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Anisotropy of the Bohemian Massif lower crust from ANT - VTI model or additional azimuthal variations?

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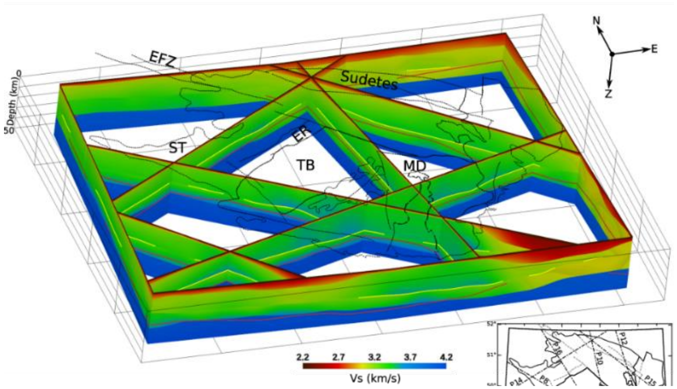
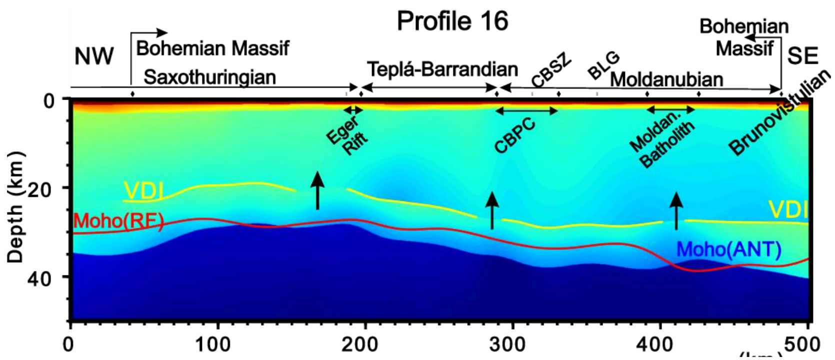
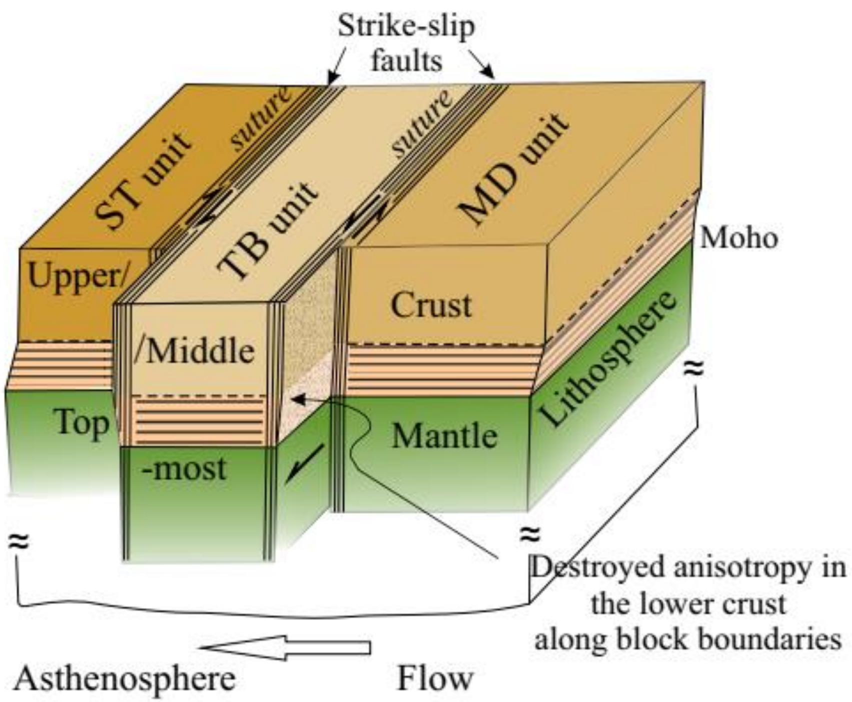
ALP ARRAY and AlpArray Working Group

Introduction

Velocity structure and Moho depth of the Bohemian Massif (BM) revealed by Ambient Noise Tomography (ANT)



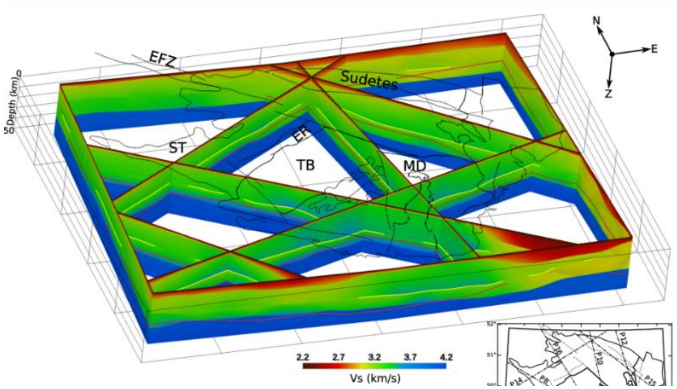




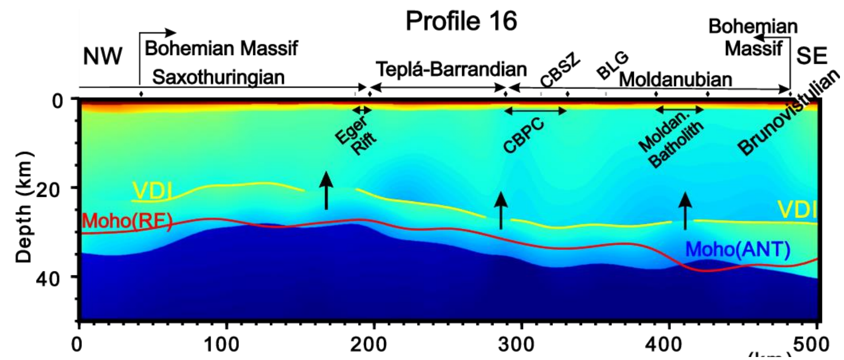
Kvapil et al., 2021 (Solid Earth)
https://doi.org/10.5194/se-12-1051-2021

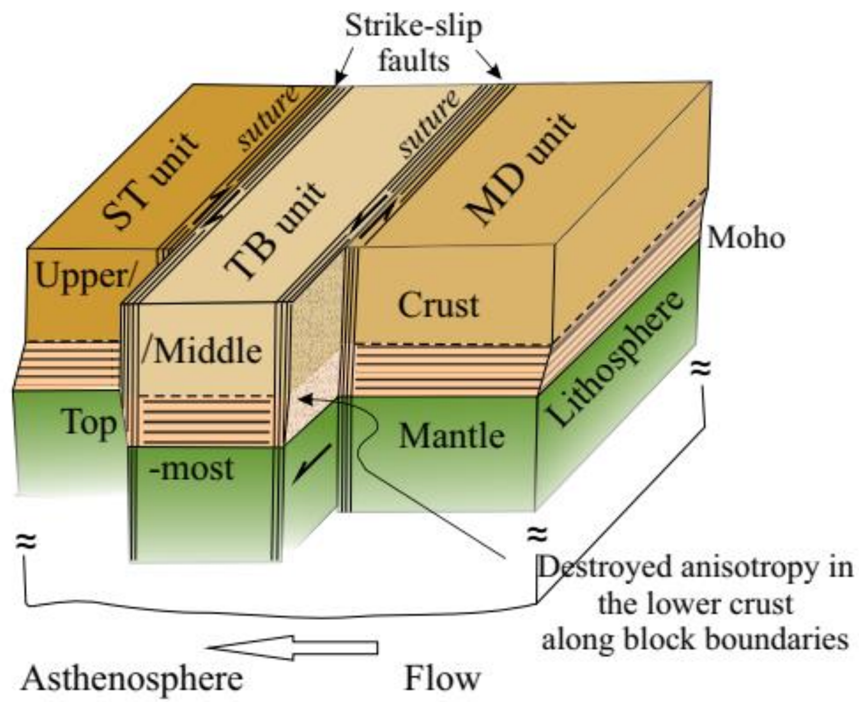
Introduction

Velocity structure and Moho depth of the Bohemian Massif (BM) revealed by Ambient Noise Tomography (ANT)



- The significant feature of this 3D v_{SV} model is the low velocity layer in the lower part of the crust at depth between 18-30 km and the Moho.
- The upper interface is characterized by a velocity drop in the 1D velocity models retrieved by the ANT.
- The interface is interrupted around boundaries of major tectonic units of the BM.





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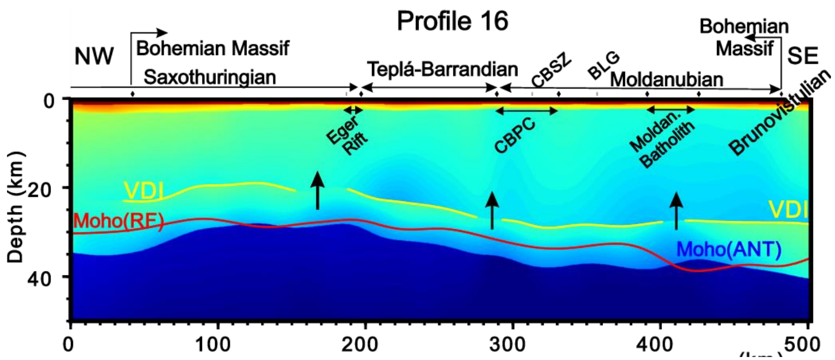
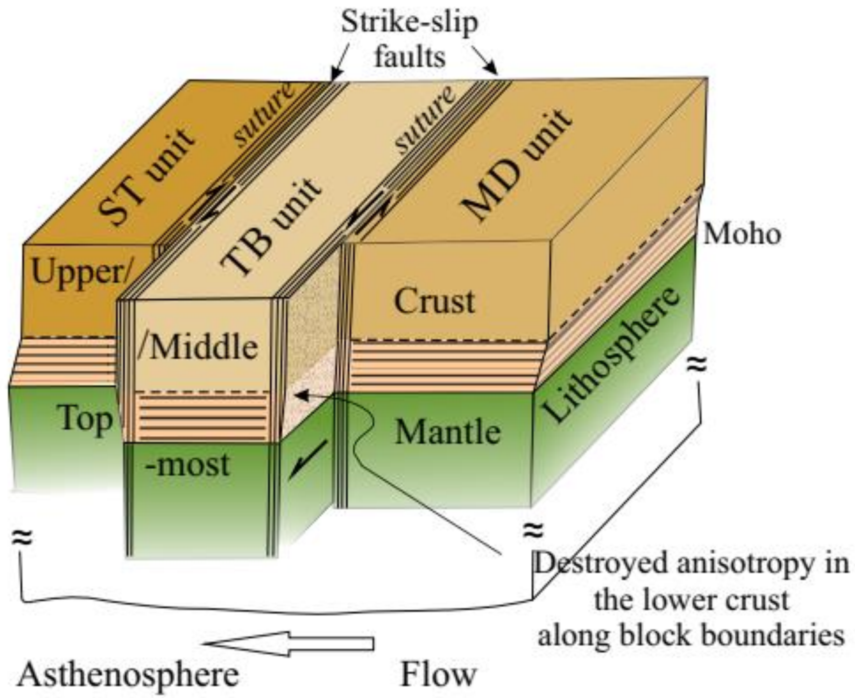
Introduction

- In this work we test, whether we are able to detect anisotropy in the lower crust, approximated up to now by anisotropic VTI model.

- We use Rayleigh and Love wave dispersion curves derived from ambient noise.

- We evaluate the anisotropy from station pairs sampling the Moldanubian Unit of the BM in the period range sensitive to the lower crust.





