



6th Asia/Oceania Meteorological Satellite Users' Conference

A New Era: Three-Dimensional Observation and Service with Fully High Resolutions on FY-4 Platform are Coming Next Year

Presented by *Qiang Guo*

2nd chief designer for ground segments of FY-2/FY-4 satellites

**National Satellite Meteorological Center (NSMC)
China Meteorological Administration (CMA)**



Tokyo, Japan. 11 November, 2015



Outline

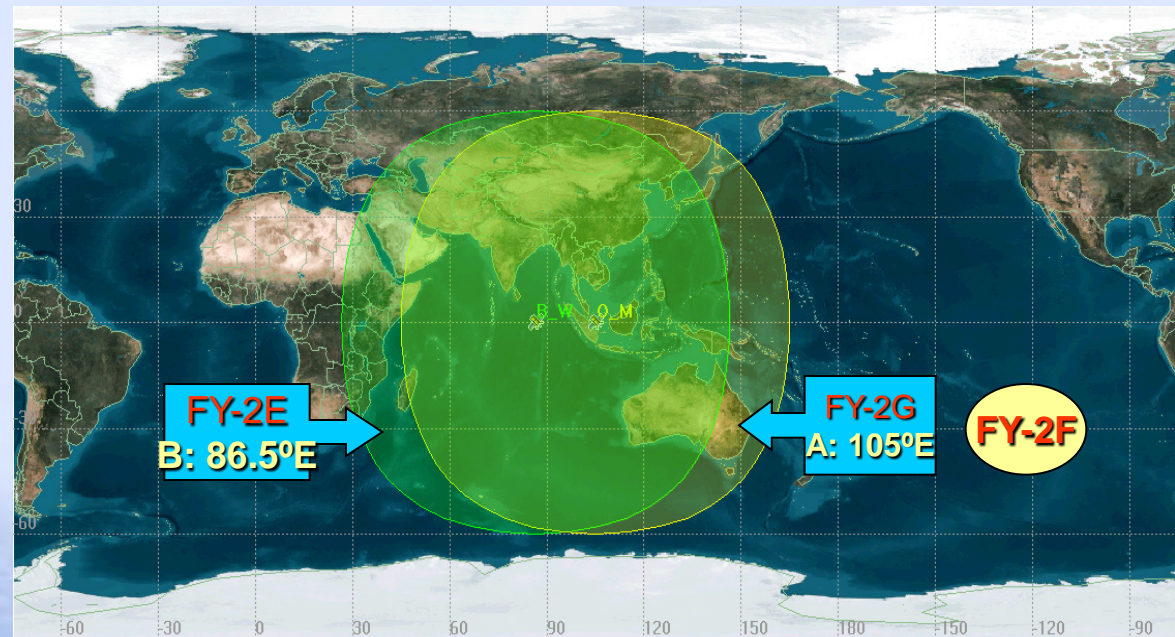
- **Overview of Current & Future GEO satellites in China**
- **Main Features of FY-4A**
- **Recent Progress of Ground Segment of FY-4A**
- **New Applications & Data Service**
- **Summary**

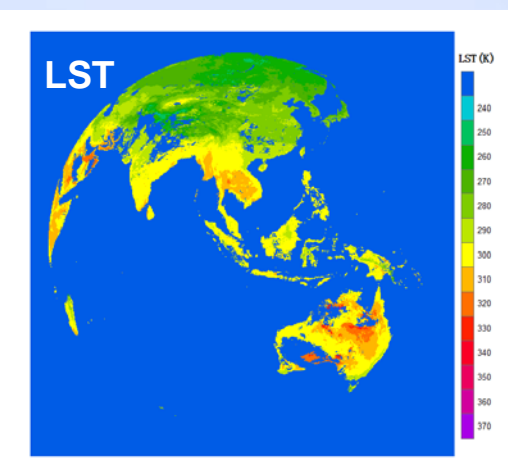
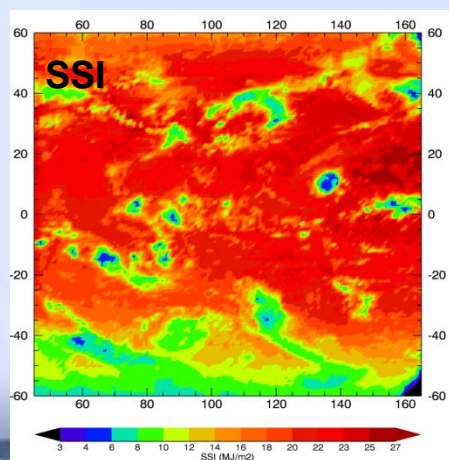
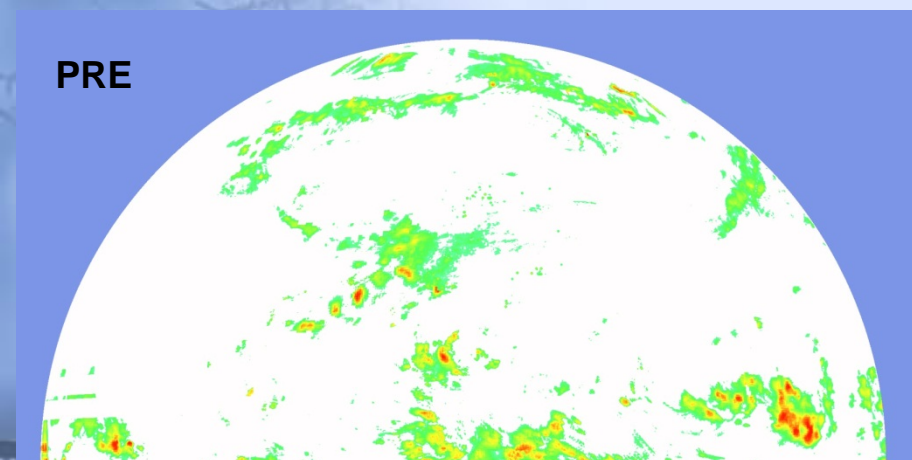
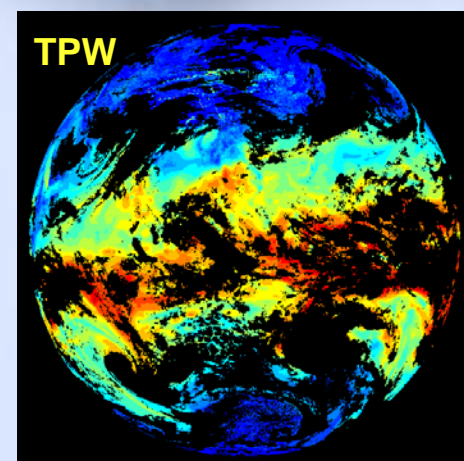
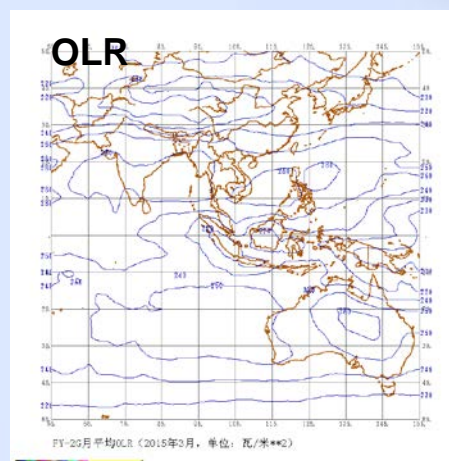
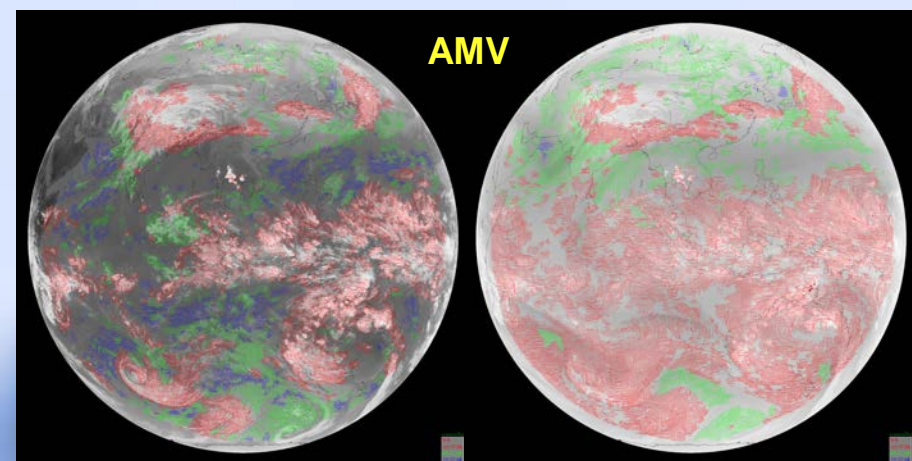
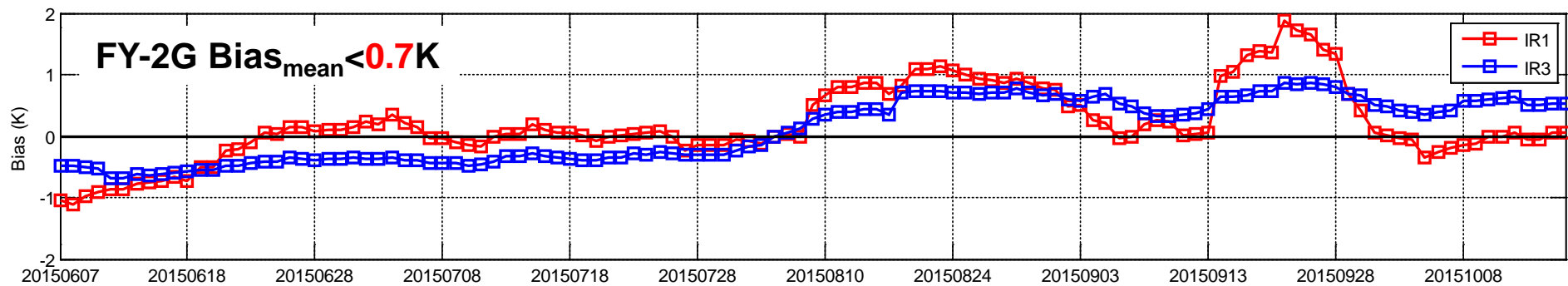
FY-2: Current CMA GEO. Constellation

No.	Position	Status	Launch
FY-2E	86.5E	Operational	Dec.23, 2008
FY-2F	112.5E	Operational	Jan. 14, 2012
FY-2G	105E	Operational	Dec.31, 2014

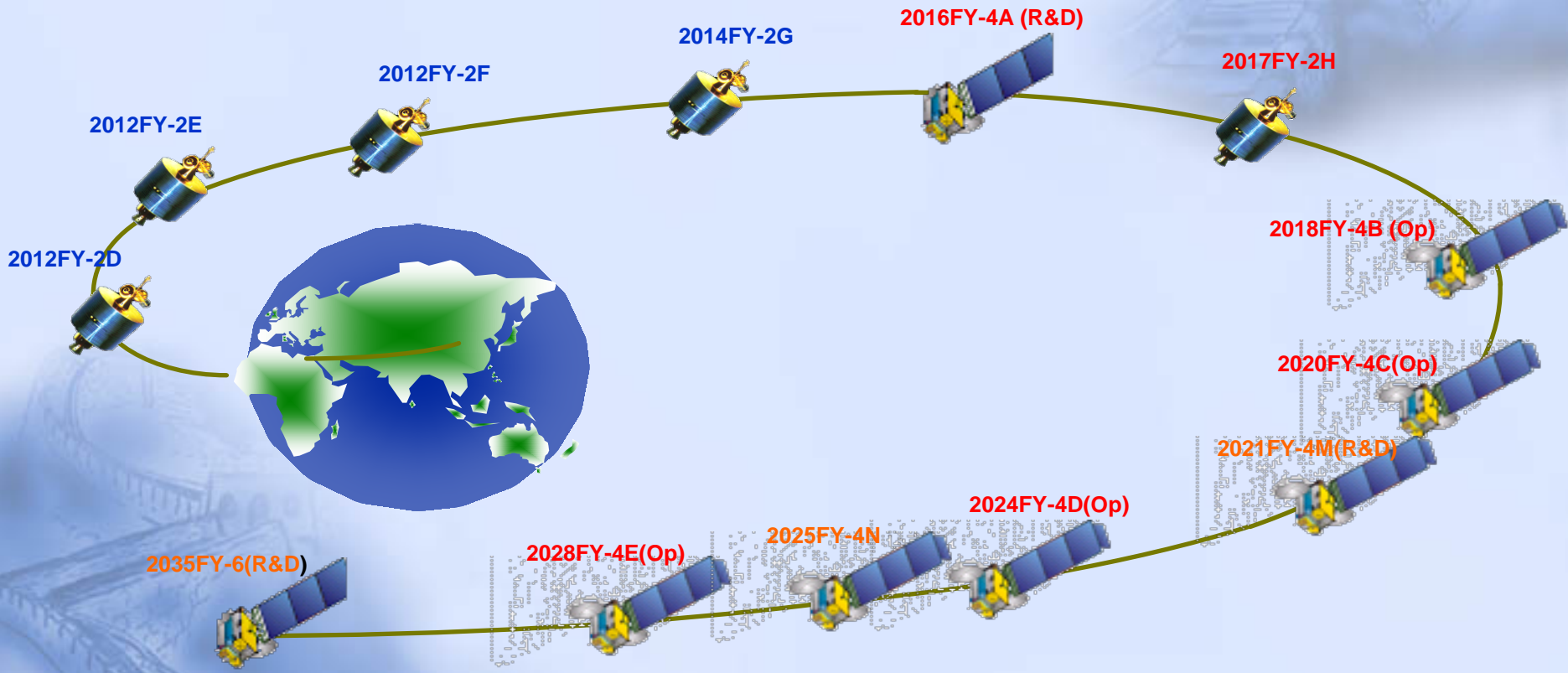
Platform: Spin stabilization
Payload: 5 chl. VISSR
Disc Obs: Every 30/60 min.

