Source effects in the simulation of the strong ground motion of the 2011 Lorca earthquake

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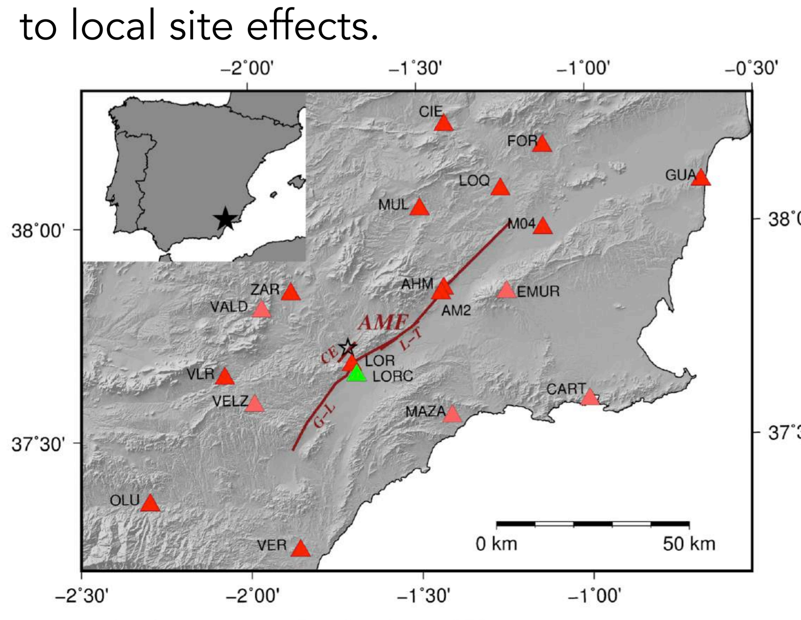
WHY this study ?

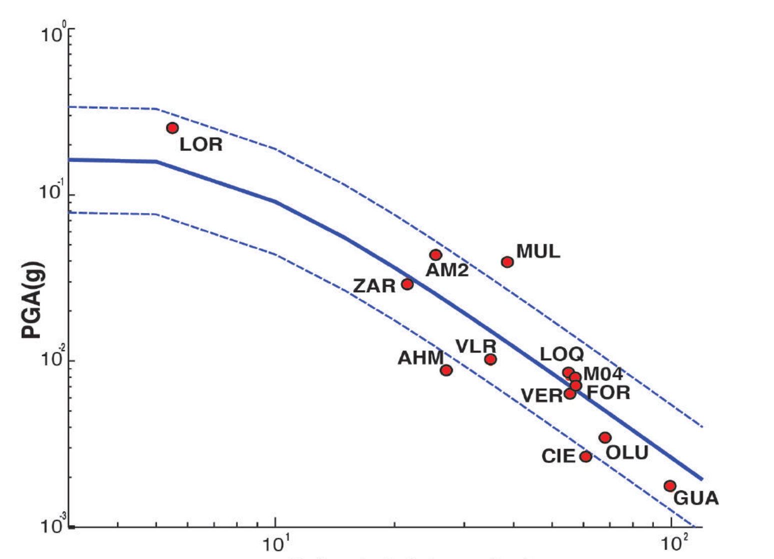
We investigate the effects of different source models in the computation of strong motion for a moderate earthquake. The M_w=5.2 2011 Lorca earthquake, widely studied because of the relevant damage produced, is our study case.

The Mw=5.2 2011 Lorca earthquake

The May 11, 2011 Lorca earthquake (Mw=5.2, South-East Spain) caused nine fatalities and more than 300 people were injured. The city suffered relevant damage reaching VII EMS Intensity. The PGA value recorded at the accelerometric station located in Lorca (LOR), the largest ever recorded in Spain, was explained as due to the source directivity, rather than to local site effects.



