Supplementary Materials for

Recent seismic sequences and activation of normal fault systems in the Mugello Basin and surrounding areas (Northern Apennines, Italy).

Gilberto Saccorotti[1], Rebecca Bruni[1,2], Marco Bonini[3], Giacomo Corti[3], Derek Keir[4,5] and Federico Sani[5]

[1] Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa. Via Cesare Battisti 53, 56125 Pisa, Italy

[2] Università di Pisa, Dipartimento di Scienze della Terra Via S. Maria 53 - 56126 Pisa, Italy

[3] Consiglio Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse, Sede Secondaria di Firenze, Via G. La Pira 4, 50121 Firenze, Italy

[4] School of Ocean and Earth Science, University of Southampton, European Way, SO14 3ZH, Southampton, United Kingdom

[5] Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Via G. La Pira 4, 50121 Firenze

Supplementary Material

1 Time Evolution of the Seismic Sequences

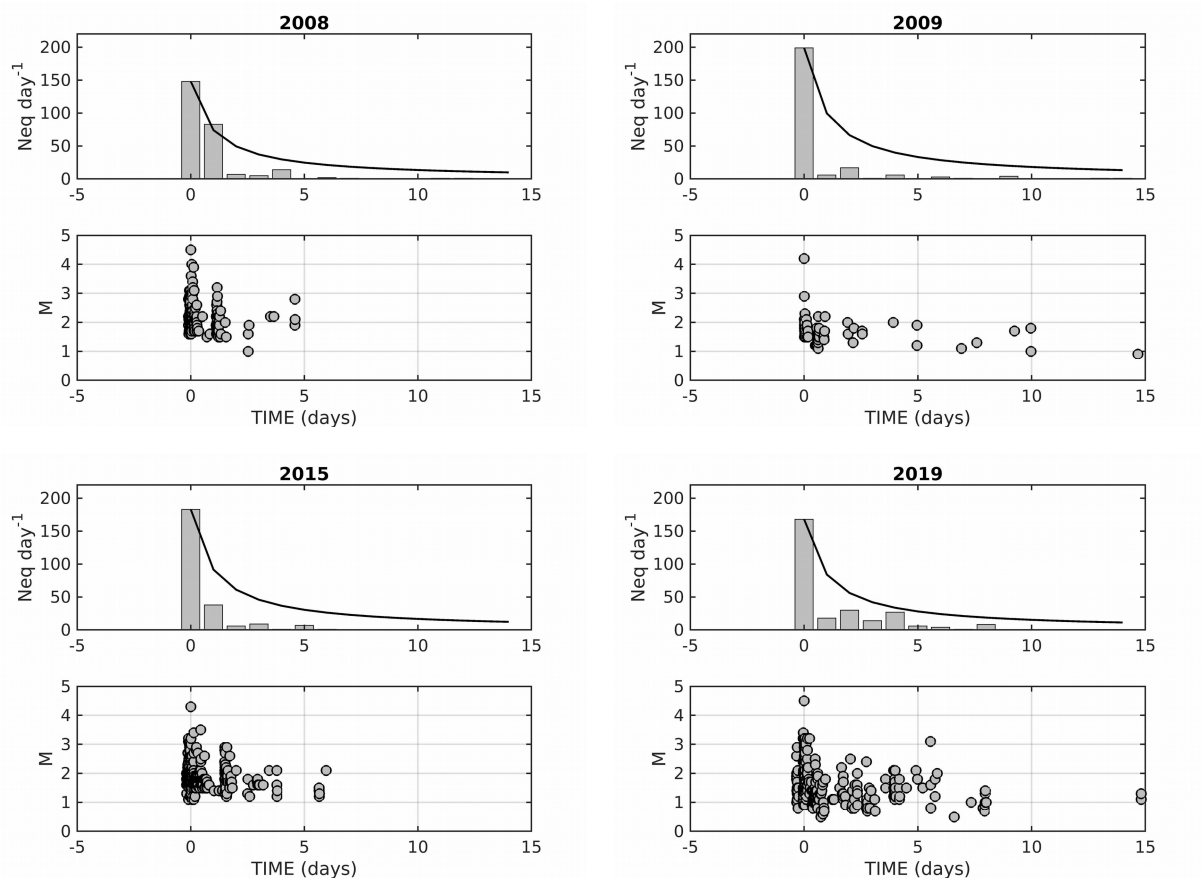
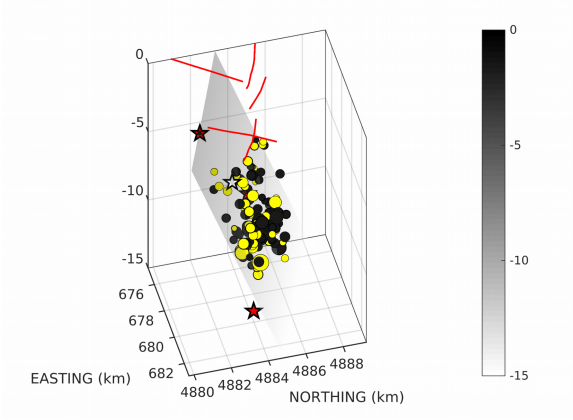


