Integrate Science, Technology and Finance into the Coordination on Regional Disaster Governance

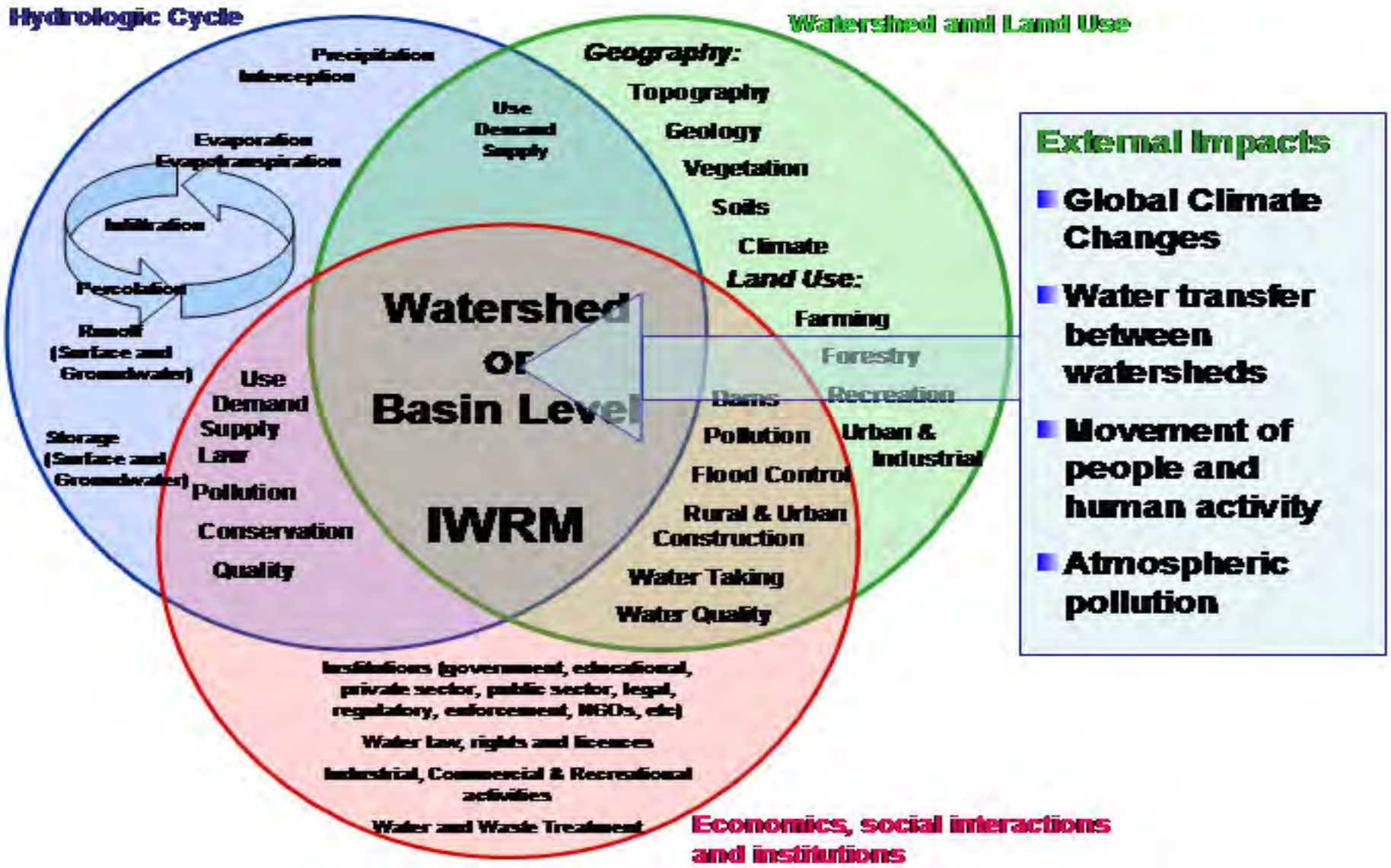
Weihua FANG

Academy of Disaster Reduction and Emergency Management,
(MoCA & MOE of China)
Beijing Normal University

Outline

1. Background
2. Concepts
3. Case Study
   - Multi-hazard Database and Risk Mapping
   - Catastrophe Risk Modeling and Risk Finance
   - Other Risk Assessments in China
4. Discussions

1. Background: Complex Disaster System



1. Background: Regional Impacts

Regional Coordination and Collaboration

Trans-boundary Hazards and Direct Loss

- Earthquake, Tsunami
- Typhoon, Flood
- Sand Storm, ……

Catastrophic Disasters

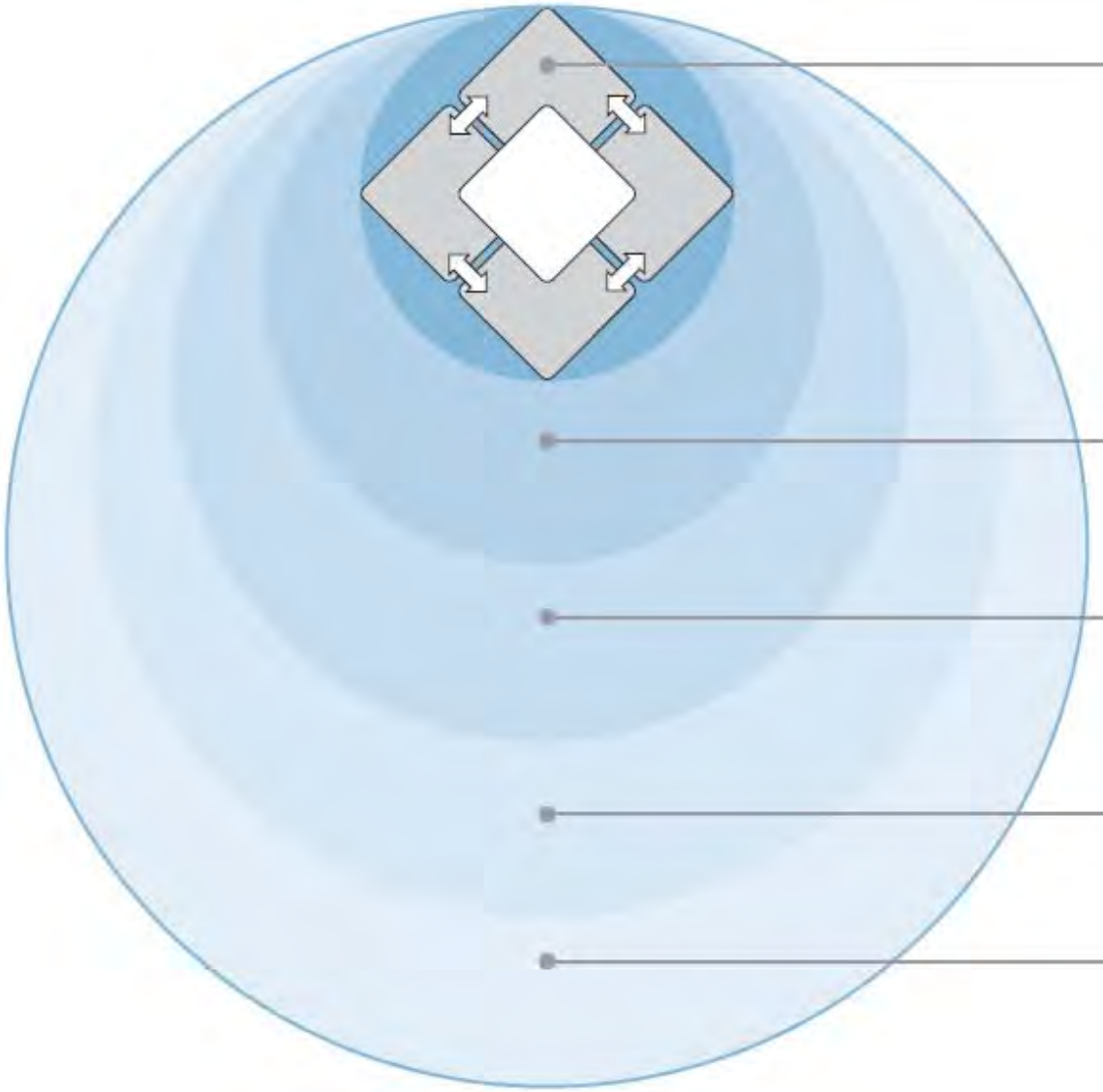
- Beyond local/national coping capacity

Trans-boundary Indirect Impacts

- Economic
- Ecological
- Environmental

2. Concepts: from Risk Management to Governance

2. Concepts: Risk Governance Framework



Core Risk Governance Process
(pre-assessment; risk appraisal: risk and concern assessments; evaluation tolerability/acceptability judgement; risk management; communication)

Organisational Capacity
(assets; skills; capabilities)

Actor Network
(politicians; regulators; industry/ business; NGOs; media; public at large)

Political and Regulatory Culture
(different regulatory styles)

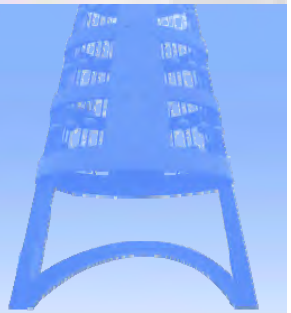
Social Climate
(trust in regulatory institutions; perceived authority of science; civil society involvement; risk culture)

2. Concepts: Stakeholders of Risk Governance

ACTORS	Regulatory bodies/industry experts	Regulatory bodies/industry experts External Scientists/ Researchers	Regulatory bodies/industry experts External Scientists/ Researchers Affected stakeholders	Regulatory bodies/industry experts External Scientists/ Researchers Affected stakeholders Civil society
TYPE OF PARTICIPATION	Use existing routines to assess risks and possible reduction measures	Maximise the scientific knowledge of the risk and mitigation options	Involve all affected stakeholders to collectively decide best way forward	Societal debate about the risk and its underlying implications
DOMINANT RISK CHARACTERISTIC	Simple	Complexity	Uncertainty	Ambiguity

As the dominant characteristic changes, so also will the type of stakeholder involvement need to change

2. Concepts: Disaster Management Cycle



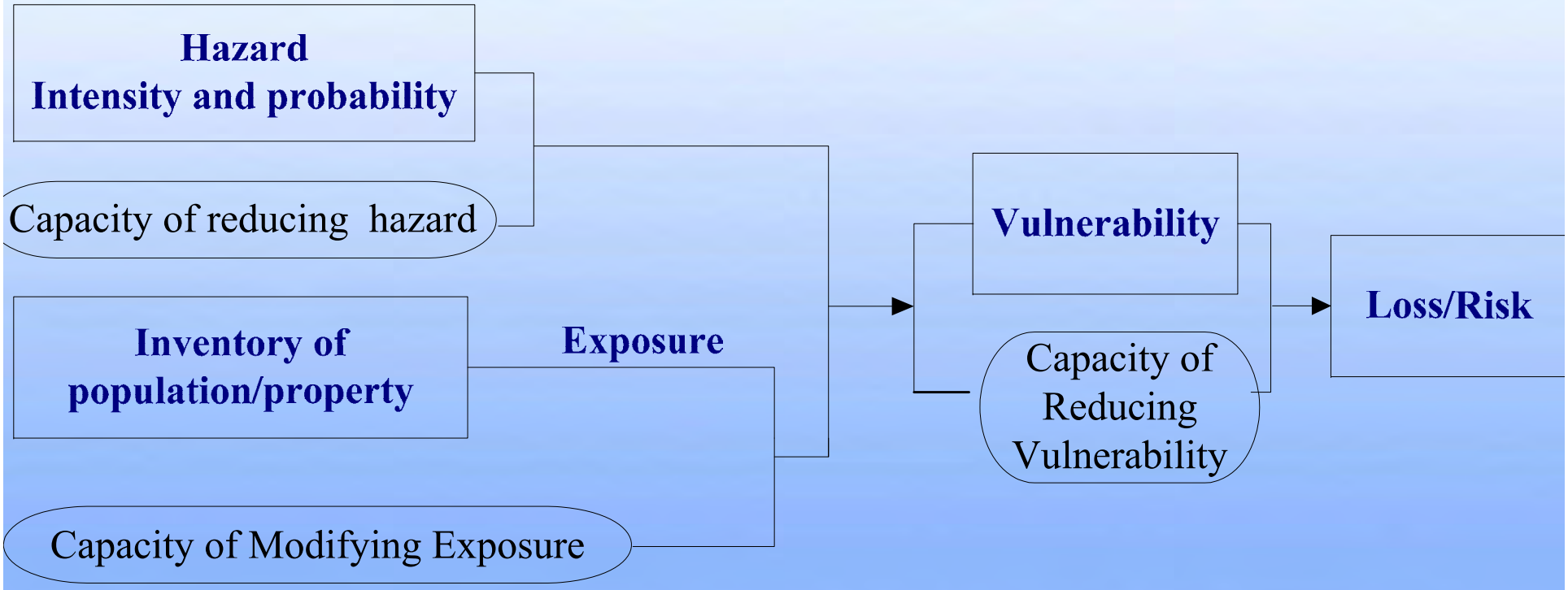
2. Concepts: Disaster Management Cycle

What stage is the most concerned by regional organizations and why?

2. Concepts: Disaster Management Cycle

What stage is the most concerned by regional organizations and why?

2. Concepts: from Emergency Response to Risk Governance



What kind of capacities should be built?

How to take proactive measures?

What are the roles of science and technology?

3.1 Case I: Purpose

- **Spatial and Temporal Heterogeneity**
  - Where? How often? How Strong?
- **Policy-Making**
  - Target Users: *National/Province/County Govs.*
  - What-if info:
    - Casualty
    - Building Damage
    - Economic Lose
    - Evacuation Population
- **Public DRR Practice**
  - Education
  - ……
- **Others**

3.1 Case I: Database

Hazards

- Earthquake
- Flood
- Typhoon
- Drought
- Snow Storm
- Sand Storm
- Storm Surge
- Landslide
- Hail
- Frost
- Forest Fire
- Grassland Fire
- Chemical incidents
- ……

Auxiliary Dataset

- GIS, social-economic
- Coping capacity……

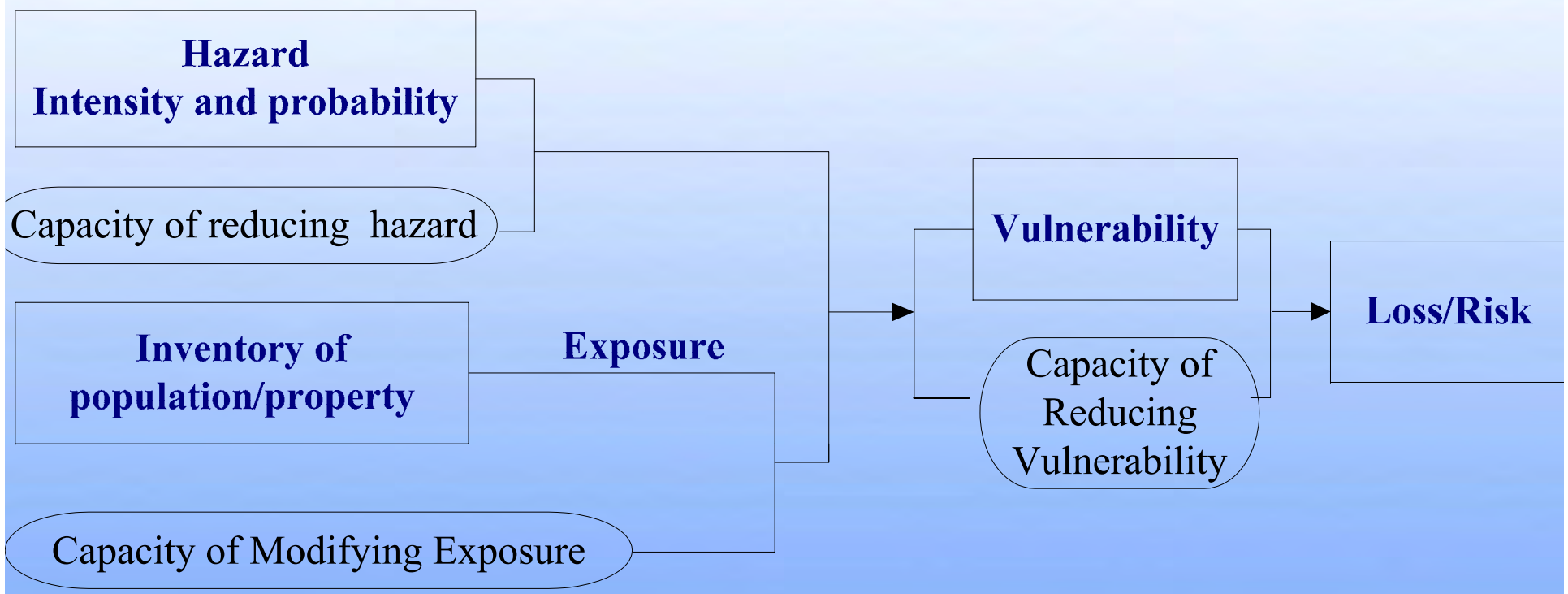
Exposure Data

- **Population**
  - County/township/zip-code
  - 1km*1km
- **GDP**
  - County/township/zip-code
  - 1km*1km
- **Building**
  - Year
  - Story
  - Type
  - Occupancy
  - …
- **Infrastructure**
  - Transportation
  - Utility
  - Evacuation site
  - Hospital
- **Crops**
  - Wheat, Corn
  - Rice…..

