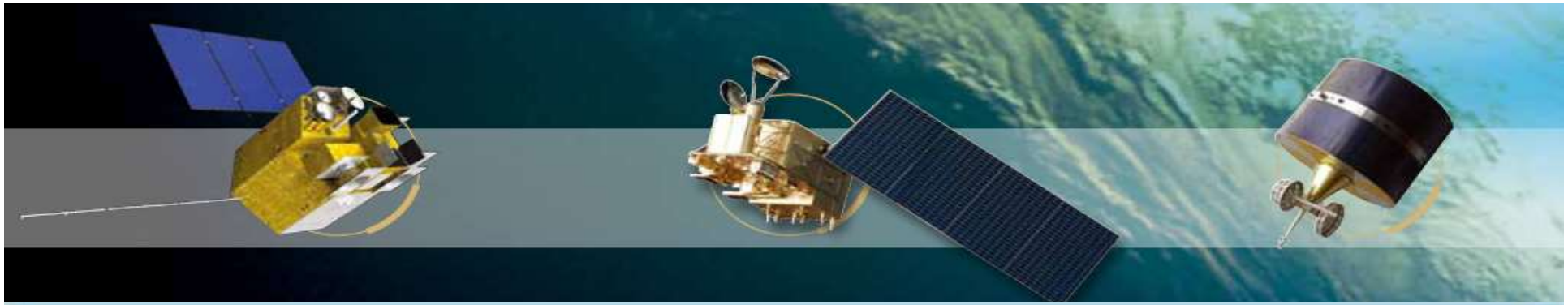

Preliminary on-orbit Results on FengYun-4A Image Navigation and Registration

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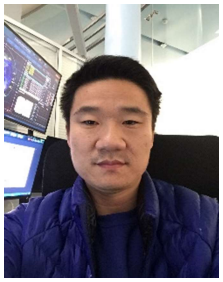
June 2017, IMAPP/CSPP 2017 ,

University of Wisconsin-Madison, USA

Fengyun-4 Image Navigation and Registration

— Ground Segment


Yang Lei


Shang Jian

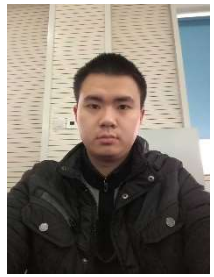

Liu Chengbao


Wang Jing


Wu Bing


Zhou Shengxiong


Zhang Hao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Tong Xiaochong


Li He


Sui Yinling


Tian Chao

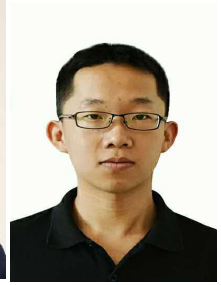

Yu Wei


Jiang Longtao


Mou Yuankai


Yang Huizhi


Cai Bowen


Su Yi

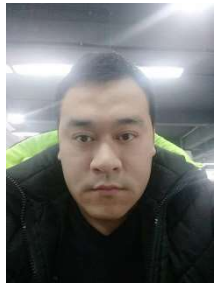

Zhang Lei


Xu Wenfei


Lai Guangning


Wang Qingxian


Hou Song


Liu Hongjun

We are young!

