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Full Waveform Seismic Inversion for the Japan Region

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We present a seismic tomography model for the Japan archipelago obtained using full waveform inversion and adjoint methods. A high-resolution seismic velocity model is essential for Japan as means to comprehend and characterize the complexity of the tectonic setting, and to further our understanding of earthquake sources and rupture propagation.

The study area covers the Japanese islands – an area between 20°-50°N and 130°-160°E – and extends to a maximum depth of 500 km. In virtue of complicated tectonics and resulting high seismicity, dense seismic networks are present in Japan and surrounding countries. We make use of broadband data from three networks – F-net in Japan, BATS in Taiwan, and notably, the National Earthquake Network in South Korea. Due to access difficulties, data from this network had not been used in the preceding tomographic study of the same area. We use >50 carefully selected earthquakes, located within the model area and occurring between 1999 and the present. Magnitudes of the events are restricted to $5 \leq Mw \leq 6.9$ for a point source approximation to be valid. A spectral-element method is used for forward waveform calculation, which comes with the geometric flexibility of finite-elements method and the accuracy of spectral methods. To quantify differences between the observed and synthetic waveforms, we use time-frequency misfits, which exploit the evolution of the frequency content of the data in time. The sensitivities (Fréchet kernels) are then calculated using adjoint methods. The employed methodology allows us to explain the data of dominant period as low as 10 s. To prevent possible over-fitting of the data, we ensure that final misfits are not lower than those obtained if additional (not yet used) data are incorporated.

The final results of this study will contribute to the 'Comprehensive Earth Model' being developed by the Computational Seismology group at ETH, with the aim to represent the snapshot of the current knowledge of the Earth's internal visco-elastic structure.