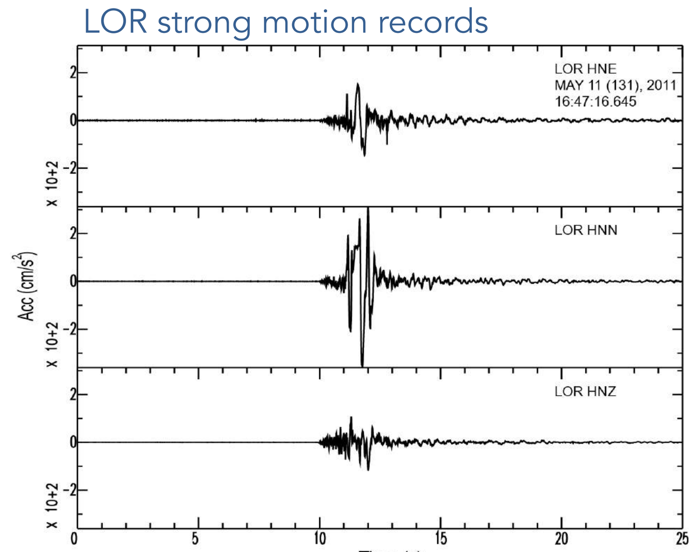
AMF = Alhama de Murcia fault, G-L=Goñar-Lorca segment, L-T=Lorca-Totana segment, CE =Cejo de los Enamorados)



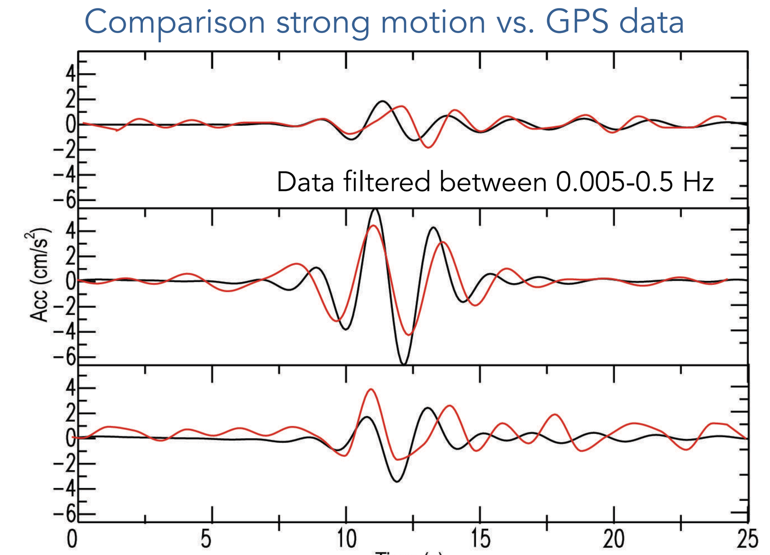
Recorded PGA vs GMPE (Akkar et al., 2014) for a reverse fault and Vs_{30}=750 m/s

The near-field station LOR recorded a PGA=0.39 g. However, the recorded PGA values are comparable with the values predicted by the GMPE of Akkar et al. (2013). Path and site effects have been observed for ZAR, AM2 and MUL (Santoyo, 2013, Cabanas et al. 2013).