Loss Data

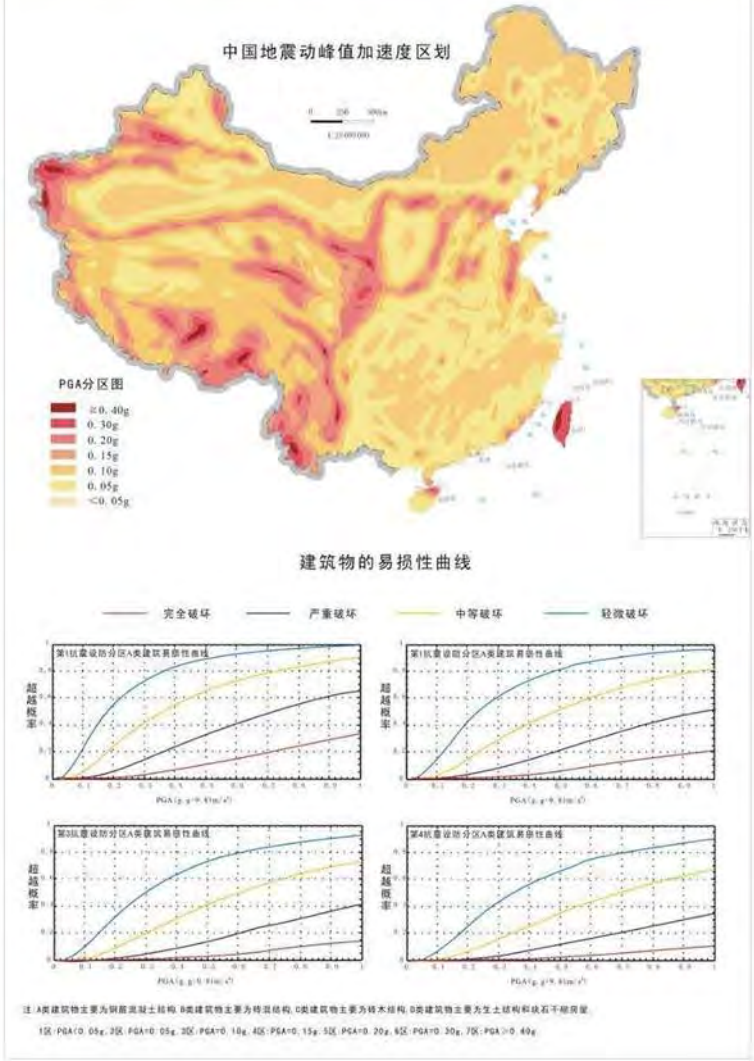
- **MoCA Statistics**
  - 1949-2009
  - County-level
  - Province level
  - Hazard-specific
- **Insurance Data**
  - Policy
  - Claim
- **Case Study Data**
  - Earthquakes
  - Flood
  - Typhoon
  - Drought
  - Wildfire
  - ……
- **Satellite-based**
  - Wildfire
  - Drought
  - Earthquake
  - Flood……

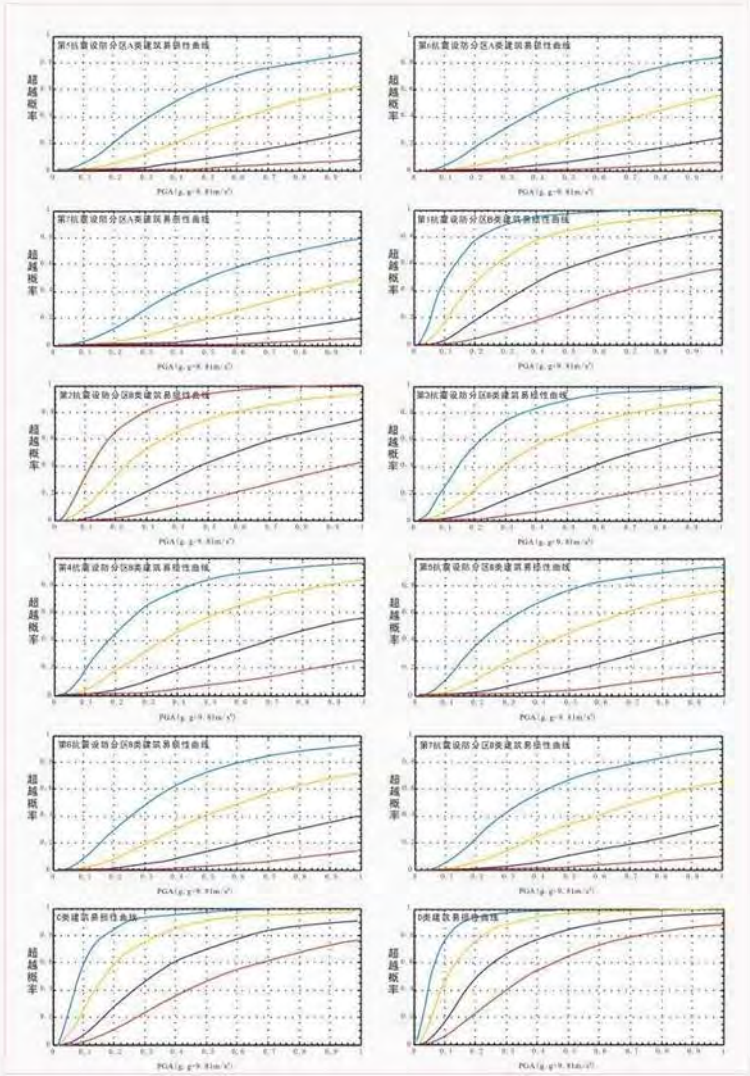
3.1 Case I: Mapping Methods



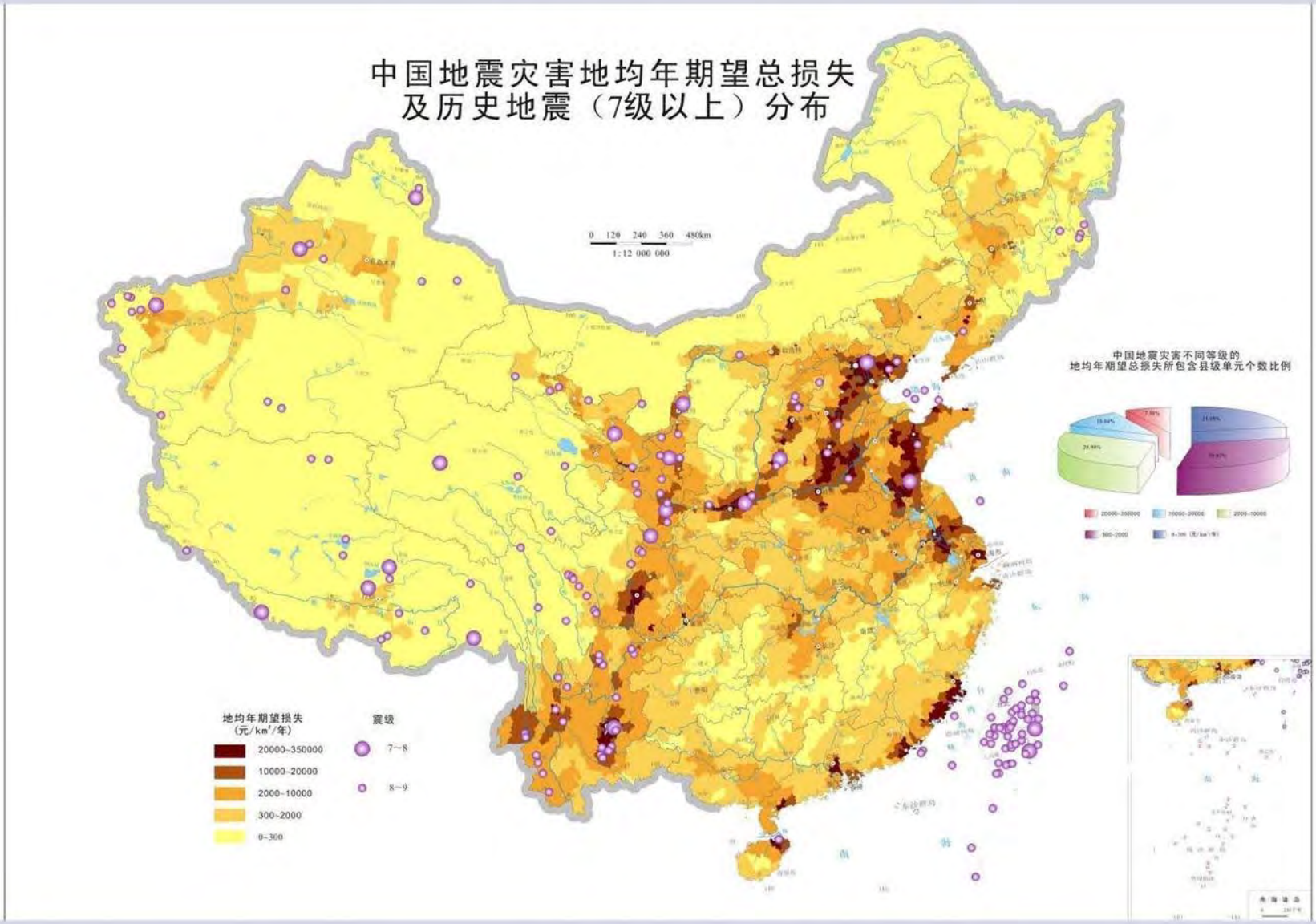
- **Map Resolution**
  - 1km grid
  - County
- **Map Types**
  - Quantitative
  - Semi-quantitative
  - Categories

3.1 Risk Mapping: Earthquake

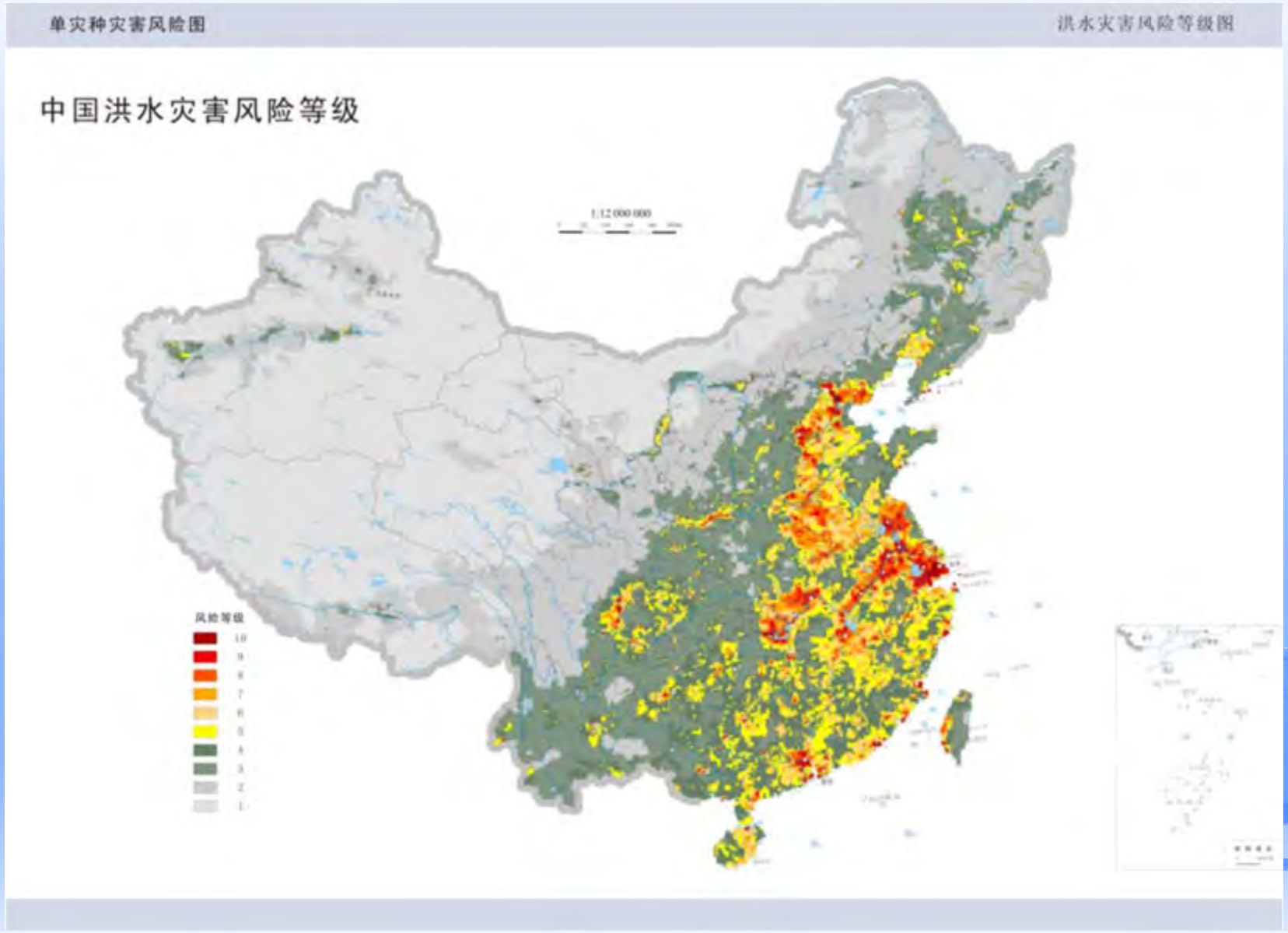




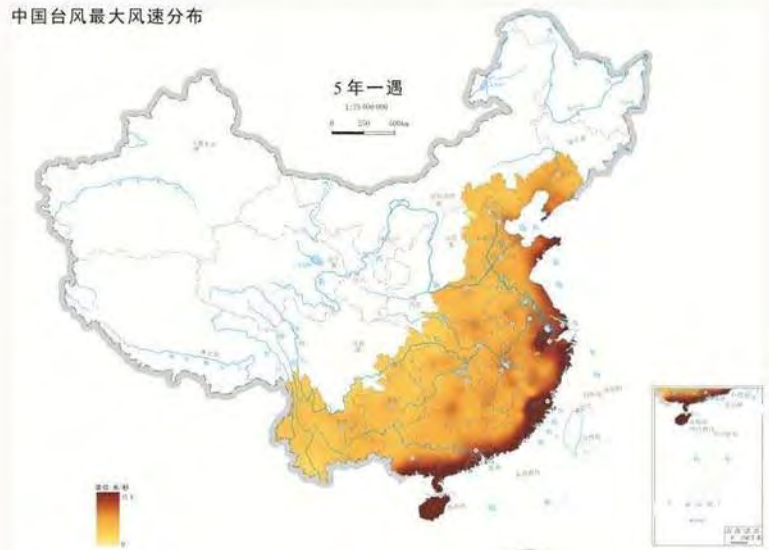
3.1 Risk Mapping: Earthquake

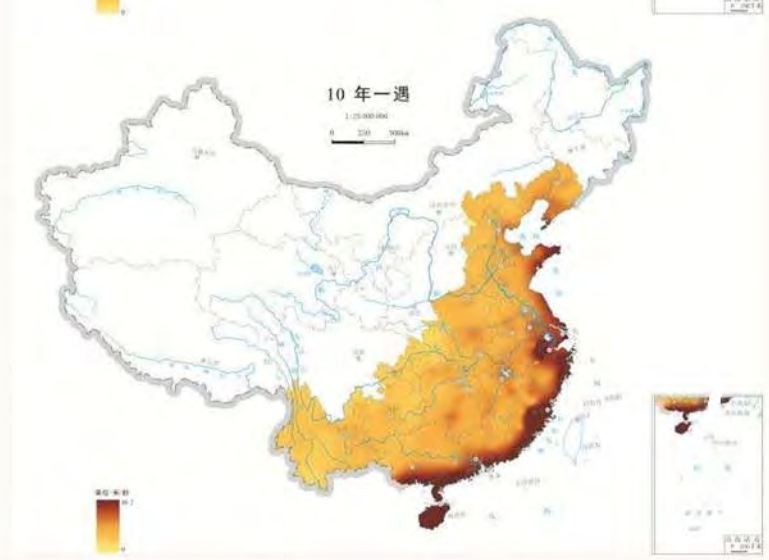


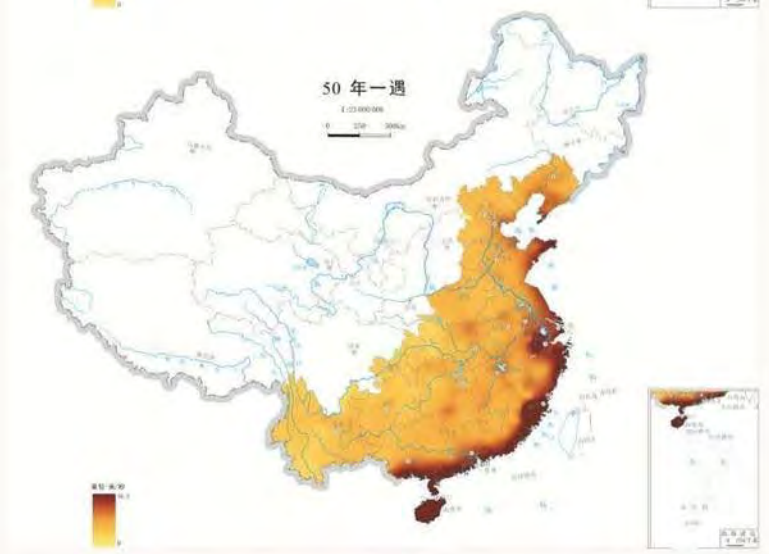
3.1 Risk Mapping: Flood



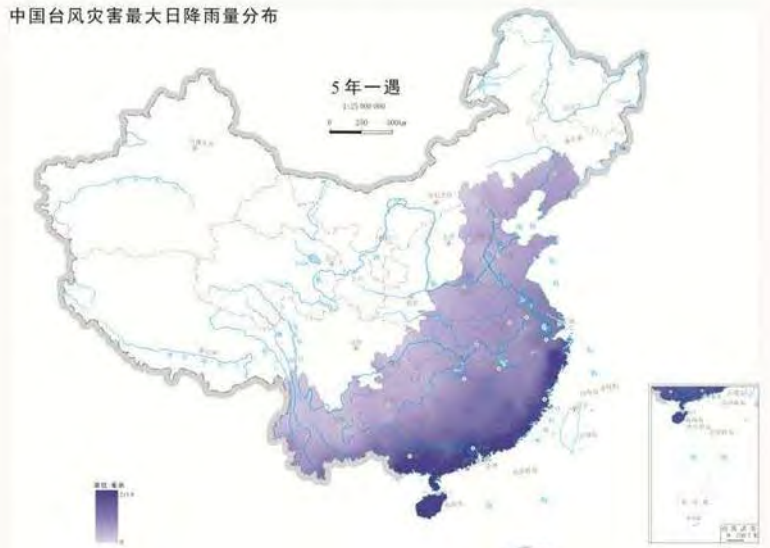
3.1 Risk Mapping: Typhoon (Wind)

