A GLOBAL SURGE OF GREAT EARTHQUAKES FROM 2004-2014 AND IMPLICATIONS FOR CASCADIA

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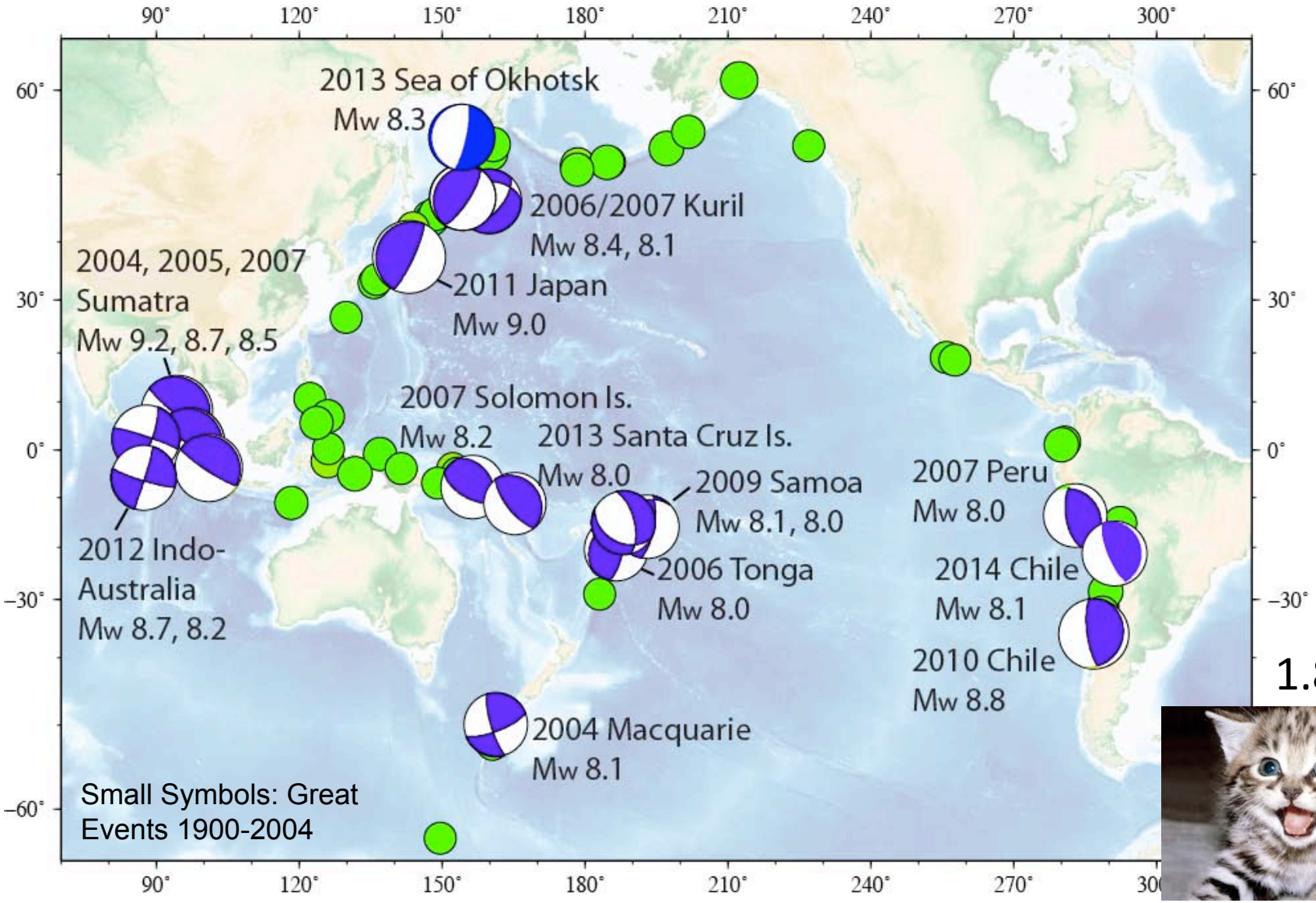
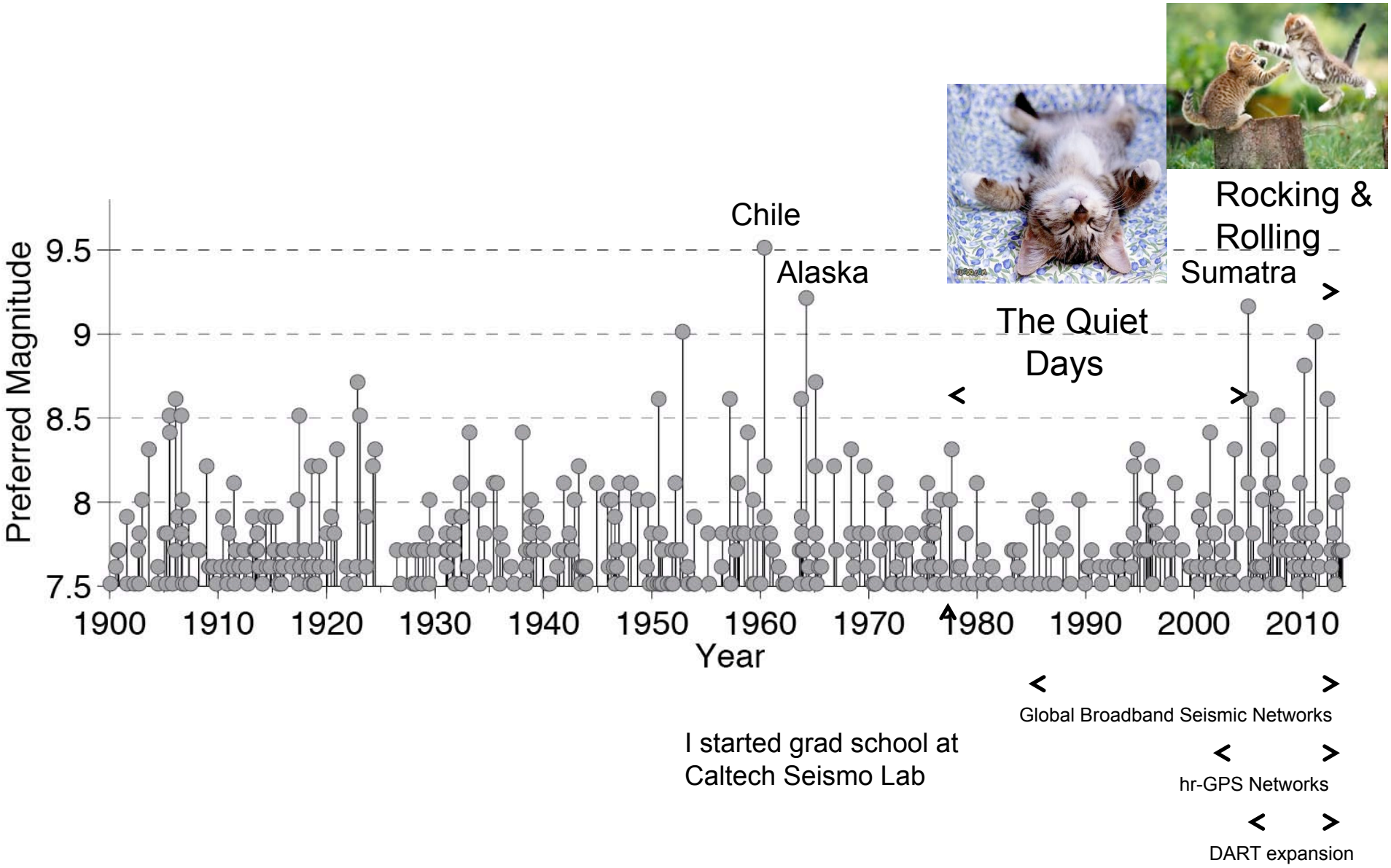
Last 10 yrs - 18 great earthquakes: rate 1.8/yr; rate over preceding century 0.7/yr



1.8/yr !

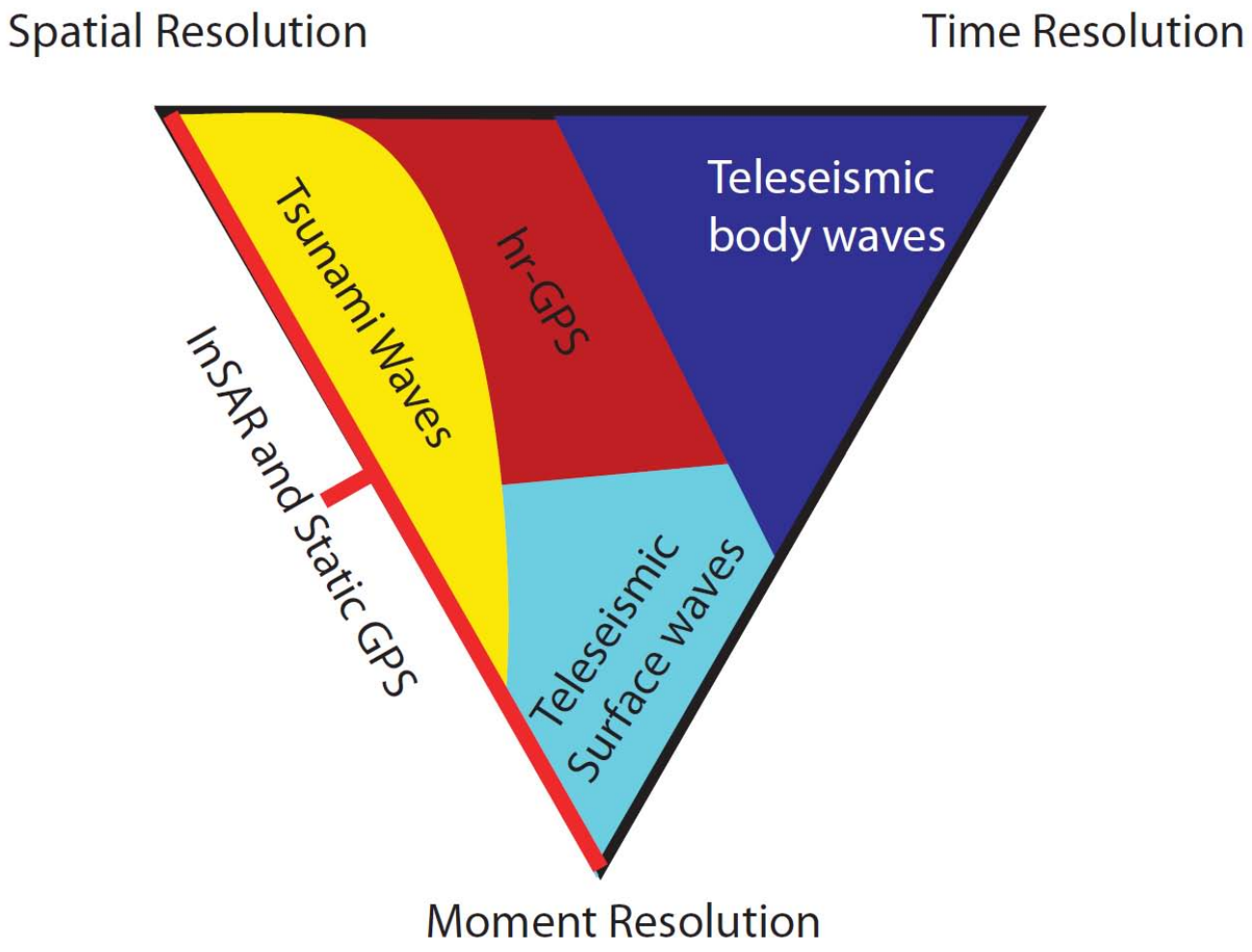
Great ($M_w \geq 8$) events from Dec. 2004-Apr. 2014

