



MISS – Project

Minderung der Störwirkung von Windenergieanlagen auf seismologische Stationen

Gefördert durch:

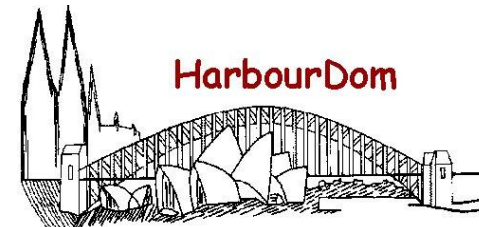


EUROPÄISCHE UNION
Investition in unsere Zukunft
Europäischer Fonds
für regionale Entwicklung

Teilprojekt WWU:

Mitigation of effects on the travel path – a theoretical approach

Rafael Abreu, Christine Thomas

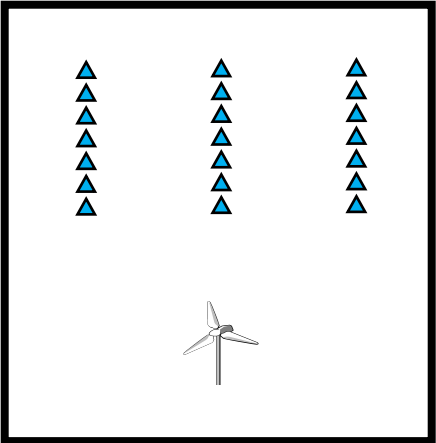


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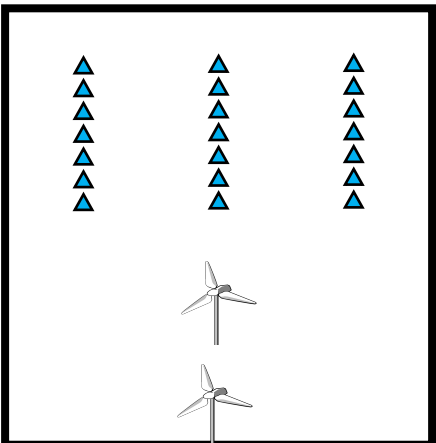


Influence of wind-turbine locations

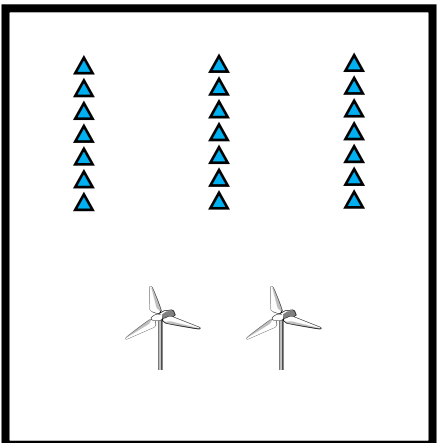
a) Single



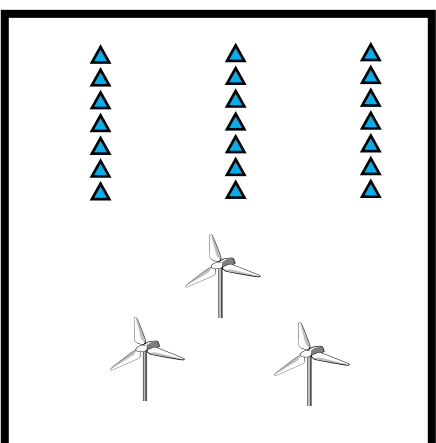
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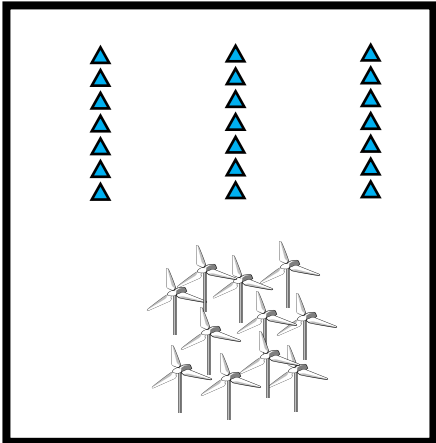
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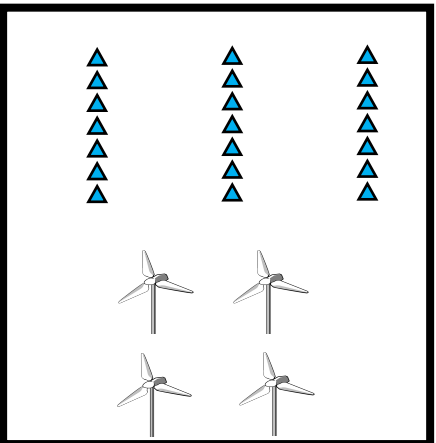
d) Triangle



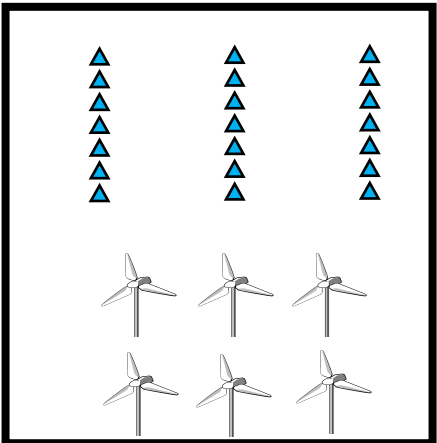
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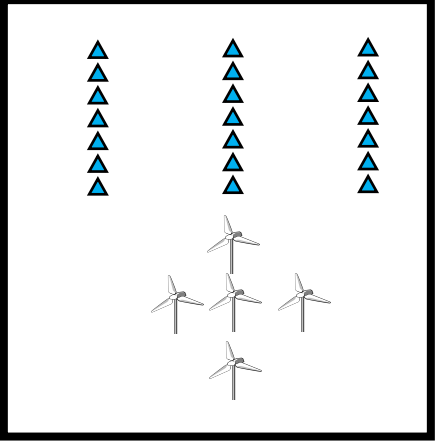
e) Square



