Manuscript Ref. No. se-2020-216: "*On the comparison of strain measurements from fibre optics with dense seismometer array at Etna volcano (Italy)*" by Gilda Currenti et al.

Referee #2 (General Comments):

I enjoyed reading this manuscript. It's very well written and the figures are overall clear.

My only major issue concerns the general objective of the paper. In the abstract, you present your experiment as a way to understand DAS potential to detect volcano-seismic signal. You insist on the great opportunity to probe its multi-faceted activity which is again very promising. But in the end, you only analyze a volcanic explosion and a LP, and rather focus on the capability to measure strain by an in-depth comparison with the more conventional broadband deployment. This is fair and, as mentioned, interesting scientifically. Yet, I'm finding the abstract and the conclusion slightly misleading. It would be interesting to know if you have detected tremor for example? I fully understand the idea of focusing on the capability to retrieve strain measurements at volcanoes, but would modify the abstract, introduction and conclusion accordingly.

Overall, as mentioned above, I'm very positive and have only several minor comments listed below.

Authors: We are pleased that the reviewer found our paper to be interesting and suitable for the journal. We would like to confirm that the main aim of the paper is to validate the DAS records. The title itself was properly chosen to highlight the main subject of the manuscript. Also the Introduction is almost dedicated to theoretical methods for indirect strain estimates and the proposal of an alternative methods of DAS records validation. For the first time we have the possibility to compare direct DAS strain with estimates of strain from a very dense seismic array at the summit of an active volcano. Since the cable was deployed in a scoria layer, we wonder if coupling was good enough to accurately sense strain generated by volcanic activity. The dataset is very rich due to the variety of volcanic activity of Etna. But, before analyzing the full dataset, we wanted to validate the measurements, which is the topic of this work. The single station procedure is the most method used for DAS data validation, which relates strain and particle velocity in the plane wave approximation. However, it suffers from the uncertainty on phase seismic velocity values, that regulate this relationship. Moreover, as pointed in the discussion, in volcanic region, where media are heterogeneous and possibly dispersive, making the estimate of the phase seismic velocity is highly challenging. Therefore, we looked for alternative methods which could give strain estimates without any assumption on the phase seismic velocity values. The good fit between DAS strain records and seismic derived strain provides us for the first time the "passport" that strain is properly recorded by DAS interrogator.

However, as suggested by the reviewer, to stress the main objective of the paper, we rephrased some sentences, where appropriate (e.g., in abstract and conclusion).

Referee #2 (Specific Comments): *27: suggest adding a comma: 'Nowadays, advances'.*

Authors: done

Referee #2 (Specific Comments): *27-30: suggest adding references to support these statements and guide the readers.*

Authors: We added further references and moved here the references, that were provided at the end of the paragraph (line 32-33 in the first version of the ms).

Referee #2 (Specific Comments): *L.35: what do you mean by multifaceted?*
Authors: As often occur at Etna, the volcanic activity was characterized by a great variety of eruptive style going from effusive to explosive with different level of intensity. We better clarified it in the ms.

Referee #2 (Specific Comments): *35: again some references are needed for Etna volcanic activity*
Authors: References have been added to describe the eruptive style of Etna volcano and the description of the activity during the acquisition period.

Referee #2 (Specific Comments): *39: as a non-native English speaker, I'm not sure about measures. I have always used measurements instead of measures. Worth checking this in detail.*
Authors: "measures" was changed with "measurements".

Referee #2 (Specific Comments): *46: 'constraints on seismic sources': could you be more specific here?*
Authors: References were checked and the content of the cited papers was better described.

Referee #2 (Specific Comments): *52-53: 'close sensors or dense arrays': it would be good to give some numbers here, again to guide the non-seismologists who may be interested in your contribution*
Authors: Numbers and references were provided to give an outline of dense array deployments.

Referee #2 (Specific Comments): *58: 'the Authors'-> 'the authors'*
Authors: done

Referee #2 (Specific Comments): *L.90: what's the natural frequency of the Trillium Compact*
Authors: We used Trilium Compact – 120 s broadband sensors. We added this information in the ms.

Referee #2 (Specific Comments): *115-116: how do you tune them?*
Authors: The smoothing parameters are tuned by performing a simple grid search with the aim to improve the fitting between observed and estimated strain. When no direct measurements of strain are available to compare, the tuning is performed on the deformation/velocity data, by omitting one sensor from the computation and then, after calculating the displacement/velocity at the same station, the recorded and interpolated displacements/velocities are compared (Paolucci and Smerzini, 2008).

