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RESEARCH ARTICLE

MATLAB codes (CodaQ) for estimation of attenuation characteristics of coda waves

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Abstract

Seismic waves recorded by seismographs have been used to study the characteristics of earthquake source, path through which they travel and near surface site characteristics. MATLAB codes (CodaQ) have been developed to estimate the quality factor (Qc) of the medium through which they travelled from coda waves. The scattered part of shear waves by the heterogeneities of the medium is known as coda waves. These waves infer the heterogeneous nature of the medium. The codes are developed based on single backscattering model proposed by Aki and Chouet (1975) and guidelines given in SEISAN software to estimate coda Q. The input time histories in sesame ascii format (SAF) have been utilised by CodaQ program to estimate frequency dependent quality factor of the medium. The codes have been verified on an earthquake occurred near Uttarkashi region of Garhwal Himalaya and recorded by a 12 station seismological telemetered network deployed around Tehri region of Garhwal Himalaya.

INTRODUCTION

Seismic waves recorded by seismographs contain information about the seismic source (e.g., hypocenter parameters, earthquake source parameters and type of faulting), the path through which they travelled and near surface site characteristics. Seismologists over the world developed theoretical background as well as methods toestimate the source, path and site effects.
The codes are developed based on single backscattering model by Aki and Chouet(1975) and guidelines followed from SEISAN, EQK_SRC_PARA software.

Methodology

Coda waves are thought to decrease in amplitude only due to attenuation and geometrical spreading and can then be written

$$A(f,t) = A_0 * R * e^{\frac{-\pi f R}{vQ}}$$

where$R$ is the hypocentral distance and v the average velocity along the path. For longer paths, the average velocity might change with hypocentral distance so is easier (and more correct) to use the travel time, which usually is a precisely known parameter for a given location and origin time.

$$A(f,t) = A_0 * t^{-\beta} * e^{\frac{-\pi f t}{Q}}$$

Where

$$\beta = \begin{cases} 1.0 & \text{for body waves} \\ 0.5 & forsurfacewaves \end{cases}$$

Taking the logarithm, (3) can be written as

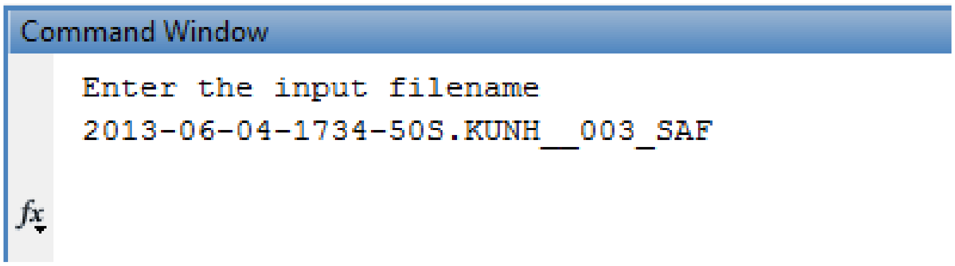
$$\ln\big(A(f,t)\big) = \ln(A_0) - \beta \ln t - \pi f t / Q(f)$$

