Strong Motion Observation System and Project Plan in China

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Contents

1. China Digital Strong Motion Observation Network
2. Demonstrative Earthquake Early Warning System under Construction
3. Development Program in the Next 10 Years
4. Strong Motion Records from the M8.0 Wenchuan Earthquake

Contents

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Distribution of Strong Motion Network Stations in China

About 3,000 stations and arrays under the management of CEA

More than 1,000 stations under the management of other institute and enterprise

Most of these stations were built in the "Strong Motion Network Project in China" (2003-2008)

Distance between 2 stations:

about 25 – 50 km in most regions

And   about 5 km in Beijing area

Legend

▲ Existing Station
▲ Station in Construction
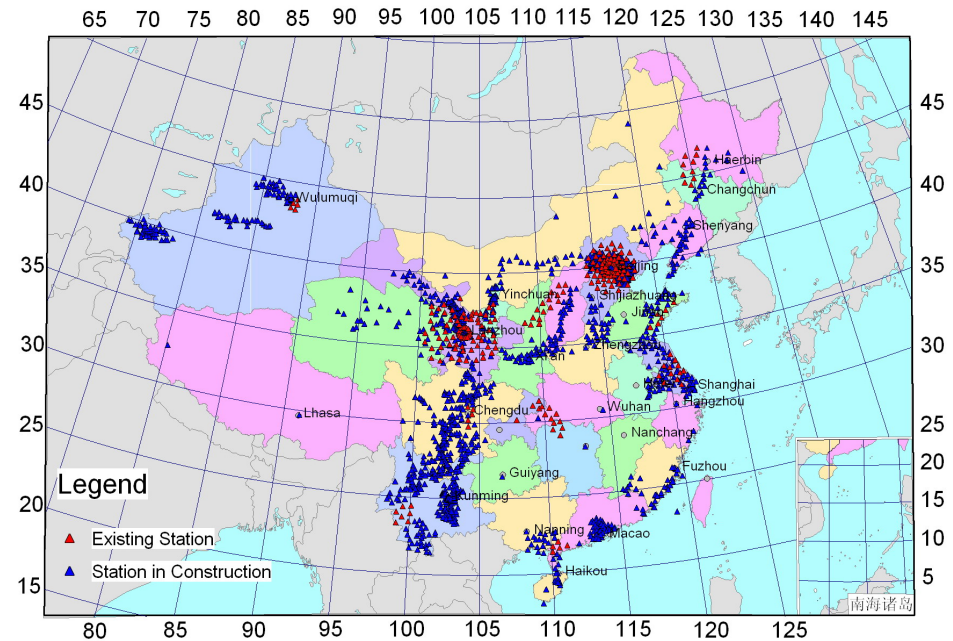
Different instrument houses for the stations


Instruments in the station

Intriduce the Project of CEA in a Five Years (2003-2008)

- **Because of the large differences between China and some countries, USA, Japan in G-M-O before 2000**
- **CEA proposed a big project plan to build a digital strong motion observation network system**
- **The project was approved by China government in 2002**
- **For the project, total investment amount is about 370 million RMB (about 60 million USD)**

How to arrange the project?
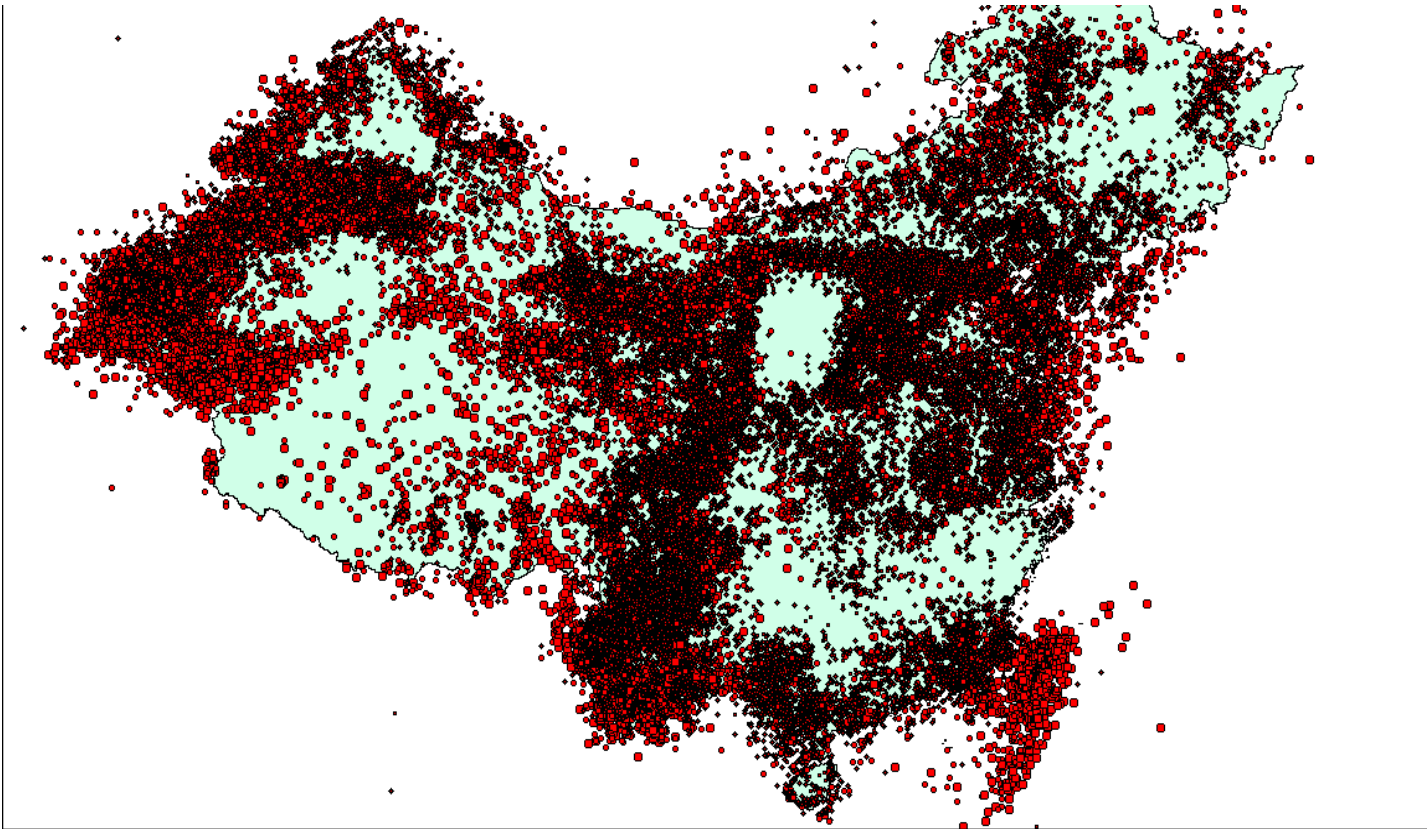   must consider an effective distribution of the observation points

Consider the Background of Earthquakes in China
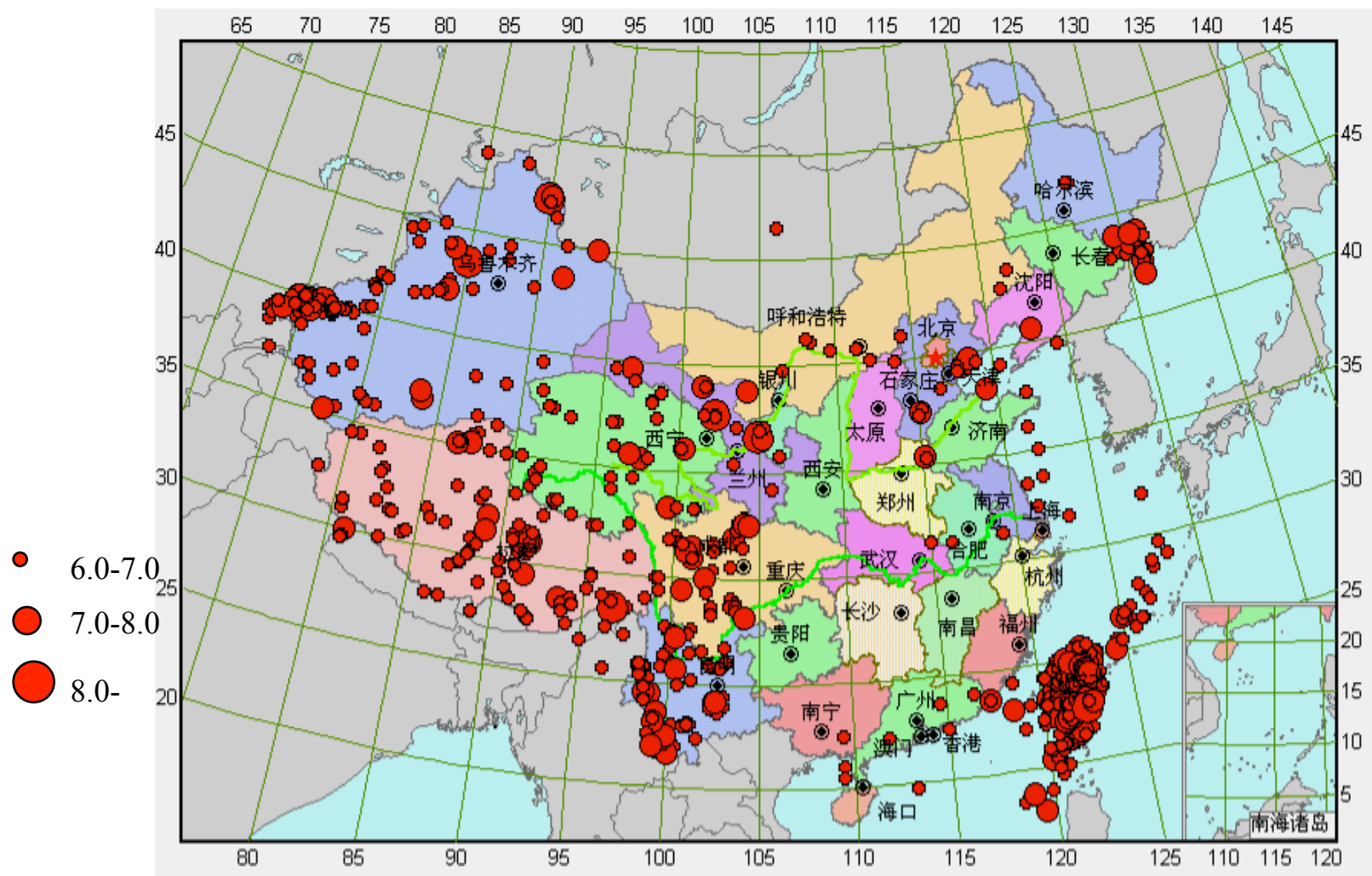

Strong earthquake distribution in China (M>= 6.0)

Background of Earthquakes in China

Earthquakes occurred were non-uniform in space

**Recorded earthquake distribution (including M<= 4.7)**

Based on the analysis results of seismic tendency,

21 main monitoring areas of strong earthquakes were divided in mainland (1995-2005)

8 first level and 13 second level

Wenchuan earthquake area
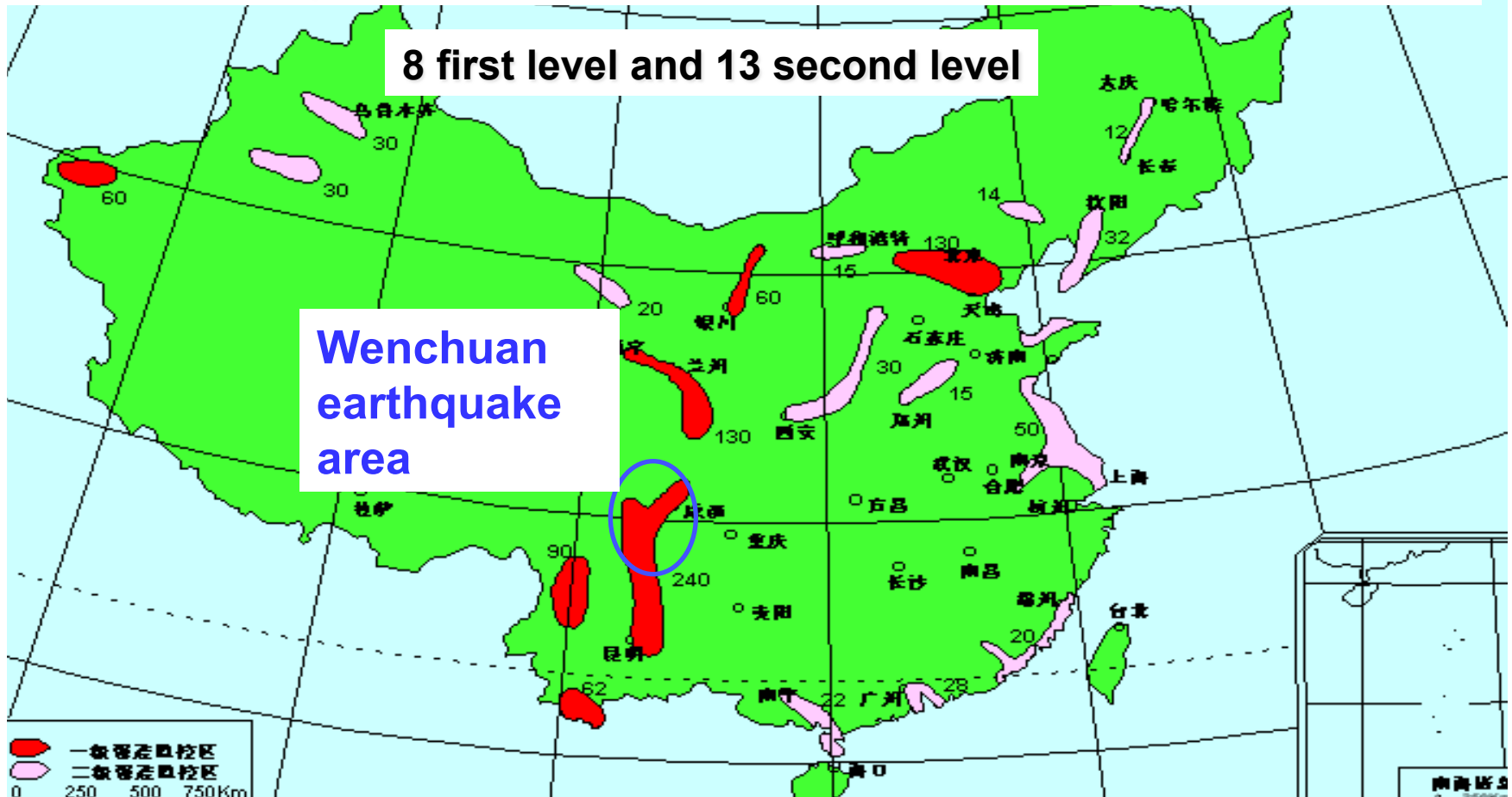
First level: bigger magnitude, higher probability

