

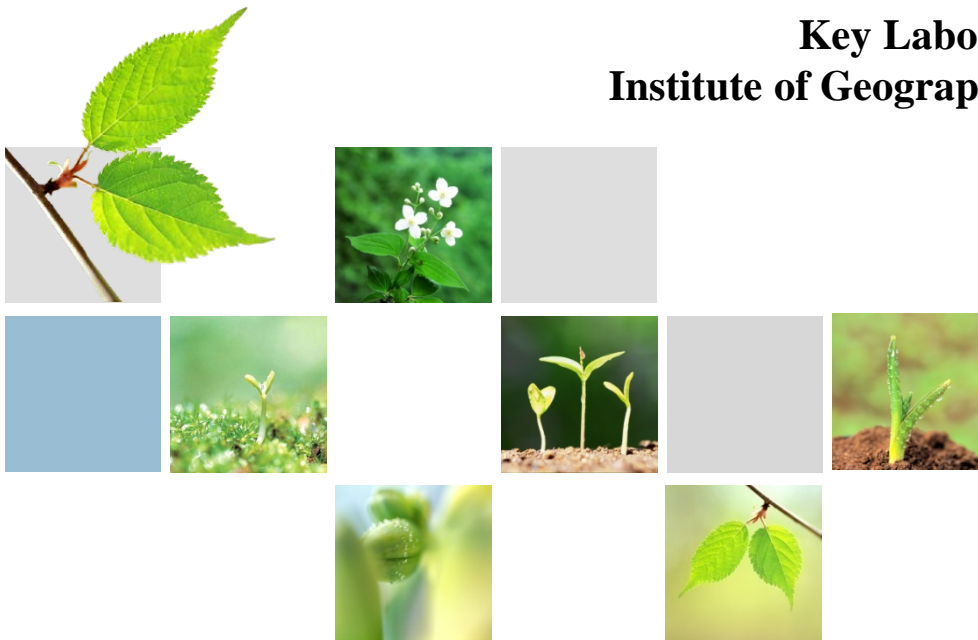


**Symposium on Floods and Health Risk Reduction:  
Sharing Asian Experiences  
26 Oct., 2015, UNU-IIGH, Malaysia**

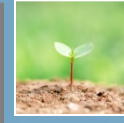
**Experiences of risk assessment of floods and health in China**

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**Linsheng YANG**



# Content



## Experiences of risk assessment of floods and health in China

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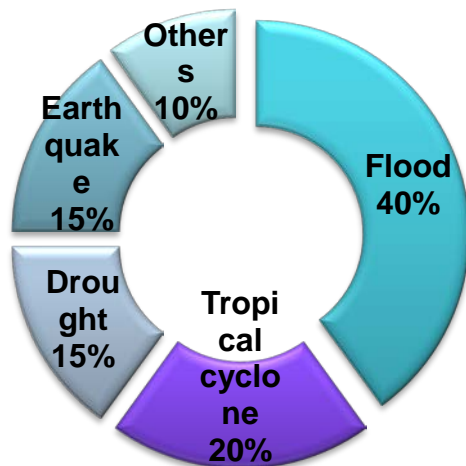
Summary



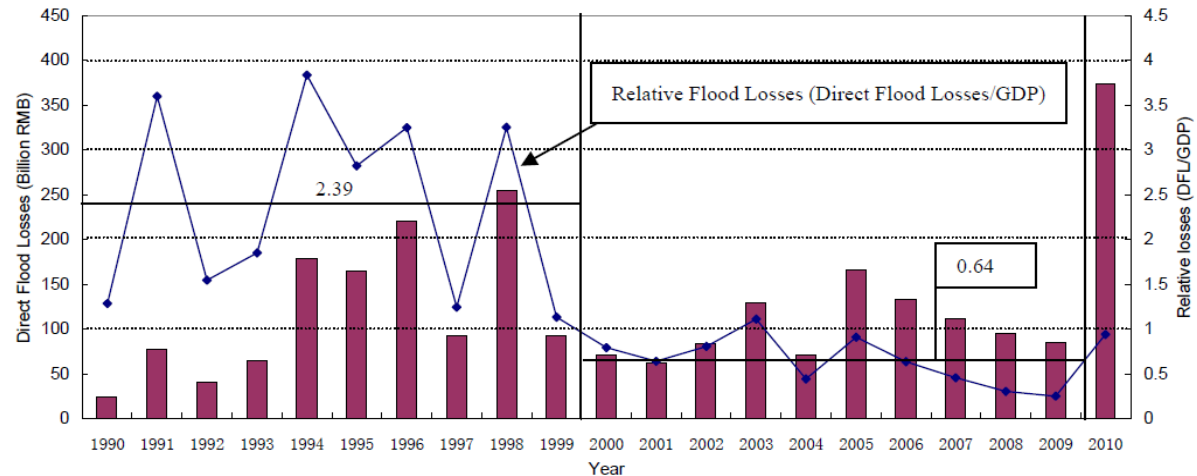
# 1. Introduction



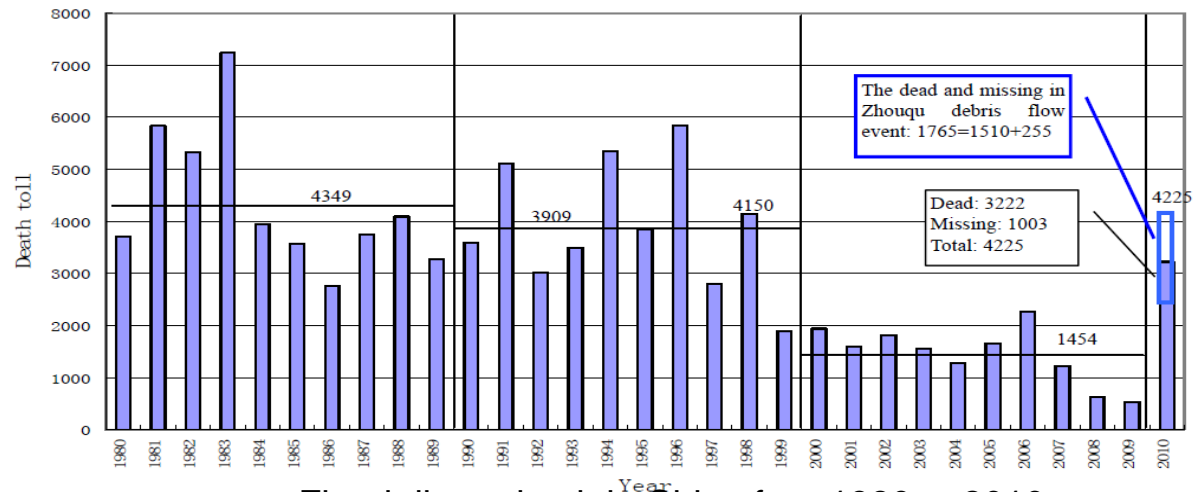
- Under the global climate change circumstance, the frequency of flood disaster increases and causes a series of losses



Economic Loss

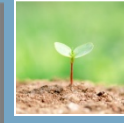


Flood direct economic losses in China from 1990 to 2010



Flood direct death in China from 1980 to 2010

# 1. Introduction



## Health risk problem

Flood related health risk are categorized into

- Short term, such as injuries , death and disrupted health services,
- Midterm like; water contamination, and communicable diseases,
- Long term consequences , such as disability and mental illnesses.

## Diseases

- Outbreaks of both water-borne and vector-borne diseases
- Common consequent diseases are;  
cholera, other diarrheal diseases, malaria, hemorrhagic fevers, et al.



## 2. Risk assessment of flood in China



### 2.1 Models and risk indicators

$$R = (E \times H) \times P$$

$$\& P = F \times I$$

**R**-risk, **E**-exposure, **H**-hazard, **P**-possibility,  
**F**-frequency , **I**- modified parameter of land surface

**Risk indicators:**

**Affected population; transfer population; death**



# 2. Risk assessment of flood in China



## 2.2 Hazard assessment

Correlation between rainfall (rainstorm) and destroy capacities of flood in flooding areas

| Indicators<br>Of flood<br>destroys | Rainfall                    |                              |                              |                               |                               |                               |                               |                   |
|------------------------------------|-----------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------|
|                                    | Largest<br>1day<br>rainfall | Largest<br>2days<br>rainfall | Largest<br>3days<br>rainfall | Largest<br>4 days<br>rainfall | Largest<br>5 days<br>rainfall | Largest<br>6 days<br>rainfall | Largest<br>7 days<br>rainfall | total<br>rainfall |
| Population                         | 0.299**                     | 0.464**                      | 0.551**                      | 0.598**                       | 0.627**                       | 0.643**                       | 0.653**                       | 0.667**           |
| Transfer<br>population             | 0.227**                     | 0.383**                      | 0.478**                      | 0.527**                       | 0.561**                       | 0.585**                       | 0.599**                       | 0.621**           |
| Death                              | 0.210**                     | 0.281**                      | 0.330**                      | 0.345**                       | 0.358**                       | 0.364**                       | 0.370**                       | 0.379**           |



# 2. Risk assessment of flood in China



## 2.2 Hazard assessment

Correlation between rainfall and destroy capacities of floods in center of flooding areas

| Indicators<br>Of flood<br>destroys | Rainfall                    |                              |                              |                               |                               |                               |                               |                   |
|------------------------------------|-----------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------|
|                                    | largest<br>1day<br>rainfall | Largest<br>2days<br>rainfall | largest<br>3days<br>rainfall | Largest<br>4 days<br>rainfall | Largest<br>5 days<br>rainfall | largest<br>6 days<br>rainfall | Largest<br>7 days<br>rainfall | total<br>rainfall |
| Population                         | 0.563**                     | 0.666**                      | 0.702**                      | 0.714**                       | 0.716**                       | 0.717**                       | 0.718**                       | 0.717**           |
| Transfer population                | 0.515**                     | 0.608**                      | 0.653**                      | 0.672**                       | 0.685**                       | 0.686**                       | 0.687**                       | 0.688**           |
| Death                              | 0.352**                     | 0.383**                      | 0.398**                      | 0.396**                       | 0.398**                       | 0.399**                       | 0.401**                       | 0.404**           |

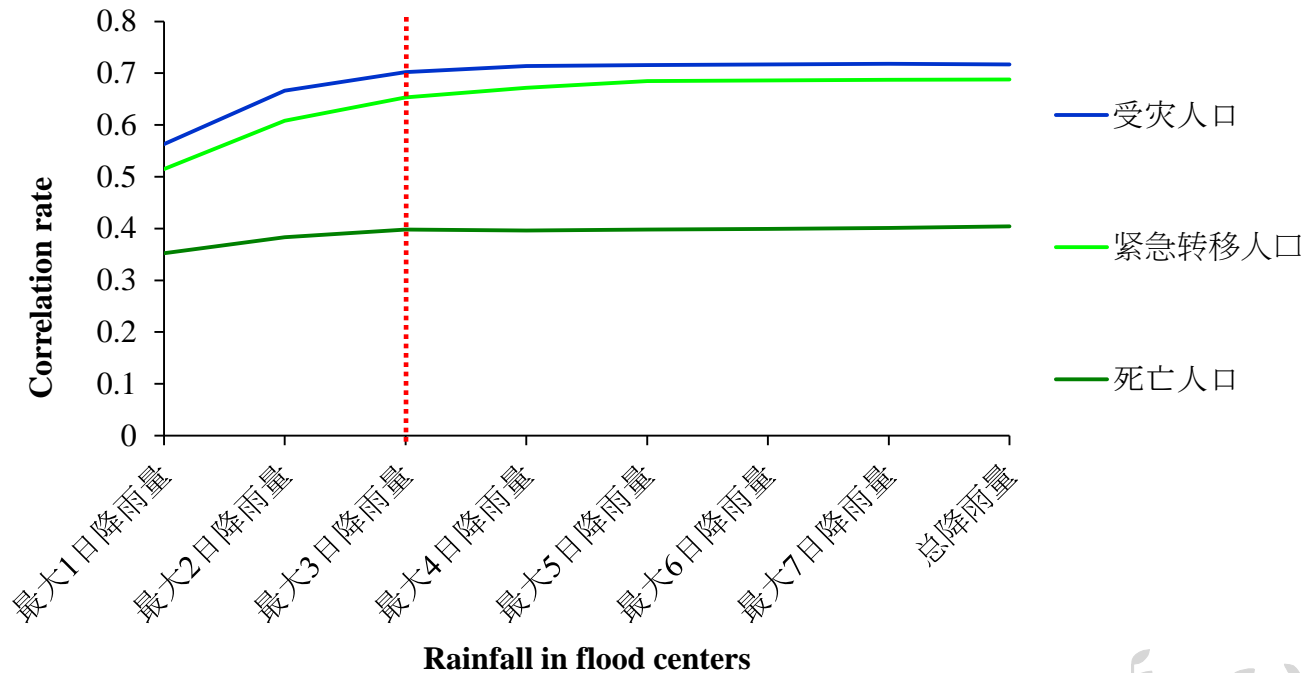


# 2. Risk assessment of flood in China



## 2.2 Hazard assessment

Largest 3 days rainfall in flood center is the best indicator





## 2. Risk assessment of flood in China



### 2.2 Hazard assessment

3 grades of rainfall by the indicator of largest 3 days

rainfall

| Rainstorm grades | 3 days largest rainfall(mm) | Population (million) | Transfer population (10 thousands) | Death (people) |
|------------------|-----------------------------|----------------------|------------------------------------|----------------|
| 1(light)         | 30(35)~150                  | 0~2                  | 0~1                                | 0~10           |
| 2(moderate)      | 150~250                     | 2~5                  | 1~10                               | 10~50          |
| 3(heavy)         | ≥250                        | ≥5                   | ≥10                                | ≥50            |