Outline

1. Brief History of China Geostationary Meteorological Satellites

2. Fengyun-4A Payloads Configuration

3. Fengyun-4A Image navigation and Registration(for 3 payloads) and preliminary on-orbit results

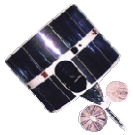
4. Conclusions

1. Brief History of China Geostationary Meteorological Satellites

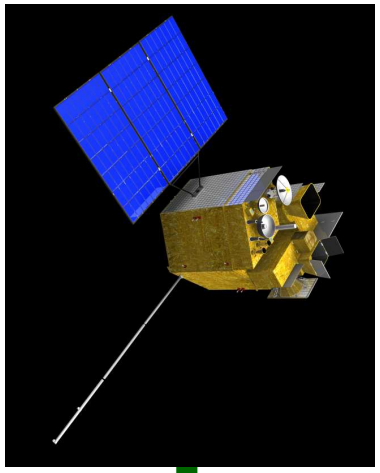
FengYun GEO Satellites

GEO System

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

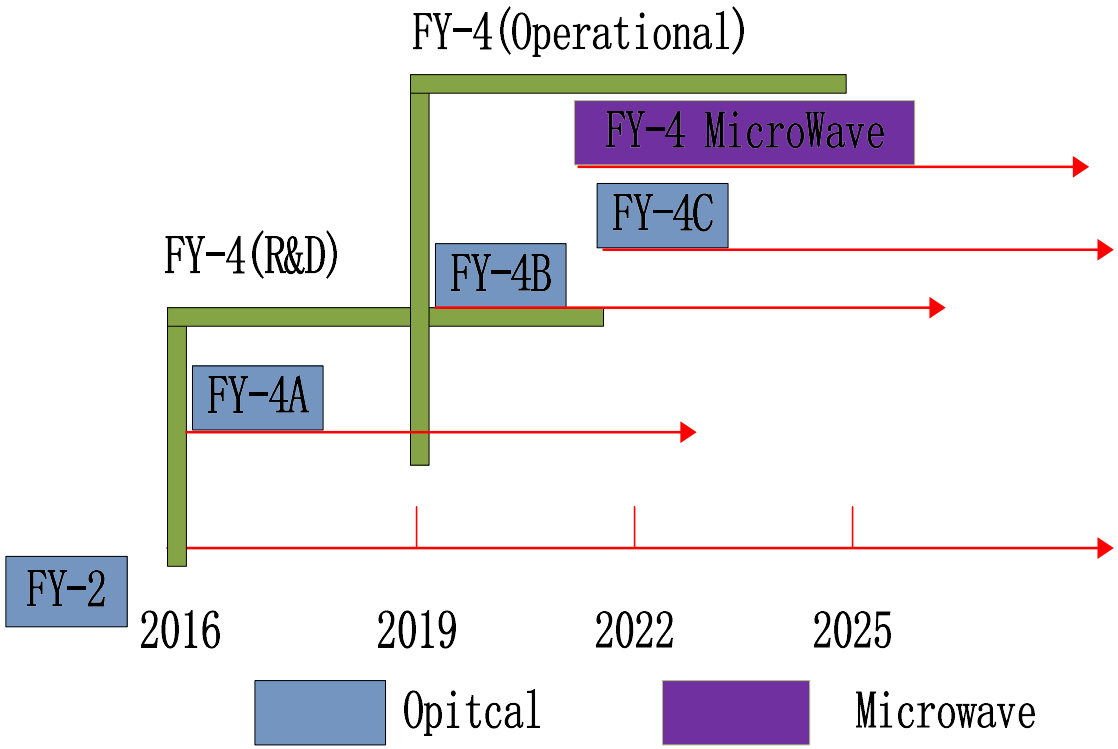


Second Generation
FY-4A , B, C, M……



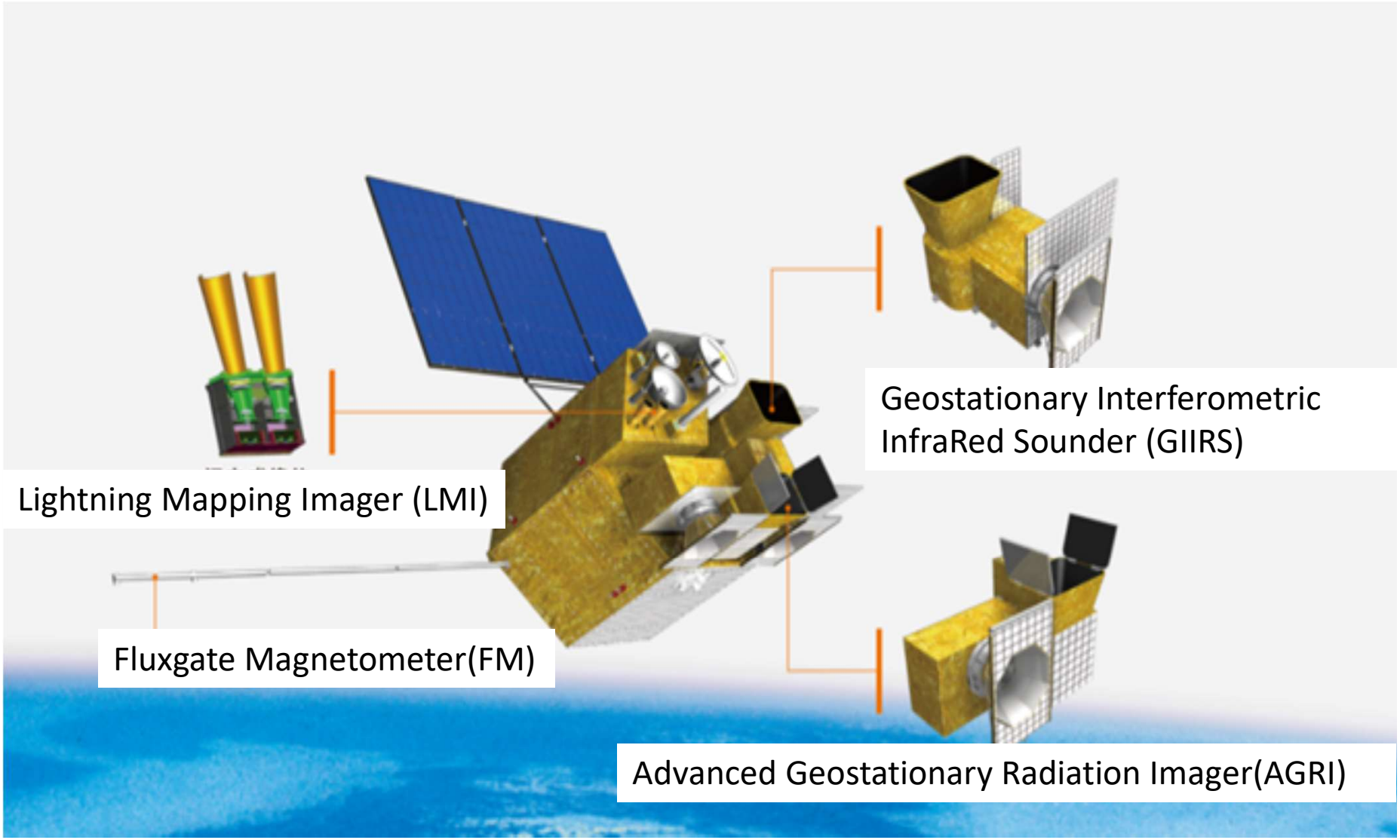
Expected around 2035

FY-4 A/B/C/M Transition



Designing lifetime FY-4A/B 7 yrs; FY-4C 10 yrs

2. FY-4A Payloads Configuration



FY-4A Important Dates

- Launched December 11, 2016
- Positioned on 99.5E above the equator and named with FY-4A -- December 17 2016
- Flipped to improve the calibration performance-- March 20, 2017
- Shifted from 99.5E to 104.7E -- May 18-25, 2017

Evolution from FY-2 to FY-4

- Platform transition from spin stabilization to 3-axis stabilization
  - **Higher observation efficiency**
  - **Flexible area scanning mode**
- Advanced radiation imager: AGRI
  - **Channels: 5->14 bands**
  - **Full disk temporal resolution: 30->15min**
  - **Spatial resolution: 1.25Km->500m**
- Interferometric Infrared Sounder, GIIRS ***new capability!***
  - **High spectrum resolution to enable better atmosphere T&H retrieval**
- Lighting imager, LMI ***new capability!***

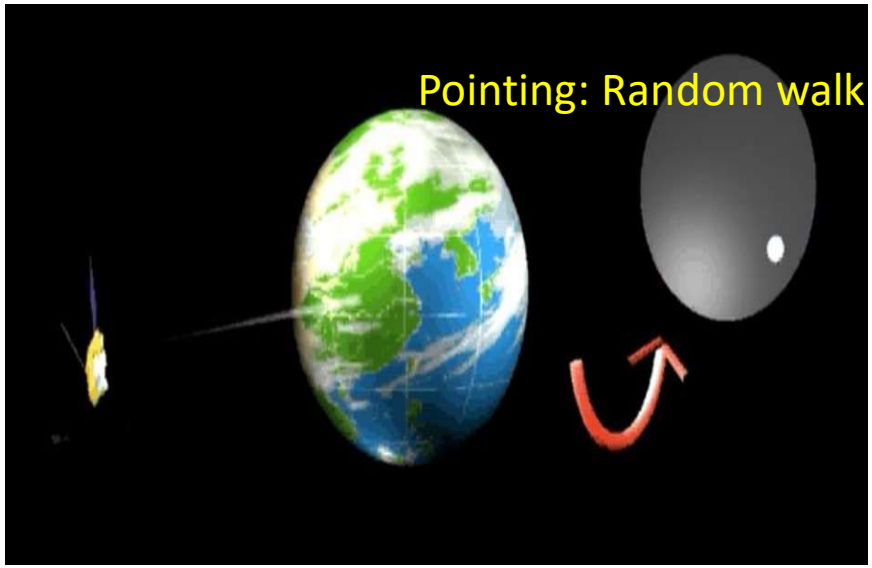
Great Challenges have been brought to Fengyun-4 Navigation and Registration.

Great Challenges to Fengyun-4 Navigation and Registration System

Benefits → Great Challenges → instant pointing

1. Simultaneous observation： Imager and Sounder in one platform
2. Viewing efficiency of the imager
3. Favorite the radiometry accuracy
4. Favorite the ability of flexible viewing

1. Pointing stability
   - ① Platform itself stability(sun pressure, minor shake, liquid shake etc.)
   - ② Imager's and Souder's mirrors influences
2. Thermal Gradient



