REGIONAL DIFFERENCES IN Lg PROPAGATION IN THE CENTRAL UNITED STATES

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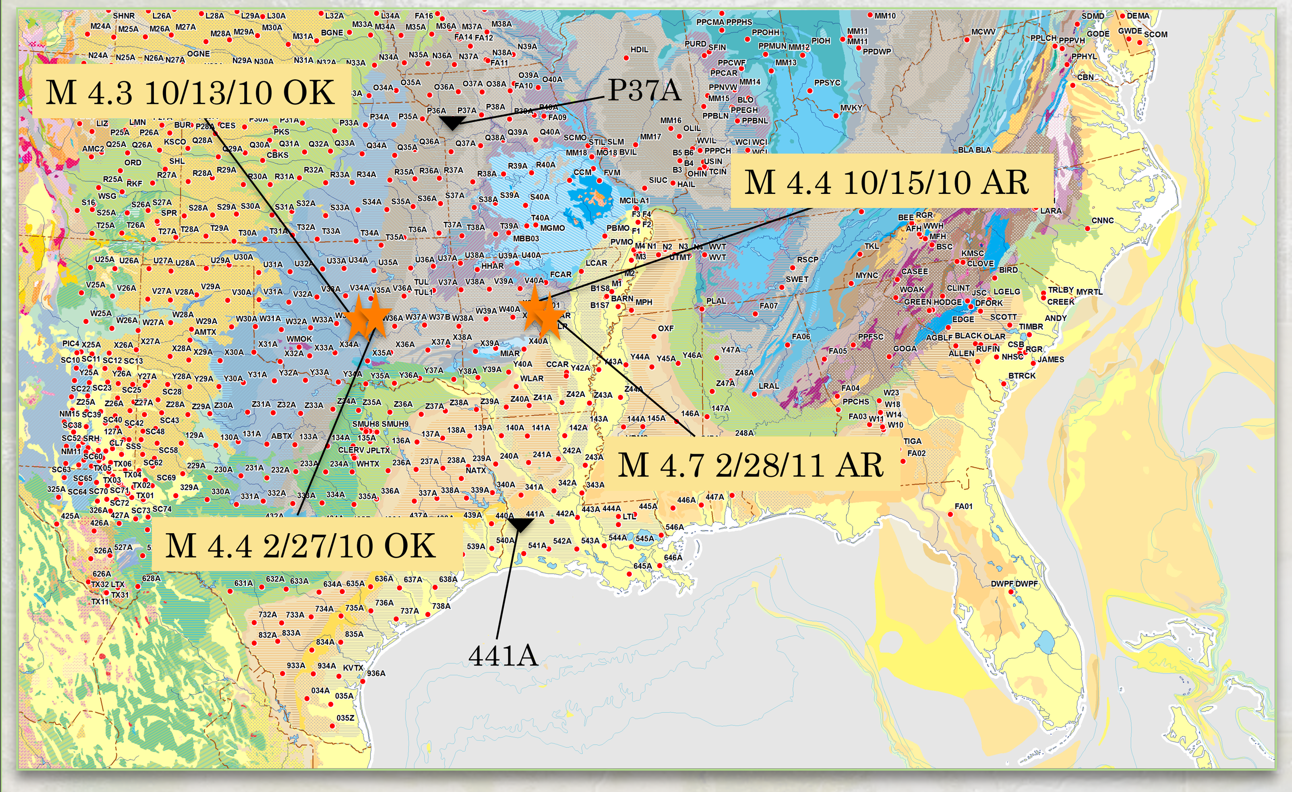
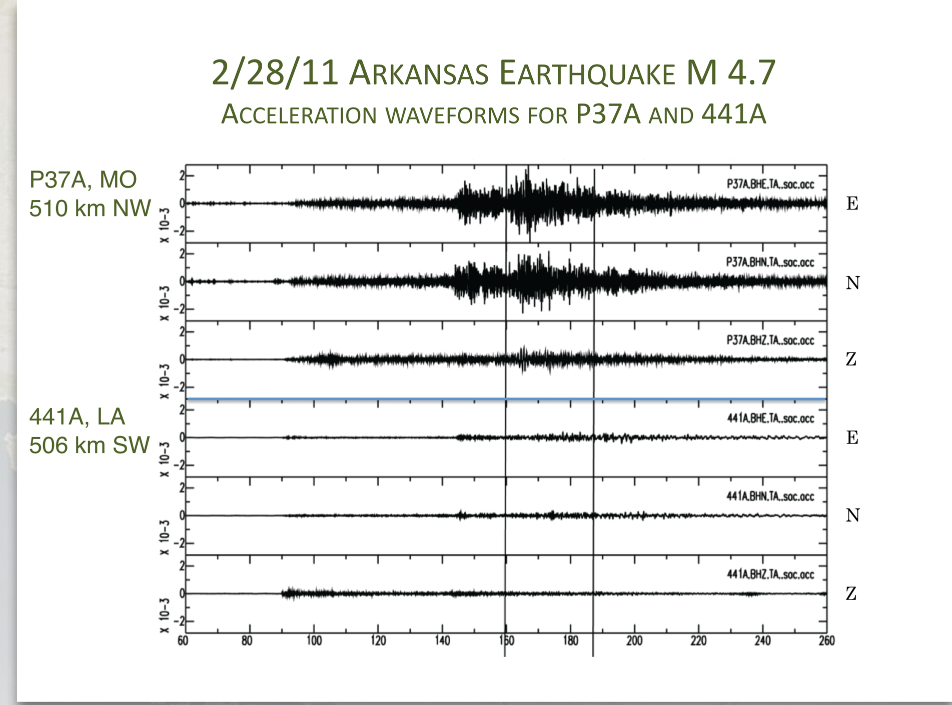
EarthScope TA Stations as of April, 2011