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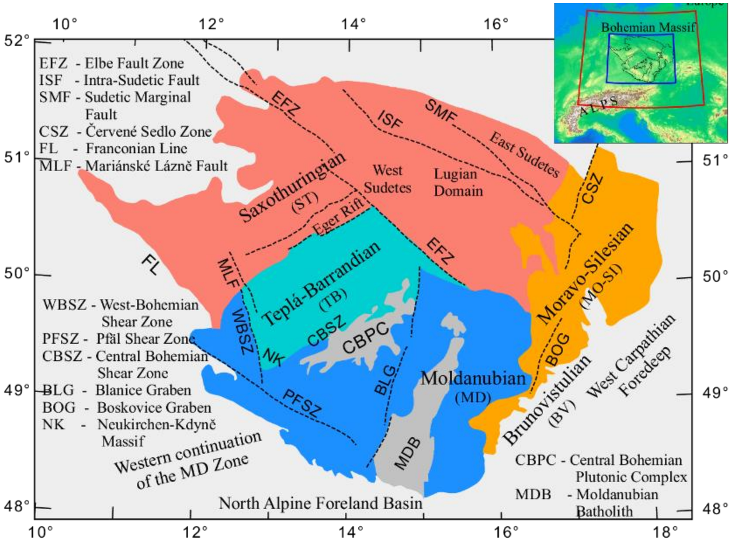
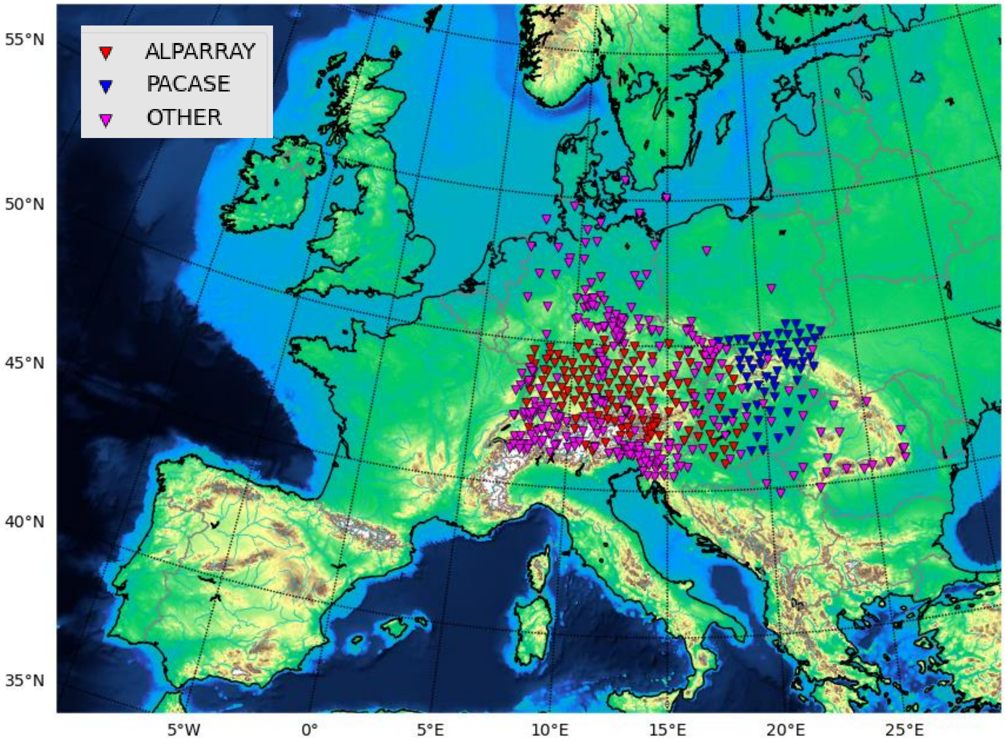
Tectonics

Bohemian Massif



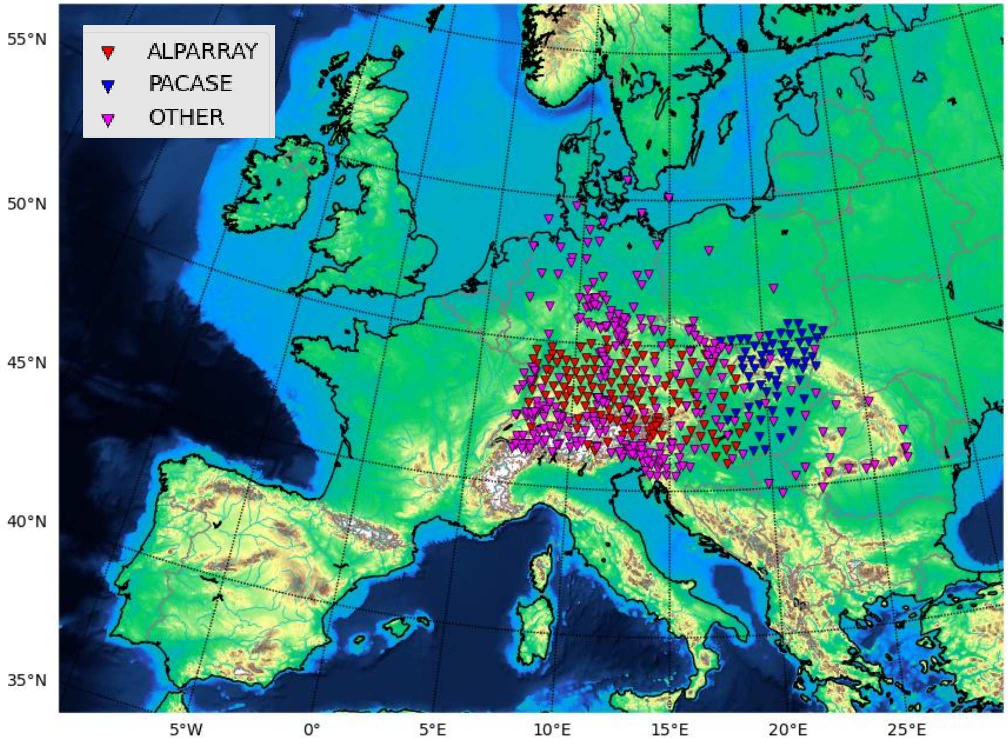
- ➢ The Bohemian Massif (BM) represents the easternmost relic of the Variscan orogenic belt in Europe.
- ➢ The massif was formed as a collage of microplates and relics of magmatic arcs.
- ➢ The core of the BM consists of three tectonic units which represent originally independent microplates:
  - Saxothuringian (ST)
  - Teplá–Barrandian (TB)
  - Moldanubian (MD)
- ➢ The eastern part of the BM consists of
  - Moravo-Silesian Zone with its
  - Brunovistulian (BV) basement

Data

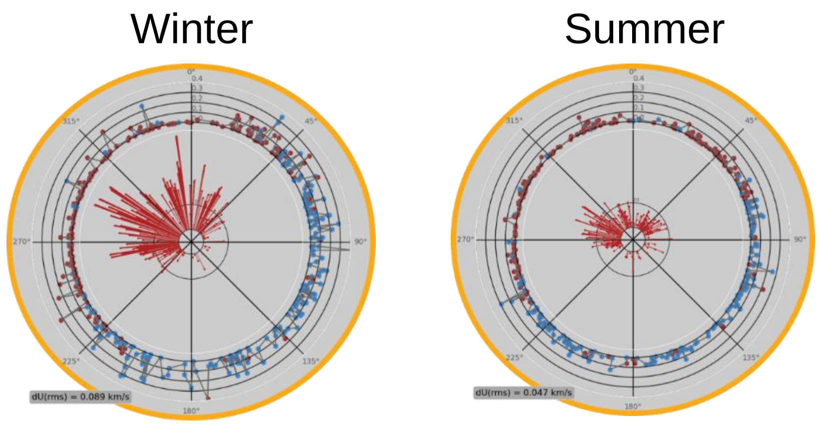


- We use data from
  - permanent seismic stations
  - AlpArray passive experiment
  - AlpArray complementary experiment PACASE

Data



T=19s (primary microseism)

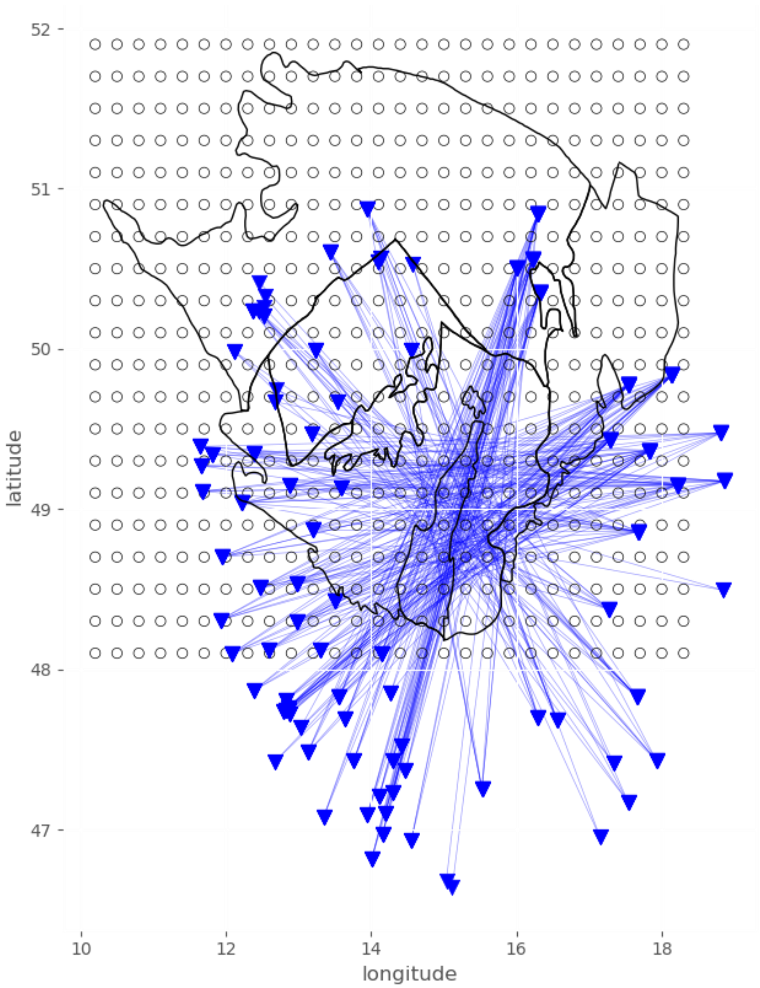


- We use data from
  - permanent seismic stations
  - AlpArray passive experiment
  - AlpArray complementary experiment PACASE
- Selection of continuous recordings from summer seasons only (avoiding strong microseism energy from Atlantic storms -> better distribution of ambient noise sources)

*Source directivity measure (ratio left/right side of CCF)

*Quality of group velocity measurement (difference left-right Group measurement)

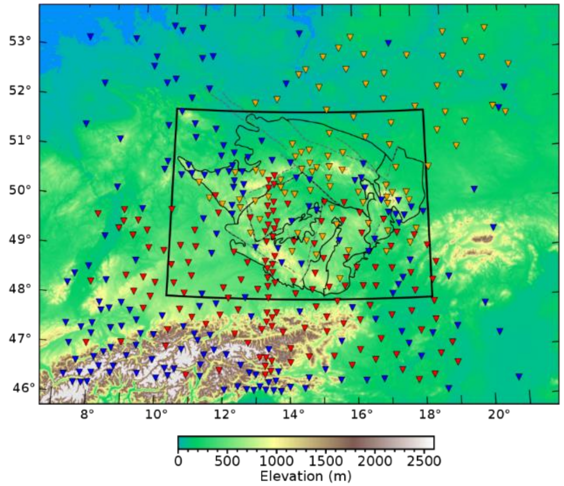
Data



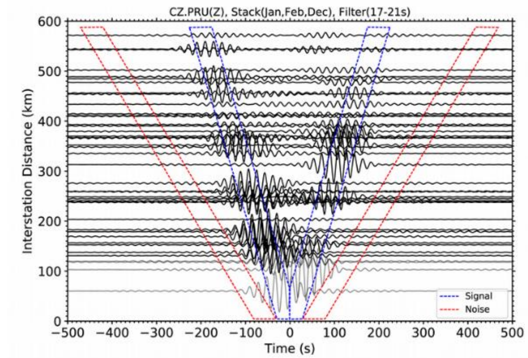
- We use data from
  - permanent seismic stations
  - AlpArray passive experiment
  - AlpArray complementary experiment PACASE
- Selection of continuous recordings from summer seasons only (avoiding strong microseism energy from Atlantic storms -> better distribution of ambient noise sources)
- We focus on Moldanubian unit with optimal coverage of raypaths from all directions
- We use 3-D v_S model (CRAB1.0) from ambient noise tomography for synthetic modeling

