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# Fourier-Based Site Response of Southern California Sedimentary Basins


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## Abstract

This ongoing study updates the Bayless and Abrahamson (2019; BA19) ground motion model for Fourier Amplitude Spectra (FAS) by incorporating two frequency-dependent site amplification model components, both regionalized for southern California:

1. A linear and nonlinear Vs30-scaling model inferred from southern California earthquake recordings, as described in SCEC Report #19097.
2. The sediment depth scaling component (also called basin depth scaling elsewhere) as described in this poster.

Nweke et al. (2022) developed a southern California site amplification model for response spectra utilizing Vs30 and sediment depth, with the depth component conditioned on type of geomorphic province: **basins, basin edges, valleys,** and **mountain/hills**.

In this study, the Nweke et al. (2022) database and province classifications are adopted to analyze the FAS. This procedure involves undertaking ground motion residual analyses using the BA19 model as the reference model. The basin parameter used is Z1.0 (depth to Vs=1 km/s horizon).

Preliminary results

- The low-frequency (long period) FAS site terms behave similarly to those for long period response spectra in Nweke et al. (2022).
- If the geomorphic province categorization is ignored, the site terms are zero-centered and scale with differential basin depth as in BA19, which was developed for all of CA.
- At low frequencies, sites categorized as **basin** and **basin edge** have positive mean amplification, and those categorized as **valley** and **mountain** provinces both have negative mean amplification.
- Minimal de-amplification is observed for **basin** sites with shallower than expected basin depths.

