Preliminary Analysis of Distributed Acoustic Sensing at the Kafadar Commons Geophysical Laboratory

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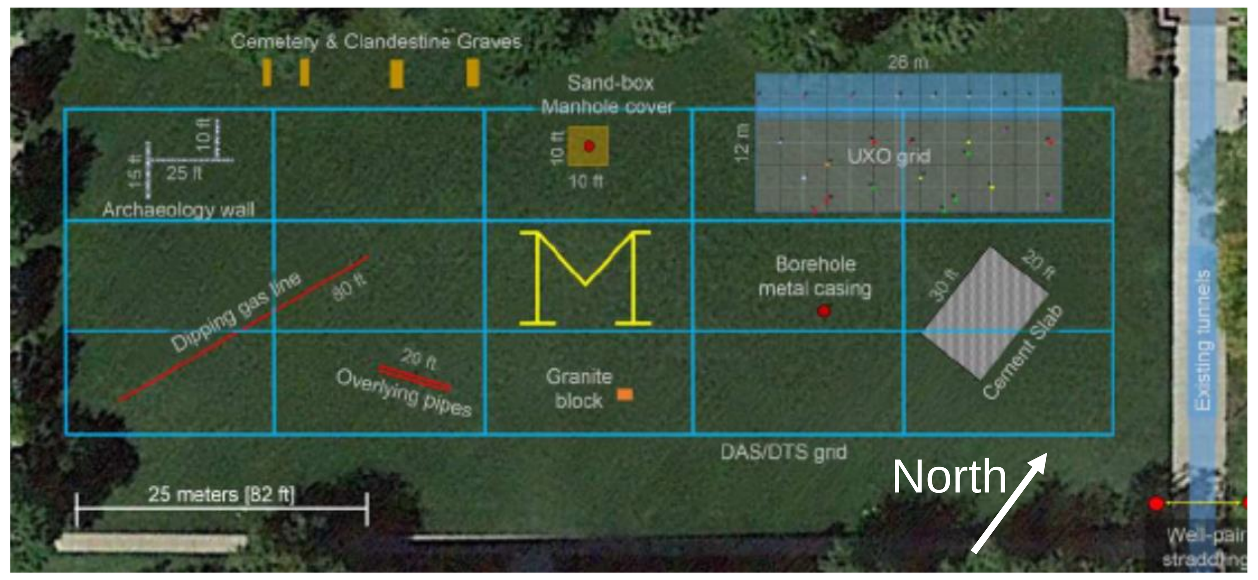
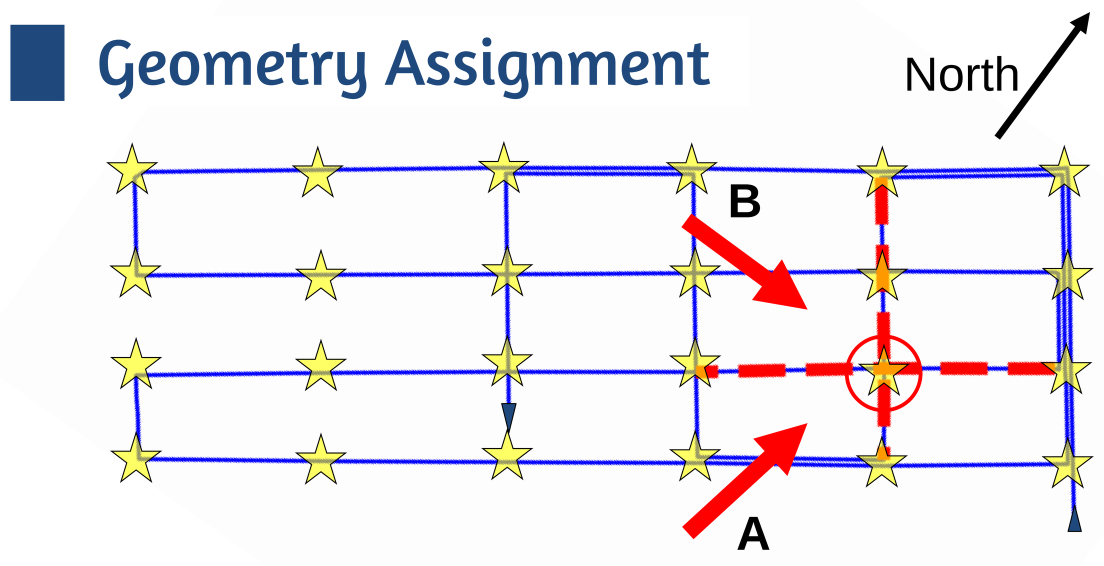
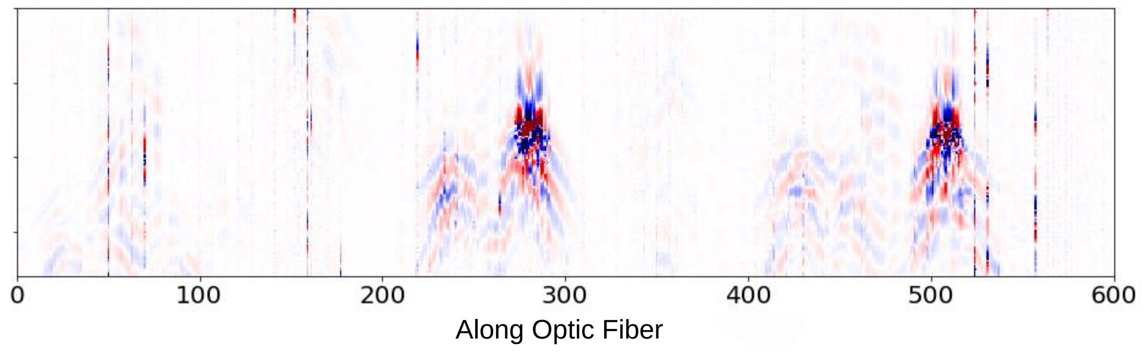
Introduction



