Generic Source Parameter Determination for Earthquake Early Warning: Theory, Observations and Implications for the Mw 7.1 Ridgecrest Earthquake

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Based on:
Lior, I. and A. Ziv (2020). **Generic Source Parameter Determination and Ground Motion Prediction for Earthquake Early Warning,** *Bull. Seismol. Soc. Am.* **110.**

Earthquake Early Warning Theory

M_0: Seismic moment
$\Delta\tau$: Stress drop
R: Hypocentral distance
T: Recorded interval
A_{rms}, V_{rms}, D_{rms}: Acceleration, velocity, displacement root-mean-squares

Equations for the seismic moment and stress drop. For detailed derivation, see Lior and Ziv (2020).

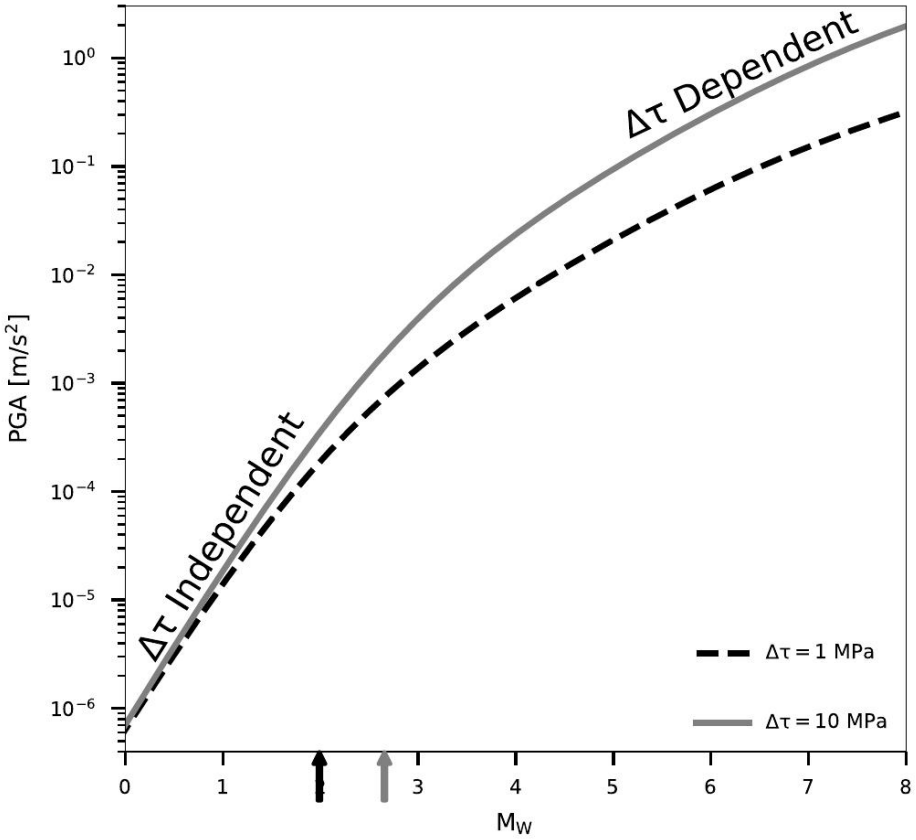
$$C_M = \frac{8\pi\rho C^3}{U_{\varphi\theta}F_s} \qquad C_{\Delta\tau} = \frac{7\rho C^3 \kappa^{1.5}}{128\pi^{0.5}U_{\varphi\theta}F_s(kC_S)^3}$$

$$M_0 = C_M R T^{0.5} \frac{D_{rms}^{1.5}}{V_{rms}^{0.5}} \qquad \Delta\tau = C_{\Delta\tau} R T^{0.5} \frac{A_{rms}^{3}}{V_{rms}^{2}}$$

$$inconsistency\ index = \max\left(\left|\log\left(\frac{A_{rms}^{obs}}{A_{rms}^{mod}}\right)\right|, \left|\log\left(\frac{V_{rms}^{obs}}{V_{rms}^{mod}}\right)\right|, \left|\log\left(\frac{D_{rms}^{obs}}{D_{rms}^{mod}}\right)\right|\right)$$

