Real-time Ground Motion Prediction Using Edge-computed Amplitude Features from the Community Seismic Network

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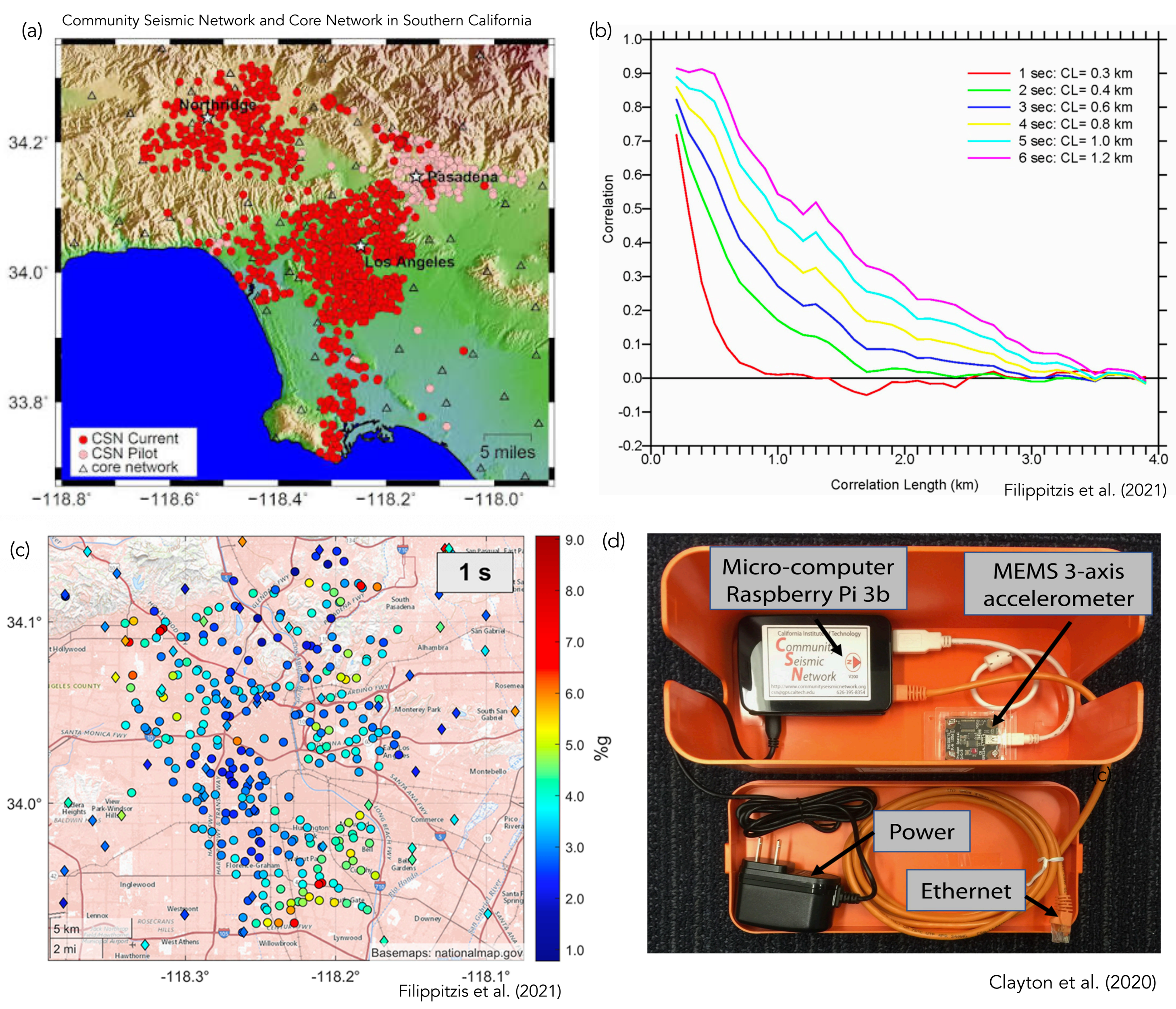
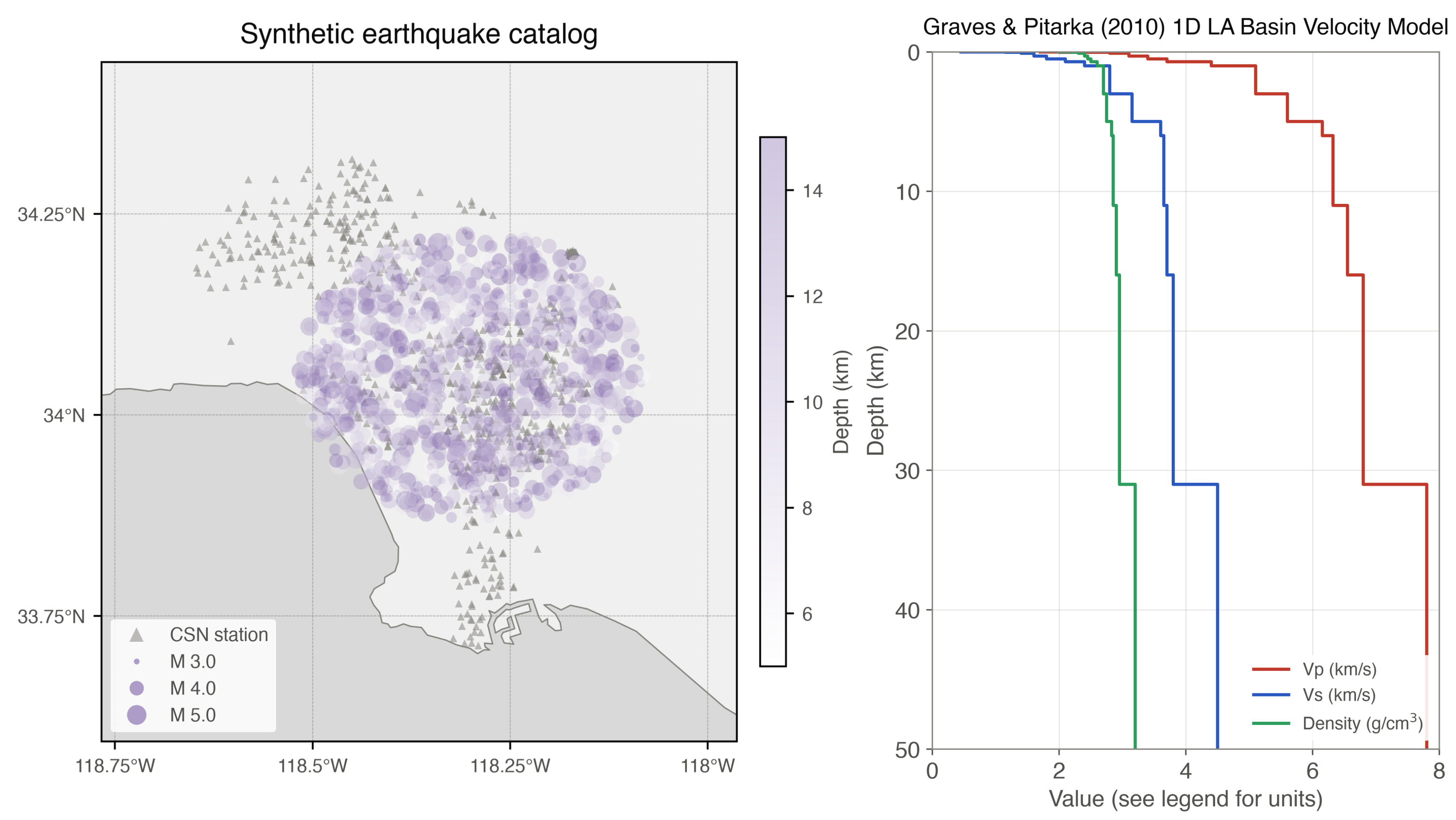
Poster #228, Group B