[Lay, 2014]



after, Ammon et al., SRL, 2010

Resolutions of Joint inversion



Recent Huge Events With "Surprises"

2004 Sumatra M_w 9.2; ruptures 1300+ km long, massive tsunami
2005 M_w 8.7, 2007 8.5, 7.9 'clustered' events along Sumatra

2006 Kuril M_w 8.4 thrust; triggers 2007 Kuril M_w 8.1 normal

2007 Peru M_w 8.0 devastates Pisco; triggered by 7.8 initial rupture

2007 Solomon Island M_w 8.2; rupture across triple junction

2008 Wenchuan M_w 7.9; unexpected thrusting

2009 Samoa M_w 8.1 normal faulting; triggers Tonga M_w 8.0 thrust

2010 Chile M_w 8.8 ruptures beyond "Darwin Gap"

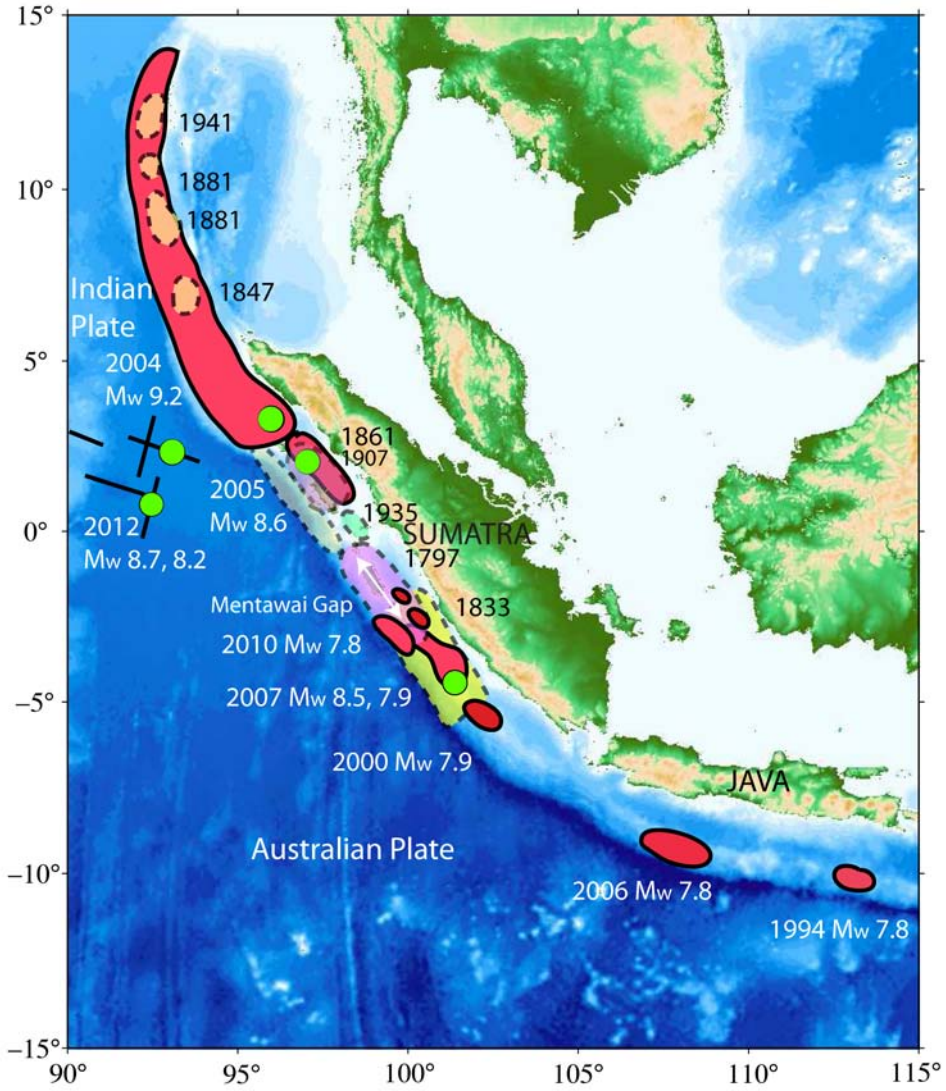
2010 Mentawai M_w 7.8 tsunami earthquake updip of 2007 8.5/7.9 Sumatra

2011 Tohoku M_w 9.0 ruptures entire megathrust, slip up to 60 m

2012 Indo-Australia M_w 8.7, 8.2 ruptures 5 fault grid- largest intraplate strike-slip

2013 Sea of Okhotsk M_w 8.3 largest/longest/most energy deep earthquake ever

Sumatra-Sunda



[Lay, 2014]

Struck by a ‘cluster’ of great/very large earthquakes since 2004.

Dec. 26, 2004 – ‘unexpected’ northward extension to Andaman Islands. 9.2

March 2005 – adjacent ‘aftershock’. 8.6

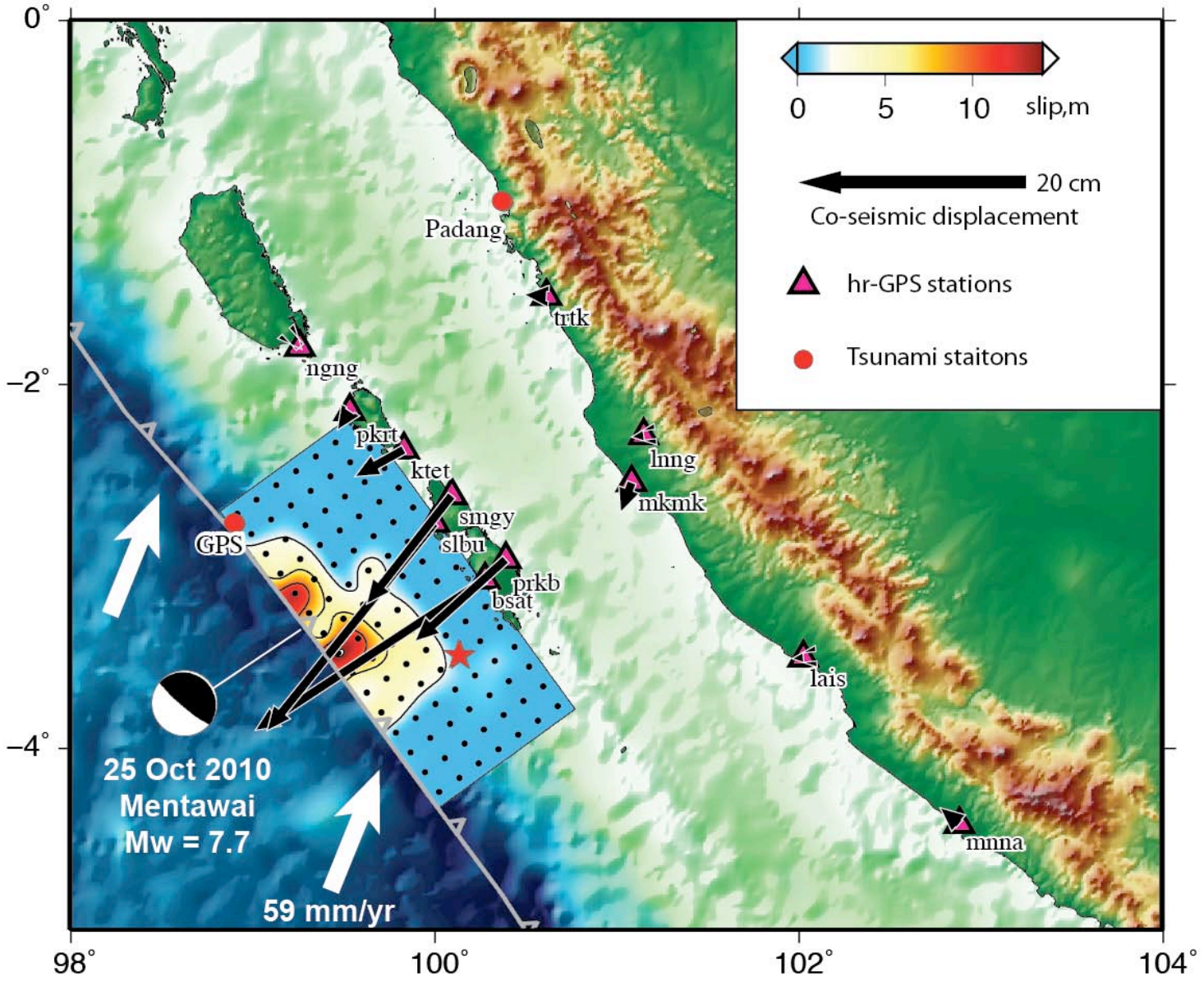
July 2006 – Java tsunami earthquake. 7.8

