

## Technologies and application in China's National Geographic Conditions Monitoring for Urban Development



Prof. Jiping Liu  
Chinese Academy of Surveying and Mapping  
May 2017

## Contents

1

**Brief View of GCM**

2

**GCM for Urban Development**

3

**Urban Expansion Monitoring Project**

4

**Conclusion & Future Work**

## 1. Brief View of GCM

**Geographic Conditions Monitoring (GCM)** refers to a dynamic and quantitative monitoring of the national geographic features by using 3S (GNSS, RS, GIS) technologies, in order to reflect the features' geo-distribution, and to discover their change trends and influencing forces through the comprehensive statistical analyses.



## 1. Brief View of GCM

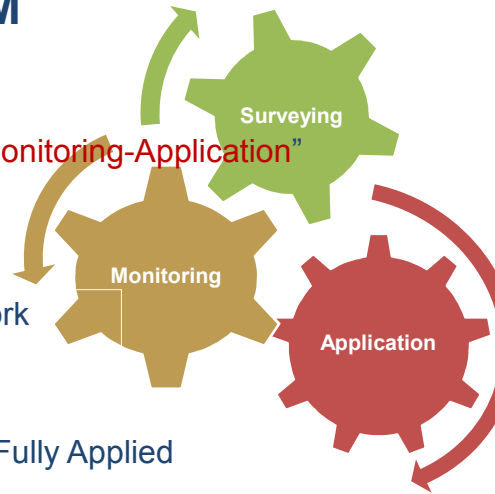
- An comprehensive observation and analysis of **geo-distribution and change trends of natural & human geographic features** of China's territory;
- Mainly focused on
  - National Land Development
  - Urban Space Utilization
  - Overall Regional Development Plan
  - Ecological Environmental Protection
  - Resources Sustainable Utilization
  - .....
- Further reflect **socio-economic development**



# 1. Brief View of GCM

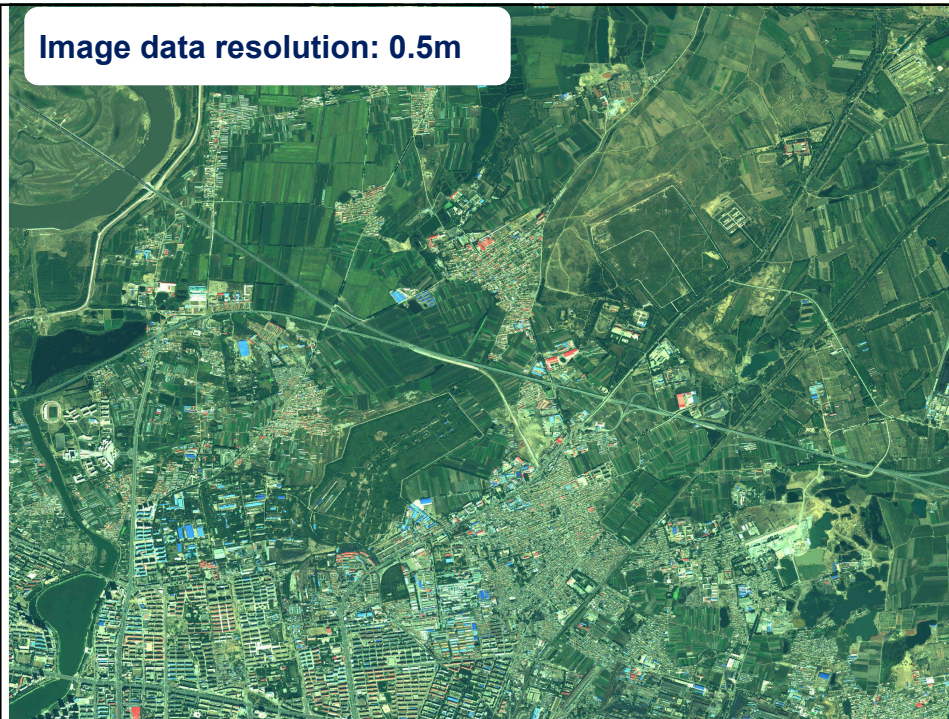
## ■ GCM Advantages

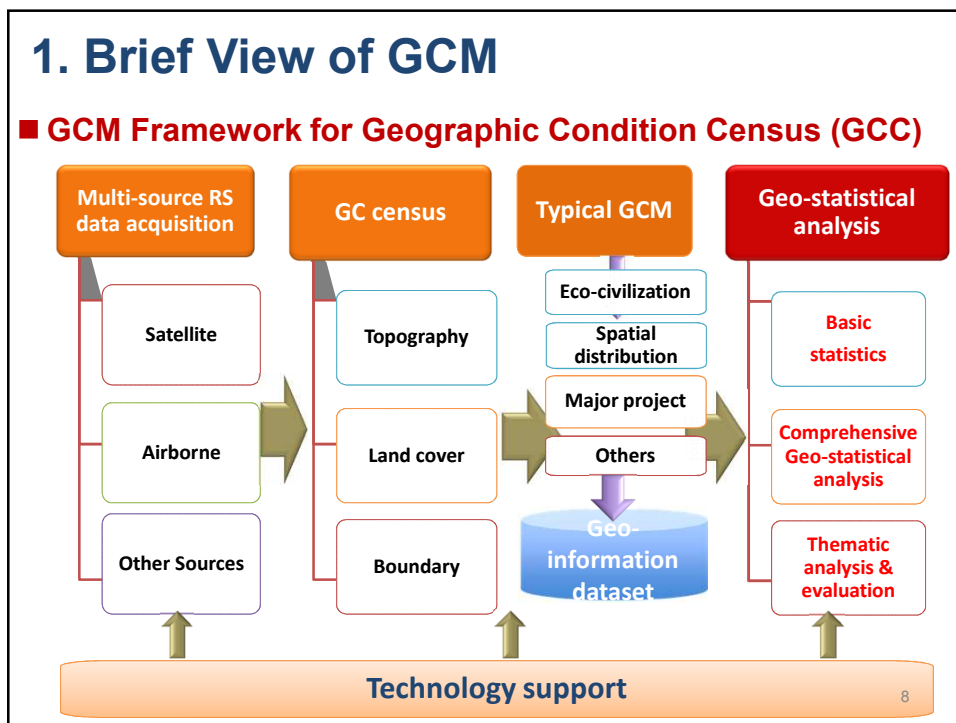
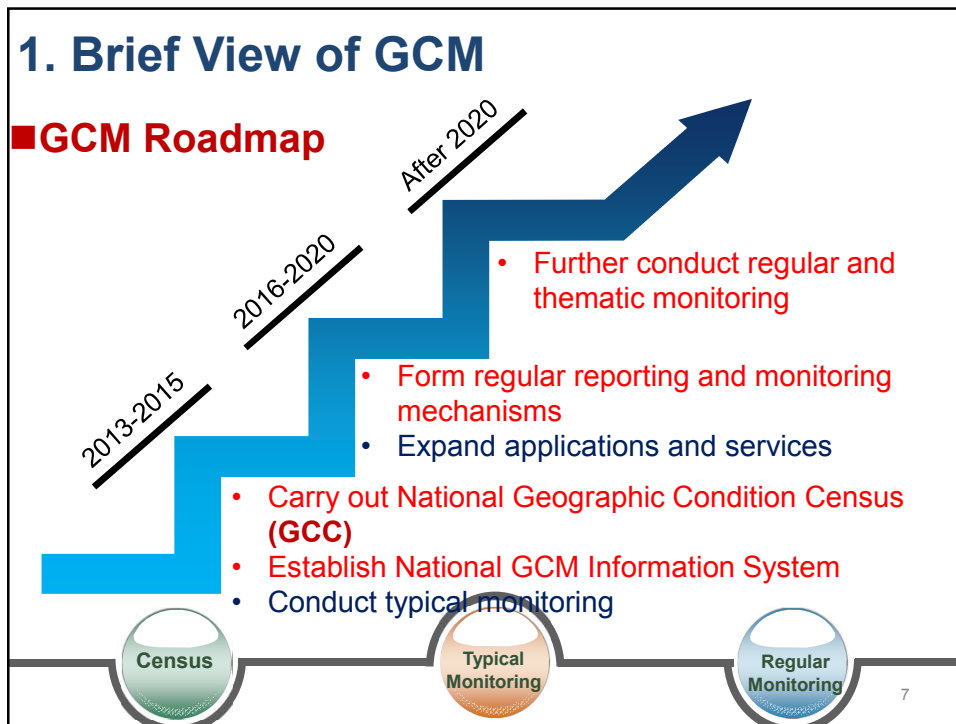
- “Synchronized **Surveying-Monitoring-Application**”  
Operation Principle
- Integrated Indoor & Field Work  
Production Pattern
- Less than 1m RS imageries Fully Applied



