Improving the first-arrival waveform signals of wide-angle seismic data via a modified supervirtual refraction interferometry

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The first-arrivals of wide-angle seismic data are most commonly used in deep Earth studies. Increasing the signal-to-noise ratio (SNR) of the first-arrival waves at far offset can effectively improve the accuracy of tomographic velocity model building of deep Earth structures. The Supervirtual Refraction Interferometry (SRI) method enhances the refraction wave based on the principle of interference. It works well when the shots and receivers are closely spaced. However, when the SRI method is applied to any wide-angle seismic data with wide station spacing and under strong environmental noise, it cannot sufficiently enhance the refraction wave, and could create artifacts in the resulted waveforms. The resulting low-SNR refraction waves can hardly be picked by hand or computer-based programs.

To cope with this problem, we propose a modified supervirtual refraction interferometry based on stacking of neighboring virtual traces (SRI-SNV). Stacking of neighboring virtual traces can effectively increase the accuracy of the virtual traces, which is the cross-correlation between the far- and near-offset traces; hence increase the SNR of the first-arrival waves. We tested the new method by using synthetic and field Ocean Bottom Seismometer (OBS) datasets. Both types of tests indicate that the SRI-SNV method is able to accurately construct the virtual traces under the situation of wide station spacing and very low SNR, and the resulting refraction waveforms have better continuity and higher SNR than those based on the conventional SRI method. Using waveforms enhanced by the SRI-SNV, the first-arrival picking can achieve significantly higher accuracy than that using the SRI method. The SRISNV method can also enhance the SNR of the refraction waves of wide-angle seismic data with wide shot spacing. Based on our method more seismic first-arrivals can be picked on wideangle seismic data, so the seismic tomography can be expected to have denser raypath coverage in deep regions and hence will achieve higher precision for deep crustal studies.