Method

Waveform data

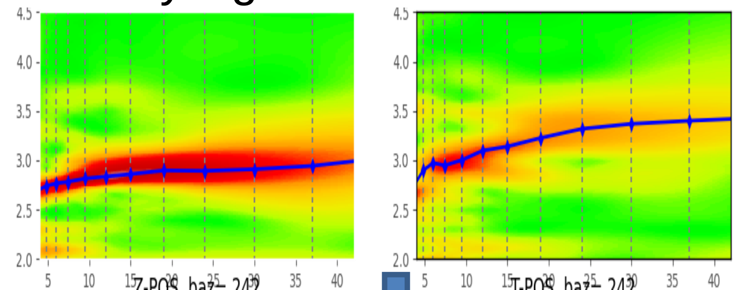


Station-pair Cross-correlations

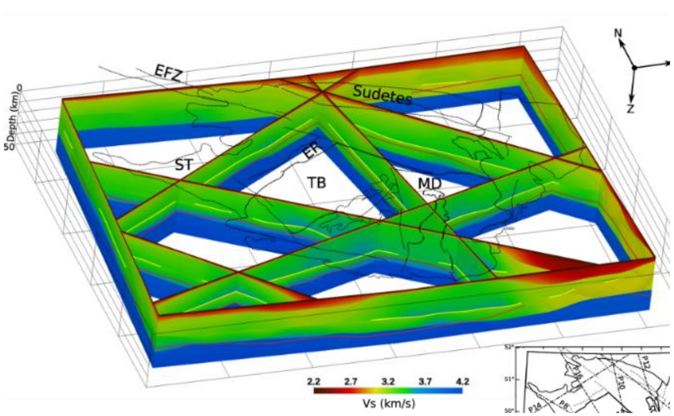


Group velocity dispersion curve picking

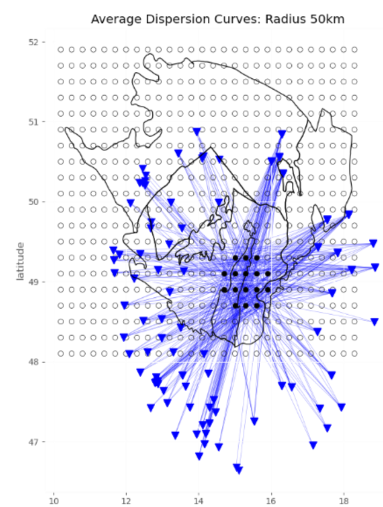
Rayleigh Love



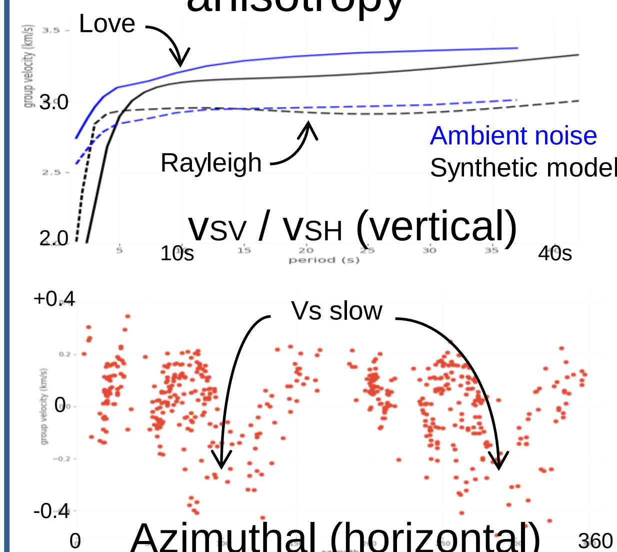
3-D v_S model



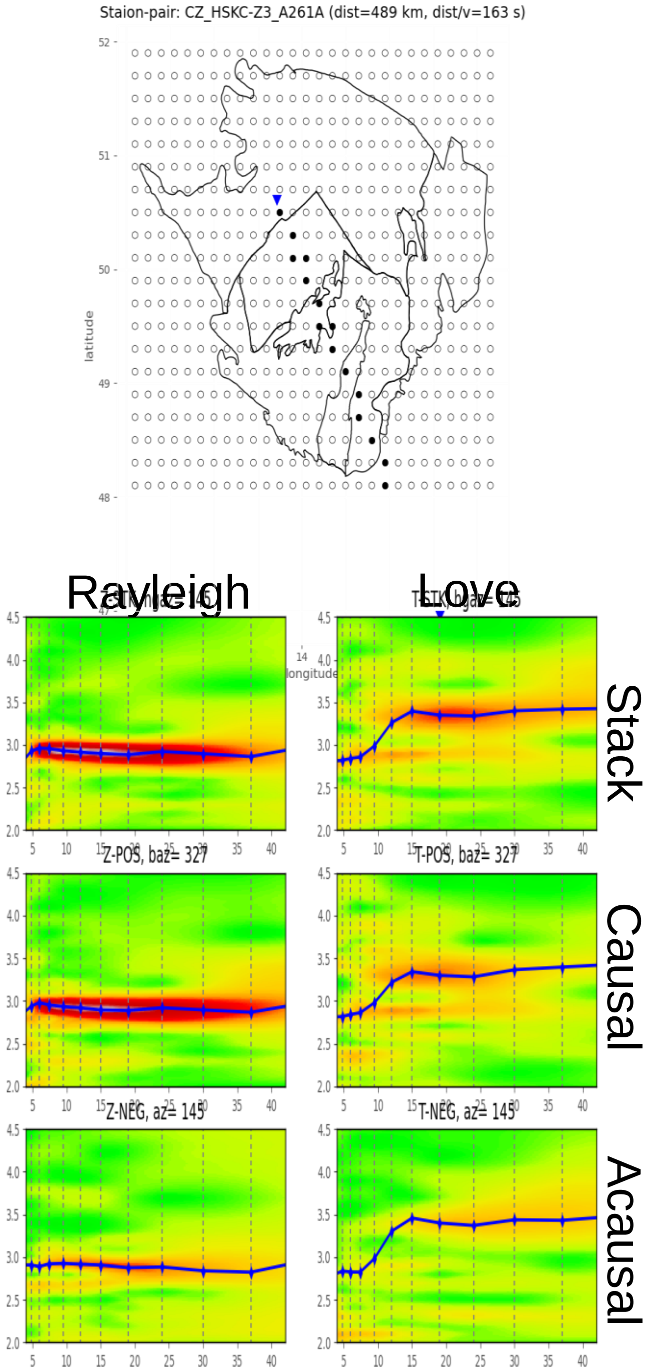
Dispersion Curve modeling



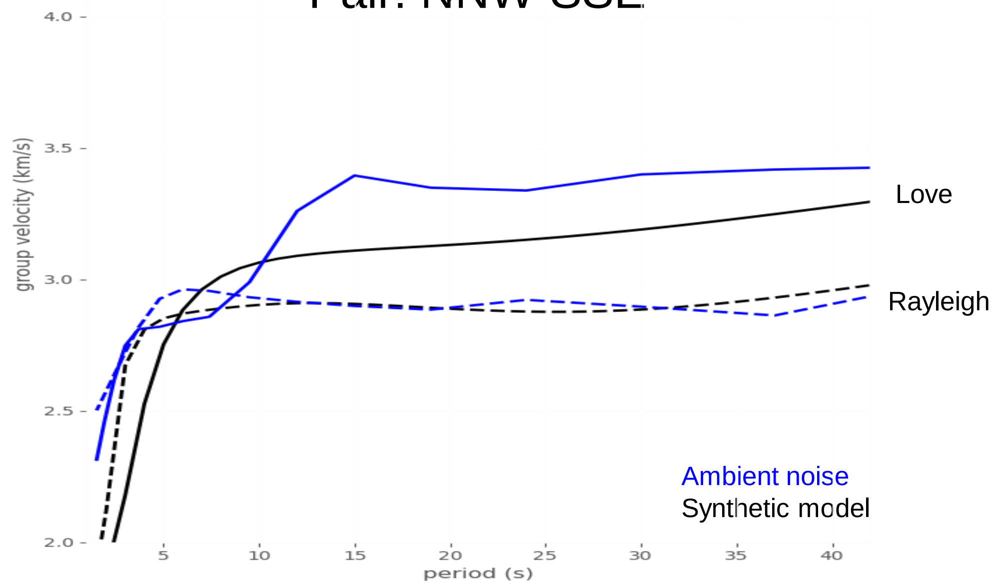
Evaluation of seismic anisotropy

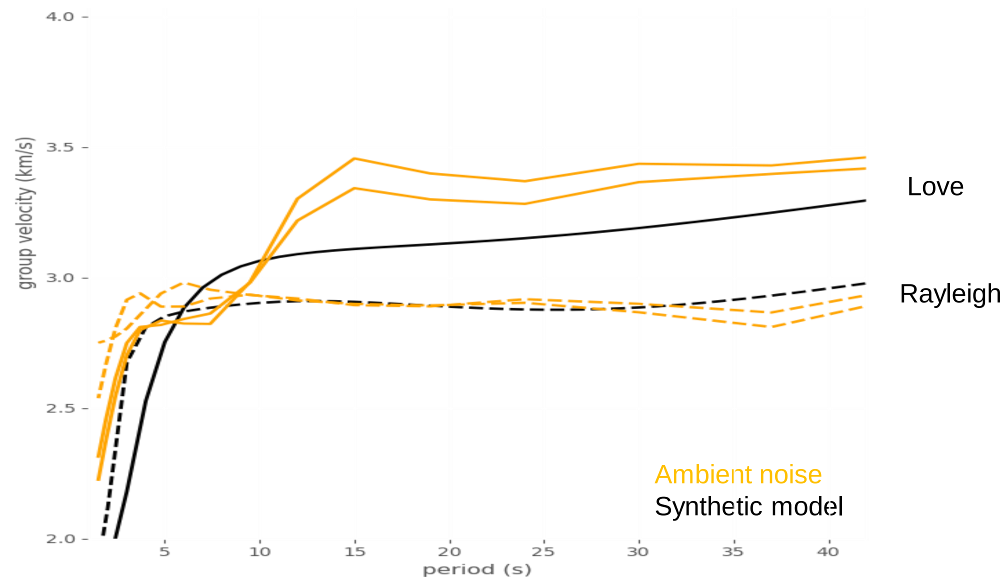


Results

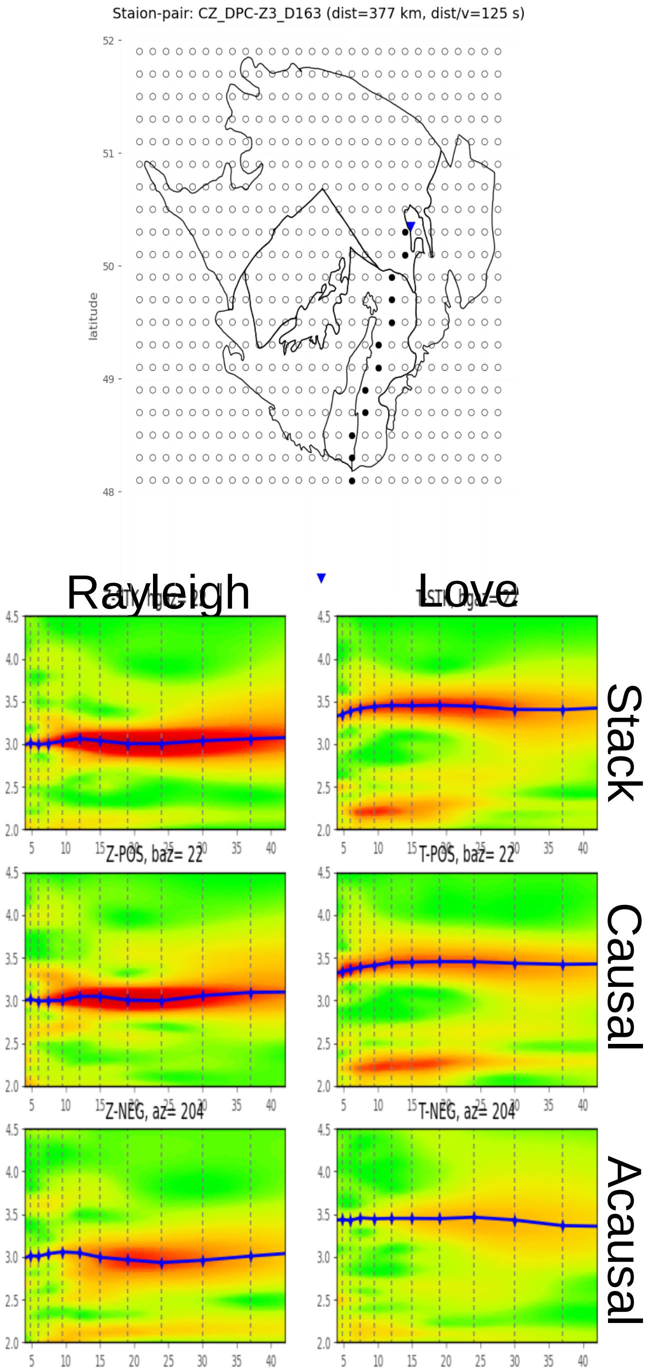


Pair: NNW-SSE

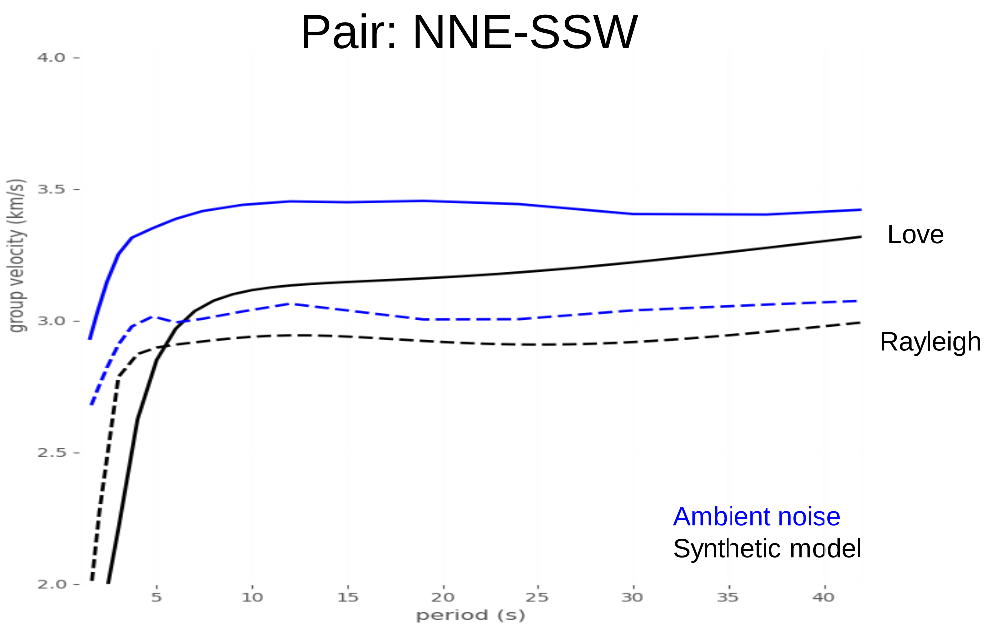




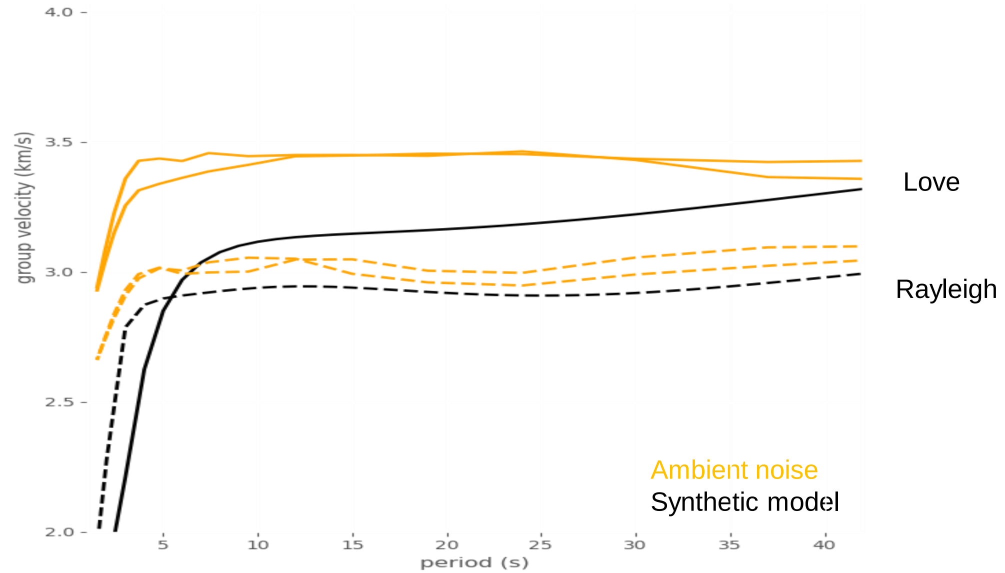
Results



Staion-pair: CZ_DPC-Z3_D163 (dist=377 km, dist/v=125 s)
latitude
Rayleigh
Love
Stack
Causal
Acausal
Z-POS, baz= 22
T-POS, baz= 22
Z-NEG, az= 204
T-NEG, az= 204

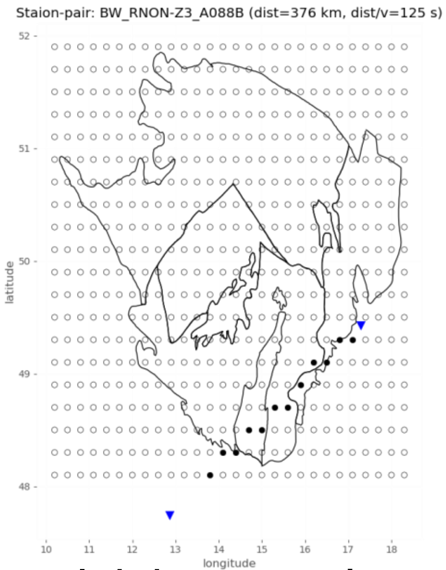


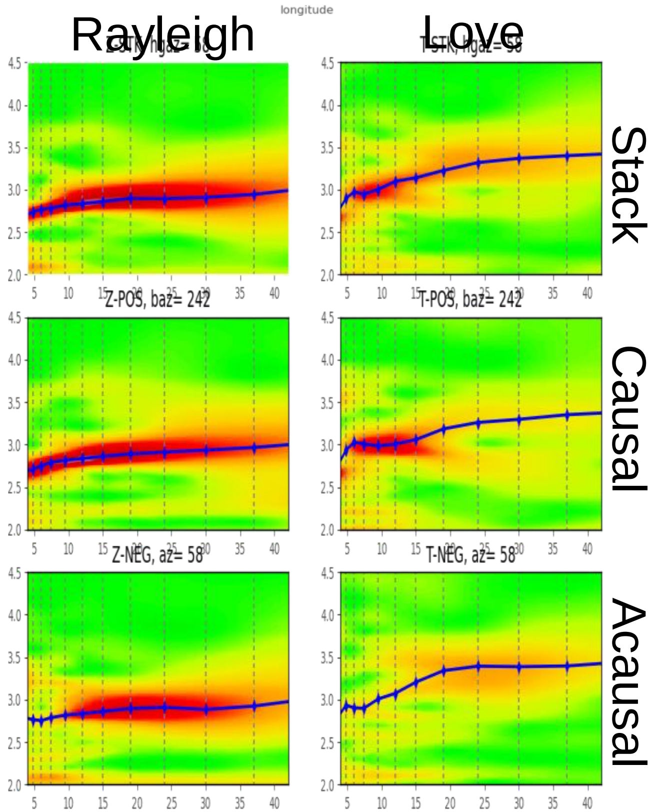
Pair: NNE-SSW
group velocity (km/s)
period (s)
Love
Rayleigh
Ambient noise
Synthetic model