The Kafadar Commons geophysical laboratory (Krahenbuhl et al., 2018) located centrally on the Colorado School of Mines campus was created to inspire and provide geophysics students with known buried targets including UXO, archaeological walls, and a dipping concrete wall, among others. Additionally, about 1 km of fiber-optic cable was buried in an approximately rectangular shape of 30 m by 90 m. For the distributed acoustic sensing (DAS) recording we use an OptaSense ODH3.1 interrogator unit. Ambient recordings began approximately on November 27, 2018 and have continued through January 8, 2019, with some intermittent downtimes. During this time, a local earthquake sequence in Glenwood Springs (183 km west of the Mines campus) was recorded, and hammer-source seismic surveys with collocated geophones have been acquired.

Geometry Assignment

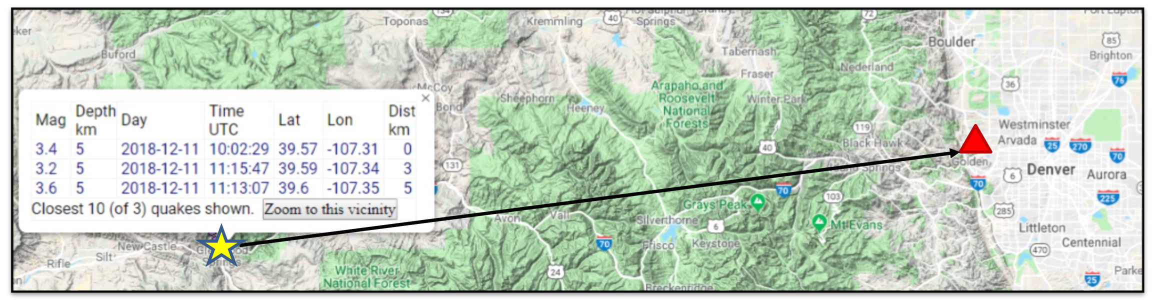


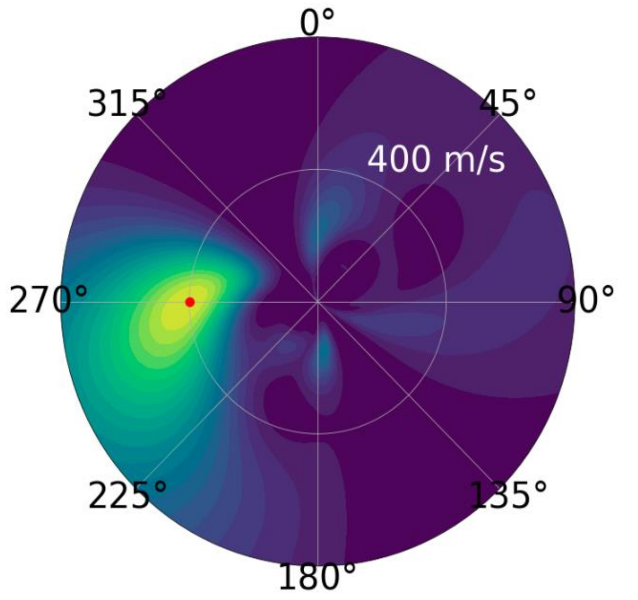


DAS channel spacing is ~1 m. We use known tap test locations to determine channel locations and thus the array geometry.

