Updated Graizer-Kalkan GMPEs (GK13)

Southwestern U.S. Ground Motion Characterization SSHAC Level 3 Workshop 2

Berkeley, CA

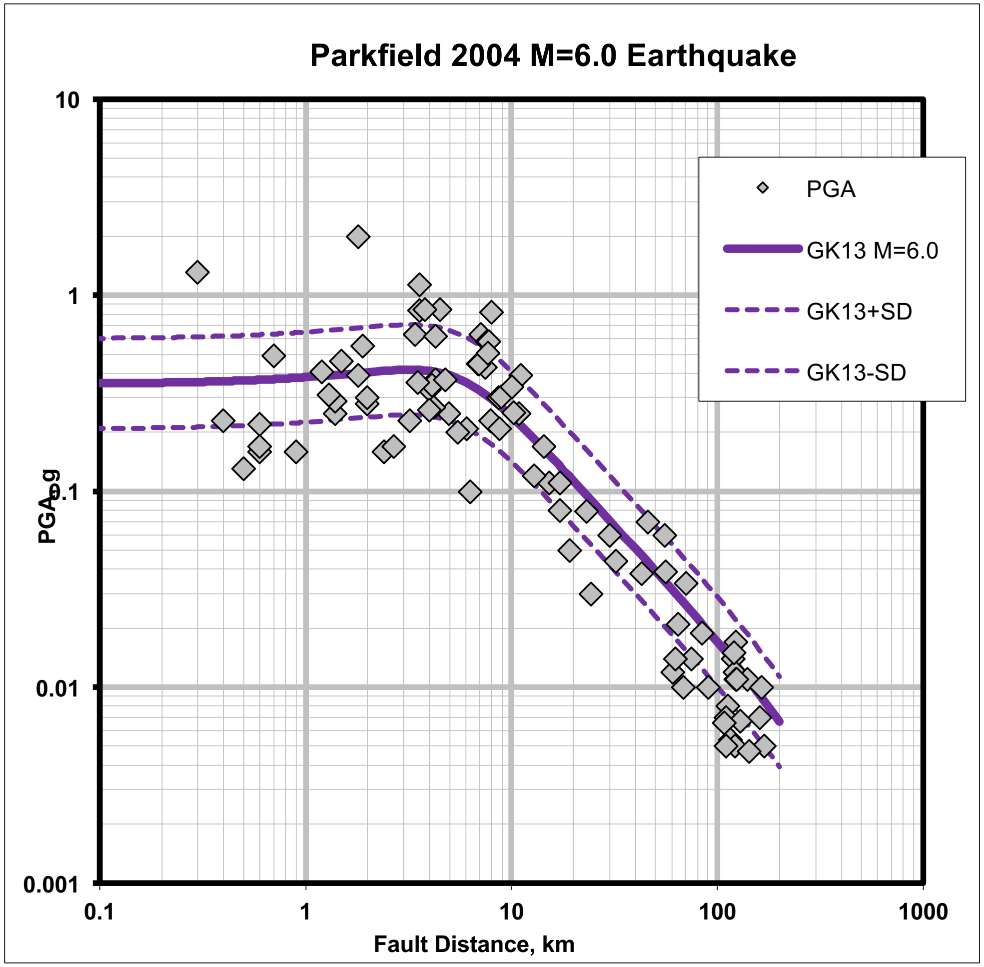
October 23, 2013

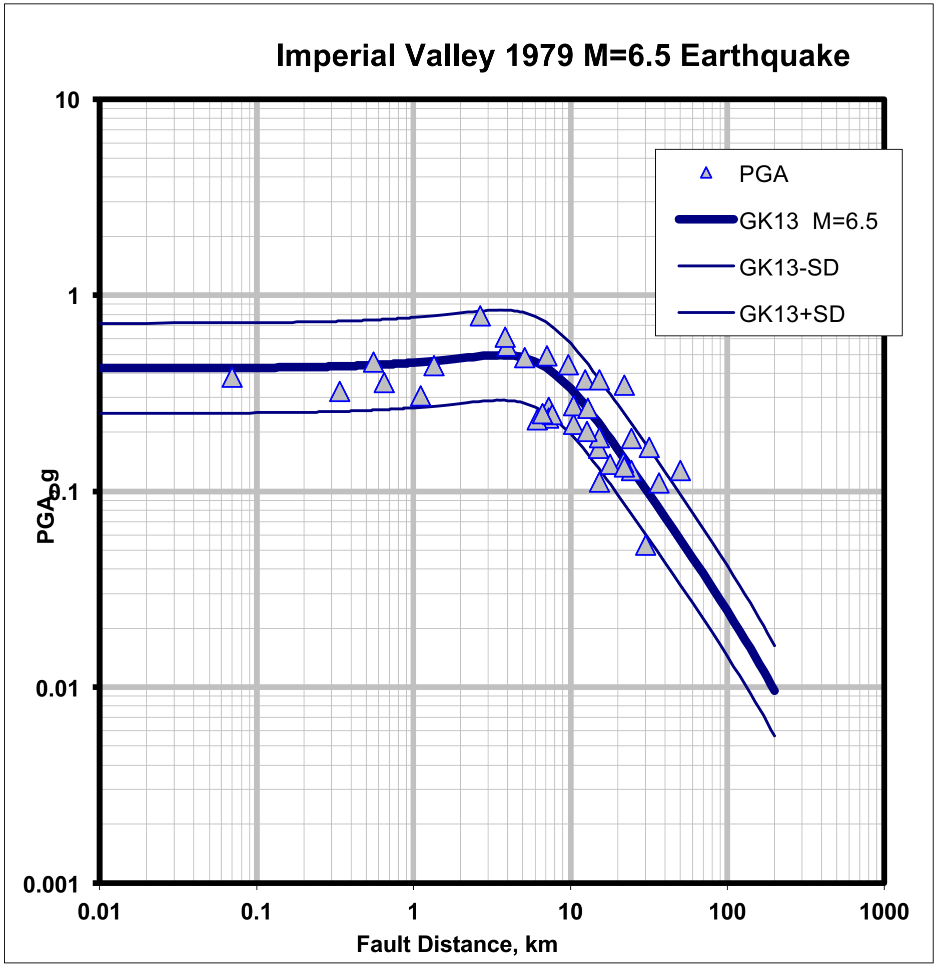
How many earthquakes show the "bump" in the distance attenuation in the near-fault region?

