A new short-term forecast of earthquake hazard in the Central and Eastern U.S.

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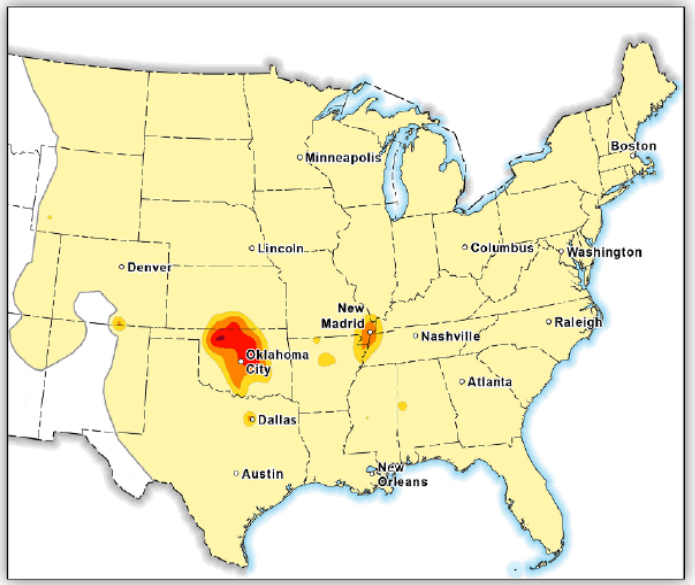
The Washington Post

Speaking of Science

7 million Americans at risk of man-made earthquakes, USGS says

2016 One-Year Seismic Hazard Forecast for the Central and Eastern United States from Induced and Natural Earthquakes

By Mark D. Petersen, Charles S. Mueller, Morgan P. Moschetti, Susan M. Hoover, Andrea L. Llenos, William L. Ellsworth, Andrew J. Michael, Justin L. Rubinstein, Arthur F. McGarr, and Kenneth S. Rukstales



Open-File Report 2016–1035

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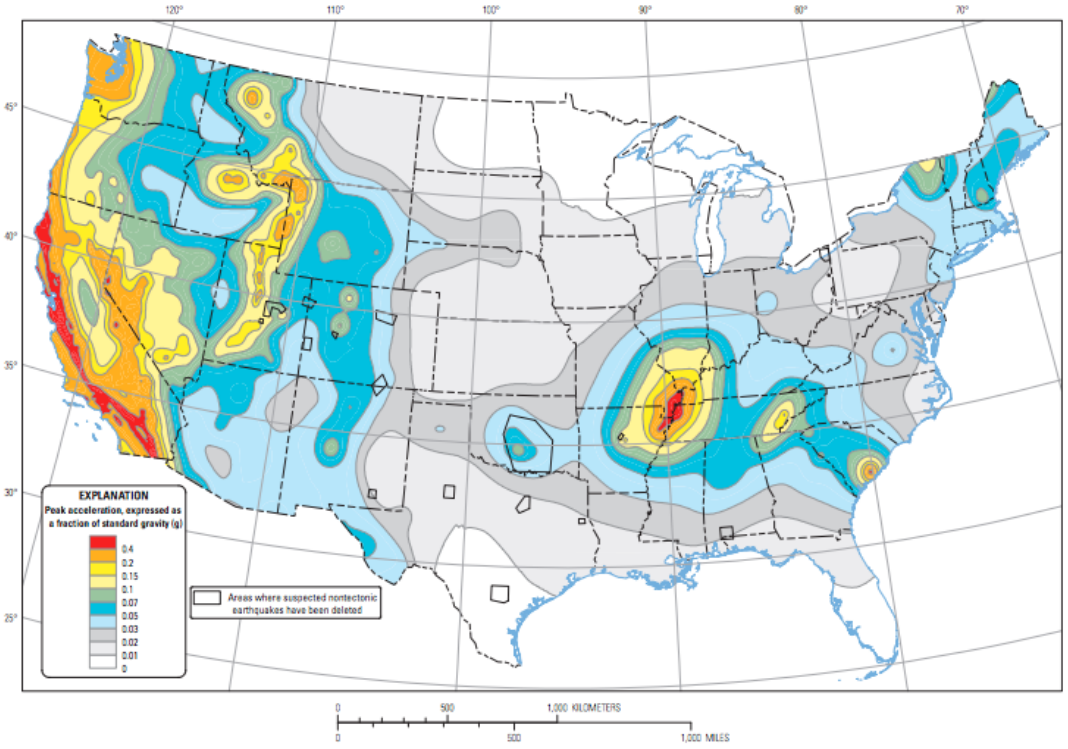
2014 USGS Map of Earthquake Hazard in the Conterminous U.S.

National Seismic Hazard Model and Maps

- probabilities of damaging ground motion
- designed to provide stable long-term estimates (50 yr. or more)
- basis for seismic provisions of building codes
- updated every six years



Ten-percent probability of exceedance in 50 years map of peak ground acceleration

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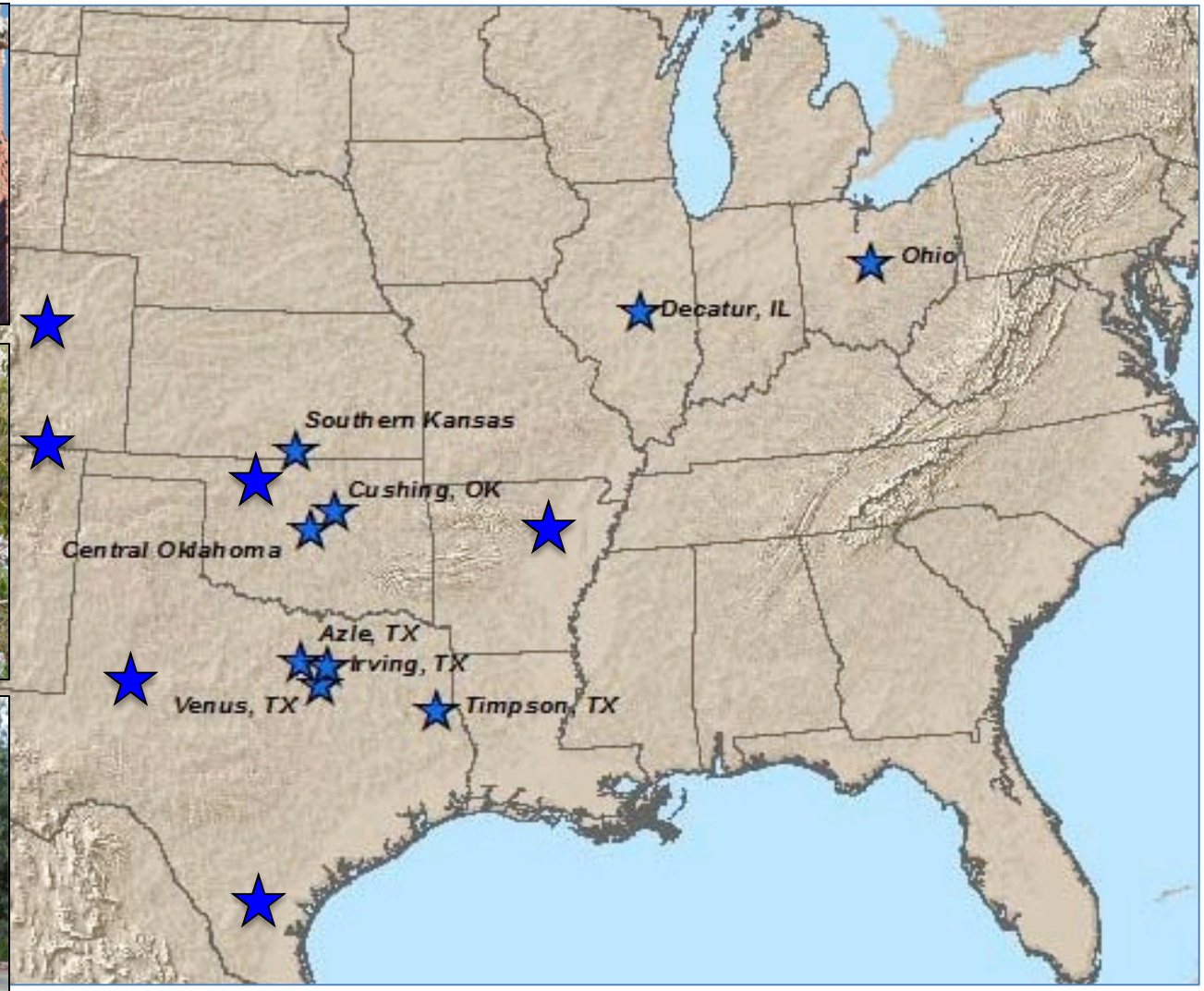
Earthquakes in unexpected places…



