



Development of Earthquake Early Warning System in Taiwan

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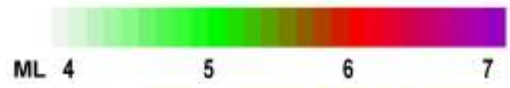
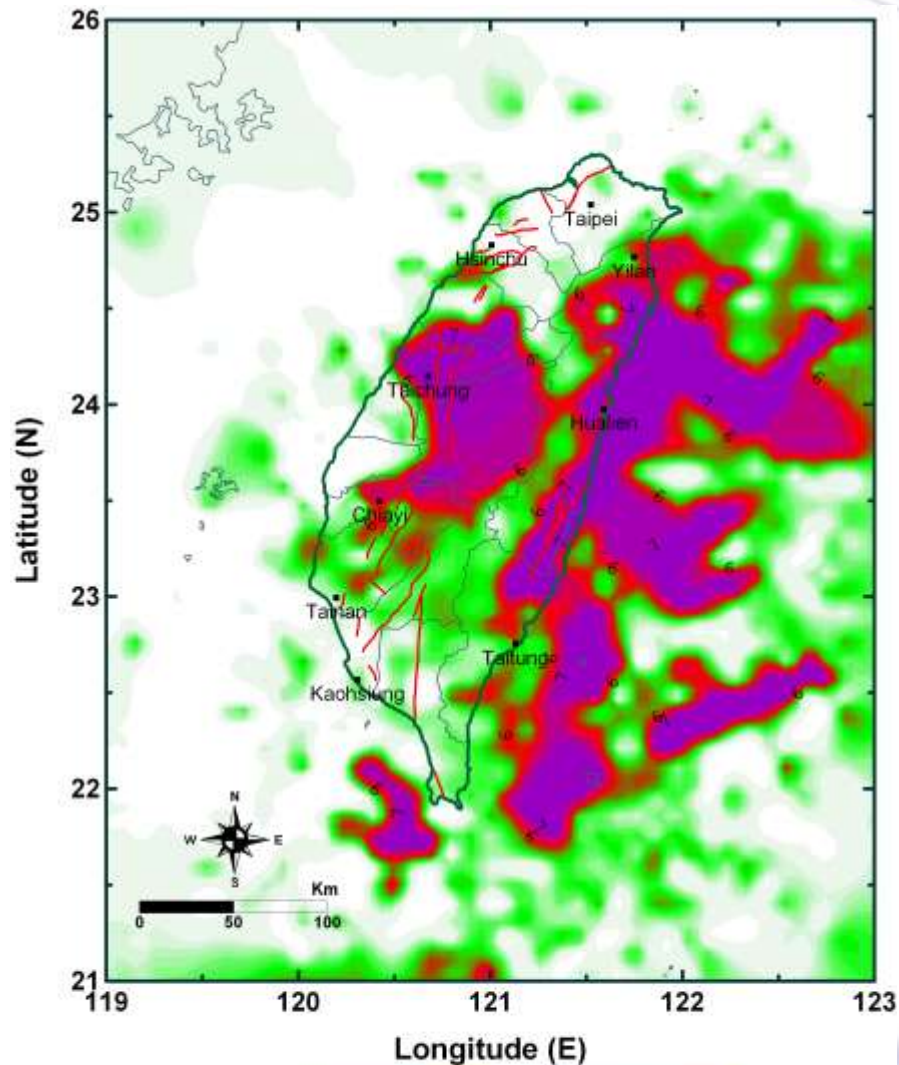
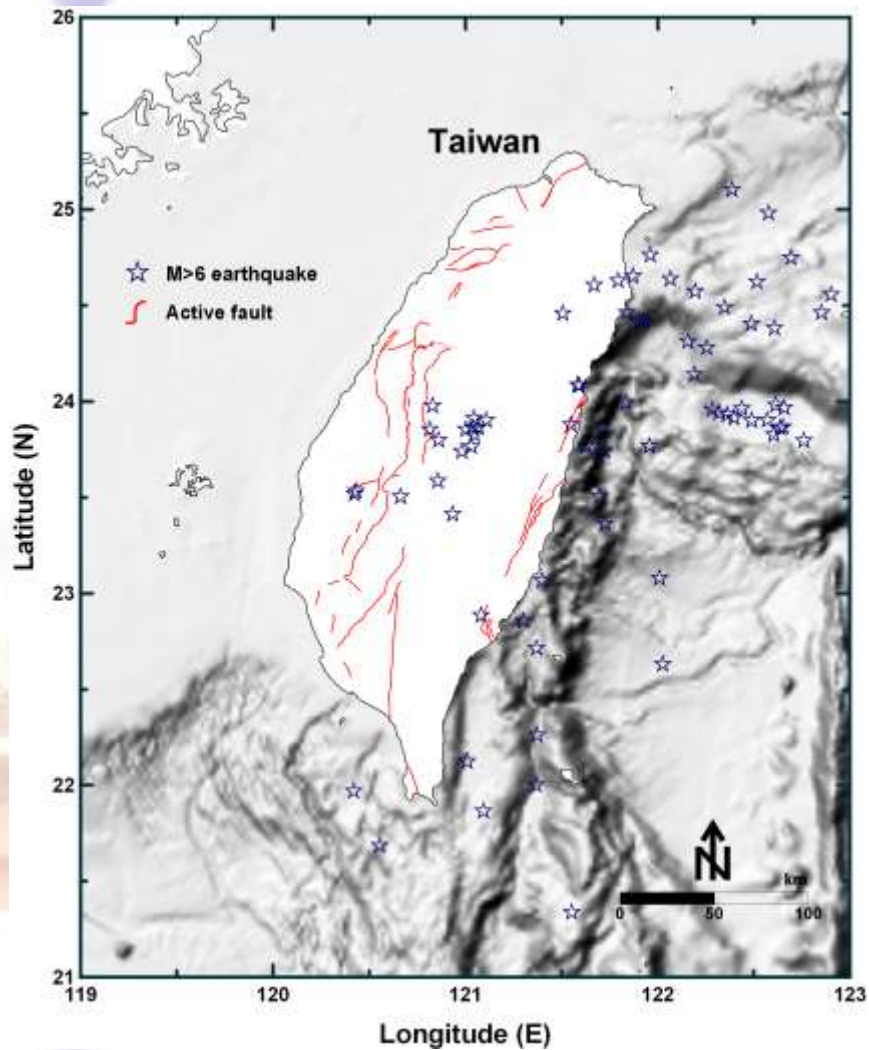
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Outline

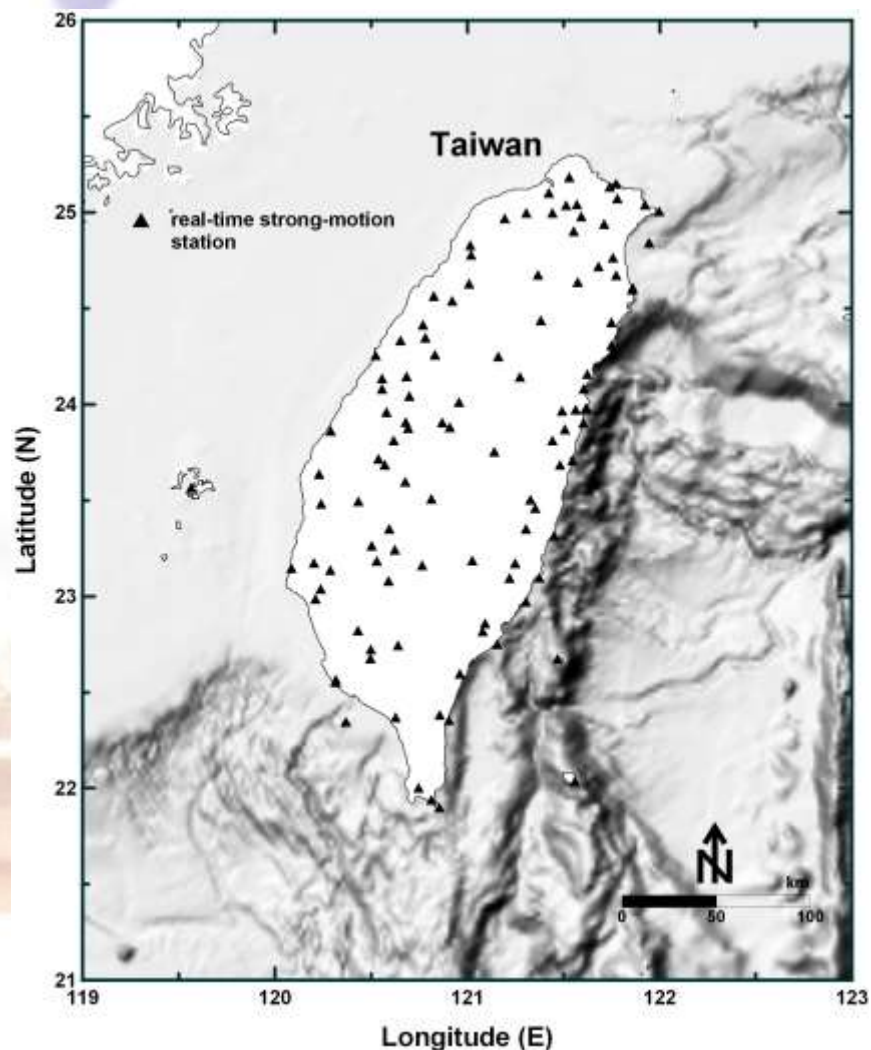
- ◆ Introduction – motivation and chance
- ◆ Current EEW system
- ◆ New proposed system
- ◆ Plan for EEW promotion