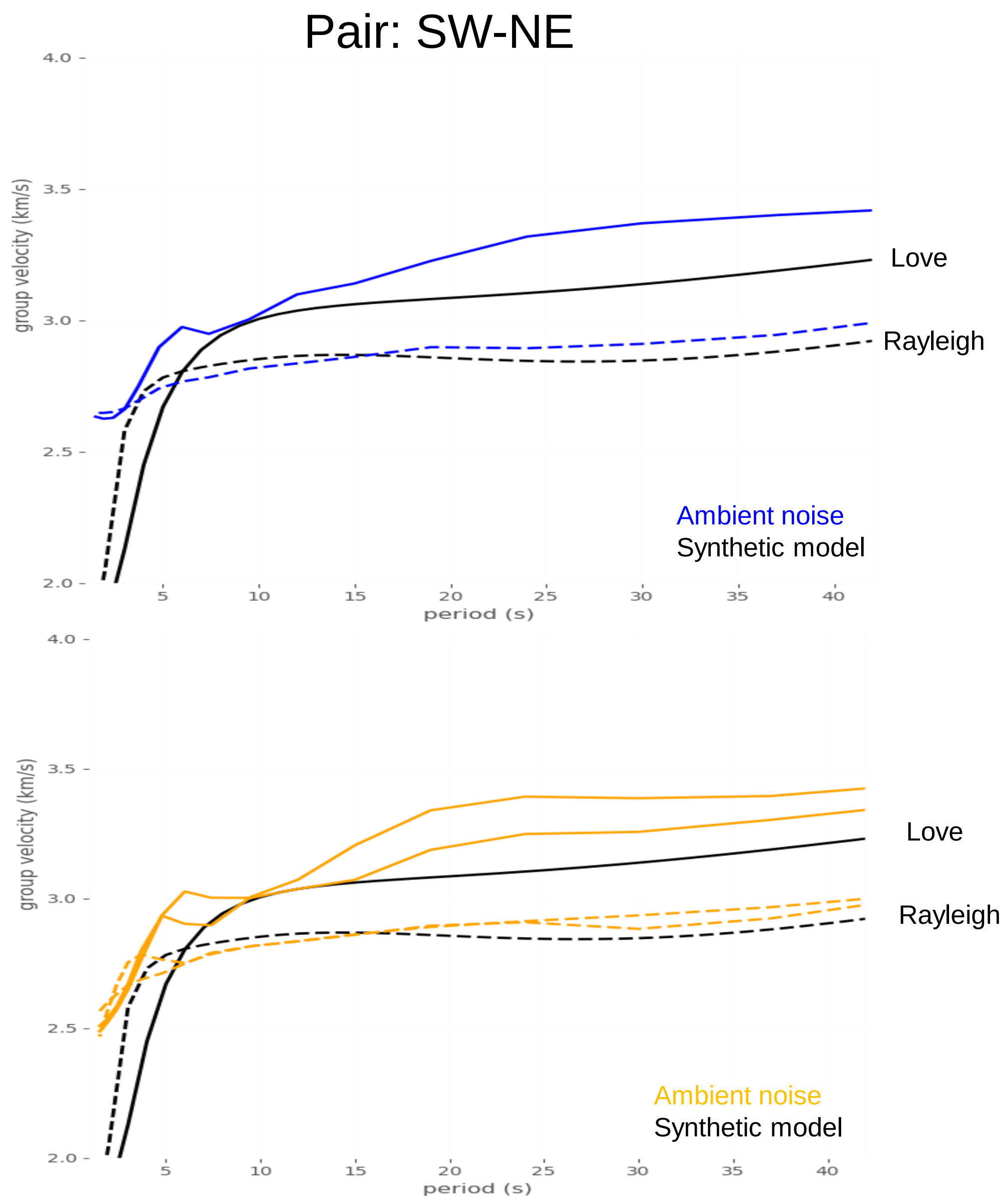


group velocity (km/s)
period (s)
Love
Rayleigh
Ambient noise
Synthetic model

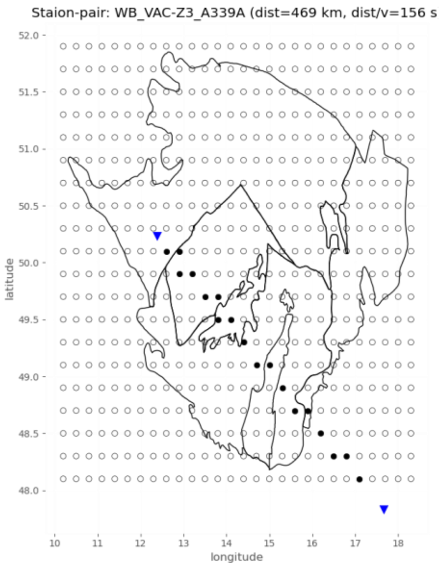
Results

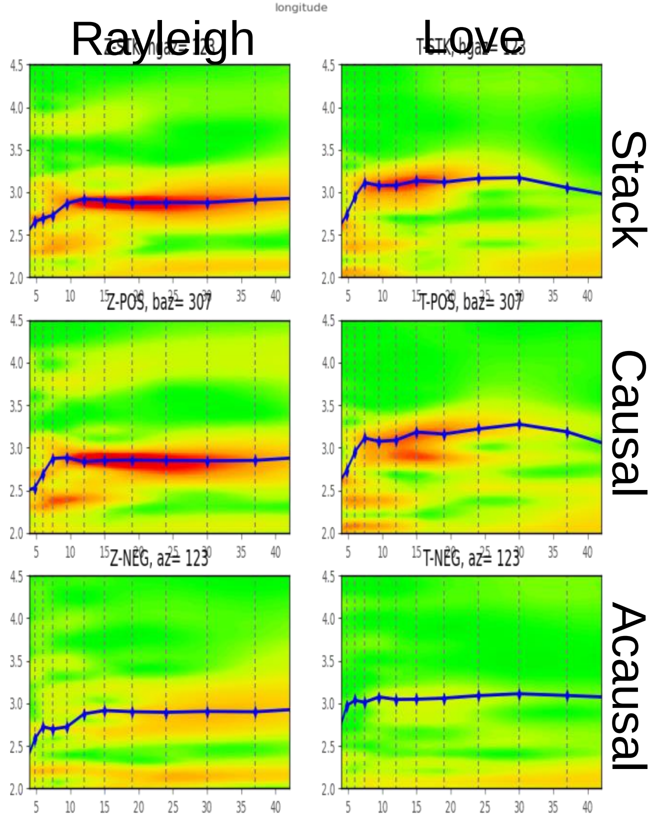

Staion-pair: BW_RNON-Z3_A088B (dist=376 km, dist/v=125 s)
latitude
longitude


Rayleigh
Love
Stack
Causal
Acausal
Z-POS, baz= 242
T-POS, baz= 242
Z-NEG, az= 58
T-NEG, az= 58

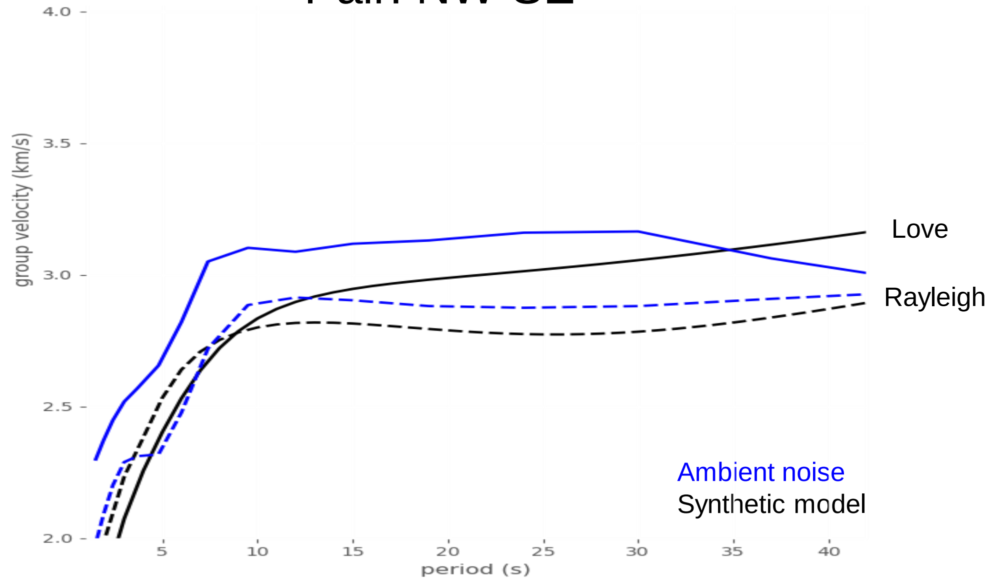

Pair: SW-NE
group velocity (km/s)
period (s)
Love
Rayleigh
Ambient noise
Synthetic model

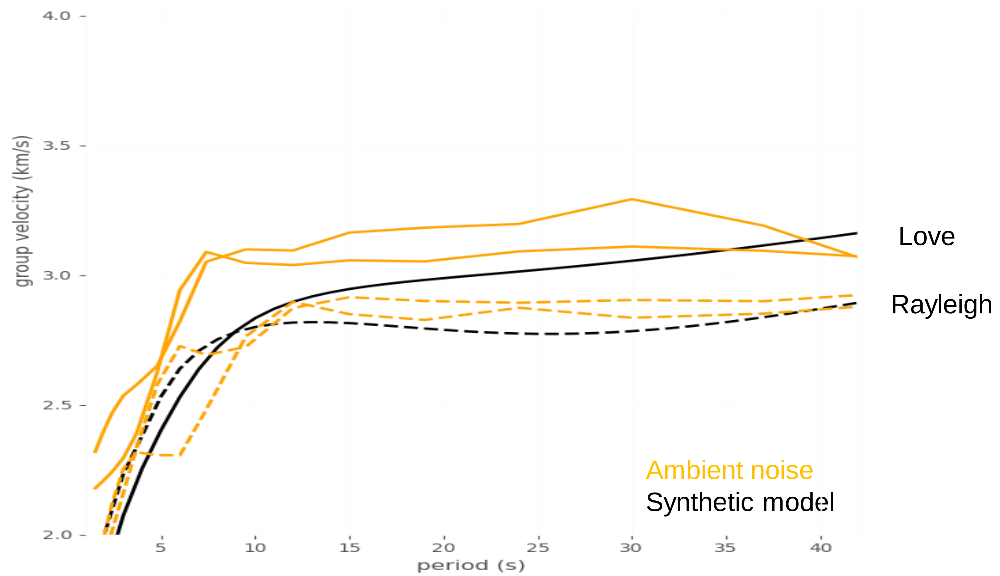
Results

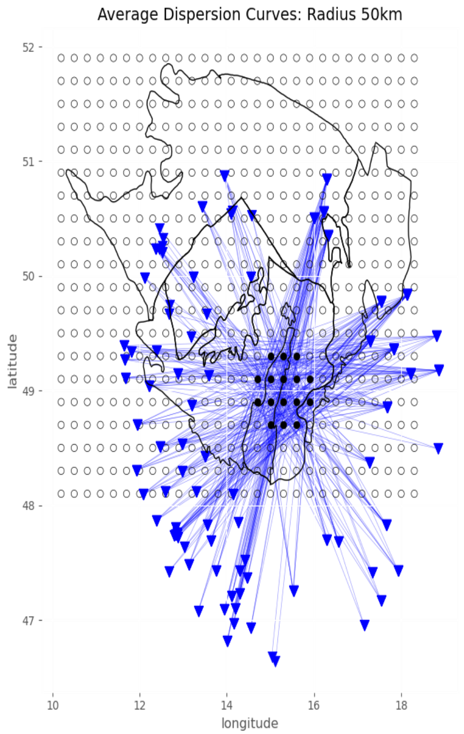




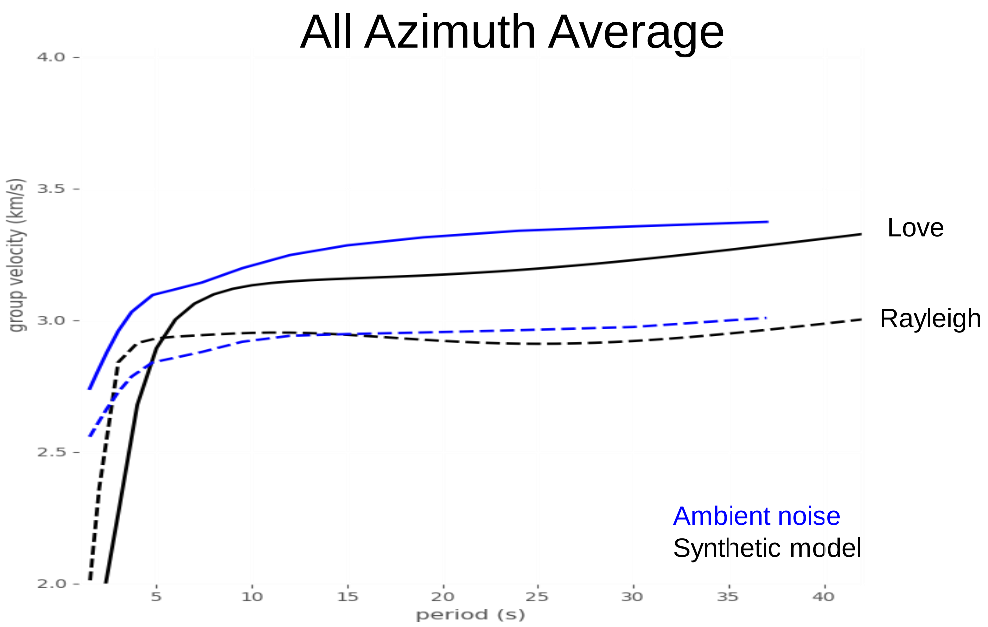
Pair: NW-SE



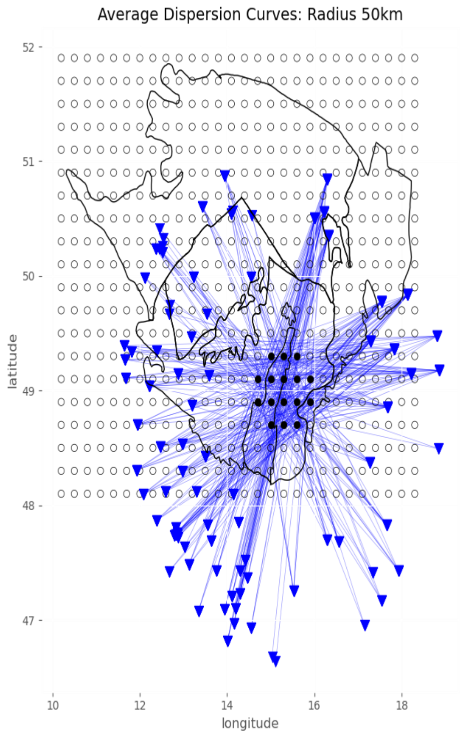



Average Dispersion Curves: Radius 50km
latitude
longitude
52
51
50
49
48
47
10
12
14
16
18

