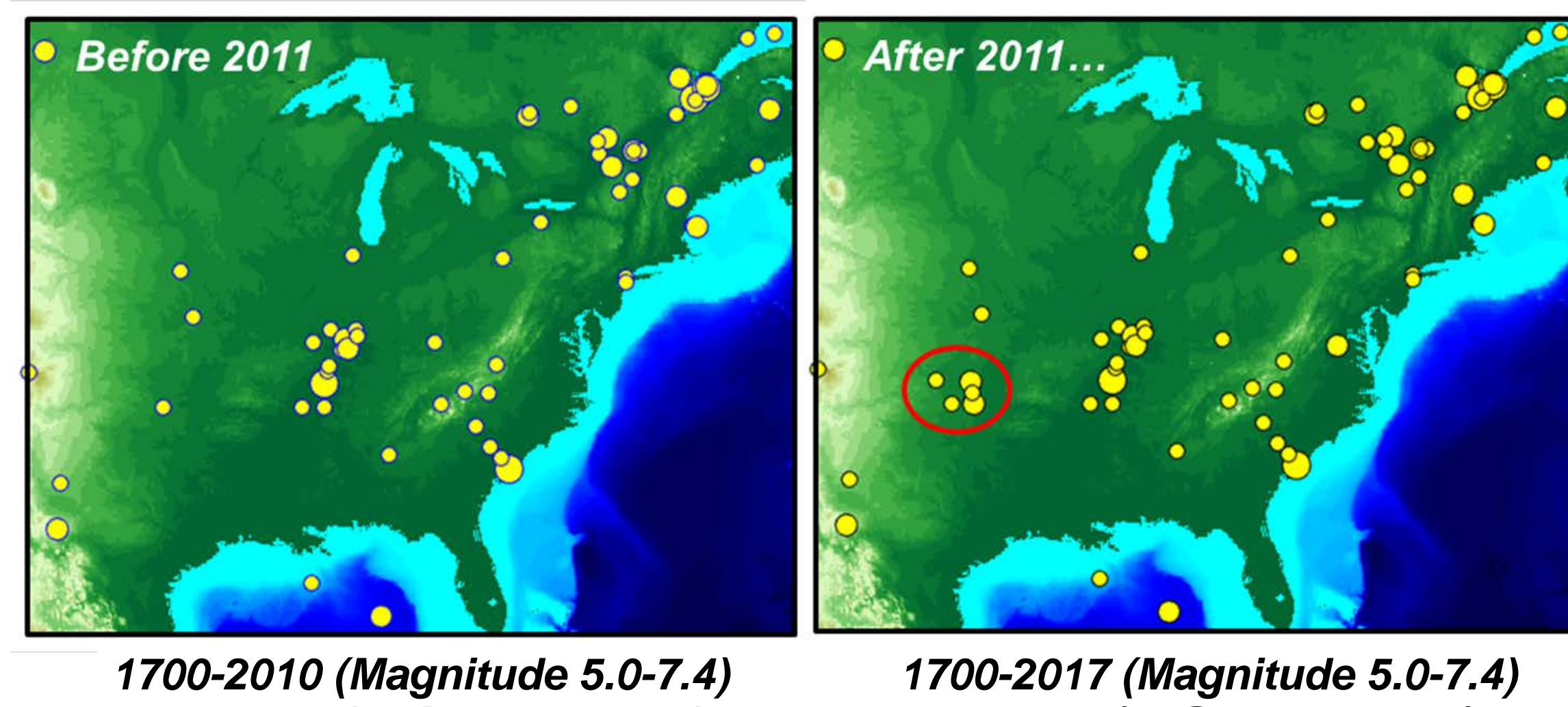


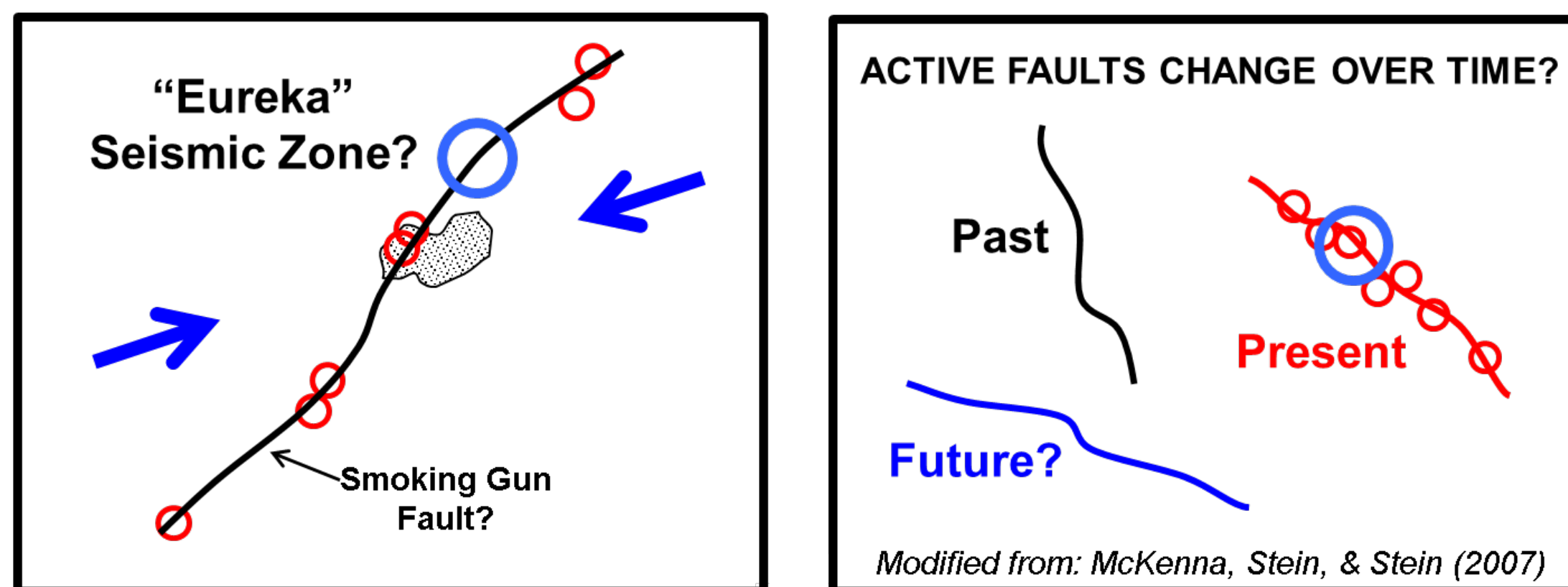
CELLULAR SEISMOLOGY PREDICTABILITY AS A MEASURE OF ASSOCIATION BETWEEN WASTEWATER INJECTION WELLS AND EARTHQUAKES: *THE STORY BEHIND THE STORY*

Alan L. Kafka (kafka@bc.edu) and Hannah E. Chambless (chambless@bc.edu)

Where Do Large Earthquakes Occur in the Eastern United States?

