Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences

Progress in Chinese Satellite Hyperspectral Missions

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16-July-2014

OUTLINE

- Introduction
- Overview of current Chinese spaceborne hyperspectral sensors
- Ongoing and future Chinese satellite hyperspectral missions
- Conclusion

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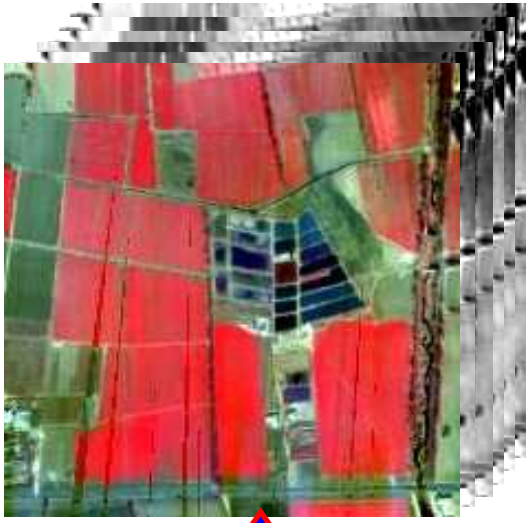
Introduction

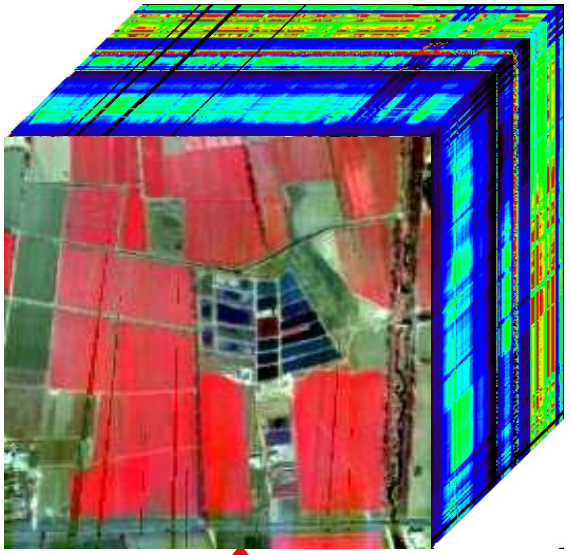
Panchromatic

Color photography

Multispectral



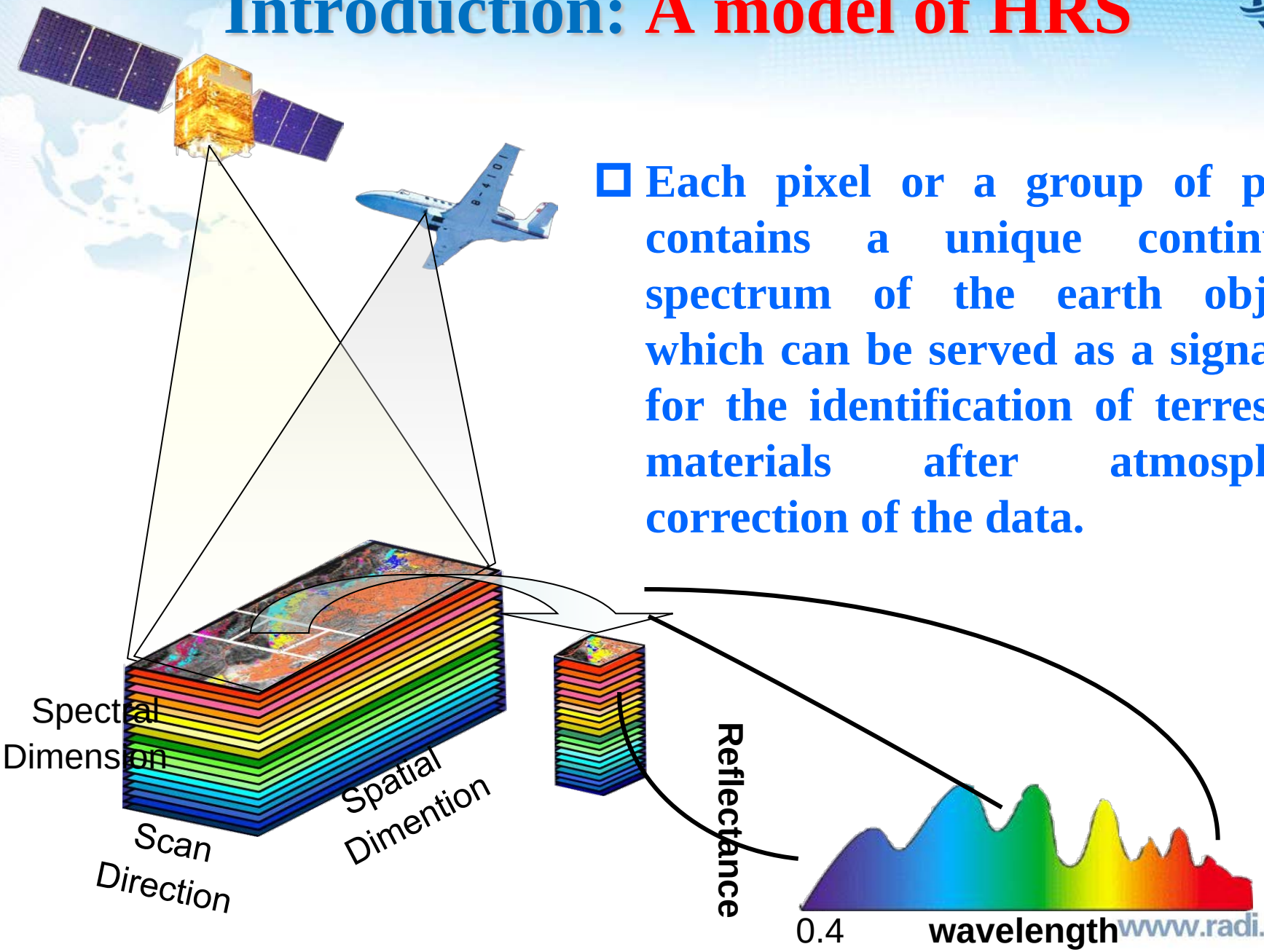
Hyperspectral



From Panchromatic to Hyperspectral—Increasing the Spectral Resolution

When the spectral resolution reached higher than λ^{-2} the Optical Remote Sensing can be Considered as **Hyperspectral Remote Sensing**

Introduction: A model of HRS



- Each pixel or a group of pixels contains a unique continuous spectrum of the earth objects, which can be served as a signature for the identification of terrestrial materials after atmospheric correction of the data.

Introduction

▲ Remote Sensing, both Airborne and Spaceborne has been greatly promoted in China due to the wide requirements by the national economic and social development.

▲ The hyperspectral RS in China was started on the beginning of 1970s.

▲ Same as other countries, the development of HRS in China was also initiated from the development of airborne hyperspectral sensors

▲ With the development of hyperspectral airborne sensors, the applications in hyperspectral remote sensing area have been widely carried out.

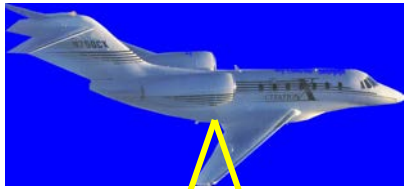
Development of Airborne Hyperspectral Technology in China

AMSS

FIMS

MAIS

PHI



OMIS

AMSS
19 Band
VIS-TIR
Early 1980's

FIMS
6 Band
SWIR
Middle 1980's

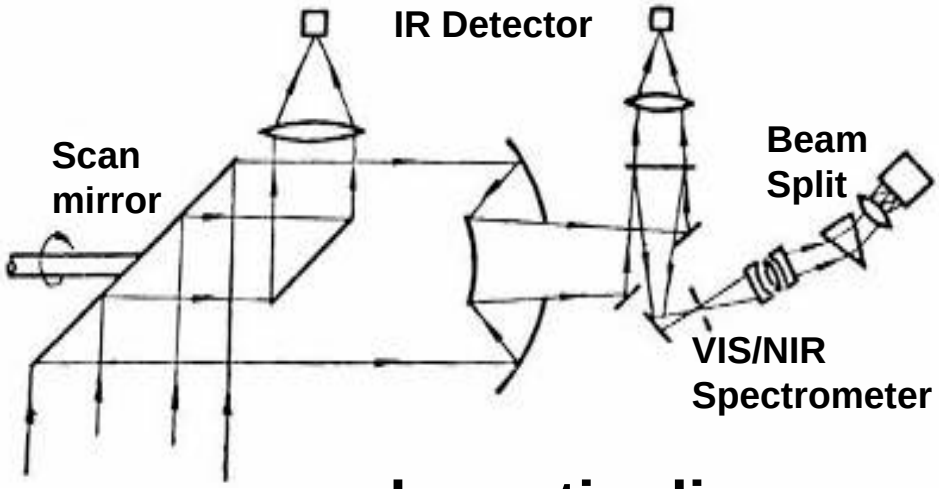
MAIS
72
VIS-32
SWIR-32
TIR-8
Early 1990's

PHI
244
VIS-NIR
Later 1990's

OMIS
128
VIS-NIR
SWIR-TIR
Later 1990's

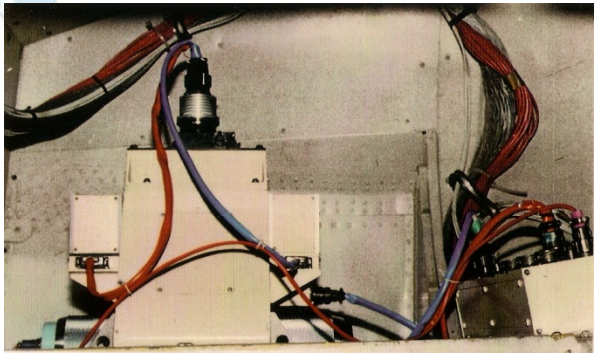
Development of Airborne Hyperspectral Technology in China

AMSS



schematic diagram

Development of Airborne Hyperspectral Technology in China



FlMS **1985**

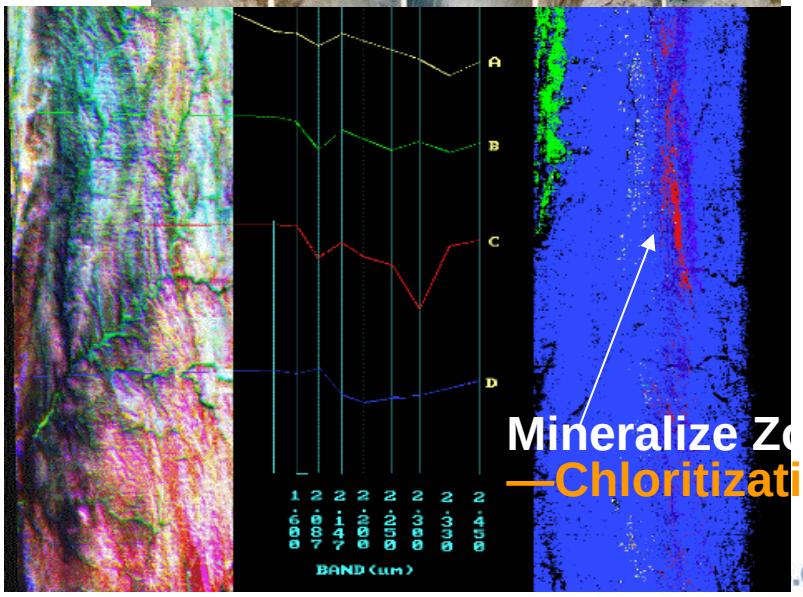
Spec.Bands: 6:

