中国科学院遥感与数字地球研究所
Institute of Remote Sensing and Digital Earth, CAS

# Satellite Earth Observation System And Spectrum Earth

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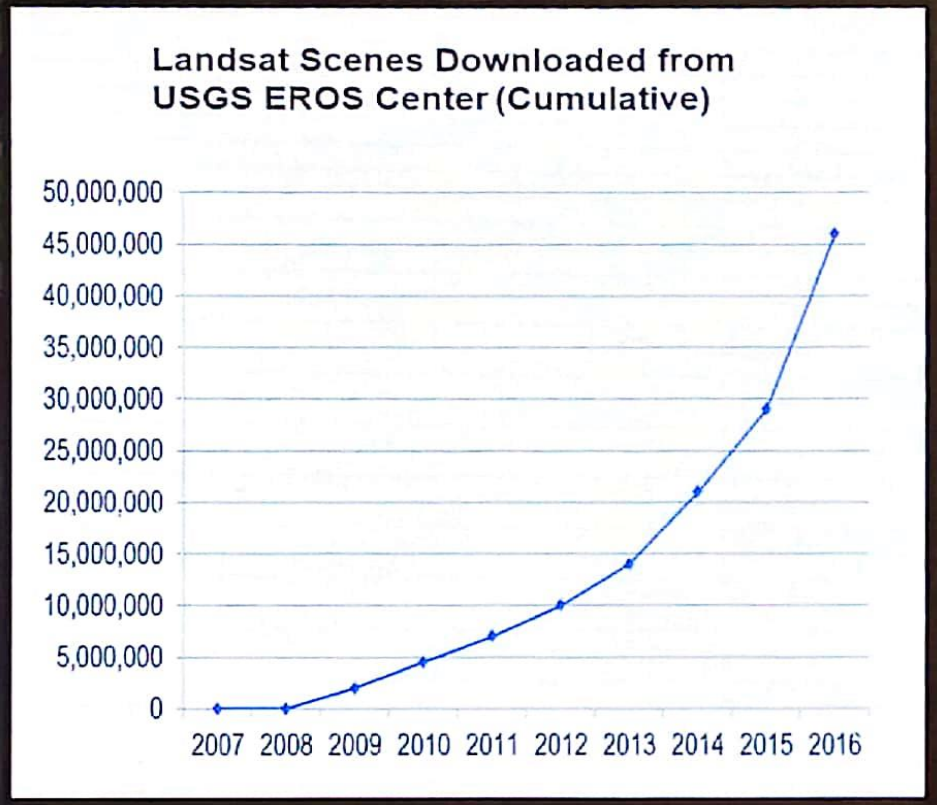



**Includes only downloads from the USGS EROS. (Google Earth delivers approximately 1 billion Landsat scenes to users per month.)**

Landsat series of Earth-observing satellites has created the longest, most comprehensive record of the Earth's condition ever assembled – the gold standard for tracking elements of land surface change.

With Landsats 7 and 8 currently operational - data collection anywhere on Earth every 8 days

More than 2 million images in the archive

Free and available to all users since 2008

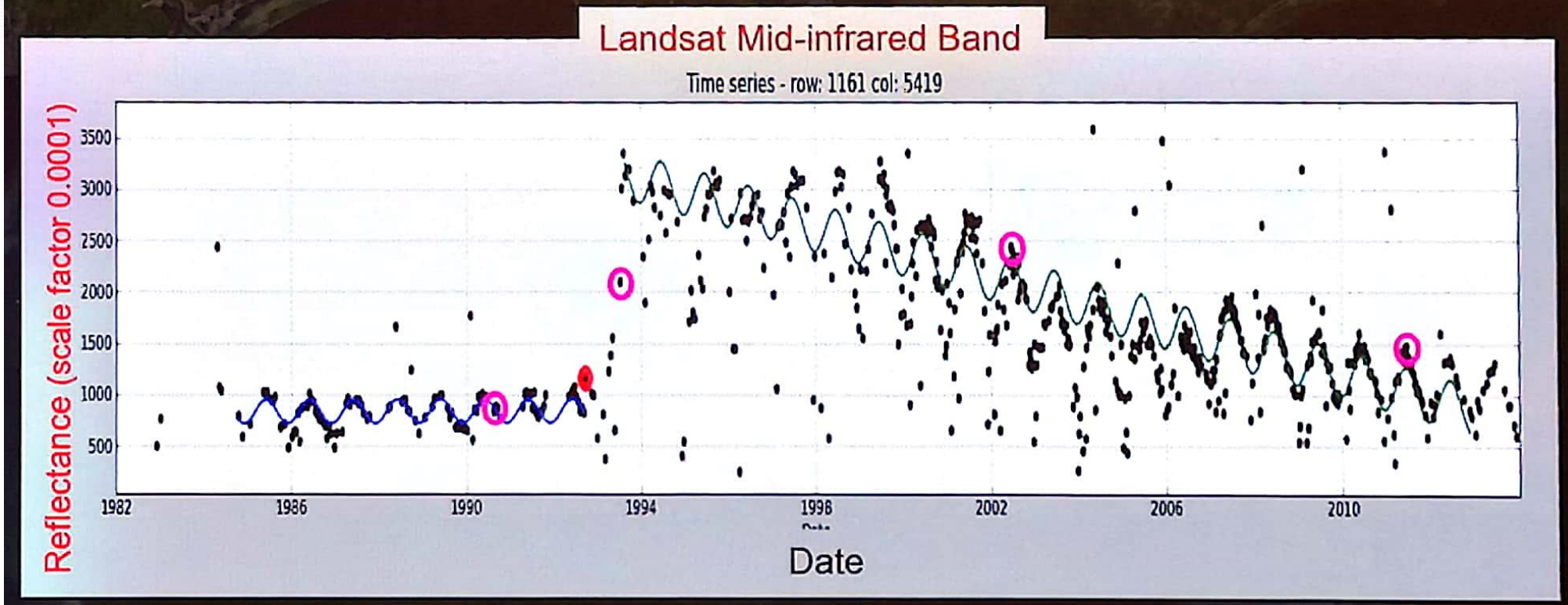
## Landsat is a Public/Private Endeavor

**Every Landsat mission has components built by the private sector. USGS ground system and flight ops teams rely heavily on the private sector.**

USGS

NASA

After 47 years of Landsat data collection, USGS is enabling user access to "**A**nalysis **R**eady **D**ata" and a new generation of time series algorithms for land cover and land change datasets.




L4-L8 Tier 1 data processed to surface reflectance and brightness temperature measurements, (Level-2 products).

Makes the archive more accessible, easier to analyze and reduces amount of time users spend on analysis of landscape change.

Allows pixel tracking in geospatially calibrated tiles and dense temporal stacks, "datacubes".

USGS

NASA

# Main Content

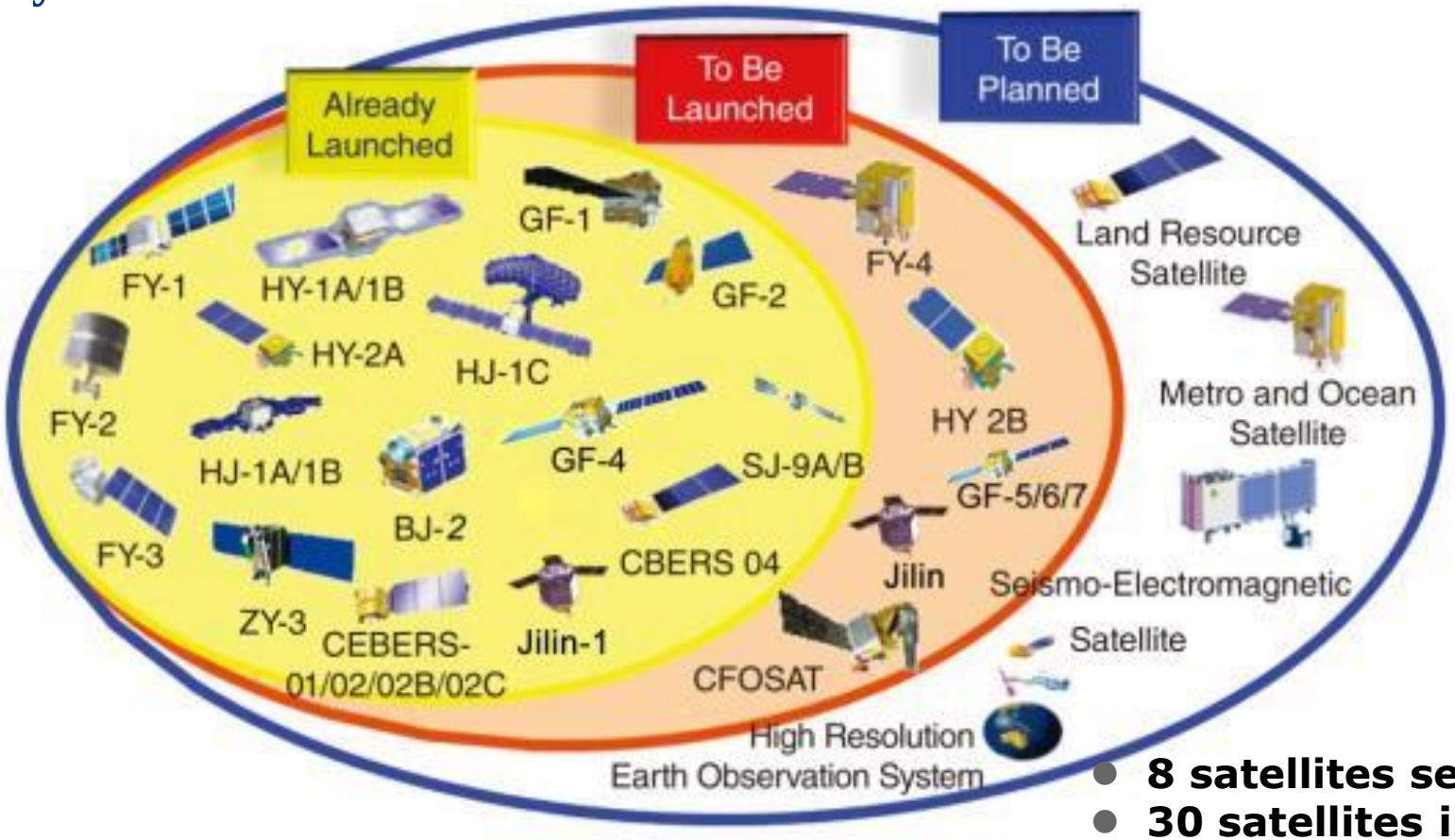
1. China Earth Observation System Development

2. Spectrum Earth: A Solution Of Developing EO System Framework

# 1. Introduction

## Satellites

**Currently, about 30 Chinese Earth observation satellites are in orbit. China will continue to develop series of Earth observation satellites during the next 10 years.**

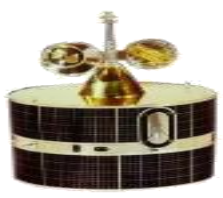
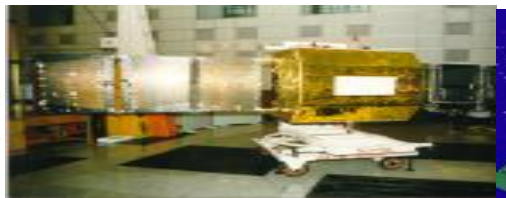
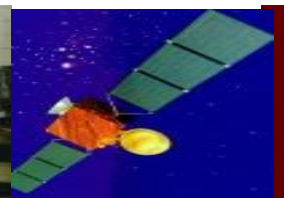
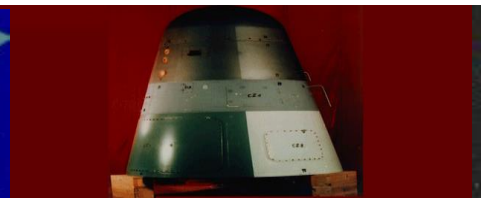


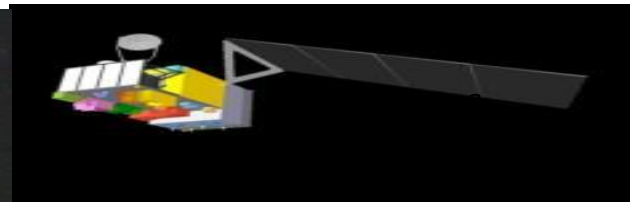

- **8 satellites series**
- **30 satellites in orbit**

# 2. Development

**China has established comprehensive system of satellite observation.**

| China Earth Observation Satellites | | |
|---|---|---|
| **Series** | **Programs** | **Administration** |
| **Meteorological** | **FY-2 E/F/G** | **China Meteorological Administration** |
| | **FY-3 A/B/C** | |
| **Ocean** | **HY-1A/B,HY-2A/B** | **State Oceannic Administration** |
| **Earth Resources** | **ZY-2(01,02,03)** | **Ministry of Land and Resources** |
| **Environmental** | **HJ-1A,B,C** | **Ministry of Environmental protection/National Disaster Reduction Center** |
| **CHEOS** | **GF-1,2,3,4,5,6** | **EOSDC** |



# 2. Development

## China High-Resolution Earth Observation System (CHEOS)

**In May 2010, China officially launched construction of Major Special Project – the China High-Resolution Earth Observation System (CHEOS), which is established as one of the major national science and technology projects.**

- **GF-1 and GF-2 are a high-resolution radar satellites, which provide effective support for the enhancement of fine monitoring.**
- **GF-3 is a high-resolution radar satellite,**
- **GF-4 is an optical geostationary satellite,**
- **GF-5 is a high spectral and atmospheric observation satellite,**
- **GF-6 is a multi-spectral satellite and GF-7 is a three-dimensional mapping satellite.**

# 2. Development

## China's national space infrastructure （CNSI)

- To realize sustainable and stable service of space-based systems following infrastructure pattern.
- To enhance the china's satellite observation and data acquisition capability, and strengthen the normalization, rationality and efficiency maximization of earth observation architecture development.

