Overview of remote sensing at CMA

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Topics

1) CMA satellite plan

2)Updates of CMA satellite system

3)The future CMA satellite program

4)The products and applications

5)Summary

Planning of CMA satellite systems

The Chinese government have approve a much more extensive program called **NSI**, which will cover atmosphere, land, and ocean satellites beyond 2020.

Atmosphere

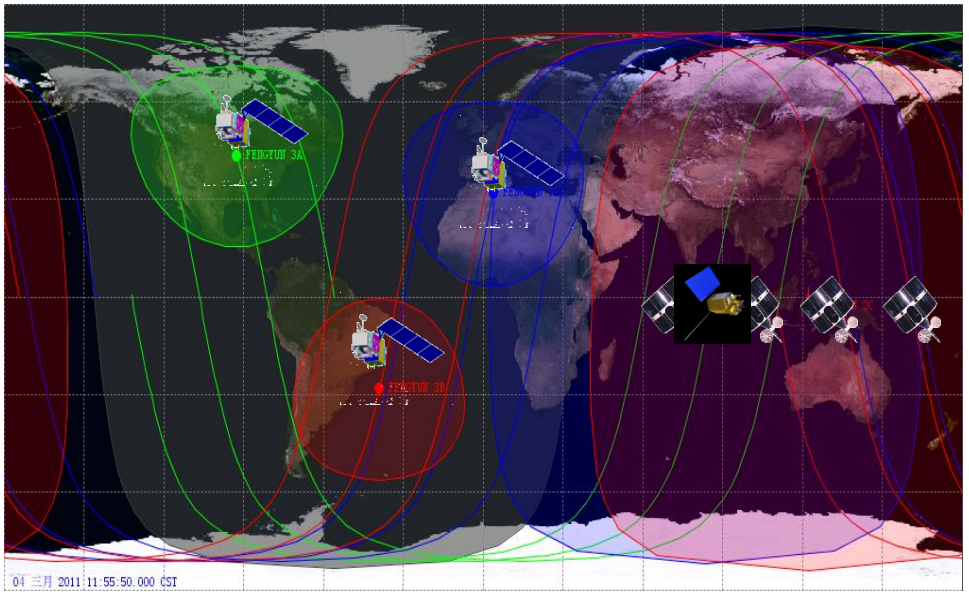
- Weather Monitoring Satellite: FY-4 follow-on
- Climate &Environment Monitoring Satellite: FY-3 follow-on
- Air Quality Monitoring Satellite: New Series for atmospheric chemistry

NSI: National Space Infrastructure

CMA Fengyun Constellation current status

LEO Programs

- FY-3A/B(R&D)
- FY-3C(op.), AM
- FY-3D(op.), PM , ready to launch!



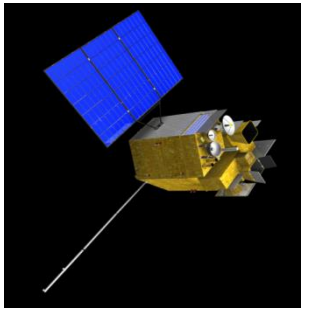
GEO Programs

- FY-2D/E/F/G(op.)
- FY-4A(R&D), new generation!

Others

- GF-4 (R&D), High Spatial Res. Imaging In GEO
- TANSAT(R&D),CO2 & aerosol

FY-3, LEO



FY-4, GEO

Mission objectives of CMA FengYun Geo.

1、 Support nowcasting and severe weather warning

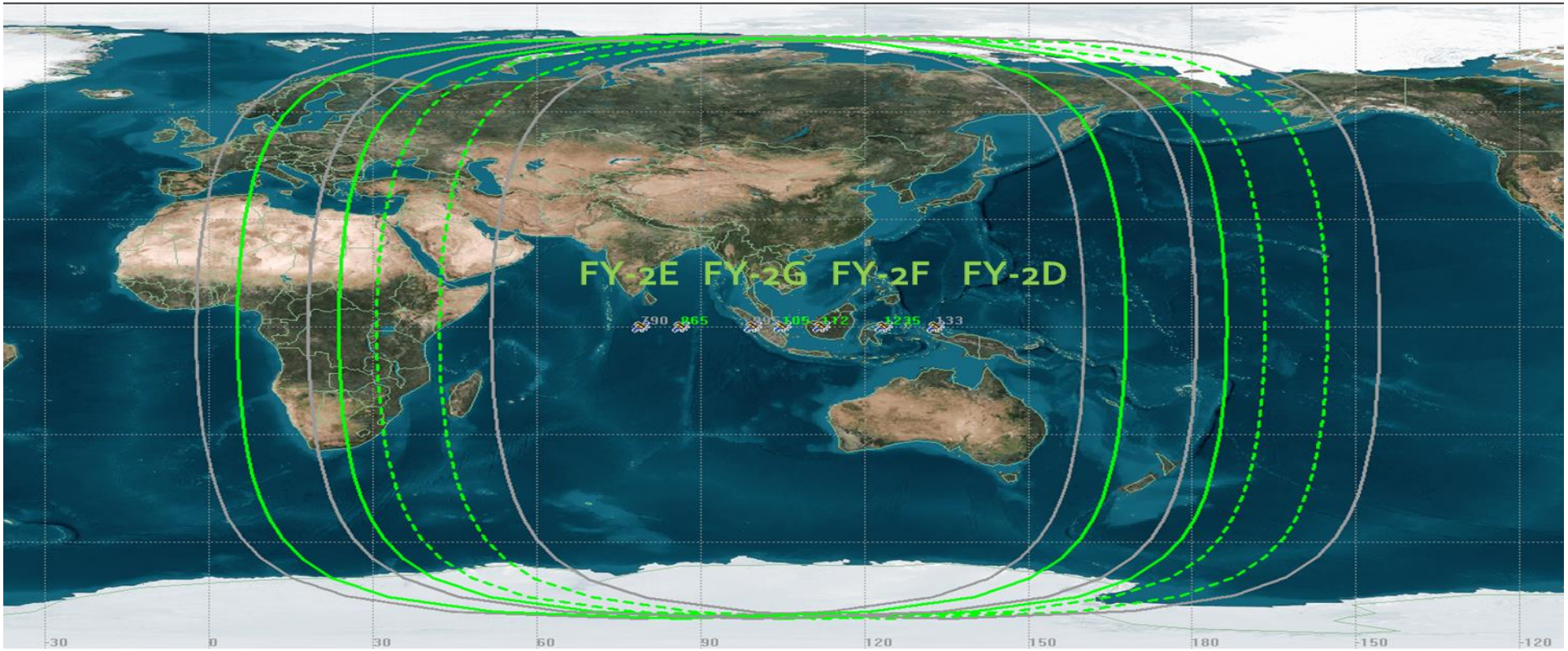
2 、Support NWP, regional and global

3 、Support climate applications

4 、Support environment and disaster monitoring

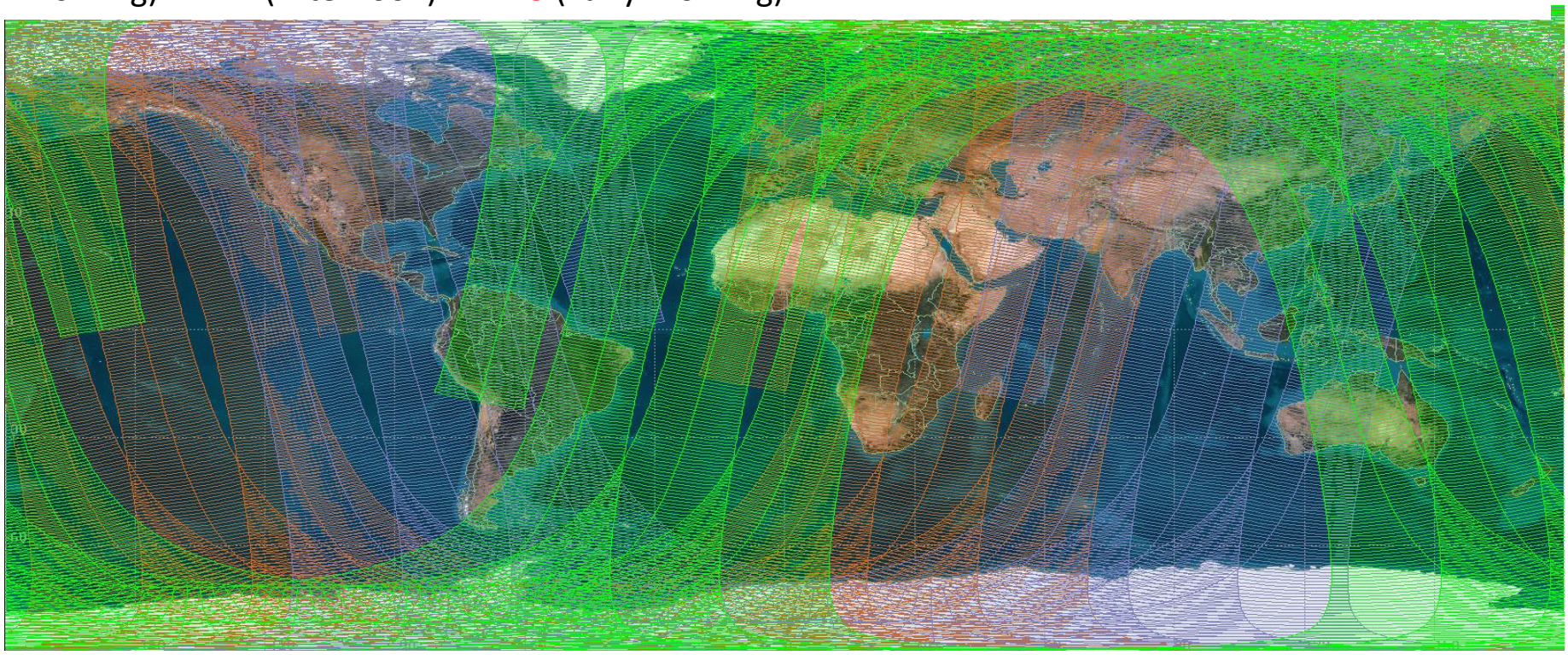
CMA Geo. Satellite constellation

1)Primary observation location: 86.5E&105.0E
2)Hot Backup and Flexible observation: 99.5E&112.0E
3)Post Launch test & On orbit storage: 79.0E,123.5E,133.0E



Mission objectives of CMA FengYun Leo.

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
FY-3 AM

NPP 13:30 PM
FY-3 PM

Topics

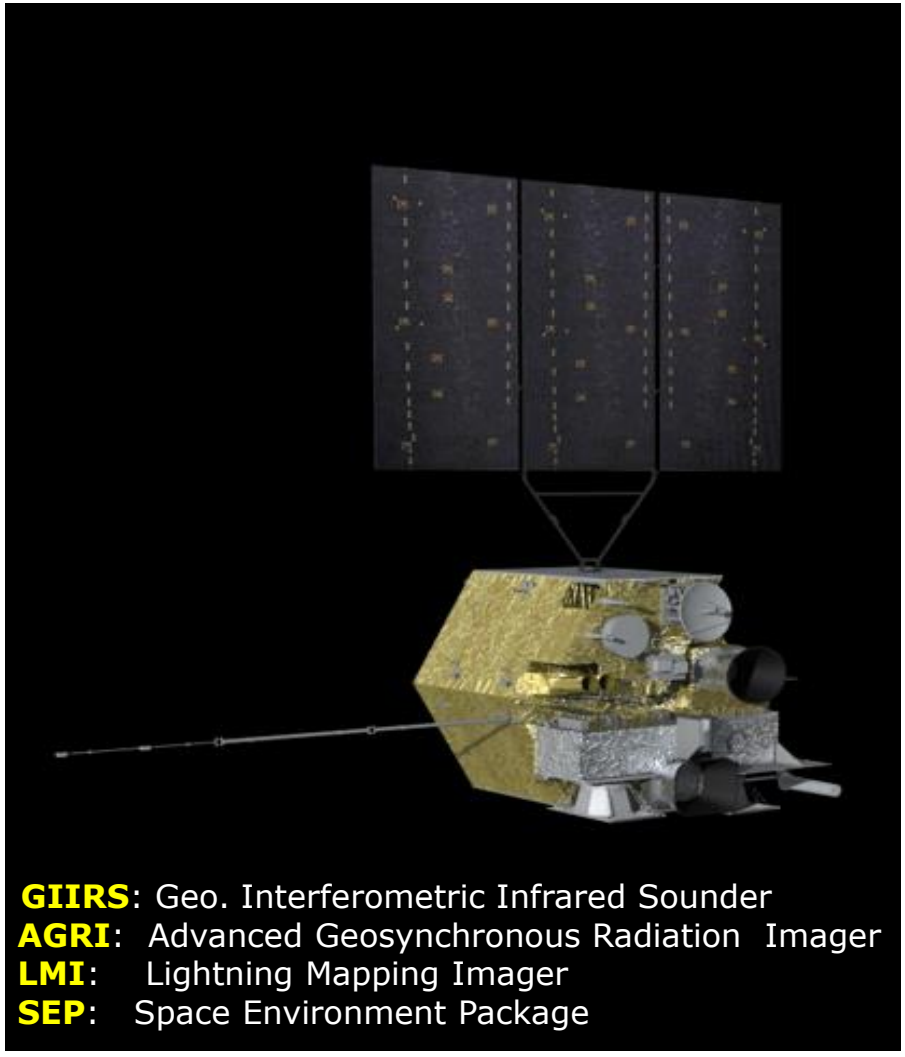
1)Overview of CMA satellite plan

2)Updates of CMA Meteorological satellite system

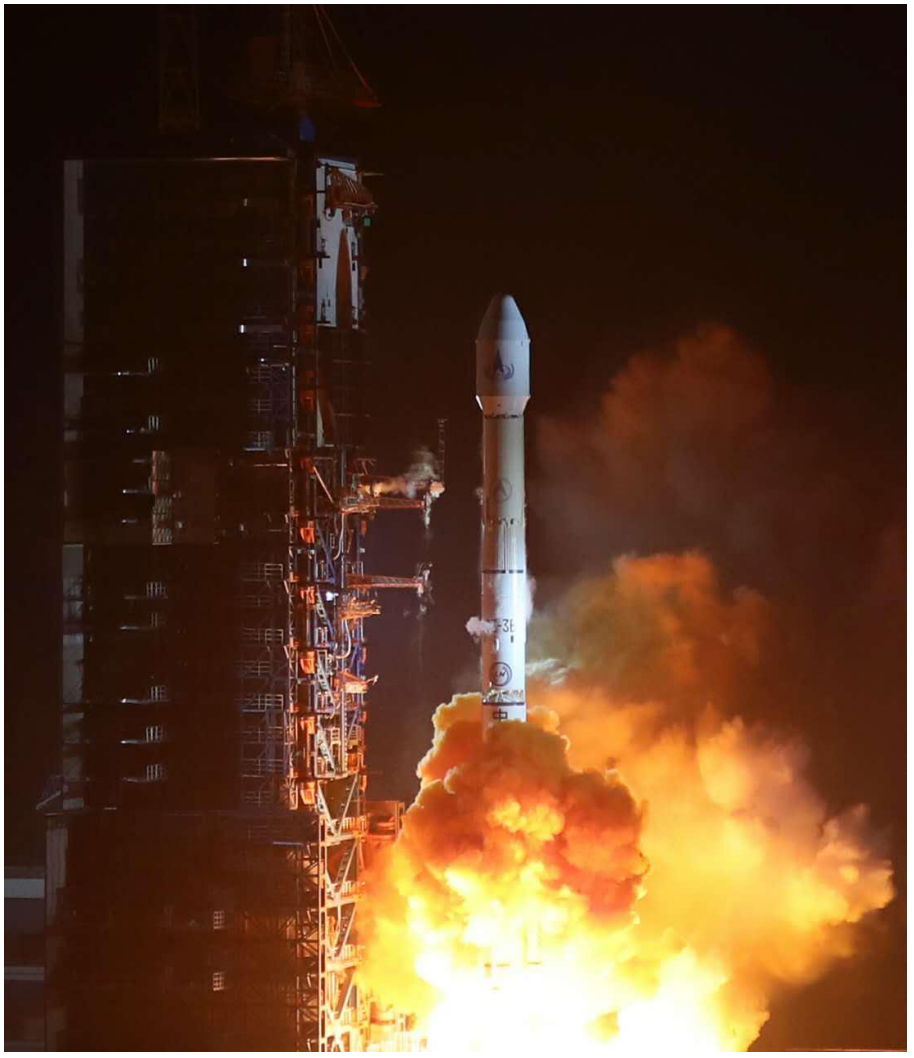
3)The future CMA satellite program

4) The products and applications under development

FY-4A: Launched on Dec,11,2016



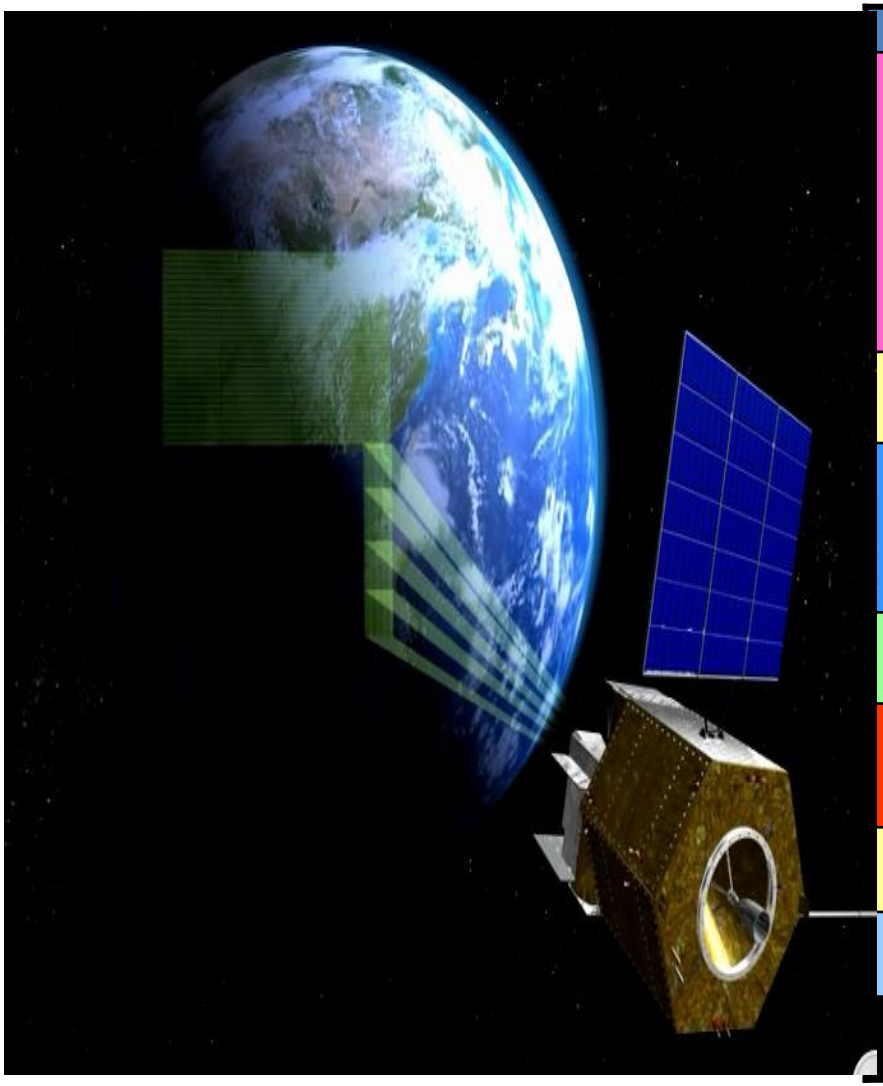
GIIRS: Geo. Interferometric Infrared Sounder
AGRI: Advanced Geosynchronous Radiation Imager
LMI: Lightning Mapping Imager
SEP: Space Environment Package