5

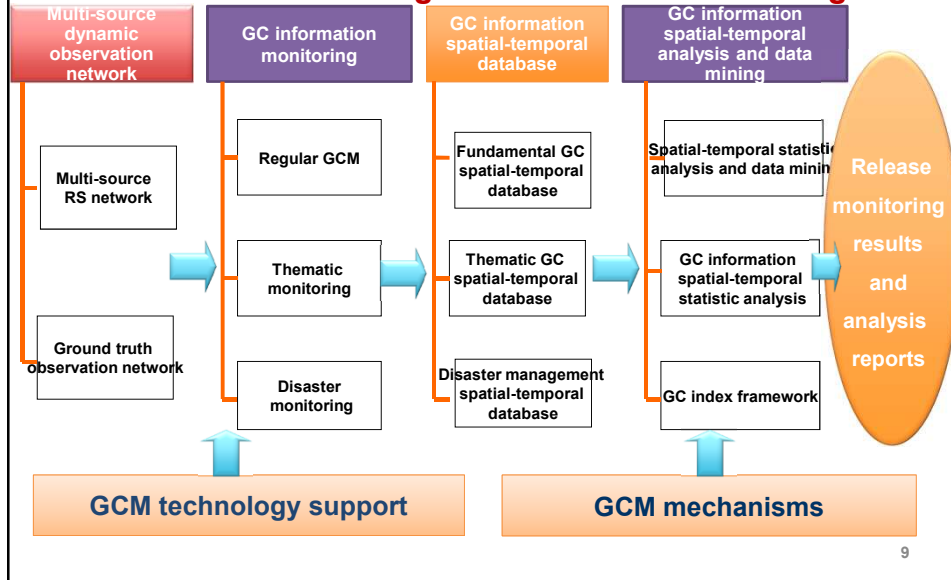
Image data resolution: 0.5m





# 1. Brief View of GCM

## ■ GCM Framework for Regular & Thematic Monitoring



## ■ Main Tasks of GCM

- Provide support for GCC;
- Carry out regular monitoring;
- Carry out thematic monitoring;
- Build a dynamic national geographic conditions information system;
- Reflect distribution and utilization of natural & human geographic features;
- Provide a basis for economic & social development and eco-civilization construction.

## GCM--Provide Support for GCC

- 28th Feb, 2013,  
Chinese Sate Council initiated  
National Geographical Conditions Census (GCC) program

030817

### 国务院文件

国发〔2013〕9号

**国务院关于开展第一次全国地理国情普查的通知**

各省、自治区、直辖市人民政府，国务院各部委，各直属机构：

为全面掌握我国地理国情现状，满足经济社会发展对国土国情普查的需求，经国务院批准，决定自2013年起开展第一次全国地理国情普查。

一、普查的目的和意义

地理国情是反映我国自然和人文地理要素的综合反映，包括自然地理要素和人文地理要素。开展第一次全国地理国情普查，是全面掌握我国地理国情现状，满足经济社会发展对国土国情普查的需求，经国务院批准，决定自2013年起开展第一次全国地理国情普查。

二、普查的范围和对象

普查范围：全国陆地国土。普查对象：自然地理要素和人文地理要素。

三、普查的组织实施

国务院成立第一次全国地理国情普查领导小组，负责普查的组织领导和统筹协调。领导小组下设办公室，负责普查的日常工作和协调服务。各省、自治区、直辖市人民政府要成立相应的普查领导小组，负责本行政区域内普查的组织领导和统筹协调。

四、普查的经费保障

普查经费由中央财政和地方财政共同承担。中央财政对普查经费给予补助，地方财政负责落实普查经费。

五、普查的进度安排

普查工作从2013年起开始，分三年完成。2013年完成普查准备和试点工作，2014年全面开展普查，2015年完成普查总结和成果汇总。

六、其他要求

各省、自治区、直辖市人民政府要切实加强领导，精心组织，周密部署，确保普查工作顺利进行。要广泛宣传普查的重要意义，充分调动广大群众的积极性和主动性。要严格执行普查经费使用规定，确保普查经费专款专用。要切实加强普查数据的安全管理，确保普查数据的安全可靠。

国务院关于开展第一次全国地理国情普查的通知

国务院各部委，各直属机构：

为全面掌握我国地理国情现状，满足经济社会发展对国土国情普查的需求，经国务院批准，决定自2013年起开展第一次全国地理国情普查。

一、普查的目的和意义

地理国情是反映我国自然和人文地理要素的综合反映，包括自然地理要素和人文地理要素。开展第一次全国地理国情普查，是全面掌握我国地理国情现状，满足经济社会发展对国土国情普查的需求，经国务院批准，决定自2013年起开展第一次全国地理国情普查。

二、普查的范围和对象

普查范围：全国陆地国土。普查对象：自然地理要素和人文地理要素。

三、普查的组织实施

国务院成立第一次全国地理国情普查领导小组，负责普查的组织领导和统筹协调。领导小组下设办公室，负责普查的日常工作和协调服务。各省、自治区、直辖市人民政府要成立相应的普查领导小组，负责本行政区域内普查的组织领导和统筹协调。

四、普查的经费保障


普查经费由中央财政和地方财政共同承担。中央财政对普查经费给予补助，地方财政负责落实普查经费。

五、普查的进度安排

普查工作从2013年起开始，分三年完成。2013年完成普查准备和试点工作，2014年全面开展普查，2015年完成普查总结和成果汇总。

六、其他要求

各省、自治区、直辖市人民政府要切实加强领导，精心组织，周密部署，确保普查工作顺利进行。要广泛宣传普查的重要意义，充分调动广大群众的积极性和主动性。要严格执行普查经费使用规定，确保普查经费专款专用。要切实加强普查数据的安全管理，确保普查数据的安全可靠。



国务院文件

2013年2月28日

## GCC Contents & Classes (1)

Code	1-Level	2-Level	3-Level	Minimum Mapped Unit (m <sup>2</sup> )
0100	Cultivated Land	2 classes Paddy field Dry land	2	400
0200	Garden Plot	7 classes Orchard Tea garden Nursery garden .....	9	400
0300	Forest Land	8 classes High-forest Shrubwood Bamboo forest .....	12	Large area forest: 1600 Others: 400
0400	Grassland	2 classes Natural grassland Artificial grassland	8	Large area grassland: 1600 Others: 400

**GCC Contents & Classes (2)**

Code	1-Level	2-Level	3-Level	Minimum Mapped Unit (m <sup>2</sup> )
0500	Housing Construction Area	<b>5 classes</b> Multi-story Buildings Low-rise Buildings Abandoned houses .....	10	Large housing area: 1600 Individual house: 200
0600	Road Network	<b>4 classes:</b> Railway Highway Urban Road County Road	4	
0700	Nonbuilding Structures	<b>9 classes:</b> Impervious surface Water Engineering Facilities Traffic Facilities City Wall Industrial Facilities .....	28	Square, open-air stadium &....:1600 Parking apron: 5000 Others: 400

13

**GCC Contents & Classes (3)**

Code	1-Level	2-Level	3-Level	Minimum Mapped Unit (m <sup>2</sup> )
0800	Artificial Built-up Land	<b>4 classes:</b> Construction Site Stacked Substance Open Evacuation Field .....	14	1600
0900	Desert & Barren Land	<b>5 classes:</b> Saline-alkali Land Rock Surface Sandy Surface .....	5	Desert :10000 Others: 1600
1000	Water Body	<b>5 classes:</b> River and Canal Lake Sea Reservoir .....	8	400

14

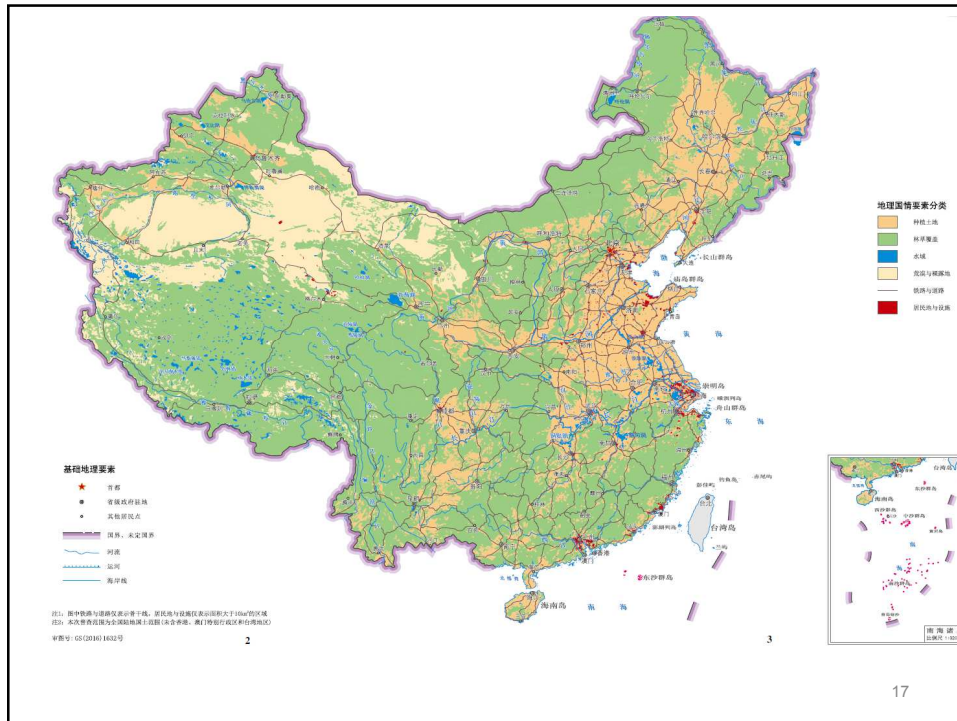
### GCC Contents & Classes (4)