Two Oklahoma and two Arkansas events are shown above, though 13 earthquakes from these states are included in this study. Stations P37A and 441A are marked on the map, and we looked at the waveforms from these stations (below) as an example of the different wave propagation patterns seen to the north versus the south. The Midwest exhibits very low attenuation, while very high attenuation is seen in the Gulf Coast.



ABSTRACT

A series of earthquakes occurred in Arkansas, Oklahoma and Texas during 2010 and 2011. The EarthScope Transportable Array (TA) was situated in the central United States at that time, and the data from the TA provide a unique opportunity to study attenuation of the Lg phase in the mid-continent. A study of the Fourier amplitude spectra of Lg in this region shows the Lg exhibiting very strong, apparent attenuation for ray paths through the Ouachita orogenic belt and into central Texas and the Gulf coastal region. Meanwhile, ray paths to stations in the north and northwest of the cratonic platform exhibit much weaker attenuation. Stations in the northern Louisiana salt basin, in the east Texas basin and along the Gulf Coast recorded rapid attenuation within the frequency range of 0.5 to 12 Hz, whereas stations in Kansas, Nebraska and Iowa show very little attenuation, particularly in the frequency range of 1 to 3 Hz. Distance-dependent attenuation is comparatively weak for paths in the cratonic platform, while there appears to be strong, distance-dependent, whole-path attenuation for source-receiver paths through the buried Ouachita orogenic belt to stations in central Texas and the gulf coastal region. Regression models that incorporate potential near-receiver (distance-independent) attenuation due to thick sediments in the Gulf Coastal Plain successfully reduce path-related bias in the regression residuals. For source and receiver paths contained within the Gulf Coastal Plain, exploratory analysis using different regional subsets of the data also suggest complex wave propagation. Overall, the data from the TA show considerable regional variability of ground motion propagation in the central United States.

MODEL

$$A_{ij}(\omega) = S_i(\omega) g(r_{ij}) \exp\left(-\frac{\omega r_{ij}}{2Q(\omega)_{Path} V_{Path}}\right) \exp\left(-\frac{\omega h_j}{2Q(\omega)_{Sed} V_{Sed}}\right)$$

$A_{ij}(\omega)$ = Fourier amplitude of the i^{th} earthquake at the j^{th} receiver.
$S_i(\omega)$ = Source amplitude of the i^{th} earthquake.
$g(r_{ij})$ = Geometrical spreading factor.
r_{ij} = Hypocenter distance.

Path Term:
$Q(\omega)_{Path}$ = Quality factor for sub-sediment crustal path.
V_{Path} = 3.5 km/s.

