Modeling Electromagnetic Propagation Over Water from Correlated Environmental Data and Neural Network Models

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Accurate computations of electromagnetic (EM) propagation in the lower atmosphere require sophisticated modeling techniques such as those employed in the JHU/APL-developed Tropospheric Electromagnetic Parabolic Equation Routine (TEMPER). Since environmental conditions affect the propagation behavior, they are an integral part of these models. However, running TEMPER or other propagation simulations may not be practically feasible when a database of long-term conditions is desired at one or more geographical locations using large amounts of environmental data. In this case, statistical models of propagation such as neural network models may prove as valuable time-savers.

This analysis supports long-term (annual) planning needs over ocean regions, although it can easily apply to monthly and seasonal planning needs as well. Development of this propagation database requires a set of correlated environmental data referring to conditions at the same time and location. The environmental data were obtained from multiple sources over a 12-year period, primarily from Numerical Weather Prediction "Reanalysis" models, and were stitched together at selected locations. This integrated global dataset includes standard weather parameters (e.g., temperature, humidity, and wind), wave heights, and precipitation rate, from which vertical profiles of refractivity and attenuation can be computed. Evaporation duct heights and optical turbulence were also calculated with other models using these data.

Correlated environmental data from a few diverse geographical locations were integrated within TEMPER to develop a statistical model of EM propagation. A neural network model was fit to the TEMPER output data to predict propagation conditions. The primary purpose of developing this model was to limit the computational time required to process vast amounts of historical data at each geographical location with TEMPER. A marine-band radar at 9.4 GHz is used as an example in this analysis. After validating the neural network model against TEMPER, the model was applied to other geographical locations to more completely map various areas. These results provide insight to historically favorable or unfavorable geographical locations for propagation based on the impacts of expected environmental conditions on this particular radar system.