



PRELIMINARY ENGINEERING REPORT ON GROUND MOTION DATA OF THE AUG 21st 2017 ISCHIA EARTHQUAKE V2.0



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Warning: This report was based on data available on Aug 27th 2017 and may be subjected to editing and revisions as new data become available, check www.reluis.it for updates.

Introduction

The earthquake occurred on August 21st 2017 at 18:57:51 UTC (20:57:51 local) near the island of Ischia in the bay of Naples (Figure 1). The sea-side settlement of Casamicciola Terme, on the northern part of the island, was the one mainly afflicted by the ground shaking that caused some structures to collapse (see <http://www.reluis.it/images/stories/Ischia-21-agosto-2017-report-fotografico.pdf>) and inflicted several casualties, including two fatalities (see [comunicato stampa DPC](#); in Italian).

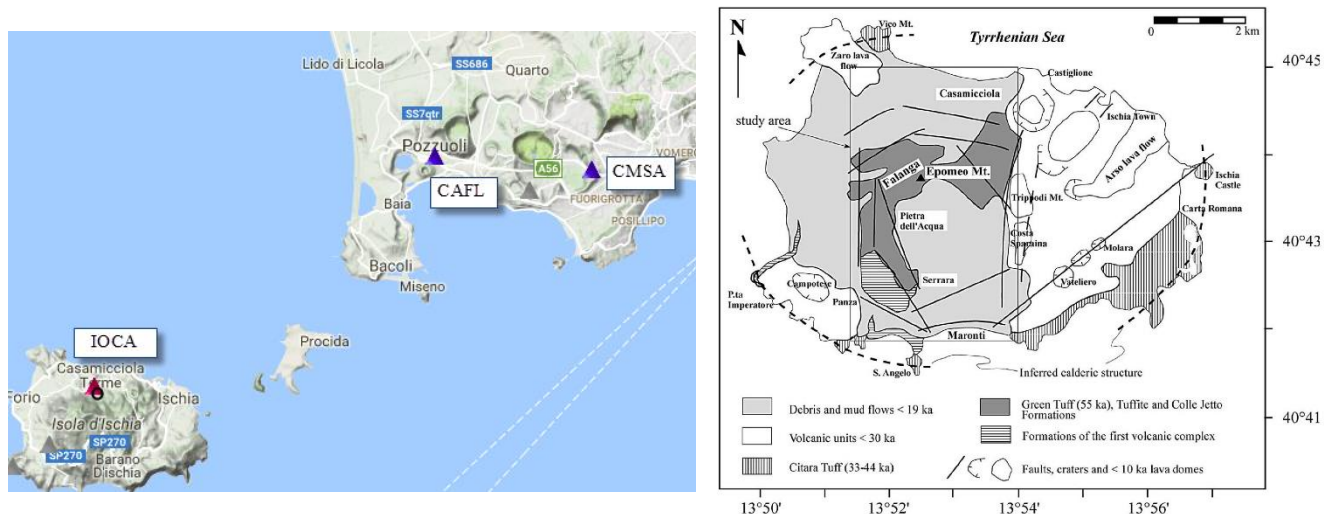


Figure 1. Map of Ischia and nearby coast indicating the position of recording stations (triangles) and 25/08/2017 INGV-OV estimate of the epicenter (black circle) on the left panel; geological map of the island taken from Molin et al. (2003) on the right panel.

Localization of the event given by the *Istituto Nazionale di Geofisica e Vulcanologia* (INGV) – *Osservatorio Vesuviano* – operations room (<http://www.ov.ingv.it/ov/> - last accessed 26/08/2017) places the epicenter at a 40.74° latitude and 13.90° longitude and estimates a *duration magnitude* M_d equal to 4.0 and a hypocentral depth of around 1.7 km³. According to the time domain moment tensor solution (<http://cnt.rm.ingv.it/event/16796811>), the

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³ The *European-Mediterranean Seismological Centre* (EMSC-CSEM) provided an estimated epicenter location 40.68° latitude and 13.85° longitude, a *local magnitude* M_L 4.3 and hypocentral depth of 2 km (<https://goo.gl/6L55o7>; last accessed 24/08/2017). The latter estimate places the epicenter a few kilometers offshore the island of Ischia while the former in the immediate vicinity of the village of Casamicciola Terme.

focal mechanism appears to belong to a moderately steep dipping normal fault (dip angle 65° , rake -46°). These preliminary estimates appear consistent with what is already contained in the *Database of Individual Seismogenic Sources* (DISS – see Figure 2 and <http://diss.rm.ingv.it/diss/>) in terms of positioning and stress regime.