Chinese FengYun Geo. imaging capability

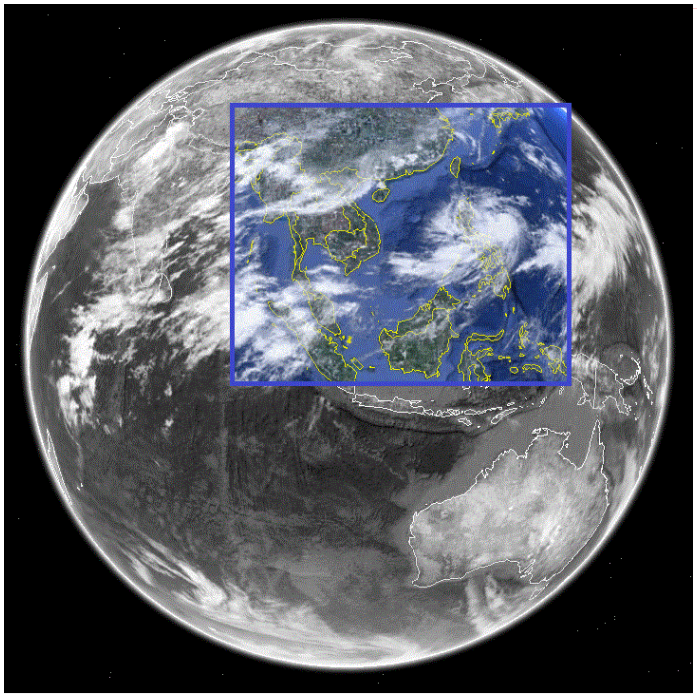
	FY-2 F/G/H VISSR			FY-4A AGRI			
Channel	Band	Spatial Resolution	Sensitivity	Band	Spatial Resolution	Sensitivity	Main Application
Visible & Near-Infrared				0.45～0.49	1	S/N≥90 (ρ=100%)	Aerosol
	0.55～0.75	1.25	2.3 @ρ=1%	0.55～0.75	0.5～1	S/N≥200 (ρ=100%)	Fog, Clound
				0.75～0.90	1	S/N≥5(ρ=1%)@0.5Km	Vegetation
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)	CTH

FY-4 GIIRS:
Geo. Interferometric Infrared Sounder

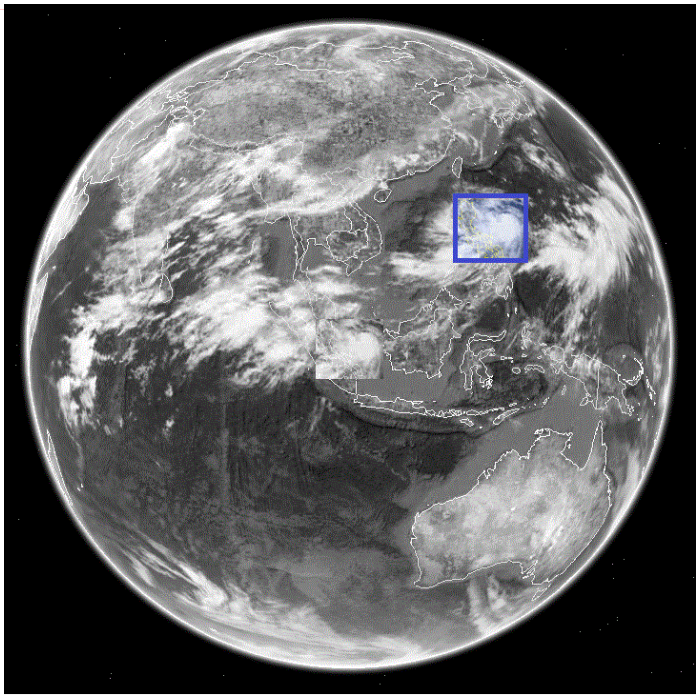


	FY-4A (R&D)	FY-4B (Operational)
Spectral Parameters (Normal mode) (Design)	Range Resolution Channels LWIR: 700-1130 Cm -1 0.8 538 S/MIR:1 650-2250Cm -1 1.6 375 VIS : 0.55-0.75 μm 1	Range Resolution Channels LWIR: 700-1130 0.625 688 S/MIR:1 650-2250 1.2 500 VIS : 0.55-0.75 μm 1
Spatial Resolution	LWIR/S/MIR : 16Km SSP VIS : 2Km SSP	LWIR/S/MIR : 8Km SSP
Operational Mode (Design)	China area 5000 × 5000 Km2 Mesoscale area 1000 × 1000 Km2	China area 5000 × 5000 Km2 Mesoscale area 1000 × 1000 Km2
Temporal Resolution	China area <1 hr Mesoscale area <½ hr	China area <1 hr Mesoscale area <½ hr
Sensitivity (mW/m2sr cm-1)	LWIR: 0.5 -1.1 S/MIR: 0.1-0.14 VIS: S/N>200(ρ=100%)	LWIR: 0.3 S/MIR: 0.06
Calibration accuracy	1.5k (3σ) radiation	1.0k (3σ)
Calibration accuracy	10 ppm (3σ) spectrum	5 ppm (3σ)
Quantization Bits	13 bits	13 bits

FY-4A GIIRS Normal observation mode

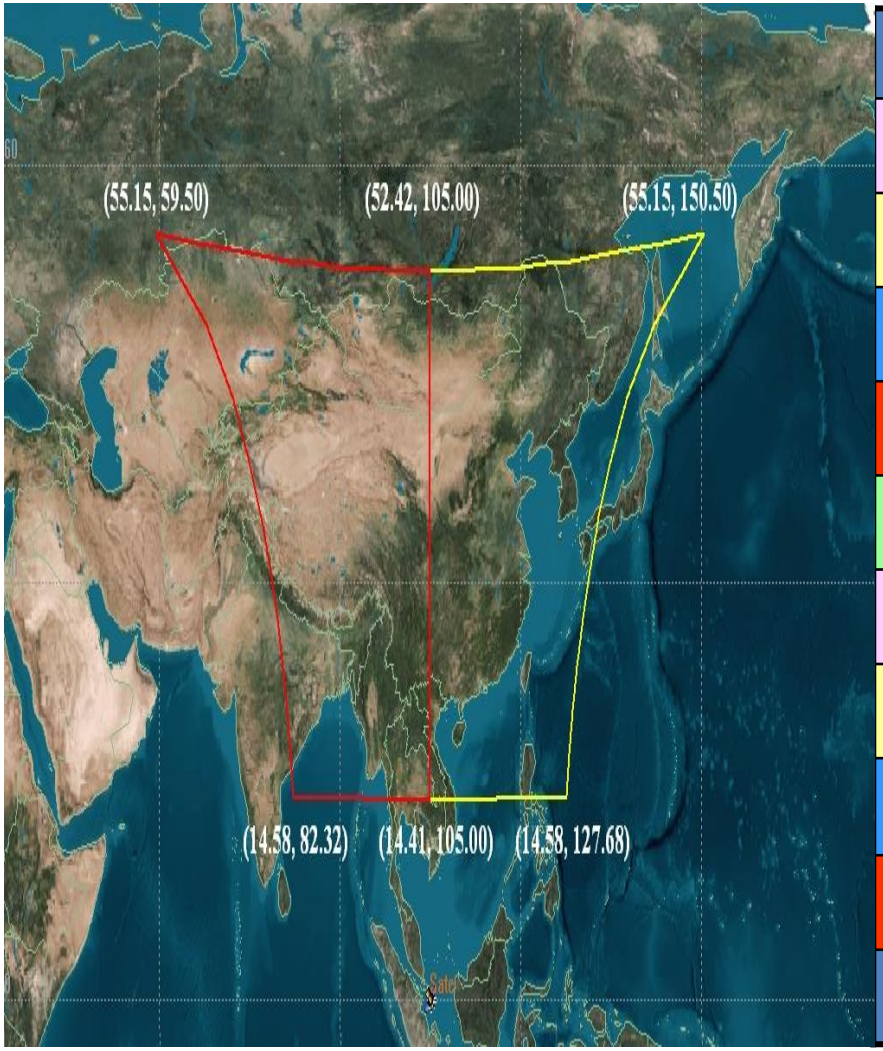


Regional: 4500KMx4500KM



Meso-scale: 1000KMx1000KM

FY-4A LMI:
Lighting Mapping Imager



Spatial resolution	about 6 km 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 (500 Frames per sec.)
Quantization	12 bits
Measurement Error	10%

FY-4A observation mode

AGRI： Baseline observation is every 3 hours , make 3 FD observation, each observation last 15 minutes. Deriving AMV ,Cloud, Precipitation, Radiance products, and support global NWP.

- **FOM(Fundamental Observation Mode):**
  40FD,56NH/Day

- **ROM(Reinforced Observation Mode): Jun-September**
  40FD,112NH/Day, Provide 7.5min interval NH observation

- **EOM(Emergency Observation Mode): thunderstorms and severe weather**
  24FD , Other time for 2.5/5/7.5 min RRS upon user order.

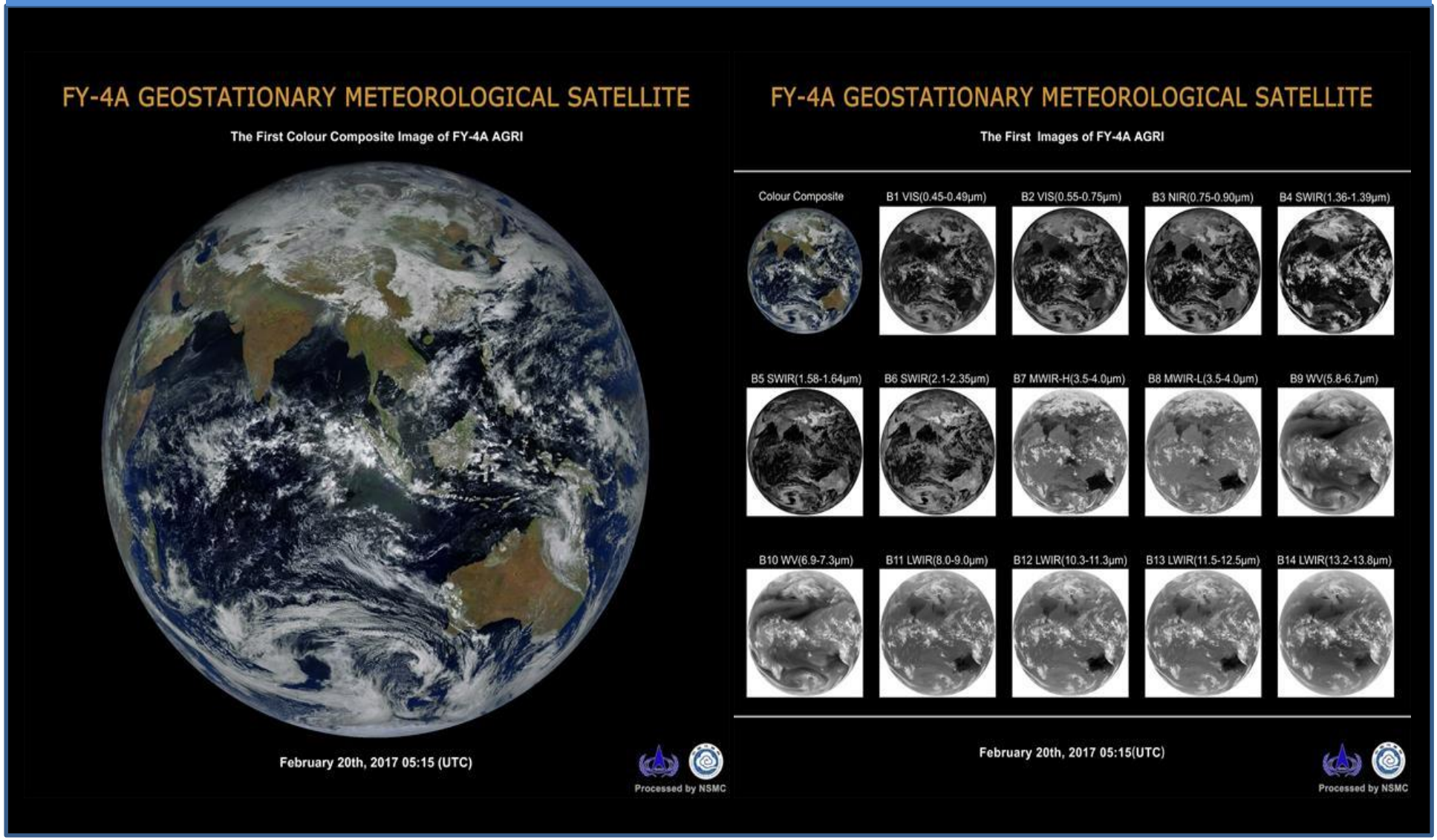
FY-4A observation mode(cont.)

GIIRS: Continuous observation, Hourly-Renewal

LMI: Continuous observation

SEP: Continuous observation

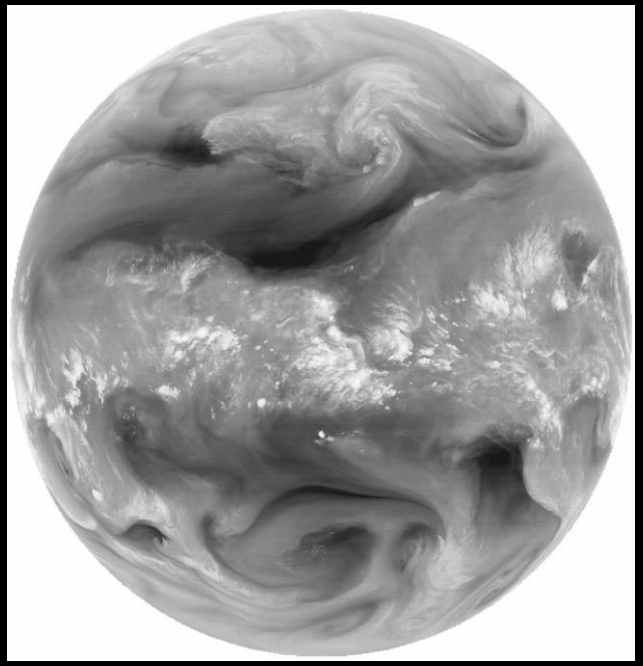
AGRI: Advanced Geosynchronous Radiation Imager



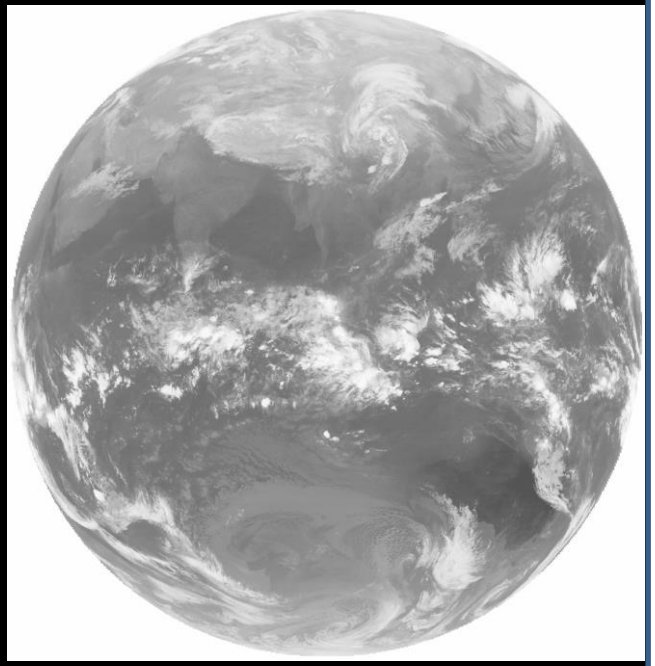
AGRI: Advanced Geosynchronous Radiation Imager

