High-resolution Earth Observation System

——Booster for smart cities

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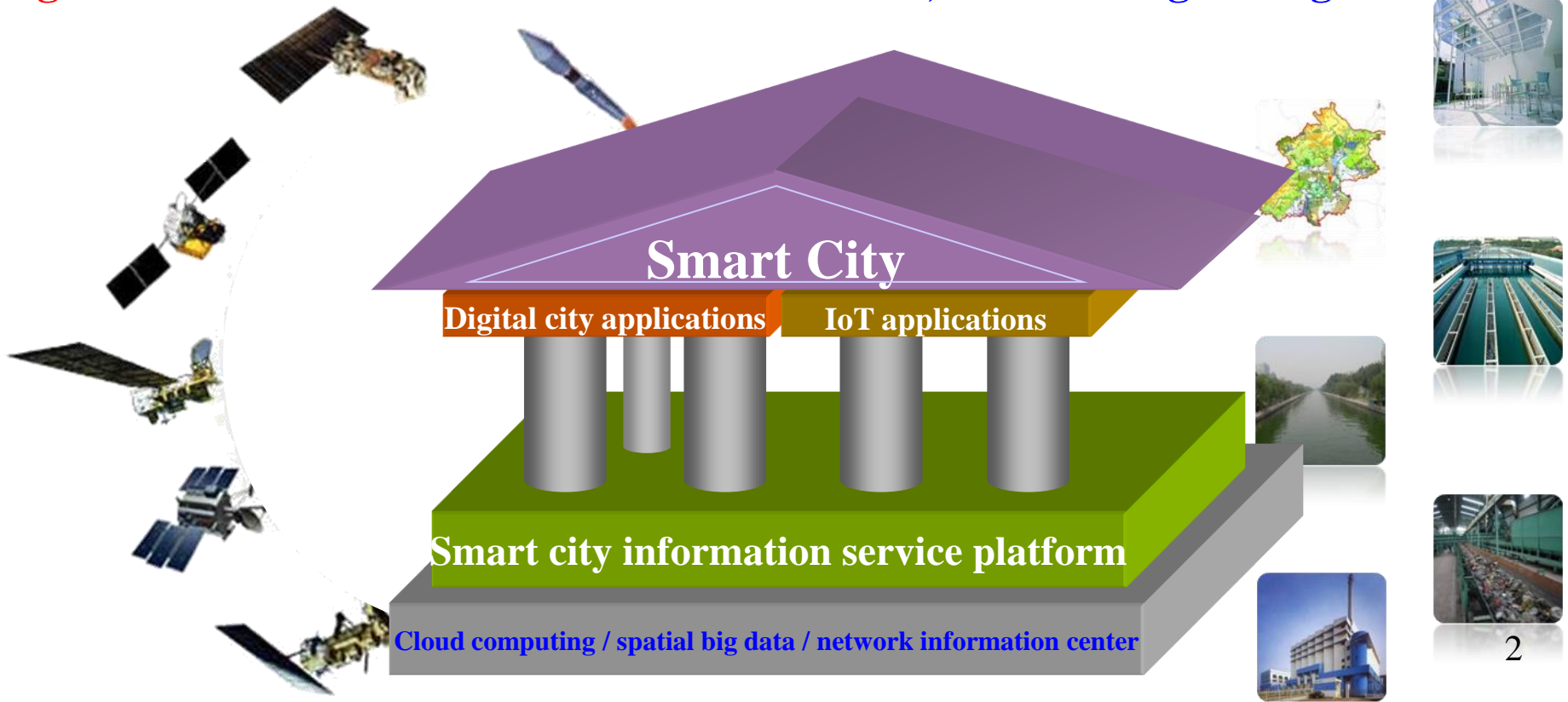
Aerospace Information Research Institute (AIR)
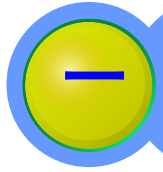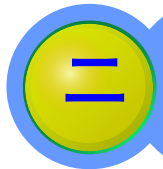
Chinese Academy of Sciences

Foreword

➢ **The Major Projects of China High-Resolution Earth Observation System will establish autonomous high-space, high-time, high-spectral resolution data acquisition capabilities and advanced ground application systems .**

➢ **It can effectively improve the self-sufficiency rate of China's spatial data, provide data, technology, products, tools, and systems, and provide basic guarantees for the construction of smart cities, which is of great significance.**

Smart City

Digital city applications   IoT applications

Smart city information service platform

Cloud computing / spatial big data / network information center

Outline

一 **Introduction to China High-Resolution EOS**

二 **High-resolution Satellite Data And Applications**

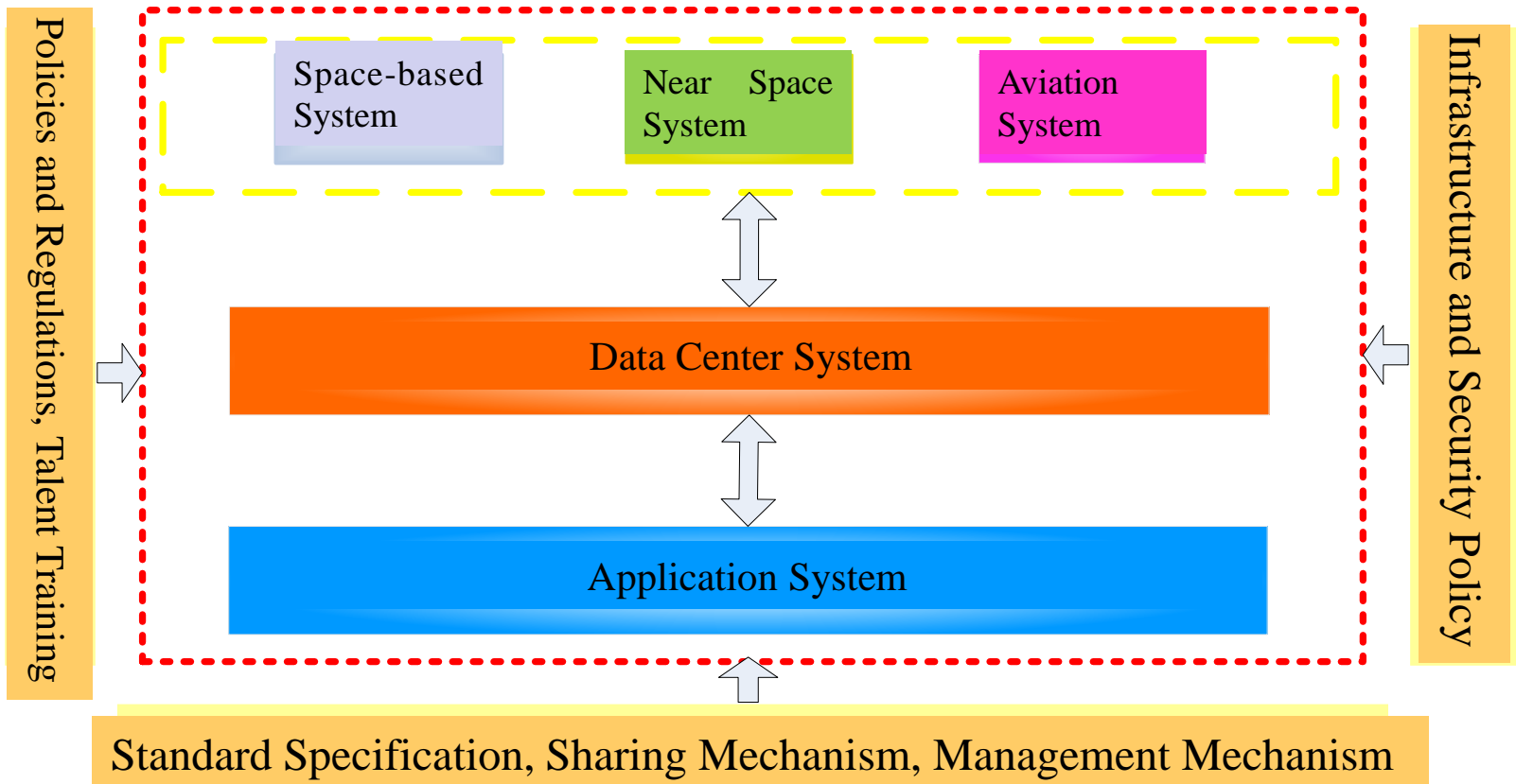**三** **High-resolution Satellite's Application in Smart City**

China Earth Observation System Planning

Strengthening Investment

With the launch of the major project of China High-Resolution Earth Observation System as the first remote sensing project, major projects such as the national space infrastructure have been demonstrated and started construction, which will vigorously promote the development of China's civil aerospace remote sensing.
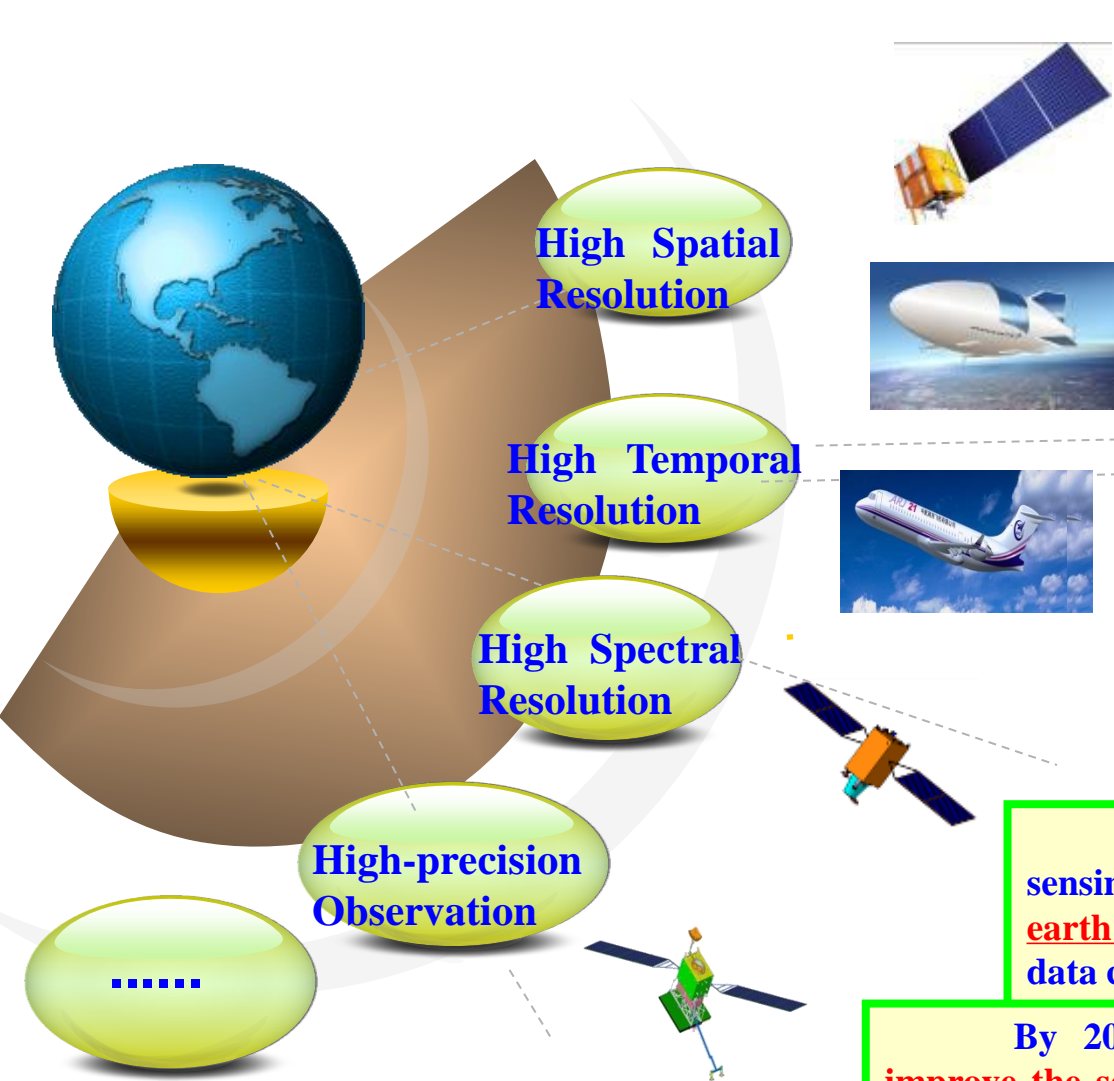
Introduction to CHEOS

 Major Projects of China High-Resolution Earth Observation System (CHEOS)focuses on the development of high-resolution advanced observation systems based on satellites, airplanes, and stratospheres, combined with other low- and medium-resolution observation methods to form a space-time coordinated, all-weather, and all-day earth observation system.

Policies and Regulations, Talent Training

Infrastructure and Security Policy

Space-based System

Near Space System

Aviation System

Data Center System

Application System

Standard Specification, Sharing Mechanism, Management Mechanism

CHEOS Background

➢ **The High-Resolution Earth Observation System is one of the 16 major special projects identified by the State Council's "Outline of the National Medium- and Long-Term Scientific and Technological Development Plan (2006-2020)."**

➢ **The High-Resolution Earth Observation System will produce major strategic products, break through key shared technologies, support major development and leading major projects in the future, achieve local leapfrog development, and fill national strategic gaps; it is of great significance to the sustainable development of the country's economy and society and national public safety.**

➢ **Through mechanism innovation and technology innovation, develop and build innovative ground observation systems. Combined with low- and medium-resolution observation methods, the military and civilian data are interconnected and resources are shared to form an integrated ground observation system that is space-time coordinated, all-weather, and all-day.**

➢ **The High-Resolution Earth Observation System is an innovative system that operates steadily, improves the self-sufficiency rate of China's space data, meets the national strategic and basic needs, and forms a space information industry link.**

Significance and Objectives

High Spatial Resolution

High Temporal Resolution

High Spectral Resolution

High-precision Observation

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High-Resolution ground observation data is a powerful basis for making macro decisions on major issues such as **agriculture, disasters, resources and the environment, and public safety**. It is a basic and strategic resource for national security.

Establishing a High-Resolution Earth Observation System and mastering the autonomy of information resources are urgent needs of the country and have great strategic significance.

Focus on the development of high-resolution advanced observation systems based on satellites, aircraft and stratospheres.

Integrate and improve existing remote sensing satellite ground receiving stations, **establish earth support systems** such as ground observation data centers

By 2020, ..., establish a stable operating system, **improve the self-sufficiency rate of China's spatial data, and form a spatial information industry chain.**

Outline

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CHEOS – Space-Based System

Satellites Developed by Space-based Systems

Land Surveying Satellite

Spectral Imaging Satellite

All Weather Radar Satellite

Satellite Geosynchronous Orbit

GF-7

GF-1

GF-2

GF-5

GF-6

GF-3

GF-4
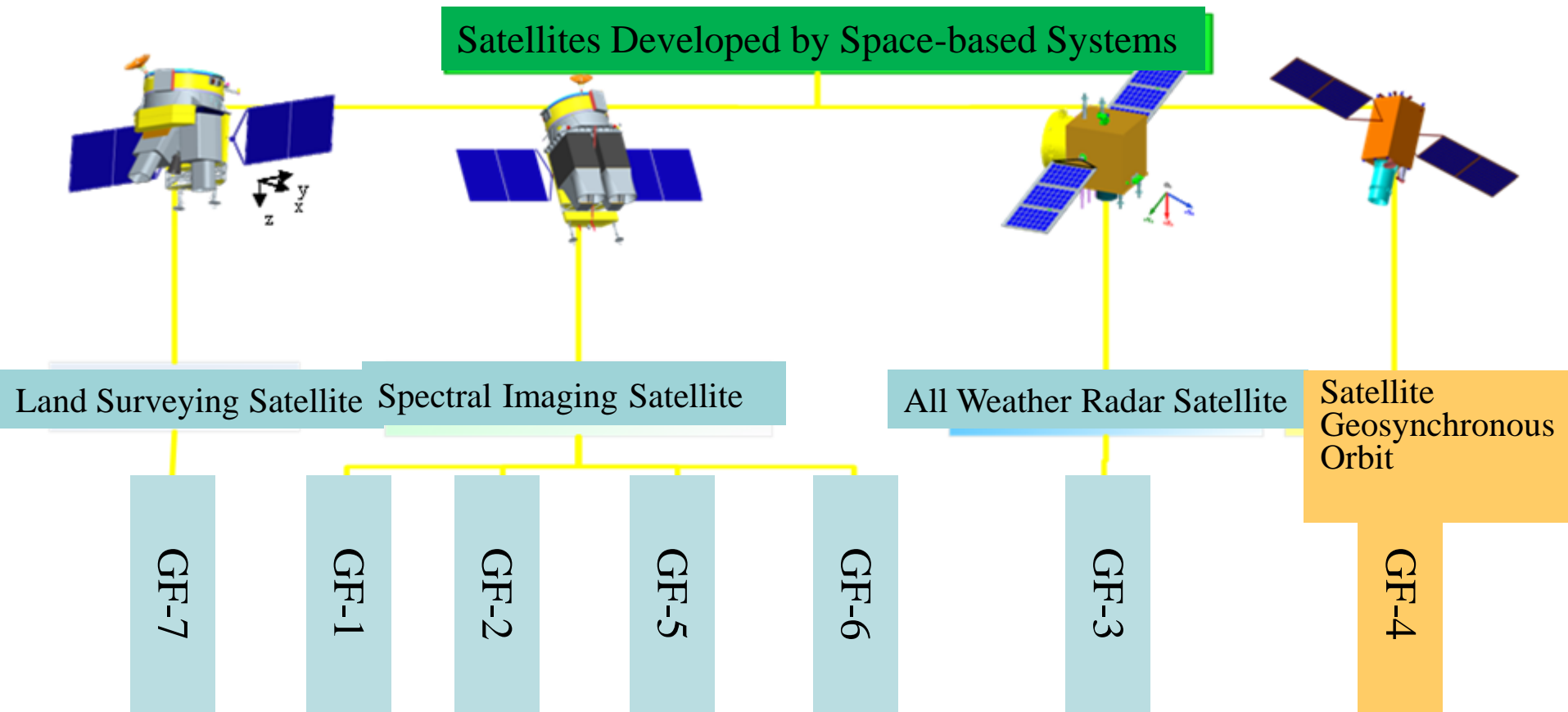
CHEOS – Space-Based System

The high partial load has the observation methods covering visible light, infrared, multispectral, hyperspectral, microwave, and laser, etc., to achieve high spatial resolution, high spectral resolution, high time resolution, and high-precision observation capabilities, serving business applications and scientific research.
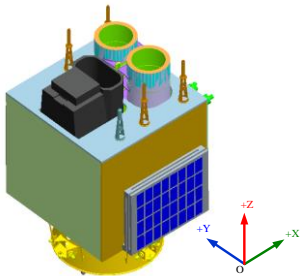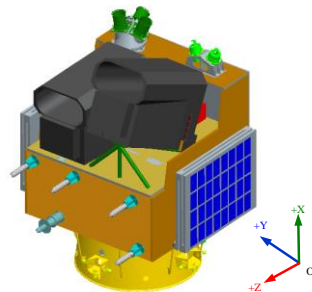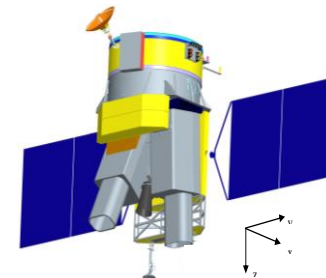

GF-1
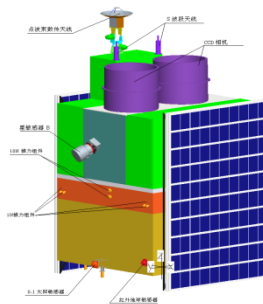
GF-2

GF-3

GF-4

GF-5

GF-6

GF-7

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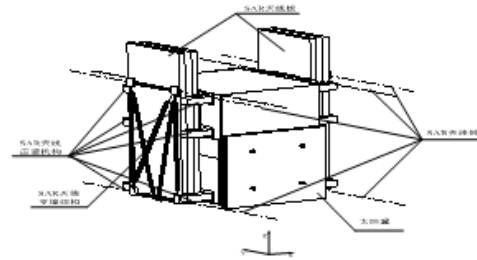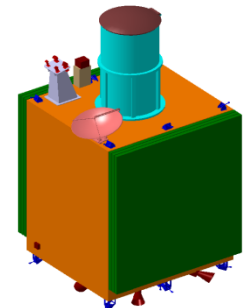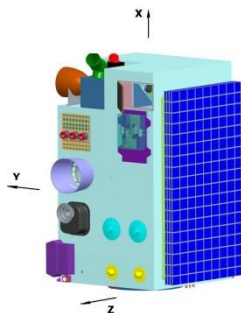
High-resolution Payload Characteristics

➤ **Fine**: high spatial resolution, high spectral resolution and high time resolution observation；

➤ **Comprehensive**: all-weather, all-day and global observations；

➤ **Efficient**: High spatial resolution and wide coverage at the same time, while increasing the spatial resolution, increase the coverage width and improve the efficiency of target detection；

➤ **New type**: Hyperspectral, multi-angle, polarization and other detection methods improve the ability of quantitative detection.

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CHEOS--Aviation System

Aviation System：

UAV platform
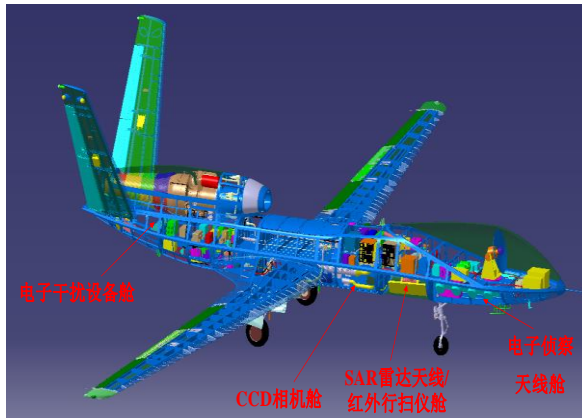
MAV platform

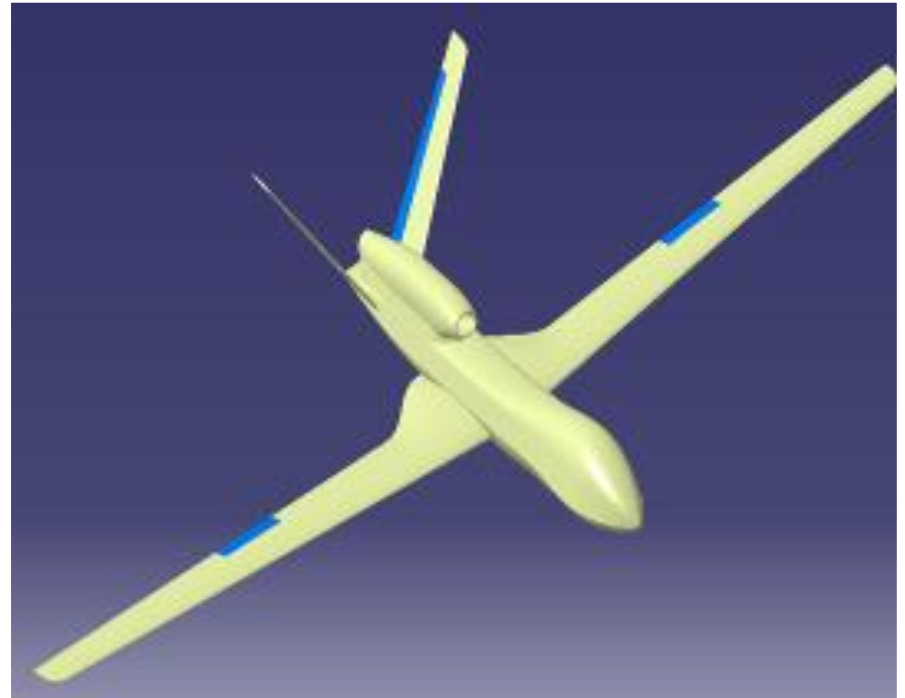| General Equipment		
Stable Platform	Position and Attitude Measurement System	Data Transmission System

Payload		
Laser Load	Microwave Load	Optical Load

CHEOS-- Aviation System

➢ **Develop a group of advanced aviation payloads with independent intellectual property rights.**

➢ **Renovate manned and unmanned aerial vehicle platforms supporting national science projects.**

➢ **Build China's Independent Aviation Observation System.**

CHEOS-- Aviation System

Aviation System Construction Goals:

Focus on breakthroughs in advanced aviation ground observation equipment technology, aviation general load technology and data processing technology, make full use of existing aviation flight platforms, form high-performance aviation ground observation systems, carry out ground observation verification tests and data acquisition, and apply to National basic surveying and mapping, resources and environment survey, natural disasters and emergency response.

CHEOS-- Ground System

The data center is responsible for unified mission planning, operation management control, global data reception, centralized organization and management, and unified shared distribution of space-based, near-space, and space-based payloads.
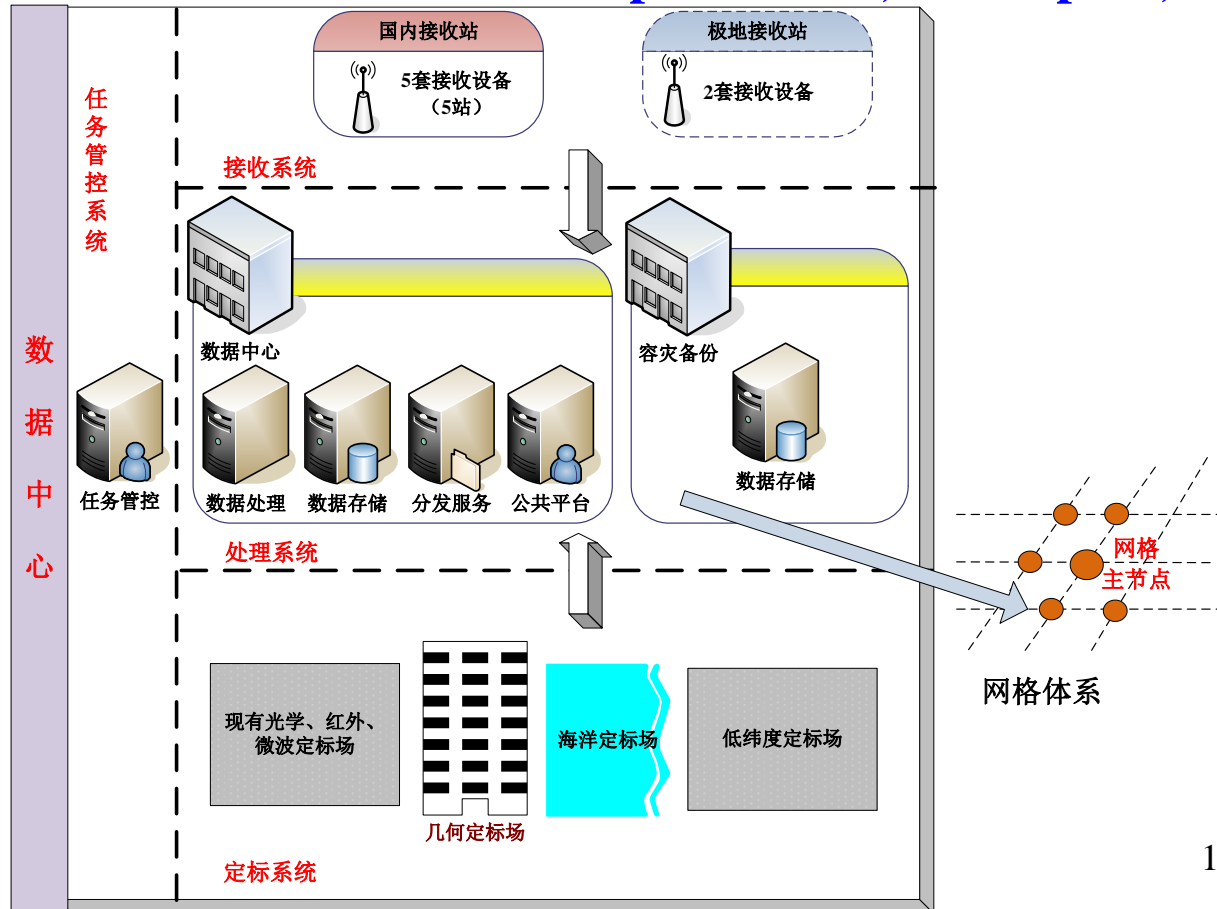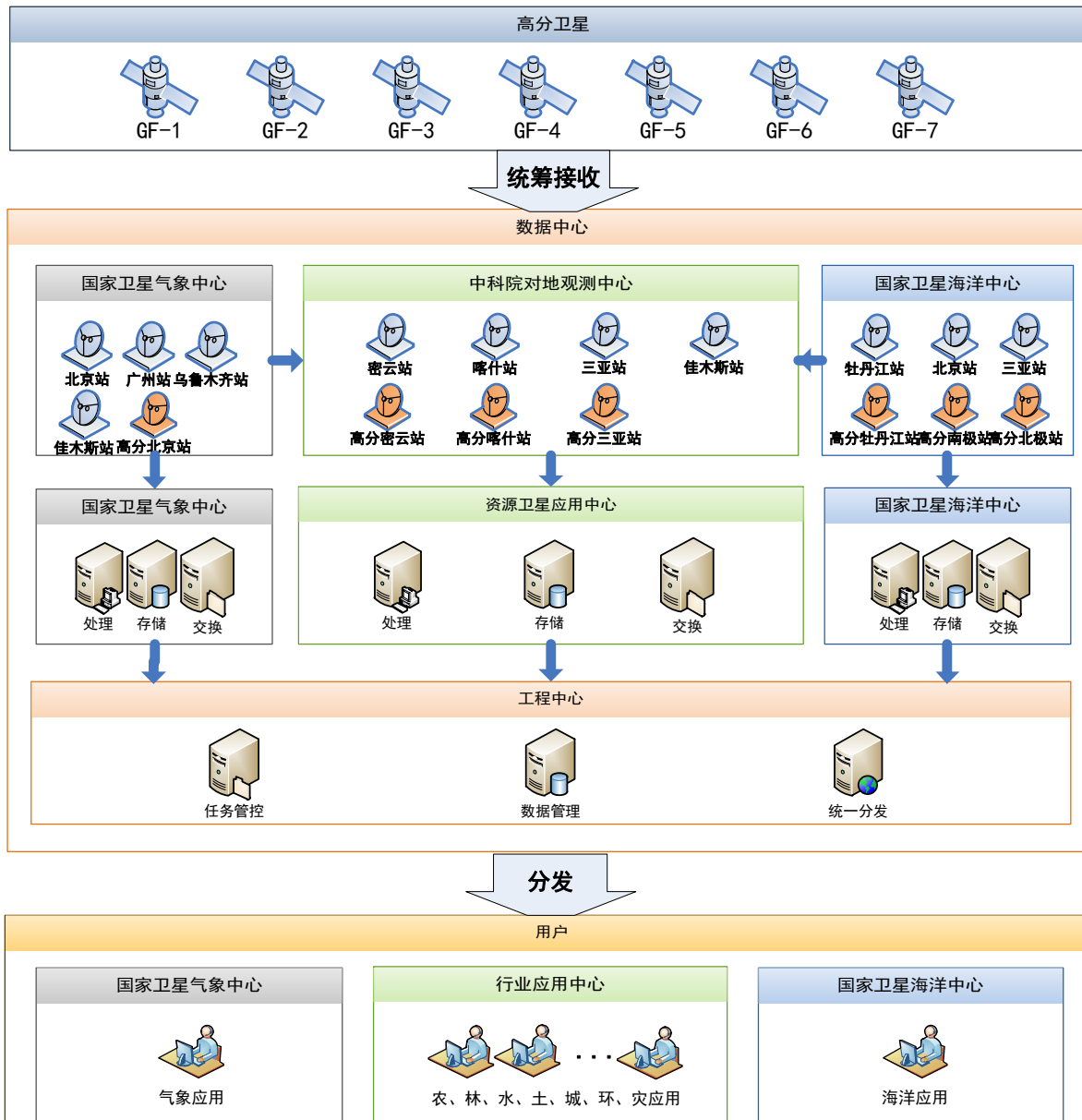
CHEOS-- Ground System

