characteristics of atmosphere that can provide a basic data resource for NWP.









Application in NWP models

ECMWF has analysed FY-3A/B data quality through a careful assessment.
….FY-3 meteorological satellite is set to become an increasingly important component of the global satellite system, supporting NWP centers worldwide,…..the date quality ……is now comparable to that from equivalent US and European meteorological satellites.

ECMWF European Centre for Medium-Range Weather Forecasts

Europäisches Zentrum für mittelfristige Wettervorhersage • Centre européen pour les prévisions météorologiques à moyen terme

15 April 2011

Re. **The Status of Data from China's FY-3 Satellite in ECMWF's Forecasting System**

Dear Sir/Madam,

This brief letter outlines the status of ECMWF work on data from the FY-3A Satellite.

Data from the FY-3 series of meteorological satellites is set to become an increasingly important component of the global satellite observing system, supporting NWP centres worldwide. As part of a CMA-ECMWF co-operation agreement data from the first satellite in the series, FY-3A, was assessed at ECMWF during 2009-2011. Much of this work was carried out by a visiting scientist from China's National Satellite Meteorological Center, actively supported by staff from CMA and ECMWF. These ground-breaking investigations led to significant improvements in the quality of the data from the FY-3A Microwave Temperature Sounder (MWTS) instrument. The data quality for the MWTS instrument is now comparable to that from equivalent US and European meteorological satellites.

Pre-operational testing has shown the FY-3A data delivers measurable positive forecast improvements in the ECMWF model, a very stringent test of the data given the global pre-eminence of the ECMWF forecast system. This represents a significant milestone for the FY-3A programme and cooperation with ECMWF. Final pre-operational testing of the FY-3A data is underway and ECMWF plans to use the data operationally in early summer 2011. The scientific work is well documented in a series of Technical Memoranda available from the ECMWF website, and in a series of journal articles.

ECMWF are very appreciative of the support provided by CMA and hope this productive collaboration strengthens in order to support the continued success of the FY-3 program.

Yours faithfully,

Prof. Erland Kallén
Director of Research

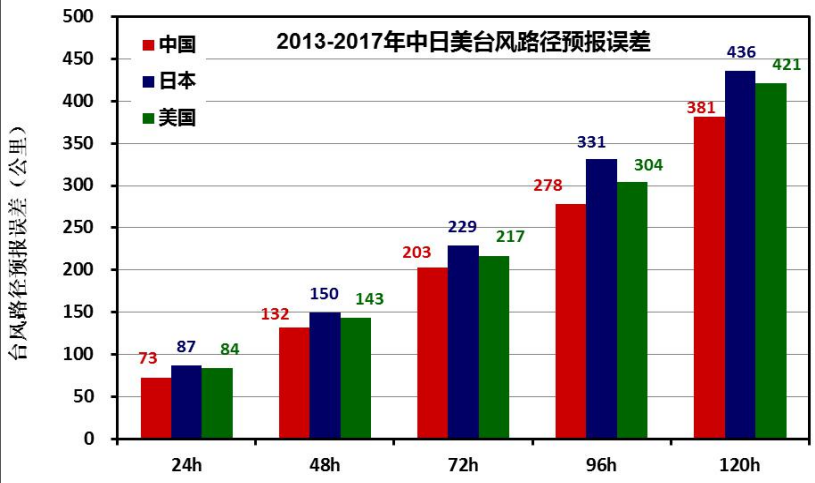
ECMWF, Shinfield Park, Reading, RG2 9AX, England
Tel: +44 (0)118 949 9000 • Fax: +44 (0)118 986 9450 • E-mail: first initial.surname@ecmwf.int • Web: www.ecmwf.int

Progress of application of FY-3 data in model

	FY-3B MWHS	FY-3C MWTS2	FY-3C MWHS2	FY-3C MWRI	FY-3C IRAS	FY-3C GNOS
ECMWF	assimilated	Can be assimilated	assimilated	Will be assimilated	Monitor	evaluated
UKMO	assimilated	Can be assimilated	assimilated	Will be assimilated		evaluated
CMA NWPC	evaluated	Can be assimilated	assimilated	Will be assimilated		assimilated

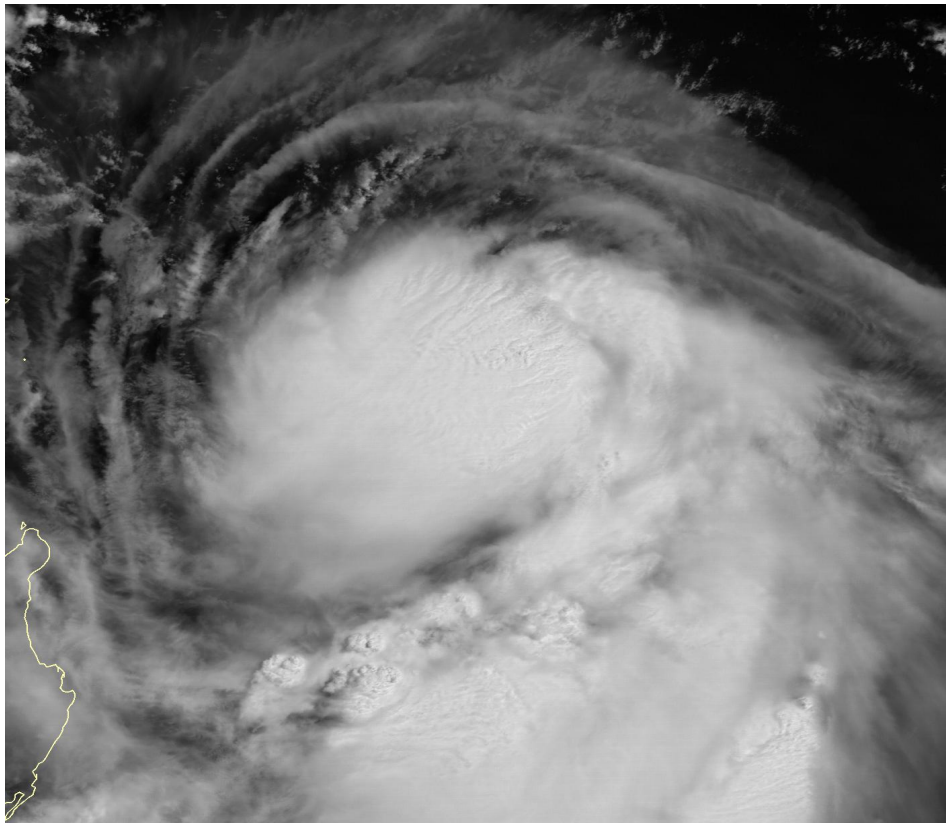
- ✓ On March 15, 2016, the British Meteorological Bureau officially assimilated the FY-3C microwave hygrometer data. On April 4, the ECMWF assimilated the data.
- ✓ Since April 2016, CMA numerical prediction center assimilated FY-3C microwave humidity and GNSS RO data.
- ✓ The data in 2017 were released globally through the BUFR format via the GTS.

The accuracy of typhoon forecast has been improved steadily since the application of FY data.



Mean error of typhoon track prediction in China, Japan and the US in recent five years (2013-2017, unit: km)

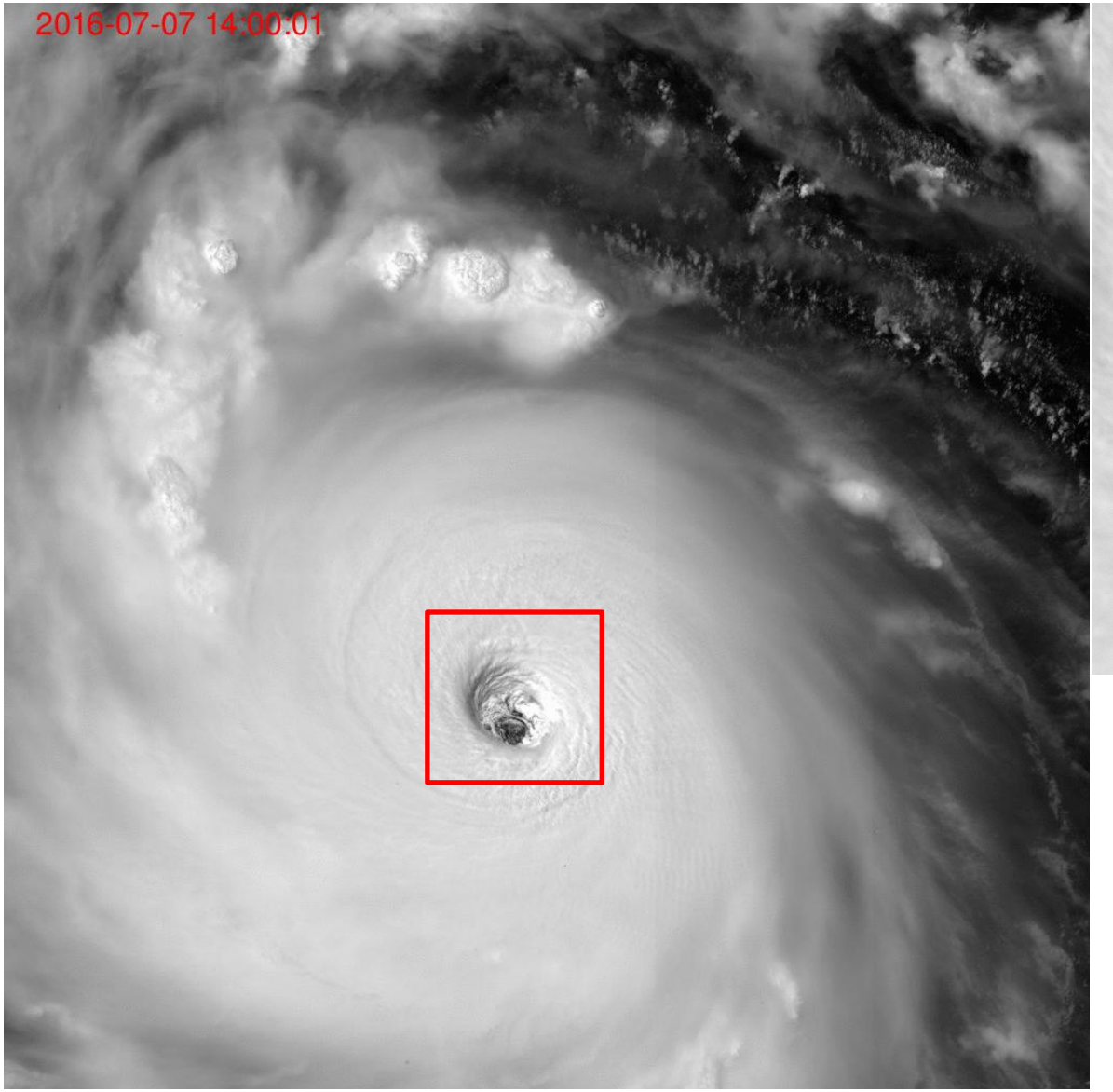
In the past five years (2013-2017), the track error of 24-hour typhoon prediction has been reduced to 73 km, which is 30% less than the average error (109 km) in previous five years (2008-2012). The prediction accuracy from 24 to 120 hours is higher than that of Japan and the US!

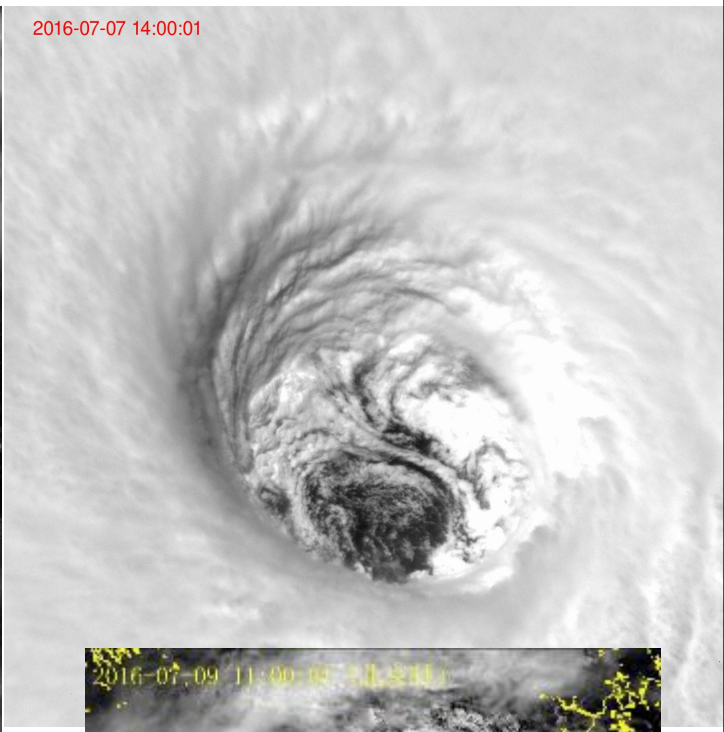


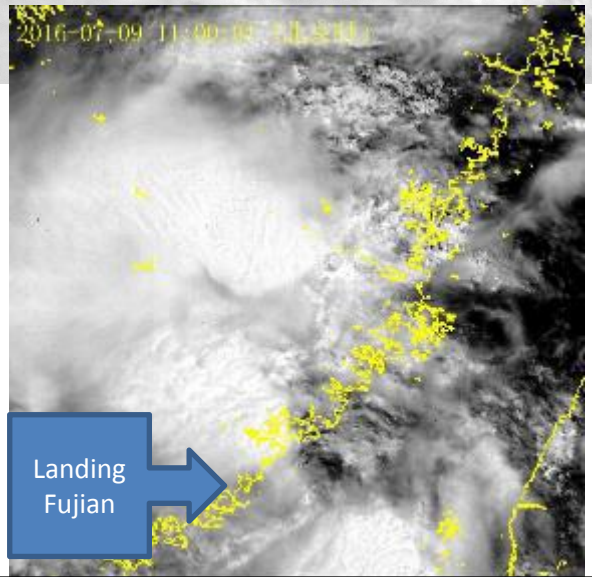
Since the launch of FY satellite, all the typhoon affecting China have been monitored.

