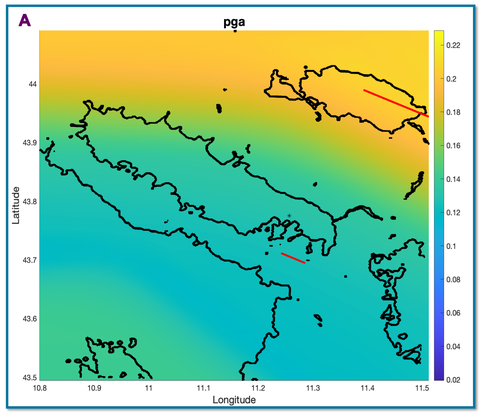
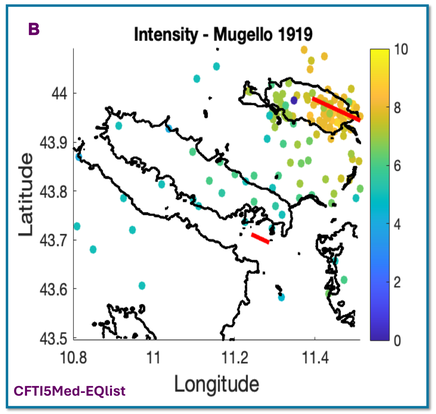
Seismic ground shaking by historical earthquakes in the Firenze metropolitan area

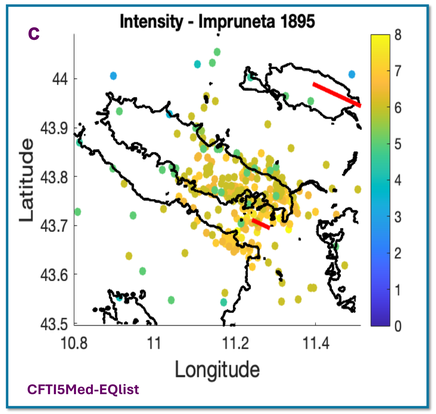
Najmeh Ayoqi and Emanuele Marchetti

University of Florence, Earth Science Department

INTRODUCTION: The seismic vulnerability assessment of a complex metropolitan area depends on the seismic source, wave propagation, and site amplification, as well as seismic response of single edifices. As a first step to evaluate the seismic vulnerability of Firenze, we computed the seismic ground motion on the rigid bedrock of the 1919, 6.3 Mw Mugello earthquake in Tuscany, Italy, through a stochastic finite-fault technique (EXSIM) in conjunction with the Python framework. The theoretical shake maps, evaluated at epicentral distances ranging between 10 and 100 km, is computed from 360 synthetic waveforms and corresponding Fourier acceleration spectrum, pseudo-spectral acceleration, peak ground acceleration, and peak ground velocity in the high-frequency range (f > 1 Hz). Synthetic waveform analysis is performed to investigate the model dependence on the various input parameters and corresponding confidence levels. Comparison between model results and shake maps obtained from historical damages was used to validate the analysis and discuss the relation between expected damages and the main seismogenic area around the city. This study is performed in the framework of the HGP project (CUP:B55F21007810001) funded within the Next Generation EU program.

