

Seismic Envelopes of Coda Decay for Q-coda Attenuation Studies of the Gargano Promontory (Southern Italy) and Surrounding Regions

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Abstract: Here, we describe the dataset of seismic envelopes used to study the S-wave Q-coda attenuation quality factor Q_c of the Gargano Promontory (Southern Italy). With this dataset, we investigated the crustal seismic attenuation by the Q_c parameter. We collected this dataset starting from two different earthquake catalogues: the first regarding the period from April 2013 to July 2014; the second regarding the period from July 2015 to August 2018. Visual inspection of the envelopes was carried out on recordings filtered with a Butterworth two-poles filter with central frequency $f_c = 6$ Hz. The obtained seismic envelopes of coda decay can be linearly fitted in a bilogarithmic diagram in order to obtain a series of single source-receiver measures of Q_c for each seismogram component at different frequency f_c . The analysis of the trend $Q_c(f_c)$ gives important insights into the heterogeneity and the anelasticity of the sampled Earth medium.

Dataset: 10.17632/w9hsj2whzm.1

Dataset License: CC-BY 4.0

Keywords: seismic envelopes; Q-coda attenuation; seismic coda decay; Gargano Promontory (Southern Italy); seismic analysis code (SAC)

1. Summary

The dataset is a collection of seismic envelopes computed from the seismograms of 280 earthquakes occurred in the Gargano area (Southern Italy) and recorded by both the OTRIONS (OT) and INGV (IV) seismic networks. The selected earthquakes belong to two bulletins: the first refers to earthquakes that occurred from June to September 2013; the second refers to earthquakes that occurred from July 2015 to August 2018. All of these earthquakes belong to a seismic database that was recently released and described [1–3] together with the seismic bulletins, station locations, velocity model [3], and seismograms.

Seismic attenuation estimates are calculated from the decay of coda waves that constitute the end of the seismic recording for local and regional events. The coda waves start after the S waves and are composed of incoherent waves scattered by inhomogeneities. The amplitude of coda waves is thought to decrease because of the seismic attenuation (both intrinsic and scattering) and because of the geometrical spreading of the wave front.

Aki and Chouet [4] showed that, assuming that coda waves are single-scattered S waves, at short source–receiver distances, the coda amplitude decay $A(f_c, t)$ is given by:

$$\log A(f_c, t) \propto -\frac{\pi f_c t}{Q_c(f_c)} \quad (1)$$

that is a linearly decreasing function of the time t elapsed from the origin time of the earthquake for a given central frequency f_c . Therefore, Q_c can be estimated by the slope of the linear regression in Equation (1) in a selected time window called a lapse time window t_L . On the seismogram $S(t)$, the seismic coda decay $A(f_c, t)$ can be evaluated by the seismic envelope calculated using the Hilbert transform $HS(t)$, as follows:

$$A(f_c, t) = \sqrt{H[S(t)]^2 + S(t)^2}. \quad (2)$$

The dependence of $A(f_c, t)$ on f_c is obtained by band-pass filtering the signal $S(t)$ around f_c . In this work, we release the seismic envelopes $A(f_c, t)$ cut between the time T3, marked on the seismogram after the S-wave arrival time, until time T4, marked on the seismogram before an energy bump or an irregularity of the coda decay or when the coda waves are indistinguishable from the noise content. All released envelopes are band-pass filtered with a two-pole Butterworth filter, considering 11 values of $f_c = [2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16]$ Hz and a band-width $\left[\frac{f_c}{\sqrt{2}}; f_c \sqrt{2}\right]$, following Bianco et al. [5]. Times T3 and T4 were manually marked on seismogram envelopes filtered with central frequency $f_c = 6$ Hz and band-width $[4.2; 8.5]$ Hz.

The first dataset of envelopes (<http://dx.doi.org/10.17632/w9hsj2whzm.1#folder-7a917d26-6be4-4014-8103-a8760541264a>, accessed on 5 September 2021), which consists of the recordings of the period from June to September 2013, was already used for the first 2D Q_c study [6] of the Gargano Promontory (Southern Italy). It consists of the recordings of 89 microearthquakes, with magnitudes ranging between 0.8 and 1.8, that were recently used to study the Gargano stress field [7] and the rheology of the Gargano crust [8].