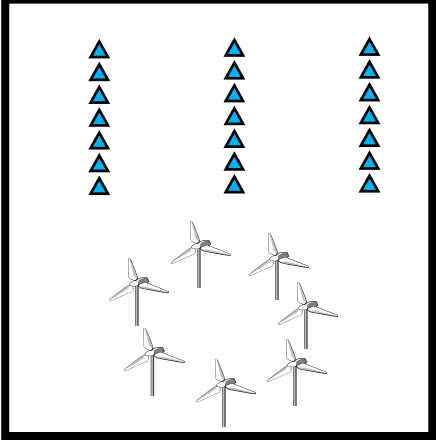
f) Rectangle



g) Crux

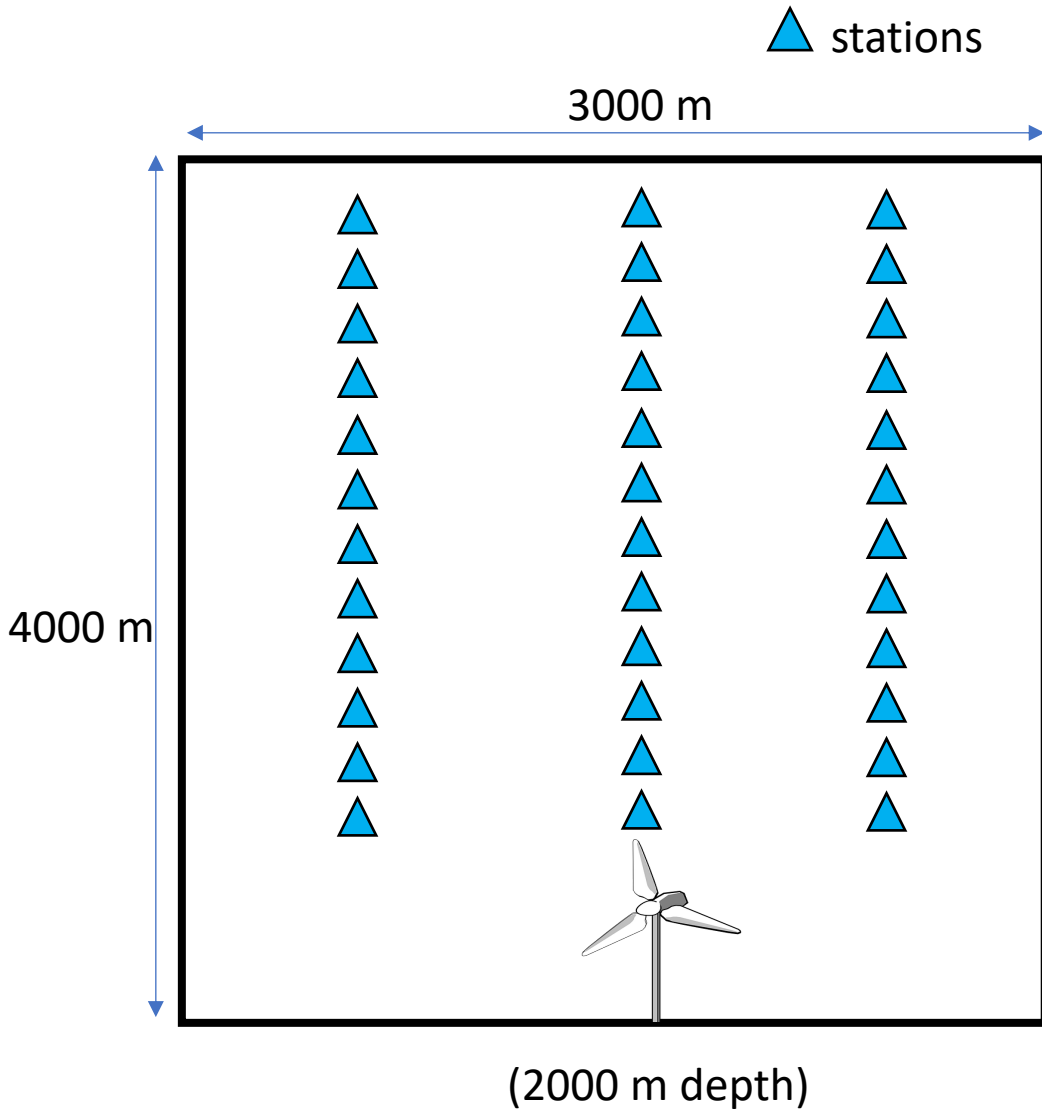


h) Circular



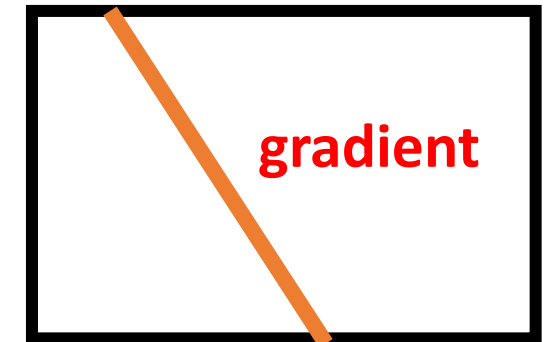
Numerical experiments: setup

Test models



Simulation of data using 3D models with one source with a model set-up of velocity increase with depth

$V_p = 1200 \text{ m/s}$
 $V_s = 900 \text{ m/s}$



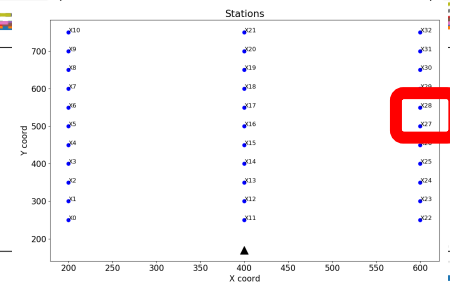
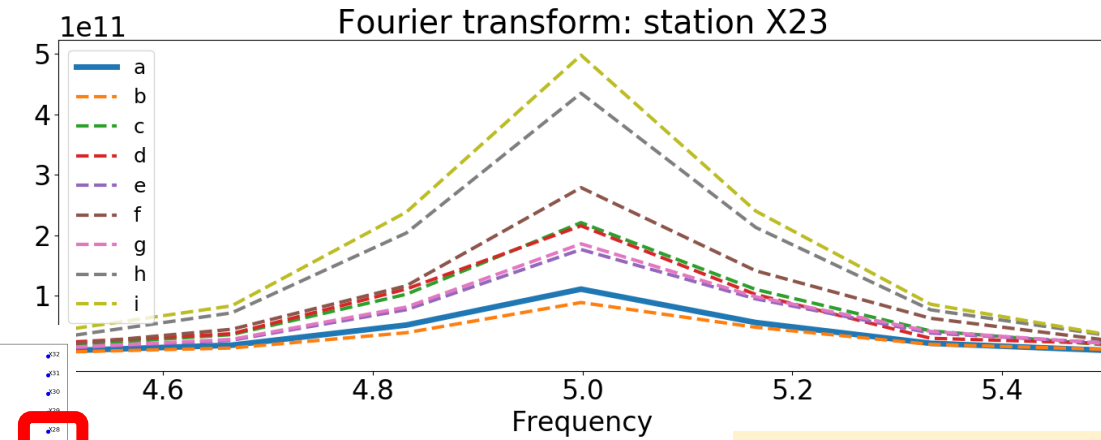
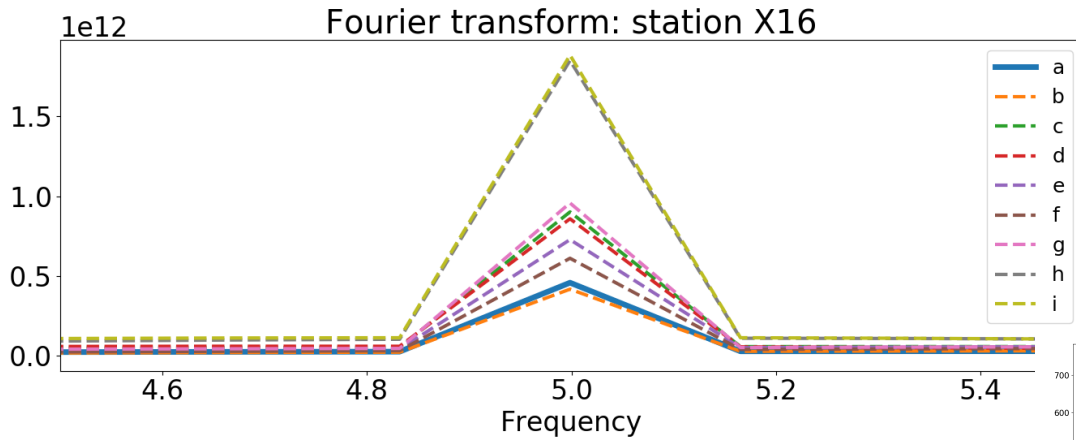
$V_p = 2500 \text{ m/s}$
 $V_s = 1400 \text{ m/s}$

Influence of wind-turbine locations

Sine source at 5Hz

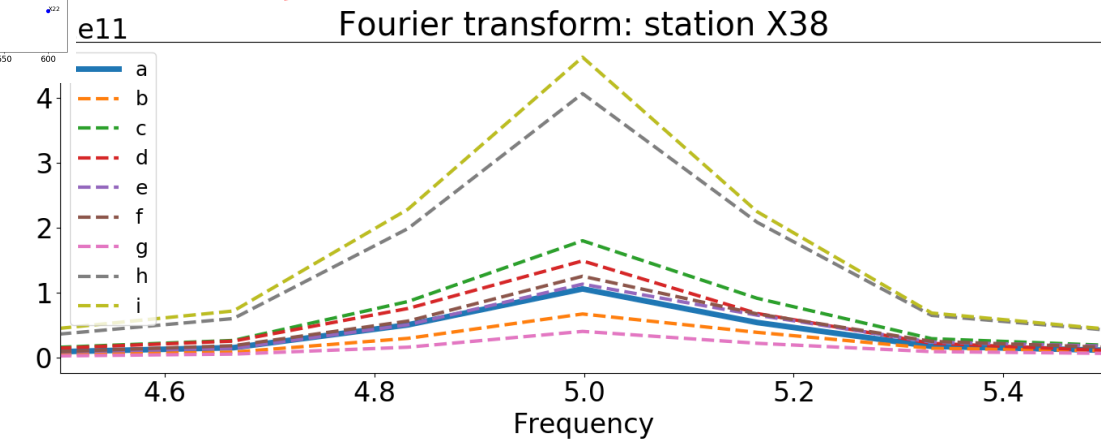
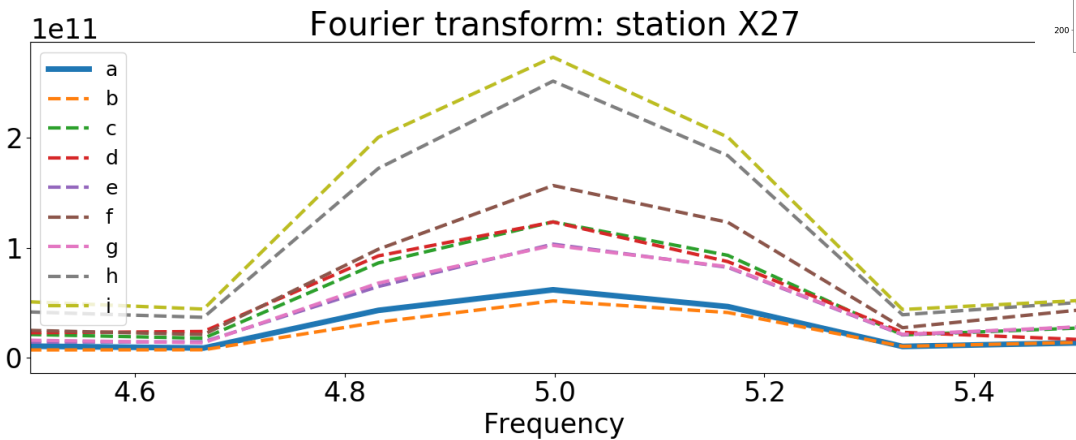
distance 200 m

