Towards continuous seismic imaging from offshore to land along the Japan trench: effects of offshore structures (sediment layers and lateral heterogeneities)

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Kim et al. (2019, AGU) have reported receiver function common conversion point (CCP) stacking image from ocean to land beneath Japan by collecting data from the land seismometers and the ocean bottom seismometers (OBSs). OBSs lie on thick (few kilometers) and low velocity (Vp ~2 km/s) sediments along the Japan trench (e.g., Nakamura et al. 2014, Takahashi et al. 2004). The sediment layer makes a time delay of energy arrivals between the vertical component and the horizontal component upon an incident teleseismic P wave, which is measurable. The continuous image was made by correcting the time delay of the image from the OBS records. However, there are two more issues left to be understood toward continuous seismic imaging. First is the amplitude affected by the seafloor sediment. The second is the lateral heterogeneities offshore that deviate from the land 1D velocity.

The receiver function CCP stacking imaging with OBS show amplitudes larger (~ 5 times stronger) than those with the land seismometers (Kim et al. 2019, AGU). The amplification due to sediments may cause bias in the interpretation of the deeper structure phase amplitudes unless properly separated. We examined various sediment models to understand and retrieve the large amplitude scale observed in the OBS CCP stacking image. The amplification of the converted phases at the vicinity of the slab top is insufficient to explain with single-layered sediment. Preliminary results show that a very-low shear wave velocity thin layer on the top of the sedimentary layers increases the overall amplitude of the phases in the receiver functions.

The offshore region of the Japan trench has a heterogeneous velocity structure (Matsubara et al. 2019, Intech Open). Due to the ~10 % velocity perturbation existing in tomography models offshore and the systematic difference along subduction direction, an approximation of the structure as a 1D velocity model cannot be held. The different velocity models utilized in offshore receiver function migration affect the connectivity of the slab structure along the dipping direction of the slab. Comparisons of the travel times between the 3D structure from tomography (Matsubara et al. 2019) and various 1D velocity profiles are tested. For instance, using the JMA model for migrating the receiver functions from OBS data makes the image stretch to deeper depths whereas structures from active source experiments are limited to a certain profile. The comparisons show that using a station-wise 1D velocity showed a good approximation of the 3D structure for migration.

The two effects of offshore structures (sediment layers and lateral heterogeneities) done in this work are essential components for continuous seismic imaging from offshore to land, which will enable imaging along the entire Japan trench.