Sept. 2007 – Kepulauan pair. 8.5, 7.9

Oct. 2010 – Mentawai tsunami earthquake. 7.8

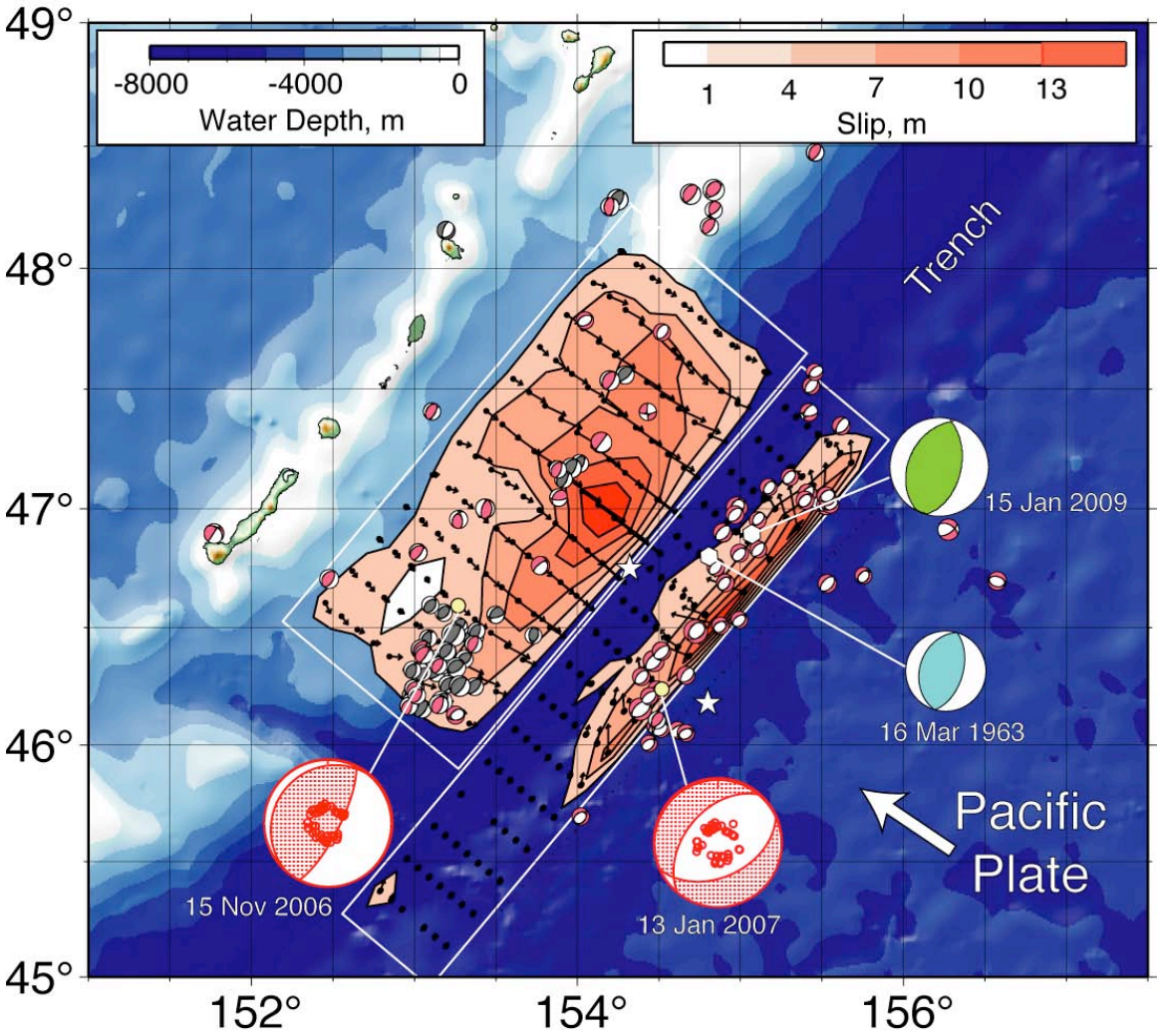
Similar to Alaska-Aleutians sequence of 1946, 1957, 1964, 1965

Where will the next one be? - 1797 ‘gap’? Sumatran Fault? Sumba potential?



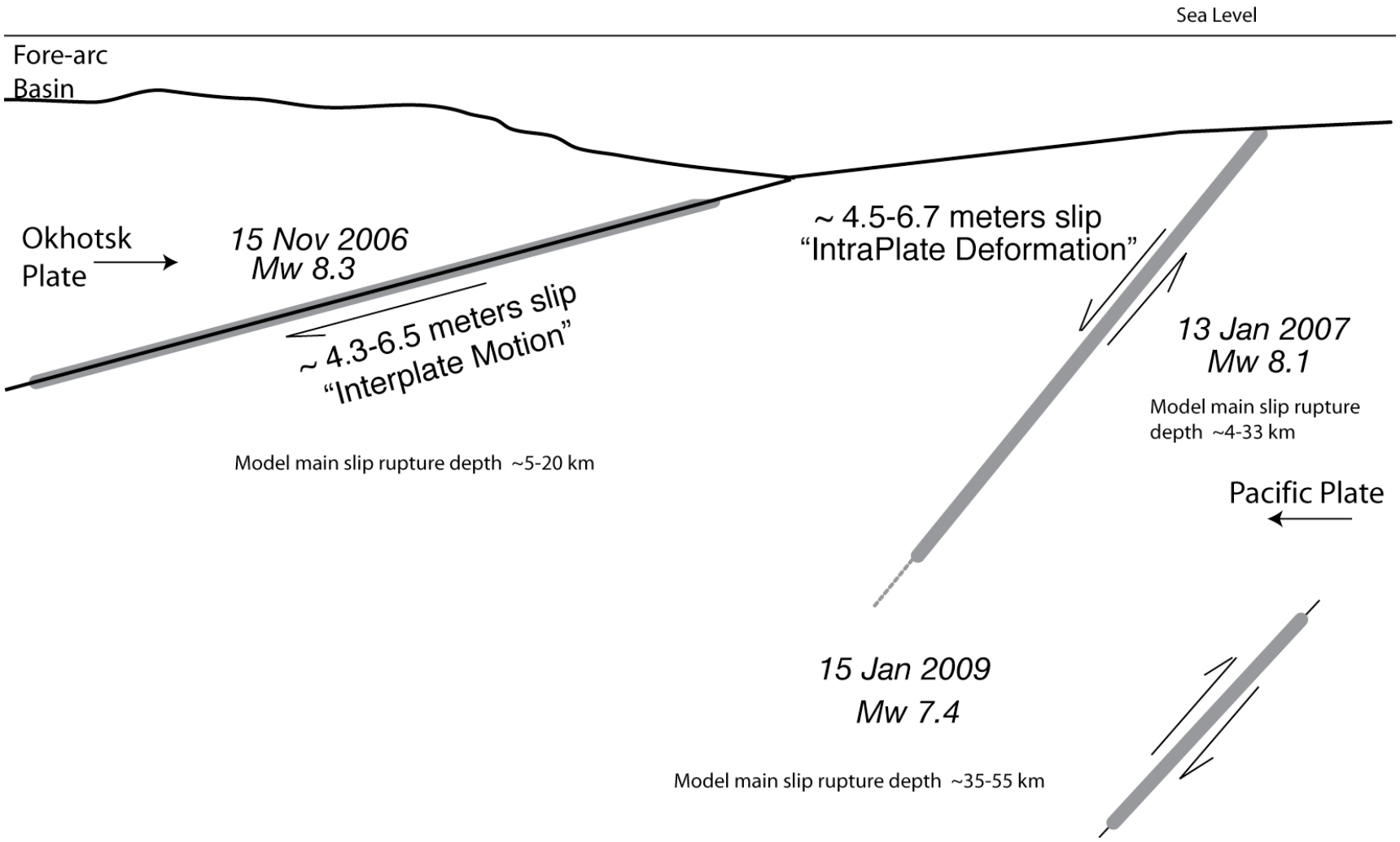
[Yue et al., 2014c]

2006-2007 Kuril Doublet: Mw 8.1 normal after Mw 8.4 thrust. Trench-slope stress cycled from compressional to extensional to compressional

