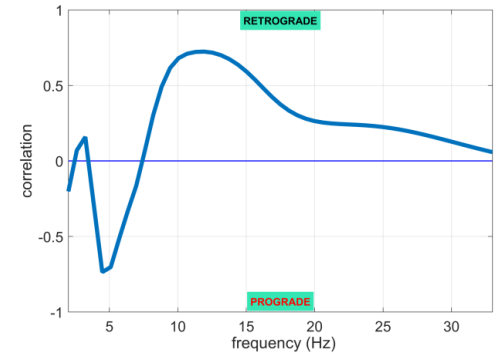
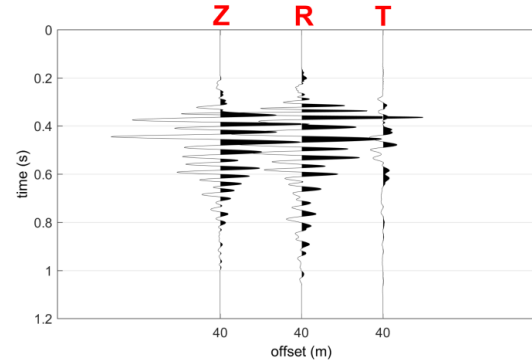
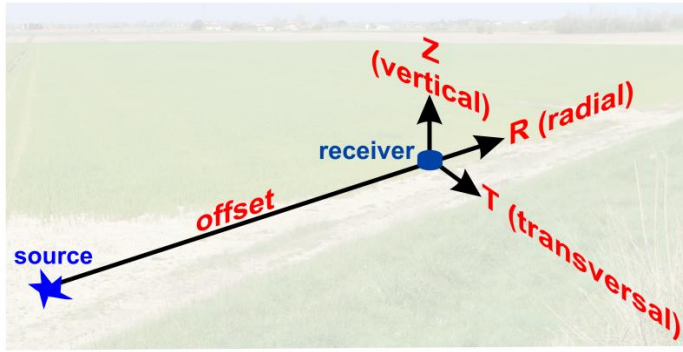


Ma chi l'ha detto che le onde di Rayleigh sono retrograde?



Giancarlo Dal Moro

Department of Seismotectonics
Institute of Rock Structure and Mechanics
Academy of Sciences of the Czech Republic
Prague - Czech Republic

dalmoro@irms.cas.cz; gdm@winmasw.com



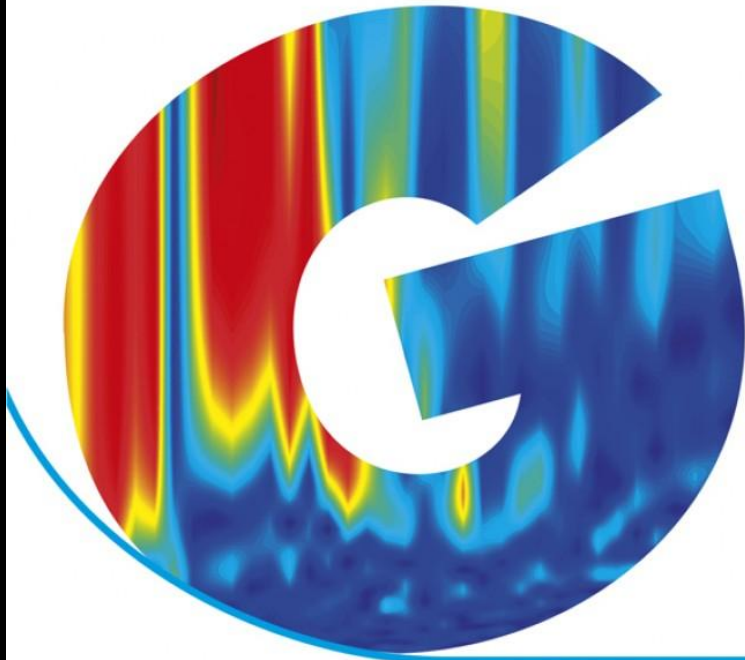
Giancarlo Dal Moro



Dario Flaccovio Editore

Onde di superficie in geofisica applicata

Acquisizione e analisi di dati secondo tecniche
MASW e HVSr



- ✓ Onde di Rayleigh e onde di Love
- ✓ Acquisizione dati
- ✓ Analisi MASW, ReMi e HVSr
- ✓ Raccolta di casi studio

SURFACE WAVE ANALYSIS
FOR NEAR SURFACE APPLICATIONS



Dal Moro

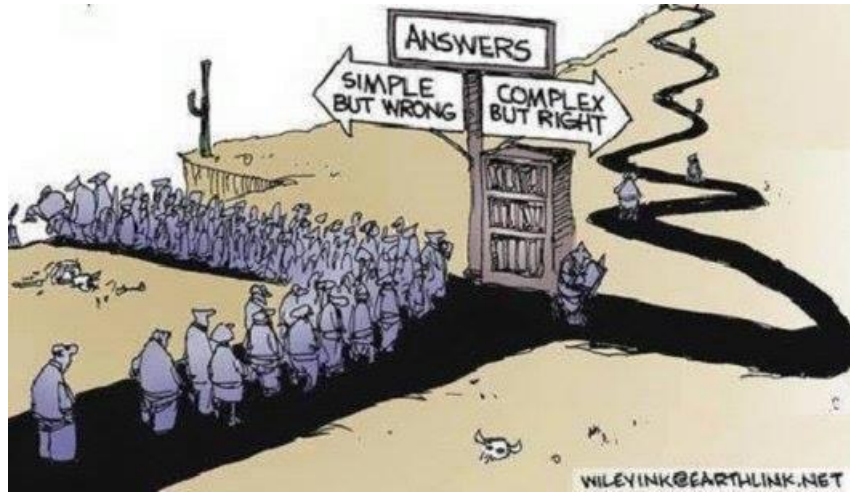
SURFACE WAVE ANALYSIS
FOR NEAR SURFACE
APPLICATIONS

Giancarlo Dal Moro



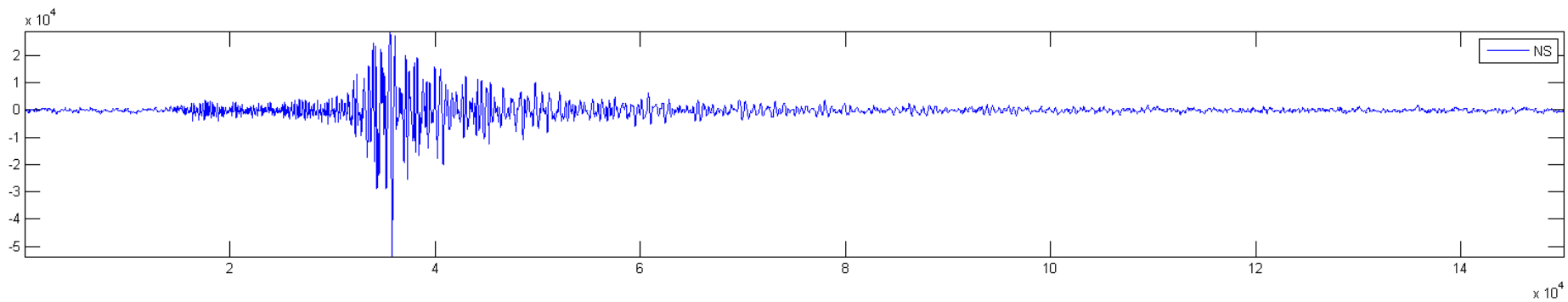
recruiting





WILEYINK@EARTHLINK.NET

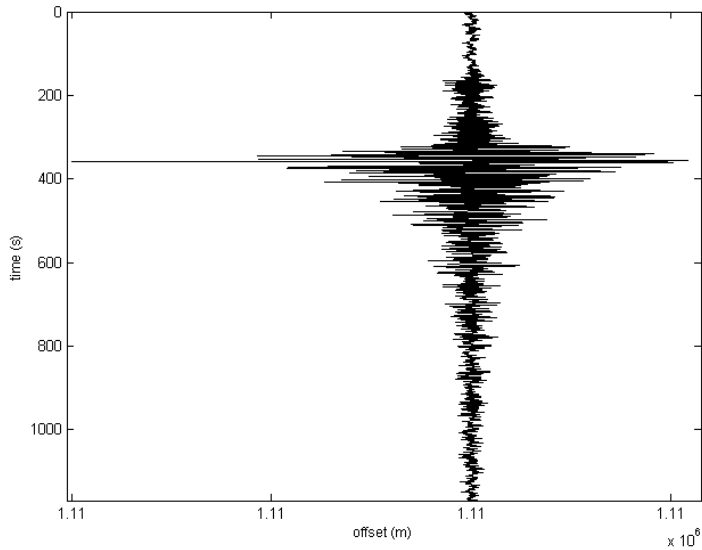
Some Garage Seismology



Some Garage Seismology

#1: data uploading & processing

dataset: THF_M_FAspectrum.mat
 sampling: 160ms [6.25Hz] - 7501 samples
 minimum offset: 1110000 m



resampling

0.5

resample

accept

data selection

activate

select 60

cancel save

filtering & spectra

filter cancel

spectrum spectrogram

refr. & refl.

refr./refl. 0.2

upload save

flip polarity clear

other tools & setting

time to visualize (s) done cut

flip traces test amplitude zero padding

#2: velocity spectrum, modelling & picking (MASW, ESAC & ReMi analyses)

MASW: compute velocity spectrum

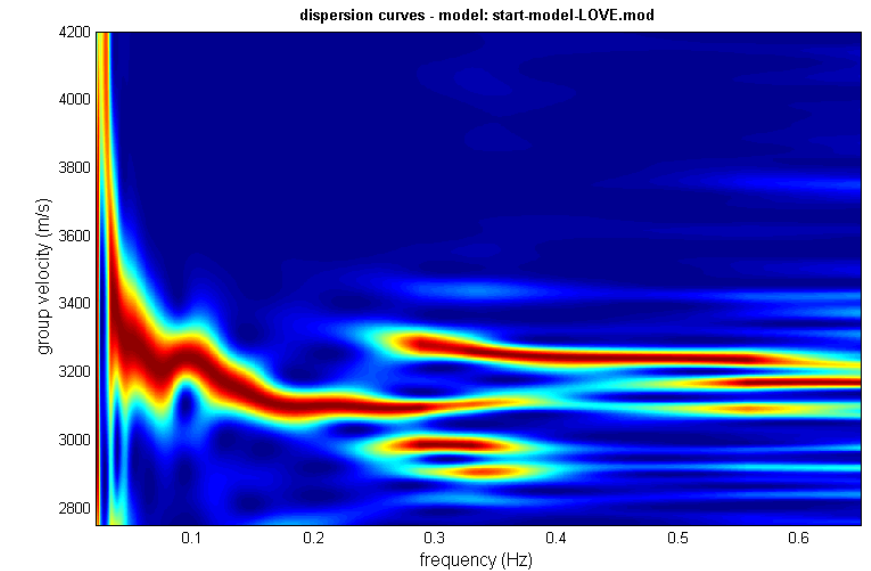
phase velocity f-k group velocity

handling the spectra

save upload merge

explore spectrum

mode separation



general setting

Love 5 group vel

0 Reference depth Refraction

H/V (body waves)

H/V (surface waves)

| Vs | Qs | Poisson | thickness |
|------|-----|---------|-----------|
| 2500 | 313 | 0.25 | 500 |
| 2900 | 338 | 0.25 | 1000 |
| 3200 | 363 | 0.25 | 3000 |
| 3300 | 375 | 0.25 | 5000 |
| 3200 | 400 | 0.25 | 5000 |
| 3300 | 425 | 0.25 | 3000 |
| 3500 | 550 | 0.25 | 0 |
| 0 | 0 | 0.3 | 0 |
| 0 | 0 | 0.25 | 0 |
| 0 | 0 | 0.2 | 0 |
| 0 | 0 | 0.15 | 0 |
| 0 | 0 | 0.15 | 0 |

modelling

synthetics

THF

shows DC

show model

just overlap

synthetics

compute report DC report SS

effective (passive)

visualize curves

input curve ?

picking

? show f-k

auto picking

dispersion curves

select mode

to select the last point of the considered mode click the right button

save picking ?

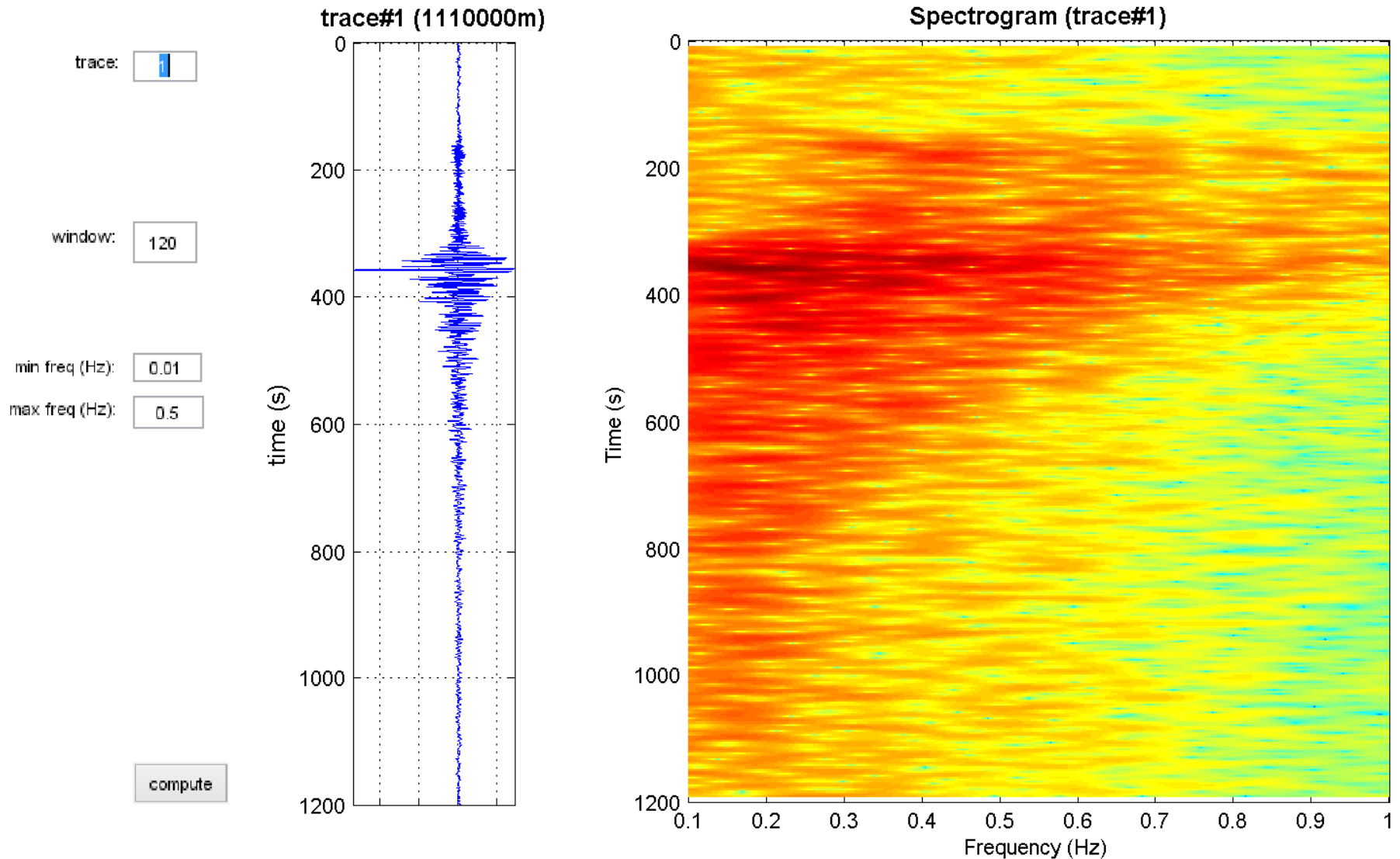
cancel picking

inversion

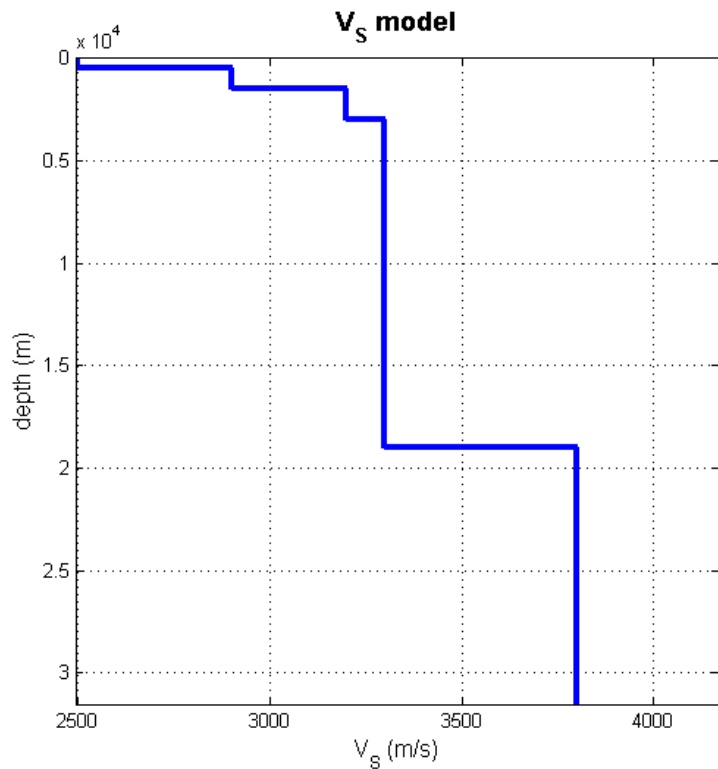
inversion

Joint DC-HV inv.

Some Garage Seismology



Some Garage Seismology



#2: velocity spectrum, modelling & picking (MASW, ESAC & ReMi analyses)

MASW: compute velocity spectrum

phase velocity
 f-k
 group velocity

handling the spectra

visualize curves

?

resampling

0.5

data selection

 60

filtering & spectra

refr. & refl.

refr./refl. 0.2

general setting

Love group vel

Reference depth Refraction

HV (body waves) HV (surface waves)

modelling

| Vs | Qs | Poisson | thickness |
|------|-----|---------|-----------|
| 2500 | 313 | 0.25 | 500 |
| 2900 | 338 | 0.25 | 1000 |
| 3200 | 363 | 0.25 | 1500 |
| 3300 | 363 | 0.25 | 2000 |
| 3300 | 375 | 0.25 | 2000 |
| 3300 | 375 | 0.25 | 3000 |
| 3300 | 400 | 0.25 | 2000 |
| 3300 | 400 | 0.25 | 3000 |
| 3300 | 425 | 0.25 | 4000 |
| 3800 | 550 | 0.25 | 59000 |
| 7000 | 875 | 0.15 | 0 |
| 0 | 0 | 0.15 | |

effective (passive)

other tools & setting

dispersion curves - model: start-model-LOVE.mod

group velocity (m/s)

frequency (Hz)

-- Love Dispersion --

Vsh (m/s): 2500 2900 3200 3300 333

thickness (m): 500.0 1000.0 1500.0

picking

dispersion curves

fundamental

to select the last point of the considered mode click the right button

THFgroup.cdp

inversion

synthetics

THF

shows DC show model

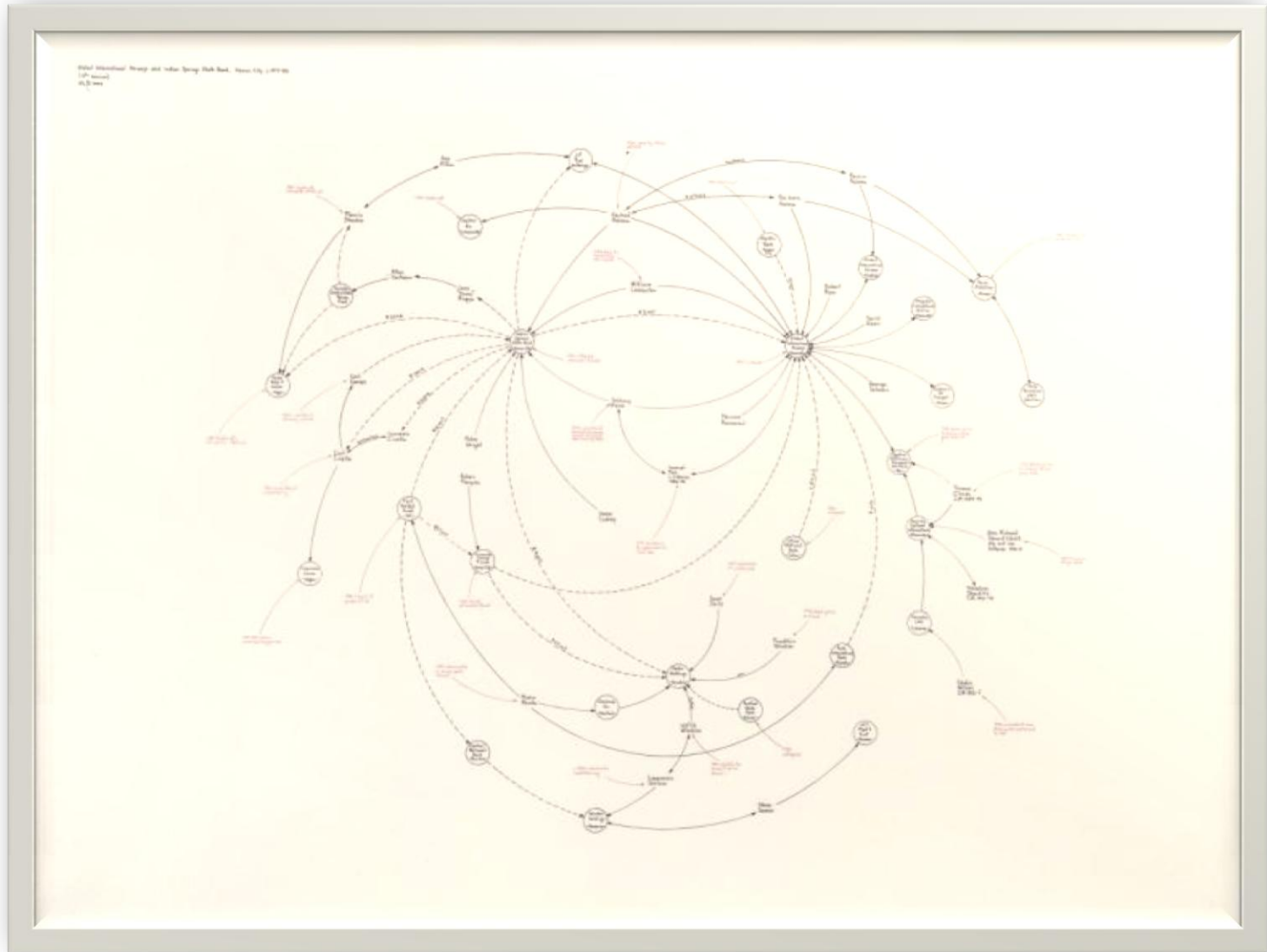
just overlap

Tutoring

It's not what you look at that matters, it's what you see.

Henry David Thoreau

Le due alternative: comprendere tutto o non capire nulla



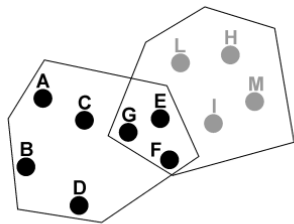
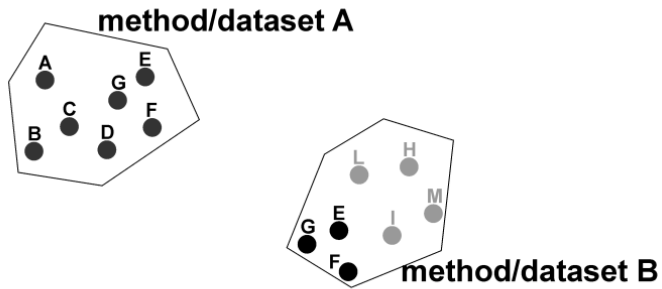


Two R&D lines

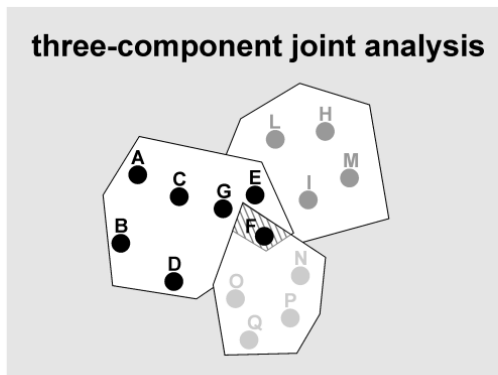
Classical (improved) methodologies

Unconventional (particularly effective) methodologies

Non-uniqueness of the solution



What could be these methods/datasets/components?
[Elsevier pdf]



Waves and components (Elsevier book)

**Waves and nomenclature
(file names and multi-component data)**

ZVF-ZEX

RVF-REX

THF

See Flaccovio and Elsevier books

dx and the vertical resolution

The number of channels: an issue?

SURFACE WAVE ANALYSIS FOR NEAR SURFACE APPLICATIONS

— Giancarlo Dal Moro

Surface Wave Analysis for Near Surface Applications presents the foundational tools and techniques necessary to properly analyze surface-wave propagation nowadays performed for a number of applications.

In the last decades, surface-wave analysis has in fact become critical to near-surface geophysics both for geotechnical goals, seismic-hazard assessment, and environmental studies. This book presents both the theoretical background and the applications which the author has assembled while considering different possible approaches selected from the latest developments in research, with a special emphasis of the joint analysis of the different components that can be conveniently considered.

The book aims at building a bridge between academic research and field practice and at illustrating a number of possible pitfalls often made while analyzing surface waves also suggesting the way to overcome them via joint analyses.

Authored by a geophysicist with nearly 20 years of experience in research, consulting, and geophysical software development.

- Nearly 100 figures, photographs, and examples aid in the understanding of fundamental concepts and techniques.
- Presents the latest research in surface wave analysis while considering both active and passive techniques (MASW, MFA, ESAC, ReMi, HVSR etc.) and different inversion strategies.
- A number of real world case studies — 14 in all — bring the book's key principles to life.

A unique blend of theory and practice, the book's concepts are based on exhaustive field research conducted over the past decades.



