Depth dependent variances of P, S and S-P residuals

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Understanding of tomographic image in terms of dynamics of the Earth's interior requires knowledge of what causes lateral variation of seismic wave velocities. One of the most likely causes is lateral variation of temperature, and the other is heterogeneity in chemical composition. A measure of discriminating the temperature effect from the chemical effect or the phase change effect is the relative ratio of S to P velocities. In order to discuss the P to S velocity ratio in the mantle, however, the existing P and S models are in general too different in resolution and frequency band. Our strategy is to measure S-P differential travel times to use them as a constraint of three-dimensionally modelling of Vp/Vs variation in the mantle. Since the P and S seismograms in this case are those at the same station for the same earthquake, the S to P velocity ratios based on these measurements are free from the difficulties associated with those derived from the mutually independent P and S velocity models. The S-P differential travel times are also little affected by the uncertainty of origin time which is a serious problem in tomography.

There is, however, an inherent difficulty of identifying S wave arrivals by hand-picking, and waveform correlation is a method to solve this problem. With an assumption of a point source model, P and S waveforms at the source are identical so that S waveform can be synthesized from observed P waveform by correcting attenuation effect. We take into account the physical dispersion which is characterized by two parameters t* and fo. The reference frequency fo is set to 2 Hz according to Oki et. al., 2004 in which they carefully compared their hand-picked and cross-correlated S arrivals to find 2 Hz as the frequency bridging the two datasets consistently. For the value of t*, cross-correlation is made for the first half cycle of waveform to search the t* value which gives the maximum coefficient. Then S-P differential travel time is measured by cross-correlating synthetic and observed S waves. S travel times can also be derived by adding S-P times to hand-picked P times. Our method is justified for the consistency of measured travel times and those of AK135 [Kennett et. al., 1995] with the consistently derived source relocation of EHB data [Engdahl et. al., 1998].

We examined 2 years of broadband seismograms to derive P, S and S-P times. The P to S relative velocity ratio can be well approximated in terms of the ratio of P and S travel time residuals. Existing studies such as Bolton and Masters, 2001 or Robertson and Woodhouse, 1996 show the spherically averaged values of travel time residuals ratio at the turning depths to see gradual increase towards deep mantle. We calculated the spherically averaged variances of P, S and S-P data at the turning depths. Little variance is found for P data over the whole mantle but for the case of S and S-P data, significant variances at upper mantle is followed by relatively quiet range of mid mantle (1000 - 2000 km), then increase again towards deep mantle and ended in decreased value at the bottom.