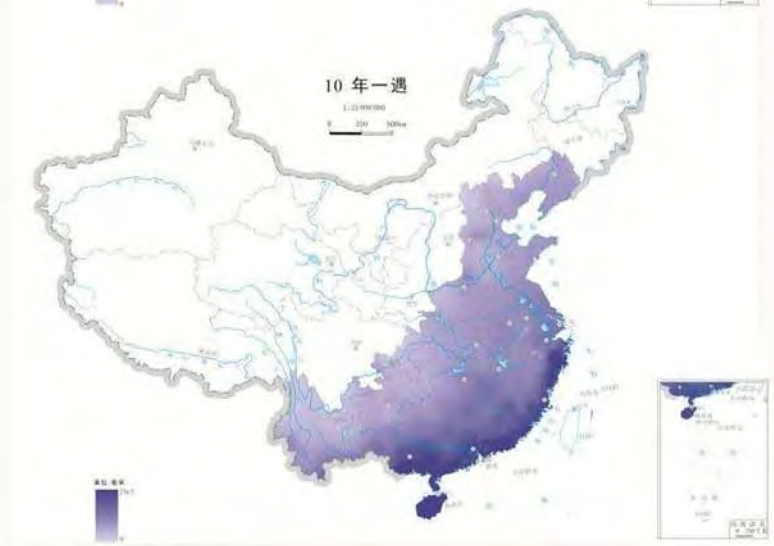


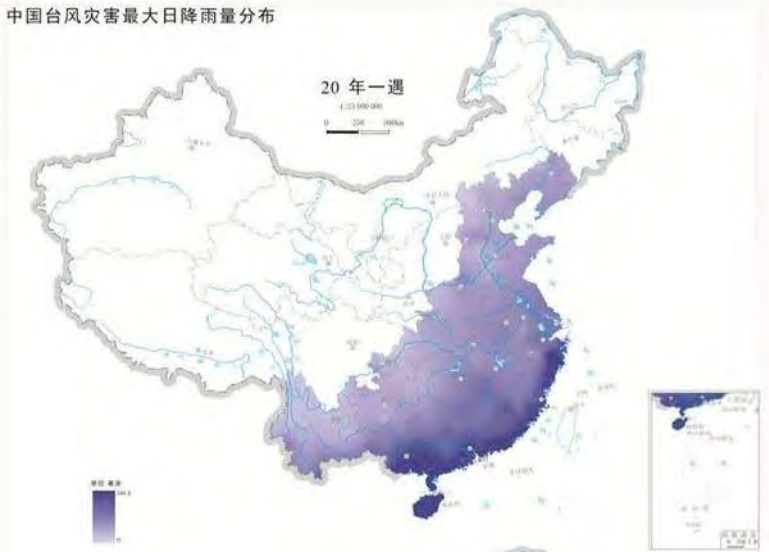


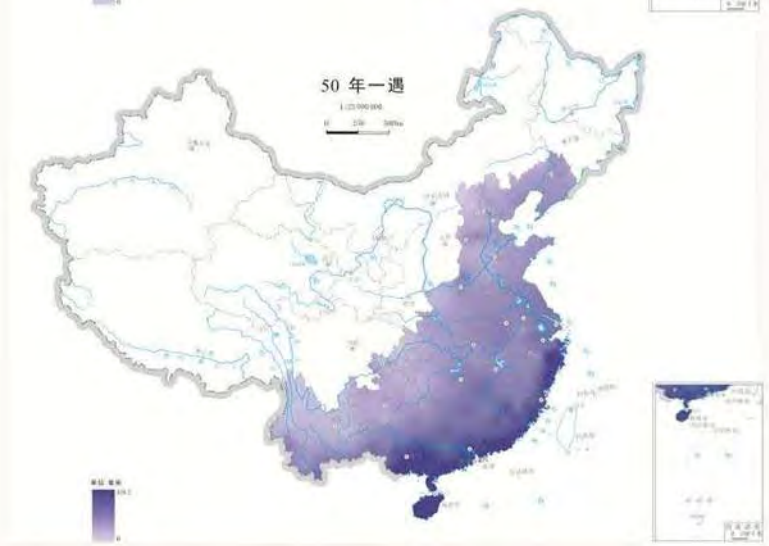


3.1 Risk Mapping: Typhoon (rainfall)

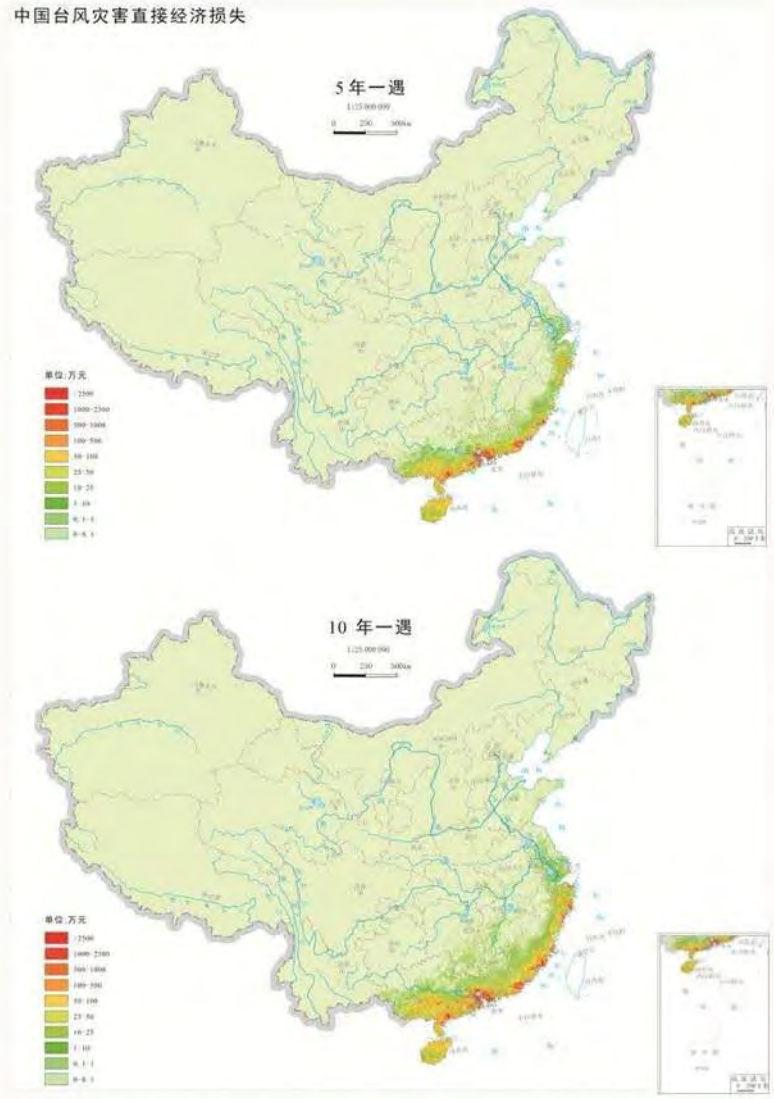


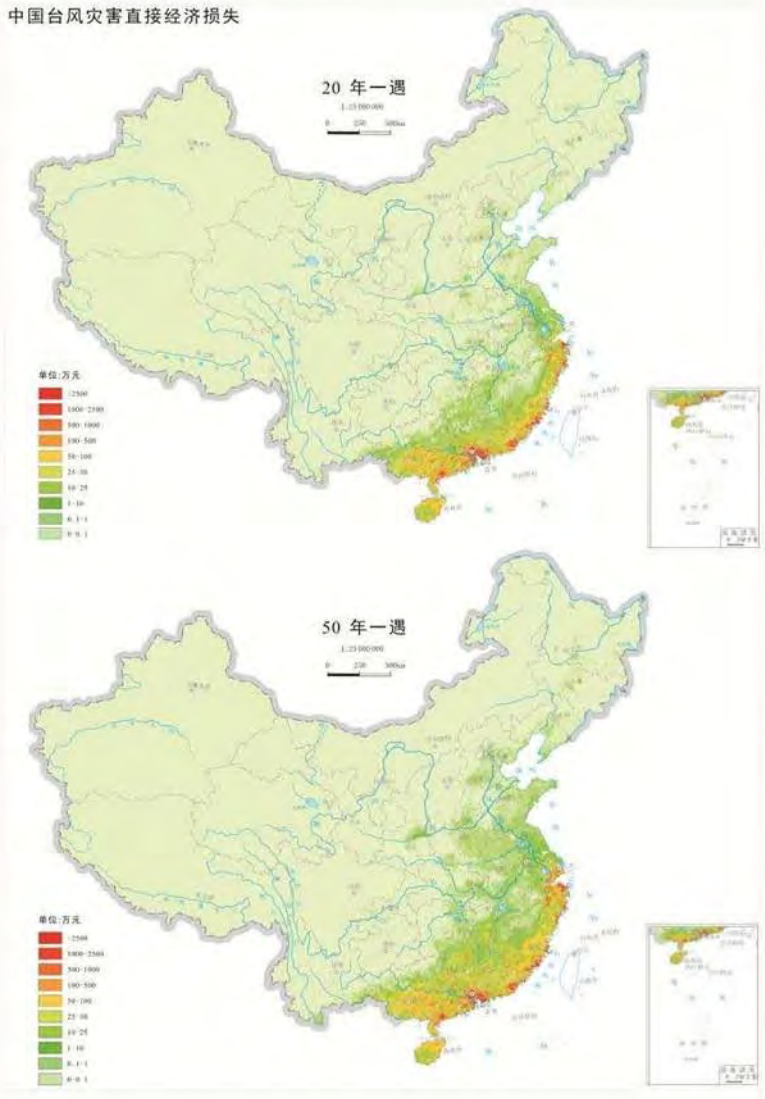




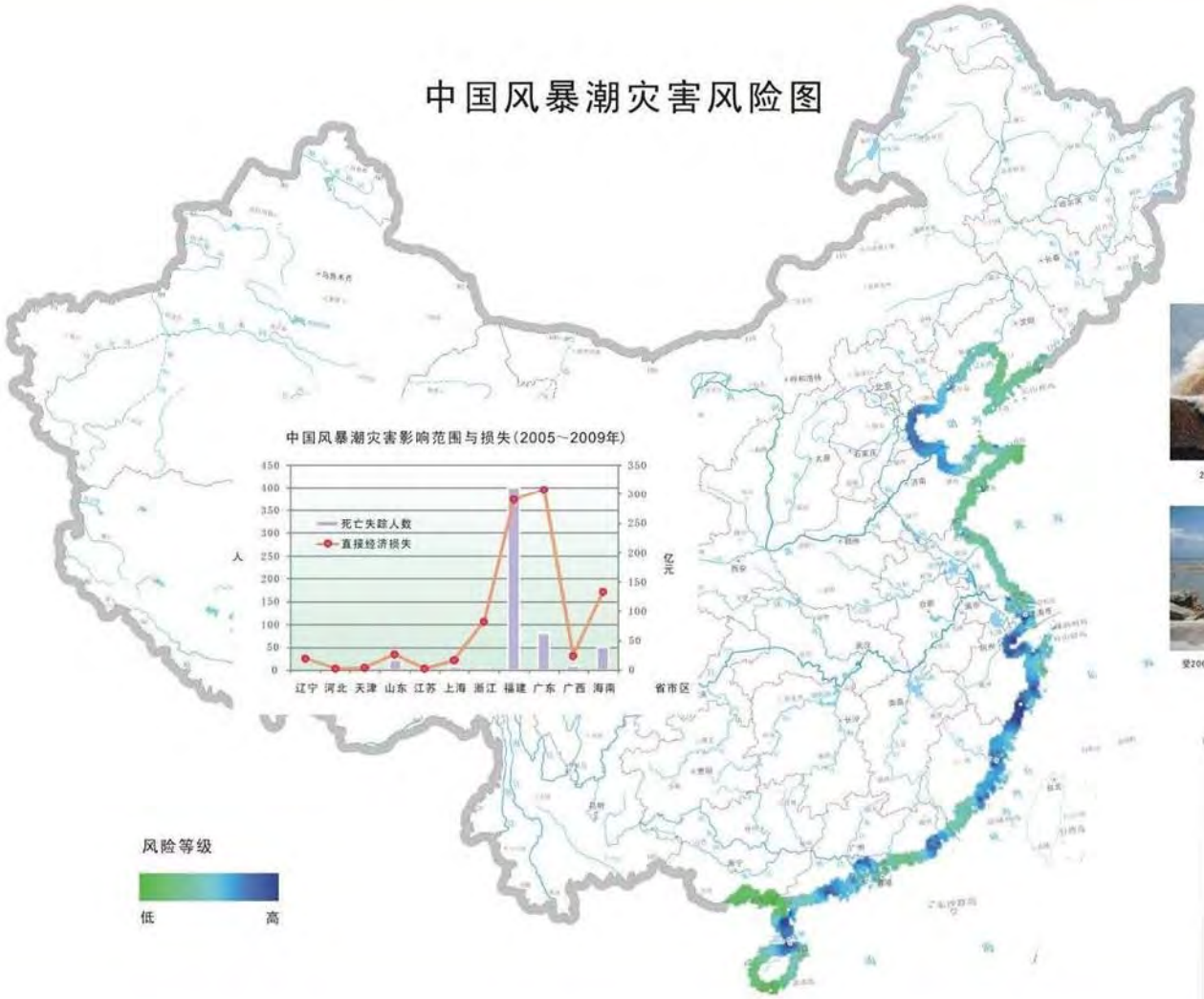


3.1 Risk Mapping: Typhoon (economic loss)



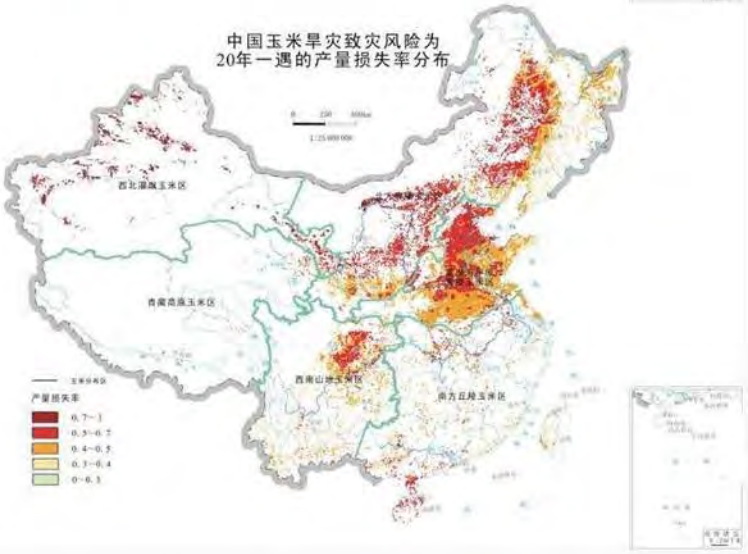


3.1 Risk Mapping: Storm Surge (ranking)

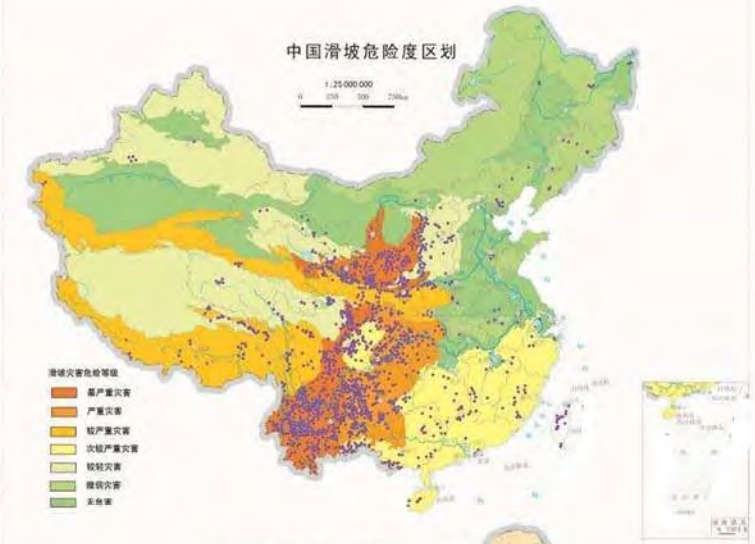


3.1 Risk Mapping: Drought (wheat)

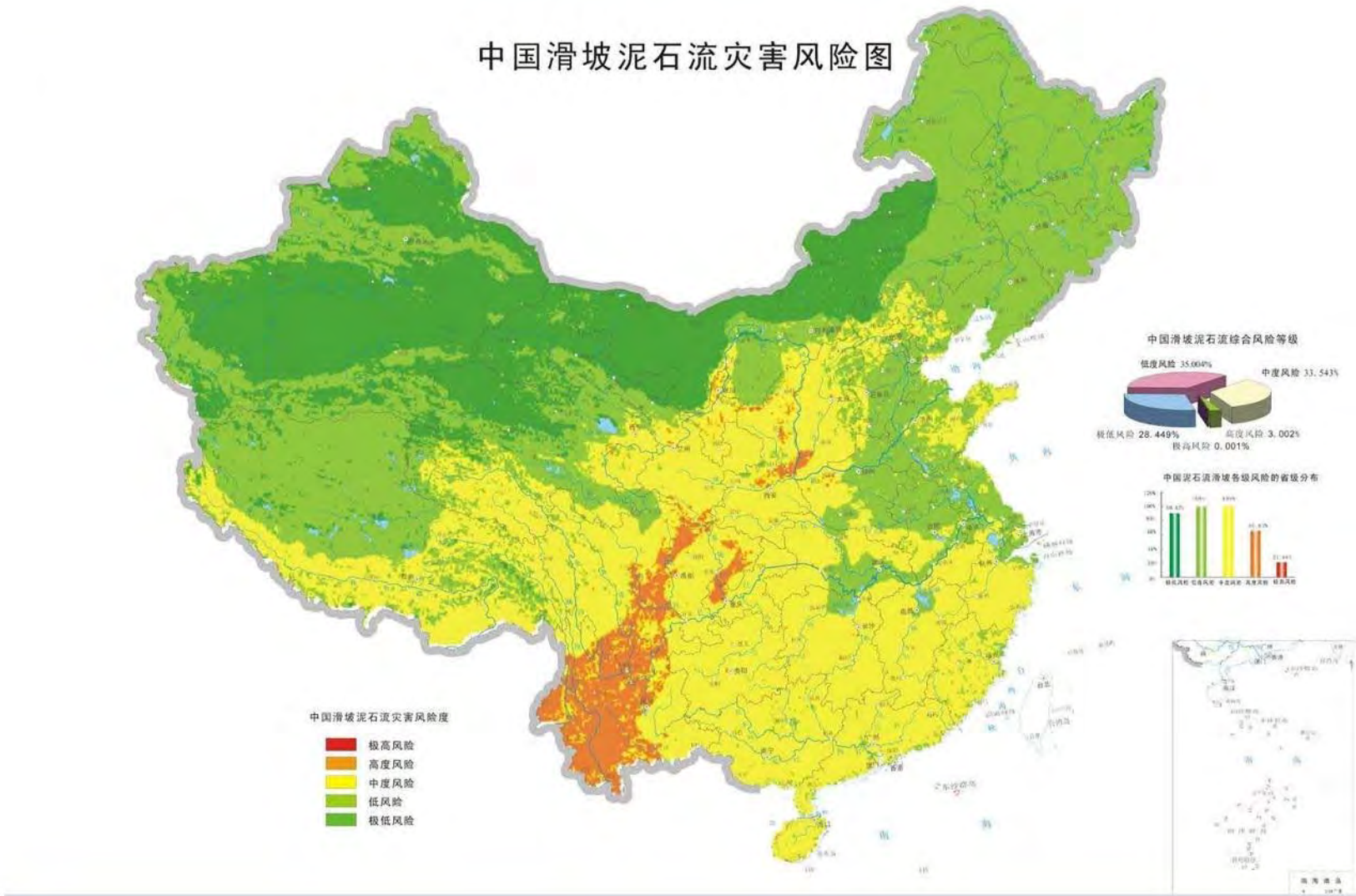
3.1 Risk Mapping: Drought (corn)



