3D FDTD modeling of the variations of Schumann resonance parameters in the Earth-ionosphere cavity

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Electromagnetic waves emitted by global lightning activity produce resonances in the Earth-ionosphere cavity. These resonances were first predicted by W. O. Schumann [Z. Naturforsch., 7a, 149, 1952] and therefore commonly referred to as Schumann resonances (SR). Because SR parameters (e.g., power, frequency and Q-factor) are mainly determined by the global lightning activity and the conductivity profile in the lower ionosphere, these resonances are widely used in many remote sensing applications [e.g., Williams, Science, 256, 1184, 1992; Cummer, IEEE Trans. Antennas Propagat., 48, 1420, 2000; Roldugin et al., JGR, 109, A01216, 2004, and references therein]. The variations of the first SR frequency during solar proton events (SPEs) and X-ray bursts have been reported in [e.g., Schlegel and Fullekrug, JGR, 104, 10111, 1999; Roldugin at el., JGR, 108, 1103, 2003]. Meanwhile, some long-term measurements of SR parameters presented in [Satori, JATP, 5, 1483,1996; Price and Melnikov, JASTP, 66, 1179, 2004] show that SR parameters also undergo diurnal and seasonal variations.

In this talk, we report results from a three-dimensional finite difference time domain (3D FDTD) model [Yang and Pasko, GRL, 32, L03114, 2005], which is used to solve SR problems in the Earth-ionosphere cavity. Results indicate a good agreement of SR parameters derived from the FDTD model with those obtained from previous well established numerical and analytical models [e.g., Sentman, JATP, 45, 55, 1983; Mushtak and Williams, JASTP, 64, 1989, 2002]. The FDTD results also indicate that the first SR frequency decreases during SPEs, and increases during X-ray bursts due to the conductivity perturbations occurring at different altitudes in these two events in good agreement with predictions provided by [Sentman, JATP, 45, 55, 1983]. In the present version of the model, the conductivity profiles derived from International Reference Ionosphere model (IRI) [Bilitza, Radio Sci., 36 (2), 261, 2001] are employed to account for the diurnal and seasonal variations of the ionosphere in the Earth-ionosphere cavity. Comparison of the FDTD results and recent experimental measurements [Price and Melnikov, JASTP, 66, 1179, 2004] shows a clear modulation in the SR parameters related to the local ionospheric height, the global lightning activity, and the receiver's position with respect to the three lightning centers on the Earth.