Sediment Site Term:
$Q(\omega)_{Sed}$ = Effective quality factor in the sediments for Gulf Coast stations.
h_j = Sediment thickness (non-zero for stations in Gulf Coastal Plain), taken from A. Salvador (1991).
V_{Sed} = Approximately 1.0 km/s.

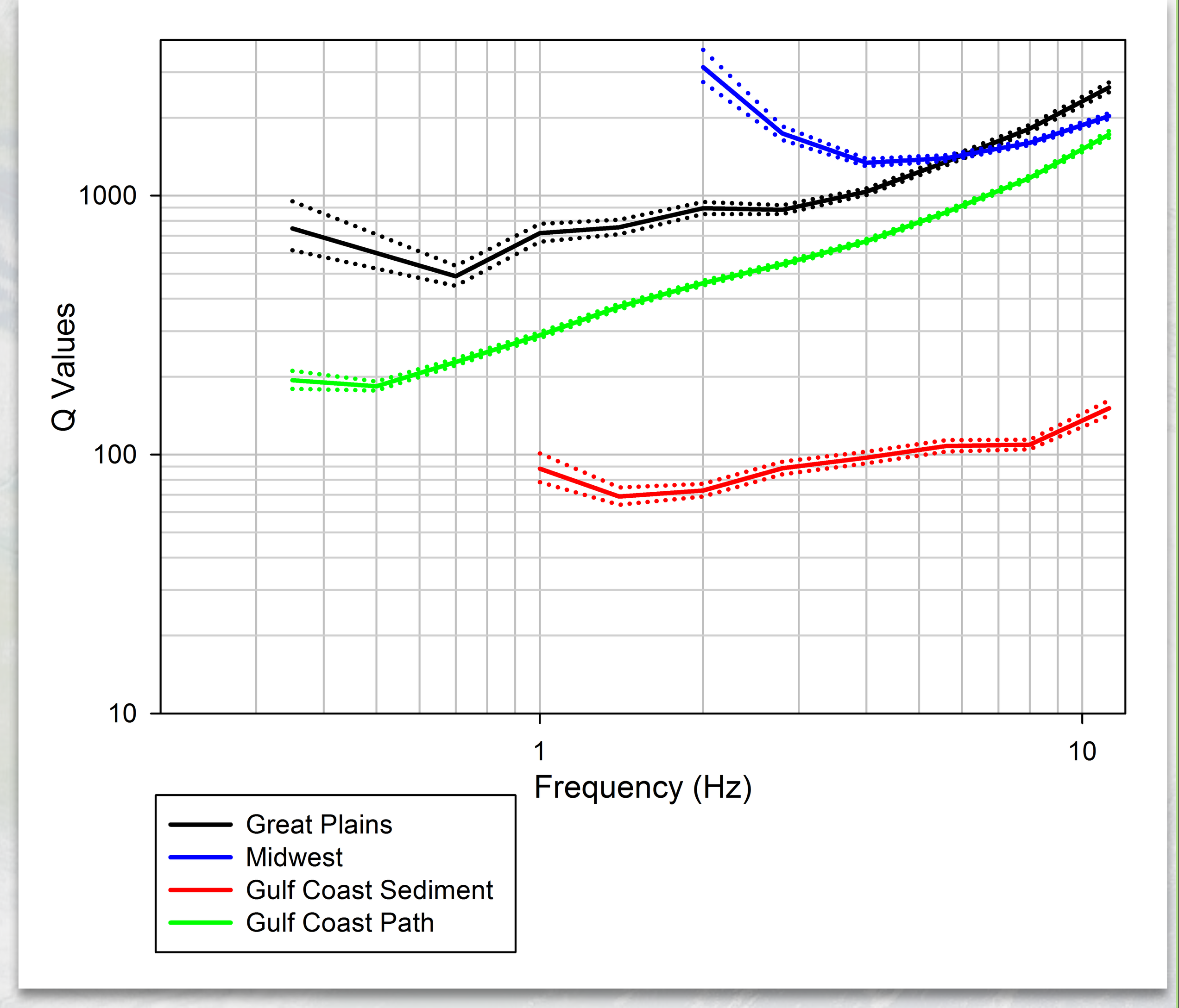
Geometrical Spreading Factor:
$g(r_{ij}) = r_{ij}^{-1.3}$ for $r_{ij} \leq 60$ km
$g(r_{ij})$ = no rate of change for 60 km < r < 120 Km
$g(r_{ij}) = 100^{-1.3}(r_{ij}/100)^{-1/2}$ for $r_{ij} > 120$ km