High resolution observations reveal fine structure characteristics of typhoon (GF-4)

Typhoon Nepartak (1601)

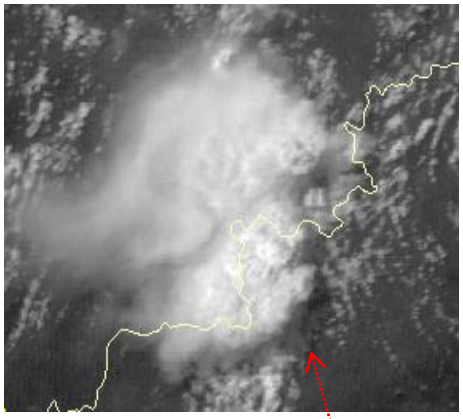


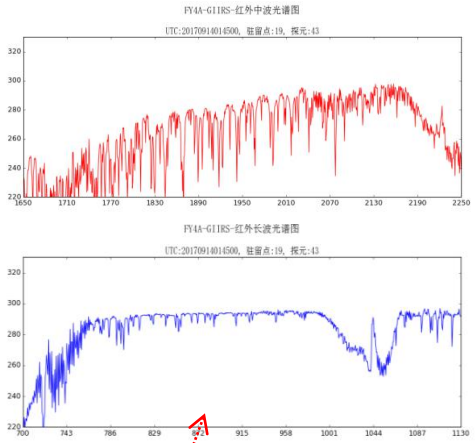


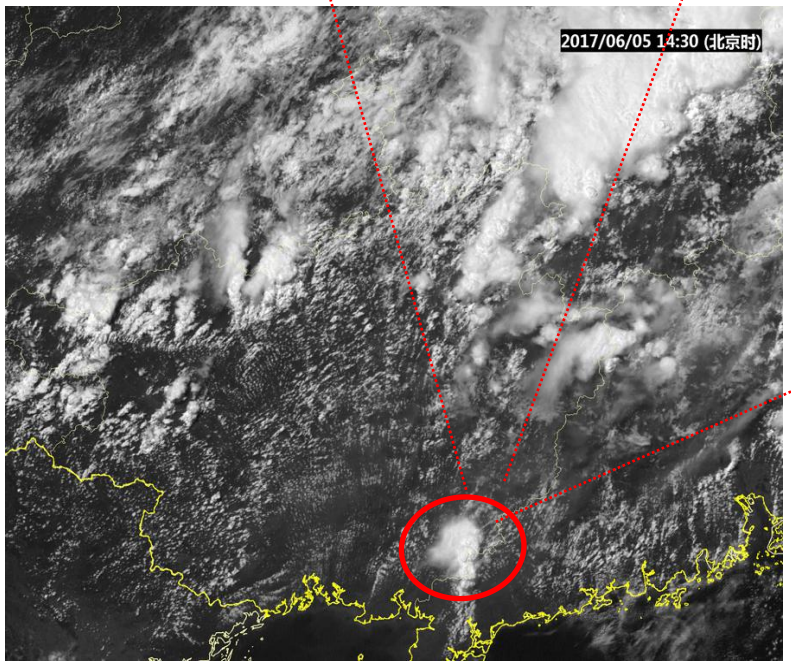


Monitoring of severe convective weather system

AGRI + LMI + GIIRS



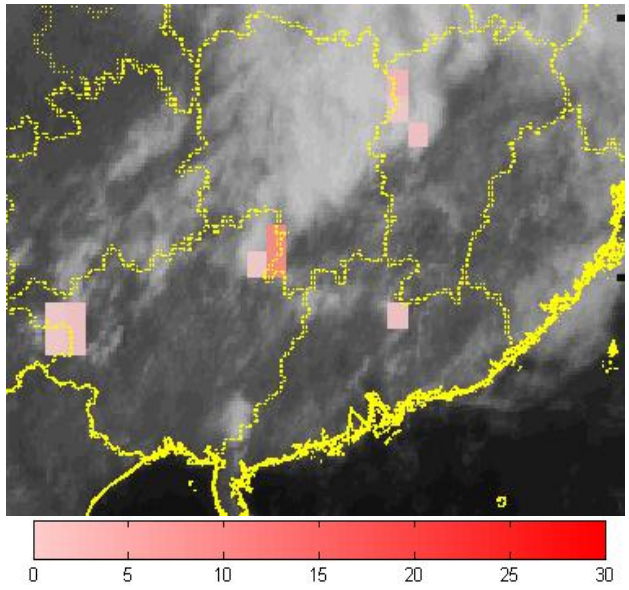




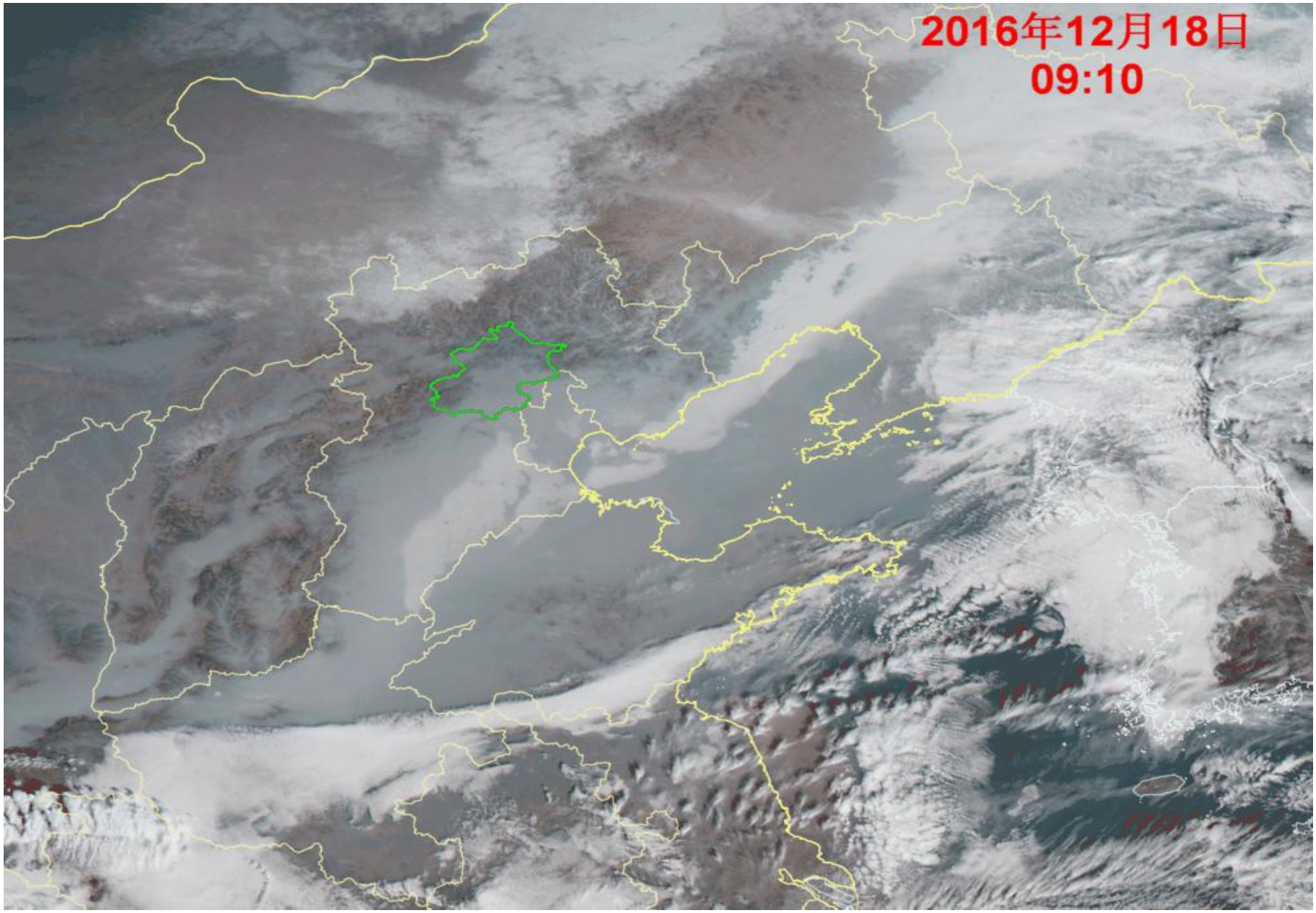
1. FY-4A high spatial resolution imager: fine structure and texture of strong convective cloud clusters; and clear small-scale cumulus line.

2. FY-4A lightning frequency map: strong convective cloud clusters often occur with obvious lightning events.

3. Cloud free atmospheric profile acquired from GIIRS can be used for nowcast warning.

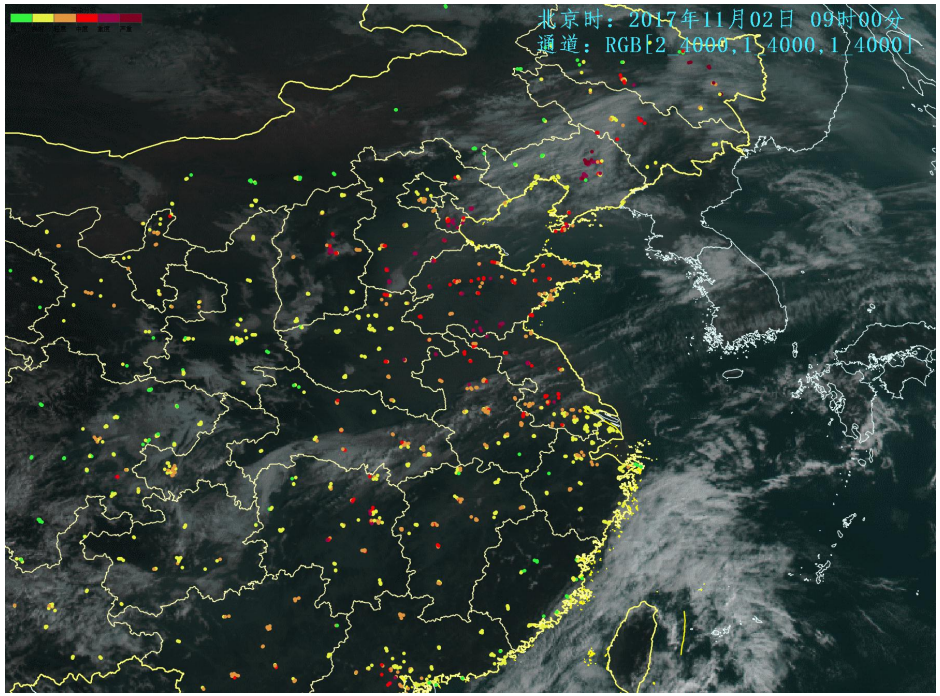


Dynamic detection of fog-haze transformation at minutes interval



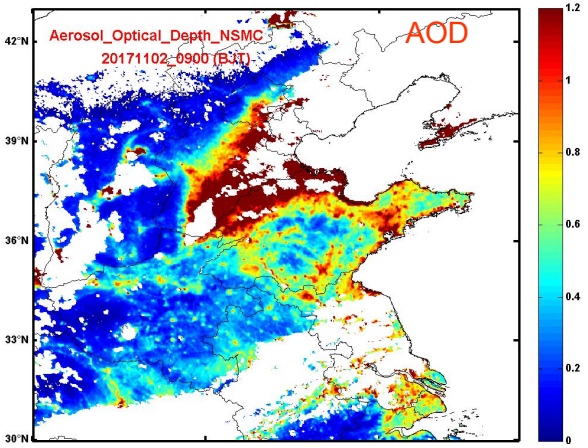
Dynamic remote sensing monitoring of PM2.5

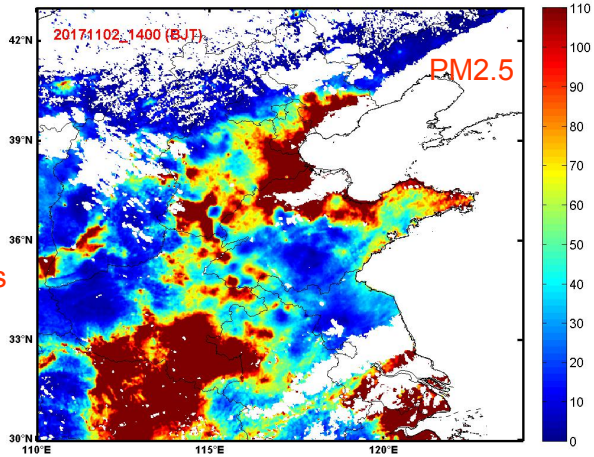
Obtaining distribution PM2.5 in large scope

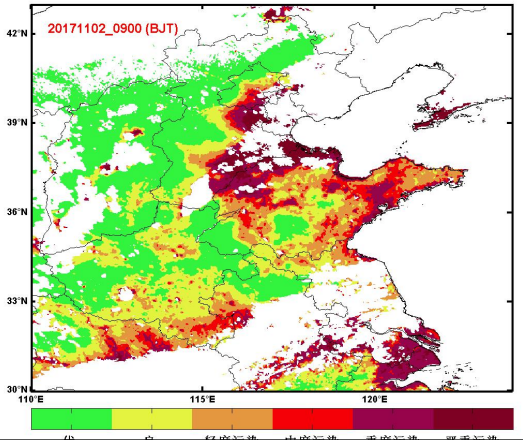


AOD
(extinction of whole atmosphere)

PM2.5
(in situ measurements are directly related to human health)