2.035, 2.087, 2.143,

2.200, 2.280, 2.380

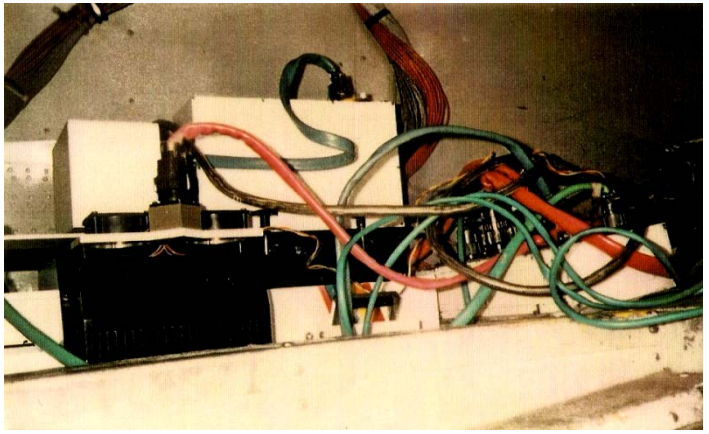
FOV: 90º

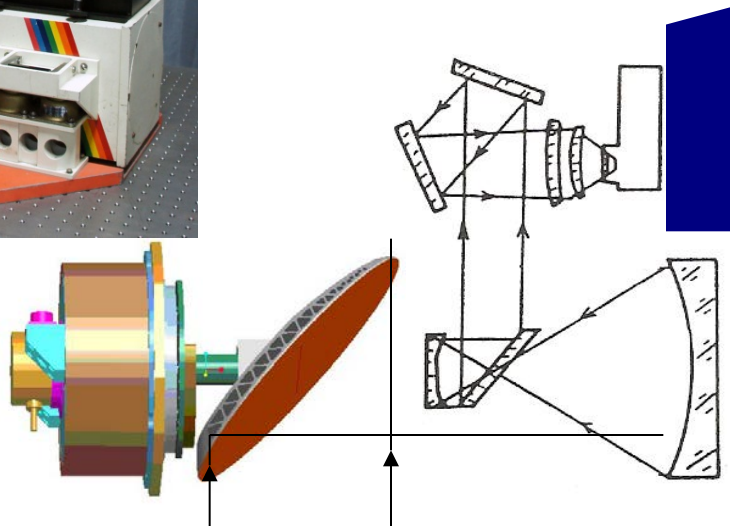
IFOV: 6 mrd.

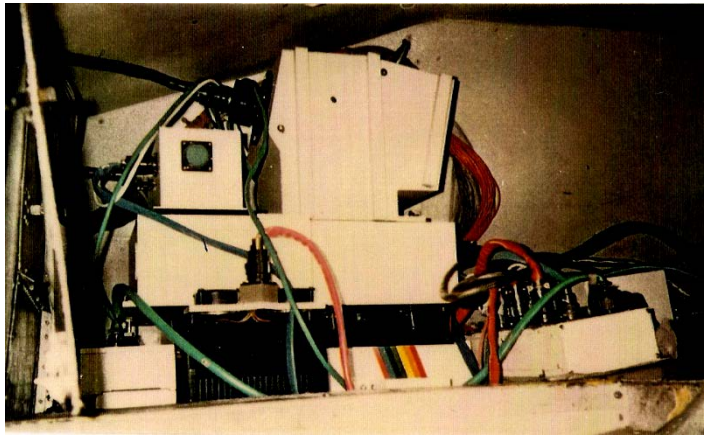


Development of Airborne Hyperspectral Technology in China

MAIS 1991





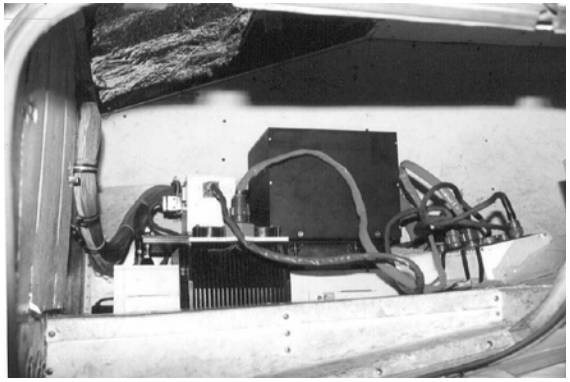


The First Real Imaging Spectrometer in China

(one optical scanning unit and three spectrometer modules for different spectral ranges)

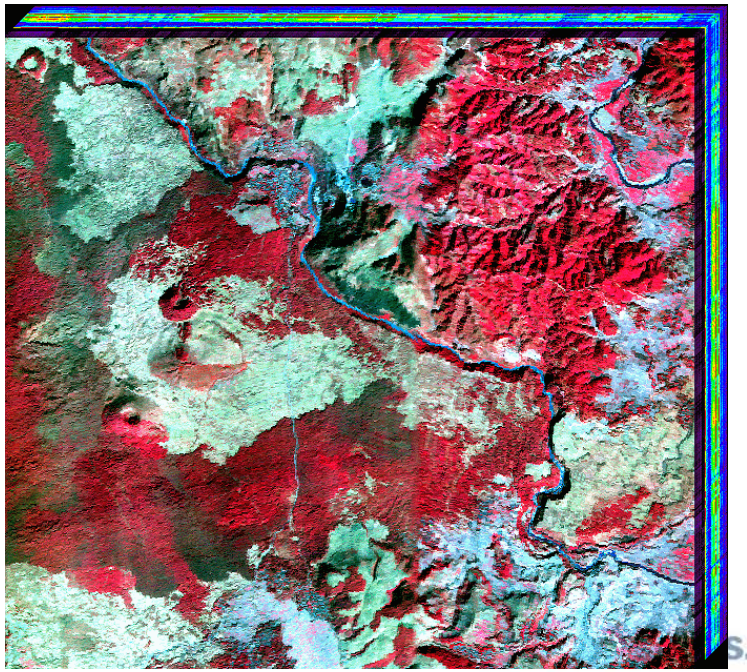
Development of Airborne Hyperspectral Technology in China

MAIS



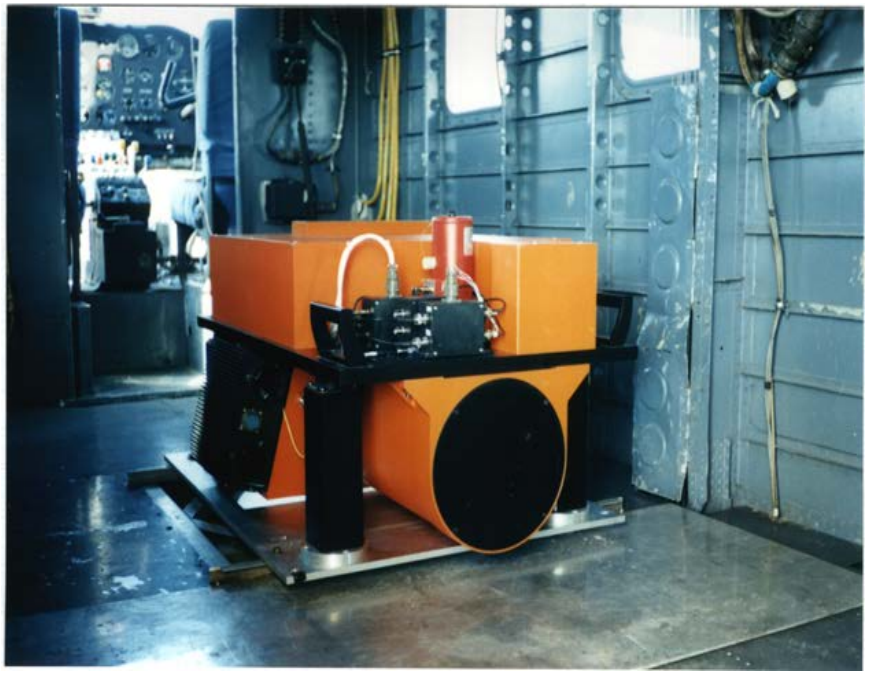
71 spectral bands

- VIS－NIR: 32 bands (0.44~1.08 um)
  Spectral resolution: 20 nm
- SWIR: 32 bands (1.5~2.45 um)
  Spectral resolution : 25 nm
- TIR: 7 bands (8.0~11.6)
  Spectral resolution : 0.45 um
- FOV: 90°
- IFOV: 3.0 mrad
- Scan Rate : 10-20 (lines/sec.)
- Digitization: : 12 bit



Development of Airborne Hyperspectral Technology in China

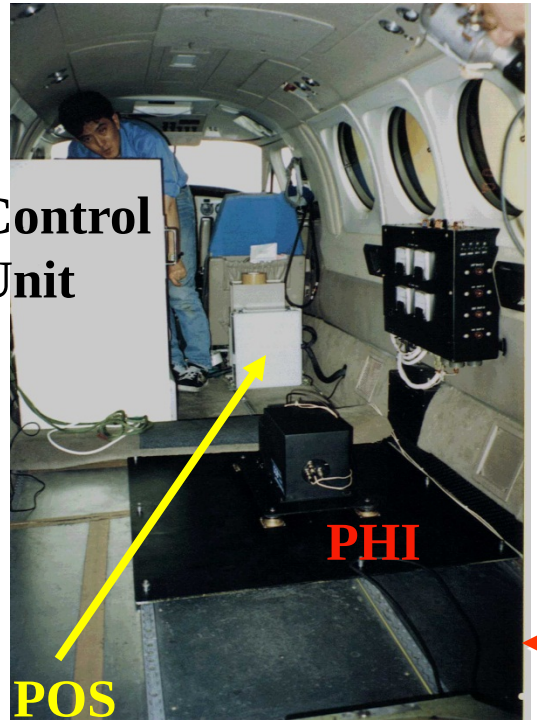
Operational Modular Imaging Spectrometer(OMIS)



OMIS-I (128 band)

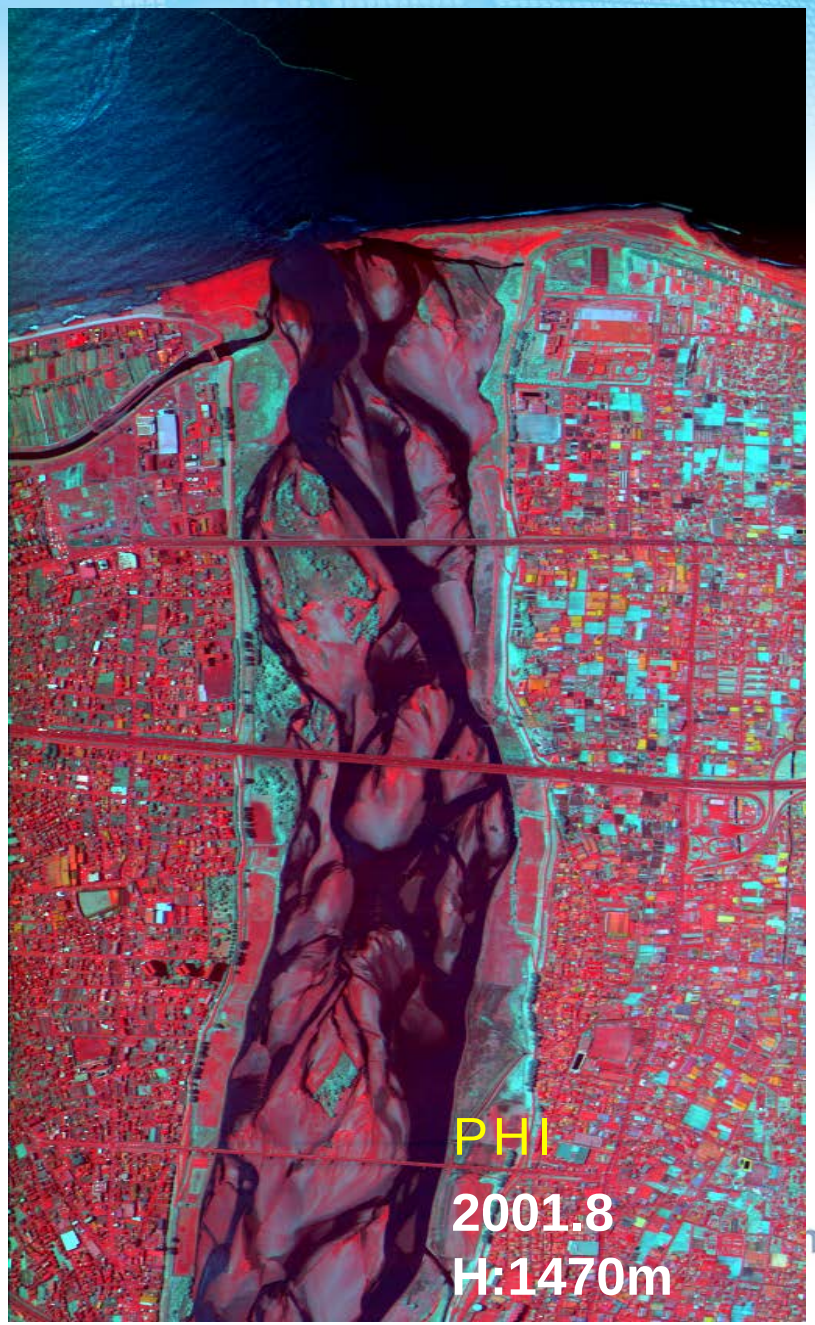
Pushbroom Hyperspectral Imager (PHI)

