

Urban Exploration and Monitoring Along Fibre Optics Infrastructure

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Urban Exploration along Fibre Optics Infrastructure

- ◆ Motivation

- Large-scale seismic surveys in densely populated areas are challenging to carry out due to the effort required to install the receivers: alternative to receivers is DAS (fibre optic cable)
- Carrying out active measurement in urban areas: passive seismic, ambient noise
- Measurements in Berlin-Adlershof
 - Pre-existing cable (dark fibre cable): Along Telecommunication Infrastructure (Adlergestell)
 - Installed fibre cable: During Construction of a Geothermal Well (BTB) in 2D

Measurements: Berlin-Adlershof

Adlergestell

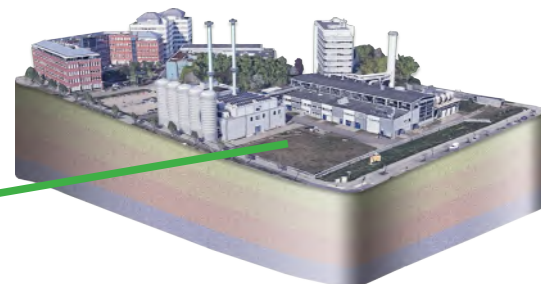
- Contractor 1&1 Company
- Telecom. dark fibre
- Timeperiod: April-March

duration	length	sampling
14 days	5km	2m
14 days	16km	8m



BTB powerplant

- 300m of fibre laid out in a heating tunnel
- 10 Geofones
- Start: November



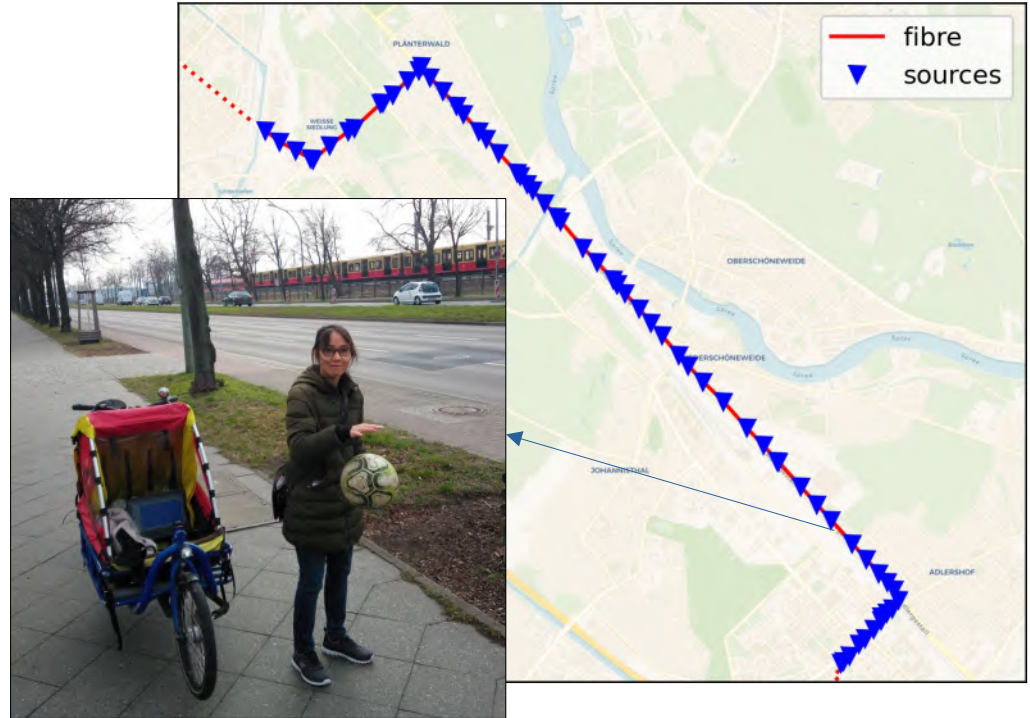
Combined heat and power plant of BTB in Adlershof, Berlin (Guido Blöcher, GFZ)