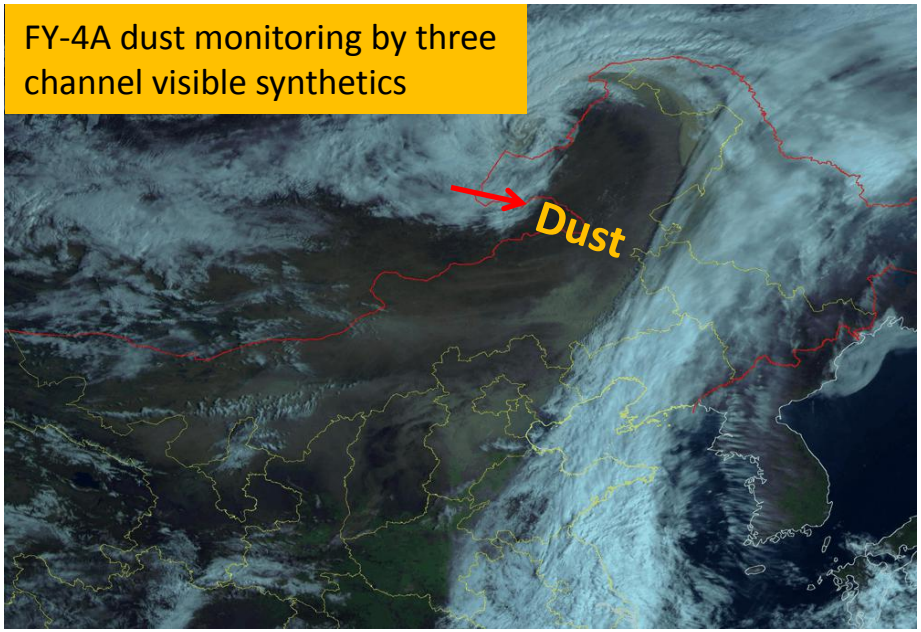


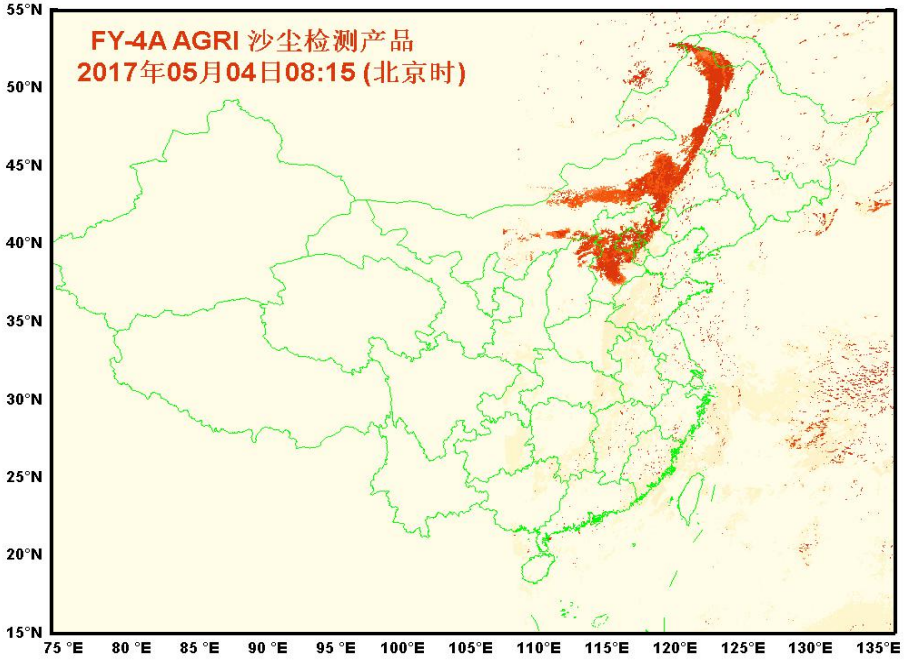




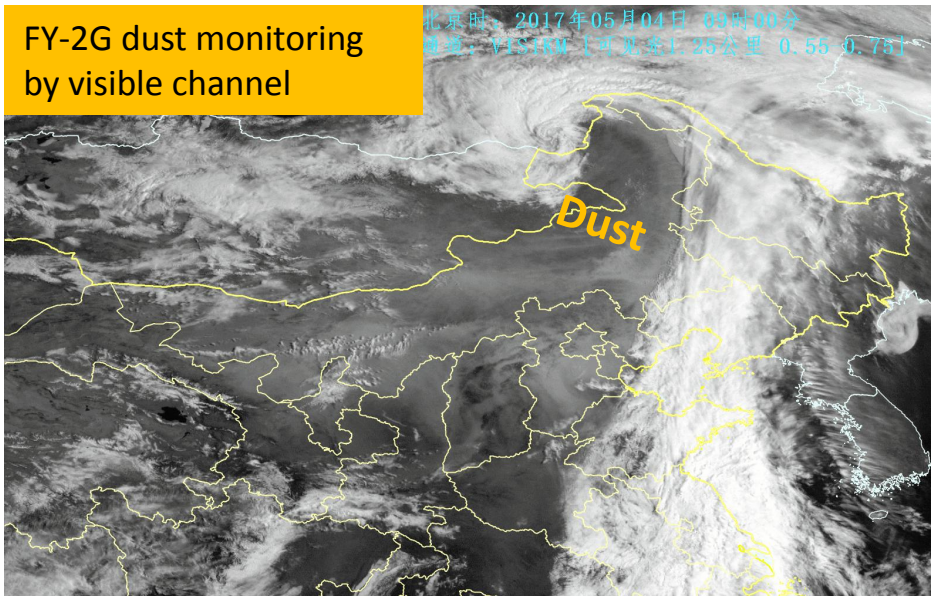
Quantitative remote sensing of dust spread

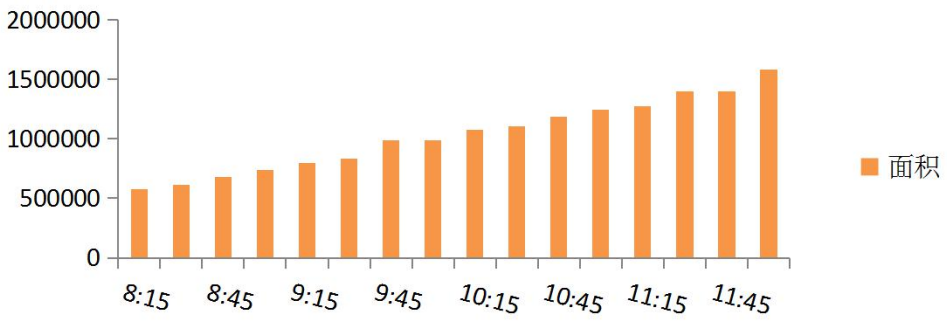
FY-4A dust monitoring by three channel visible synthetics



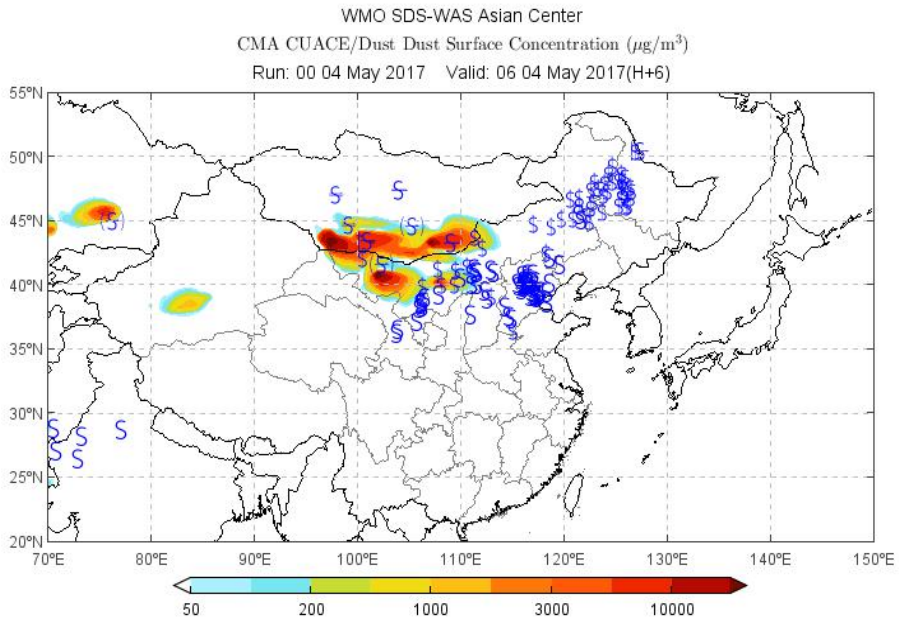


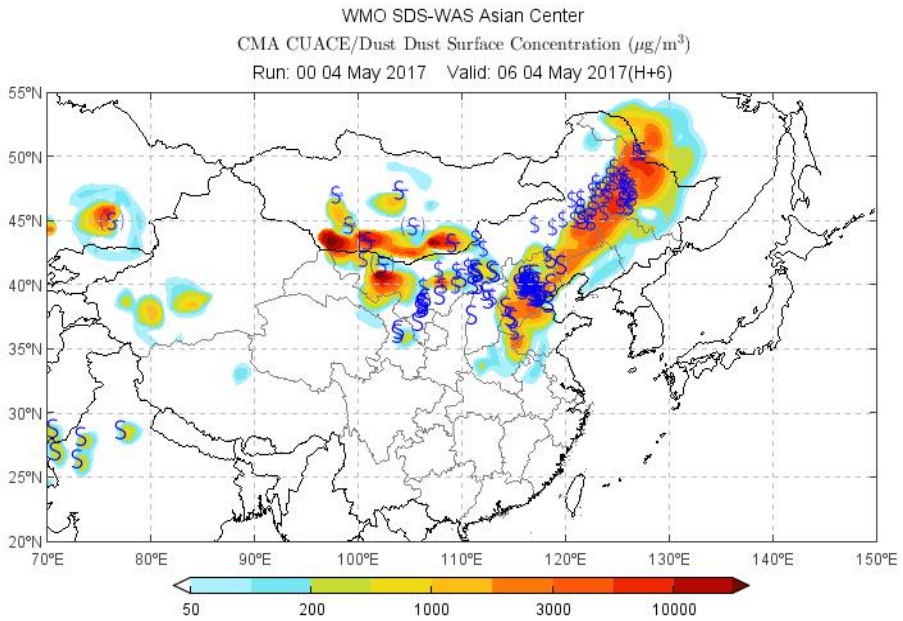
FY-2G dust monitoring by visible channel

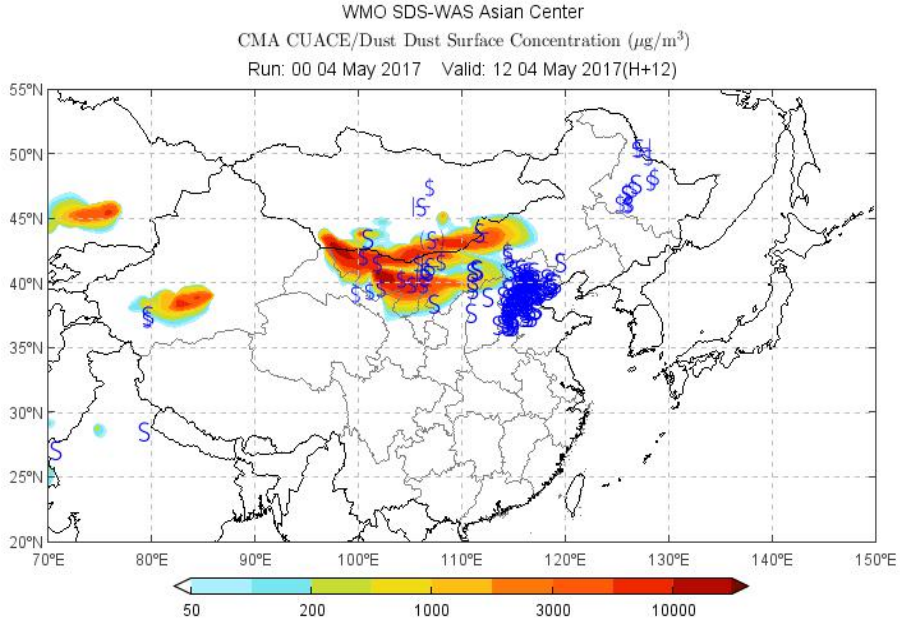




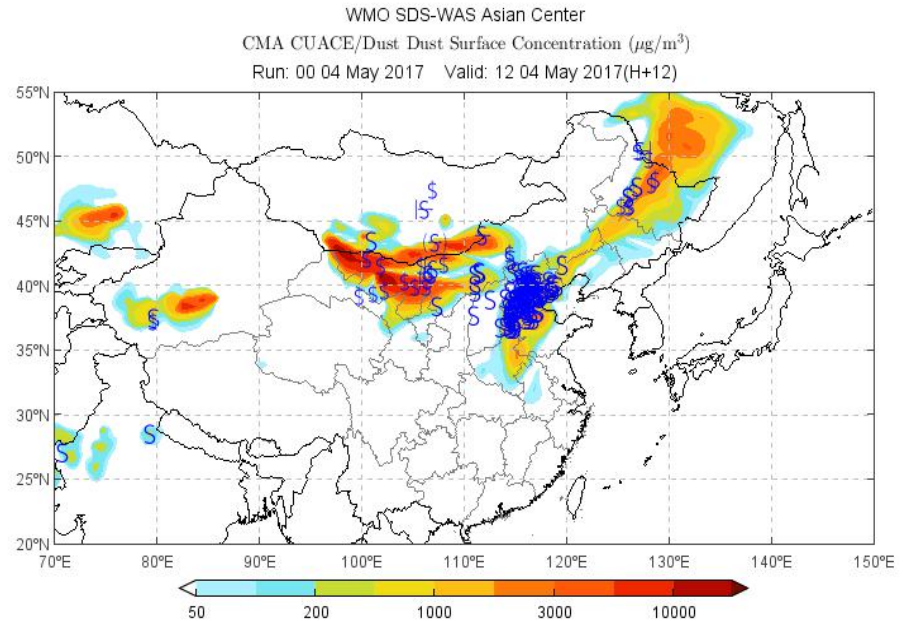
FY-4 aerosol monitoring product can significantly improve the accuracy of quantitative prediction of dust.





