Looking under and above the surface using DAS

Results from the PIMS Industrial Problem Solving Workshop 2018

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Department of Geoscience
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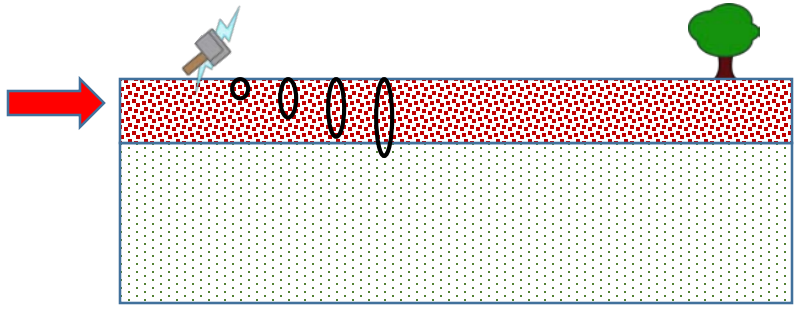
Introduction

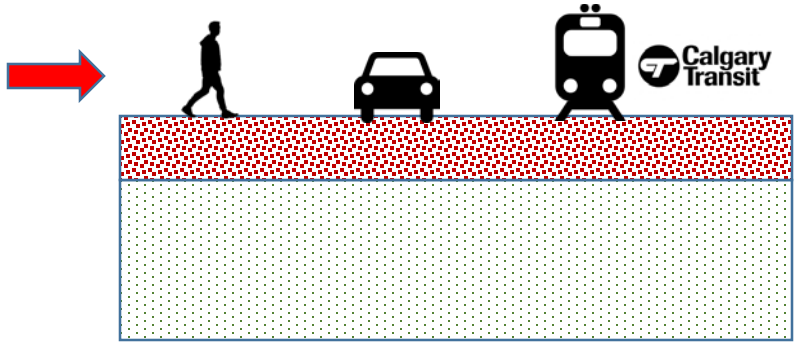
Under the surface:

- Surface-wave dispersion
- Traveltime interferometry
- Computing dispersion curves using DAS

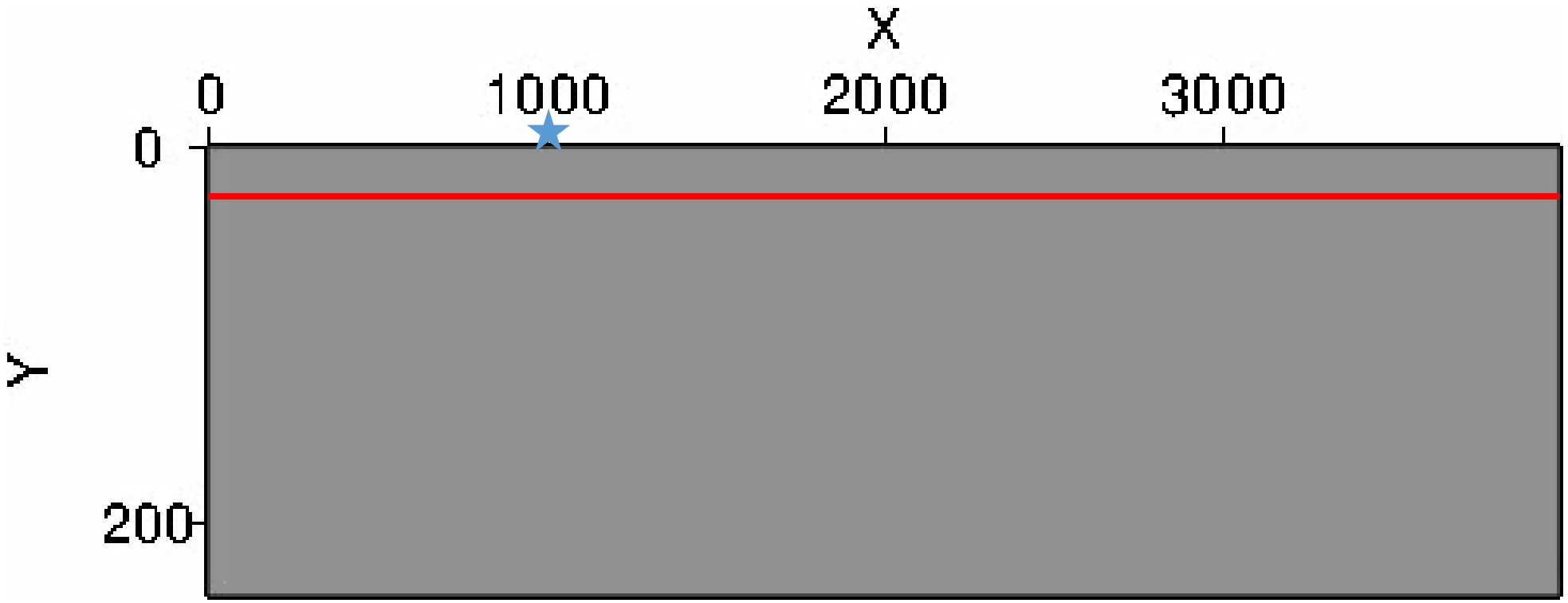


Above the surface:

- Traffic signals recorded with DAS
- Attributes extraction for traffic monitoring



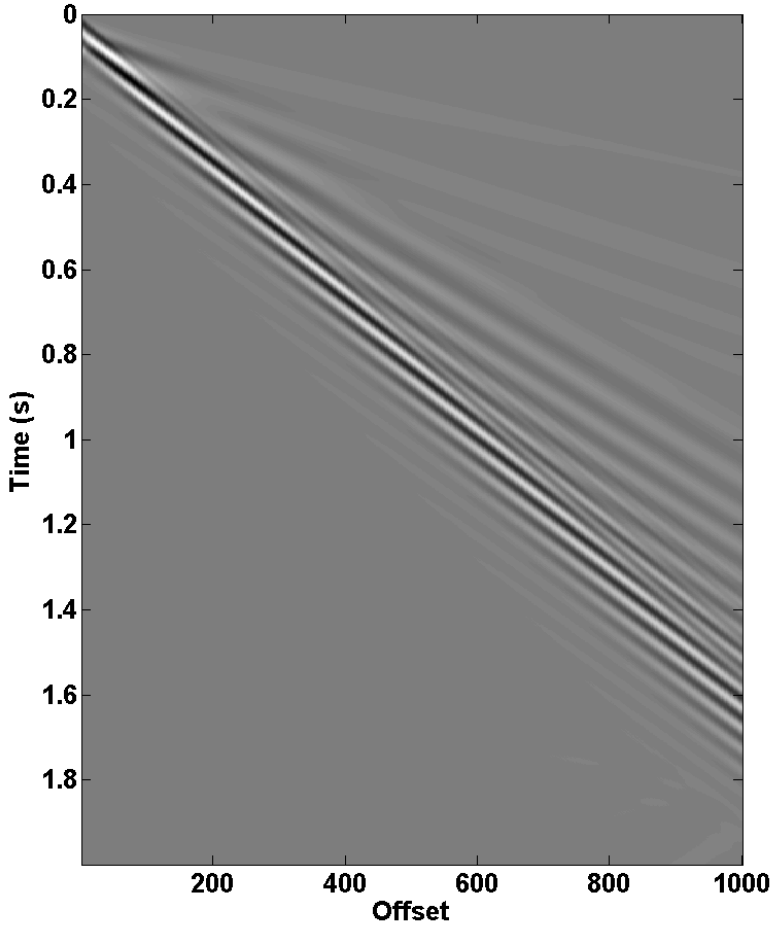
Surface-wave propagation



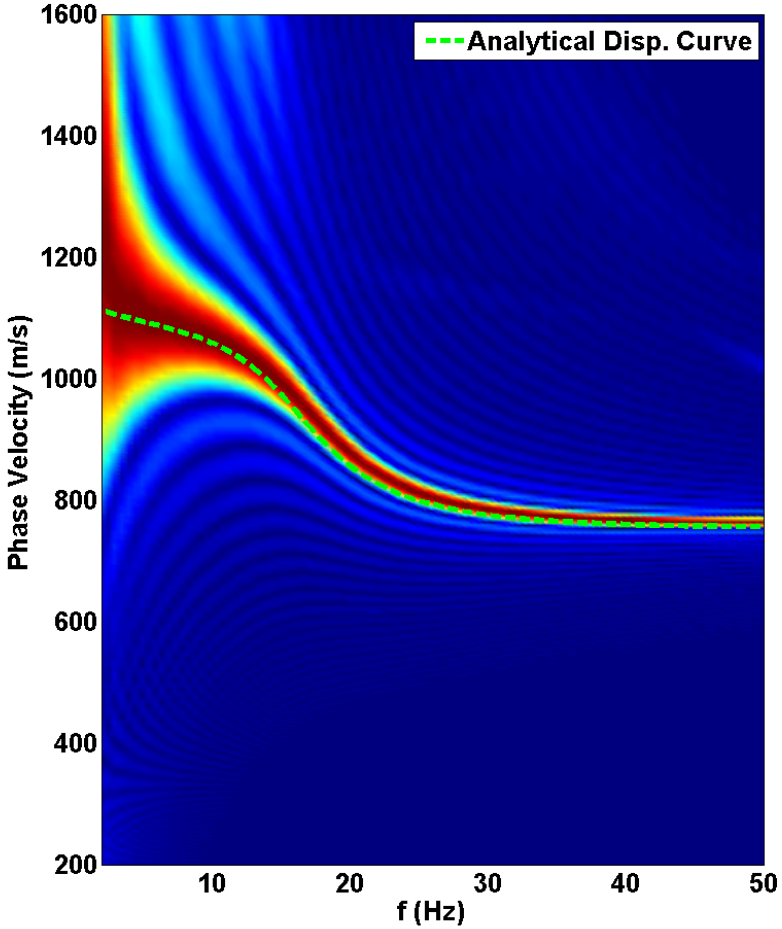
Surface waves are very energetic and they are confined in the near-surface (<100 m depth).
They are very useful for studying the conditions of the sediments (consolidation, fluids saturation, etc)

Dispersive character of surface waves

Shot gather

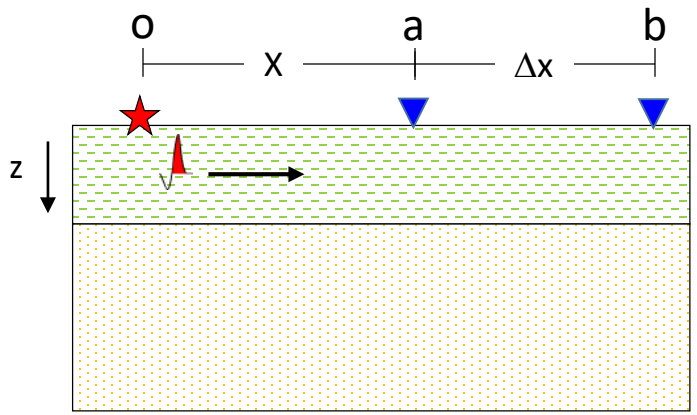


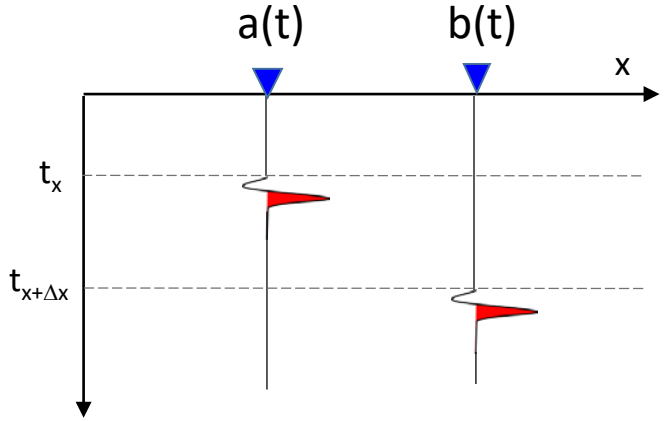
Dispersion spectrum



The dispersion spectrum shows at what velocity is traveling each frequency.
Each frequency is related to a different wavelength and penetration depth in the near-surface