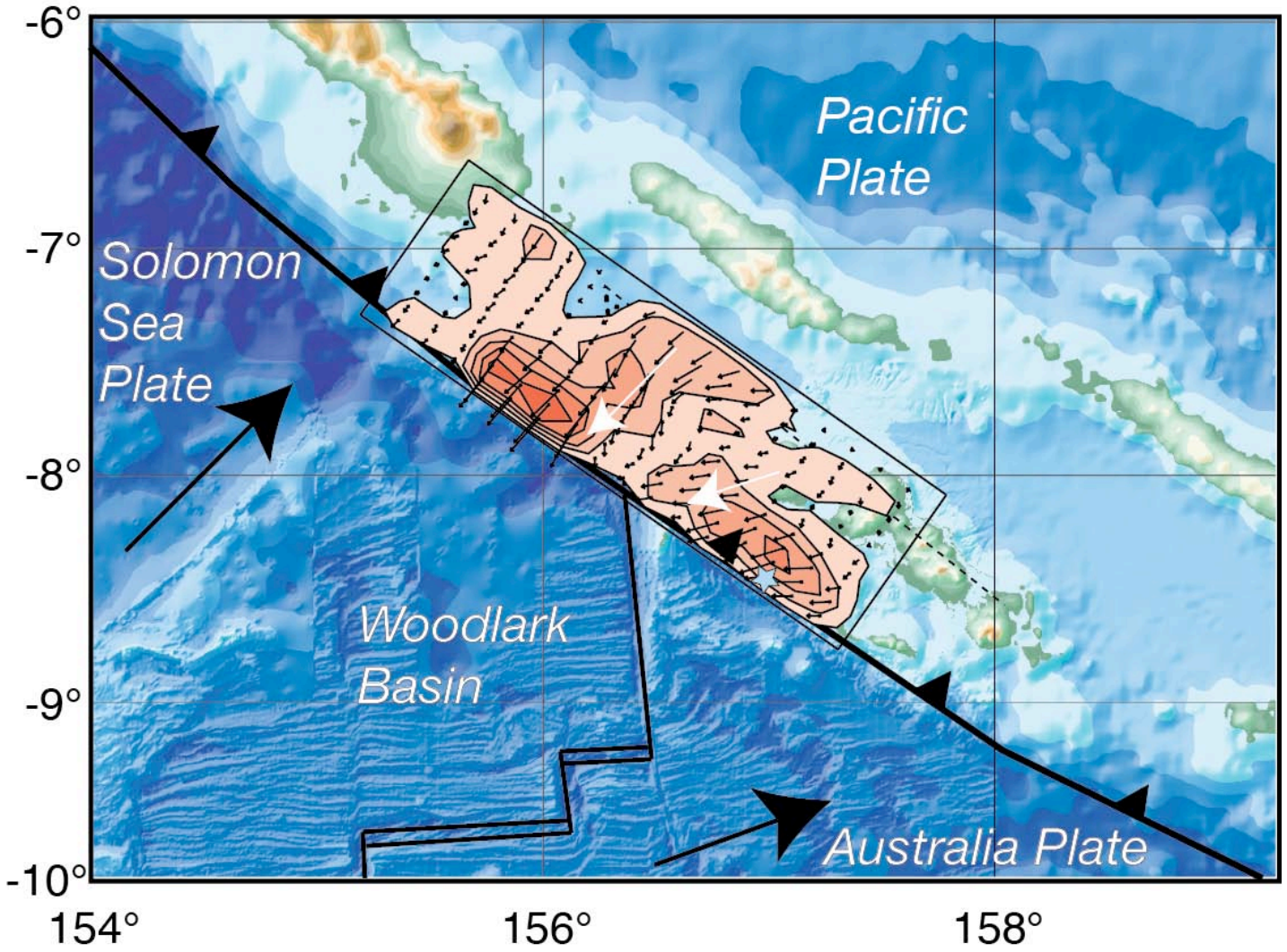


Lay et al., JGR (2009)

Kuril Islands Great Doublet



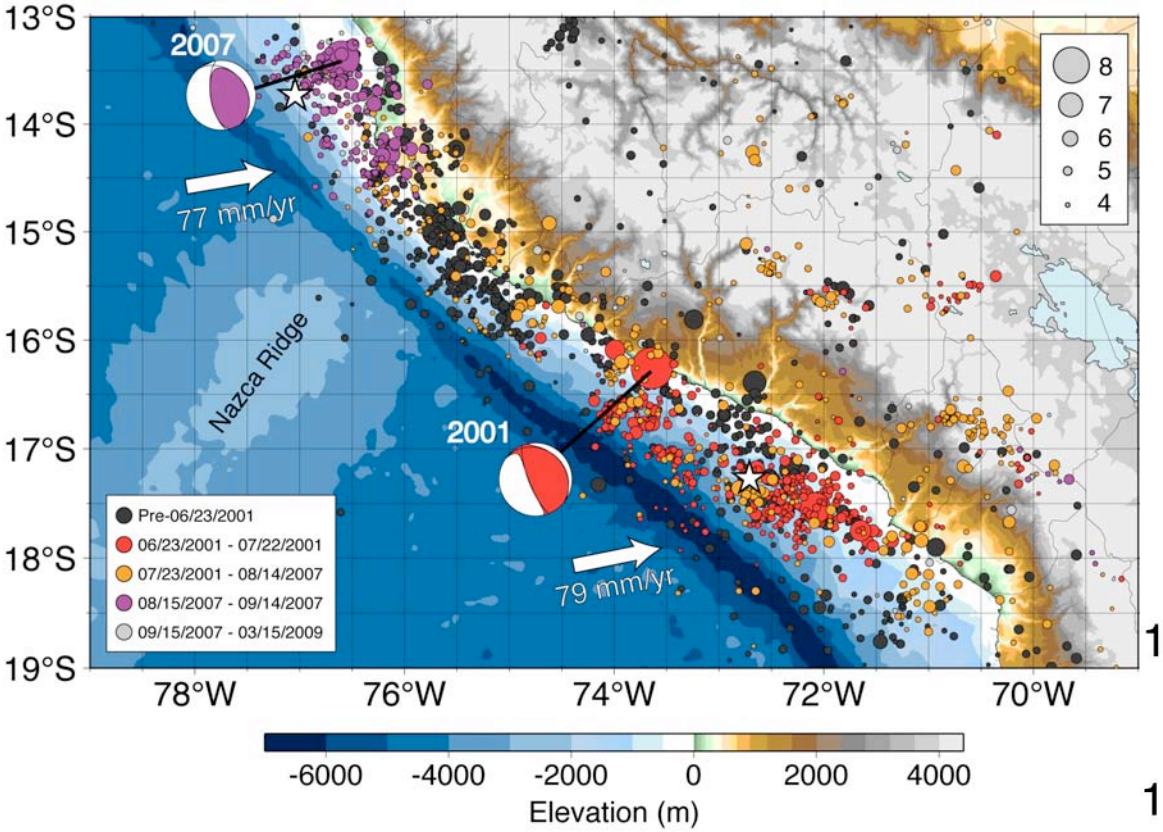
Lay et al., JGR (2009)

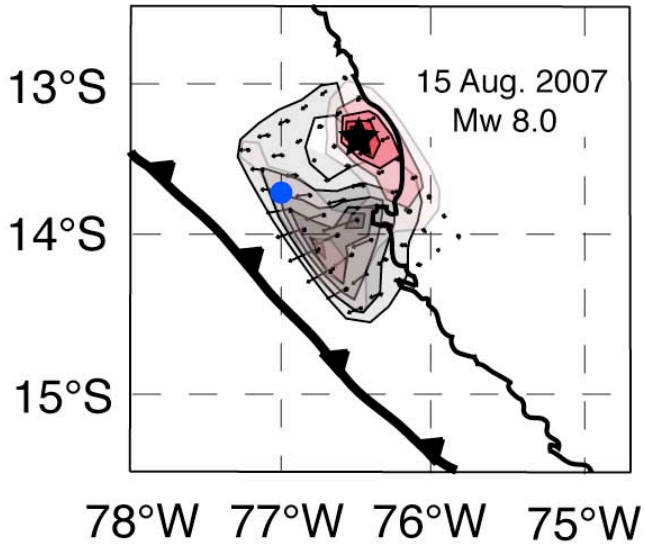


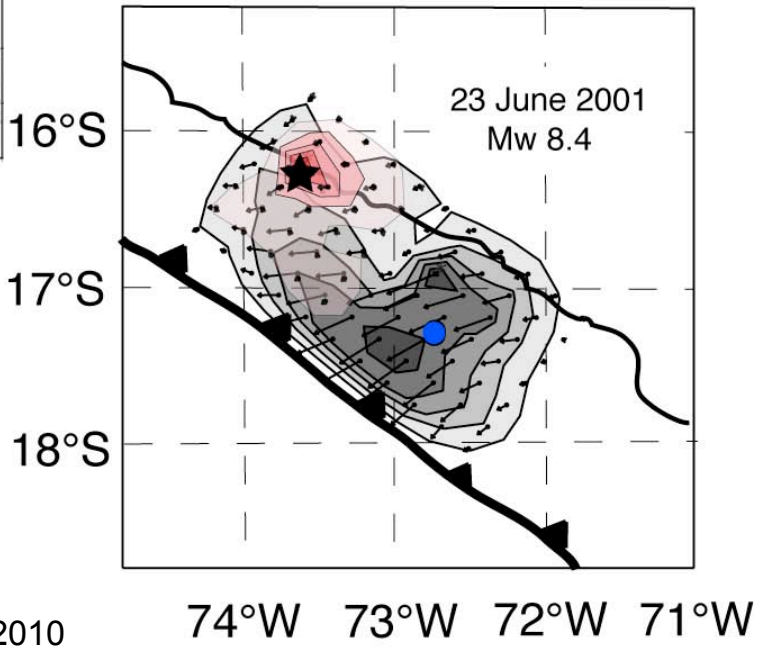
Furlong et al., Science (2009)

April 1, 2007 Solomon Islands Earthquake M_w=8.1 Rupture Across a Triple Junction

Great events along southern Peru megathrust: Ruptures triggering large second rupture with complex expansion.





