Reviewer 1 comments

[R1.1] Figure 1. “Mainshock” may be a better choice rather than “Main shock”. Does ”The principal aftershock” mean the largest one?

We corrected the figure legend. In lines 138-139 of the revised manuscript we define the “principal aftershock” as:

“*The largest aftershock of local magnitude 2.65 was recorded by DAS on 2019-11-23 22:14:54 UTC, which we refer to as the* principal aftershock.”

[R1.2] Figure 2. colorbar may help for understanding.

We added a colourbar.

[R1.3] Line 162-163. Authors used a constant apparent phase velocity, which may not too far away for S-wave and Surface wave. But 3 km/s may be too small to P wave, which looks pretty strong in Figure 2e. The azimuth of the segment 3 looks very different from values of the other two segments shown in Figure 2. Was the seismometer’s record rotated to cable’s direction?

The challenge with converting strain rate spectra to acceleration, is deciding on an appropriate reference velocity. Our initial reasoning was that the S-wave dominated the spectrum, but as the reviewer pointed out, the P-wave energy is not negligible. We therefore increased the apparent velocity to 5 km/s, as to strike a balance between the P- and S-phase. All the DAS spectra displayed in Fig. 3 have been shifted upward as a result.

The average azimuth (w.r.t. N) for each segment are as follows:

Segment 1: 145.5
Segment 2: 132.2
Segment 3: 154.6

We previously assumed an average azimuth of 135 degrees, equally balancing the N and E components of the seismometer, but we revised Fig. 3 to rotate these horizontal components more precisely. The resulting correction of the seismometer spectra in Fig. 3 is of the order of several percent, which on the logarithmic scale is indistinguishable.

[R1.4] Figure 3 and Line 171-178, One peak around 10Hz is observed on DAS spectra. Why?. Frankly speaking, figure 3 is not easy to follow.

We are unsure which peak the reviewer is referring to. The DAS recordings show a typical Brune acceleration spectrum (modulated by attenuation) with a peak at around 10 Hz, which is in line with a relatively low stress drop of 0.2 MPa (of the same order as the mainshock stress drop). The nighttime noise spectra of all the DAS segments show a small peak around 10 Hz, which could result from vibrations experienced by the interrogator itself (such as a fan in the server room where it was installed).

The figure itself indeed conveys a lot of information, and we agree that it requires some concentration to distil qualitative messages from it. In Section 4 we tried to guide the reader step by step through our interpretation. We experimented with adding arrows and text within the figure itself, which, in our opinion, did not improve readability.

[R1.5] Line 203-204, how many aftershocks were reported by the catalog? Why only used three aftershock as template events?

As previously mentioned in Section 3 (lines 137-138 of the revised manuscript), 25 aftershocks were recorded by the seismometer network while the DAS acquisition was on-going. Out of those 25 events seen on the seismometers, only 3 could be seen in the DAS data (Supplementary Fig. S3). We added this clarification to lines 140-142 of the revised manuscript. For the template matching on the DAS data, we could not use the seismometer recordings, and so we were limited by those 3 events with (barely) sufficient SNR to serve as templates.

[R1.6] Line 218-219, one recent study compare performance of TMF on colocated DAS and short-period seismometer (Lv et al., 2024, SRL). Their result suggests that using about 100-channel sub-array may get better detection capability. I'd like to encourage authors try similar analysis.

We thank the reviewer for pointing us to this very recent work. The results of the analysis of Lv et al. seem to indicate that template matching of DAS data can systematically outperform a conventional seismometer when stacking at least 100 DAS channels (note that we stack over 4000 channels). When we performed a "cross-detection" test (using one template event to detect the other template events), we do observe a significant excursion in the CC-value that would have resulted in a detection. Unfortunately, an in-depth statistical analysis is not possible with a sample size of 3.

[R1.7] Line 363-365, some practices suggest that the DAS deployment time can be down to one day (e.g., Bao et al., 2022, doi:10.1360/TB-2022-0155)

We added this reference to the discussion.

Reviewer 2 comments

[R2.1] Line 63-64: This sentence mentions several challenges of aftershock monitoring, and I can relate DAS to mitigate some of them. However, I feel it would be better to explicitly address how DAS could help with these issues to strengthen the arguments in the following paragraph. For example, the deployment of a DAS interrogator is much simpler, and the interrogator can be outside of the damaged region, so it is more robust to power outage etc.

