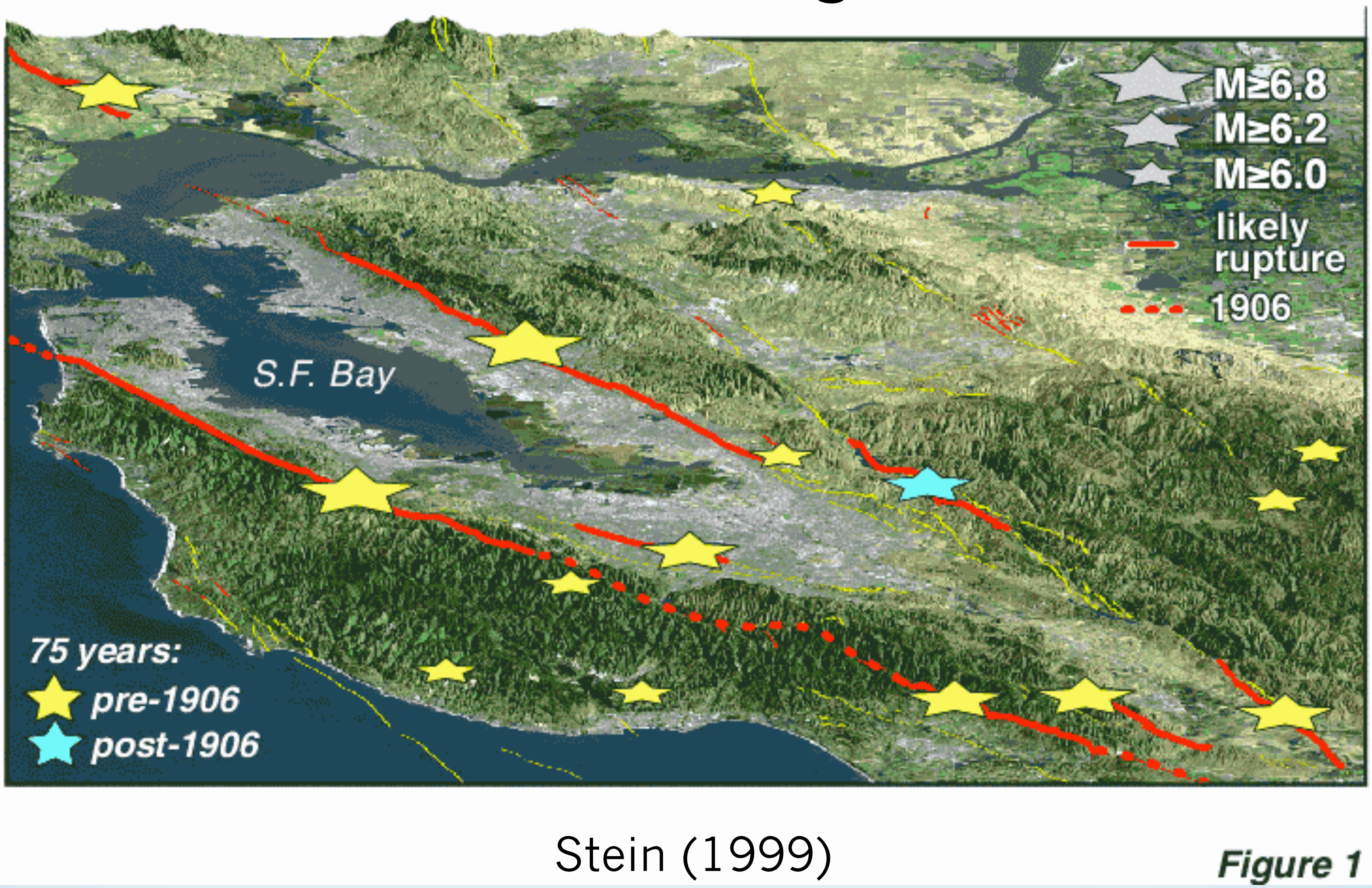
The empirical model, or what's going on with our seismicity rates??

