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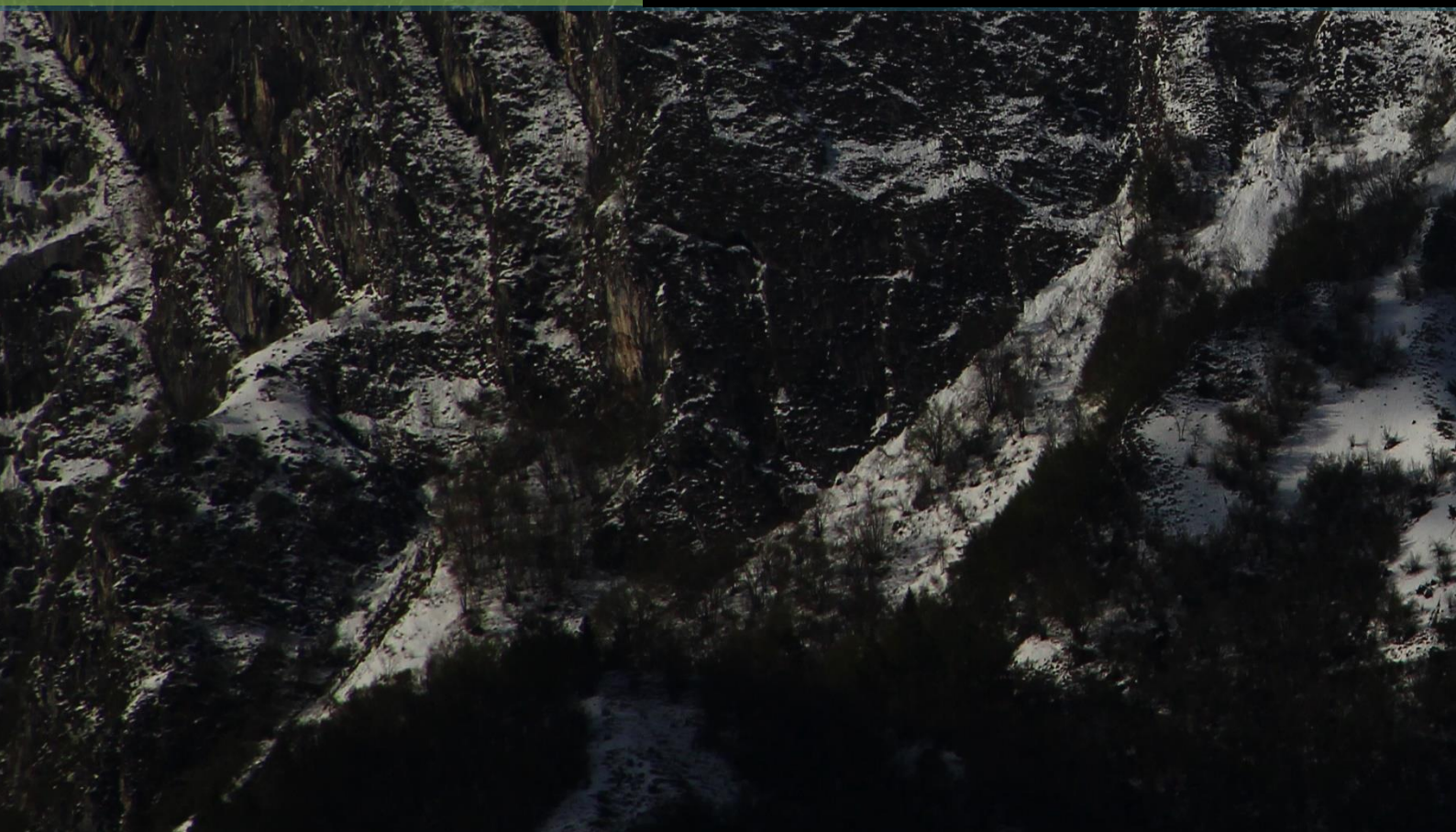

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Surface Waves & Beyond

Document	**Guidelines_for_seismic_acquisitions_and_winMASW_fact_sheet.pdf**
Last modified	**December 2020**

ELIOSOFT - GEOPHYSICAL SOFTWARE AND SERVICES

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WE PROVIDE

Fully-equipped **ACQUISITION SYSTEMS** (seismographs, seismic cables, geophones etc.) optimized for the efficient acquisition of multi-component holistic seismic data

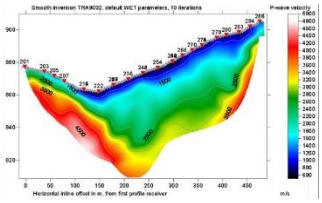
SOFTWARE APPLICATIONS

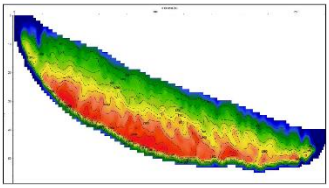
HoliSurface®
Holistic analysis of surface waves and vibration data

winMASW®
surface waves and beyond

VSP ELIOSOFT
DownHole seismics

RayFract





ReflexW

DATA PROCESSING for your seismic data (see e.g. our ADAM2D service)

This document consists of two sections that we recommend to carefully read:

1. Basic guidelines for seismic acquisitions for multi-component MASW, ReMi, ESAC and HVSR

2. winMASW® fact sheet (presentation of the different versions of winMASW®) with the general selling conditions for our software applcations

In case you already have an acquisition system (seismograph etc.), please, indicate the geophones you have (vertical, horizontal and/or 3-component).

In case you do not have a seismograph (acquisition system), please clearly state that.

If you already have some of our products and are interested in an **update/upgrade**, please specify your current software (version and release – for instance, "I have winMASW standard 6.0 and I would like to upgrade to *winMASW*-3C or *Academy*, so I also need 12 horizontal geophones").