distance 1700 m



distance 3500 m

distance 2500 m

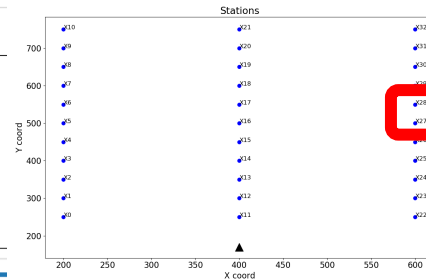
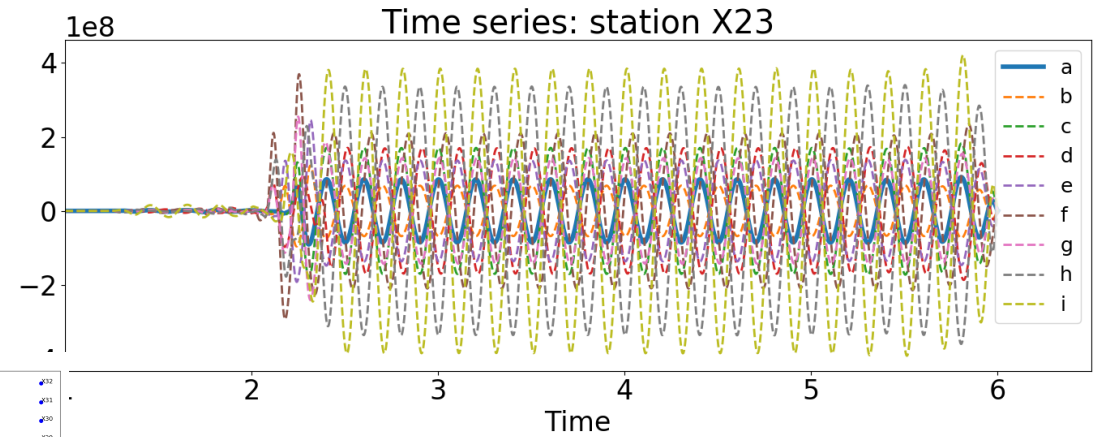
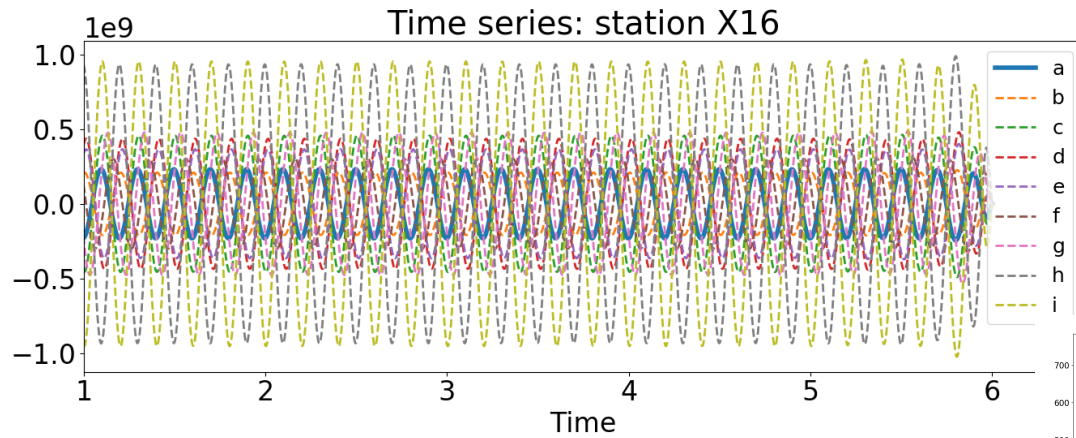


Influence of wind-turbine locations

Sine source at 5Hz

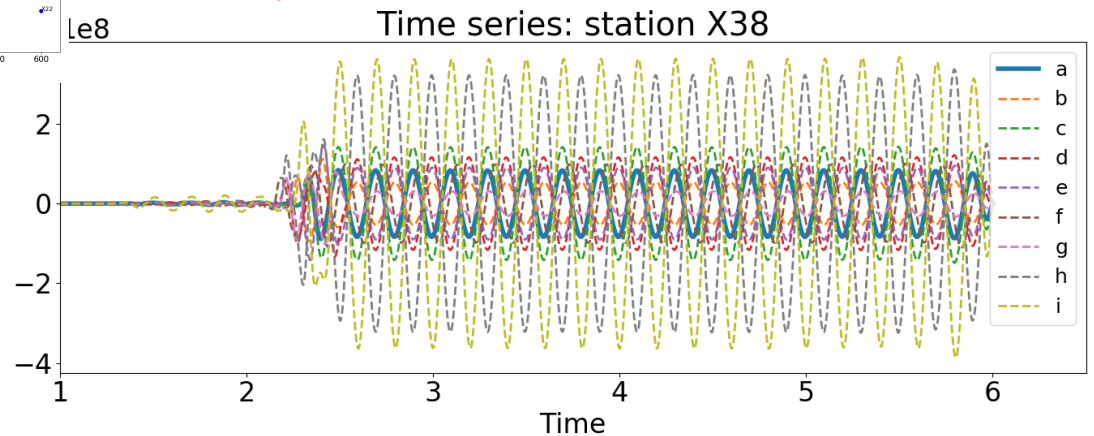
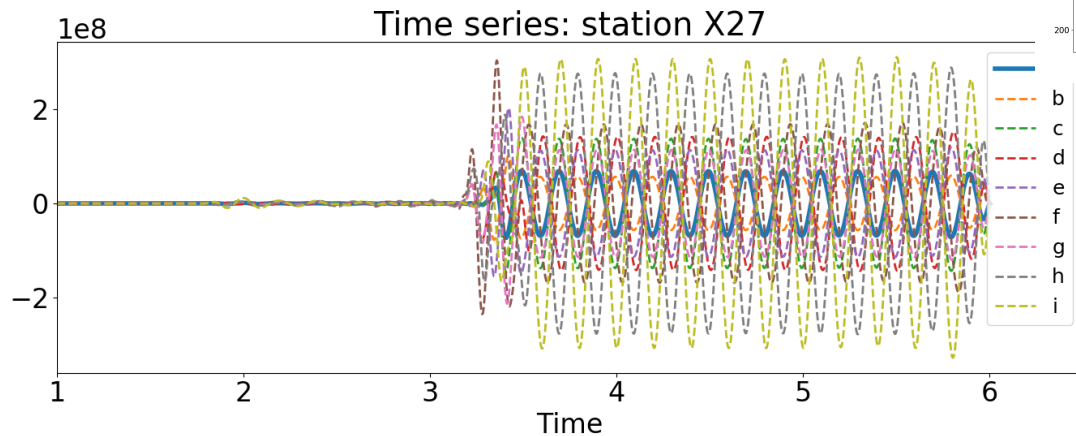
distance 200 m

distance 1700 m



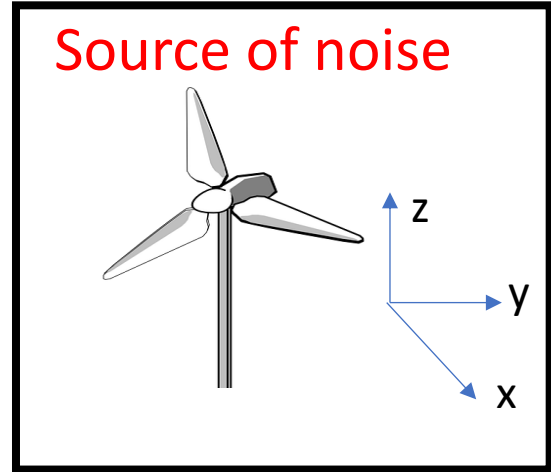
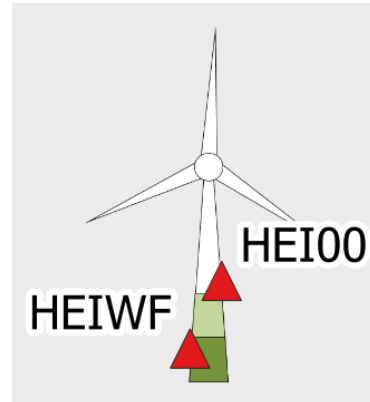
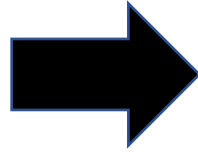
distance 2500 m

distance 3500 m



Different types of noise sources from DMT

Seismic stations at the wind turbine



+

3 components measurements (X,Y,Z)