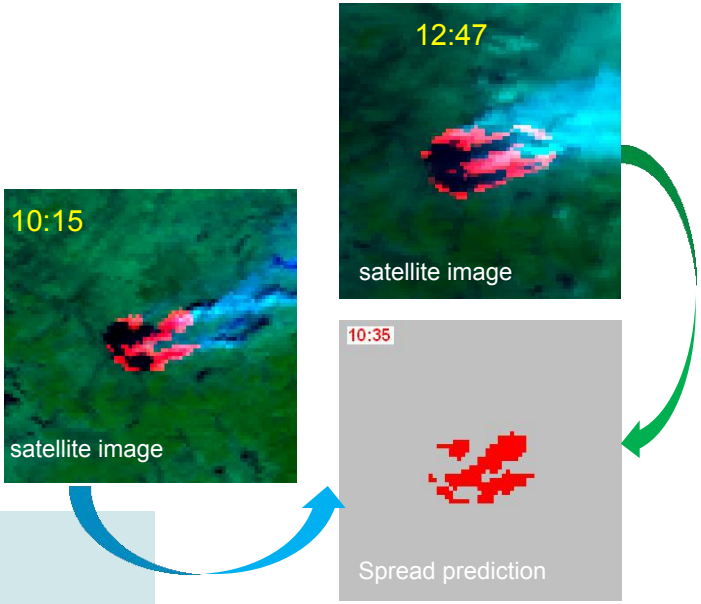


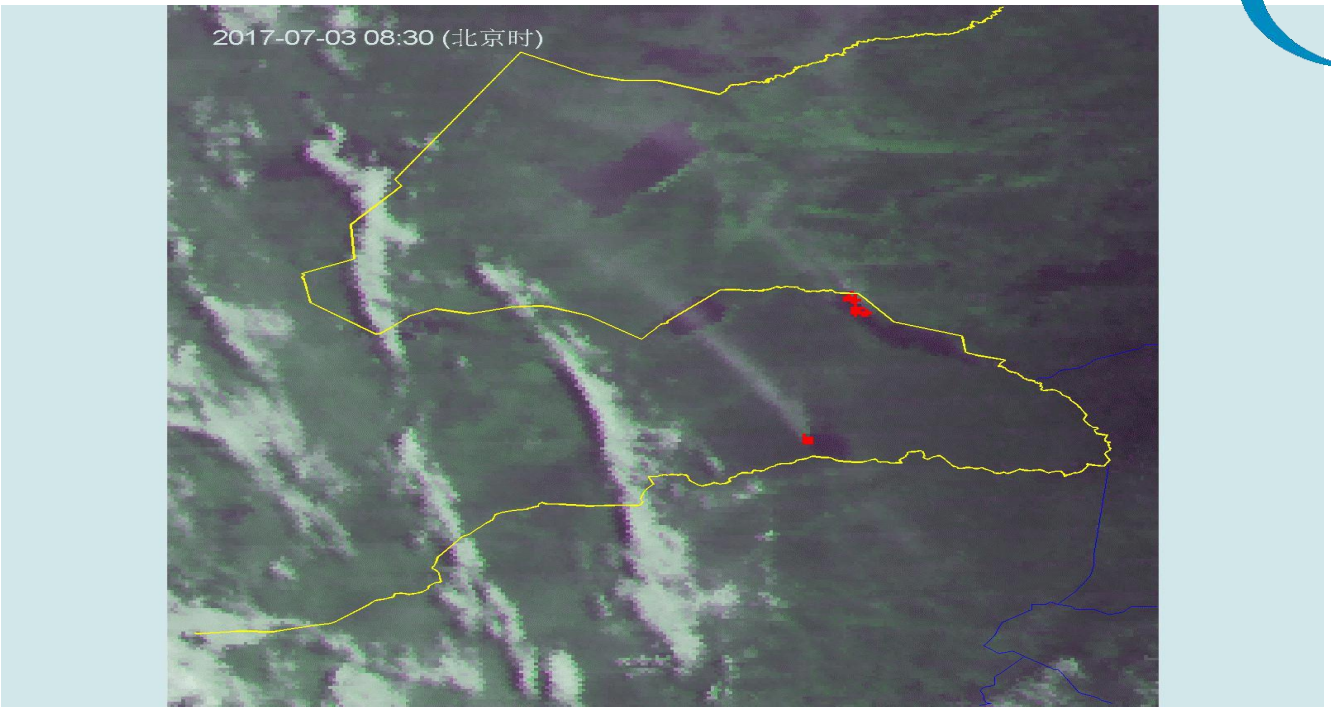
No satellite measurement assimilated



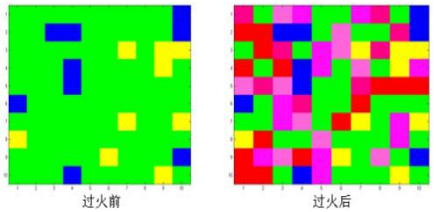
Prediction with assimilation of satellite data

Monitoring and evaluation of fire and weather forecast support for mitigation of fire disaster





Continuous and timely monitoring and recognition of fire point with high precision for 24 hours.

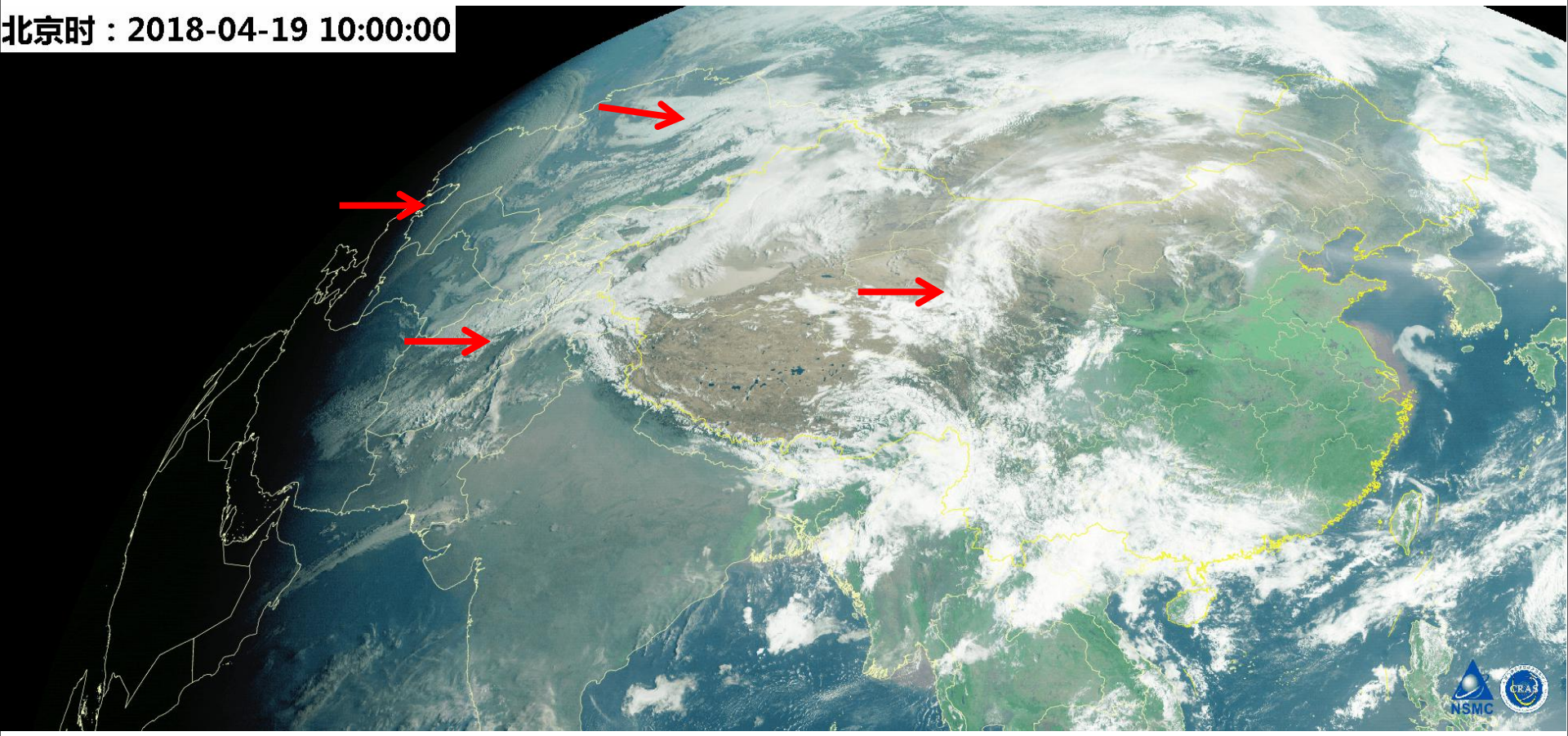


Estimation of burned area using multi-source satellite data on sub-pixel scale

FY satellite service for “The Belt and Road” countries

The Belt and Road regions are the source of China's high impact weather system.

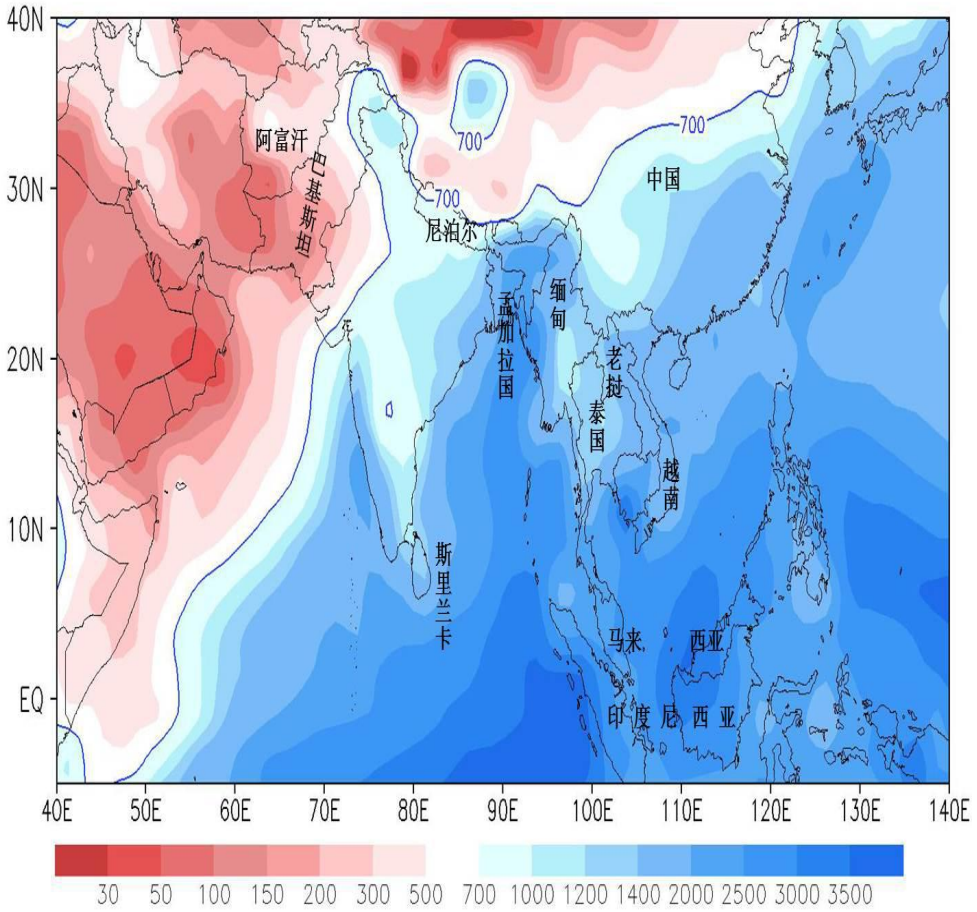
China is located in the westerly belt. The Belt and Road countries are the source of China's high impact weather system. Meteorological satellite observation of the regions can better monitor the occurrence and development of the weather system.



“The Belt and Road” country’s disaster prevention and reduction need support of meteorological satellite observation.