Data Center System:

The main function is to receive, process, store and distribute observation data. Integrate the construction of a national data center to achieve High-resolution system data and resource sharing, professional and public services .
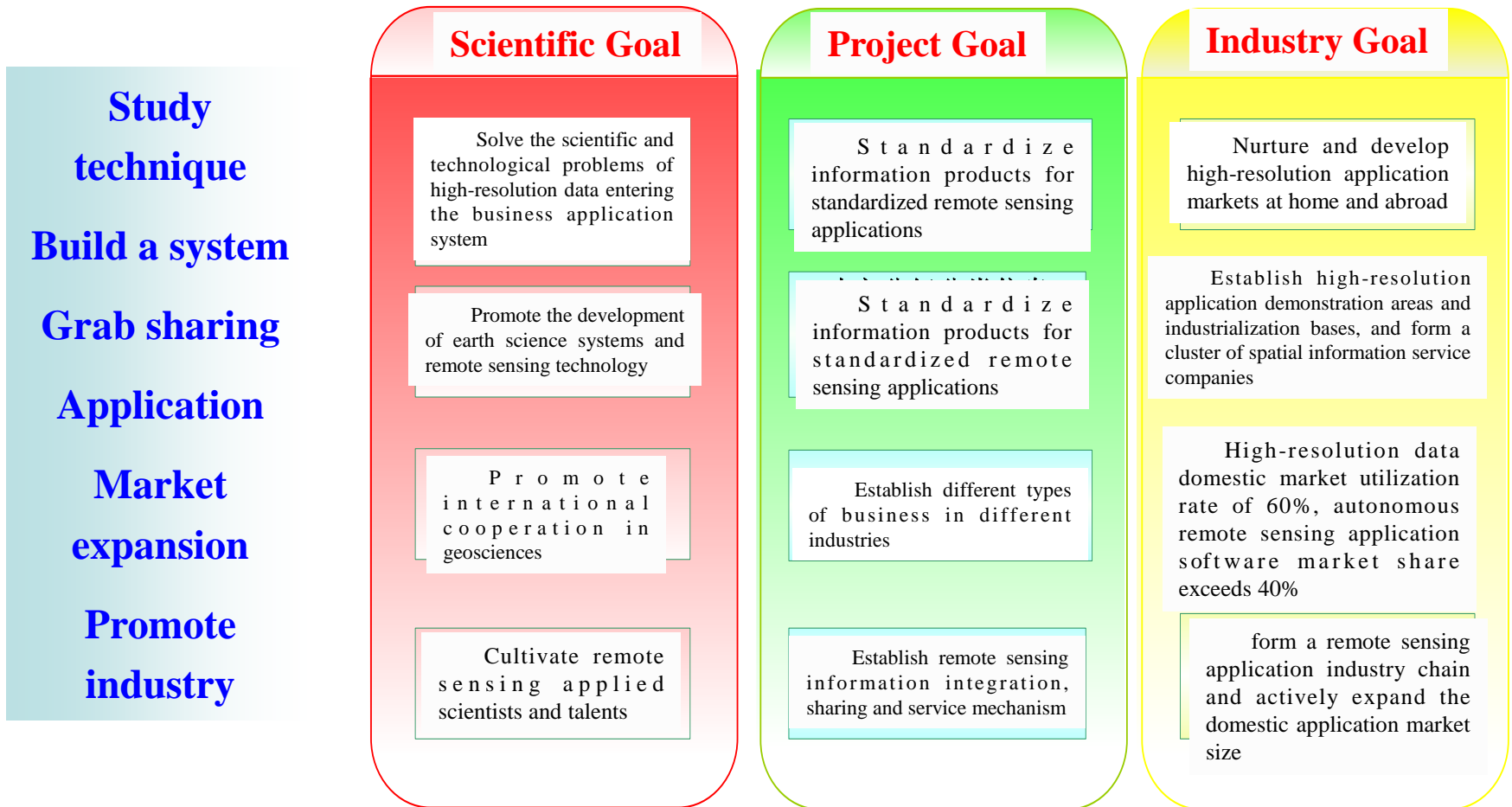
CHEOS-- Ground System

CHEOS-- Application System

➢   **The main function is to form common technical support for applications, implement application demonstration projects in key national industries and regions, promote the development of high-score application business, promote public and commercial application services, establish several industrial bases, and form a high-score information industry chain.**

➢   **It consists of industry application demonstration, regional application demonstration, industrialization demonstration, and common technology R & D and service system.**
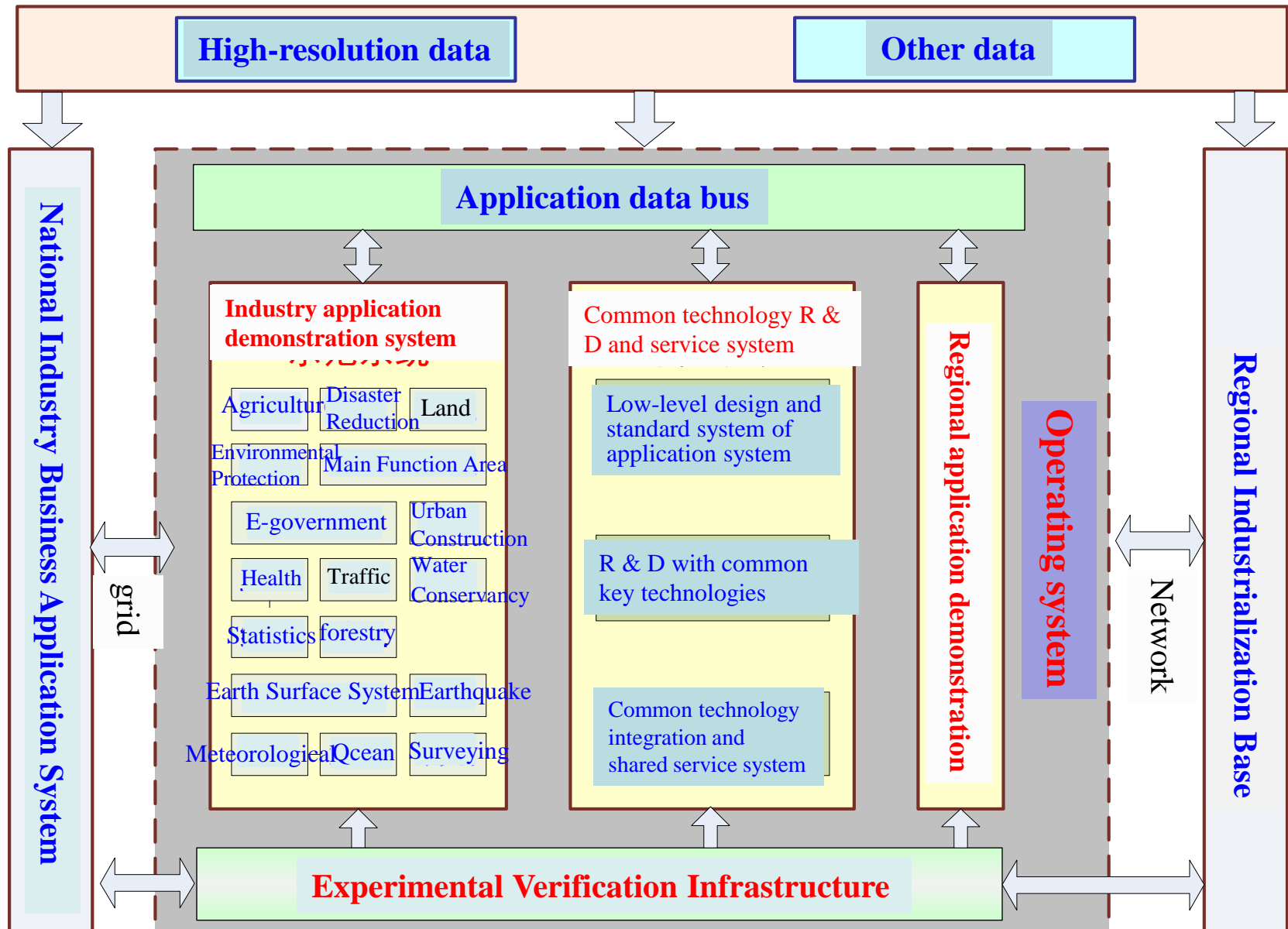
CHEOS-- Application System

➢   The application system focuses on solving the problem of "use" of High-resolution information sources, and is the "starting point" and "landing point" of the High-resolution system;

➢   Aim at national strategic needs, strengthen mechanism innovation and application model innovation, promote the transformation of civil aerospace from application test to business service, and become a new growth point of the national high-tech industry;

➢   Formed three systems of high-score application technology support, service demonstration and industrial promotion, with three major capabilities of independent research and development capabilities, business capabilities, and industrialization.

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Application System Construction Objectives

Study technique

Build a system

Grab sharing

Application

Market expansion

Promote industry

Scientific Goal

Solve the scientific and technological problems of high-resolution data entering the business application system

Promote the development of earth science systems and remote sensing technology

Promote international cooperation in geosciences

Cultivate remote sensing applied scientists and talents

Project Goal

Standardize information products for standardized remote sensing applications

Standardize information products for standardized remote sensing applications

Establish different types of business in different industries

Establish remote sensing information integration, sharing and service mechanism

Industry Goal

Nurture and develop high-resolution application markets at home and abroad

Establish high-resolution application demonstration areas and industrialization bases, and form a cluster of spatial information service companies

High-resolution data domestic market utilization rate of 60%, autonomous remote sensing application software market share exceeds 40%

form a remote sensing application industry chain and actively expand the domestic application market size

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1.   Build an advanced and comprehensive technical support system
2.   Build a multi-industry, multi-region High-resolution application system and share a cooperative operating environment to form an information processing and service system oriented to application needs
3.   Improve the operational application capability of autonomous remote sensing information sources and form a complete spatial information industry chain

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Composition of CHEOS

High-resolution data	Other data

National Industry Business Application System

Application data bus

Industry application demonstration system

Agriculture | Disaster Reduction | Land

Environmental Protection | Main Function Area

E-government | Urban Construction

Health | Traffic | Water Conservancy

Statistics | forestry

Earth Surface System | Earthquake

Meteorological | Ocean | Surveying

Common technology R & D and service system

Low-level design and standard system of application system

R & D with common key technologies

Common technology integration and shared service system

Regional application demonstration

Operating system

grid

Network

Regional Industrialization Base

Experimental Verification Infrastructure

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Composition of CHEOS

Industry Application Demonstration:

➢ **Based on High-resolution data, combined with the main business of each department, an industry High-resolution application demonstration system is established to form a typical thematic product processing capability of the industry at level 2 or higher, and a typical, leading, driving and innovative demonstration with industry characteristics is combined with the demonstration area. Application, drive industry sectors to promote the application of high score data.**

➢ **The main tasks include building agriculture, disasters, land, environmental protection, development and reform commissions (main functional areas, e-government), cities, transportation, water conservancy, health, statistics, forestry, Chinese Academy of Sciences (Surface System Science), earthquakes, meteorology, oceans, surveying and mapping and other industries to apply the demonstration system, and build the corresponding standard specifications and indicator systems, research and develop special products, and carry out demonstration applications in demonstration areas.**

Composition of CHEOS

Regional Application Demonstration:

➢ Select typical regions in China, rely on local governments and social professional institutions, make full use of industry application demonstration results through mechanism innovation, and construct several **regional application demonstration systems** in combination with major regional needs to form integrated application capabilities for level 2 data products and develop regional characteristics. Demonstration applications, driving local departments to widely use High-resolution data.

➢ The main tasks include demonstration of comprehensive application in the capital circle, demonstration of ecological environment monitoring in Xinjiang, demonstration of comprehensive development and construction monitoring in Sichuan after the disaster, refined management and spatial information services in cities, demonstration of development management in small and medium-sized towns, environmental monitoring and comprehensive development evaluation in coastal development zones Wait for **6** regional demonstration projects.

Composition of CHEOS

Industrialization Demonstration:

➢ **The industrialization demonstration mainly focuses on three aspects: High-resolution information processing services, data and information public processing services, and spatial information application services; communicating with local government departments to promote High-resolution industrialization and promoting base construction; promoting the construction of High-resolution technology alliances and Industry alliances; evaluate related software, products, and services, and promote the construction of intellectual property, education and training, and High-resolution brands.**

High-resolution Payload Characteristics

High Spatial Resolution

- **See more clearly**：**It is the primary requirement for regional refined monitoring. High-resolution special deployment of 5 satellites（GF-1 、GF-2 、GF-3 、GF-6 、GF-7 ）**

High Spectral Resolution

- **See more carefully**：**Finely monitor the environment (atmospheric environment, water environment) to promote green city construction**

High Temporal Resolution

- **See faster**：**Capture the dynamic changes of the area, provide high-frequency data, and promote efficient urban management and regional development**

High-resolution Data Characteristics

High Spatial Resolution Data

GF-1 、 GF-2 、 GF-6 、 GF-7 satellite, etc.

Feature：

➢ **High spatial resolution and strong discrimination of ground objects**

➢ **With rich texture information and structure information, it can more intuitively reflect the actual surface situation.**

Extraction of information on green space, buildings, water bodies, roads, etc., service area planning and management .

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Outline

一　**Introduction to China High-Resolution EOS**

二　**High-resolution Satellite Data And Applications**

三　**High-resolution Satellite's Application in Smart City**

Gaofen-1 Satellite Image

➢ **Successful launch on April 26, 2013.**

➢ **Equipped with 2 high-resolution cameras with 2m panchromatic / 8m multispectral resolution (observation combination width is better than 60km) and 4 multispectral medium-resolution wide-resolution cameras with 16m resolution Combined width is better than 800 kilometers)**

➢ **The satellite operates in a sun-synchronous orbit at an altitude of 600-700km and at the point of descending intersection at 10:30 am, and the design life is 5-8 years.**

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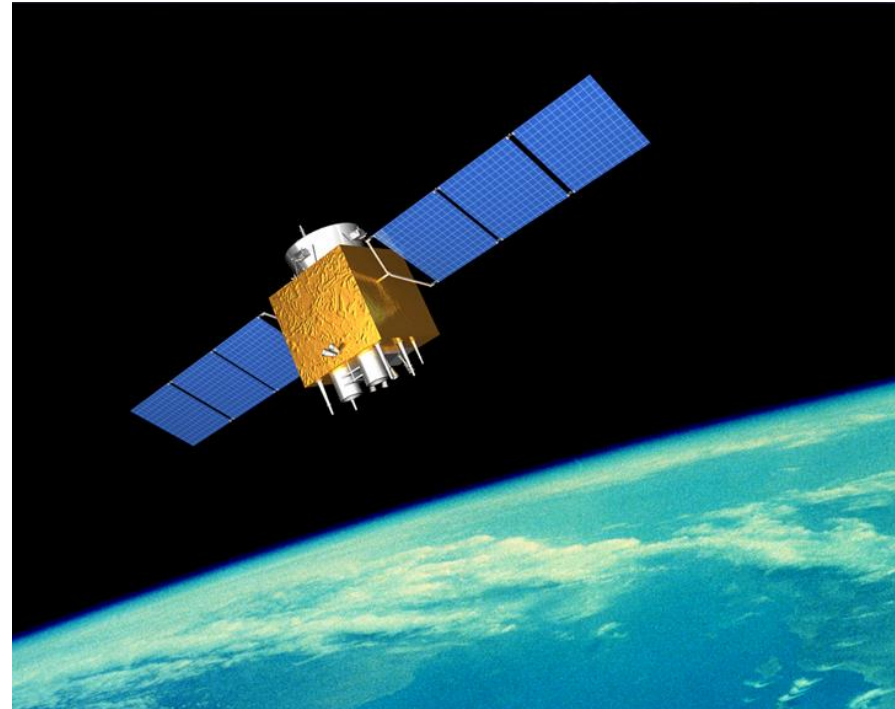
Satellite and its Payload

GF-1 Satellite Load

Load	Band	Spectral range (μm)	Spatial resolution (m)	Quantify (Bits)	Width (km)	Coverage cycle (Day)
	P	0.45-0.9	2	10	70	41
PMS	B1	0.45-0.52	8	10	70	41
	B2	0.52-0.59				
	B3	0.63-0.69				
	B4	0.77-0.89				
WFV	B1	0.45-0.52	16	10	200*4	4
	B2	0.52-0.59				
	B3	0.63-0.69				
	B4	0.77-0.89				

Satellite and its Payload

Remote Sensing Satellite Orbital Characteristics

➢ **Near-circle:**

> Small eccentricity, typical value is 0.001. The satellites operate approximately uniformly, making it easy to obtain images at different scales in different regions.

➢ **Near Polar:**

> In favour of increasing the total observation range of the satellite, the typical value is in the range of 80-85 degrees north-south latitude.

➢ **Sun-synchronous:**

> The angle between the satellite orbital plane and the Sun-Earth connection in the ecliptic plane does not change as the earth orbits the sun. It is beneficial for the satellite to image the ground under similar lighting conditions, and it is also beneficial for the solar cells on the satellite to obtain stable solar illumination.

➢ **Repeating track: regression characteristics.**

Satellite and its Payload

GF-1 Satellite Orbit Characteristics

Track form	Sun synchronous return to frozen orbit
Track height (km)	644.5
Eccentricity	0.0011
Orbit inclination (degrees)	97.96
Intersection period (minutes)	97.466
Run circles per day	14+31/41
Return period (days)	41
total number of turns	605
Distance between adjacent tracks (km)	66.34
Down intersection local time	10：30

General Overview

Gaofen-1 satellite：

    This data is widely used in land use dynamic remote sensing monitoring, mineral resources survey, environmental monitoring and investigation, crop area remote sensing dynamic monitoring, disaster reduction and prevention, and forest protection.

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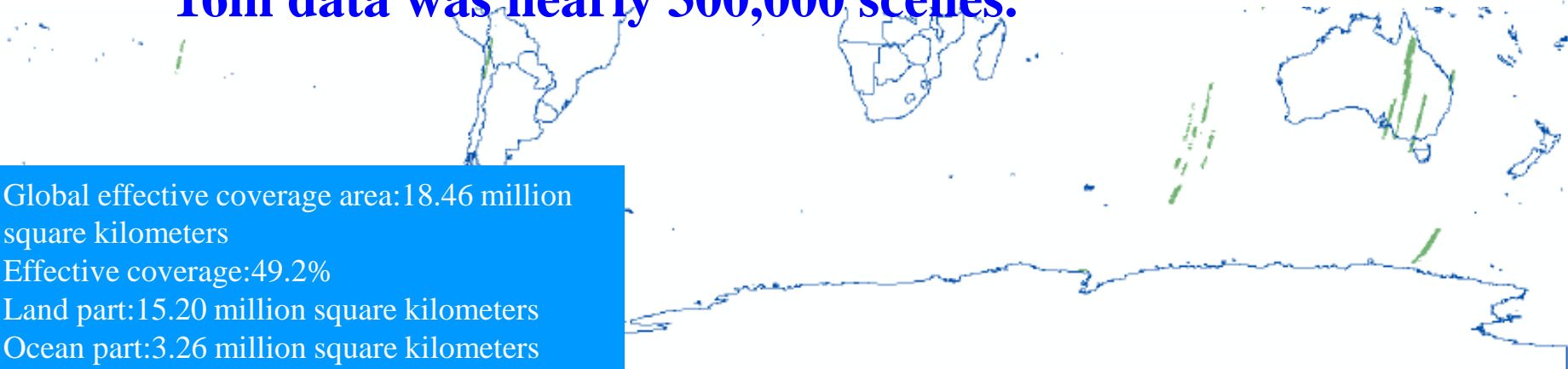
Gaofen-1 Satellite Data and Application Display

to September 18, 2014:

Nearly 1.3 million scenes were distributed for the Gaofen-1 satellite data; 2m / 8m data exceeded 1m scenes, and 16m data was nearly 300,000 scenes.

Global effective coverage area:18.46 million square kilometers
Effective coverage:49.2%
Land part:15.20 million square kilometers
Ocean part:3.26 million square kilometers

Global effective coverage of 2m / 8m full-color multispectral data in the first half of 2014

China's effective land area:6.94 million
square kilometers(72%）

**National effective land coverage of 2m / 8m full-color
multispectral data in the first half of 2014**

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GF-1 Satellite Data and Application Display

Global effective coverage area:33.08 million square kilometers
Land part:23.08 million square kilometers
Ocean part:10.00 million square kilometers
China land:9.42 million square kilometers(98%)
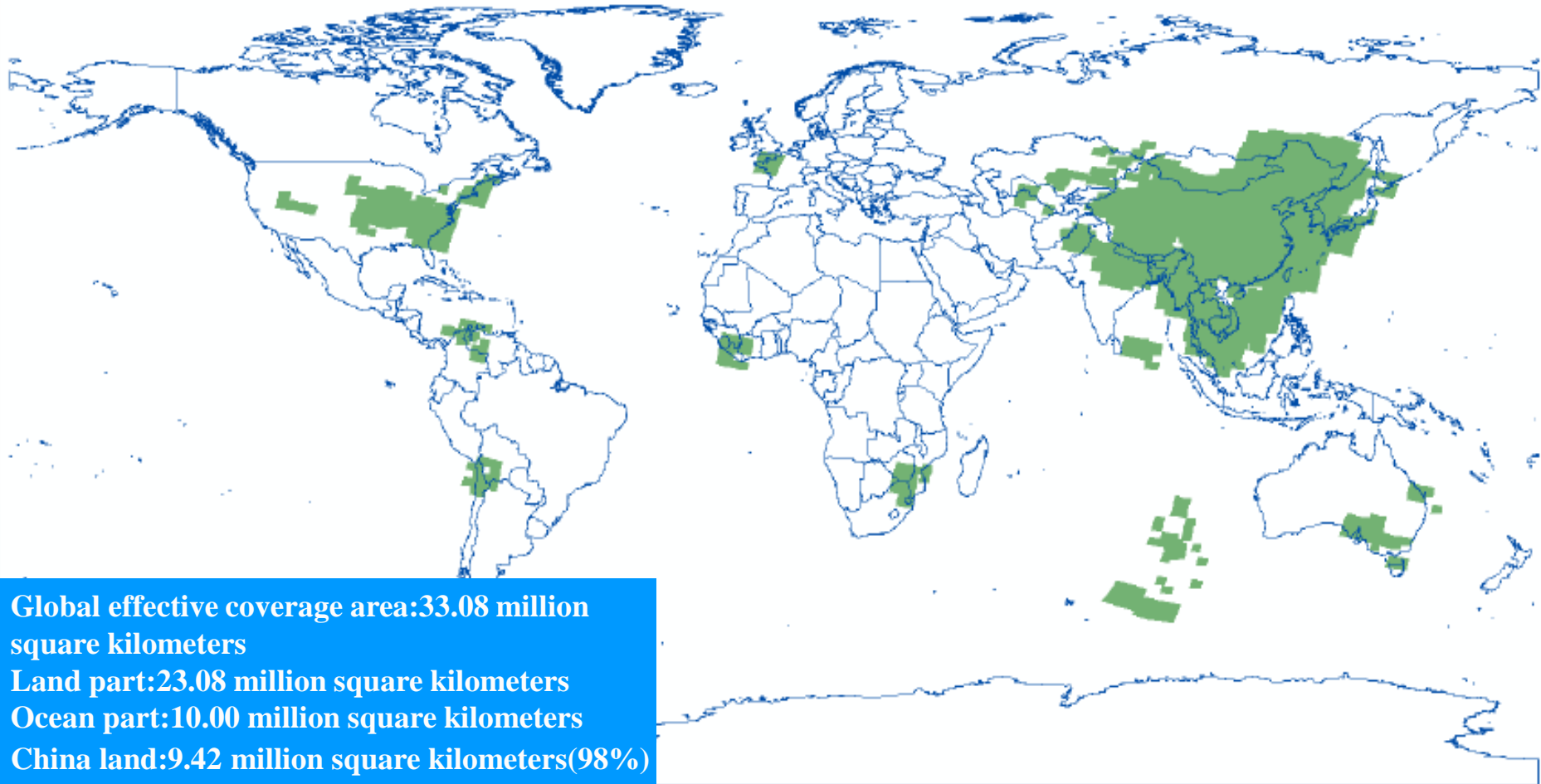
Global effective coverage of 16m multispectral data in the first half of 2014

Gaofen-1 Satellite Data and Application Display

It can clearly identify typical urban features such as urban buildings and urban green spaces, and can be applied to urban construction archives management, urban gardening, urban planning, and urban environmental assessment, serving urban refined management.

National Theatre
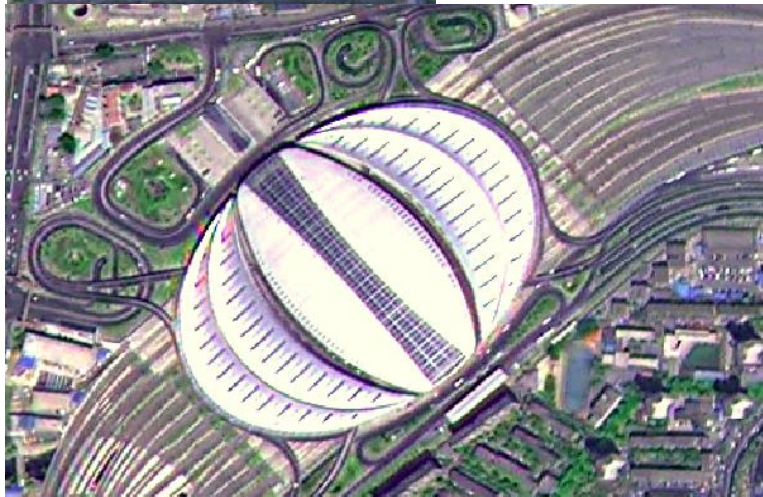
The forbiddenCity

Beijingnan Railway Station

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Gaofen-1

PMS
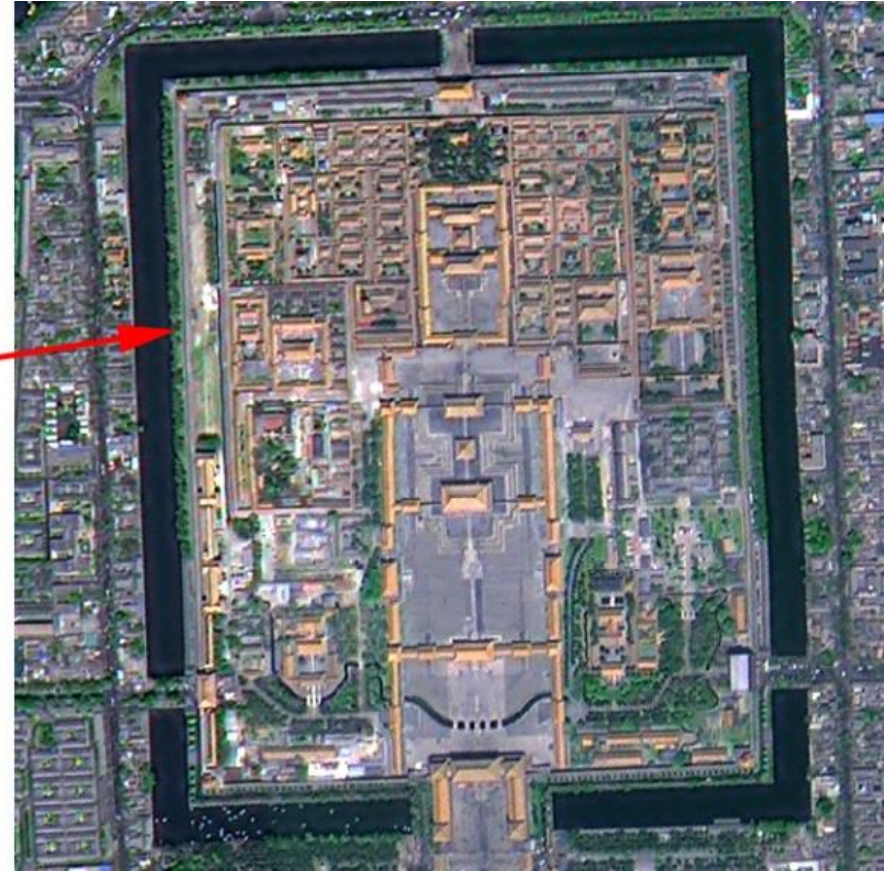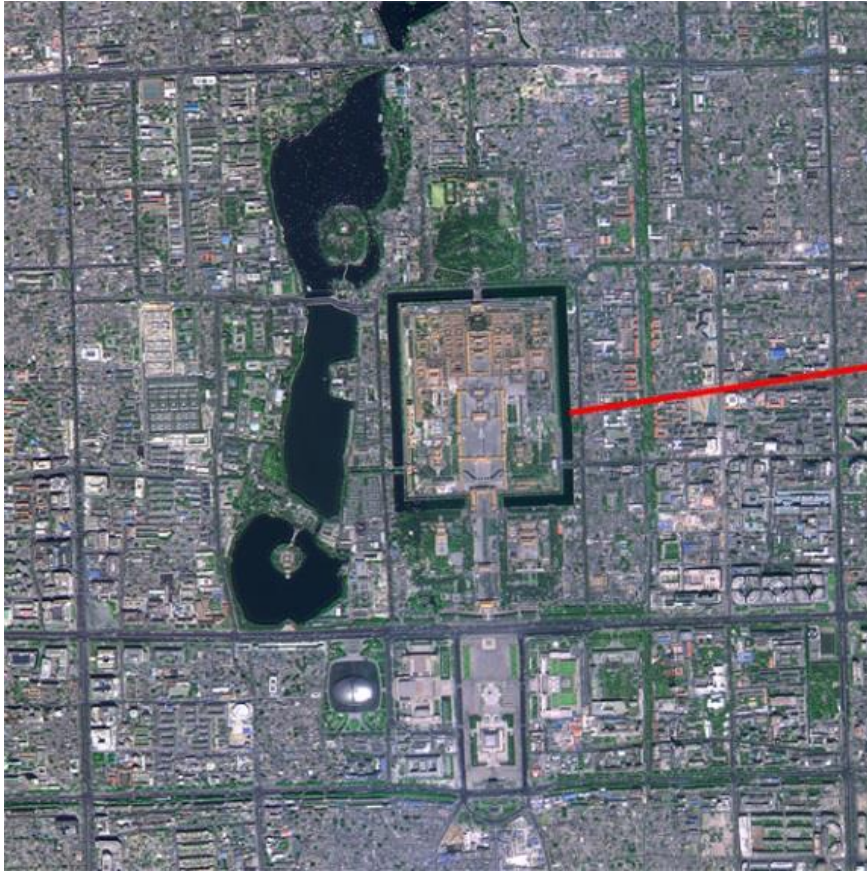
Gaofen-1

WFV

GF-1 16 meters 800 kilometers wide

Gaofen-1

WFV

Gaofen-1 application example-atmospheric environment monitoring

Wind Blows Haze Away (Beijing-Tianjin-Hebei area of North China Plain)
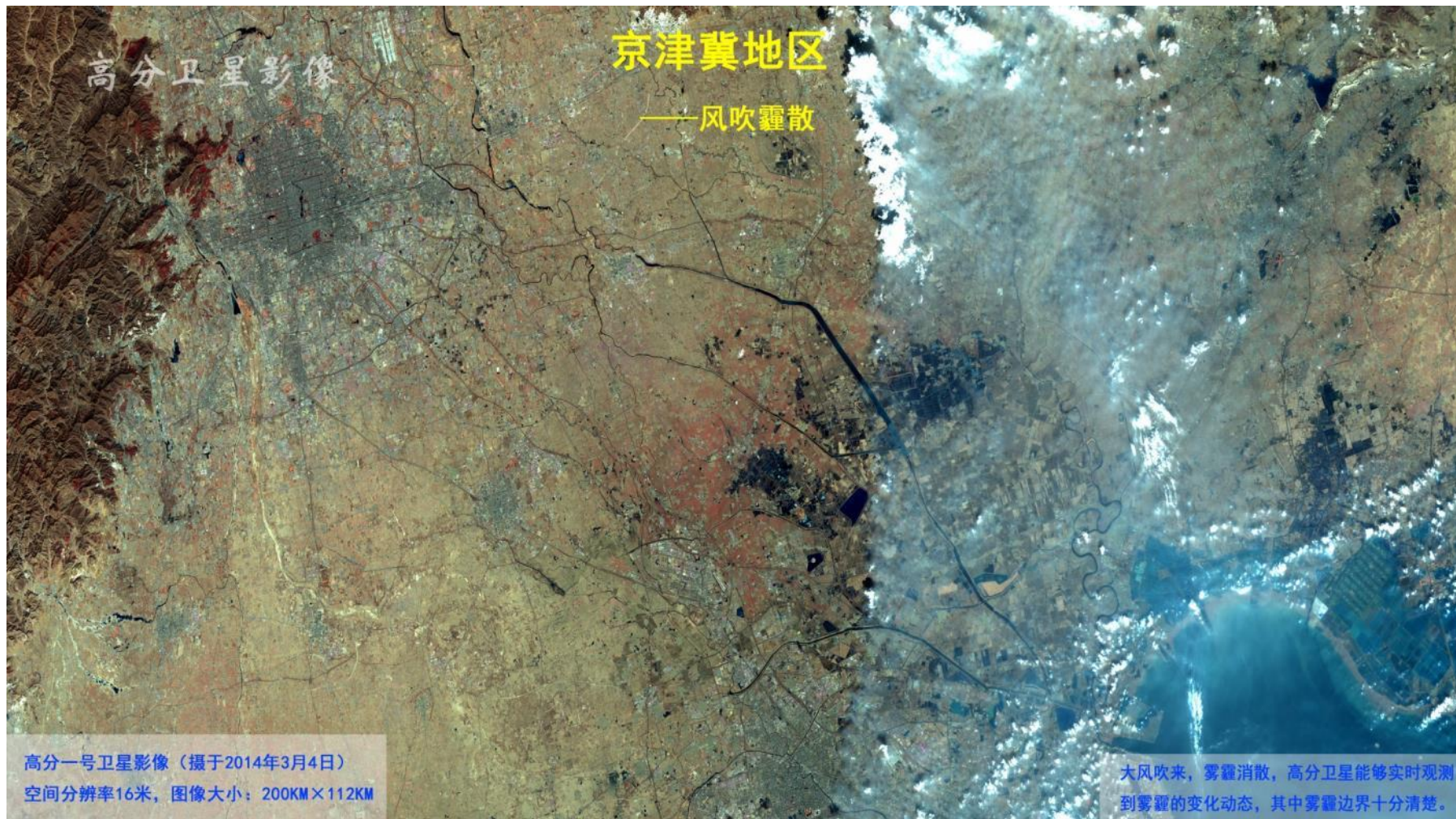
Gaofen-2 satellite

On August 19, 2014, GF-2 was successfully launched at the Taiyuan Satellite Launch Center, marking that China's remote sensing satellites have entered the sub-meter level of "high score era".