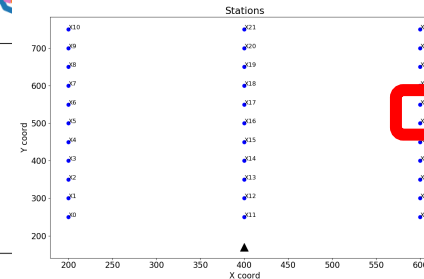
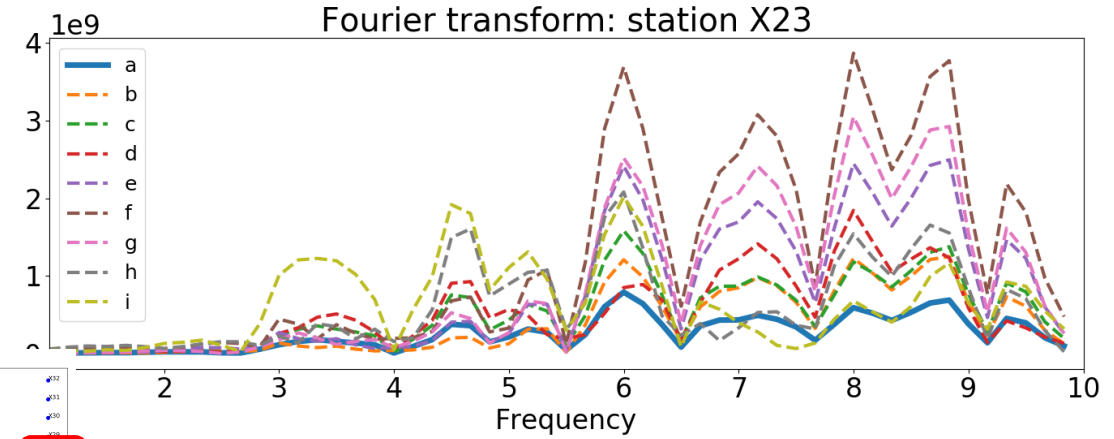
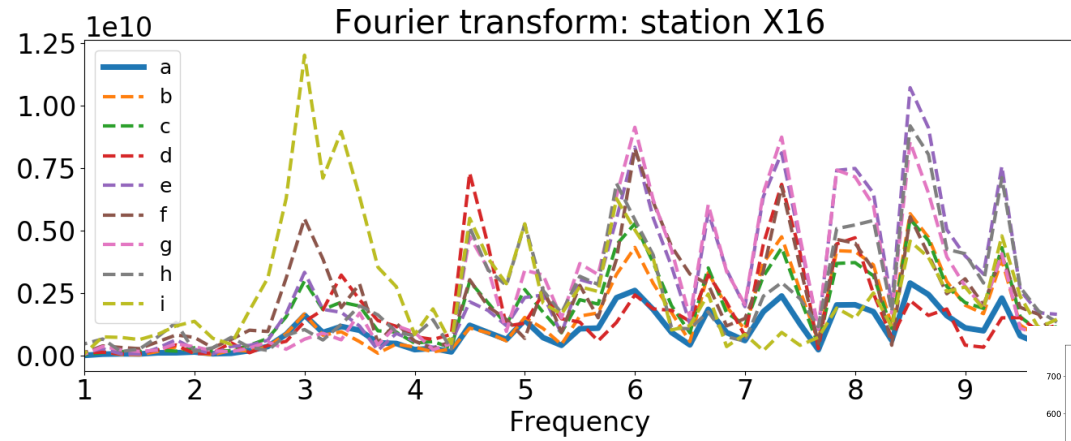
TOTAL of measurements: 3 (comp) x 1 (sta) x 1 (scenarios) = 3 source time functions

Influence of wind-turbine locations

high wind speed

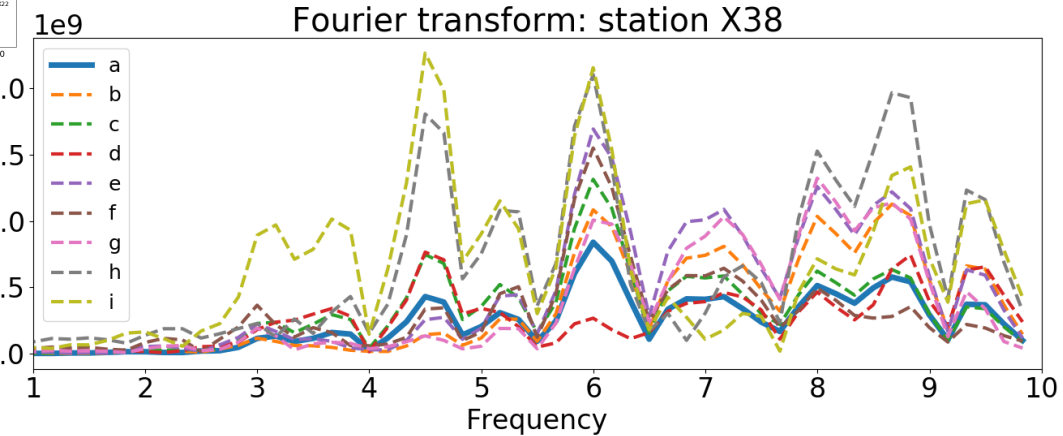
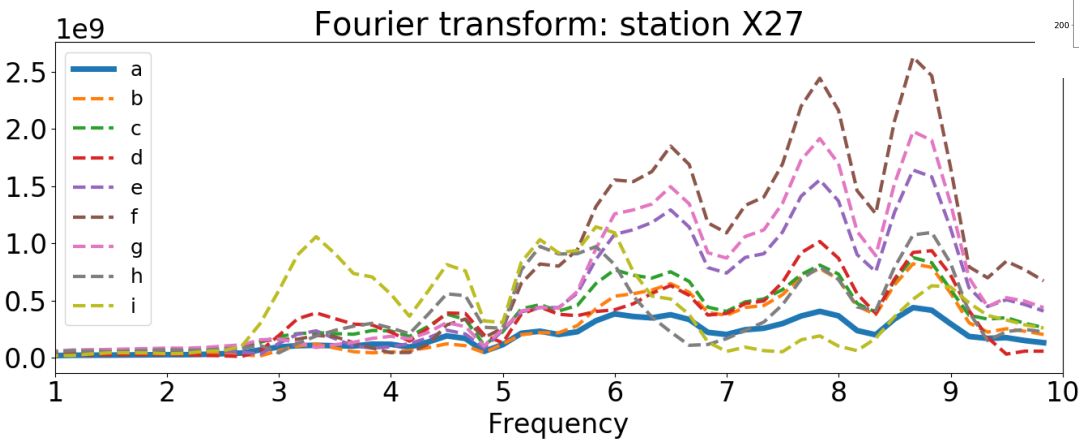
distance 200 m

distance 1700 m



distance 3500 m

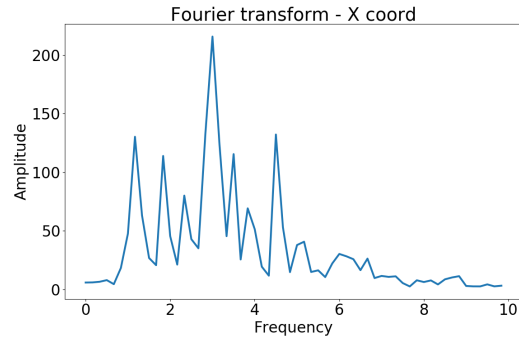
distance 2500 m



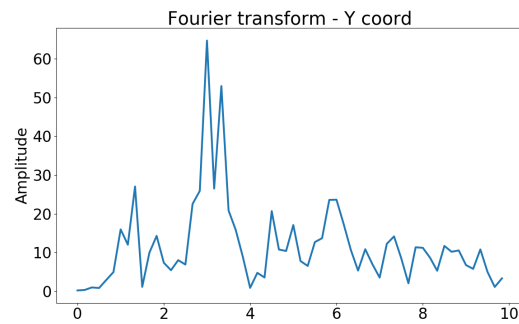
Comparison with distance- stack of all simulated spectra

