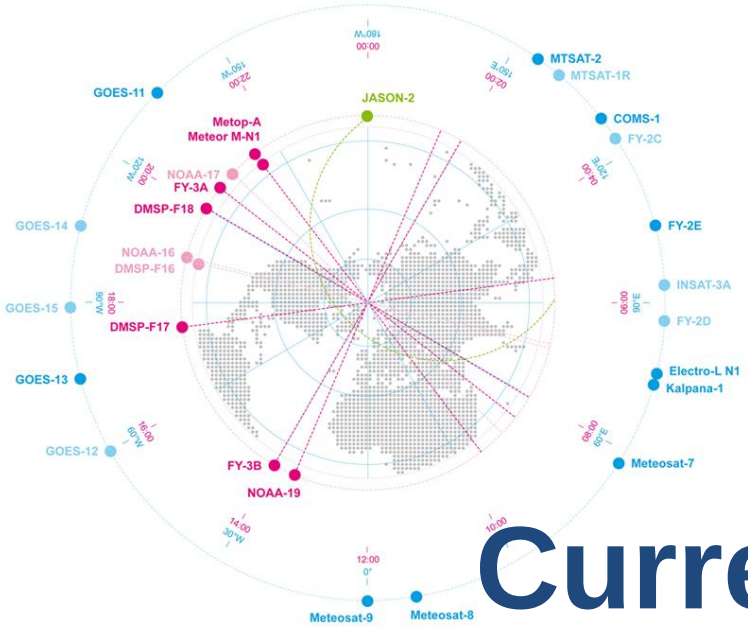


Current and future CMA MetSat systems

Presented to second WMO/ITU Seminar, 23 October 2017

Jing NIE

National Satellite Meteorological Centre, CMA

Outline

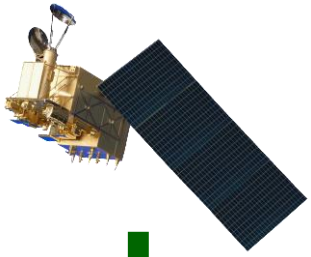
- Overview of FENGYUN satellite systems
- FENGYUN Metsats Application
- Data and Products Service
- Use of Radio Spectrum

1、Overview of FENGYUN satellite systems

Polar and low light orbit System

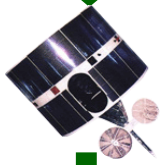
First Generation
FY-1 A, B, C, D

Second Generation
FY-3 A, B, C, D, E, F, G

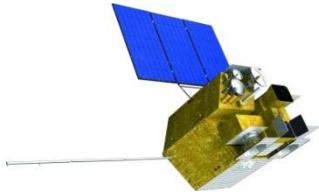


Expected until 2025

Geostationary System



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



Second Generation
FY-4 A, B, C, D, E

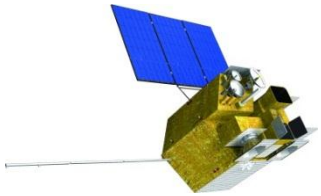
Expected until 2030

Use of Radio Spectrum for CMA current and future Metsat systems

Polar-orbiting Series Launched Satellites

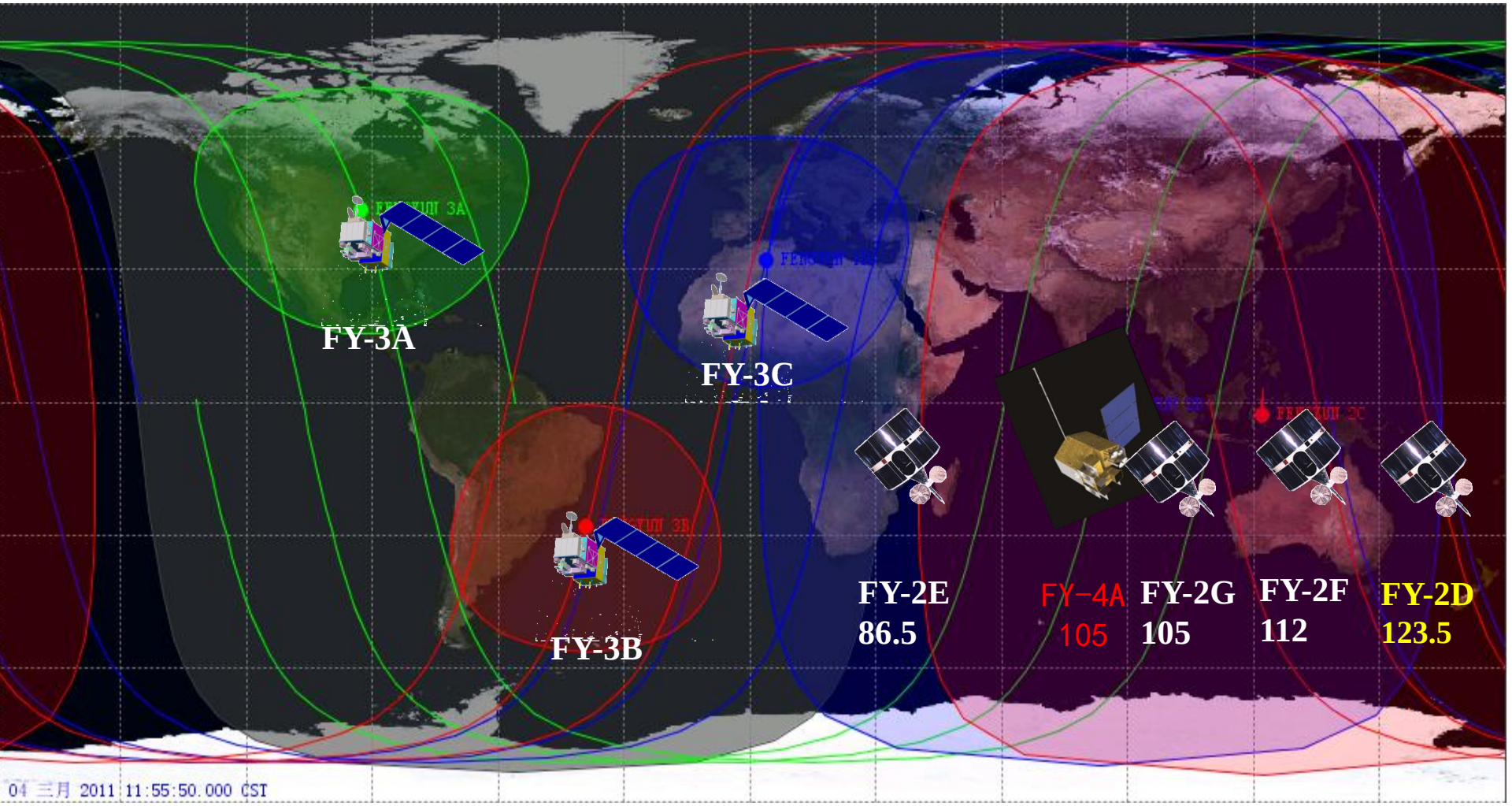
1988.09.07	FY-1A	Experimental	39 Days	CZ-4
1990.09.03	FY-1B	Experimental	158 Days	
1999.05.10	FY-1C	Operational	6.5 Years	
2002.05.15	FY-1D	Operational	>10 Years	
2008.05.17	**FY-3A**	**Experimental**	**Operation**	
2010.11.05	**FY-3B**	**Experimental**	**Operation**	
2013. 9.23	**FY-3C**	**AM Orbit**	**Operation**	

Geostationary Series Launched Satellites



1997.06.10	FY-2A	Experimental	De-orbited	CZ-3A
2000.06.25	FY-2B	Experimental	De-orbited	
2004.10.19	FY-2C	Operational	De-orbited	
2006.12.08	**FY-2D**	**123.5E**	**backup**	
2008.12.23	**FY-2E**	**86.5E**	**Operation**	
2012.01.13	**FY-2F**	**112.5E**	**Operation**	
2014.12.31	**FY-2G**	**105E**	**Operation**	
2016.12.11	**FY-4A**	**Experimental, 105E**	**Operation**	CZ-3B

On Orbit FENGYUN Satellites



- 6 satellites in operation
- 1 satellite in orbit test
- 1 satellite on backup

1.1 FENGYUN GEO Constellation

- **In operation**

FY-2G: Full Disk (105E)

FY-2E: Full Disk (86.5E)

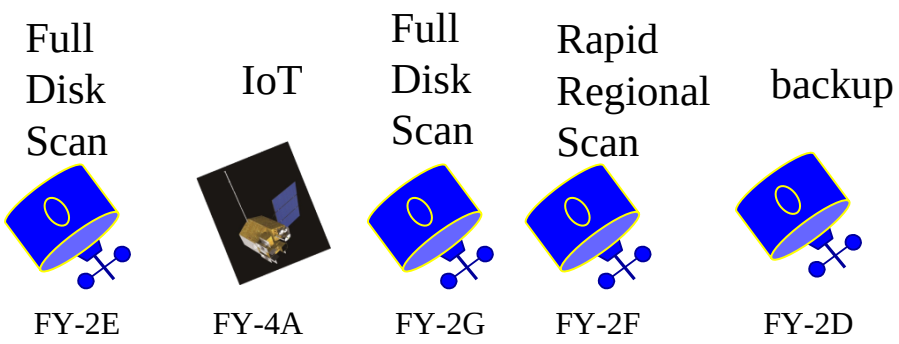
FY-2F: Regional (112E)

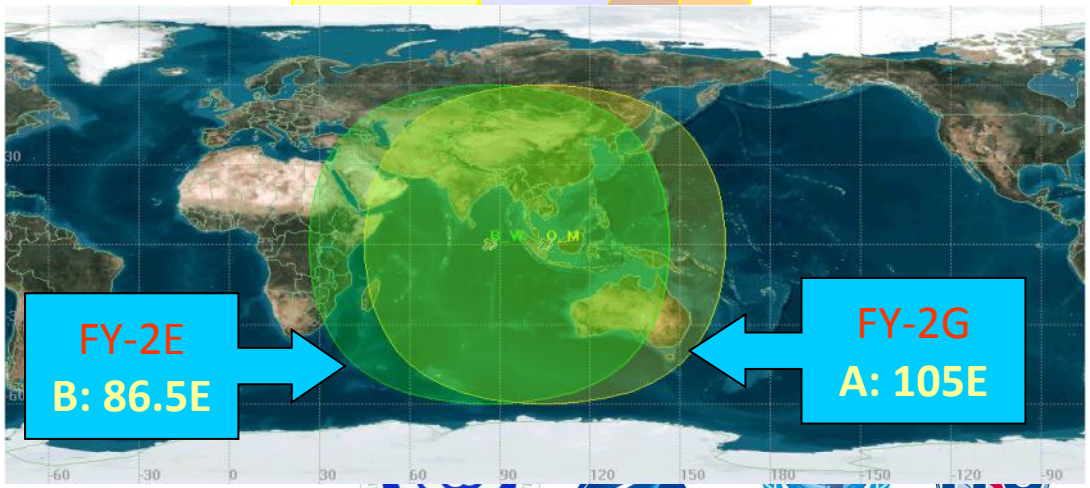
- **In commission test**

FY-4A: (105E)

