Dear editor & reviewers,

We greatly appreciate your constructive comments to improve this paper, and we have revised our manuscript accordingly. According to all comments, we highlight all modifications in yellow in the revised manuscript. Below you will find point-by-point responses to these comments in the color blue.

Reviewer #1 (by Dr. Baoshan Wang)
In this paper, the authors presented the a one-year continuous DAS experiment, which is the first long term urban DAS practice with "dark fibre" in eastern US. The DAS records are callibarted with seismic records from a 3-component seismic station. The DAS recorded signals from natural earthquakes, thunderstorms, mining explosion, pace steps, and even live music. The experiment is interesting and the results are important references for future DAS applications. The paper is well written with appropriate analysises. Thus I would recommend publication after a minor revision with further clarification on following points.
Thank you for positive recommendation. We addressed all your comments here below.

Major points:
Comment 1, Two seismometers (SSPA, PSRS) were used respectively for calibration and signal comparison. If possible I would suggest to use the same station for different purpose. And please mark the relative location of different observation in at least one of the maps.
We redrew Figure 4 with labels of the relative location of two stations SSPA and PSRS.

Comment 2, Line 157, "DAS surface energy is much stronger than S-wave", which is not obvious to me. Please further clarify this.
It is in Line 175. This sentence has been revised to "*Surprisingly, DAS has strong S-waves and seismometer surface wave energy is much stronger than S-wave.*". These phases are labeled in the new version of Figure 6.

Comment 3, For the blast signal (section 5.2), I would expect the Rayleigh surface wave to be dominate, which is unlikely to show flipped polarity. Please further discuss this issue.
We think that the strong energy is likely S-waves that exhibits the reversed polarity not surface wave. In section 5.2 (Line 259-261), we've rewritten the sentence as follow:
Figure 14a shows high frequency P- and S-waves (10-20 Hz). In Figure 14b, we can see strong low frequency transverse motions. Same as previous observations, this low frequency transverse waves exhibits the flipped polarity in the orthogonal fiber locations (e.g., indicated by arrows in channels 170 and 600), which is either SH or Love wave and was also observed in previous DAS recordings from the Stanford DAS array (Martin, 2018; Fang et al., 2020).

Minor points:
Comment 1, Please clarify the frequency band of seismometers used.
There was one missing statement of the bandpass frequency band in section 5.2. They are [1-2.5] Hz, which has been added in section 5.2.

Comment 2, Please mark the arrival times of P, S, and surface waves in corresponding seismograms (Figs. 3,4,6,13,14).
We've added phases in Figs 3, 4, 6, 13, 14.

Comment 3, Fig. 7, the subfigures are not capationed.
The caption (b) and (c) has been added in Figure 7.

Comment 4, In fig. 8, please also provide the spectra of different signals from seismometer for better comparison.
Since these DAS data represent strain rate, the power spectra here is the averaged value of all 2137 traces (channels). We think that detailed direct comparison is not informative in this case due to the distance between the DAS array and seismometer, differing near-surface conditions and different noise environment near the DAS array and seismometer. We would refer readers to Lindsey et al. (2020) JGR paper for full comparisons between a collocated seismometer and DAS. Below is the power spectra plot of all these signals for a nearby seismometer PSRS for reference.

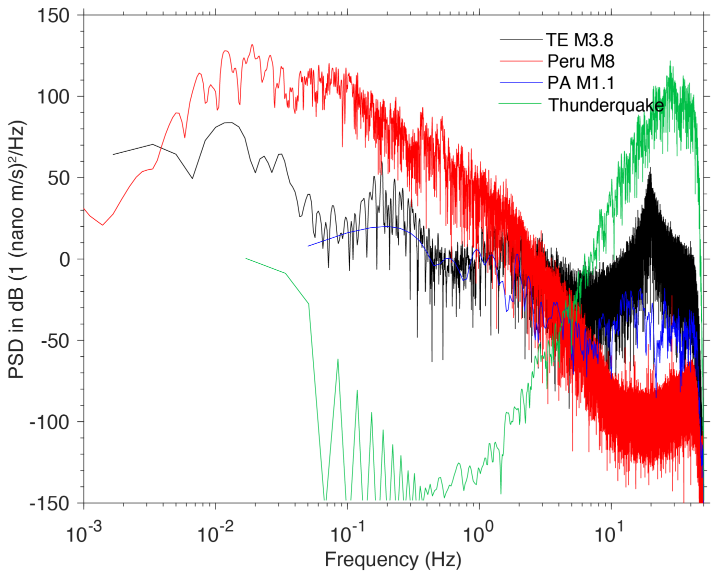

Figure R1: Power spectra density of particle velocity records of four quakes recorded by nearby seismometer PSRS. Its unit of dB is relative to 1 (nano m/s)^2 /Hz.

Reference: Lindsey, N. J., Rademacher, H., and Ajo-Franklin, J. B.: On the broadband instrument response of fiber-optic DAS arrays, Journal of Geophysical Research: Solid Earth, 125, e2019JB018 145, 2020.

Comment 5, Fig. 8, add the unit of horizontal axis (Hz).
The unit "Hz" has been added in Figure 8.

