GeoPRISM Workshop
April 15, 2013@Wellington, NZ
1:30-1:55pm

Global perspective on controls on megathrust slip behaviour

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Controls on Megathrust Slip

- Controls on Dynamic Rupture
  - Multiscale Patch Model for the 2011 Tohoku-Oki Earthquake

    Ide & Aochi (2013, Tectonophysics)
- Controls on Tectonic Tremors
  - Two End Member of Spatial Variable Tremors

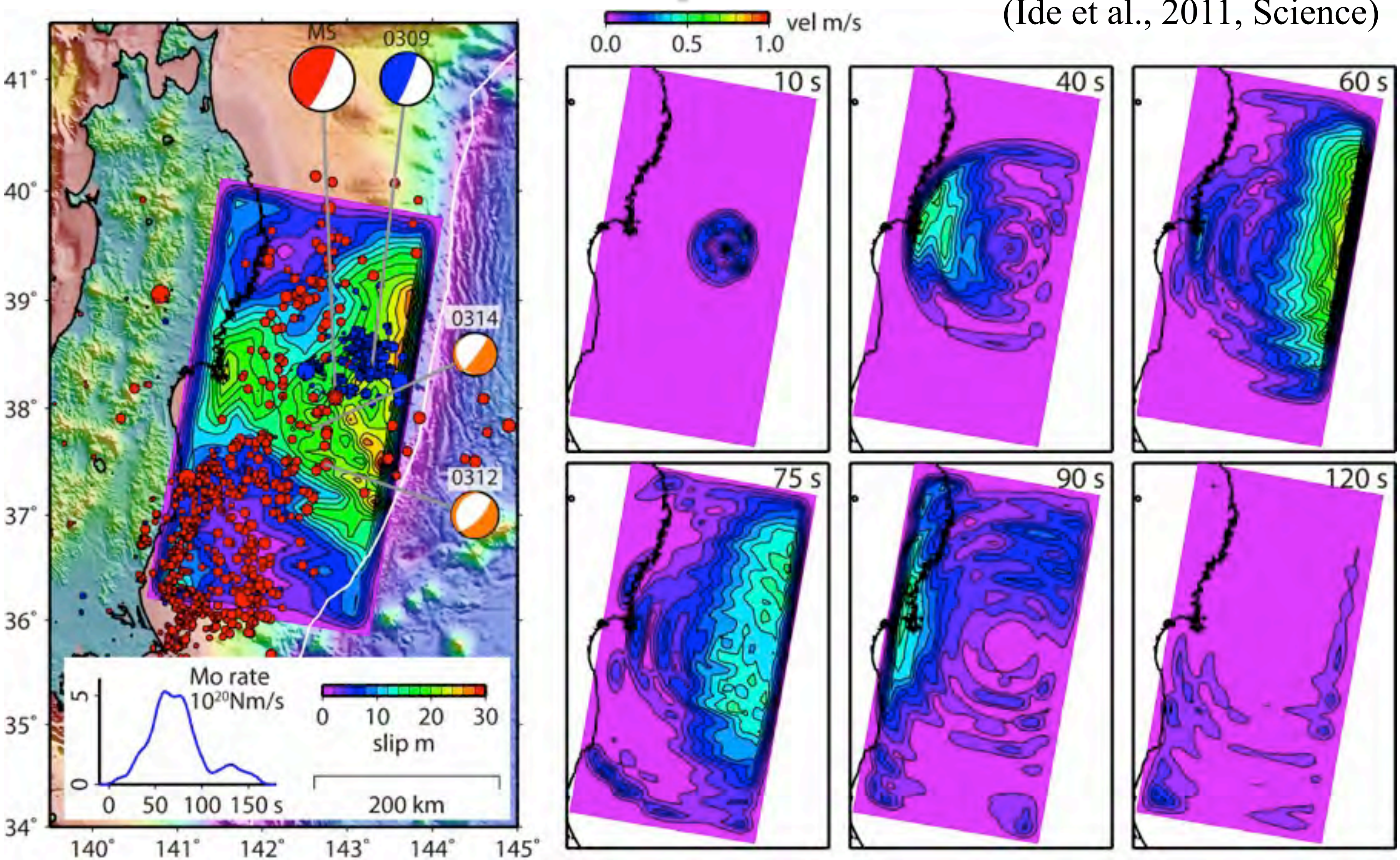
    Ide (2010, Nature; 2012, JGR)
- Controls on Seismicity
  - Background Seismicity vs. Plate Motion

    Ide (2013, submitted)
- Spatial Heterogeneity Controlling Megathrust Slip

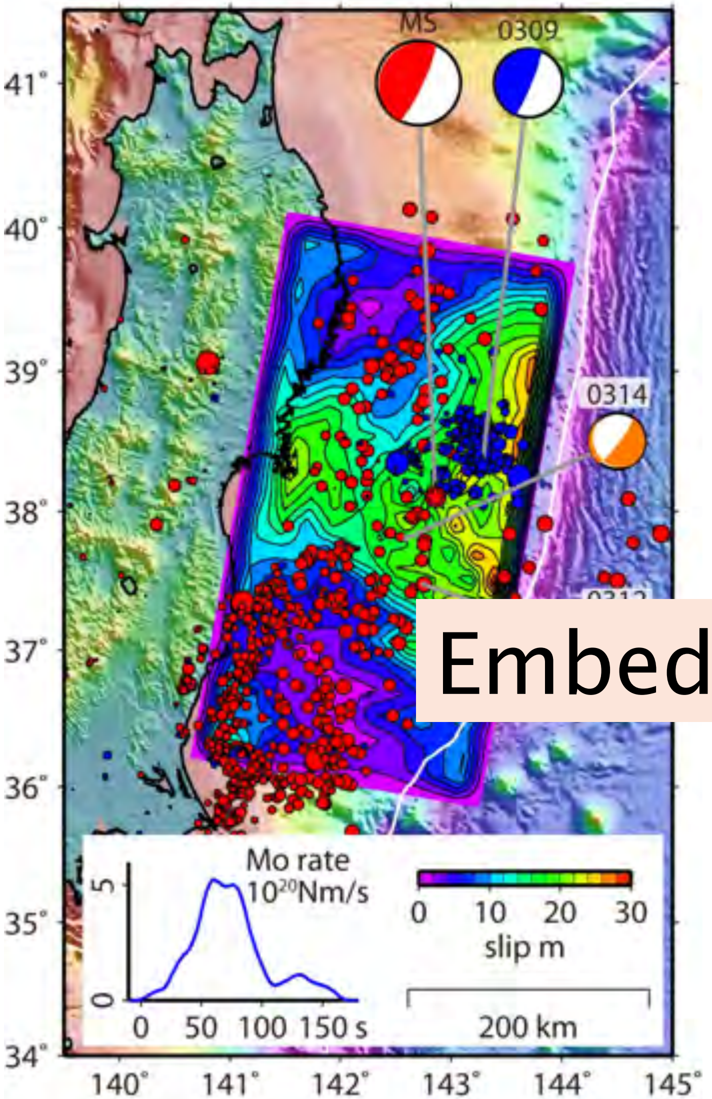
Controls on Dynamic Rupture

Tohoku-Oki Slip model

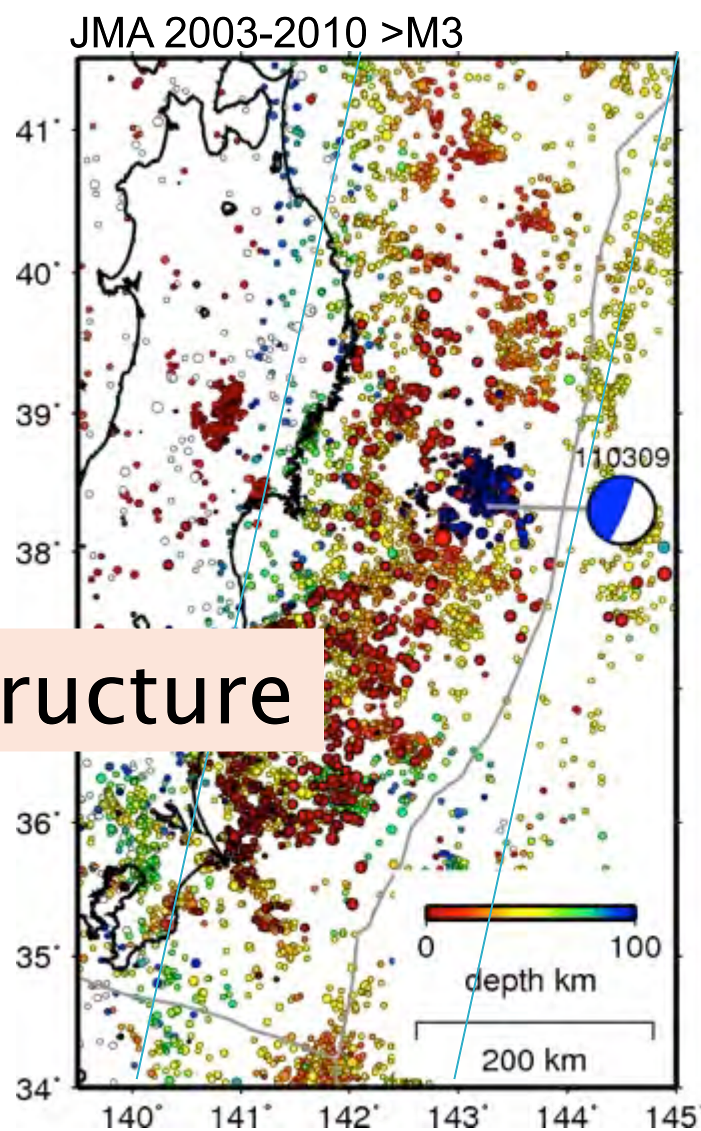
(Ide et al., 2011, Science)



