Seismicity of the Shoreline and Hosgri Faults, Estero Bay, and Irish Hills

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Questions:

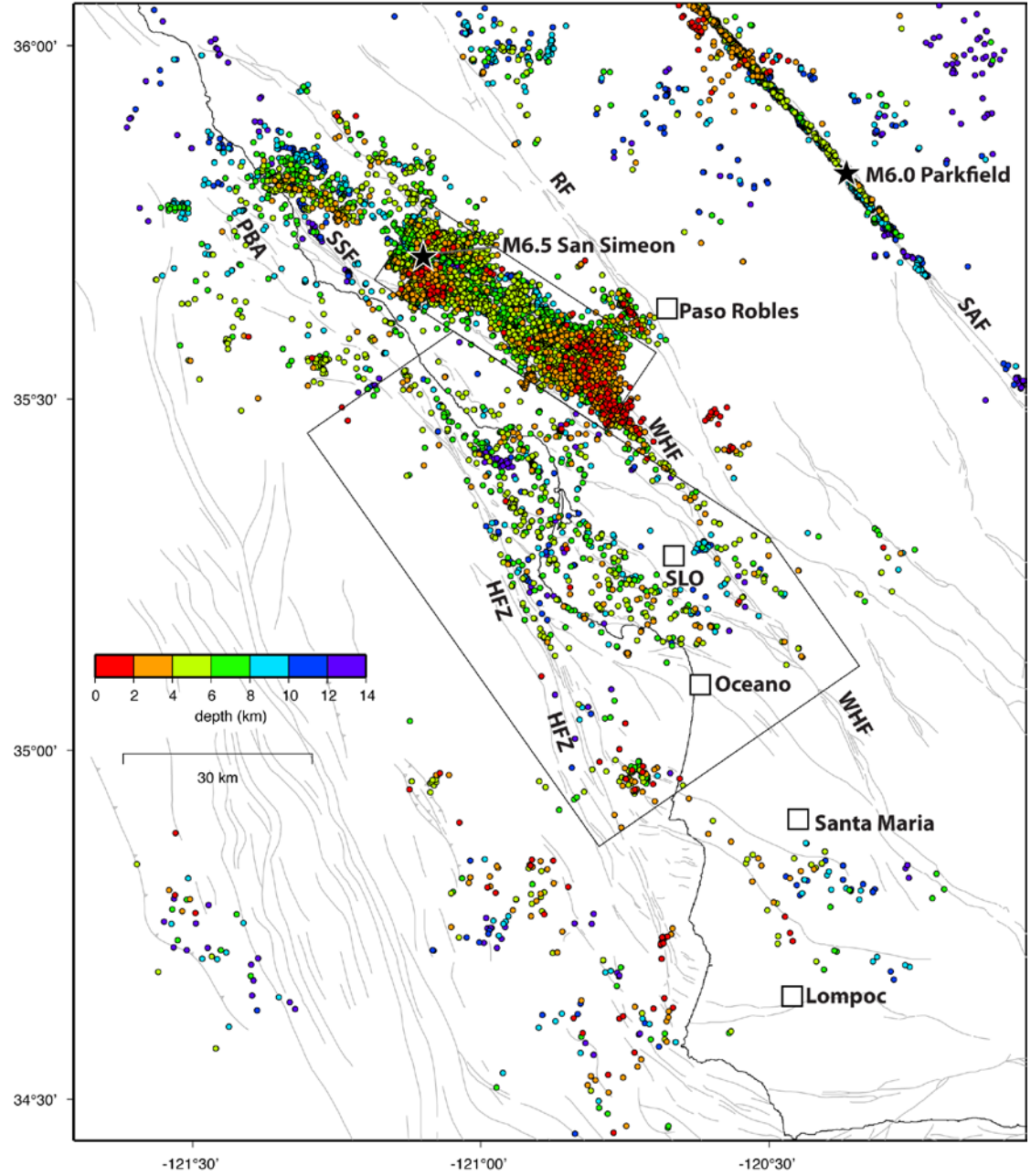
Seismicity of the Hosgri and Shoreline faults and adjacent areas

a. The location, slip sense, and dip of the Hosgri fault zone, with specific attention to the fault adjacent to DCPP;

b. The seismicity lineaments in Estero Bay;

c. Does the distribution of seismicity provide insights on faulting beneath the Irish Hills; and

d. Does the distribution of seismicity provide insights on the kinematic relation between the Hosgri and Shoreline faults.



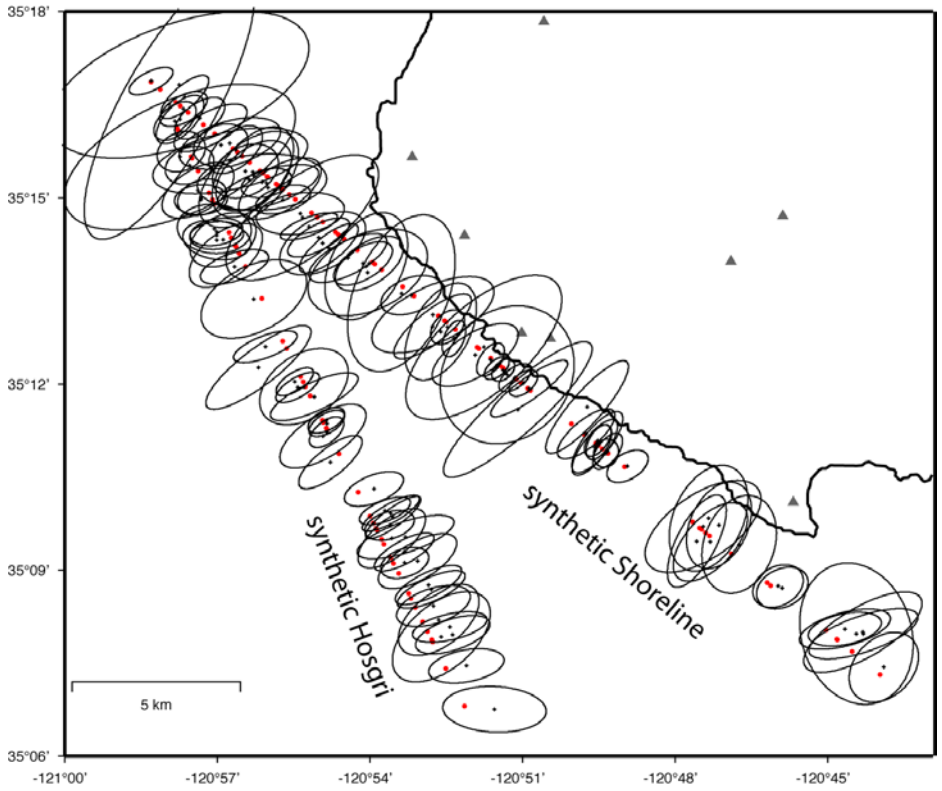
15,925 relocated earthquakes

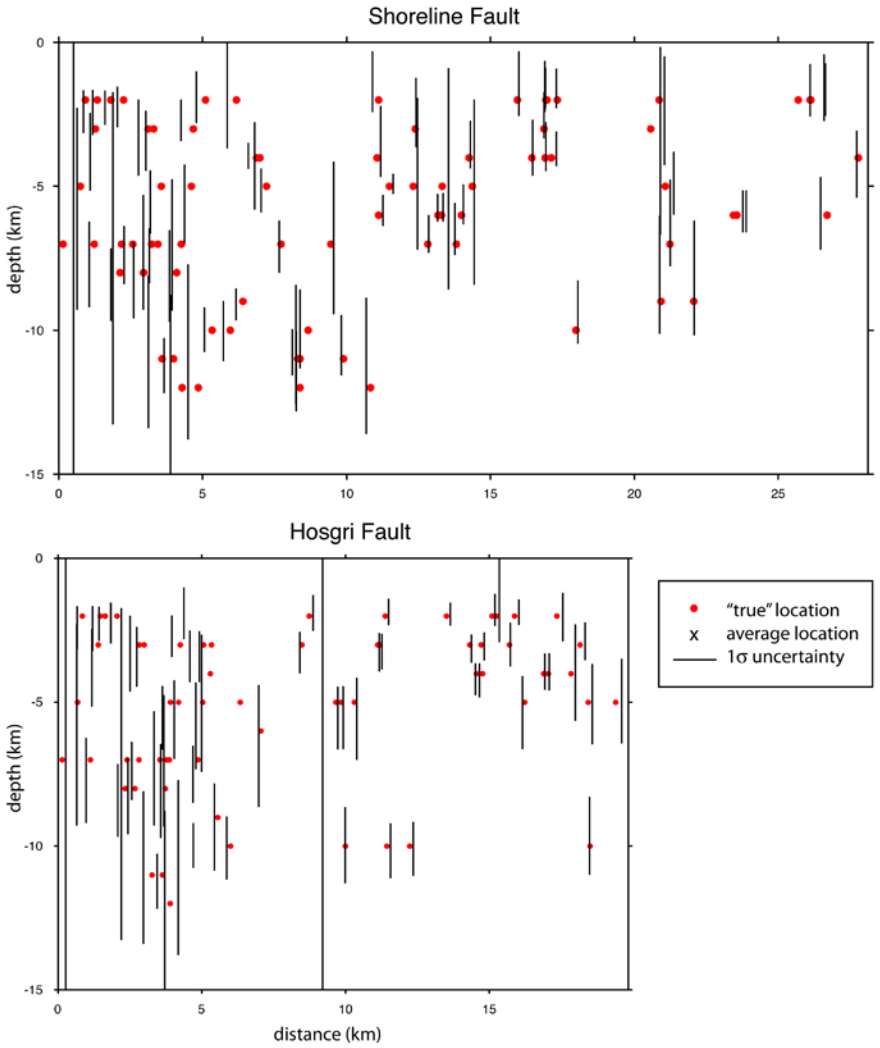
1987-2008

Hardebeck, J. L., *Bull. Seism. Soc. Am.*, 100, 1031-1050, 2010.

