

Ambient Vibration H/V Spectral Ratio (HVSR) Method Data Analysis and Archival Guidelines



QuakeCoRE Technology Platform 2

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Pre-Analysis Data Preparation

List of required items

- SD cards from the Nanometrics portable broadband seismometers
- A computer

List of required software

- Python 2.7 with the Scipy stack and the Obspy package.
- “reducemseedHVSr.py”

The Centaur data loggers are configured to continuously archive the data. At the end of each hour, a data file in the miniseed format is created and stored on the removable SD card. If tests are completed at multiple sites within a day, the Centaur data logger may be continuously powered. At the end of the day, the Centaur should be powered off and multiple miniseed data files will have been created (one for each hour). These hour-long data files need to be merged together and then sliced into individual files containing the data of interest for each test/site. These sliced data files are used for HVSr processing.

Step-by-step instruction for merging and slicing the test data

- 1) Copy the test data from the SD cards to a local hard drive, keeping them in one folder for each instrument. The data will be organized by date with an individual miniseed file for each hour the Centaur data logger was powered on. Note that the Centaur data logger references the data to Coordinated Universal Time (UTC), as obtained via GPS, not local time (e.g., NZST or NZDT). For a field work day in NZ, the raw data likely will be logged over two consecutive UTC days and should be put into a single folder for merging and slicing, as shown in the figure below.

Name	Date modified	Type	Size
UC.S02_centaur-3_1912_20180828_180000.miniseed	28/08/2018 7:00 PM	MINISEED File	54 KB
UC.S02_centaur-3_1912_20180828_190000.miniseed	28/08/2018 8:00 PM	MINISEED File	1,316 KB
UC.S02_centaur-3_1912_20180828_200000.miniseed	28/08/2018 9:00 PM	MINISEED File	1,311 KB
UC.S02_centaur-3_1912_20180828_210000.miniseed	28/08/2018 10:00 PM	MINISEED File	1,313 KB
UC.S02_centaur-3_1912_20180828_220000.miniseed	28/08/2018 11:00 PM	MINISEED File	1,597 KB
UC.S02_centaur-3_1912_20180828_230000.miniseed	29/08/2018 12:00 AM	MINISEED File	1,747 KB
UC.S02_centaur-3_1912_20180829_000000.miniseed	29/08/2018 1:00 AM	MINISEED File	2,039 KB
UC.S02_centaur-3_1912_20180829_010000.miniseed	29/08/2018 2:00 AM	MINISEED File	1,823 KB
UC.S02_centaur-3_1912_20180829_020000.miniseed	29/08/2018 3:00 AM	MINISEED File	1,948 KB
UC.S02_centaur-3_1912_20180829_030000.miniseed	29/08/2018 4:00 AM	MINISEED File	1,833 KB
UC.S02_centaur-3_1912_20180829_040000.miniseed	29/08/2018 5:00 AM	MINISEED File	1,889 KB
UC.S02_centaur-3_1912_20180829_050000.miniseed	29/08/2018 6:00 AM	MINISEED File	1,748 KB
UC.S02_centaur-3_1912_20180829_060000.miniseed	29/08/2018 6:16 AM	MINISEED File	354 KB

Two Dates UTC
28/08/2018 UTC

28/09/2018 UTC

- 2) Copy “reducemseedHVSR.py” into the data folder(s), which may be downloaded from:

<https://github.com/ucgmsim/TechPlatform2>.