- ✓ FY-2G was positioned in primary position 105E Since June 1st, while FY-2E was moved to 86.5E to support IOC cooperated with EUMETSAT in July this year.
- ✓ FY-2E & FY-2G are working together to implement 15 min. interval obs., and backup each other
- ✓ FY-2F stands specially for 6 min. flexible rapid scan in case of needs





Fengyun GEO Meteorological Satellite Mission from 2011-2035



Outline

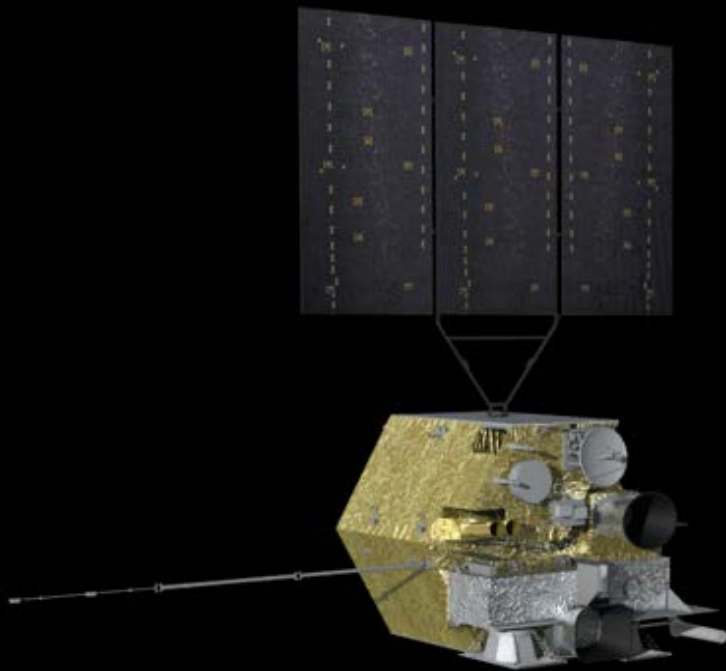
- Overview of Current & Future GEO satellites in China
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FY-4A: New Era of GEO Satellite

together with GOES-R, MTG, Himawari-8. Launch is scheduled in the end of 2016

Spacecraft:

1. Launch Weight: approx 5300kg
2. Stabilization: Three-axis
3. Attitude accuracy: 3"
4. Bus: 1553B+Spacewire
5. Raw data transmission : X band
6. Output power: $\geq 3200W$
7. Design life: over 7 years



GIIRS: Geo. Interferometric InfraRed Sounder

AGRI: Advanced Geosynchronous Radiation Imager

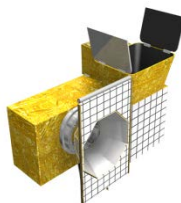
LMI: Lightning Mapping Imager

SEP: Space Environment Package

Characteristics of Payloads (Specification & Main Usage)

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

AGRI



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:

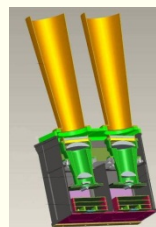
Acquire atmospheric temperature and humidity profile structures under clear condition

LMI's Main Usage:

Acquire lightning distribution maps for a certain coverage

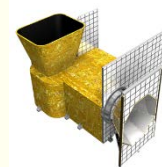
Spatial resolution	about 7.8Km at SSP
Sensor size	400x300 x2
Wave-length at center	777.4nm
Band-width	1nm \pm 0.1nm
Detection efficiency	>90%
False-alarm ratio	<10%
Dynamic range	>100
SNR	>6
Frequency of frames	2ms
Quantization	12 bits
Measurement Error	10%

LMI

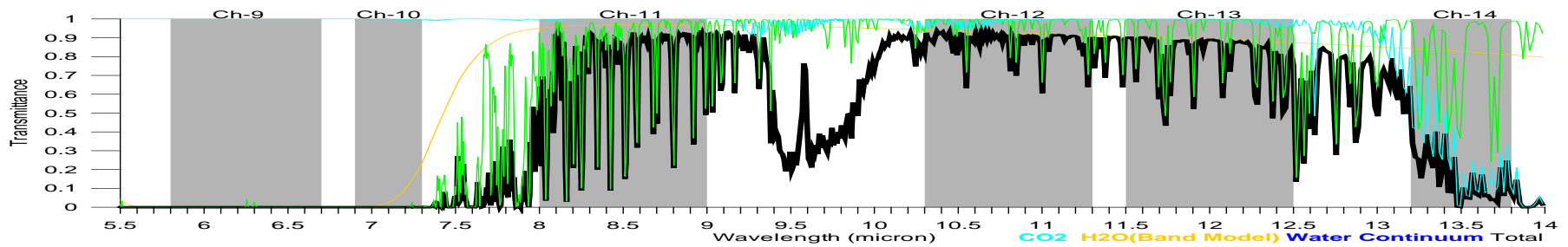
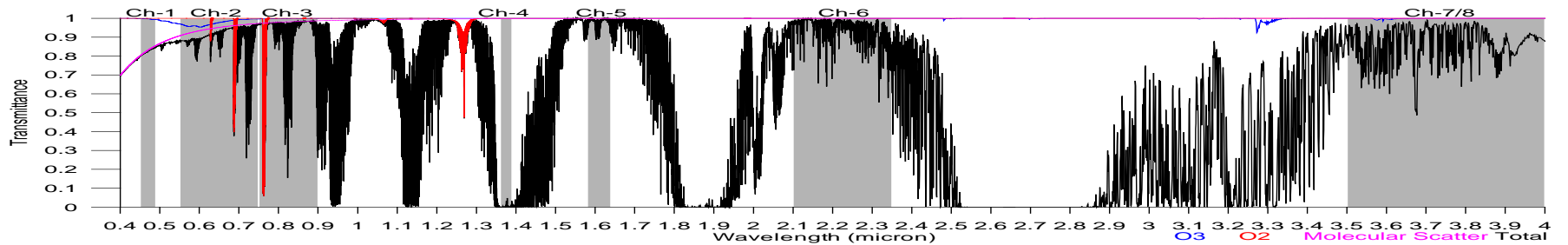
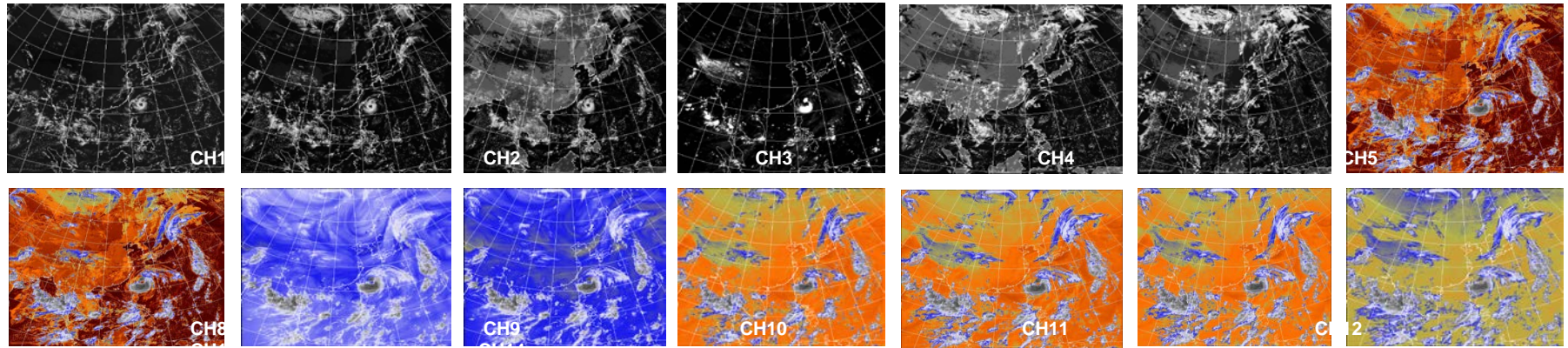


	Range	Resolution	Channels
Spectral Parameters (Normal mode)	LWIR: 700-1130 cm^{-1}	0.8	538
	S/MIR: 1650-2250 cm^{-1}	1.6	375
Spatial Resolution	VIS : 0.55- 0.75 μm		
	LWIR/MWIR :	16 Km SSP	
	China area	5000 x 5000 Km^2	
Operational Mode	Mesoscale area	1000 x 1000 Km^2	
	China area	<1 hr	
Temporal Resolution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

GIIRS



Simulated Imagery of FY-4A AGRI



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Development Flow of FY-4 Ground Segment

Phase C (Qualification and Production)

2015.1 to now

- Engineering development for the whole ground-segment

Phase A (Preliminary Definition)

between 2010.1 and 2013.12

- Tradeoff study
- Navigation & calibration conceptual research
- Key Product Algorithm Design

Phase B (Detailed Definition)

2014.1 to 2014.12

- Design, integration and validation of the whole ground-segment, including data acquisition and service, mission definition and observation schedule arrangement, INR, C&V, product generation and applications
- Interface between space and ground segments optimization and confirmation

**Readiness before
Oct.,2016**

Prophase (Mission Definition)

before 2009.12

- User Requirements Analysis
- Feasibility Analysis for payload configuration
- Key Technology of Payloads Research

Image Navigation & Registration

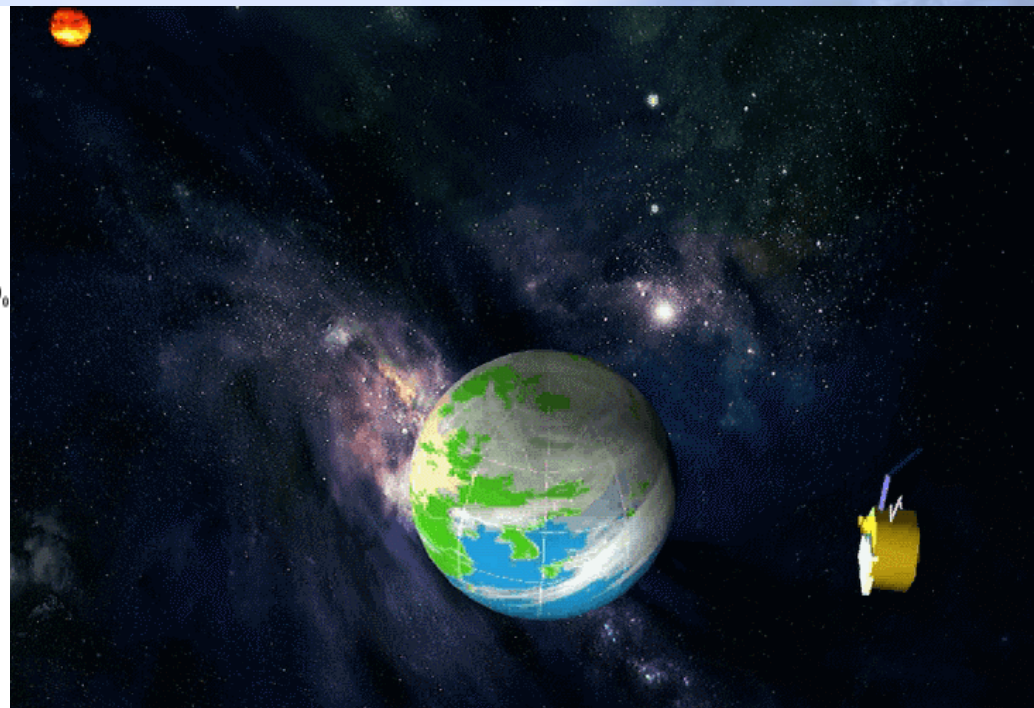
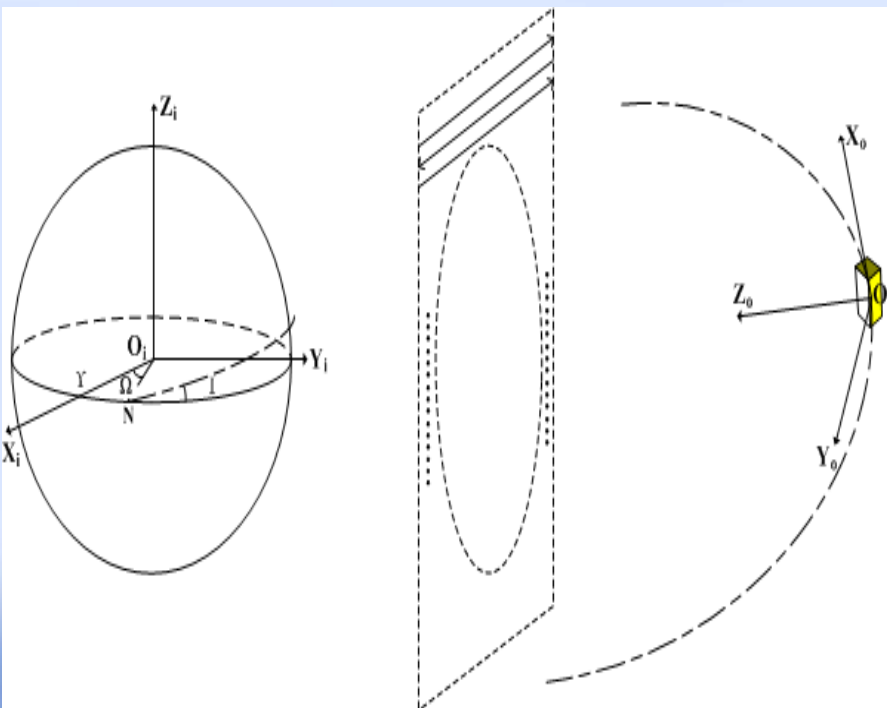