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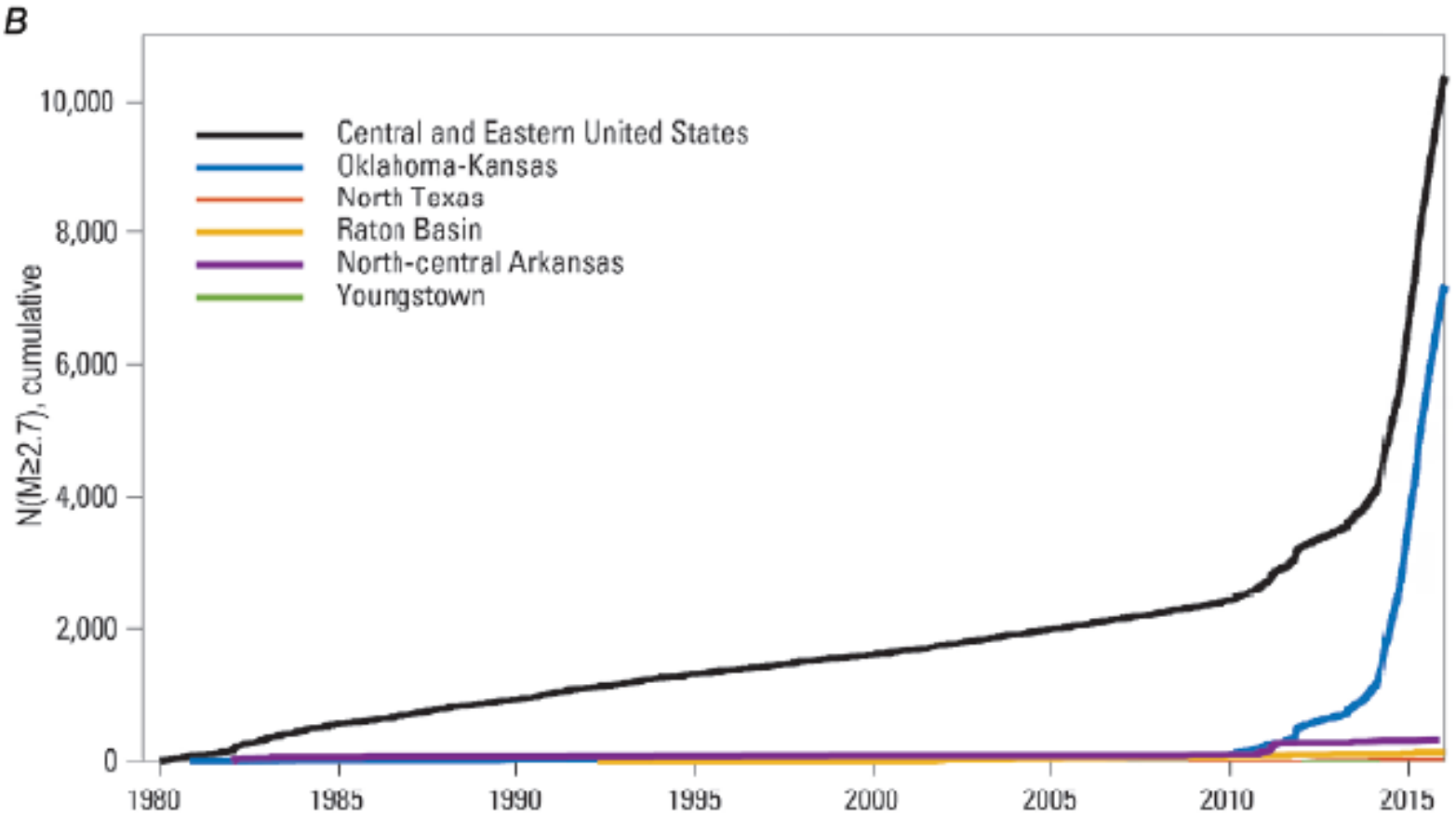
Earthquake Counts, M≥2.7