- 3) Create “testname.txt”, “starttime.txt”, and “endtime.txt” files, which contain the test/site name, the test start date and time, and test end date and time in plain text with one line per test/site. The site/test name should be limited or abbreviated to 3 or 4 letters (e.g.; LOC1, LOC2, and LOC3; or BGPK, ABRD, ALBT) and match the name noted on the field datasheet. The start and end dates and times need to be specified in reference to UTC, not local NZ time. An example of the format of the test name and the time (yyyymmddhhmmss) is shown below:

“testname.txt” BGPK ABRD	“starttime.txt” 20180828225000 20180829000500	“endtime.txt” 20180828232000 20180829003500
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- 4) In the command prompt, navigate to the data folder and run the following command:

```
python reducemseedHVSR.py
```

- 5) This will create a single file per test, which is automatically named using the station network name (e.g., UC) and station number (e.g., S02) which have been set in the Centaur data logger and site/test name or abbreviation (e.g., LOC1 or ARBD) as defined by you in “testname.txt”. Example files names appear as follows:

```
UC.S02.BGPK.miniseed  
UC.S02.ARBD.miniseed
```

Each file will contain three traces, one for each sensor component (i.e., vertical, horizontal north, and horizontal east).

- 6) The individual, sliced site/test miniseed files are the “raw data” used for data archival and used to compute the H/V spectral ratio.

H/V Spectral Ratio (HVSr) Processing Using Geopsy

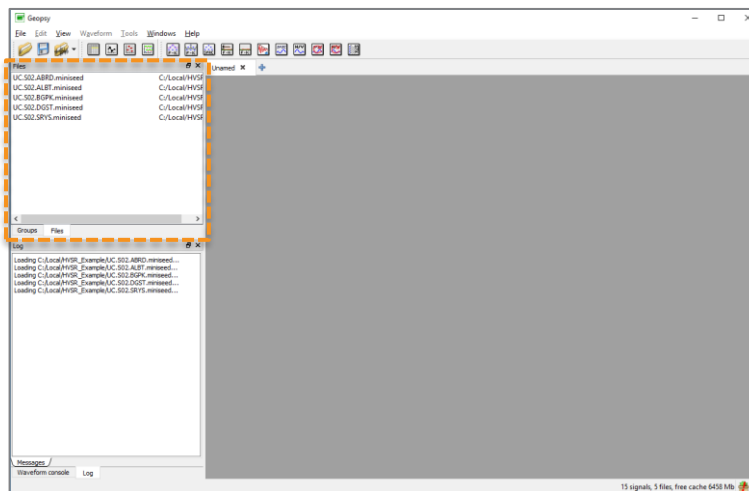
Geopsy is an open source software package for geophysical research and analysis which enables a quick assessment of the quality of the recorded data and HVSr processing. Here we focus on the use of Geopsy, however other methods are available to process this data.

List of required software

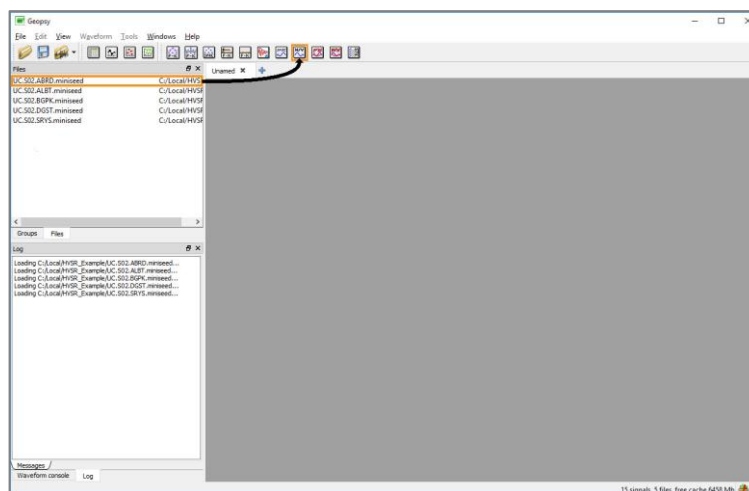
- Geopsy – www.geopsy.org

Step-by-step instruction

- 1) Load the measured ambient vibration data into Geopsy. This can be done by drag-and-dropping the sliced test miniseed files into the Geopsy window. When the files are successfully loaded, they will appear in the “Files” tab, as shown in the following figure.