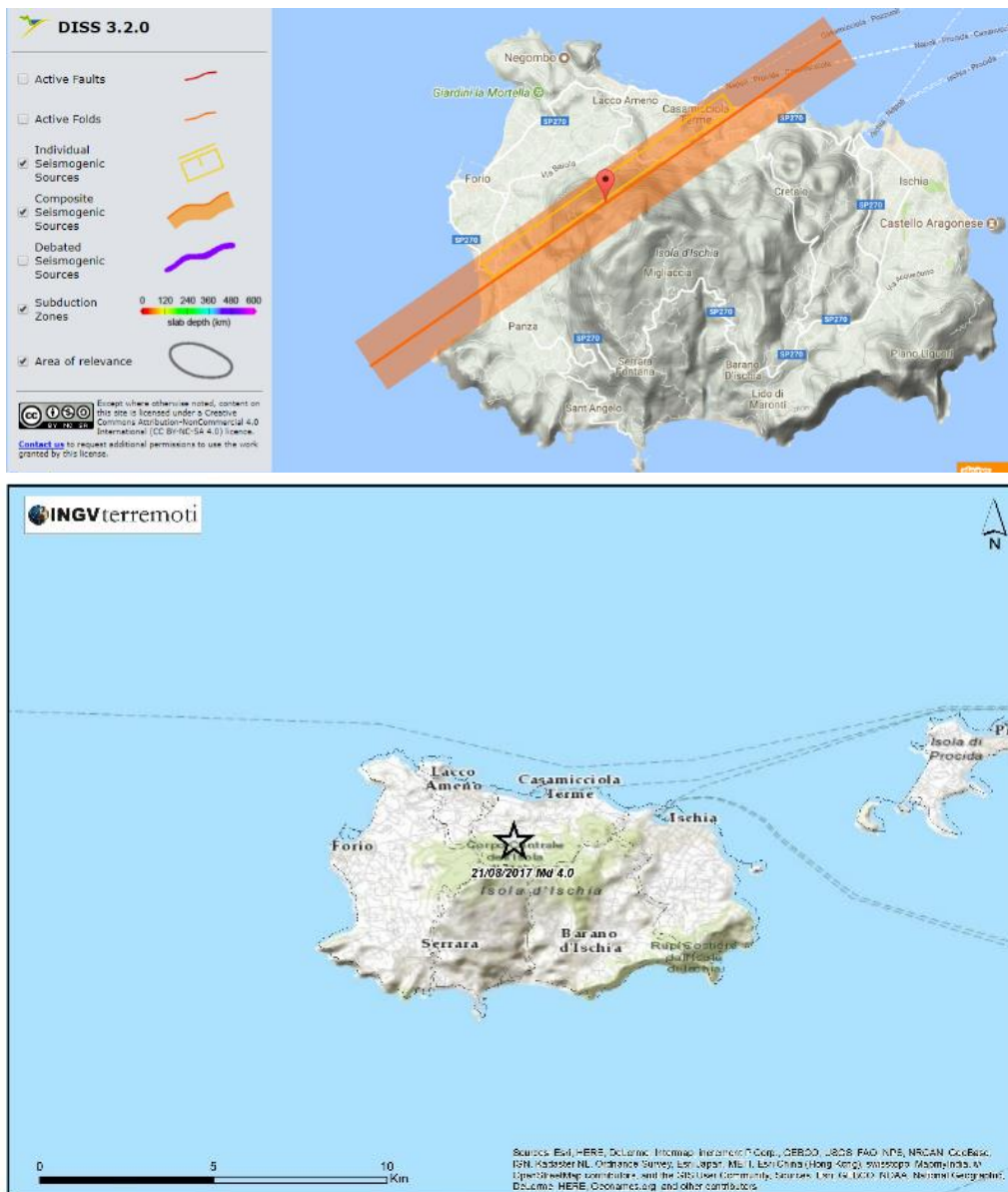


Figure 2. Ischia seismogenic source from the DISS (upper panel, image taken from <http://diss.rm.ingv.it/diss/>); INGV-OV epicenter localization according to the 25/08/2017 updated estimate (lower panel, image taken from <http://terremoti.ingv.it/>).