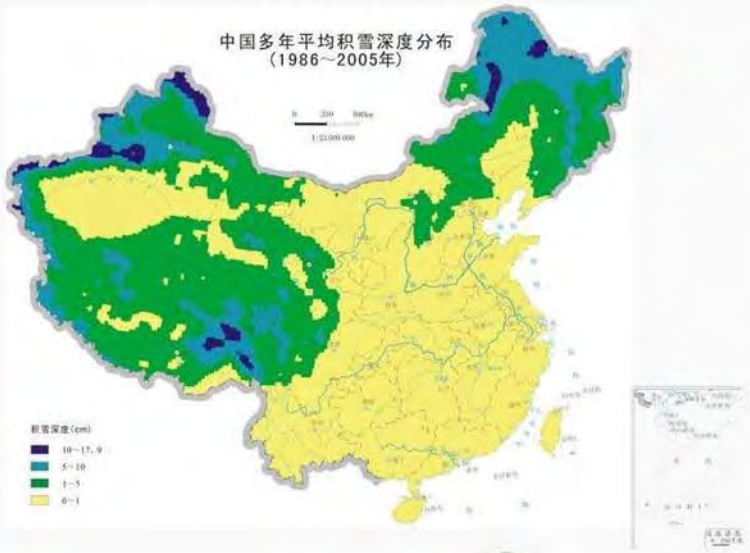
3.1 Risk Mapping: Landslide

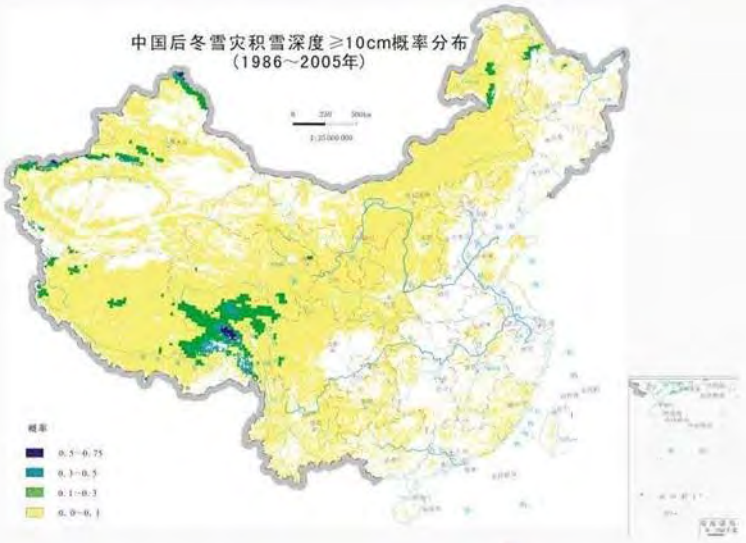


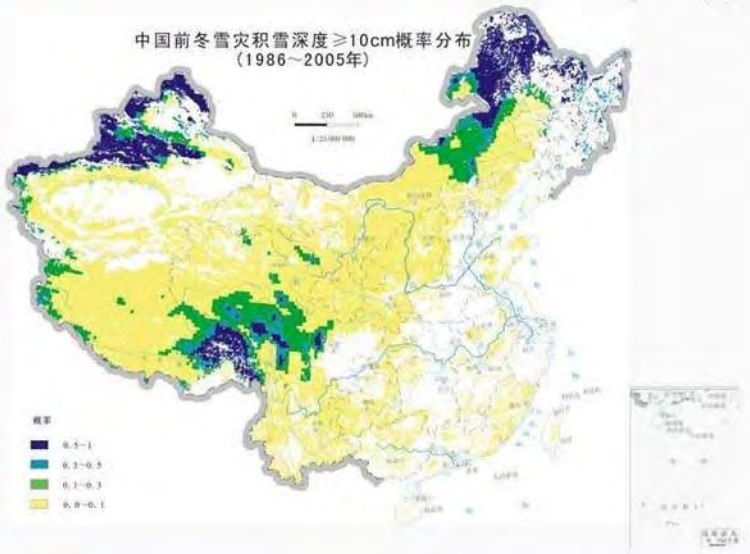
3.1 Risk Mapping: Landslide

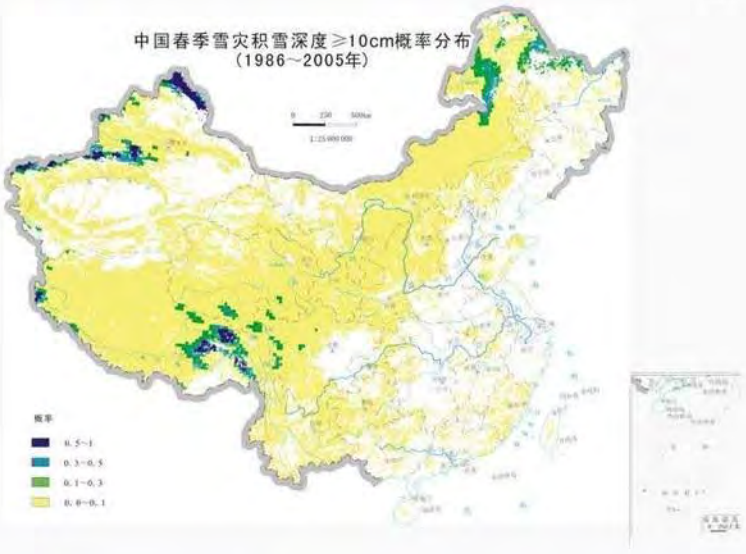


3.1 Risk Mapping: Snowstorm

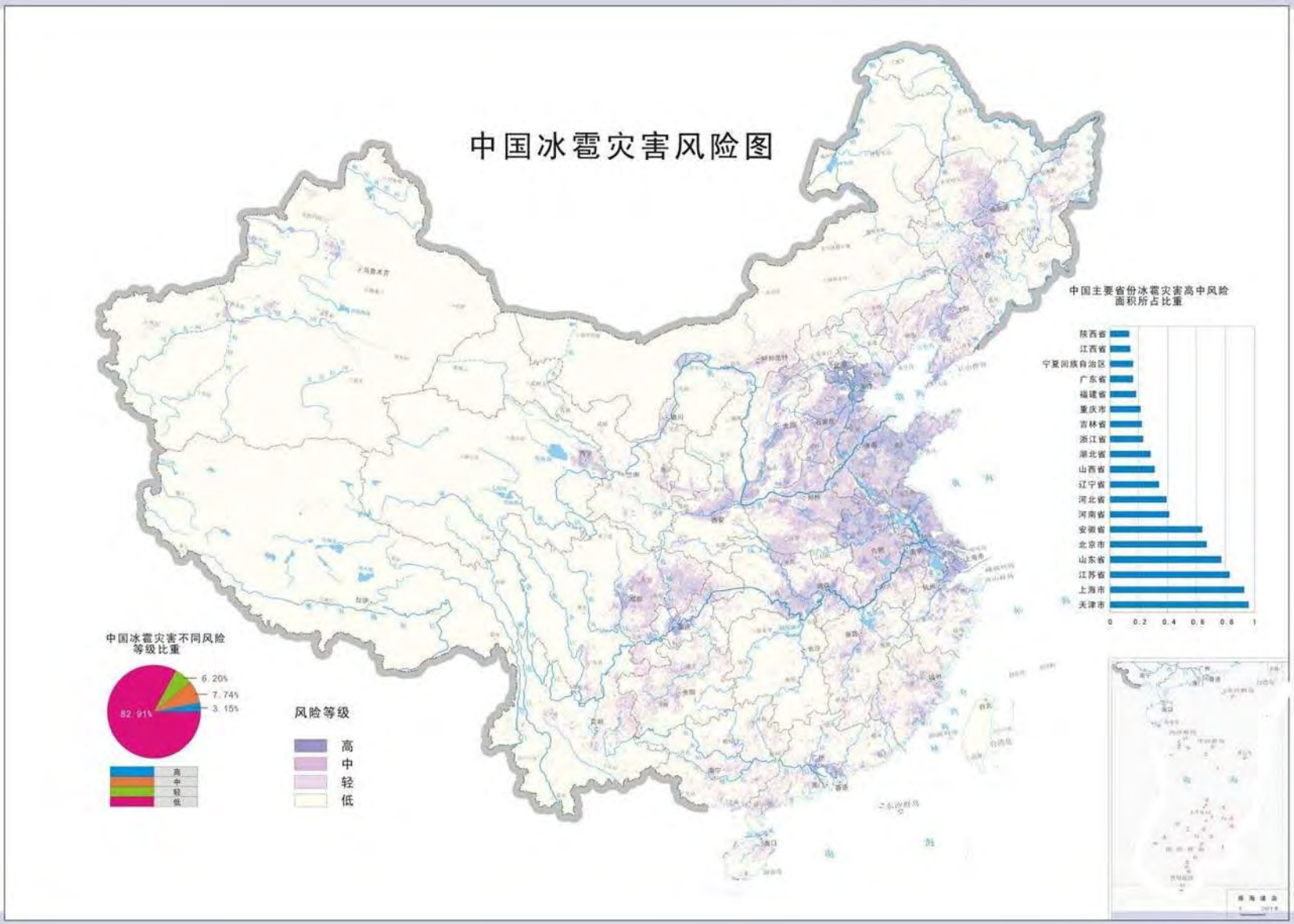




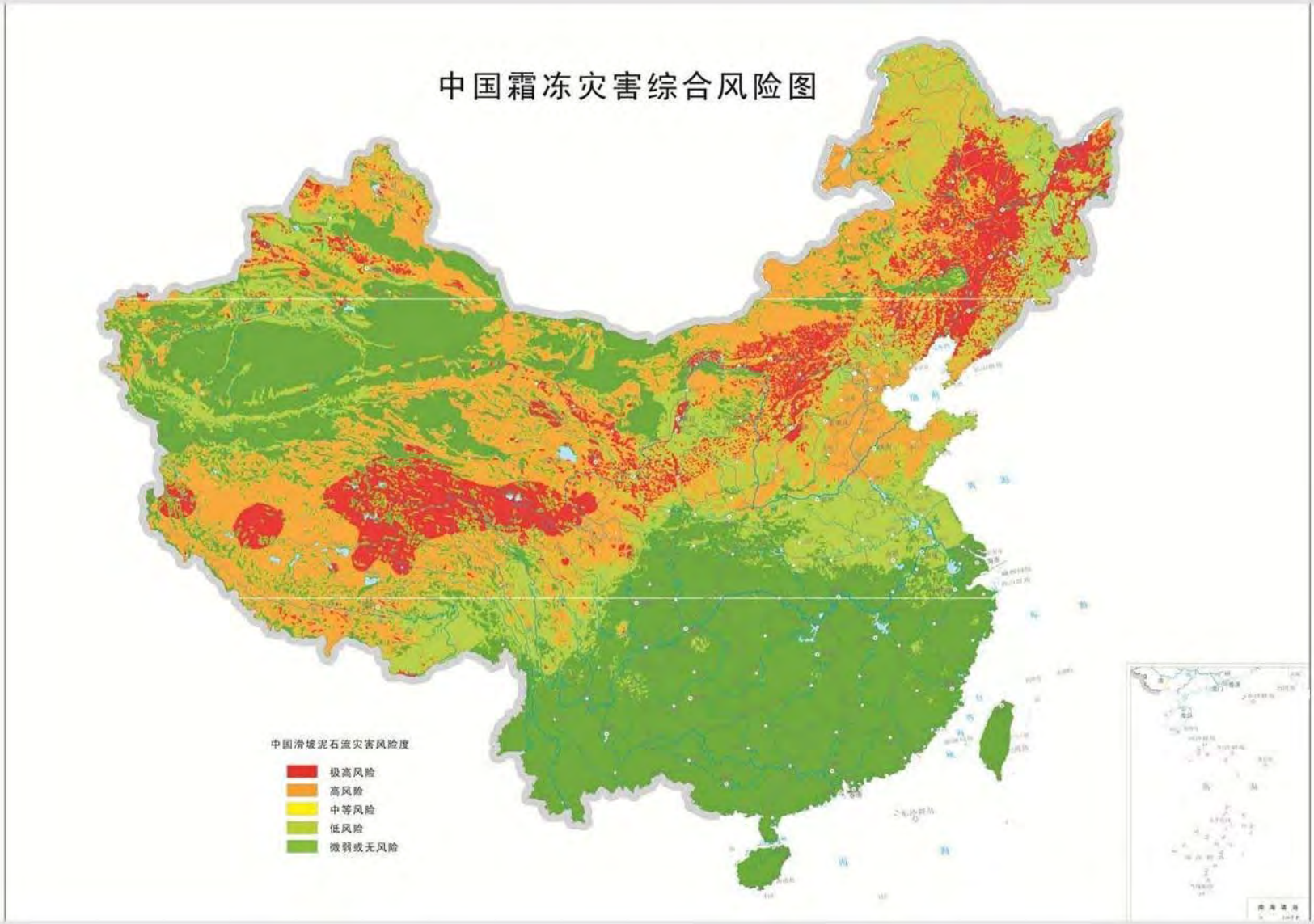




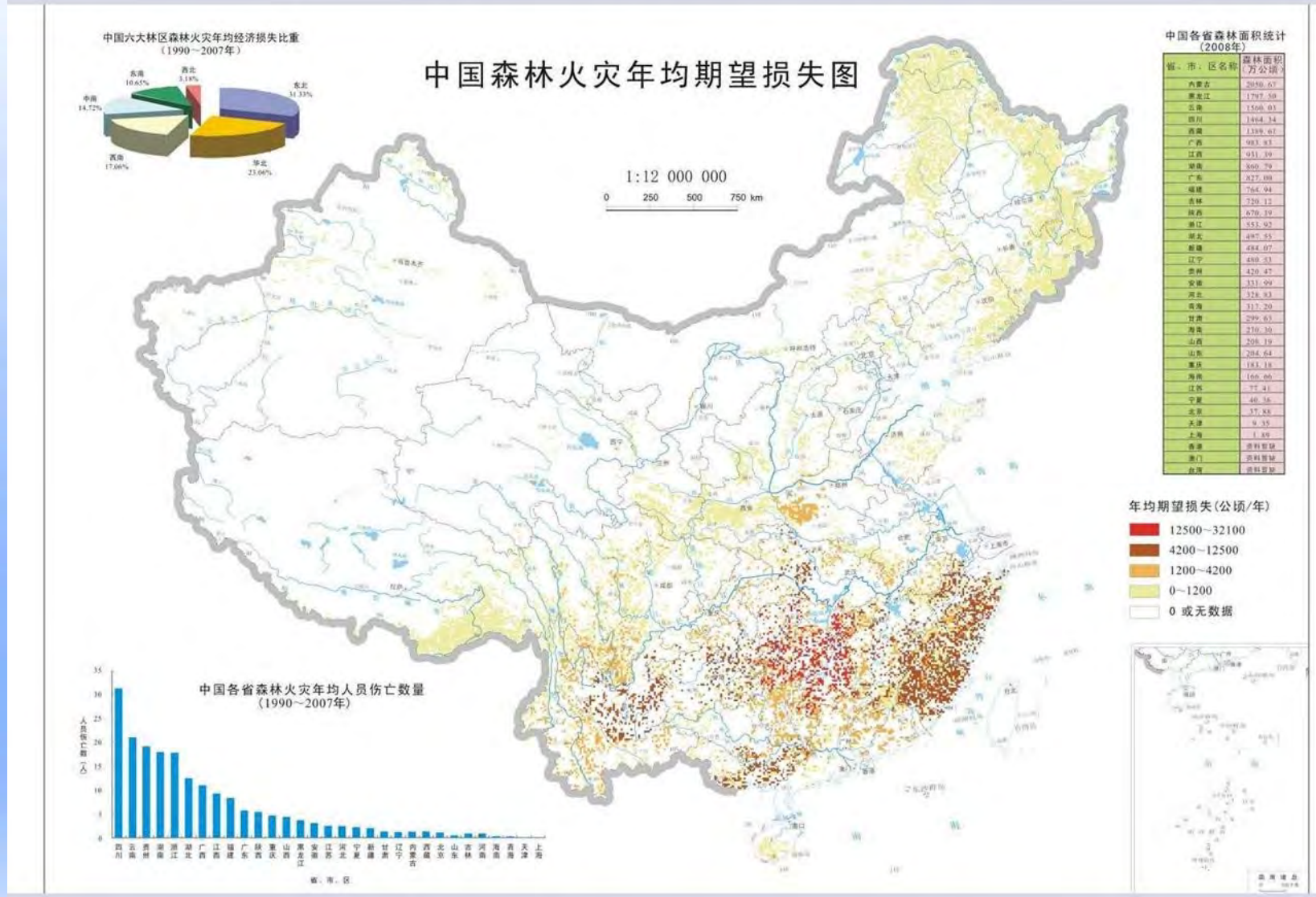
3.1 Risk Mapping: Hail (ranking)



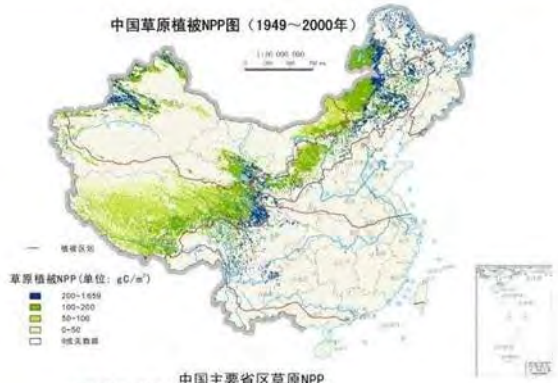
3.1 Risk Mapping: Frost (ranking)