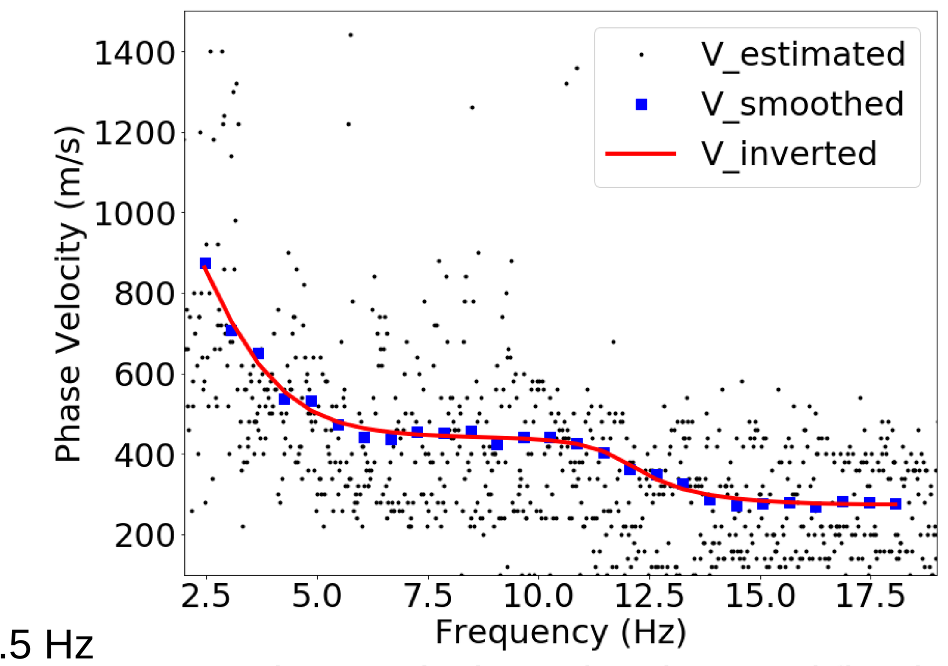
Dispersive Surface Wave Analysis

1. M3.6 Glenwood Springs Earthquake

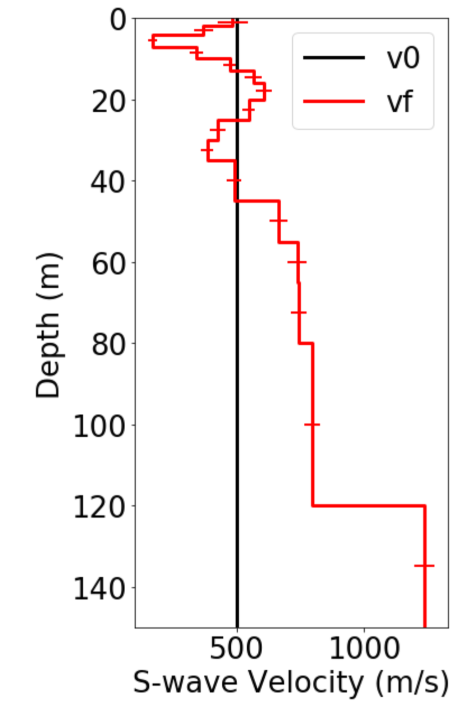




Normalized power spectral density at 7.5 Hz using f-k analysis (Bozdağ & Kocaoğlu, 2005; Rost & Thomas, 2002)