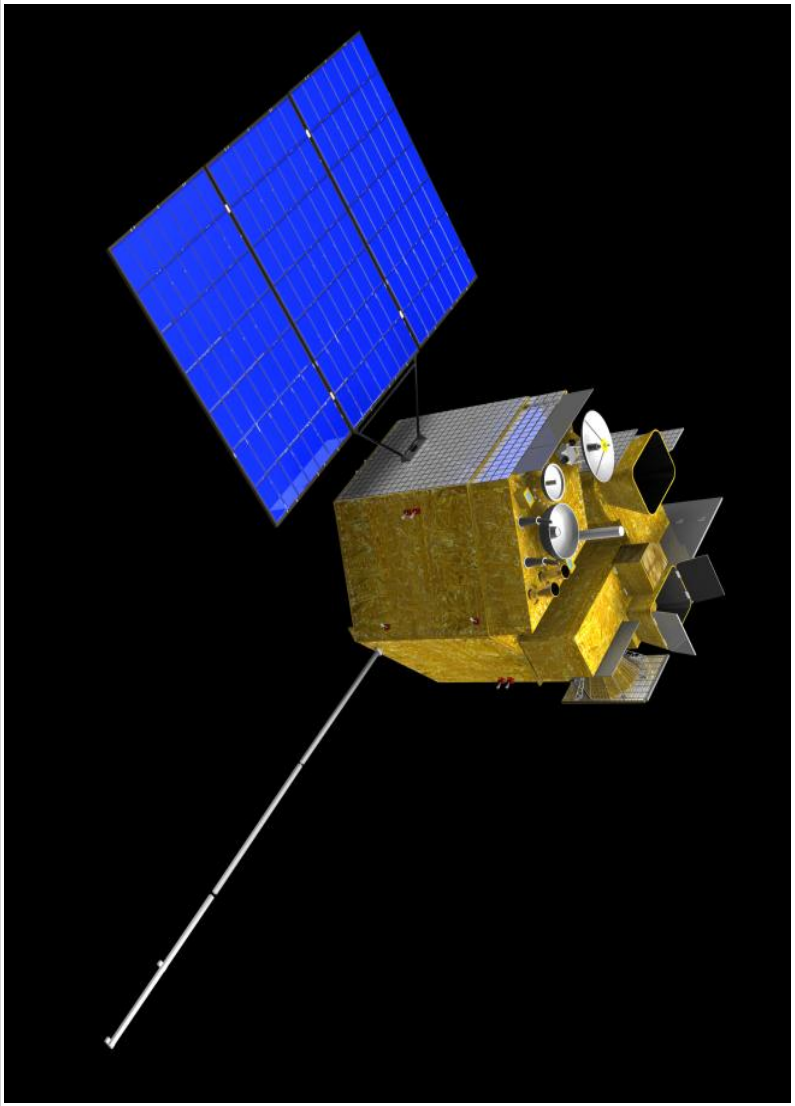
- **In backup**

FY-2D (123.5E)





Sencond Geostationary Generation : FY-4



Main Instruments:

1) AGRI: Advanced Geosynchronous Radiation Imager
2) GIIRS: Geo. Interferometric Infrared Sounder
3) LMI: Lightning Mapping Imager
4) SEP: Space Environment Package

Spacecraft:

1. Launch Weight: approx 5300kg
2. Stabilization: Three-axis
3. Attitude accuracy: 3″
4. Bus: 1553B+Spacewire
5. Output power: >= 3200W

Use of Radio Spectrum for CMA current and future Metsat systems

Spectral Coverage	Spectral Band (μm)	Spatial Resolution (Km)	Sensitivity	Main Applications
VIS/NIR	0.45～0.49	1	S/N≥90 (ρ=100%)	Aerosol
	0.55～0.75	0.5～1	S/N≥200 (ρ=100%)	Fog, Clouds
	0.75～0.90	1	S/N≥5(ρ=1%)@0.5Km	Vegetation
	1.36～1.39	2		Cirrus
	1.58～1.64	2	S/N≥200 (ρ=100%)	Cloud,Snow
	2.10～2.35	2～4		Cirrus,Aerosol
Middle-wave IR	3.50～4.00	2	NEΔT≤0.7K(300K)	Fire
	3.50～4.00	4	NEΔT≤0.2K(300K)	Land surface
	5.80～6.70	4	NEΔT≤0.3K(260K)	WV
	6.90～7.30	4	NEΔT≤0.3K(260K)	WV
Long-wave Infrared	8.00～9.00	4	NEΔT≤0.2K(300K)	WV,Clouds
	10.3～11.3	4	NEΔT≤0.2K(300K)	SST
	11.5～12.5	4	NEΔT≤0.2K(300K)	SST
	13.2～13.8	4	NEΔT≤0.5K(300K)	Clouds,WV

AGRI's Main Usage:

Acquire multiple band, high temporal resolution, high radiation accuracy images of Earth's surface, atmosphere and cloud

GIIRS's Main Usage:

Acquire atmospheric temperature and humidity profile structures under clear condition

LMI's Main Usage:

Acquire lightning distribution maps for a certain coverage

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%

	Range	Resolution	Channels
Spectral Parameters (Normal mode)	LWIR: 700-1130 cm^{-1}	0.8	538
	S/MIR:1650-2250 cm^{-1}	1.6	375
	VIS : 0.55- 0.75 μm		
Spatial Resolution	LWIR/MWIR : 16 Km SSP		
	VIS : 2 Km SSP		
Operational Mode	China area 5000 × 5000 Km^2		
	Mesoscale area 1000 × 1000 Km^2		
Temporal Resolution	China area <1 hr		
	Mesoscale area <½ hr		
Sensitivity (mW/m^2srcm^2)	LWIR: 0.5-1.1 S/MIR: 0.1-0.14		
	VIS: S/N>200(ρ=100%)		
Calibration accuracy	1.5 K (3σ) radiation		
Calibration accuracy	10 ppm (3σ) spectrum		
Quantization Bits	13 bits		

Use of Radio Spectrum for CMA current and future Metsat systems

TABLE 2. Products of FY-4 and FY-2.

FY-2		FY-4	
Products	**Payloads**	**Products**	**Payloads**
Cloud detection	VISSR	Cloud masks	AGRI
Cloud classification	VISSR	Cloud type	AGRI
Total cloud amount	VISSR	Total cloud amount	AGRI
Precipitation estimation	VISSR	Rainfall rate/quantitative precipitation estimate	AGRI
Atmospheric motion vector	VISSR	Atmospheric motion vector	AGRI
Outgoing longwave radiation	VISSR	Outgoing longwave radiation	AGRI
Blackbody brightness temperature	VISSR	Blackbody brightness temperature	AGRI
Surface solar irradiance	VISSR	Surface solar irradiance	AGRI
Humidity product analyzed by cloud information	VISSR	Legacy vertical moisture profile	GIIRS
Total precipitable water	VISSR	Layer precipitable water	AGRI
Upper-tropospheric humidity	VISSR	Layer precipitable water	
Dust detection	VISSR	Aerosol detection (including smoke and dust)	AGRI
Sea surface temperature	VISSR	Sea surface temperature (skin)	AGRI
Snow cover	VISSR	Snow cover	AGRI
Land surface temperature	VISSR	Land surface (skin) temperature	AGRI
Cloud-top temperature	VISSR	Cloud-top temperature	AGRI
		Cloud-top height	AGRI
		Cloud-top pressure	AGRI
		Cloud optical depth	AGRI
		Cloud liquid water	AGRI
		Cloud particle size distribution	AGRI
		Cloud phase	AGRI
		Downward longwave radiation: surface	AGRI
		Upward longwave radiation: surface	AGRI
		Reflected shortwave radiation: top of atmosphere	AGRI
		Aerosol optical depth	AGRI
		Convective initiation	AGRI
		Fire/hot spot characterization	AGRI
		Fog detection	AGRI
		Land surface emissivity	AGRI
		Land surface temperature	AGRI
		Land surface albedo	AGRI
		Tropopause folding turbulence prediction	AGRI
		Legacy vertical temperature profile	GIIRS
		Ozone profile and total	GIIRS
		Atmosphere instability index	GIIRS
		Lightning detection	LMI
		Space and solar products	SEP

FY-4 new products are compared with FY-2

TABLE 3. Advancement of *FY-4A* compared with the current operational FY-2 series. SEM = Space Environment Monitor. SSP = subsatellite point.

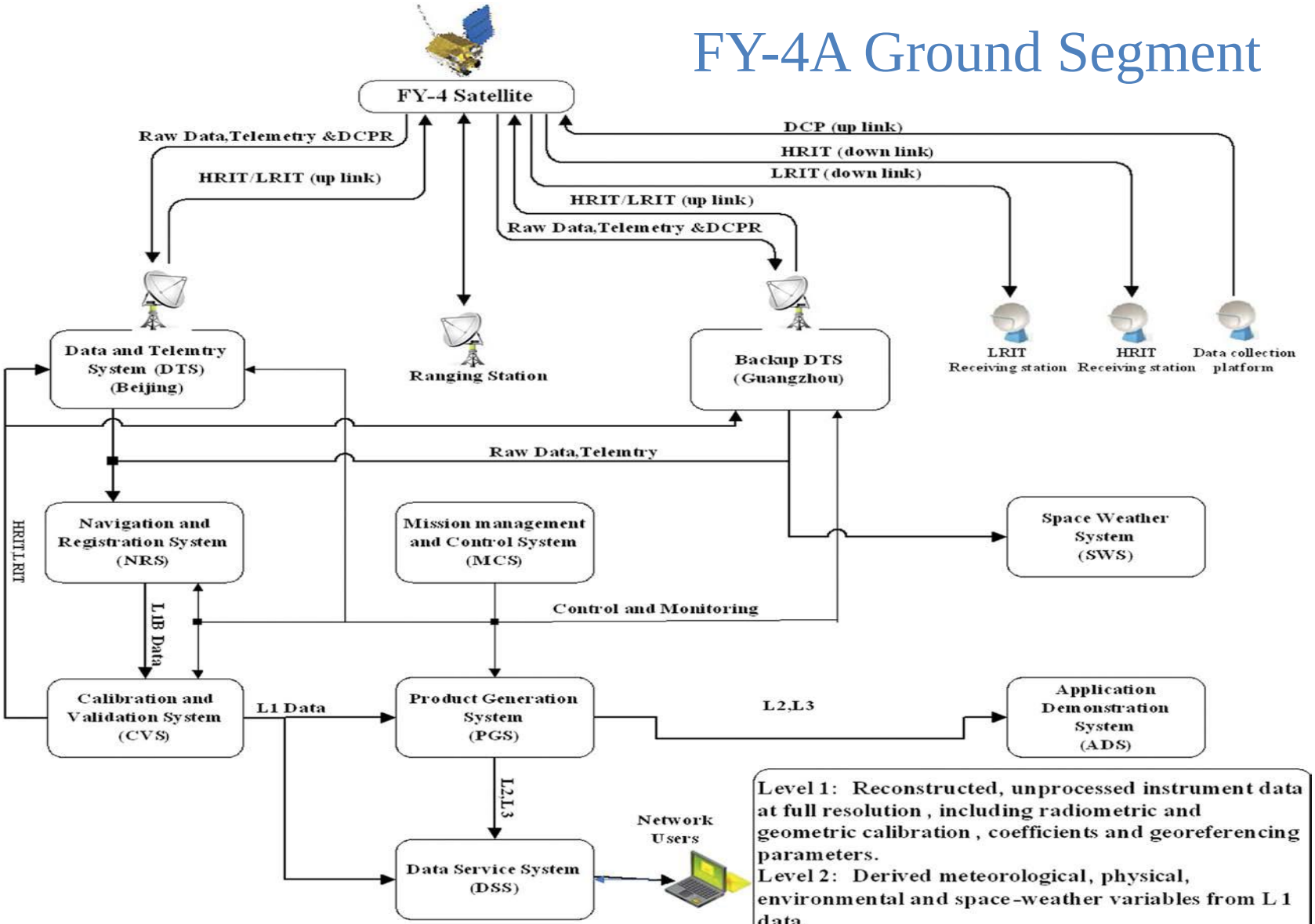
	FY-4A (experimental)	FY-4 (operational)	FY-2 (operational)
Stabilization	Three axis	Three axis	Spin
Designed life	7 years (designed life)	7 years (operation life)	4 years
Observation efficiency	85%	85%	5%
Observation mode	Imaging + sounding + lightning mapping	Imaging + sounding + lightning mapping	Imaging only
Main instruments	AGRI: 14 channels Resolution: 0.5–4 km Full disc: 15 min	AGRI: 18 channels Resolution: 0.5–2 km Full disc: 5 min	VISSR: 5 channels Resolution: 1.25–5 km Full disc: 30 min
	GIIRS: 913 channels SSP resolution: 16 km Spectral resolution: 0.8, 1.6 cm^{-1}	GIIRS: >1,500 channels SSP resolution: 8 km Spectral resolution: 0.625 cm^{-1}	—
	LMI Area coverage SSP resolution: 7.8 km	LMI Full-disc coverage SSP resolution: 7.8 km	—
	SEP High-energy particles Magnetic field	SEP High-energy particles, magnetic field, solar imager	SEM High-energy particles Solar X-ray fluxes