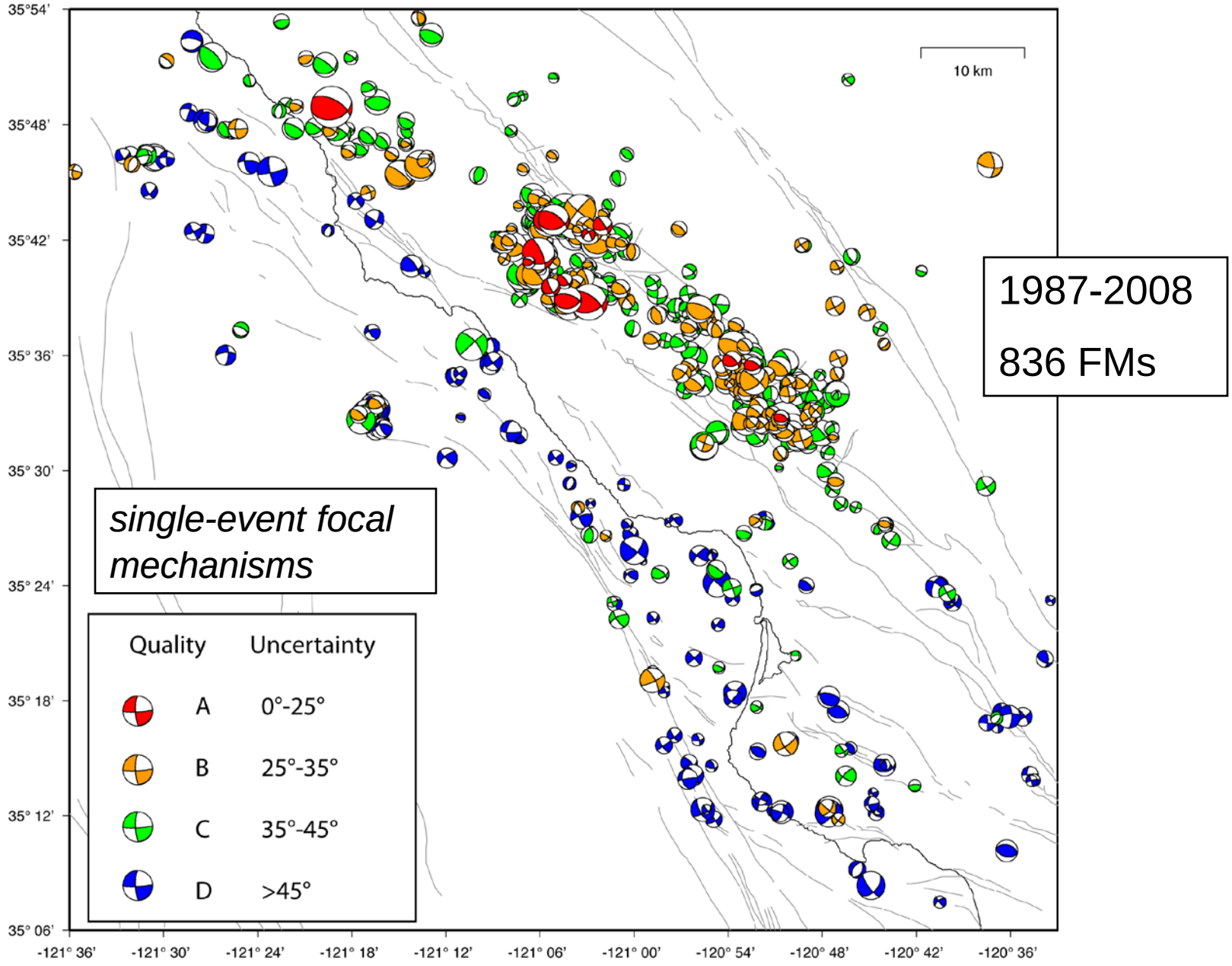
Locations available at: http://www.seismosoc.org/publications/BSSA_html/bssa_100-3/2009307-esupp/index.html

Estimate of location uncertainty using synthetic catalogs.





Hardebeck, BSSA, in press (Feb 2013)



Mechanisms from: Hardebeck, J. L., *Bull. Seism. Soc. Am.*, 100, 1031-1050, 2010.

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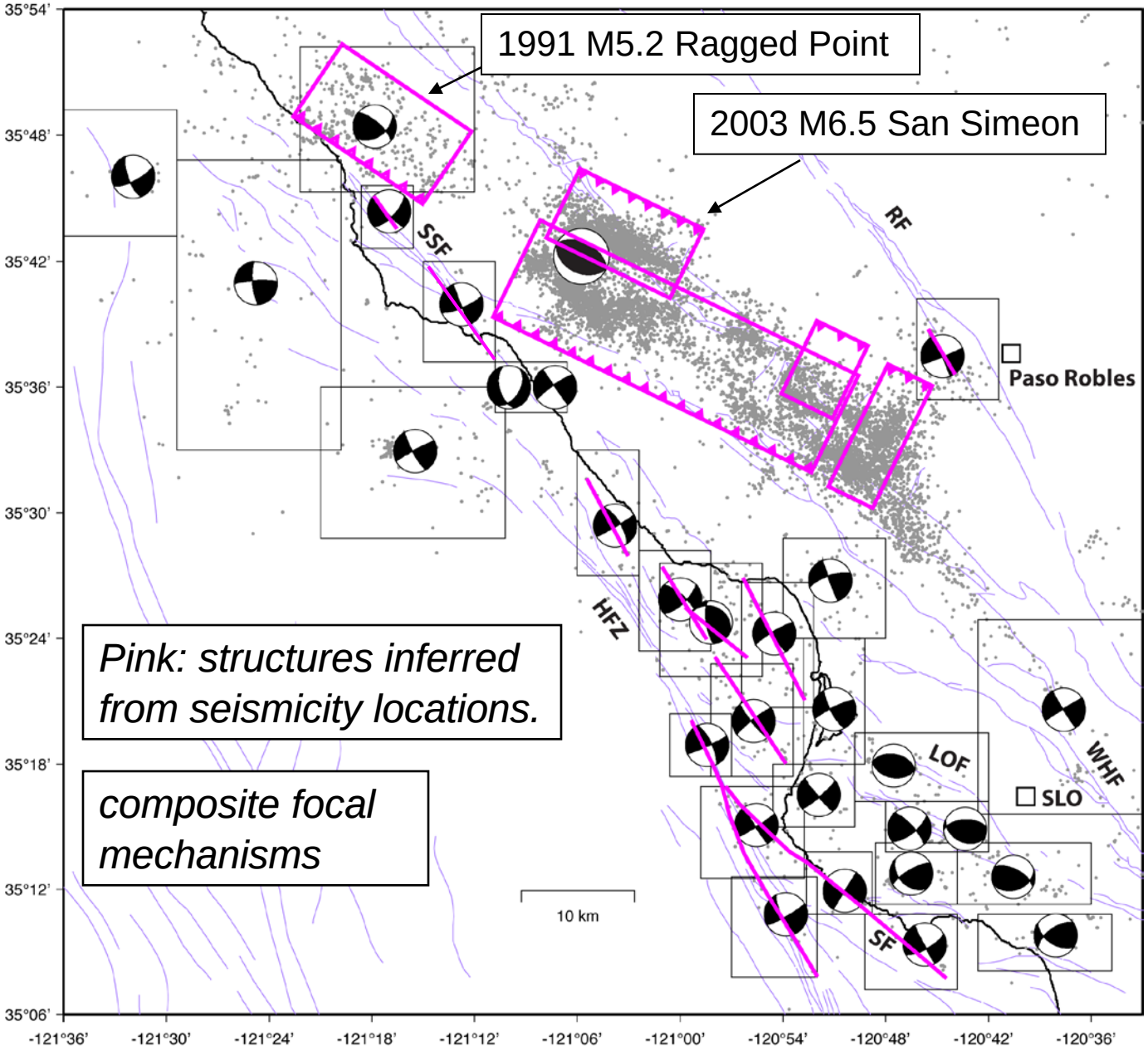

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Large degree of uncertainty in earthquake locations and mechanisms.

Common philosophy in geophysics: *find the least complicated model that fits the data to within its uncertainty*.