Earthquake Early Warning

Theory - from the asymptotic solutions



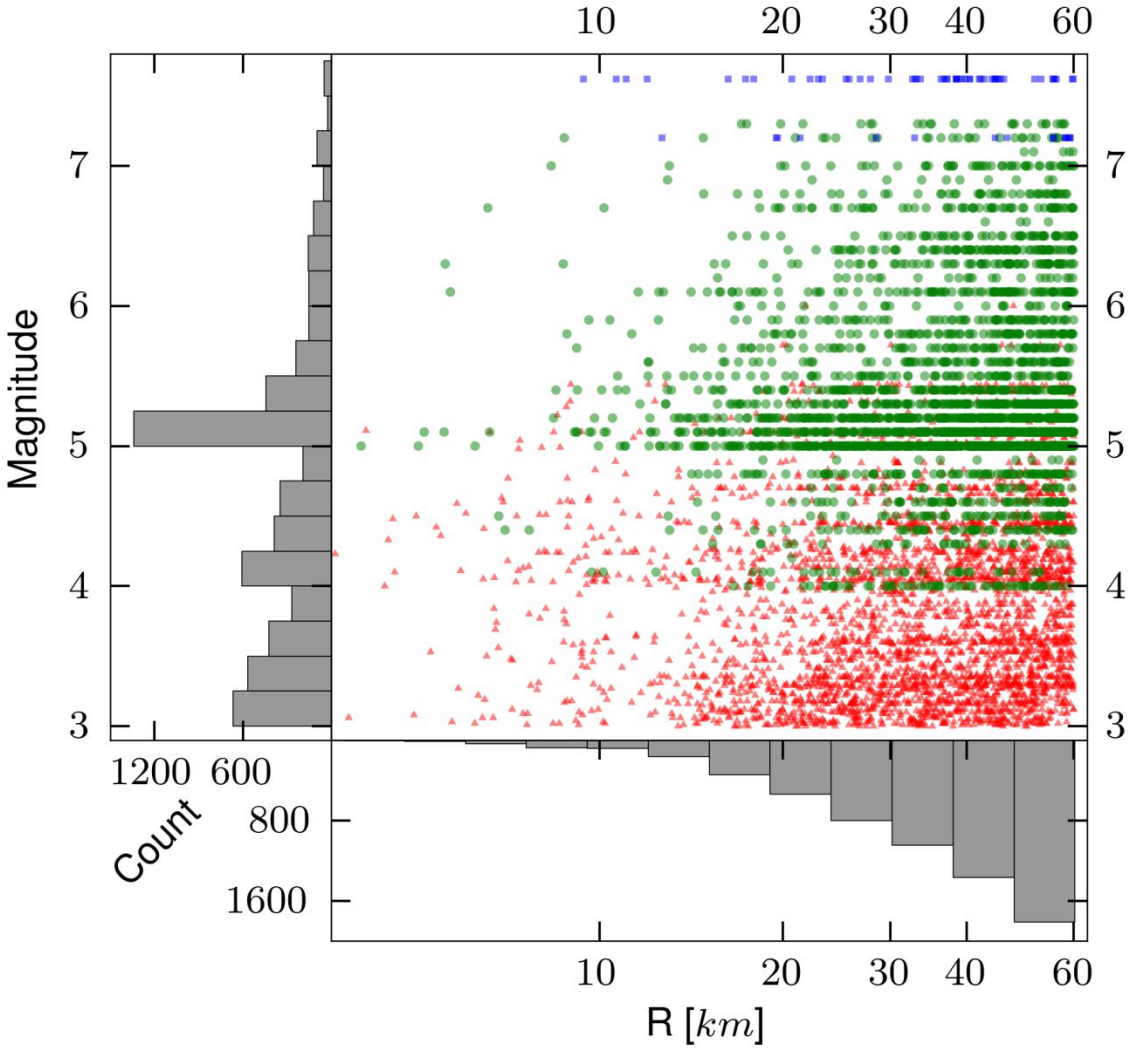
The stress drop is crucial in determining ground motions.
Its effect increases with increasing magnitude.

$$\Delta\tau = C_{\Delta\tau} R T^{0.5} \frac{A_{rms}^3}{V_{rms}^2}$$

Data

- Japan
  - 2917 records
- California
  - 3328 records
  - Ridgecrest (M_W 6.4 *and* 7.1)
- Mexico (M_W 7.2)
- Taiwan (M_W 7.6)