Referee #2 (Specific Comments): *L.125: odd : the size of the text suddenly increases*
Authors: The size of the font was adjusted to 10 overall the ms.

Referee #2 (Specific Comments): *L.155: it would be interesting to take a similar gauge length for the DAS to more directly compare with the broadband array*

Authors: The used iDAS interrogator has a fixed gauge length of 10 m, that cannot be changed by the user. It would indeed have been interesting to perform measurements at different gauge lengths. Following the suggestion of the Referee #1 we performed additional computations to observe the smoothing of the DAS strain as gauge length is increased. We report the results in Supplementary Figures.

Referee #2 (Specific Comments): *L.172: the font size has again changed for some reason*

Authors: The size of the font was adjusted to 10 overall in the text.

Referee #2 (Specific Comments): *L.183: is that really giving a local estimate of their respective performance? I have the feeling it somewhat highlight their discrepancy but not their performance.*

Authors: We agree with this comment and accordingly changed the text.

Referee #2 (Specific Comments): *L.189: comment on Poisson's ratio value: how did you come to this conclusion?*

Authors: We tested a range of Poisson ratio from -1 (fully decoupled) to 0.25 and 0.5 (elastic) to 1.0 (incompressible). By comparing the misfits, the solutions with an optimal value of 0.25 was chosen.

Referee #2 (Specific Comments): *L.191: I only partly agree. RMSE misfits are also much higher in the northern and southwestern sections. Could you comment on this? But I agree with the fault zones.*

Authors: Thanks for highlighting this feature. Indeed, we are fully aware that larger misfits are along the two nearly EW branches (channel 134-302; 449-787), because the strain wavefield (Fig. 2 and Figs. S1-S2) is more complex and amplified with respect to the nearly NS branch (channel 302-449). This feature is maybe related to the relative direction between the main structural geology and the cable branches.

Referee #2 (Specific Comments): *L.194-195: this sentence is not clear to me. What is your aim? To assess DAS performance? Why on irregular points?*

Authors: Usually, interpolation are performed on regular grid to compute displacements/velocity and then to derive strain/strain rate tensor by simply finite difference scheme. The derivation of analytical expression for strain allows for directly computing the strain on points distributed irregularly overcoming the limit to use regular grid. This also allows for a better accuracy. Since DAS cable layout are usually not regular in geometry, the proposed interpolation methods offer advantages with respect to simple gradient method. This concept is fully described at the end of the Discussion. To avoid repetition and misunderstanding due to a too short sentence at the beginning of the paragraph, we remove the L194-195.

Referee #2 (Specific Comments): *The first paragraph is very convincing. Well done.*

Authors: Thanks for appreciating.

Referee #2 (Other Questions): *207: I suggest using 'coinciding with' rather than 'in correspondence'*
Authors: done.

Referee #2 (Other Questions):*L.220: have you tried to compute simple H/V ratios for the broadband to better understand the site effects?*
Authors: Thank for the suggestion. A study is undergoing to characterize the ground response in Piano delle Concazze using and comparing several methods. H/V ratios is one of the methods we are investigating.

Referee #2 (Other Questions): *I would like to see a spectrum for each event before any filtering, perhaps as supplementary material.*
Authors: We added two Supplementary Figures (Figs. S1 and s2) which show the raw strainrate DAS records and its spectra for the two events. The spectra are computed and plotted all along the DAS channels. We also show the strain computed by integrating over time the DAS records. The signals are dominated by the continuous volcanic tremor at Etna whose seismic frequency band is in 0.5-5 Hz (Cannata et al., 2009). It is worth of noting the small amplitude strain changes related to the LP event, which is barely visible in the raw strainrate data.

Referee #2 (Other Questions): *There seems to be more phases excited following the VE compared to the LP. Could you comment on this?*
Authors: Yes, it is true. As already noted during the experiment performed in 2018 (Currenti et al., 2020), the explosive events excite more phases due to scattering and reflection on faults and layered geology.
Currenti, G., Jousset, P., Chalari, A., Zuccarello, L., Napoli, R., Reinsch, T., and Krawczyk, C.: Fibre optic Distributed Acoustic Sensing of volcanic events at Mt Etna, EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-11641, https://doi.org/10.5194/egusphere-egu2020-11641, 2020

Referee #2 (Other Questions): *Figure 1: strange geometry. Could you explain the rationale for selecting this geometry? What is the DEM resolution?*
Authors: The rationale behind defining the DAS geometry was guided by the aim to record dynamic strain changes along several directions. The Digital Surface Model has a resolution of 2 m (Palaseanu-Lovejoy et al., 2020).