We rephrased part of this paragraph as follows:

"*The installation of the interrogator itself is relatively straightforward, and requires less specialised handling than e.g. seismometers and GNSS sensors. While most DAS experiments operate in a campaign style with data being recorded locally, real-time data streaming protocols compatible with e.g. SeedLink are currently being developed, facilitating real-time aftershock monitoring. Furthermore, fibre-optic cables are highly robust and require no electrical current, and the measurement itself is single-ended, i.e., no closed-loop circuit needs to be constructed. One can therefore envision deploying a DAS interrogator outside of a severely impacted aftershock region, and leveraging its long sensing range to penetrate this region to provide local measurements. Even when local network and vehicular traffic infrastructures are severely disrupted, part of the fibre-optic telecommunication network may still be available to DAS.*"

[R2.2] Line 85-88: This long sentence might be rephrased or shortened to improve the clarity.

We removed a few decorative words to shorten the sentence as follows:

"*Specifically for rapid response aftershock monitoring, Li et al (2021) demonstrated the value of a DAS array located within the epicentral zone of the 2019 Mw 7.1 Ridgecrest event; by applying a template matching algorithm on the DAS data, these authors were able to detect 6 times more aftershocks than recorded in the standard catalogue.*"

[R2.3] Line 88-89: I personally feel this sentence can be ambiguous. Readers who are not familiar with DAS might misinterpret this sentence as the deployment of a DAS unit can take up to four days.

We added the following clarification:

"*While the deployment of the instrument itself may take as little as one hour, access to the fibre network needs to be negotiated with the local telecom operator, which significantly adds to the time before a rapid response acquisition can commence.*"

[R2.4] Line 99: I suggest removing 'even', as there are more advanced detection workflows proposed to be applied on DAS.

"Even" removed

[R2.5] Line 126: Spatial resolution often refers to channel spacing. It might be helpful to explicitly say channel spacing and gauge length are both 3.2m in the main part of the sentence.

We updated this sentence as:

"*The DAS data were recorded with a gauge length and channel spacing of 3.2 m, […]*"

[R2.6] Line 156-157 and Figure 2 c-e: These subplots aim to compare signal quality across segments. The authors conclude that the segment 3 is more favorable for detection by comparing seismic amplitudes. It might be helpful to add SNR information/plot a normalized waveform of selected channels on these subplots, especially noting that Figure 3 indicates a higher noise level on segment 3.

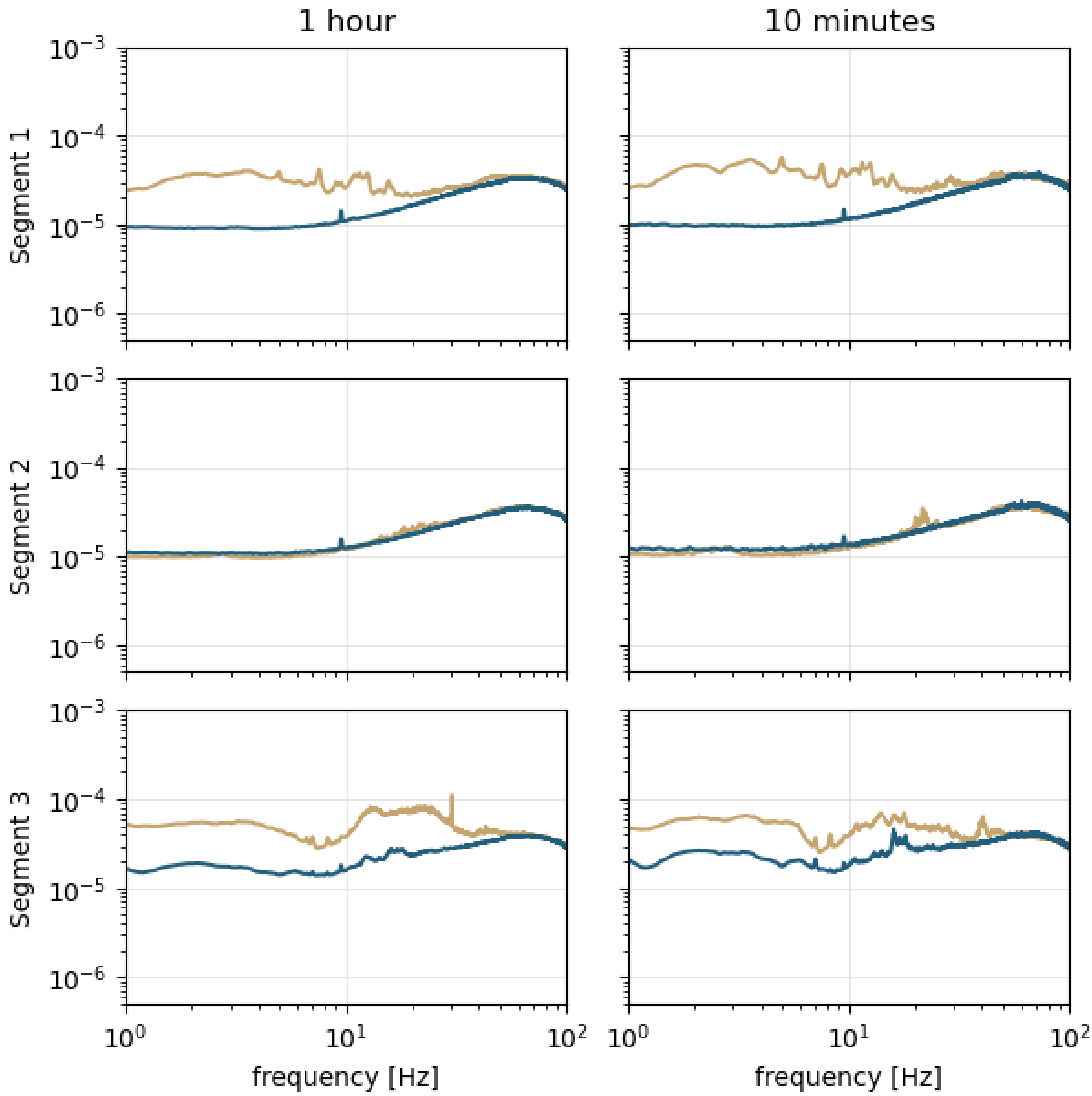
We added the normalised waveform of the middle channel in each segment for reference, which highlights the point that this segment experiences higher signal amplitudes (and higher SNR as a result). As we discussed in subsequent paragraphs, we disentangle the proximity of to the seismic source and the intrinsic quality of the DAS segments by analysing the spectra. This is more informative than a single SNR number, which includes both contributions simultaneously.