Vis Composite

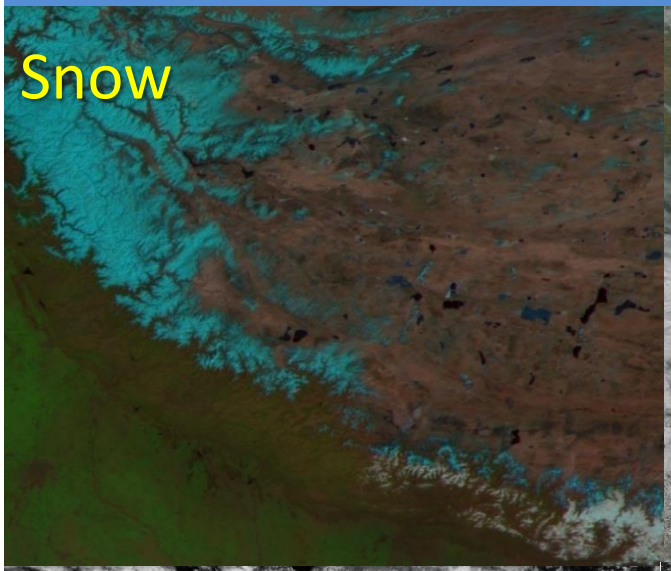
Wv

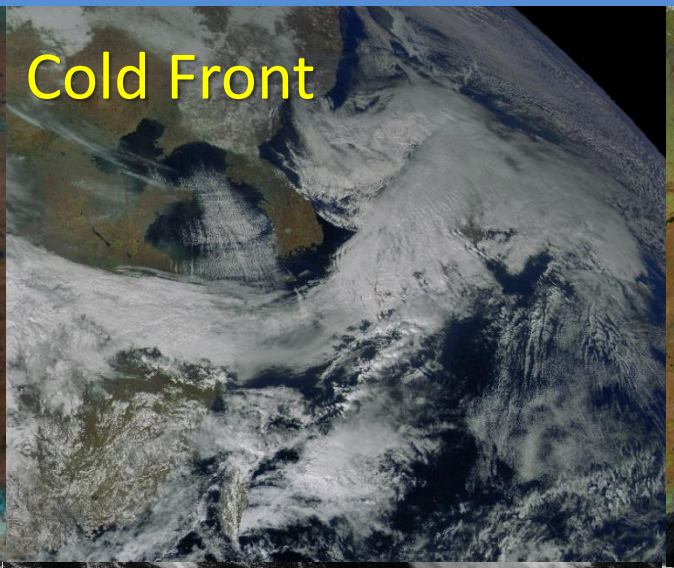


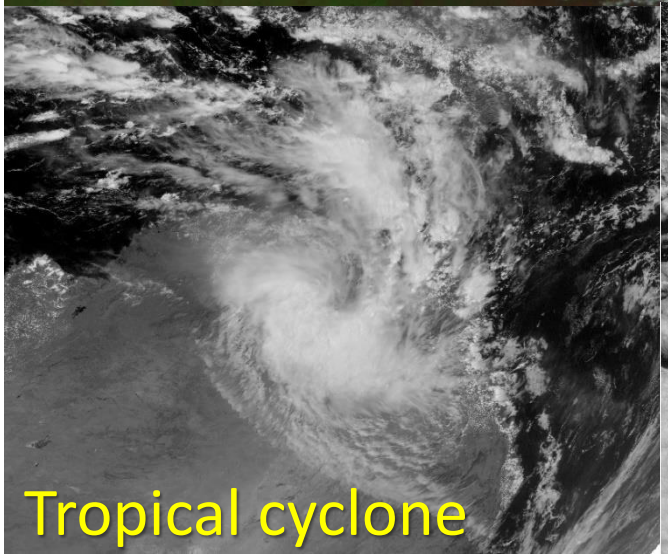
Ir

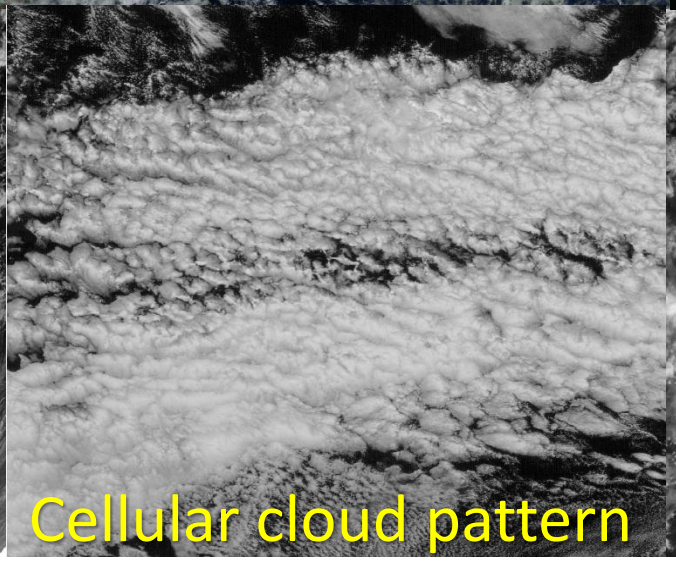


AGRI: Advanced Geosynchronous Radiation Imager

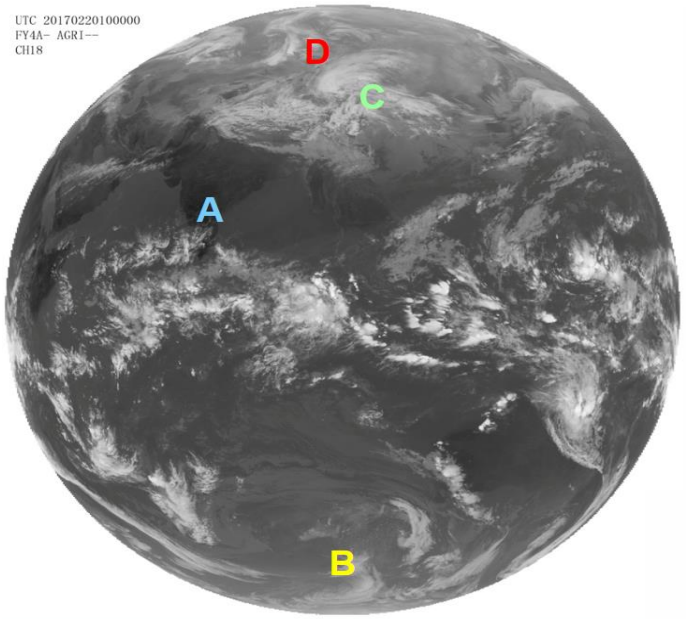




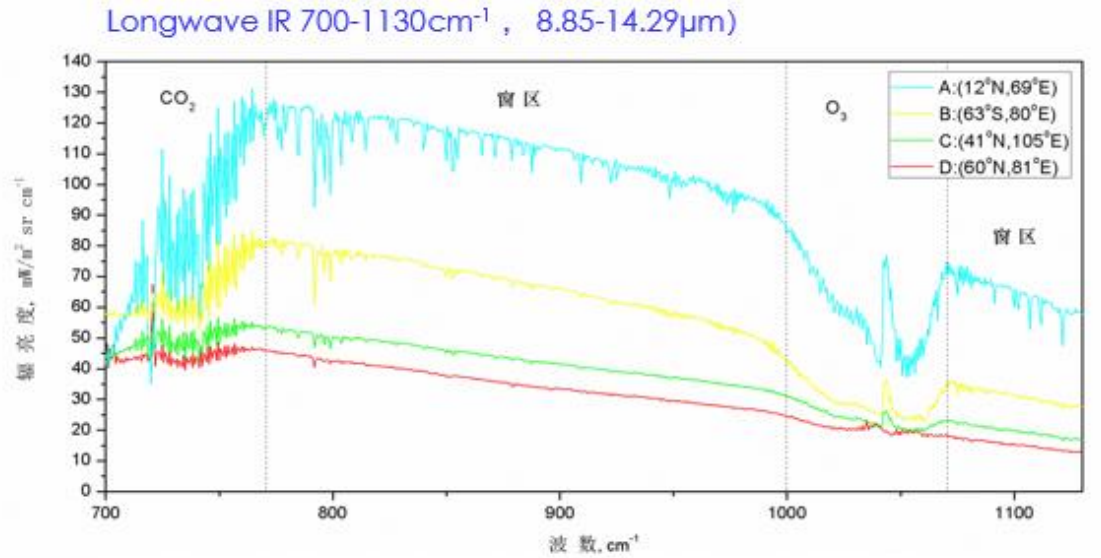


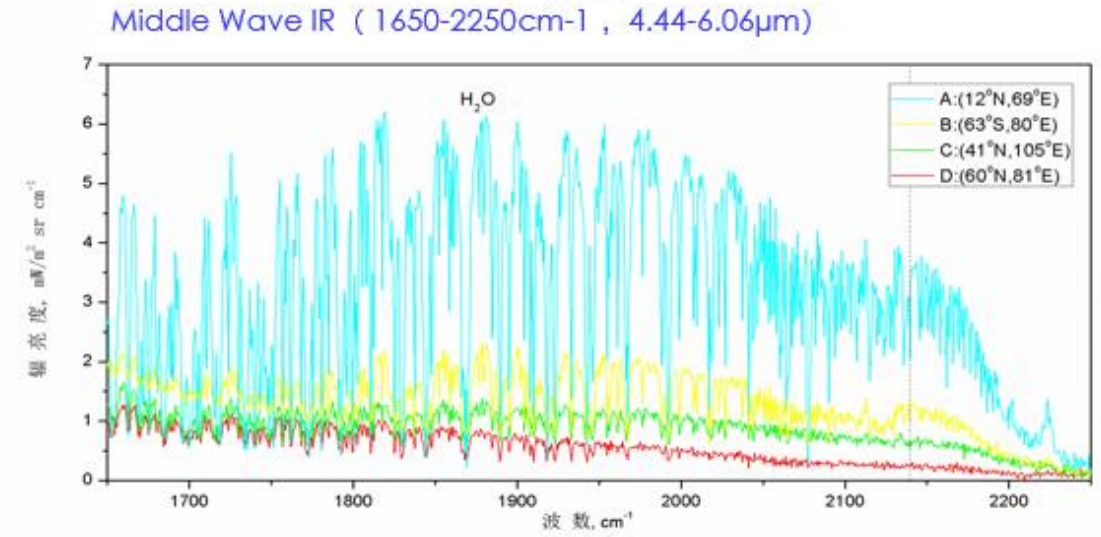


Geo. Interferometric Infrared Sounder

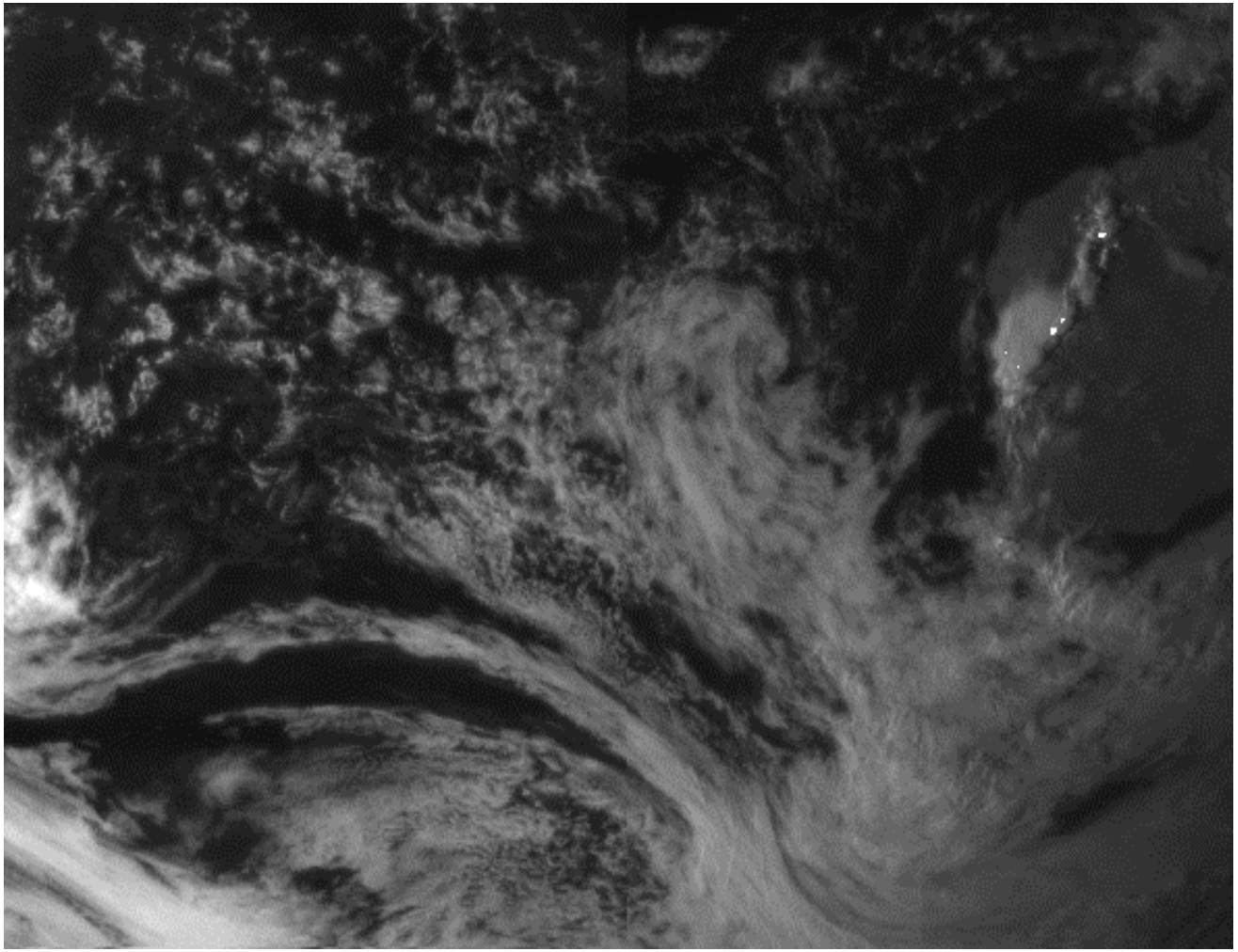


Spatial resolution: 16km,
Spectral resolution 0625 cm-1





FY-4A:LMI:　Lightning Mapping Imager

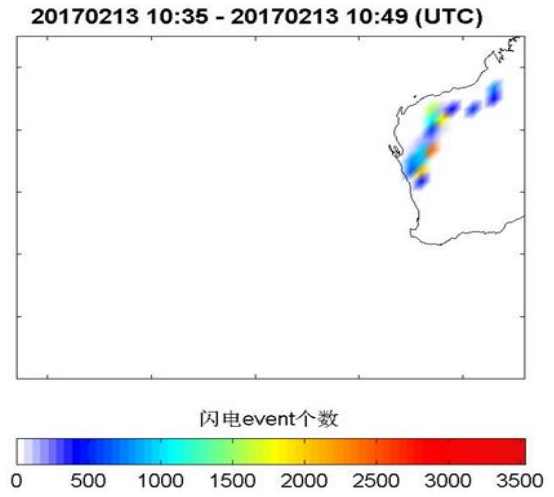


Swan Valley vineyards submerged

Wine growers in Western Australia's Swan Valley say they were disappointed by last week's unprecedented floods and rains.

Laura and Derek Pearse own the Upper Reach Winery and said their vineyards have been completely flooded.

