



Numerical modeling of seismo-ionospheric disturbances by FDTD method and comparison with experimental results from Japanese VLF observation network

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Recently many experimental results have been reported concerning the ionospheric perturbation associated with major earthquakes. VLF/LF transmitter signal received by network observations are used to detect seismo-ionospheric signatures such as amplitude and phase anomalies. These signatures are due to the ionospheric perturbation located around the transmitter and receivers. However the physical properties of the perturbation such as electron density, spatial scale, and location have not been understood well. In this paper we carried out the numerical simulation on the subionospheric VLF/LF signals including the various conditions of seismo-ionospheric perturbations by using a two-dimensional finite-difference time-domain (2D-FDTD) method to determine the perturbation properties. The amplitude and phase for the various cases of an ionospheric perturbation are calculated relative to the normal condition (without perturbation) as functions of distance from the transmitter and distance between the transmitter and perturbation. These numerical results are compared with our observation for several major earthquakes. As a result, we found that the received transmitter amplitude depends greatly on the distance between the transmitter and ionospheric perturbation, on the spatial scale and height of the perturbations. Moreover results of modeled ionospheric perturbation for the recent 2011 off the Pacific coast of Tohoku earthquake are compared with those from our VLF network experiment.