This event comes as an addition to the twelve historical earthquakes that hit Ischia in the past and are listed in the *Italian Parametric Earthquake Catalogue*– shown here in summary as Table 1 (see also <https://goo.gl/XAoKGA> for Casamicciola). The most notable among the past events in the catalogue is the 1883 earthquake that devastated the same settlement of Casamicciola. One notes that the magnitude *estimates* for these past events are generally modest, as in the case at hand.

Table1. Estimated moment magnitude (M_w), MCS scale macroseismic intensity (I_{max}) and positioning of historical seismic events at Casamicciola Terme (taken from <http://comunicazione.ingv.it/>; in Italian).

Year	MM	DD	Epicentral Area	Reference	Lat	Lon	I_{max}	M_w	$\pm Err M_w$
1275	11	02	Island of Ischia	CFTI4med	40.743	13.942	8-9	4.01	0.5
1557			Island of Ischia	MOLAL008	40.721	13.953	D	3.5	0.5
1762	07	23	Island of Ischia	AMGNDT995	40.746	13.909	6-7	3.5	0.5
1767			Island of Ischia	AMGNDT995	40.735	13.919	D	3.5	0.5
1796	03	18	Island of Ischia	CFTI4med	40.746	13.909	8	3.88	0.5
1828	02	02	Island of Ischia	CFTI4med	40.745	13.899	9	4.01	0.5
1841	03	06	Island of Ischia	MOLAL008	40.749	13.899	6	3.25	0.5
1863	01	30	Island of Ischia	MOLAL008	40.746	13.909	5	2.87	0.5
1867	08	15	Island of Ischia	MOLAL008	40.746	13.909	5-6	2.99	0.5
1881	03	04	Island of Ischia	CFTI4med	40.747	13.895	9	4.14	0.5
1883	07	28	Island of Ischia	CFTI4med	40.744	13.885	10	4.26	0.5
1980	04	23	Island of Ischia	MOLAL008	40.718	13.89	5	4.37	0.2

Recorded ground motion at Casamicciola Terme

The strong ground motion recording of primary interest (provided by INGV – Osservatorio Vesuviano, corrected data available at <https://t.co/it4I2tZj68> (i.e., from the *Engineering Strong-Motion Database*; Luzi et al., 2016) correction according to Paolucci et al. (2011) was the only one that could be obtained on the island of Ischia at IOCA station (*Ischia Osservatorio Casamicciola* – see Figure 1), exhibiting a horizontal peak ground acceleration (PGA) of 0.28g in the east-west component. The station is situated at an elevation of 123 m from sea level and the soil classification according to Eurocode 8 is reported as B (inferred from geological maps, not measured - see <https://t.co/uWrJ6mtEC9> for location and site classification). The epicentral distance of the station during the event was calculated at $R=0.8$ km according to the INGV-OV's 25/08/2017 estimate of the epicenter location ($R=8.5$ km according to the EMSC-CSEM estimate). The corrected acceleration and velocity time-history traces are shown in Figure 3. PGA, peak ground velocity (PGV) and displacement (PGD) per component are given in Table 2 below.

Table 2. PGA, PGV and PGD per recorded component of ground motion at IOCA station.

	PGA (g)	PGV (cm/s)	PGD (cm)
IOCA East-West	0.280	17.8	2.32
IOCA North-South	0.192	11.5	1.72
IOCA Vertical	0.275	11.8	1.45

Figure 4 shows the 5% damped pseudo-acceleration (S_a), pseudo-velocity (S_v) and displacement (S_d) spectra of all three ground motion components. It can be observed that the vertical component exhibits a PGA of 0.275g, almost identical to the EW components' 0.28g (with the NS component having 0.19g). Furthermore, the vertical spectral acceleration remains comparable with the horizontal components' up to a period of 0.40s but then drops off rapidly.