We applied this model to the TA data and solved for values of Q. We first compared the model with and without the sediment site term, which takes into account the sediment thickness of the Gulf Coast. Next, we divided the central U.S. into three regions: the Gulf Coast, the Great Plains and the Midwest. Using the model with the sediment site term, we applied a least squares fit of the model to each location and plotted the residuals to see if the fit improved with regionalization. The residual plots for 1.4 Hz for each region are below.

Results and Conclusions

Below is a graph of the Q values we calculated for each region. As expected, higher values of Q are seen in the Great Plains, while the Gulf Coast exhibits lower Q values. In the Midwest, we see anomalously high values of Q, which we have not yet been able to explain. Note, this is still a work in progress.

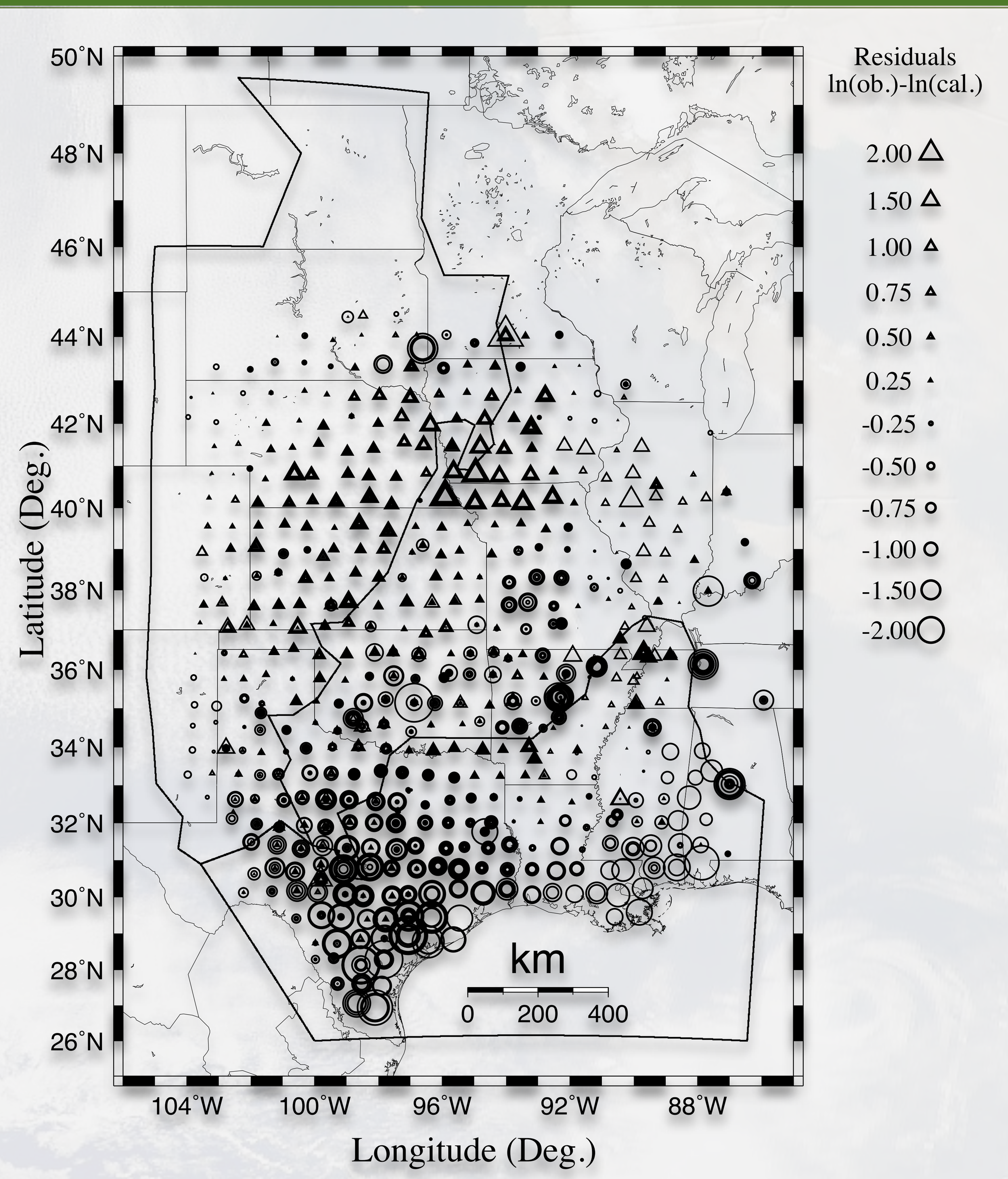
Q VALUES



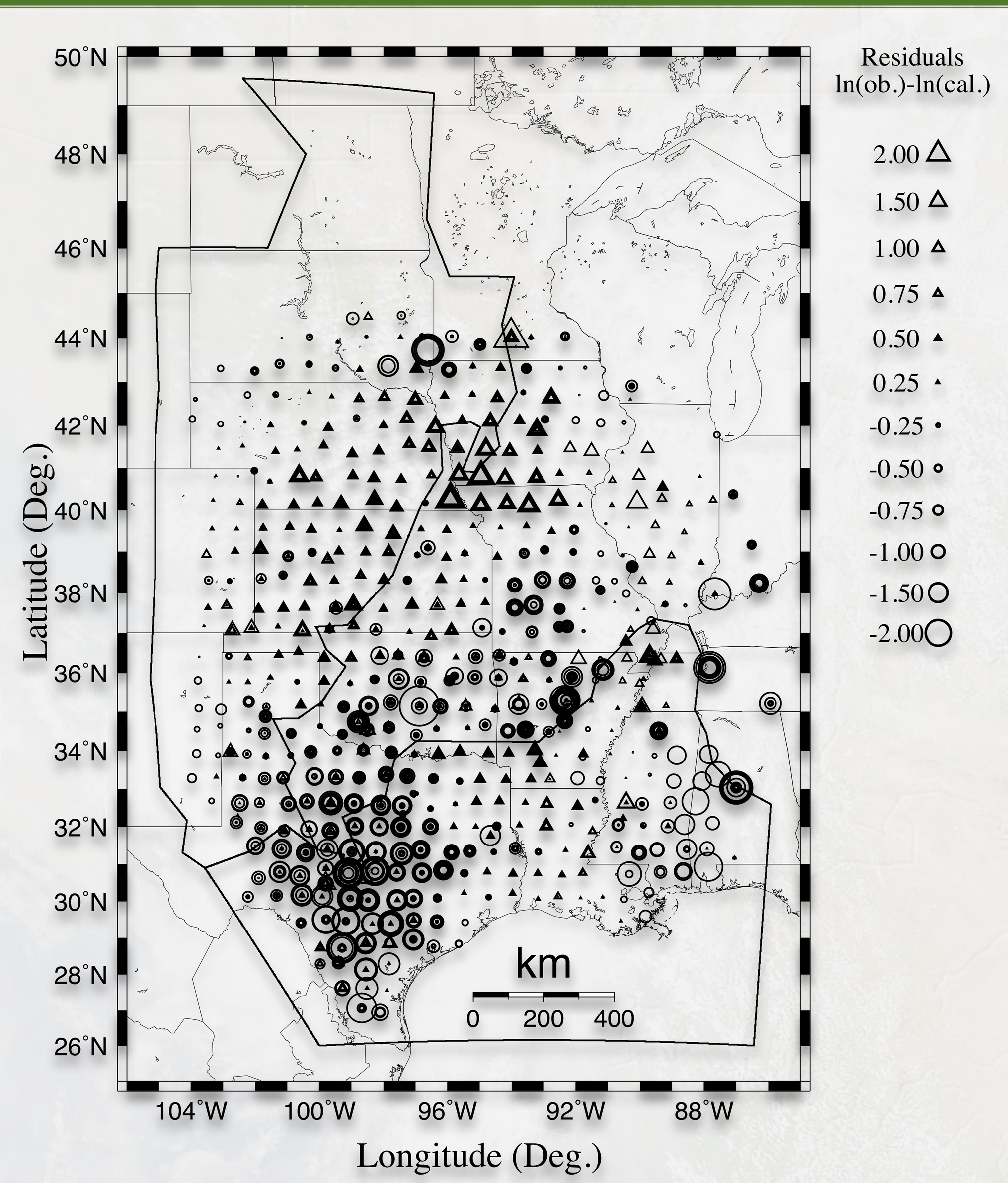
References:
A. Salvador (1991) The Geology of North America, Vol. J., Plate 3: Structure at the base and subcrop below Mesozoic marine section, Gulf of Mexico Basin, Geological Society of America.

