Evaluating the Compatibility of Dynamic-Rupture-Based Synthetic Ground Motion with GMPE

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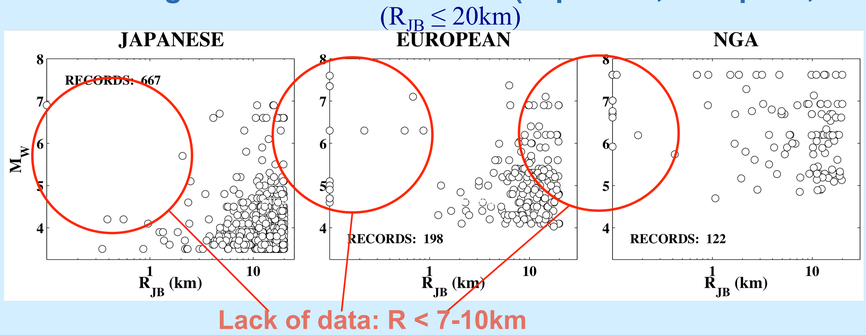
Summary: We performed an assessment of a data-base of synthetic ground motion generated by a suite of dynamic rupture simulations to verify compatibility of the peak ground amplitudes with respect to empirical Ground Motion Prediction Equations (GMPE). The dynamic rupture model data-base, developed by Dalguer and Mai (2011), is composed by 360 earthquake scenarios with moment magnitudes in the range of 5.5-7, for three mechanisms of faulting (reverse, normal and strike-slip), for both buried faults and surface rupturing faults, depth and non-depth dependent normal stresses. Initial shear stress distribution follows von Karman stochastic distribution. Overall, we show quantitatively that the upper frequency limit of the suite of simulations is 1.0Hz. Up to this frequency the synthetic data are compatible with the empirical model, which means that the residuals, which are defined as the differences between observed and predicted ground motions, do fall in the range of ±σ of the empirical GMPE. Characteristics of the mean values along distance (10 to 45km) and period T≥1.0 s, including standard deviation of the synthetic response spectra and peak ground velocity (PGV) are comparable to their counterpart empirical GMPE. At very near-source (<10km), where GMPE are based solely on recorded data that are sparse, synthetics show supersaturation of the mean peak values, which is different to the saturation features predicted by the GMPEs. Effect of source parameters, such as stress drop, peak slip velocity and rupture speed, and effects of surface and buried rupture as well as hanging wall and footwall are considerably sensitive to ground motion, suggesting that these effects contribute to the variability of ground motion near the source, and inclusion of them in the source terms may contribute to reduce uncertainties in GMPEs. This study opens new roads oriented to develop hybrid physics-based GMPEs, i.e. merging features observed in physics-based models into empirical GMPEs, particularly in the very-near field

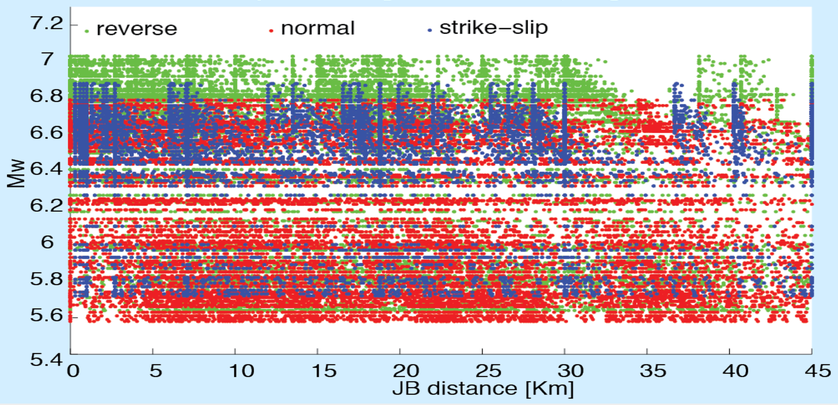
Near-Source ground motion database (Japanese, European, NGA)

($R_{JB} \leq 20$km)

