Strong Ground Motions from 2010 Chile and 2011 Tohoku Earthquake

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Pacific NW Hazard

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Maule (Chile) Earthquake Collaborators

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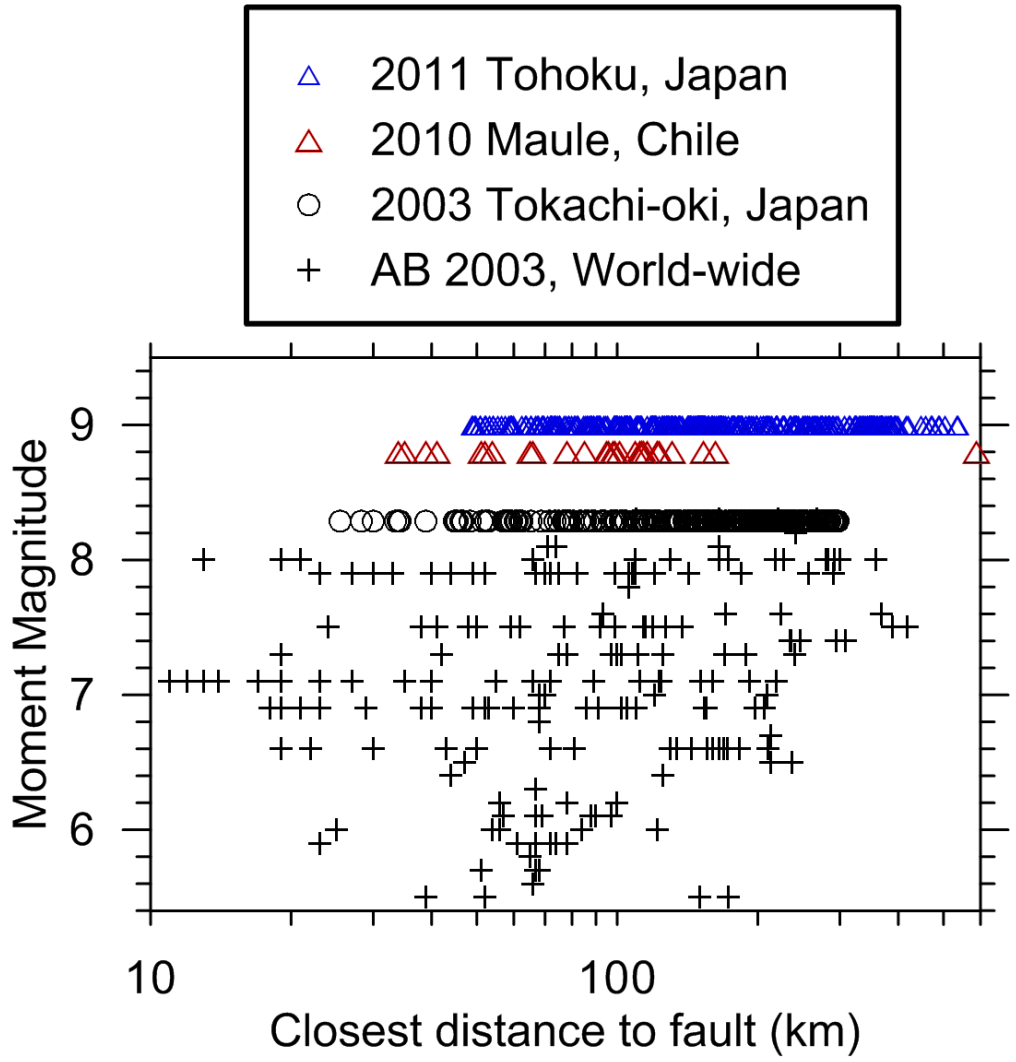
- **Víctor Contreras**, *University of Chile*
- **Dong Youp Kwak**, *UCLA*

Tohoku (Japan) Earthquake Collaborators

- **Saburoh Midorikawa,** *Tokyo Institute of Technology*
- **Hiroyuki Miura**, *Tokyo Institute of Technology*
- **Khatareh Khodaverdi**, *UCLA*
- **Yousef Bozorgnia**, *PEER center*
- **Kenneth Campbell**, *EQECat*
- **Robert W. Graves**, *USGS Pasadena*

Significance of these Data

Interface subduction earthquakes

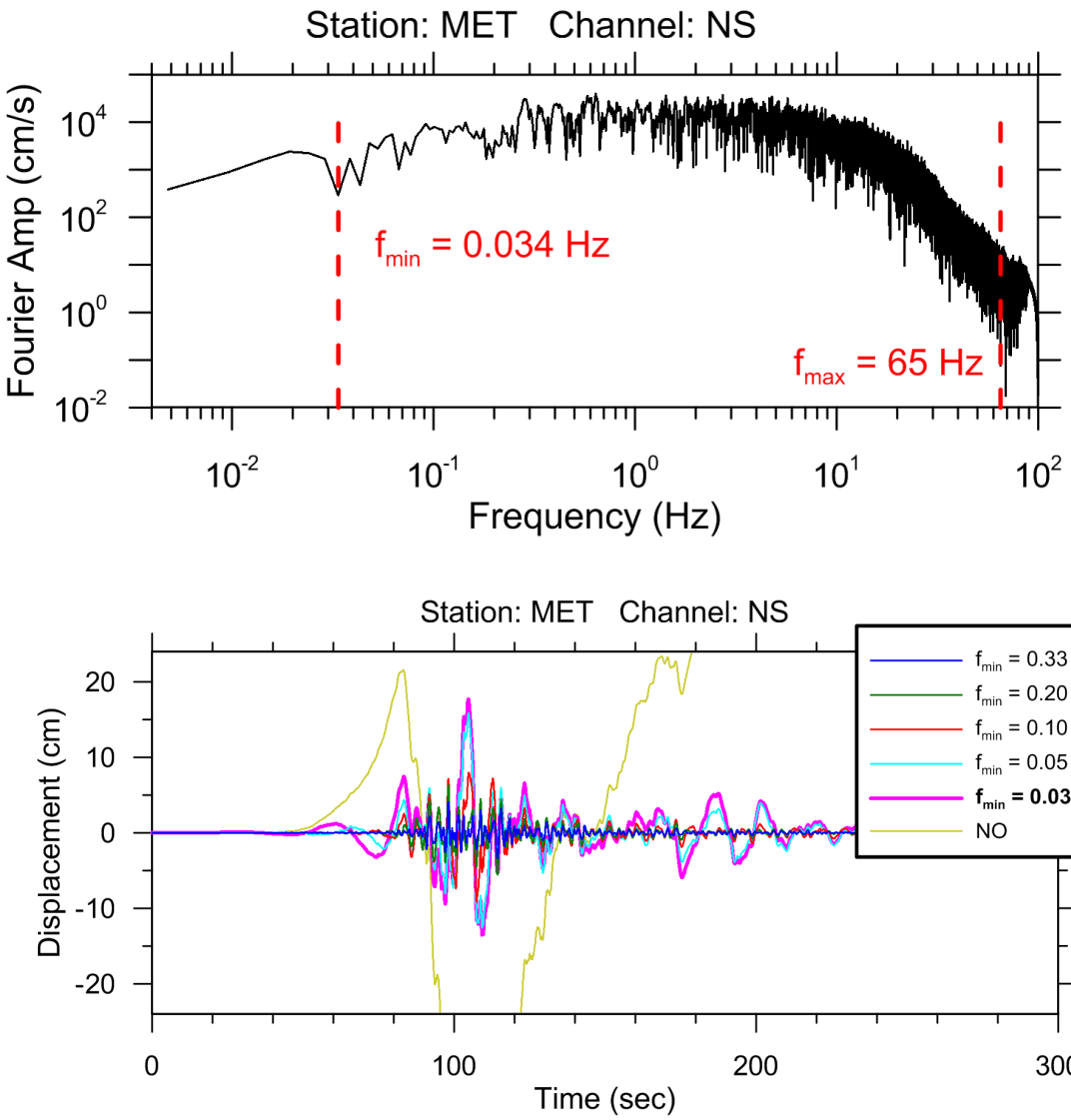


Outline

- Record processing. Database attributes.
- Finite fault model. Computation of site-to-source distances (R_{rup}, R_{jb})
- Direct data interpretation: Site effects, directivity, etc.
- GMPE comparisons: Magnitude-scaling, distance scaling, event terms, intra-event standard deviation (ϕ).