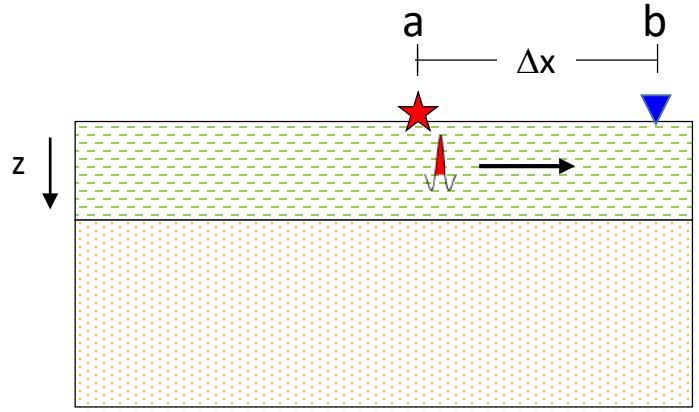
Traveltime interferometry

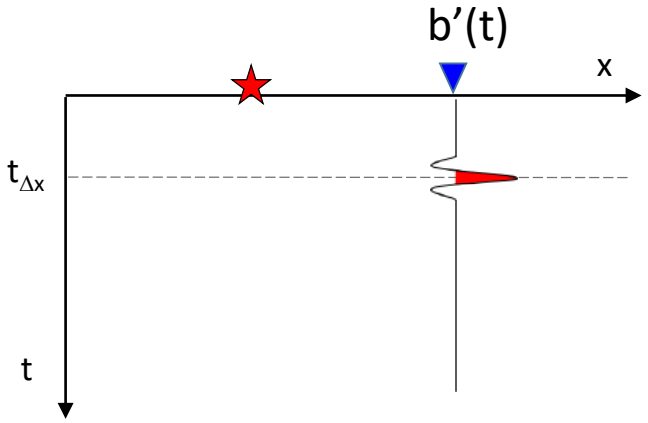




$$a(t) \otimes b(t) = F^{-1}\{2\pi A(\omega)B(\omega)^*\}$$

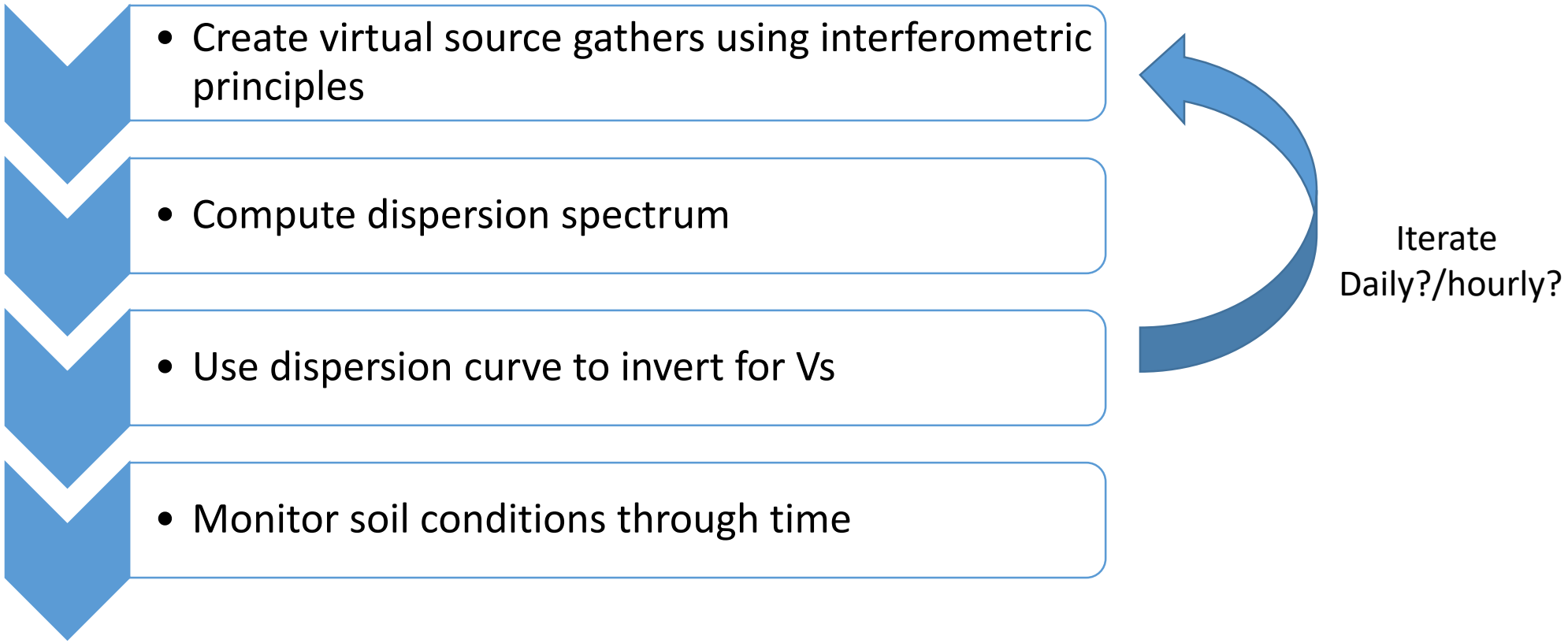
$$A(\omega)B^*(\omega) = e^{i\omega t_x} * e^{-i\omega(t_x+t_{\Delta x})} = e^{i\omega t_{\Delta x}}$$



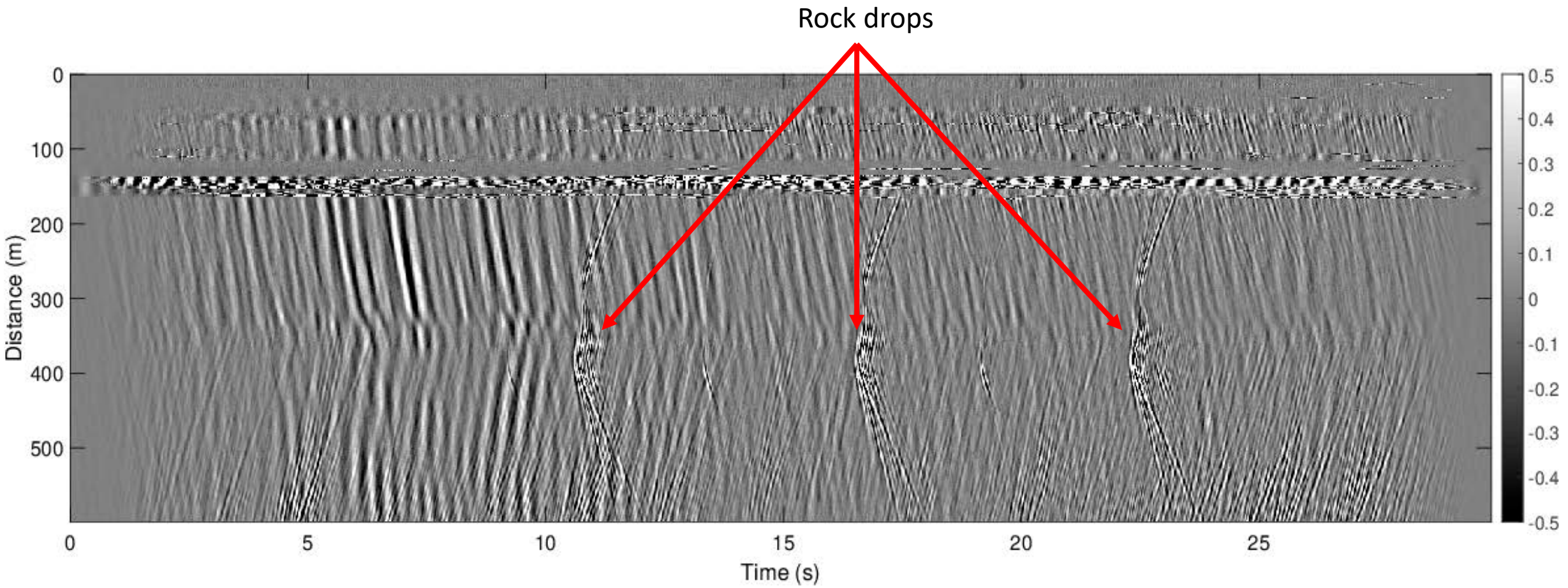


$$b'(t) = F^{-1}\{e^{i\omega t_{\Delta x}}\} = \delta(t - t_{\Delta x})$$

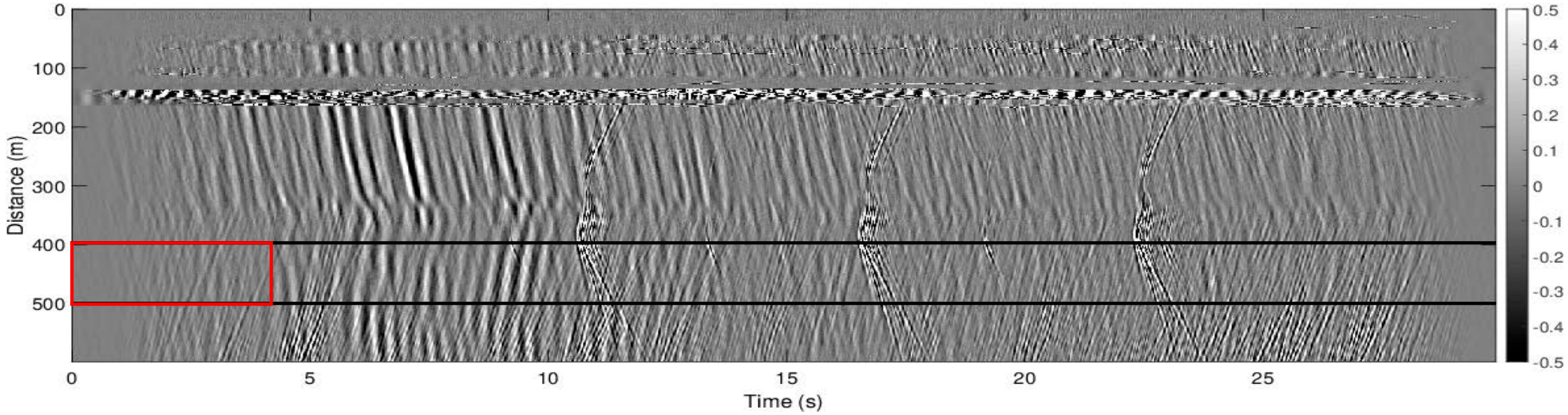
Near-surface characterization using DAS data

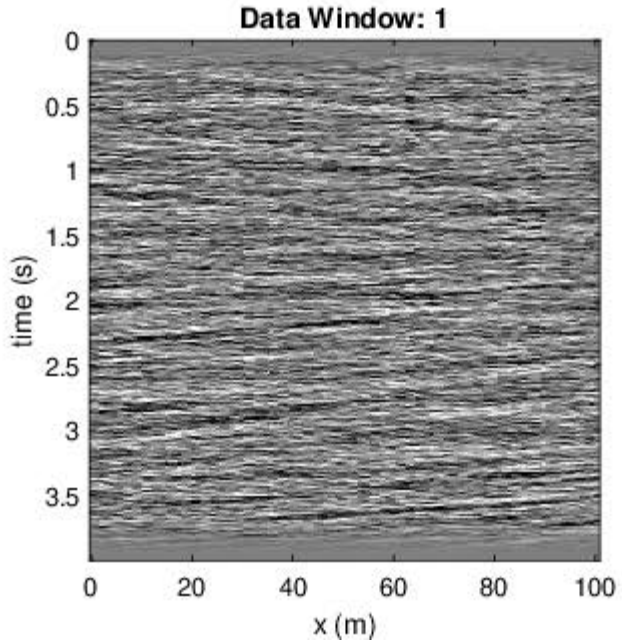


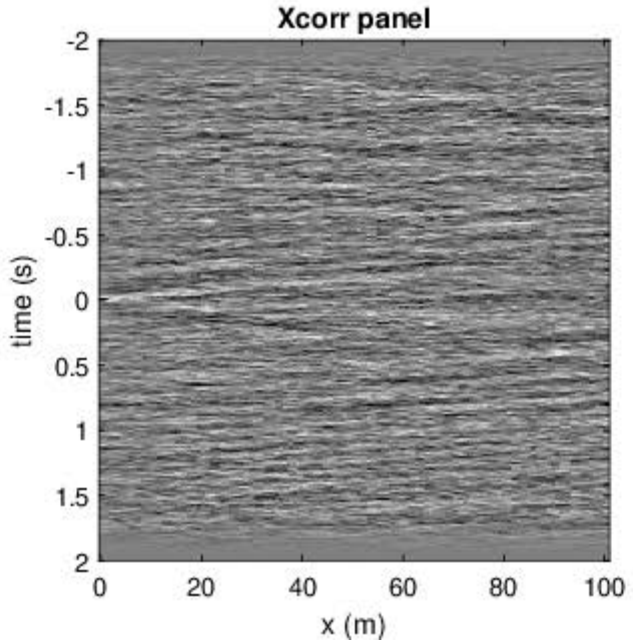
DAS data

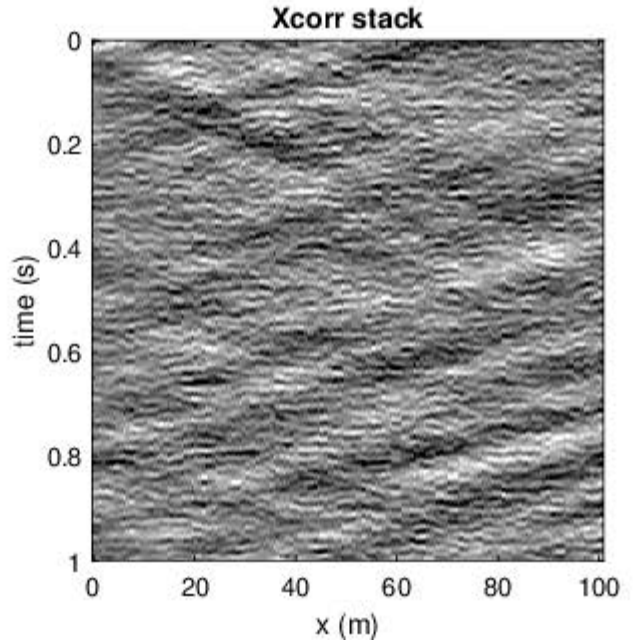

Rock drops
Distance (m)
0
100
200
300
400
500
Time (s)
0
5
10
15
20
25
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5

