

7-8 .59

UD-1W-133

Effects

What does 1811-1812 liquefaction
imply about M?

1 mile



Thomas L. Holzer
USGS

1811-1812 Liquefaction

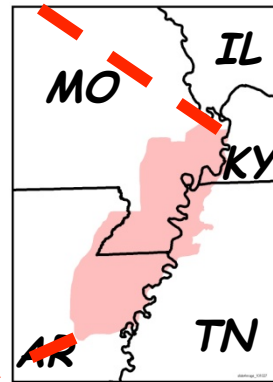
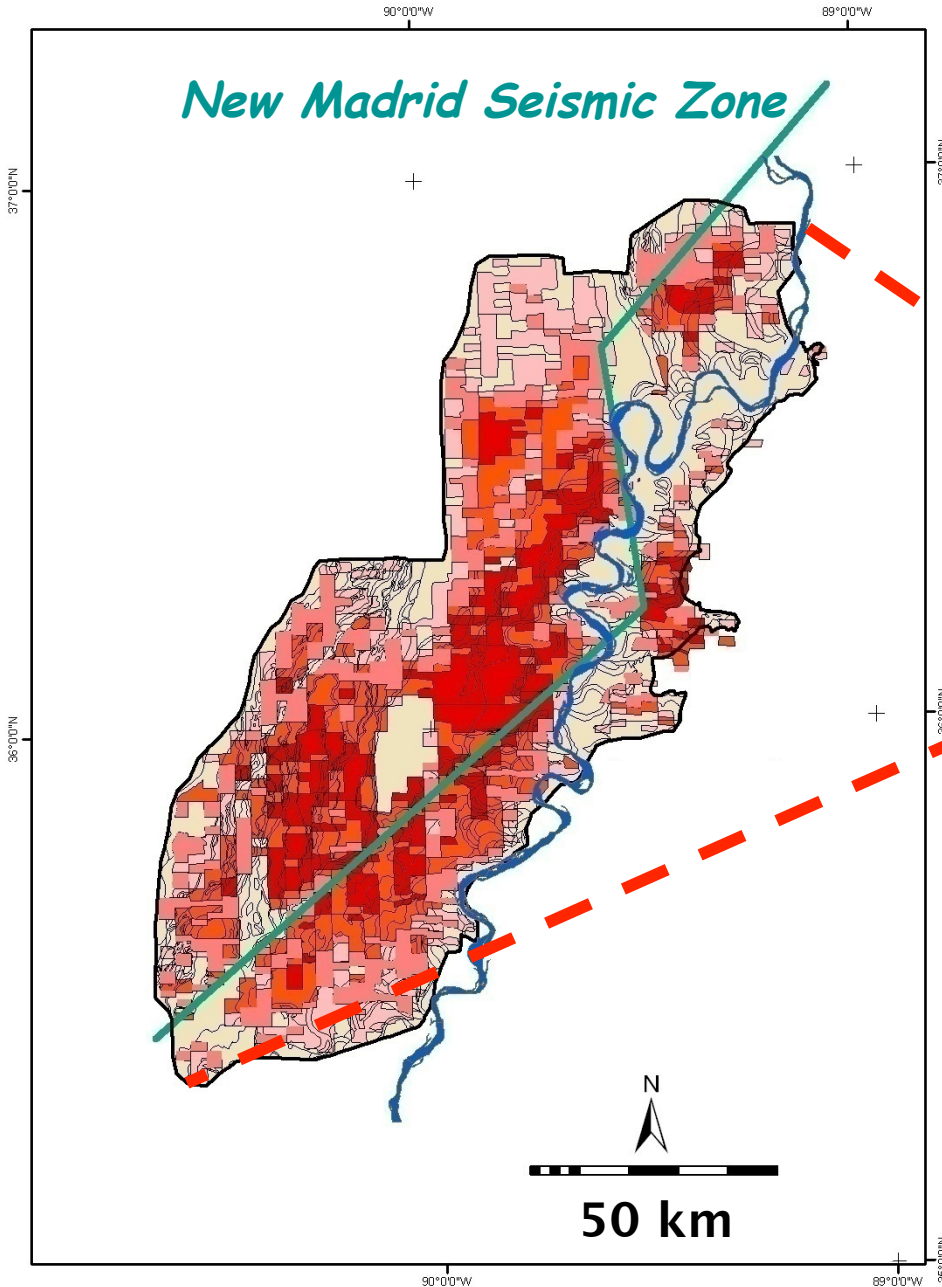
136-acre sand boil



Lateral spreading

Percentage of land area covered by sand boils (Obermeier, 1989)

New Madrid Seismic Zone



Area covered by liquefaction



Lines of Argument for Large 1811-12 Magnitude Based on Liquefaction

1. Historical and qualitative observations of liquefaction
2. Regional comparison of predicted with observed liquefaction
3. Distance of liquefaction from seismic sources

1. Historical Observations of Liquefaction

- Large volumes of extruded water and sediment
- Acres of subsided ground
- Tall water spouts (>10 ft)
- Massive river bank failures
- Widespread and extensive (10's of miles) liquefaction
- Long and wide ground cracks