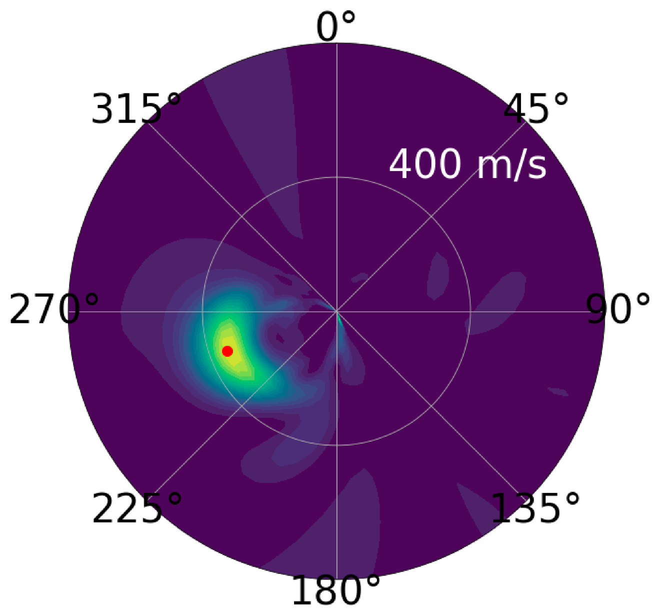


Phase velocity estimations and fitted dispersion curve (at 2.5~18 Hz)

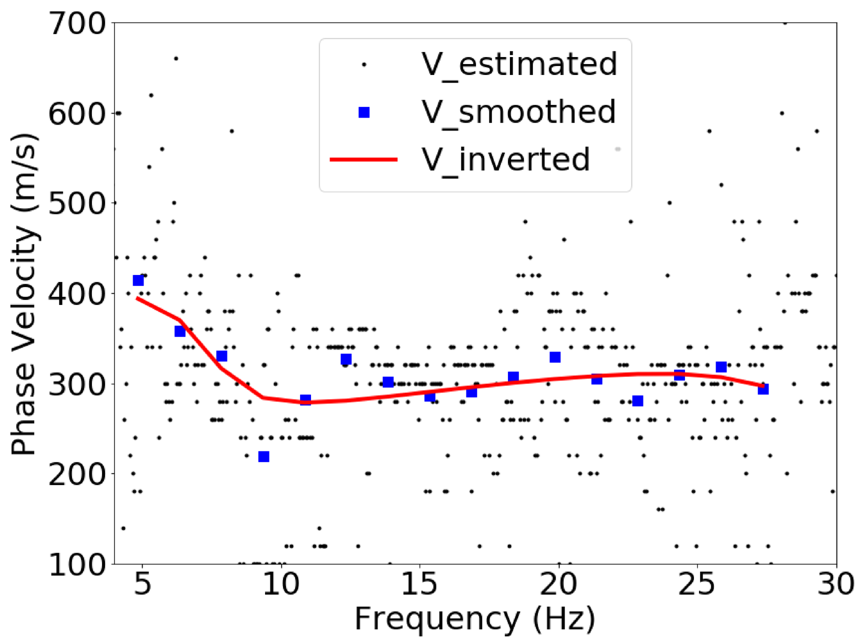


1D S-wave velocity inversion using SWAMI (Lai & Rix, 1998)

