New Madrid Full Logic Tree

A CEUS Workshop Presentation

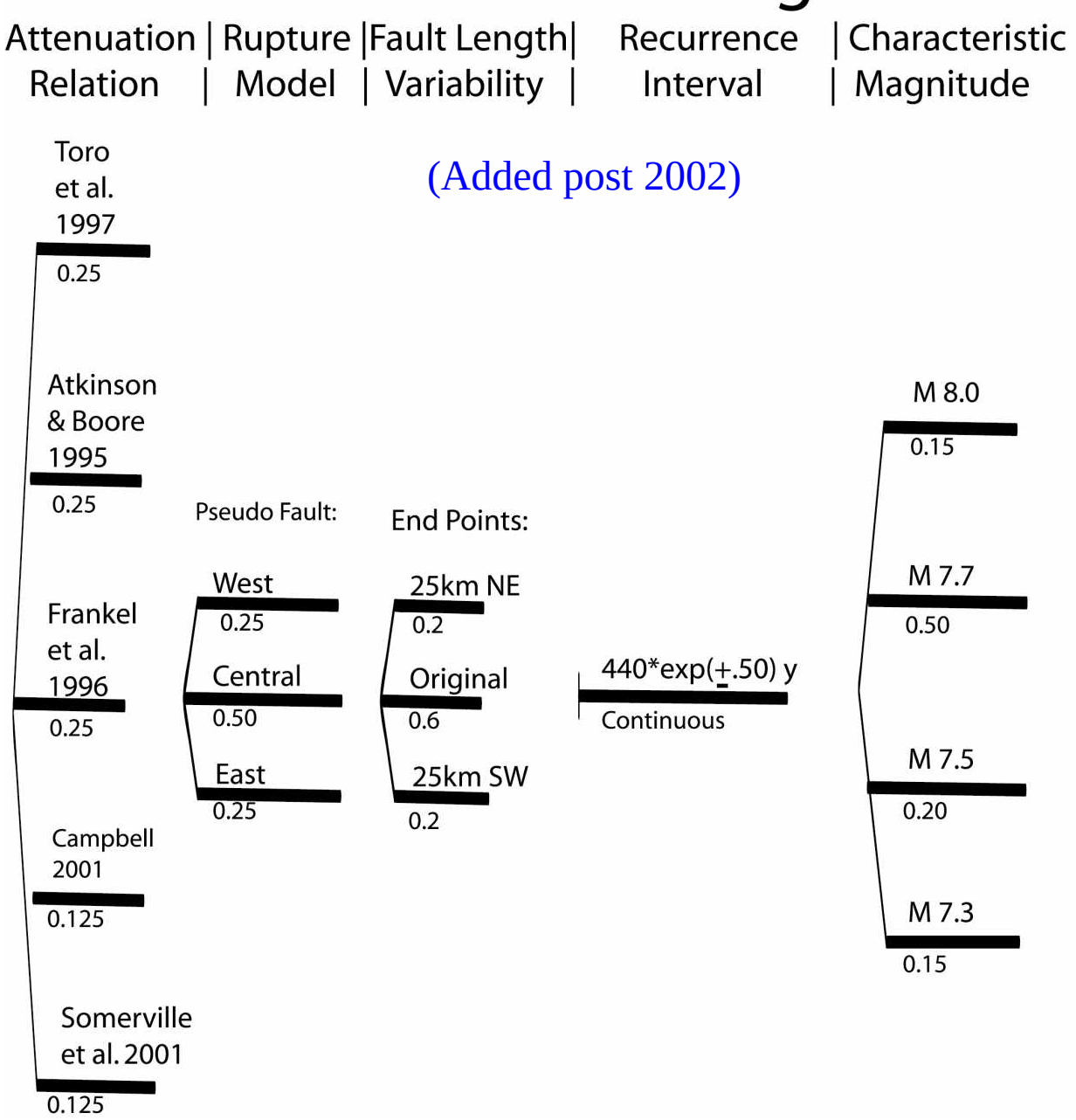
by Chris Cramer

May 9, 2006 at Cambridge, MA

Outline

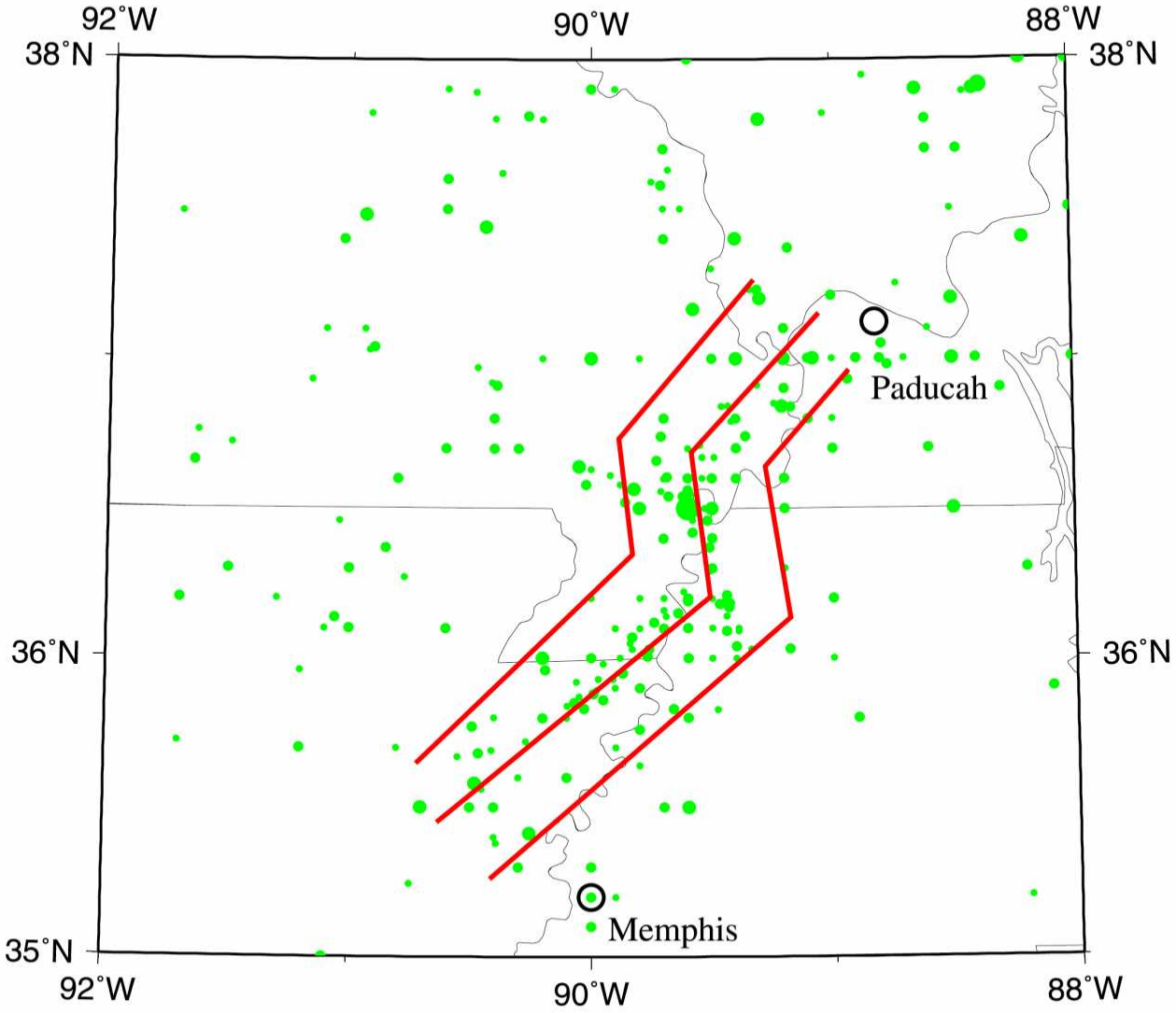
- 2002 Full Logic Tree
- Current Issues
  - Recurrence
  - NE NMSZ rupture
  - Fault alternative branches

CEUS New Madrid Logic Tree



NMSZ 2002 Sources

Red - Pseudo-Flts; Green - Eqks



Current New Madrid Issues

- Recurrence rate from updated paleoseismic data
- Where was the January 23, 1812 rupture?
- Fault model alternatives

Paleoseismic Dates

- Tuttle et al., 2005:

  1811-1812

  AD 1450 ± 75 (1 Std. Dev.)

