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THE WEIGHTED RMS STACKING TO RETRIEVE EMPIRICAL GREEN 'S FUNCTIONS FROM AMBIENT SEISMIC NOISE

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The ambient seismic noise correlation technique has become a standard method to extract empirical Green's functions (here after EGFs) when the noise sources distribution are considered uniform around the station pairs. Nemours studies (Shapiro et al., 2005; Stehly et al., 2006) have exploited this method for subsurface imaging and monitoring. In fact, the distribution of noise sources in the Earth would be not ideal (homogeneous and isotropic) around the station pairs. In this way, the signals generated by the noise sources in the stationary area will be constructively contributed and in the non-stationary area will be destructive interference within retrieving EGFs (e.g., Snieder and SensSchoenfelder 2015). In this study, we considered estimating effect of the noise source distributions on retrieved EGF signals. In this regard, we present Weighted RMS stacking method (hereafter WRMS) to alleviate non-uniform energy distribution and normalize the flow of energy which comes from a specific direction. The study area is located in the northwest of Iran (Figure 1-a). After the preparation of the seismic recorded data (segmentation, removing mean and trend, normalization in the time and frequency domain, band pass filtering), the prepared data were cross-correlated between all available station pairs. In the stacking process, the Root-Mean-Square (RMS) values are calculated in signal, noise and zero lag windows associated to each positive and negative elapse-time sides of noise correlation functions (hereafter NCFS). It should be not that, the term signal window refers to a window around the expected arrival time of the fundamental mode Rayleigh wave at a given period as shown in top panel of Figure 1-b. Afterwards, NCFs associated with stationary source were selected based on the simple constrain (Equation 1) in positive and negative elapse-time sides for each interstation, individually.

$$RMS_{signal\_window} / RMS_{zero\_lag\_window} \geq 1 \quad \& \quad RMS_{signal\_window} / RMS_{noise\_window} \geq 1 \qquad (1)$$

These NCFs are directly contributed in WRMS stacking procedure for each station pairs. In brief, emitted signals from the stationary zone have the main contribution in retrieving EGF signal, and emitted signals from the non-stationary zone are rejected by this constrain. In addition to the non-symmetric signals, energy and number of repetition of the stationary sources affect extracted EGFs. In order to prevent this effect, each NCF signal should be normalized to energy and number of repetition as below.

$$EGF \equiv \frac{RMS \cdot C}{n_{new}} \left\{ \frac{1}{rms_1 \cdot c_1} CCF_1 + \frac{1}{rms_2 \cdot c_2} CCF_2 + \cdots + \frac{1}{rms_{n_{new}} \cdot c_{n_{new}}} CCF_{n_{new}} \right\} \qquad (2)$$

where $RMS \cdot C = \sum_{i=1}^{n_{new}} \sum_{l=1}^{\eta} \sum_{k=1}^{m_{new}} rms_{il} \cdot c_i$. For this normalization, we define a time window with a fix length (half of the maximum period). By moving this window (Ω in Figure 1-c) within the signal window, we will eliminate the effect of the stationary noise source repetitions. Also, the RMS value corresponding to each envelope can present the energy of station source or a set of sources. Finally these selected NCFs were linearity stacked based on WRMS stacking method.

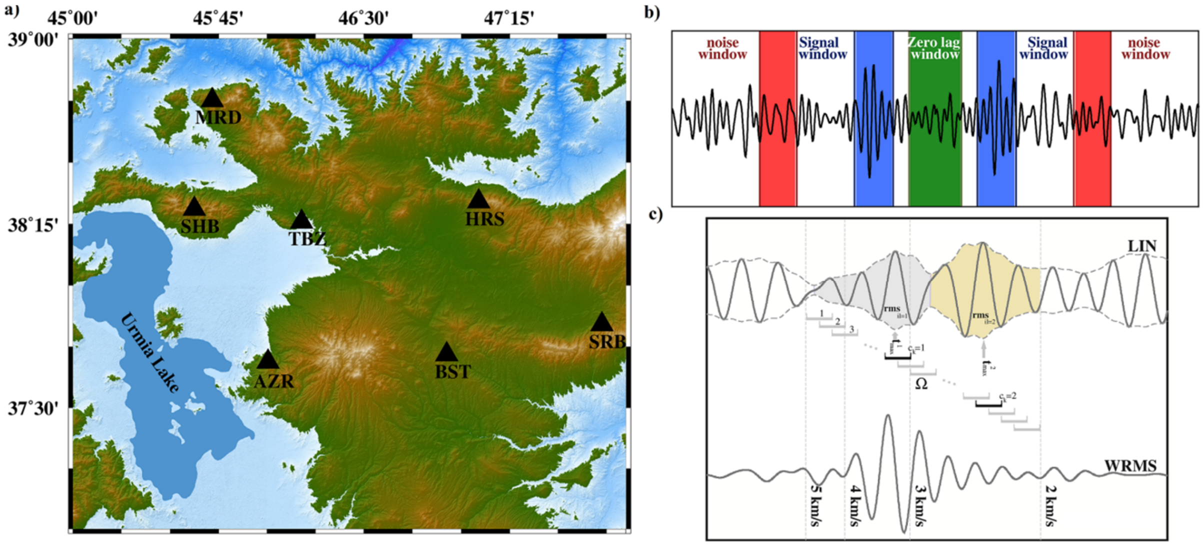

Figure 1. (a) The study area and stations with interstation distances ranging between 47 and 198 km. (b) The green, blue and red windows illustrate the location of zero lag and signal and noise windows in positive and negative time lags respectively. (c) The signal's envelope and fixed length window (Ω) depict by dotted gray lines and gray brackets, respectively. The EGFs retrieved from Linear (LIN) and WRMS stacking methods depicted in top and bottom trace respectively.

Moreover, during the stacking process, after stacking each time window EGF, the RMS value of the signal (within the signal window) should be increased to select coherent NCF signals. Otherwise, the corresponding NCF signal is rejected from the stacking process. This constraint ensures that the measurement results agree with one another (or selecting coherent signals). This condition (stacking non-consecutive signal window) leads to the enhancement of the signal-to-noise ratio (hereafter SNR) of the obtained signals (Safarkhani and Shirzad, 2019). For instance, Figure 1-c, represents the comparison between EGF signals extracted by Linear (LIN) and WRMS stacking method. Because of sequential stacking of all NCFs, the LIN method retrieves a signal with low SNR. Our results indicate that WRMS method tackles problem including low SNR value. In brief, NCFs selection based on special conditions before and during the stacking procedure is caused to obtain stable and reliable EGFs using WRMS stacking method.

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