

1 **Dynamics of the Seismicity in the Alto Tiberina Fault System revealed by a High-**
2 **Resolution Template Matching Catalog**

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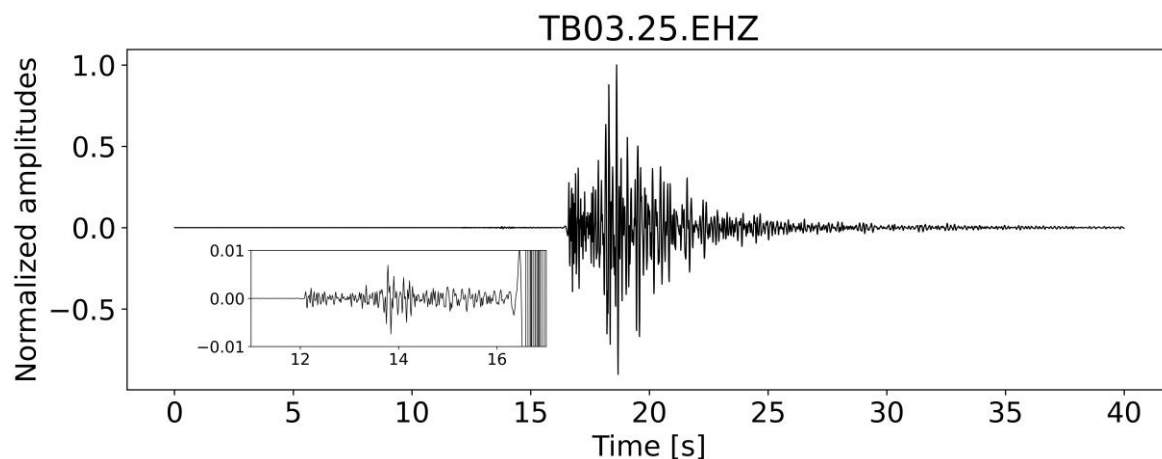


Figure S1: Normalized waveform of a $M=2.8$ event (2014-12-20T12:14:24) at station TB03.25. The zoomed inset allows to see a smaller event $M\sim-0.2$ preceding the larger event by 3s. Notably, both events share elevated similarity in terms of waveforms having a high CC of ~ 0.66 .

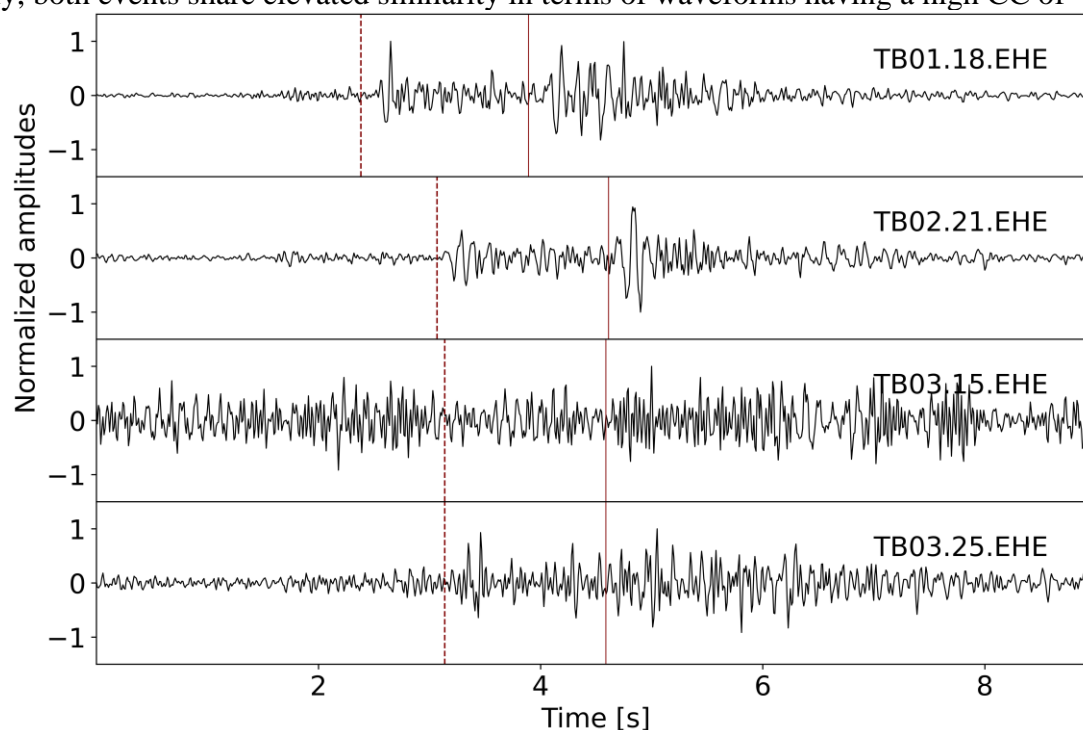


Figure S2: Normalized waveforms for the East components of all used stations of two consecutive events (2013-12-21T22-57-54.75 and 2013-12-21T22-57-56.33) following each other by ~ 1.5 s. The red dashed line indicates the theoretical s-wave arrival time assuming the travel time of the detecting template. The red solid line indicates the same but for the second template.