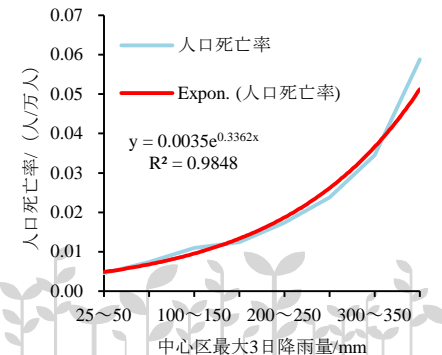
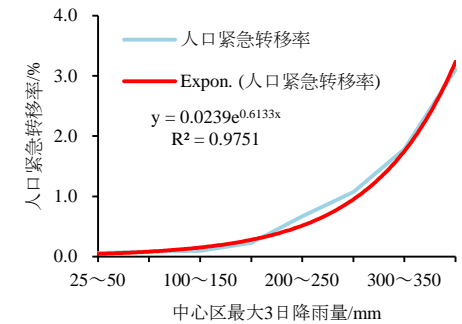
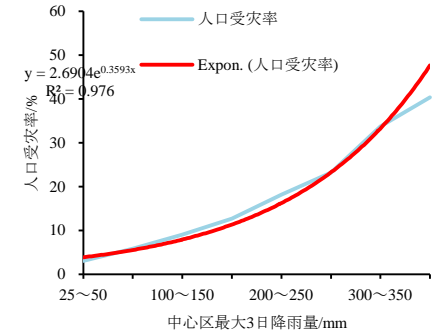


# 2. Risk assessment of flood in China



## 2.2 Hazard assessment

relationship between largest 3 days rainfall and flood impact rate of population (transfer population, death)



## 2. Risk assessment of flood in China



### 2.2 Hazard assessment

flood destroys of population by rainfall grade in different areas

| areas       | Grades of rainstorm | population(%) | Transfer (%) | Death (1/10 thousands) |
|-------------|---------------------|---------------|--------------|------------------------|
| North China | 1                   | 5.42          | 0.04         | 0.01                   |
|             | 2                   | 10.16         | 0.12         | 0.02                   |
|             | 3                   | 30.73         | 0.73         | 0.04                   |
| Middle-east | 1                   | 6.64          | 0.04         | 0.005                  |
|             | 2                   | 16.07         | 0.16         | 0.011                  |
|             | 3                   | 30.27         | 0.86         | 0.024                  |
| South       | 1                   | 7.01          | 0.12         | 0.01                   |
|             | 2                   | 10.69         | 0.35         | 0.02                   |
|             | 3                   | 26.31         | 1.60         | 0.04                   |
| South-west  | 1                   | 6.88          | 0.13         | 0.01                   |
|             | 2                   | 14.83         | 0.27         | 0.02                   |
|             | 3                   | 32.08         | 1.17         | 0.04                   |
| west        | 1                   | 5.0           | 0.03         | 0.01                   |
|             | 2                   | 10.0          | 0.10         | 0.02                   |
|             | 3                   | 20.0          | 1.00         | 0.04                   |



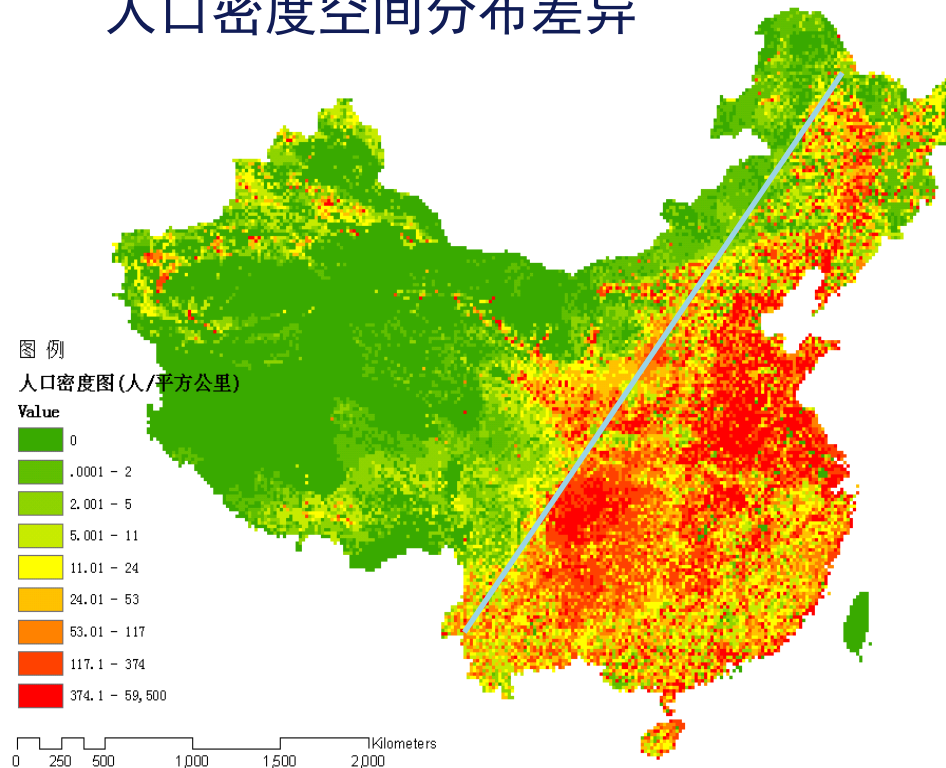
## 2. Risk assessment of flood in China



### 2.3 Exposure assessment

#### Population density

#### 人口密度空间分布差异



## 2. Risk assessment of flood in China



### 2.4 Possibility assessment

Frequency of the largest 3 days rainfall in 50 years

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**rainstorm grades**

**3 days largest rainfall(mm)**

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**1(light)**

**30(35)~150**

**2(moderate)**

**150~250**

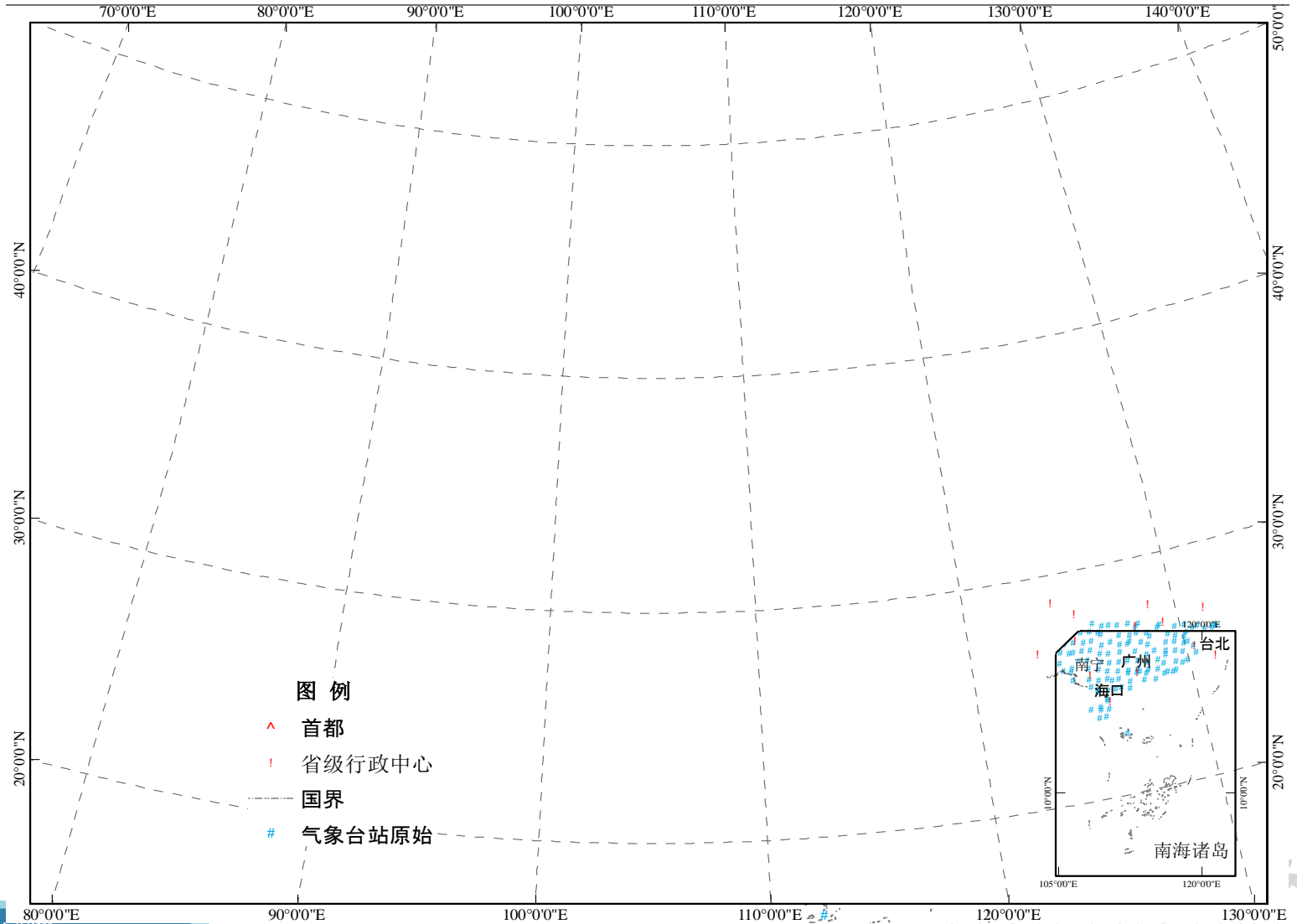
**3(heavy)**

**≥250**

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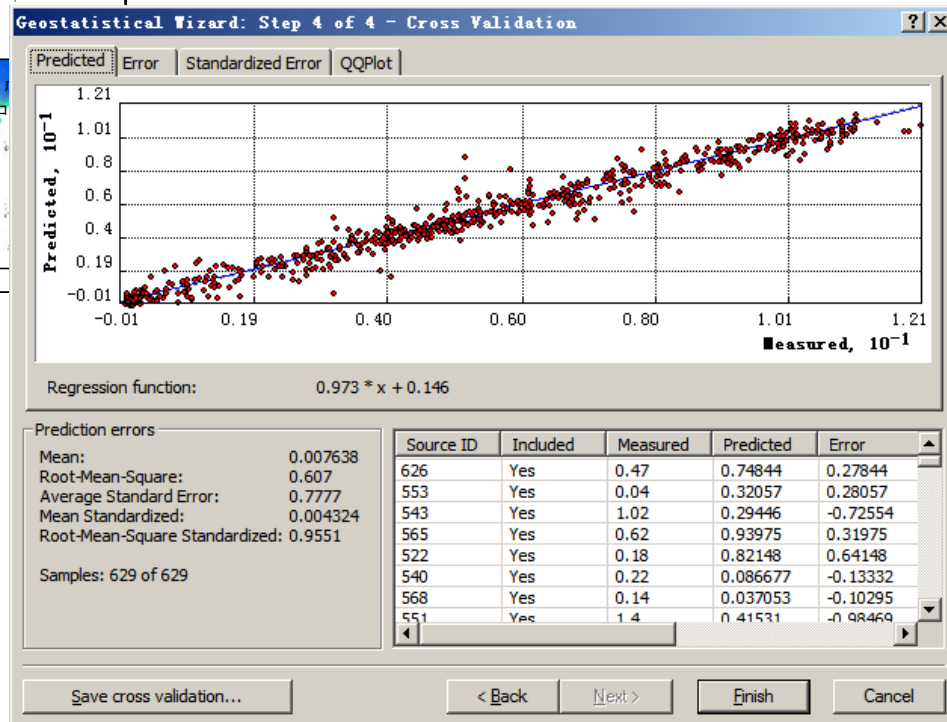
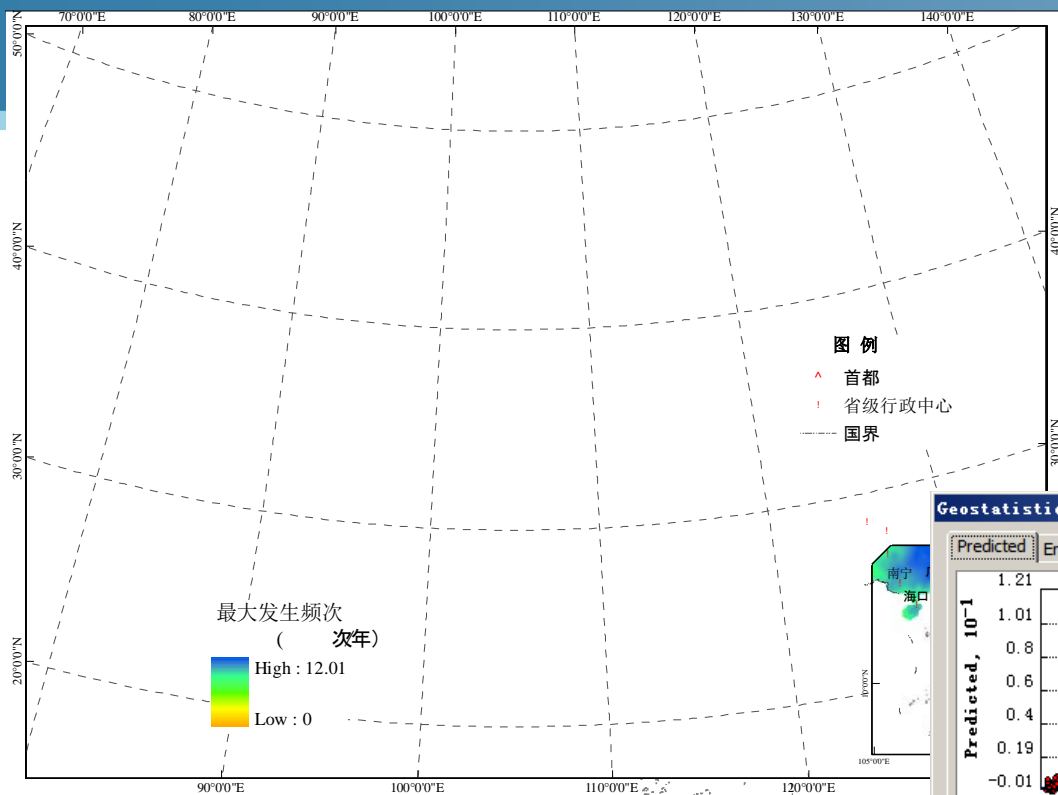