Ground motion in the Los Angles basin measured by the Community Seismic Network



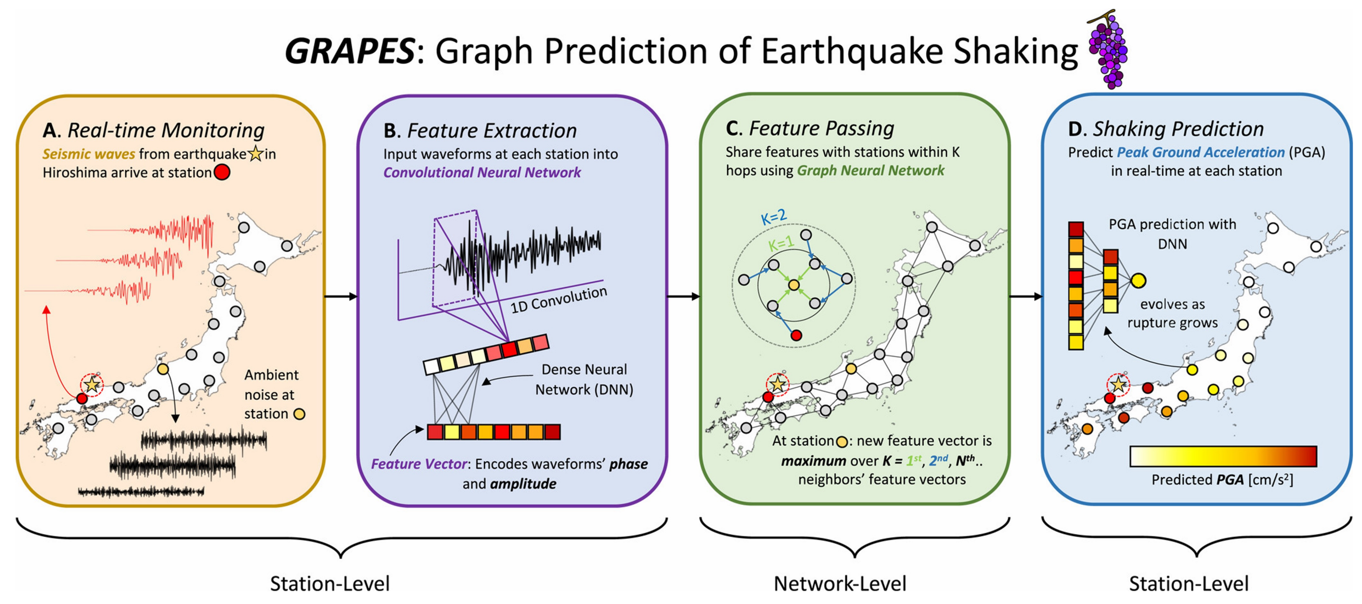
The Community Seismic Network (CSN) provides dense ground motion observations in the Los Angeles Basin (a) which could be used to rapidly create maps of ground motion for emergency response. Ground motions in the region can vary sharply over short distances (b & c). Full waveform transmission can be too slow for warning purposes, though onboard microcomputers at each CSN station (d) calculate peak ground acceleration (PGA), peak ground velocity (PGV), and spectral accelerations (SA) at 0.3, 1.0, and 3.0 seconds. These amplitudes are then sent to a central server with small enough latency to be used for earthquake early warning and rapid ground motion maps.

Generation of synthetic ground motion data



We generate synthetic data to train our model using 10,000 randomly generated earthquakes with moment magnitudes of 3.0 to 5.0, depths 5 to 15 km, and varying focal mechanisms. We simulate seismograms using QSEIS (Wang, 1999) and the 1D LA Basin velocity model, and plan to examine the method's sensitivity to a 3D model. Using the synthetic seismograms, we compute PGA, PGV, and SA (0.3, 1.0, and 3.0 seconds) in 1-second intervals using the same code used for the CSN amplitude calculations.

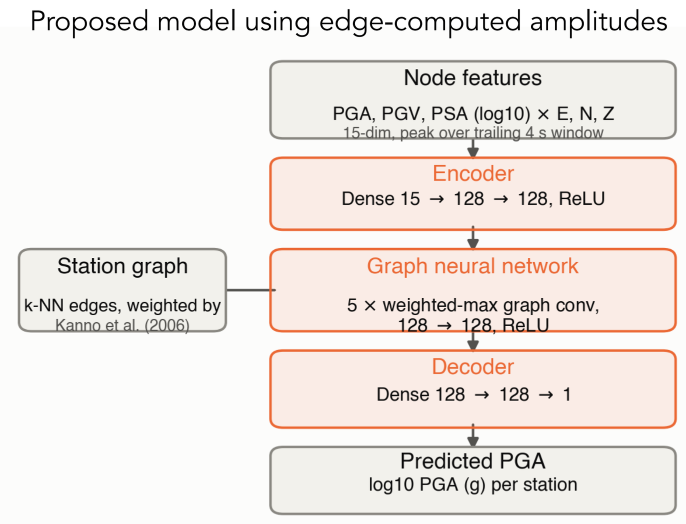
Machine learning models for ground motion prediction



