Workshop on Central and Eastern U.S. Seismic Hazard- National Seismic Hazard Maps

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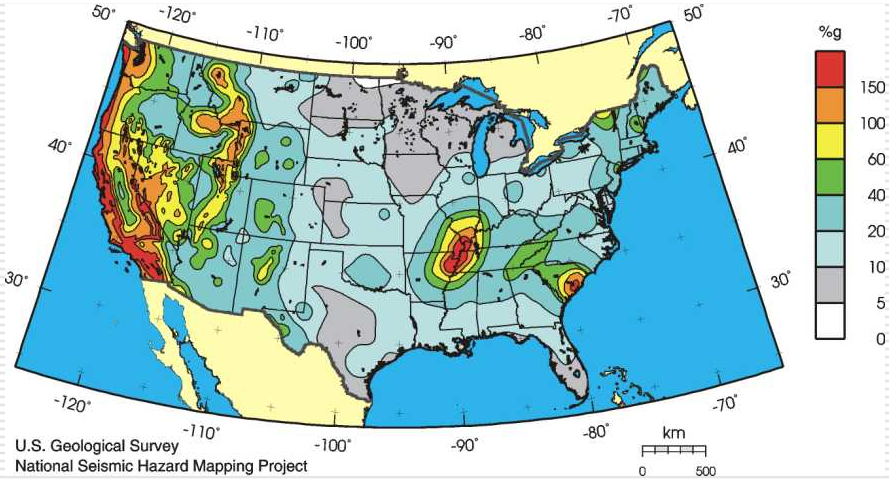
U.S. Geological Survey



Thanks to John Ebel, Chris Cramer, Art Frankel, and Chuck Mueller

Boston, MA May 9-10, 2006

http://earthquake.usgs.gov/hazmaps

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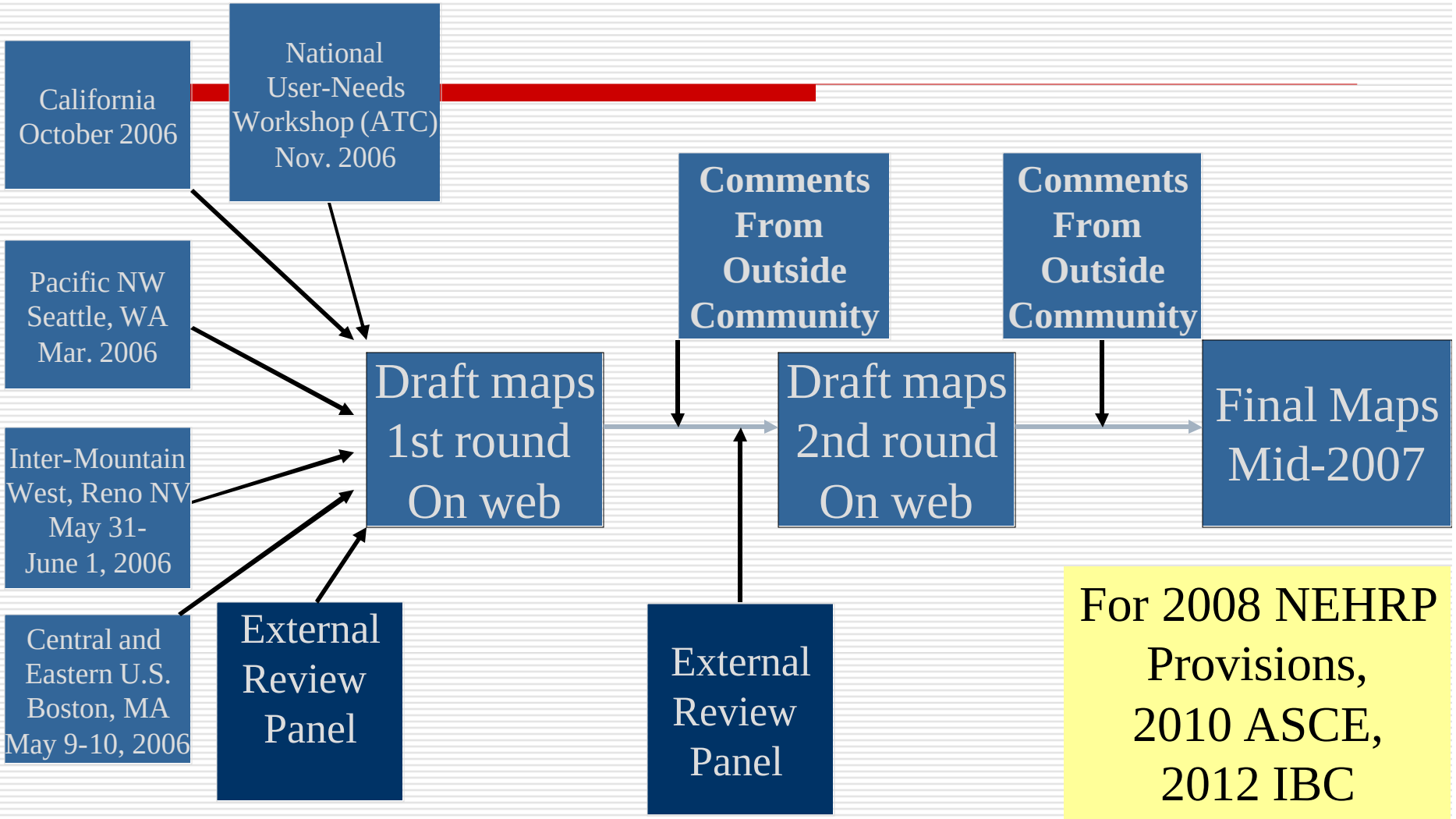
Process for 2007 Maps



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Issues for the Central and Eastern U.S. Hazard Maps

TUESDAY

- Northeast U.S. sources
  (paleoliquefaction data, NE Seismicity models, SE Canada seismicity, 1755 Cape Ann earthquake - M 5.8-6.3)
- New Madrid sources
  (seismicity, paleoliquefaction, intensity, GPS data, logic tree – clustered earthquakes)
- Charleston sources
  (new information and models)
- Other sources
  (three potential new sources: SW Memphis, E side of Reelfoot Rift, Saline River)
- User issues and discussion
  (Risk modeling, Building Code, State surveys, Modeling and catalog issues)

WEDNESDAY

- New attenuation relations
  (Atkinson and Boore, Toro et al., Frankel et al., Tavakoli and Pazeshk, Campbell, EPRI)
- Near-field ground motions and modeling parameters
  (addition of finite fault sources, stress drops and kappa for CEUS earthquakes, aleatory random uncertainty issues)
- Weighting schemes for attenuation relations
  (epistemic uncertainty - by methodology, by data)

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Summary

- Maximum magnitude for extended margin?
- New Madrid logic tree (magnitudes, rupture frequency, source location)
- Earthquake Clustering models
- Better documentation
- Better specification of uncertainty
- Weighting of attenuation relations

1996-2002 Methodology

- Seismicity Models: b=0.95;
  - 1. Smoothed Mb 3 since 1924 (wt=0.4)
  - 2. Smoothed Mb 4 since 1860 (wt=0.2)
  - 3. Smoothed Mb 5 since 1700 (wt=0.2)
  - 4. background zone- craton (Mmax7.0) and extended crust (Mmax7.5), Adaptive weighting avoids lower hazard in higher seismicity areas -wt=0.2 (low) or 0.0 (high seismicity)
- Special zones: Eastern Tennessee Mb 3 since 1976; Wabash Valley zone (Mmax7.5); Charlevoix (b=0.76)
- Large earthquake source models M 7: New Madrid (M7.3-8.0, 500yrs); Charleston SC (M6.8-7.5, 550 yrs); Meers fault in OK (M7, 4000yrs); and Cheraw fault in eastern CO (0.5mm/yr, Mchar 7.1)

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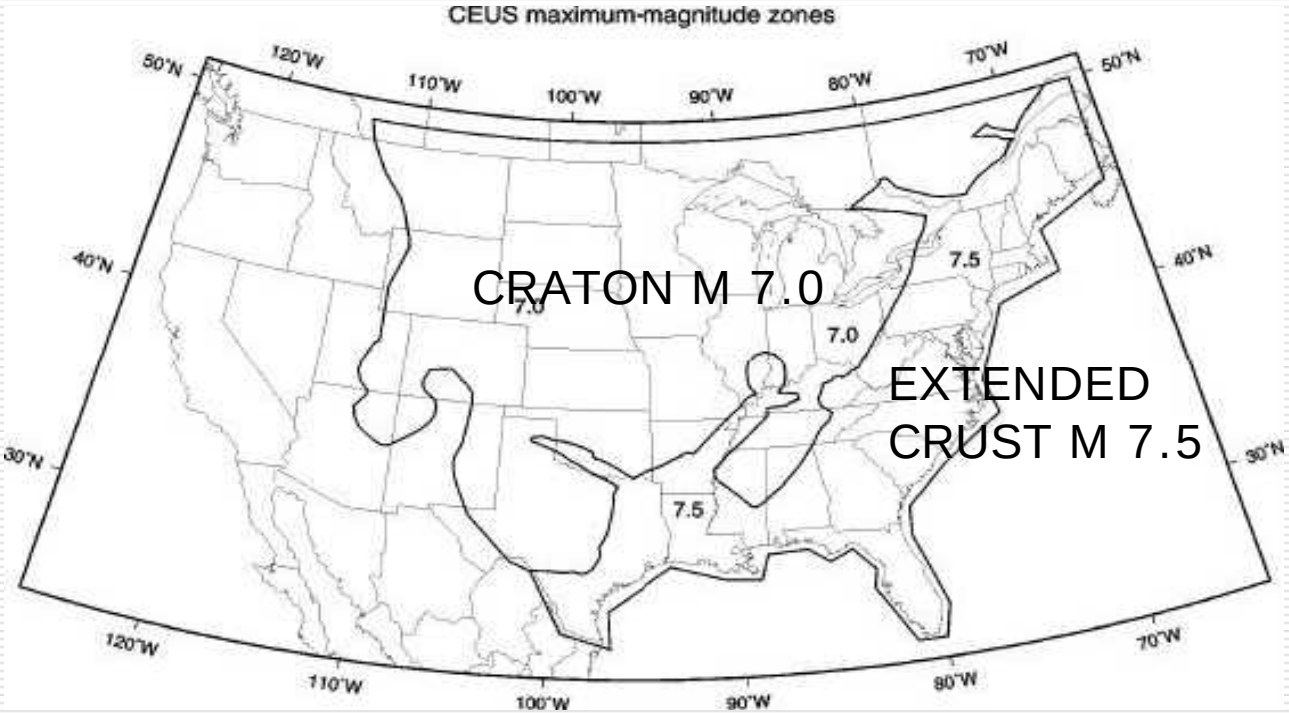
BACKGROUND SOURCE ZONES