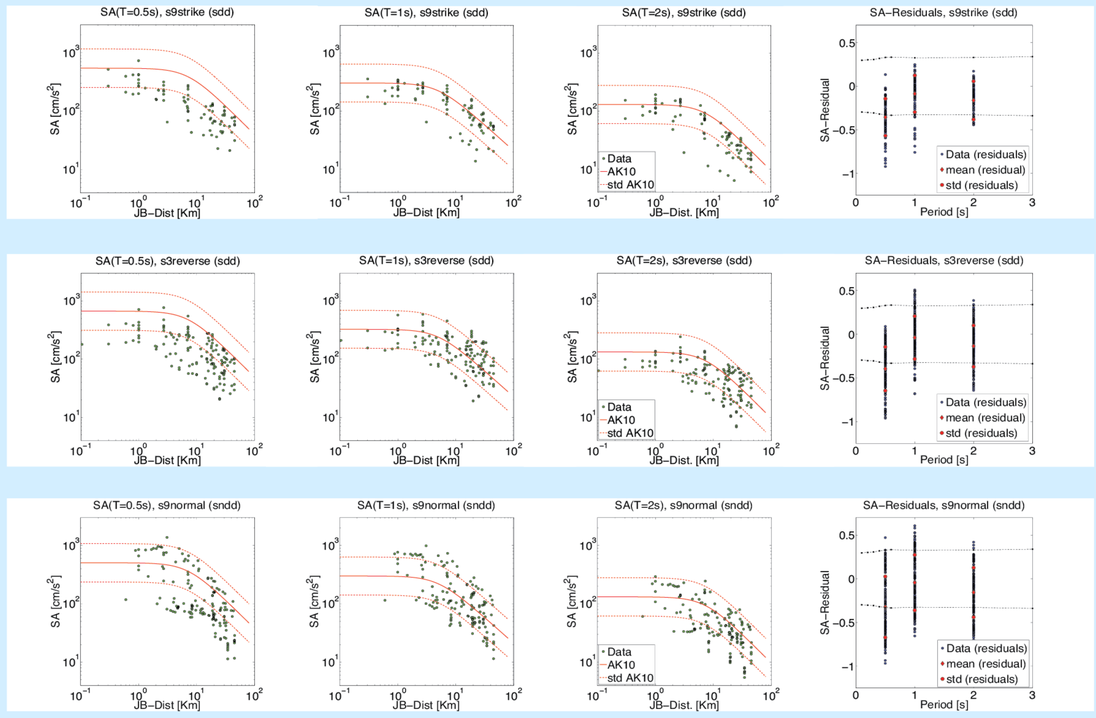


Lack of data: R < 7-10km
Need to fill this lack of data!!

A data base of 360 dynamic rupture models (Dalguer and Mai, 2011)



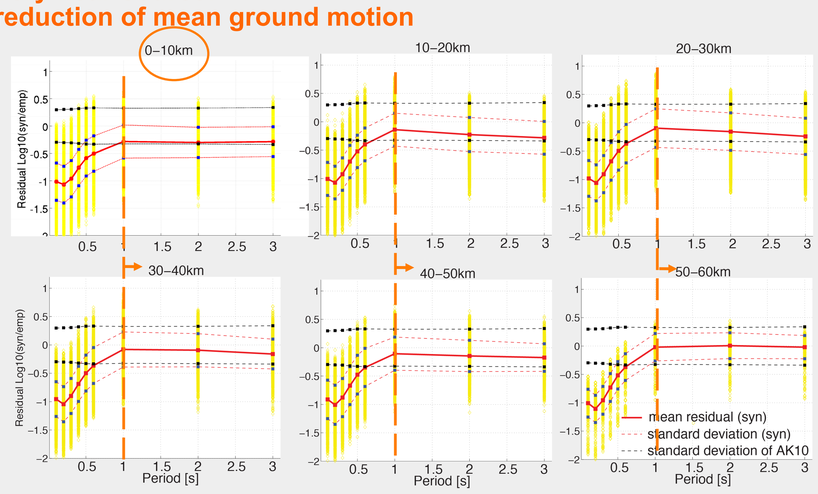
Spectral Acceleration (SA) of some selected models