How many Californian (M≥6) earthquakes are well-recorded in the near-fault region?

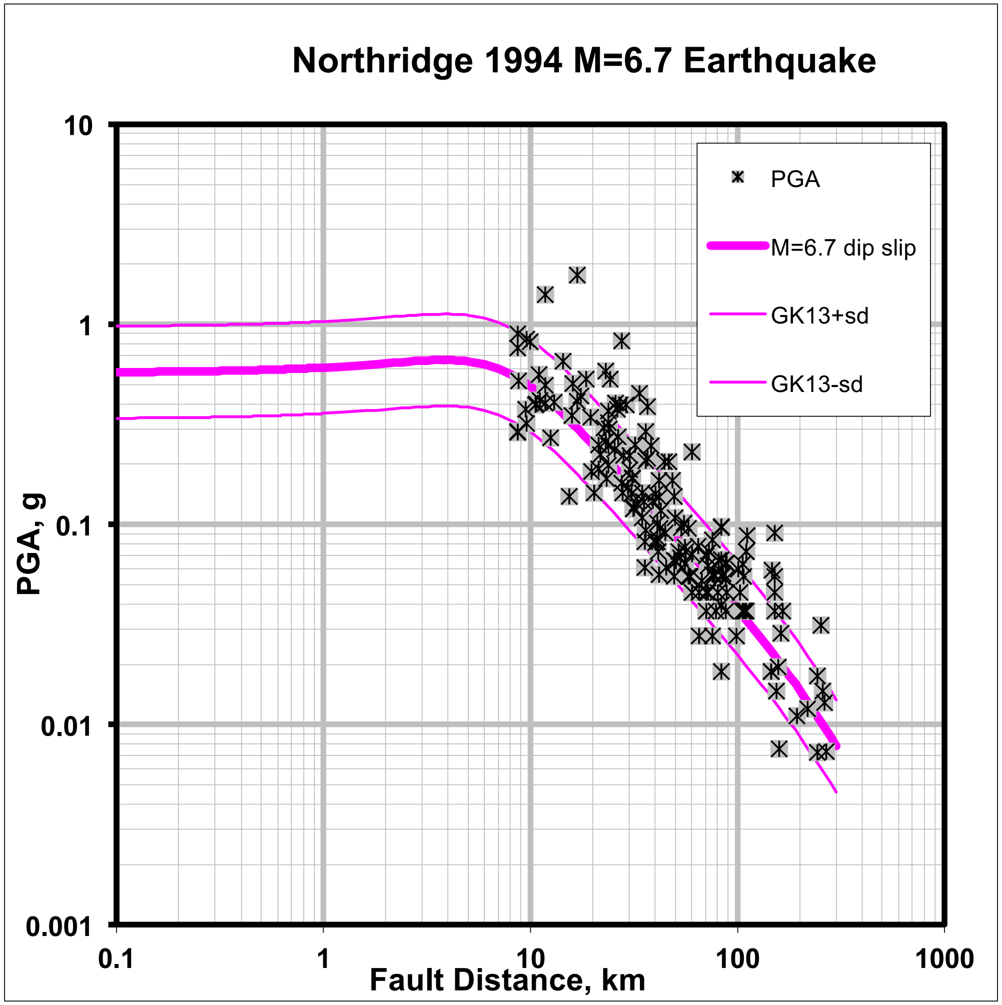
Earthquake	Stations at Fault Distance ≤ 5km	Stations at Fault Distance ≤ 10 km
Parkfield	35	50
Imperial Valley	9	17
Northridge	0	9
Loma Prieta	2	6