Seismic Island



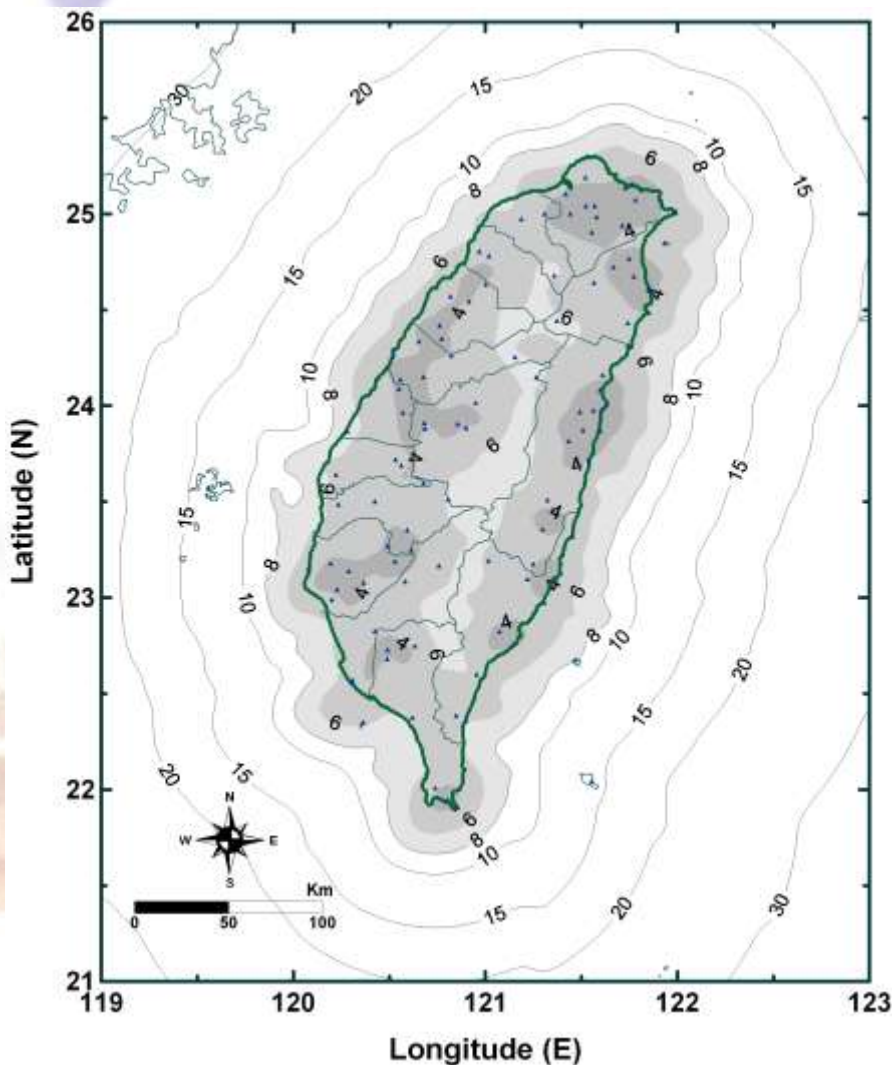
1980~2009, totally 87 Eqs

Real-time strong-motion network



- ◆ Accelerometer -
 - 102 stations (20km averaged spacing)
 - 16 bits resolution
 - $\pm 2g$ Max. amplitude
- ◆ Telemetry -
 - Real-time data stream (RTD)
 - 4.8K dedicated telephone line
 - Sampling rate 50 sps
 - 0.2 sec averaged delay
- ◆ Data processing -
 - Taipei data center
 - Windows-based workstation

Real-time strong-motion network

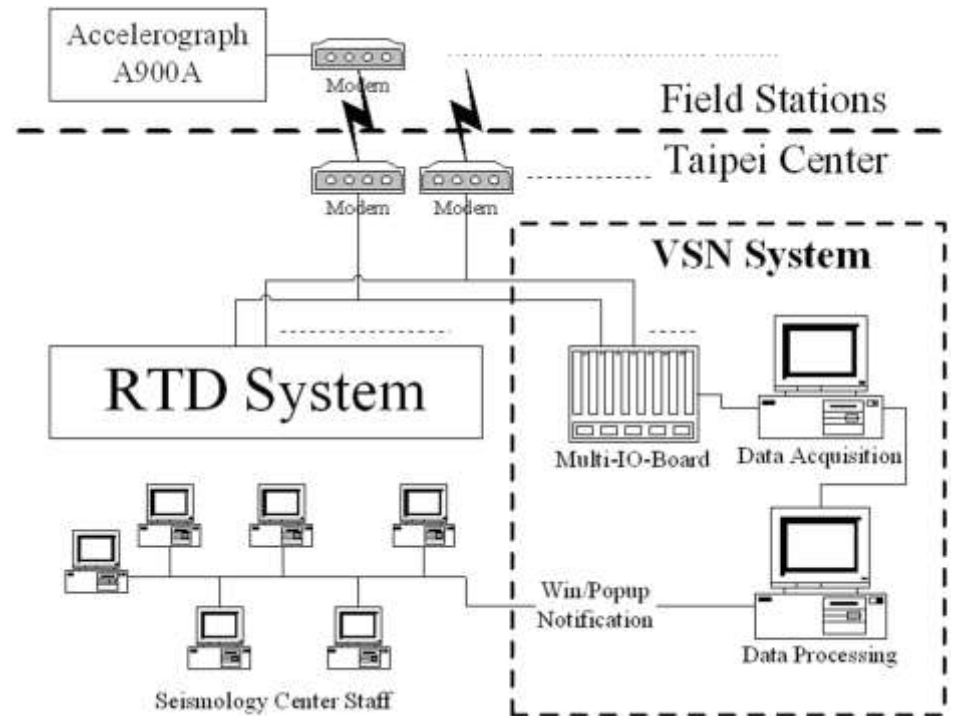
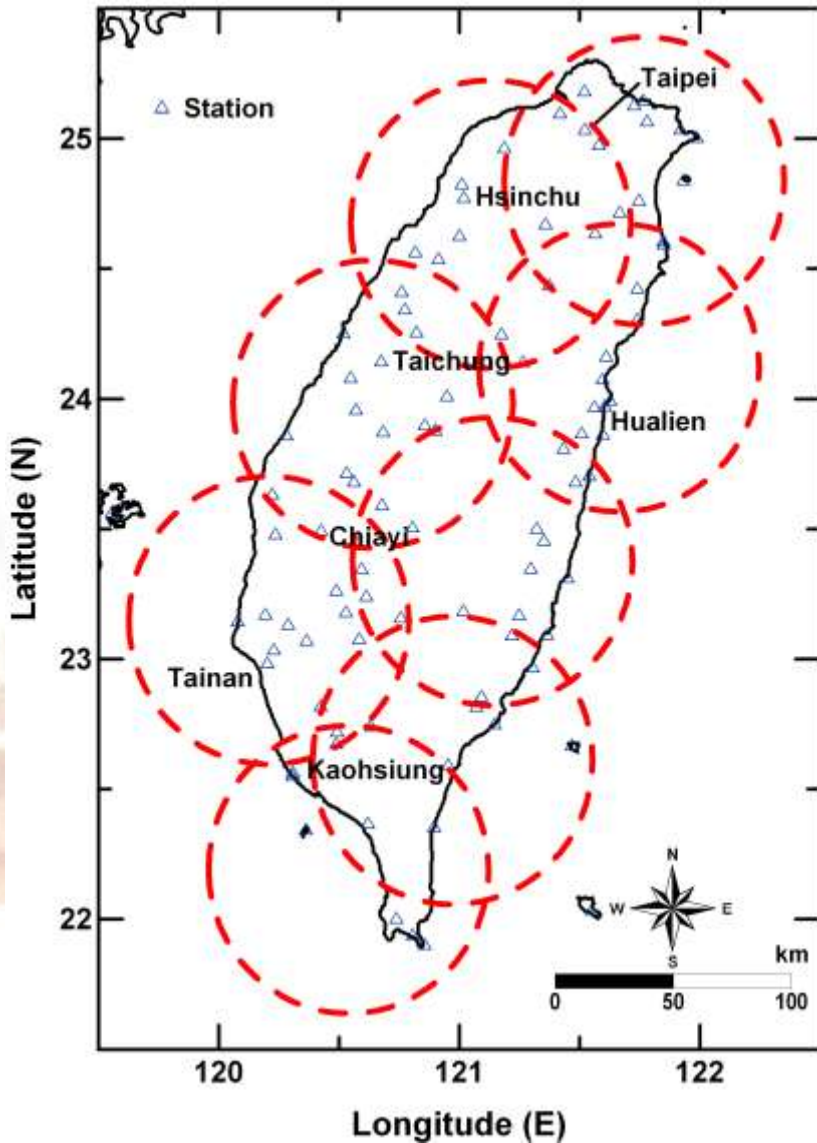