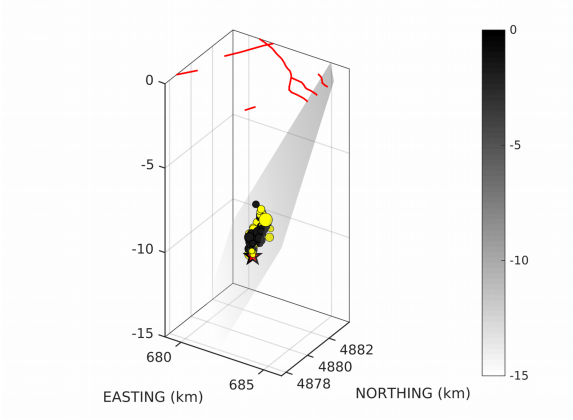
Figure S1 - Temporal evolution of the four seismic sequences analyzed in this study; time is taken relative to the origin time of the mainshock. In each panel, the top plot reports the daily earthquake rate (bars), and a simplified Omori-type relationship in the form $N(t)=k\ t^{-1}$ (black line). Data are from the integrated catalog obtained for this study. The bottom plots report the temporal evolution of magnitudes, taken from the INGV catalog available at http://http://cnt.rm.ingv.it/ (last accessed March 25, 2022).

2 Best Fit Planes and TDMT Solutions

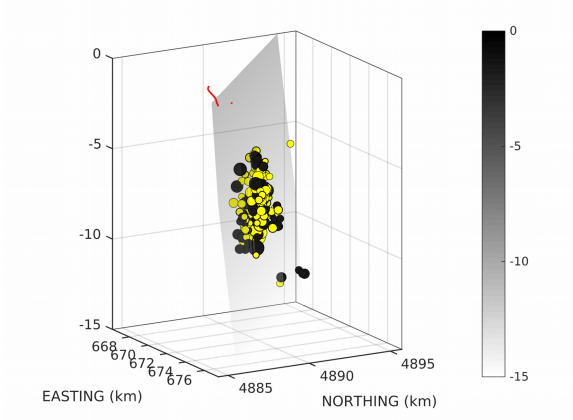
2008



2009



2015



2019

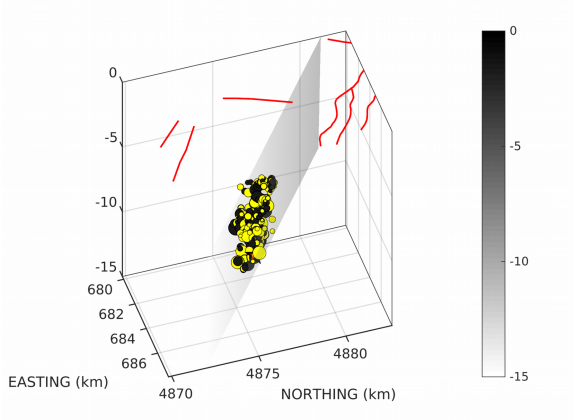


Figure S2 - Results of fitting a plane to hypocentral data from Double-Difference relocation of individual seismic sequences. The fit is conducted using an orthonormal regression via Principal Component Analysis.