Second level: smaller magnitude, low probability
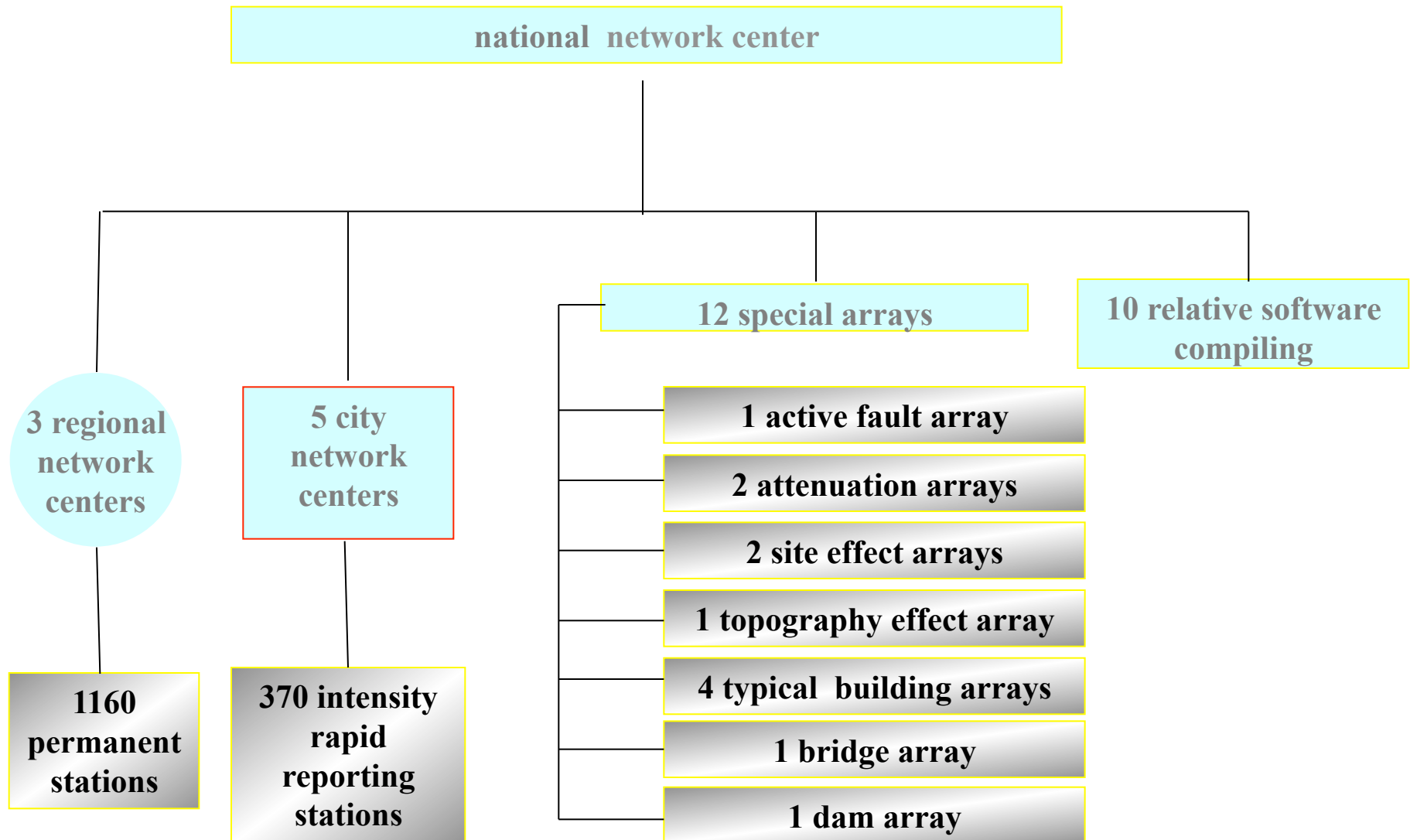
Distribution of strong motion network Stations
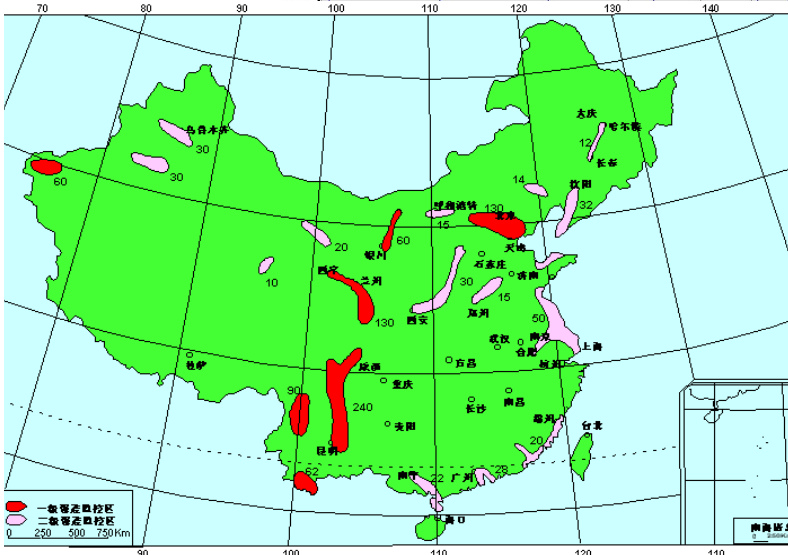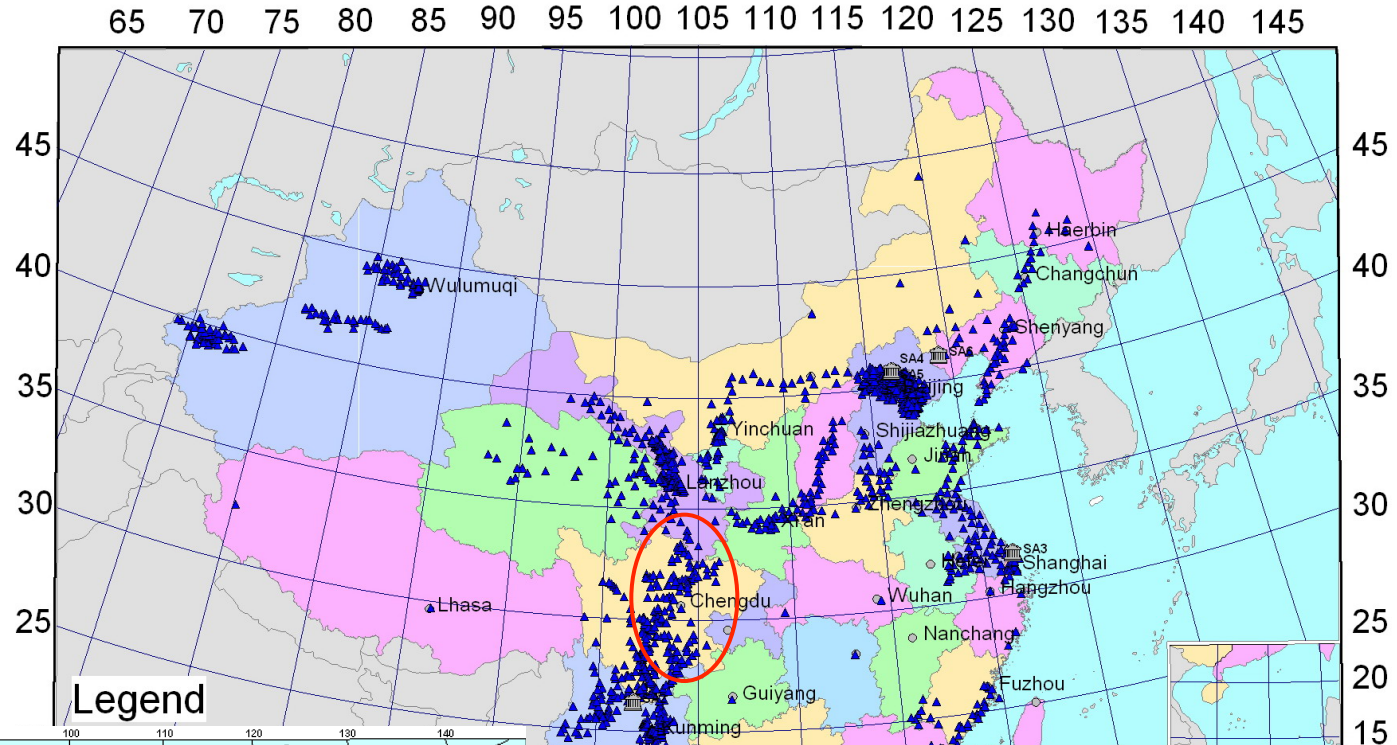
Target of the project was to control the density of stations in different areas.

Space between 2 stations is:

1. about **25km** in 8 first level monitoring areas
2. about **40km** in 13 second level monitoring areas
3. less than 10 km in 5 main cities for intensity rapid reporting

