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Seismic wavefield polarization: a study of spatial coherency within the LSBB 3-component broadband array to extract seismic phases

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In seismology, the key to interpreting data is wavefield characterization independent from the nature of the wavefield whether it is seismogram from earthquake or seismic noise from hydrocarbon production or ocean swell. The seismic wavefield is a combination of polarized waves. These waves are characterized not only by their propagation properties (i.e. velocity and direction of propagation) but also by the local particle motion trajectories they generate. These particle motion trajectories are the polarization properties of the waves and play a large part in identifying and extracting the seismic phases. To study the polarization, 3-component data are required. The LSBB (Low Noise Underground Laboratory) 3-component seismic array offers the possibility to study the spatial coherency of polarization properties of propagating waves through the array.

An optimized time-frequency decomposition of the polarization properties, such as the ellipticity, the rectilinearity vector or the planarity vector, is done for each station of the array by approximating each time-frequency contribution by an elliptical motion lying in a plane in the 3D space. By assuming coherent polarization properties for plane waves propagating through a seismic array, these properties' spatial coherency could be integrated in advanced array processing techniques. Applied to teleseismic records, the study of the spatial coherency of the polarization yields three main results: (i) a very precise station orientation (lower than 1 degree) is required to observe a significant spatial coherency, (ii) a relative station orientation can be done by maximizing the spatial coherency of the polarization, and (iii) if the precision of the station orientation is sufficient, identifying seismic phases according to their coherent polarization parameters becomes possible.

This type of array polarization analysis can be performed as well on telesismic records as on seismic noise. Our first results demonstrate the possibility to extract coherent part of the microseismic noise using the polarization and can help understanding the structure of the microseismic noise.