Record Processing

- From V1 data (digitized, acc units, mean removal)
- High-pass filter applied (acausal, Butterworth)

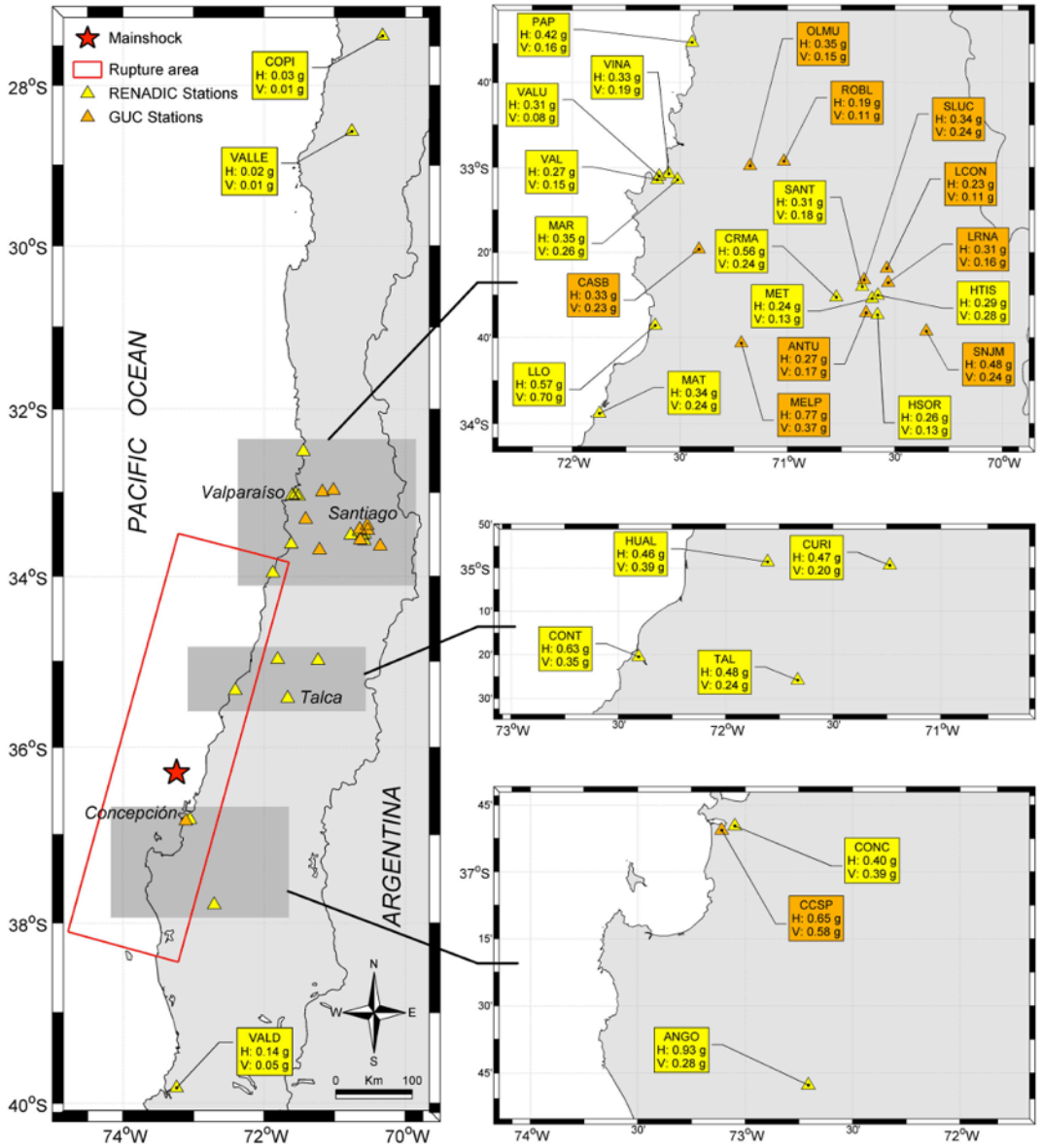

Station: MET Channel: NS
Fourier Amp (cm/s)
10^4
10^2
10^0
10^{-2}
f_{min} = 0.034 Hz
f_{max} = 65 Hz
10^{-2}
10^{-1}
10^0
10^1
10^2
Frequency (Hz)
Station: MET Channel: NS
Displacement (cm)
20
10
0
-10
-20
f_{min} = 0.33 Hz
f_{min} = 0.20 Hz
f_{min} = 0.10 Hz
f_{min} = 0.05 Hz
f_{min} = 0.03 Hz
NO
0
100
200
300
Time (sec)

Record Processing

- From V1 data (digitized, acc units, mean removal)
- High-pass filter applied (acausal, Butterworth)
- Pseudo-acceleration response spectra computed (3-component)
- Processing by U. Chile (Maule) and PEER (Tohoku; in progress)

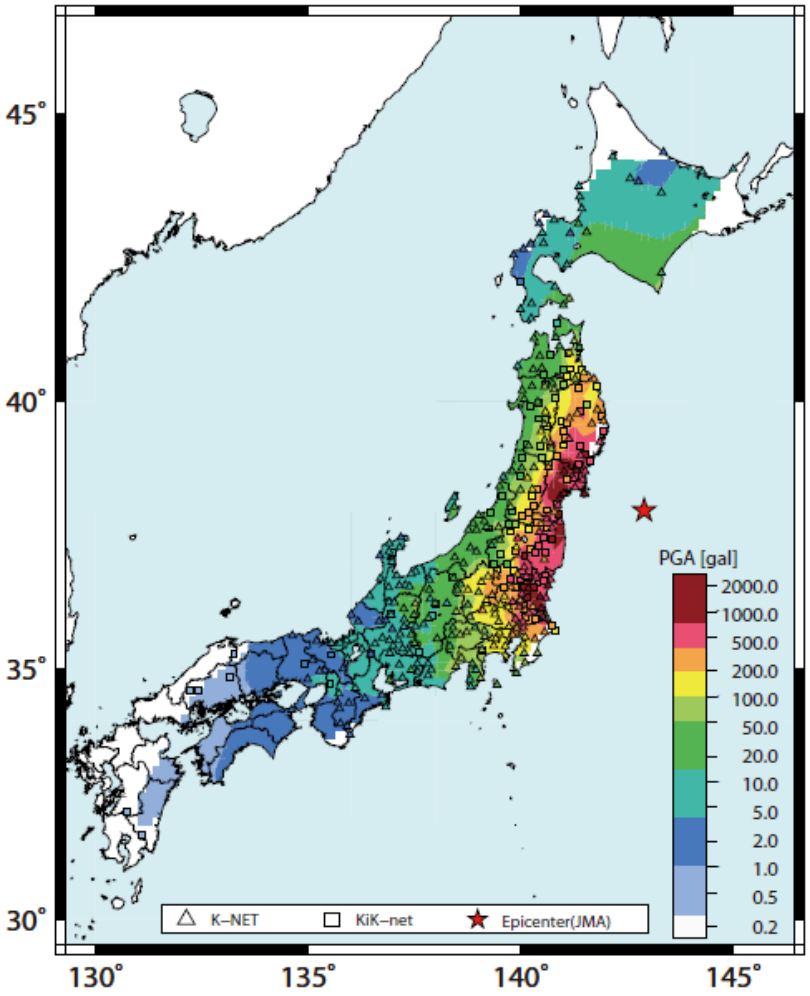
Database Attributes (Chile)

- 31 recordings
- Most SMA and QDR
- Mostly north of fault
- 34–730 km
- Preliminary site classifications



Database Attributes (Japan)

- Approx. 1200 Knet and Kiknet
- Eventually 2000
- All digital
- 49–500 km
- V_s profiles for most sites.