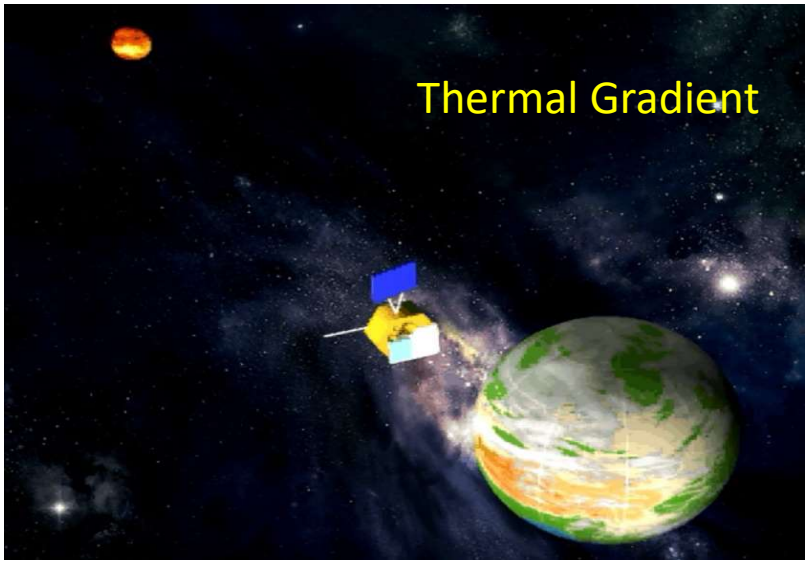
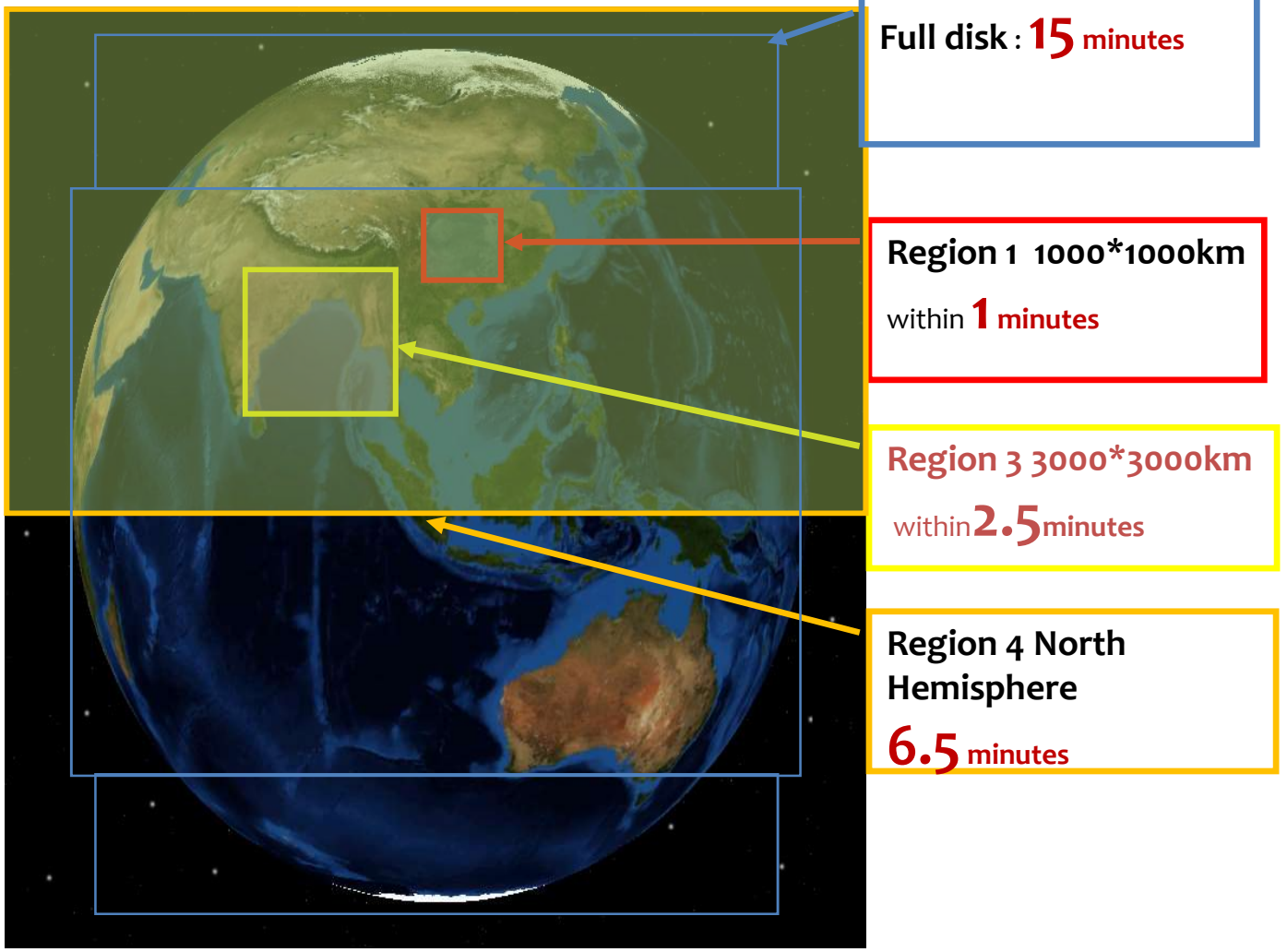


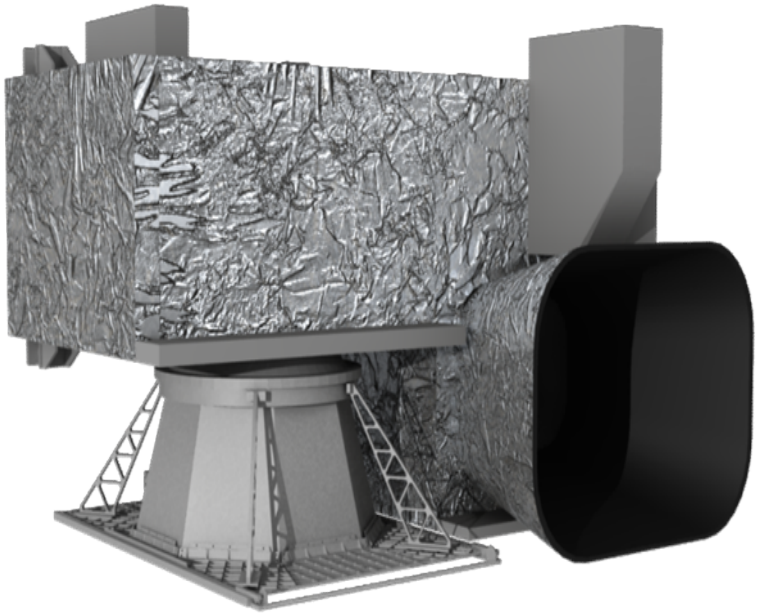
Figure 1. Platform Stability and thermal gradient

Fengyun-4 Observation Capability

- Continuous Full Disk
  - 15 minute Full Disk
- Flex Mode
  - 1 min 1000*1000 km
  - 2.5min 3000*3000 km
  - 6.5min north hemisphere
- Star observation, deep space/blackbody observation, earth observation are included.