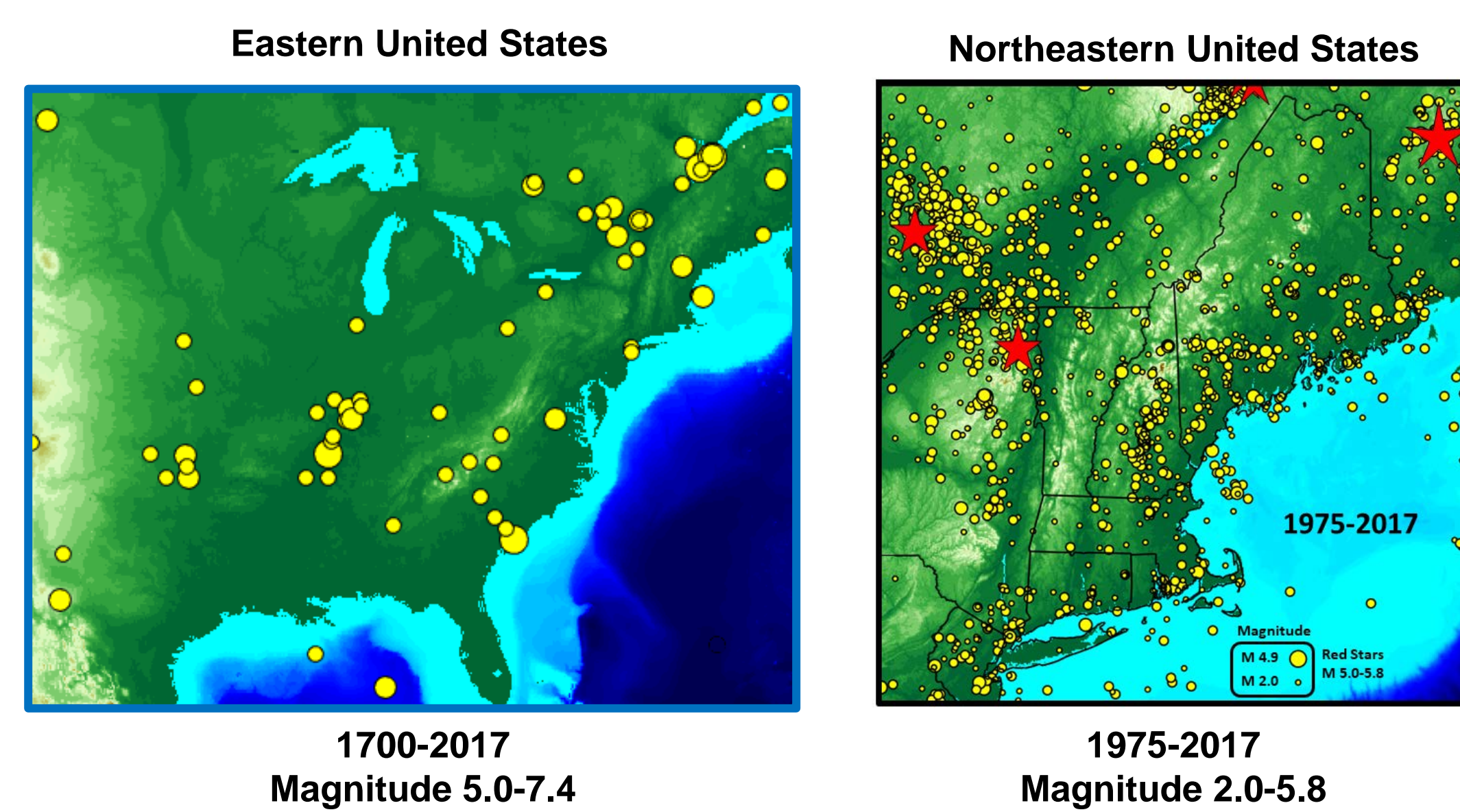


Models of Where Large Earthquakes Occur in the Central and Eastern United States



Large earthquakes occur in areas where geological faults and other tectonic features are observed - based on seismic, geophysical, and geological information.