Karen Felzer

USGS, Pasadena

The Classic Figure



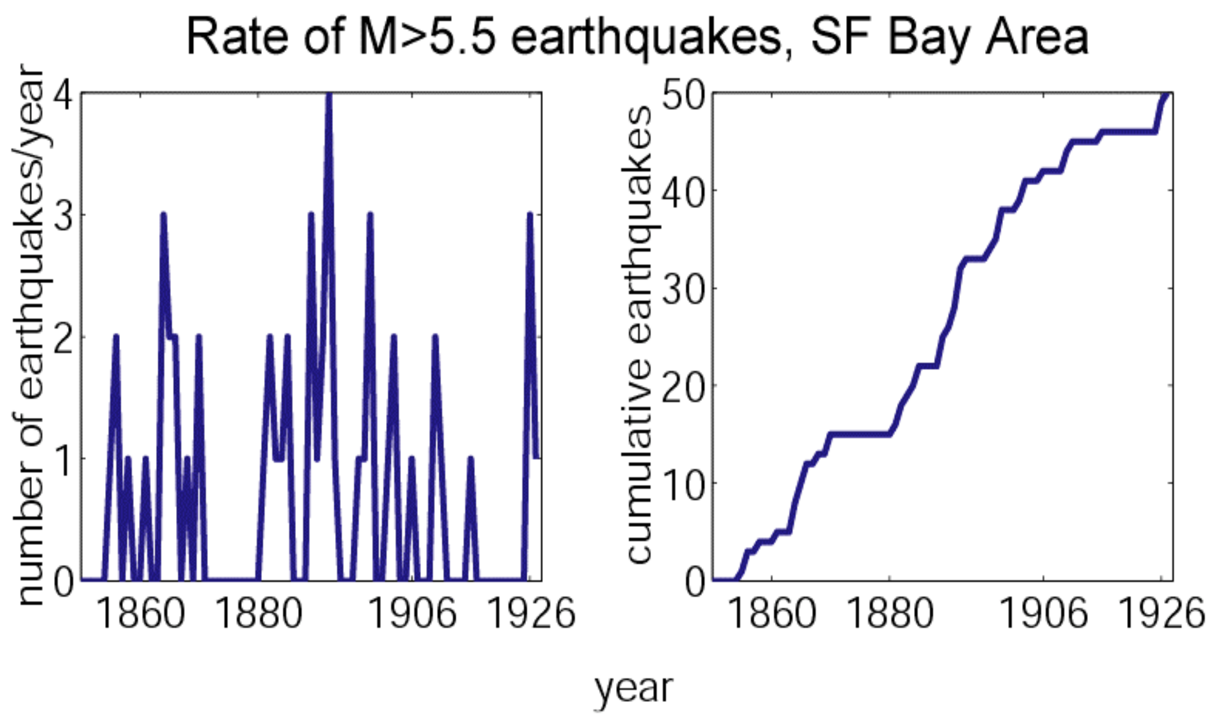
Stein (1999)

1906 earthquake = Quiets Bay Area via static stress shadow
Modeling the stress shadow should give us time dependent risk