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SURFACE WAVE ANALYSIS
FOR NEAR SURFACE APPLICATIONS

SURFACE WAVE ANALYSIS FOR NEAR SURFACE APPLICATIONS

— Giancarlo Dal Moro

See paragraph: “2.2.1 Multichannel Acquisition (MASW)”

ReMi versus ESAC

SURFACE WAVE ANALYSIS FOR NEAR SURFACE APPLICATIONS

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SURFACE WAVE ANALYSIS
FOR NEAR SURFACE APPLICATIONS



SURFACE WAVE ANALYSIS FOR NEAR SURFACE APPLICATIONS

— Giancarlo Dal Moro

See paragraphs: “2.3 PASSIVE METHODOLOGIES” and “3.3 ABOUT PASSIVE METHODS”

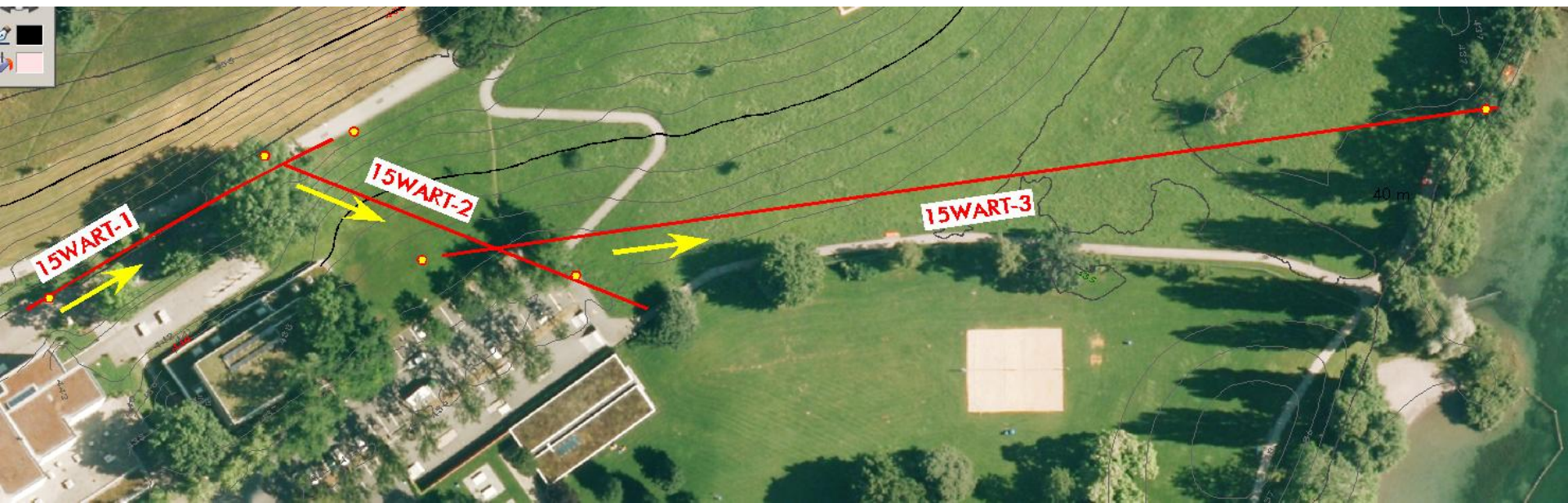
drifting and HVSR

Done *live* during the lecture

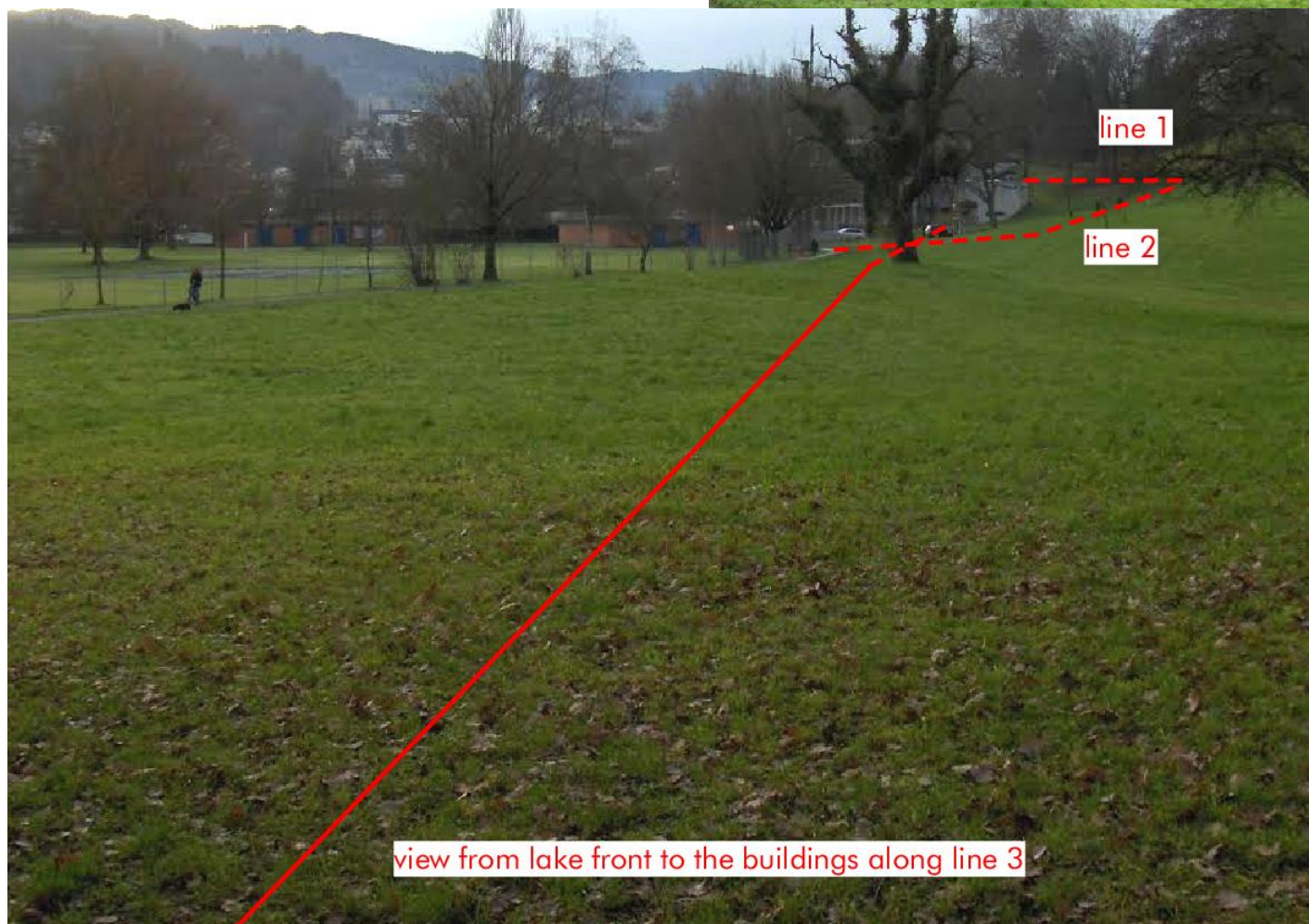
Not *what*, but *how*



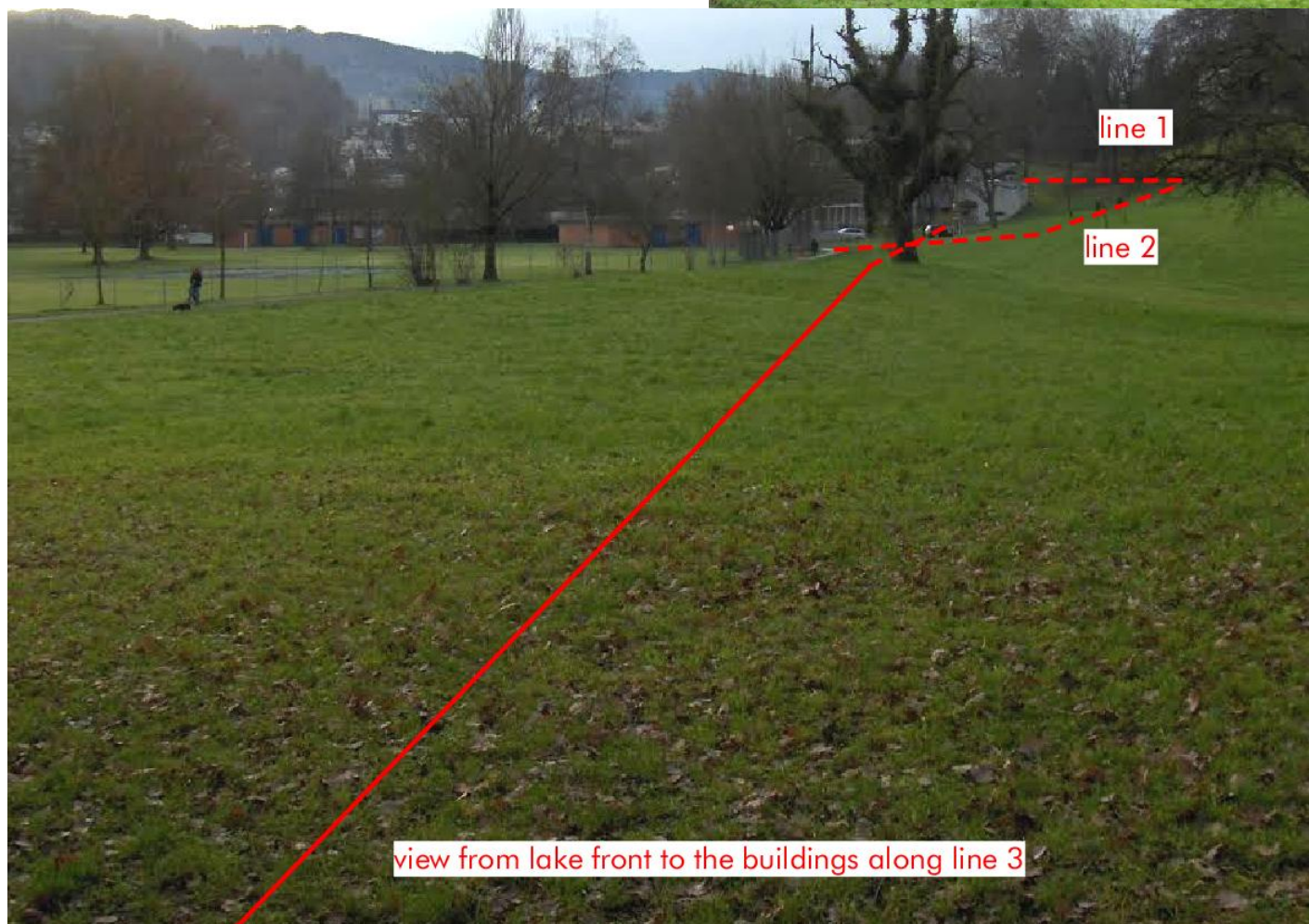
Esempio di efficienza: "Vierwaldstättersee" survey



Vierwaldstättersee survey



Vierwaldstättersee survey



ADAM-2D

Apparent-Dispersion Analysis of Multicomponent Data – 2D

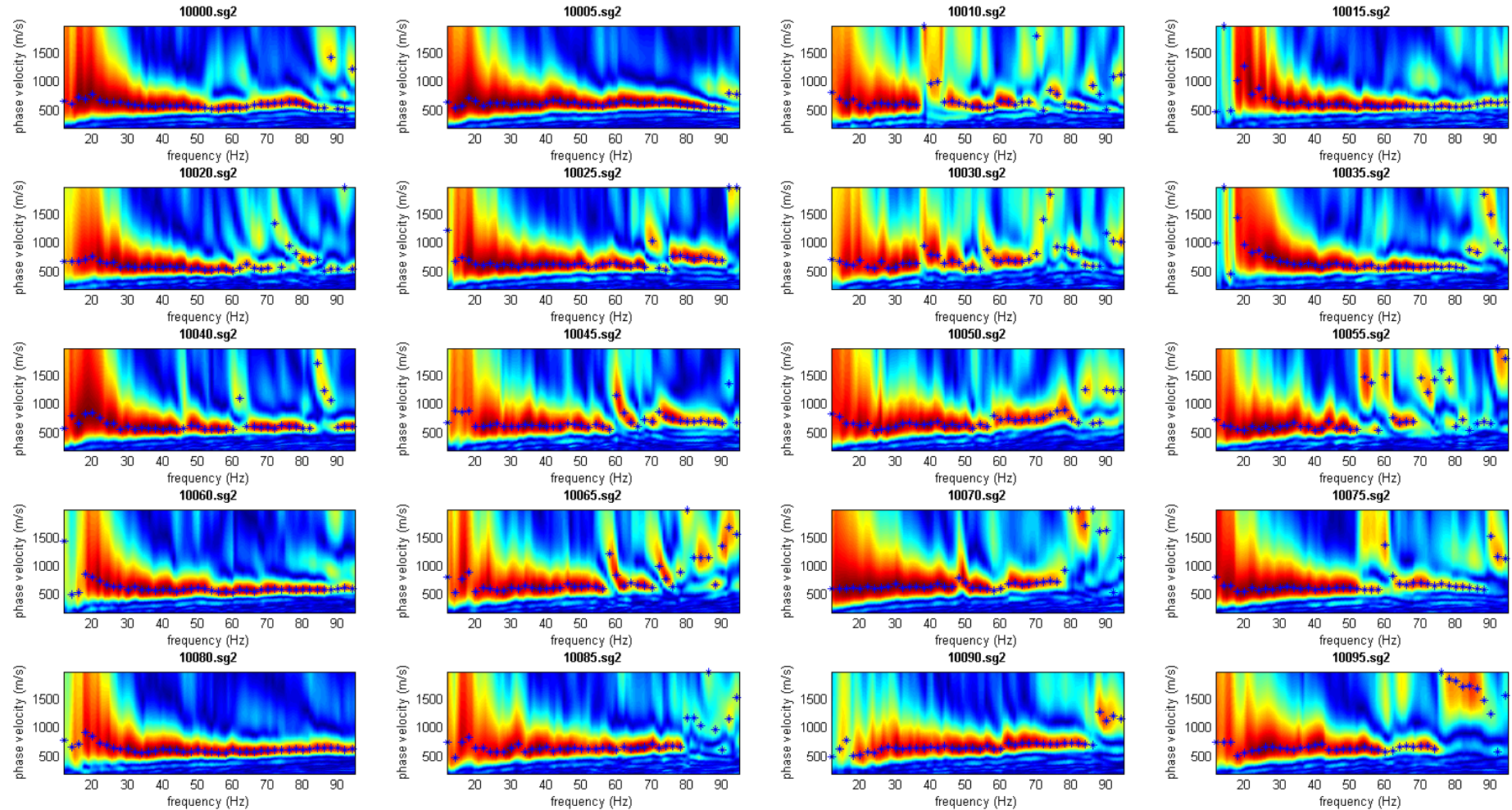


ADAM-2D

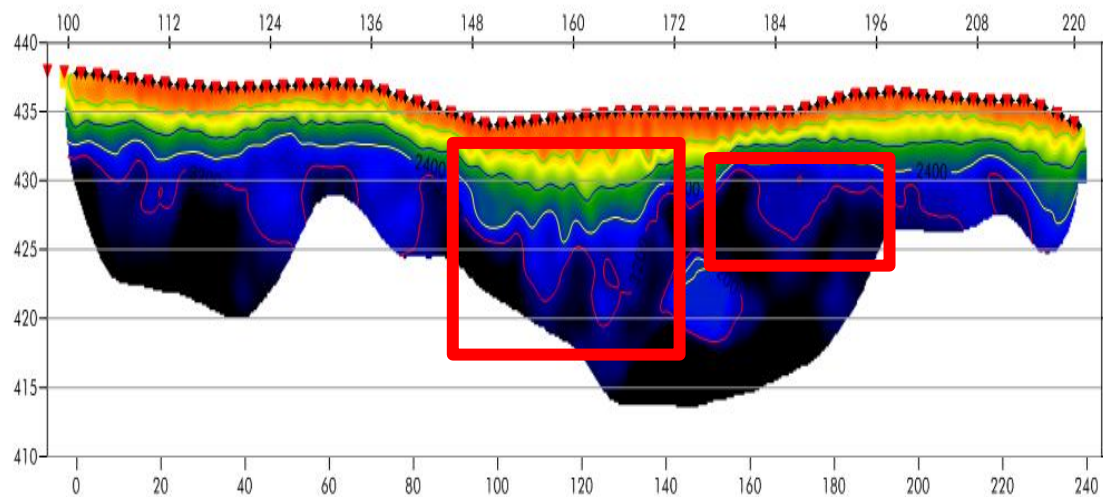
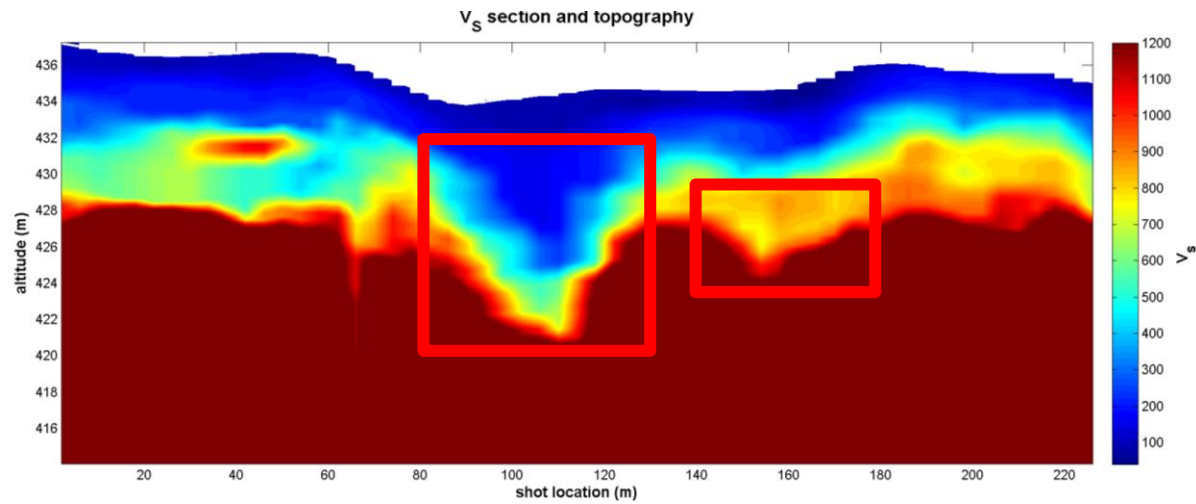
Apparent-Dispersion Analysis of Multicomponent Data – 2D

Automatic computation of velocity spectra and apparent dispersion curves for multi-component data

Qatar survey



ADAM-2D



Oberflächengebundene Bestimmung eines robusten Vs-Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

L. Keller^{1*}, G. Dal Moro², C. Lacave³

(¹) roXplore gmbh, seismic service provider, Amlikon (Switzerland)

*e-mail: lorenz@roxplore.ch

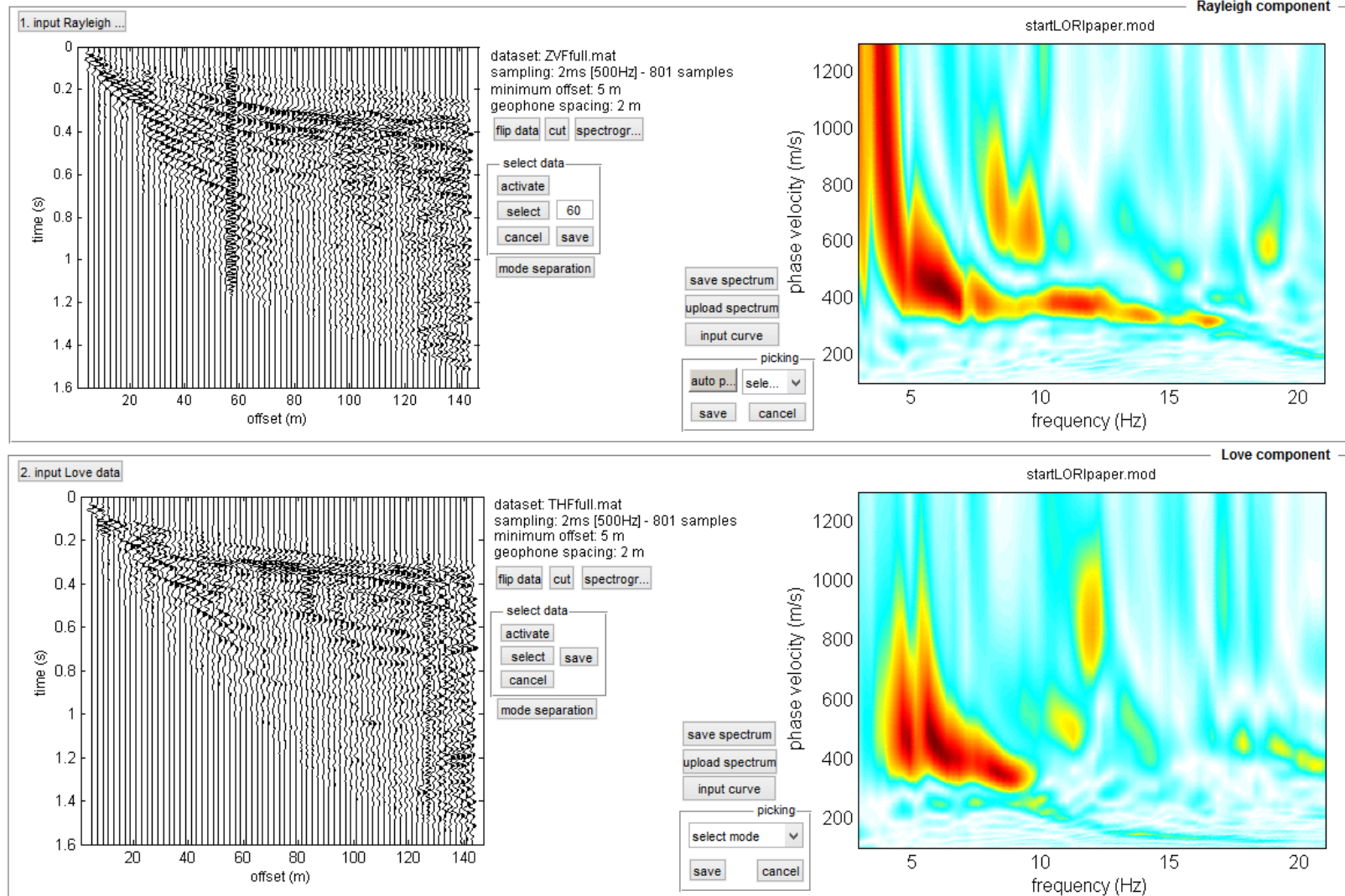
(²) Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic, Prague (Czech Republic)

(³) Résonance Ingénieurs-Conseils SA, dynamic engineering, Carouge (Switzerland)



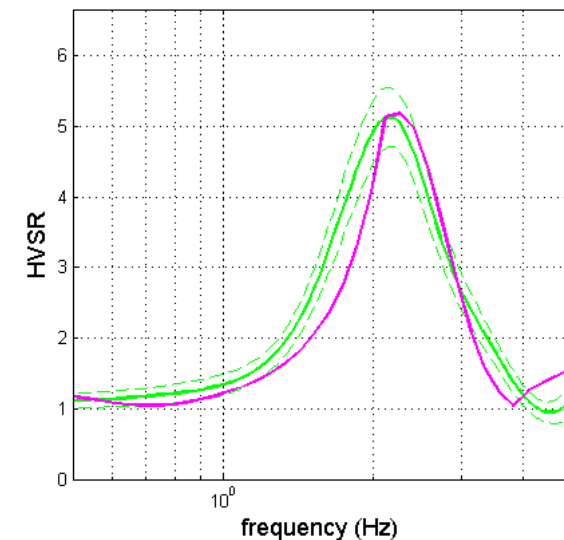
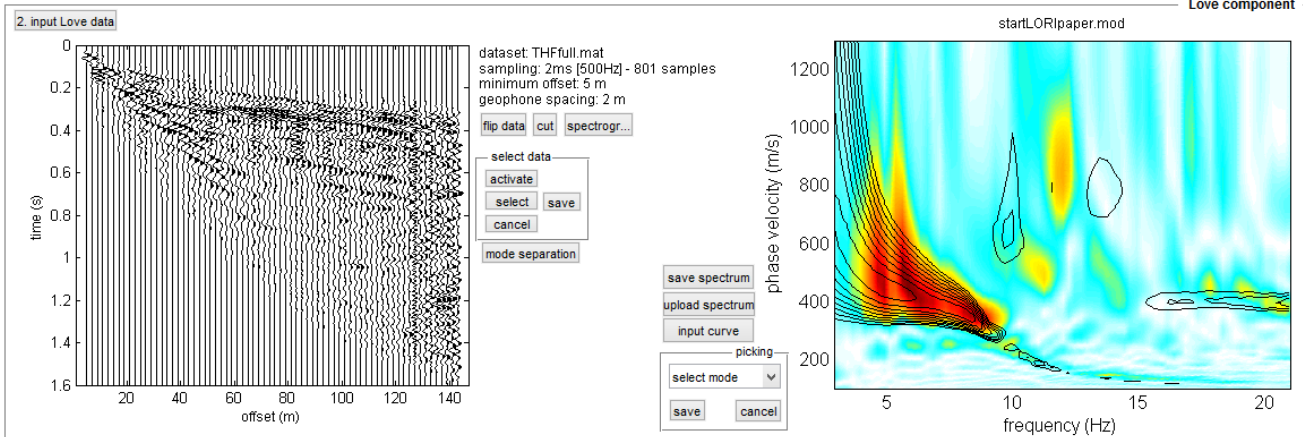
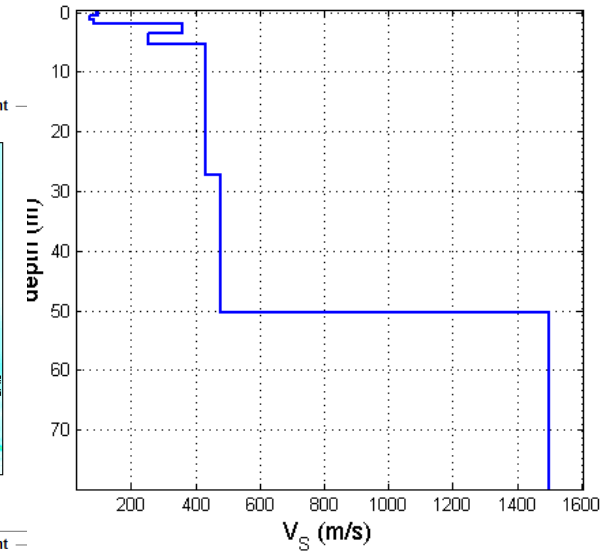
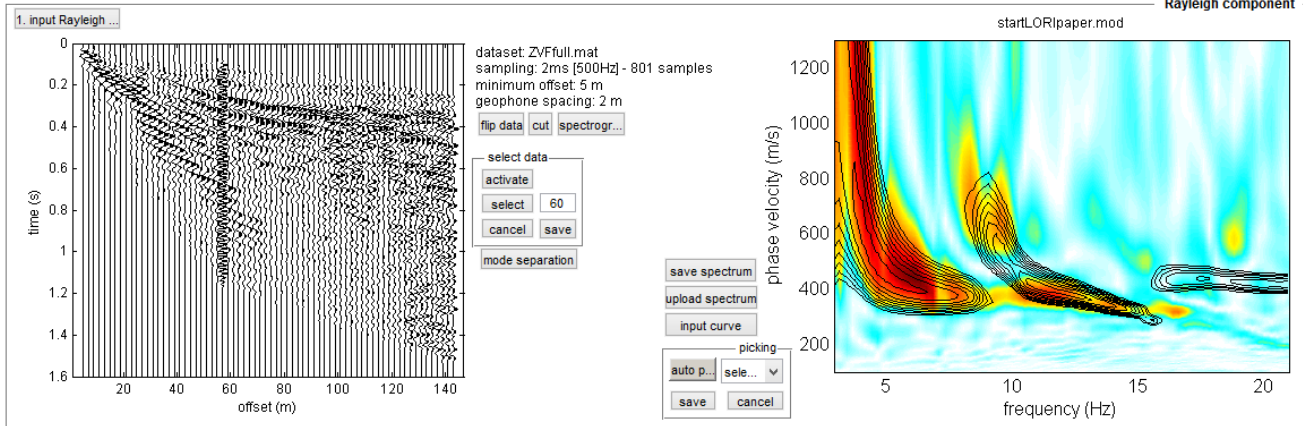
Oberflächengebundene Bestimmung eines robusten Vs-Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