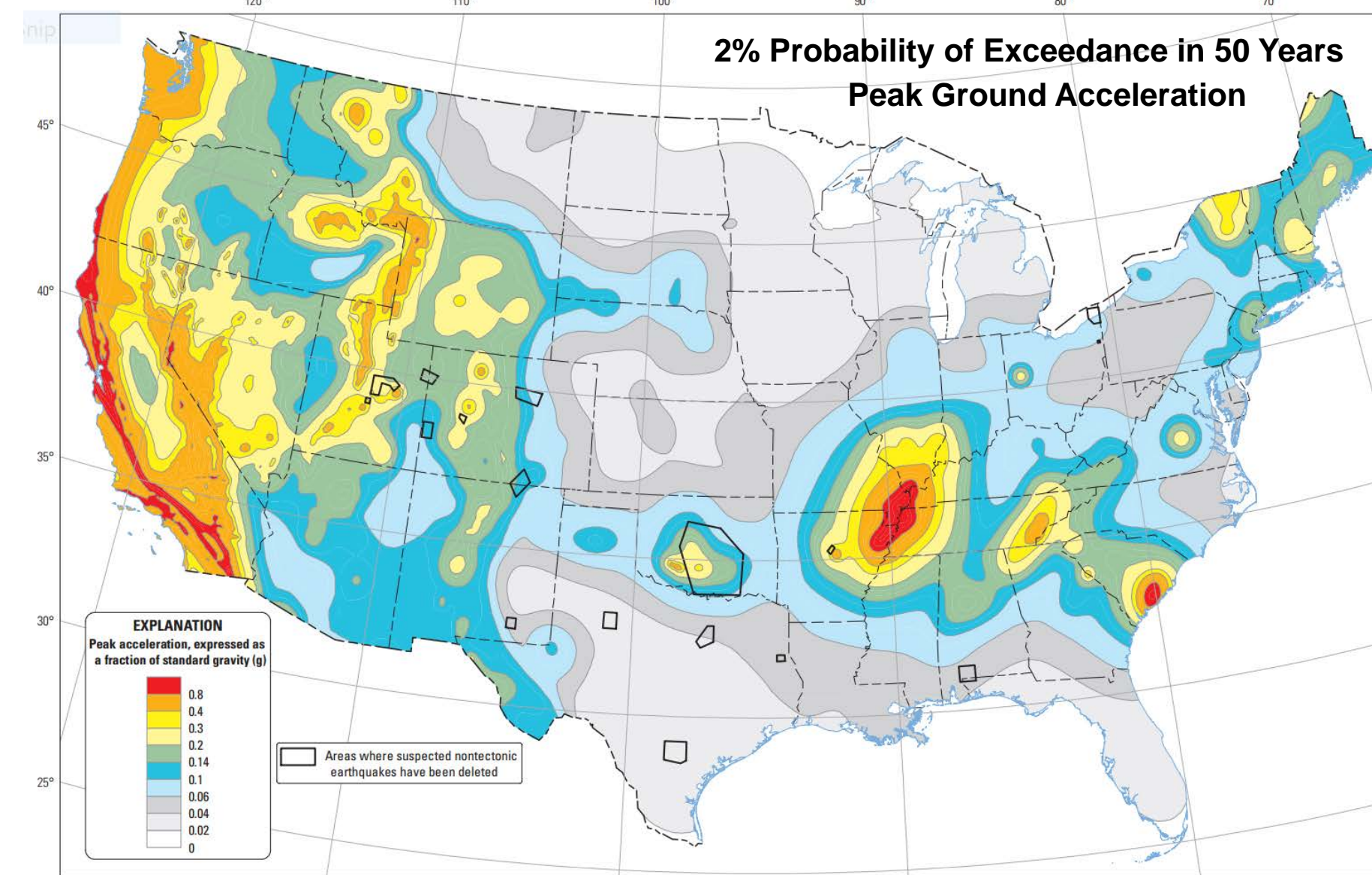
Large earthquakes can occur in areas where past seismicity has not been observed and on tectonic features that have not been active in recent times.



The search is on, but for now... As much as some seismologists may wish (or imagine or fantasize or pray for) it to be otherwise:

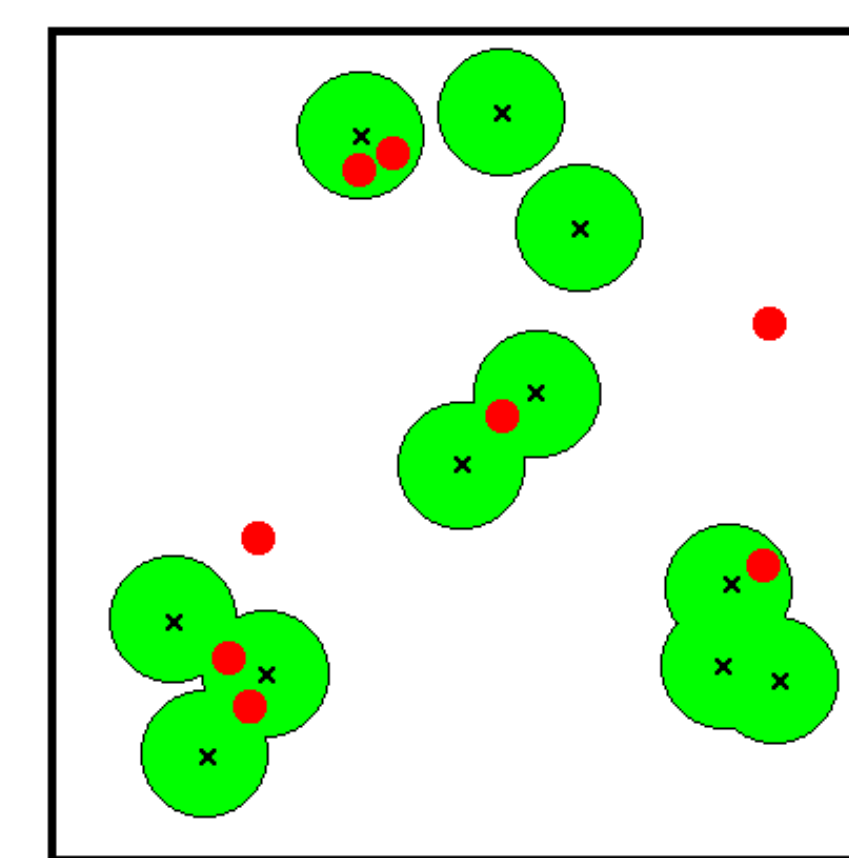
Nobody in the Eastern U.S. has (yet?) found a "San Andreas Fault" in their backyard...

2014 USGS National Seismic Hazard Map



For Central and Eastern U.S.
Past Seismicity → Future Earthquakes

"Cellular Seismology" (analogous to a cellular phone system)



Choose a radius such that circles fill P percentage of map area.

