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Seismic imaging of Q structures by a trans-dimensional coda-wave analysis

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Wave scattering and intrinsic attenuation are important processes to describe incoherent and complex wave trains of high frequency seismic wave (>1Hz). The multiple lapse time window analysis (MLTWA) has been used to estimate scattering and intrinsic Q values by assuming constant Q in a study area (e.g., Hoshiba 1993). This study generalizes this MLTWA to estimate lateral variations of Q values under the Bayesian framework in dimension variable space. Study area is partitioned into small areas by means of the Voronoi tessellation. Scattering and intrinsic Q in each small area are constant. We define a misfit function for spatiotemporal variations of wave energy as with the original MLTWA, and maximize the posterior probability with changing not only Q values but the number and spatial layout of the Voronoi cells. This maximization is conducted by means of the reversible jump Markov chain Monte Carlo (rjMCMC) (Green 1995) since the number of unknown parameters (i.e. dimension of posterior probability) is variable. After a convergence to the maximum posterior, we estimate Q structures from the ensemble averages of MCMC samples around the maximum posterior probability. Synthetic tests showed stable reconstructions of input structures with reasonable error distributions. We applied this method for seismic waveform data recorded by ocean bottom seismograms at the outer-rise area off Tohoku, and estimated Q values at 4-8Hz, 8-16Hz and 16-32Hz. Intrinsic Q are nearly constant at all frequency bands, and scattering Q shows two distinct strong scattering regions at petit spot area and high seismicity area. These strong scattering are probably related to magma inclusions and fractured structure, respectively. Difference between these two areas becomes clear at high frequencies. It means that scale dependences of inhomogeneities or smaller scale inhomogeneity is important to discuss medium property and origins of structural variations. While the generalized MLTWA is based on a classical waveform modeling in constant Q medium, this method can be a fundamental basis for Q structure imaging in the crust.