Airborne Imaging Spectrometer (OMIS-PHI) in Operation in Japan

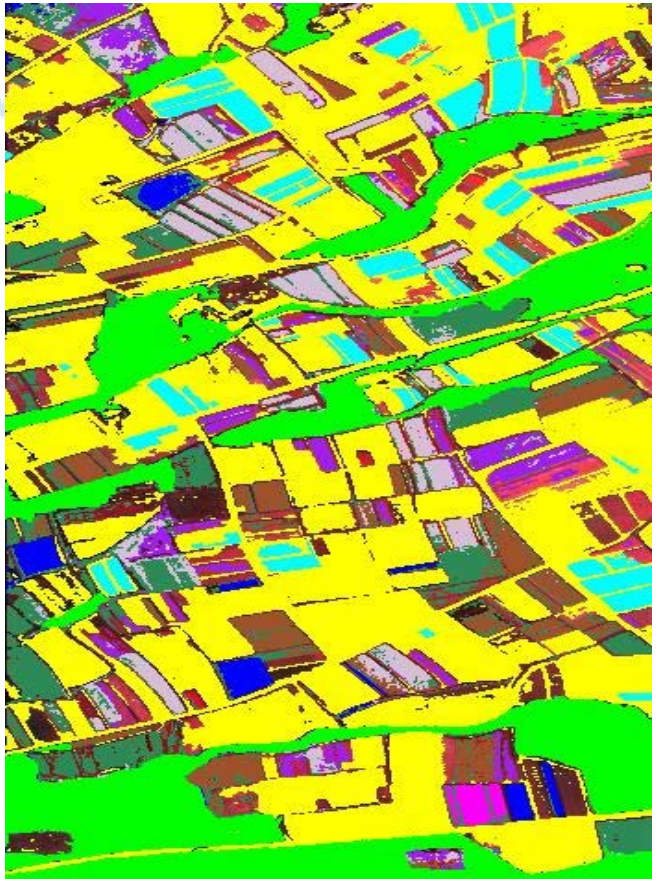


Flying PHI and OMIS onboard "King Air" Aircraft

Aragawa Tokyo, Japan



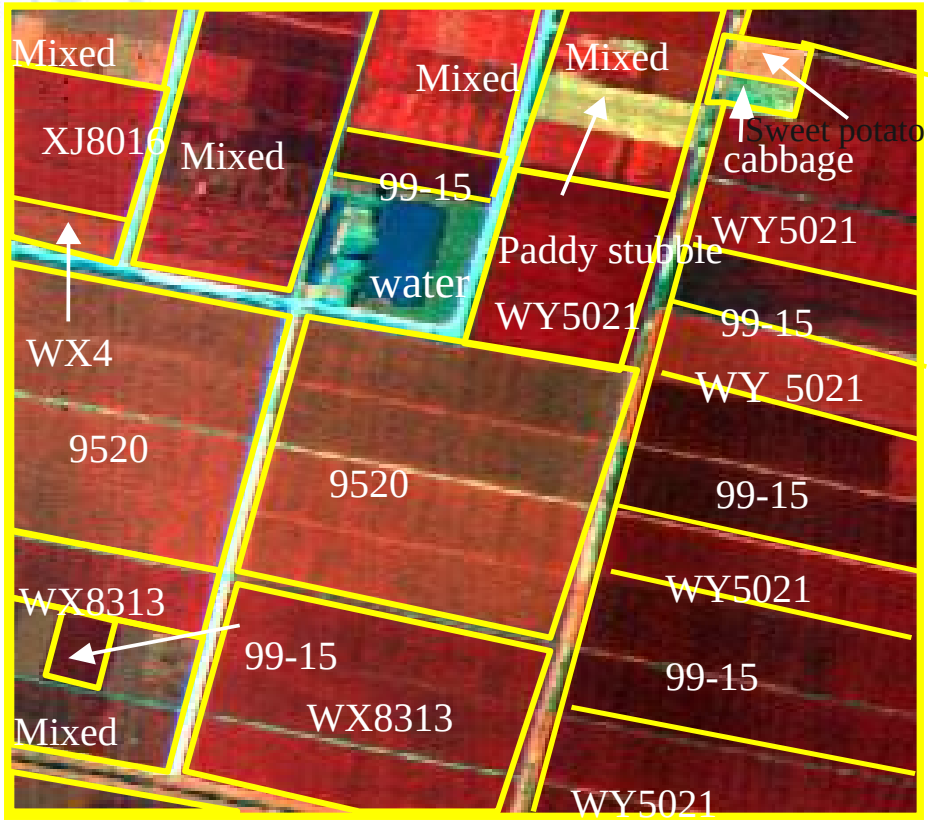
Application of Airborne Hyperspectral Technology in China

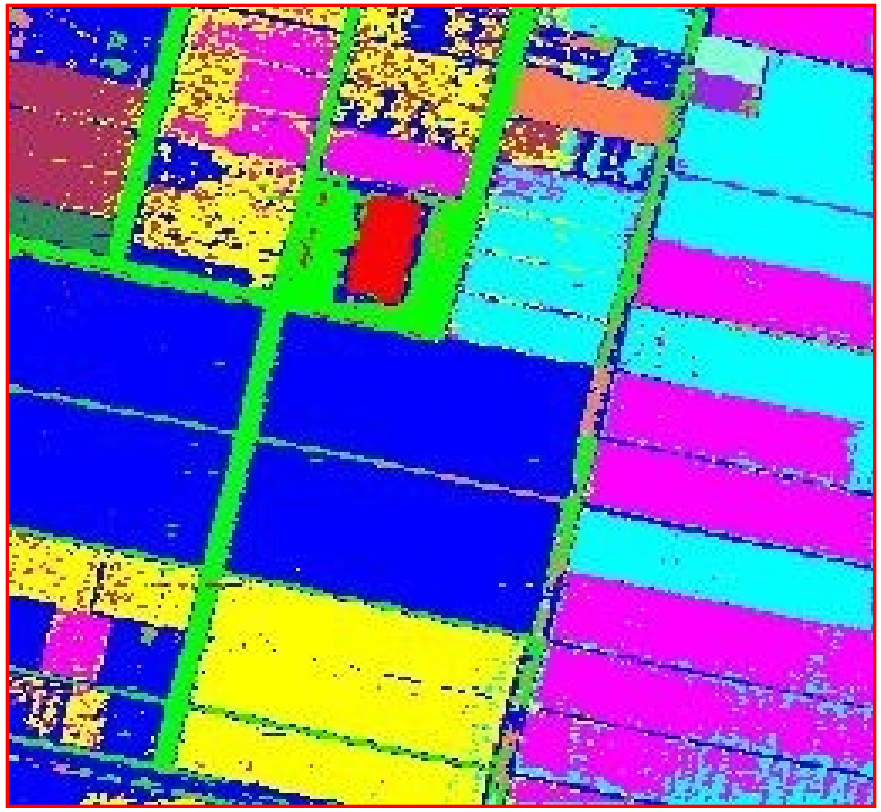


Japanese cabbage
Chinese cabbage
radish
lettuce
Forage grass
Pole bean
forest
mulch
naked soil

Precise classification of farmland area in Japan based on PHI image

Application of Airborne Hyperspectral Technology in China



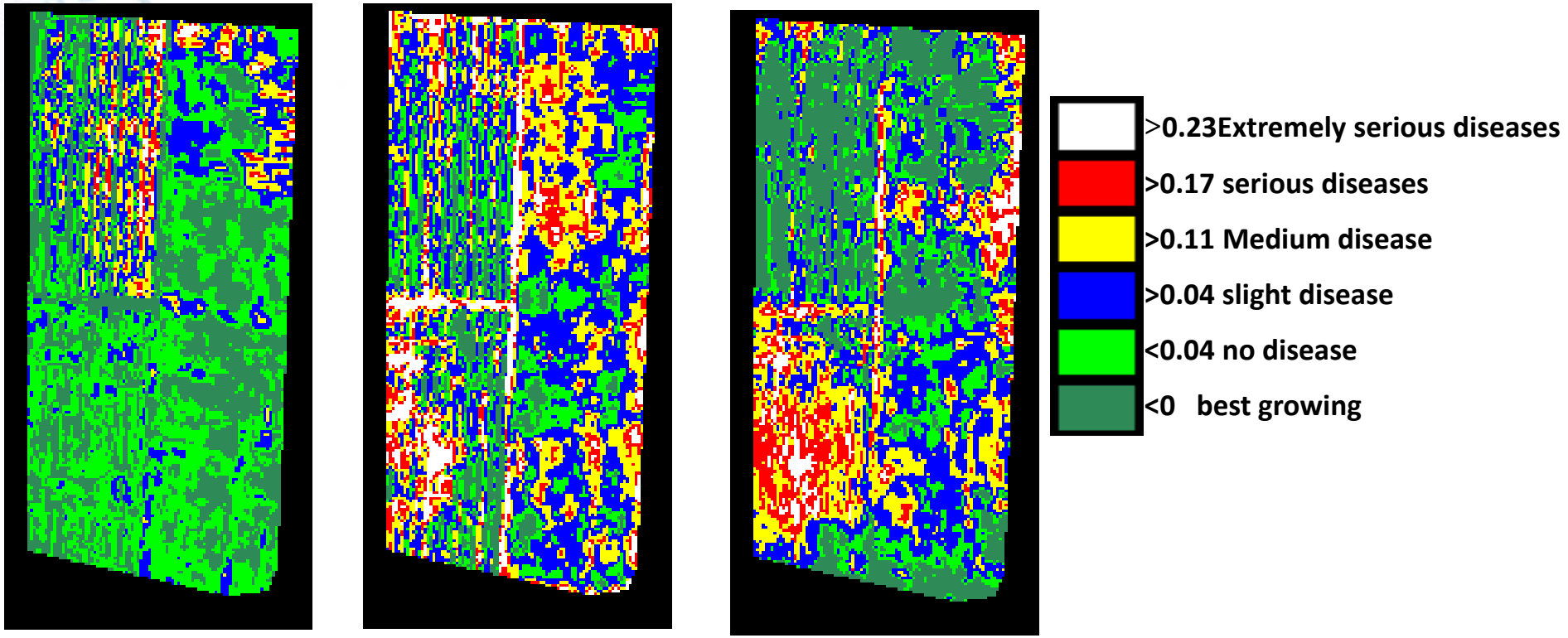


Sweet potato cabbage water WX4 WX8313 99-15

the harvested rice crop cement ground XJ8016 9520 WY5021

Classification result of rice varieties based on the PHI image. The left figure shows the correspondindg ground survey map, which is quite consistent with the classification result (right).