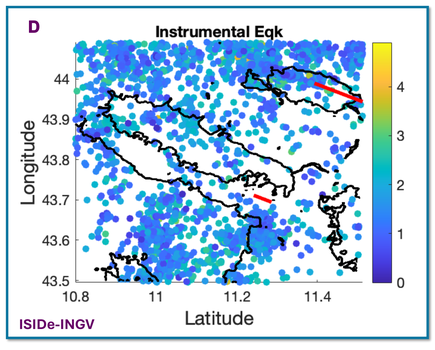


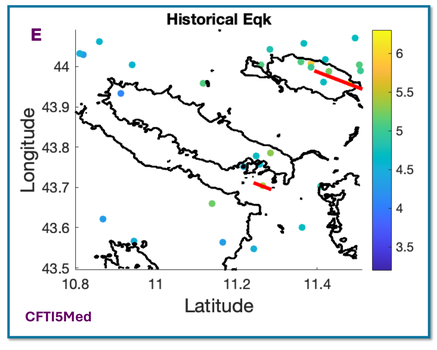


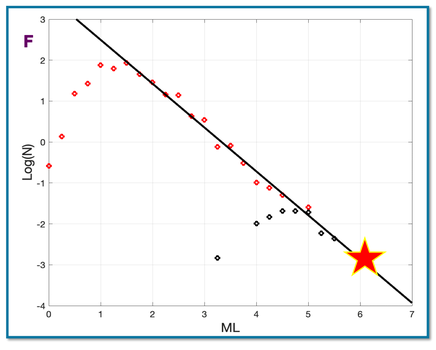


Motivation: Figure A shows the PGA for the vicinity of Firenze historical city in central Italy. The expected PGA with a return period of 475 years is 0.13.g.

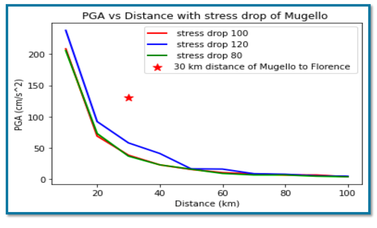
The area was affected by two historical earthquakes(red lines) Mugello1919 (Ml:6.3) and Impruneta-1895(Ml:5.4), which had a maximum intensity of 10 and 8 respectively in the vicinity of Firenze (Figure B, C). Instrumental (Figure D) and historical (Figure E) earthquakes are used to calculate the Gutenberg-Richter (Figure F) relation, which suggests an expected earthquake with magnitude 6 every 475 years. aim of this poster is to simulate the PGA in the Firenze region by those historical earthquakes using EXSIM.

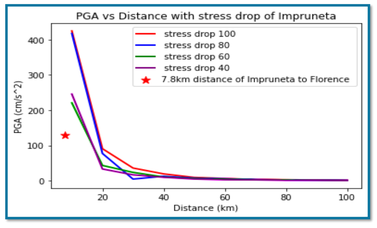


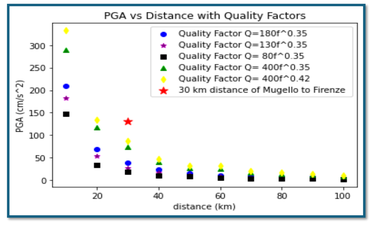


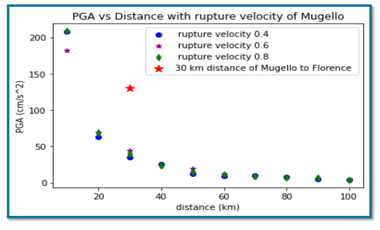


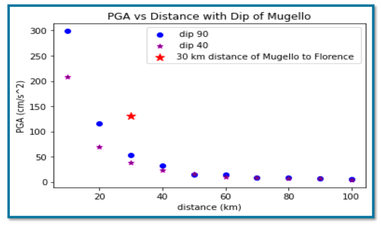
Sensitivity analysis of EXSIM results on model input parameters (quality factor, stress drop, fault dip, and rupture velocity), compared to expected PGA in Firenze (0.13g with red star). The model is strongly dependent on quality factors and stress drop. The PGA expected in Firenze is likely not produced by an earthquake similar to Mugello 1919 but by one similar to Impruneta 1985. This is consistent with the felt intensity of historical earthquakes.











EXSIM is an Open-Source Stochastic finite-source simulation algorithm for the evaluation of ground motion time series related to the rupture propagation on fault. (Atkinson, 2005)