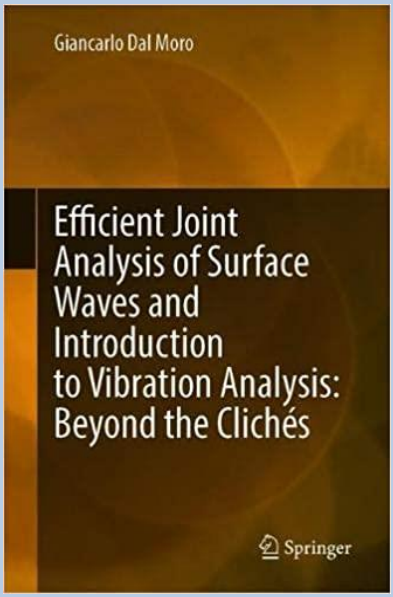
The winMASW® software is available in different versions (see following pages) and it is important to clearly identify the version that better suits your needs (in any case the "minimum" version we recommend is the 3C).

This means that, if you just write us something like "I want to know the price of winMASW", we cannot help you.

1. Basic guidelines for multi-component MASW, ReMi, ESAC and HVSR acquisitions (with a note on seismic refraction)

If you think that the HVSR represents the amplification curve and the resonance frequency and if you think that "MASW" means deploying a series of vertical geophones, interpret and pick the modal dispersion curve(s) and "invert" it/them you need to read these two books.

Theory, practice and case studies about state-of-the-art surface wave and vibration data acquisition and analysis:

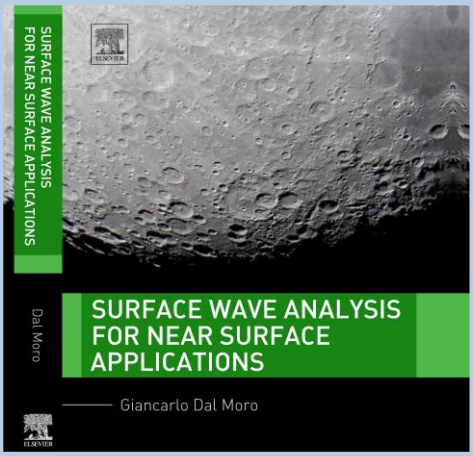


Efficient Joint Analysis of Surface Waves and Introduction to vibration Analysis: Beyond the Clichés

G. Dal Moro, 2020, Springer, ISBN 978-3-030-46303-8

266 pages, over 200 illustrations in color

CLICK HERE for more information.



Surface Wave Analysis for Near Surface Applications

G. Dal Moro, 2014, Elsevier, ISBN 978-0-12-800770-9

252 pages

Theory, field practice and advanced joint analysis

These books can be provided together with *winMASW*® *Academy* and/or *HoliSurface*®

FOREWORD

The present document cannot be considered as exhaustive of the topic. What we need to know (both during field operations and in the data processing/analysis) can be fully understood only through a balanced synergy between a solid *theoretical background* and a *long field practice*.

INTRODUCTION

The acronym MASW stands for *Multi-channel Analysis of Surface Waves* and that clearly means that our aim is to analyze Surface Wave (SW) propagation in order to determine their dispersive properties (which will eventually allow us to reconstruct the vertical V_S profile).

The basic principle is that the lower the frequency (i.e. the longer the wavelength) the deeper the penetration (this is why we need 4.5Hz geophones). As, in most of the cases, deep layers are characterized by higher V_S velocities this will mirror in higher SW phase velocities for the low frequencies.

Please, notice that SW propagation depends mainly on V_S and thickness of the layers, being density and V_P almost irrelevant.

The so-to-speak standard MASW exploits Rayleigh-wave propagation (see Figures 1 and 2 to see how to generate and record Rayleigh waves) but **we strongly suggest to generate, record and jointly analyze Love waves as well**. This way, data interpretation (thus the final V_S profile) will be much more robust also avoiding possible errors in Rayleigh-wave spectra interpretation. In fact, Rayleigh-wave spectra can be very problematic to interpret (see e.g. Safani et al. 2005; Dal Moro and Ferigo 2011; Dal Moro 2012, 2014, 2019, 2020), while Love waves are much simpler.

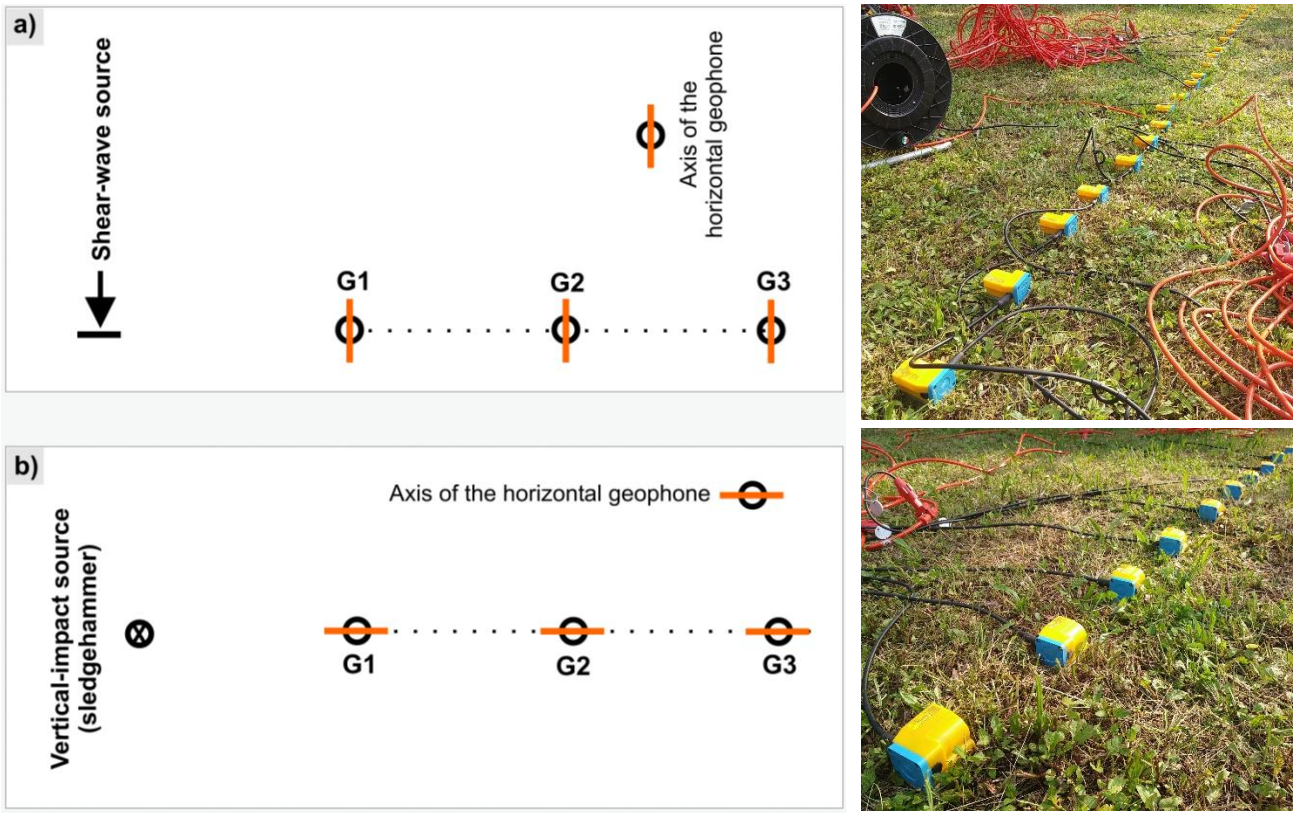
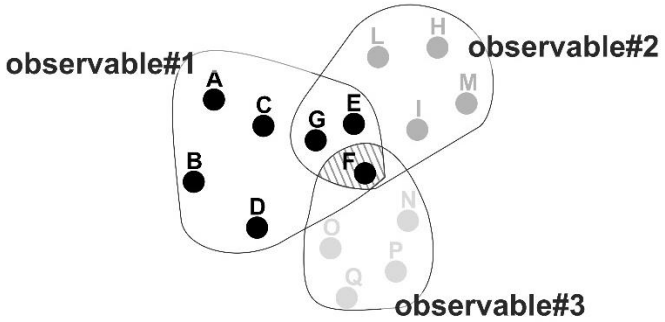


