Application of Ensemble Weather Forecasts to Electromagnetic Propagation Modeling

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Electromagnetic propagation through the atmosphere can vary significantly due to weather conditions. Accurately characterizing weather is therefore important for propagation modeling. Numerical weather models can provide such characterizations, but are sensitive to their initial conditions. In most cases, initial conditions for weather models are not perfectly known due to measurement errors and sparsity.

To address this uncertainty, a set of forecasts can be run with varied initial conditions. This set of forecasts is known as an ensemble. Each forecast produces a distinct representation of the atmosphere across the model's spatial grid based on a unique configuration of initial conditions. The spread of values across the ensembles therefore represents the uncertainty in the forecast. Ensemble weather forecasts have been applied to air quality monitoring, tropical cyclone forecasting, and wildfire modeling. This paper presents an application of ensemble forecasting to electromagnetic propagation modeling.

The approach described in this paper models electromagnetic propagation in each distinct forecasted atmosphere. This produces propagation factor across five dimensions (time, ensemble forecast number, range, bearing, and height). Statistics of propagation factor are assessed across the ensemble forecasts and carried forward into subsequent applications, such as radar range prediction. Examples of ensemble propagation modeling are drawn from an experimental dataset collected off the coast of Virginia in April and May 2000. This dataset includes high-resolution measurements of microwave propagation and coincident meteorological parameters. The experiment was recently re-analyzed with the Naval Research Laboratory's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) weather model as an ensemble forecast.

Statistics of propagation factor from the ensemble modeling are presented and compared with propagation measurements from the experiment. Results indicate the degree to which uncertainty in a forecast impacts propagation factor and radar range prediction. They also present a technique for generating a confidence interval on radar range predictions based on uncertainty across the ensemble forecasts.