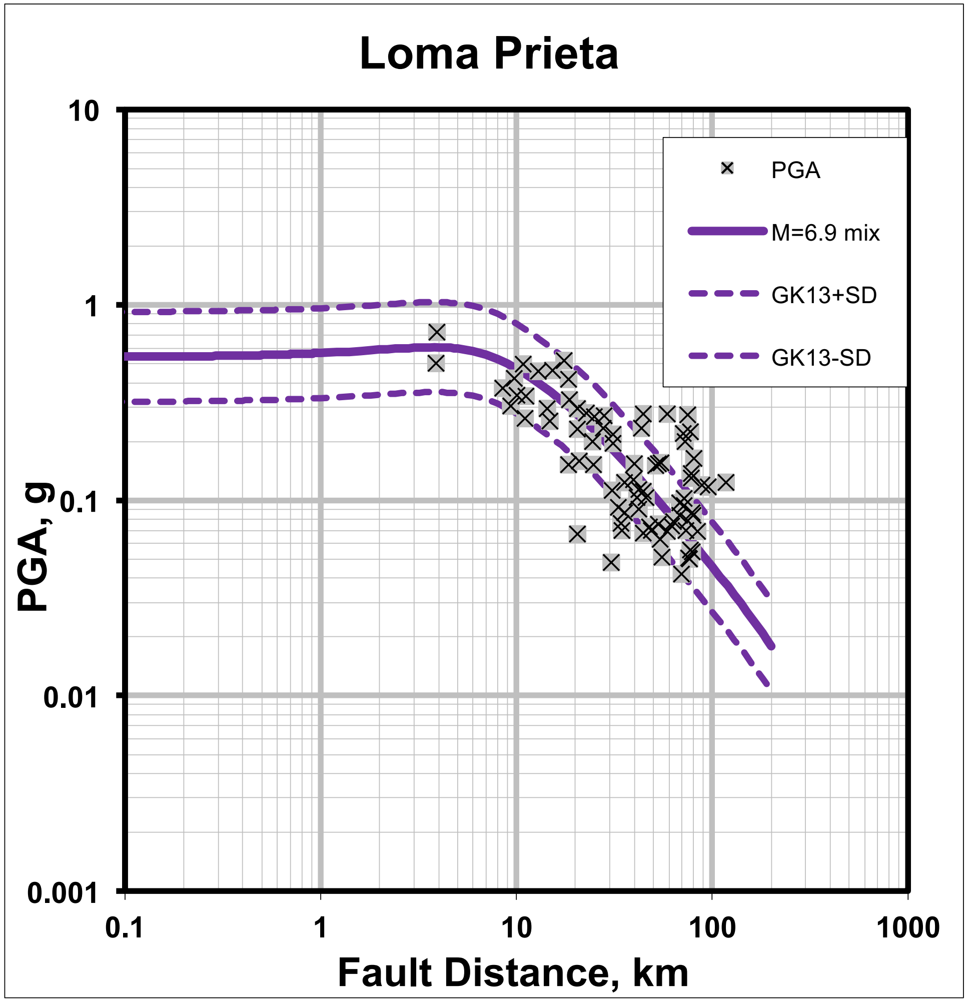
Parkfield and Imperial Valley Eqs.