Slip Model vs. Seismicity Catalog



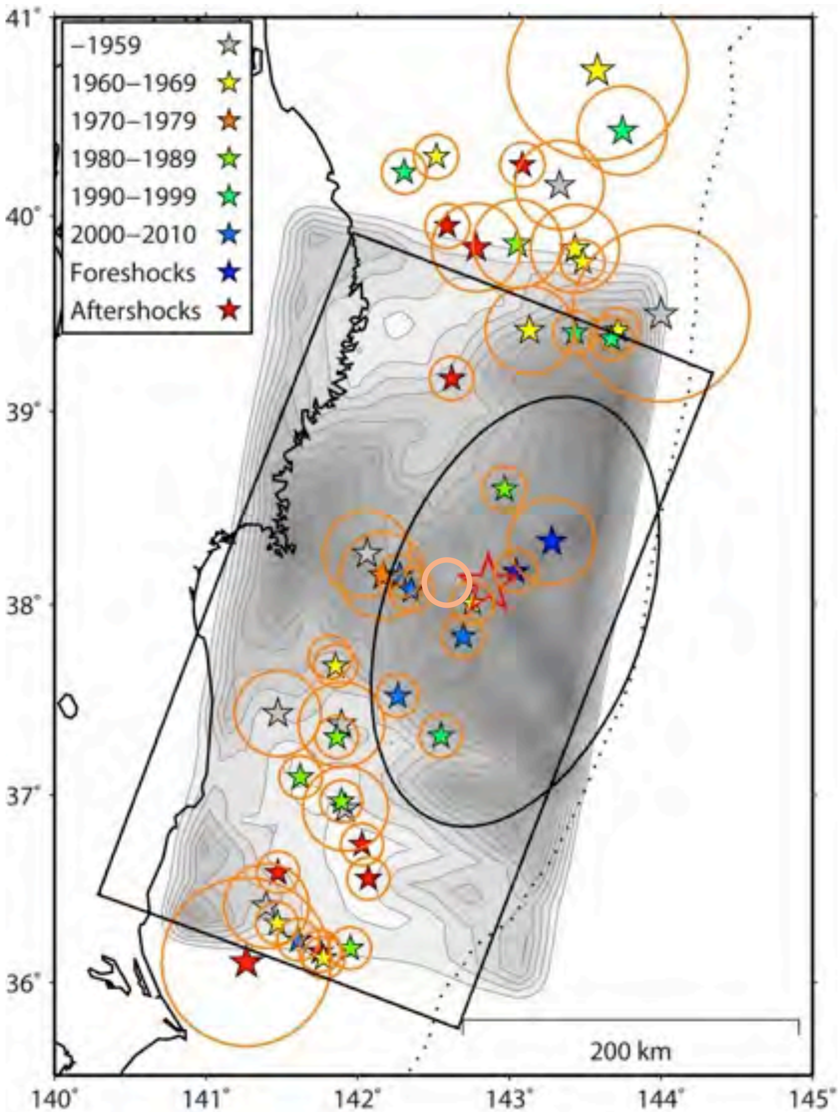
?

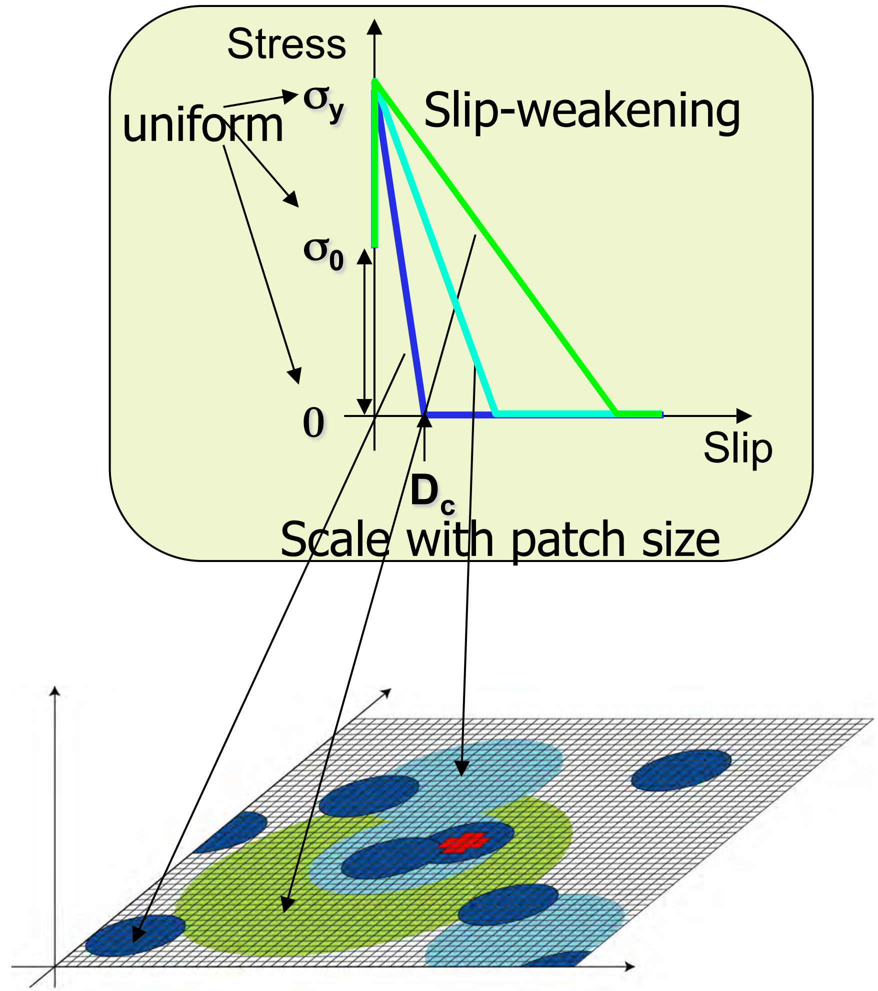


Embedded structure

Hypocenters → Segments

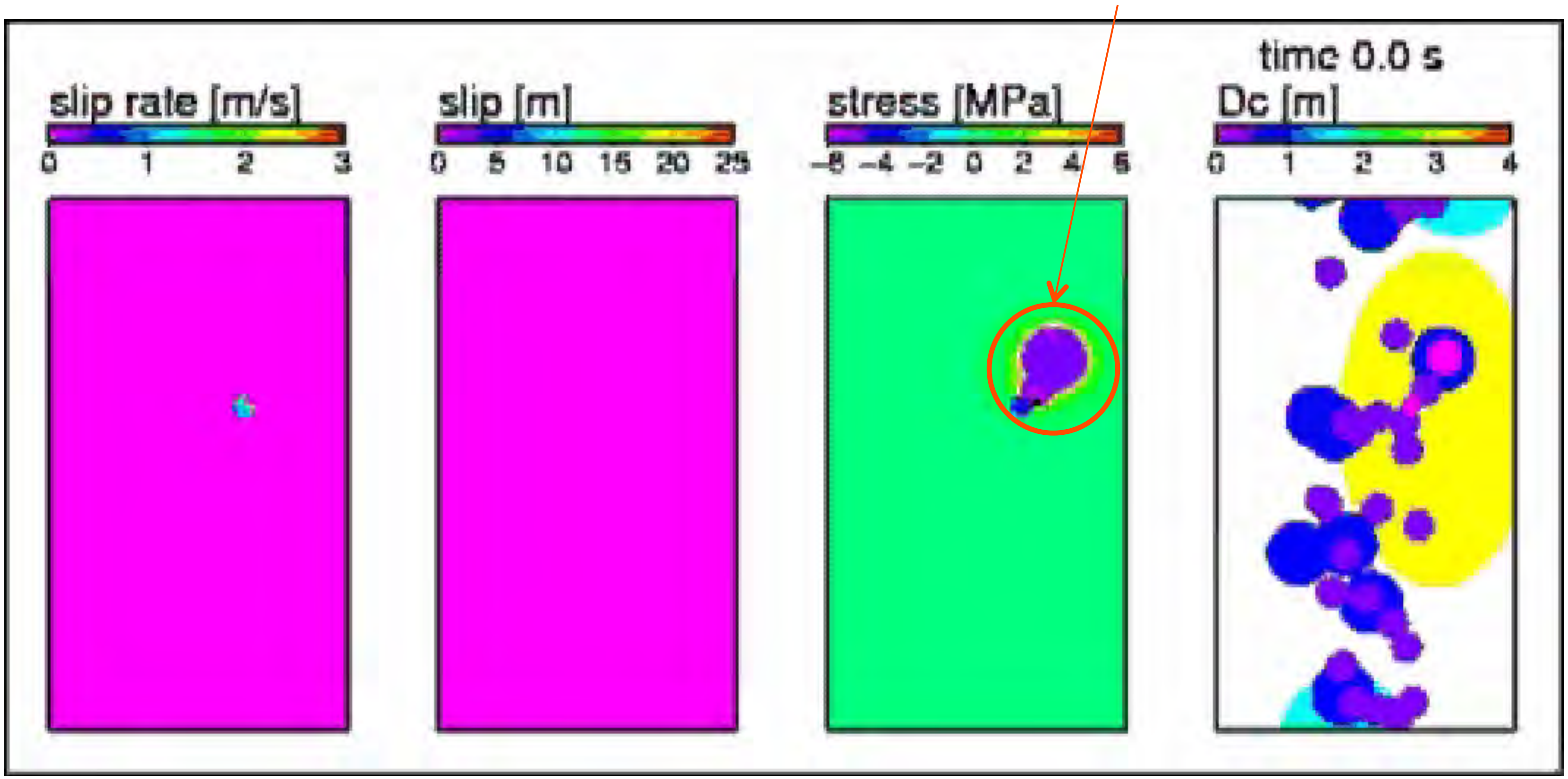
(Ide and Aochi, 2005, JGR)