Reference:

Jun Yang., 2017: INTRODUCING THE NEW GENERATION OF CHINESE GEOSTATIONARY WEATHER SATELLITES, FENGYUN-4 , BAMS,1637-1658

- FY-4 will improve most products of FY-2 and introduce many new products, such as atmospheric temperature and moisture profiles, atmospheric instability index, layer perceptible water vapor, and rapidly developing clouds, and others.
- FY-4 products are expected to provide enhanced applications and services.
- The FY-4 GIIRS is one of the Group on Earth Observations (GEO) sounders planned by Global Earth Observation System of systems (GEOSS) member states in response to the call from the WMO for advanced sounders in the geostationary orbit.
- FY-4 will become an important GEO component of the global Earth-observing system.

FY-4A Ground Segment



Level 1: Reconstructed, unprocessed instrument data at full resolution , including radiometric and geometric calibration , coefficients and georeferencing parameters.

Level 2: Derived meteorological, physical, environmental and space-weather variables from L 1 data.

Level 3: The average or other statistical results from L2 Data.

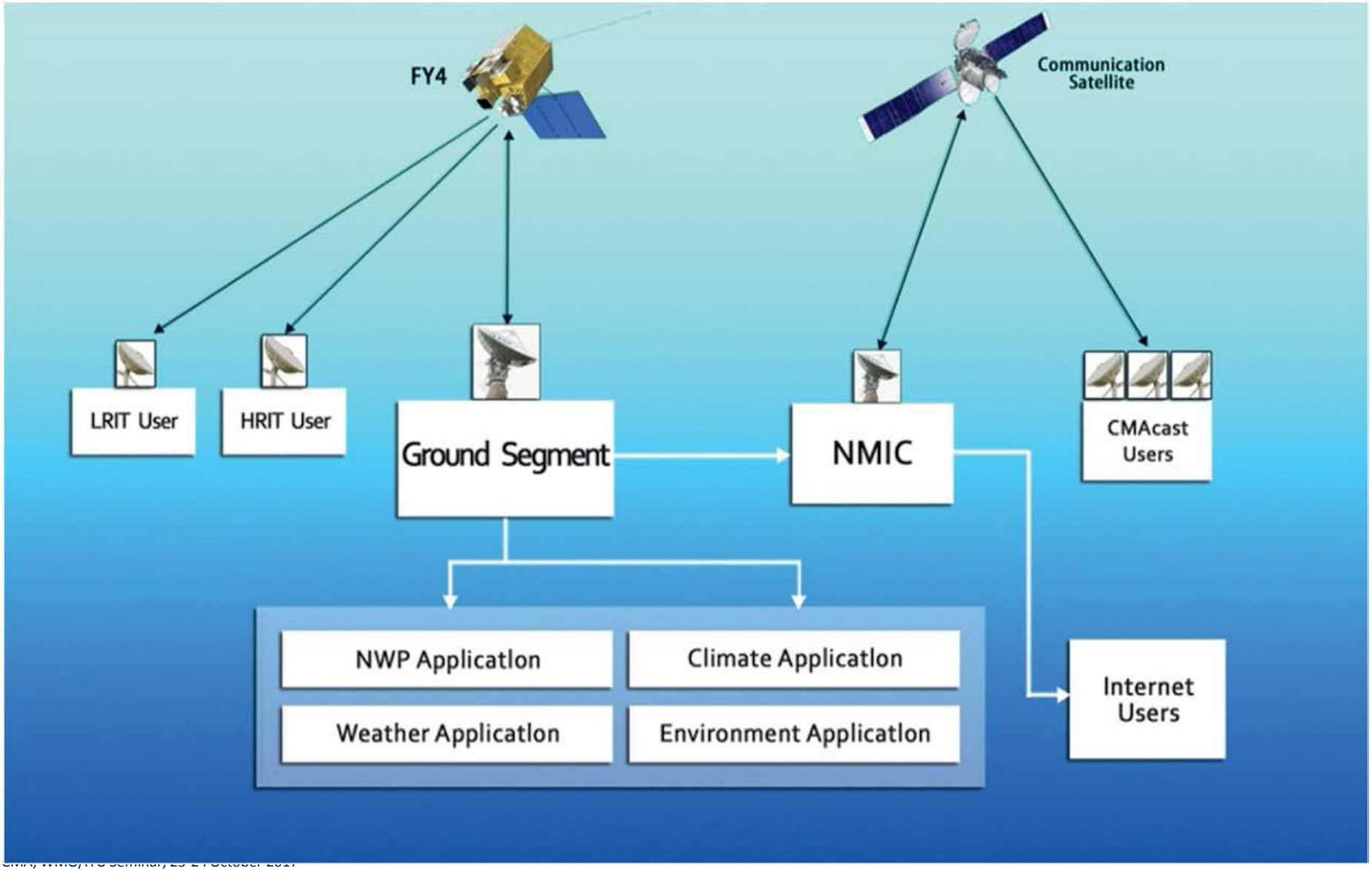
DCP: Data Collection Platform

DCPR: Data Collection Platform Report

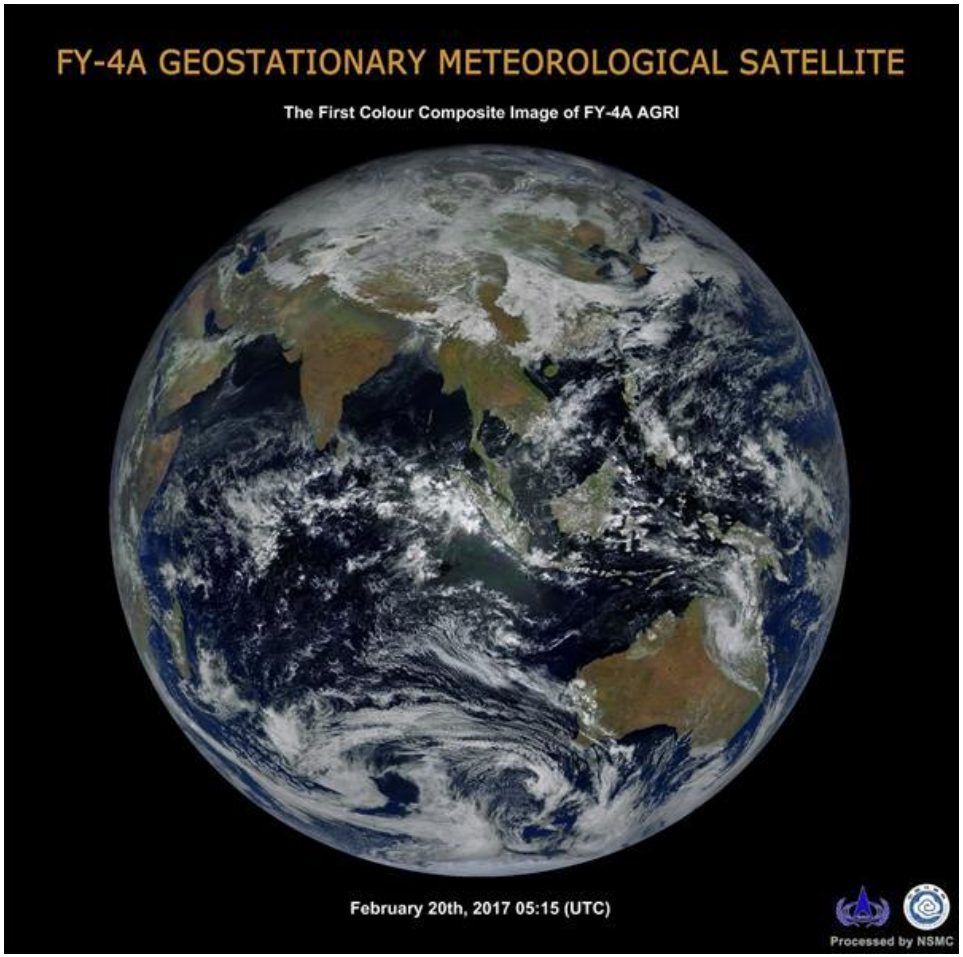
Primary ground missions as follows:

1) Receiving raw data from the satellite;
2) Determining and predicting the satellite orbit based on ranging measurements to the satellite;
3) Monitoring the satellite and controlling the payloads;
4) Undertaking the mission management and operation control of the satellite and ground systems;
5) Processing data for geolocation and registration;
6) Processing data for measurement calibration;
7) Producing quantitative products;
8) Providing an archive and distribution service for the data and products;
9) Carrying out applications for the weather, climate and environment;
10) Accomplishing monitoring and predicting services for space weather.