Application of Airborne Hyperspectral Technology in China

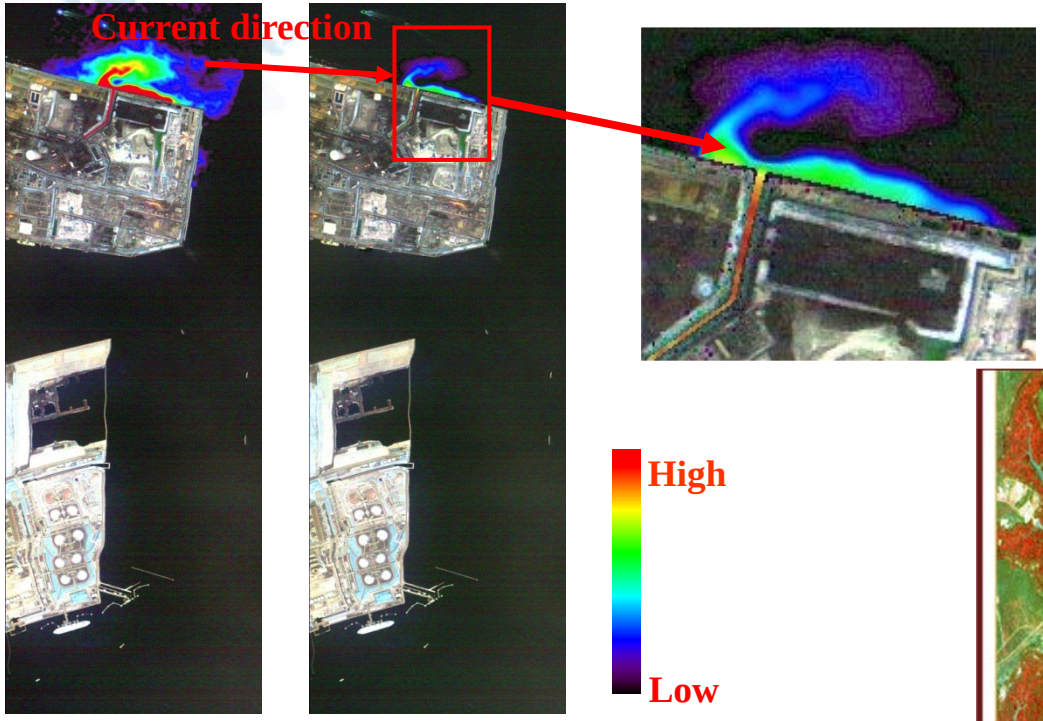


elongation stage grouting stage milk stage

Wheat disease indices by spectrum monitoring based on PHI image

（Liu liangyun，2002）

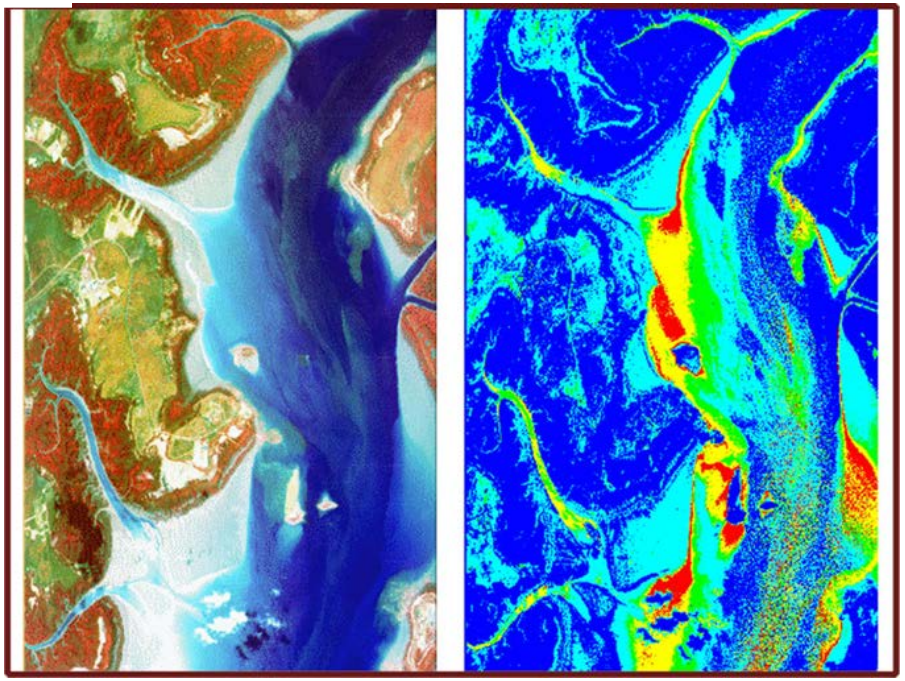
Application of Airborne Hyperspectral Technology in China



Offshore thermal pollution in Japan

Ecological monitoring

Coastline environment survey



Development of Spaceborne Hyperspectral RS

- With the development of airborne hyperspectral remote sensing, hyperspectral sensors have been considered as important spaceborne payloads to meet the needs of the resources surveying and environmental monitoring

- Some hyperspectral sensors have been used as the payload in the airborne remote sensing system and in a series of China's satellites, the Spaceships and for Lunar mission.

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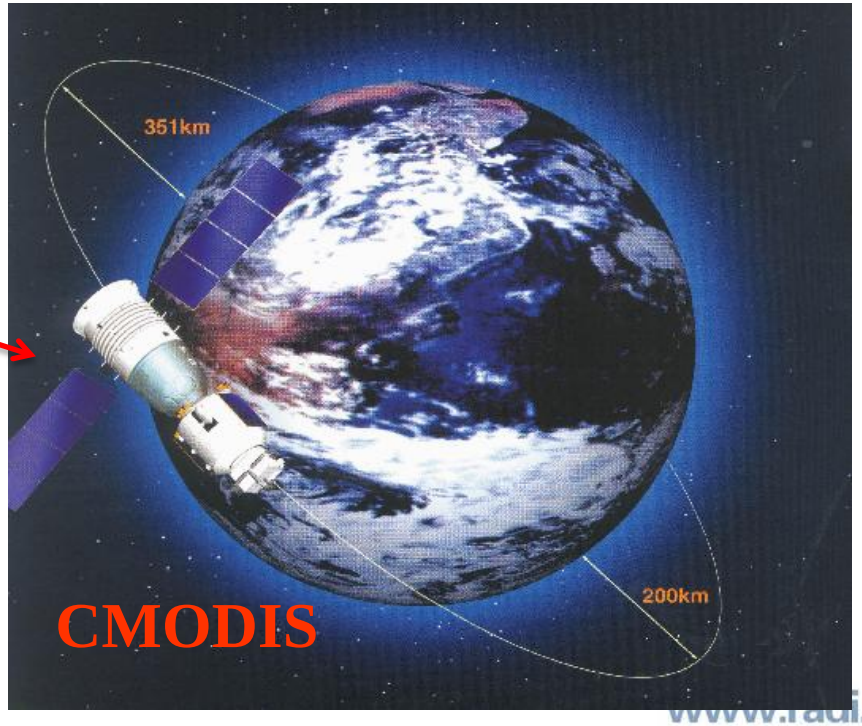
The first satellite hyperspectral imager—CMODIS onboard Shenzhou-3 Spaceship

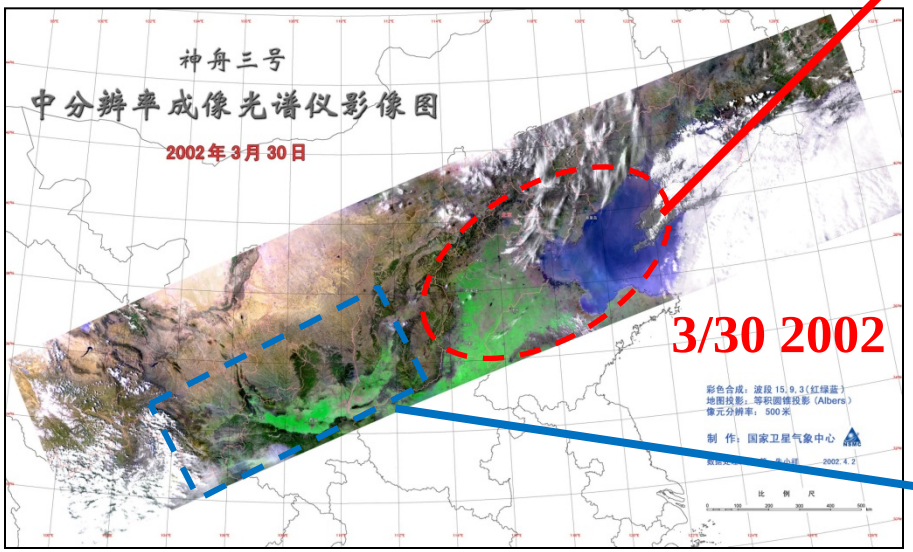
- No. bands: 34, Include:
- Visible: 20 (20nm, from 412 nm)
- NIR: 10 (20nm, from 822 nm)
- SWIR: 1 (2.150-2.250 μm)
- TIR: 3

(8.40-8.90,10.30-11.30 μm,11.50-12.50 μm）

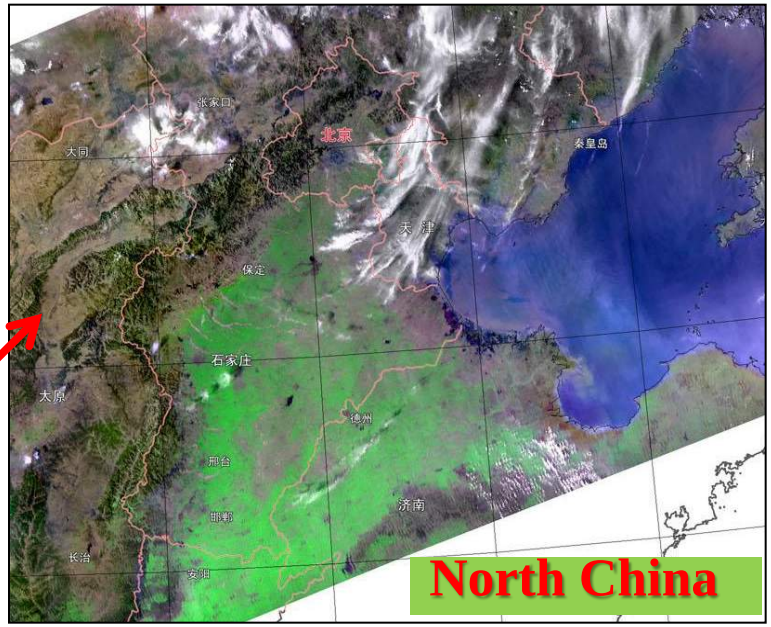


The first satellite hyperspectral imager--CMODIS

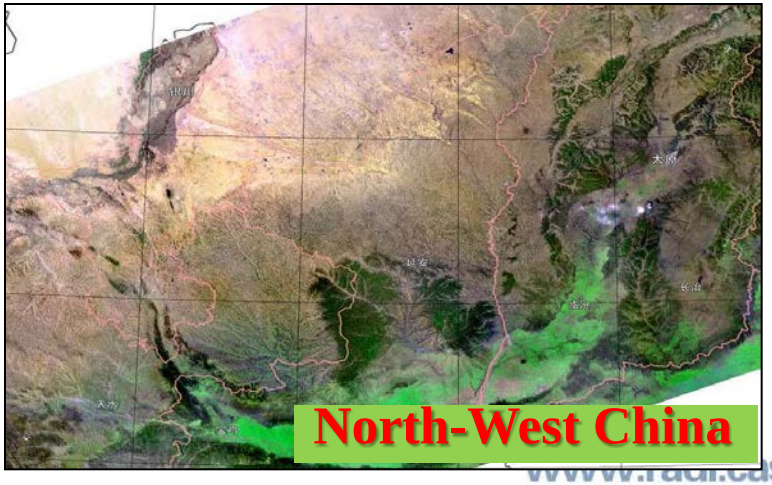
- In early October 2002 the Orbital Module was operated almost 200 days with more than 2000 cycles around the Earth