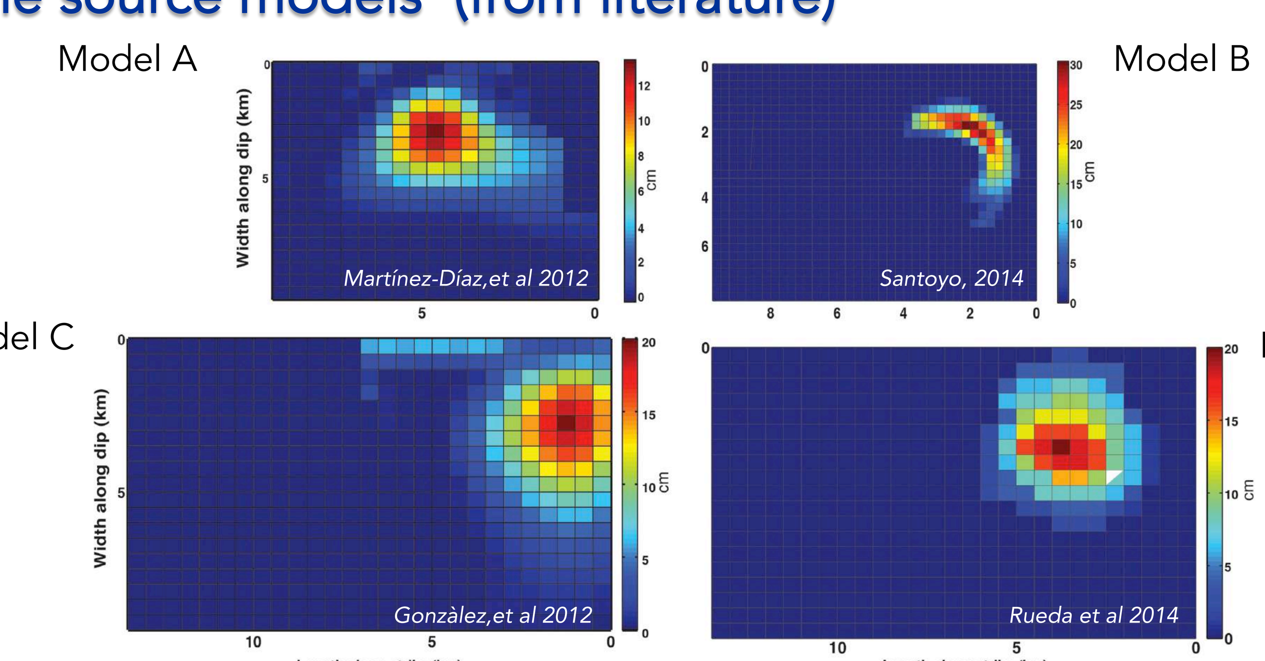
LOR strong motion records



Comparison strong motion vs. GPS data



Some source models (from literature)



Starting from the above source models, published in the literature, we modeled 4 source cases. The main differences of the source models can be ascribed to the different data used for the inversion, to the chosen inversion technique as well as to the model parameterization.

