3-D shear wave velocity structure and seismo-tectonics beneath eastern Tibetan Plateau

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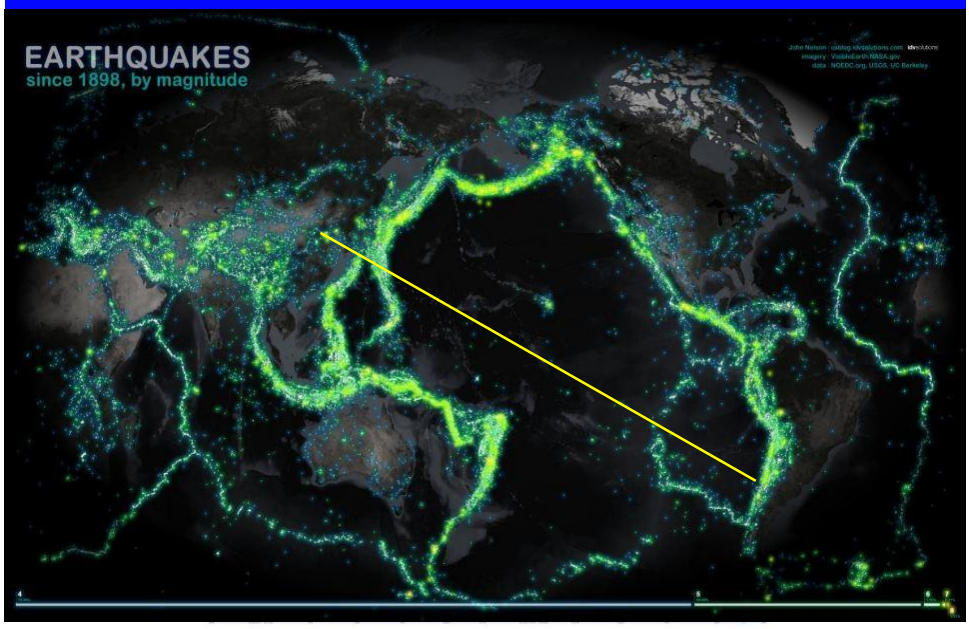
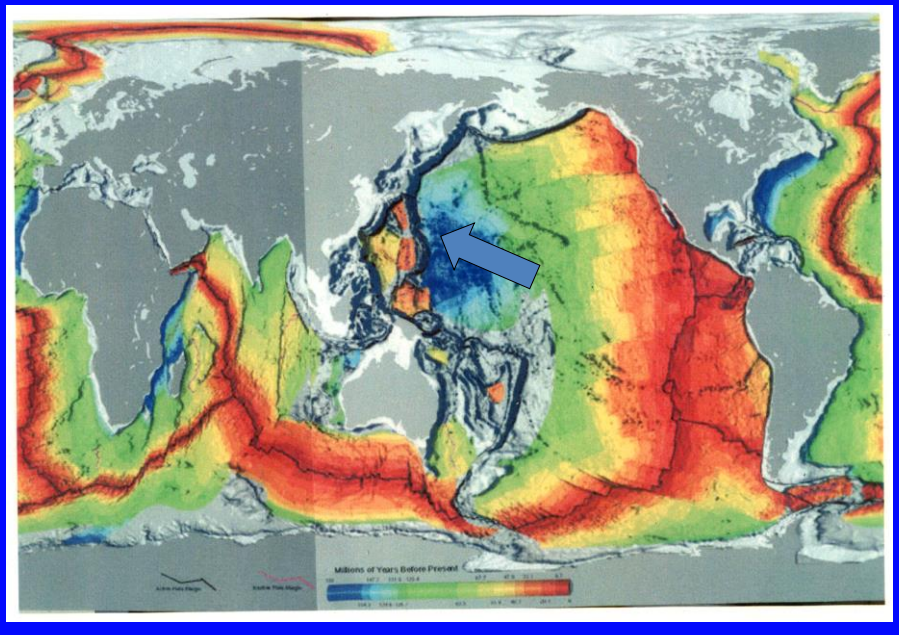
Outlines

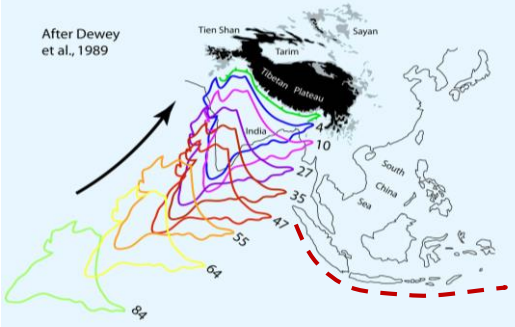
- Earthquake Monitoring Systems in China
- Some Key Projects Ongoing in China Earthquake Administration
- ChinArray and Velocity Structure & Seismo-tectonics beneath Eastern Tibetan Plateau



Subduction of Pacific Plate toward West



Collision between Indian Plate and Eurasian Plate



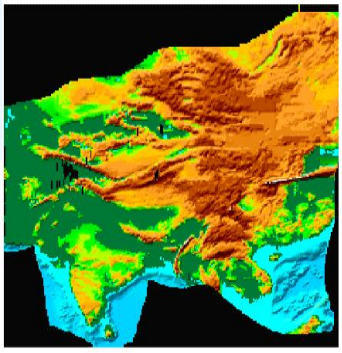
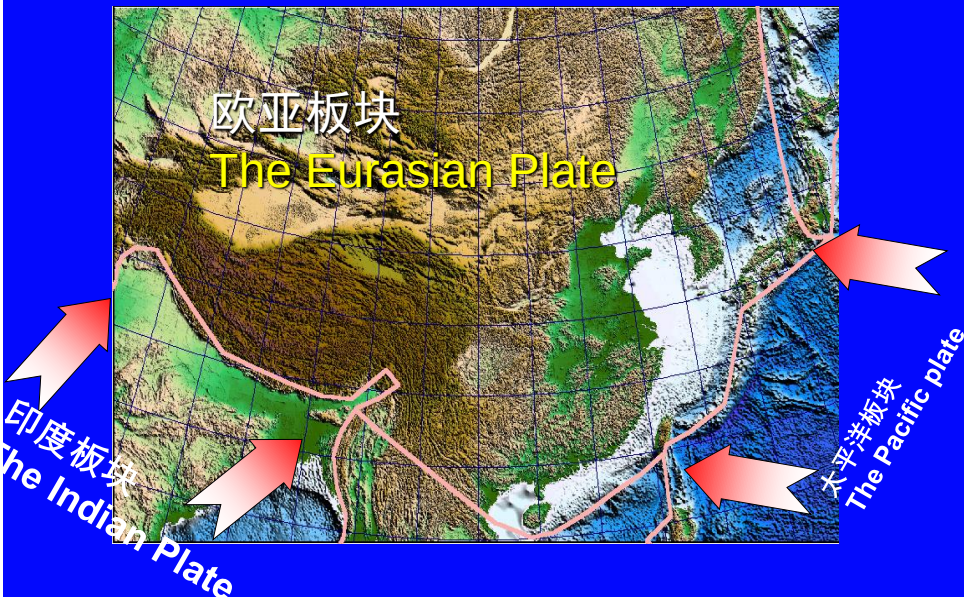
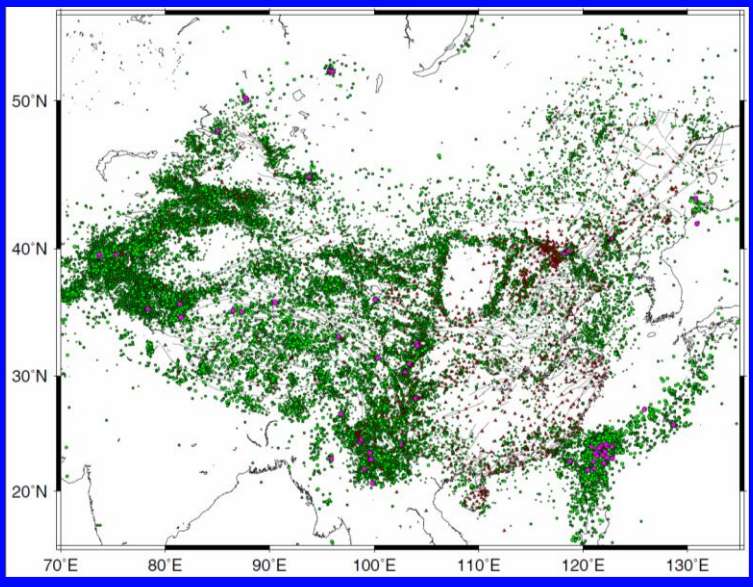


Plate movement in China and its adjacent area

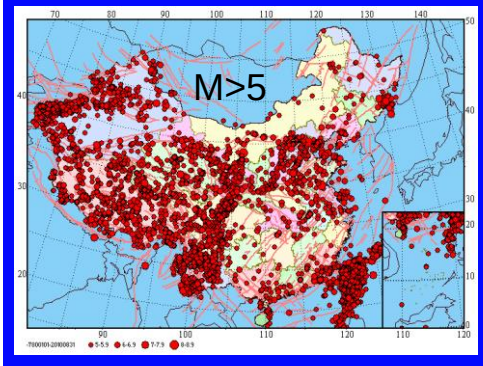


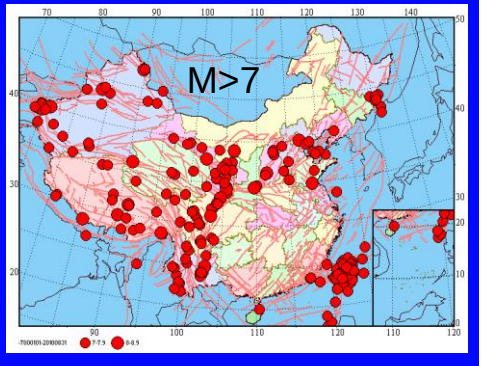
Seismicity in China and its adjacent area

（1970~2014，≥M3.0）



Seismicity and Earthquake Losses





Suffer serious earthquake disaster

2008, Wenchuan EQ., Ms 8.0, 69227 death, 17923 missing

2010, Yushu EQ. , Ms 7.1, 2698 death, 270 missing

2013, Lushan EQ., Ms 7.0, 196 death, 21 missing

2014, Ludian EQ., Ms 6.5, 617 death, 112 missing

“3+1” Approaches for Earthquake Disaster Reduction in China

1. Earthquake Monitoring & Prediction

monitoring of earthquake, precursor and crustal movement, long-, medium-, short-term prediction, ……

2. Earthquake Disaster Preparedness

seismic design for structures, engineering assessment for important constructions, earthquake safety for rural residence, ……

3. Earthquake Emergency Response

early assessment of disaster and rapid collection of disaster information, emergency relief and rescue, ……

