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Investigations into the Use of V_{S30}-Derived dM_L Site Corrections in ShakeAlert Magnitude Calculations

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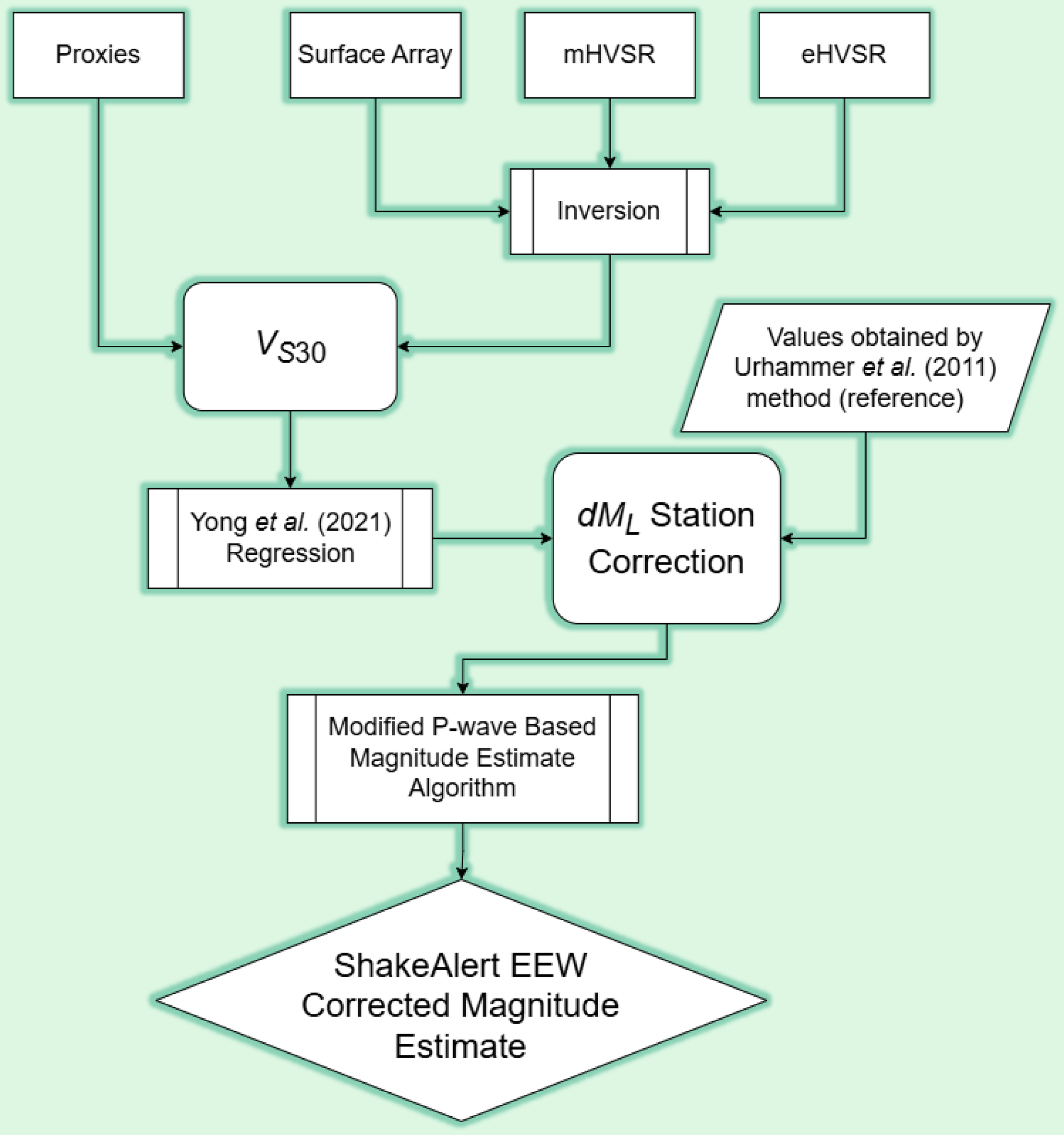

Figure 1: Flow chart describing data types and processes to produce a new magnitude estimate for EEW.

Why use V_{S30}?

V_{S30} is ubiquitous in site characterization for geotechnical applications. While less descriptive than a full velocity model, it provides a single value to compare between sites. As such, a site's V_{S30} index is a valuable proxy by which a dM_L value can be obtained. Yong *et al.* (2021) provides a regression through which we obtain a dM_L value from the V_{S30} value at a given site.

