

EGU2020-7832

<https://doi.org/10.5194/egusphere-egu2020-7832>

EGU General Assembly 2020

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## Optimal processing and unphysical effects in seismic noise correlations

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A wide spectrum of processing schemes is commonly applied during the calculation of seismic noise correlations. This is intended to suppress large-amplitude transient and monochromatic signals, to accelerate convergence of the correlation process, or to modify raw correlations into more plausible approximations of inter-station Green's functions. Many processing schemes, such as one-bit normalisation or various non-linear normalizations, clearly break the linear physics of seismic wave propagation. This naturally raises the question: To what extent are the resulting noise correlations physically meaningful quantities?

In this contribution, we rigorously demonstrate that most commonly applied processing methods introduce an unphysical component into noise correlations. This affects noise correlation amplitudes but also, to a lesser extent, time-dependent phase information. The profound consequences are that most processed correlations cannot be entirely explained by any combination of Earth structure and noise sources, and that inversion results may thus be polluted.

The positive component of our analysis is a new class of processing schemes that are optimal in the sense of (1) completely avoiding the unphysical component, while (2) closely approximating the desirable effects of conventional processing schemes. The optimal schemes can be derived purely on the basis of observed noise, without any knowledge of or assumptions on the nature of noise sources.

In addition to the theoretical analysis, we present illustrative real-data examples from the Irish National Seismic Network and the Lost Hills array in Central California. This includes a quantification of potential artifacts that arise when mapping unphysical traveltimes and amplitude variations into images of seismic velocities or attenuation.