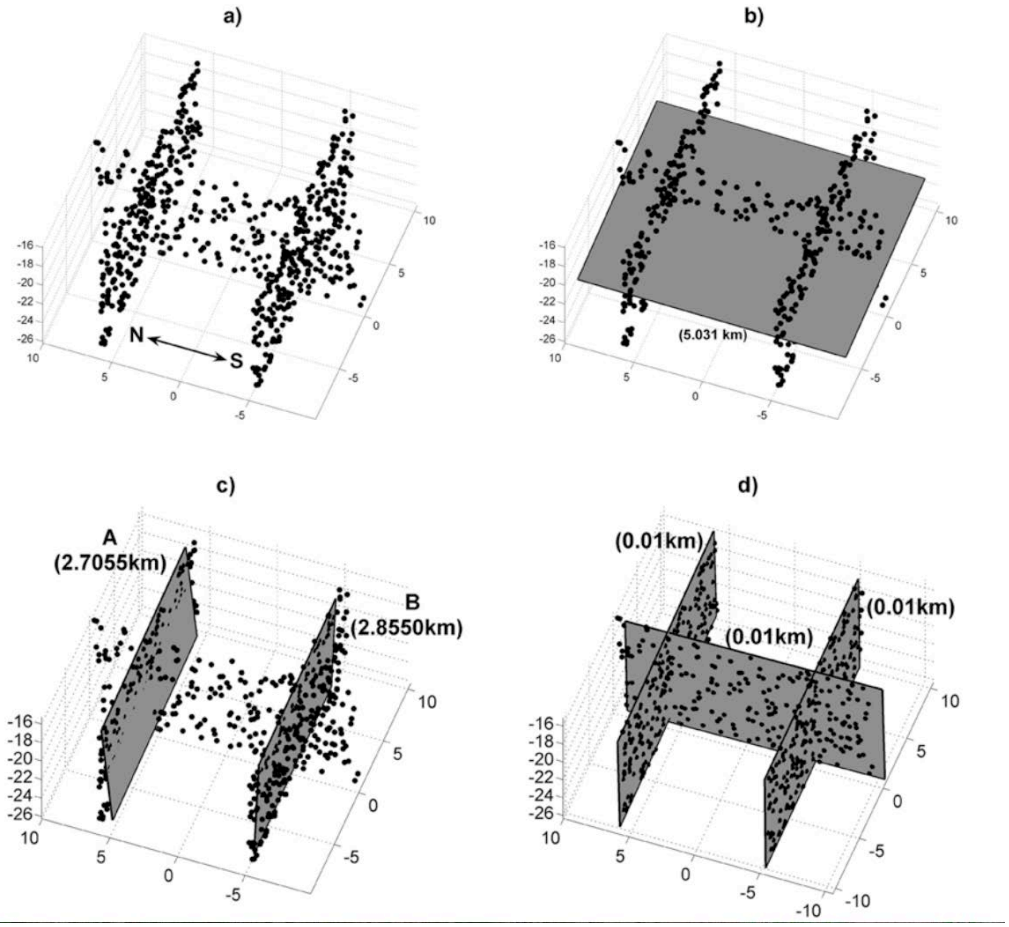
- There may be additional complexity in the real world, but you **can not** constrain that complexity because it is within the noise.

- There may be additional apparent complexity in the observations, but you **can not** interpret it as real complexity, this results in interpreting noise.

Another common philosophy in geophysics*: be quantitative and objective*.

- Often seismicity is interpreted by looking at plot and drawing lines based on what you see. This is qualitative and subjective. Objective, quantitative alternatives exist.

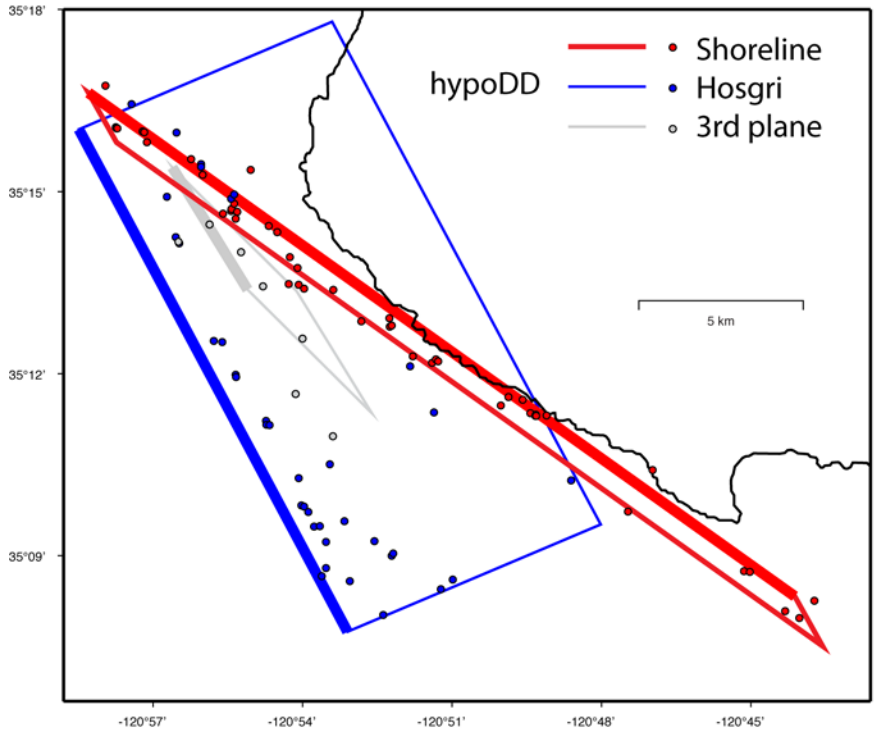
Optimal Anisotropic Dynamic Clustering (OADC)
[Ouillon et al., JGR 2008].

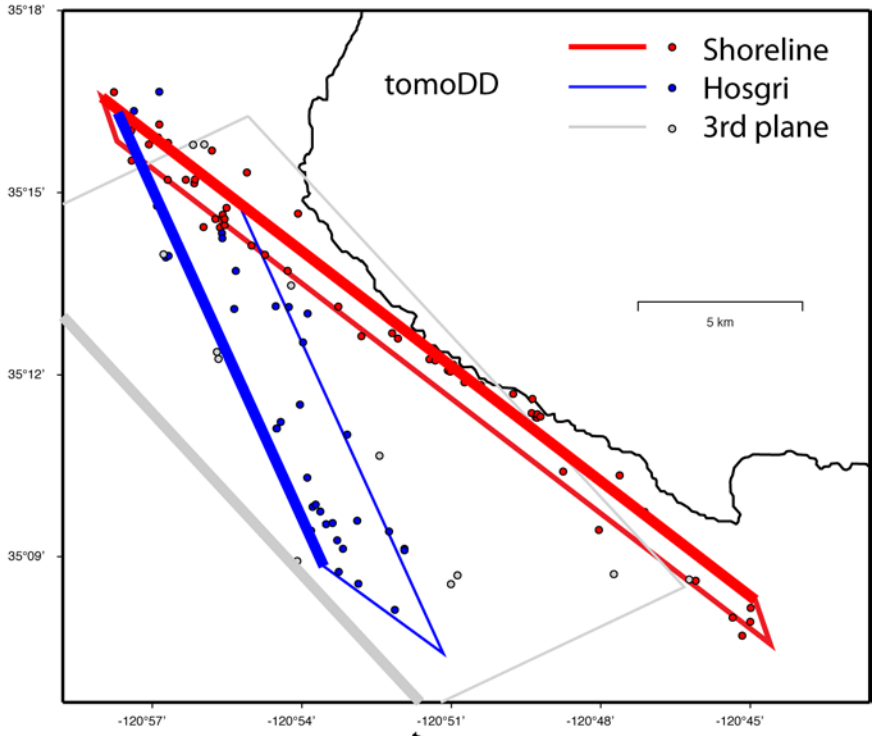


Finds the simplest planar fault geometry that fits the seismicity to within the location uncertainty.

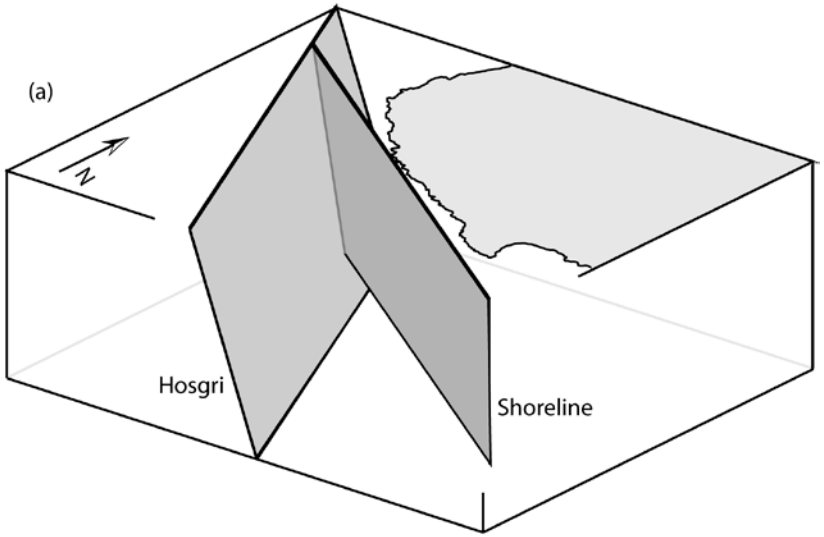
Objective algorithm, with no tunable parameters.