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Table S1 - Comparison between fault planes derived from Moment Tensor inversion (TDMT) of the mainshocks and those obtained from Principal Component Analysis of hypocentral coordinates (PCA). Event ID refers to the identification reported in INGV's catalog (ISIDE Working Group, 2007)

	PCA		**TDMT**		**Mainshock ID**
Sequence	**Strike (°)**	**Dip (°)**	**Strike (°)**	**Dip (°)**	
2019	107	68	105 308	46 46	23558121
2015-2017	313	85	304 127	30 60	4875411
2009	141	68	303 122	45 45	2105009
2008	296	74	300 116	52 38	1801889

3 Static and Dynamic Stresses

Table S2. Seismic source parameters of the main earthquakes that hit the northern margin of the Mugello Basin in the period 2008–2019. Focal coordinates and fault parameters are those derived in this study from double-difference (DD) relocation and PCA analysis, respectively (see also Table S1). Coulomb stress changes (ΔCFF) imparted by a given source fault are calculated at the hypocentral depth of subsequent, potentially triggered earthquakes. The two events in gray have been relocated separately, after careful repicking of waveforms. For the 2008-03-01, 08:43 UTC earthquake, we considered a location included within the 95% confidence bounds of the original location, but more consistent with the rupture plane delineated by the hypocenters distribution (see Fig. 5a,b in the main text). Fault data marked with an asterisk are taken from the corresponding INGV-TDMT solution.

Earthquake					**Source fault**			**ΔCFF**
Date, time (UTC)	Magnitude (Mw)	Lat. N	Long. E	Depth (km)	strike	dip	rake	**(kPa)**
2008-03-01 07:43:13	4.5	44.083	11.266	12.7	296	74	-88*	
2008-03-01 08:43:46	4.0	44.079	11.238	5.3	101*	53*	-110*	
2008-03-01 10:43:06	3.9	44.089	11.226	7.4	118*	64*	-117*	
2009-09-14 20:04:31	4.2	44.049	11.282	10.1	141	68	-90*	4.8
2015-01-23 06:51:20	4.3	44.140	11.151	8.9	313	85	-93*	0.3
2019-12-09 03:37:03	4.5	44.008	11.320	9.2	107	68	-106*	1.0

Table S3 - Coulomb stress changes (ΔCFF) using earthquake focal mechanisms and locations from INGV TDMT catalog (Scognamiglio et al., 2006; http://terremoti.ingv.it/tdmt)

Earthquake						Source fault			ΔCFF(kPa)
ID	Date, time (UTC)	Magnitude (Mw)	Lat. N	Long. E	depth (km)	strike	dip	rake	
1801889	2008-03-01 07:43:13	4.5	44.063	11.253	12	300	52	-88	
1802089	2008-03-01 08:43:46	4.0	44.046	11.227	12	101	53	-110	
1802349	2008-03-01 10:43:06	3.9	44.054	11.203	9	118	64	-117	
2105009	2009-09-14 22:04:31	4.2	44.025	11.275	6	122	45	-90	1.7
4875411	2015-01-23 06:51:20	4.3	44.128	11.121	6	304	30	-93	0.1
23558121	2019-12-09 03:37:03	4.5	44.005	11.319	6	105	46	-106	2.9