National Strong Motion Observation Network System

national network center

3 regional network centers

5 city network centers

12 special arrays

10 relative software compiling

1160 permanent stations

370 intensity rapid reporting stations

1 active fault array

2 attenuation arrays

2 site effect arrays

1 topography effect array

4 typical building arrays

1 bridge array

1 dam array

National and Regional Network Centers

1 national center and 4 regional centers
for the network management

Lanzhou

National center
Beijing regional center

Nanjing

Kunming
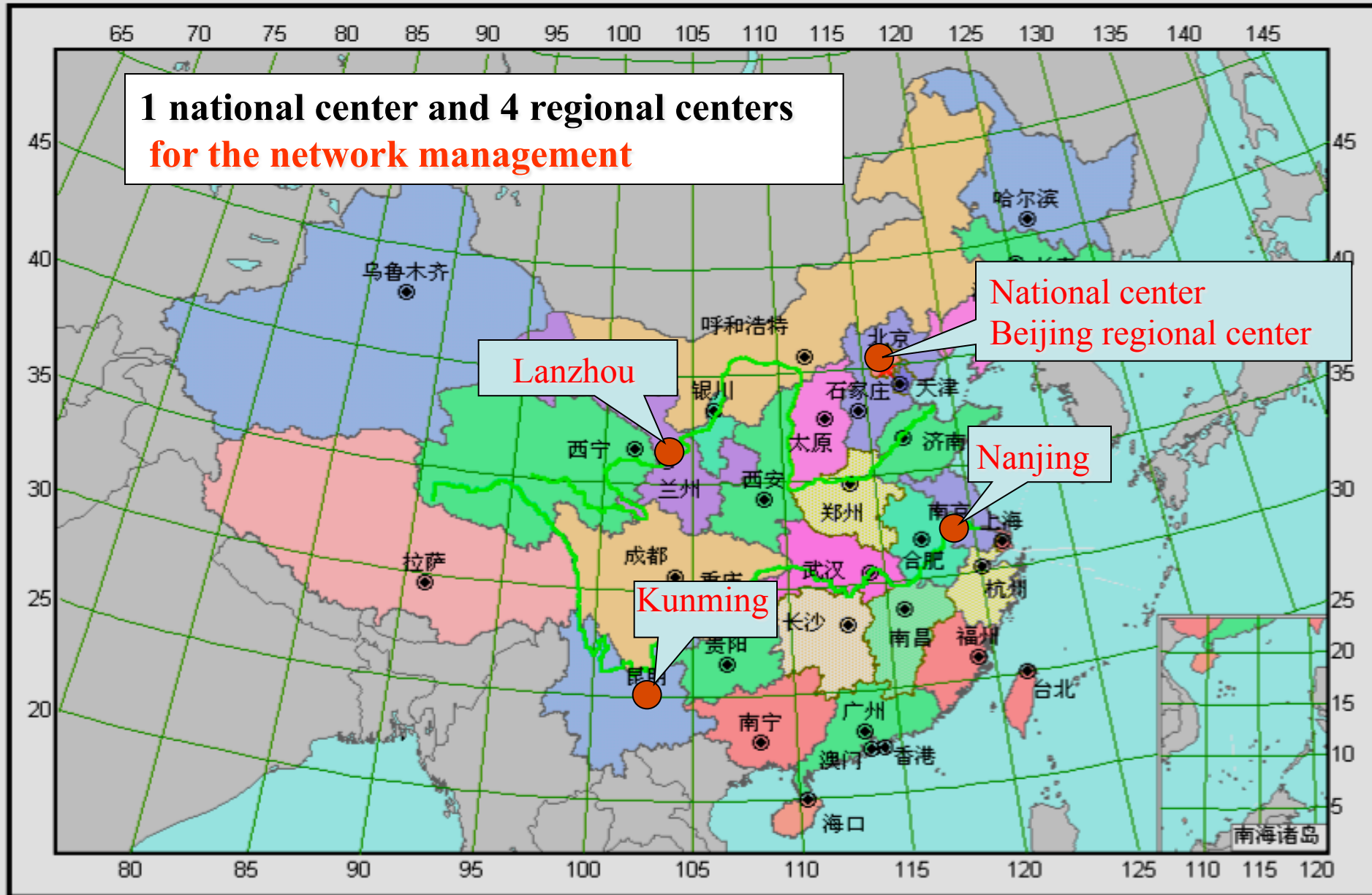
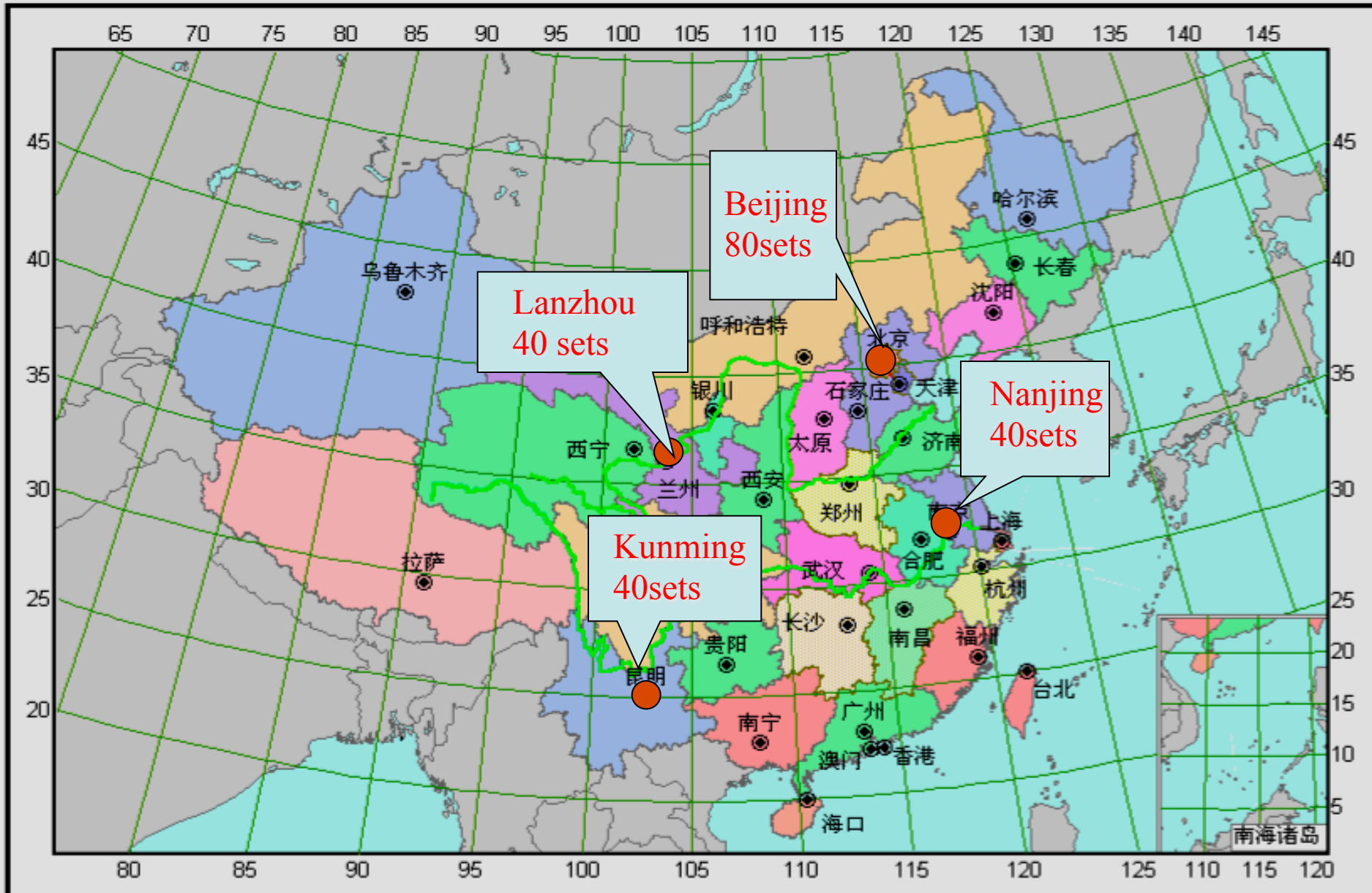# Intensity Rapid Reporting Network for 5 Cities
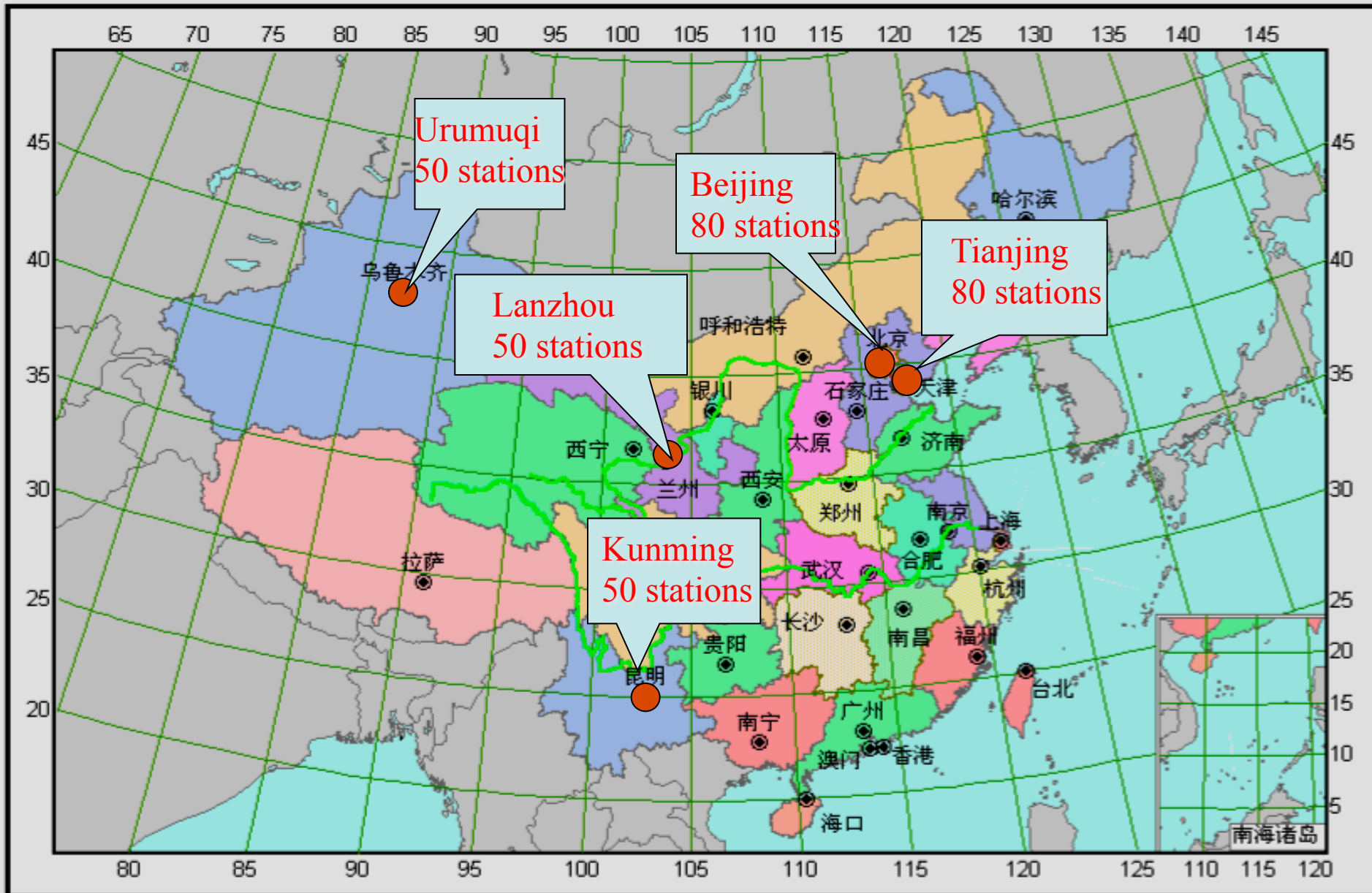
Beijing Intensity Rapid Reporting Network
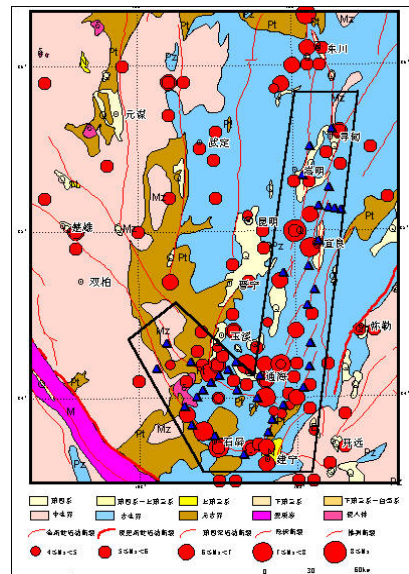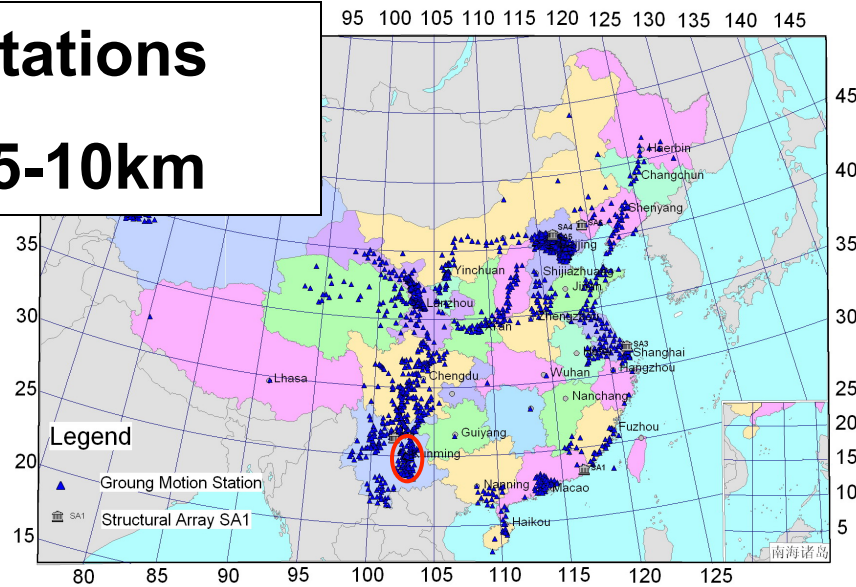
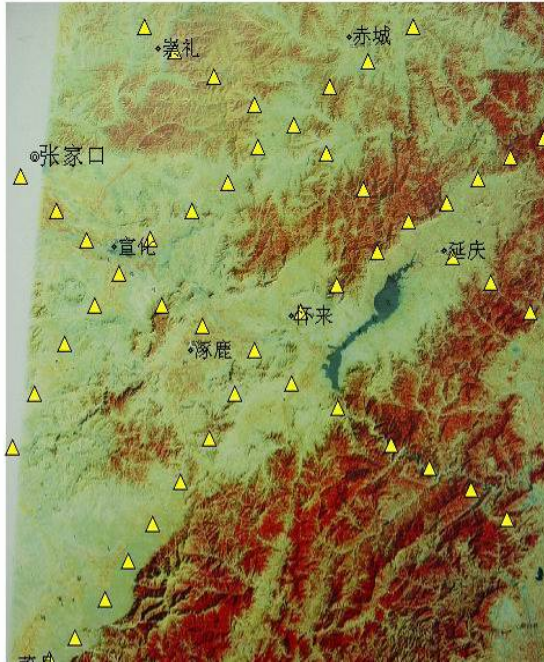**80 stations**
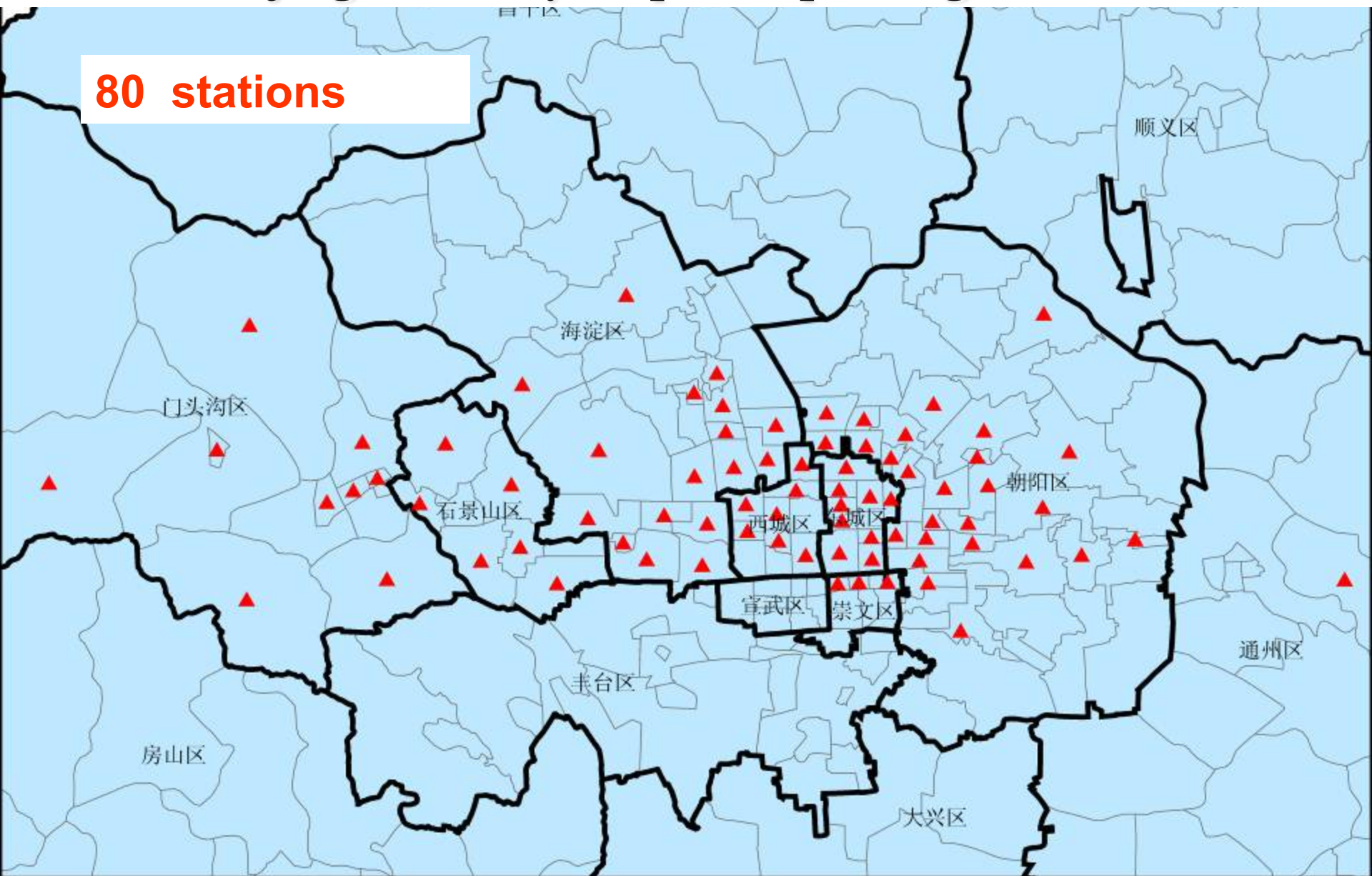
Mobile observation centers
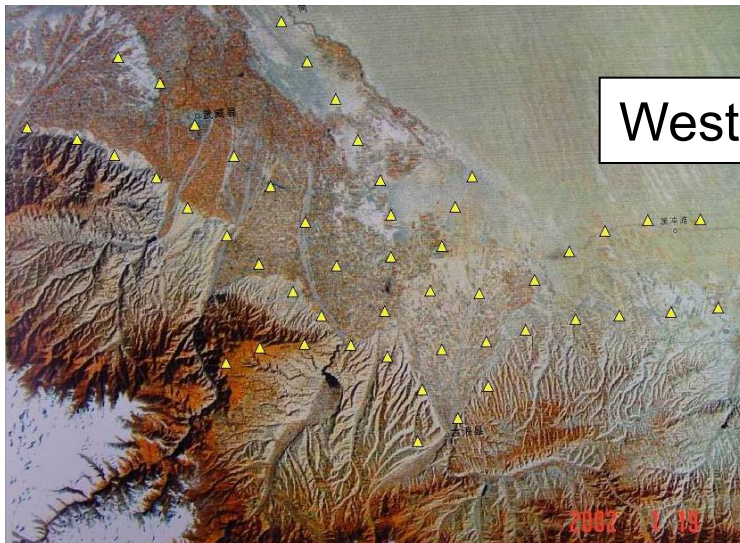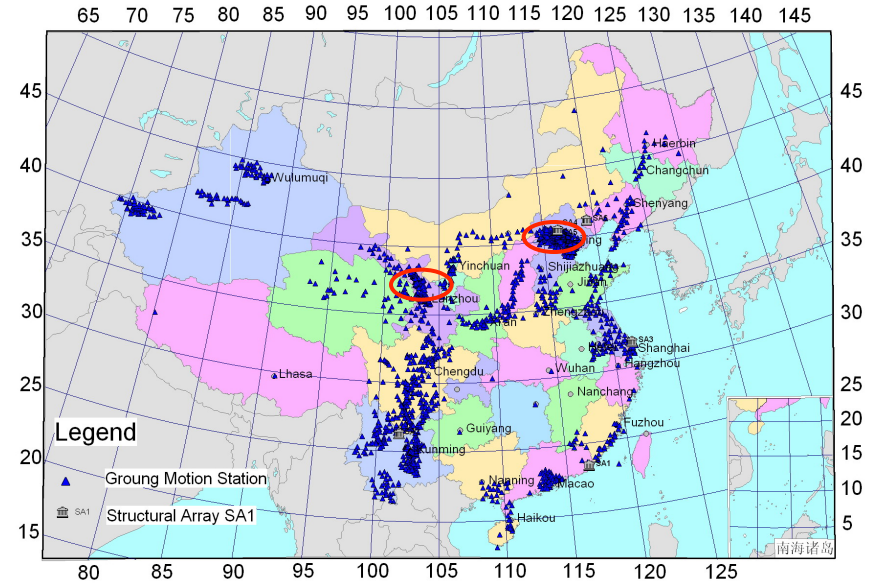
Near Fault Ground Motion Observation Array

