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Estimation of Structure of the Shallow Low-Velocity Layer by High-Frequency (1-5Hz) Receiver Function Inversion

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In our previous study (Petukhin et al., 2001) we realized the importance of the low-velocity layer (LV, uppermost 3-5km) on estimation of the Q-value in the seismogenic zone (upper crust). Concretely, in the presence of sharp interface, for example between LV and upper crust, estimated Q-value can increase 2-3 times in comparison with result of inversion based on uniform velocity model, because of decreasing of the `geometrical spreading` term. To demonstrate this effect we calculated Q-value in the upper crust for three different piece-wise models of LV: (1) step-like model; (2) gradient model with velocity discontinuity; (3) gradient model without discontinuities. Model (1) has largest effect on estimation of Q-value and model (3) lowest.

To select acceptable model among these three models we applied the receiver function method to estimate structure of the LV. We expect that this method especially sensitive to the existence of the velocity discontinuity due to the Ps conversion at the discontinuity. The problem is that to estimate shallow velocity structure we need to use high-frequency seismic waves, which usually have large scattering. To avoid this problem we selected only records of close (10-30km) and shallow (8.5-16km) earthquakes. Data of the high-sensitivity network (HiNET) in Kinki region were used. We succeed to select such kind of data at 18 stations, and calculated empirical receiver functions for them using high-frequency cut-off at 4-5Hz. At some stations receiver functions had high level of noise before the P-arrival. We rejected stations with the noise level amplitude more than approximately 1/3 of the amplitude of receiver function after P-arrival. The rest 11 receiver functions we inverted for velocity structure using Genetic Algorithm.

Inversion results show that all three types of the velocity model can be valid: in 3 cases model (3) was preferable; in 2 cases we can select model (1) as the best; and in 4 cases model (2) with a velocity discontinuity at 3000-4000m depth was acceptable. In one case we didn't succeed to get good fitting. Figure 1 below shows examples of invertion result for each case. Although statistically we cannot say that model (2) is preferable (only 4 cases against 2 and 3), we could recommend this model for estimation of Q-value in low-seismicity regions, for example Chugoku and Northern Kinki regions, where direct estimation of the structure of LV using this method may be impossible.

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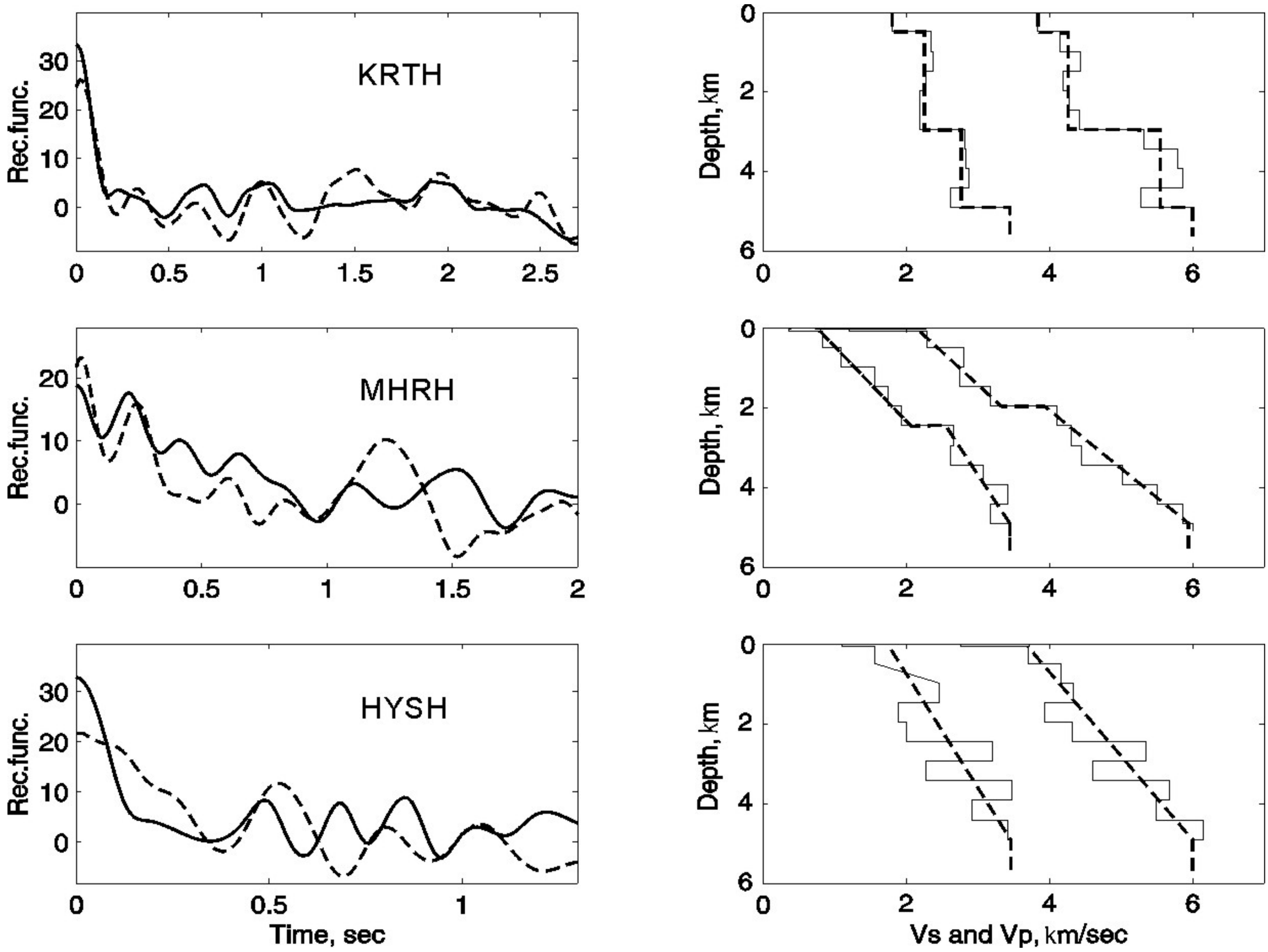
Figure 1. Examples of inversion result for three types of structure. Graphs in the left side show results of nonlinear fitting of observed (dashed line) and synthetic (solid line) receiver functions for stations KRTH, MHRH and HYSH. Graphs on the right side show inverted velocity models (thin solid line) and their piece-wise interpretation (dashed line). Result for station KRTH shows example of step-like model, for station MHRH - gradient model with discontinuity, and result for station HYSH shows example of gradient model.



KRTH
MHRH
HYSH
Rec.func.
Time, sec
Depth, km
Vs and Vp, km/sec