



# Spatial Information Technology and Disease Prevention & Control in China

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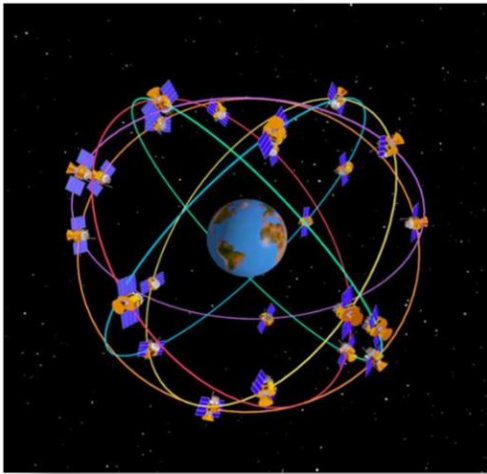


# Outline

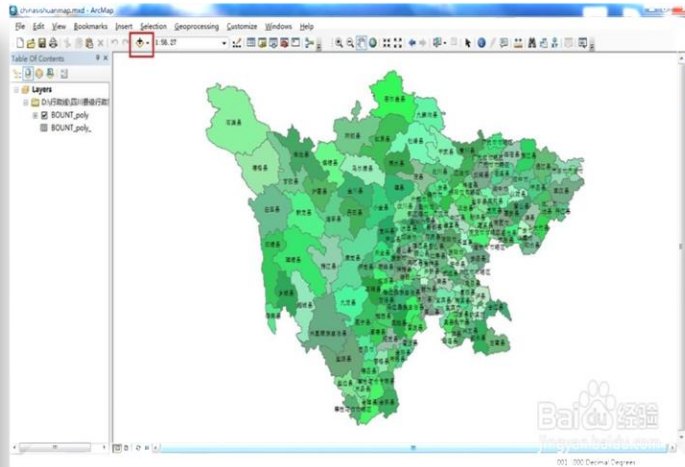
- 1. Introduction of development history of spatial information technology in health field (SITHF) in China.**
- 2. Main scientific research institutes of SITHF in China.**
- 3. Research and application of SITHF in China.**

# 1. Introduction of development history of SITHF in China

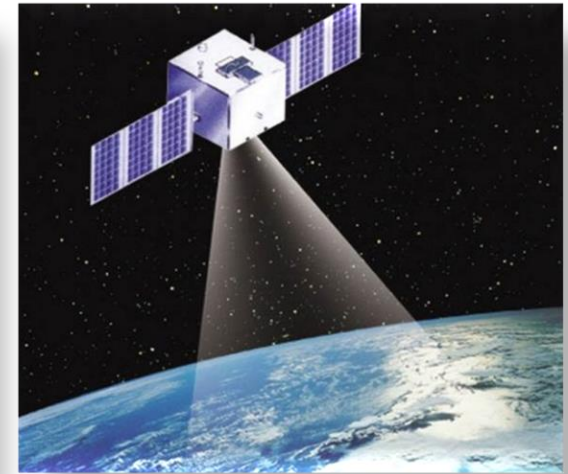
- **Spatial Information technology (SIT) is a Global Positioning System (GPS), Geographic Information System (GIS) and Remote Sensing (RS) technology as the main content.**



GPS



GIS



RS



# 1. Introduction of development history of SITHF in China

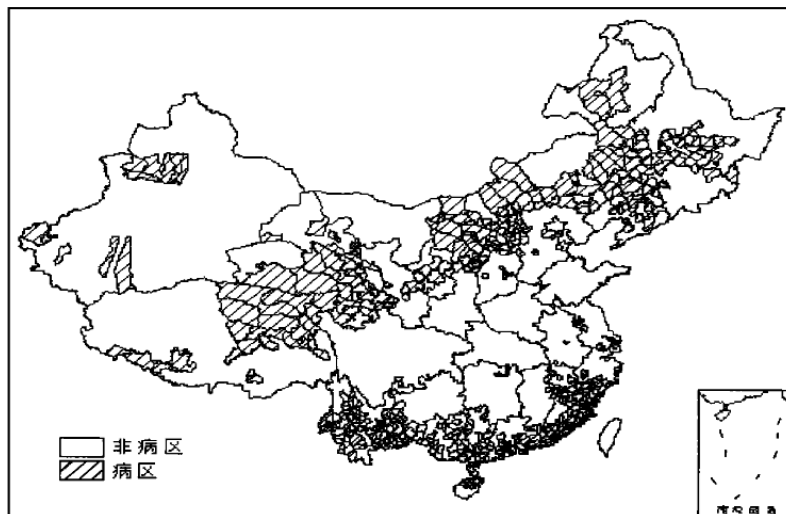
1980s~1990s

1990s~2003

2003~2008

After 2008

- GIS started to be applied in public health as early as the late 1980s in China.
- In 1990s, RS and GIS was used to study the distribution of infectious disease(schistosomiasis and plague).