- Space system consists of remote sensing satellites, communications and broadcasting satellites, navigation satellites.
- By the end of 2015, more than 60 satellites were in orbit to provide services.
- It is predicted that the number of satellites in orbit would be more than 70 in 2020 and nearly 100 in 2025 respectively.

# 2. Development

## Commercial satellite series - BJ series

**Beijing-2 Satellites constellation comprising three identical optical EO satellites, which makes it possible to target anywhere on Earth once per day**


Disaster & Emergency Response

City Management

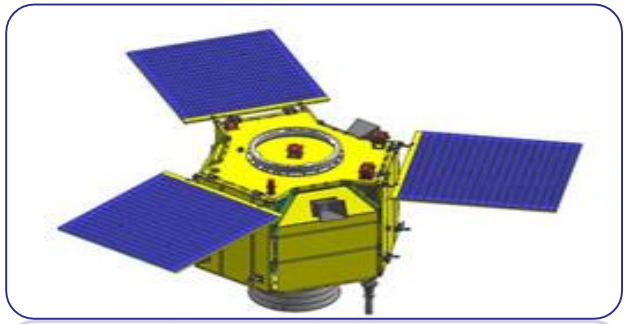
| | |
|---|---|
| Number of satellites | **3** |
| Satellite orbit | **Sun-synchronous orbit**<br>**Altitude: 651 km**<br>**LTAN: 10:30am** |
| GSD | **<1m PAN**<br>**<4m MS** |
| Bands | **B/G/R/NIR** |
| Swath width | **23.4 km** |
| MTF | **PAN: 10% MS: 20%** |
| Signal to noise | **>100** |
| Off-pointing capacity | **±45°** |
| Revisiting | **1 Day** |
| Lifetime | **7 years** |
| Image file format | **GeoTIFF/TIFF** |

# 2. Development

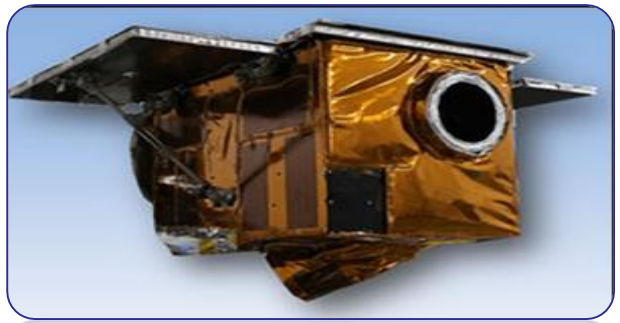
## Commercial satellite series - Jilin-1 Satellites

- China's first domestically developed commercial Earth imaging satellites. Launched in October 2015
- Plan to have 60 satellites operational by 2020, allowing 30-minute revisit capability anywhere around the globe
- Jilin-1 consists of 4 satellites
  - Two providing high-definition video
  - One for commercial high-definition images
  - One for testing new space technology

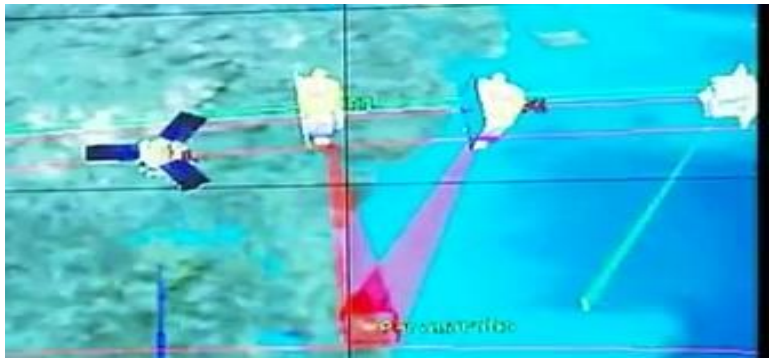
**Jilin-1A optical satellite**



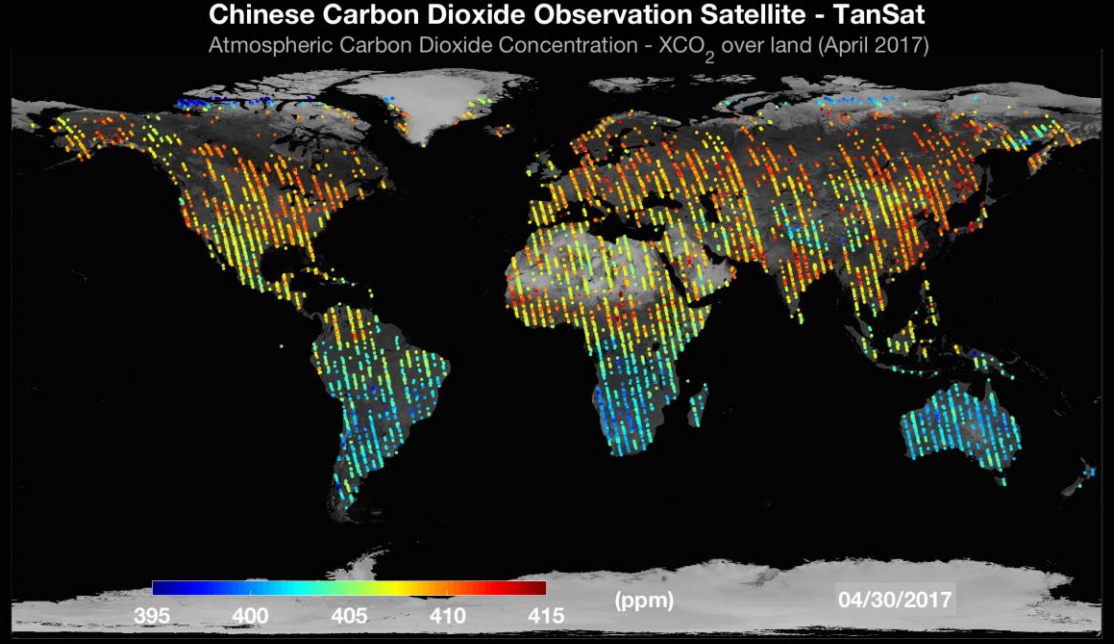
**Jilin-1B video satellite**



- **High-definition camera:**
  - **Pan: 0.72m、Multi: 2.88m**
- **Video camera:**
  - **GSD: 1.12m**



- **support to areas including**
  - **land resources monitoring**
  - **land surveying**
  - **mineral resources development**
  - **smart city construction**
  - **agriculture yield estimation**
  - **environmental monitoring**
  - **disaster prevention**
  - **…**

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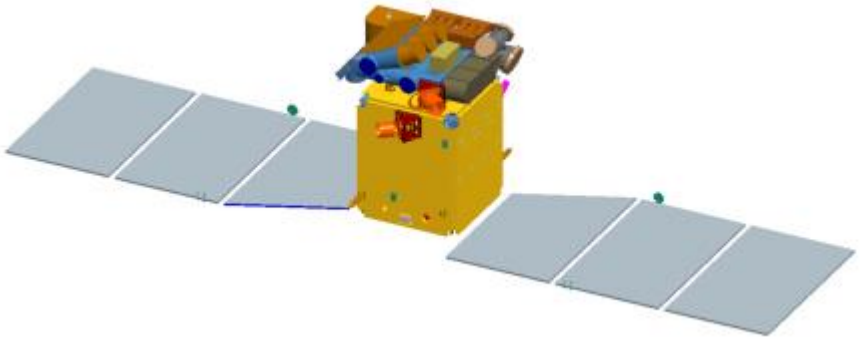
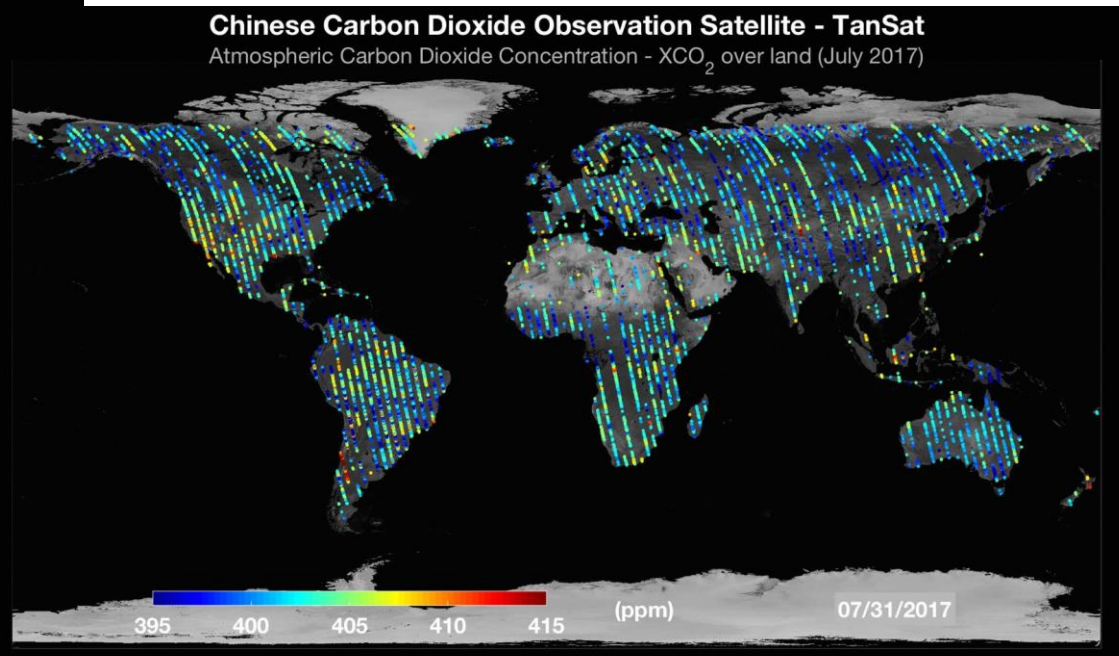





The first Mapping of Global Atmospheric $xCO_2$ over land with Tansat (2017)

- by Prof Liu Yi from CAS/IAP at 2018

# Main Content

1. China Earth Observation System Development

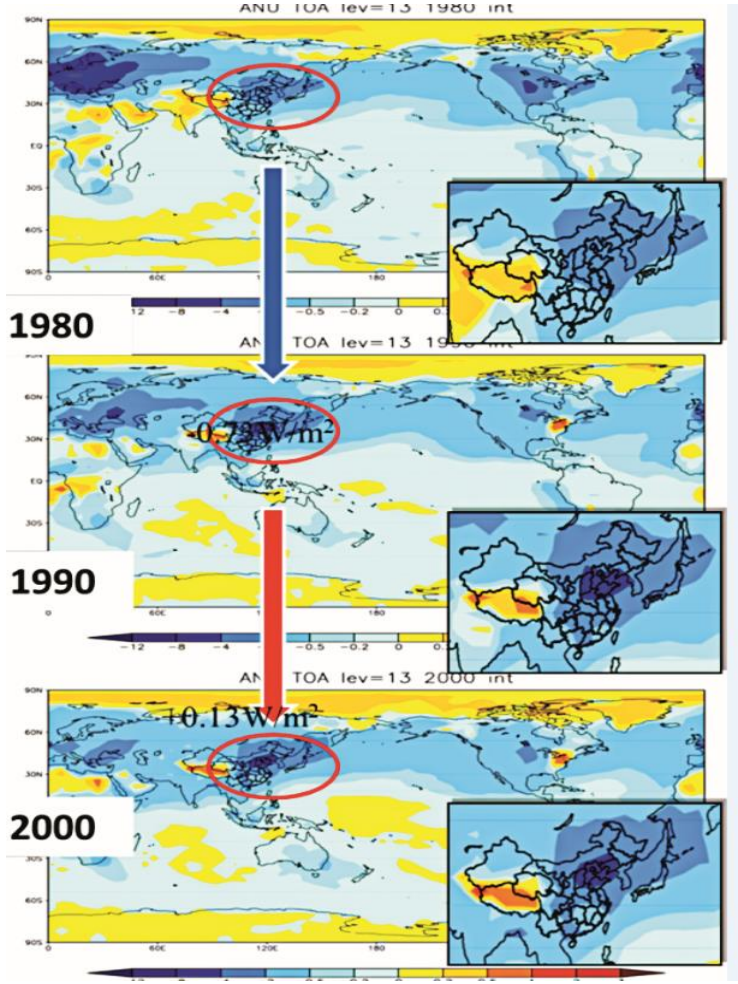
2. Spectrum Earth: A Solution Of Developing EO System Framework