PHOTO: Shiraz vines at Upper Reach winery were submerged in the flood. (ABC News: Sarah Collard)



FY-4A: Post Launch Test plan

Dec, 2016: FY-4A Satellite Launch
Dec, 2016: Satellite and instrument adjust

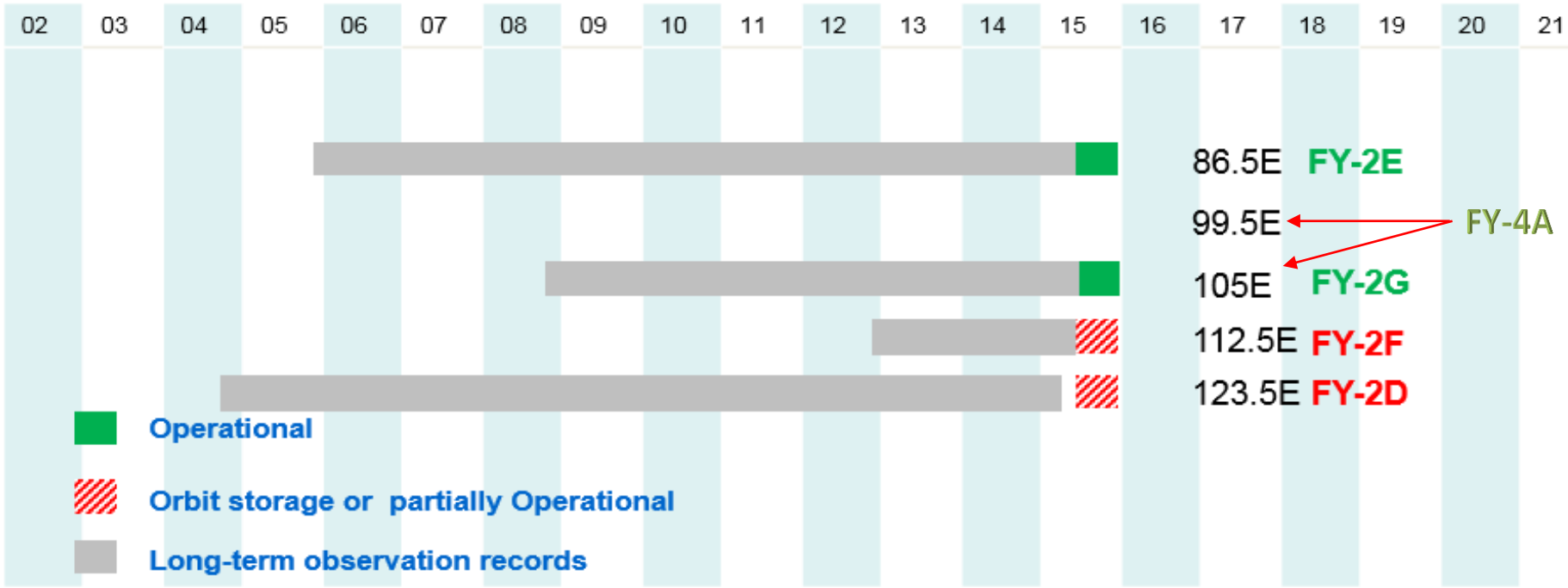
----------Phase I : Space segment test
Jan, 2017: Post Launch test start, Payload test
Mar, 2017: Calibration &INR test , Release FY-4A first set imagery
Jun, 2017: L1 products test, Release FY-4A first set L1 products
Jun,30 2017: Phase I test finish, satellite handover to CMA

----------Phase II: Ground segment and Application test
July-Sept, 2017: L2/L3 products test Application system test.
Sept-Dec, 2017: Pre operation of ground segment
Dec, 31 2017 : Phase II test finish, system is ready for operational

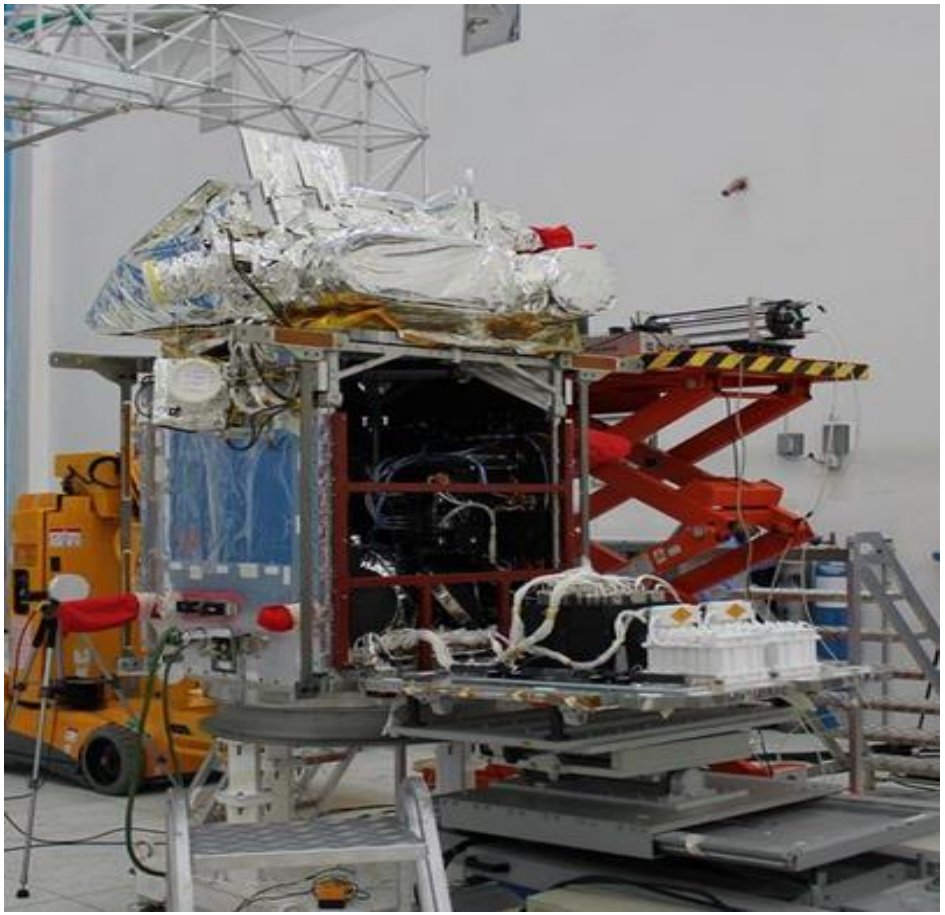
CMA FengYun Geo. 2017

CURRENT CMA GEO SATELLITES

For CMA GEO satellite system. 105E is primary position and 86.5E secondary.



TanSat: Launched on Nov,23,2016

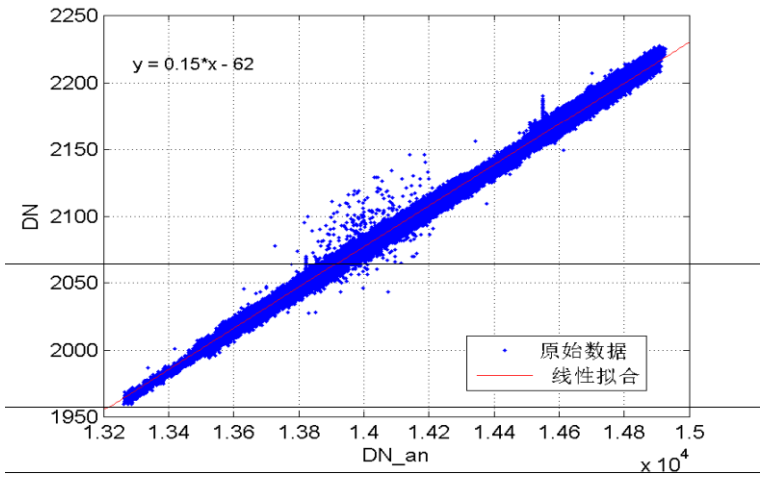


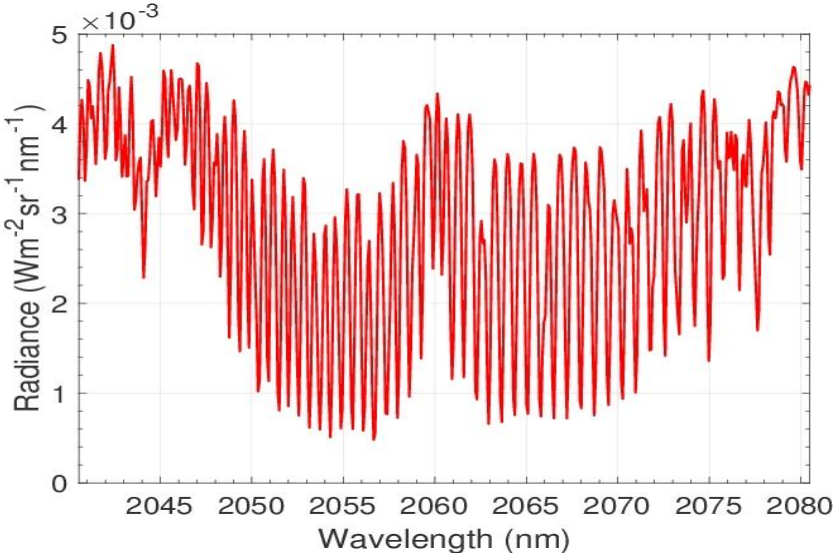
Mission objectives: to acquire global atmosphere column-averaged CO2 dry air mole fraction

Jun, 2017: Finish Post Launch test.
July, 2017: Operation by CMA

Recent progress of TanSat Post Launch test

- The bad pixel identification of FPA has been finished using single pixel mode.
- The coefficients for calculating the dark background signal has been improved through the dark signal measurements on orbit.
- The first spectra of the three bands are very encouraging.

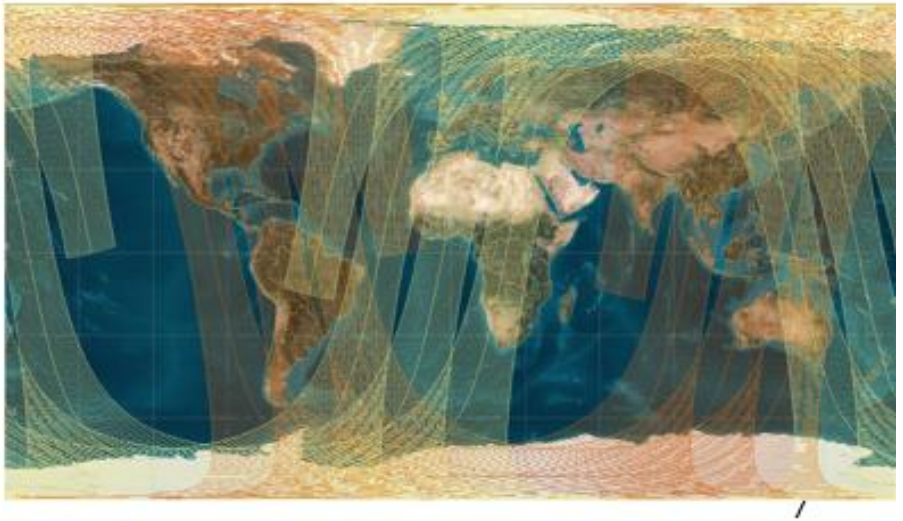




FengYun Leo : Launched on Sept,23,2013

✓***FY-3C*** was launched on Sep 23,2013

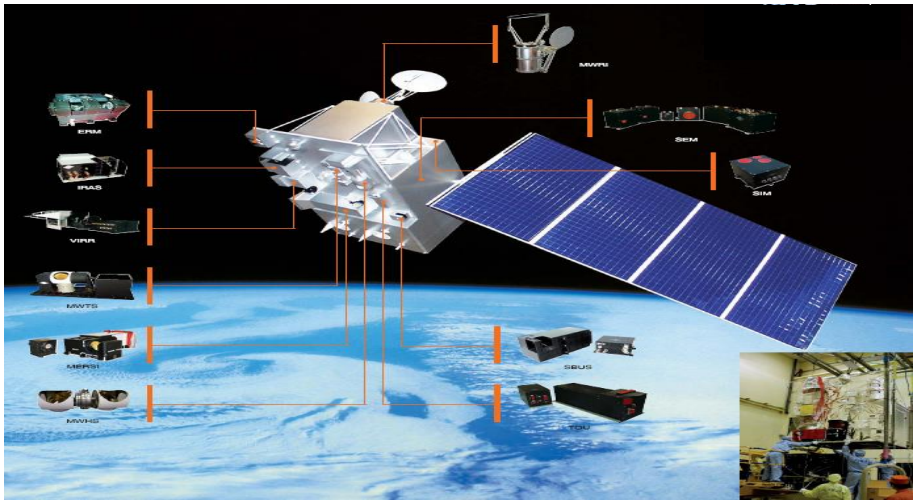
It's china's first operational polar orbit satellite of 2nd generation

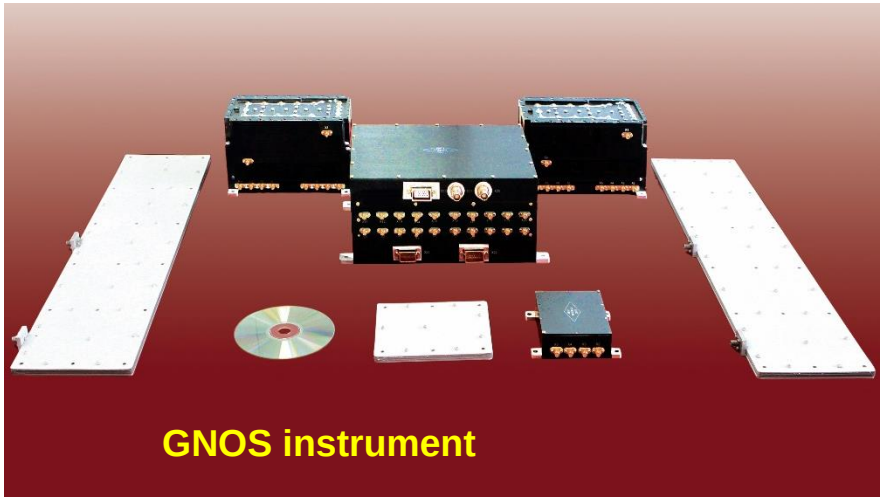


FY-3C LTC 10:30 AM

FY-3B LTC 13:40 PM

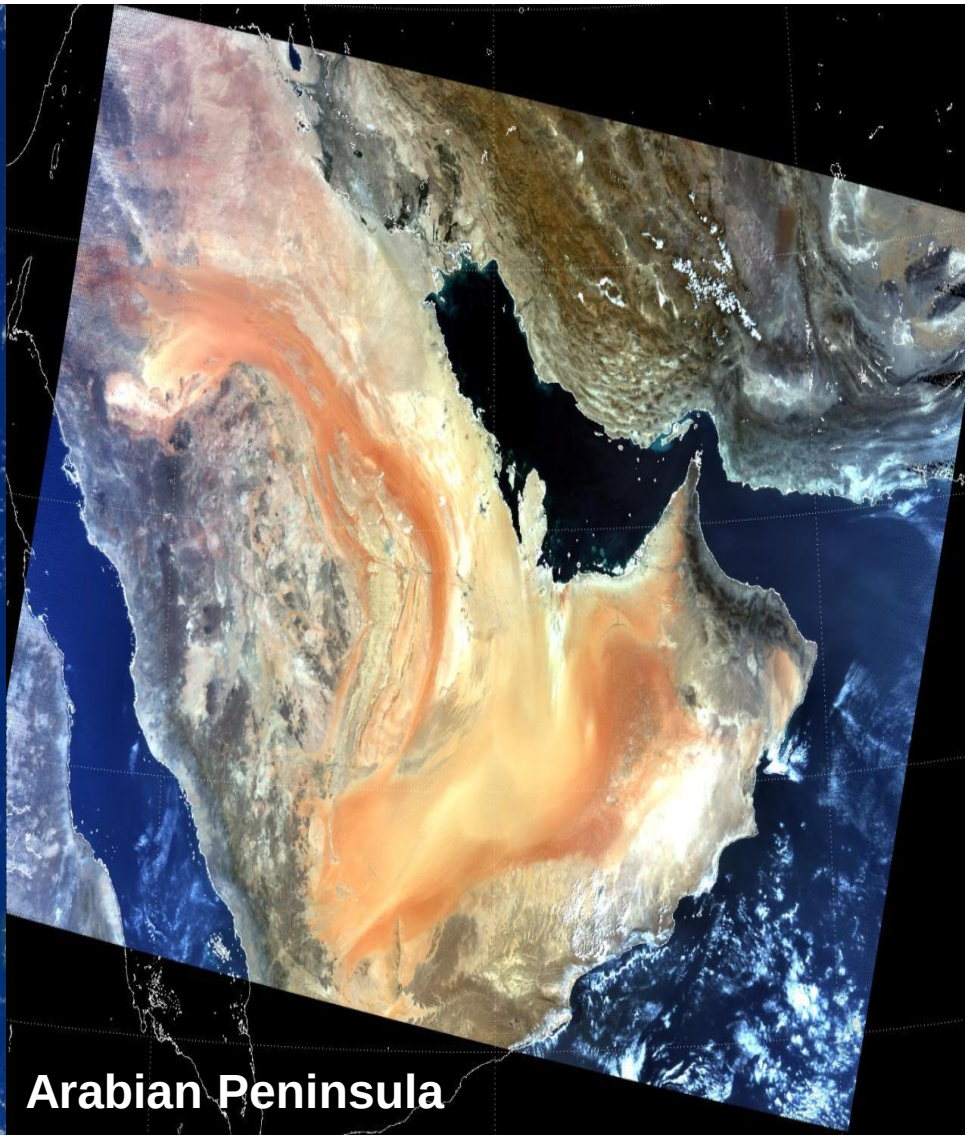
Improvement of FY-3C





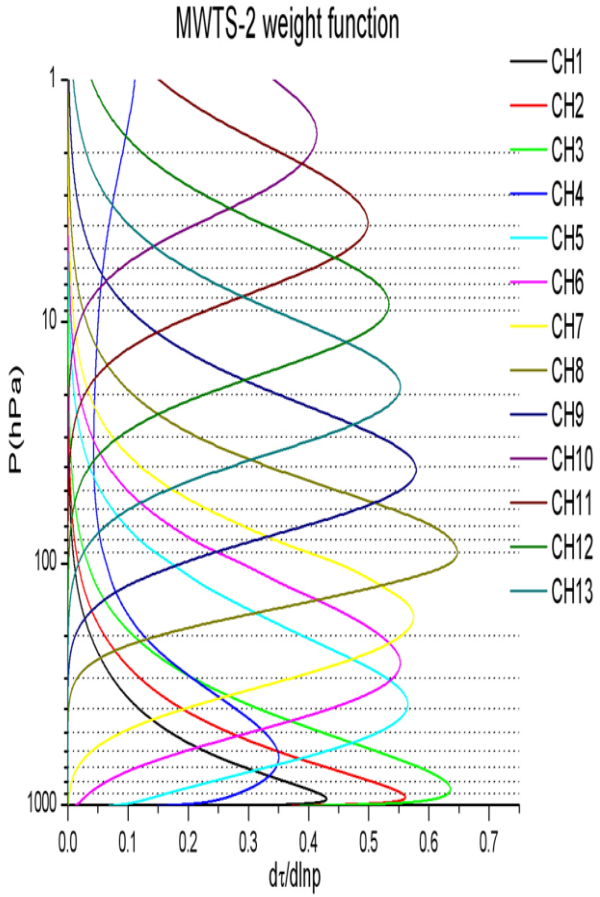
number	FY-3B Payloads	number	FY-3C Payloads
1	MERSI:Medium Resolution Spectral Imager	1	MERSI:Medium Resolution Spectral Imager
2	VIRR:Visible and Infra-Red Radiometer	2	VIRR:Visible and Infra-Red Radiometer
3	IRAS:Infrared Atmospheric Sounder	3	IRAS:Infrared Atmospheric Sounder
4	MWTS:MicroWave Temperature Sounder	4	MWTS(II):MicroWave Temperature Sounder
5	MWHS:MicroWave Humidity Sounder	5	MWHS(II):MicroWave Humidity Sounder
6	MWRI:MicroWave Radiation Imager	6	MWRI:MicroWave Radiation Imager
7	ERM:Earth Radiation Monitor	7	ERM:Earth Radiation Monitor
8	SIM:Solar Irritation Monitor	8	SIM(II):Solar Irritation Monitor
9	SBUS:Solar Backscatter Ultraviolet Sounder	9	SBUS:Solar Backscatter Ultraviolet Sounder
10	TOU:Total Ozone mapping Unit	10	TOU:Total Ozone mapping Unit
11	SEM:Space Environment Monitor	11	SEM:Space Environment Monitor
	/	12	GNOS:GNSS Occultation Sounder