Northridge and Loma Prieta Eqs.


Northridge 1994 M=6.7 Earthquake


Loma Prieta

How many out of these 4 earthquakes demonstrate "bump"?

2 out of 4

How many are non-conclusive?

2 out of 4

Explanation of “Bump”

“Bump” phenomenon, recently demonstrated in modeling geometrical spreading and the relative amplitudes of ground-motions in EUS, is attributed to radiation pattern effects combined with wave propagation through a one-dimensional layered earth model (Chapman and Godbee, 2012 - BSSA).

We speculate that, in the case of recorded earthquakes, it is a result of:

- Focusing and radiation pattern (aforementioned);
- Directivity;
- Nonlinear behavior of media in the near-source;
- Measuring distance as closest distance to rupture plane and not from the seismogenic (most energetic) part of the rupture.

Style of Faulting

Style of faulting is considered to be a simple scale factor. According to the results of Sadigh et al. (1997) reverse fault events create ground motions approximately 28% higher than those from crustal strike-slips. Following this, we adapted *F*=1.0 for strike-slip and *F*=1.28 for reverse faults.

We used F=1.14 for mixed strike and reverse faults.

A limited number of normal fault data points in our data set did not allow us to constrain the fault parameter for this particular mechanism; therefore normal fault data points were treated in the same category as strike-slip faulting.

Ztor (depth-to-top of rupture)

- This parameter is not present in seismological catalogs.
- It’s values can vary significantly depending upon the source of information.
- It is rarely available within short period of time after an earthquake.
- Most reverse faults in California don’t reach the surface, while strike slips reach the surface and effect of deeper relative to shallower events is at least partially taken care by the style of faulting factor.

Our modeling philosophy is to avoid any independent parameters that are not unique and not present in seismological catalogs.

Hanging Wall Effect

- As shown in Graizer, 2011, HW effect in AS2008 and CY2008 can produce unstable results.
- HW effect is neither considered in BSSA (2013) nor Idriss (2013).
- We were not allowed to have access to NGA-West2 database at time of GMPE development and were not able to assess reliability of current HW module.
- However, we intend to evaluate our equations further with respect to directivity and hanging wall effects.

“What constraints were applied for magnitude scaling between M7-M8?”

