Seismic wave field imaging based on the replica exchange Monte Carlo

*Masayuki Kano[1], Hiromichi Nagao[1,2], Daichi Ishikawa[2], Shin'ichi Sakai[1], Shigeki Nakagawa[1], Muneo Hori[1], Naoshi Hirata[1]

1.Earthquake Research Institute, the University of Tokyo, 2.Graduate School of Information Science and Technology, the University of Tokyo

Earthquakes sometimes cause serious disasters not only directly by ground motion itself but also secondarily by damage of infrastructures, especially in the case of metropolitan areas that have numerous populations and capital functions in the country. For reducing such the secondary disasters, it is potent to evaluate seismic hazards rapidly by analyzing seismic response of each structure due to ground motion input from the bottom. In this study, we propose a methodology that consists of physics-based and data-driven approaches, in order to obtain seismic wave field as an input for seismic response analysis of structures. One of the Markov chain Monte Carlo (MCMC) methods, the replica exchange Monte Carlo, is adopted for the estimation of seismic wave field together with local crustal structure. Two numerical tests are conducted to examine the feasibility of the proposed method using the analytical solution with a horizontally layered crustal structure. The geometry of observation sites is referred to dense seismological network, Metropolitan seismic observation network (MeSO-net). It is confirmed that 1) the proposed method is possible to search the parameters related to the local crustal structure in broader space compared to a fundamental MCMC method, Metropolis method and 2) the seismic wave field estimated by the proposed method is almost coincident with the true wave field even if the local crustal structures are not so well estimated around the assumed values. On the other hand, the wave field estimated by the ordinary kriging, a classical interpolation method for spatial data, is hardly possible to reproduce the wave propagation and is much different from the true one even in low frequencies. This indicates that the proposed combined method taking both physics-based and data-driven approaches into consideration is essential for the seismic wave field imaging utilizing a dense observation network like MeSO-net. Acknowledgments: This research is supported by the Special project for reducing vulnerability for urban mega earthquake disasters from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Keywords: MCMC, MeSO-net, seismic wave field, earthquake ground motion

