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Estimation of the Earth Ionosphere Waveguide Using Narrowband VLF Transmitters

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1 Extended Abstract

The D-region ionospheric electron density profile plays an important role in many applications. However, determining this profile on large scales and over long periods of time has been a challenge. The D-region is about 60 to 90 km in altitude, which makes in-situ measurements difficult since it is higher than planes and balloons can fly but lower than satellites can orbit. Researchers have previously used VLF remote sensing techniques, from either narrowband transmitters or sferics, to estimate the density profile, but these estimations are typically during a short time frame and over a single propagation path.

We report an algorithm for estimating the daytime electron density profile for the D-region ionosphere over multiple narrowband transmitter-receiver paths within the continental United States. The cornerstone of the algorithm is an artificial neural network (ANN), a form of machine learning, where input values are the received amplitude and phase from the narrowband transmitters and the outputs are h' and β, the two parameters of a widely used exponential electron density profile from [1].

Training the ANN is done by creating many random, but realistic, ionospheres and estimating the received amplitude and phase at each receiver for a large number of generated ionospheres. The International Reference Ionosphere (IRI) 2007 [2] is used as the foundation for a basic ionosphere. Randomized perturbations are then superimposed and interpolated on the basic ionosphere, creating the randomized ionospheric data set. For each random ionosphere, the Navy's Long-Wavelength Propagation Capability (LWPC) code [3] is used to determine the received amplitude and phase along all possible transmitter-receiver combinations. Test data is created in the same manner as training data. Modeled results show the algorithm performs well under smooth ionospheric conditions and when proper geometries for the transmitters and receivers are used.

References

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