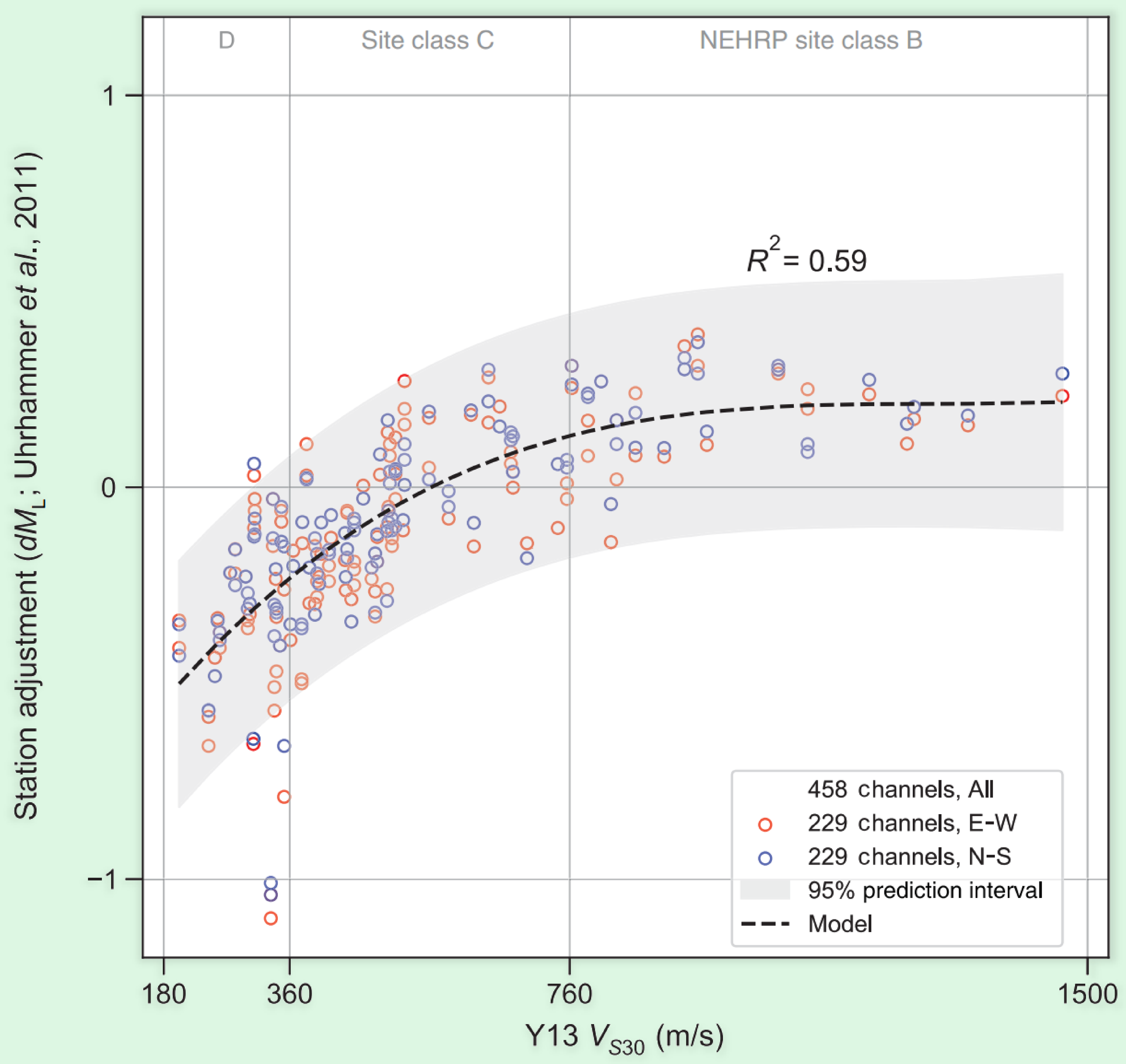

Figure 3: Regression curve developed by Yong *et al.* (2021) as a method to convert V_{S30} values to dM_L corrections. We focus on the R^2 value of 0.59 as a target value when comparing other methods against dM_L values. The V_{S30} values here are the same array-based inversions from Yong *et al.* (2013) shown in plots 4 and 5.