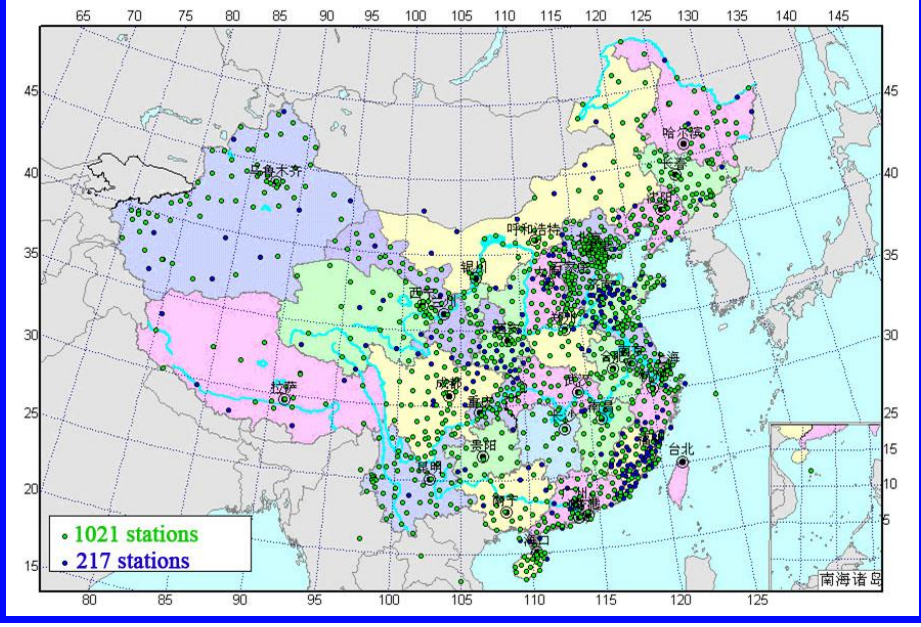
4. Science and Technology

supporting 1 to 3 approaches, basic and applied studies, ……

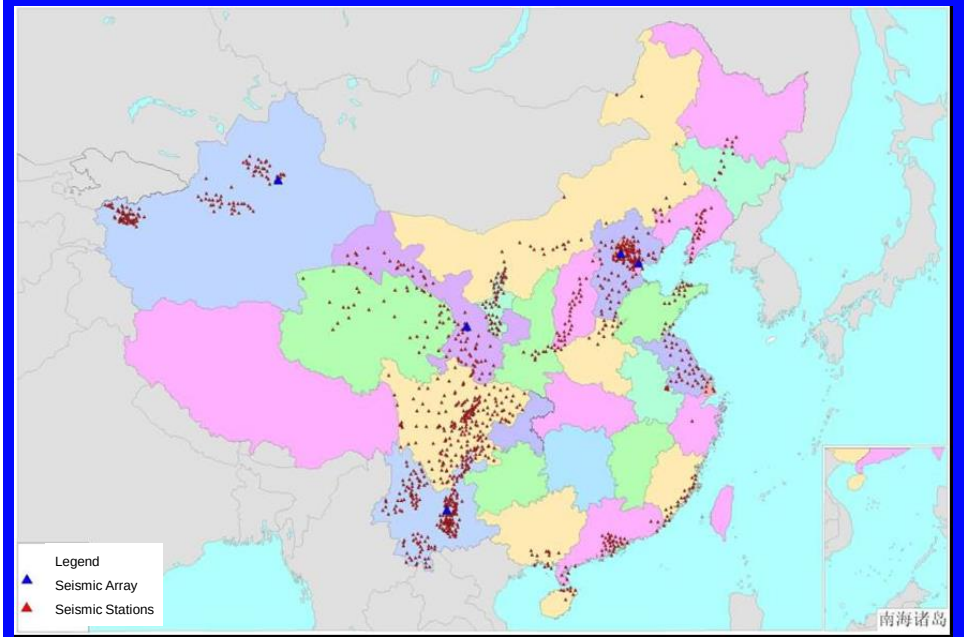
Outlines

- **Earthquake Monitoring Systems in China**
- **Key Projects Ongoing in China Earthquake Administration**
- **ChinArray and Velocity Structure & Seismo-tectonics beneath Eastern Tibetan Plateau**

China National Digital Seismic Network



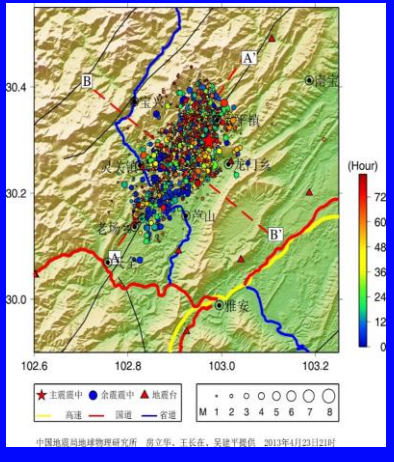
Digital Strong Ground Motion Network

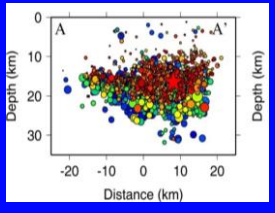


Earthquake Information Report

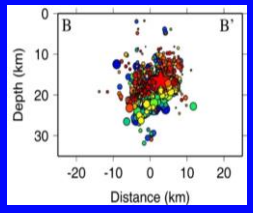
- Automatic earthquake rapid report：2 minutes
- Artificial earthquake rapid report ：10 minutes.
- The real-time automatic earthquake information is released to the society through mobile phone, website, blog, mobile clients and other channels.

Earthquake Location
Aftershock Sequence Relocation



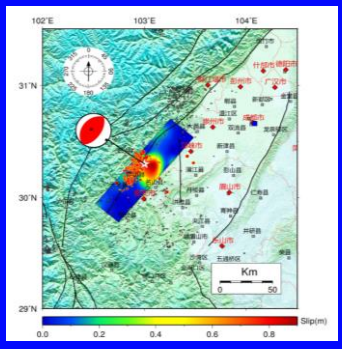


Earthquake rupture length: 35-40km

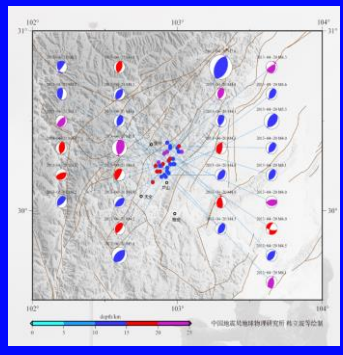


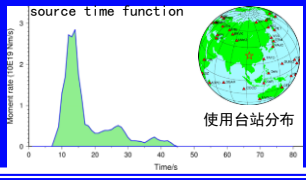
Fault tendency to northwest。

Source rupture process



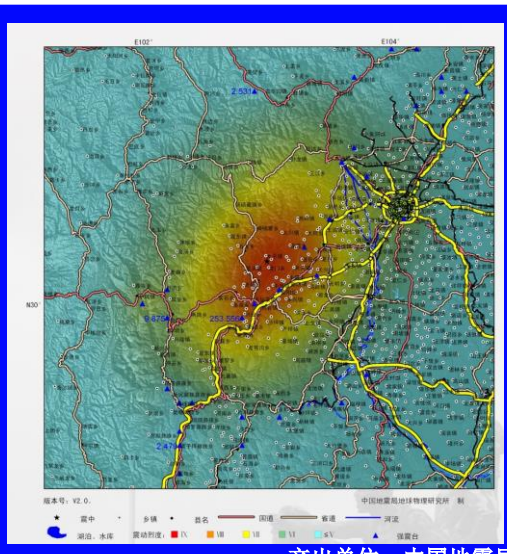
The slip distribution projected on ground surface



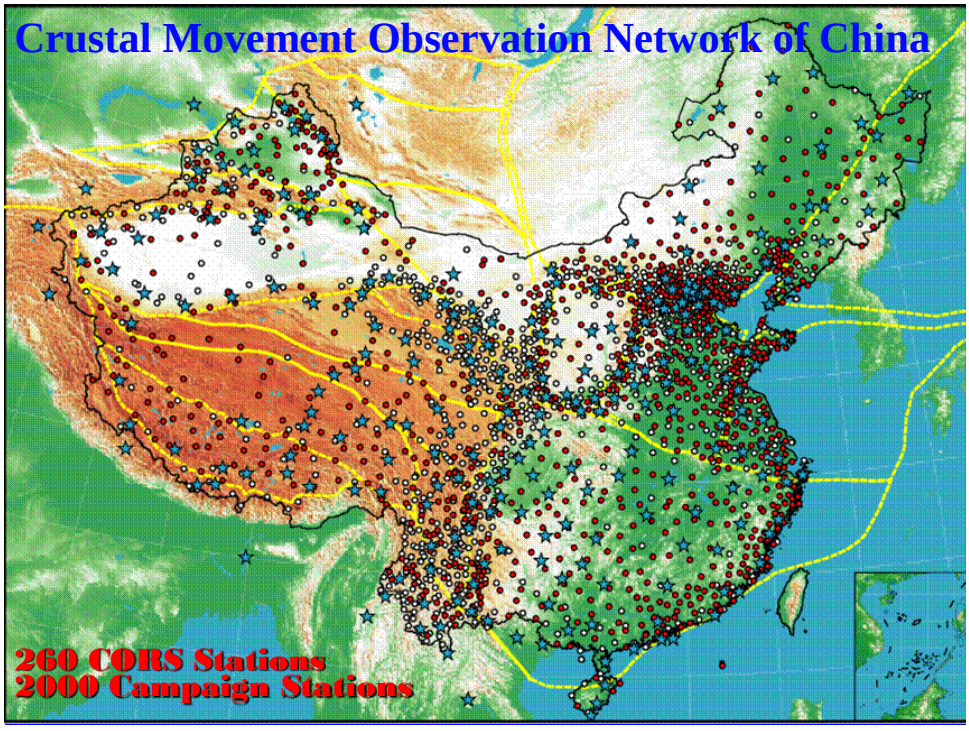


- Mw: 6.7
- Rd: 30s
- Dmax: 1.6m

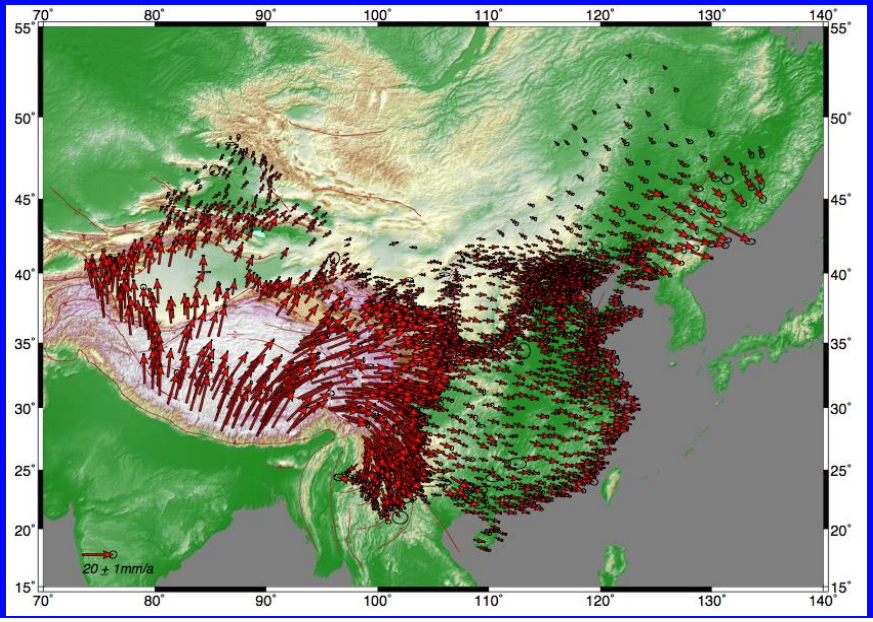
Estimated ShakeMap



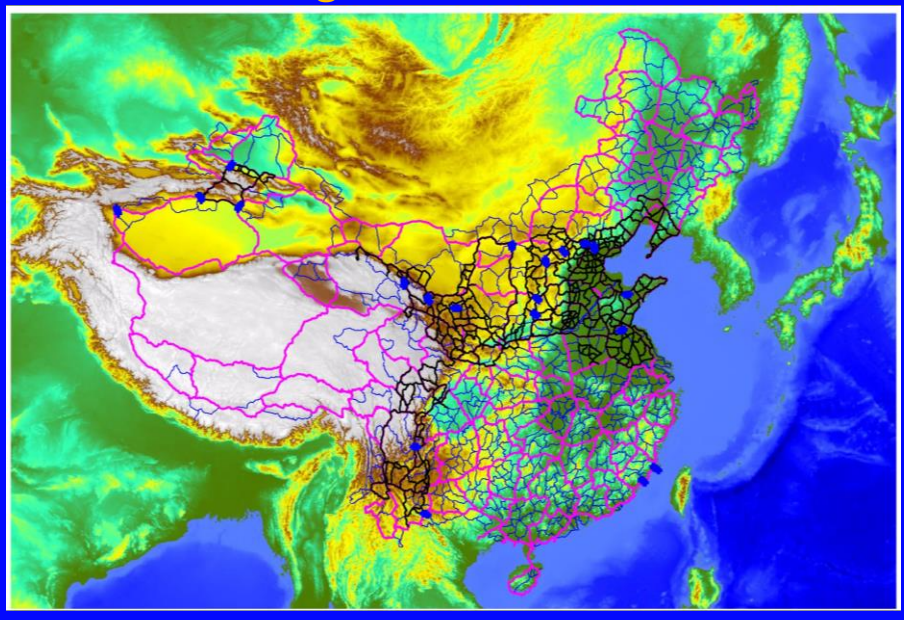
产出单位：中国地震局地球物理研究所



Horizontal Movement Velocity of China Continent (2009-2013)