MERSI/FY-3C Images



Improvement of FY-3C

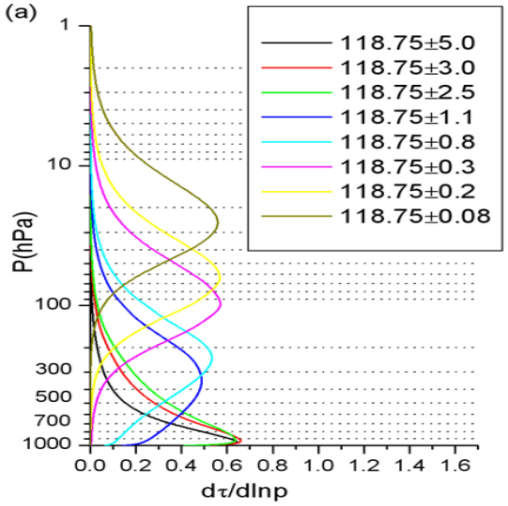
MWTS-**II:** total channel number increased from 4 tc

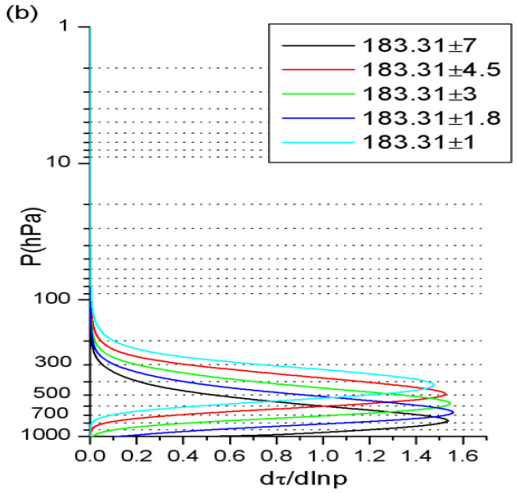


FY-3A/B/ MWTS		FY-3C/ MWTS(II)		
channel	Central frequency（GHz）	channel	Central frequency（GHz）	Purpose
1	50.30	1	50.3	
		2	51.76	Surface Emiss.
		3	52.8	
2	53.596±0.115	4	53.596	
		5	54.40	
3	54.94	6	54.94	
		7	55.50	
4	57.290	8	57.290344(fo)	Atmospheric Temperature Profile
		9	fo±0.217	
		10	fo±0.3222±0.048	
		11	fo±0.3222±0.022	
		12	fo±0.3222±0.010	
		13	fo±0.3222±0.0045	

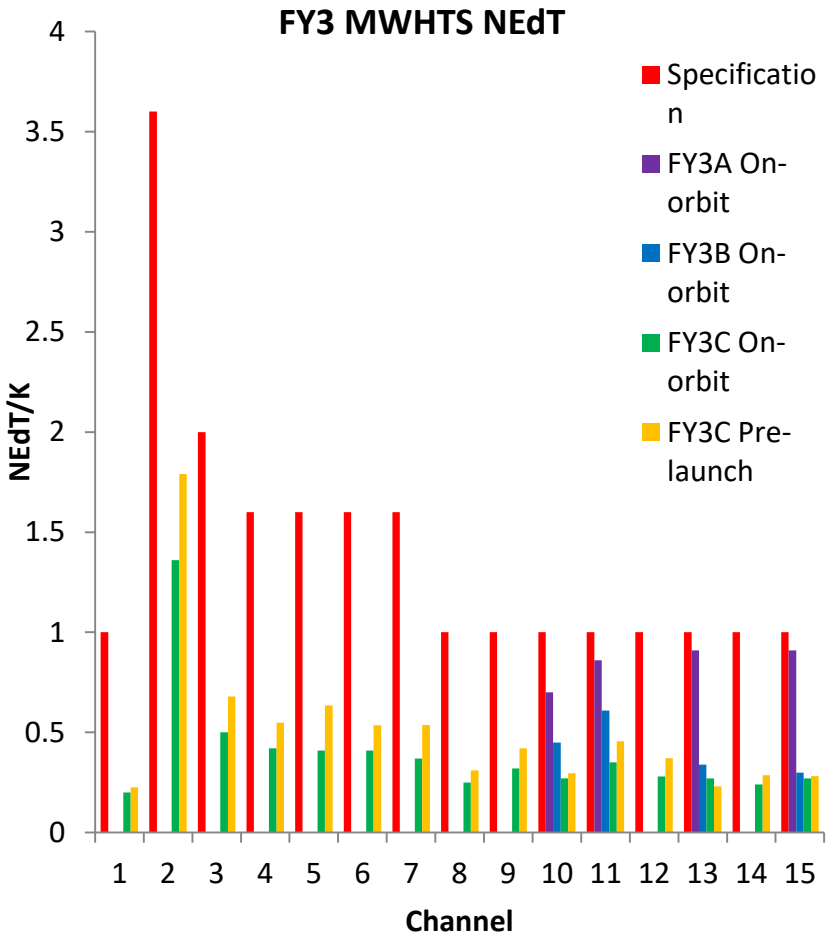
Improvement of FY-3C

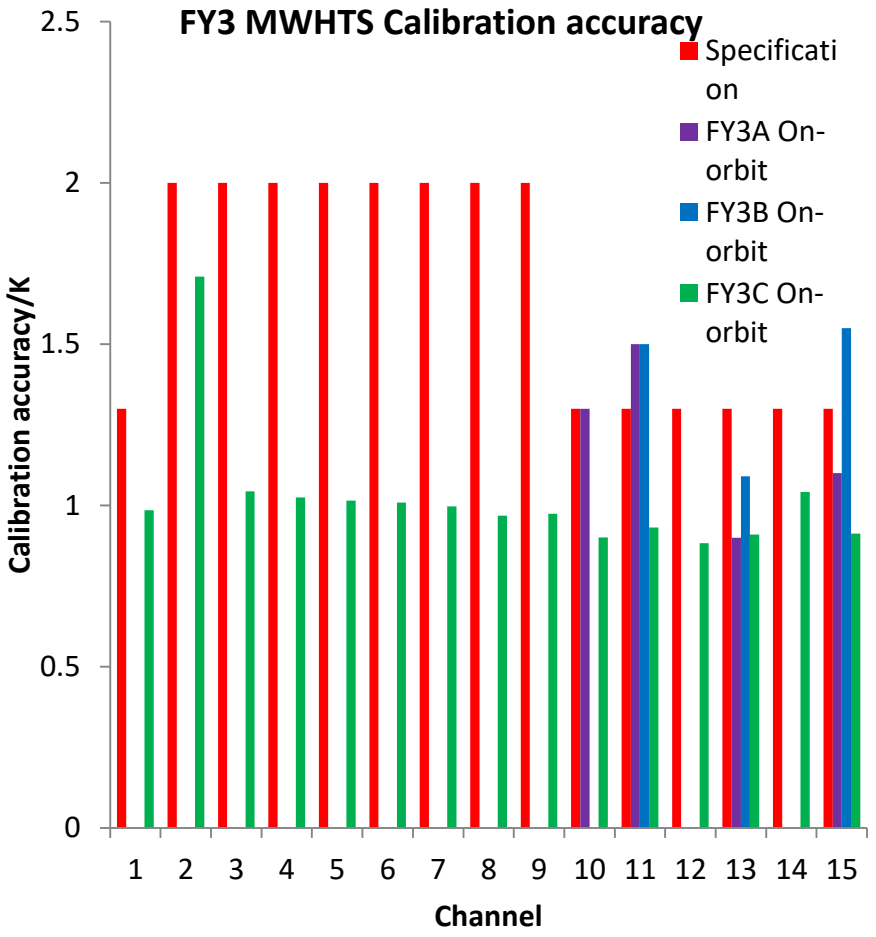
MWHS-II： increase two sounding frequency(89Ghz and 118Ghz)，total channel number increase from 5 to 15.



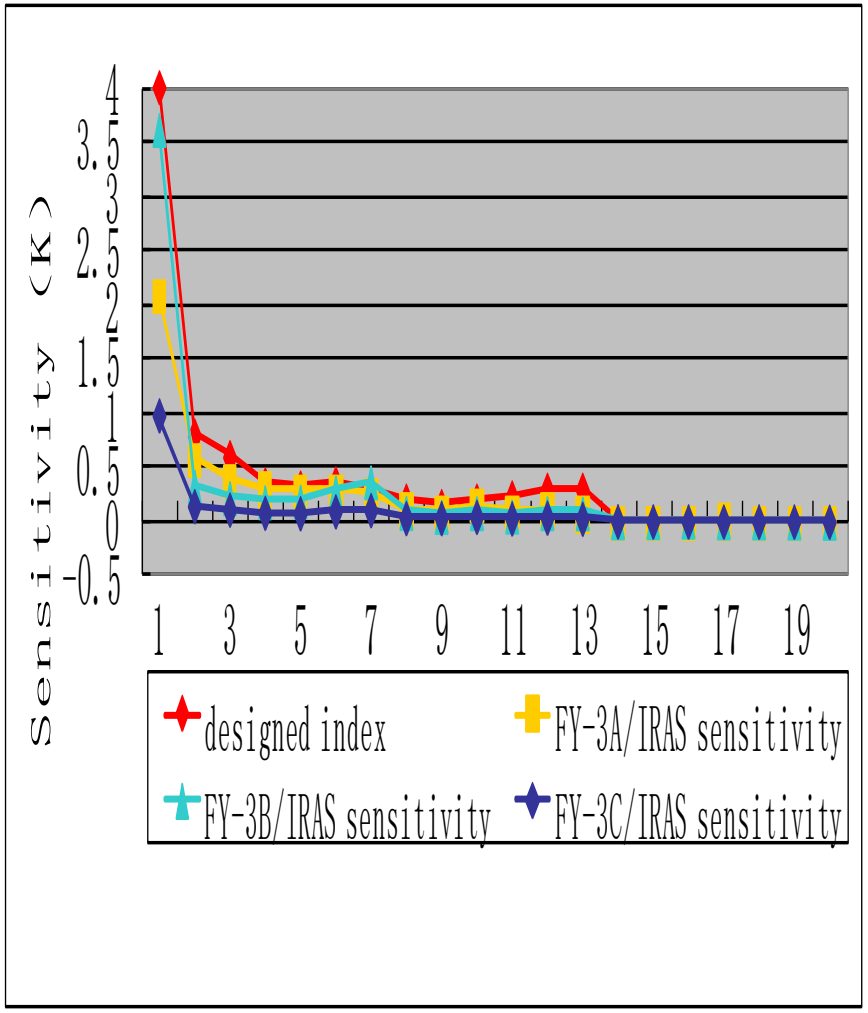


FY-3A/B/ MWHS		FY-3C/ MWHTS		
chan nel	Central frequency（GHz）	channel	Central frequency（GHz）	Purpose
		1	89.0	Surface and Precipitation
		2	118.75±0.08	
		3	118.75±0.2	
		4	118.75±0.3	
		5	118.75±0.8	Atmospheric Temperature Profile
		6	118.75±1.1	
		7	118.75±2.5	
		8	118.75±3.0	
		9	118.75±5.0	
1	150(V)	10	150.0	Surface and Precipitation
2	150(H)			
3	183.31±1	11	183.31±1	
		12	183.31±1.8	Atmospheric Moisture Profile
4	183.31±3	13	183.31±3	
		14	183.31±4.5	
5	183.31±7	15	183.31±7	

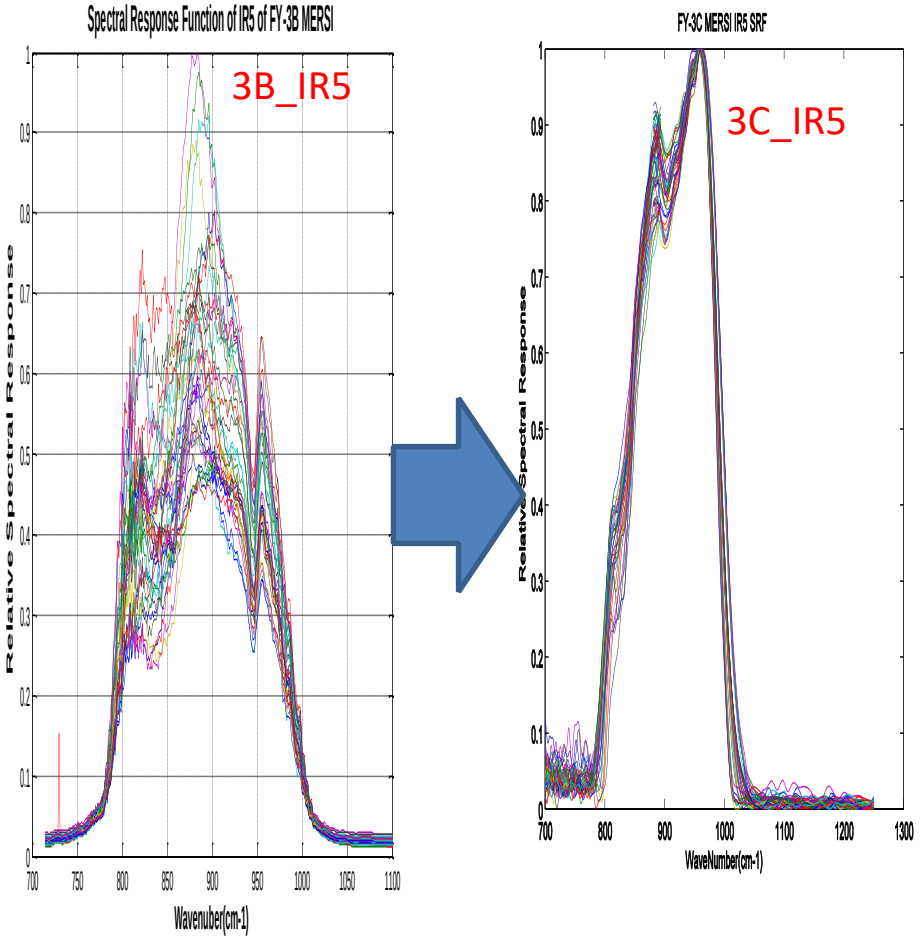

FY3 MWHTS NEdT
NEdT/K
Channel
Specification
FY3A On-orbit
FY3B On-orbit
FY3C On-orbit
FY3C Pre-launch
0
0.5
1
1.5
2
2.5
3
3.5
4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


FY3 MWHTS Calibration accuracy
Calibration accuracy/K
Channel
Specification
FY3A On-orbit
FY3B On-orbit
FY3C On-orbit
0
0.5
1
1.5
2
2.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Improvement of FY-3C



Improvment of instrument Sensitivity



SRF homogeneity of the Multi detectors

Topics

1)Overview of CMA satellite plan

2)Updates of CMA Meteorological satellite system

3)The future CMA satellite program

4) The products and applications under development

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

NO.	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	√			

FY-3D: Launch scheduled in September 2017

Significant improvements compared with FY-3A/B/C:

1) Successive instruments with great enhancements :

MERSI-II：Optical imager improved from MERSI

HIRAS: Hyperspectral IR sounder upgraded from the filer-type IRAS

2) Brand New Instruments:

GAS: Greenhouse gases Absorption Spectrometer

WAI: Wide-angle Aurora Imager (for space weather)

IPM: Ionospheric Photometer (for space weather)

Ground segment is construction by CMA, and it is ready now.