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- **Finite fault model. Computation of site-to-source distances (R_{rup}, R_{jb})**
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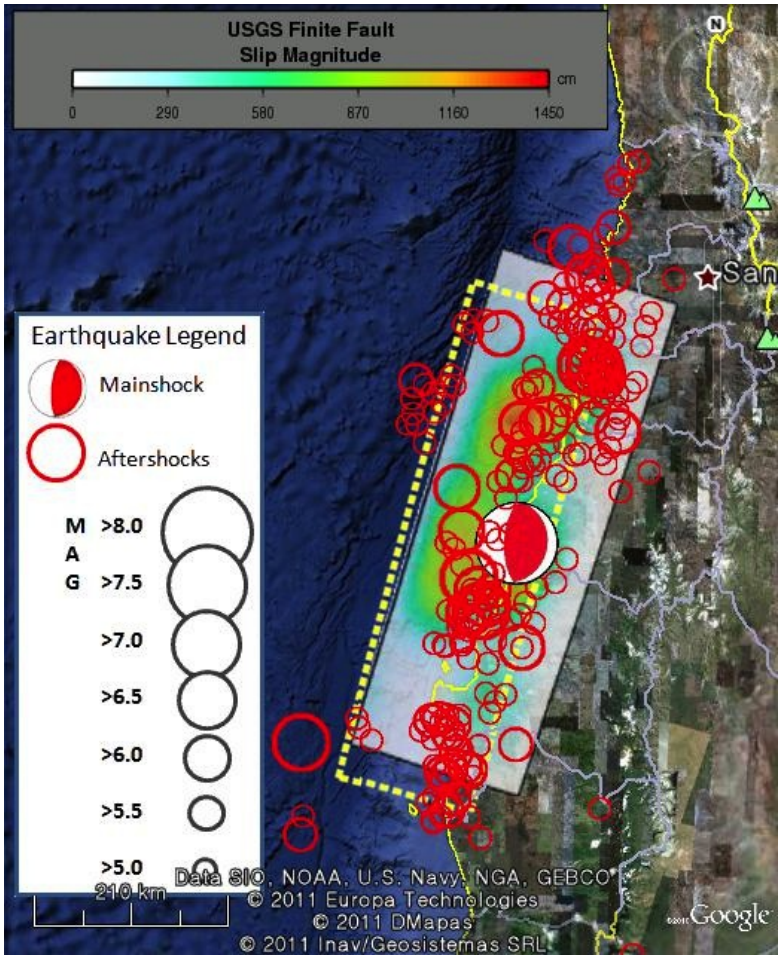
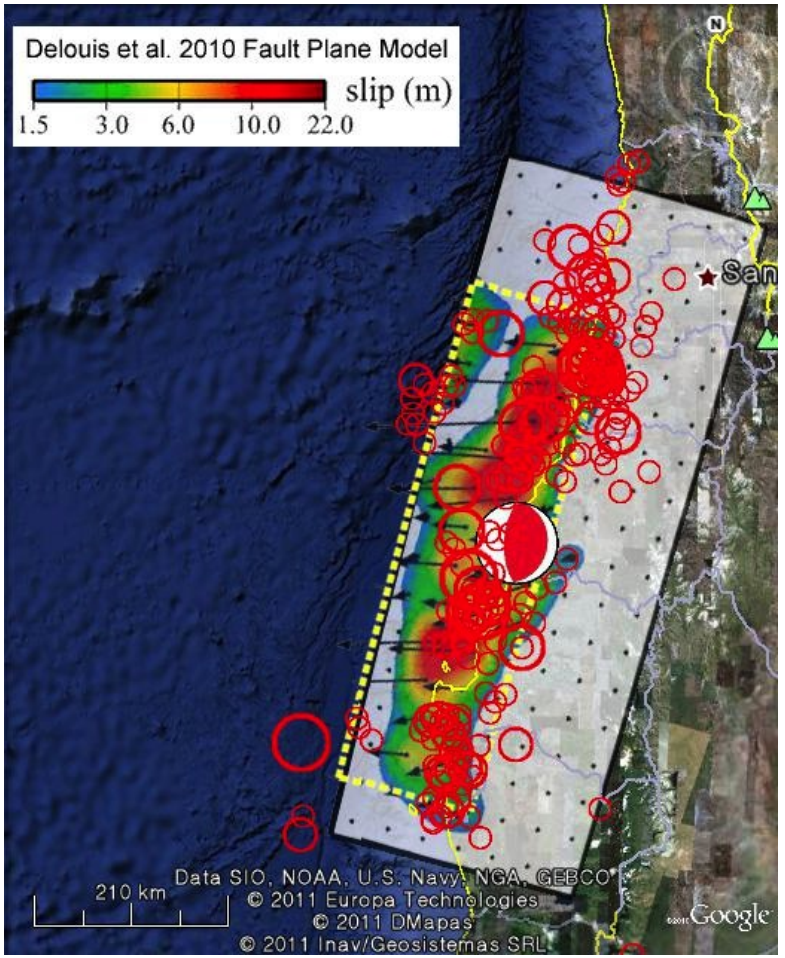
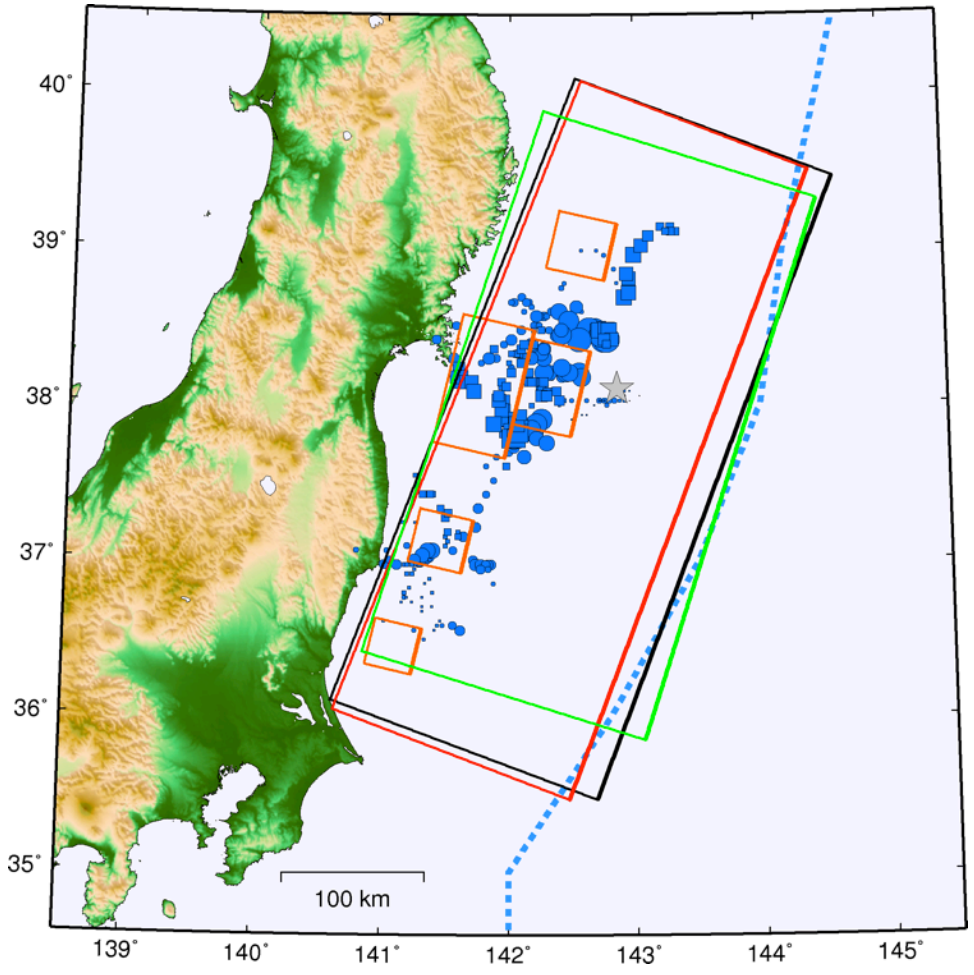
Finite Fault Models

