Deducing Ionospheric Conductivity from the Properties of the Slow-Tails of Sferics

C. Le Cocq[1] and A.C. Fraser-Smith[2]

[1] Space, Telecommunications and Radioscience Laboratory
Stanford University
350 Serra Mall, Room 306
Stanford, CA 94305 USA
cisou@stanford.edu

[2] acfs@alpha.stanford.edu

Abstract

The slow-tails of sferics radiated by lightning strikes propagate in the lowest-order mode of the earth-ionospheric waveguide. The shape of the slow-tail is determined by the distance of propagation, the height of reflection and the effective ionospheric conductivity. Knowing the distance propagated and height of reflection we can deduce the conductivity by examining a recorded slow-tail. Examples of the conductivities calculated by this method agree well with previously published values and allow us to approximate the changes over time.

Introduction

Lightning strikes emit low-frequency electro-magnetic radiation called sferics. Sferics are typically considered a very-low frequency (3kHz < f < 30kHz) phenomenon but they also have an extremely-low frequency (3Hz < f < 3kHz) component called the slow-tail. *Wait* [1962] derived a mode theory for the propagation of sferics in the earth-ionosphere waveguide. His theory assumed an isotropic ionosphere and a constant height of reflection throughout the waveguide. The propagation of the slow-tail occurs only in the lowest order mode. This simplifies the theory and allows us to compute slow-tails dependent on the variables, h, ρ and σ, or height of reflection, distance of propagation and effective ionospheric conductivity respectively. We have previously used this model to successfully approximate the distance of propagation of a sferic. In the case of data recorded for known locations and times we can now fit this model by solving for conductivity.

Observations

We have many recorded sferics which propagated in day and nighttime conditions. The daytime slow-tails tend to be more consistent, while the nighttime show a larger variation. This shows the conductivity, and therefore electron density, is not as constant in the nighttime sky. With lightning strikes occurring throughout the night and all over the world, we can examine slow-tails to approximate the changes in conductivity over time over different locations.

Discussion

With sferics being recorded across the world, using slow-tails to approximate the conductivity and electron density of the lower ionosphere could lead to a global coverage of how these values change over time.

References

Wait, J.R., Electromagnetic waves in stratified media, *Oxford:Pergamon Press.*, 1962.