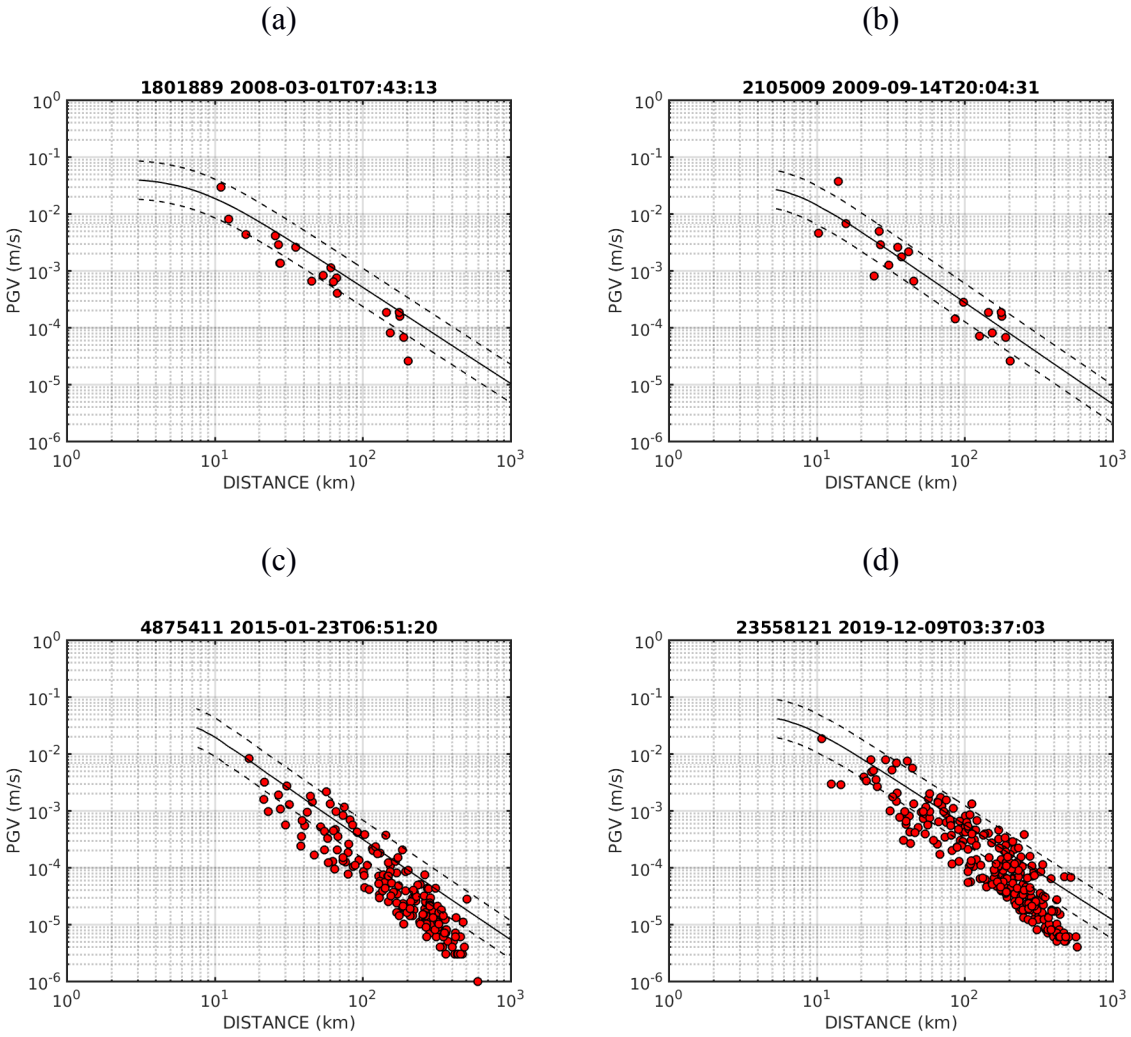

Figure S3 - Peak ground velocity (PGV) observations (red dots) for the mainshocks of the four analyzed seismic sequences. The black lines indicate the prediction equation by Bindi et al. (2011), with corresponding uncertainties (dashed lines). Data are taken from the ShakeMap archive, available at http://shakemap.ingv.it/shake4/ (last accessed January, 2022).