Preliminary Results and Future Work

- The Geyin & Maurer (2022) proxy model (GM2022 Model2) provides the lowest R^2 value when converted to dM_L and compared against values obtained via the Urhammer *et al.* (2011) method. We will be investigating other models to exhaust all possibilities and ensure the highest accuracy possible from proxies.
- eHVSR-based inversions are promising in our initial subset and more will be acquired to determine the utility of this method.
- mHVSR inversions will be compared against eHVSR results to determine this method's viability in the workflow.
- After a final workflow and methods base is established, we will determine how to best incorporate dM_L into the P_d amplitude-based magnitude algorithm.

Introduction

The USGS ShakeAlert Earthquake Early Warning (EEW) system in California estimates earthquake magnitude from P-wave displacement (P_d) amplitudes using the Earthquake Point-Source Integrated Code (EPIC) algorithm. We aim to improve magnitude estimates for EEW by incorporating site effects into this algorithm by using the dM_L correction as described in **Urhammer et al. (2011)** as a proxy for a P_d-based magnitude correction. Because the Urhammer *et al.* (2011) method requires 30+ events within 500 km of a site, a correction obtained by this method is infeasible for an EEW system used across regions with sparse seismicity. Here, we investigate using the time-averaged S-wave velocity (V_S) from the surface to 30 m depth at a location (V_{S30}) as a proxy for site conditions and convert to dM_L corrections using the regression formulated by **Yong et al. (2021)**.

Method	Quality	Pros	Cons
Proxy Models	1	Broad spatial coverage, etc.	Inaccurate
Array-Based	3	Traditional, established method for obtaining V_{S30}, etc.	Inversion, surveys often prohibited by cost or site environment
mHVSR	?	Obtainable shortly after install, uses on-site data, etc.	Inversion, limited accuracy
eHVSR	?	Improved accuracy and frequency content over mHVSR, etc.	Inversion, events required
Urhammer *et al.* (2011)	4	Highest degree of accuracy for obtaining dM_L values	Inversion, requires 30+ events within 500 km

HVSR Inversions

HVSR inversions are performed via the code developed in Nagashima *et al.* (2014). This code allows inversion of S-wave velocities from a single site's H/V spectrum and an initial model. This inversion is performed at 10 sites and converted to dM_L and compared against the reference dM_L values alongside the converted dM_L values derived from array-based inversion values described in Yong *et al.* (2013) and the proxy models (Figure 4). We plan to perform additional eHVSR inversions to further our study.