$$rms = \sqrt{\sum_{i=1}^{n} [AZ_i^2 + AE_i^2 + AN_i^2]/n}$$

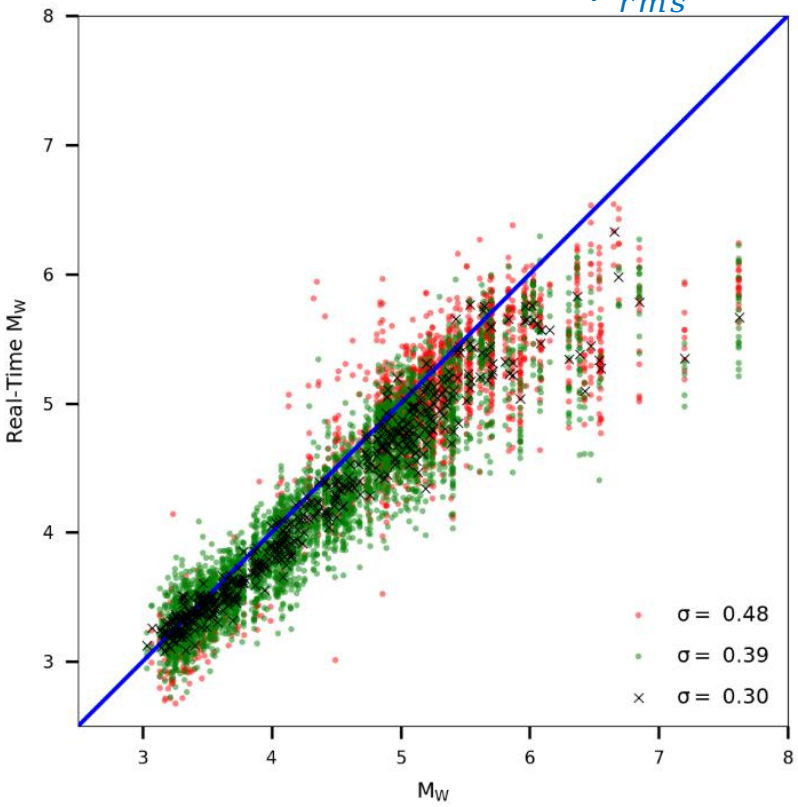


Earthquake Early Warning

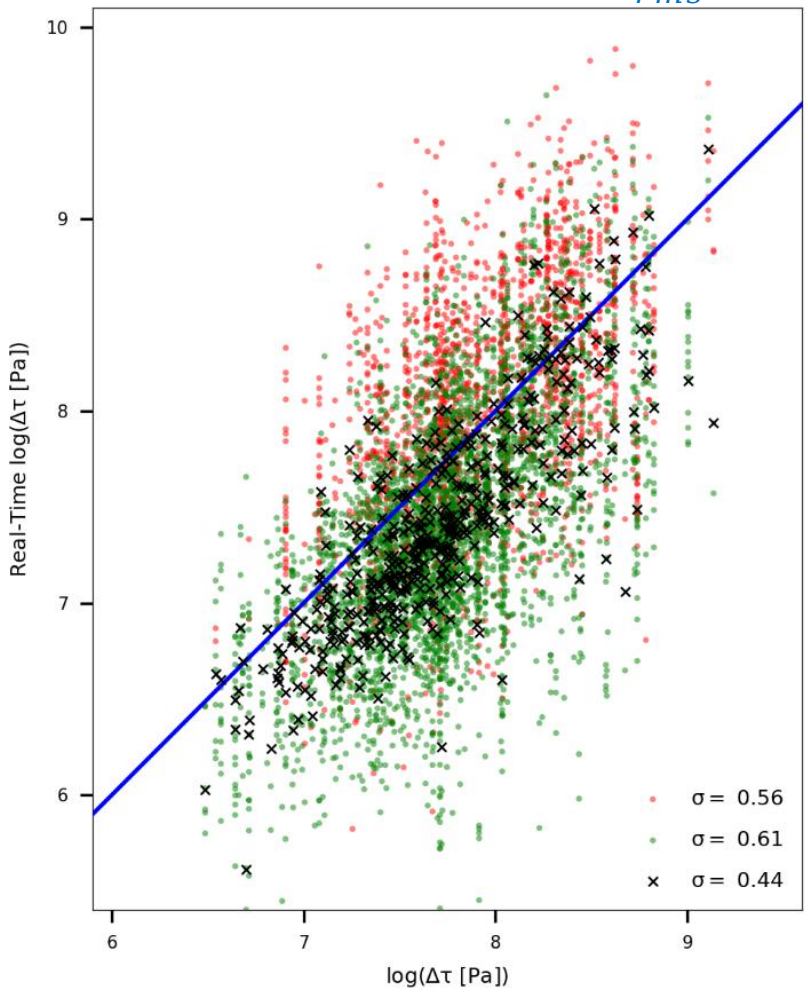
$M_W, \Delta\tau$

2 sec

$$M_0 = C_M R T^{0.5} \frac{D_{rms}^{1.5}}{V_{rms}^{0.5}}$$



