## Research Project Highlight

# A Non-Ergodic Ground-Motion Model for California

*TSRP Topic M1 - Improved characterization of GM & hazard intensity*

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**Start-End Dates:**
Jan 2019 - Dec 2020

**Abstract**
As ground-motion data sets have grown, it has become clear that there are strong systematic effects in the source, path, and site effects for specific site/source pairs that are not captured by the average magnitude, distance, and VS30 scaling in traditional ergodic GMPEs. While we have known of this limitation of ergodic models for decades, the size of the effect is much larger than originally thought: recent data show that about 60% of the variance in ergodic GMPEs is due to repeatable source, path, and site effects. These systematic effects are incorrectly characterized as randomness that can occur at any site in the ergodic approach. To address this limitation, we develop a complete non-ergodic GMPEs for California, with the coefficients of the GMPE that depend on the longitude and latitude of the earthquake and the site.

The empirically-based non-ergodic model will include the epistemic uncertainty in both the base scaling (how the GMPEs extrapolate to large magnitudes and short distances) and in the non-ergodic terms (how well the regional variations in the ground motion are constrained). The non-ergodic GMPE will include the same 21 spectral periods between 0.01 and 10 seconds given in the Abrahamson et al. (2014) NGA-West2 GMPE.

**Deliverables**
A PEER report and a journal paper describing the non-ergodic GMPE for California

**Research Impact**
Properly accounting for the systematic source, path, and site effects using non-ergodic GMPEs can have a large effect on the ground motion for a given scenario. Using these new GMPEs, we will greatly increase the accuracy of the hazard in regions with adequate ground-motion data. In regions with limited ground-motion data, the new GMPEs will show that the epistemic uncertainty is large.

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An example comparing the ergodic and non-ergodic distance scaling of T=0.2 sec spectral acceleration for M6 earthquakes is shown in Figure 1. In the non-ergodic GMPE, the geometrical spreading coefficient (upper right) and the source constant (upper left) vary depending on the location of the earthquake. This results in a direction-dependent attenuation with distance. For a site in LA, the attenuation along the east direction (lower left) differs from the attenuation along the north direction (lower right).

The transition from ergodic to non-ergodic hazard codes will lead to the largest changes (improvements) in estimated hazard in California since the change to include the standard deviation of the ground motion occurred in the 1980s. At a given site in California, the ground motion for a return period of 2500 years may increase or decrease by up to a factor of 2 relative to the current hazard based on ergodic GMPEs. Due to the steep slopes of hazard curves in California, the risk of collapse of structures may increase or decrease by up to factor of 8 as we begin to incorporate non-ergodic GMPEs.

**Project Image**

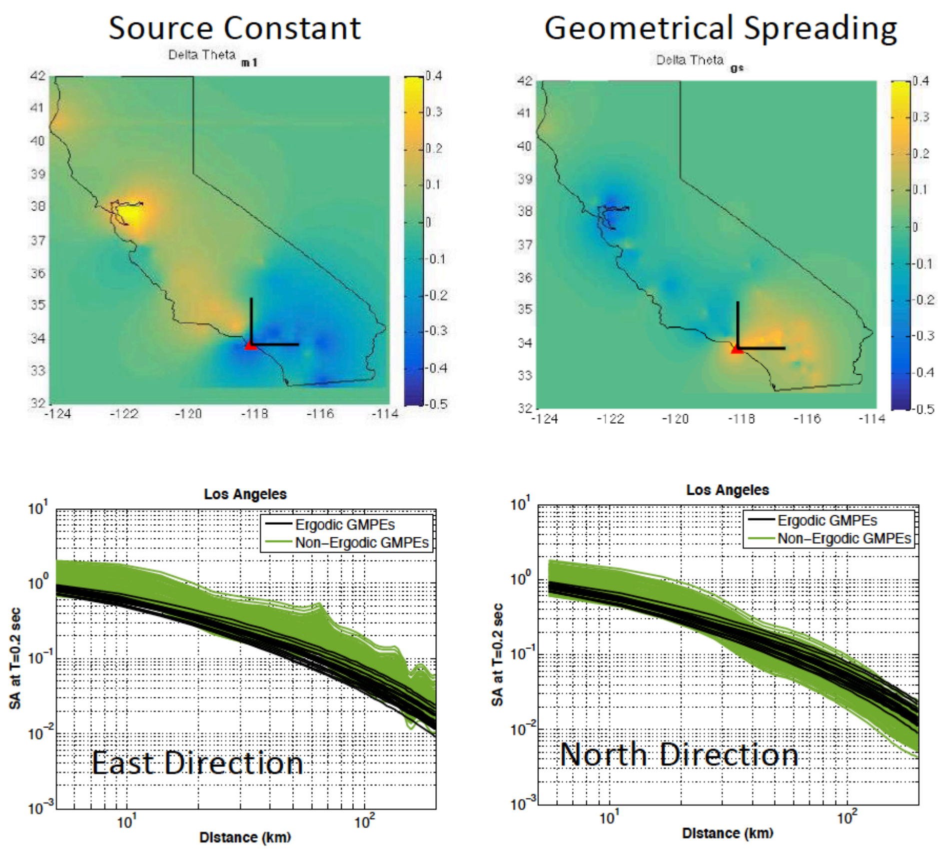


Figure 1. Spatially varying coefficients lead to direction-dependent attenuation of ground motion.