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Imaging near-surface feature using cross-correlation analysis of multi-channel surface-wave data

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In this paper, we demonstrate that Common Receivers Location (CGX) cross-correlation gathers of multi-channel and multi-shot surface waves give accurate surface wave velocity perturbation estimation, and enable us to reconstruct two-dimensional (2D) velocity structures with high resolution, without the systematic calculation of surface wave dispersion like for spectral analysis of surface wave (SASW). Data acquisition for cross-correlation analysis is similar to acquisition for a 2D seismic reflection survey. Data processing seems similar to coda wave interferometry used for seismological data, but differs in that the cross-correlation of the original waveform is calculated on active seismic data. Data processing in cross-correlation analysis consists of the following three steps: First, cross-correlations are calculated for every traces of each shot gather on the whole seismic line with the same offset trace of a reference shot gather. Second, the maximum of the time-shifted cross-correlation gather is picked for different frequencies and traces having the same receiver location are averaged in order to calculate S-wave velocity (Vs) perturbation as described in the theory of coda wave interferometry. Finally, a 2D S-wave velocity profile is reconstructed, applying the lateral S-wave velocity perturbation to a homogeneous S-wave velocity profile obtained through inversion of the dispersion of the reference shot gather. Analyses of waveform data from numerical modelling and field observations indicate that the new method is valid and could greatly improve the accuracy and resolution of subsurface S-velocity structure, compared with conventional surface-wave methods.