30+20 stations

space: 5-10km

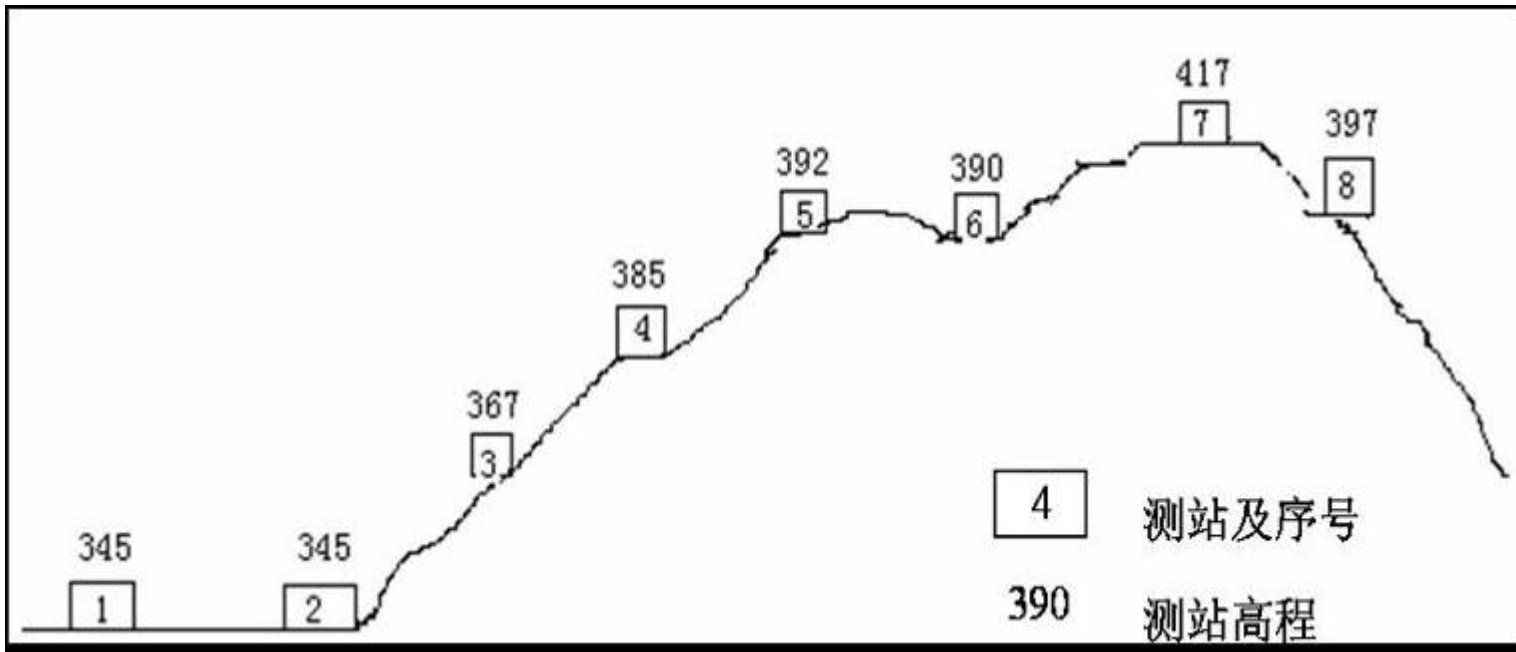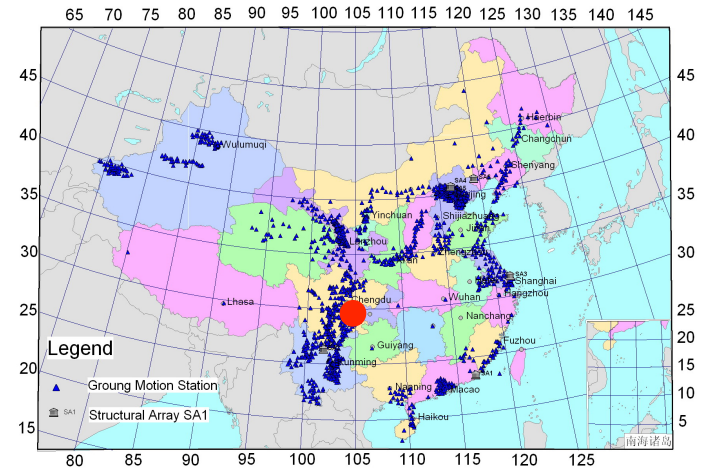# Ground Motion Attenuation Observation Array

East one

West one

50 stations in each array

space: 5-10km

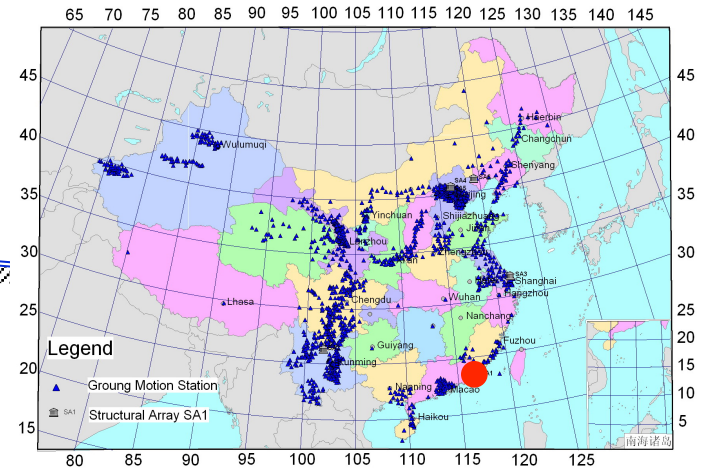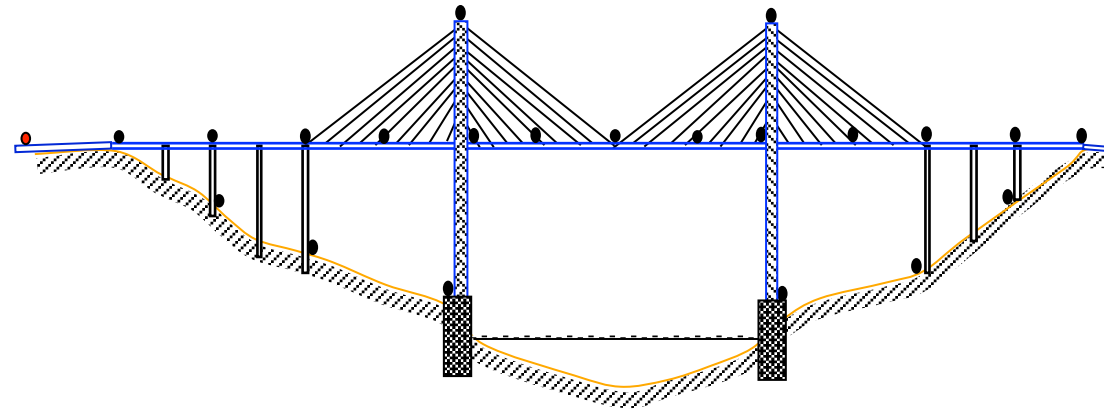# Site Effect Observation Array (east and west)

west array in Yunan

East array in Tangshan

8 points (3 comp.) for each

450m   460m   360m

1号测点   2号测点   3号测点   4号测点

基岩

soil layers

覆盖土层

-25m

-45m

-50m

-90m

▲ 地面加速度计

■ 井下加速度计

bedrock

Topography Effect Observation Array

In Sichuan

8 points (3 comp.)
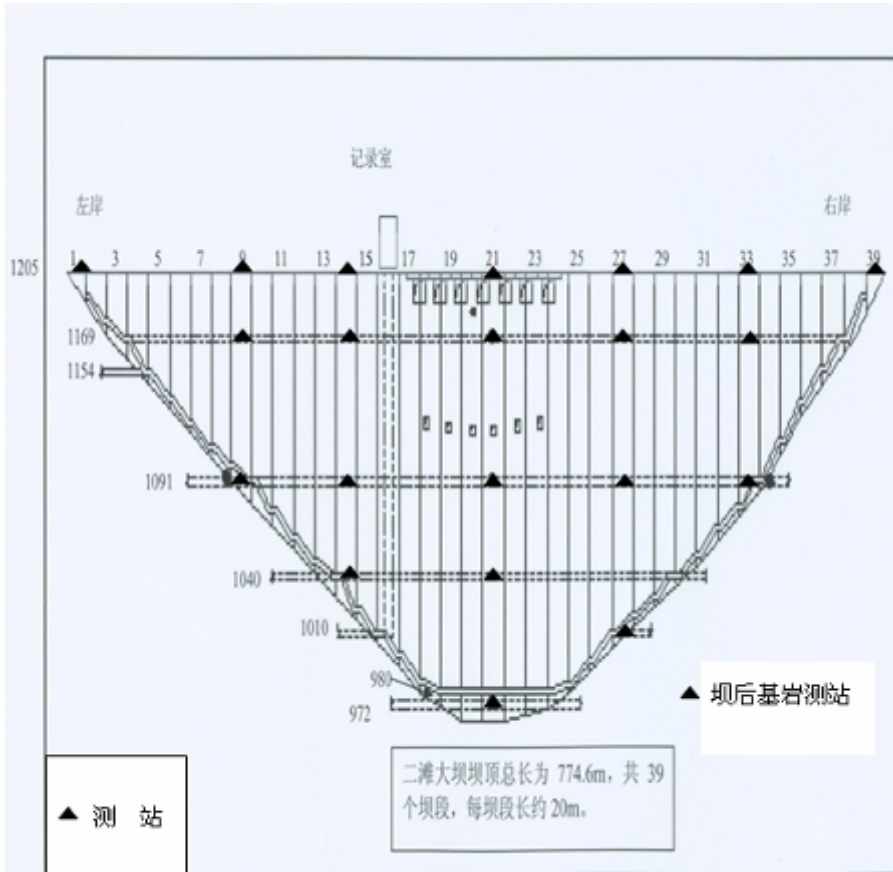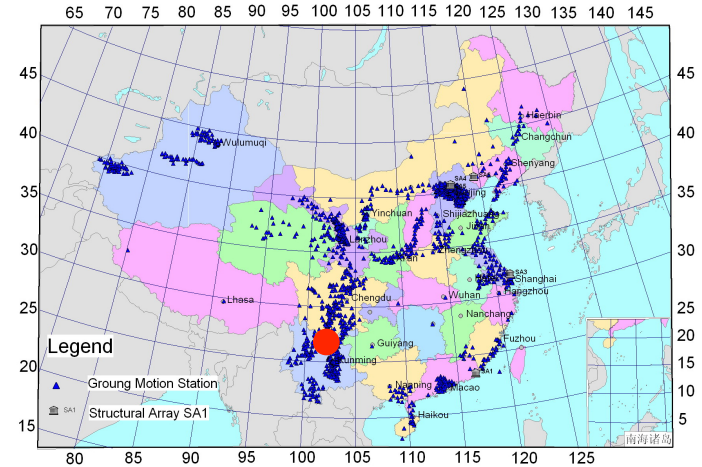
Bridge Response Observation Array

Dangshi bridge in Santou bridge Length is 3467m main span is 512m 23 points (3 comp.)
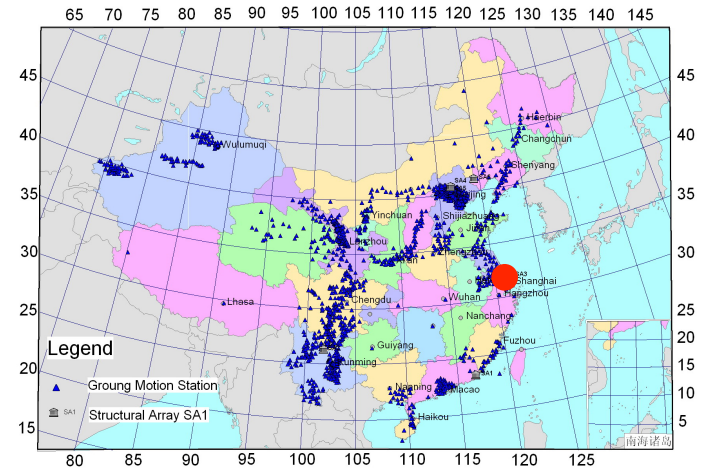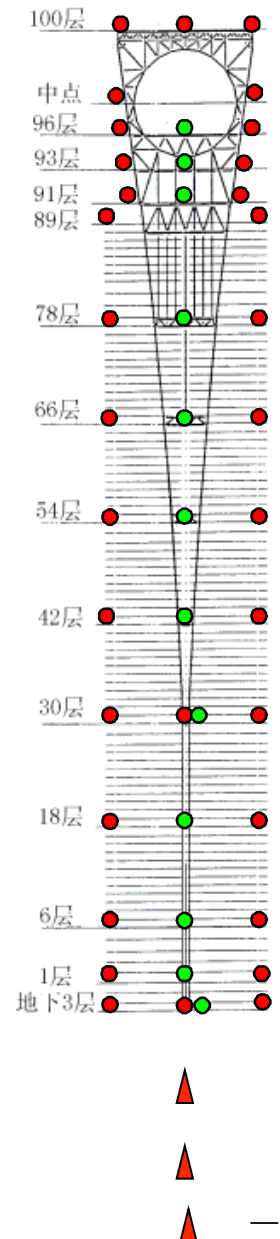
Dam Response Observation Array

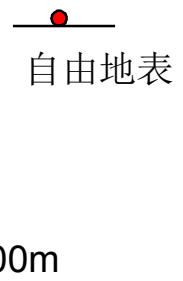**Ertan arch dam in Sichuan**

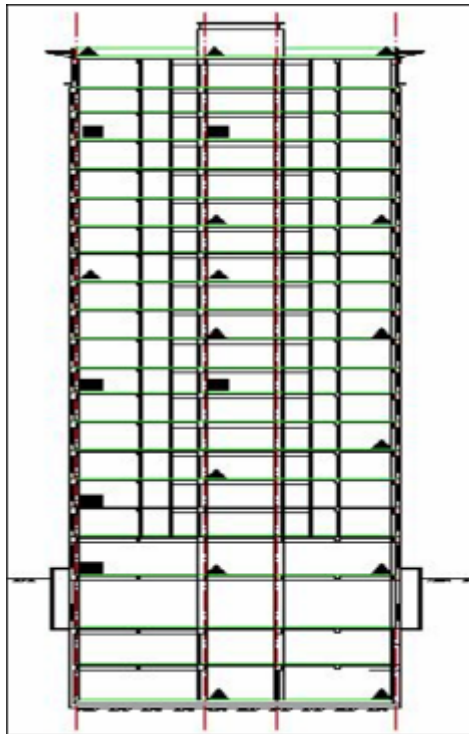**height is 240m**

22 points (3 comp.)