The “ordinary” multi-channel approach



Oberflächengebundene Bestimmung eines robusten Vs-Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

The “ordinary” multi-channel approach



the unordinary approaches



*The more you know,
the less you need.*

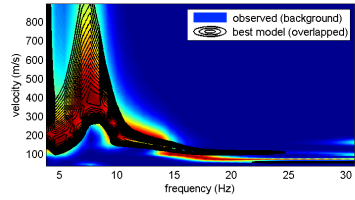
Yvon Chouinard

Oberflächengebundene Bestimmung eines robusten V_s -Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

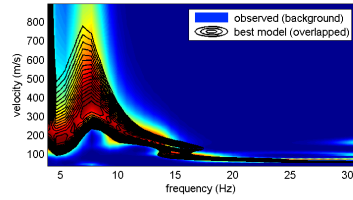
Pure HoliSurface



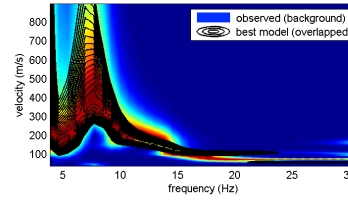
Minimum "global" GA model (vertical component)



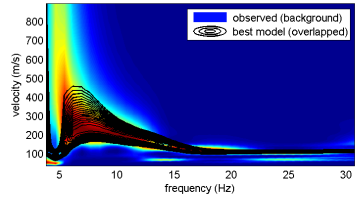
Minimum-distance model (vertical component)



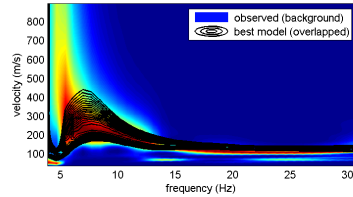
Mean model (vertical component)



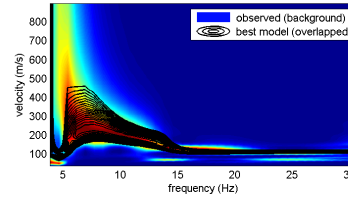
Minimum "global" GA model (radial component)



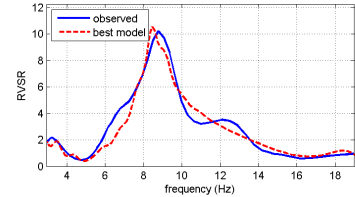
Minimum-distance model (radial component)



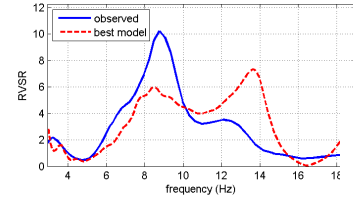
Mean model (radial component)



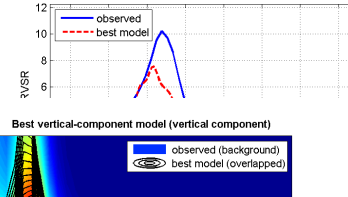
Minimum "global" GA model (RVSR)



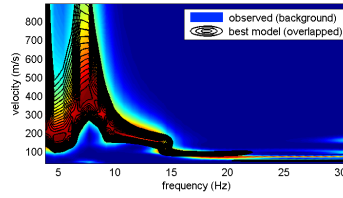
Minimum-distance model (RVSR)



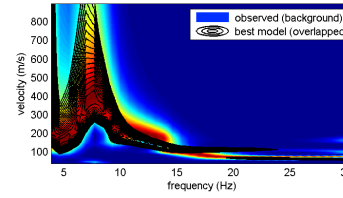
Mean model (RVSR)



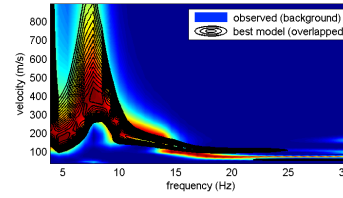
Best vertical-component model (vertical component)



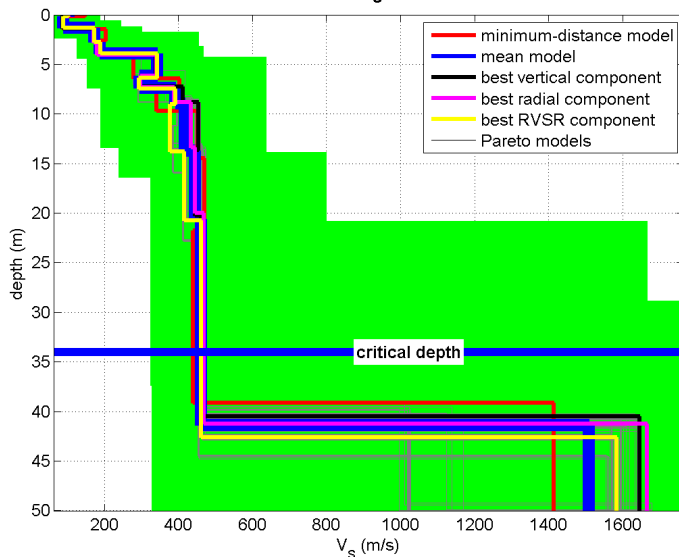
Best radial-component model (vertical component)



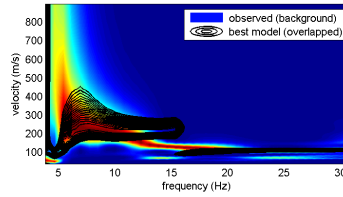
Best RVSR model (vertical component)



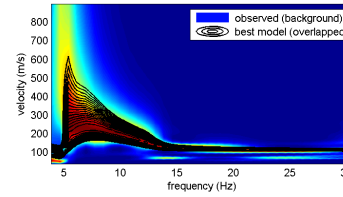
vertical V_s profile



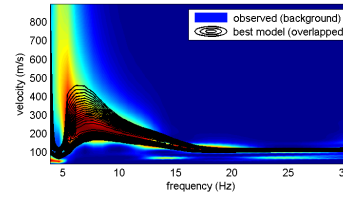
Best vertical-component model (radial component)



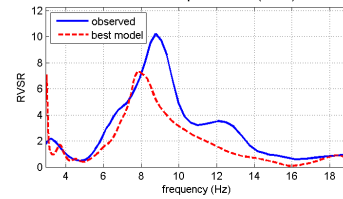
Best radial-component model (radial component)



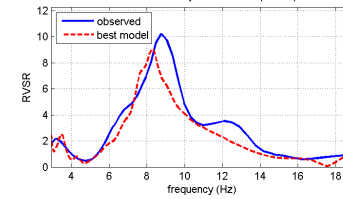
Best RVSR model (radial component)



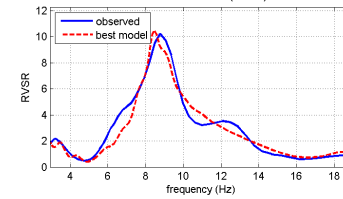
Best vertical-component model (RVSR)



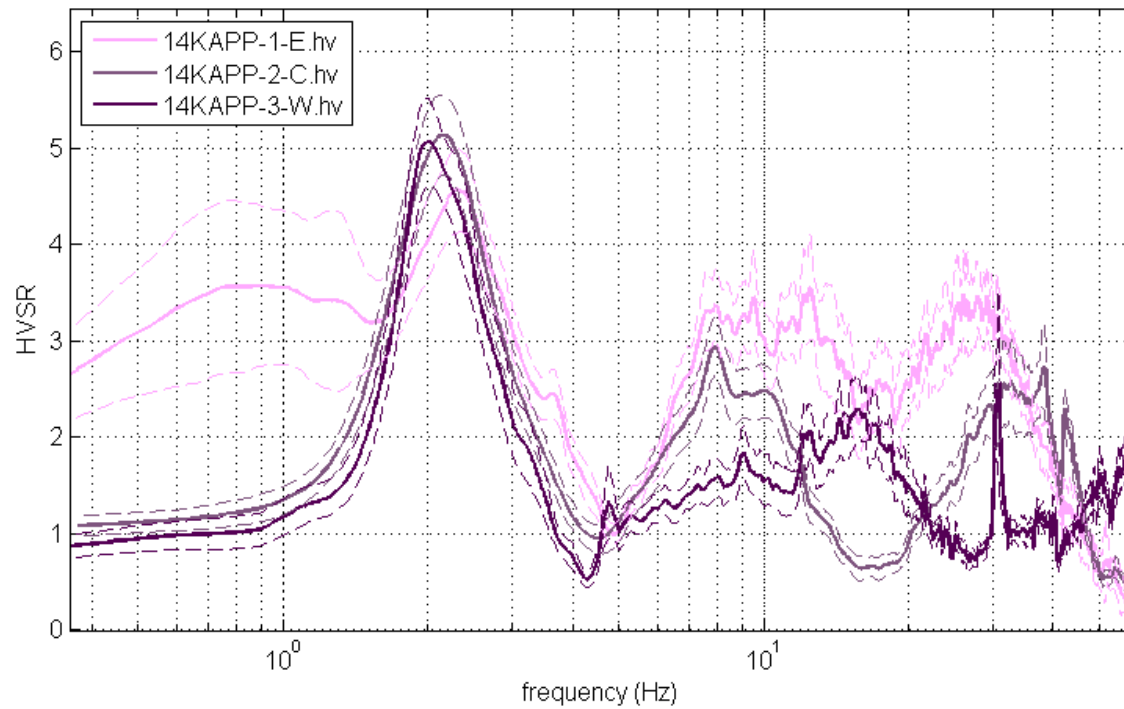
Best radial-component model (RVSR)



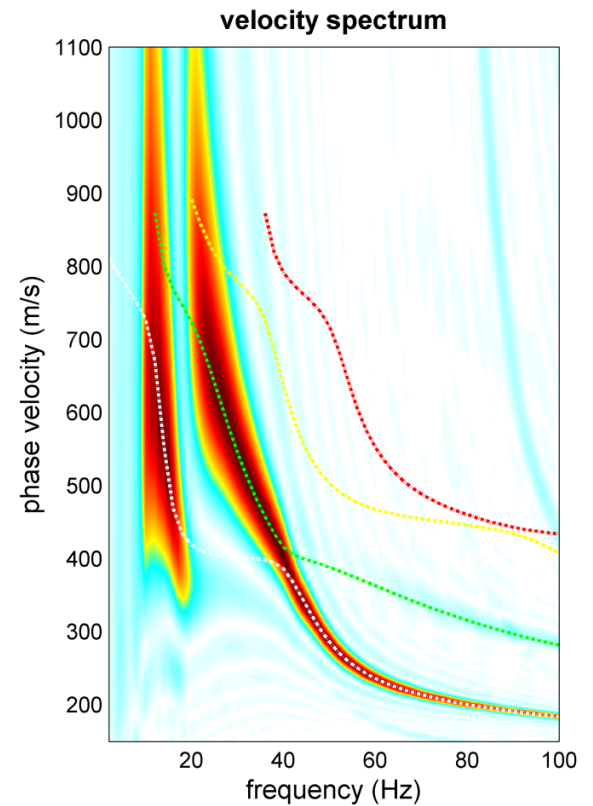
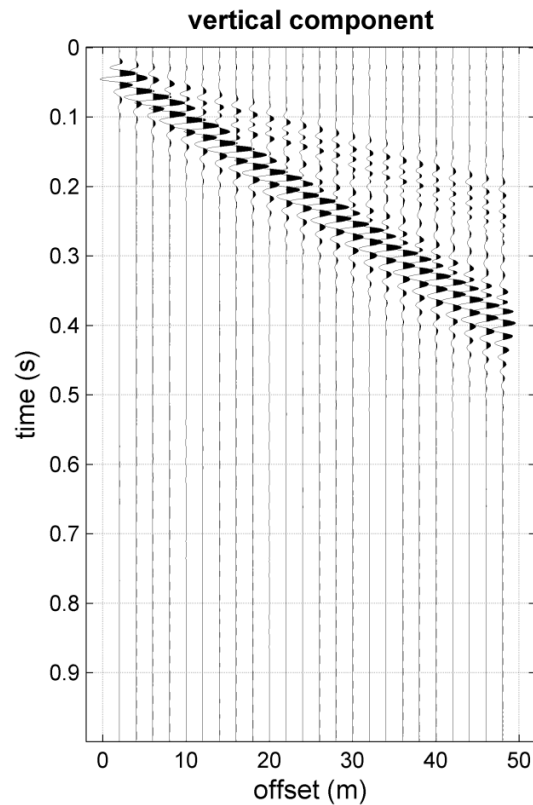
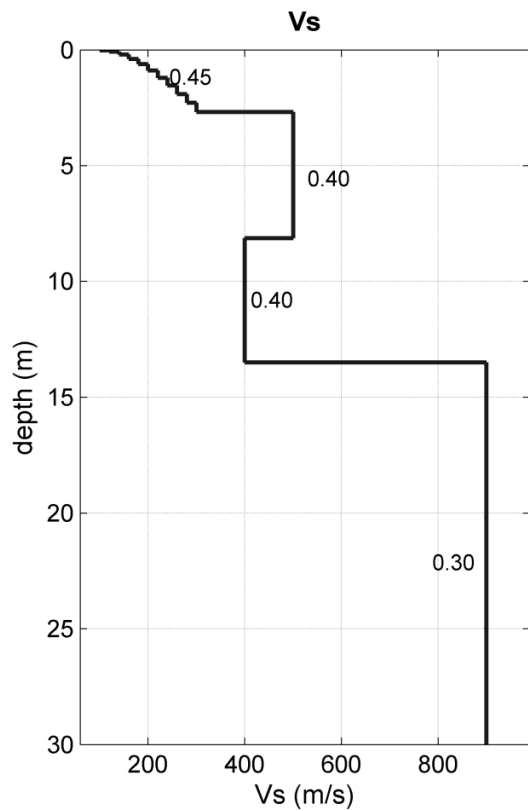
Best RVSR model (RVSR)



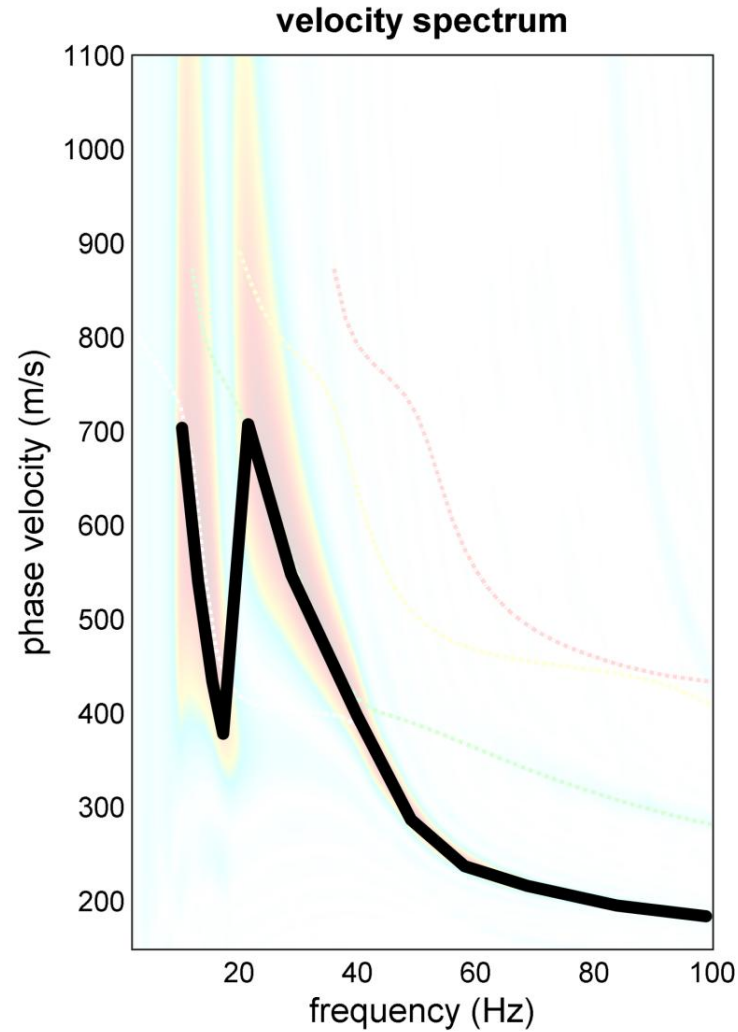
Oberflächengebundene Bestimmung eines robusten Vs-Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche



Modal and effective dispersion curves: problems and solutions



Modal and effective dispersion curves: problems and solutions



Modal and effective dispersion curves: problems and solutions

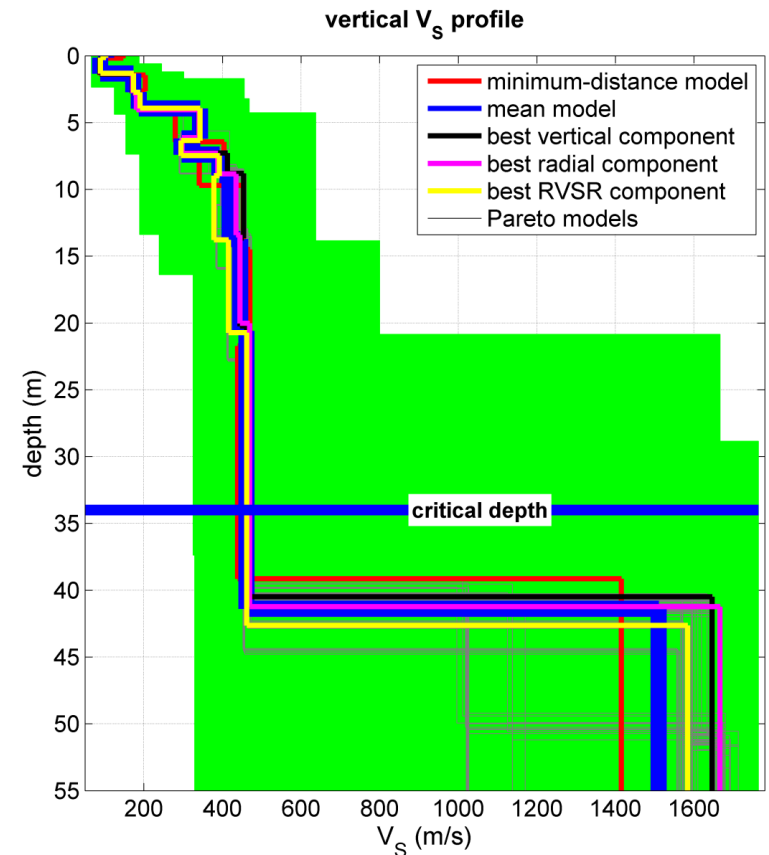
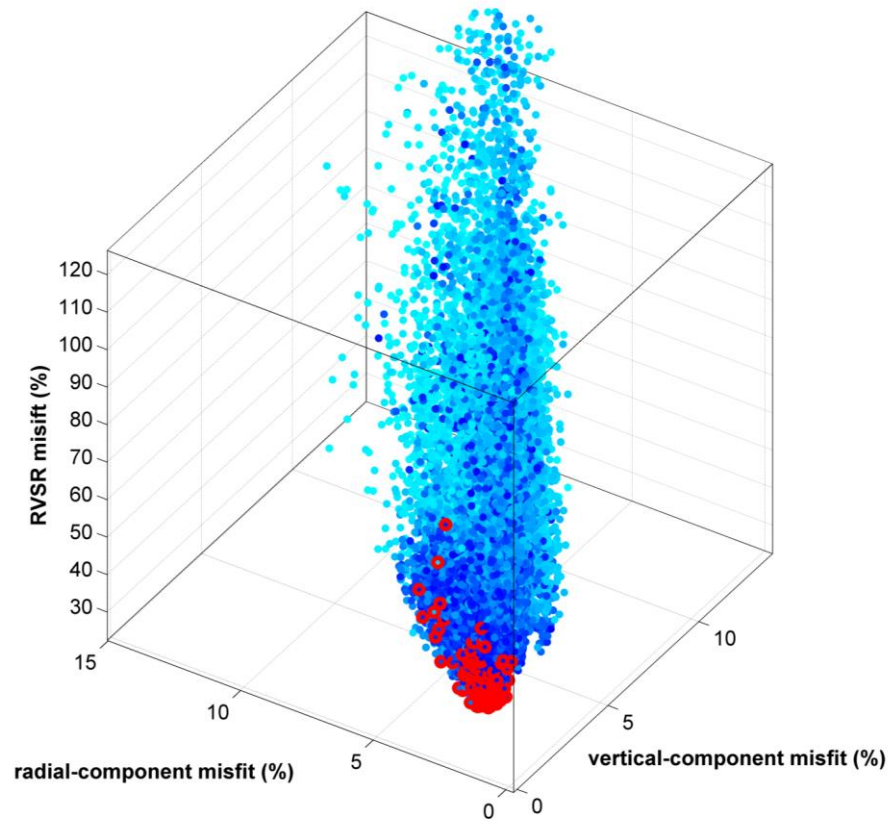
From (11) and (12), the relative powers of the vertical and horizontal motions of m th mode can be expressed as $A_m^2 c_m$ and $(A_m [\dot{u}/\dot{w}]_m)^2 c_m$, respectively. Hence, by knowing A_m , c_m , and $[\dot{u}/\dot{w}]_m$ of each mode for a frequency f , the apparent phase velocities of vertical and horizontal motions for a given sensor distance can be determined as

$$c_{sv} = \frac{2\pi f D}{\cos^{-1} \left[\frac{\sum_{m=1}^M A_m^2 c_m \cos \left(\frac{2\pi f D}{c_m} \right)}{\sum_{m=1}^M A_m^2 c_m} \right]} \dots \dots \dots (20)$$

$$c_{sh} = \frac{2\pi f D}{\cos^{-1} \left[\frac{\sum_{m=1}^M \left(A_m \left[\frac{\dot{u}}{\dot{w}} \right]_m \right)^2 c_m \cos \left(\frac{2\pi f D}{c_m} \right)}{\sum_{m=1}^M \left(A_m \left[\frac{\dot{u}}{\dot{w}} \right]_m \right)^2 c_m} \right]} \dots \dots \dots (21)$$

Oberflächengebundene Bestimmung eines robusten V_s -Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

Oberflächengebundene Bestimmung eines robusten V_s -Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche



HS

The unordinary *HoliSurface* approach

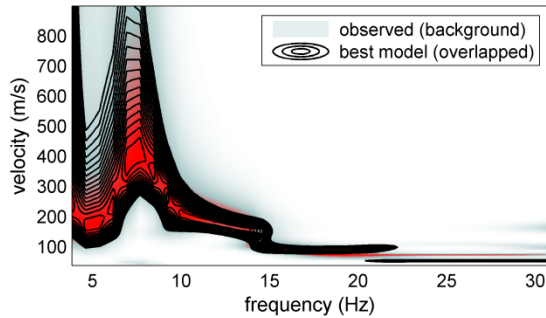


Oberflächengebundene Bestimmung eines robusten Vs-Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

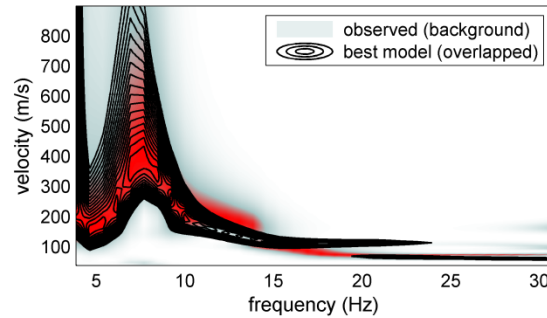


The unordinary *HoliSurface* approach

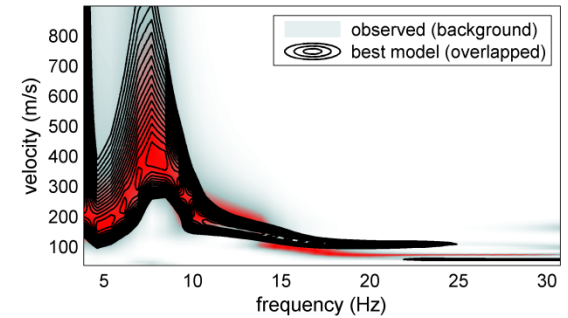
Best vertical-component model (vertical component)



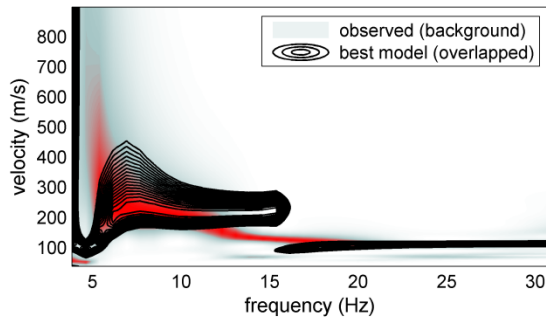
Best radial-component model (vertical component)



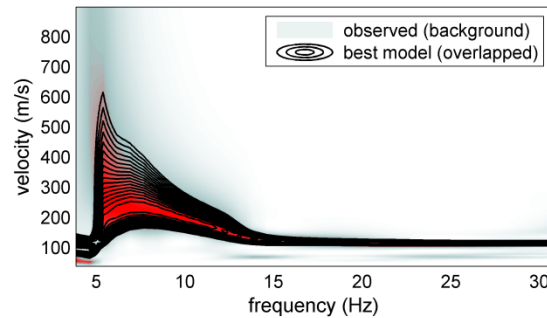
Best RVSr model (vertical component)



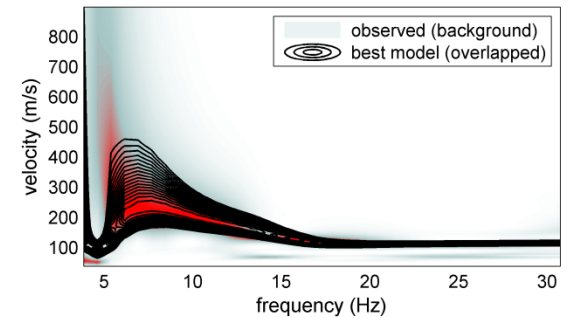
Best vertical-component model (radial component)



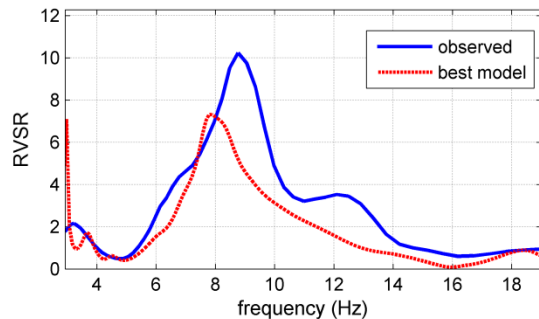
Best radial-component model (radial component)



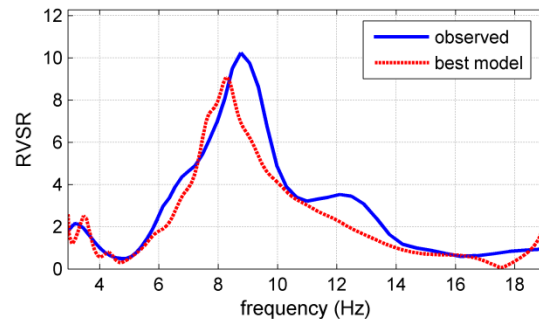
Best RVSr model (radial component)



