

The Role of the Surface Waves in Forming the Propagation Pattern of EM Signals over the Ocean and Wavy Boundary Layer Measurements during RED

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LONG-TERM GOALS

The long term goal of this research is to bring better understanding of how atmospheric conditions and sea state affect the propagation pattern of EM signals over the ocean. Scattering from layered structure of the atmosphere (Wait, (1970)), random fluctuations of the refractive index as well from the rough ocean surface, are intricately involved in the pattern formation, although their interaction and quantitative contribution is incompletely understood. A particular focus of this work is to reveal the role of the atmospheric pressure fluctuations (Bean and Dutton, (1968), Ishimaru, (1978)), both turbulent and wave-induced, in the variability of the refractive index, as well as to enhance our understanding of the EM scattering properties of the ocean surface as a function of the sea state.

OBJECTIVES

As reported by Hitney (1999) propagation models currently employed by the Navy show discrepancies with experiments, mainly by overestimating measured intensity of pulsed signals. Thus the primary objective of this project is to bring measurements and models closer together. The roles of the surface waves and pressure fluctuations are of particular interest. The waves influence on the propagation pattern is hypothesized to be threefold: the waves can modify the refractivity profile, induce refractivity fluctuations in the wind, and determine the reflective properties of the sea surface (Weber and Barrick, (1977), Beckmann and Spizzichino, (1963)). In this context we are planning to address deficiencies in models which:

- describe propagation in layered media (i.e. in ducting conditions);
- describe the reflective properties of the sea surface: the Miller-Brown (Miller, Brown and Vegh, (1984)) model is based on assumptions which are poorly justified, thus it requires reexamination.

We will also concentrate on the role of the pressure field. From the considerations of Ishimaru (1978) as well as from experimental data we can conjecture that for adiabatic atmosphere we should account for the pressure contribution to refractivity fluctuations. Pressure fluctuations measurements are known as challenging and are rarely performed. Their contribution to the refractive index structure has been routinely ignored.

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APPROACH

The structure of the atmospheric refractive index as well as scattering properties of the sea surface are to be inferred experimentally from meteorological and waves measurements in the ocean conducted on the stable research platform *FLIP*. We are collecting data for wind velocity, temperature, humidity, ocean waves and currents, atmospheric pressure and its fluctuations, inertial navigation etc. At the interpretation stage of this project, these data will be used to reexamine preexisting models on EM propagation through Marine Atmospheric Boundary Layer.

WORK COMPLETED

The instruments for pressure fluctuation measurements have been assembled. Laboratory tests of these instruments have shown satisfactory sensitivity (0.05Pa at 3Hz) and response time characteristics. Preparation for the experiment has been completed. About 40 instruments are now integrated in a data acquisition system. We are now conducting the experiment off the coast of Oahu, Hawaii.

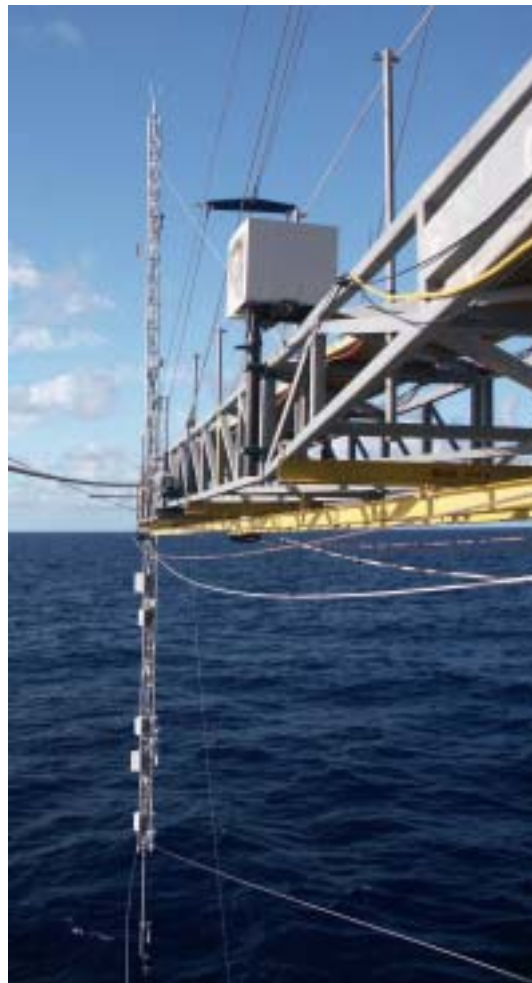


Figure 1. Instruments mast, as deployed during the Rough Evaporation Duct (RED) experiment. The instruments installed on it include sonic anemometers at 6 levels, a cup anemometer and a vane, pressure, humidity, temperature sensors, wave wire, and inertial navigation devices.

RESULTS

The Rough Evaporation Duct (RED) Experiment is currently in progress. Until now all the instruments are deployed and provide data as planned.

IMPACT/APPLICATIONS

The data from the experiment will serve to reassess and upgrade models for EM signals propagation over the ocean. We expect that updated models will improve communications and radar applications conducted over the ocean.

TRANSITIONS

Results, measurement techniques and data interpretation methods from this research will be used for air-sea interaction and surface waves studies. The atmospheric pressure fluctuations are known to have significant role in the structure of the atmospheric boundary layers, thus the instruments we created as part of this project will have broad application in studies of atmospheric turbulence. The data acquisition system implemented for this experiment has proven to be reliable, flexible, and scalable (i.e. allowing easy addition of new instruments). Software tools for data management and analysis (Hristov *et al.*, (1998), Hristov *et al.*, (2000)) are being provided to the RED team. The experimental information on the Marine Boundary Layer dynamics is useful in design and simulation studies of man-made objects flying low above the surface waves.

RELATED PROJECTS

The structure and dynamics of the Marine Atmospheric Boundary Layer, whose impact on EM propagation is studied in RED, is also a focus of the CBLAST initiative (<http://www.whoi.edu/science/AOPE/dept/CBLASTmain.html>), currently funded by ONR.

SUMMARY

The Rough Evaporation Duct (RED) project currently proceeds as planned at its experimental stage. As part of this proposal we designed and built sensors for pressure fluctuations, deployed during the experiment. Over the next three years the data analysis phase of the project should bring information on the signature of the atmospheric conditions and the sea state onto the EM signals transmission. This project follows a tradition at University of California, Irvine in studies on EM propagation in random media.

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PUBLICATIONS

None.

PRESENTATIONS

- “Critical layer effects in the wind above ocean waves”, Invited talk, University of Miami, January 26th, 2001
- “Experimental Support for the Critical Layer Theory of Wind-Wave Interactions”, Invited talk, University of California, San Diego, February 12th, 2001
- “Surface Waves Signature in Marine Atmospheric Boundary Layer”, Invited talk, Nova Southeastern University, May 26th, 2001
- “Field Experiment Study on the Mechanism of Wind-Wave Coupling”, EGS XXVI General Assembly, Nice, France, 25-30 March 2001.