1. Historical Descriptions - Width of Ground Cracks

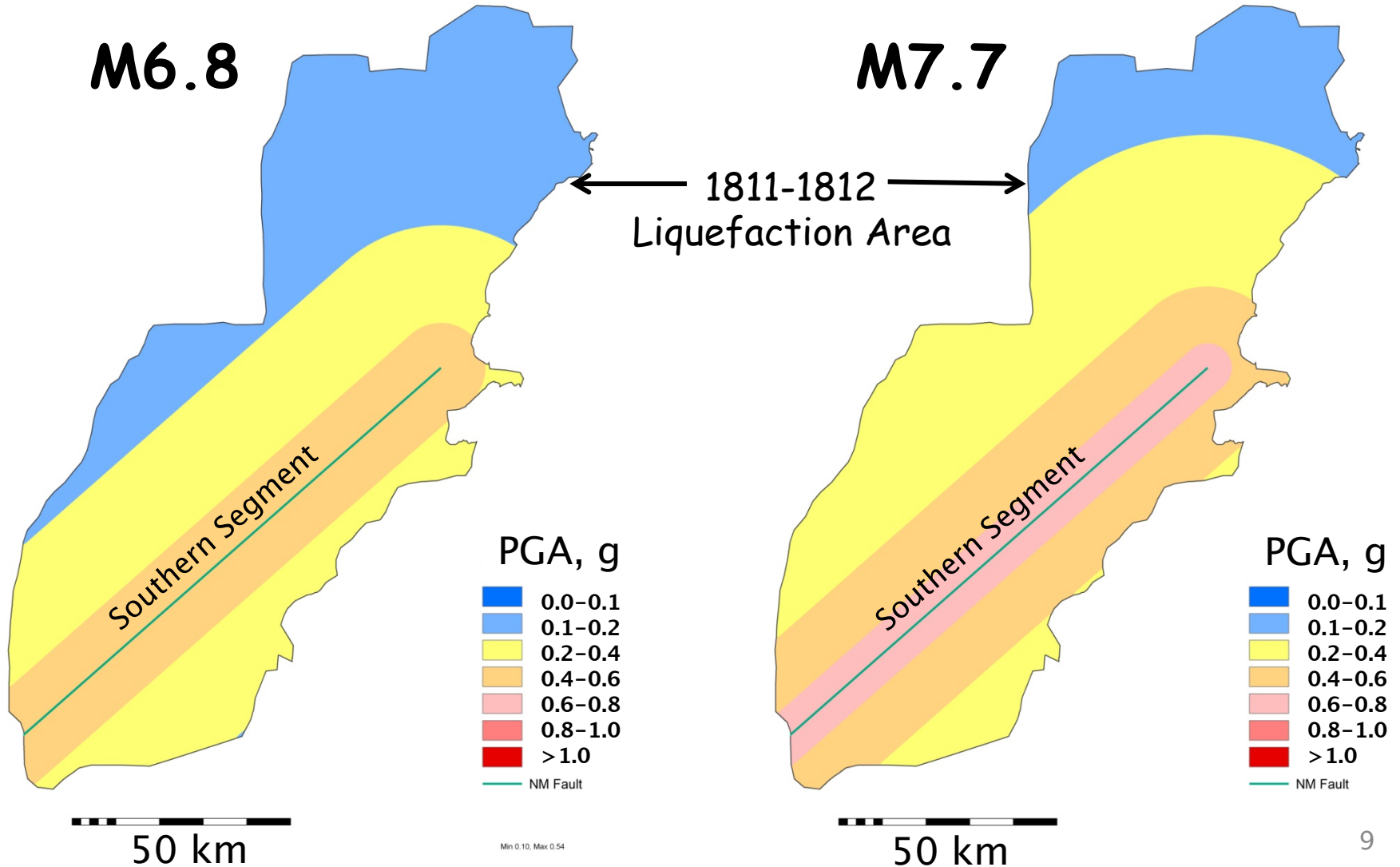
- *"Fissures would be formed, six hundred and even seven hundred feet in length, and **twenty or thirty feet in breadth.**"* - A. N. Dillard
- *"The surface of the ground was cracked in almost every direction and stood like **yawning gulphs.**"* - James McBride
- *"The earthquake had rent the ground in **large and numerous gaps.**"* - William Leigh Pierce
- *"...**fissures of amazing width...**"* - Weekly Register

2. Regional comparison of predicted with observed liquefaction

Range of 1811-1812 New Madrid Earthquake Magnitude Estimates

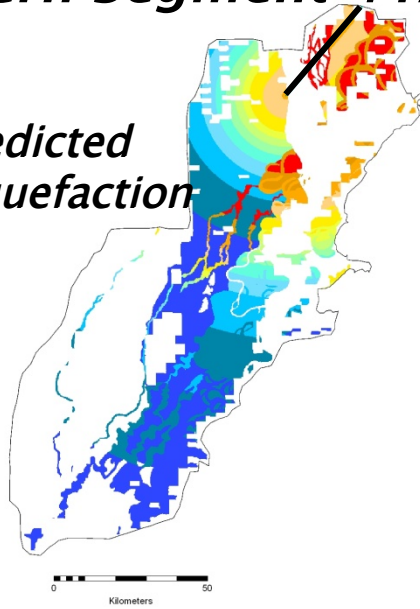
Event		Rupture Segment	Hough and Page (JGR, 2011)		Hough and others (2000) Hough and Martin (2002)	Bakun and Hopper (2004)	Johnston (1996b)	2008 USGS National Map			
			Model 1	Model 3				← Weights →			
			0.5	0.15	0.2	0.15					
NM1	December 16, 1811	Southern (Cottonwood)	6.7	6.9	7.2-7.3	7.6	8.1	7.7	7.3	7.5	8.0
NM1A	December 16, 1811 (dawn aftershock)	Southern	6.5	6.7	7.0						
NM2	January 23, 1812	Northern	6.8	7.0	7.0	7.5	7.8	7.5	7.1	7.3	7.8
NM3	February 7, 1812	Central (Reelfoot)	7.1	7.3	7.4-7.5	7.8	8.0	7.7	7.3	7.5	8.0