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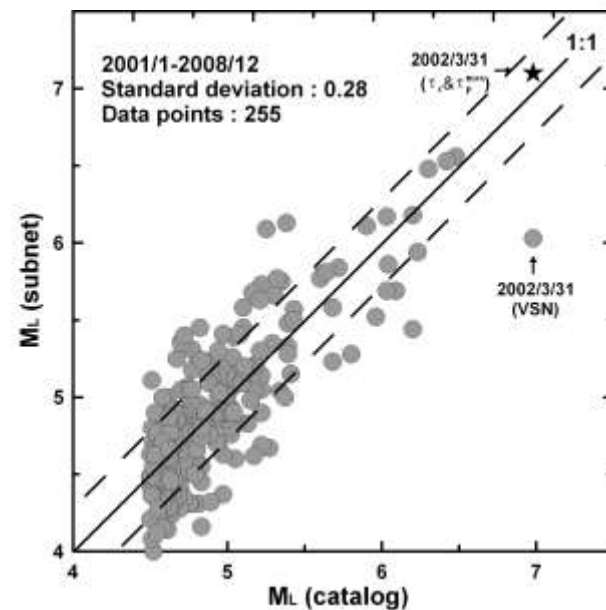
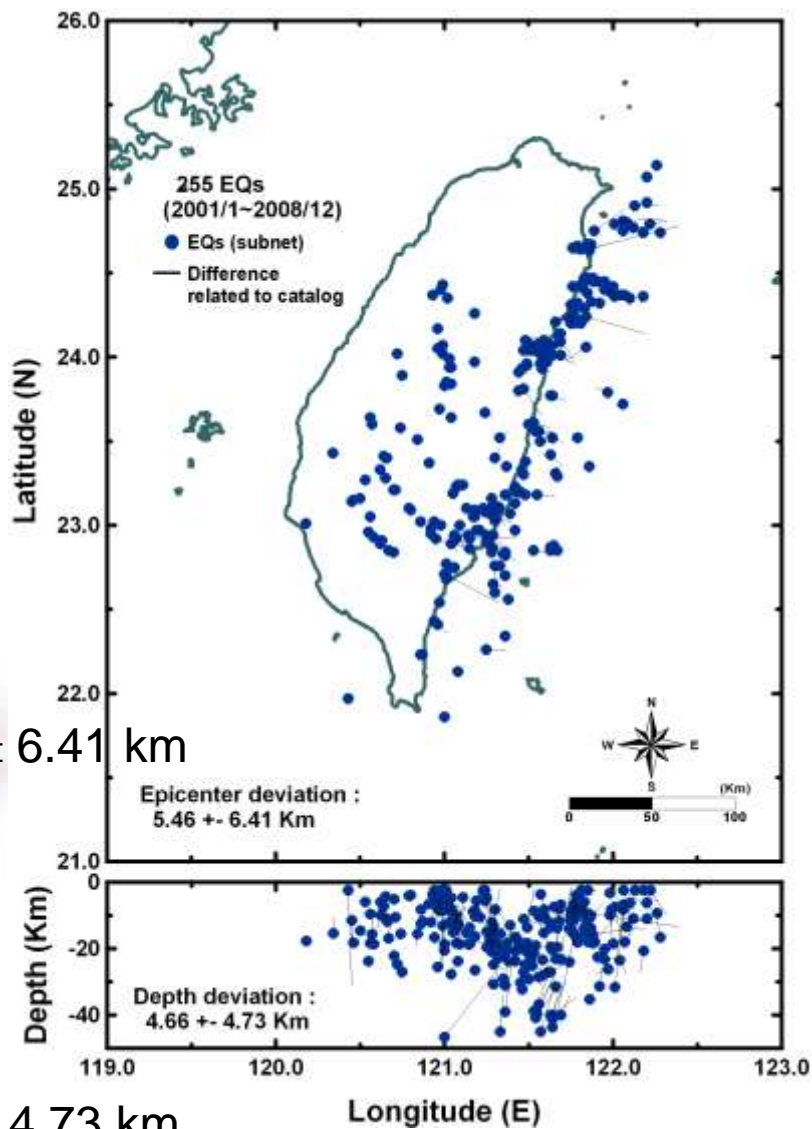
Current EEWS in Taiwan

- ◆ Based on a real-time strong-motion network
- ◆ A virtual sub-network approach for EEW experiment was carried out at first (Wu et al., 1999)
- ◆ P-wave methods proposed by Allen and Kanamori (2003) , and Wu and Kanamori (2005) were also tested for EEW capabilities lately (Hsiao, 2007)
- ◆ Other researches for EEW application including shake maps generation (Wu et al., 2001; Hsiao, 2007) and seismic loss estimation (Wu et al., 2002) were proceeded as well