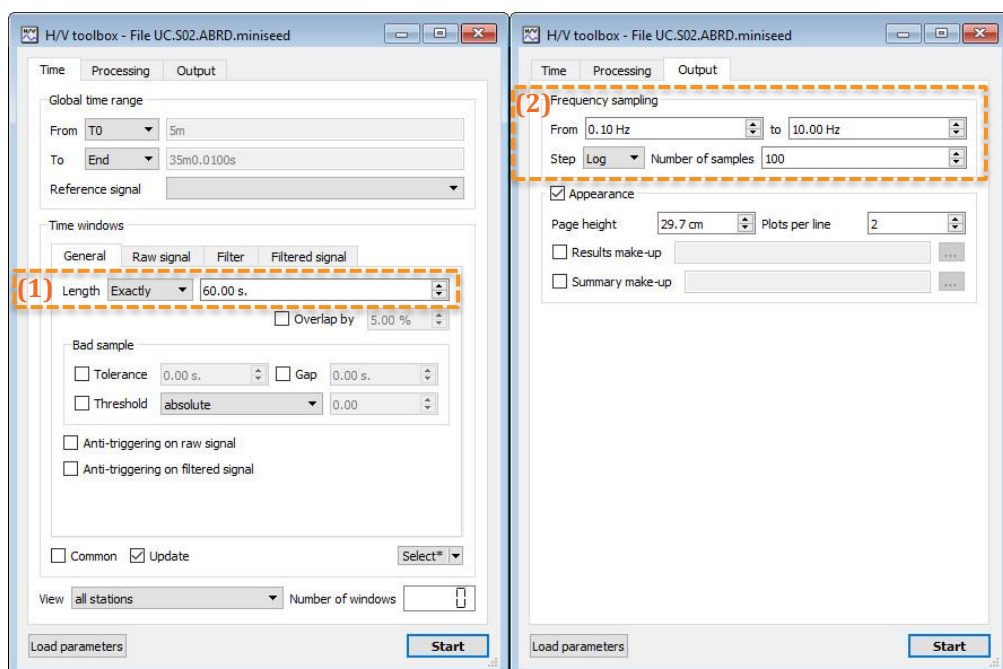


- 2) Select an individual test miniseed file from the “Files” tab, and drag it to the toolbar button labeled “H/V”.

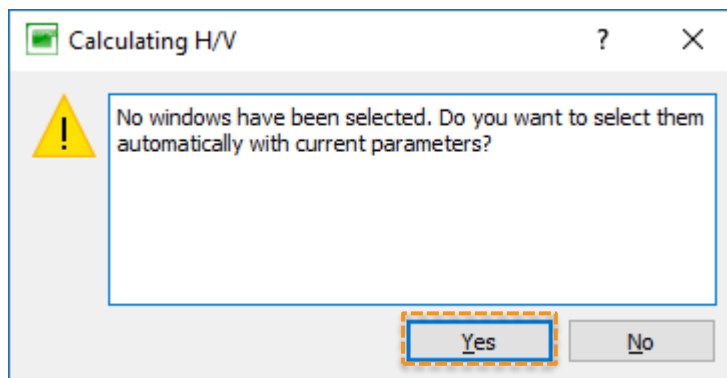


- 3) The analysis parameters are selected in the H/V toolbox settings. The appropriate parameterisation will vary depending on site characteristics and should be discussed with research collaborators.

