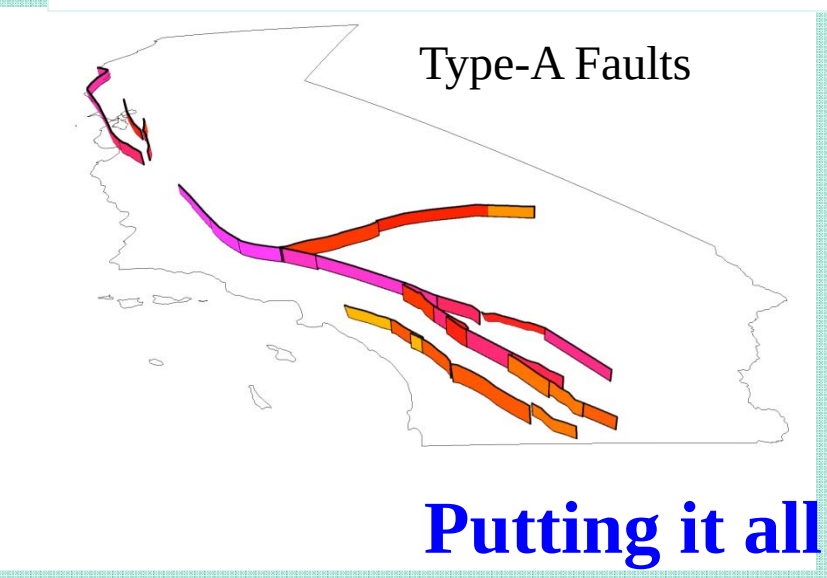
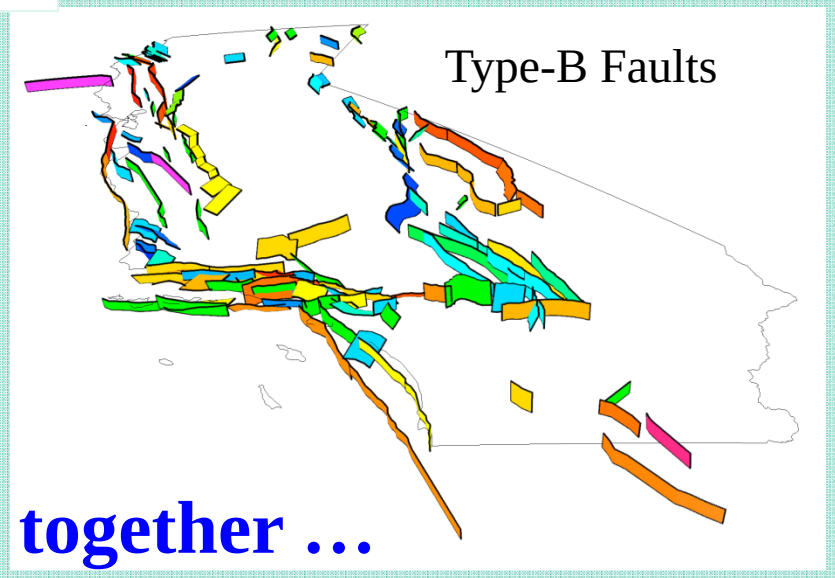
Southern California Earthquake Center

- Operates 1991 – present, $3 - $5 million per year
- NSF Science and Technology Center at first
- **Mission: Provide scientific basis for seismic hazard assessment.**
- Involves Seismology, Geology, Geodesy
- One year + in consensus building,
  - 4→100→20 participants
- **Management plan: "Center without walls," led by Prof. Kei Aki, member of NAS**
- Funding from NSF, USGS, CGS, USC
- **High profile seismic hazard reports from 1993**
- **Community data bases –faults, earthquakes, 3-D seismic velocity**

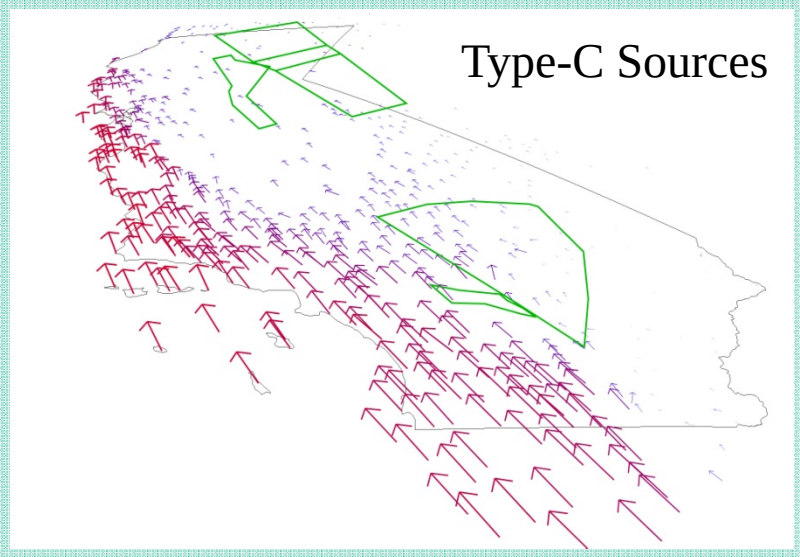
Uniform California Earthquake Rupture Forecast
UCERF2 Earthquake Rate Model 2008