Except: Observations are not consistent with the stress shadow hypothesis

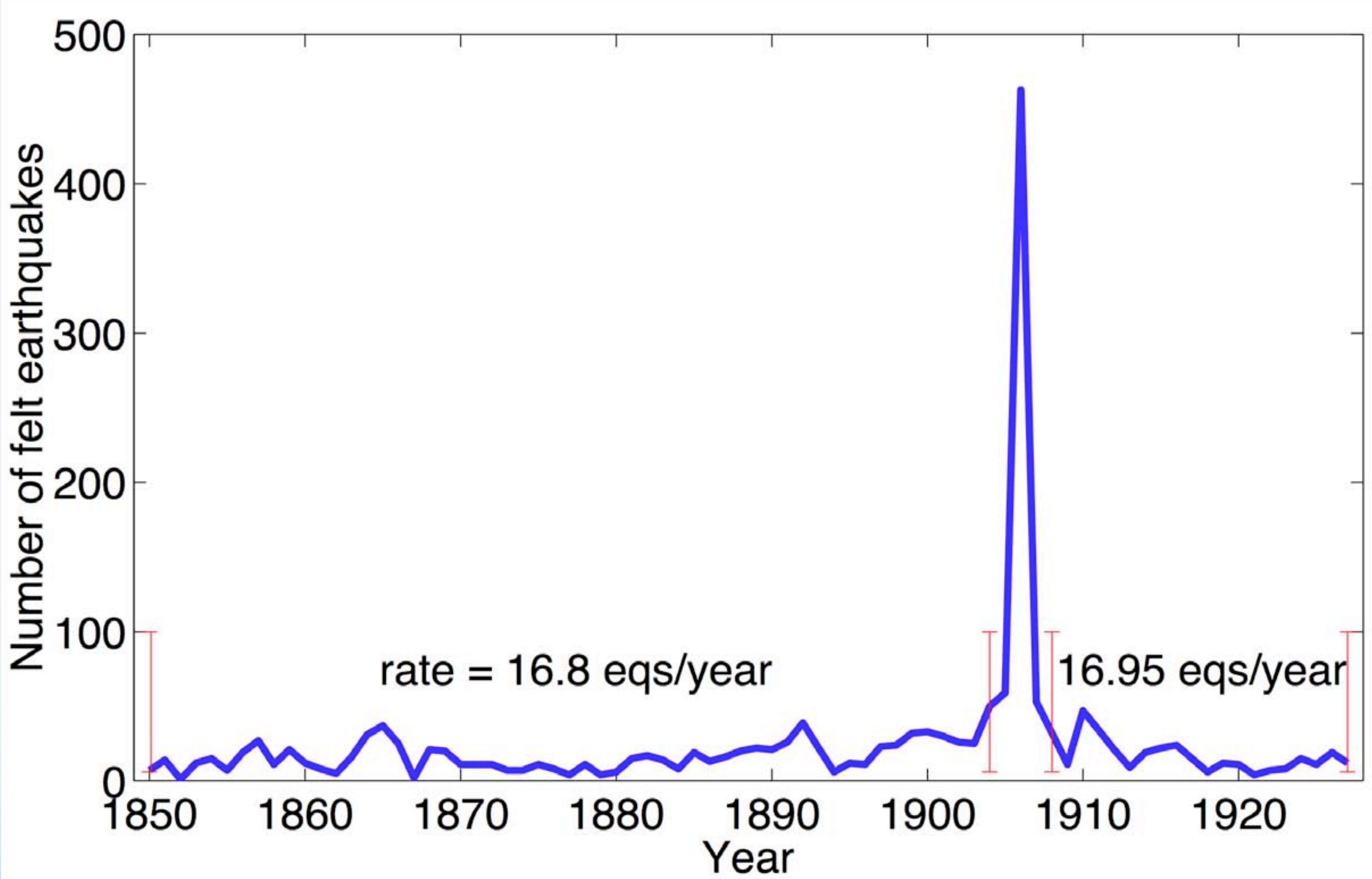
- Decrease of Bay area seismicity started in late 1920s, not 1906 (*Bufe and Varnes*, 1993; *Jaume and Sykes*, 1996)
- Seismicity rates have not gradually recovered, although the stress shadow should have eroded.
- The “shadow” extends into the area where stress should have been increased (*Bakun*, 2000; *Toppozada et al.* 2002).
- The rate decrease covers the whole San Andreas system, and other parts of state (*Felzer and Brodsky,* 2005; WGCEP 2007).