[R2.7] Line 165: The authors choose to use a 20-s window to calculate spectral amplitudes. It might worth trying to apply a smaller time window, as both Figure 1 and Figure 2 show waveforms in 5-s window.

We have updated Fig. 3 with earthquake spectra (DAS and seismometers) for a shorter time window of 10 seconds, which tightly encompasses the full earthquake waveform (including the coda, which is not completely shown in Fig. 2).

[R2.8] Line 166-168: For DAS noise floor estimation, it might be more convincing to take average over the whole recording period or averaging over longer periods than one hour to consider daily variations.

We consider the distinction between the day- and nighttime noise levels a relevant component of the analysis, and so we prefer not to average over the entire recording period, yielding a single noise curve. Moreover, we investigated the stability of the noise floor estimates by comparing the spectra obtained over a 10-minute period with those obtained over a 1-hour. As shown in the figure below for each DAS segment, the 10-minute spectra (right column) are highly similar to their 1-hour counterparts period (left column). This suggests that the noise floor estimates converge rapidly, and so averaging over a period longer than 1-hour does not lead to more stable estimates.



[R2.9] Line 186: experiences -> records

Corrected.

[R2.10] Line 187-188: The subject of the sentence should be the spectral energy of the event instead of the event itself.

Corrected.

[R2.11] Line 190-191: I personally feel the sentence a bit confusing.

We've clarified this sentence as:

"*Given the unfavourable noise floor characteristics of the DAS array, which limits energy-based detection methods such as STA/LTA, a reasonable strategy would be to apply a template matching procedure to the DAS data.*"

[R2.12] Line 193: maybe change to buried by the noise or beneath the noise floor. Li and Zhan (2018) also detects events beneath the noise floor with TM on DAS, so it is not only for conventional seismometers.

We have rephrased this as "buried by noise".

[R2.13] Line 200-204: The authors conduct TM analysis by 60-s chunks and apply an absolute threshold for event identification if I understand correctly. I found the threshold of 8*10^-4 is surprisingly small if it represents cross-correlation coefficient. If it represents the threshold on CC function, it might be more reasonable to apply a comparative threshold such as median absolute deviation (MAD). In that case, a much longer chunk needs to be chose, for example one-hour window. In addition, I think for each template, it is not necessary to do TM on all channels. Maybe implementing a channel selection criterion and only applying TM on best-quality channels can improve the results.