# 2. Risk assessment of flood in China





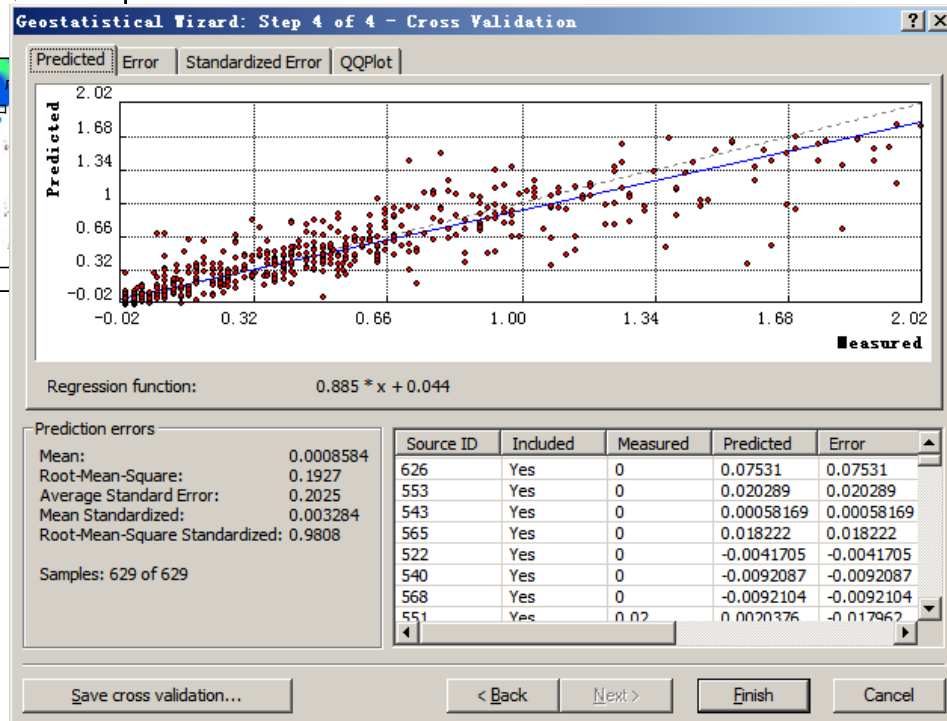
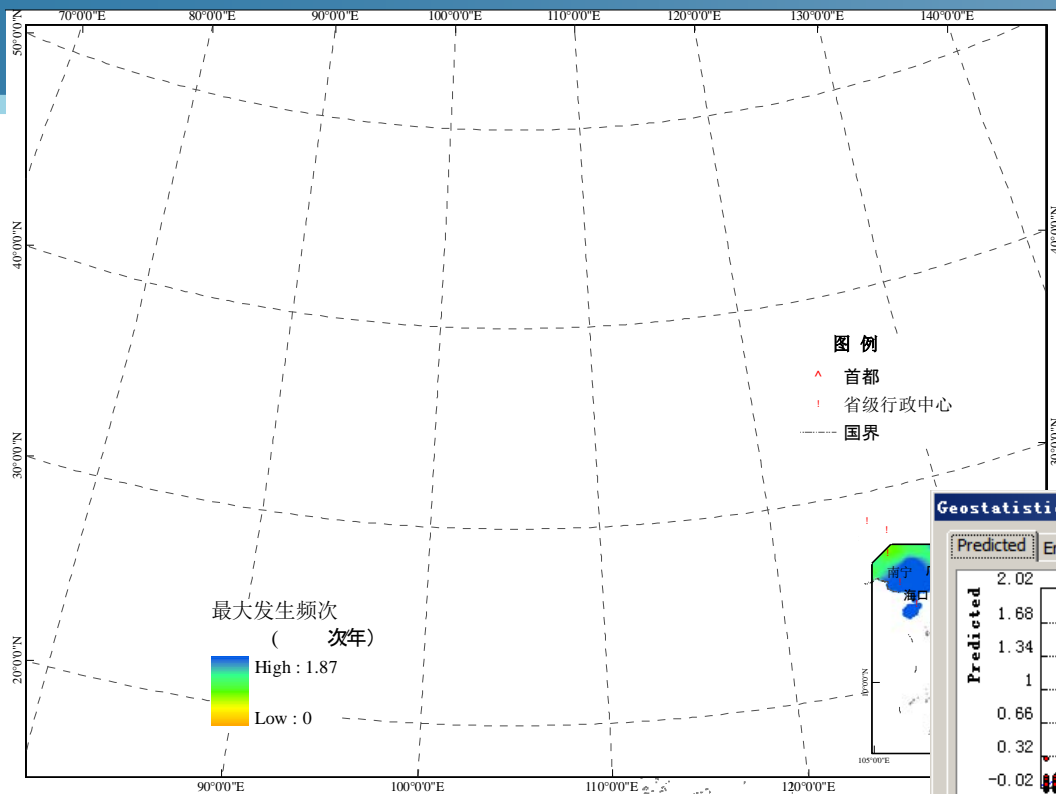
## 普通克里格