A typical CMODIS image

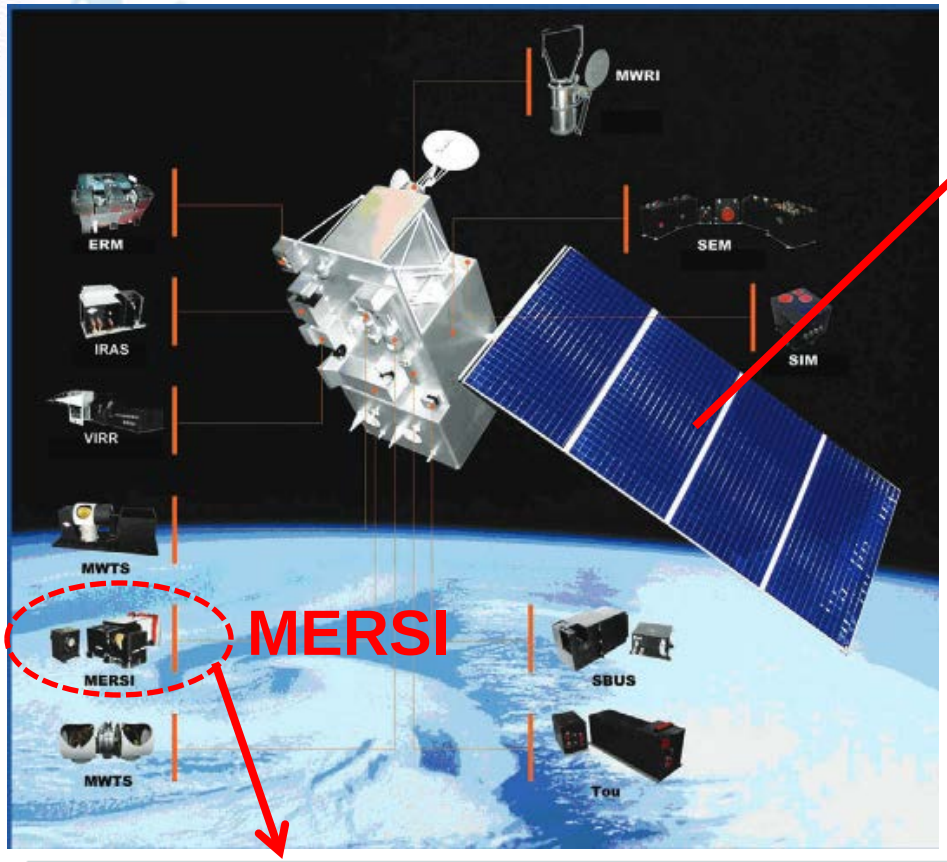


North China



North-West China

Medium-Resolution Spectral Imager (MERSI) onboared Meteorological FY-3A

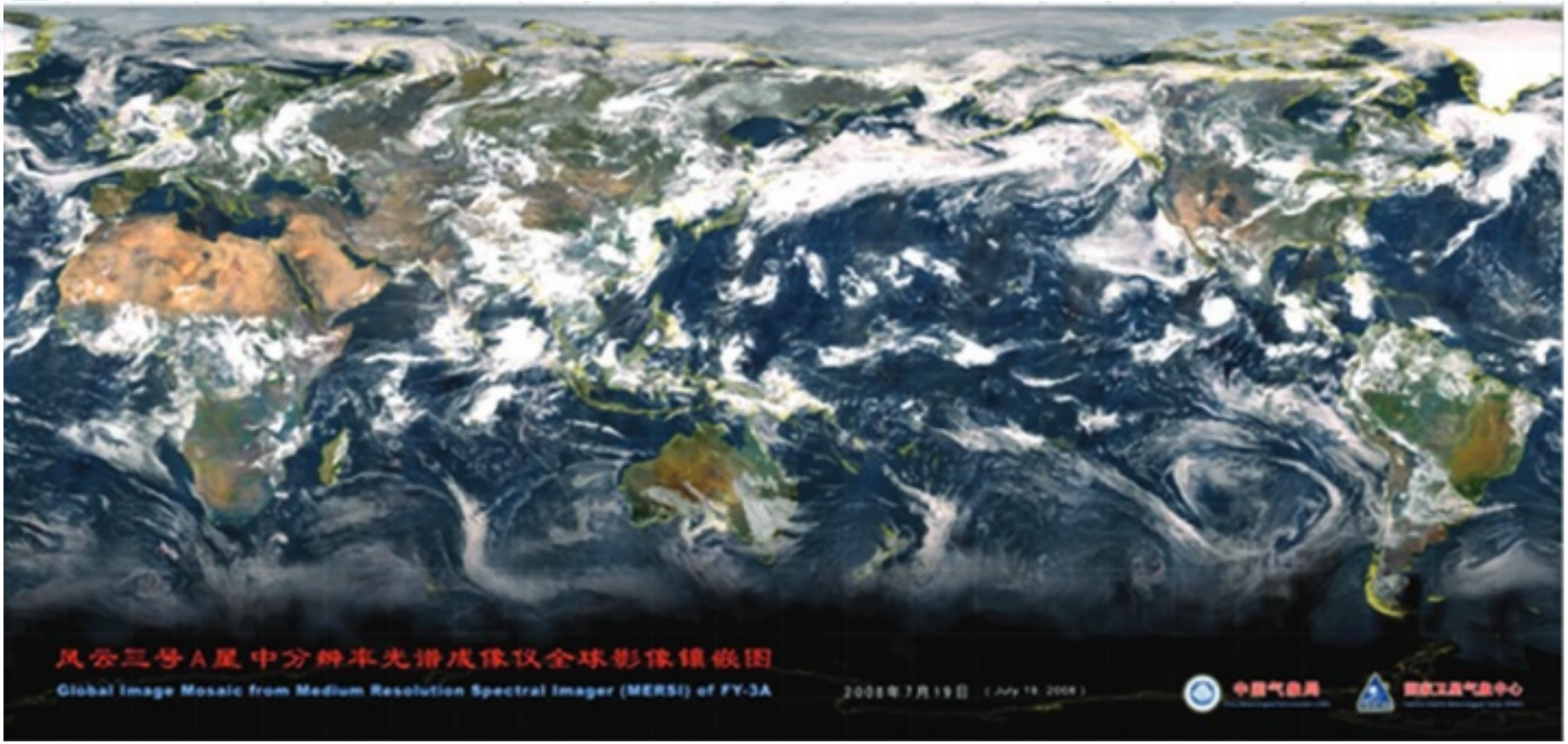


Satellite Specifications and orbital parameters

Orbit	Sun synchronous
Altitude (km)	831
Power	1100 W
Launch mass	2298.5 Kg
Size	4.38 × 2.0 × 2.0 m (in stowed) 4.44 × 10.0 × 3.79 m (in flight)
Orbital period (min)	101.49
Inclination (°)	98.81
Eccentricity	<0.0013
Local time at descending node	1005 UTC
Orbital maintenances	15 min (2 yr)$^{-1}$
Onboard data storage	144 GB
Attitude control	Three-axis stabilization
Quasi-repeat time	5 days
Launch vehicle	LM-4B
Design life	3 yr

Spec.Range: 0.4-12.5um
Number of Bands: 20
Spatial Resolution: 0.25-1km
Scanning range: ±55.4°
Quantization: 12 bit
Radiometric calibration Accu. <7%
Assembling two onboard calibration systems

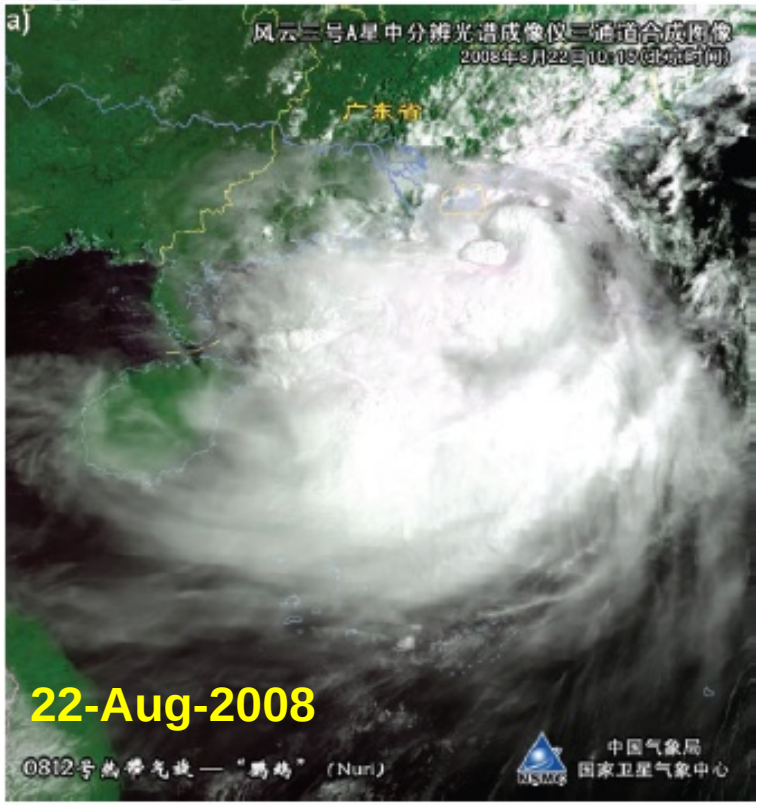
Meteorological FY-3A Medium-Resolution Spectral Imager (MERSI)



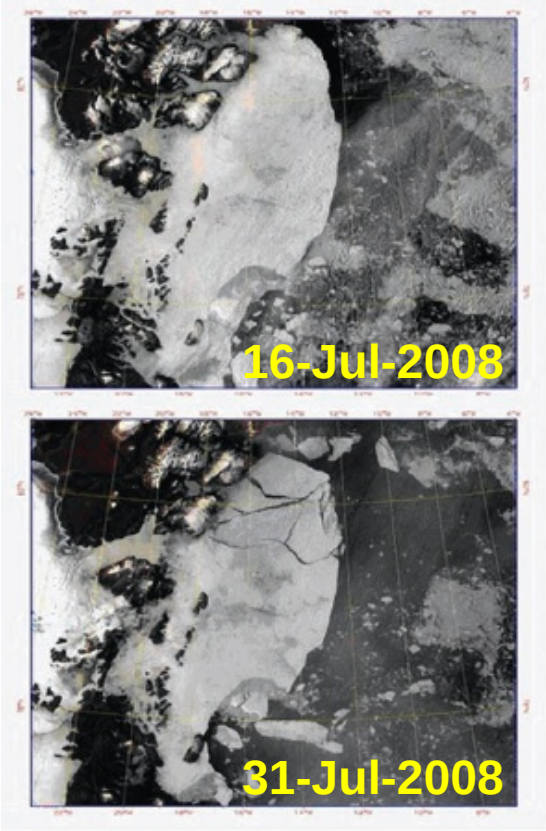
A global image mosaic from MERSI with natural color and resolution of 3 km

(Courtesy: Chaohua Dong *et al.*)

Meteorological FY-3A Medium-Resolution Spectral Imager (MERSI)