Distribution of plague in China  
(Yang et al, 2000)

# 1. Introduction of development history of SITHF in China

1980s~1990s

1990s~2003

2003~2008

After 2008

- **During the prevention and control of SARS in 2003, GIS had a wide range of applications.**
- **With the application of national infectious disease surveillance system and spatial information technology, the research in the prediction of public health emergencies and the outbreak of diseases has made great achievements.**



# 1. Introduction of development history of SITHF in China

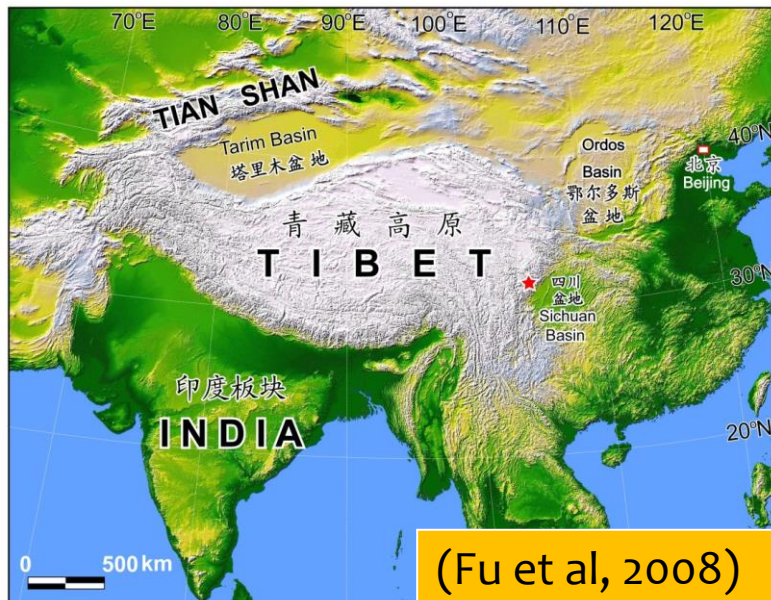
1980s~1990s

1990s~2003

2003~2008

After 2008

- On May 12, 2008, an earthquake of 8.0 Ms occurred in Wenchuan, Sichuan Province, killed 69,195 people and left 18,392 missing.
- SIT caught great concern of the government and public institution after the earthquake due to its advantages to help rescue and hazard assessment.



- \* Wenchuan Earthquake is considered to be a model since the spatial information technology played such important role in the disaster relief work, it is unique for the rescue has involved so many departments and data sources.

--- Deren Li  
(Academicians of CAS)

# 1. Introduction of development history of SITHF in China

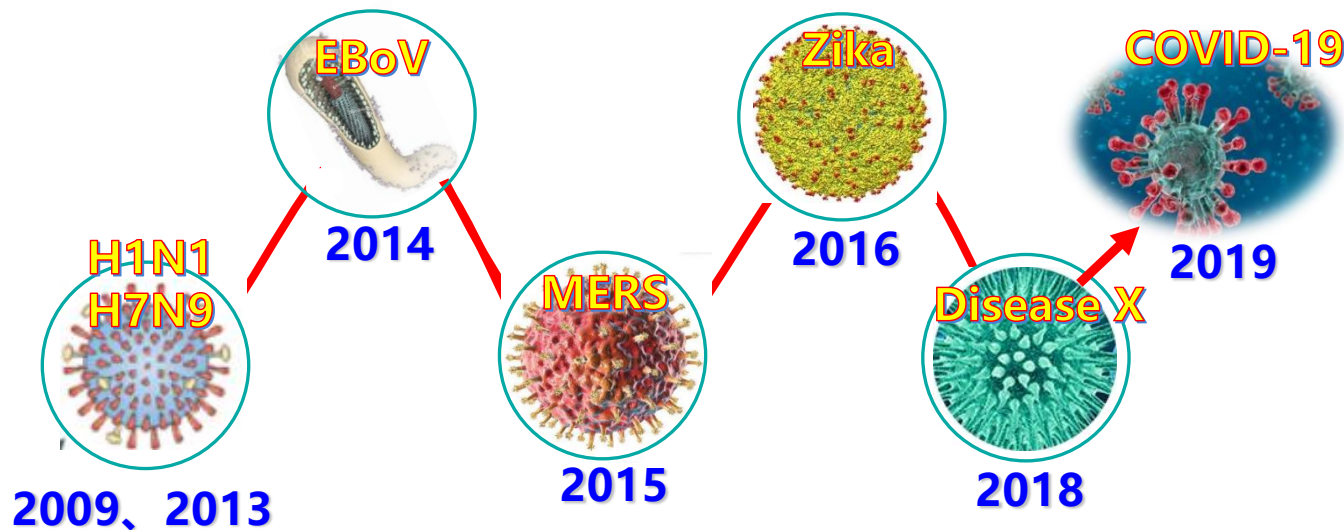
1980s~1990s

1990s~2003

2003~2008

After 2008

- More large-scale refined application of SITHF



## 2. Main scientific research institutes of SITHF in China

- Scientific Research Institution

- Chinese academy of sciences (Institute of Geographic Sciences, Institute of Remote Sensing Application, etc.)
- National Health Commission's affiliated institutions (China CDC, Chinese Medical University, Peking Union Medical College Hospital, Peking University Third Hospital)