1) A sudden seismicity decrease is not seen in 1906 in the catalog



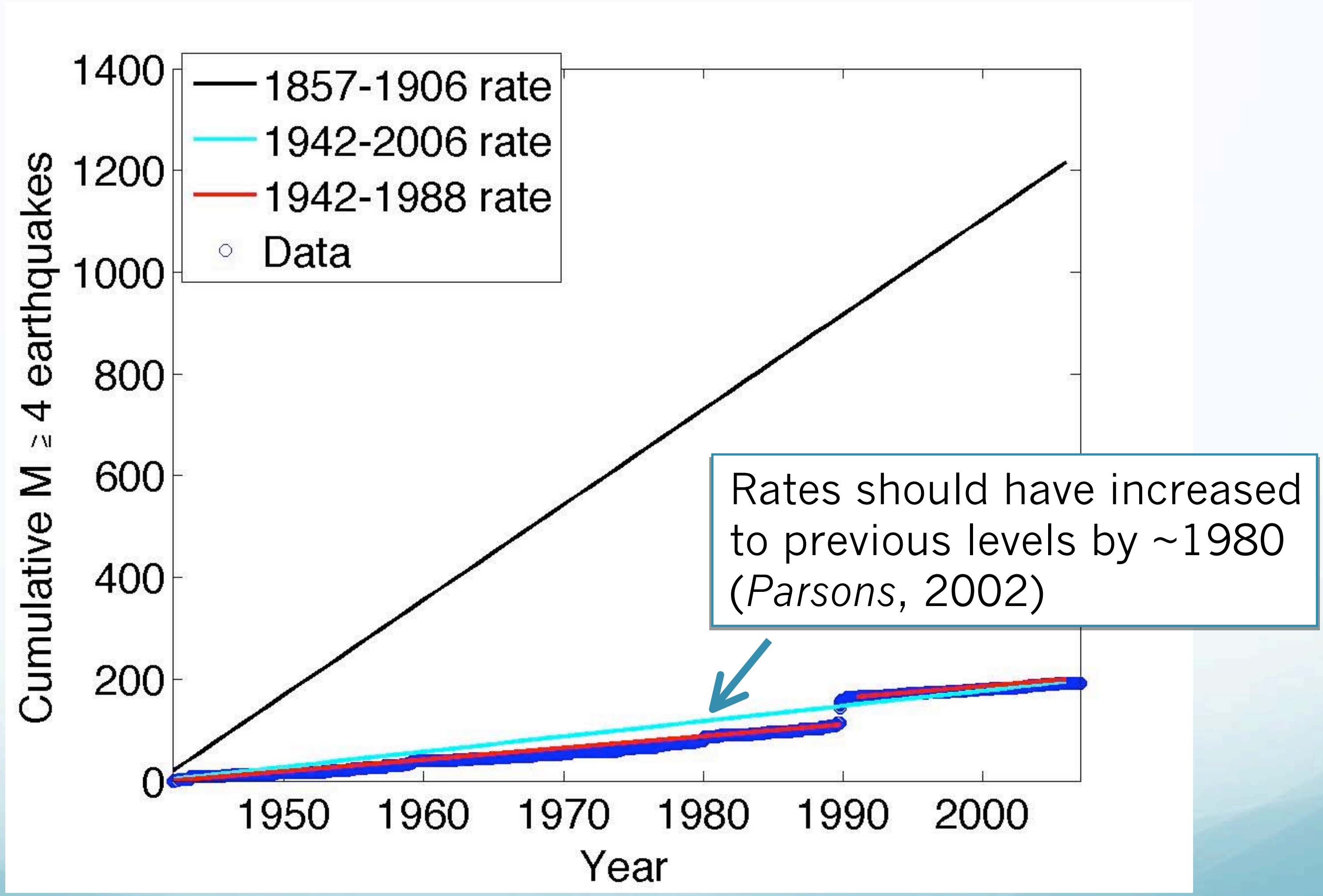
California Geological Survey Catalog, Compiled from *Toppozada,* (1978,1981,2000,2002)