Virtual Source Gather









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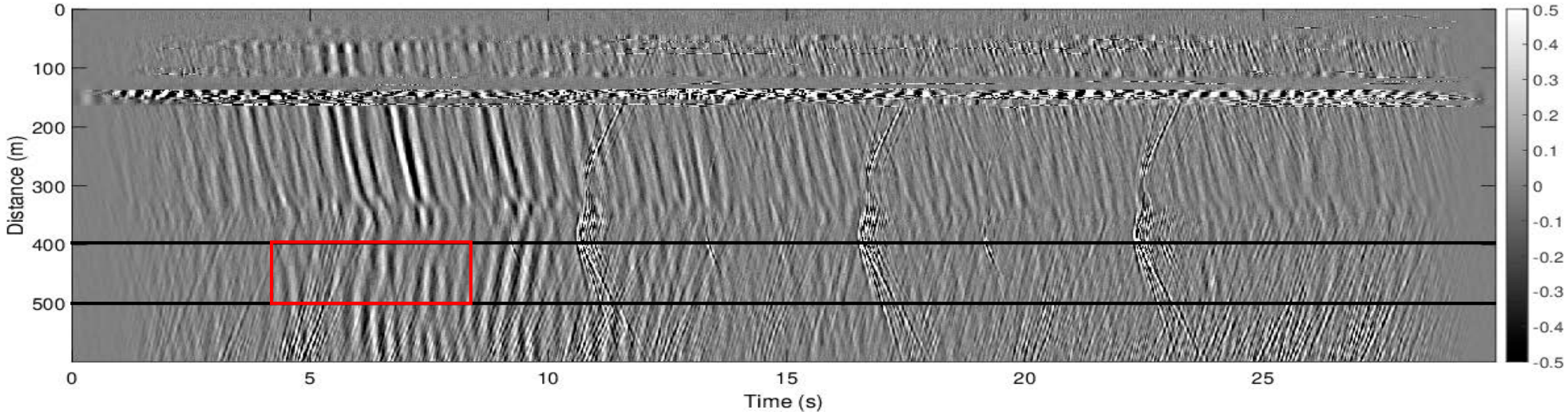

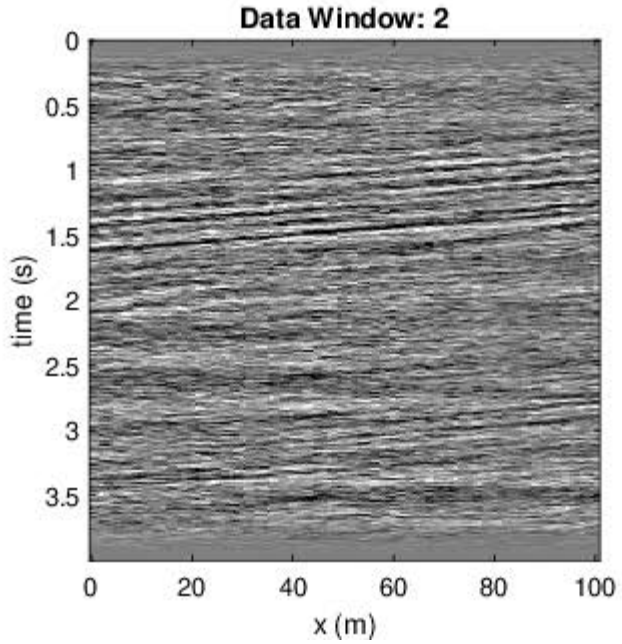

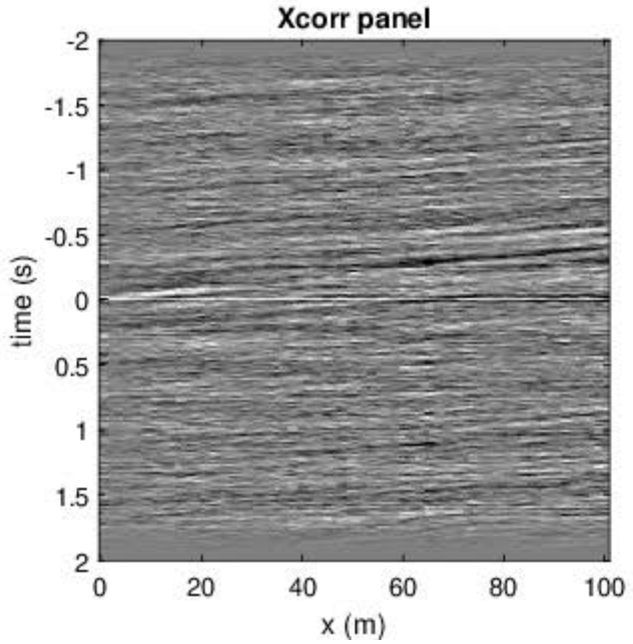

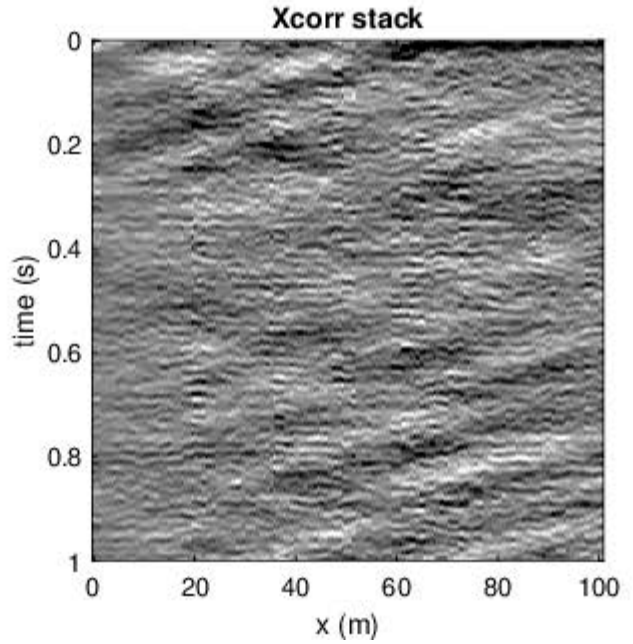

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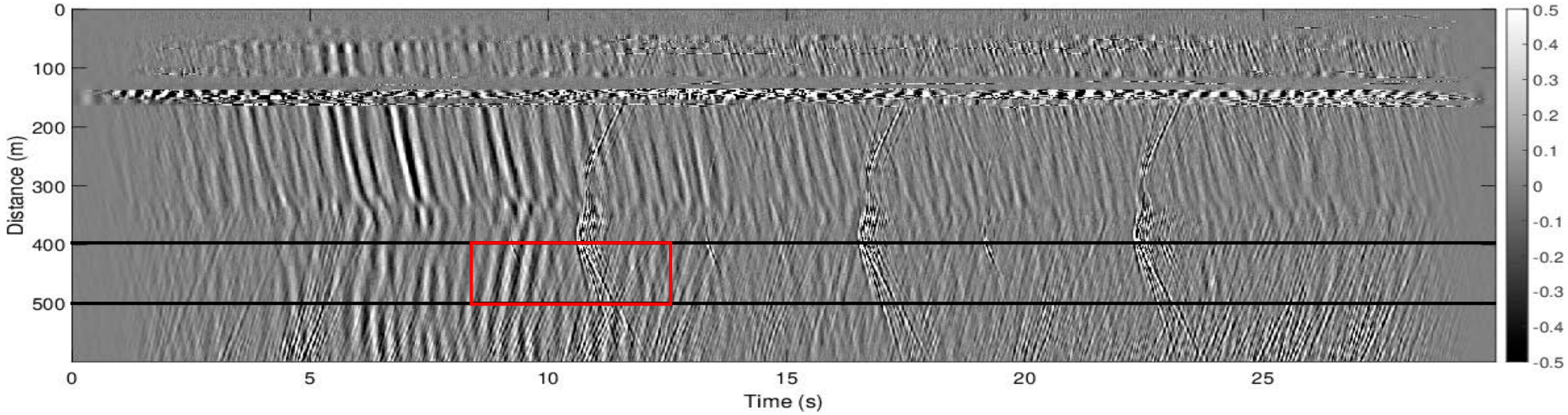
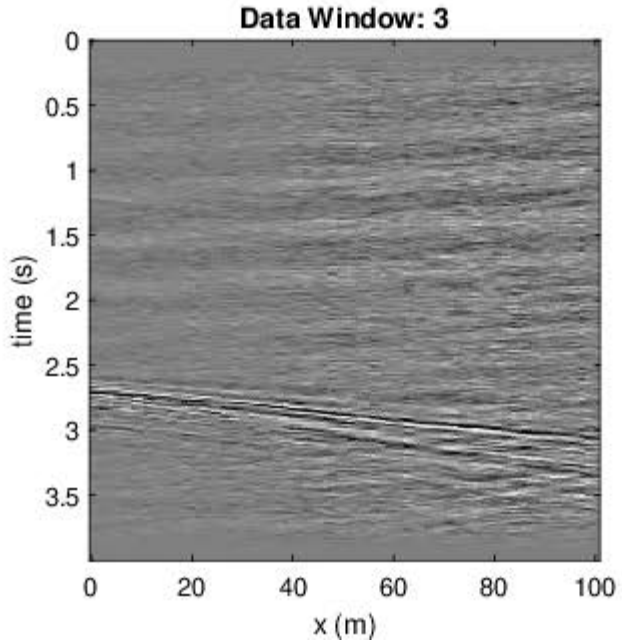
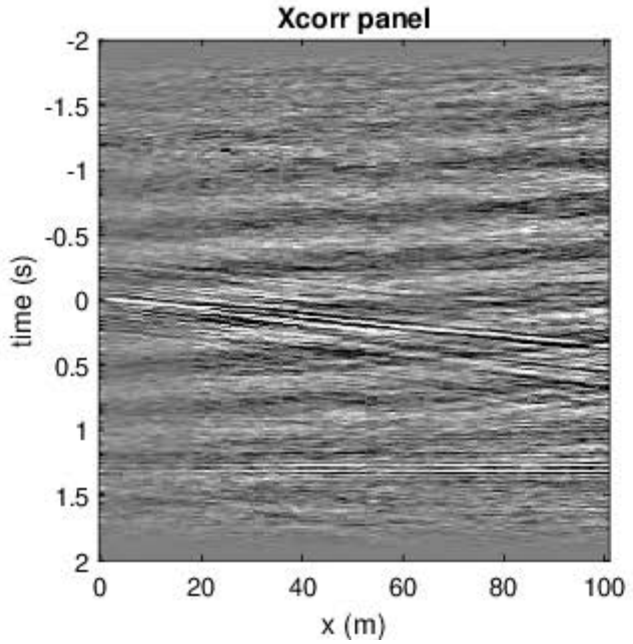
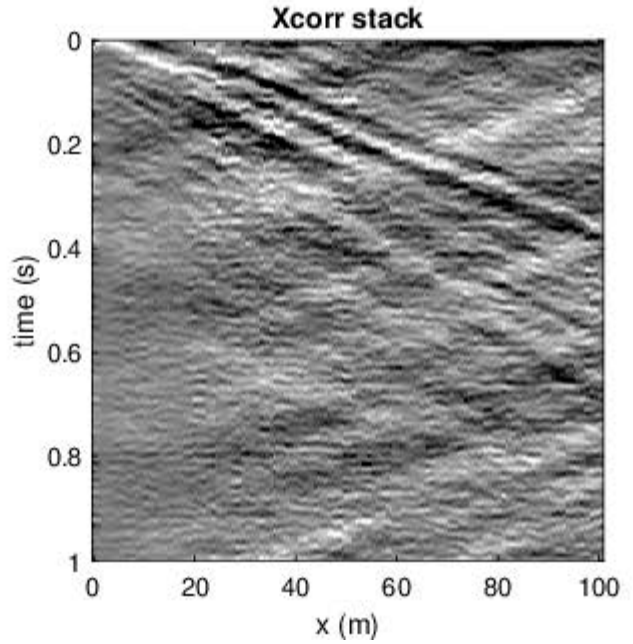
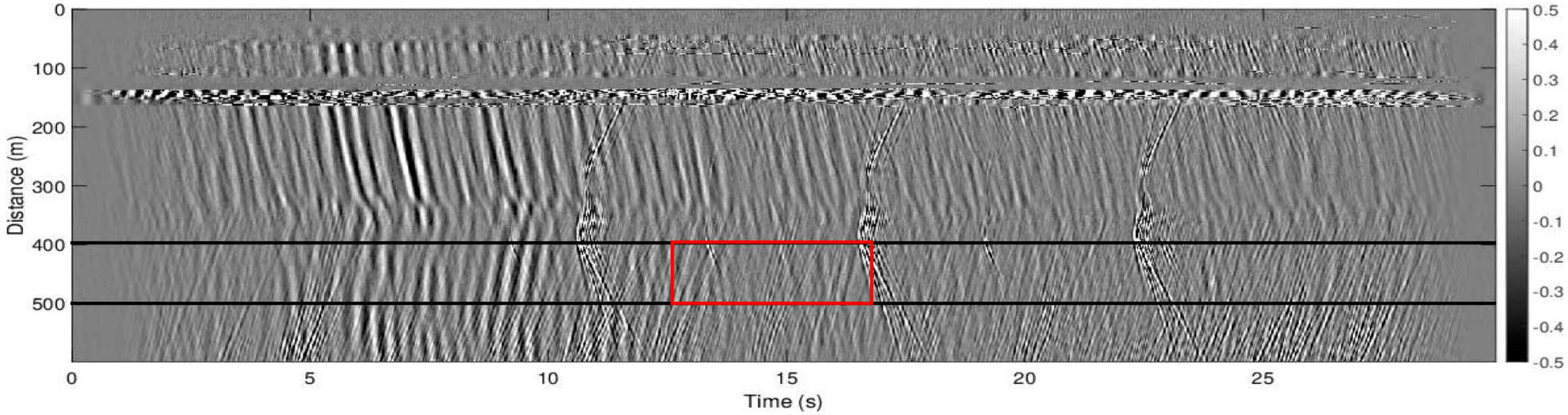