# 1、Introduction

## Description

**SpectrumEarth :**

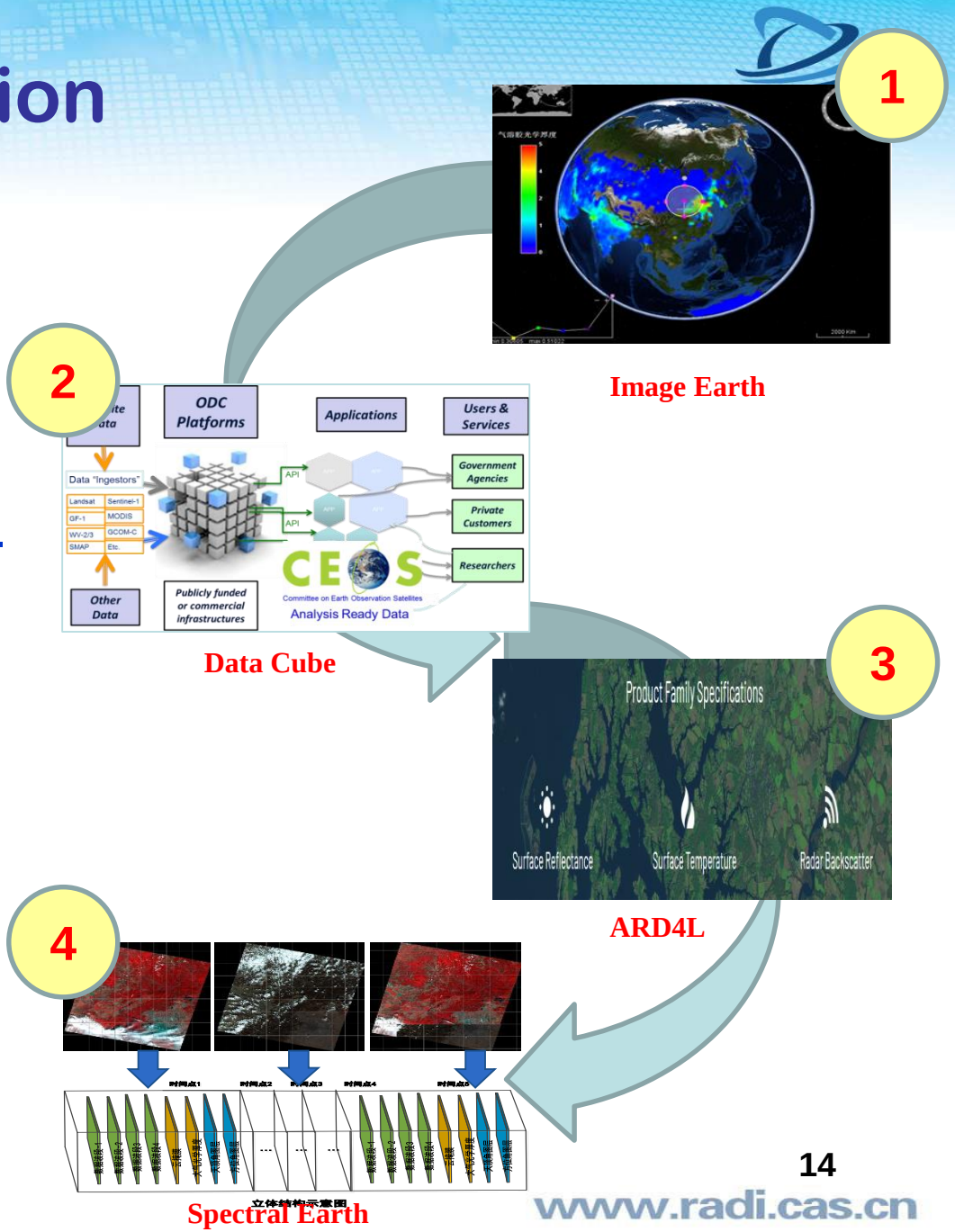
- ✓ continuous, verifiable land surface, atmospheric and marine multi-element quantitative remote sensing product data set;
- ✓ Supporting the applications on ecological environment, urbanization, modern agriculture, intelligent city, water resources, disaster reduction at global and regional
- ✓ hardware and software platform



# 1、Introduction

## Spectrum Earth and other Concepts

1. **Data Earth, Image Earth (Google Earth; Day Map): Single Phase, Geometric Correction - Mosaic Image**
2. **Data Cube (DataCube, Australia, GEO): Multi-temporal, sliced, geometrically corrected image**
3. **Analysis-Ready Data (ARD4L, CEOS): multi-temporal, slice, geometry-radiation-atmospheric corrected image**
4. **Spectral Earth: Multi-temporal, Slice, Geometry-Radiation-Atmospheric Correction-Inlaid Image+Time Fusion-Space Fusion-Spectral Fusion**



# 1、Introduction

## System composition

### SpectrumEarth

#### SpectrumEarth production

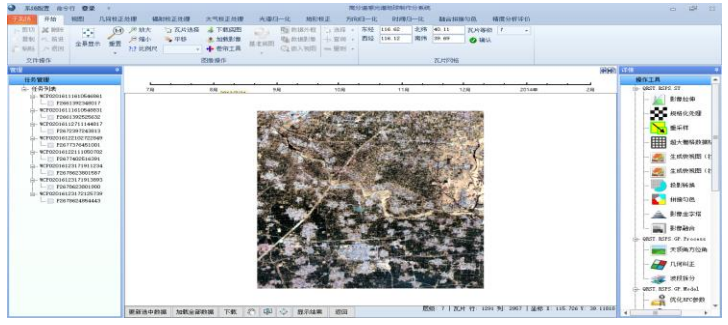
- ✓ Support high-performance processing of fundamental products and spatial-temporal fusion products;
- ✓ Radiance, TOA reflectance, Surface Reflectance

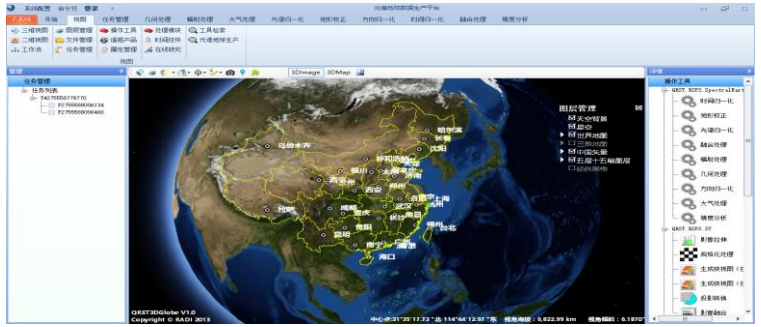
#### Demonstration & Analysis

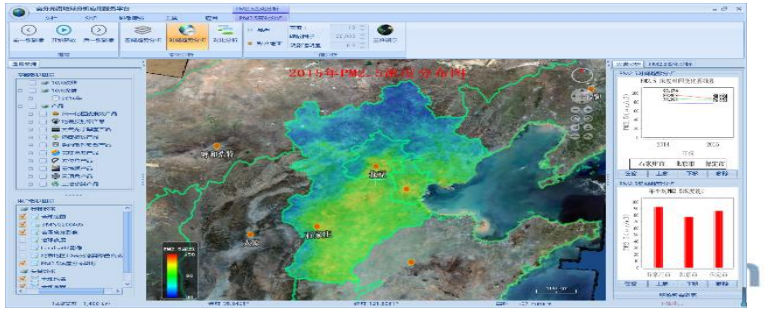
- ✓ Integrated visualization environment, algorithms & model, time and space analysis tools

#### Applications

- ✓ Build the application systems and services based on SpectrumEarth, with support of multi-source data, in-situ observation data and evaluation algorithms;







# 1、Introduction

## System Function

Combined with the requirements of quantitative remote sensing information extraction and intelligent analysis, Spectral Earth integrates the results of independent remote sensing technology, and has professional service capabilities for multi-level users, including the following functions:

**Function 1**

**Time-space spectral data (apparent radiance, apparent reflectance, AOD, surface reflectance, cloud mask, geometric precision correction products, etc.) production function.**

**Function 2**

**Spectral data analysis, management, portal construction, real-time rapid extraction of thematic information products, spectral product spatial analysis, visual analysis, online calculations, etc.**

**Function 3**

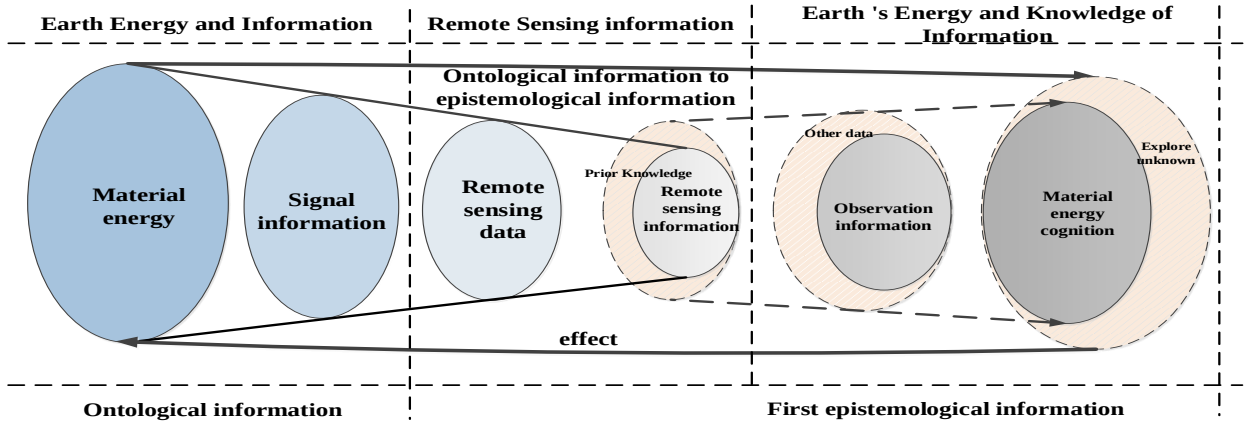
**Provide users with one-stop service (display, customization, inspection, drawing) functions of typical thematic products (land use, air quality, water environment, etc.).**

# 1、Introduction

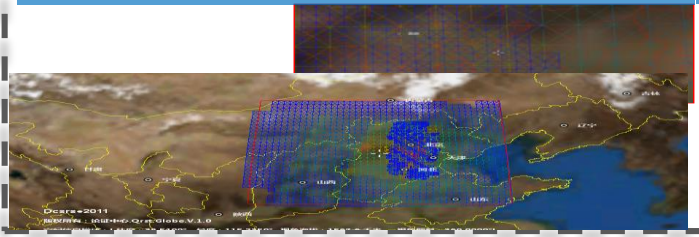
## Remote Sensing Data Engineering Theory

### Remote Sensing Data Information Density Function Model

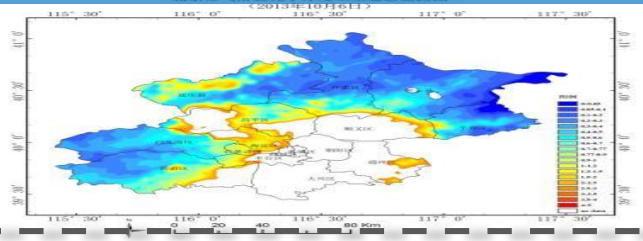
The distribution of the representation information in the data space,that is the distribution of the probability functions of the data converting to valid information.




### Small data: "One tile" application



### Big data: "a map" application



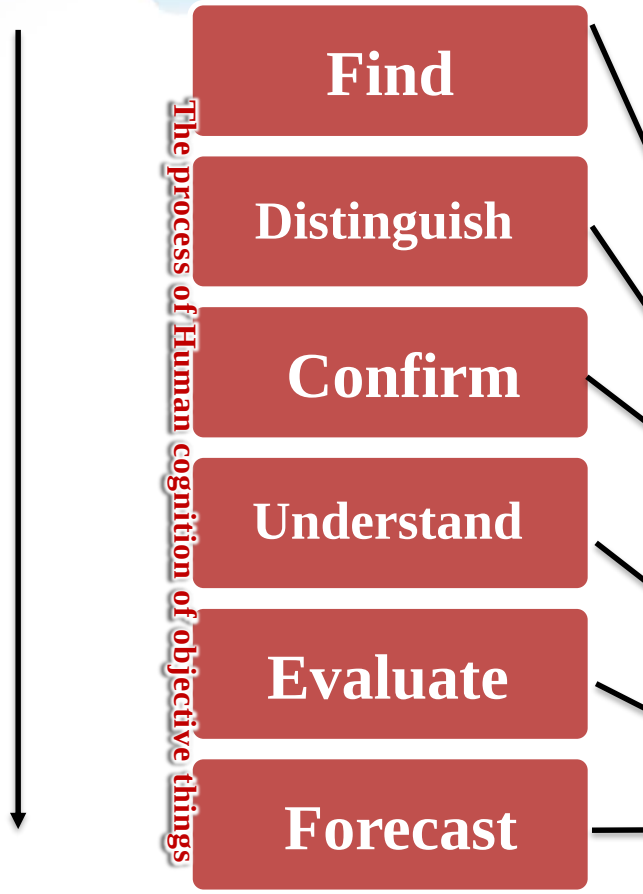
### Spatial Data Normalization Model

**"5-level 15 grade" : the effective unity of spatial data standardization model: remote sensing satellite sampling size, surface latitude and longitude grid, standard of scale.**

| layer | level | Tile size（°）（1000*1000） | Pixel scale（°） | Cell size at the equator（m） | Spatial resolution level（m） | Country basic scale |
|---|---|---|---|---|---|---|
| 6 | … | | | | | |
| | H | | | | | |
| | G | | | | | |
| 5 | F | 50 | $5\times10^{-2}$ | 5566.11 | 5,000 | |
| | E | 25 | $2.5\times10^{-3}$ | 2783.05 | 2,500 | |
| | D | 10 | $10^{-2}$ | 1113.22 | 1,000 | |
| 4 | C | 5 | $5\times10^{-3}$ | 556.61 | 500 | |
| | B | 2.5 | $2.5\times10^{-3}$ | 278.31 | 250 | |
| | A | 1 | $10^{-3}$ | 111.32 | 100 | 1:1,000,000 |
| 3 | 9 | 0.5 | $5\times10^{-4}$ | 55.66 | 50 | 1:500,000 |
| | 8 | 0.25 | $2.5\times10^{-4}$ | 27.83 | 25 | 1:250,000 |
| | 7 | 0.1 | $10^{-4}$ | 11.13 | 10 | 1:100,000 |
| 2 | 6 | 0.05 | $5\times10^{-5}$ | 5.57 | 5 | 1:50,000 |
| | 5 | 0.025 | $2.5\times10^{-5}$ | 2.78 | 2.5 | 1:25,000 |
| | 4 | 0.01 | $10^{-5}$ | 1.11 | 1 | 1:10,000 |
| 1 | 3 | 0.005 | $5\times10^{-6}$ | 0.557 | 0.5 | 1:5,000 |
| | 2 | 0.002 | $2\times10^{-6}$ | 0.222 | 0.2 | 1:2,000 |
| | 1 | 0.001 | $10^{-6}$ | 0.111 | 0.1 | 1:1,000 |
| 0 | A | 0.0005 | $5\times10^{-7}$ | 0.0557 | 0.05 | 1:500 |
| | B | 0.0002 | $2\times10^{-7}$ | 0.0222 | 0.02 | |
| | C | 0.0001 | $10^{-7}$ | 0.0111 | 0.01 | |