Code	1-Level	2-Level	3-Level	Minimum Mapped Unit (m <sup>2</sup> )
1100	Geographic Unit	<b>4 classes:</b> Administrative Unit Socio-economic Unit Physical Geographic Unit Urban Function Unit	30	Not Mapped as Land Cover Features
1200	Topography	<b>3 classes:</b> Elevation Slope Aspect	3	Not Mapped as Land Cover Features

15

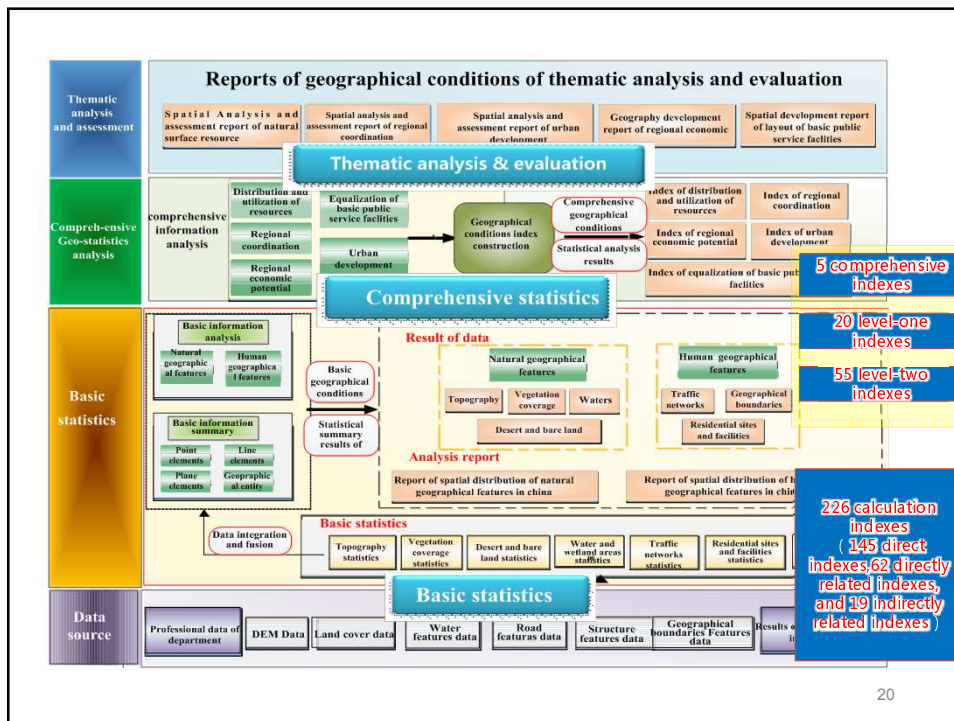
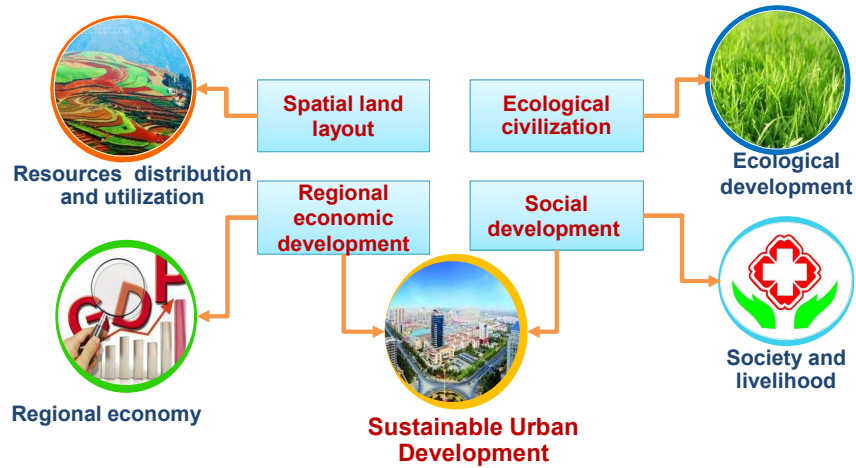
First-level classes (12)	Level 2 classes (58)	Level 3(135)
<ul style="list-style-type: none"> <li>➤ Cultivated Land</li> <li>➤ Garden Plot</li> <li>➤ Forest Land</li> <li>➤ Grassland</li> <li>➤ Housing Area</li> <li>➤ Road Network</li> <li>➤ Structures</li> <li>➤ Artificial Bare Land</li> <li>➤ Desert &amp; Bare Land</li> <li>➤ Water Area</li> <li>➤ Geographical Unit</li> <li>➤ Topography</li> </ul>	<ul style="list-style-type: none"> <li>➤ Paddy field</li> <li>➤ Dry land</li> <li>➤ .....</li> <li>➤ .....</li> <li>➤ Lake</li> <li>➤ River &amp; Canal</li> <li>➤ Reservoir</li> <li>➤ Sea</li> <li>➤ Glacier and permanent snow</li> <li>➤ .....</li> <li>➤ .....</li> </ul>	<ul style="list-style-type: none"> <li>➤ .....</li> <li>➤ .....</li> <li>➤ .....</li> <li>➤ River</li> <li>➤ Canal</li> <li>➤ Pond</li> <li>➤ Snow</li> <li>➤ Tunnel</li> <li>➤ Bridge</li> <li>➤ Highway entrance</li> <li>➤ .....</li> </ul>





## GCM--Provide Basis for Comprehensive Statistical Analysis

Integrated with socio-economic data, to analyze:



### ■ Achievements of GCM

- ❑ An comprehensive observation and analysis of geo-distribution and change trends of **natural & human geographic features of China**
- ❑ **Less than 1m high resolution RS imageries** covering China's territory fully applied
- ❑ Integrated with various industrial and thematic data, established a **full coverage, spatial continuous, high accuracy** national geographic conditions **information system**
- ❑ Which contains 12 first-level, 58 second-level, 135 third-level classes, and **2.6 billion land type & use units**

21

### ■ Achievements of GCM

#### GCC project makes a thorough investigation into:

- ❑ Area and spatial distribution of **all types of landform** of the entire land territory of China
- ❑ Area and spatial distribution of **9 cultivated land types**.  
Total area: 1.59 million km<sup>2</sup>
- ❑ Area and spatial distribution of **10 forest and grass covered land types**
- ❑ Total area: 5.96 million km<sup>2</sup>
- ❑ Composition and spatial distribution of **water body**.  
Area of glacier and long-persistent snows: 47,700 km<sup>2</sup>

22

## ■ Achievements of GCM

- Categories, area, composition and spatial distribution of **desert and barren land**.  
Total area: 1.32 million km<sup>2</sup>;
- Area, total length and composition and spatial distribution of **railway and roadway networks**.  
Total length: 116,500 km.
- Total area of **housing and constructions**:153,100 km<sup>2</sup>

23

## Contents

1

Brief View of GCM

2

**GCM for Urban Development**

3

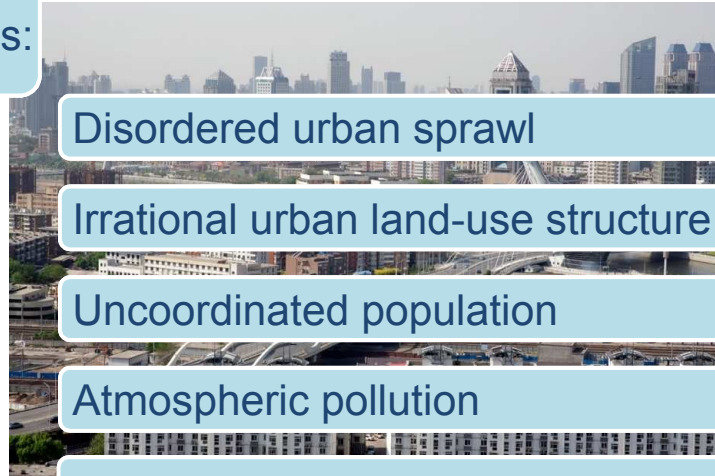
Urban Expansion Monitoring Project

4

Conclusion &amp; Future Work

## 2. Geographic Conditions Monitoring for Urban Development

Challenges:



Disordered urban sprawl

Irrational urban land-use structure

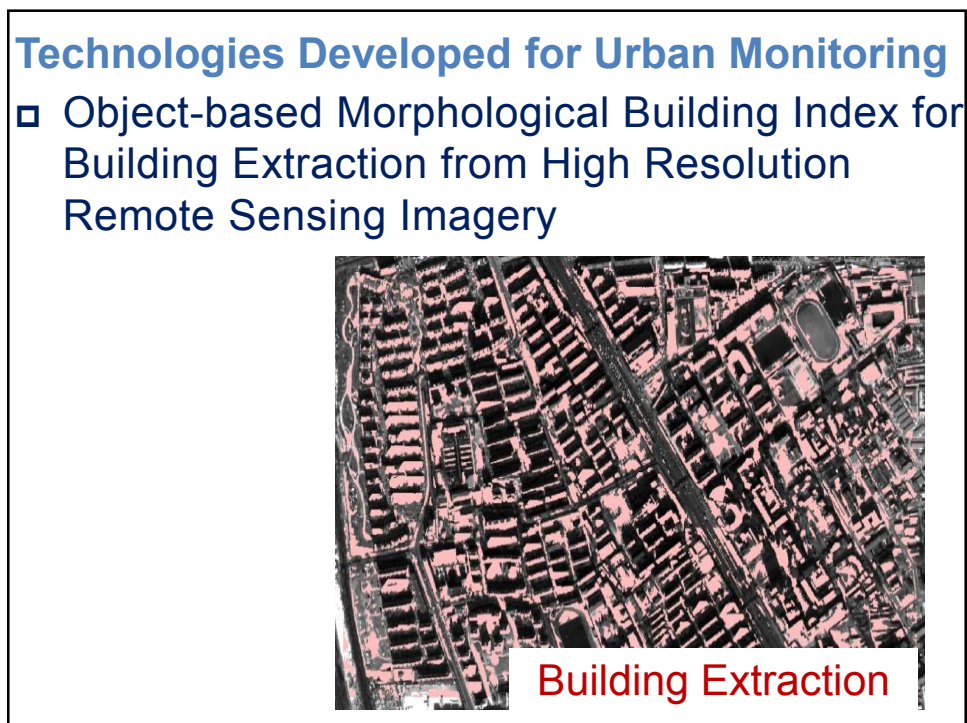
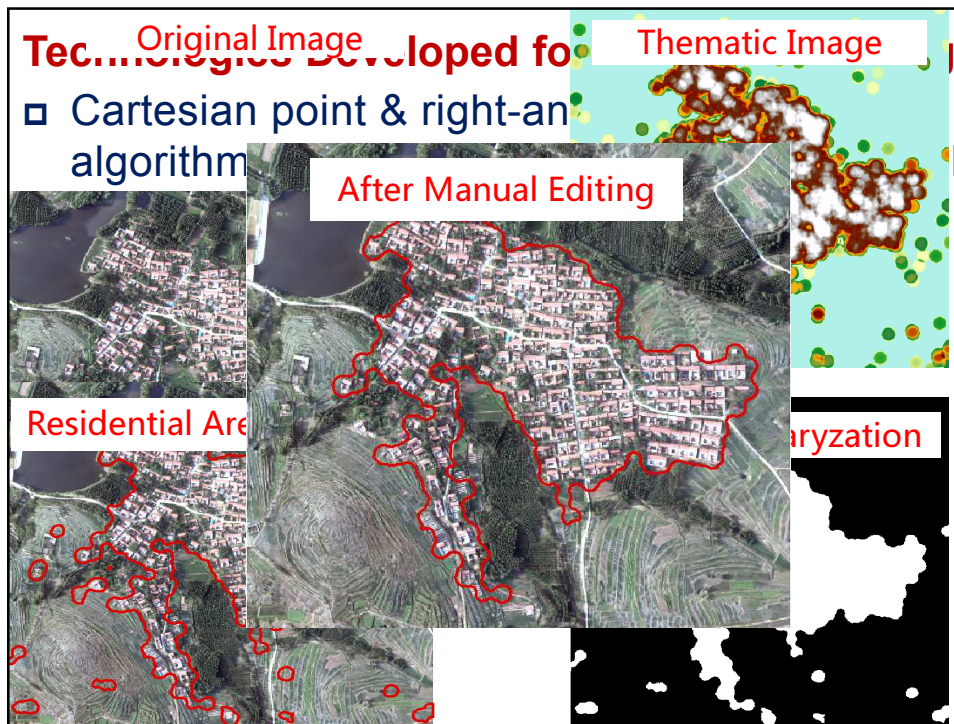
Uncoordinated population

Atmospheric pollution

.....

## 3. Geographic Conditions Monitoring for Urban Development

- RS technology, with advantages of high spatial-temporal resolution, large monitoring scale and accurate result, has been widely applied in the urban monitoring of GCM
- A series of technologies and specifications focusing on urban monitoring, boundary extraction and analysis has been developed and applied
- Provide a great practical value for a new urban development towards a compact, intensive, green and livable urban agglomeration



## Technologies Developed for Urban Monitoring

- Object-based Shadow Extraction from High Resolution RS Imagery



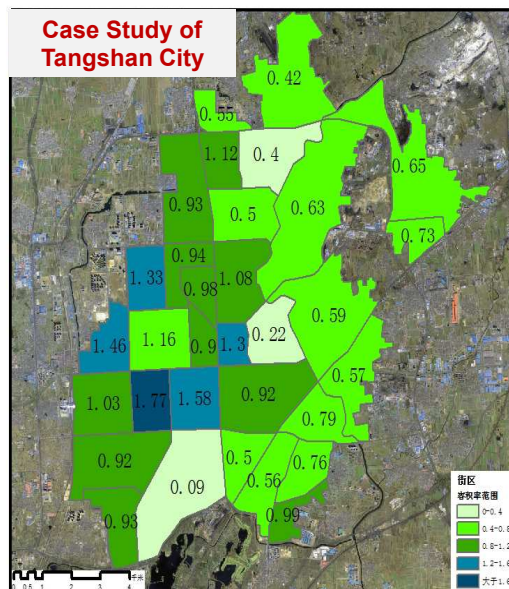
Image 1

Image 2

## Technologies Developed for Urban Monitoring

- Urban Plot Ratio Building Classification

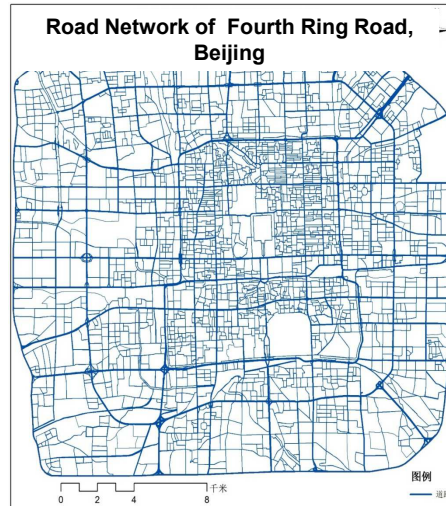
Calculated Plot Ratios



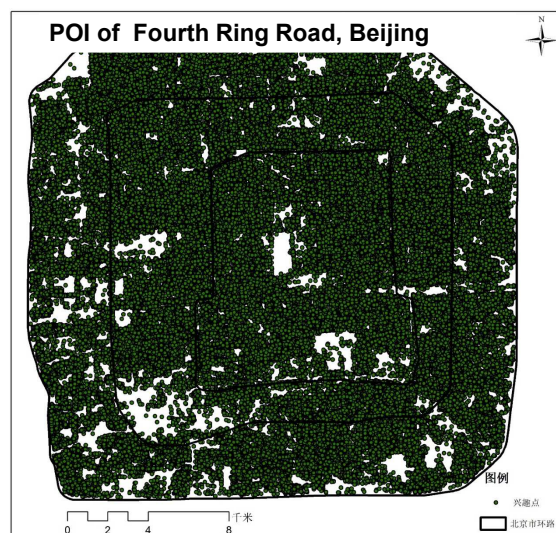
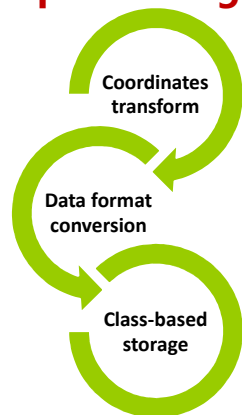
# Technologies Developed for Urban Monitoring