- Consider published models in peer-reviewed journals
- Various data sources (InSAR, GPS, teleseismic, strong motion, tsunami). Preference to models that include strong motion (Japan)
- Models trimmed to remove patches with low slip





Delouis et al. 2010 selected and trimmed as shown



Trimmed surface projections

High frequency zones on fault

SGMA locations of Kurahashi and Irikura (2011): orange

High frequency (0.5 – 1 Hz) radiation areas determined using back-projection of teleseismic array observations. Meng et al. (2011): blue

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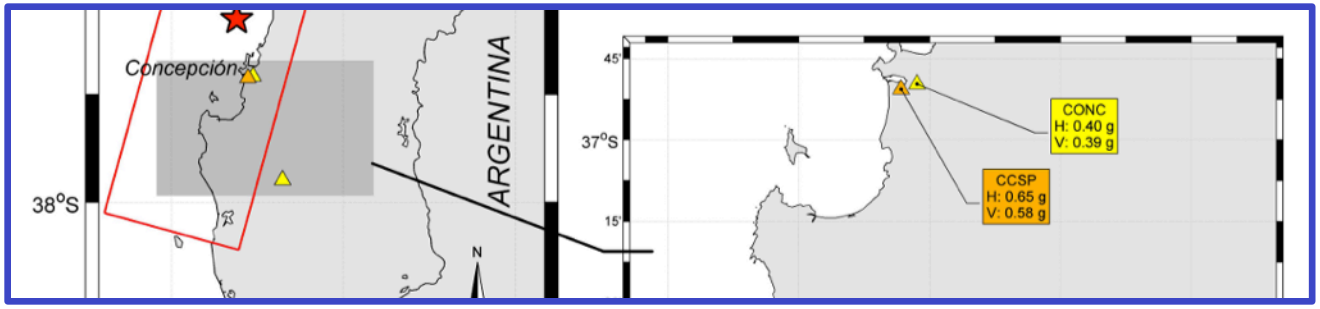
Concepción records:

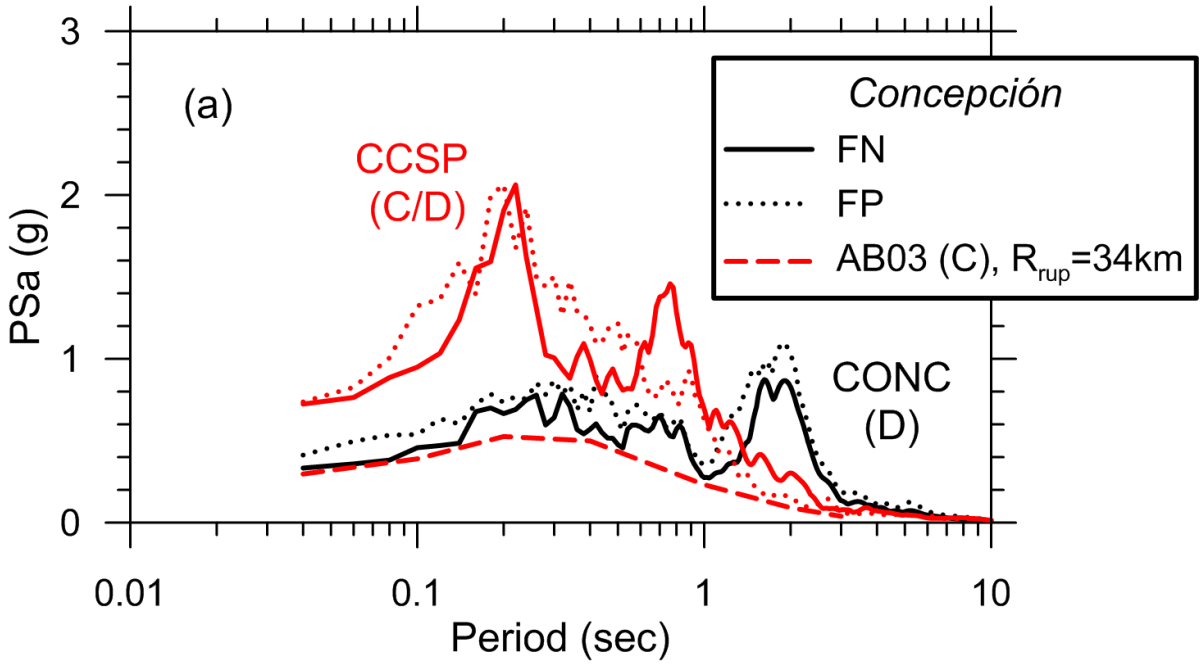


CONC (soft soil) CCSP (firm soil)

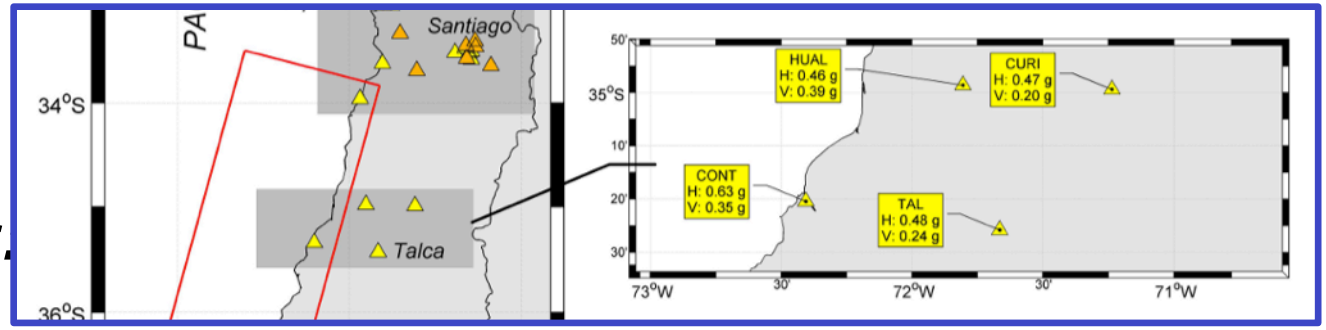
R_{rup} = 34–35 km

No polarization in FN direction

Apparent site period at CONC



Talca records.