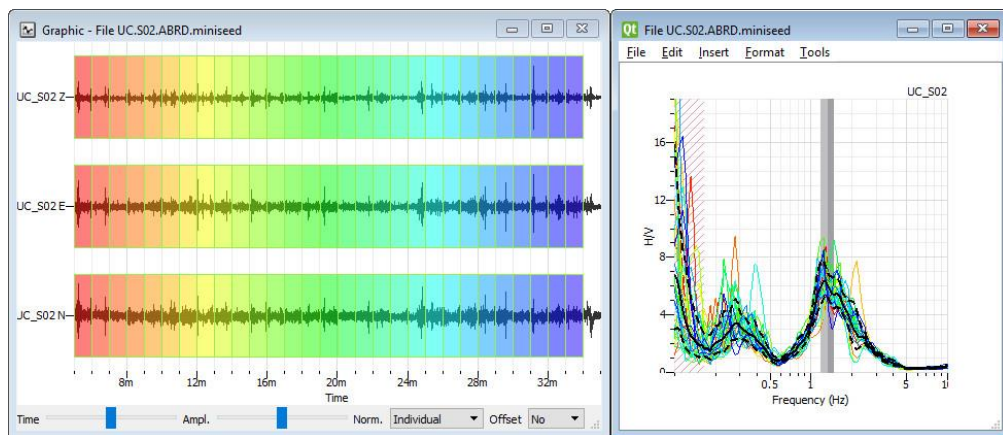
For a first level H/V analysis, only two parameters need to be changed (as shown in the figure below): (1) The time window *Length* should be changed to “**Exactly**” “**60.00s**”. (2) The *Frequency sampling* range should be specified *From* “**0.10 Hz**” to “**10.00 Hz**” with a “**Log**” *Step* over “**100**” *Number of samples*. Depending on site conditions and the length of the record, these values can and should be varied. Begin the analysis by clicking the “**Start**” button at the bottom of the “H/V toolbox” window.



- 4) Allow Geopsy to automatically select the time windows based on this parameterisation by clicking the “**Yes**” button.

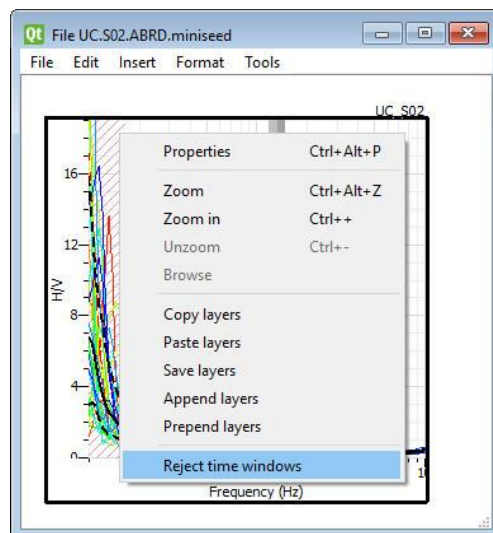


- 5) The windowed time records and the computed H/V curves with an automatically selected peak frequency are displayed after a brief processing period.

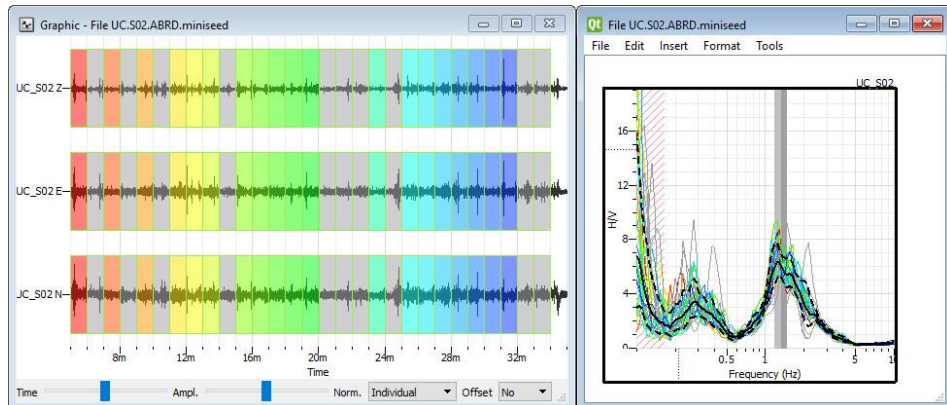


- 6) At this point it is possible to (a) remove bad time windows and (b) verify that the selected processing parameters makes sense.