- Urban land-use Pattern Extraction based on POI & GIS Spatial Analysis

## Road Network Preprocessing



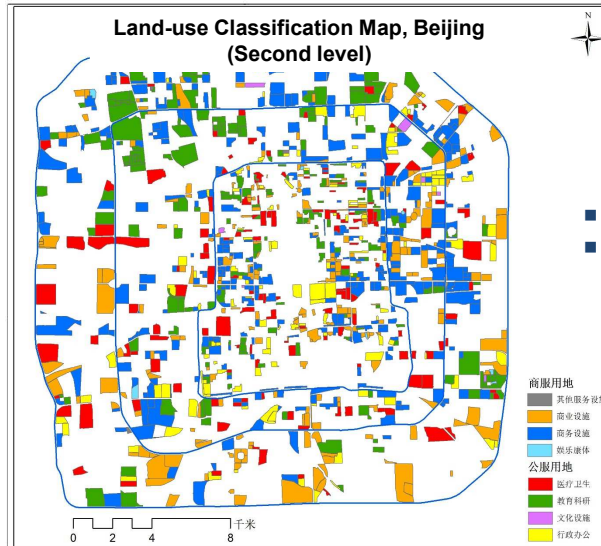
## POI Data Pre-processing





# Technologies Developed for Urban Monitoring

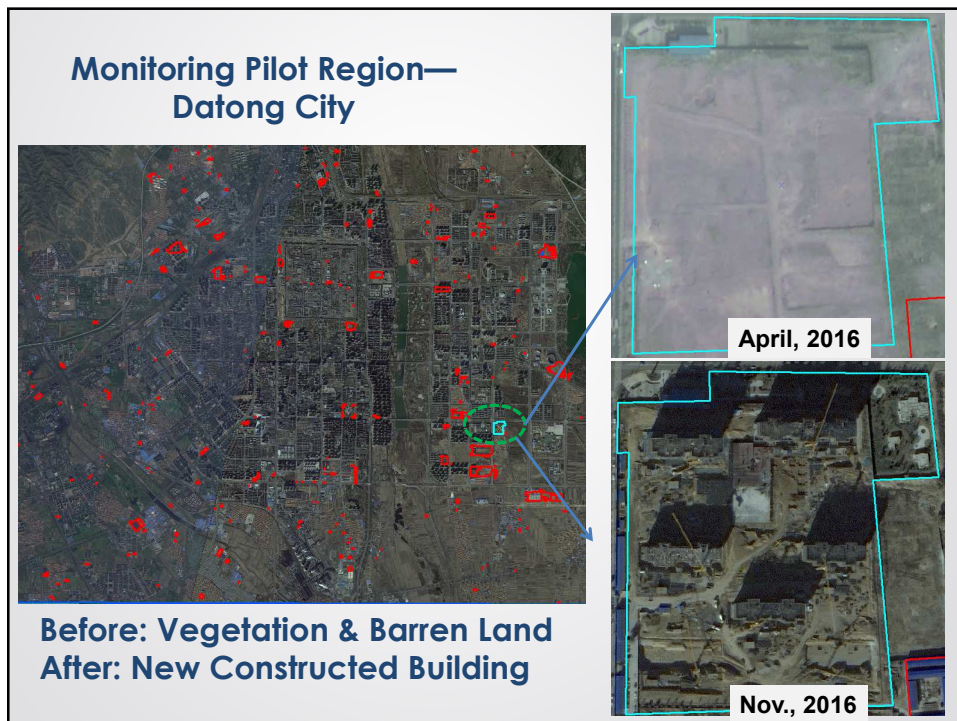
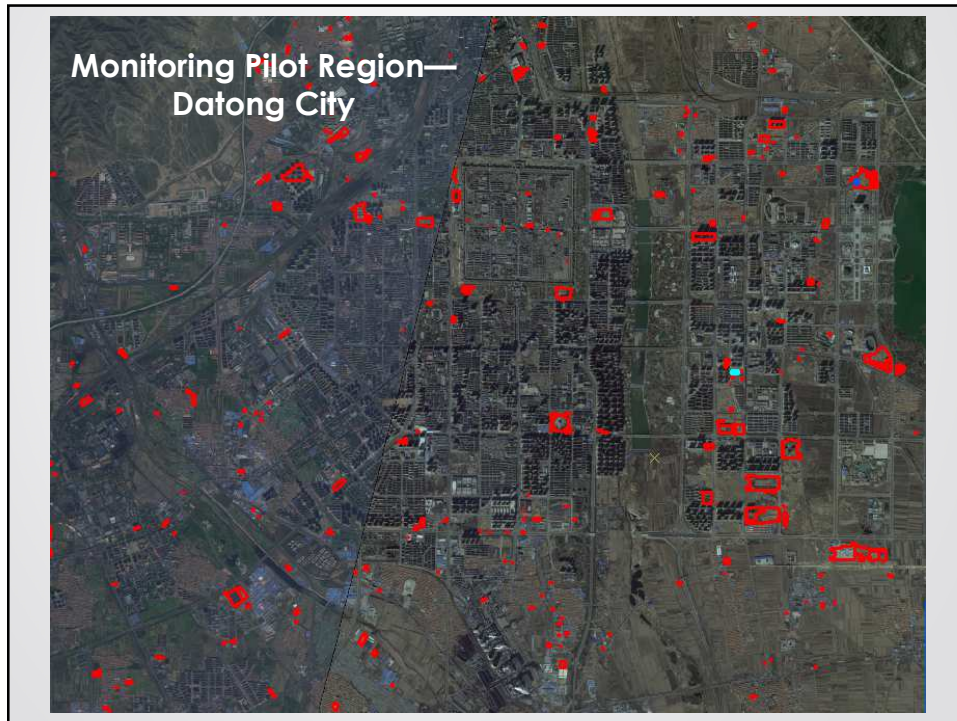
## Urban Land-use Pattern Classification Modeling

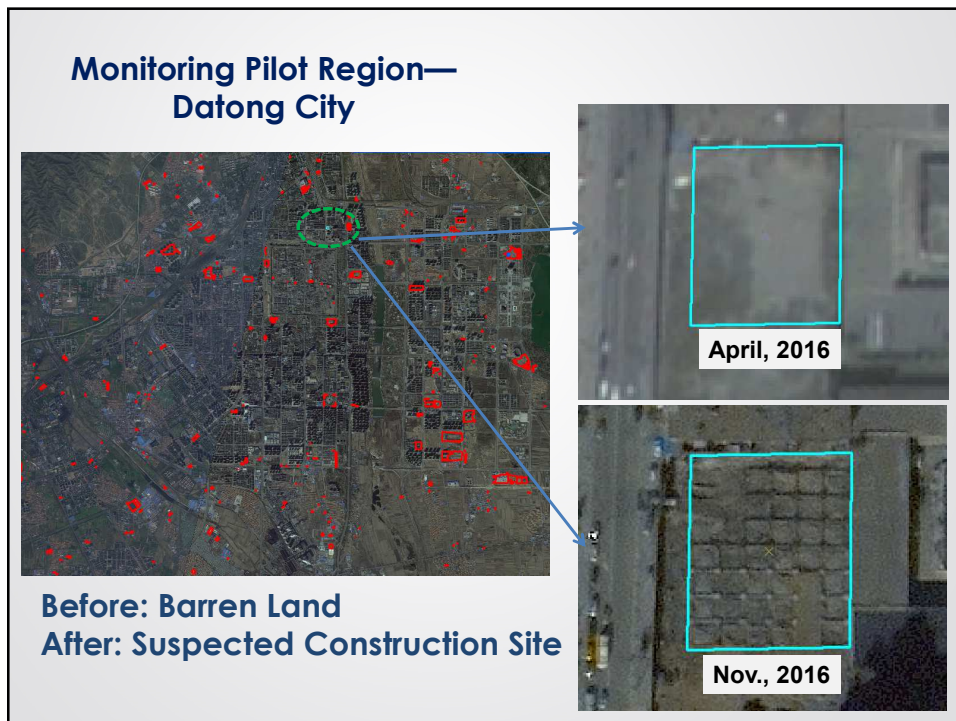
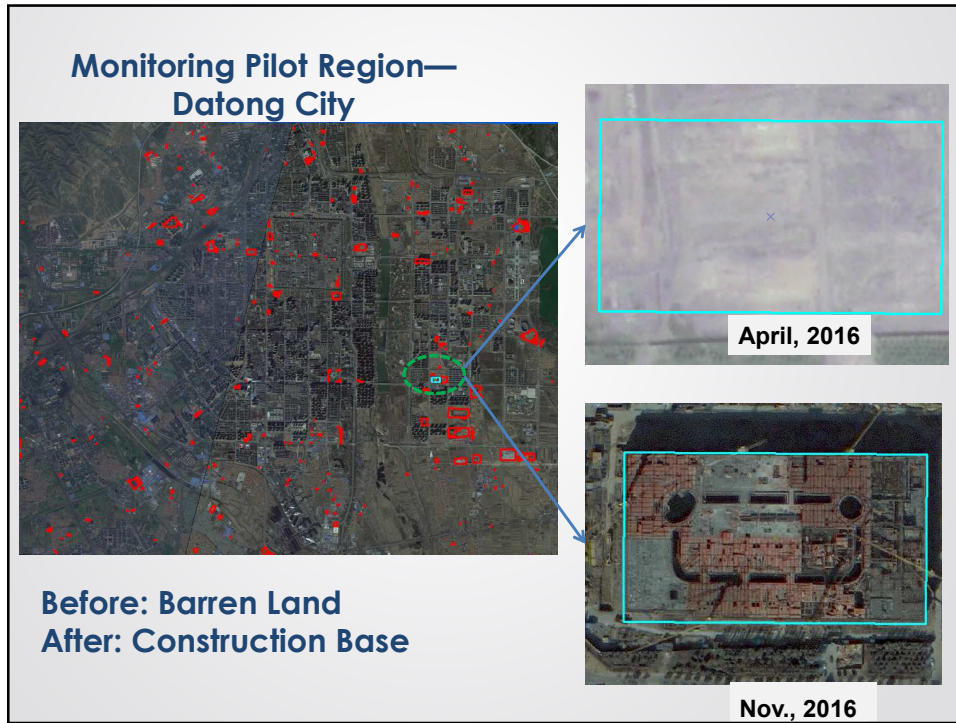