Figure 2. Data acquisition <u>using only horizontal geophones</u>: a) geophone array for SH-wave refraction and Love-wave analysis; **b)** geophone array for Rayleigh-wave analyses (radial component). Of course, Rayleigh waves can be detected using also vertical geophones but in case you are using horizontal geophones, you can record both Rayleigh (their radial component) and Love waves and, therefore, you can jointly analyze them and obtain a much more reliable V_S profile.

Compared to Rayleigh waves (which can be extremely complex to understand), **<u>Love waves</u>** are much simpler and, therefore, represent an **extremely** useful tool for getting a more robust data interpretation and, consequently, a reliable vertical V_S profile (see our Elsevier and Springer books).

Dealing with Love waves is quite simple: the procedure to generate and record them is the same used for the acquisitions of the data used for SH-wave refraction studies.

Our software applications are designed in order to solve this problem. This is accomplished though the joint analysis of several components/objects, so to obtain a final model (the V_S profile) free from major ambiguities (otherwise inevitable).
A simple **conceptual scheme** will clarify this critical point (for details and synthetic and real-world example see our books published by *Elsevier* and *Springer*).
Let us imagine we are considering three different observables (e.g. the Rayleigh-wave velocity spectrum, the Love-wave velocity spectrum and the HVSR curve).



In case we would use only the method/dataset A (e.g. the Rayleigh-wave velocity spectrum), the possible solutions would be the A, B, C, D, E, F and G models.
In case we would use only the method/dataset B (e.g. the Love-wave velocity spectrum), the possible solutions would be the G, E, F, L, I, M and H models.
In case we would use only the method/dataset C (e.g. the HVSR curve), the possible solutions would be the F, O, N, Q and P models.

It is clear that the only model which is consistent with all the three considered methods/datasets is the model F.

Only through the joint analysis of several *observables* you can obtain the right model (in this case labelled as F), which is consistent with all the considered data/methods.
A concrete/simple example is the joint analysis of Rayleigh and Love waves (recorded by using just 12 horizontal geophones – see *Guidelines for the data acquisition*) jointly with the HVSR.

A SIMPLE BUT CRUCIAL RECOMMENDATION

In order to determine a reliable V_S profile and avoid pitfalls and data misinterpretation, just use just 12 (twelve) horizontal geophones and jointly analyse the radial component of Rayleigh and Love waves.

The joint acquisition and analysis of MASW (Rayleigh and Love) and HVSR is the suggested procedure (see the guidelines provided in the following pages).

Please, strictly follow the recommendations reported in this document

Please, notice that just by rotating the horizontal geophones by 90° it is possible (just using horizontal geophones) acquiring datasets useful both for Rayleigh and Love analyses (see Fig. 2). In other words and by **using only a set of horizontal geophones**:

1) **Love waves:** place the horizontal geophones with the axis perpendicular to the array (Figure 2a) and use a shear-wave source (see wooden been in Figure 3);

2) **Rayleigh waves (radial component):** rotate the horizontal geophones by 90° (so now the axis is parallel to the array - Figure 2b) and hit your plate vertically (vertical-impact sledgehammer).

Now we have two datasets (one about Rayleigh and one about Love waves) and your analysis will strongly benefit from it.