Measurements Along Telecommunication Infrastructure

Adlergestell, South-East Berlin

From Adlershof towards the City-Center

- 9 km of geo-referenced fibre
- 6 km of straight fibre along main street with cars and trains
- 3 km of which were probed for 4 weeks @ 8 m spacing
- Geo-referenced @ 64 locations



Measurements during the Construction of a Geothermal Well

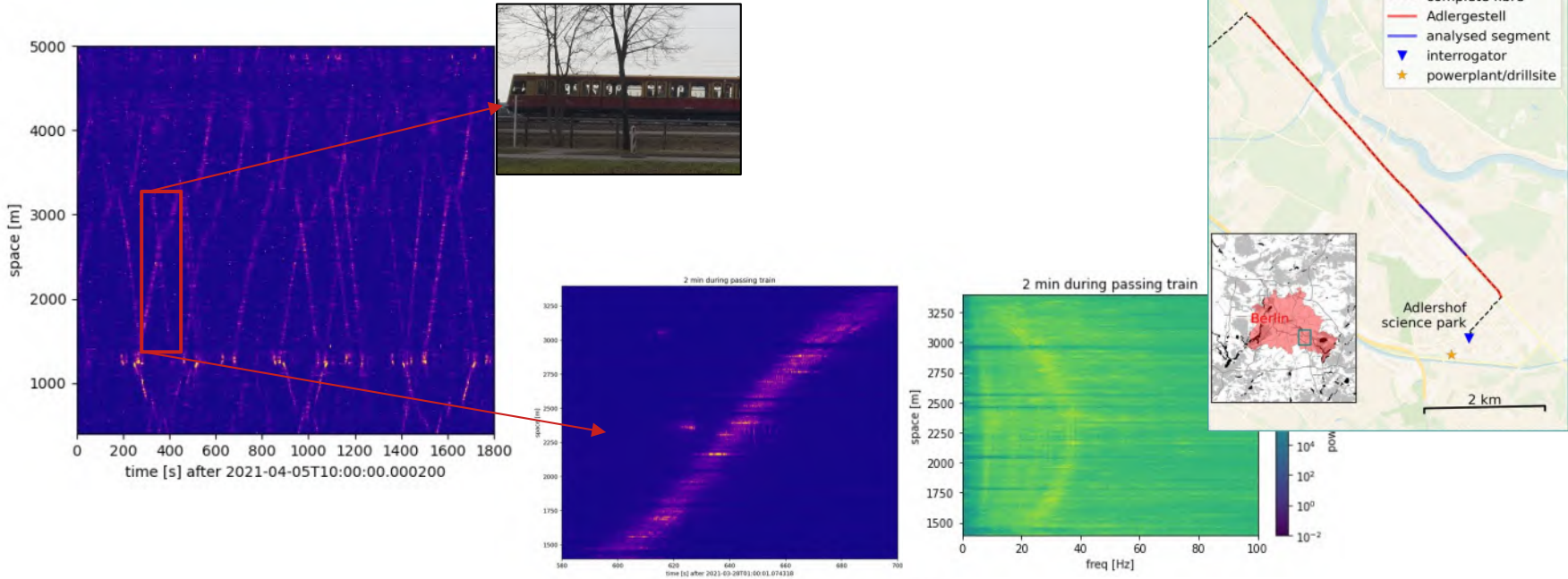
Horizontal fibre in heating tunnel (300m)

- 240m straight fibre are short
- Opportunity to learn
 - about the coupling,
 - noise sources (e.g. ducts),
 - Effects from local infrastructure



Measurements Along Telecommunication Infrastructure

Recorded strain-rate data



Measurements Along Telecommunication Infrastructure

workflow of ambient noise tomography

Future work:

- Validation of results against the lithology retrieved from a nearby scientific borehole
- Improve the frequency range of dispersion
- The detection of micro-earthquakes
- Planning new set of active and passive measurements in 2D for monitoring

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Subsurface investigation with ambient distributed acoustic sensing in an urban area

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1 Introduction

Distributed acoustic sensing (DAS) is a developing technology that uses fibre optic cables, which need to be distributed along an existing telecommunication infrastructure, to monitor ambient seismicity. This technology is an essential tool for monitoring geological structures based on recording seismic data at the surface. However, large-scale seismic surveys for subsurface imaging in urban areas are challenging due to the large amount of active components and complex modalities. Ambient noise tomography can be used to infer the seismic wave structure beneath the surface.

