ABSTRACTS (MASTER THESIS)

Analysis of generation mechanism of geomagnetically induced current using the FDTD method

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Geomagnetically induced currents (GIC) are known to flow in electric power transmission lines. GIC is induced by the ionospheric and magnetospheric currents, so that the GIC is a risk to power transmission system at high latitude where auroral electrojets flow in the ionosphere. The magnitude of GIC is small at middle and low latitude, and had been thought to be safe until the discovery that Sun-like stars can cause an extremely large solar flare, called a super flare. A possible impact of the solar flare on the Earth environment is fully unknown. To assess the risk for GIC in Japan, we need to understand the generation mechanisms of the ionospheric current and GIC. For the first step, we focused on GIC under the non-uniform electrical characteristics. The magnitude of the GIC depends on electrical characteristics under the ground, and the electrical characteristics are complicated under the Japan islands. It is still unclear the quantitative relationship between the ionospheric current and GIC under the complicated electrical characteristics. The purpose of this study is to investigate the generation mechanism of GIC and dependence on geographical characteristics by using the finite difference time domain (FDTD) method. First, we simulated the GIC in the case that the permittivity, conductivity and permeability depend on horizontal distance and depth (Figure 1). Our simulation result showed that the non-uniformity in the horizontal direction leads to the deviation of the charge at the discontinuity (Figure 2), and difference in the horizontal current (Figure 3). In contrast, the non-uniformity in the vertical direction leads to phase difference of the current. Secondly, we simulated the GIC in some realistic geometrical models, including an island model, a peninsula model, and a lake model. In these models, we gave the permittivity, conductivity and permeability in accordance with water and ground in the 3-dimensional space. In these cases, the charge tends to be accumulated at the discontinuity, resulting in the large electric field at the boundary (Figure 4).

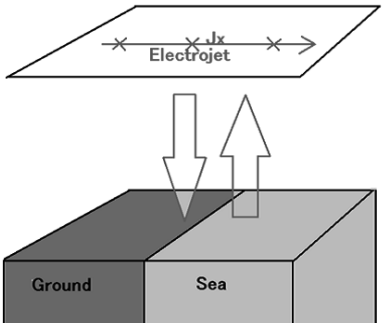

Figure 1. An example of a model depending on the horizontal direction.

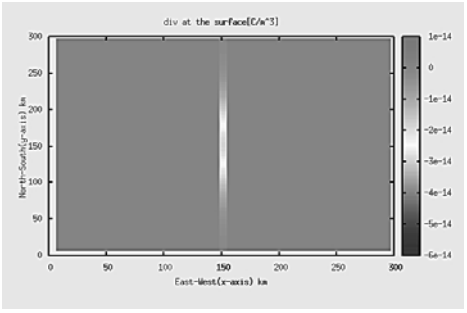

Figure 2. Accumulated charge.

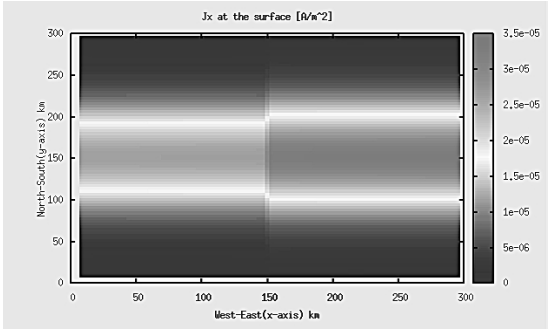

Figure 3. Current density flowing at the surface.

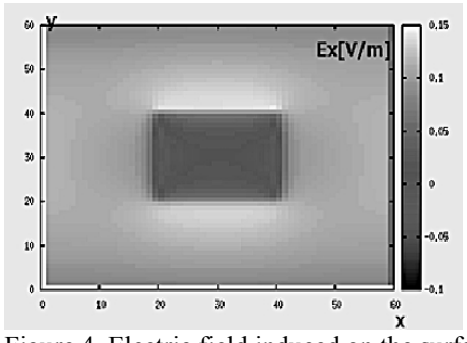

Figure 4. Electric field induced on the surface.