High-rise Building Response Observation Array

Shanghai Huanqiu Finance Center

104-storey (3 underground)

The height is 492m

46 points (3 comp.)

自由地表

－200m

Multi-storey and Base Isolated Building Response Observation Array

室外地表

▲ 测点

Legend

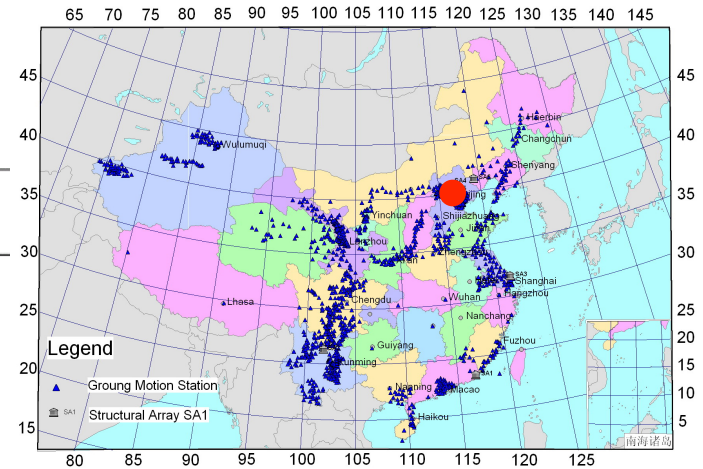▲ Groung Motion Station

🏛 SA1 Structural Array SA1
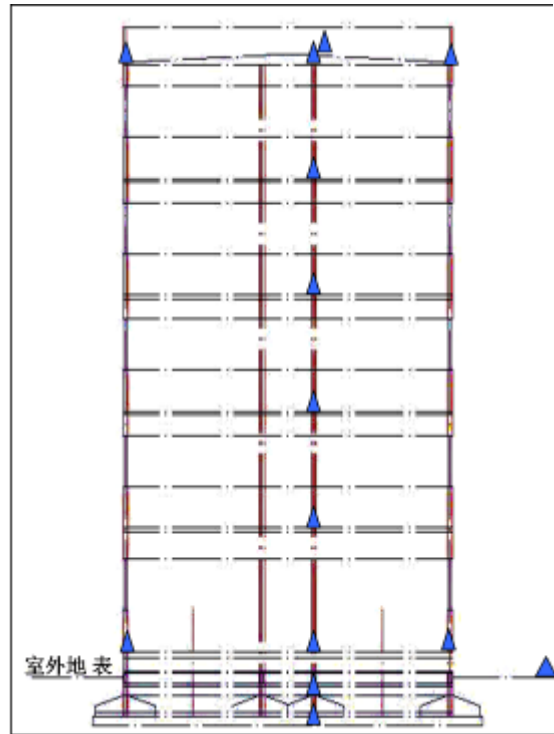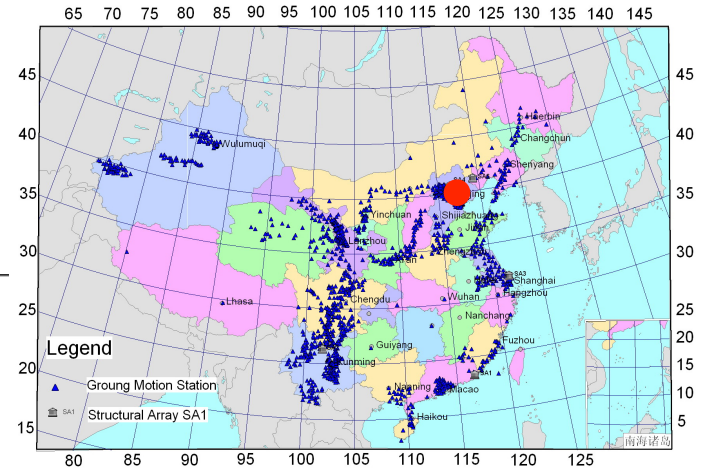
Large Span Building Response Observation Array

A sport hall for 2008 Beijing Olympic games

46 points (3 comp.)

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Project of CEA in other Five Years (2008-2012)

- **Considering the benefit of earthquake early warning system in Japan and other countries, CEA proposed a new project plan to build demonstrative earthquake early warning system**

- **The project would be carried out from 2008 to 2012**

- **For the project, total investment amount:**
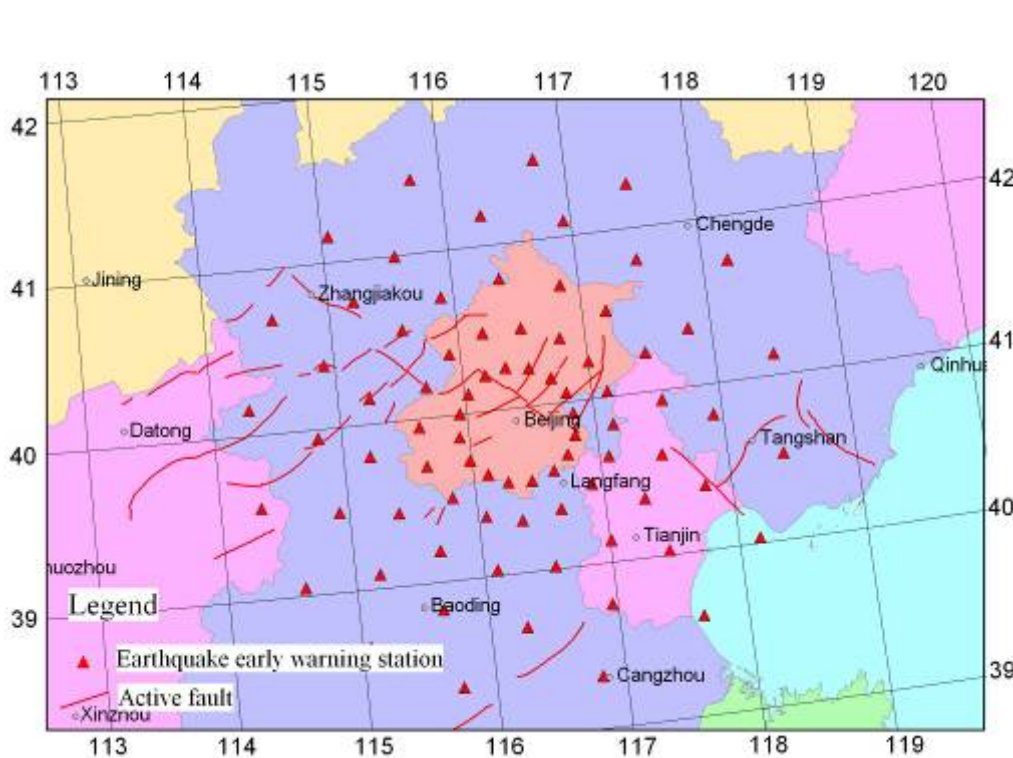 **about 70 million RMB**
  (about 10 million USD)

Earthquake Early Warning System in Construction (2008-2012)

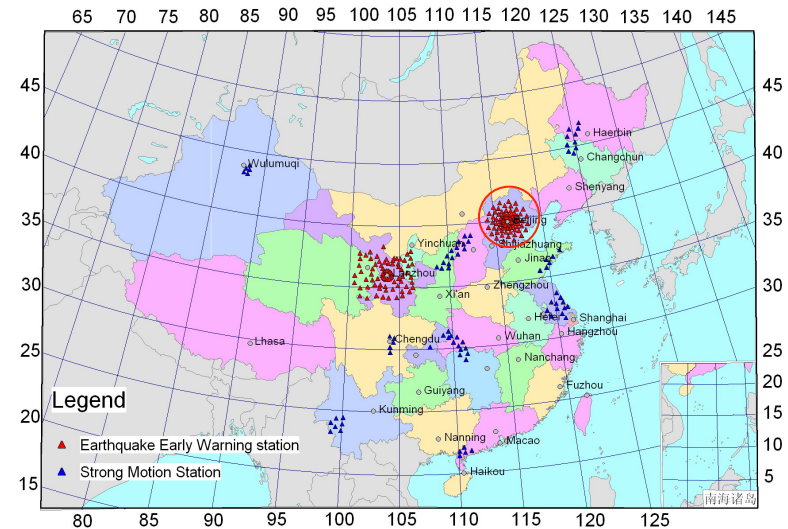**In this project**

- **Two earthquake early warning system arrays**
- **and some free-field stations**
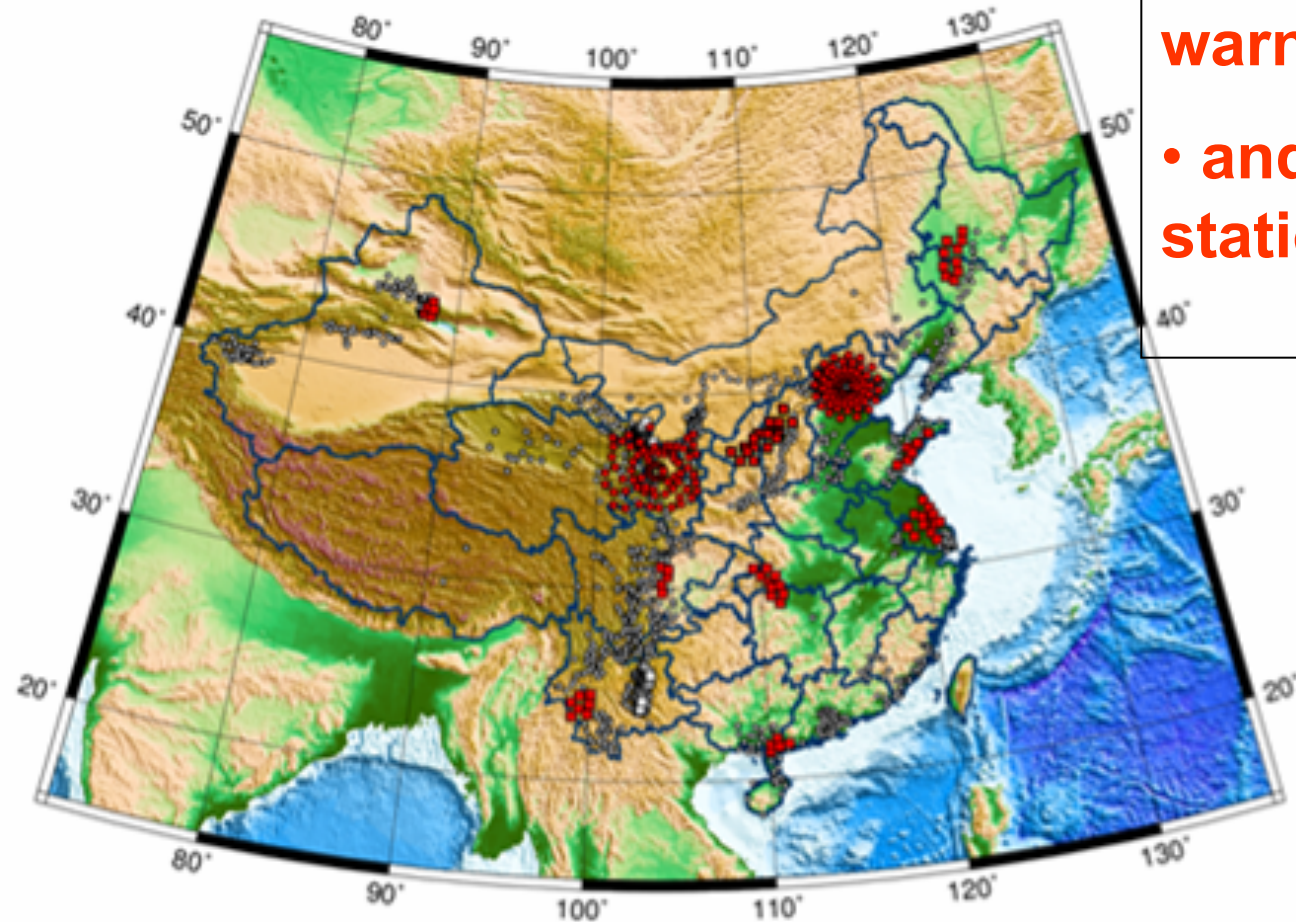
Earthquake Early Warning System in Construction