Referee #2 (Other Questions): *Figure 2: I would suggest to avoid the use of jet colours for the colormap (https://gorelik.net/2020/08/17/what-is-the-biggest-problem-of-the-jet-and-rainbow-color-maps-and-why-is-it-not-as-evil-as-i-thought/).*
Authors: We prefer to not change the colormap.

Referee #2 (Other Questions): *I can't see the red line: 'DAS channel 501 (red line)'*
Authors: Thanks for noting this typo. There is no red line and we remove it in the caption.

Referee #2 (Other Questions): *Figure 4: you should again mention here what are the open circles and black lines*
Authors: We added the meaning of open circles and black lines.

Referee #2 (Other Questions): *Figure 6: the green color is very hard to see*
Authors: We changed the green color in dark green and increased the thickness of the lines.

Referee #2 (Other Questions): *Figure 7: any reason why there seems to be more scattering for some channels, e.g., 200? Any local amplification?*
Authors: Channel 200 is in coincidence with the first fault that the optic fibre cable crosses along its path. Therefore, the scattering is likely associated to this fault. To better read the data and results, we show the channel numbers at cable corners in Figure 3 and 4.

Referee #2 (Other Questions): *Figure 8: why are there some discrete lines around channels 600 and 300 for example?*
Authors: Around channel 600 and 300 the cable turns abruptly.

On the comparison of strain measurements from fibre optics with dense seismometer array at Etna volcano (Italy)

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Supplementary Information

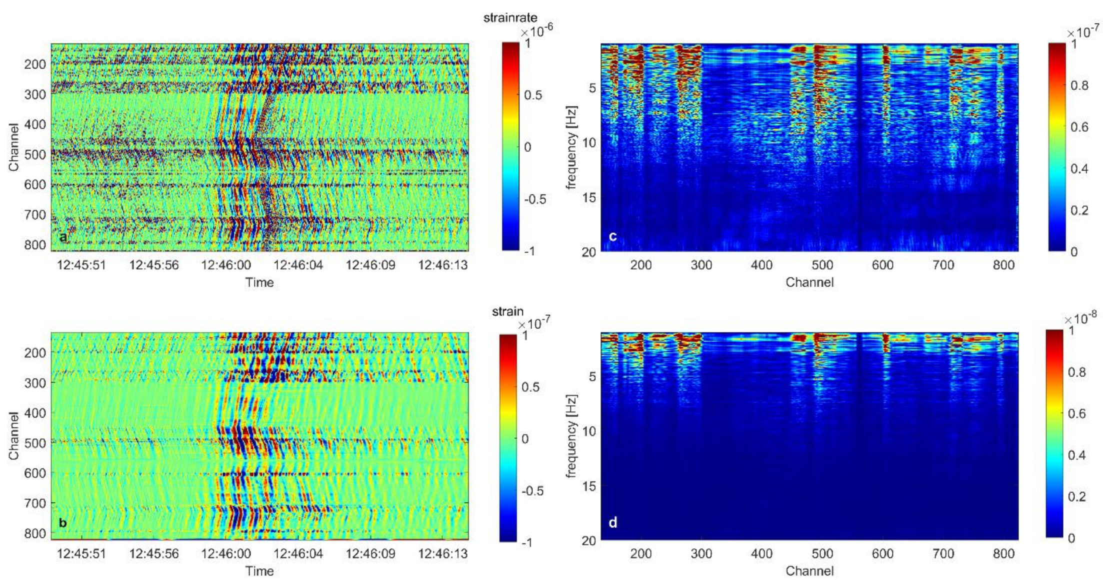

Figure S1: Time series (a, b) and spectra (c, d) during a small volcanic explosion (VE) at Etna on 6 July 2019. (a) Raw DAS strainrate; (b) strain computed by integrating over time the raw strainrate data; (c) spectra of the raw strainrate DAS records overall the channel; (d) spectra of strain records.