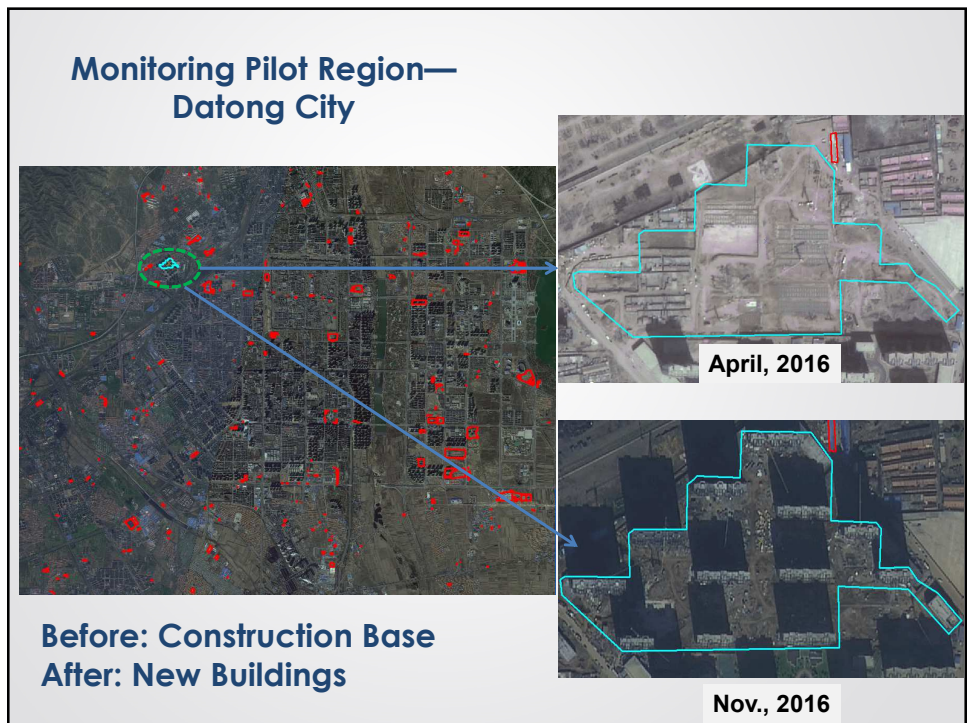
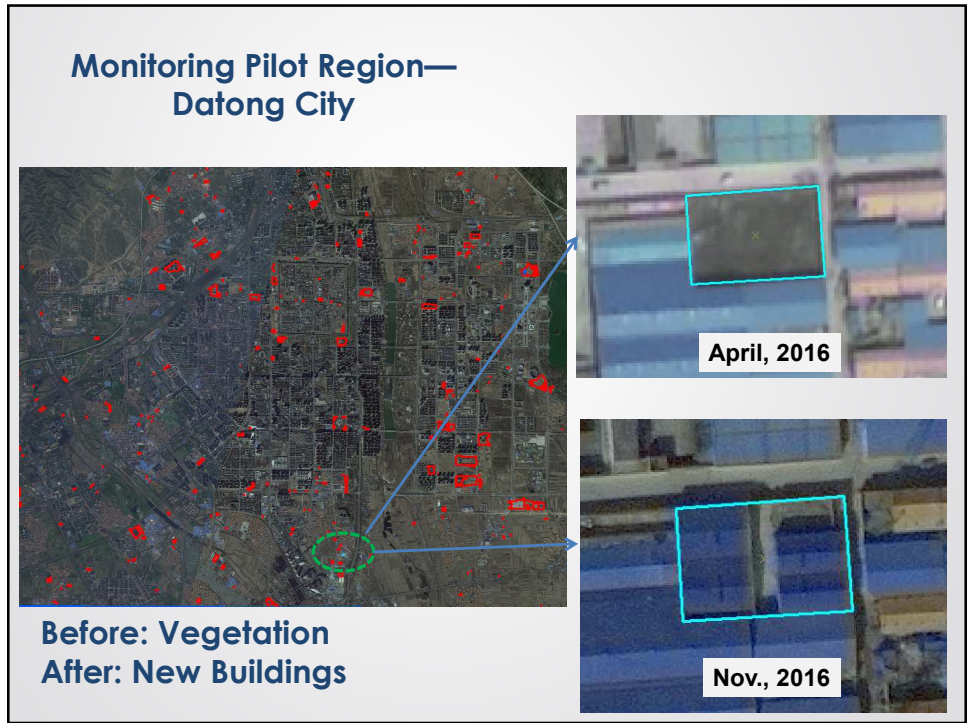
- Overall accuracy: 77%
- Kappa coefficient: 0.72

**Changed land parcel** →

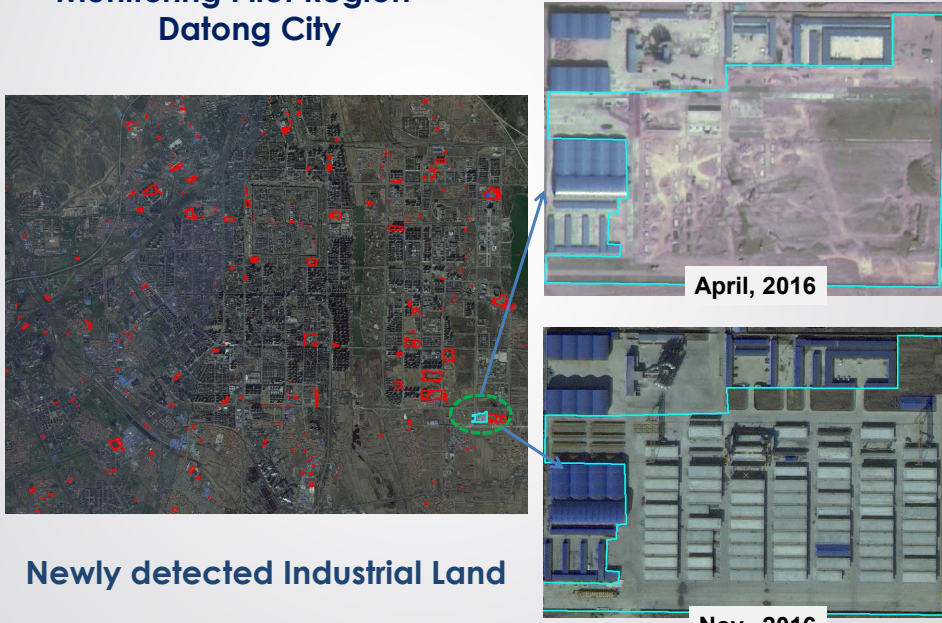
**Integration of monitoring images, land use & urban planning data, for illegal constructions fast detection**







### Monitoring Pilot Region— Datong City



Newly detected Industrial Land

April, 2016

Nov., 2016

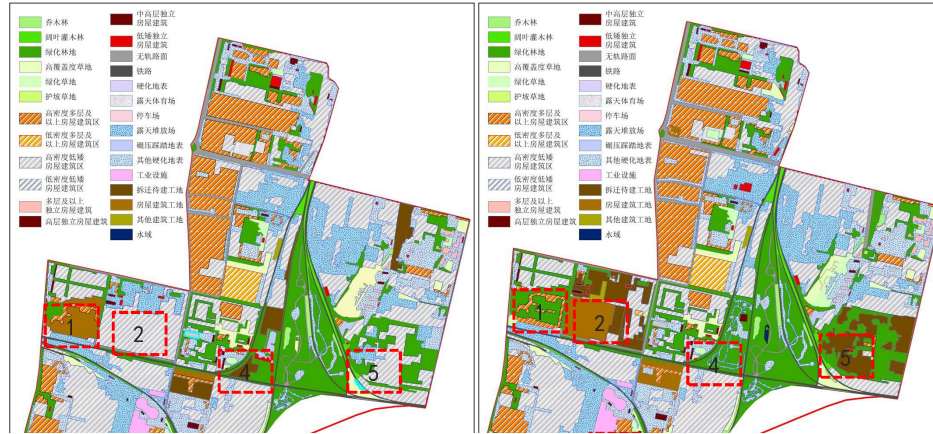
### Improve Government Administration & Supervision Capability



Seasonal Dynamic Monitoring

Provide basis for Land Administration from  
**Passive to Active**

## □ Pilot Project on Old Industrial Town Relocation & Reconstruction Monitoring—Land Cover



1 Before: Industrial Region,  
 2 Before: High Density Low Rise Individual Buildings,  
 3 Before: Demolished Industrial Area,  
 4 Before: Demolished Industrial Area,  
 5 Before: High Density Low Rise Buildings,

After: High Density Multi-story Buildings  
 After: Building Construction Site  
 After : Building Construction Site  
 After : Park & Green Land  
 After: Industrial Area to be Built

## Technical Specifications for Urban Monitoring

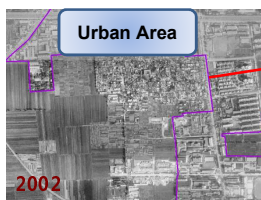
### □ Urban Boundary Extraction



## Urban Boundary Extraction



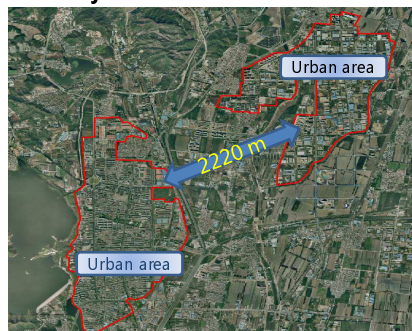
**Surrounded by High-rise Buildings**



**Adjacent to Urban Area**



Area > 60000 m<sup>2</sup>,  
Distance from Urban Boundary > 50m  
Not included into Urban Area



