Transionospheric propagation of terrestrial VLF radiation

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Ground based Very Low Frequency (VLF, 3-30kHz) transmitters have played an important role in precipitation of energetic particles. In the past, the contribution of the VLF electromagnetic wave to the radiation belt losses was quantitatively calculated based on the early model of transionospheric, such as the Helliwell absorption curve, and so on, but recent studies have indicated that the calculation results of these models have obvious errors in estimating the transionospheric absorption. In this study, a full-wave modelof transionospheric propagation of VLF waves has been constructed to calculate the electromagnetic distribution excited by NWC communication station which has been compared with DEMETER satellite record. Although thehorizontal inhomogeneity of the ionosphere has not been considered in the full wave model, the calculation result was still comparable with observation. The attenuation of the electromagnetic energy in the earth-ionosphere waveguide and the absorption in D/E region with different geomagnetic parameters, ionospheric parameters and different radiation sources have been calculated with the verified full-wave model.
The spatial distribution of electromagnetic field excited by ground-based VLF transmitters with different radiation frequency and power under different geomagnetic parameters and ionospheric parameters have also been stimulated using the full-wave model constructed. Focusing the absorption in the D/E region of the ionosphere, we can concluded that the attenuation of VLF radiation in the waveguide is only affected by the wave frequency in the near field which decreases with the increase of the wave frequency, while the D/E region absorption and total attenuation increase with wave frequency. The variation of the radiation power has no effect on the attenuation in the waveguide and the D/E region absorption. The D/E region absorption decreases with the increase of the geomagnetic field and the dip angle of the geomagnetic field. The D/E region absorption increases with ionospheric electron density and collision frequency.

Keywords: VLF transmitter, Full-wave solution