Reviewer #2

The paper shows an application of DAS measurement to permanent 2D network using dark fibers located in Pennsylvania Univ. State campus. The paper does not show really new results using DAS recordings, but it demonstrates quite synthetically how to turn a campus optical fiber network into a seismic network, its design and its sensitivity. This paper can thus serves as a reference for people interested in doing the same kind of experiment. However, in order to do so, the authors should reinforce the signal processing part with more detailed explanations, some demonstrations need to be clarified and they need to present figures in a way they can be used for comparison. Details are below.

Thank you for your positive comments. This paper aims to document the details of the new DAS array from installation to data recordings. In addition to earthquakes and mining blasts, this experiment reported several new DAS recordings for the first time, including the footstep signals, thunderquakes, and music signals. We expect that adding examples of these unique signals to the literature will have value for other groups struggling to identify the wide variety of signals detected by DAS arrays in populated areas. These new recordings extended previous knowledge of the surprisingly high sensitivity of DAS using underground telecom fibers. Potentially, DAS arrays could be useful tools for solving several geologic and environmental problems in Eastern US. New discovered sources (thunderquakes) may be potentially used for earth imaging in this region which has limited seismicity.

Below we addressed all your detailed questions.

Questions/remarks:

1) On line 130 (and figure 3) you explain your process to go from strain rate to velocity. At first sight, this operation should only require a single spatial integration. Can you explain in detail why you have to go through one time integration followed by one time derivation in addition to the 1/k integration? Could the process being done directly in the spatial Fourier domain using a high-pass wavenumber filter plus 1/k integration?

Figure 3 shows individual step to convert strain rate $\frac{\partial \varepsilon}{\partial t}$ to velocity v:

1) Strain rate $\frac{\partial \varepsilon}{\partial t}$ to strain ε by time integration
2) Strain ε in the FK domain
3) Rescale strain by $v(f,k) = -\frac{\omega}{k}\,\varepsilon(f,k)$
4) Apply inverse Fourier transform to $v(f,k)$ to get velocity v

Along with each step, we show the data in the right side. We refer readers to other references (e.g., Daley et al., 2016; Wang et al., 2018) for different conversion methods.

Reference: Daley, T., Miller, D., Dodds, K., Cook, P., and Freifeld, B.: Field testing of modular borehole monitoring with simultaneous distributed acoustic sensing and geophone vertical seismic profiles at Citronelle, Alabama, Geophysical Prospecting, 64, 1318–1334, 2016.
Wang, H. F., Zeng, X., Miller, D. E., Fratta, D., Feigl, K. L., Thurber, C. H., and Mellors, R. J.: Ground motion response to an ML 4.3 earthquake using co-located distributed acoustic sensing and seismometer arrays, Geophysical Journal International, 213, 2020–2036, 2018.

2) Line 139 mentions many factors that may influence waveform discrepancies. The authors mention the gauge length effect; it seems to me that the length of integration (40*2=80m) compared to much larger wavelengths may also play a role?. It would be interesting to give more details and to show a more qualitative comparison (e.g. coherency), or to cite references that analyze this in detail. Nevertheless, it is good to see that the scaling factor is correct.

In our calibration following Wang et al., 2018, we use f-k transform to calculate the scale factor $\frac{\omega}{k} = c$ to complete the conversion $v(f,k) = -\frac{\omega}{k}\ \varepsilon(f,k)$. This 80 meter length (40 channels for clean signals) allows us to grab a collection of nearby channels to yield a 2D waveform (x,t) which is required to calculate the f-k transform (x,t)→ (k,f). We repeat our data processing flow with longer length 800 m. Due to large waveform variation across channels (Fig s2a) possibly caused by DAS instrument response, different scaling factors resulted in different waveforms (Fig s2b). This waveform difference from many channels may mix with DAS instrument response slightly (Lindsey et al. 2020), who calibrated the DAS instrument response using the ratio of seismometer trace and DAS trace. The final result of this process is a velocity equivalent trace for each channel (not an average/stack of the channels).