Nor is it seen in # felt earthquakes

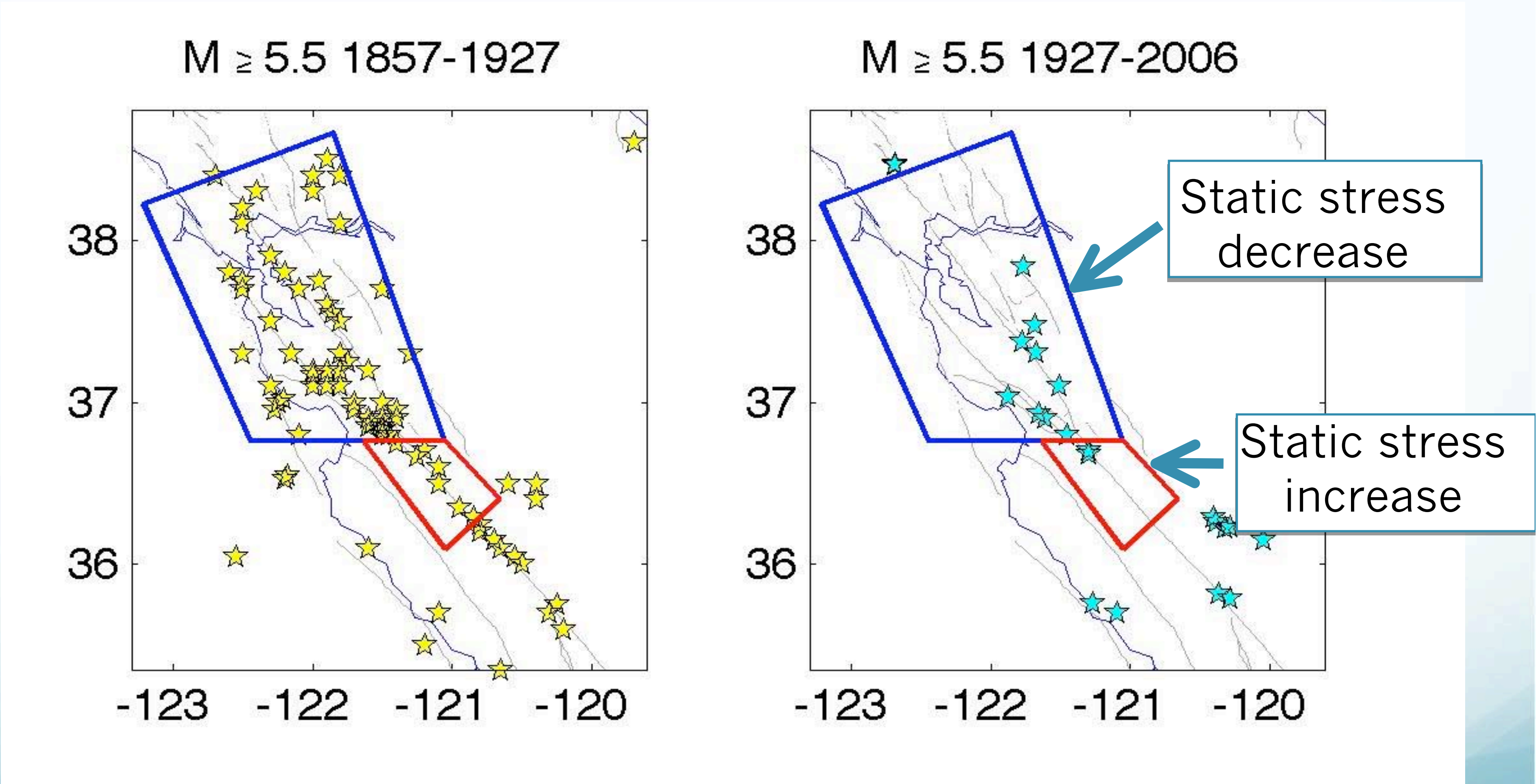


Earthquakes felt at Berkeley, Townely-Allen catalog

2) Seismicity rates have not increased with time since 1906

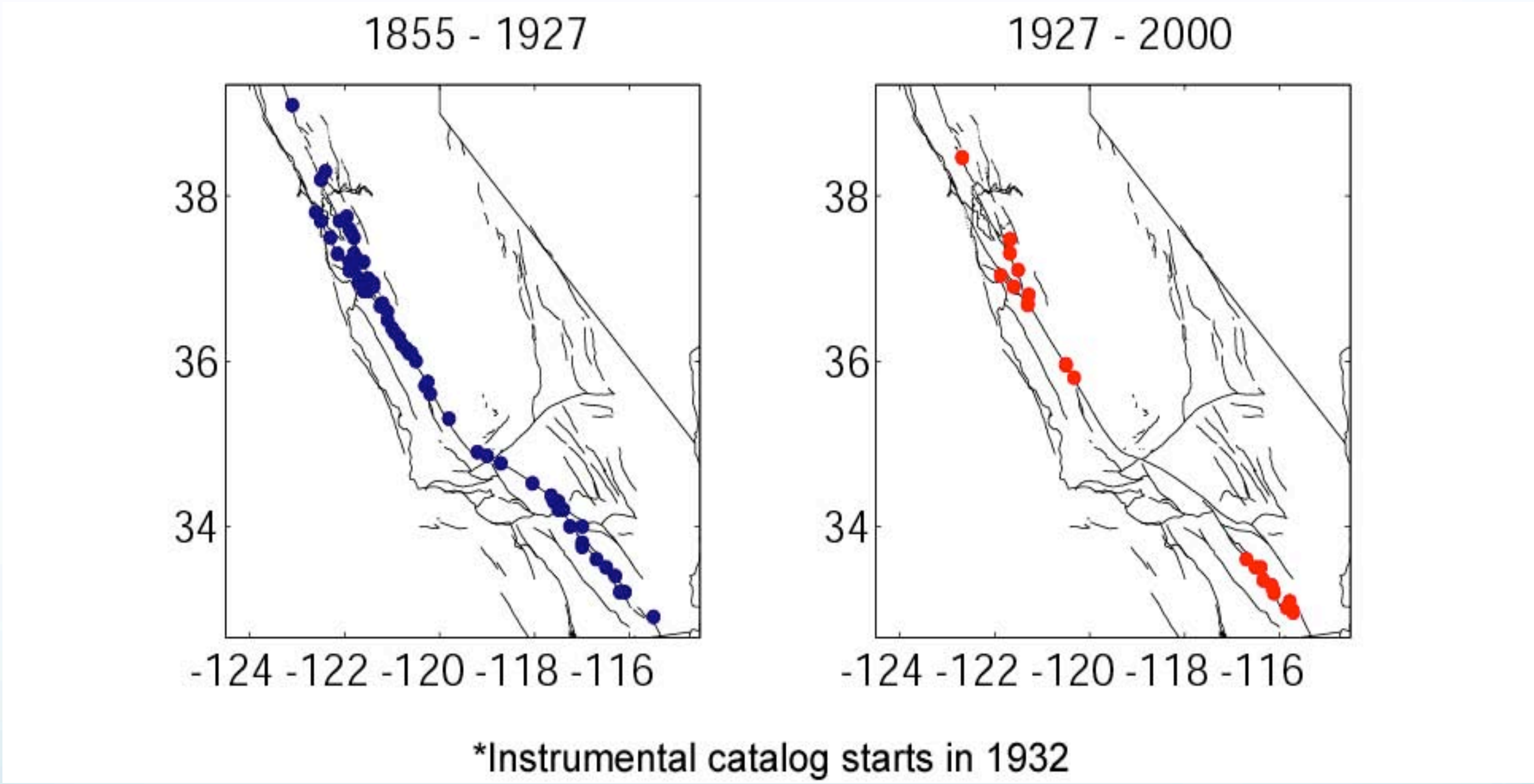