Nuri typhoon monitoring

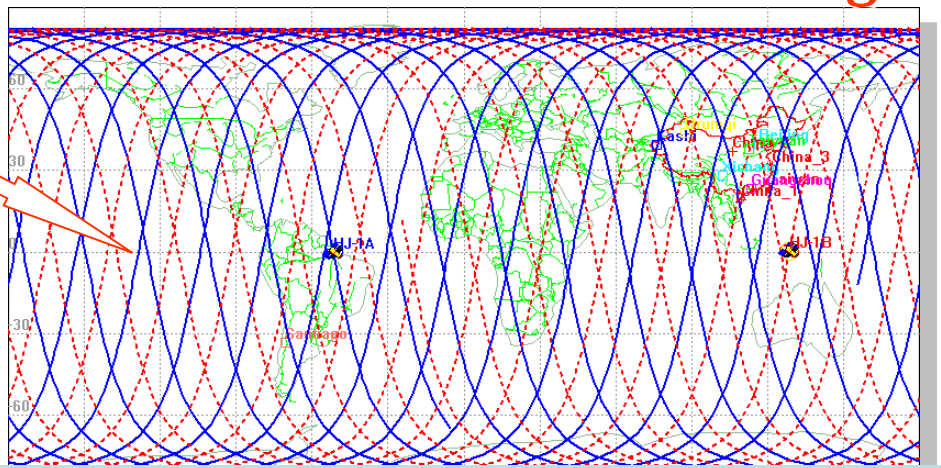


Greenland sea ice monitoring with MERSI 250-m datasets

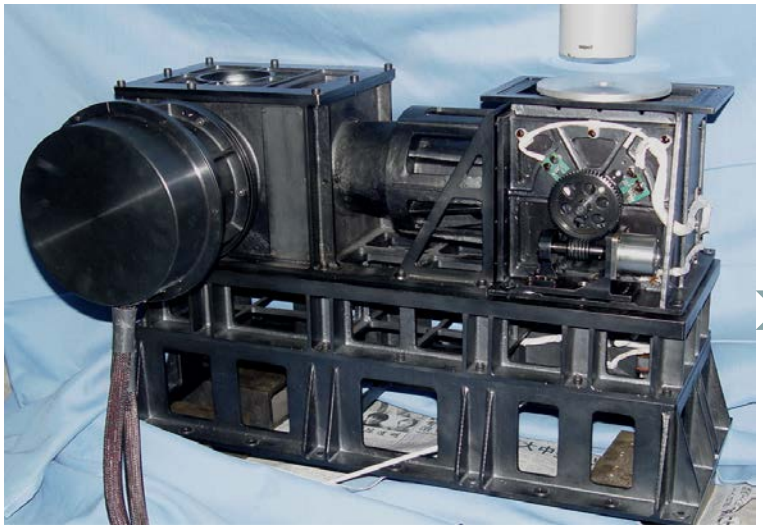
(Chaohua Dong *et al.*)

HJ-1 Small Satellite Constellation for Environment and Disasters Monitoring

A Constellation of 2 Small Satellites (HJ-1) was launched in Sept. 6, 2008 for Environment and Disasters Monitoring



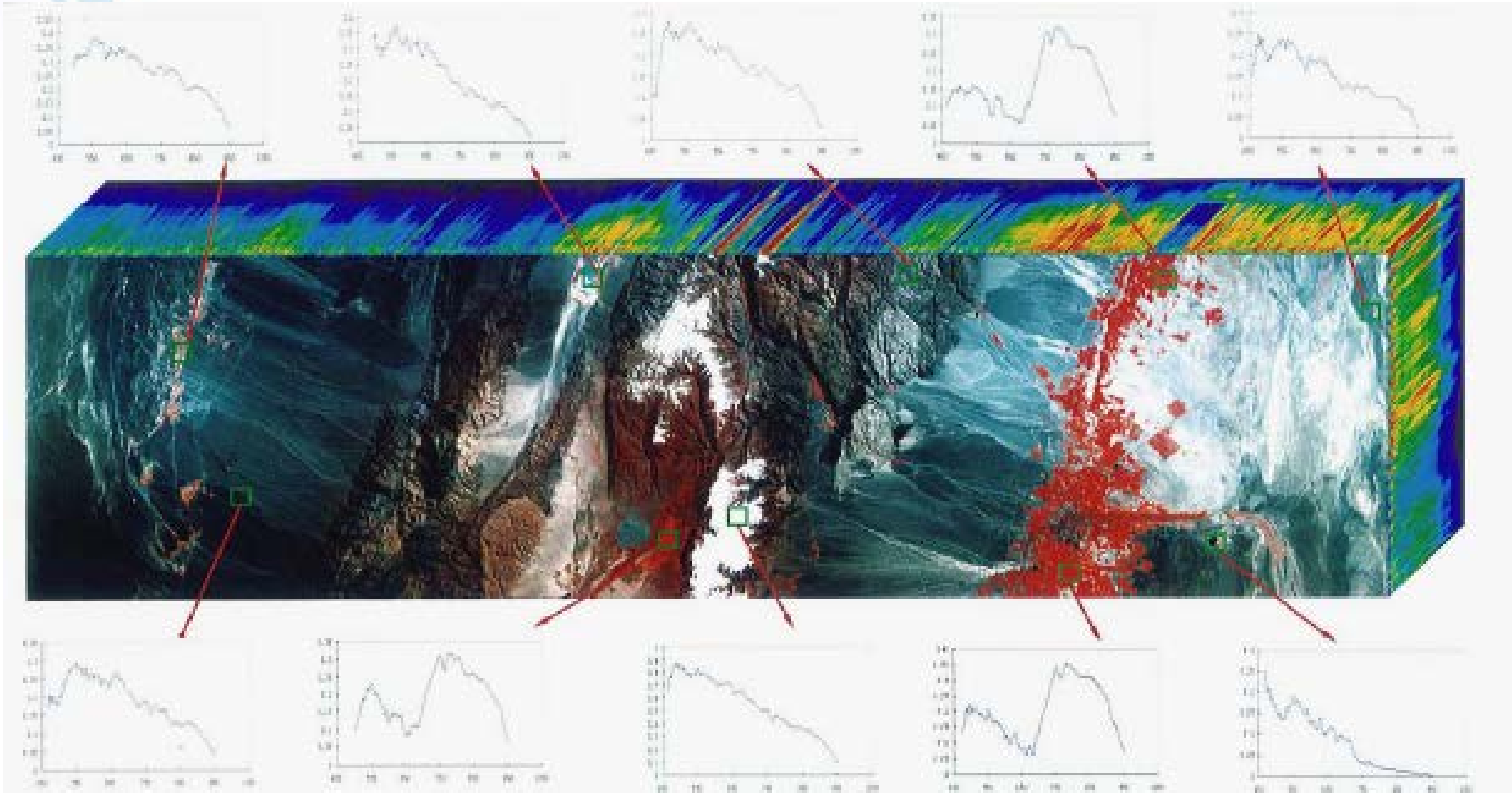
One of the Main Payloads on Board of the Satellite is a VIS-NIR Imaging Spectrometer (HSI)



Spec.Range: 450nm-900nm
Number of Bands: 115
Spatial Resolution: 100m
Ground Coverage: 50km
Side Looking: ±30°
Revisit: 4-31days

HJ-1 Small Satellite Constellation for Environment and Disasters Monitoring

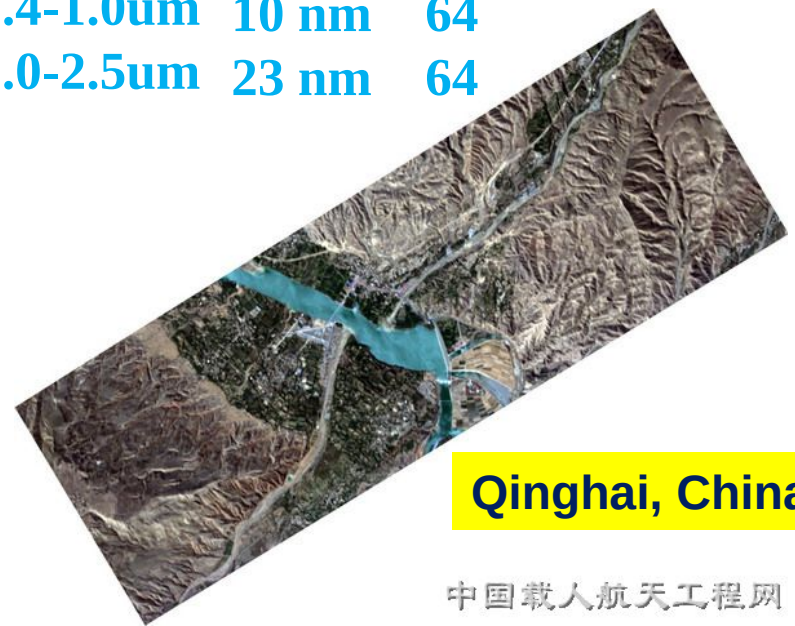
A typical Image Cube from HJ-1 Satellite



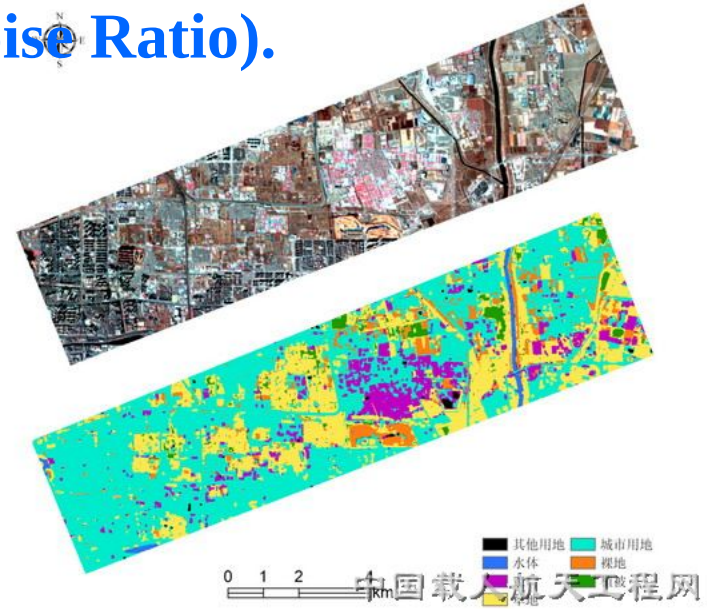
China's first target vehicle Tiangong-1 (TG-1 HSI)

- Numerous applications have indicated that the TG-1 HSI has achieved high performance levels in spatial, spectral, and SNR (Signal to Noise Ratio).