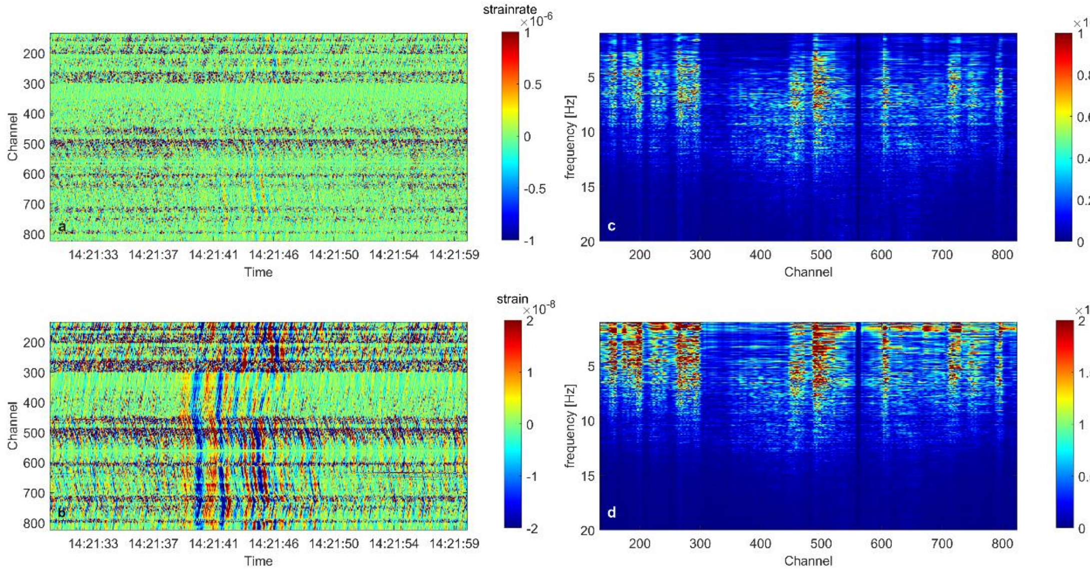

Figure S2: Time series (a, b) and spectra (c, d) during an LP event (LP) at Etna on 27 August 2019. (a) Raw DAS strainrate; (b) strain computed by integrating over time the raw strainrate data; (c) spectra of the raw strainrate DAS records overall the channel; (d) spectra of strain records.

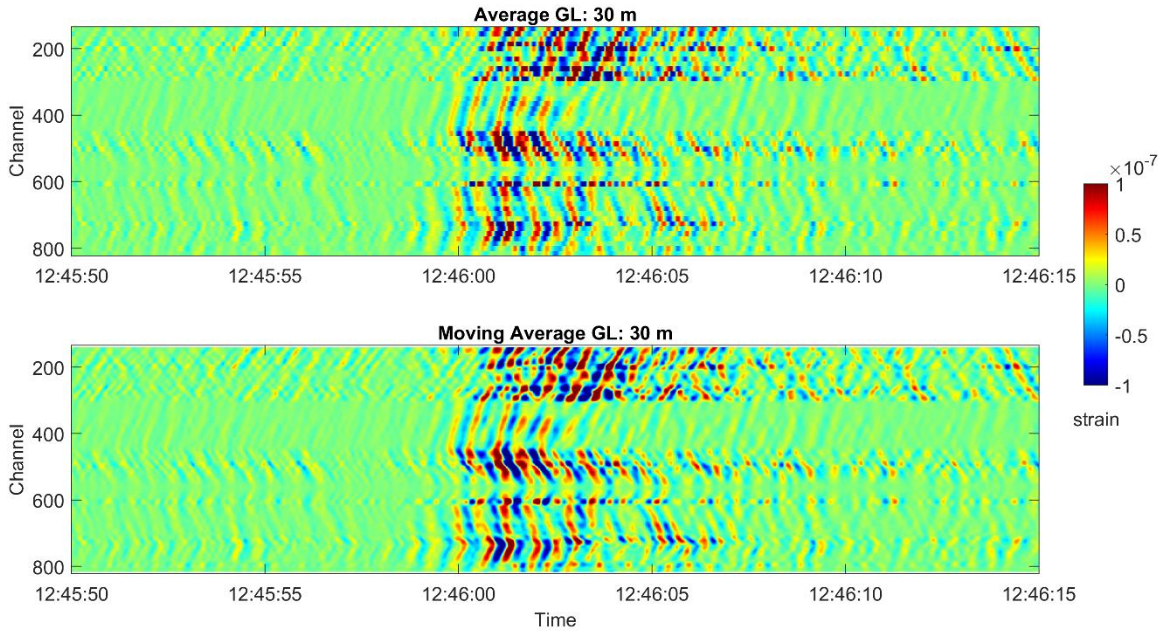

Figure S3: Strain data (volcanic explosion on 6 July 2019) after increasing the gauge length to 30 m. Two methods were used: (top) averaging the data every 15 channels (30 m); (bottom) averaging the data with a mobile mean over 15 channels with a shift of 1 channel.