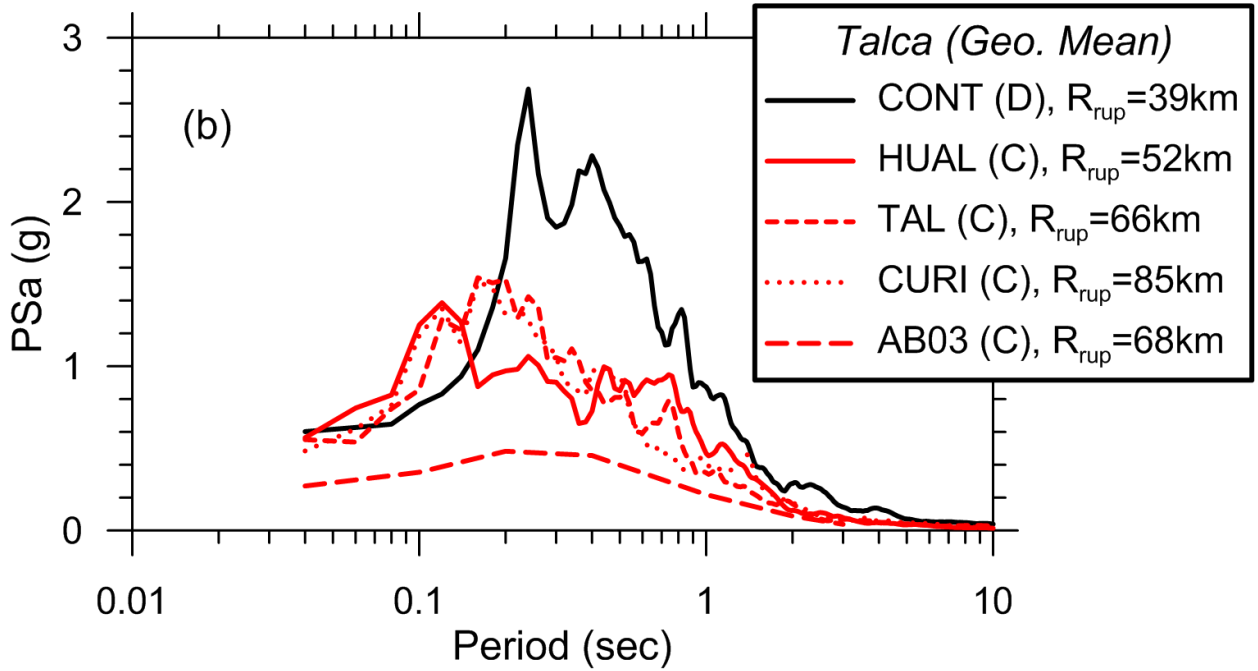


CONT (soft soil) Others (firm soil)

R_{rup} = 40–85 km

Consistent spectra on firm ground

Apparent broad amplification at



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Selected Subduction GMPEs

- BC Hydro [2011]: Worldwide
- Arroyo *et al*. [2010]: Interface, Mexico
- Atkinson & Boore [2003]: Worldwide
- Garcia *et al*. [2005]: Intraslab, Mexico
- Kanno *et al*. [2006]: Japan
- Lin & Lee [2008]: Taiwan
- McVerry *et al*. [2006]: New Zealand
- Youngs *et al*. [1997]: Worldwide
- Zhao *et al*. [2006]: Japan

GEM Project, Task 2

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GEM Project, Task 2

Magnitude Scaling

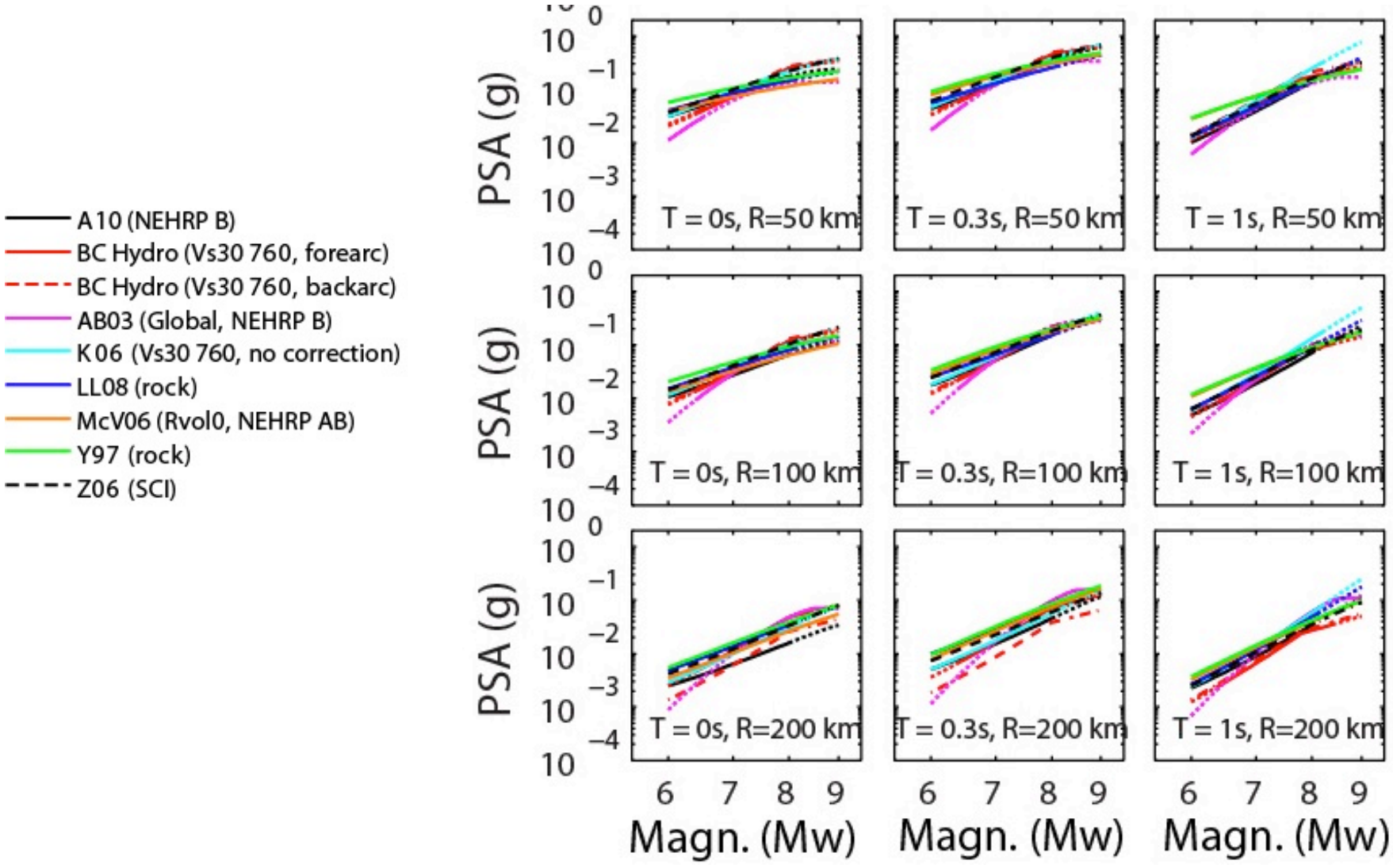
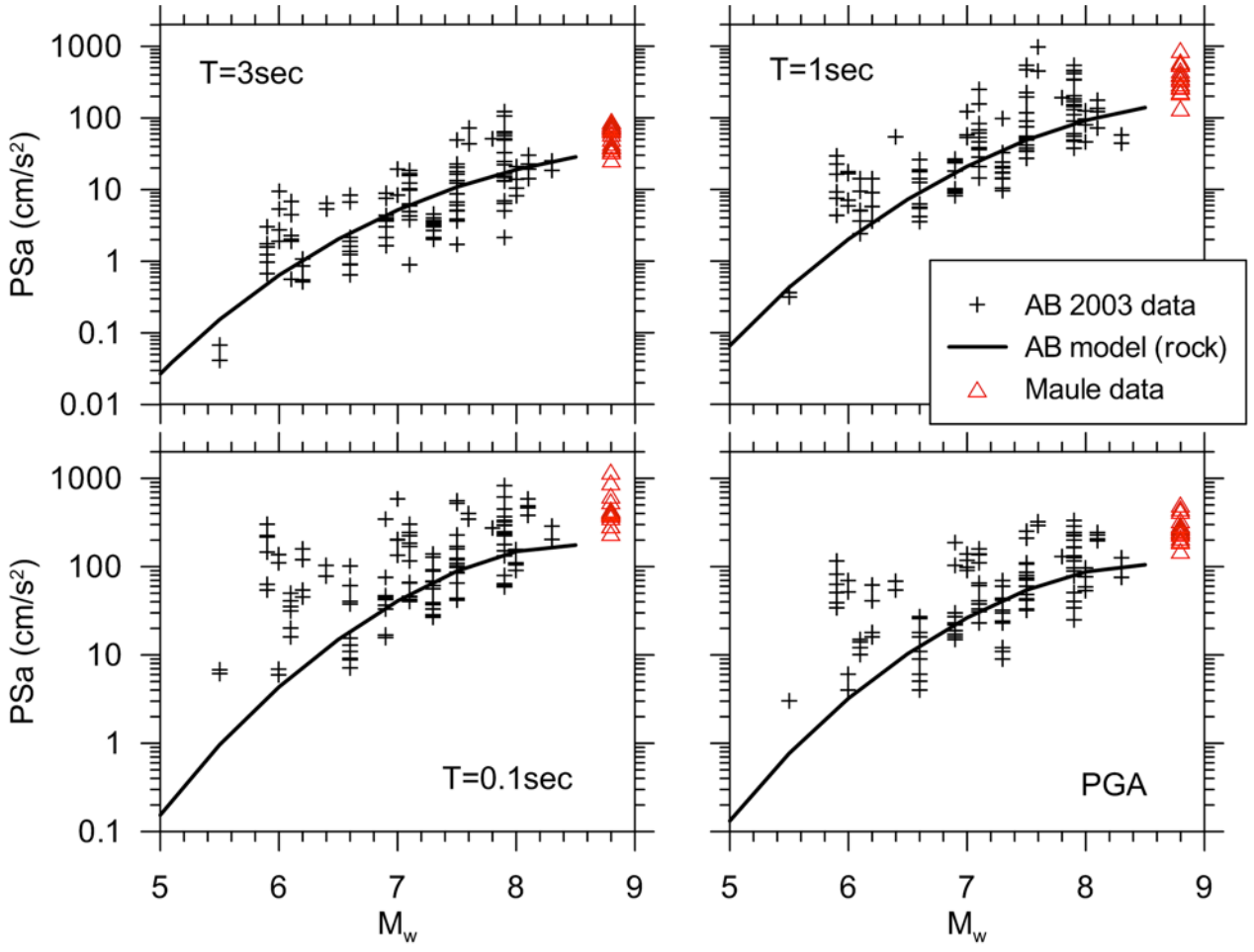