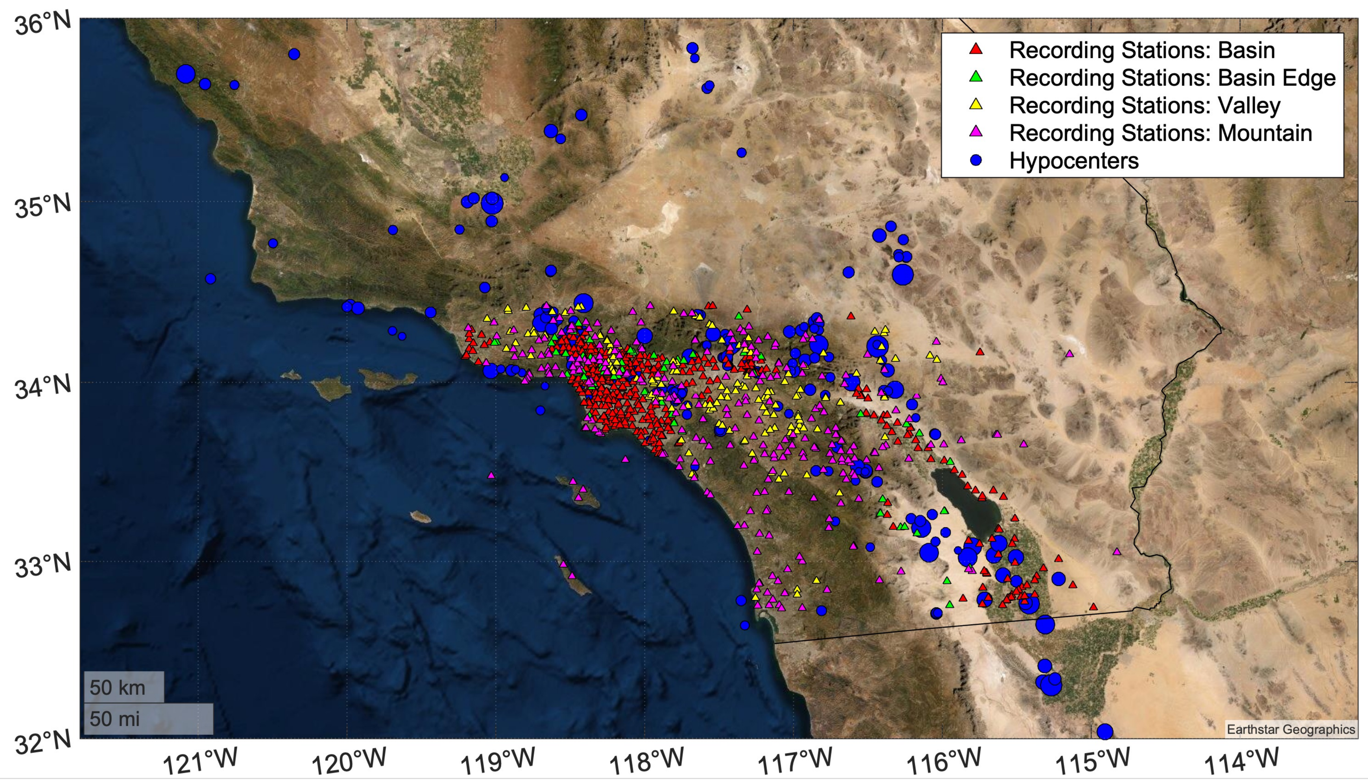
Next Steps

This study will conclude by finishing the residual analysis and comparing results with those from Nweke et al. (2022) for response spectra, and by developing a parametric model for the sediment depth scaling conditioned on southern California geomorphic province. The sediment depth scaling model will be combined with the Vs30-scaling model to complete the southern California regional update of BA19.