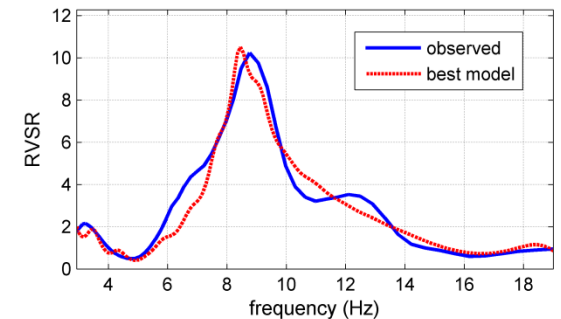
Best vertical-component model (RVSr)



Best radial-component model (RVSr)



Best RVSr model (RVSr)

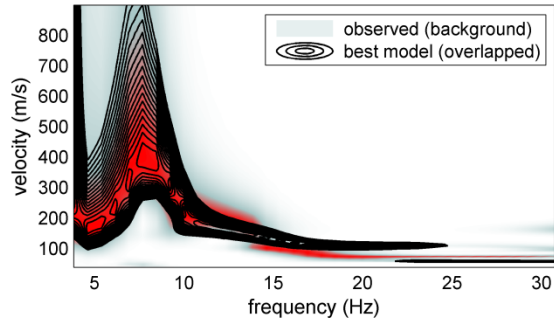


Oberflächengebundene Bestimmung eines robusten Vs-Modells als Eingangsparameter zu bodendynamischen Berechnungen an einer historischen Klosterkirche

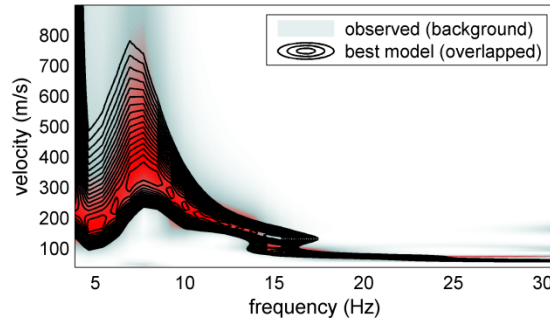


The unordinary *HoliSurface* approach

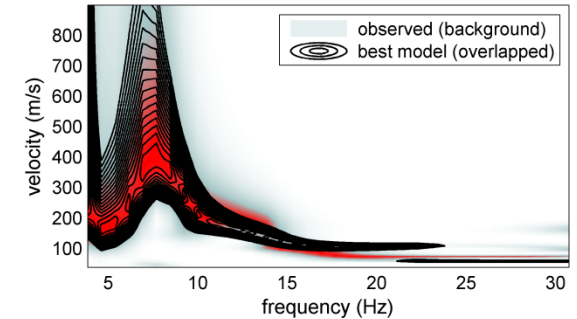
Minimum "global" GA model (vertical component)



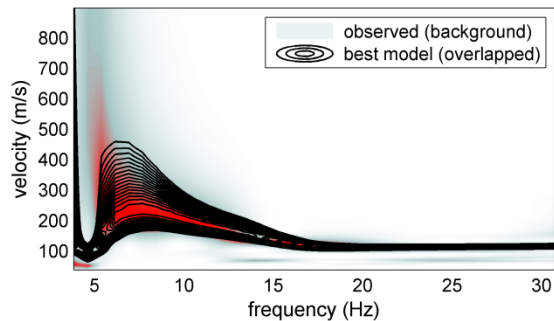
Minimum-distance model (vertical component)



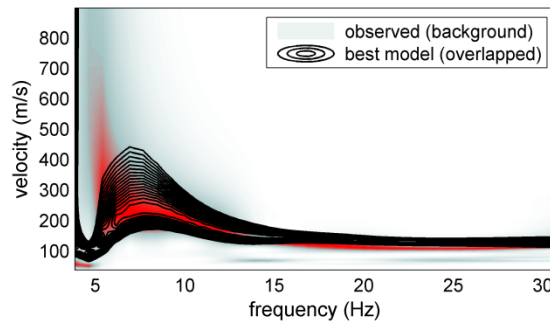
Mean model (vertical component)



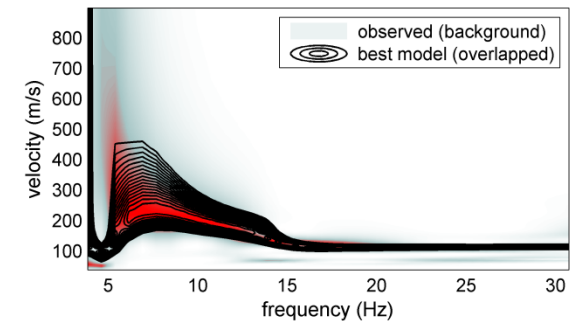
Minimum "global" GA model (radial component)



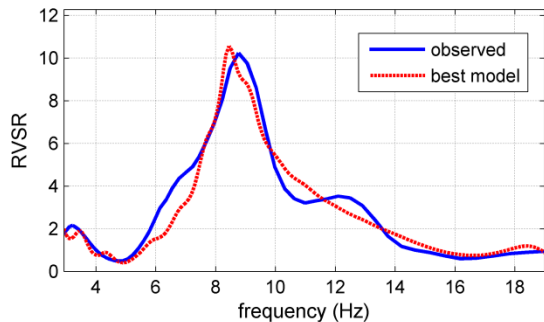
Minimum-distance model (radial component)



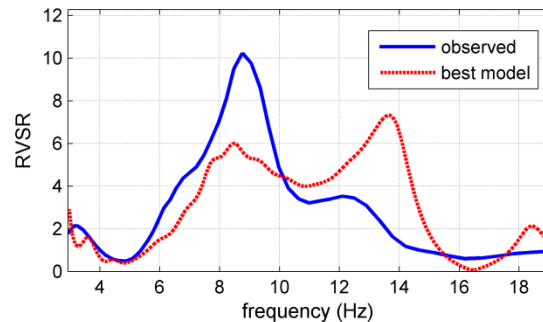
Mean model (radial component)



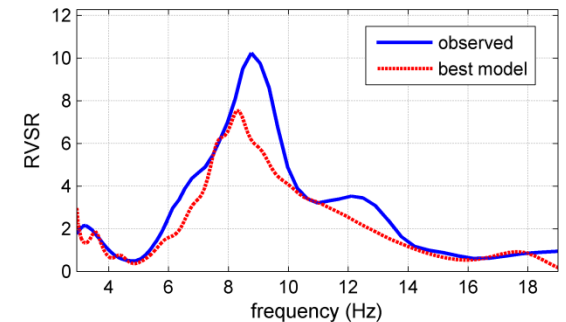
Minimum "global" GA model (RVSR)



Minimum-distance model (RVSR)



Mean model (RVSR)

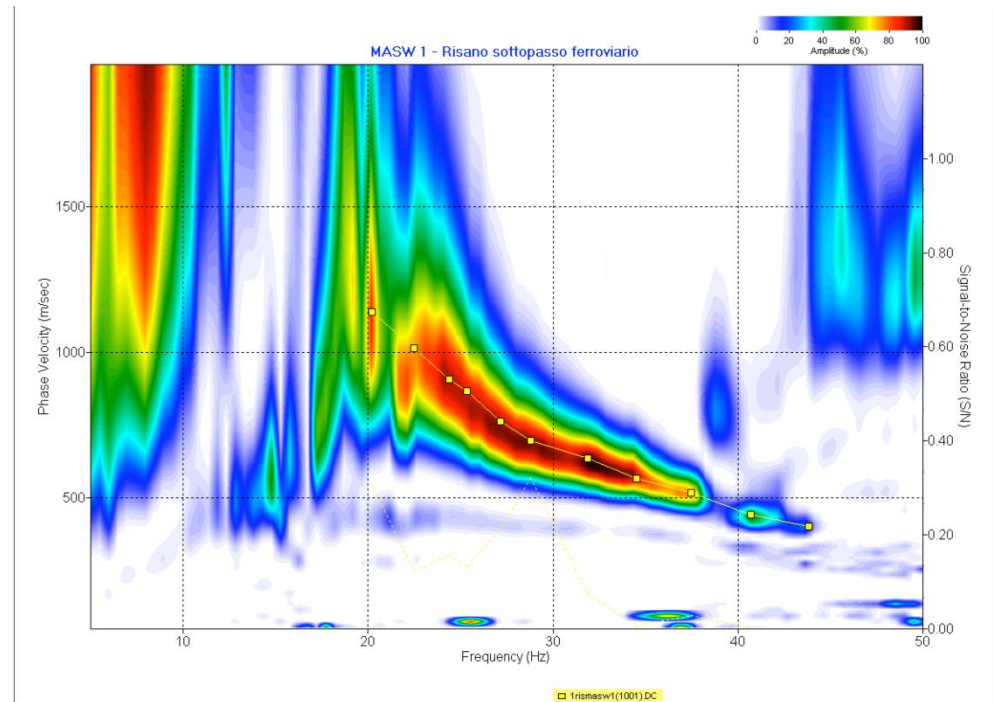


Modal and effective dispersion curves: problems and solutions

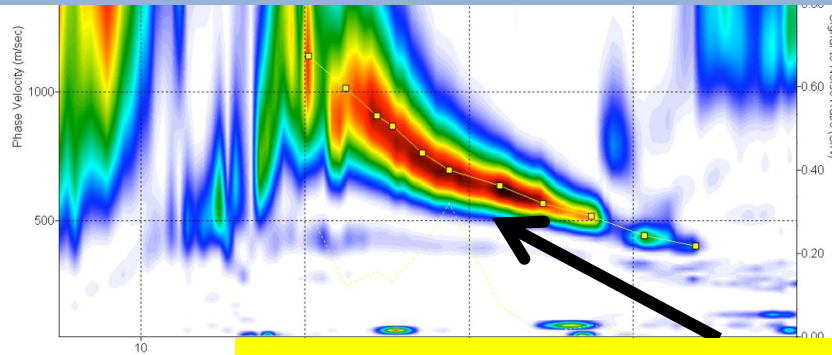
“MASW”

Downhole

P-wave refraction

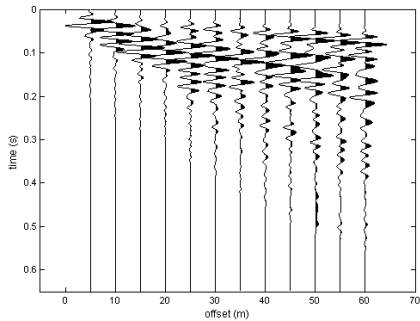


Modal and effective dispersion curves: problems and solutions



Dies ist nicht der Fundamentalmodus!

1. input Rayleigh data



dataset: zvf.mat
sampling: 1ms [1000Hz] - 651 samples
minimum offset: 5 m
geophone spacing: 5 m

flip data cut spectrogram

select data

activate

select

cancel

save

mode separation

save spectrum

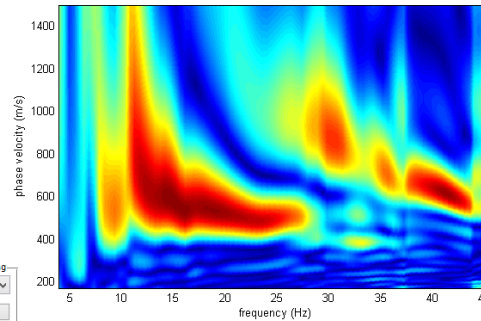
upload spectrum

input curve

picking

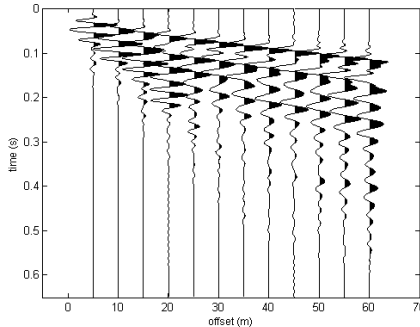
auto pick select ...

save cancel



Love component

2. input Love data



dataset: thf.mat
sampling: 1ms [1000Hz] - 651 samples
minimum offset: 5 m
geophone spacing: 5 m

flip data cut spectrogram

select data

activate

select

cancel

save

mode separation

save spectrum

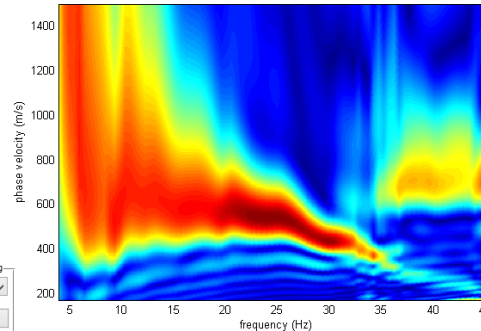
upload spectrum

input curve

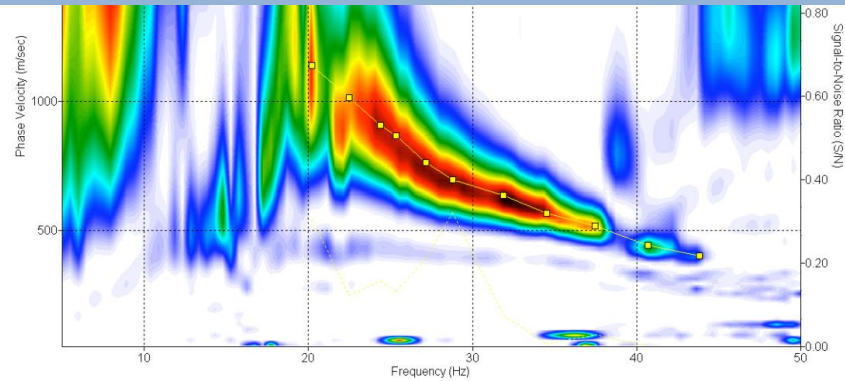
picking

select mode

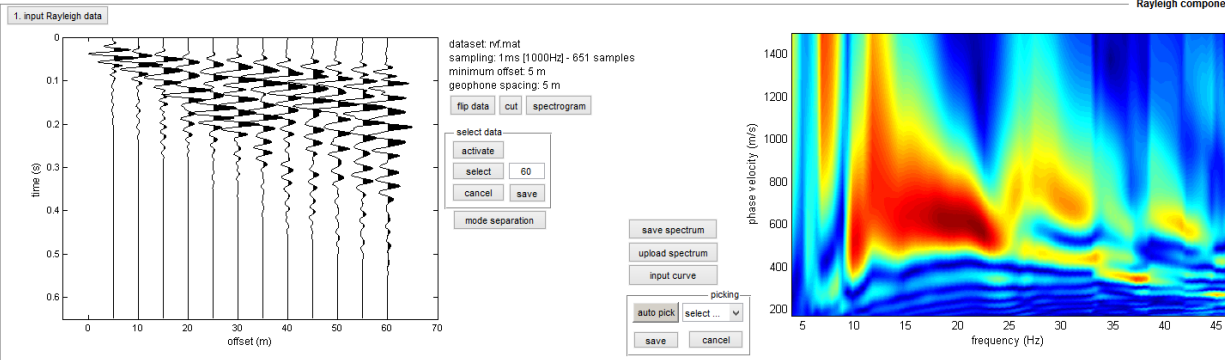
save cancel



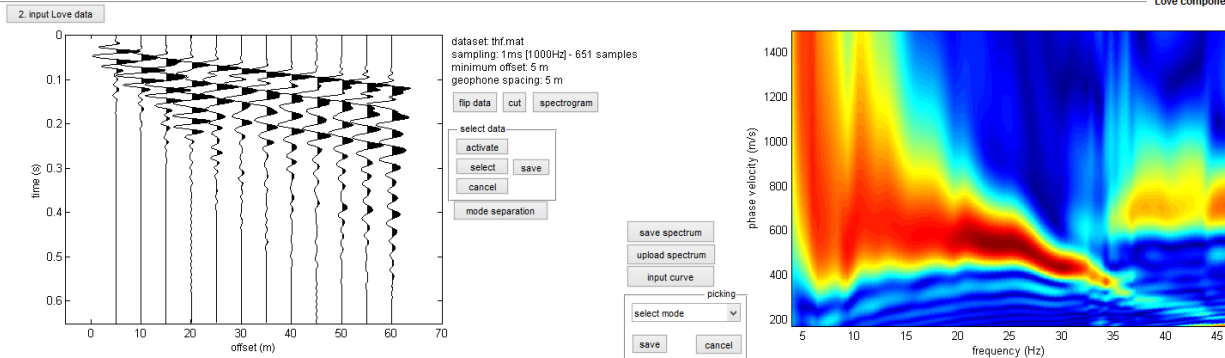
Modal and effective dispersion curves: problems and solutions



Rayleigh component

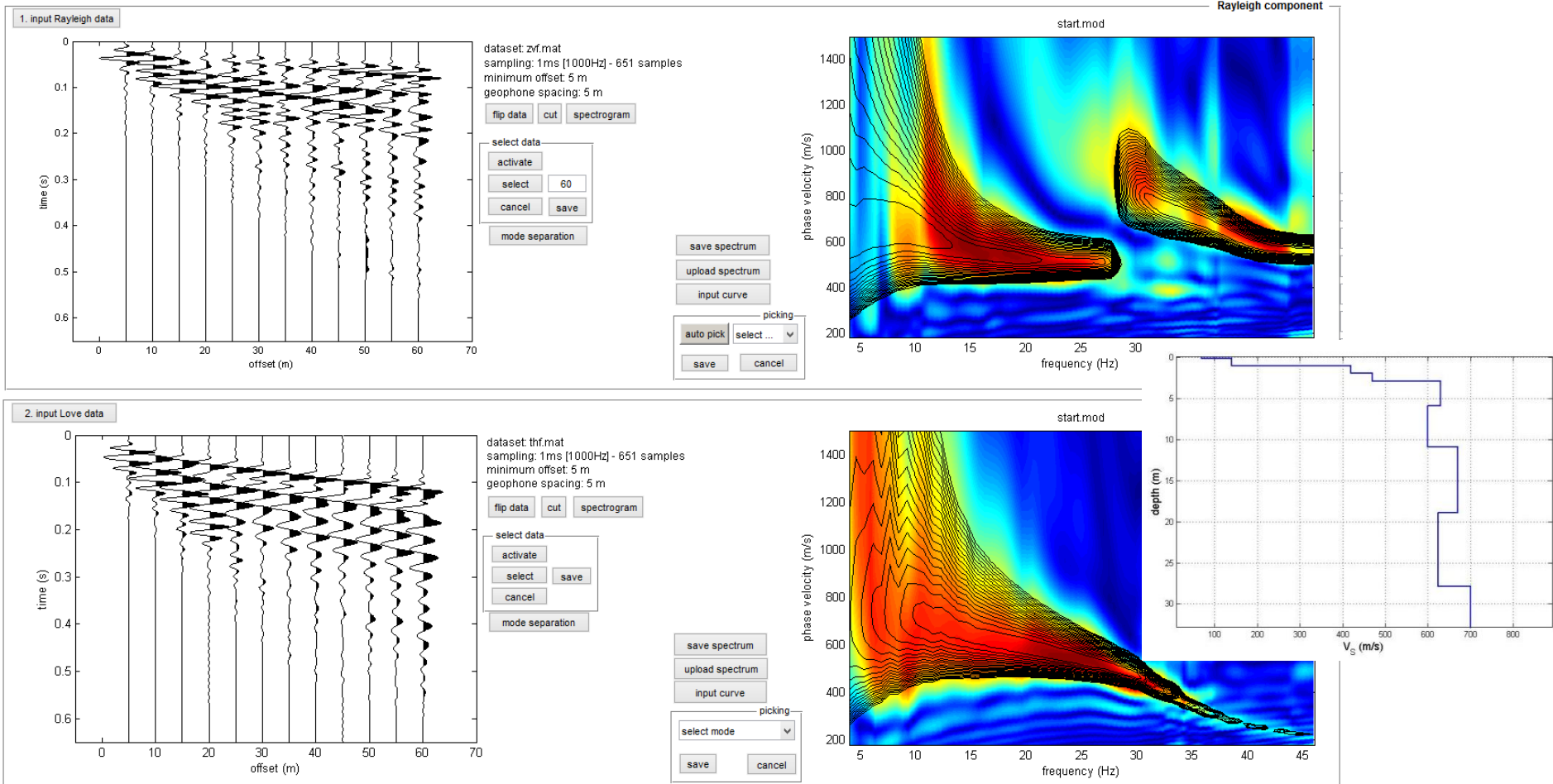


Love component



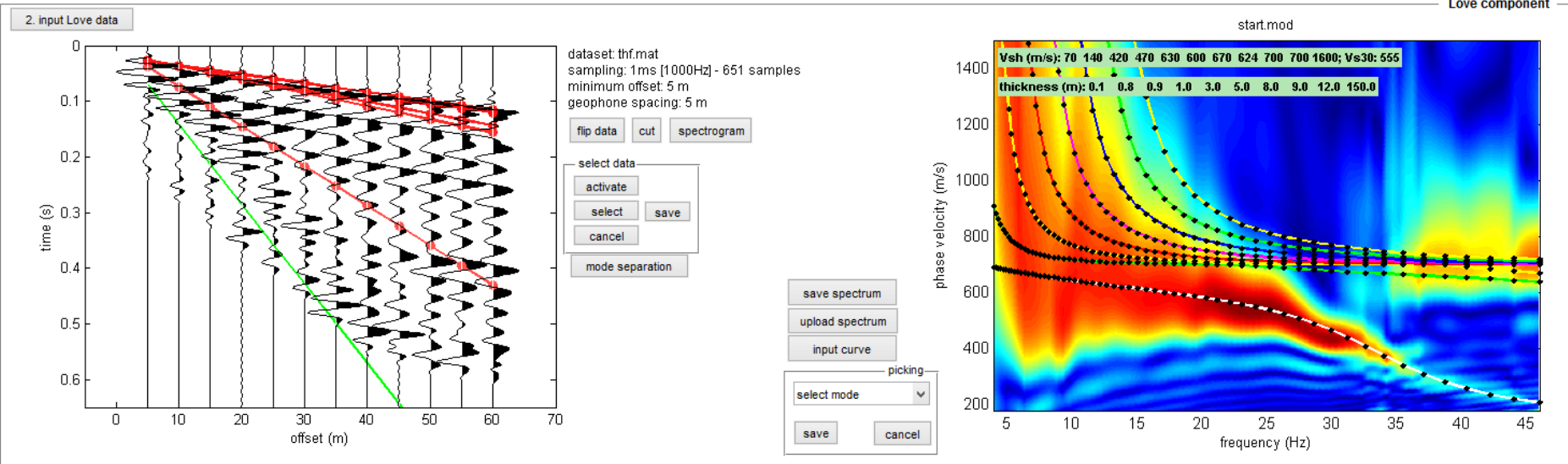
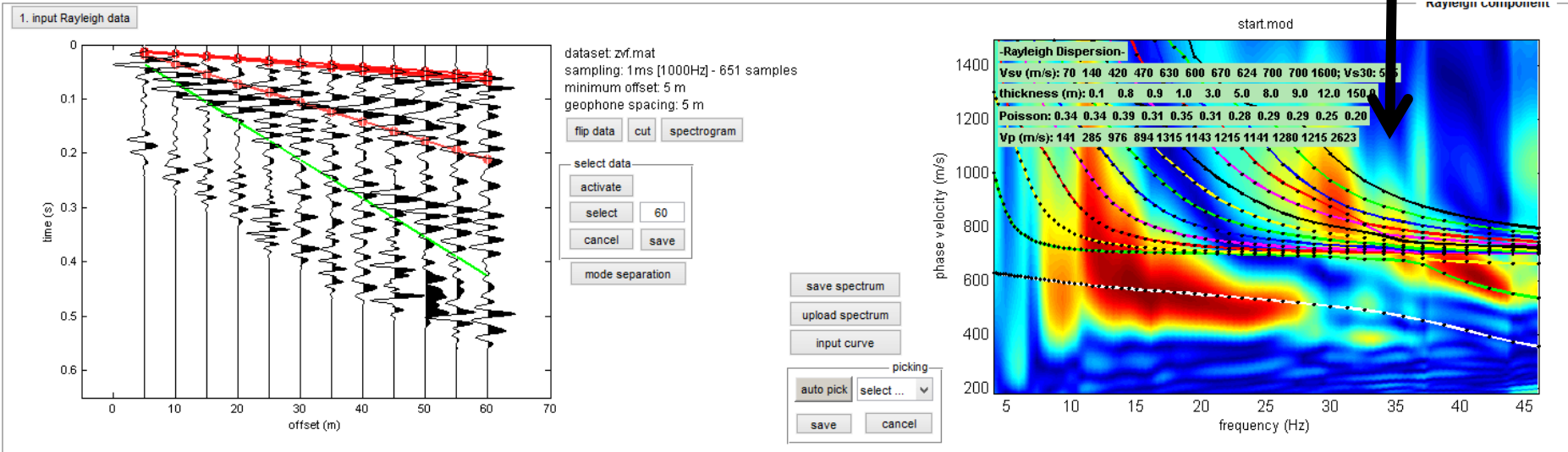
Modal and effective dispersion curves: problems and solutions

Our joint FVS solution



About modes (and refraction)

Dies ist nicht ein einziger Modus!



Lesson:

- 1) DO NOT use modal dispersion curves;**
- 2) DO NOT use (only) Rayleigh waves.**

So:

- 1) Use FVS (*Full Velocity Spectrum*) analysis and/or the *effective* dispersion curves;**
- 2) Use (also) Love waves.**

What's in common?