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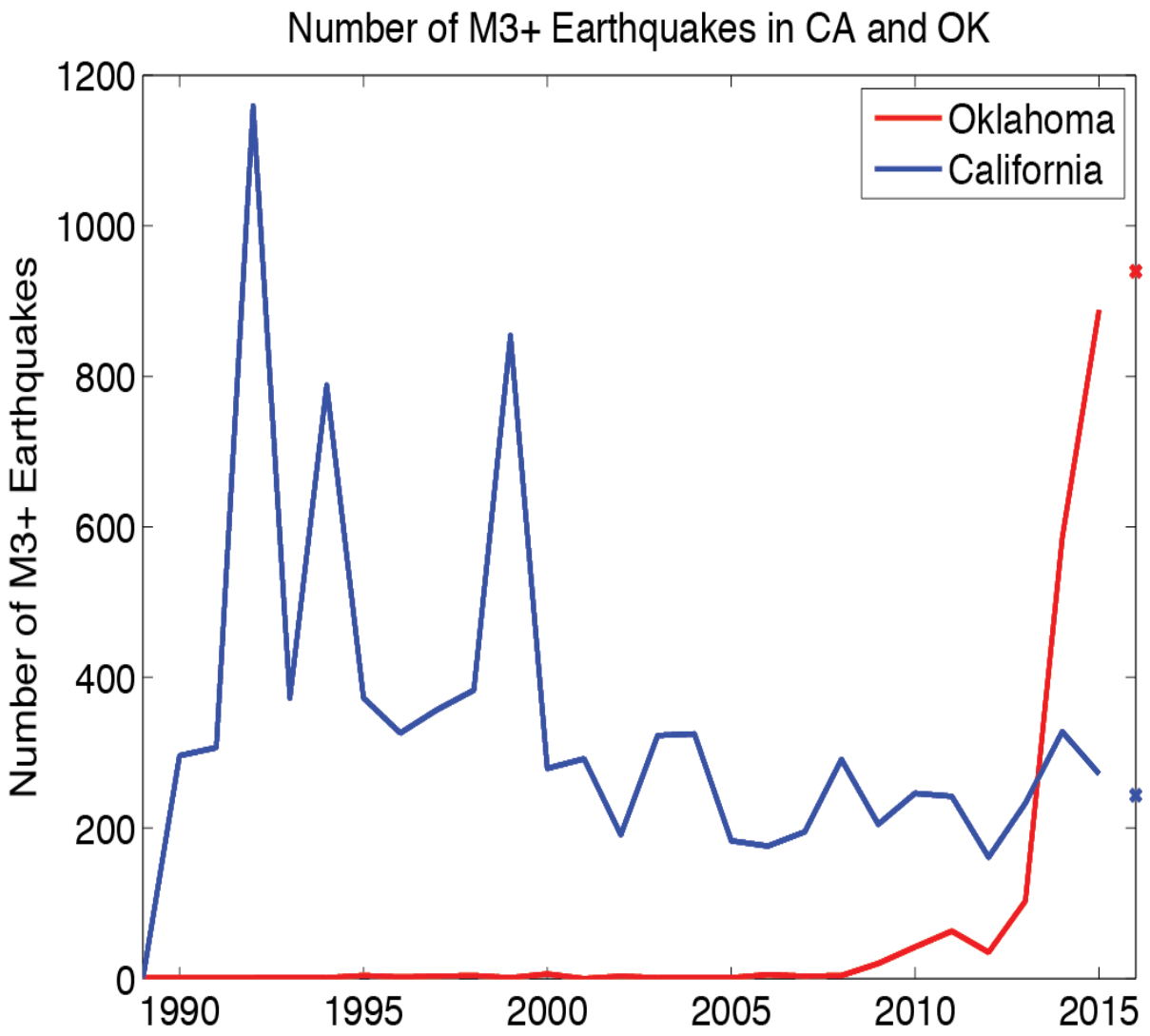
Oklahoma vs. California



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Not fracking, primarily wastewater disposal

Top Arbuckle saltwater disposal volumes

County	2014 volume (barrels)	Percent change 2012-2014
1. Alfalfa	293,771,009	**802%**
2. Woods	89,540,711	**117%**
3. Payne	72,112,469	**479%**
4. Grant	57,409,140	**842%**
5. Noble	54,605,675	**271%**
6. Garfield	50,547,806	**1,319%**
7. Kay	36,755,093	**-35%**
8. Creek	36,250,211	**5%**
9. Seminole	34,407,843	**98%**
10. Logan	25,618,242	**2,507%**

SOURCE: THE OKLAHOMAN ANALYSIS OF OKLAHOMA CORPORATION COMMISSION DATA

mostly “Produced Water” —
not spent frack fluid

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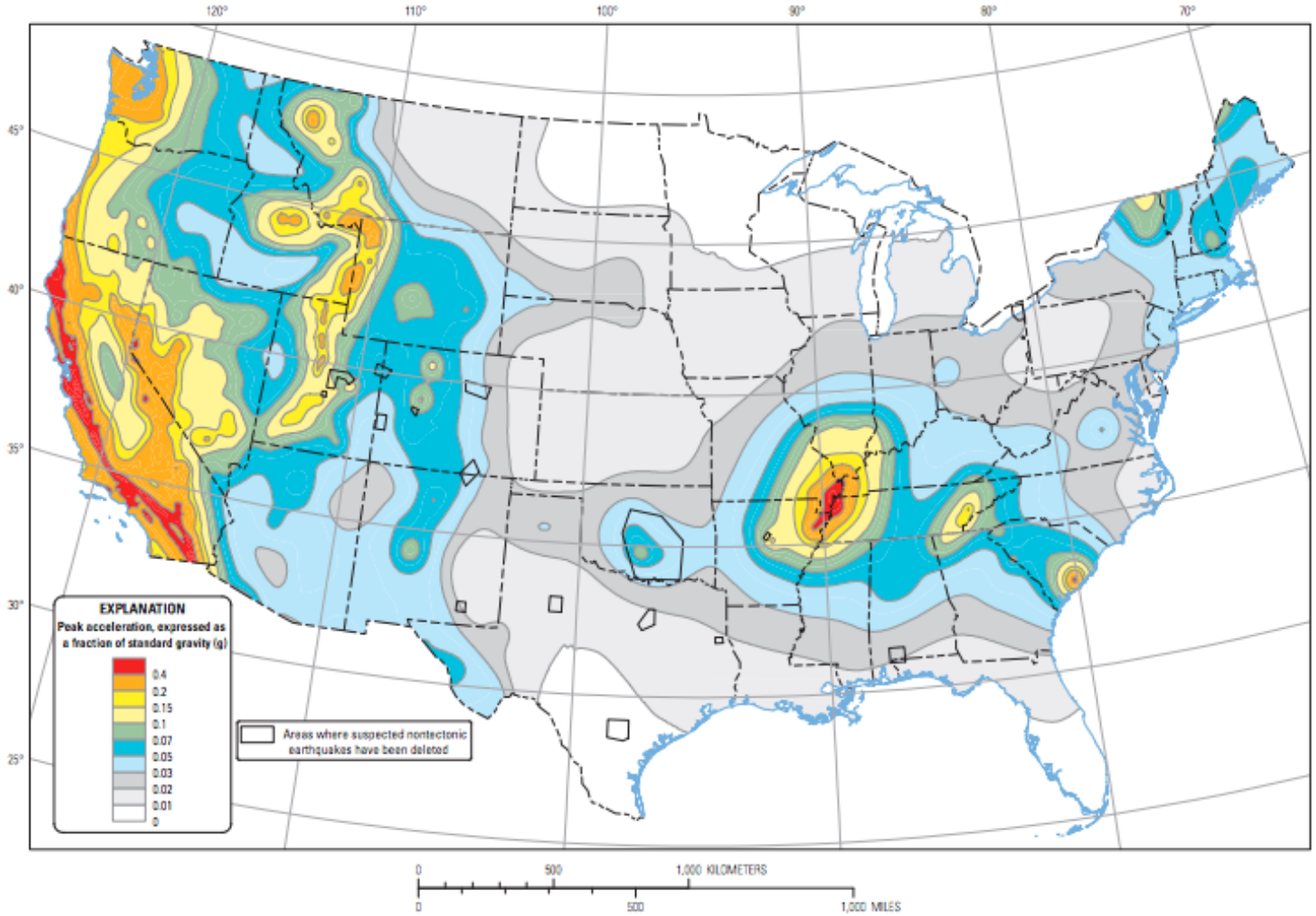
2014 USGS Map of Earthquake Hazard in the Conterminous U.S.



