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A Bayesian approach to spatial estimation of fluid content and geometry in the mantle wedge

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Recent development of seismic tomography enables us to image the detailed velocity structure in the mantle wedge beneath the Japanese islands (e.g. Nakajima et al., 2001). Nakajima et al. (2005) clarified the variations of porosity and pore geometry from the f reduction degree of Vp and Vs data sets in the mantle wedge of the NE Japan by using the unified formulation of the effect of fluid phase on the seismic velocity. However, it is difficult to image the spatial distributions of porosity and pore geometry because seismic velocity data always have error. In this study, we try to image the porosity and pore geometry by using the Markov random field model, which is a type of Bayesian stochastic method that is often applied to image analysis. The spatial continuity of porosity and pore geometry is incorporated by Gaussian Markov Chains as prior probabilities in order to apply the MRF model to our problem. The most probable estimation can be obtained by maximizing the posterior probability of the fluid distribution given the observed velocity structures. In the present study, the steepest descent method was implemented in order to maximize the posterior probability using the Markov chain Monte Carlo (MCMC) algorithm. First, synthetic inversion tests are conducted in order to investigate the effectiveness and validity of the proposed model. Then, we apply the model to the natural data sets of the seismic velocity structures in the mantle wedge (Matsubara et al. 2008), by assuming the physical properties other than porosity and pore geometry (i.e. temperature and type of fluid) are given. Finally, we discuss the validity of the assumption and our model.

Keywords: fluid, mantle wedge, Bayesian estimation