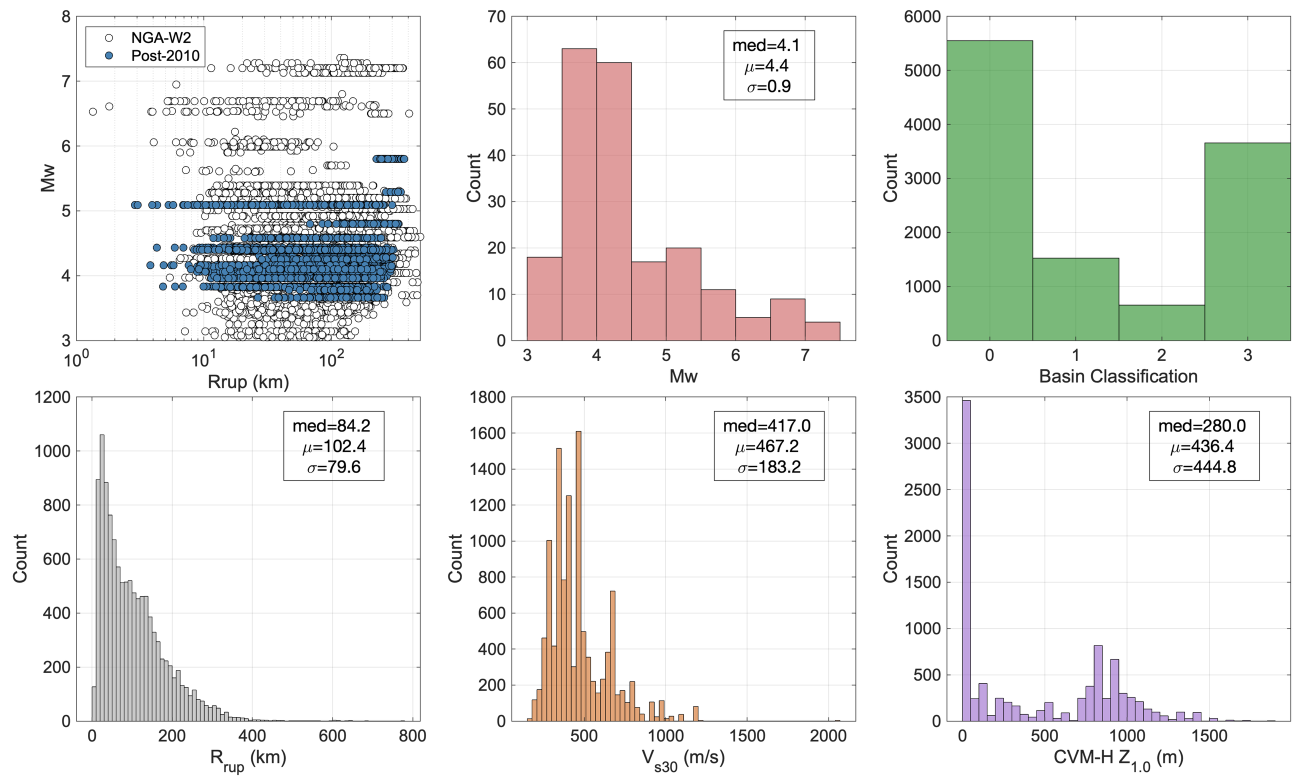

## (1) Data

- Nweke et al (2020; 2022) performed a substantial data collection effort to supplement the PEER NGA-West2 database (Ancheta et al, 2014). In the Los Angeles region, this database includes 1004 recording sites, 789 of which are from the NGA database, and 215 of which are newer additions.
- This study uses the Effective Amplitude Spectrum (EAS) component of the Fourier amplitude spectrum, defined Goulet et al. (2018). The EAS is the orientation-independent horizontal component FAS of ground acceleration.
- The Nweke et al. (2022) database was extended to include the EAS, calculated from acceleration time histories, by the UCLA geotechnical group.
- The California ground motion database assembled by the UCLA geotechnical group is available online at https://www.uclageo.com/gm_database/api/index.php
- The figure at right shows a magnitude-distance scatterplot of the data used, and histograms of the data by magnitude, distance, basin classification, etc.

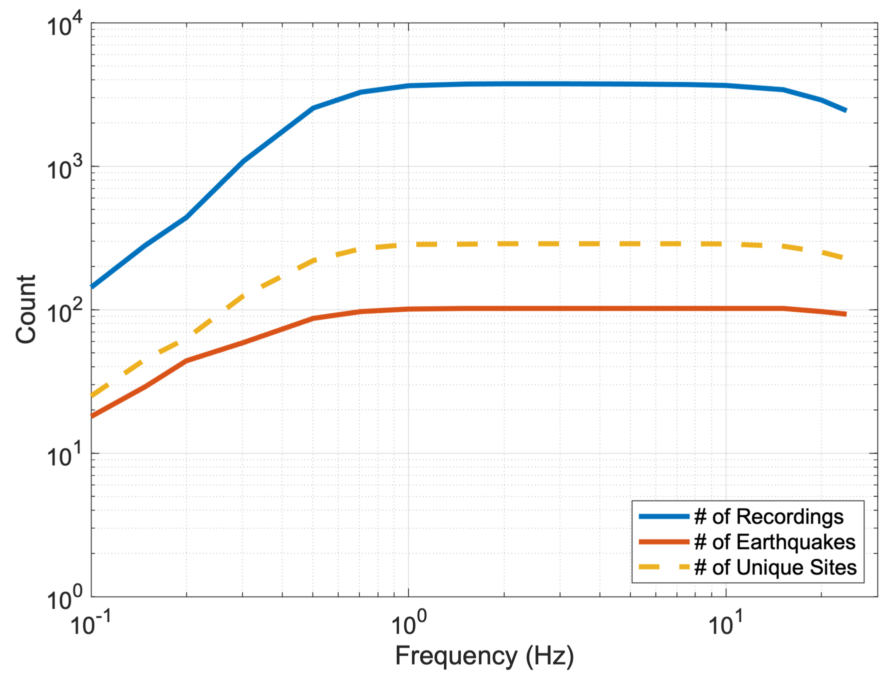
Map of the database: hypocenters and basin classifications




Database Summary




Number of Recordings, Earthquakes, and Unique Sites used in the Regression by Frequency