This short-period peak Sa spectrum has been observed previously even for such modest magnitude events at such short epicentral distances – see for example the case of the 1997 Mw 4.3 event record at the *Colfiorito Casermette* station (<https://goo.gl/1p5xzF>) with a horizontal PGA of 0.4g and a vertical of 0.7g (Suzuki and Iervolino, 2017). Maximum Arias intensity among the two components (EW) was calculated at 39.4 cm/s and significant duration D_{5-95} at 3.61s.

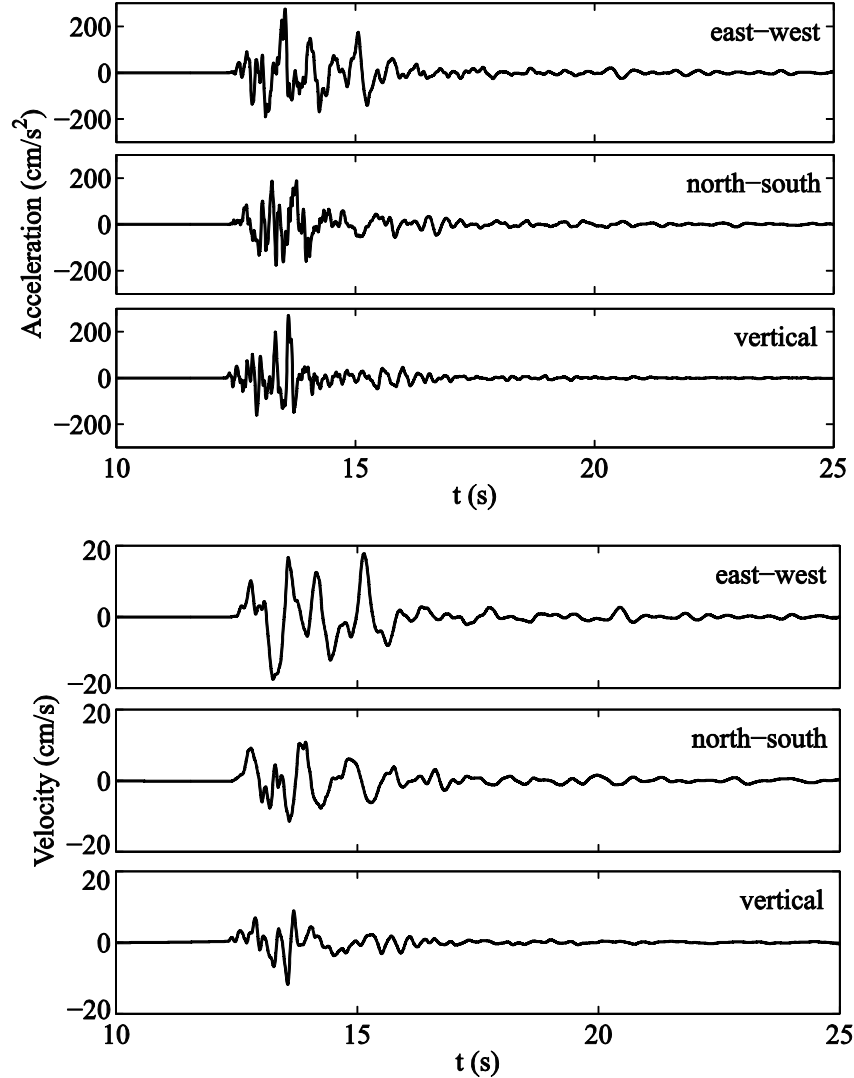


Figure 3. Acceleration (above) and velocity (below) corrected time history traces recorded at the IOCA station in Casamicciola Terme.

An interesting feature that can be seen on the horizontal component spectra is the existence of local amplification peaks at a vibration period of around 0.60s in the velocity and acceleration spectrum of both components simultaneously. Such isotropic amplification could hint at a local stratigraphic effect and this appears to be corroborated by the horizontal to vertical (H/V) ratios calculated for the IOCA site and two more locations on the island by the INGV's EMERSITO workgroup (EMERSITO Working Group, 2017) and shown in Figure 5.

