Physics-Anchored Short-Term Earthquake Hazard Characterization Using Large-Scale Seismic Data Waveform-Derived Sequence Information Improves Leakage-Safe Short-Term Regional Hazard Indicators Beyond Catalog-Only Baselines

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Because exact earthquake prediction remains unavailable and retrofit budgets are limited, I developed a physics-anchored continuous space-time model to rank where short-term regional seismic hazard is most elevated so inspection, retrofit planning, and readiness can be prioritized. The model combines an ETAS baseline with a learned interaction term built from enriched event histories and waveform-derived marks. To avoid aftershock leakage, I used strict chronological train/validation/test splits and causal masking so each forecast depended only on information available before time t. I distilled about 340 TB of continuous California waveform data from 2008 to 2023 into reusable products, including phase picks, relocations, enriched catalogs, and event-level sequence marks, so training and inference no longer required repeated access to raw waveforms. I evaluated the model on observed California seismicity by estimating the probability of a moderate earthquake occurring within a predefined time and geographic window and then aggregating those probabilities into corridor-level rankings. The waveform-enhanced model reached an AUC-ROC of 0.79 with 95% block-bootstrap confidence intervals. At the same prioritization budget, Top-5 corridor capture increased from 26.7% to 31.9%. The distilled workflow also ran about 75× faster in inference and 36× faster in training per epoch than a neural spatiotemporal point-process baseline. A later Southern California refinement showed clear mini-corridor rank shifts after enrichment and waveform-derived marks. Overall, the results show that continuous waveforms add useful short-term sequence information beyond standard catalogs and can change which corridors rise to the top when resources are limited.

Awards Won:
Second Award of $2,400