Predicted PGA with Consensus GMPE and V_{S30} Site Correction



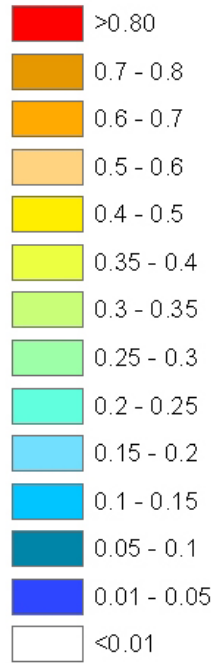
Northern Segment-M7.5

Predicted Liquefaction



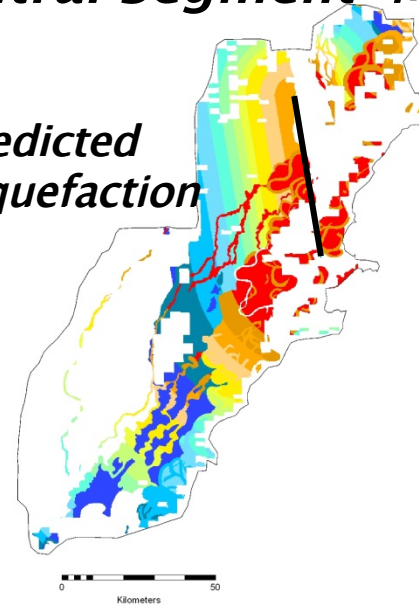
110234

Prob.



Central Segment-M7.7

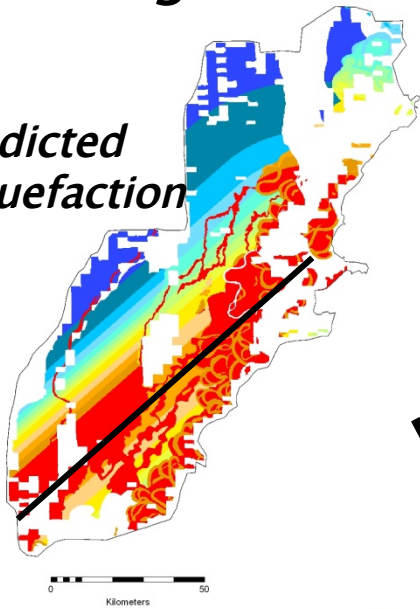
Predicted Liquefaction



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Southern Segment-M7.7

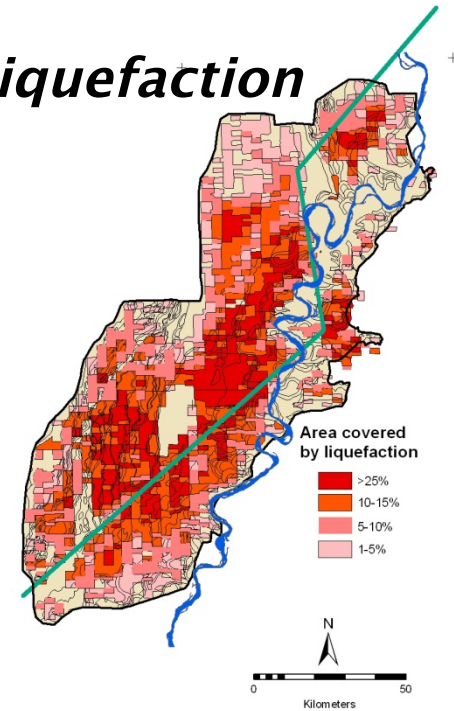
Predicted Liquefaction



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Observed Liquefaction 1811-1812

Upper Magnitudes

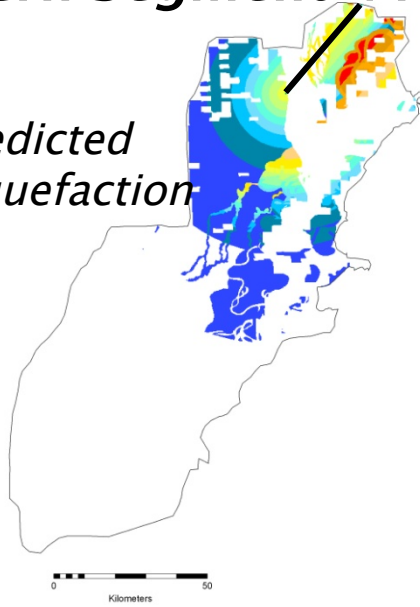


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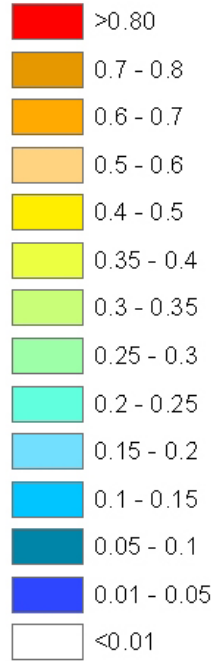
Northern Segment-M6.9

Predicted Liquefaction



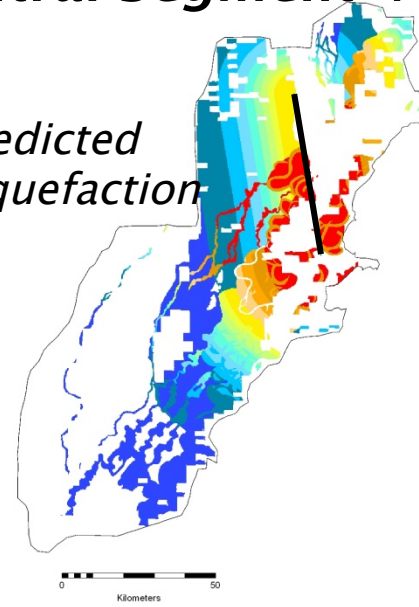
110224

Prob.



