Seismic network and earthquake rapid report in Taiwan

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Seismic networks in operation

CWBSN
Central Weather Bureau Seismic Network

Tasks:
- Earthquake catalog
- Earthquake rapid notification and early warning
- Tsunami warning
- Seismological related research

TSMIP
Taiwan Strong Motion Instrumentation Program network

Tasks:
- Strong-motion database
- Strong-motion seismology research
- Earthquake engineering application

TGNS
Taiwan Geophysical Network for Seismology

Tasks:
- Geophysical database
- Earthquake precursor study
- Crustal deformation and active fault monitoring

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Seismological Center, Central Weather Bureau
CWBSN framework

137 stations totally

http://www.cwb.gov.tw
6-channel station

- The main seismic stations for earthquake observation in Taiwan for the past 20 years.
- Totally upgrade the resolution to 24 bits in 2012.
- 69 stations established.
Broadband station

- Start to build the stations and install broadband seismometers in 2001.
- High quality and resolution data are acquired for seismological related research.
- 33 stations established.
Downhole station

- Start to build the stations in 2007 in order to establish the next generation of seismic station in Taiwan.
- Borehole depth is set to 300 meter.
- 3 seismometers are installed in a station, include 1 borehole broadband sensor, 1 borehole FBA sensor, and 1 surface FBA sensor.
- 20 stations established, and plan to build 70 stations totally for the next few years.
**Specification**
1. Well type: dry
2. Well material: anti-rust steel
3. Drilling depth: 318m
4. Well length: 300m
OBS station

- 1 cable based OBS station is constructed off northeastern Taiwan in 2011 to improve the capabilities of earthquake monitoring.

- Cable laid from Toucheng, Yilan county. The cable length is about 45 km, and the water depth of station is about 300 meter.

- 1 broadband sensor and 1 FBA sensor are installed.

- Plan to extend the cable length and add more OBS in the future.
OBS system framework
Integrated data processing platform

USGS Earthworm Cluster
1. Collecting & integrating different type data
2. Producing various seismic files for further processing

Frame Relay, ADSL, GPRS, Marine Cable

FBA+SP
BB
OBS
Downhole
Others

Retrieving module
Retrieving module
Retrieving module
Retrieving module
Retrieving module

LAN

ERR/EEW
Seismicity observation
CMT
Other research

Database
Real-time data integration

Real-time data

Tankplayer → WAVE_RING → Waveserver → Tank

Strong-motion, Broadband, Short period

Pick_eew → Processing program

Waveman2disk → Specific format data → Processing program

SAC, MiniSeed, SUDS, TANK, CWB24

(陳達毅)

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中央氣象局地震測報中心 Seismological Center, Central Weather Bureau
Main tasks in operation

- Earthquake catalog publish
- Earthquake rapid reporting
- Earthquake early warning
Magnitude of completeness

Earthquake catalog publish

Frequency-Magnitude distribution

http://www.cwb.gov.tw  中央氣象局地震測報中心  Seismological Center, Central Weather Bureau

(張建興)
## Taiwan earthquake catalog

### Earthquake catalog publish

<table>
<thead>
<tr>
<th>Year</th>
<th>Events No.</th>
<th>P arrivals</th>
<th>S arrivals</th>
<th>Polarity No.</th>
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<td>1991</td>
<td>4,933</td>
<td>63,157</td>
<td>30,970</td>
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<td>251,787</td>
<td>223,648</td>
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<td><strong>Totally</strong></td>
<td><strong>401,417</strong></td>
<td><strong>4,691,604</strong></td>
<td><strong>3,582,607</strong></td>
<td><strong>574,773</strong></td>
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**http://www.cwb.gov.tw**

中央氣象局地震測報中心

Seismological Center, Central Weather Bureau

(張建興)
Seismicity observation

Earthquake catalog publish

http://www.cwb.gov.tw Seismological Center, Central Weather Bureau
Seismogenic structure study
Earthquake rapid notification

- Real-time incoming signals
- PC trigger recording & auto-location
- Automatic Broadcast via E-mail, Pager, Mobile Phone SMS, WWW and FTP Server
- Solutions Bank
- Manual Broadcast via FAX, E-mail, Mobile Phone SMS, WWW and Vocal Report on Demand through Telephone System

Average Response time:
- 1 min
- 3 min
- 5 min

http://www.cwb.gov.tw
Seismological Center, Central Weather Bureau
Earthquake report statistics

2006~2011
781 Events

5.36 ± 6.72 km

4.97 ± 5.96 km
Earthquake rapid reporting

**Reporting time**

2006~2011 自動定位與地震報告發布時效

![Graph showing earthquake occurrences and reporting times]

- **發布報告平均時效**: 04:48 ± 02:31
- **自動定位平均時效**: 48 ± 12 sec

**Occurrence of earthquake**

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中央氣象局地震測報中心 Seismological Center, Central Weather Bureau
Earthquake rapid reporting

Example (Wutai earthquake)

>Automatic earthquake report → 50 sec

Seismic Intensity map / Location of the earthquake

>Confirmed earthquake report → 03:59
>Mobile phone text message → 04:00
>Web server → 04:00
>Phone inquiries → 04:00
>FAX → 04:00
>TV channels → 05:08

http://www.cwb.gov.tw  中央氣象局地震測報中心  Seismological Center, Central Weather Bureau
Virtual Sub-Network for EEW
Earthquake early warning

EEW Capability

2006~2011
161/172 Events (93.6%)

Epicenter deviation: 6.57 ± 8.75 km

Depth deviation: 5.10 ± 5.05 km

6.57 ± 8.75 km

5.10 ± 5.05 km

0.28 ± 0.24

18.7 ± 3.2 sec

http://www.cwb.gov.tw

Seismological Center, Central Weather Bureau
Advanced EEW procedure developed

1. Pick P wave arrival
2. Calculate P wave amplitudes and period

M_{tc} = 4.218 \times \log_{10}(\tau_c) + 6.166 \quad \text{(Wu et al., 2010)}

M_{pd} = 3.905 + 2.198 \times \log_{10}(Pd) + 2.703 \times \log_{10}(R) \quad \text{(Hsiao et al., 2010)}
Earthquake early warning

Example

Origin time (Taiwan Standard Time: GMT+08:00):
2262012 10:35: 0.4
Location: 22.75N, 120.75E
i.e. 28.4 km ENE of Pingtung County
Depth: 26.3 km
Magnitude (ML): 6.4
The End

Thank you for your attention!
### Intensity estimate

161个地震中3539笔震度预估，与实际观测值比较，震度完全吻合者53%，震度相差1级者44%，相差2级者3%。

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