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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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Anonymous Referee #1

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Referee: This paper proposes an improvement to the method of Green's function retrieval from ambient noise by cross-correlation. A specific stacking method is proposed which discards partial correlation results that are not coherent with the average correlation result. After applying an iterative procedure, a correlation function is obtained with a higher signal-to-noise ratio than the ones obtained by other stacking methods.

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Discussion paper

The method is illustrated with two preliminary field data examples. The authors discuss the advantages and limitations of the method. This reviewer is familiar with the theory of Green's function retrieval but does not have a broad overview of the many processing methods that have been developed. Therefore it is difficult to judge the originality of the proposed method. I recommend that the paper be reviewed at least by one additional reviewer, who is more experienced with the practical aspects of Green's function retrieval. Assuming the proposed method is original, I recommend publication after moderate revision, taking the following comments into account: âĂć I wonder why the authors call their method "signal-to-noise ratio (SNR) stacking". Aren't all stacking methods aiming to improve the SNR? The proposed method stands out because it discards incoherent correlation results. Please consider a new name, which better matches the specific aspects of the proposed method. For example: "Coherent stacking"? "Coherent cross-correlation stacking"?

Authors: We agree that all stacking methods aim to increase SNR of evaluated EGF. Nevertheless, we call the method "SNR-stacking", because of using "signal-to-noise ratio" as a parameter that is optimized in our suggested algorithm. The methods perform global optimization search by retrieving EGF with the highest SNR. Using other terms like "coherence", in our opinion, may mislead readers because we use this term only in order to shorten the description of the method. Our definition of the term "coherence" is defined in the Introduction part of the manuscript.

Referee: âĂć On page 2 the authors mention that they want to use high-frequency surface waves to extract information about deep structures. This sounds as a contradiction. Surface waves do not penetrate deep into the subsurface, and using high frequencies makes it even more difficult to reach deep structures. Please be quantitative about the depths that need to be reached.

Authors: The sentence with the description of the depth of investigation has been corrected as proposed by Referee.

Referee: âĂć Page 3, line 2. The introduction of _te via the inequality is confusing. Is _te the time-lag interval, or is the inequality ôĂĂĂtds < _te < tds the time-lag interval (as actually stated in line 2)? If _te is the time-lag interval (as stated in line 7), what does it mean that it can take a negative value (as stated in line 2)? Please explain.

Authors: This was a mistake in the definition. The _te is time lag, not time lag interval. An additional explanation has been added to the text. Our algorithm is based on global optimization trying to optimize the SNR and we are calculating the SNR as a function of time lag that is variable and also other variables such as initial function number etc.) with the expected signal. In most cases, we do not know the azimuthal distribution of noise sources. That is why we need to consider both casual (positive time lags) and acasual (negative time lags) parts of crosscorrelation functions. In this case, we use the time interval with zero point at _te with a width of two periods of expected signal.

Referee: âĂć Explain abbreviations, such as MEMS and BB sensors.

Authors: MEMS – microelectromechanical system. BB – broadband. The explanation has been added to the text.

Referee: âĂć Mention the area of the experiments in all figure captions (Fig1: Pyhäsalmi mine area, Fig2: Kuusamo Greenstone Belt area, etc.).

Authors: Figure captions are corrected as proposed.

Referee: âĂć Figure 6a: I am surprised that the time-shift of the peak appears almost at t=0. Why don't you show a more representative example with a time-shifted peak, corresponding to well-separated receivers?

Authors: On figure 6 we show differences in signal-to-noise ratio for EGFs, obtained by different methods of stacking. In this case, the time lag, which corresponds to signal, is small compared to the length of noise wavetrain, and on the figure it looks like zero-lag. Nevertheless, for illustration of the quality of EGF obtained, it is necessary to show the whole time interval that was used for calculation of noise level. It seems for us, that for

visualisation of signal-to-noise ratio improvement it is better to use a large time window, in which the difference between noise and signal is seen better.

Referee: âĂć Figures 6b and 6c: I think these figures (or the corresponding captions) should be interchanged: the SNR in 6b looks better than that in 6c, but the captions say the opposite.

Authors: This was a typo and it has been corrected.

Referee: âĂć Figure 7. The SNR of the proposed method converges to 40. However, according to the caption of fig 6a the SNR equals 71. Please explain. Are these different experiments?

Authors: This was a typo and it has been corrected.

Referee: âĂć Figs 9 and 10 show only some preliminary results of the method for both regions. These figures show that Green's functions can be retrieved and the derived velocities seem to be in agreement with earlier derived results. I would have liked to see more discussion on what can be done with these results (or do we need more data before useful inferences about the area of investigation can drawn?)

Authors: Extracted empirical Greens functions can be processed by the same techniques as a signal from a controlled source. Further processing of the signal (EGF in our case) is simpler if the signal-to-noise ratio is relatively higher. The goal of our paper is to describe a method for improving EGFs quality and its possibilities. We plan to use the method with the data of other experiments, with a larger number of sensors.

Referee: âĂć Last but not least, the paper needs significant language editing! Authors: We are very thankful to the reviewer for this comment and additional text editing was done.

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