These H/V ratios were derived from the Fourier spectra of ambient seismic noise velocimetric signals and reveal significant amplification exhibited by the IOCA site between frequencies of 1.5 Hz and 2.0 Hz (i.e., periods of 0.5s to 0.67s). Such pronounced amplification effects are not encountered in the other two stations, which is a

testament to the heterogeneity of local site response in the island's volcanic subsoil (for further details see EMERSITO Working Group, 2017).

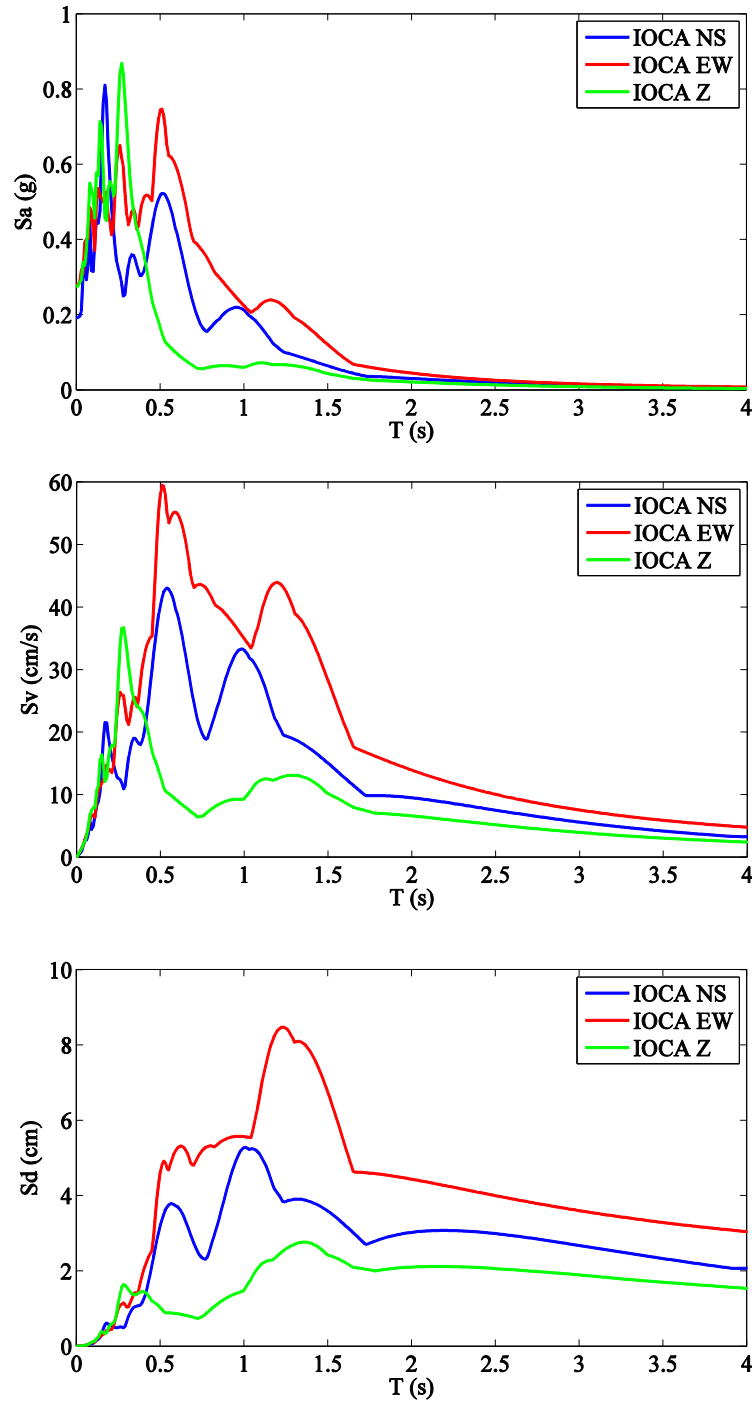


Figure 4. Five percent damped Pseudo-acceleration (above), pseudo-velocity (middle) and displacement (below) spectra of all three ground motion components recorded at the Ischia – Osservatorio Casamicciola station.