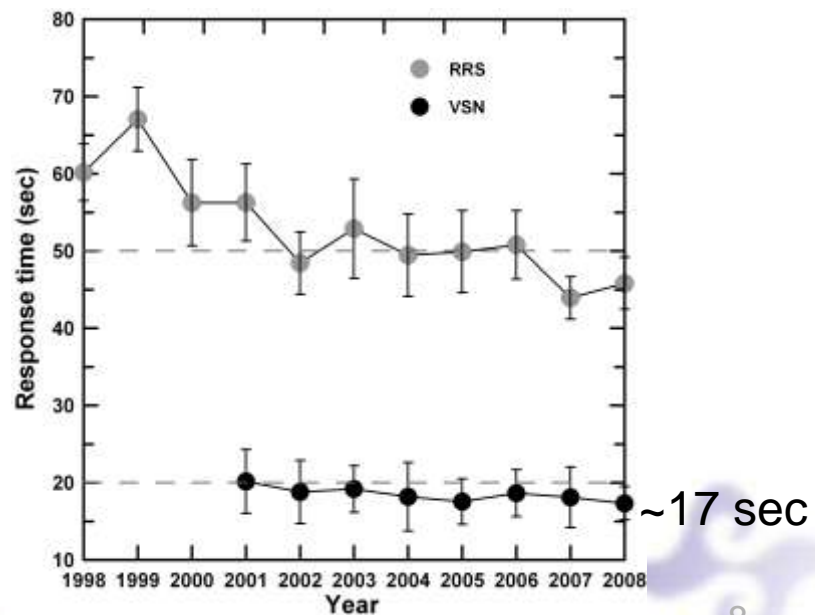
Virtual sub-network approach



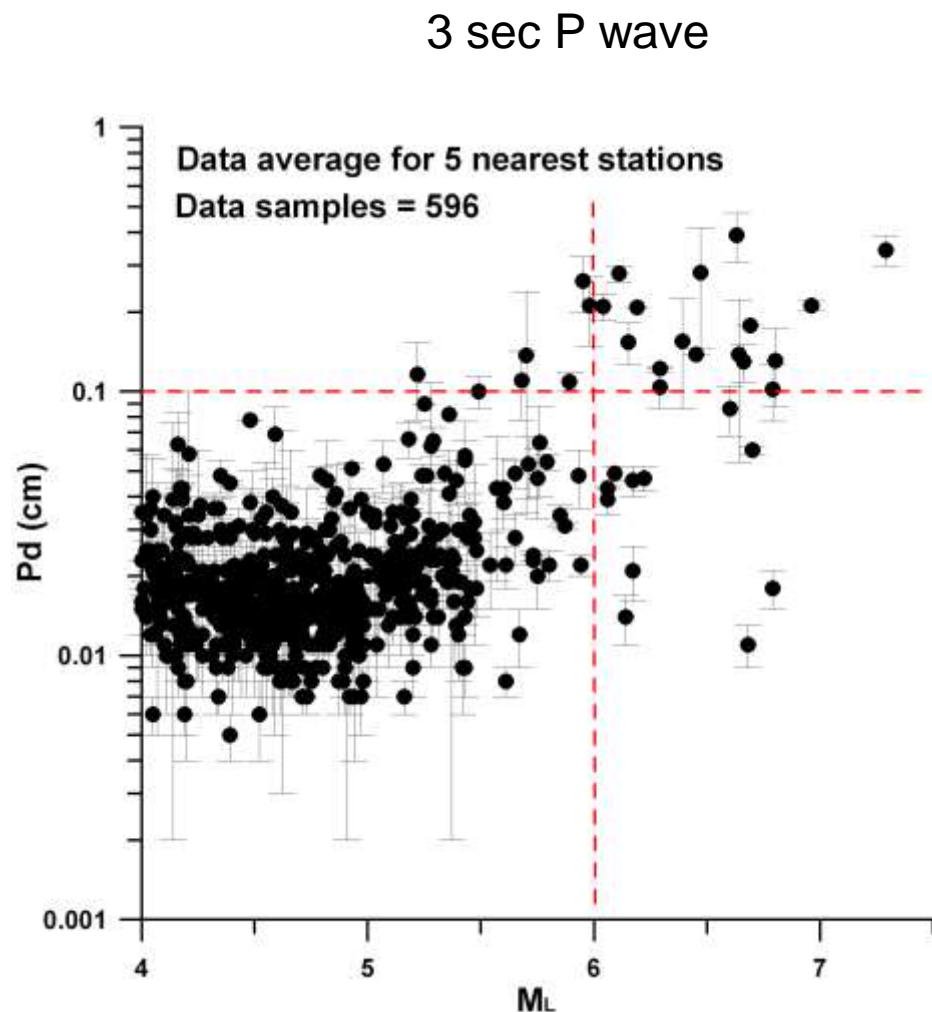
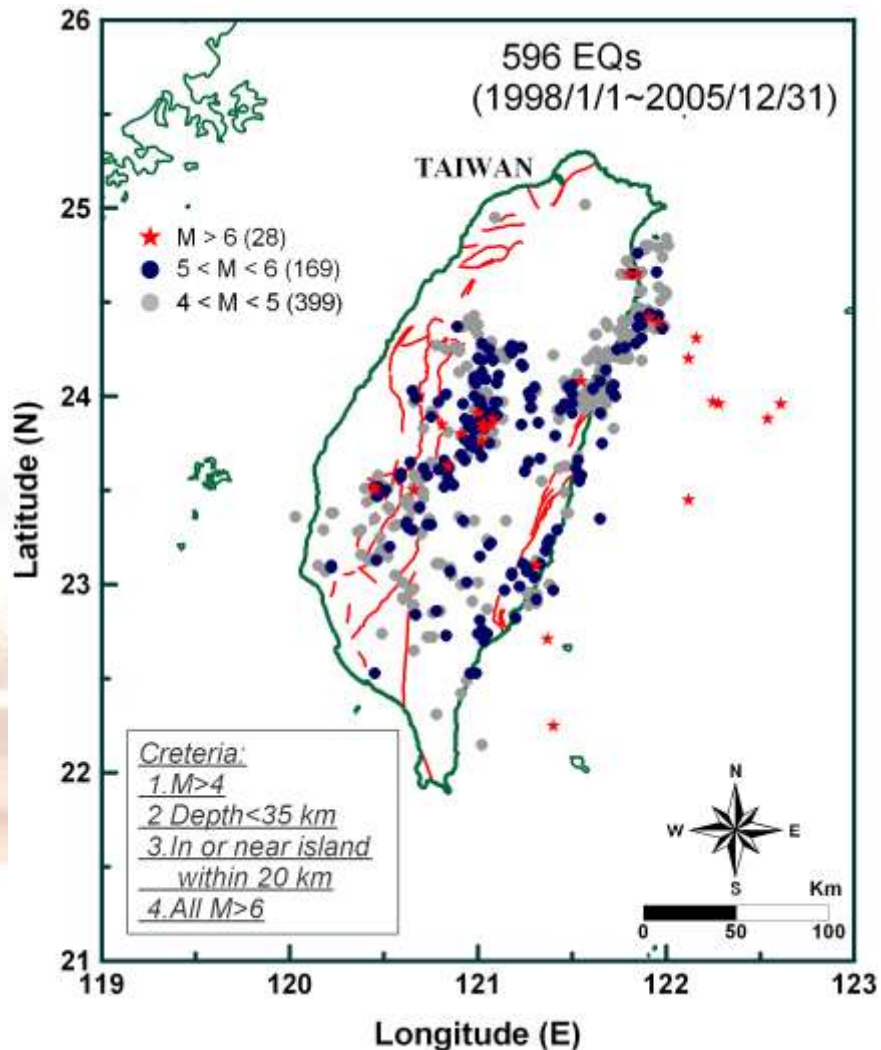
Performances for VSN



0.28



Pd discriminator



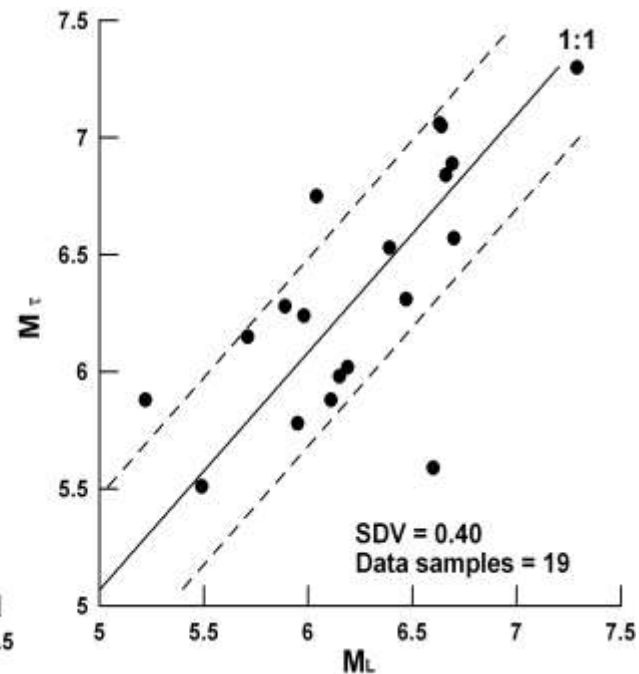
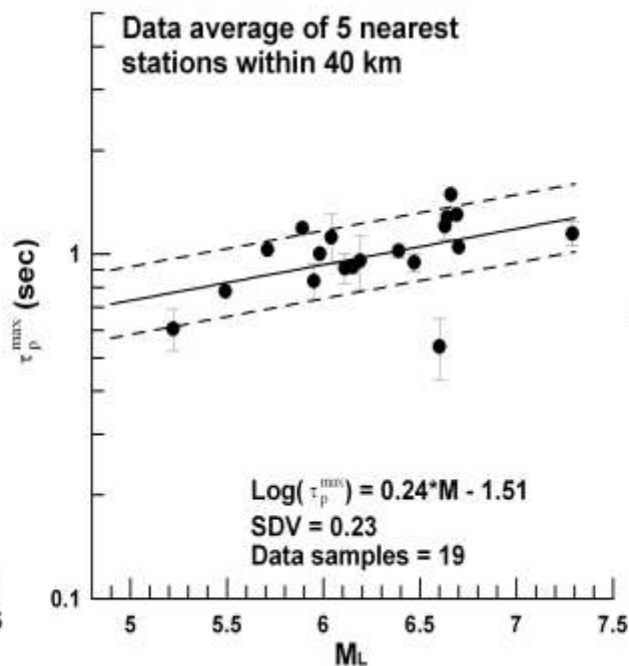
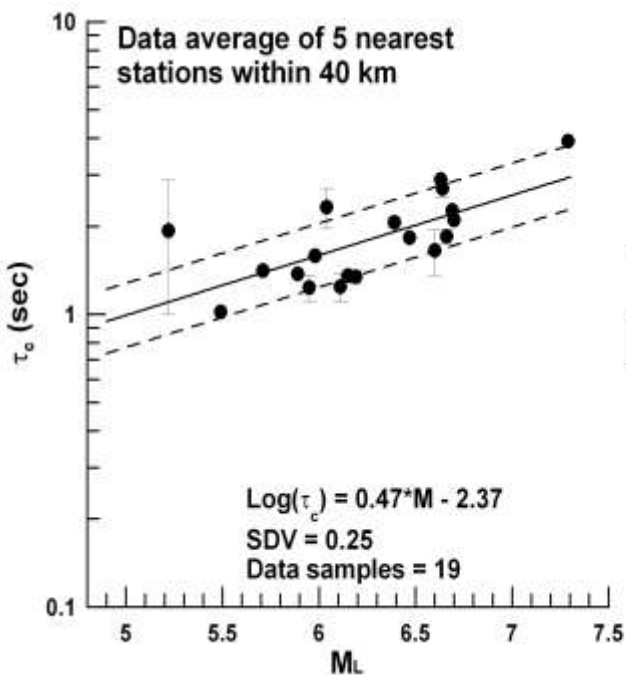
Magnitude estimated