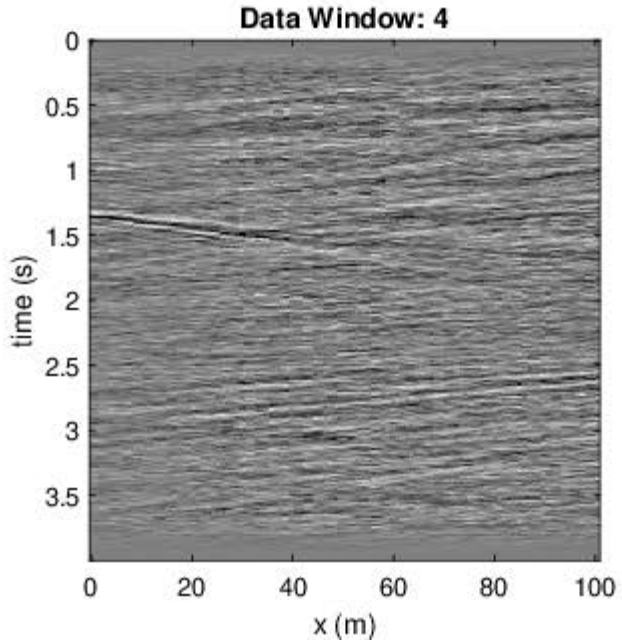


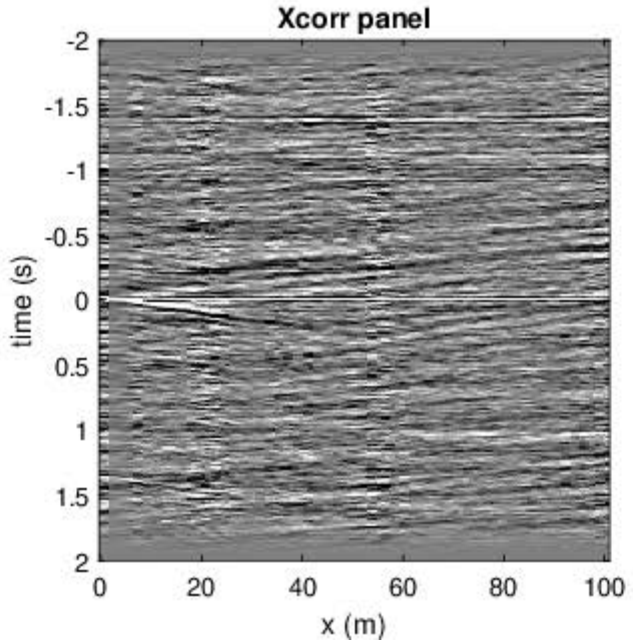


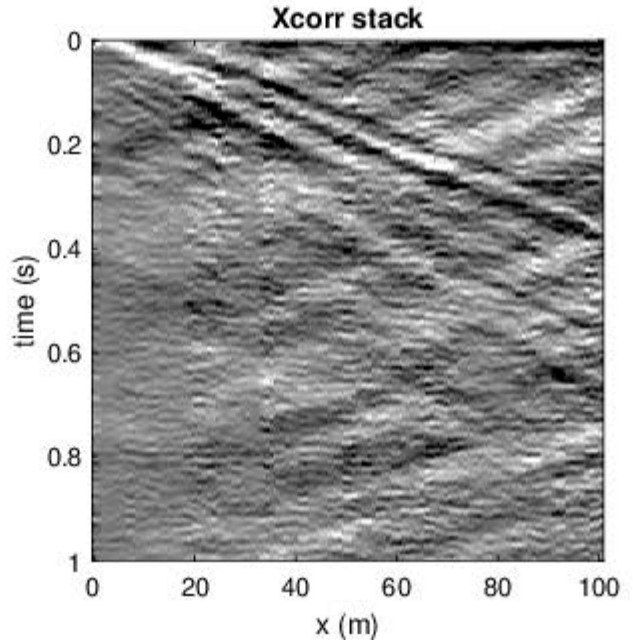


Virtual Source Gather

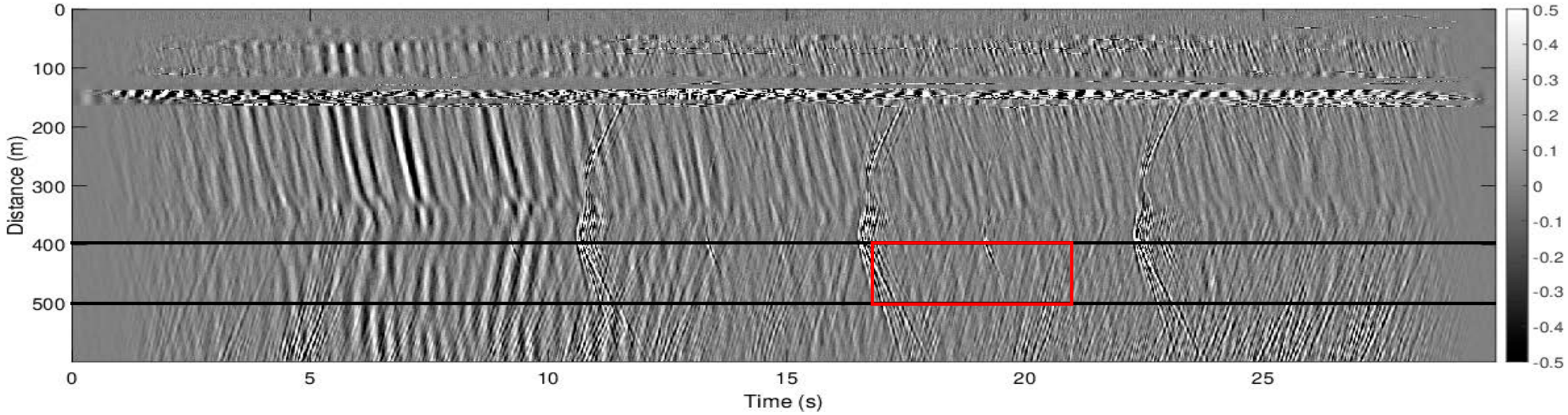


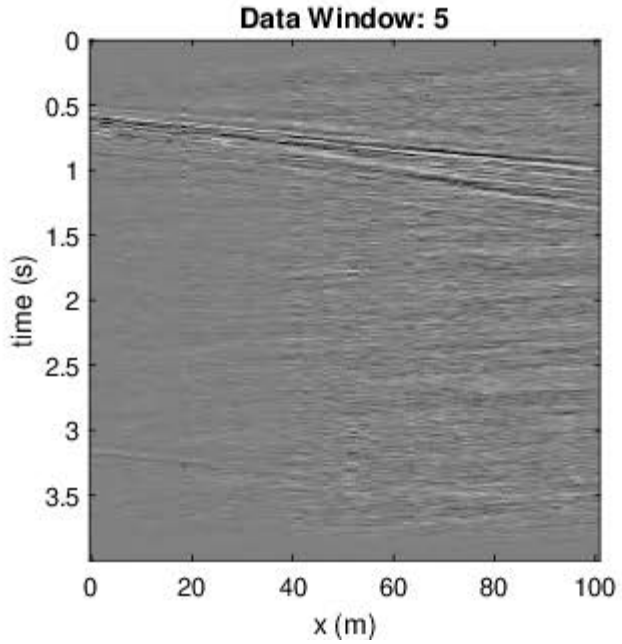


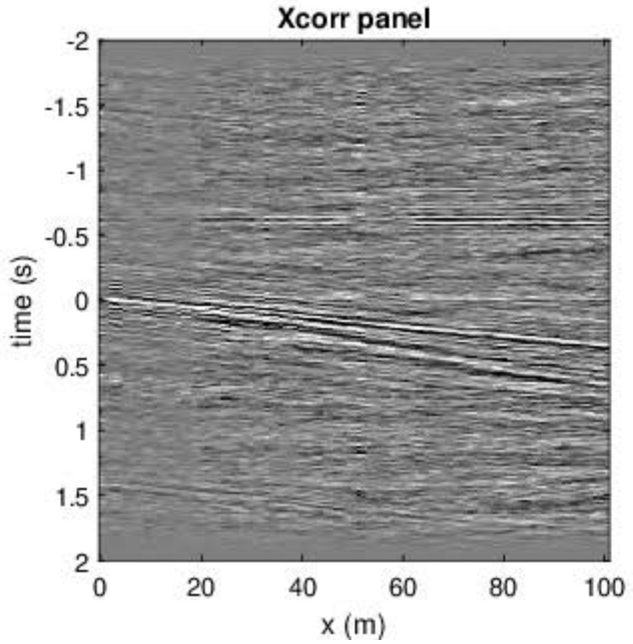


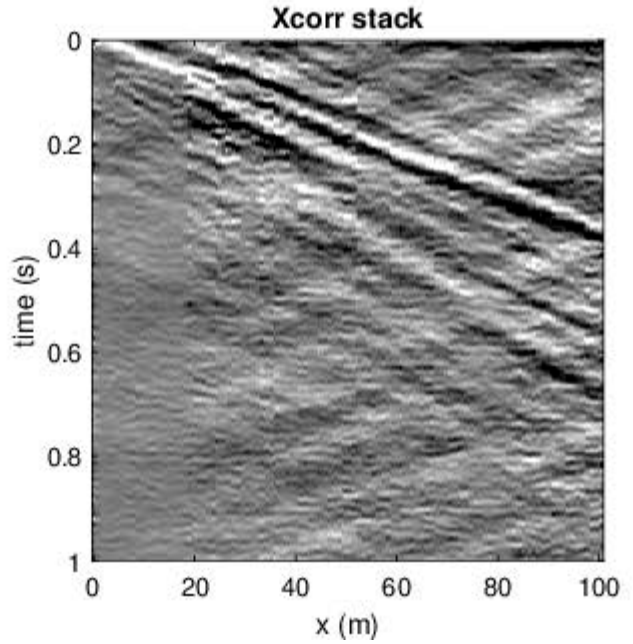


Virtual Source Gather









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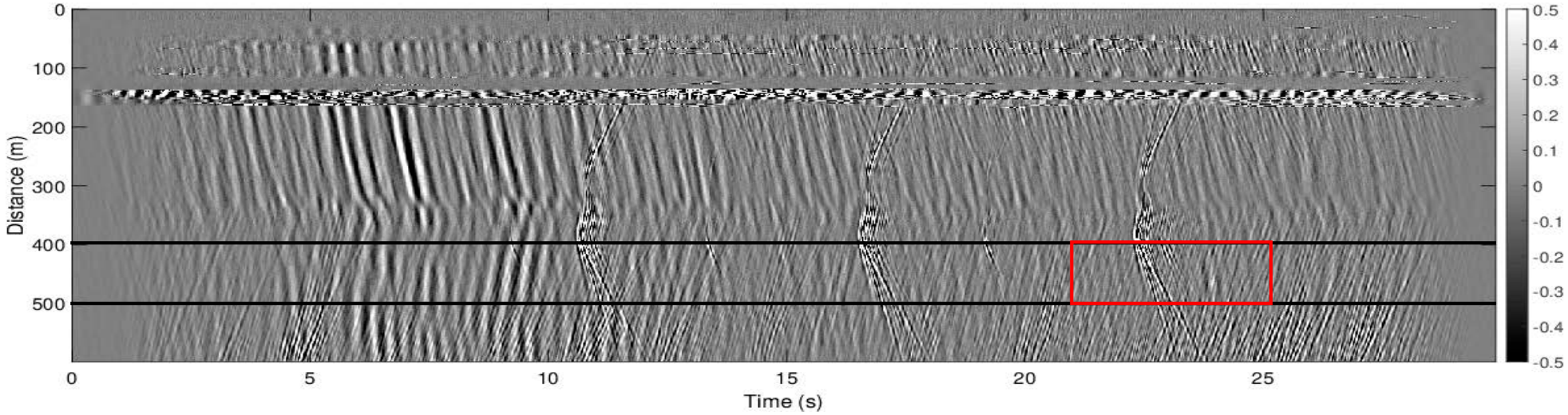