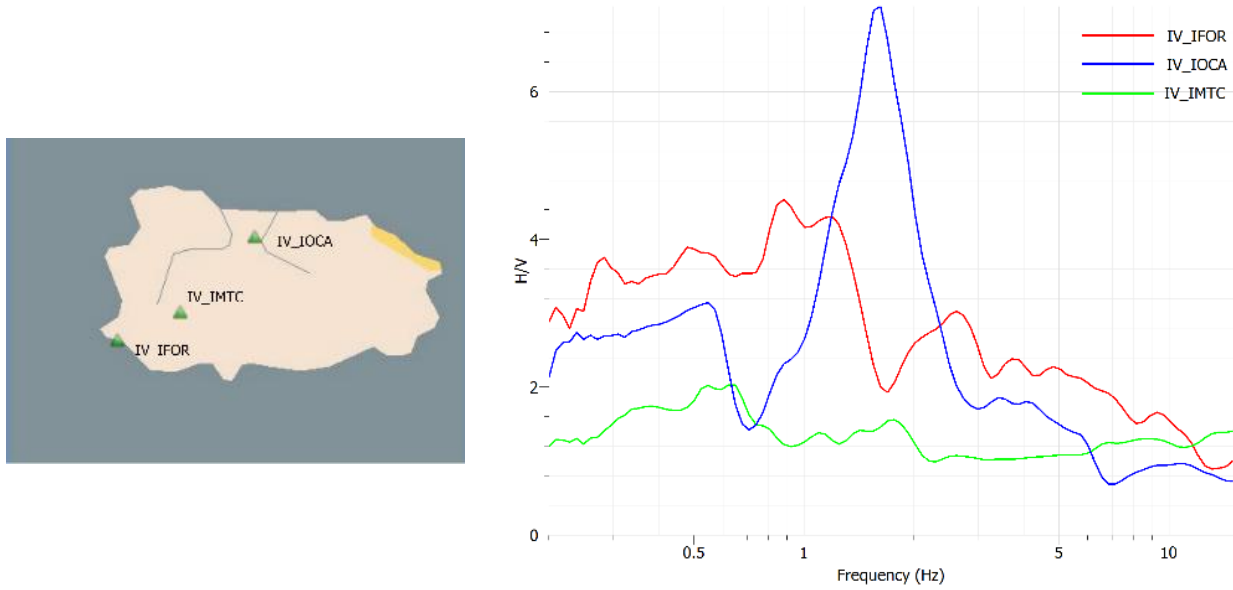


Figure 5. H/V ratios for three recording stations on the Island of Ischia (EMERSITO Working Group, 2017).

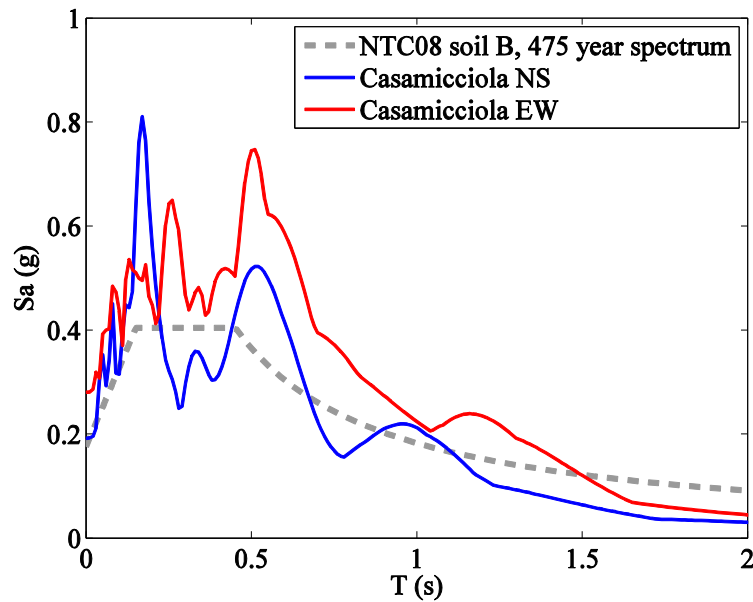


Figure 6. Horizontal pseudo-acceleration spectra recorded at Casamicciola Terme and corresponding NTC08 475 year return period spectrum. (Data to build the code spectrum for the site taken from <https://t.co/uWrJ6mtEC9>, last accessed 26/08/2017)

Another interesting observation is the fact that, despite the modest estimated magnitude, both horizontal components' acceleration spectra are comparable with those for new construction according to the Italian code (*Norme Tecniche per le Costruzioni* 2008 – NTC08). In fact, according to Figure 6, the EW component's spectrum appears to exceed the code spectrum, for 475 year return period elastic spectrum at various vibration periods. Such exceedances are not totally unexpected and can be due to a combination of proximity to the source, shallow hypocentral depth and local site conditions; some relevant discussion can be found in Iervolino and Giorgio (2017).