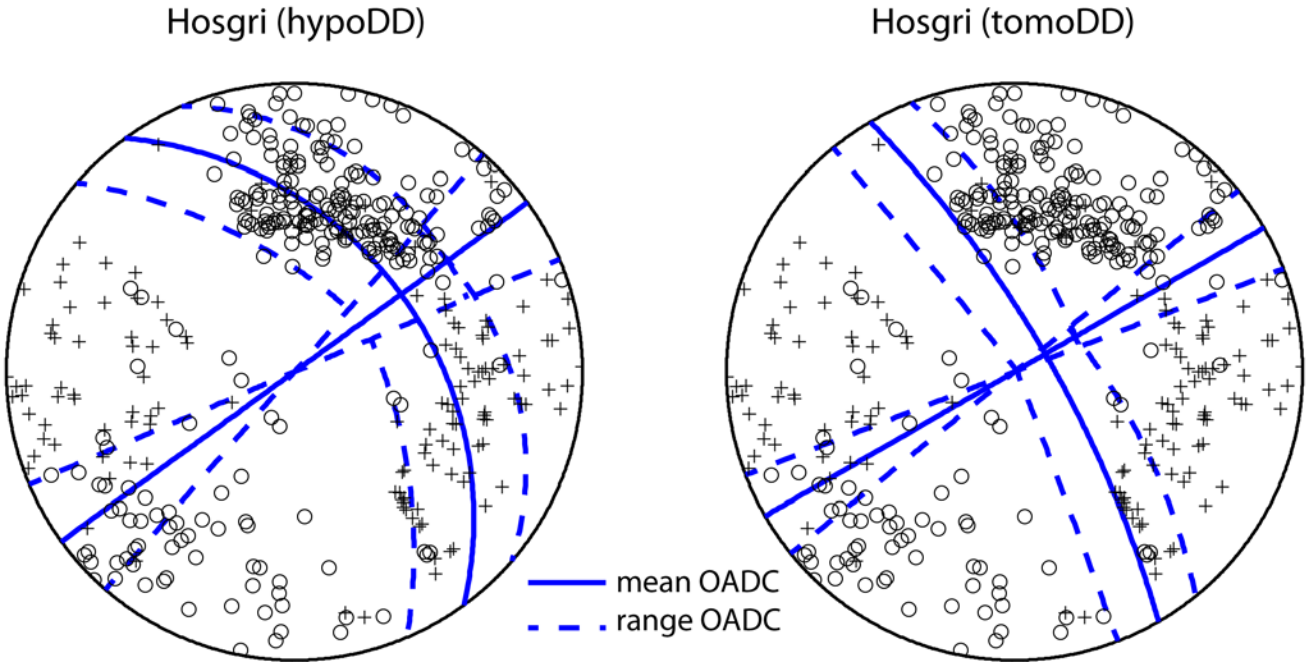
Sensitivity to starting planes, modified to run repeatedly to find a range of models, defines fault plane uncertainty.





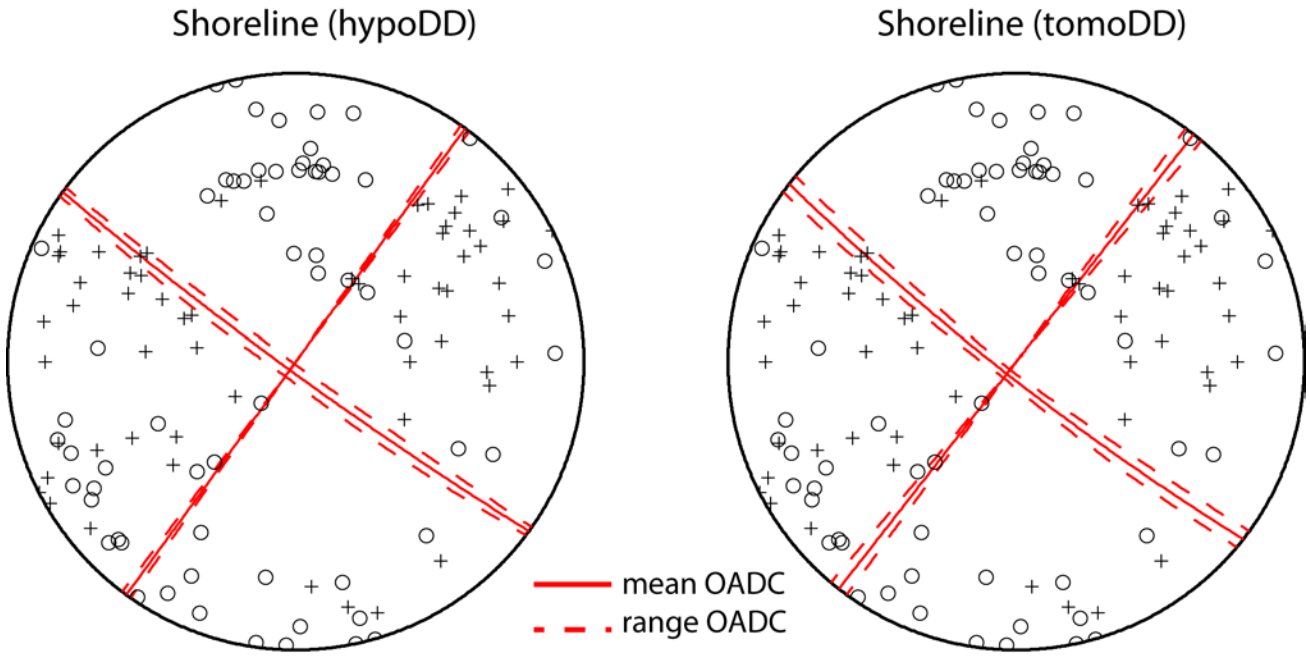
OADC applied to Hosgri & Shoreline faults near DCPP, for two different double-difference relocated catalogs.





Incompatible with composite first-motion polarities.

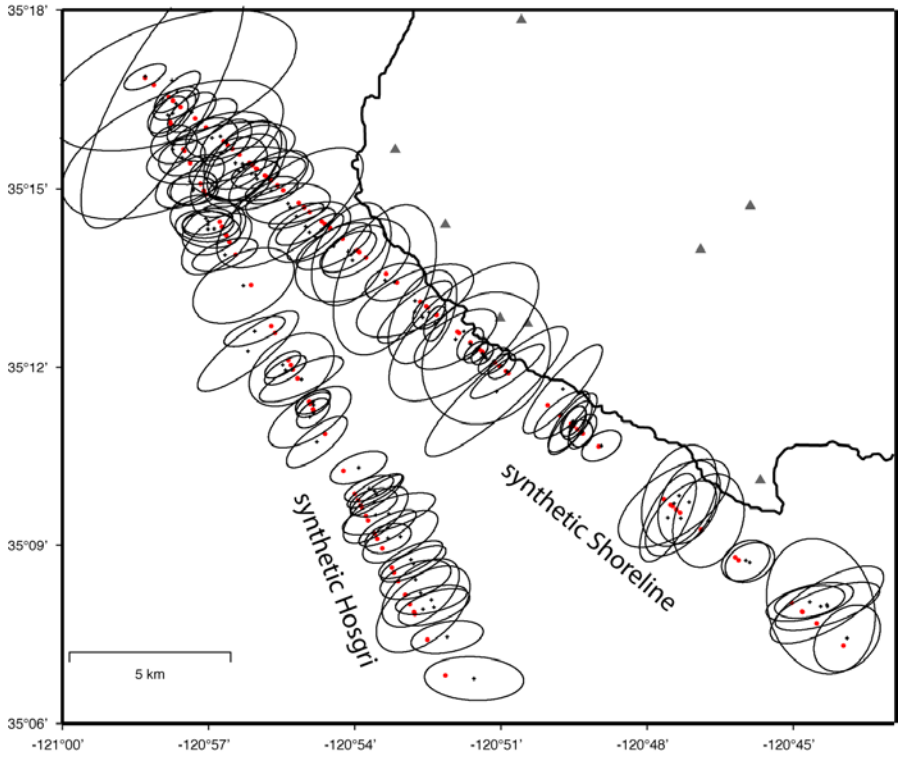
Compatible for mean and steeper dips.
Dip=76° -89° NE.
Rake (from FM fit)=180° ±24° .

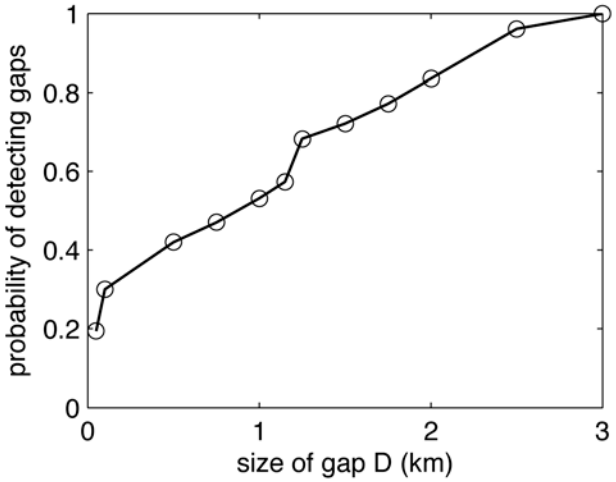


Stable plane orientation, compatible with composite first-motions.
Dip=82°-89°SW.
Rake (from FM fit)=178°±25°.