1) Data injected as source time functions

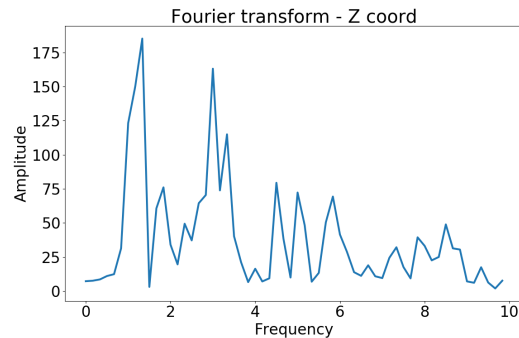
a) X component



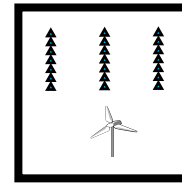
b) Y component



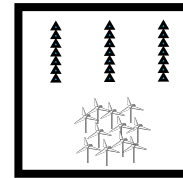
c) Z component



a) Single WT as a source

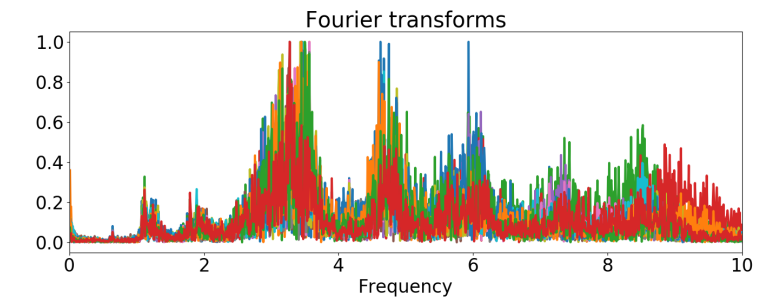
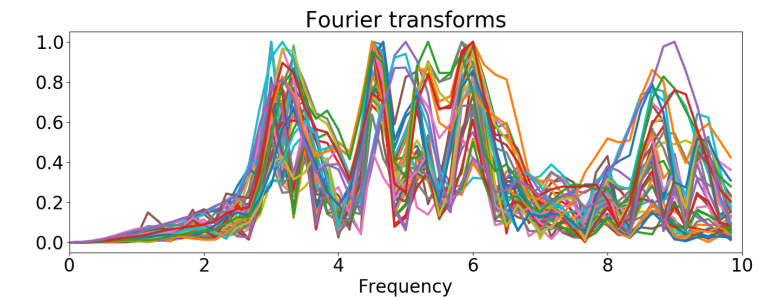
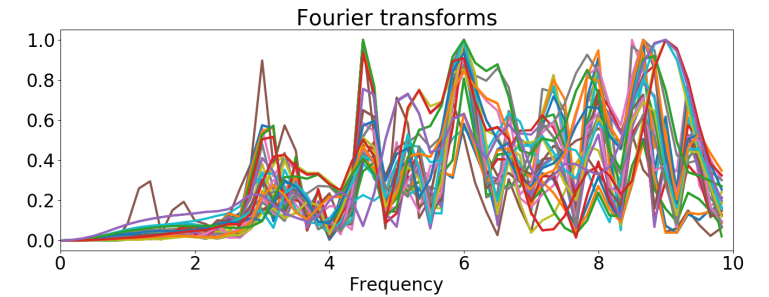


b) Random arrangement of WTs as sources



c) Data

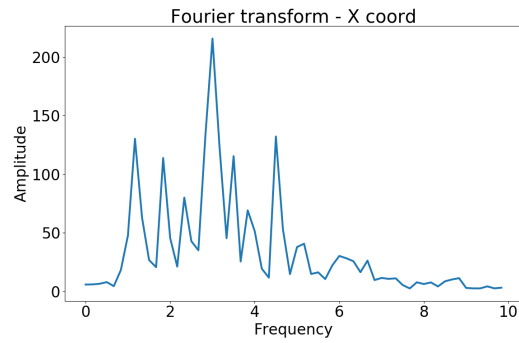
Z component



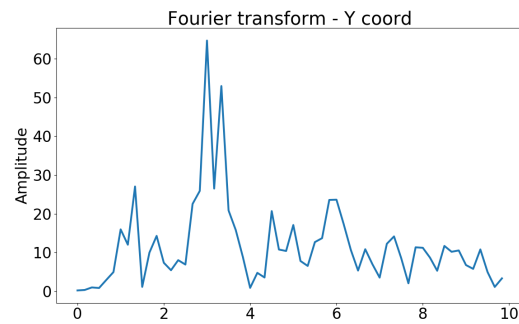
Comparison with distance- stack of all simulated spectra

1) Data injected as source time functions

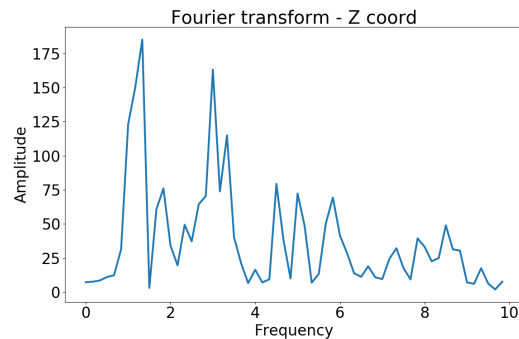
a) X component



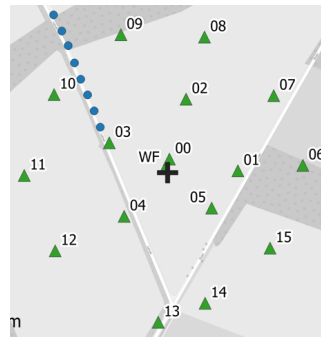
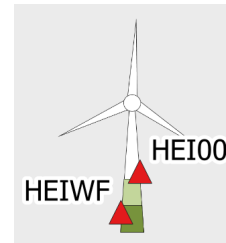
b) Y component