WHAT we did

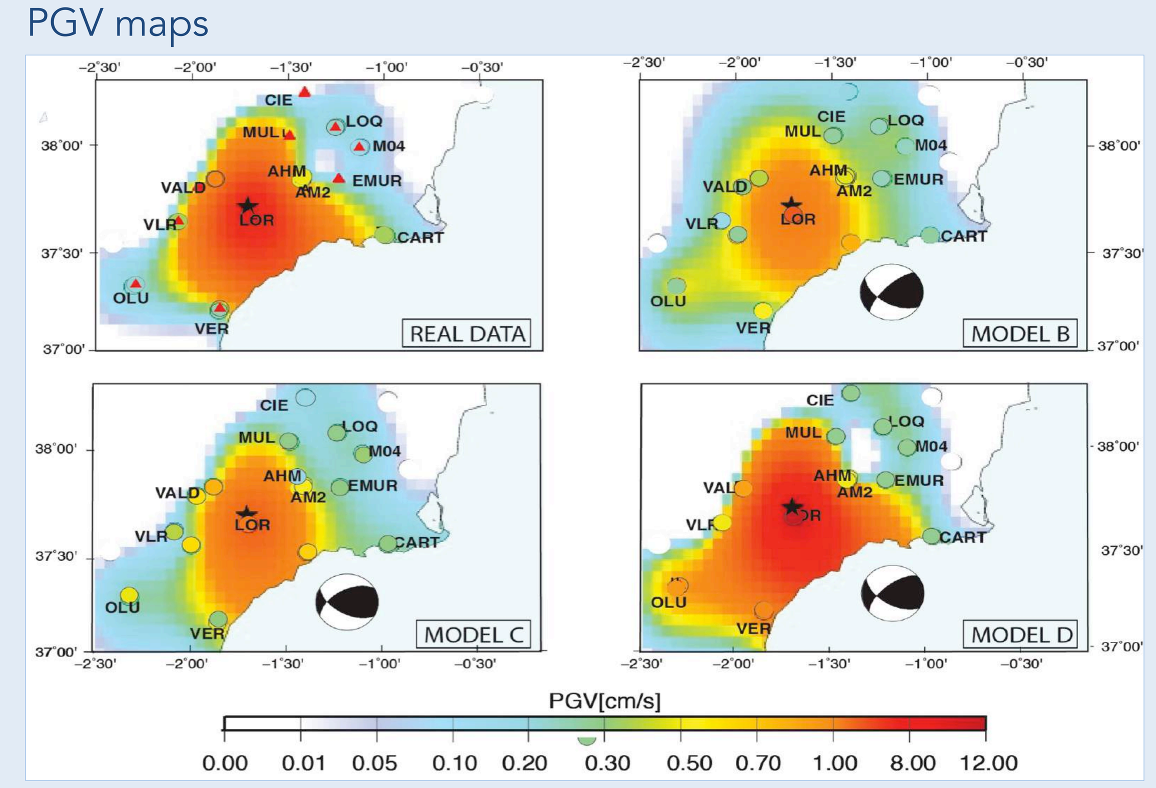
Strong motion modelling

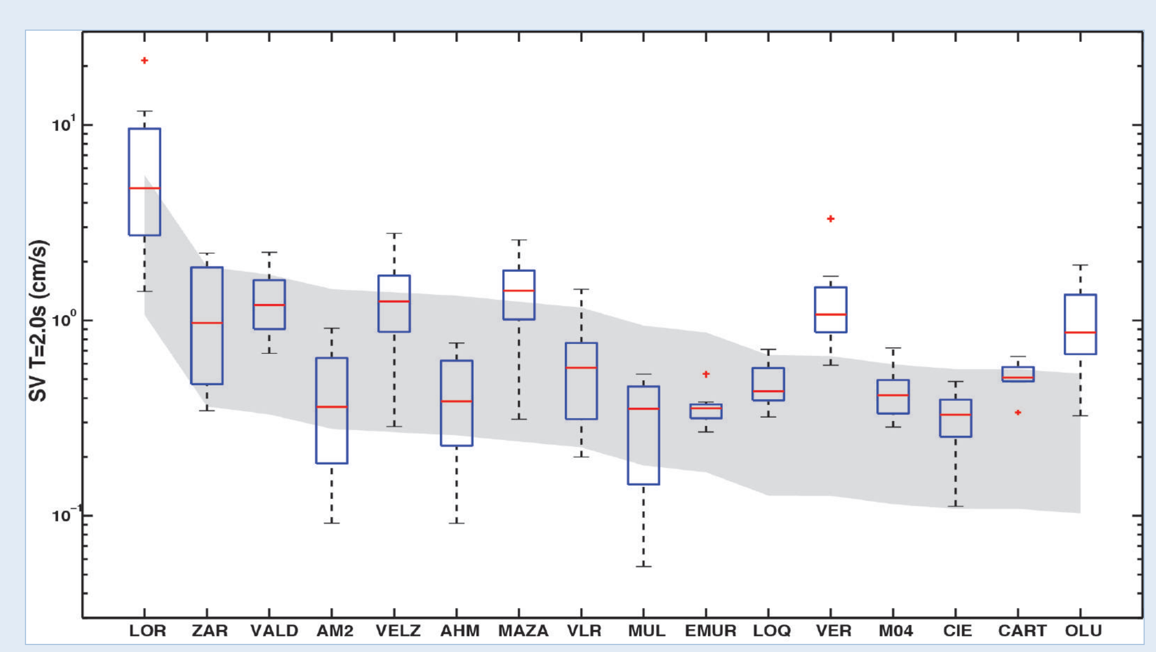
We computed synthetic seismograms up to 1 Hz applying the COMPSYN software (Spudich and Xu, 2003). The sources were modelled as finite fault with the pseudo-dynamic approach (Guattieri et al., 2004) to emulate the main features of the fault rupture. The 1D velocity model is taken from Corchete and Chourak (2011). Time series were computed only for the six stations with epicentral distance less than 50 km.

