32nd URSI GASS, Montreal, 19–26 August 2017

Ionospheric remote sensing using lightning-generated VLF/LF sferics in space and time

Jackson C. McCormick*[1], Morris B. Cohen[1]
(1) Georgia Institute of Technology, Atlanta, GA, 30319

1 Extended Abstract

The D-region of the ionosphere (60-90 km altitude) is highly variable on timescales from fractions of a second to many hours, and on spatial scales from 10 km to many hundreds of km. VLF and LF (3-30kHz, 30-300kHz) radio waves are guided to global distances by reflecting off of the ground and the D-region, making the Earth-ionosphere waveguide (EIWG). Therefore, information about the current state of the ionosphere is encoded in received VLF/LF radio waves since they act like probes of the D-region.

The return stroke of lightning is an impulsive event that radiates powerful broadband radio emissions in VLF/LF bands known as 'radio atmospherics' or 'sferics'. Lightning flashes occur about 40-50 times per second throughout the Earth. An average of $\sim$2000 lightning storms occur each day with a mean duration of $\sim$30 minutes creating a broad spatial and temporal distribution of lightning VLF/LF sources. This allows for greater spatial and temporal study of the D-region compared to past VLF transmitter-based studies. Furthermore, the broadband nature of lightning allows more spectral information compared to a single frequency VLF wave generated by VLF transmitters.

This wide distribution of VLF/LF sources is a significant and global source of electromagnetic noise in the same frequency band. A sferic's frequency content is strongly modulated by return stroke current, distance from return stroke, and the current state of the D-region of the ionosphere. Therefore, good knowledge of the current state of the D-region of the ionosphere is necessary to be able to predict characteristics of the noise environment generated by lightning strokes.

We describe a technique to recover the amplitude and phase of sferics and quantify the detectability of an ionospheric change, such as from solar flares and other natural ionospheric disturbances, from their spectra change. We demonstrate the utility of our technique with ambient and modified ionospheric conditions. This technique allows for simultaneous study of spatial and temporal ionospheric variation and detection of ionospheric disturbances.