Range	Resolution	band num
0.4-1.0um	10 nm	64
1.0-2.5um	23 nm	64



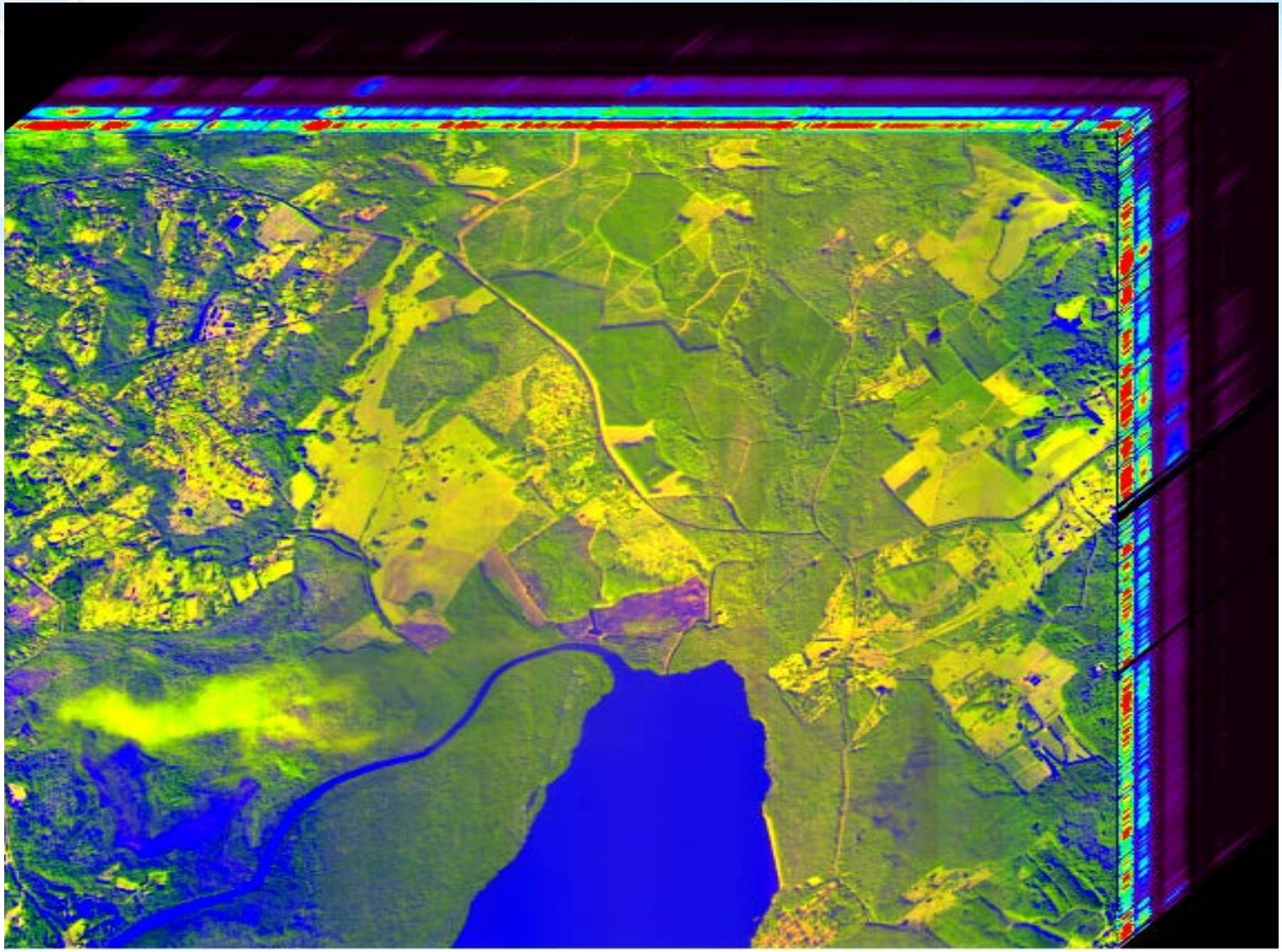
Qinghai, China



Land use monitoring, Beijing, China

(China Manned Space Engineering)

TG-1 HSI Image Cube(SWIR1.0-2.5μm)

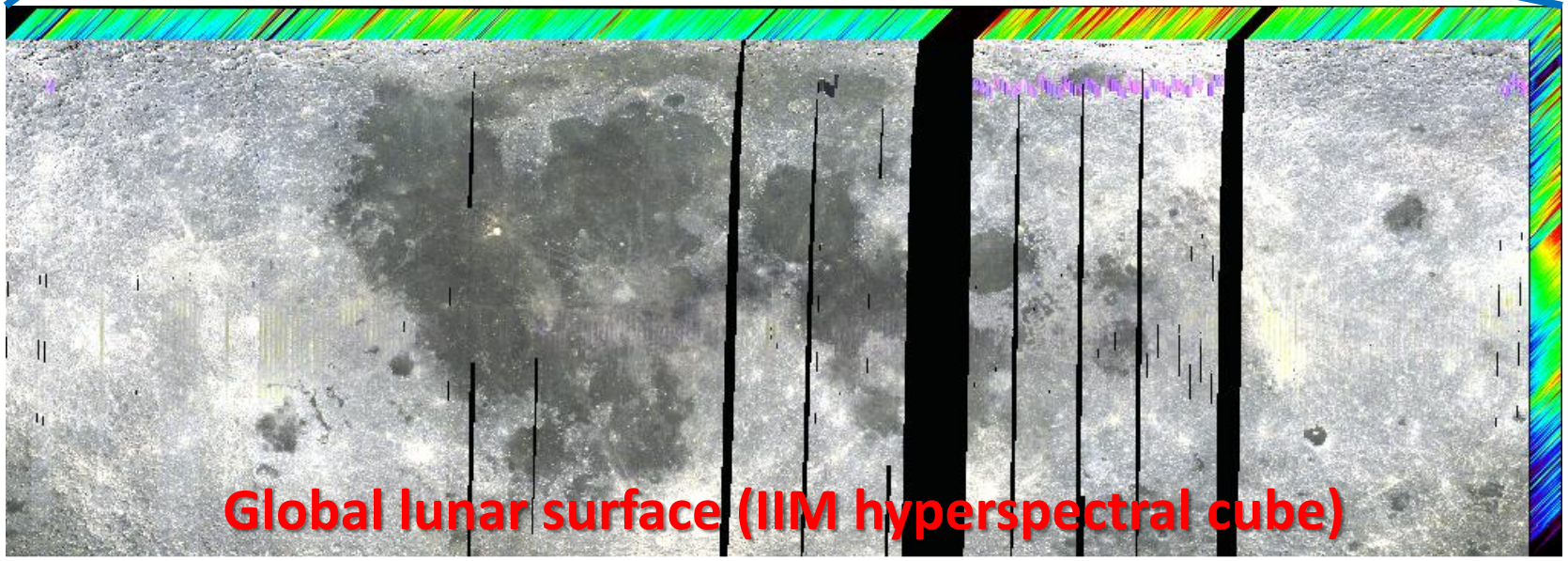


(Date: 05- Oct.-2011, Australia)

Interferometric Imaging Spectrometer (IIM) onboard Chang'E-1Lunar Mission

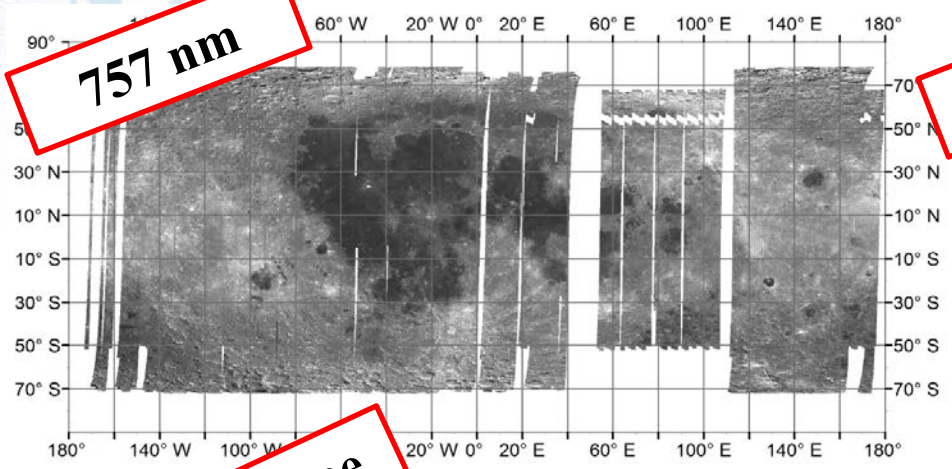
24-Oct-2007

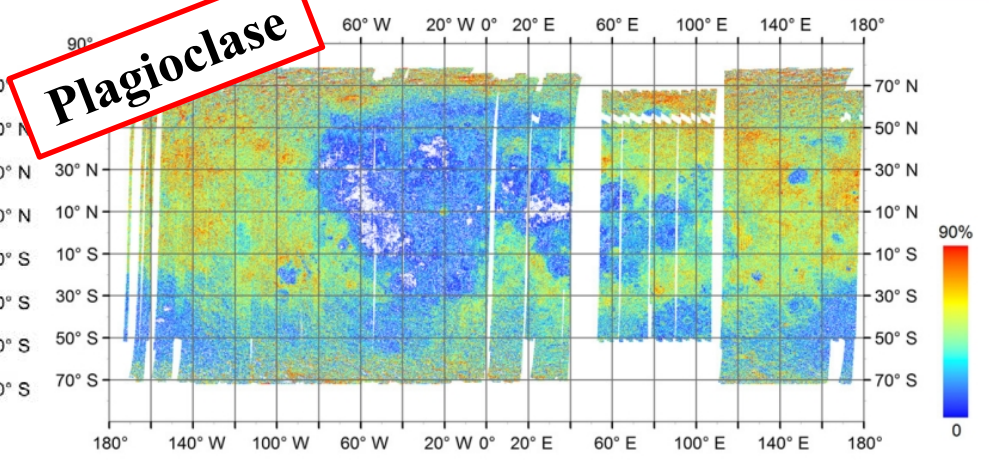
Width of Swath	25.6km
Spatial Resolution	200m
Imaging Region	75° N~75° S
Spectral Range	480~960nm
Spectral Bands	32
Digitazation	12bit
MTF	≥0.2

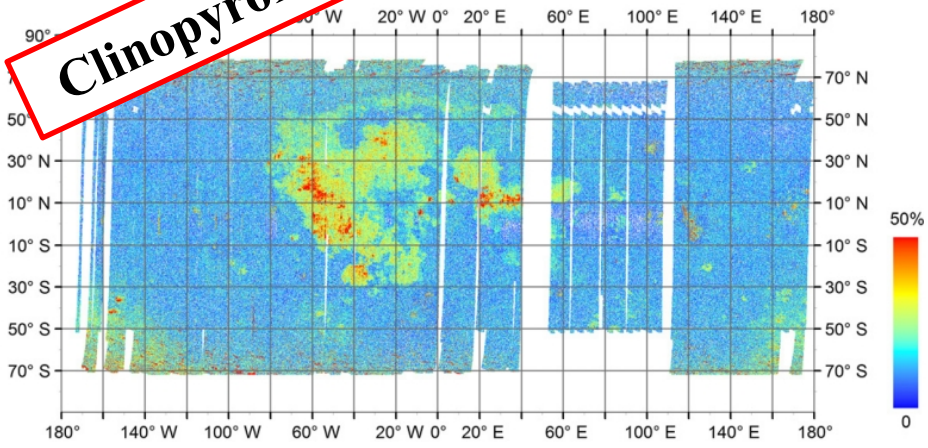


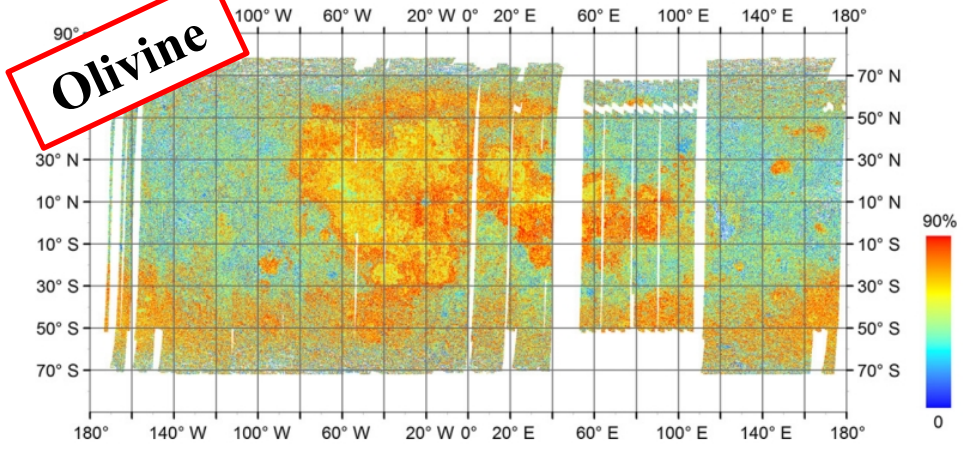
Global lunar surface (IIM hyperspectral cube)

Lunar Mission (Chang'E-1) Imaging Spectrometer (IIM)









Abundance Distribution Map of the major Lunar Minerals

Current Chinese Spaceborne Hyperspectral Imaging Sensors

Sensor	wavelength/ μm	Spectral Resolution/ nm	Bands	Available Date
CMODIS	0.4-12.5	20	34	2002
HJ-1A HSI	0.45–0.95	5	115	2008
FY-3 MERSI	0.44–0.89 0.39–1.04 1.62-2.15 10-12.5	50 20 50 2500	5 12 2 1	2008
Chang'E-1 IIM	0.48-0.96	15	32	2009
TG-1 HSI	0.40-1.0 1.0-2.5	10 23	64 64	2011