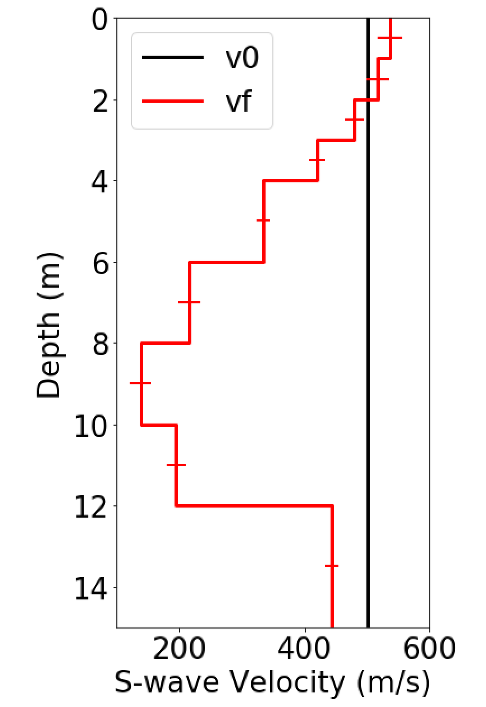
2. Nearby Construction Activity (Rock Smashing) Recordings



Normalized power spectral density at 12.5 Hz



Phase velocity estimations and fitted dispersion curve (at 5~27 Hz)

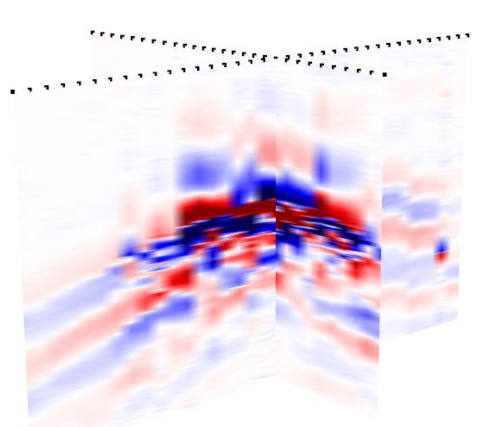


1D S-wave velocity inversion

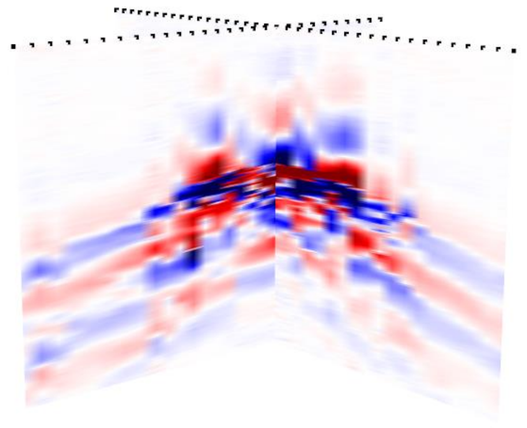
3D Data Visualization

Visualize DAS signals in 3D using vtki and PVGeo (Sullivan & Kaszynski, 2019; Sullivan & Trainor-Guitton, 2019)

Tap test signals (https://tinyurl.com/y6f4zylg)

