Distance and azimuthal dependence of ground-motion variability for unilateral strike-slip ruptures

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Poster no.: EGU2016-9185
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1 Motivation

- GMPEs use constant ground-motion variability $\phi_{ln(Y)}$ (e.g., Boore et al., 1997; Chiou and Youngs, 2006; Boore and Atkinson, 2008).
- Studies show that ground-motion variability:
  -decreases with increasing magnitude (Youngs et al., 1995)
  -depends on azimuth (Ripperger et al., 2008)
  -depends on distance and magnitude (Rodriguez-Marek et al., 2011)
  -shows distance-dependence with rupture style (Imtiaz et al., 2015)
- However, the number of studies are limited and the physics of $\phi_{ln(Y)}$ dependencies is not yet fully understood.
- **Objective: We investigate $\phi_{ln(Y)}$ as function of distance and azimuth for unilateral directive ruptures.**

2 Landers simulations and validation

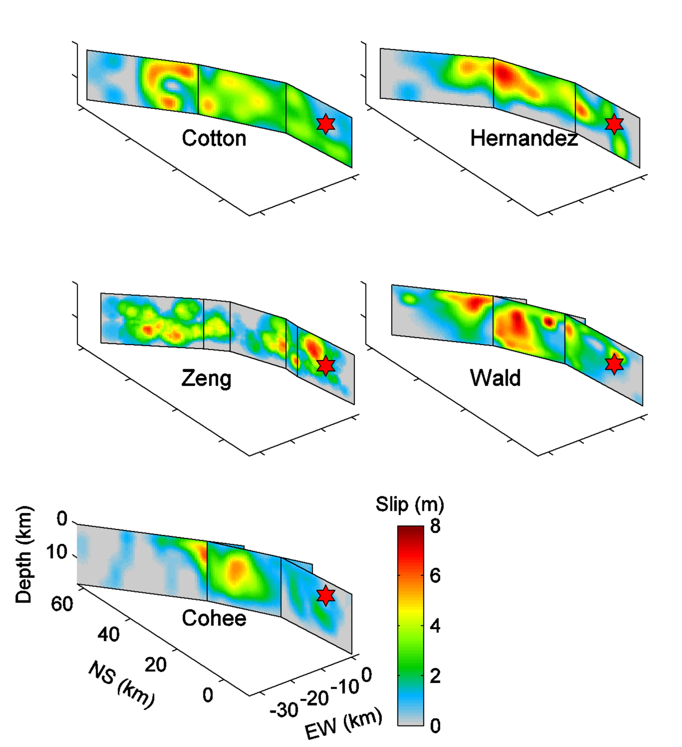


Figure 1: Five source models of 1992 Landers earthquake

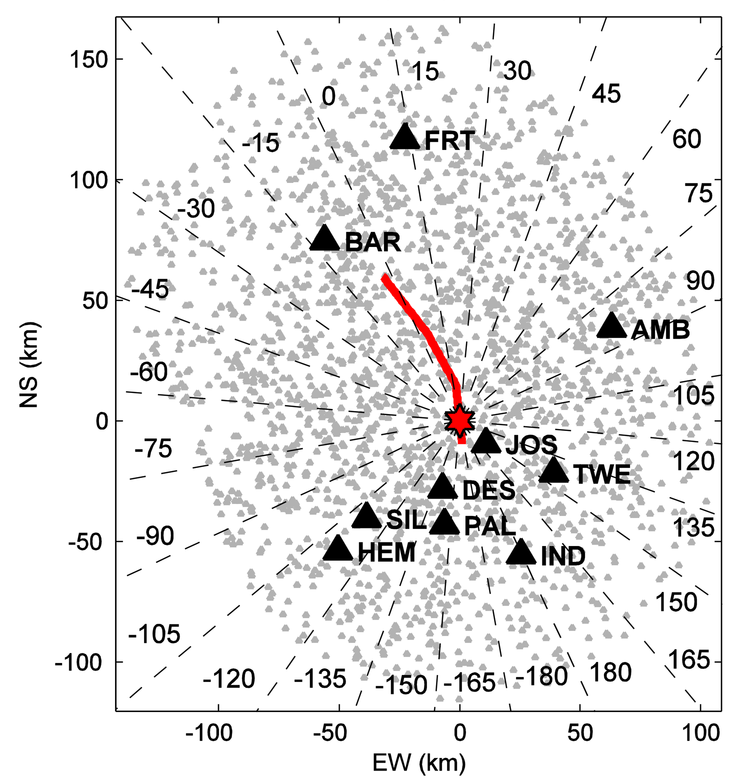


Figure 2: Receiver geometry used for calibration and $\phi_{ln(PGV)}$ investigation.