- Colleges and Universities

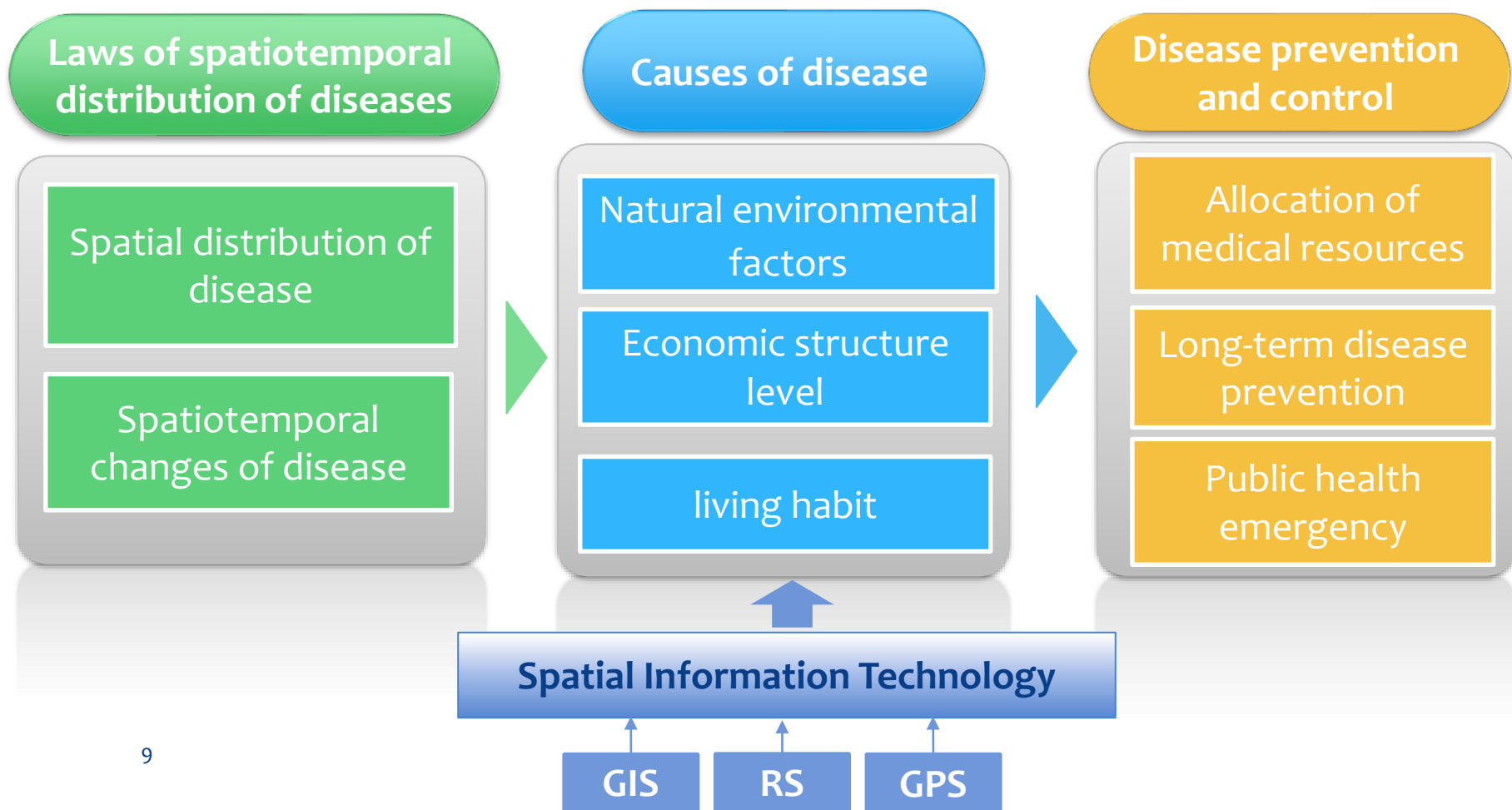
- Institute of space and population, Peking University Medical College
- School of environment, tsinghua university
- School of environment, beijing normal university





# 3. Research and application of SITHF in China

## • Application of Spatial Information Technology



### 3. Research and application of SITHF in China

- **Spatial dimension: Occurrence, Distribution, Epidemiological characteristics, Activities of patients, Distribution of medical and health institutions, etc.**
- **Time dimension: Phenomenon of infectious diseases is not constant, and the type or distribution of its causes will change over time.**
- **The spatiotemporal characteristics of infectious diseases contain masses of laws that reveal the epidemic process of infectious diseases.**

### 3. Research and application of SITHF in China

- **Typical infections——Dengue Fever**

**Dengue fever is an acute infectious disease, which is mainly transmitted through the bites of *Aedes albopictus* and *Aedes aegypti* in China.**