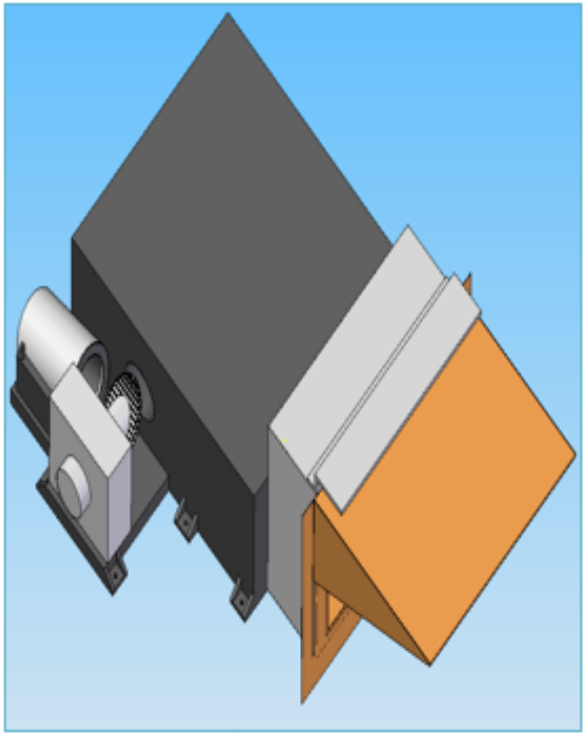
Update status of FY-3D

number	FY-3C Payloads	number	FY-3D Payloads
1	MERSI(I):Medium Resolution Spectral Imager	1	MERSI(II):Medium Resolution Spectral Imager
2	VIRR:Visible and Infra-Red Radiometer		
3	IRAS:Infrared Atmospheric Sounder	2	HIRAS
4	MWTS(II):MicroWave Temperature Sounder	3	MWTS(II):MicroWave Temperature Sounder
5	MWHS(II):MicroWave Humidity Sounder	4	MWHS(II):MicroWave Humidity Sounder
6	MWRI:MicroWave Radiation Imager	5	MWRI:MicroWave Radiation Imager
7	ERM(I):Earth Radiation Monitor		/
8	SIM(II):Solar Irritation Monitor		/
	/	6	GAS
9	SBUS:Solar Backscatter Ultraviolet Sounder		/
10	TOU:Total Ozone mapping Unit		/
11	SEM:Space Environment Monitor	7	SEM:Space Environment Monitor
	/	9	IPM
	/	10	WAI
12	GNOS:GNSS Occultation Sounder	11	GNOS:GNSS Occultation Sounder

MERSI-II Characteristics

Primary Usage	Band	Band Center (um)	Bandwidth (nm)	Spatial Resolution (m)
Land/Cloud/Aerosols Boundaries	1	0.470	50	250
	2	0.550	50	250
	3	0.650	50	250
	4	0.865	50	250
	5	1.24/1.03	20	1000
	6	1.64	50	1000
	7	2.13	50	1000
Ocean Color/Phytopiankton/Biogeochemistry	8	0.412	20	1000
	9	0.443	20	1000
	10	0.490	20	1000
	11	0.555	20	1000
	12	0.670	20	1000
	13	0.709	20	1000
	14	0.746	20	1000
	15	0.865	20	1000
Water Vapor	16	0.905	20	1000
	17	0.936	20	1000
	18	0.940	50	1000
Cirrus Cloud	19	1.38	20/30	1000
Surface/Cloud Temperature	20	3.8	180	1000
	21	4.050	155	1000
Water vapor	22	7.2	500	1000
	23	8.550	300	1000
Surface/Cloud Temperature	24	10.8	1000	250
	25	12.0	1000	250

HIRAS Specification



Specification	LWIR Band	MWIR Band	SWIR Band
Spectral Range	650 – 1136 cm-1 (15.38-8.8 μm)	1210 – 1750 cm-1 (8.26-5.71 μm)	2155-2550 cm-1 (4.64-3.92 μm)
Spectral Res	0.625 cm-1	1.25 cm-1	2.5 cm-1
NEΔT @250K	0.15~0.4K	0.1~0.7K	0.3~1.2K
Num. of Chan.	778	433	159
pixes per scan line	58		
Scan Angle	±50.4° around nadir		
Spatial Res	1.1 degrees (16.0km) IFOV at arranged in 2×2 array		

HIRAS/FY-3: Michelson interferometer
Aims: global temperature and moisture sounding from the infrared spectrum from 650 to 2550 cm-1

1) retrieving atmospheric temperature and humidity profiles with high accuracies for numerical weather prediction and climate research at high vertical resolution.
2) Trace gases to be derived from HIRAS include ozone columnar amounts in deep layers and columnar amounts of carbon monoxide, nitrous oxide, methane, and carbon dioxide.
3) Cloud parameters .

FengYun LEO Satellites Launch Plan by 2025

No.	Orbit	Status	Launch
FY-3D	PM	Op. ready	2017
FY-3E	Early Morning	Op, planed	2018
FY-3F	PM	Op, planed	2020
FY-3G	AM	Op, planed	2020+(TBD)
FY-3 RM	Inclined	R&D, Planed	2020+(TBD)

FengYun GEO Satellites Launch Plan by 2025

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

Topics

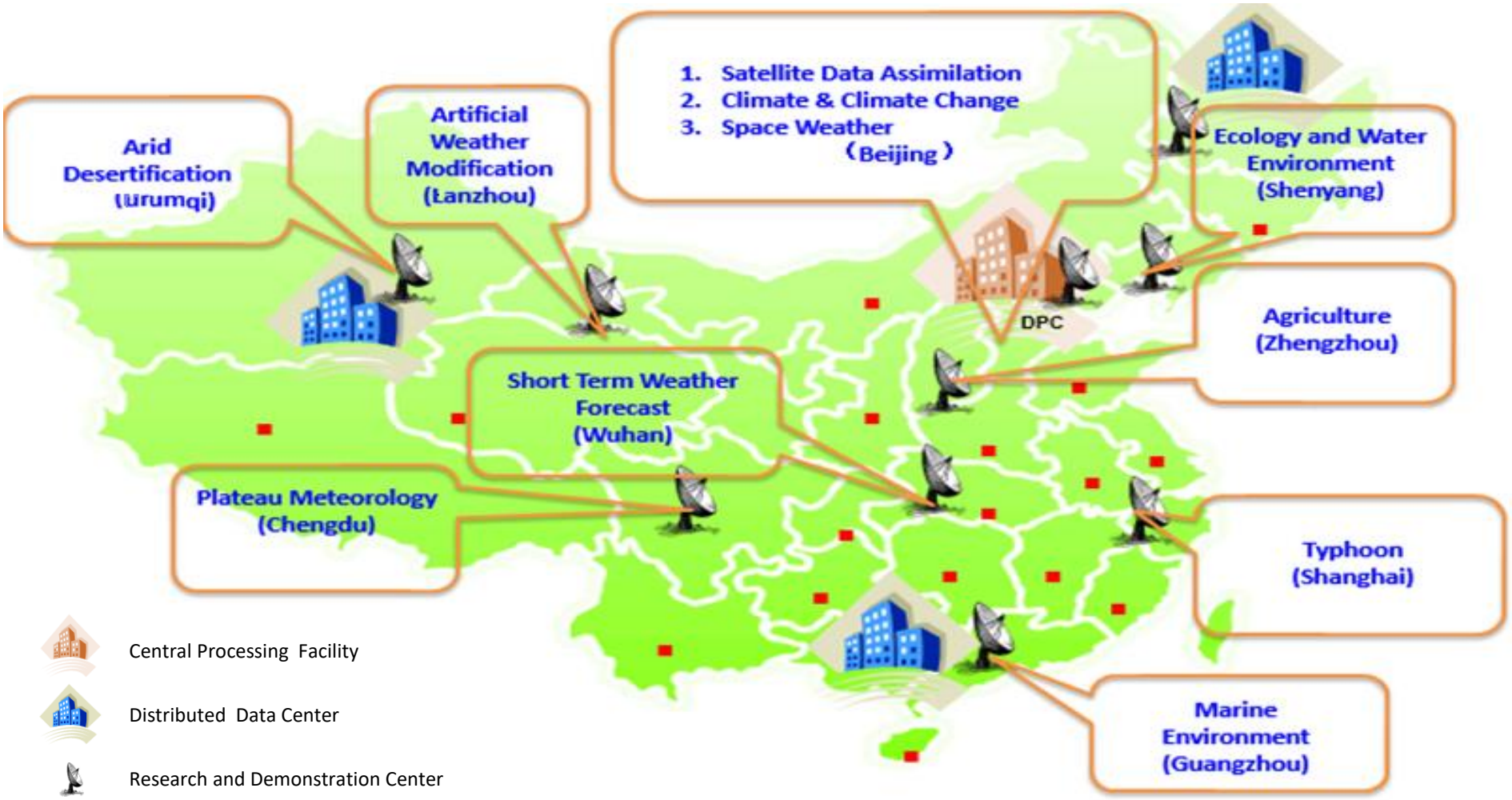
1)Overview of CMA satellite plan

2)Updates of CMA Meteorological satellite system

3)The future CMA satellite program

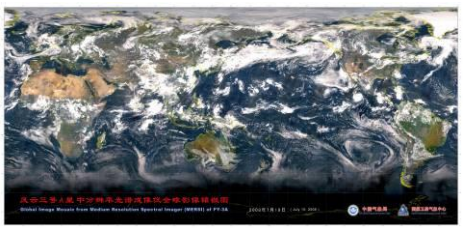
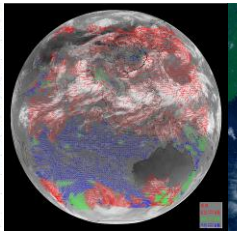
4) The products and applications under developmet

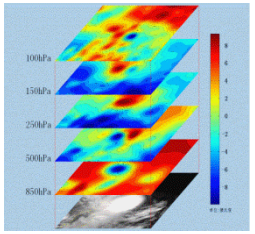
Satellite Application Facility



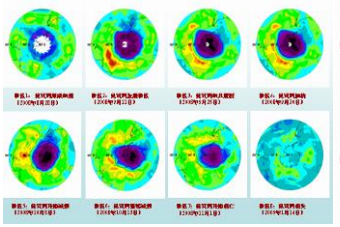
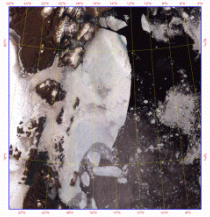
Fengyun satellite Applications

Weather

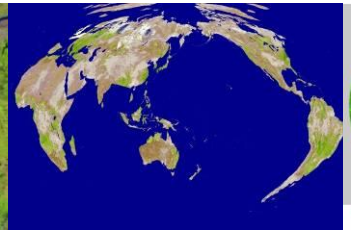
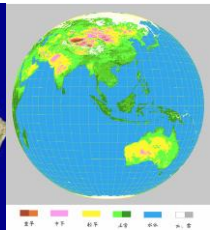





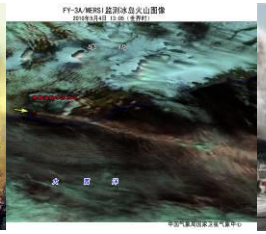
Climate

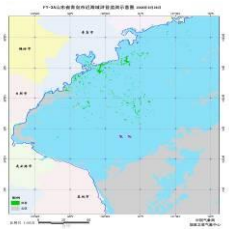
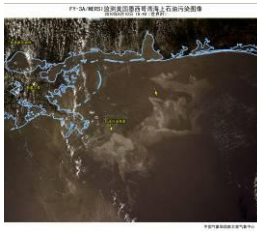
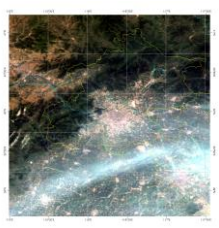
Resource

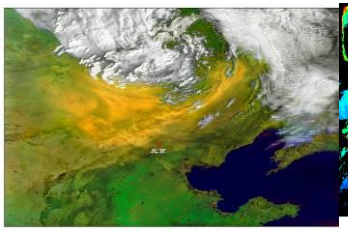
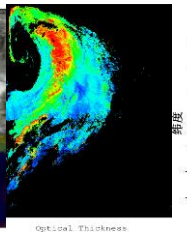



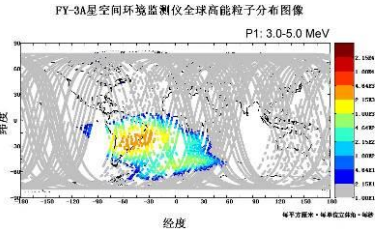
Disaster

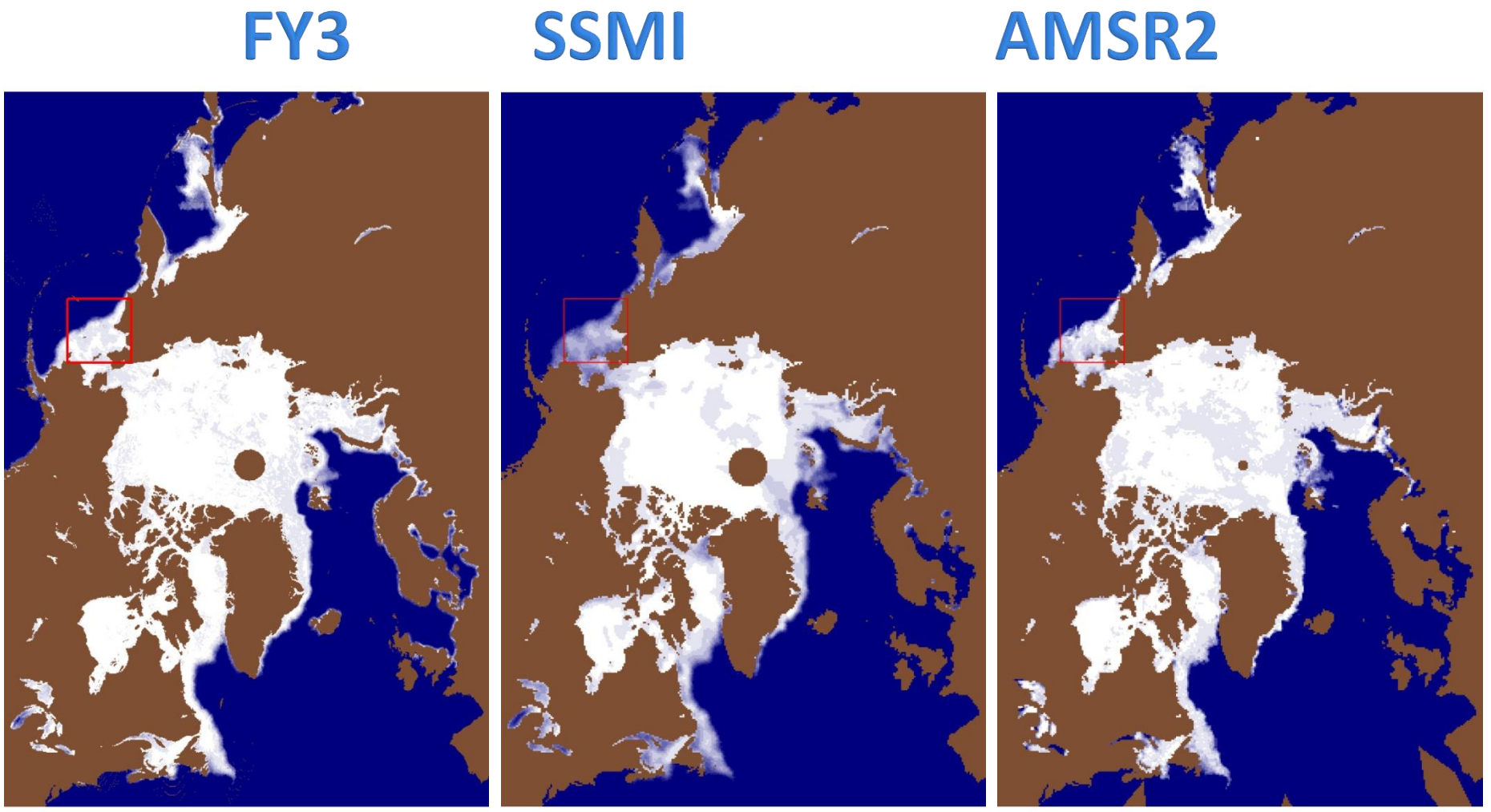
Environment

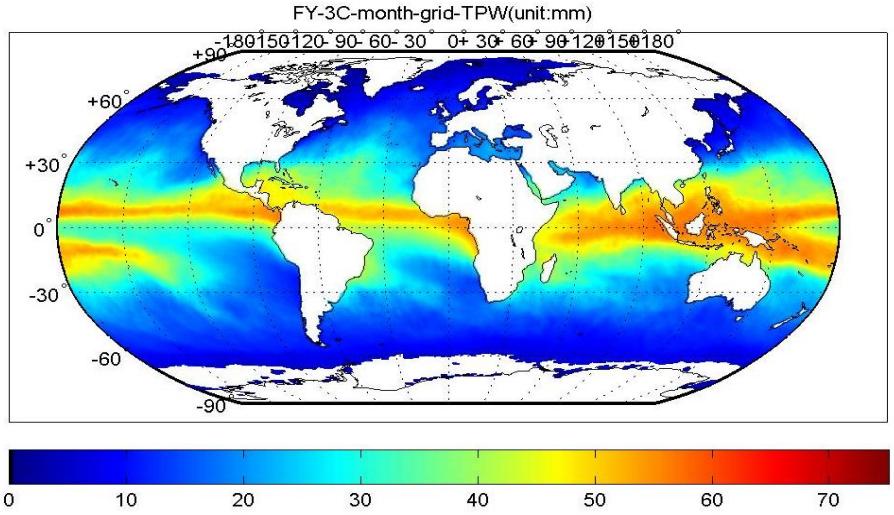



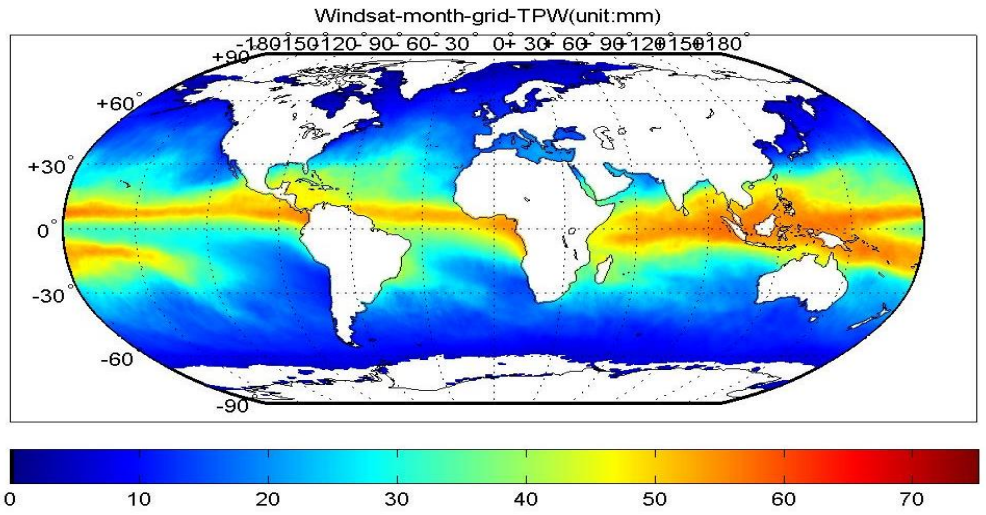


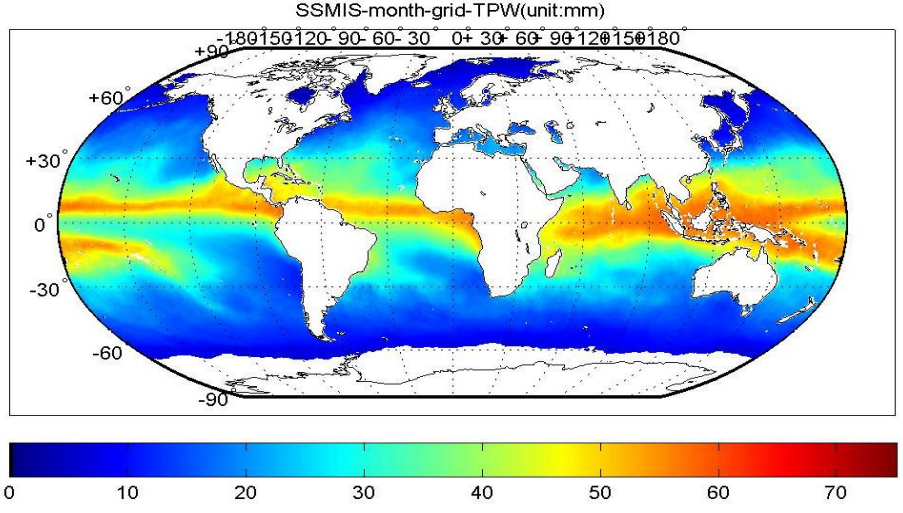
Fy-3C products by example



Fy-3C products by example







satellite		samples	bias （mm）	RMSE （mm）	Correlation coefficient
FY3C	SSMIS	510763	0.3760	1.2812	0.9965
FY3C	Windsat	515952	0.4654	1.3293	0.9963
Windsat	SSMIS	505349	-0.0685	1.2476	0.9963