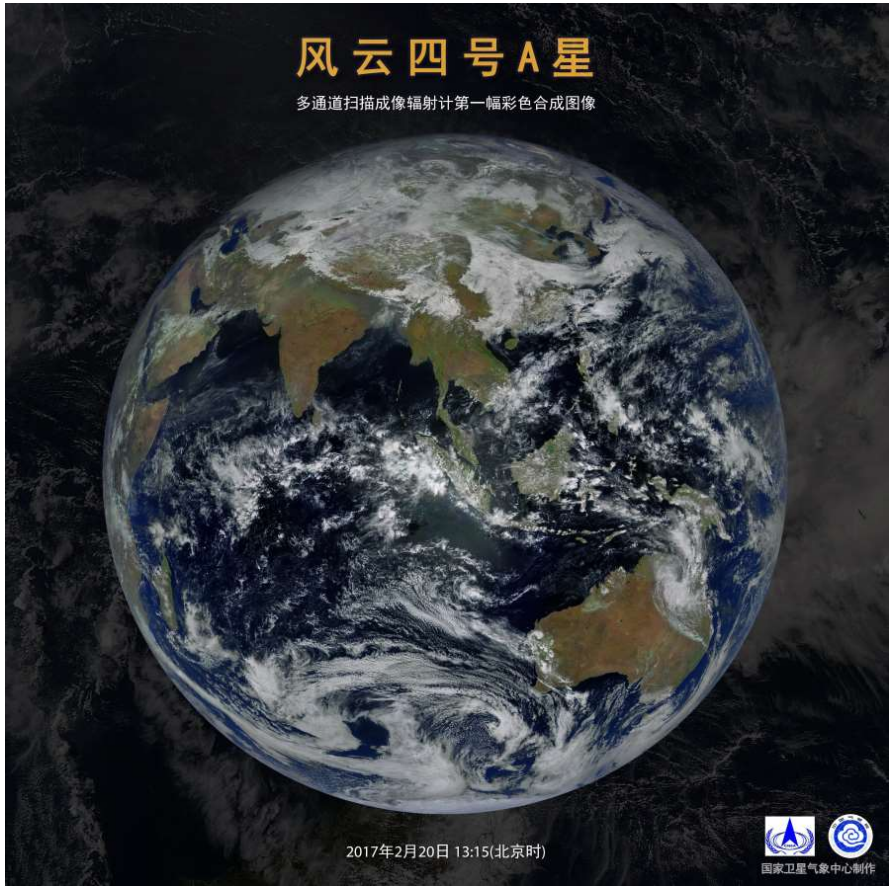


Fengyun-4 AGRI

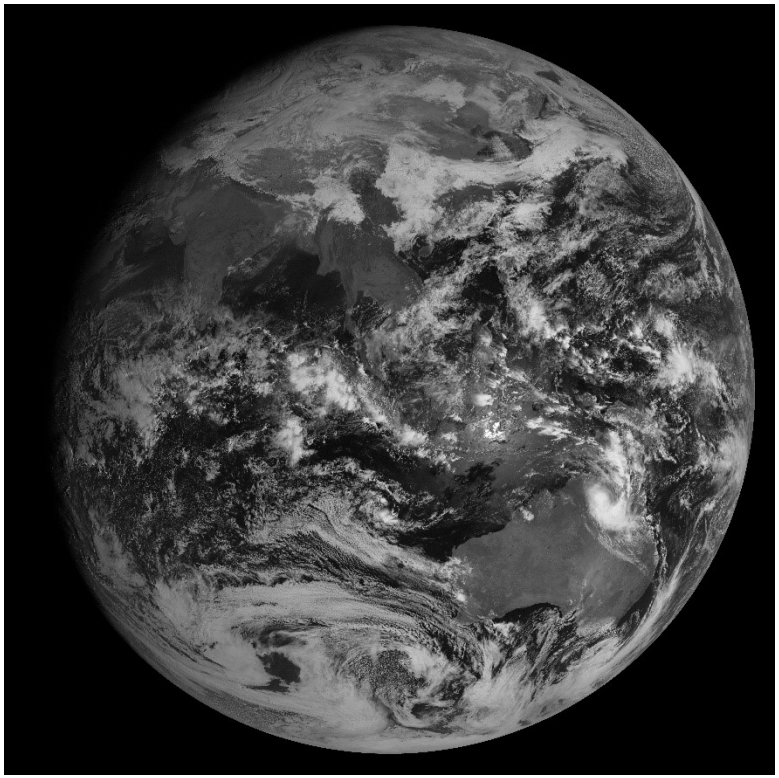


- Mass：306kg
- Number of Channels：14(6 vis/near IR channels, 2 Middle IR, 2 water vapor channels and 4 LWIRs)
- Spatial Resolution: vis/near IR 0.5 ~ 1 km, IR 2~4km
- Full disk scanning: 15min.
- Regional scanning time:: 1min.（1000kmx1000km）
- SNR>3@1%，NEdeltaT0.2K

First FY-4/AGRI image released February 20



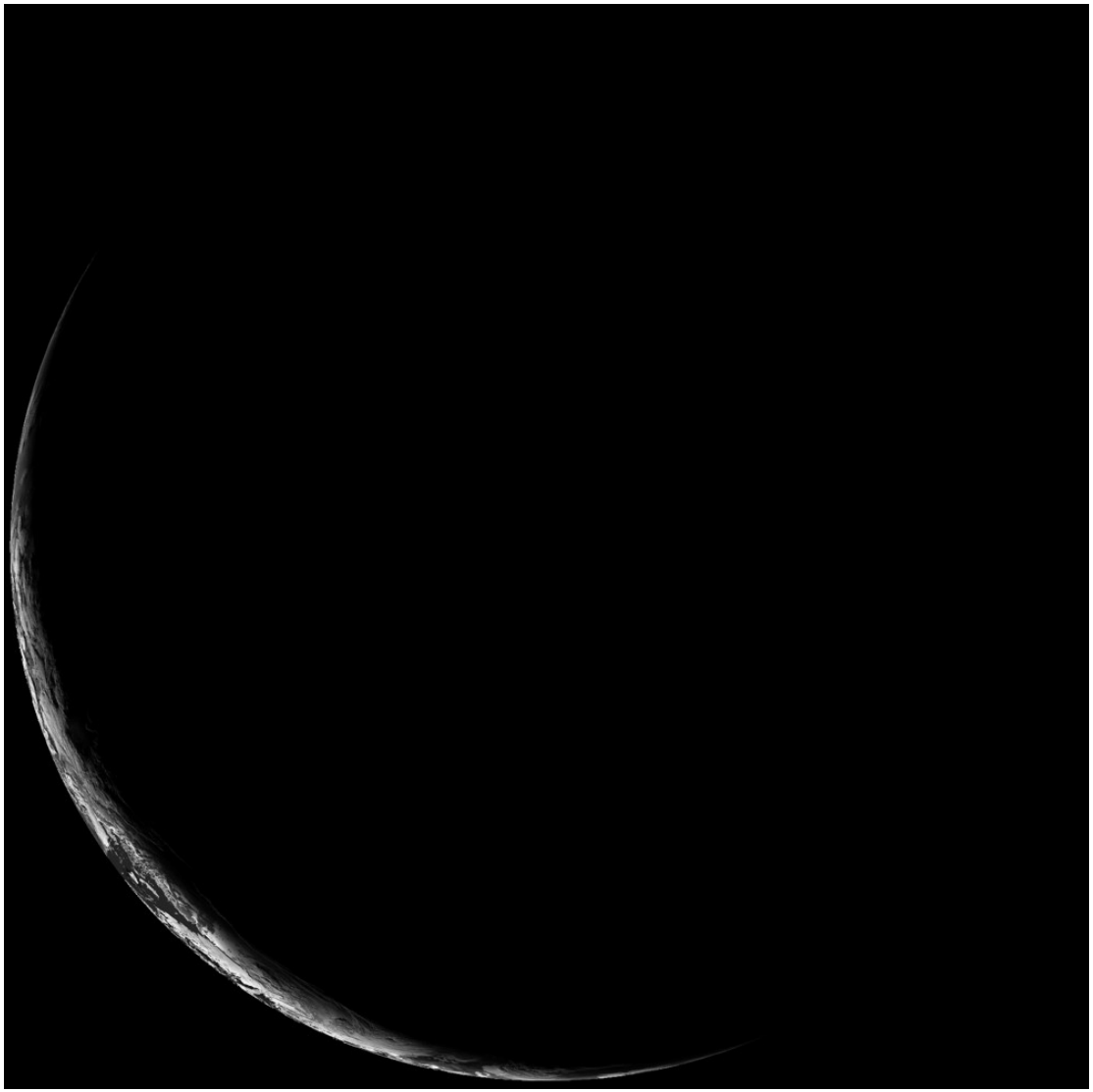
FY-4A AGRI VIS 20170220_0315
(UTC, Positioned on 99.5E)



FY-2G VIS 20170220_0300
(UTC, Positioned on 105E)

