

Supplementary materials for "The imbricated foreshock  
and aftershock activities of the Balsorano (Italy)  $M_w$   
4.4 normal fault earthquake and implications for  
earthquake initiation"

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**Additional Supporting Information**

1. Seismic catalog for the seismic sequence associated to the 2019 ( $M_W$  4.4) Balsorano  
earthquake

Table S1: General information of the 2019  $M_w$  4.4 Balsorano earthquake. All this information is taken from the INGV's online catalog.

Mainshock data	
Magnitude	$M_w$ 4.4
Lat (°) / Lon (°)	13.61 / 41.78
Depth (km)	14.0
NP1: Strike / Dip / Rake	299 / 58 / -120
NP2: Strike / Dip / Rake	166 / 42 / -51
Reported activity	$\approx$ 150 events
# Stations < 100 km	6

Table S2: Receiver locations. The distances reported are measured with respect to the mainshock epicentral location (taken from the INGV).

Receiver	Lon. (°)	Lat. (°)	Dist. (km)
CERT	41.94903	12.98176	72.297
GUAR	41.79450	13.31229	33.093
INTR	42.01154	13.90460	41.820
POFI	41.71743	13.71202	13.112
PTQR	42.02193	13.40057	35.780
VVLD	41.86965	13.62324	10.411

Table S3: Velocity model used for the relocation process. A  $V_P/V_S$  ratio equal to 1.73 is assumed. Slightly modified version from the model proposed by [Bagh et al. \(2007\)](#)

Depth of top of layer (km)	P-wave velocity (km/s)
0.0	5.360
3.0	5.360
6.0	5.800
14.0	6.650
25.0	6.900

Table S4: Reference templates and phase traveltimes at the six available stations (estimated from INGV data).

#	Origin time	P <sub>tt</sub> CERT	P <sub>tt</sub> GUAR	P <sub>tt</sub> INTR	P <sub>tt</sub> POFI	P <sub>tt</sub> PTQR	P <sub>tt</sub> VVLD	S <sub>tt</sub> CERT	S <sub>tt</sub> GUAR	S <sub>tt</sub> INTR	S <sub>tt</sub> POFI	S <sub>tt</sub> PTQR	S <sub>tt</sub> VVLD
1	11/07/2019 00:37:18	9.63	5.51	6.9	3.46	6.37	3.48	17.09	9.11	11.95	5.82	11.28	5.71
2	11/07/2019 03:21:00	9.72	5.38	6.92	3.57	6.62	3.57	17.15	9.4	12.12	5.87	11.36	5.82
3	11/07/2019 10:37:05	9.69	5.39	6.93	3.7	6.52	3.54	17.15	9.15	12.05	6.00	11.38	5.82
4	11/07/2019 17:35:21	9.7	5.38	7.01	3.54	6.48	3.59	17.22	9.02	12.12	5.89	11.52	5.92
5	11/07/2019 17:47:53	9.77	5.4	6.93	3.32	6.53	3.55	17.29	9.12	12.07	5.45	11.42	5.68
6	11/07/2019 18:04:55	9.74	5.35	6.9	3.39	6.54	3.49	17.21	9.12	11.86	5.68	11.45	5.72
7	11/07/2019 23:19:50	9.62	5.29	7.09	3.54	6.44	3.55	16.89	8.99	12.19	6.00	11.20	5.79
8	11/08/2019 03:08:06	9.06	5.14	7.06	3.56	6.45	3.42	16.85	8.76	12.21	5.85	11.08	5.58
9	11/08/2019 08:10:56	9.93	5.56	6.75	3.17	6.72	3.37	17.33	9.23	11.69	5.39	11.58	5.48
10	11/08/2019 08:16:10	9.84	5.44	6.88	3.44	6.51	3.54	17.40	9.49	12.00	5.76	11.53	5.71
11	11/08/2019 10:43:24	9.50	5.15	6.89	3.32	6.29	3.38	17.00	8.91	12.08	5.78	11.19	5.61
12	11/08/2019 12:00:43	9.75	5.44	7.04	3.34	6.61	3.55	17.29	9.13	12.44	5.70	11.35	5.77
13	11/08/2019 13:07:07	9.41	5.08	6.86	3.32	6.22	3.34	16.88	8.77	12.31	5.64	11.04	5.45
14	11/08/2019 14:22:12	9.52	5.14	6.92	3.39	6.48	3.38	16.99	8.79	12.39	5.69	11.19	5.56
15	11/09/2019 10:57:09	9.72	5.35	6.87	3.21	6.54	3.46	17.20	9.03	11.98	5.52	11.33	5.70
16	11/09/2019 22:14:15	9.59	5.27	6.66	3.24	6.43	3.14	17.07	9.04	11.61	5.33	10.91	5.04
17	11/09/2019 23:09:52	9.79	5.49	6.90	3.62	6.61	3.59	17.48	9.12	11.88	5.69	11.66	5.91
18	11/10/2019 03:31:36	9.55	5.15	6.58	3.51	6.37	3.42	16.82	8.68	12.21	5.79	11.07	5.55
19	11/10/2019 06:56:28	9.62	5.15	6.56	3.15	6.40	3.07	17.04	9.04	11.92	5.42	11.39	5.09
20	11/11/2019 01:43:21	9.59	5.31	6.90	3.44	6.42	3.53	18.00	9.27	12.05	5.25	11.44	5.76
21	11/11/2019 13:41:33	9.46	5.11	7.00	3.49	6.22	3.39	16.81	8.79	12.20	5.85	11.10	5.54
22	11/11/2019 16:04:53	9.39	5.05	6.95	3.43	6.25	3.34	17.07	8.70	12.27	5.75	11.08	5.52
23	11/11/2019 17:46:53	9.61	5.22	6.86	3.32	6.40	3.43	17.05	8.97	12.44	5.22	11.23	5.62