Dynamic rupture process

Stress concentration due to the foreshock



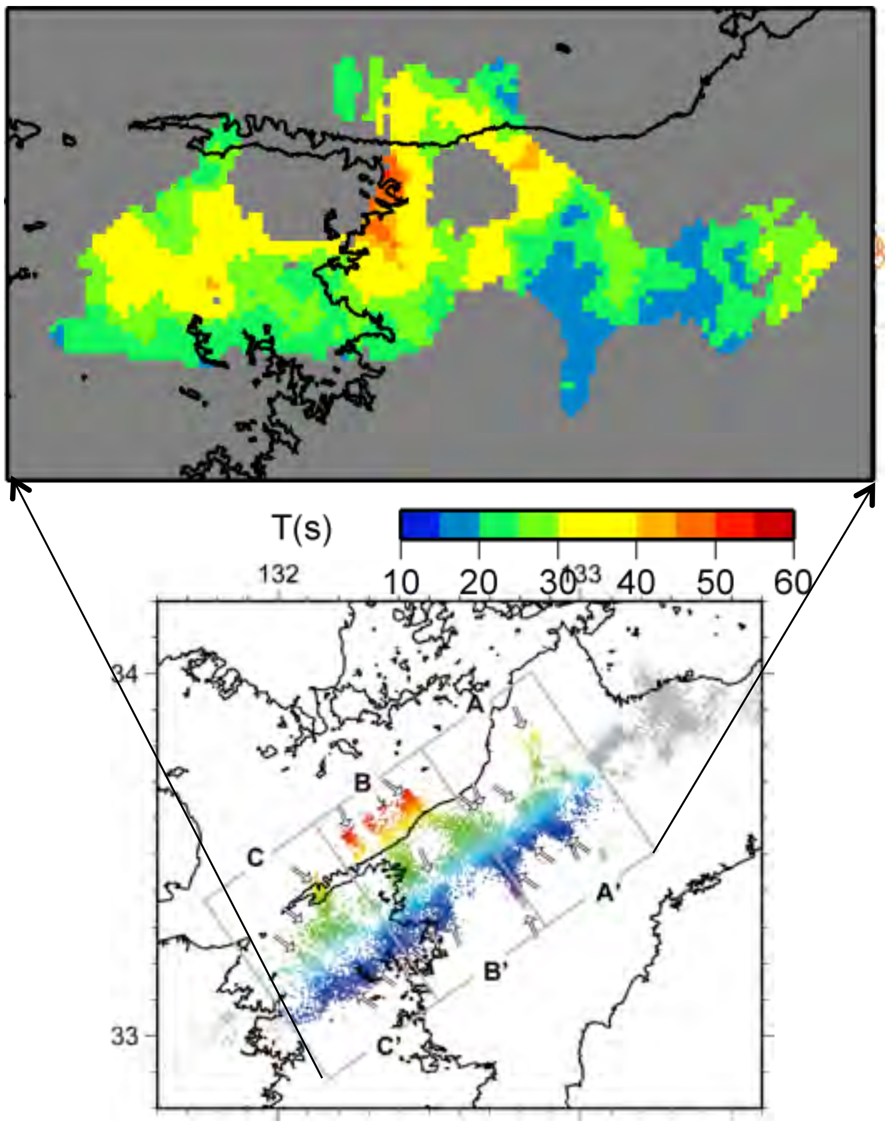
Controls on Dynamic Rupture

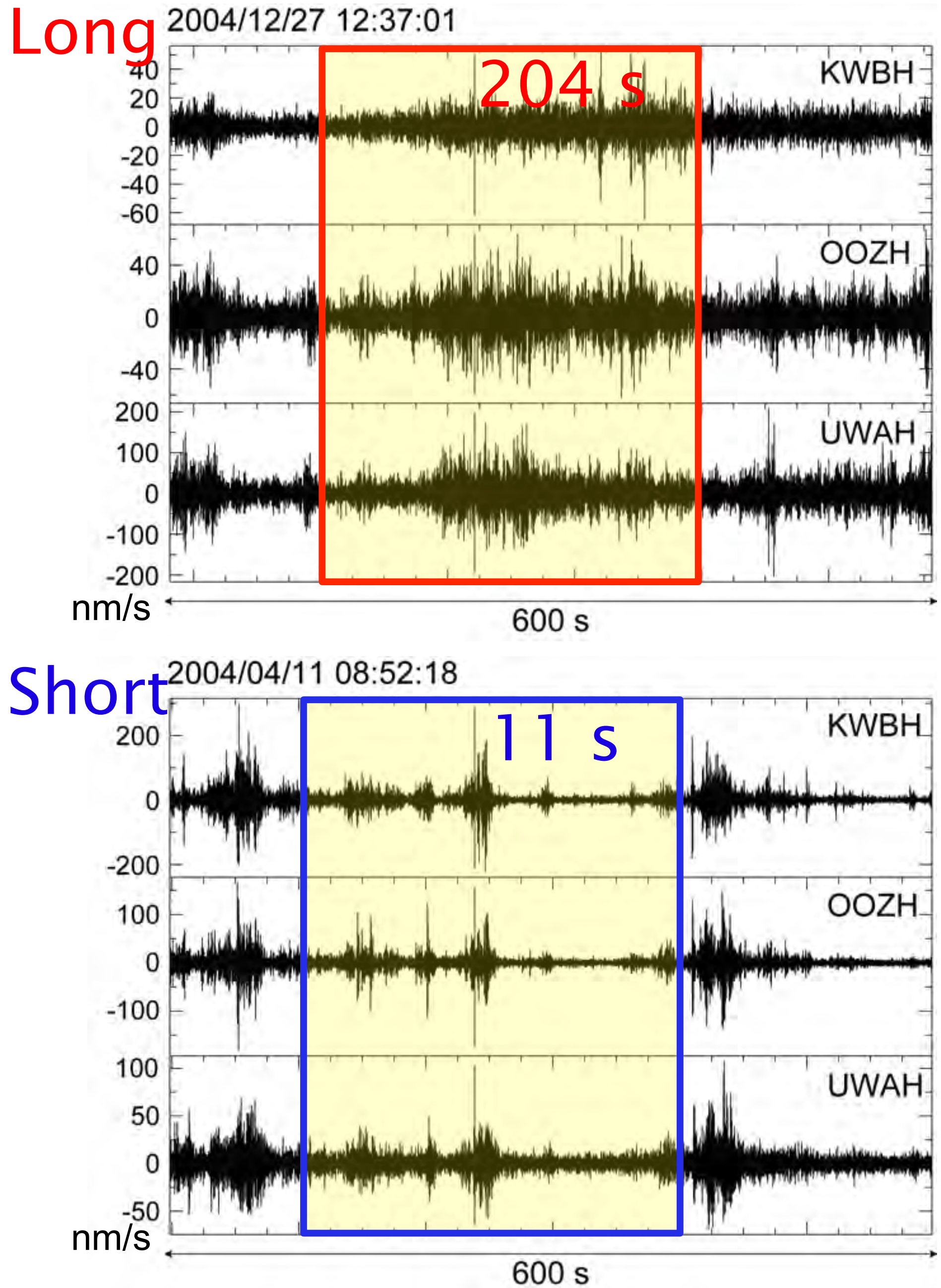
- Pre-existing structure controls
  - Hypocenter distribution
  - Dynamic rupture propagation

- Multi-scale structure
  - Stress --- fairly homogeneous
  - Fracture energy --- changes by orders