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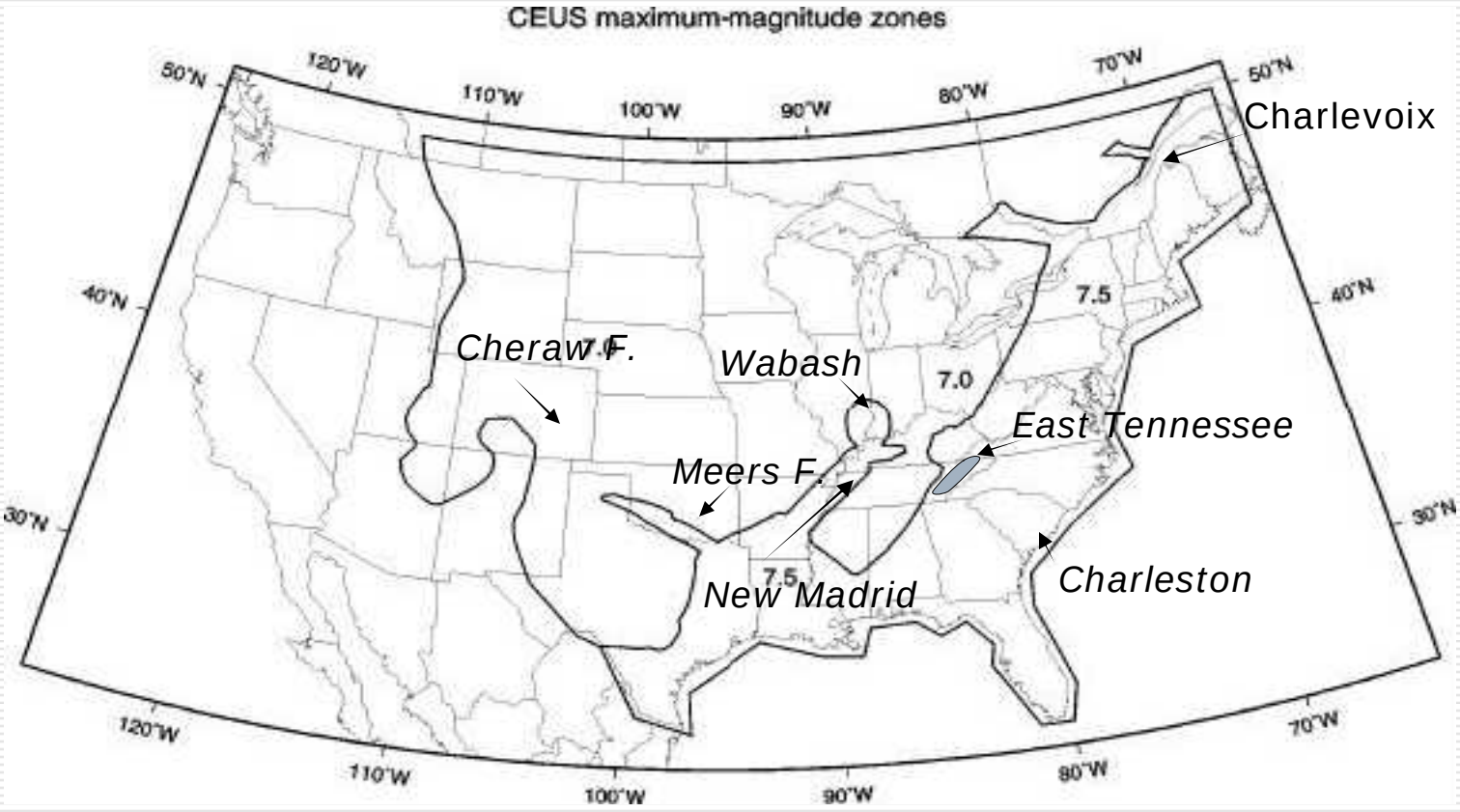
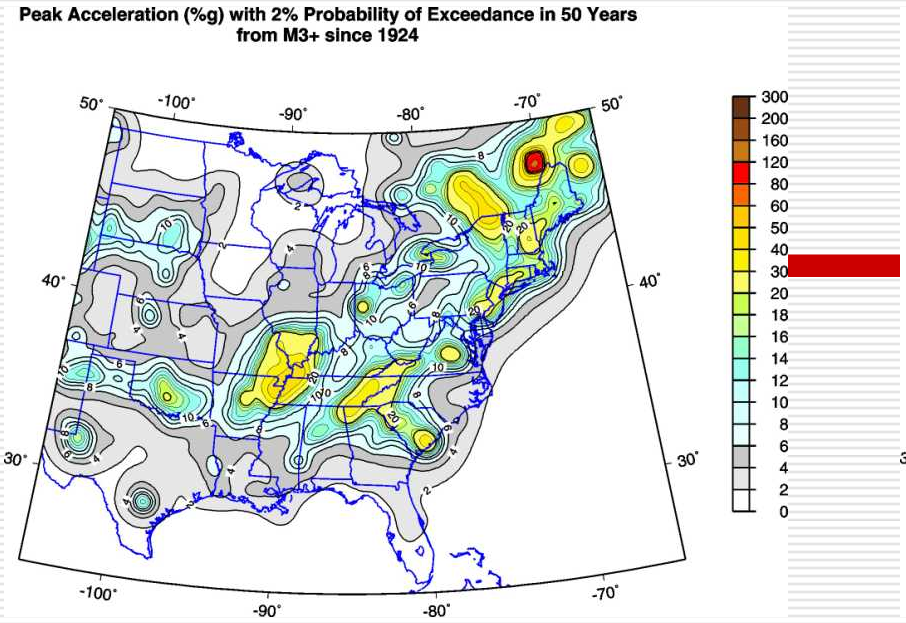
SPECIAL ZONES AND FAULTS



MODEL 1



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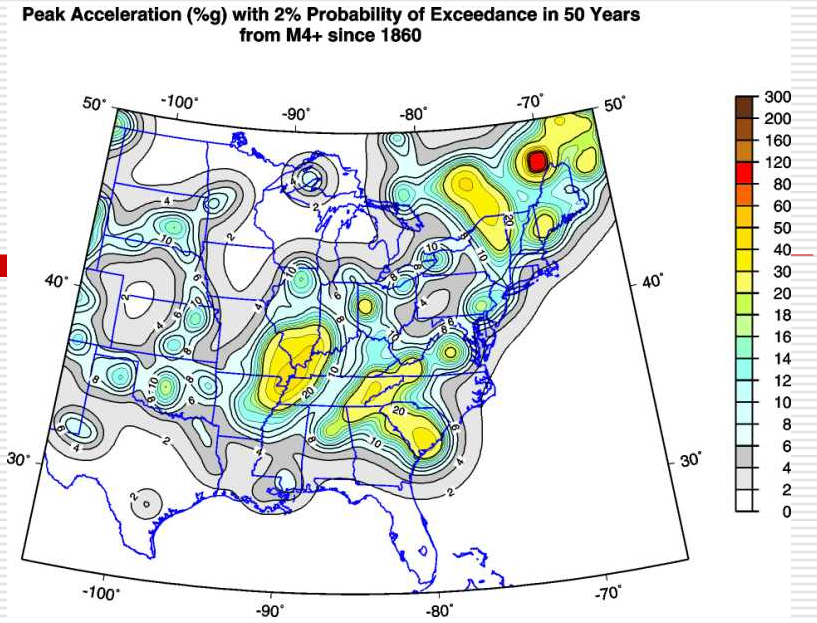
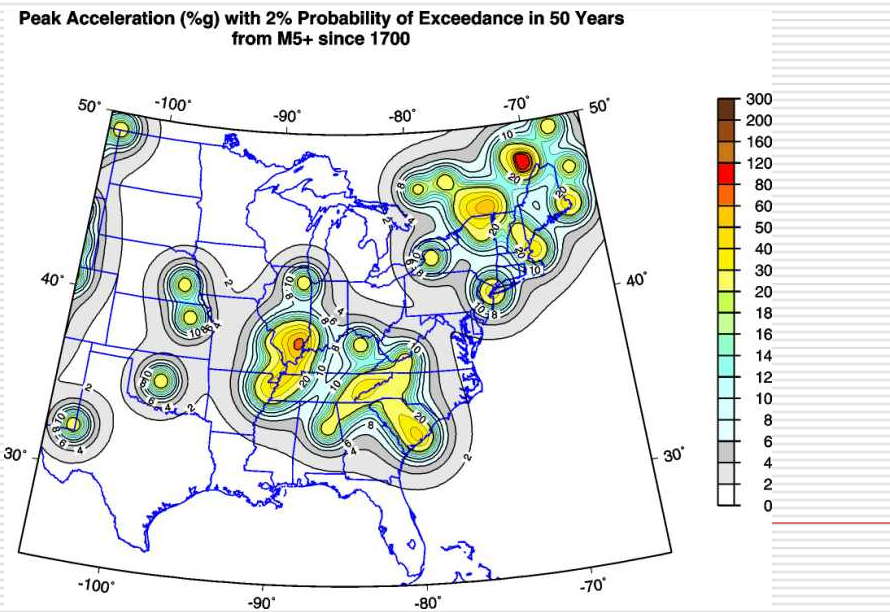
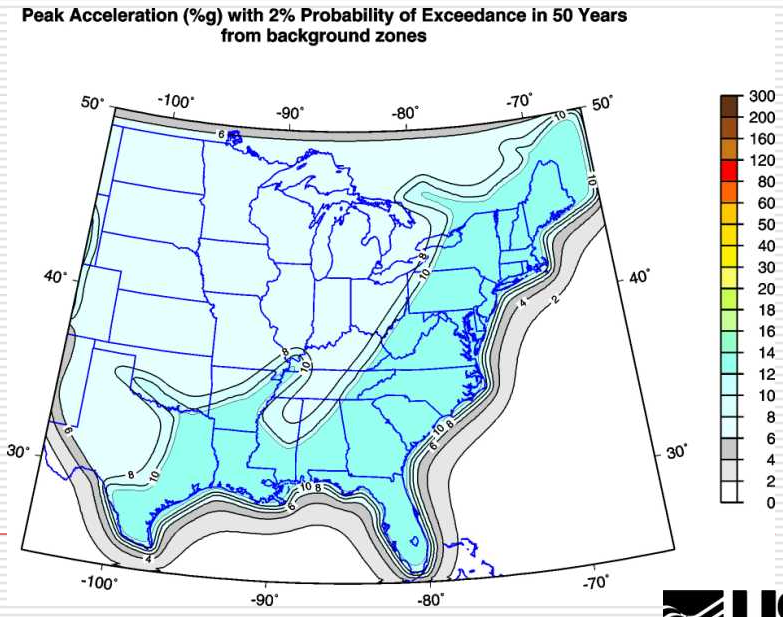


