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Signature of the seasonal migration of global lightning in the variation of Schumann resonance peak frequencies - Theory versus experiment

Gabriella Sátori (1), Vadim Mushtak (2), Earle Williams (2), and Tamás Nagy (1)

(1) Geodetic and Geophysical Research Institute, HAS, Sopron, Hungary (gsatori@ggki.hu, +3699508355), (2) Massachusetts Institute of Technology, Parsons Laboratory, Cambridge, MA 02139, USA

The distance between the active lightning sources and a fixed receiver changes when the global lightning migrates northward/southward over the year. Schumann resonance (SR) peak frequencies depend on both the source-observer geometry and the propagation conditions in the Earth-ionosphere cavity. The source-observer geometry can be manifest in frequency variations with different signs for the different modes and field components. This distance- dependent frequency variation is demonstrated in SR frequency observations at Nagycenk, Hungary. The position of the lightning centroids is documented with respect to the observer in the longitudinal range of the three tropical chimney regions for each month on the basis of the OTD/LIS satellite observations. Simulation of the distance-dependent frequency variation is based on the computation of the spectra of the vertical electric, north-south, and east-west magnetic field components, via the Two-Dimensional Telegraph Equation (TDTE) technique (Kirillov, 2002) for each chimney region in its diurnal phase of greatest activity, and with each (Maritime Continent, Africa, America) having well established spatial-temporal dynamics. Modal peak frequencies are being obtained, along with modal intensities and quality factors, by means of the least-squares fitting of “experimental” spectra by the “classic” Lorentzian functional (Williams et al., 2006). For each chimney region, numerous scenarios have been simulated; to consider the first and second Lorentzian-modes, a five-mode (N=5) Lorentzian procedure has been exploited. The largest frequency response (maximum in Northern hemisphere summer, minimum in winter) for the seasonal migration can be observed in the case of the 1st Ez mode when it is dominated by the Maritime Continent (7-10 UT). According to the simulation, this maximal response is attributed to the source proximity to the nodal region at about 10 Mm distance, where the frequency exhibits singular behavior. In the case of Africa, the frequency varies little during the seasonal migration and has opposite sign: lower in Northern Hemisphere summer than winter. The frequency has only minor fluctuation in the case of the American source due to the seasonal migration path being roughly perpendicular to the source-receiver great circle. The 1st magnetic mode has increasing frequency at Nagycenk with increasing source distance in accordance with the theoretical description. These general methods are suitable to identify global redistribution of global lightning due to climate change.