c) Z component

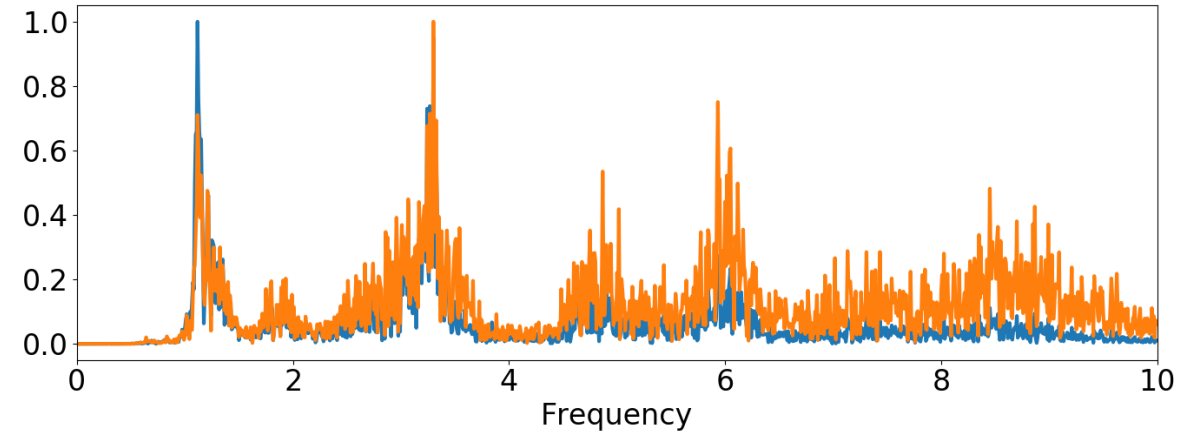


stations

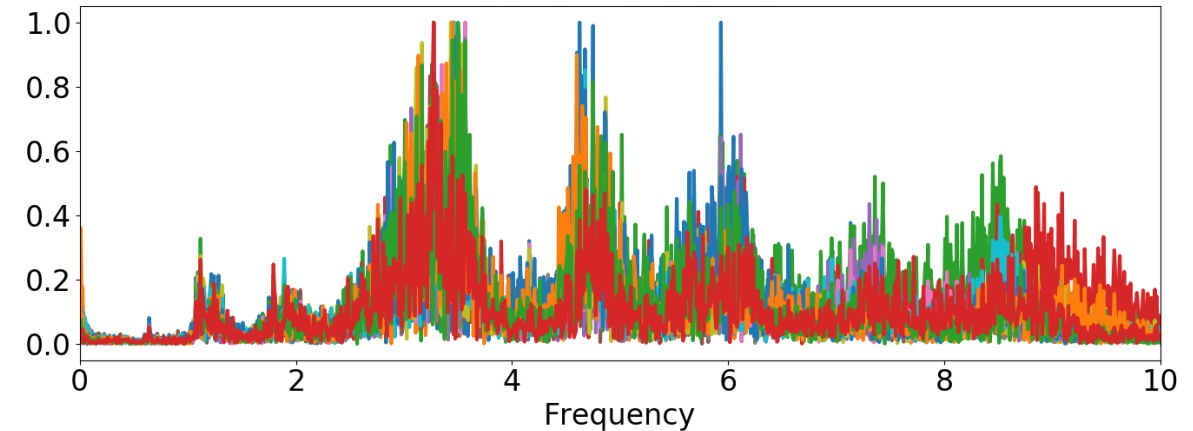


Data - Z component

Fourier transforms

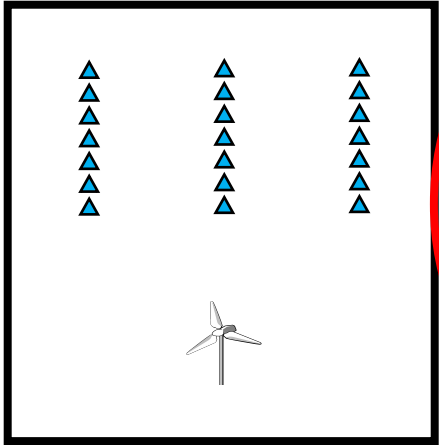


Fourier transforms

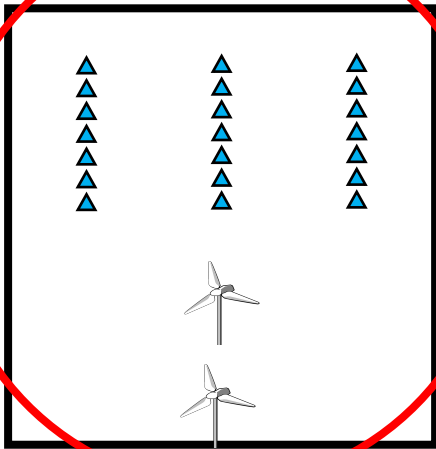


Influence of wind-turbine locations

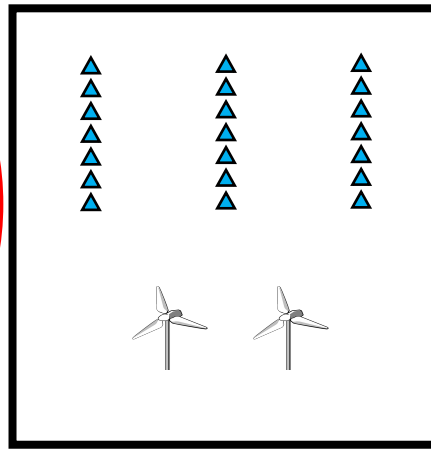
a) Single



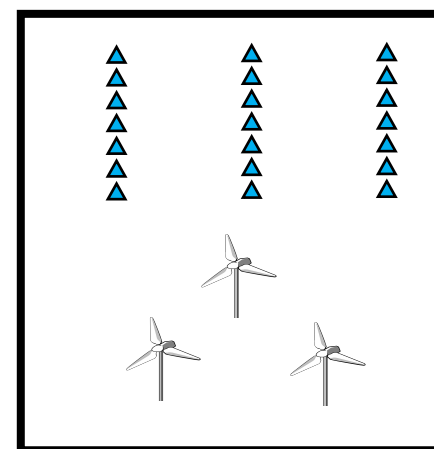
b) Two vertical



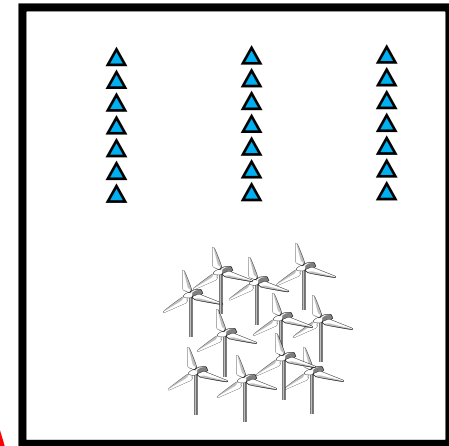
c) Two horizontal



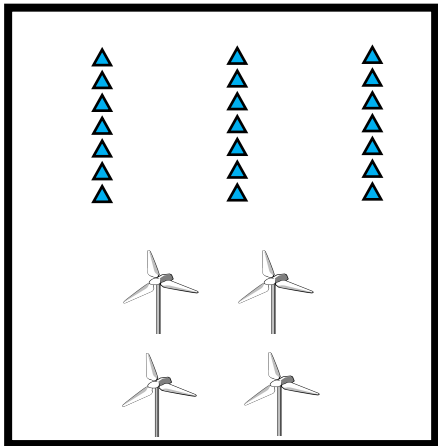
d) Triangle



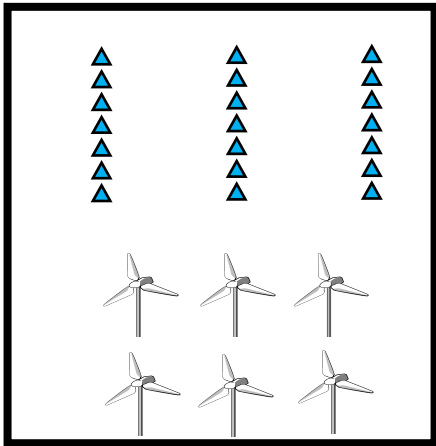
i) Random



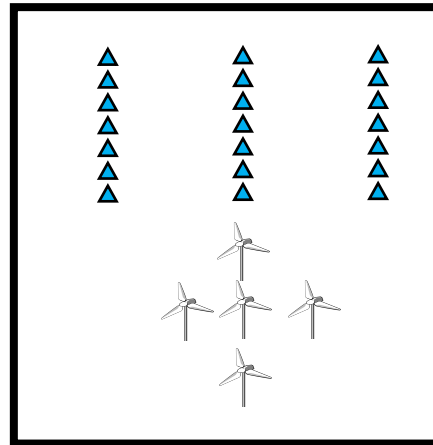
e) Square



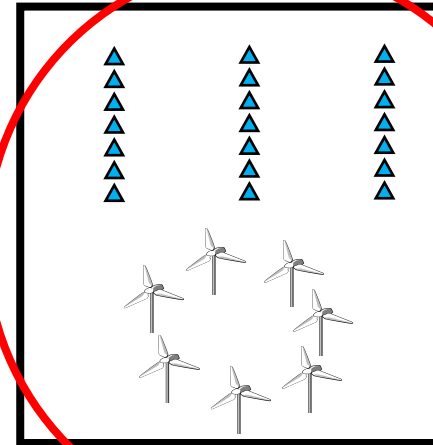
f) Rectangle



g) Crux



h) Circular