MODEL 3



MODEL 4



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Earthquake chronologies from historical accounts and paleoliquefaction evidence

- New Madrid: large earthquakes in 1811-1812, 2-3 similar sequences since 500 A.D. (Tuttle et al., 2002); about 500 year average recurrence time for M7.5-8.0

- Charleston, SC: large earthquake in 1886, 2 similar earthquakes since 1000 A.D and 5 other liquefaction producing eq's over past 6000 yr (Talwani and Schaeffer, 2001); about 550 year average recurrence time for M6.9-7.5

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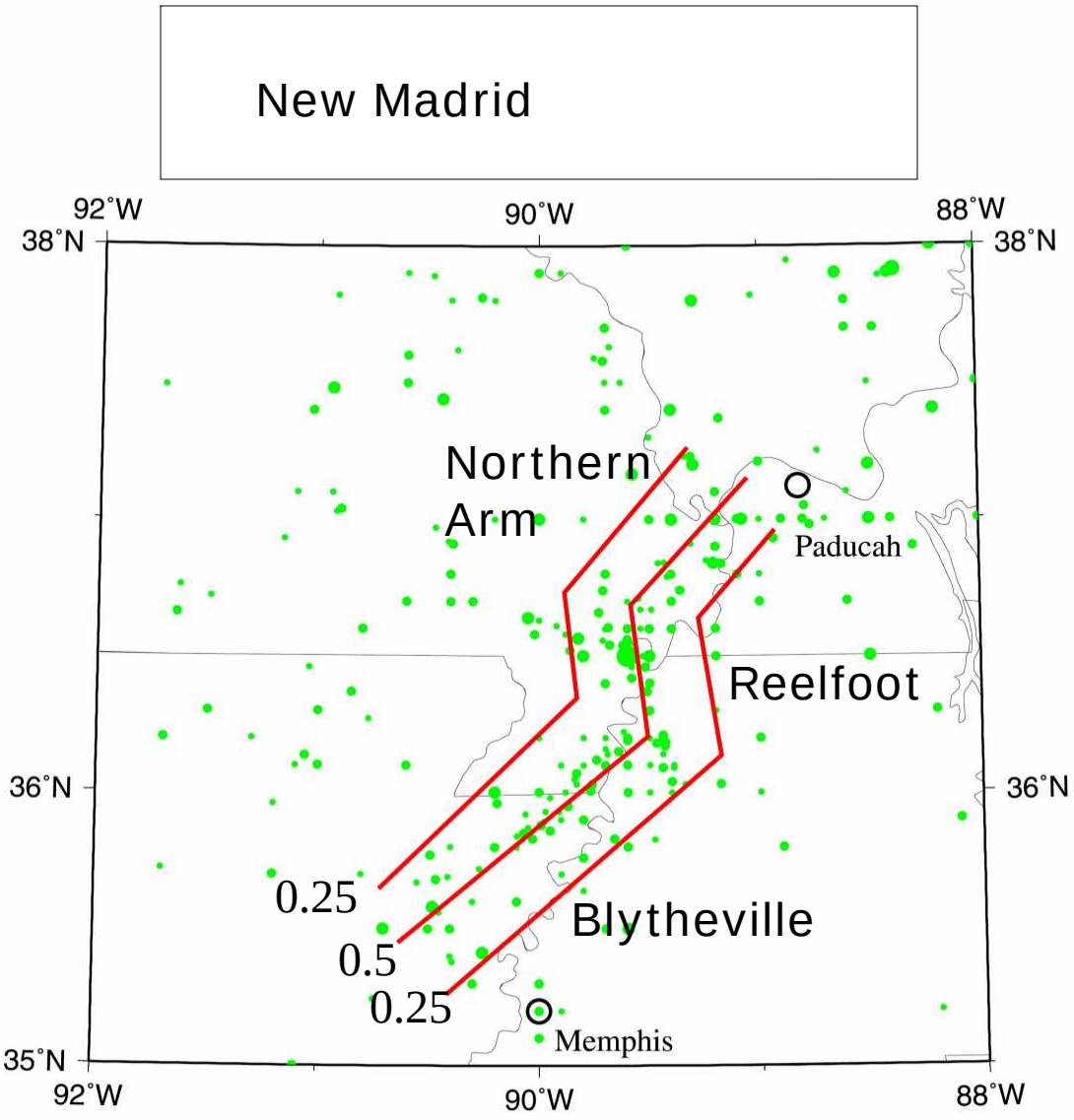

M7.3-8.0, 500 yr

Mag	wt
M7.3	(0.15)
M 7.5	(0.2)
M 7.7	(0.5)
M 8.0	(0.15)

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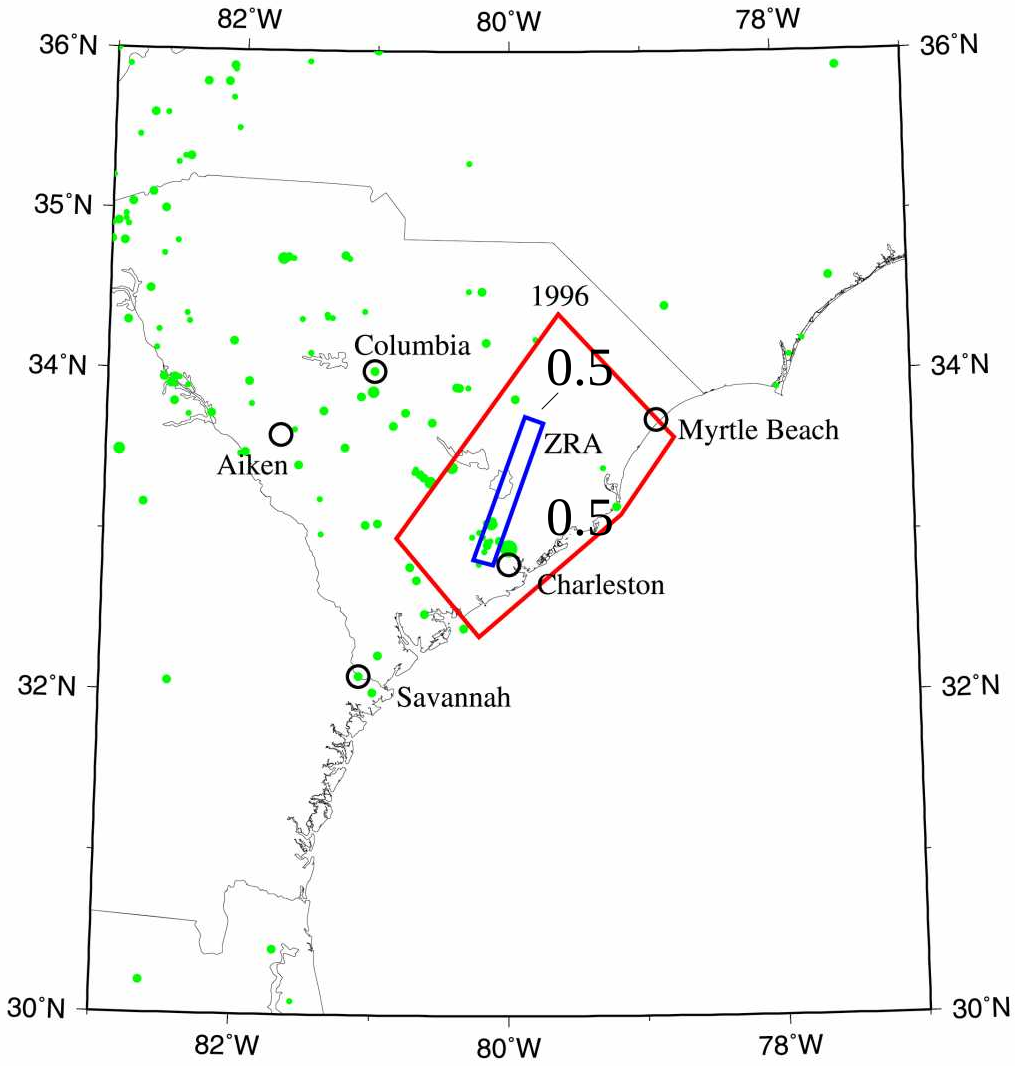
CSZ Alternative Sources

Blue - ZRA Zone; Red - 1996 Zone; Green - Eqks



M 6.8-7.5, 550 yrs

Mag	wt
M 6.8	(0.2)
M 7.1	(0.2)
M 7.3	(0.45)
M 7.5	(0.15)

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CEUS Attenuation Relations

2002

- Toro et al. (1997)
  wt (seis)=0.286, wt (char)=0.25
- Frankel et al. (1996)
  wt (seis)=0.286, wt (char)=0.25
- Atkinson and Boore (1995)
  wt (seis)=0.286, wt (char)=0.25
- Campbell (2003)
  wt (seis)=0.143, wt(char)=0.125
- Somerville et al. (2001) wt (char)= 0.125

2007 Potential additions

- Atkinson and Boore
- Tavakoli and Pezeshk
- Campbell
- Silva et al.
- Toro et al.
- Frankel et al.