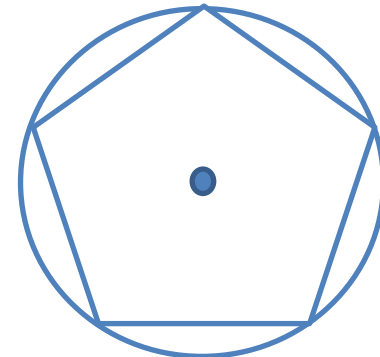
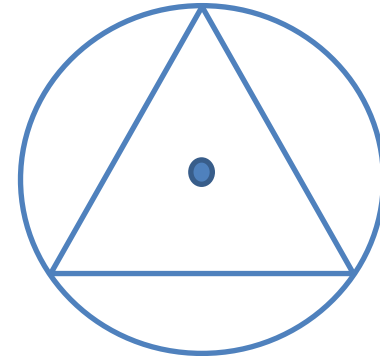
A circle, a line: they look good, they are abstract, they are common knowledge. They belong to everyone and equally to the past, the present and the future.
Richard Long



HS

HVSR

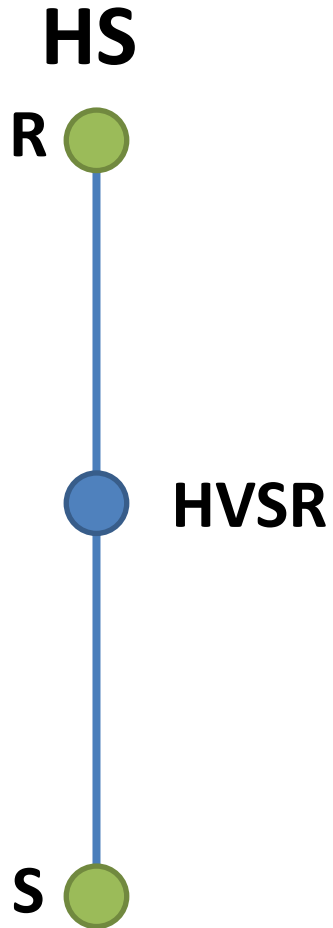
MAAM



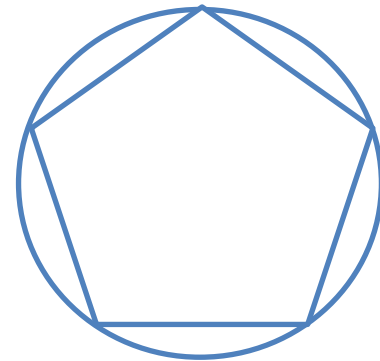
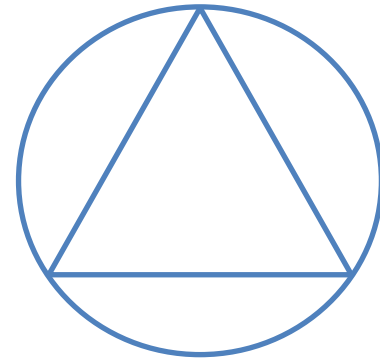
Noise

Two volunteers, please

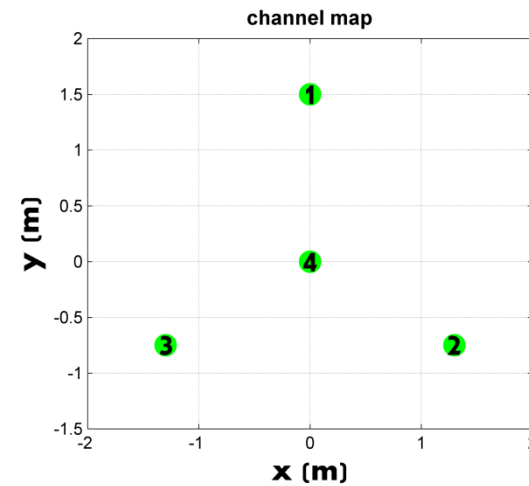
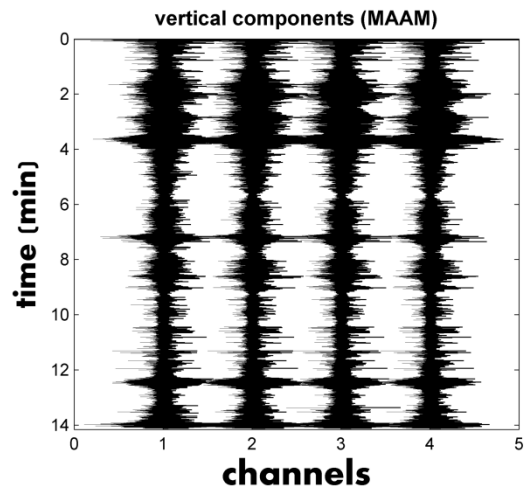
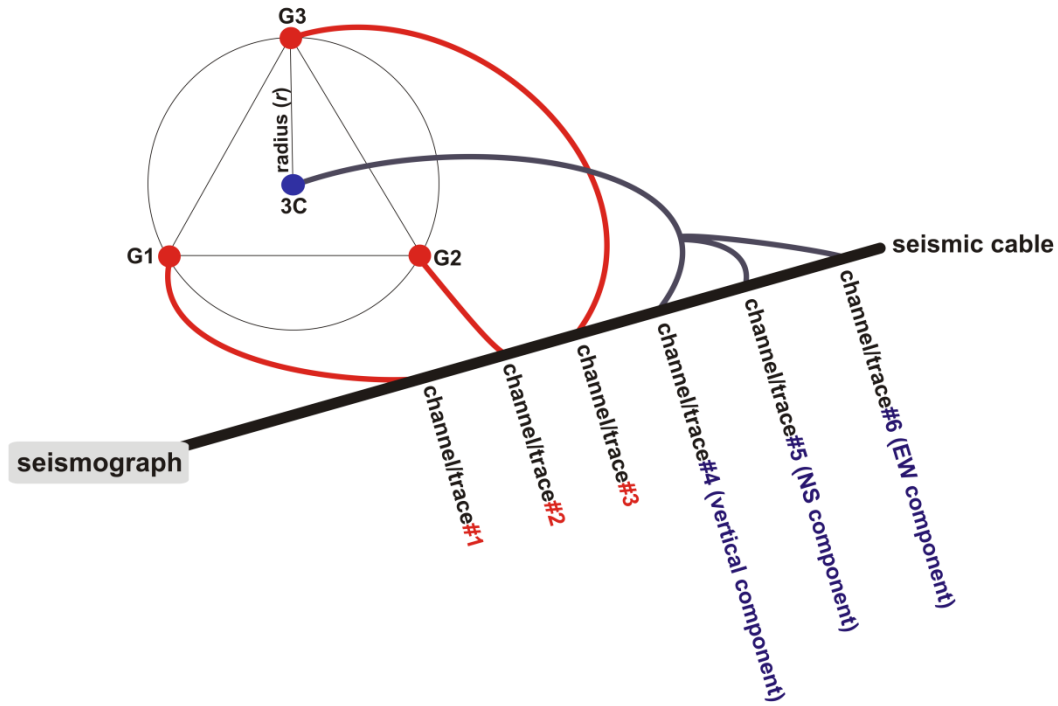




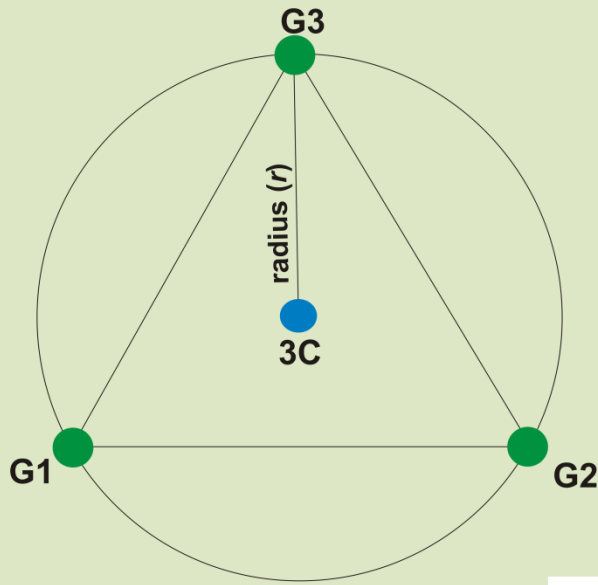
MAAM



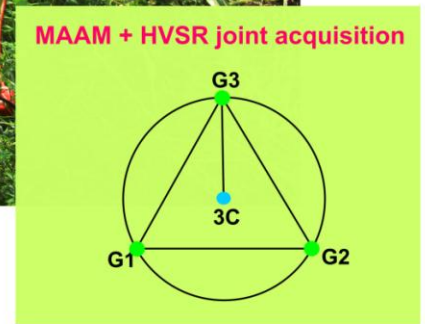
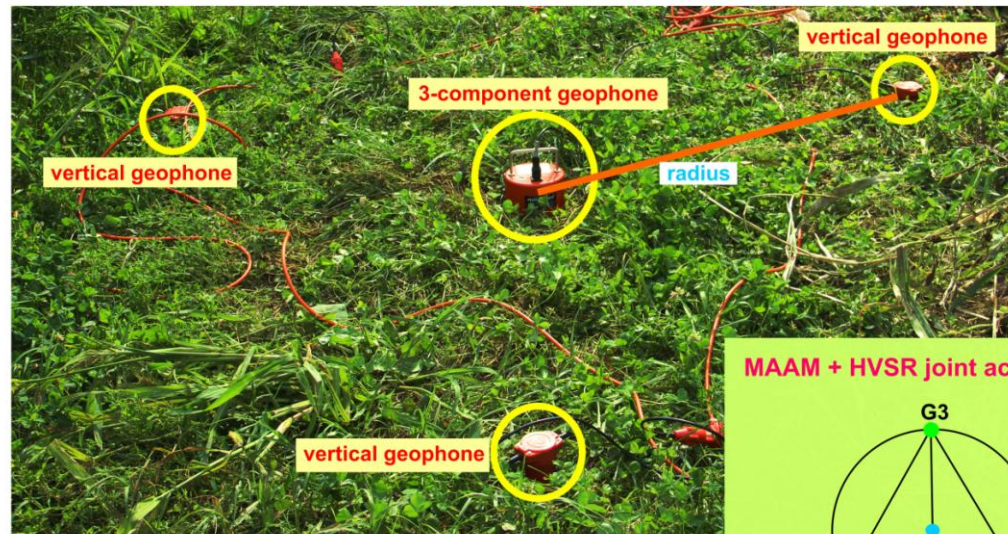
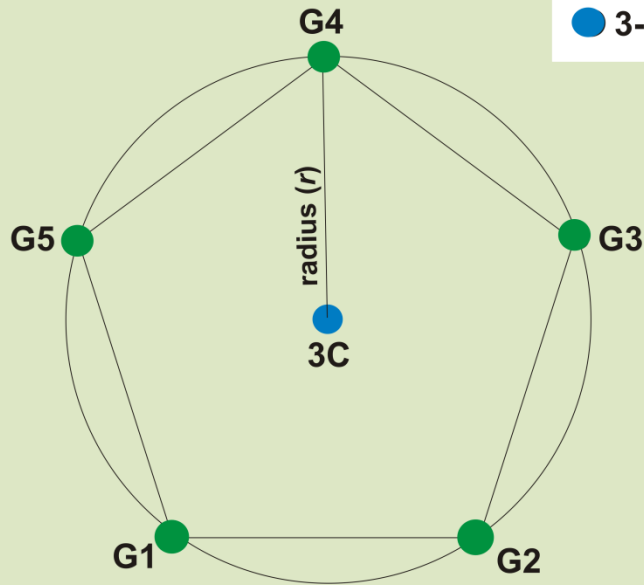
An efficient urban palindrome



MAAM + HVSR joint acquisition



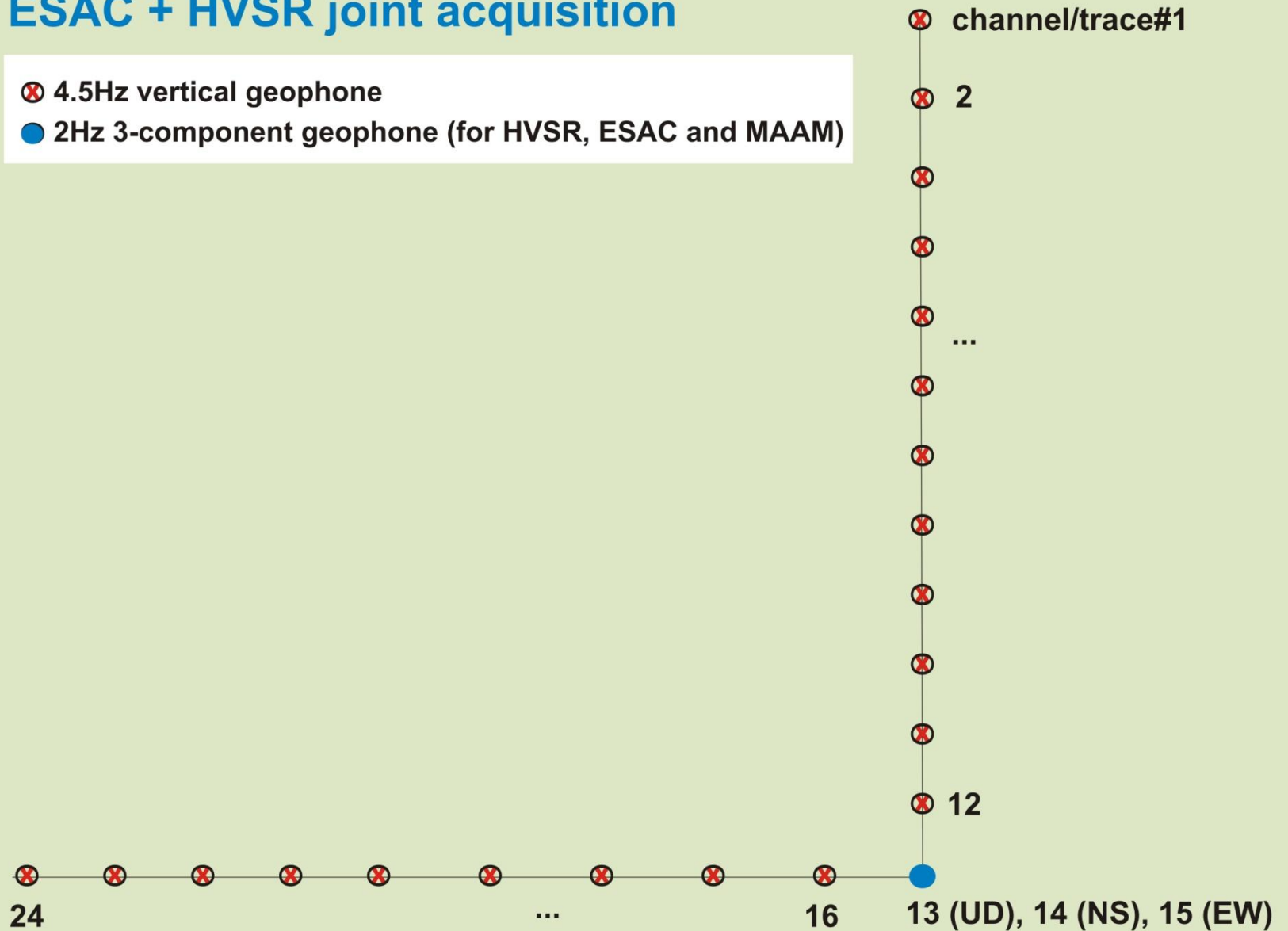
- 2Hz vertical geophone
- 3-component geophone (for HVSR and MAAM)



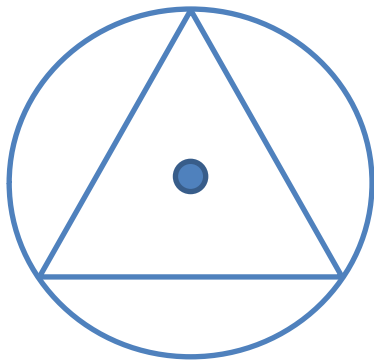


ESAC + HVSR joint acquisition

- ⊗ 4.5Hz vertical geophone
- 2Hz 3-component geophone (for HVSR, ESAC and MAAM)



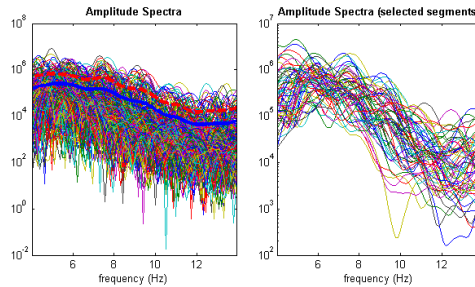
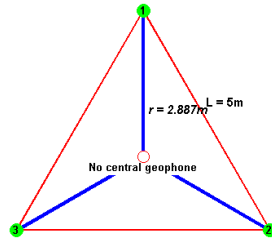
MAAM



resample to 4ms (250Hz)

| | | | |
|-------------------------|--------------------------------|---------------|---------------|
| data | radius (m): 2.887 | save geometry | show location |
| number of channels: 3 | <input type="checkbox"/> n-CCA | show data | spectrogram |
| show/update channel map | | clean data | PSD |

folder: C:\Users\gdm\Desktop\ltdl\interessanti o da analizzare\PURGESSMORIGHT_CCA\vertical+HVSRI
dataset: singlechannels.mat
sampling: 2ms (Nyquist frequency: 250Hz)



phase velocity spectrum

min freq: 4 max freq: 14
min vel: 40 max vel: 800

parameters

5.9 window length (s)
25% spectral smoothing
5% tapering (%)
40 tolerance
5 m/s velocity increment

hold on
 noise computation
 verbose

compute

picking

effective dispersion curve

start picking | save picking
to select the last point
click the right button

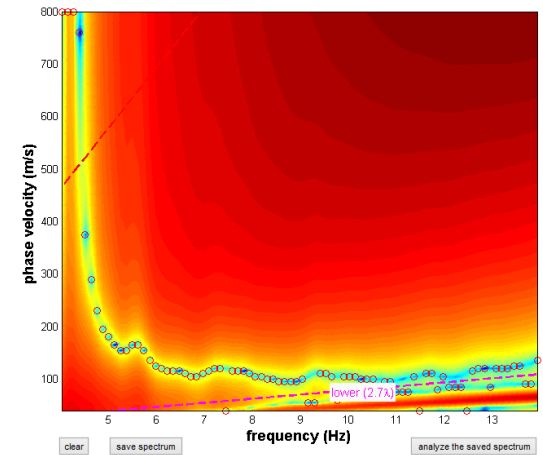
cancel picking

HVSRI computation

quick HVSRI

HoliSurface® pre-processing tools

TCMCD



*A circle, a line: they look good, they are abstract, they are common knowledge.
They belong to everyone and equally to the past, the present and the future.*

Richard Long

Scavo 2 – (corrispondente H/V2)

0-45/50 terreno agrario

45/50-270 limo da debolmente sabbioso a sabbioso

270-370 sabbia fine limosa

370-410 ghiaia e ciottoli in scarsa matrice limosa

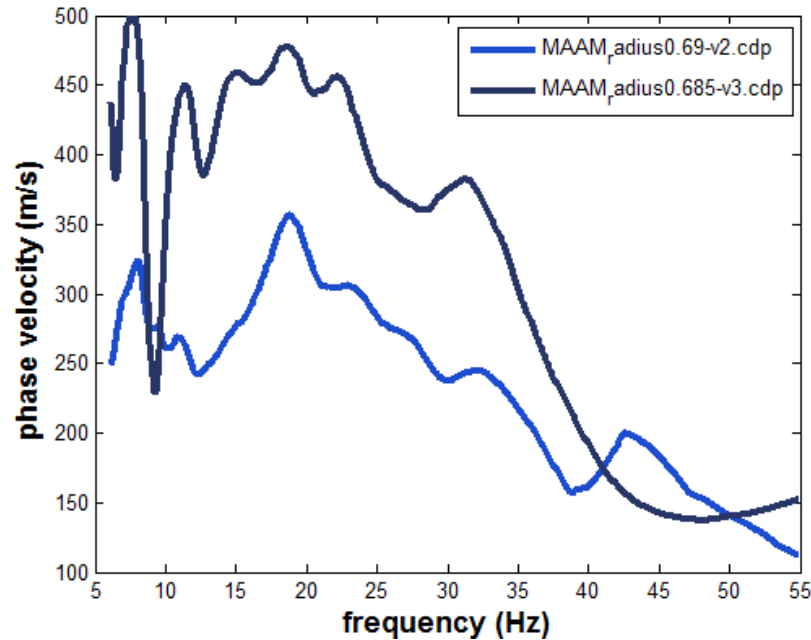
Scavo 3 – (corrispondente H/V3)

0-40/45 terreno agrario

40/45-110 limo da debolmente sabbioso a sabbioso

110-180 ghiaia e ciottoli in matrice limosa

180-300 ghiaia sabbia con ciottoli



Comparing the effective dispersion curves at site#2 and #3

A “noisy” desperate case

select data

 60

tools
 time length to visualize (sec)

HVSRR arranged hv

frequency (Hz)

MAAM

 effective phase vel

Vs30: 246 m/s

group-velocity spectra (vertical & radial components)
Rayleigh waves (radial)

group velocity (m/s)

frequency (Hz)

general settings

reference depth ?
 refraction
 HVSRR from body waves
 alfa factor (SW)

| Vs (m/s) | Qs | Poisson | Qp | thk (m) |
|----------|-----|---------|-----|---------|
| 127 | 12 | 0.36 | 12 | 0.4 |
| 165 | 12 | 0.328 | 12 | 0.4 |
| 165 | 19 | 0.33 | 19 | 2 |
| 155 | 19 | 0.336 | 19 | 3.9 |
| 296 | 22 | 0.3306 | 14 | 3 |
| 271 | 19 | 0.4326 | 19 | 2.4 |
| 180 | 24 | 0.44 | 24 | 5.8 |
| 414 | 42 | 0.46 | 42 | 6 |
| 455 | 20 | 0.484 | 20 | 6.75 |
| 296 | 45 | 0.326 | 45 | 33 |
| 484 | 85 | 0.282 | 85 | 133 |
| 1100 | 164 | 0.249 | 164 | |

model:

reference freq. (Hz):
k factor:
number of modes:
Rayleigh-wave source:
detail:
 verbose

Velocity Spectra

just THF

dataset: 01_VF_0m_F.SAF
offset: 40 m
sampling: 1 ms



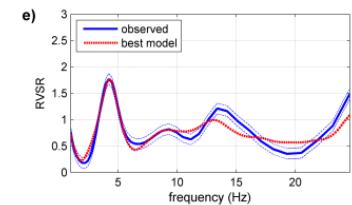
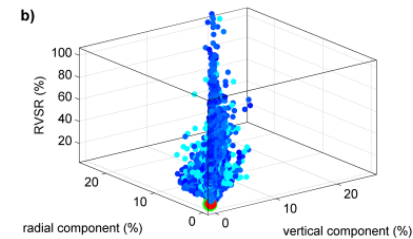
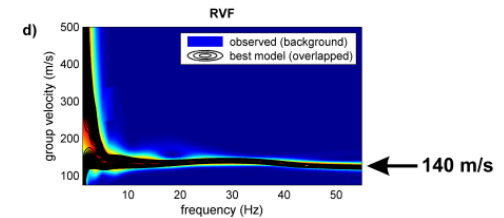
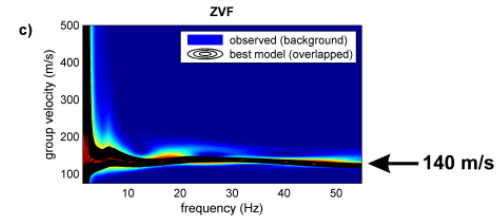
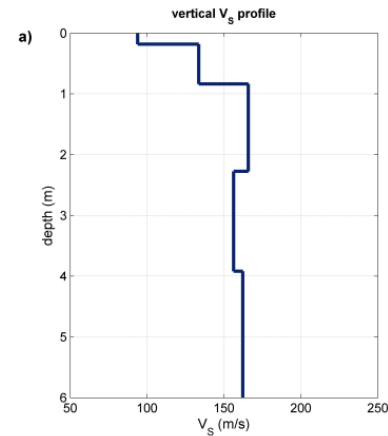


A LINE MADE BY WALKING

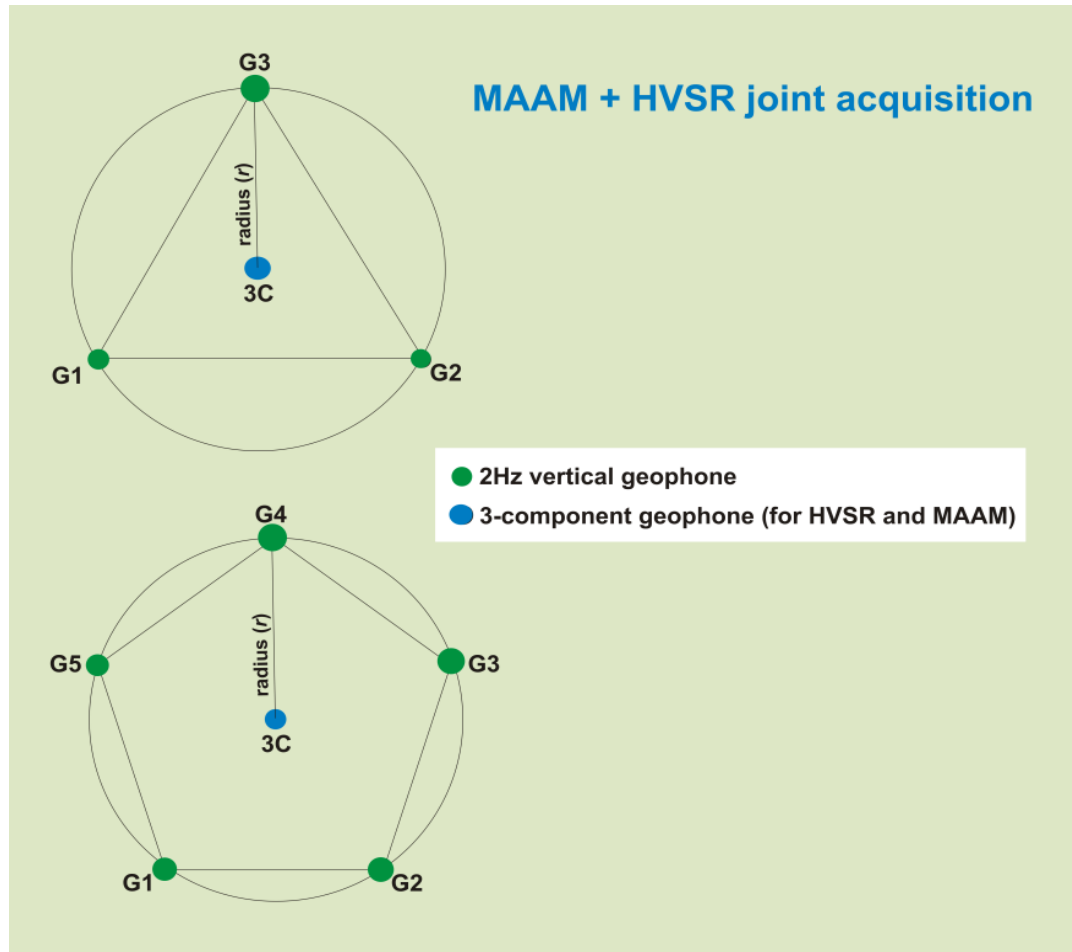
ENGLAND 1967

What's in common?

