Sequential seismic tomography: method and application to the Hidaka region

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Seismic traveltime tomography has been widely used for imaging velocity structures in the earth in various scales. In a technical point of view, there still remain several kinds of problems to be solved.

First, we need to calculate raypath and travel time as accurate as possible for many combinations of sources and receivers. Second, we have to solve an inverse problem in the form of a large and sparse matrix. For the first aspect of problems in tomography(i.e. ray tracing), we adopt the Huygens' method by Saito(2001). This method enables us to estimate travel time and ray path from a source to any point in a model space with reliable accuracy in short computation time. Moreover, this method can calculate travel time and ray path accurately even in a strongly heterogeneous medium without any significant increase of computations. For the second problem, that is, the problem related to the large and sparse matrix, we use the inversion scheme originally proposed by Rodgers(1976). With this method, we can solve the inverse problem sequentially as the number of available data increases. In contrast to the standard seismic tomography, our approach combining the Huygens' method with this inversion scheme enables us to solve a tomography problem in high stability and accuracy without the re-calculation for a new whole data set each time when an additional data set becomes available. Since the model is revised at each sequence of this inversion

scheme, we need only to perform one ray tracing for the additional data set (i.e. the single combination of a source and a receiver) in the updated model to get more accurate travel time and ray path with the Huygens' method. We call this method `sequential tomography method`. We show the validity of this method with several numerical tests for synthetic data. Then, we apply the method to the real observation data of the Hidaka region, southern Hokkaido, Japan, and compare our result with the other previous tomographic results. Our results share the common overall feature of other tomographic results such as Katsumata et al.(2002), but there are some differences in detail. Among them, a low velocity zone appearing only in our method is perticulaly important. This low velocity zone in the east of the Hidaka mountains at the 10km depth may correspond to the collision zone of the Northeastern Japan arc and the Kurile arc.