Illustration of space-to-Earth Obs. of FY-4

INR: **Position**(Orbit)+**Pointing**(sight of view)

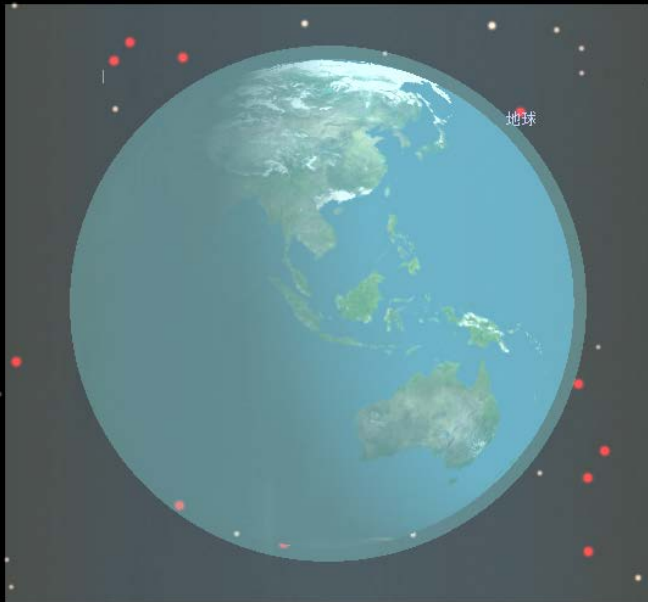
Position: Ranging with 5 stations to remove the effects of ionosphere

Pointing: including the errors of **attitude**, **installation**, **thermal deformation**

The **most** important navigation error of FY-4 INR is the **pointing of scanning mirror** caused by the **thermal deformation**

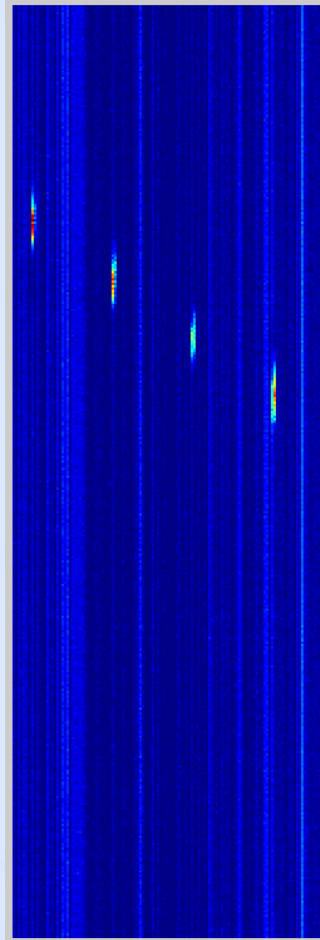
Important Progress in INR

Prediction of Observable Stars

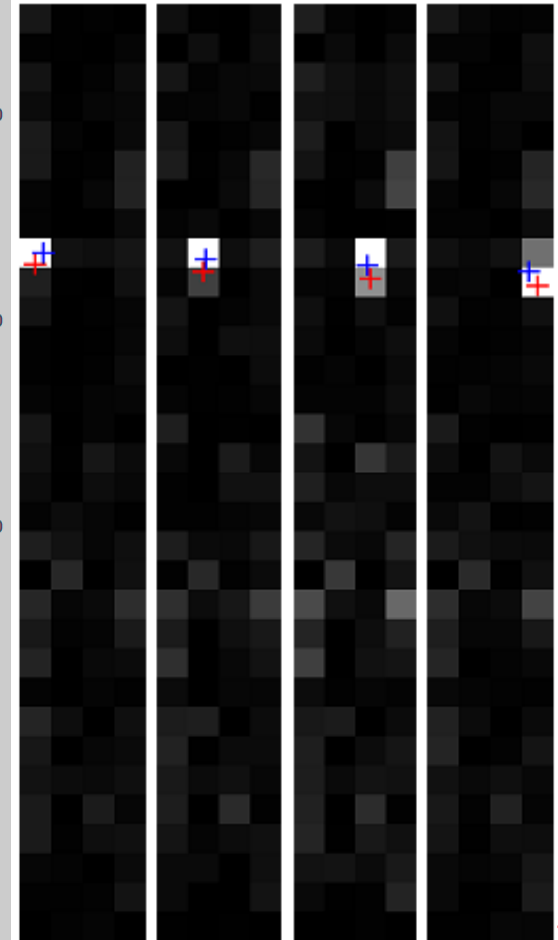


日期及时间
2016 / 5 / 1 0 : 0 : 0

Results from 32*4 array sensor



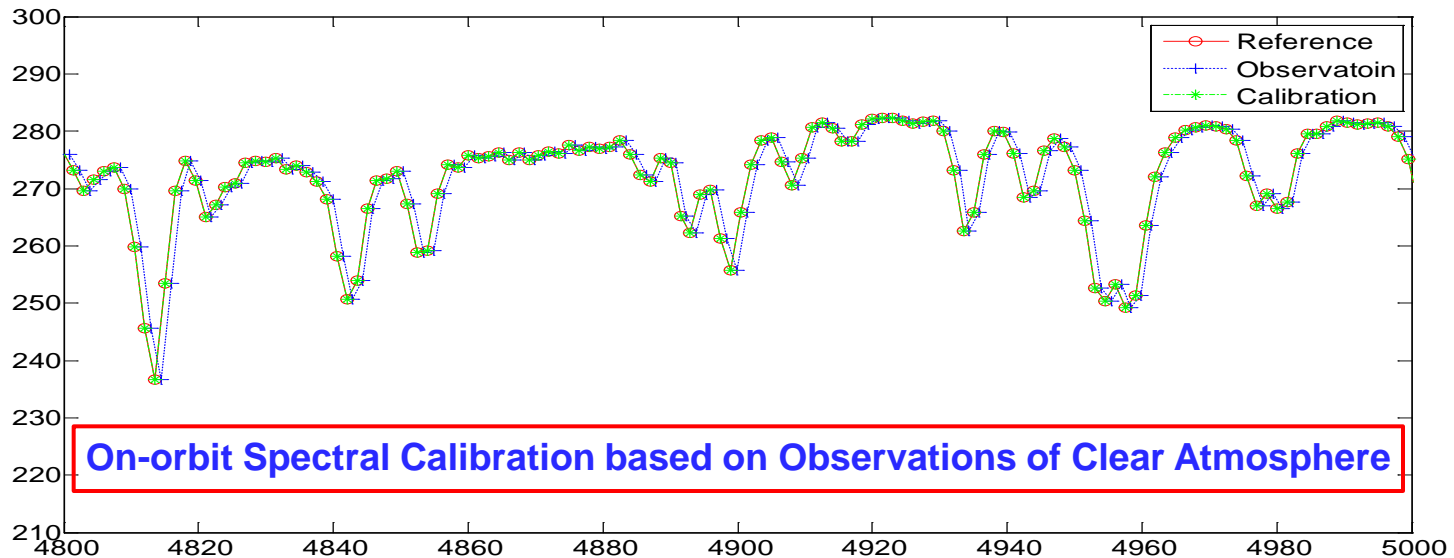
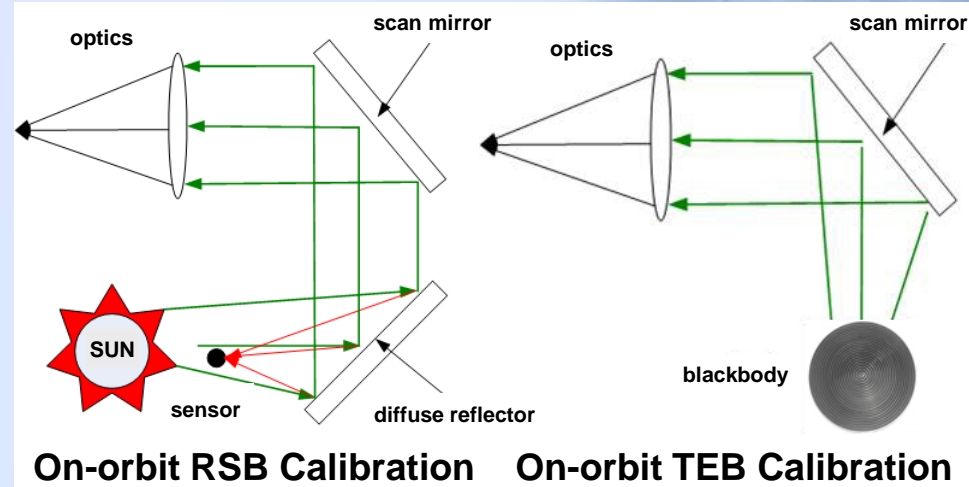
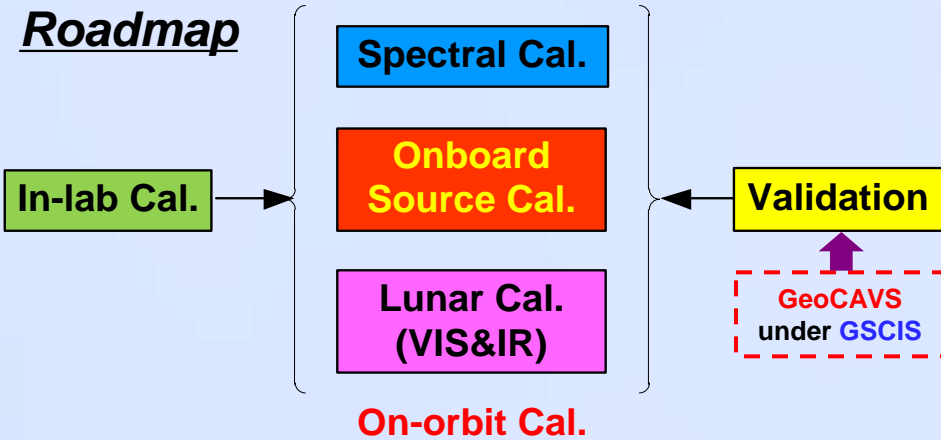
Centroid extraction from the left image