FY-4 Baseline Products

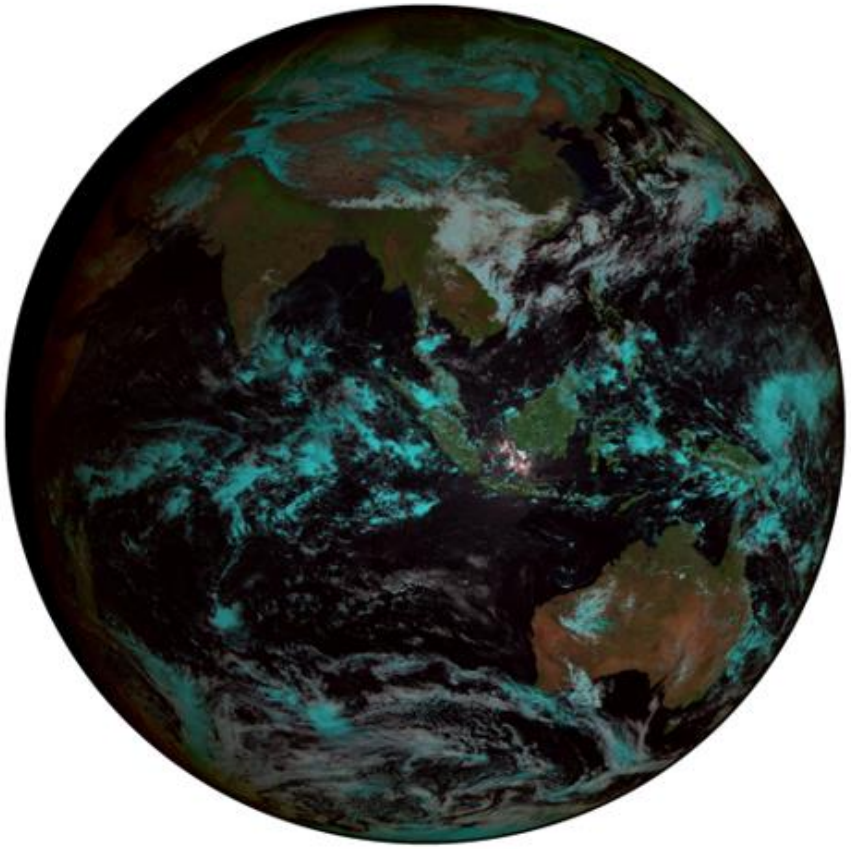
AGRI baseline products (25)
Clear Sky Masks
Cloud Type
Cloud Optical Depth
Cloud Liquid Water
Cloud Particle Size Distribution
Cloud Phase
Cloud Top Temperature
Cloud Top Height/Pressure
Fog Detection
Aerosol Detection
Aerosol Optical Depth
Tropopause Folding

AGRI baseline products (cont.)
Surface Solar Irradiance
Blackbody Brightness Temp.
Outgoing Longwave Radiation
Downward Longwave Radiation
Upward Longwave Radiation
Reflected Shortwave Radiation
Land Surface Temperature
Sea Surface Temperature
Land Surface Temperature
Land Surface Albedo
Land Surface Emissivity
Snow Cover
Fire/Hot Spot

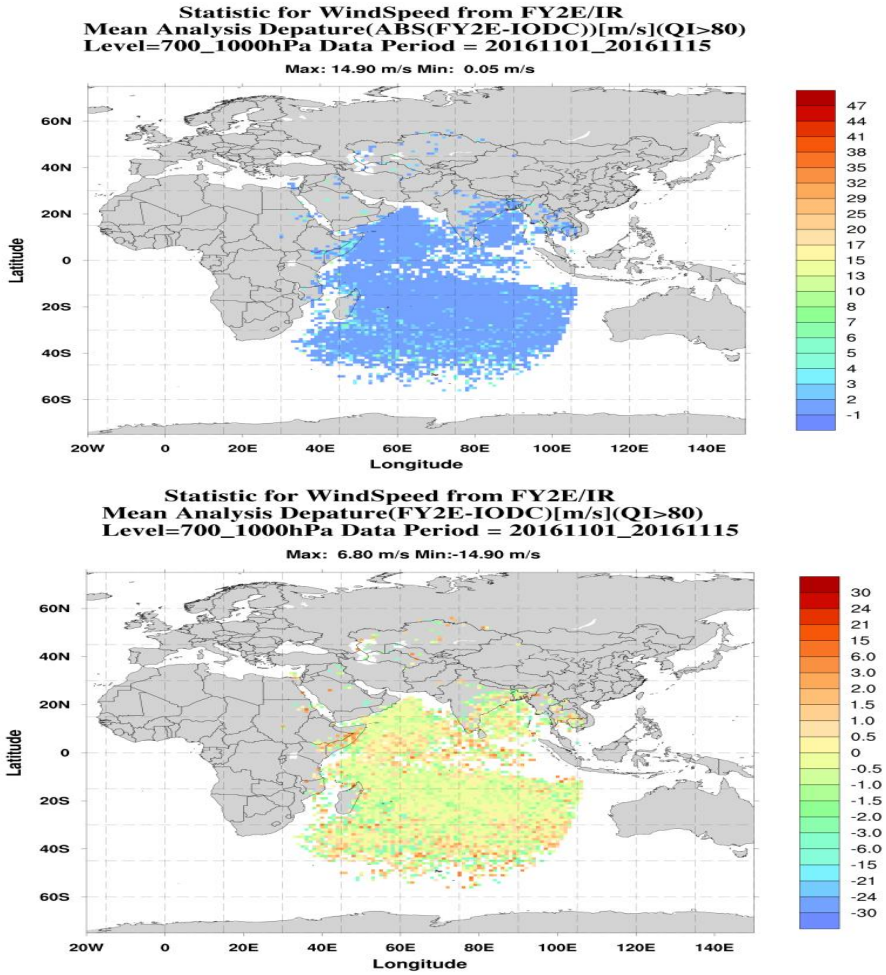
GIIRS baseline products (10)
Temperature Profile
Moisture Profile
Ozone Profile
Total Ozone
Total Precipitable Water
Lifted Index
CAPE index
K index
SI index
TT index

LMI baseline products (3)
Flash
Group
Event

FY-4A:Products and quality control



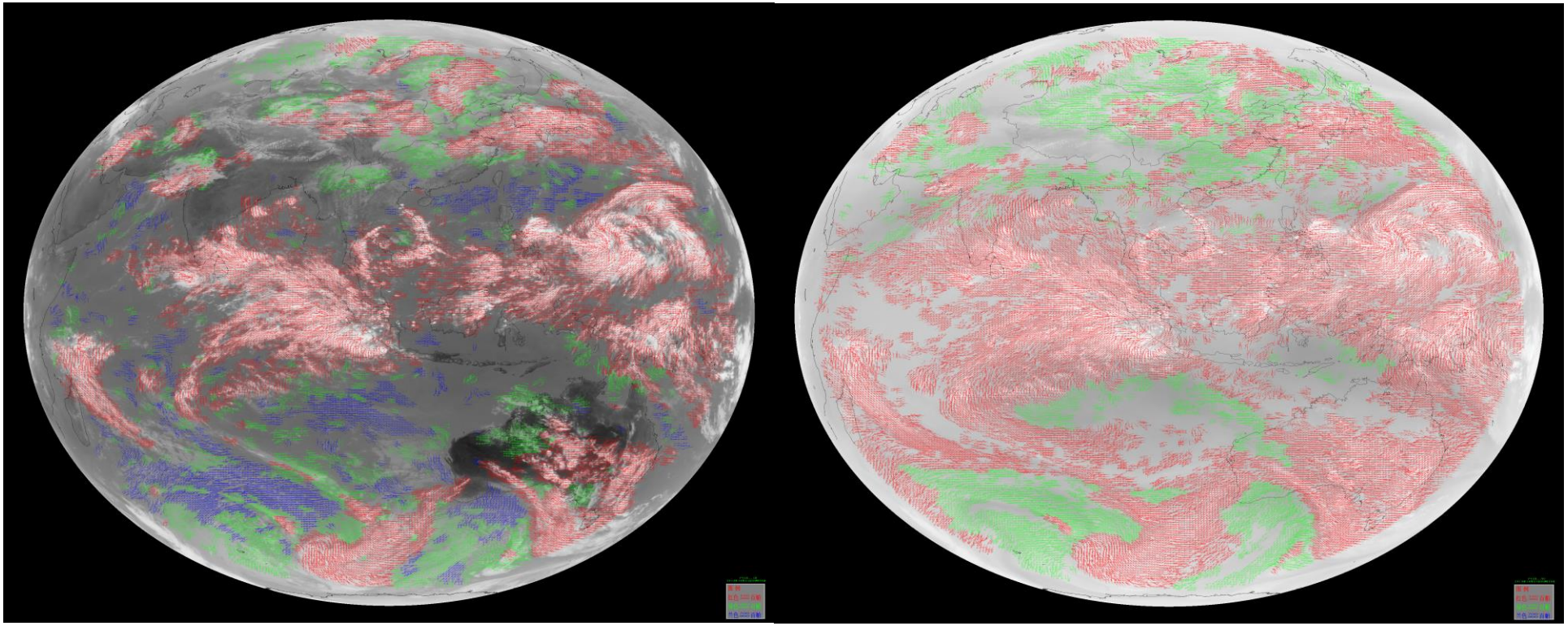
FY-4A Color Composite Image
(1/3/4 band)



Intercomparison of Fengyun/MSG products

MSG CMV sample data were kindly provided by Eumetsat

FY-4A AGRI products by example



CH12	10.3～11.3	64km
CH10	6.9～7.3	64km
CH09	5.8～6.7	64km
CH02	0.55～0.75	16km

Long-wave IR Cloud-drift Winds

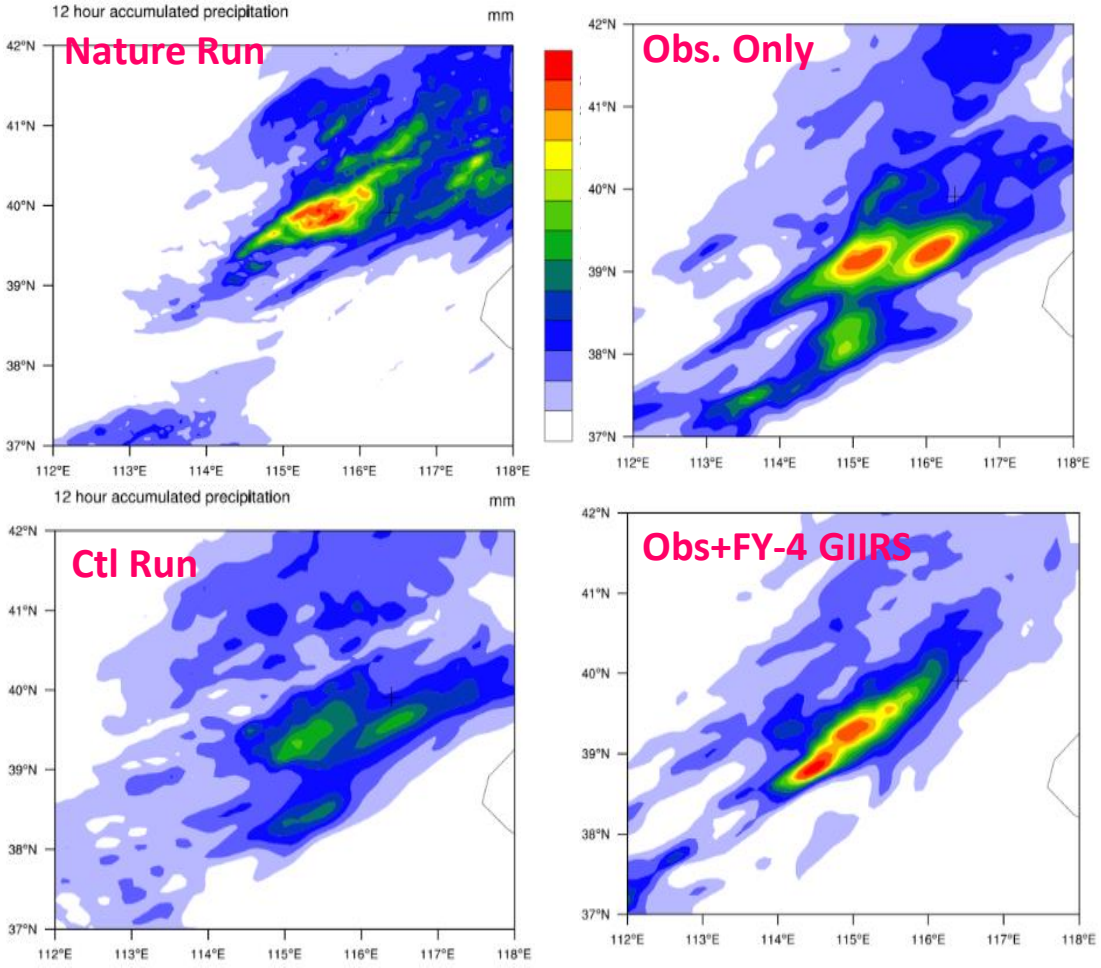
- Day and night; Lower, mid, and upper troposphere

Water Vapor Winds

- Cloud-top and Clear-sky; Mid and Upper troposphere

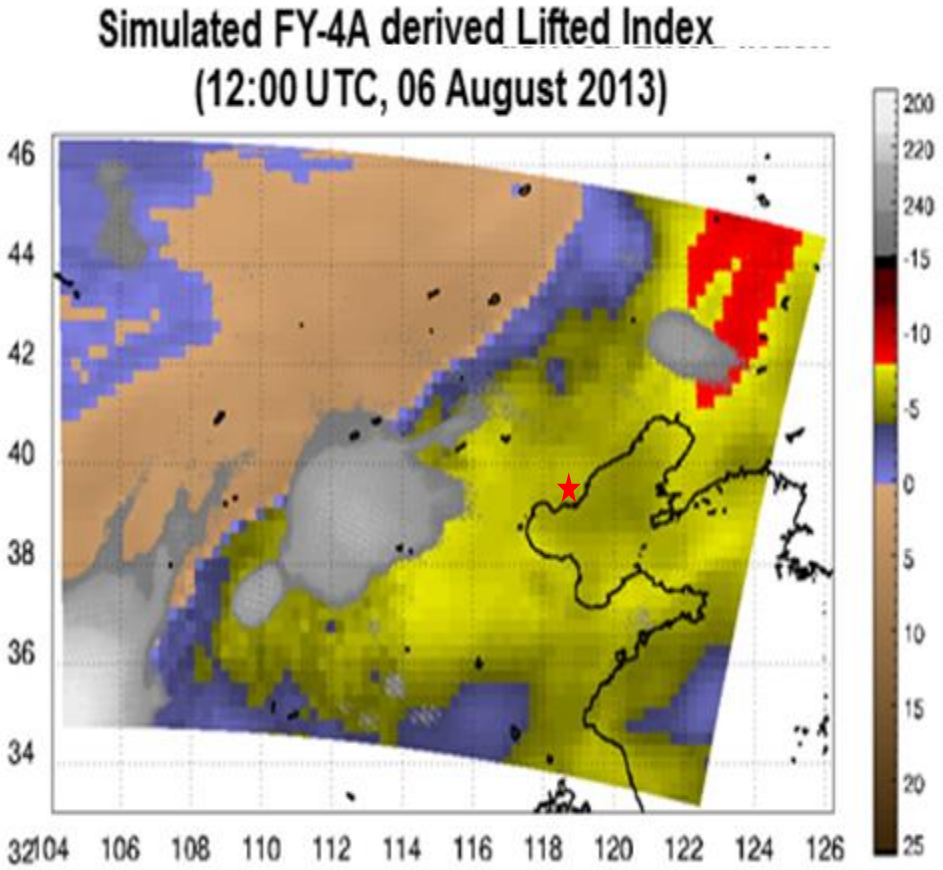
Courtesy of Prof. Jianmin Xu &Xiaohu Zhang-NSMC FY-4 AWG

FY-4A GIIRS product Validation(OSSE)