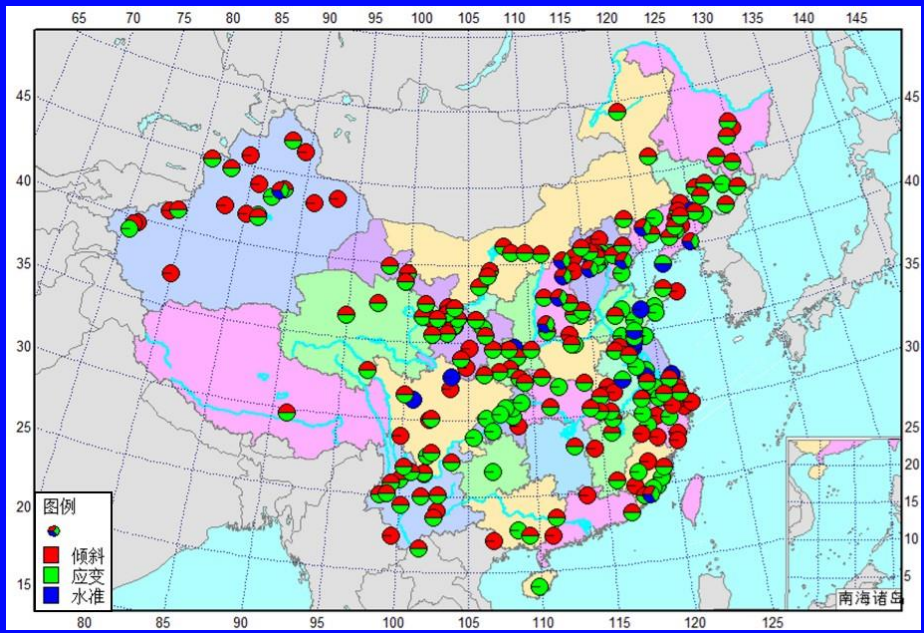


Precise Leveling Network in China Continent

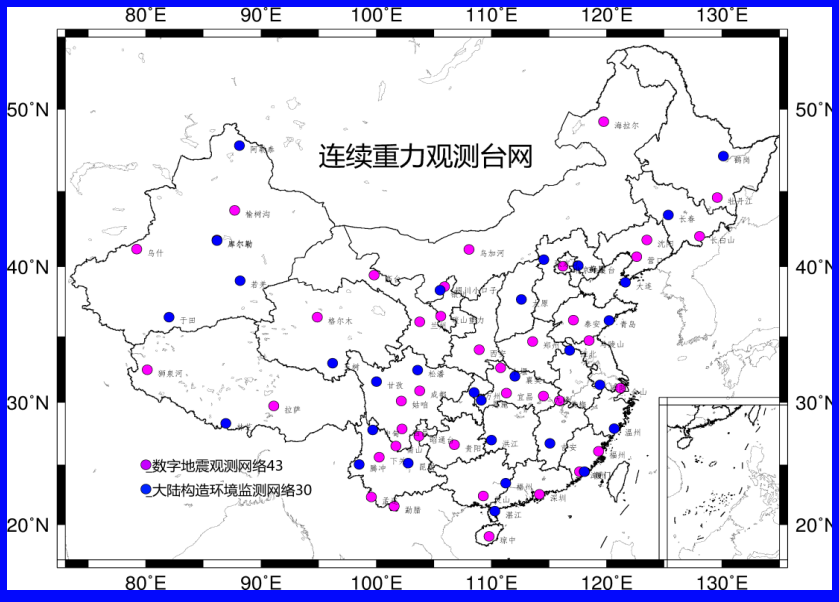


Not managed by CEA

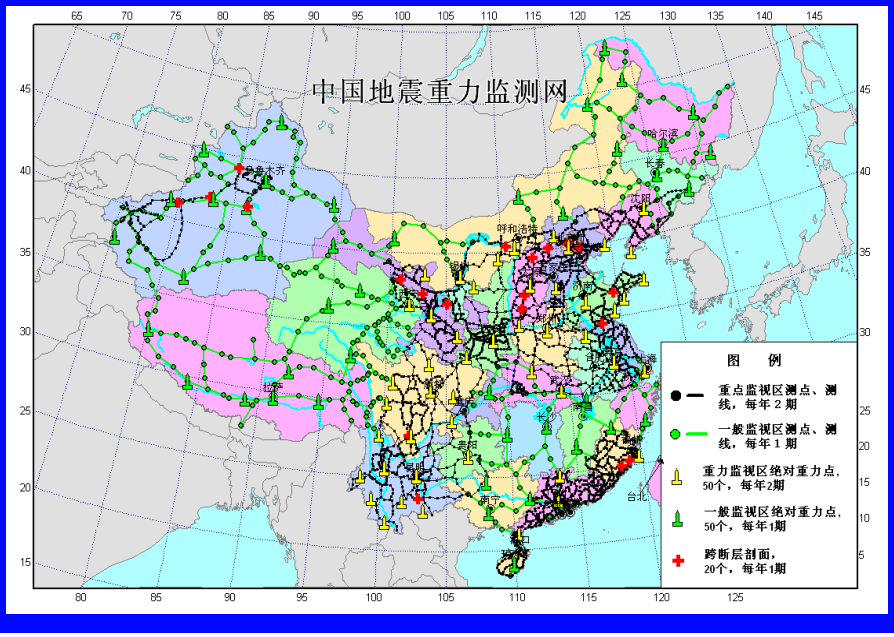
Tilt & Strain Observation Network



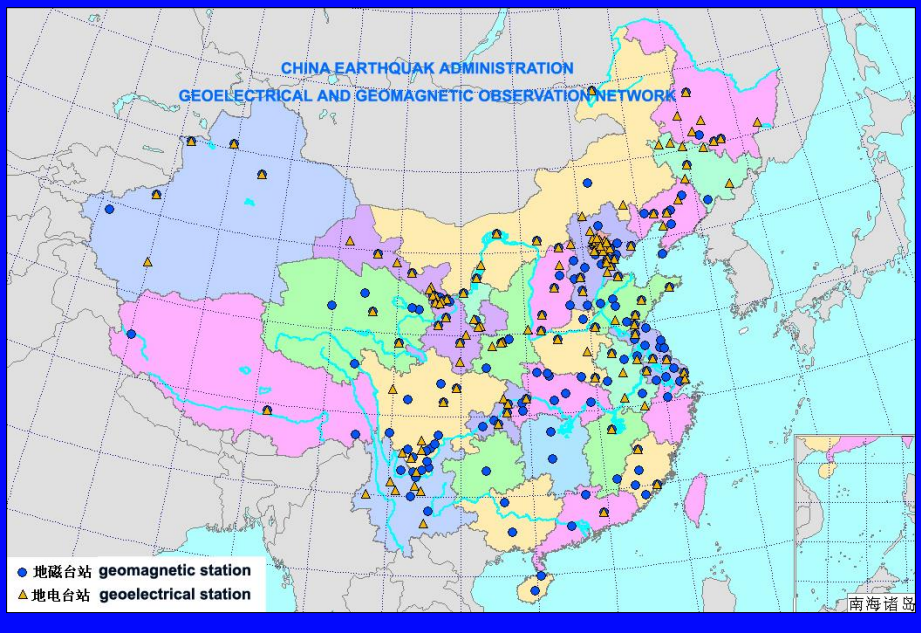
Gravity Observation Network



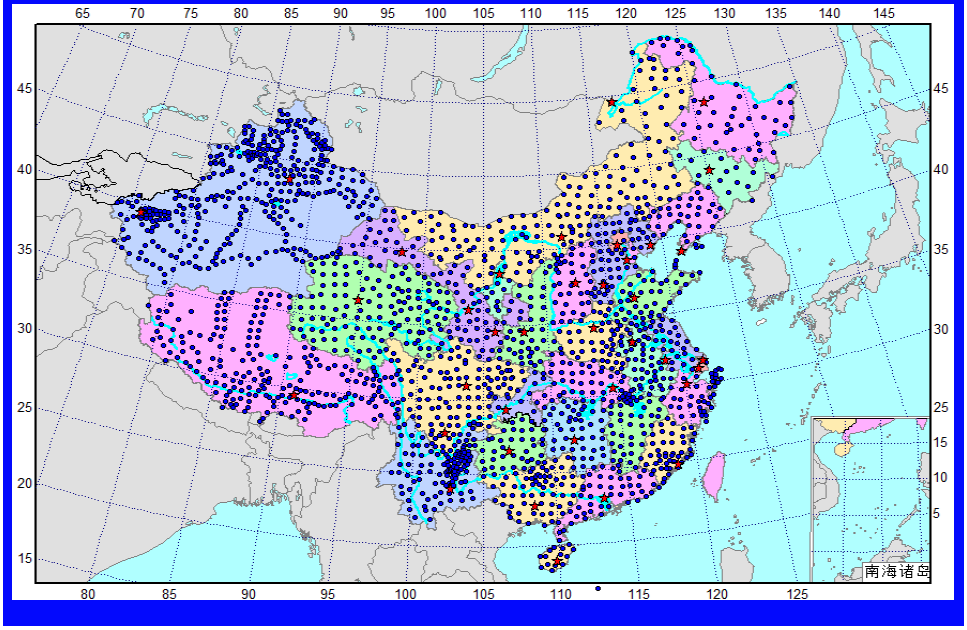
Mobile Observation Network of Gravity



Geomagnetic & Geoelectrical Observation Network



Mobile Observation Network of Magnetism



Outlines

- Earthquake Monitoring Systems in China
- Some Key Projects Ongoing in China Earthquake Administration
- ChinArray and Velocity Structure & Seismo-tectonics beneath Eastern Tibetan Plateau

- National Seismic Intensity Rapid Reporting & Earthquake Early Warning System
- Observation and Prospecting on Earthquake Tectonics in China Continent
    1. ChinArray
    2. Active fault mapping
    3. Geophysical Observations

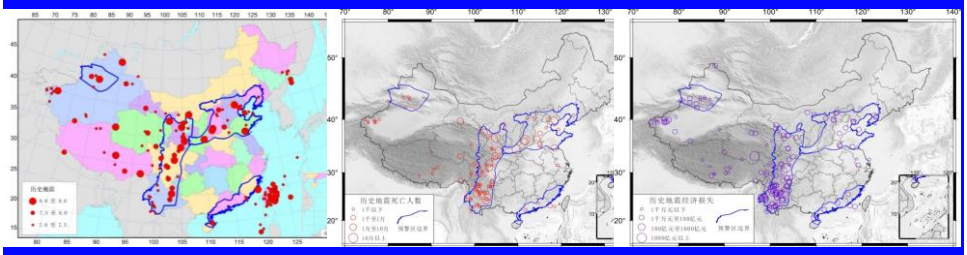
National Seismic Intensity Rapid Reporting & Earthquake Early Warning System

The project aims at establishing a SIRR & EEW system in China Continent and providing EQ emergency information.