Central Segment-M7.2

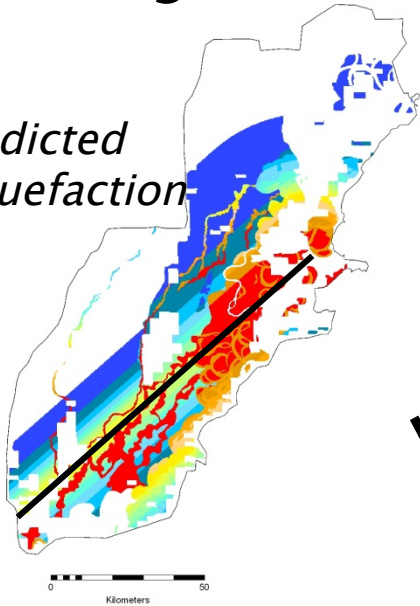
Predicted Liquefaction



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Southern Segment-M6.8

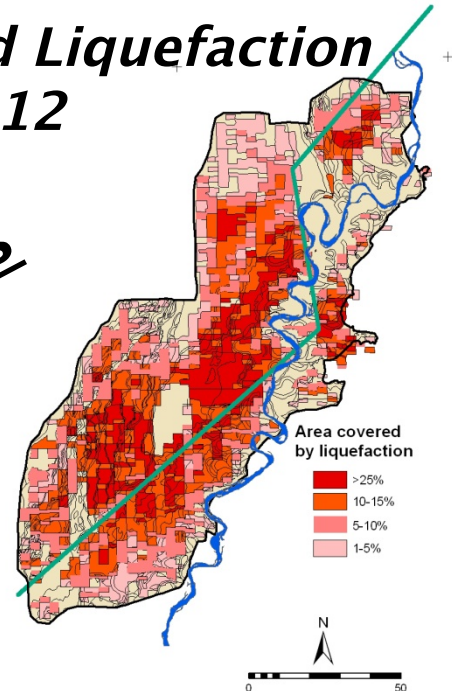
Predicted Liquefaction



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Observed Liquefaction 1811-1812

Lower Magnitudes



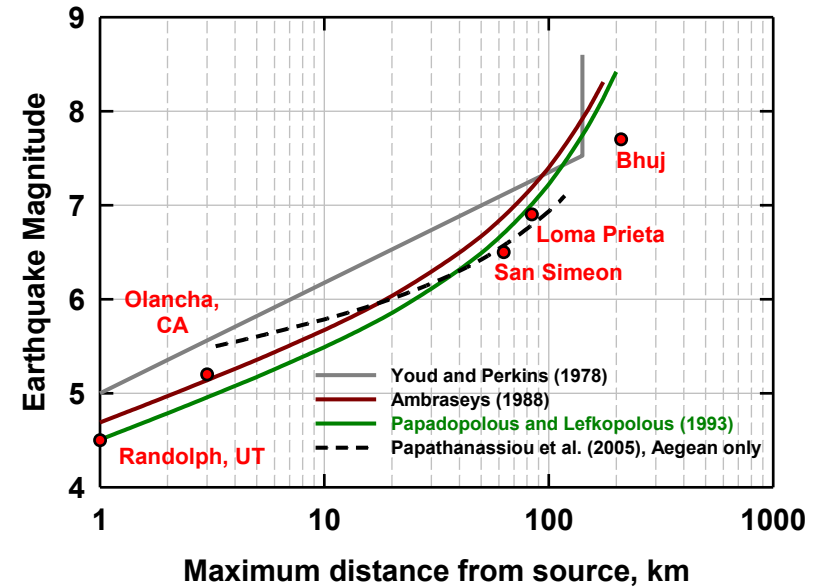
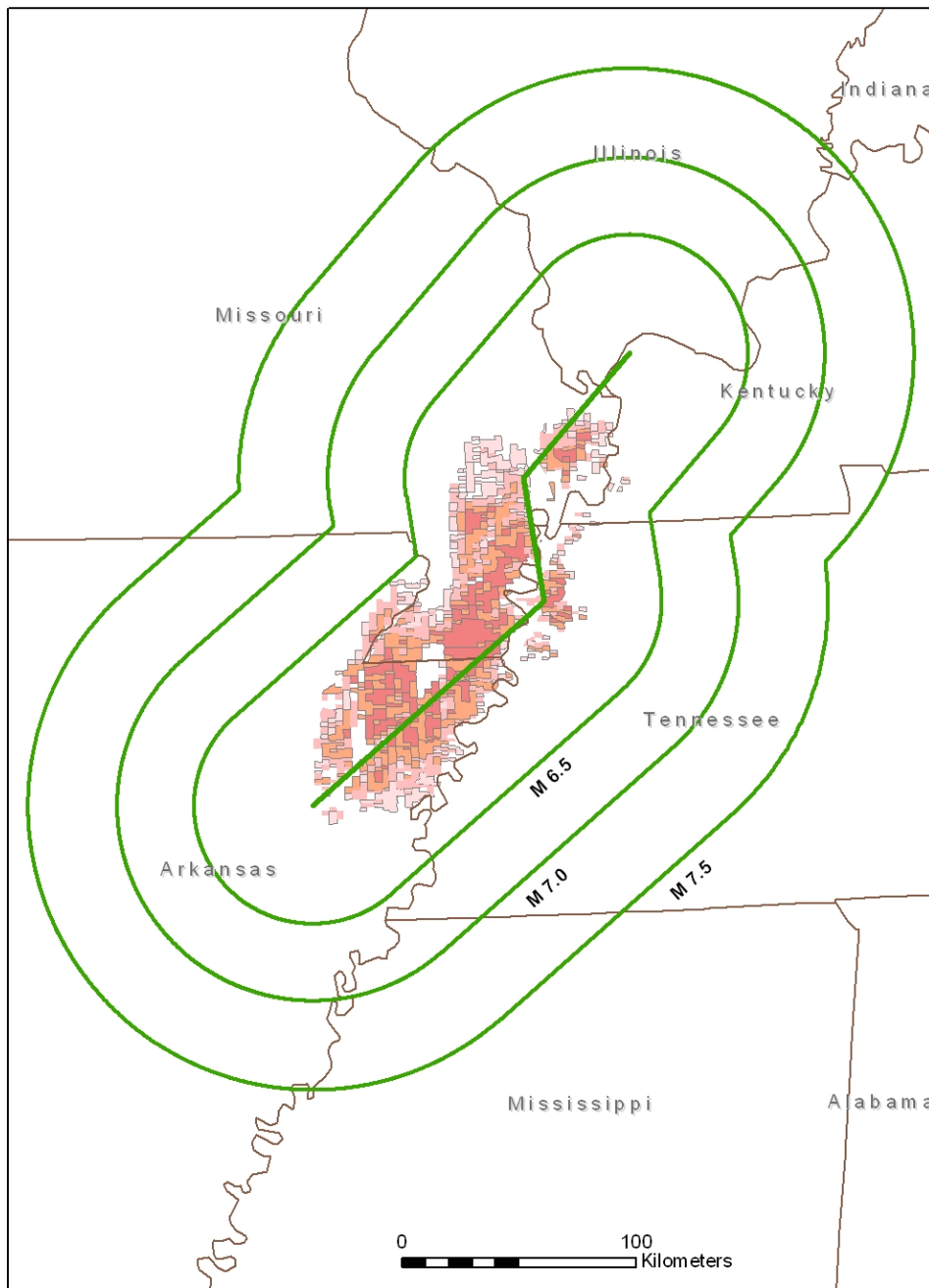
Area covered by liquefaction