Stations on the 5 circles

one earthquake early warning system array in Capital area

Earthquake Early Warning System in Construction
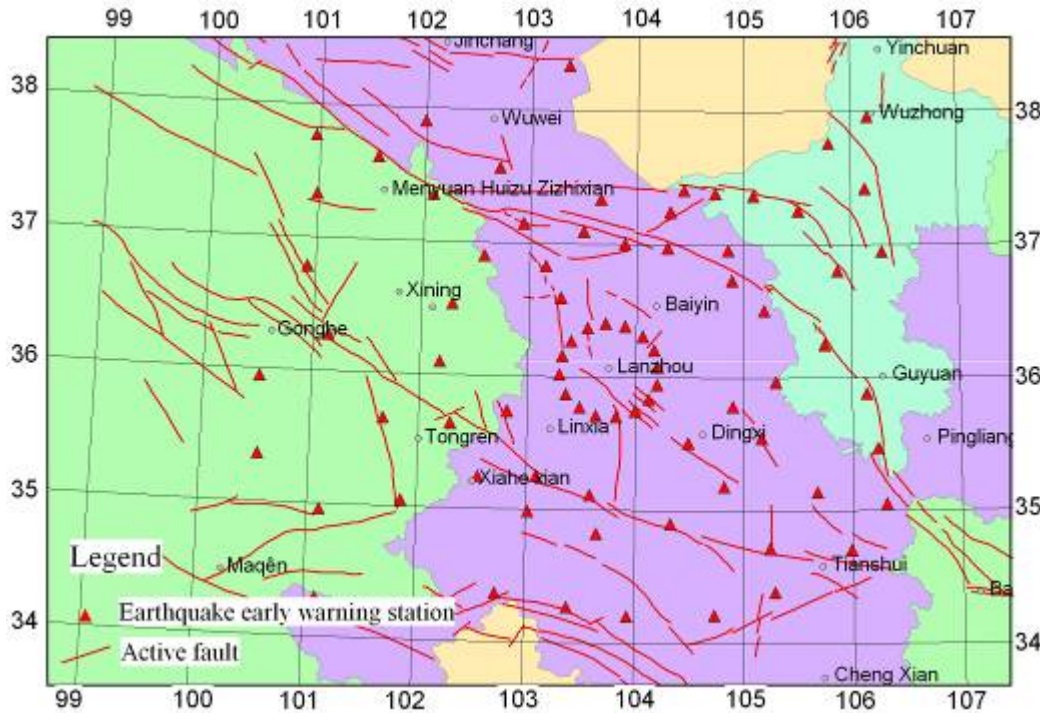
Stations on the several circles
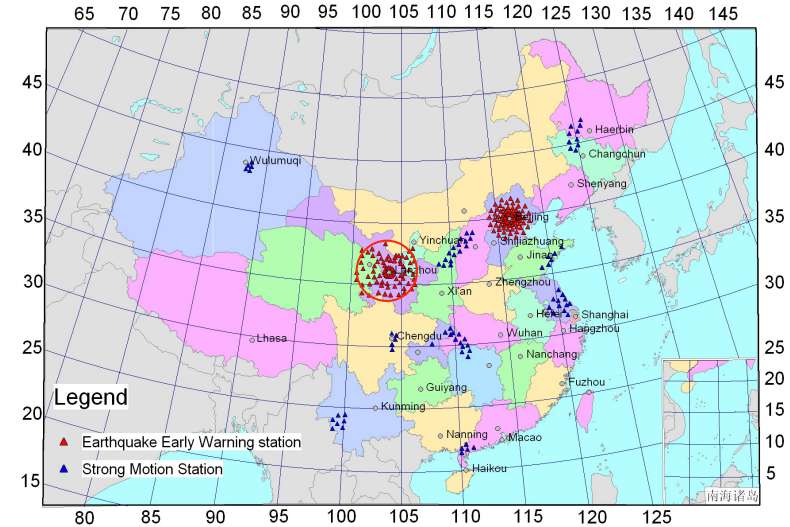
Other earthquake early warning system array in Lanzhou area

Distribution of Strong Motion Network Stations in Mainland of China After 2012
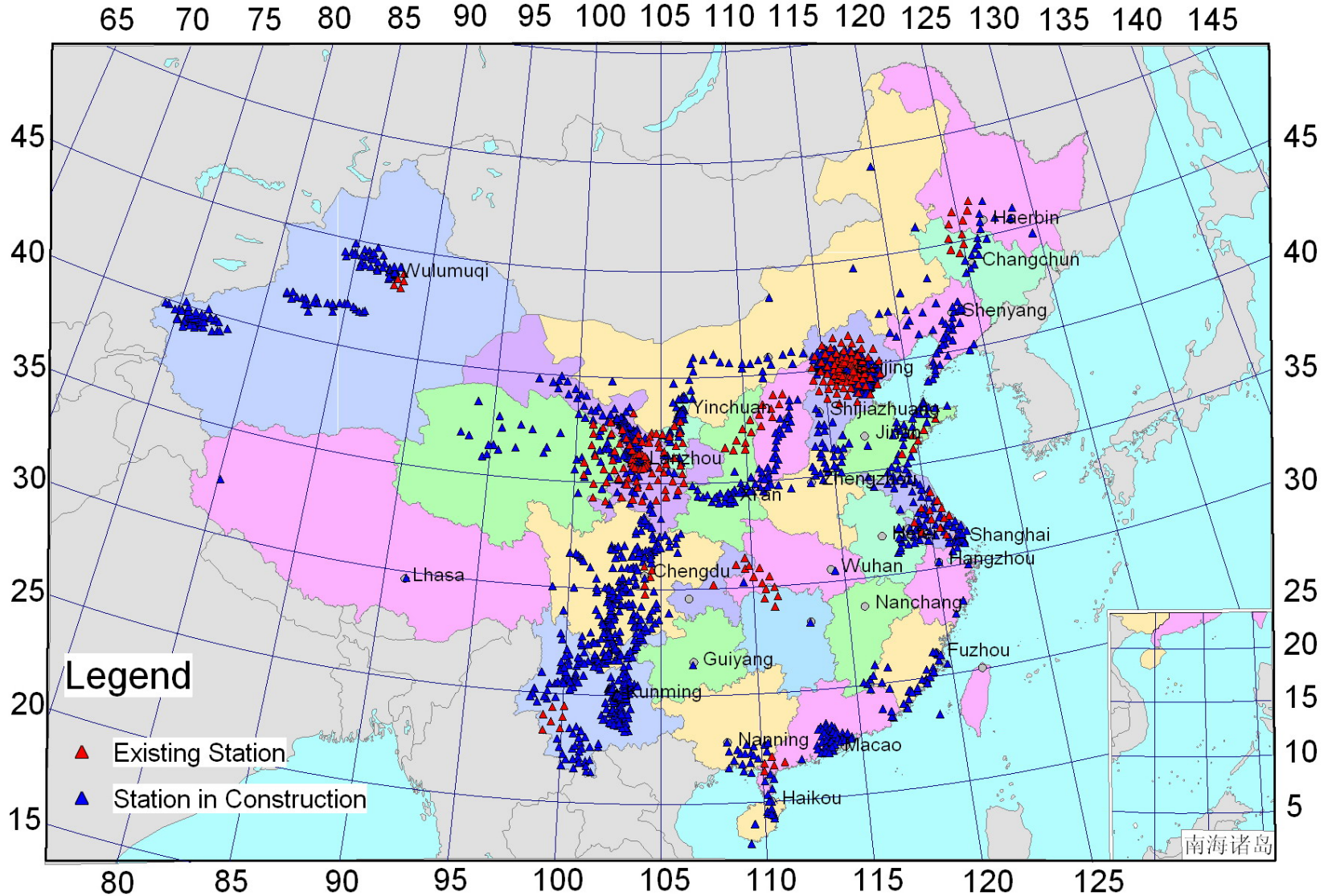
Distribution of Strong Motion Network Stations in Beijing-Tianjin area After 2012
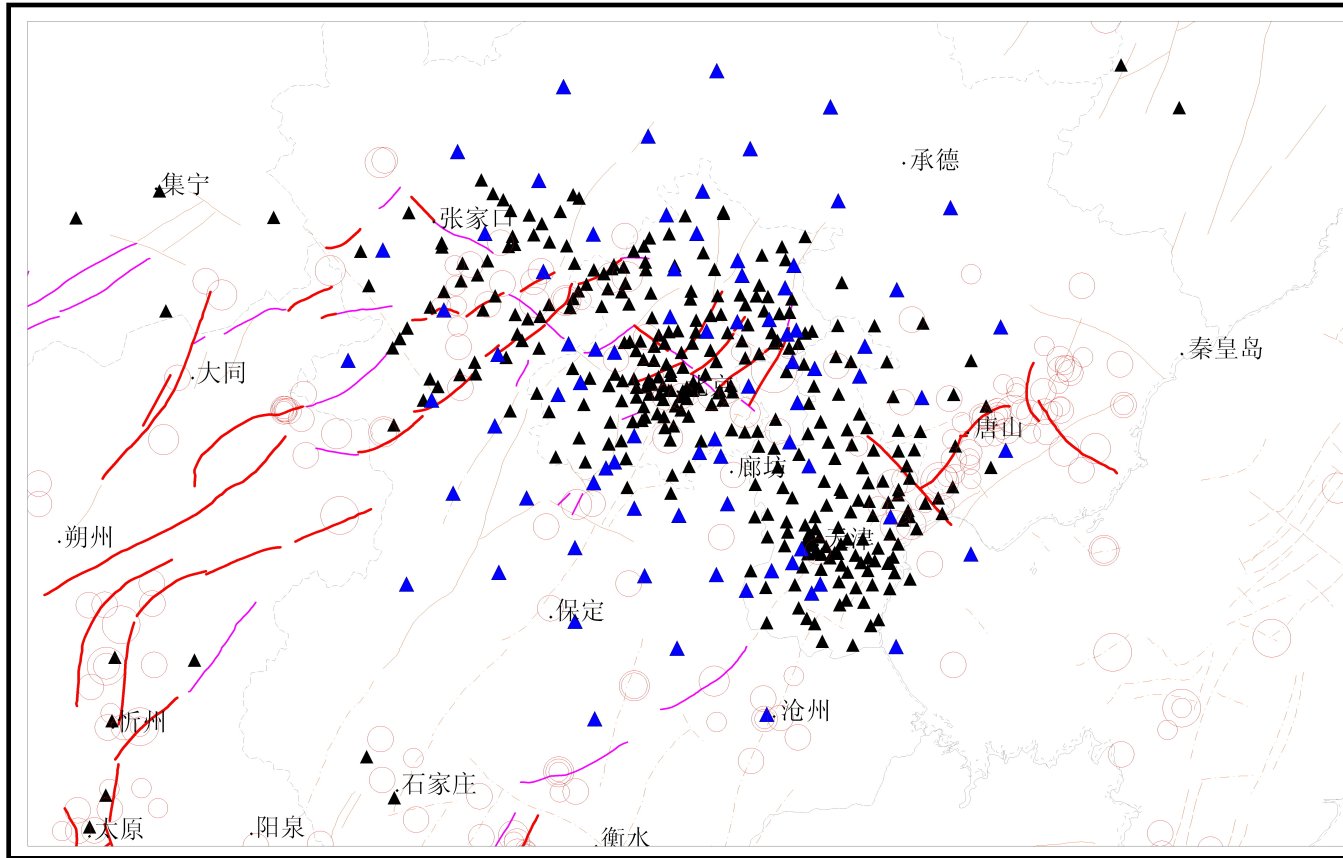
About 500 stations (2006-2012)

space: less than 5km

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China Earthquake Intensity Rapid Reporting and Earthquake Early Warning System (2013-2020)

- **After the construction of the digital strong motion observation network system (2003-2008) and the demonstrative earthquake early warning system (2008-2012), the next great project is proposed**

- **An earthquake Intensity Rapid Reporting and Earthquake Early Warning System will be constructed**

- **In the system, about 9,000 stations will spread all over mainland of China.**

- **For the project, the estimated investment amount is about 3.0 billion RMB (about 0.45 billion USD)**

Distribution of about 9,000 Stations in the planed system

新建基准站(1451个)　　新建基本台(5430个)

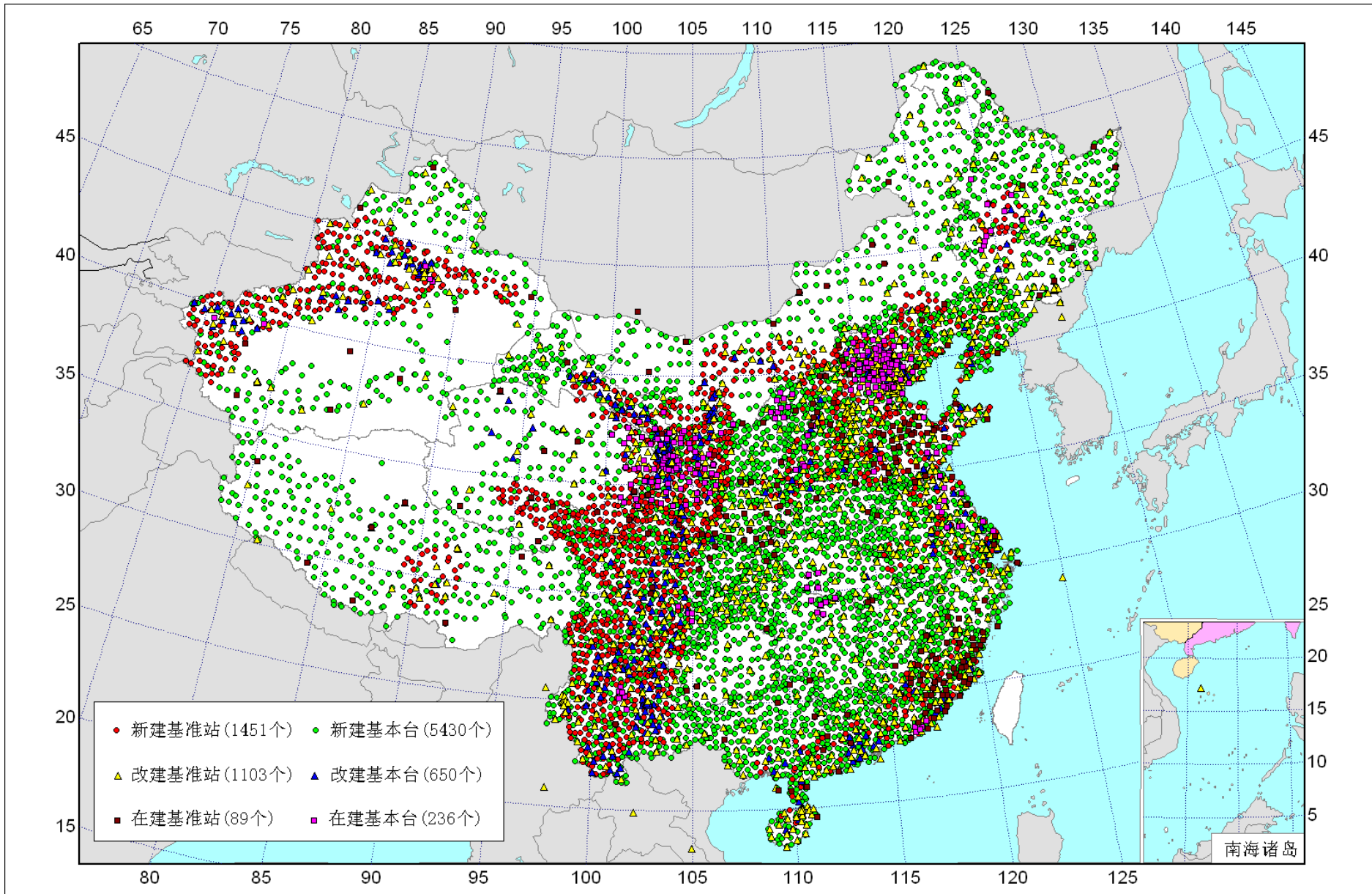改建基准站(1103个)　　改建基本台(650个)

在建基准站(89个)　　在建基本台(236个)

南海诸岛

Contents

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Records from the earthquakes before 2000

- **The strong motion observation in China began in 1962**
- **In 1962, the first strong motion record in mainland of China was obtained at the Xinfengjiang reservoir site in the south China after the Xinfengjiang reservoir-induced earthquake M6.1 in 1962**
- **But only about 3000 useful records had been obtained from only 283 stations and arrays until 2000**