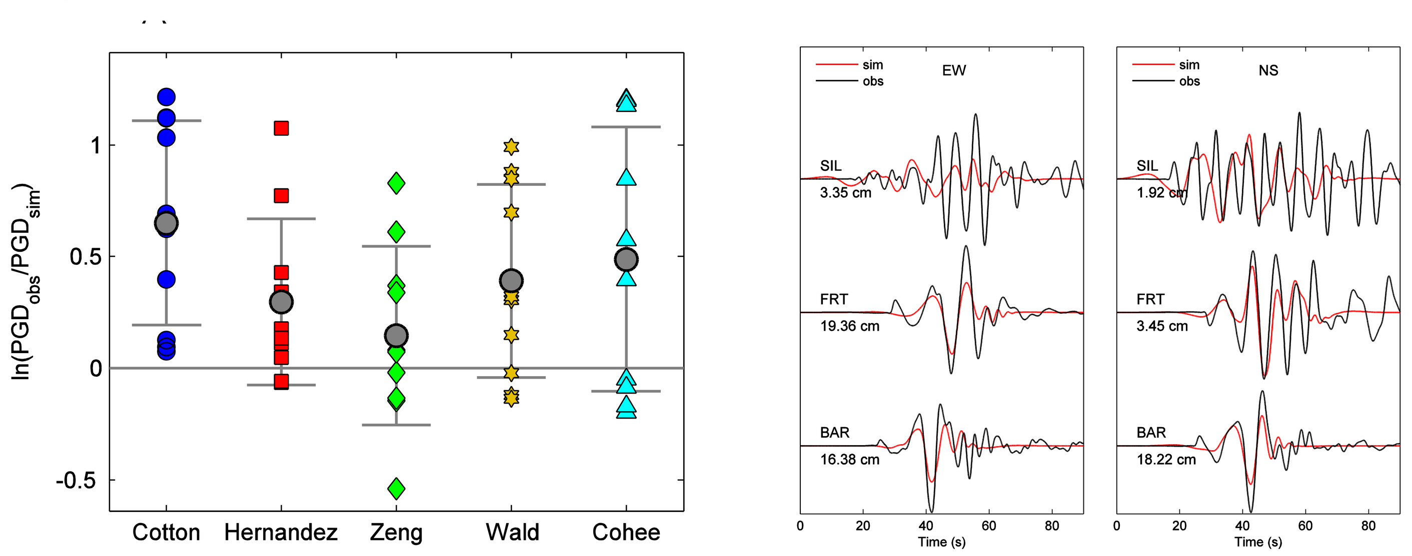


Figure 3: Validation of simulations with respect to observed data.

- We first simulate M 7.3 Landers earthquake, perform statistical analysis on shaking levels and build physical understanding of $\phi_{ln(PGV)}$. Then validate our findings from large M 7.8 ShakeOut scenario simulation.
- In Landers and ShakeOut simulations:
  -complex geometries of the sources are respected.
  -1D layered media for Landers and 3D heterogeneous medium for ShakeOut.
- Numerical simulations performed using 2nd order generalized finite difference method for seismic wave propagation (Ely et al., 2008).

3 Statistical analysis and physical interpretation

Figure 4: Distance and azimuthal dependence of $\phi_{ln(PGV)}$ from ground-motions simulations of 1992 Landers earthquake.