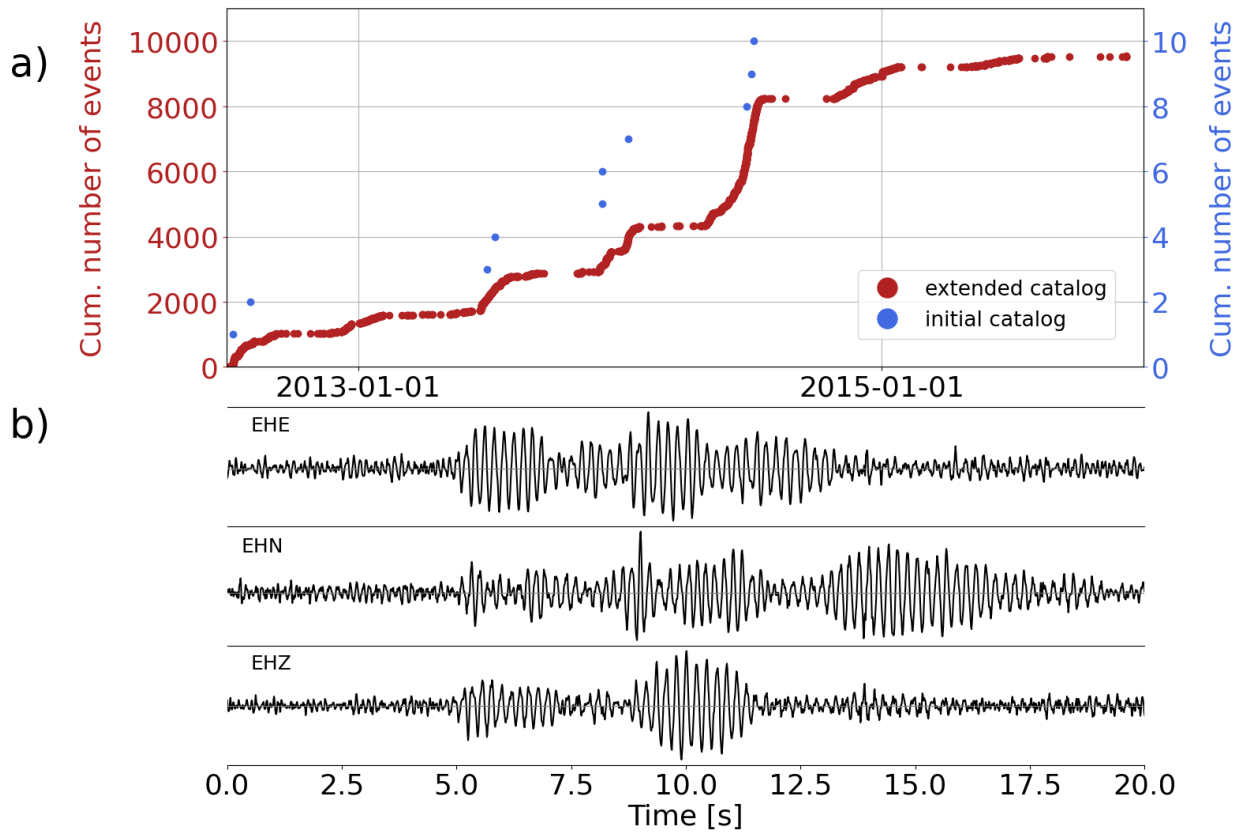


Figure S3: (a) Cumulative number of events as a function of time for events radiated at shallow depths close to a cement factory in the southern part of the Gubbio basin. Note the different scale for the two catalogs. (b) Normalized three-component waveforms recorded at TB02 for one of the events.