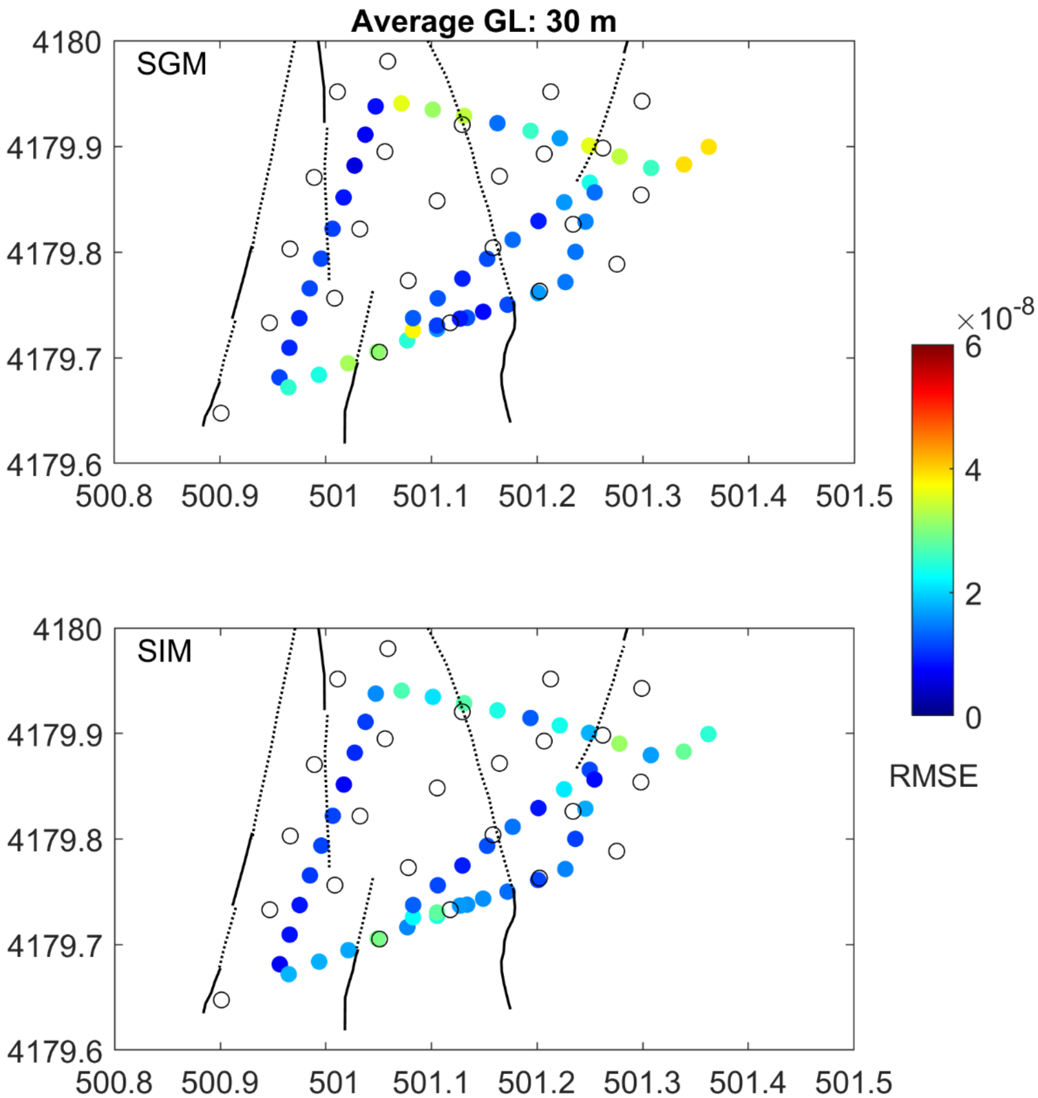

Figure S4: Misfits between the array derived strain and the DAS strain data (volcanic explosion on 6 July 2019) after increasing the gauge length to 30 m using a simple average.

