DAS applications for near-surface characterization and traffic conditions assessment

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Abstract

Using distributed acoustic sensing (DAS), previously deployed telecommunication optical fibres can be repurposed as permanent seismic sensors. The ability of this system to acquire data for large distances (>10 km) and with a dense sampling (<1 m) makes this technology very attractive for near-surface monitoring and characterization. We show two applications that illustrate the potential of DAS data for these purposes. First, by using interferometric principles, we compute virtual source gathers from the ambient noise recorded by the fibre. This process allowed us to reconstruct the surface-wave propagation that would have been recorded between two different points along the fibre simulating an active source experiment. Then, dispersion spectra were computed from the data showing the ability of the DAS data to provide the necessary input for near-surface characterization methods like MASW (multichannel analysis of surface waves). A second application of DAS is explored using data acquired along the Ctrain tracks in the City of Calgary. From the raw data, it is possible to identify the signature of different sources propagating with different apparent velocities. Here, we compute the velocities of these signals by using a series of windowed τ-p transformations. Assuming that most of these signals are generated by vehicles driving along the roads next to the Ctrain tracks, this information can be used for monitoring traffic condition in terms of the velocity of the vehicles recorded at any time of the day. We also compute spatial average velocities, vehicle density and estimated travel times that can be used to interpret changes in traffic conditions throughout the day in a given section of the road.

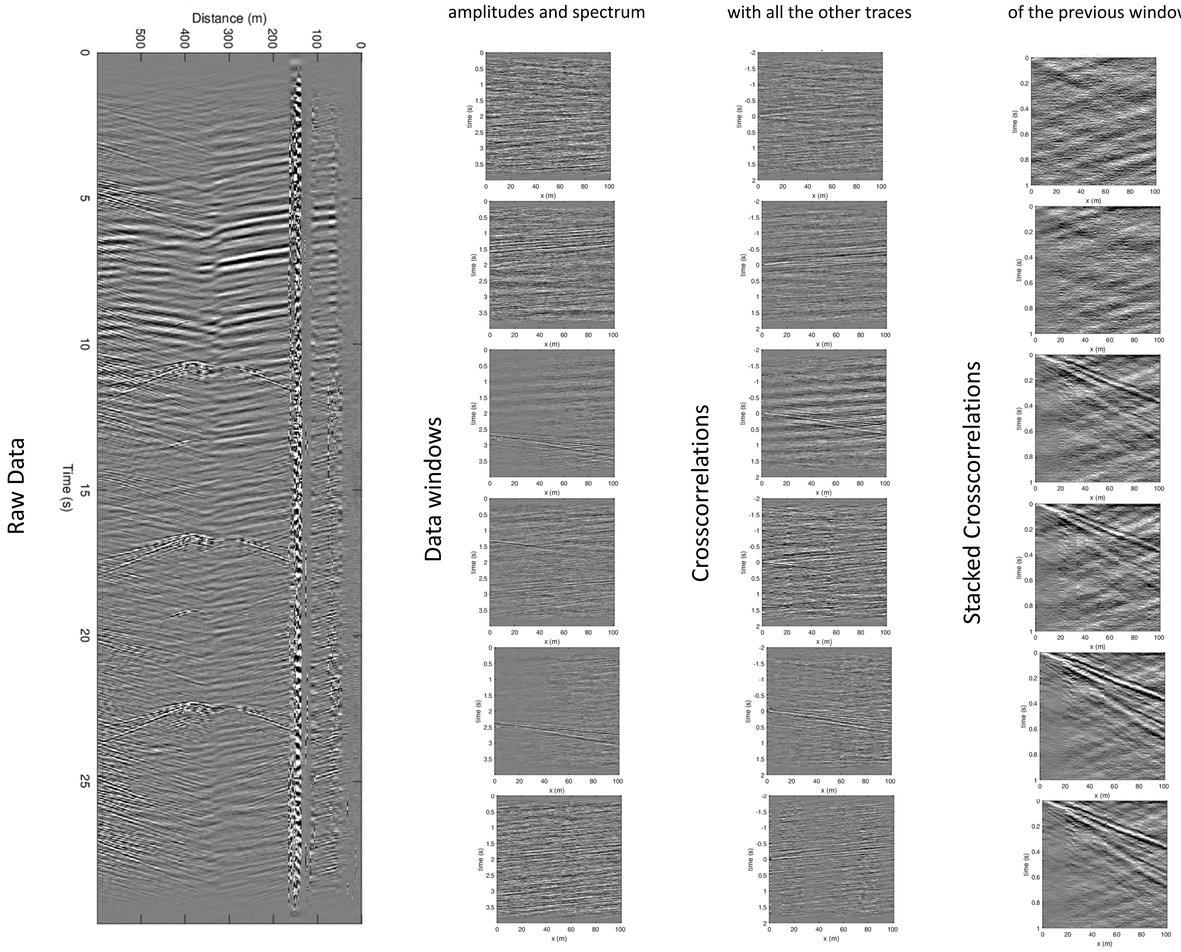
Interferometric computation of surface-wave dispersion spectrum