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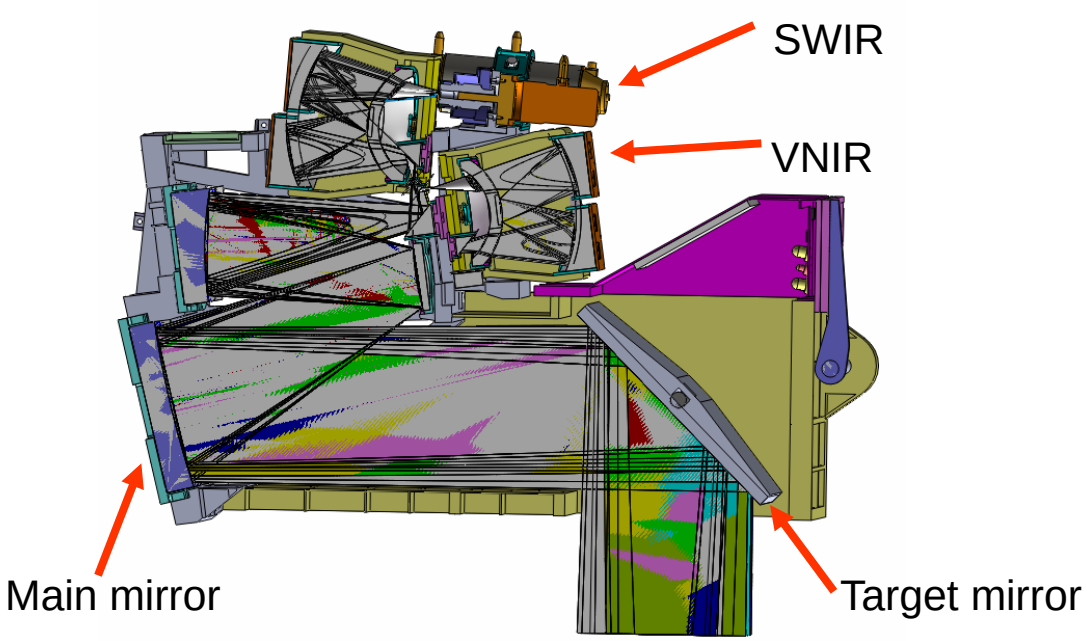
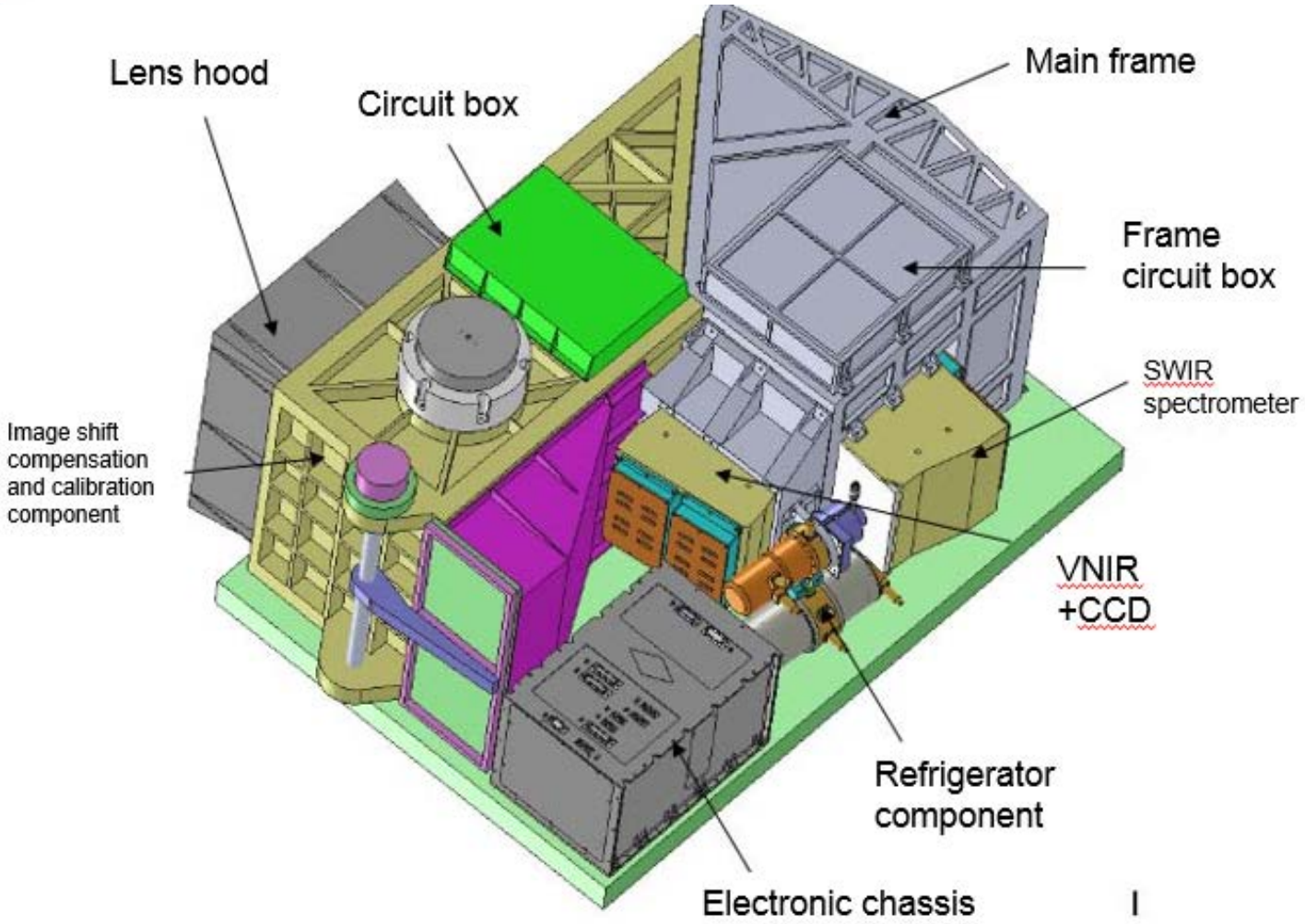
China Commercial Remote-sensing Satellite System (CCRSS)

- CCRSS is scheduled to be launched in 2016 (TBD). It is composed of two satellites, i.e. CCRSS-A and CCRSS-B.
- CCRSS-A will provide commercially panchromatic/ multispectral imagery and hyperspectral imagery from visual to shortwave infrared.



Optic figure of CCRSS-A

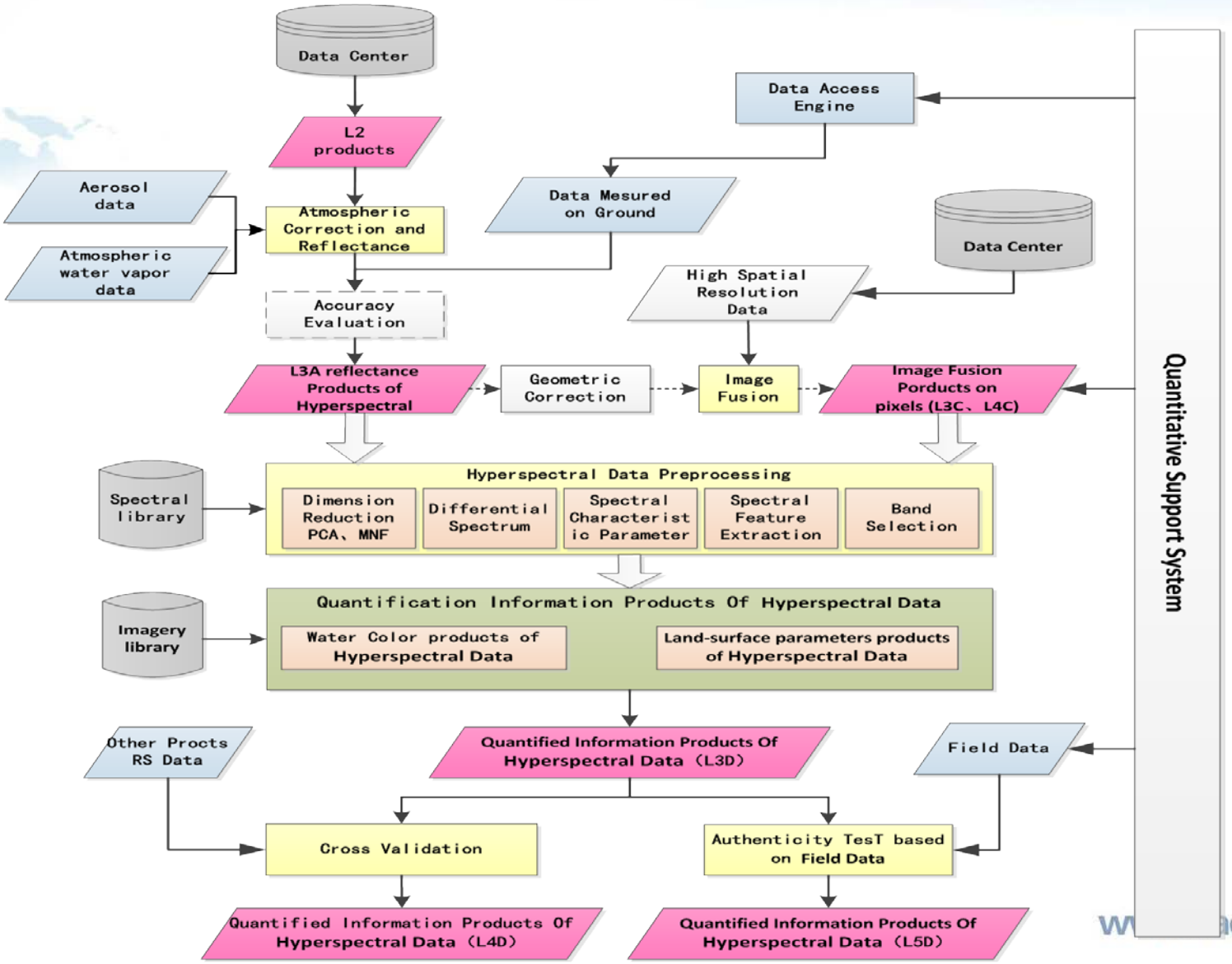
Framework of CCRSS-A



Scheme comparisons for CCRSS-A

Scheme & Para.	Scheme I	Scheme II	Scheme III	Scheme IV
	HRS	HRS+ infrared	HRS	HRS+ Infrared
Spec. range	0.4-2.5μm	0.4-2.5μm 8.0-12.5μm	0.4-2.5μm	0.4-2.5μm 8.0-12.5μm
No. bands	328	328+2~5	328	328+2~5
Width	40Km	30 Km	30 Km	30 Km
Spatial Res.	30m	30/60m	15m	15/30
Aperture	180mm	135mm	300mm	300mm
Volume	1020*980*550mm	1150*1000*500mm	1600*1100*800mm	1600*1200*700mm
Weight	147kg	187 kg	260 kg	300 kg
Power	260W	360 W	300 W	400 W
Budget	0.17 billion	0.22 billion	0.18 billion	0.23 billion
Period	2.5 years	3.5 years	2.5 years	3.5 years

Flow Chart of quantitative information products of CCRS-A hyperspectral data



OUTLINE

- Introduction
- Overview of current Chinese spaceborne hyperspectral sensors
- Ongoing and future Chinese satellite hyperspectral missions
- **Conclusion**

Conclusion

- Hyperspectral Remote Sensing is a newly developed technology, it has a wide potential in applications in different fields.
- Great attention has been paid to development of Hyperspectral Remote Sensing techonology and it applications in China. During last 30 years both airborne and spaceborne hyperspectral have been developed and wide international cooperation has been achieved.
- As an important technology HRS has been widely applied in vegetation, agriculture, forestry, urban, oceanic, environment, geology and mineral identification, classification and recognition.
- Hyperspectral remote sensing will also a basic technology for lunar, planets and the deep space exploration and especial attention has been paid to its development and application.

Thanks!



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