# frequency distribution of Light flood



## 简单克里格

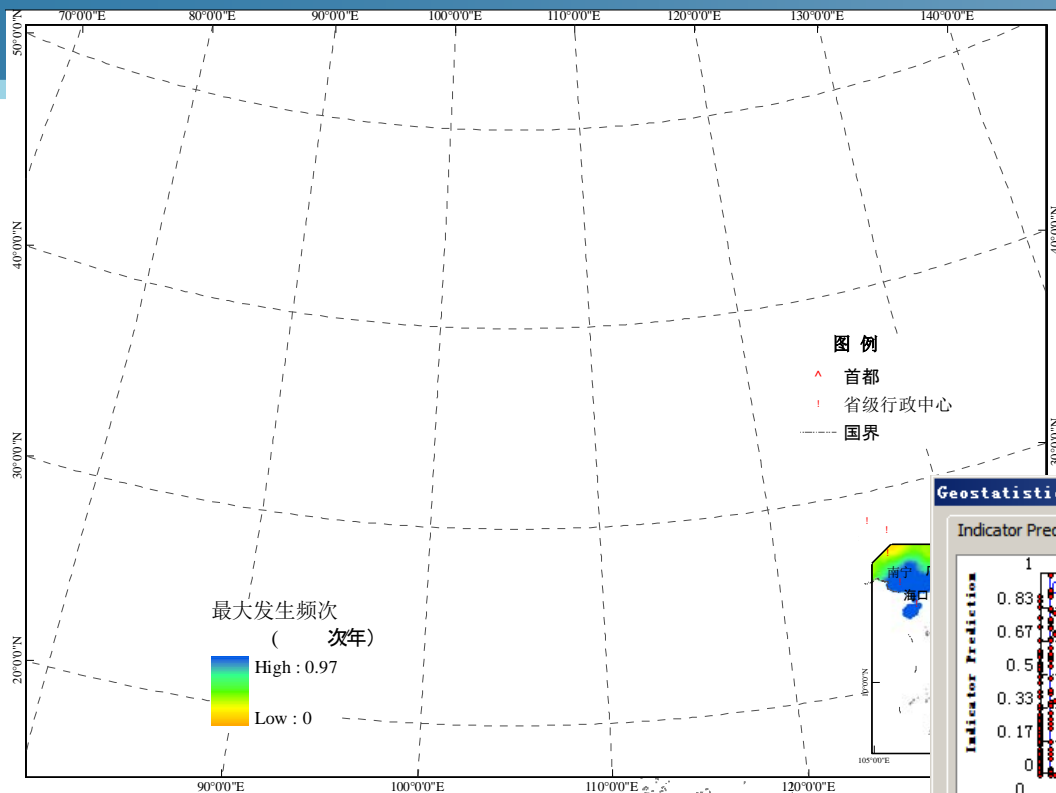


# Frequency distribution of moderate flood

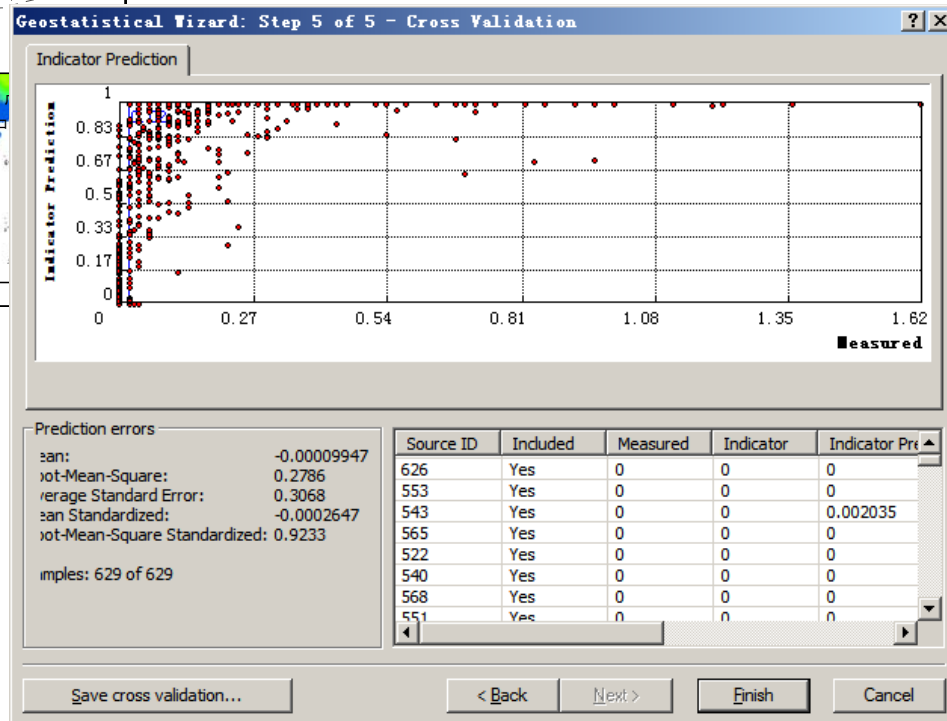




## 指示克里格法



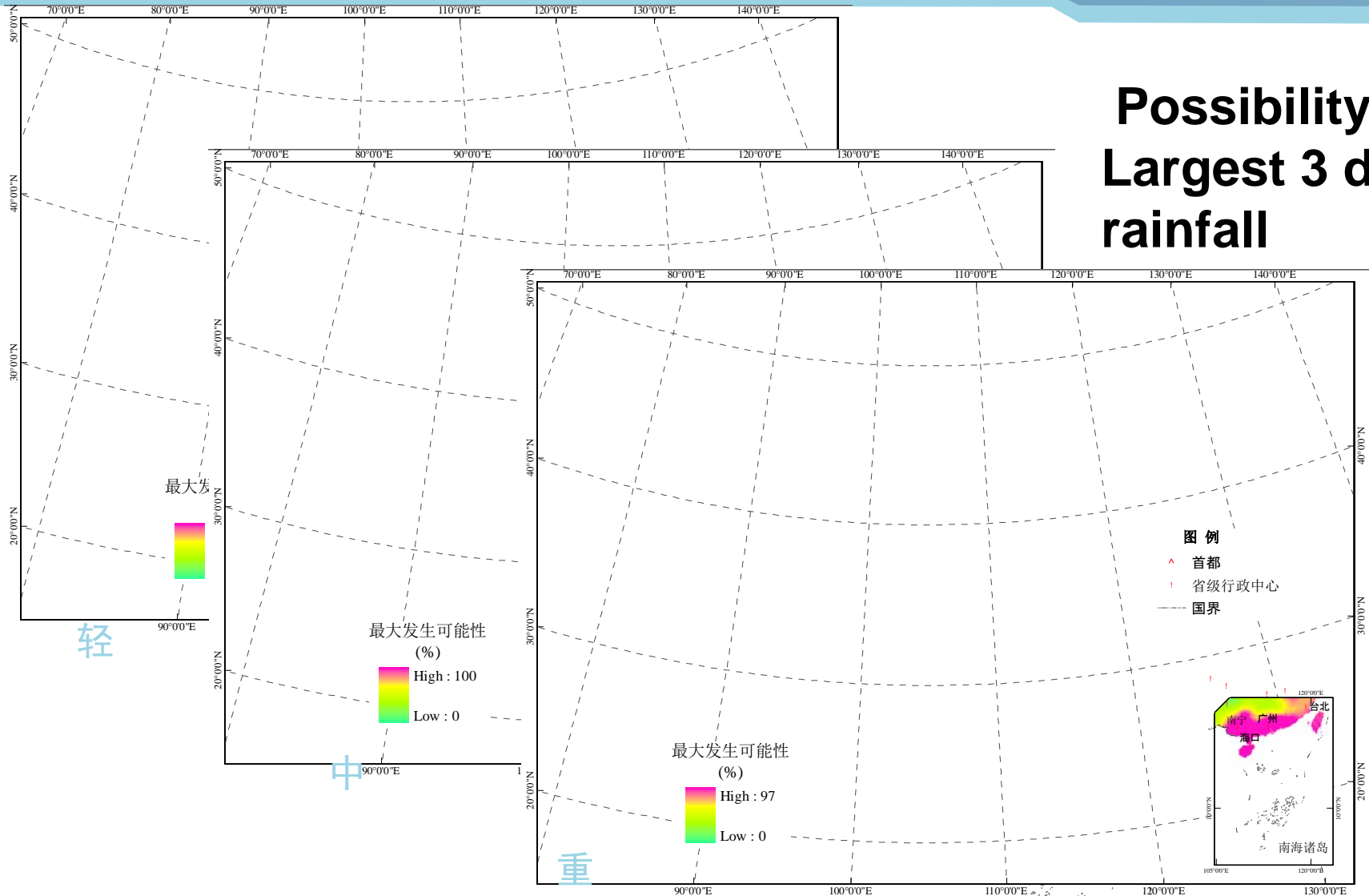
# Frequency distribution of heavy flood



# 2. Risk assessment of flood in China



## Possibility of Largest 3 days rainfall



# 2. Risk assessment of flood in China

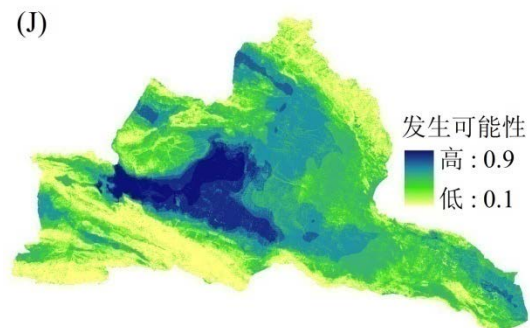
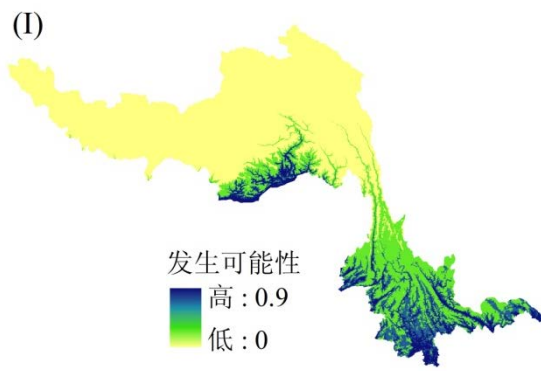
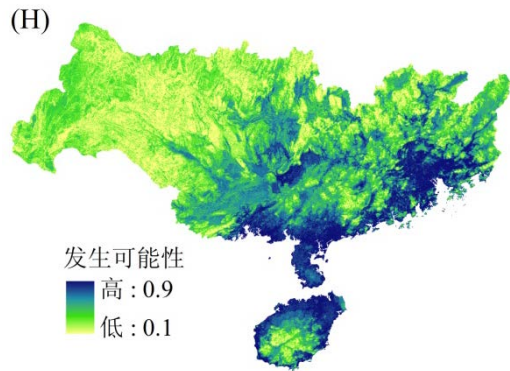
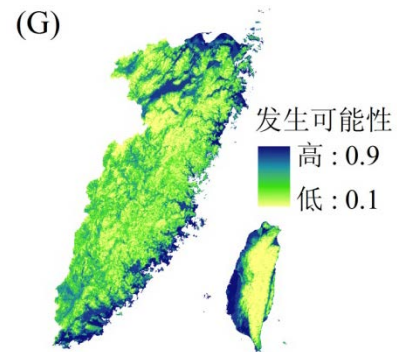
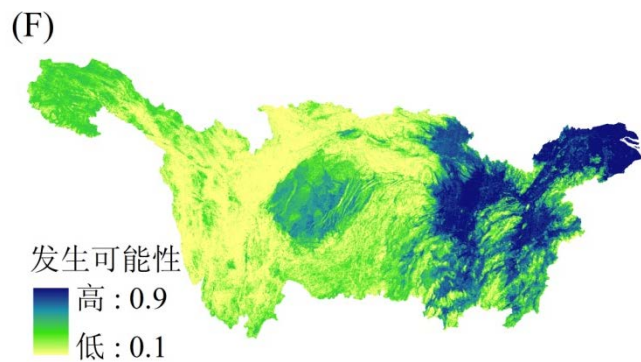
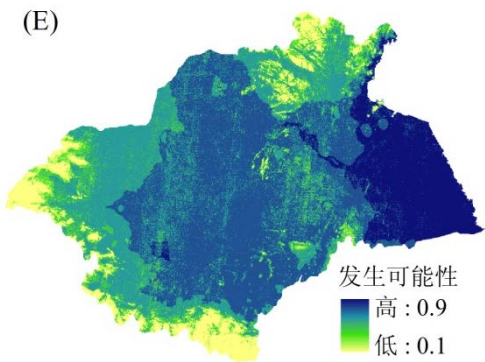
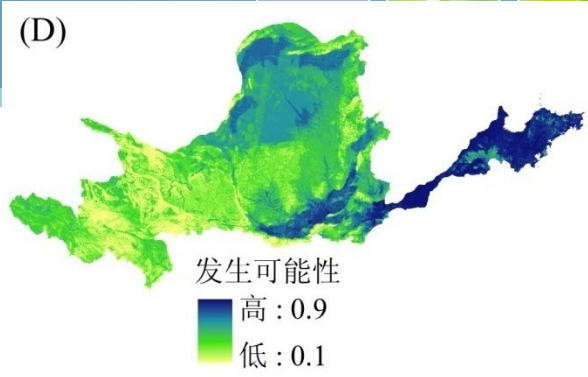
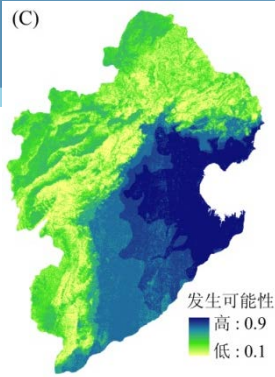
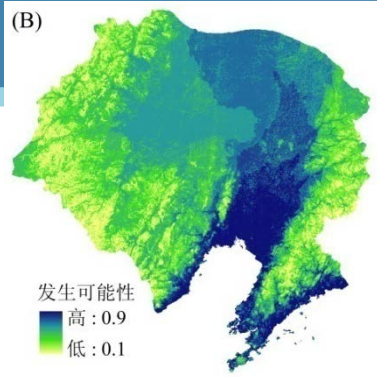
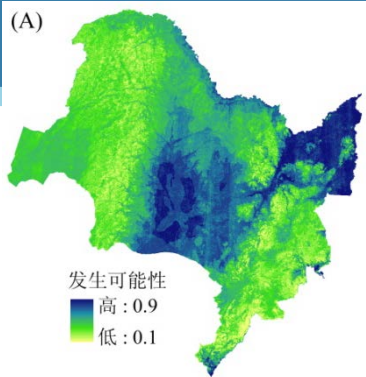


## 2.4 Possibility assessment

### Possibility of flood, modified by land surface

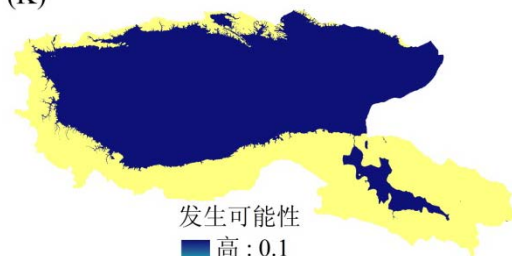
- flood possibility in different altitude
- flood possibility in different slope
- 13 drainage







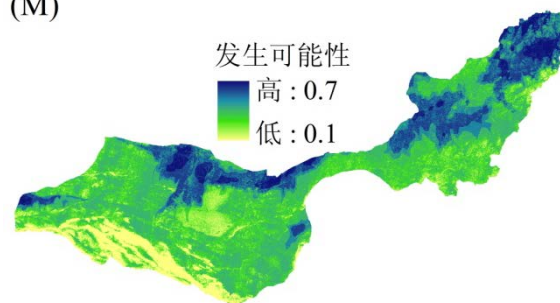
(K)

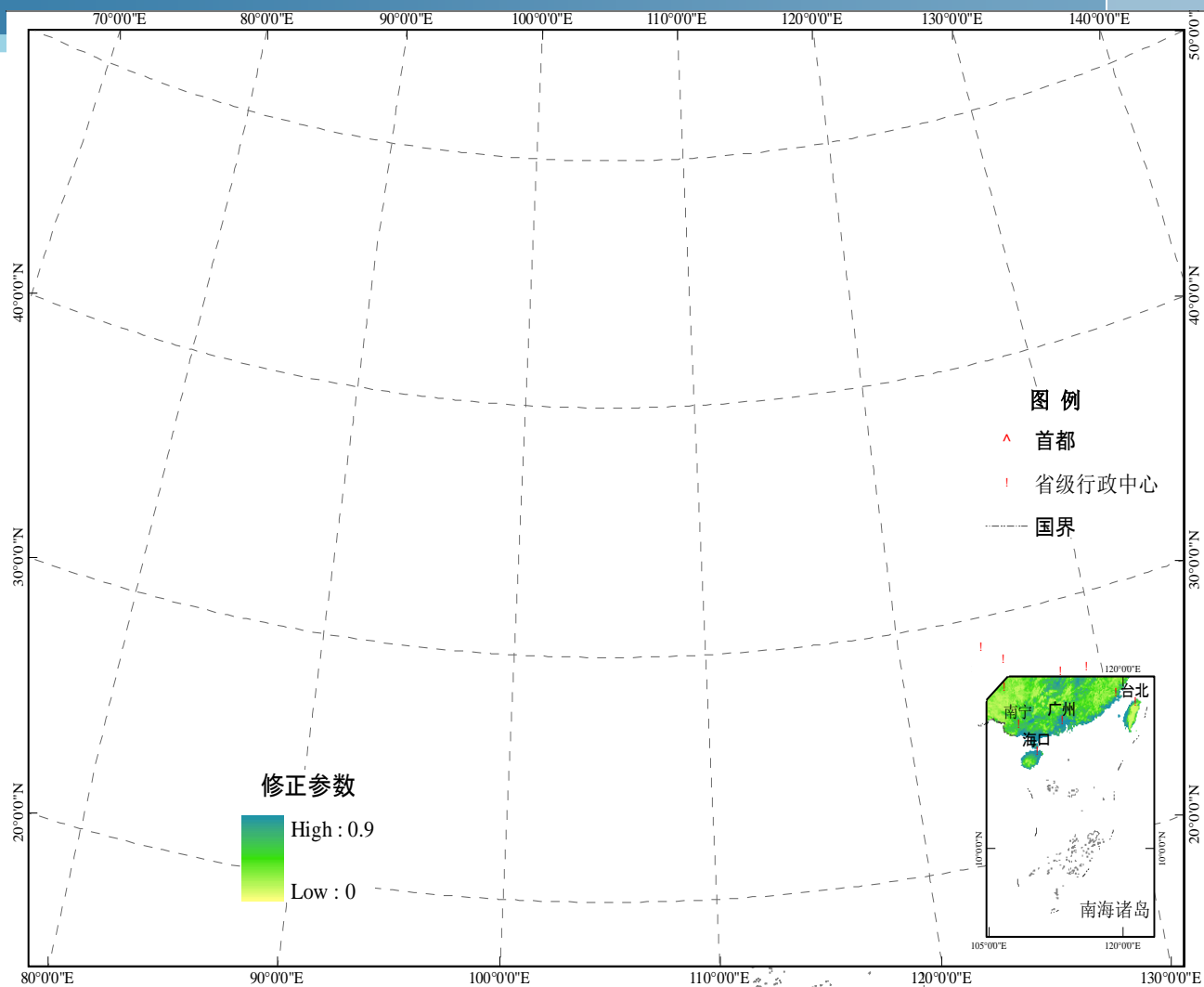


(L)



(M)



