Littoral Refractivity Prognostic Advancement

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LONG-TERM GOALS

The goal of this research is to improve Coupled Ocean/Atmosphere Prediction System (COAMPS®) to the point that it provides engineering quality refractivity fields in the littorals. These engineering quality refractivity fields will be able to support radio frequency system testing, acquisition, radar system performance forecasts and radar sea and land clutter forecasts.

OBJECTIVES

The objective of this research is to improve the Coupled Ocean/Atmosphere Prediction System (COAMPS®) atmospheric boundary layer (ABL) wind and refractivity field forecasts in the littorals with respect to error threshold requirements established by the chemical sensor testing, propagation, and surface radar sea and land clutter model communities. Assimilation of special field measurements will be investigated with a focus on improving the model forecast refractivity fields. This technology will provide situational awareness of the 3D radio-frequency (RF) propagation environment and a quantitative diagnostic and prognostic capability for assessing sub- and super-refractive conditions in the littorals. The research will lead to the exploitation of anomalous RF propagation fields in order to re-deploy spectrum, sensor, and communications assets to avoid propagation liabilities and to take advantage of propagation opportunities validating with US Naval surface sensor test data.

APPROACH

Leverage NSWCDD Chemical Agent Plume Tracking Capability (CAPTC) computational resources (two Linux clusters) to adapt COAMPS® – On Scene (COAMPS-OS®) coupled mesoscale forecast and data assimilation system in the testing of model advancements that directly impact the electromagnetic (EM) propagation environment over Wallops Island, Virginia and the Potomac River

Test Range (PRTR). Focus on Improvement associated with increased vertical and horizontal resolution, new stable boundary layer physics, entrainment parameterization, and assimilation of special weather data. Benchmark error threshold diagrams will be analyzed from uncoupled and coupled model forecasts using field data to determine linkages between errors in state variables such as wind, SST, moisture gradient and inversion strength, to errors in ducting characteristics and to errors in RF propagation path loss and gain, radar horizon and signal to noise ratio.

WORK COMPLETED

Validated a surface layer model blending technique that extends modified refractivity profiles to the surface at each COAMPS® grid point. Compared COAMPS® /AREPS modeled propagation to measured propagation from Wallops 2000MPME. Analized the impact of a diurnally evolving high-resolution SST on coastal and open ocean ducting layers. Evaluated mesoscale influences on coastal refractivity and atmospheric ducting within evolving large-scale dynamics. Evaluated high resolution horizontal grids for predicting mesoscale refractive environments. Inter-compared mesoscale NWP forecast methods from US, UK, CA and NZ for characterizing atmospheric refractivity to assess environmental representation in EM propagation models.

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RESULTS

The surface layer blending technique is robust and validated for measurements at S, C and X band. The modeled propagation data compared to measured propagation data lead to a radar community accepted engineering metric for use in all other validation work. High-resolution SST fronts and temperatures dramatically alter the structure of the marine atmospheric boundary layer changing ducting characteristics rapidly and over very short distances. Over warm water regions, duct frequencies are 30% greater but duct strengths are two times weaker. The strongest ducts form on cold side of sharp SST fronts. Sea-breeze enhanced ducting increases occurrence by 10% within 50 km of shore.

Ducting statistics improve with improving horizontal resolution up to 4km horizontal resolution. The greatest sensitivity of coastal refractivity is related to horizontal grid resolution less than 5 km, sea surface temperature, mesoscale initialization, large-scale synoptic forcing and data assimilation moisture analysis.

The work described above led to the following publications.

Marshall, R. E. and T. Haack, “The Influence of Sea Surface Temperature Fronts on Radar Performance,” Proceedings of the International Radar conference, Bordeaux, France, October, 2009

Marshall, R. E. and J. Stapleton, “Multi-wavelength Impacts on Coastal Radar Performance During a Sea Breeze ,” Proceedings of the IEEE Radar Conference, Pasadena, CA, May, 2009

Marshall, R. E. and Horgan, K., “The Contribution of Dry Surface Air Over Land To the Strength of Radio Frequency Trapping Layers in the Sea Breeze Circulation,” AMS Annual Meeting, Phoenix, AZ, 2009

Haack, T and W.T. Thompson, “Influence of SST on Atmospheric Trapping Layers”, AMS Annual Meeting, Phoenix, AZ, Jan 2009

Haack, T, C. Wang, S. Garrett, A. Glazier, and R. Marshall, “Mesoscale modeling of Coastal Refractivity”, Mesoscale Conference, Utah, Aug 2009

Thompson, W. T. and T. Haack, “COAMPS Ducting Validation: Wallops 2000”. Coastal Atmospheric and Oceanic Prediction and Processes, Jan, Phoenix, AZ.

Haack, T, C. Wang, S. Garrett, A. Glazier, J. Mailhot and R. Marshall, “A Mesoscale Model Inter-comparison of Boundary Layer Refractivity and Atmospheric Ducting,” accepted in JAMC.

Thompson, W.T. and T. Haack, "An Investigation of Sea Surface Temperature Influence on Microwave Refractivity: The Wallops-2000 Experiment“ In preparation

As a result of this work, Tracy Haack and Robert Marshall have been asked by the US Commission F of the International Union of Radio Science to organize and co-chair a special session on numerical weather prediction and wave propagation modeling at the January 2011 National Radio Science Meeting in boulder, CO

IMPACT/APPLICATIONS

Radio frequency ducting and super-refraction are not resolved to the accuracy required for real time operational adjustments to radar engineering settings. However, the qualitative nature of COAMPS® refractivity fields is useful for qualitative radar test and evaqluation and radar acquisition performance requirements. COAMPS® refractivity fields are now beginning to be used for forensic analyses of Fleet RF system failures or interference incidents.

TRANSITIONS

The COAMPS® refractivity fields are being employed by the Sensors Division at the Naval Surface Warfare Center, Dahlgren Division to establish performance specifications for future Navy radar and communication systems as part of the acquisition process. COAMPS® fields are also used to support over the water prototype radar and communication systems testing at Port Hueneme, the Potomac River Test Range, and Wallops Island, VA. COAMPS® refractivity fields combined with AREPS radar performance models will be used in an FY11-13 program to develop a tactical decision aid for surface Warfare Officers.

RELATED PROJECTS

The ABCANZ Numerical Weather Prediction Experiment involves mesoscale numerical weather prediction modelers and models from the UK Met Office, Environment Canada, New Zealand Defence Technology Agency, and the Austrailian Defence Science and Technology Organisation modeling the Wallops 2000 experiment and the 2009 New Zealand Sea Breeze Experiment and comparing results to the COAMPS® analysis.