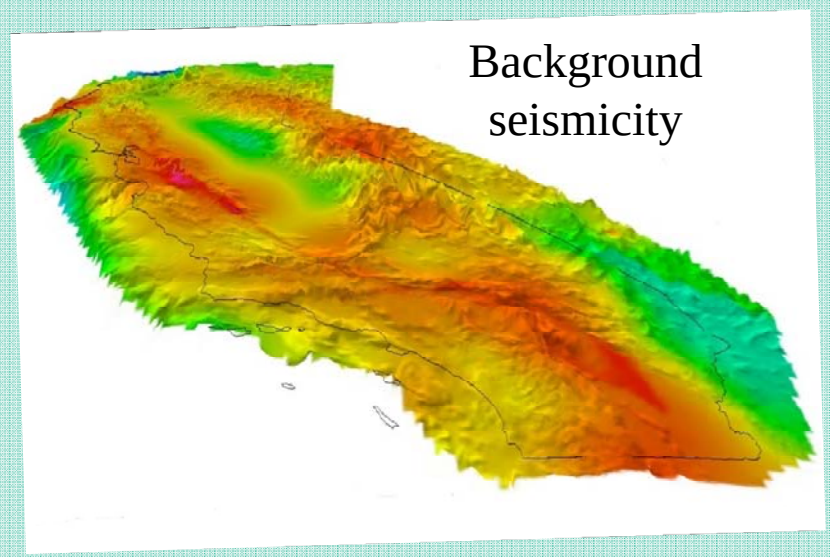




Quake rates on known faults

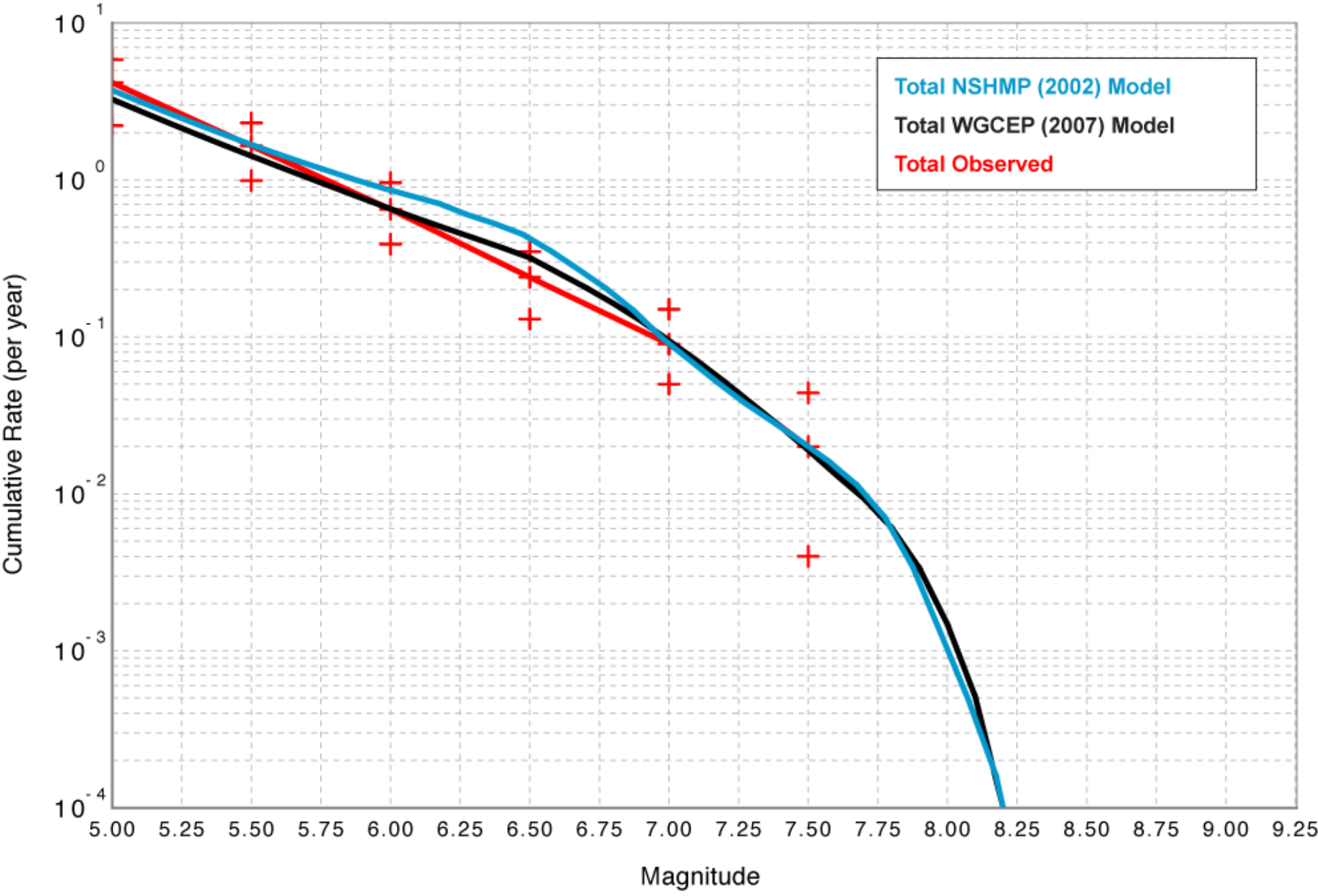
Putting it all together …





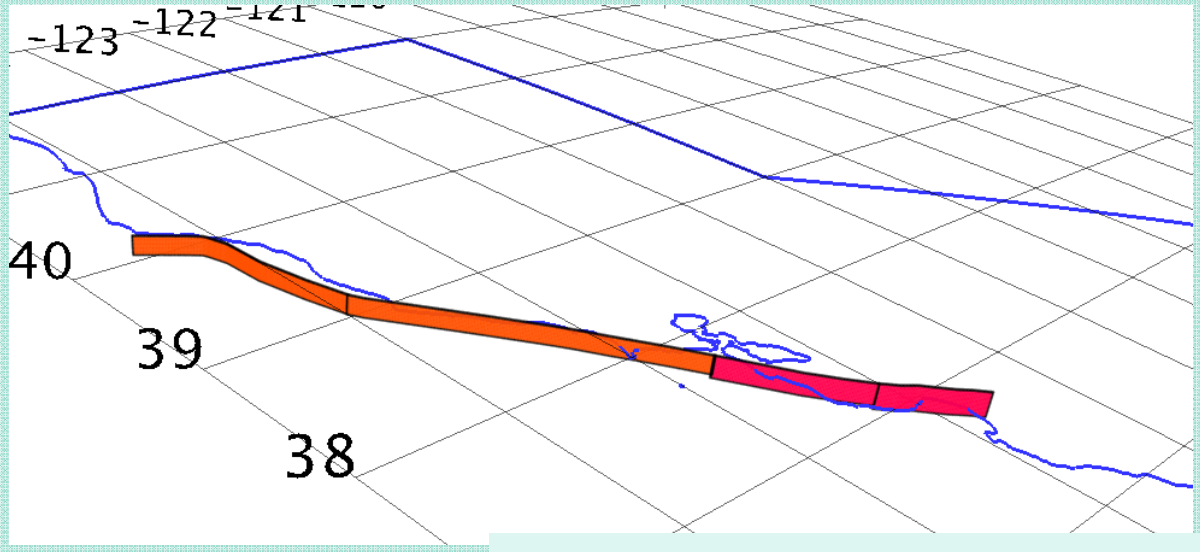
Quake rates elsewhere

Magnitude Frequency Distribution



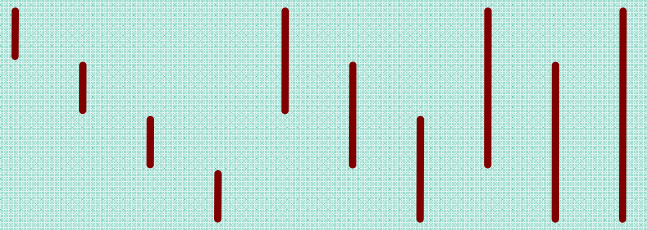
UCERF2 Recipe for Type A Faults:

(from WGCEP (2002 & 2007)



Northern San Andreas Fault (NSAF)

Possible Ruptures



New Approach: 2014 version

System of Equations

Frequency (rate) of the r^{th} rupture - what we're solving for

$$\sum_{r=1}^{R} D_{sr} f_r = v_s$$

$$\sum_{r=1}^{R} G_{sr} P_r^{paleo} f_r = f_s^{paleo}$$

$$f_r = f_r^{a-priori}$$

$$f_r - f_{r+1} = 0$$

$$\sum_{r=1}^{R} M_{mr}^{g} f_r \leq GR_m^{g}$$

A stochastic forecast of California earthquakes based on fault slip and smoothed seismicity