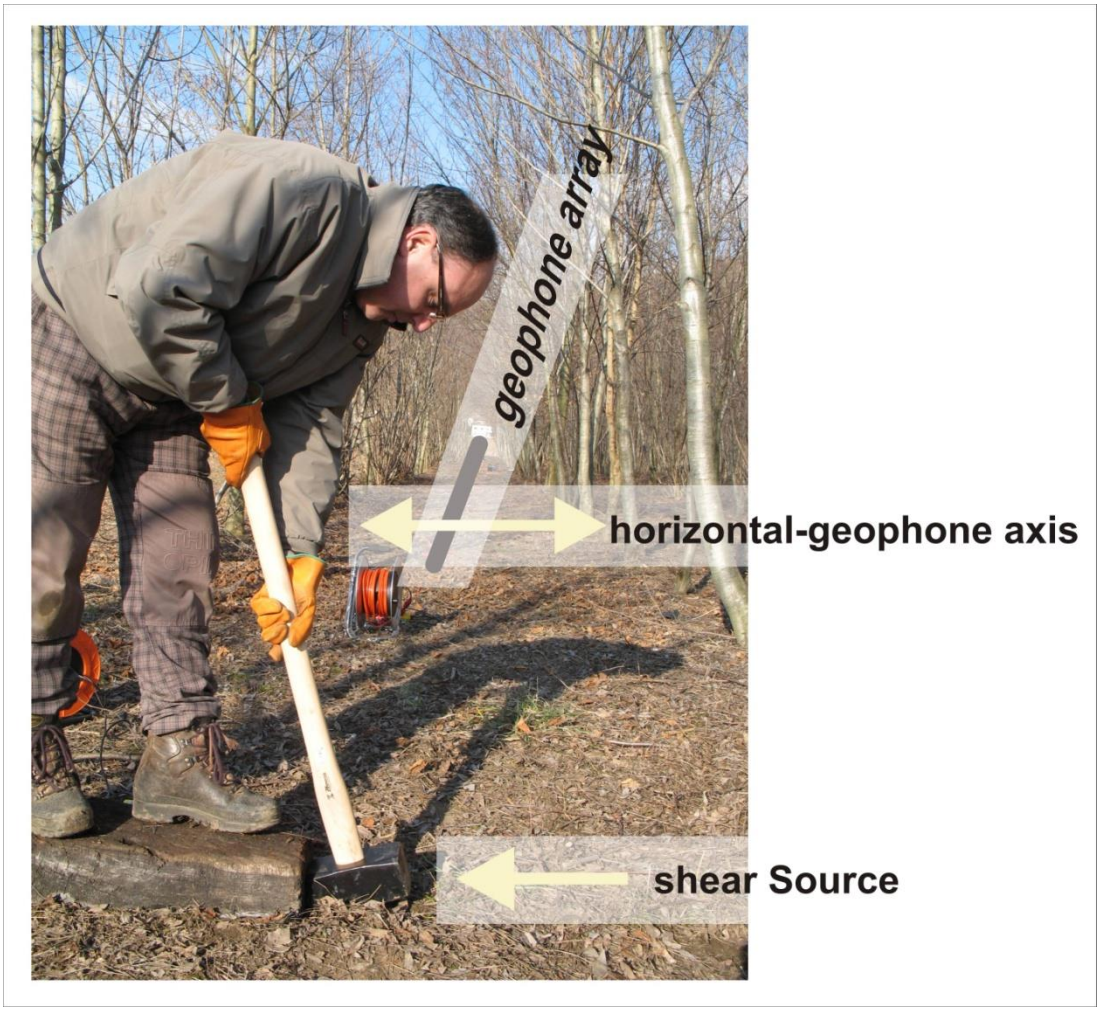


Figure 3. Data acquisition for SH-wave refraction travel time determination and Love-wave dispersion analysis (shear source and geophone-axis perpendicular to the array – see also Figure 2).

MASW acquisition: Rayleigh and Love waves

The geometry is very simple (see Figure 1). Remember that, **in order to get good data in the low-frequency range (related to the deepest layers) it is important to have an *array* as long as possible. Geophone spacing is quite irrelevant:** just take advantage of all the space available and spread the *array* accordingly.
For instance: if the available space is 75 meters and you have 12 geophones, then you can fix the geophone distance equal to 6 m and a minimum offset of 9 m.

Tab 1. **Summary table for MASW acquisitions: main facts**

***minimum offset* (mo): distance between source and first geophone**	5-20 m Suggestion: you could acquire a couple of datasets by moving the source so to have 2 dataset with two different minimum offsets. You will choose the best dataset while analyzing the data.
geophone spacing (dx)	The point is the following: the length of the geophone array must be as long as possible. If the available space is for instance 75 meters and you have 24 geophones, then you can fix the geophone distance equal to 3m (with a minim offset distance equal to 5 m)
geophones (4.5 Hz)	Rayleigh waves: vertical or horizontal (axis radial to the array) Love waves: horizontal perpendicular to the array (see Figures 2 and 3) **For active (MASW) data, we strongly recommend to buy just 12 horizontal 4.5Hz geophones to acquire both Love and Rayleigh (radial component) waves.** **For details, please see the Elsevier book "*Surface Wave Analysis for Near Surface Applications* ".**
record time/length (s)	2 seconds are usually enough (it is essential that the full surface wave trend is entirely recorded even at the very last channel)
number of channels/geophones	12-24 Less channels are sometimes sufficient The crucial point is anyway the total length of the array, possibly not less than say 50 meters, much better 70-90 meters (to reach the suggested length just act by modifying the geophone distance)
***dt* (sampling rate)**	0.001s (1 ms, 1 millisecond)
stack	The more, the better. It depends on the length of the array and on the amount of noise in the investigated area. Never less than 5 and even up to 20 in case of long arrays and noisy (e.g. urban or industrial) areas.
Important notes	No AGC (*Automatic Gain Control*) No filter Keep the same gain for all the channels. Be careful: avoid saturation (see later on)

Gain

The amplification/gain should be the same for all the channels. This is not mandatory if you just need to deal with SW dispersion analyses (to estimate the V_S vertical profile). It is mandatory only to analyze seismic attenuation to estimate quality factors Q through Rayleigh-wave attenuation analysis for the very shallow part (say down to a depth of 10 meters).
Of course, in some case (if the site very noisy and the soil very attenuating) you might be forced to increase the amplification/gain of the distant offsets/channels (this is especially necessary when dealing with refraction studies where the amplitude of the first arrivals can be very small).

In case you want to analyze Surface Waves, it is mandatory to avoid trace saturation/clipping (see Figure 4). In case your traces are saturated, just decrease the gain until you obtain a dataset similar to the one shown in Figure 5.

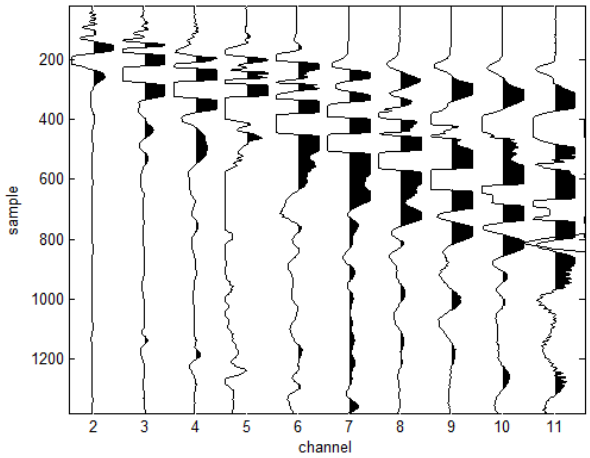


Figure 4. **Dataset characterized by trace clipping** (the amplitude is too high for the dynamic range of the seismograph: gain must be decreased).