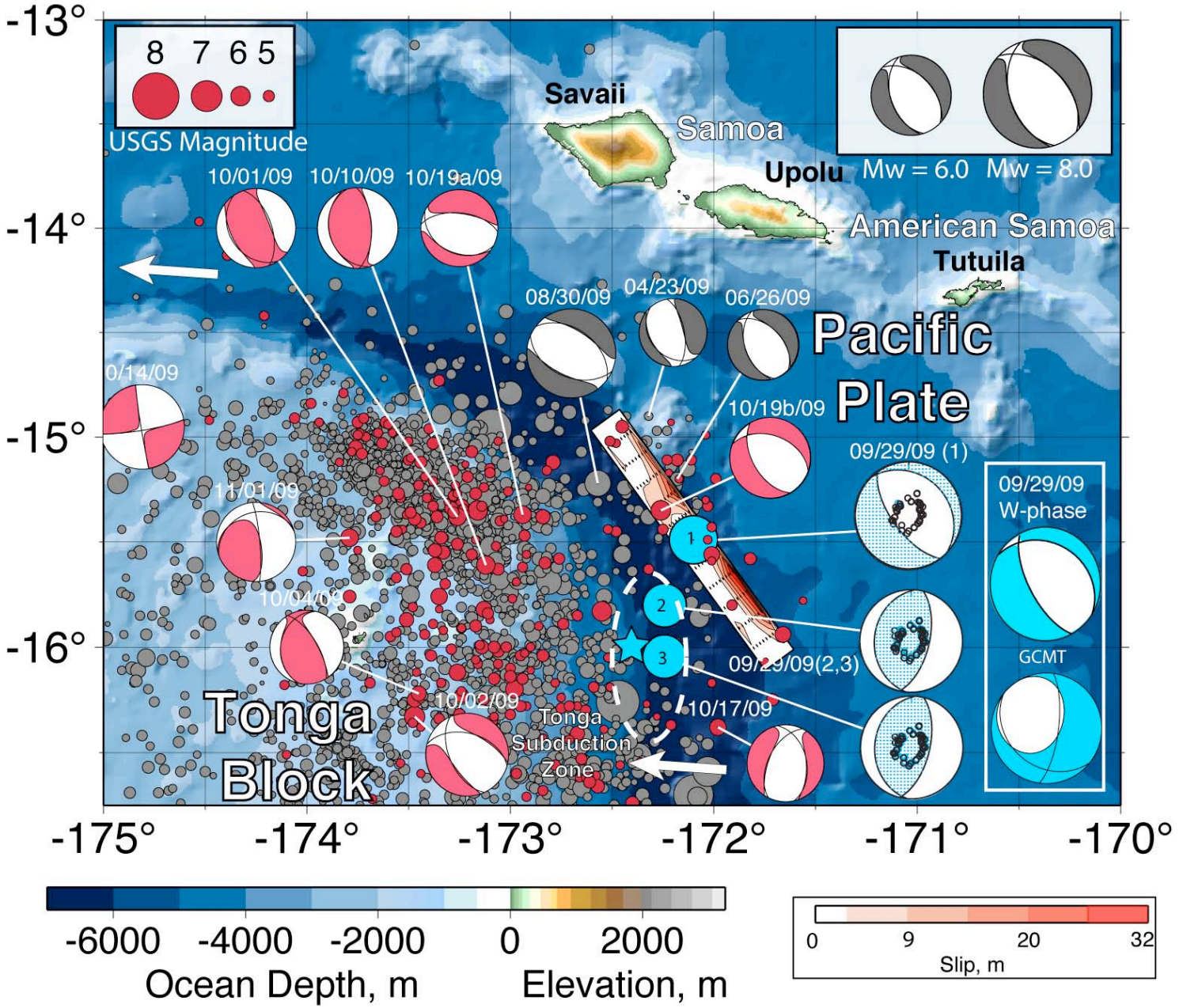


2001 Peru (M_w 8.4) – Initial 7.5 triggers rupture of 8.4 on ~Rayleigh wave arrival

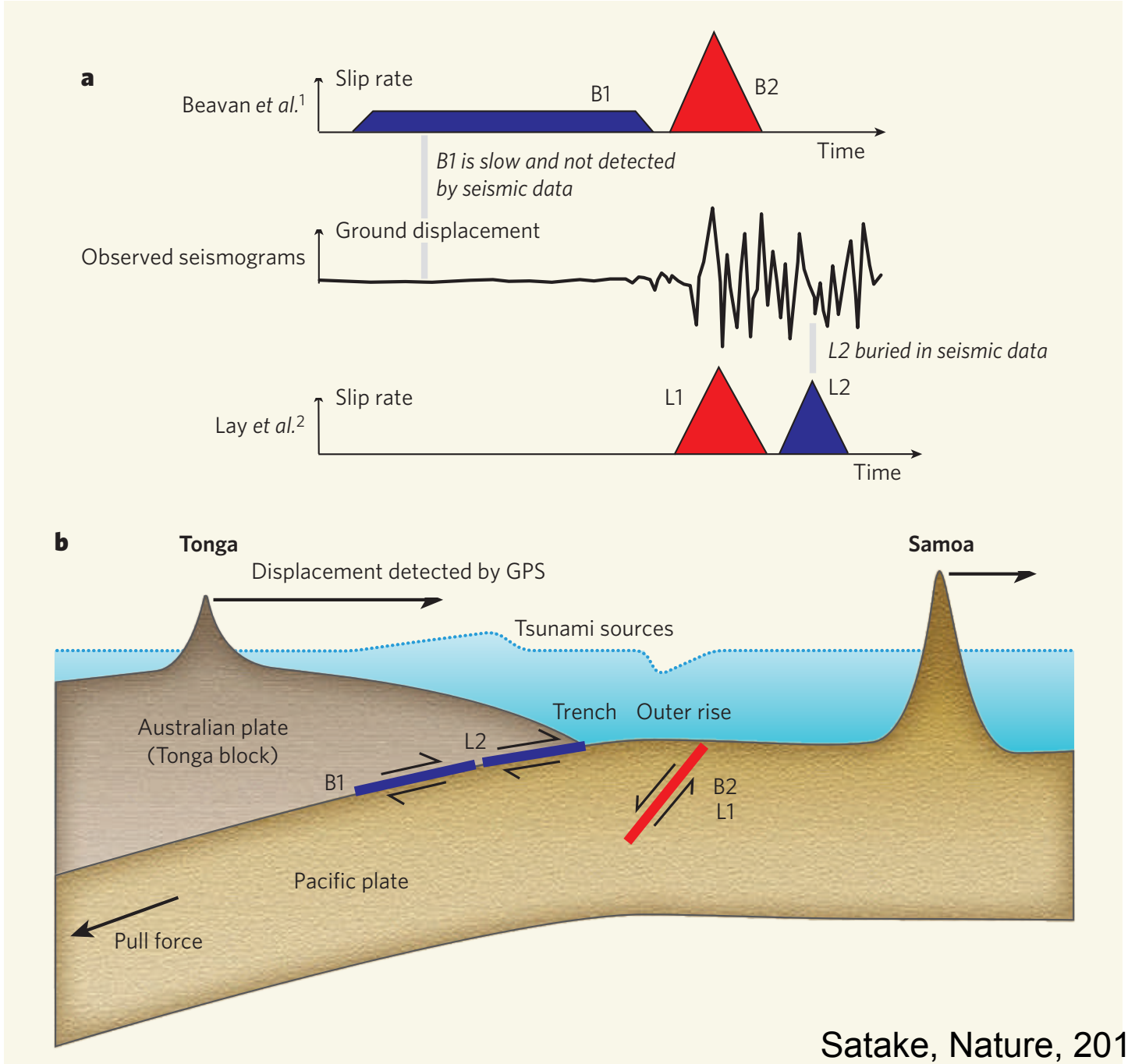
2007 Peru (M_w 8.0) – Initial 7.8 triggers rupture of 8.1 after ~60 s hiatus`

Lay, et al., BSSA, 2010

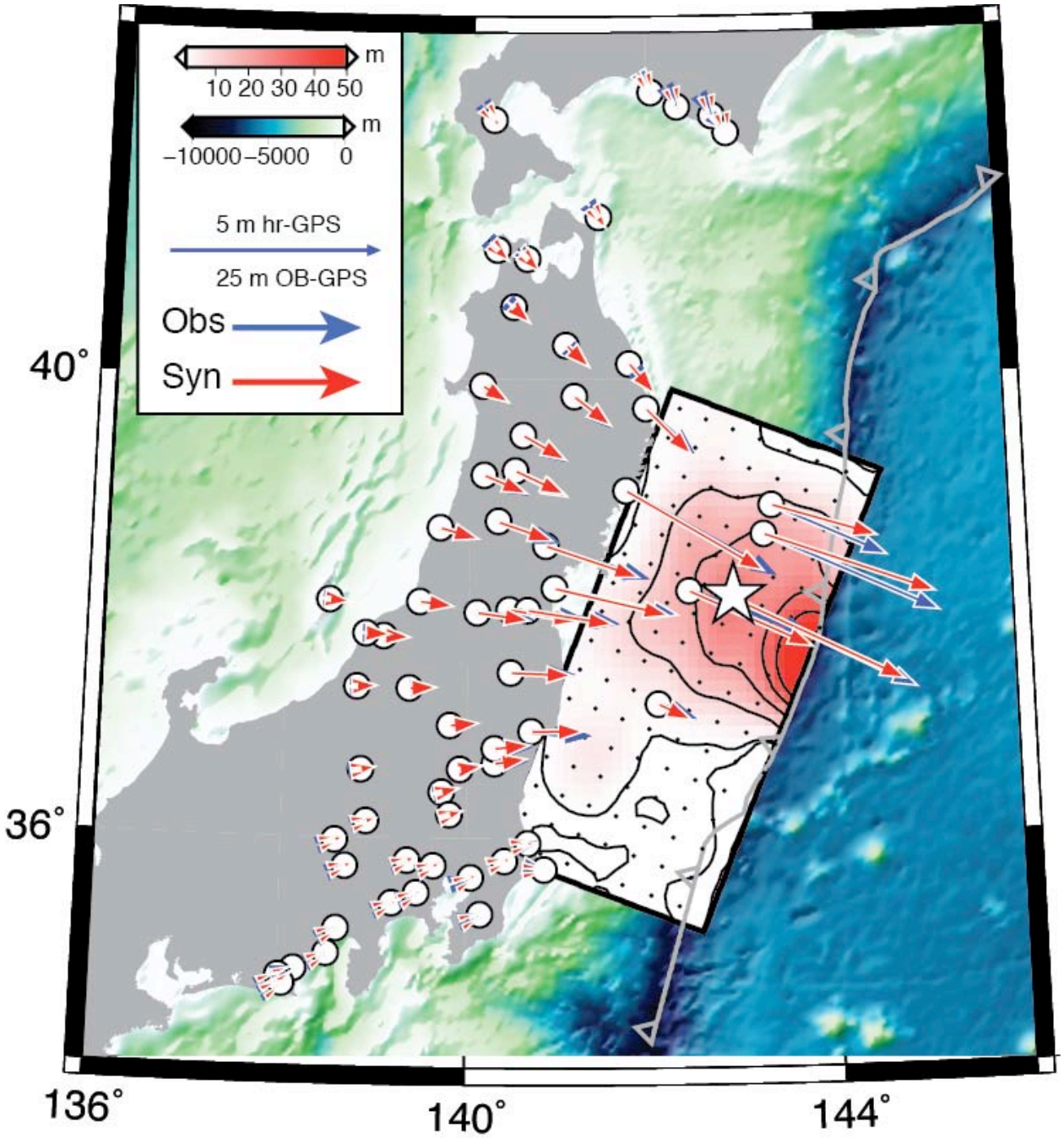
2009 Samoa-Tonga Triggered Doublet (M_w 8.0, 8.0)