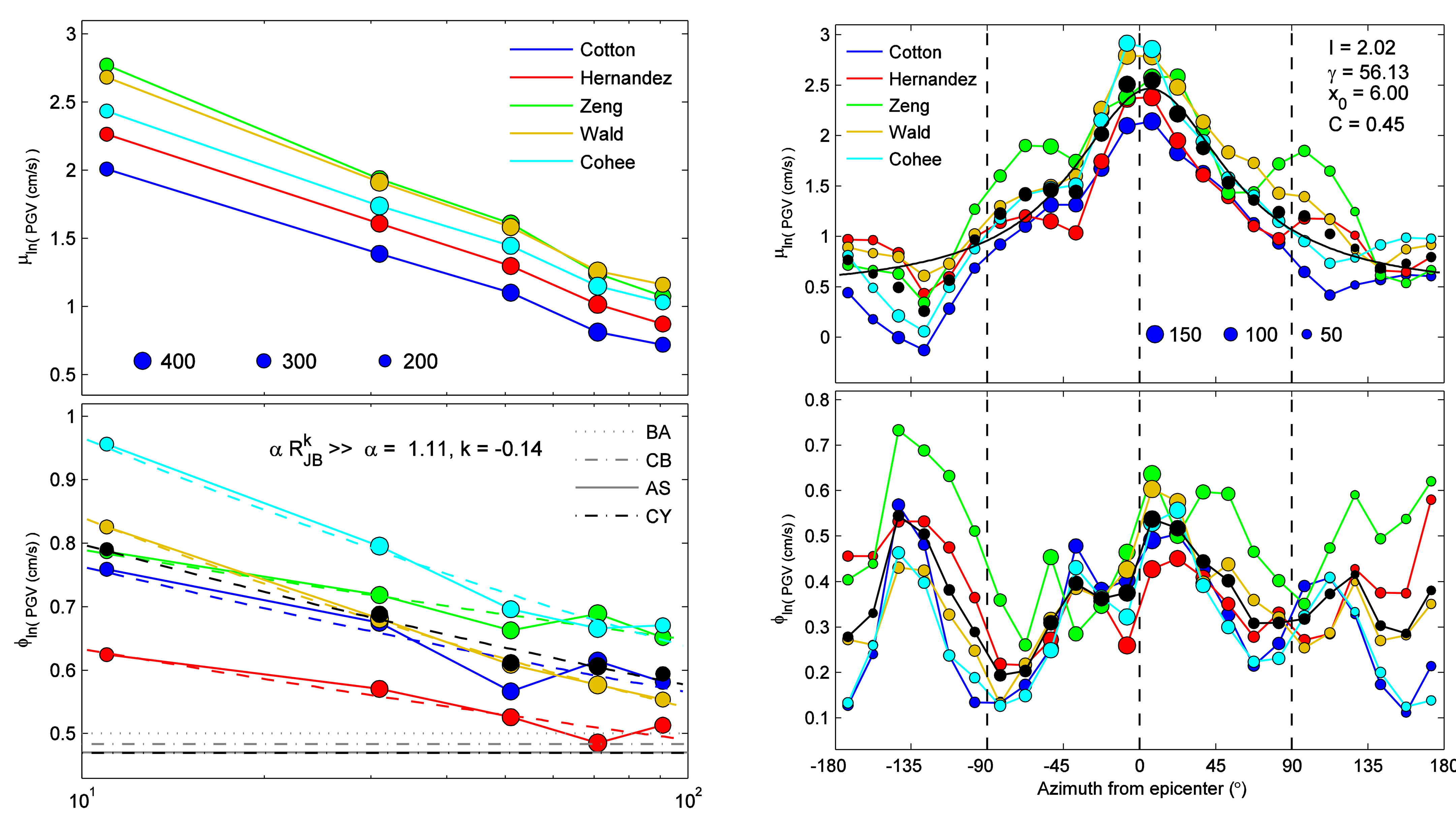
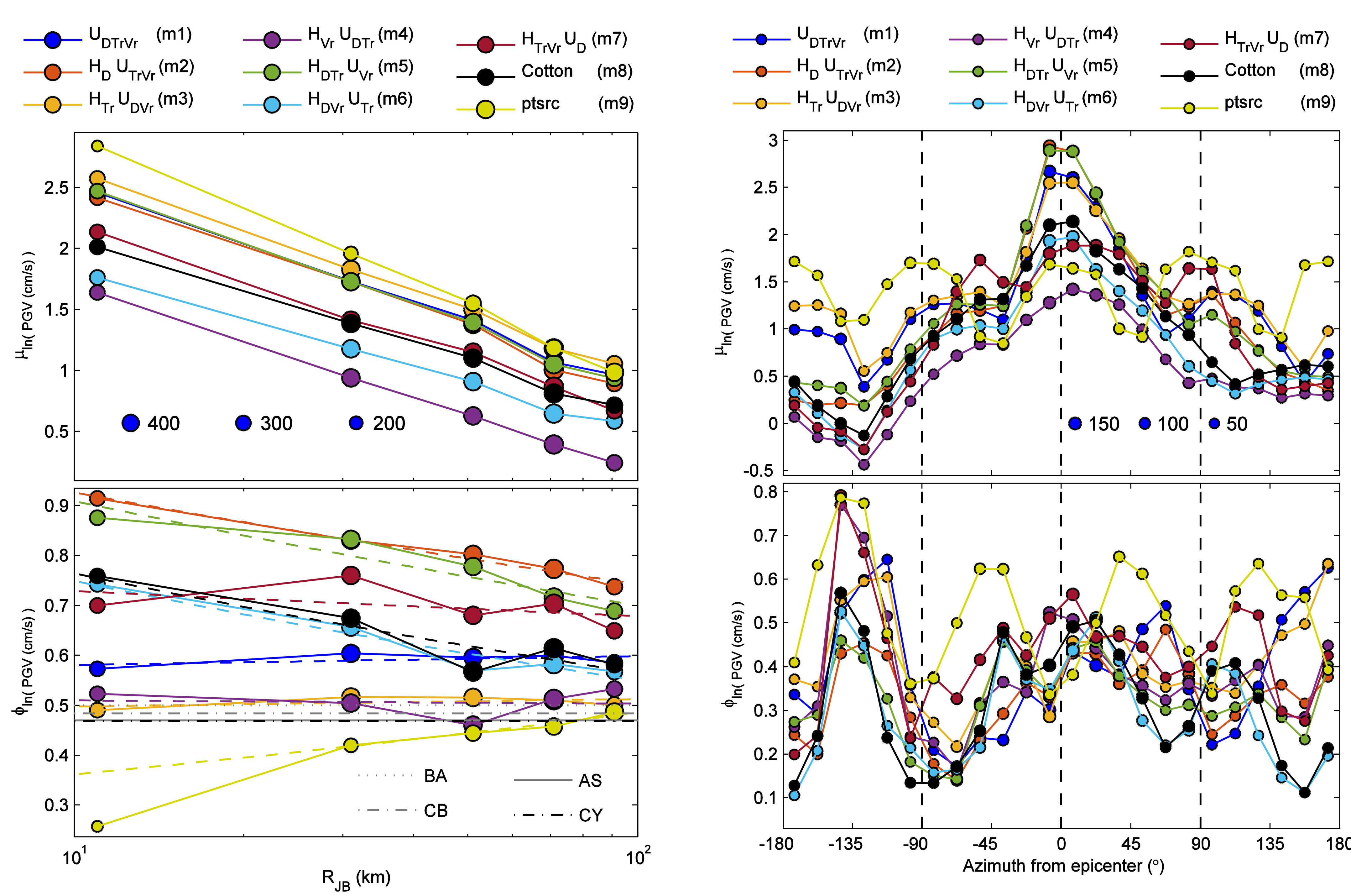