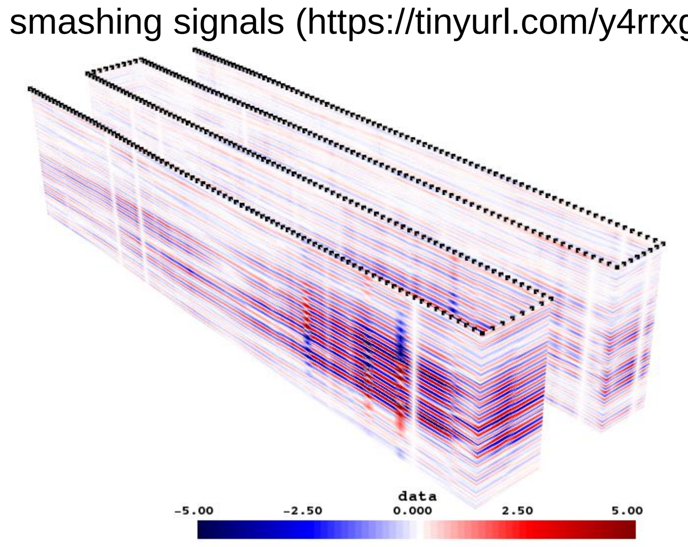


Perspective A



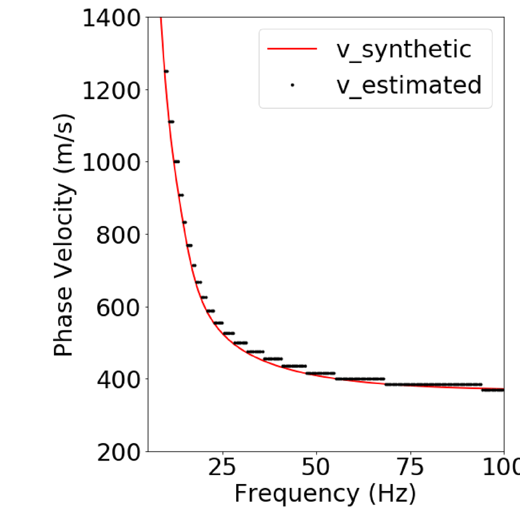
Perspective B

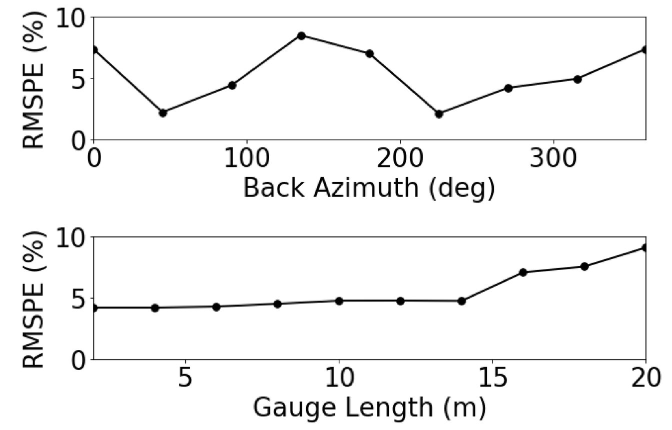
Rock smashing signals (https://tinyurl.com/y4rrxgy6)



Discussion

1. Fiber-optic array response to synthetic surface waves





- Compare synthetic dispersion curve with estimated dispersion curve of synthetic surface waves (Herrmann, 2013)
- Root mean square of percentage error (RMSPE) between the two curves is slightly sensitive to back azimuth, and remains low for gauge length below 14 m (7 m in this study).

2. Diverse sources for subsurface structure exploration

- Passive sources: Earthquake (2~10 Hz, ~100 m at depth), Rock smashing (10~25 Hz , ~10 m at depth), Two-month-long ambient noise recordings
- Active sources: Hammer survey and tap tests

3. Future work

Preliminary surface wave analysis of the DAS signals reveals a 1D velocity structure below the fiber-optic cable.
We propose further investigation of the diverse DAS recordings to image shallow heterogeneity beneath the Kafadar Commons using the following methods:

- Multichannel surface wave analysis of subarrays
- Seismic reflection tomography of active sources
- Ambient noise cross-correlation imaging

References

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Acknowledgments

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