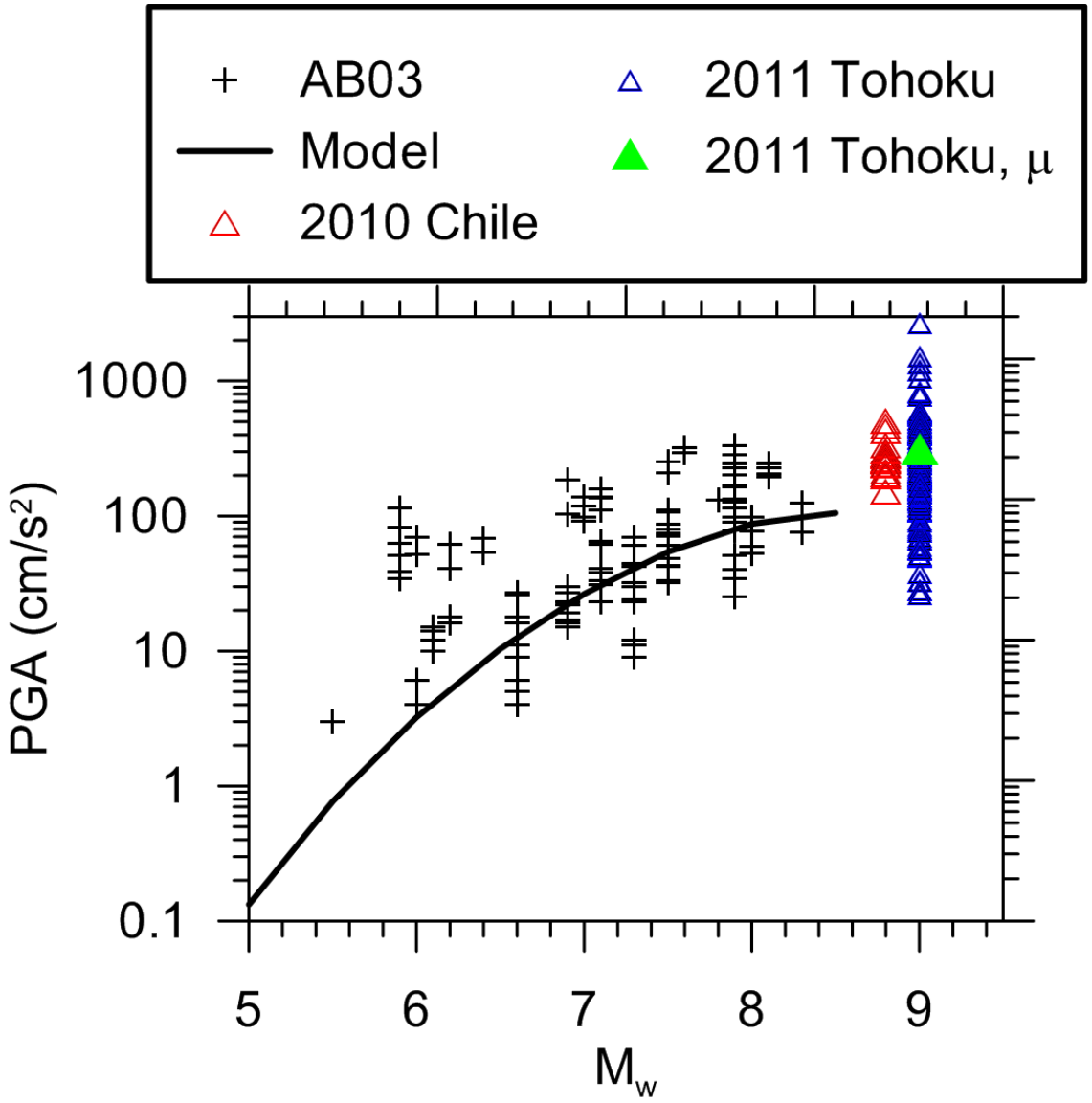
Figure courtesy Carola Di Alessandro

Magnitude Scaling

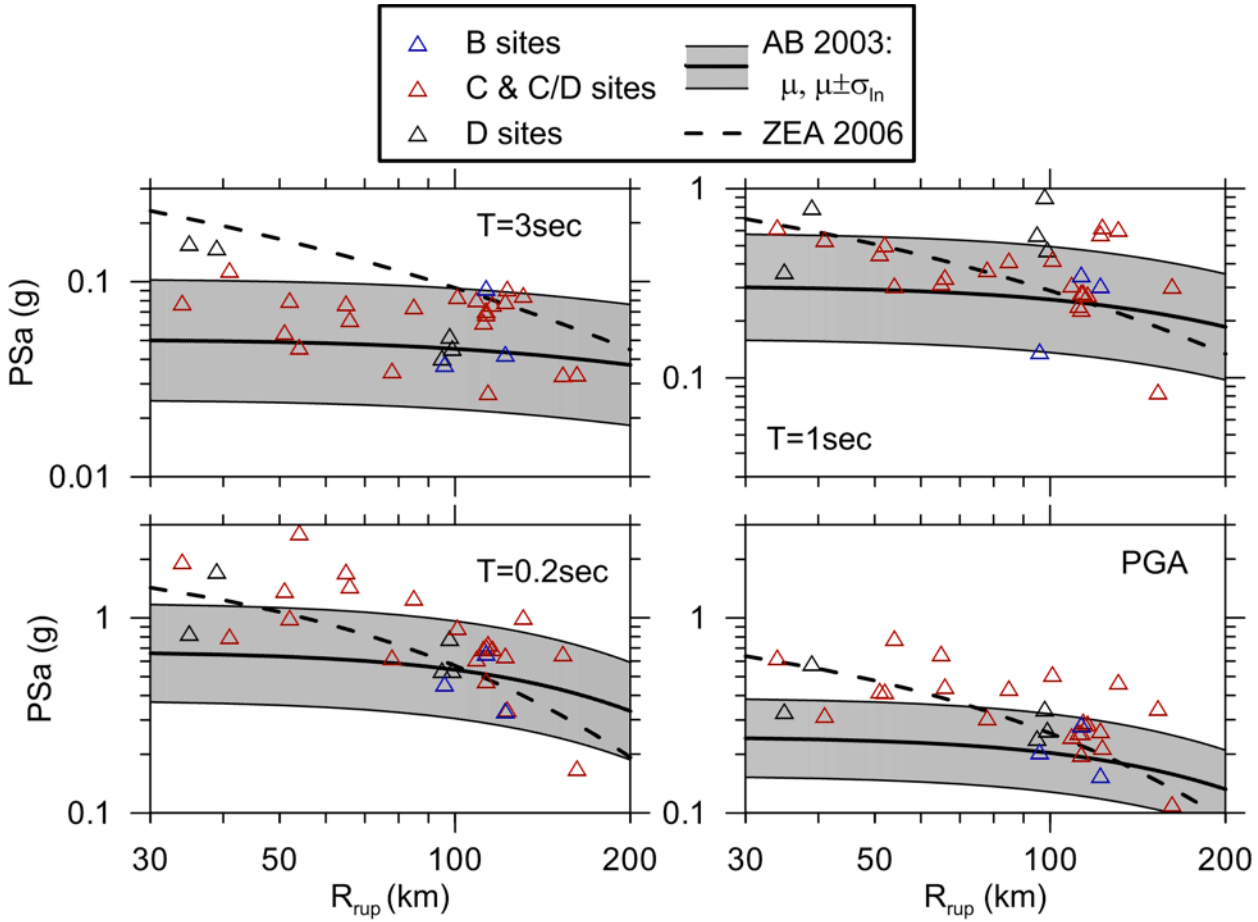


Data from 70 to 150 km

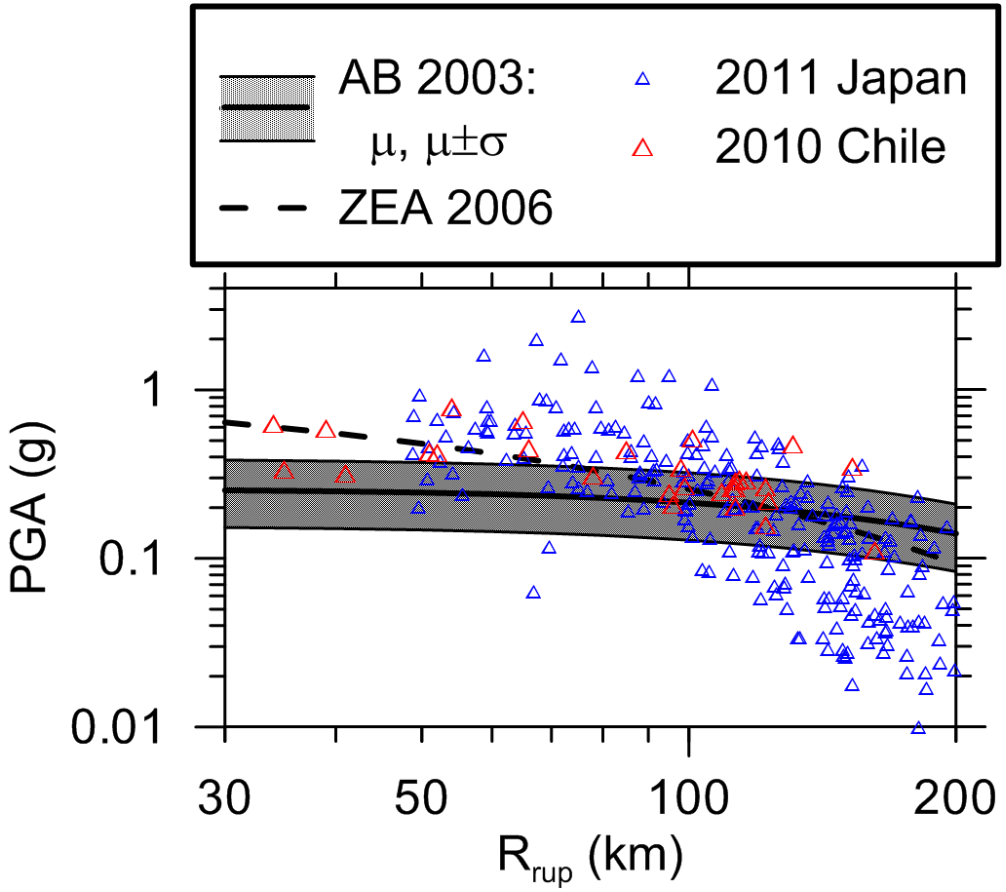
Magnitude Scaling



Distance Scaling

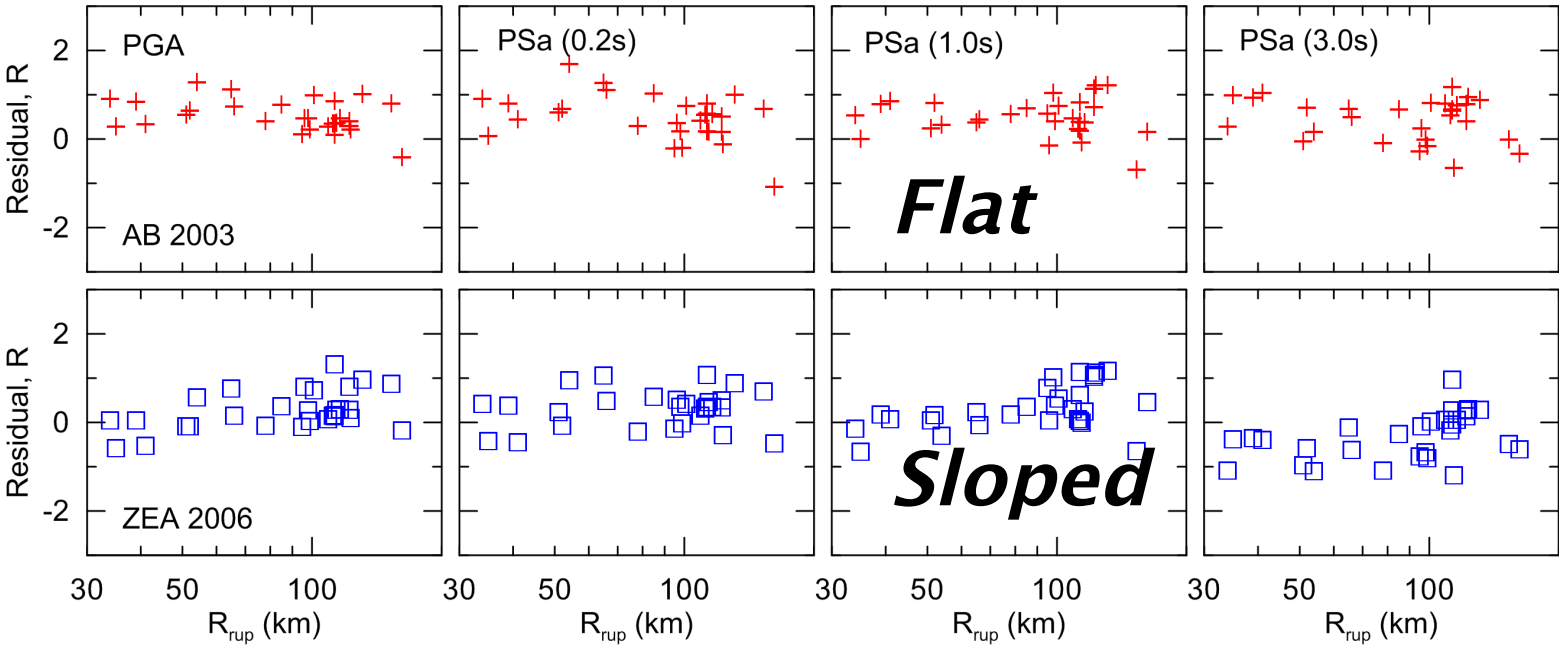


Distance Scaling



Residuals Analysis

$$R_i = \ln\left(IM_i\right)_{rec} - \ln\left(IM_i\right)_{GMPE}$$