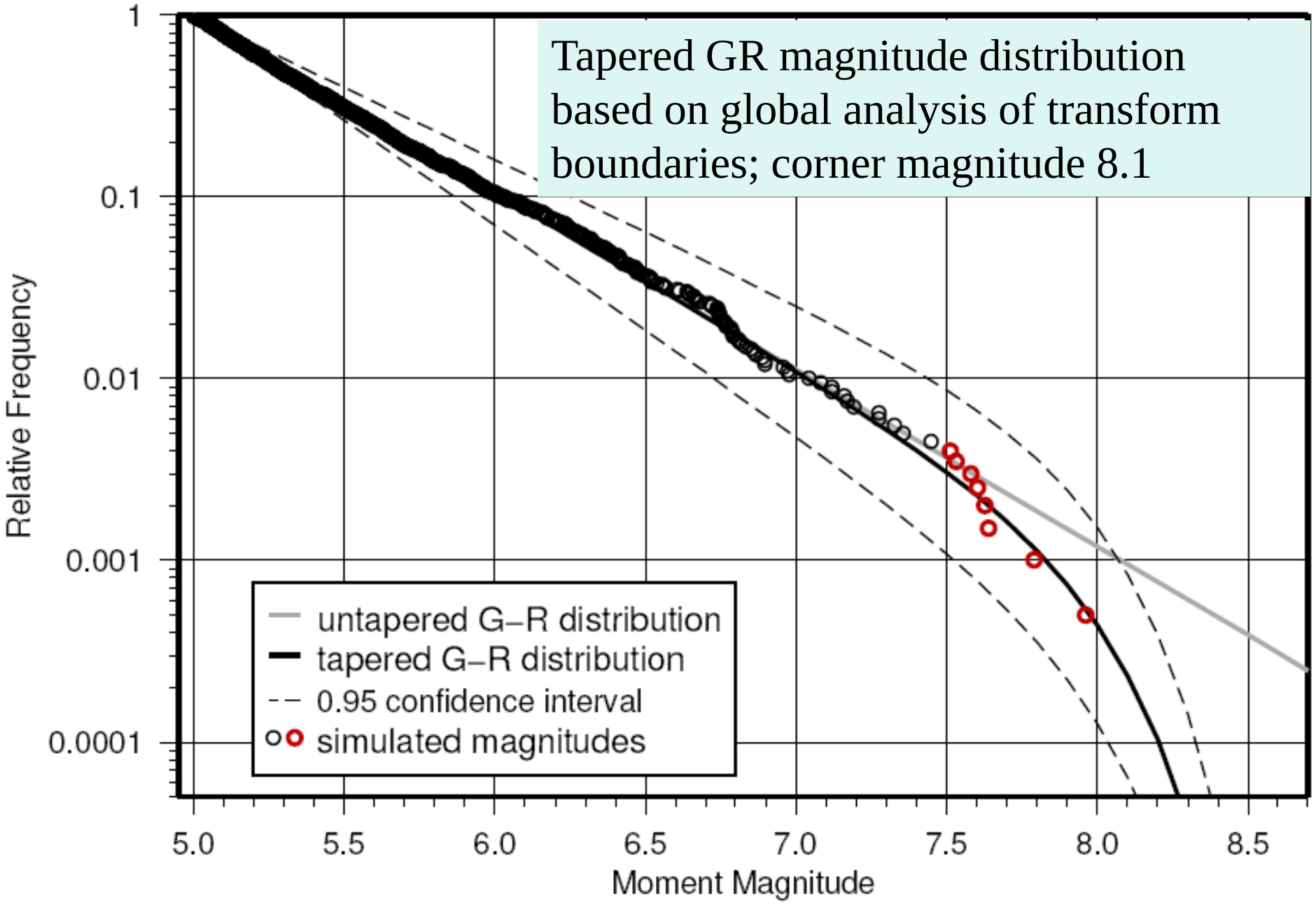
S. Hiemer, ETHZ,

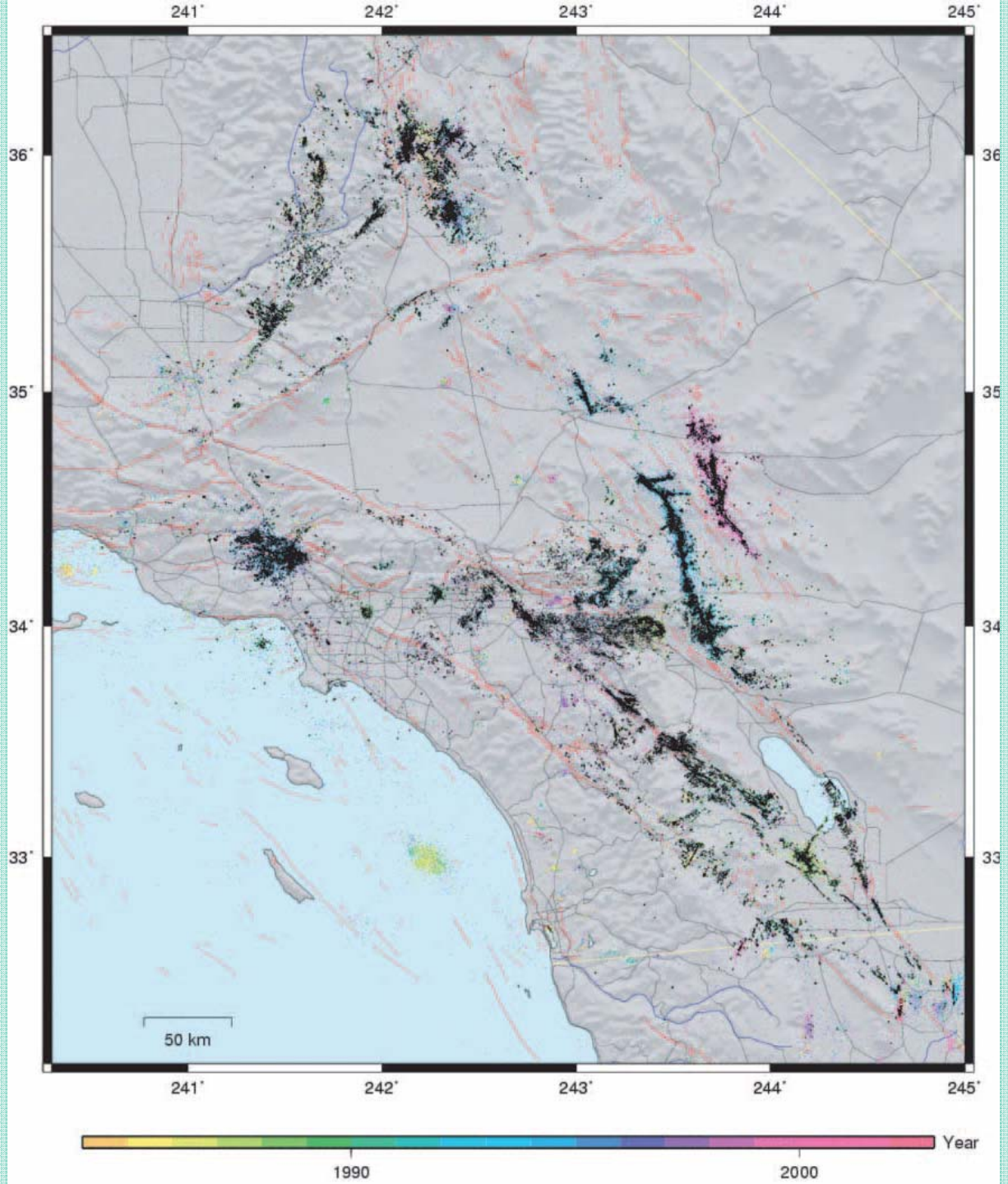
D.D. Jackson, Q. Wang,Y. Y. Kagan, UCLA

J. Woessner, J. D. Zechar, S. Wiemer ETHZ

Approach

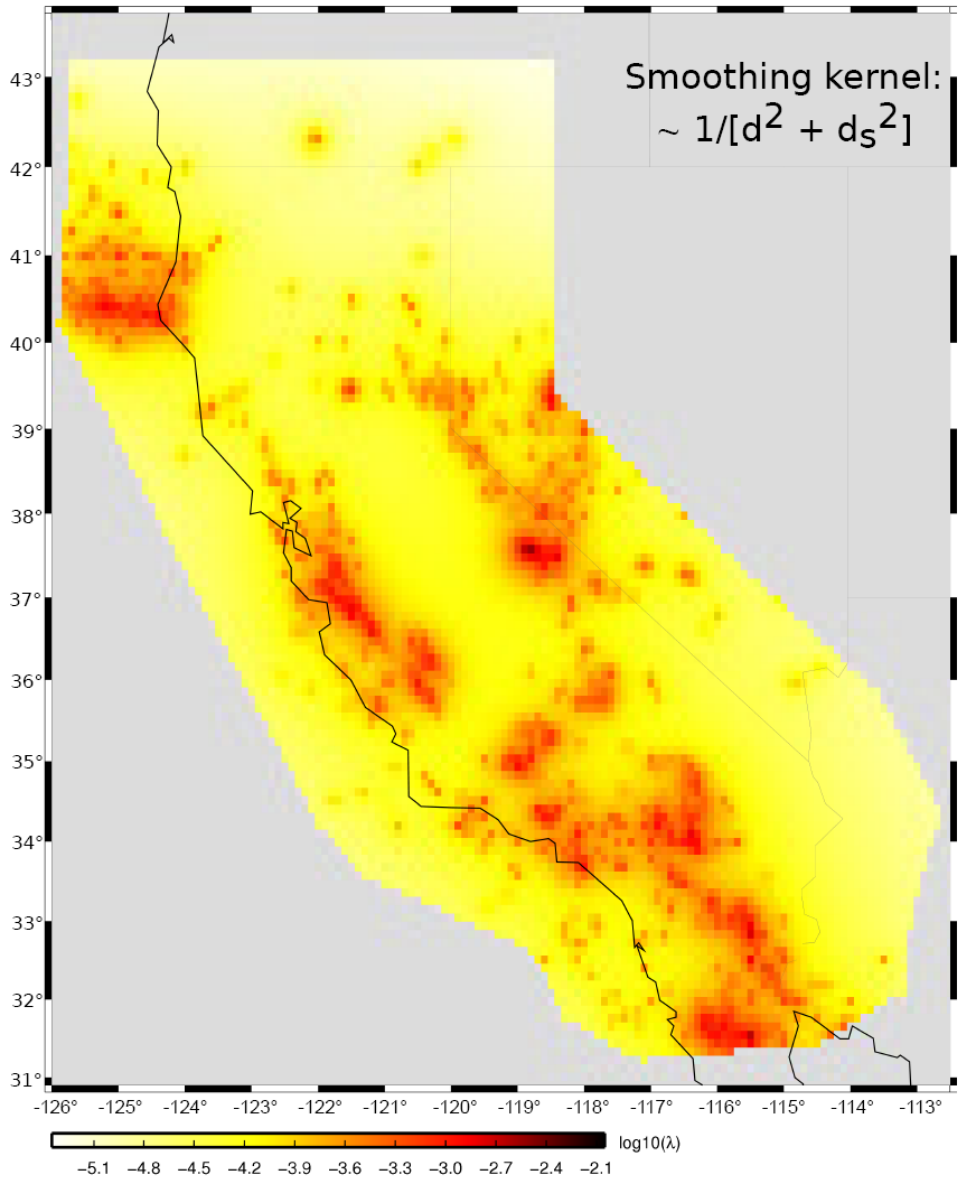
- Start with the answer! Include physics only as it is expressed in observable distributions
- Synthesize (in this order)
  - Magnitude
  - Location wrt faults and prior earthquakes
  - Focal mechanism
  - Fault dimesions
  - Fault orientation
- Weighted average of earthquake and fault info


Tapered GR magnitude distribution based on global analysis of transform boundaries; corner magnitude 8.1
Relative Frequency
1
0.1
0.01
0.001
0.0001
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
Moment Magnitude
untapered G–R distribution
tapered G–R distribution
0.95 confidence interval
simulated magnitudes