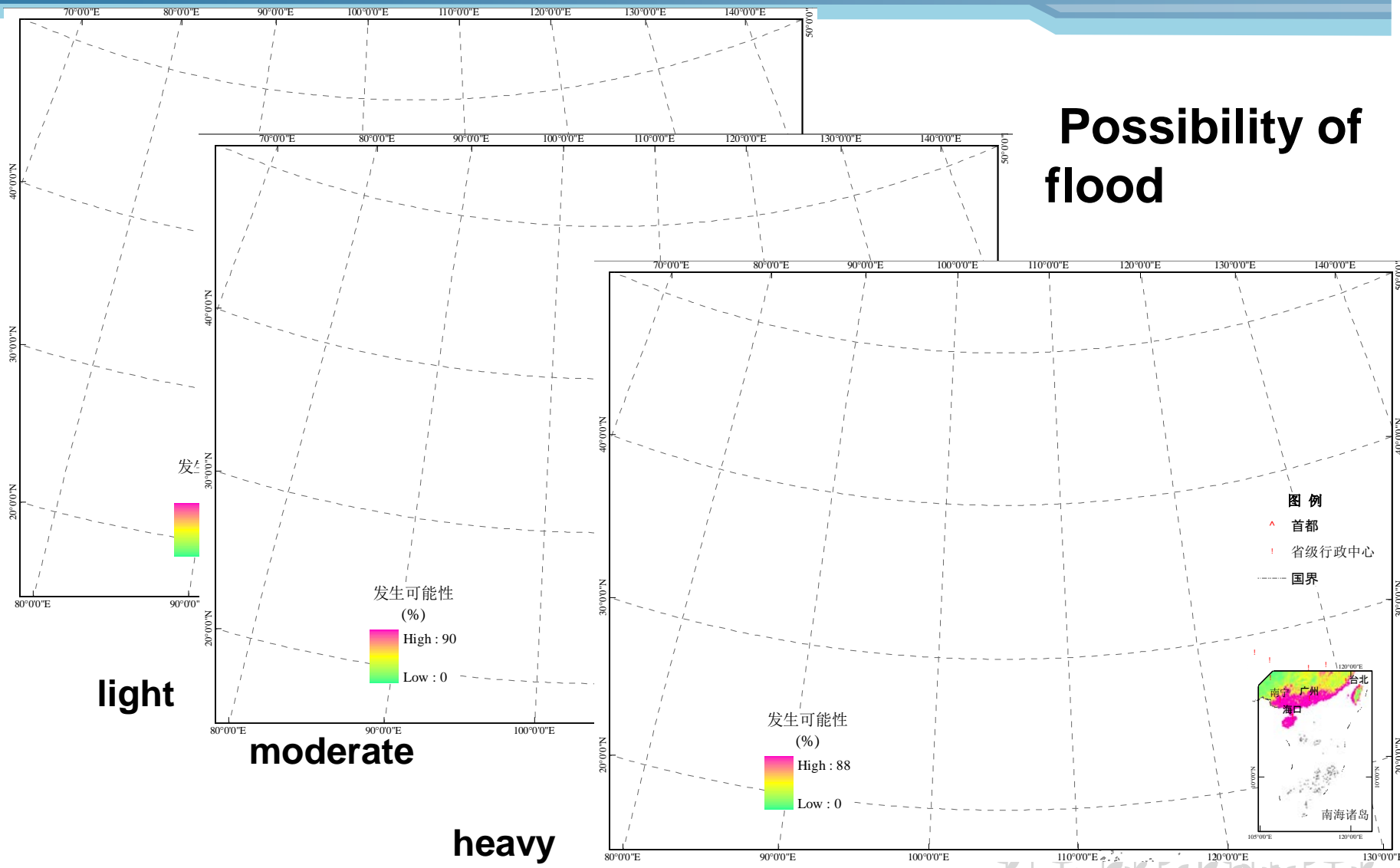


Modified parameter





# Possibility of flood



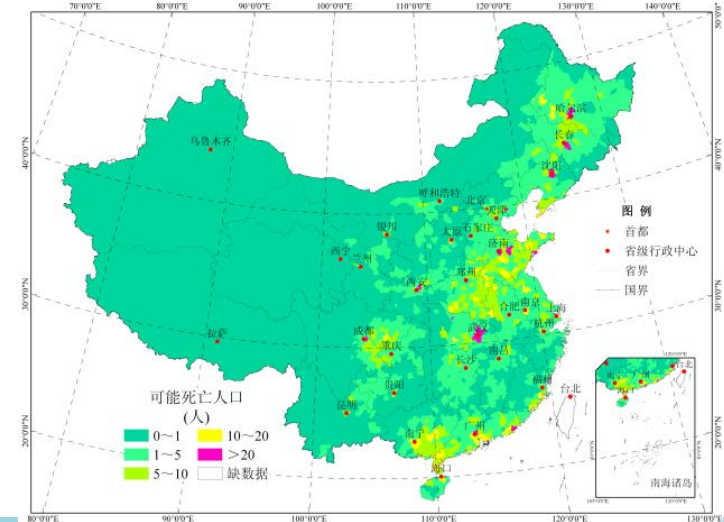
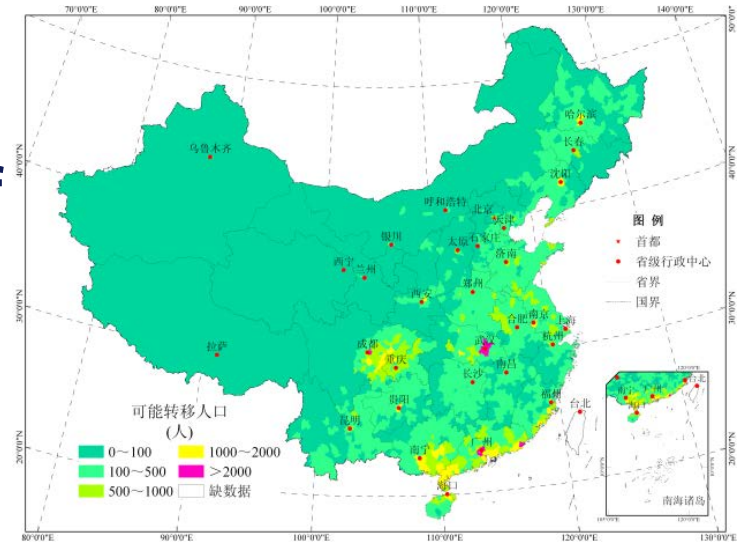
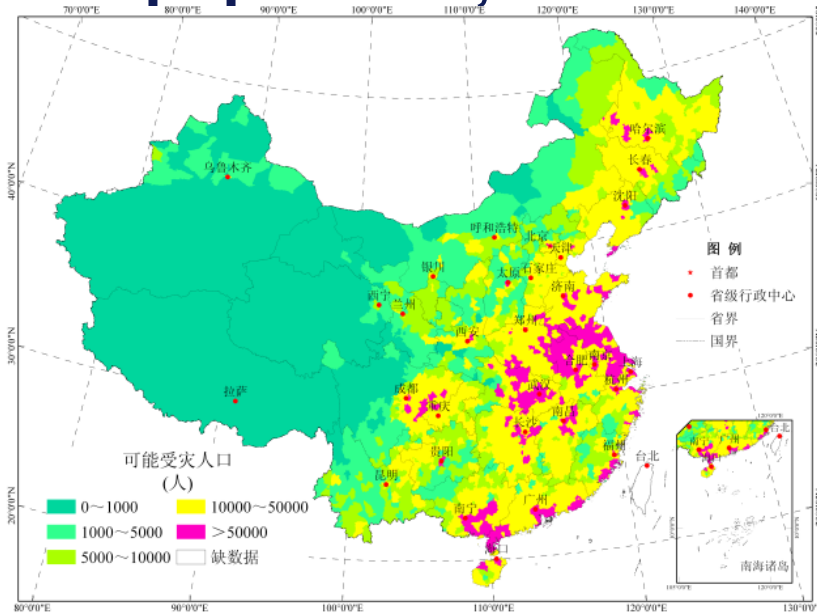
# 2. Risk assessment of flood in China



## 2.5 Risk results

### Light flood

No. of affected population; No. of transfer population; No. of death





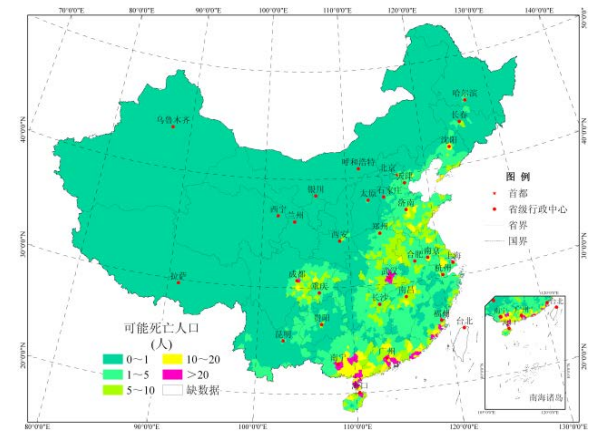
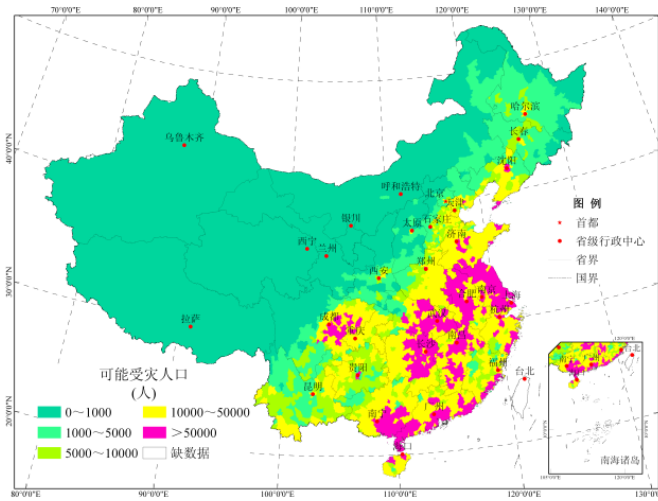
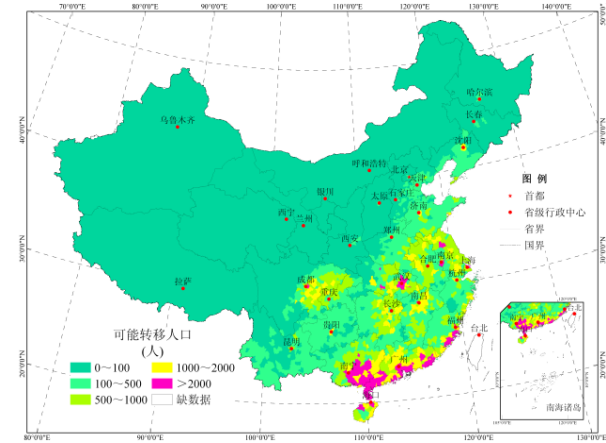
# 2. Risk assessment of flood in China



## 2.5 Risk results

moderate flood

No. of affected population; No. of transfer population; No. of death



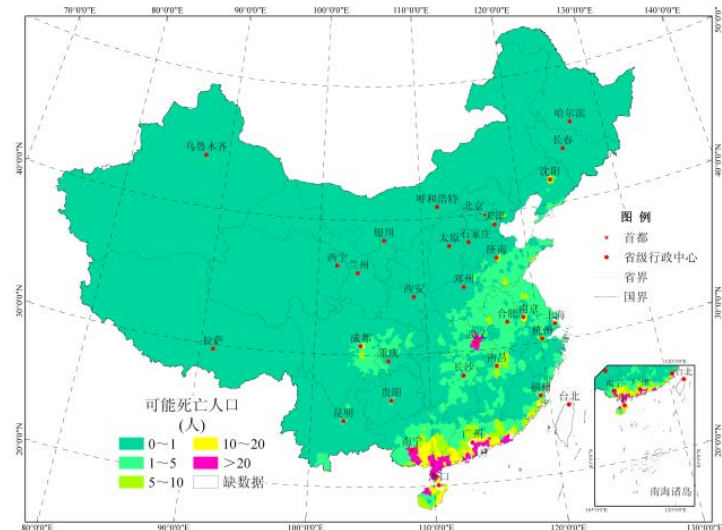
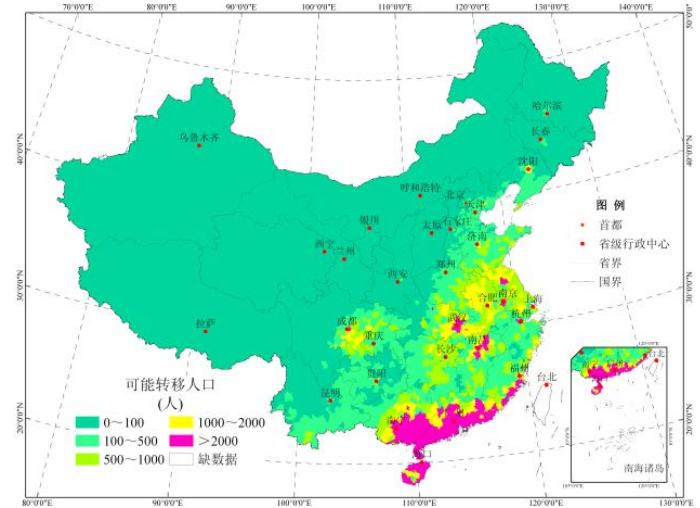
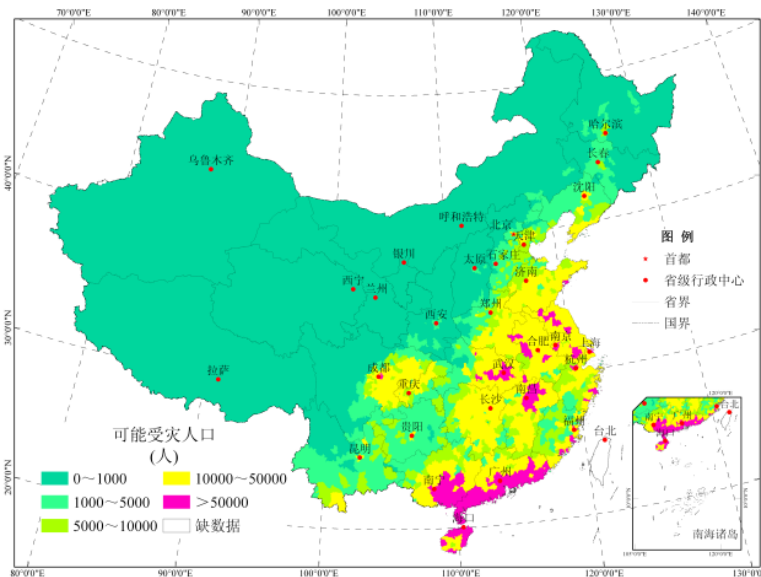
# 2. Risk assessment of flood in China



