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Body wave extraction by using sparsity-promoting time-frequency filtering

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Different phases of seismic waves generated by earthquakes carry considerable information about the subsurface structures as they propagate within the earth. Depending on the scope and objective of an investigation, various types of seismic phases are studied. Studying surface waves image shallow and large-scale subsurface features, while body waves provide high-resolution images at higher depths, which is otherwise impossible to be resolved by surface waves. The most challenging aspect of studying body waves is extracting low-amplitude P and S phases predominantly masked by high amplitude and low attenuation surface waves overlapping in time and frequency. Although body waves generally contain higher frequencies than surface waves, the overlapping frequency spectrum of body and surface waves limits the application of elementary signal processing methods such as conventional filtering. Advanced signal processing tools are required to work around this problem. Recently the Sparsity-Promoting Time-Frequency Filtering (SP-TFF) method was developed as a signal processing tool for discriminating between different phases of seismic waves based on their high-resolution polarization information in the Time-Frequency (TF)-domain (Mohammadigheymasi et al., 2022). The SP-TFF extracts different phases of seismic waves by incorporating this information and utilizing a combination of amplitude, directivity, and rectilinearity filters. This study implements SP-TFF by properly defining a filter combination set for specific extraction of body waves masked by high-amplitude surface waves. Synthetic and real data examinations for the source mechanism of the M_w=7.5 earthquake that occurred in November 2021 in Northern Peru and recorded by 58 stations of the United States National Seismic Network (USNSN) is conducted. The results show the remarkable performance of SP-TFF extracting P and SV phases on the vertical and radial components and SH phase on the transverse component masked by high amplitude Rayleigh and Love waves, respectively. A range of S/N levels is tested, indicating the algorithm's robustness at different noise levels. This research contributes to the FCT-funded SHAZAM (Ref. PTDC/CTA-GEO/31475/2017) and IDL (Ref. FCT/UIDB/50019/2020) projects. It also uses computational resources provided by C4G (Collaboratory for Geosciences) (Ref. PINFRA/22151/2016).

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