$$\hat{p} = 6/8 = 75\% = \text{sample of binomial random variable, } \rho.$$

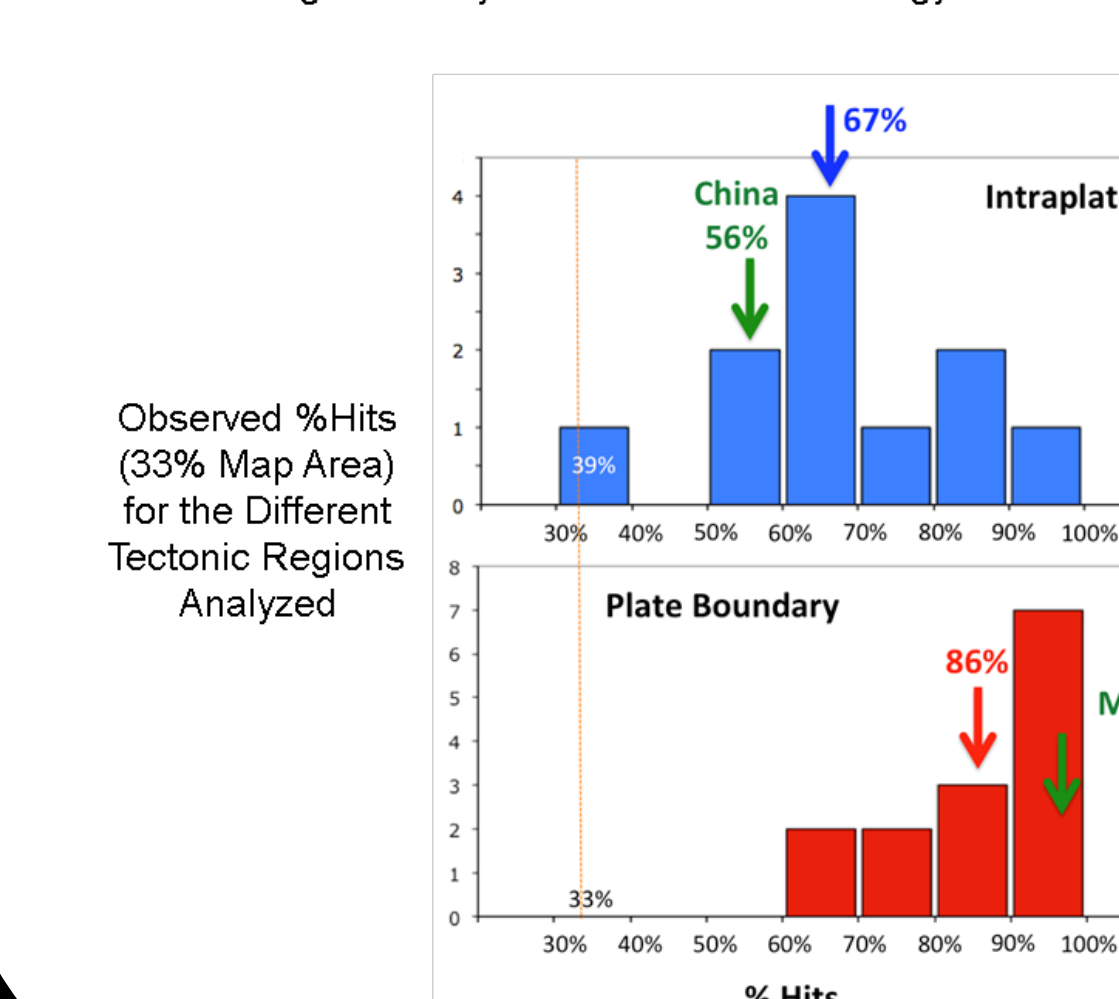
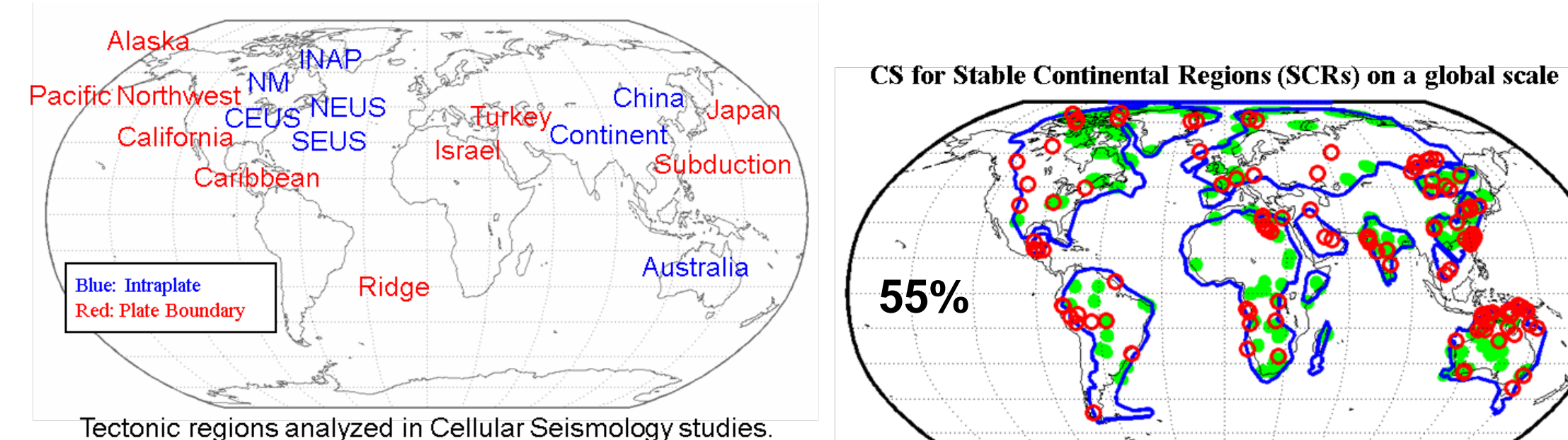
ρ = Probability ("success")

success = red circle occurs within one of the green circles.

● past (earlier) "Pre-CAT" ● future (later) "Post-CAT"