# 1、Introduction

## Standardization of the Product level




| Classification | Product Name |
|---|---|
| L0-L2 | Image |
| L3 | Map (when & where) |
| L4 | Target attribute (what) |
| L5 | Target state (how) |
| L6 | Thematic feature (why, which, how much, who) |

Common product

# 2、Advantages

## System performance

### Data Service

More than 3 million scenes, near 3PB satellite remote sensing data。

### Information extraction capability

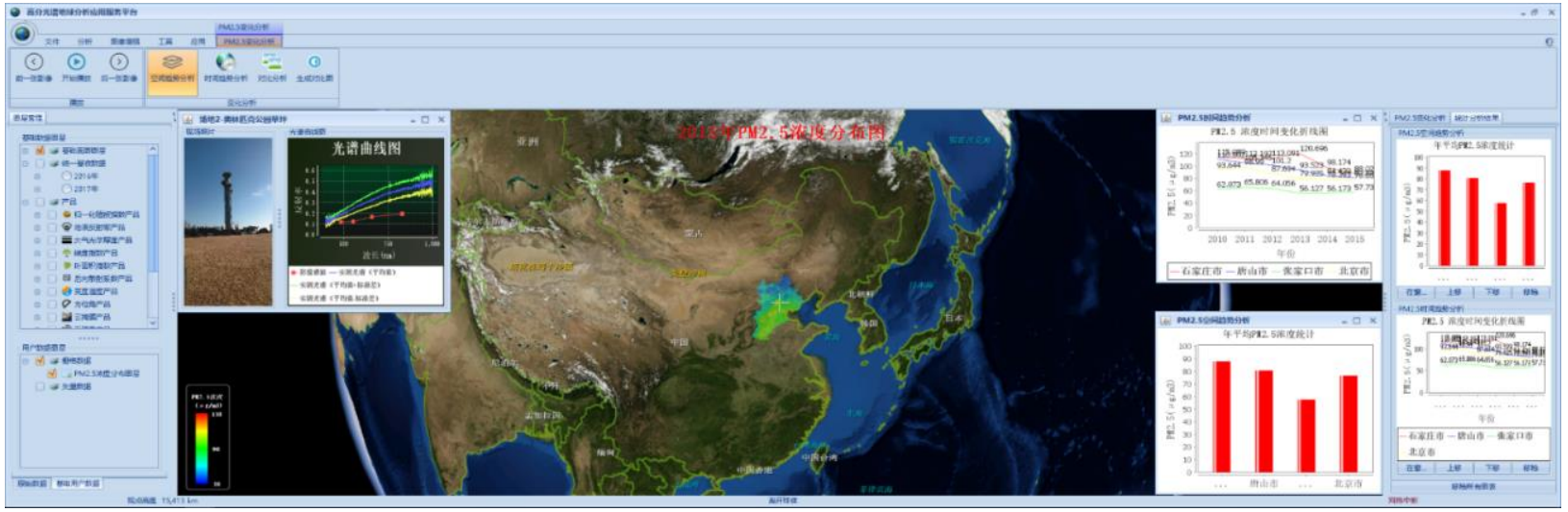
More than 300 information product extraction algorithms。

### Computing capability

100 trillion times per second platform processing capability。

### Group

Nearly 200 remote sensing information R & D and production teams 。





RADI

www.radi.cas.cn

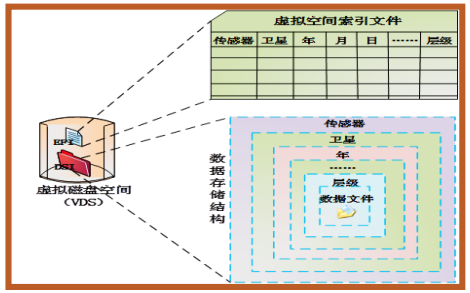
# 2、Advantages

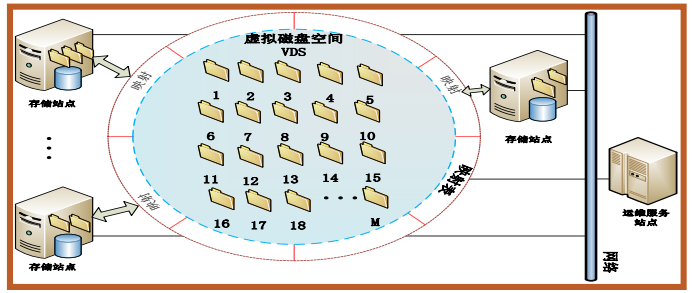
## Big data computing power

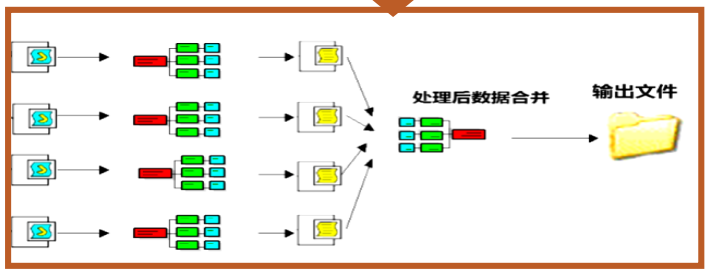
- Satellite data and product application standard specification
- Quantitative remote sensing scale processing technology
- Data preprocessing system
- Support multi domain application system construction and large-scale quantitative application.