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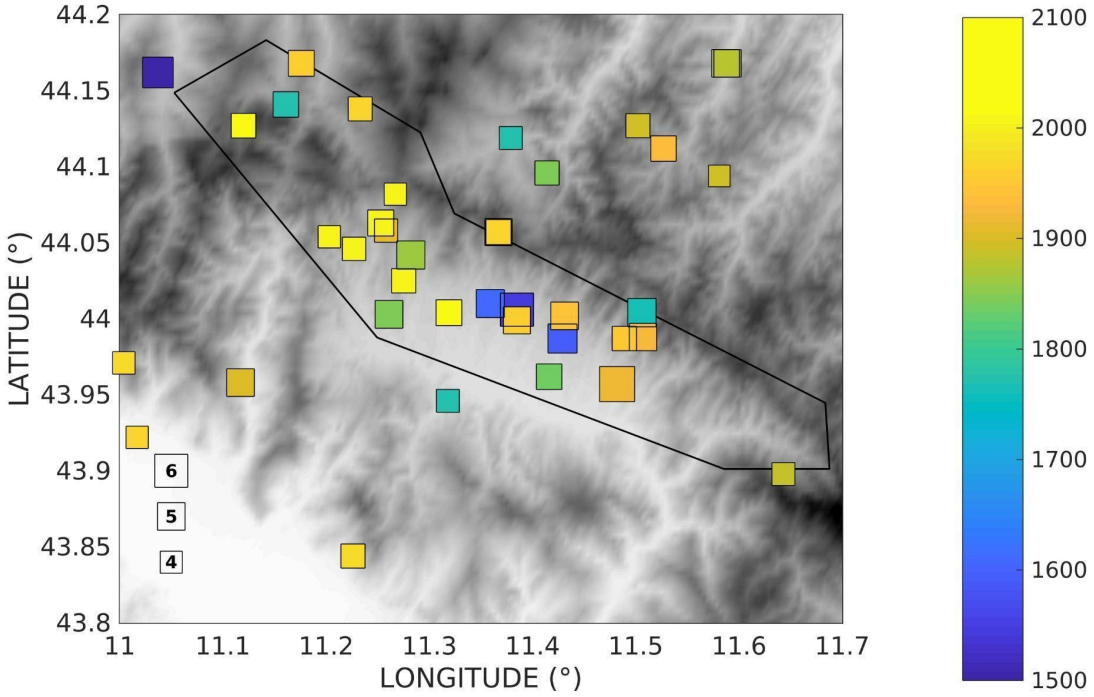
Table S4 - PGV and dynamic stresses generated by individual mainshocks at the locations of the mainshocks of the subsequent sequences. The last two columns at the right of the table refer to the upper and lower bound of dynamic stress estimates, once uncertainties in PGV predictions are taken into account.

Source earthquake	**Receiver hypocenter**	**Dist (km)**	**PGV (m/s)**	σ_{pd} **(kPa)**	σ_{pd}^{MAX} **(kPa)**	σ_{pd}^{MIN} **(kPa)**
2008-03-01T07:43:13	2009-09-14T20:04:31	5.58	0.031034	310.3	677.2	142.2
2008-03-01T07:43:13	2015-01-23T06:51:20	14.03	0.012124	121.2	265.2	55.4
2008-03-01T07:43:13	2019-12-09T03:37:03	9.07	0.020644	206.4	452.5	94.2
2009-09-14T20:04:31	2015-01-23T06:51:20	16.70	0.006299	62.9	137.	28.9
2009-09-14T20:04:31	2019-12-09T03:37:03	4.21	0.026478	264.8	574.6	122.0
2015-01-23T06:51:20	2019-12-09T03:37:03	21.06	0.005158	51.5	112.4	23.7

4 Historical Seismicity

(a)



(b)

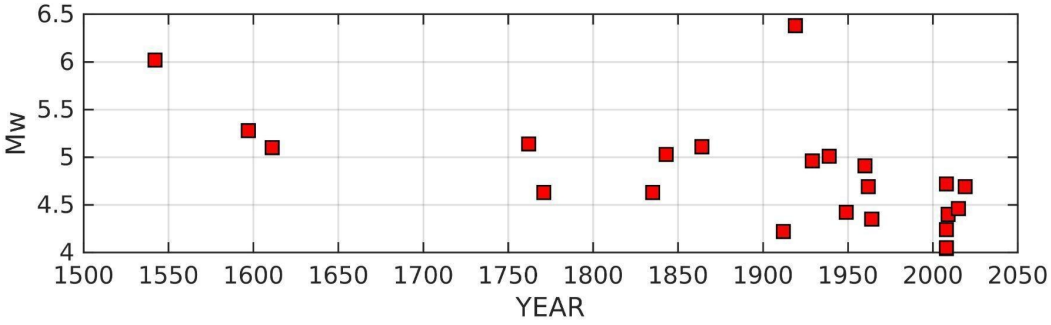


Fig. S4 - (a) Distribution of M>4 earthquakes within and around the Mugello Basin. The size of the symbols scales with the magnitude, according to the scale at the bottom left corner. Colors denote the year of occurrence according to the colorbar at the right. The black polygon encompasses the Ronta Fault System (RFS)and adjoining fault segments addressed in this study; for that region, the magnitude vs time plot is reported in panel (b) (Data after Rovida et al., 2021).