Natural and social factors influencing the incidence of dengue

The spatial heterogeneity of dengue fever

The contribution of influencing factors

Advice on prevention and control

# 3. Research and application of SITHF in China

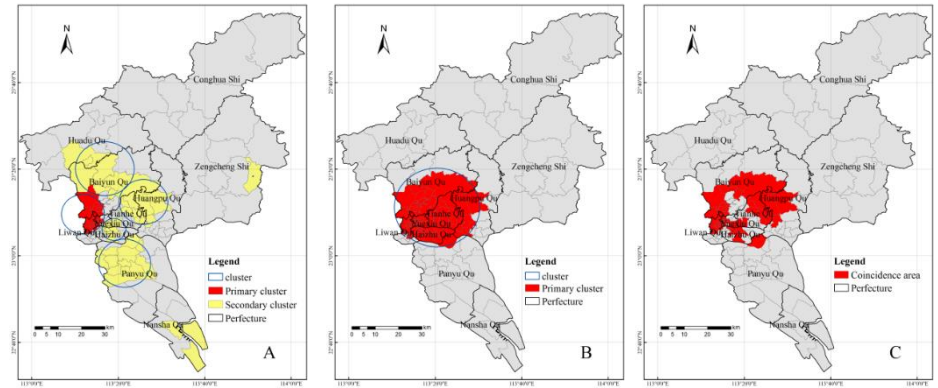
## Typical infections——Dengue Fever

### Spatiotemporal scanning statistics

(A) 14 days and 10% risk population

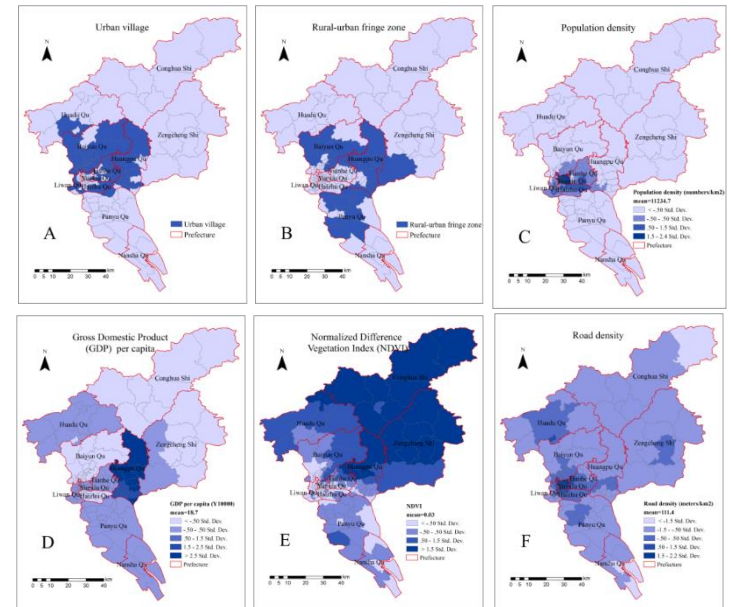
(B) 14 days and 40% risk population

(C) The area of agreement in analysis results.



### Generalized Additive Models (GAM)

$$\log(\text{case}) = \beta_0 + \beta_1(\text{urban}_{\text{village}}) + \beta_2(\text{urban}_{\text{village}}_{\text{fringezone}}) + s(\text{pop\_density}) + s(\text{GDP\_per\_capita}) + s(\text{NDVI}) + s(\text{road\_density}).$$



### 3. Research and application of SITHF in China

- **Typical infections——Schistosomiasis**

**The only intermediate host of schistosomiasis is *Oncomelania hupensis* .**

Spatiotemporal distribution and risk assessment

Spatiotemporal  
distribution of snail  
density

Analysis of the main  
decided factors

Rapid  
Monitoring and  
Evaluation

# 3. Research and application of SITHF in China

## Typical infections——Schistosomiasis

### ✓ Local spatial auto-correlation

Anselin Local Moran's I:

$$I_i = \frac{x_i - \bar{x}}{S^2} \sum_j w_{ij} (x_j - \bar{x}) \quad Z(I_i) = \frac{I_i - E(I_i)}{\sqrt{VAR(I_i)}}$$