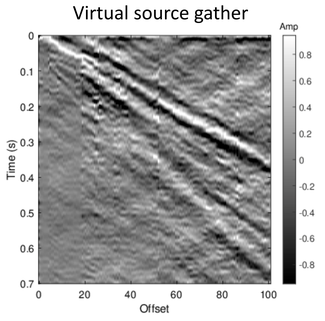
Data was acquired using a buried segment of fibre next to a road. Surface waves are exited by person dropping a rock next to the fibre.

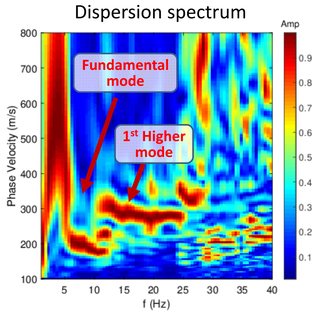
1. Data is split in windows of 4 s by 100 m. Decon and AGC are applied to balance amplitudes and spectrum

2. The first trace of the window is crosscorrelated with all the other traces

3. Crosscorrelations are stacked with the output of the previous window





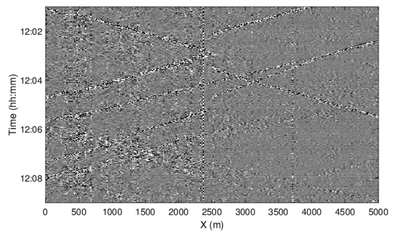


Remarks

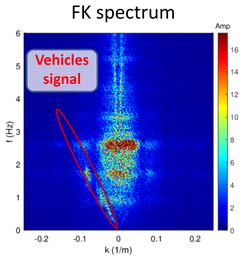
- A dispersion spectrum was computed from DAS data acquired with a very inexpensive source effort.
- Dispersion curves can be picked on the spectrum and used for computing S-wave velocity models.
- Time lapse measurements of changes in Vs can be used to monitor the condition of the near-surface sediments.
- An early warning system for hazardous conditions can be developed based on this principles.

Traffic flow monitoring

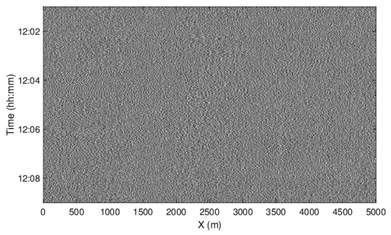
Raw DAS data along Ctrain tracks



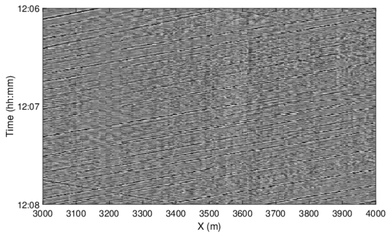
FK spectrum



Filtered DAS data along Ctrain tracks
(FK filter + AGC 5 s)

