Multi-mode surface wave phase speed distribution in North America

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The recent deployment of high-density broadband seismic networks in continental regions enables us to investigate the detailed seismic images of the continental upper mantle using seismic surface waves. Making the most of such seismic arrays, we have recently developed two-step array-based methods for (1) the multi-mode phase speed measurements based on a *f-k* analysis with a long-linear array, and (2) the modal waveform decomposition for the centroid location of array, based on the linear Radon transform (Matsuzawa & Yoshizawa, GJI, 2019). Such array-based multi-mode phase speed measurements are expected to be of help in enhancing the vertical resolution of 3-D S-wave speed models.

We applied the method (1) to an extensive data set from the Transportable Array stations of USArray, and mapped phase speed distributions in North America (Matsuzawa & Yoshizawa, AGU Fall Meeting 2018). We could obtain preliminary phase speed maps of the fundamental-mode and the first four higher-mode surface waves. Although the large-scale anomalies (i.e., fast phase speeds in cratons in the stable eastern US., slow phase speeds in the tectonically active western US.) could be identified, the lateral resolution of the phase speed maps was limited, compared with earlier tomography models using inter-station and single-station measurements. This suggests that the small-scale tectonic features tend to be blurred and averaged out due to the long linear array (2000–4000 km).

To overcome this problem, we apply the inter-station dispersion analysis (Hamada & Yoshizawa, GJI, 2015) and the eikonal tomography method (Lin *et al.*, GJI, 2009) to the decomposed modal waveforms of the fundamental-mode derived from the method (2). In the eikonal tomography, the phase speed distributions can be retrieved by calculating the gradient of the phase traveltime field without any inversion processes.

The resultant fundamental-mode phase speed maps of Rayleigh and Love waves exhibit enhanced lateral resolution, showing some small-scale tectonic features in the inland of the US. The results indicate that the decomposed modal waveforms at the centroid of the linear array represent the average phase speeds in a relatively small area of several-hundred kilometers, which is equivalent to the wavelength of the fundamental-mode surface waves. Such decomposed fundamental-mode seismograms can be further used to enhance the quality of higher-mode measurements through the mode-stripping of the fundamental-mode from the observed seismogram.

Keywords: surface wave, higher mode, tomography, array-based analysis

