A High Resolution, Local-scale Characterization of Lg Attenuation in the Rocky Mountain–Central United States transition zone

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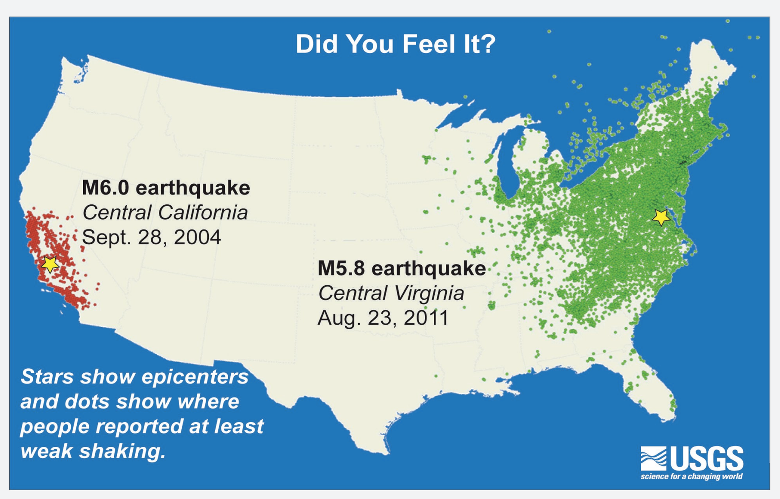
1.1 Introduction

- Well established that the attenuation (1/Q), or the inefficiency of energy propagation, of Lg-phase waves is greater west of the Rocky Mountains than east of the Rocky Mountains (Benz et al., 1997)
- Less clarity in delineating the boundary or defining the transition in attenuation between the Western U.S. (WUS) and the Central and Eastern US (CEUS)
- Local geology and surface topography can amplify or dampen seismic waves, and consequenctly the observed local shaking associated with an earthquake