  AD 900 ± 50

  AD 300 ± 100

New Estimate of Recurrence Rate

- Approach
  - Monte Carlo generation of 1002 intervals from the paleoseismic dates and uncertainties

- Estimates:
  - Median: 485 years
  - Assumed ln sigma of 0.5
  - Mean Recurrence Rate of 550 years

Hazard Impact

- A change in mean recurrence interval of

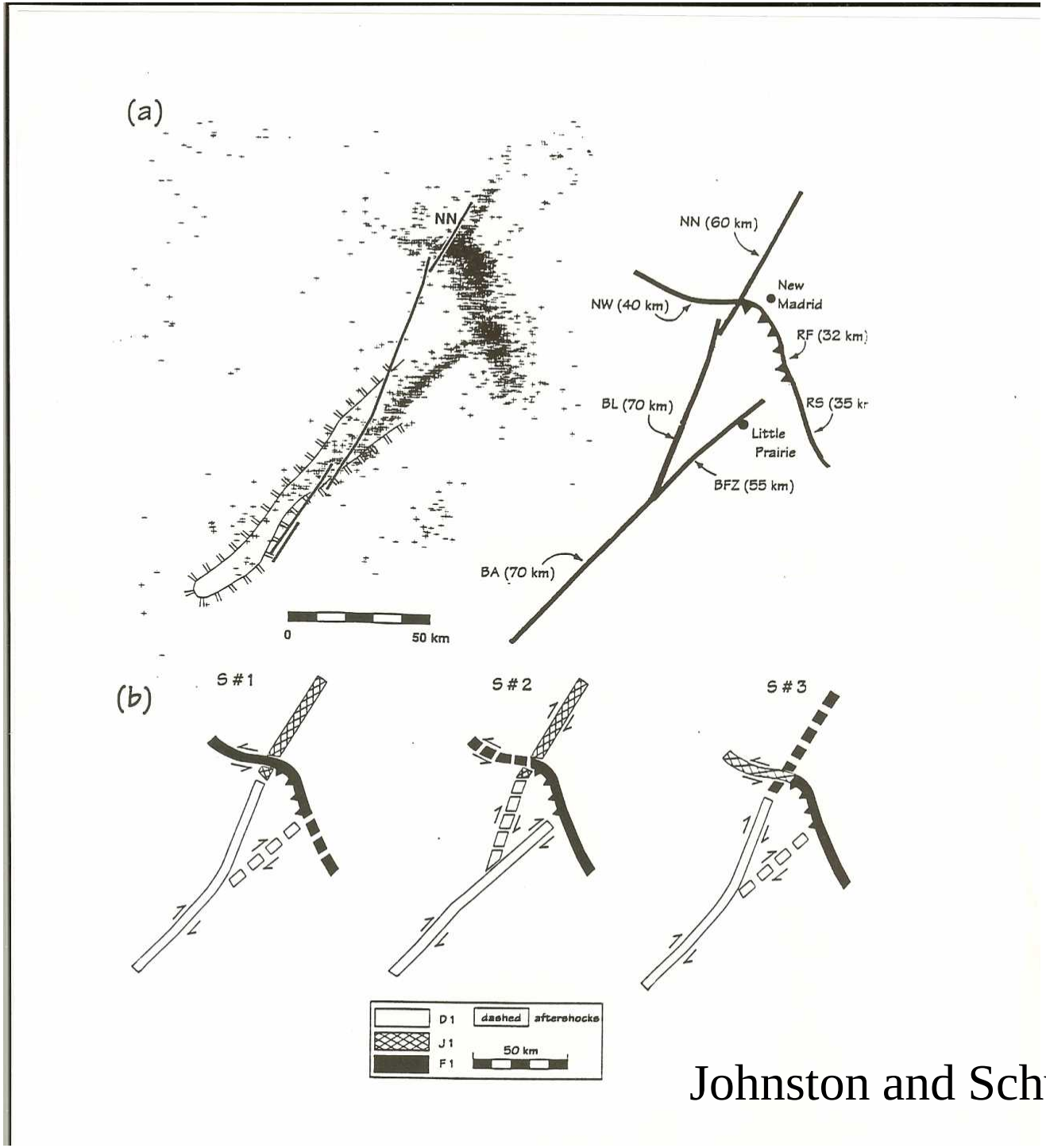
  500 -> 550 years

  does not significantly lower seismic hazard.

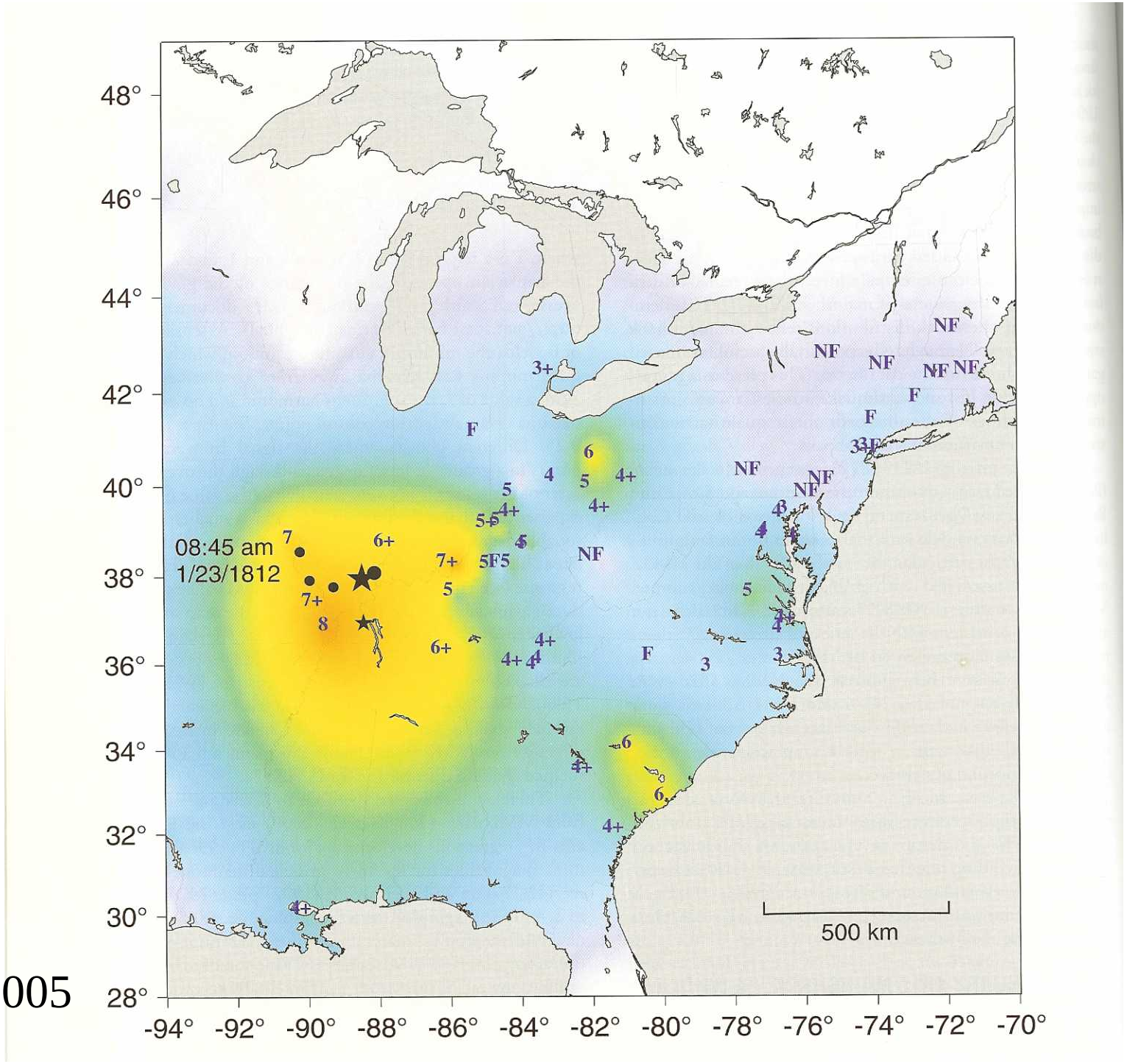
Where did the January 23, 1812 Rupture Occur?

Proposed Rupture Locations

- Where did the January 23, 1812 New Madrid earthquake rupture occur?
  - Johnston and Schweig (1996):
    - Northern New Madrid Seismic Zone
  - Mueller et al. (2004); Hough et al. (2005):
    - White County in Southern Illinois



Johnston and Schweig, 1996



Hough et al., 2005

M7s of 1811-1812 Sequence

1811-1812 M7s

Event	Hough	Bakun	Johnston
Dec. 16, 08:15	7.2-7.3	7.6	8.1
Dec. 16, 14:15	7.0		
Jan. 23, 15:00	7.0	7.5	7.8
Feb. 7, 09:45	7.4-7.5	7.8	8.0

