Continuously recording, dense seismic arrays could help us better understand the near surface and its response to earthquakes, but such arrays have been expensive to maintain long-term and are logistically difficult to install in populated areas where they have great potential to impact human life. We combine two methods to make continuous near-surface monitoring significantly cheaper: measuring vibrations as meter-scale strain rate profiles along standard fiber optic cables, and using ambient noise interferometry to extract signals similar to active source seismic surveys. In addition, the continuously recorded data from fiber optics can be used to analyze earthquake ground motion.

We show through comparison to earthquake catalog times and an active source survey with both nodes and fiber optics that our arrival times are reliable, but the waveforms are strain rates as opposed to particle velocities and look quite different. We show some examples of the changes in waveforms that occur due to the change from velocity to strain rate. Further, these changes have an effect on the signals extracted from ambient noise interferometry depending strongly on the array geometry (see Figure 1). These issues will be shown in the context of two data sets: a buried fiber array near a road in Alaska for monitoring permafrost thaw, and a fiber network in existing telecom conduits under the Stanford campus for earthquake hazard analysis.

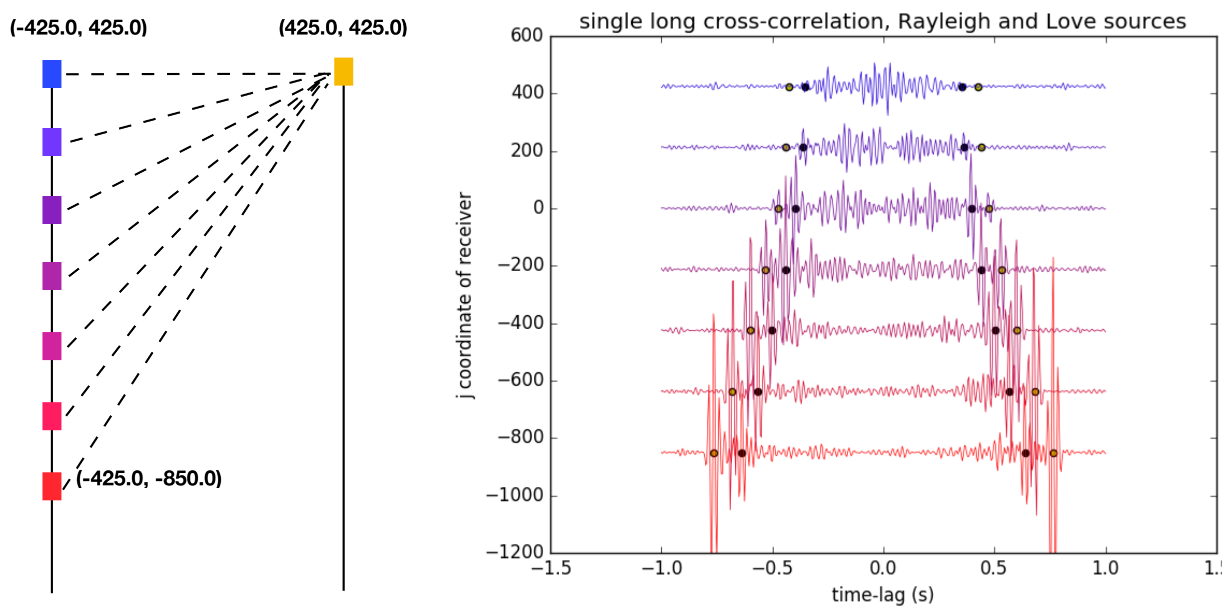

Figure 1: Compared to geophones, different geometries are useful for ambient noise interferometry with fiber optic data. Say there are two parallel fiber optic cables on the surface of the earth at the geometry drawn on the left with some selected receivers highlighted in red to blue on one line, and one receiver marked in yellow on the other line acting as the virtual source. They record a few thousand synthetic transverse wave (velocity 2400 m/s) and longitudinal wave (velocity 2000 m/s) sources, and the average cross-correlations are shown at right, with the true expected arrival times marked with black and yellow markers. Rather than yielding a clear transverse wave signal with the blue receiver, no clear signal is extracted. Instead, channels offset by an angle yield both transverse and longitudinal wave signals.