Project Objectives

- **Few Seconds**
  - EEW (Priority Areas)
- **1～2 Minutes**
  - SIRR, county level, Nationwide
  - SIRR, town level, Priority Areas
- **2~5 Minutes**
  - Automatic Earthquake Rapid Report (Nationwide)
- **5 Minutes~24 Hours**
  - Disaster Rapid Assessment(Nationwide)
- **Long-term**
  - More products for scientific and engineering purposes

Priority Areas



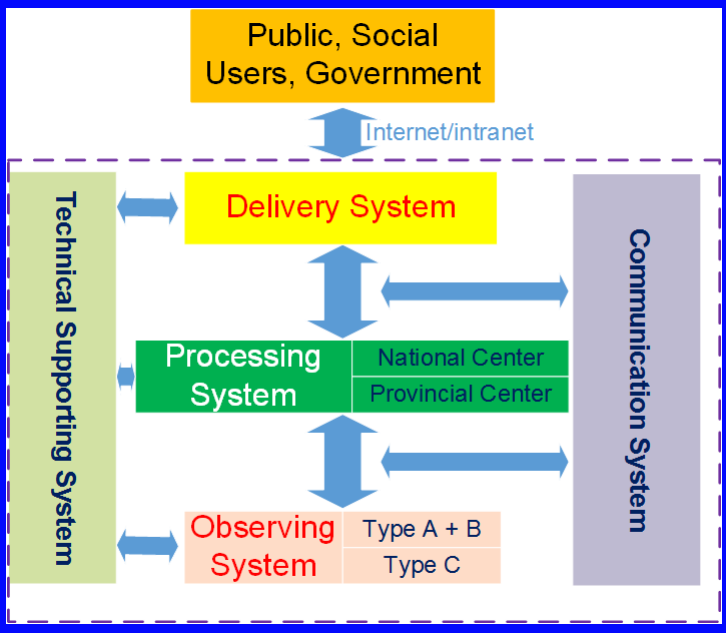
Historical Earthquakes with Ms > 7

Historical Earthquakes with 1000+ death

Historical Earthquakes with huge Economic loss

Criteria	Priority Areas	Expectations
◆ Historical earthquakes ◆ Hazard prediction ◆ Population ◆ Economy	● North China ● Southeast Coastal ● North-south Seismic Belt ● Northwestern Xinjiang	● 10-15 km ● EEW ● SIRR

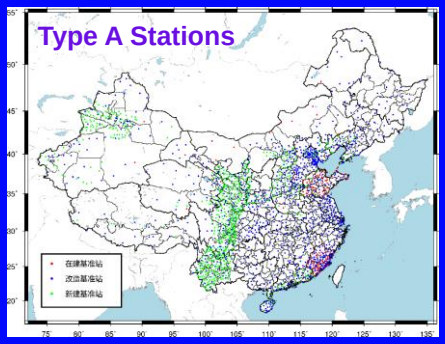
System Framework

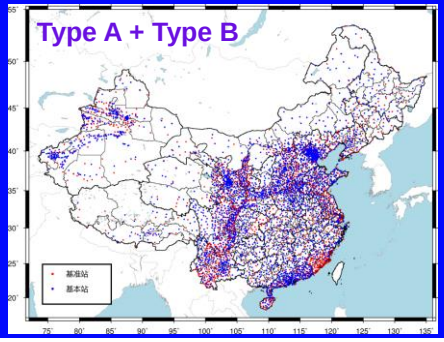


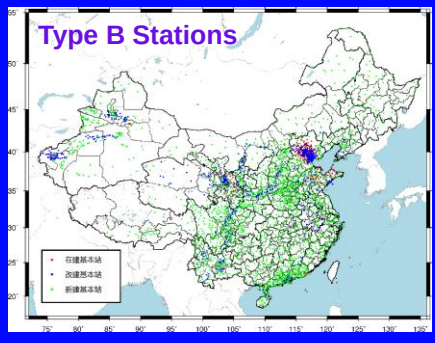
Observing System

- **Type A (~2000)**
  - Seismometers (BB/ VBB) & Accelerometers
  - Vault/Tunnel/Borehole/Posthole
  - Upgrade exiting （ ~1100）
  - Add（~900）
- **Type B (~3000)**
  - Accelerometers
  - Free field (Pier)
  - Upgrade exiting（ ~1000 ）
  - Add（~2000）
- **Type C (~10000)**
  - Low Cost MEMS Sensor
  - Free field /low-rise buildings
  - Add（~10000）

Observing System



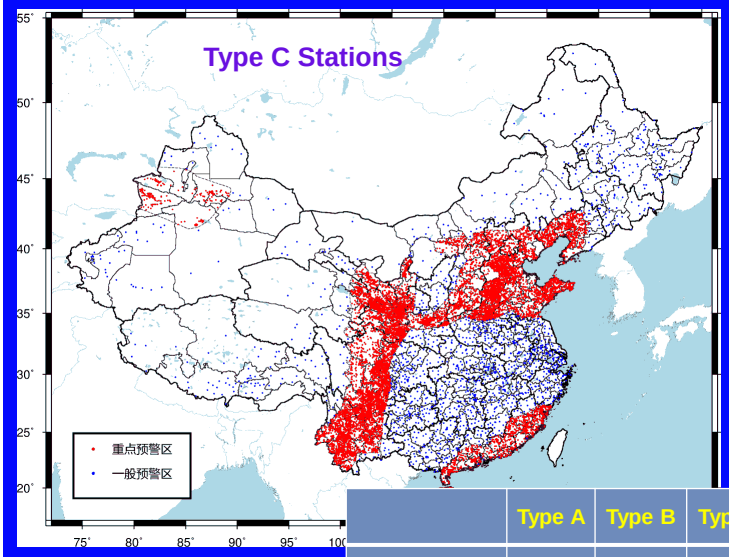




Spacing (km)

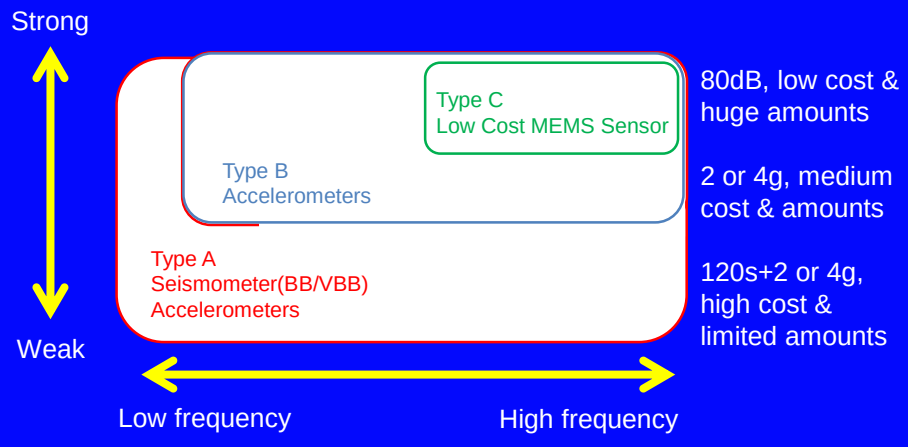
	Type A	Type B	Type A+B
Priority Areas	35	28	22
Others	131	99	79