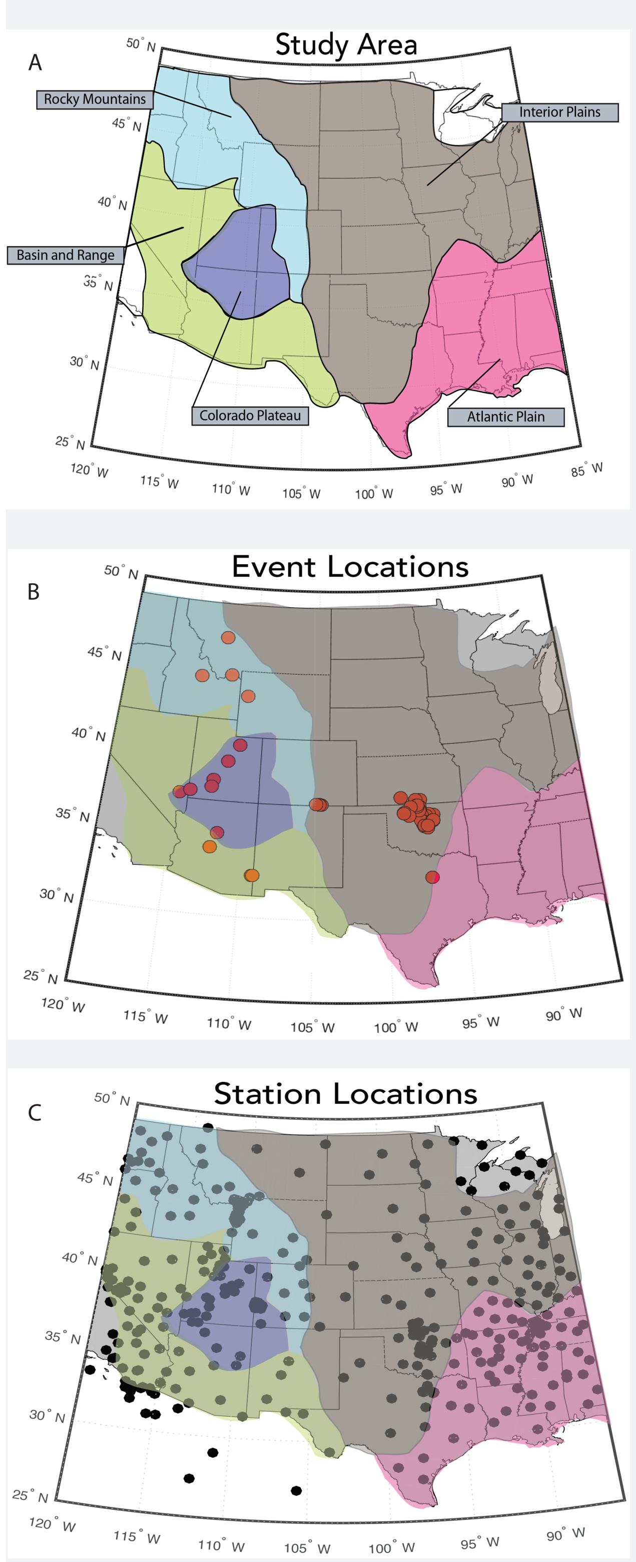
1.2 Motivation

- Attenuation is a crucial component for modeling the spatial variation of ground motion prediction equations (GMPEs)
- Lg waveform inversion can provide insight into local-scale attenuation mechanisms and site response can improve ground motion characterization and help to mitigate seismic hazards

Figure 1: Map of USGS 'Did you Feel it Reports', highlighting the differences in attenuation and their expression in observed ground shaking in the WUS and EUS . Source: USGS



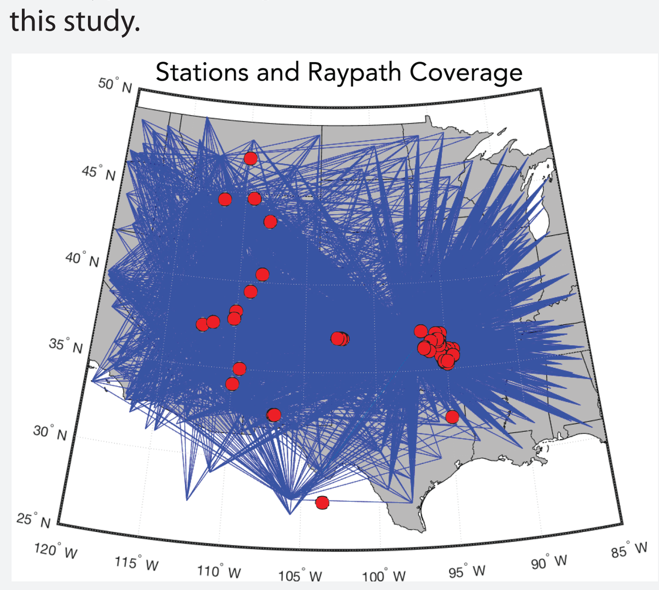
2.1 Data Selection



- Lg waveform data (BHE, BHN, BHZ) acquired from the USGS Global Seismograph Network (GSN), Advanced National Seismic System (ANSS), and the USArray Transportable Array (TA) programs and accessed through the IRIS Data Management Center (DMC)
- Approximately 95 events, recorded at 382 stations within study area from June 2006 to June 2016
- Events limited to magnitude 4.0+, limited to 40 km depth

Figure 2 (left): Map of study area (A), seismic events (B), and seismic stations (C) included in this study.

Figure 3 (below): Map of stations (red circles) and raypath coverage (blue lines) included in this study.



2.2 Waveform Inversion and Determination of Regional Q

- Inversion of Lg-phase wave amplitudes at 1.5 Hz for source term (size of seismic event), receiver term (characterizing local geology), and path averaged Q (attenuation)
- Path averaged apparent Q regionally averaged for the Basin and Range, Rocky Mountains, Interior Plains, Colorado Plateau, and Atlantic Plain Regions

3.1 Results

- Highest Q (lowest attenuation) found in Interior Plains region, followed by the Colorado Plateau and Rocky Mountains regions
- Lowest Q (highest attenuation) found in Atlantic Plain followed by the Basin and Range region
- Lg waves are amplified in sites with soft sediment (Interior Plains and Atlantic Plain regions), and dampened in sites with surficial hard rock (Colorado Plateau and Basin and Range regions)
- Areas with high relief correspond broadly to the dampening of seismic waves, whereas areas with low relief correspond broadly to amplification.