In this study we investigate the feasibility of applying seismic interferometry and Multi-Channel Analysis of Surface Waves (MASW) to ambient noise recordings acquired with DAS. The data was obtained along a 1 km long stretch of the night urban road Adligasse in Berlin-Germany for which we present a shear-wave velocity model.

2 Survey & Method

2.1 DAS data acquisition

The study site is located in the southeast of Berlin. Fig. 1 shows the 11 km long path of the fibre inter-connected with a commercial fibre-DAS unit and the 1 km long subsegment evaluated for this study. Recording work is an optical 1 km long temporal sampling was done between March 17th and April 18th, 2021.

2.2 Noise processing and correlation

All data was decomposed to the frequency of 250 Hz. We followed a standard workflow (Shapiro et al., 2007) including the removal of mean and linear trend, spectral leakage filtering (15-40 Hz), followed by temporal normalization and spectral whitening.

3 Preliminary results


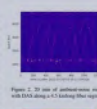
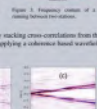
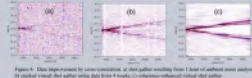
3.1 Ambient wavefield

Fig. 2 presents the average value of 21 days of raw ambient DAS recordings along 4.5 km of fiber which starts and ends are shown in figure 1. The seismic traces are visible at intervals. Their relative length is visible at intervals. The second dashed line indicates the location of the borehole (see Fig. 1) for comparison. The red asterisk indicates the location of the station. The averaged frequency content of the 21 days recorded data dispersion is a set of 4 km of one consecutive station and illustrates the wave speed during the journey.

3.2 Virtual source response

The concept of the effect of 1722 m was recorded as a virtual source. Cross-correlation was performed with 1 km long records for all channels along the 1 km of the analyzed segment, comprising 128 channels in total. The values generated by cross-correlation are zero by wave suppression by applying mean filter.

The Signal-to-Noise Ratio (SNR) was improved by stacking cross-correlations from the noise free working recording period as well as applying a coherence based wavefield observation (Schwarz et al., 2021) (Fig. 4).

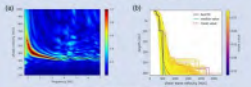
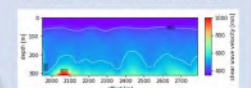





3.3 MASW workflow

The symmetry of the real and virtual branches of the virtual shot gather indicate a fairly uniform distribution of noise sources on each extension and value of the fibre. Normalization of both branches further increases the SNR. To suppress the near-field effects, the first two channels were removed.

The dispersion spectrum (Fig. 3) was calculated with the method of shear stacking of the ground-roll at the frequency domain (O'Dell et al., 2003). These downward mode of dispersion spectrum was picked for inversion.

The best fit results from the inverted dispersion curve (Wahrle 2009) with 3 layers showed the ground shear of shear wave velocity with depth (Fig. 5, Fig. 6).

4 Conclusions & Outlook

- The frequency content of DAS data reveals that the raw shear rate recorded by DAS has the potential for seismic tomographic effects.
- Stacking and coherence analysis significantly improves the SNR of virtual shot gathers especially for long offset channels.
- Dispersion of a dispersion curve extracted from ambient noise within the frequency band 0.7-1.70 Hz provides consistent shear wave velocity model.
- Analysis of consecutive fiber segments to obtain 2D velocity model.
- Validation of results against the lithology extracted from a nearby scientific borehole.

4 References

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