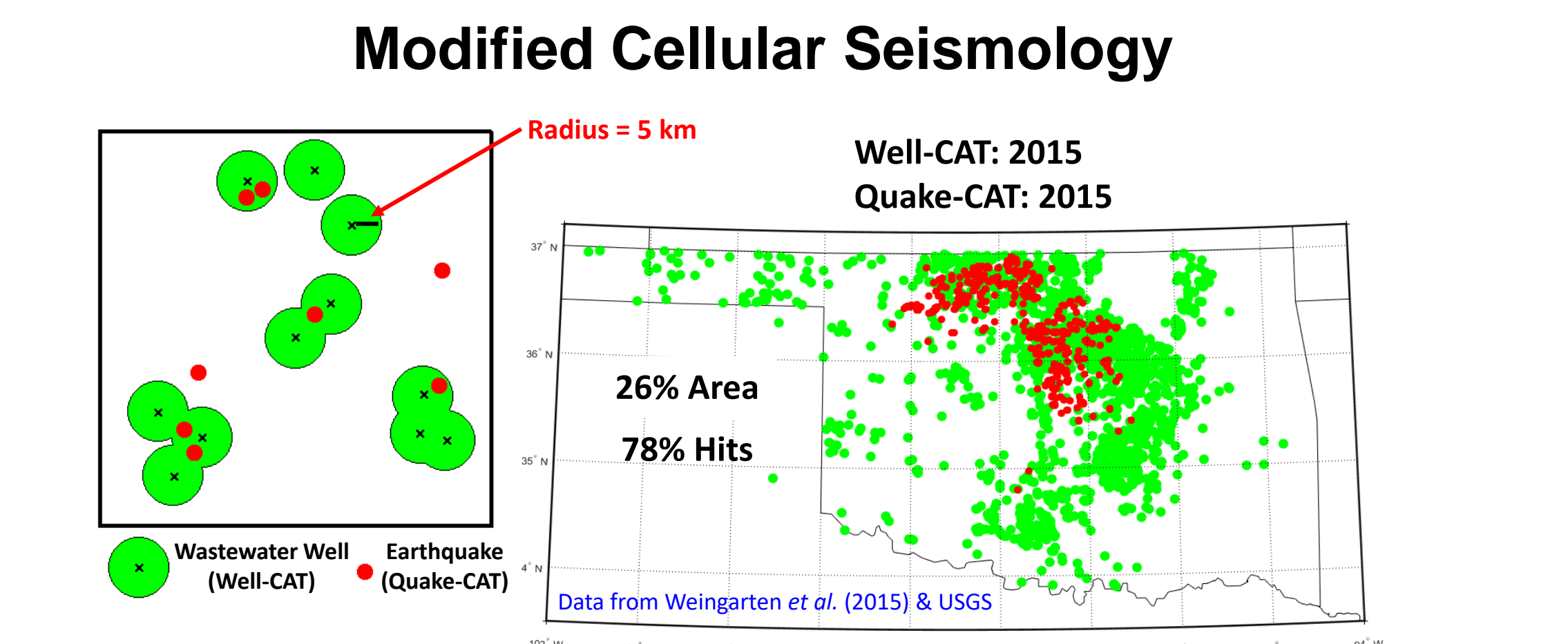
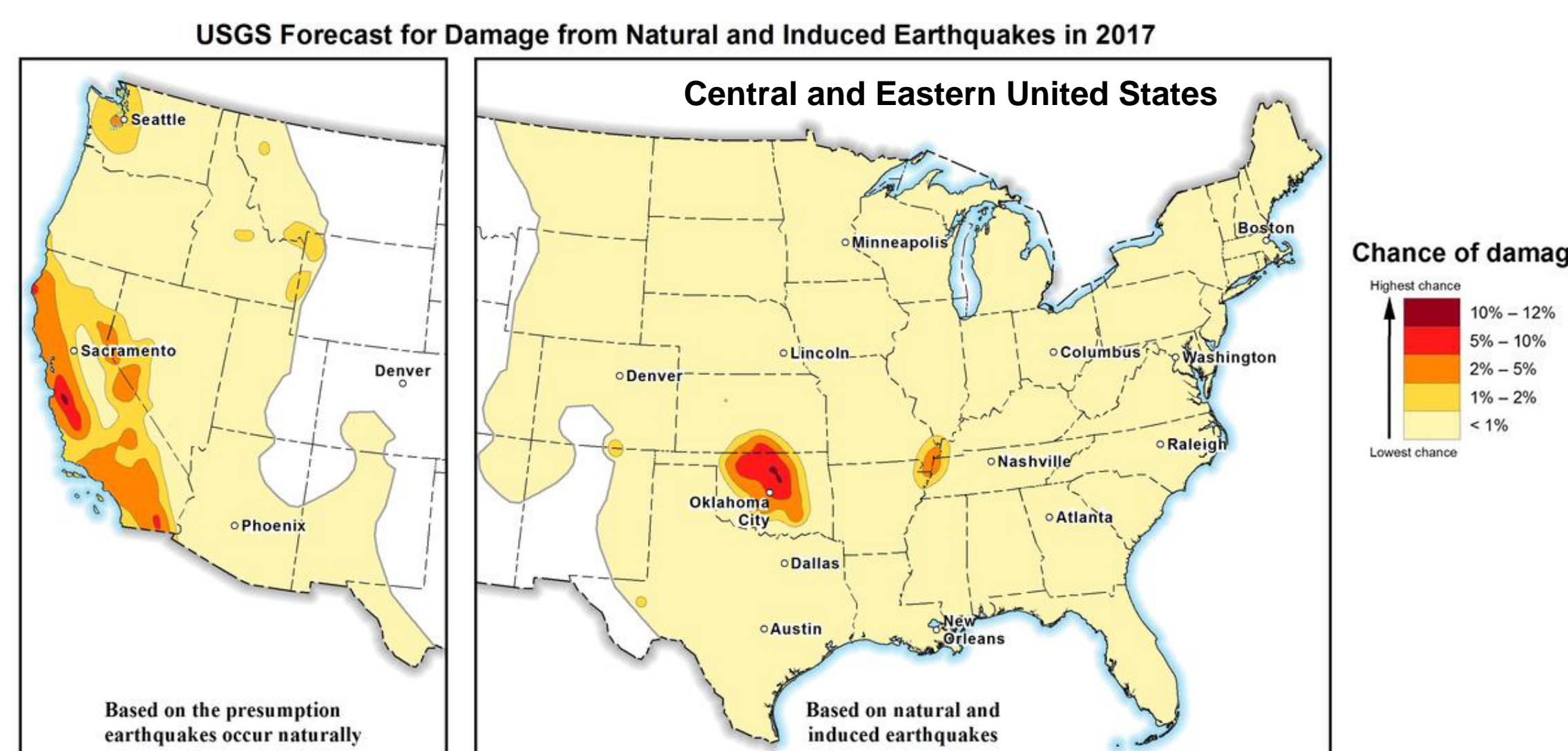
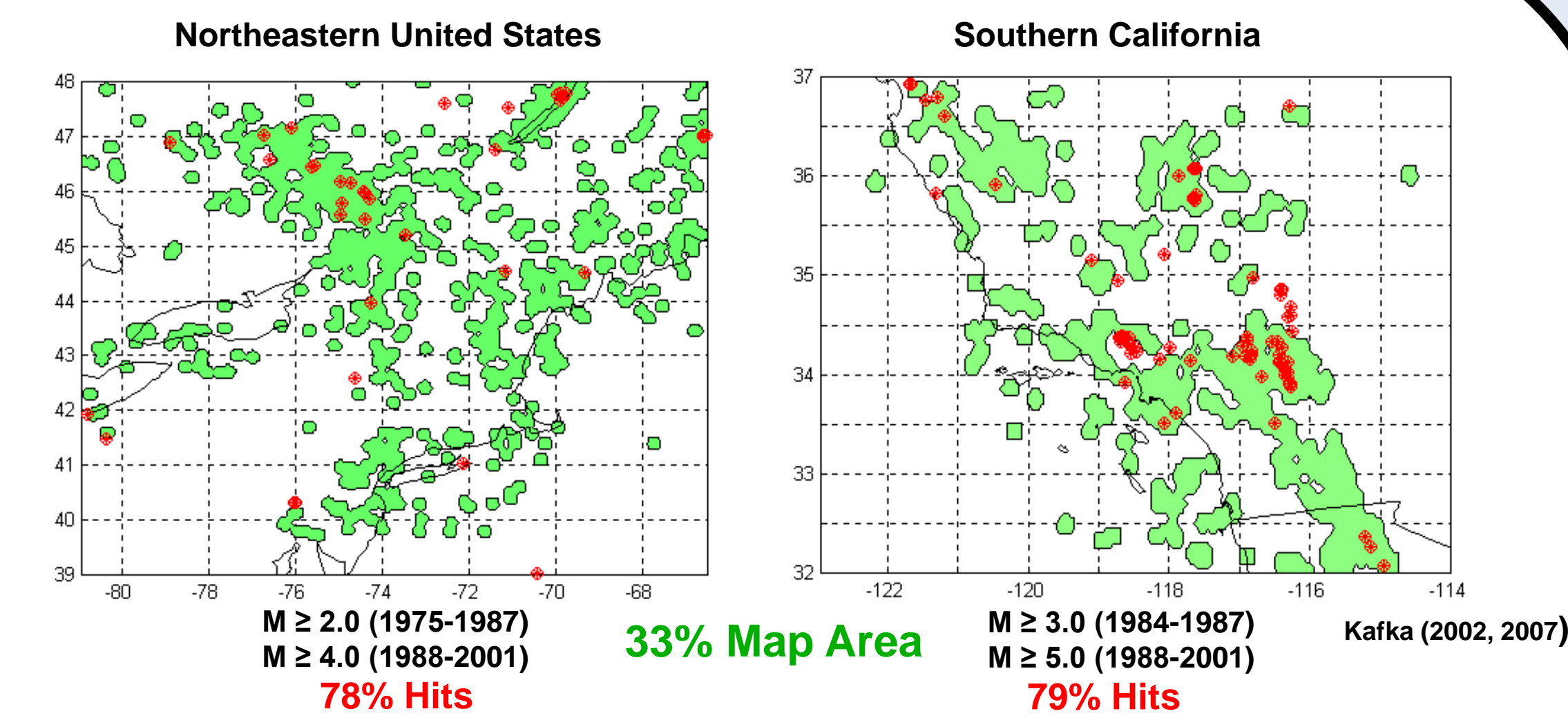
From Kafka (2002, 2007)