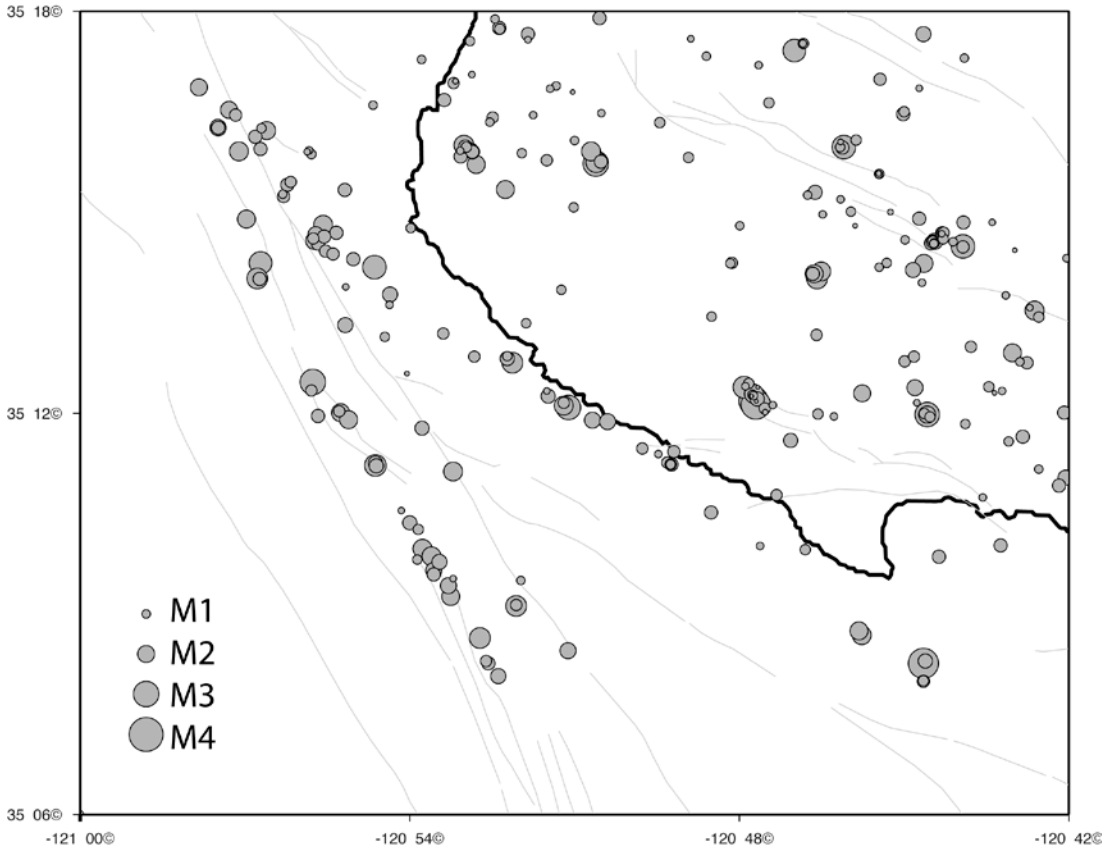
OADC result for Shoreline Fault is a single 25-km-long plane.

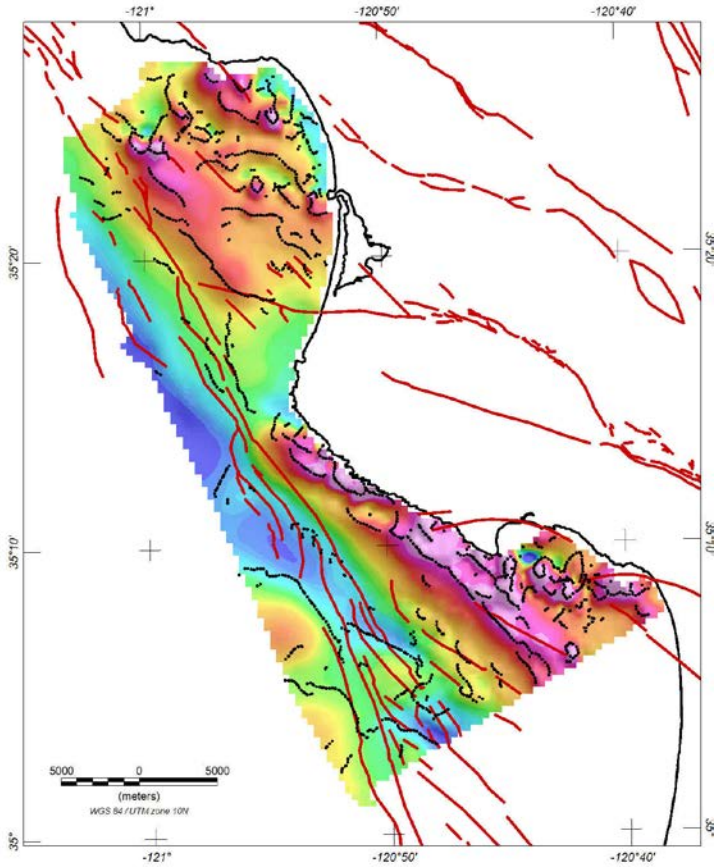
How likely is the OADC procedure to find offsets, given the large location uncertainty? Tests on synthetic datasets imply that substantial offsets (>1 km) are likely to be identified if they exist. Therefore, unlikely to be substantial offsets of Shoreline Fault.





Shoreline Fault extends south of San Luis Bay fault. The largest Shoreline Fault earthquake (M3.5) occurred south of this junction. The magnetic anomaly associated with the Shoreline Fault also continues south of this junction.

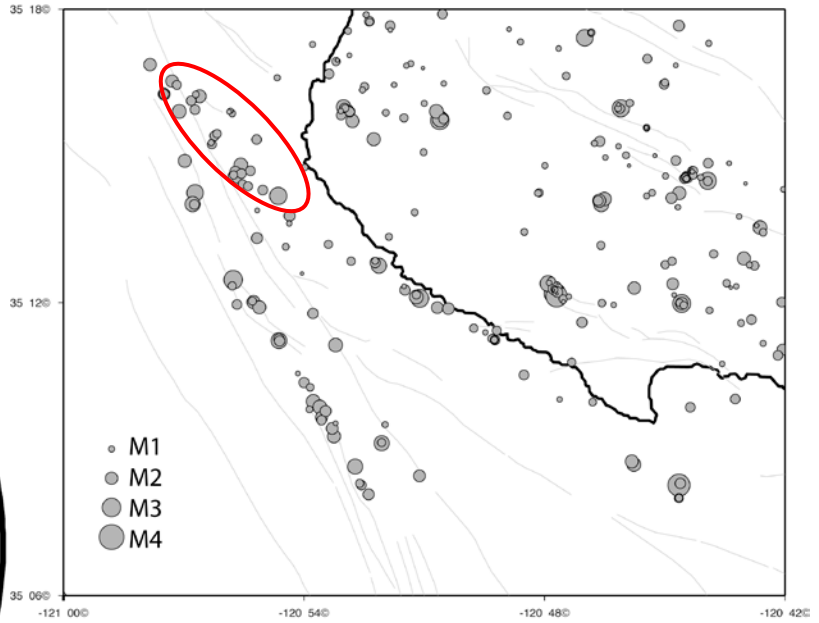


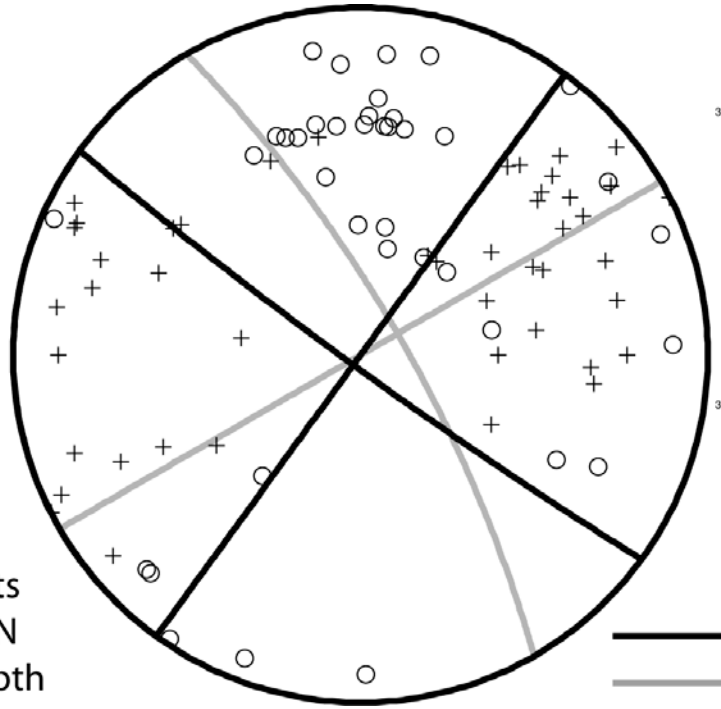


From Janet Watt.

Composite focal mechanism shows that the northernmost Shoreline Fault events are aligned with the Shoreline Fault, not the Hosgri Fault.