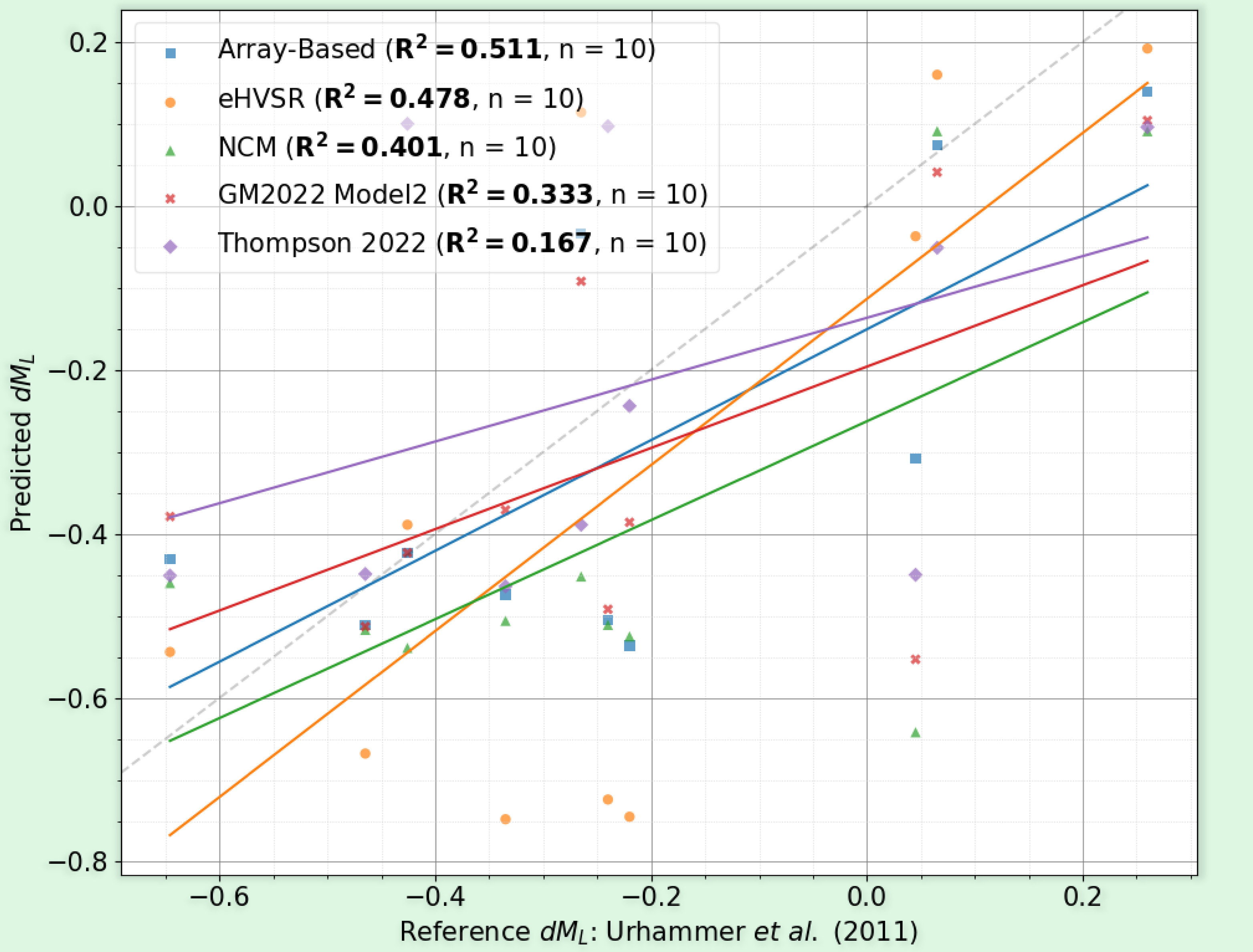

Figure 4: Comparisons of 10 sites with dM_L values from the Urhammer *et al.* (2011) method against eHVSR inversions, array-based inversions, and three proxy models, using linear trend fits. Note the gray dashed line as the "ideal" 1:1 case. The R^2 value of 0.59 is our target value, as this is the R^2 value inherent to Yong *et al.* (2021)'s regression. **GM2022 Model2** is a national, machine-learning generated V_{S30} model with 15 parameters, not including geologic map data. **Thompson 2022** is a California V_{S30} model incorporating geology, slope, and geostatistics. **NCM** is the National Crustal Model providing a velocity framework from which we derive V_{S30}.