If a red circle is inside a green circle, we call that a "hit" ...
And, we analyze the percentages of hits for different cases.

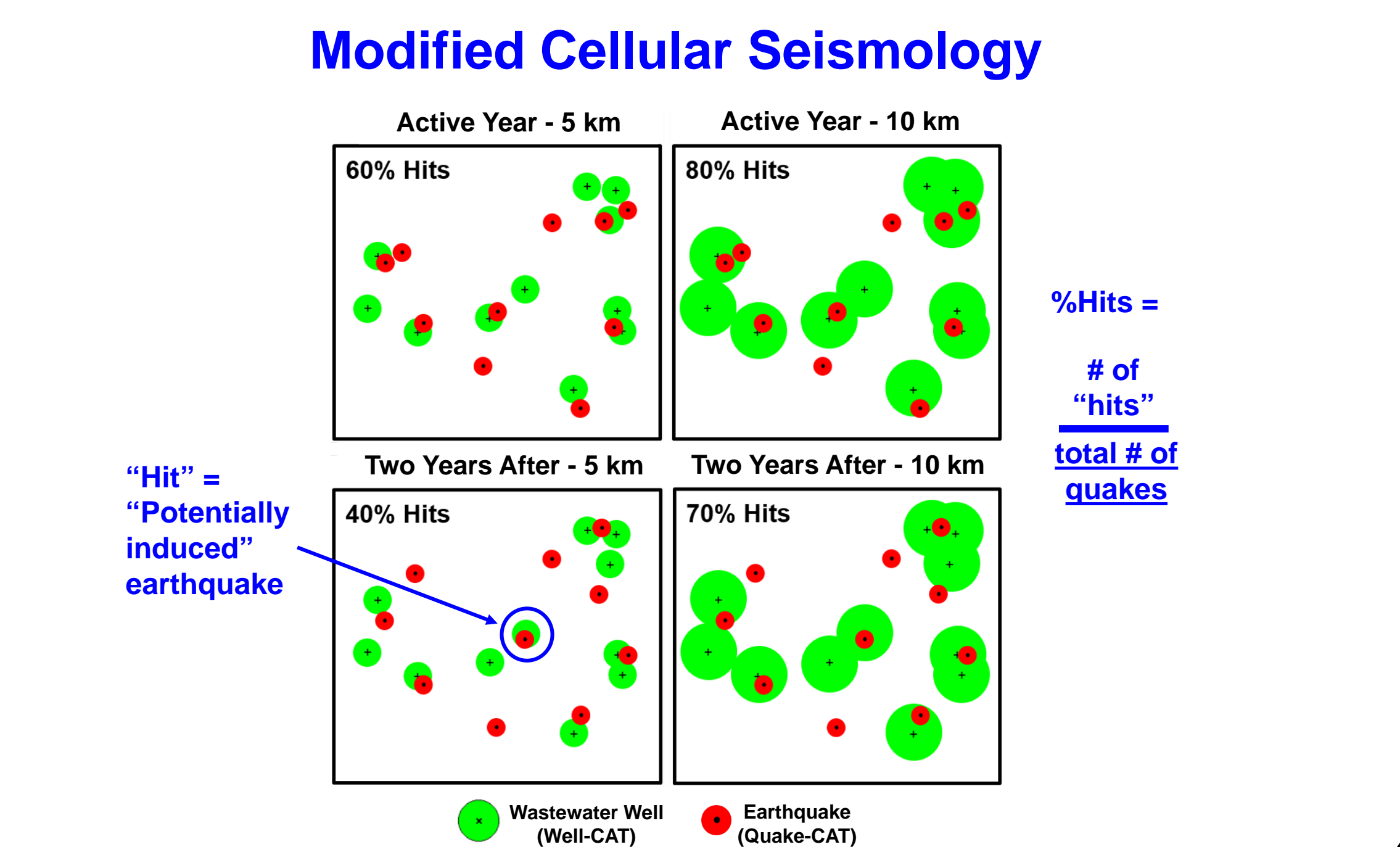


Cellular Seismology results for percentage of hits – generally lower for intraplate regions (67%) than for plate boundary regions (86%).