Ten-percent probability of exceedance in 50 years map of peak ground acceleration

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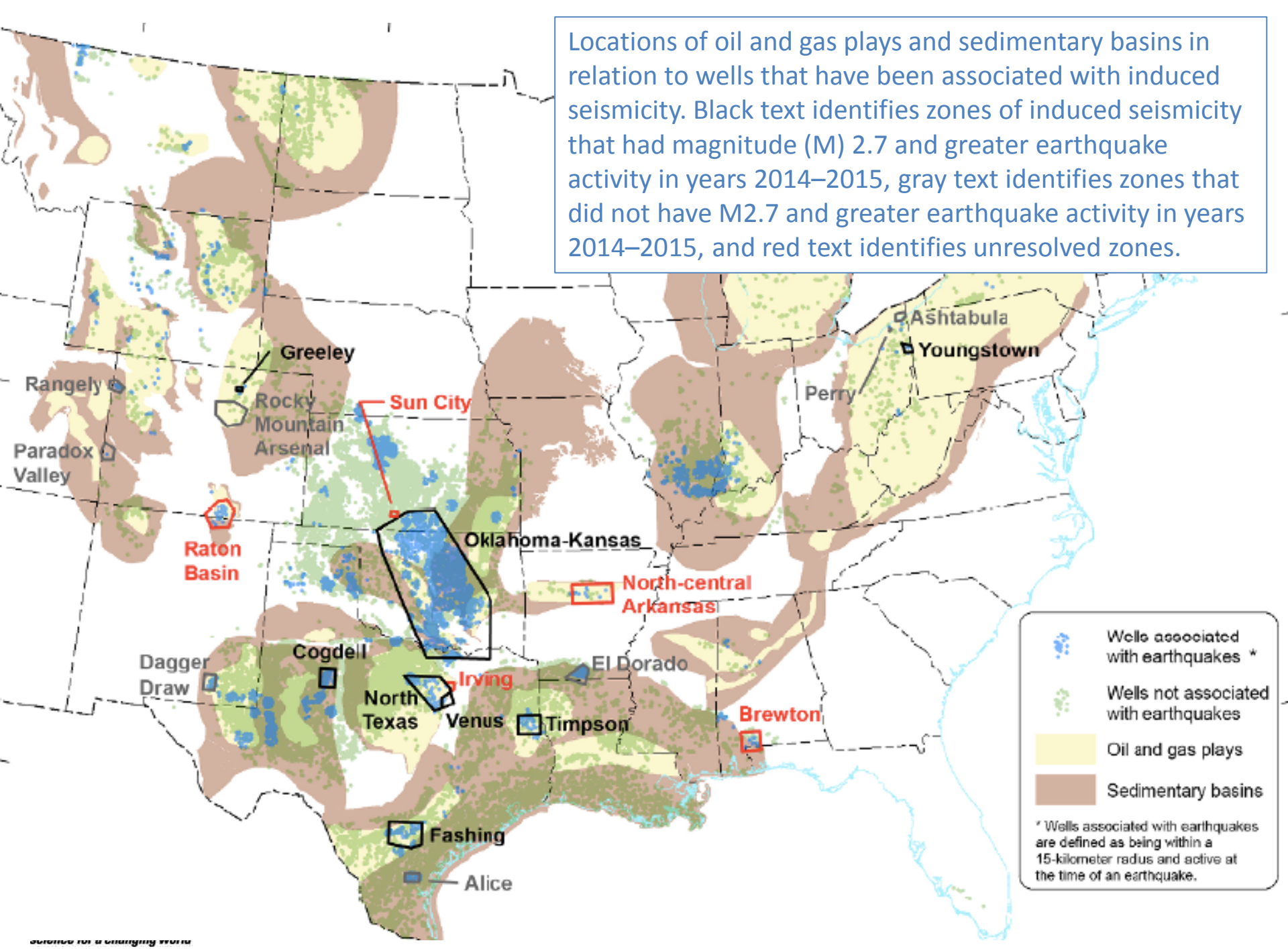
Locations of oil and gas plays and sedimentary basins in relation to wells that have been associated with induced seismicity. Black text identifies zones of induced seismicity that had magnitude (M) 2.7 and greater earthquake activity in years 2014–2015, gray text identifies zones that did not have M2.7 and greater earthquake activity in years 2014–2015, and red text identifies unresolved zones.
Greeley
Rangely
Rocky Mountain Arsenal
Sun City
Paradox Valley
Raton Basin
Oklahoma-Kansas
North-central Arkansas
Ashtabula
Youngstown
Perry
Dagger Draw
Cogdell
Irving
North Texas
Venus
Timpson
El Dorado
Brewton
Fashing
Alice
Wells associated with earthquakes *
Wells not associated with earthquakes
Oil and gas plays
Sedimentary basins
* Wells associated with earthquakes are defined as being within a 15-kilometer radius and active at the time of an earthquake.

New Publication: One-Year Seismic Hazard Forecast for the Central and Eastern U.S. from Induced & Natural Earthquakes

KEY POINTS:

- The USGS has produced a 1-year earthquake hazard forecast for 2016 for the Central and Eastern United States that includes contributions from both induced and natural earthquakes. The model assumes that earthquake rates calculated will remain relatively stationary and can be used to forecast earthquake hazard and damage intensity for the year 2016.
- Near some areas of active induced earthquakes, hazard is higher than in the 2014 USGS National Seismic Hazard Model by more than a factor of 3; the 2014 NHSM did not consider induced quakes.
- In some areas, previously observed induced earthquakes have stopped, so the seismic hazard reverts back to the 2014 NSHM. Increased seismic activity, whether defined as induced or natural, produces high hazard.
- Some places in Oklahoma, Kansas, Colorado, New Mexico, Texas, and Arkansas may experience damage if the induced seismicity continues unabated.
- The chance of having damaging earthquake shaking is 5–12 percent per year in north-central Oklahoma and southern Kansas, similar to the chance of damage caused by natural earthquakes at sites in parts of California.
- This assessment is the first step in developing short-term earthquake forecasts for any area, as the analysis could be revised with various seismicity and model parameters