The main users of Gaofen-2 satellites are the Ministry of Land and Resources, the Ministry of Housing, Transport and forestry. After the GF-2 satellite is put into use, it will cooperate with the GF-1 satellite in orbit to promote the application of high-resolution satellite data for dynamic monitoring of land use, survey of mineral resources, monitoring and evaluation of urban and rural planning, and road network planning , forest resource survey, desertification monitoring and other industries and regional applications such as the capital circle to provide service support.

General Overview

Gaofen-2 satellite：

➢   **Launched on August 19, 2014, the spatial resolution of panchromatic image data is better than 1 meter, the spatial resolution of multispectral image data is better than 4 meters, and the combined width is better than 40 kilometers.**

Gaofen-2

High RS , 0.5m

Gaofen-2 Satellite Image

高 分 二 号 卫 星 北 京 融 合 影 像

融合方式: 全色影像(0.8米)和多光谱影像(3.2米)融合
接收日期: 2014年09月27日   比例尺 1:4 000
国防科工局重大专项工程中心
中 国 资 源 卫 星 应 用 中 心   制作

The forbidden City, as an emperor palace building group, has the most oriental style. From the picture, you can distinguish the scale of the forbidden City and the pattern of buildings.

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Gaofen-2 Satellite Image

高 分 二 号 卫 星 上 海 融 合 影 像

融合方式： 全色影像(0.8米)和多光谱影像(3.2米)融合
接收日期： 2014年09月25日   比例尺1：4 000   国防科工局重大专项工程中心
                                                             中 国 资 源 卫 星 应 用 中 心 制作

The figure highlights the large-scale buildings and shadows such as the Oriental Pearl and the Jinmao tower in Dong'an on the Huangpu River.

Gaofen-2 Satellite Image

高 分 二 号 卫 星 上 海 虹 桥 机 场 融 合 影 像

融合方式： 全色影像(0.8米)和多光谱影像(3.2米)融合
接收日期： 2014年09月25日

比例尺 1：4 000

国防科工局重大专项工程中心
中 国 资 源 卫 星 应 用 中 心　制作

Reflecting the pattern of Shanghai Hongqiao Station and the architectural style of Hongqiao Airport, it can accurately measure all types of aircraft parked at the airport.

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CHEOS Composition

Gaofen-3 satellite：

➢   It is launched in early 2016. The C-band fully polarized microwave image data has multiple working modes with a resolution of 1 meter to 500 meters.
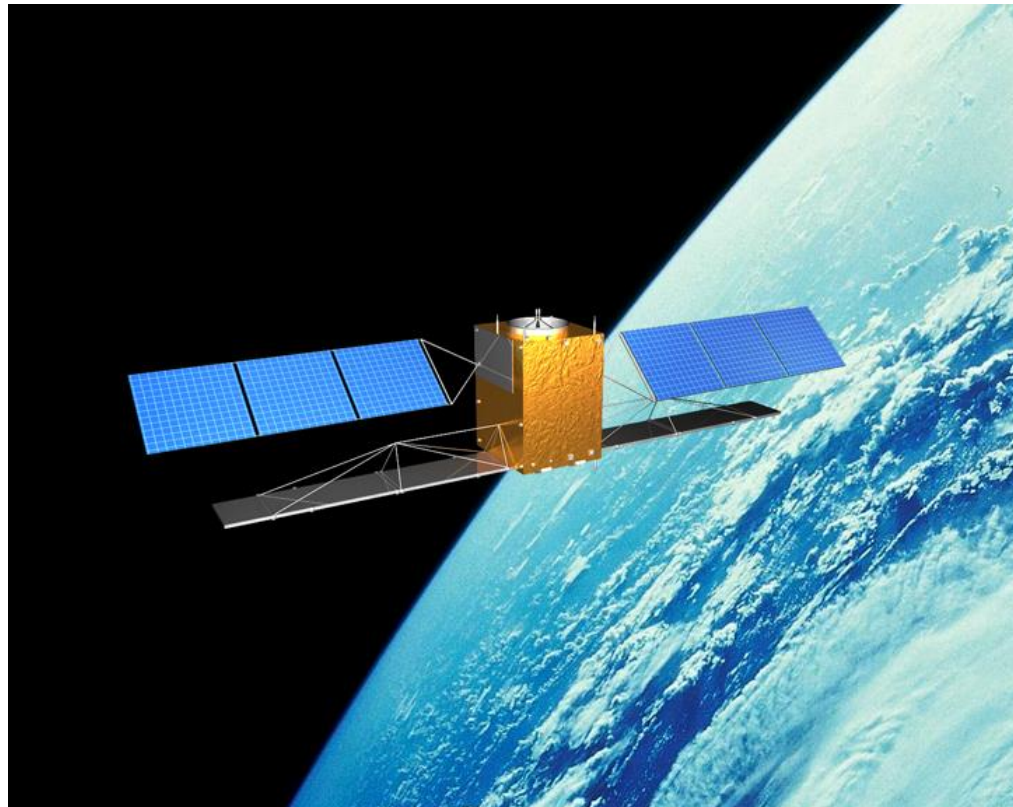
Gaofen-3

Gaofen-3 Satellite Image · Wuhan, Hubei
Spotlight mode 1 m resolution

Gaofen-3 Radar satellite

The GF-3 mission, launched in Audust 2016, has 12 imaging modes, such as Spotlight Mode, Stripmap Mode, Scan Mode. It is the first Chinese SAR satellite to acquire muti-polarized SAR image with resolution of 1~500 meters and cover a total swath of 10~650 kilometers. The maximum working duration is 50 minutes.

High-resolution Data Characteristics

High-resolution SAR data

Gaofen-3 satellite

Features:

➢ **With all-day, all-weather observation capability**
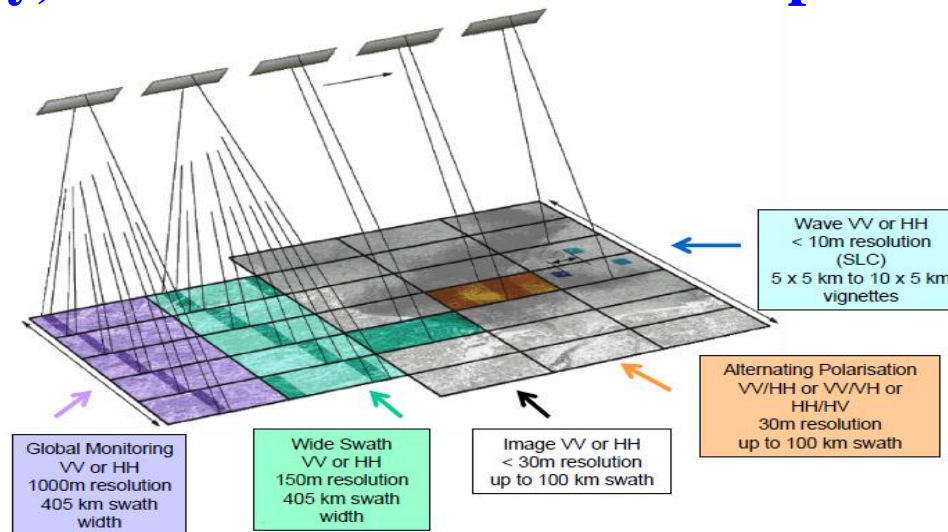
Water flood monitoring, etc.

High-resolution Data Characteristics

Characteristics of SAR load

Gaofen-3 satellite

- **Working frequency band: C-band / 5.4GH**
- **Polarization method: full polarization (HH, HV, VH, VV)**
- **Working modes: (12 types) spotlight mode, strip mode (super fine, fine strip I, fine strip II, standard strip, fully polarized strip I, fully polarized strip II), scan mode (Narrow, wide), wave mode, global monitoring mode, extended incident angle mode**
- **Spatial resolution: 1m (bunching), 3m, 5m, 8m, 10m, 25m (strip), 50m, 100m (scanning), 10m (wave mode), 500m (global), 25m (extended incident angle)**
- **Width: 10km × 10km (bunch), 30km, 40km, 50km, 100km, 130km (strip), 300km, 500km (scan), 5km × 5km (wave mode), 650km (global), 80km, 130km (extended) Angle of incidence)**
- **With dual-side imaging capability**

GF-3 Radar Satellite Main Parameters (Red GF-3, Green Radarsat-2)

Imaging Mode	Resolution(m)	Swath(km)	Incidence angle(°)	Polarization
Spotlight(Radarsat-2 test mode)	1（0.8×3）	10×10（20×8）	20~50	Optional Single Polarization
Hyperfine Stripmap	3（3）	30（20）	20~50（30~40）	Optional Single Polarization
Fine Stripmap 1	5（8,2 looks）	50（50）	19~50（30~50）	Optional Dual Polarization
Fine Stripmap 2	10（8）	100（50）	19~50（30~50）	Optional Dual Polarization
Stripmap	25（25）	130（100）	17~50（20~49）	Optional Dual Polarization
Narrow Scan 1	50（50）	300（300）	17~50（20~47）	Optional Dual Polarization
Wide Scan 2	100（100）	500（500）	17~50（20~49）	Optional Dual Polarization
Full Polairzation Stripmap 1	8（8）	30（25）	20~41（20~41）	Full Polarization
Full Polairzation Stripmap 2	25（25）	40（25）	20~38（20~41）	Full Polarization
Wave Imaging(No)	10	5×5	20~41	Full Polarization
Global observation(No)	500	650	17~53	Optional Dual Polarization
Extended incidence angle(near、far)	25（25）	130/80（75）	10~20/50~60（49~60）	Optional Dual Polarization

Gaofen-3

GF-3 Satellite Image · Wuhan, Hubei

Spotlight mode 1 m resolution

Gaofen-3

Xiamen City(HH / 1 m)　　**Wuhan City(HH / 1 m)**

Xiangshan County, Zhejiang Province

HH	HV
Pseudo-color	
VH	VV
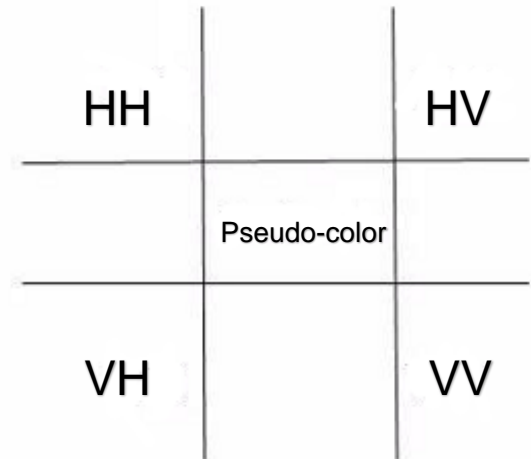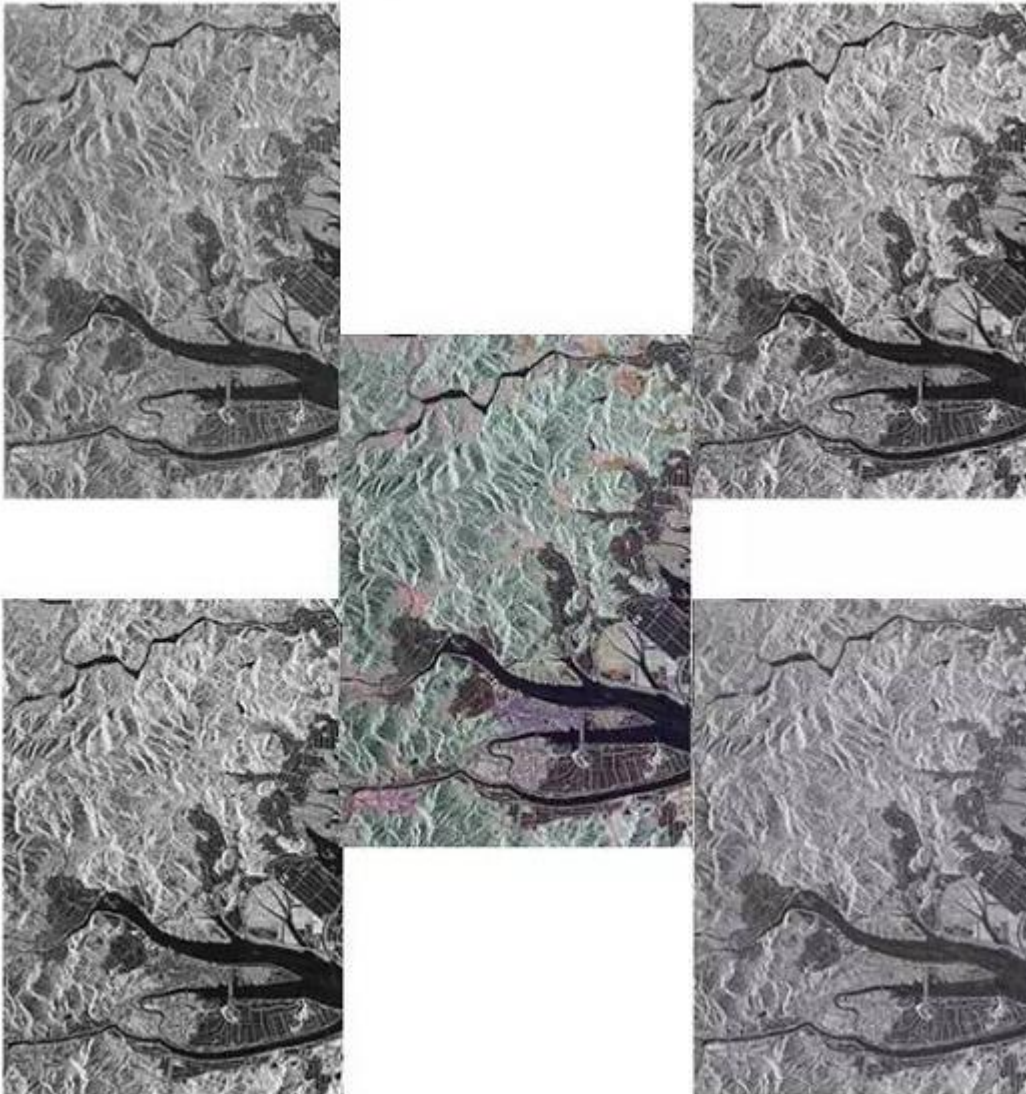
8 m / Full polarization

System Composition

Gaofen-4 satellite：

➢ **It is planned to be launched at the end of 2015. It is a geosynchronous orbit high-time resolution satellite (10-minute class), with full-color / multispectral image data with a resolution of 50 meters.**

Gaofen-4 Satellite
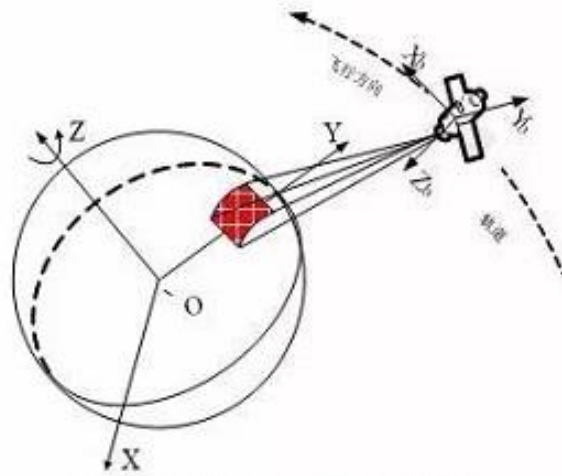
（a） Gaze Imaging Mode
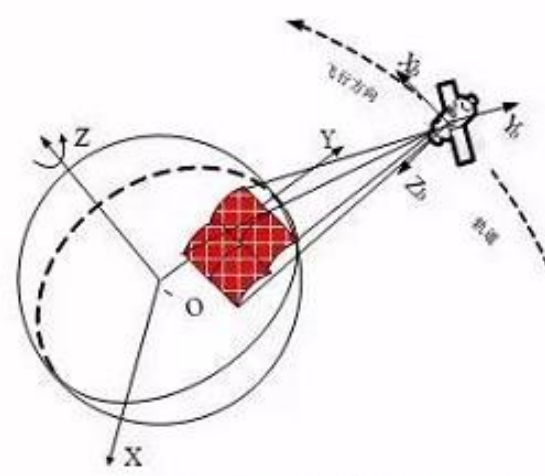
（b） Area Imaging Mode
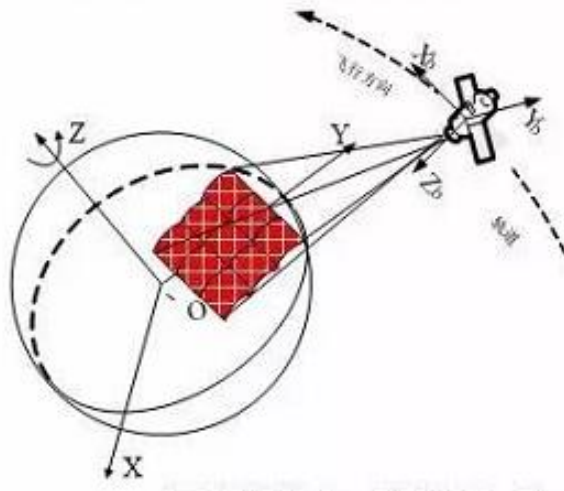
（c） Regional Census
Imaging Mode
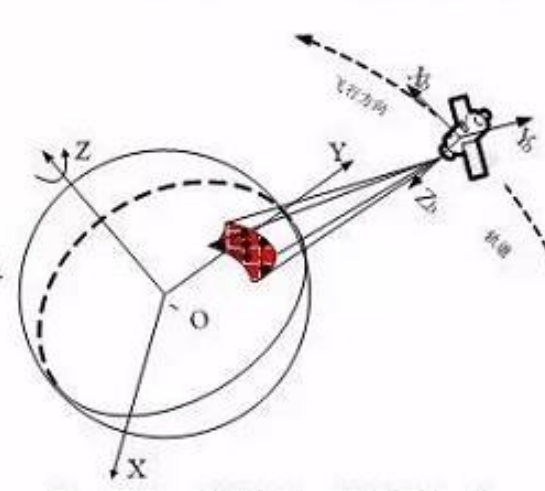
（d） Mobile Inspection
Imaging Mode

Data Characteristics

Characteristics of High Time Resolution Loads

Gaofen-4 satellite

- ➢ **Orbit:** geosynchronous orbit
- ➢ **Band:** full color: 0.45 ～ 0.90μm
- ➢ **Multispectral:** B1: 0.45 to 0.52 μm, B2: 0.52 to 0.60 μm, B3: 0.63 to 0.69 μm, B4: 0.72 to 0.90 μm
- ➢ **Infrared:** 3 ～ 5μm
- ➢ **Resolution:** full color / multispectral is better than 50m, infrared is better than 400m, temperature resolution is better than 0.2K
- ➢ **Single scene coverage area:** visible light 500km × 500km, mid-infrared 400km × 400km
- ➢ **Area imaging capability:** 2000 × 2000km / 10min
- ➢ **Satellite imaging area:** 7000km × 7000km

Gaofen-4 Satellite

Item	Visible Light Near Infrared Channel	MW Infrared Channel
Spectral Range	B1：450~900nm B2：450~520nm B3：520~600nm B4：630~690nm B5：760~900nm	B6：3.5um~4.1um
Focal Length	6600mm	1350mm
Cell Size	9um	15um
Detector	10K X 10K	1K X 1K中红波外器件
Ground Instantaneous Field of View	50m	400m
Single Scene Imaging Area	500km X 500km	400km X 400km
Fov	0.8° X 0.8°	0.66° X 0.66°
Integration Time	0.5ms~100ms	0.1ms~10ms

Gaofen-4 Satellite

Qiongzhou Strait

Bohai Bay

Data Characteristics

High Time Resolution Data

Gaofen-4 satellite

Features：

➢ **High time resolution is conducive to capturing the changing process of the ground features, and has the ability to respond quickly to key events.**

Serving agriculture, forestry, environment, cities, disasters, construction, etc.

Application of remote sensing with high time and space resolution in model assimilation

satellite data

Remote sensing inversion by LAI

LAI

compare

modify

Crop growth model

Parameter set
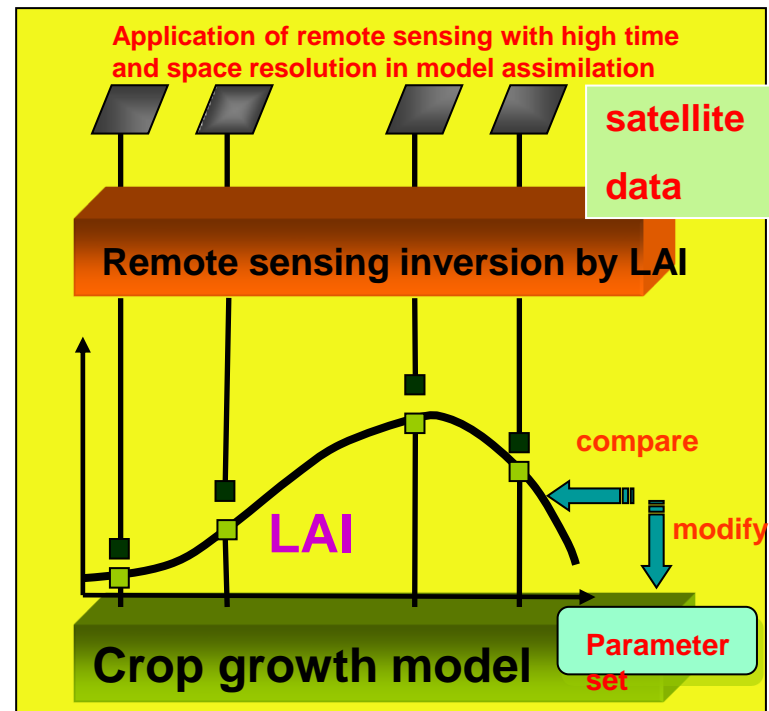
Gaofen-4 Satellite

Gaofen-4(GF-4)

➤   **Launched on 29 December 2015，Location at 105.6°E**

➤   **GF-4 is China's first high resolution geostationary satellite. Its spatial resolution is 50m at visible and near infrared band, and 400m at mid-infrared band. Its temporal resolution can reach several seconds.**

62
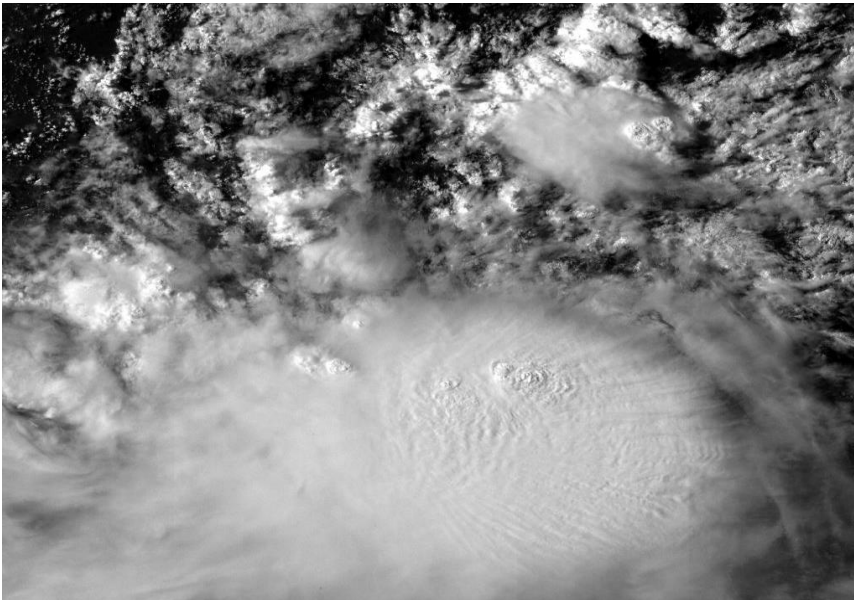
Gaofen-4 Satellite Data

Gaofen-4 satellite has achieved the second observation of 50m resolution in geostationary orbit for the first time in the world.

The observation result of the satellite Gaofen-4 on Typhoon Nida, the spatial resolution is 50 meters, and the observation frequency is 1 minute.

From this, we can clearly observe the refined structural characteristics of the typhoon eye area and the evolution characteristics of small and medium-scale convection in the cloud system, which provide important references for improving the accuracy of typhoon paths and intensity forecasts.
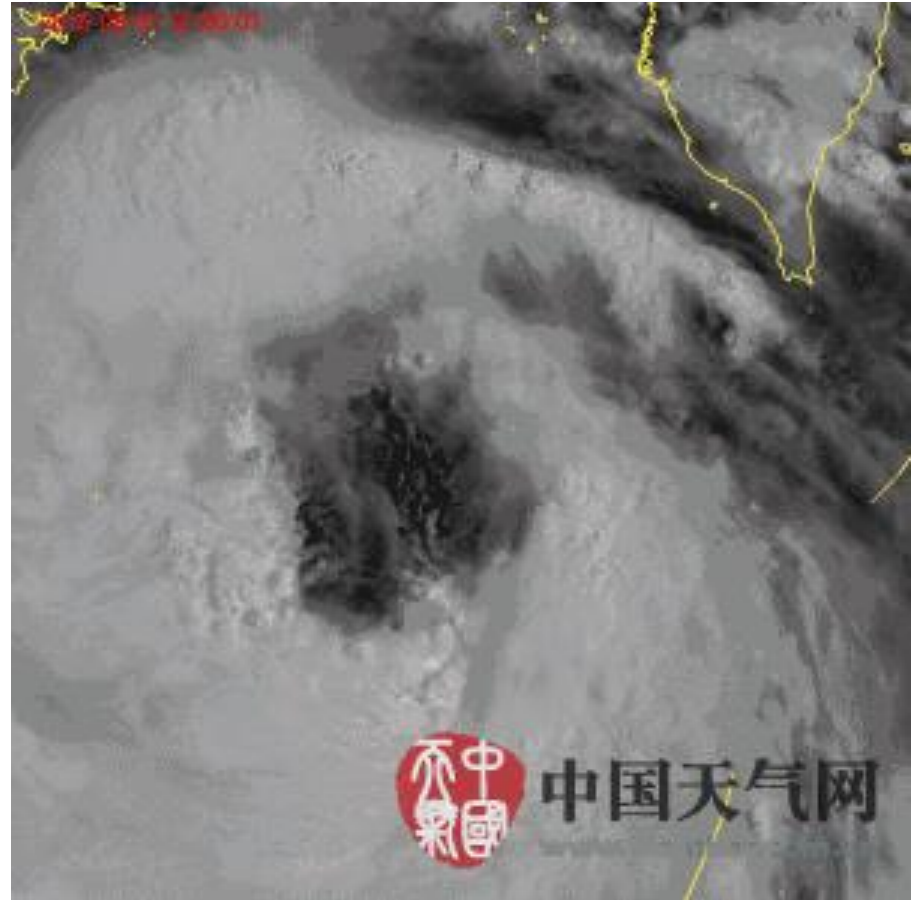
GF-4 dynamic monitoring
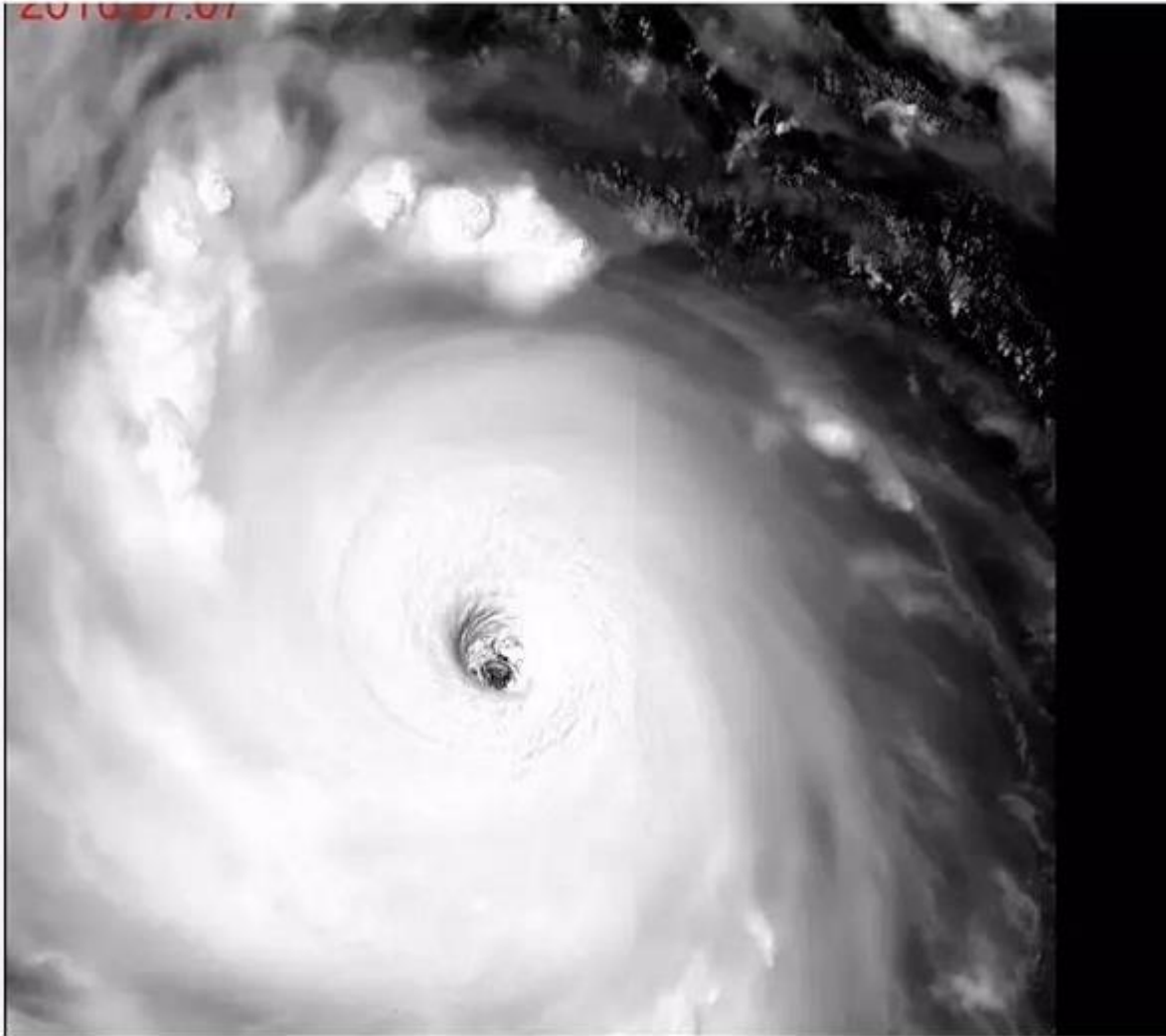
Spatial Resolution: 50m