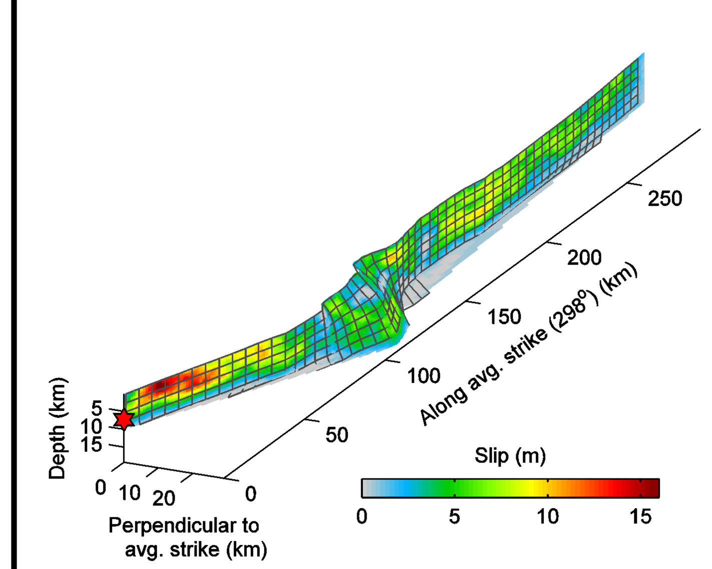