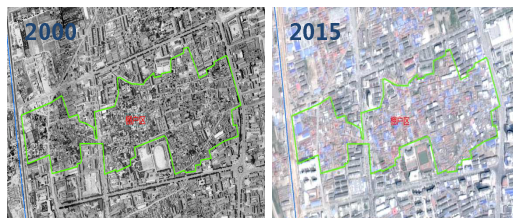
Enclave  
Distance from Urban Boundary > 200m  
Area > 600000 m<sup>2</sup>, Included into Urban Area

## Technical Specification for Urban Monitoring

### Urban Village Extraction



**Urban village**



**Shanty areas  
( Not Urban Village)**

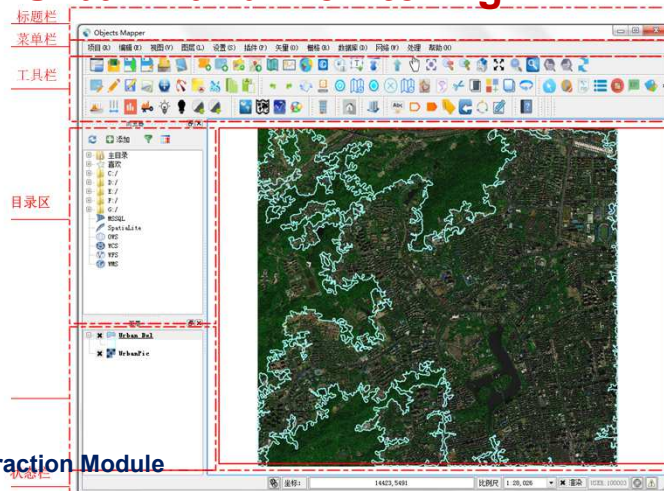


Land-use regions with same function shall be extracted as a whole piece



**Urban village parcels  
divided by road**

## Targetmapper – Designed for Urban Land Monitoring



- Urban Boundary Extraction Module
- Plot Ratio Calculation Module
- Building Extraction Module
- Building Shadow Extraction Module

- The GCM Technologies, Specifications and the Targetmapper for urban monitoring have been widely applied in provincial, regional and municipal surveying and mapping administrations throughout China
- Have also been applied by the Ministry of Land and Resources, Ministry of Housing and Urban-Rural Development, National Development and Reform Commission, as well as local government



## Contents

1

Brief View of GCM

2

GCM for Urban Development

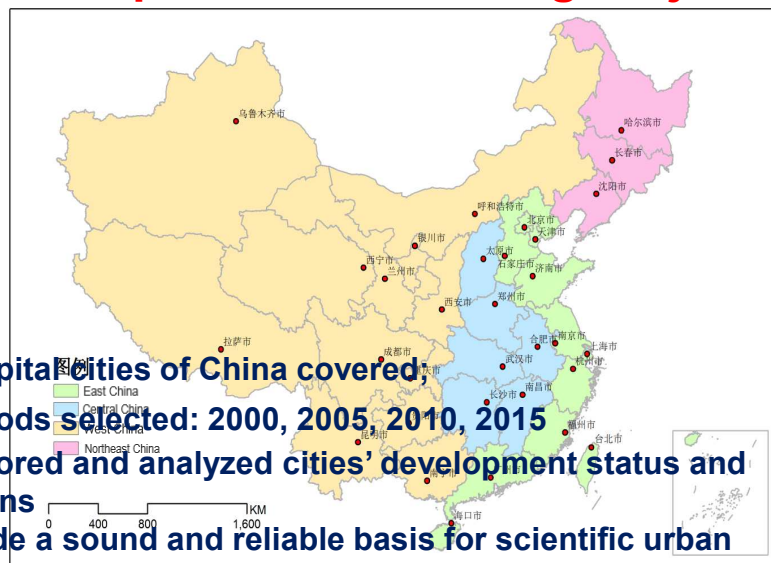
3

**Urban Expansion Monitoring Project**

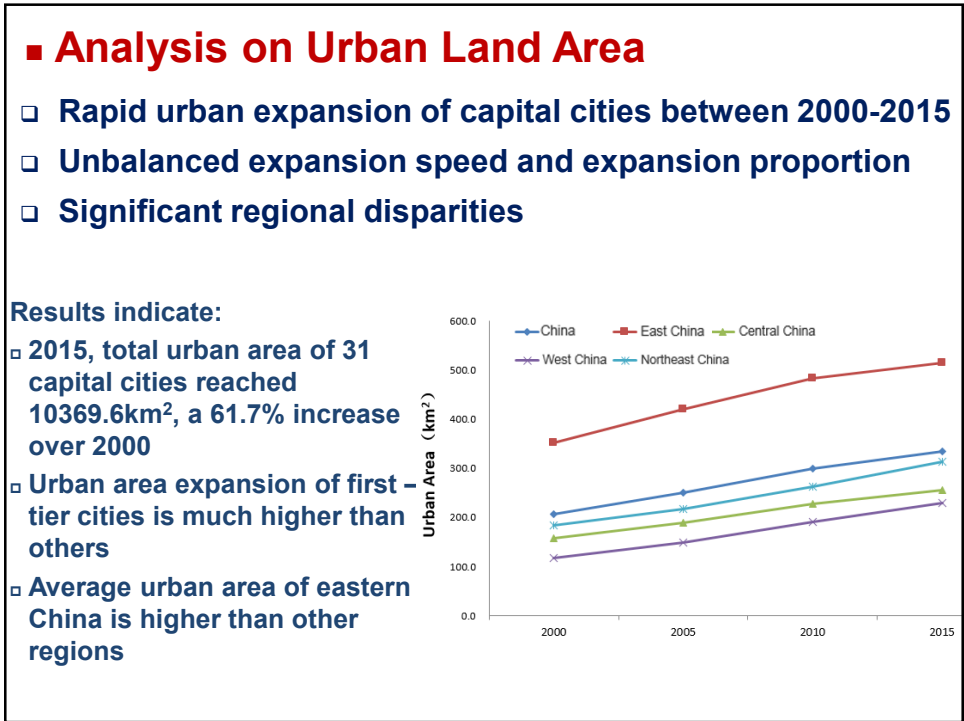
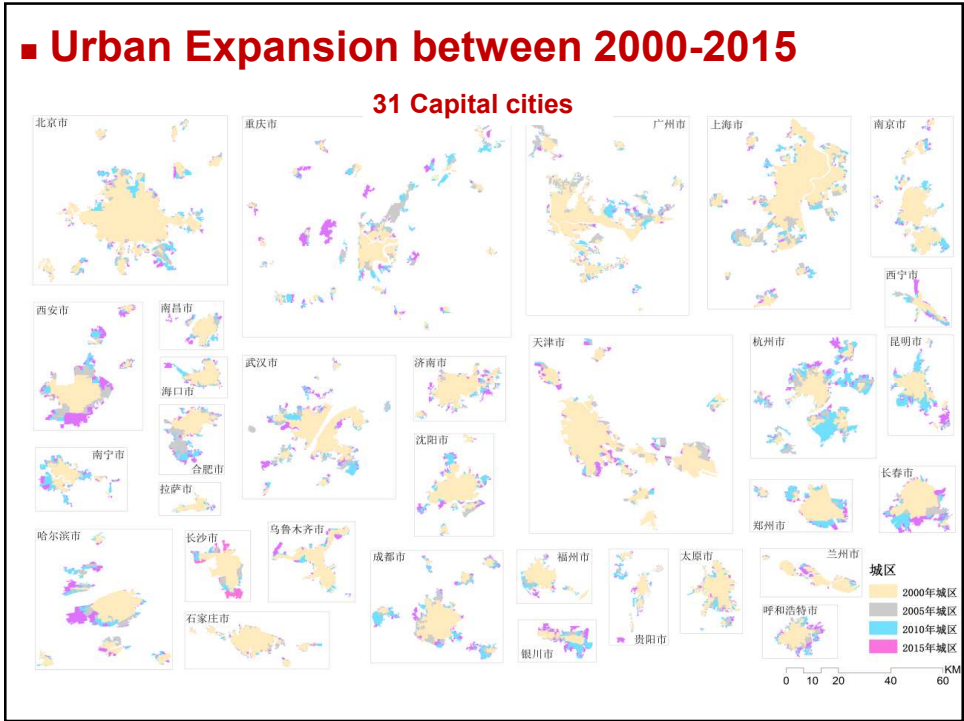
4

Conclusion &amp; Future Work

### 3. Urban Expansion Monitoring Project

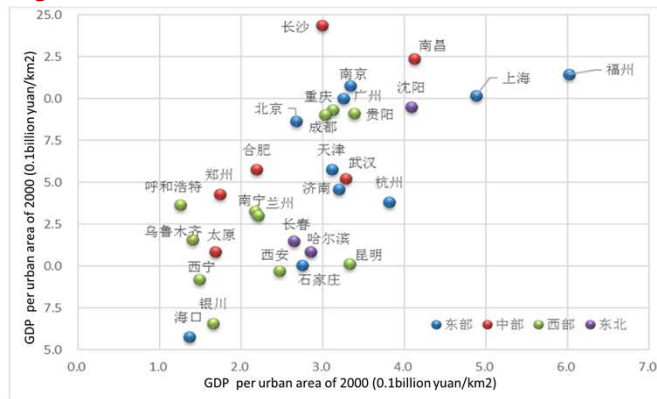


- 31 Capital Cities of China covered;
- 4 periods selected: 2000, 2005, 2010, 2015
- Monitored and analyzed cities' development status and patterns
- Provide a sound and reliable basis for scientific urban plan and urban sustainable development