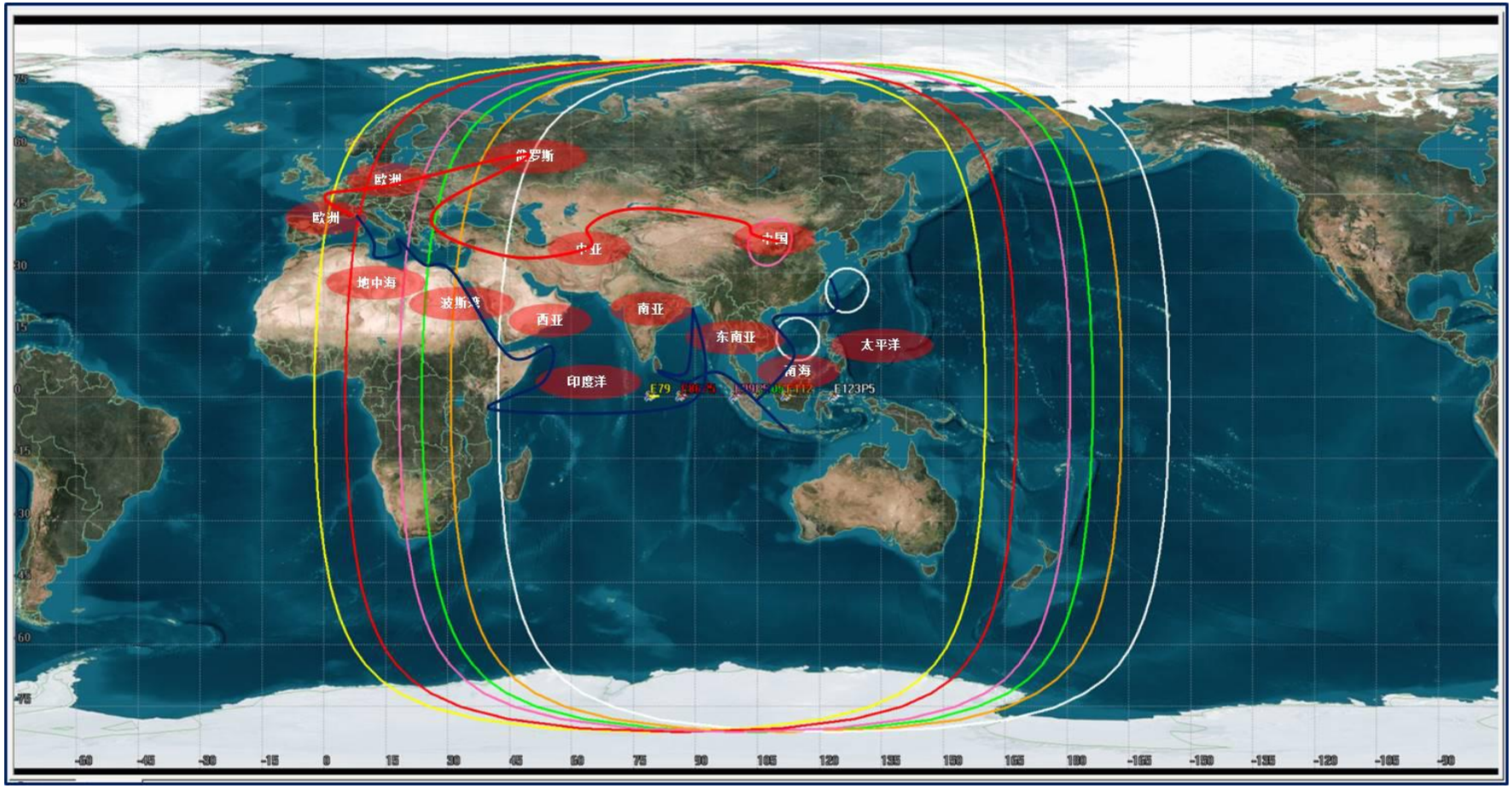
“The belt and road" countries and regions are located in one of the most crucial areas suffering meteorological disasters. Rainstorm, flood, typhoon and drought occur frequently.

气候区分布



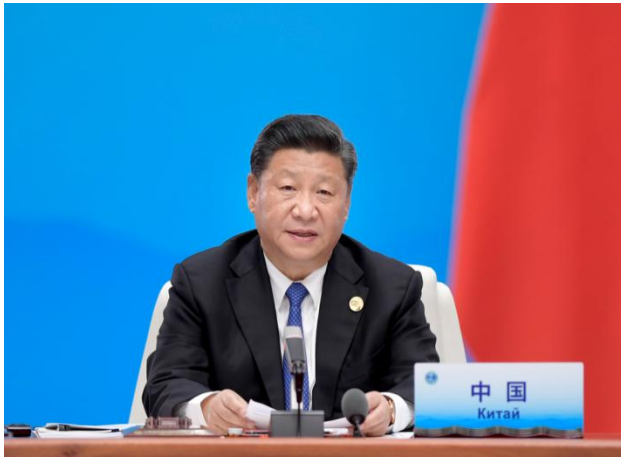
气候平均降水量分布 （毫米/年）

FY geostationary meteorological satellite layout: support the national “The Belt and Road” initiative



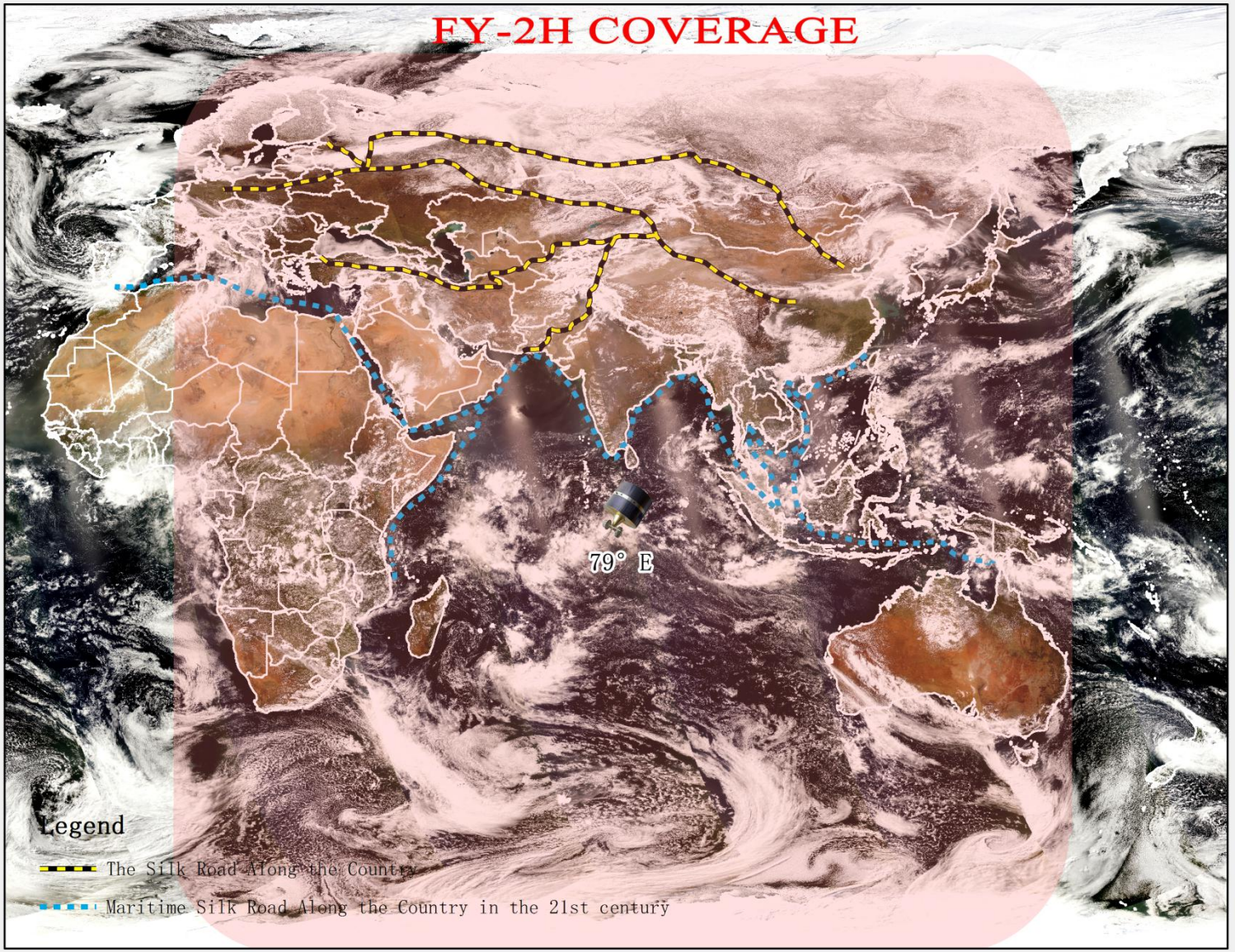
FY polar-orbiting and geostationary meteorological satellites can completely cover “The Belt and Road” countries.

FY-2H： Special support to Belt and Road countries

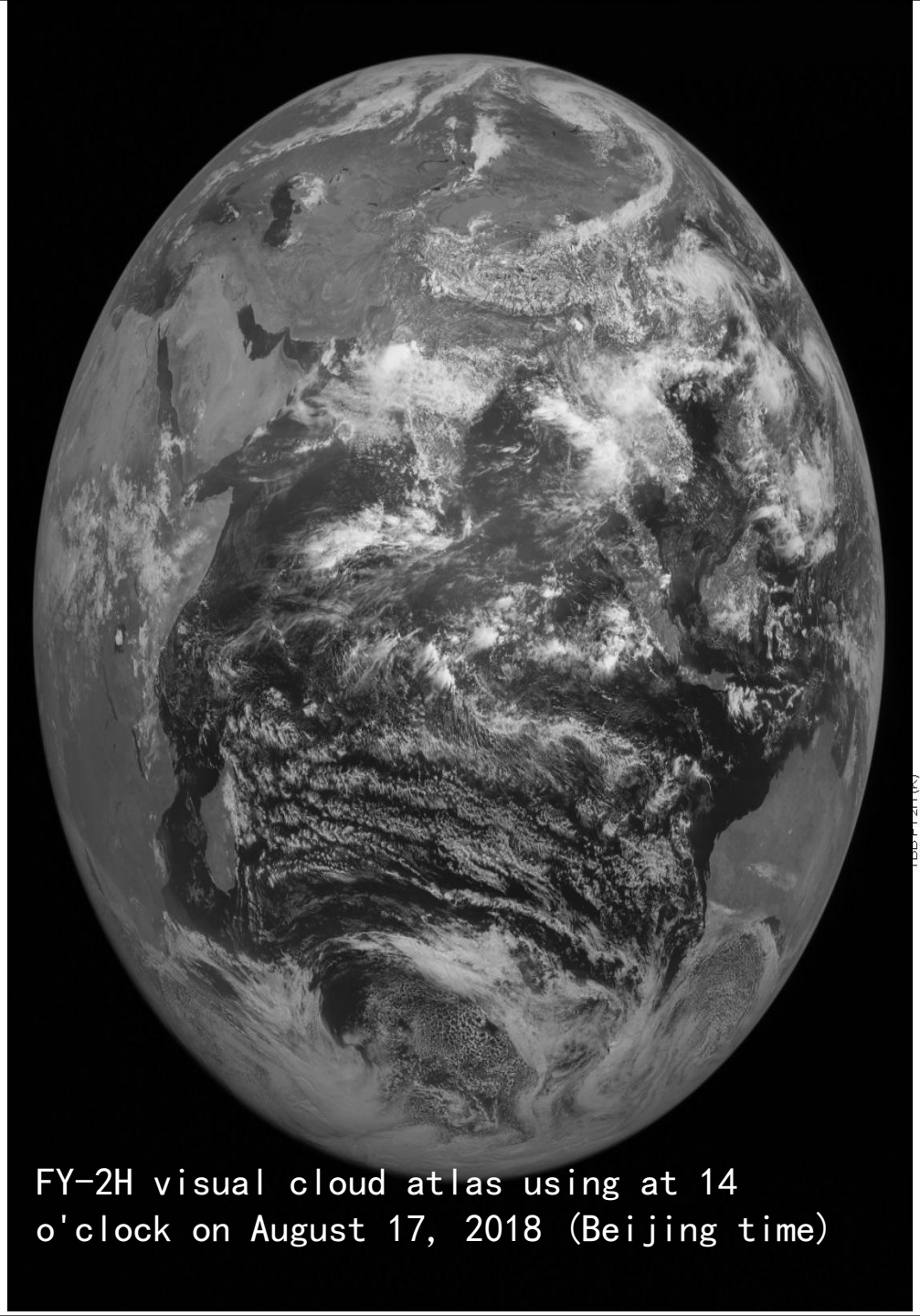


- Launched on June 5, 2018
- positioned at 79° E on July 28
- From Oct., FY-2H will provide operational service over the Indian Ocean.

On June 10, at Shanghai Cooperation Organization (SCO) summit in Qingdao，Chinese President Xi Jinping made a commitment that China will provide meteorological services by using FY-2 meteorological satellite.”

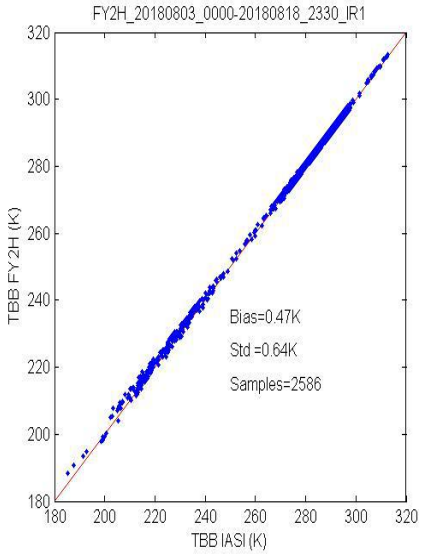


- *FY-2H at 79°E owns the reasonable coverage over the "Belt and Road" area.*
- *FY-2H will perform the flexible regional observations about 6-min interval when required.*

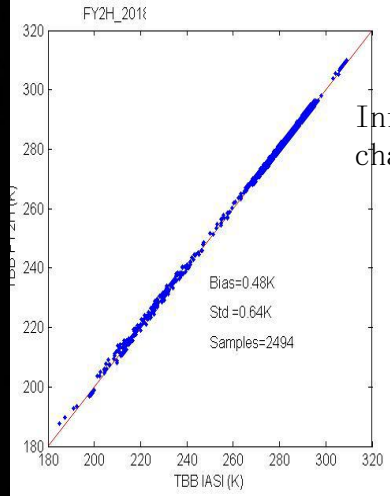


FY-2H visual cloud atlas using at 14 o'clock on August 17, 2018 (Beijing time)

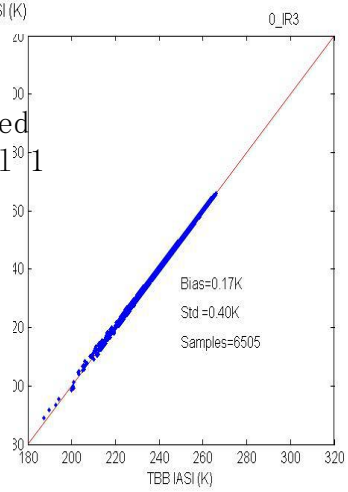
FY-2H infrared channel calibration test results



