



# CRISP DB INGV 2021- Seismic Analysis

This document reports the standard analysis performed routinely and archived in the section Seismology.

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Note: all the parameters here reported are to be considered as indicative, the values actually used depend on the available data and the analyst experience.

## 1. Continuous HV Earthquake Analysis - HVEQ

The continuous HV earthquake analysis is executed with an automatic unix script based on Geopsy software ([www.geopsy.org](http://www.geopsy.org); Wathelet et al. 2020). The Italian seismic Bulletin (<http://terremoti.ingv.it/en/bsi>) provides the list of events that are downloaded from continuous seismic data of permanent stations by means of webservices (<http://eida.ingv.it>). The spectral ratio for each event is calculated on a 6 seconds window length starting from the theoretical arrival time of S-wave, according to the seismic ray theory applied to a 1D model corresponding to the area of interest (average of the Italian 3D model by Di Stefano & Ciaccio, 2014). The Signal-to-Noise Ratio (SNR) is chosen to remove the results coming from data with low signal-to-noise ratio but trying to keep a sufficient number of results necessary for their statistical treatment.

For each analysis, the script returns one-page report (Figure 1) with the following information:

- parameters used for analysis and event selection (n. of earthquake, minimum SNR, time range, magnitude range, distances, smoothing type, smoothing width, minimum reliable frequency);
- frequency and amplitude values of the fundamental frequency ( $f_0$ ,  $A_0$ );
- map with the number and distribution of selected earthquakes;
- image with the HV curves for each selected event (color scale proportional to the SNR ratio), and the smoothed geometric mean with relative standard deviation.

Details on the procedure can be found in Vassallo et al. (2022).



Number of earthquakes used for the analysis: 27  
Minimum signal to noise ratio: 10.0  
Time range: 2016-06-28 02:33:43 - 2021-06-22 16:37:04  
Magnitude range: 1.0 - 3.9  
Range of distances from station: 0.6 - 143.9 km  
Smoothing type: KonnoOhmachi  
Smoothing width<sup>(1)</sup>: 20%  
Minimum reliable frequency: 0.5  
 $f_0^{(2)}$  (Hz): 1.52  
 $A_0$ : 7.13

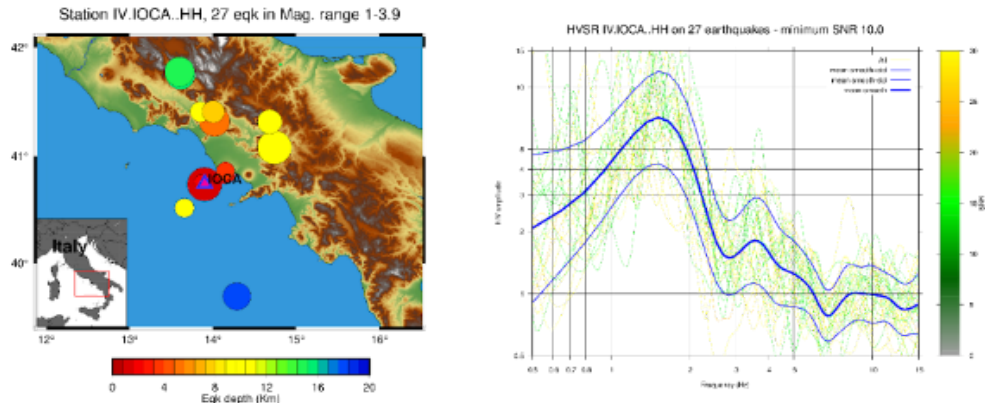


Figure 1. Example of report for the H/V analysis on earthquakes from continuous recordings.

## 2. Continuous HV Noise Analysis - HVNOISE

The continuous HV noise analysis is executed with an automatic unix script based on Geopsy software ([www.geopsy.org](http://www.geopsy.org); Wathelet et al. 2020). Continuous seismic data of permanent stations are downloaded for a selected time interval by means of webservices (<http://eida.ingv.it>) and daily H/V curves are obtained as an average of 60-sec windows on a day-long record (86.400 sec).