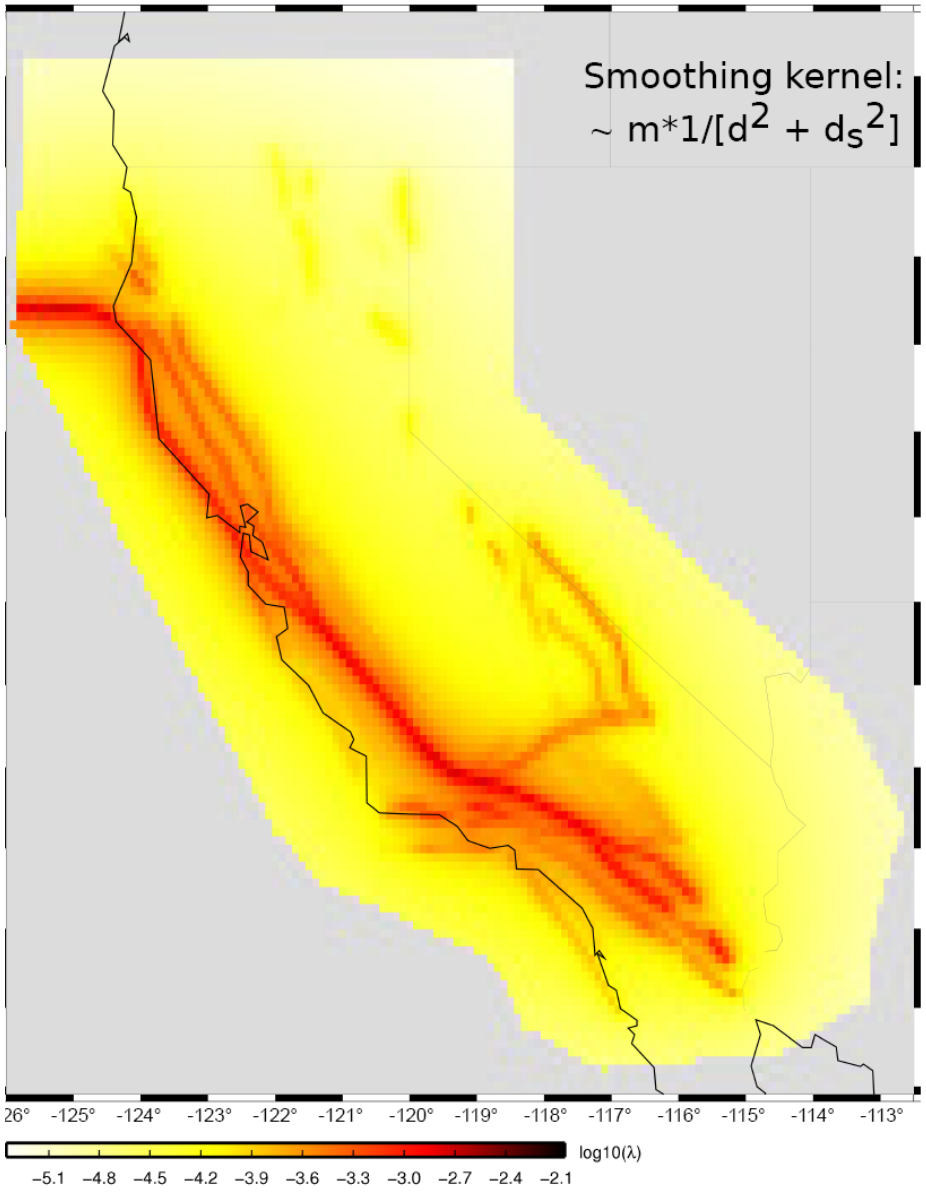


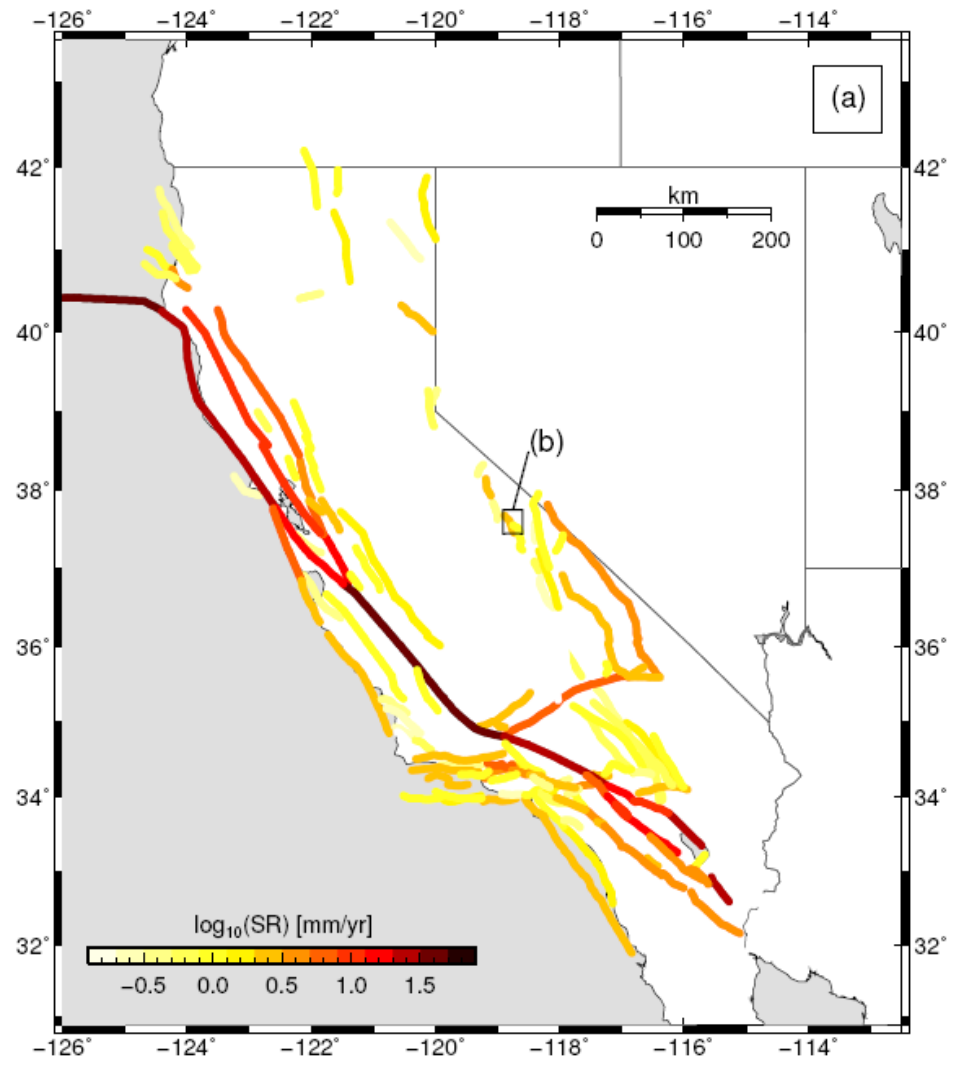
Southern California earthquakes, mostly located using precise waveform correlation. Typical horizontal location uncertainty “tens of meters.”From Shearer et al., BSSA 2005