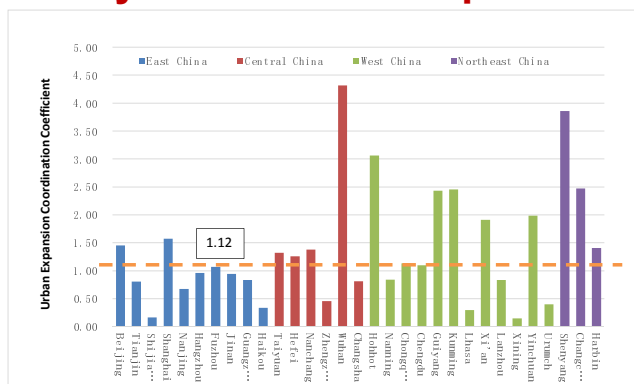


## ■ Analysis on Urban Land-Use Efficiency



- ❑ Capital cities with high GDP per Urban Area are widely distributed
- ❑ While cities with low GDP per Urban Area mainly locate in western and northeastern parts

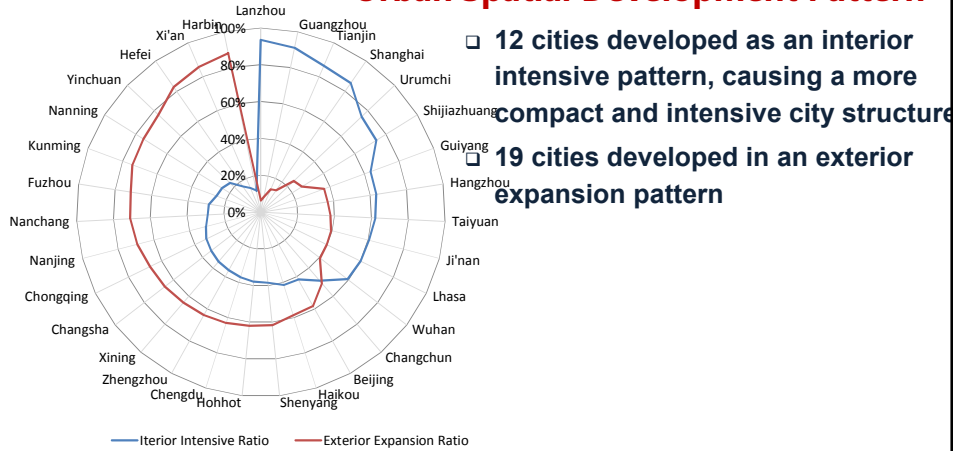
## ■ Analysis on Urban Expansion Coordination



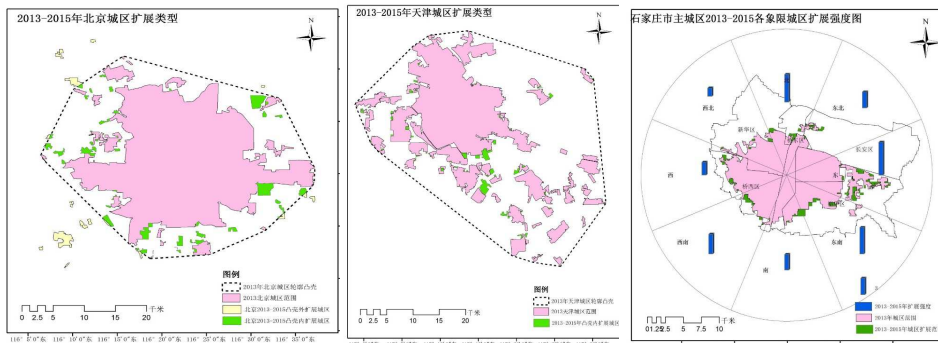
- ❑ 2000-2015, 31 capital cities all experienced an uncoordinated development between urban land and urban population
- ❑ Eastern region: urban land expansion lags behind population growth
- ❑ Northeast and central regions: urban land expansion exceeds the demand of population growth

## ■ Analysis on Urban Spatial Development Pattern

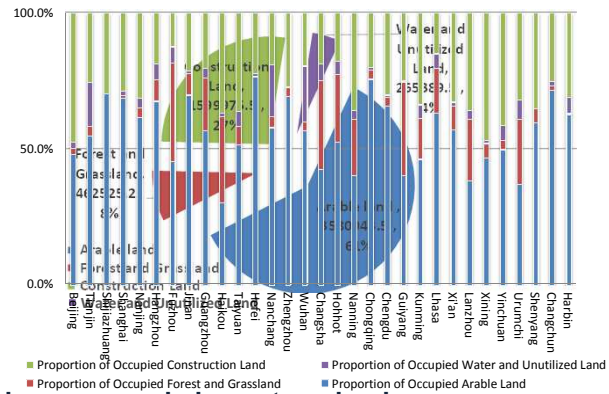
### Urban Spatial Development Pattern



## Urban Spatial Development Pattern of typical cities

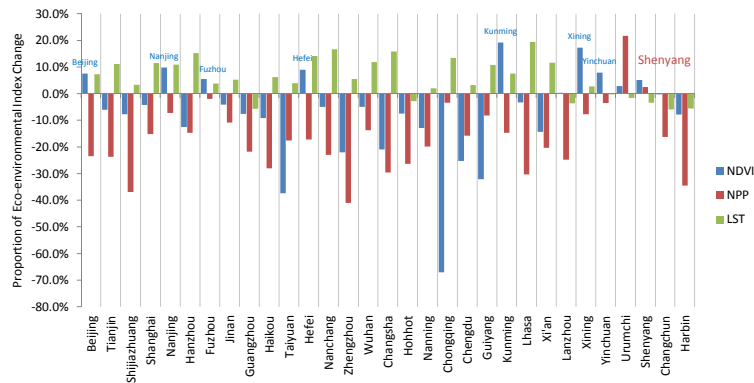


## ■ Analysis on Urban Expansion and Occupied Land Type



- Urbanization process has a severely impact on land use structures of the surrounding area
- Most cities expand by occupying arable land
- Very few grow by taking other land types

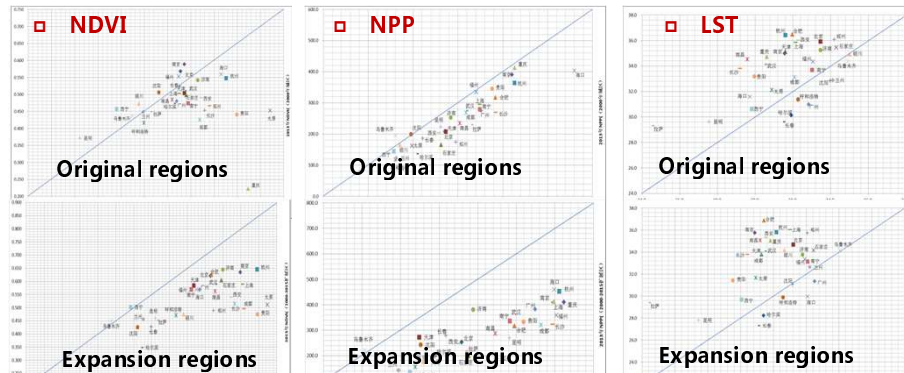
## ■ Urban Expansion and Impacts on Eco-Environment



The ecological environment change of the original area of provincial capital city in 2000-2015

- Excessive urban expansion caused a weak carbon sink, reduced vegetation cover, and increased land surface temperature
- Further led to a severe eco-environmental degradation

## ■ Urban Expansion and Impacts on Eco-Environment



( 1 ) NDVI values of original regions are general decreased over 2000-2015 , but the values of 10 cities are increased. In expansion regions, the values only in Xining and Urumqi are increased.

( 2 ) NPP values of original regions are general decreased over 2000-2015 , but the values of 2 cities are increased. In expansion regions, the values only in Urumqi are increased.

( 3 ) LST values of original regions are general increased over 2000-2015 ,

## Contents

1

Brief View of GCM

2

GCM for Urban Development

3

Urban Expansion Monitoring Project

4

Conclusion &amp; Future Work

## Conclusions

Under the GCM framework:

- ❑ Numbers of pilot and thematic monitoring projects on urban space development, eco-environmental protection and resources sustainable utilization have been organized
- ❑ A dynamic national geo-information information system has been constructed
- ❑ Continually provide fundamental support and spatial reference for urban land sustainable development and ecological civilization construction
- ❑ Consistently releasing spatially and temporally reliable geo-information, enhance the service capability of information on national geographic conditions for the government, enterprises and the general public.

63

## Future Work

- ❑ Based on the existing GCM framework and developed technologies, to further establish consistent and in-time data acquisition and dissemination mechanisms, so as to promote the best application of geospatial information for economic & social development, contribute to a robust and sustainable urban environment
- ❑ Further carry out thematic monitoring projects on state-level new areas, typical urban agglomeration and prefectural-level cities, to clarify their spatial change patterns, so as to provide a reliable, spatial and temporal data basis for sustainable urban planning and implementation

64