$\bar{x}$ : the average of  $x$

$w_{ij}$ : a binary weighting matrix for adjacent spaces

$$S^2 = \frac{\sum_{j=1, j \neq i}^n x_j^2}{n-1} - \bar{x}^2$$

### ✓ Geographically Weighted Regression

$$y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i$$

$y_i$ : the dependent variable of point  $i$

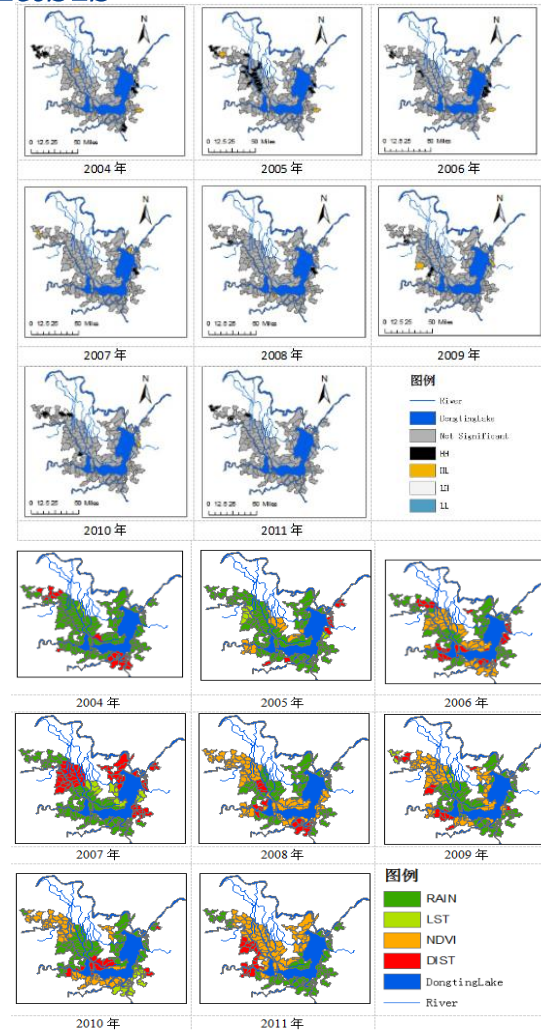
$x_{ik}$ : the  $k$ th independent variable at point  $i$

$k$ : the numeration of the independent variable

$i$ : the numeration of sample points  $\varepsilon_i$ : the residual

$(u_i, v_i)$ : the space coordinates of the  $i$ th point

$\beta_k(u_i, v_i)$ : the value of the continuous function at point  $i$ .



Spatial distribution pattern of snail density from 2004 to 2011

Leading factors in the spatio-temporal distribution of *Oncomelania hupensis*

## 3. Research and application of SITHF in China

- **Typical infections——Plague**

**Plague is a severe infectious disease mainly spread by *Yersinia pestis* through rodent fleas, a natural foci disease that is widespread among wild rodents.**

Spatiotemporal distribution characteristics

The nest flea  
indexes cluster  
\\hotspot analysis

Influencing factors of  
nest indexes  
contribution

Advice on  
prevention and  
control

# 3. Research and application of SITHF in China

## • Typical infections——Plague

### ✓ Getis-Ord $G_i^*$

$$G_i^* = \frac{\sum_j w_{ij} x_j - \omega_i^* \bar{x}}{s \sqrt{(ns_{1i} - w_i^{*2}) / (n-1)}}$$

### ✓ Ordinary Least Square estimation

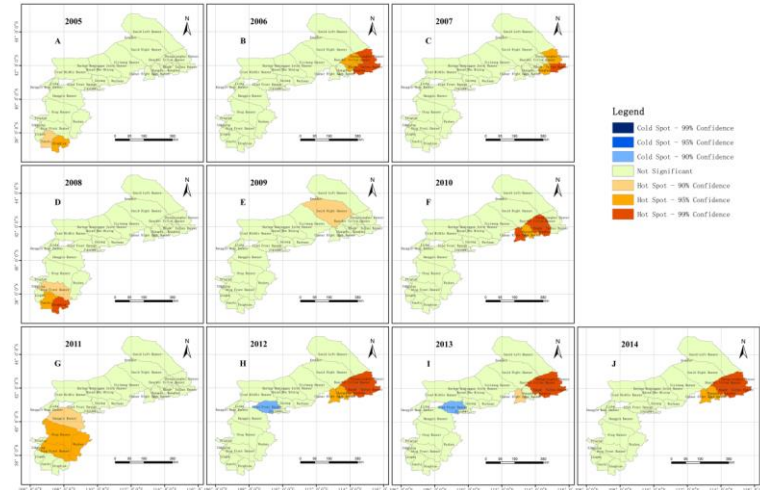
$$y = \rho W y + X \beta + \varepsilon$$

### ✓ Spatial Lag Models

$$y = (I - \rho W)^{-1} X \beta + (I - \rho W)^{-1} \varepsilon$$

### ✓ Spatial Error Models

$$y = \lambda W y + X \beta - \lambda W X \beta + \varepsilon$$



Maps of the hot spot regions of the nest flea indexes

**Dependent variable:**

the nest index

**Independent variable:**

Host density, Temperature, DEM, NDVI, Rainfall



## 3. Research and application of SITHF in China

- **Typical infections——Covid-19**

**In China, SIT is used to provide important scientific and technical support to allow the government to judge the epidemic situation and formulate prevention and control measures.**