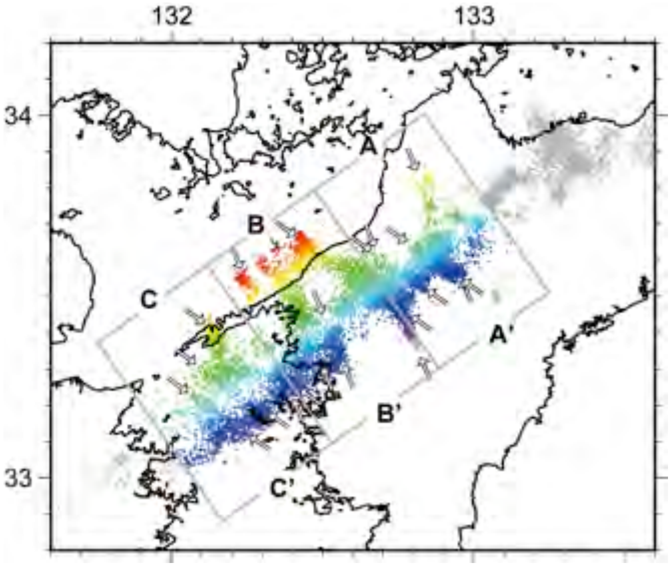
Controls on Tectonic Tremors

Tremor Heterogeneity

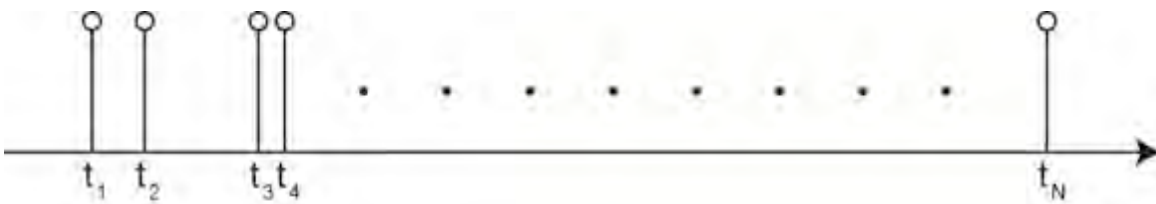




Sensitivity to tidal stress

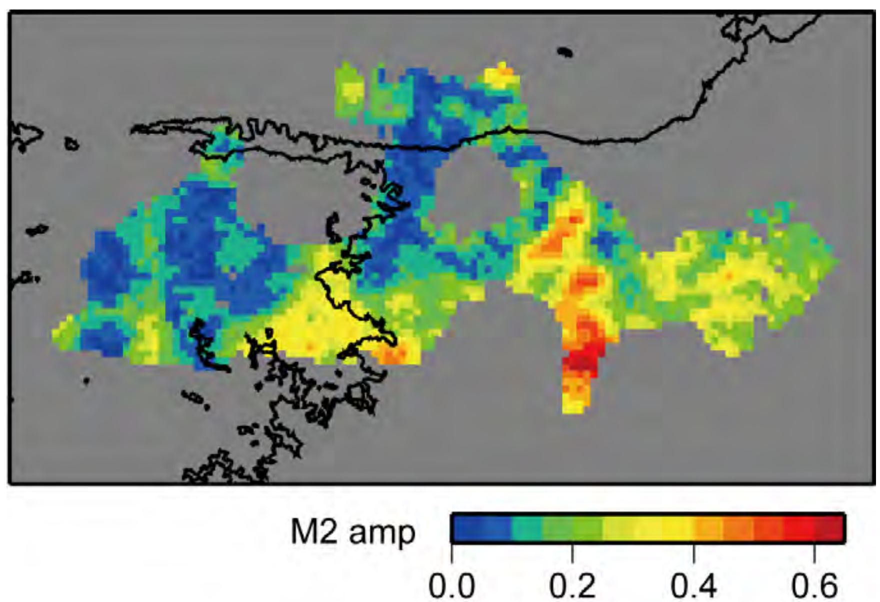


N = 100

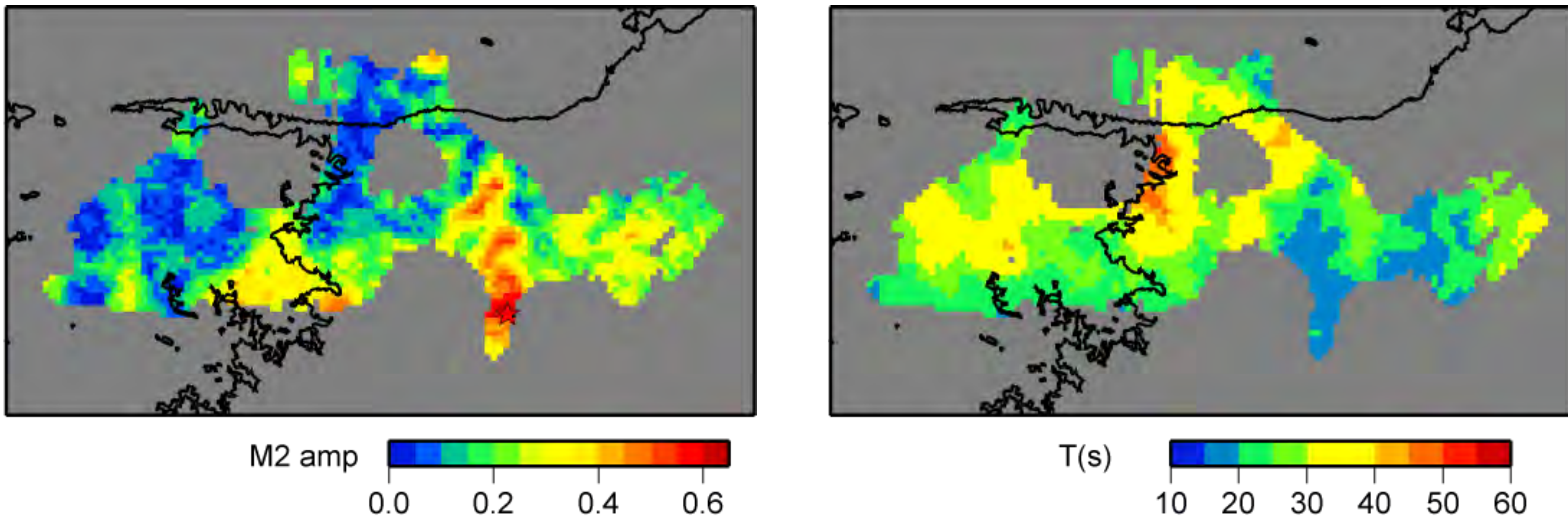


$$s = \left| \sum_{i=1,..N} \exp(2\pi i t_i / t_0) \right| / N$$

at t_0=12.42 hr
(M2 semi-diurnal)