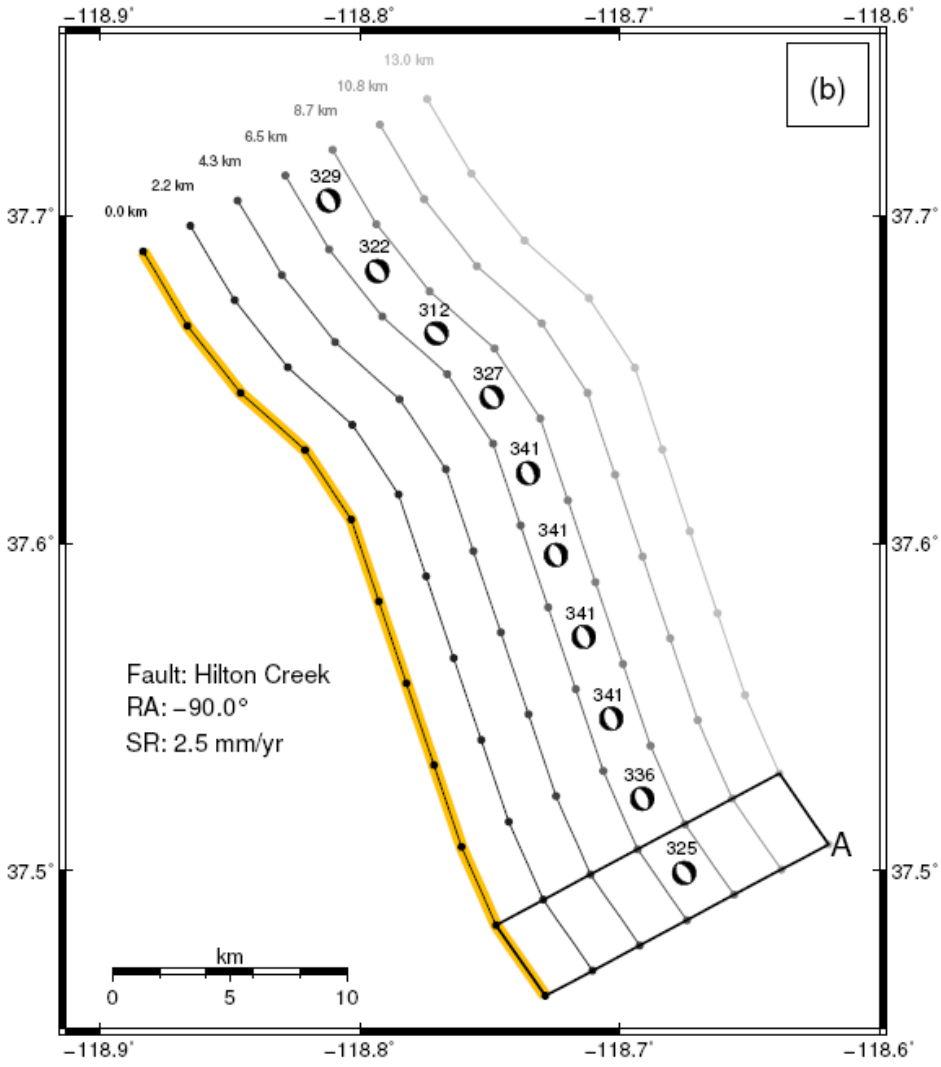
Seismicity

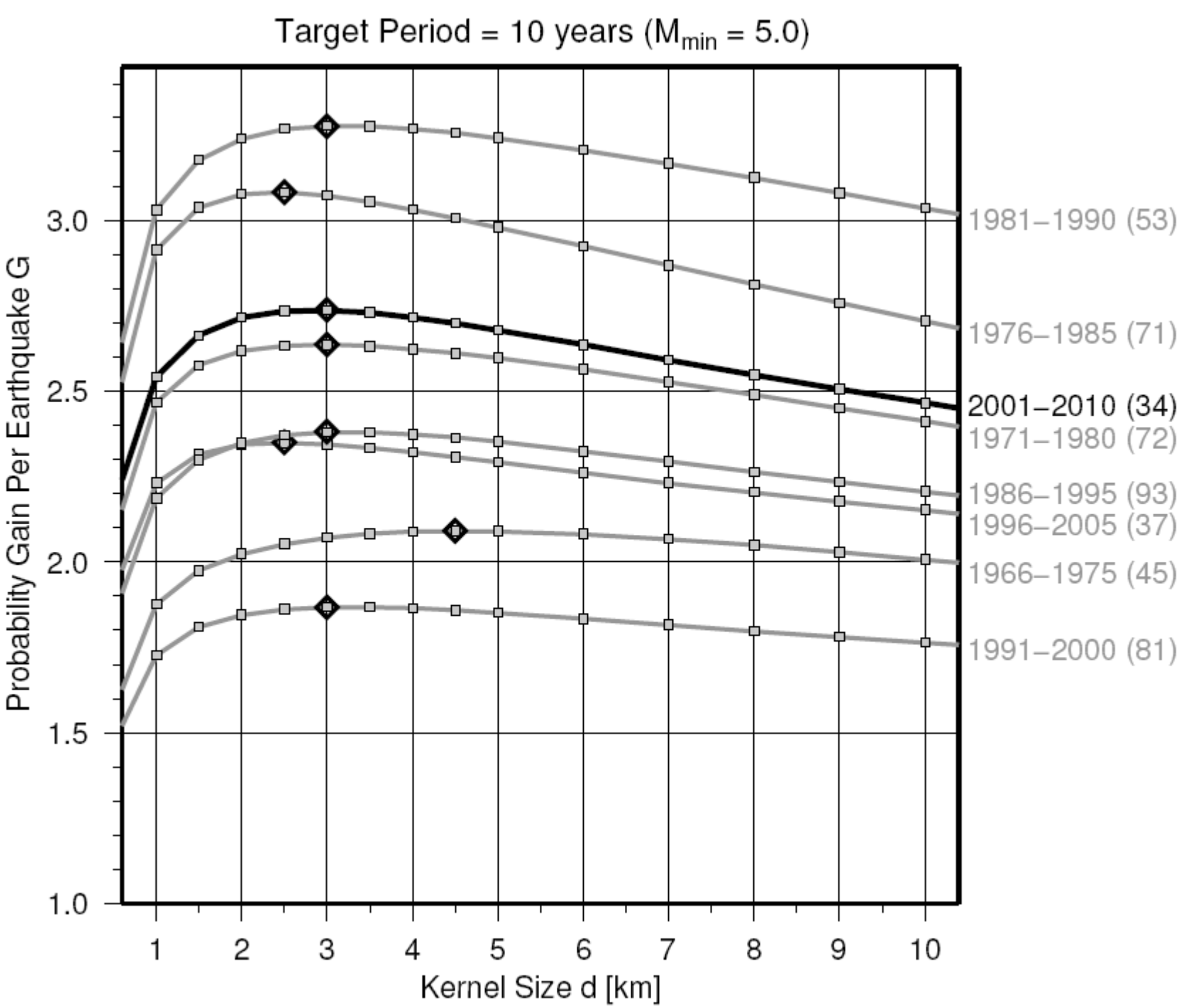


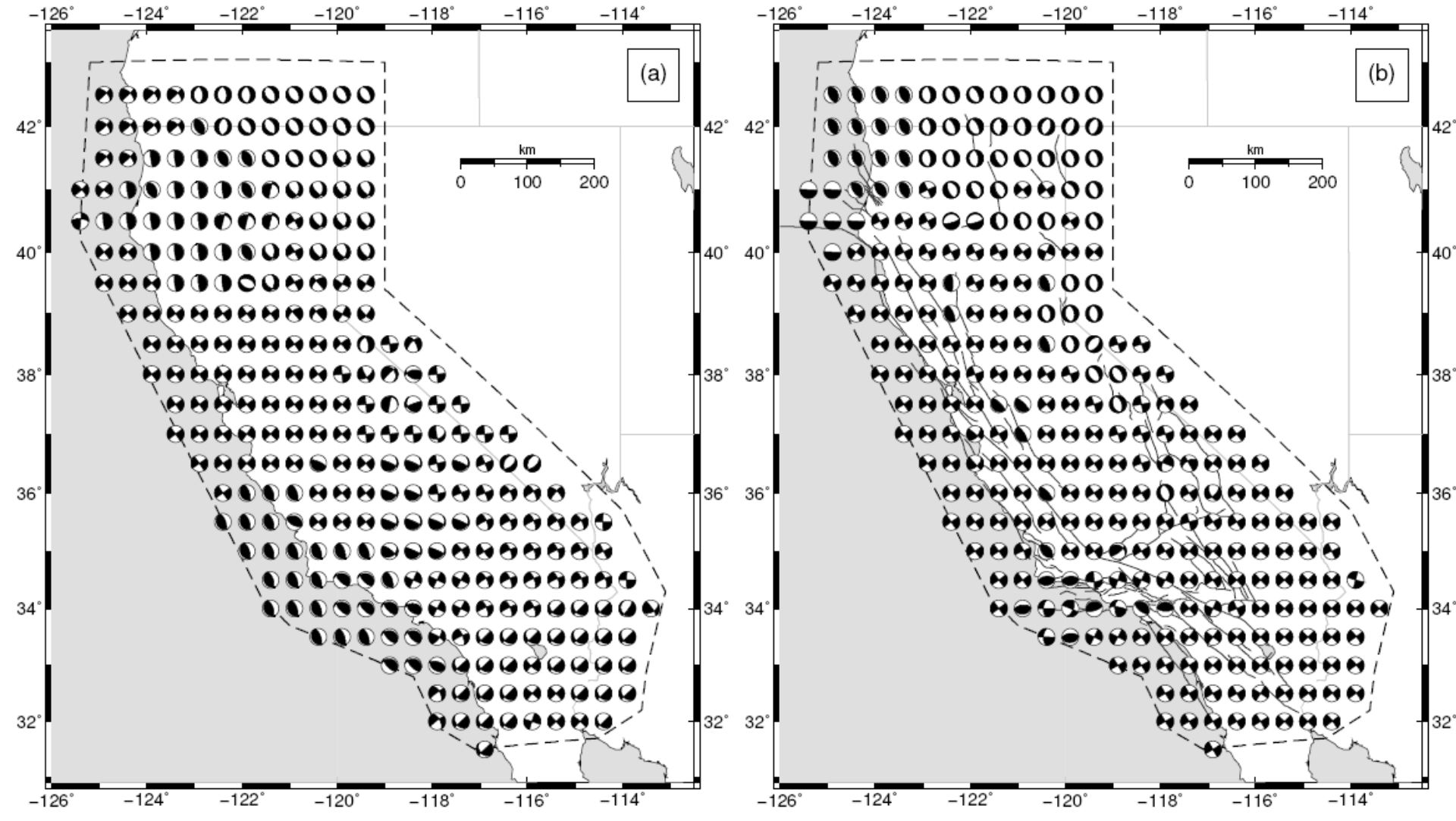
Faults