Time Resolution:
5 ~ 20 seconds
Field of View: 0.8 degrees
format: 400 * 400 km

Gaofen-4 Satellite

Observe Typhoon Eyes Every 10 Seconds
(GF-4 Satellite Image · Typhoon Monitoring)

Gaofen-4 Satellite

7s
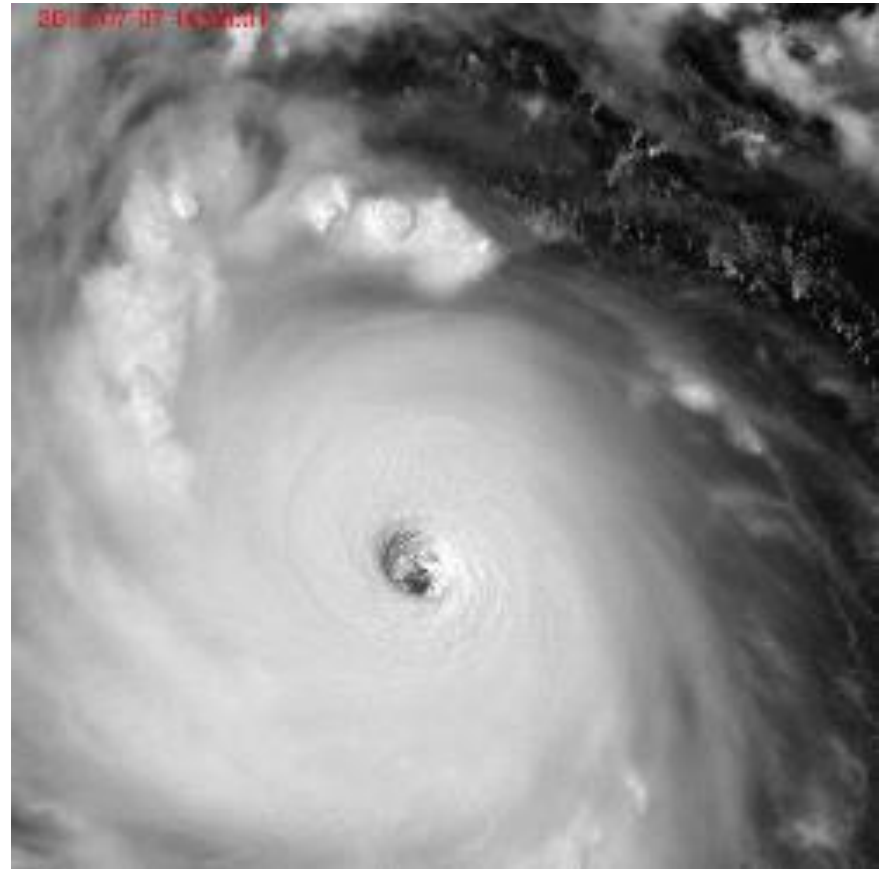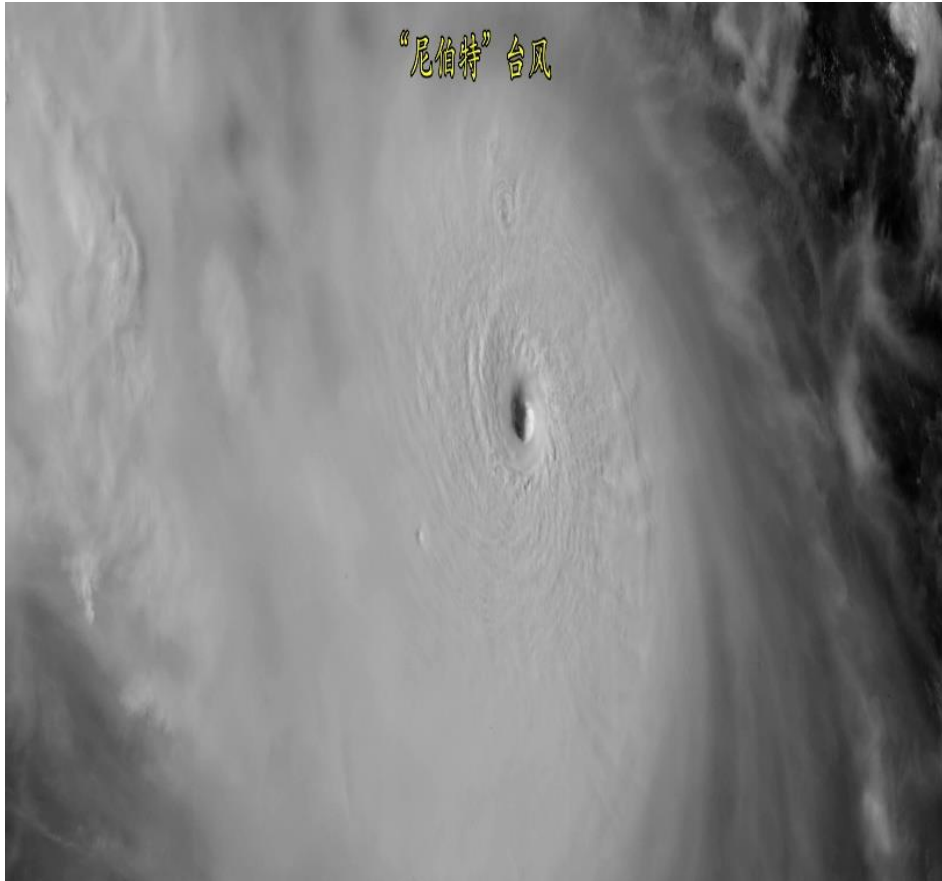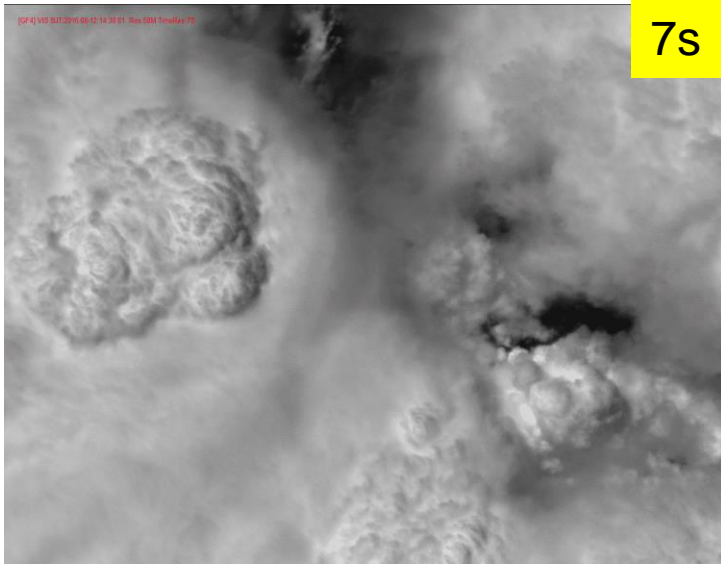
Our studies show that to capture the evolution of a rapid growing meco-or small scale convective system, the observation frequency should be less than 1 minute.

154 s

28s

Gaofen-4 Satellite

2016-07-07 14:00:01

2016-07-07 14:00:01

2016-07-09 11:00:09

Landing

67
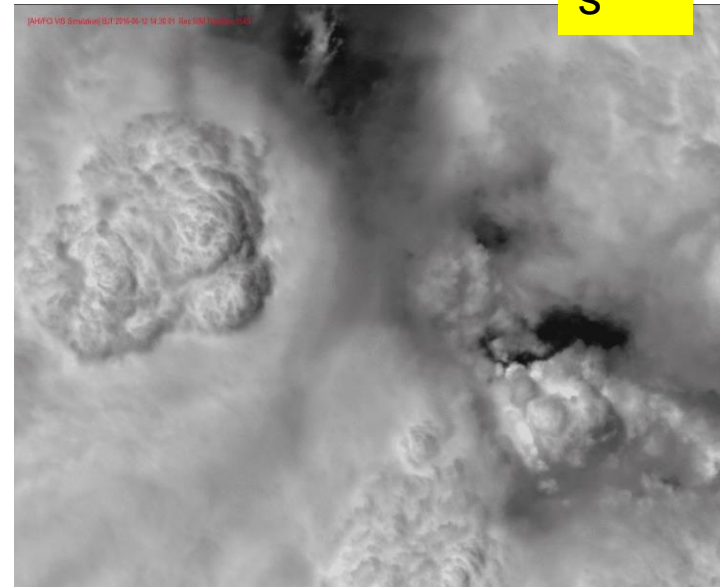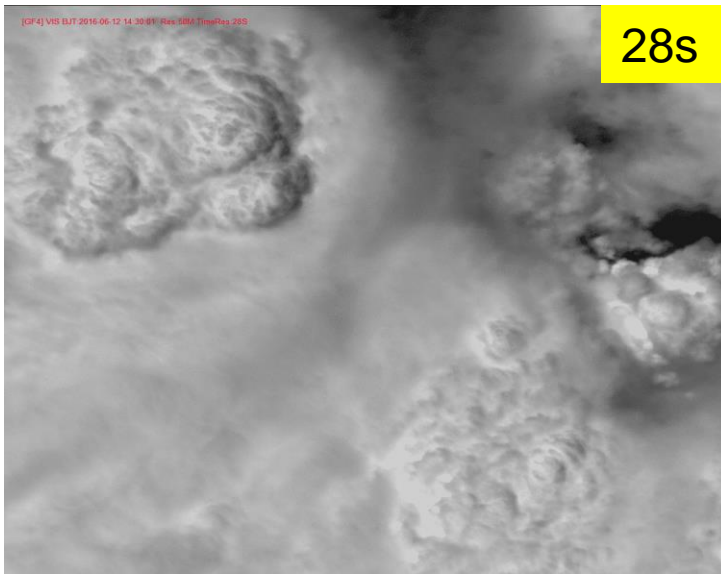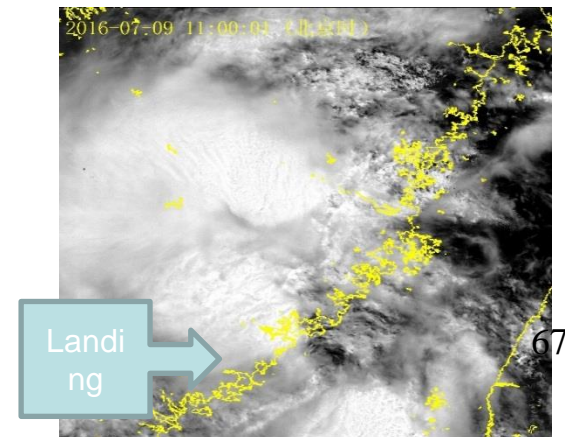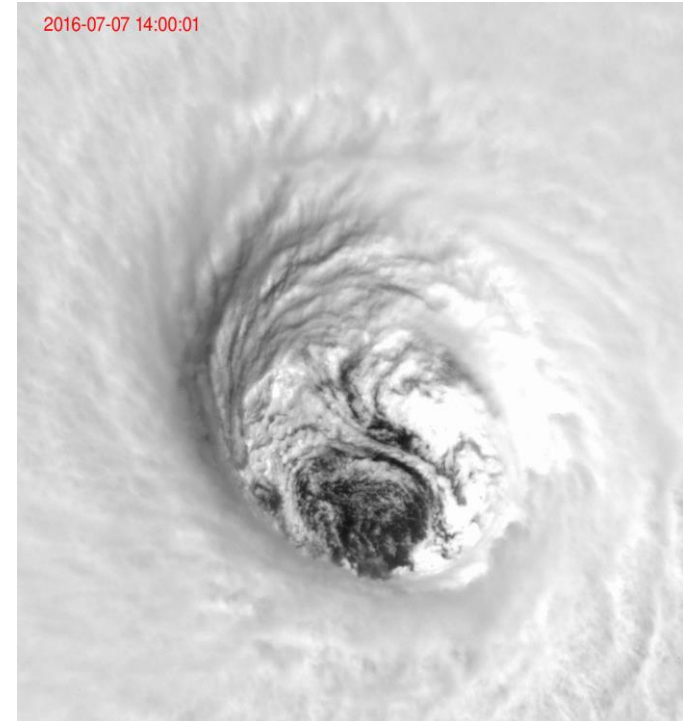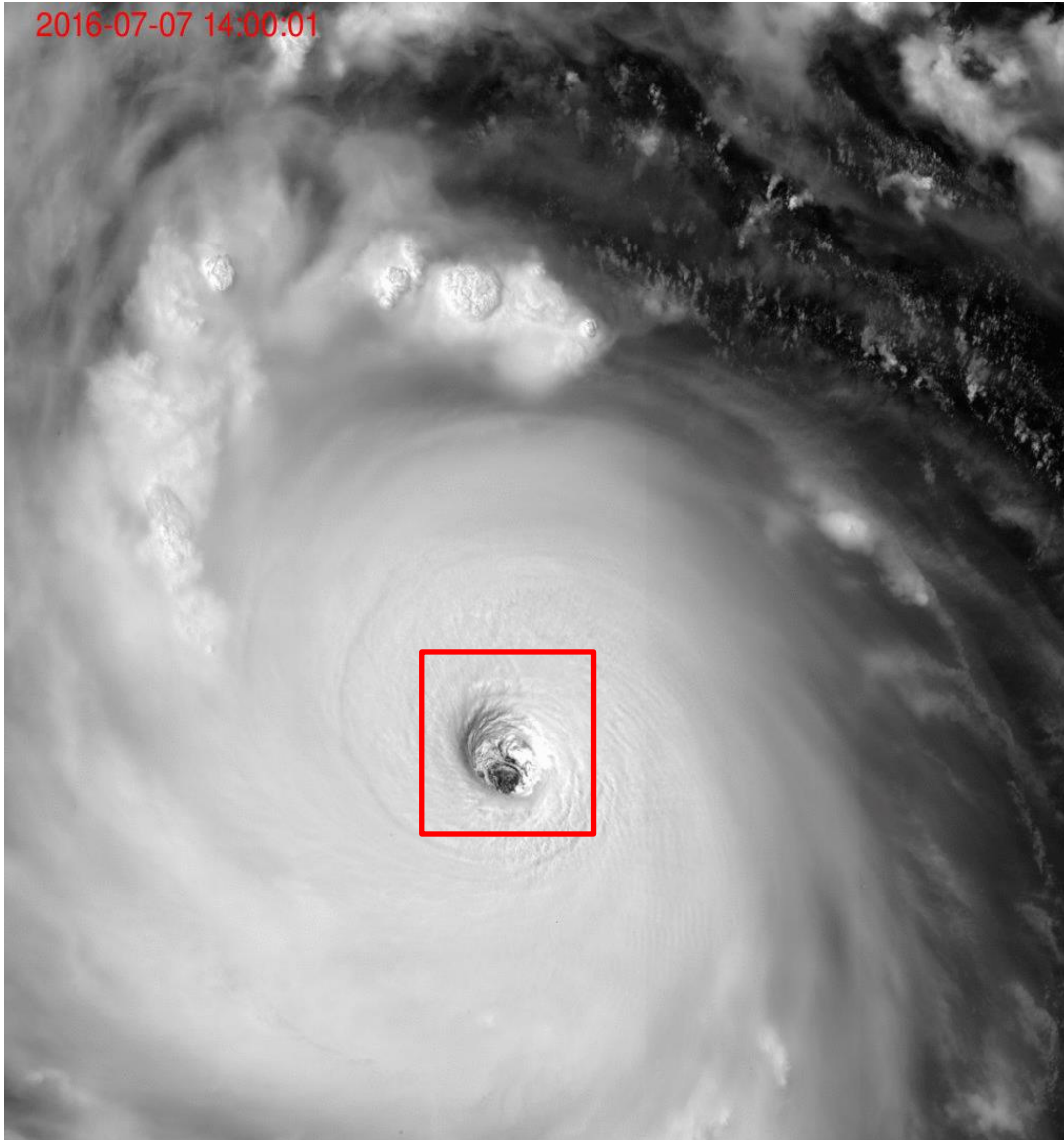
System Composition

Gaofen-5 satellite：

➢ **Planned for launch in 2016, the spatial resolution of visible short-wave infrared hyperspectral camera data is 30 meters, the spectral resolution of visible near-infrared data is 5 nanometers, and the spectral resolution of short-wave infrared data is 10 nanometers; spatial resolution of visible near-infrared data for full-spectrum imagers is 20 meters, short-wave infrared data spatial resolution of 40 meters; atmospheric greenhouse gas monitor CO_2, CH_4 monitoring data spectral resolution 0.27cm-1, O_2 monitoring data spectral resolution 0.6cm-1; the spectral resolution of atmospheric environment infrared high spectral resolution detector data is 0.03 cm-1; the spectral resolution of the atmospheric trace gas differential absorption spectrometer is 0.3 to 0.5 nm; the accuracy of the polarization calibration of the atmospheric aerosol multi-angle polarization detector is 2%.**

System Composition
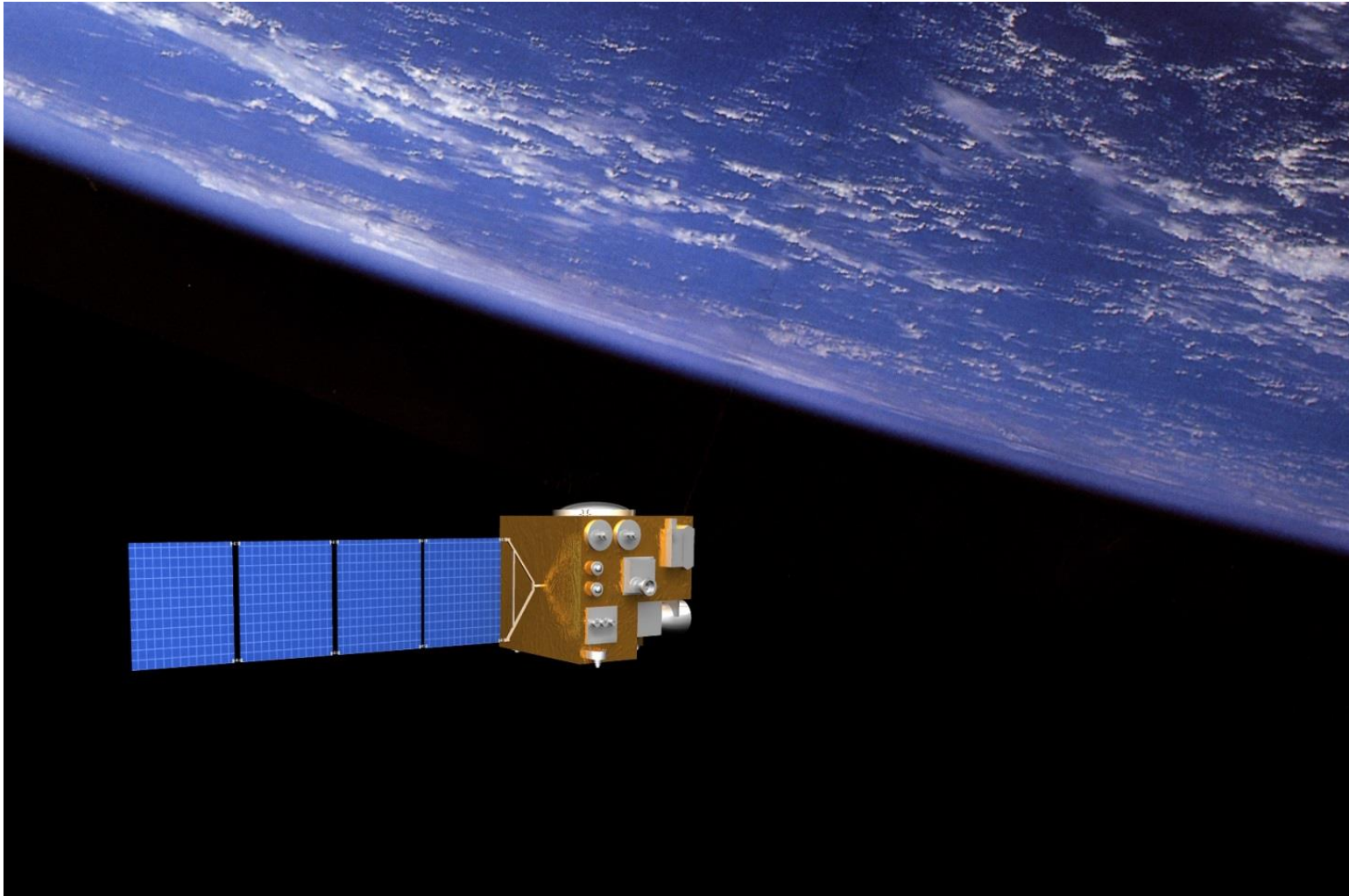
Gaofen-5 satellite：

Data Characteristics

Hyperspectral Resolution Data

Gaofen-5 satellite hyperspectral detection

Features：

➢ **Spectral information is abundant, which provides the possibility for fine identification of ground features.**
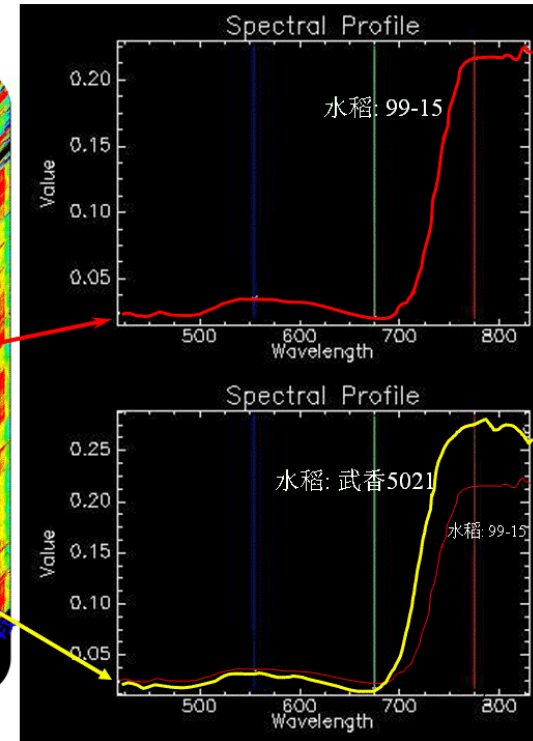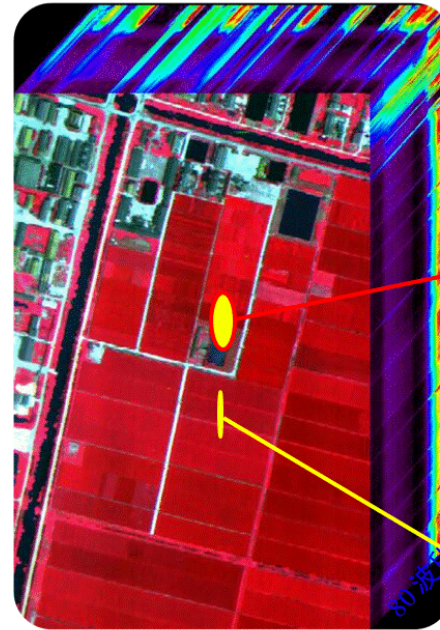
Urban heat island monitoring, water quality monitoring, road material identification, etc.

Data Characteristics

Gaofen-5 satellite—Hyperspectral detection
Features：

➢ **By imaging in continuous narrow bands, finer spectral information of ground objects is obtained, and the recognition ability is greatly improved.**

Haze monitoring, air pollutant monitoring, etc.

71
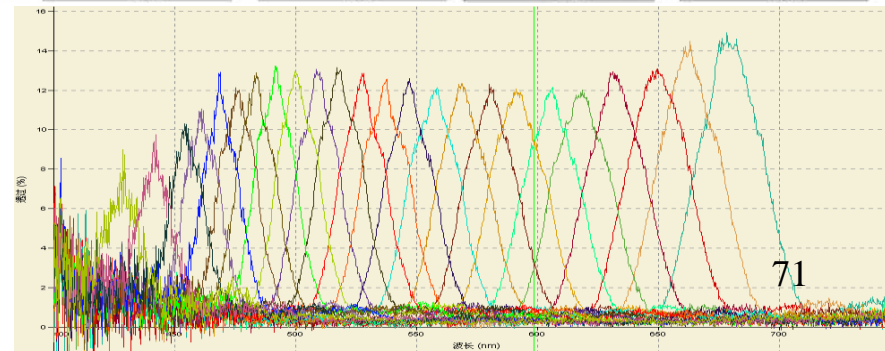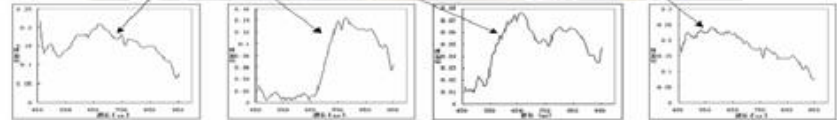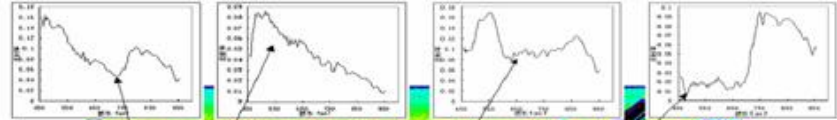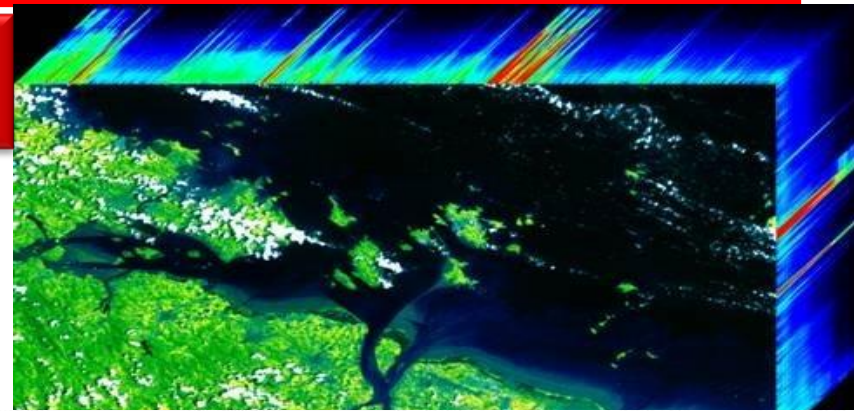
Data Characteristics

Characteristics of Hyperspectral Load

Gaofen-5 satellite—Hyperspectral detection

1) Atmospheric main greenhouse gas monitor
- **Central wavelength: 0.765 μm (O2), 1.575 μm (CO2), 1.65 μm (CH4), 2.05 μm (CO)**
- **Working mode: Zenith (main mode) / flares**
- **2) Atmospheric environment infrared very high spectral resolution detector**
  - **Spectral range: 750 to 4100 cm-1 (2.4 to 13.3 μm).**
  - **Spectral resolution: 0.03nm (@ 2.4μm).**
- **3) Atmospheric trace gas differential absorption spectrometer**
  - **Spectral range: 287 ~ 490nm, 490 ~ 700nm, 1940 ~ 2040nm, 2265 ~ 2380nm.**
  - **Spectral resolution: 0.3 ～ 0.5nm (UV ～ VIS), 0.2nm (NIR).**

Data Characteristics

Multi-angle polarization data

Gaofen-5 satellite—Multi-angle polarization detection Features：

➢ **Can detect ground objects in multiple directions at the same time**

➢ **Can provide polarization information of ground features**

39°

60°

MSPI

70° (at Earth)
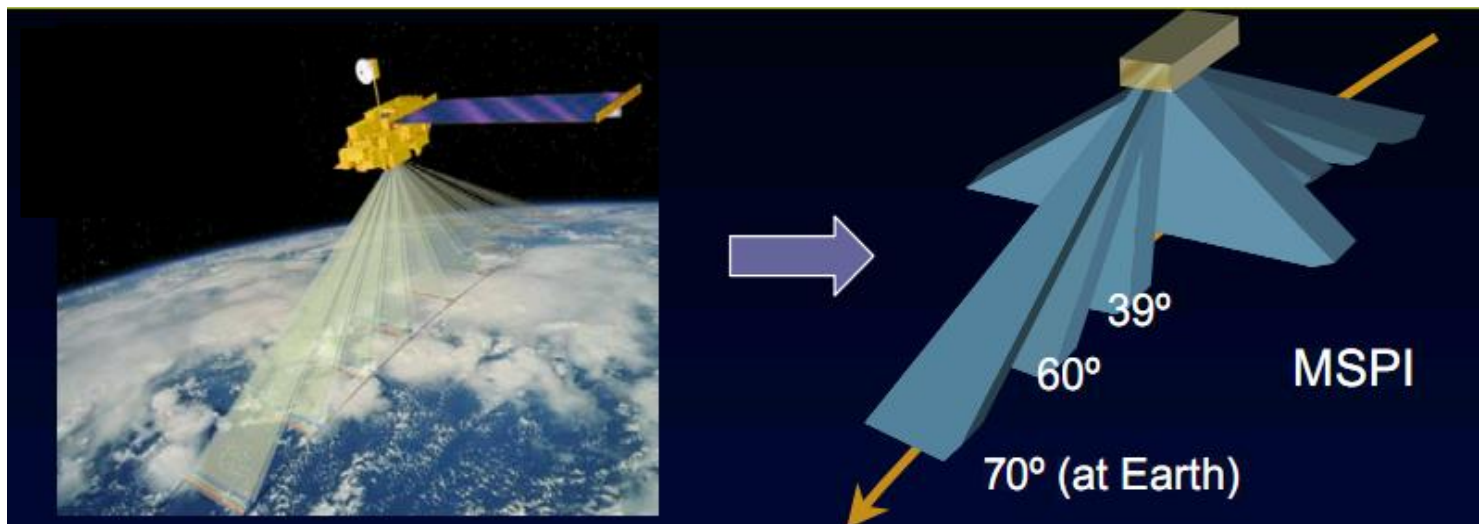
Urban aerosol and haze monitoring

Data Characteristics

Characteristics of multi-angle polarization load

Gaofen-5 Satellite—multi-angle Polarization Detection

1）Atmospheric aerosol multi-angle polarization detector

➢ **Operating band: 490nm, 555nm, 665nm, 865nm.**

➢ **Polarization measurement accuracy: 2%.**

System Composition

Gaofen-6 satellite：

➢   It is planned to launch in 2017. The full-color image data has a resolution of 2 meters and the multi-spectral image data has a resolution of 8 meters, a width of 100 kilometers, a resolution of 16 meters, and a width of 1,000 kilometers.

Gaofen-6

Launched in 2018, its characteristics are relatively close to the **GF-1(A satellite).** There are two sets of sensors of 16 meters wide and 2 meters. The difference is that the 16-meter wide camera has added a **red band** to **detect the growth status of plants.** and its wide width is completely completed by one camera independently rather than four cameras.