Of course, in case just 1 or 2 traces (out of 24) are clipped there is no problem!
Figure 5 reports an example of correct gain: no trace is clipped and the signal-to-noise ratio is good even for the distant offsets.

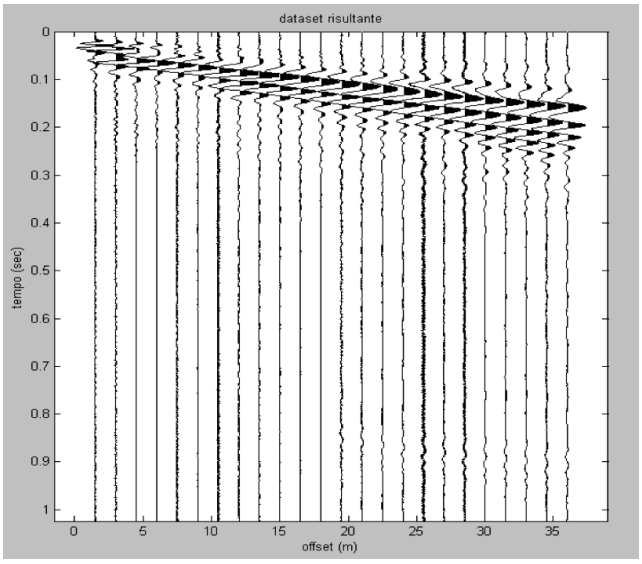


Figure 5. **Dataset with a correct amplitude** (gain values set to a correct value).

Combining 2 datasets (to double the number of channels)

In case you have a 12-channel seismograph and want to have a 24-channel acquisition (in general terms you can double the channels of your seismograph) **you can perform a double acquisition on the field and eventually proceed in their combination through the *winMASW*® software**
There are **three possible procedures to do that** (see Figure 6). **The first method reported (Figure 6a) is definitely the best one in terms of field procedures and accuracy of the dataset.**
Clearly, such a trick is not possible for passive acquisitions.

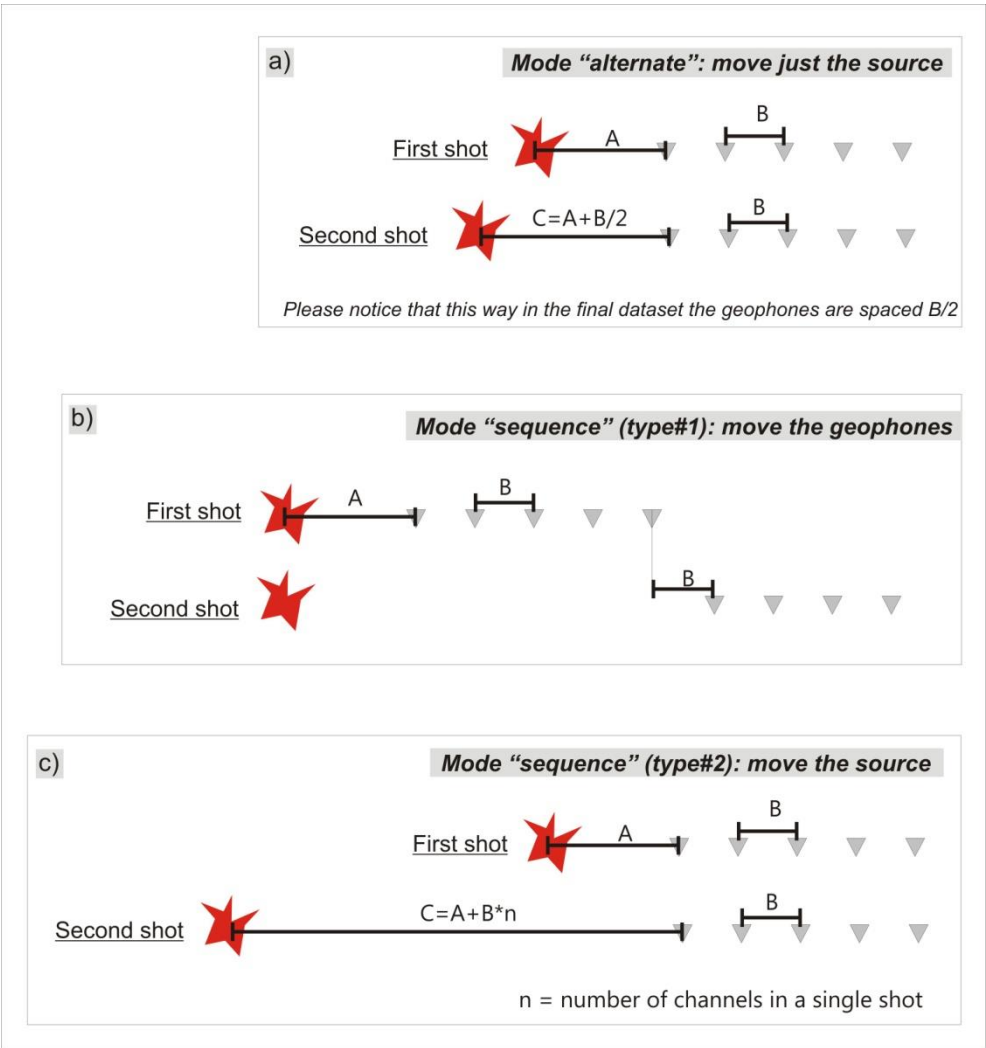


Figure 6. Three ways to combine 2 *datasets* (to obtain a final dataset with double number of channels).

A couple of notes on the process of *dataset* combination:

1. Clearly, the **combination of two or more datasets is useful for any kind of seismic study (reflection and refraction as well).**
2. A ***dataset* got from the combination of two datasets** (to double the number of channels) **is perfectly fine for most of the possible analyses** (reflection, refraction, SW dispersion analysis) **but not for attenuation** (aimed at evaluating the quality factors Q) studies.