Epidemic situation、 prevention and control measures

Spatio-temporal  
statistical analysis

&

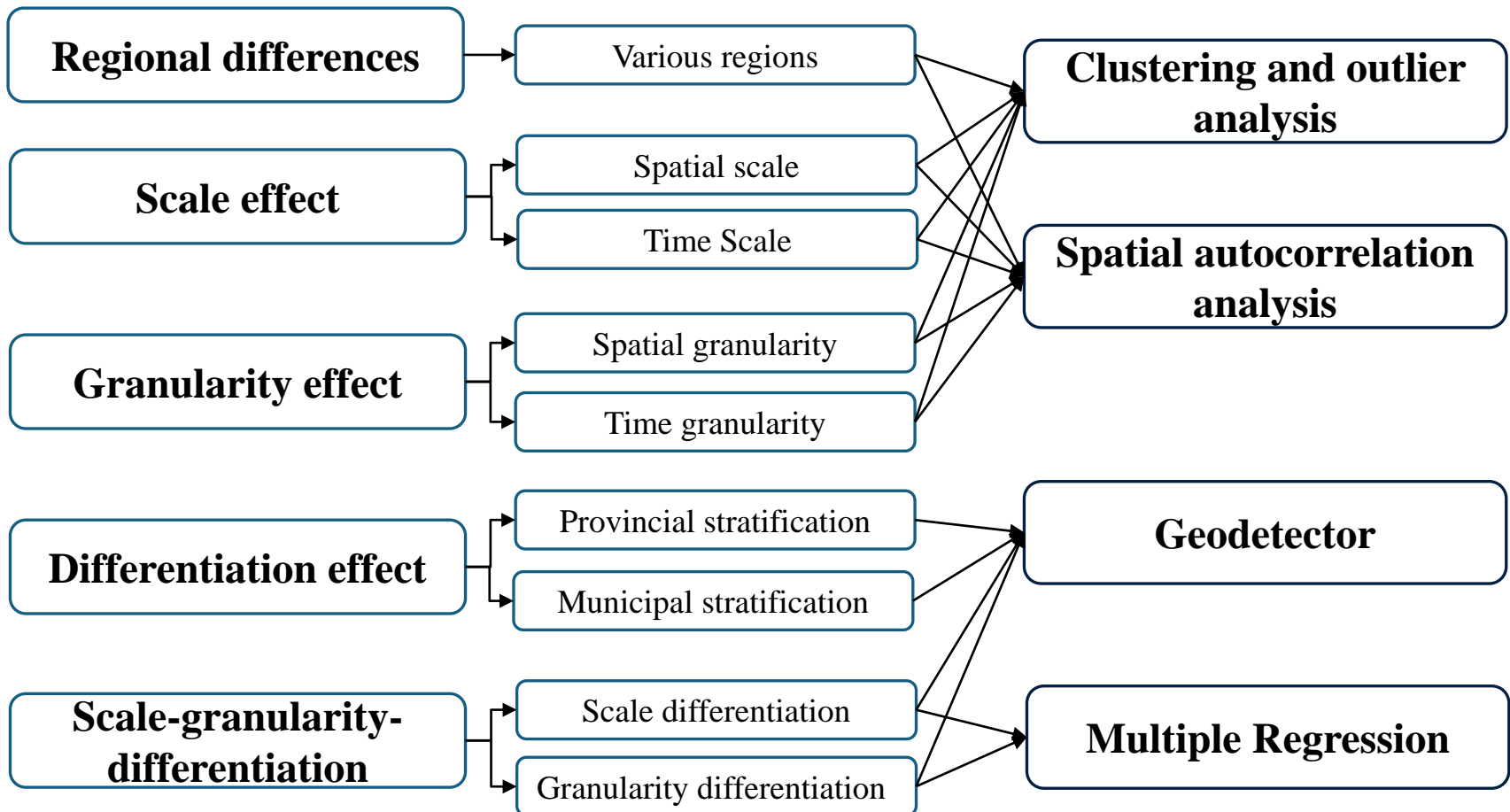
Application of big  
data technology

&

Construction of  
information  
platform

# 3. Research and application of SITHF in China

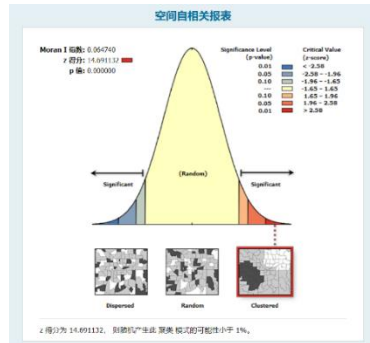
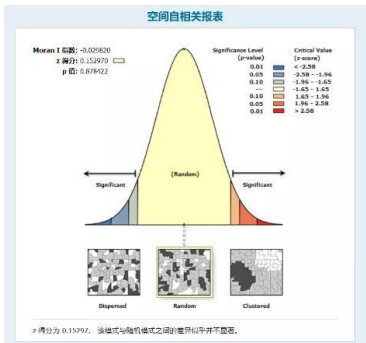
- Spatial Disparity Measurement Based on Covid-19 Epidemic Data**