Infrared channel 1



Infrared channel 2



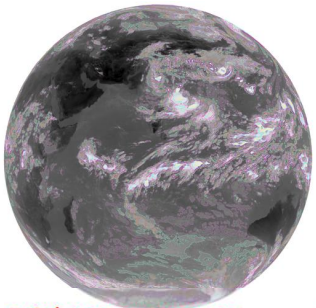
Infrared channel 3

IR1-IR3 Monthly Bias vs. IASI: ~0.2K@290K/260K

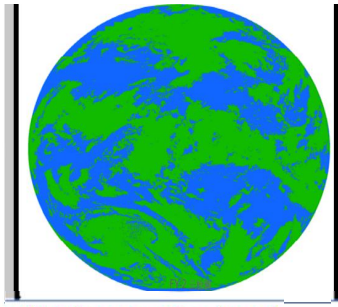
--support radiation assimilation in NWP model

FY-2H: Products

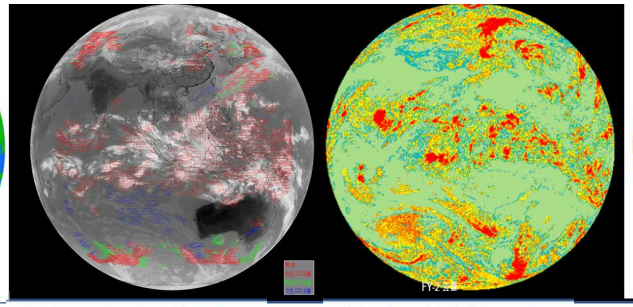
Essential 10 Products (via CMACast)	
▪ Surface incidence solar radiation	▪ Atmospheric Motion Vectors
▪ Outgoing long wave radiation	▪ Black body brightness temperature
▪ Cloud Type	▪ Cloud Total Amount
▪ Snow Cover	▪ Total precipitation Water for clear sky
▪ Precipitation Estimate	▪ Humidity Profile derived from cloud Analysis



Bright temperature contour
展宽图-亮温等值线

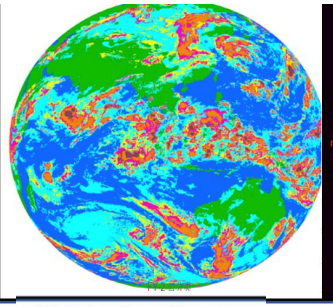


Cloud Detection (CLD)
云检测

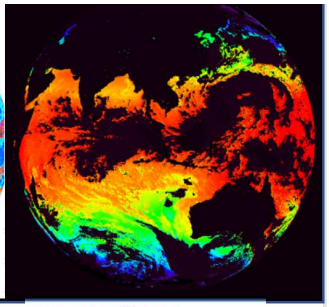


Atmosphere Motion Vector (AMV)
云导风

Cloud Total Amount (CTA)
总云量

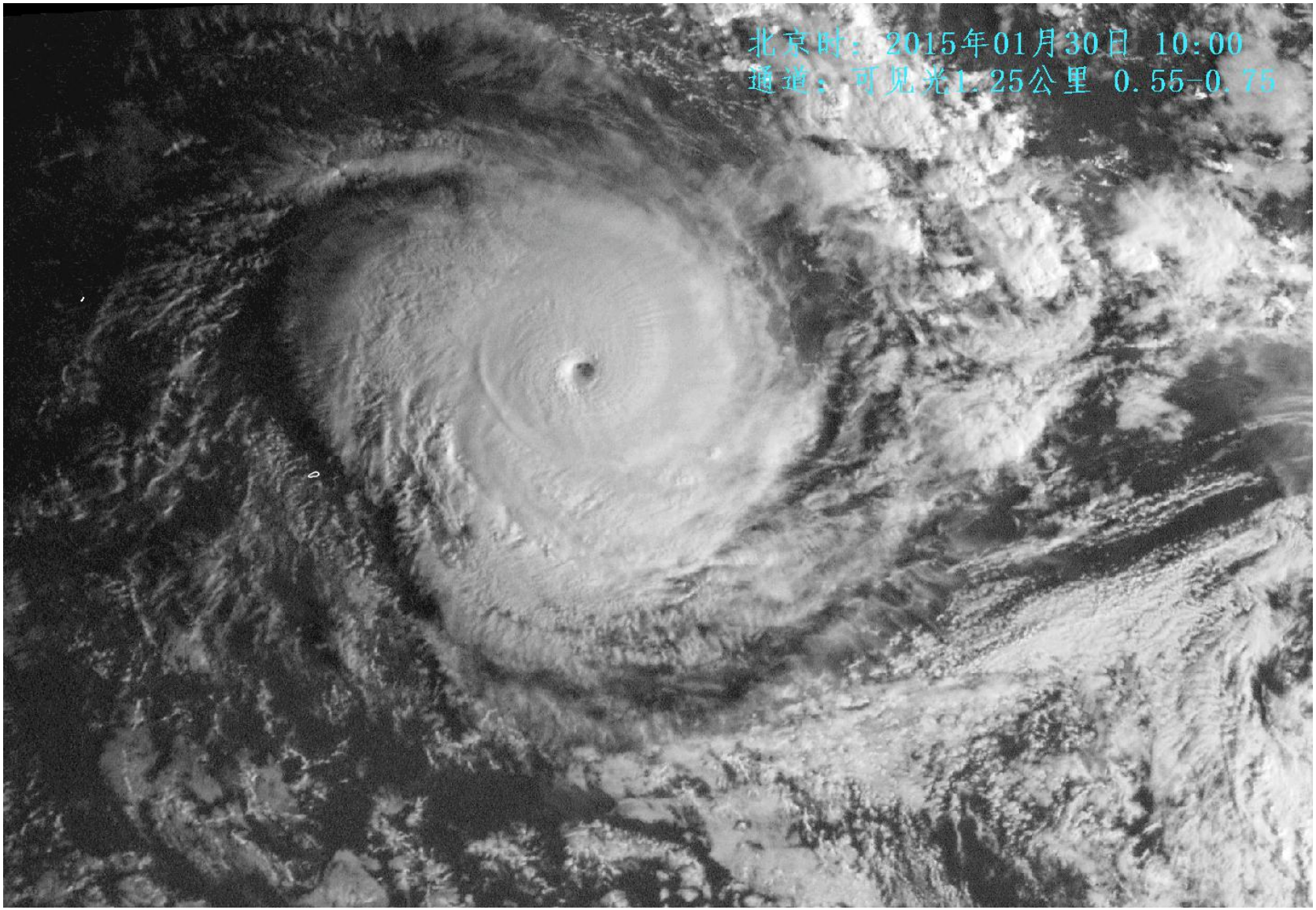


Cloud Classification (CLC)
云分类



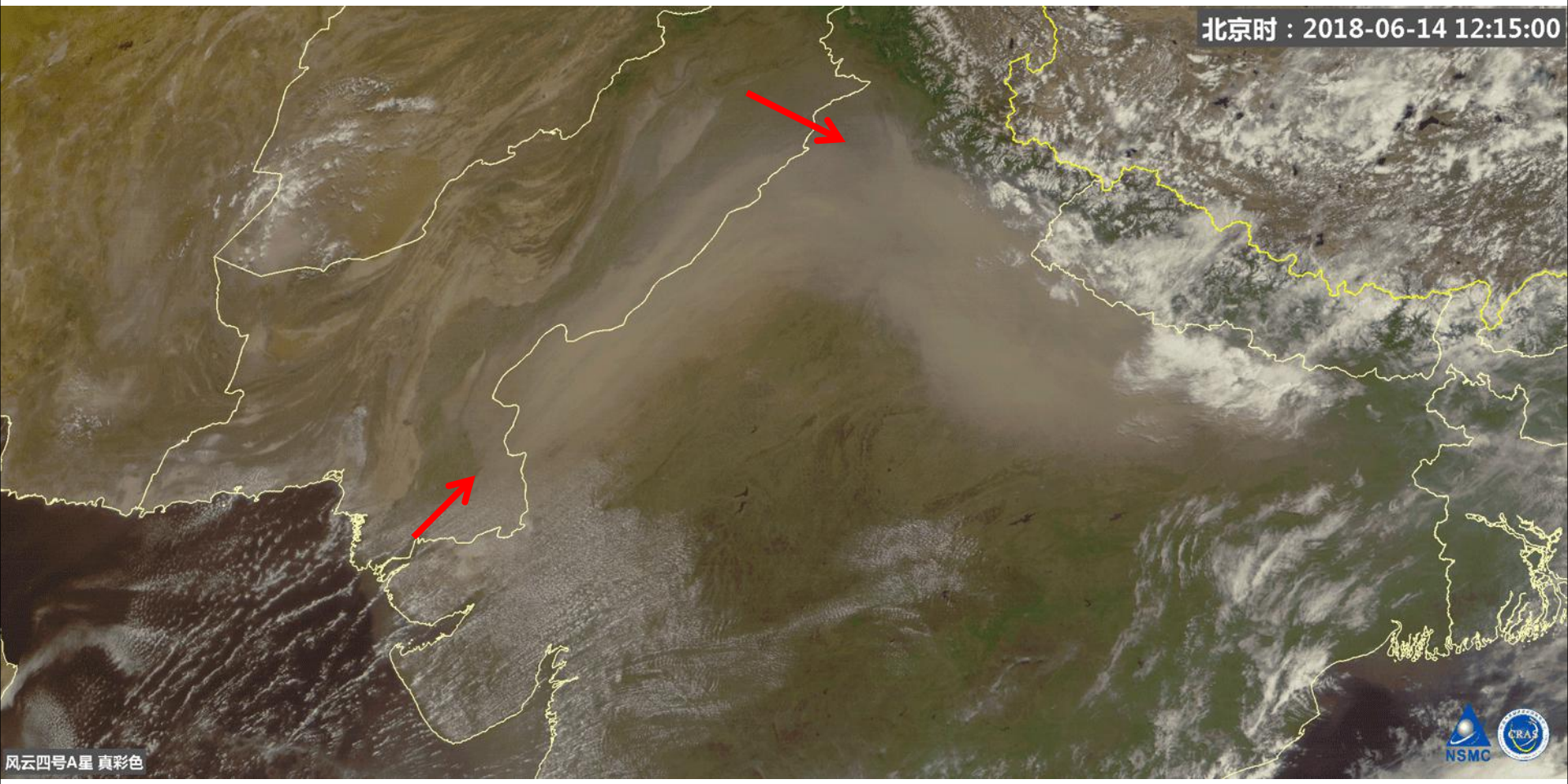
Sea Surface Temperature (SST)
海面温度

Typical application：regional-scan observation (per 6min.）animation



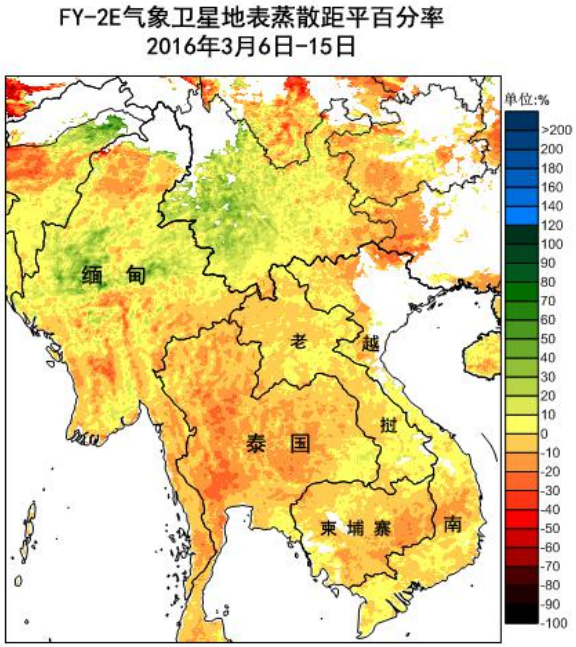
super typhoon Eunice in southwest Indian ocean

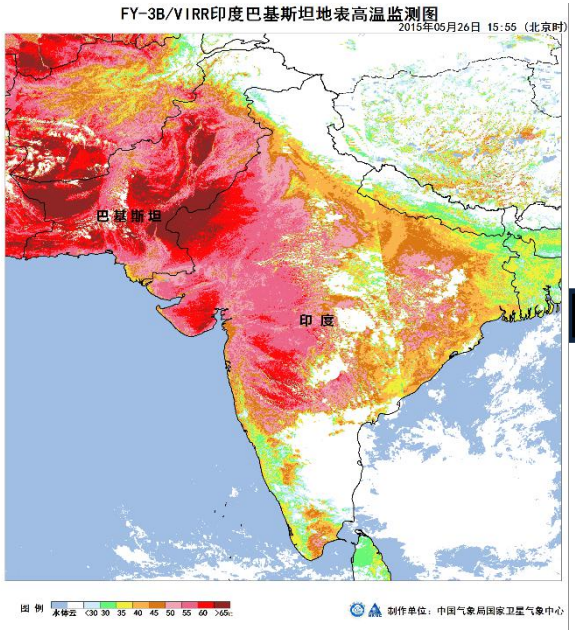
Sand storm in South Asia



Caused by the strong south wind, the sand storm happened in north-western Indian and eastern Pakistan. The sand storm spread northward then eastward when it reached the Himalayas.