Comparison of important parameters of GF6, S2 and L8

	LANDSAT8	SENTINEL2A/B	GAOFEN6
Resolution	15~30米	10、20、60米	16米
Band	9个（不计全色）	13个	8个
Width	180公里	290公里	850公里
Return cycle	16天	10天（两个卫星5天）	4天（加上GF1为2天）
Addition			还有2/8米相机

Gaofen-6

GF-6 is currently **the only** medium-resolution satellite in China **with a wide-band imaging capability of 8 spectral bands.**

➢ **New bands:** new purple band (0.40-0.45μm), yellow band (0.59-0.63μm), red band 1 (0.69-0.73μm) and red band 2 (0.73-0.77μm)

➢ **Large angle:** the field of view can reach 30º, the width is better than 850 km, and it is highly mobile and flexible

➢ **High frequency:** Can be networked with GF-1 / 2 to obtain high frequency remote sensing images. The revisit period is better than 3 days.
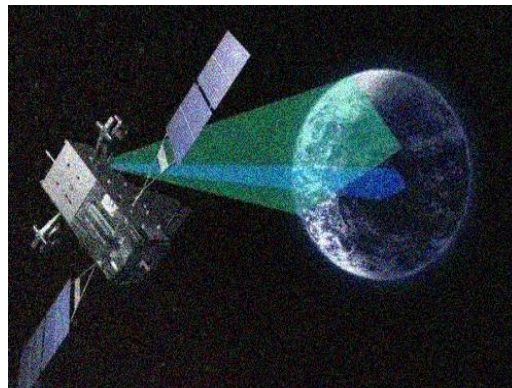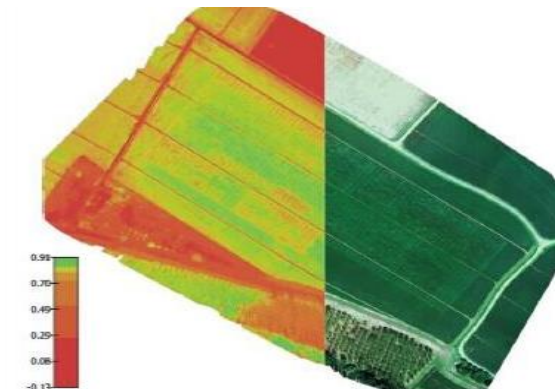
Urgent need to tap the potential of GF-6 applications

Gaofen-6
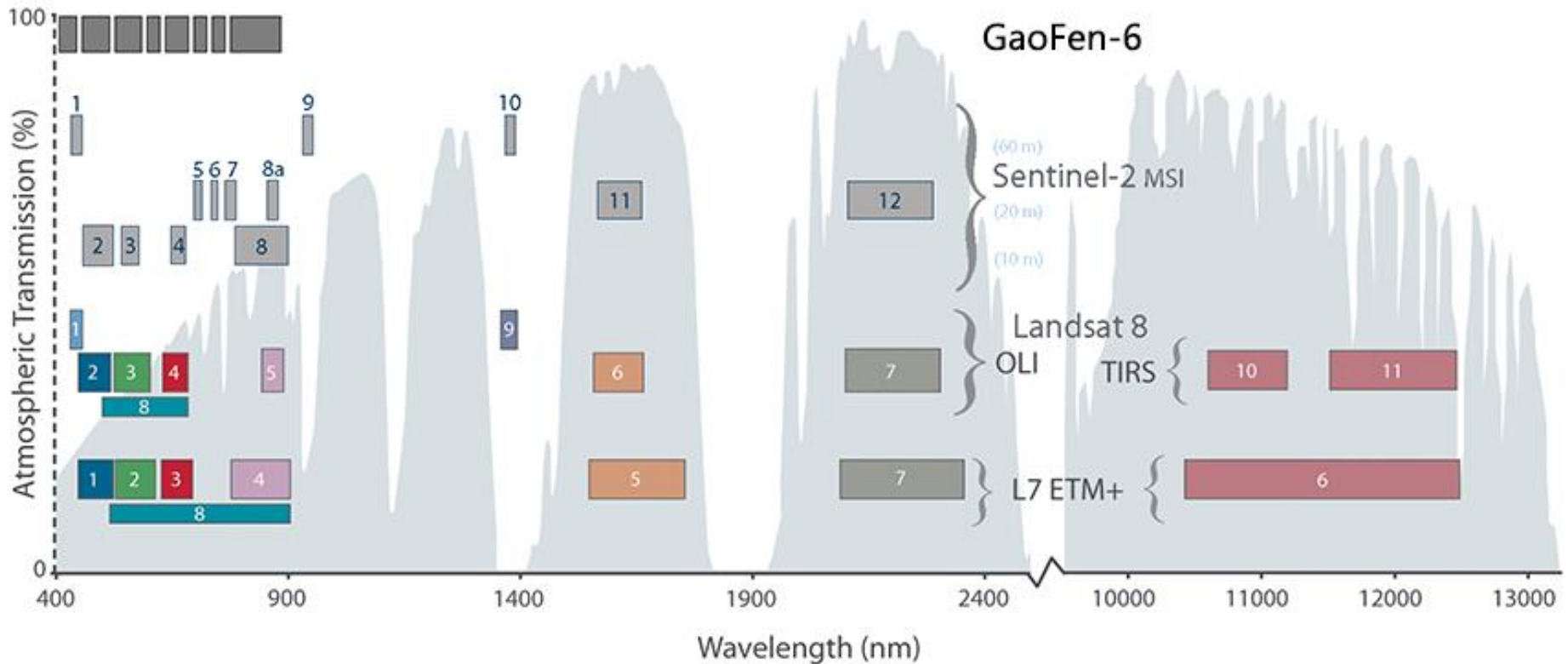
Spectral band distribution of GF6, Sentinel-2, Landsat 8

Gaofen-7

➤   **It is planned to launch in 2019. The full-color front and rear vision image data is better than 1 meter resolution, and the accuracy of laser altimetry data is better than 1 meter.**

Data Characteristics

Stereo Mapping Data

Gaofen-7 satellite

Features：

➢ **measuring topographic map of high scale**

➢ **First high-resolution domestic stereo imaging payload**

➢ **Extraction of high-precision position information and elevation information**
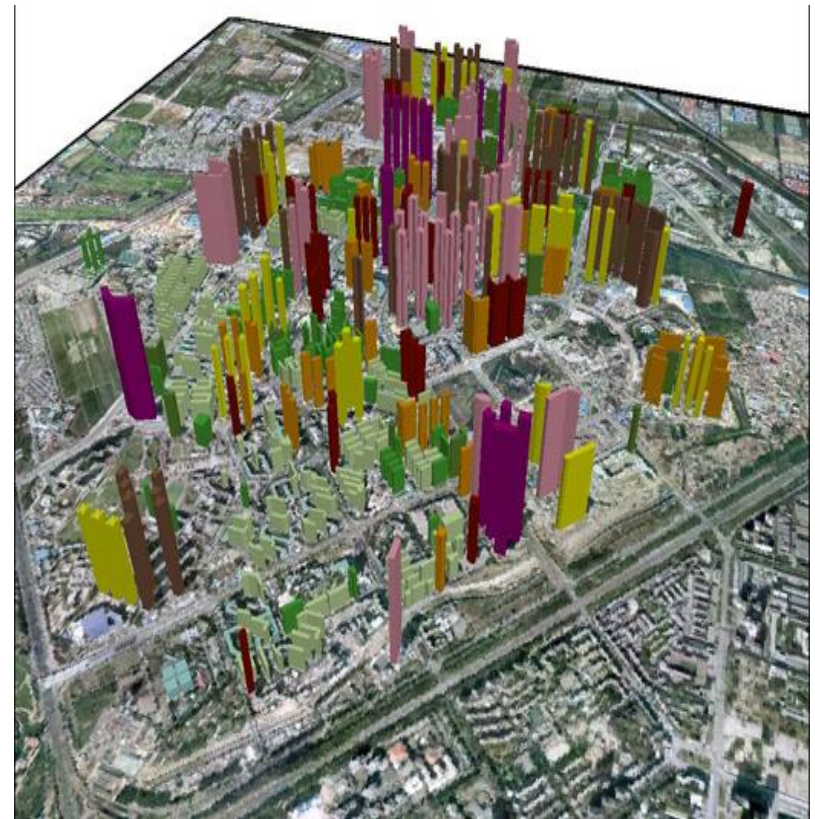
Extraction of urban terrain, extraction of urban buildings, etc.

Data Characteristics

Characteristics of Stereo Mapping Load

Gaofen-7 satellite

➢ **Orbit: Sun-synchronous orbit**

➢ **Band: Full color: 0.50 ～ 0.80μm**

➢ **Spatial resolution:**

➢ **Full color: 0.6m**

➢ **Visible light near infrared multispectrum: 5m, short wave infrared multispectral: 10m**

➢ **Width: 40km**

➢ **Ranging accuracy: 1 ~ 2m (RMS)**

Outline
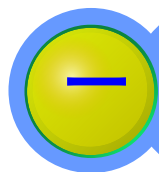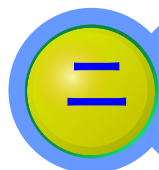
一 Introduction to China High-Resolution EOS

二 High-resolution Satellite Data And Applications
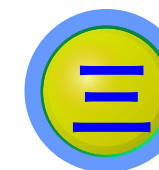
三 High-resolution Satellite's Application in Smart City

High-resolution Satellite's Application in Smart City

A smart city is a new model of urban planning, construction, and management that strengthens urban planning, construction, and management through the comprehensive use of modern science and technology, integration of information resources, and overall business application systems to achieve intensive, intelligent, green, and low-carbon development.

Utilizing High-resolution data can carry out urban resource and urban environment monitoring and evaluation, and provide technical support for smart city construction.

➢ Rapid acquisition and processing of remote sensing information

➢ Mass Spatial Information Scheduling and Management

➢ Visualization and analysis of multi-dimensional spatial information

➢ Intelligent Network Services

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Remote Sensing Application of Urban Resources

City Planning
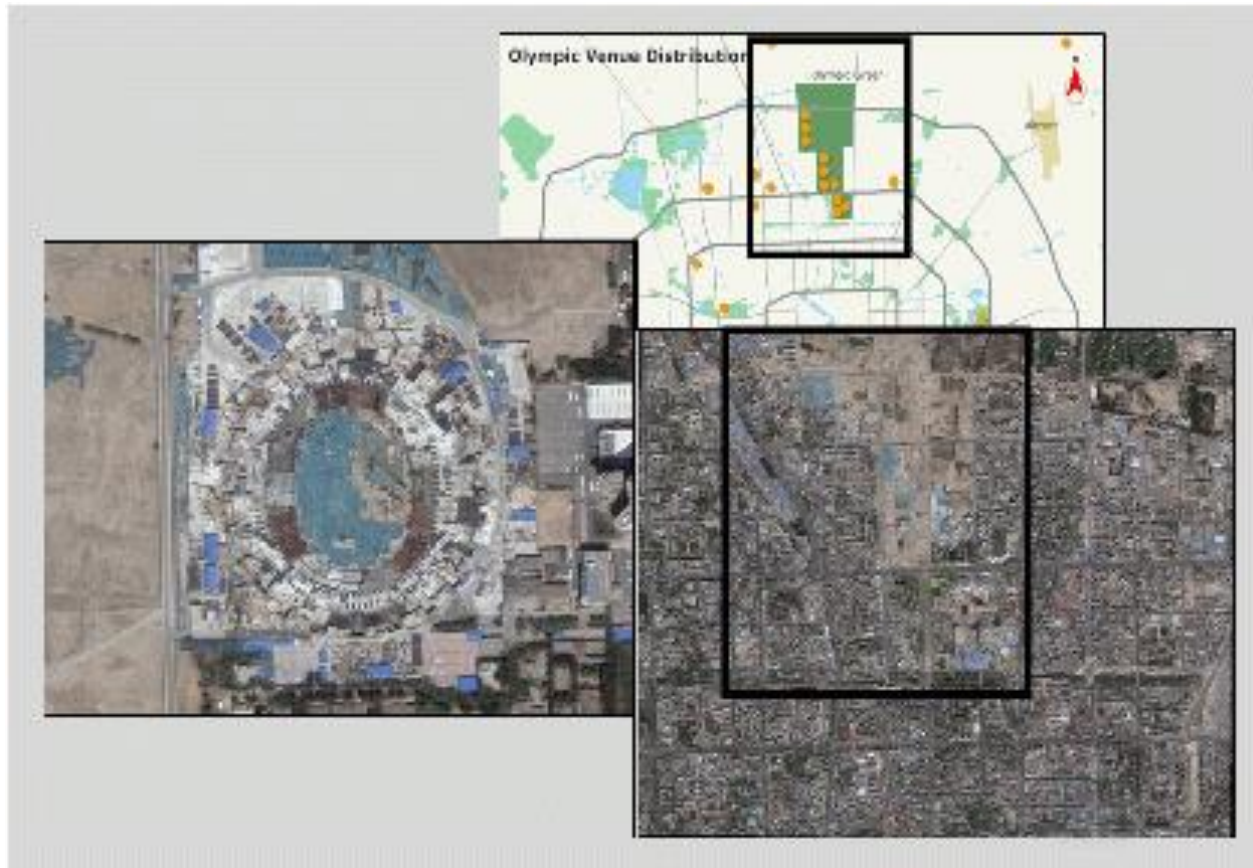
Beijing Olympic Site Construction in 2005-Urban Planning

Remote Sensing Application of Urban Resources

City 3D Cartography

望京地区阴影测高三维显示专题图

图例

0.00 - 10.00 米	50.00 - 60.00 米
10.00 - 20.00 米	60.00 - 70.00 米
20.00 - 30.00 米	70.00 - 80.00 米
30.00 - 40.00 米	80.00 - 90.00 米
40.00 - 50.00 米	90.00 - 110.00 米

85
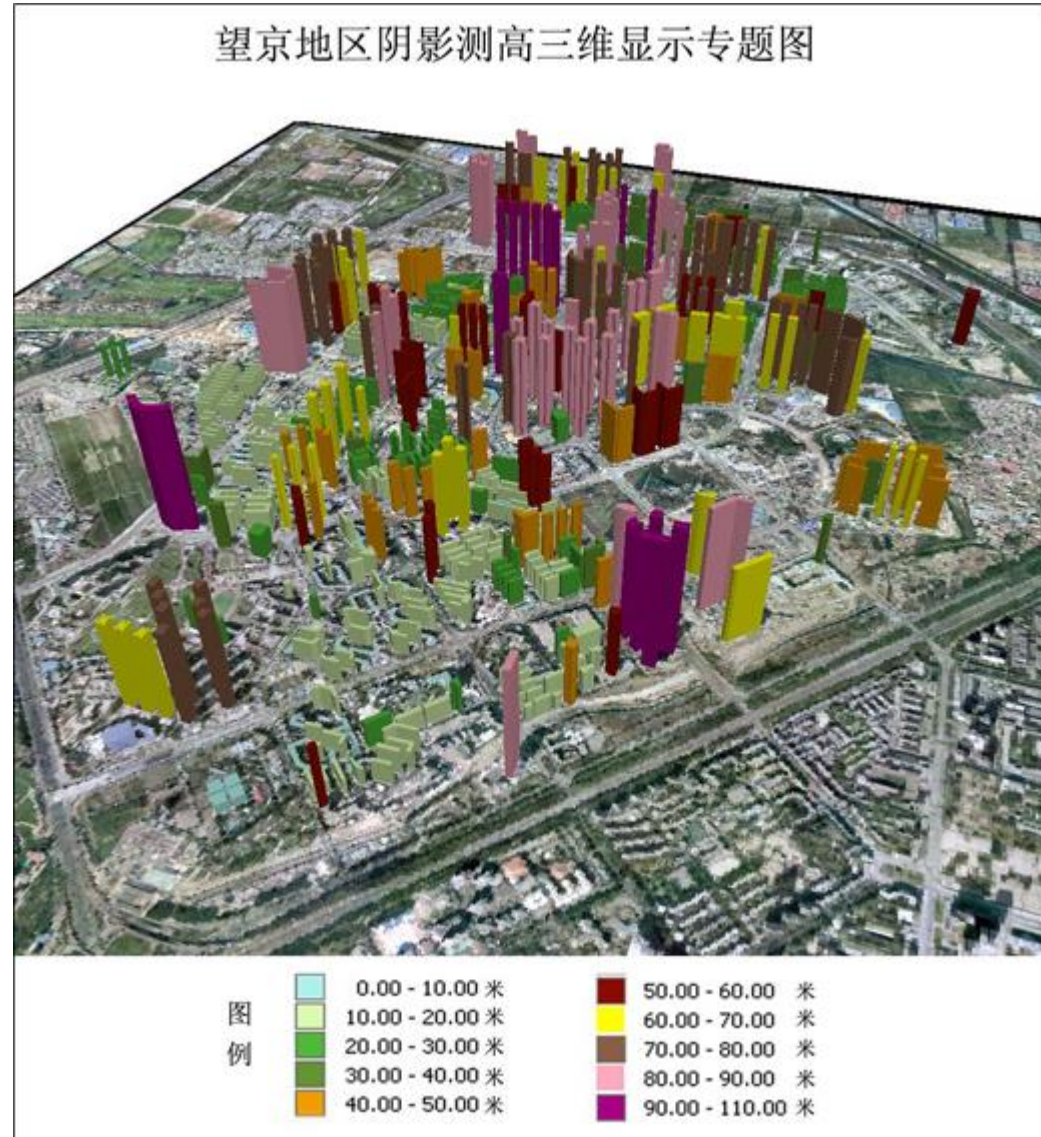
Remote Sensing Application of Urban Resources

Urban Land Supervision

顺义区赵全营镇基本农田被建设占用分布图

天津市东丽区机场附近土地利用遥感分类图

2010年5月
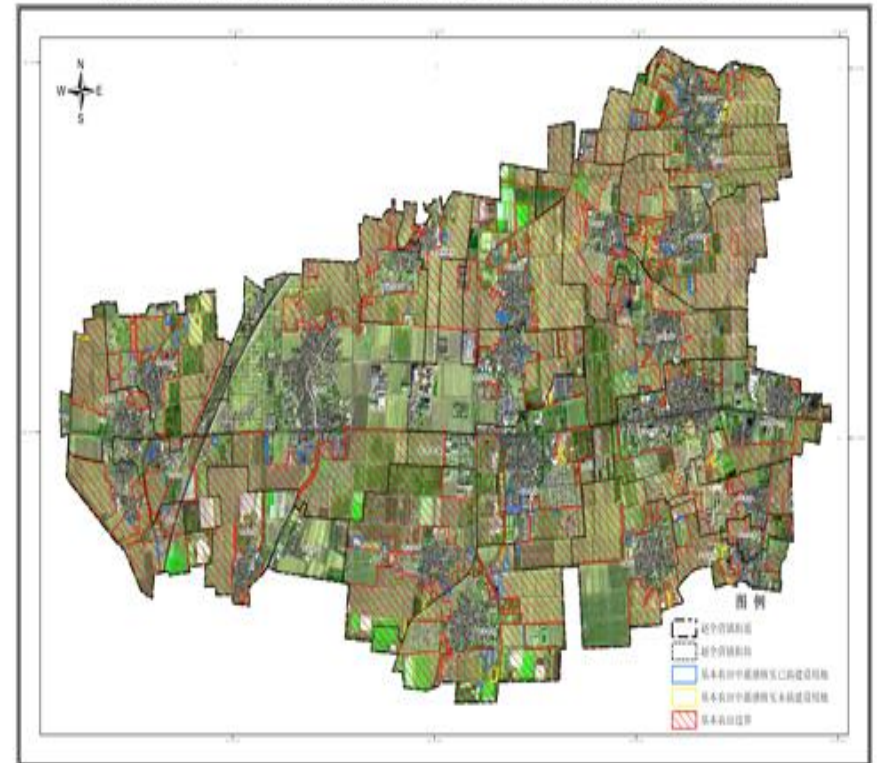
High-resolution Remote Sensing of Urban Resources

Monitoring and Management of Scenic Spots

庐山 (2001年4月至2003年11月)
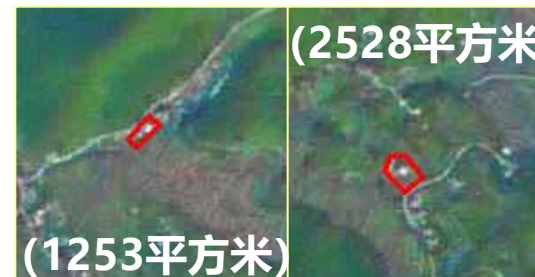
江西部分干部违规在庐山景区抢建私家别墅(图)

(21590平方米)

(2528平方米

(1253平方米)

High-resolution Remote Sensing of Urban Resources

Urban Forest Survey

2007年北京市森林资源分布图
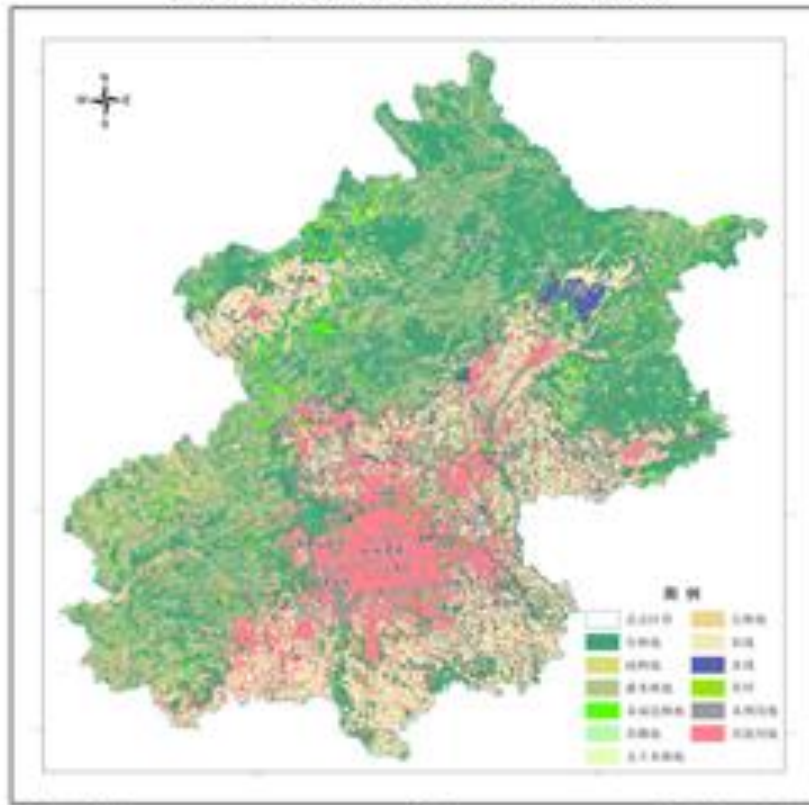
2006年北京市灌木林分级示意图
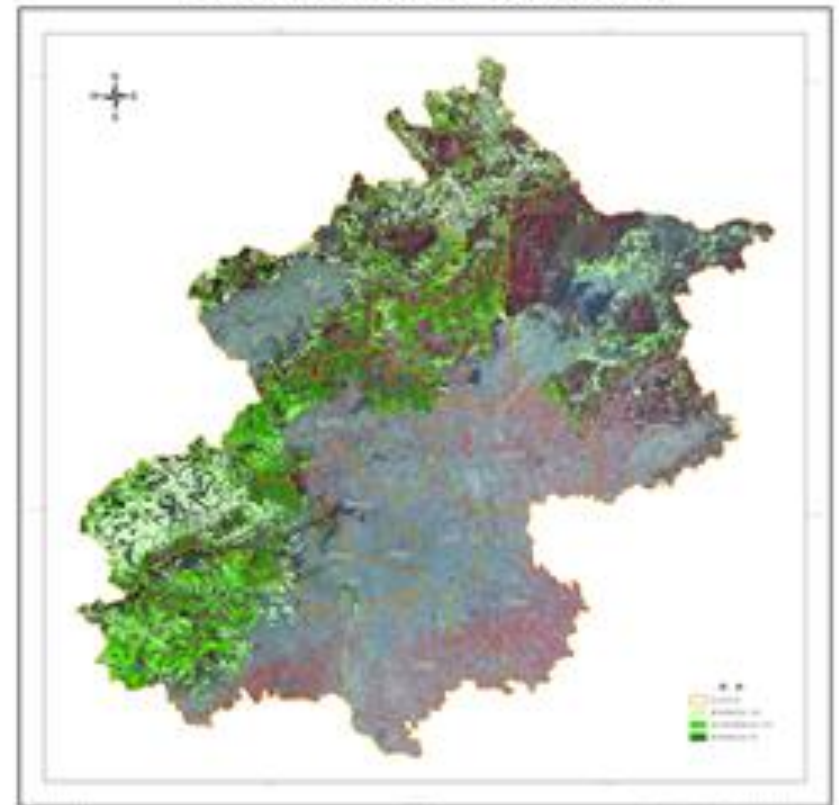
High-resolution Remote Sensing of Urban Resources

Urban green space monitoring
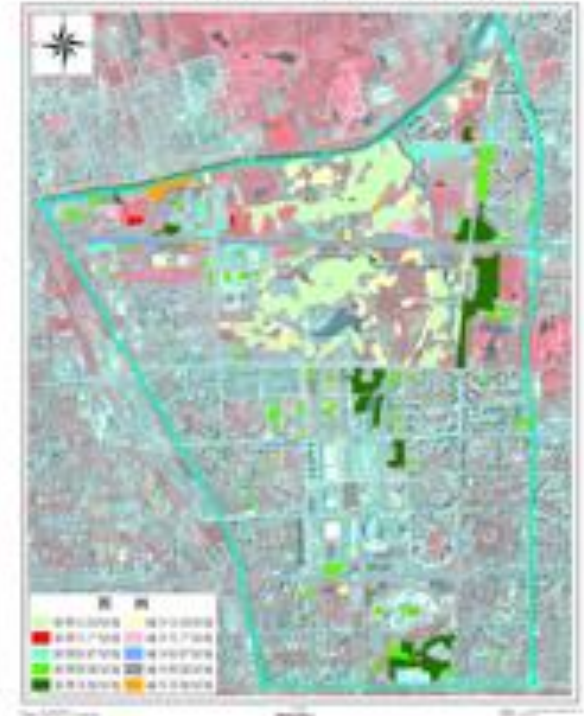
High-resolution Remote Sensing of Urban Resources

Urban Landscaping Monitoring

1. Investigation and evaluation of urban garden greening status, review of national garden cities;

2. Assisting decision-making in the preparation, approval, implementation and modification of urban green space system plans;

3. Fine management of urban green space: spatial information management of various green spaces in the city as well as famous trees and ancient trees, daily maintenance management of urban green space, and management of urban greening projects.
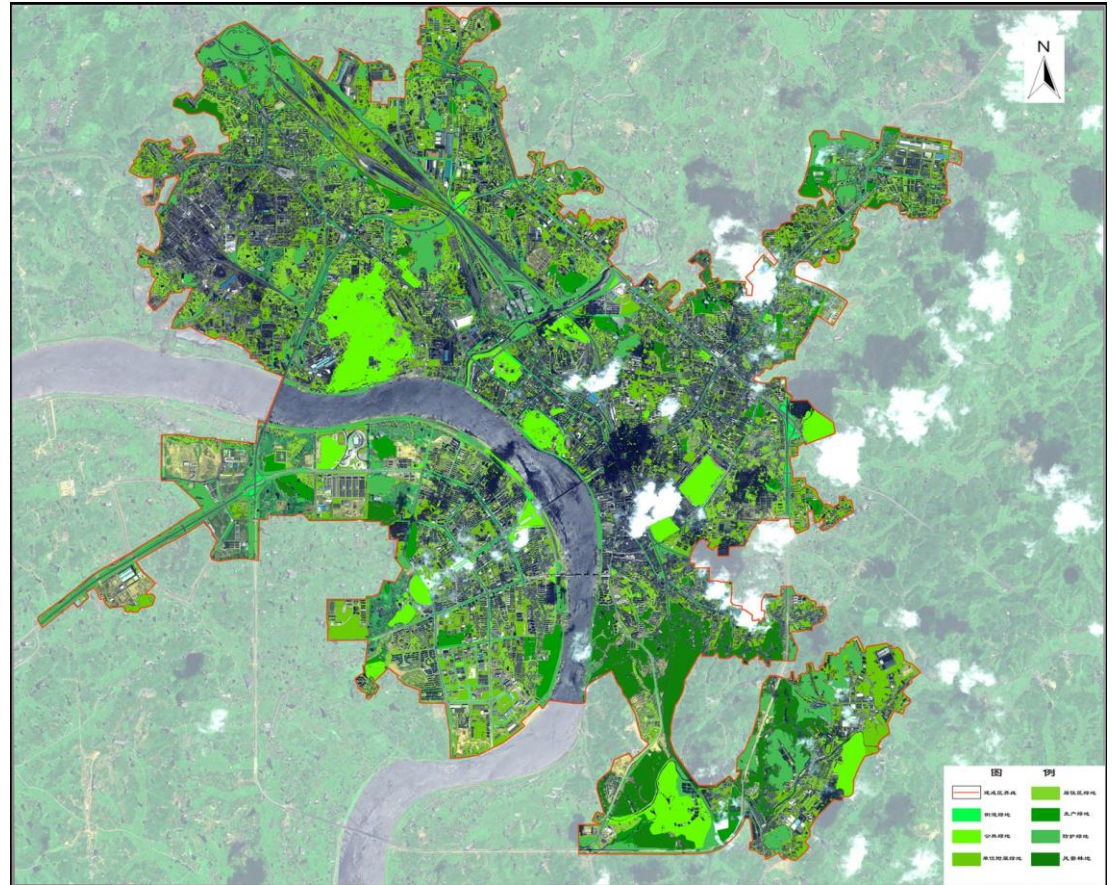
High-resolution Satellite's Application in Smart City

City Object Detection

It can clearly identify traffic elements such as roads, bridges, and vehicles, and is used in traffic network management and planning monitoring, waterway, ship management, and even traffic flow monitoring, serving national and local traffic planning, design, management, and decision-making.