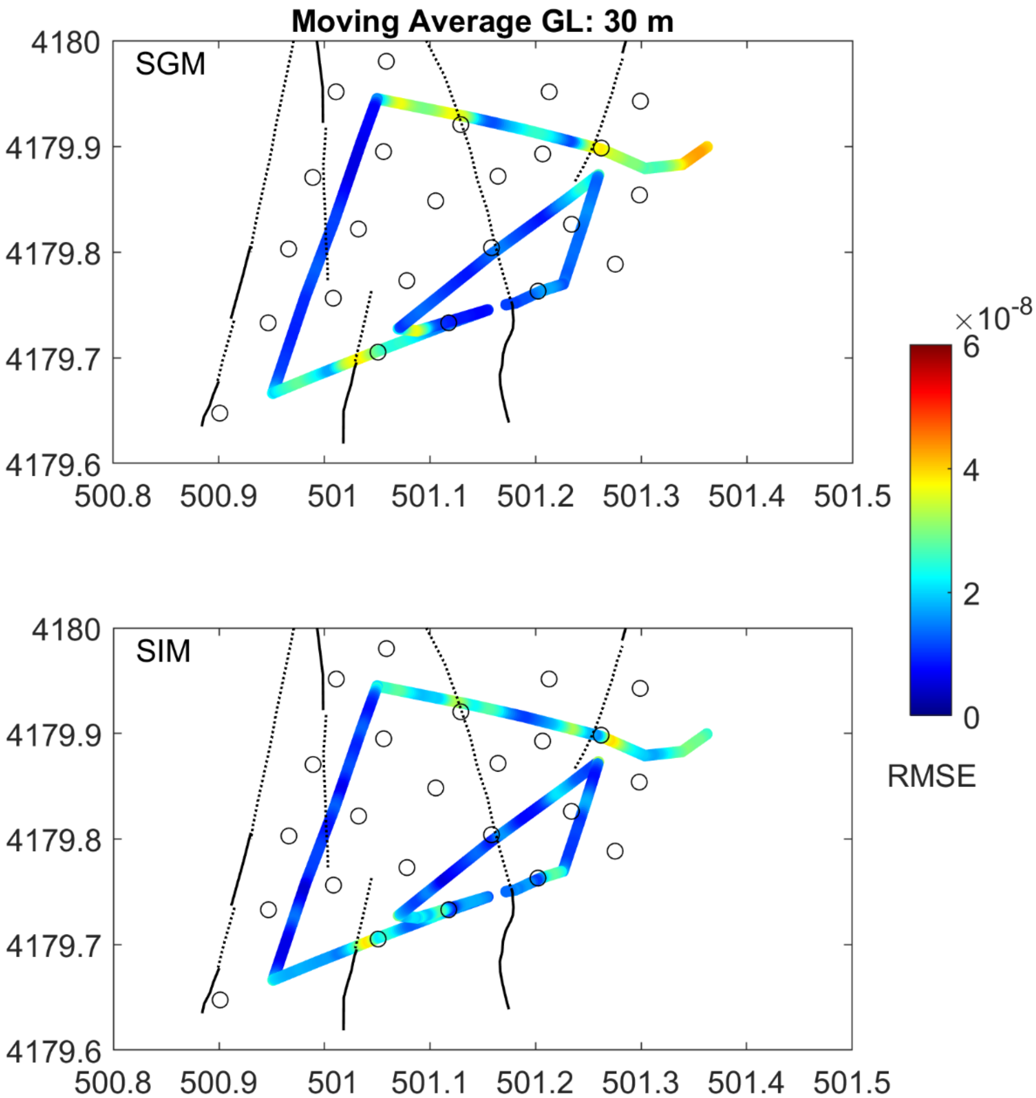

Figure S5: Misfits between the array derived strain and the DAS strain data (volcanic explosion on 6 July 2019) after increasing the gauge length to 30 m using a moving average.