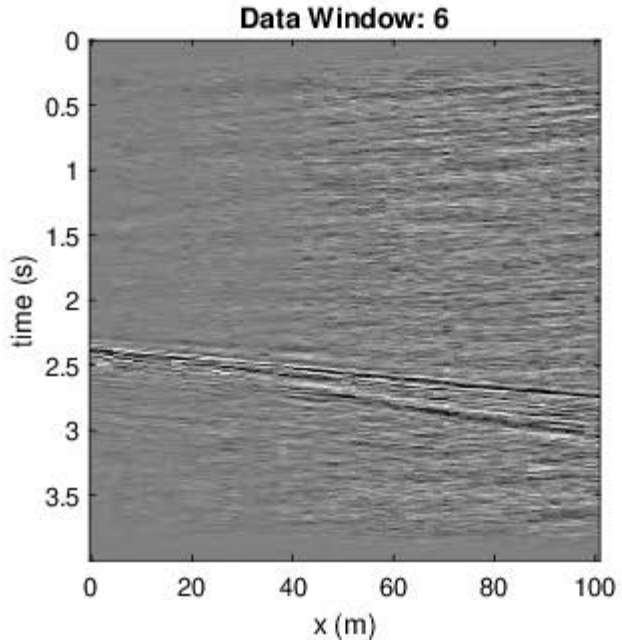

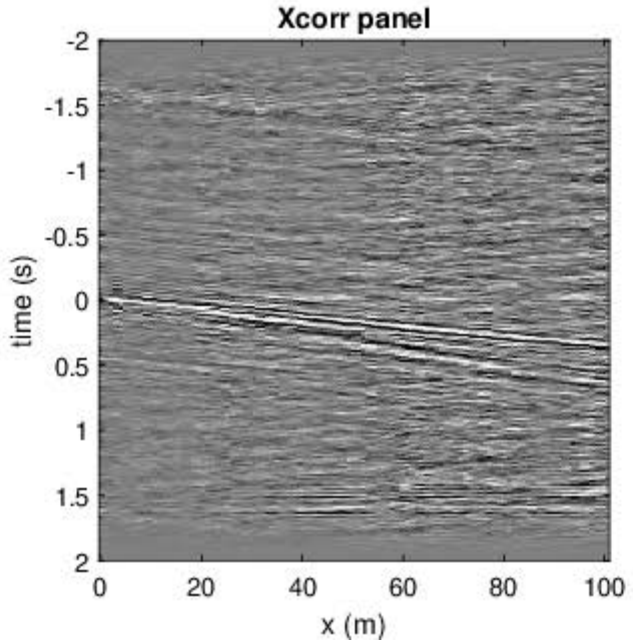

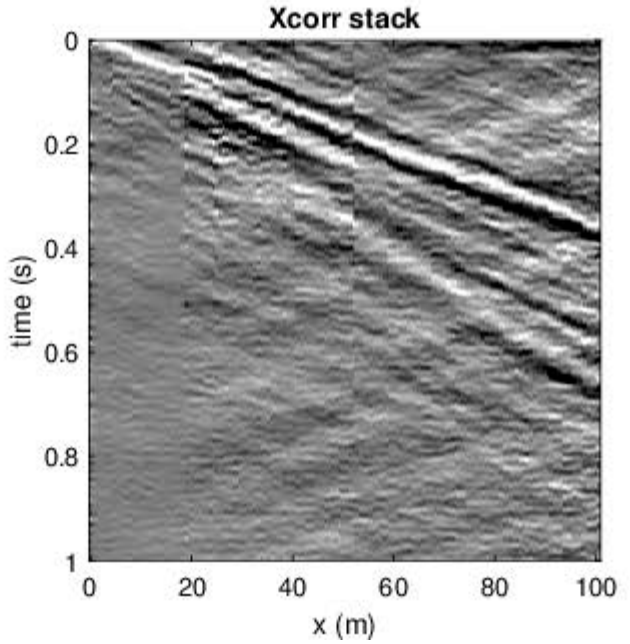

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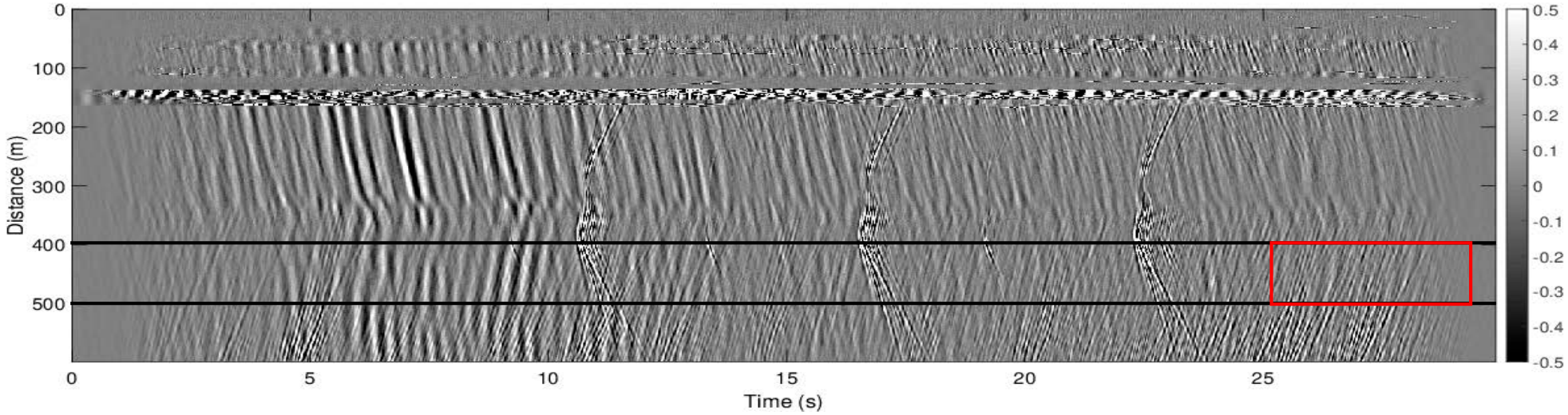
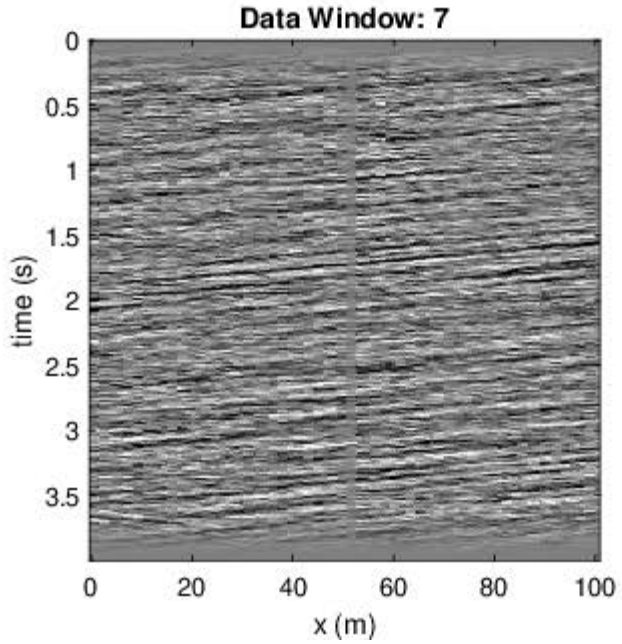
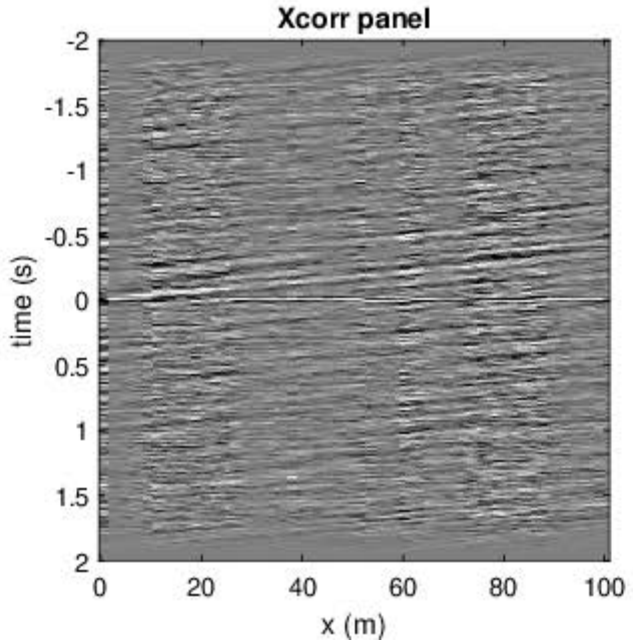
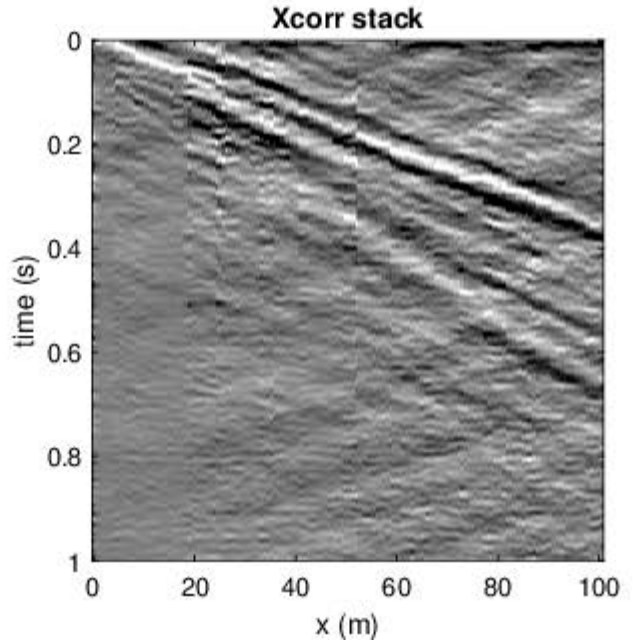