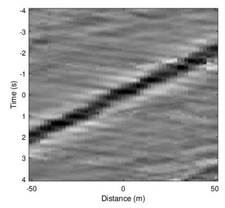


Zoom
(2 min by 1 km)

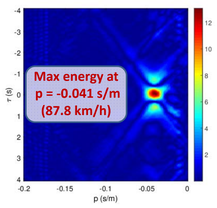


Moving vehicles appear as linear events

Data window
(8 s by 100 m)

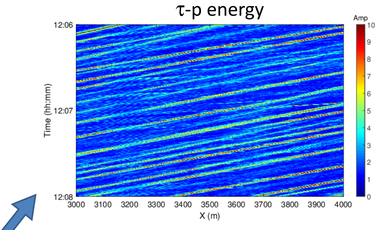


τ-p transform

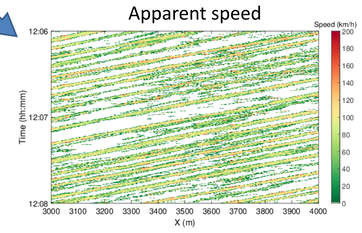


The apparent velocity of the events is computed by performing a series of tau-p transformations over small windows.

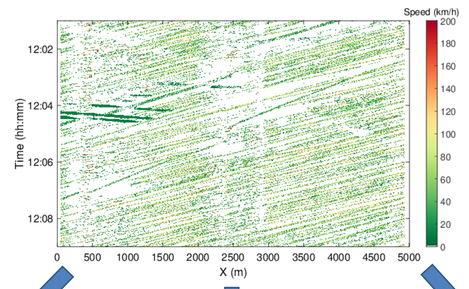
τ-p energy



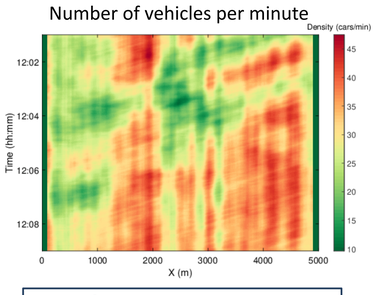
Apparent speed



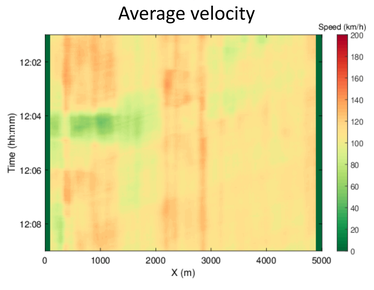
Apparent speed
(All data)



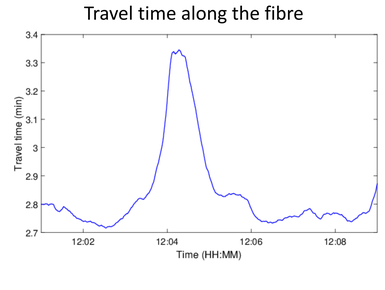
Number of vehicles per minute



Average velocity



Travel time along the fibre



Remarks

- Intelligent transportation systems require accurate traffic flow data to improve safety, efficiency, and sustainability of transportation networks. Optical fibres provides access to very large (>10 km) and dense (< 1 m) continuous acoustic measurements that might help with these goals.
- From an existing communication optical fibre we extracted three basic parameters to understand traffic flows: vehicles density, average velocity, and travel time. Calibration with other sources of data is needed to validate these results.
- We only used 10 minutes of data over a 5 km segment of fibre buried along the Ctrain tracks. Extension of this analysis to larger datasets spanning several hours or days remains to be explored.

Acknowledgements

The authors thank the sponsors of CREWES for continued support and the Pacific Institute for the Mathematical Sciences (PIMS) for organizing the Industrial Problem Solving Workshop 2018. We are also grateful to Fotech Solutions for access to the DAS data. This work was funded by CREWES industrial sponsors, CFREF (Canada First Research Excellence Fund) and NSERC (Natural Science and Engineering Research Council of Canada) through the grant CRDPJ 461179-13. Da Li thanks the China Scholarship Council (CSC) for supporting this research.