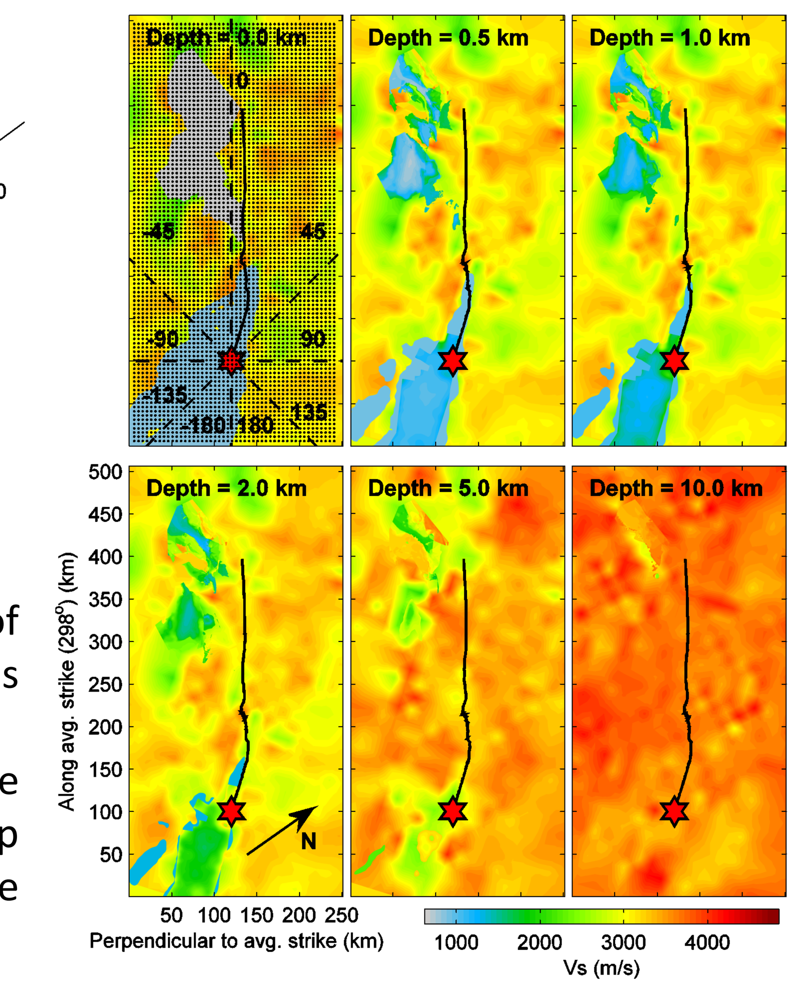
Figure 5: Distance and azimuthal dependence of $\phi_{ln(PGV)}$ from eight simplified rupture models of Cotton.