Road
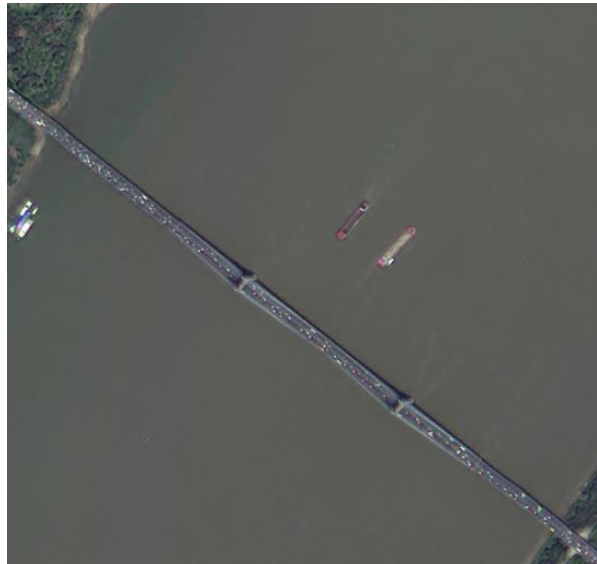
Bridges and Boats

Airport
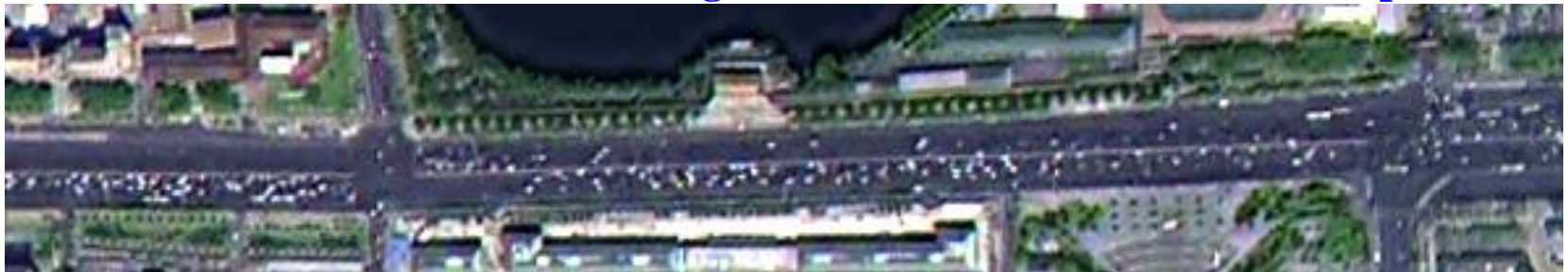
Vehicle

Remote Sensing Application of Urban Resources

Urban Change Monitoring

Remote Sensing Application of Urban Resources

Urban Expansion Monitoring
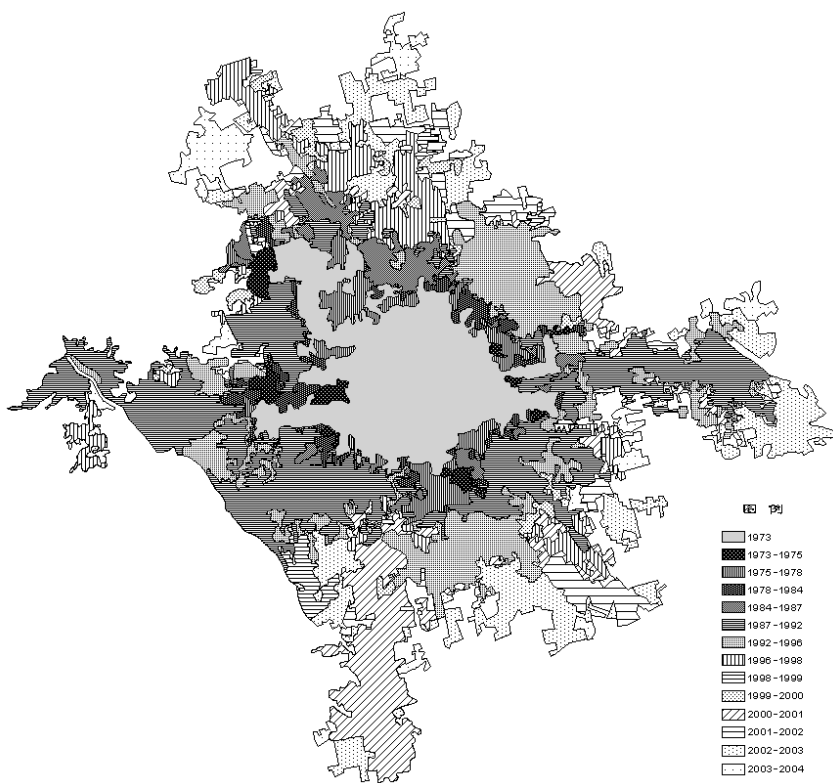
图 5　北京市市建成区 1973～2004 年扩展过程图

1973～1978　　1978～1984　　1984～1987

1987～1992　　1992～1996　　1996～1998

1998～1999　　1999～2000　　2000～2001

2001～2002　　2002～2003　　2003～2004
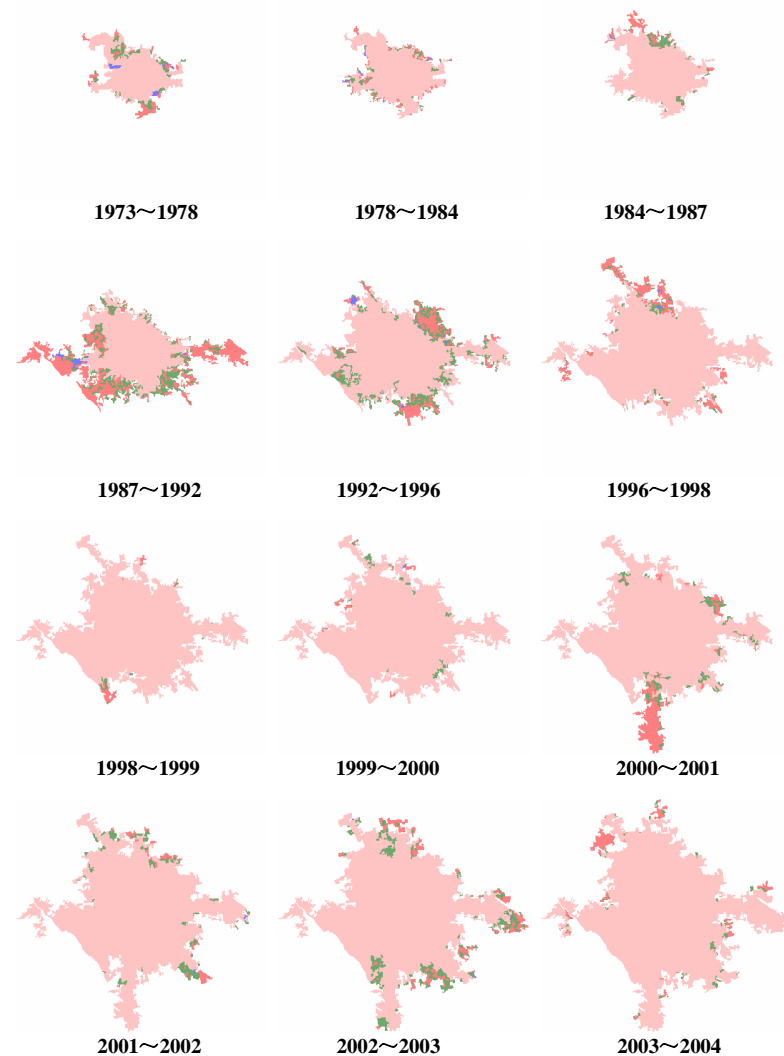
图
例　　原建成区　　　　　　城市扩展中占用的其它土地
　　　城市扩展中占用的耕　　城市扩展融入的农村居民点和其它建设

1973～2004 年北京市不同时期城市扩展的土地利用影响

Gaofen-1 Satellite Data and Application Display

Monitoring of New Construction Land In Cities

江苏省徐州市贾汪区新增图斑分布图
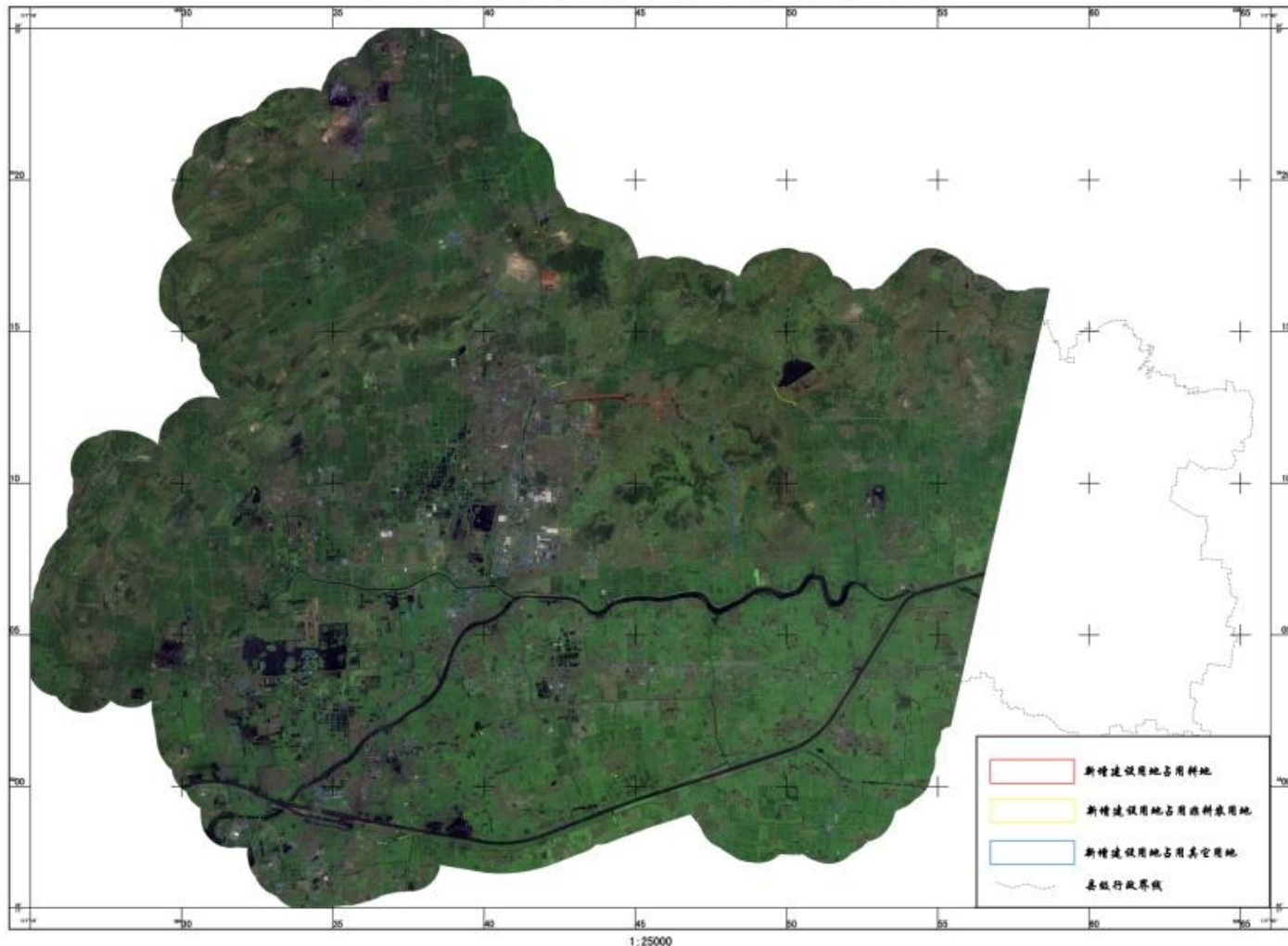
High-resolution remote Sensing Application of Urban Resources

Urban Expansion Monitoring

1956   1976   1996

Gaofen-1 Satellite Data and Application Display

Dynamic Monitoring of Urban Vegetation

Hierarchical map of vegetation coverage in the project area before implementation
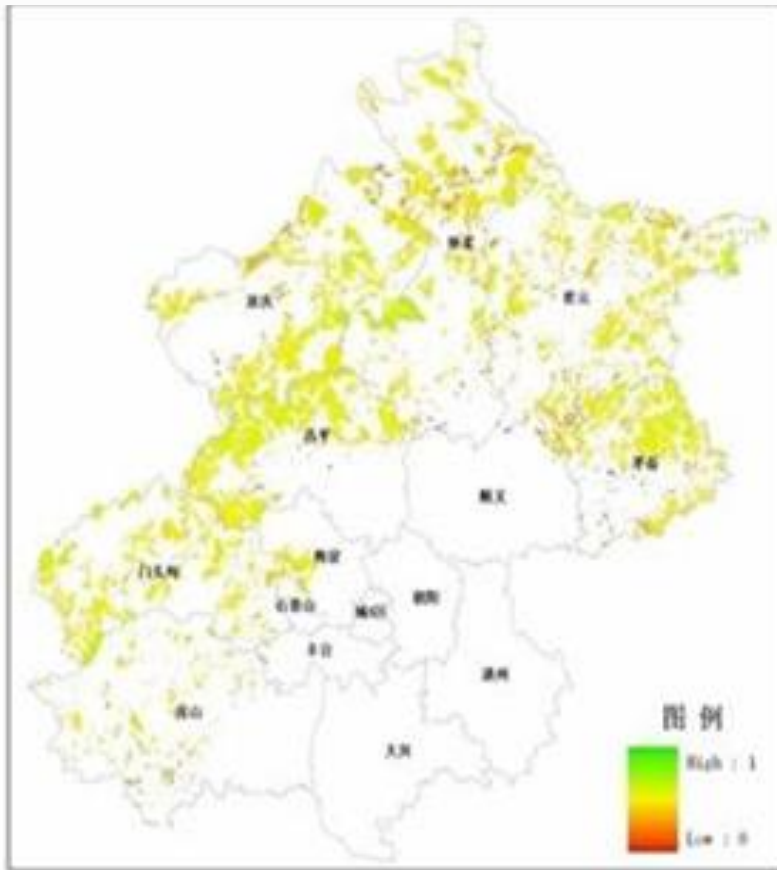
Hierarchical map of vegetation coverage in the project area after implementation
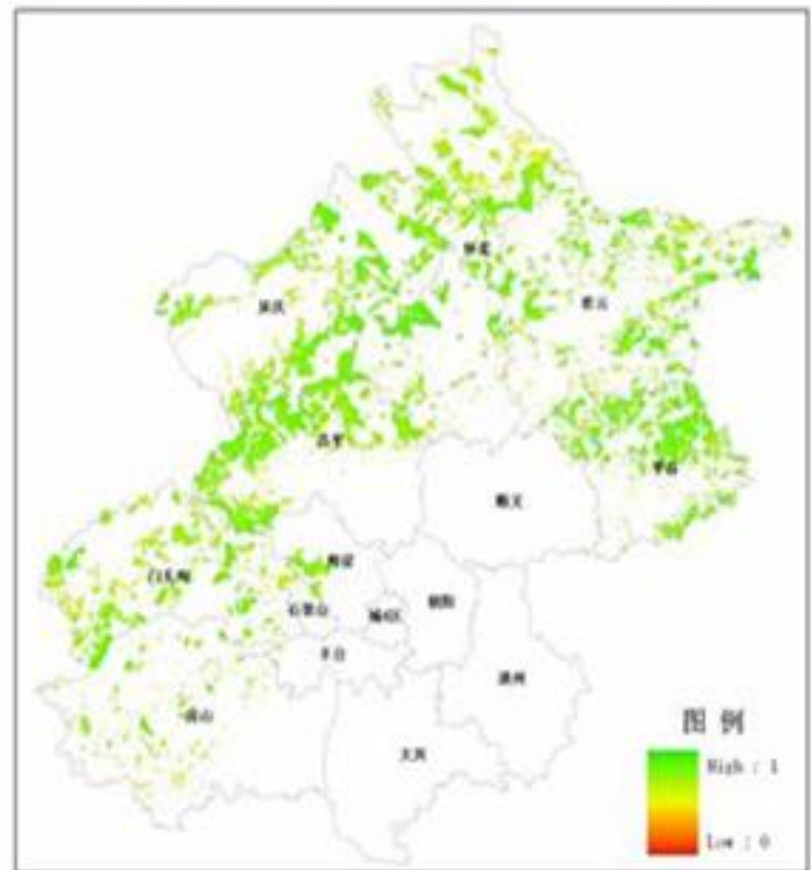
Dynamic monitoring map of vegetation status before and after the implementation of the Beijing-Tianjin sandstorm source control project

High-resolution Satellite's Application in Smart City

Urban Dynamic Expansion Monitoring
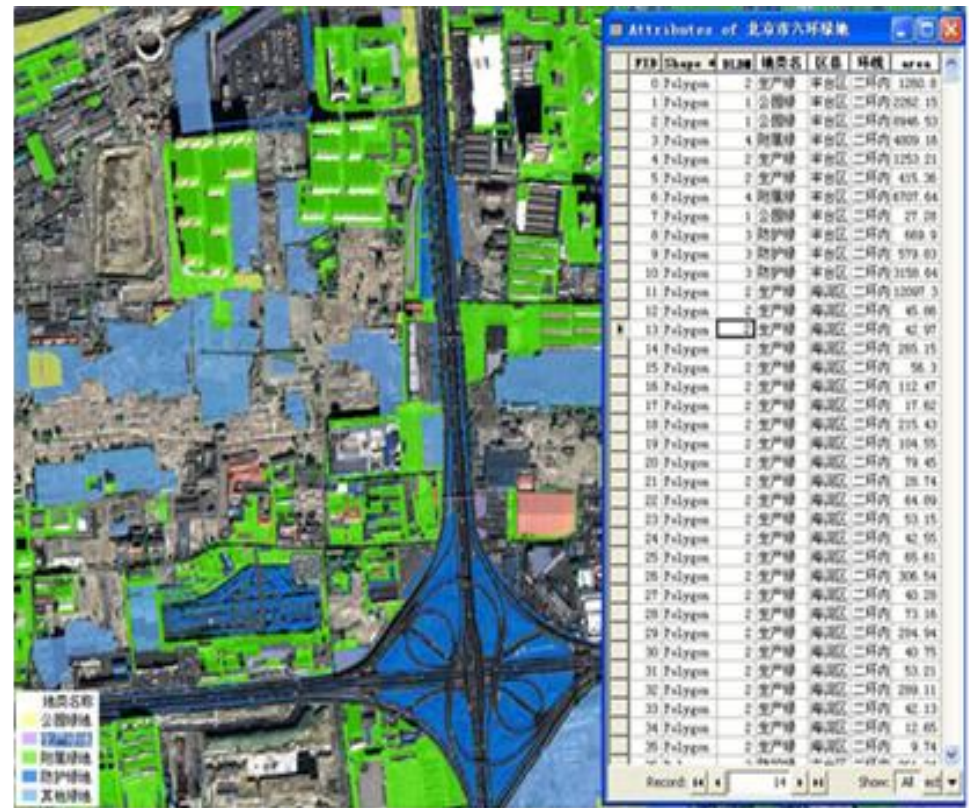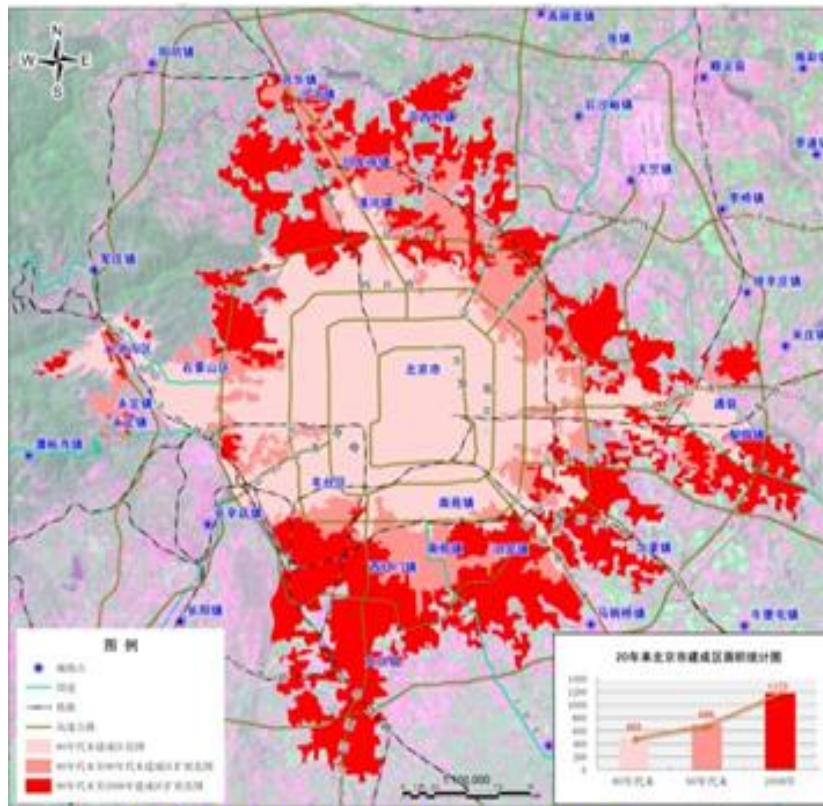
Analysis of the spatial pattern of urban expansion

Remote sensing monitoring of urban green space changes

Remote sensing survey of Beijing's ecological environment in ten years

High-Resolution Remote Sensing Application of Urban Typical Feature

City Building Extraction

Medium density low-rise building extraction results
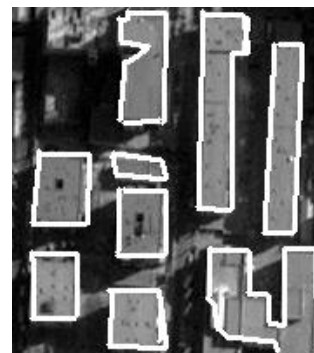
(a) Original image (b) Automatic extraction results (c) Manual drawing results

Extraction of buildings around the old city
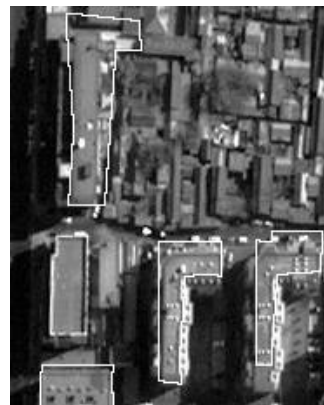
(a) Original image (b) Automatic extraction results (c) Manual drawing results

High-resolution Satellite's Application in Smart City

Urban Solid Waste, Development Zone Extraction

Based on the 2m panchromatic and 8m multispectral data of Gaofen No. 1 satellite on August 10, 2013, the urban ecological environment in the urban area of Beijing was monitored. After the image is processed by radiation correction, geometric projection, fusion and other data, it is classified and processed to extract solid waste and development zone information to reflect the urban ecological environment.

北京示范区高分一号影像图 （2013年08月10日）

数据来源：高分一号2m/8m融合数据 （2013年08月10月）　　环境保护部卫星环境应用中心

北京示范区城市固废分布图 （2013年08月10日）
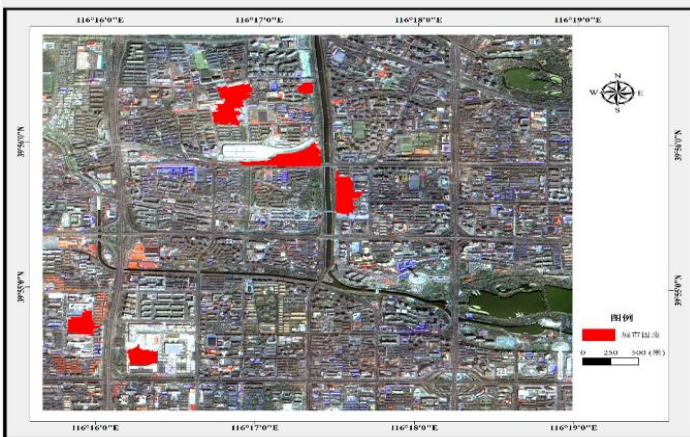
数据来源：高分一号2m/8m融合数据 （2013年08月10日）　　环境保护部卫星环境应用中心

北京示范区高分一号影像图 （2013年08月10日）

数据来源：高分一号2m/8m融合数据 （2013年08月10日）　　环境保护部卫星环境应用中心

北京示范区城市开发区分布图 （2013年08月10日）
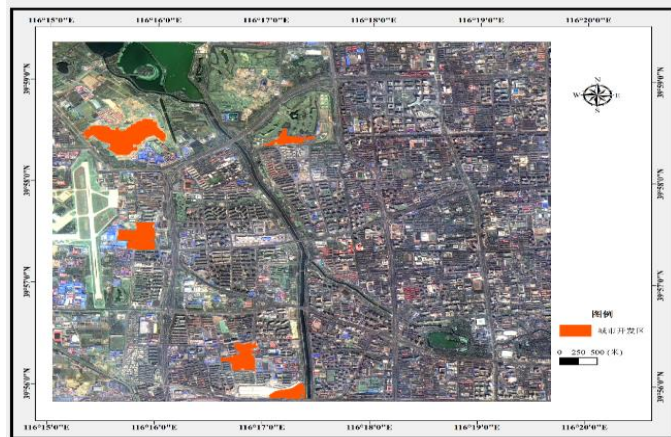
数据来源：高分一号2m/8m融合数据 （2013年08月10日）　　环境保护部卫星环境应用中心

High-resolution Remote Sensing of Urban Environment

Urban Thermal Environment Monitoring

(1) Due to the high thermal conductivity of the underlying surface composed of cement and asphalt in urban areas, coupled with the large amount of air pollutants, it can absorb more solar energy, and a large amount of artificial heat enters the air;

(2) Due to the dense buildings, it is not conducive to heat diffusion, forming a high-temperature center, and thus decreasing to the periphery.

High-resolution Remote Sensing of Urban Environment

Building thermal energy loss monitoring
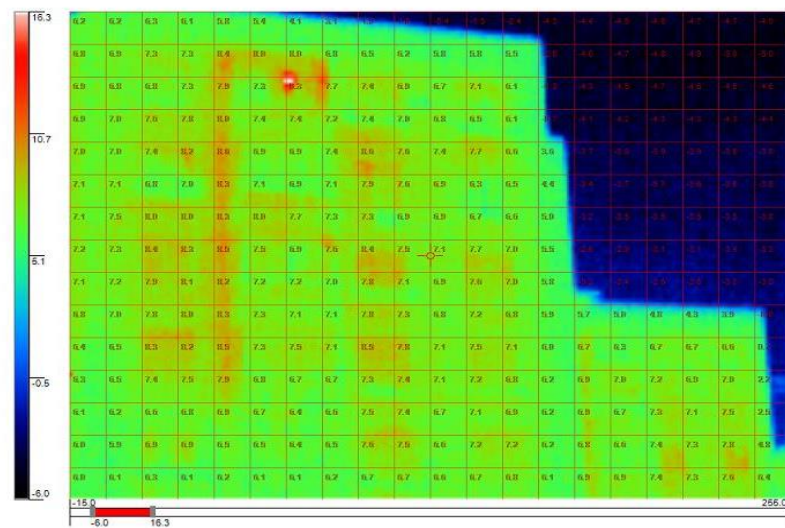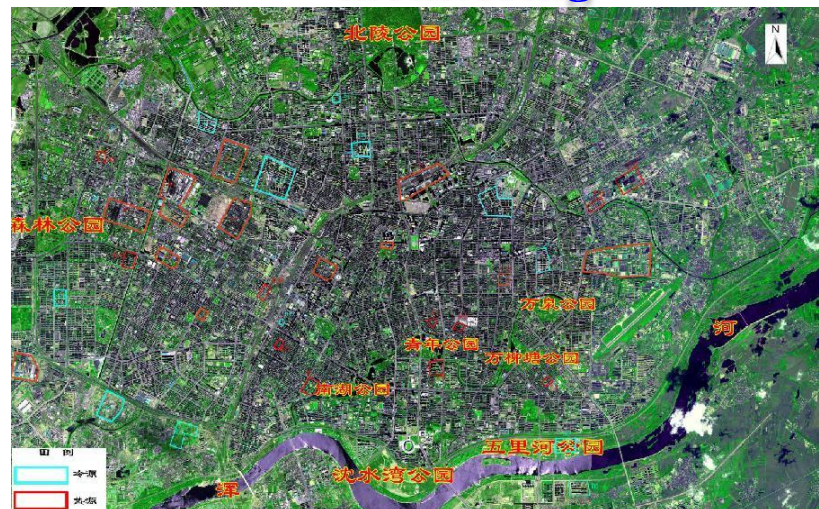
Urban Environment High-resolution Remote Sensing
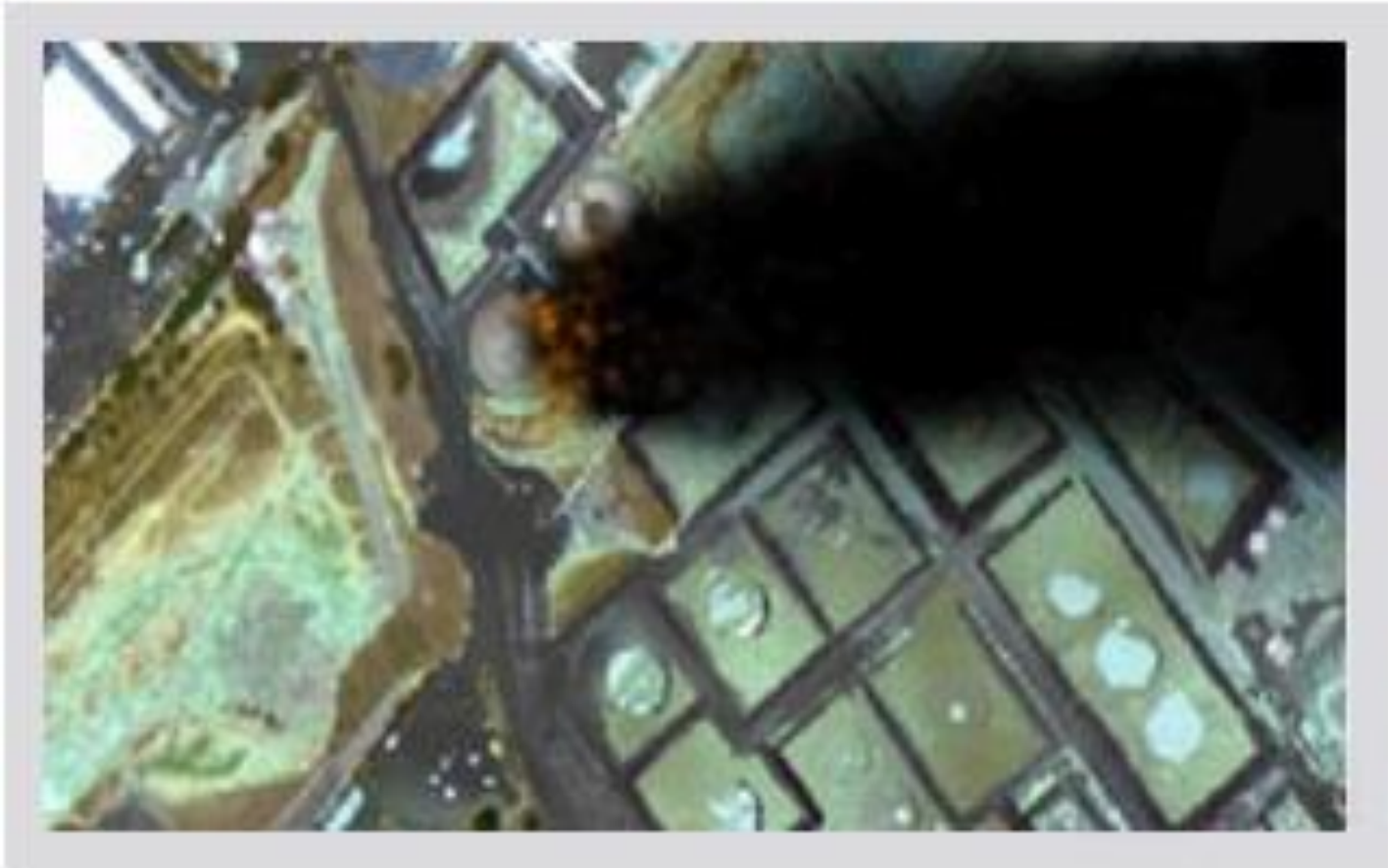
Air Pollution

Air pollution monitoring

Urban Environment High-resolution Remote Sensing

Air pollution

Spatial Distribution of PM2.5 and Pollutant Gas NO2, SO2, O3 Concentrations in Beijing

TERRA Satellite

OMI on AURA
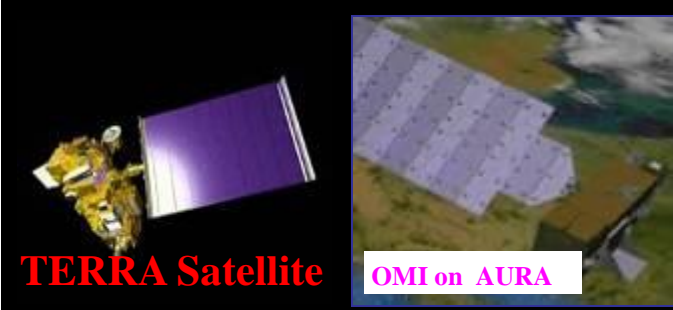
PM2.5 concentration near the ground using satellite remote sensing

MODIS Receiving Station

Solar Photometer
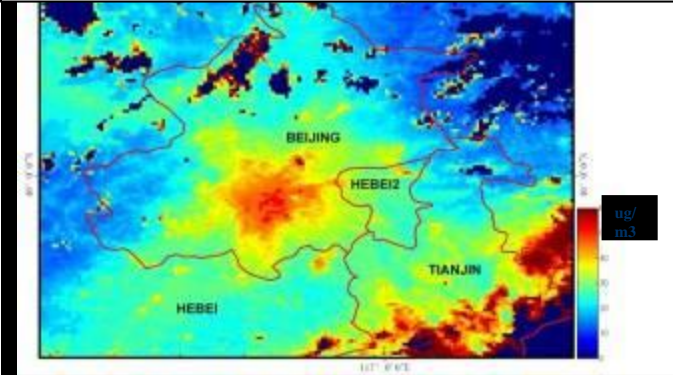
Satellite monitoring to monitor Beijing's atmospheric NO2 concentration

15日 16日 17日

18日 19日 20日

5 pixels
9 pixels

Trop NO₂
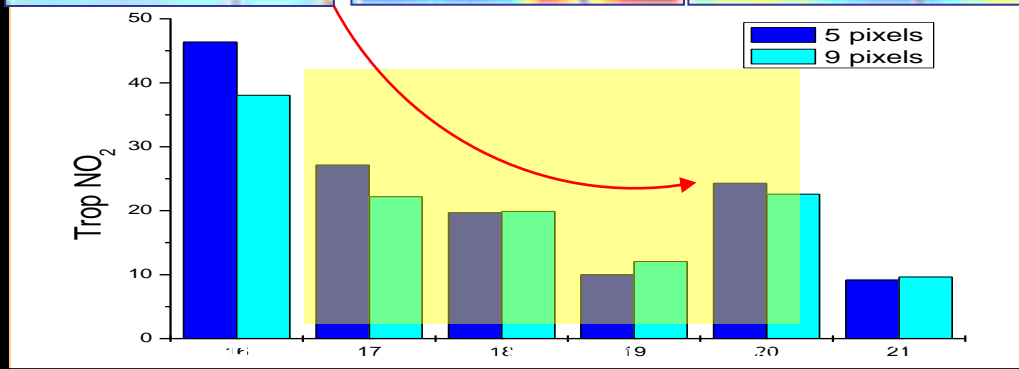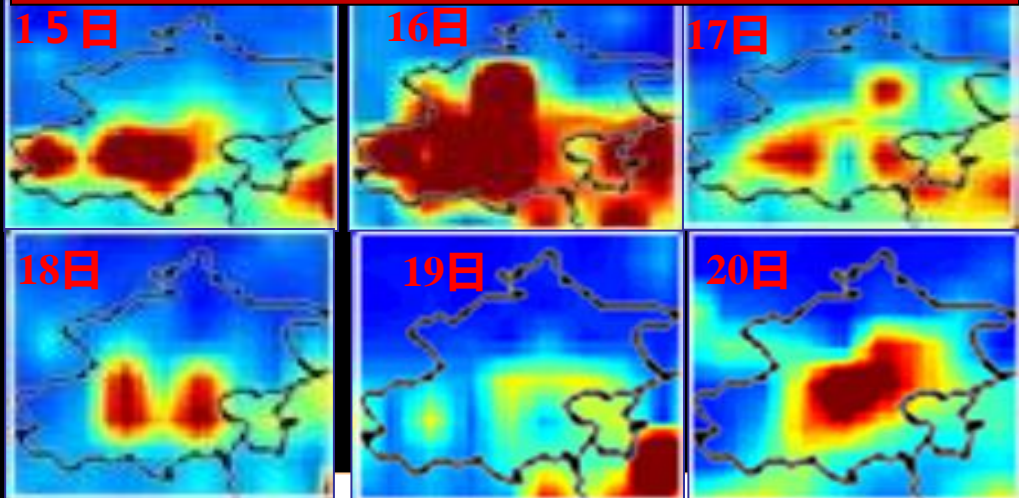
The decline of NO2 column concentration in Beijing during vehicle limit

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Urban Environment High-resolution Remote Sensing

City Atmospheric Detection

It can clearly identify factory chimneys and their smoke and dust emissions, and can be used to monitor the emission of polluted gases and serve the environmental protection of the atmosphere.

