ELECTROMAGNETIC PROPAGATION

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LONG TERM GOALS

Develop electromagnetic propagation models for use in operational or engineering propagation assessment systems.

OBJECTIVES

Develop an advanced unified hybrid propagation model combining the capabilities of the Radio Physical Optics (RPO) and Terrain Parabolic Equation Model (TPEM) methods for both surface-based and airborne applications. Resolve differences between current techniques used to model propagation effects under rough surface and strong ducting conditions, including an experimental program.

APPROACH

We develop parabolic equation, ray optics, waveguide, and other models as necessary to produce both accurate and efficient models to be used in propagation assessment systems. In many cases we can use variations of existing models to achieve this goal, but sometimes completely new models are necessary. Once developed, these models are compared to other models and to experimentally collected propagation data for verification of accuracy. We stay abreast of other researchers' newest models by reading current literature, participating in propagation workshops, and attending conferences as appropriate. There is a strong international exchange of ideas and techniques in this area, as some of the best current work is performed outside of the USA.

WORK COMPLETED

In FY97 we completed the first releasable version of the Advanced Propagation Model (APM Version 1.0) that is being used as the exclusive propagation model in the Advanced Refractive Effects Prediction System (AREPS). APM 1.0 includes the full functionality of the Radio Physical Optics (RPO) model and the Terrain Parabolic Equation Model (TPEM) plus other considerations to give us one seamless efficient radio propagation model. In the airborne hybrid model work, we finalized hybrid techniques that will be incorporated into APM in future years.

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In the surface roughness work, we finalized the Parabolic Equation Exact Rough Surface (PEERS) model into a Fortran research-quality model that can be used for laboratory and engineering purposes. PEERS is too slow for an operational model, but it does consider both range dependent environments and surface roughness effects. Plans were finalized for the Rough Evaporation Duct (RED) experiment, but due to funding limitations this experiment has been postponed for one year.

For the NATO Surface Ship Radar Cross Section (RCS) Analysis effort performed under NATO AC243, Panel 3, Research Study Group 21 (RSG-21), we held two meetings to coordinate and analyze the radar cross-section data taken during the Livorno '96 experiment (3-17 May 1996 in Livorno, Italy). Germany, France, and the United Kingdom presented preliminary results from their radars (Italy, Norway, and Denmark have not completed a preliminary analysis). Surface and upper-air meteorological data were reviewed by France (met. data were taken by Germany, France , and the U.S.). Preliminary modeling results, based on each country's propagation/RCS prediction codes, are to be completed by the autumn meeting (28-31 Oct 1997 in Copenhagen, Denmark).

RESULTS

In FY97 we developed a fully integrated hybrid model that considers terrain effects and properly packaged that model for use by propagation assessment systems. The tropospheric scatter propagation mechanism was particularly troublesome, as the method used in RPO cannot be used in the general terrain case, since the maximum angle in the PE model must frequently exceed the scattering angle by a large amount. This difficulty was finally resolved by implementing the Yeh troposcatter model in APM, which is applicable to both over-terrain and over-sea paths. In addition, the RPO troposcatter model was modified to run in a stochastic mode, and comparisons of simulated and measured distributions of troposcatter signals were made.

In the airborne hybrid model area, we supplemented the PE model for elevation angles above and below the maximum and minimum PE angles, such that a fairly efficient hybrid model can be constructed. These models have not yet been implemented in APM, but they will be implemented in future years.

In the rough surface effort, we searched for existing data to validate the rough surface propagation models. The 1972 Greek Island 37 GHz data set may be useful, and a re-analysis of these data is planned for FY98. Also, the Wallops Island propagation experiment planned for spring 1998 may prove useful for validating rough surface models, and we plan to participate in this experiment and analyze appropriate data for this purpose. However, we still believe that a specially designed experiment in an area of consistent high evaporation duct heights and high wind speeds, such as Hawaii, would result in the best data for validating rough surface propagation models. The RED experiment originally planned to begin in FY98 has been postponed to begin in FY99, due to funding limitations. Under the current plan, the actual experiment will be conducted in June and July 2000.

For the NATO RCS work, surface and upper-air meteorological data have been analyzed and each country has a consensus data set to be used with their propagation/RCS prediction codes.

Radar calibration data (sphere and Luneberg lens targets) have been analyzed by the U.S. (SSC-SD) and distributed.

IMPACT

The goal of this work is to produce the best possible hybrid radio propagation model for incorporation into U.S. Navy assessment systems. Current plans call for APM to be the single model for all applications. As APM is developed it will be properly documented for delivery to the Oceanographic and Atmospheric Master Library (OAML), from which it will be available for incorporation into Navy assessment systems. Without a model such as APM, advanced propagation assessment would not be possible.

TRANSITIONS

During FY97, RPO 1.16 and TPEM 1.5 were documented and delivered to OAML. RPO 1.16 is an upgrade to previous versions that have been certified in OAML, and TPEM 1.5 is expected in due course to be included as a certified baseline model in OAML. A preliminary engineering change proposal (PECP) will be submitted to OAML during FY98 to eventually replace both RPO and TPEM with APM. OAML is our primary transition point for models developed under this project.

In FY97, APM 1.0 was incorporated into the Advanced Refractive Effects Prediction System (AREPS) which will become a DII COE compliant component of the Tactical Environmental Support System - Next Century (TESS-NC). In addition, RPO and TPEM were selected as OAML standard models for inclusion into the Interactive Multisensor Analysis Training (IMAT) system. TPEM was also selected for a new Coast Guard system to predict communications coverage in coastal areas.

RELATED PROJECTS

Coastal Variability Analysis, Measurements and Prediction (COVAMP), ONR Modeling and Prediction Program. The goal of this project is to provide representative three-dimensional time-varying refractivity fields to be used with the models described here as inputs to propagation assessment systems. Also, our models are documented and finalized for OAML under the Tactical EM Propagation Models Project funded by SPAWARSYSCOM PMW-185 (PE 0603207N).

REFERENCES

Propagation Division home page: http://sunspot.spawar.navy.mil