Pointing Determination with On-orbit Star Observations

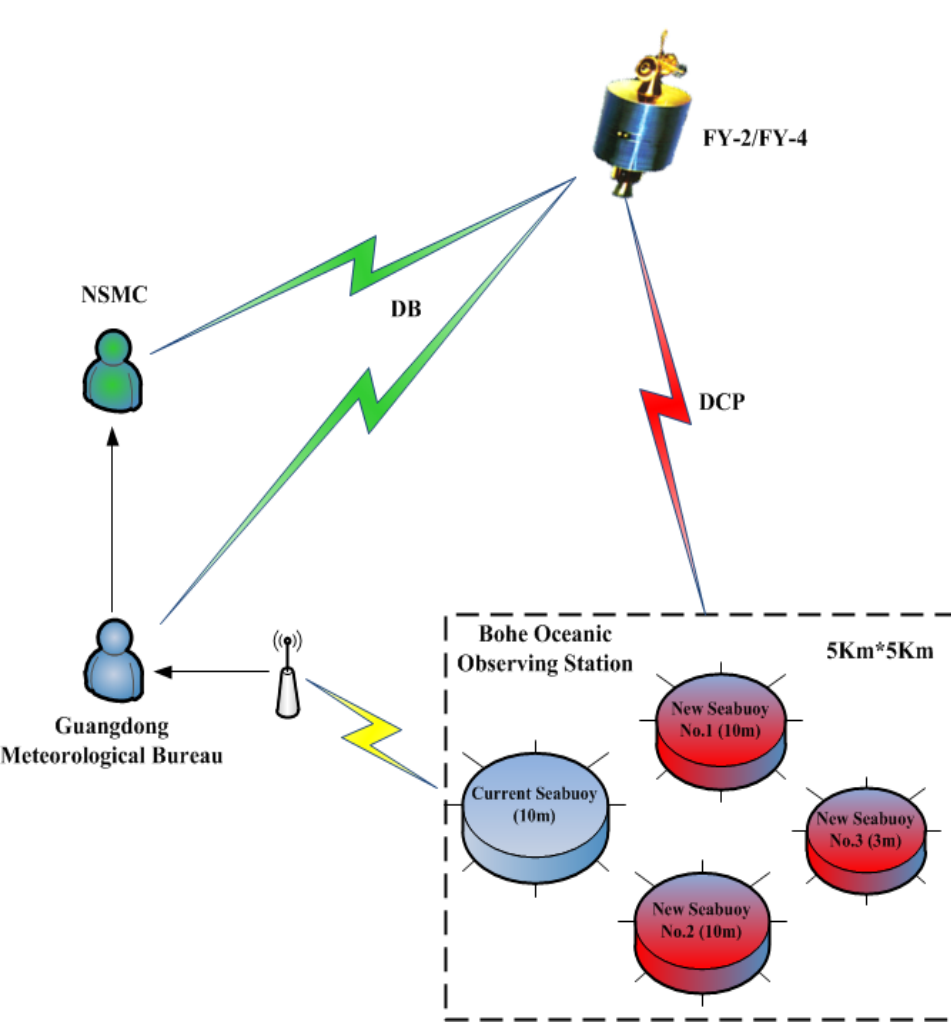
Radiometric & Spectral Calibration

Roadmap

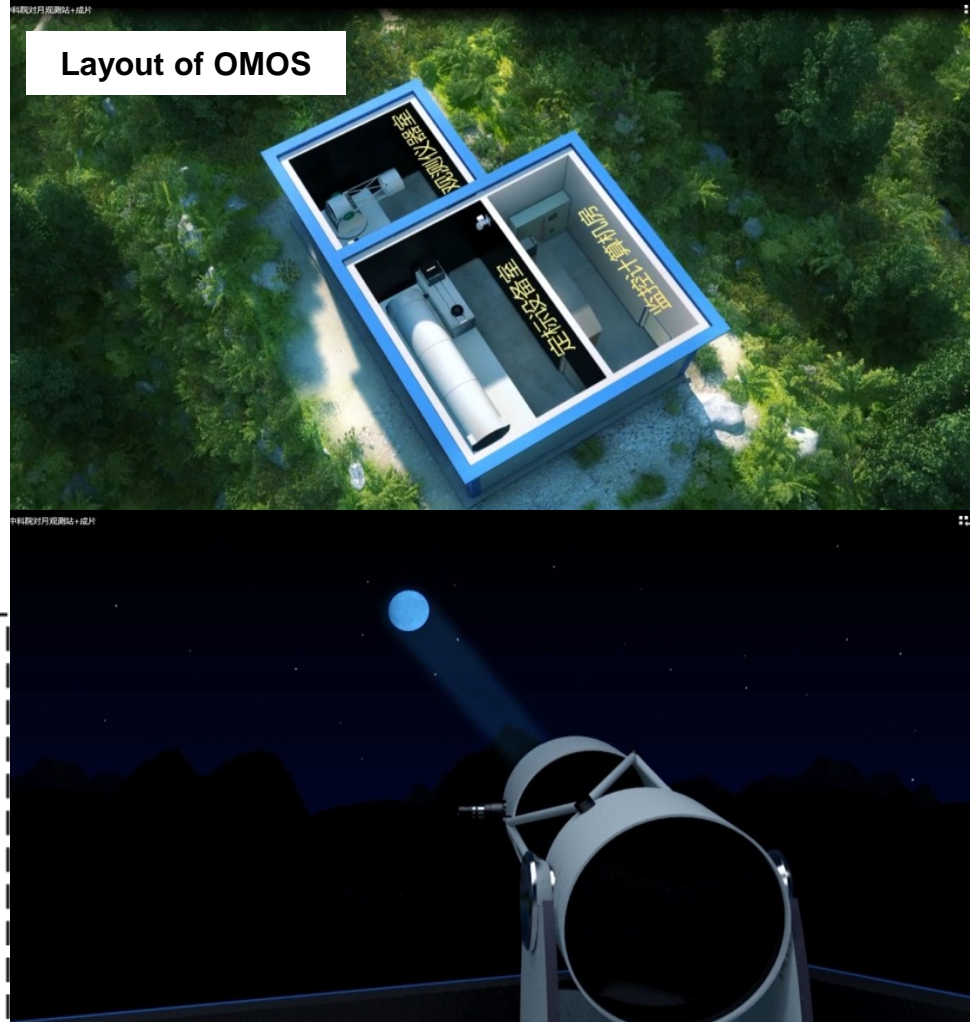


New Validation Approach for TEB Calibration

Radiometric Reference Measurement System



High-Confident Sea-buoy (HCS)



On-ground Moon Observe System (OMOS)

Products Development

Baseline Products of imager(AGRI) & LMI

No .	Products	No.	Products
1	Cloud Mask	13	Downward Shortwave Radiation: Surface
2	Cloud Type	14	Derived Motion Winds
3	Cloud Top Temperature	15	Lightning Detection
4	Cloud Top Pressure	16	Rainfall Rate/QPE
5	Cloud Optical Depth	17	Convective Initiation
6	Cloud Liquid Water	18	Tropopause Folding Turbulence Prediction
7	Cloud Particle Size Distribution	19	Sea Surface Temperature (skin)
8	Aerosol Detection	20	Fire/Hot Spot Characterization
9	Aerosol Optical Depth	21	Land Surface (Skin) Temperature
10	Downward Longwave Radiation: Surface	22	Land Surface Emissivity
11	Upward Longwave Radiation: TOA	23	Snow Cover
12	Upward Longwave Radiation: Surface		

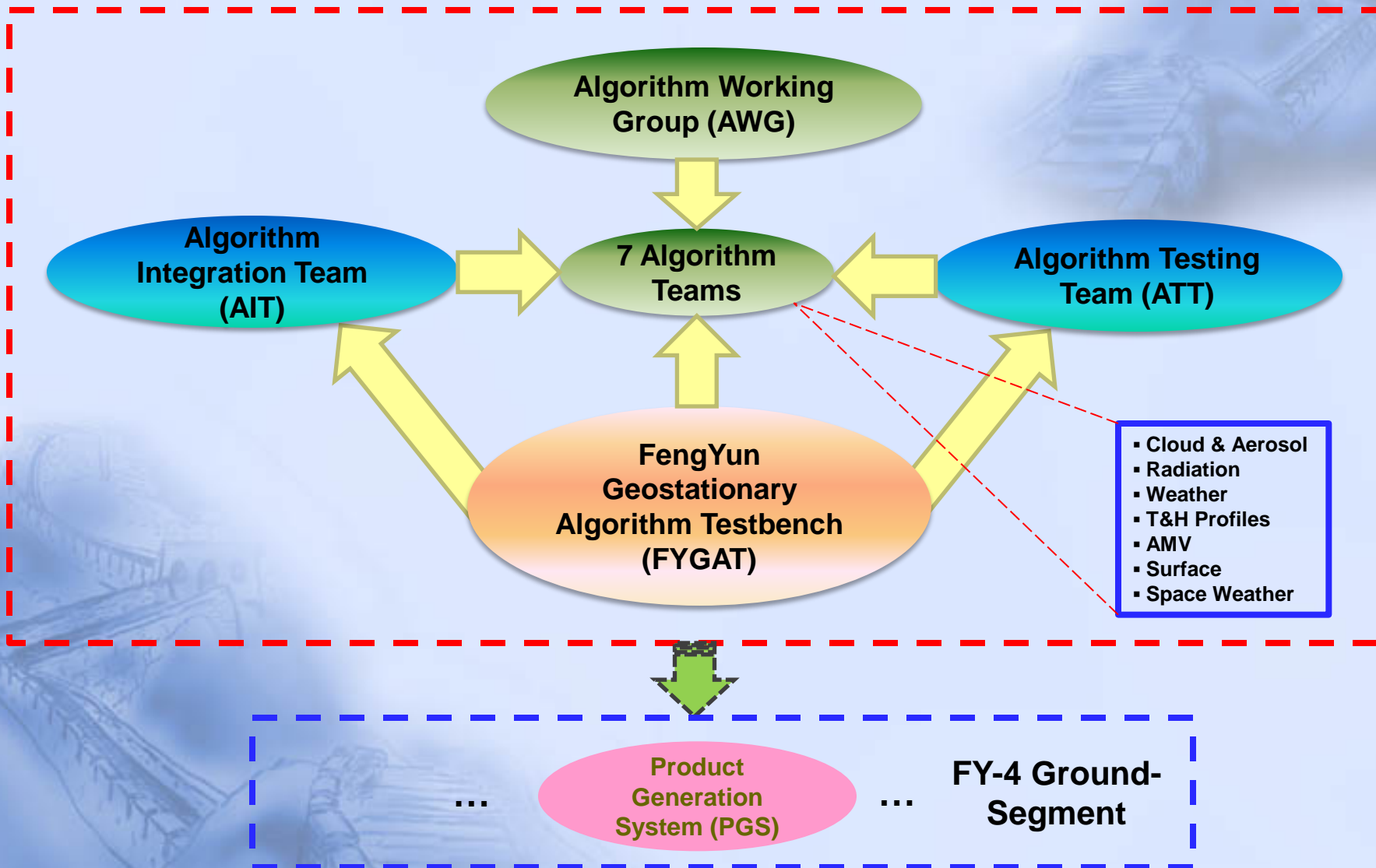
Baseline Products of sounder(GIIRS)

No .	Products
24	Atmospheric Temperature, Humidity and Ozone Profiles (Clear)
25	Atmospheric Temperature and Humidity Profiles (Cloudy)

Baseline Products of SEP

No .	Products
26	Distribution of High Energy Particle
27	Intensity of Magnetic Field
28	Effects of Spatial Environment