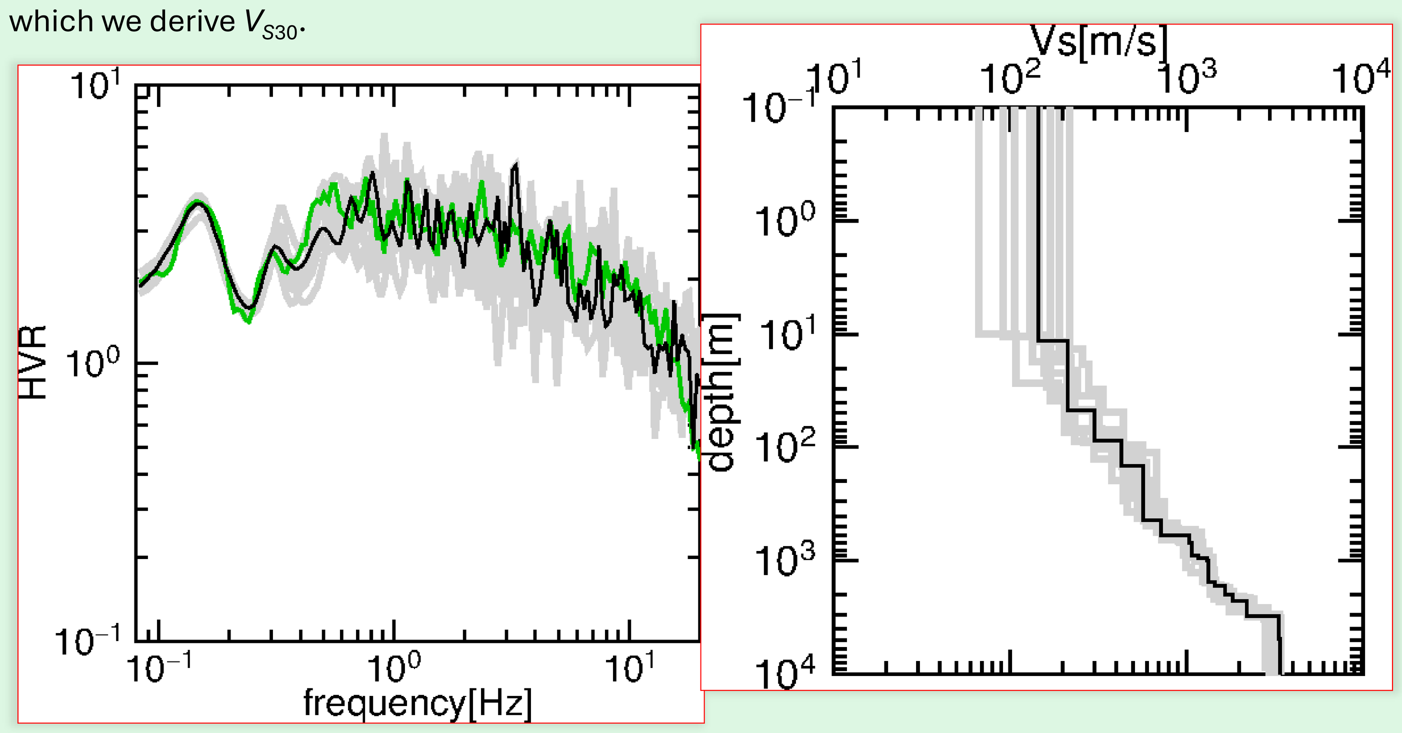

Figure 6: Example eHVSR inversion for site CI.ERR using Nagashima *et al.* (2014) inversion code. Note that the result provides a velocity model as well as a single V_{S30} value.