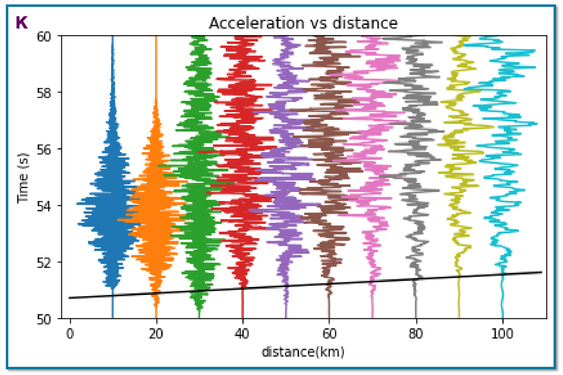
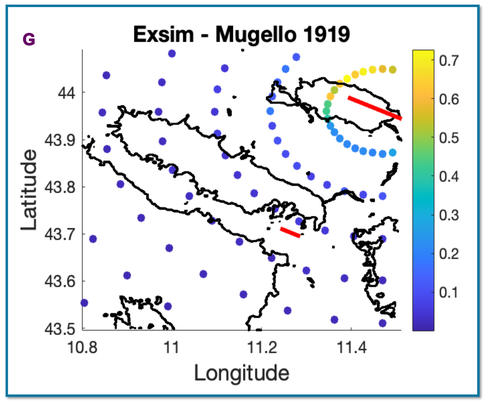
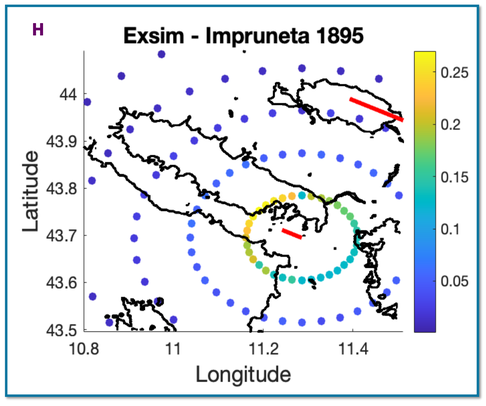


Table 1: input parameters of EXSIM

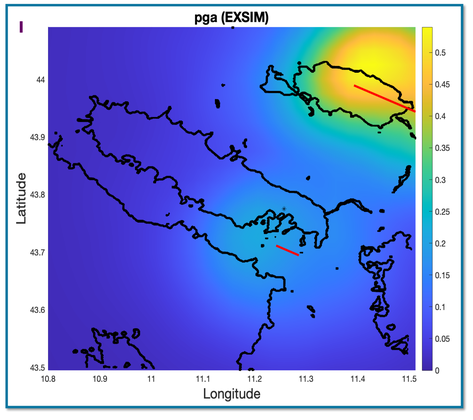
	parameter	Description	Value assumed	reference
Source	$\Delta\sigma$ (bar)	Stress Drop	100	Viti, M, 2012
	M_W	Moment Magnitude	6.3	
	Lat (km)	Fault Geometry	43.93	https://www.ingv.it
	Lon (km)		11.54	
	L (km)		14	
	W (km)		9.8 (km)	
	Dip (deg)		40	
	Strike (deg)		298	
	Depth(km)		0.6 - 6.9	
	Fault type		N	
Path	$Q(f)= Q_0 f^{\alpha}$	The quality factor for crustal attenuation in central ITALY	? $130 \times f^{0.35}$	Malagnini 2000
		Q_0 in EXSIM is Qr2	?	Boore, 2003
		Exponent	?	
	dt	Time spacing	0.002 s	
Site	κ	Kappa	0.02	Morasca, P 2004





The Mugello and Impruneta's ground motion has been evaluated at epicentral distances ranging from 10 to 100 km Figure K using EXSIM to compute 360 synthetic waveforms in the high-frequency band (Figure G, H).

Superposition of model PGA for the Mugello 1919 (stress drop:100 bar) and Impruneta 1895 (stress drop:60 bar) for the area of Firenze Figure I.



CONCLUSION

1. EXSIM requires precise input parameters for accurate modeling results.
2. EXSIM performs successfully the modeling of the amplitude, frequency, and signal duration with the epicentral distance.
3. EXSIM Fails to model propagation time with the distance and the polarity of the first pulse.
4. The PGA expected in Firenze is likely not produced by an earthquake similar to Mugello 1919 but by one similar to Impruneta 1985.

Next step :

1) Perform spectral analysis of modeled waveform.
2) Include the site effects.
3) Use other open-source programs like openSWPC or SPECFEM3D for waveform modeling.