3) The "stress shadow" also exists where static stress was increased...



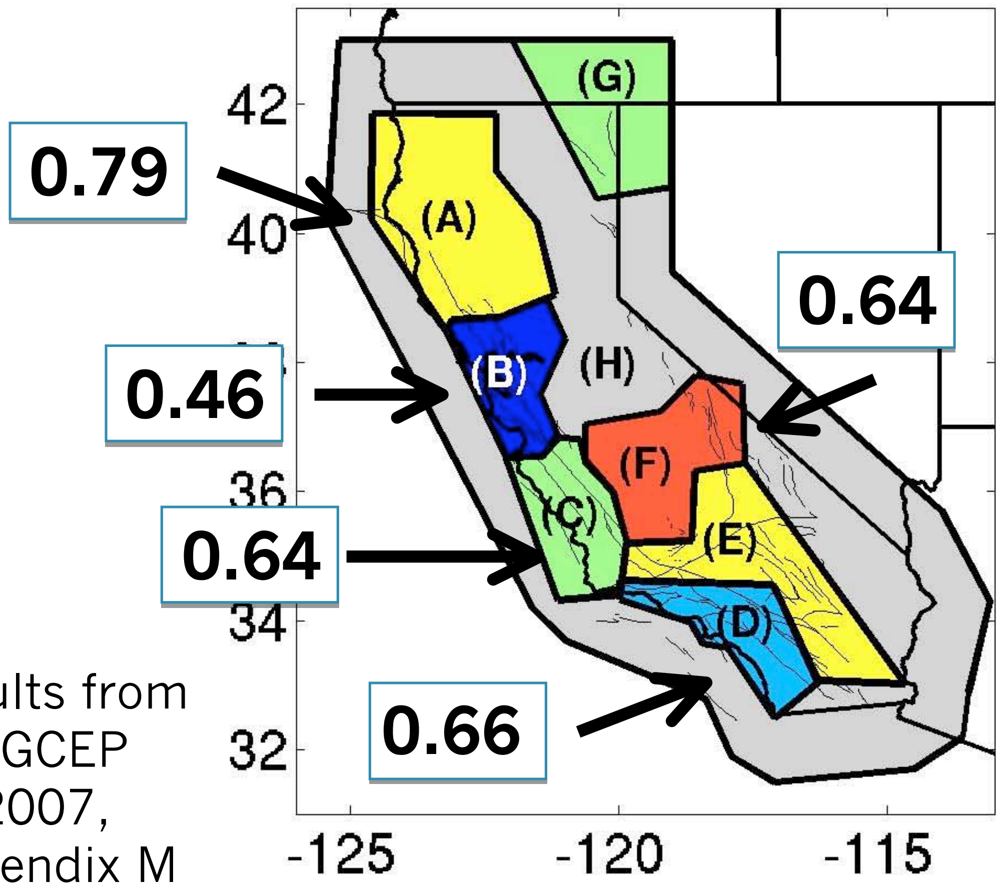
Stress change areas estimated from *Doser et al*. (2009)

4) And exists over the entire San Andreas system!