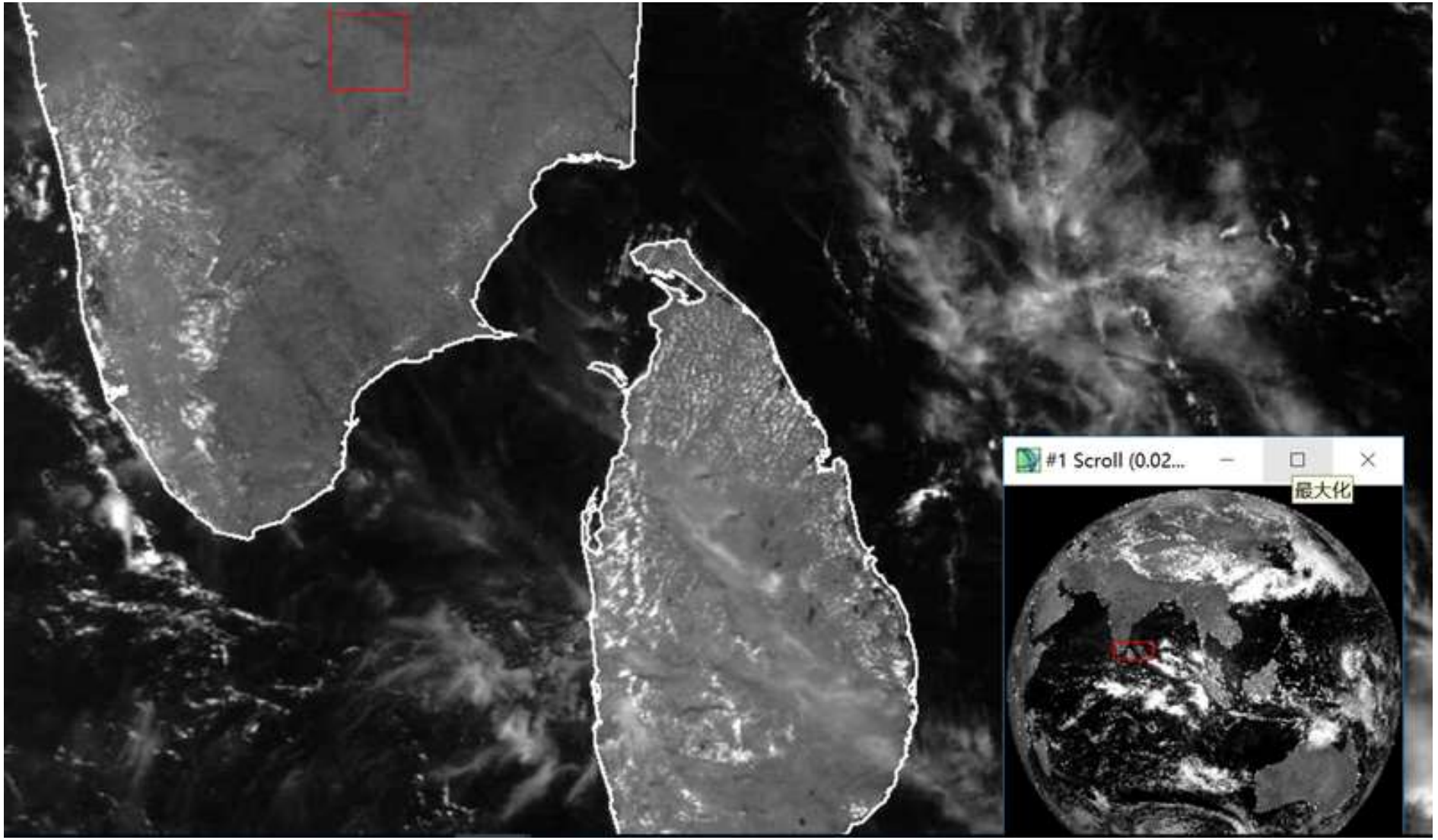
FY-4 vs FY-2 on February 20, 2017

FY-4/AGRI Animation



January 22nd 2017 FY-4/AGRI

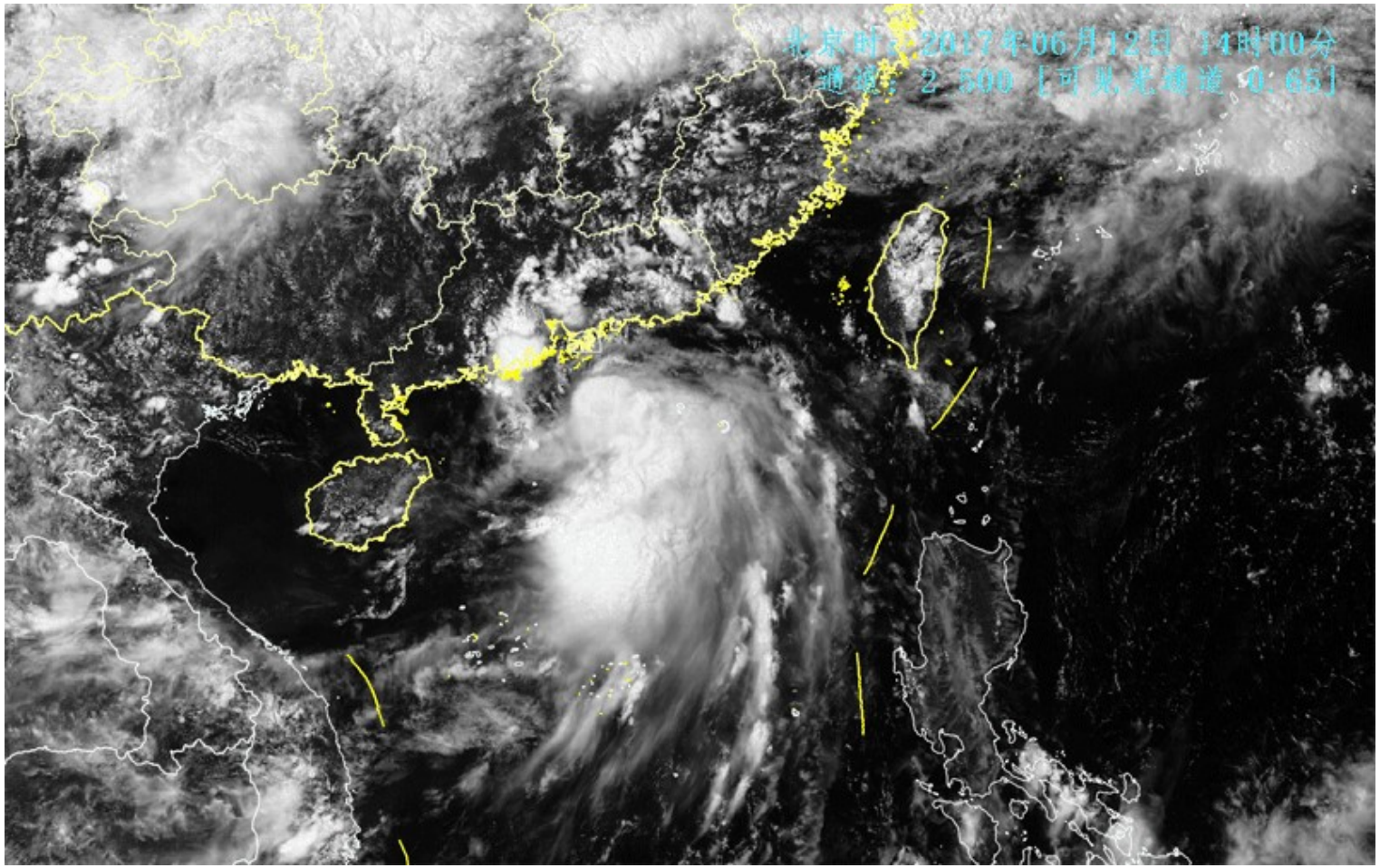
FY-4/AGRI Image Navigation



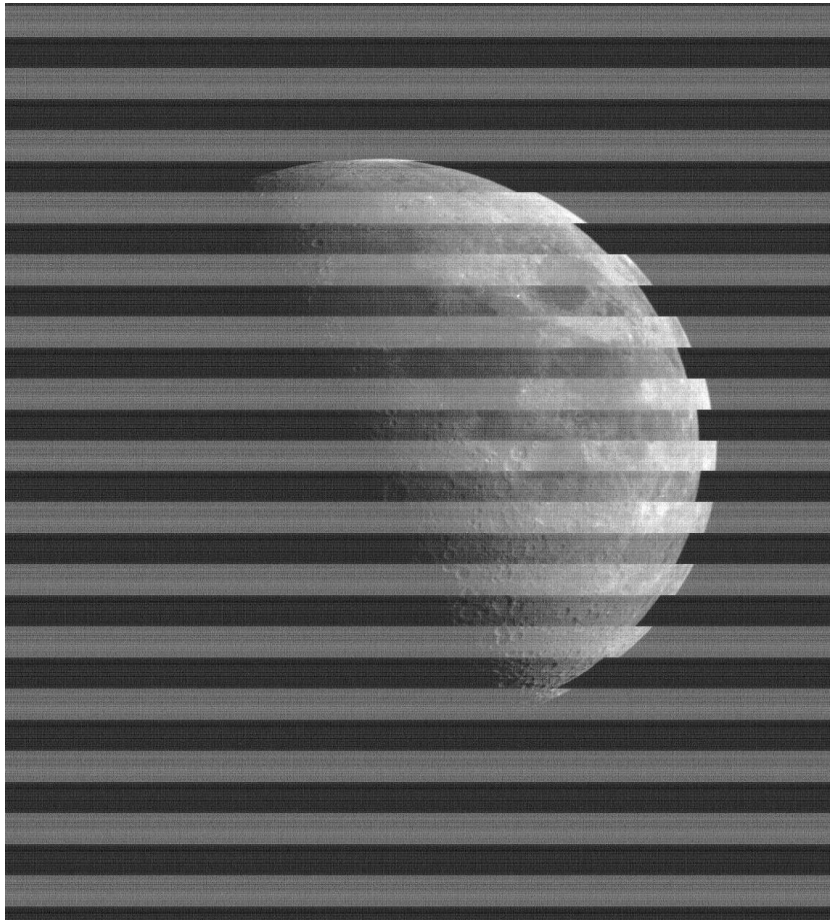
southern Indian subcontinent

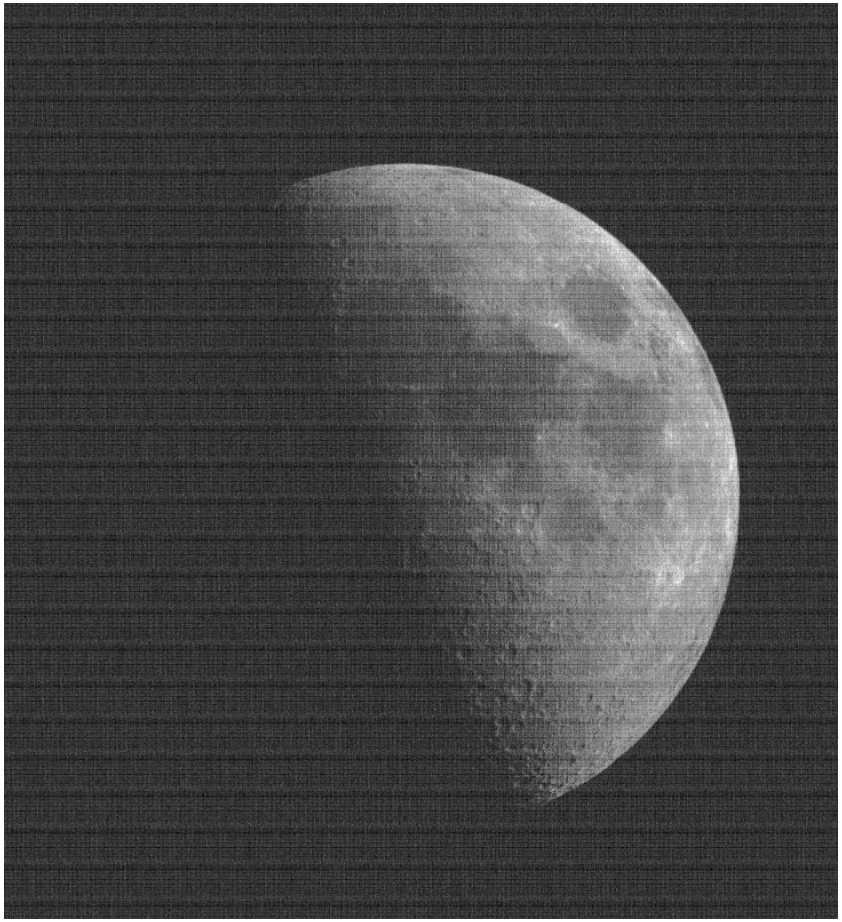
201704110500 UTC 0.75~0.90um

“Merbok”—The 2017’s first typhoon to land in China on June 22, 2017 (FY-4A VIS 0.5km Animation)



FY-4/AGRI Sees the Moon

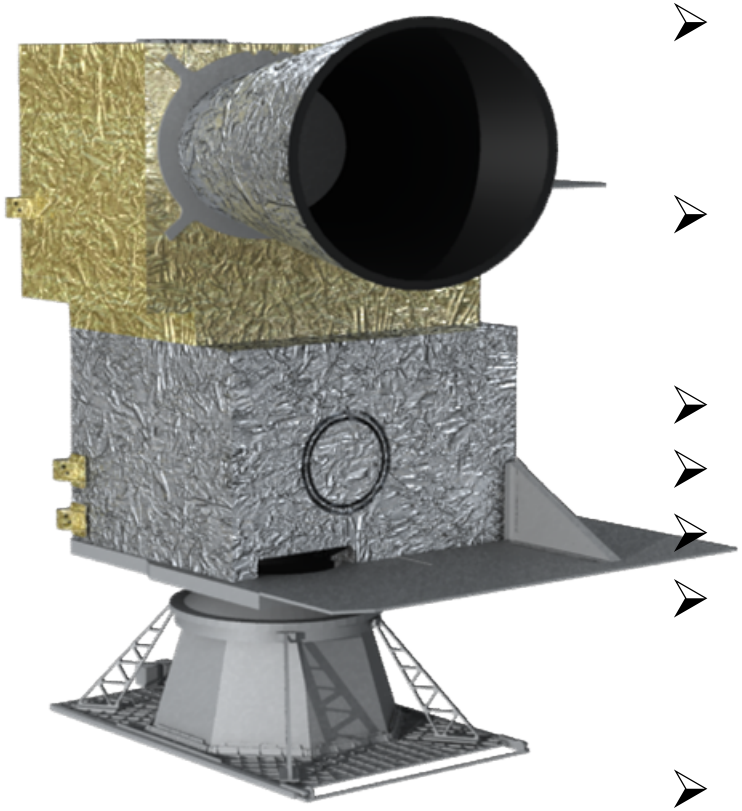




Moon registration and image motion compensation
20170601225751_CH2

FY-4/AGRI Image Navigation

Fengyun-4 GIIRS



- Mass：315 kg
- Size：
  1353.5mm(long)×2179.9mm(width)×1549mm(height)
- Channel：
  LWIR:700-1130cm^{-1} （8.85-14.29μm）