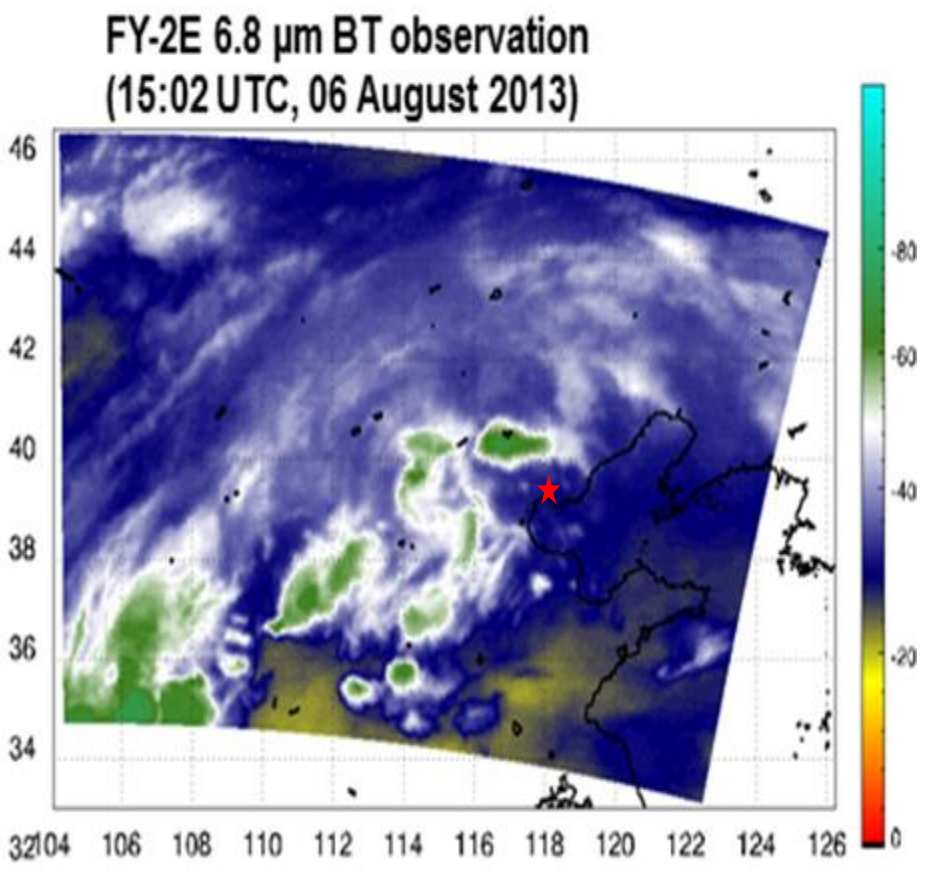


Courtesy of Dr. Jun Li-NSMC FY-4 AWG

Supporting now casting: Lifted index products

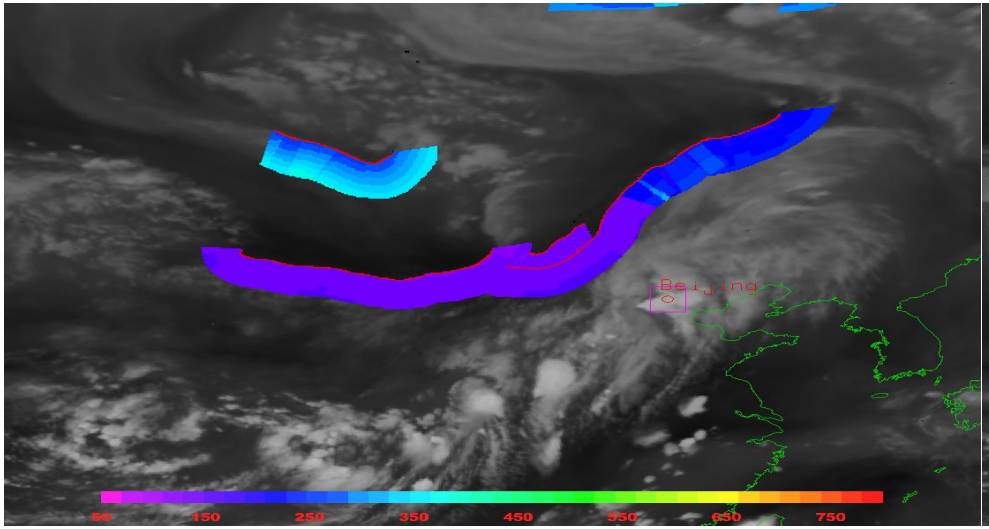


FY-4 GIIRS LIFTED INDEX 12 UTC

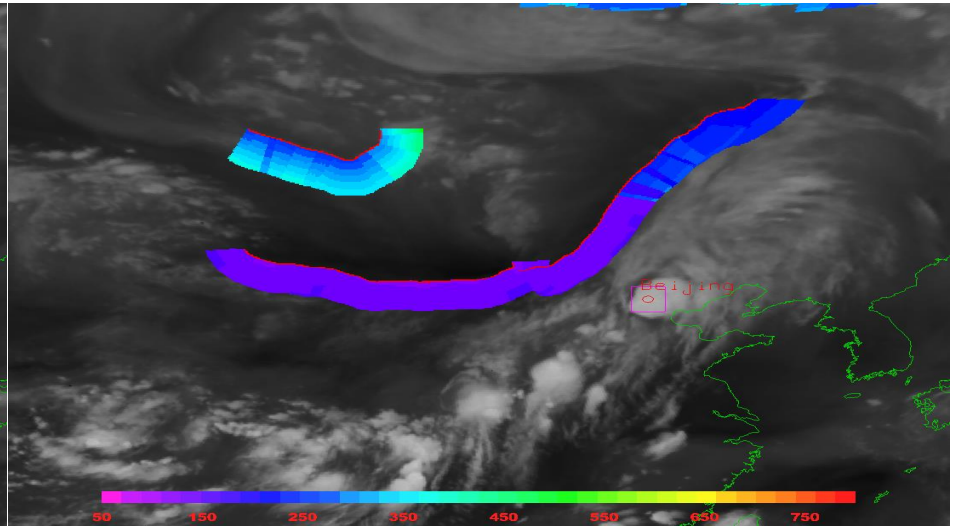


FY-2E WV IMAGES 15 UTC

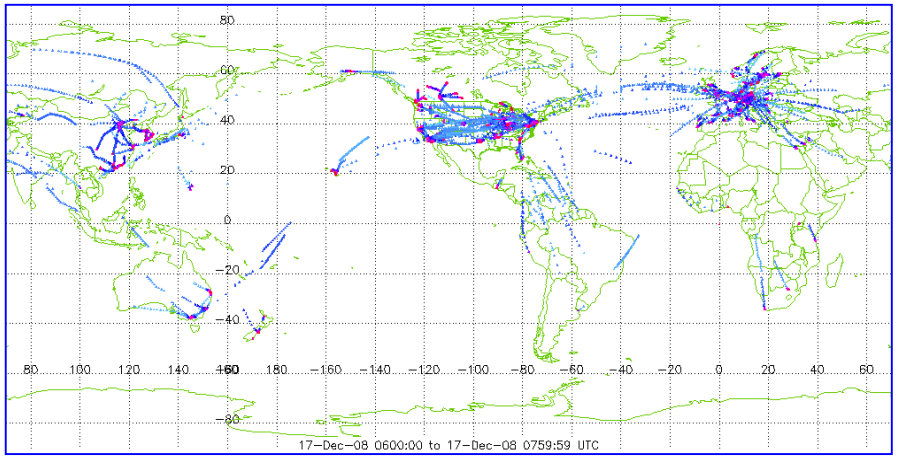
Supporting now casting &aviation Service: TFTP

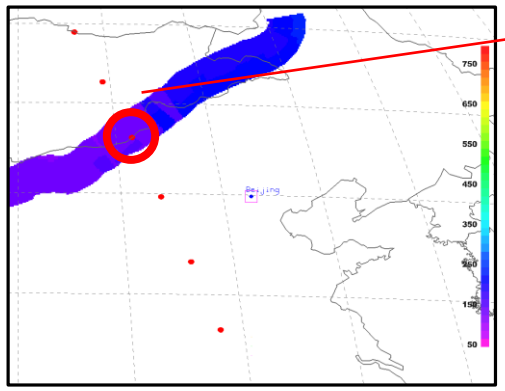


2012 0721 10UTC

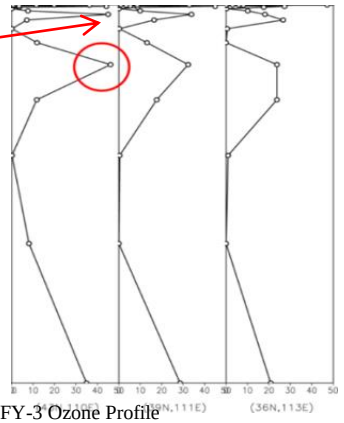


2012 0721 12UTC





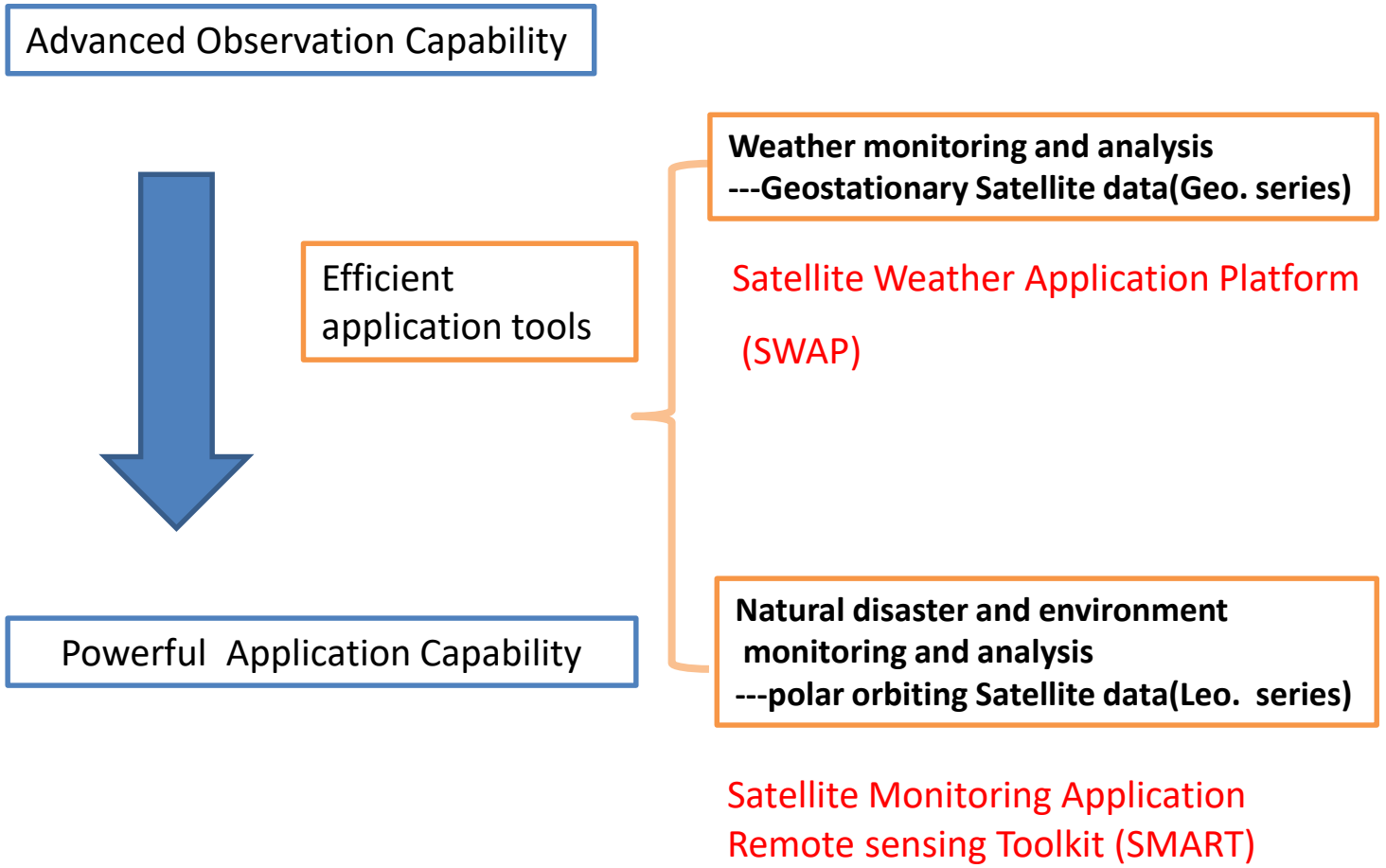
2012 0721 0500UTC TFTP



FY-3 Ozone Profile

Courtesy of Dr. Yixuan Shou–NSMC FY-4 AWG

CMA Concerns on Satellite Application Platforms



Summary

- CMA/NSMC focuses on operational satellite meteorological applications and capacity building. In-depth research and demonstration efforts are encouraged for the applications of new data in weather analysis, NWP, Environment etc., Current CMA Oceanographic application focal point is SST and Sea surface wind.

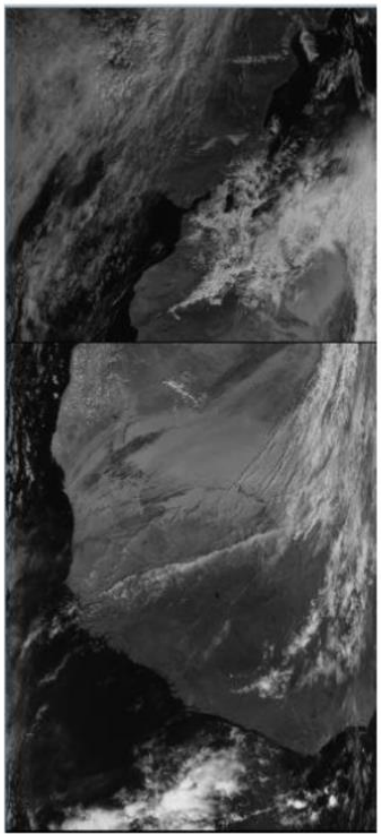
- CMA will keep its commitment to open data policy for Fengyun data. Engagement of regional and global users in the application of Fengyun data are welcome.

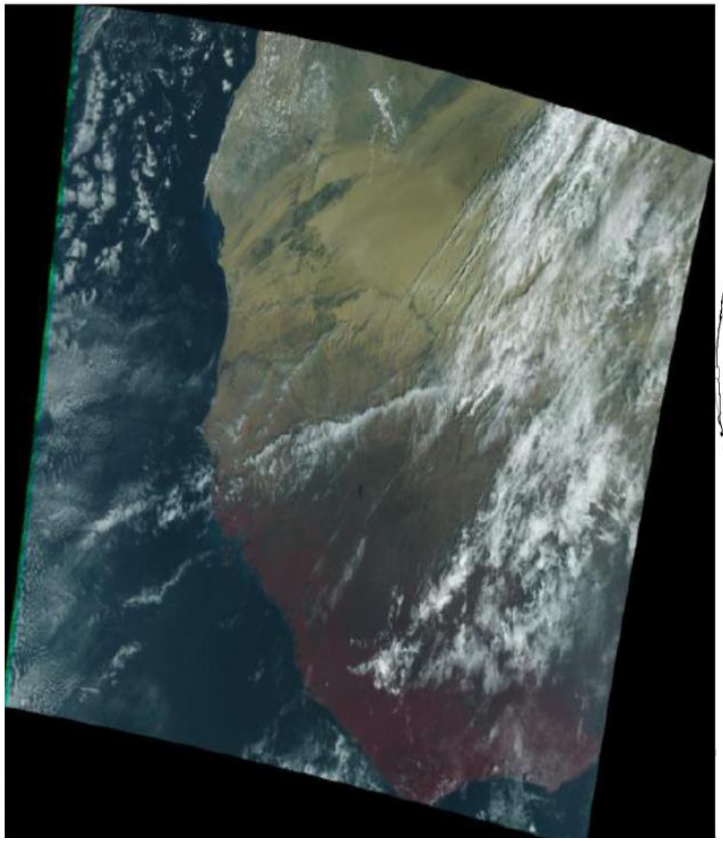
- **International partnerships are essential. Satellite Oceanography Users community is a very important value added benefit to CMA satellite applications.**

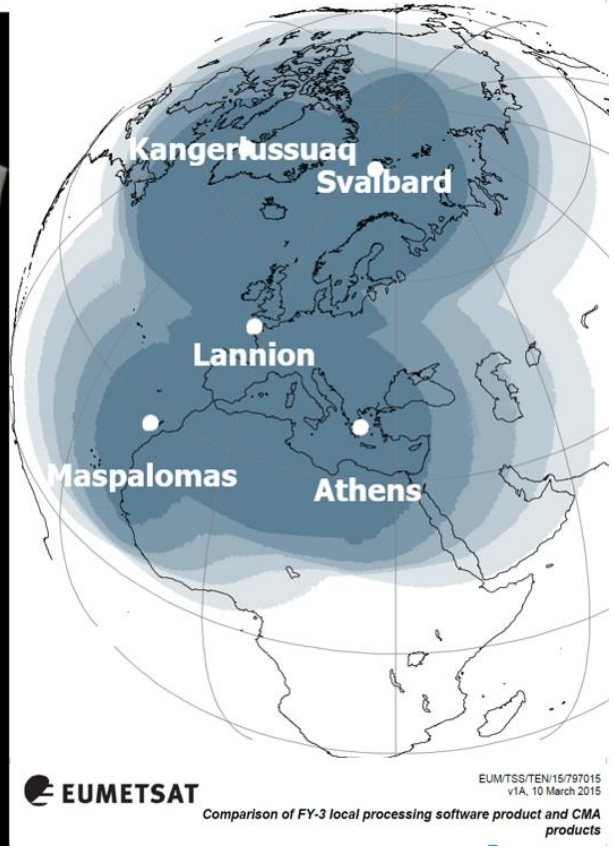

Thank you
for your attention
Lufeng@cma.gov.cn

FY-3 D/B Applications worldwide

FY-3 Ready European Direct Broadcast stations







How to Access?

1) DB Users （registed user）

2) CMACAST （registed user）

3) Web-based Service（registed user）

4) FTP Push （ specific applications ）

5) FTP Pull （registed user）

6) Manual Service （ specific applications)