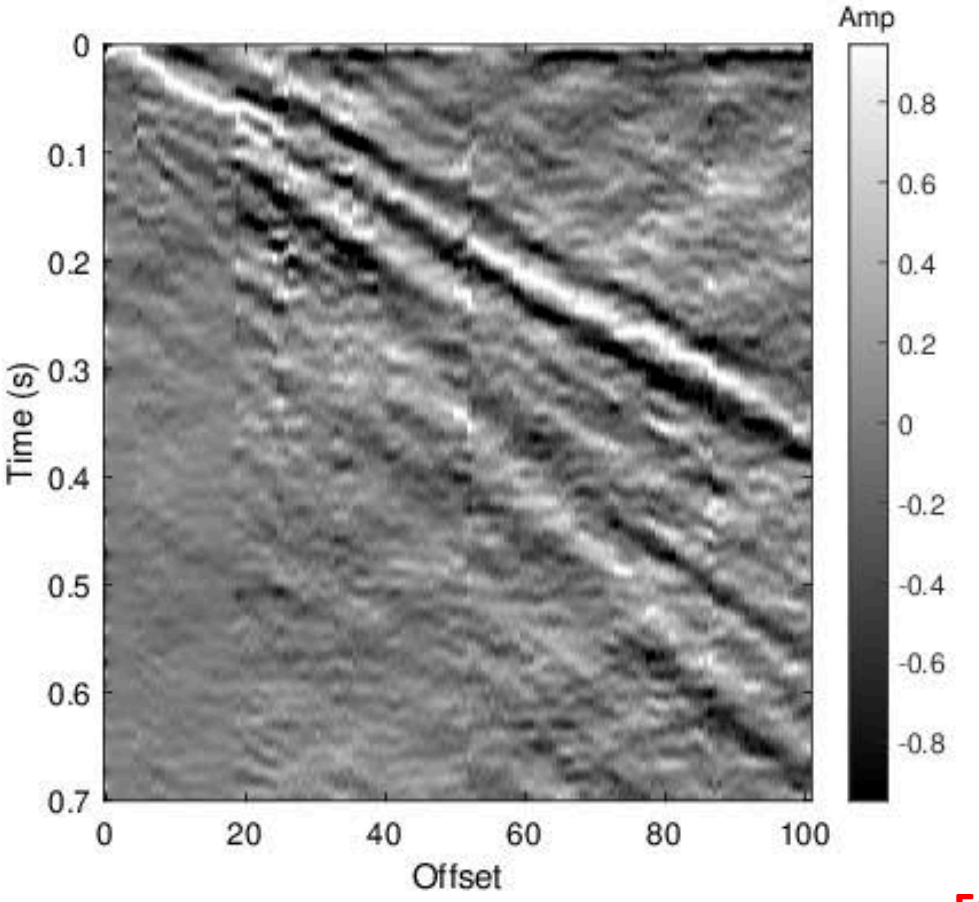




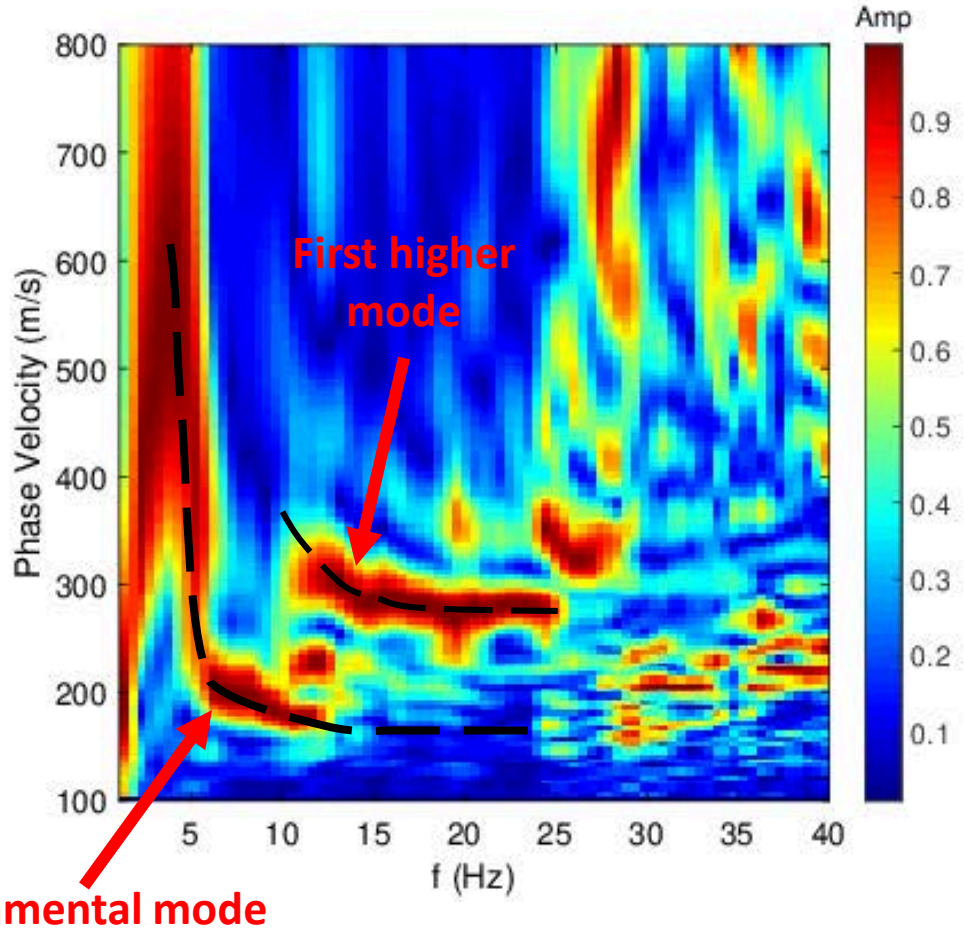


Virtual Source Gather

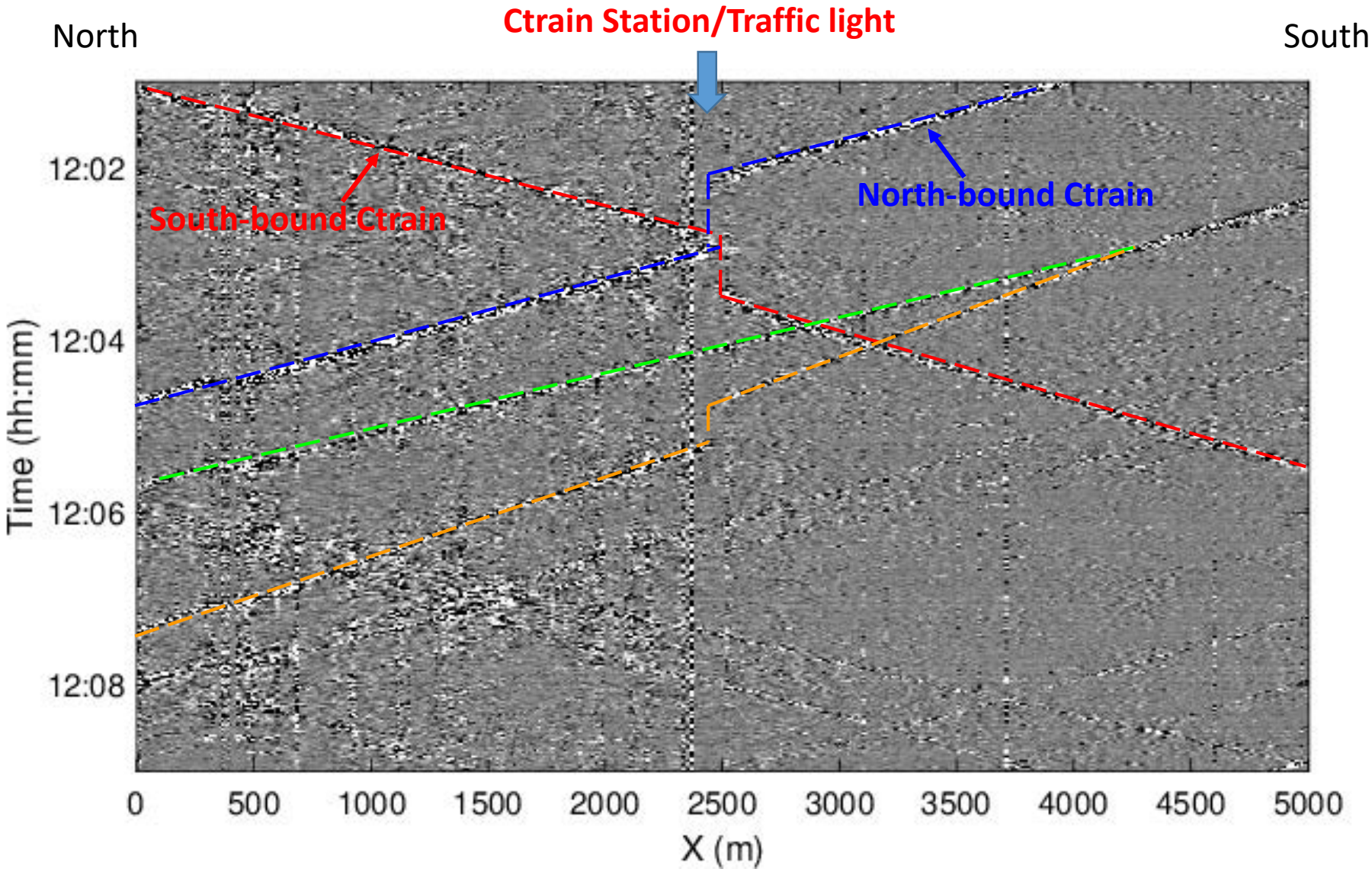
Virtual source gather



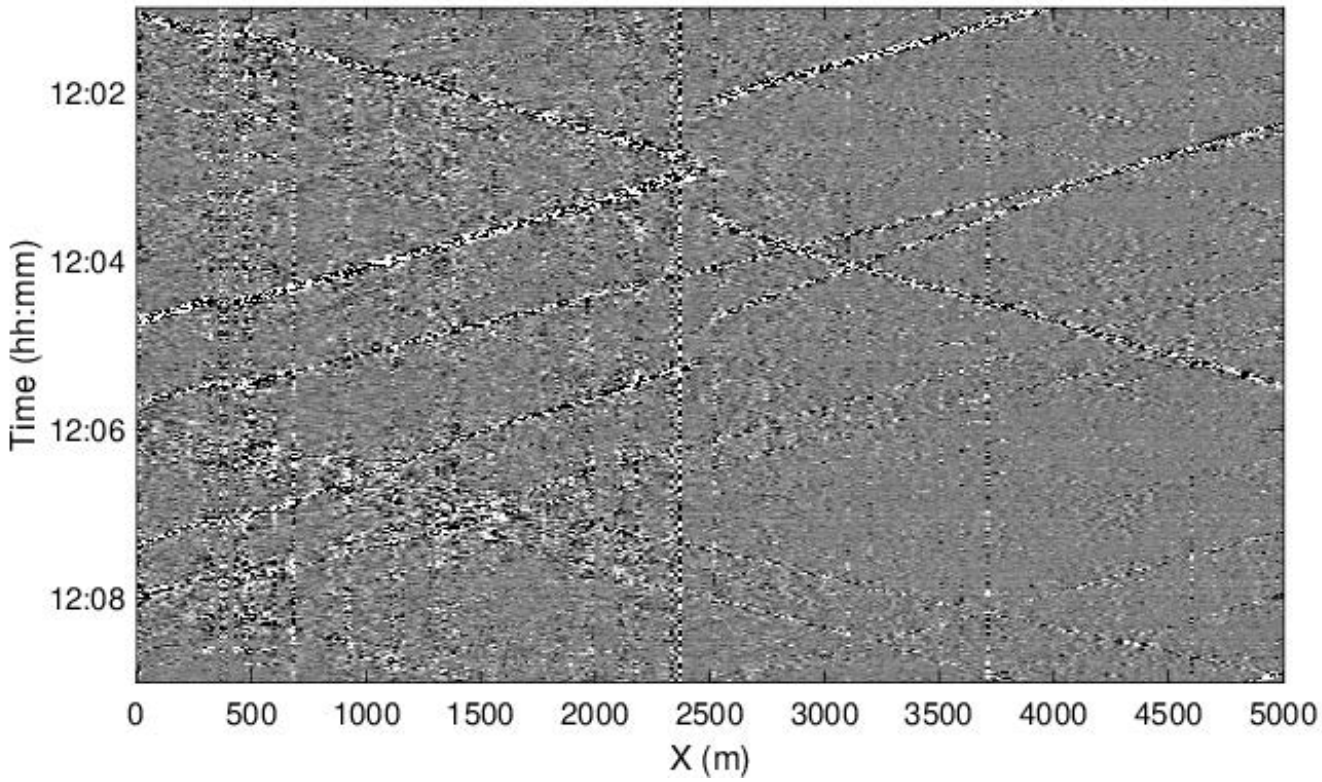
Dispersion Spectrum

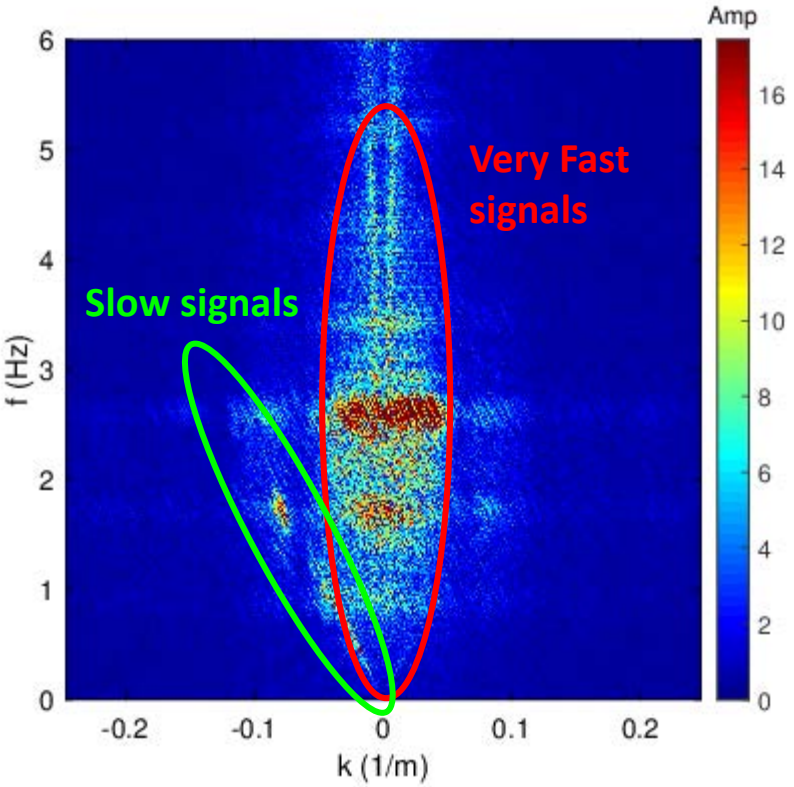


