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Numerical method of tsunami simulation including the effects of seafloor topography

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Japan is surrounded by the sea and has been suffered from tsunami so often. For tsunami disaster mitigation, we should predict the arrival time and the run-up height, and we usually use numerical simulation of tsunami propagation to understand those kinds of information. Many simulations focus on the prediction of the first arrival times and the initial height of tsunami. When tsunami propagates, however, reflected waves are generated by the real change of water depth and influence the tsunami height estimation. In particular, the later phases of tsunami are strongly affected by it, and the prediction about them is difficult by conventional numerical codes. In the case of the tsunami cased by the earthquake at Kuril Islands in 2006, maximum height waves arrived at the lands a few hours after the first arrival of tsunami reached, because the tsunami waves are scattered by the Emperor Seamount Chain. To consider these phenomena, it is necessary to think of the effects of the seafloor topography on propagation of tsunami.

In this study, by introducing the seafloor topography to tsunami simulation, we express the reflected waves and think about the effects of the topography on tsunami propagation. We generate a model that allows us to calculate tsunami propagation considering seafloor topographic variation, such as a slope, on the basis of the 500m-mesh bathymetry data from JODC(Japan Oceanographic Data Center). The simulation is performed using 3 dimensional in-equally spaced grids in FDM(Finite Difference Method). By using this code, we simulate tsunami propagation over the real changes of the water depth of the sea near Japan.

We find that the simulated tsunami shows some features caused by the topography and the propagation is different from that expressed by the conventional method. We conclude that the real seafloor topography is needed to consider for practical tsunami simulation including later phases. Our results indicate that reflection, scattering, need to be accommodated in the propagation of tsunami. So the results will lead to simulate the later phases of tsunami, which is our purpose of this study. On the other hand, studying about the accuracy of the calculation is important to think about the later phases of tsunami. When the grid intervals are sparse, waves with large wave numbers cannot be calculated, and this limitation strongly affects the later phases of tsunami. We consider how the reduction of accuracy affects the expression of tsunami in this study.

Keywords: Tsunami, seafloor topography, simulation method, in-equally spaced grids, later phases of tsunami, accuracy of the calculation