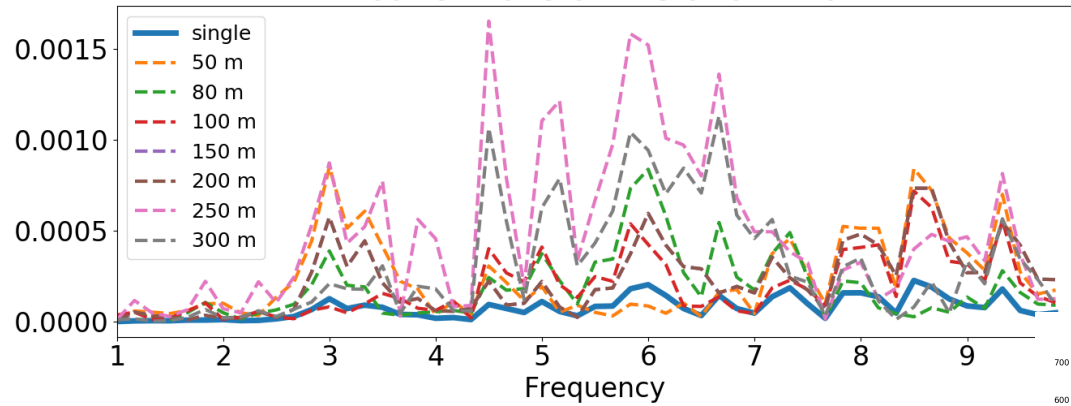


Circular array of WTs seems to attenuate the seismic noise

Influence of radial distance

distance 200 m

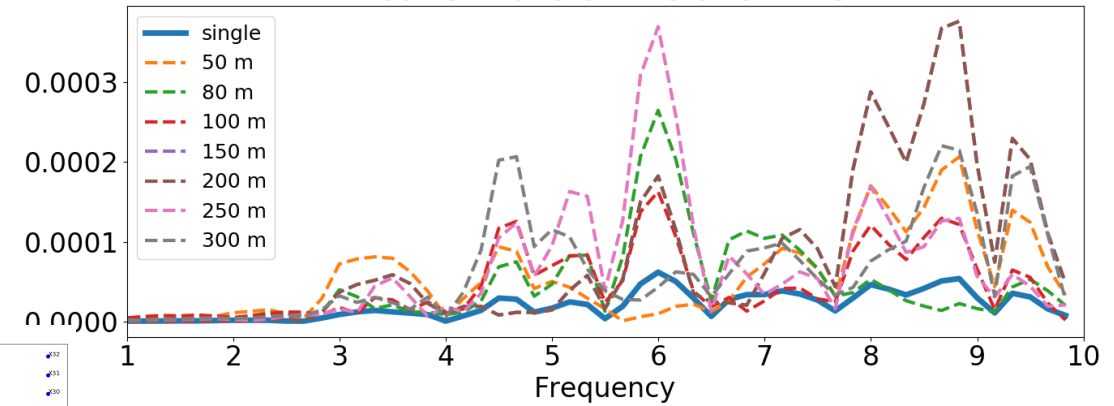
Fourier transform: station X16



Clear reduction of the energy at 6 Hz

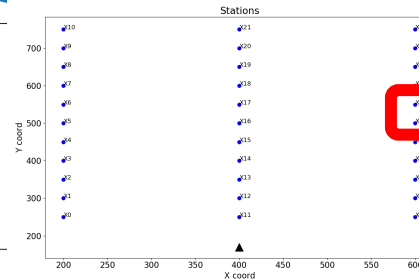
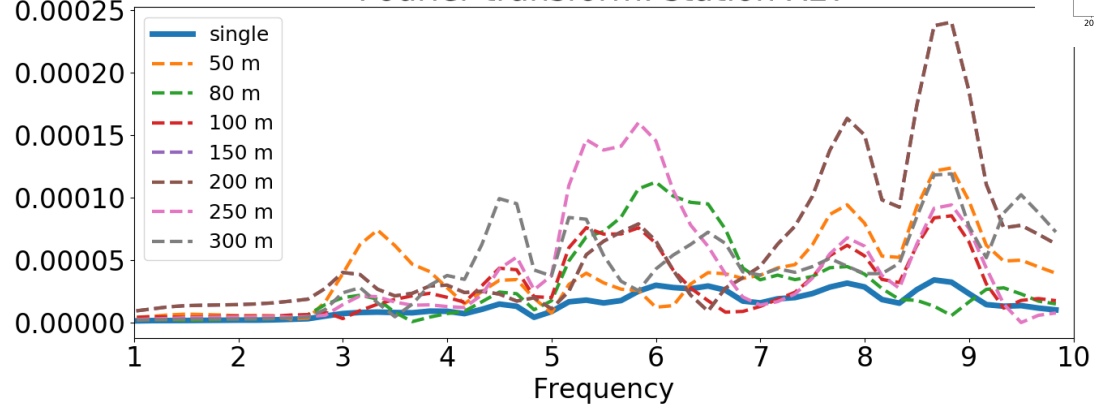
distance 1700 m

Fourier transform: station X23



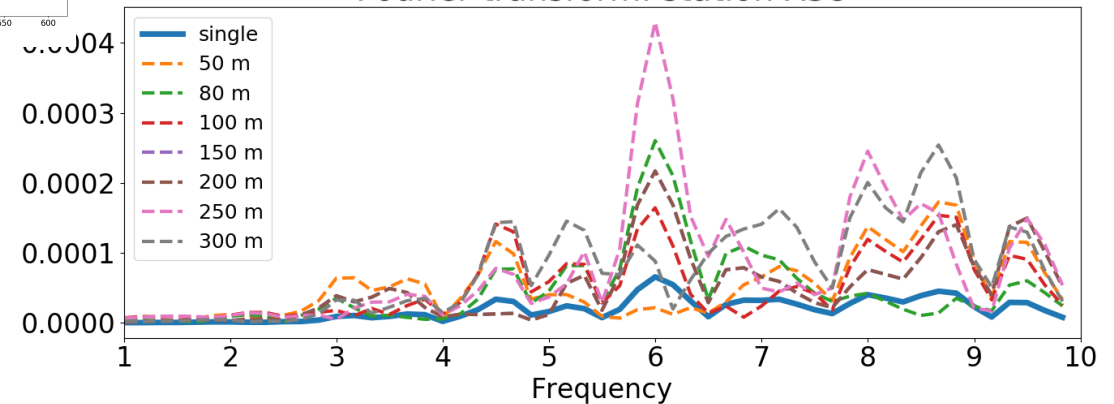
distance 3500 m

Fourier transform: station X27



distance 2500 m

Fourier transform: station X38



Influence of radial distance (shifted input signals)

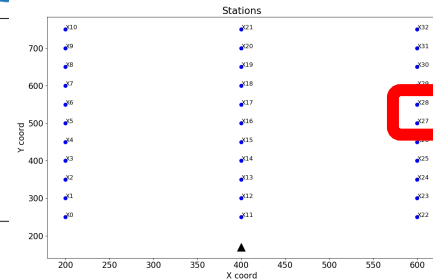
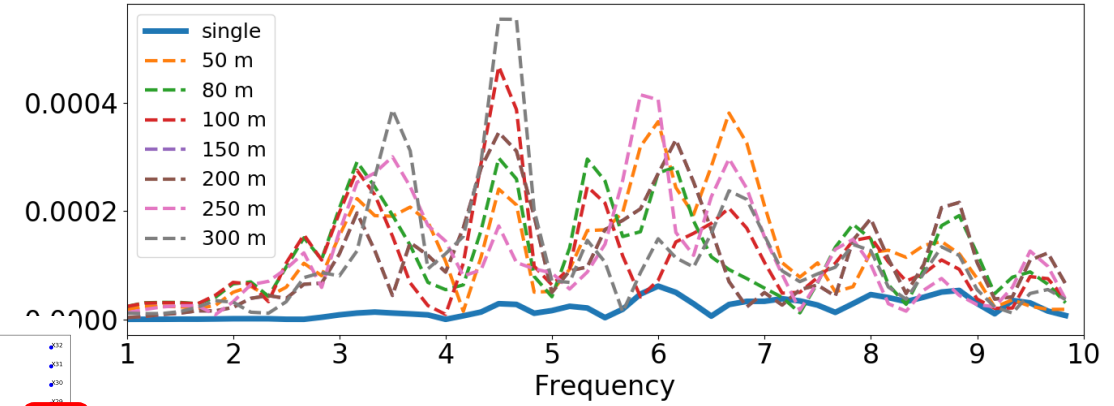
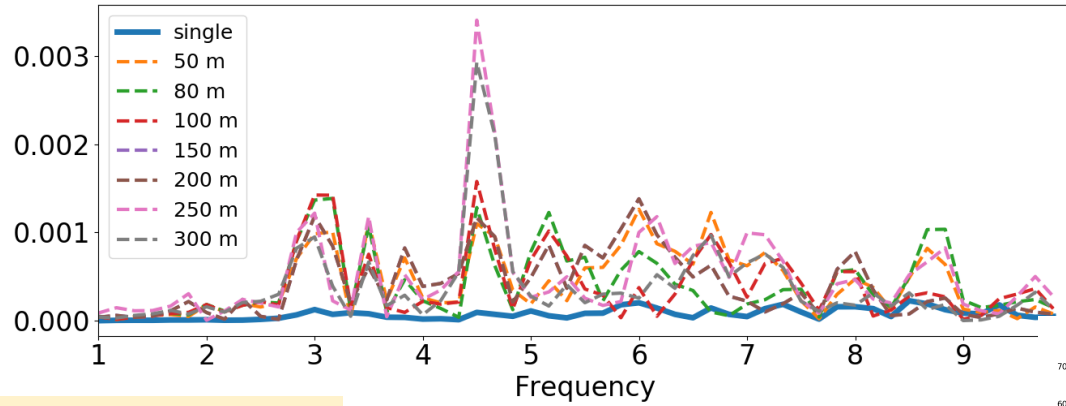
distance 200 m