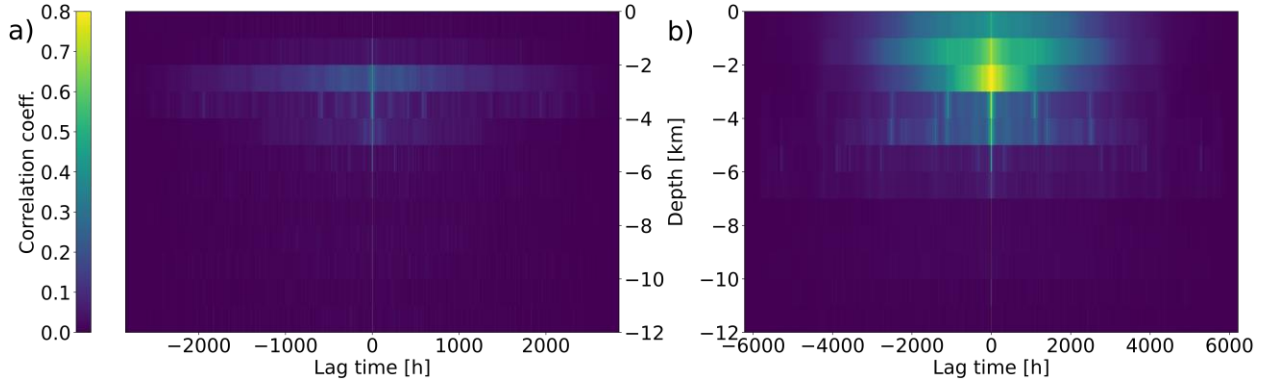


Figure S4: Auto-correlation functions of the event count time series binned in 1 km along depth and 1-hour lasting time bins for (a) the pre-swarm and (b) the swarm time period. For both plots, the color-bar ranges from 0 to 0.8.

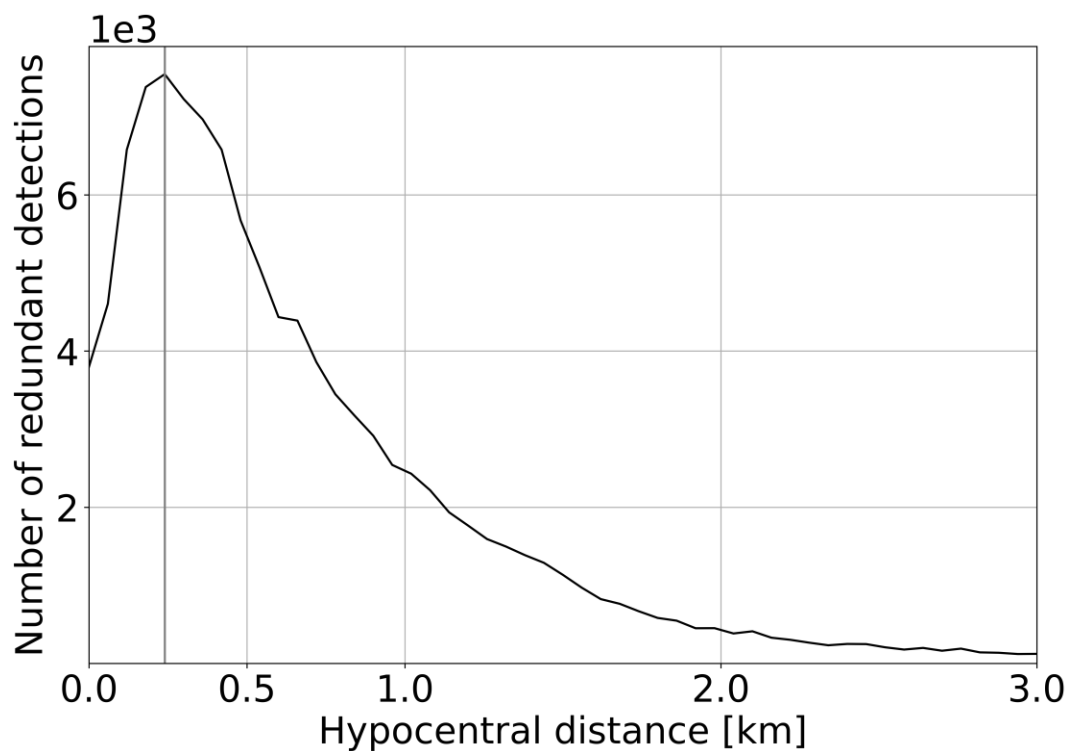


Figure S5: Number of redundant detections as a function of hypo-central distance between the redundant detection and the auto-detection