Calibrated and triggered geophone



MAAM (Miniature Array Analysis of Microtremors)



MAAM

Preliminary equipment test

N+1 identical geophones (2 or 4.5Hz?)

radius/radii

Tolerance & smoothing

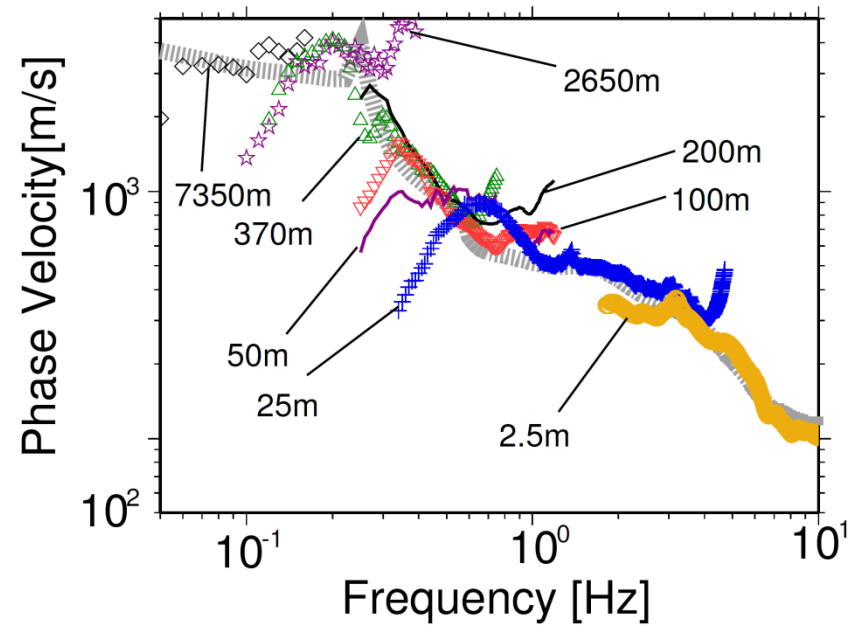
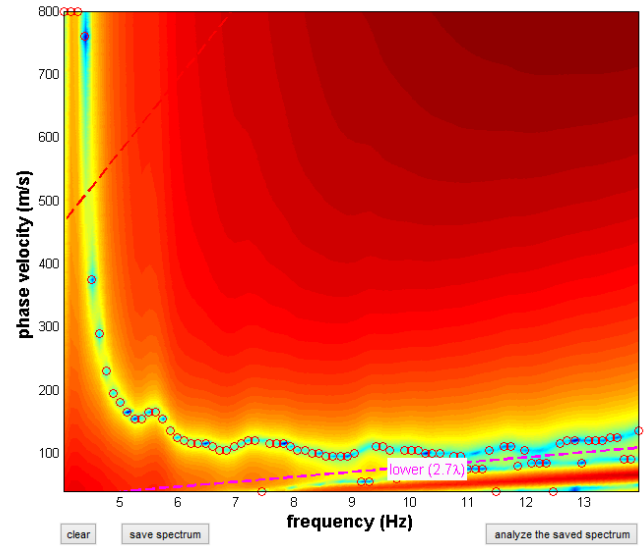
window length

data cleaning

MAAM



MAAM



MAAM Comparing MASW-ZVF

1. Purgessimo

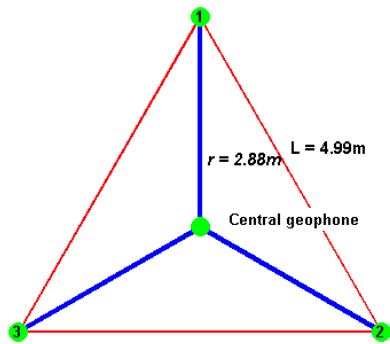
resample to 4ms (250Hz)

data

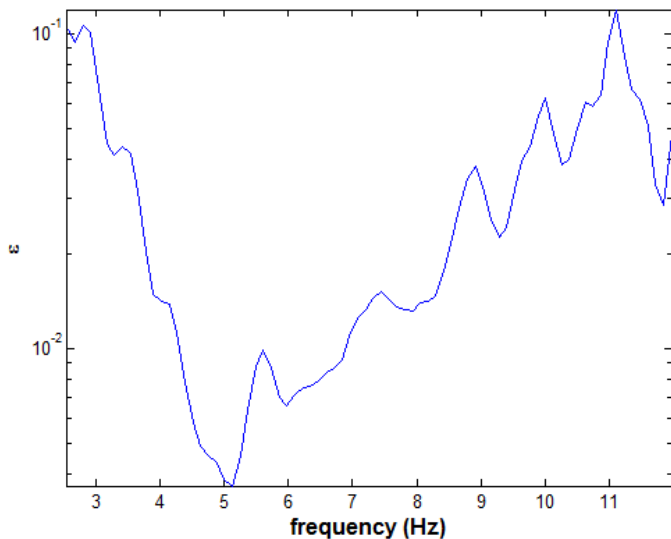
radius (m):

number of channels: nc-CCA

Folder: C:\Users\gdm\Desktop\kati_da_analizzare\PURGESSIMO-MAAM\RIGHT_CCA\only4VERTICAL\
 Dataset: singlechannelsmaam-5m-clean.mat
 Recording time: 13.75 min
 Sampling: 4 ms [Nyquist frequency: 125Hz]



Noise-to-Signal Ratio



phase velocity spectrum

min freq. max freq.

min vel. max vel.

parameters

window length (s)

spectral smoothing

tapering (%)

tolerance

velocity increment

hold on

noise computation

verbose

picking

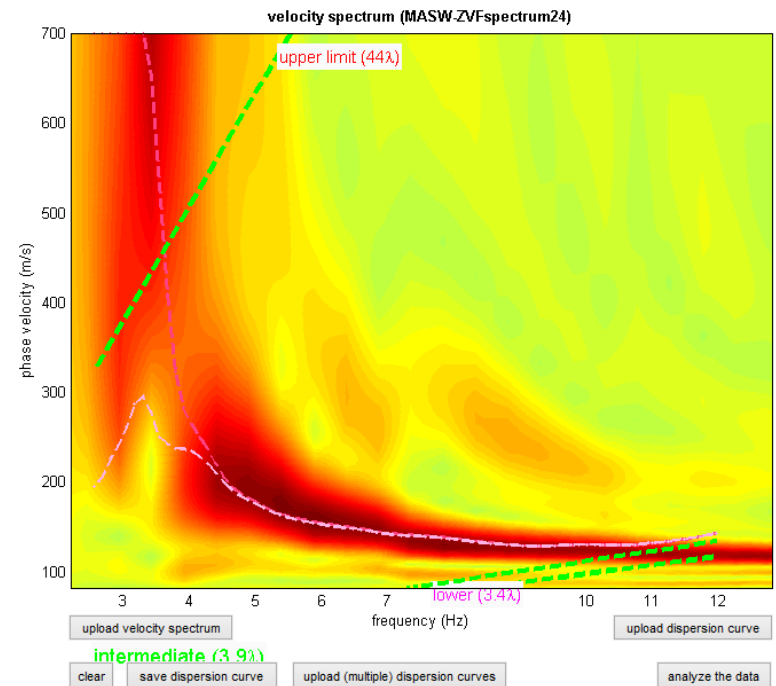
effective dispersion curve

to select the last point
click the right button



pre-processing tools

No noise computation/compensation



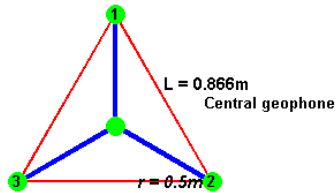
resample to 4ms (250Hz)

data

radius (m):

number of channels: nc-CCA

Folder: C:\Users\gdm\Desktop\data_da_analizzzare\Muscoli-Cimitero\MAAMradius50cm\
Dataset: MAAM-data-clean.mat
Recording time: 14.49 min
Sampling: 4 ms [Nyquist frequency: 125Hz]



phase velocity spectrum

min freq. max freq.

min vel. max vel.

parameters

window length (s)

spectral smoothing

tapering (%)

tolerance

velocity increment

- hold on
 noise computation
 verbose

picking

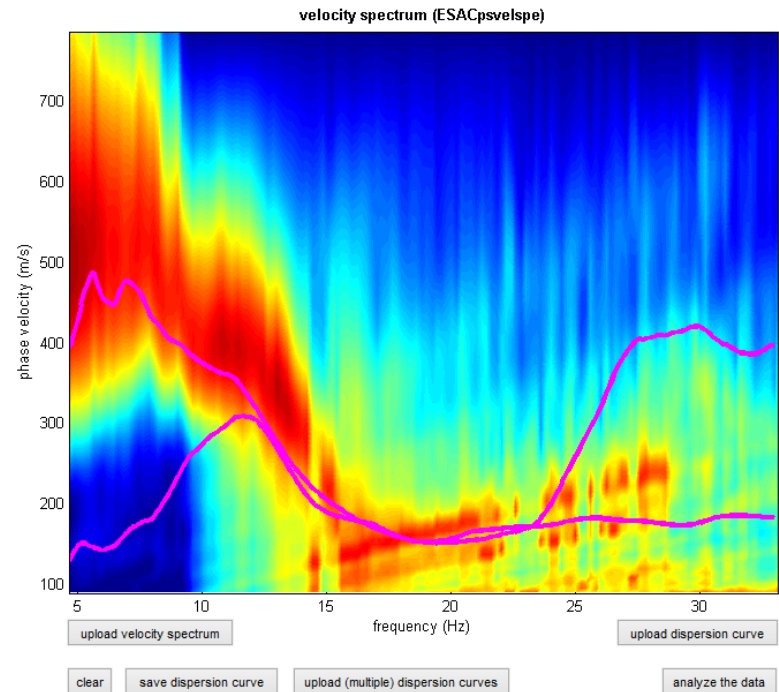
effective dispersion curve

to select the last point
click the right button



pre-processing tools

Noise (epsilon) computed [dispersion compensated]



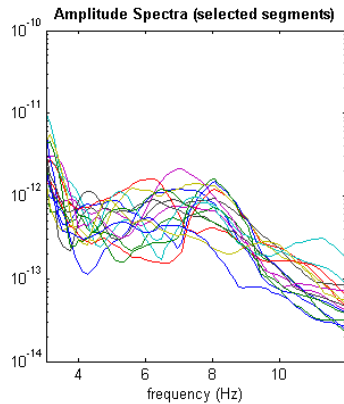
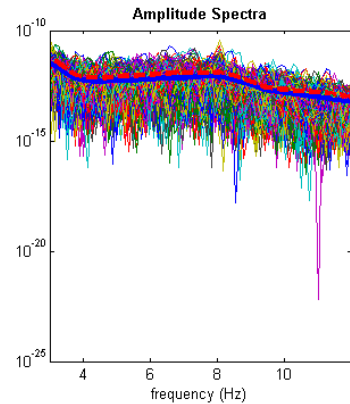
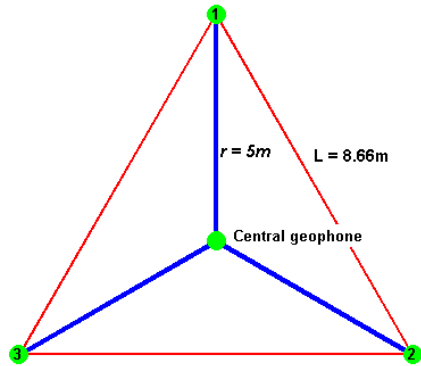
resample to 4ms (250Hz)

data

radius (m):

number of channels: nc-CCA

Folder: C:\Users\gdm\Desktop\data_da_analizzare\Acquisizioni La Spezia Gab and Lorenzo\MAAM\radius5\
Dataset: MAAM-data-clean.mat
Recording time: 25.93 min
Sampling: 4 ms [Nyquist frequency: 125Hz]



phase velocity spectrum

min freq. max freq.

min vel. max vel.

parameters

window length (s)

spectral smoothing

tapering (%)

tolerance

velocity increment

hold on

noise computation

verbose

picking

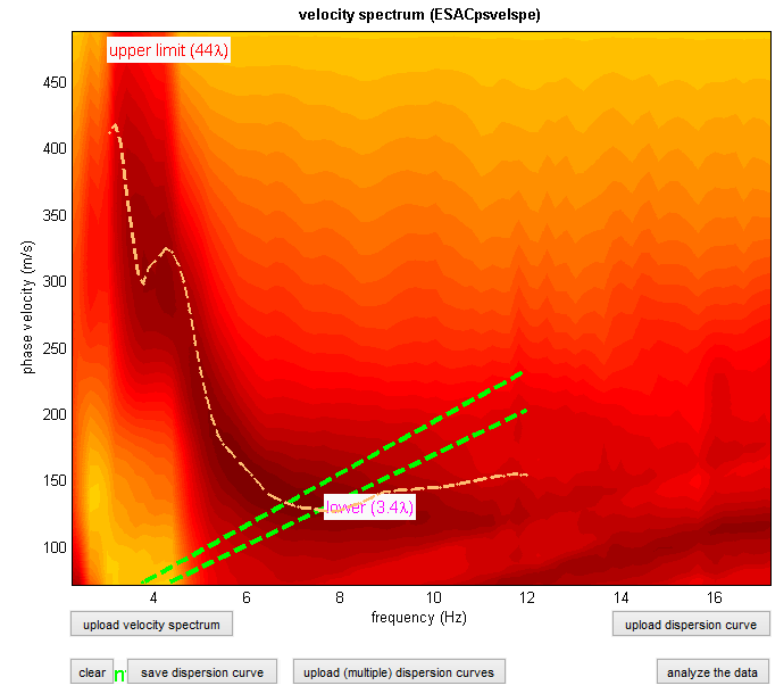
effective dispersion curve

to select the last point
click the right button



pre-processing tools

Noise (epsilon) computed [dispersion compensated]



Two radii (5 and 2m)

resample to 4ms (250Hz)

data

radius (m):

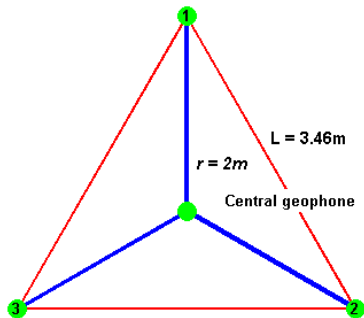
number of channels: nc-CCA

Folder: C:\Users\yadm\Desktop\dati_da_analizzare\Acquisizioni La Spezia Gab and Lorenzo\MAAM\radius2\

Dataset: MAAM-data-clean.mat

Recording time: 24.14 min

Sampling: 4 ms [Nyquist frequency: 125Hz]



phase velocity spectrum

min freq: max freq:

min vel: max vel:

parameters

window length (s)

15% spectral smoothing

50% tapering (%)

5 tolerance

5 m/s velocity increment

hold on

noise computation

verbose

central TR=last

picking

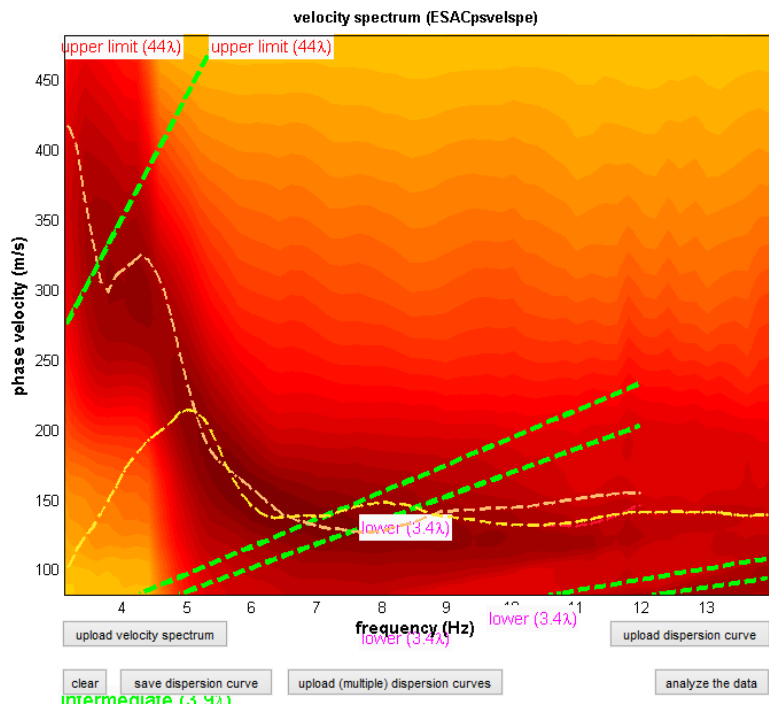
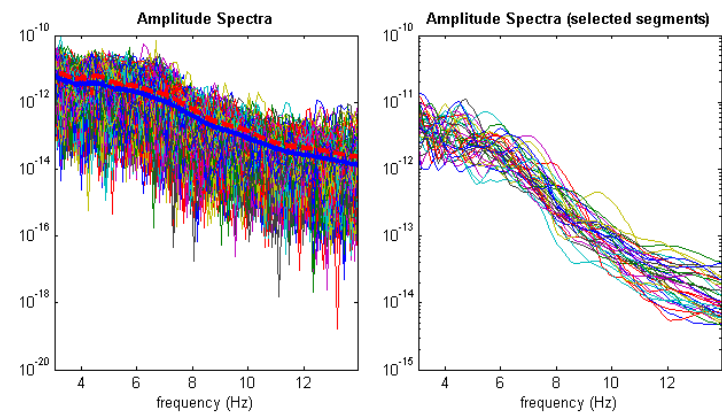
effective dispersion curve

to select the last point click the right button



pre-processing tools

Noise (epsilon) computed [dispersion compensated]



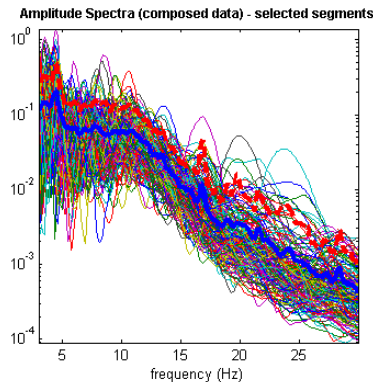
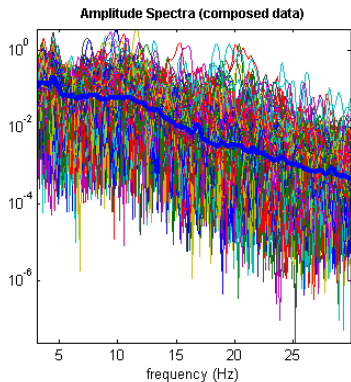
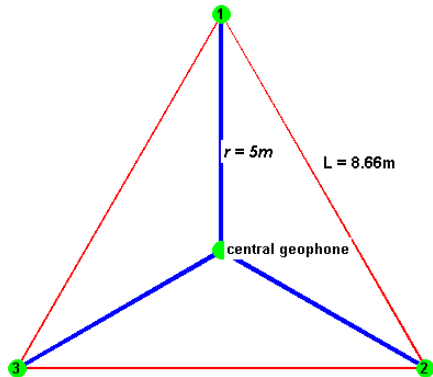
resample to 4ms (250Hz)

data

radius (m):

number of channels: nc-CCA

Folder: C:\Users\gdm\Desktop\dati interessanti in corso\Modena-tests-Lorenzo_Del_Maschio\MAAM_DoReM\MAAM_5m
 Dataset: MAAM-data-clean.mat
 Recording time: 11.91 min
 Sampling: 4 ms [Nyquist frequency: 125Hz]



phase velocity spectrum

min freq. max freq.

min vel. max vel.

parameters

window length (s)

spectral smoothing

tapering (%)

tolerance

velocity increment

upper limit

hold on

noise computation

trace normalization

verbose

advanced processing

auto (for raw data)

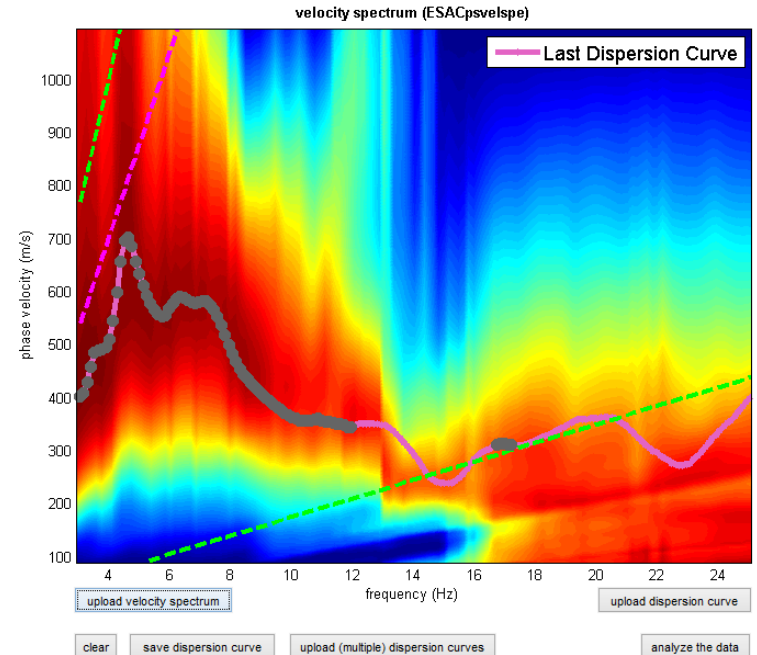
picking

effective dispersion curve

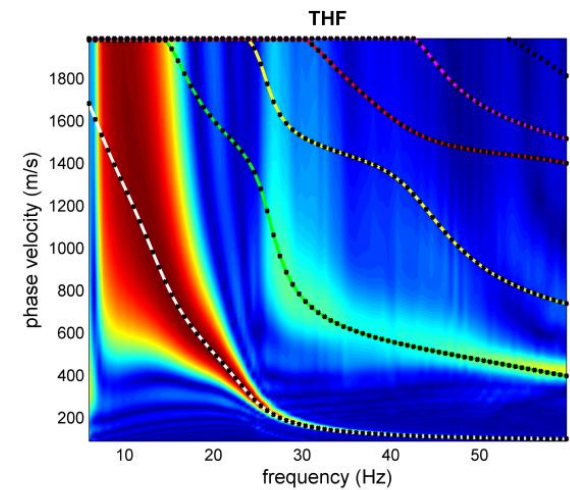
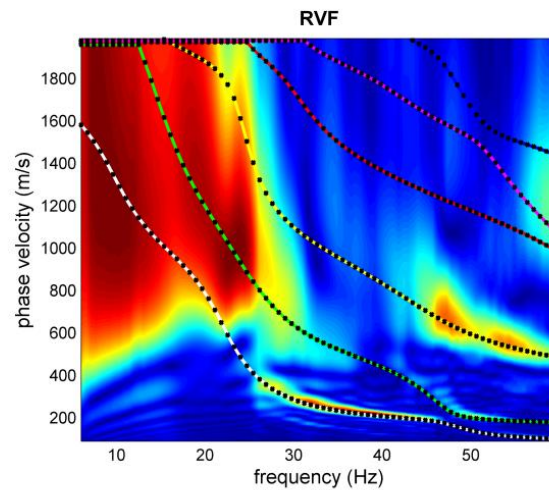
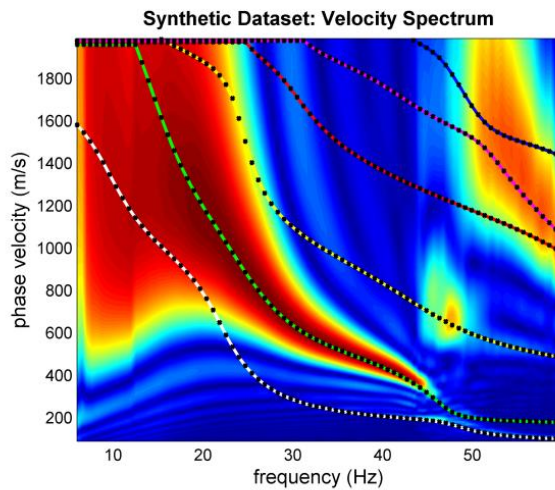
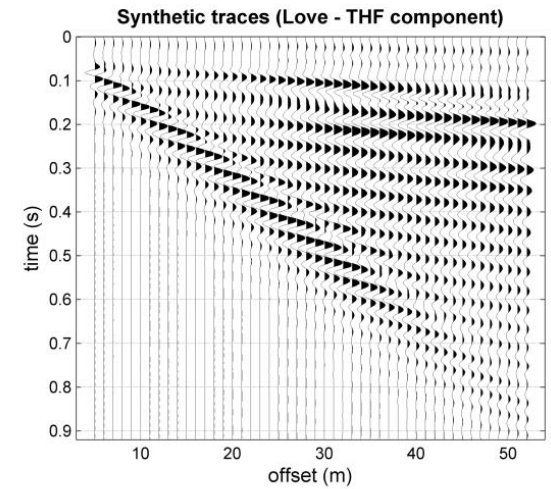
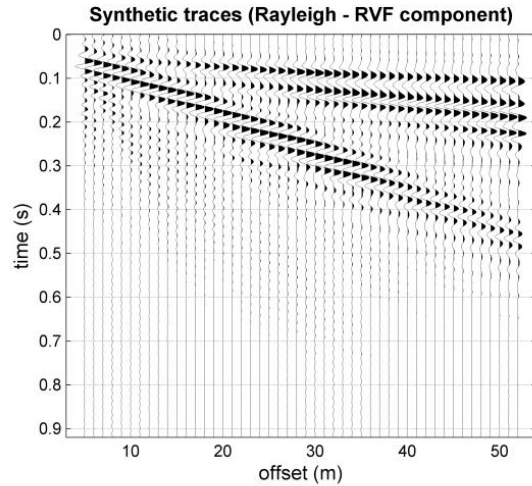
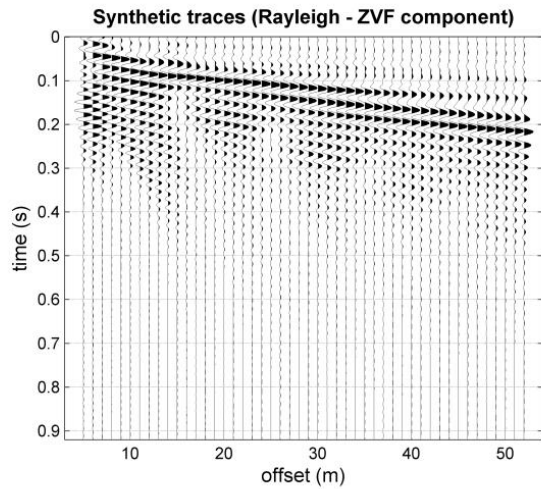
to select the last point
click the right button

Radius (5m)

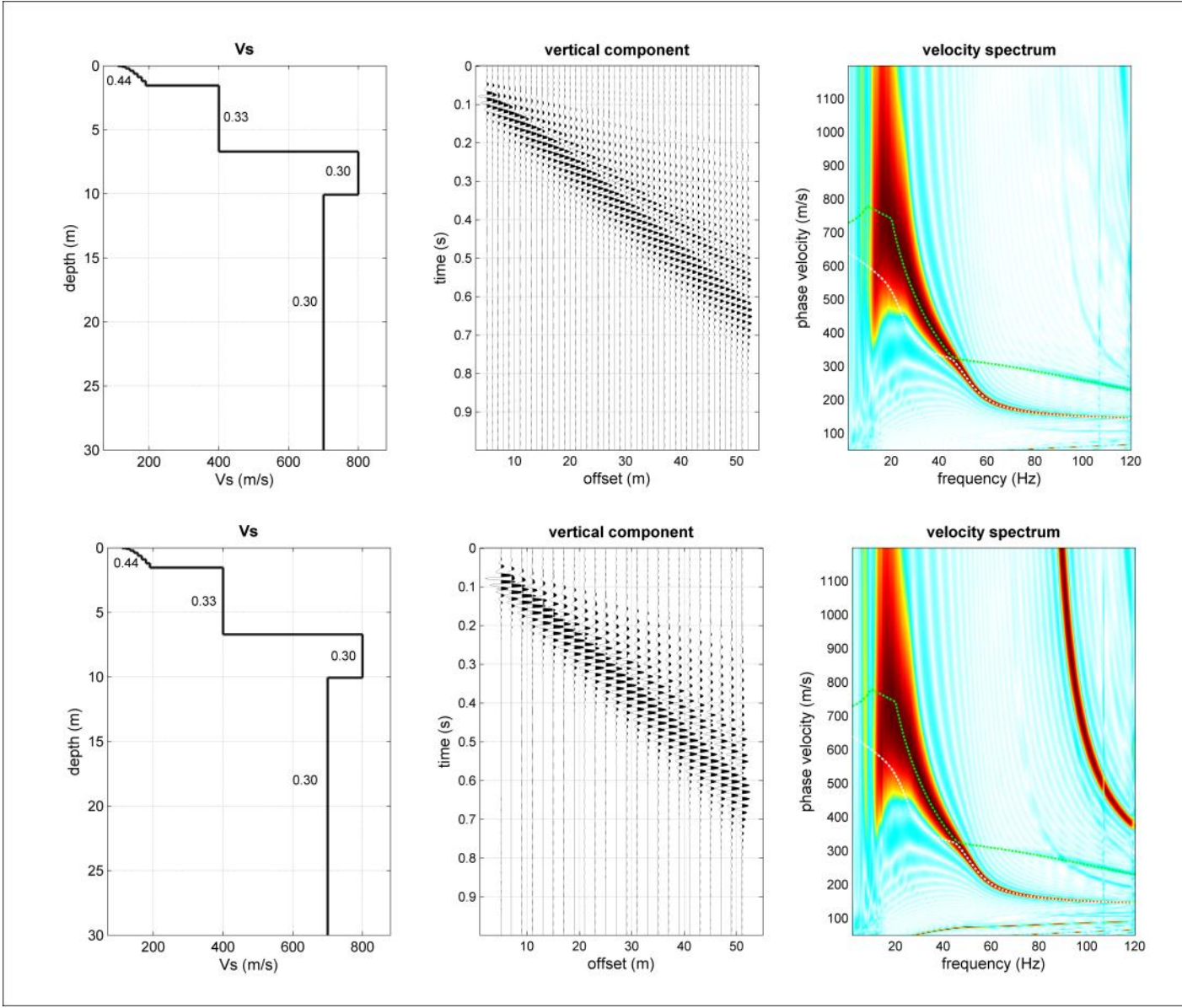
Noise (epsilon) computed [dispersion compensated]



MASW: are you sure to know everything you need to know?