**Computing power of 100 million billion times per second**

**Distributed storage architecture for remote sensing data**

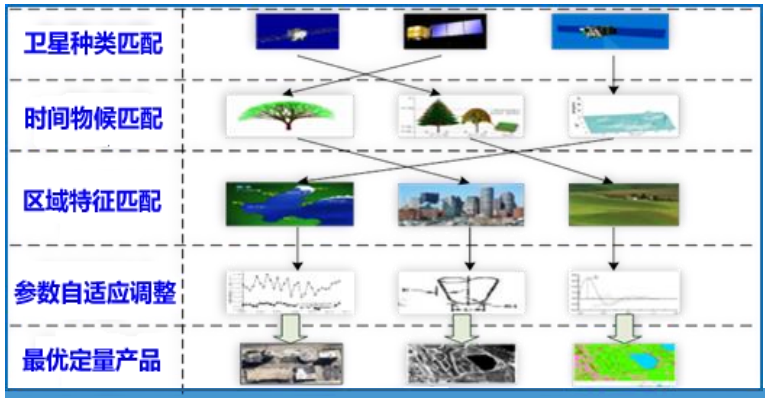




Data and product application standards



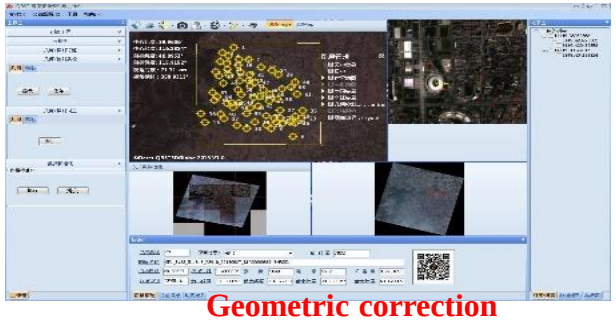

Scale processing technology

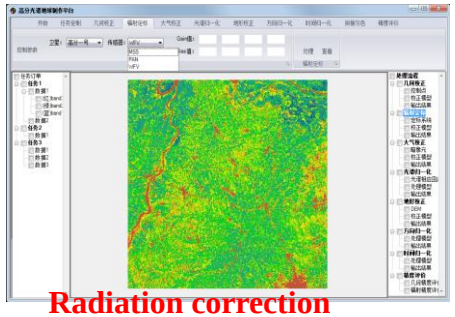
Star cluster data preprocessing system

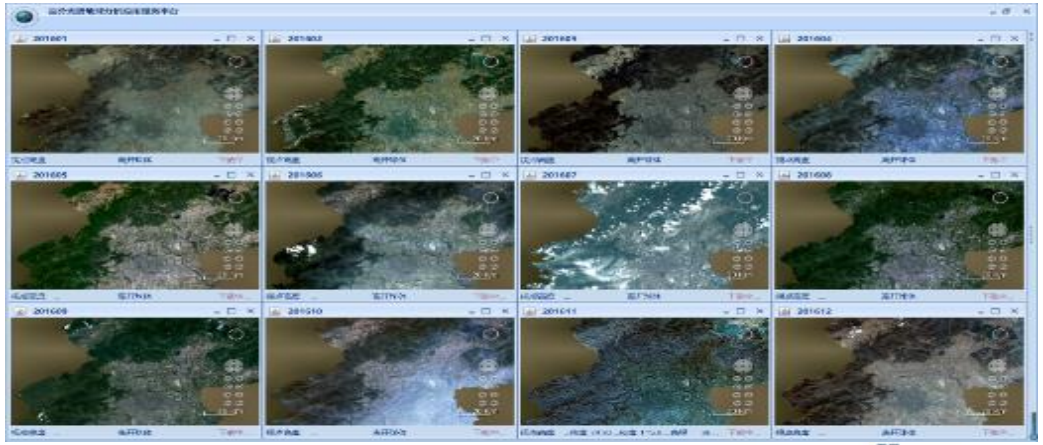
# 2、Advantages

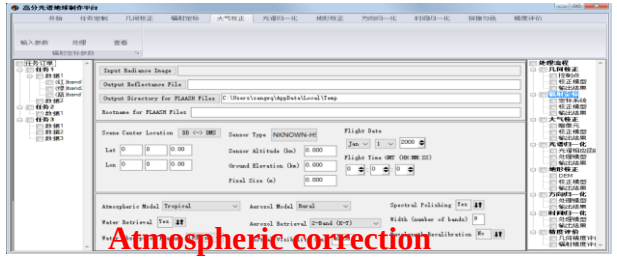
## Processing ToolSet

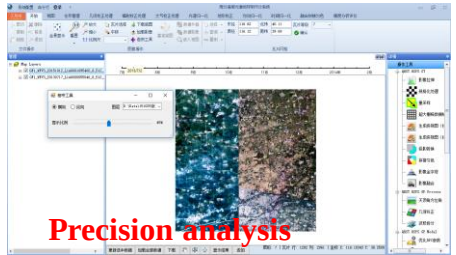




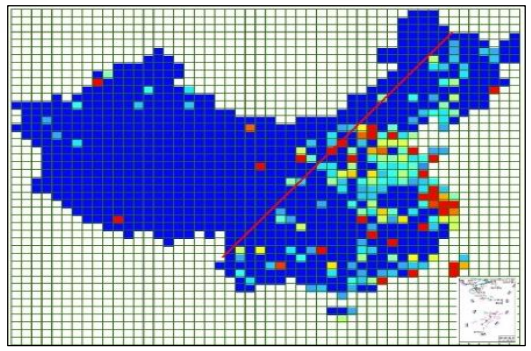


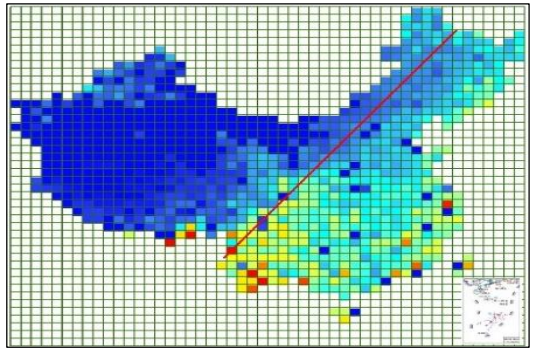
# 2、Advantages

## Data Fusuon

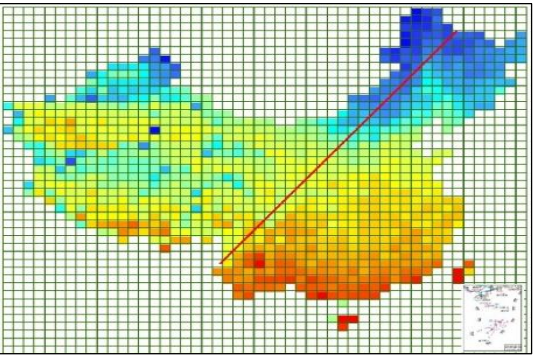
- **Pan-Huline Model Fusion**



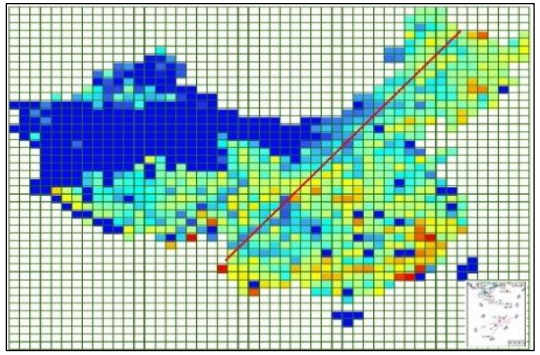
1°National population density



1°NPP

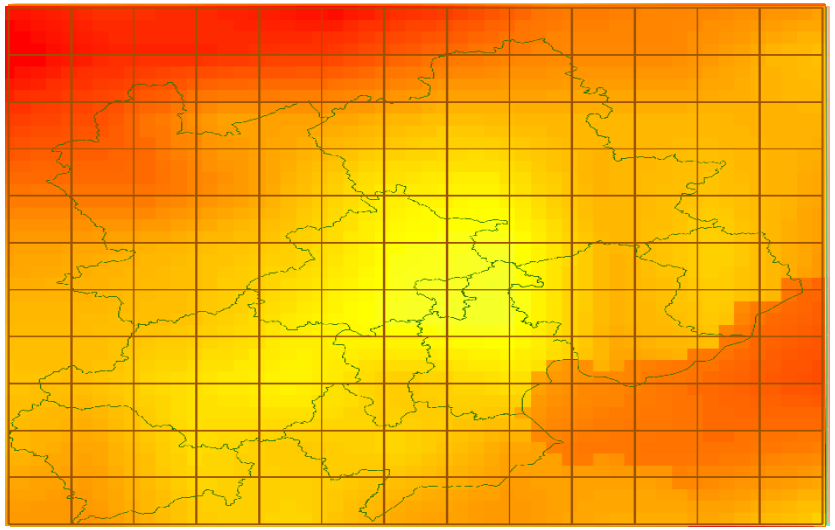


1°mean monthly temperature



1°National evapotranspiration

- **Fusion of field and remote sensing data**



0.5°京津冀风场

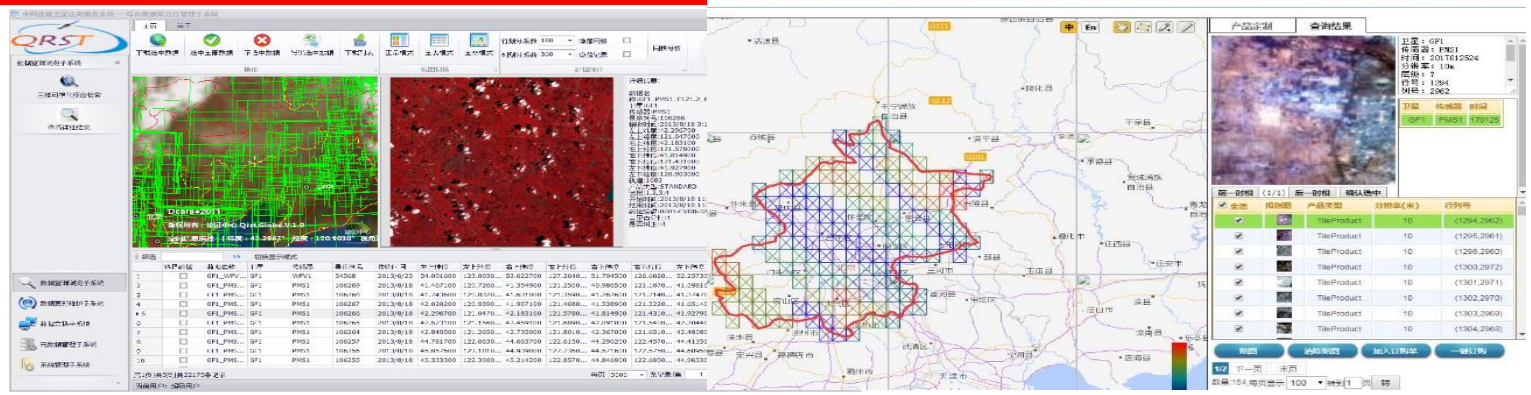
# 2、Advantages

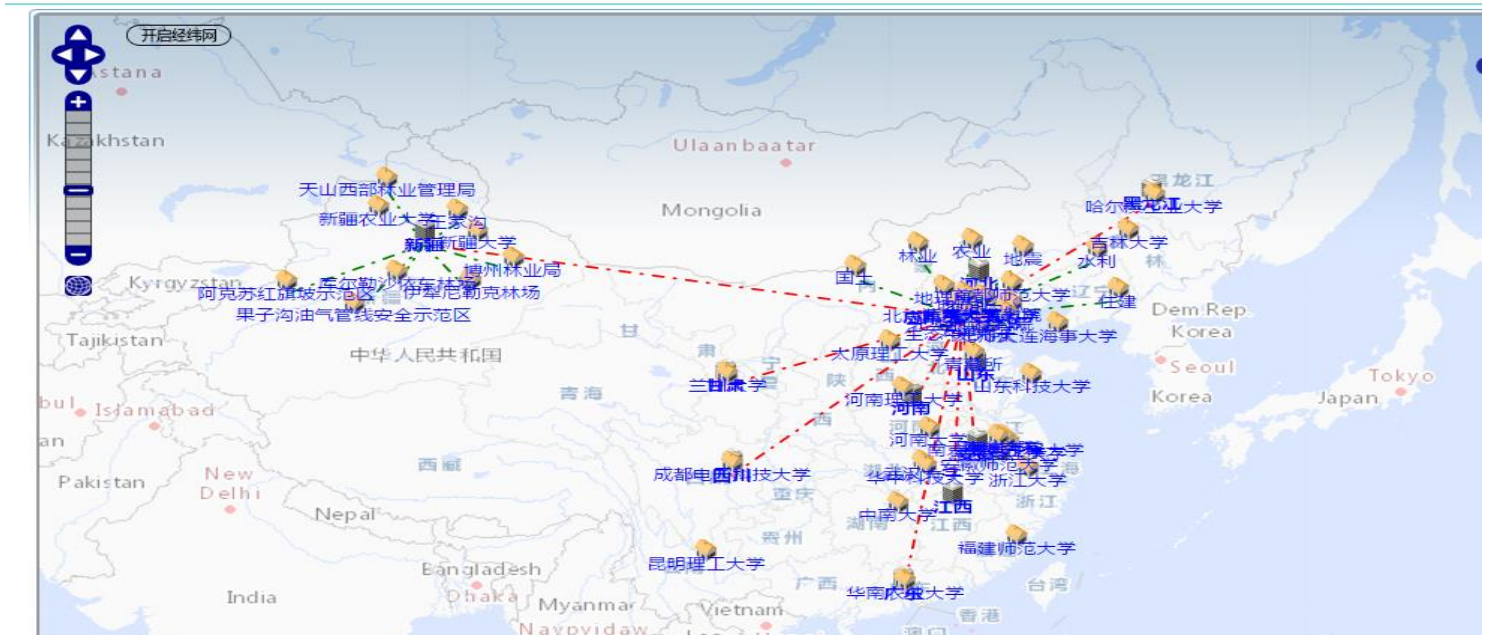
## Networked service capability

- **Data Center：** Store and manage data about 2,000,000 views, raw data and product tool 3PB storage。

- **Area：** Xinjiang, Sichuan, Heilongjiang, Hebei, Guangxi, Guangdong, Zhejiang, Gansu, etc. 19 provinces;

- **Science and education unit：** more than 53；

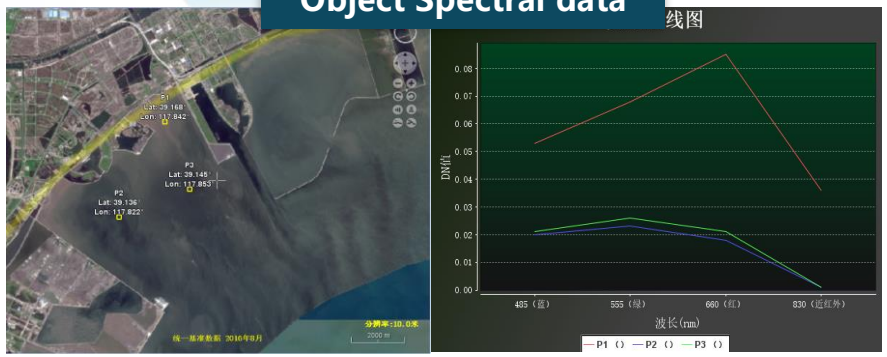




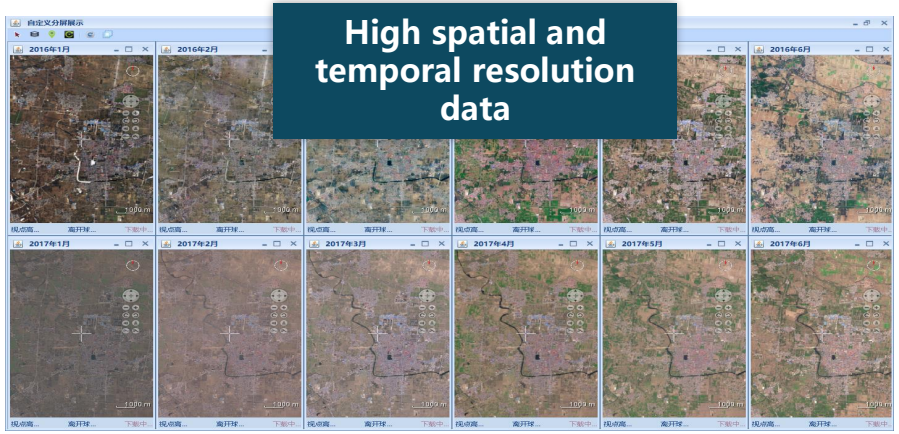
# 3、Applications

## Image Earth

### Object Spectral data



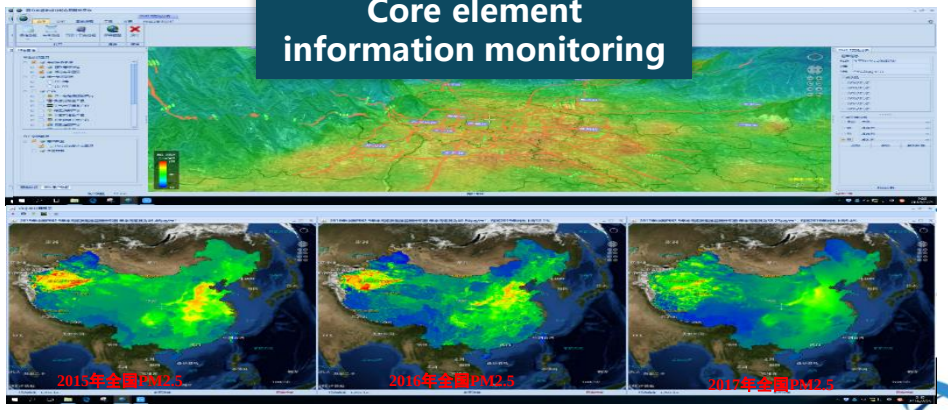

### High spatial and temporal resolution data




## Information Earth

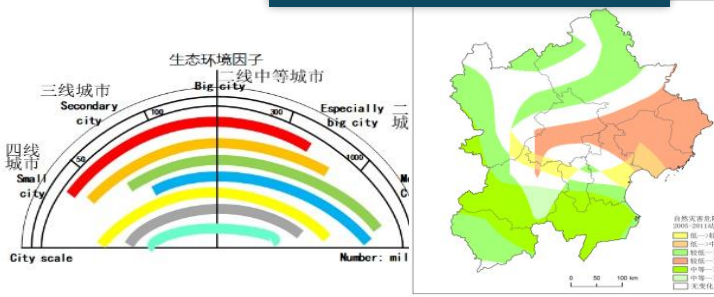
### Object recognition and change detection