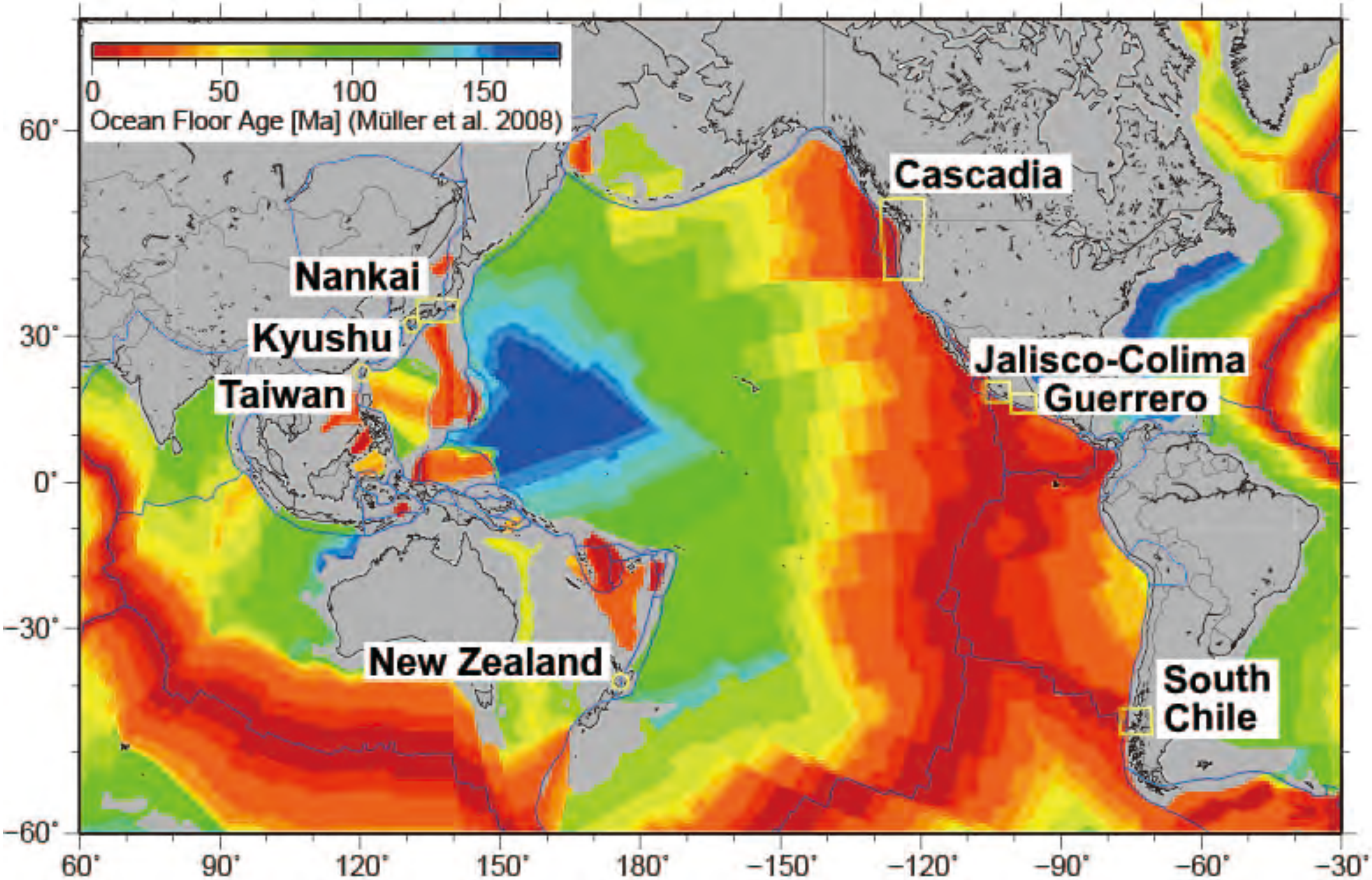
Tidal Sensitivity & Duration



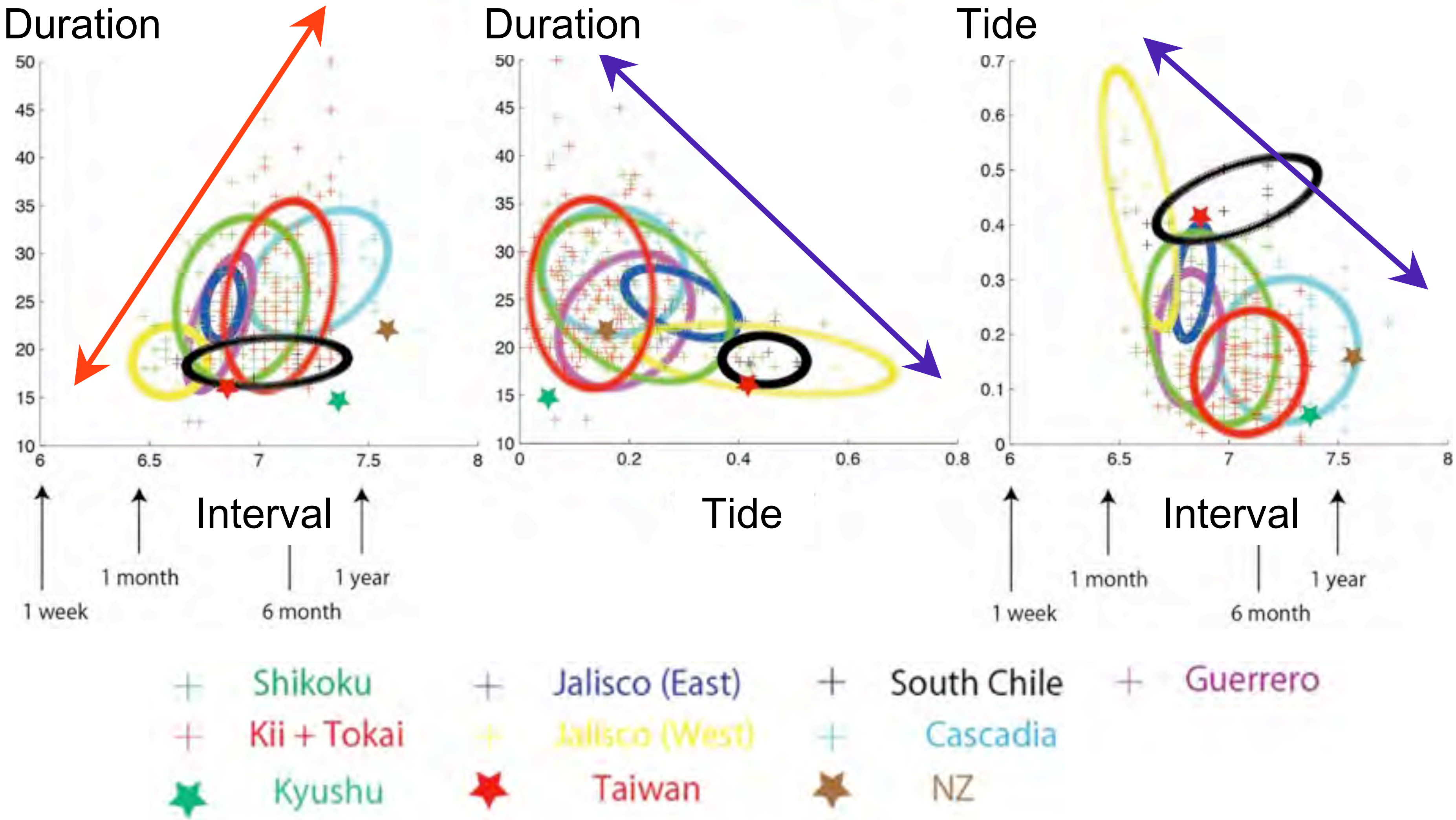
Duration	Long ~ 100s	Short ~ 10s
Recurrence Interval	Long, 3-6mo	Short, days
Tidal sensitivity	Insensitive	Sensitive

→ other tremor zones?

Application to world tremor



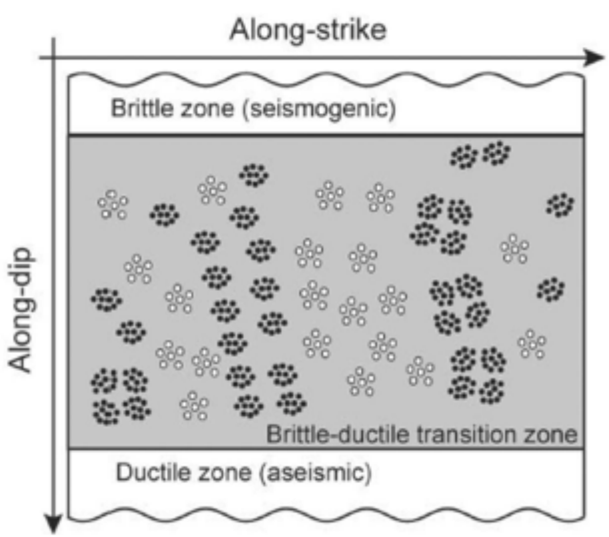
Duration-Tide-Interval



Controls on Tectonic Tremor

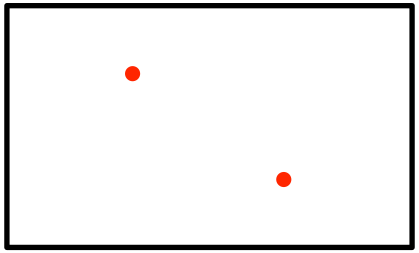
Two End Members

Event duration	Short	⇔	Long
Recurrence interval	Short	⇔	Long
Tidal stress effect	Sensitive	⇔	Insensitive

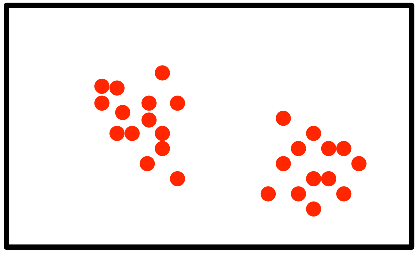


(Ando et al., 2012)

Weak patch



Strong patch



Controls on Seismicity

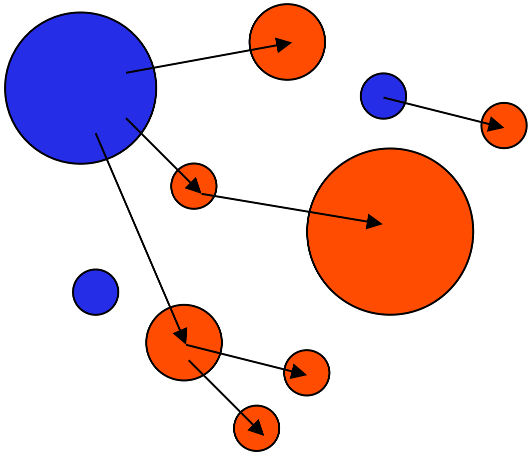
Problems

- "Maximum event" is difficult to estimate
  - Earthquake is a power-law phenomenon
  - Small chance for any large events
- What is the average property of subduction zones?
  - Seismicity of medium & large earthquakes (background seismicity)

Seismicity and ETAS model

Ogata (1988)