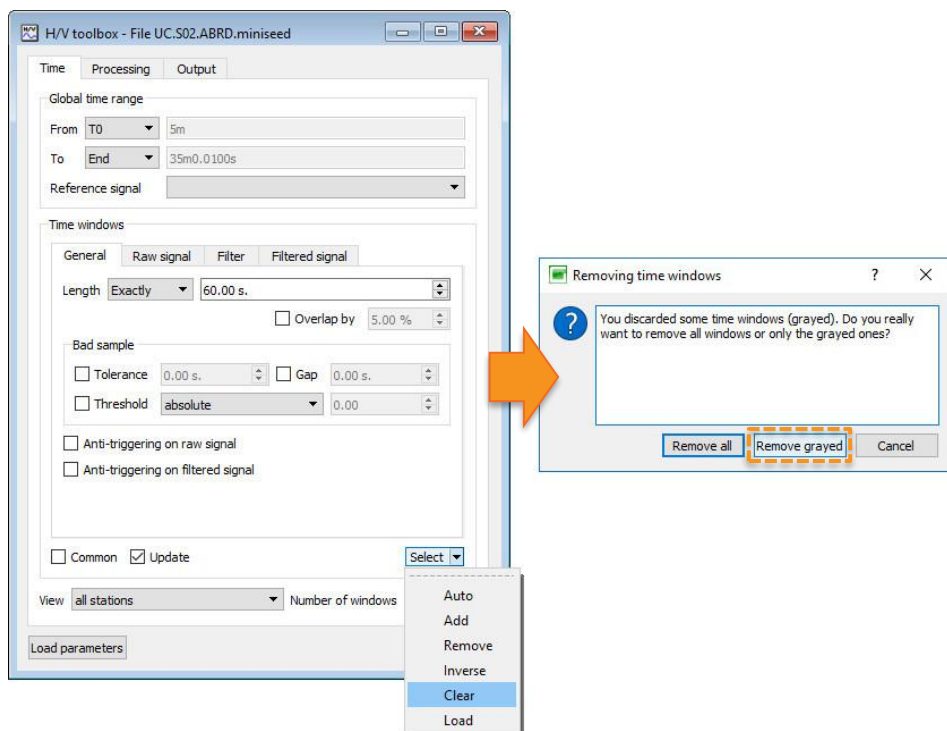
- a) “Bad” time windows which yield outlier H/V curves or contain excessive transient noise may be removed from the analysis. In the “H/V Results” window, *right click* anywhere on the plot and select “Reject time windows,” as shown in the figure below.



In the “H/V Results” window, click and drag over the specific time H/V curves to be removed. Both the H/V curve(s) and the corresponding time window(s) will be grayed out.



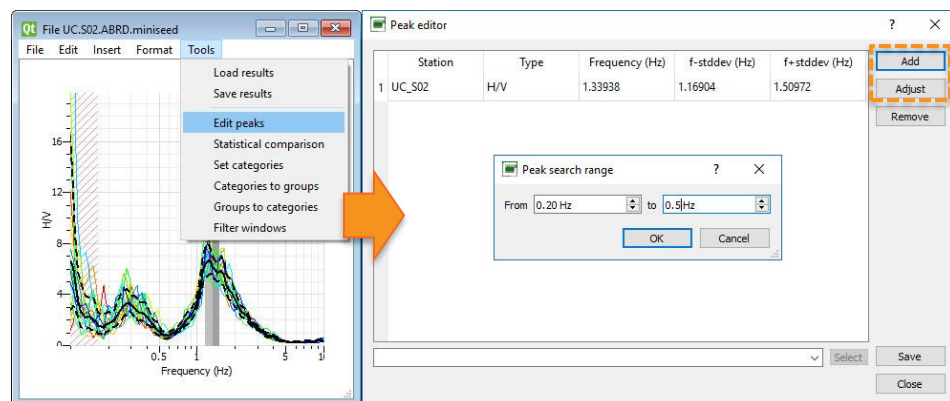
Once the all of the H/V curves and time windows to be removed have been selected and grayed out, in the “H/V toolbox” window → “Time” tab, *click* the “Select” dropdown menu and select the “Clear” option. In the pop-up “Removing time windows” window, click the “Remove grayed” button.



Once all the “bad” time windows have been removed, click “Start” in the “H/V Toolbox” to reprocess the data.