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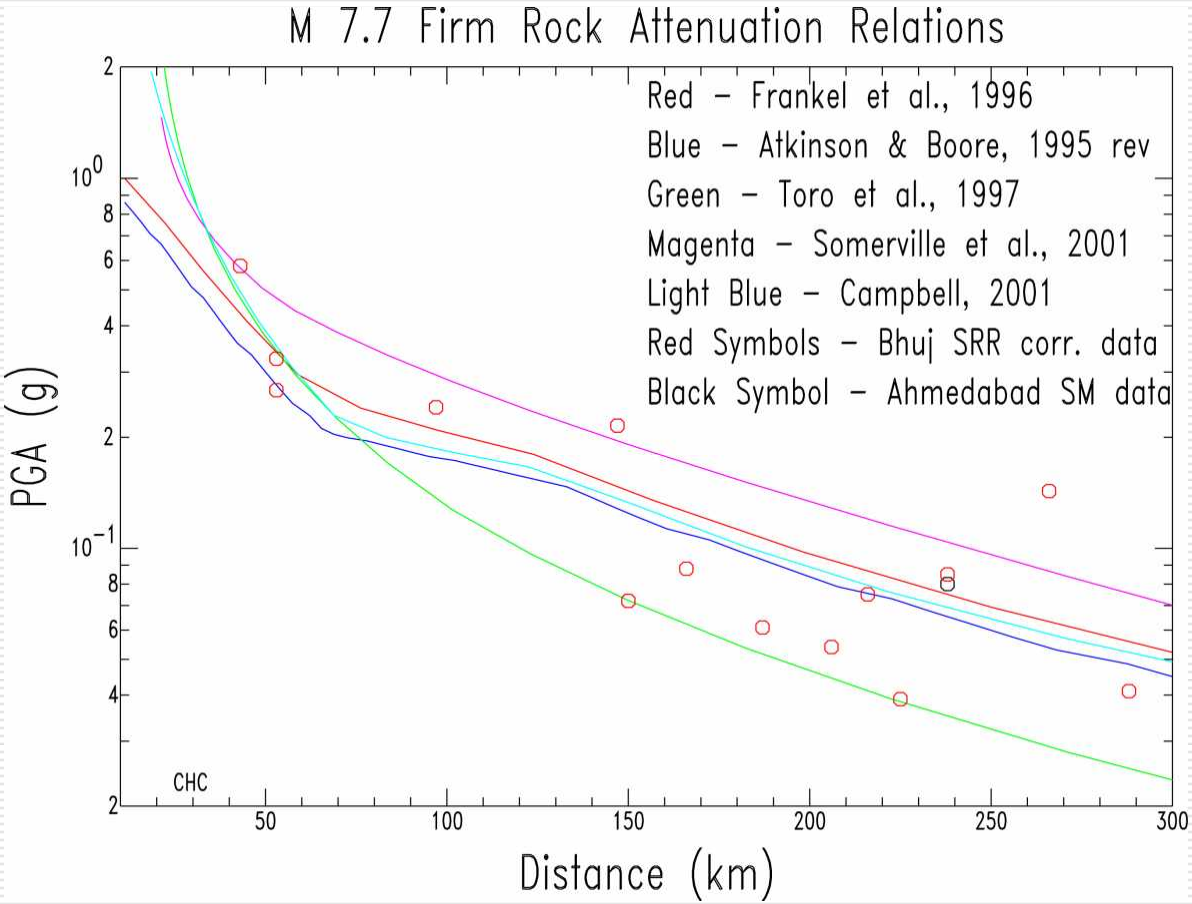
Comparison of 2002 attenuation relations



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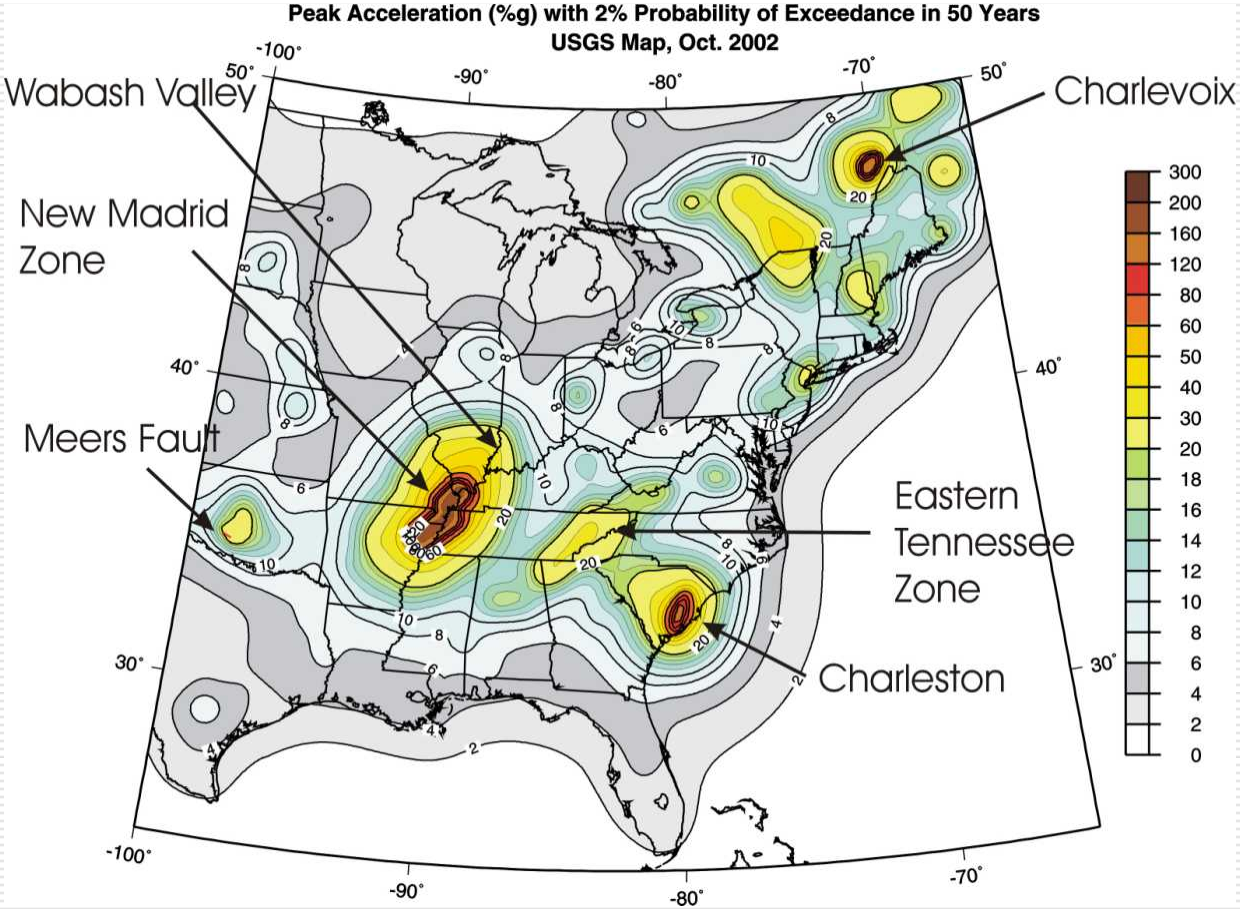
2002 SEISMIC HAZARD MAPS



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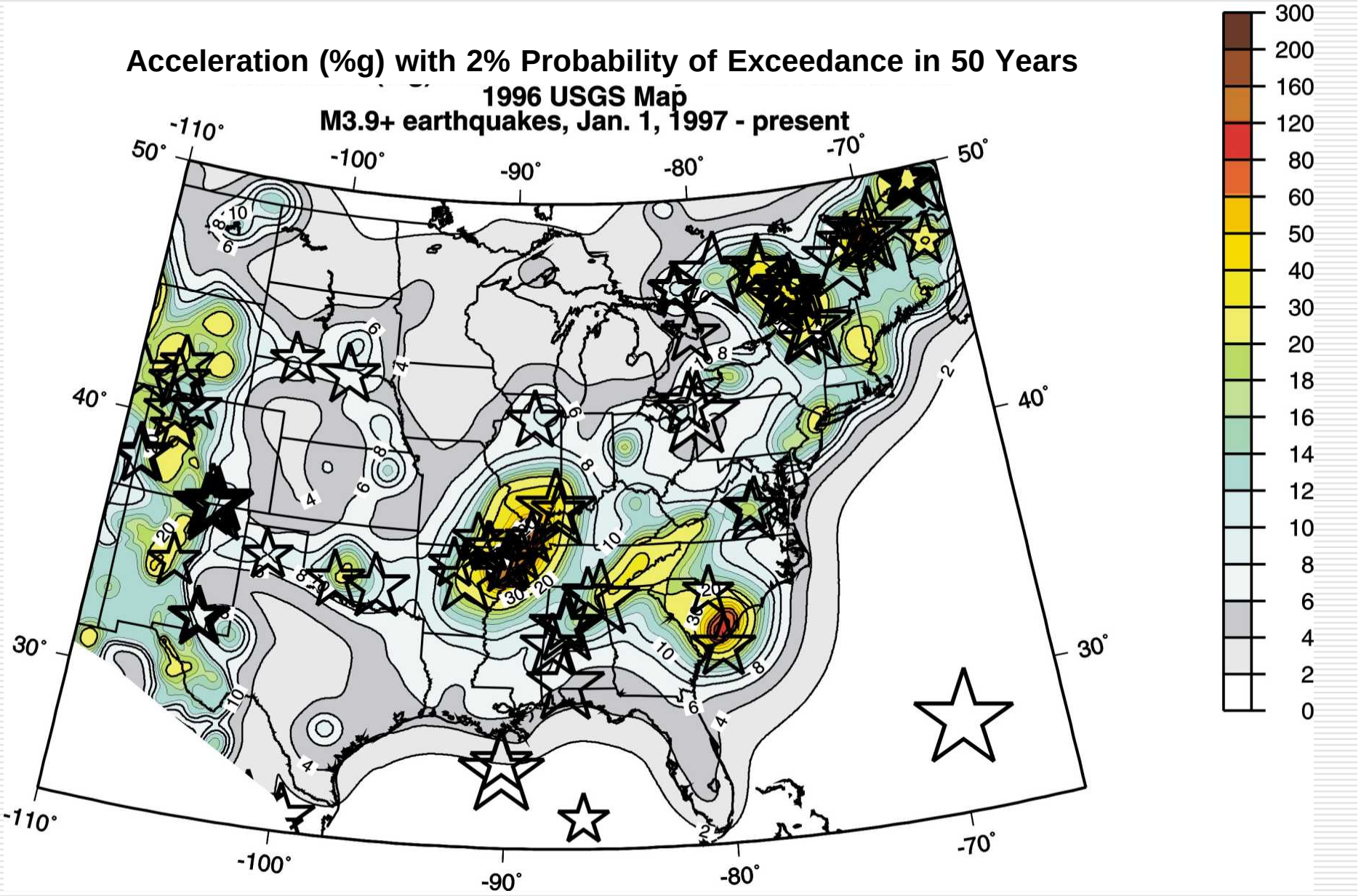
Acceleration (%g) with 2% Probability of Exceedance in 50 Years