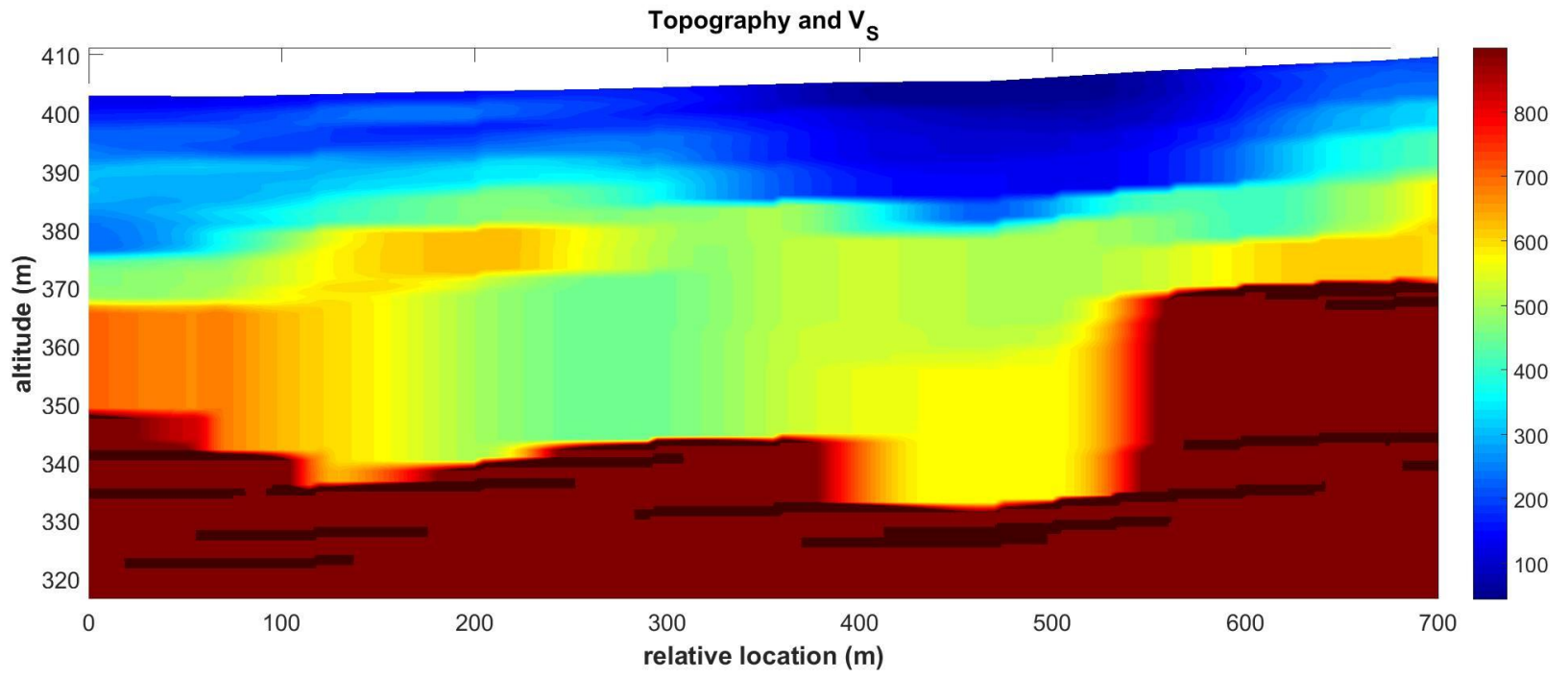
MASW: are you sure to know everything you need to know?



Further exploitation of the HS approaches



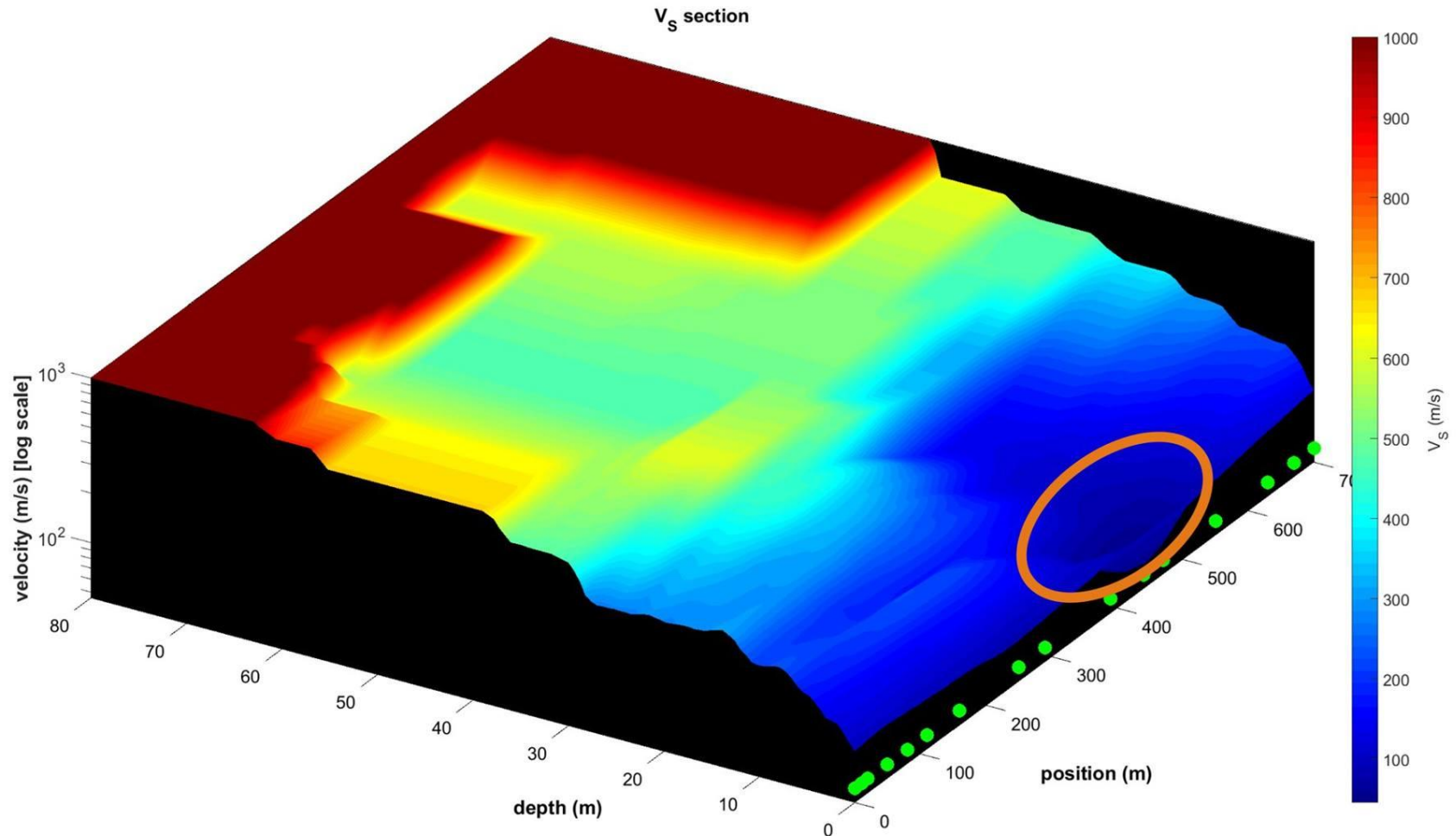
A Swiss work



Further exploitation of the HS approaches



A Swiss work: log scale for the velocities



RPM frequency curve (see Dal Moro et al., 2016 – BSSA): why?

1. Improved Back-scattering analyses

2. Advanced seismic-vulnerability analyses

390

M.D. Trifunac / Soil Dynamics and Earthquake Engineering 29 (2009) 382–393

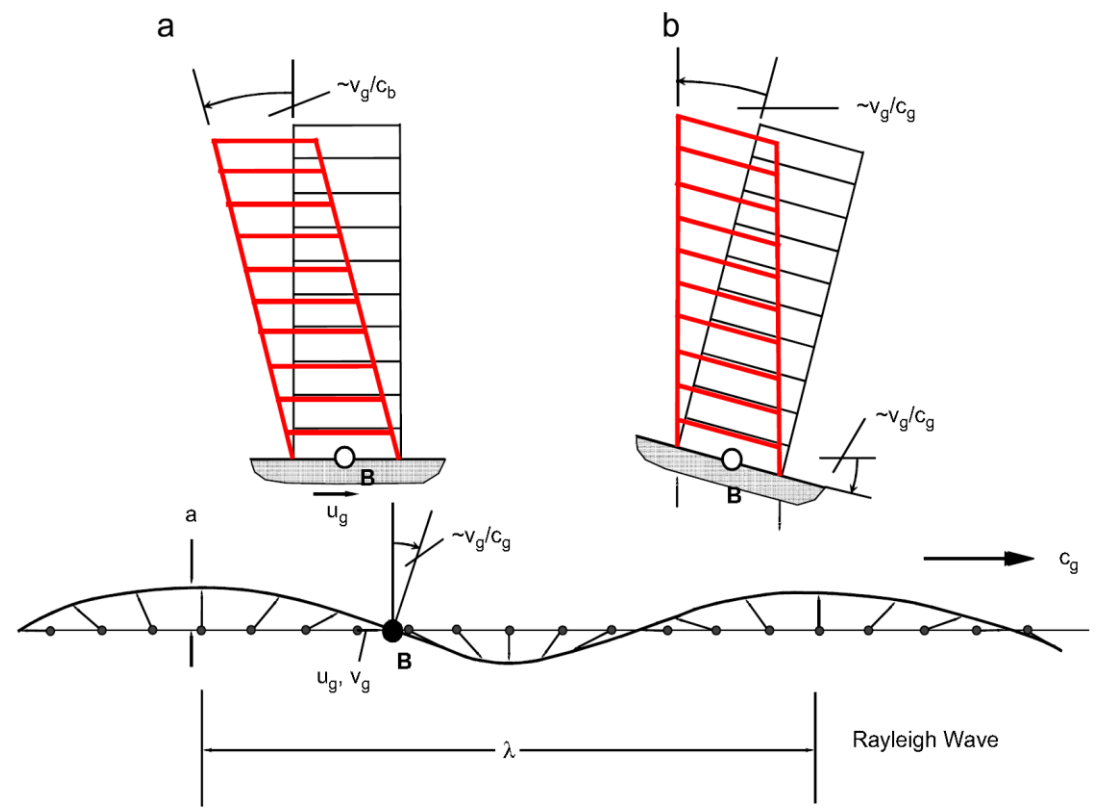


Fig. 8. Geometric interpretation of how horizontal translation and rocking can contribute to the total drift in a simple building during passage of a Rayleigh wave.

3. Exploration of large 2/3D areas

RPM frequency curve: how?

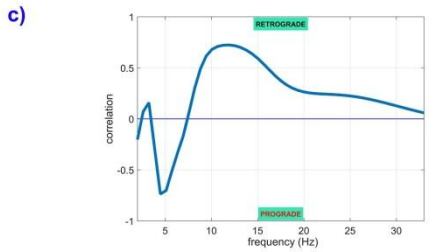
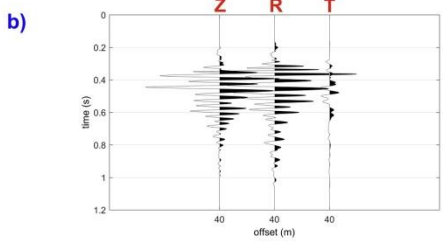
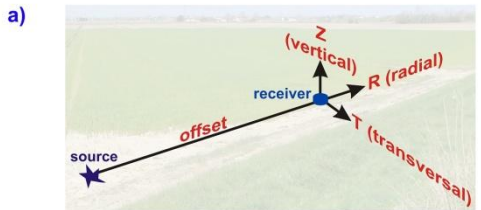


The BSSA paper

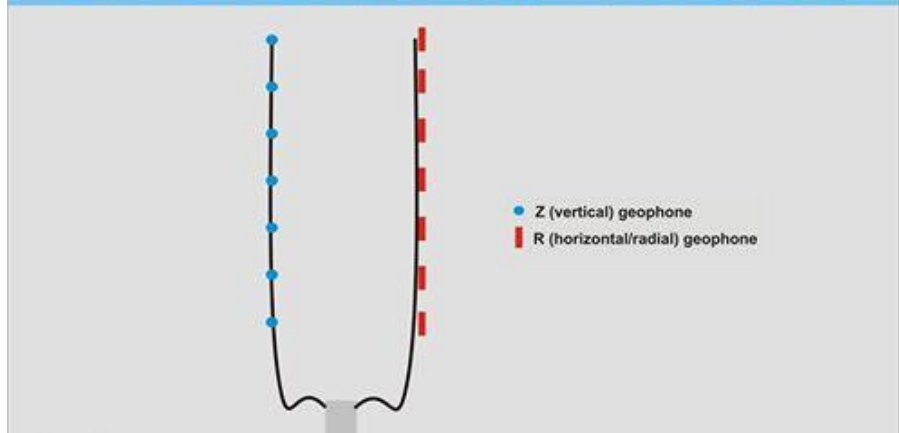
More about Joint Analysis of ZVF+RVF+RPM

1. Jail dataset (NE Italy): multi- and single-offset data

2. Tuscany (industrial) dataset



Joint Acquisition of the Vertical (Z) and Radial (R) Components of Rayleigh waves



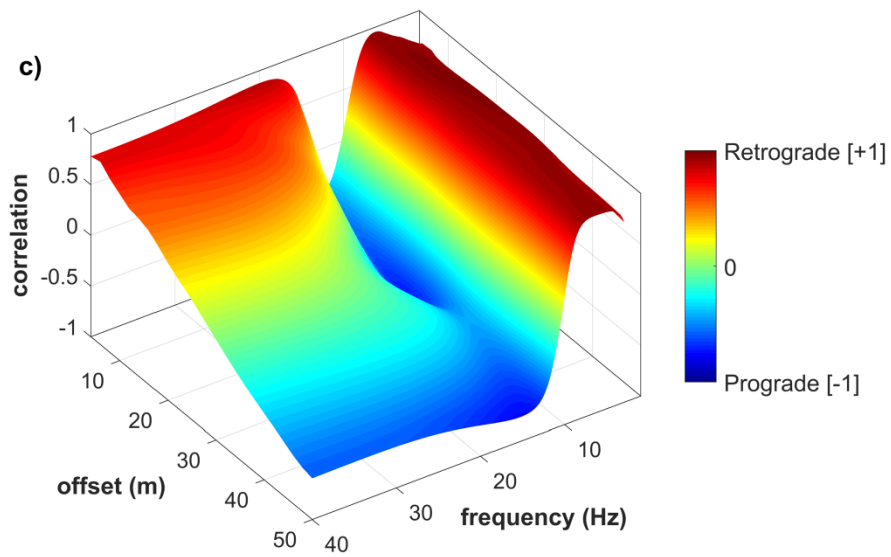
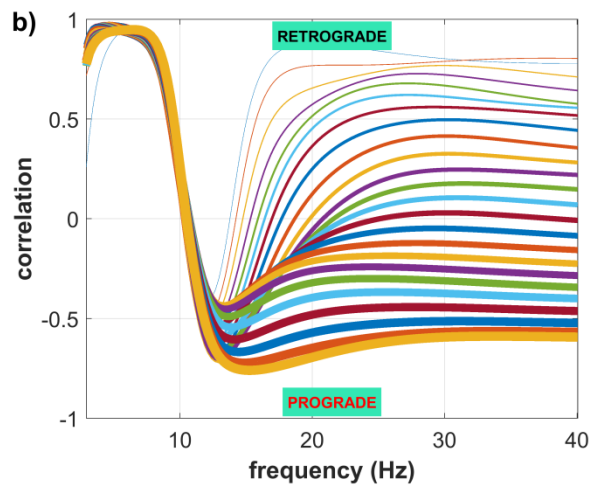
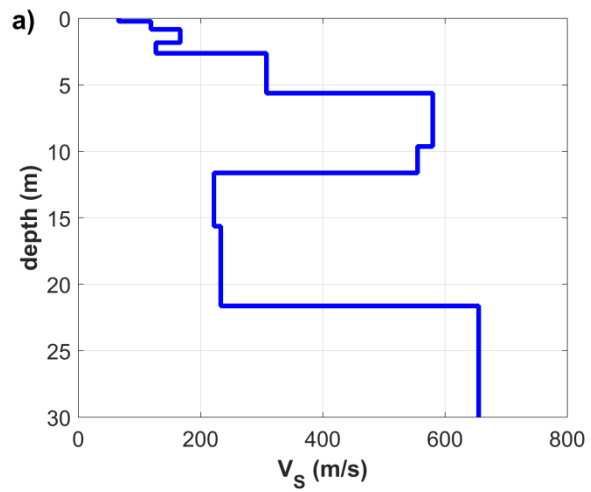
● Z (vertical) geophone
■ R (horizontal/radial) geophone

Example:
while using a common 24-channel seismograph (12+12 channels),
we use 12 channels for the Z geophones and 12 channels for the R geophones.

What do you get this way and what can you do with these data?

**The
Polarity
issue!!!**

Do you know your polarity?



The RPM effective frequency curve

1. Compared to other methods for defining the RW polarity (Gribler et al., 2016), the RPM frequency curve describes the Rayleigh motion at each specific frequency (not as a whole gross thing);

To investigate Rayleigh wave particle motion, we convert our vertical (V) and horizontal inline (H) time series from Cartesian coordinates into polar coordinates, using the following equations:

$$A(t) = \sqrt{V(t)^2 + H(t)^2},$$

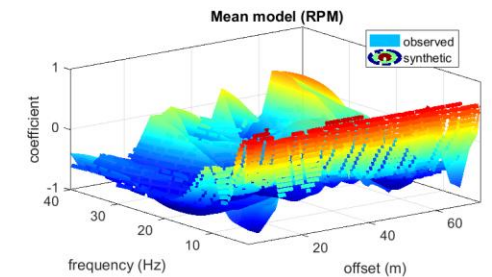
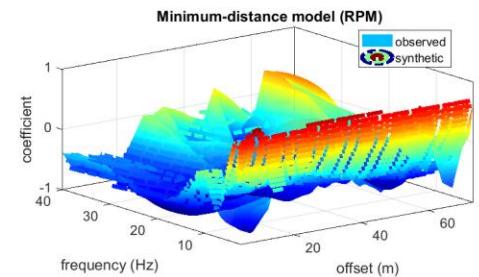
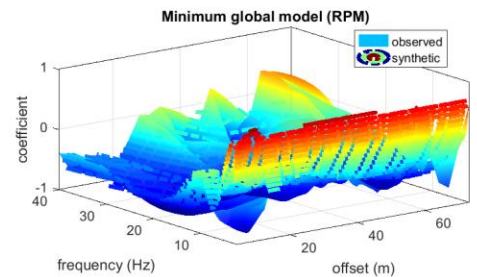
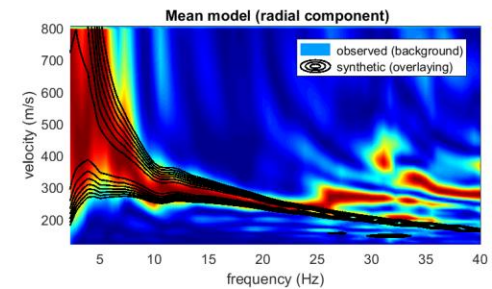
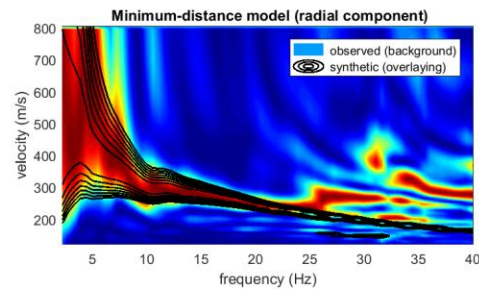
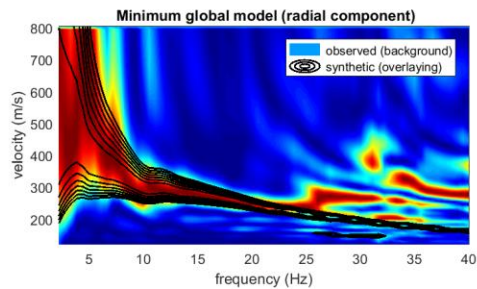
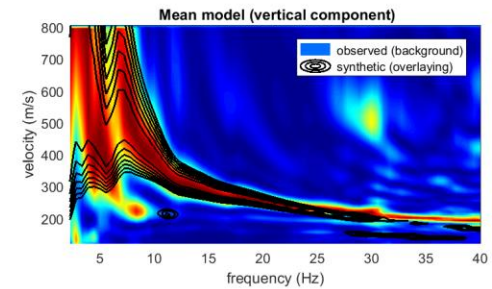
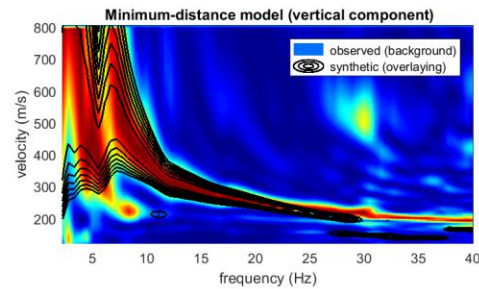
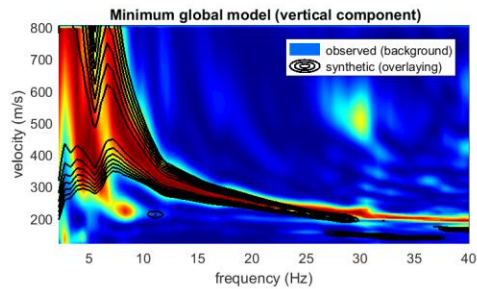
$$\Phi(t) = \tan^{-1} \left(\frac{V(t)}{H(t)} \right),$$

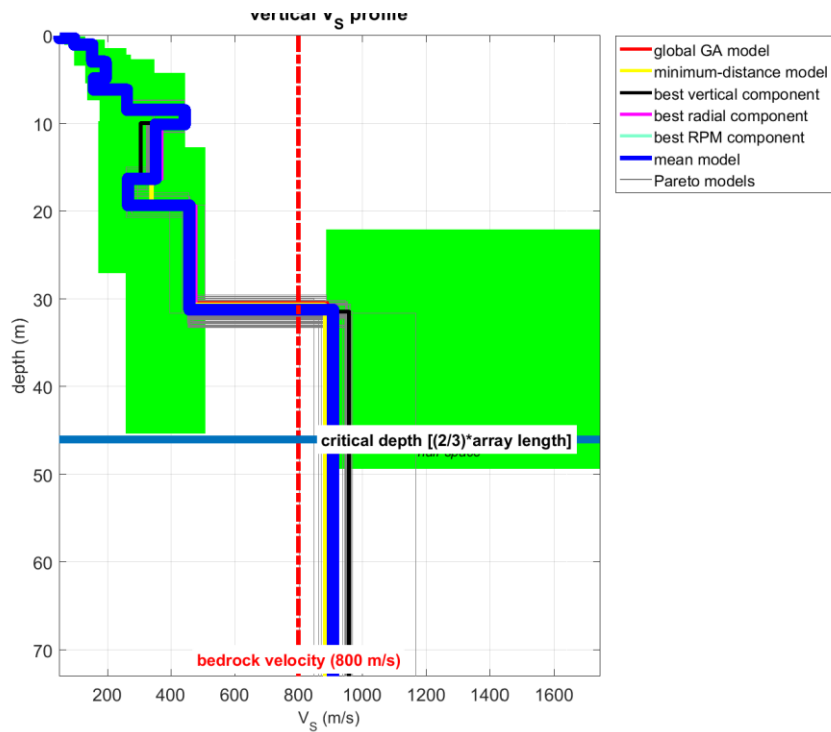
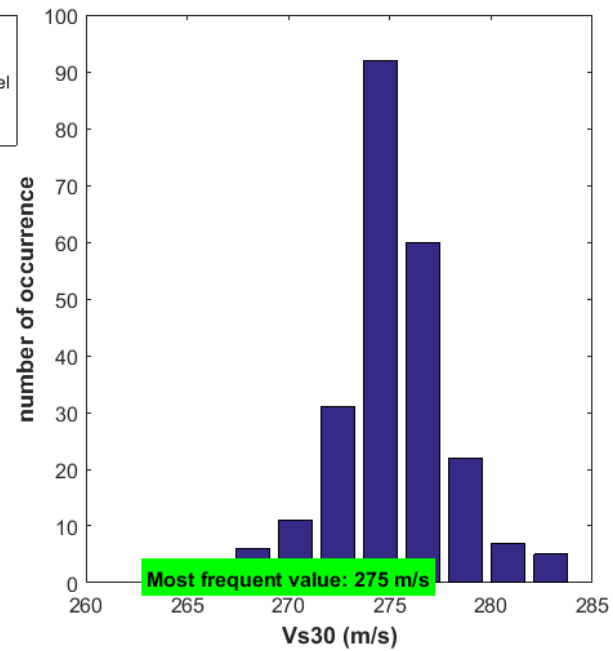
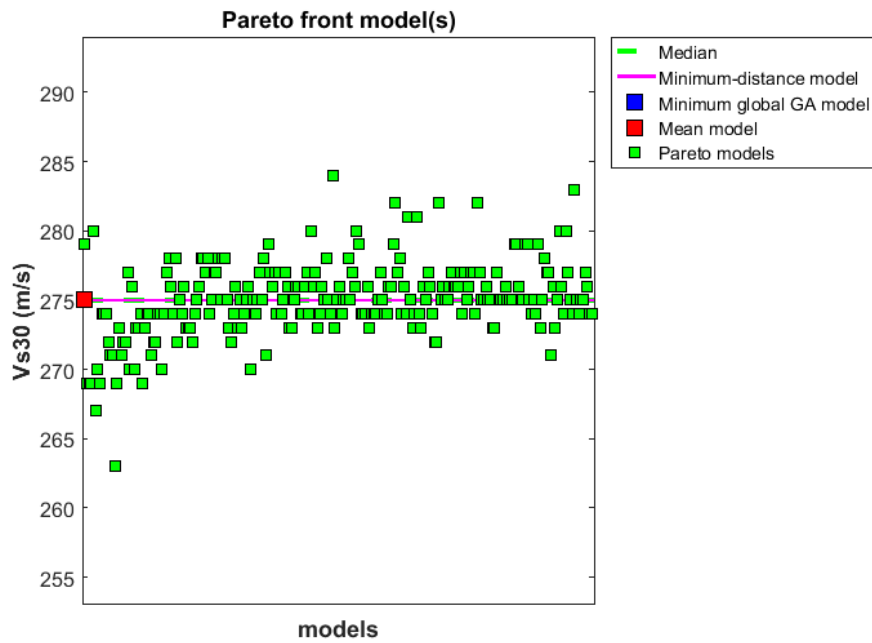
2. It does not require the use of Z and R calibrated geophones.