Observing System

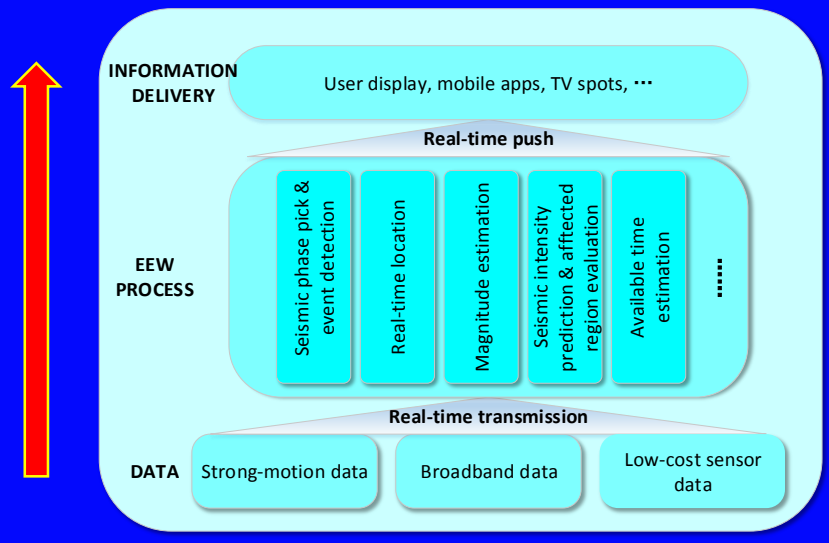


	Type A	Type B	Type A+B	Type A+B+C
Priority Areas	35	28	22	12
Others	131	99	79	62

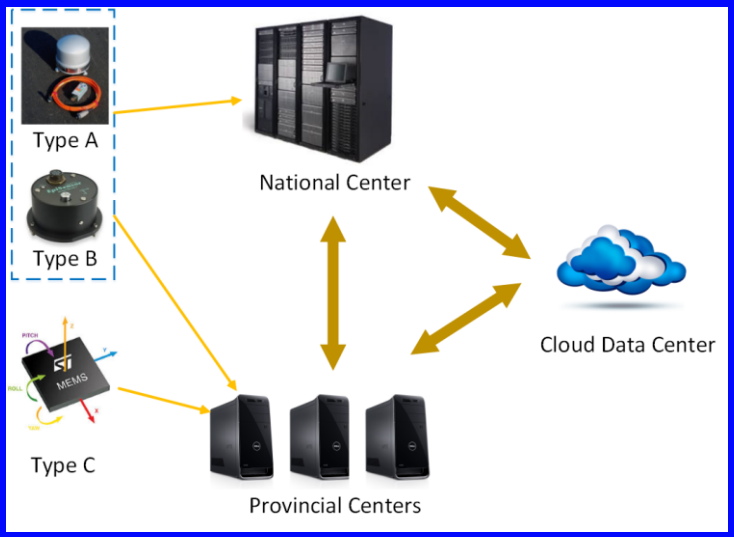
Three Types of Stations in SIRR & EEW



Processing System Architecture



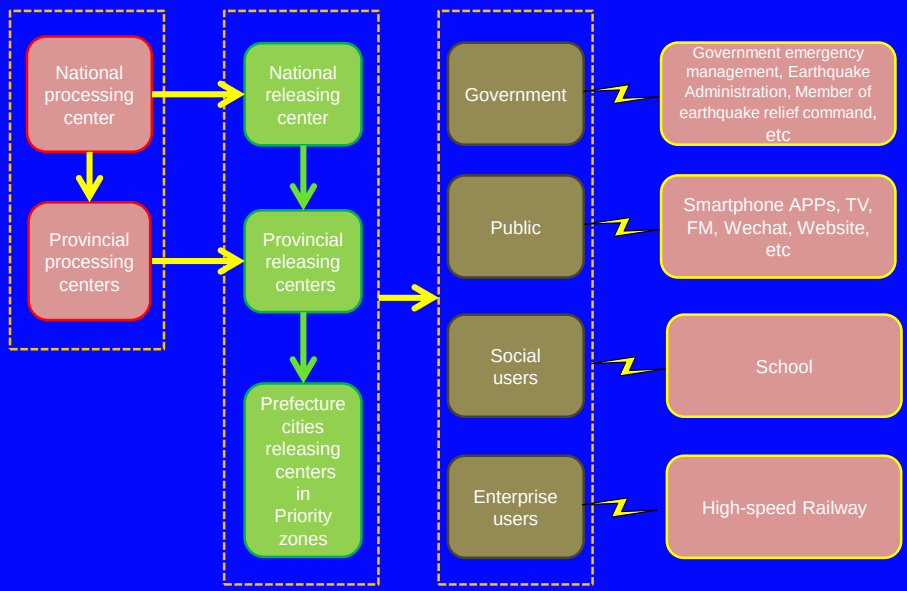
Distributed Data Processing System



Products

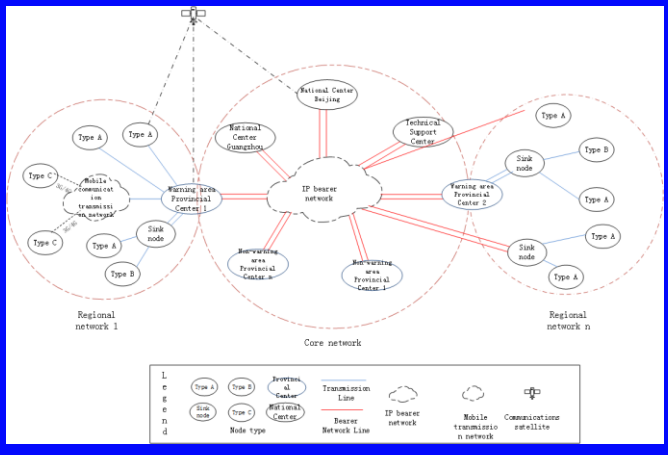
● Scientific researches and engineering applications	✓ Waveform data
● Multi-parameter Reporting	✓ Intensity distribution ✓ Wave propagation ✓ Accumulative energy exposure ✓ Source parameters
● Intensity Reporting	✓ Measured intensity scatterplot ✓ Peak ground motion distribution (PGA PGV) ✓ Acceleration response spectra
● Earthquake Reporting	✓ Earthquake magnitude, Epicenter
● Early Warning	✓ Predicted Magnitude, Epicenter ✓ Affected Areas ✓ County/predicted intensity (PGA PGV) ✓ County/arrival time

Block Diagram of Release System



Block Diagram of Communication System

- Real-time transmission system for stations and releases
- Type A and B, using intranet (dedicated optical fibre and satellite backup)
- Type C, using internet (Wired and wireless)



Supporting System

National Supporting System

- Software Testing
- Operation Monitoring
- Technology Training
- Data post-Processing

Provincial Supporting Systems

- Maintenance
- Backup Equipments

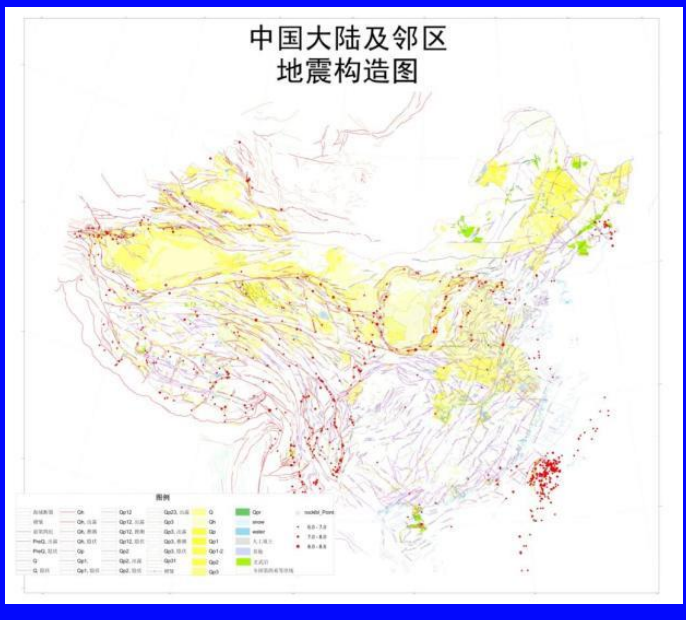
- **Observation and Prospecting on Earthquake Tectonics in China Continent**

1. ChinArray

2. Active fault mapping

3. Geophysical Observations

2. Active Faults Mapping Project

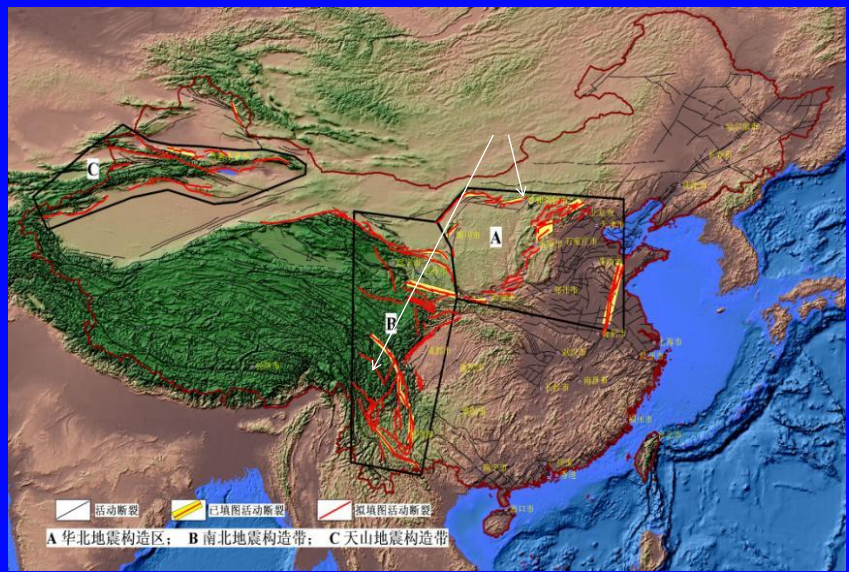


Project Objective

- To perform geological mapping of more than 100 active faults in three regions with scale of 1:50,000 and to conduct several seismic reflection profiles across the key block-boundaries.
- To determine most possible faults which are capable to generate destructive earthquakes, and to evaluate the maximum magnitude and probability.
- To survey concealed active faults in urban region and their accurate locations, and to determine the width of the possible earthquake hazard zone associated with the active faults.

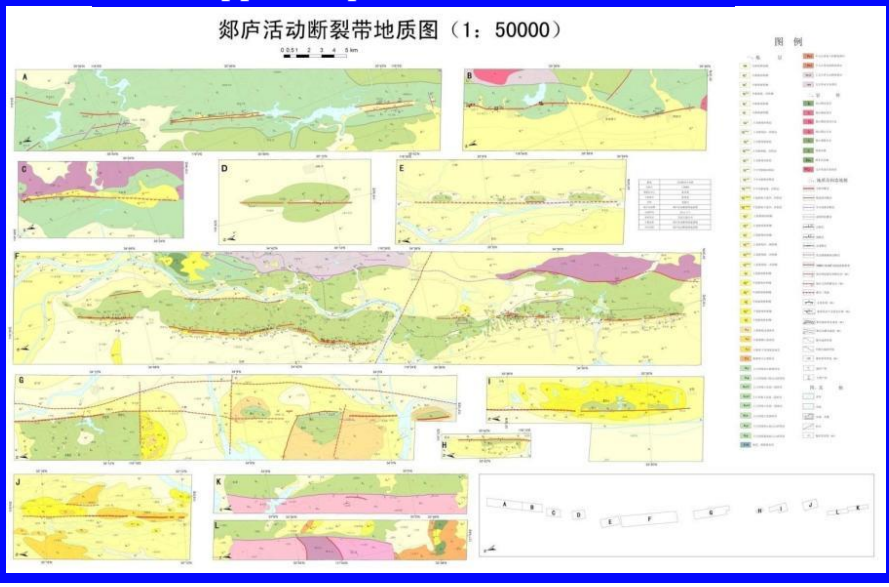
Schedule of the Project

(A) North China--finished (B) Eastern Tibetan Plateau--in the research
(C) Tianshan Region--in the coming years

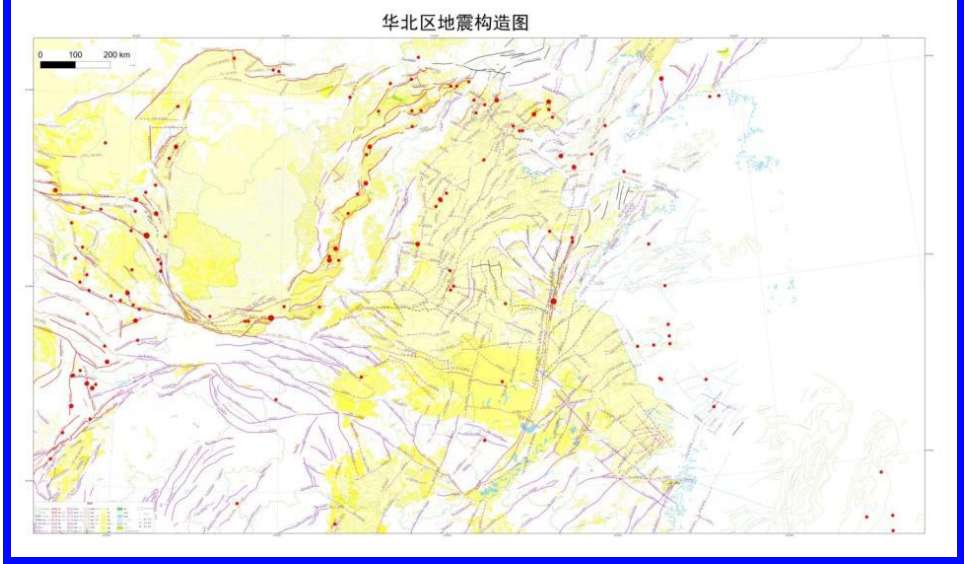


Mapping Case in the North China

Stripped map of the Tan-Lu fault



Finished Compilation



Active faults in North China Region with scale of 1:250,000

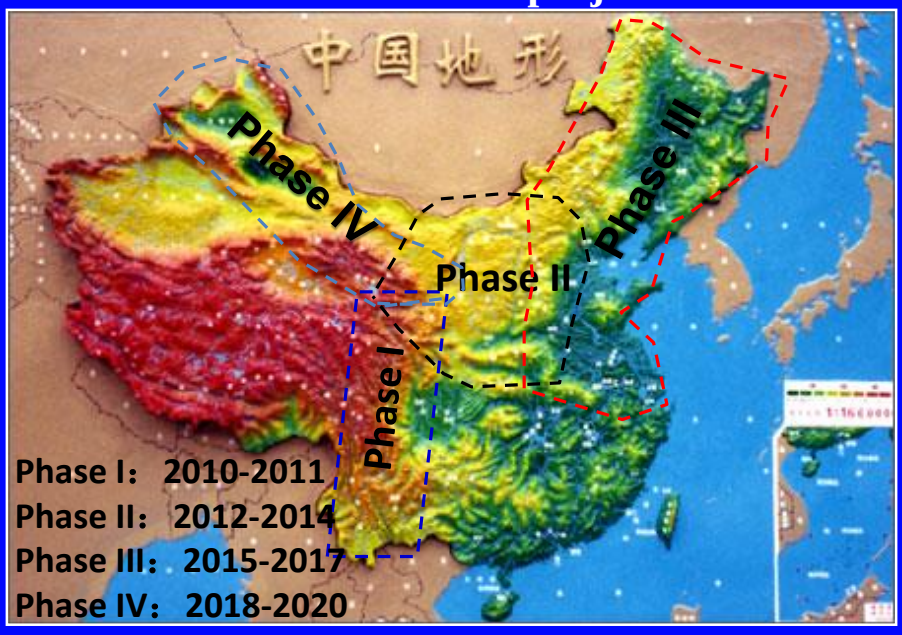
3. Geophysical Observations

The Project aims at obtaining 3-D crust movement image and evolution of physical fields, and providing information for medium- to long- term earthquake forecast.