FY-4A data distribution and applications

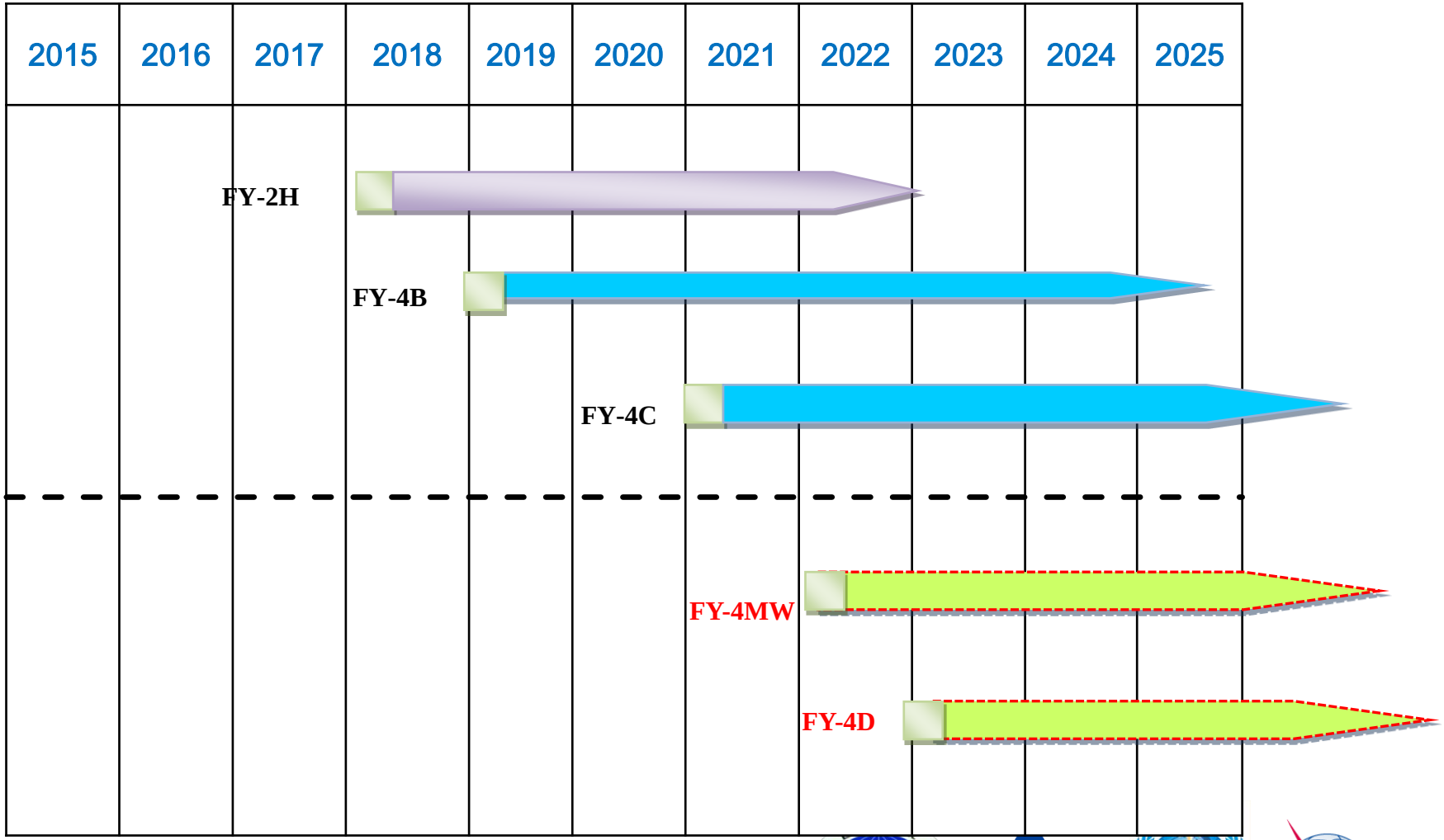


THE FIRST IMAGES FROM THE AGRI OF FY-4A



2017/10/17

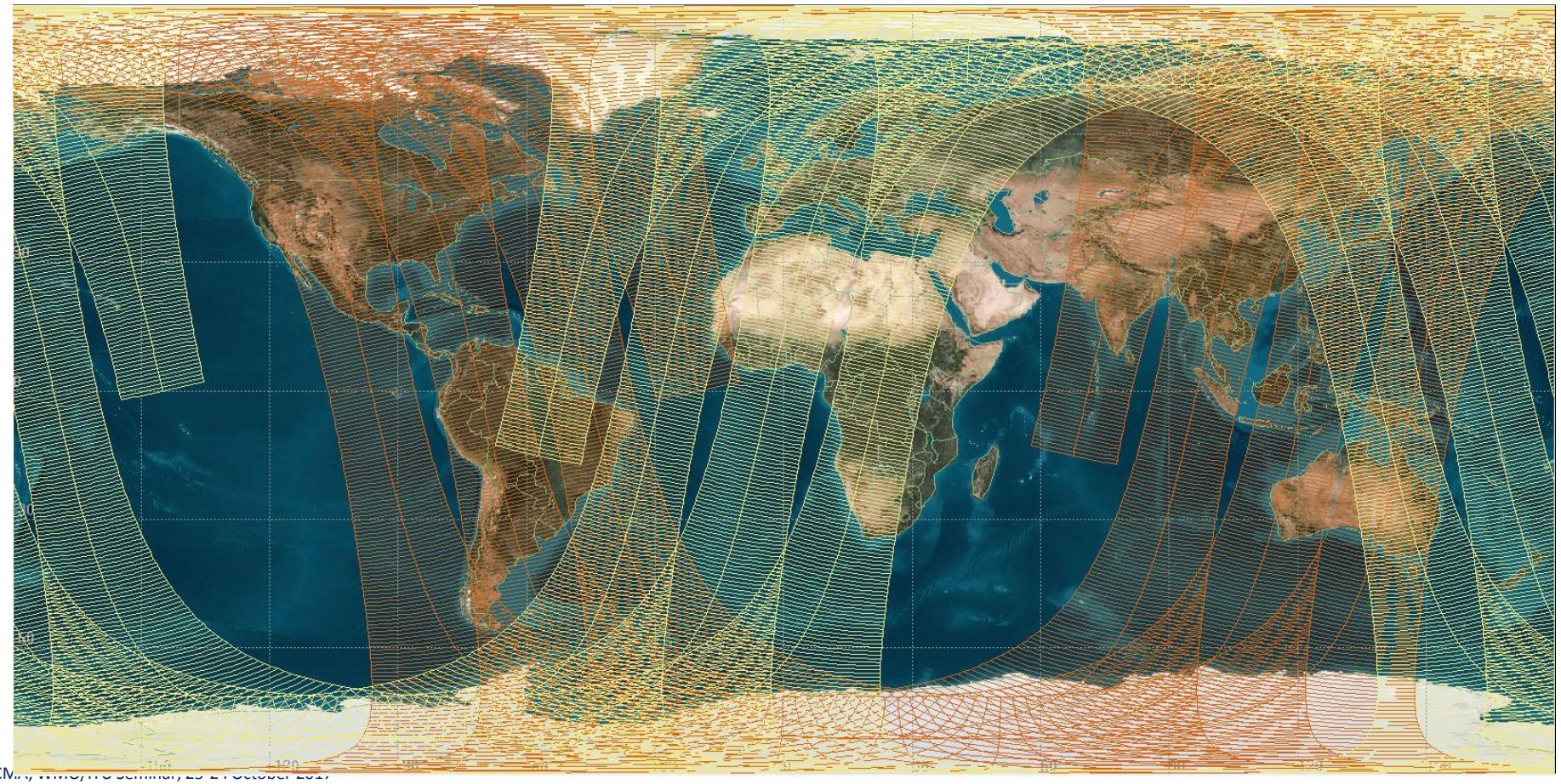
FENGYUN future GEO Satellites Launch Plan by 2025



1.2 FENGYUN Polar Constellation

In operation: FY-3B (global) **+ FY-3C** (global) **+ FY-3A** (regional)

FY-3C LTC 10:20 AM **FY-3B LTC 13:40 PM**



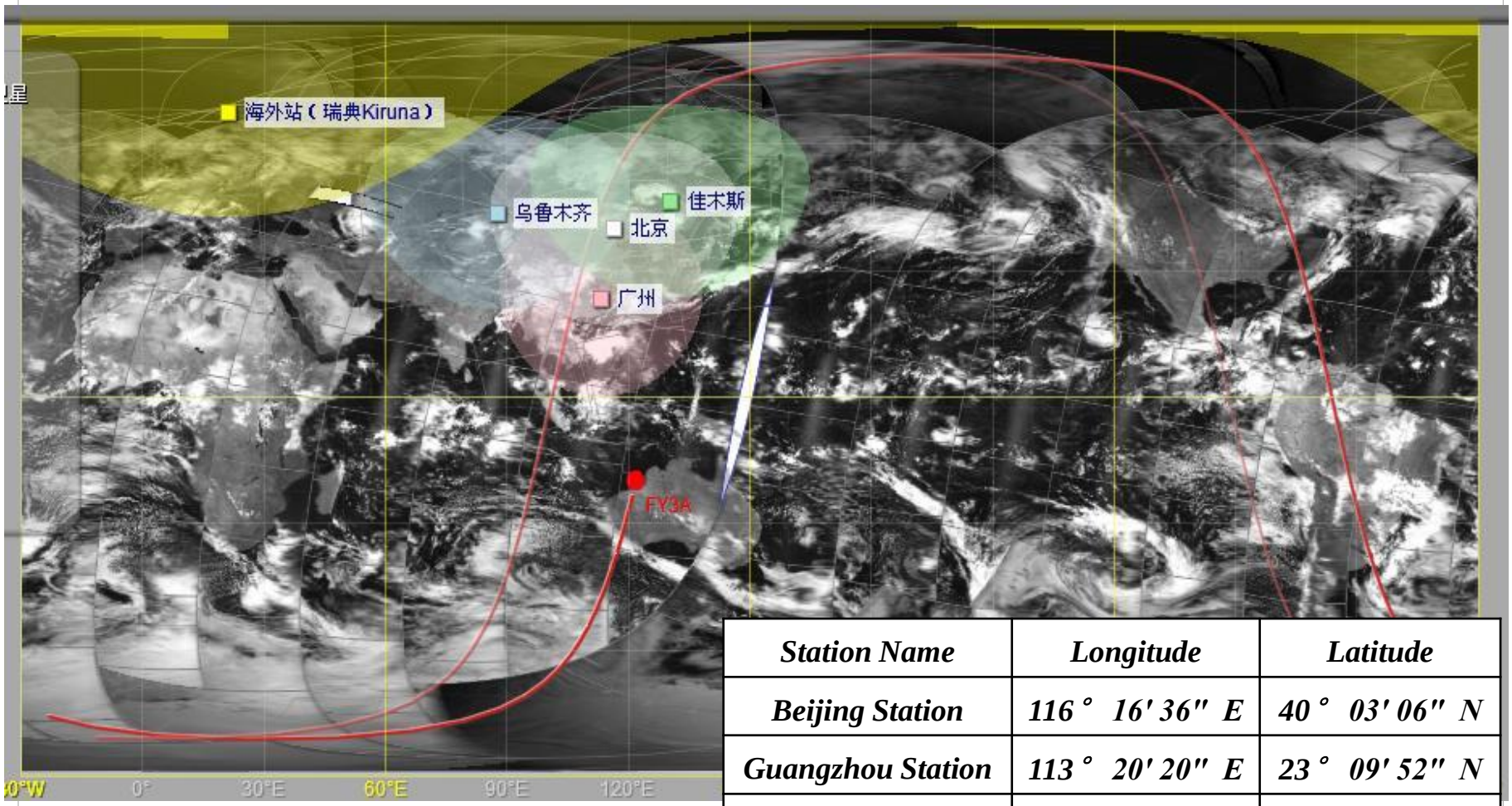
The second polar orbit generation : FY-3

- 11 instruments
  - ✓Atmospheric sounding
  - ✓Microwave Imaging
  - ✓ Ozone sounding
  - ✓ Radiation budget for Earth system
- Spatial Resolution from Km to 250m

Compared with the FY-1 satellite, the FY-3 satellite is more capable in many terms:

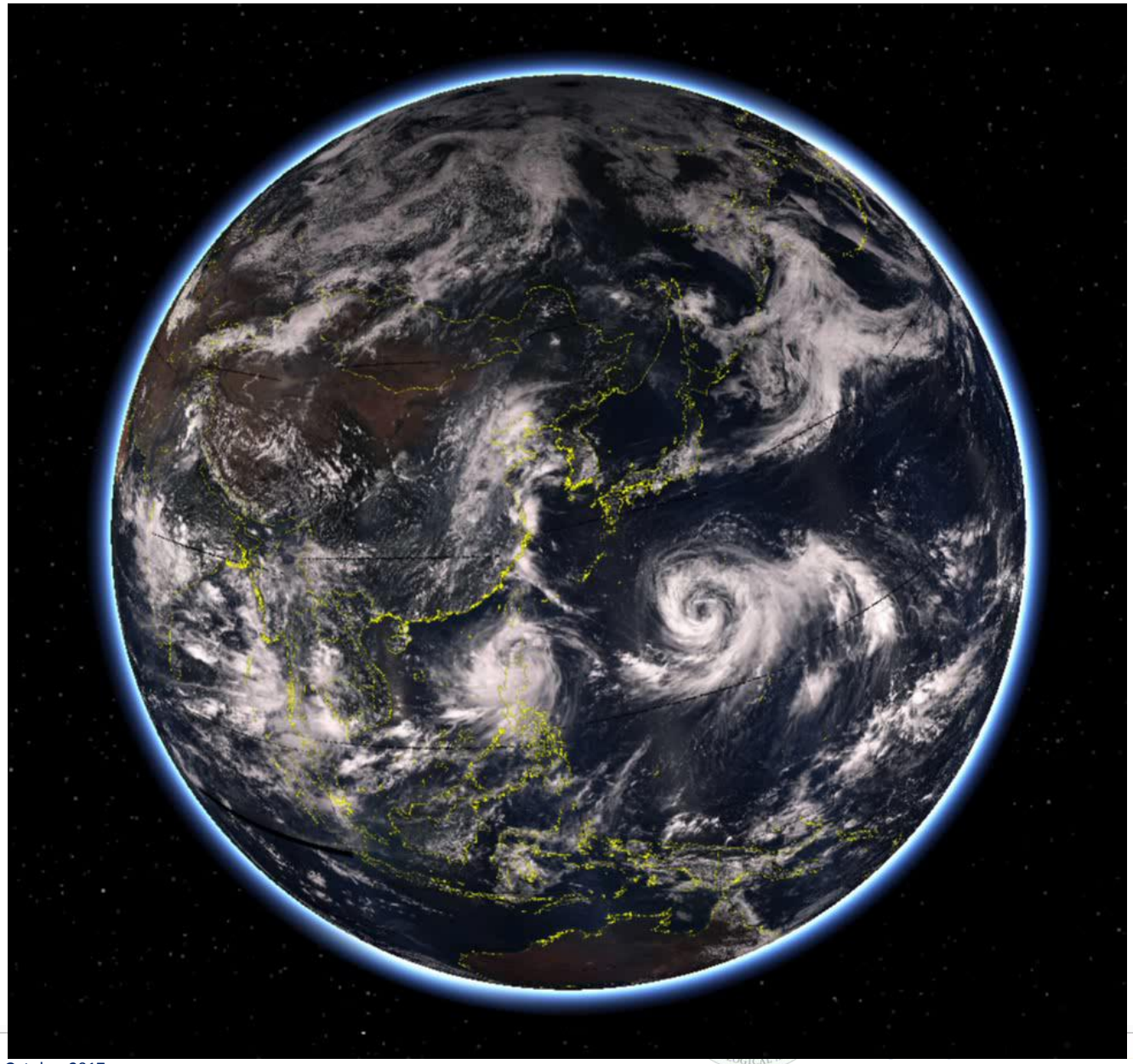
- Vertical temperature and humidity sounding,
- Ozone detection
- Microwave sensor
- Visible,
- Infrared imaging.

Global Data Latency within 4 hours maximum

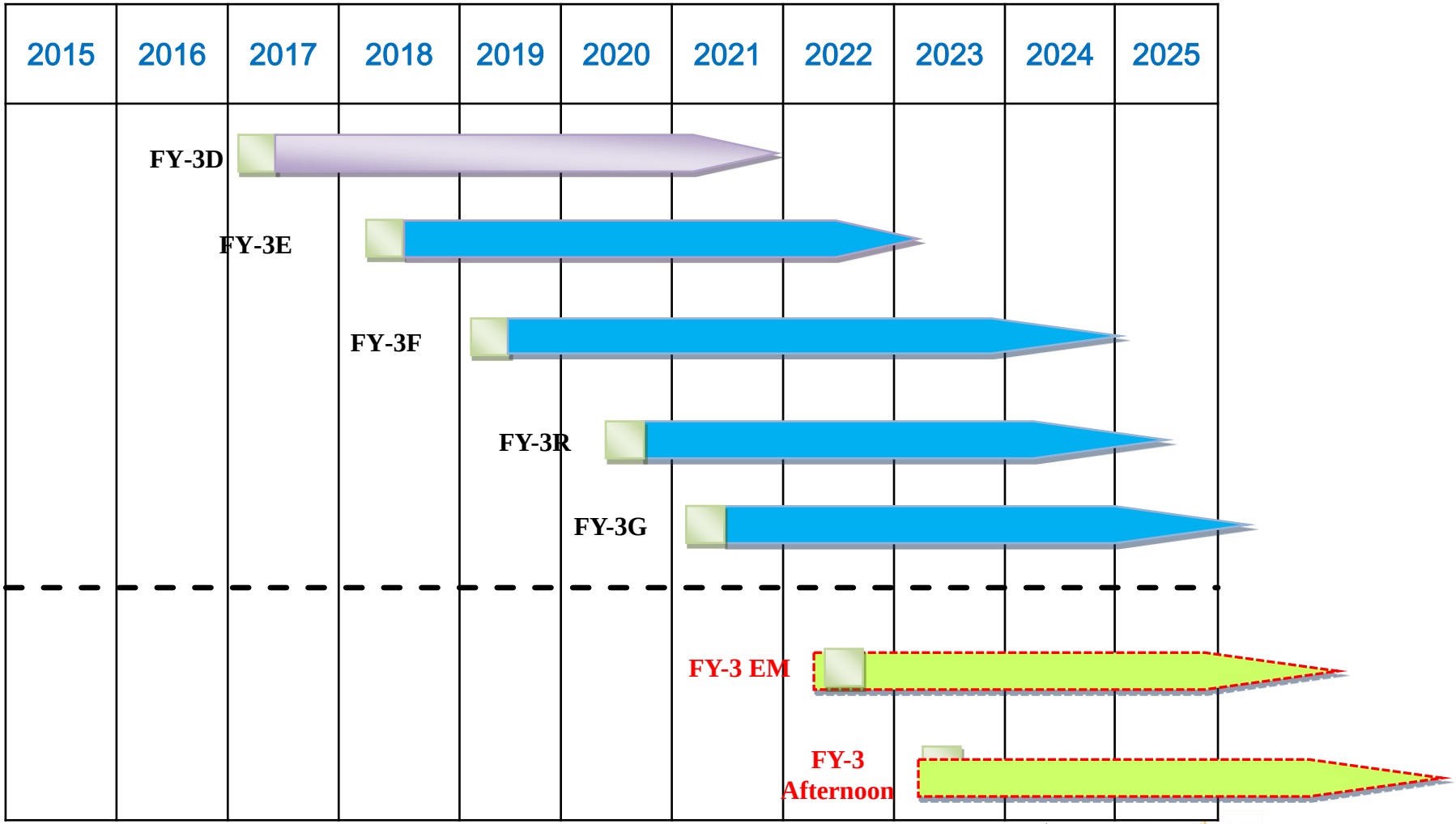


Station Name	Longitude	Latitude
Beijing Station	116° 16′ 36″ E	40° 03′ 06″ N
Guangzhou Station	113° 20′ 20″ E	23° 09′ 52″ N
Wulumuqi Station	87° 34′ 08″ E	43° 52′ 17″ N
Jiamusi Station	130° 22′ 48″ E	46° 45′ 20″ N
Kiruna Station	21° 02′ E	67° 32′ N

FY-3B Global Image 20110827——Typhoon Talas、Nanmadol and Hurricane Irene



FENGYUN future LEO Satellites Launch Plan by 2025



1.3 CURRENT CMA RECEIVED OTHER SATELLITES

1) GF-4

- The 4th satellite in High res. Earth Obs, Satellite Project led by **CNSA**.
- Successfully launched in Dec. 29,2015
- Commissioning test finished and handover declared on June 1st, 2016
- **CMA is responsible for GF-4 data reception and transmission, as well as data preprocessing in MET mode.**

2) TANSAT

- Launched in Dec. 22, 2016
- A joint research & development satellite program initiated by MOST(Ministry of Science and Technology) and supported by CMA and CAS(Chinese Academy of Sciences).
- **CMA is responsible for data reception, processing and distribution, taking advantage of current FY-3 earth station resources.**

1.4 Space Weather

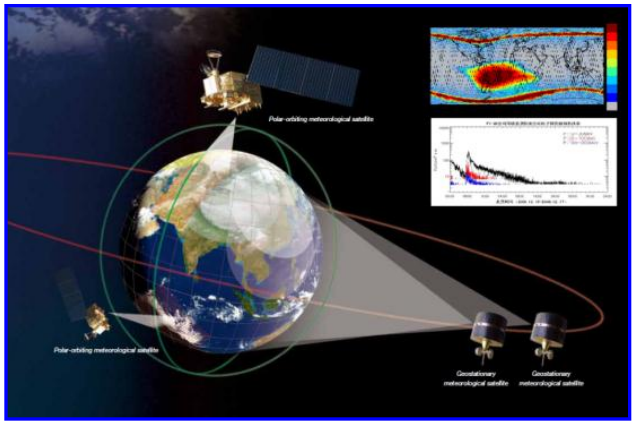
- In 2002, CMA was authorized by the National Council to establish the **National Center for Space Weather (NCSW)**, assigned to the National Satellite Meteorological Center.
- NCSW began to **provide space weather operational service** On July 1, 2004.
- NCSW now has preliminary developed a complete operation system covering space weather monitor, forecast, and service.

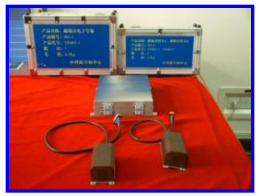
Missions of NCSW

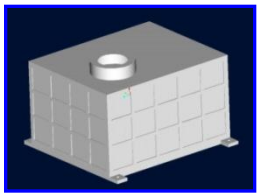
- ✓ To study and draft strategy and development programs for China’ s Space weather operations.
- ✓ To build up space-based and ground-based monitoring systems for China’ s space weather operations.
- ✓ To be responsible for receiving, processing, distributing and studying space weather data.
- ✓ To provide space weather monitoring and warning operations and services

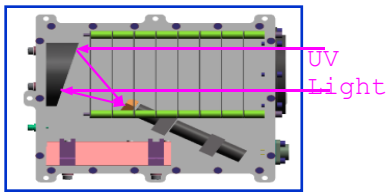
The FY satellites have been playing an important role in space weather observations

- **The Polar satellites** could monitor impacts of energetic particles. The FY-3C could give the ionosphere information by GNSS radio occultation receiver.
- **The Geo. satellites** could measure solar X-ray and energetic particles. FY-4 will provide the solar imaging and geomagnetic field observations.