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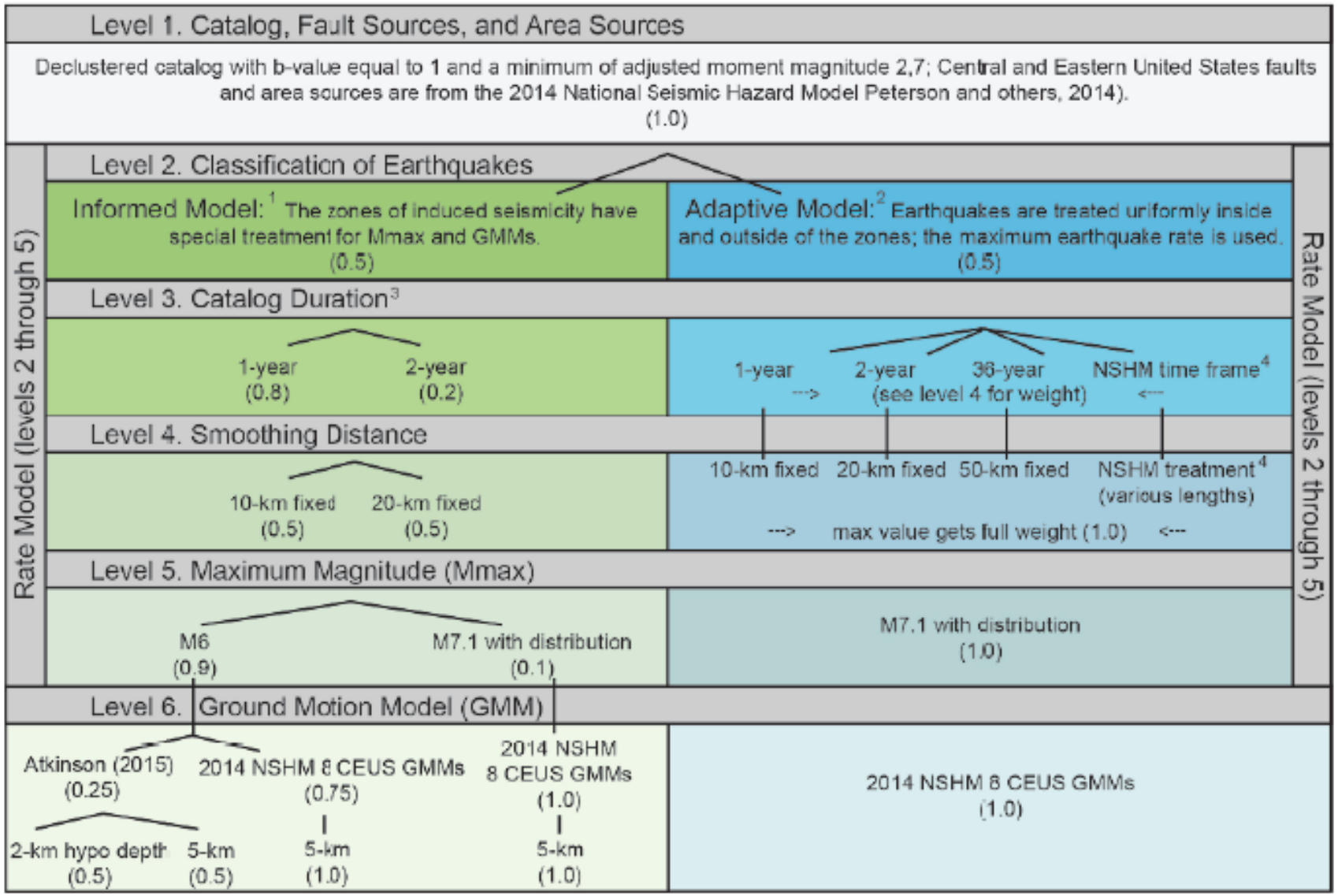
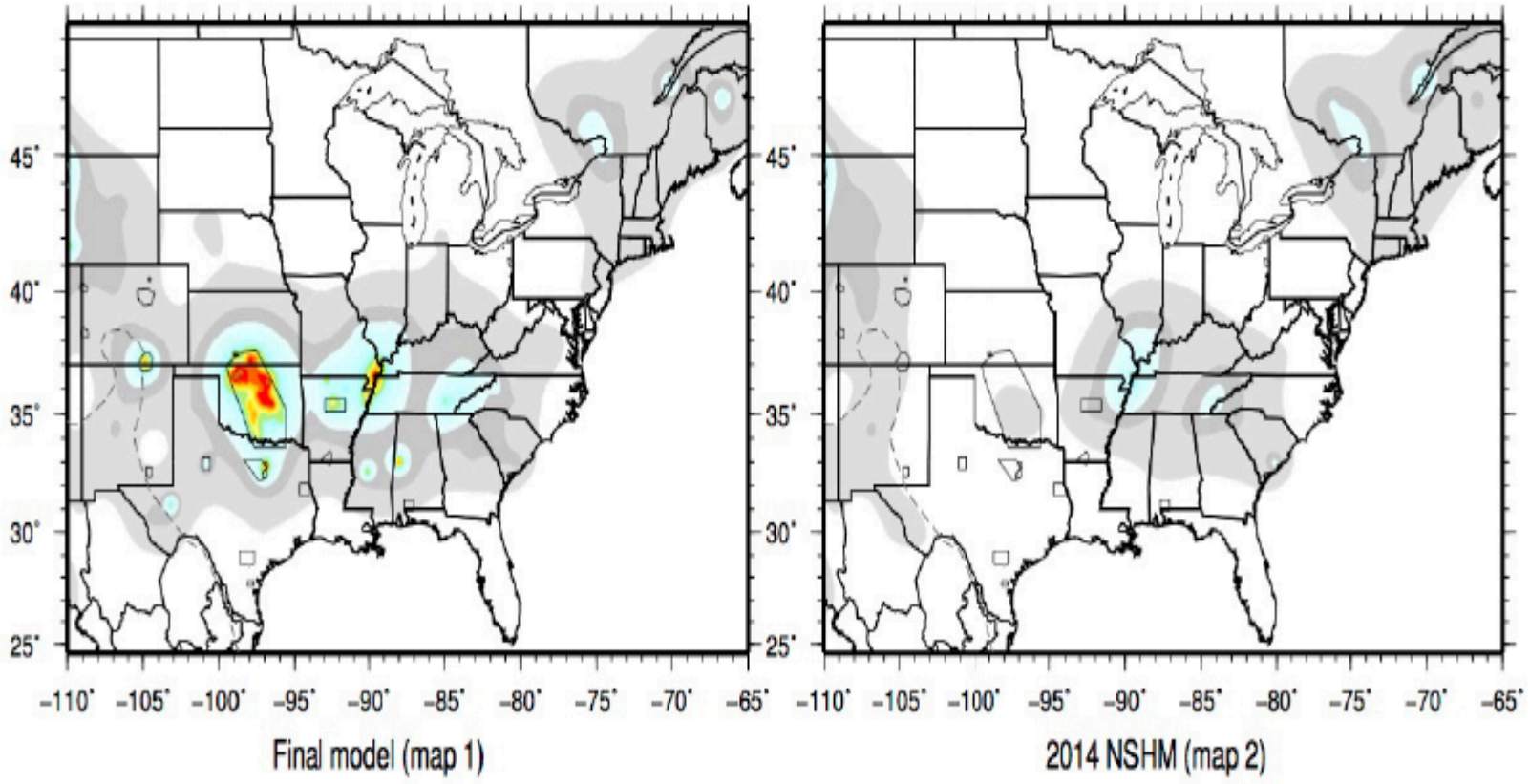
Probabilistic Analysis



