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Full-wave modeling of long subionospheric propagation and fractional-hop whistlers on electric field data of the DEMETER satellite

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Electromagnetic impulses generated by lightnings may propagate subionospherically along the surface of the Earth (spherices). The shape of the wideband impulse signal is determined by the length of the wave propagation and by the geometry of the waveguide formed by the conductive Earth's surface and the lower ionosphere. By modeling the modal structure of the recorded spheric (tweek) it is possible to determine the propagation direction and the distance between the thunderstorm region and the receiving station on the ground. Furthermore, tweek impulses with known lightning origin are perfect tools to monitor the 'effective height' in the lower ionosphere. The propagating energy partially can enter the Earth's magnetoionic plasma environment reaching the plasmasphere through the ionosphere in whistler mode propagation. We have found numerous fractional-hop whistlers recorded on board the DEMETER low-Earth-orbit satellite exhibiting the modal features of subionospheric propagation beside the effect of ionospheric dispersion. Large number of fractional-hop whistlers appeared on ICE VLF recordings of the DEMETER satellite were analyzed and found to be long distance propagated in the Earth-ionosphere waveguide. Application of our full-wave, short impulse (UWB) propagation description in waveguides (subionospheric propagation) and in arbitrary inhomogeneous media (propagation in the ionosphere) made it possible to model successfully the recorded waveforms of modal structured fractional hop whistlers. This analysis proved that realistic interpretation of impulse propagation in the Earth-ionosphere waveguide and through the inhomogeneous ionosphere to the

satellite is a proper way to determine propagation and medium characteristics.