Acquiring data for ReMi analyses (for Rayleigh-wave analyses only)

Few important points:

1. the **geophone array should be as long as possible** (not less than say 69 m – i.e. 24 geophones spaced each 3 m or 12 geophones 6 m spaced).
2. **vertical 4.5Hz geophones** (ReMi acquisitions only allow for Rayleigh-wave analyses – for this kind of (passive) acquisitions horizontal geophones can be used by with some cautions).
3. **record time: 10-20 minutes**
4. **sampling rate: 4 msec**
5. **in case there is a particular source of "noise"** (such as a motorway or an industrial facility) **orientate your geophone array perpendicular to it.**

ESAC (Extended Spatial Auto-Correlation)

It is the "generalized" (i.e. more flexible) version of the SPAC methodology and should be preferred to any other passive methodology for the definition of the dispersive properties (definitely much better than ReMi).

For details download the *winMAW*® manual:
http://download.winmasw.com/documents/manual_winMASW_eng.pdf

HVSR acquisitions

You need a calibrated 3-component geophone (that we can provide you – see below)

Just a couple of recommendations (further details in our books):

1. **record time: 10-30 minutes** (depending on the lowest frequency we are interested in)
2. **sampling rate: 8 msec** (125 Hz)
3. **recommended** (standard) **format: first trace UD** (vertical), **second trace NS** component, **third trace EW** component

HERE an **example of HVSR analysis in *winMASW*® and *HoliSurface*®**

Please, consider that we provide 3C geophones and software applications also for the following applications (see our HoliSurface® software application):

☑ **ACTIVE SEISMIC: *HoliSurface*® acquisition/analysis (patented method)**
☑ **VIBRATION MEASUREMENTS: site construction monitoring**
☑ **VIBRATION MEASUREMENTS: determination of the *eigenmodes* (vibration frequencies and determination of the motion – flexural/torsional) of a building/structure**

HOLI3C GEOPHONE DATASHEET

YOU RECORD, WE ANALYZE

If you send us your data for **MASW/ReMi/ESAC/SPAC/MAAM/HoliSurface and HVSR analyses**, **please remember to provide us the necessary information about the data (geophone distance *dx*, minimum offset *mo* [i.e. the distance between the source and the first geophone], etc).**

The best way to do that is to use the file naming described in the **Elsevier book** (see **paragraph 2.2**)

If you acquired your data for passive analyses (ESAC/SPAC/ReMi/HVSR/MAAM), please indicate the orientation of the array with respect to main noise sources such as streets, industrial facilities etc.

It is also necessary to provide us with some **information about the stratigraphy.**

Please, also provide us with a photo with the GPS coordinates of the site.
If you use your smartphone and the App ***MapCam*** or *GPS Map Camera*], the GPS information (Latitude, Longitude, Altitude) is automatically reported in the output report.

MapCam **GPS Map Camera** **Action cameras** **Drones**

<u>Please, keep in mind that</u>:

if you want to have a reliable V_S profile we strongly recommend you the acquisition and analysis of three *observables*:

Rayleigh waves + Love waves + HVSR

Therefore, we usually expect 4 seismic files (let us imagine *dx* is 4 m and *mo* 8 m):

- RVF_dx4_mo8 (for the radial component of Rayleigh waves)
- THF_dx4_mo8 (for the transversal component,. i.e. Love waves)
- HVSR#1 [passive dataset in the middle of the array]
- HVSR#2 [passive dataset in another point along the array]

In addition: a couple of photos of the site/array and some info about the stratigraphy

To keep it simple: it is usually **impossible** to obtain the correct V_S profile through the analysis of the data recorded using (**just) vertical geophones** and the *interpretation* of the **modal dispersion curve(s)** (this is the standard approach that, unfortunately, some fellows still consider *the* MASW technique).

2. winMASW® fact sheet

the different versions of the winMASW® software application

winMASW® is a software application for the **joint analysis of seismic data** designed in order to achieve highly-reliable V_S (shear-wave velocity) vertical profiles.
The key feature of ***winMASW***® is represented by the joint analysis of different data according to various active and passive techniques, offering a complete arsenal of tools capable of handling any kind of analysis and problem. This way we can overcome the problems related to non-uniqueness of the solution and all the possible ambiguities in the data interpretation.

winMASW® is available in six different versions: ***Academy, Professional, 3C, Standard, Lite & winHVSR***

Lite	The entry-level version that allows only the analysis of Rayleigh waves via *modal* dispersion curves. This standard approach presents some critical points that are widely illustrated in our books.
winHVSR	HVSR analysis: computation and modeling of the HVSR (*Horizontal-to-Vertical Spectral Ratio*) to estimate the resonance frequency and the Vs30 value.
Standard	**Standard MASW and ReMi techniques (Rayleigh waves only) through the analysis of the** *modal* **dispersion curves.** Please consider that ReMi is a very problematic/poor technique (as highlighted in the *winMASW*® manual and in the Elsevier book) because the linear array generates ambiguity in determined and determinable velocities. *In order to get information about the deepest layers we recommend the joint analysis of surface waves (Rayleigh and Love waves) and the HVSR*.
3C	Joint analysis of Rayleigh and Love waves (via *modal* dispersion curves) and their joint inversion together with the HVSR, 1D modelling of refractions only for the P waves. **This version represents the "minimum" approach we recommend** and **it is a good compromise between very basic analyses based just on Rayleigh waves (see** *Lite* **and** *Standard* **versions) and the very advanced procedures available in** *winMASW*® *Academy***. To work efficiently we suggest:** twelve 4.5 Hz horizontal geophones and one 3-component geophone (if chosen carefully, it allows you to do much more than HVSR - see **HoliSurface** software).
Professional	MASW analyses considering both Rayleigh and Love waves (and their joint inversion); ReMi analyses (passive seismics), computation and modeling of the H/V spectral ratio (Nakamura's method) to estimate the resonance frequency, Vs30 calculation; 1D modelling of P and S-wave *refraction travel times* (also considering low-velocity layers), ESAC and FK analyses only for linear *arrays*, analysis of Rayleigh-wave attenuation to determine Q_S quality factors.
Academy	In addition to the tools implemented in the Professional version: multi-component dispersion analysis also according to the *Full Velocity Spectrum* (FVS) [synthetic seismograms] approach, ESAC (bidimensional arrays), tools for the multi-component analysis of passive data also for the estimation of lateral variations, highly-sophisticated HVSR modeling, group velocities analysis, RPM (*Rayleigh Wave Particle Motion*) analysis, not equally-spaced MASW analyses, Site Response (Response Spectra) tool, various tools for active and passive data editing and creation of 2D sections, etc. It is the ***most complete version which implements an arsenal of tools and highly-innovative solutions to jointly analyze surface wave propagation according to all the multi-channel active and passive methods***. In other words, **everything you might need for an endless series of applications.**