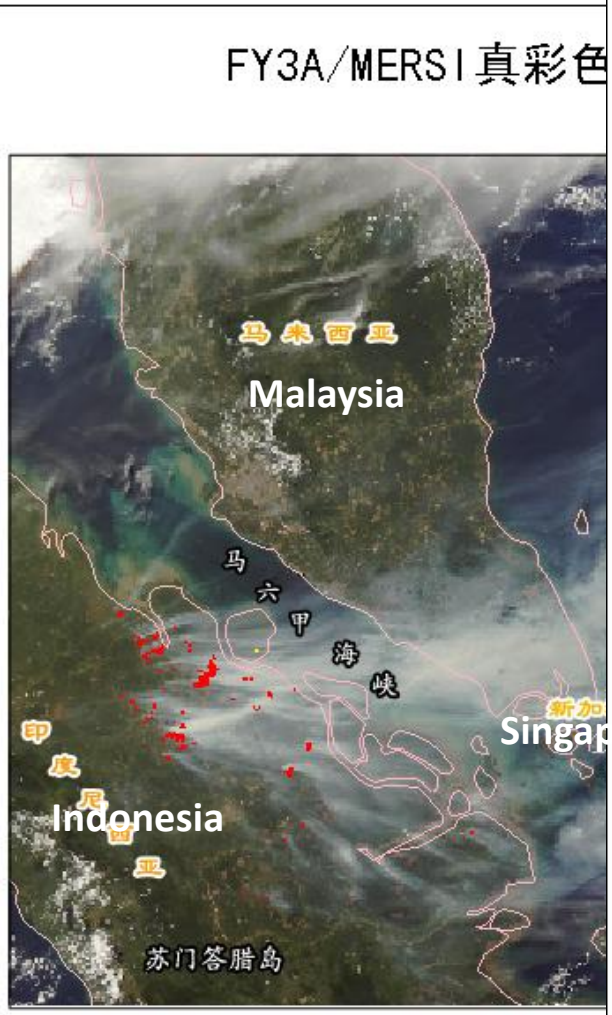
Heat wave in Southeast Asia

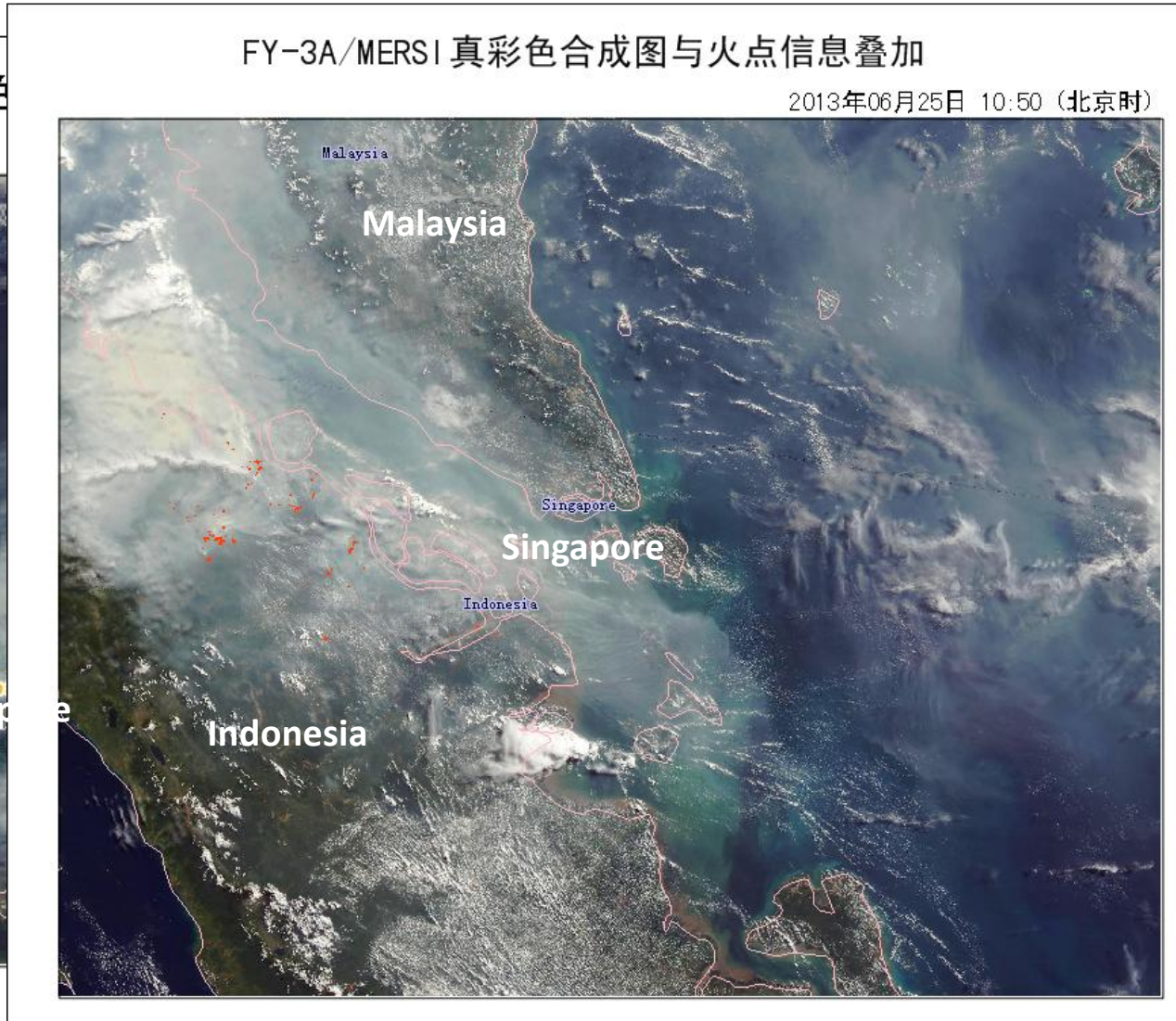




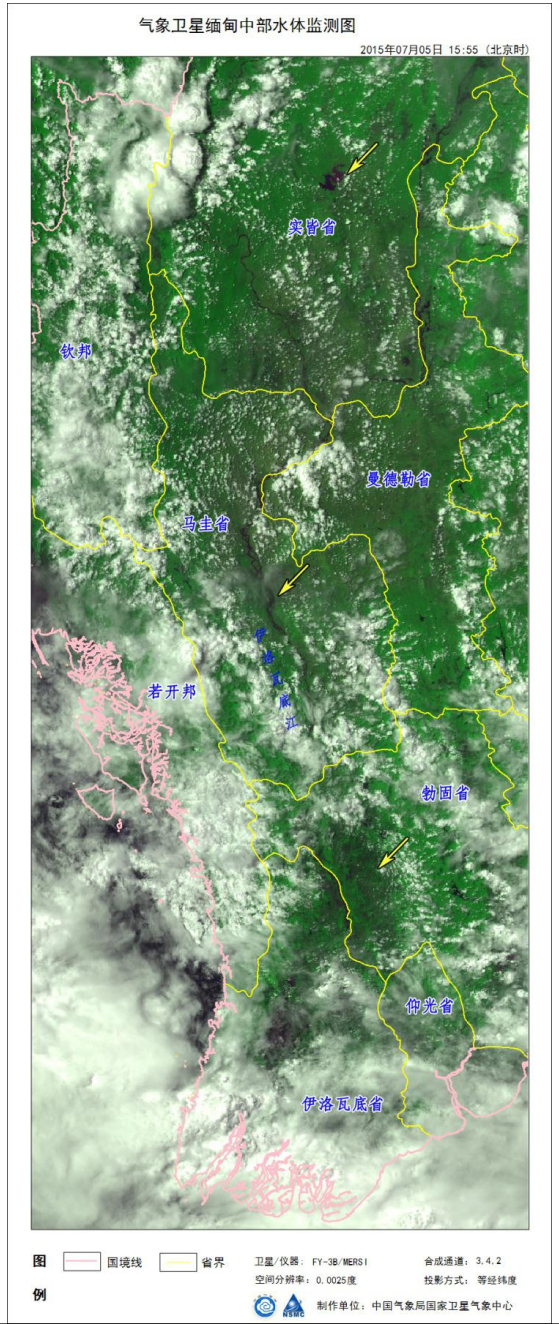
Heat wave in Southeast Asia caused by the super strong EI Nino in 2015-2016 monitored by using FY satellite products.

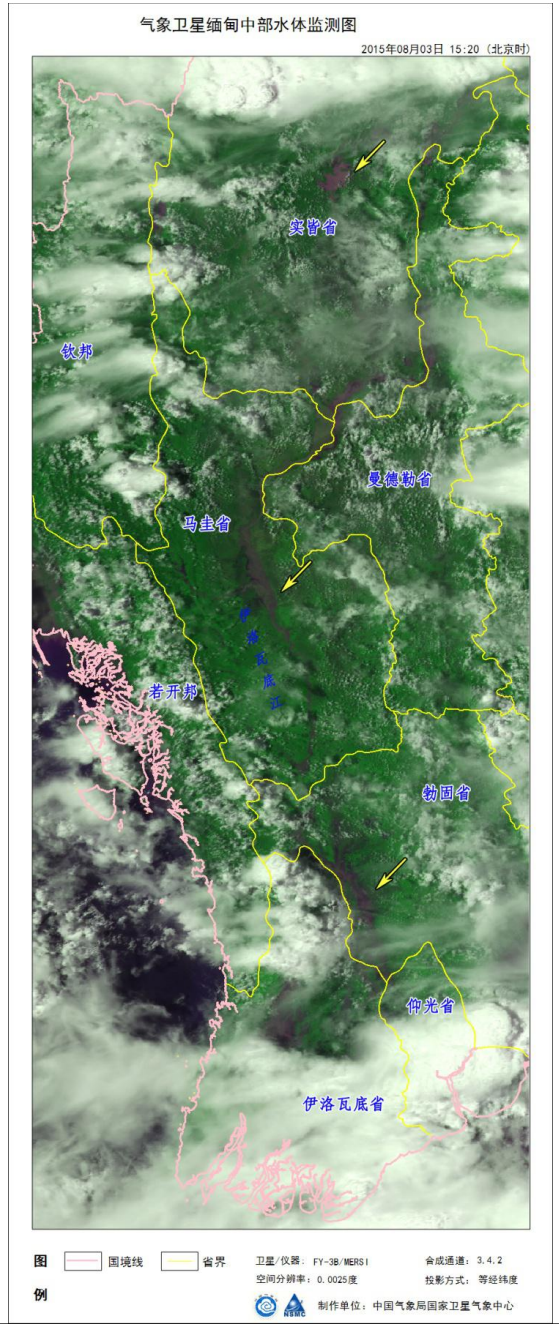
Fire in Indonesia

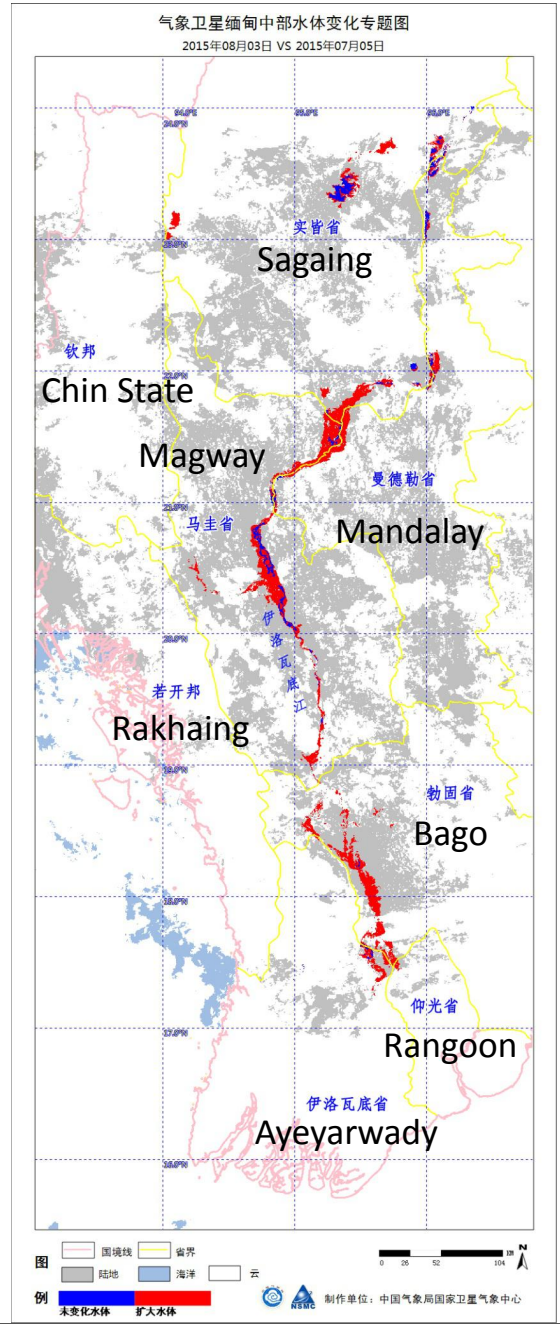




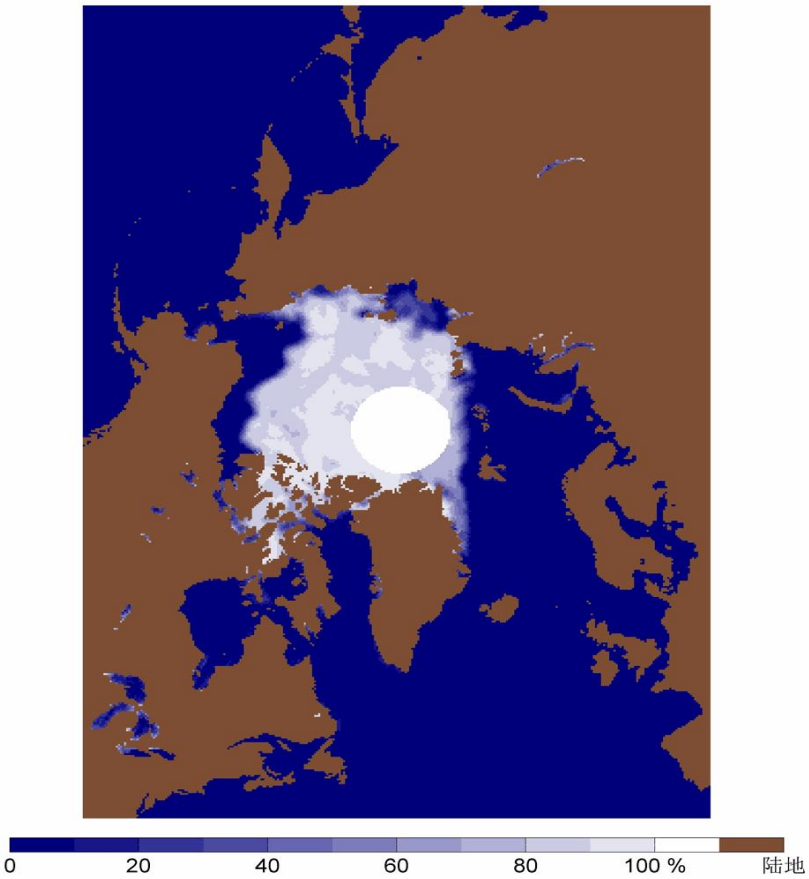
Flood monitoring in Myanmar in Aug. 2015