Residual estimation of peak ground amplitudes with respect to GMPE of Akkar and Bommer (2010)

SA residuals of the 360 models

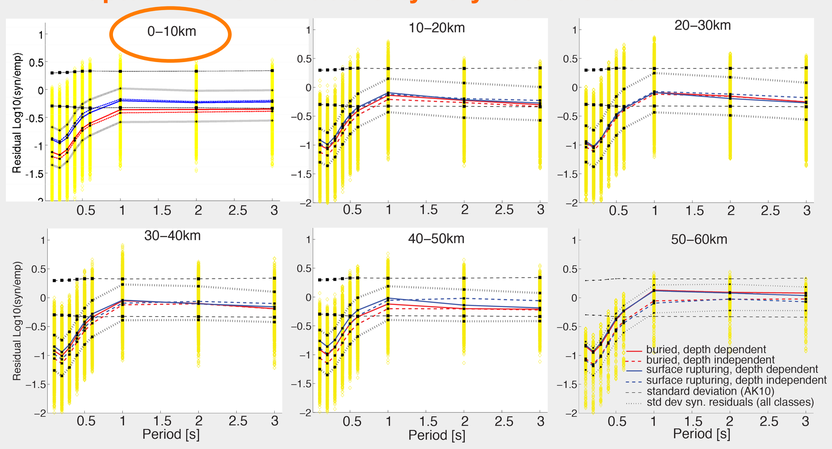
Very near-source: reduction of mean ground motion



At period >= 1s, synthetic data are compatible with GMPE

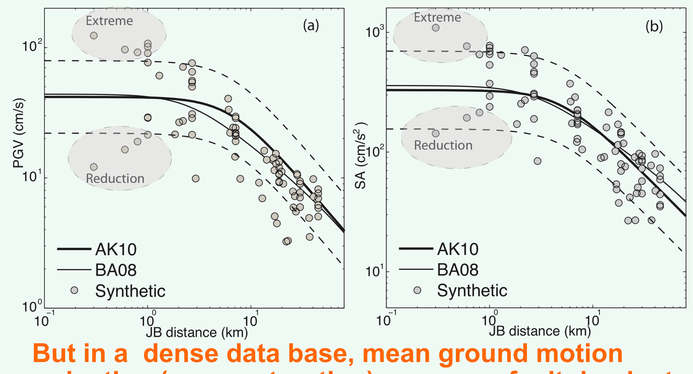
Buried and surface-rupturing earthquakes

Ground motion differences between buried and surface rupture are remarkable only very near the fault!



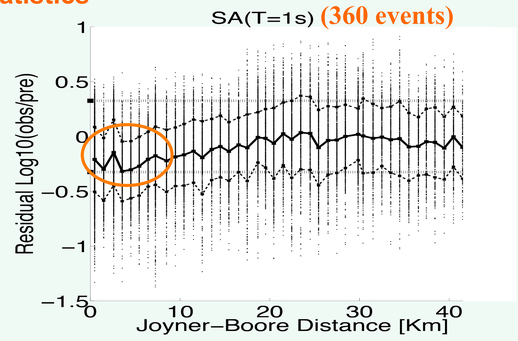
Ground Motion very Near-fault

Very near the fault: Extreme and Reduction of ground motion is observed in some events

