The ground motion prediction equation (GMPE) provides the intensity of ground shaking caused by a hypothetical earthquake. This model generally includes the dependence of earthquake magnitude, the distance between the earthquake and a site of interest, and site condition. Nowadays, building GMPE traditionally uses the ergodic approach that assumes the statistical properties of the ground-motion parameters do not change in space. While the ergodic GMPE produces stable ground motion models globally, it suffers from significant aleatory uncertainty. This uncertainty can not be reduced by gaining data and knowledge due to ignoring the systematic spatial variation of those parameters. This motivates the development of non-ergodic models: relaxing the ergodic assumption by considering site-, source- and path-relevant terms that used to be treated as epistemic uncertainties. This approach is potentially able to reduce the aleatory uncertainties significantly.

Among these newly added non-ergodic terms, the source term lacks a systematic physical explanation, which hampers future better constraints for the source term. In this study, we propose to associate such source term with the dynamic stress drop. We adopt a dataset from Trugman and Shearer (2018) that contains 5297 earthquakes in the San Francisco Bay area from 2002 to 2016 with a magnitude range of M1-4. In this database, we have estimated stress drops of these earthquakes and observed peak ground accelerations (PGAs) within 100 km of those earthquakes. We develop a non-ergodic GM model using the Gaussian Process Regression(GPR) method, which is widely used for constructing non-ergodic ground motion models reflecting spatially variable source, path, and site terms. A similar algorithm is also adopted to get a non-ergodic stress drop model that considers a spatially variable mean stress-drop term to reflect the systematic variations of stress drop. Our result shows that the source term of non-ergodic GMM and the stress-drop spatial term are highly correlated, implying that dynamic stress drop is the key factor in controlling the source term of the non-ergodic ground motion model. And it has the potential for further adjustment to the median ground motion in the base ergodic model by stress drop database.
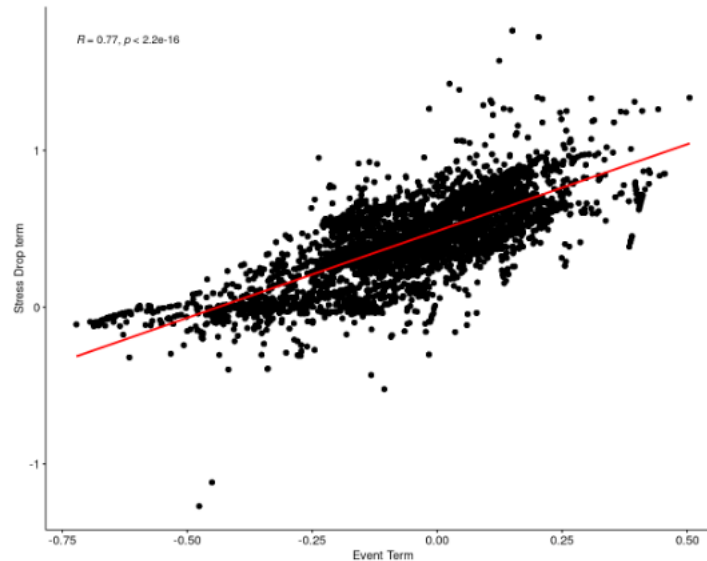

Figure 1 Correlation between the source term of non-ergodic GMPE and stress-drop spatial term. Red line is a 1:1 line.
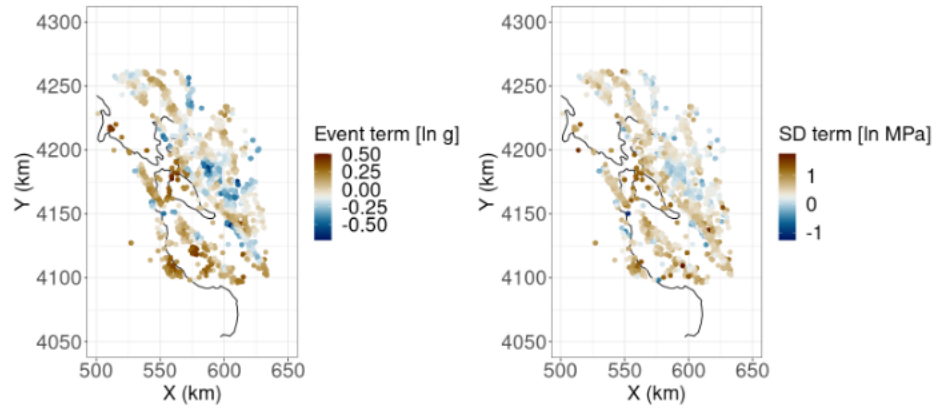
Figure 2. Spatial distributions of event term of non-ergodic ground motion model and stress-drop spatial term of non-ergodic stress drop model. They are spatially associated.