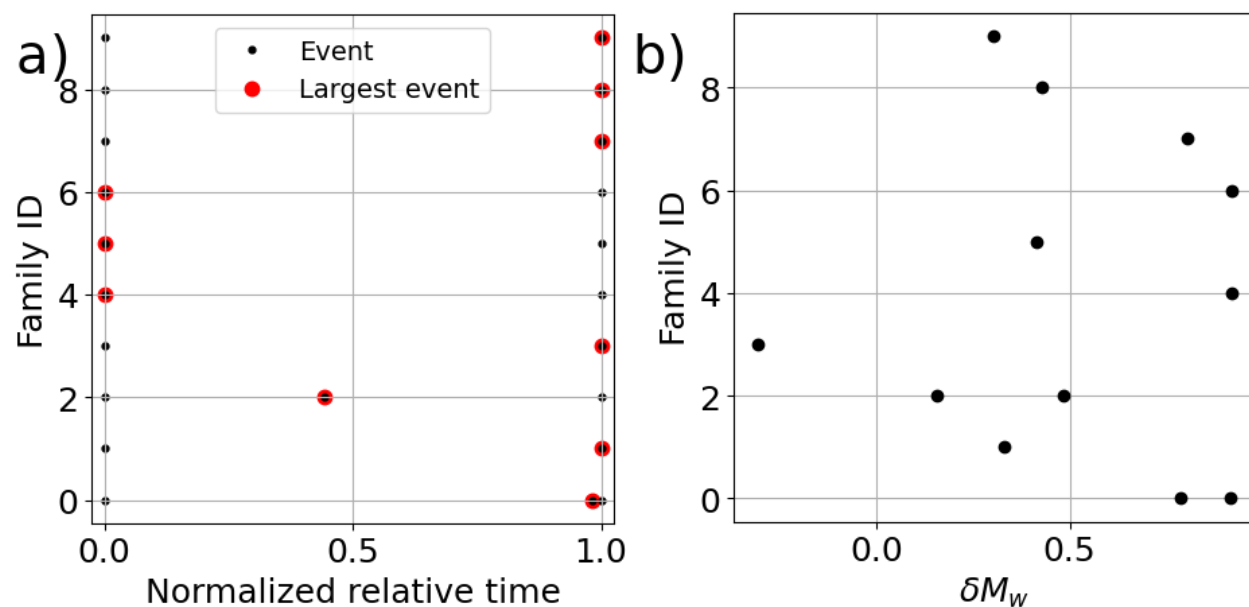


Figure S6: (a) Normalized relative times for each family of repeating events. Red dots indicate the largest event within a family. (b) The difference between the largest event and the other events within each family in δM_w

Table S1: 1-d p wave velocity model (Chiaraluce et. al, 2007)

Layer top [km]	p-wave velocity [km/s]
0	4.6
3	5.5
5	6.0
7	6.7
38	7.9

Table S2: Families of repeating events. If events within a family were detected by different templates, they have different locations. In this case we computed the average location between them.

lat [deg]	lon [deg]	depth [km]	origin time first event	duration [s]	nr_events
43.43607 07601	12.59830 9199	8.76996	2013-03-15T07:36:33	9965.625 624	3
43.41519 54651	12.54738 85536	8.21381	2013-03-16T09:17:48	16.41872 8	2
43.23249 30827	12.79992 51684	9.35883	2013-03-16T23:07:36	1110.068 787	3
43.24079 13208	12.67919 34967	8.37477	2013-05-17T22:17:12	4722.86	2
43.37870 97931	12.74312 68692	12.17099 5	2013-09-14T19:19:33	240.3852 6	2
43.45399 09363	12.57639 12201	8.512165	2013-09-21T17:08:56	4942.709 734	2
43.39792 63306	12.69310 66513	9.59176	2014-11-22T03:42:20	100.95	2
43.20241 54663	12.66066 07437	8.59461	2015-02-18T10:14:04	1798.788 118	2
43.44217 49115	12.60103 36876	9.163845	2015-07-31T19:30:15	1366.510 071	2
43.43663 0249	12.62002 75421	9.175625	2015-08-09T23:21:46	1836.393 349	2

Logistic function used to weight the maxima of each component wise cross-correlation function depending on the SNR of the correlated waveforms (for more details see Duverger et al., 2018)

$$f(x) = \frac{L}{1+e^{-k(x-x_0)}} \quad (1)$$

Where $L = 1$, $k = 2.5$, and $x_0 = 3$ (Duverger et al., 2020).

Reference

Chiaraluce, L., Chiarabba, C., Collettini, C., Piccinini, D., & Cocco, M. (2007). Architecture and mechanics of an active low-angle normal fault: Alto Tiberina fault, northern Apennines, Italy. *Journal of Geophysical Research: Solid Earth*, 112(B10).

Duverger, C., Lambotte, S., Bernard, P., Lyon-Caen, H., Deschamps, A., & Nercessian, A. (2018). Dynamics of microseismicity and its relationship with the active structures in the western Corinth Rift (Greece). *Geophysical Journal International*, 215(1), 196-221.