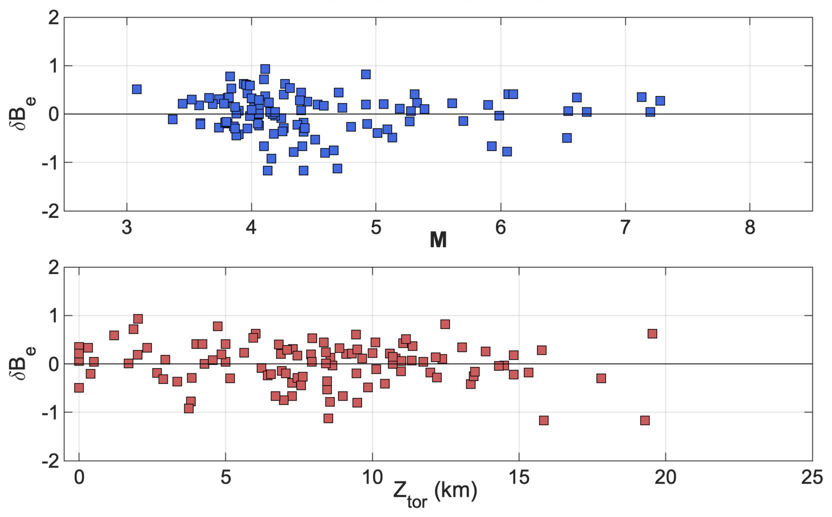



## (2) Residual Analysis

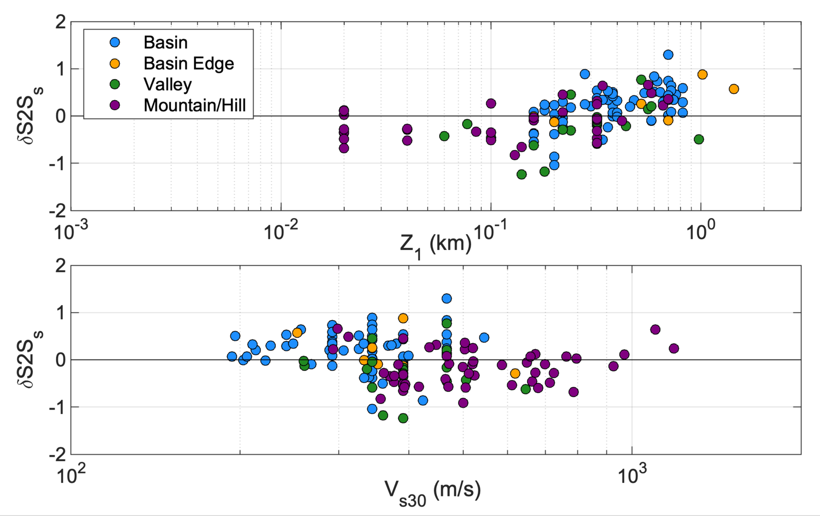
The residual analysis involves the following steps, performed at each frequency (f) using BA19 as the reference model:

1. Database screening for magnitude (>3), rupture distance (<150 km), usable frequency range, and minimum number of recordings per earthquake (5) and site (5).
2. Nonlinear mixed effects residual analysis to partition residuals into model bias terms, event terms, site terms, and within-site terms. The following details apply to this step:
   - The southern California Vs30-scaling model is used (SCEC Report #19097)
   - The residuals are for the "reference sediment depth condition" meaning the Z1.0-scaling is set to zero. This isolates the Z1.0-based effects in the site terms.
3. The model bias, event terms, site terms, and within-site terms are examined by plotting against the predictive parameters to confirm that the model components are unbiased.
   - The figures below show these plots for f=0.3 Hz.
   - The site terms versus Z1.0 have an expected trend because Z1.0-scaling was set to zero.
4. The trends of site terms with differential depth ($\delta_{z1}$) are investigated by geomorphic province (at right, box #3 on this poster).