- Earthquakes are
  - Triggered by a previous event
  - Background seismicity

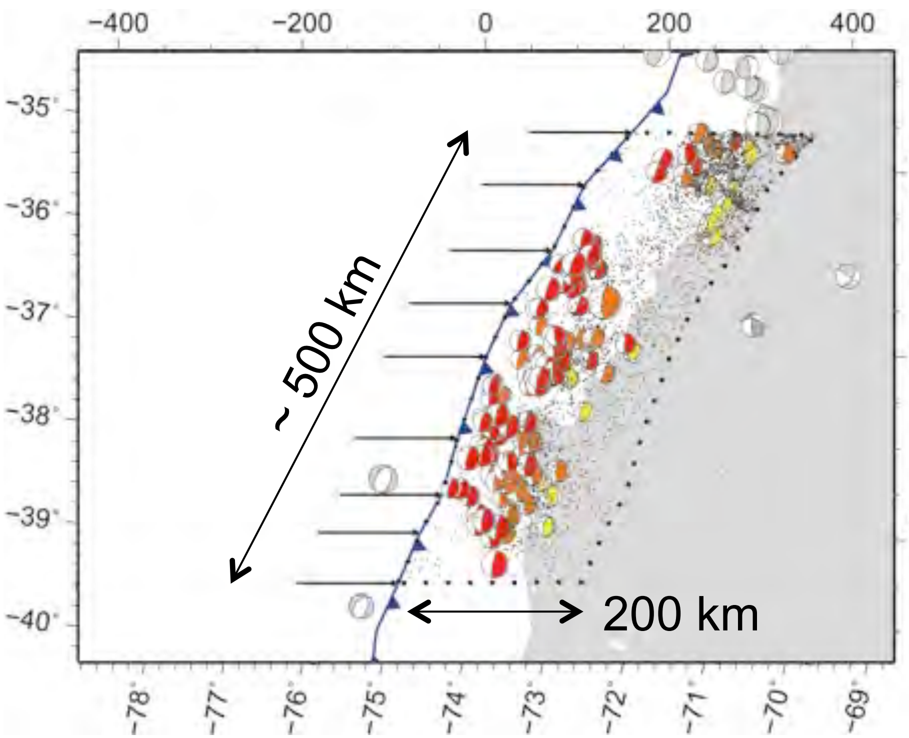


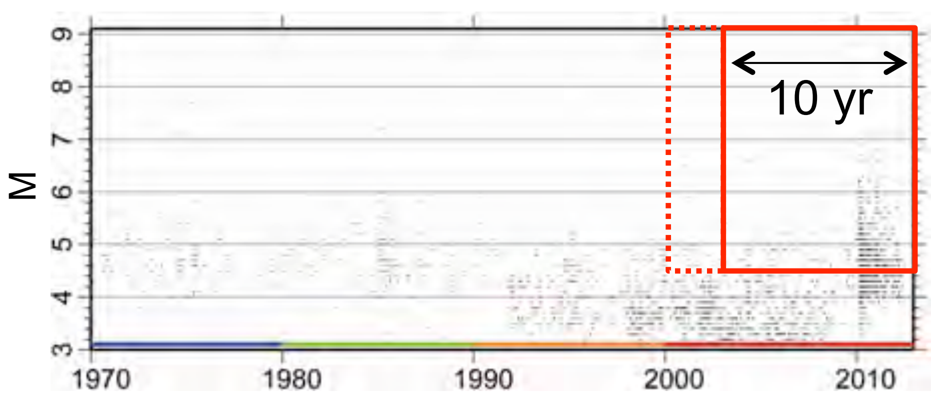
seismicity
rate
for a point process

$\lambda(t)=\mu+\sum_{t_i<t} K e^{\alpha(M_i -}$

Background seismicity is stable ?