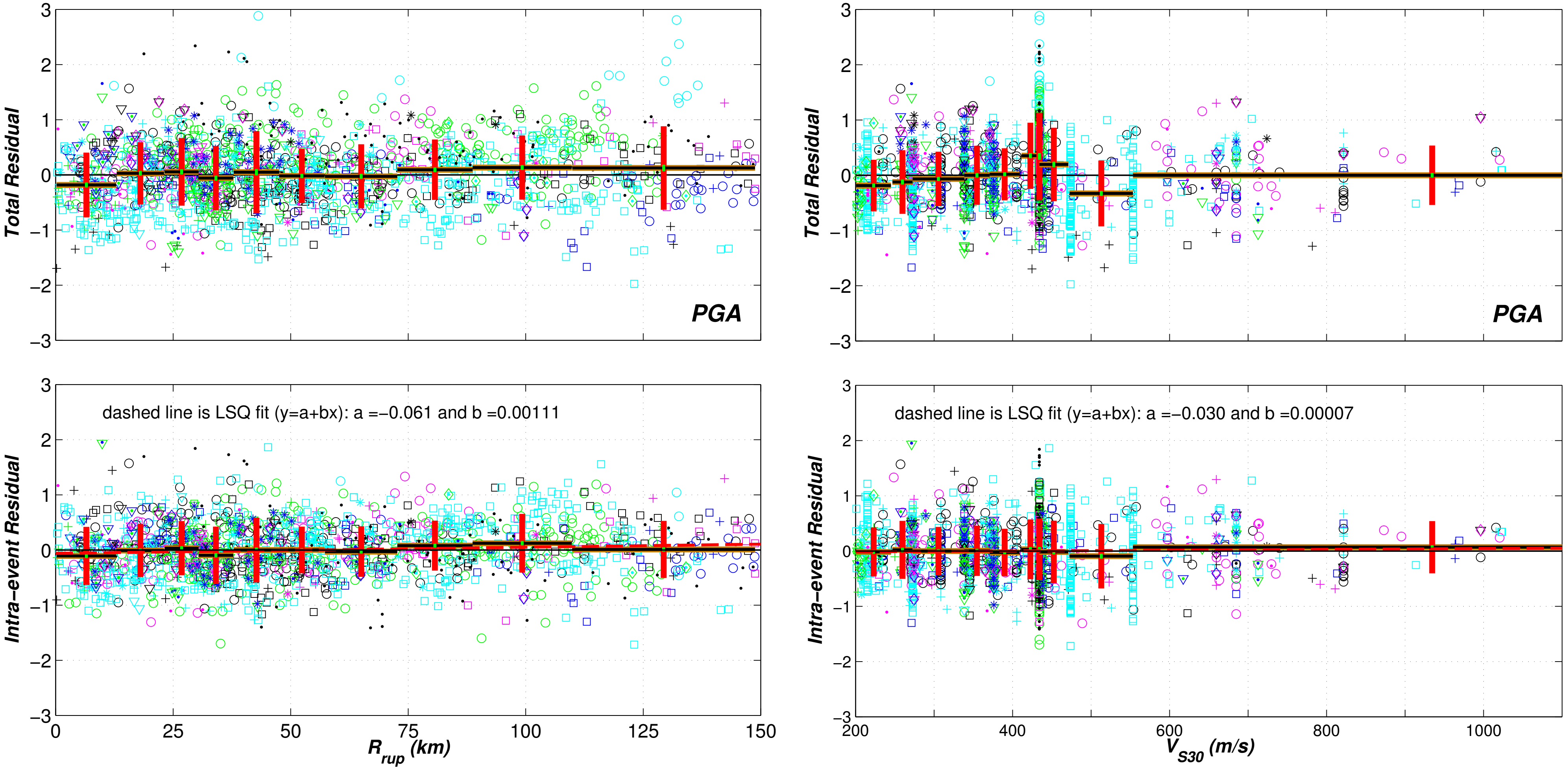
Earthquake	Moment magnitude
Denali	7.9
Kocaeli (Turkey)	7.4
Landers	7.3
Manjil (Iran)	7.4
Chi-Chi (Taiwan)	7.6
Duzce (Turkey)	7.2
Hector Mine	7.1

Database driven magnitude scaling is constrained by nonlinear optimization using seven earthquakes in NGA-West database. No data from simulations were utilized.