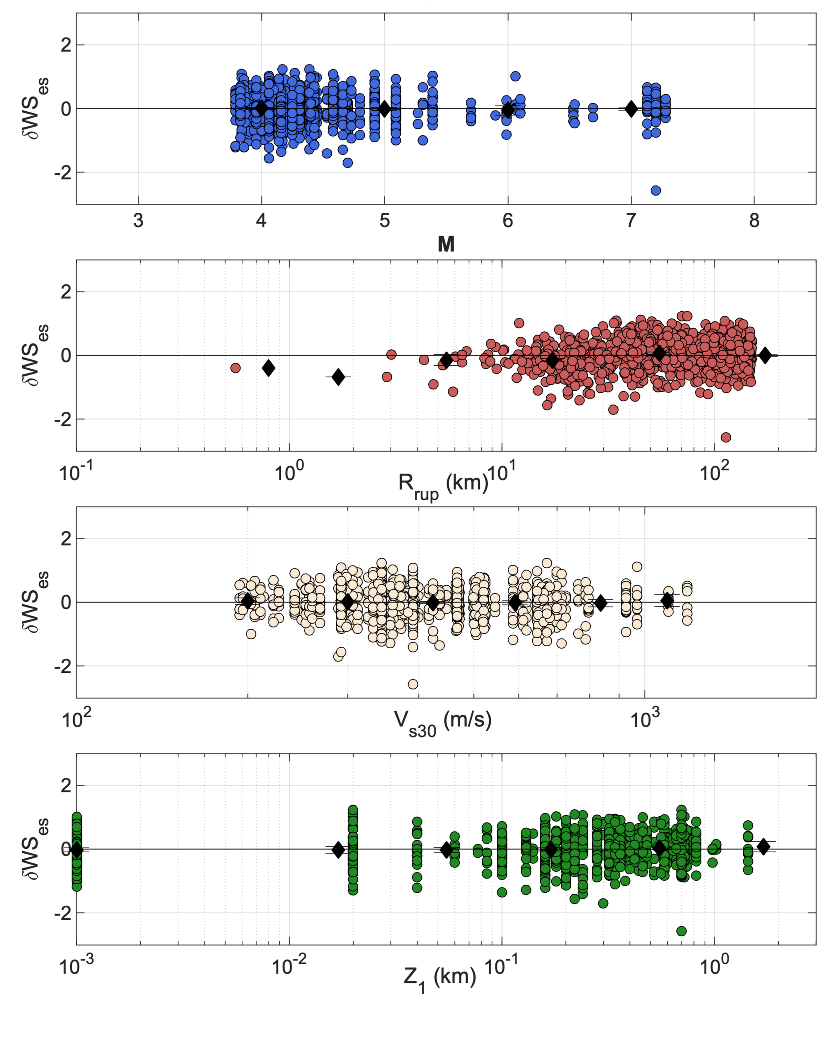
Event Terms




Site Terms




Within-Site Terms




## (3) Site Terms by Province

**Basin Sites**

Low freq: Mean amplification (dashed line), scales with differential depth ($\delta_{z1}$)
High freq: doesn't scale with differential depth