$$\Delta\tau = C_{\Delta\tau} R T^{0.5} \frac{A_{rms}^3}{V_{rms}^2}$$

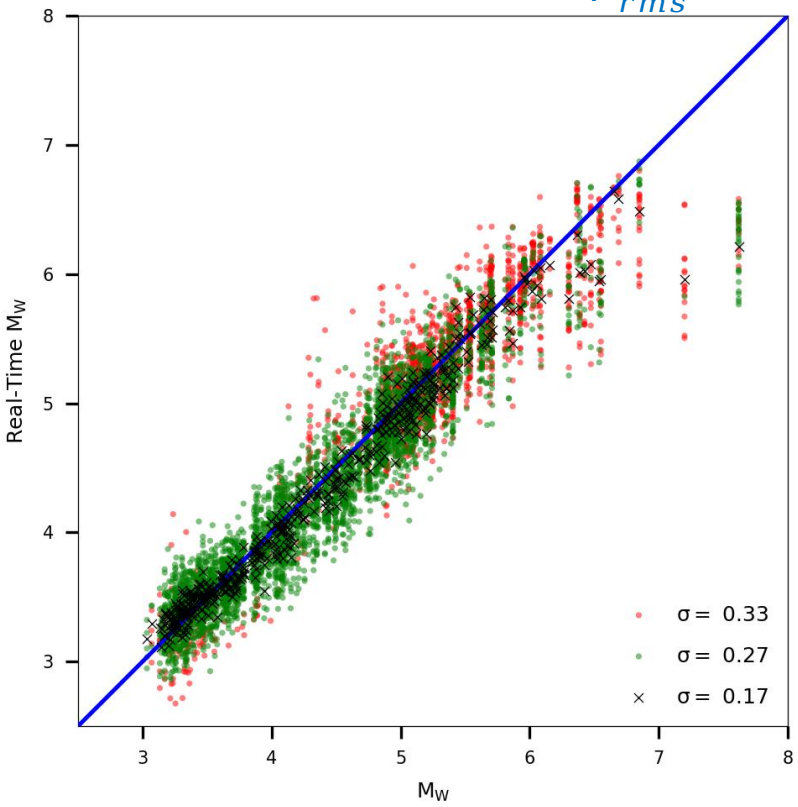


Earthquake Early Warning

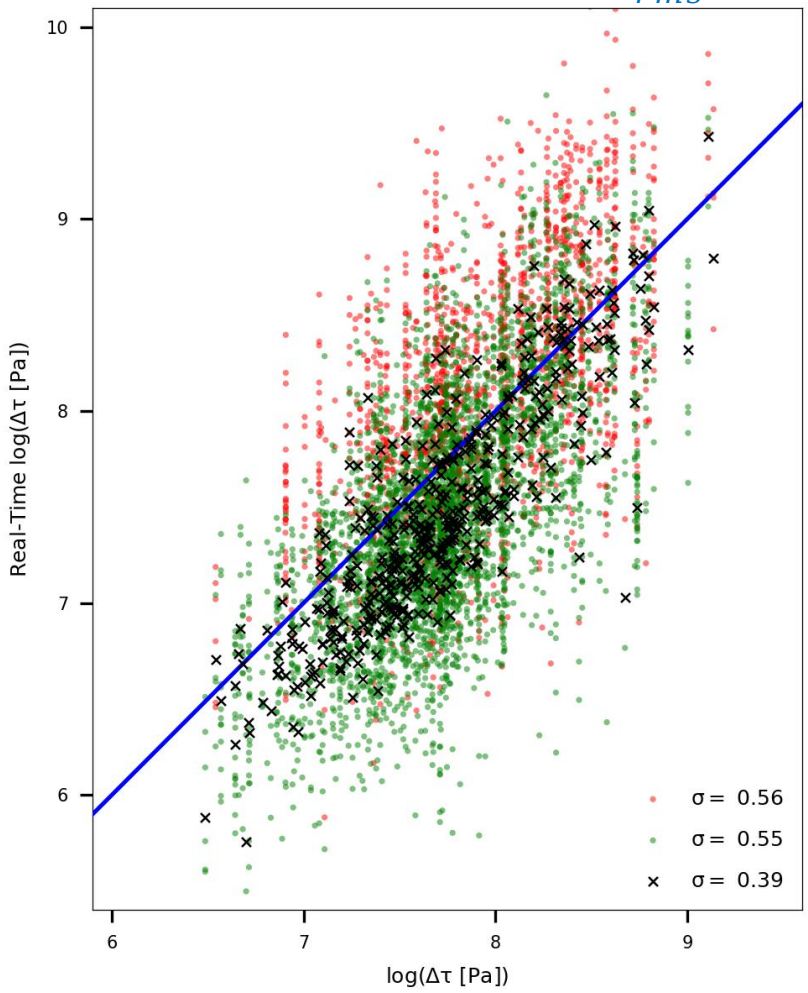
$M_W, \Delta\tau$

4 sec

$$M_0 = C_M R T^{0.5} \frac{D_{rms}^{1.5}}{V_{rms}^{0.5}}$$