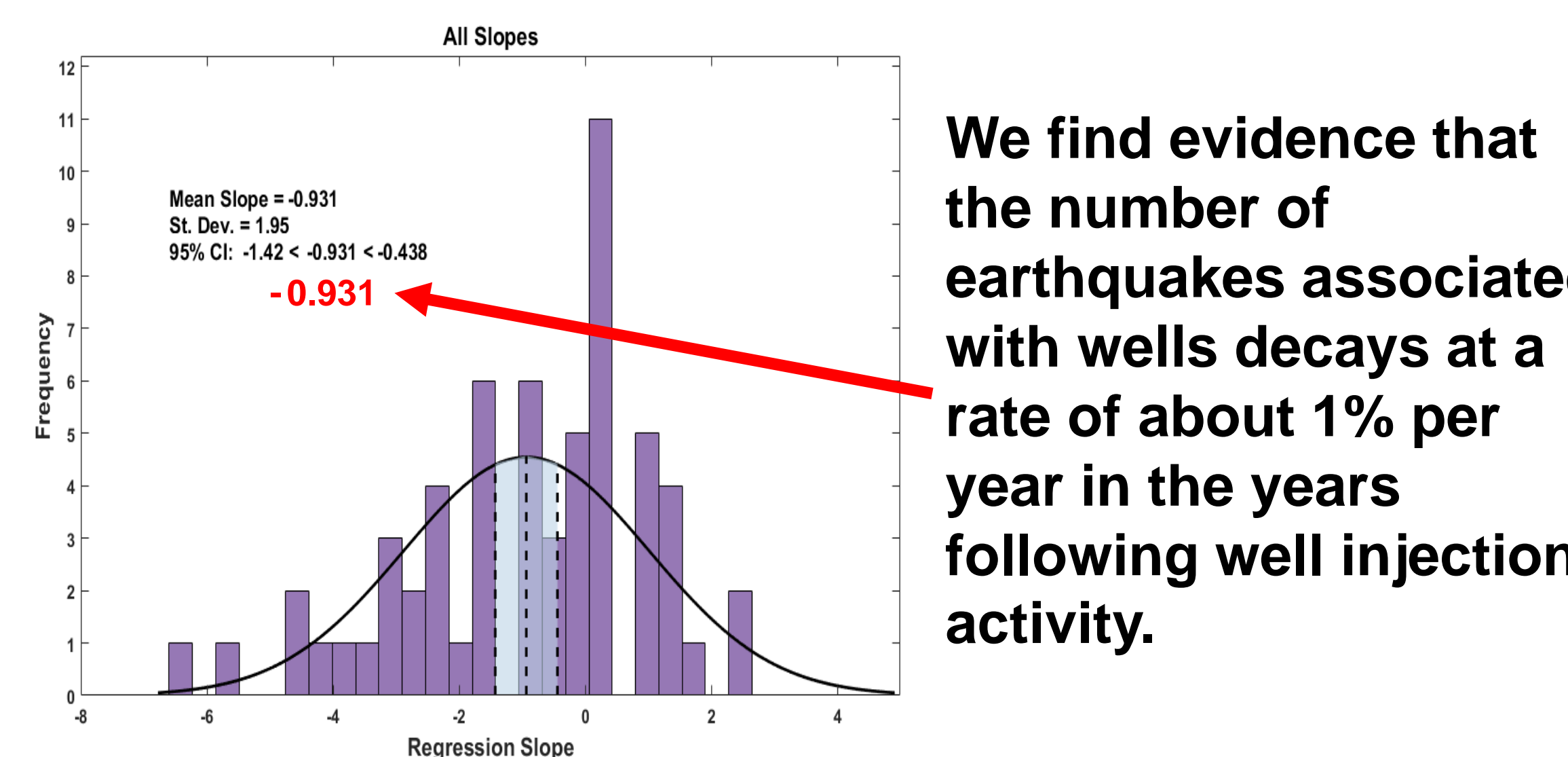
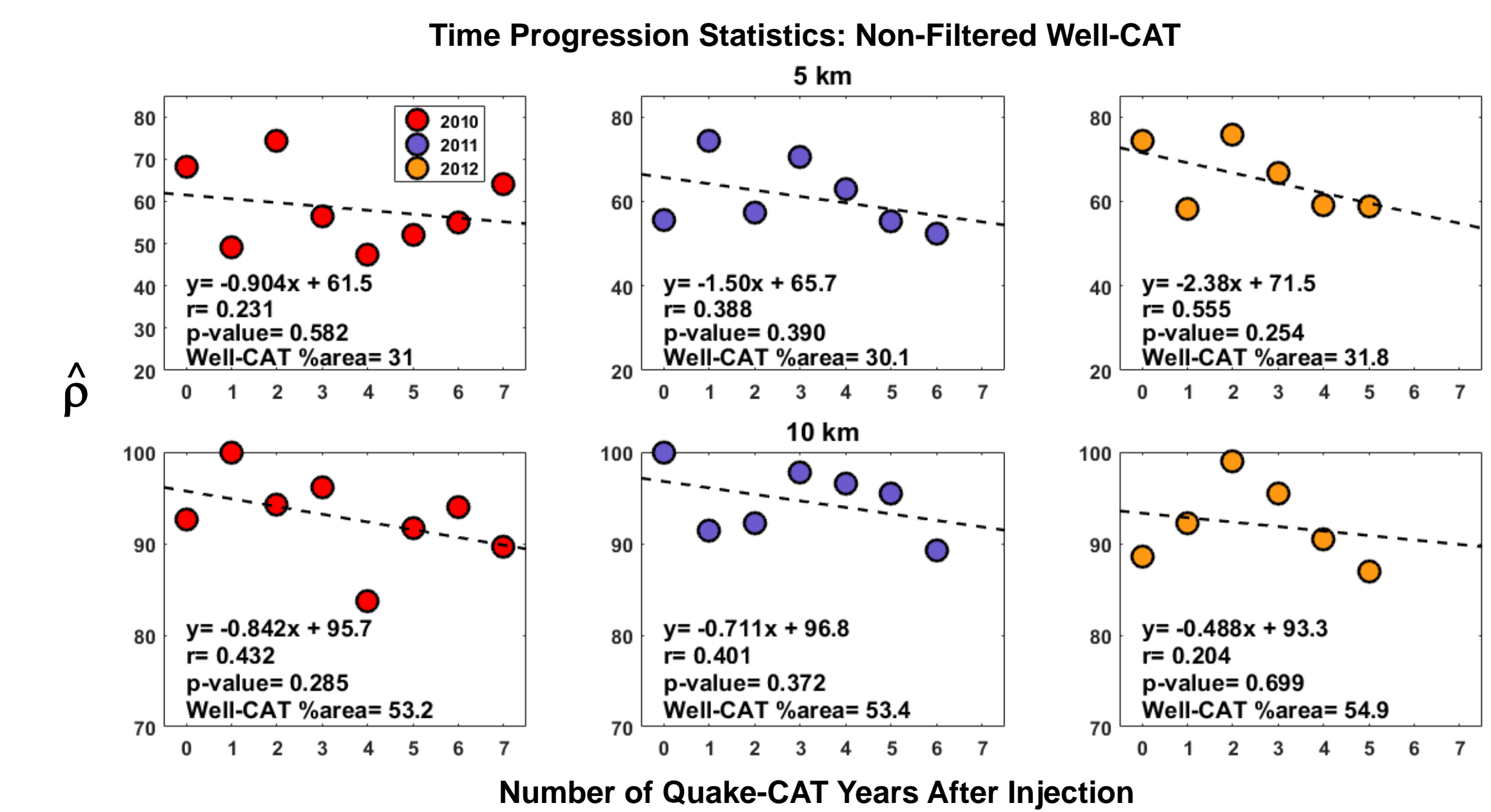
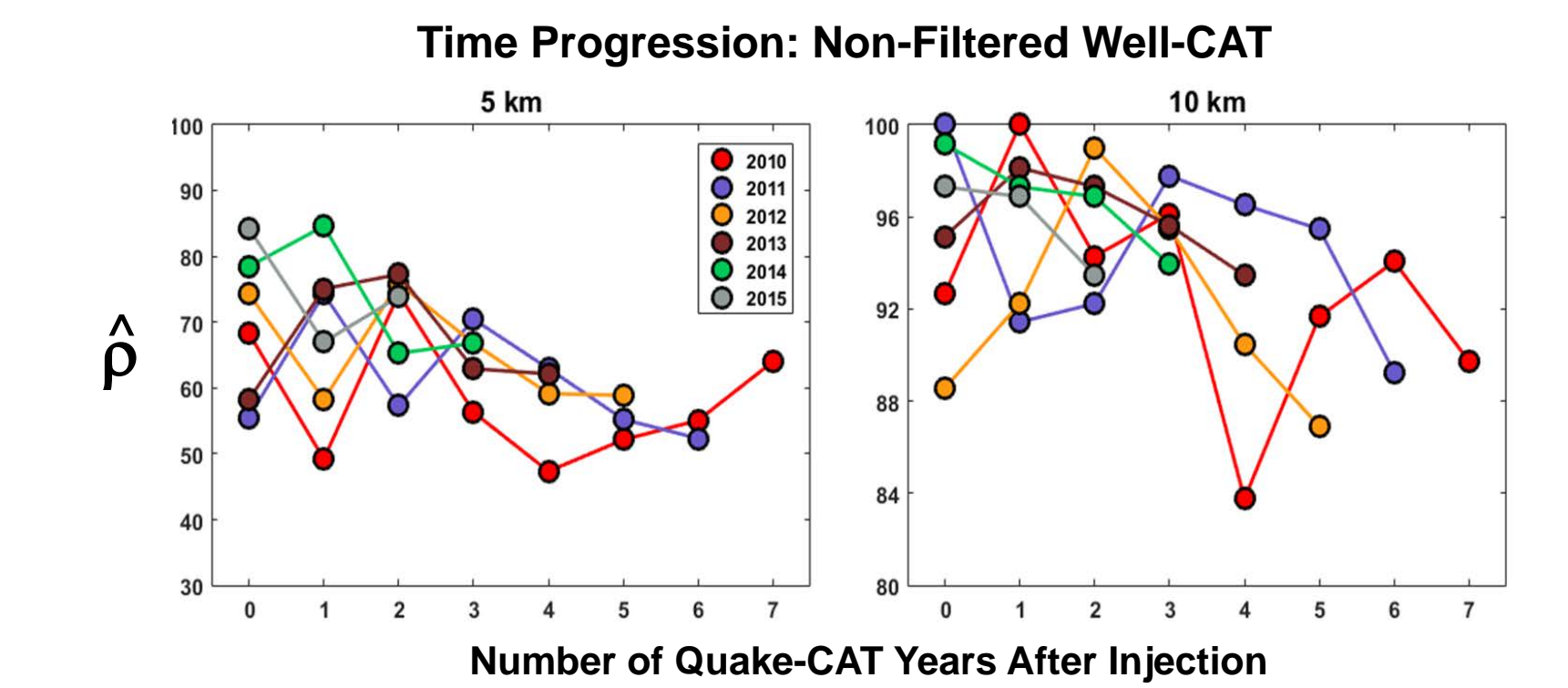
Results from 1988-2017



%Hits → Level of "CS Predictability"
We use "CS Predictability" (%Hits) as an operational definition of the extent to which injection wells are associated with induced earthquakes.



SO, WHAT'S THE STORY?



We find evidence that the number of earthquakes associated with wells decays at a rate of about 1% per year in the years following well injection activity.

See: Chambless and Kafka (2018, at this meeting)

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