Source parameters used in this study

Source model	M_w	Location Lat, Long	Z km	Fault T	L	W	Rupture direction	Strike	Dip	Rake	References
MODEL A	5.2	37.727° 1.686°	4.5	1.5	4.0	3.0	70%->SW	235°	55°	39°	Martínez-Díaz et al. (2012)
MODEL B	5.2	37.727° 1.686°	4.5	—	4.0	4.0	75%->SW	240°	55°	45°	Santoyo (2014)
MODEL C	5.1	37.727° 1.686°	4.0	0.5	8.0	5.0	SW	225°	70°	36°	González et al. (2012)
MODEL D	5.2	37.718° 1.677°	4.0	1.0	3.7	3.8	SW	230°	64°	37°	Rueda et al. (2014)

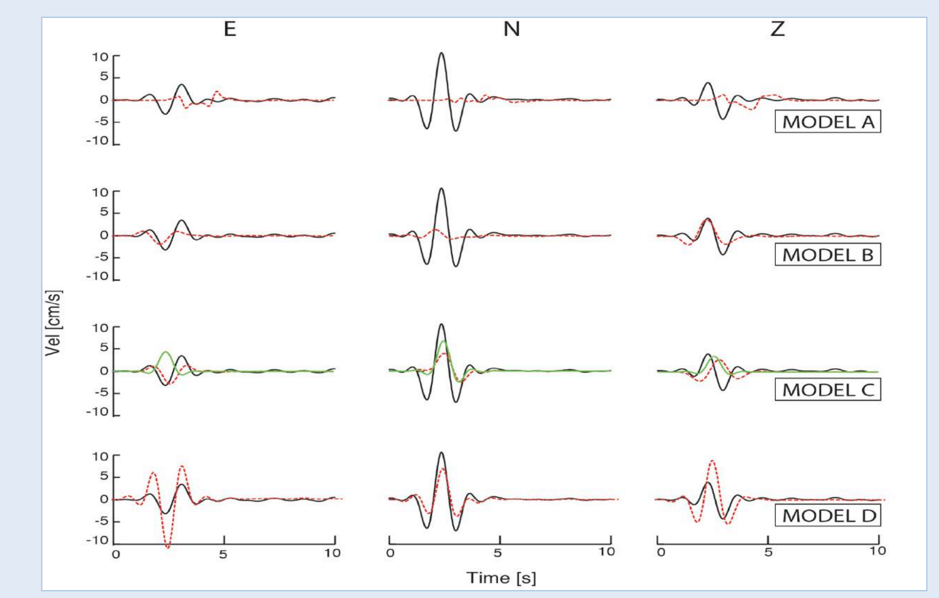
PGV maps

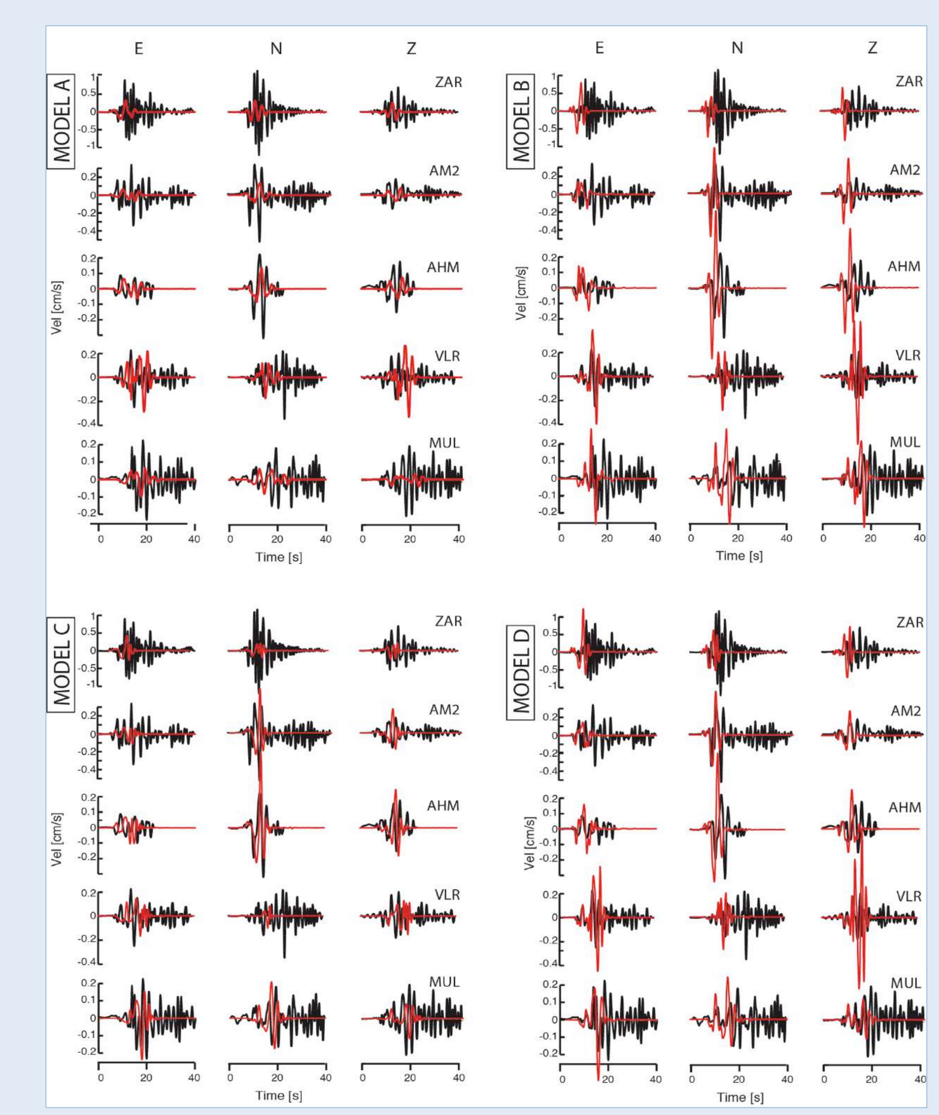




Boxplot of the PSV (2.0 s) for all the source model simulations at each receiver. The shadow area is the GMPE $\pm\sigma$ by Akkar et al. (2014).