Paleoseismic Evidence

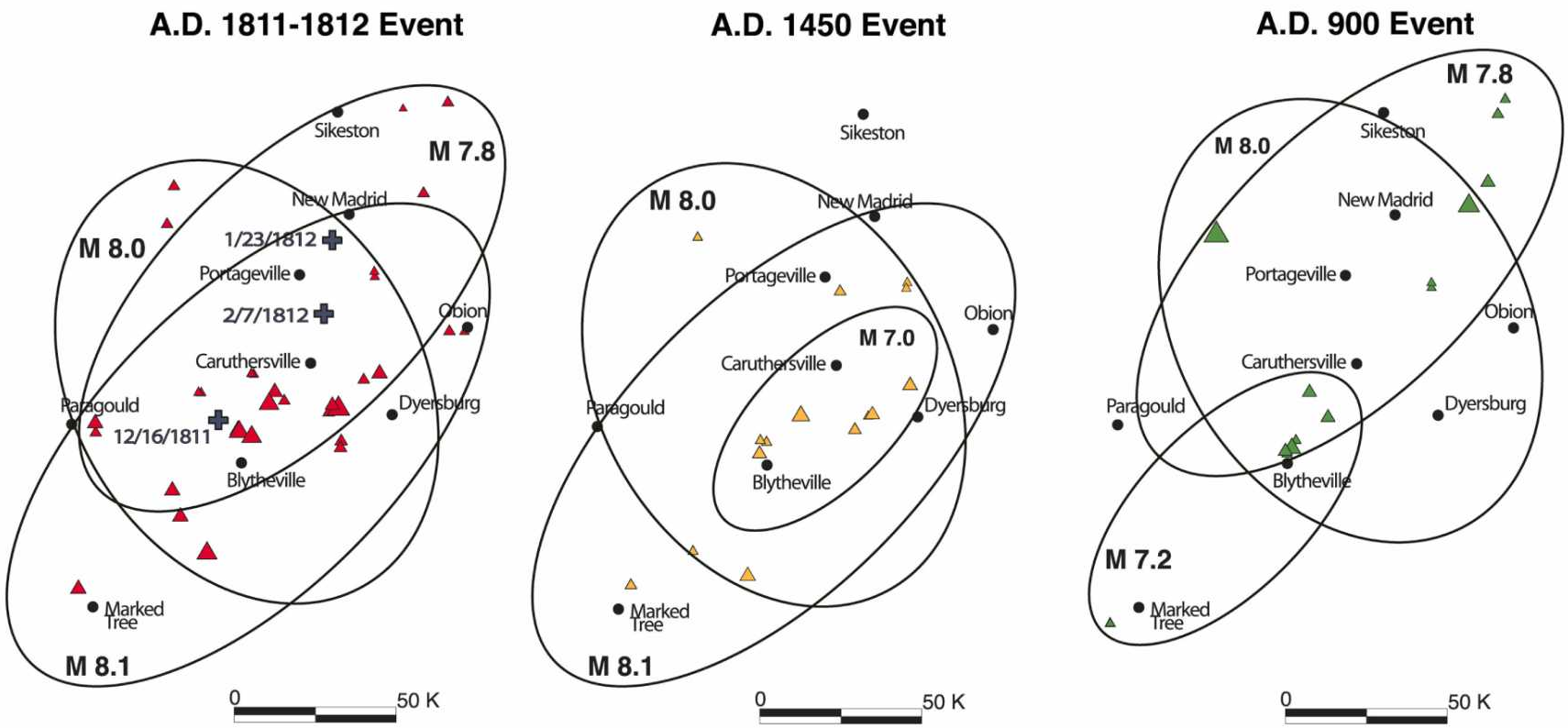


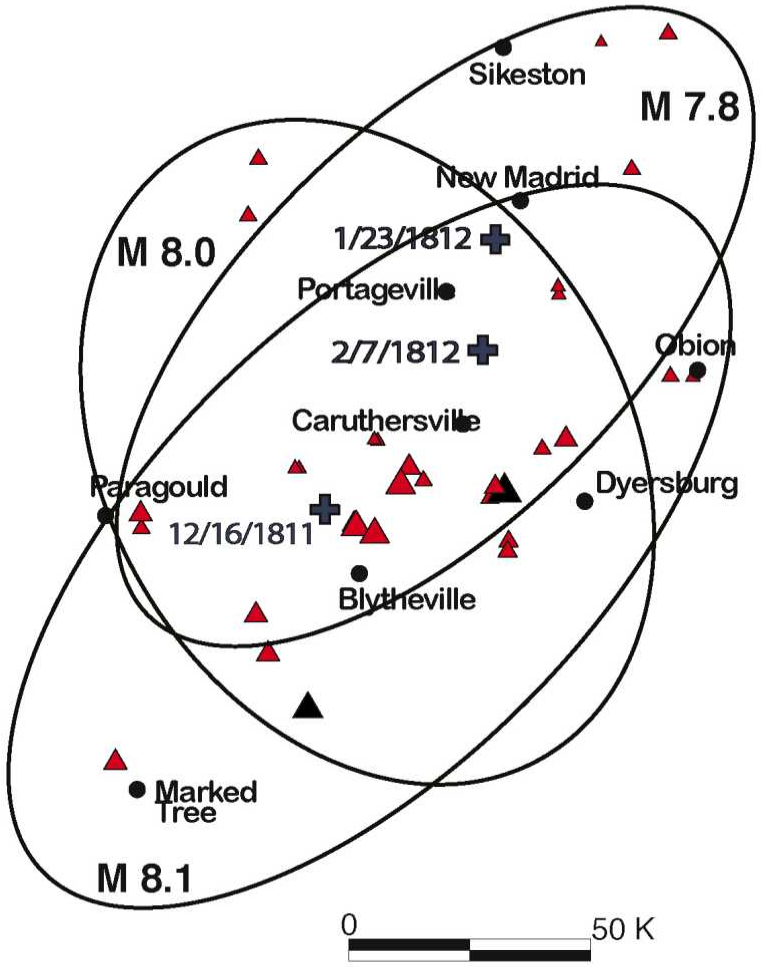
Figure 6. Liquefaction fields for 1811-1812, A.D. 1450, and A.D. 900 events as interpreted from spatial distribution and stratigraphy of sand blows. Magnitudes of individual earthquakes in A.D. 1450 and A.D. 900 are inferred on basis of size of liquefaction fields compared to those related to 1811-1812 earthquakes.

Tuttle et al., 2002

1811-1812 Liquefaction Data

- Tuttle et al. (2002):
  - "composed of one to four, fining-upward depositional units"
    - Three major and one lesser events

A.D. 1811-1812 Event



▲ Sand Blows Composed of 4 Depositional Units (as of 2001)

Modified from Tuttle et al., 2002

Strongest Evidence

- Paleoseismic data of Tuttle et al., 2002 gives the only conclusive evidence that all four M7 New Madrid events occurred in the New Madrid seismic zone.

- However, this is only a general location (NMSZ), not a specific fault that ruptured.