Comparison of 1-year model with 2014 National Seismic Hazard Map



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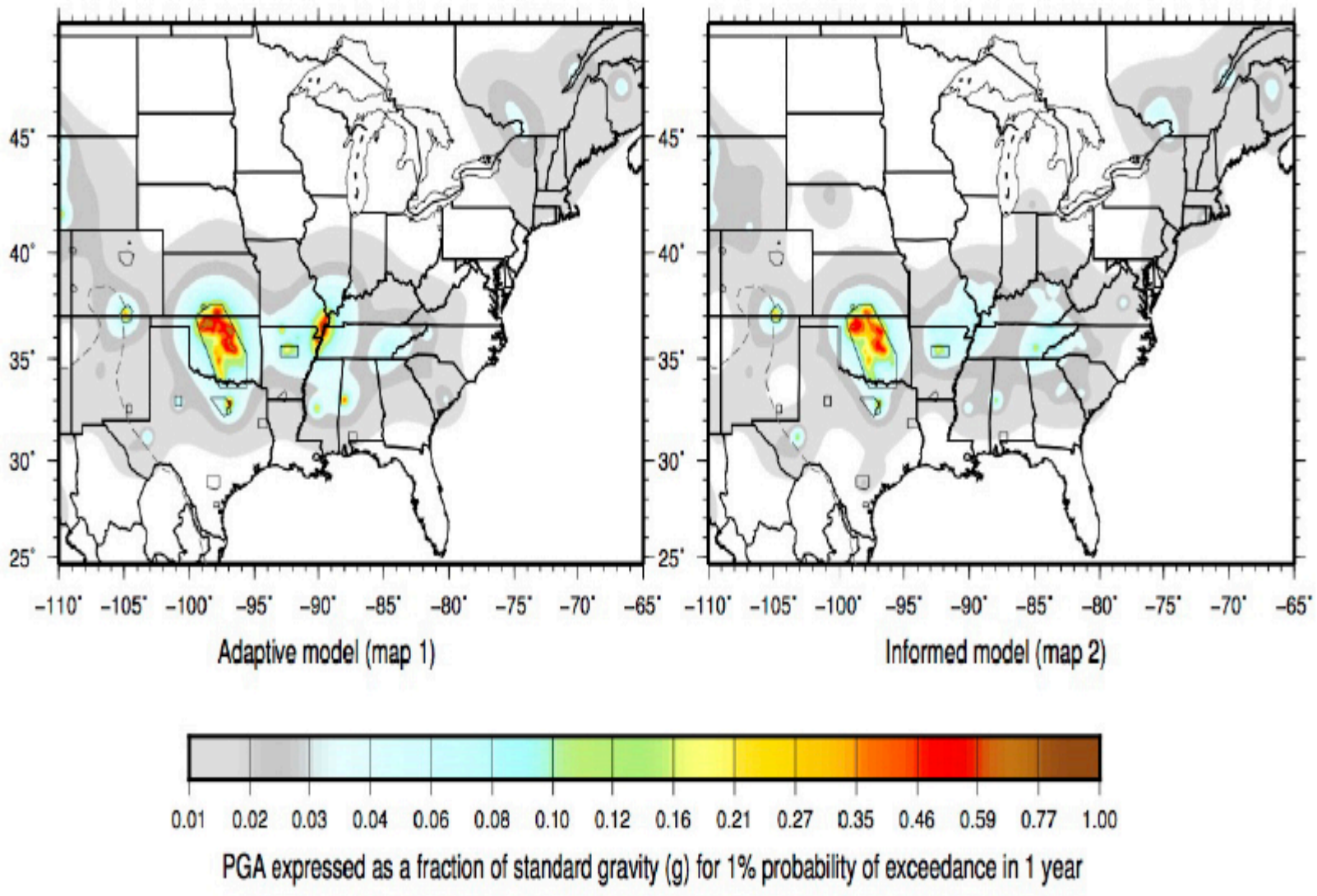
Comparison of Adaptive and Informed Models



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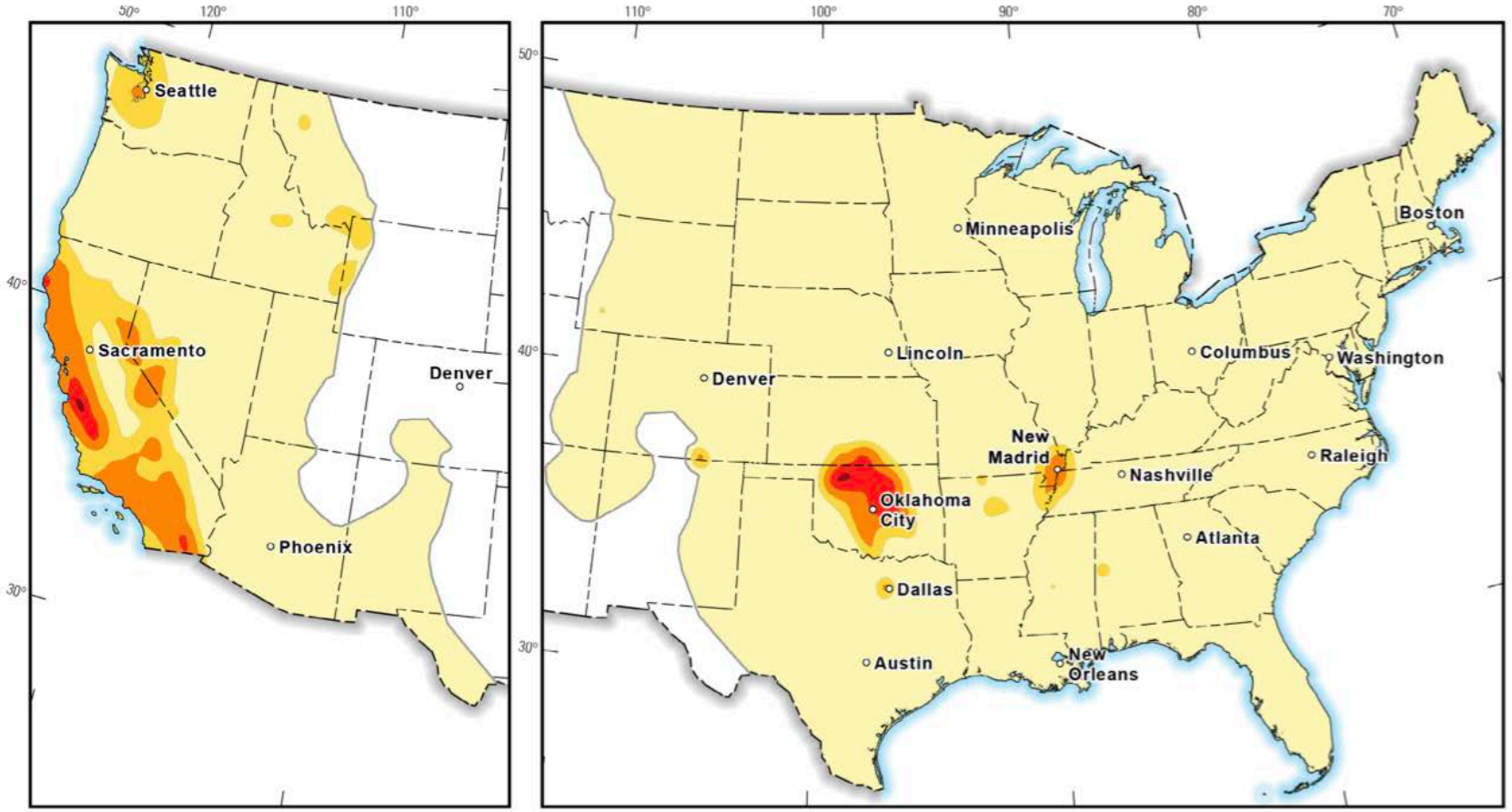
Comparison of Damage Probabilities



