Numerical Modeling of Ship Motion and Sea Surface Roughness Effects on X-Band EM Propagation Measurements of the CASPER Campaigns

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An important application of air-sea interaction research is in characterizing ducting properties in order to predict radar and radio communication conditions in the marine environment. This ongoing research project, CASPER (Coupled Air-Sea Processes & EM Ducting Research), conducted its first major experimental campaign off the coast of Duck, NC, during October-November of 2015 to measure EM propagation concurrently with extensive co-located atmospheric and oceanographic observations (CASPER East). The main objective of the EM experimental component of this project is to obtain data that is sufficient for determining the prevailing ducting conditions and range-dependent refractivity profiles based on improved environmental models. A versatile X-band receiving array is deployed to measure the one-way propagation loss between the emitters and receivers as a function of antenna height and range. In this paper a parabolic wave equation (PWE) computer code is used to model the propagation measurement scenarios of the CASPER experimental campaigns.

The CASPER East experiment demonstrated that the X-band system is capable of measuring signals up to 75 km, which is well beyond the line-of-sight horizon. During the measurements, the ship roll, pitch and yaw due to ocean waves causes the received signal to fluctuate. The rough sea surface can also affect the EM propagation in the evaporation duct. The results of a simulation study of ship motion and sea surface roughness will be presented to quantify their impact on the propagation measurements.

In preparation for the CASPER West campaign to be conducted in the fall of 2017 off the coast of southern California, the PWE code will be used to study the field distribution along vertical cuts as a function of range for the expected ducting conditions. This will allow us to optimize the configuration of the vertical receiving array and antenna polarization to sample the fields at a minimum number of points. The phase of the signal will also be included in the study to ascertain if phase information is helpful for inverting the refractivity profile from measurements. If so, the X-band system will be upgraded to measure the relative phase between the elements of the receiving array.