30 Years of CERI Recording: 1975 - 2005

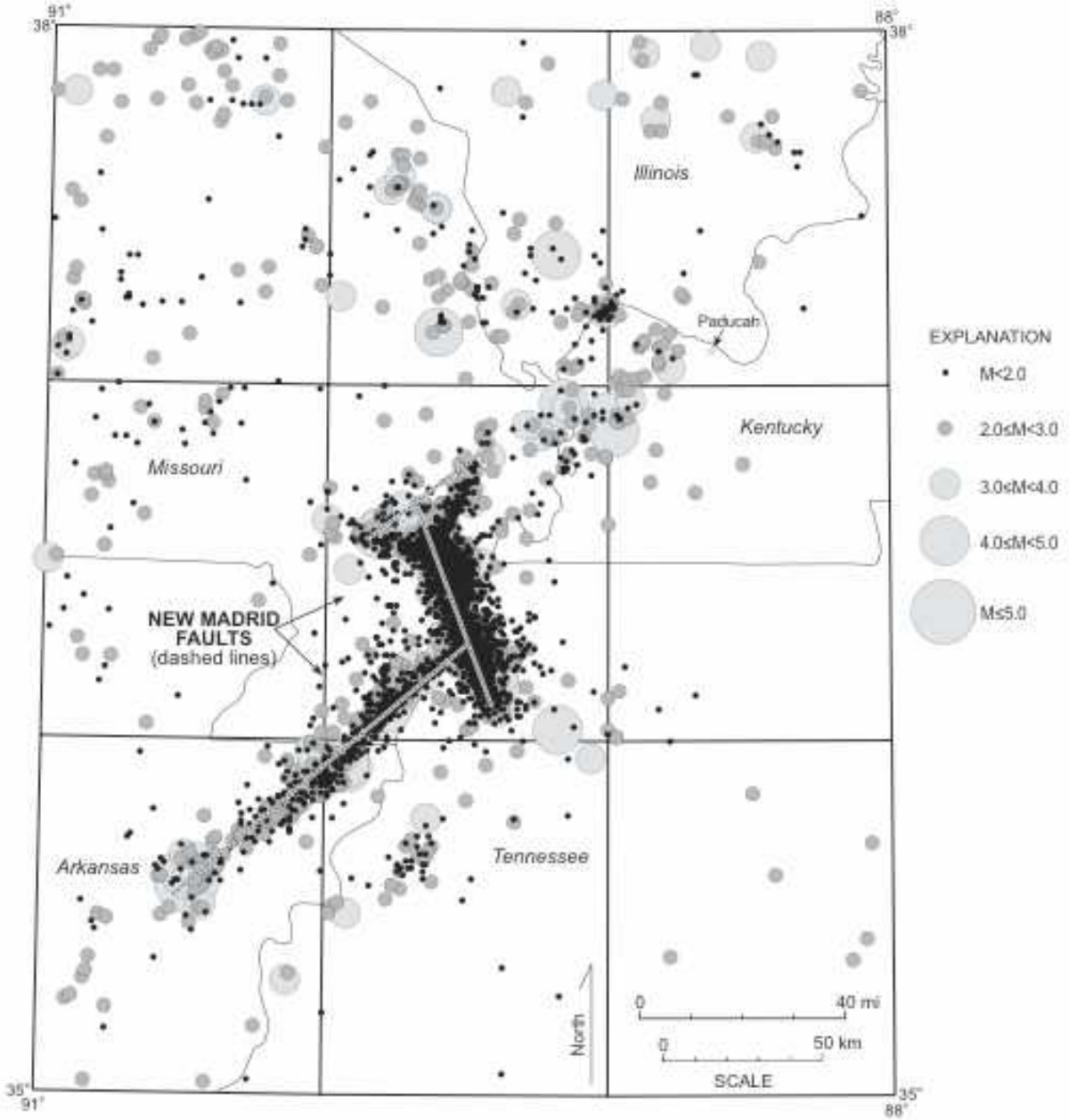
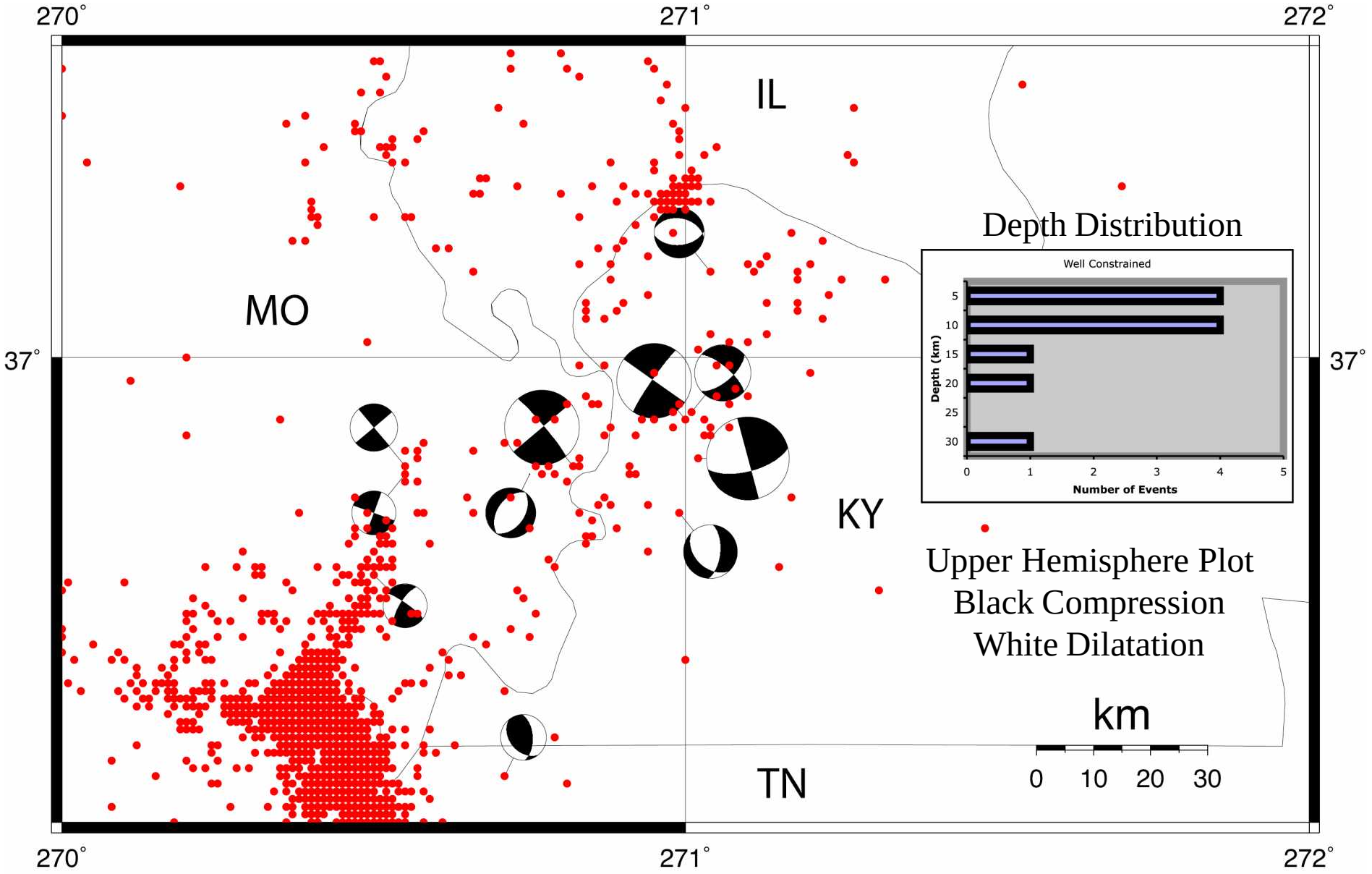


Figure 10. Locations of earthquakes in the central United States since 1974 (from the Center for Earthquake Research and Information).

KGS SP6

Well Constrained



Shumway, 2006

Geological Explanation for White County, Illinois, Liquefaction

Northeastern Termination of Rupture

- Northeast end of short arm of intense activity (~200 km from White Co.)
- Confluence of Ohio and Mississippi Rivers (~150 km from White Co.)
- Ohio River north of Paducah, KY (~100 km for White Co.)

Effect of Magnitude

The larger the magnitude, the longer the duration of strong ground shaking and the greater likelihood of liquefaction in susceptible sediments

Effect of Geology

- Method (see USGS OFR 2004-1294):
  - Use Three Reference Profiles
    - Quaternary Embayment
    - Tertiary Embayment
    - Outside Embayment
  - Use Depth to Bedrock to Constrain Sediment Thickness
  - Determine Median Amplification for Scenarios (equivalent linear analysis)

Effect of Geology

- Site Specific Constraints:
  - Memphis (~1 km of sediments)
  - Paducah (100 m of sediments)
  - White Co.
    - Sediment thickness of 50 m (Hough et al., 2005)
    - Vs Profile (provided by Rob Williams):