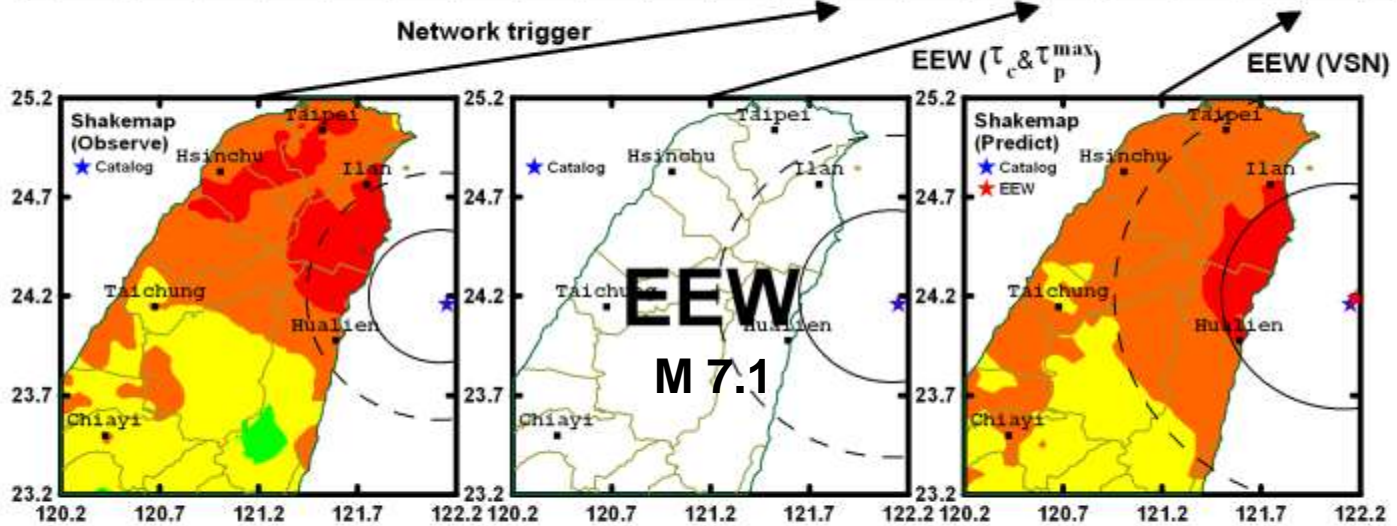
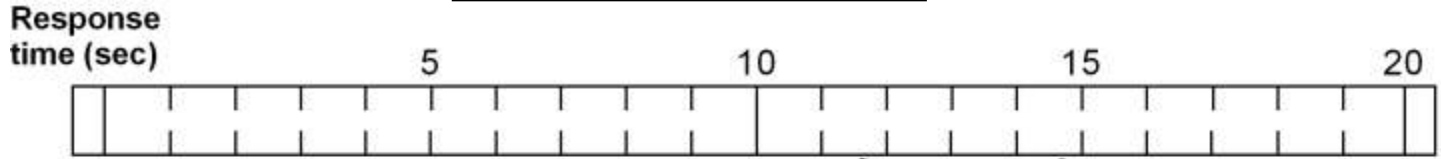
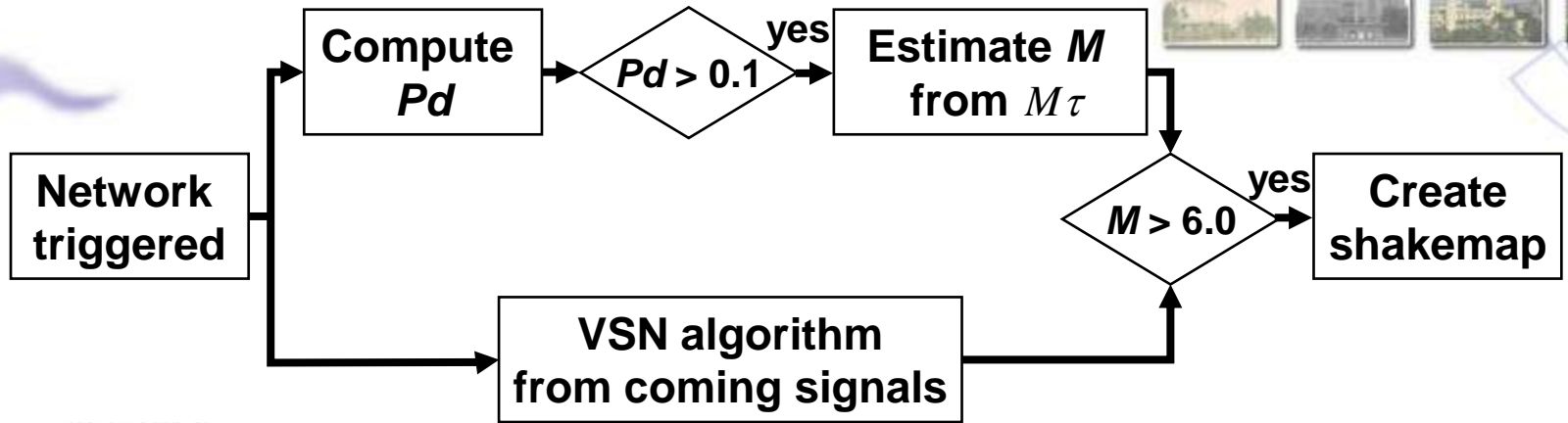
τ_c