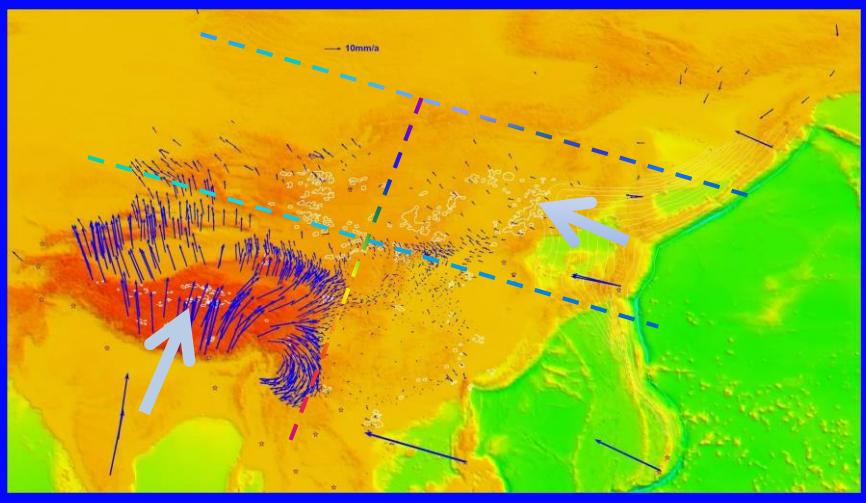
Project Contents

- **To obtain horizontal crust movement velocity field based on CORS and Campaign stations of CMONOC.**
- **To obtain vertical crust movement velocity field based on The Precise Leveling Network in China Continent.**
- **To obtain surface gravity field based on The Gravity Monitoring Network in China Continent.**
- **To obtain lithospheric magnetic field based on Observation stations for China Geomagnetic Reference Field.**

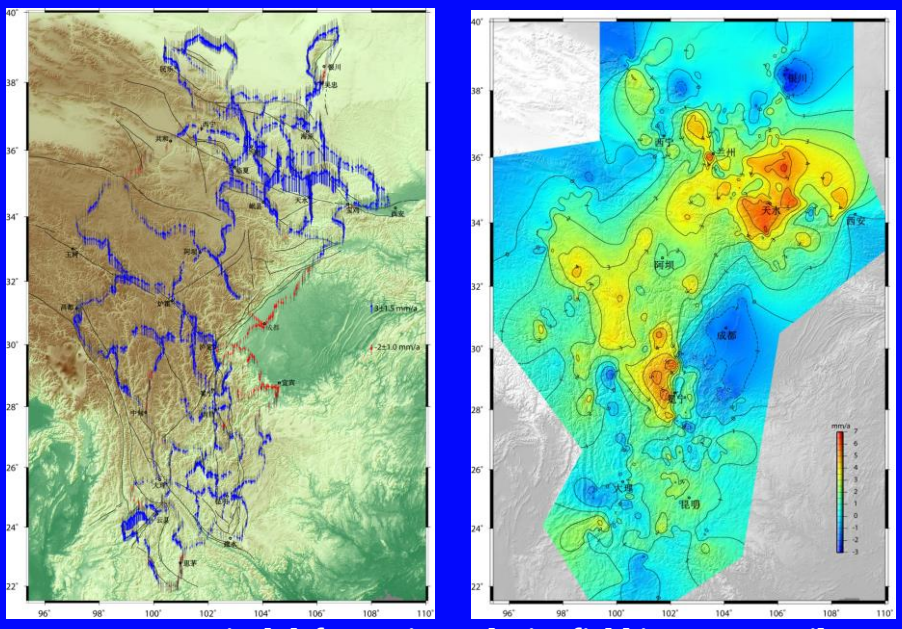
Schedule of the project



Some Preliminary results from Phase I

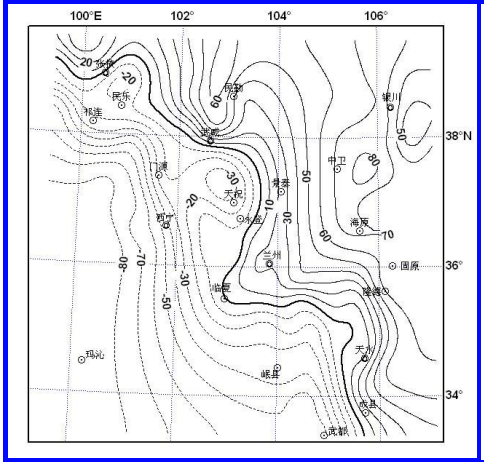


The horizontal crust movement velocity field in East Asian continental (relative to East China)

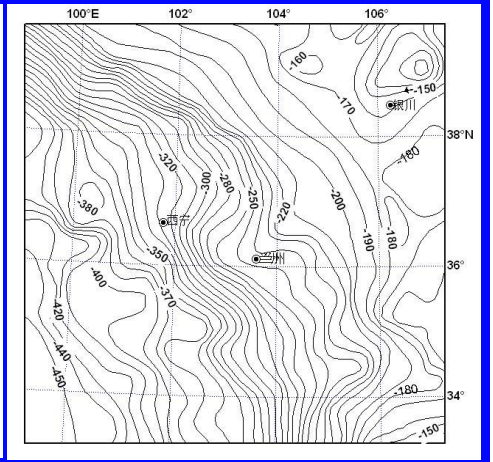


Long-term vertical deformation velocity field in Eastern Tibetan Plateau（1970s-2011, relative to Sichuan Basin)

The “micro-behavior” variation of gravity and bouguer gravity anomaly in Eastern Tibetan Plateau



The long-term gravity change contours （1993-2003, microgal）



The bouguer gravity anomaly contours （milligal ）

Outlines

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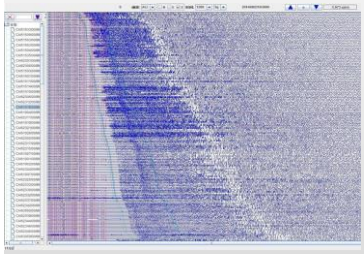
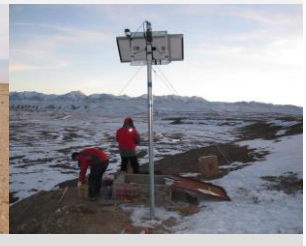
- ChinArray and Velocity Structure & Seismo-tectonics beneath Eastern Tibetan Plateau

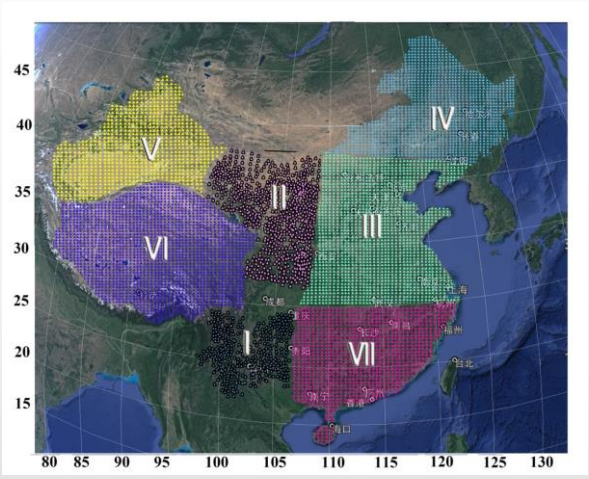
ChinArray Project

The Project aims at accumulating the observation data from the dense seismic array over China continent, imaging the crustal and upper mantle structures, understanding the seismogenic surroundings and Continental dynamic process.





ChinArray Phase I and II

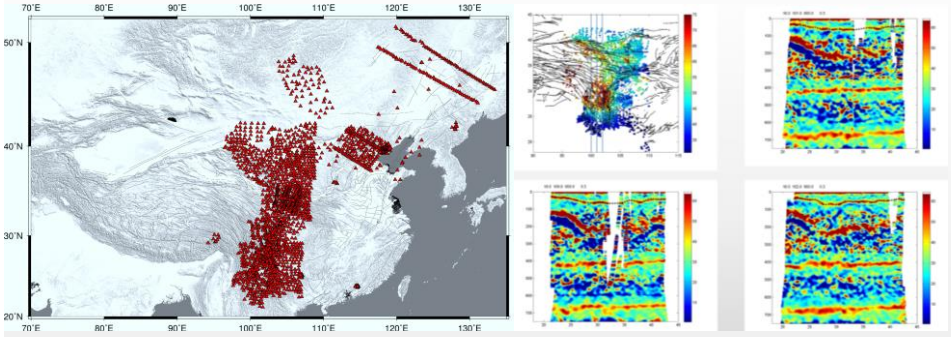


Station Distribution of ChinArray Phase I and II

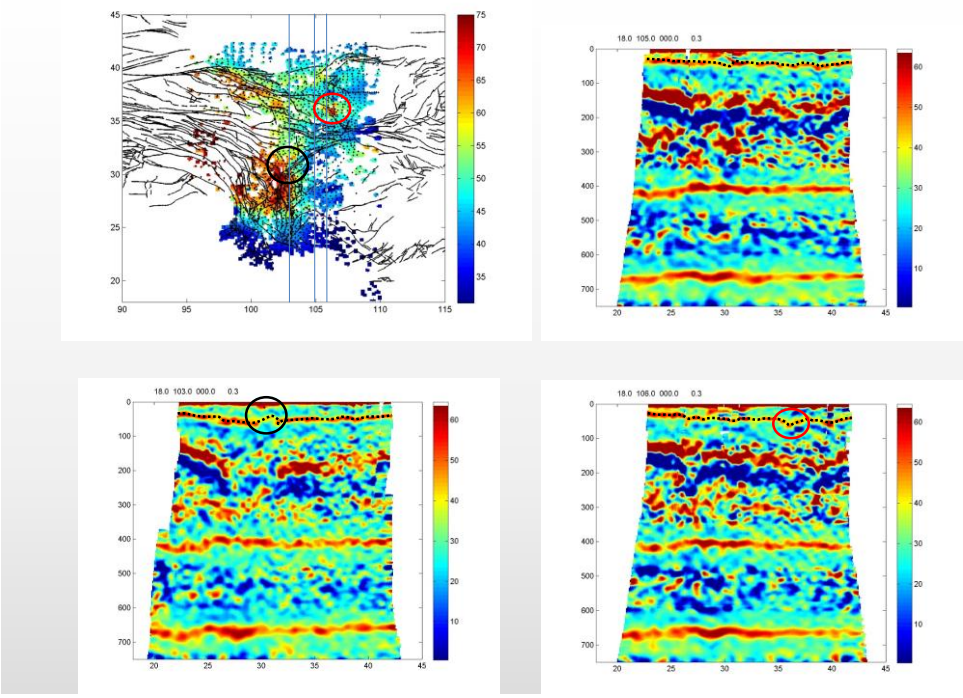
Phase I:
350 seismic stations were installed in and around Yunnan.

Phase II:
674 portable seismic array stations were installed in the northern areas.