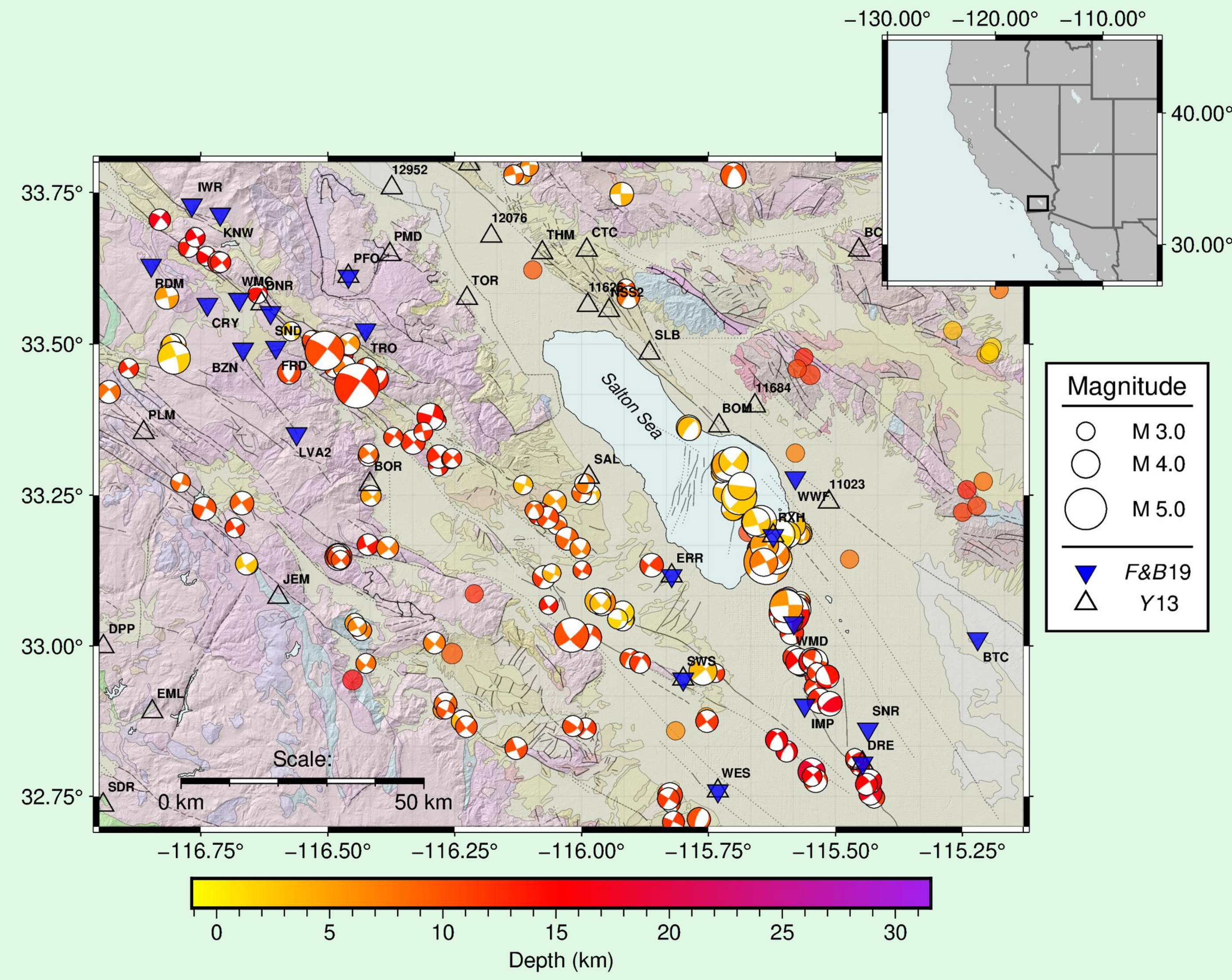

Figure 2: Map of stations and earthquakes in eHVSR inversions to compare against array-based inversion results and several proxy models (Figure 4).

Proxy Model Comparison

Broad coverage of V_{S30} proxy and velocity models provides an alternative to local recording for determining a V_{S30} value at a site. This is valuable for sites with minimal seismicity or high noise levels that may make HVSR inversions difficult. We are in the process of comparing the different models to determine the best fit when converted to dM_L.