- >25%
- 10-15%
- 5-10%
- 1-5%

N

3. Distance of liquefaction from seismic sources

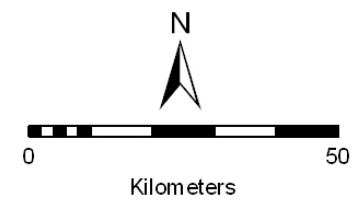
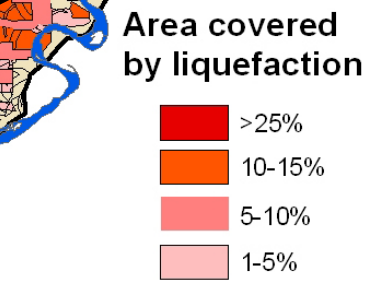
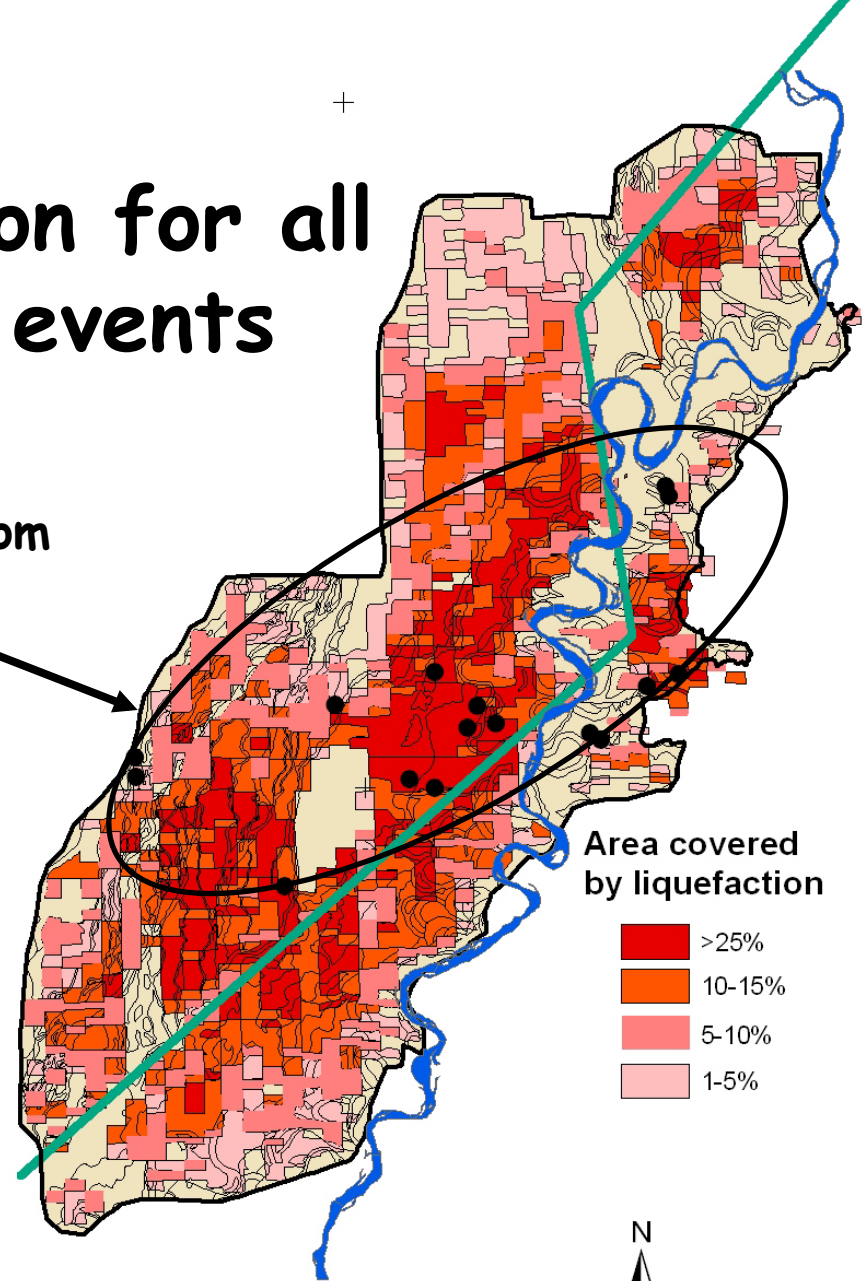
Maximum Distance to Liquefaction from Seismic Source