τ_p^{\max}

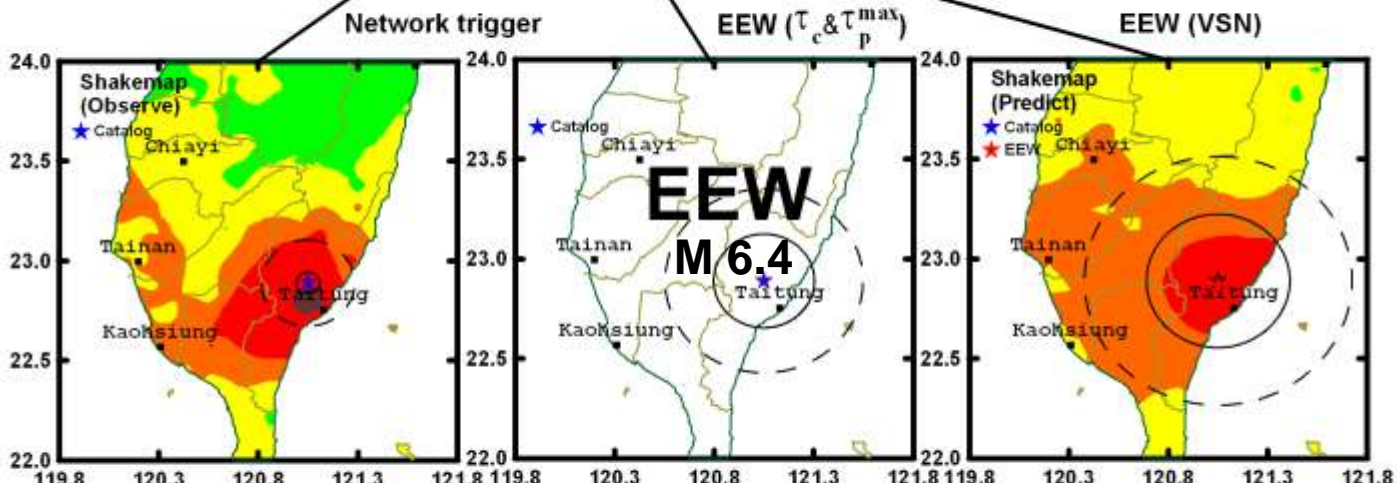
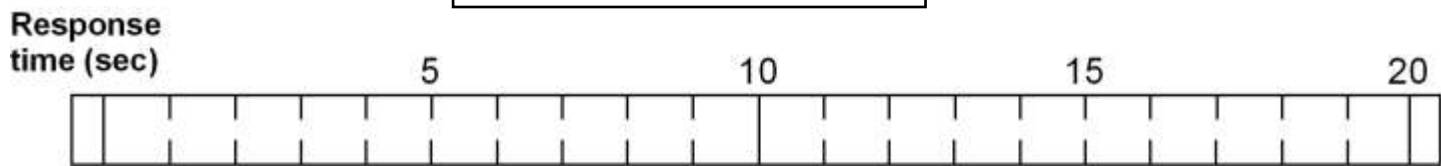
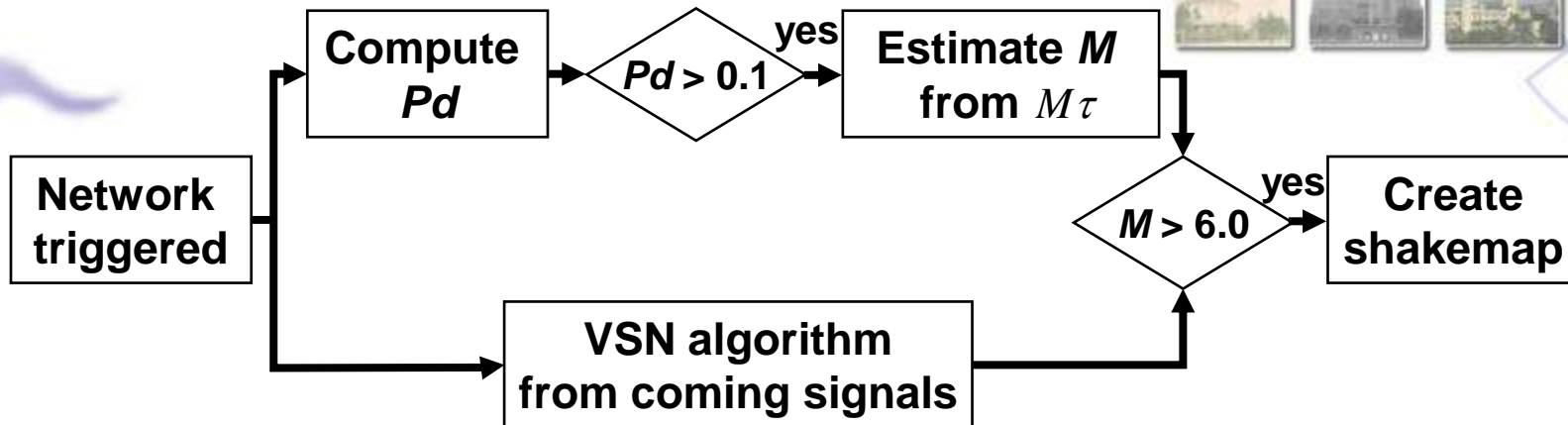
M_τ



