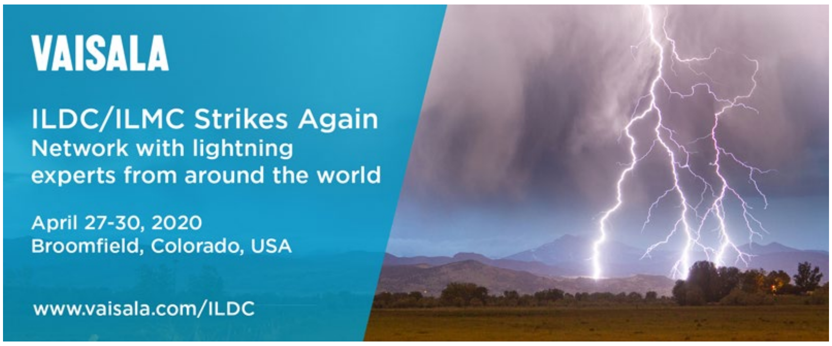

Empirical Determination of VLF Propagation Parameters in the Earth-Ionosphere Waveguide Using GLD360 Sensor Data

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Abstract

Global-scale lightning locating systems (LLS) rely on efficient Very Low Frequency (VLF) propagation through the Earth-ionosphere waveguide (EIW) to detect lightning-generated radio atmospherics at distances measured in many thousands of kilometers. While the EIW propagation channel enables long-distance detection, it also imposes a variable attenuation and propagation delay on each radio atmospheric. Properly accounting for these radio propagation properties is crucial to measuring well-calibrated range-normalized amplitudes and arrival times, which are in turn necessary to determine accurate estimates of the source peak current and location. An accurate attenuation model is also necessary for a robust model of the LLS's detection efficiency (DE; Pessi et al 2009).

Many researchers have successfully used numerical propagation models to account for propagation effects in the EIW waveguide. These models use either steady-state mode finding (eg Cummer 2000), or a time-domain ray-hop approach (eg Qin et al 2017). Each of these models accounts for reflections off an anisotropic ionosphere, where the reflection coefficient depends on time, location, and propagation direction. However, a commercial global LLS must apply corrections for all propagation conditions encountered between lightning sources and sensor locations. Thus, while numerical modeling can provide insight to the propagation characteristics, an empirical model using real-world radio atmospheric measurements can natively account for subtleties that may be missed in a theoretical model.

This paper presents both an empirical attenuation and delay model that accounts for propagation in the EIW waveguide. Each uses a boot-strapping approach using GLD360 sensor data and network solutions. Given its importance to DE and peak current calculations, emphasis is given to the development and results of the attenuation model. In particular, attenuation dependencies on distance, relative propagation direction, and magnetic inclination are shown. The residual amplitude measurement error is analyzed to provide an estimate of the peak current magnitude error by region and time of day.

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Cummer, Steven A. "Modeling electromagnetic propagation in the Earth-ionosphere waveguide." *IEEE Transactions on Antennas and Propagation* 48.9 (2000): 1420-1429.

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Topic Areas

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