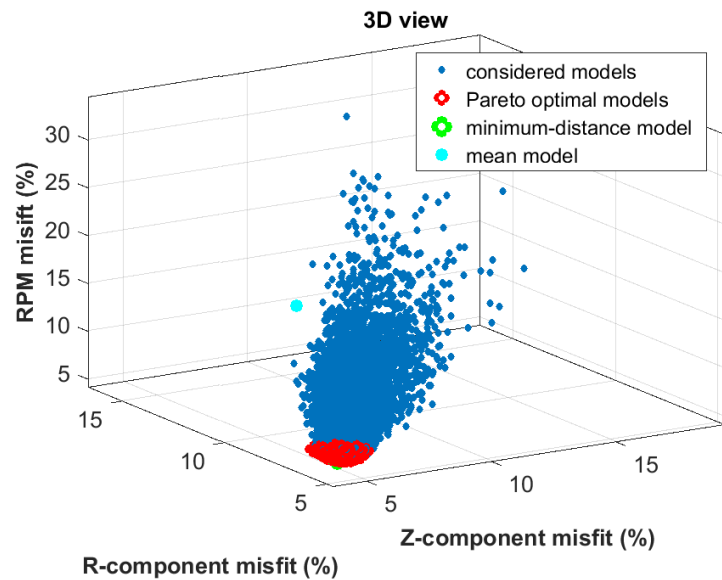
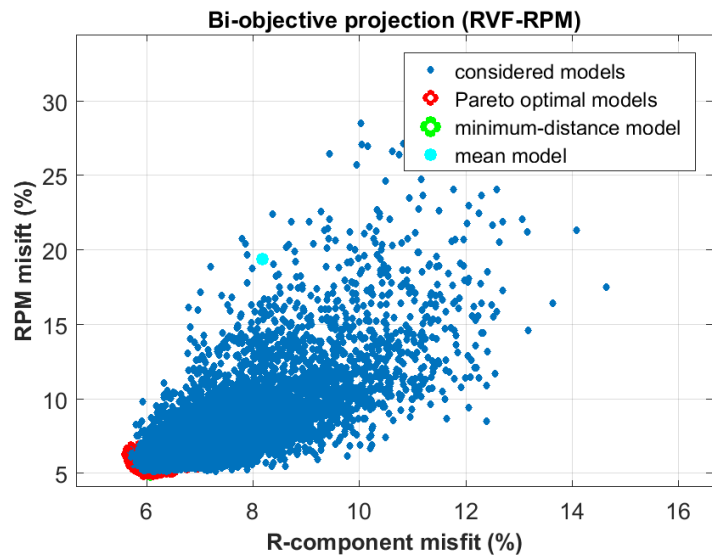
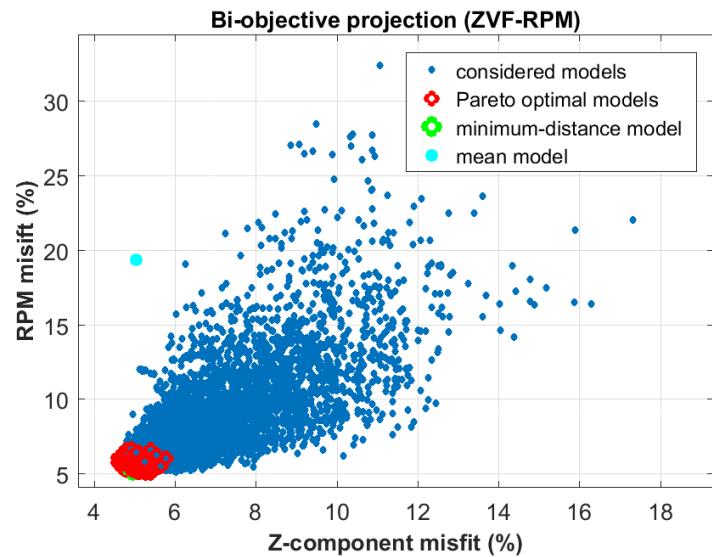
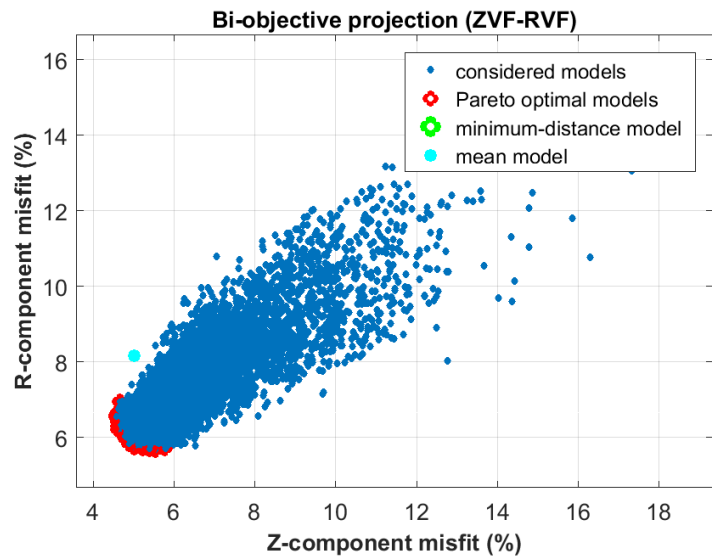
2. Tuscany (industrial) dataset:): multi-offset data

See also:

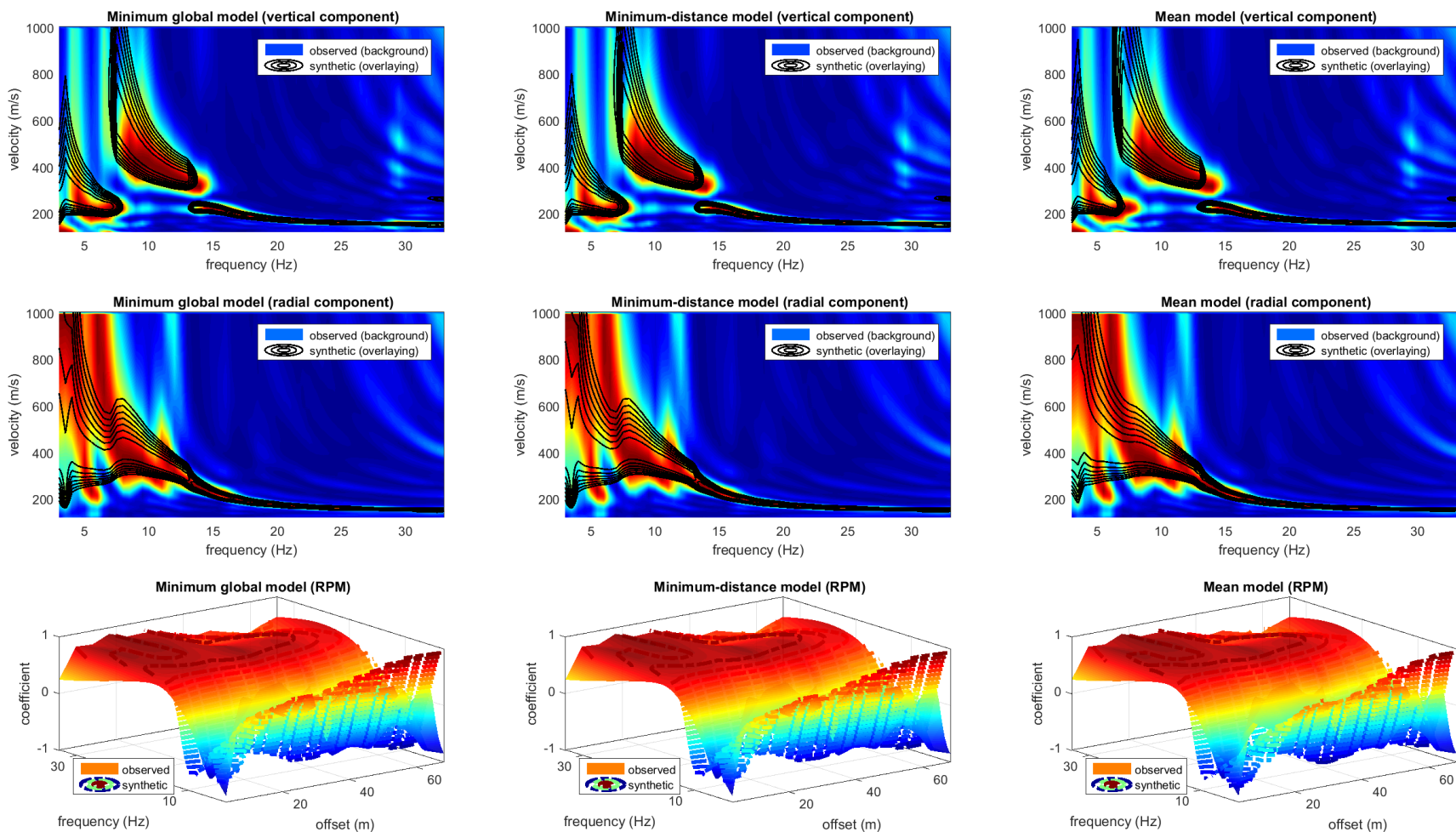
Multi-component Joint Analysis of Surface Waves ([Dal Moro G., Moura R.M., Moustafa S.R., 2015](#)), *J. Appl. Geophysics*, 119, 128-138

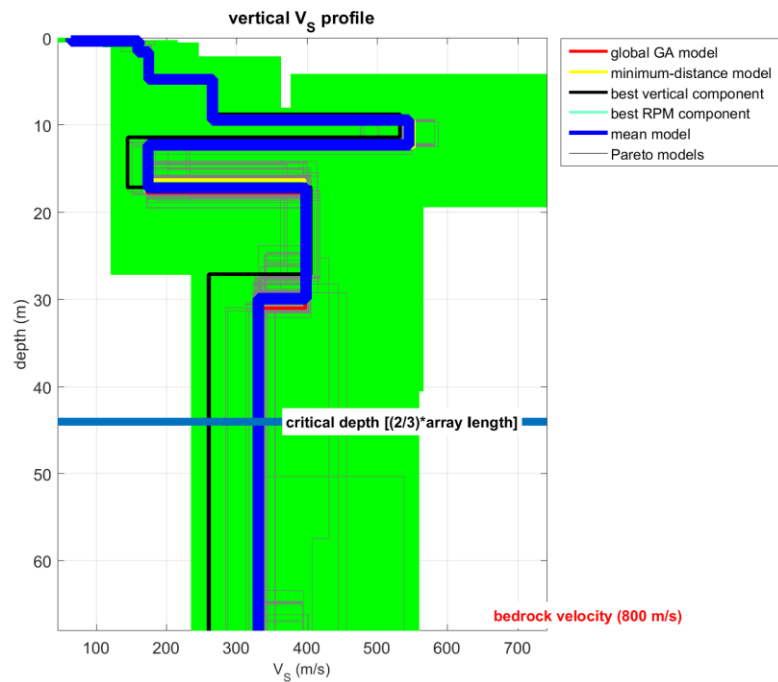
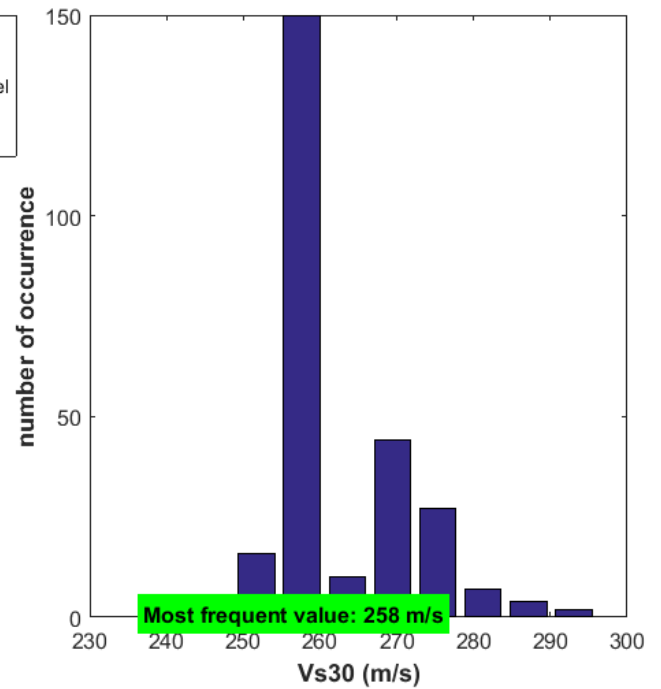
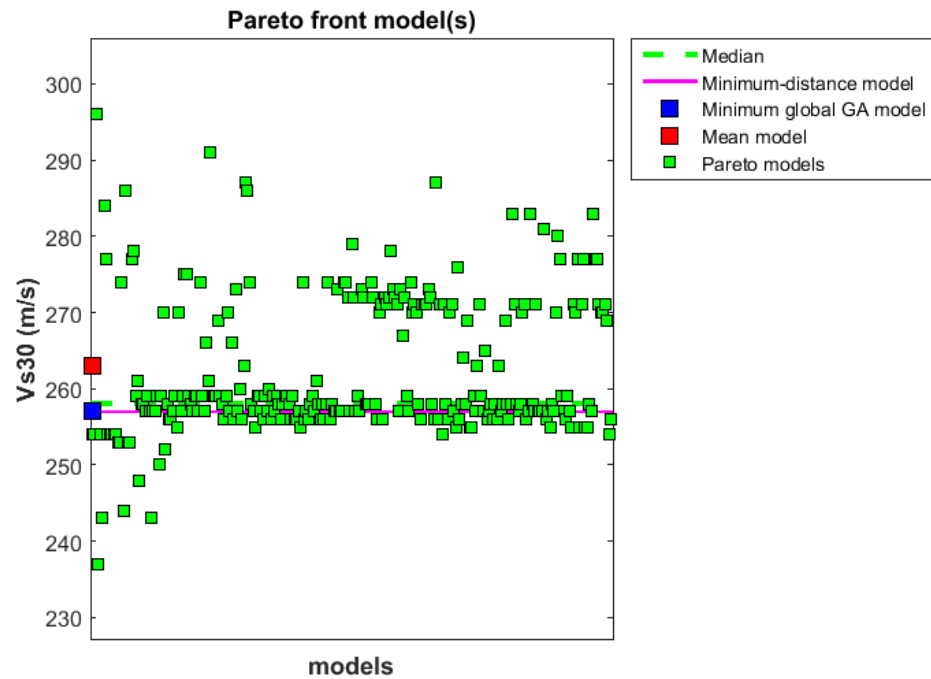




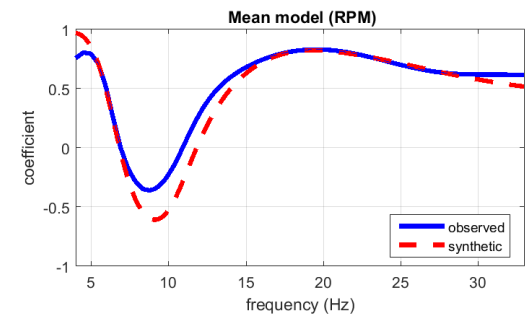
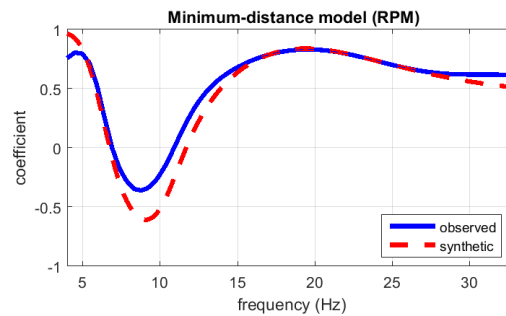
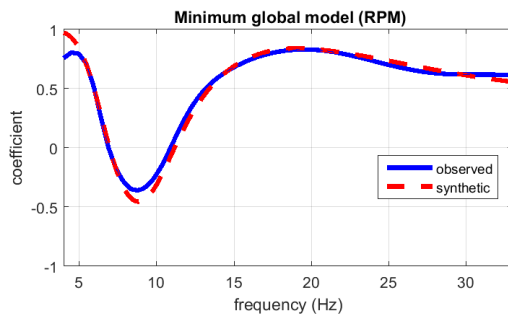
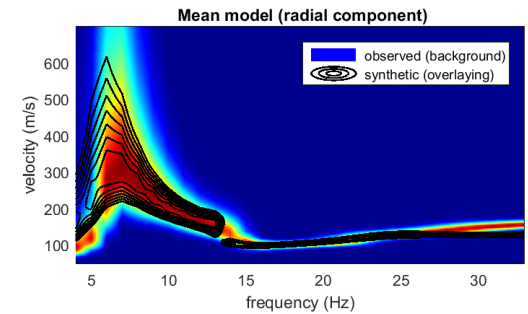
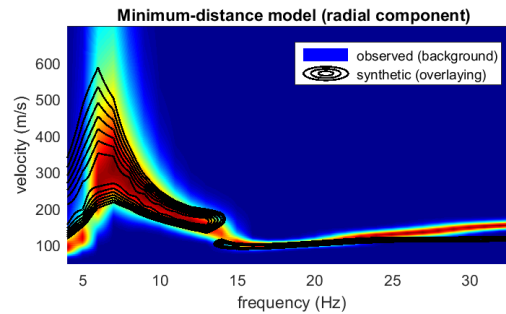
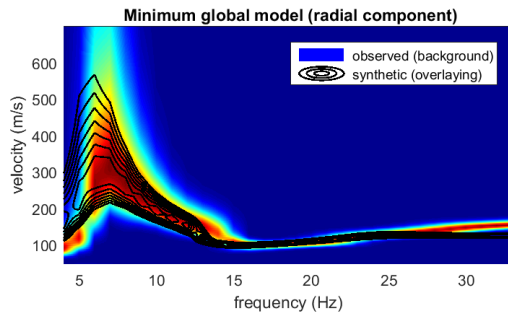
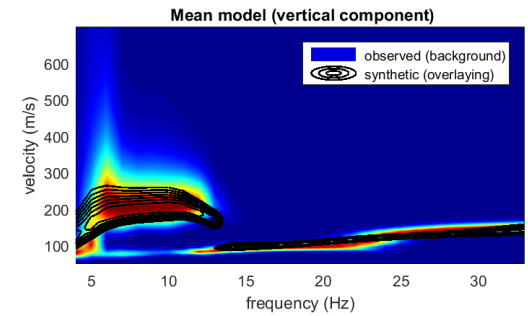
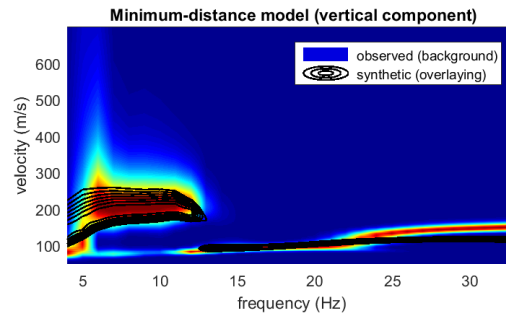
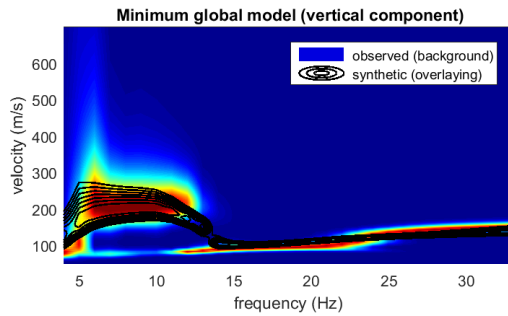


1. Jail dataset (NE Italy): multi-offset data

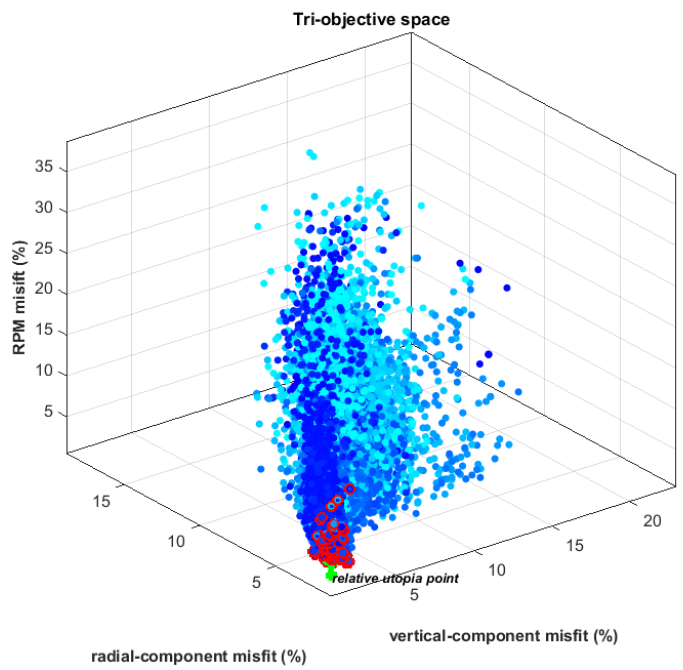
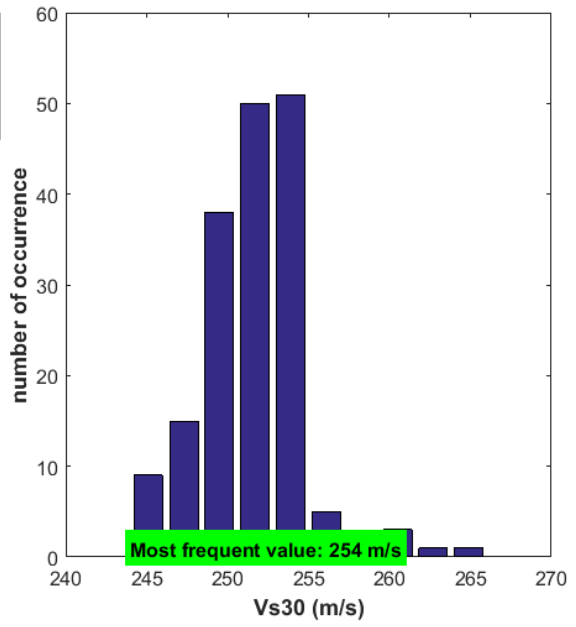
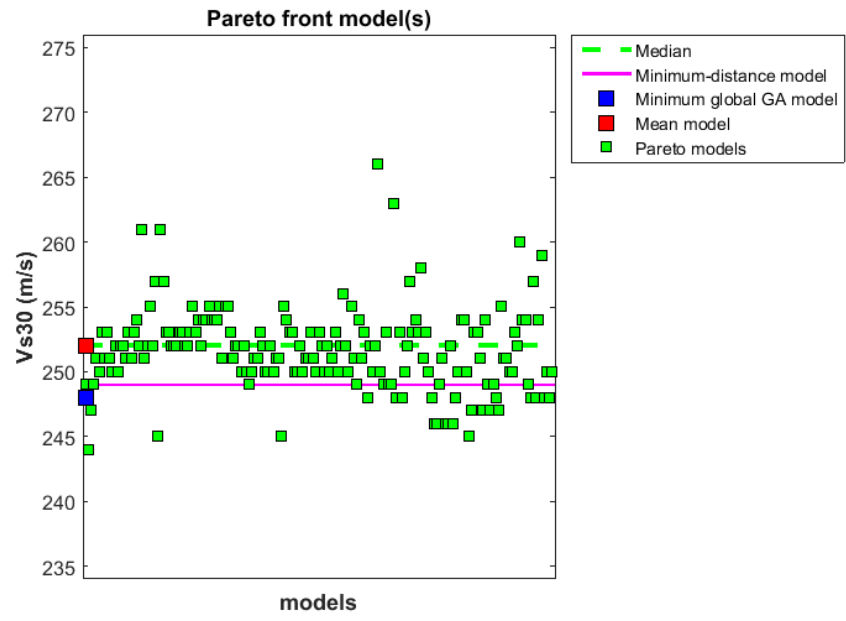




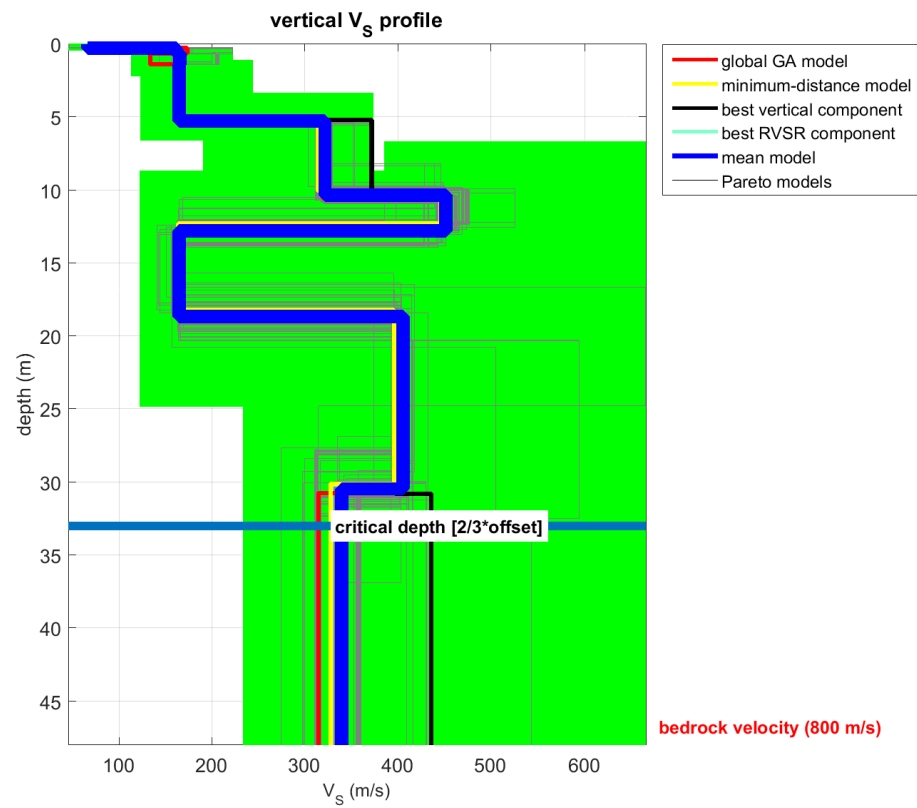
1. Jail dataset (NE Italy): single-offset data



1. Jail dataset (NE Italy): single-offset data



1. Jail dataset (NE Italy): single-offset data



Some References

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