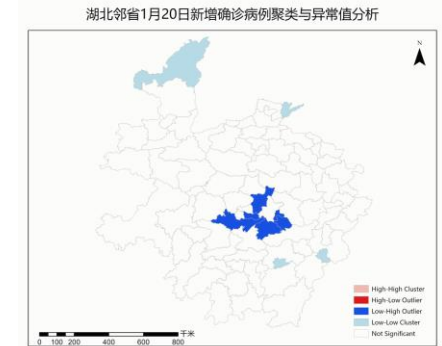
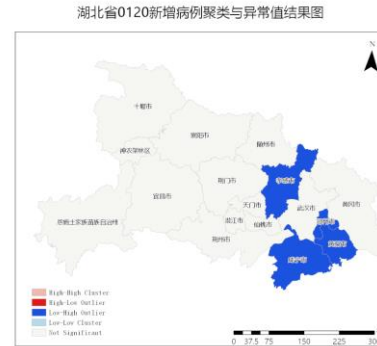
# 3. Research and application of SITHF in China

## • Spatio-temporal statistical analysis on Covid-19 Epidemic Data

### Spatial autocorrelation analysis



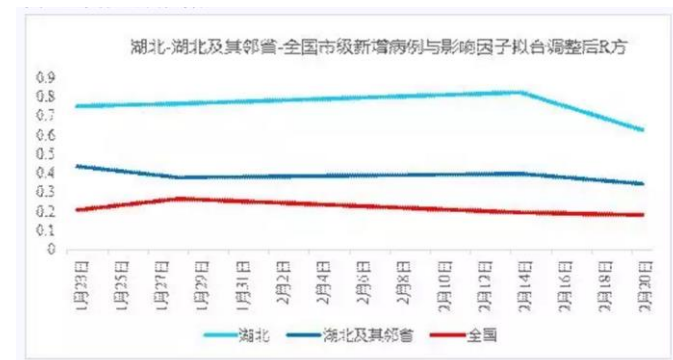
### Clustering and outlier analysis



### Geodetector

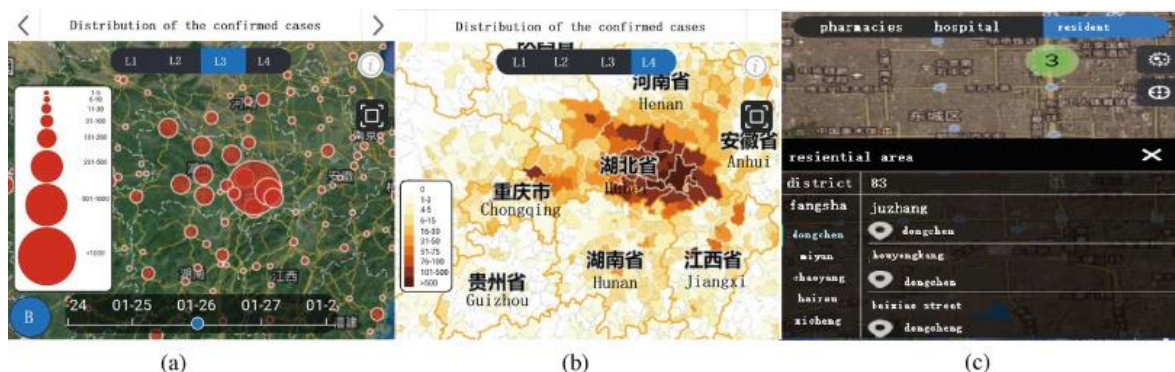
因子探测	纬度	城市等级	邻接关系	百度迁移量	GDP	人口密度
q statisti	0.01010	0.17233	0.99389	0.12323	0.99709	0.00754
c	6	3	8	5	6	6
p value	0.70135	0.54088	0	0.81513	0	0.74117
	5	5		2		7

### Multiple Regression



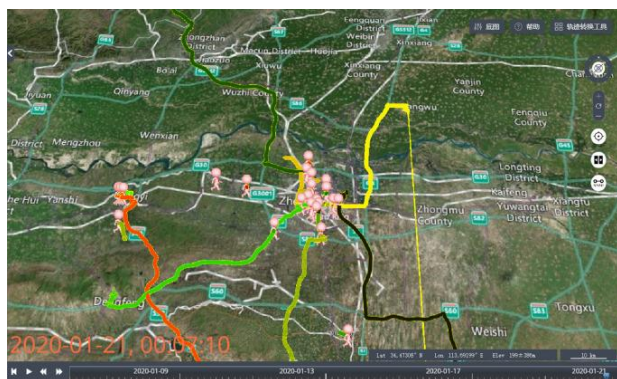
# 3. Research and application of SITHF in China

- Rapid construction of a big data information system for epidemics



Dynamic information query system for different scales:  
 (a) City level; (b) County level;  
 (c) Community level

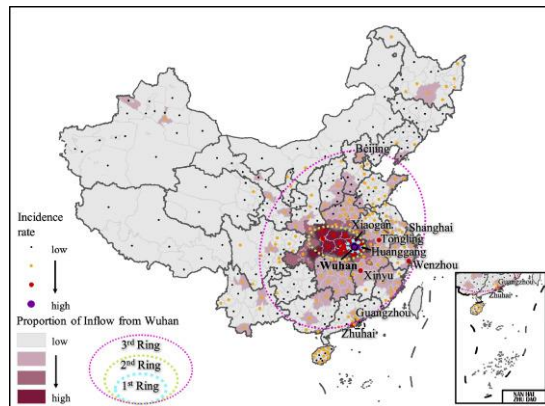
## Spatial tracking and spatiotemporal trajectory