Based on results from the 2014 National Seismic Hazard Model

Based on results from this study

Chance of damage from an earthquake in 2016

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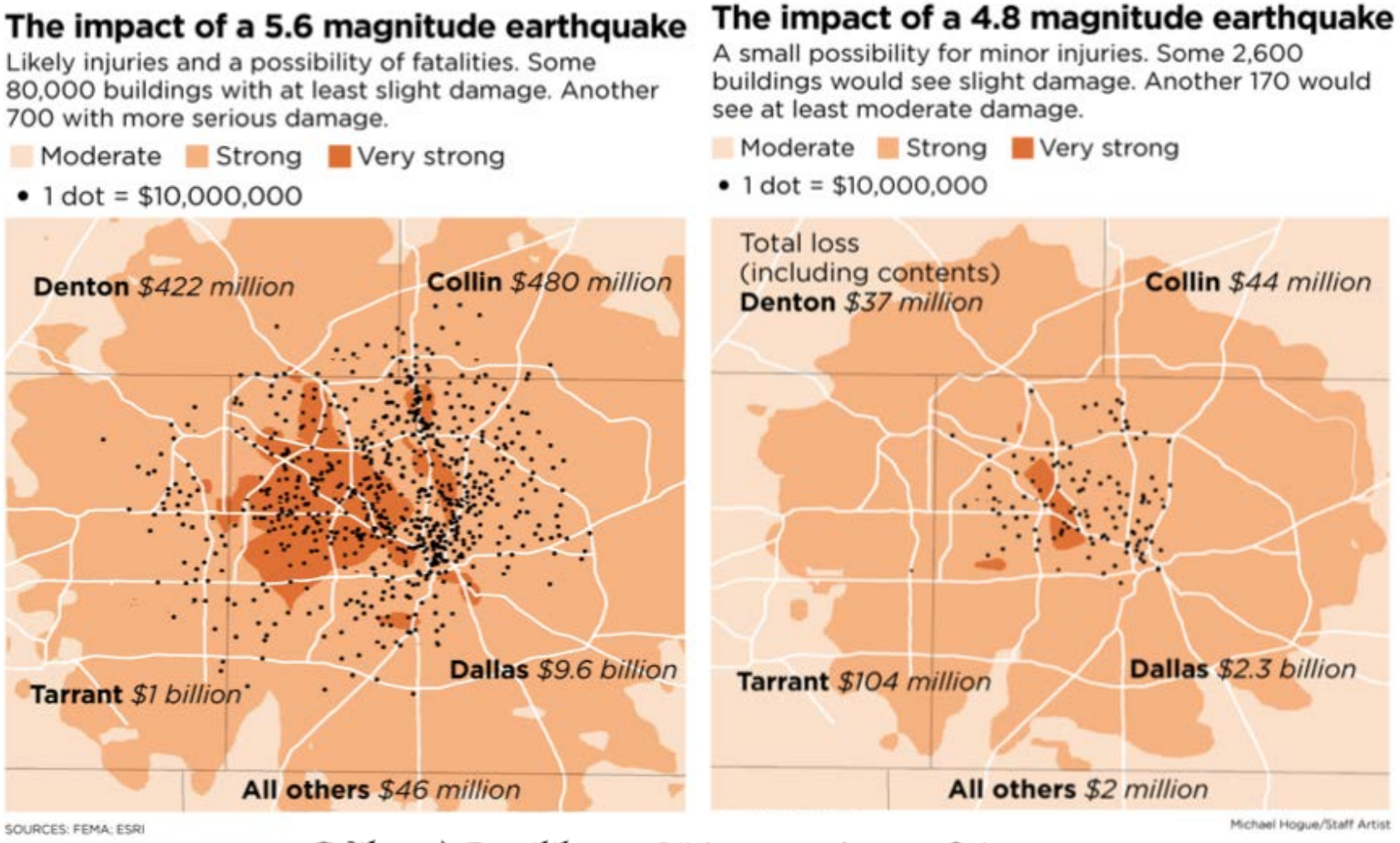
Summary Points

- Recent high rates of seismicity in the CEUS have significantly increased earthquake hazard and risk in a few areas.
- USGS identified 21 areas in several states with higher seismicity in recent years, most of which are suspected induced seismicity due to oil and gas activities.
- Near some areas of active induced earthquakes, hazard is higher than in the 2014 USGS National Seismic Hazard Model by more than a factor of 3, notably in Central Oklahoma and Southern Kansas
- Whether the recent earthquake swarms are assessed as induced or not does not greatly affect the hazard calculations

DFW Earthquake Scenarios (FEMA-USGS)