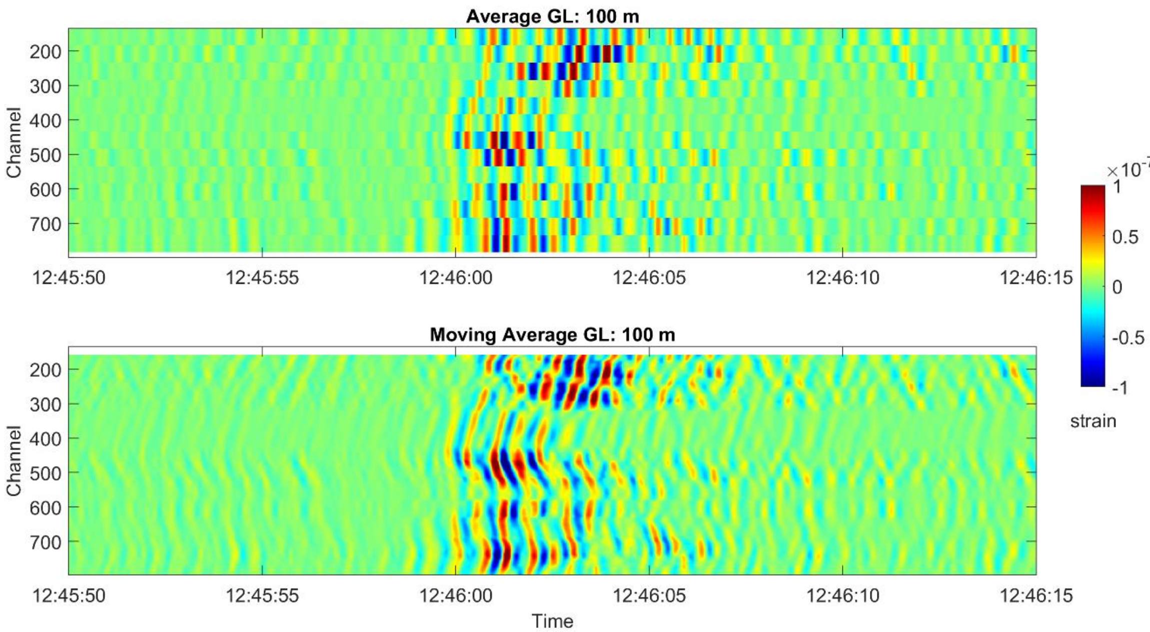

Figure S6: Strain data (volcanic explosion on 6 July 2019) after increasing the gauge length to 100 m. Two methods were used: (top) averaging the data every 50 channels (100 m); (bottom) averaging with a mobile mean over 50 channels with a shift of 1 channel.

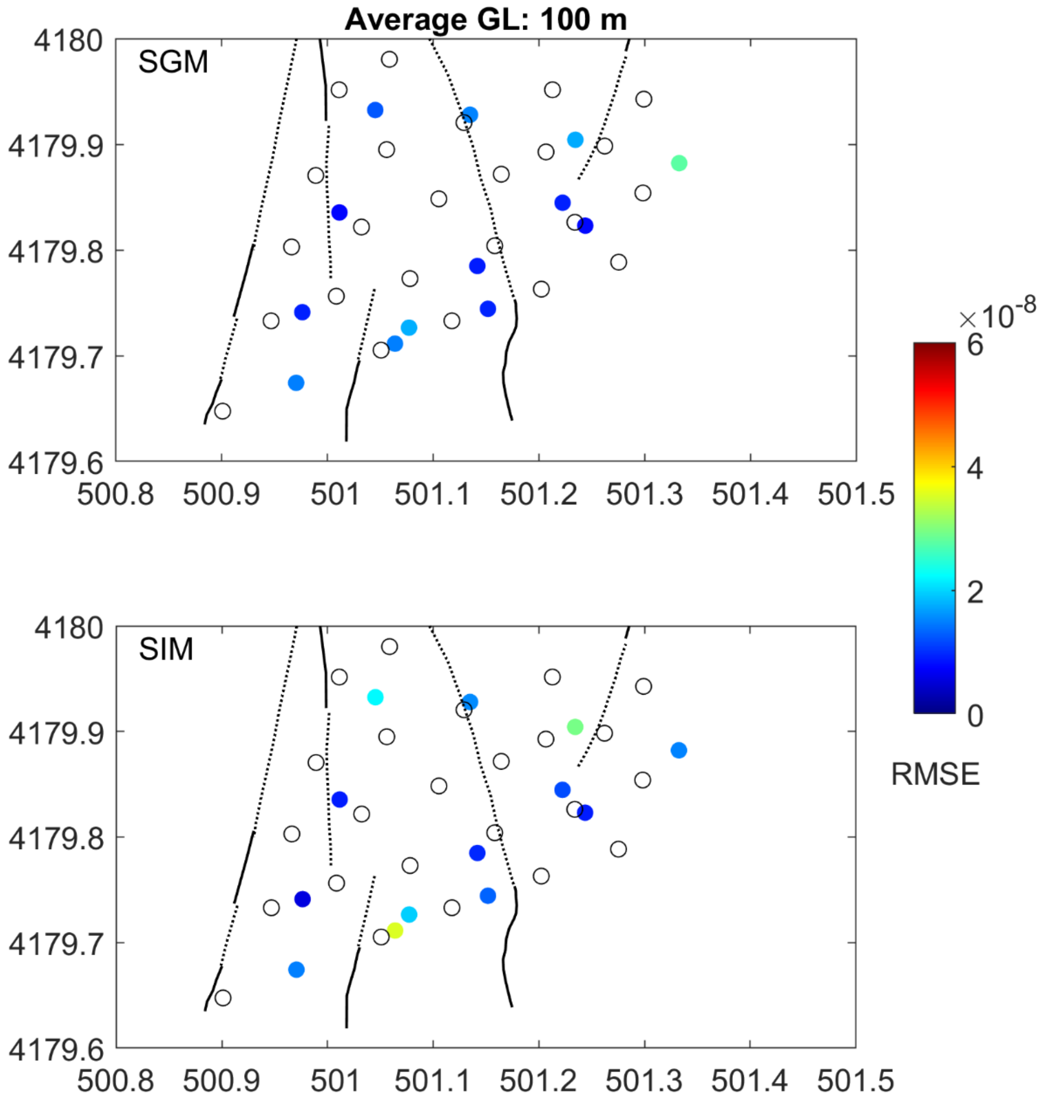

Figure S7: Misfits between the array derived strain and the DAS strain data (volcanic explosion on 6 July 2019) after increasing the gauge length to 100 m using a simple average.