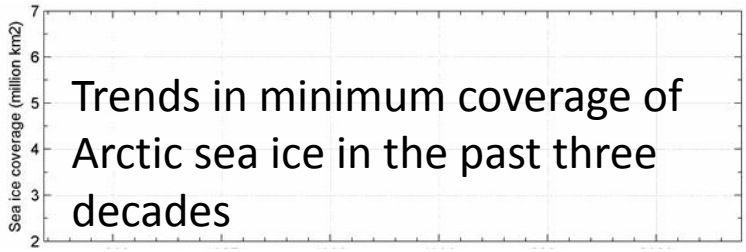




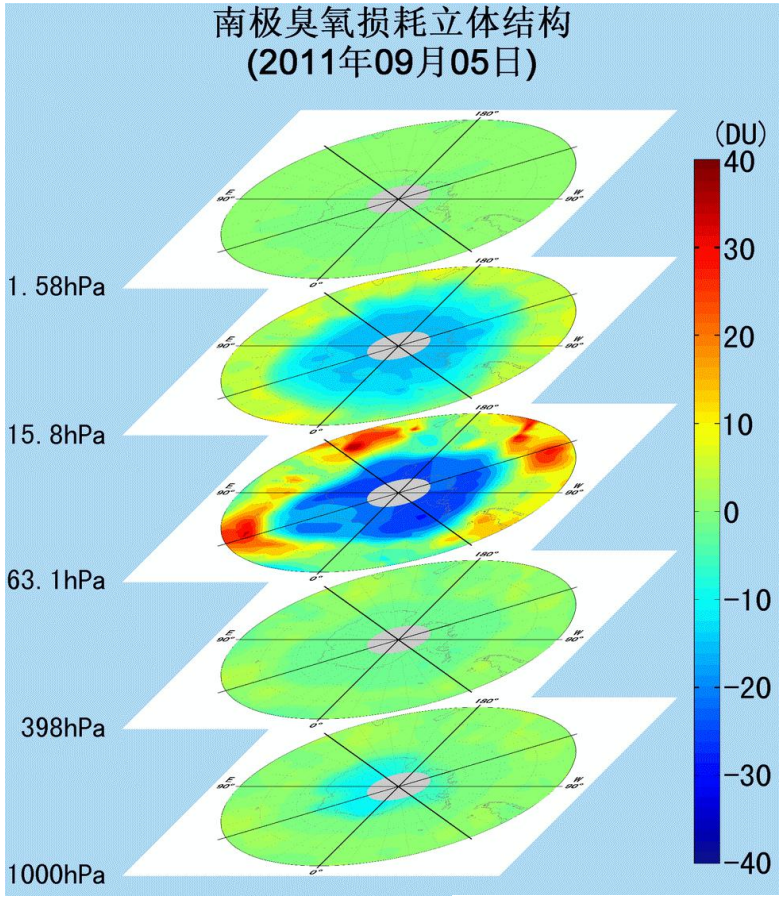


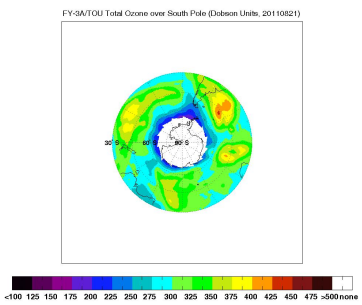
Satellite products used in polar region monitoring

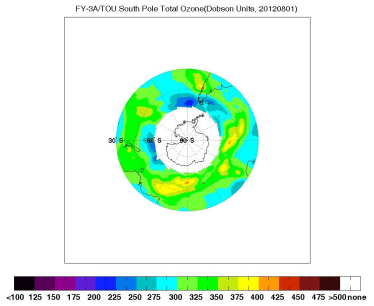




Trends in minimum coverage of Arctic sea ice in the past three decades







Put the Emergency Support Mechanism of FENGYUN Satellite（FY ESM）into practice

Conditions for a Request

An international user may request CMA to activate FY ESM before, during and after an extreme event such as typhoon, heavy rain, severe convection, forest or grassland fire and sand and dust storm, etc., with one of the following references provided:

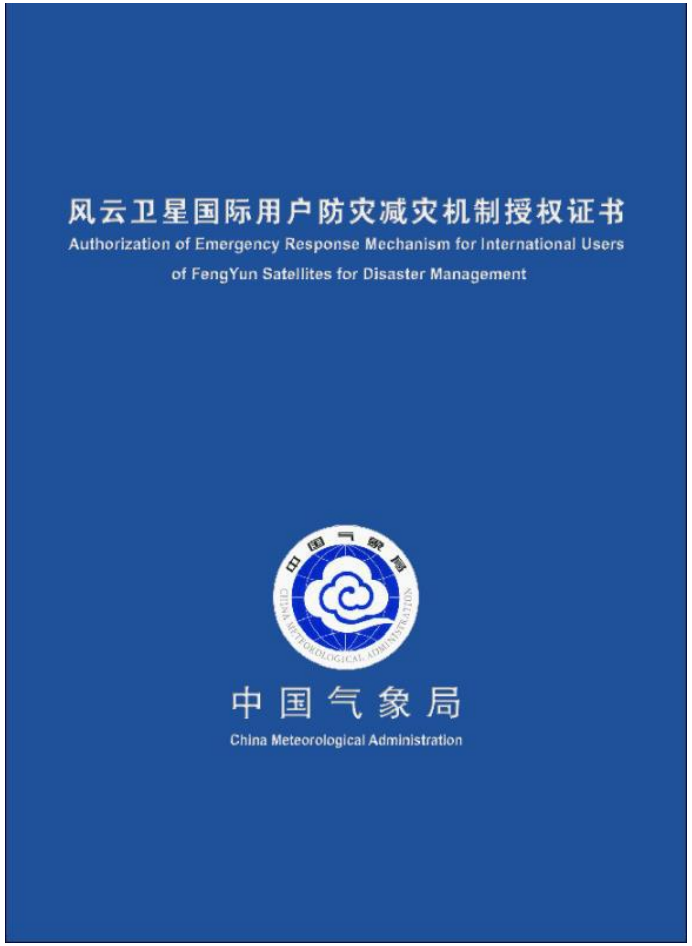
- Typhoon: The central wind force exceeds 28m/s and the impact is expected to be felt within 24 hours;
- Heavy rain and severe convection: It is expected that the rainfall will exceed 200mm within 24 hours;
- Fire: A forest/grassland fire breaks out, posing a grave threat;
- Flood: A widespread flood looms large; · Other extreme events predicted to pose a grave threat.

- issued **On April 24th,2018**

Once the request is approved, CMA will command the on-duty FY satellite for frequent and targeted observation over affected areas. The images and products will be transmitted through CMACast, internet and direct satellite broadcast reception.

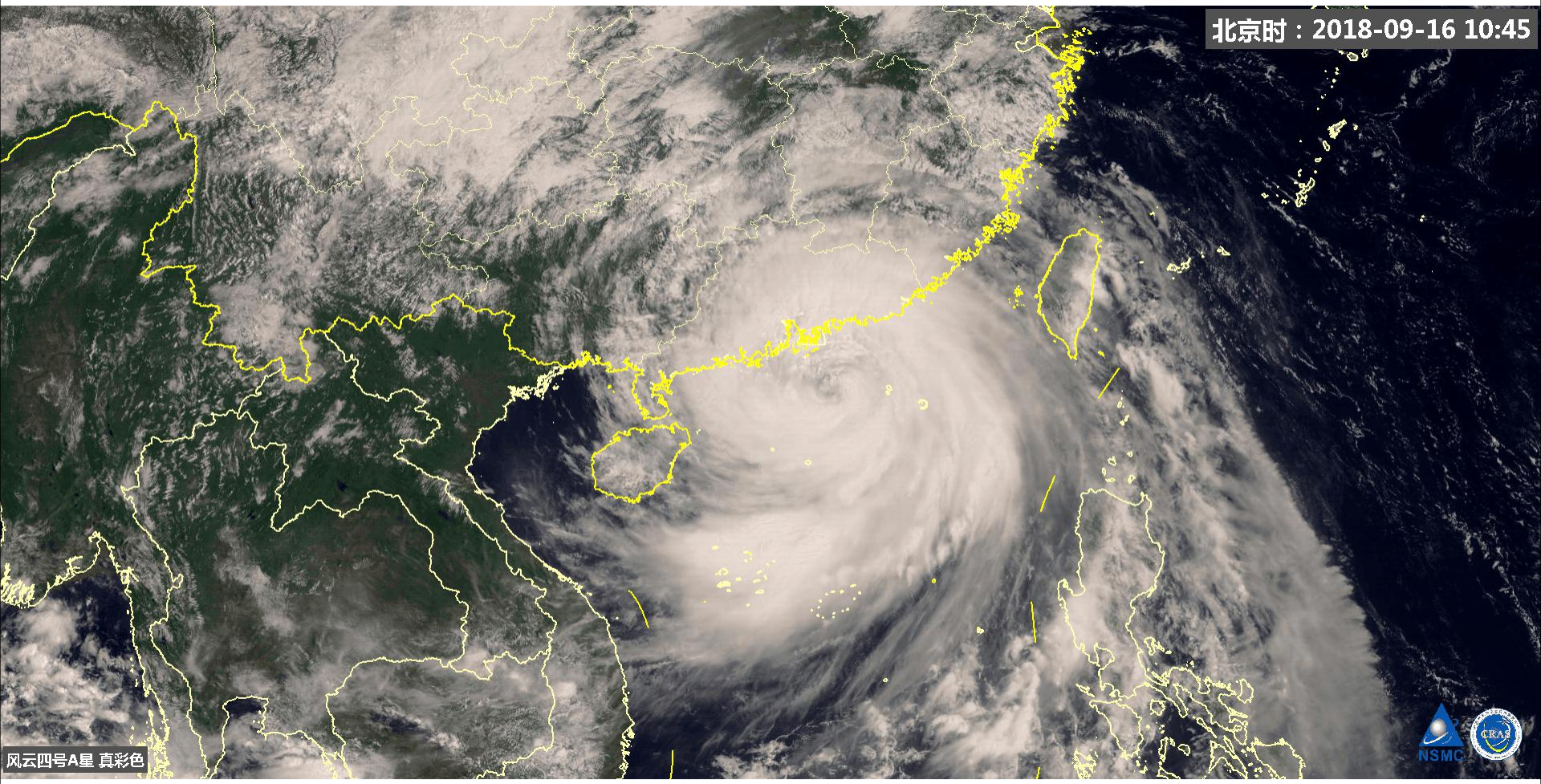
18 Authorized FY ESM Users

As of September 2018, there are 18 Authorized FY ESM users, including Indonesia, Vietnam, Laos, Myanmar, Thailand, Philippine, Malaysia, Singapore, Kazakhstan, Kyrgyzstan, Pakistan, Russia, Tajikistan, Uzbekistan, Afghanistan, Iran, Mongolia, Sri Lanka



FY-2 flexible regional observations about 6-min interval

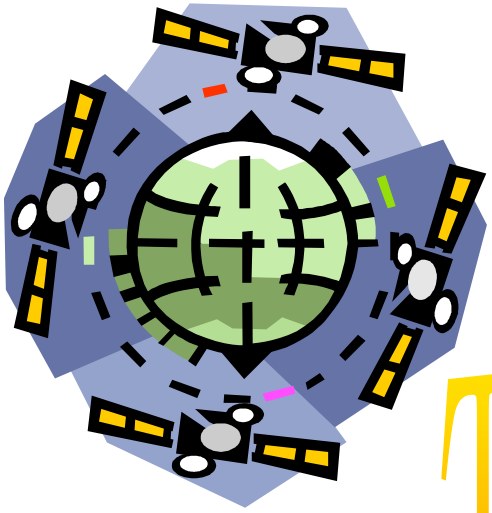
Typhoon Mangkhut，
Vietnam “Disaster Management Center” and “Meteorological and Hydrological Administration” initiated a FY-ESM.



CMA started a FY-2F 6-min Regional Observation from 14th to 16th Sep. 2018.
CMA has provided FY-2 、FY-4and FY-3 data images via ftp server and website to users.

Summery:

- After nearly half a century, Fengyun Meteorological Satellites have developed two operational series, i.e. polar and geostationary, which offer timely and efficient observation capabilities of extreme weather, climate and environmental events on a global and regional scale;
- The new generation of polar orbiting meteorological satellite Fengyun 3-D is able to perform global three-dimensional atmospheric, all-weather and multi-element observations, covering 4 global observations per day, with less than 1 hour temporal resolution and maximum 250 meters spatial resolution;
- The new generation of geostationary meteorological satellite Fengyun 4-A is able to achieve continuous tracking and monitoring of weather system and rapid response to disaster emergency. The full disc observation takes 15 minutes, and the regional observation can reach 1 minute interval;
- The quantitative observation of new generation meteorological satellites, provides more detailed meteorological information, which can be used to accurately monitor and analyze the weather system, and supports numerical weather prediction models, improve the accuracy of forecasting and minimize disaster losses.
- The combined application of Fengyun series satellites will significantly enhance the monitoring capabilities of weather, climate and ecological environment of South Asia, Central Asia, West Asia, Africa and other regions and countries, and support the national “Belt and Road” initiative.



..... Stop Here

Thank you!