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Paleoliquefaction data

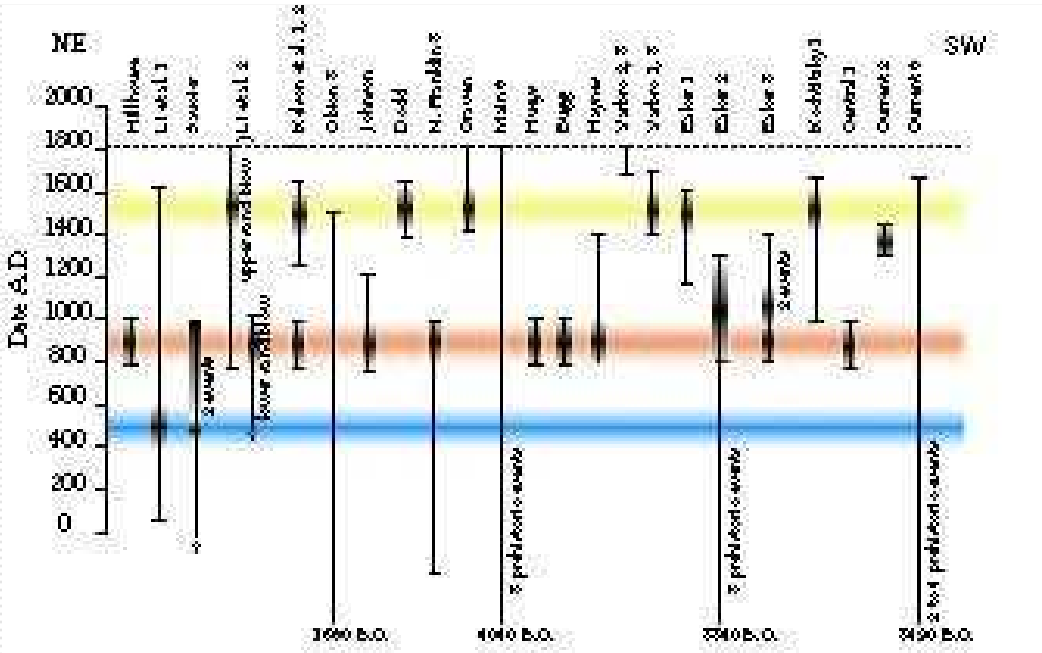

Figure 3

Paleoliquefaction dates from Tuttle et al. (2002)

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NEW MADRID SEISMIC ZONE

- 1811-12: three largest earthquakes felt as far away as New England, producing intensity 8+ in W. TN, very large liquefaction area
- between 1300 and 1600 A.D.: sequence of three large earthquakes with similar liquefaction area as 1811-12 (Tuttle and Schweig)
- between 800 and 1000 A.D.: sequence of three large earthquakes with similar liquefaction area as 1811-12 (Tuttle and Schweig)
- also: M6.6 earthquake in 1895 in Charleston, MO; M6 in 1843 in Marked Tree, AR; history of M5.1 and smaller events since 1900

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Components of Seismic Hazard Maps for the Central and Eastern U.S.

Derived From Historic Seismicity

Mmax = 7.5 in extended margin
Mmax= 7.0 inboard of margin

M3+ since 1924, smoothed spatially
For west of 104W: M3+ since 1976

M4+ since 1860, smoothed spatially
For west of 104W: M4+ since 1963

M5+ since 1700, smoothed spatially
For west of 104W: M5+ since 1860

Background Source Zones

Rates adjusted when necessary to account for catalog incompleteness

Derived From Specific Fault Sources

New Madrid,
Charleston, Meers Fault,
Cheraw Fault

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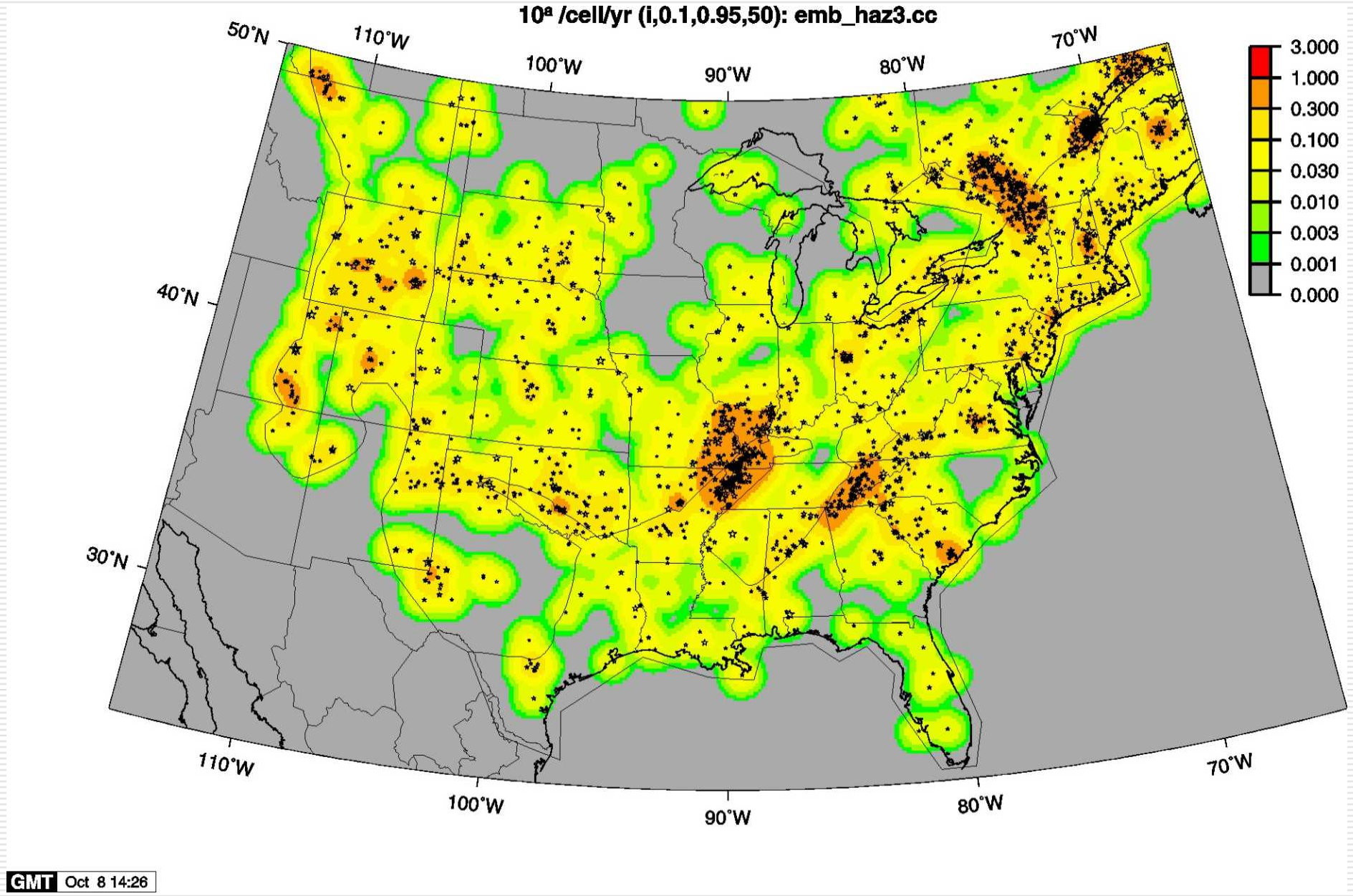
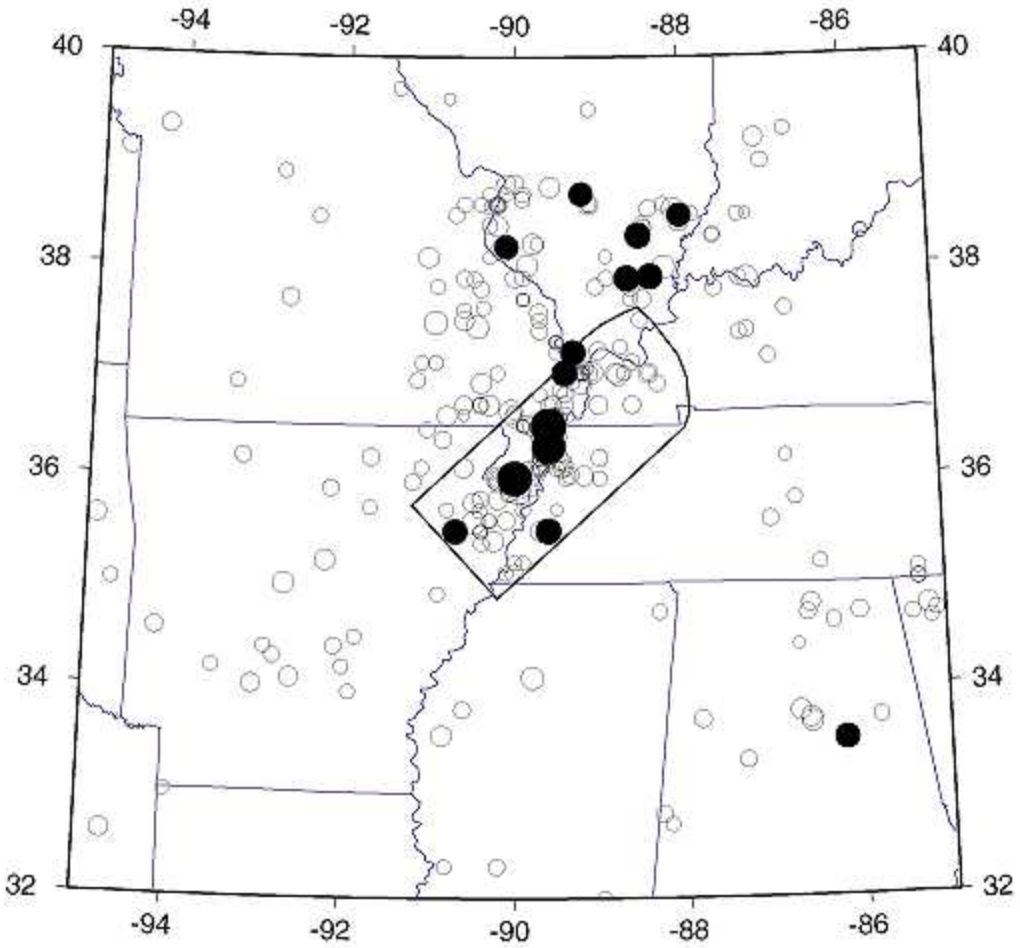