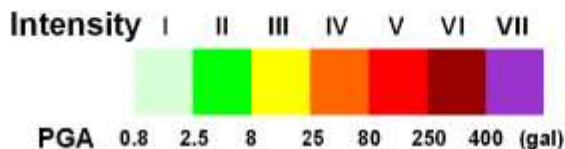
0.40



2002/3/31 M 7.0
Offshore Hualien earthquake



2006/4/1 M 6.5
Taitung earthquake

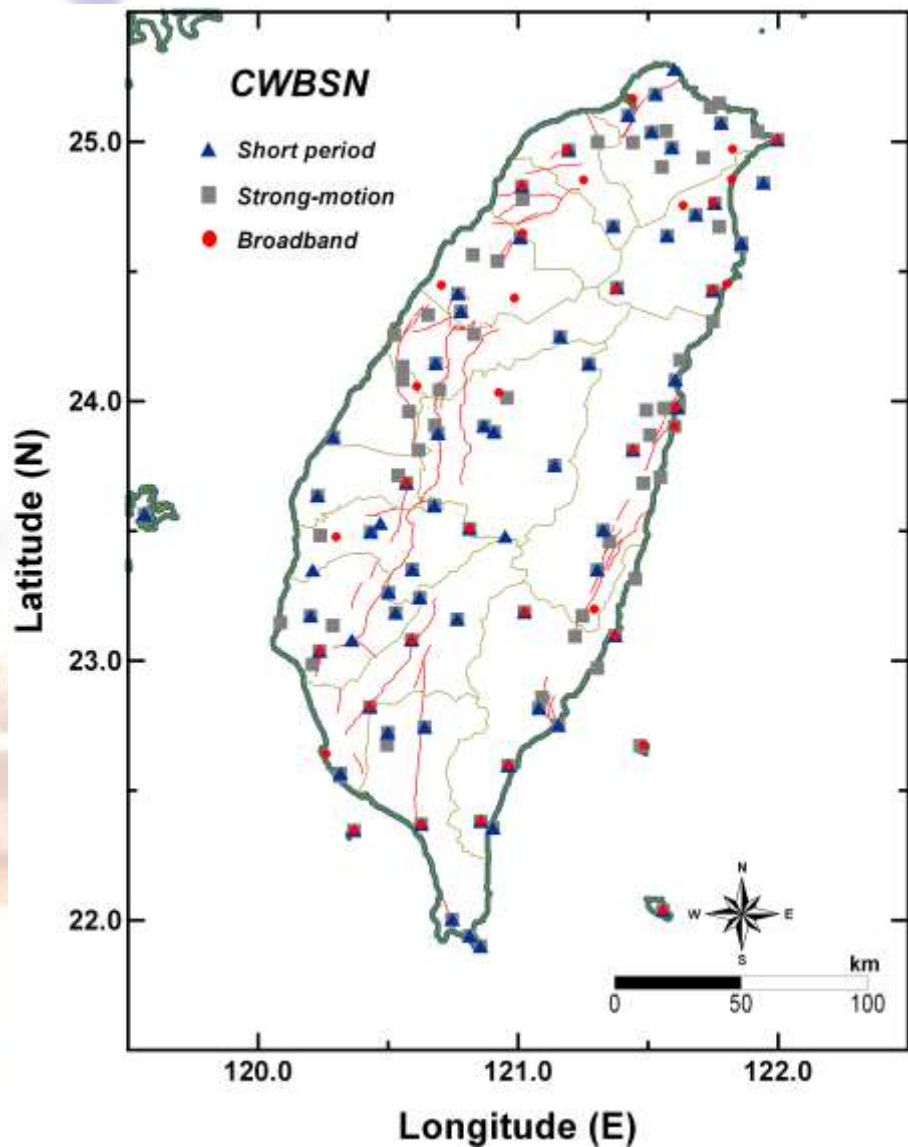


--- P wave
— S wave

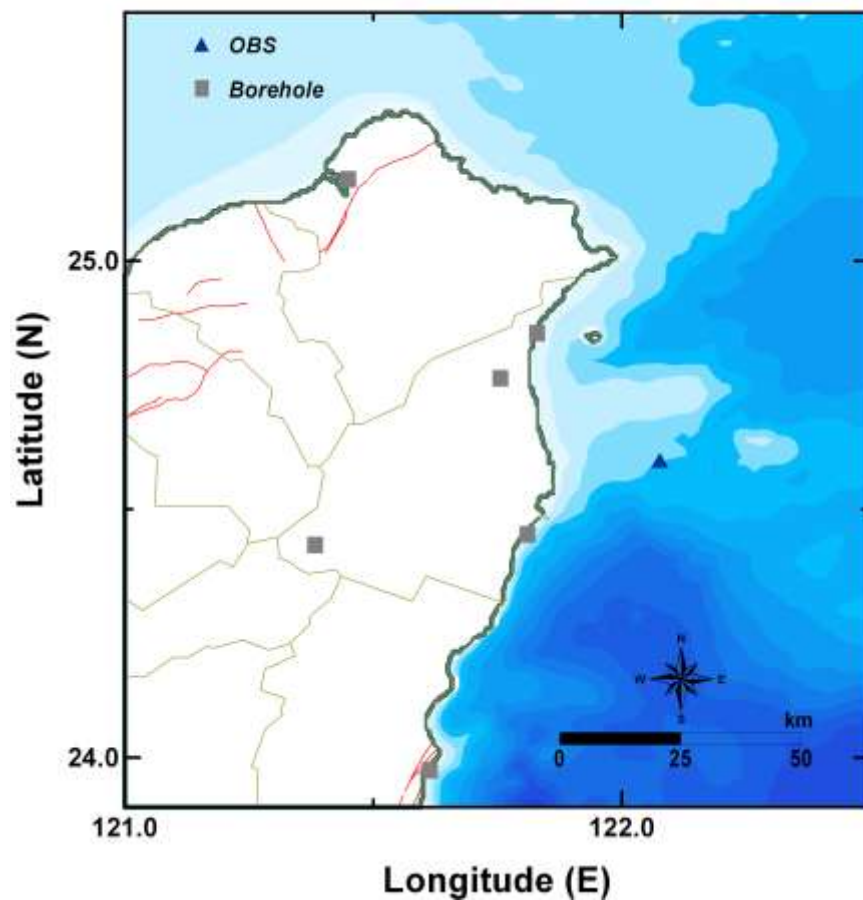
New proposed EEW system

- ◆ All seismographs installed by CWB are included for EEW evaluation
- ◆ Use the Earthworm as the platform of different seismic data format integration
- ◆ Pd and τ_c are used to estimate magnitude

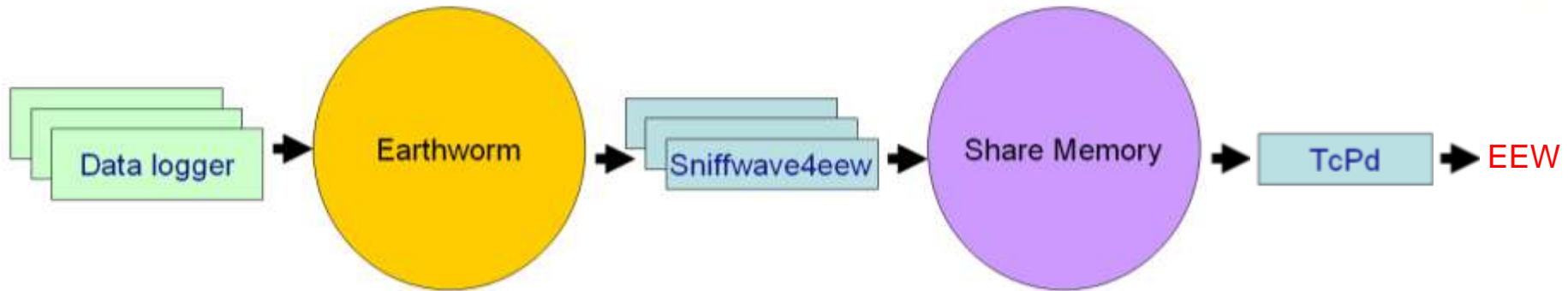
CWB seismographic network



New established stations



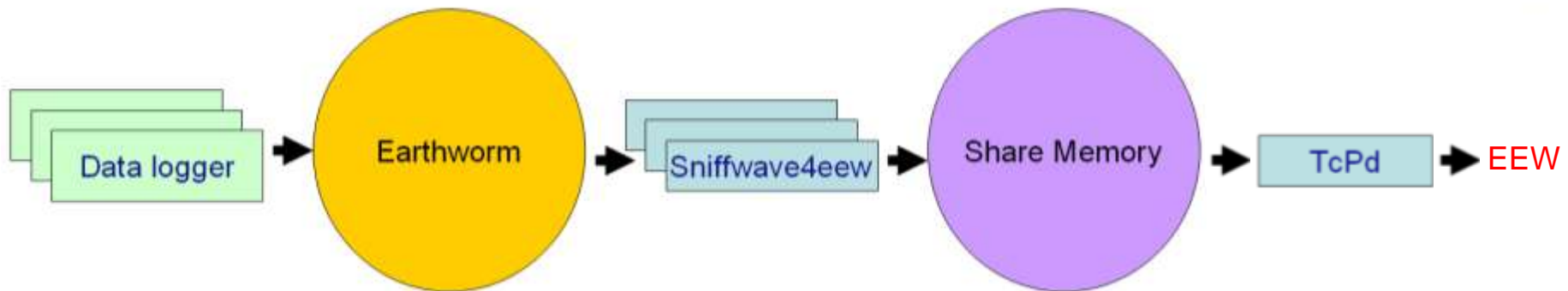
Flowchart of new proposed system



◆ Data loggers:

- Programs for receiving real-time data: Scream, GeoHub, rtdrec
- There exists corresponding Earthworm's modules for data importing, such as scream2ew, Import_generic, slink2ew, rtd2ew, s132ew

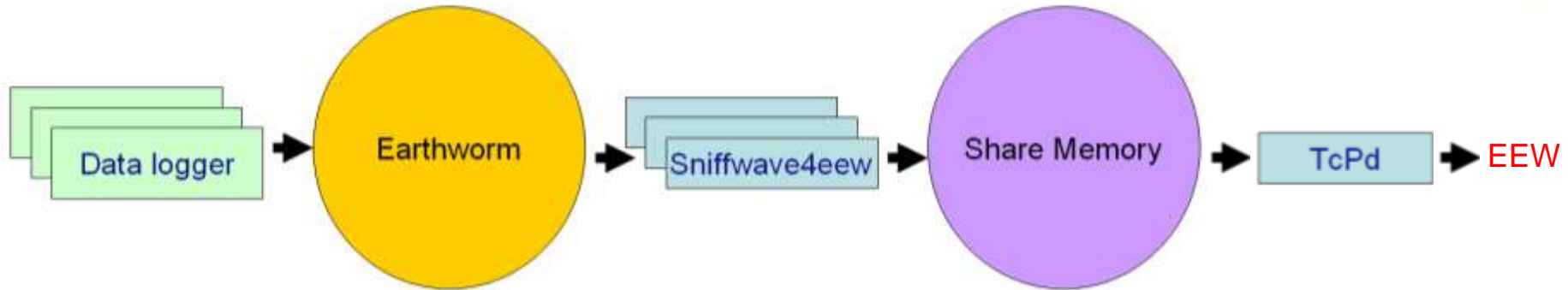
Flowchart of new proposed system



◆ Sniffwave4eew:

- Open the share memory for EEW
- Extract data of a certain station from Wave_Rings in Earthworm for trigger judgment in real-time
- Pick P arrival and calculate P_a , P_v , P_d , and τ_c while triggering
- Put obtained P wave parameters into the share memory