  MWIR: 1650-2250cm^{-1} （4.44-6.06μm）
- Spectral resolution：0.625cm^{-1}
- The number of channels：1650
- Spatial resolution：16km
- Temporal resolution：
  768km×960km（30min.）
  4480km×5000km（60min.）
- Radiation Cal Accu.：1.5K
- Spectral Cal. Accu.：10ppm
- For CMOS: 2km@ssp(star/landmark observation and cloud detection)

FY-4/GIIRS—Pointing Stability

20170322041500

The pointing variation is less than 0.05 IR pixel during 16 frames of sounding, which is very helpful for getting sounding profiles.

FY-4/GIIRS—image navigation accuracy

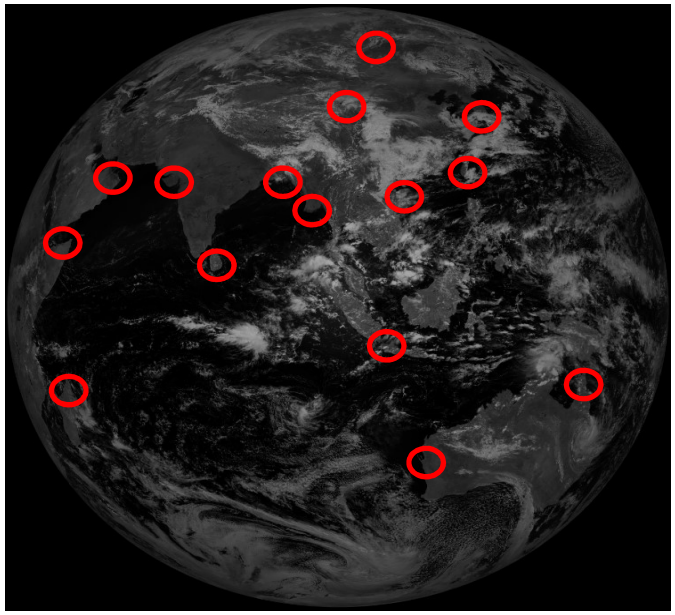


Fig.1 Landmarks used for FY-4/GIIRS Image Navigation Evaluation

Fig.2 FY-4/GIIRS CMOS Landmark matching results (mean value less than 0.5 IR pixel)