$$\Delta\tau = C_{\Delta\tau} R T^{0.5} \frac{A_{rms}^3}{V_{rms}^2}$$

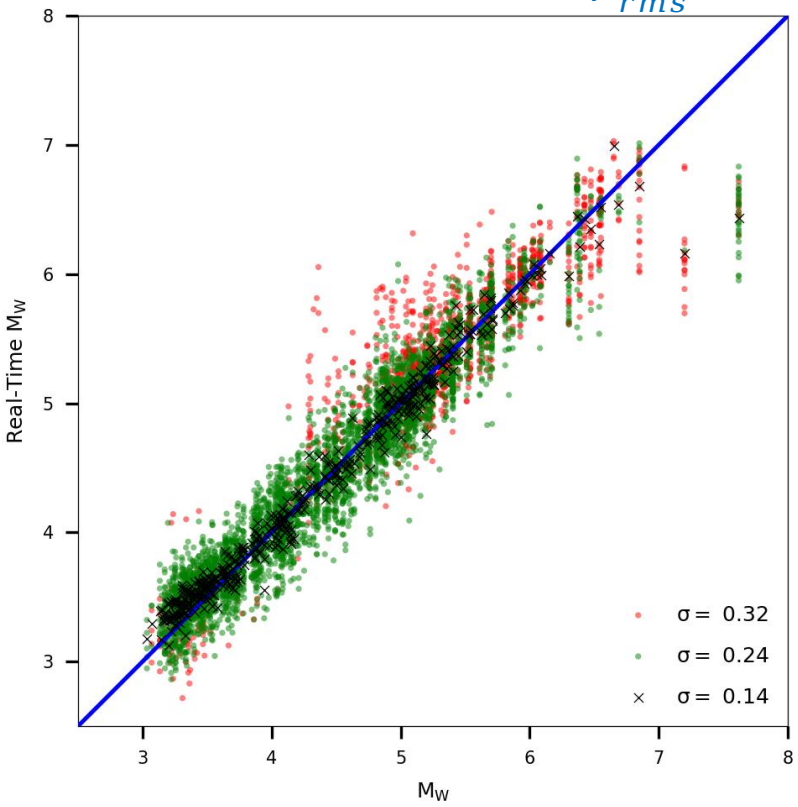


Earthquake Early Warning

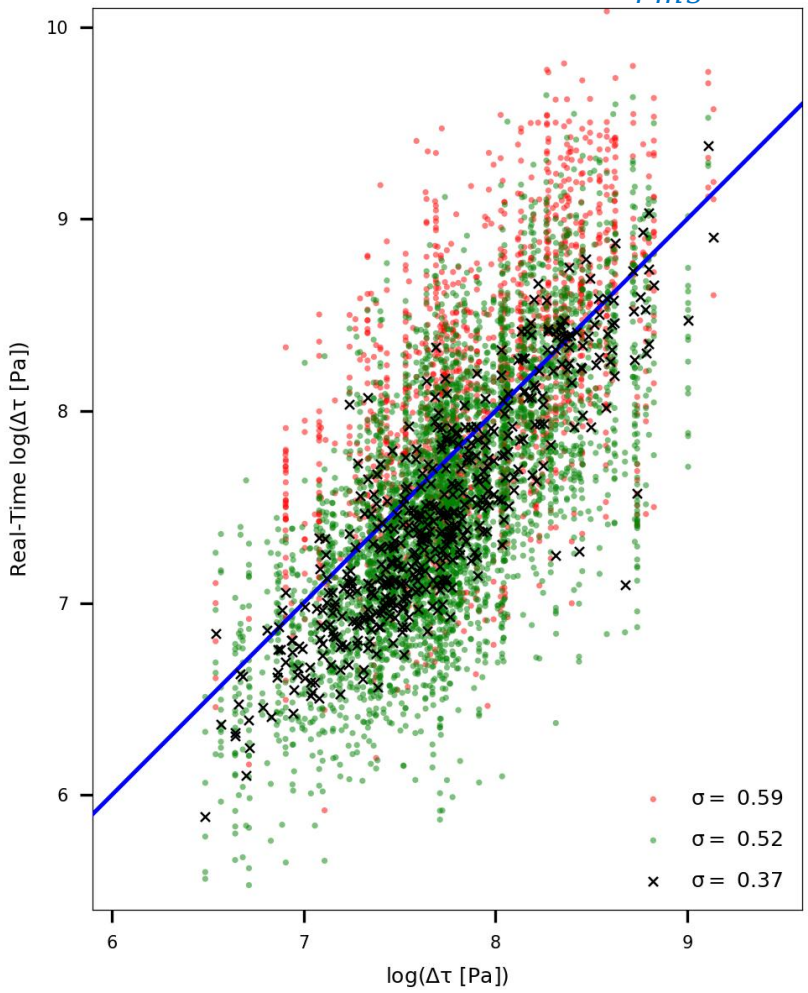
$M_W, \Delta\tau$

6 sec

$$M_0 = C_M R T^{0.5} \frac{D_{rms}^{1.5}}{V_{rms}^{0.5}}$$