      177 m/s at 0 m

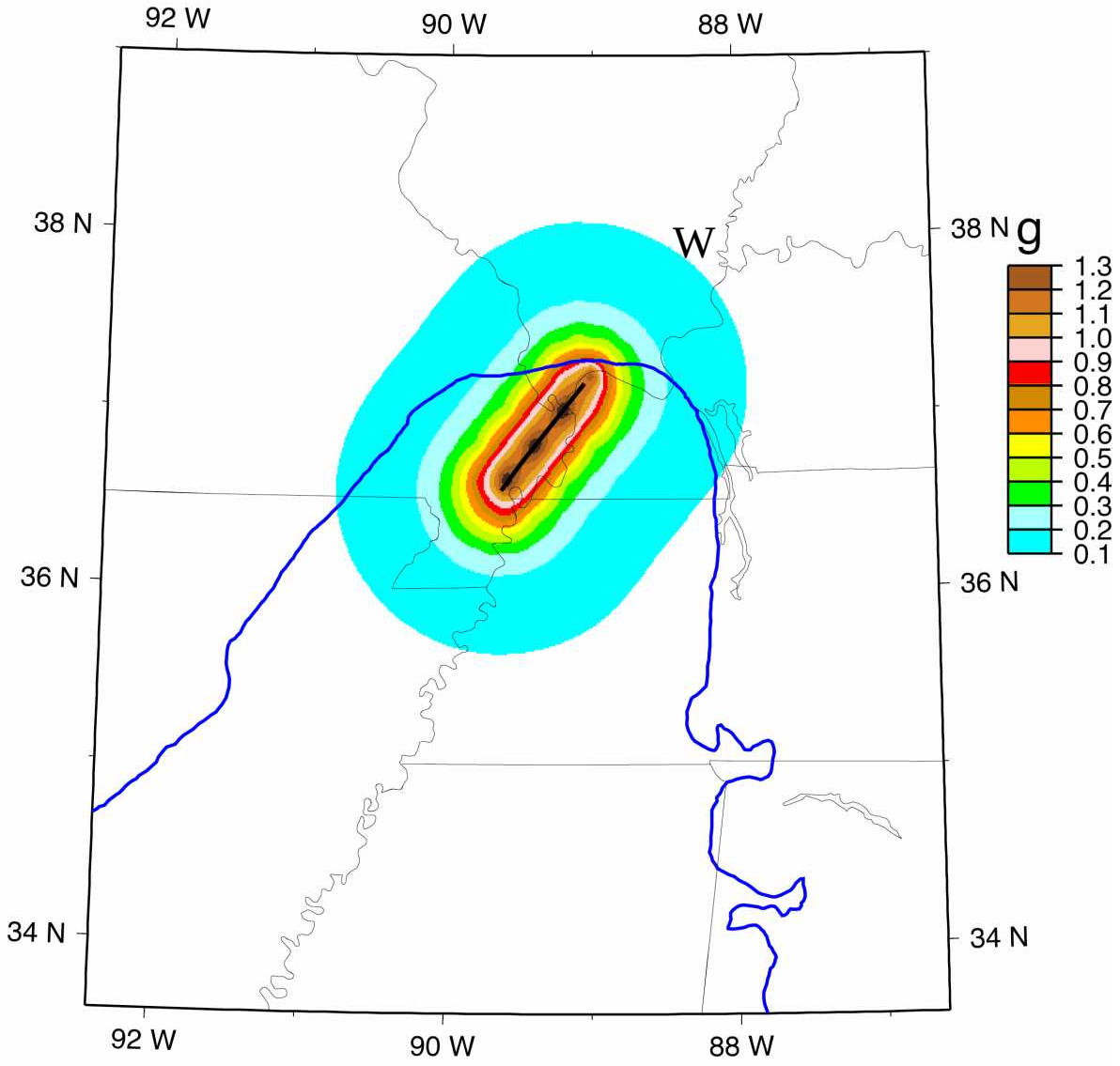
      228 m/s at 4 m

      280 m/s at 12 m

      520 m/s at 28 m

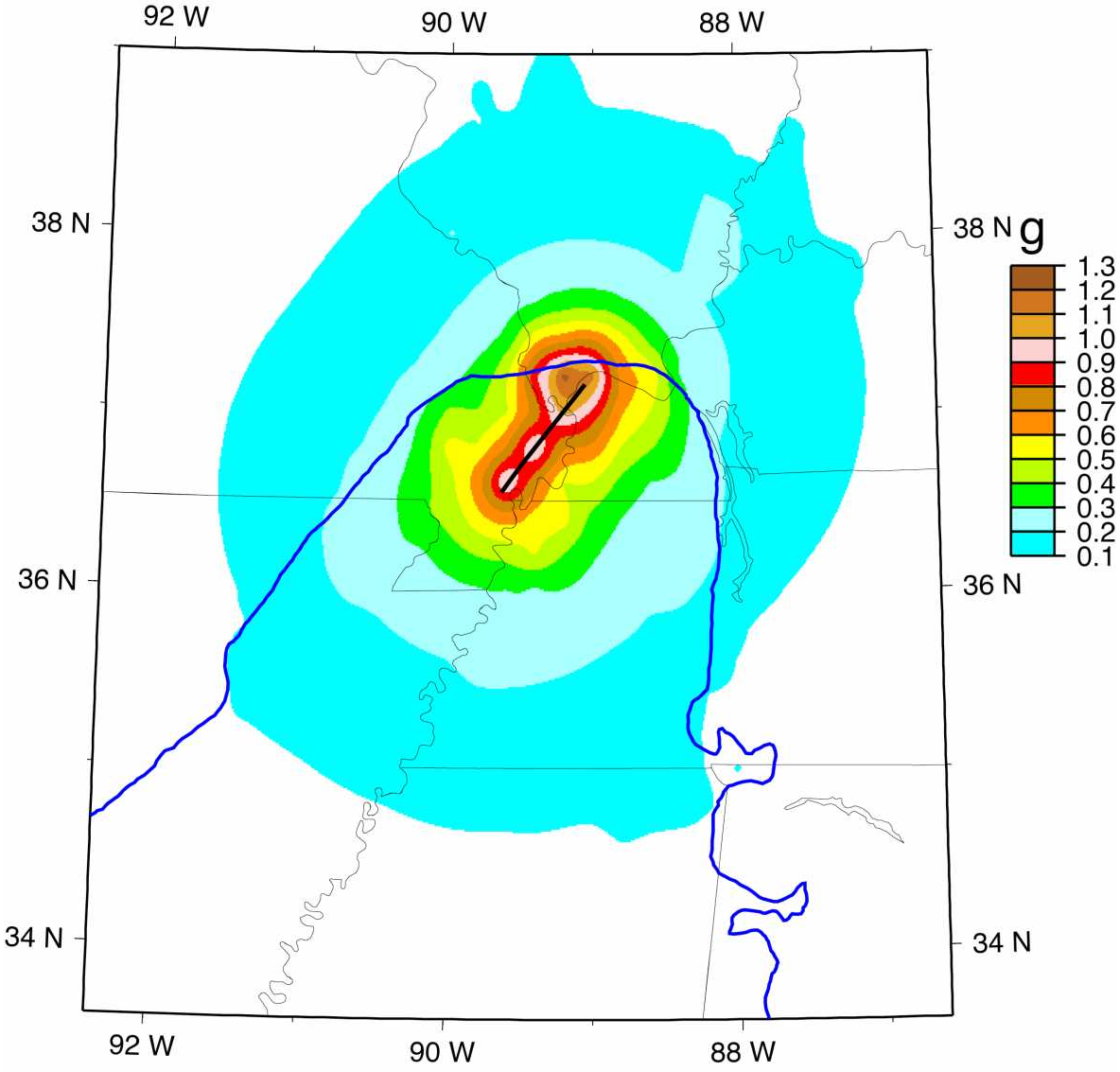
      2.8 km/s at 50 m

NMNEI M7.5 PGA HR Scenario Map



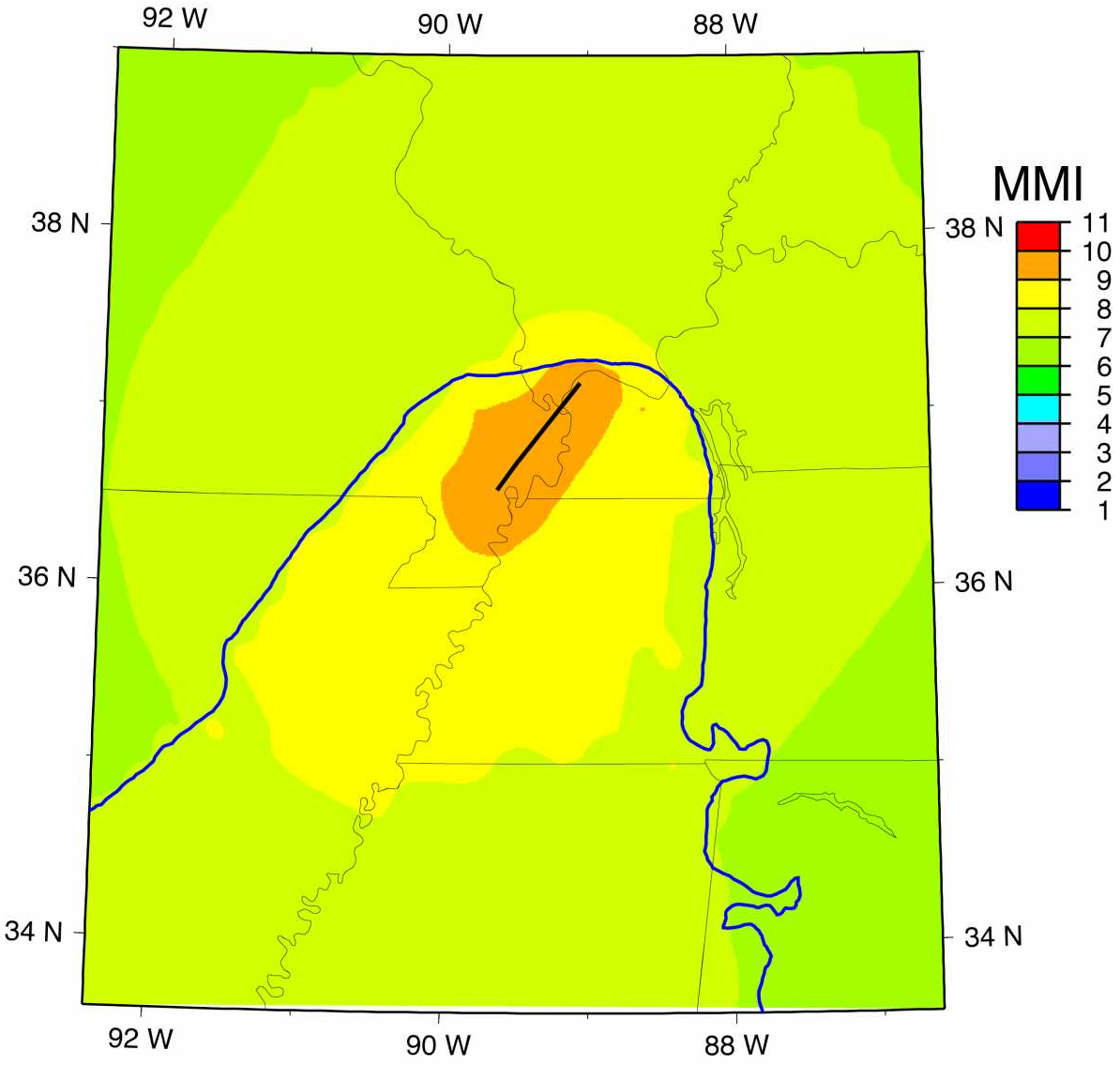
Scenario PGA Hazard Map

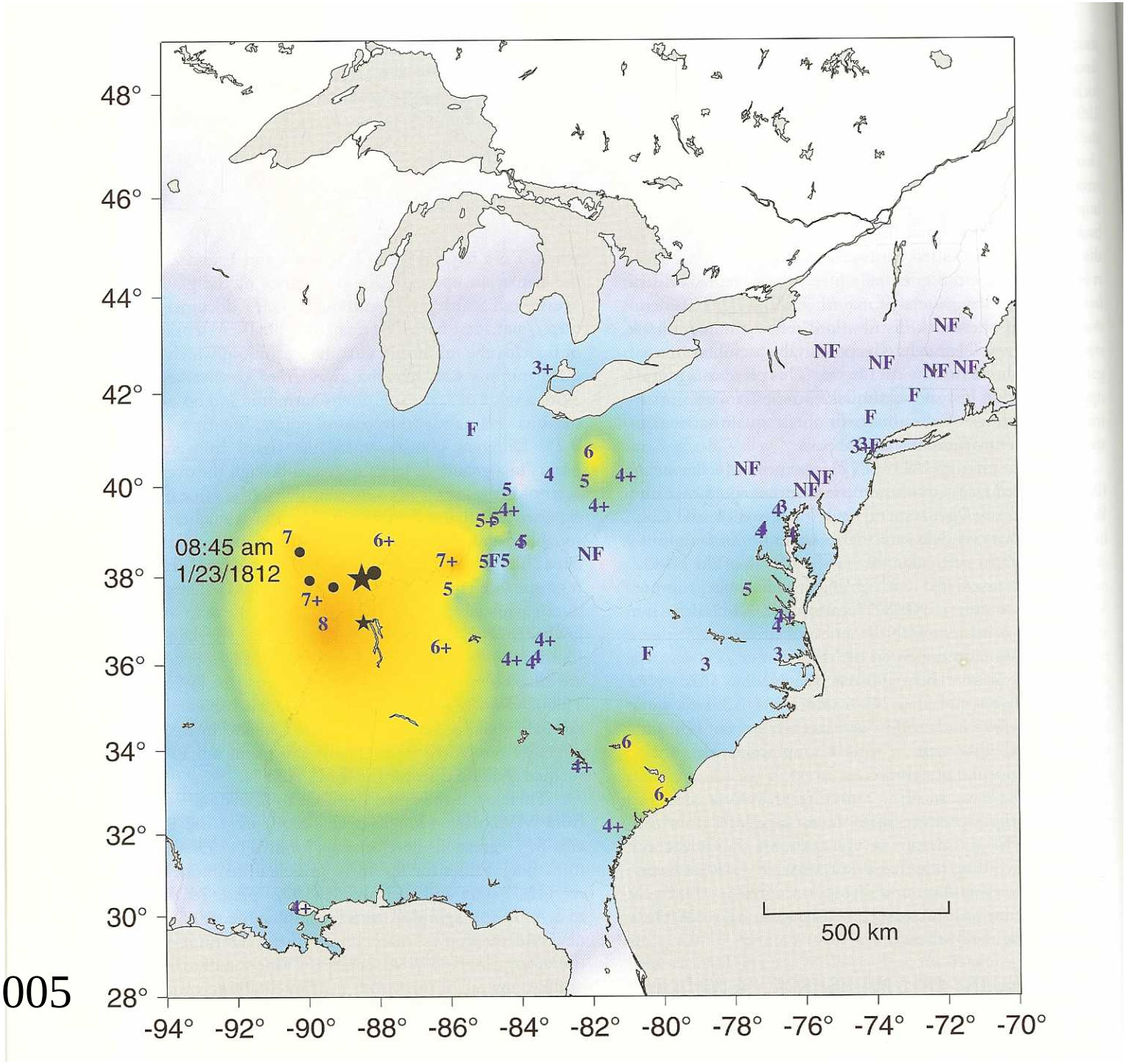