Lay et al., Nature (2010)



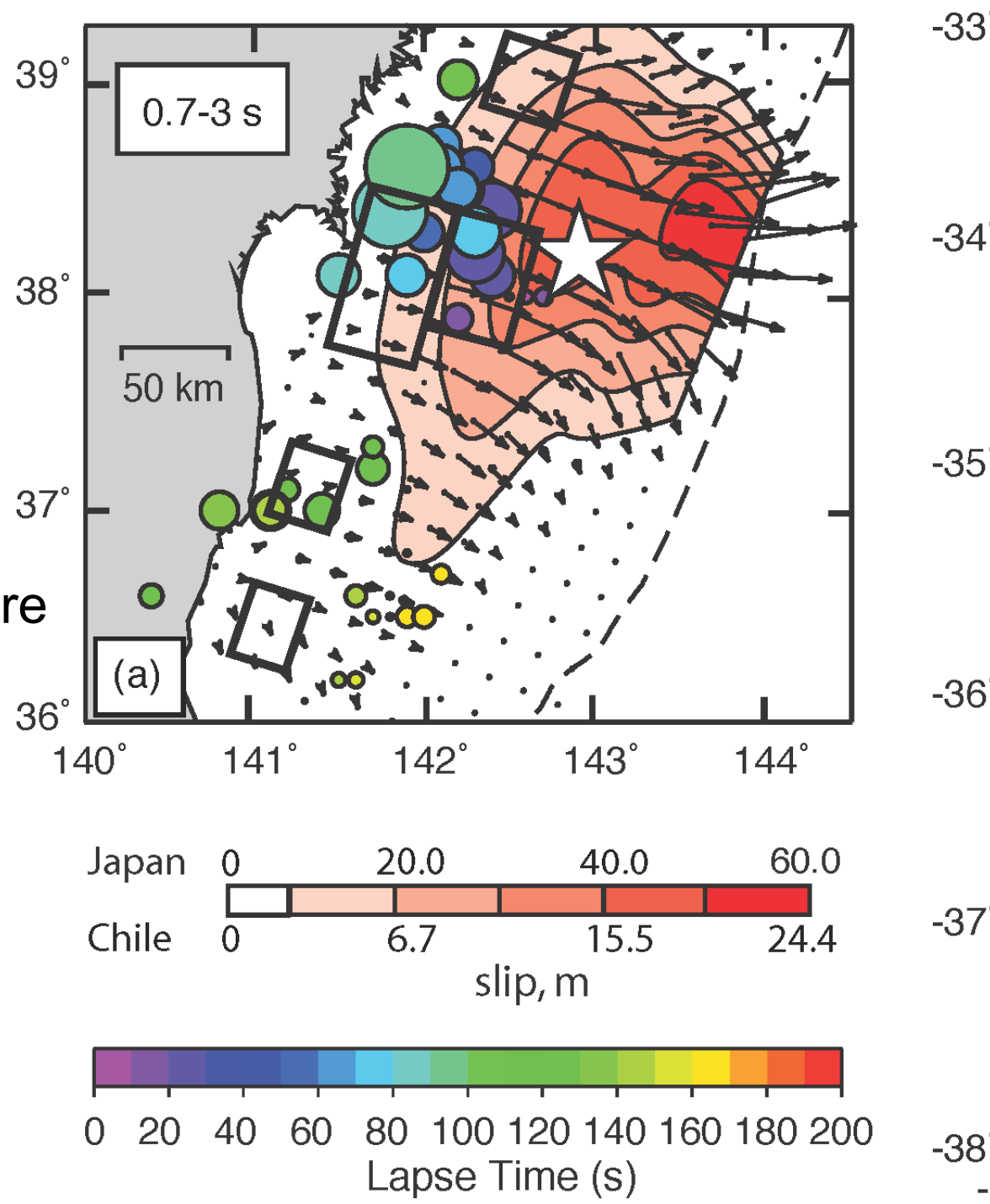
Satake, Nature, 2010



[Yue and Lay, 2013]

The tsunami hazard is produced by the large slip out near the trench. The shaking hazard from the low slip area down-dip on the fault near the coast.

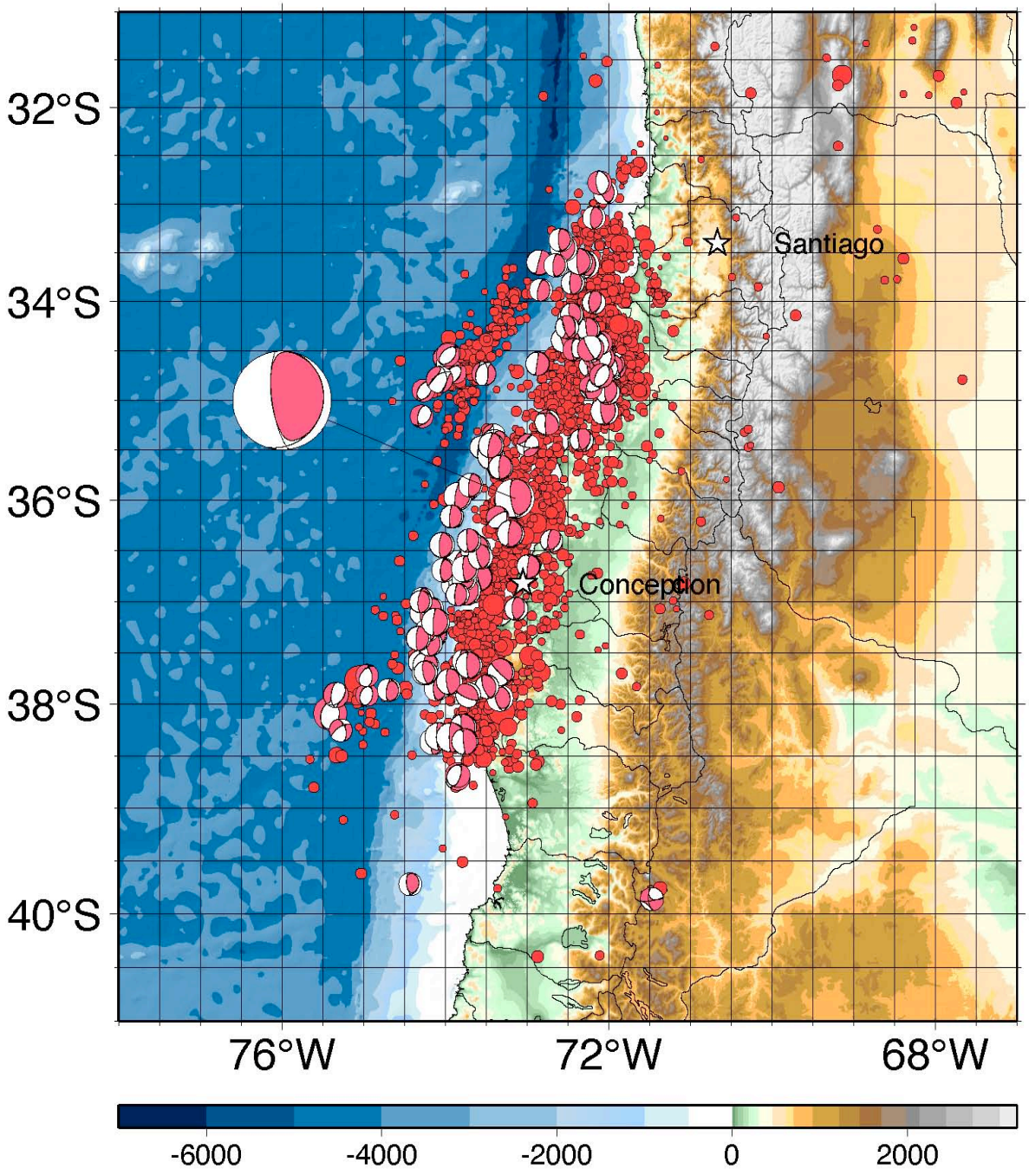
The boxes are regions where strong motions were generated.