RESIDUAL PLOTS 1.4 Hz

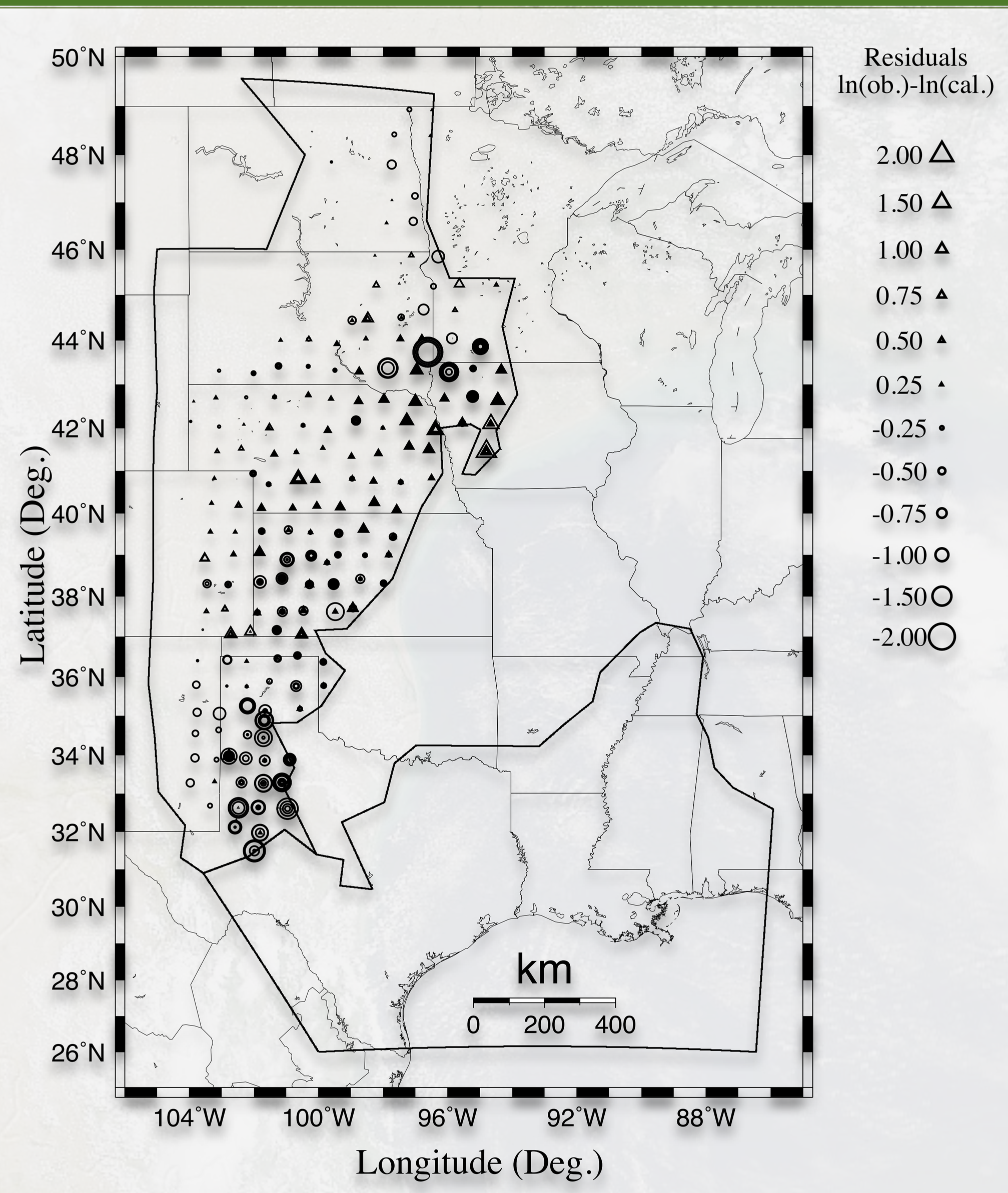
All Stations
Without Sediment Term



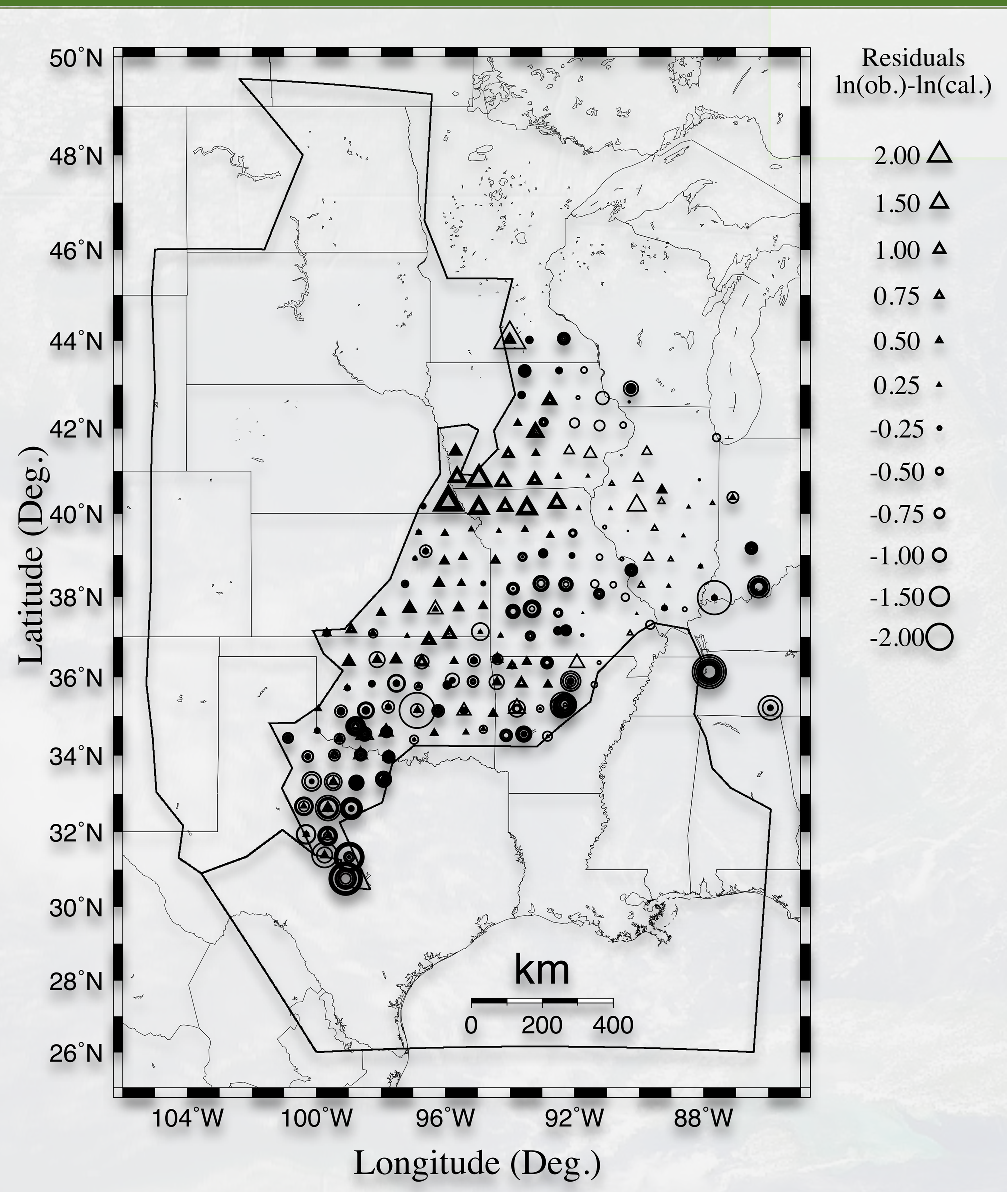
All Stations
With Sediment Term



Great Plains Stations



Midwest Stations



Gulf Coast Stations
With Sediment Term