Some results from ChinArray

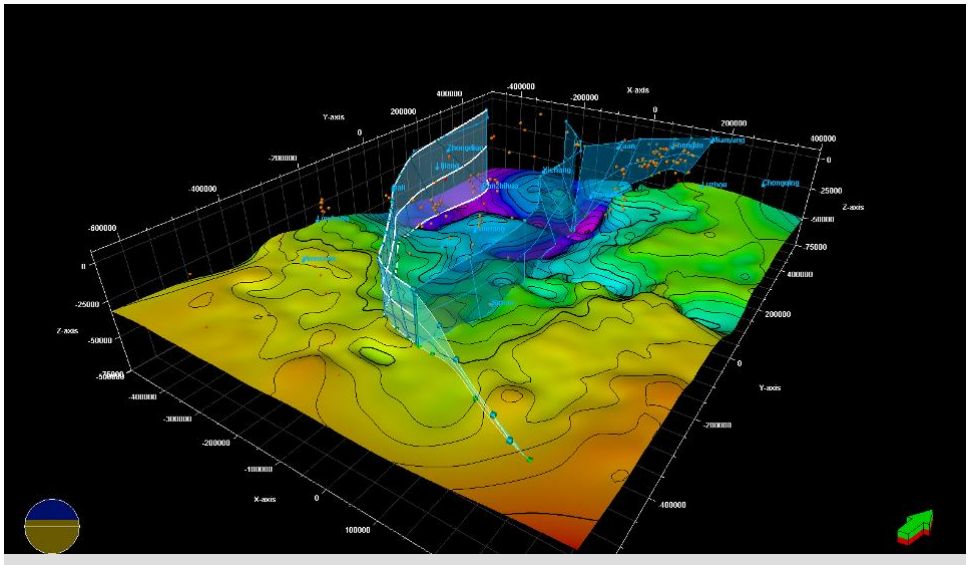


We collected the seismic data of densely deployed seismic arrays and the permanent seismic network, and obtained high resolution three dimensional S wave velocity structure by using receiver function CCP stacking, surface wave tomography, and joint inversion of receiver function and surface wave dispersion data.



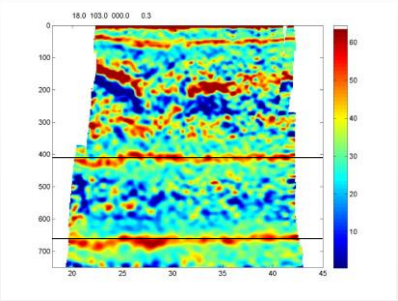
Some results from ChinArray

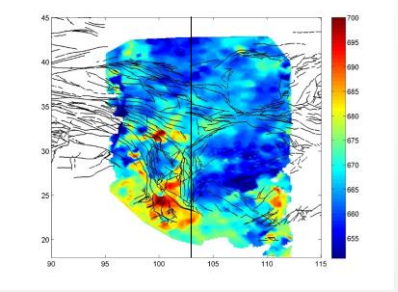
Moho discontinuity

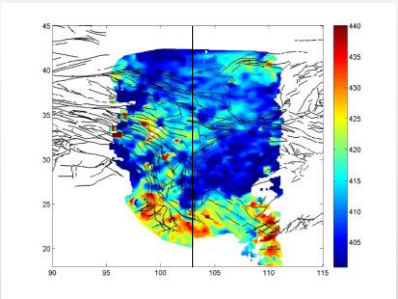


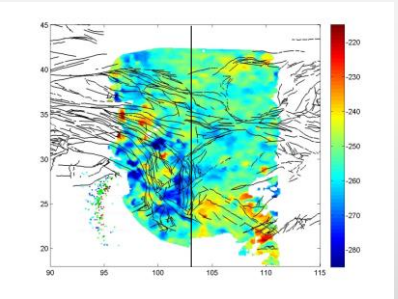
Some results from ChinArray

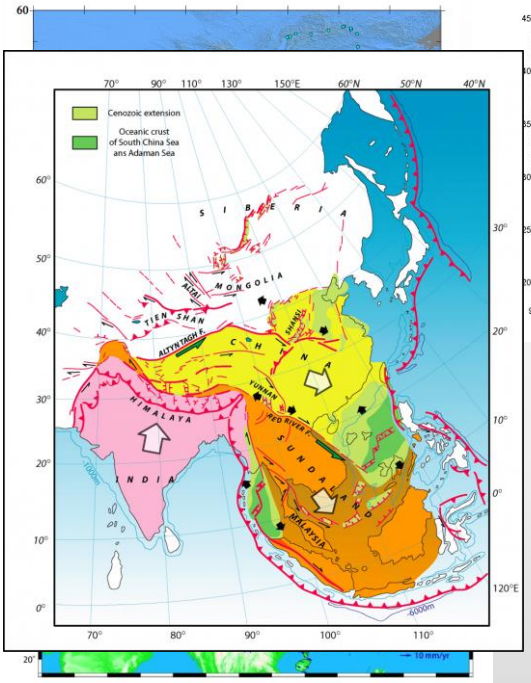
Mantle discontinuity

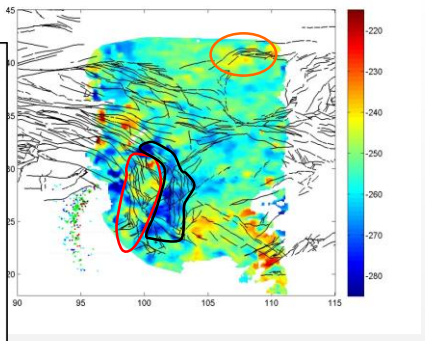


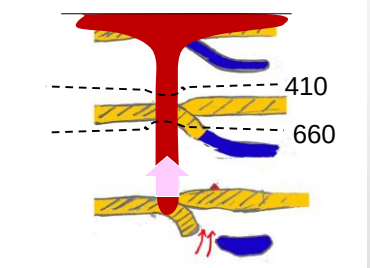




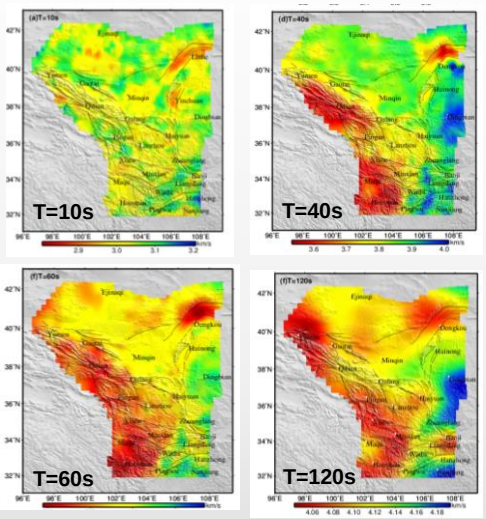






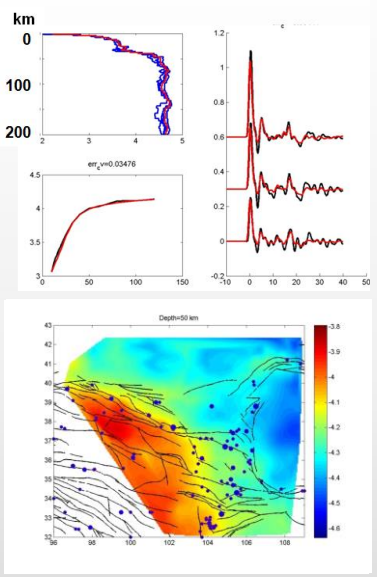


Surface Wave Tomography



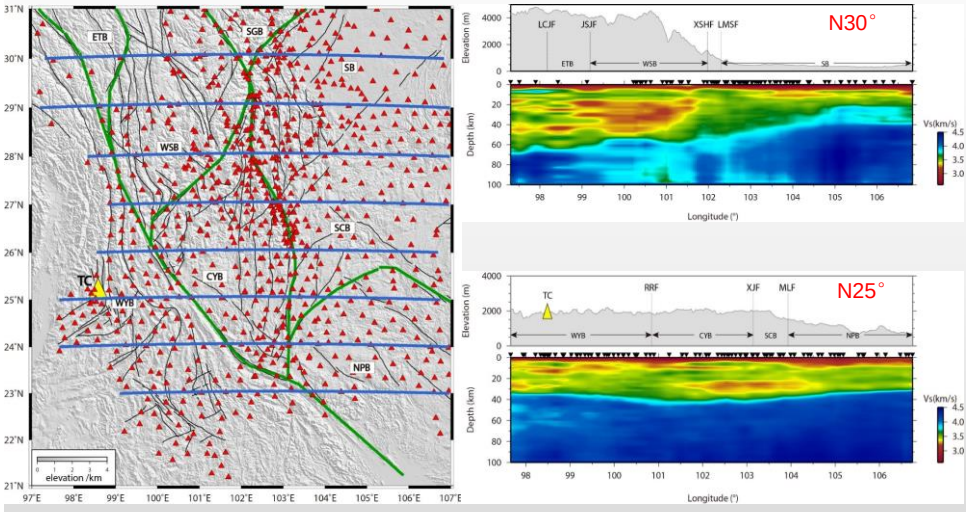
Phase velocity（10-120s）

S-wave velocity structure from joint inversion

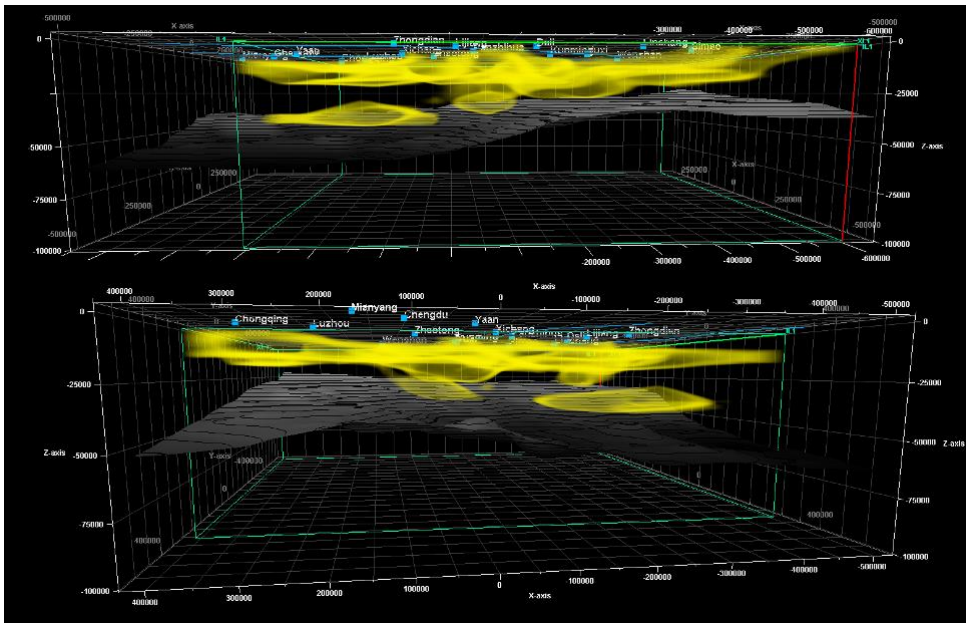


Some results from ChinArray

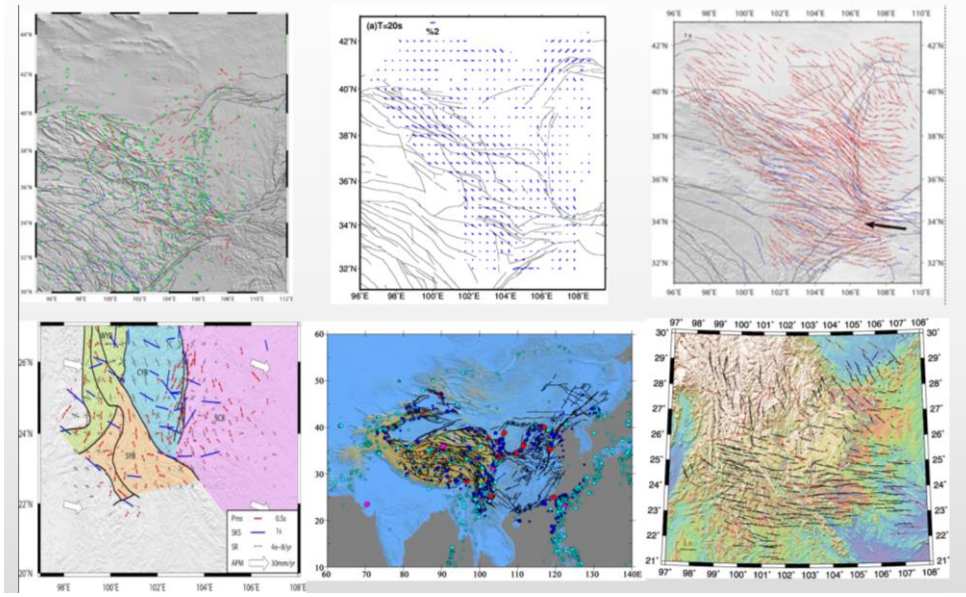
S-wave velocity Profiles



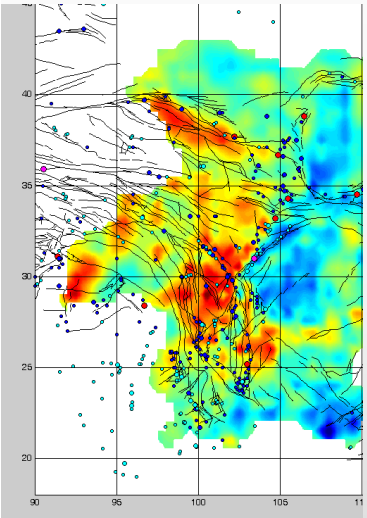
Distribution of low velocity zones



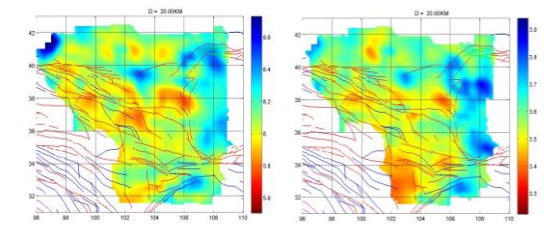
Anisotropy from surface wave tomography, Receiver function and SKS splitting analysis