Records from the earthquakes during 2000 to 2008

- **From 2000 to 2008 before M8.0 Wenchuan earthquake, over 6,000 records were obtained from earthquakes M<6.5**
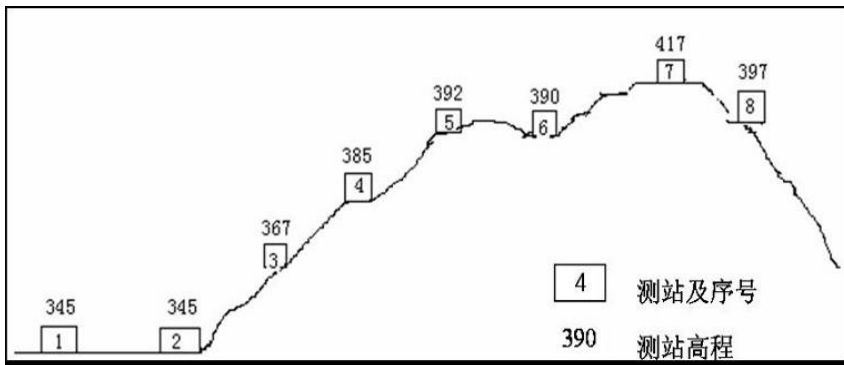
  Most of them was recorded by the New digital strong motion observation system in construction at that time
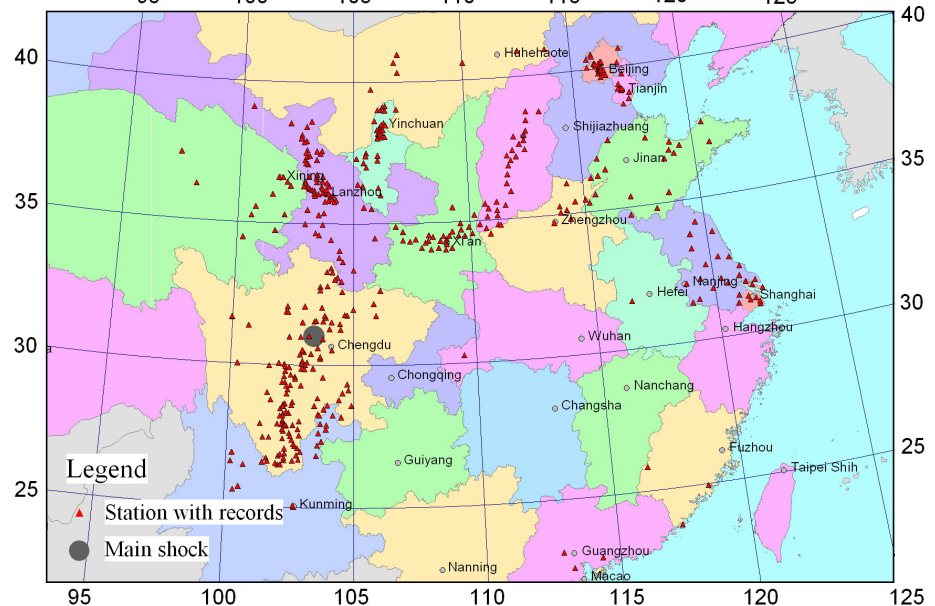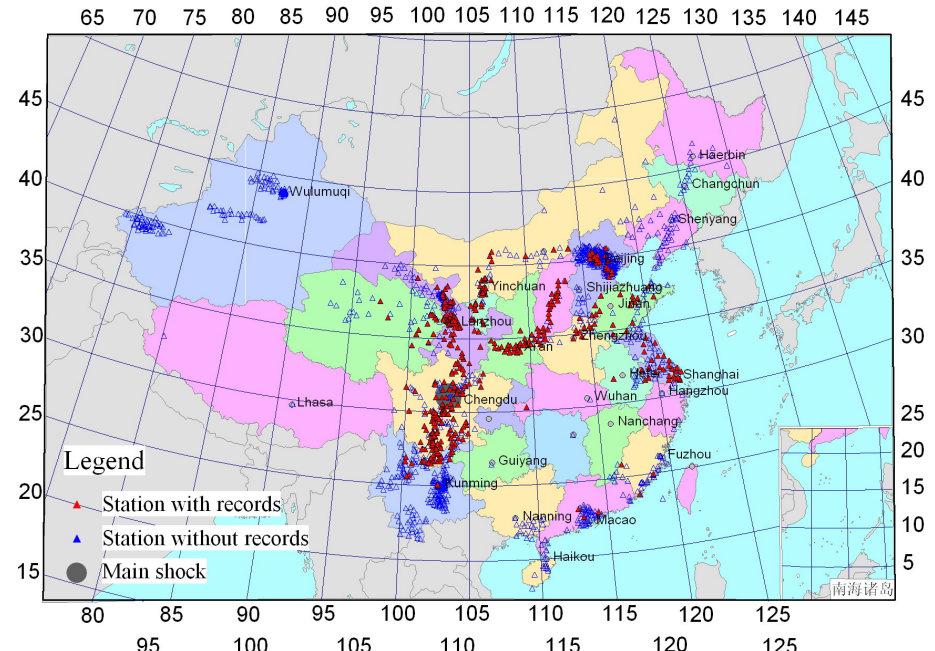
- **But only about 1,000 records with PGA>10 gal**

Records from M8.0 Wenchuan earthquake (2008)

Large numbers of records were obtained from the main shock and aftershocks of Wenchuan Earthquake

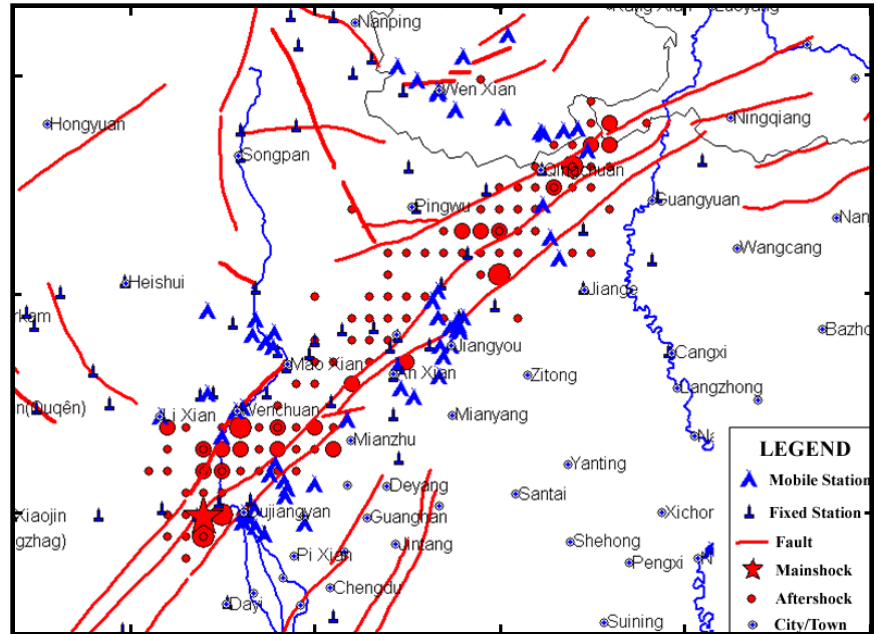1. **460 stations and 3 arrays obtained 1,350 records from the main shock**

Topography Effect Observation Array

Records from M8.0 Wenchuan earthquake (2008)

2. **15,903 components of records were obtained from 949 aftershocks**

   Most of them were recorded by the mobile stations

LEGEND
- ▲ Mobile Station
- ⊥ Fixed Station
- — Fault
- ★ Mainshock
- ● Aftershock
- ⊚ City/Town

After main shock, quickly deployed mobile stations at more than 70 points

Records after the Wenchuan eathquake

- **there were about 4000 components of strong motion records obtained from 510 earthquakes except the M8.0 Wenchuan earthquake and aftershocks in 2008~2009**

- **And also some records were obtained in this 2 years**

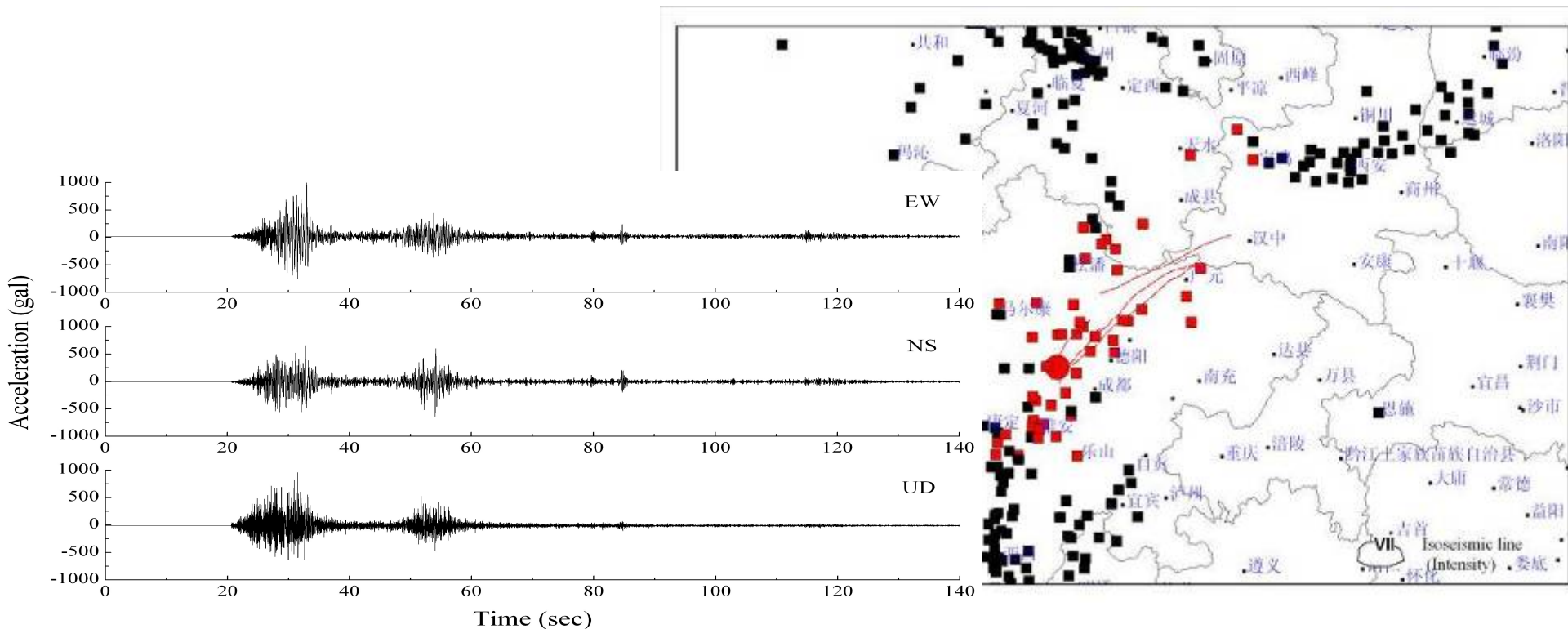# Strong Motion in the Wenchuan Earthquake

In the records from the main shock：
239 Stations with PGA>＝10 gal
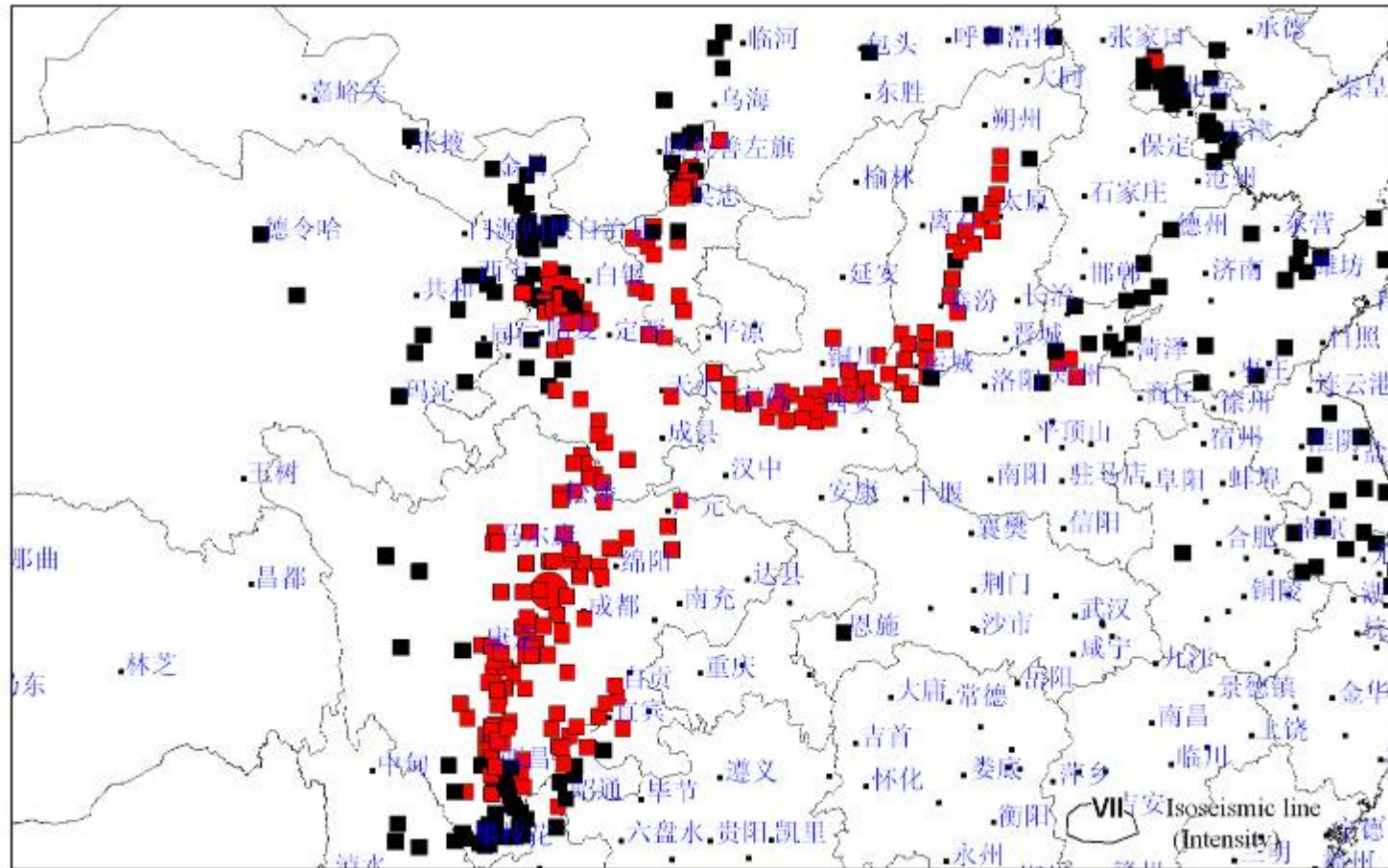
Strong Motion in the Wenchuan Earthquake