$$\ln\big(A(f,t)\big) + \beta \ln t = \ln(A_0) - \frac{\pi f}{Q(f)} t$$

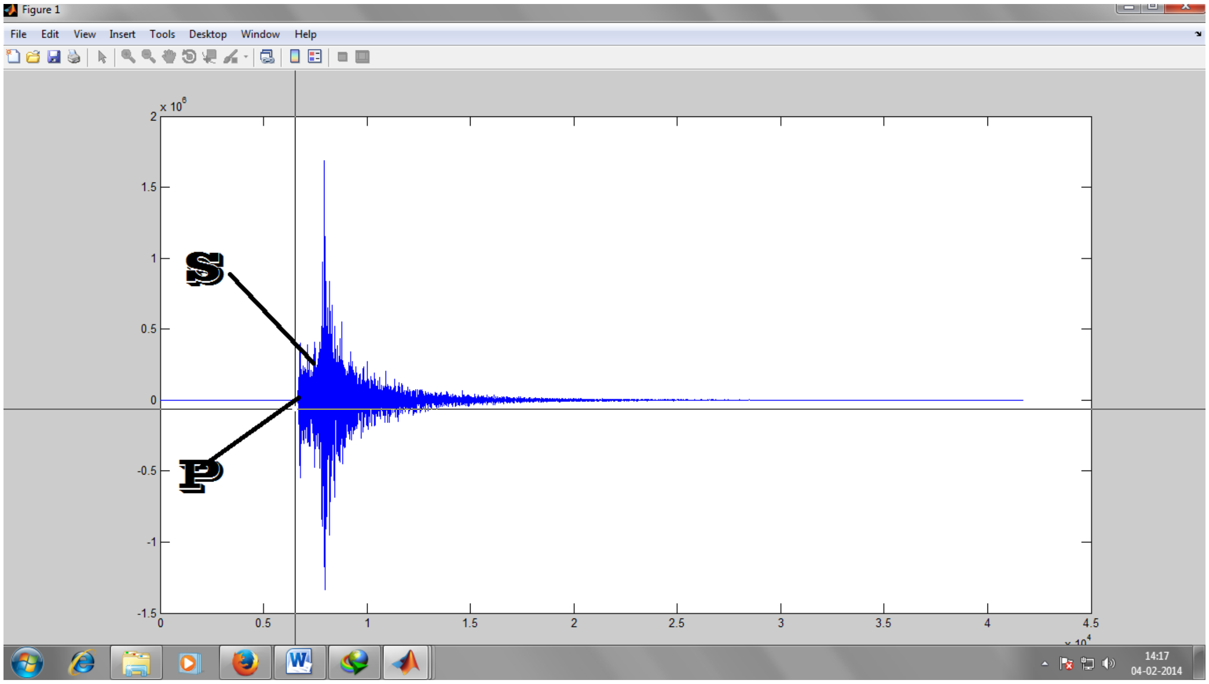
Plotting the envelope of $\ln\big(A(f,t)\big) + \beta \ln t$ as a function of t at a given central frequency after band pass filtering the signal, gives a straight line with slope= $-\frac{\pi f}{Q(f)}$ and hence *Q (f)* can be determined.

Procedure Adopted

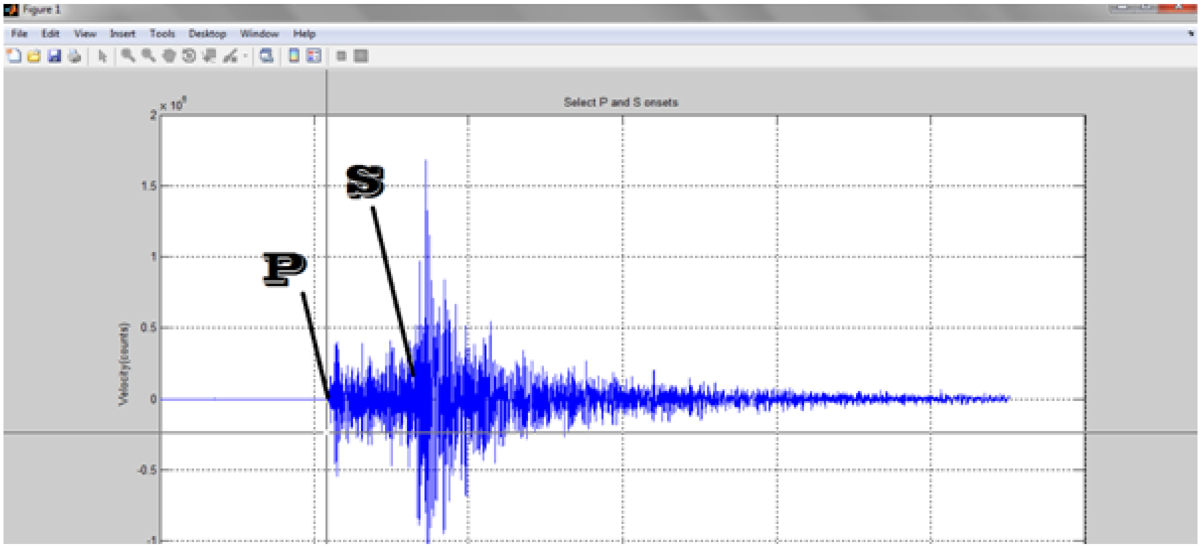
The program requires input data in SAF format.
Run Qcoda.m program then enter input file name



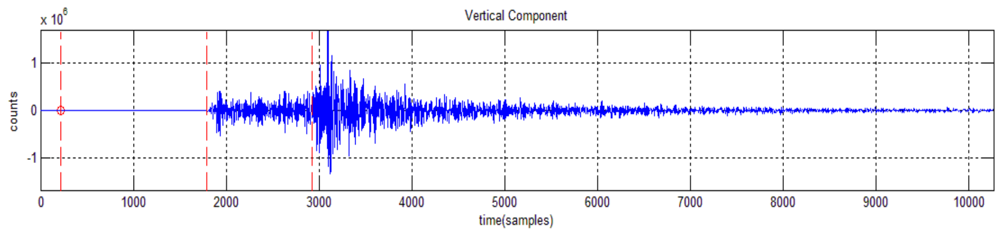
Then plot of time series appear along with marker prompted for graphical input:
MARK APPROXIMATE POSITION OF P and S onset



