

Time-domain simulation of magnetic fields due to tsunami-driven electric currents in the ocean and ionosphere

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SUMMARY

Large tsunamis generate significant magnetic field variations. Firstly, the movement of conductive seawater through the Earth's ambient magnetic field induces electric currents in the ocean, leading to associated magnetic variations. Numerous studies have reported on the magnetic variations caused by the tsunami-driven oceanic dynamo effect during major tsunami events. Secondly, large tsunamis create atmospheric disturbances that reach the ionosphere, resulting in dynamo electric currents at high altitudes. These effects have been observed through variations in total electron content or ground-level magnetic variations. To fully understand the electromagnetic changes during tsunami events, it is essential to consider both effects simultaneously.

To this end, we have developed a time-domain finite-element simulation code that models both oceanic and ionospheric electric currents. This code is based on the tsunami electromagnetic simulation code by Minami et al. (2017). Our simulation solves the induction equation in terms of the vector magnetic potential using the secondary field method. Spatial and temporal discretization of the equations are carried out using the edge-based finite-element method and the second-order backward Euler method, respectively. A key advantage of our method is its ability to incorporate arbitrary spatio-temporal variations of the source electric currents in both the ocean and the ionosphere.

In this presentation, we will apply our method to the 2011 Tohoku earthquake and tsunami event and explain the magnetic data observed on land and on the seafloor during this event.

Keywords: time-domain, finite-element, simulation, tsunami, ionosphere
