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Interactive comment on "Improving quality of empirical Greens functions, obtained by cross-correlation of high-frequency ambient seismic noise" *by* Nikita Afonin et al.

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Please see below the comment to the manuscript about method for retrieval of Green's function (GF) with high S/N ratio in selected time window. The review is submitted as Short Comment to online discussion: https://www.solid-earth-discuss.net/se-2019-29/.

This post is encouraged by one of the comments of the Anonymous Refree #1 suggesting to focus on the originality of proposed ambient-noise processing technique. In this paper authors propose a method to retrieve improved version of Green's function between receiver pairs and apply it on two different datasets. The paper is enjoyable to read and seems like a great case study.

The method is based on rejecting cross-correlation functions which after stacking do not increase the S/N ratio in the time window related to arrivals of the desired phases. The S/N ratio in this method is calculated according to equation 1 (Page 3), and generally is obtained by dividing the maximum amplitude in time interval of expected arrival by the summed amplitudes in the remaining part of CCF. If adding the CCF does not increase the S/N ratio, then it is rejected.

Generally all methods basing on S/N criteria are robust and effective, and they are commonly used as part of ambient-noise processing workflows. The main issue of 'S/N ratio stacking' proposed here is that the method seems to be not novel. To give some examples please see the papers by Olivier et al. (2015) and Nakata et al. (2015). Both papers describe the process of extracting body-waves form ambient noise and both apply S/N ratio based method as one of the steps in processing workflow.

Olivier et al. (2015) designs the selective stacking algorithm for enhancing the S-wave arrivals recorded with array of receivers in the underground mine. In their method the root-mean-square value (RMS) of the signal in the lag-time window of the correlation function around the expected arrival times of the S-waves is divided by the RMS of the signal in the time window of coda waves. It is practically the same method, just instead of maximum amplitude authors use rms.

Nakata et al. (2015) as part of his ambient-noise processing designs two different S/N ratio based techniques. First one is more elaborate, so please see the mentioned publication. The second one is (direct citation from paper): "To confirm that we can successfully isolate the traces with strong body wave energy with the second correlation, we compute SNR, which is defined as the average RMS amplitudes between 1.3 and 1.9 s divided by the average RMS amplitudes between 0.0 and 4.5 s." – again please note the striking similarity of the method.

It is important to note that the two above techniques were just one step of the more elaborated processing workflows, and both of the mentioned papers included also extensive synthetic tests and applications of tomography.

Second part of comment is related to the line 15 (Page 2) in the discussion manuscript where authors provide their definition of 'coherent' term. According to this definition the two EGFs are coherent if their maxima fall in the same time window (appear at the same time-lag). While, this definition of coherence is comfortable in terms of improving Green's function it might not necessarily be correct for the field applications.

In lines 25-30 (Page 2) Authors argue that stacking only EGFs with which increase S/N ratio given in equation 1, does automatically increase the coherency. This is true, but only for the specific definition of coherency given in this manuscript, which however does not relate to retrieval of correctly estimated Green's function, which needs source in the stationary phase areas. In line 10 (page 2) authors indeed comment that its important to use systems which allows to estimate the azimuth distribution of noise sources (to increase a chance of capturing the sources in stationary phase areas), yet this comment does not suffice to make a method feasible for improved processing, as usually the exact distribution of sources is not known. In such cases, specific methods can be used for estimation these azimuths (like beamforming etc.), yet when this directional analysis is already done, then it is enough just to stack these sources. After this, any measure of the increase of amplitude in expected time window becomes trivial task.

Generally it is reasonable to measure the EGF using coherency because it will, in ideal situation, selectively correct virtual traces which contribute to the stack. However, using S/N ratio in selected time windows might not be necessarily correct, as the source we are stacking might be located in non-stationary phase areas. In other words, the maximum amplitude we eventually get, may not mean we stack sources related to the stationary phases (which depends on the source-receiver configuration).

Second issue related to possibly biased coherency improvement is related to the division in equation 1. The coherency improvement is theoretically assured if S/N ratio calculated from equation 1 is increasing. This might not be necessarily true, e.g., if coda wave part gets smaller (the denominator in equation 1) the S/N also increases, and again it means that source contributing to desired time-windows might be not related to the stationary region.

Thanks for reading and looking forward to your reply.

Kind regards, Michal Chamarczuk

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