NM NEl Segment, M7.5, w/ Geology



Scenario MMI Hazard Map

NM NEl Segment, M7.5, w/ Geology





Hough et al., 2005

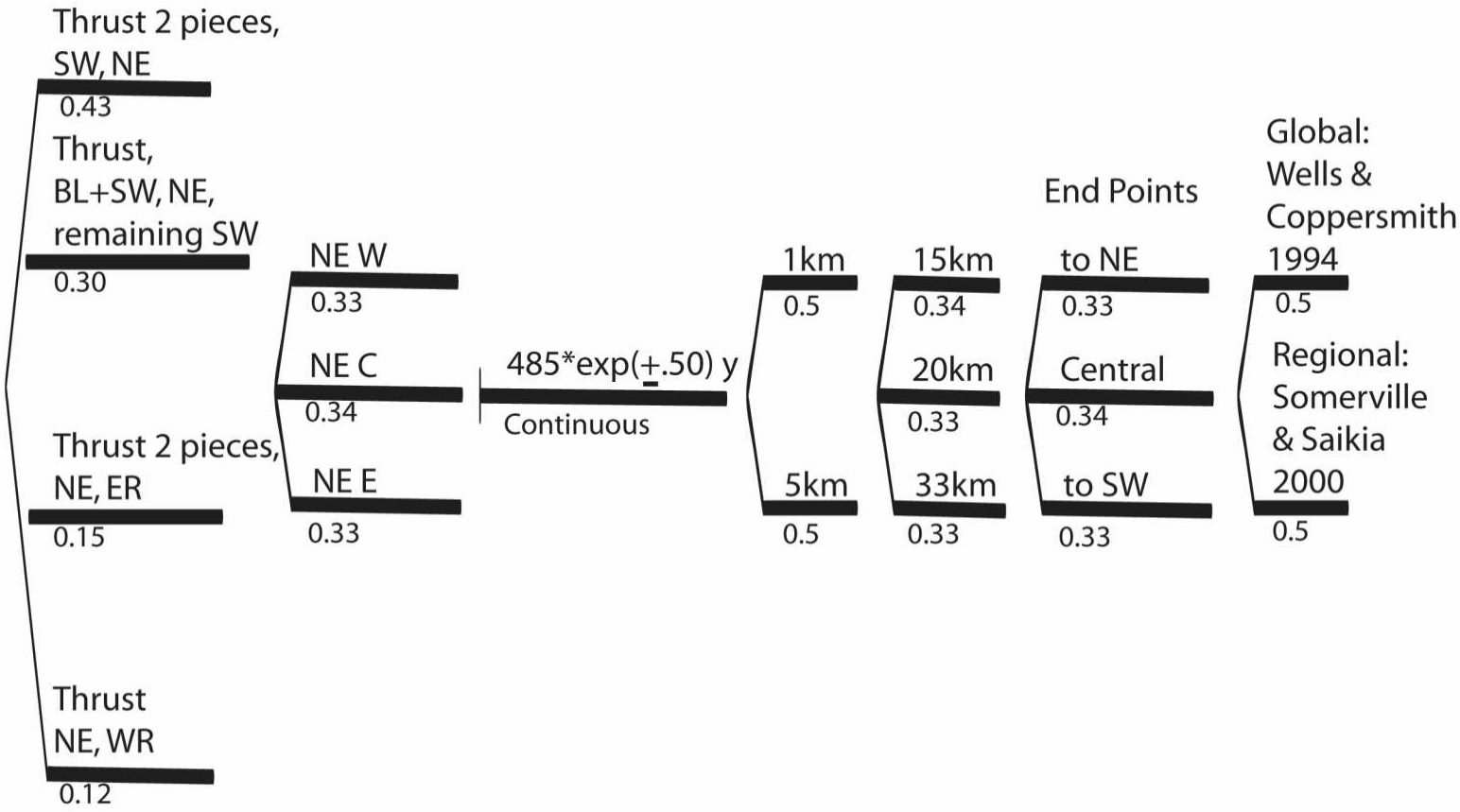
Suggestion for Actual Faults Alternatives Branches

- Rupture Alternatives update from Cramer, 2001
- Rupture area uncertainty
- Magnitudes from rupture areas