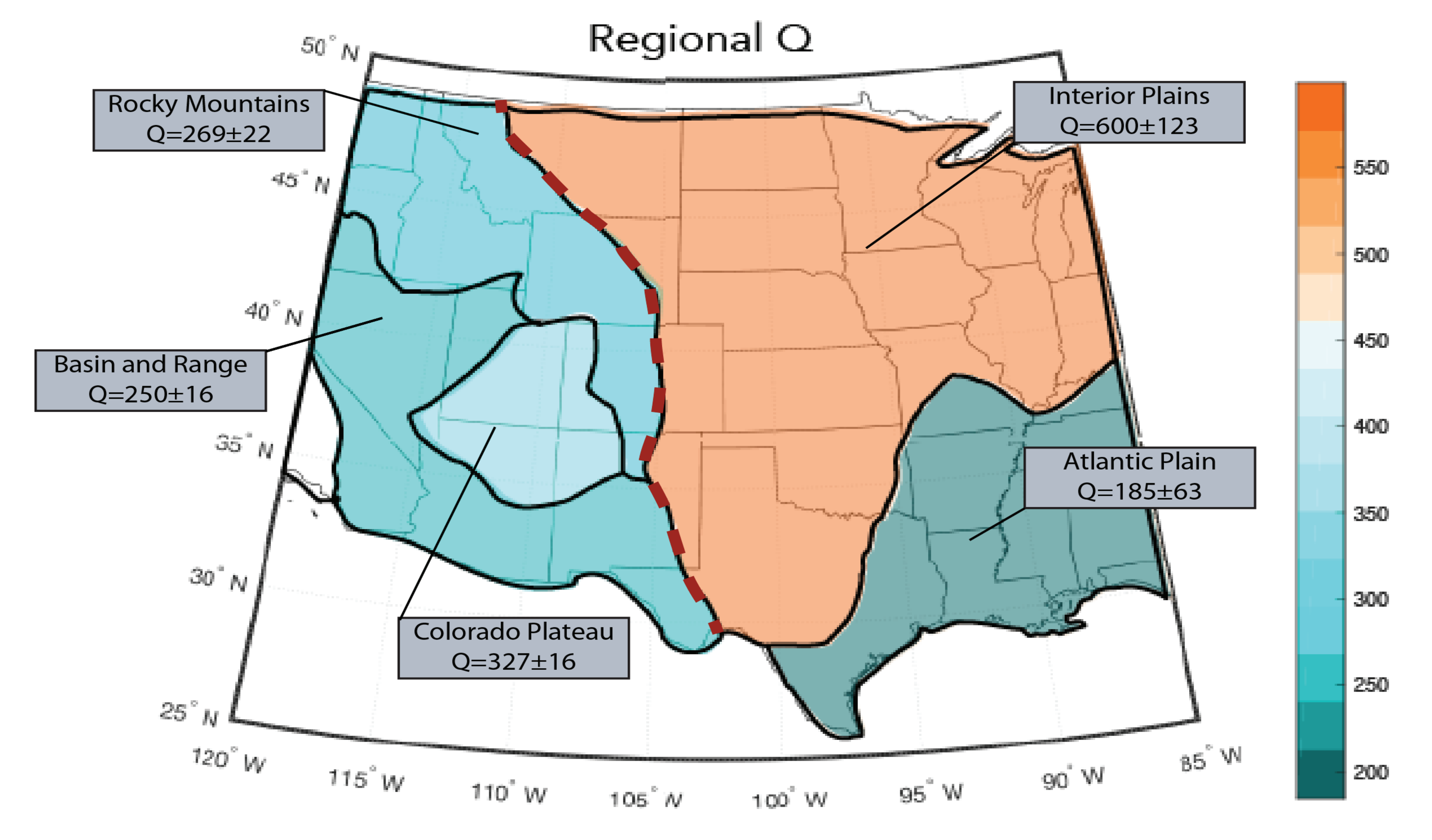


Figure 4: Map of regional Q (inverse of attenuation) for the Basin and Range, Rocky Mountains, Interior Plains, Colorado Plateau, and Atlantic Plain regions. Q is notably lower (higher attenuation) west of the Rocky Mountains region (denoted by red dashed line) and higher in the areas east of the Rocky Mountains region. Additionally we find low Q in the Atlantic Plain, likely due to the attenuative (low Q) sediments.