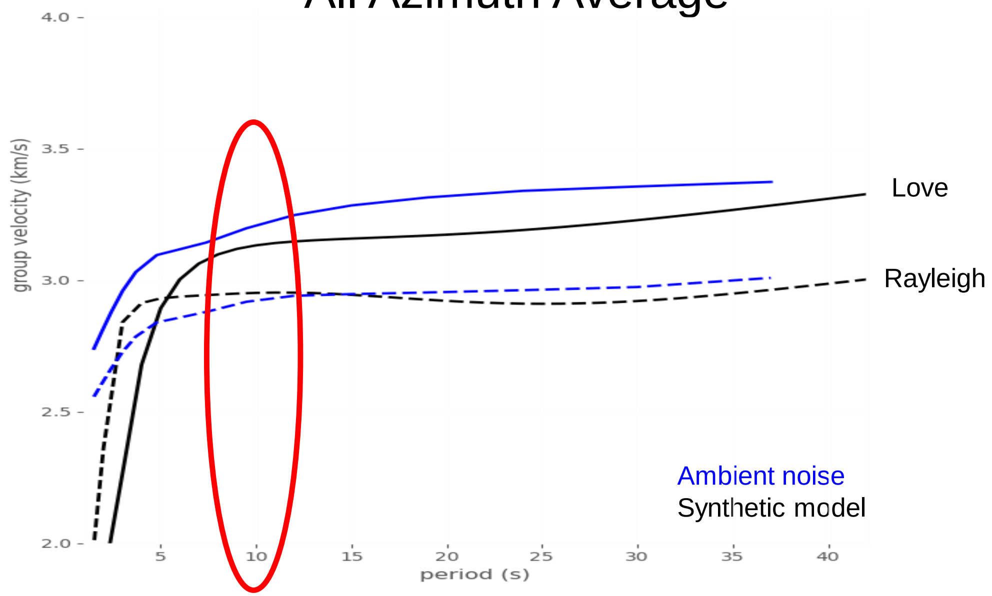
Results


All Azimuth Average
group velocity (km/s)
period (s)
4.0
3.5
3.0
2.5
2.0
5
10
15
20
25
30
35
40
Love
Rayleigh
Ambient noise
Synthetic model