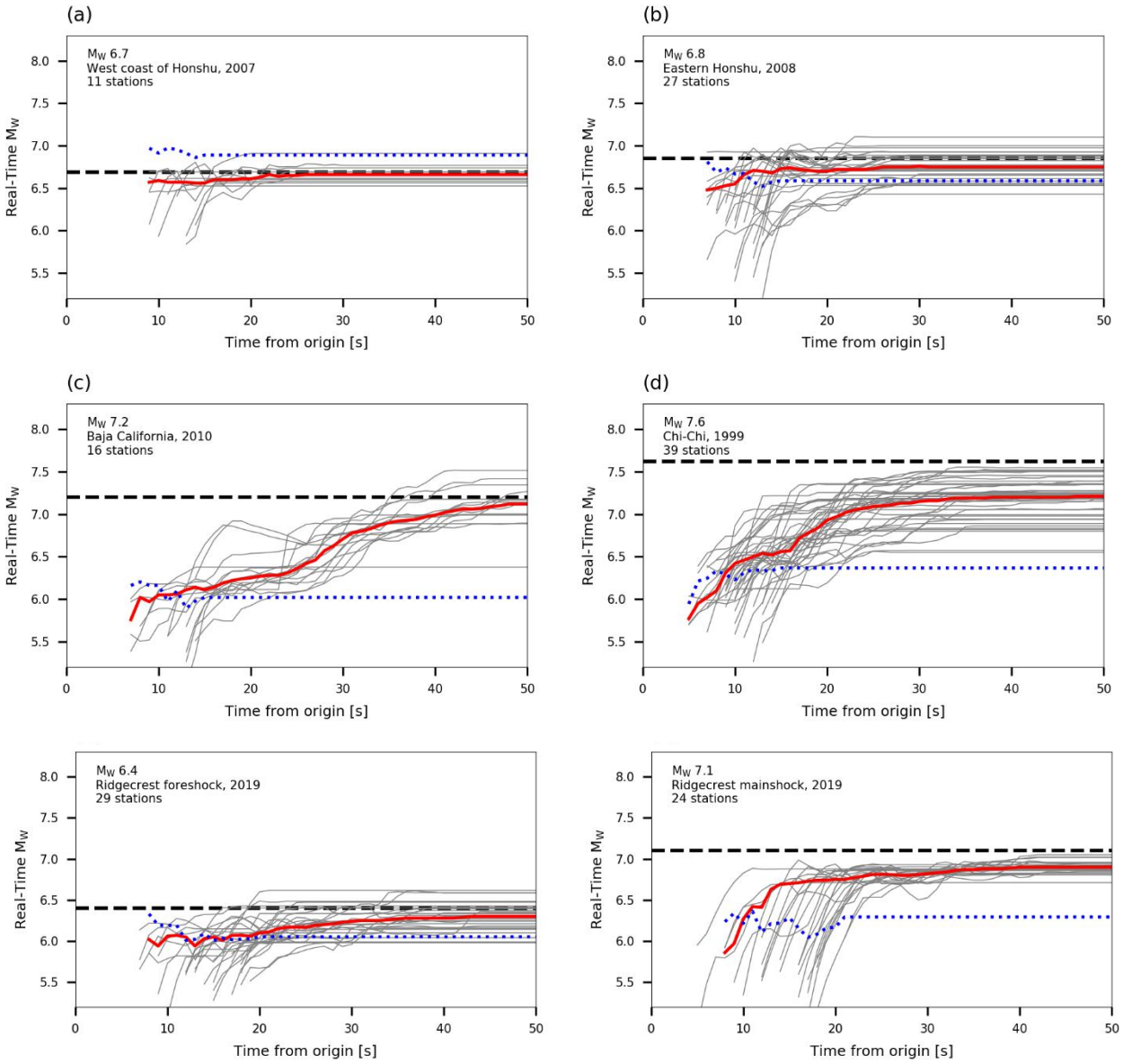


$$\Delta\tau = C_{\Delta\tau} R T^{0.5} \frac{A_{rms}^3}{V_{rms}^2}$$



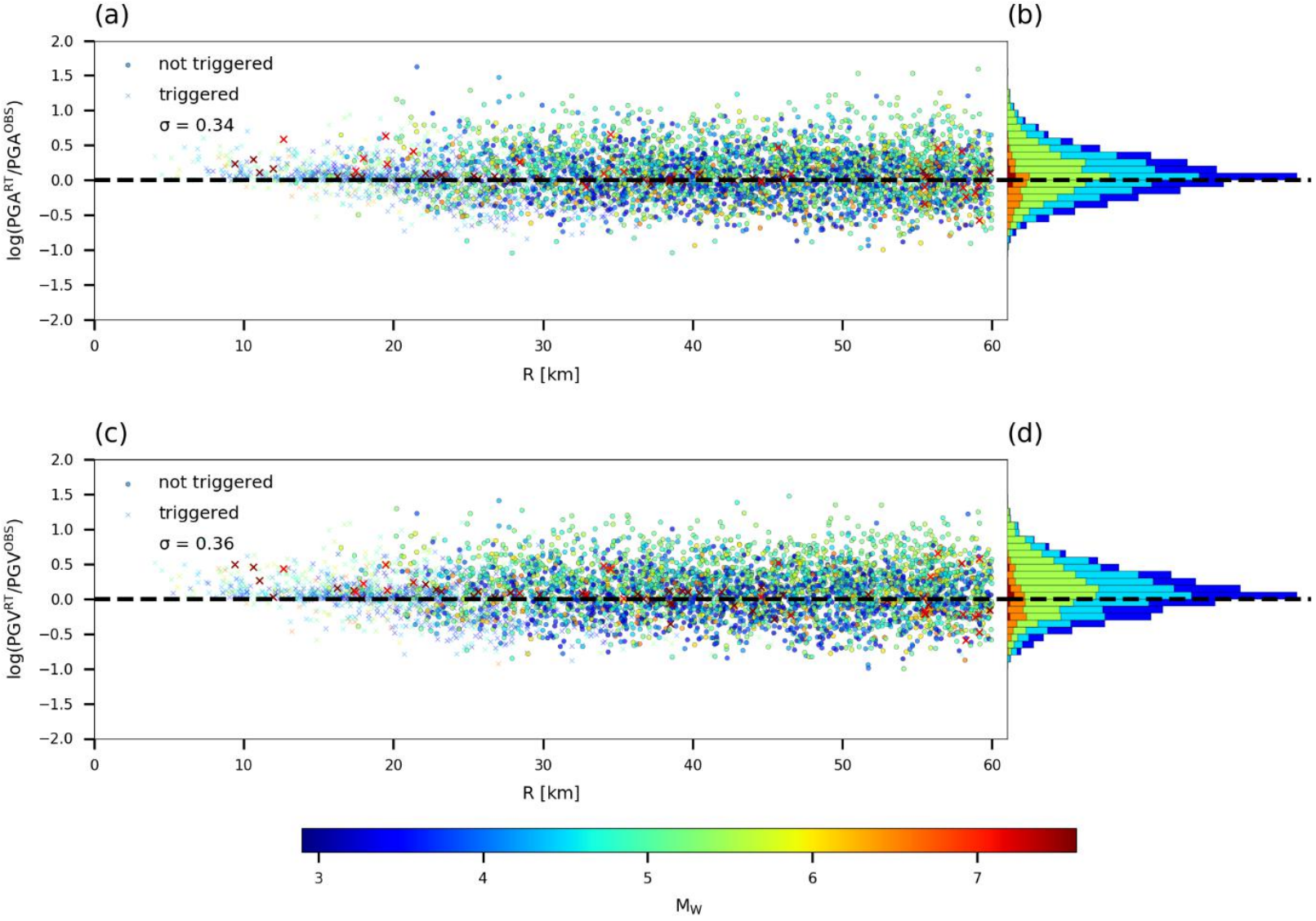
Earthquake Early Warning

$M_W, \Delta\tau$



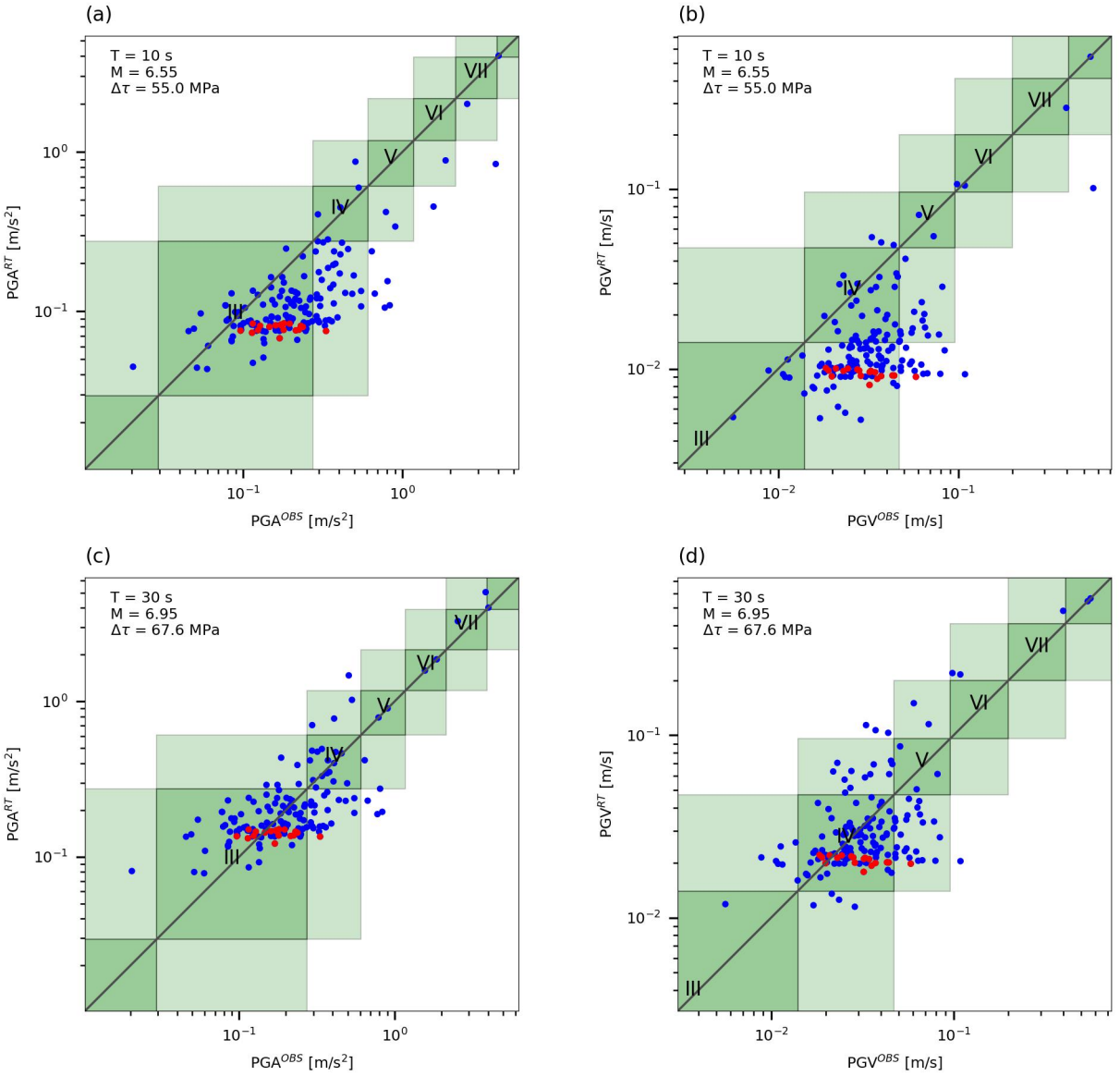
Ridgecrest earthquakes

Earthquake Early Warning GMPE



Earthquake Early Warning GMPE

Real-time ground motion prediction and mercalli intensity for the 7.1 Ridgecrest earthquake



Summary

- Theoretical equations
  - No new physics (based on the omega-squared model and attenuation)
- Theoretical GMPEs
  - Geographically independent
  - Account for the stress drop
- Early Warning
  - Accurate real-time magnitude and stress drop
  - Quality control on source parameter estimates
  - Self consistent source parameters and GMPE