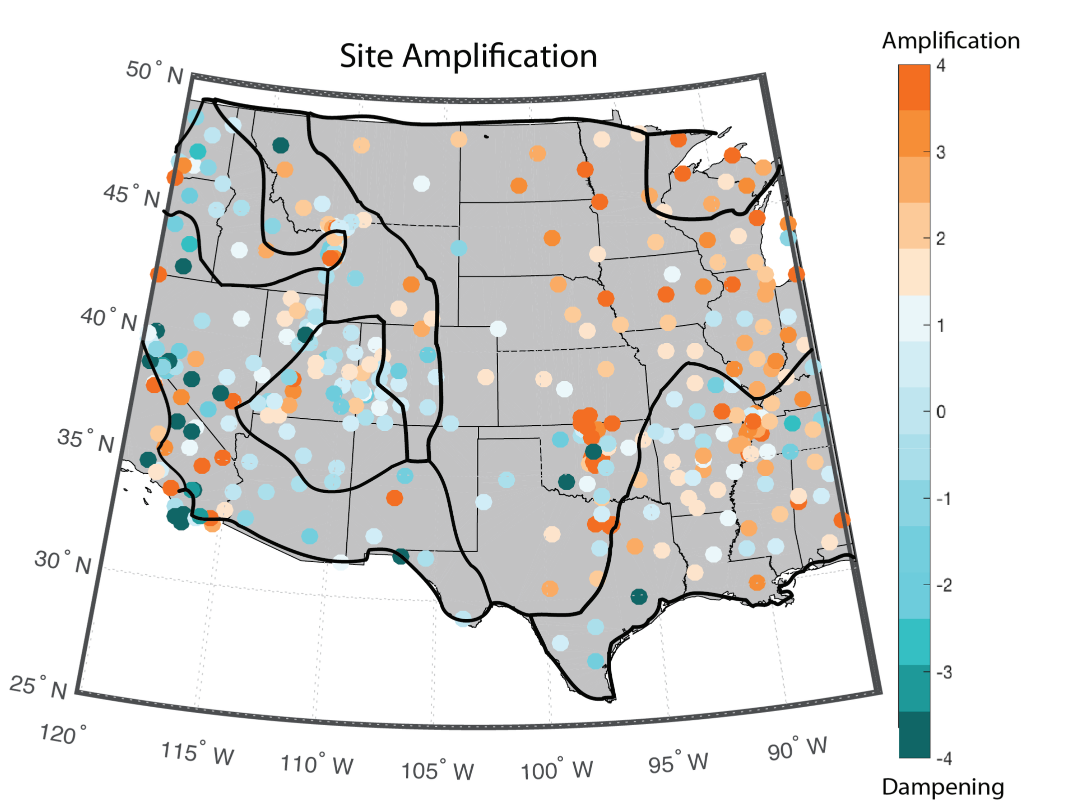


Figure 5: Map of site amplification of Lg waves at each seismic station included in this study. Notably, Lg waves are amplified in the Interior Plains and Atlantic Plain regions (soft sediment sites) and dampened in the Colorado Plateau and Basin and Range regions (hard rock sites).