4 Validation of findings

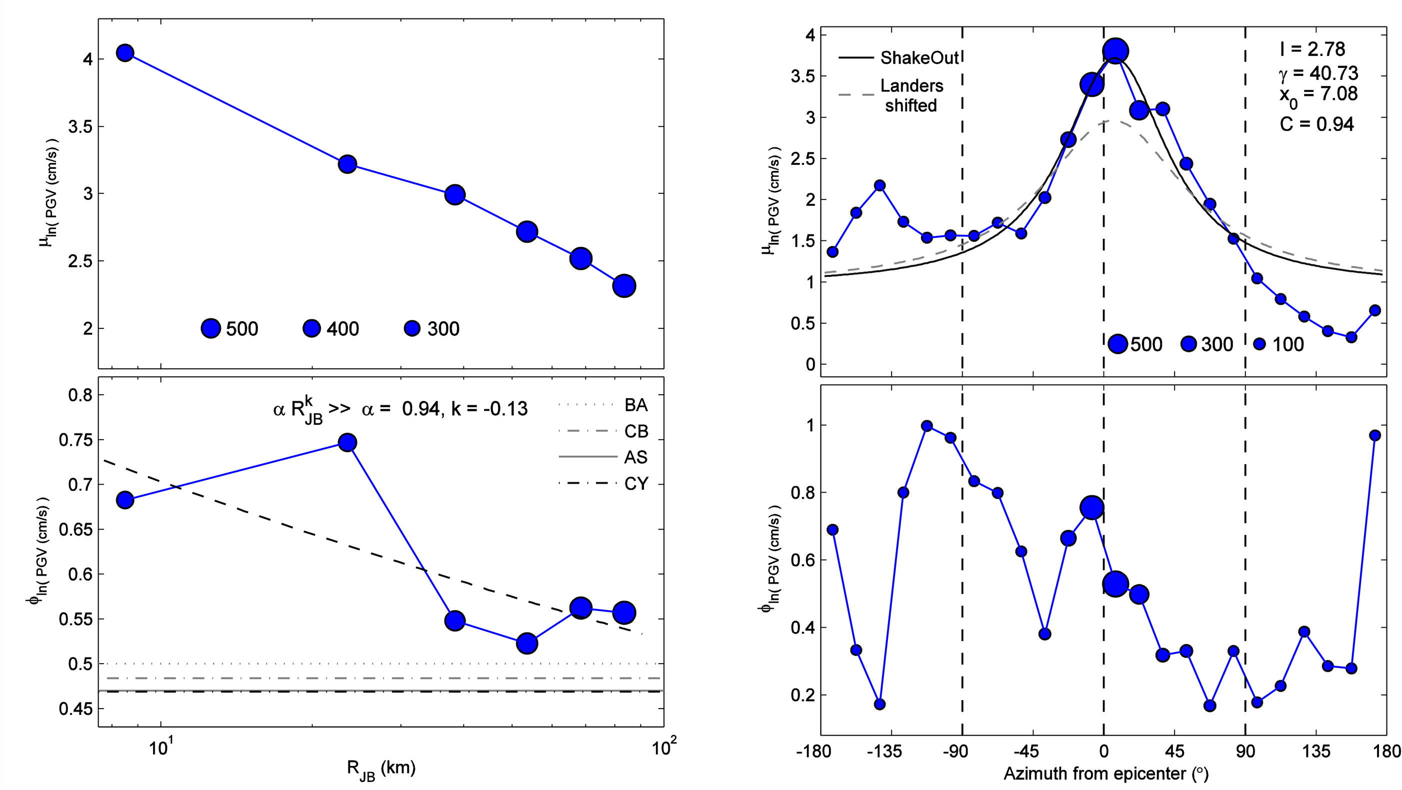
Figure 6: ShakeOut source and 3D velocity-depth layers used for simulation.





- ShakeOut is a scenario rupture of M 7.8 earthquake on San Andreas fault.
- Independent source time functions in strike and dip directions allow temporal rake rotation.

Figure 7: Distance and azimuthal dependence of ShakeOut simulation.



5 Conclusions

- $\phi_{ln(PGV)}$ is higher in close distances to the fault (< 20 km), and decreases with increasing distance following a power law. The physical explanation is the presence of strong directivity and rupture complexity.
- Power law decay of $\phi_{ln(PGV)}$ is primarily controlled by slip heterogeneity.
- High values of $\phi_{ln(PGV)}$ occur in the rupture-propagation direction, but small values in the direction perpendicular to it.
- $\phi_{ln(PGV)}$ as function of azimuth, is sensitive to variations in both rupture speed and slip heterogeneity.
- The $\mu_{ln(PGV)}$, is well described by a Cauchy-Lorentz function that provides a novel empirical quantification to model the spatial dependency of ground-motion.

Recent publication:

Vyas J. C., P. M. Mai, M. Galis (2016). Distance and azimuthal dependence of ground-motion variability for unilateral strike-slip ruptures. Accepted in Bull. Seis. Soc. Am.