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Ionosphere Activity Effects on Anthropogenic VLF Wave measured by DEMETER and Application to Earth Electromagnetic Survey

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Very Low Frequency (VLF) signal from the world-wide powerful VLF stations network, for navigation and military communication is commonly used for ground level electromagnetic survey in geophysics because part of the recorded signal is of internal origin, from induction in the Earth. This VLF signal has been observed also at satellite altitude during the DEMETER mission. The VLF electromagnetic field is recorded on the 15 - 20 kHz frequency band by the ICE et IMSC sensors on-board the spacecraft and provide simultaneously the electric and magnetic component of the electromagnetic signal. The waves transmitted by the ground-based VLF antennas propagate in free space and may pass through the ionosphere, depending on ionosphere properties or orientation of the wave vector relative to the Earth magnetic field. They can only cross the ionosphere and reach the satellite in the case of low ionosphere activities. The ionization varies according to time of day or season and it has been shown that man made VLF waves can precipitate radiation belt energetic electrons into the ionosphere. We study the effect of the interaction between VLF wave transmitted from ground and the ionosphere to analyze the contribution of ionosphere to the signal measured by DEMETER. We calculate the electromagnetic field of the VLF antennas placed on the surface of the Earth and transmitted through the ionosphere up to the satellite as a function of earth electrical resistivity. To compare with the data, we define the ratio between the electric and magnetic field that we call wave impedance. The comparison between the theoretical and observed impedance allows to deduce the average resistivity of the earth for shallow depth from the satellite data.