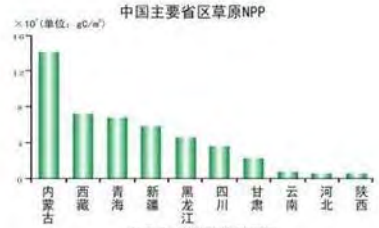


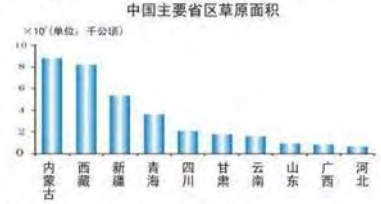
3.1 Risk Mapping: Forest Fire

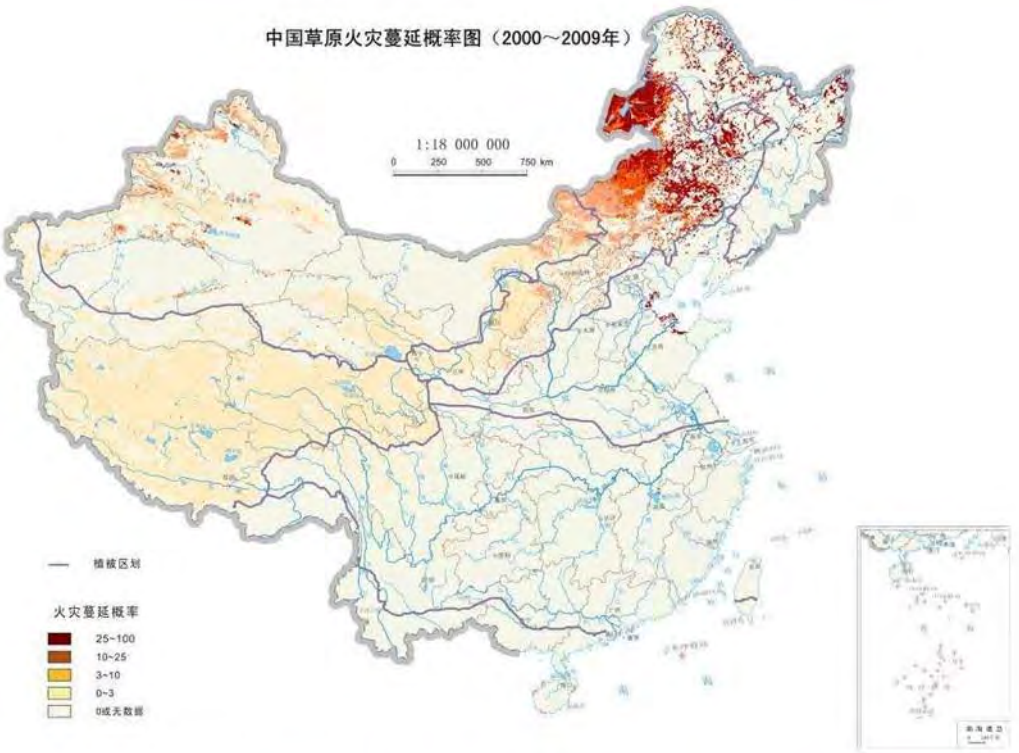


3.1 Risk Mapping: Grassland Fire

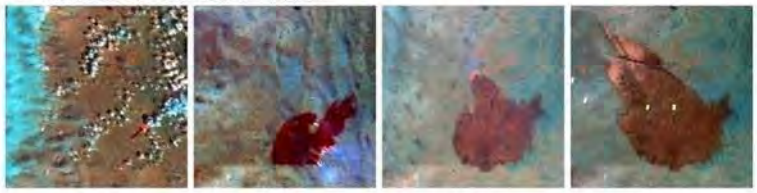








2003年5月发生在中蒙边境的草原火灾



2003年5月21日　2003年5月22日　2003年5月24日　2003年5月26日

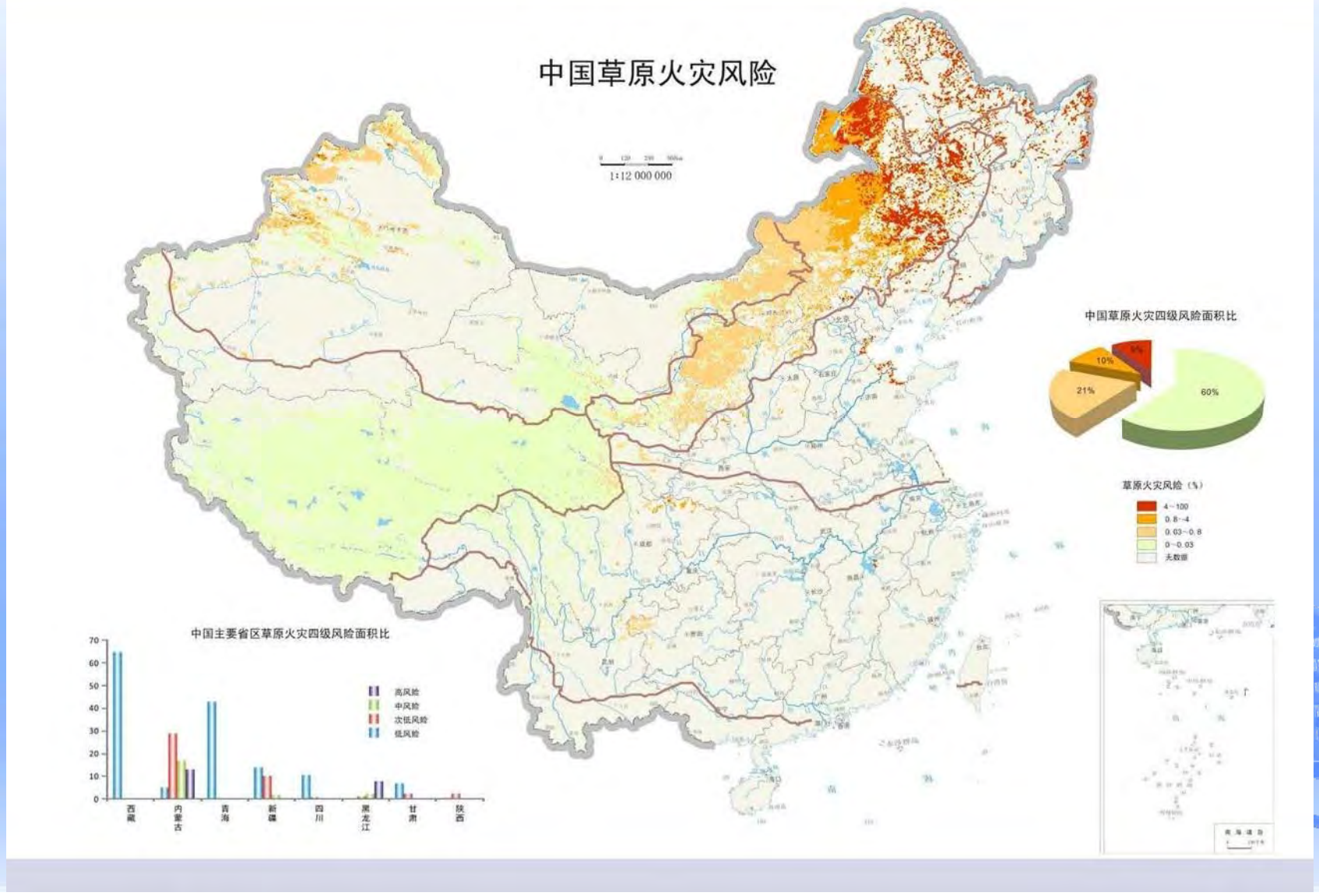
棕色区域为火灾蔓延后的迹地，桔红色为火点

2005年10月发生在中蒙边境的草原火灾

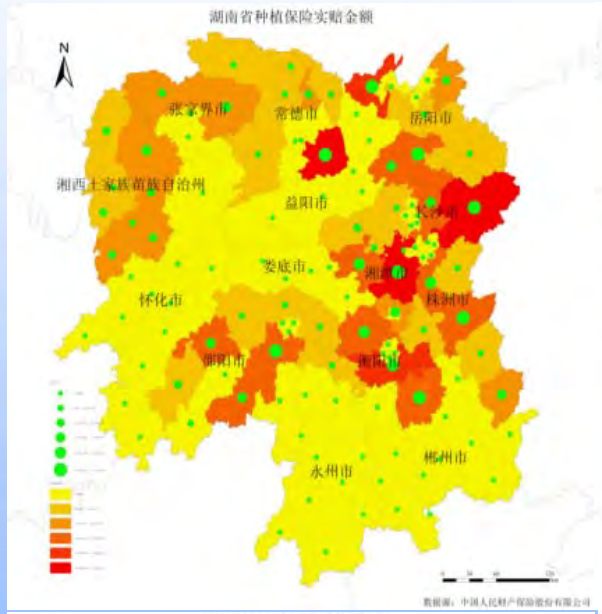
2005年10月24日　2005年5月25日　2005年5月29日　2005年5月30日

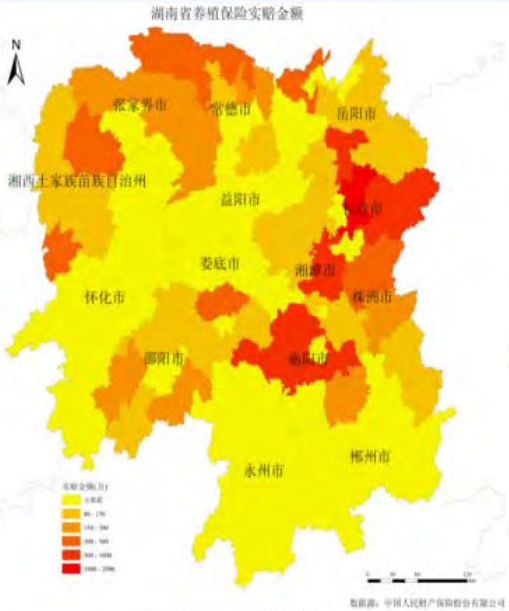
棕色区域为火灾蔓延后的迹地，桔红色为火点

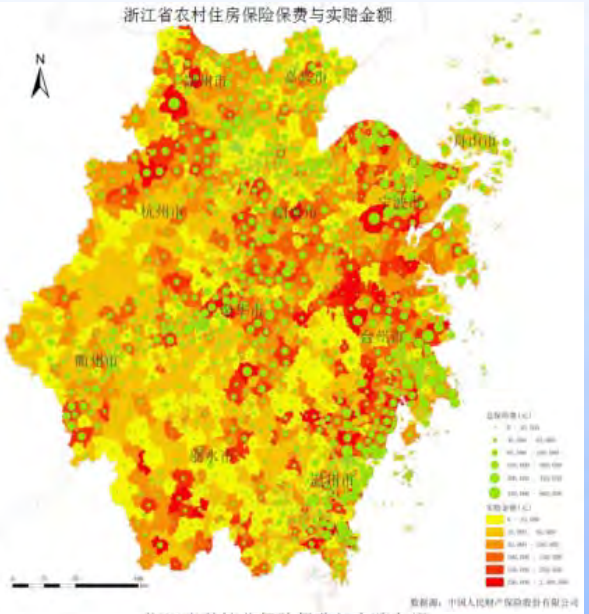
3.1 Risk Mapping: Grassland Fire

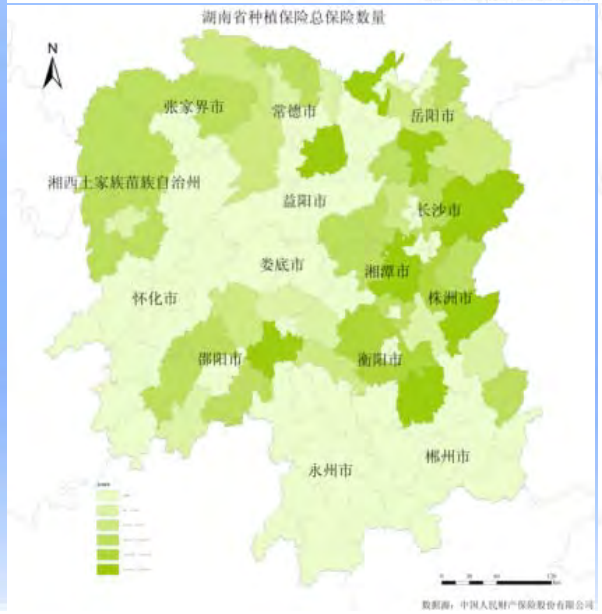


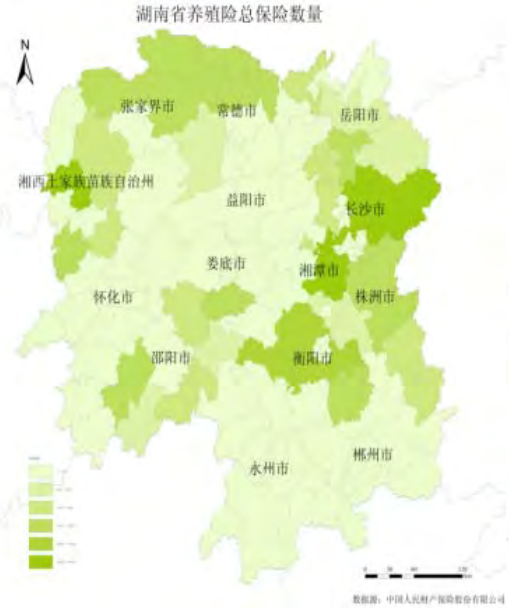
3.1 Risk Mapping: Insurance Policy and Claim

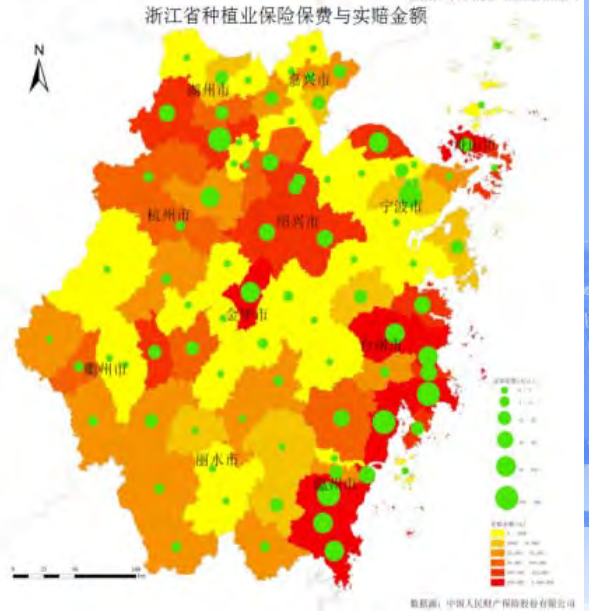








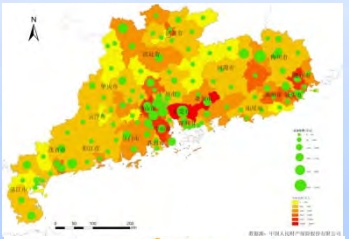


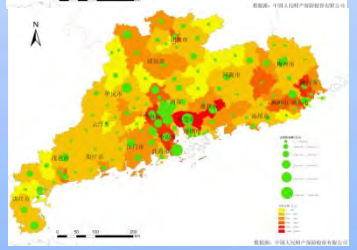


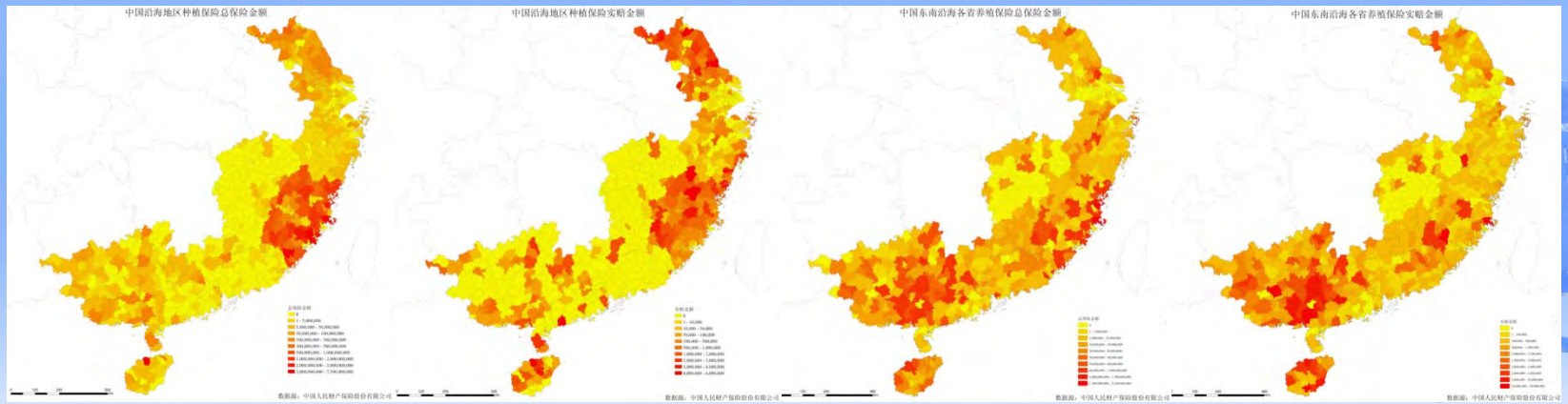
3.1 Risk Mapping: Insurance Policy and Claim

表 1.17.1 保险专业数据库分省记录数量

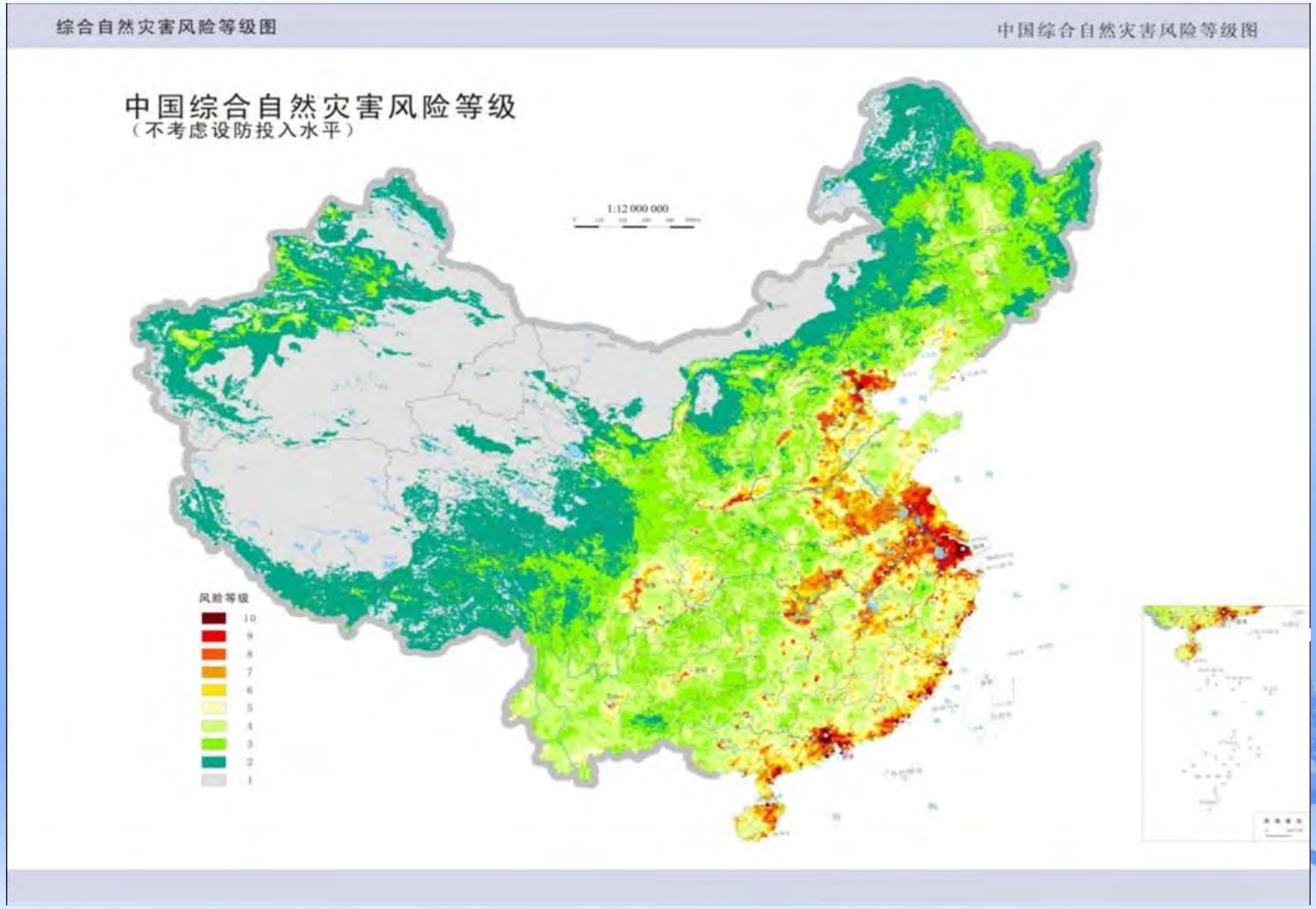
省市\险种	企业财产险		农村住房保险		种植业保险		养殖业保险		林业保险		合计
	承保	理赔	承保	理赔	承保	理赔	承保	理赔	承保	理赔	
浙江省	183,685	22,307	27,934	16,458	15,131	2,541	8,656	26,887	70	78	**303,747**
海南省					720	297	1,692	23,559	12		**26,280**
湖南省			186	3,247	64,870	17,177	8,635	132,922	3,133	733	**230,903**
福建省			504	4,408	1,335	4,229	18,002	34,061	3,008	465	**66,012**
广东省	1,872,299	33,762			243	424	4,461	30,711	415	497	**1,942,812**
湖北省				2,366	39,863	15,008	35,328	67,828	386	10	**160,789**
广西省			1,280	2,980	564	752	8,298	150,539	1,001	179	**165,593**
江苏省	124,939	7,207			11,636	4,104	5,679	24,767	33	22	**178,387**
江西省	28,573	2,532			34	37	6,658	34,762	429	173	**73,198**
上海市	58,620	3,508					429	173	3		**62,733**
合计	**2,268,116**	**69,316**	**29,904**	**29,459**	**134,396**	**44,569**	**97,838**	**526,209**	**8,490**	**2,157**	**3,210,454**