Structural Framework



Important Milestones of Product Development

Key Products Algorithm Design

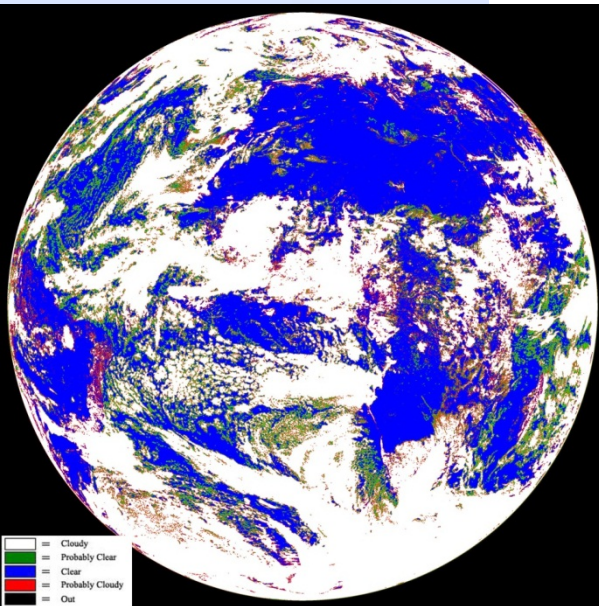
Jan. 2010 – Dec. 2013

Prototype Software Development & Validation

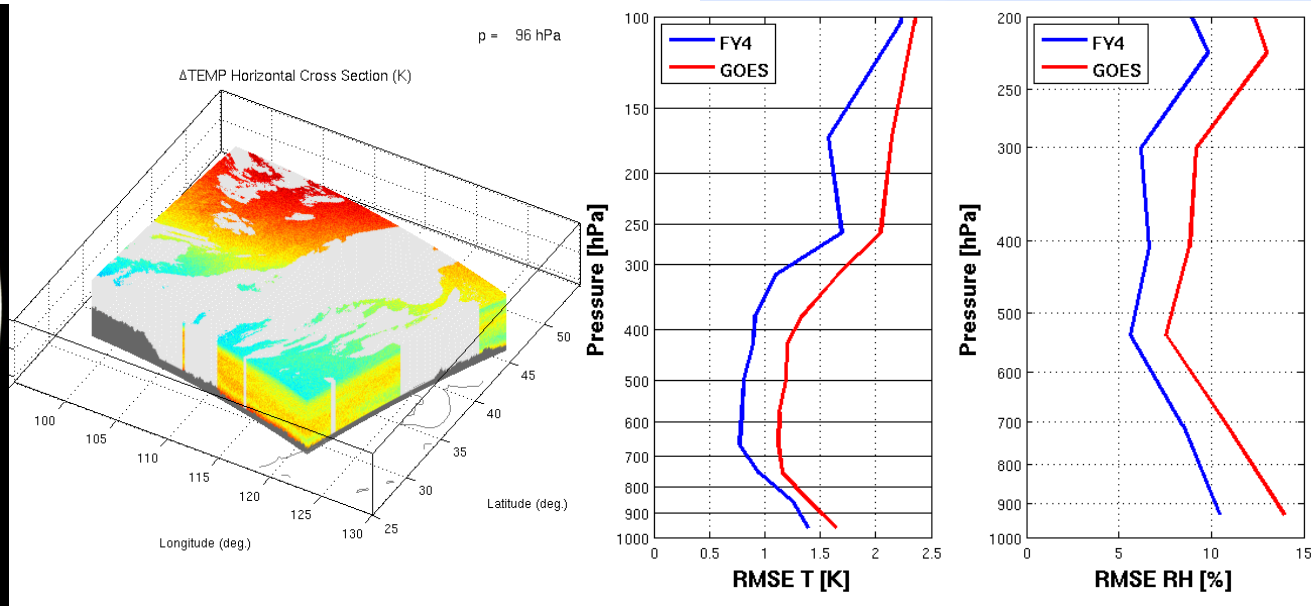
Jan. 2014 – Dec. 2014

Algorithm Engineering & Testing

Since Jan. 2015

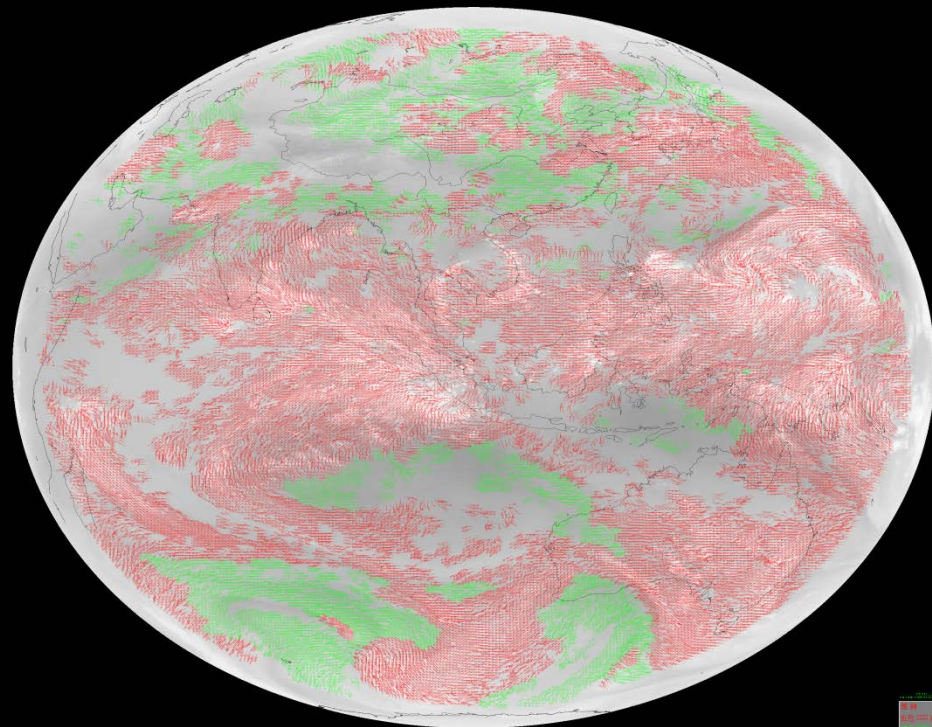
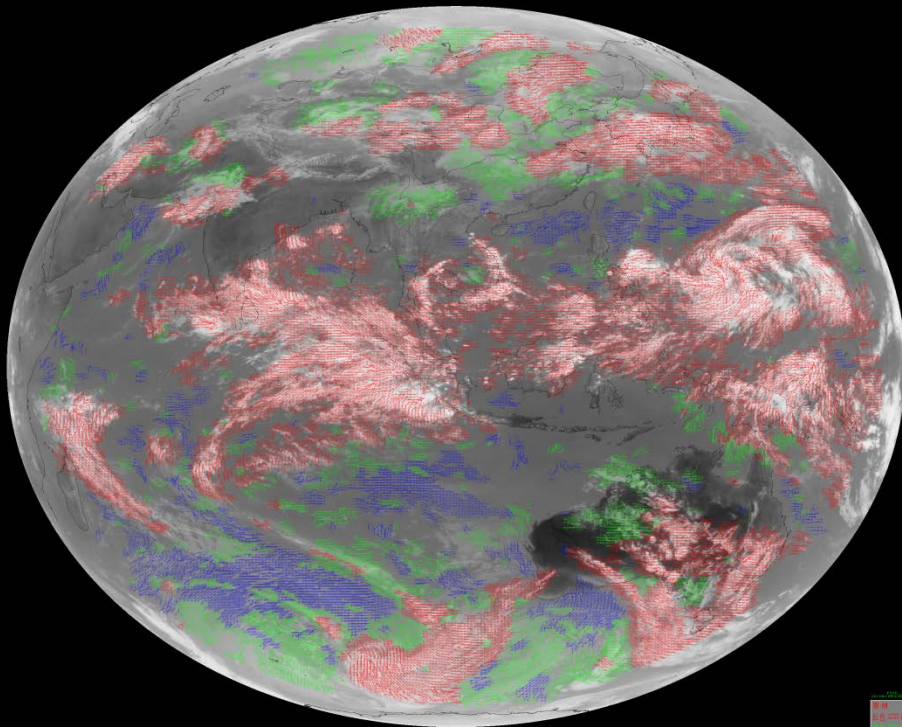


Cloud Detection(CLD)



Atmospheric T/H Profiles (Clear)

FY-4A AGRI products by example



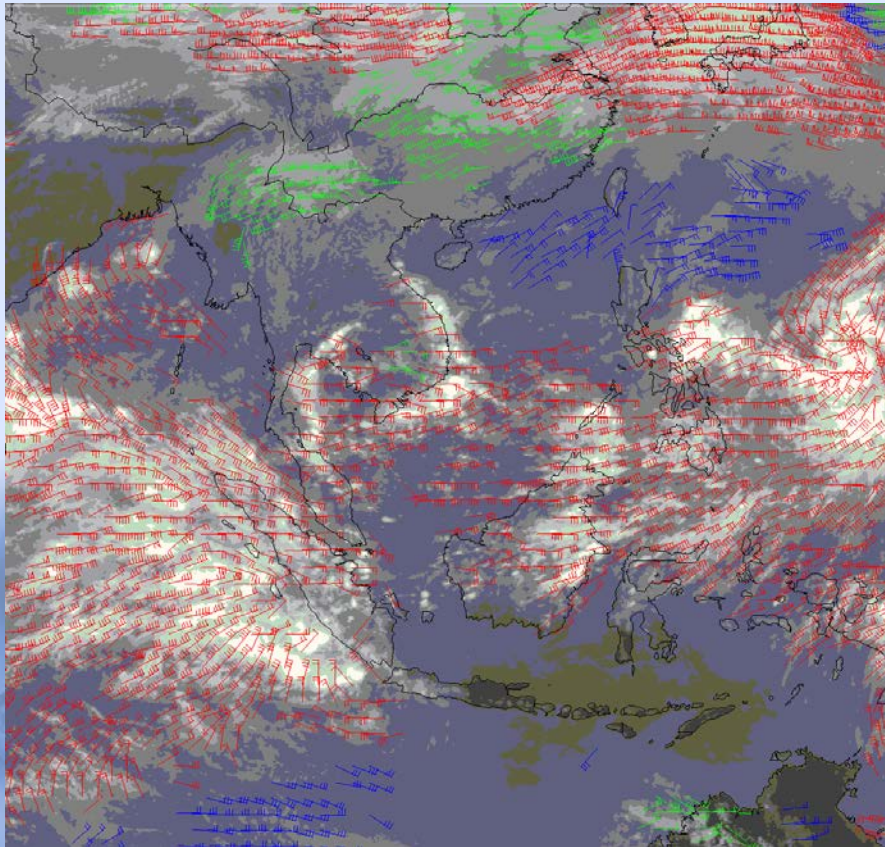
CH12	10.3~11.3	64km
CH10	6.9~7.3	64km
CH09	5.8~6.7	64km
CH02	0.55~0.75	16km

Long-wave IR Cloud-drift Winds
- Day and night; Lower, mid, and upper troposphere

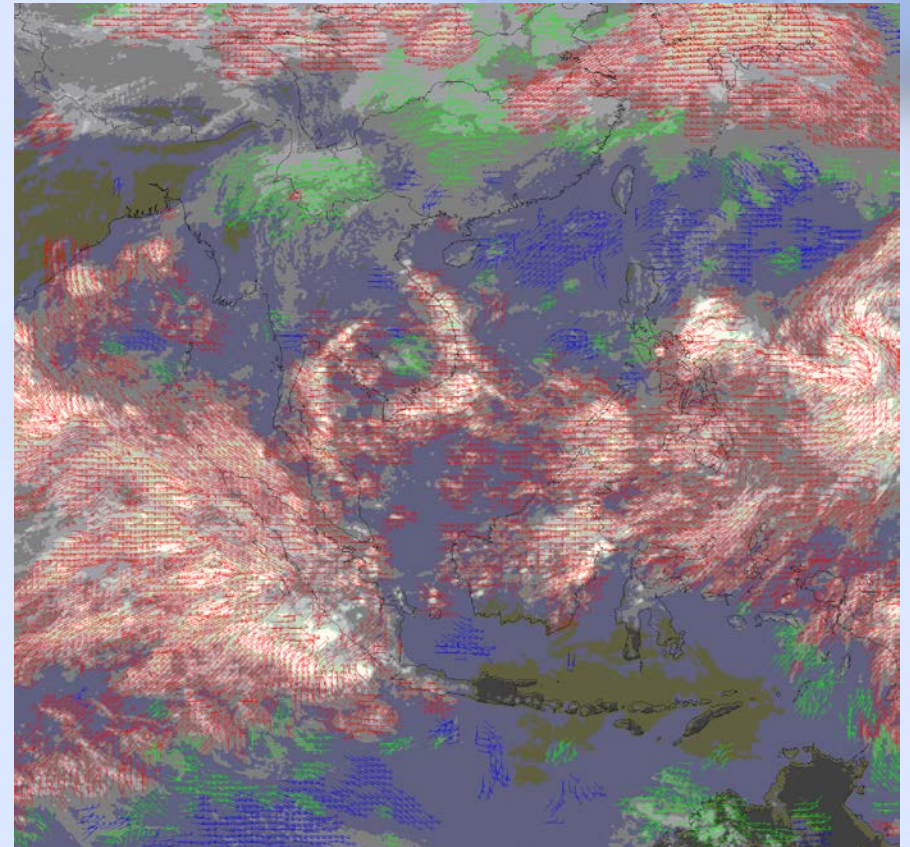
Water Vapor Winds
- Cloud-top and Clear-sky; Mid and Upper troposphere

