A Physics-Based Model for the Amplitude Distribution
of Bistatic Sea Clutter

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The performance evaluation of maritime radar detection in the presence of sea clutter remains a challenging problem in radar systems analysis. Detection of a small target in sea clutter requires a detailed understanding of sea clutter statistics. In particular, the amplitude distribution function for sea clutter is important for designing target detection algorithms and also for assessing the utility of varying bistatic geometries in target detection applications. Various amplitude distribution models for sea clutter have been developed through empirical fits. This study presents a physics-based model for the amplitude distribution of sea clutter for both monostatic and bistatic configurations.

In this initial work, a Monte Carlo simulation of sea clutter is performed using sea surface realizations created with the Elfouhaily unified spectrum model. These realizations are produced using a "two scale" approach: "small scale" roughness represents a radar range cell from which scattering is evaluated using the second order Small Slope Approximation (SSA2). The "large scale" roughness represents tilting of the radar range cell caused by sea surface roughness on length scales large compared to the radar resolution. In the Monte Carlo simulation, each small scale surface facet is tilted by a realization of the large scale surface slopes, with the resulting ensemble of sea clutter returns regarded as representative of returns from a sea surface range cell. Initial results of the Monte Carlo simulation show that finer range resolution and higher wind speed lead to more tilting of range cells so that the amplitude distribution of the simulated sea surface shows more significant departures from the Rayleigh distribution expected with no tilting.

In this paper, we study the amplitude distribution of the simulated sea surface as a function of frequency, polarization, and the bistatic configuration. The goal is to identify combinations of these parameters that yield improved detection performance. Also, we study the sensitivity of the amplitude distribution to wind speed in order to assess the potential of amplitude distribution measurements for the remote sensing of sea winds. It is noted that the model developed does not include sea surface features such as breaking waves, so that the "sea spike" behaviors of sea clutter important at lower grazing angles are not captured. The model is therefore limited to application at larger grazing angles.