## 2.5 Risk results

heavy flood

No. of affected population; No. of transfer population; No. of death



## 2. Risk assessment of flood in China



### 2.5 Risk standardization

$$\delta = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$$

$$\alpha = \frac{x_i - \bar{x}}{\delta}$$

### Population + transfer population + death

---

| Times of $\alpha$ | Risk class |
|-------------------|------------|
| $>1.5$            | highest    |
| $0.5 \sim 1.5$    | high       |
| $0.5 \sim -0.5$   | moderate   |
| $-0.5 \sim -1.5$  | low        |
| $<-1.5$           | lowest     |

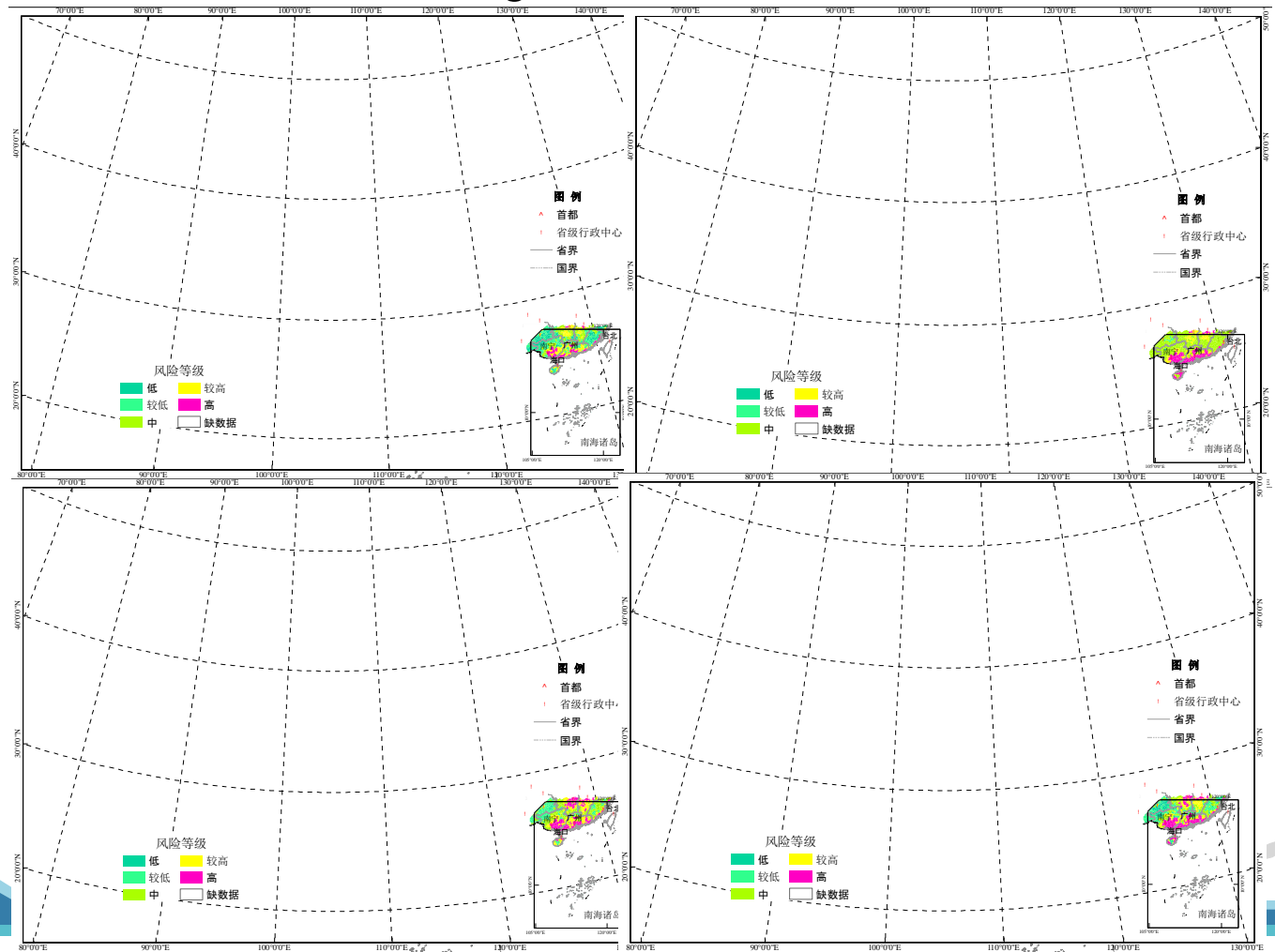
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# 2. Risk assessment of flood in China



- Risk standardization
- 1-low Flood; 2-moderate flood; 3-high flood
- 1+2+3



## 3. Health risk assessment of flood



### 3.1 models

$$R_{health} = (E_{health} \times H_{health}) \times P$$

$$E_{health} = E \times V \times A$$

**R<sub>health</sub>**-risk of health, **E<sub>health</sub>**-exposure of health,

**E**-population exposure, **H<sub>health</sub>**-health hazards of flood,

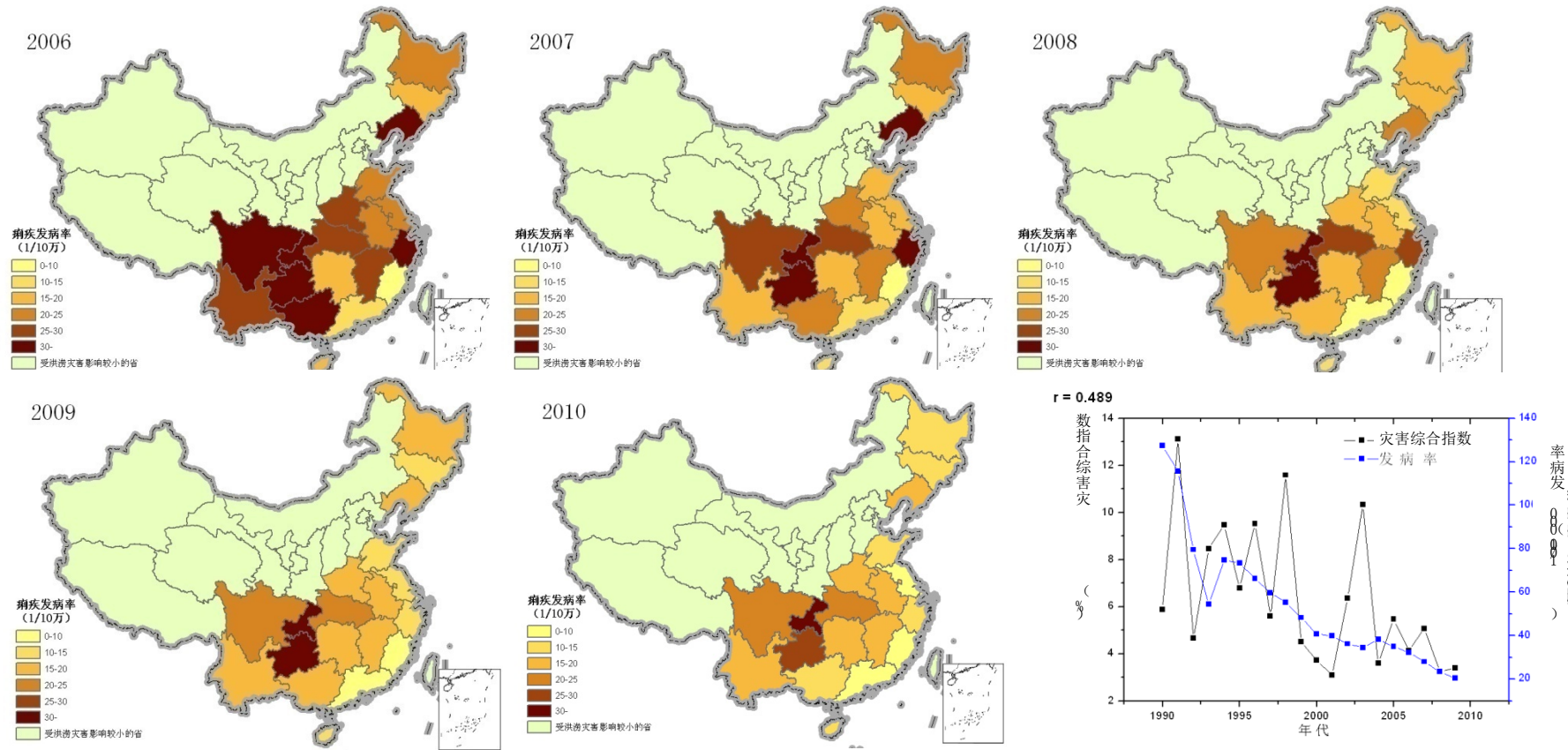
**P**-possibility, **V**-vulnerability, **A**-health adaption capacity



# 3. Health risk assessment of flood



- 3.2 assessment health hazards of flood
- Example of disease: Bacillary Dysentery (2006-2010)



# 3. Health risk assessment of flood



- **3.2 assessment health hazards of flood**
- **Correlation rate between the incidence of bacillary dysentery and flood index in China**

| year | All provinces | 20 flood affected provinces | 11 non-flood provinces |
|------|---------------|-----------------------------|------------------------|
| 2006 | -0.31         | -0.44                       | -0.24                  |
| 2007 | -0.21         | 0.22                        | -0.44                  |
| 2008 | -0.31         | 0.13                        | -0.65                  |
| 2009 | -0.21         | 0.49                        | -0.51                  |
| 2010 | -0.31         | 0.16                        | -0.50                  |

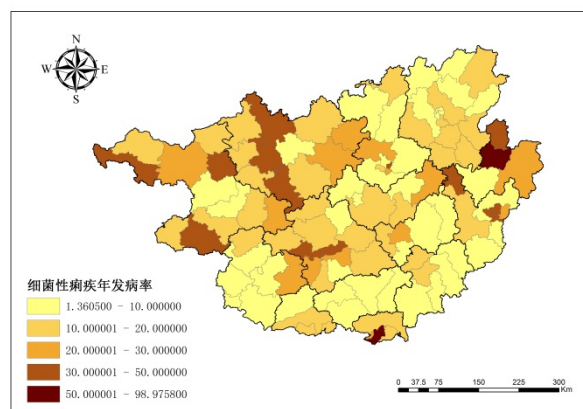
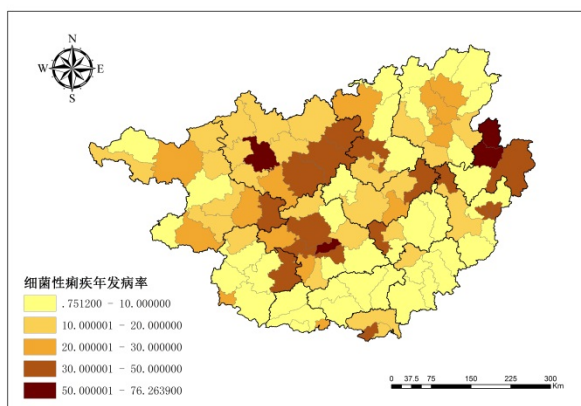
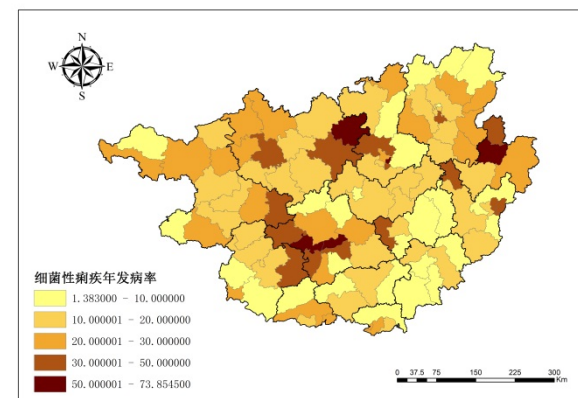
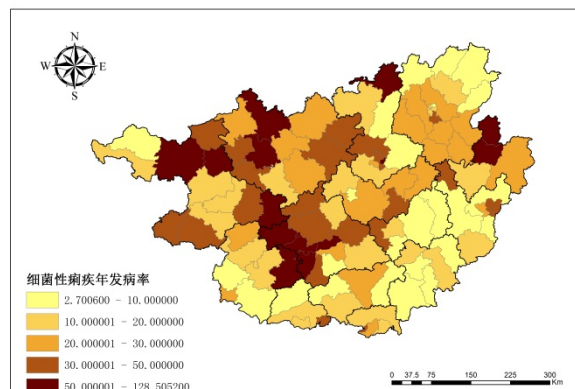
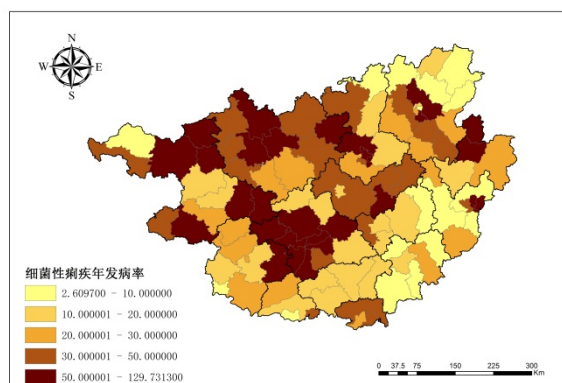


# 3. Risk assessment of health of flood in China



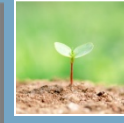
## 3.2 assessment health hazards of flood