New Madrid Real Faults Branches

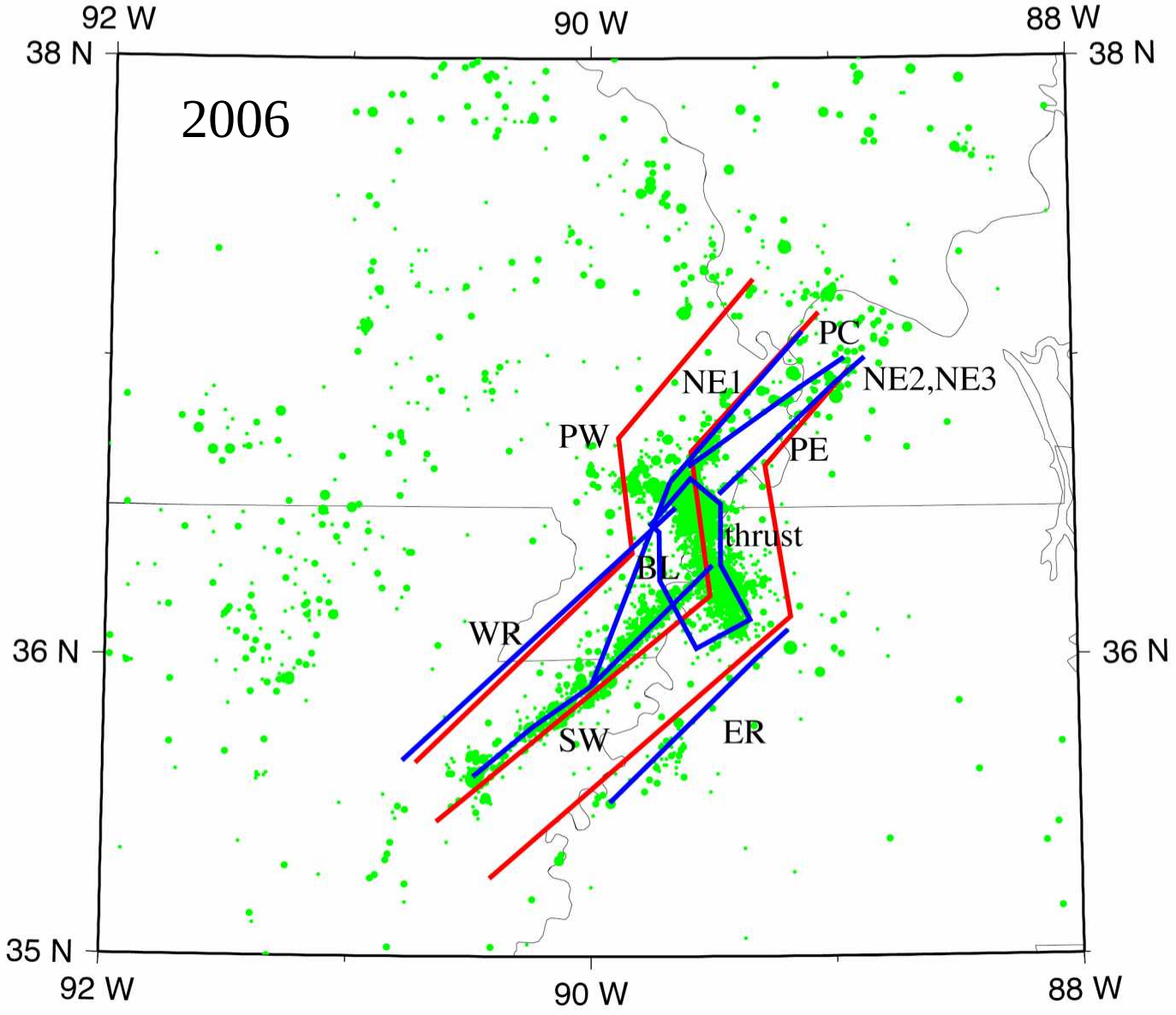
1811-1812 Rupture Model	Recurrence Interval	Seismogenic Width	Fault Length Variability	Characteristic Magnitude

Suggested Alterative Source Model



NMSZ Alternative Sources

Blue - Actual Flts; Red - Pseudo-Flts; Green - Eqks



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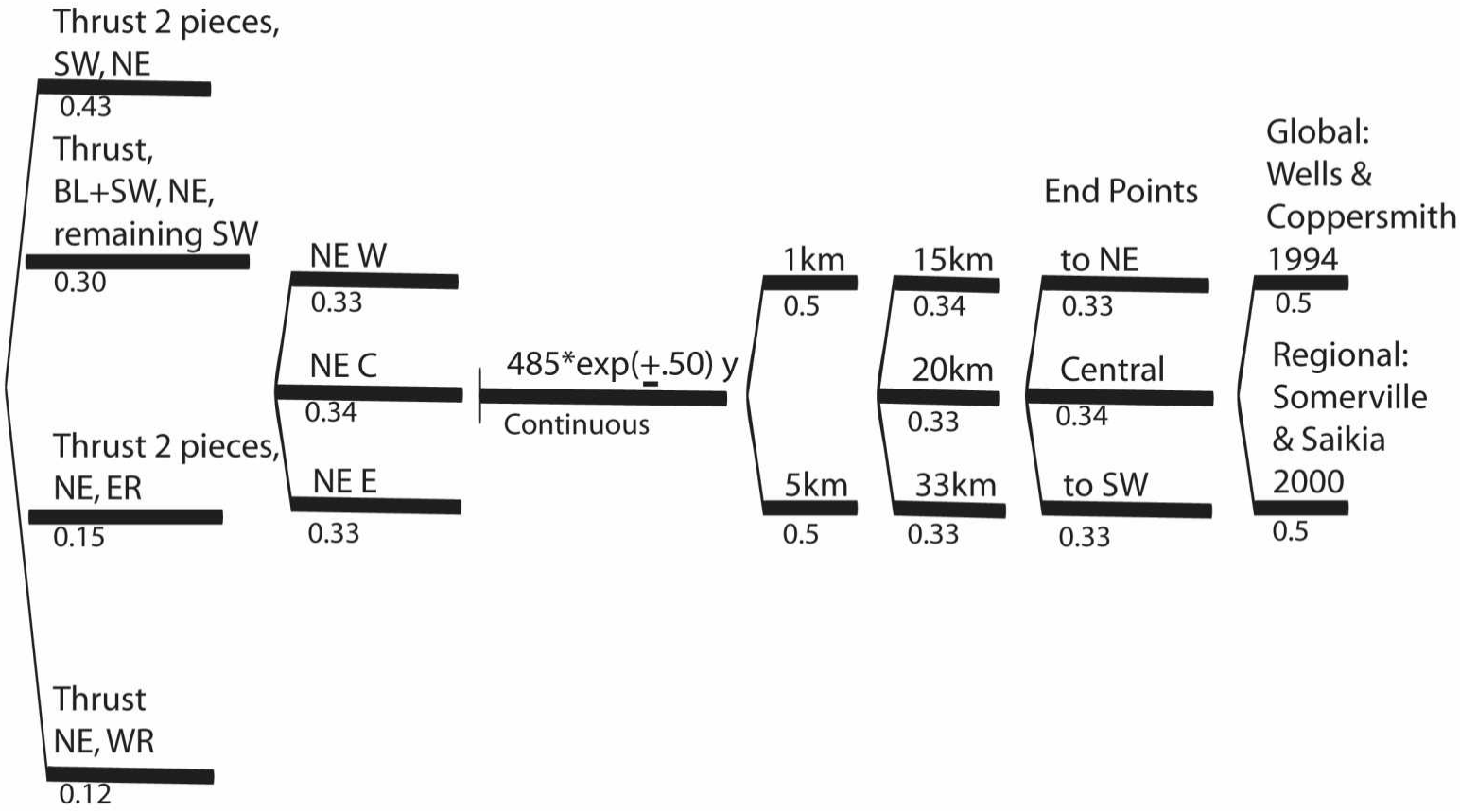
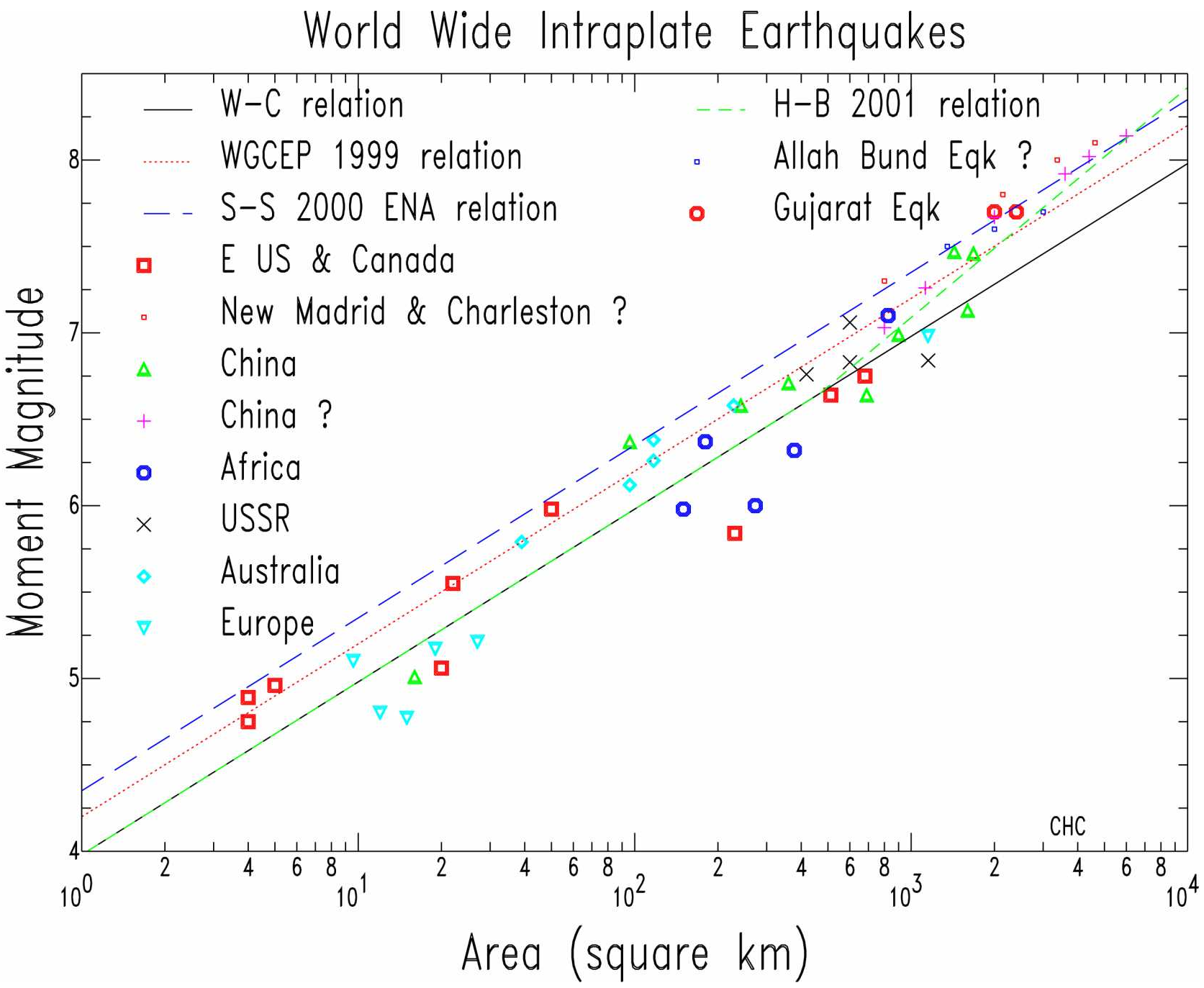
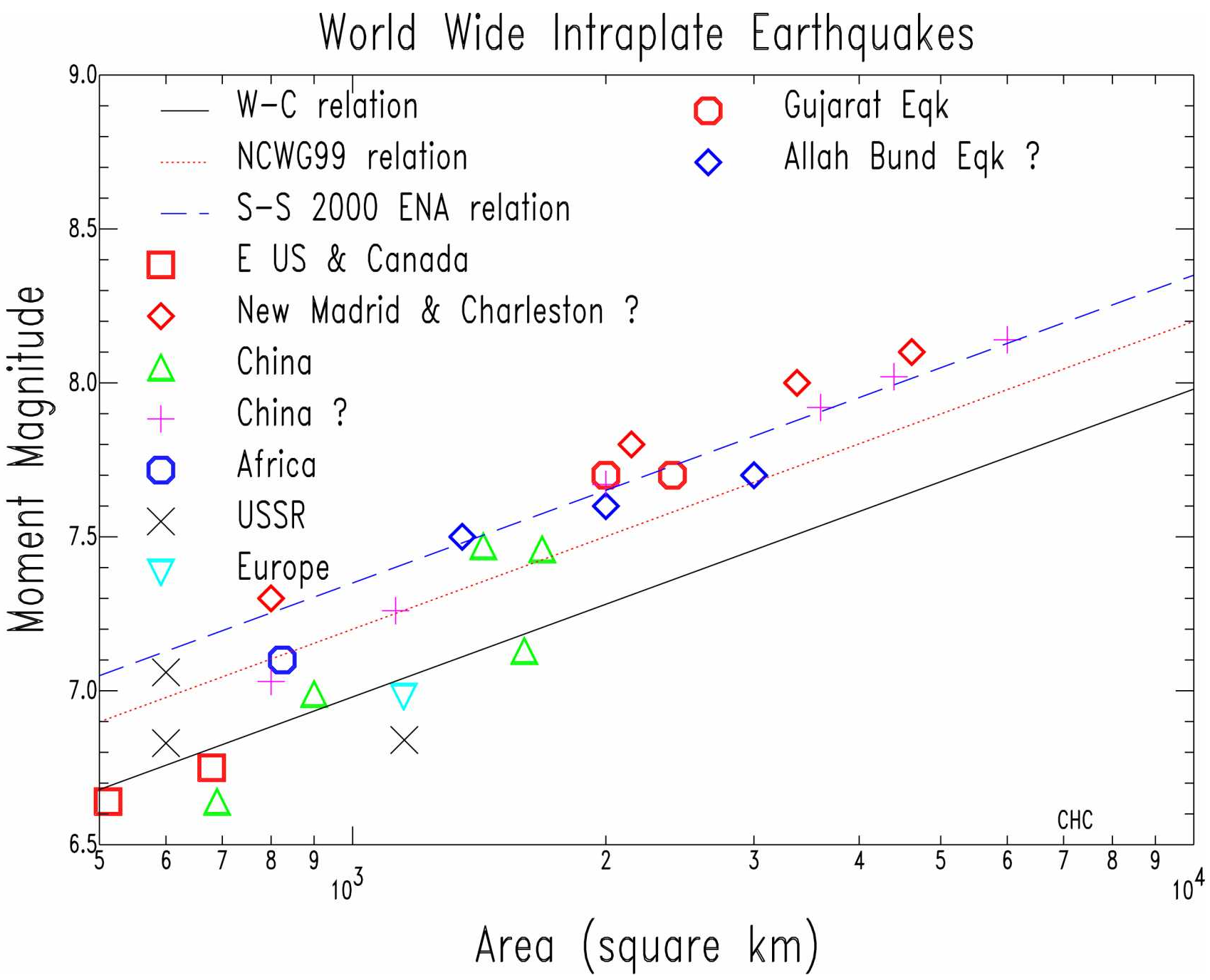