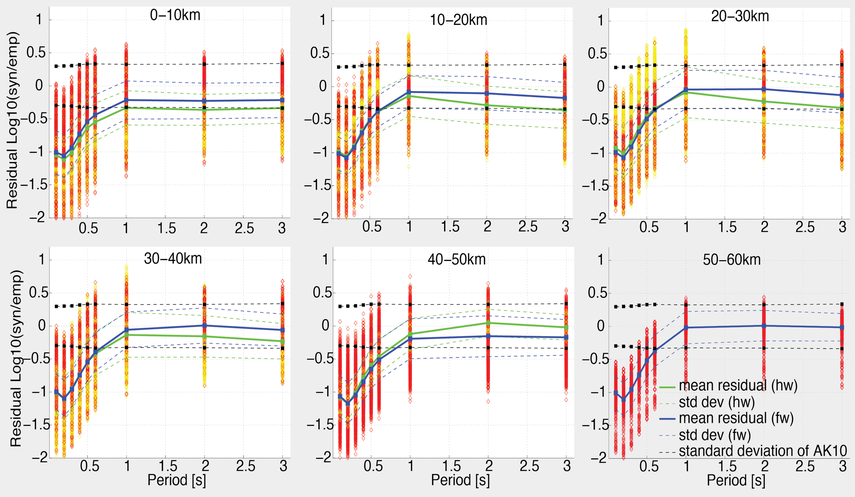


But in a dense data base, mean ground motion reduction (supersaturation) very near-fault dominates the statistics

SA(T=1s) **(360 events)**

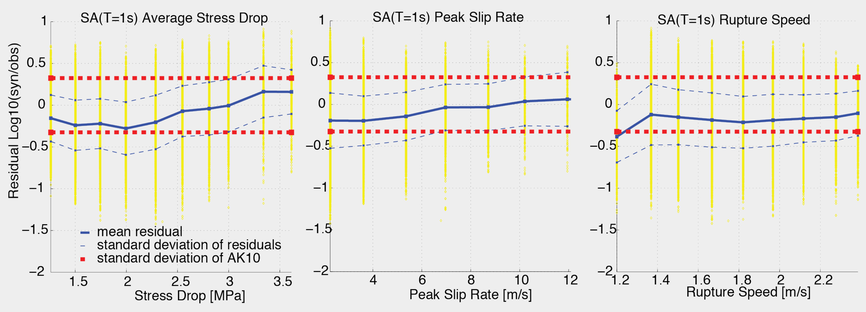


Hanging wall (hw) and footwall (fw)



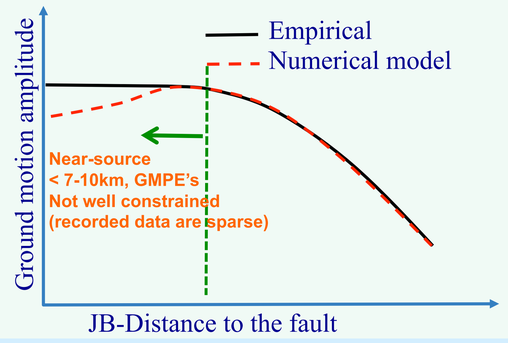
Ground motion in hw and fw are different at all distances

Considering source parameters: (stress drop, peak slip rate and rupture speed)



Ground motion increases with these source parameters!!

Synthetic GMPE vs empirical GMPE's



Conclusions

1) The synthetic ground motion are in statistical sense comparable to the empirical GMPE at frequency lower or equal than 1.0Hz and at distance >10km.

2) Standard deviation of the synthetics is comparable to its counterpart empirical GMPE . It suggests that the synthetic data contain similar effects as the empirical data that contribute variability to ground motions.

3) Stress drop, peak slip velocity, rupture speed, effect of surface-rupture, buried rupture, hanging-wall and foot-wall appear to be sensitive to the peak ground motions. It suggest that the introduction of these source parameters in the source term may contribute to reduce the standard deviation of the GMPE

4) While extreme events very near-source (<10km) are exceptionally observed in some of our numerical models, in a dense amount of data near the source, the mean peak values are dominated by the reduction of peak values (oversaturation) which is contrary to the consistent saturation of ground motion predicted by the empirical GMPE. Some observed data suggest supersaturation (Akkar and Bommer, 2007).

5) This study opens new roads oriented to develop hybrid physics-based GMPEs, i.e. merging features observed in physics-based models into empirical GMPEs, particularly in the very-near fiel**d.**

This work has been submitted to BSSA (Baumann and Dalguer, 2013, BSSA, in review)