Residuals Analysis

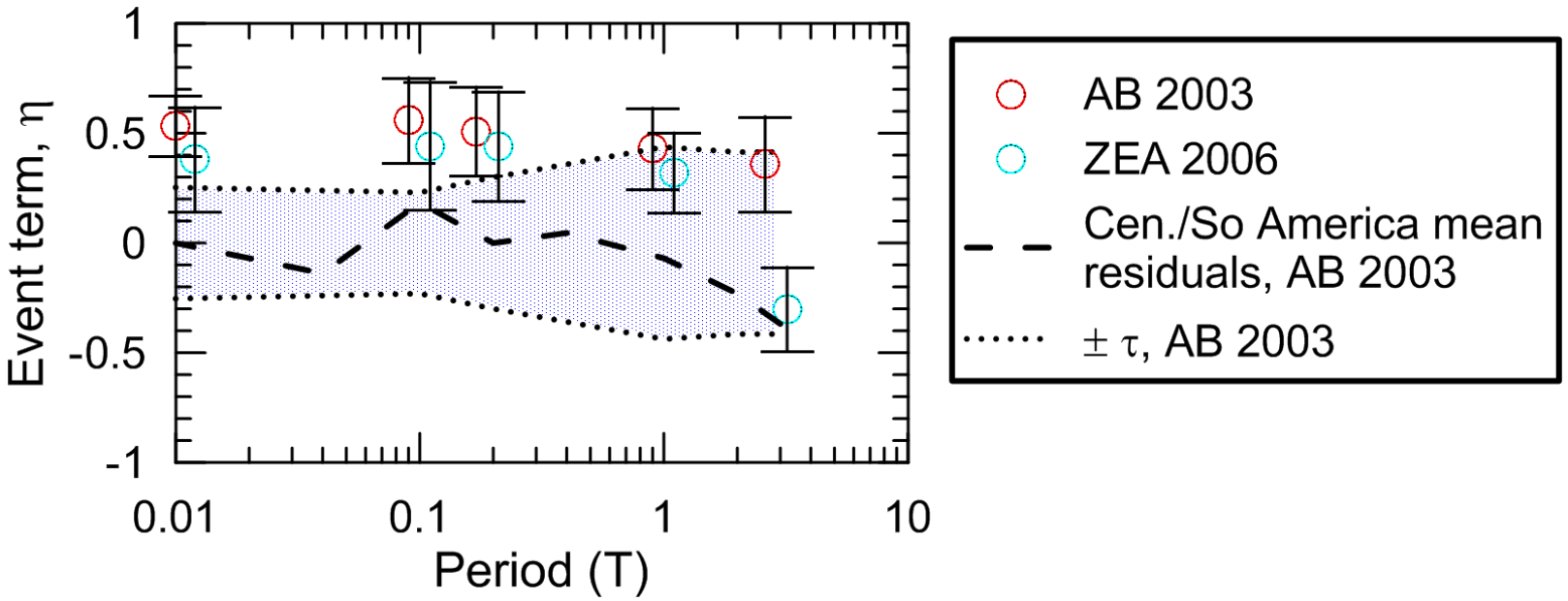
$$R_i = \ln\left(IM_i\right)_{rec} - \ln\left(IM_i\right)_{GMPE}$$

Median of R_i: Event term, η (well recorded earthquakes)

Standard deviation of R_i: Intra-event standard deviation, ϕ

Only Maule data. No residuals analysis yet for Tohoku data

Residuals Analysis



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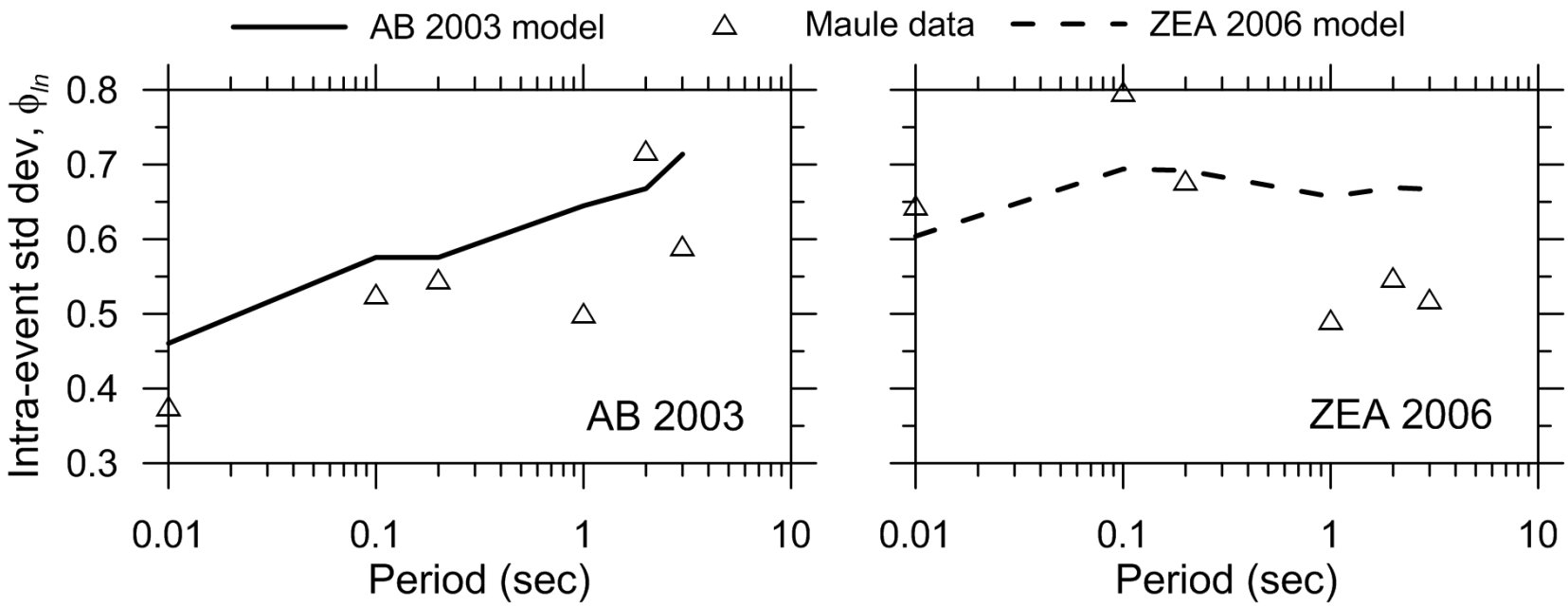

Reasonable match

Large ϕ from attenuation misfit

Preliminary Conclusions

- Evidence of strong motion being controlled by low-slip portions of fault (Tohoku)
- No evidence of ground motion polarization from directivity (Maule data)
- Data useful for:
  - Constraint of magnitude scaling functions
  - Site effects in subduction regions
  - Regional variations in distance attenuation rates