World Wide Intraplate Earthquakes
W-C relation
WGCEP 1999 relation
S-S 2000 ENA relation
E US & Canada
New Madrid & Charleston ?
China
China ?
Africa
USSR
Australia
Europe
H-B 2001 relation
Allah Bund Eqk ?
Gujarat Eqk
Moment Magnitude
Area (square km)
CHC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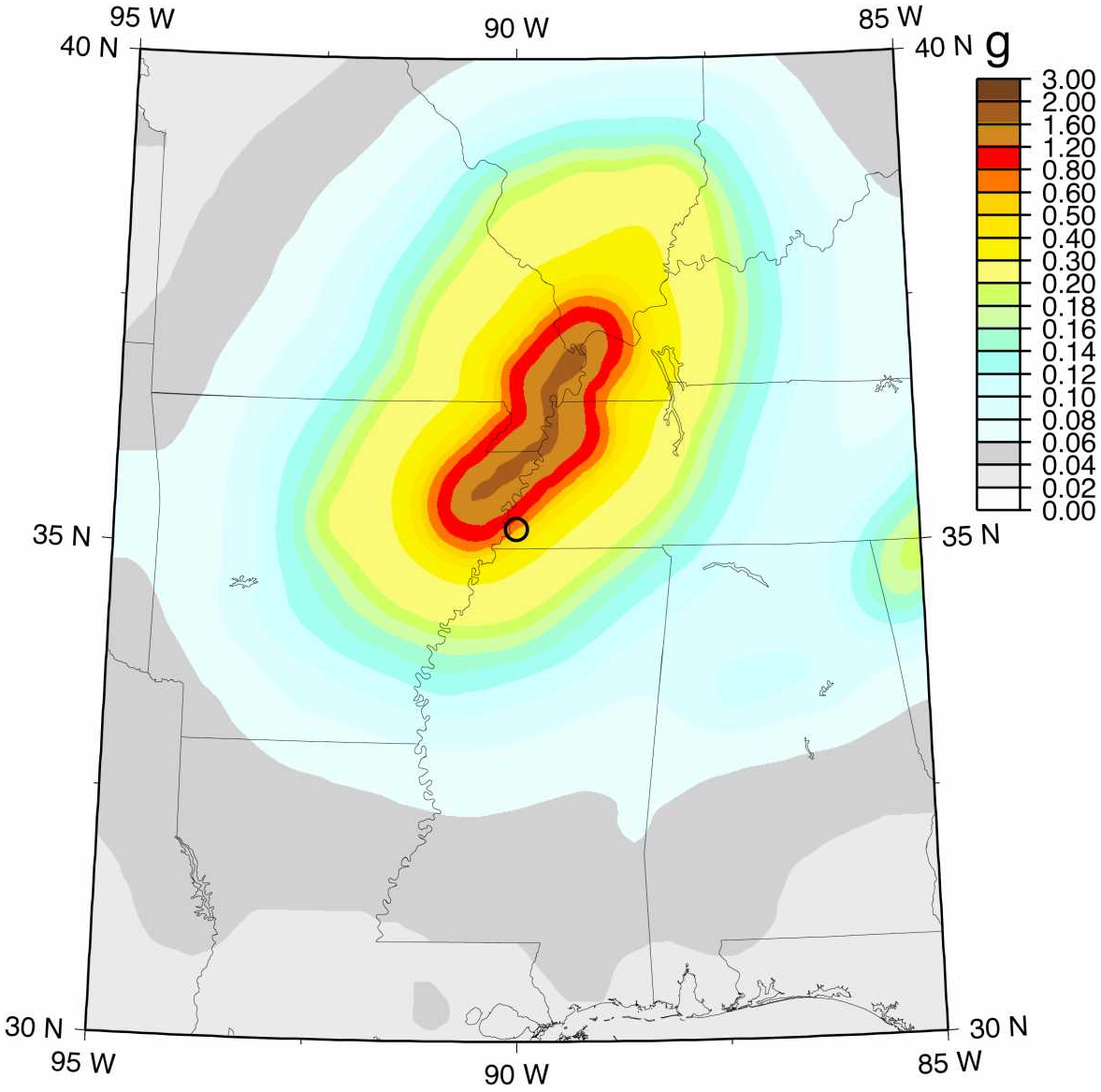
Allah Bund Eqk ?
Moment Magnitude
9.0
8.5
8.0
7.5
7.0
6.5
5
6
7
8
9
10^3
2
3
4
5
6
7
8
9
10^4
Area (square km)
CHC

2% in 50y PGA Hazard Map

Logic Tree, 2002



2% in 50y PGA Hazard Map

Logic Tree, 2006 w/ real faults