Results

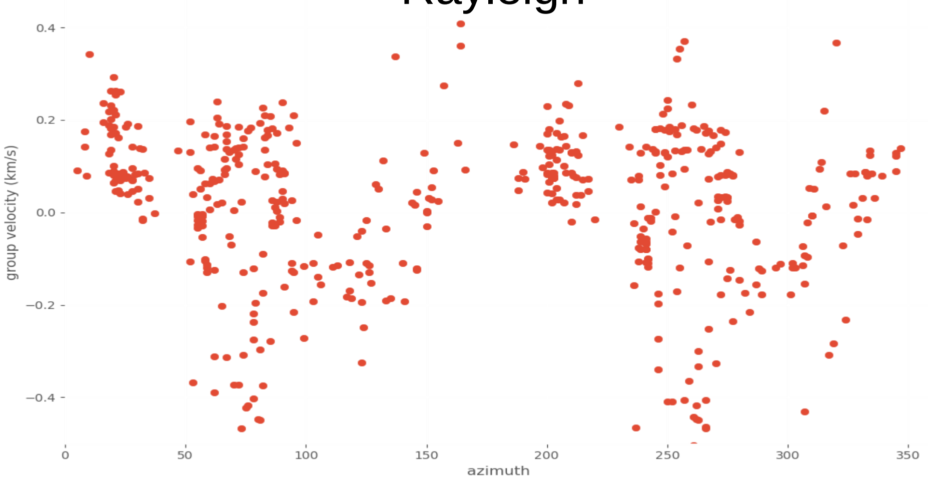


All Azimuth Average

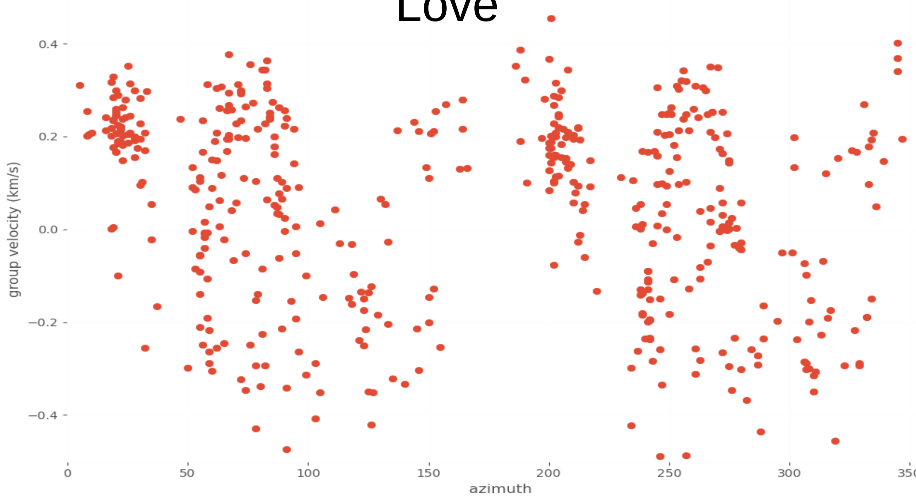


Velocity variations with azimuth, T = 10s

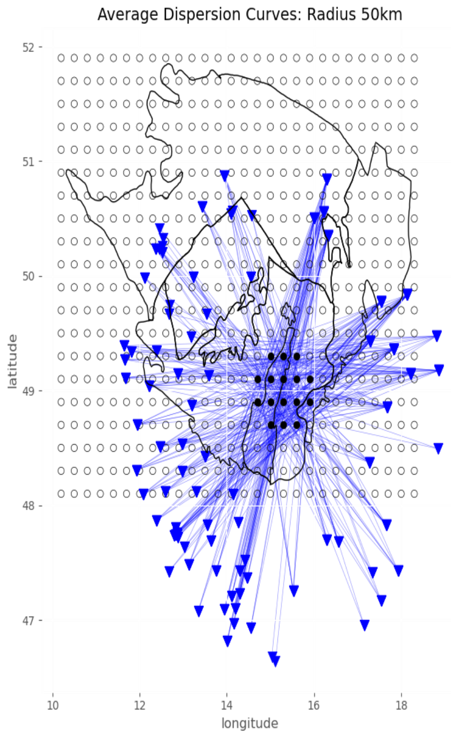
Rayleigh

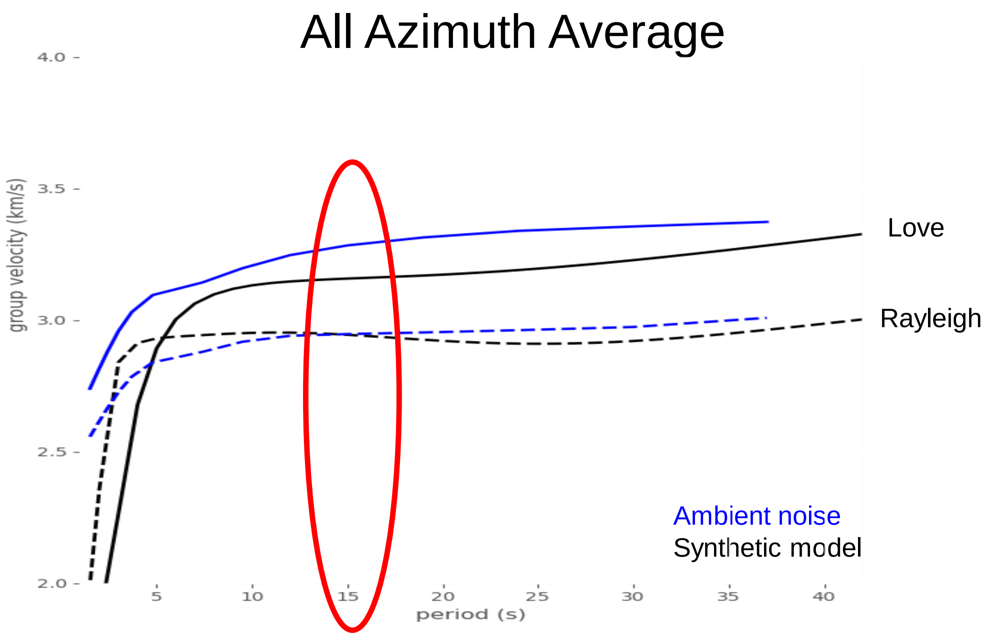


Love

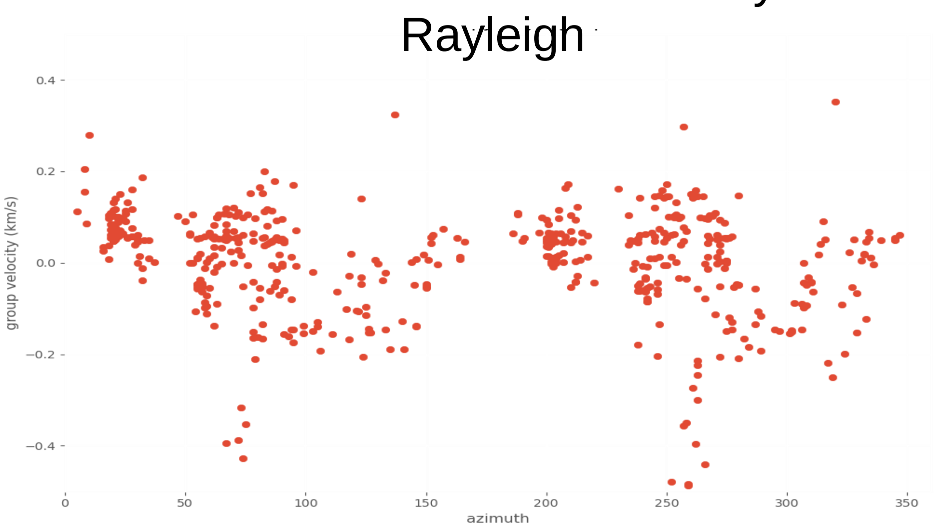


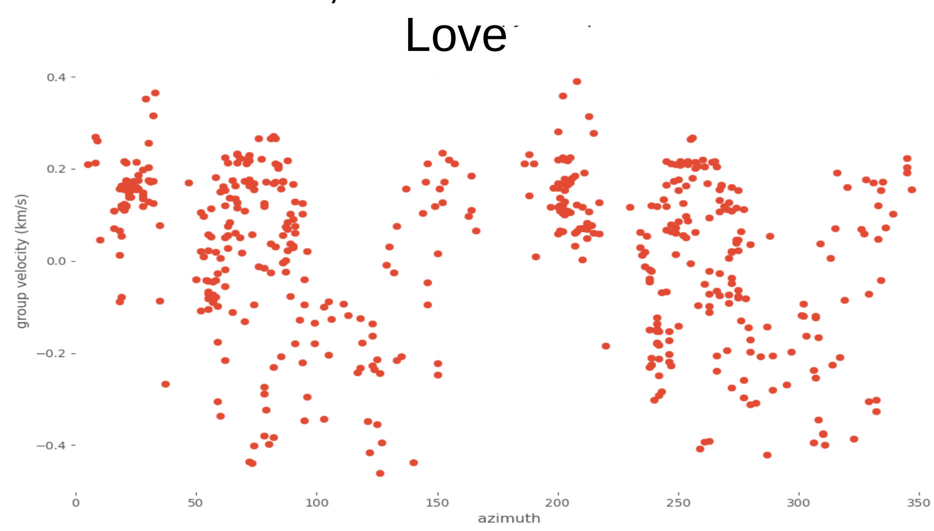
Results



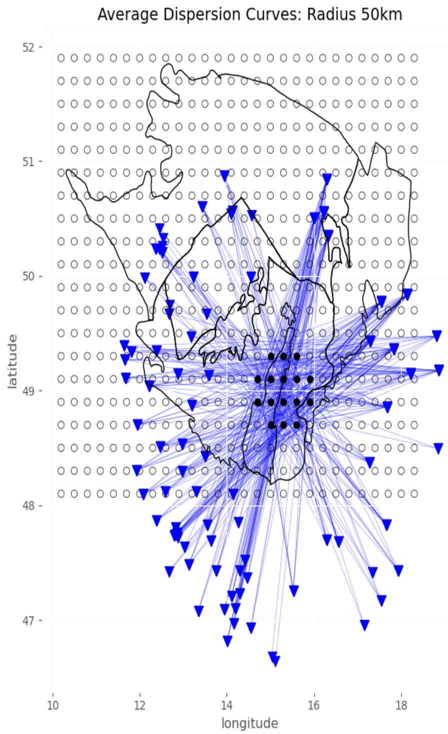


Velocity variations with azimuth, T = 15s

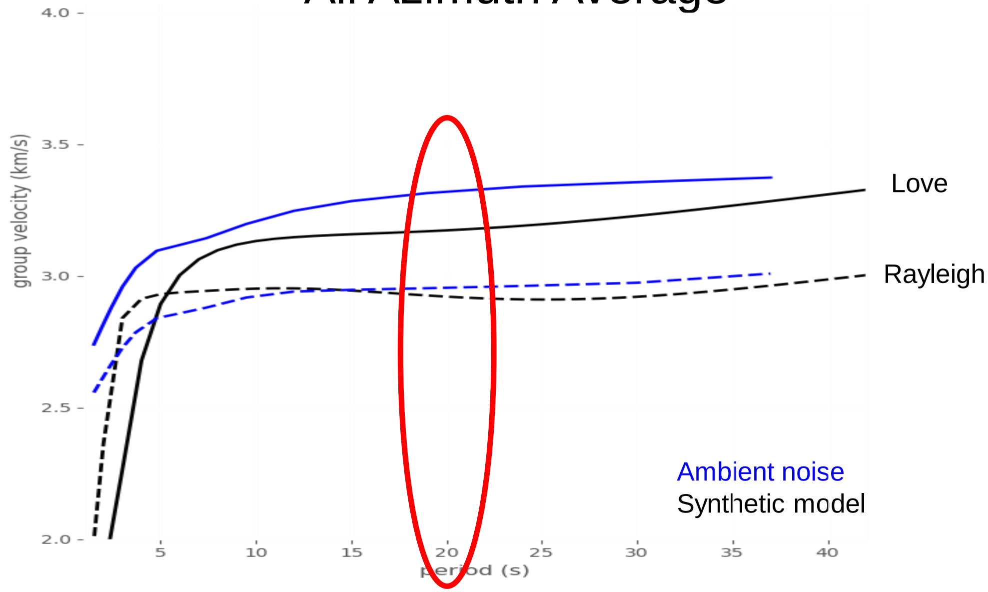