Ground motion recorded on the mainland

Ground motion resulting from this modest-magnitude event was characterized by rapid attenuation with distance, probably due to the shallow hypocentral depth and volcanic nature of the propagation medium. The two nearest-to-the-source recording stations on the mainland (see Figure 1), Arco Felice (CAFL) found at an epicentral distance of $R=19.9$ km and Monte Sant'Angelo (CMSN) at $R=26$ km recorded PGAs in the order of $0.005g$ and $0.002g$, respectively, which are two orders of magnitude inferior to the those recorded on the island of Ischia. The corresponding pseudo-acceleration spectra can be seen in Figure 7, where the richness in long-period frequency content typically acquired during propagation far from the source is evident. Significant duration D_{5-95} for these stations (maximum between horizontal components) was $45.0s$ at CAFL and $79.7s$ at CMSN.

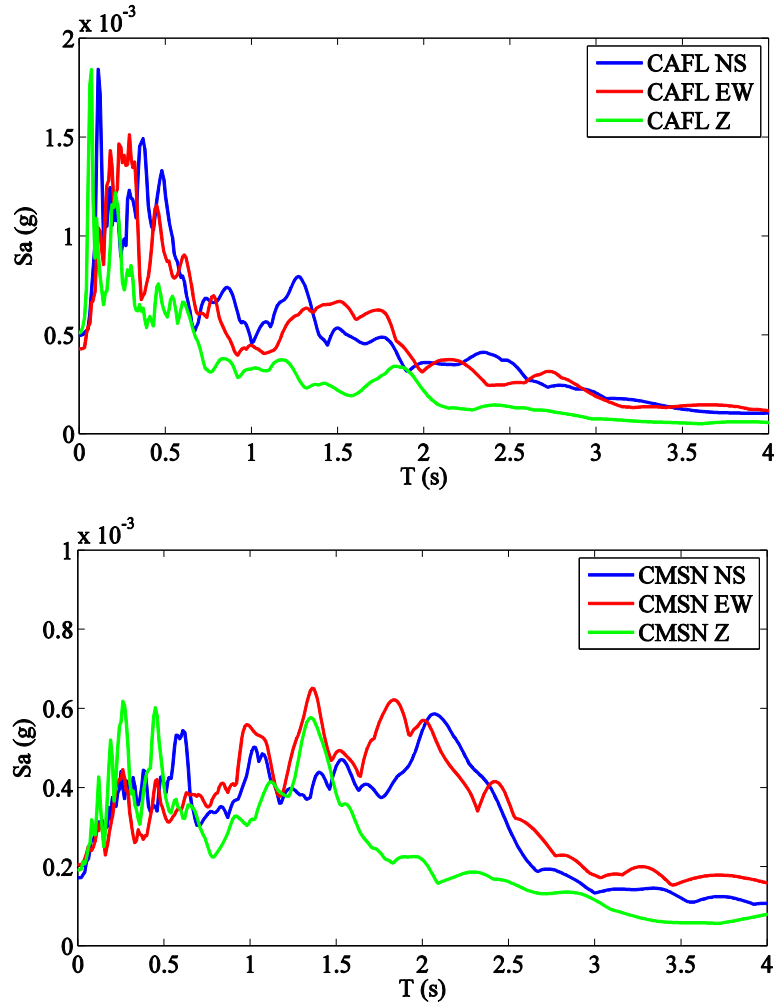


Figure 7. Five percent damped Pseudo-acceleration spectra of all three ground motion components recorded at the Arco Felice (top) and Monte Sant'Angelo (bottom) stations.

Acknowledgements

For data and the valuable insights, we would like to thank Giovanna Cultrera, Lucia Luzi, Alberto Michelini, Giuliano Milana and Rodolfo Puglia, all of INGV, as well as Mauro Dolce of Italian Civil Protection.

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