Giant earthquakes and strong ground motions in South America

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Contents

• Historical Mega-earthquakes of South America and the source model of the 2010/2/27 Maule earthquake, Chile (Mw 8.7).
• Earthquake scenarios for Central Andes (Peru).
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Great historical megathrust earthquakes in South America
Rupture process of the 2010/2/27 Maule earthquake, Chile [Mw=8.7]

**Data**
- P waveforms (38 stations)
- Anti-alias, Butterworth lowpass filter
- Subfault size: 18x18km²
- Velocity model - Bohm et al. [2002]
- Geodetic data (28 sites) - Farias et al. [2010]
- Strong motion record at Concepción

**Method**
- ABIC inversion including estimation errors of Green's functions, Yagi and Fukuhata [2011]
- Elastic dislocation model - Okada [1992]

**Rupture process of the 2010/2/27 Maule earthquake, Chile [Mw=8.7]**

Rupture velocity 2.8km/s

**Estimation of the permanent displacement at Concepción from a strong motion record and comparison with a 1Hz-GPS record**
Comparison of slip models of megathrust earthquakes

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Historical earthquakes in Peru

- 1940 05 24 Huacho, M8.2
- 1942 08 24 San Juan, M8.0
- 1966 10 17 Barranca, M8.1
- 1974 10 03 Lima, M8.1
- 1996 02 21 Chimbote, M7.5
- 2001 06 23 Atico, M8.4
- 2007 08 15 Pisco, M8.0

Adapted from Okal et al (2006)
**GPS campaigns in Peru-Northern Chile**

- 87 surveyed sites (1993-2003) from Lat. 11°S to Lat. 24°S.
- Including measurements from ocean bottom GPS off-shore Lima

Kendrick et al. (2001), Chlieh et al. (2004), Gagnon et al. (2005)

**Slip deficit rate for Peru and Northern Chile and scenario earthquake for Central Peru**

- Slip deficit since 1746 (265 years)
- Maximum slip is 15 m
- Magnitude Mw~8.9, neglecting the 20 century earthquake sequence

\[ S(x) = C(x) \cdot v_0 \cdot t \]

(Pulido et al. 2011)

**Construction of broadband wavenumber slip (Pulido et al. 2011)**

- PSD of geodetic scenario slip, and Von Karman PSD function
- Interscismic slip deficit (low wavenumber slip)
- Slip heterogeneity from a Von Karman ACF (high wavenumber slip)
- Broadband slip model (low + high wavenumber slips)

\[ P(k_x, k_d) = \frac{k_x k_d}{\left(1 + \left(\frac{k_x a_s + k_d a_d}{k_1}ight)^2\right)^H} \]

- Correlation length along strike: \( a_s = 110 \text{ km} \)
- Correlation length along dip: \( a_d = 40 \text{ km} \)
- Hurst exponent: \( H=1.0 \)
- \( k_x \) and \( k_d \) are wavenumbers along strike and dip

**Comparison of PSD of scenario slip and PSD of Maule earthquake slip (Pulido et al. 2011)**

- Peru scenario earthquake (Mw 8.0) (low wavenumber slip)
- 2010 Maule earthquake, Chile (Mw 8.7) (low wavenumber slip)
- Circular Averaged Spectral Density of slip

[Pulido et al. 2011]
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Source model of the 2007/8/15 Pisco, Peru earthquake [Mw=8.0] (Sladen et al. 2010)

Strong motion records Pisco earthquake (IGP)

Radiation pattern from asperity 1 (SH waves)

Radiation pattern from asperity 2 (SH waves)

Observed and simulated strong motion simulation at PCN (Pulido et al. 2011) (data from IGP)

Observed and Simulated (Blue) Accelerations PCN station

Observed (red) and Simulated (blue) Velocities PCN station

Strong motion simulation at Pisco city from the Pisco earthquake (Vs = 150 m/s)

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Field survey of the 2010 Maule earthquake

Strong Motion, Geotechnical explorations
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Gaku Shoji (Tsukuba University)
Jorge Alva (UNI)
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Observed strong motion during the 2010 Maule earthquake

Microtremors Measurements at Concepción city

Microzonation map (Ramírez and Villalobos 2009)
Salas 1343 building
Heavily damaged building at Concepción city during the 2010 Maule earthquake

The soil surrounding the damaged building exhibit a large deformation suggesting a building rocking around its long axis.

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Array microtremors measurements in Lima, and installation of a strong motion network [SATREPS project]
Velocity models obtained from microtremors arrays in Lima and their 1D transfer functions (Calderón et al. 2012)

Simulated strong ground motion at Callao (seismic bedrock)

Simulated strong ground motion at Callao including site effect

Conclusive remarks

• Our source model of the 2010/2/27 Maule earthquake, Chile (Mw 8.7), suggests a significant correlation between coseismic slip and plate coupling distribution.
• Our results based on geodetic and historical earthquakes data, indicate that an earthquake of magnitude Mw 8.9 is likely to occur in the Central Andes region (Peru).
• Observed and simulated strong ground motions of the 2007 Pisco earthquake, Peru, indicate a significant contribution from a complex source rupture process.
• We obtained preliminary results of the strong motion simulation in Lima for a scenario earthquake.