10ª /cell/yr (i,0.1,0.95,50): emb_haz3.cc
50°N
110°W
100°W
90°W
80°W
70°W
40°N
30°N
3.000
1.000
0.300
0.100
0.030
0.010
0.003
0.001
0.000
GMT Oct 8 14:26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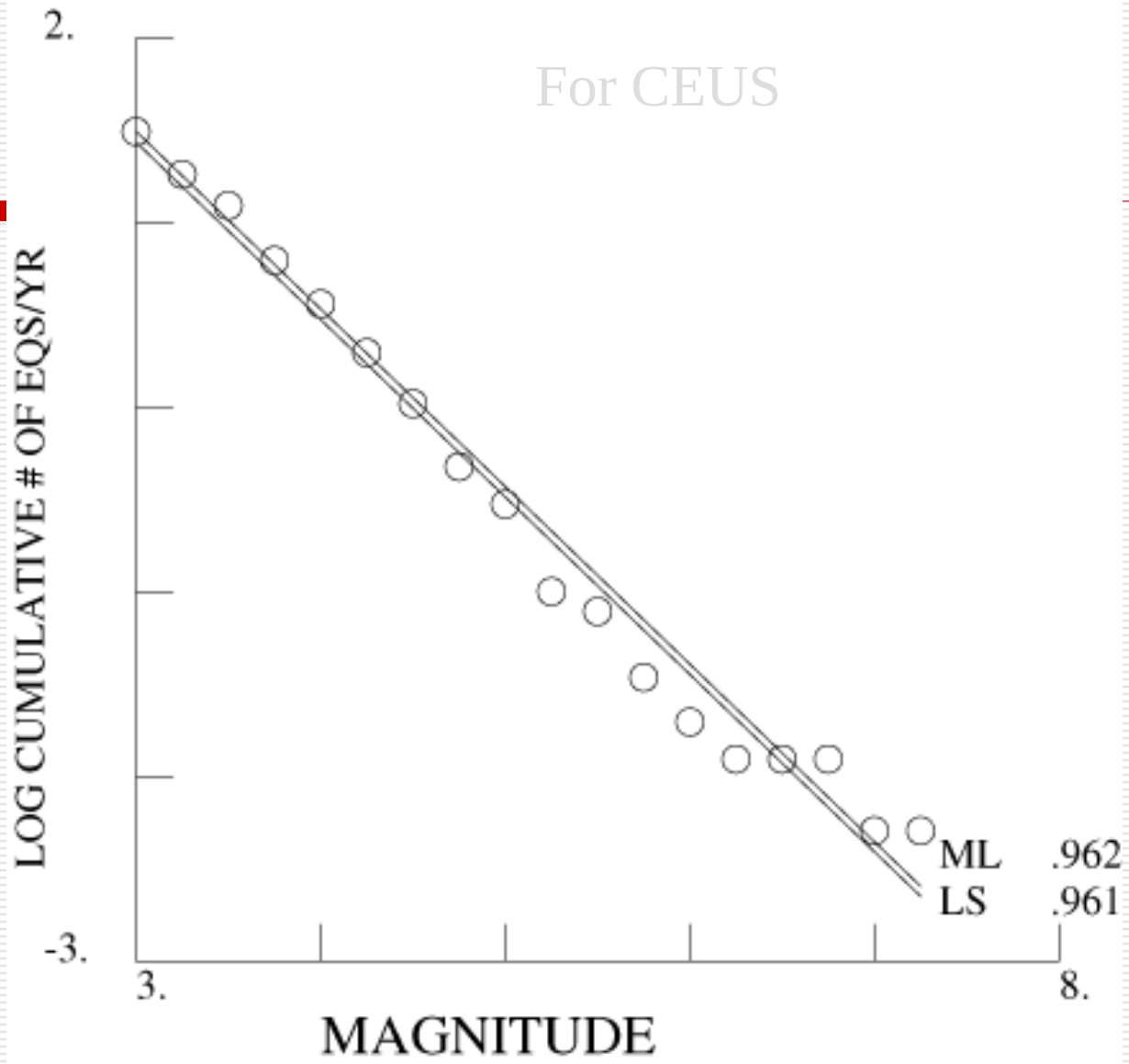
-92
-90
-88
-86
40
38
36
34
32


For CEUS
2.
-3.
LOG CUMULATIVE # OF EQS/YR
3.
8.
MAGNITUDE
ML .962
LS .961

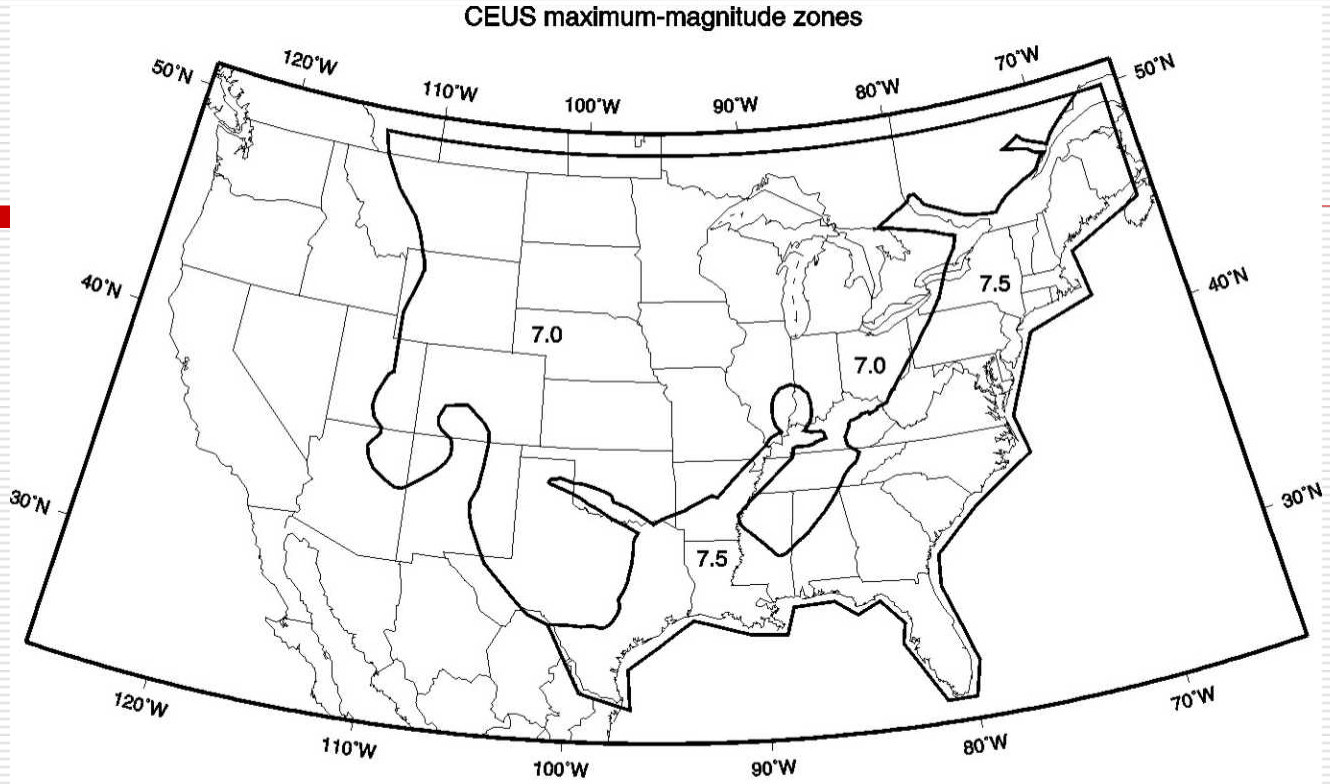


Fig. 3. Mmax zones for CEUS used for 2002 maps.