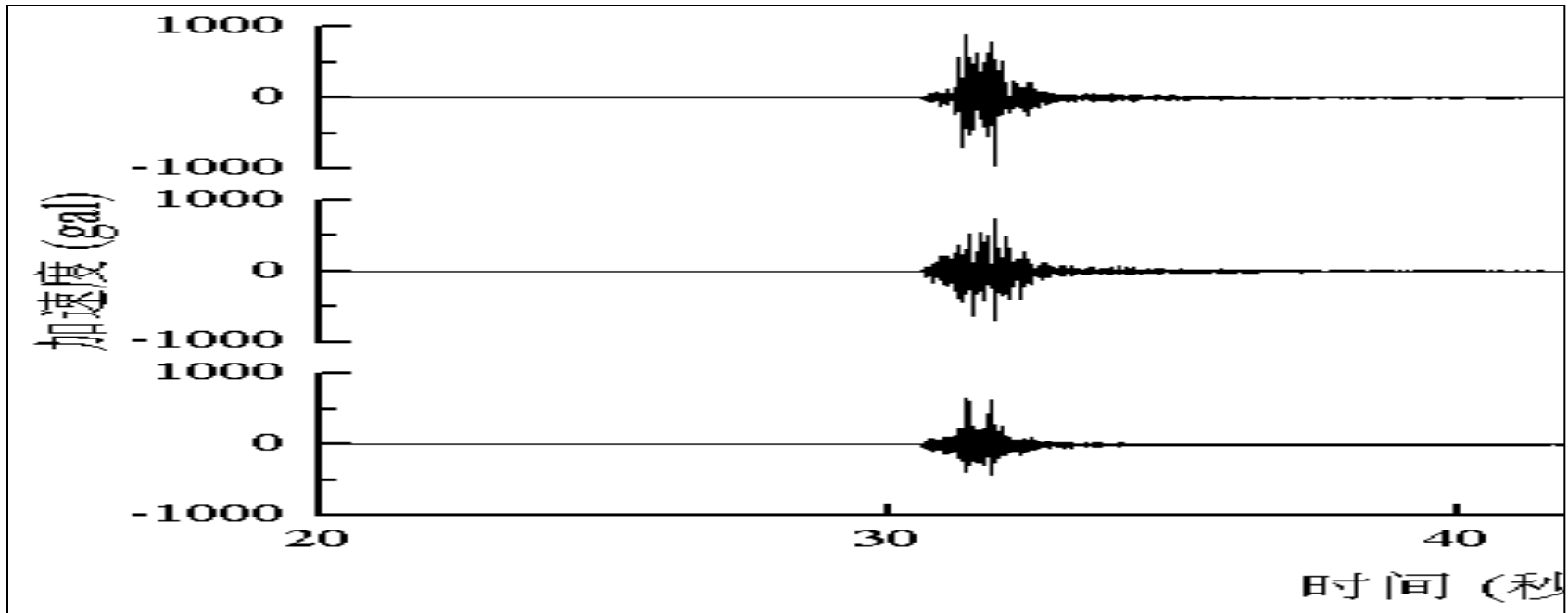**In the records from the main shock：**

- **The largest PGA：958 gal at Wolong station**
- **in the hanging wall area with a rupture distance of 23 km**

Strong Motion in the Wenchuan Earthquake

The interesting result:

- the largest PGA of aftershock records
  was 966 gal from Qingchuan Eq. M4.2 (2008.08.10)
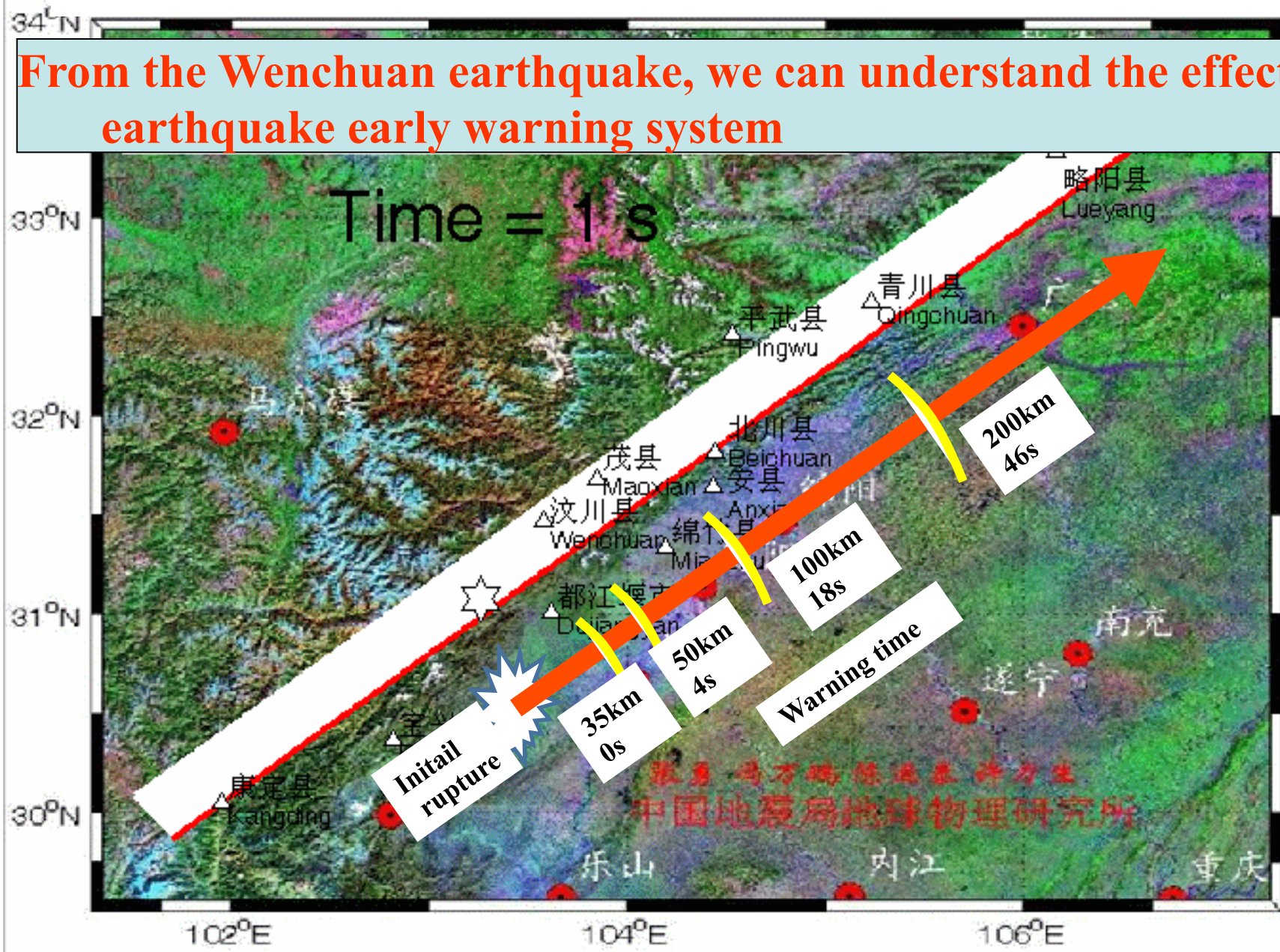- but M4.2, and epicentral distance is 1.4 km

Strong Motion in th Wenchuan Earthqake

Strong rupture directivity effect and multi-segment rupture effect

Different shapes of time-histories from records in different locations

Strong Motion in 311 East Japan Earthquake

Strong rupture directivity effect and multi-segment rupture effect

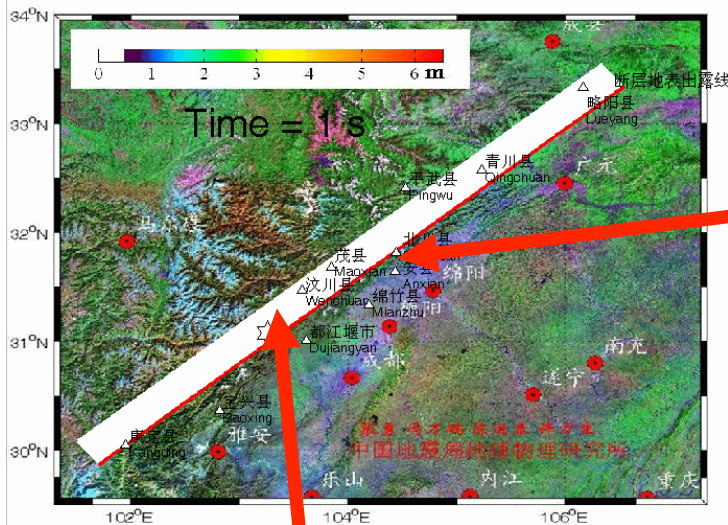**Different shapes of time-histories from records in different locations**
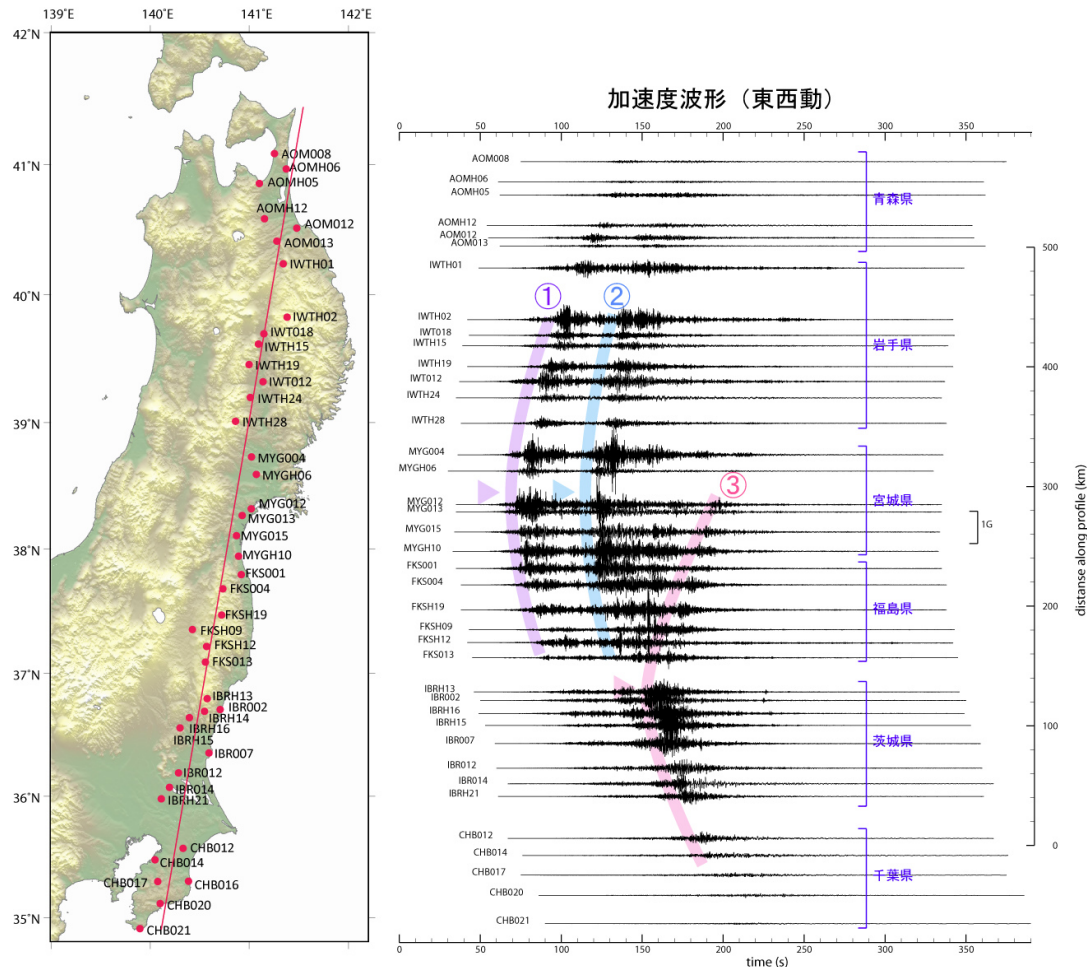
Earthquake Early Warning in Wenchuan Earthquake?
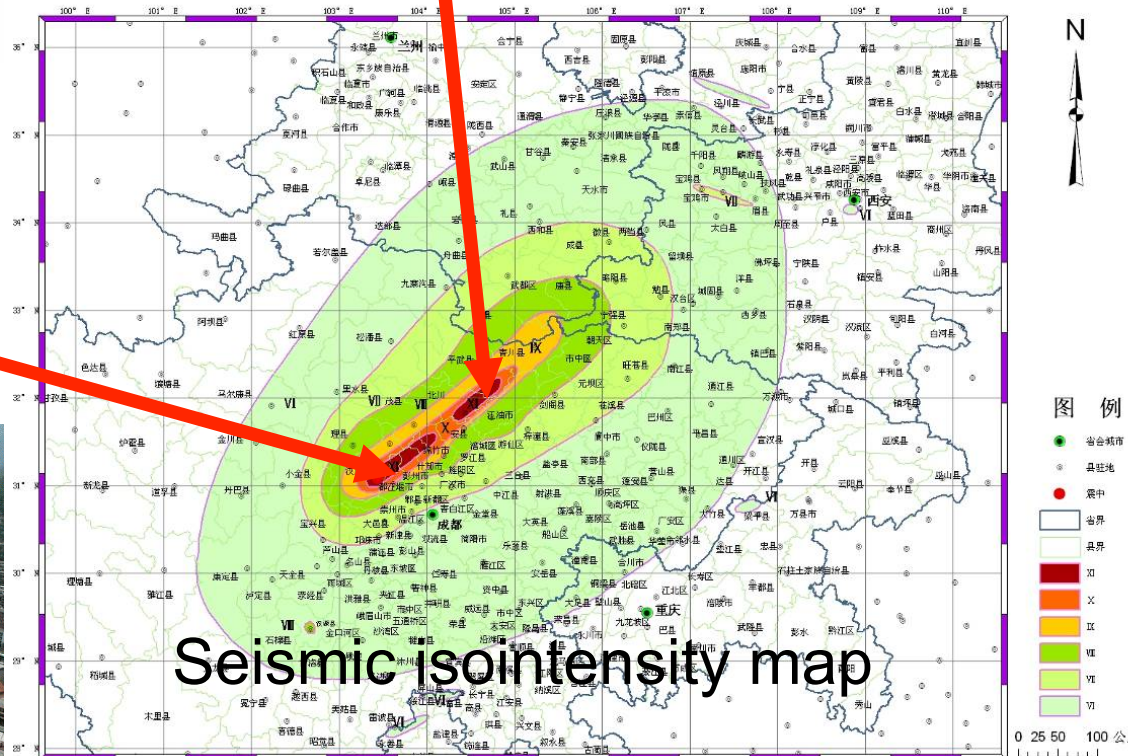

From the Wenchuan earthquake, we can understand the effect of earthquake early warning system

the effect of earthquake early warning system？

Time = 1 s

Seismic isointensity map

Thanks !