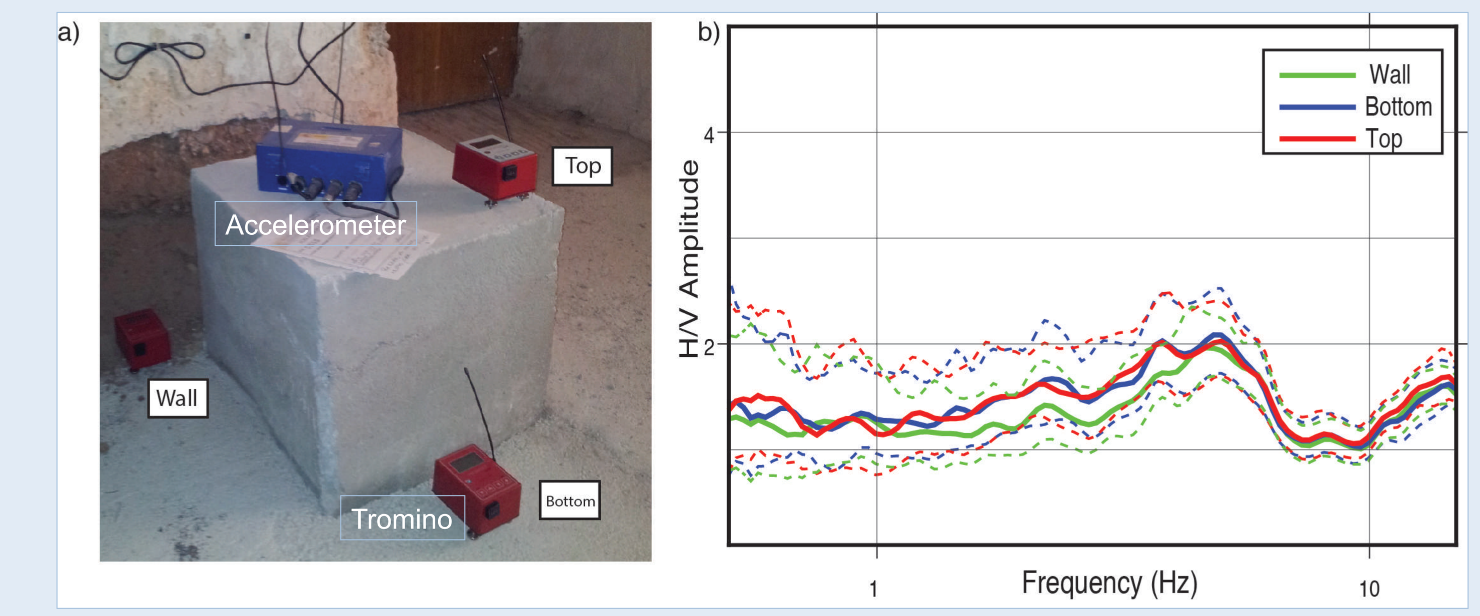
LOR data (black) vs. computed waveforms





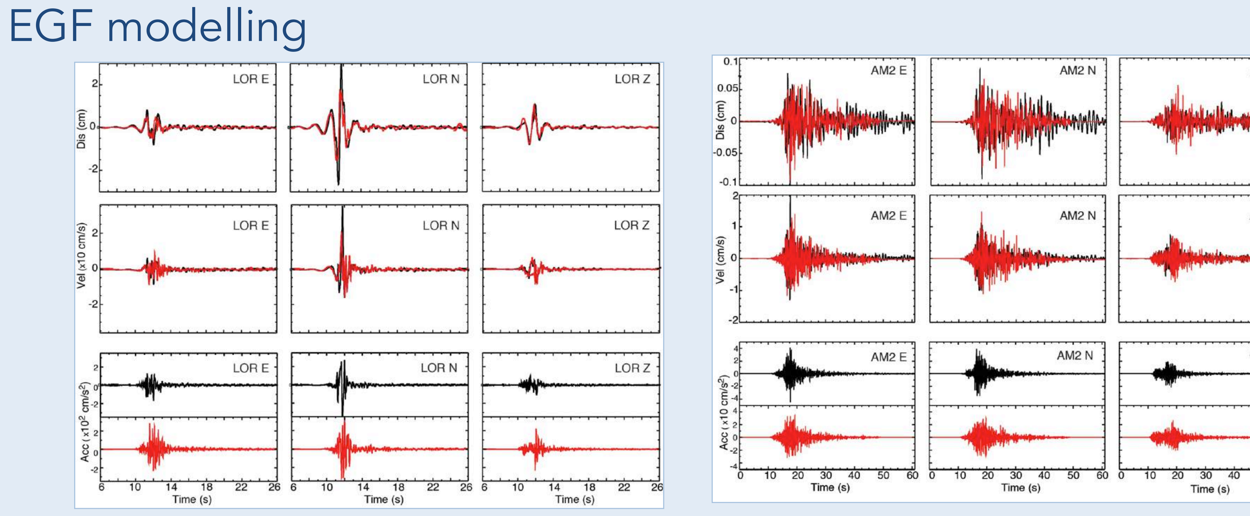
Comparison between the recorded seismograms (black lines) and the computed ones (red lines) for the different source models.

Pillar effects in the LOR records?



The LOR accelerometer (blue box) was placed on a pillar close to a thick wall. Three Tromino® seismic sensors (red boxes) were used simultaneously for 1 hour noise measurements to evaluate possible effects due to the site, the pillar and the building. The horizontal average H/V ratios from the noise temporal signals, shows no significant amplification effects for frequencies lower than 15 Hz.

EGF modelling



Comparison between the recorded seismograms (black) and the computed EGF (red) for model D but assuming a bilateral rupture, toward NE and ¾ toward SW.

Conclusions

Within our simulation approach:

- Different seismic moment distributions, linked to the various rupture models, generate a large variability in the computed motion. Especially in the forward directivity area (SW from Lorca).
- The PSV (2s) differences can span over one order of magnitude. However the 2s PSV interquartile ranges are well within the uncertainties of the GMPE estimates.
- Model D (a simple one slip patch model) fits better than the other models adopted in this study, the recorded LOR data, both for low (< 1Hz) and high frequencies.

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