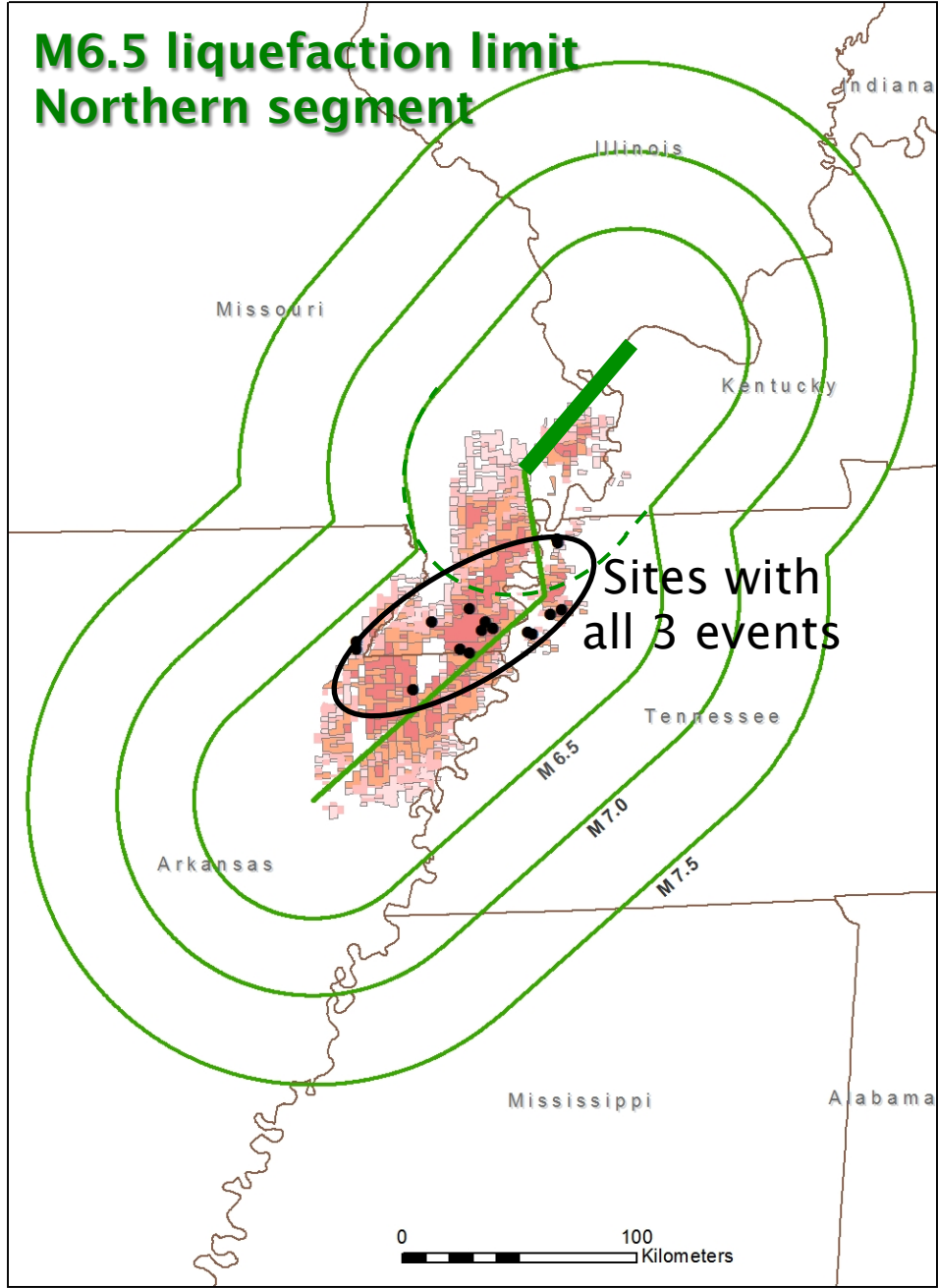
Sites with liquefaction for all three 1811-1812 events

Multiple liquefaction event sites from Tuttle and others (2002) •

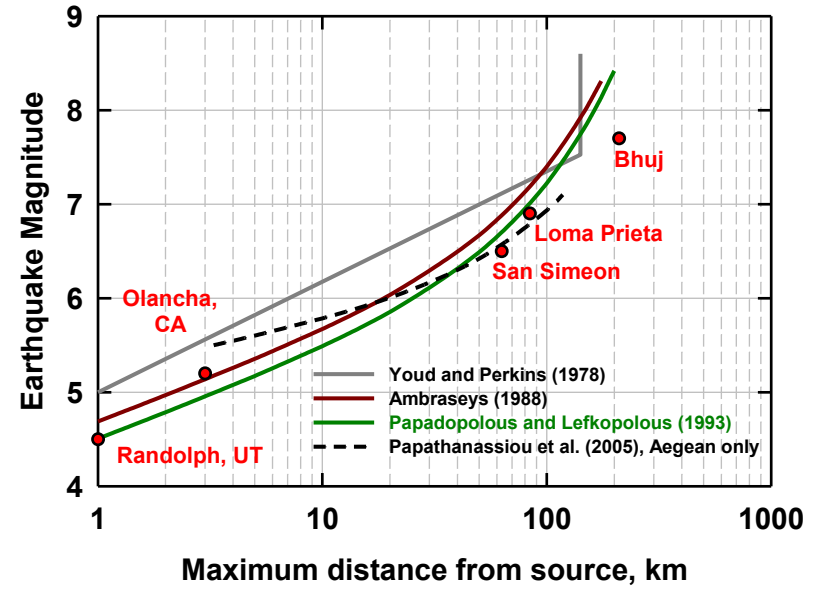
Liquefaction map from Obermeier (1989)