**Basin Edge Sites**

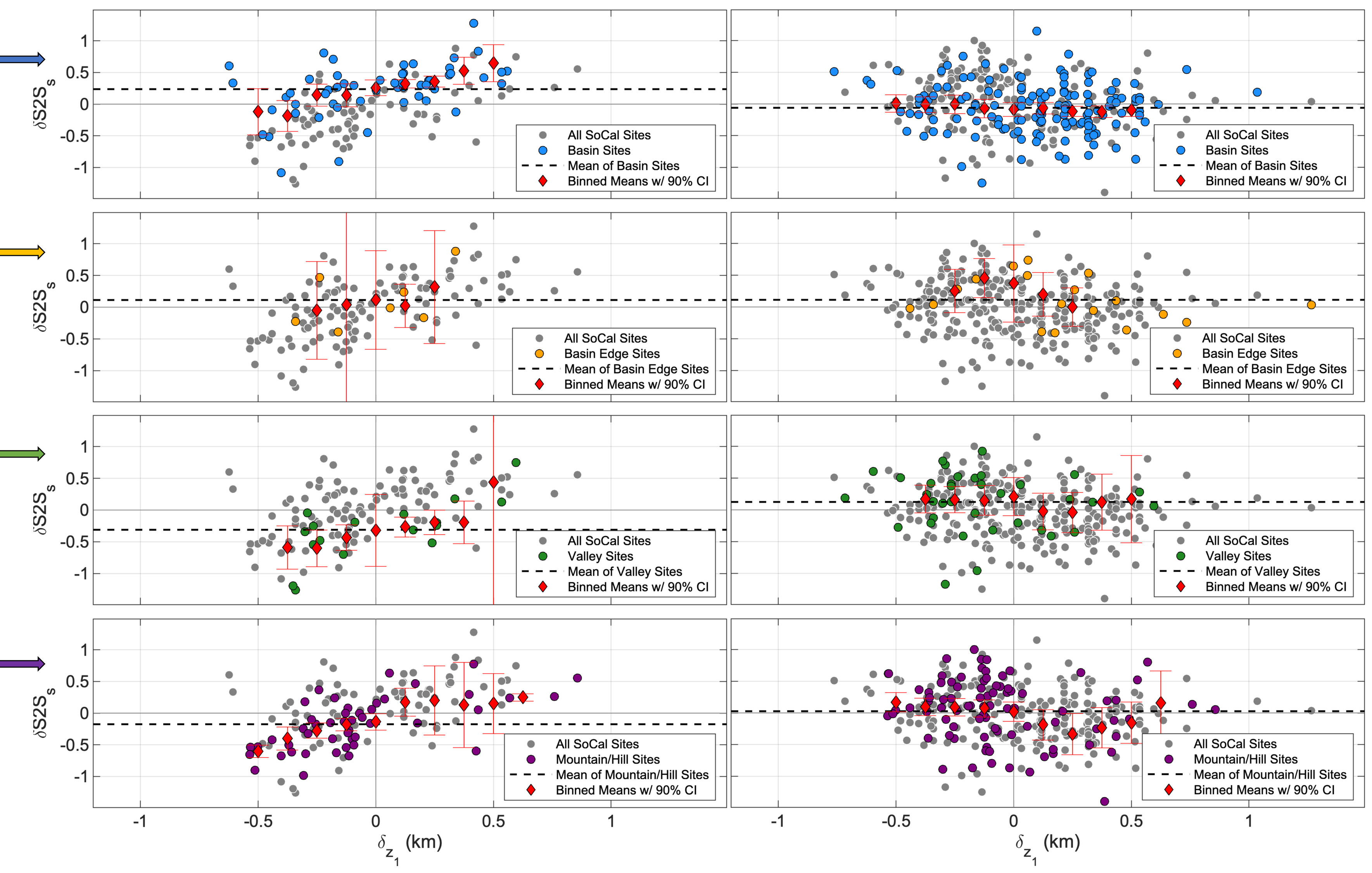
Relatively fewer sites – larger uncertainty
Low freq: Mean amplification is small, may scale with differential depth
High freq: may not scale with differential depth

**Valley Sites**

Low freq: Mean de-amplification, scales with differential depth
High freq: doesn't scale with differential depth

**Mountain Sites**

Low freq: Mean de-amplification, may scale with differential depth, scaling flattens for larger $\delta_{z1}$
High freq: may not scale with differential depth




## (4) Next Steps

The completion of this study requires the following:

- Implementing refined values of Z1.0 and Vs30 into the analysis (values from Nweke et al., 2022)
- Repeating the residual analysis with Z1.0 values from a second SCEC Community Velocity Model
- Evaluation of these results
- Developing parametric models for the sediment depth scaling, conditioned on the geomorphic province
- Comparing these models with those from Nweke et al. (2022) for informational purposes
- Combining of the Z1.0-scaling and Vs30-scaling models to complete the southern California regional update of BA19


## Acknowledgements

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