### Core element information monitoring

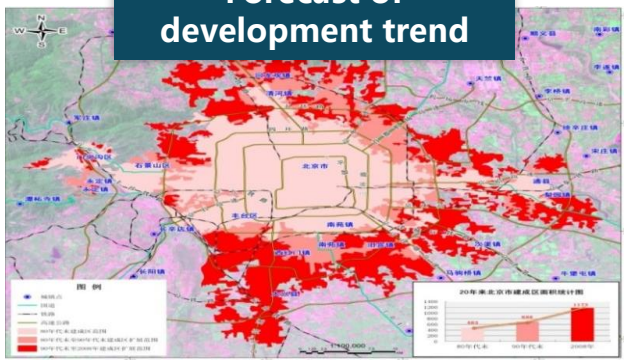



## Knowledge earth

### Development status evaluation



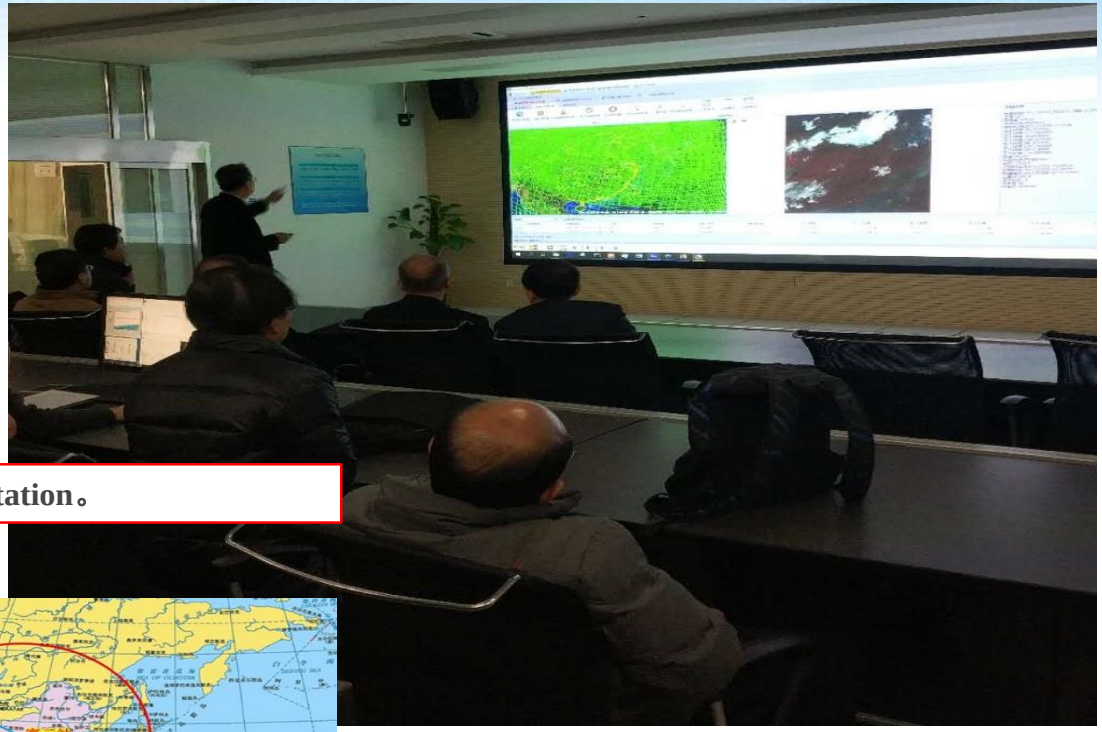

### Forecast of development trend



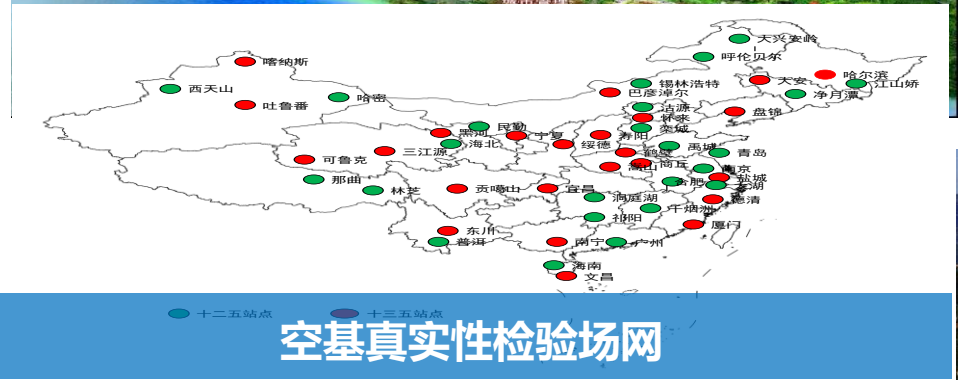
# 3、Applications

## Image Earth

China High resolution earth observation system（7 satellites）
and others Data quantity > 10PB。