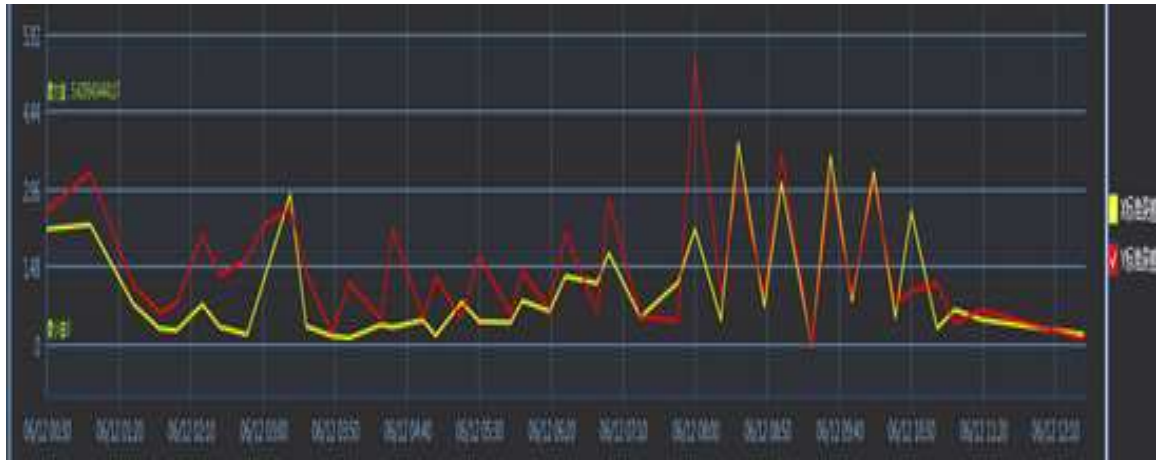


Fig.3 FY-4/GIIRS CMOS Landmark matching results(std)

FY-4 Lightning Mapping Imager (LMI) Image navigation

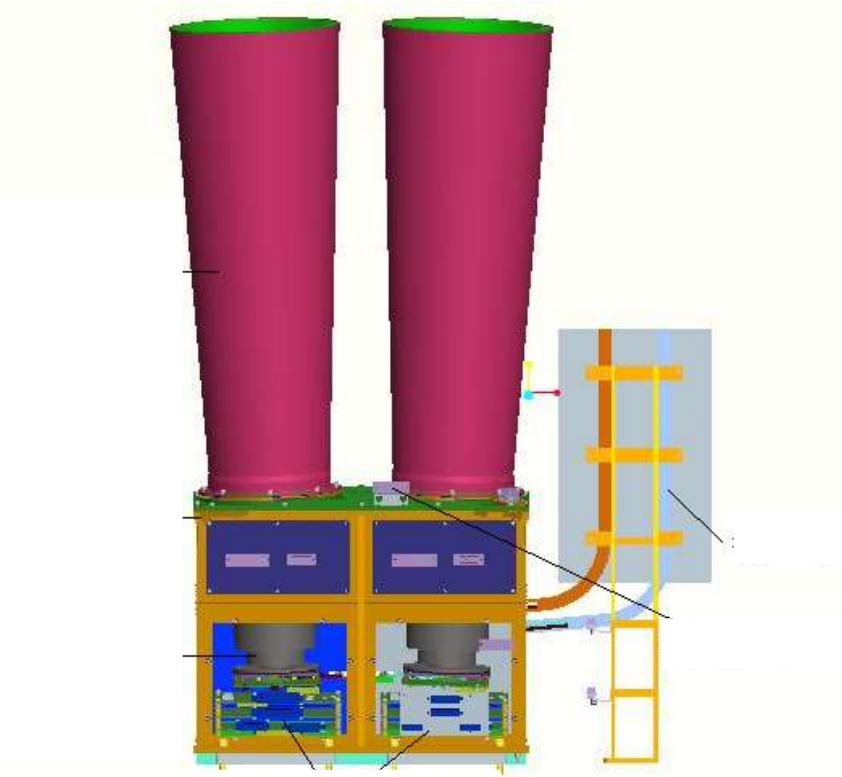


Fig.1 FY-4/LMI Prototype

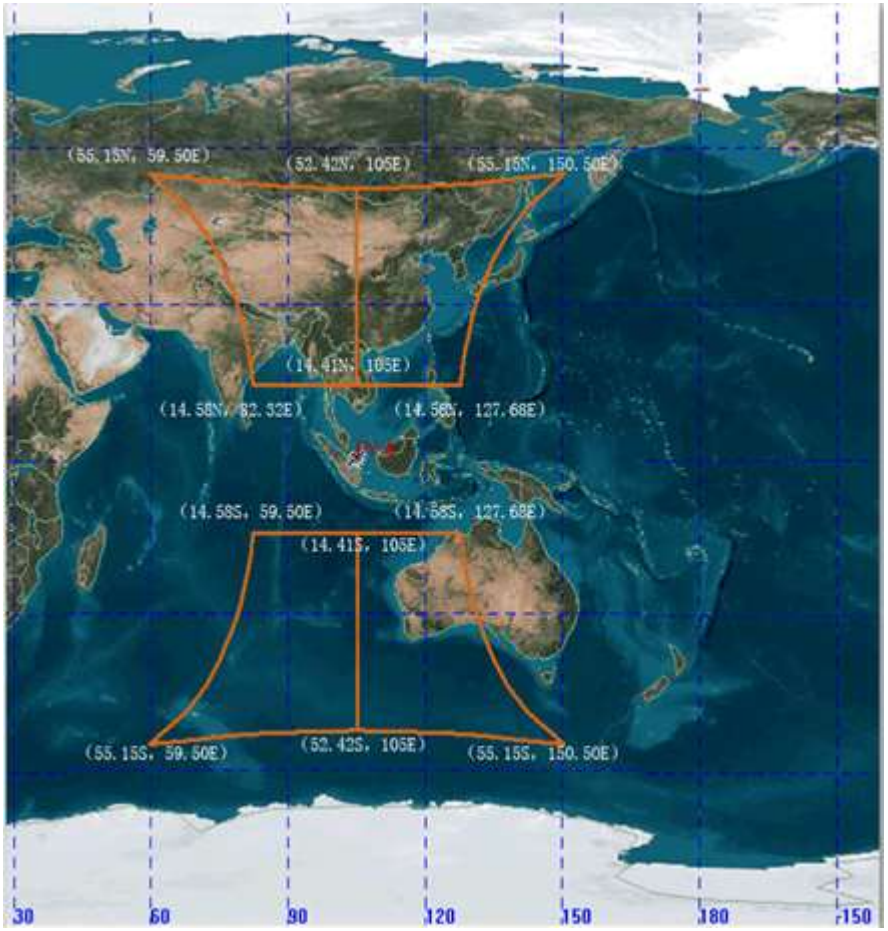
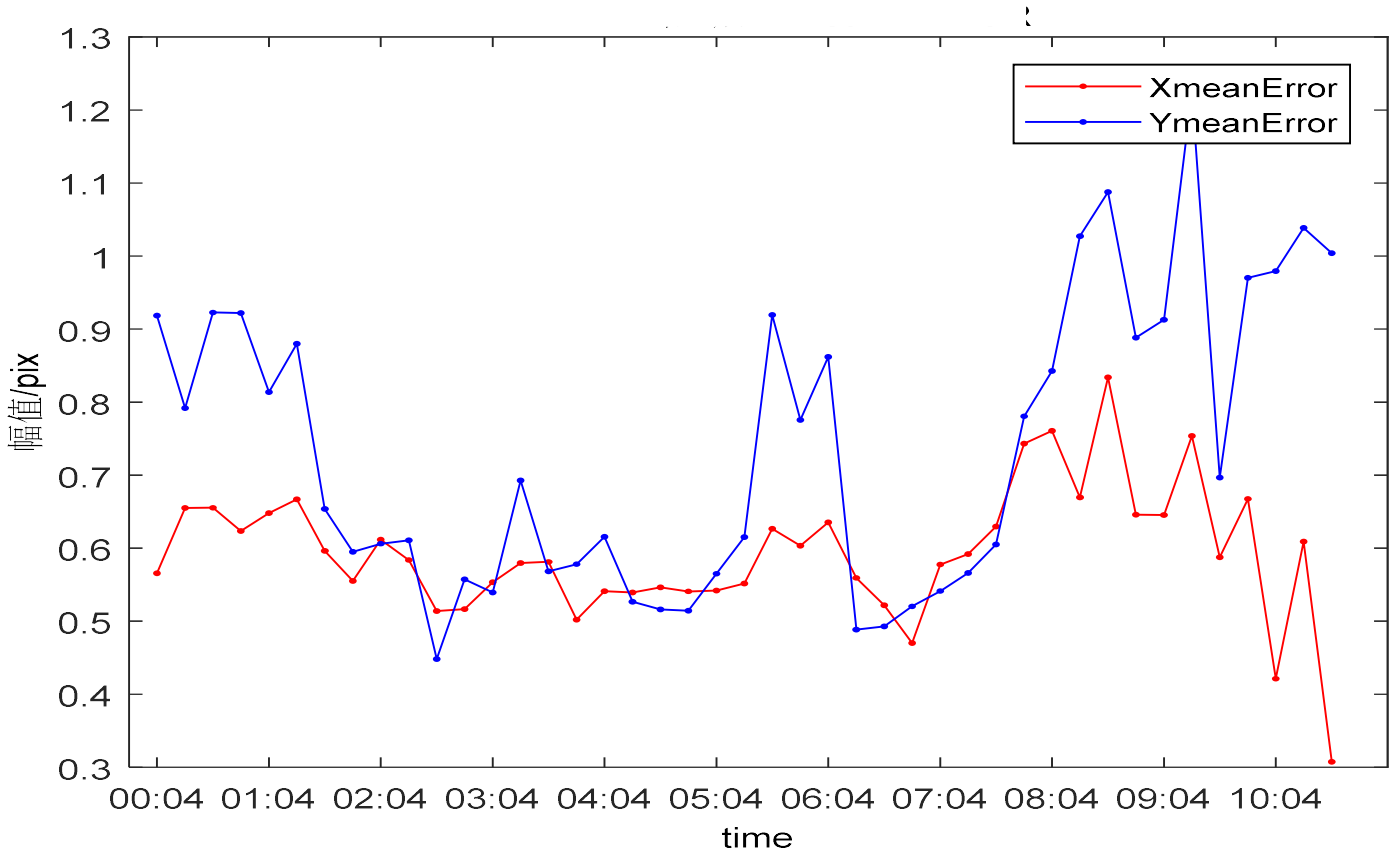