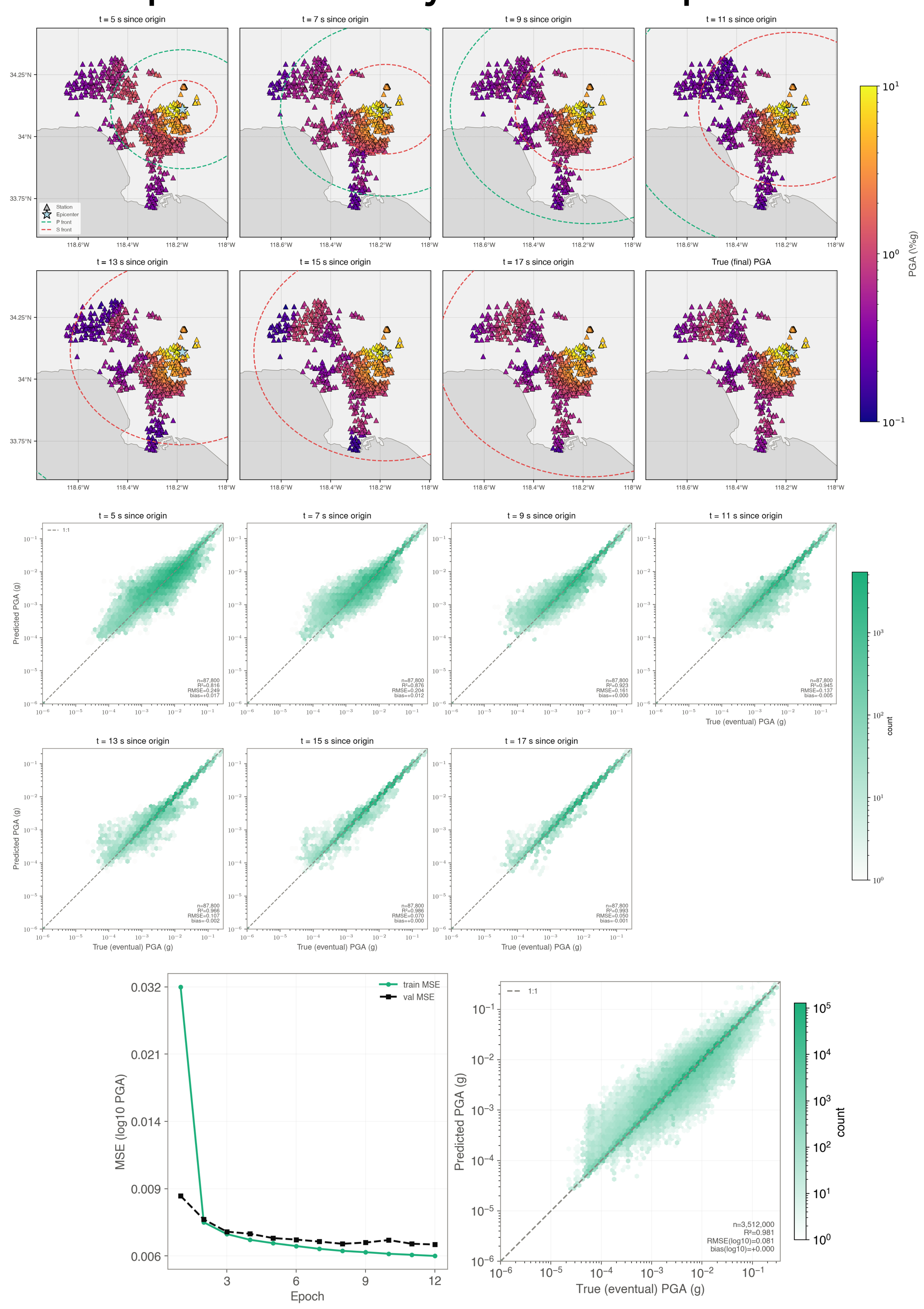
Clements et al. (2024)

We design our model based on the GRAPES architecture (Clements et al., 2024). Instead of encoding the waveform phase and amplitude using a dense neural network as in GRAPES, we use the CSN edge-computed PGA, PGV, and spectral accelerations within the 1-second increments. Each station's 15-dimensional log-amplitude feature vector (peak PGA, PGV, and SA at three periods, across three components), is propagated through five weighted-max graph-convolution layers over a k-nearest-neighbor station graph whose edges are weighted by empirical distance attenuation (Kanno et al., 2006), and decoded to a single predicted PGA per station.