Data of China's satellite earth station。


空基真实性检验场网

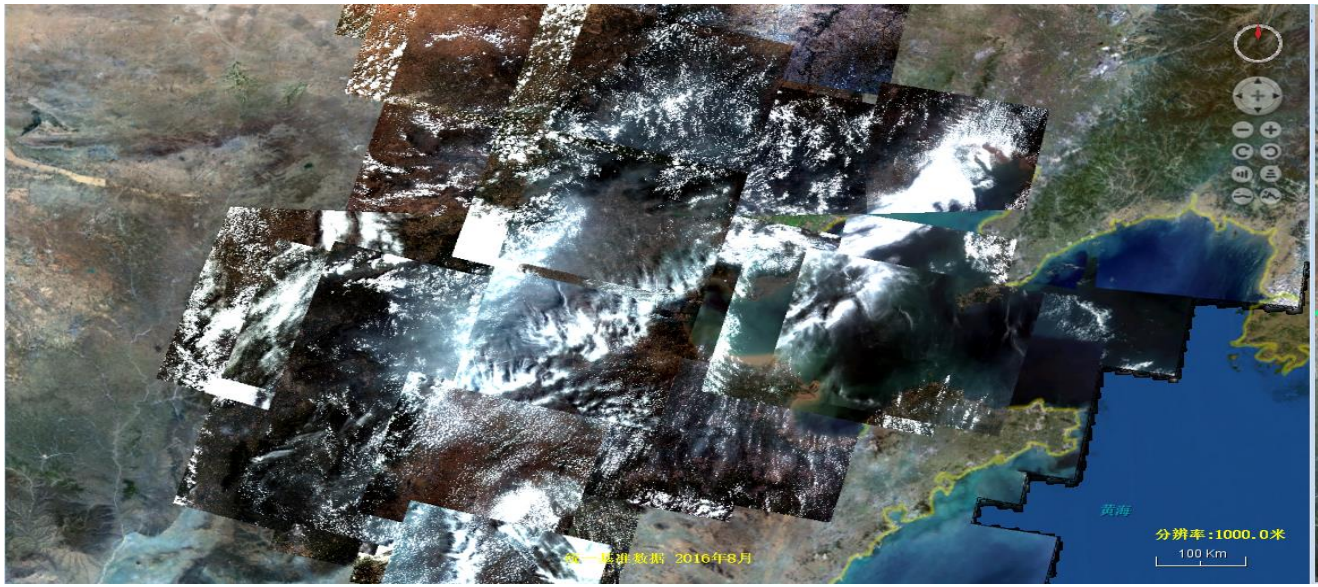
Aerial remote sensing aircraft

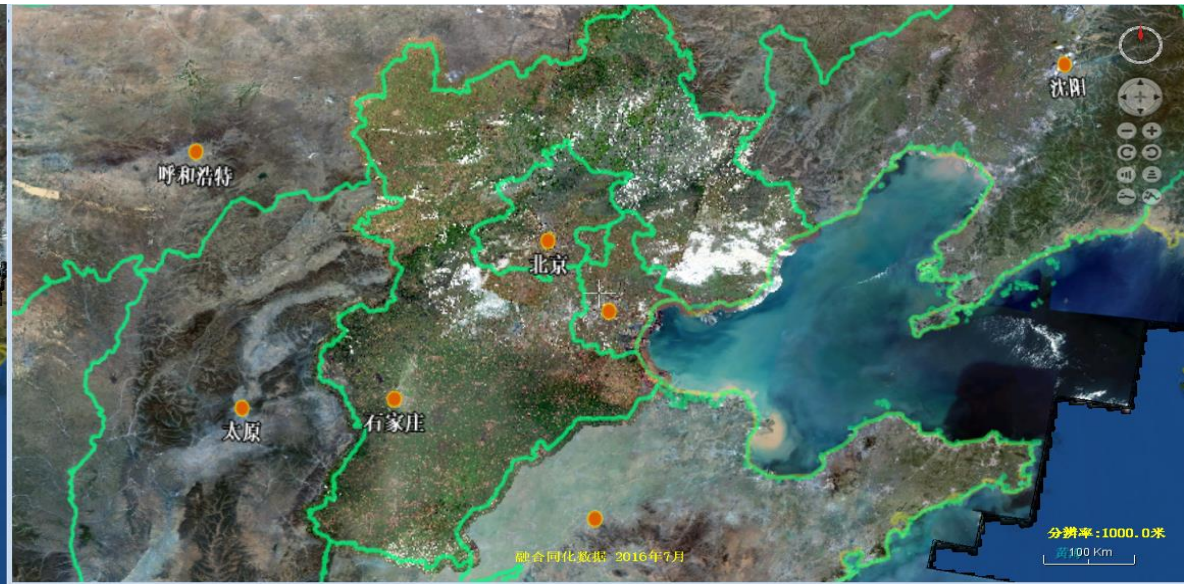
# 3、Applications

**Image Earth**

## Comparison of images and processed Dataset

Time: July, 2016

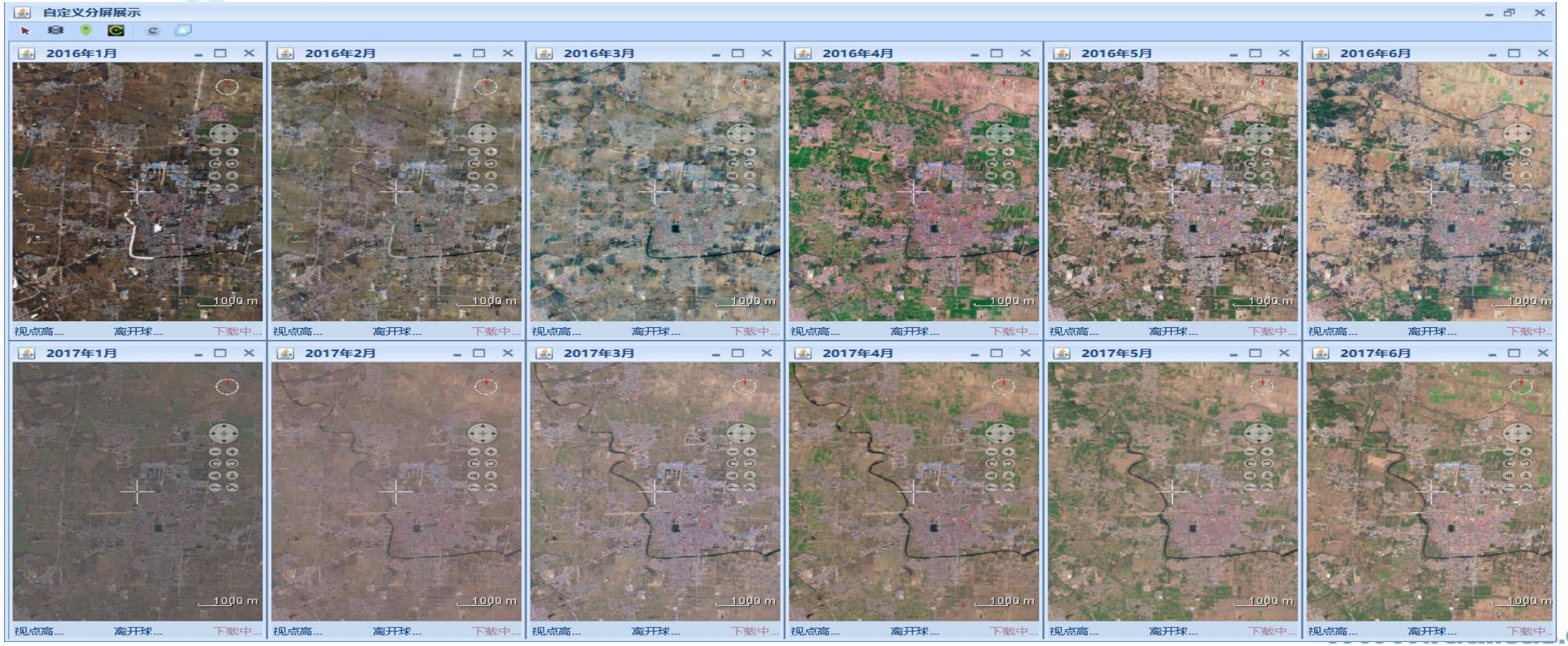


# 3、Applications

**Image Earth**

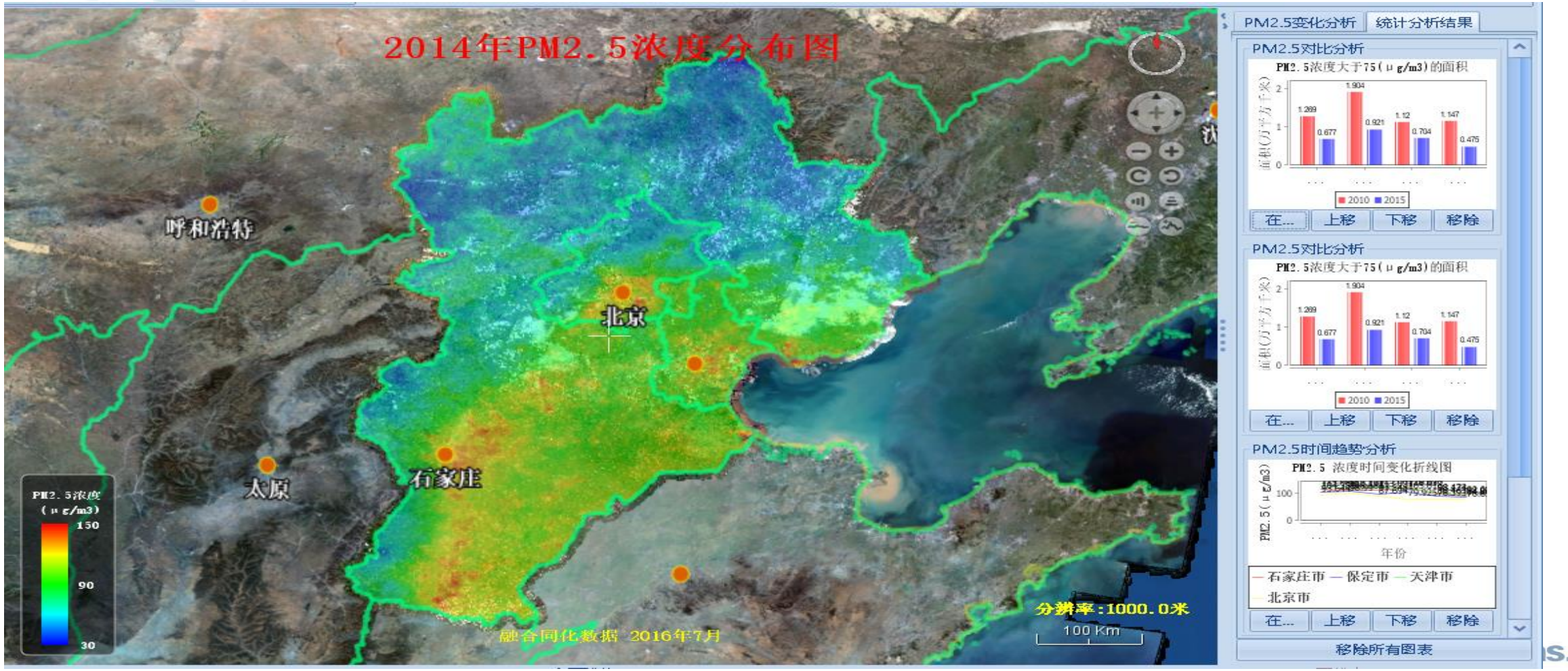
## Comparison between different years



# 3、Applications

**Information Earth**

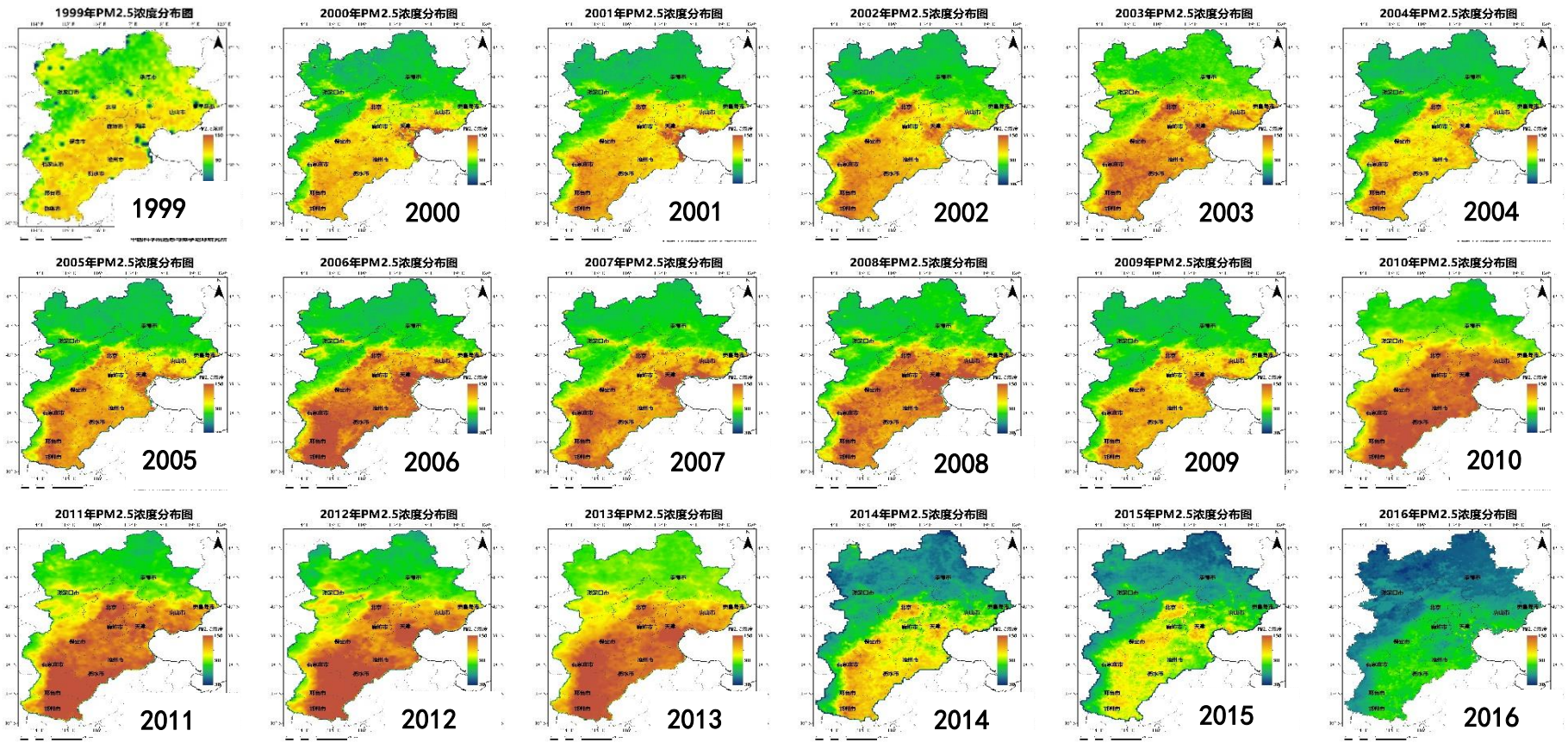
**PM2.5 yearly average result in 2014, Beijing, Tianjin and Hebei**



# 3、Applications

## Information Earth

### Remote sensing of atmospheric particulate matter




◆From 2011 to 2016, the concentration of PM2.5 in Beijing was high in the southeast and low in the northwest.

◆After the implementation of the 2013 Air Pollution Action Plan (referred to as the Air Ten), the PM2.5 concentration dropped significantly.。

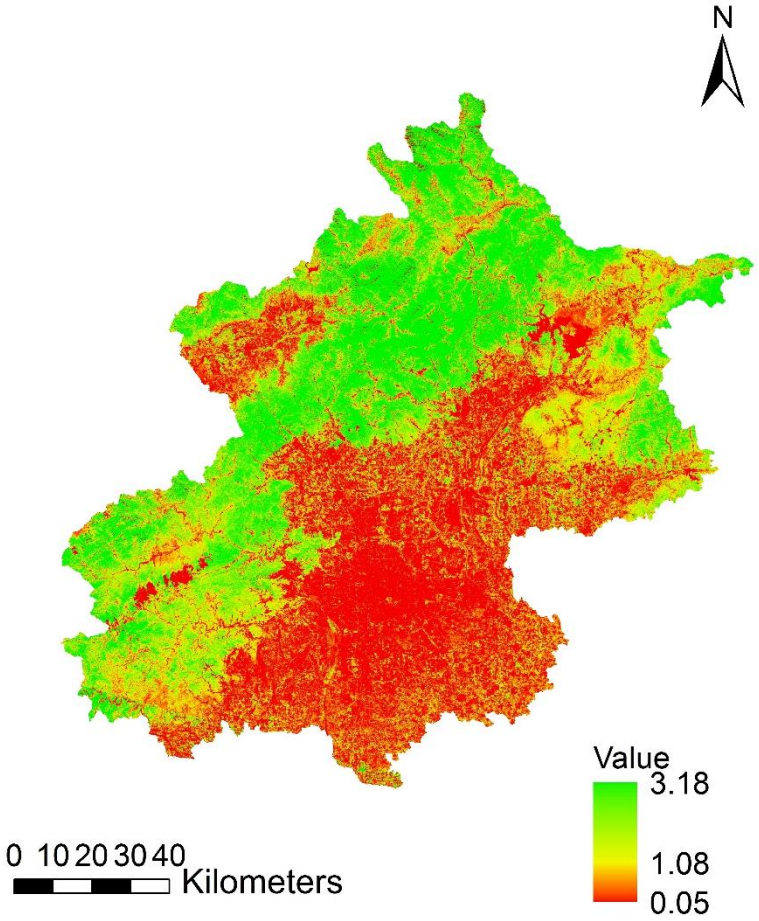
120-150 μg/m$^3$ 90-120 μg/m$^3$ 60-90 μg/m$^3$ 30-60 μg/m$^3$

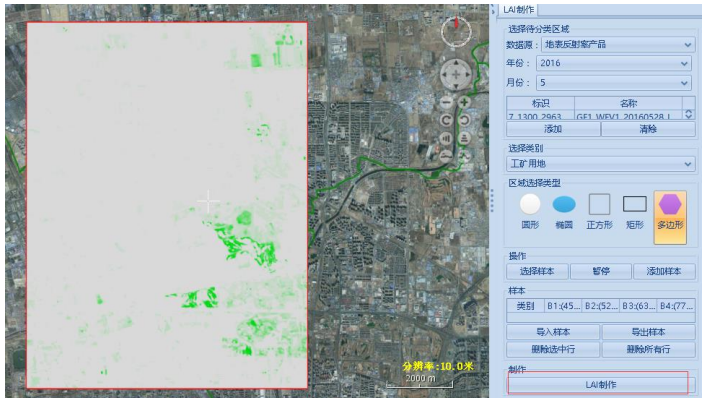
# 3、Applications

**Information Earth**

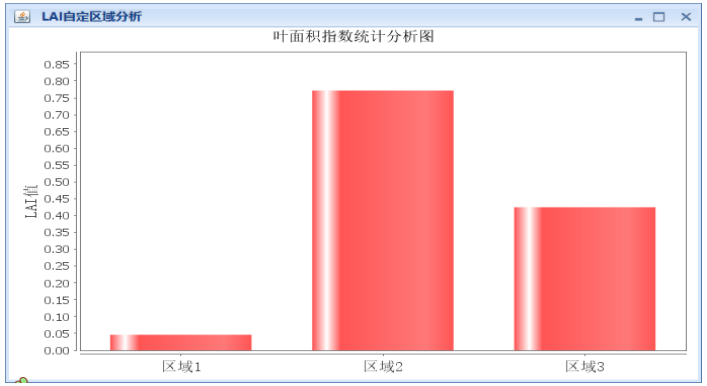
## LAI of Beijing 2015

For Beijing, all the tile data (including tiles with different phases) of Spectral Earth in September 2015 were used to generate LAI space-time integrated products.