The second dataset of envelopes (<http://dx.doi.org/10.17632/w9hsj2whzm.1#folder-7a917d26-6be4-4014-8103-a8760541264a>, accessed on 5 September 2021), which consists of the recordings of the period from July 2015 to August 2018, was used in a 3D study of Q_c ([9]) of the Gargano Promontory and surrounding areas (Southern Italy). It consists of the recordings of 191 microearthquakes, with magnitudes ranging between 1 and 2.8, that were recently used to study the Gargano active faults [10].

The manual work behind the time markers recognizing procedure is very expensive in terms of time costs. Nevertheless, we think that with this manual time marking procedure we obtained a very robust dataset of time envelopes with respect to an automatic time cut of seismic recordings. The released datasets of seismic envelopes can be very useful for seismological studies of intrinsic and scattering attenuation of Southern Italy, the Adriatic Sea, and other surrounding regions at different time lapse windows t_L .

2. Data Description

2.1. First Envelope Dataset

The compressed folder Seismic_Envelopes_2013.zip contains 89 folders named with a numerical code (YYMMDDHHmm) each of them related to the earthquake origin time (YY = year, MM = month, DD = day, HH = hour, mm = minute) (see Table 1).

Table 1. Contents of the folder Seismic_Envelopes_2013.

First Dataset	Event Folders
Seismic_Envelopes_2013	201306031549
	201306050513
	201306061512
	...

Each event's folder collects the time envelope files in data format (.dat) named as follows: "envSTNM.COM.f_{fc}.LAPSE.dat" (STNM = station name, COM = component, f_c = central frequency) (see Table 2).

Table 2. Contents of the event folder.

Event Folder	Envelope File
201306031549	envOT01.EHE.f02.LAPSE.dat
	envOT01.EHE.f03.LAPSE.dat
	envOT01.EHE.f04.LAPSE.dat
	...

Each envelope file is made of two columns: time (s) from absolute midnight and amplitude in (counts/s) (see Table 3).

Table 3. Contents of the envelope file.

Envelope File	File Content	
envOT01.EHE.f02.LAPSE.dat	(Time s)	(Amplitude counts/s)
	56,998.7383	148.276596
	56,998.7422	151.102402
	56,998.7461	154.158295

The envelope file in Table 3 is plotted in Figure 1.

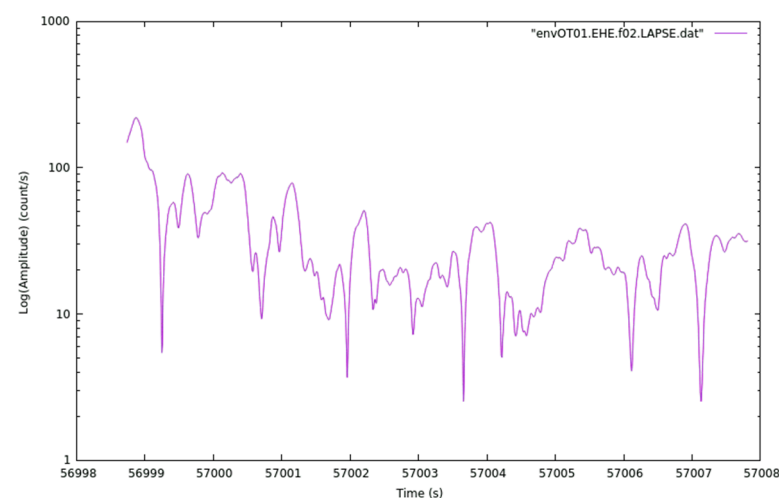


Figure 1. Plot of the first envelope file in Table 3, as an example.

2.2. Second Envelope Dataset

The compressed folder Seismic_Envelopes_2015_2018.zip contains 191 folders named with a numerical code (YYMMDDHHmm) each of them related to the earthquake origin time (YY = year, MM = month, DD = day, HH = hour, mm = minute) (see Table 4).

Table 4. Content of the folder Seismic_Envelopes_2015_2018.

First Dataset	Event Folders
Seismic_Envelopes_2015_2018	201607031216
	201507040338
	201507201850
	...

Each event's folder collects the time envelope files in text format (.TXT) named as follows: "*SN.STNM..COM.D.YYYY,JuD,hh/mm/ss.FCfc.TXT*" (*SN* = station network, *STNM* = station name, *COM* = component, *YYYY* = year, *JuD* = Julian day, *hh:mm:ss* = hours:minutes:seconds of the recording origin time, *fc* = central frequency) (see Table 5).