Ctrain DAS Data



Fk Filtering





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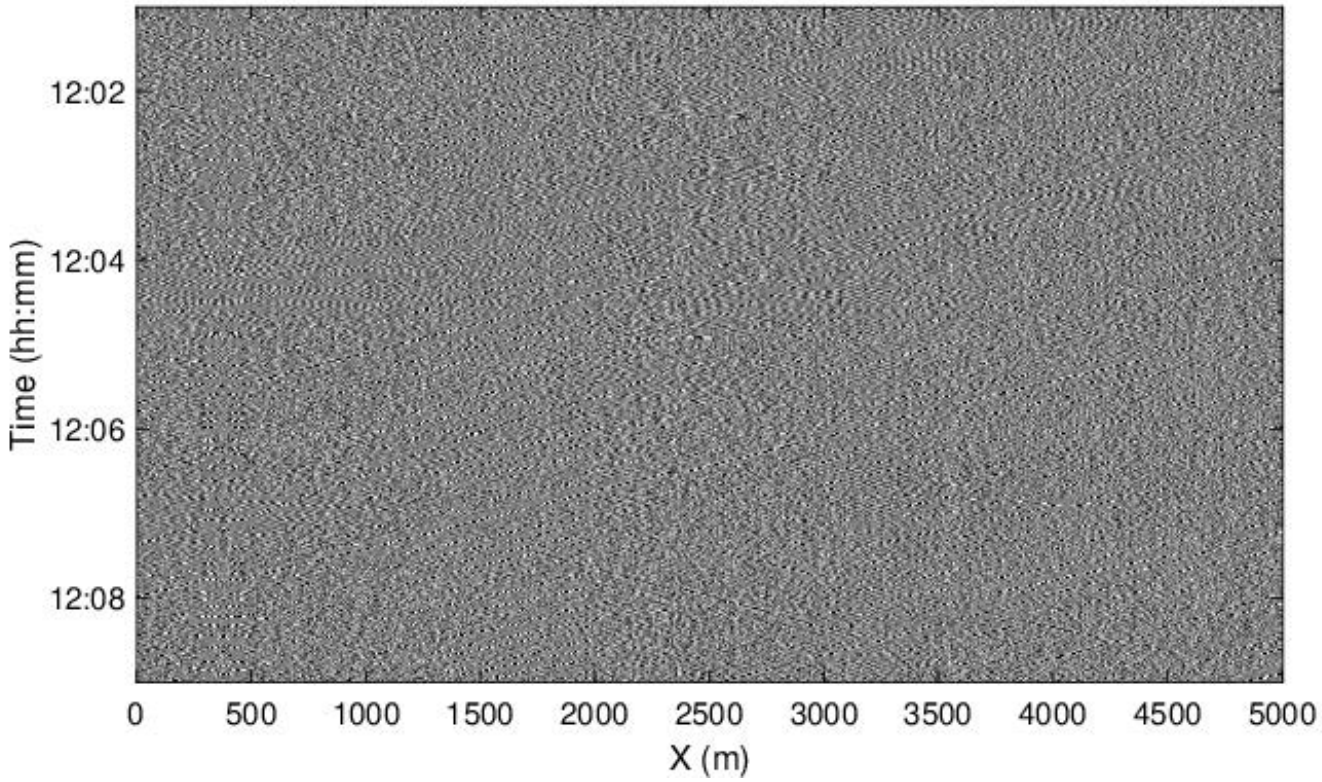
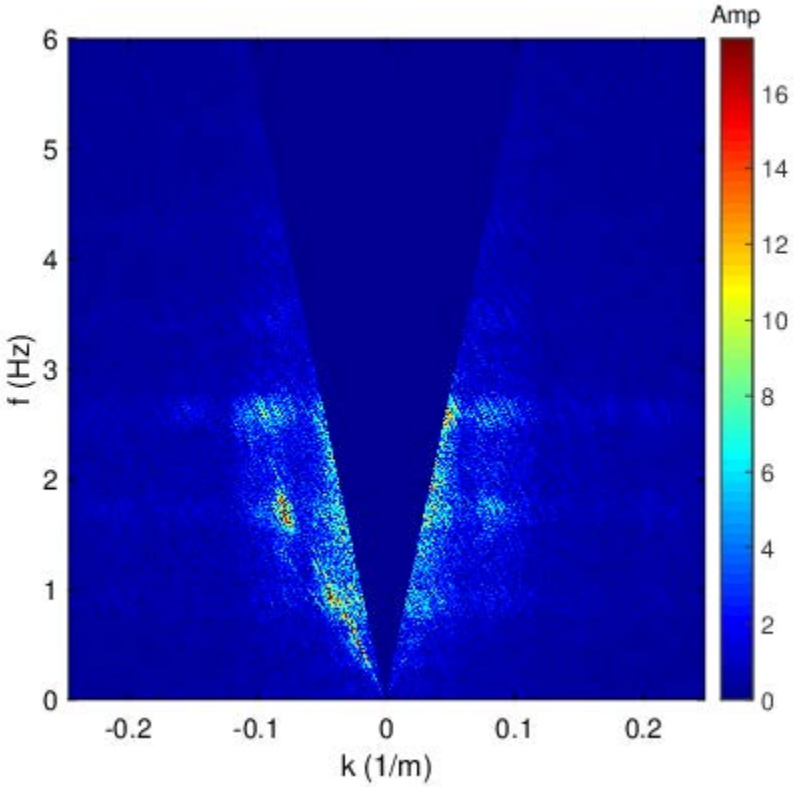
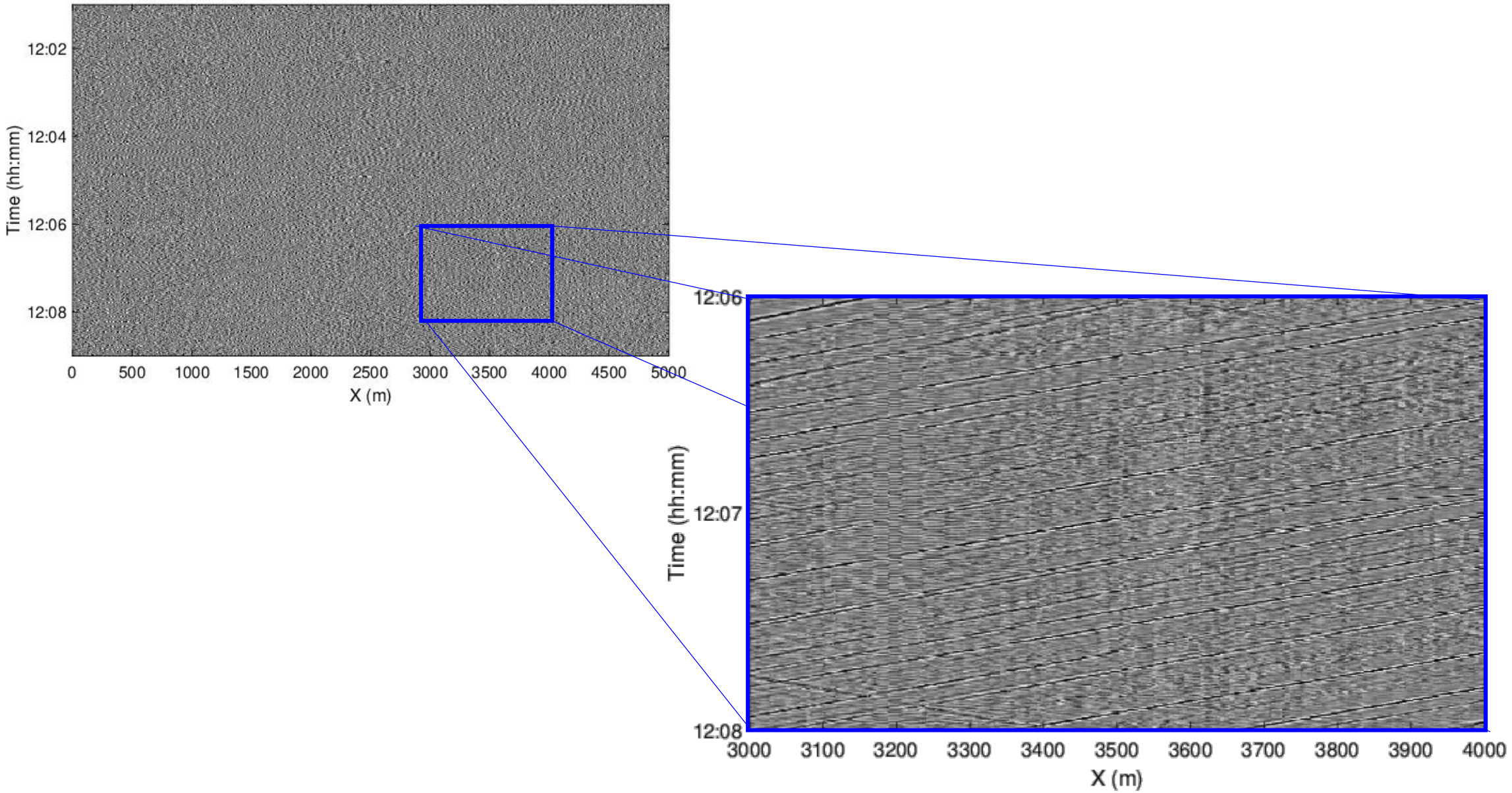
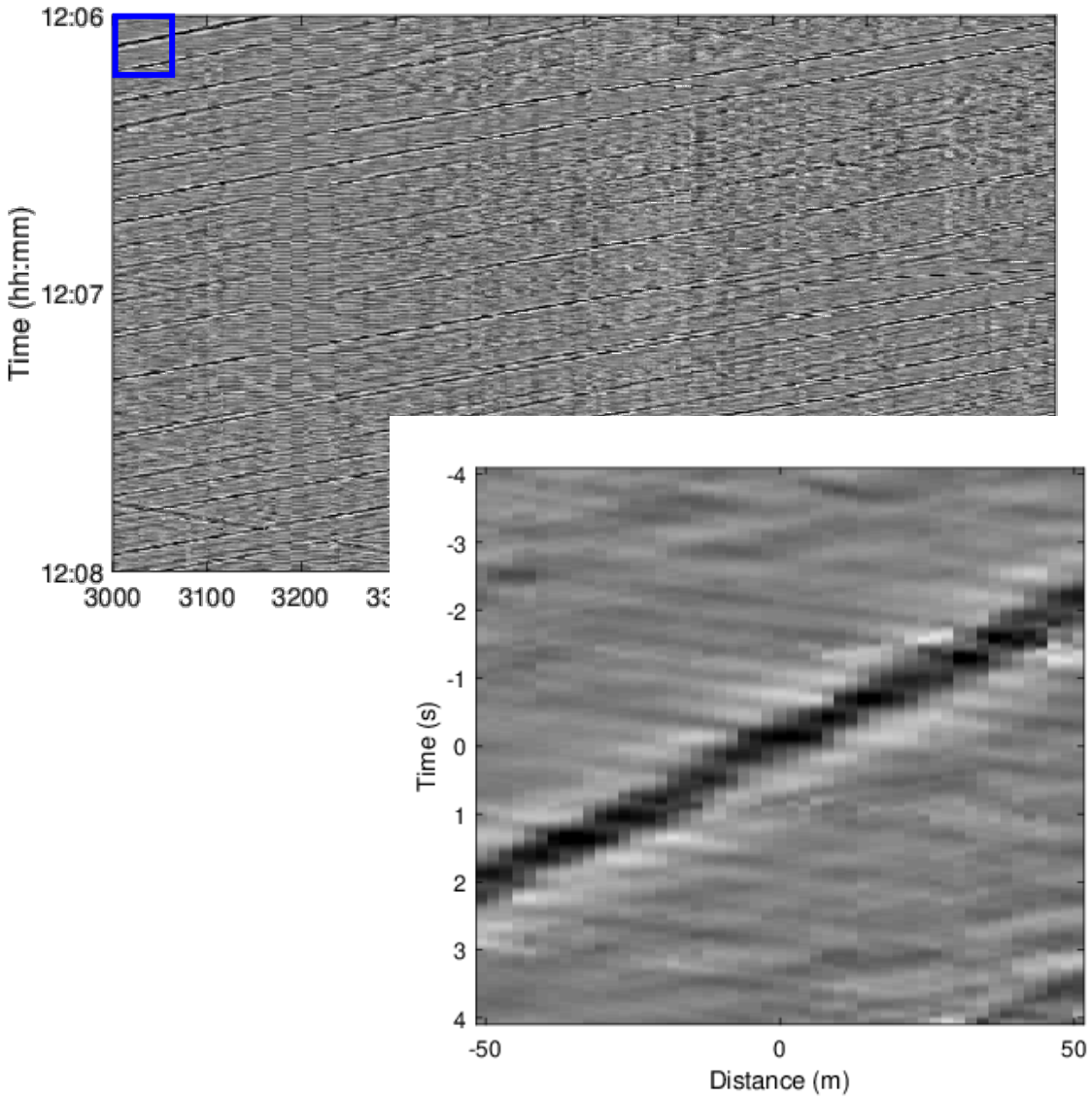