Flowchart of new proposed system

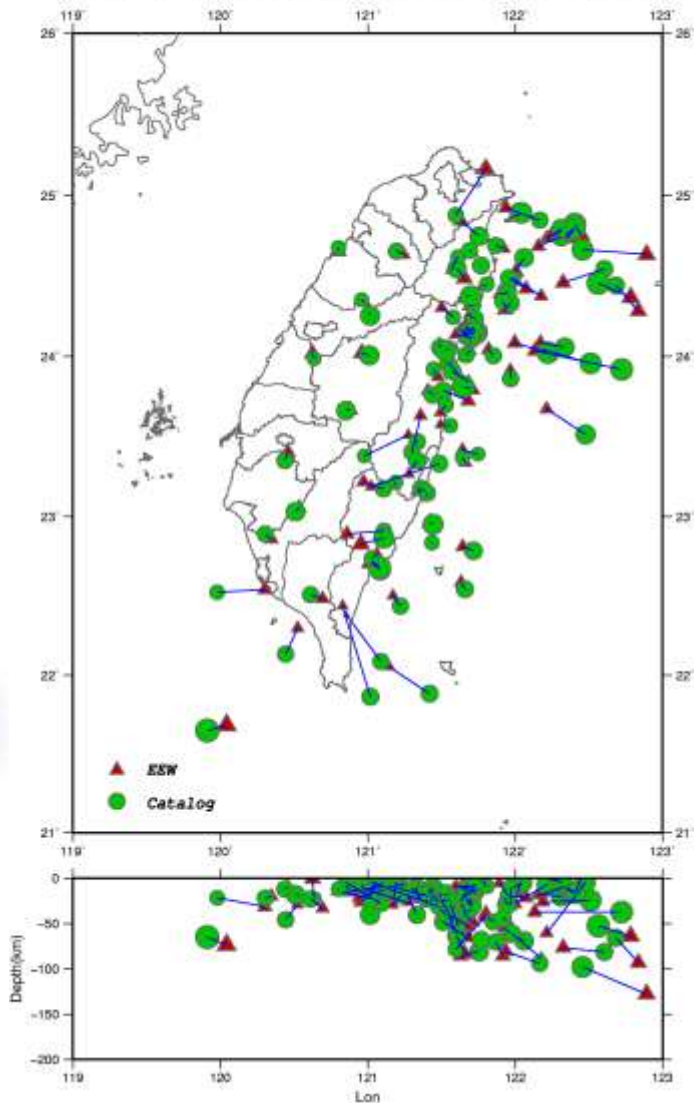


◆ TcPd:

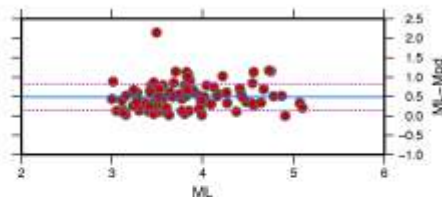
- Check P wave parameters of stations in the share memory
- If reach trigger threshold, calculate M_{τ_c} , and M_{P_d} while the hypocenter is obtained
- Create EEW report
- Revise EEW report when more data come in

Preliminary test for new system

200901~0413 Report 1 of EEW(BroadBand Only)

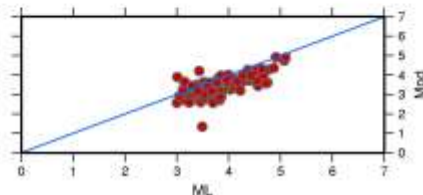


Magnitude Difference

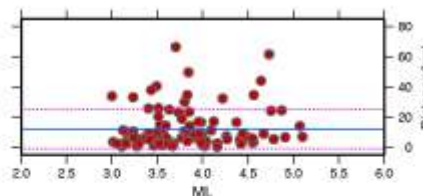


0.48 ± 0.34

Magnitude Relationship

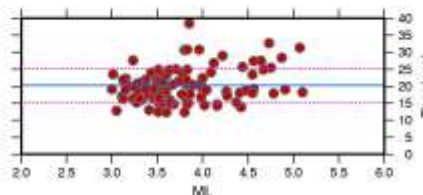


Location Error



12.01 ± 13.01 km

Response Time

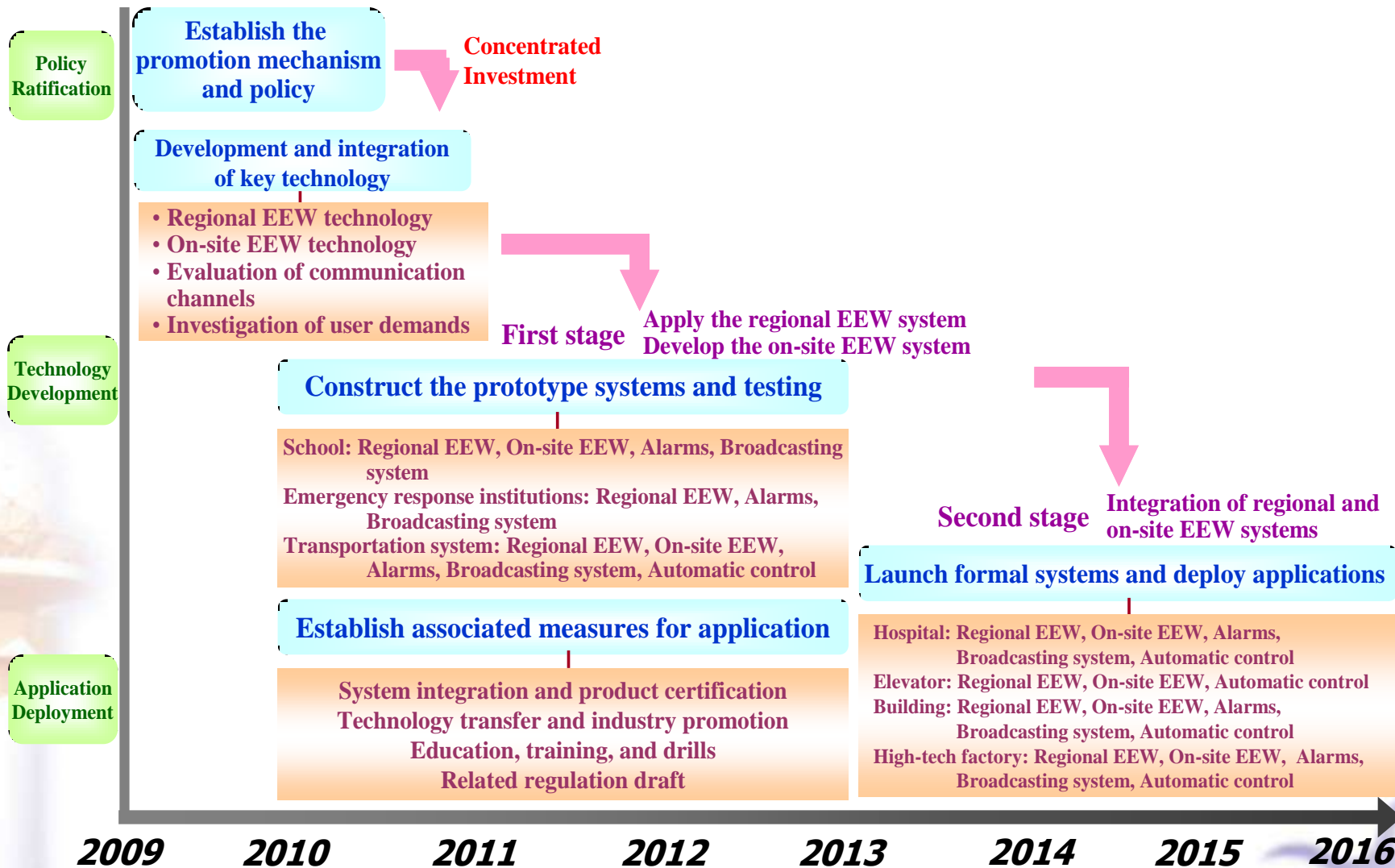


20.2 ± 4.9 sec

Plan for EEW promotion in Taiwan

- ◆ The rapid earthquake reports issued by the EEW system are not available to the general public, except for experimental purposes by some relevant organizations such as railway administration, rapid transit companies, and disaster prevention agencies etc.
- ◆ Encouraged by the recent successful examples in the research and application of EEW system in Japan, a joint program to promote the EEW system with the participation of various organizations will proceed in the near future in Taiwan.

Promotion plan



Summary

- ◆ The performances for current EEWS:
 - Epicenter deviation: 5.46 ± 6.41 km
 - Depth deviation: 4.66 ± 4.73 km
 - Magnitude deviation: 0.28
 - Reporting time: ~17 sec
- ◆ Applying P-wave method into current EEW system, a 10-second response time for inland earthquake can be achieved. And the uncertainty for magnitude estimation by Characteristic periods of the initial P waves is about 0.4.
- ◆ A new EEWS based on Earthworm system has been tested now
- ◆ A promotion plan for EEW by cooperative organizations has been drawn up in Taiwan in the coming years



The End

Thank you for your attention!