No reduction of the energy at 6 Hz

distance 1700 m

Fourier transform: station X16

Fourier transform: station X23

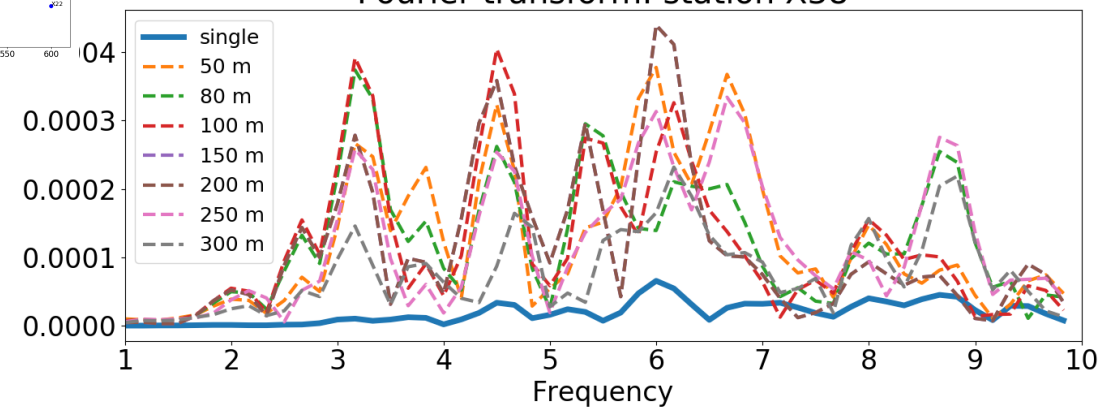
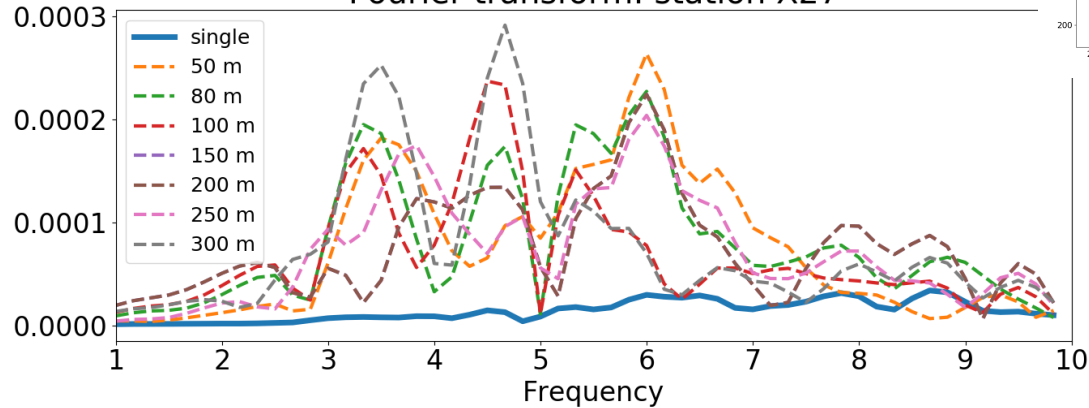


distance 3500 m

distance 2500 m

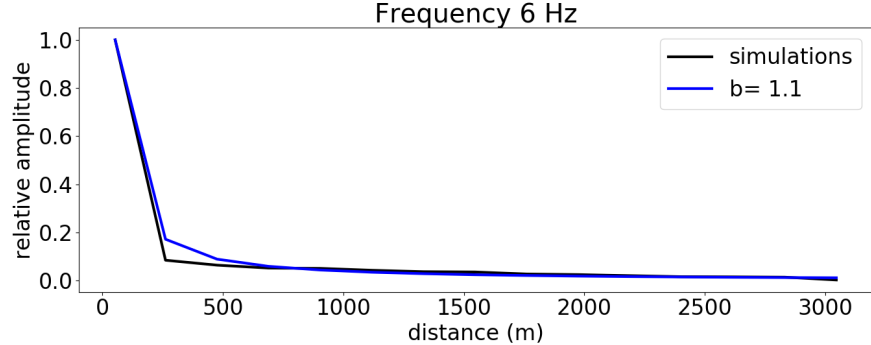
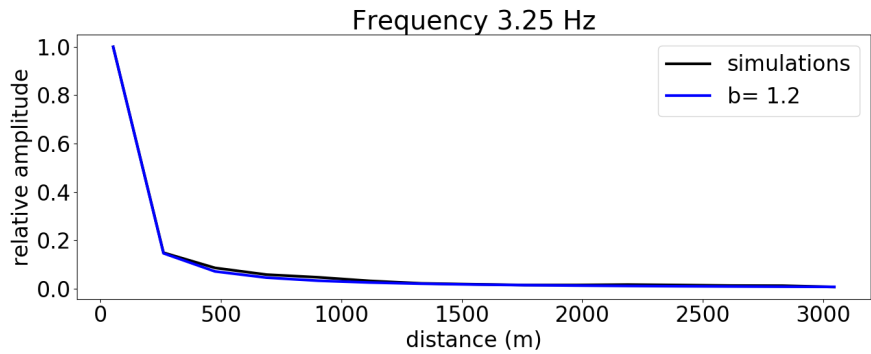
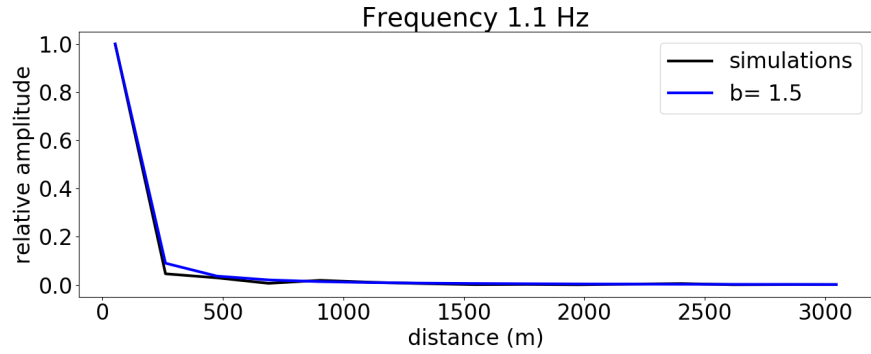
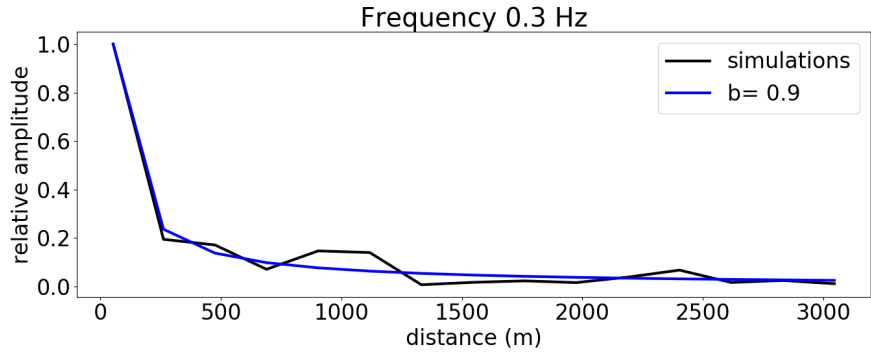
Fourier transform: station X27

Fourier transform: station X38



Attenuation due to geometrical spreading

Amplitude decay fit: r^{-b}



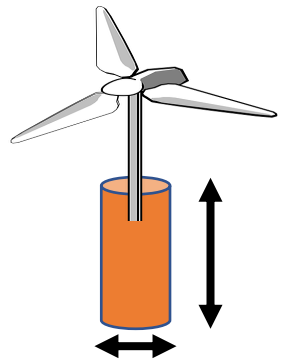
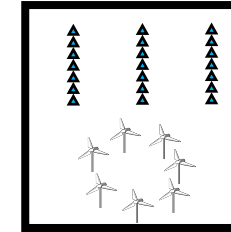
Local geology is a decisive factor for the attenuation of WT noise

Frequency peaks of 0.3-2 Hz do not propagate long distances

6Hz is in agreement with Neuffer et al 2020
6 Hz -- $b=0.86$

Concluding remarks

- ✓ Considering arrangements of circular WT seem to mitigate the energy radiated.
- ✓ Full 3D geometrical spreading reproduces the attenuation measurements observed. However, local geology plays a crucial factor in attenuation measurements.
- ✓ Circular holes located in front of the WTs seem to be enough to mitigate the seismic noise radiated



- Answer the question: how much depth and width matter?

Fill models with:

- Pumice, tuff (light) materials
- Any other possible cheap candidate (water)

Concluding remarks

- ✓ Is it enough to consider a source as an explosion? Another source with bending? What magnitude on each direction?
- ✓ Test putting the time series of the source in phase. What happens?
- ✓ Poroelastic simulation with SpecFEM not working! The problem in the meshing reading (it is not straightforward to solve!)

Error: interface poro-elastic index mismatch: iglob_po = 10595 iglob_el = 10531 Error interface index not matching