The Dallas Morning News

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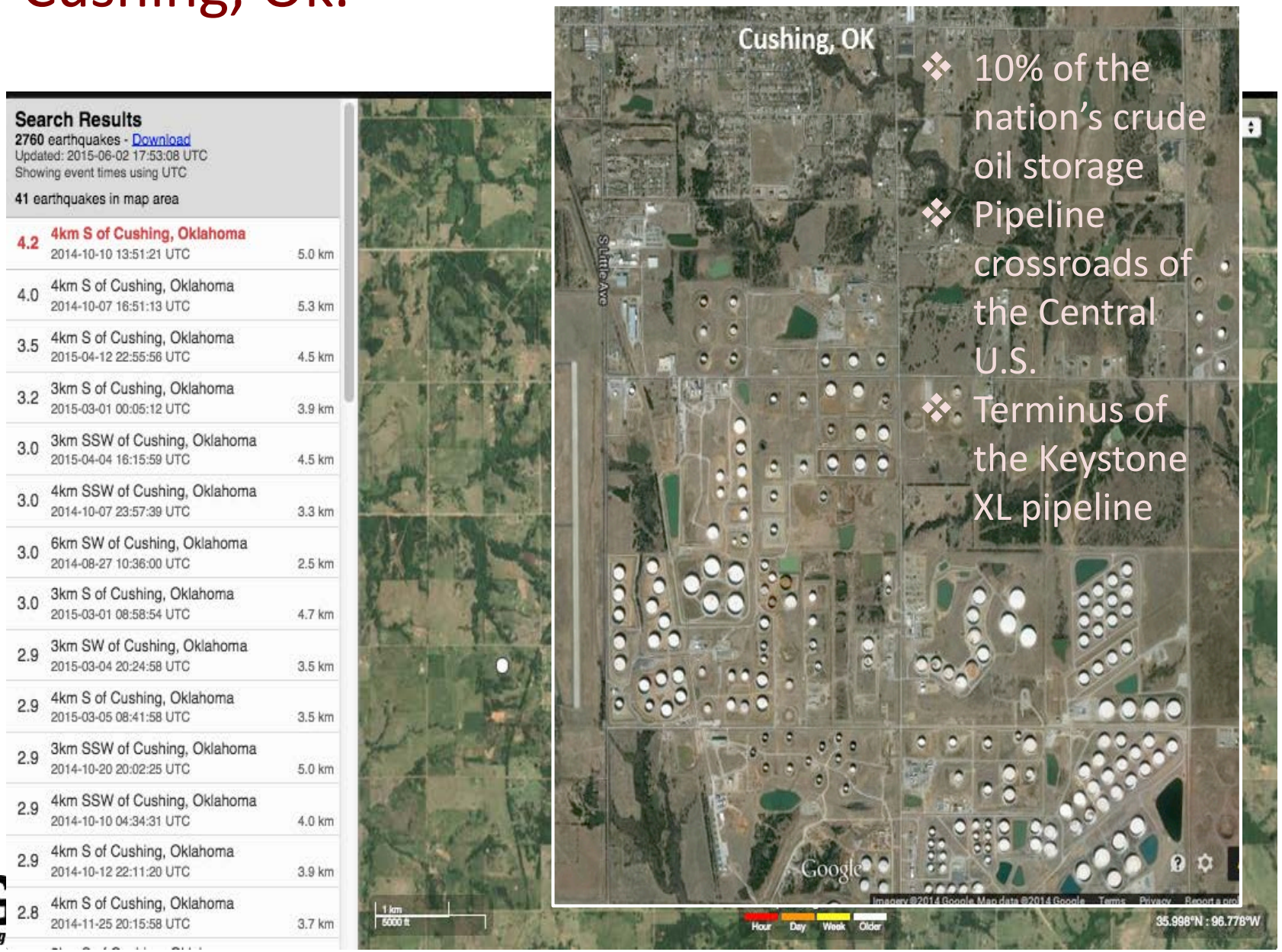
From Hazard to Risk: Earthquakes at Cushing, Ok.



- 10% of the nation's crude oil storage
- Pipeline crossroads of the Central U.S.
- Terminus of the Keystone XL pipeline

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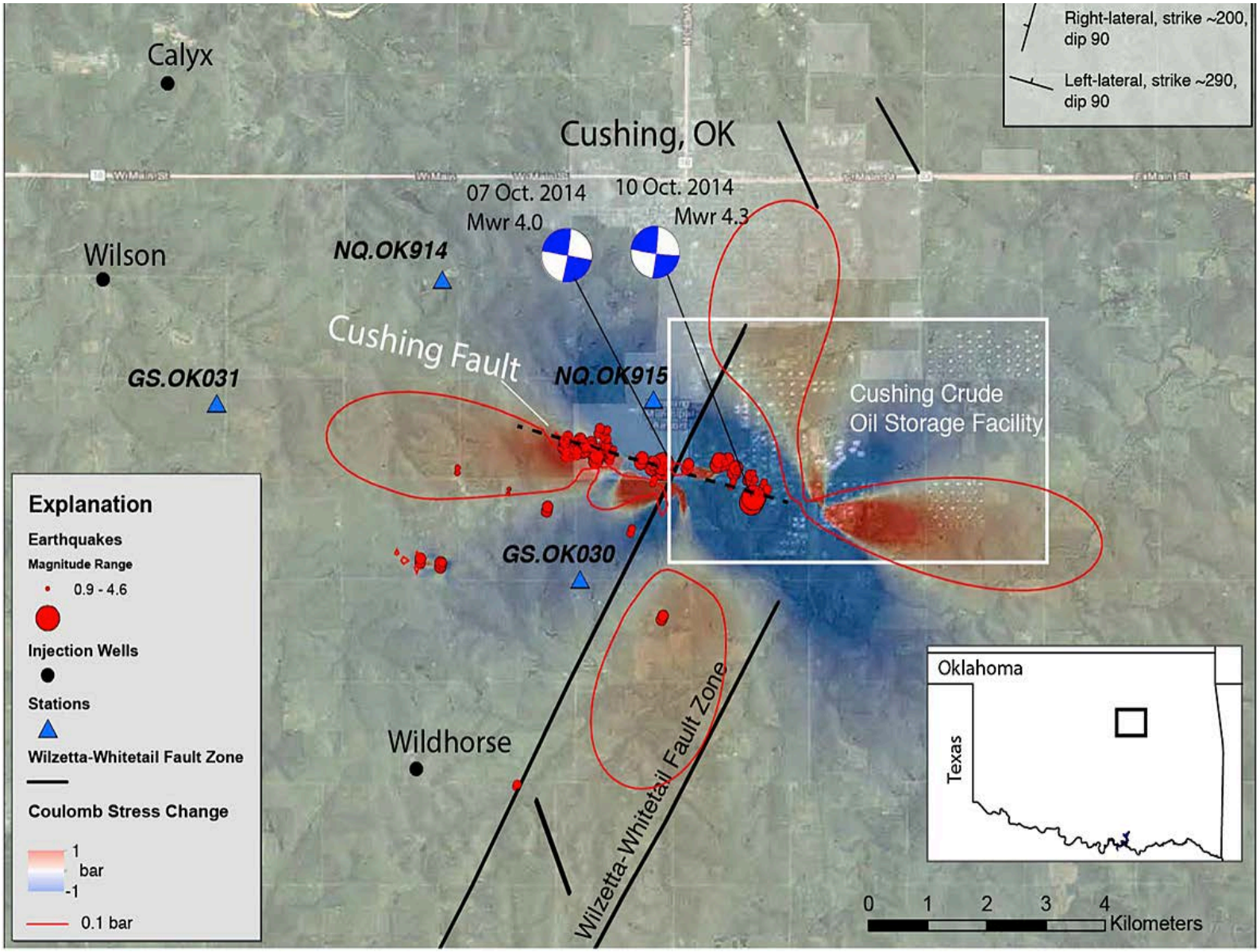
Risk Communication:
Example of Cushing, Oklahoma

McNamara et al, 2016



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