Lay et al., JGR, 2012

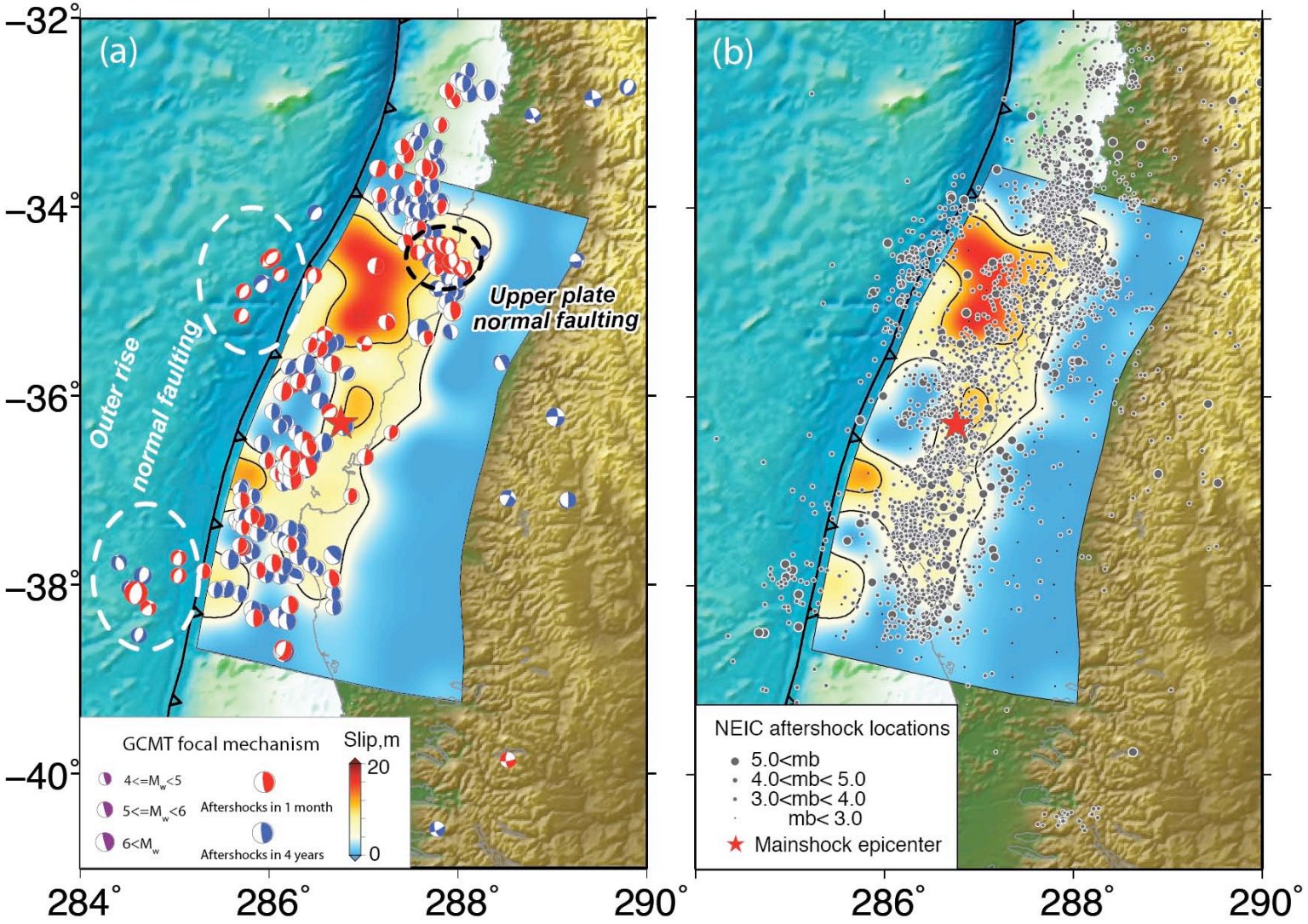
Feb. 27, 2010 Chile
M_w 8.8

Filling the 1835 seismic gap?
But it went well beyond that…



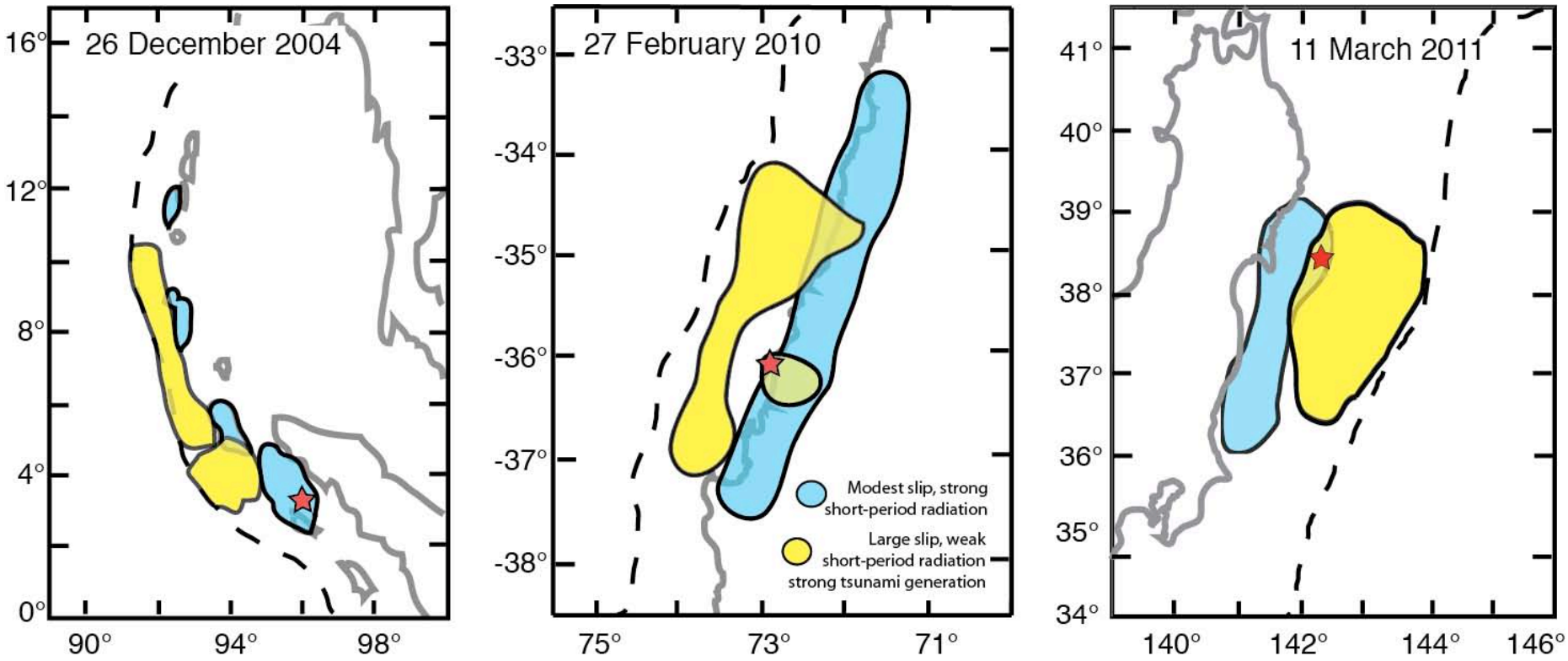
Updated From: Lay et al., GRL, 2010

Complementary pattern with the aftershock distribution

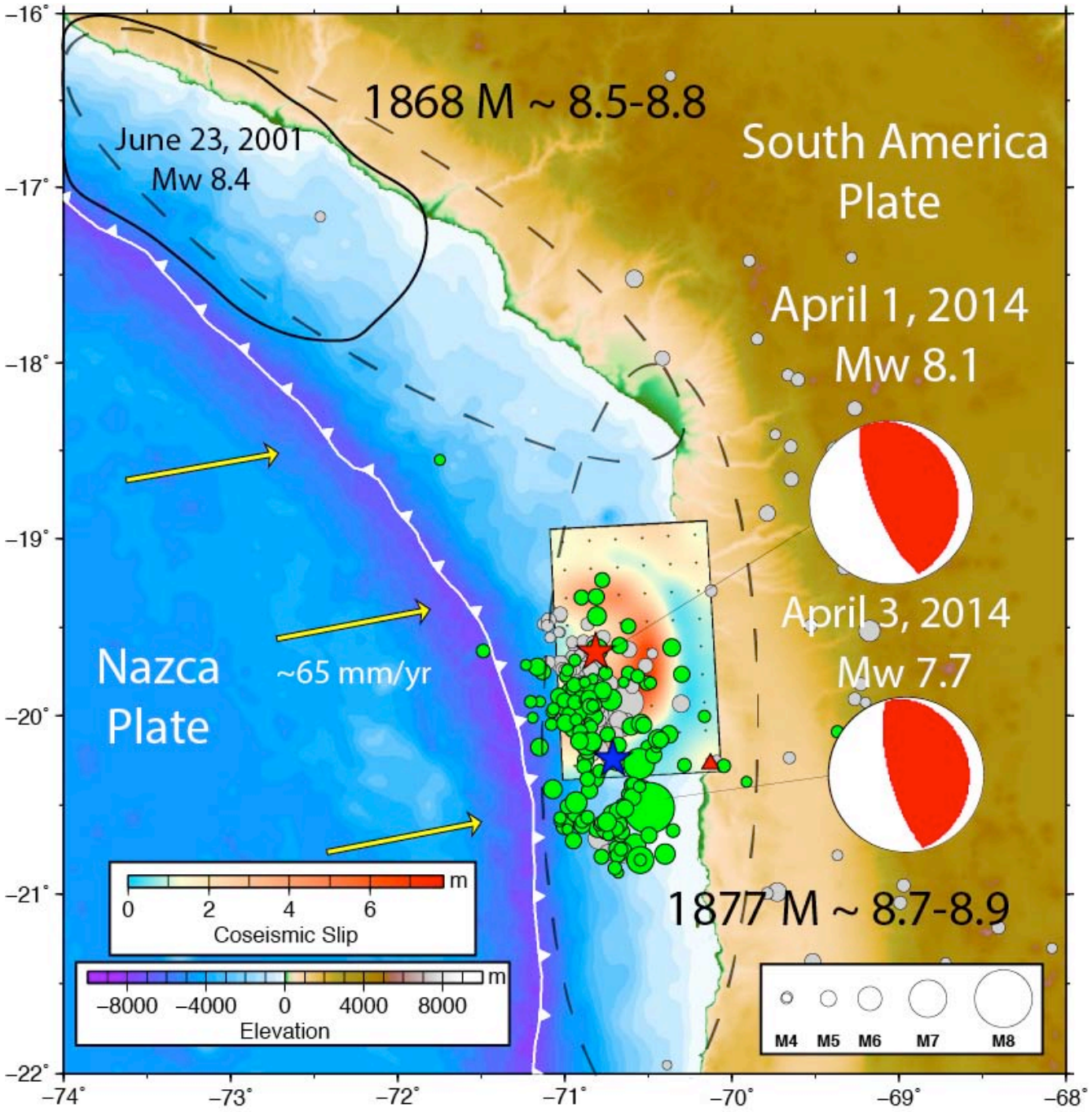


[Yue et al. 2014b]