Implies that the Shoreline Fault does extend to the Hosgri at seismogenic depths.





Shoreline events north of 35.23°N above 8 km depth

Shoreline OADC plane (180° rake)

Hosgri OADC plane (180° rake)

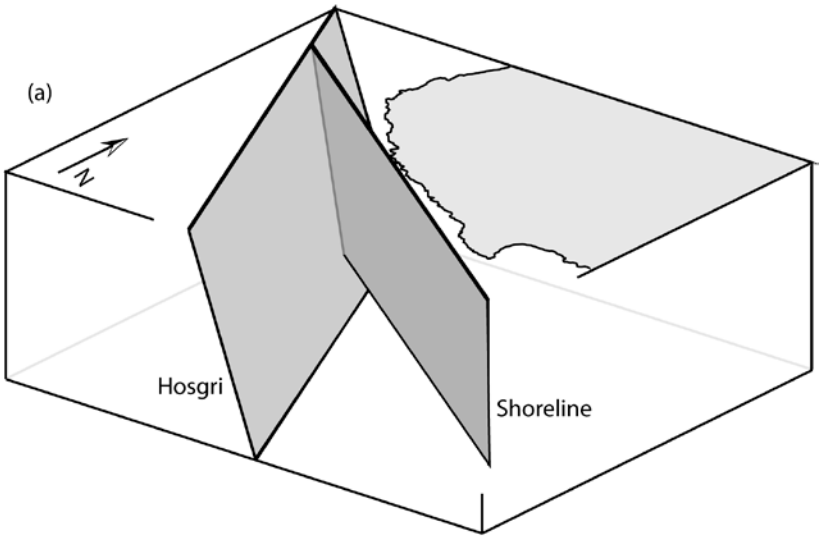
Given the apparent connection - and definite close proximity - of the Shoreline and Hosgri faults, it does not seem prudent to rule out a joint rupture.

o No reason a north-going earthquake on the Shoreline Fault couldn't make the slight (~30˚) bend and continue onto the Hosgri Fault.

o No reason an earthquake couldn't nucleate at the junction and propagate bilaterally onto both faults.

o Modeling (Kame, 2003) suggests branching from Hosgri to Shoreline is unfavorable. However, this is a simplified model:

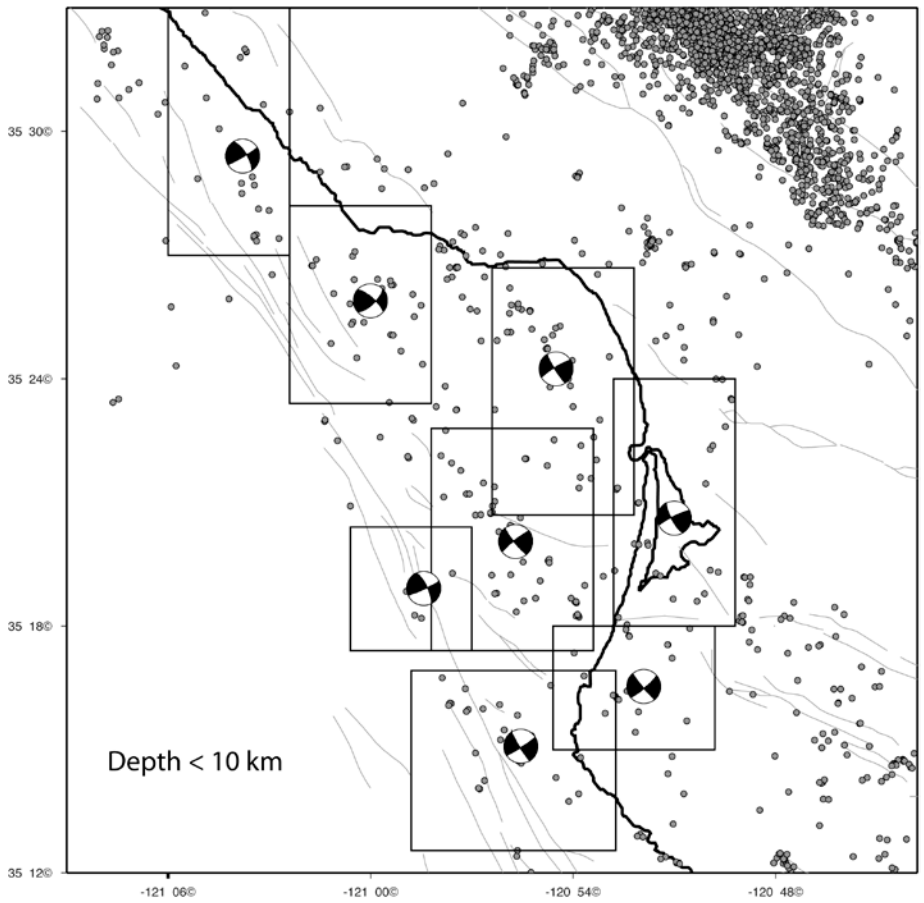
- 2D, as opposed to real 3D fault structure.
- Simple slip-weaking fault friction.
- Constant stress and fault strength everywhere.
- No local effects on stress/strength from previous earthquakes.

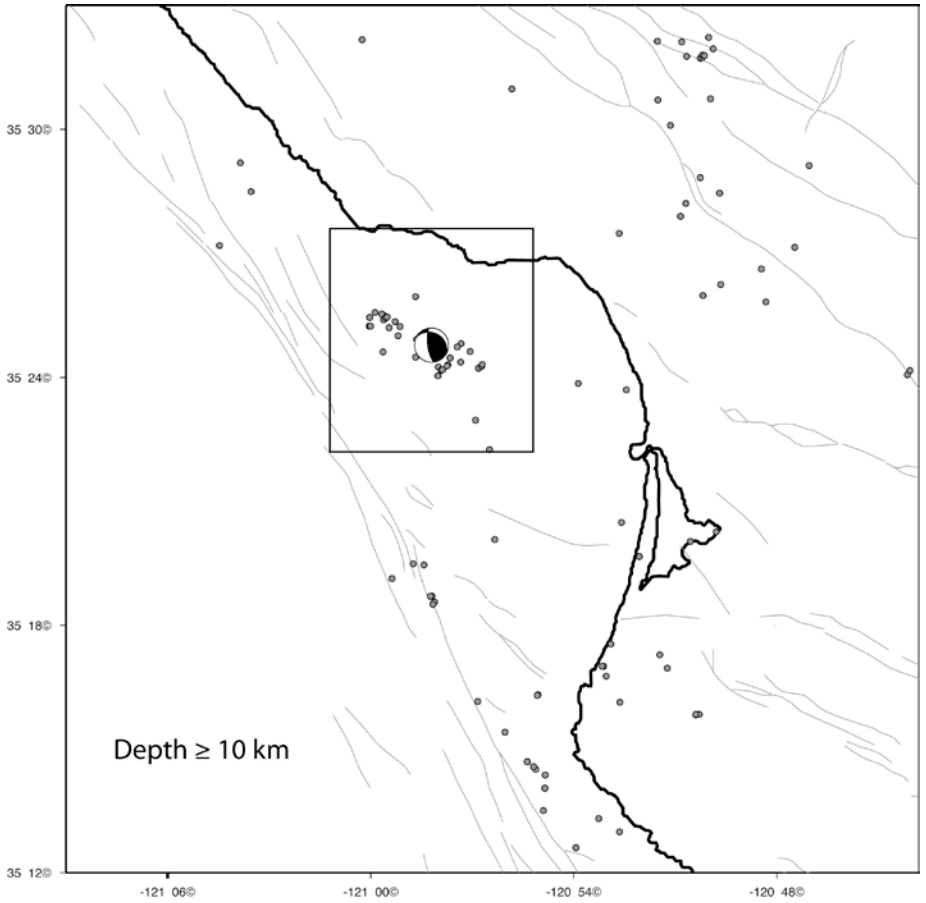


Hypothetical Maximum Magnitude Event on Shoreline Fault:

- Shoreline defined by seismicity:
  - L = 25 km
  - W = 11 km
  - Mmax = 6.7 (stress drop 3 MPa)
- Shoreline extended to coast:
  - L = 35 km
  - W = 11 km
  - Mmax = 6.8 (stress drop 3 MPa)
- Shoreline + Hosgri (from Shoreline/Hosgri intersection to WGCEP UCERF2 fault termination near Big Sur):
  - L = 130 km
  - Mmax = 7.2 (stress drop 3 MPa)