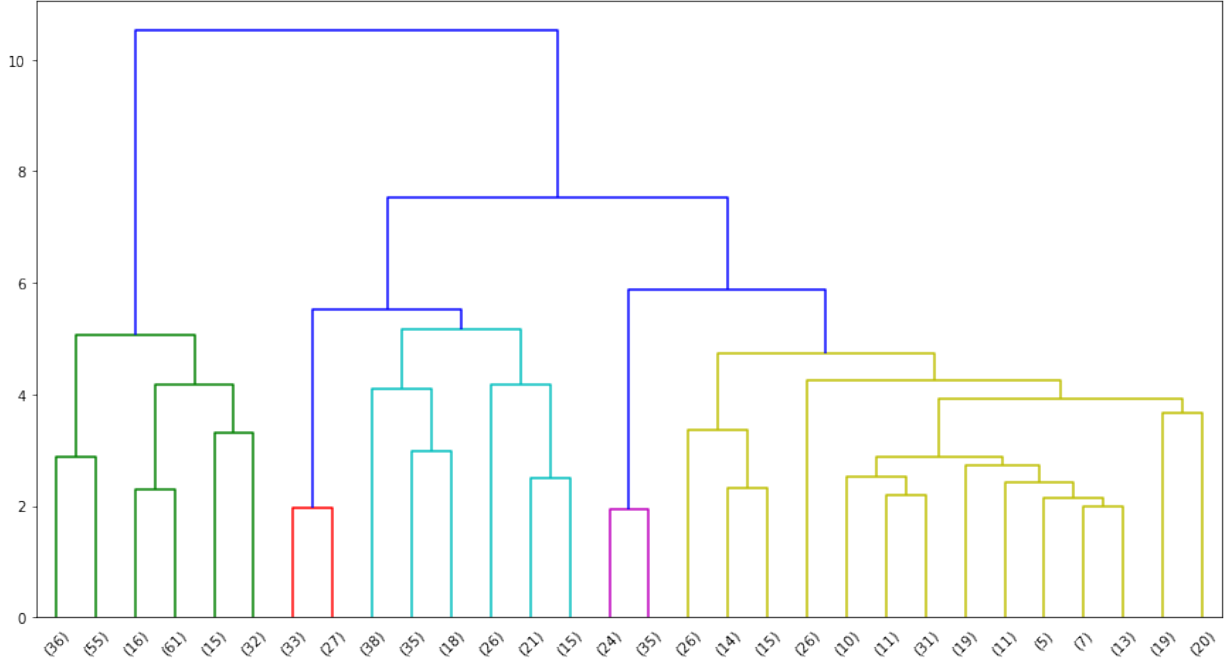


Figure S1: Dendrogram obtained from the waveform-based hierarchical clustering performed. The distance metric between two different waveforms ( $i$  and  $j$ ) is estimated as  $1-C_{ij}$ . Ward's minimum variance linkage technique is used. The distance threshold to define the final number