Then press enter and again zoomed window will appear along with marker prompted for graphical input
NOW pick P and S onsets precisely



The position of P and S onsets will be required to estimate origin time and lapse (travelled) time for coda waves.
Origin Time = tp – 1.38 [ts-tp]



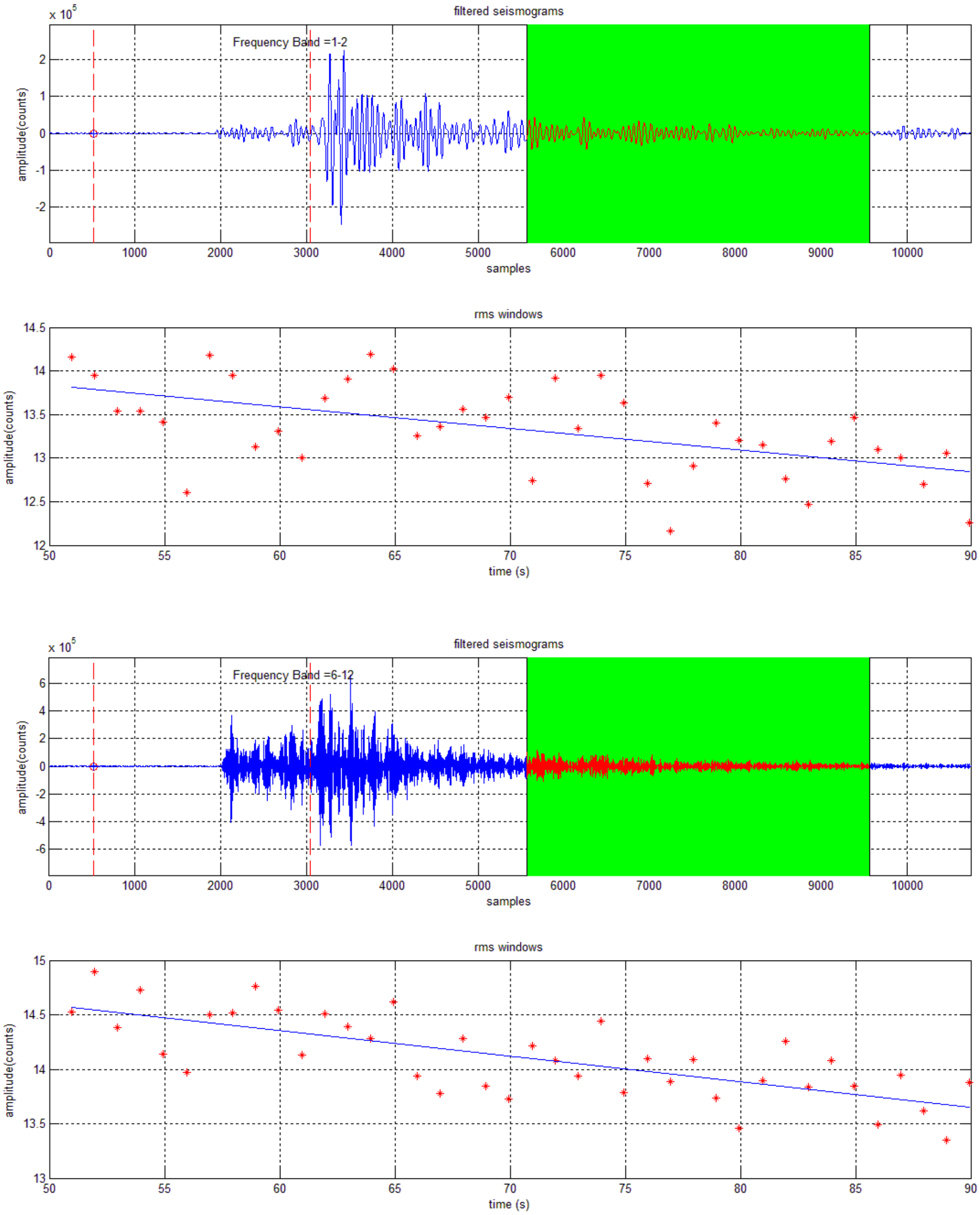
The input time history has been band-pass filtered with Butterworth filter at various central frequencies. The filtered time history has been stored in output file "filterout.txt" in columns, each column corresponds to central frequency defined.