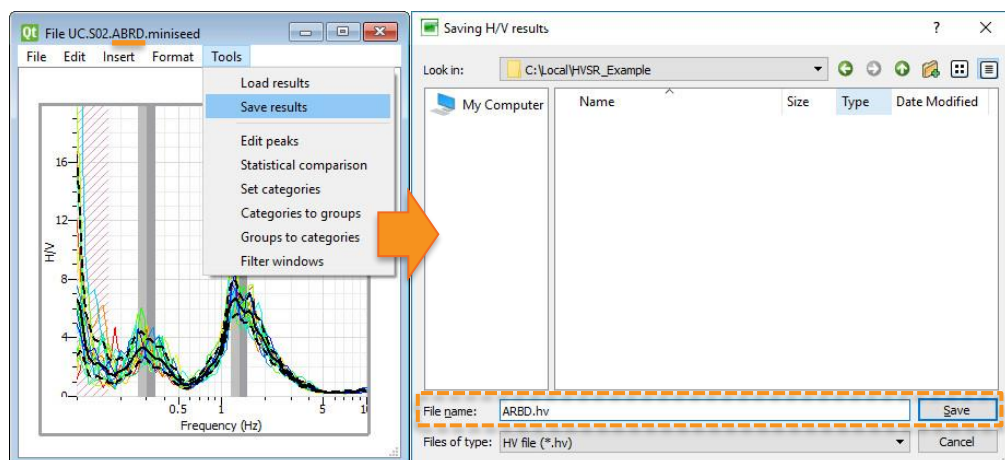
- b) Initially, H/V peak frequency is automatically picked. In order to manually adjust the frequency band for peak picking, click the “Tools” → “Edit peaks” menu in the “H/V Results” window. Select

the peak details in the table in the “Peak editor” window, and then click “**Adjust**”. The searchable frequency range from which the peak is identified may be defined in the pop-up window, effectively limiting peak selection. If multiple peaks are present, clicking the “**Add**” button in the Peak editor window will add a new line to the table which may also be adjusted, as described above. For this example, an additional lower-amplitude peak frequency is searched for and added between 0.20 Hz and 0.50 Hz.



- 7) The median and the confidence interval of computed H/V curves and the picked H/V peak details should be exported to a text (.hv) file by clicking the “Tools” menu → “Save results” option in the “H/V Results” window. The figure should also be saved using the “File” menu → “Export image” option.

For consistency and data archival purposes, the output text and image files should be named using the site abbreviation. For this example, the site abbreviation is “**ARBD**” and the text file is saved as “**ARBD.hv**”.



Reference:

<http://www.geopsy.org/documentation/geopsy/hv.html>

H/V Spectral Ratio (HVSr) Data Archival Guidelines

To support further research, it is important to carefully document and properly archive field testing data.

Each QuakeCoRE TP2 field testing project should be archived on the DesignSafe-CI (<https://www.designsafe-ci.org/>), in its own project folder. The main project folder should contain three items: (1) A project metadata file, (2) a RawData folder, and (3) a ProcessedData folder.

It is important for each individual test/site, that the three or four letter test/site name is consistent as listed in the metadata file, the raw miniseed data filename, and the associated processed data filenames.

Metadata Requirements

A single project metafile should be produced following the format outlined in the sample metadata file. This metadata will include the overall project details and the details for each individual HVSr test/site.

Raw H/V Test Data – Sliced Waveform Files

The sliced test/site miniseed files are the HVSr “raw data” to archive for use by other researchers interested in examining or reprocessing the data. Within a project data archive folder, all of site/test miniseed files should be placed together in a single “RawData” sub-folder, regardless of the field test date.

Analysed H/V Spectral Ratio Results – Text and Image Files

The processed HVSr data output from Geopsy includes two files: (1) the “.hv” text file with the frequency peak(s) and HVSr curve statistics, and (2) an image file with the processed HVSr curves and picked peaks indicated for quick visualization of the data. Each of these two files for each site/test should be placed together in the single “ProcessedData” project sub-folder.