3.1 Risk Mapping: Integration

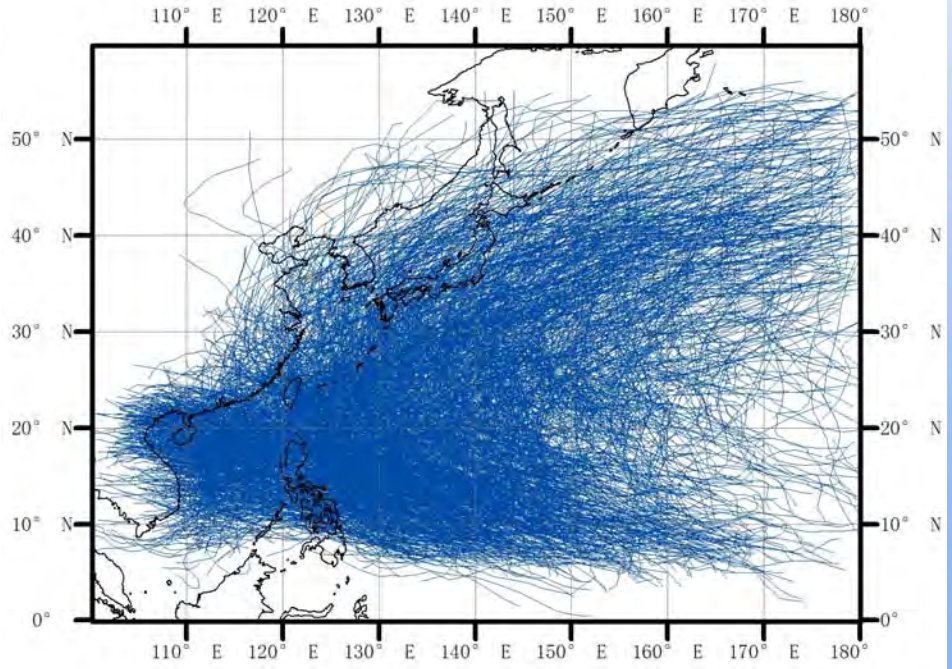


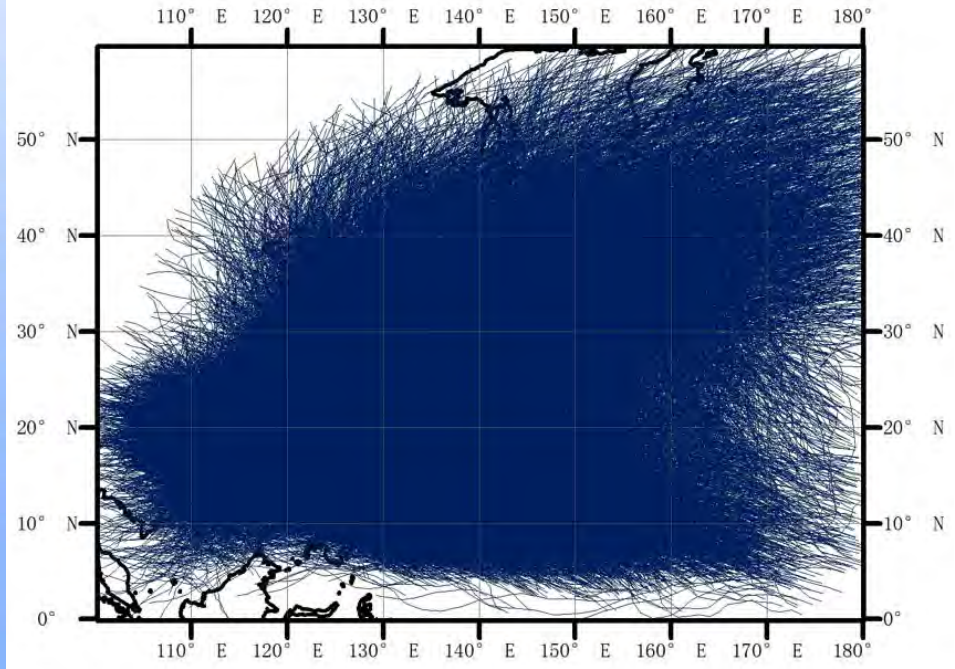
3.2 Case 2: Components of Typhoon Risk Model

- **Stochastic Event Module:** Track and Intensity Modeling
- **Hazard Module**: Wind and Rainfall Modeling
- **Vulnerability Module**: Linking Hazard and Loss
- **Risk Module: Statistics, Actuary, Cost-Benefit Analysis**

3.2 Case 2: Stochastic Event Set Generation

Genesis, Moving, Landing, Decay (filling), Lysis





Stochastic event set (right, 620 years) based on historical tracks (left, 62 years, 1949-2010): West-Northern Pacific

3.2 Case 2: Parametric Wind Model

➢What

•Typhoon wind field model is used to estimate the spatial and temporal distribution of typhoon wind.

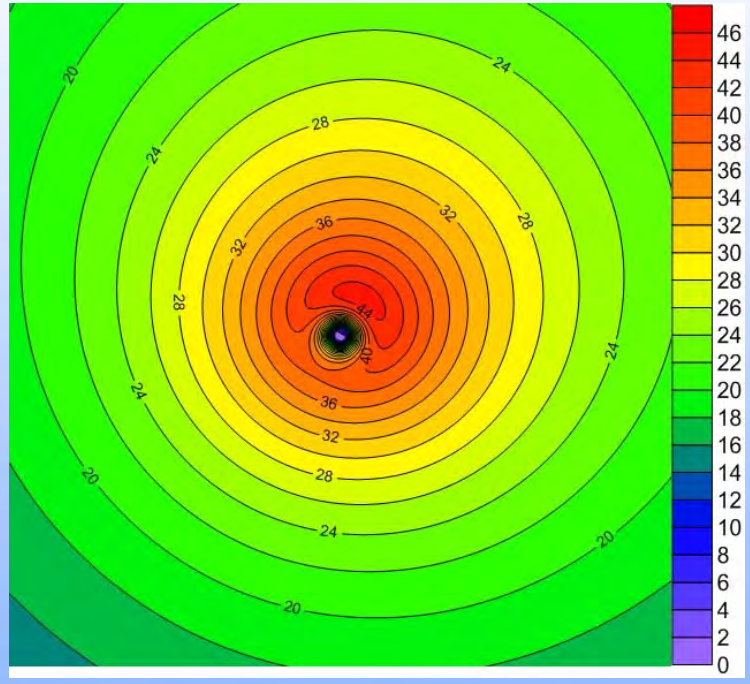
➢Why

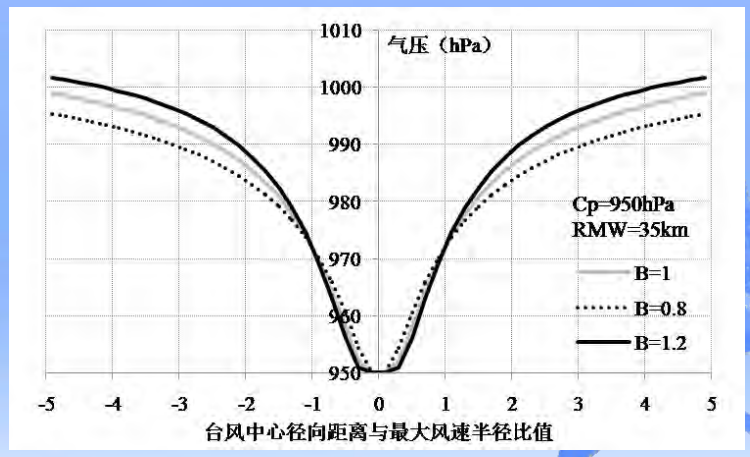
•The historical observation data is inadequate in space and time with limited observation year range

➢How

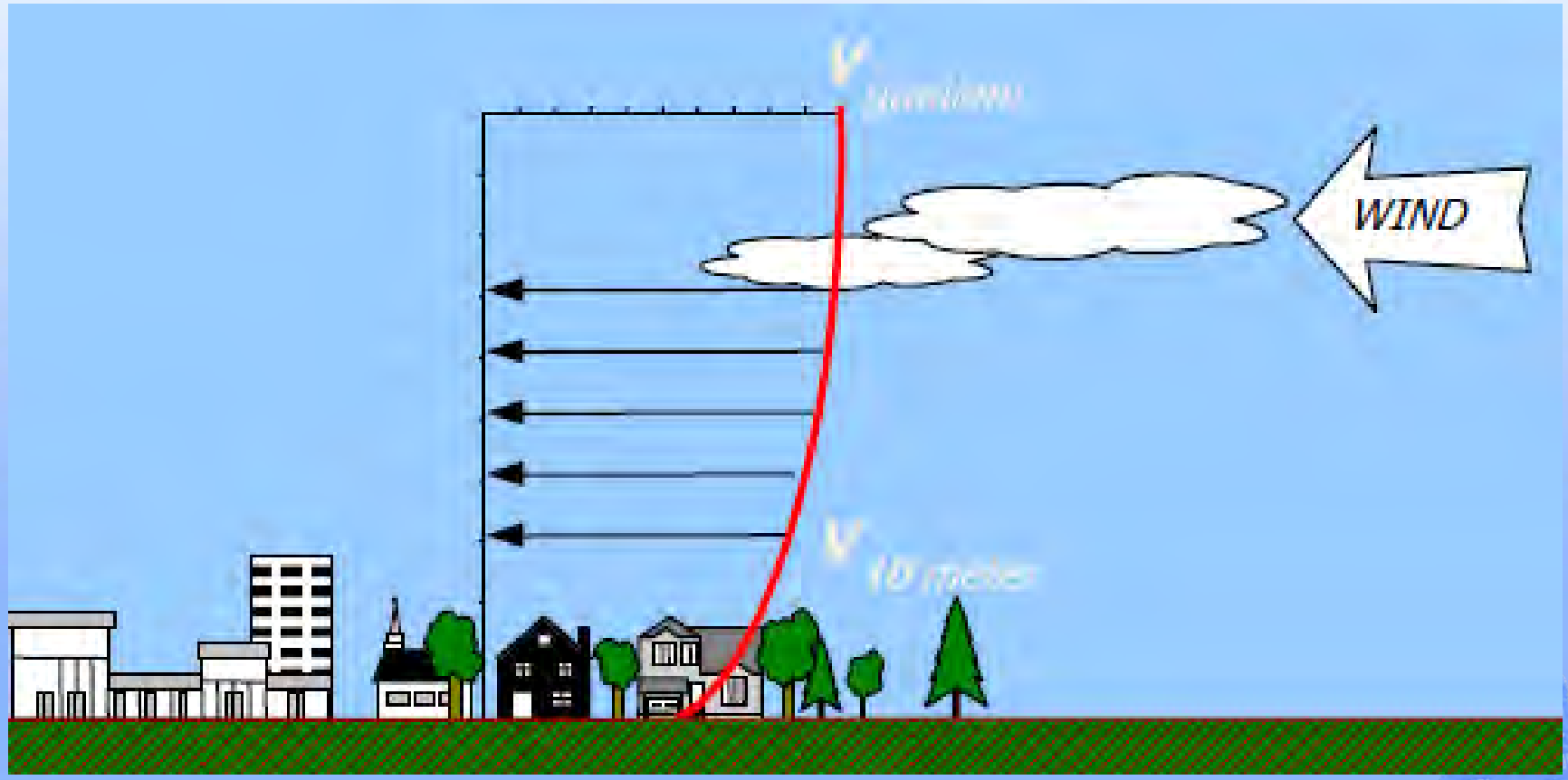
•Parametric Model

•Numerical Model



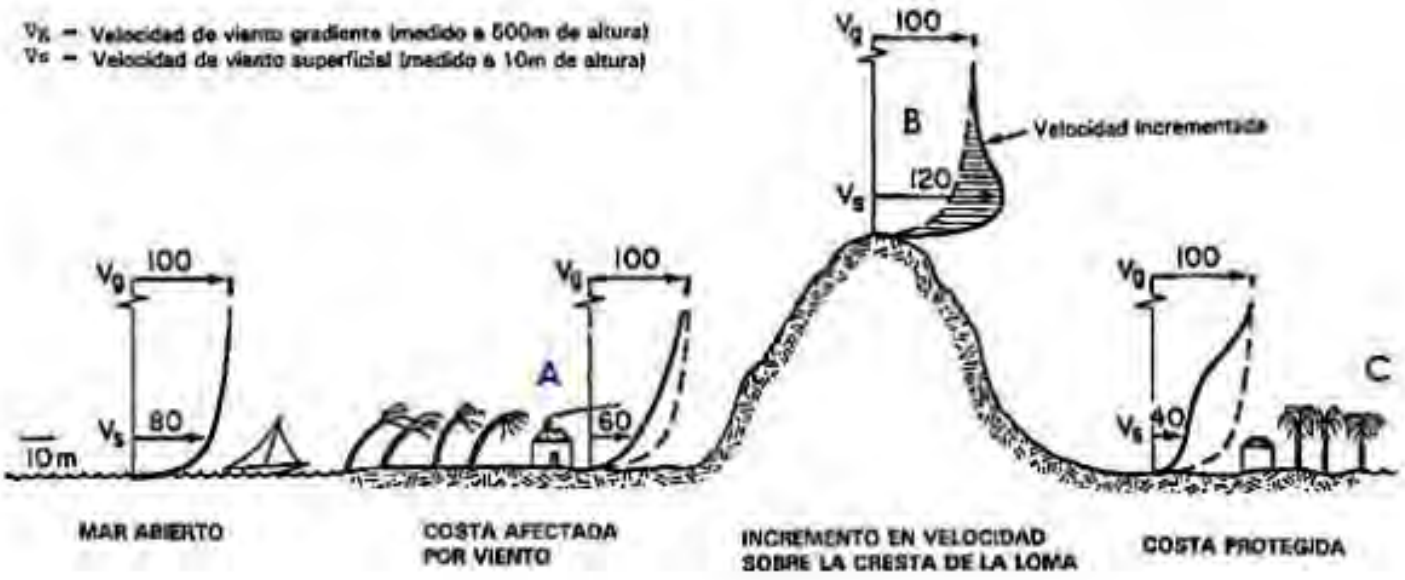


3.2 Case 2: Parametric Wind Model

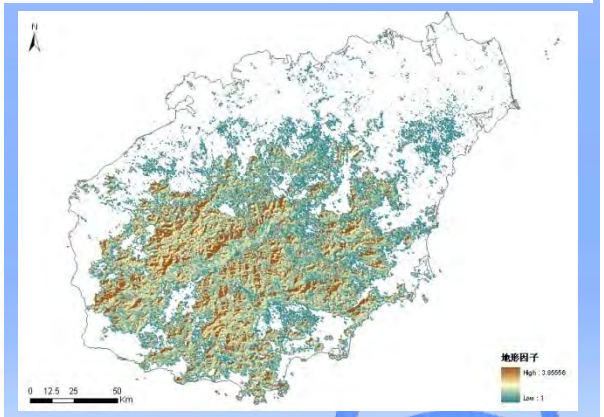


- **Boundary Layer Model**: Estimation of the surface mean wind speed adjusted from gradient mean wind speed
- **Key Input**: Surface roughness length, determined from LULC data.

3.2 Case 2: Parametric Wind Model



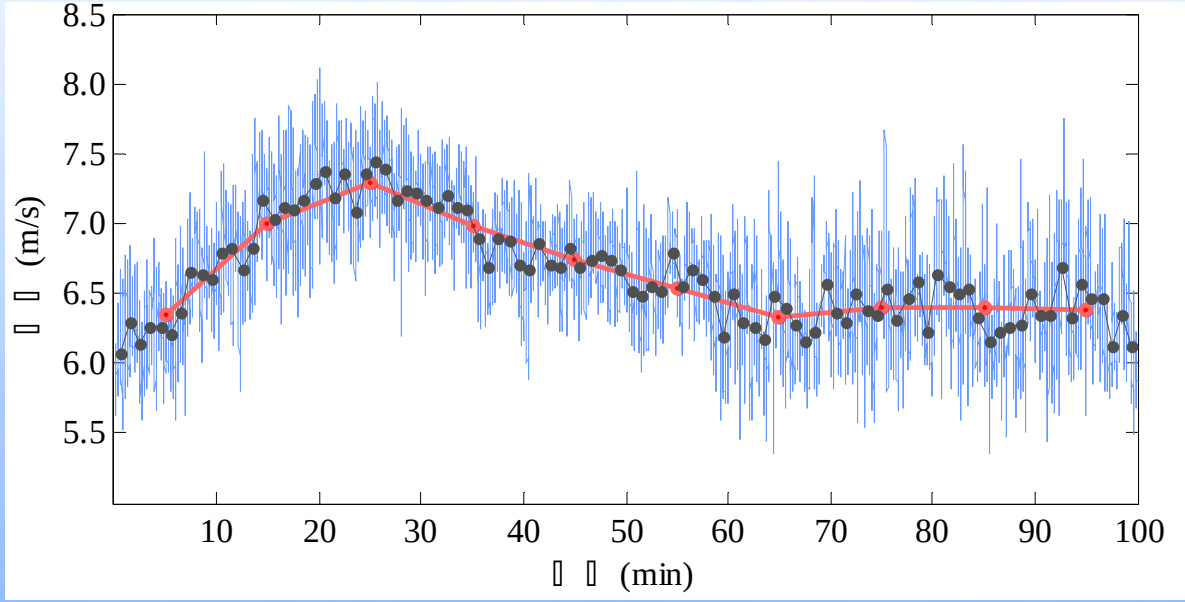
(ERN-Capra, 2013)



Directional Topographic Effect

3.2 Case 2: Parametric Wind Model

Gust Factor



10min mean wind speed

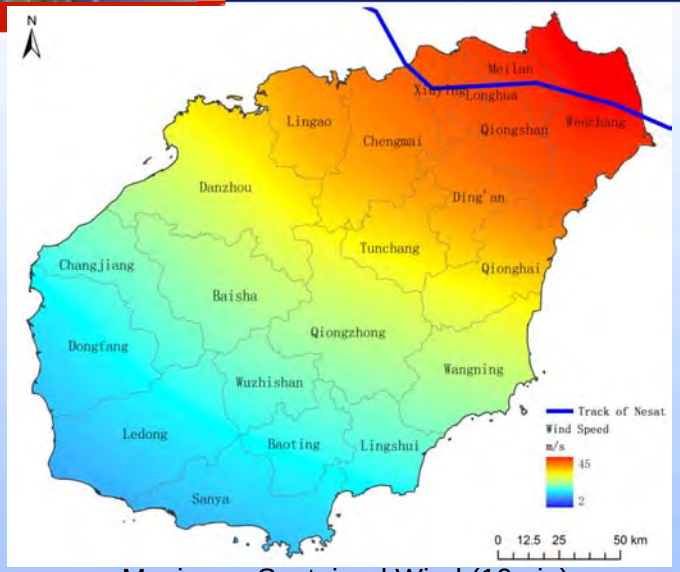
1min mean wind speed

Gust Factor Definition:

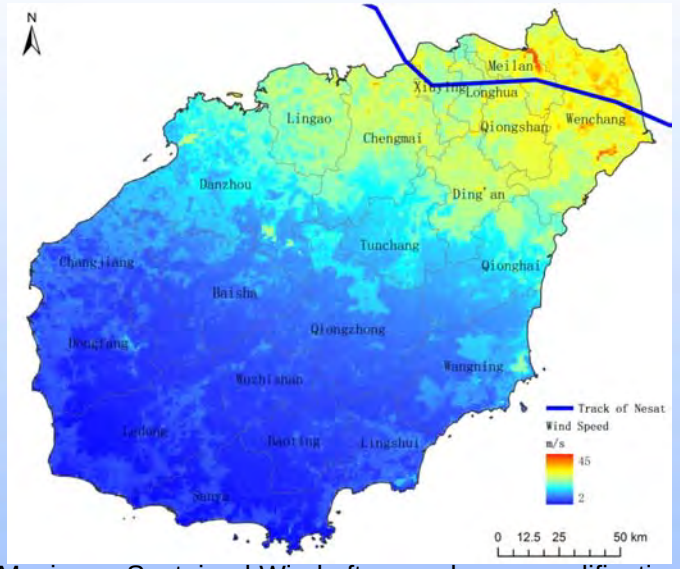
$$G_{\tau,T_0} = \frac{V_{\tau,T_0}}{V_{T_0}}$$

Example: Set τ=3 s, T_0=10min, get $G_{3,600}$

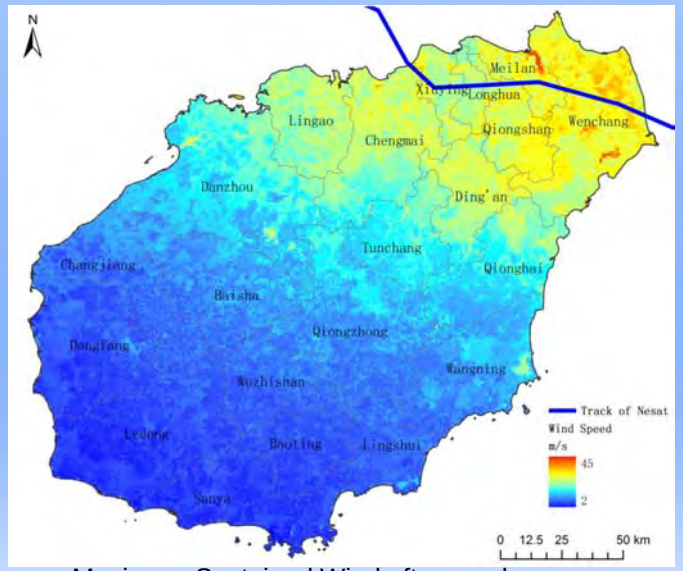
3.2 Case 2: Parametric Wind Model



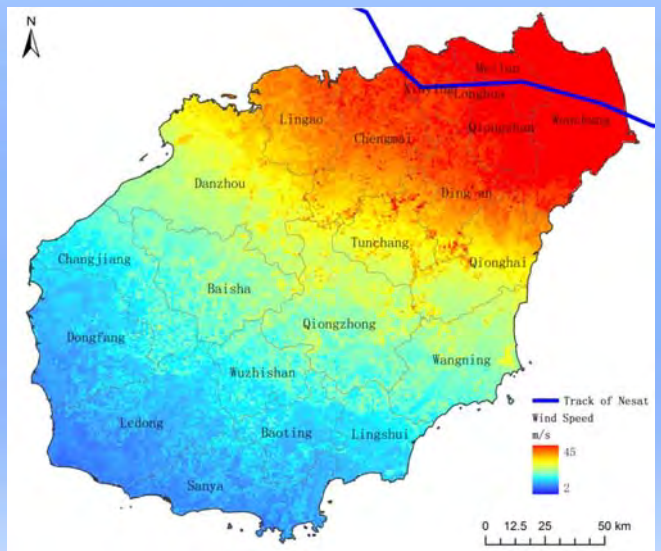
Maximum Sustained Wind (10min)



Maximum Sustained Wind after roughness modification



Maximum Sustained Wind after roughness, and topographic modification

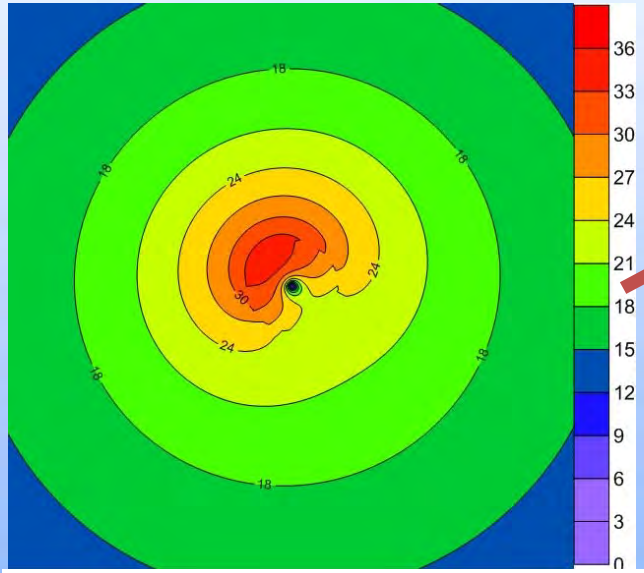


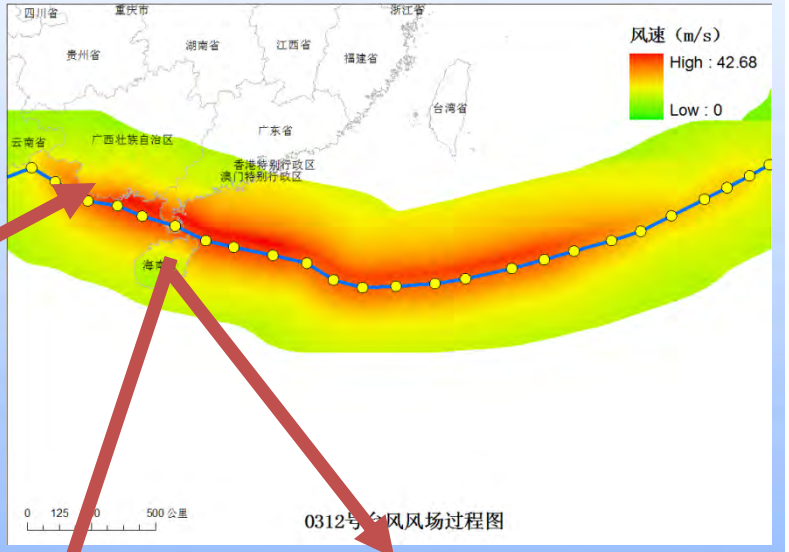
Gust Wind (3s) after modification of roughness, topographic gust factor

3.2 Case 2: Parametric Wind Model

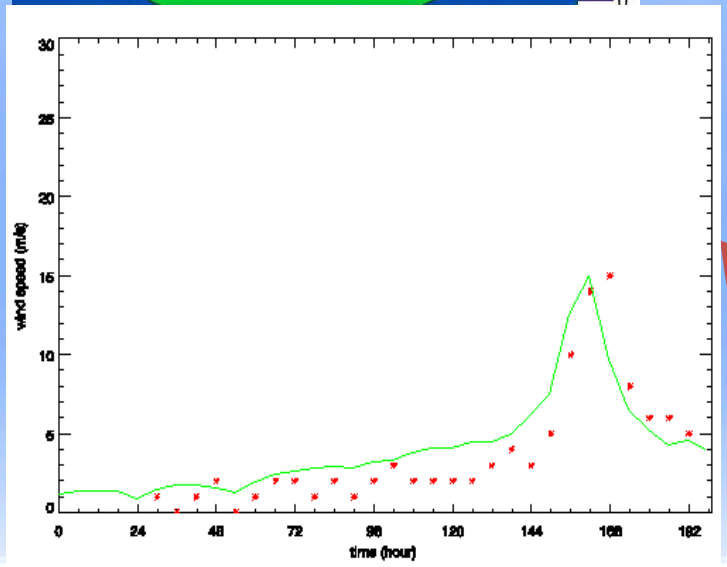
Output and Verification

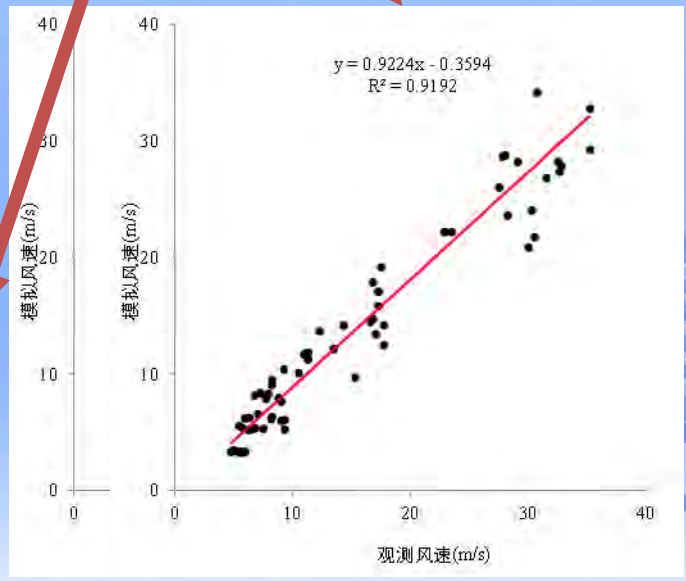
Modeling of instantaneous wind field to wind swath





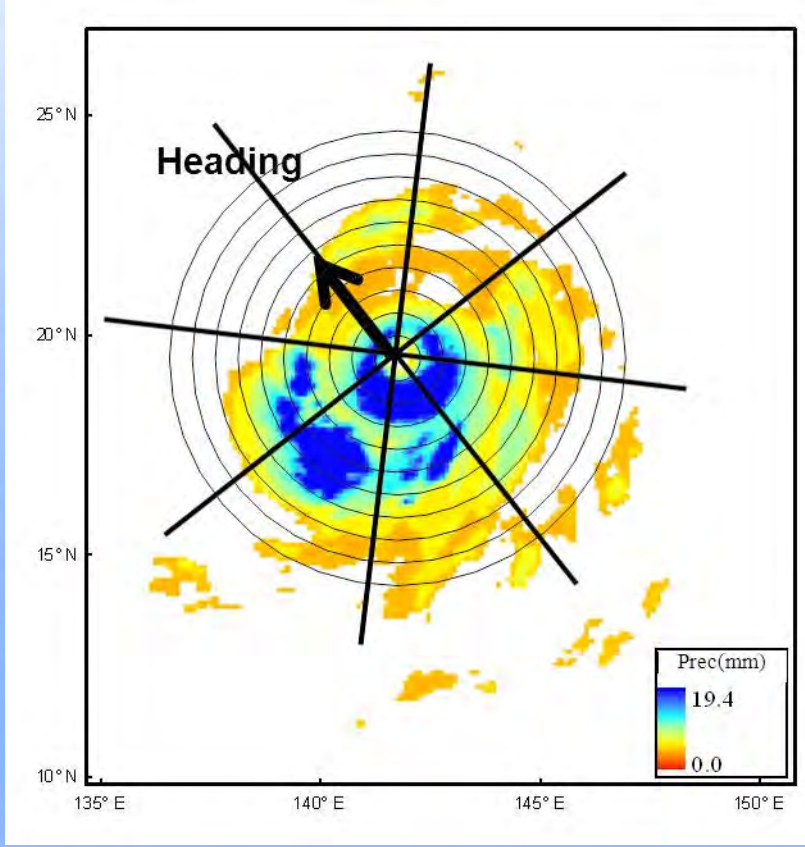
Model verification using observation data





3.2 Case 2: Parametric Rainfall Model

Conceptual Model of Typhoon Rainfall Structure



FY-2C 1-hour PRE
rainfall rate at 2009-09-16 14:00UTC

- TC key parameters

Intensity (MWS，P_{min}）
Position (lon, lat)
Translating speed and direction

- Underlying surface conditions

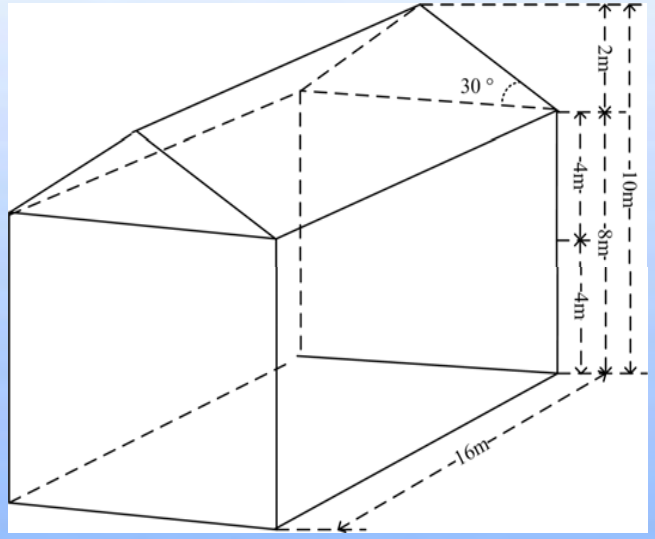
topographic condition
(DEM, slope aspect, etc.)
SST
land-sea distribution

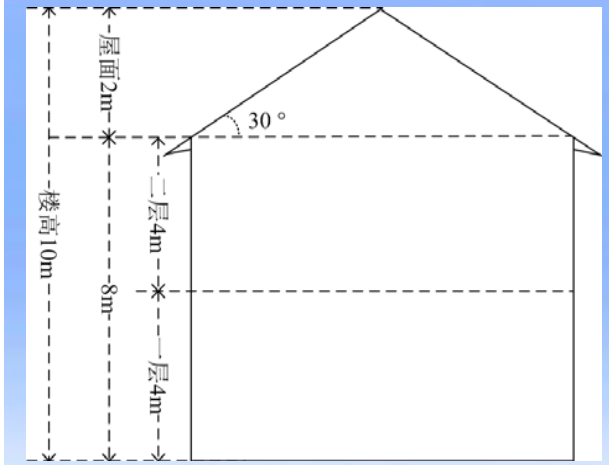
- Environmental variable and general circulation

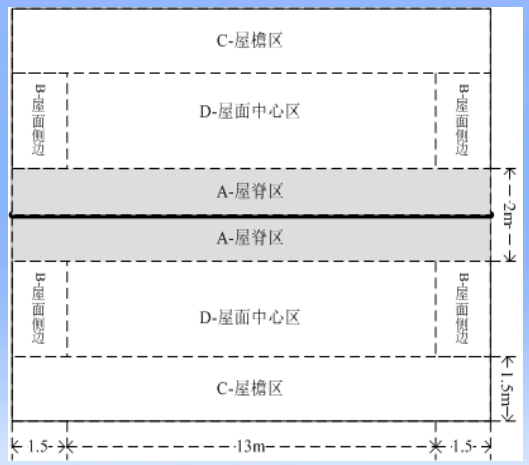
Vertical Wind Shear
Moisture and water vapor transport
westerly trough
easterly wave

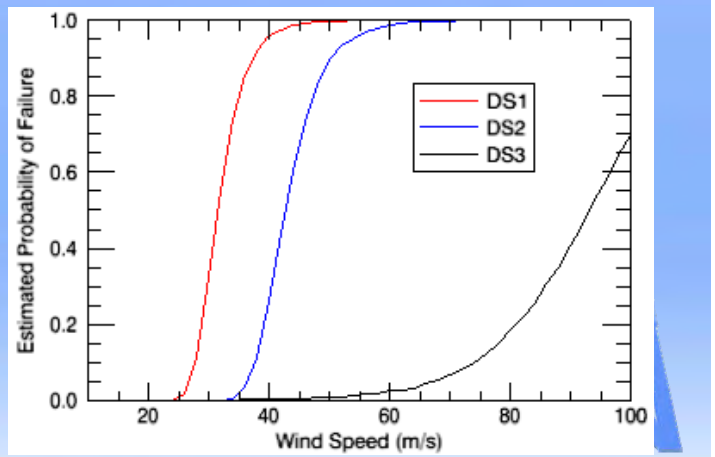
3.2 Case 2: Building Vulnerability Model

Wind Load & Resistance: Example of Rural Residential Building in Coastal Area of China



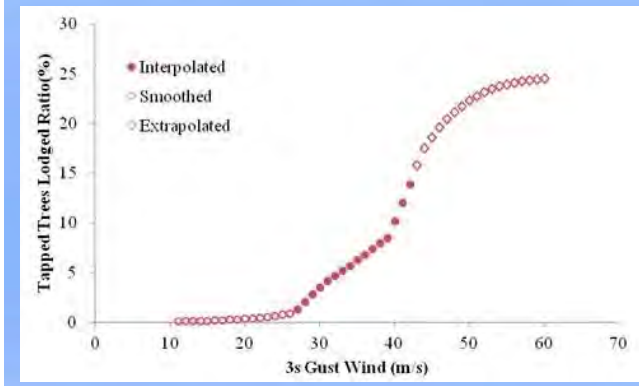


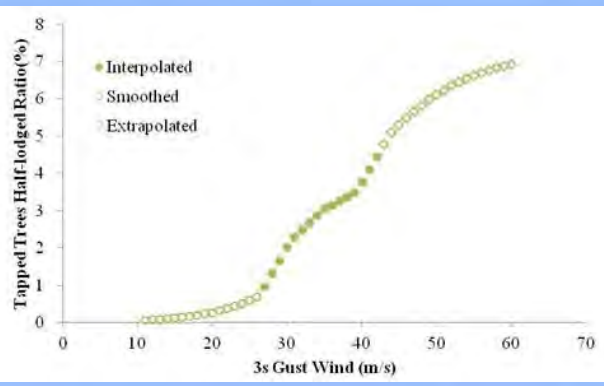


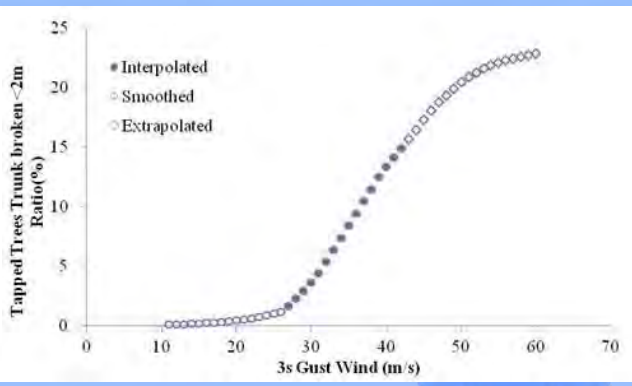


3.2 Case 2: Rubber Tree Vulnerability Model

Empirical Vulnerability Curve: Example of Rubber Tree to Wind in Hainan Island







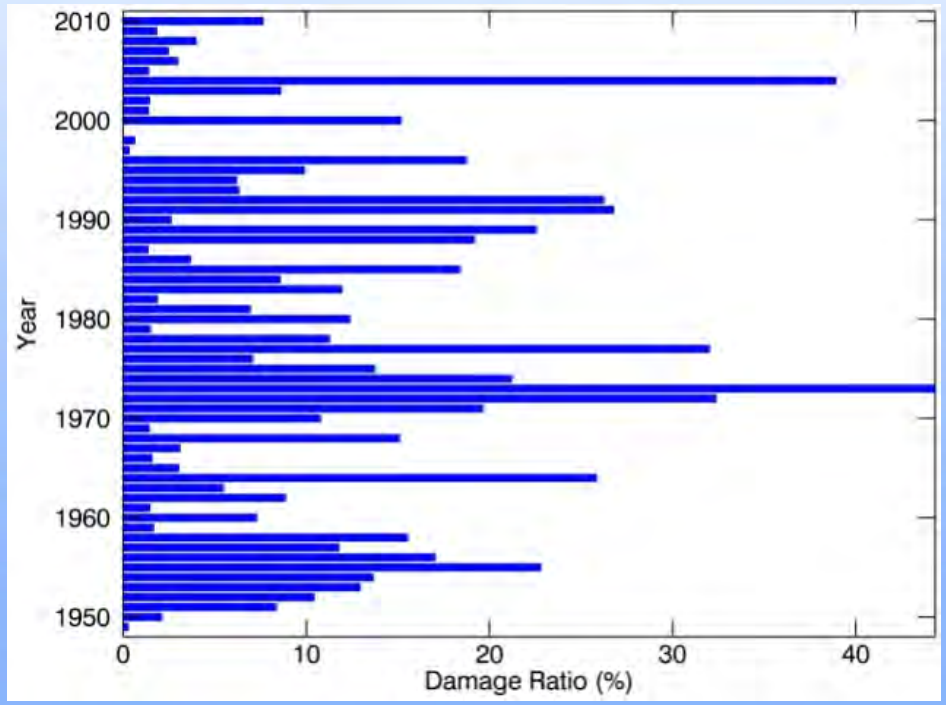
Totally Destroyed **Serve Damage** **Moderate Damage**

