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# Coupled Air-Sea Processes and Electromagnetic Ducting Research (CASPER)

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## LONG-TERM GOALS

The long-term goals of the project are to improve the prediction of the electromagnetic (EM) wave propagation in the atmosphere, with the focus on EM ducting environments.

## OBJECTIVES

A five year research program is planned to improve the prediction of EM/EO propagation through the lower atmosphere by extensive field measurements/analyses and numerical modeling for the objectives of 1) obtaining a better understanding of the physical processes contributing to refractive gradients; 2) improving the representation of these processes in operational forecast models; and 3) developing new approaches in quantifying and modeling EM propagation in the atmosphere.

## APPROACH

CASPER aims at making coincident observations at sea of the air-ocean-wave conditions and EM/EO propagation measurements in challenging or rapidly evolving coastal regimes. Additionally, CASPER involves theoretical analyses, numerical modeling, and parameterization development at multiple scales. Two intensive observation periods (IOP) have been planned, one on the East coast in October 2015 and one on the West coast in august 2017 to capture various ducting conditions, utilizing unique sampling strategy to adequately quantify EM/EO ducting conditions. The observations will be guided by theoretical analyses and extensive modeling efforts on large eddy scale as well as on mesoscales.

Qing Wang is the lead PI and is responsible for the overall CASPER project. She is also responsible for the near-surface measurements/analyses and aircraft data analyses. Robert Burkholder is responsible for EM measurements, modeling, and analyses; Joe Fernando is responsible for ship-based meteorological measurements and theoretical analyses; Djamal Khelif is responsible for aircraft measurements and analyses, particularly the Controlled Towing Vehicle (CTV); Kipp Shearman is responsible for ship operations and under-water measurements and analyses; and Lian Shen is responsible for CASPER modeling efforts, particularly on fine-scale wave and/or coupled air-ocean modeling.

## WORK COMPLETED

CASPER MURI started on July 1, 2014 with a minimum startup fund for CASPER team. The following tasks have been completed.

1) CASPER kick-off meeting held on Aug. 5 and 6, 2014 at the Naval Postgraduate School (NPS). In addition to CASPER PIs and participants, the kick-off meeting was also attended by many collaborators or potential collaborators from Naval Research Lab at DC, Monterey and Stennis, Naval surface Warfare Centers, SPAWAR, Army Research Lab, Woods Hole Oceanography Institutes, and National Center for Atmospheric Research (NCAR).
2) First site visit to the Army Field Research Facility (FRF) at Duck, North Carolina. Details of the near-shore measurements for CASPER East pilot and CASPER extended measurements were discussed with the FRF host and among CASPER PIs.
3) Preliminary planning for CAPSER East Pilot experiment. The pilot experiment will occur at the pier of FRF at Duck, NC and about 20-30 km offshore of the Duck pier April 5-18, 2015.

4) Initial planning for CASPER East IOP on October 2015. In addition to preparation within each PI group, teleconferences have been held to discuss specific topics such as electromagnetic propagation measurement and strategy of research vessel usage.

5) We have worked extensively on design of the pier-based near-surface measurement system focusing on the mounting of the up-side-down sensor hosting mast and the surf zone mast sensor mounting to be deployed at the CASPER East pilot experiment. A similar mast with a small suite of meteorological sensors was erected at the beach of Monterey for testing purposes. At the same time, we are working on the development of a expendable air-sea interface float and the Wave Glider based turbulence measurement system to be deployed in CASPER East IOP (Naval Postgraduate School).

6) We have developed an initial understanding of the measured data needed for extracting EM propagation model parameters and are in the process of preparing the hardware needed for the experiment campaigns (Ohio State University).

7) Preliminary theoretical analyses have been completed, based on certain assumptions on boundary layer similarity and the nature of turbulence. Collaborative activities with Army Research Lab (ARL) has been initiated and periodic telecons are being carried out with ARL personnel (University of Notre Dame).

8) We have been inventorying our instruments and sensors and testing both hardware and software to be used on both the Twin Otter and the CTV. In early September we performed extensive ground tests at CIRPAS on the existing video transmitter/receiver pairs to characterize the shortcomings (range, image quality, interference with other communication systems) of each one of them. This helped us determine the specifications of the optimal transmitter/receiver pair. Subsequently, we obtained from a leading manufacturer demo units that would meet these specifications. Ground tests of the demo pair were very conclusive and confirmed it provides very good quality picture, has plenty of range and does not interfere with the two other CTV communication links (science data and CTV control) or with the GPS L1, L2 signals. This is a significant progress and there should be no technical limiting factor for routine operation of the CTV at 9-10 m over the ocean. We also worked with CIRPAS chief mechanic on the integration of UCI Riegl scanning lidar topographic mapper system to be used for 3D characterization of ocean surface wave field. A crude mockup was devised to simulate its collocation with the CTV docking and winch system on the aft downward-looking port (University of California, Irvine).

9) We have been working on ship time requests (STR) with ONR Navy Research Facility and relevant ship operating institutions. Communication with University-National Oceanographic Laboratory System (UNOLS) to finalize ship use for CASPER is still ongoing (Oregon State University).

10) Based on the coastal condition of the CASPER-East experiment, we have further improved our wave simulation program so that it now has the capability of simulating finite-depth waves. We have also achieved the dynanical couplying of our new finite-depth wave simulation code with our wind LES code, which establishes a useful tool for the study of CASPER-East in the coming years (University of Minnesota).

## RESULTS

CASPER MURI project started on July 1, 2014 with minimum startup fund for travel. No significant science results have been produced.

## RELATED PROJECTS

NONE