Solid Earth Discussions

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Comment on se-2020-219

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Referee comment on "Strain to ground motion conversion of distributed acoustic sensing data for earthquake magnitude and stress drop determination" by Itzhak Lior et al., Solid Earth Discuss., https://doi.org/10.5194/se-2020-219-RC1, 2021

Dear authors,

I've had the chance to read manuscript SE-2020-0219, entitled "Strain to Ground Motion Conversion of DAS Data for Earthquake Magnitude and Stress Drop Determination." I found the seismological applications very interesting and exploring uncharted territory. This paper should undoubtedly be published, but I think some components of the velocity estimation part can be improved. I will give some general comments in the following paragraphs and will be happy, if needed, to give the paper a final read for minor comments after you address these issues.

First, I have to admit that I found the semblance part slightly confusing. Traditionally, semblance is applied on seismic traces – physical measurements with real values. You use an extension to the complex domain, but it is quite unclear because, in Equation 2, h(t) is first defined as the complex portion of the signal and then as its Hilbert transform. If I understood correctly, you are using the signal envelope (i.e., the absolute value of the Hilbert, hence a real argument), so I do not see why the extended semblance is needed. Besides, the discussion about the choice of estimation window is very important, but I think you missed the temporal element. Semblance, at least in the context of seismic exploration, is usually applied over a temporal window. While sample-by-sample semblance is relatively noisy, SNR and resolution can be improved by computing the windowed semblance over a time period that matches the seismic wavelet (or half-wavelet, if you are using the signal instead of its envelope). Finally, I wonder if applying a semblance threshold would be useful for cases in which a certain phase is invisible due to the DAS directivity, such as the P-wave in your synthetic example.

I suspect that dispersion effects should be considered during the phase velocity estimation beyond the discussion's few sentences. You filter the signal to the frequency band of interest and estimate a single phase velocity for all frequencies in that band. It is clearly worth verifying if applying the same slant-stack procedure to signals filtered at different frequency bands will yield different phase velocities, at least for the Scholte waves in the synthetic part. If so, you may be able to reconstruct ground motion more accurately by scaling each frequency component with a different phase velocity and hopefully reduce the discrepancy in the later parts of your signal. Park (1999) has a great example of this procedure for Rayleigh waves, but the idea is the same (*Multichannel analysis of surface waves, Geophysics*).

I also think that the comparison to the alternative approach is slightly unfair. Scaling with a constant slowness is an unrealistically bad option, especially for the field data – a phase velocity of 400 m/s for body waves! The naïve but more reasonable alternative would be to apply this conversion in the FK domain. Since it is straightforward to implement, I recommend using it as a baseline for your comparisons. You will certainly need relatively large windows, but it is still much better than a constant slowness. I first emphasize this point because, strictly speaking, you do not need to estimate the different phases' velocities except as a scaling factor. Therefore, the delicate interpretation that you correctly mention in the introduction can be skipped. Second, even a constant slowness is not terrible from a source inversion standpoint, so I wonder how the FK alternative approach will perform.

The paper also does not address fiber coupling issues, which are the main drawback in using DAS data acquired from existing cables. I wonder if the first arrivals from known, distant sources, can be used to "track" fiber coupling, as their changes along the array should be quite gradual. It is also worth mentioning, in my opinion, that your scaling accuracy depends on the geometry of the problem. Not only some phases will be weaker because of DAS directivity, but their scaling will also be noisier (as happens with the synthetic P-wave). Along that line, it would be useful to see a map of the earthquakes you used and not only a distance-depth plot, along with some coarse explanation of the apparent velocities you observe.

Finally, a visual comment - in many figures (2-d, 3-b, 8-d, 10), some elements are practically invisible in the legend and hard to see in the plot. Please edit them. In Figure 9, I couldn’t understand which symbols represent a constant slowness.

Thank you again for the interesting read. Stay safe and all the best!

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