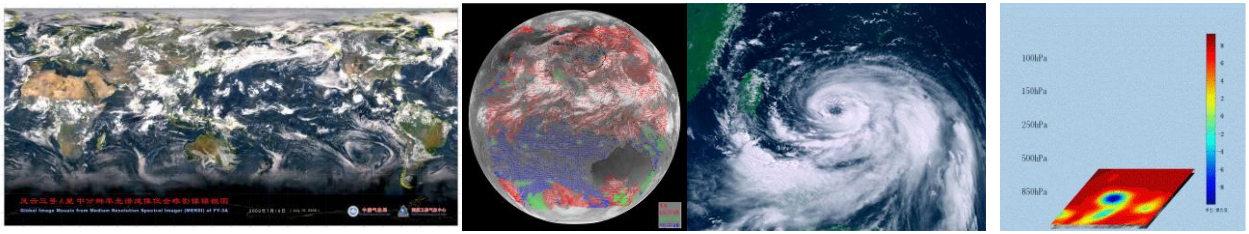




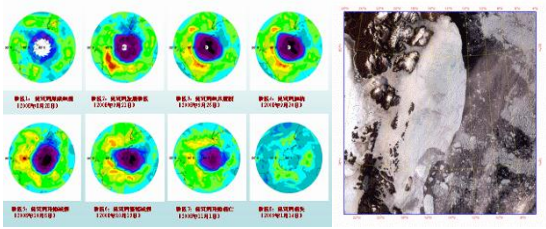


2、Applications

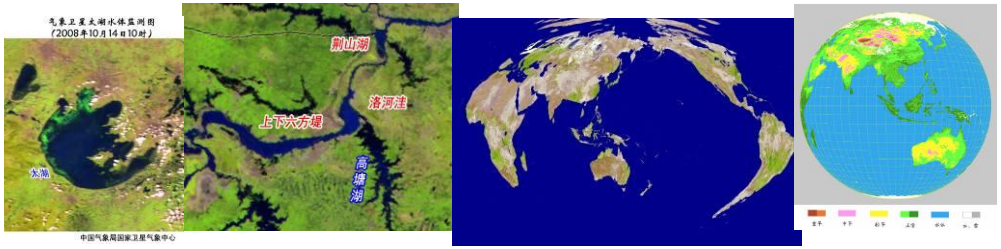
Weather



Climate

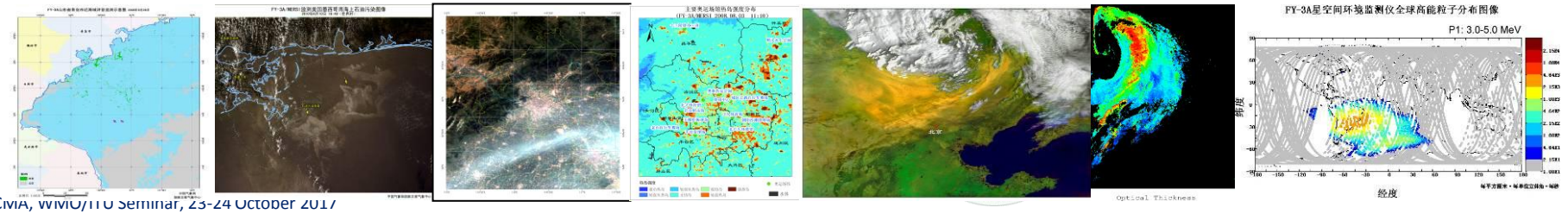


Resource

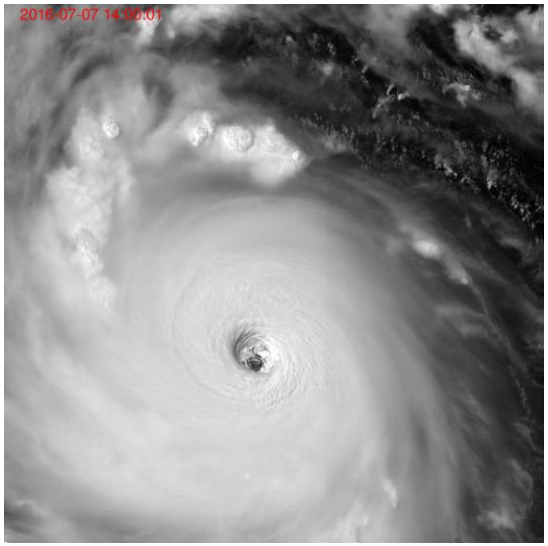


Disaster

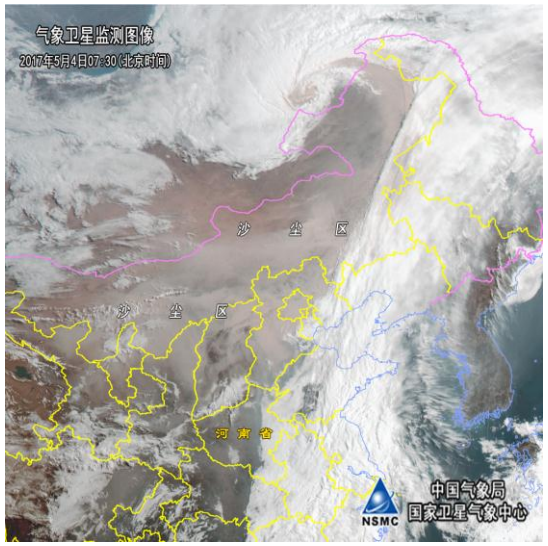
Environment



Use of Radio Spectrum for CMA current and future Metsat systems

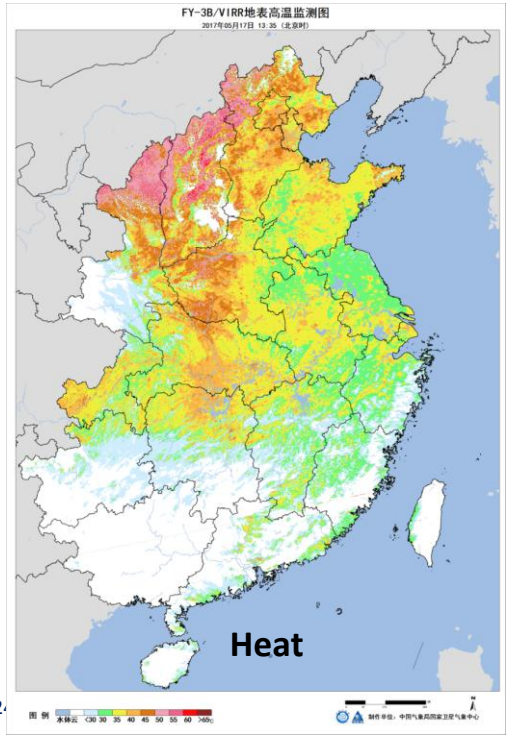


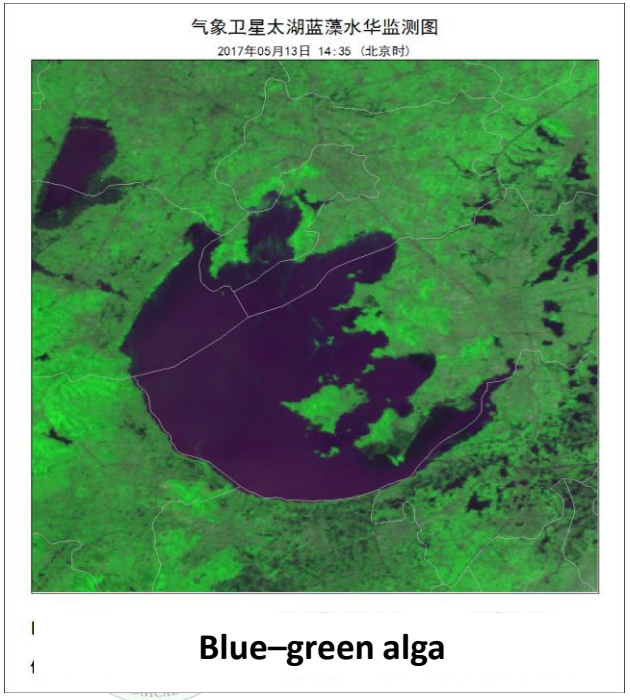
Typhoon



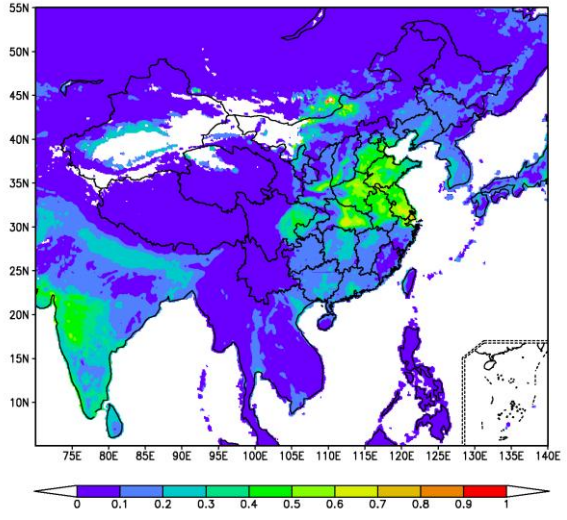
Sand Storm

Fire monitor

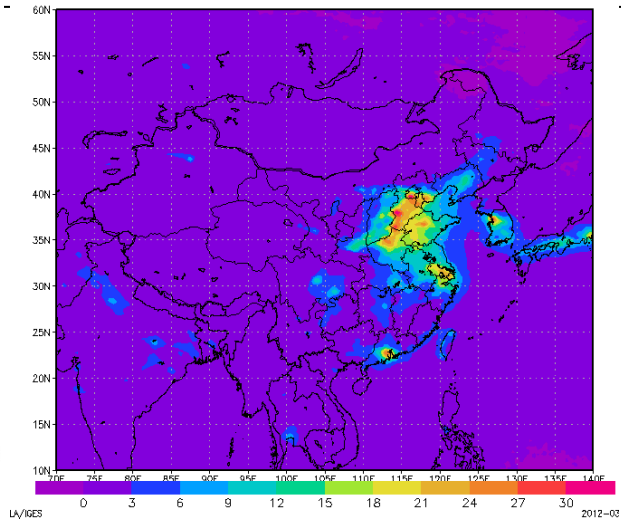




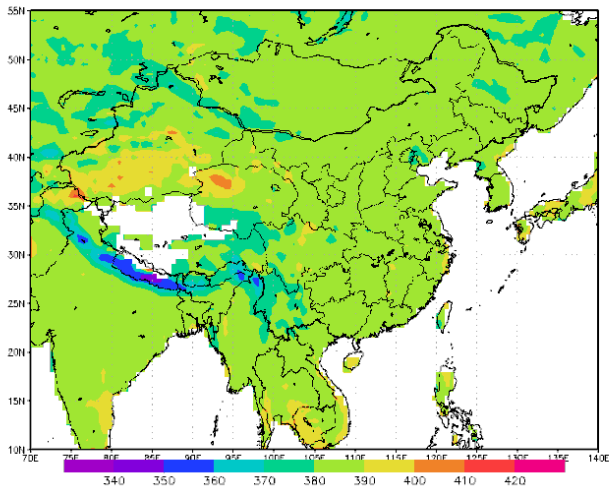
Haze and PM2.5



aerosol

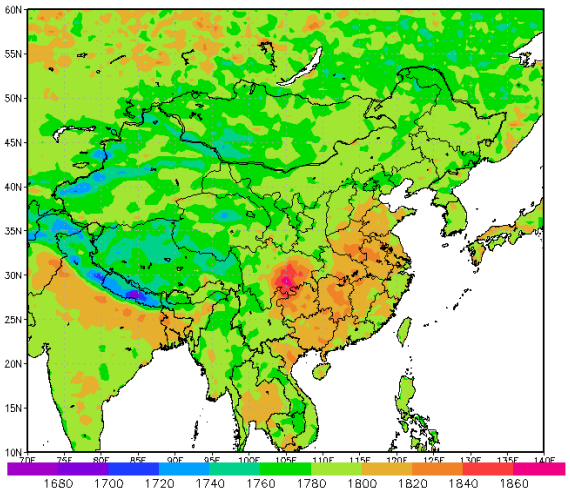


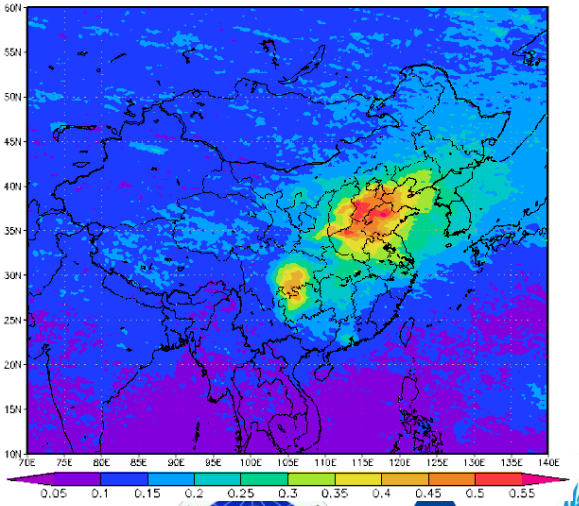
NO2



CO2

CH4





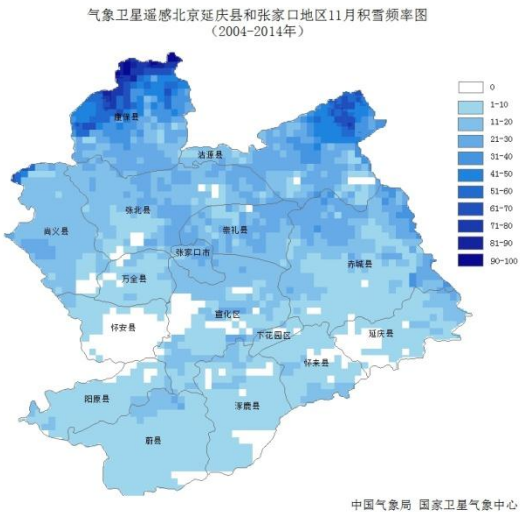
SO2

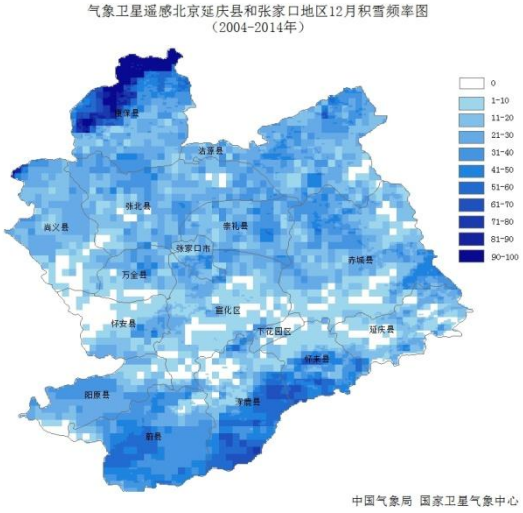