M≥5.5 earthquakes within 15 km of the Hayward, San Andreas, and San Jacinto faults

Statewide ratios of average short term rates* vs. 1857-2006

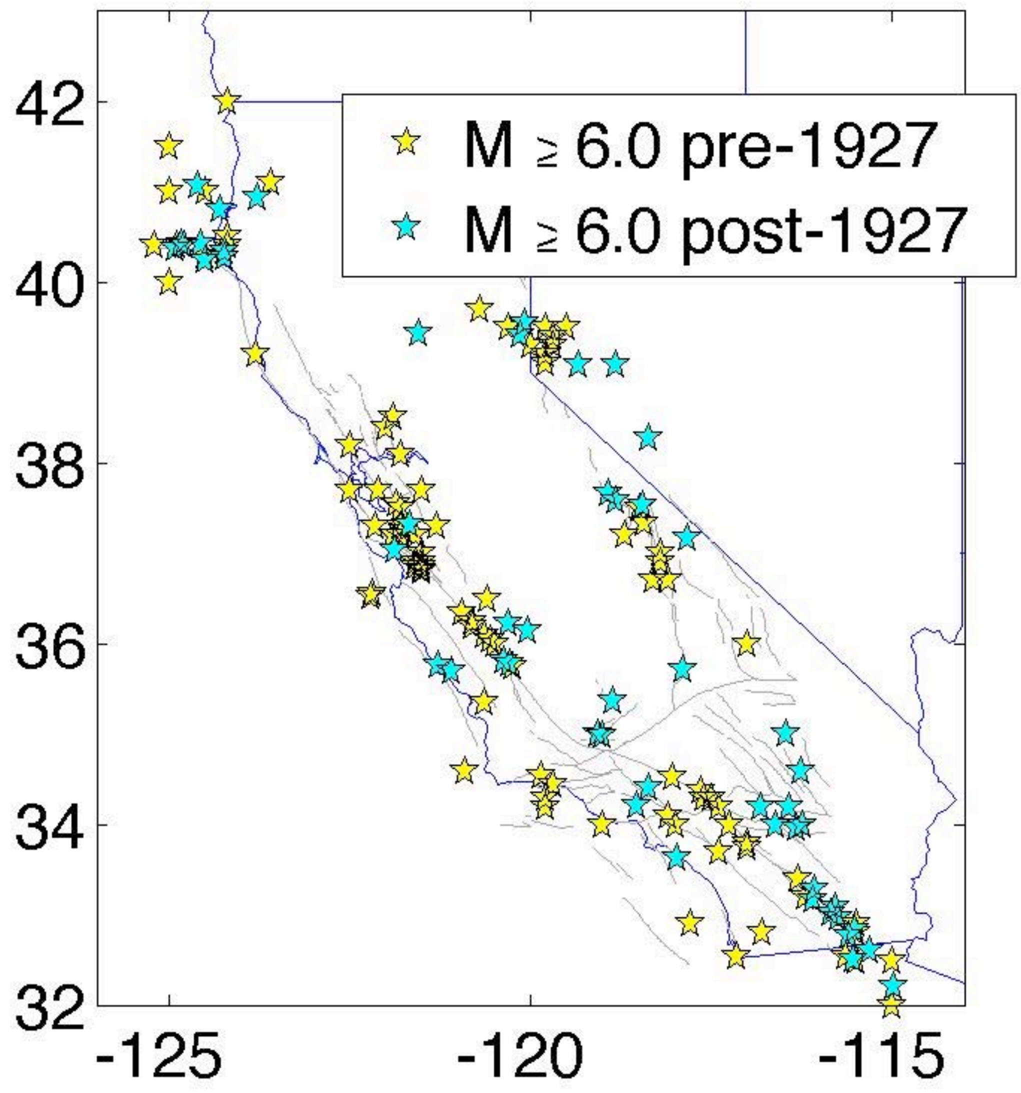


Statewide:0 .82

Results from WGCEP 2007, Appendix M

*Average short term = average of 1906-2006, 1942-2006, and 1984-2006

Statewide, rate of M≥6.0 1857-1927 is ~65% of 1927-2006



What is going on?