Spatial and temporal of Bacillary Dysentery Incidence in Guangxi Province from 2006-2010





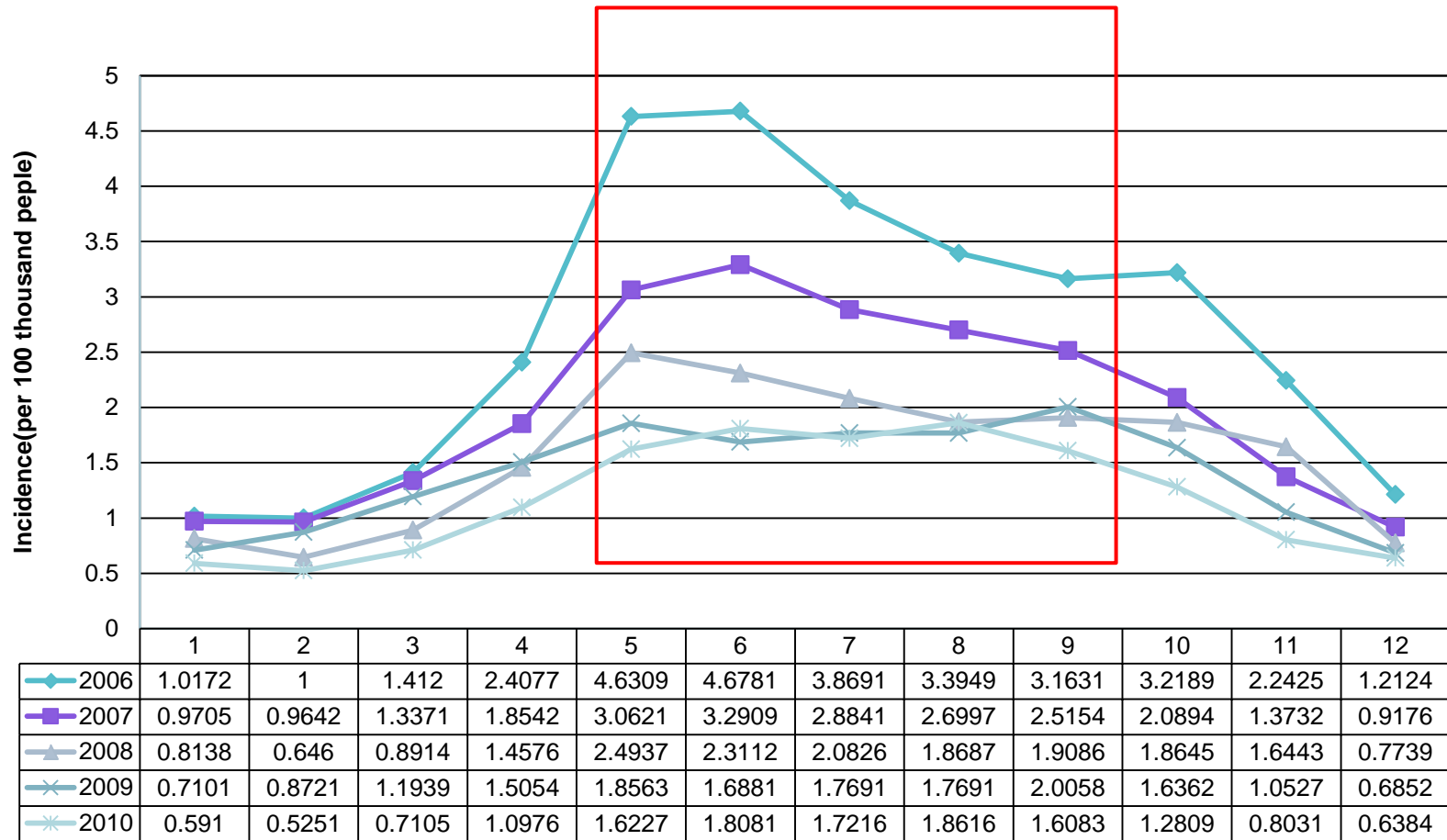
# 3. Risk assessment of health of flood in China



## • 3.2 assessment health hazards of flood

Spatial and temporal of Bacillary Dysentery Incidence in Guangxi Province from 2006-2010

Concentration of Flood Disaster in Guangxi

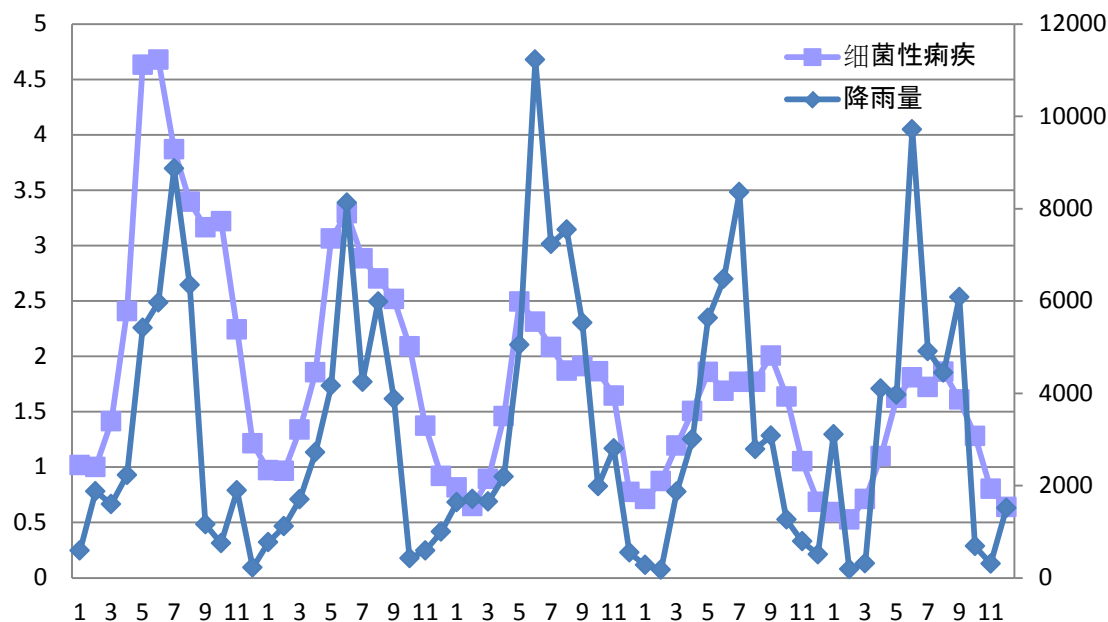


# 3. Risk assessment of health of flood in China



## • 3.2 assessment health hazards of flood

Spatial and temporal of Bacillary Dysentery Incidence in Guangxi Province from 2006-2010



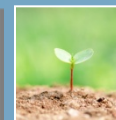
### Correlation Analysis

| Precipitation | Days                              | Accumulated precipitation |
|---------------|-----------------------------------|---------------------------|
| All           | 0.550**                           | /                         |
| 25mm          | 0.542**                           | 0.518**                   |
| 50mm          | 0.528**                           | 0.491**                   |
| 80mm          | 0.491**                           | 0.442**                   |
| 100mm         | 0.528**                           | 0.407**                   |
| 150mm         | 0.356**                           | 0.330*                    |
| Temperature   |                                   |                           |
| 25°C          | /                                 | 0.694**                   |
| 30°C          | * Significant at the 0.05 level.  |                           |
| 35°C          | ** Significant at the 0.01 level. |                           |

Characteristics of precipitation and Bacillary Dysentery from 2006 to 2010

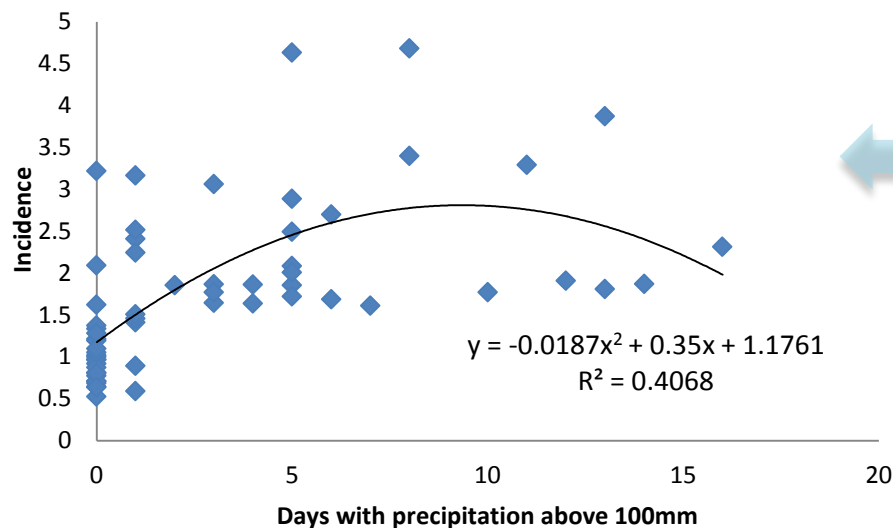


# 3. Risk assessment of health of flood in China



## • 3.2 assessment health hazards of flood

Spatial and temporal of Bacillary Dysentery Incidence in Guangxi Province from 2006-2010



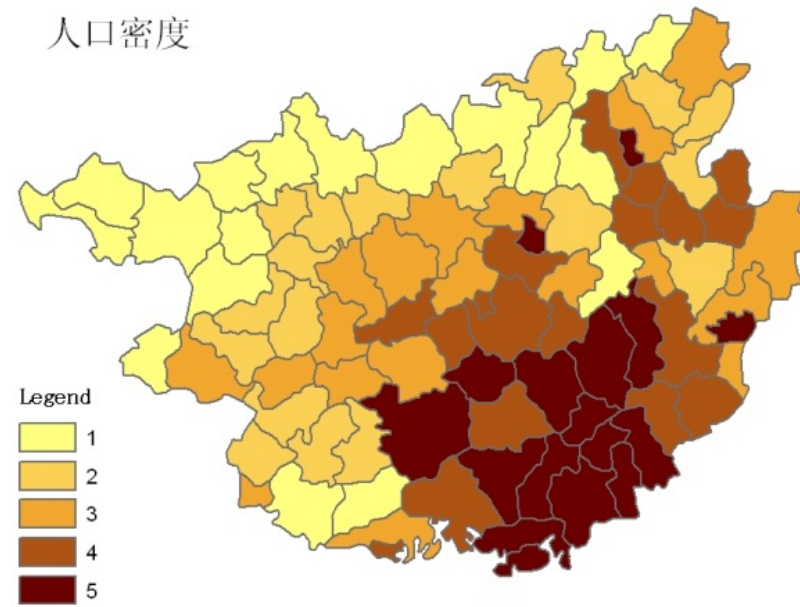
| Precipitation | Days          | Accumulated precipitation |
|---------------|---------------|---------------------------|
| All           | 0.3509        | /                         |
| 25mm          | 0.3474        | 0.3890                    |
| 50mm          | 0.3924        | 0.3989                    |
| 80mm          | 0.3703        | 0.3702                    |
| <b>100mm</b>  | <b>0.4068</b> | 0.3258                    |
| 150mm         | 0.1966        | 0.2404                    |



# 3. Risk assessment of health of flood in China



- 3.3 Exposure assessment of health of flood
- population density
- 



# 3. Risk assessment of health of flood in China



- **3.3 Exposure assessment of health of flood**
- **vulnerability assessment**
- Sex
- age

| year      | Total people |          | Incidence cases |        | Incidence rate (1/100000) |        |
|-----------|--------------|----------|-----------------|--------|---------------------------|--------|
|           | male         | female   | male            | female | male                      | female |
| 2009-2010 | 51000952     | 45719069 | 9310            | 6914   | 18.25                     | 15.12  |

| Age group | Total prople | Incidence cases | Cases/total cases (%) |
|-----------|--------------|-----------------|-----------------------|
| 0-5       | 16224        | 9120            | 56.21                 |
| 6-20      | 16224        | 1851            | 11.41                 |
| 21-40     | 16224        | 1458            | 8.99                  |
| 41        | 16224        | 3795            | 23.39                 |



# 3. Risk assessment of health of flood in China



- 3.3 Exposure assessment of health of flood
- vulnerability assessment
- employment

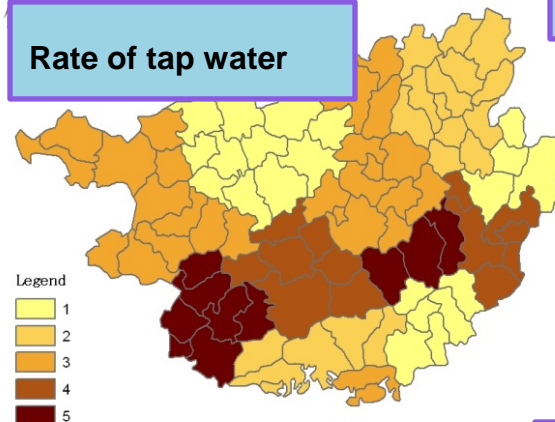
| occupation                  | cases | Total cases | Cases/total cases (%) |
|-----------------------------|-------|-------------|-----------------------|
| Restaurant                  | 17    | 16224       | 0.10                  |
| Official civilian           | 145   | 16224       | 0.89                  |
| workers                     | 207   | 16224       | 1.28                  |
| Long distance Driver/sailor | 5     | 16224       | 0.03                  |
| House wives/jobless         | 322   | 16224       | 1.98                  |
| teachers                    | 79    | 16224       | 0.49                  |
| retiree                     | 319   | 16224       | 1.97                  |
| Farmer workers              | 109   | 16224       | 0.67                  |
| Farmers                     | 3722  | 16224       | 22.94                 |
| Non-school Children         | 8444  | 16224       | 52.05                 |
| Business servicers          | 85    | 16224       | 0.52                  |
| Students                    | 1386  | 16224       | 8.54                  |
| Medical staffs              | 17    | 16224       | 0.10                  |
| Children in kindergarden    | 1039  | 16224       | 6.40                  |
| others                      | 328   | 16224       | 2.0                   |

# 3. Risk assessment of health of flood in China

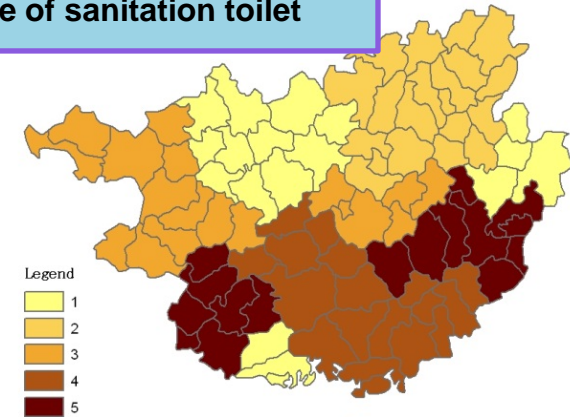


- 3.3 Exposure assessment of health of flood
- vulnerability assessment
- safety drinking water (tap water)
- Sanitation
- Incomes...