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

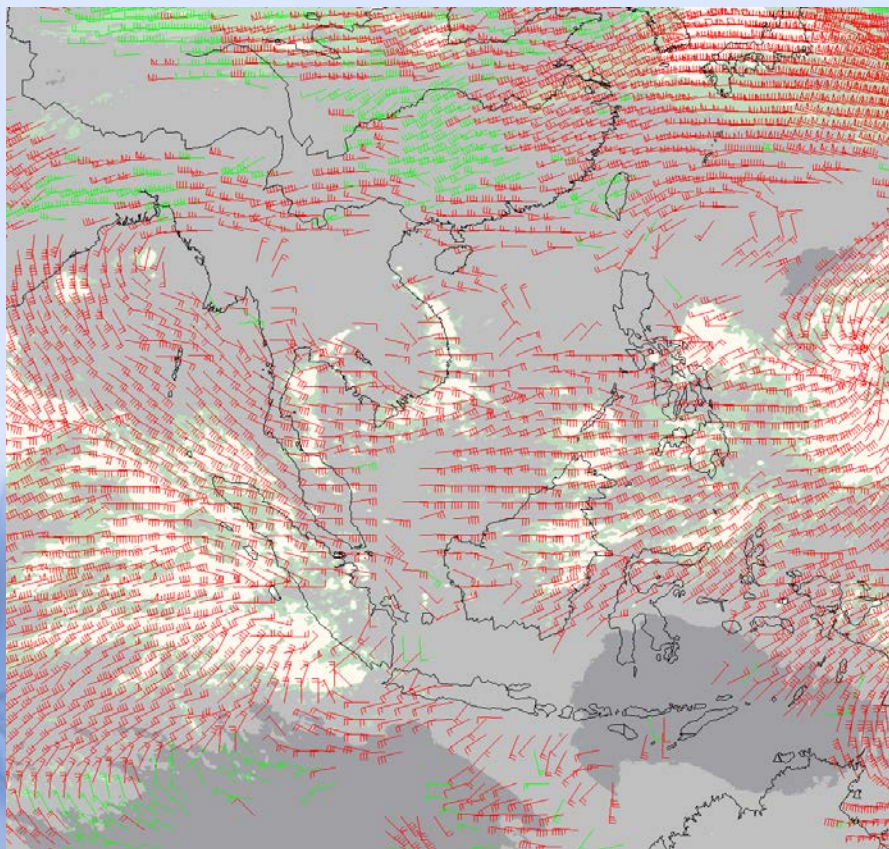
CMA current Operational IR AMV



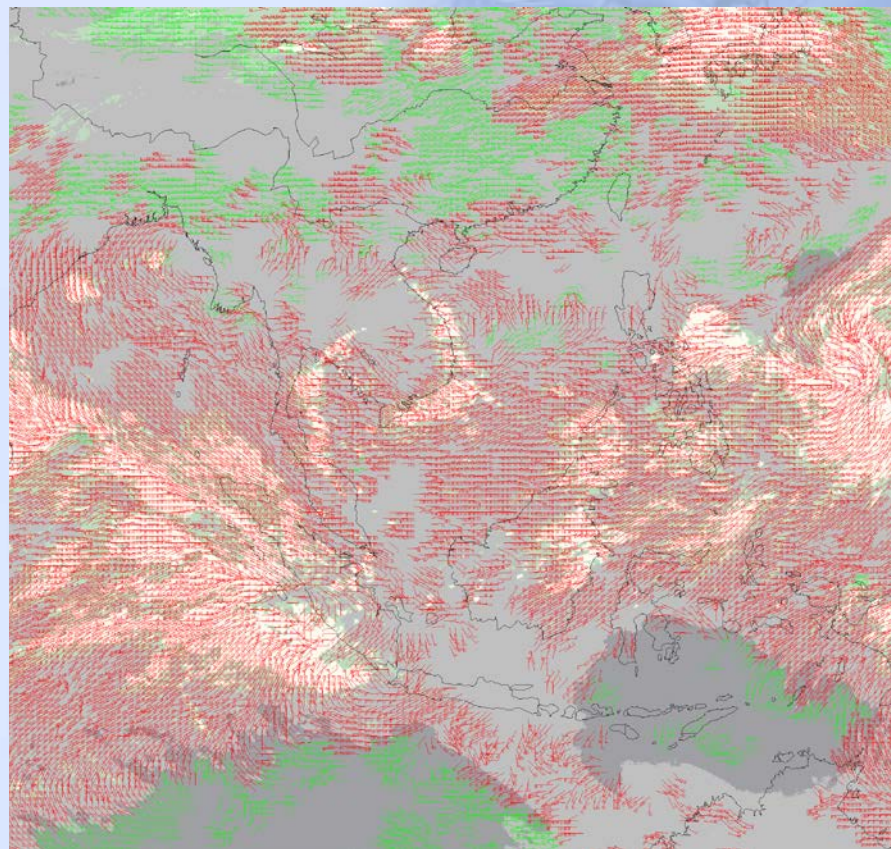
CMA next generation IR AMV



CMA current Operational WV AMV

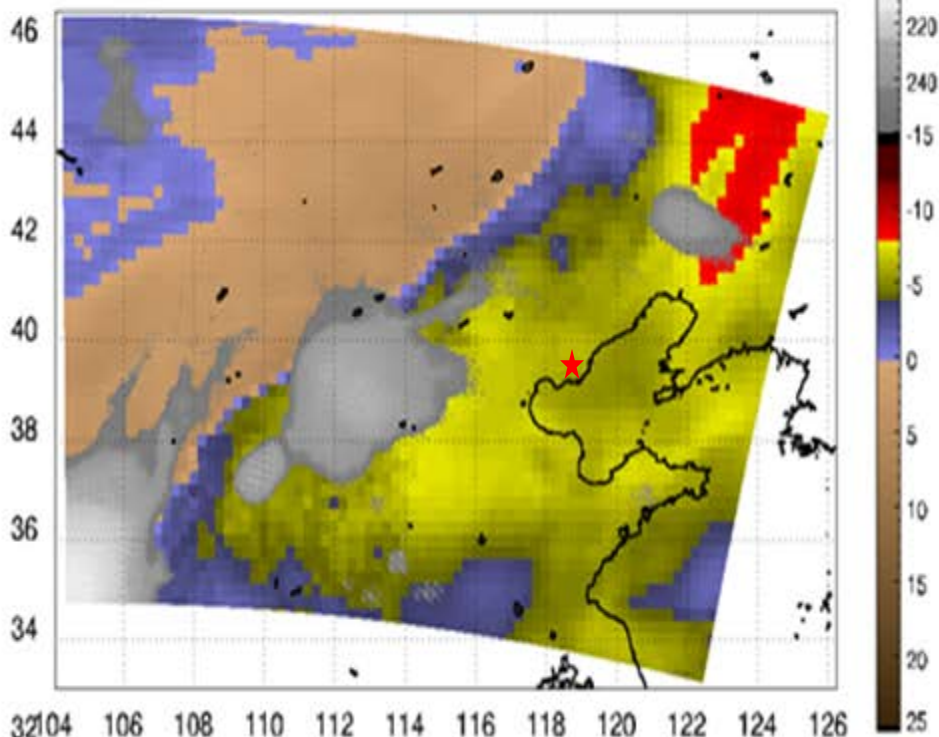


CMA next generation WV AMV

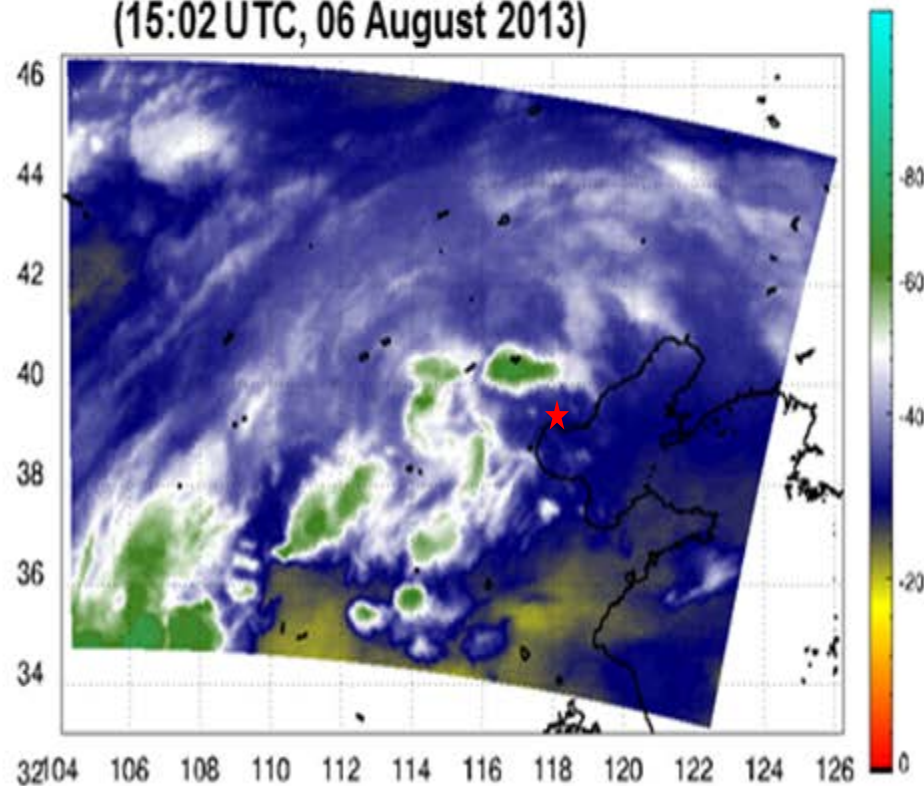


Supporting Nowcasting: Lifted Index Product

Simulated FY-4A derived Lifted Index
(12:00 UTC, 06 August 2013)



FY-2E 6.8 μm BT observation
(15:02 UTC, 06 August 2013)



FY-4 GIIRS LIFTED INDEX 12 UTC

FY-2E WV IMAGES 15 UTC

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Application Demonstration System

Structural Framework

Application System

Image Interpretation

Heavy Storm & Strong Convection

Tropical Cyclone & Ocean

Atmospheric Environment

Climate and Resource

Surface & Disaster

Public Mete. Service

Demonstration

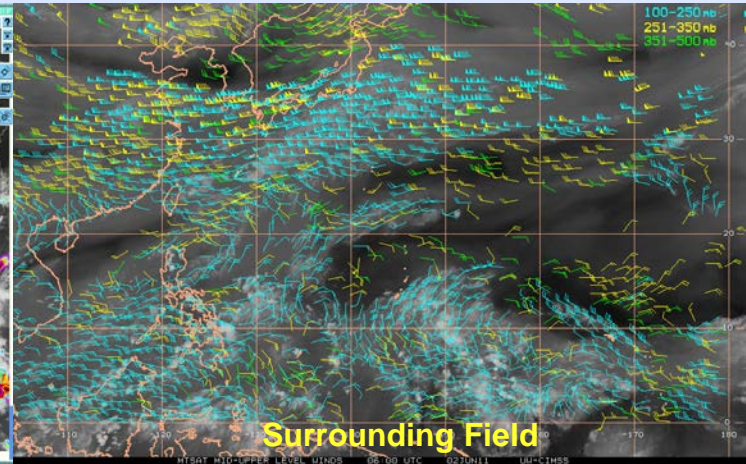
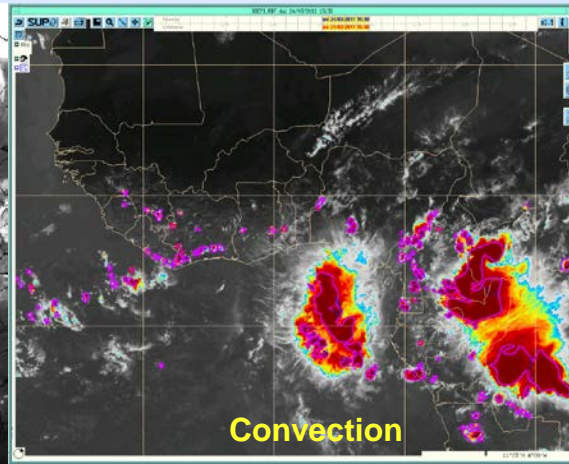
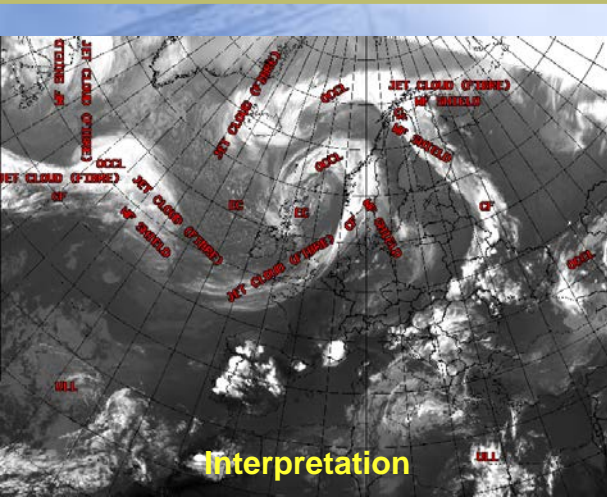
Weather

Climate

Environment

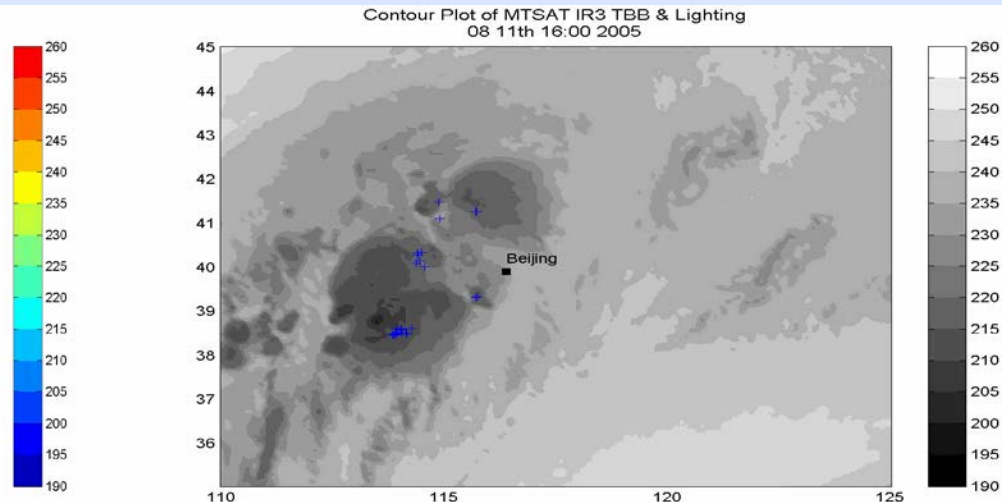
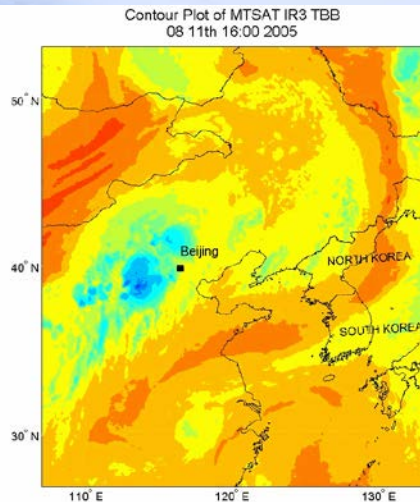
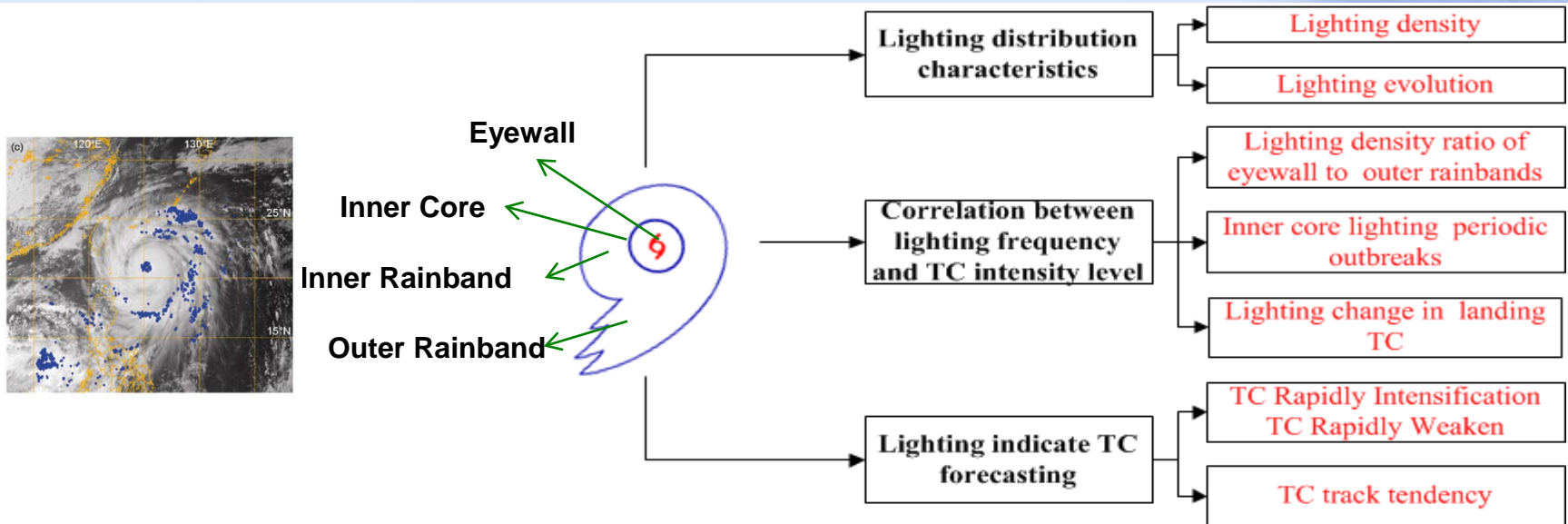
NWP