NSMC

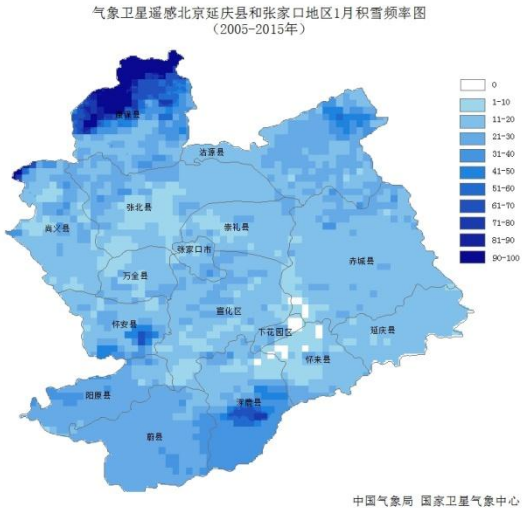
WMO

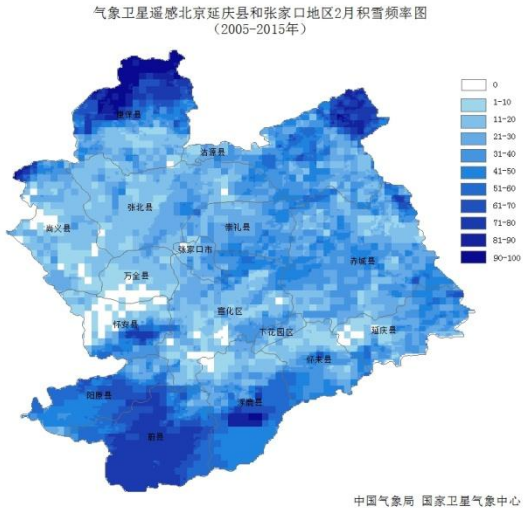
ITU

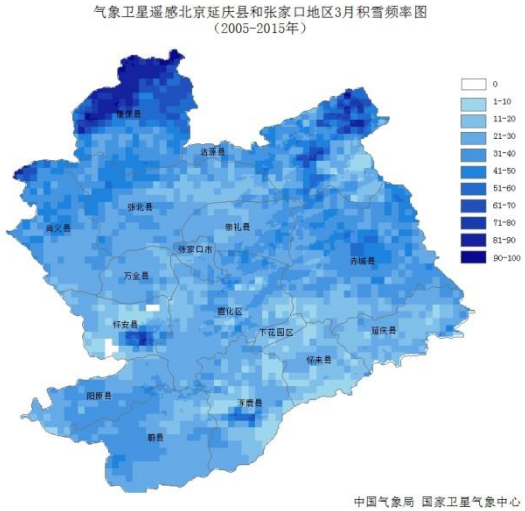
Snow Cover





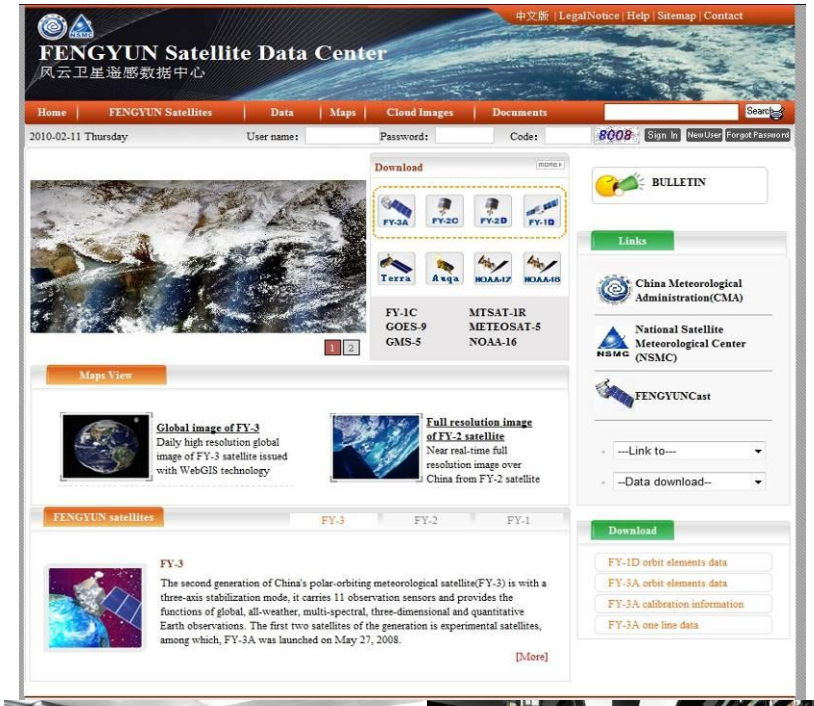






2022 Winter Olympics, Yanqing and Zhangjiakou

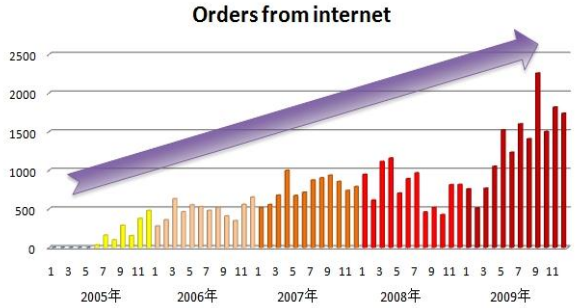
3、Data and Products Service

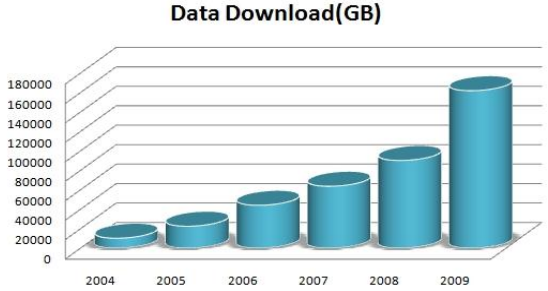


- Long-term historic satellite data since 1984, over 600 TeraByte
- http://satellite.cma.gov.cn/eng

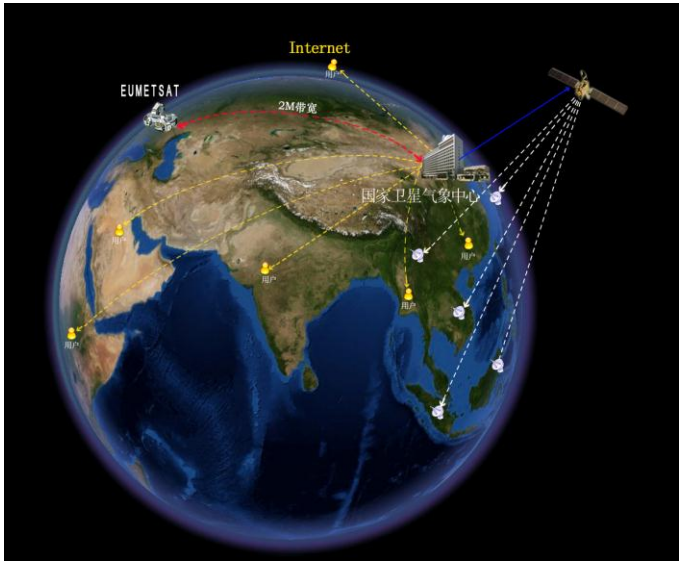
  (2005 - 2010)
- http://fy3.satellite.cma.gov.cn/arssen/

  (2009 - present)



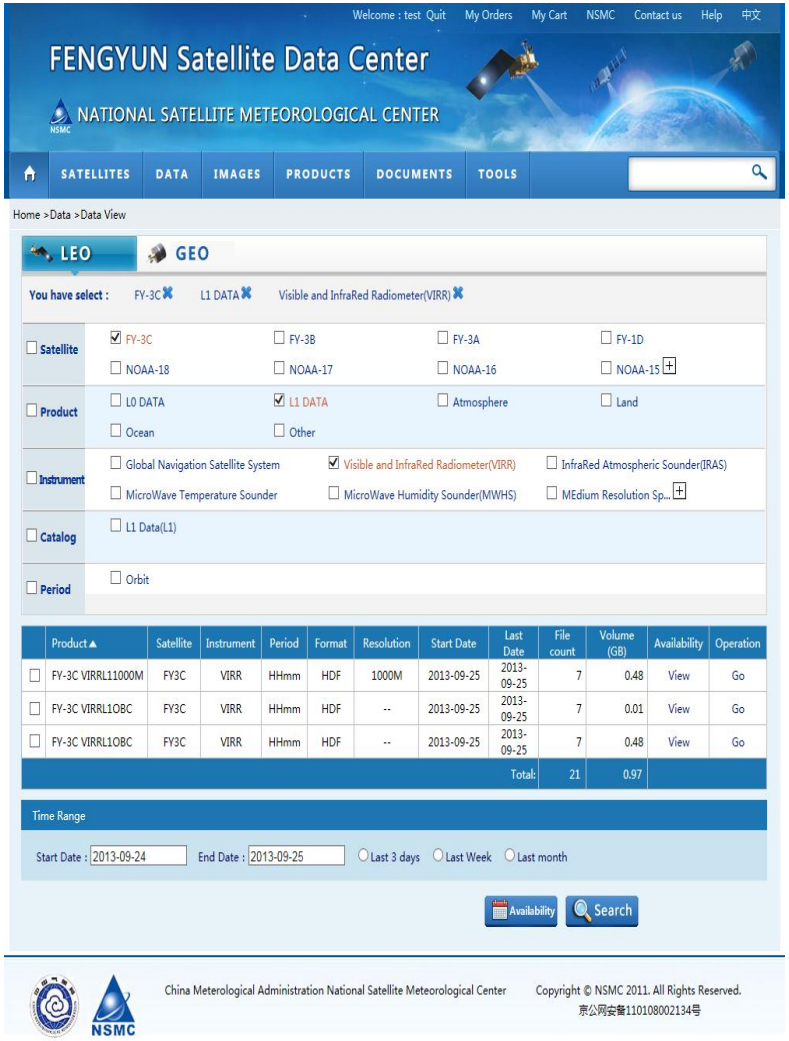


1) Web-based Service（register user）
2) CMACast（register user）
3) FTP Push （important user）
4) FTP Pull （register user）
5) Manual Service （emergency）
6)DB Users （register user）
7)Cloud service mode for FY-4 data application (all users)

