The Seasonal Variations of Global Lightning Activity Extracted From Schumann Resonances Using a Genetic Algorithm Method

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The combination of the highly conducting terrestrial surface boundary and the conducting ionospheric outer boundary separated by an insulating air layer creates a spherically concentric cavity, Earth-ionosphere cavity. Electromagnetic waves emitted by global lightning activity can produce resonances in this cavity. The electromagnetic resonances in the Earth-ionosphere cavity 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 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].

In our previous study, a 3D FDTD model originally introduced by Yang and Pasko [GRL, 32, L03114, doi:10.1029/2004GL021349, 2005] was applied to solve SR problems in the Earth-ionosphere cavity. A good agreement on SR frequencies and Q-factors between our FDTD results and previous work [Sentman, JATP, 45, 55, 1983; Mushtak and Williams, JASTP, 64, 1989, 2002] indicates that our FDTD model is suitable for solving ELF problems in the Earth-ionosphere cavity.

In this talk, an inverse method based on our FDTD modeling and genetic algorithms (GA) is developed to extract information (e.g., central time, duration and magnitude) of lightning activity in three main thunderstorm regions (Africa, South-East Asia, and South America) from observed SR intensity data measured at MR station in Israel [Price and Melnikov, JASTP, 66, 1179, 2004] and a Polish polar station (HRN) [Nesta and Satori, Poland. Przegl. Geofiz. Engl. Transl., 3-4, 189, 2006]. Similar seasonal variation patterns of the lightning activity in three thunderstorm centers are clearly derived from SR measurements at those two stations using our FDTD-GA model. Furthermore, those seasonal variations are in a good agreement with the previous studies by other authors on related subjects [e.g., Christian et al., JGR, 108 (D1), 4005, doi:10.1029/2002JD002347, 2003; Williams and Satori, JASTP, 66, 1213, 2004]. In this talk, the different SR frequency variations associated with seasonal variations of global lighting activity in three main thunderstorm regions are also discussed.