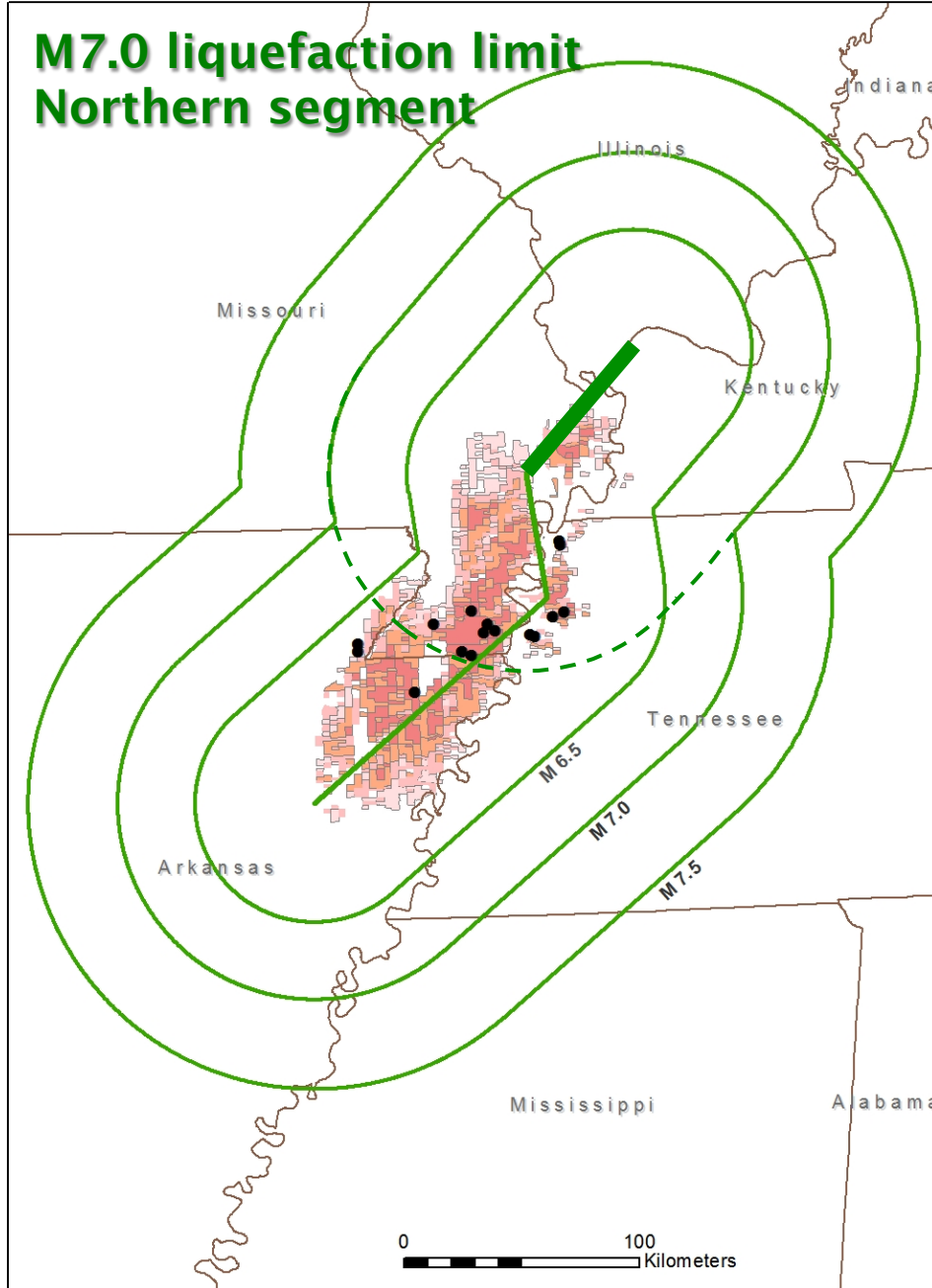
M6.5 liquefaction limit Northern segment



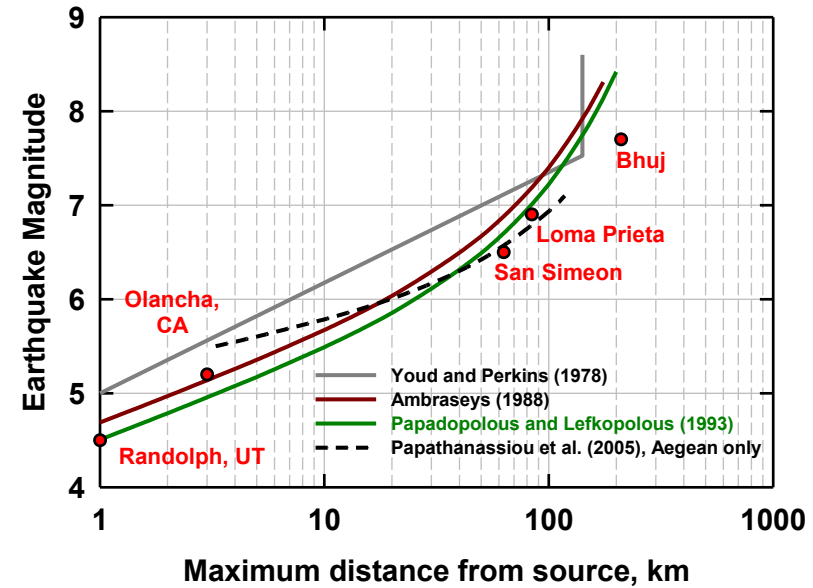
Maximum Distance to Liquefaction from Seismic Source