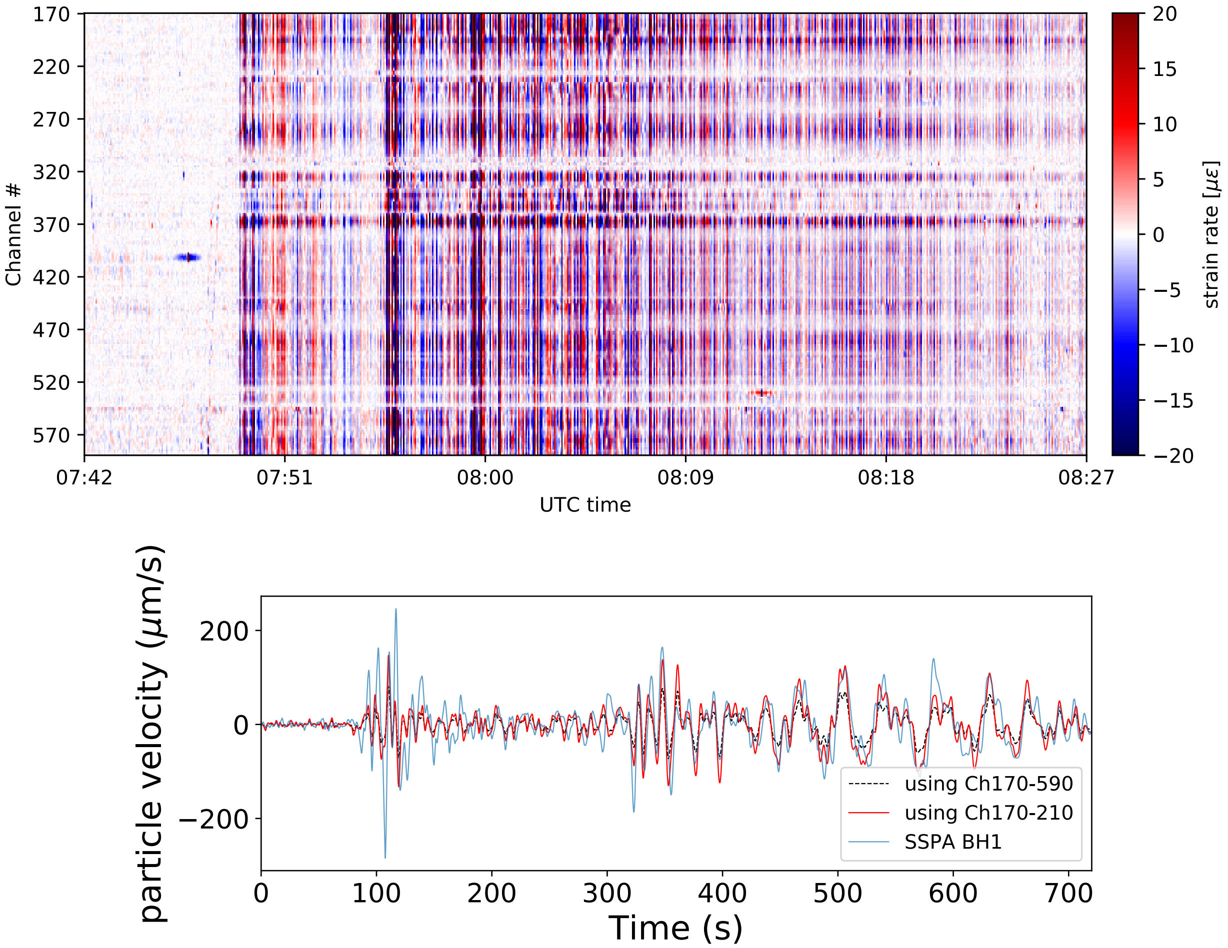

Figure s2: (a) waveform in Channel 170 – 590; (b) scaled waveform with different length against seismometer waveform.

In the manuscript, we would refer to Wang et al. 2018 paper and Lindsey et al. 2020 for details of unit conversion since they have full data comparison with collocated seismometers and DAS.

Reference: Wang, H. F., Zeng, X., Miller, D. E., Fratta, D., Feigl, K. L., Thurber, C. H., and Mellors, R. J.: Ground motion response to an ML 4.3 earthquake using co-located distributed acoustic sensing and seismometer arrays, Geophysical Journal International, 213, 2020–2036, 2018.
Lindsey, N. J., Rademacher, H., and Ajo-Franklin, J. B.: On the broadband instrument response of fiber-optic DAS arrays, Journal of Geophysical Research: Solid Earth, 125, e2019JB018 145, 2020.

3) The lower frequency band specified on line 202 is a bit optimistic. According to figure 8, there is not much energy available below 0.02 Hz to bring such conclusion.
Since the frequency content of the teleseismic recording of the Peru earthquake shows strong low-end frequency response (red curve in Figure 8 with uptick in energy on the left side), this leads us to see that lower frequencies can be recorded by DAS as low as 0.001 Hz.

4) Figures 8 and 11 show power spectra with arbitrary unit. Please specify what is the reference for the dB scale you show.
Figures 8 & 11 show the averaged power spectra density of the strain rate DAS trace in dB with respect to 1 (nanostrain/sec)^2 /Hz. We average the PSD (in dB) across 2137 channels from the DAS array. So the output is the average PSD of all 2137 traces.

5) What is the interest of figure 1b on lower right (fiber end)? Is it very small and we cannot deduce any information from it.
This photo shows a particular way to terminate the fiber by wrapping around the pencil to reduce the noise. Some other DAS interrogator units require the use of specialized termination hardware, or require that the fiber makes a loop back to the interrogator, but the one we use can be simply terminated in this way.

typos: - Is reference Martin et al, 2019, line 54, page 2 correct? This paper doesn't seem to deal with Stanford array
It's a typo and we refer to Martin's PhD thesis (2018).

- missing word at end of line 103
This sentence is fixed in the revised manuscript.

We hope the responses above address your comments and answer your questions satisfactorily. Thank you very much for your review and we truly appreciate your comments.

Sincerely,

Tieyuan Zhu

Tieyuan Zhu
Penn State Geosciences
On the behalf of co-authors.