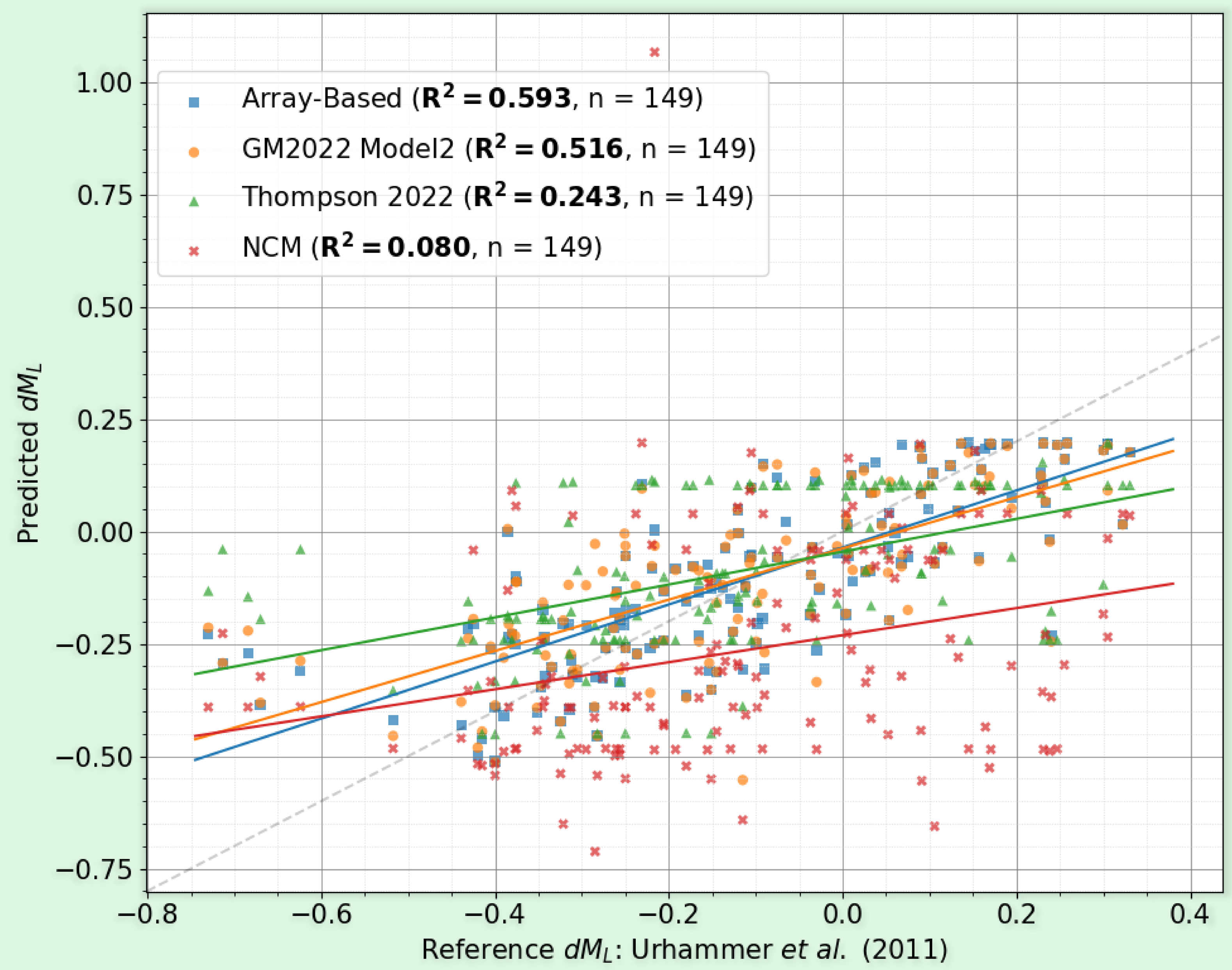

Figure 5: Comparisons of 149 sites with dM_L values from the Urhammer *et al.* (2011) method against array-based inversions and three proxy models, using linear trend fits. Note the gray dashed line as the "ideal" 1:1 case. The R^2 value of 0.59 is our target value, as this is the R^2 value inherent to Yong *et al.* (2021)'s regression. **GM2022 Model2** is a national, machine-learning generated V_{S30} model with 15 parameters, not including geologic map data. **Thompson 2022** is a California V_{S30} model incorporating geology, slope, and geostatistics. **NCM** is the National Crustal Model providing a velocity framework from which we derive V_{S30}.

References

1. Boyd, O.S., Shah, A.K., Sweetkind, D.S., Sowers, T., and Langenheim, V.E., 2018, *Components of the USGS National Crustal Model (ver. 2.0, September 2025)*: U.S. Geological Survey data release, https://doi.org/10.5066/P9T96Q67.
2. Geyin, M. and Maurer, B.W. (2022). *U.S. National VS30 Models and Maps Informed by Remote Sensing and Machine Learning*, 10.31224/2466.
3. Nagashima, F., Matsushima, S., Kawase, H., Sánchez-Sesma, F. J., Hayakawa, T., Satoh, T., & Oshima, M. (2014). *Application of Horizontal-to-Vertical Spectral Ratios of Earthquake Ground Motions to Identify Sub Structures at and around the K-NET Site in Tohoku, Japan*. Bulletin of the Seismological Society of America, Vol. 104, No. 5, pp. 2288–2302, October 2014, doi: 10.1785/0120130219
4. Uhrhammer, R. A. , M. Hellweg, K. Hutton, P. Lombard, A. W. Walters, E. Hauksson, and D. Oppenheimer (2011). *California Integrated Seismic Network (CISN) Local Magnitude Determination in California and Vicinity*, Bulletin of the Seismological Society of America, Vol. 101, No. 6, pp. 2685–2693, December 2011, doi: 10.1785/0120100106
5. Thompson, E.M., 2018, *An Updated Vs30 Map for California with Geologic and Topographic Constraints (ver. 1.1, July 2022)*: U.S. Geological Survey data release, https://doi.org/10.5066/F7JQ108S.
6. Yong, A., E. Cochran, J. Andrews, K. Hudson, A. Martin, E. Yu, J. Herrick, and J. Dozal (2020). *V_{S30} and Dominant Site Frequency (f_d) as Provisional Station M_L Corrections (d_{ML}) in California*, Bull. Seismol. Soc. Am. 111, 61–76, doi: 10.1785/0120200130
7. Yong, A., A. Martin, K. Stokoe, and J. Diehl (2013). *ARRA-Funded VS30 Measurements Using Multi-Technique Approach at Strong-Motion Stations in California and Central-Eastern United States*, USGS Open-File Report 2013–1102