The dependence of the tsunami electromagnetic signals observed at islands on the subsurface resistivity

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SUMMARY

The electromagnetic (EM) field variations due to large tsunamis have been observed at seafloor stations and land ones close to coastlines. If the subsurface resistivity affects the tsunami EM signals, the phenomena could be applied to investigation of the resistivity structure as well as prediction of tsunami arrivals and heights. As for tsunami EM signals at the flat seafloor, Shimizu and Utada (2015) revealed that the EM field variations due to long waves are less affected by the subsurface resistivity. However, the dependence of the EM field observed at land and island stations has not been clarified and needs further investigation.

In this study, we investigated the subsurface resistivity dependence of the tsunami EM singles on island by numerical calculations for the following two cases. In Case 1, plane waves propagate in a flat seafloor with a constant depth and passes through a simple conical island; in Case 2, the 2011 Tohoku tsunami reached Chichijima Island. In both cases, we assumed a simple semi-infinite homogeneous resistivity structure below the island and the adjacent seafloor, and calculated the tsunami EM signals using the TMTGEM tsunami EM simulation code (Minami et al. 2017). In the EM field calculations for Case 1, we tested several radii of the island and three homogeneous subsurface resistivities of 1000,100, and 10 Ωm. We found in the result of Case 1 that the amplitude of the magnetic vertical component (Bz) varies by a maximum of 10% and the electric horizontal component (Eh) does by a maximum of 40%, in terms of those for 1000 Ωm. The variations in the amplitude were not so affected by the radius of the island. In Case 2, the case of Chichijima, we used the fault model of the 2011 Tohoku earthquake estimated by Tatehata et al. (2015) as the tsunami source for tsunami simulation and tested three subsurface resistivities in the same manner as Case 1. The results of Case 2 show that the amplitude of Eh varies by a maximum of 60%, and that of Bz varies by a maximum of 30%, in terms of those for 1000 Ωm. The results both in Case 1 and 2 indicate that the tsunami-generated Eh on the island is affected by the subsurface resistivity and may be possible to utilize in exploring the resistivity structure of islands. We succeeded in explaining the dependence of the amplitude of Eh on the subsurface resistivity by a simple stationary parallel circuit model. The stationarity of the circuit model accounting for the simulation results implies that the tsunami-generated electric field variation observed at islands are explained by the stationary process, and that the resistivity structure below the island could be explored by the tsunami electric sounding.

Keywords: tsunami, island, resistivity, simulation, FEM