For further details:

- ***winMASW***® manual
- ***winMASW***® page for further info and case studies
- **video tutorials**
- **Facebook page** for suggestions, small case studies and news

Software activation and system requirements

winMASW® works by means of an hardware key (USB dongle) and can be installed on an unlimited number of computers (to use the software it is clearly necessary to insert the key).

winMASW® runs under windows operating system but, through appropriate emulators, even on Mac.

RAM: to work with a certain easiness we recommend 8M at least.

CPU (processor): for lower profile versions (based only on the analysis of modal curves) a simple dual-core CPU can be enough, but to minimize the computation time of the Academy version a higher-performance CPU is necessary (see ***System requirements*** in the winMASW®/HoliSurface® manuals).

winMASW® works only on 64bit operating systems (windows 10 recommended).

Why *winMASW*®?

- ***winMASW***® **allows you to do much more than the so-called (standard) MASW**. The **joint analysis of several *observables* (please, see the *winMASW*® manual and our articles and books) is the only approach that allows identifying a reliable solution** free from major ambiguities.
- ***winMASW***® is a flexible software. If you choose a basic version (e.g. *Lite* or *Standard*), you can upgrade to a higher and more complete version at any time.
- by choosing ***winMASW***® you can benefit from a relevant scientific technical support (see **publications**) based on over twenty years of research activity in the field of surface wave analysis.

Educational License

The *Educational License* is reserved to Universities and scientific institutions for educational purposes only. The cost is the same as for a regular license but, instead of just one USB dongle (standard/commercial license), two USB dongles are provided (together with the manual and one book).

Since we strongly believe that the use of the software for educational purposes requires the most advanced techniques for the analysis of surface waves currently available, the *Educational License* is provided only for *winMASW*® *Academy* and *HoliSurface*®. Institutions who choose such a license are required not to use the software for not merely educational purpose.

If an Institution wishes to obtain for an *Educational License*, a formal declaration (signed by the head of the Department/ Institution) about the merely-educational use of the software is required.

Demo version

The *winMASW*® software (in particular the *Academy* version) is a highly-sophisticate tool that, in order to be fully and properly used, requires some training that we are glad to provide to our clients.

If you try to use *winMASW*® while keeping in mind simplistic and erroneous assumptions (for instance about the way modes appear and disappear in a velocity spectrum - unfortunately real-world data can be extremely counter-intuitive), you risk not to catch the real point(s) that *winMASW*® (with all its tools) attempts to address through the joint analysis of several "objects" (observables). Please, visit our web site and have a look to our **articles** and **books** as well as to our **video tutorials**.

For these reasons, no *Demo* version is currently provided but, in case of concrete interest, **we are willing to analyze one of your datasets (please, strictly follow the recommendations provided in our guidelines, provide us with both Rayleigh and Love waves, as well as the HVSR; please, follow the nomenclature explained in the *Elsevier* book - paragraph 2.2).**

■ Eliosoft provides an acquisition system and all types of geophones

- **4.5 Hz horizontal and vertical geophones**

  Remember that for active acquisitions (MASW), **twelve horizontal geophones are enough and absolutely recommended to acquire both Rayleigh (radial component) and Love waves (you can also use them for SH refraction/reflection).**

  Vertical geophones allows to acquire only the vertical component of Rayleigh waves (according to both active and passive techniques, but they are often ambiguous and lead to overestimate the V_S - see the Elsevier book) and the P waves refraction (which is influenced by the presence of water in the ground and, consequently, often more problematic than SH refraction).

  Vertical geophones are necessary for ReMi and ESAC acquisitions and multi-offset RPM analyzes. Please, consider that the purchase of 10 Hz geophones for refraction makes no sense [see **FAQ page**].
- **3-component geophones**:

  Useful for the HVSR and several kinds of vibration analyses on buildings (e.g. GHM technique), UNI/DIN regulations, SSR (*Standard Spectral ratio*) and *Spectral Difference* (SD) (see our ***HoliSurface***® pages)
- **HS acquisition system** optimized for the ***HoliSurface***® approach but excellent also for all the classical multi-channel world (active and passive seismics).

■ Order confirmation and shipping

To proceed with the purchase, please send an email to **winmasw@winmasw.com** specifying the version of ***winMASW***® you are interested in, the company data for the invoice and the shipping address.
Delivery time: shipping via courier 3/4 days after receiving official order and payment.

To start working efficiently we suggest the following solution:

☑ *winMASW*® 3C: joint MASW (Rayleigh e Love waves) + HVSR
☑ twelve (12) 4.5 Hz horizontal geophones: radial component of Rayleigh waves, Love waves and SH-wave refraction/reflection.
☑ one 3-component geophone for HVSR and much more (see *HoliSurface*®)

Please, consider that the only way to correctly determine the V_s profile is the following: joint analysis of Rayleigh and Love waves together with the HVSR.