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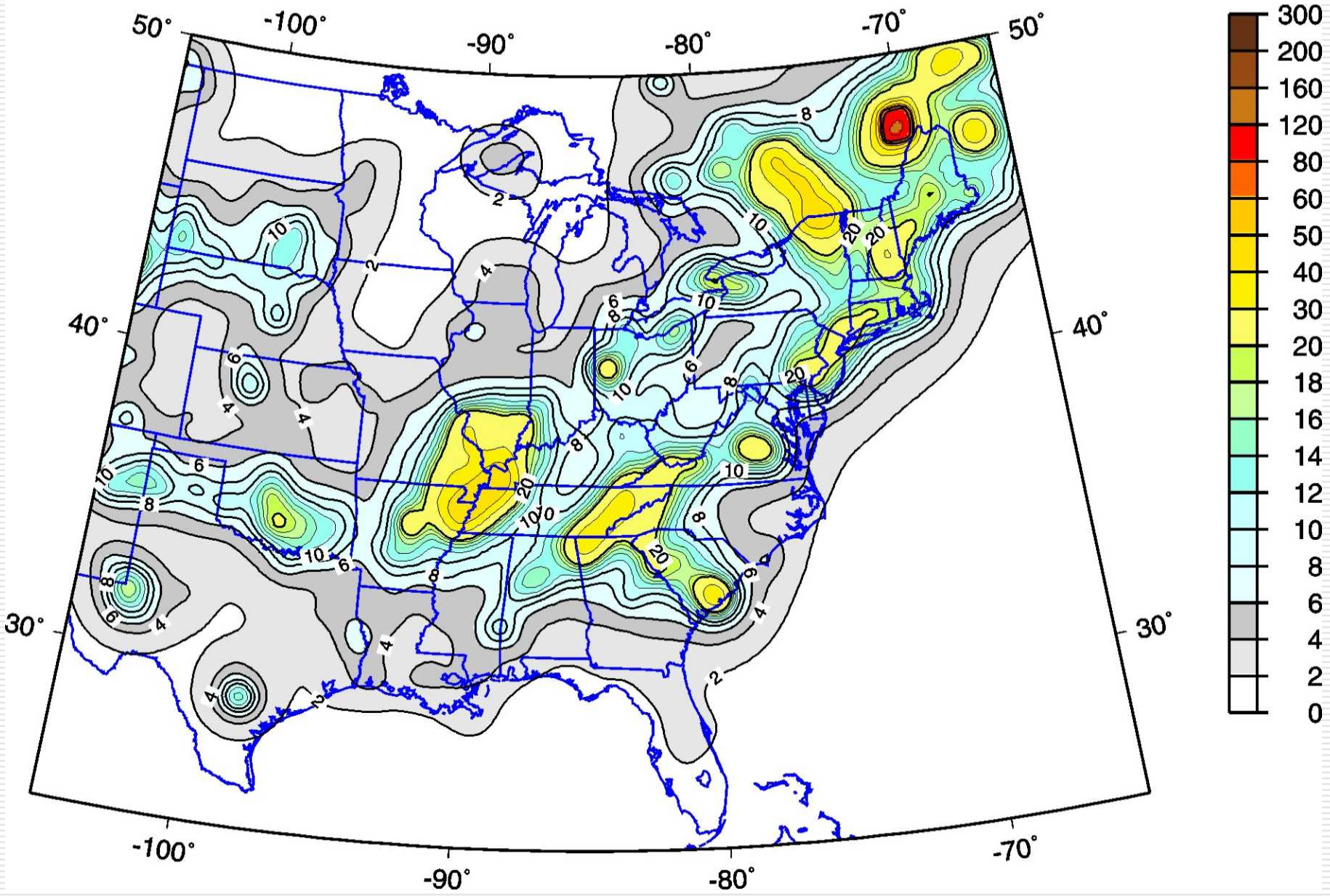
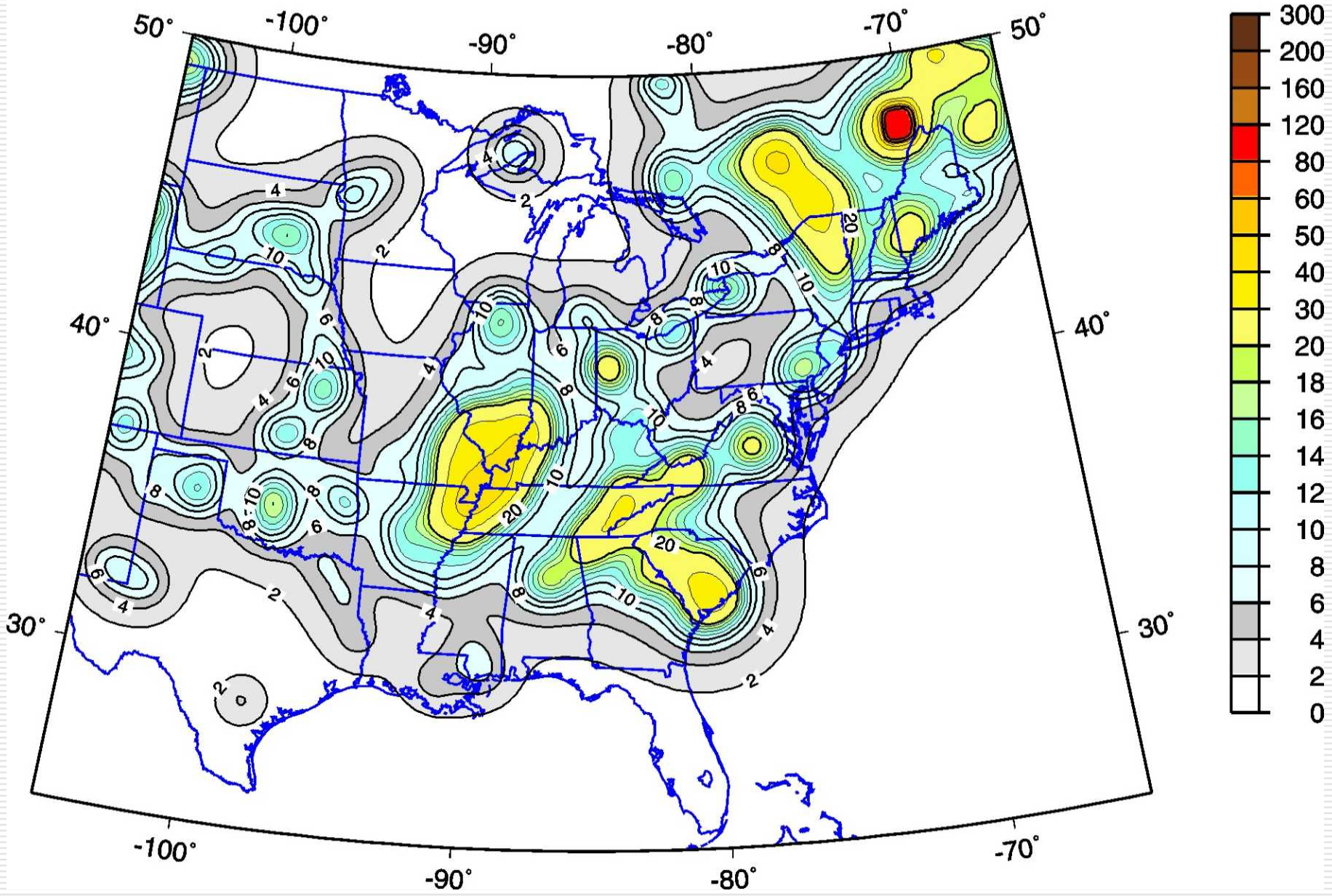
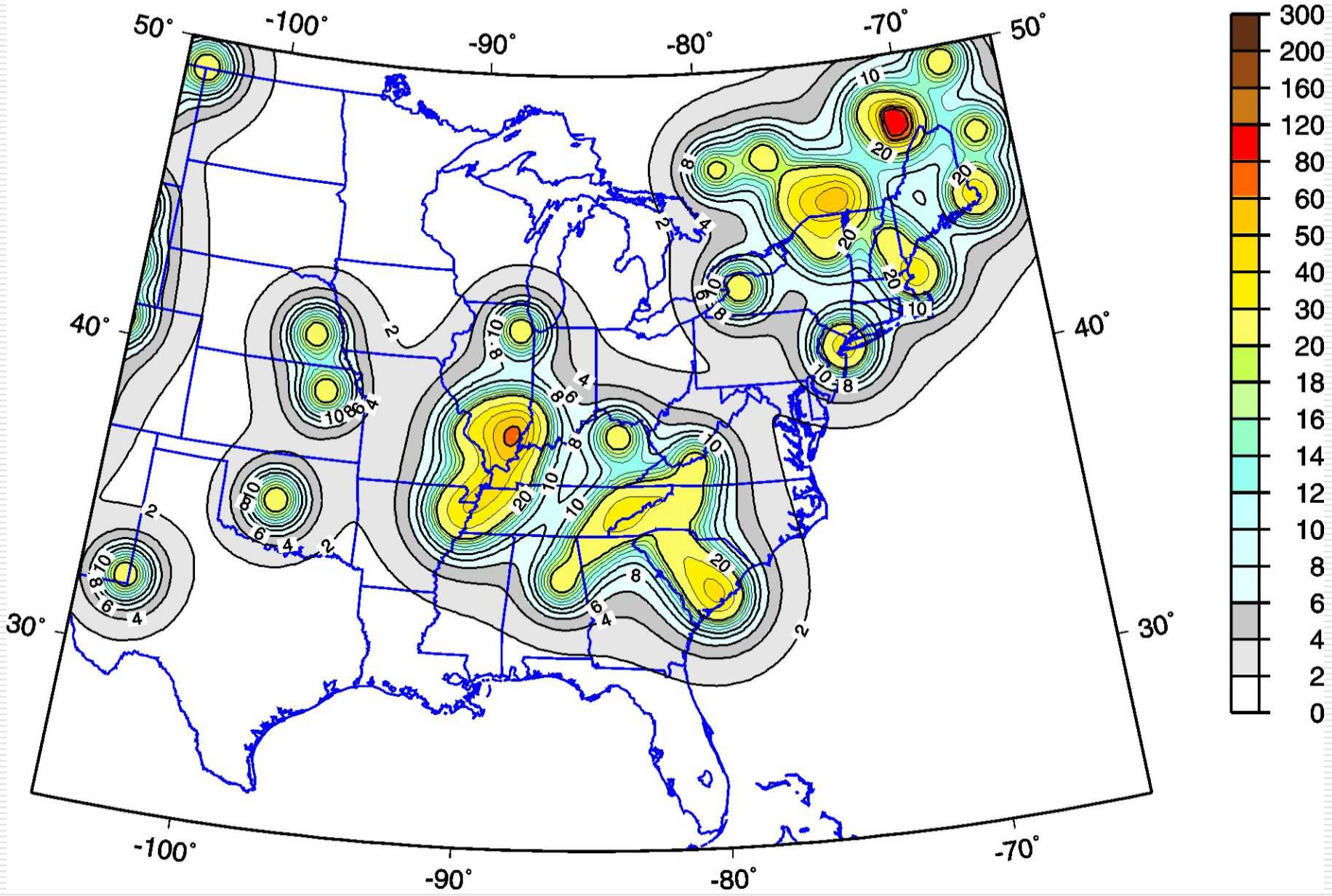
Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years from M3+ since 1924