Teleseismic tomography

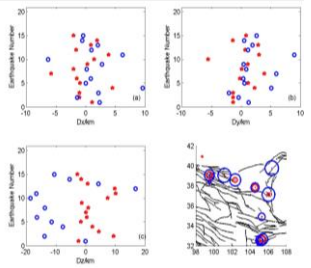


Regional travel time tomography



Depth Deviation:
Locsat: 13.4km
Loc_3D: 3.7km
(1 : 3.62 , 72%)
Horizontal Deviation:
Locsat: 5.2 km
Loc_3D: 2.9km
(1 : 1.79 , 44%)

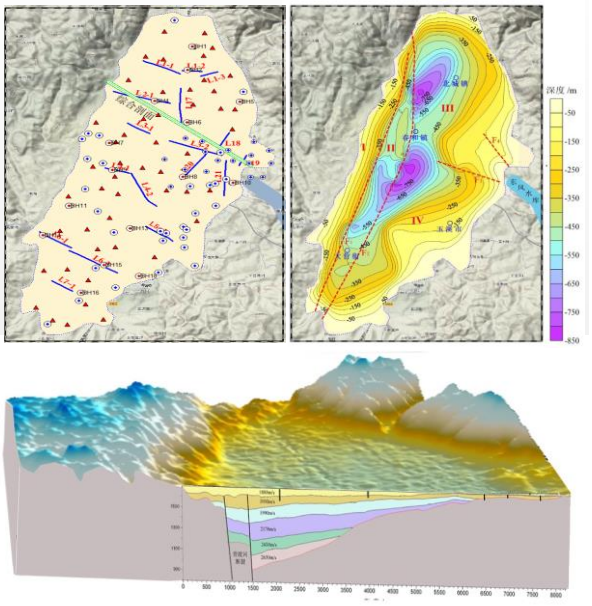
For earthquake location

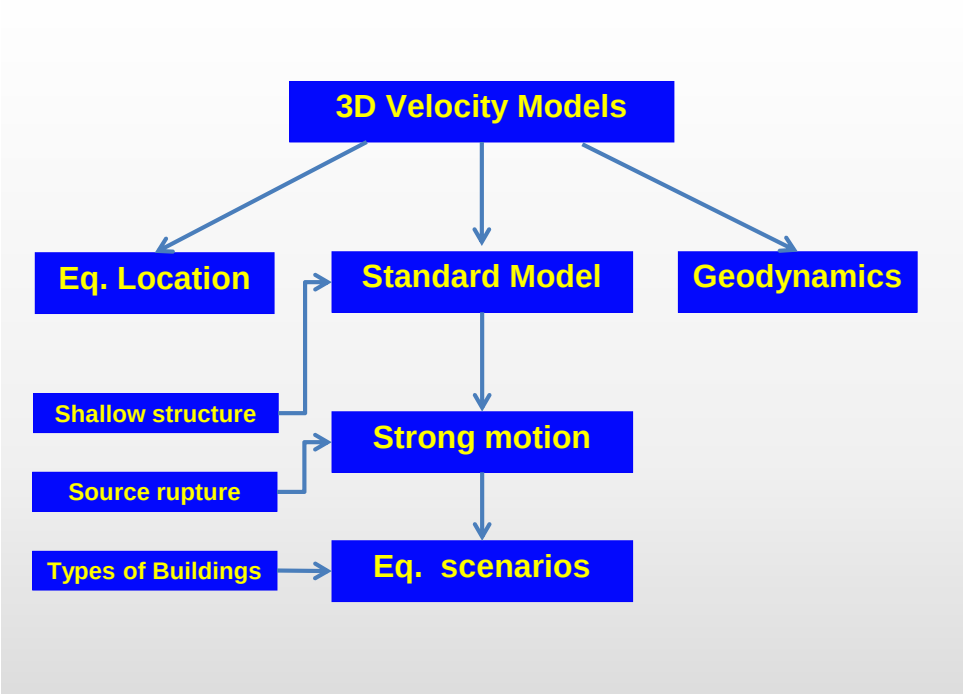


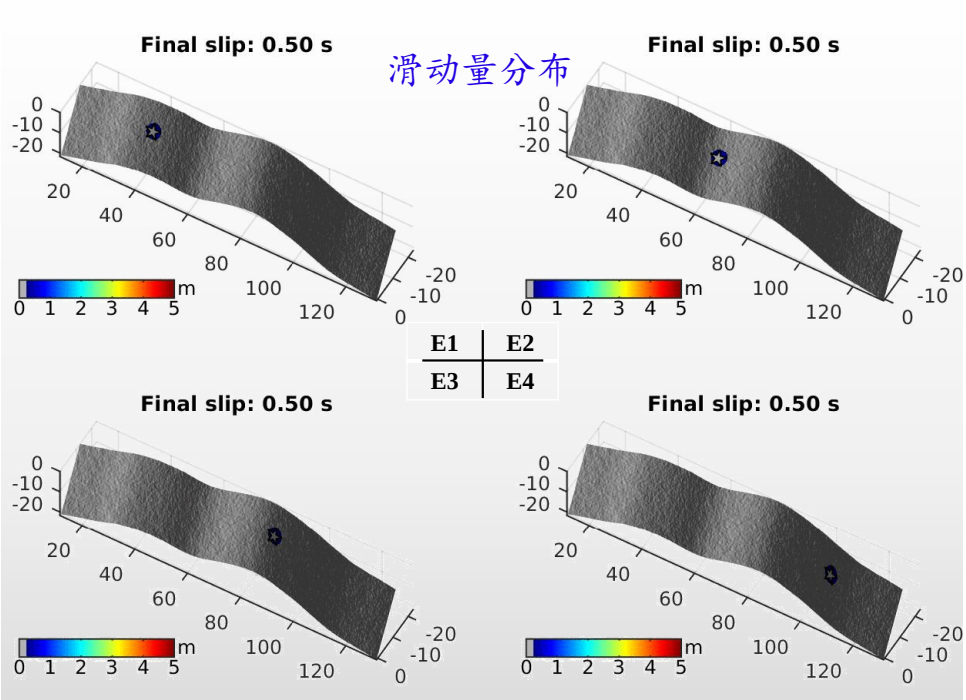
The Shallow velocity structure of Yuxi Basin

Shallow structure
sediment thickness

reflection surveys
Surface wave exploration
borehole data

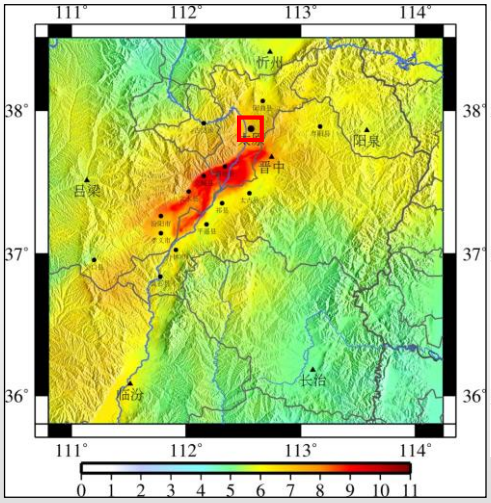



3D Velocity Models
Eq. Location
Standard Model
Geodynamics
Shallow structure
Source rupture
Types of Buildings
Strong motion
Eq. scenarios

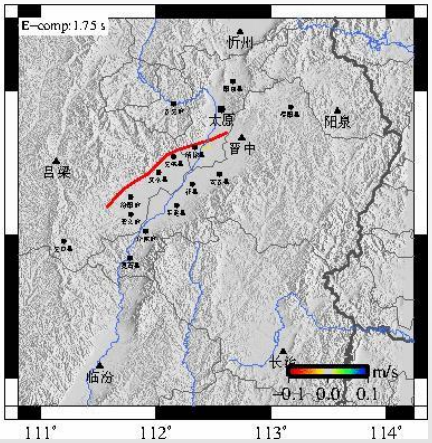

Final slip: 0.50 s
滑动量分布
Final slip: 0.50 s
E1
E2
E3
E4
Final slip: 0.50 s
Final slip: 0.50 s
m

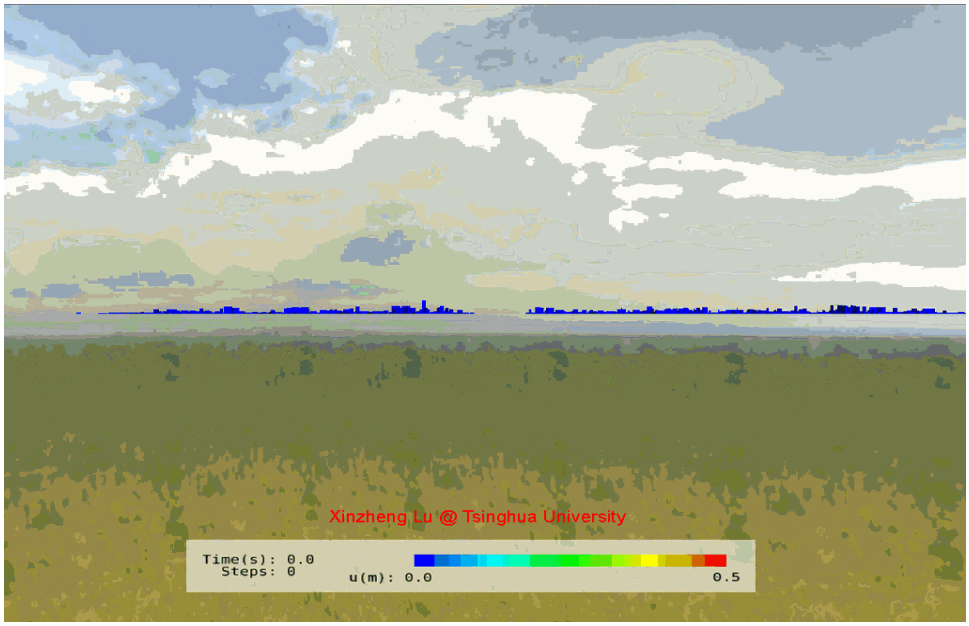
Event 4：

Estimated Intensity



Wave Propagation
（E-W component）






Thank you
for your attention !