Factory chimney

Urban Environment High-resolution Remote Sensing

Beijing City Atmospheric Monitoring

北京市气溶胶光学厚度卫星遥感监测图
（2013年10月5日）
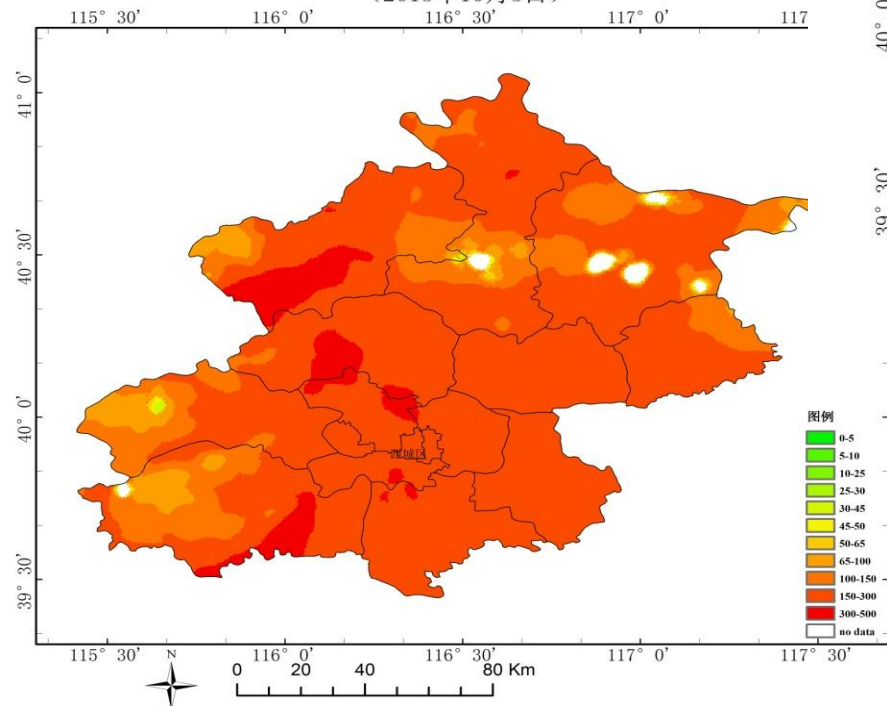
北京市PM2.5卫星遥感监测图
（2013年10月5日）
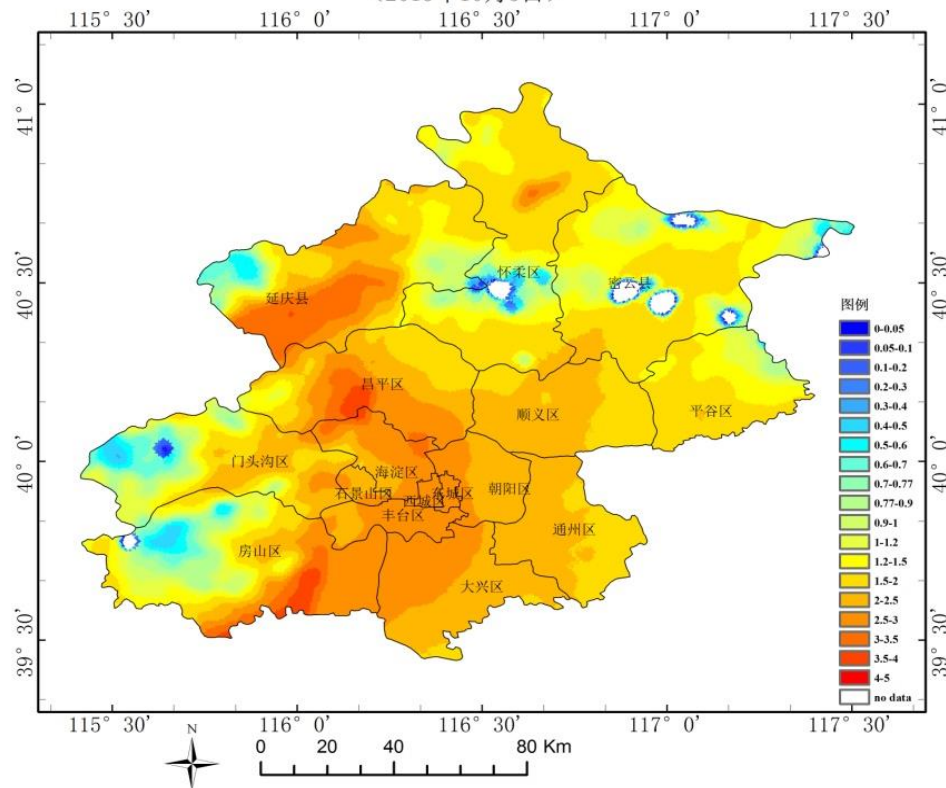
The comparison with the AERONET foundation observation results shows that the foundation observation on October 5, 2013 was 3.2, and the corresponding inversion result was 1.9. The comparison with the PM2.5 observations revealed that the ground-based observation on October 5, 2013 was 351, and the corresponding remote sensing monitoring result was 255.

Urban Environment High-resolution Remote Sensing

Beijing aerosol optical thickness and PM2.5 monitoring on October 6, 2013

北京市PM2.5卫星遥感监测图
（2013年10月6日）
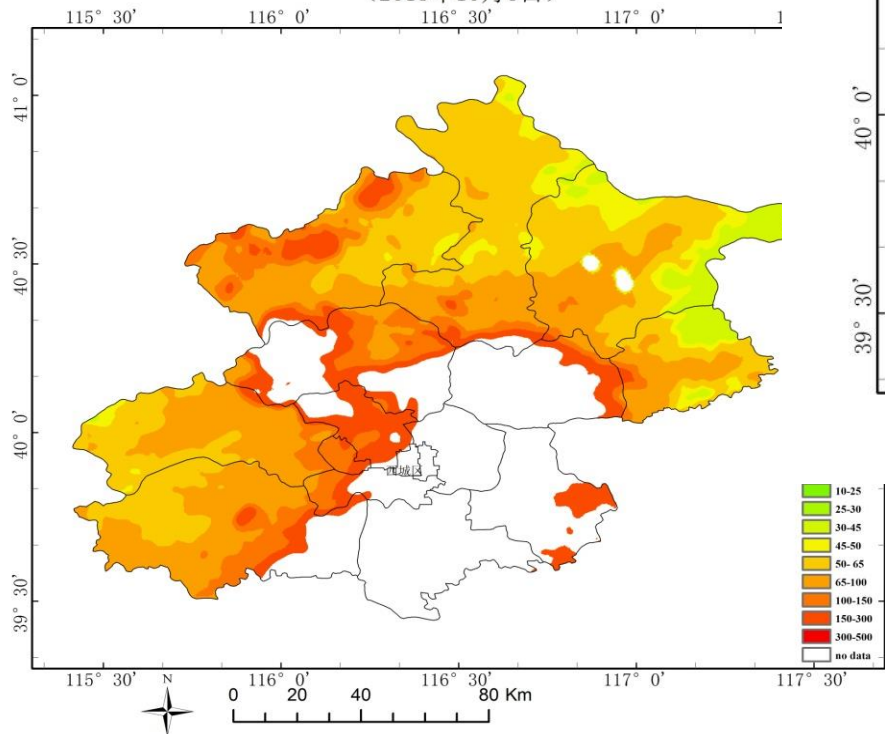
北京市气溶胶光学厚度卫星遥感监测图
（2013年10月6日）
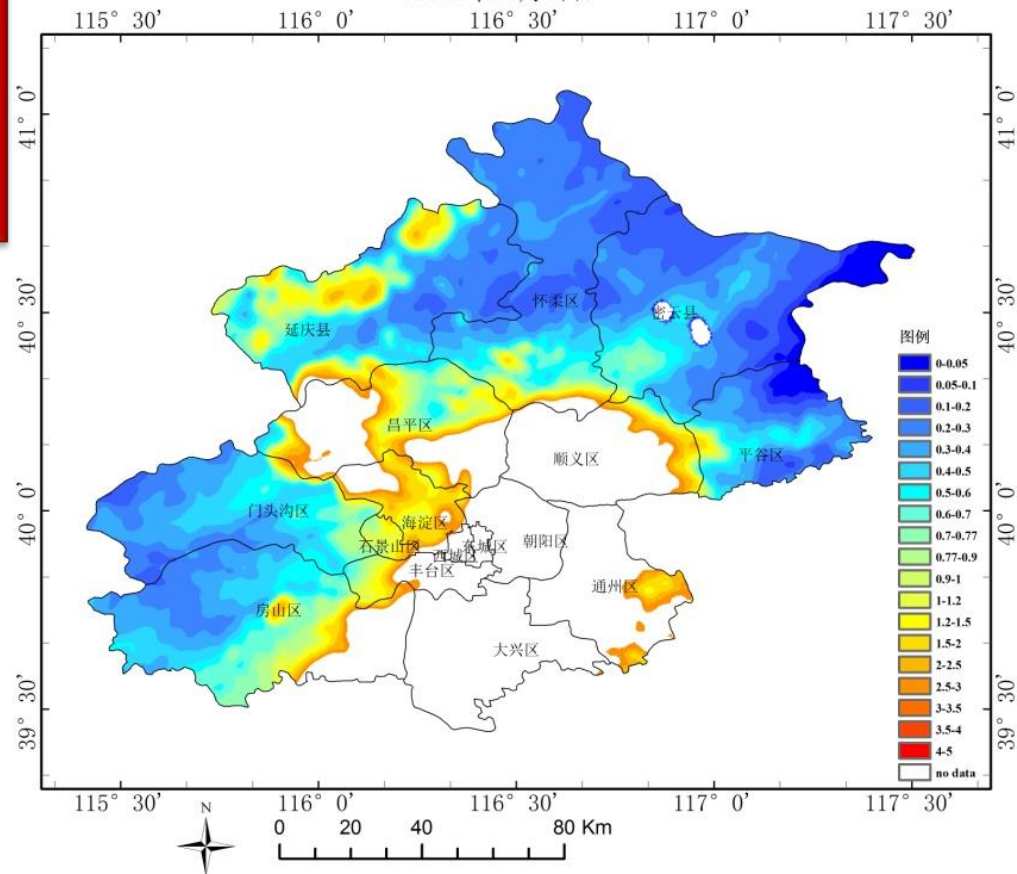
Clouds on October 6th, no observation at AERONET site

Urban Environment High-resolution Remote Sensing

Beijing, Tianjin and Hebei PM2.5 remote sensing monitoring

京津冀PM2.5遥感监测图
（2013年10月5日）

PM2.5
0–50
50–100
100–150
150–200
200–300
300–500

高分专项应用技术中心（筹）
中国科学院遥感与数字地球研究所
《美丽中国》事业部 2014年3月17日制作
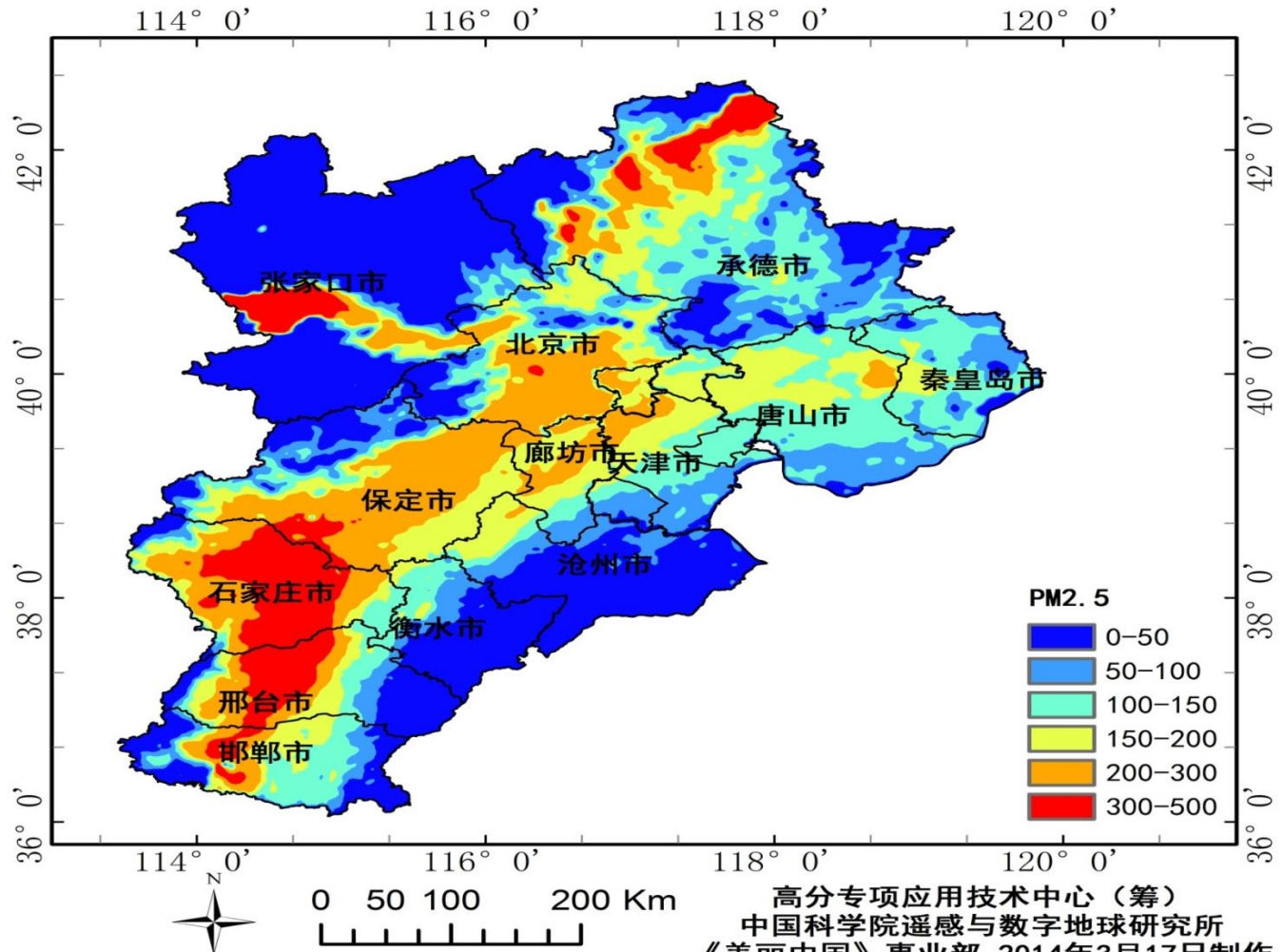
High-resolution Remote Sensing Application of Urban Environment

Urban Water Pollution Monitoring
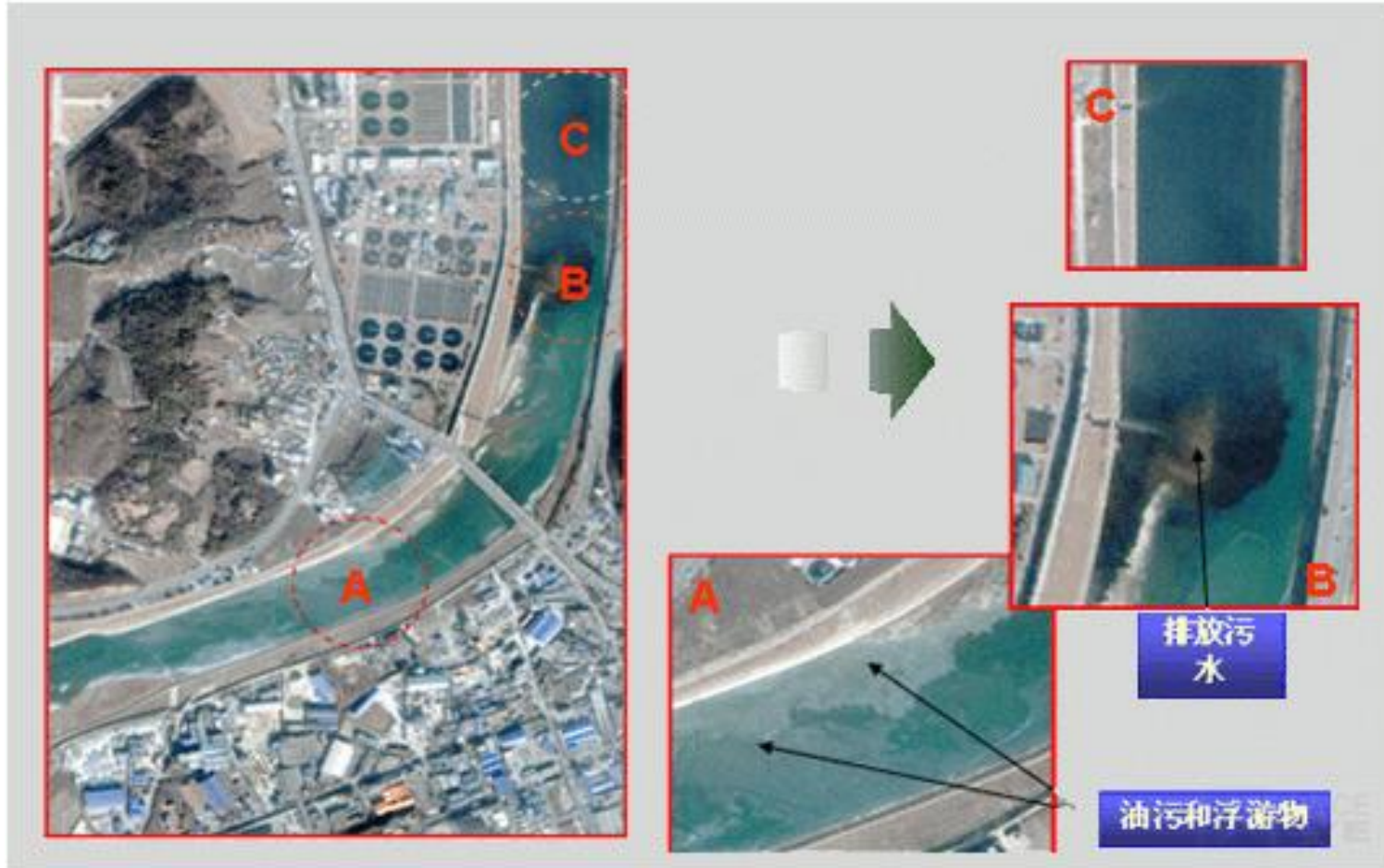
Outfall monitoring

High-resolution Remote Sensing Application of Urban Environment

Urban Water Management

    The images can clearly identify the water bodies such as lakes, reservoirs, and the monitoring of water conservancy dams. It can be applied to surface water body surveys, lake water fine monitoring applications, water conservancy engineering facility monitoring, and serves for the comprehensive management of water resources.

Lake

Water dam

High-resolution Remote Sensing Application of Urban Environment

Chlorophyll a Concentration In Water
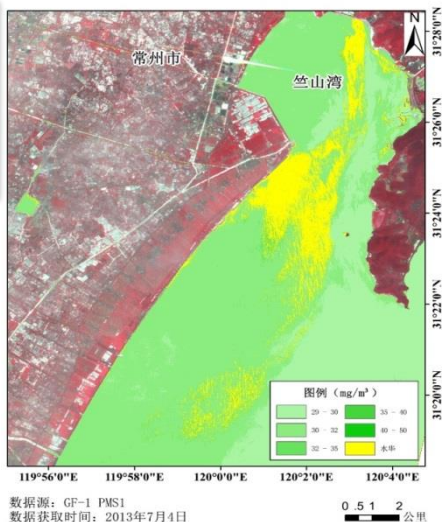
2013.07.04West
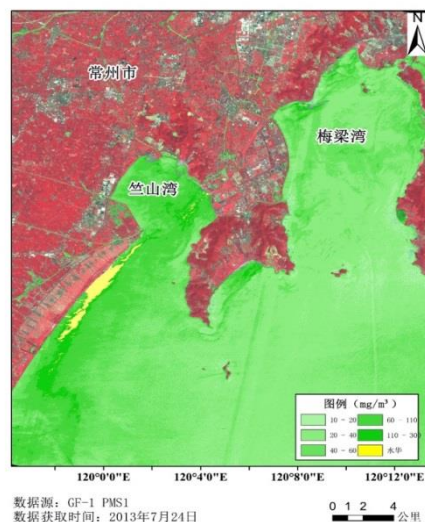
2013.07.24 Northwest
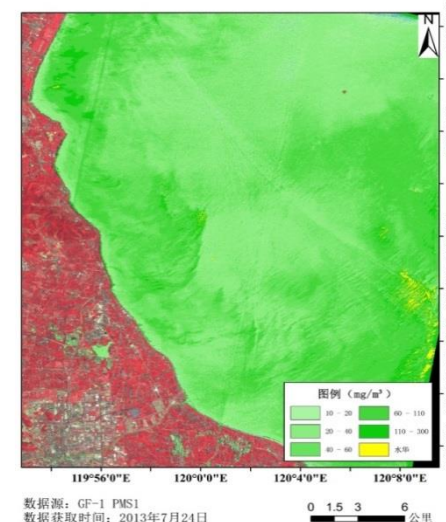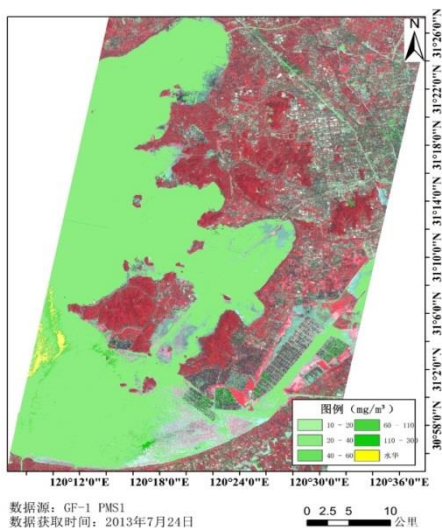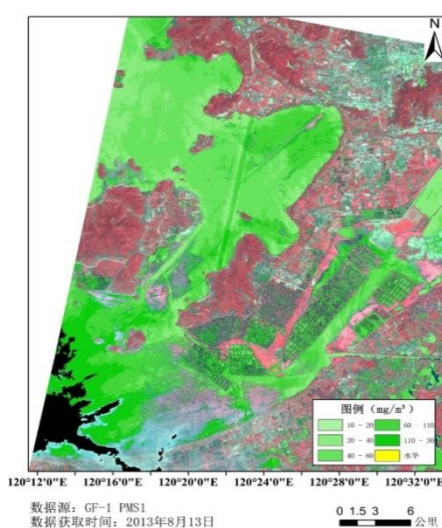
2013.07.24 Southwest

2013.07.24East

2013.08.13 Southeast
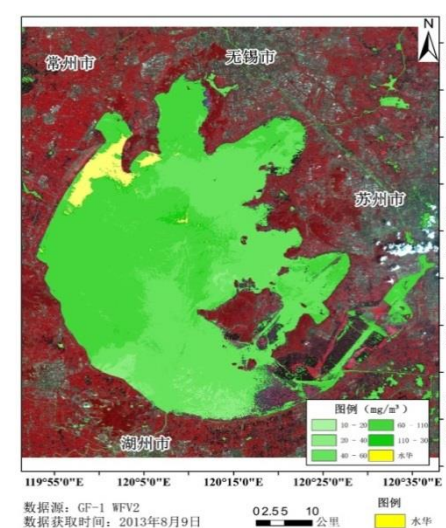
2013.08.09 Panoramic

High-resolution Remote Sensing Application of Urban Environment

Eutrophi-cation Index
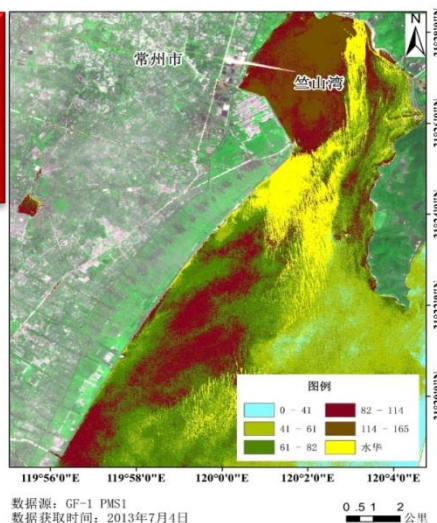
2013.07.04West
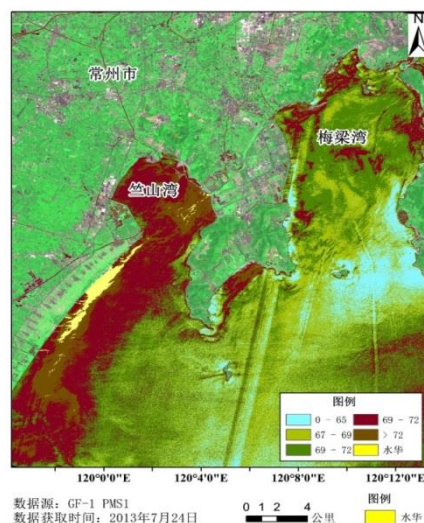
2013.07.24 Northwest
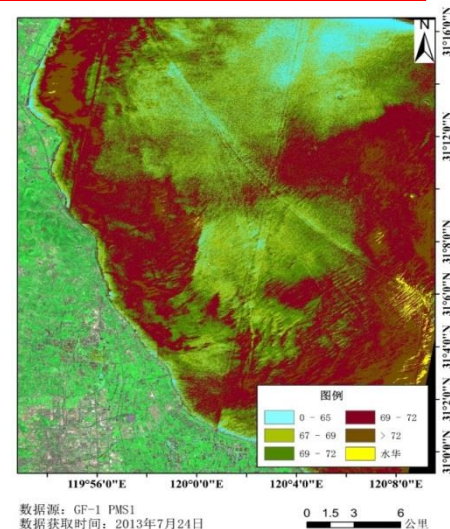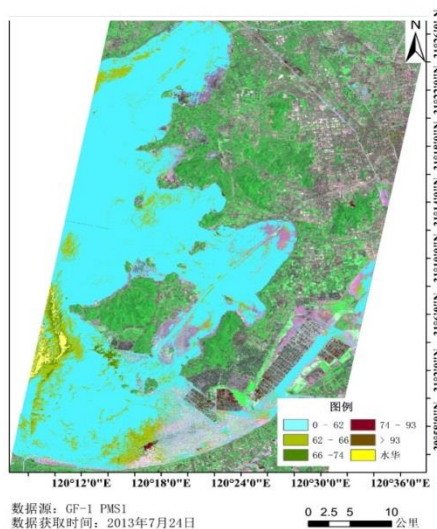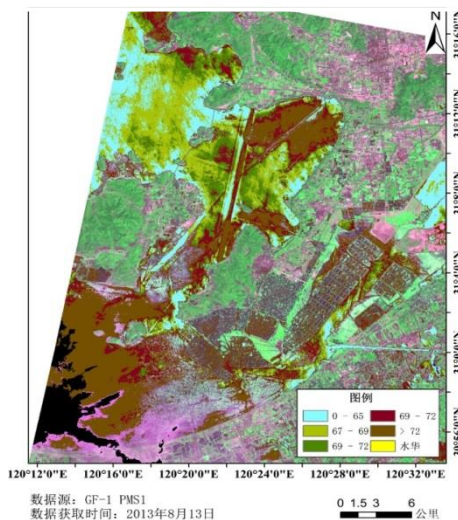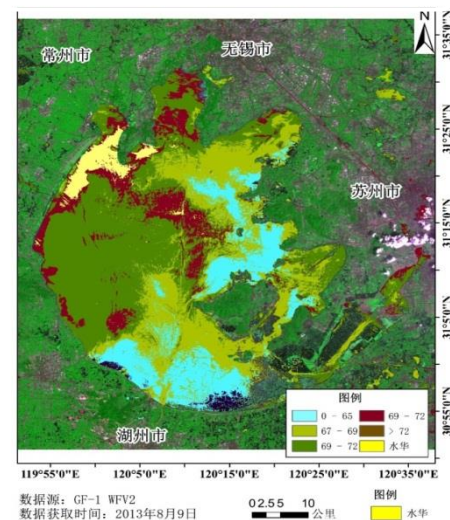
2013.07.24 Southwest