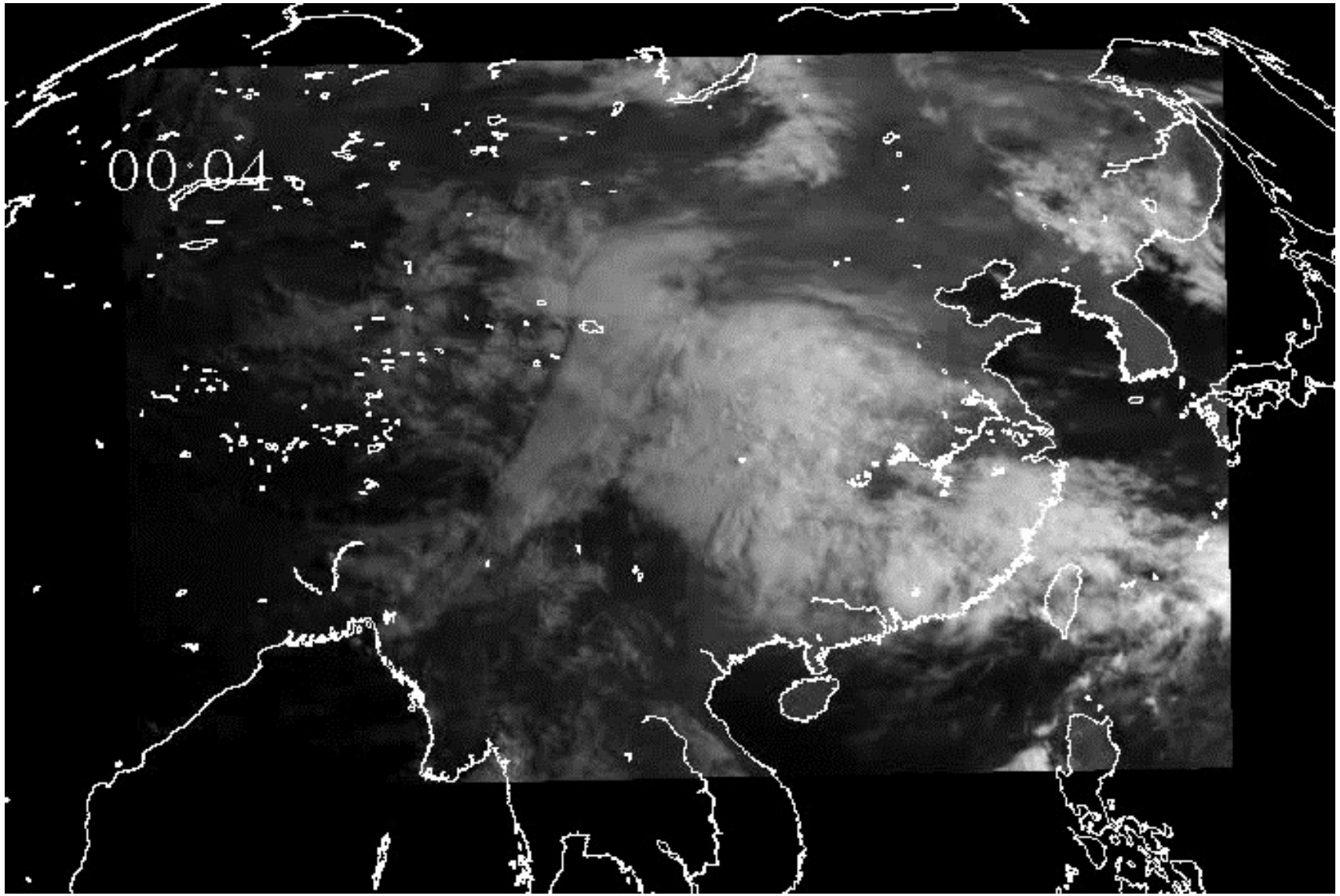
Fig.2 FY-4/LMI Spatial Coverage (7.8km@ssp)

FY-4/LMI—image navigation accuracy



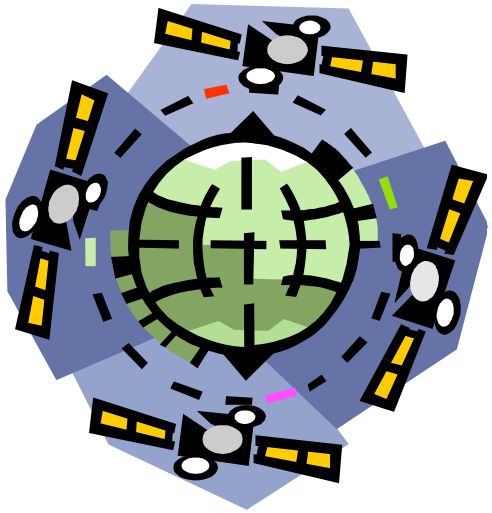
20170611 FY-4A/LMI Image Navigation Performance

FY-4/LMI animation(15 mins interval)



Conclusions

- Fengyun-4 image navigation & registration algorithm and system have been developed.
- Newly updated preliminary results have revealed:
  - ✓ the imager AGRI: better than 1 IR pixel.
  - ✓ the sounder GIIRS: image navigation accuracy is better than 0.5 IR pixel and pointing variation during 16 frames is better than 0.05 IR pixel.
  - ✓ LMI: 1 pixel for the day time.
- All the above results are in normal operations. The system performance during the eclipse, the mid-night could be worse. More on-orbit test work are needed.



Thank you!

Figure1. FY-4A/AGRI and FY-2/Imager Specifications

	FY-4A/AGRI		FY-2/Imager	
Band No.	Wavelength（μm）	Spatial Resolution（Km）	Wavelength（μm）	Spatial Resolution（Km）
1	0.45～0.49	1		
2	0.55～0.75	0.5	0.55～0.9	1.25
3	0.75～0.90	1		
4	1.36～1.39	2		
5	1.58～1.64	2		
6	2.1～2.35	2～4		
7	3.5～4.0（high）	2	3.5～4.0	5
8	3.5～4.0（low）	4		
9	5.8～6.7	4	6.3～7.6	5
10	6.9～7.3	4		
11	8.0～9.0	4		
12	10.3～11.3	4	10.3～11.3	5
13	11.5～12.5	4	11.5～12.5	5
14	13.2～13.8	4		