- Pre-1932 earthquake catalog data is not instrumental. If historical magnitude errors are >> than realized, rate decrease may not all be real.
- Earthquake triggering causes periods of clustered seismicity, beyond obvious aftershocks. 1857-1927 may have been a period of particularly intense clustering in California.

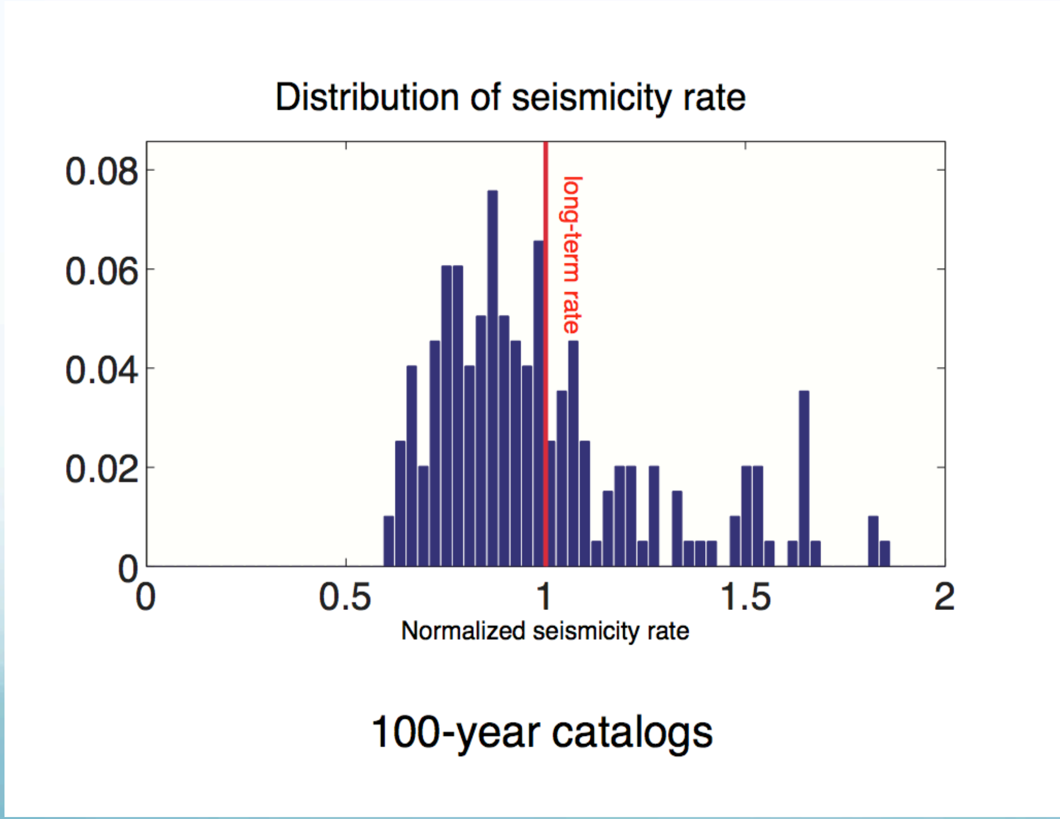
What do we do about it?

- Pre-1932 earthquake catalog data is not instrumental. If historical magnitude errors are >> than realized, rate decrease may not all be real.

A detailed re-analysis project of the historical catalog may be warranted.

What do we do about it?

- Earthquake triggering causes periods of clustered seismicity, beyond obvious aftershocks. 1857-1927 may have been a period of particularly intense clustering in California.



Simulations show that aftershock clustering can cause ~50% deviations from the average rate, even over 100 year periods

Simulations and figure courtesy of Morgan Page

What do we do about it?

- Earthquake triggering causes periods of clustered seismicity, beyond obvious aftershocks. 1857-1927 may have been a period of particularly intense clustering in California.

More ETAS modeling could be performed to indicate what possible suite of seismicity rates might be expected in the near future

Conclusions

- Modern seismicity rates in California are significantly lower than historical rates, if the historical catalog is correct.
- Characteristics of the rate decrease are not consistent with what we would expect from a 1906 earthquake stress shadow.
- One explanation for the rate change is aftershock-driven earthquake clustering. Stochastic modeling could indicate how rates might evolve from here.