For the analysed time interval, the script returns one-page report (Figure 2) with the following information:

- input parameters (start day, n. of used days, dayling recording duration, window length, minimum reliable frequency, total n. of windows, taper type, taper width, smoothing type, smoothing width, composition of horizontal components);
- frequency and amplitude values of the fundamental frequency ( $f_0$ ,  $A_0$ );
- image showing the contour plot of the H/V amplitude as a function of time and frequency, where the colour scale is proportional to the spectral ratios amplitude;
- image with the daily H/V curves together with the overall average  $\pm 1$  standard deviation.

Details on the procedure can be found in Vassallo et al. (2022).



Start date: 2016-01-01T00:00:00  
Number of days used: 1766  
Daily recording duration<sup>(1)</sup> (sec): 86400  
Window length (sec): 60  
Minimum reliable frequency: 0.1  
Total number of windows: 2490610  
Taper type: Tukey  
Taper width: 5%  
Smoothing type: KonnoOhmachi  
Smoothing width<sup>(2)</sup>: 20%  
Composition of the horizontal components: Vectorial sum  
 $f_0$ <sup>(3)</sup> (Hz): 0.26  
 $A_0$ : 2.19

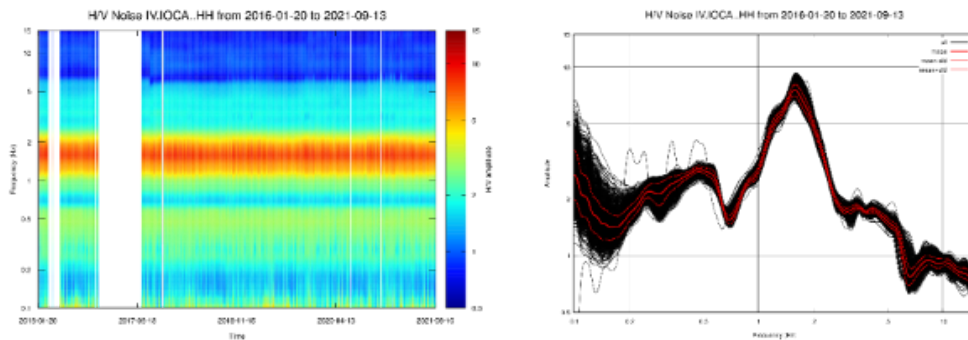


Figure 2. Example of report for the H/V analysis on continuous noise recordings.

### 3. Parameters for Noise analysis - HVNOISE

Software: Geopsy 2.4.1 (<http://www.geopsy.org>):

Input parameters: window length: 120 - 30 sec (depending on record length available)  
no overlap  
Smoothing Konno-Ohmachi,  $b=40$   
Tapering cos 5%  
AntiTrigger - STA=1s, LTA=30s, Min STA/LTA= 0.2, Max STA/LTA=2.5  
minimum selected windows number after the antitrigger for the analysis: 60

Analysis execution on 12 daily tracks, one per month, to evaluate seasonal daily and random variation.

#### Criteria for signal amplification:

Amplitude peaks are reported if  $A \geq 2$ .

### 4. Parameters for Polarization analysis - SIGNAL POLARIZATION

Executed if rotational analyses with Geopsy software evidence polarized behavior.

Software: Wavopol (Covariance matrix method, Burjaneek et al., 2010)



*Input parameters:* record used on HV noise analysis  
frequency range 0.1-20.0 Hz  
histograms bins: 72 for strike and dip, 50 for ellipticity

**Criteria for polarization detection:**

In order to discriminate peaks associated with directional ground motion, following the method proposed by Pischiutta et al. (2018), we consider the function  $B(f)$  representing the ratio between minimum and maximum value of the HVSR curves ( $A_{\text{MIN}}(f)$  and  $A_{\text{MAX}}(f)$ , respectively). Based on our practice and common experience with directional amplification effects, we set as a threshold for  $B(f)$  the value 1.5 as follow:

$$B(f) = \left\{ \frac{MaxHV(f)}{MinHV(f)} \geq 1.5 \rightarrow \text{directional amplification}, \frac{MaxHV(f)}{MinHV(f)} < 1.5 \rightarrow \text{not directional amplification} \right.$$

The frequency band of directional amplification is the portion of  $C(f)$  where two conditions are satisfied:

$$1. \quad C(f) > \overline{C(f)} \qquad 2. \quad A_{MAX} > 2$$

where:

$$C(f) = \frac{MaxHV(f)^2}{MinHV(f)}$$

and  $\overline{C(f)}$  is its average value over the frequency band 1-15 Hz.