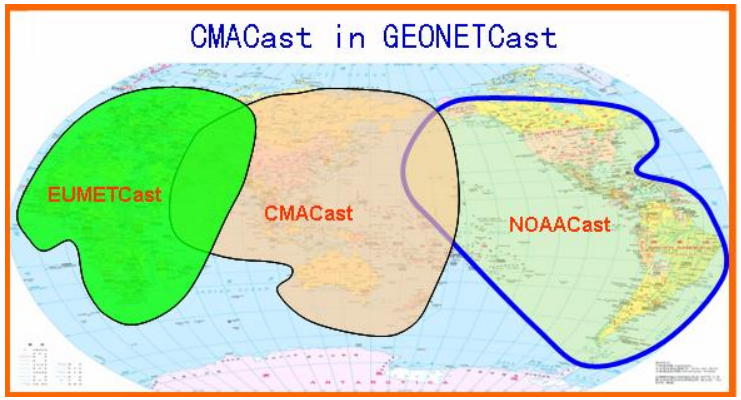


http://satellite.cma.gov.cn

Access to Satellite Data and Products

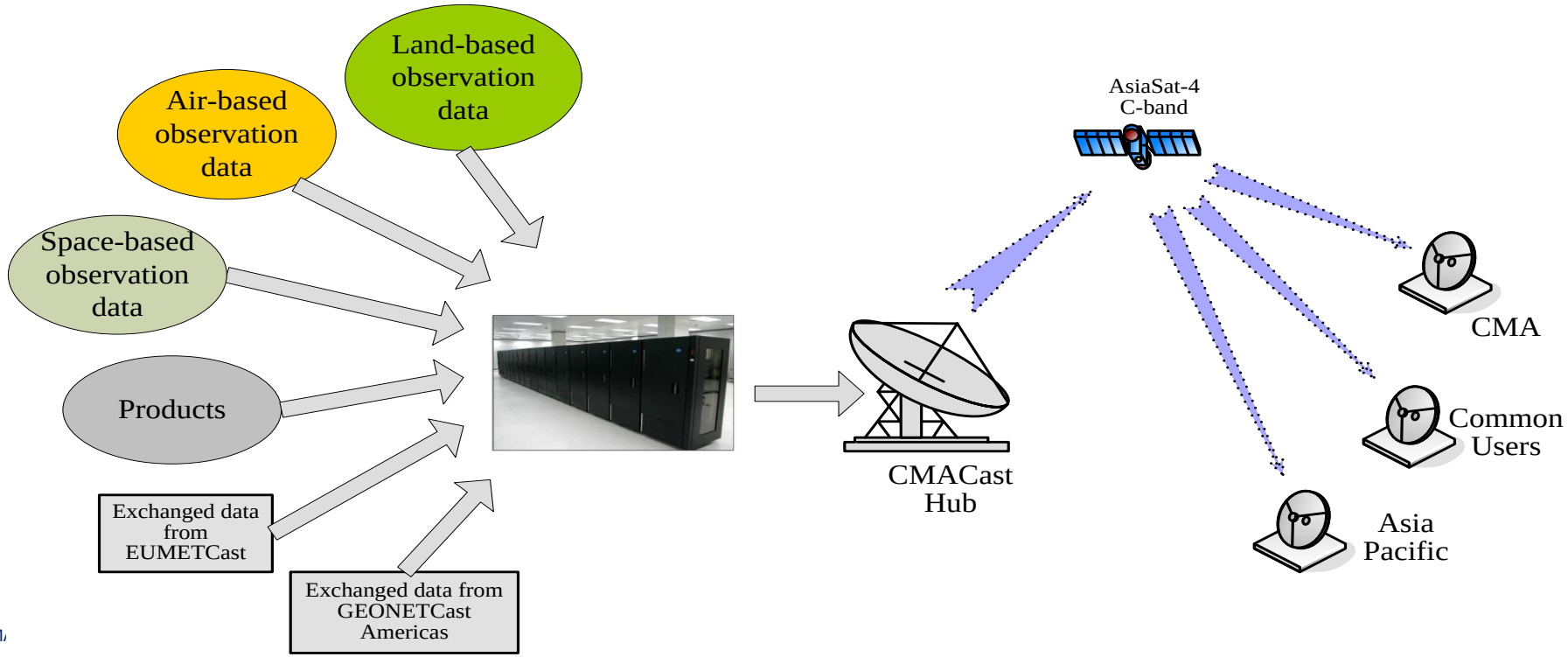


Satellite Data Service and Sharing



CMACast

CMACast is based on DVB-S2 technology with both file and multimedia transmission capability. It uses an entire 36MHz C-band transponder of communication satellite to distribute meteorological data and satellite sensing data to users of Asia-Pacific region.



4、Use of Radio Spectrum

4.1 FY-2

Mission name: FY-2D, FY-2E, FY-2F, FY-2G and FY-2H

General objective: Chinese first generation geostationary meteorological satellite systems.

ITU filing name: FY-2A, FY-2AS, FY-2B, FY-2BS, FY-2C, FY-2CS, FYGEOSAT-86.5E, FYGEOSAT-99.5E, FYGEOSAT-105E, FYGEOSAT-112E, FYGEOSAT-123.5E.

Orbit: GEO (86.5E, 99.5E, 105E, 112E and 123.5E)

Main earth station(s): Beijing, Guangzhou, Xinjiang (China)

Service frequencies: See below table.

Use of Radio Spectrum for CMA current and future Metsat systems

Frequency range (MHz)	Emission	Bandwidth (MHz)	Direction	Service
1671.6-1691.6	20M0G1D--	20	S-E	CDAS
2046.5-2048.5	2M00G1D--	2	E-S	S-VISSR
1686.5-1688.5	2M00G1D--	2	S-E	S-VISSR
2050.87-2051.13	260KFXD--	0.26	E-S	LRIT
1690-1691	1M00G2W--	1	S-E	LRIT
1690.87-1691.13	260KFXD--	0.26	S-E	WEFAX
401.1-401.4		0.3	E-S	DCP
402.0-402.1		0.1	E-S	DCP
2059.487-2059.513	26K0FXD--	0.026	E-S	S-WEFAX
1699.487-1699.513	26K0FXD--	0.026	S-E	S-WEFAX
2050-2051	1M00G2W--	1	E-S	Ranging
1690-1691	1M00G2W--	1	S-E	Ranging
2046-2047	1M00G2W--	1	E-S	Ranging
1686-1687	1M00G2W--	1	S-E	Ranging
2044-2045	1M00G2W--	1	E-S	Ranging
1684-1685	1M00G2W--	1	S-E	Ranging

4.2 FY-3

Mission name: FY-3 series
General objective: Chinese second generation non-geostationary meteorological satellite systems.
ITU filing name: FY-3, FY-3-A
Launch Date: FY-3A, FY-3B and FY-3C of FY-3 series were launched on 27 May 2008 , 5 November 2010 and 23 September 2014 respectively, FY-3D will be launched on Second half of 2017.
Orbit: Polar orbiting satellite, Apogee: 854km, Perigee: 818km
Service frequencies: L, S and X bands.
Local time of descending node: 1) FY-3A and FY-3C:10:00-10:20; 2) FY-3B and FY-3D :13:40-14:00.
Main earth station(s): Beijing, Guangzhou, Xinjiang, Jiamusi(China), Kiruna(Sweden).

1) Data transmission

Missions	Frequency (MHz)	Emission	Bandwidth (MHz)	Direction	Service
FY-3A /FY-3B	1704.5	6M80G1W--	6.8	S-E	HRPT
	7775	45M0G1W--	45	S-E	MPT
	8145.95	149MG1W--	149	S-E	DPT
FY-3C	1701.4	6M80G1W--	6.8	S-E	HRPT
	7780	60M0G1W--	60	S-E	MPT
	8175	300MG1W--	300	S-E	DPT
FY-3D	1706.7	6M80G1W--	6.8	S-E	HRPT
	7820	60M0G1W--	60	S-E	MPT
	8250	300MG1W--	300	S-E	DPT

2) Passive sensor

Payload name	Frequency （GHz）
Microwave Radiation Imager MWRI	18.6-18.8, 23.6-24, 36-37, 86-90
Microwave Temperature Sounder	50.2-50.4,51.56-51.96, 52.6-53,54.2-54.6, 55.3-55.7 53.396-53.566, 54.740-55.140, 57.125-57.455
Microwave Humidity Sounder	89,150； 113.75,123.75,176.31,178.81,187.81,190.31； 115.75,121.75,180.31,186.31； 181.51,185.11； 182.31,184.31； 116.25,117.65,117.95,119.55,119.85,121.25； 118.45,119.05； 118.55,118.95； 118.67,118.83;

3) Active sensor

Payload name	Frequency center / bandwidth GHz）	Frequency band（GHz）
Precipitation measurement radar, PMR	13.6/0.0006	13.5997-13.6003
	35.75/0.5	35.5-36
Wind radar, WMFR-C	5.41/0.32	5.25-5.57
	5.3/0.02	5.29-5.31
Wind radar, WMFR-KU	13.5/0.5	13.25-13.75
	13.276/0.02	13.266-13.286

4.3 FY-4

Mission name: FY-4 series

General objective: Chinese second generation geostationary meteorological satellite systems.

Launch Date: The FY-4A was launched in 11Dec 2016, the second satellite, FY-4B, will be launched in year 2019.

ITU filing name: FYGEOSAT-99.5E/-A-99.5E, FYGEOSAT-105E/-A-105E.

Orbit: GEO (99.5E/105E) FY-2A, FY-2AS, FY-2B, FY-2BS, FY-2C, FY-2CS, FYGEOSAT-A-79E, FYGEOSAT-86.5E/-A-86.5E, FYGEOSAT-99.5E/-A-99.5E, FYGEOSAT-105E/-A-105E, FYGEOSAT-112E/-A-112E, FYGEOSAT-123.5E/-A-123.5E and FYGEOSAT-A-133E.

Main earth station(s): Beijing, Guangzhou, Xinjiang and Zhangjiakou or Chengde(China); Zhangjiakou or Chengde station is under considering.

Service frequencies: Frequencies, bandwidth and direction of missions for FY-4 missions are listed in the bellow table.

1) Data transmission

Frequency range (MHz)	Direction	Service
401.1-401.4	E-S	DCP
402.0-402.1	E-S	DCP
1675-1690	S-E	HRIT/DCPR
1690-1696	S-E	Ranging
1696-1698	S-E	LRIT/EWAIB
2056.5~2057.5	E-S	LRIT
2042-2052	E-S	Ranging
2222-2232	S-E	Ranging
7450-7550	S-E	RD
8175~8215	E-S	HRIT
18100-18400	S-E	RD
25500-27000	S-E	RD

Frequency use of future FENGYUN satellites

1) Data transmission

- Higher frequency, higher bandwidth and higher speed: 25.5-27GHz
- Data relay: 25.25-27.5GHz

2) Sensor

- Active: 94GHz
- Passive:229GHz, 243GHz, 325GHz,448GHz, 664GHz

Thanks!