Table 5. Content of the event folder.

Event Folder	Envelope File
201607031216	RM.OT03..EHE.D.2015,184,10:35:01.FC02.TXT
	RM.OT03..EHE.D.2015,184,10:35:01.FC02.TXT
	RM.OT03..EHE.D.2015,184,10:35:01.FC02.TXT
	...

Each envelope file is made of two columns: amplitude in (counts/s) and time (s) elapsed from the origin time of the event (see Table 6).

Table 6. Content of the envelope file.

Envelope File	File Content	
RM.OT03..EHE.D.2015,184,10:35:01.FC02.TXT	(Amplitude counts/s)	(Time s)
	5549.86621	6.40
	5474.11377	6.41
	5359.18904	6.42

The first envelope file in Table 6 is plotted in Figure 2.

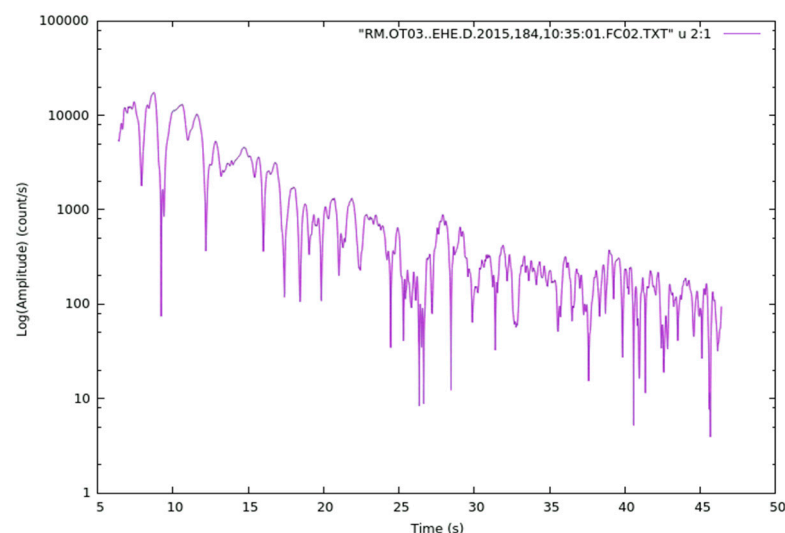


Figure 2. Plot of the first envelope file in Table 6, as an example.

3. Methods

The two datasets described in Sections 2.1 and 2.2 were collected by using the SAC (Seismic Analysis Code) software [11,12]. Starting from the original seismogram in Figure 3, a filtering procedure is applied by using a two-pole Butterworth filter considering a central frequency $f_c = [2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16]$ Hz and a band-width $\left[\frac{f_c}{\sqrt{2}}; f_c \sqrt{2}\right]$, thereby obtaining 11 new files for each seismogram component (for an example, see Figure 4). To each filtered seismogram, the SAC function "ENVELOPE" was applied, which computes the envelope function using a Hilbert transform using Equation (2) (for an example, see Figure 5). The released datasets are the envelopes cut inside the [T3, T4] time window, as

shown in Figure 1. To these files, a linear regression in Equation (1) was applied to retrieve the Q_c value at each frequency [6]. A discussion about errors and uncertainties can be found in [9].

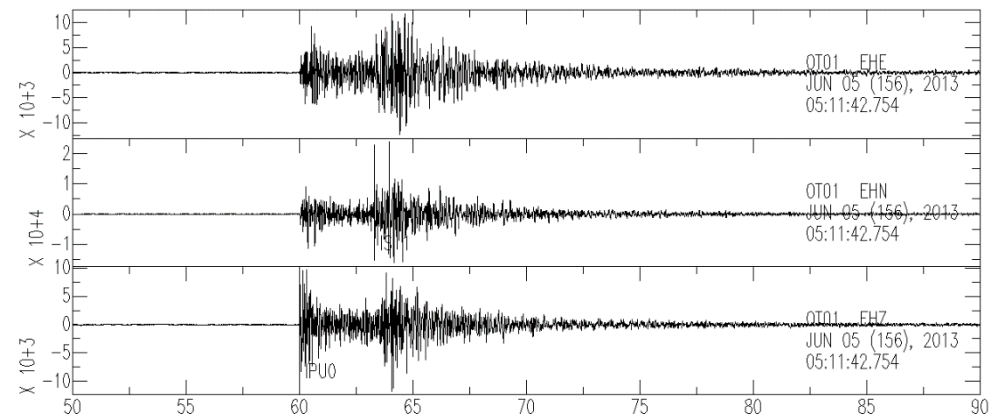


Figure 3. Three-component seismograms at station OT01, as an example. Over each record, the origin time in absolute time is overwritten; the X-axis is time (s), the Y-axis is amplitude (counts/s). The P-wave marker (IPU0) and S-wave marker (IS) are overwritten.