Estero Bay: relocations and composite mechanisms





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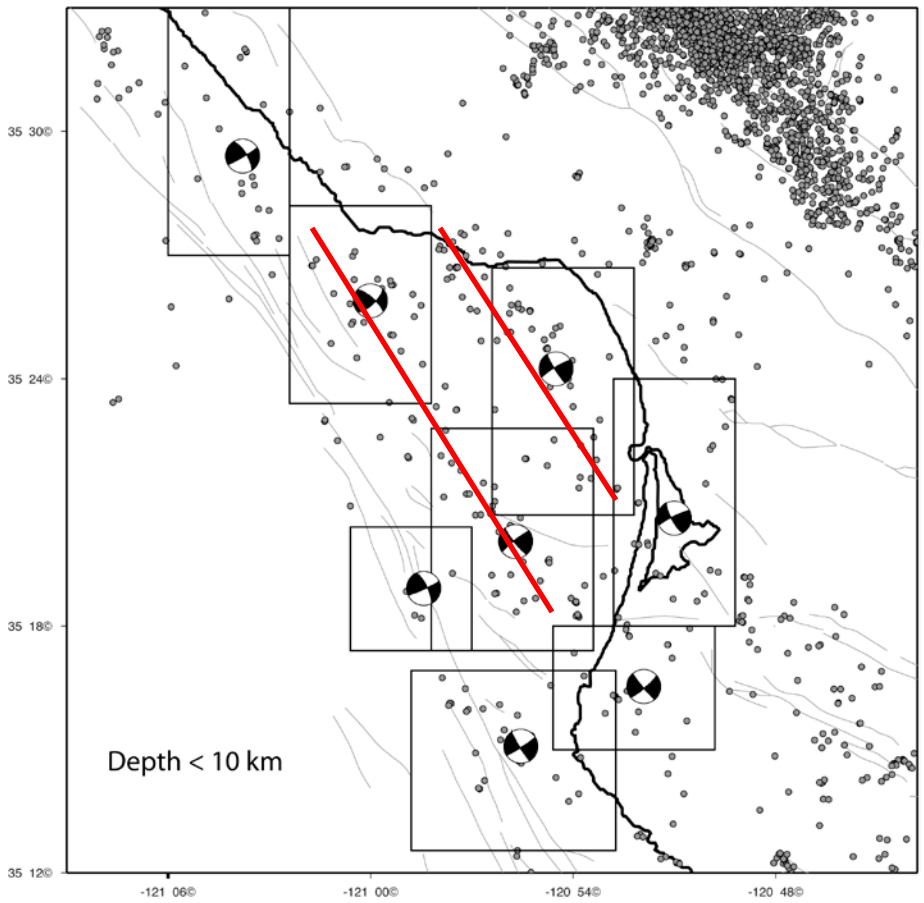
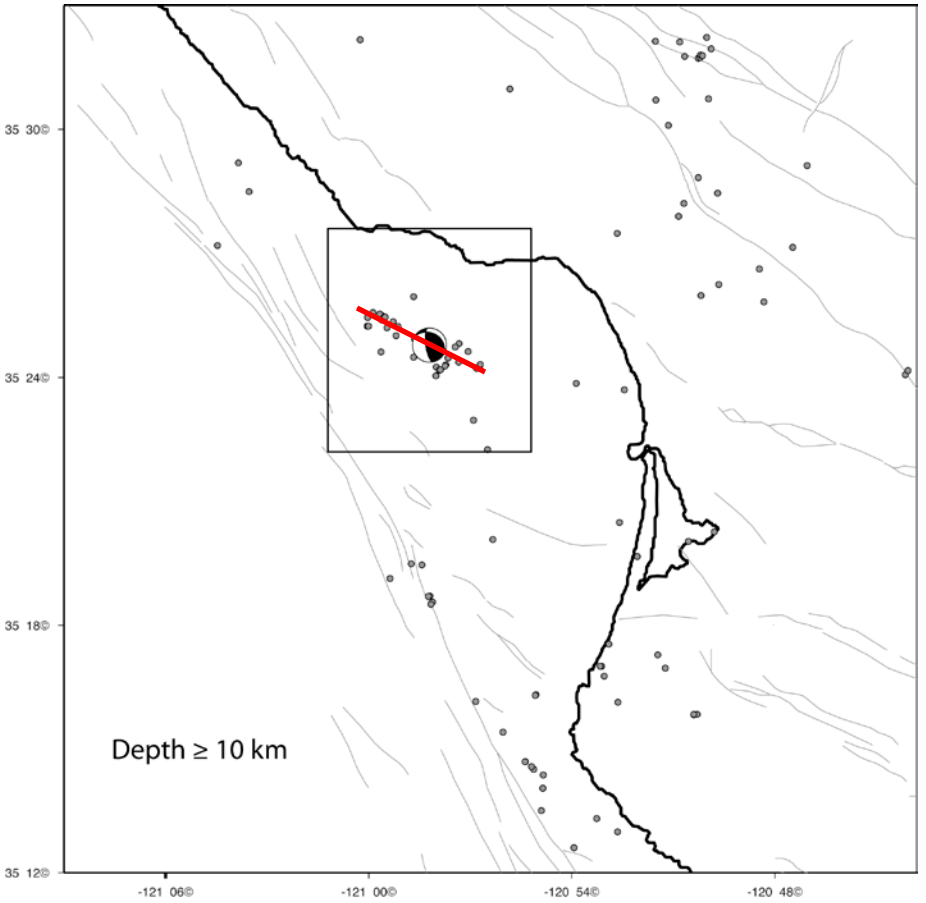
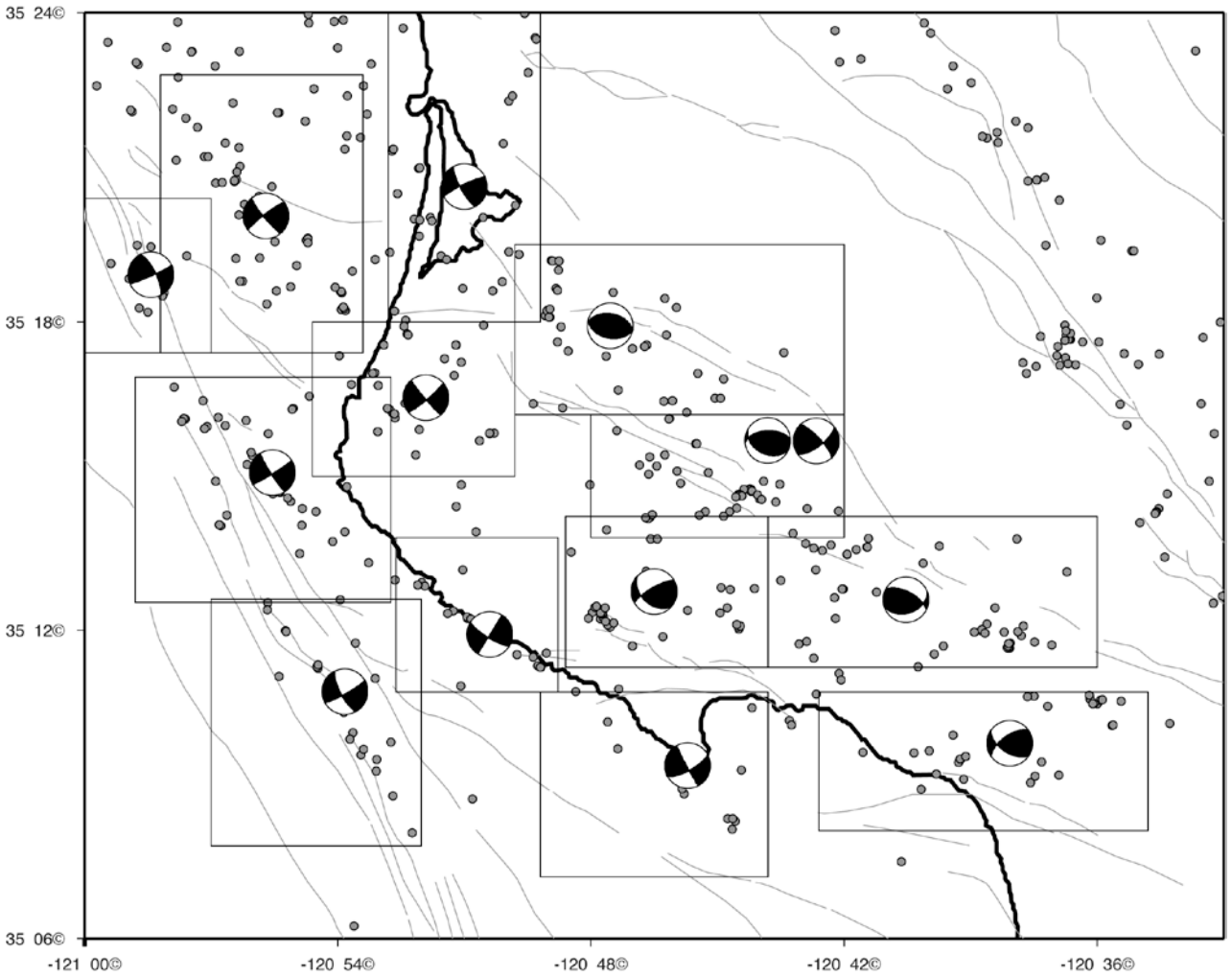




Shallow strike-slip structures parallel to Hosgri Fault?