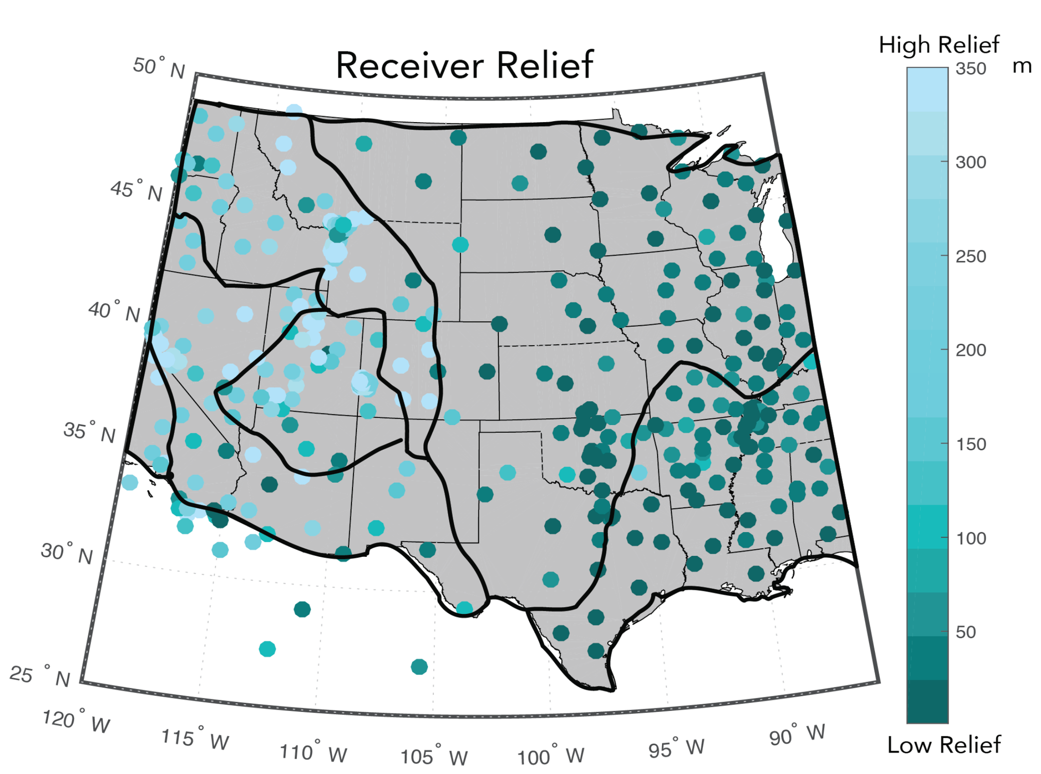
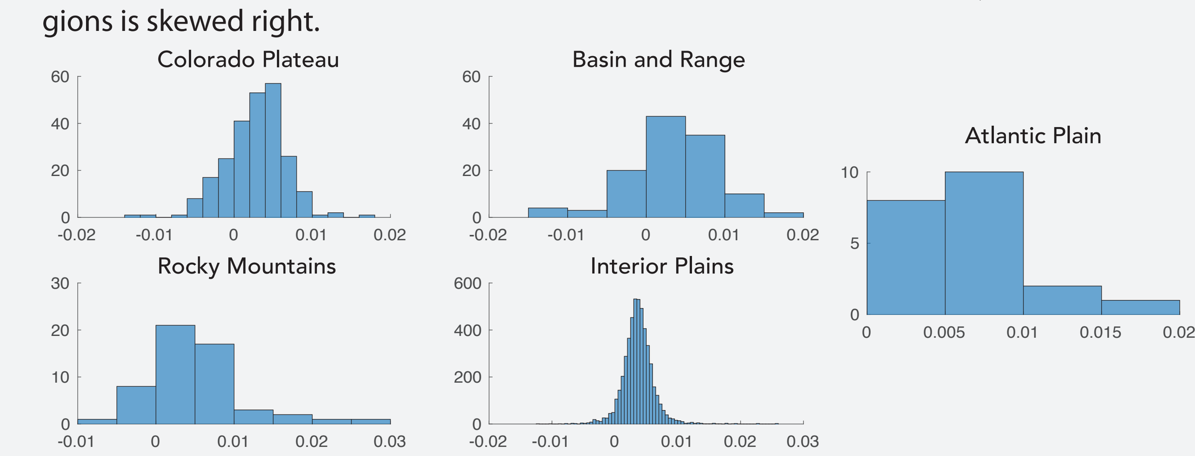


Figure 6: Map of topographic relief at each seismic station included in this study. Areas with high relief correspond broadly to the dampening of seismic waves, whereas areas with low relief correspond broadly to amplification.

4.1 Discussion

- Attenuation and consequently Q, show a strong qualitative correlation with local geology and topography
- Attenuation is highest in areas with recent volcanism, geothermal and tectonic activity, corresponding to the findings of previous studies of attenuation (Phillips and Stead,2008, Pasyanos, 2013, Erickson et al., 2004)
- Topographic relief can serve as an effective proxy to infer ground shaking due to site amplification and dampening
- Sparsity of events and ray paths in the Atlantic Plain and Rocky Mountains regions creates a low resolution upper limit characterization of Q in these areas

Figure 7: Histograms of path averaged attenuation in each region. Note: the quantity of ray paths included in each region vary (an artifact of clustered event and station distribution) and the distribution of attenuation in the Atlantic Plain and Rocky Mountains regions is skewed right.



5.1 Future Work

- Incorporation of additional frequency bands (e.g., 0.5 Hz, 1 Hz, 3 Hz, 6 Hz, 12 Hz)
- High-resolution Q(f) tomographic inversion to provide an enhanced understanding of the changes in attenuation across geologic boundaries (similar to that of Pasyanos et al., 2009) and as a function of frequency
- Incorporation of measured Vs30 values in the CEUS to better characterize local ground shaking
- Improved event distribution, particularly within the Central US region

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