Proposed model using edge-computed amplitudes

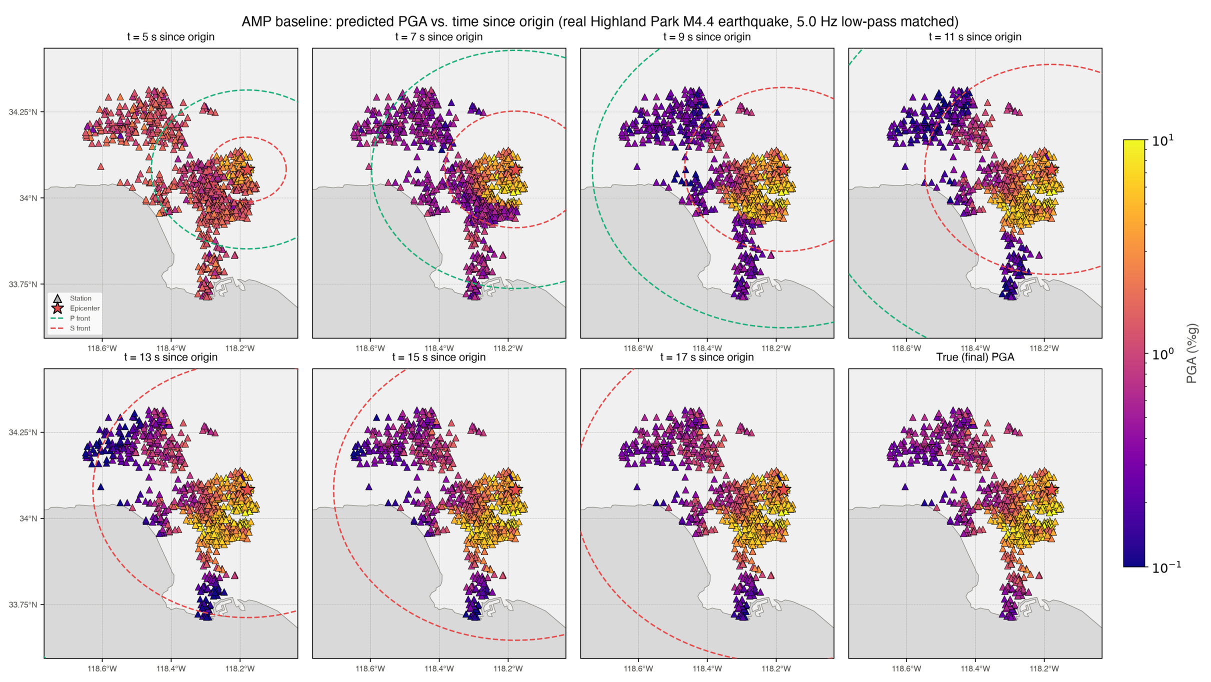


Model predictions on synthetic earthquake data

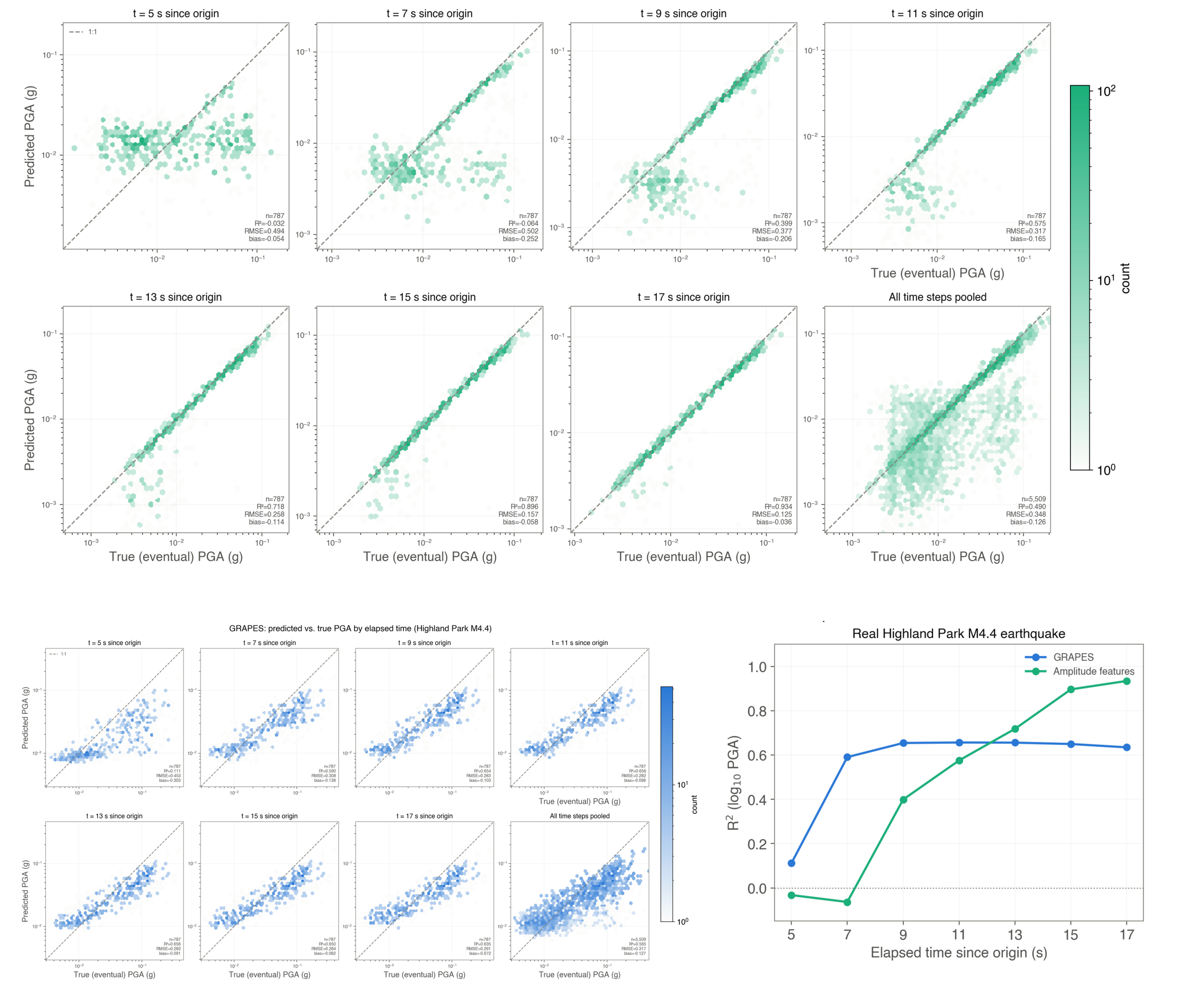


The model is trained end-to-end by minimizing mean-squared error between predicted and true log10 PGA with the Adam optimizer, using a 70/20/10 train/validation/test split across all scenarios. A high R^2 suggests that the model accurately predicts PGA in the area, and the predictions improve as time after origin increases.

Model predictions for the M4.4 Highland Park earthquake



We use our model to predict PGA for the M4.4 Highland Park CSN. We lowpass filter the data to to 5 Hz to match the input training data for an apples-to-apples comparison. We also compare our model with the GRAPES predictions for the same earthquake.



Conclusions and plans for future work

- Edge-computed CSN ground motions provide timely measurements useful for making ground motion maps and earthquake early warning
- Our new model is accurate for the 1D synthetic seismograms. The predictions for the real Highland Park earthquake could be improved with 3D synthetics, site response terms, or using real data in the training process. We will assess the method's sensitivity to a 3D velocity model will add more recent earthquakes in the LA basin for our comparison.
- We aim to predict ground motion for the entire area, not just at the CSN station locations, though the data volume remains a challenge. DYFI and cellphone data may be useful in the future.

References

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