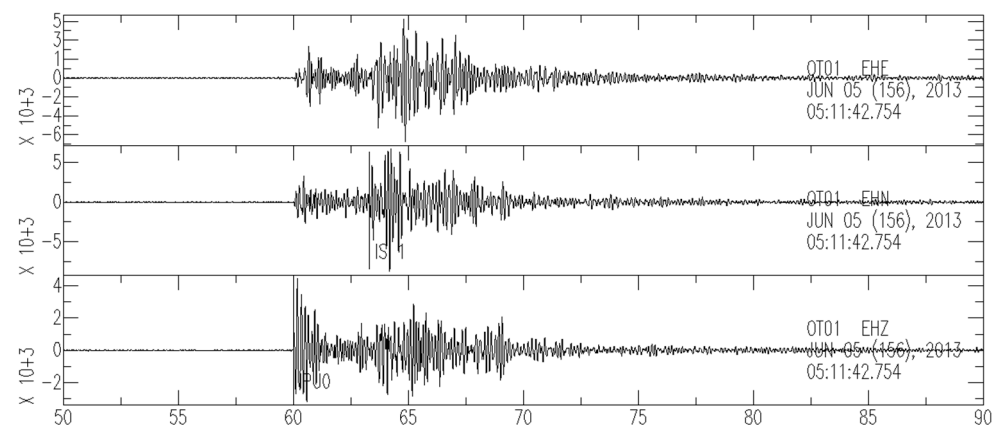


Figure 4. Three-component seismograms at station OT01, filtered with $f_c = 6$ Hz and band-width [4.24; 8.48] Hz, as an example. Over each record, the origin time in absolute time is overwritten; the X-axis is time (s), the Y-axis is amplitude (counts/s).

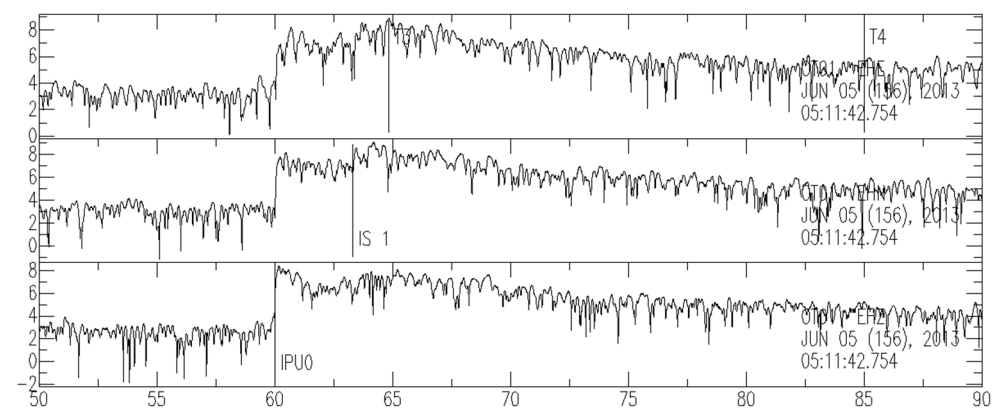


Figure 5. Envelopes of the filtered seismograms in Figure 4. Over the first record, the T3 and T4 markers are overwritten; the X-axis is time (s), the Y-axis is amplitude (counts/s).

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Supervision: M.F., S.d.L., E.D.P., G.P., E.D.P. and A.T.; Validation: M.F. and S.d.L.; Writing—original draft: M.F.; Writing—review and editing: M.F., S.L., S.d.L., E.D.P., G.P. and A.T. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: Data [1] are available at Mendeley Data repository: [doi:10.17632/w9hsj2whzm.1](https://doi.org/10.17632/w9hsj2whzm.1), accessed on 19 August 2021.

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Conflicts of Interest: The authors declare no conflict of interest.

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