Exposure analysis of a patient's spatial trajectory

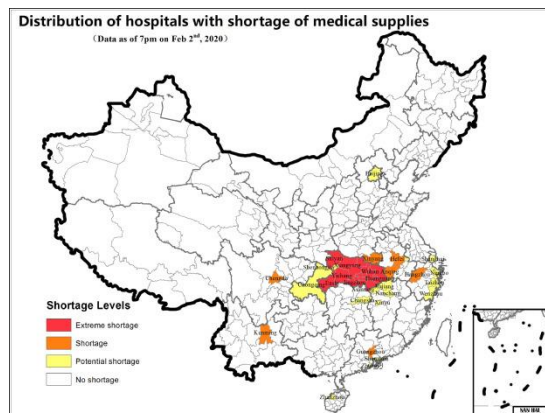
# 3. Research and application of SITHF in China

## Spatial segmentation of the epidemic risk and prevention level



A risk assessment model was constructed with the spatial distribution of the number of **confirmed cases** and the **population migration**, and three risk level areas were outlined on the regional scale and on the urban scale for the cities with high risks of epidemics.

## Spatial dynamic balancing of supply and demand for medical resources



Based on the factors of online hospital **help information, local cases and forecasts, and existing resource data**, the current dynamic situation of medical protective equipment across the country were analyzed.

# 3. Research and application of SITHF in China

- COVID-19 distribution system

Designed with **SOA** architecture, the front end is implemented based on **ArcGIS API** for JavaScript, and the server uses **ArcGIS Enterprise**.



PC



Mobile



# Current problems

- **Technology:** Limitation of further application.

The further applications including spatial modeling, spatial data analysis and professional software are limited compared with other developed countries.

- **Data:** Insufficiency of data sharing.

Sharing and openness between spatial data and public health data is insufficient, which will restrict the further development.

- **Personnel:** Lack of interdisciplinary personnel.

The current personnel in public health field is mainly majored in health-related subjects. They lack relevant knowledge about spatial information technology.



# Several publications

- Juan Qiu, Rendong Li, Hong Zhu, Jing Xia, Ying Xiao, Duan Huang and **Yong Wang**. 2020, The effect of ecological environmental changes and mollusciciding on snail intermediate host of *Schistosoma* in Qianjiang city of China from 1985 to 2015. *Parasites & Vectors*, 13,397:1-10
- Juan Qiu, Rendong Li, Ying Xiao, Jing Xia, Hong Zhu, Yingnan Niu, Ying Cui, and **Yong Wang**. 2019, Spatiotemporal Heterogeneity in Human *Schistosoma japonicum* Infection at Village Level in Hubei Province, China. *International Journal of Environmental Research and Public Health*, 2019, 16, 2198;
- Wei Ji, **Yong Wang**, Dafang Zhuang. 2019, Spatial distribution differences in PM2.5 concentration between heating and non-heating seasons in Beijing, China. *Environmental Pollution*.
- **Wang Yong**, Qu Yubin, et al. 2018, Identification of Suitable Area of Dengue Vector in Guangzhou City Using High Score Remote Sensing Images, *Chinese Journal of Health Informatics and Management*
- **Wang Yong**, Zhuang Dafang, et al.. 2018, Design and Application of Disease Monitoring and Evaluating System Based on High Resolution Remote Sensing Technology, *Chinese Journal of Health Informatics and Management*.
- Yubing Qu, Xun Shi, **Yong Wang** , et al. 2018. Effects of socio-economic and environmental factors on the spatial heterogeneity of dengue fever investigated at a fine scale. *Geospatial Health*.
- Yixian Chen, **Yong Wang**. 2018, Spatial characteristics of heavy metal pollution and the potential ecological risk of a typical mining area: A case study in China. *Process Safety and Environment Protection*.
- Haiwen Du, **Yong Wang**, et al. 2017, Temporal and spatial distribution characteristics in the natural plague foci of Chinese Mongolian gerbils based on spatial autocorrelation. *Infectious Diseases of Poverty*.
- Gong Cheng, **Yong Wang**. 2016, The influence of natural factors on the spatio-temporal distribution of *Oncomelania hupensis*. *Acta Tropica*.
- **Yong Wang**, Dafang Zhuang. 2015, A rapid monitoring and evaluation method of Schistosomiasis based on spatial information technology, *International Journal of Environmental Research and Public Health*.
- **Yong Wang**, Dong Jiang, et al.. 2013, Effective key parameter determination for an automatic approach to land cover classification based on multispectral Remote Sensing imagery. *PLoS ONE*.
- Daping Song, Dong Jiang, **Yong Wang**, et al., 2013. Study on association between spatial distribution of metal mines and disease mortality: A case study in Suxian district, South China. *International Journal of Environmental Research and Public Health*.





# Thank you!

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