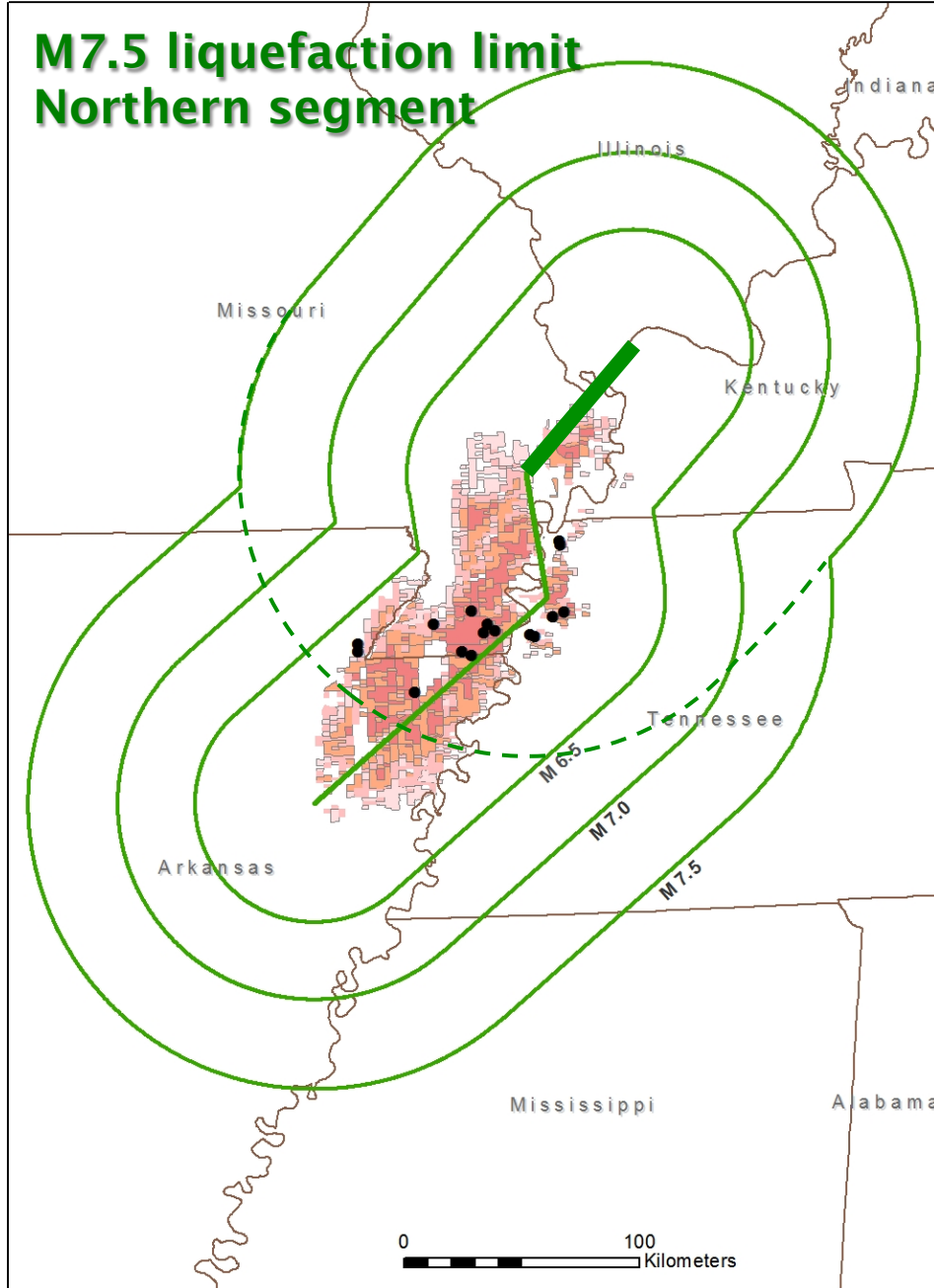
M7.0 liquefaction limit Northern segment



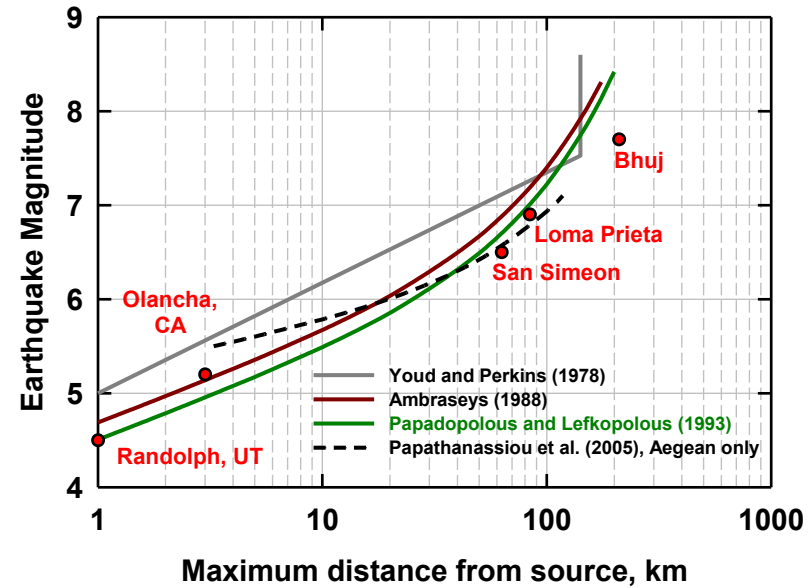
Maximum Distance to Liquefaction from Seismic Source



M7.5 liquefaction limit Northern segment



Maximum Distance to Liquefaction from Seismic Source



Summary

Lines of Argument for Larger Magnitudes

- Qualitative observations of 1811-1812 liquefaction deformation and intensity
- Regional comparison of observed and predicted liquefaction
- Distance of liquefaction from seismic sources