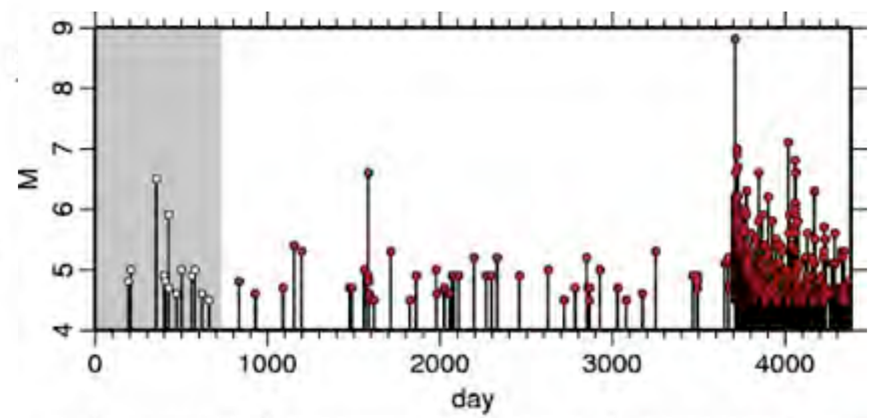
ETAS modeling for each region

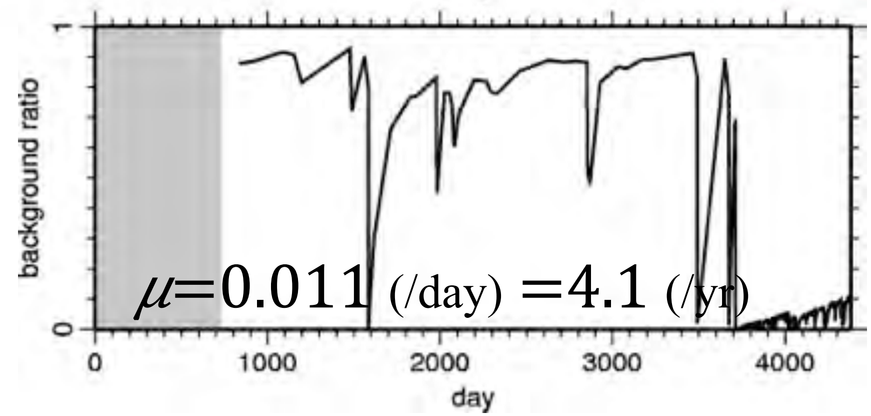




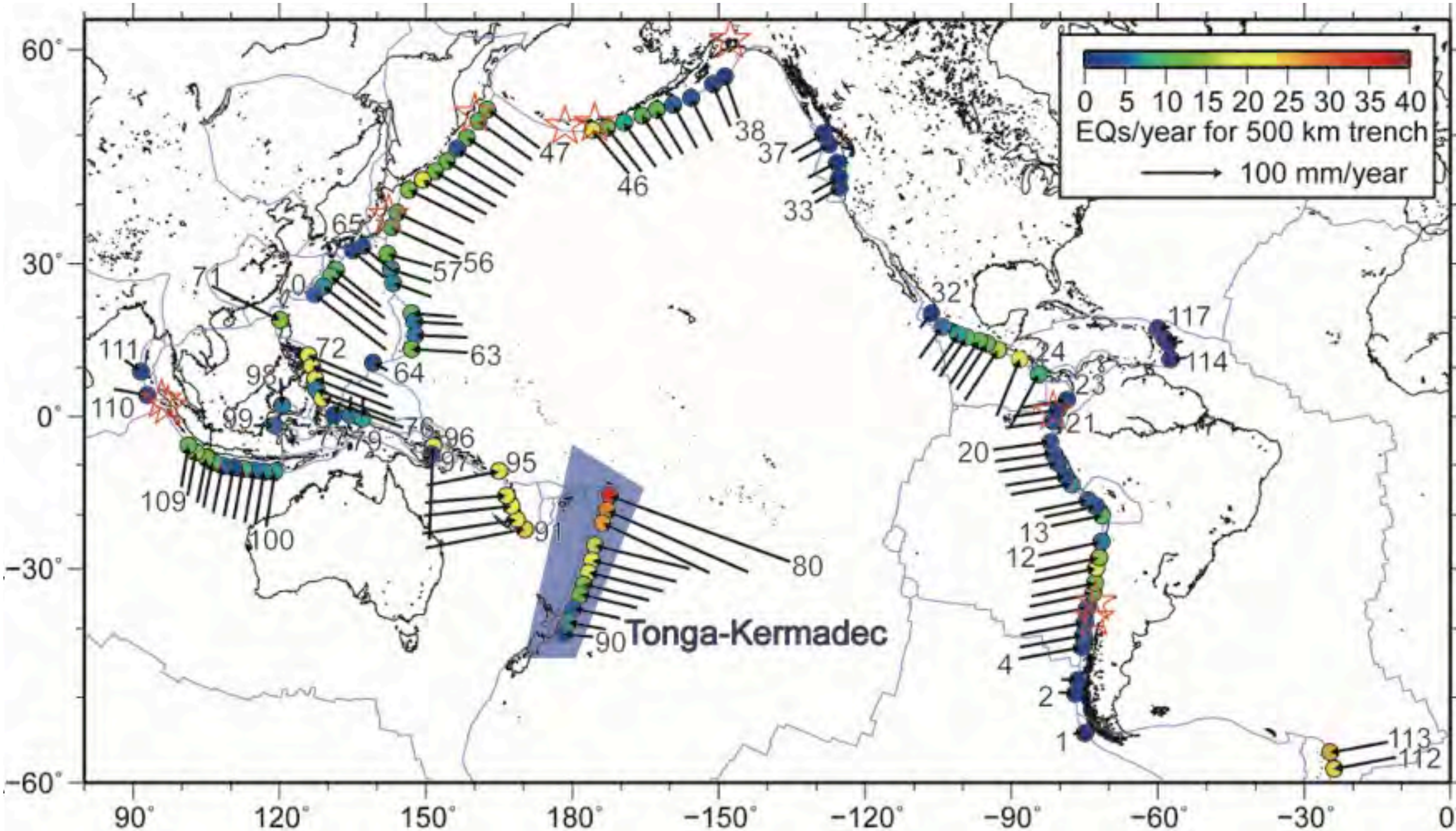
Depth 0 – 70 km
M ≥ 4.5

Mechanisms not checked

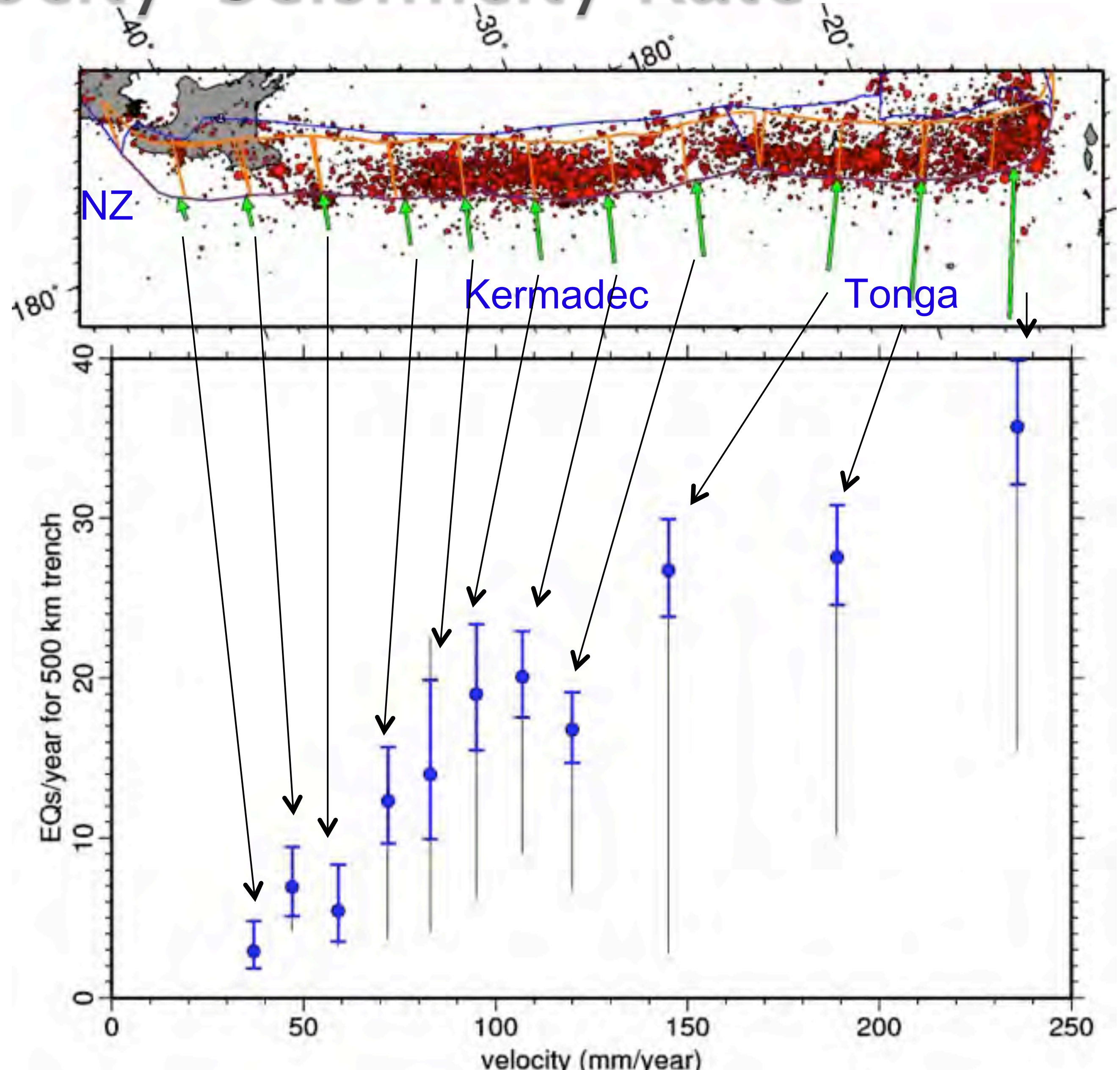




Estimated background seismicity

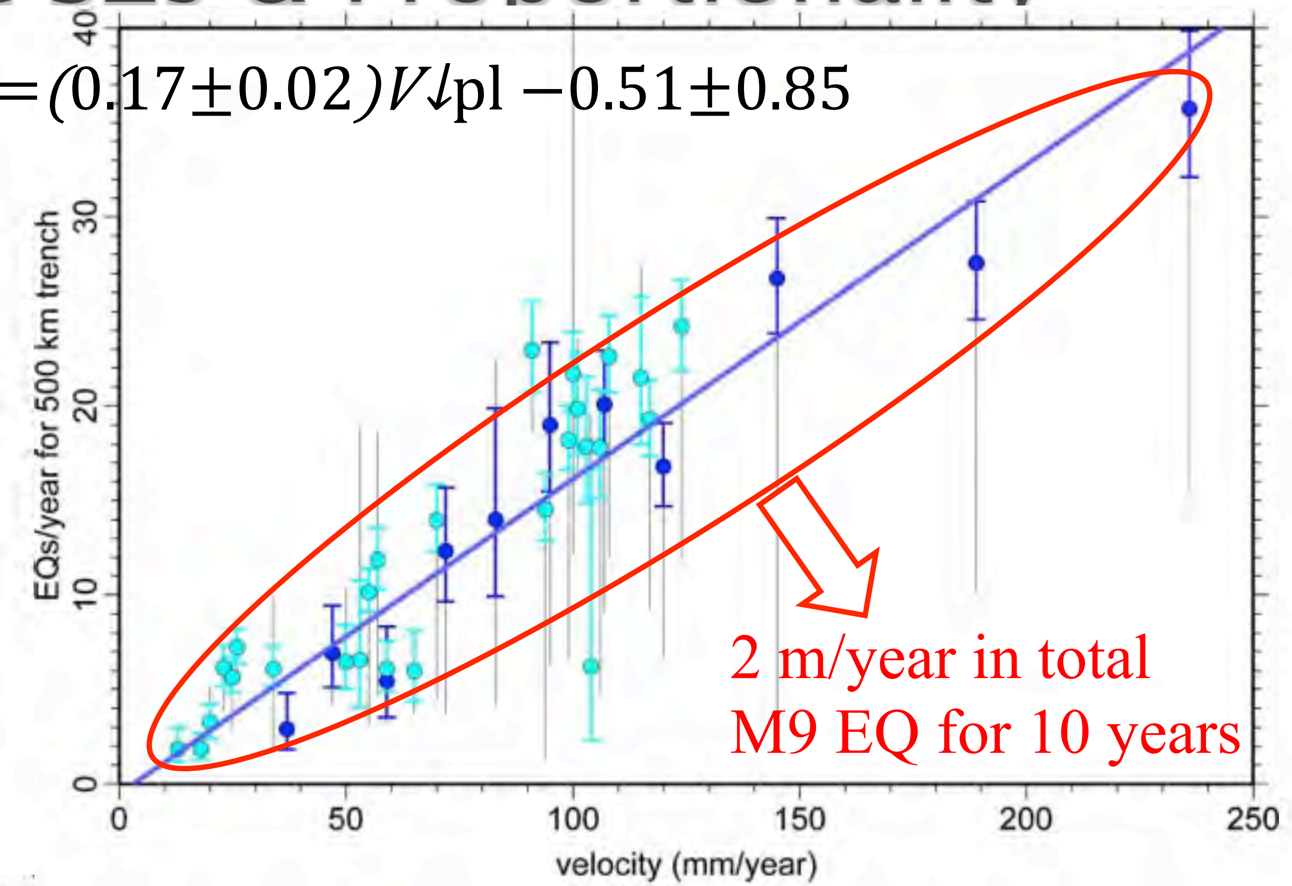


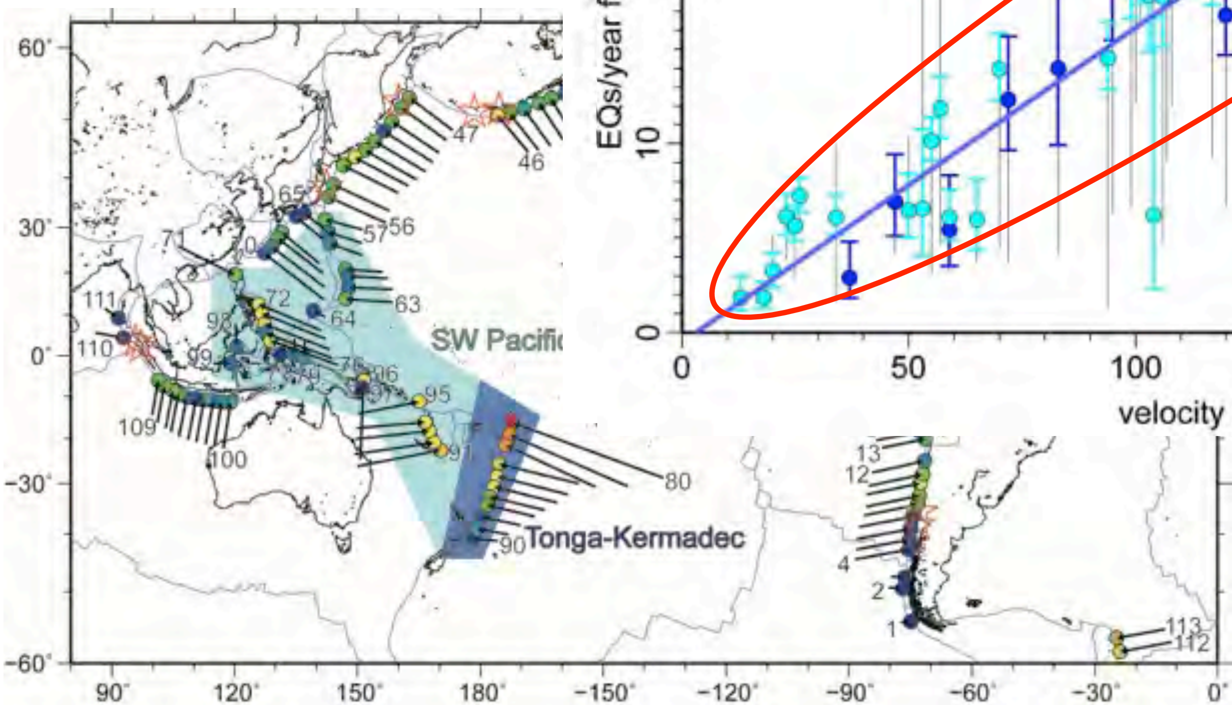
Velocity-Seismicity Rate



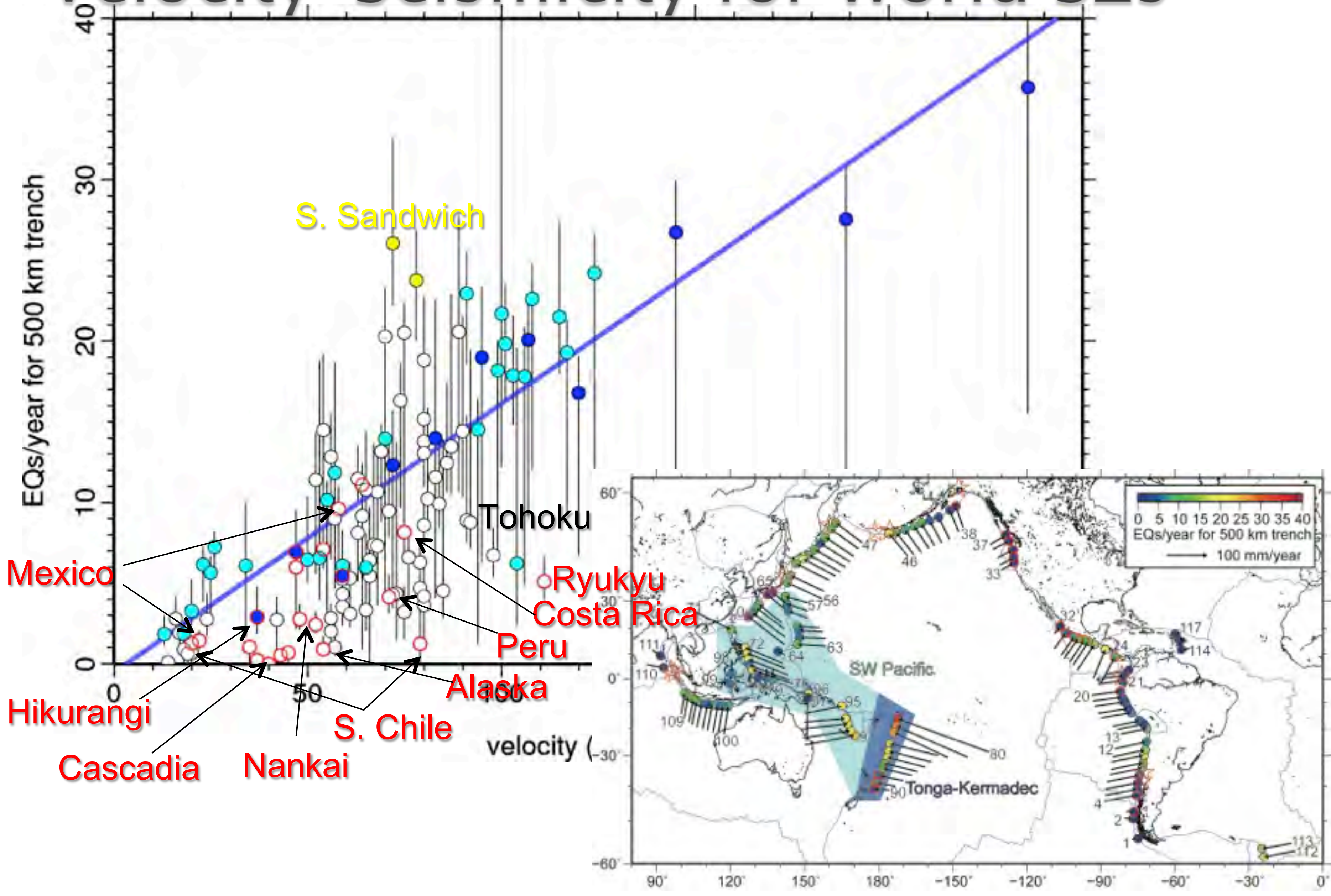
SW-Pacific SZs & Proportionality

$$\mu = (0.17 \pm 0.02) V_{pl} - 0.51 \pm 0.85$$





Velocity–Seismicity for World SZs



Paradox in Seismicity

Velocity-Scaled

Seismicity

Low ←→ High