2013.07.24East

2013.08.13 Southeast

2013.08.09 Panoramic

High-resolution Remote Sensing Application of Urban Environment
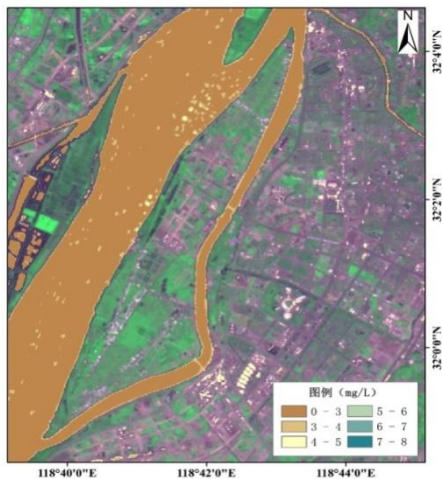
2013.07.24
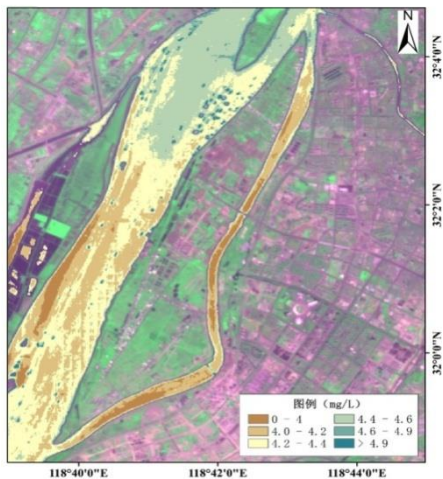
2013.08.09

2013.08.13

2013.09.19

COD浓度

南京夹江水质分级遥感监测图
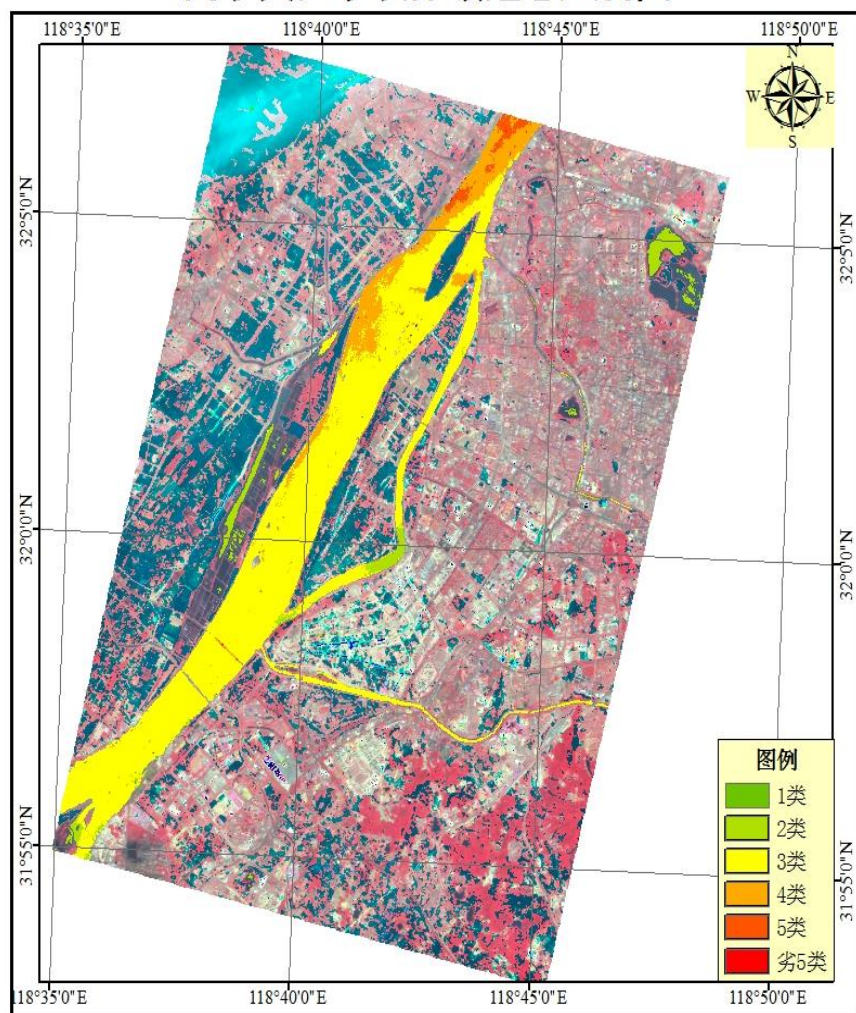
数据源：高分一号
获取时间：2013年08月13日
比例尺：1:135,000

环境保护部卫星环境应用中心

High-resolution Remote Sensing Application of Urban Environment

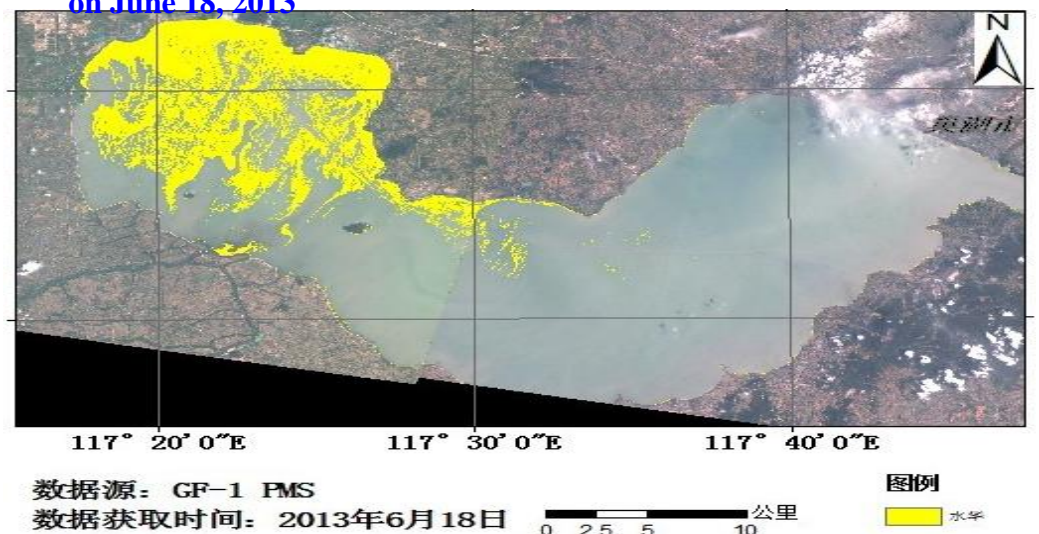**Distribution map of blooms in the northwest corner of Taihu Lake on July 4, 2013 (8m camera)**
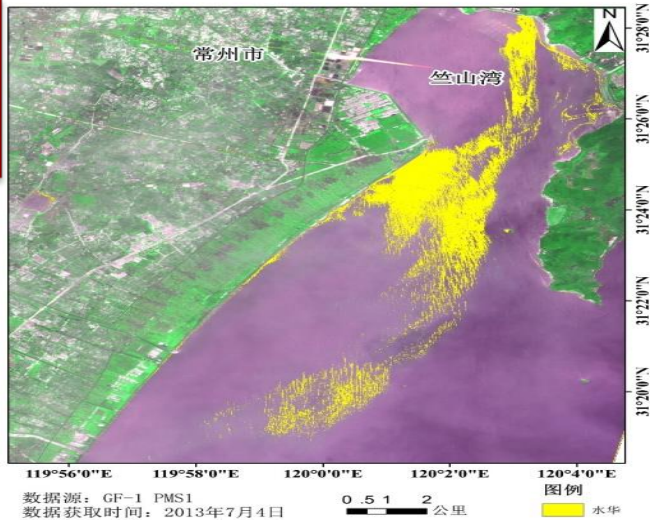
8m resolution multispectral remote sensing image of GF-1 satellite on June 18, 2013
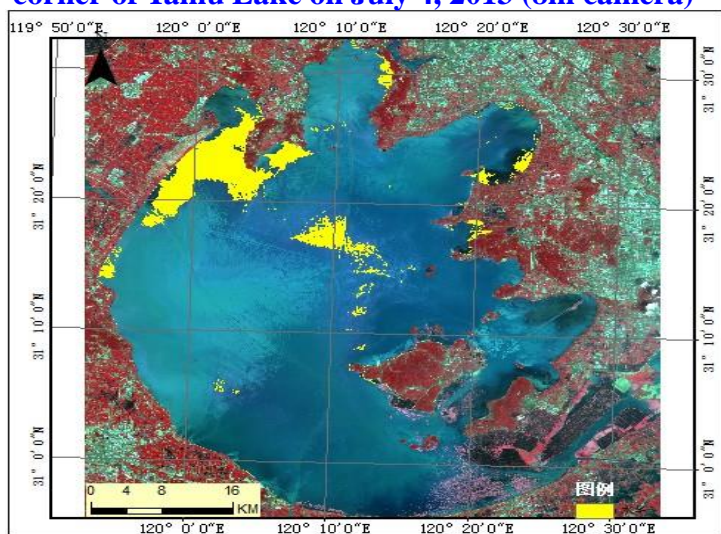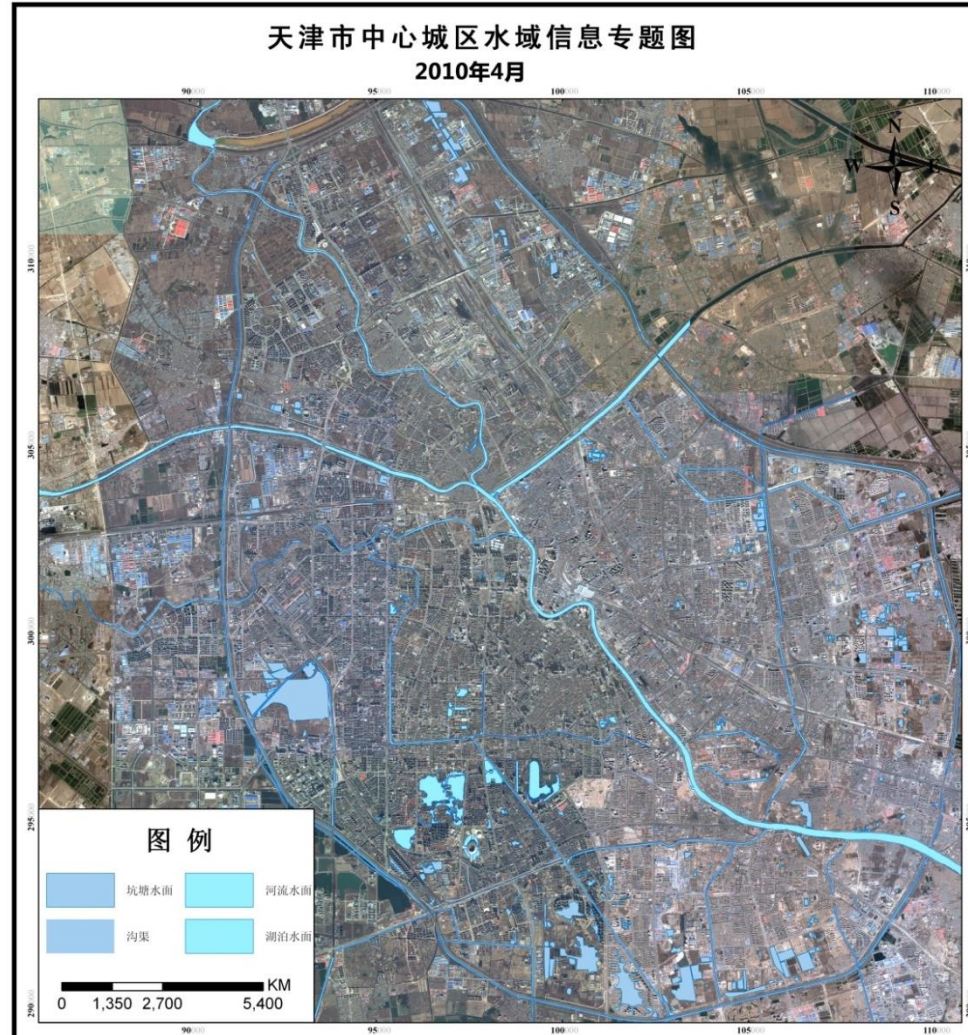

Distribution map of Taihu blooms on August 9, 2013 (16m camera, area 137.5 square kilometers

Distribution map of Chaohu blooms on June 18, 2013 (8m camera, area 69.09 square kilometers
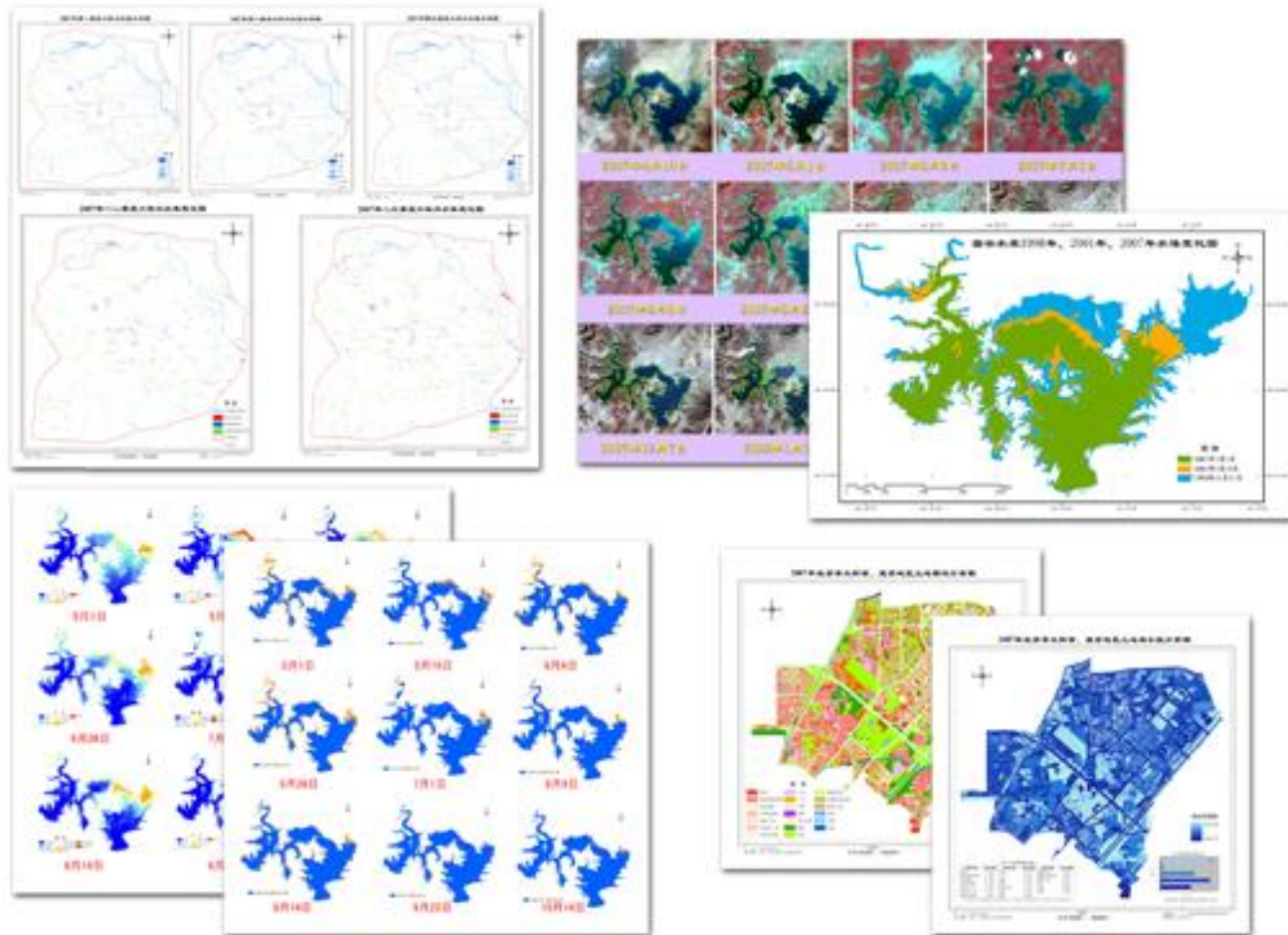
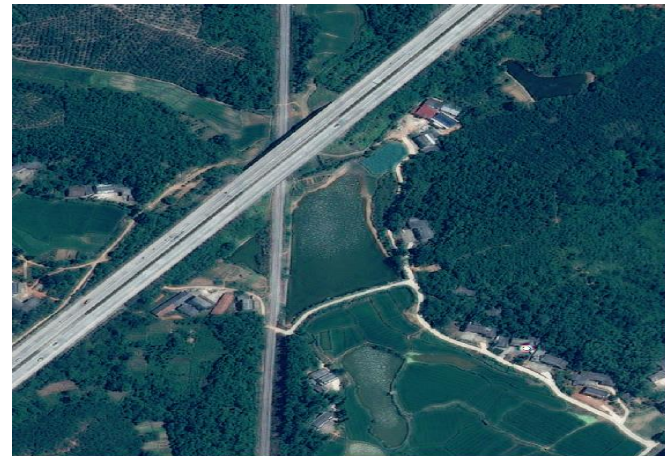# High-resolution Remote Sensing of Urban Resources
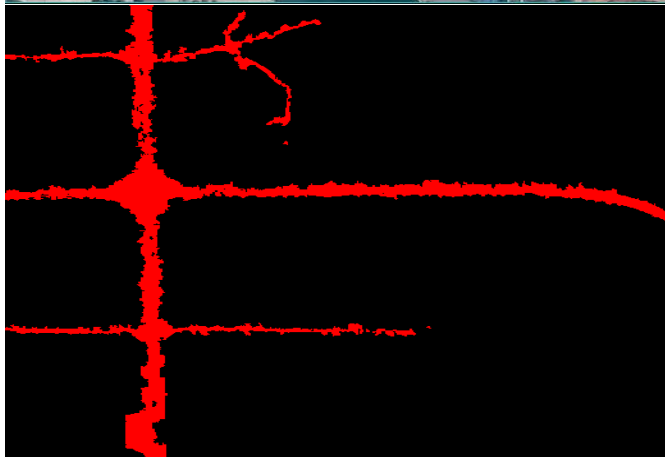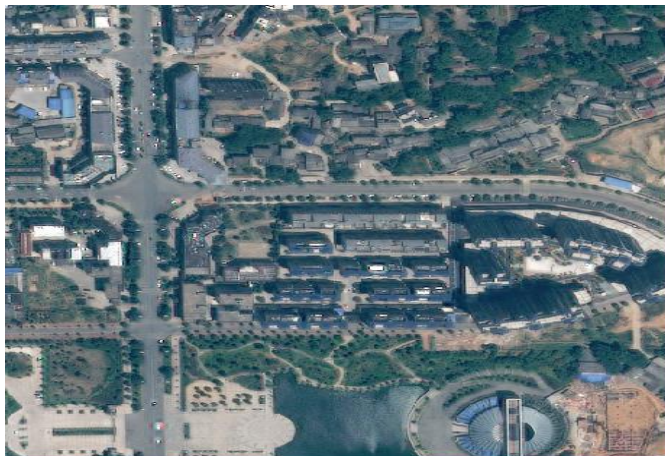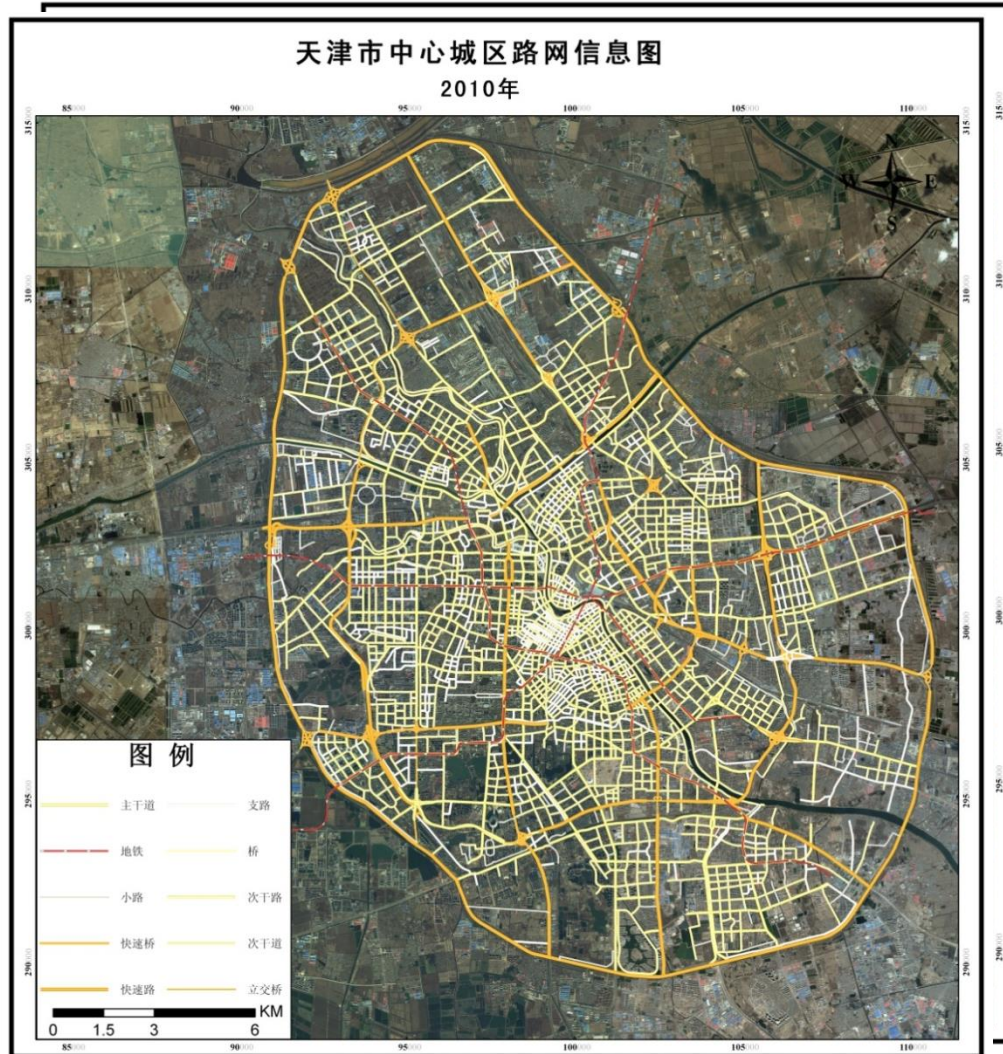
Urban Water System Monitoring

High-resolution Remote Sensing of Urban Resources

Urban Water System Monitoring

High-Resolution Remote Sensing Application of Urban Typical Feature

Main Road Extraction

**Urban Road Network Monitoring**

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High-Resolution Remote Sensing of Urban Typical Feature

Urban cultural heritage

Monitoring of historical and cultural cities

1. Assisted decision-making in the preparation, approval, implementation and modification of protection plans for historical and cultural cities, towns and villages;

2. Real three-dimensional reconstruction of historical blocks, ancient buildings, and cultural relics protection units, providing a data foundation for the restoration and reconstruction of historical and cultural heritage.
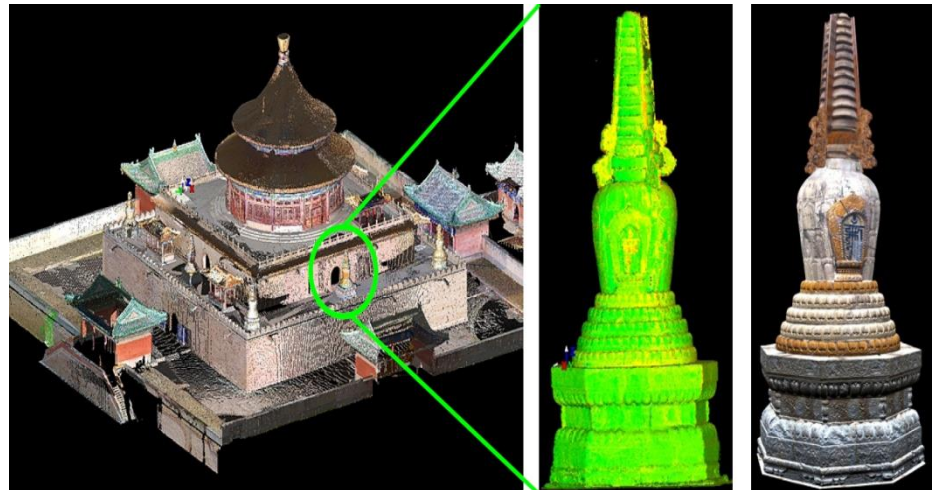
High-resolution Remote Sensing Application of Urban Disasters

Urban Floods
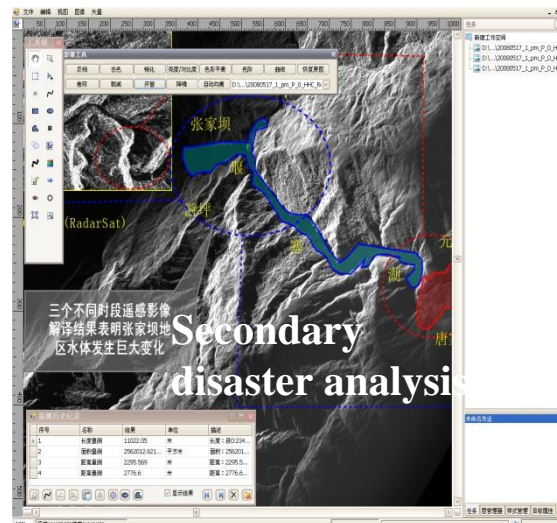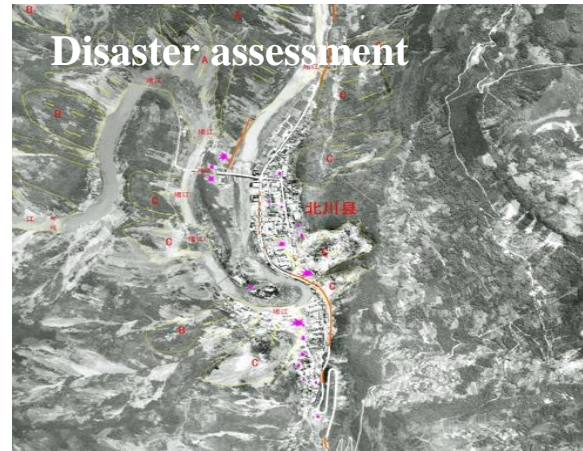

Flood Boundary Extraction

High-resolution Remote Sensing Application of Urban Disasters

Rapid Assessment of Urban Emergency and Disaster

1.In cities, in natural disasters and emergencies, timely acquisition of High-resolution data and processing results of related industries, and rapid sharing of data processing and analysis results of the industry;

2. Identification of urban and rural construction targets under various disaster conditions, damage assessment and early warning;

3. Auxiliary planning for post-disaster reconstruction of urban and rural construction.

Disaster assessment

Reconstruction aid planning

Secondary disaster analysis

Disaster warning

Conclusion

Industrial and economic development → Industrial upgrading → Intensive

City Management and Services → Social governance / Improvement of livelihood → intelligent

Urban construction and function enhancement → Ecosystem → green

Security system and infrastructure construction → Infrastructure → Low carbon
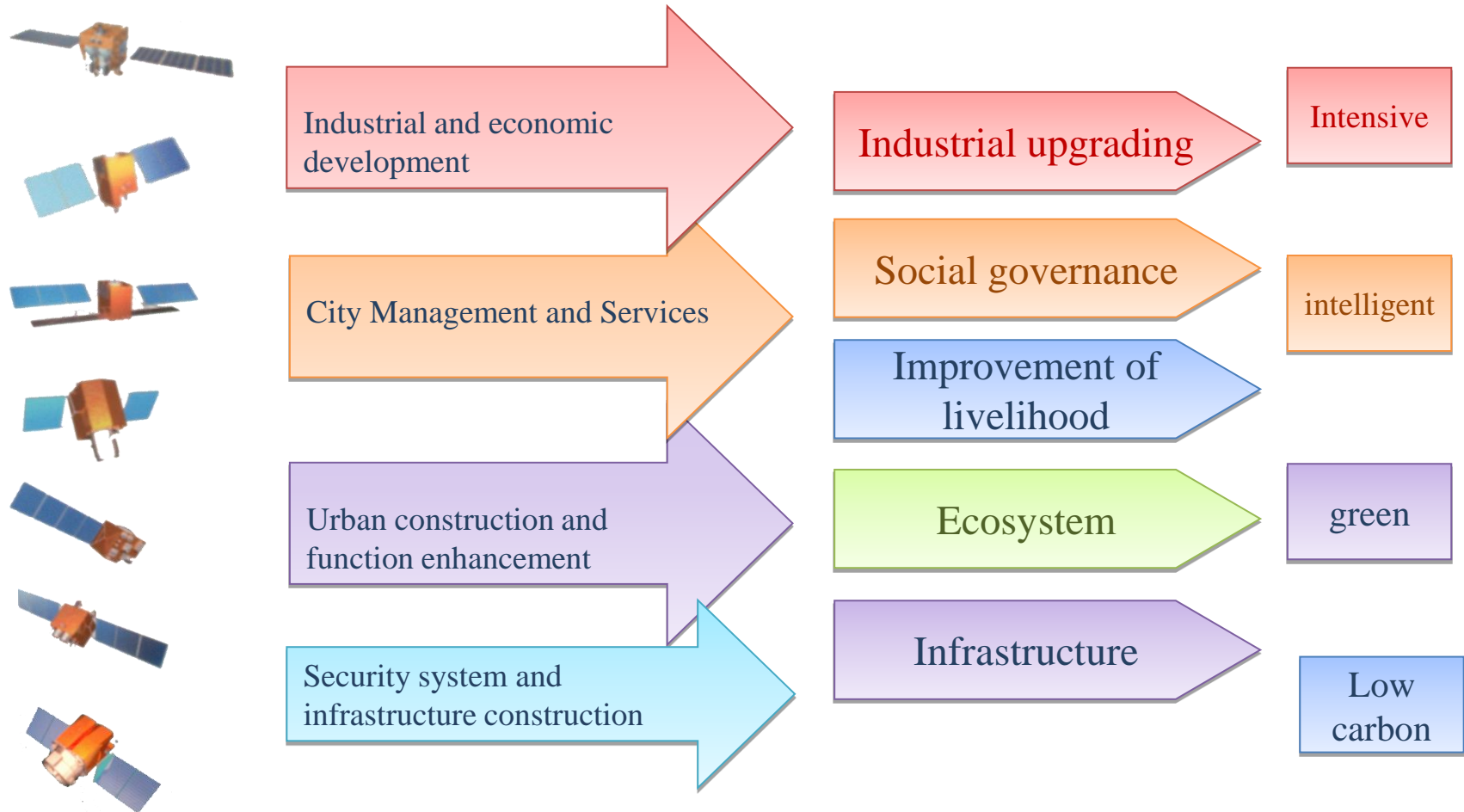
Promote the construction of smart cities through high-resolution projects, and solve the problems of industrial upgrading, social governance, improvement of people's livelihood, ecological environment and infrastructure in urban development

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Conclusion

Promote China's High-resolution Satellite Data Industry Business System

Promote the business application of high-grade special technical results, support the refined development of cities, and promote the construction of smart cities

Smartly build eco-towns and beautiful China, and contribute to the full realization of smart city planning goals.
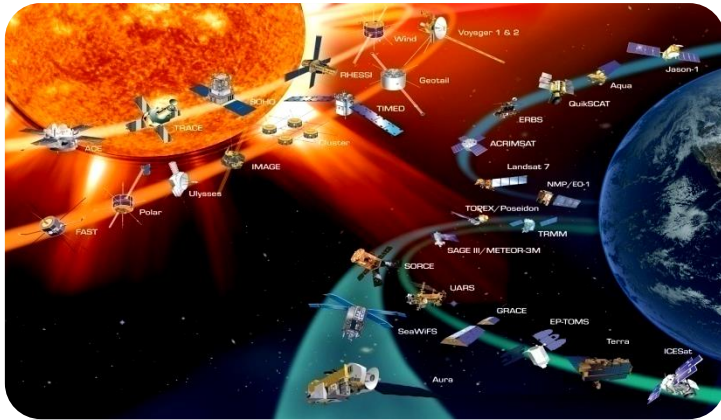
What To Be Mastered and Considered

To Be Mastered:

1. Understand the overall situation of the High-resolution project and its composition and characteristics;

2. Familiar with the type, spectrum band, resolution of 7 satellites;

3. Understand the application fields of the High-resolution special system;

To Be Considered:

1. What are the new applications of High-resolution satellite data in urban environmental monitoring?

2. What are the application techniques of High-resolution satellite data in your own research field?

Thanks !