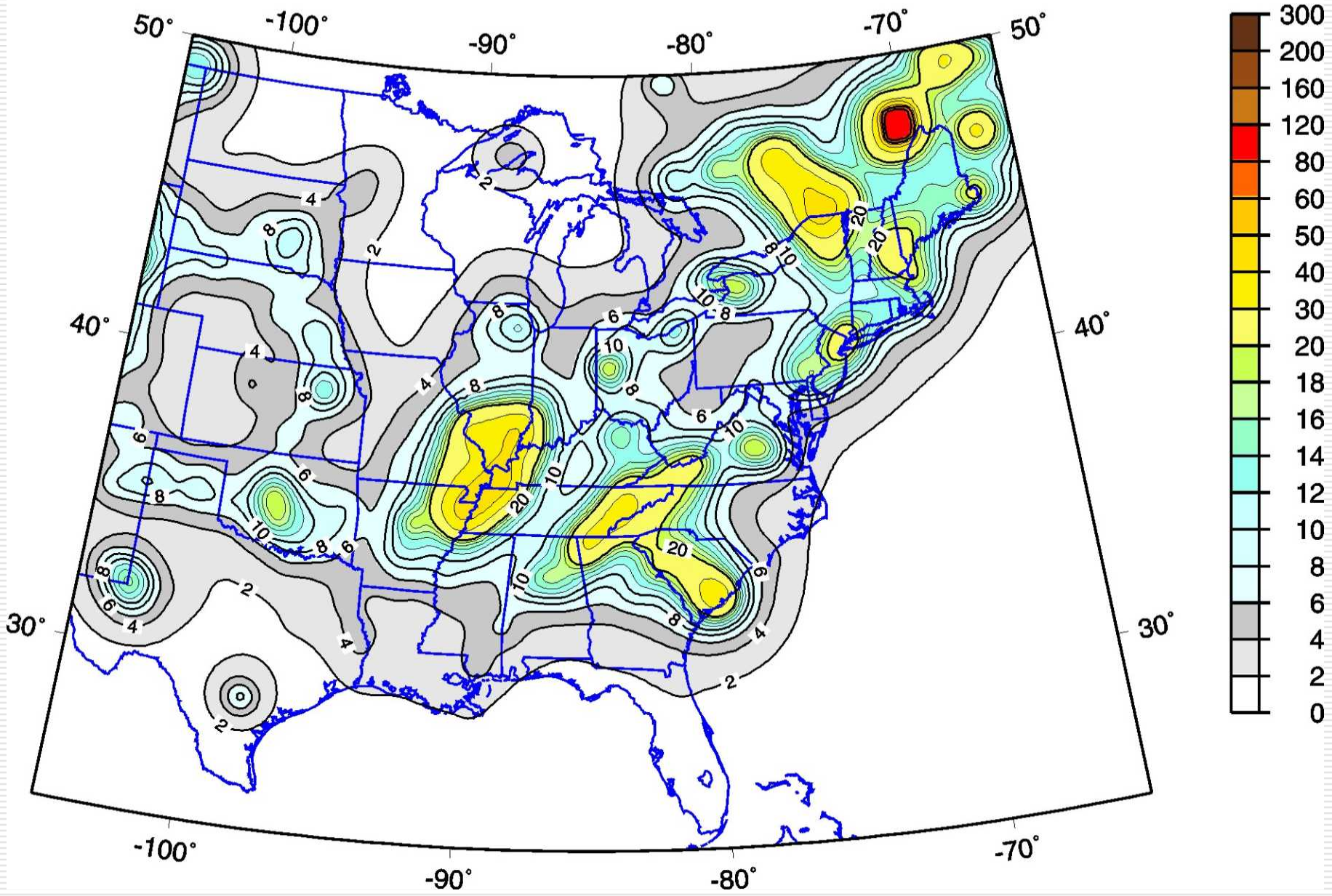
Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years from M4+ since 1860



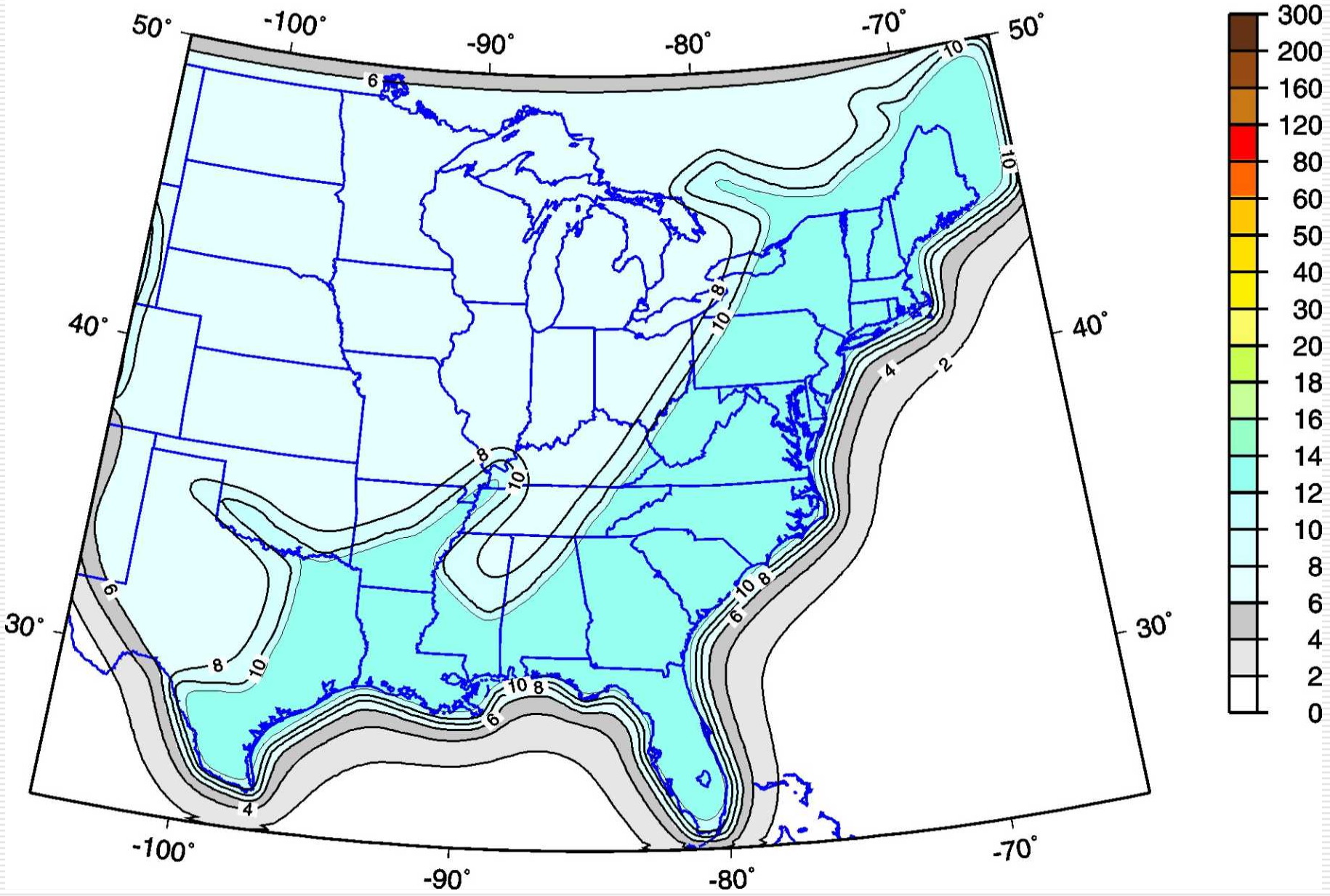
Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years from M5+ since 1700



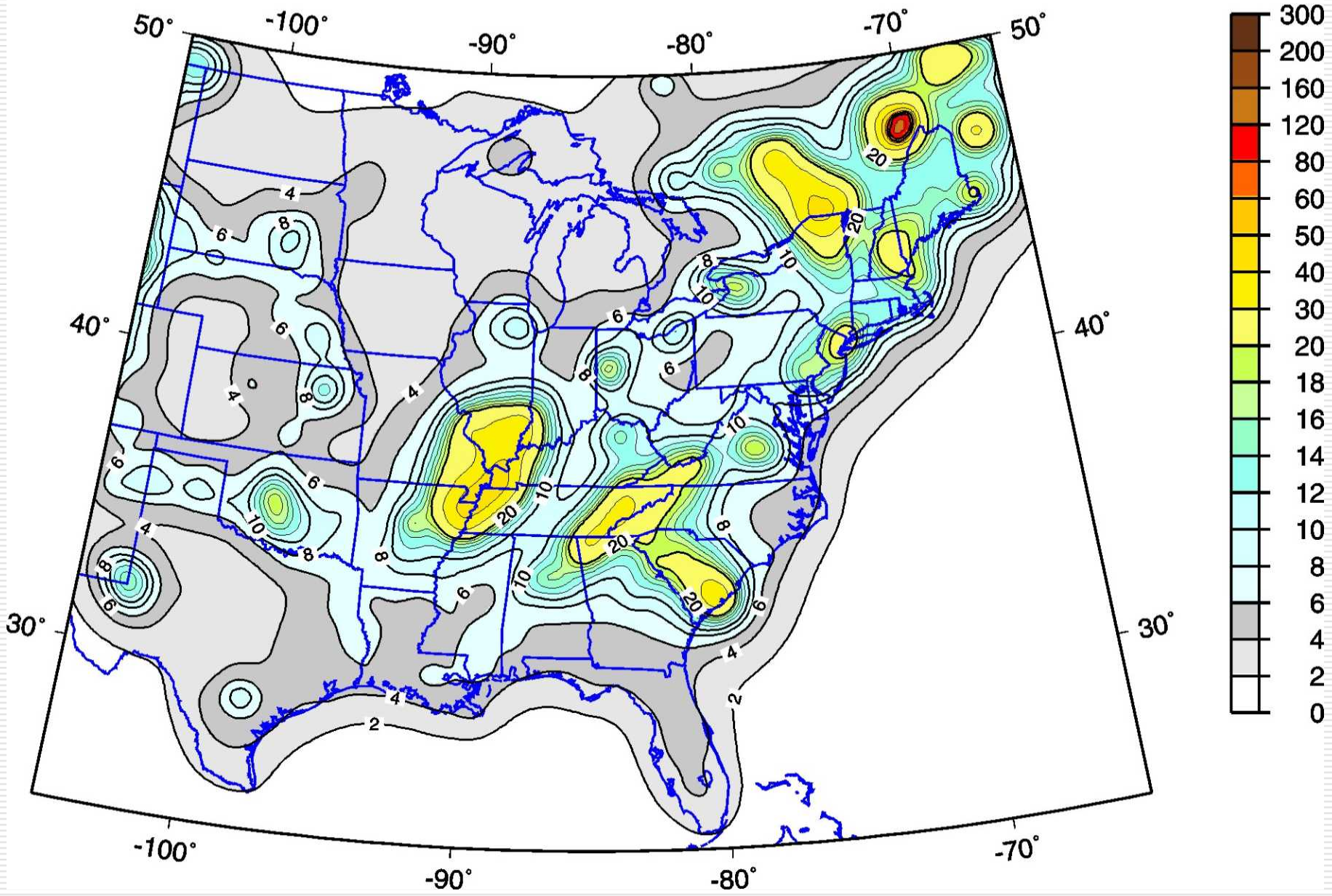
Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
from models 1-3, no background zones



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years from background zones



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years from models 1-4



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
all sources