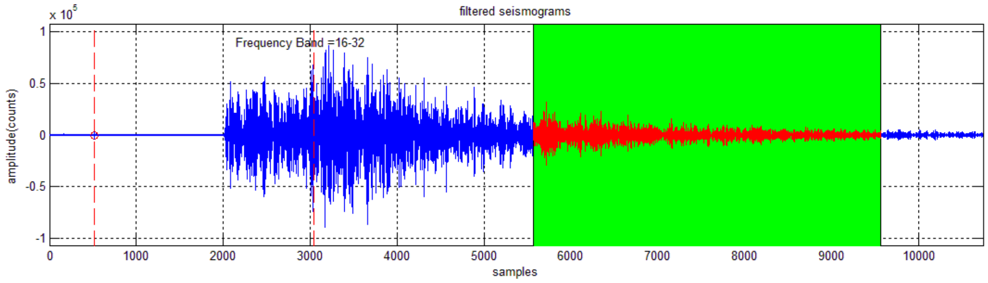
For each filtered time history signal has been chosen from TC (Coda arrival) to TC+window length (e.g., 20, 30 or 40 seconds). Then amplitudes has been multiplied by 't^{β}' to account for geometrical spreading (β=1 for local earthquakes).

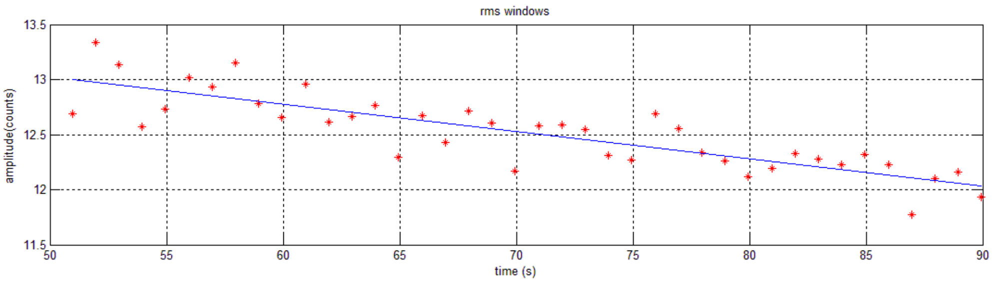
Then plot of log(Amp*t) vs t gives

$$b = \frac{-\pi f_c}{Q_c}$$

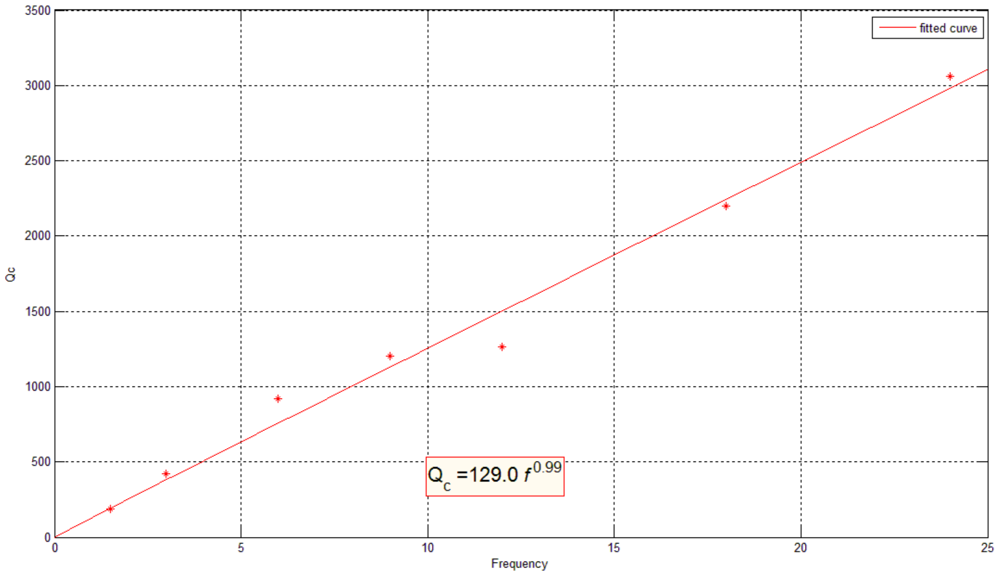
Where b=slope of straight line fitted, f_c is central frequency.


filtered seismograms
x 10^5
Frequency Band =1-2
amplitude(counts)
samples
rms windows
amplitude(counts)
time (s)
filtered seismograms
x 10^5
Frequency Band =6-12
amplitude(counts)
samples
rms windows
amplitude(counts)
time (s)





Final value of $Q_c(f)$ will be obtained by fitting power function to f_c vs Q_c:



The obtained frequency dependent relationship 129 $f^{0.99}$ is similar to 126 $f^{0.94}$ estimated by Gupta et. al. (1995).

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