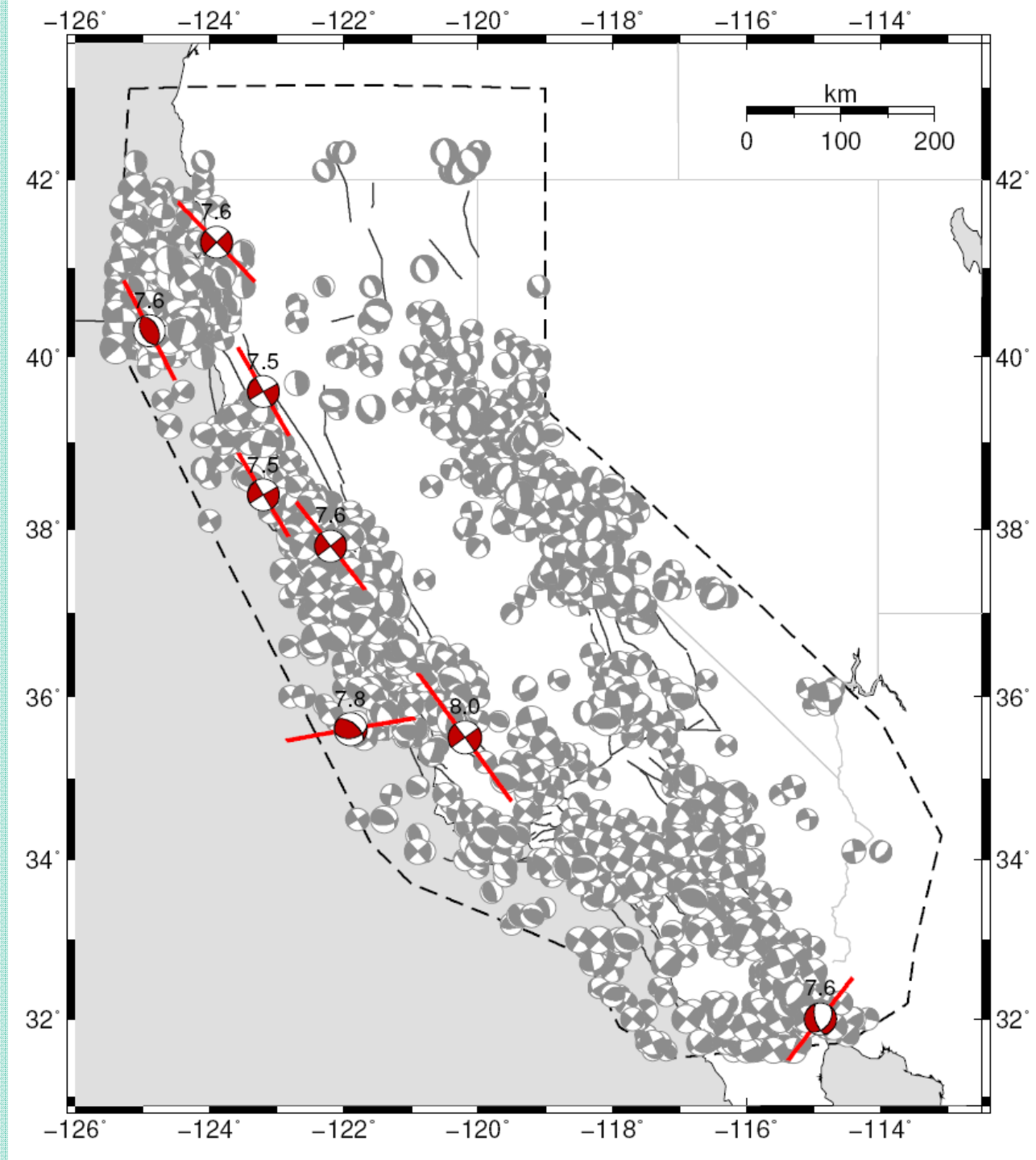

(a)
km
0
100
200
(b)
log10(SR) [mm/yr]
−0.5
0.0
0.5
1.0
1.5
−126°
−124°
−122°
−120°
−118°
−116°
−114°
42°
40°
38°
36°
34°
32°