Mixed-Effect Residual Analysis

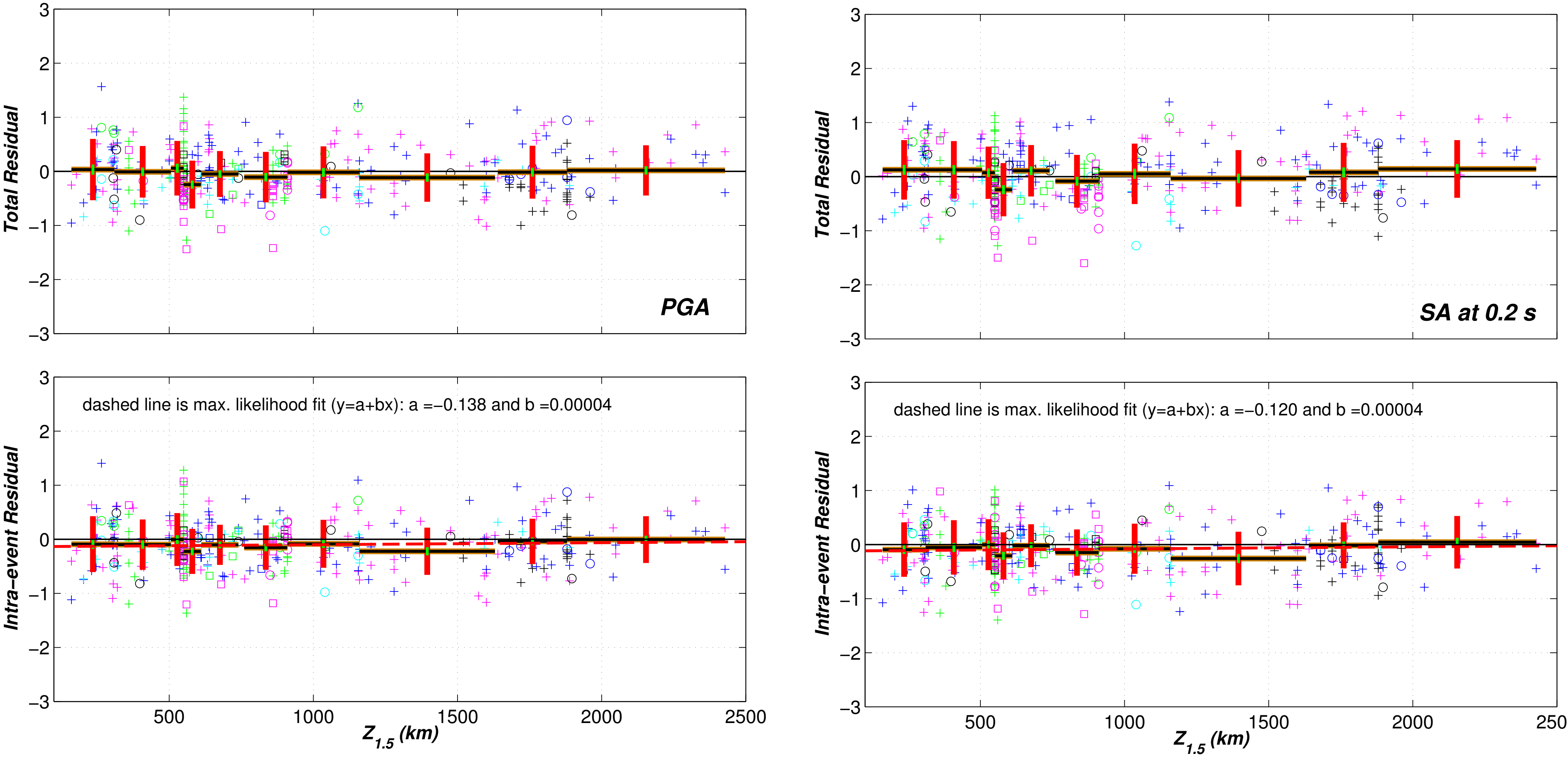
- We used maximum likelihood mixed-effect approach to compute intra- and inter-event residuals.
- Binned means and trend lines (either by LSQ fit or maximum likelihood fit) are plotted to show that there is no bias in event terms against any independent estimation parameters (M, R_{rup}, V_{S30} and $Z_{1.5}$).

Intra-event Residuals



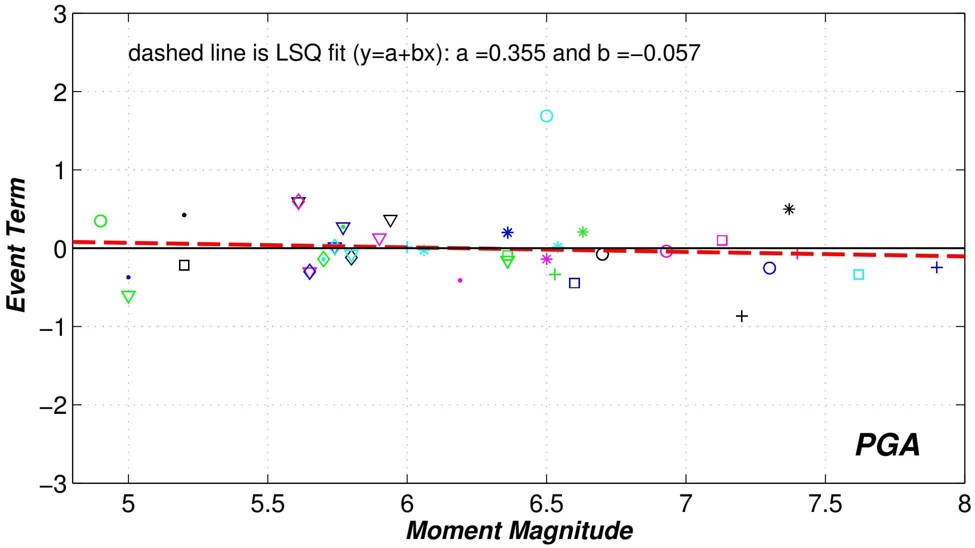
No noticeable bias with respect to R_{rup} or V_{S30}; slopes of trend lines are practically zero.