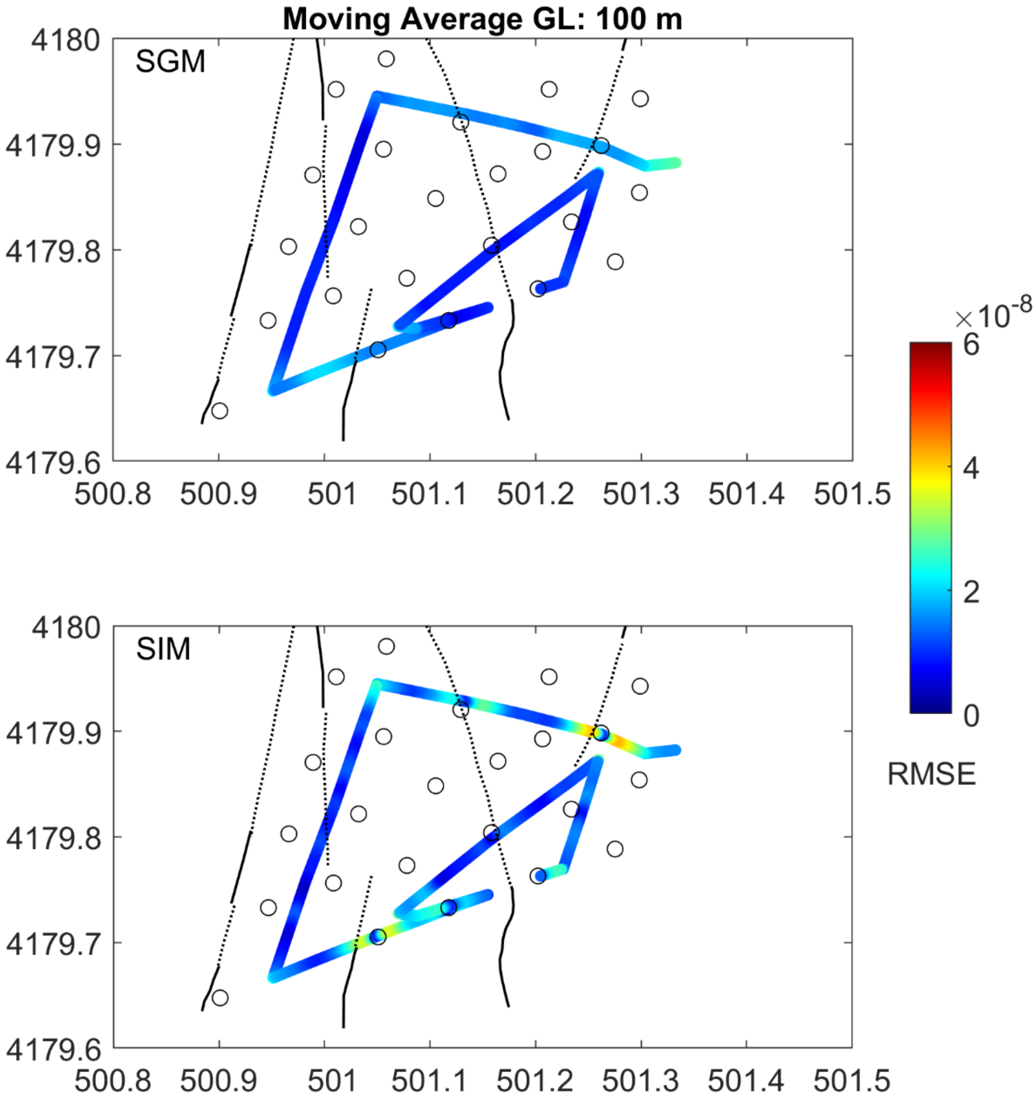

Figure S8: Misfits between the array derived strain and the DAS strain data (volcanic explosion on 6 July 2019) after increasing the gauge length to 100 m using a moving average.