Further info: **winmasw@winmasw.com**

winMASW® software: available versions and tools

	HVSR	Lite	Standard	Professional	3C	Academy
MASW analyses considering both Rayleigh and Love waves (and their joint inversion)		Rayleigh waves	Rayleigh waves	✓	✓	✓
Analysis of Rayleigh-wave attenuation to determine Q_S quality factors				✓		✓
ReMi analyses (passive seismics)			✓	✓		✓
ESAC and FK analyses (bidimensional arrays)				Only linear *arrays*		✓
Group-velocity Analyses (*Multiple Filter Analysis*) for group-velocity determination (both for Rayleigh & Love)						✓
Joint analysis of phase & group velocities						✓
Computation and modelling of the H/V spectral ratio (Nakamura's method) to estimate the resonance frequency	✓			✓	✓	✓
Band- Low- High-pass filters		✓	✓	✓	✓	✓
Vs30 and VsE (Vs Equivalent) calculation	✓	✓	✓	✓	✓	✓
Spectral analyses: computation of amplitude and phase spectra and spectrograms (frequency content over time)		✓	✓	✓		✓
1D modelling of *refraction travel times* (also considering low-velocity layers)				✓	Only for P waves	✓
1D modelling of *reflections* (also considering low-velocity layers)						✓
Tool to combine two shots and simulate a dataset with a double number of channels (or three times, etc)		✓	✓	✓		✓
Elastic moduli calculation tool			✓	✓	✓	✓
Synthetic seismograms (*modal summation*) both for Rayleigh & Love waves						✓
Computation of the *apparent* (or *effective*) dispersion curves (recommended for passive datasets e.g. from ESAC analyses)						✓
Velocity-spectra inversion via synthetic seismogram computation: no need of dispersion-curve picking but longer computational times						✓
Tool for the *vertical stacking*						✓
Tool for creating 2D sections						✓
Tool for putting in evidence specific (even "hidden") modes						✓
Tool for combining several traces acquired by a single 3-component geophone (using different offsets) and obtaining datasets useful for MASW analysis considering both Rayleigh (radial and vertical component) + Love waves.				✓	✓	✓
Tool TCEMCD (*Three-Component Extraction from Multi-Channel Data*) for efficient passive joint ESAC + HVSR acquisitions: connect your vertical geophones and our HOLI3C (3-component geophone) to your seismic cable and with this tool you'll then be able to extract the data for the joint analysis of dispersion (via ESAC) and HVSR						✓
Site Response (Response Spectra) panel						✓
Pure Synthetics						✓
Back-scattering analysis						✓
Non-equally spaced MASW analysis						✓

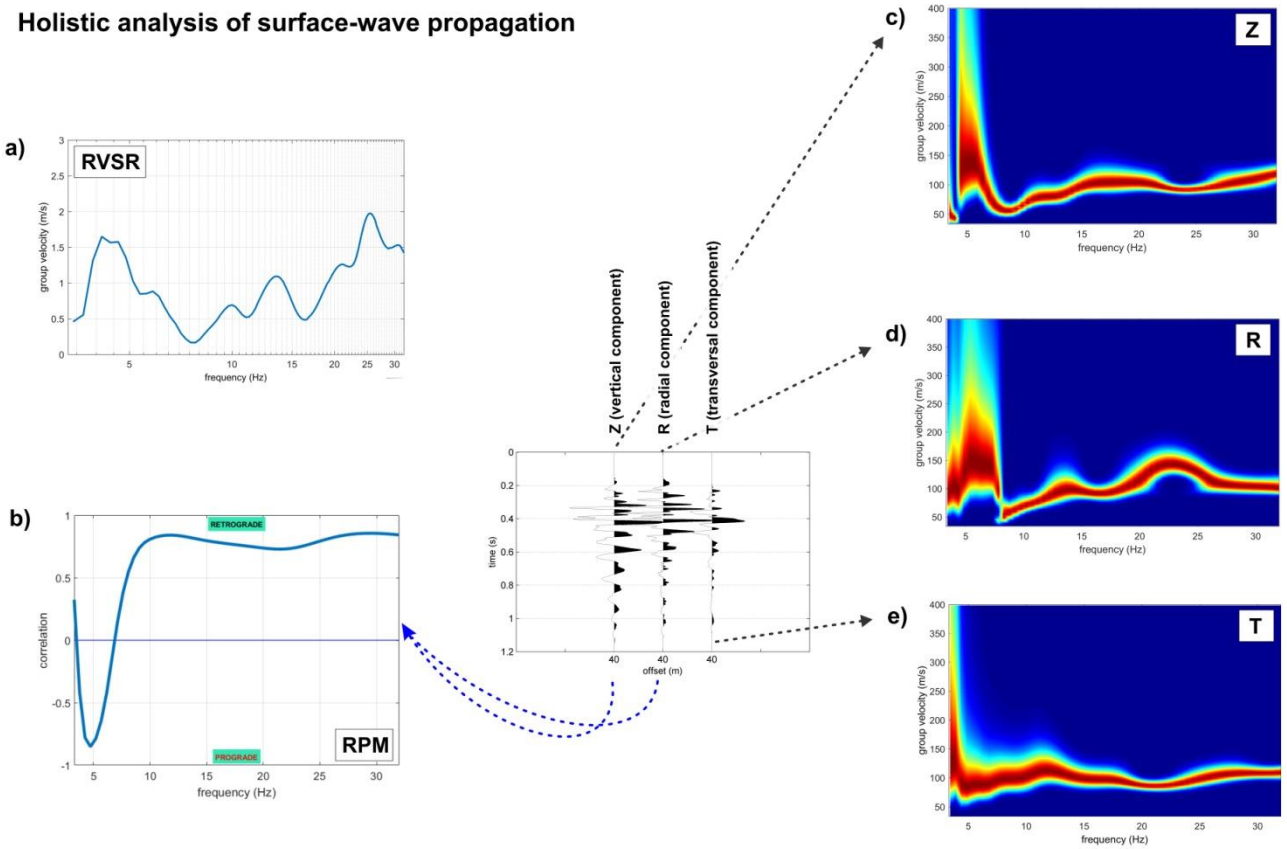
Several important improvements and modules in the 2021 editions!

Discounts?

In case you mention one of our software applications in an article published in a good peer-reviewed journal [Q1 and Q2 quartiles] or in the proceedings of an important congress, you can access to free updates or discounts on some of our products. Please, contact us in advance (before submitting your paper) so to reach a clear and formal agreement about it.

Please, also consider our top product: the *HoliSurface*® software application and the HS acquisition system

- **CLICK HERE for the *HoliSurface*® user manual**
- **CLICK HERE for the video introduction to data acquisition according to the *HS methodology***
- **CLICK HERE for the video introduction to data acquisition for the joint analysis of HVSR and MAAM data**

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