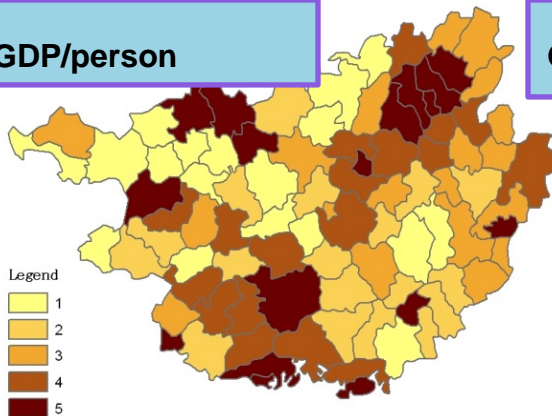
Rate of tap water



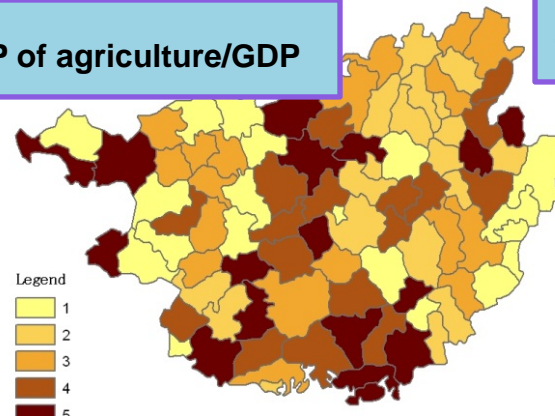
Rate of sanitation toilet



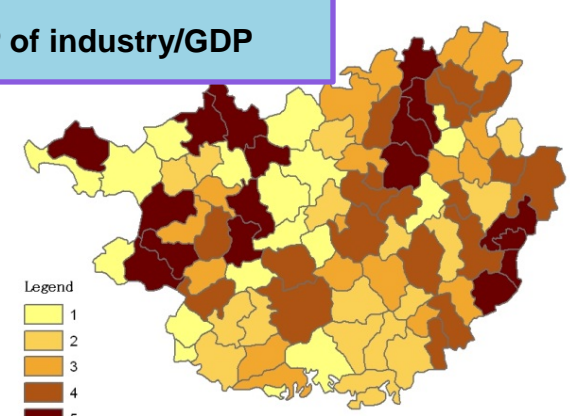
GDP/person



GDP of agriculture/GDP



GDP of industry/GDP



# 3. Risk assessment of health of flood in China



- **3.3 Exposure assessment of health of flood**
- **vulnerability assessment**
- safety drinking water (tap water)
- Sanitation
- Incomes...

| Indicators for space correlation analyse | Morian's I | Confidence degree (%) |
|--|------------|-----------------------|
| Percent of tap water                     | -0.121     | 99.8                  |
| Percent of sanitation toilet             | -0.114     | 99.8                  |
| Percent of agriculture industry          | 0.069      | 94.2                  |
| Percent of second industry               | -0.055     | 90.8                  |
| GDP/person                               | -0.041     | 78.3                  |
| Population density                       | -0.033     | 71.3                  |

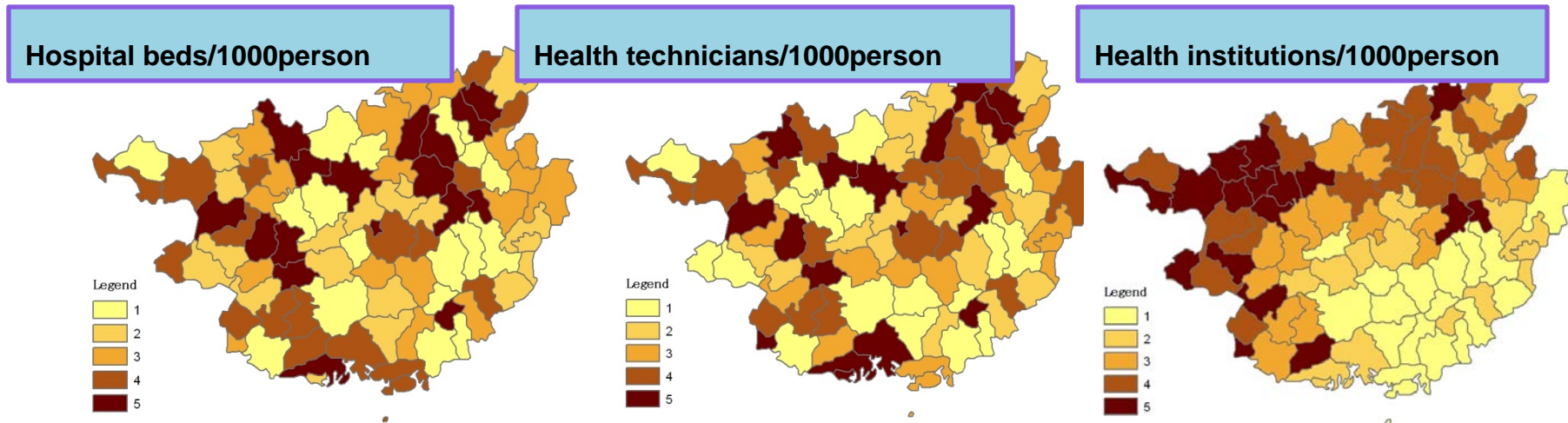




# 3. Risk assessment of health of flood in China



- **3.3 Exposure assessment of health of flood**
- **Adaption capacity assessment**
- health institutions
- health professionals
- hospital beds



# 3. Risk assessment of health of flood in China



- **3.3 Exposure assessment of health of flood**
- **Adaption capacity assessment**
- health institutions
- health professionals
- hospital beds

| Indicators for space correlation analyse | Morian's I | Confidence degree (%) |
|--|------------|-----------------------|
| Hospital beds/1000person                 | -0.030     | 64.3                  |
| Medical technicians/1000person           | -0.025     | 60.7                  |
| Medical institutions/1000person          | 0.038      | 68.7                  |



# 3. Risk assessment of health of flood in China



- 3.4 health risk assessment of flood
- weighting indicators by AHP (Analytic hierarchy process)

| Level 1  | Level 2                     | indicators  | Type                             | Weight   | Total |     |
|--|-----------------------------|---|----------------------------------|----------|-------|-----|
| Bacillary<br>Dysentery<br>risk of<br>flood in<br>Guangxi | hazards                     | Rainfall G1   | positive                         | 0.308    | 1.0   |     |
|  |                             | storms > days of 100mm G2   | positive                         | 0.509    |       |     |
|  |                             | Slope G3  | negative                         | 0.064    |       |     |
|  |                             | Altitude G4   | positive                         | 0.119    |       |     |
|  | Exposure                    | population G5   | positive                         | 1.000    | 1.0   |     |
|  | Vulnerability<br>& adaption | Percent of tap water in rural G6<br>Percent of sanitation toilet G7<br>Children under 5 yrs G8<br>Rural population G9<br>male/female G10<br>Percent of second industry G11<br>Medical technicians G12<br>Medical institutions G13<br>GDP/person G15 | Percent of tap water in rural G6 | negative | 0.353 | 2.0 |
|  |                             |   | Percent of sanitation toilet G7  | negative | 0.307 |     |
|  |                             |   | Children under 5 yrs G8          | positive | 0.124 |     |
|  |                             |   | Rural population G9              | positive | 0.112 |     |
|  |                             |   | male/female G10                  | positive | 0.040 |     |
|  |                             |   | Percent of second industry G11   | negative | 0.058 |     |
|  |                             |   | Medical technicians G12          | negative | 0.297 |     |
|  |                             |   | Medical institutions G13         | negative | 0.163 |     |
|  |                             |   | GDP/person G15                   | negative | 0.540 |     |

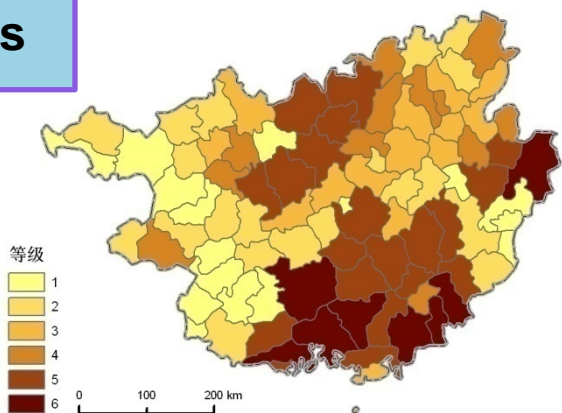


# 3. Risk assessment of health of flood in China

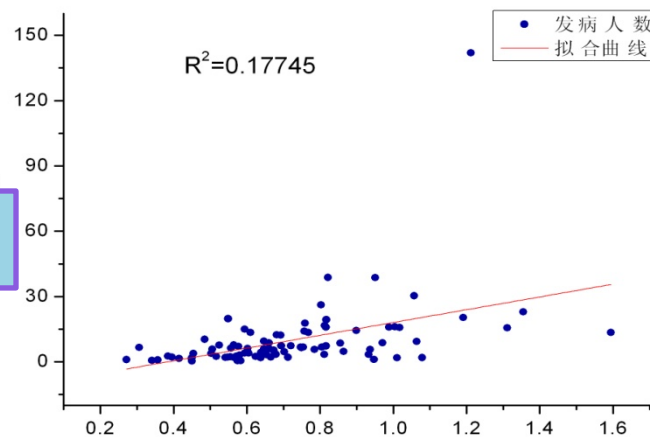


- 3.4 health risk assessment of flood
- results of Guangxi

risks



incidence



risks

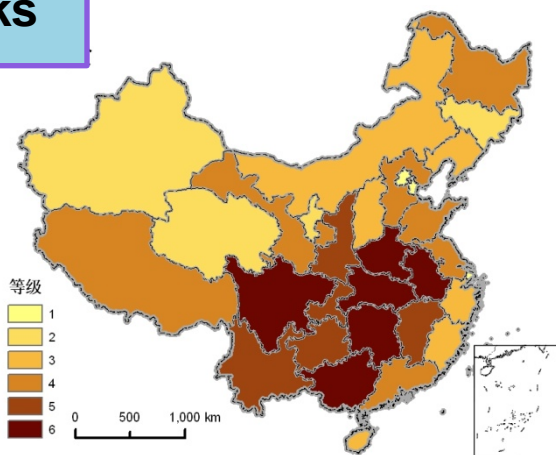


# 3. Risk assessment of health of flood in China

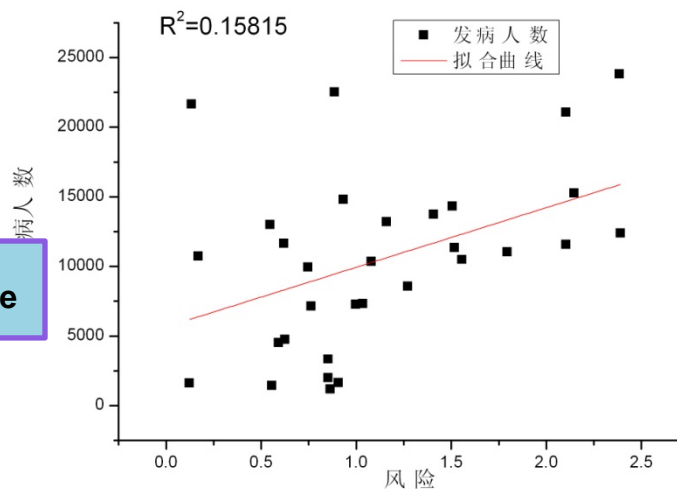


- 3.4 health risk assessment of flood
- results of China

risks



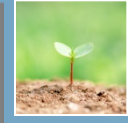
incidence



risks



# 5. Summary



- It's a primary study used risk assessment model of hazard to assessment health risk of flood.
- More works should be done on data collection and the mechanisms to address the relationship between health or diseases and flood.
- Regional difference of same health problem like bacillary dysentery and its impact factors should considered in large country as country of China.
- All-around health risk of flood is very important for further study.
- Mapping risk for decision-makers.





# Thank you