The original phrasing of the TM analysis was a bit misleading, as it raised the suggestion that the detections were made automatically, only to be manually verified later. Rather, we inspected the entire time-series of cross-correlation values manually, and selected significant deviations from the background fluctuations, roughly corresponding to an amplitude of 8e-4. We rephrased this part as (lines 214-217):

"*We then manually inspected these time-series and identified 9 occurrences for which the cross-correlation coefficient exceeded the background fluctuations. From this manual inspection, we could only recognise the original templates, but not any other aftershocks. Rather, most of these detections seemed associated with high-amplitude traffic noise.*"

Moreover, we performed several trials with different subsets of high-SNR DAS channels, which we found to increase the sensitivity to traffic noise, hence increasing the background fluctuations. Stacking over a large number of channels seemed to greatly suppress these local noise sources.

[R2.14] Line 204-205: It might be more self-evident to explicitly say how many of the 25 aftershocks are recorded by DAS. Otherwise, it may raise a question: why not using other detected events as templates other than the chosen three.

We added the following clarification to lines 140-142 of the revised manuscript:

"*Out of the 25 aftershocks in the seismometer catalogue, only 3 (including the principal aftershock) could be visually confirmed in the DAS data (see Supplementary Fig. S2).*"

[R2.15] Line 218: add 'that' after 'note' to make it easier to read.

Corrected.

[R2.16] Line 277: I notice the authors keep 43 pickings from DAS, which is about the same number of pickings from conventional sensors. I wonder if it is a coincidence of spatial down-sampling, or it is intentional to leverage the weights of different instruments when measuring differential times?

Yes, this downsampling ensures an equal weighting between the two types of instruments. Moreover, picks from neighbouring DAS channels are highly correlated (as the channels were picks jointly rather than individually), so increasing the number of DAS picks does not necessarily add independent information to the inversion.

[R2.17] Equation 4: It might be helpful to explicitly say that i,j represent two sets of obversion/synthesis from two receiver locations so it help to explain what 'differential time' stands for.

We added this clarification to lines 292-294.

[R2.18] Line 282-283: Since the author mentioned P and S waves are both picked, is $\Delta tij - \Delta \tau ij$ calculated with P wave, S wave or the average of two phases in this study?

EDT permits any pair of phase arrivals, and so we combined all the phase picks in a single set of observations (with equal weighting between P and S arrivals). We added this clarification to lines 295-296.

[R2.19] Line 285-290: In line 285, it says p is measured with random shuffling and drawing of receiver pairs, but in line 290 and in equation 4 it uses mean over all N_t^2 pairs. If I understand correctly, the random drawing procedure is only applied when there is a large number of the receivers but not in this study. It may help the readers to better understand by rephrasing the sentence in line 287-289 to explicitly address that the all-pair method is adapted in this study.

This interpretation is correct. We clarified this in lines 300-303 as:

"*In the present study, the number of observations is limited and hence we compute p over all N_t^2 observation pairs, but when $N_t \gg 1000$ (for instance when applying an automated phase picker to a DAS array with 10,000 sensors), it is computationally beneficial to approximate p stochastically.*"

[R2.20] Line 293-296: This comment is more of my own curiosity. The authors compare the pickings of two different methods. Figure S3 also supports this argument. It seems that a reliable velocity model is critically important for earthquake location. But I wonder if the location inversion results would change much because it is a relative scheme, i.e., differential times at i and j are both biased by the velocity model. It would be very informative to readers who want to use this method to understand the importance of the chosen velocity model.

This is an interesting point, which was discussed (to some extent) by Lomax & Henry (2023; doi:10.26443/seismica.v2i1.324) as a motivation for their NLL-SSST approach. They argue that differential time methods would reduce aleatoric uncertainties (picking noise) leading to improved small-scale precision (sharpness), but that epistemic uncertainties (velocity model inaccuracies) remain unaffected. This argument is intuitive, as for a given hypocentre location, different velocity models would produce different moveouts, which cannot be reduced to a simple bias (offset) to cancel out in the EDT formulation.

The inversion approach adopted for our study requires access to gradients passing through the forward model, i.e., the forward model needs to be differentiable. This is easily satisfied for simple velocity models (like the constant velocity-gradient model of Delouis et al.), but is infeasible for the layered model proposed by Causse et al. Hence, we could not compare the results obtained with each model to investigate the role of the velocity model, and to what extent EDT mitigates such uncertainties.

[R2.21] Section 7: this is a general comment. Maybe the real-time data transmission feature of DAS can be discussed in this section, especially when the authors mention 'operational forecasts can be continuously updated over time' in the first paragraph of Overview.

Currently, real-time data transmission is still in an experimental stage, but we added a mention to this feature in lines 80-82, in the same section where the "operational forecasts" are mentioned:

"*While most DAS experiments operate in a campaign style with data being recorded locally, real-time data streaming protocols compatible with e.g. SeedLink are currently being developed, facilitating real-time aftershock monitoring.*"