Output of Loss Probability Model

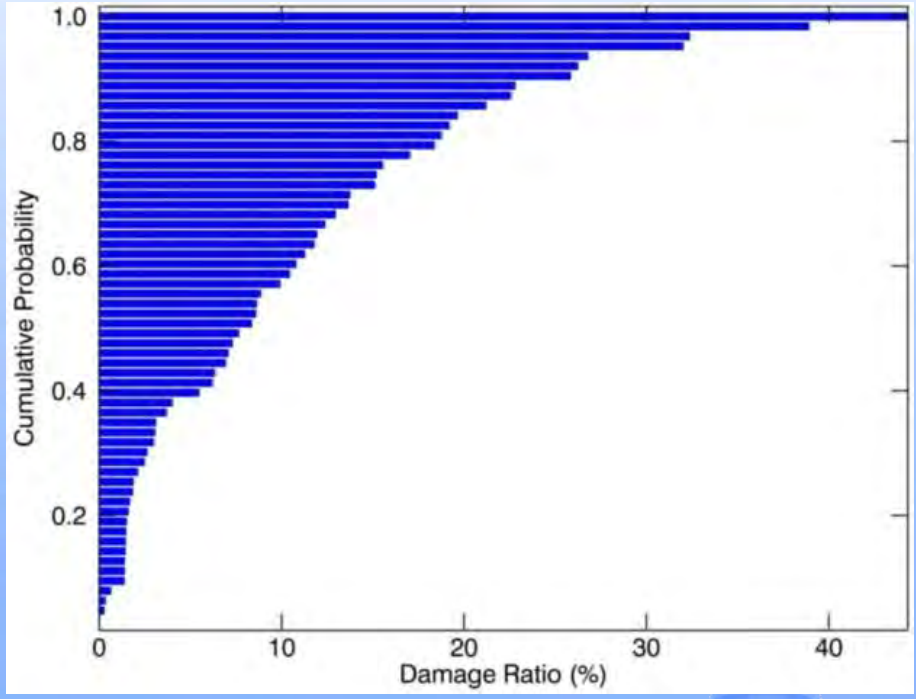
1. Annual Exceedance Probability (AEP)
2. Occurrence Exceedance Probability (OEP)
3. Exceeding Probability Curve (EP)
4. Fine-resolution Risk Mapping (30m /1000m)
5. Risk of Insured Property (Deductibles & Limits)
6. Portfolio Management

3.1 Case 2: Loss Probability Modeling

- Loss Distribution of an Example Farm

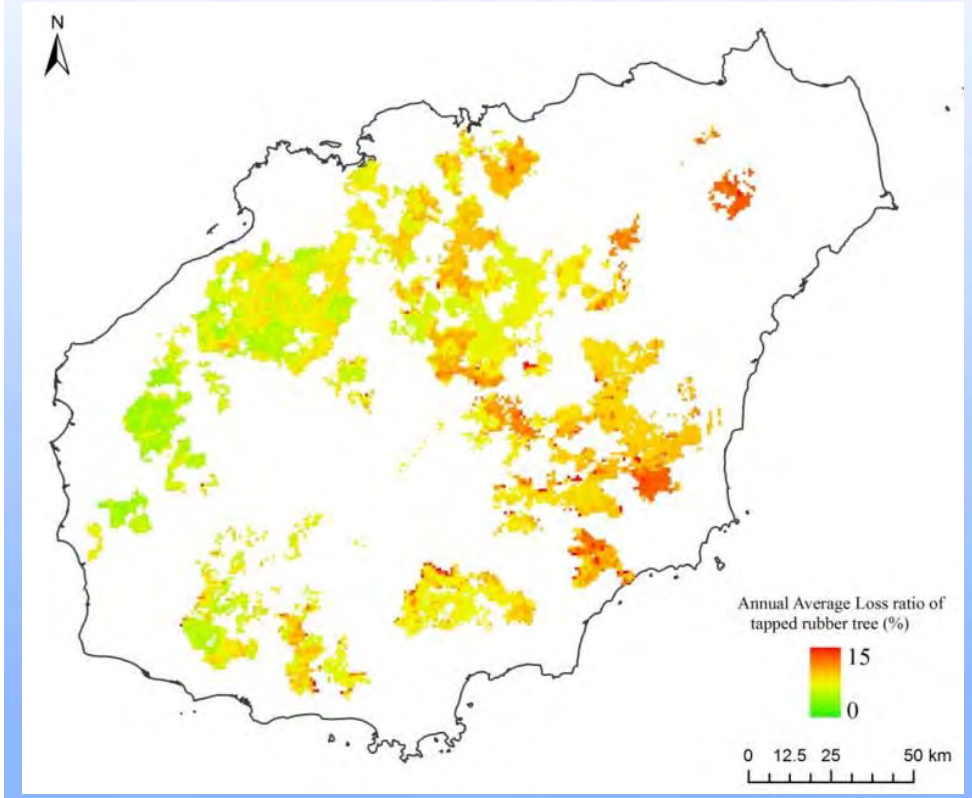


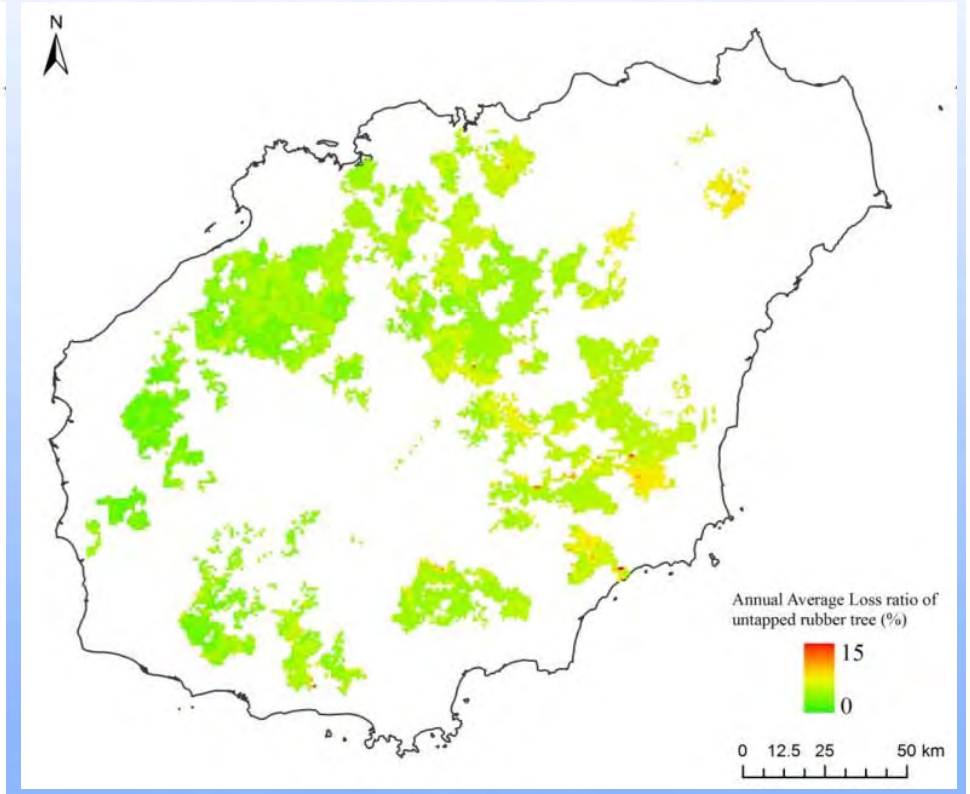
Loss Events



Cumulated Distribution Probability of Loss

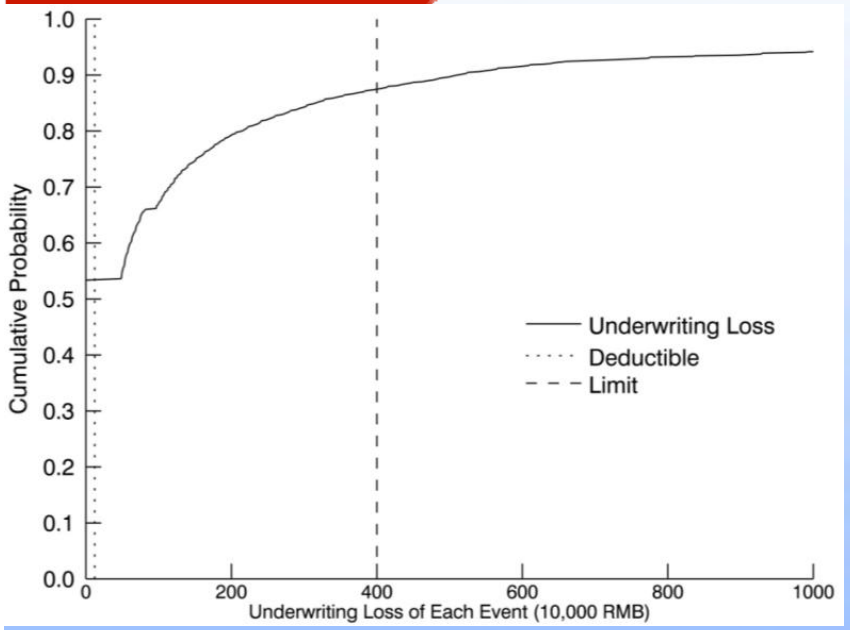
3.1 Case 2: Insurance Rate Calculation

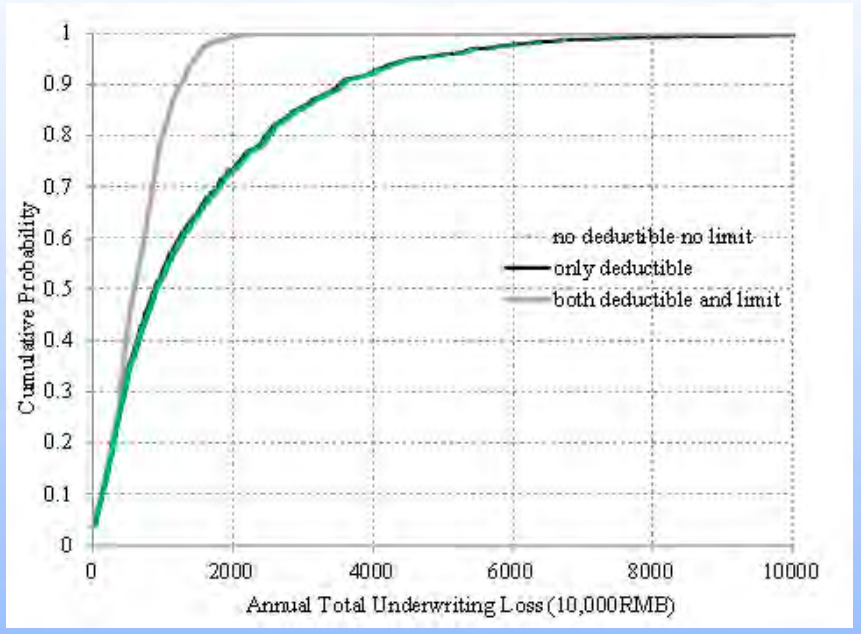


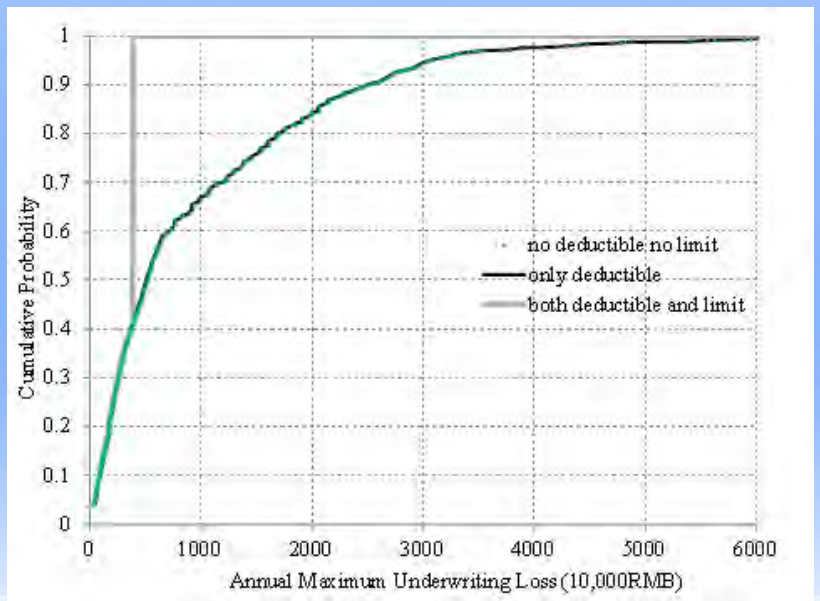


Annual Aggregate Loss of Rubber Tree
(Pure Insurance Rate)

3.1 Case 2: Insurance Portfolio







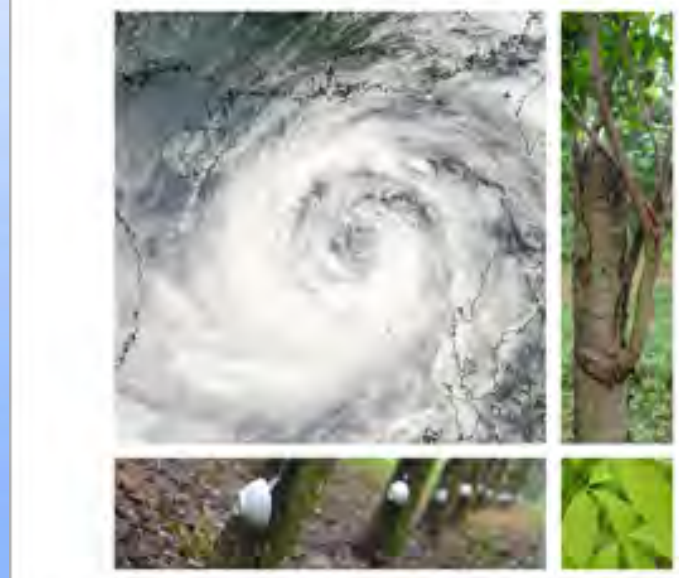
Cat Model can Help Understand the Risks of Complicated Portfolio

3.1 Case 2: Payouts Triggered by Wind Speed

- **Benefits of Parametric Insurance**
  - No moral hazard.
  - No adverse selection
  - Lower operating costs
  - Transparency
  - No cross-subsidization
  - Immediate disbursement.
  - Reinsurance and securitization.
- **Stochastic Event and Wind Field Model**
  - Basis risk
  - Model bias
  - Technical limitations of insurable hazards
  - Education

3.2 Case 2: Parametric Typhoon Insurance

A Parametric Insurance Project (Research and Pilot)
Supported by Ministry of Finance of China



Output 3: Final Report

China Economic Reform Implementation Project (TCC5)

Rubber Tree Index-based Typhoon Insurance in Hainan Province: Research and Pilot

Research on Typhoon Wind Risk Modeling for Rubber Trees in Hainan Province

Final Report

Research on Typhoon Modeling for Rubber Trees in Hainan Province

Academy of Disaster Reduction and Emergency Management

Beijing Normal University

December 2013

3.2 Case 2: Many Application Potentials

- **Applications in Insurance Industry**
  - Index-based Wind Risk Insurance of Rubber Tree in Hainan Province (World Bank Project 2013)
  - County-level Reference Insurance Rate by CIRC
  - Supporting Multi-peril Property Insurance of PICC

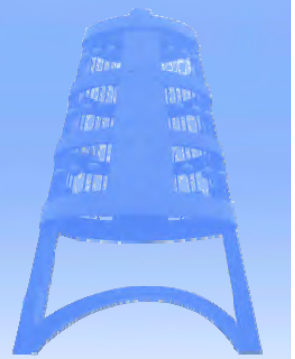
- **Stochastic Event and Wind Field Model**
  - Stochastic event sets + wind field model + numerical storm surge model (ADCIRC) → Mapping coastal flood hazard (flooding areas of various return periods) → Land Use Planning
  - Synthetic tracks + ADCIRC → mapping of Probable Maximum Storm Surge (PMSS) → CBDM → Evacuation Planning
  - Wind field model + numerical wave model (SWAN) → Wave Risk

- **Stochastic Event and Rain Field Model**
  - Stochastic event sets + wind field model + runoff model → mapping riverine flood risk

3.3 Case 2: Welcome to Join OpenCyclone!

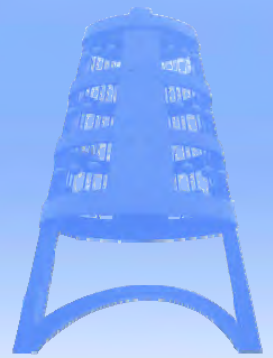
- **Cross-Platform: Windows, *NIX, Mac**
  - ✓ DB & GIS: PostGIS
  - ✓ Model library: Java
  - ✓ Desktop System: Java
  - ✓ Cloud (B/S): user only need provide exposure data

- **Development Plan (3 products)**
  - CycloneRisk
  - CycloneWarning (proto-type)
  - CycloneLoss



3.3 Other Risk Assessments

- **Ministry of Civil Affairs**
  - Multi-hazards, focusing on loss
- **Ministry of Water Resource, Ministry of Agriculture**
  - Floods, Droughts
- **China Earthquake Administration**
  - Earthquakes
- **Ministry of Land Resource**
  - Geological Disasters
- **China Marine Administration**
  - Storm Surge, Wave, Tsunami, Sea Ice, Sea Level Rise
- **Community-Level Risk Assessment**
  - Contingency Planning
  - Evacuation



4. Discussions

1. Disaster Mitigation

- Mainstreaming and Planning
- Cost-benefit Analysis / Budget Application
- Priority Analysis

2. Regional Risk Finance

- Regional Catastrophe Fund?

1. Regional Emergency Response

- Regional Emergency Response Fund?

Thank you for your attention

Weihua FANG

weihua.fang@bnu.edu.cn

•Ph.D., Associate Professor

Academy of Disaster Reduction and Emergency Management, MoCA & MOE, China

Beijing Normal University