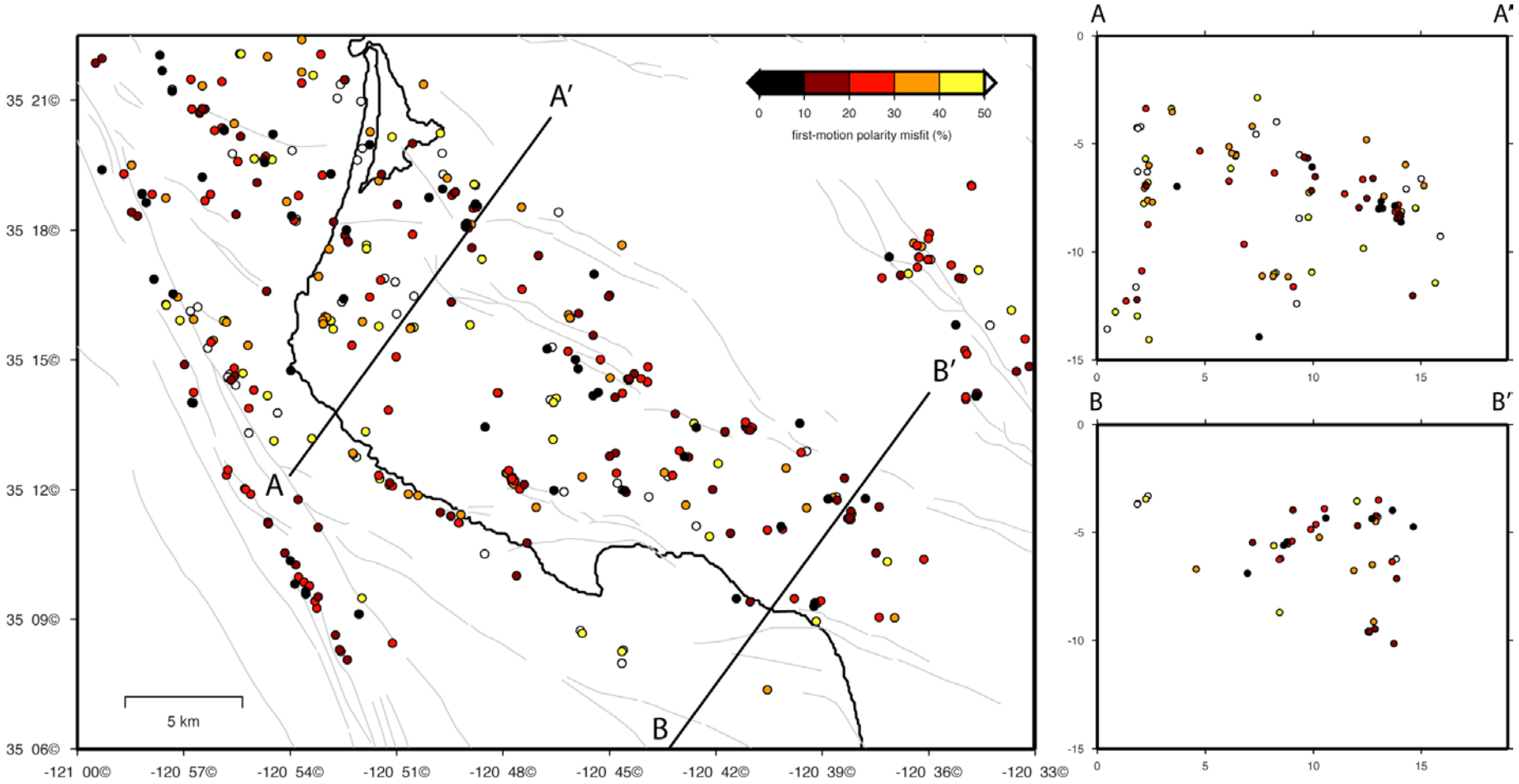
Deep oblique-reverse faulting on near-horizontal plane; top of remnant slab?

Irish Hills: relocations and composite mechanisms



Strike-slip faulting dominates around Point Buchon and Morro Bay, reverse faulting dominates along the onshore Los Osos Fault.

Irish Hills seismicity: search for reverse faults at depth.
darker color = better first-motion agreement with reverse faulting mechanism



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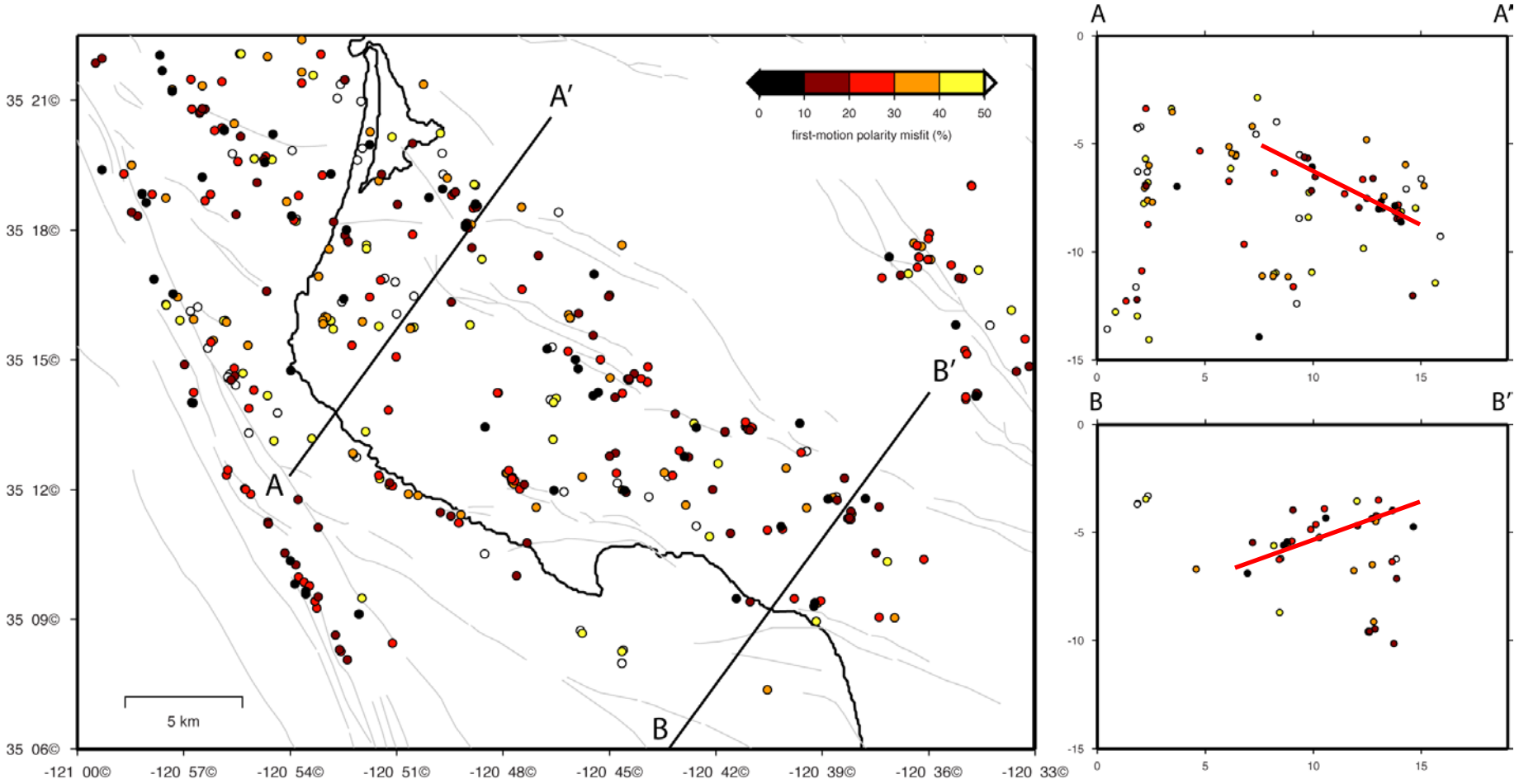

Hints of both NE-dipping and SW-dipping seismicity alignments.

Hosgri Fault

- Dip = 76° -89° NE, Rake =180° ±24° , near DCPP.

Shoreline Fault

- Dip= 82° -89° SW; Rake= 178° ±25° .
- Single plane at seismogenic depths, to within ~1 km earthquake location uncertainty.
- Northwest end at Hosgri Fault.
- Southeast end unclear, fault extends southeast of San Luis Bay fault.
- Length ≥25 km; Width≈11 km; Mmax≈6.7.
- Doesn't seem prudent to rule out a Shoreline-Hosgri joint rupture; Mmax≈7.2.

Estero Bay

- Apparent Hosgri-parallel vertical strike-slip faults.
- Deep earthquakes suggest oblique-reverse faulting at the top of remnant slab.
- Requires more quantitative, objective study.

Irish Hills

- Strike-slip faulting dominates around Point Buchon and Morro Bay, reverse faulting dominates along the onshore Los Osos Fault.
- Hints of both NE-dipping and SW-dipping seismicity alignments.
- Requires more quantitative, objective study.

References:

1) Hardebeck, J. L. (2010), Seismotectonics and Fault Structure of the California Central Coast, *Bull. Seism. Soc. Am.*, 100, 1031-1050.

Data available at: http://www.seismosoc.org/publications/BSSA_html/bssa_100-3/2009307-esupp/index.html.

2) Hardebeck, J. L., Geometry and Earthquake Potential of the Shoreline Fault, Central California, *Bull. Seism. Soc. Am.*, in press (Feb 2013.)

3) Ouillon, G., C. Ducorbier, and D. Sornette (2008), Automatic reconstruction of fault networks from seismicity catalogs: Three-dimensional optimal anisotropic dynamic clustering, *J. Geophys. Res.*, 113, B01306.