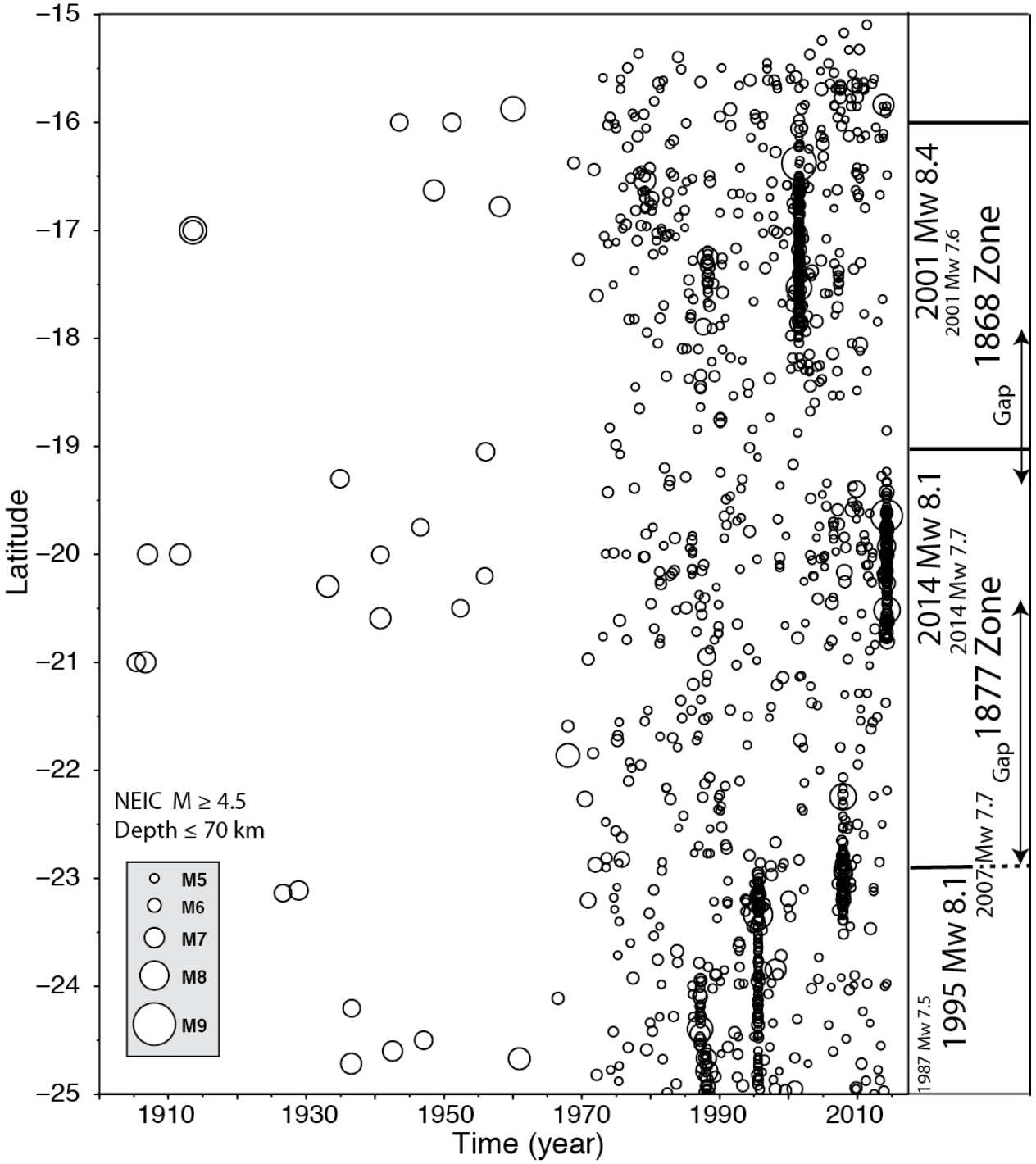
Summary: Recent great ruptures share similar depth-varying frequency-dependence. It has been recognized that upper 15 km depth range had ‘tsunami’ earthquakes, with very low short-period radiation, but central portion of megathrust also has little coherent short-period radiation.



Lay et al., JGR, 2012

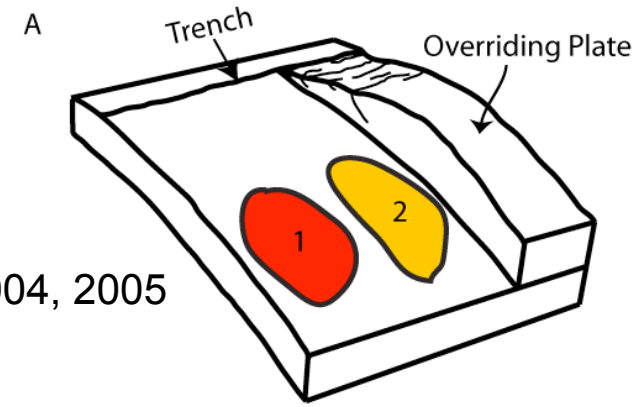


[Lay et al., 2014]

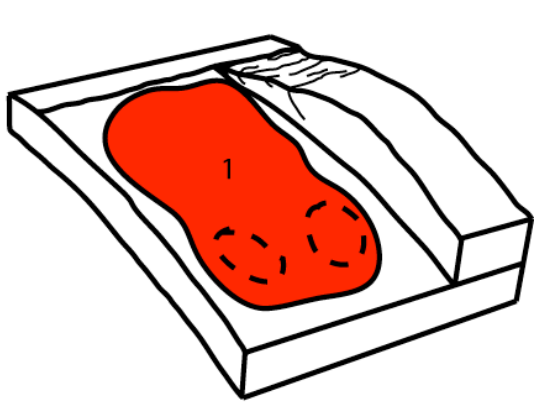


[Lay et al., 2014]

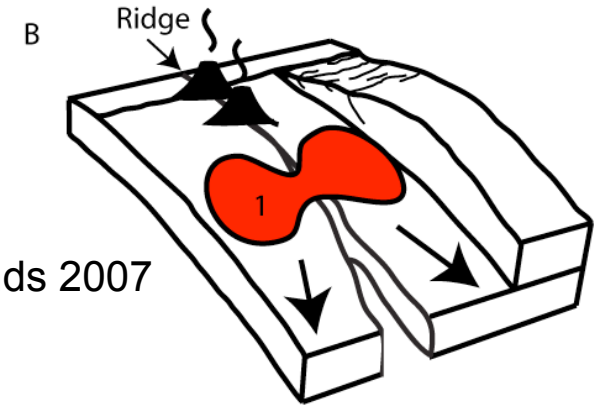
Great Earthquake Scenarios



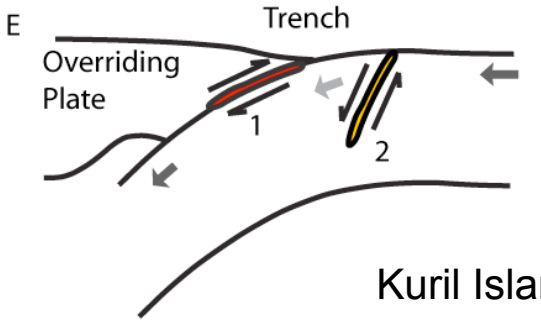
Sumatra 2004, 2005
2007



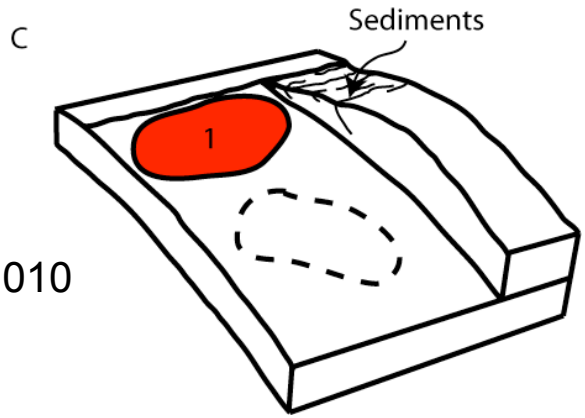
Tohoku 2011
Chile 2010



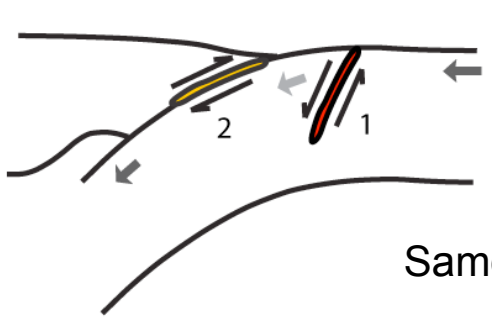
Solomon Islands 2007



Kuril Islands 2006, 2007



Mentawai 2010



Samoa 2009a,b

[Lay, 2014]

Implications for Cascadia

Rupture of full seismogenic zone length and width
- – Tohoku 2011, Chile 2010 (Need offshore geodesy to determine slip deficit)

Partial rupture of ‘seismic gap’, up-dip tsunami earthquakes
- – Chile 2014, Mentawai 2010 (Enhanced tsunami hazard)

Cascading rupture growth
- – Peru 2001, 2007 (Challenge for rapid warning)

High frequency radiation from deeper region
- – Tohoku 2011, Chile 2010 (Enhanced shaking hazard)

Triggering of interplate faulting - Outer rise normal faulting
- – Tohoku 2011, Kuril 2006/2007, Chile 2010, Samoa 2009 (Cascadia lithosphere too young?)

Rupture of bathymetric segment ‘boundaries’
- – Solomon 2007 (Don’t count on segmentation)