Data After Filtering

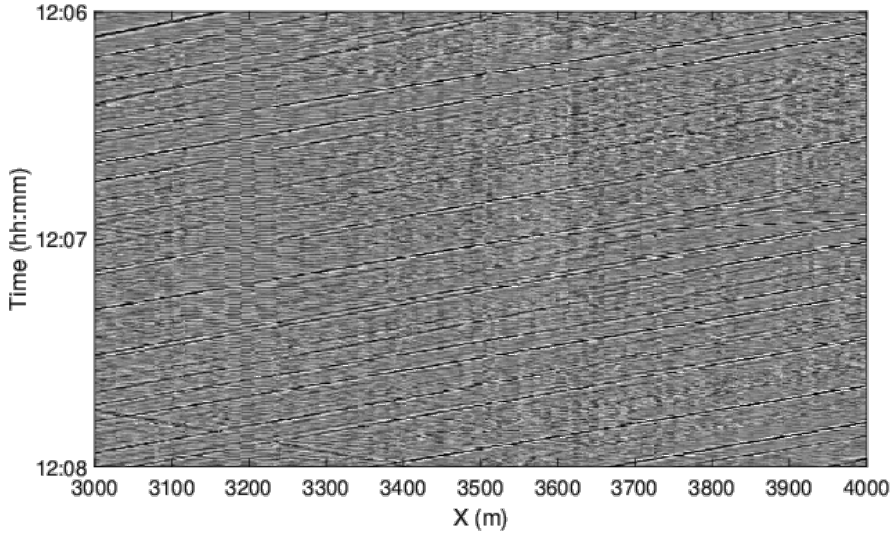


Windowed τ – p transform

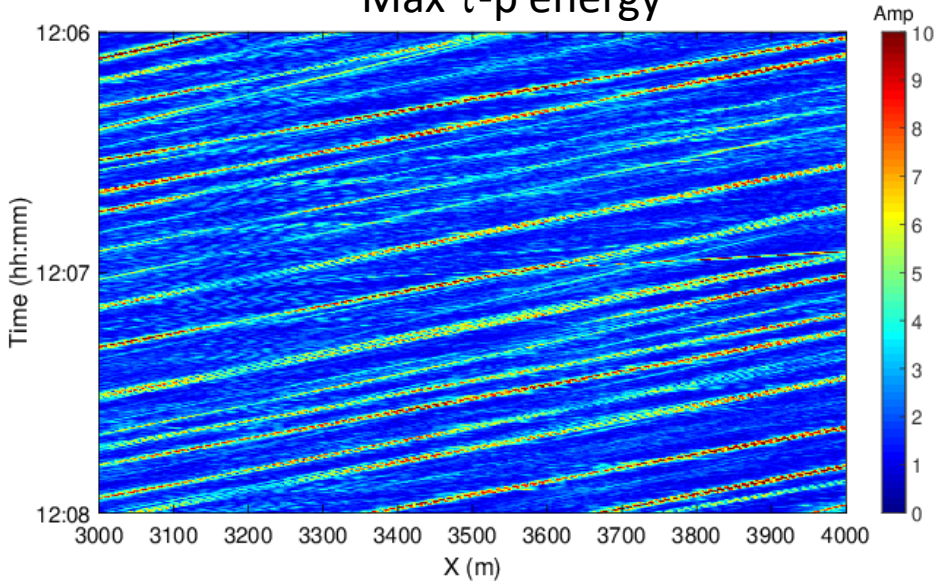


τ – p attributes

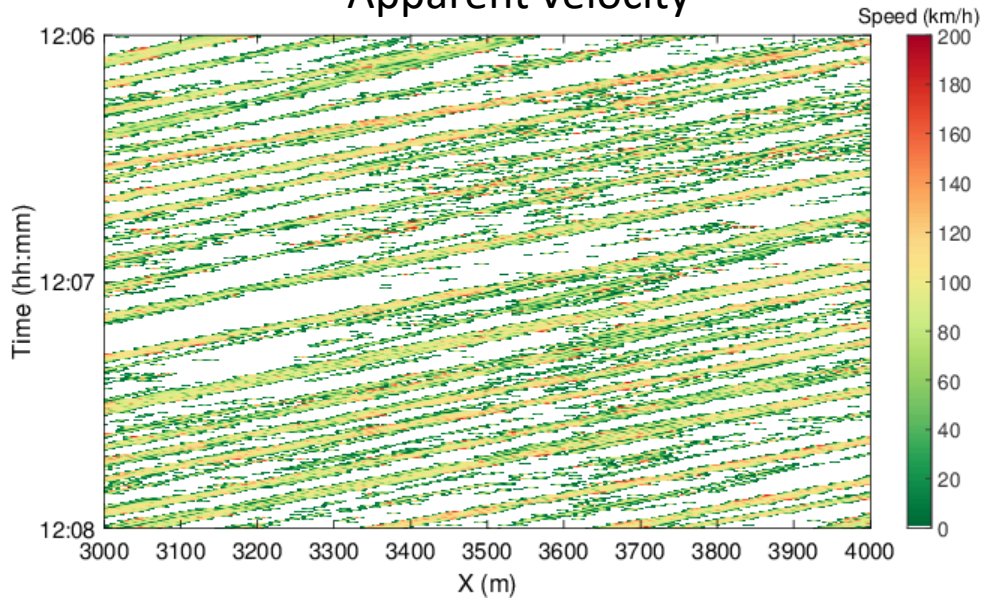
Filtered DAS data



Max τ-p energy

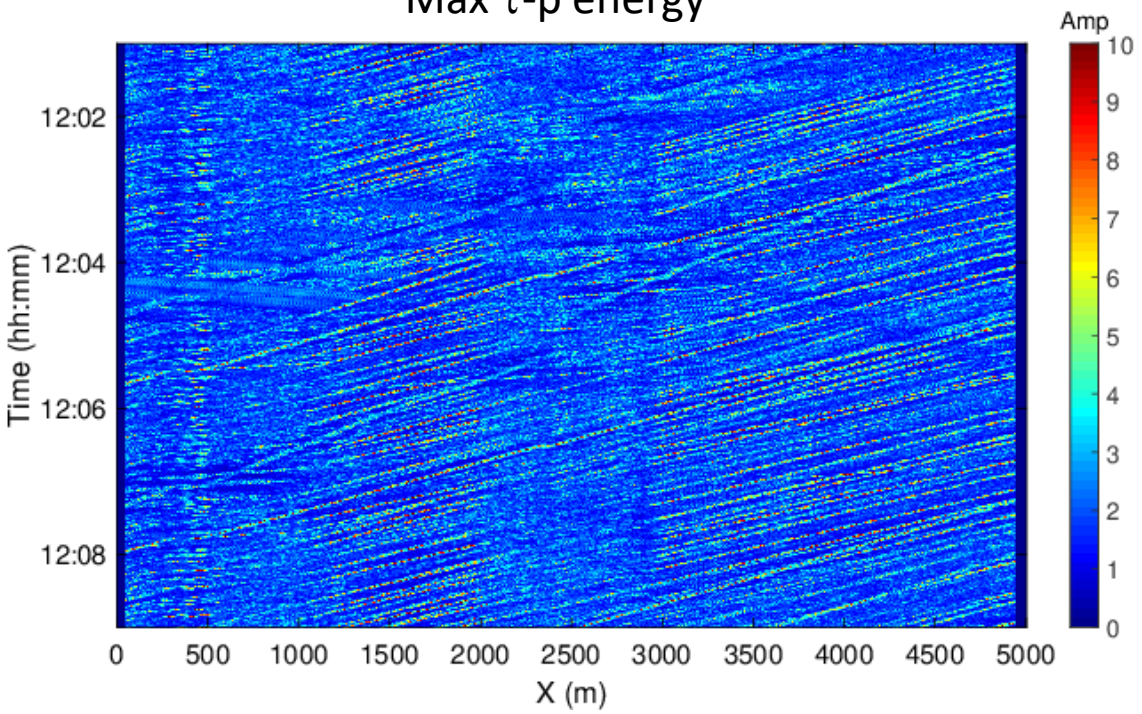


Apparent velocity

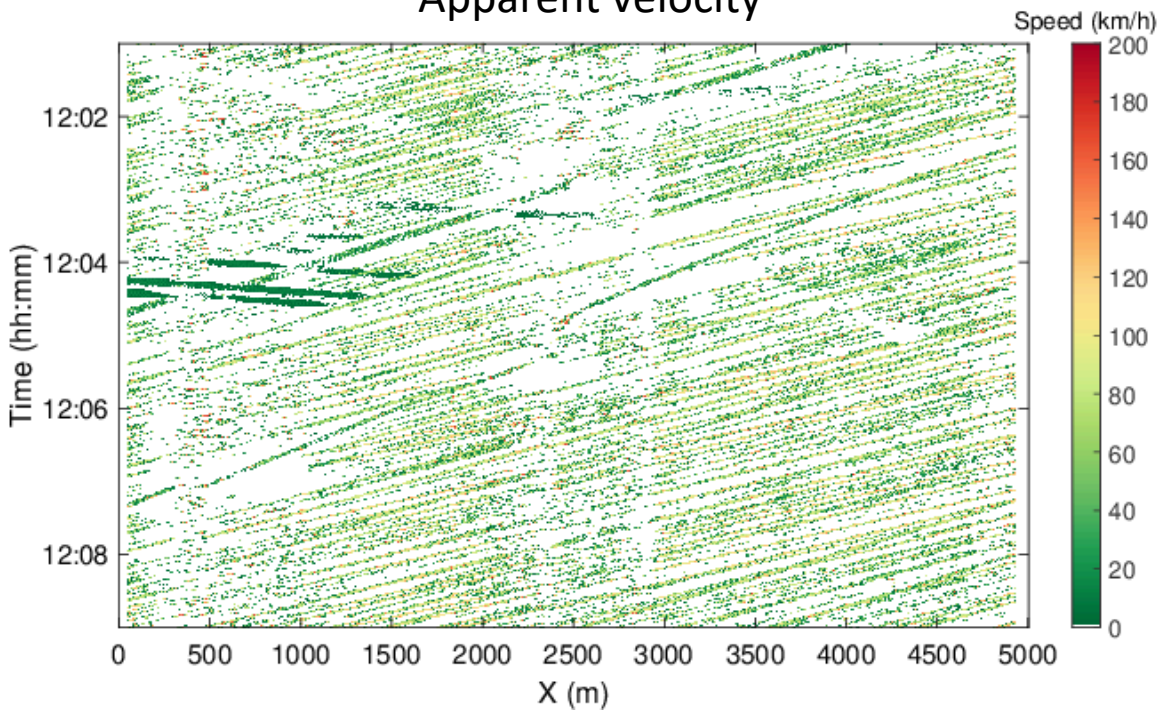


τ – p attributes

Max τ-p energy

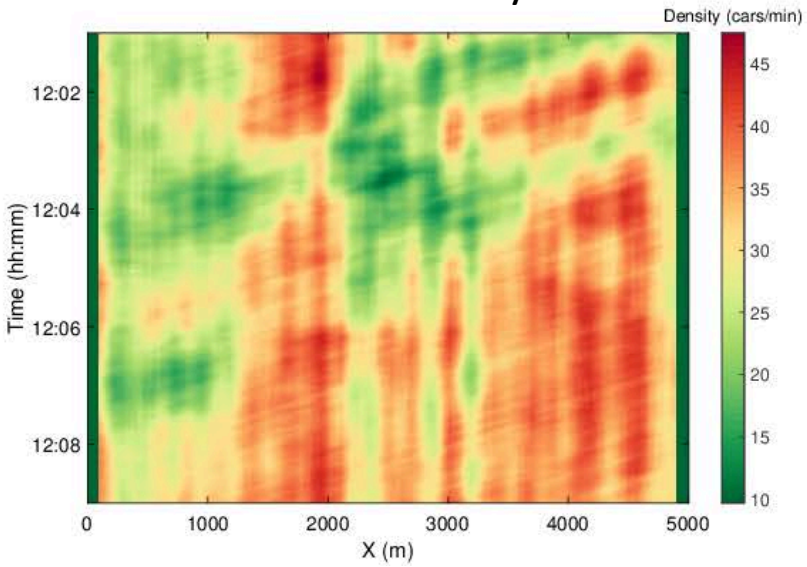


Apparent velocity

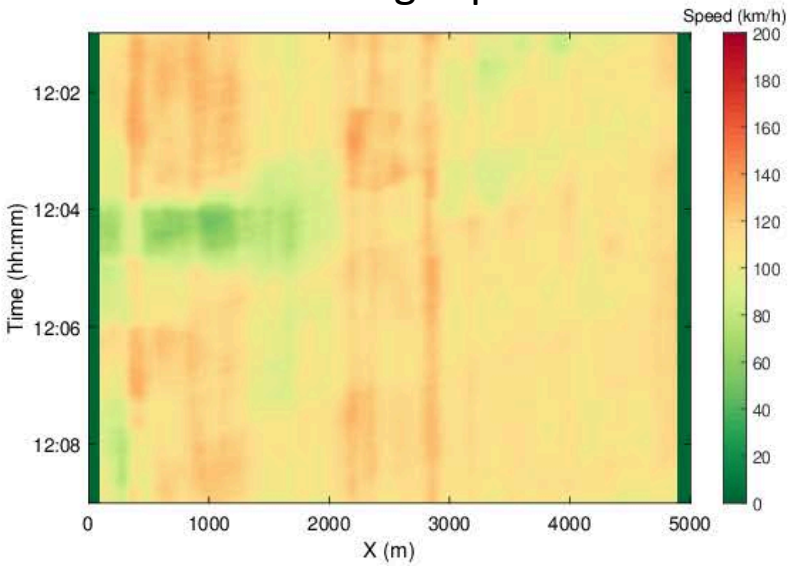


Traffic Attributes

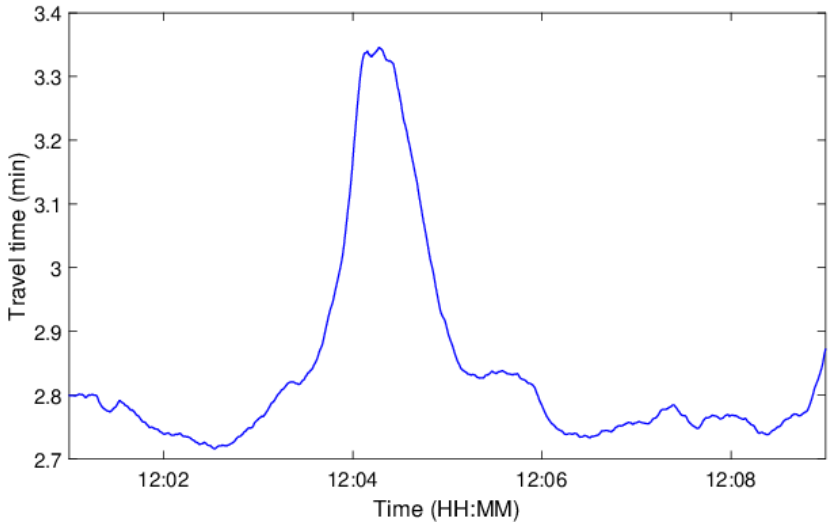
Traffic density



Average speed



Travel time



Remarks

- Using continuous DAS measurements and relatively low-energy sources it is feasible to create virtual source gathers for dispersion curves extraction.
- This process could be performed in a hourly basis for monitoring S-wave velocity changes in the near-surface.
- 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.
- Traffic monitoring data can be used for understanding traffic patterns and helping with roads management and law enforcement.
- This type of real-time DAS data could complement the data recorded by onboard sensors (limited detection range, weather sensitive) installed in vehicles to improve autonomous driving systems.

Acknowledgements

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- Fotech Solutions
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- Canada First Research Excellence Fund (CFREF)
- CREWES sponsors
- CREWES faculty, staff and students.