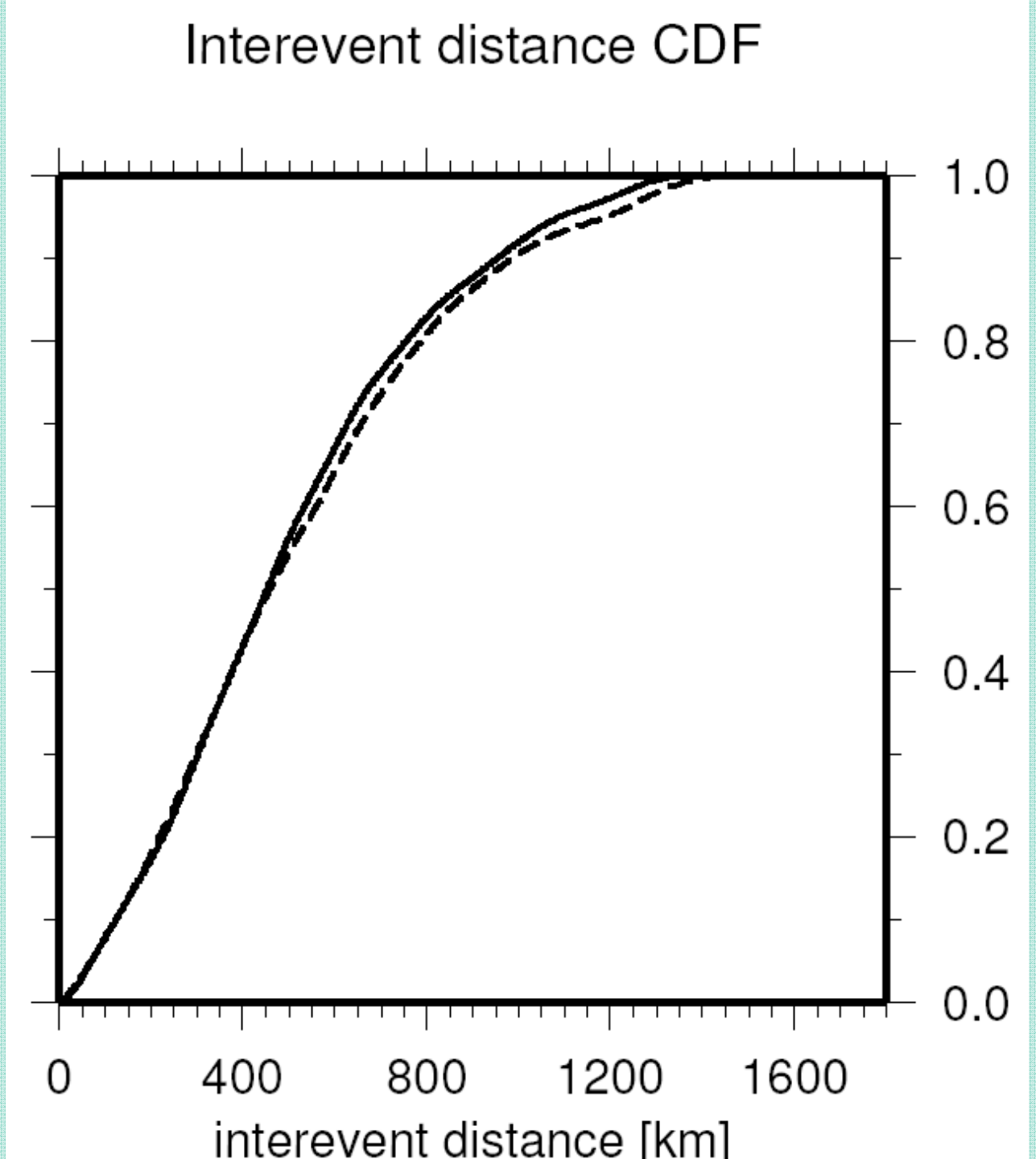

(b)
13.0 km
10.8 km
8.7 km
6.5 km
4.3 km
2.2 km
0.0 km
329
322
312
327
341
341
341
341
336
325
A
Fault: Hilton Creek
RA: −90.0°
SR: 2.5 mm/yr
km
0
5
10
−118.9°
−118.8°
−118.7°
−118.6°
37.7°
37.6°
37.5°

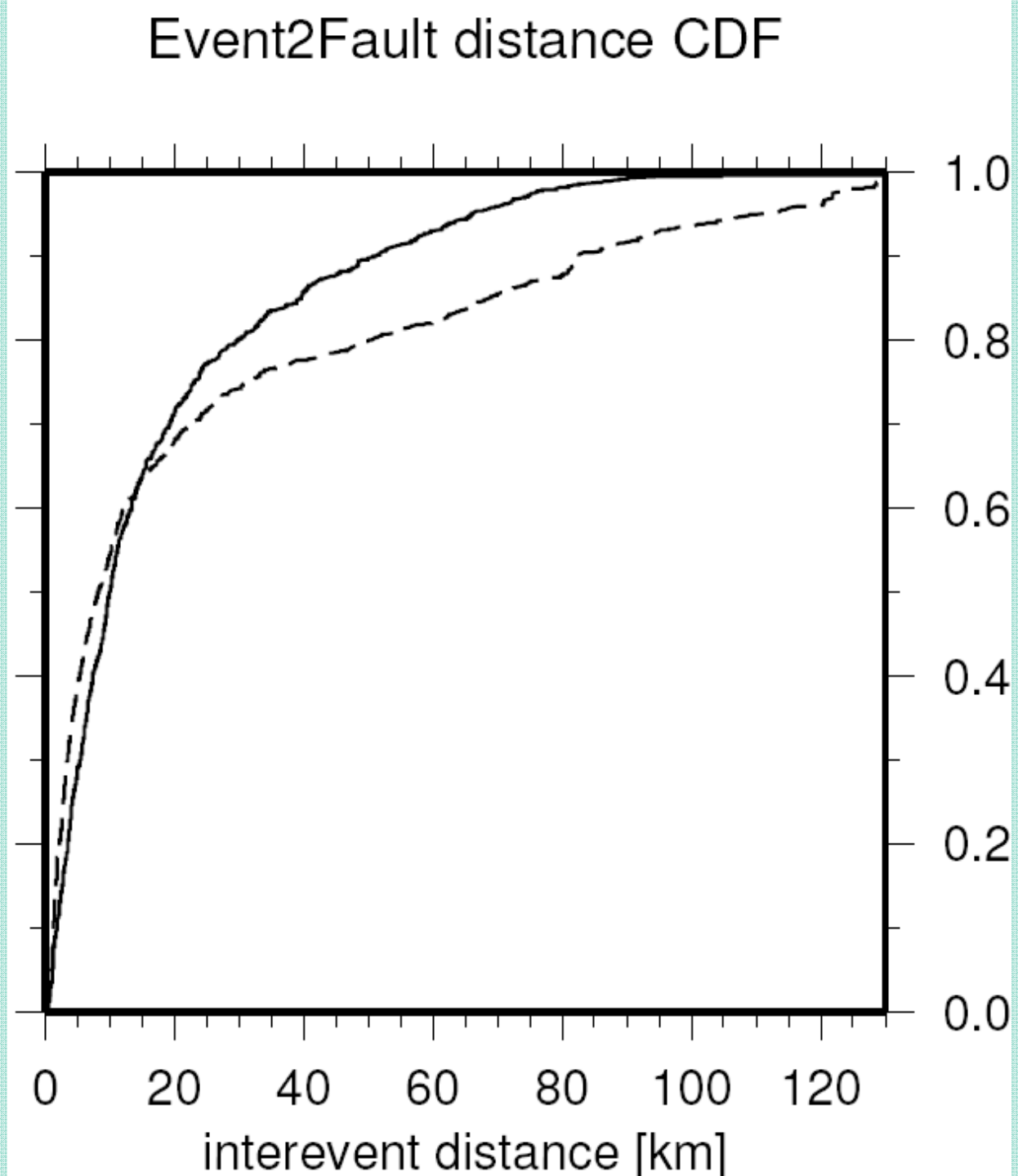

Target Period = 10 years (M_{min} = 5.0)
Probability Gain Per Earthquake G
3.0
2.5
2.0
1.5
1.0
1
2
3
4
5
6
7
8
9
10
Kernel Size d [km]
1981–1990 (53)
1976–1985 (71)
2001–2010 (34)
1971–1980 (72)
1986–1995 (93)
1996–2005 (37)
1966–1975 (45)
1991–2000 (81)


(a)
km
0
100
200
−126°
−124°
−122°
−120°
−118°
−116°
−114°
42°
40°
38°
36°
34°
32°

(b)
km
0
100
200
−126°
−124°
−122°
−120°
−118°
−116°
−114°
42°
40°
38°
36°
34°
32°


−126°
−124°
−122°
−120°
−118°
−116°
−114°
42°
40°
38°
36°
34°
32°
km
0
100
200
7.6
7.6
7.5
7.5
7.6
7.8
8.0
7.6


Interevent distance CDF
1.0
0.8
0.6
0.4
0.2
0.0
0
400
800
1200
1600
interevent distance [km]


Event2Fault distance CDF
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
interevent distance [km]

Conclusions

- Model fits observed distributions
  - Magnitude,
  - Inter-event distance
  - Epicenter-fault distance
  - Pair-wise focal mechanism rotations
  - Fault-focal mechanism rotations?
- Largest earthquakes occur very near faults
  - Implies b-value variation
- Expect Surprises