Mega-Earthquake

Seismic Risk

Low High ←→ High Low

Alaska
Cascadia
S. Chile
Nankai

Ryukyu
Peru

Costa Rica
Hikurangi

Mexico

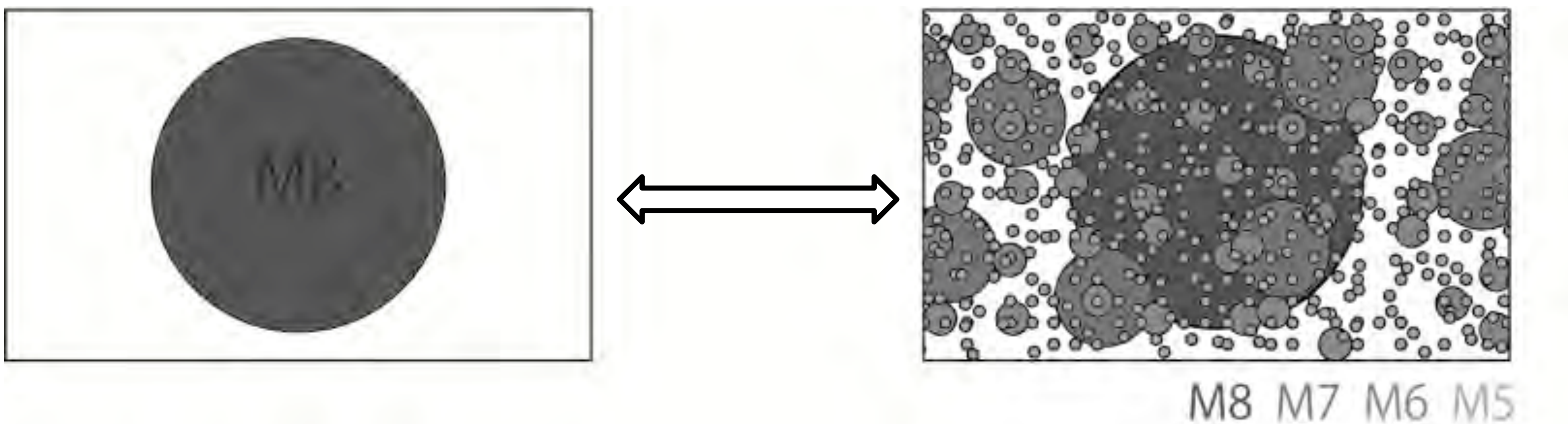
Slow EQ Zones

Tohoku
Sumatra

Tonga Kermadec
Mariana
SW Pacific
S. Sandwich

Characterize SZ with patch models

Multi-scale structure of fracture energy



Characteristic ⟷ Multiscale

Alaska
Cascadia
S. Chile
Nankai

Costa Rica
Hikurangi

Ryukyu
Peru

Mexico

Slow EQ Zones

Tohoku
Sumatra

Tonga Kermadec
Mariana
SW Pacific
S. Sandwich

Multi-scale structure of fracture energy may control megathrust slip behaviour

Thank you for your attention!