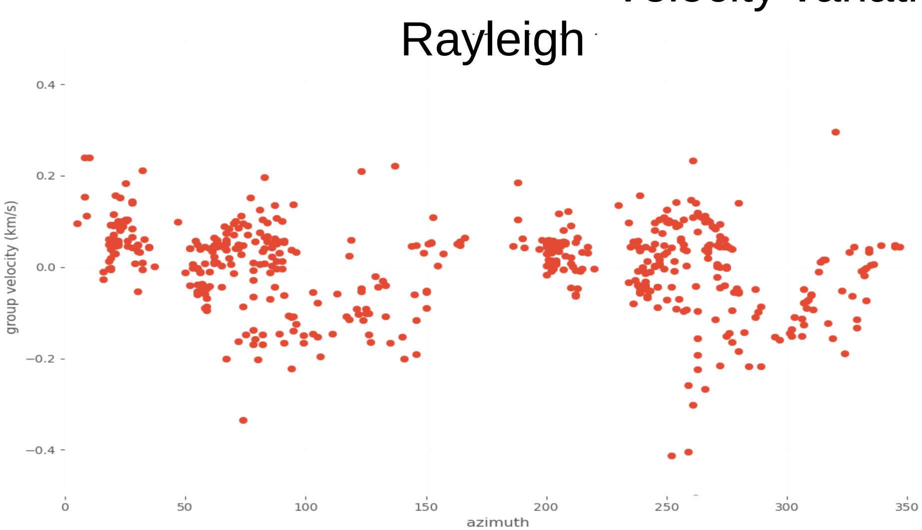
Results

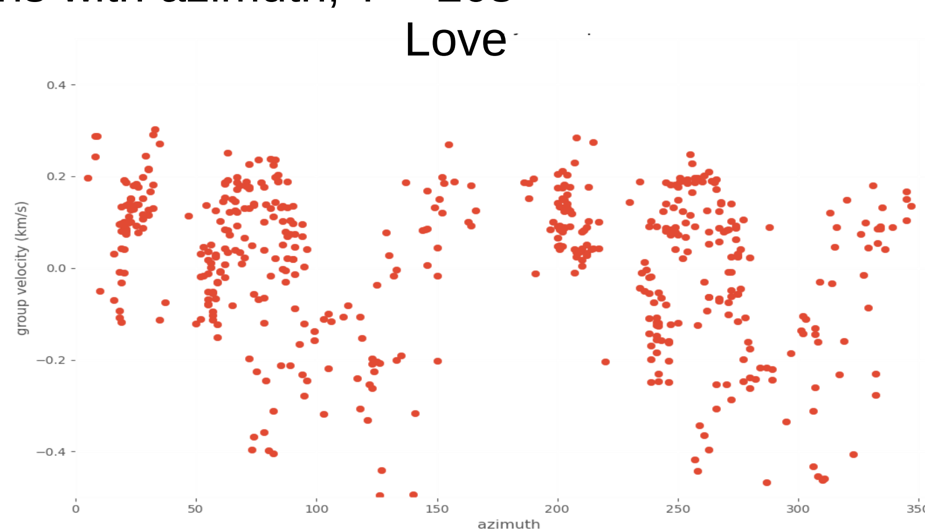


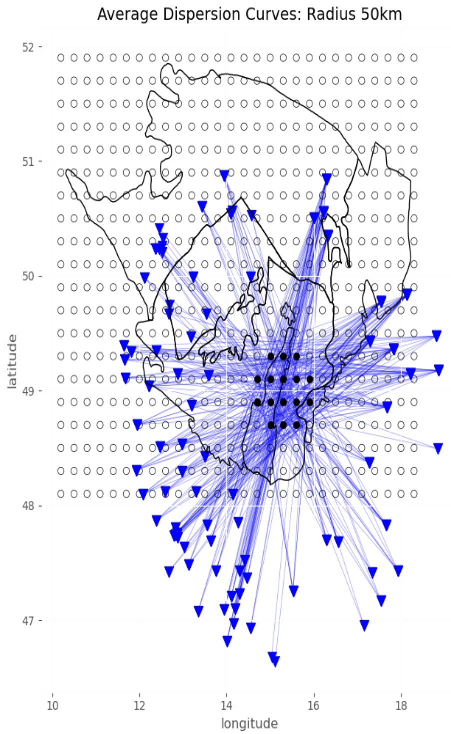
All Azimuth Average



Velocity variations with azimuth, T = 20s

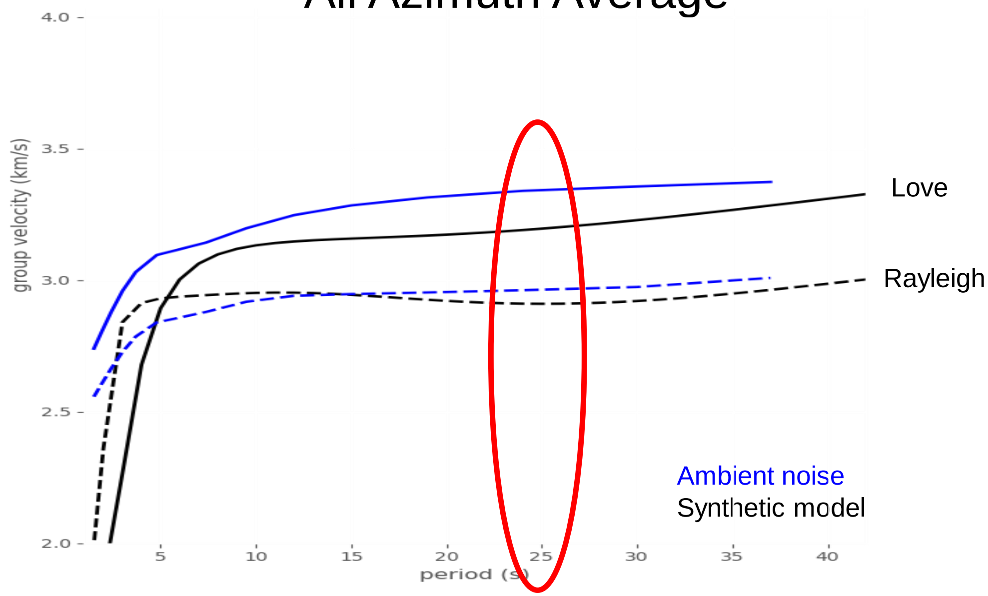






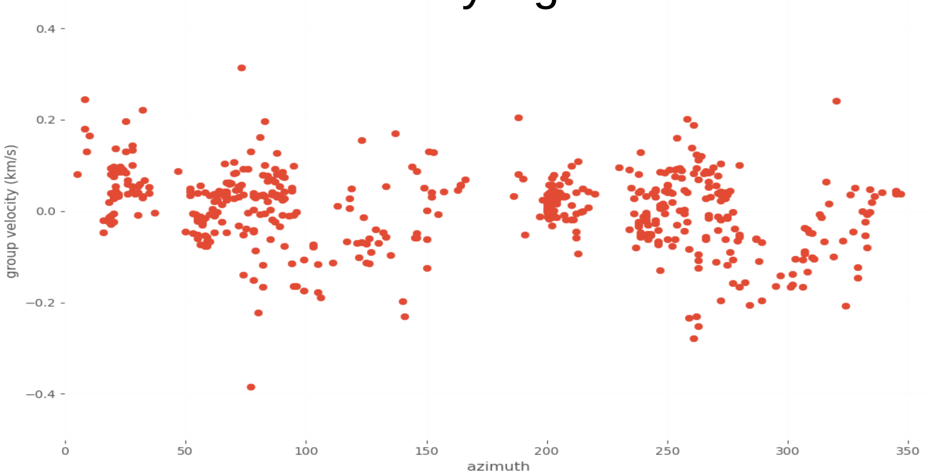
Results

All Azimuth Average

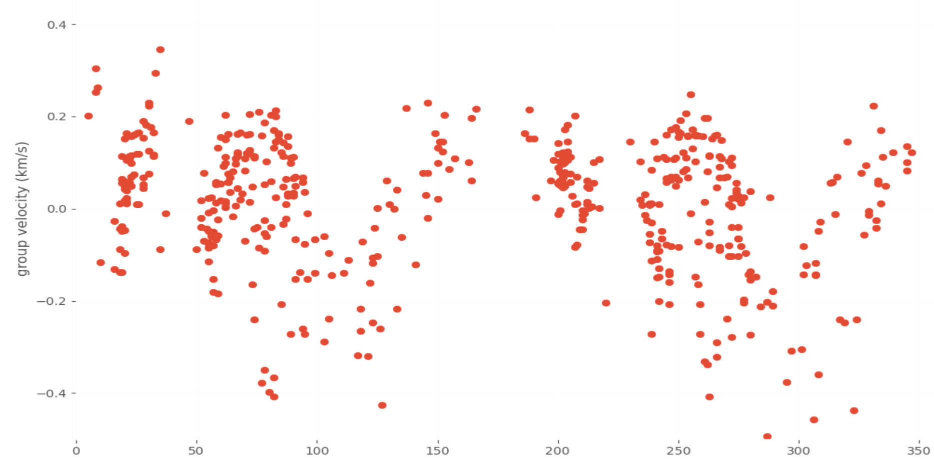


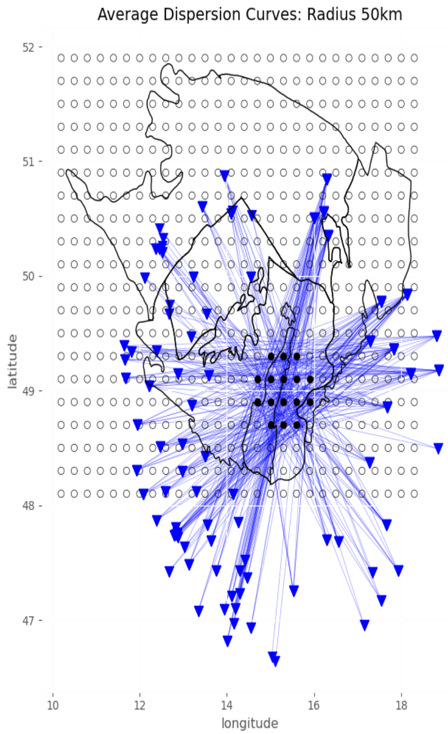
Velocity variations with azimuth, T = 25s