calculation

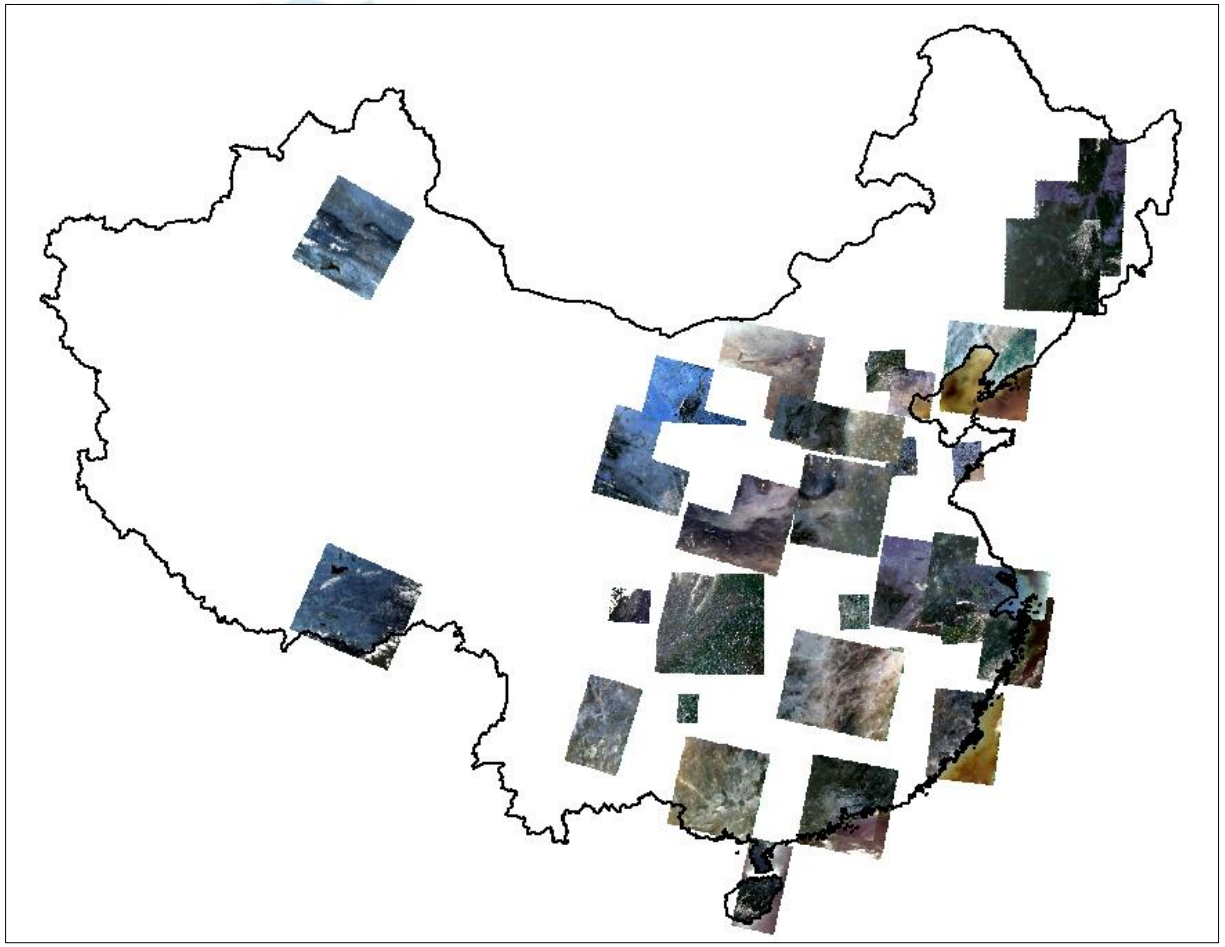



analysis

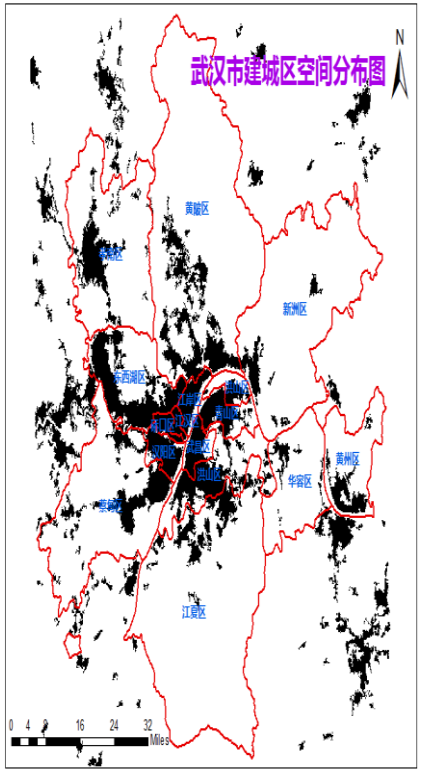
# 3、Applications

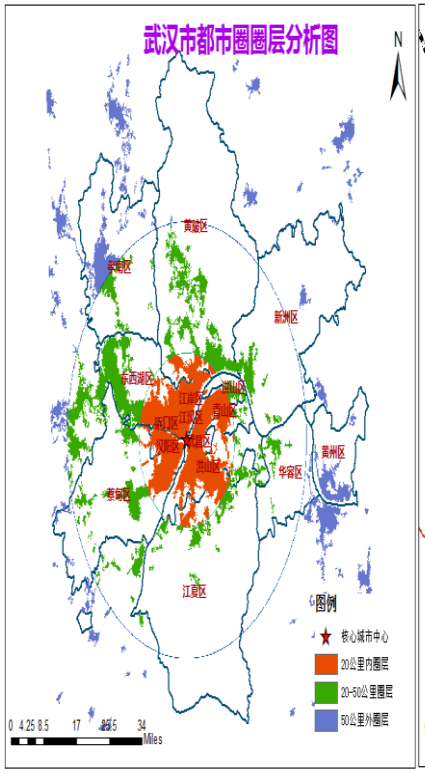
**Information Earth**

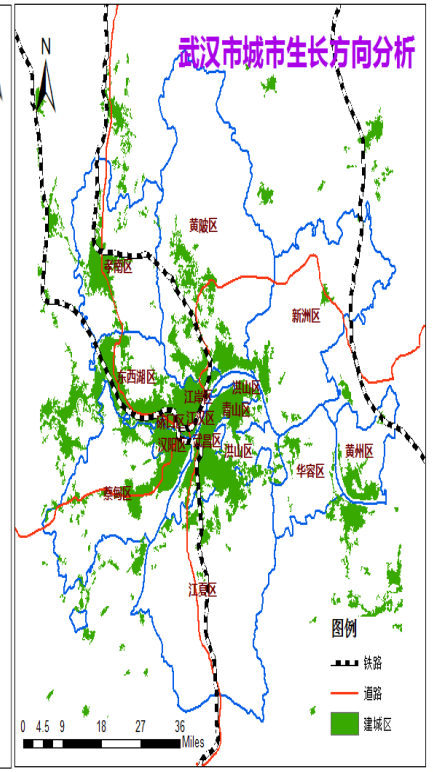
## Landcover classification of urban region



- 37 main cities of China, more than 400,000 sq.km
- 6 classes: forest/grass/crop/buildings/soil/water
- Urban development analysis

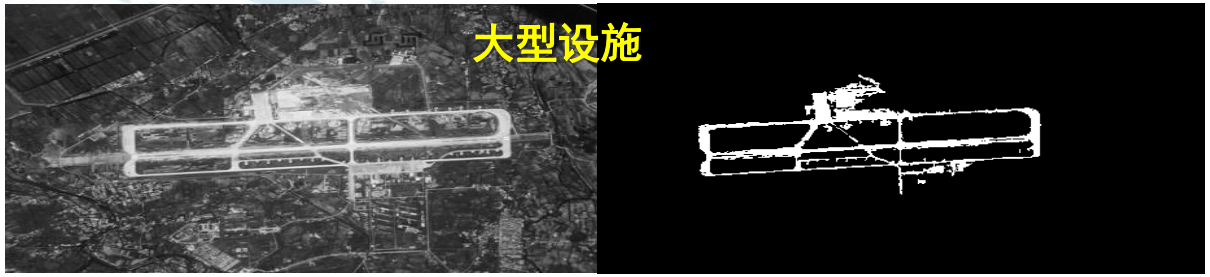


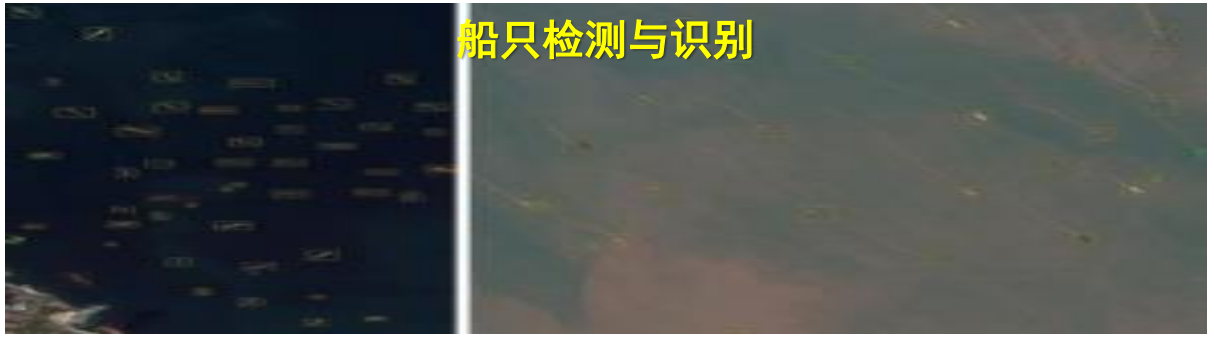



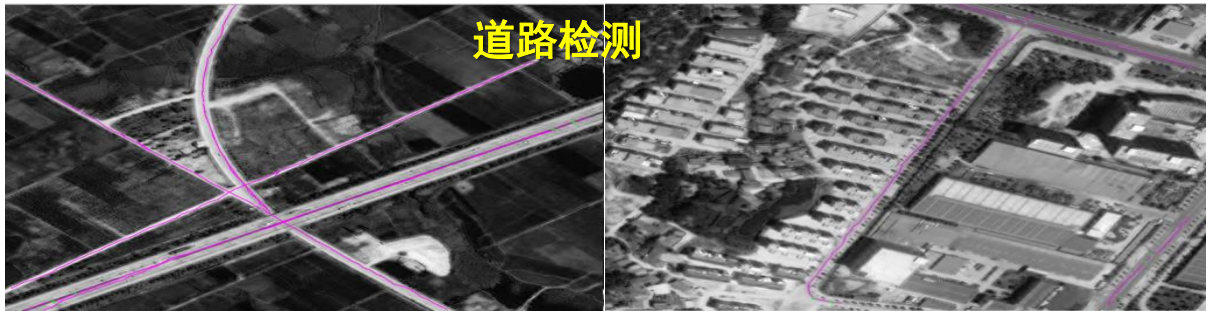
# 3、Applications

## Information Earth





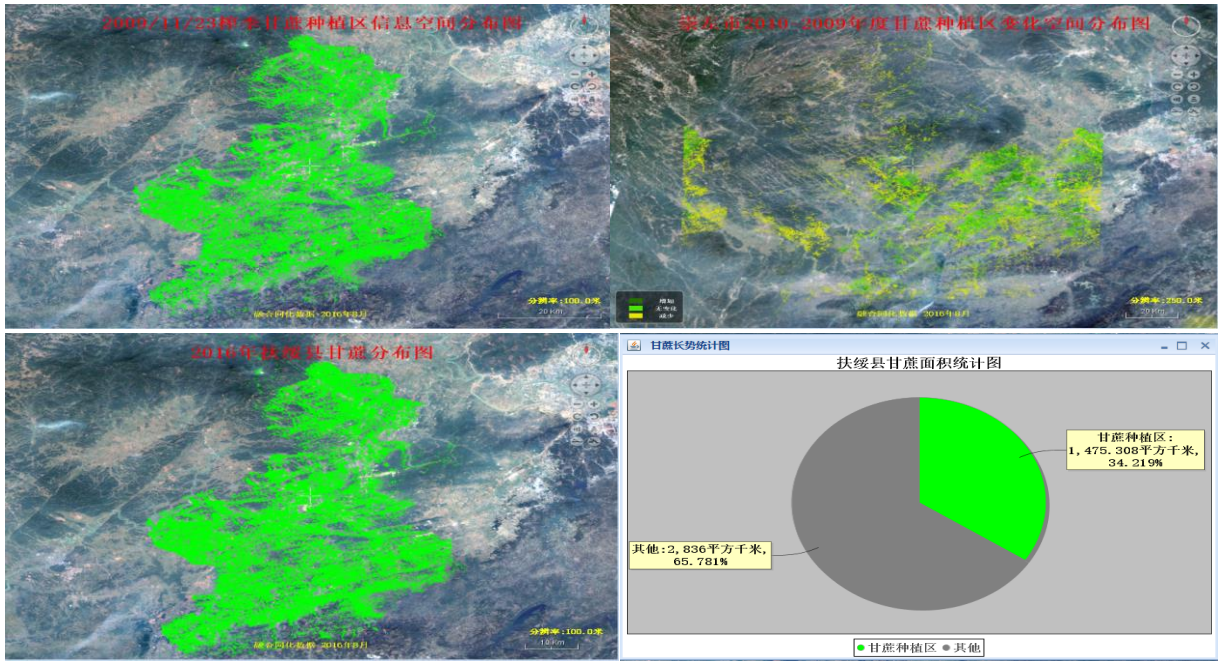





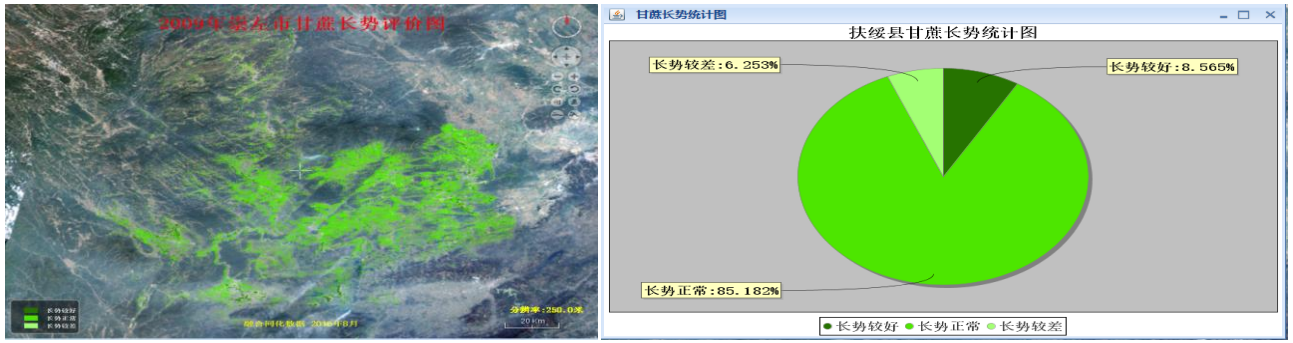
# 3、Applications

Knowledge Earth

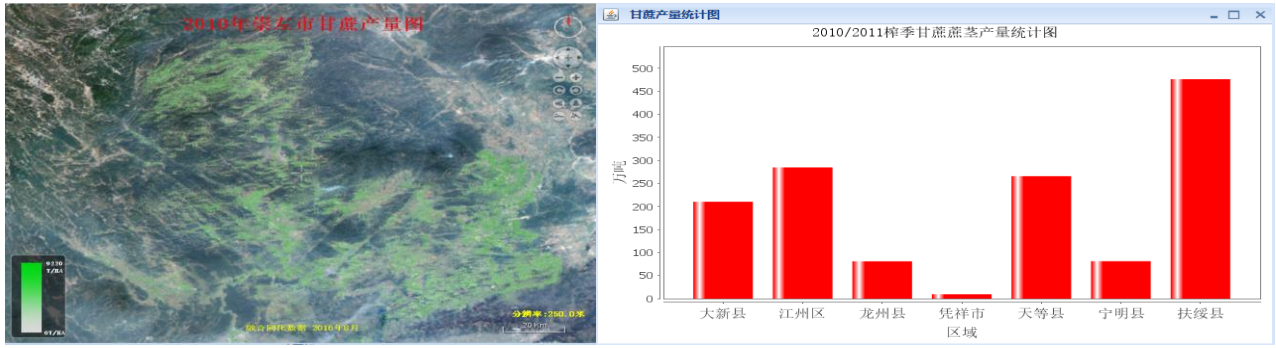
## Sugar cane in Guangxi




Area




growth




Yield estimation

# 4. Future development

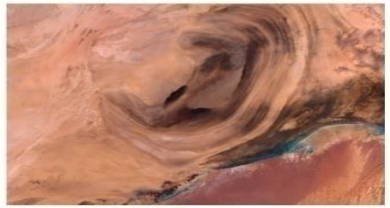
1. Integrate massive spectral datasets with concurrent access capabilities of more than 10,000 users to build a shared spectral globe that blends time and space.

2. Optimize high-speed spectral product processing engine, integrate algorithms, knowledge base, super-calculation platform and other advantageous resources to achieve quasi-real-time typical element information extraction and analysis capabilities.

3. Dynamic monitoring of core elements of sustainable development such as service ecological environment, new urbanization, modern agriculture, smart cities, water resources, and disaster reduction, meeting the major application needs

# Thanks!



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