of cluster is set to 5.3 (the largest separation observed form dendrogram).

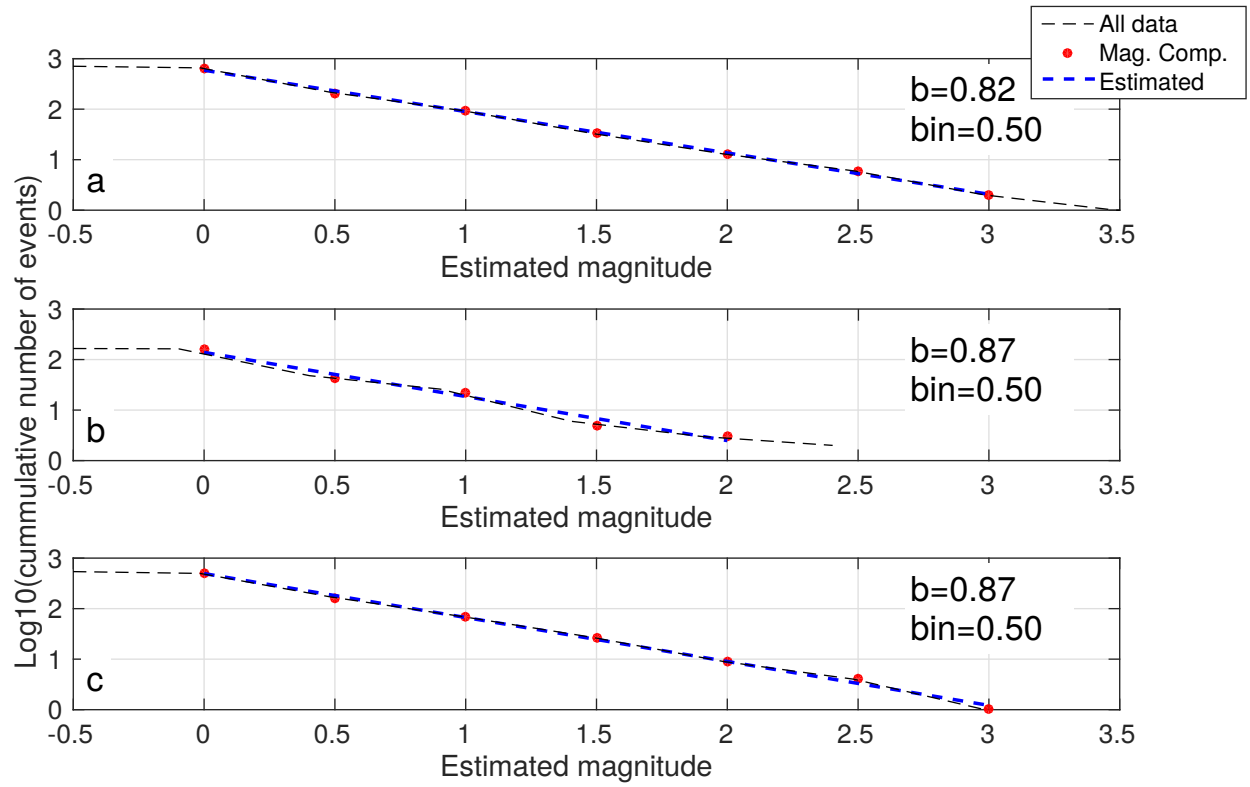


Figure S2: Cumulative number of events per magnitude for a) whole experiment b) foreshocks c) aftershocks. B-values are seen in the legend.

## 16 **References**

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