Quality Control



Some Highlight Application Aspects

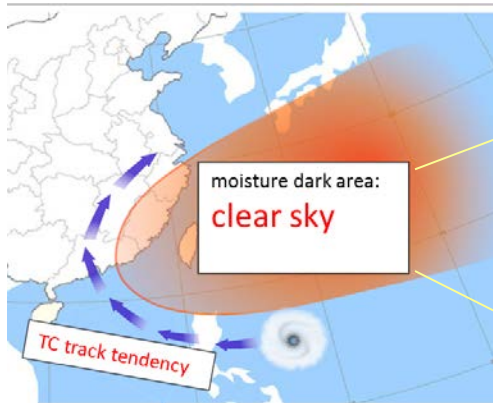
New Application 1: Lighting in Tropical Cyclone & Strong Convection



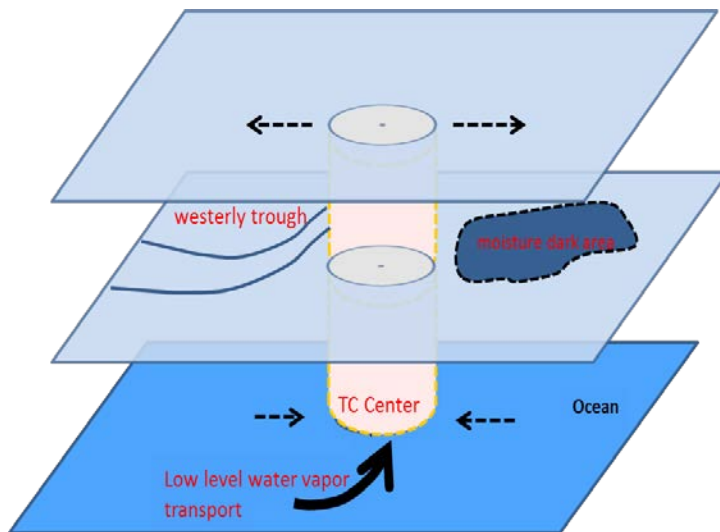
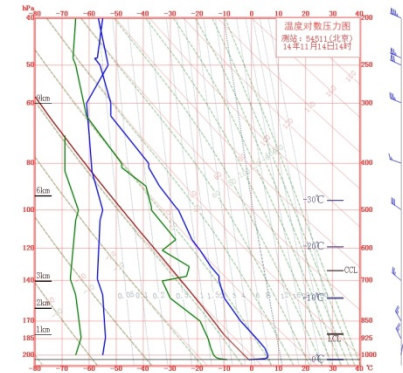
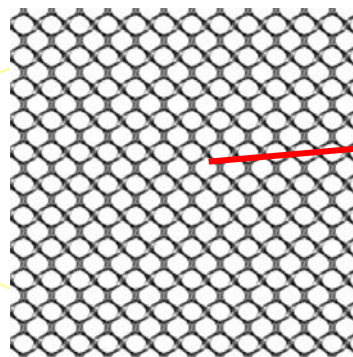
- Combined with satellite images and lightning distribution maps, the variation tendencies of cloud cluster, e.g. movement and intensity, and the focused convection can be extracted directly

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

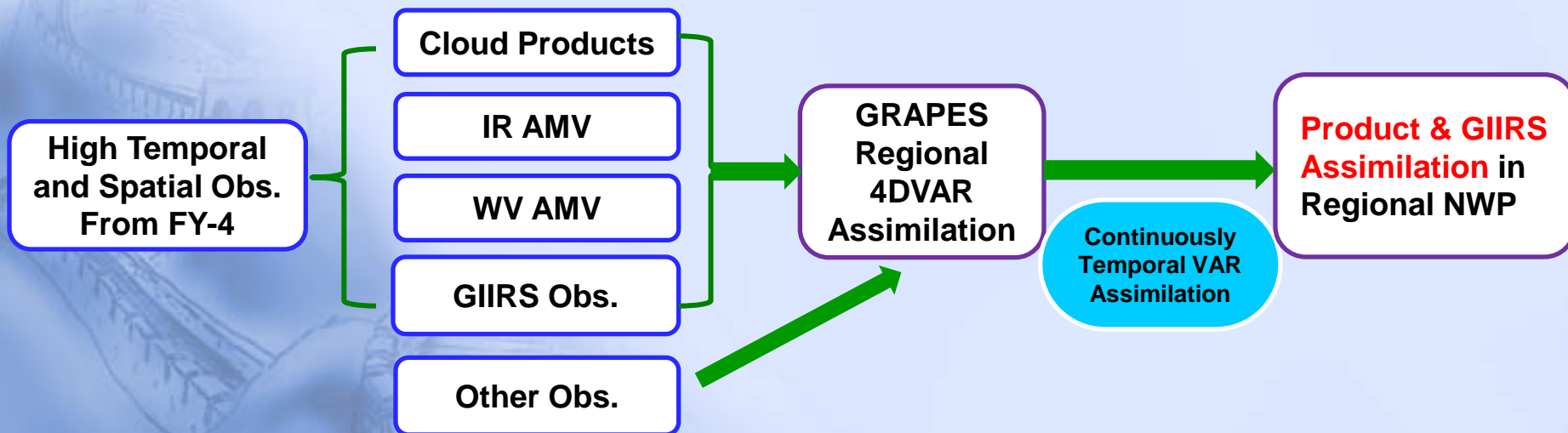
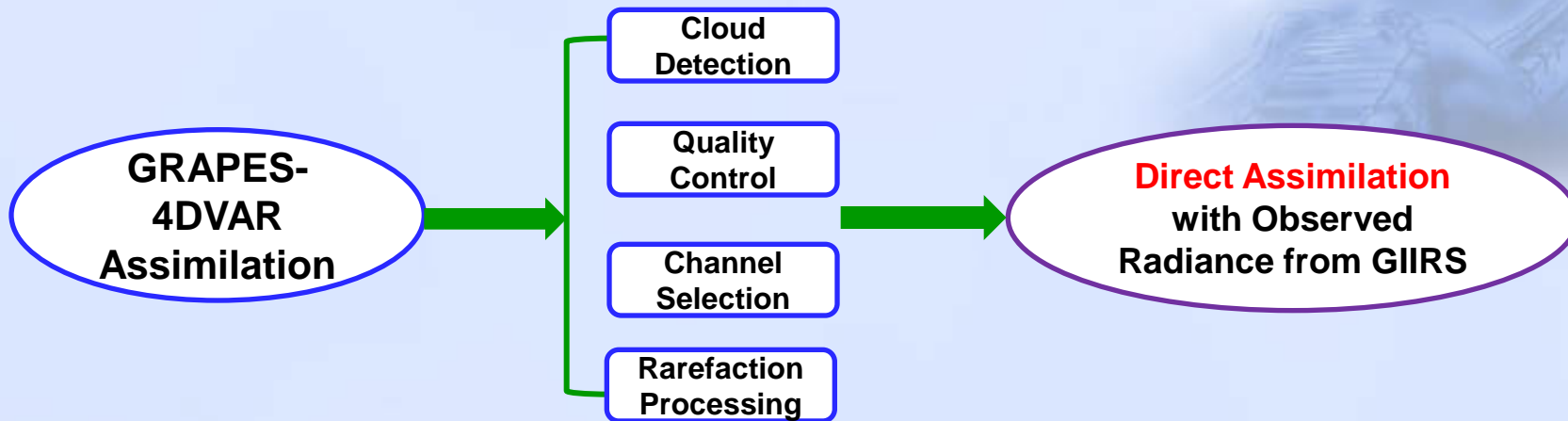


GIIRS Obs.



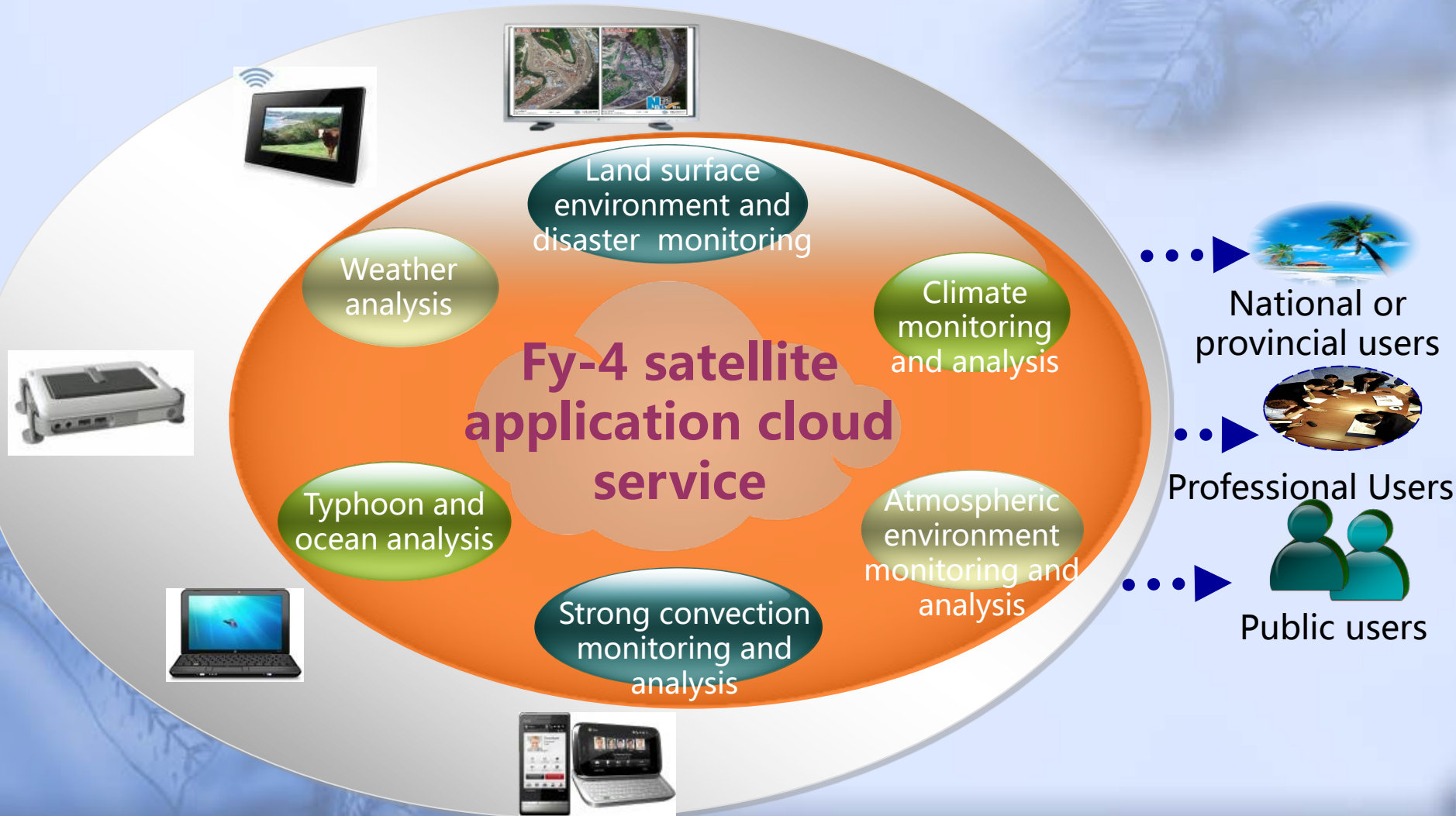
TC's track and intensity are closely related with the large-scale atmospheric circulation changes, for example, the subtropical high which is TC's guiding airflow and determines TC's track tendency.