Rayleigh



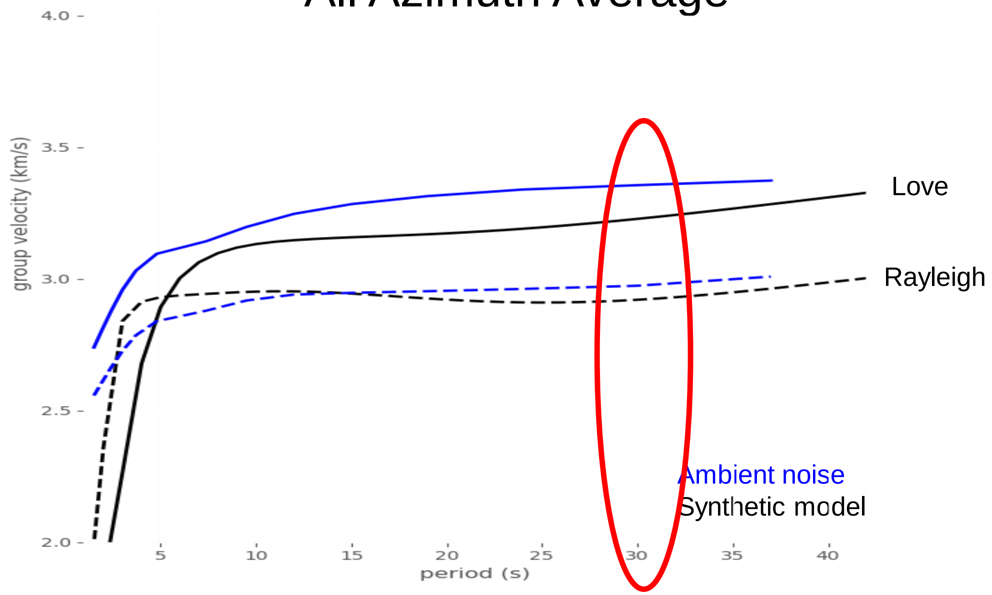
Love





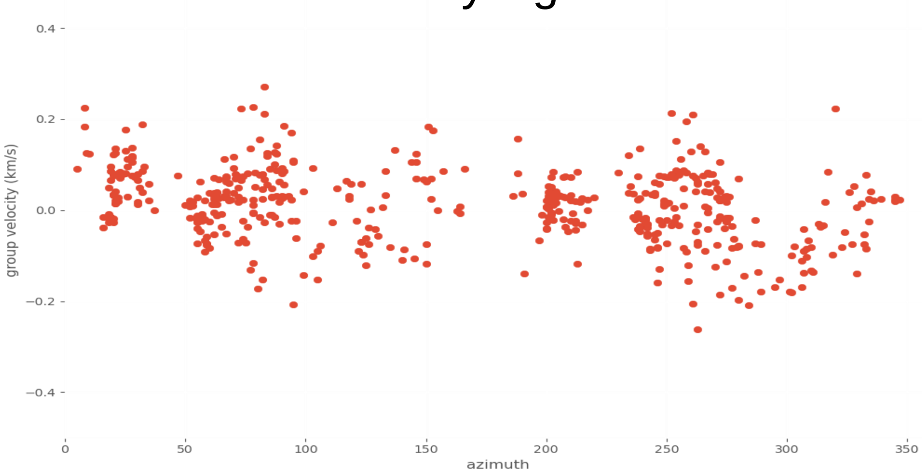
Results

All Azimuth Average

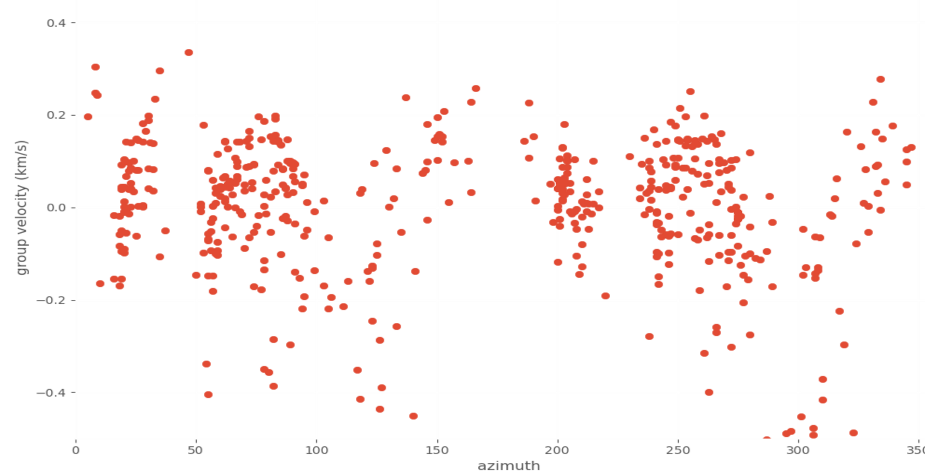


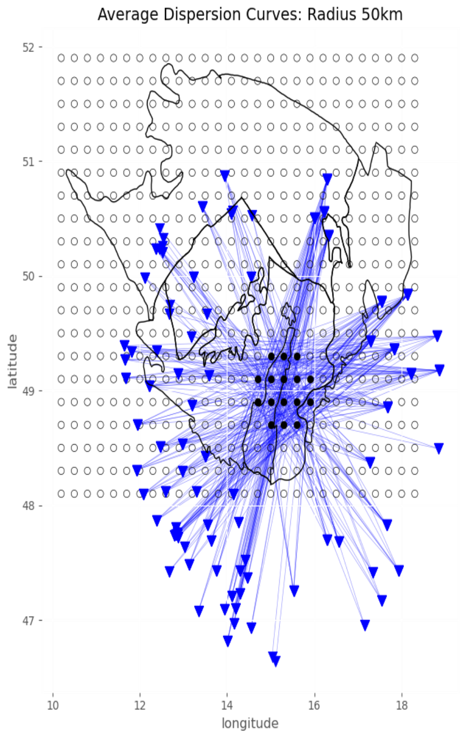
Velocity variations with azimuth, T = 30s

Rayleigh



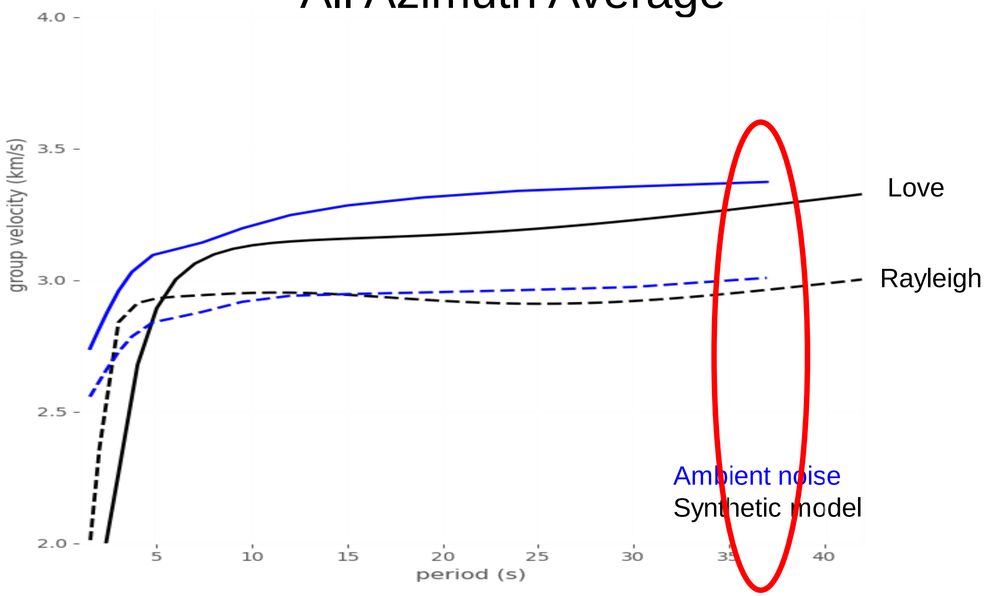
Love





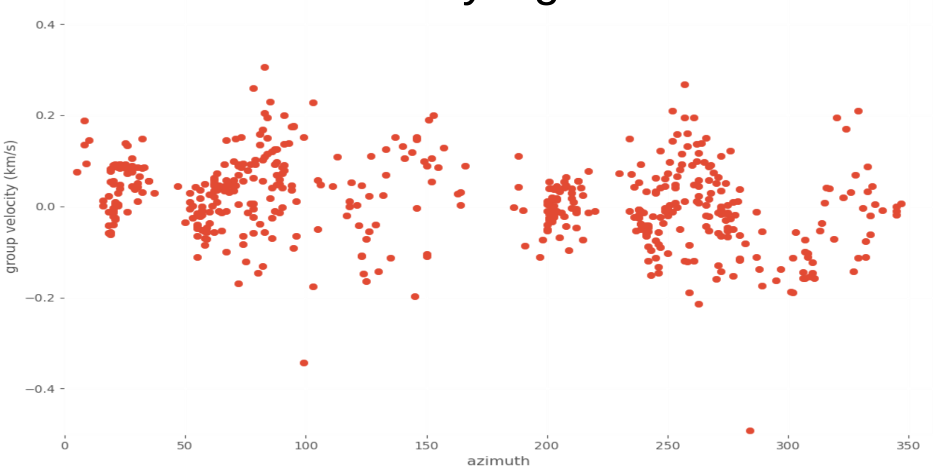
Results

All Azimuth Average

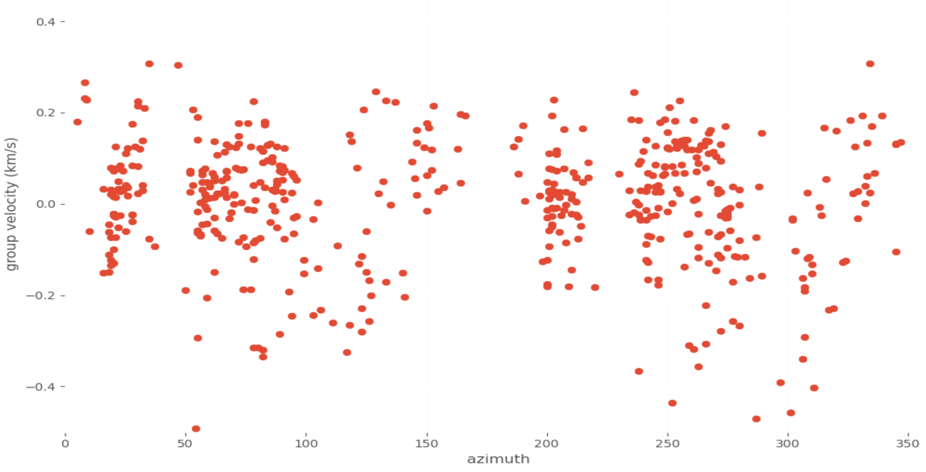


Velocity variations with azimuth, T = 37s

Rayleigh



Love



Conclusions

- Surface waves derived from ambient noise are sensitive to azimuthal anisotropy in the lower crust. As expected, the Love wave dispersion curves better detects azimuthal variation than Rayleigh waves.

- Retrieved variations of azimuthal anisotropy are focused in periods from 20 to 30s, with the fast velocity directions around NNE-SSW.

- The derived Love wave dispersion curves are higher than those modelled from isotropic 3D Vs model, whilst the Rayleigh wave dispersion curves fit to their synthetic models. It supports the interpretation, that the low velocity layer in the lower part of the crust on the ANT model indicates the anisotropic fabric in the lower crust.

- We interpret the lower crust anisotropy layer as an imprint of the Variscan orogenic processes and the late-Variscan strike-slip movements along boundaries of the crustal units.