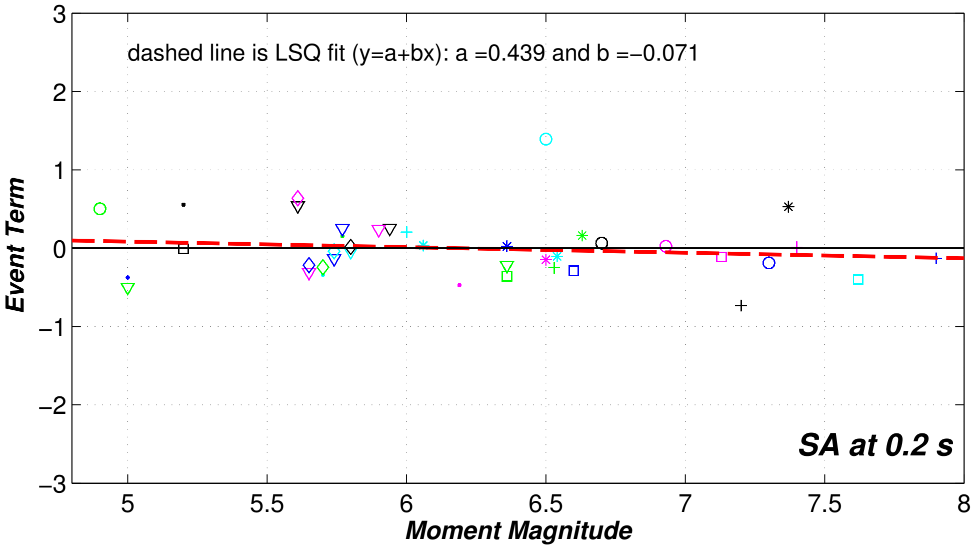
Intra-event Residuals

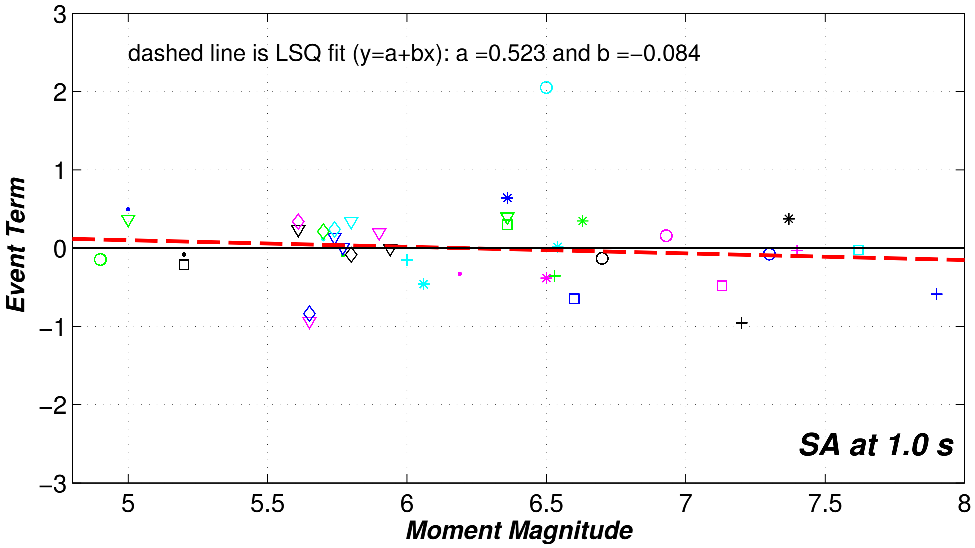


No noticeable bias with respect to $Z_{1.5}$;
slopes of trend lines are practically zero.

Inter-event Residuals







No noticeable bias in event terms; slopes of trend lines are practically zero for PGA, SA(0.2) and SA(1.0).

Number of Eqs = 40

Summary

- Our GMPEs can be adjusted to other active tectonic environments (e.g., using regional Q-factor).
- Our GMPEs are easier to implement. They are not dependent upon any information that may vary significantly depending upon the source.
- Our SA model is a continuous function of period.
- Residual analyses based on mixed-effect approach clearly show unbiased estimates of our GMPEs.

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