New Application 3: GIIRS & Products in Assimilation of NWP

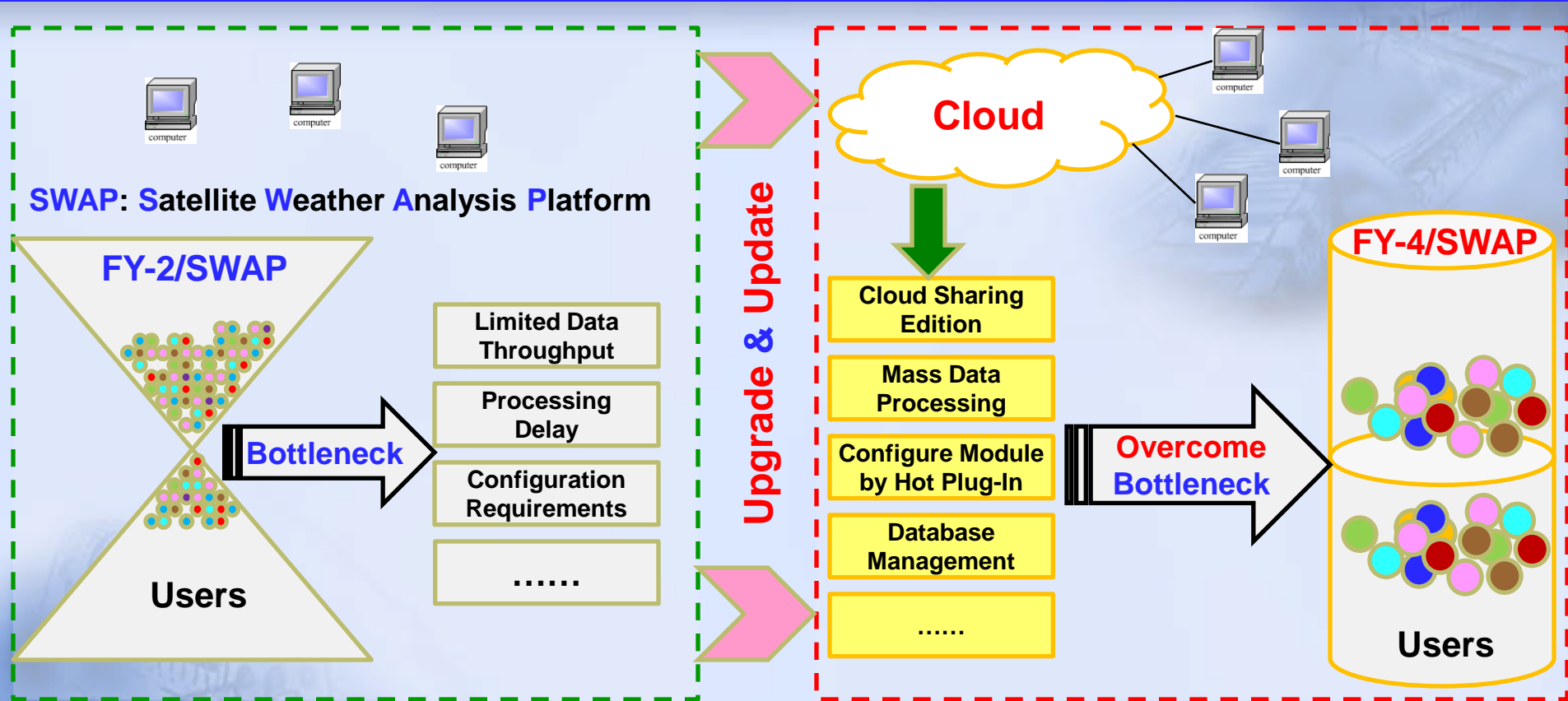


Application Service Mode

All the application products will be produced on the cloud server and users can utilize them rapidly and conveniently.

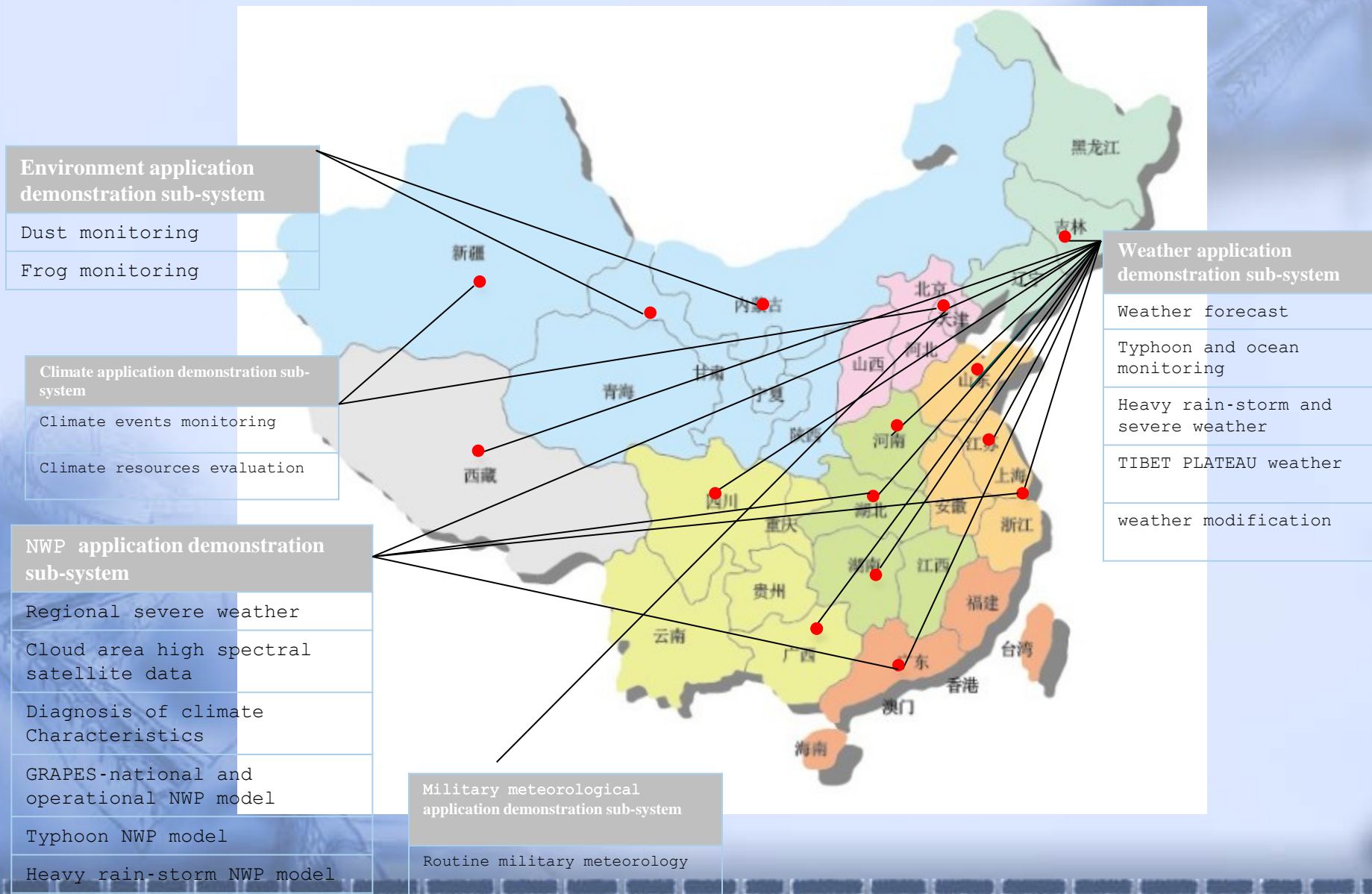


User Readiness

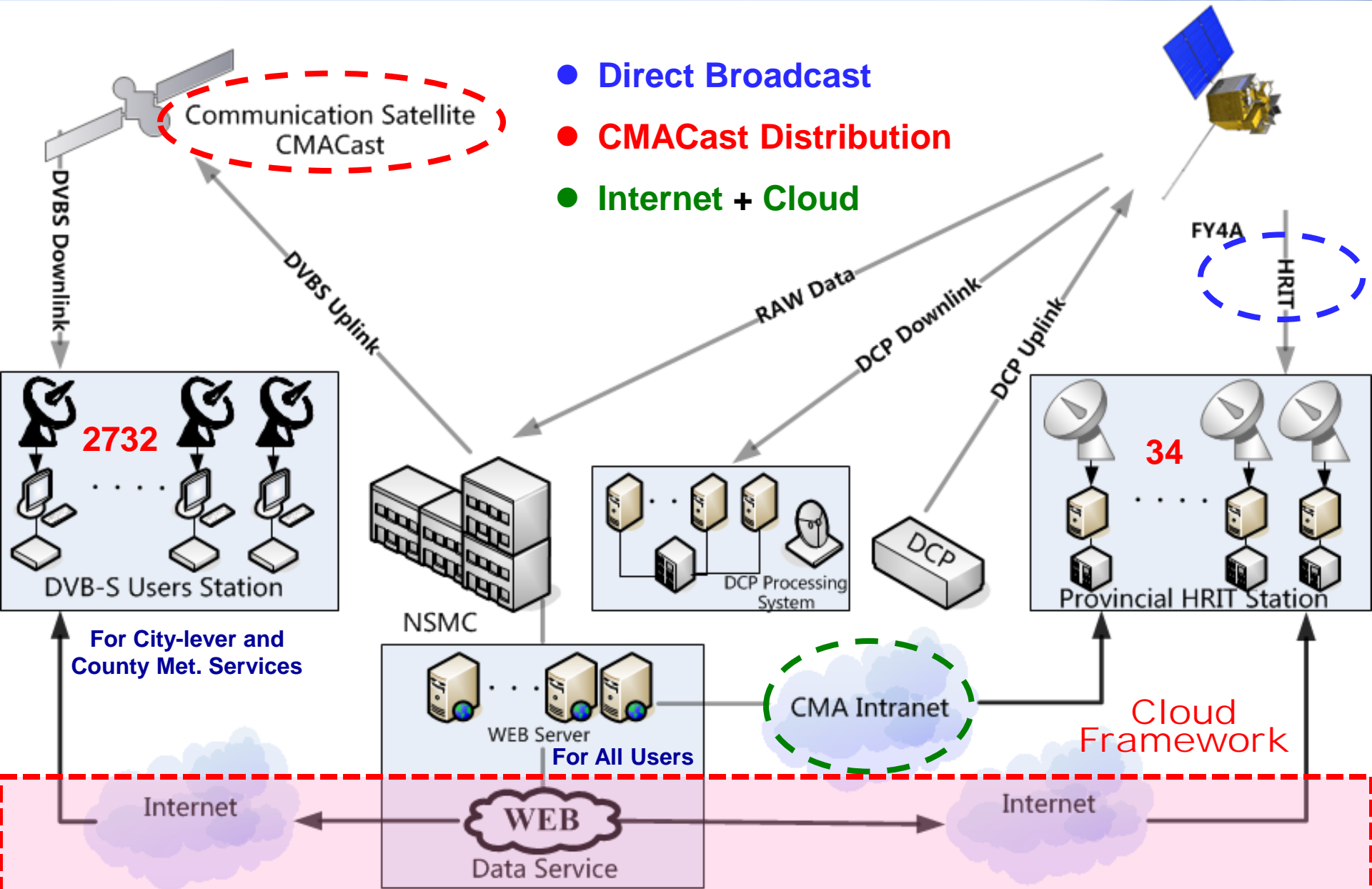


Application Demonstration

More than 30 FY-4 demonstration projects were open to encourage user community involvement.



Data Accessibility (Distribution & Service)



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- FY-4A is scheduled to be launched at the end of **2016**.
- 3D observations with high temporal (**1 minute** for region with its size at the 10^3 Km^2 order), spatial (**500m** for visible band at nadir) and spectral (**0.8cm^{-1}** for long-wave infrared band) resolutions are coming into reality next year.
- The ground-segment of FY-4A has made great progress to be **readiness** for users.
- New measurement results from lightning imager (LMI), interfering sounding (GIIRS), are shown and discussed to provide some **new application** fields.
- The latest data and product service plans, for example data **broadcasting** and **sharing**, product **distributing** and emergency observation support, are presented to benefit the user community.
-



Thank you for your attention!

