# SCATTERING PROPERTIES OF THE OCEAN SURFACE: MILLER-BROWN MODEL REVISITED

Hristov, T. S. [1], Anderson, K. D. [2]
[1]Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD 21218 USA
[2]SSC-San Diego, 2858, 53560 Hull St., San Diego, CA 92152

Abstract Submission Form

2004 National Radio Science Meeting

Abstract: hristov18632

Date Received: September 24, 2004

Describing the propagation of electromagnetic signals in refractive ducts over the ocean requires to account for the scattering from the water surface. Although available, the exact formulation of the scattering problem is commonly replaced by approximations for computational efficiency. Miller-Brown's result for the scattering crossection of the sea surface (A. R. Miller, R. M. Brown, and E. Vegh, *IEE Proceedings, Part H*, **131(2)**, 114–116, 1984) has been broadly accepted and has been employed in models for electromagnetic propagation over the ocean.

Miller-Brown model is built on two essential elements: the Kirchhoff approximation and the assumption about the probability distribution of the ocean surface elevations. Using the analytic signal representation of the surface waves $\eta(\mathbf{x}, t) = A(\mathbf{x}, t) \exp[i\phi(\mathbf{x}, t)]$, the Miller-Brown model prescribes that wave amplitudes $A(\mathbf{x}, t)$ follow a Gaussian distribution and the wave phases $\phi(\mathbf{x}, t)$ have an uniform distribution. Consequently, the surface elevations maintain the distribution $P(\eta) = \pi^{-3/2}\sigma^{-1} \exp\left[-\eta^2/(8\sigma^2)\right] K_0 \left[\eta^2/(8\sigma^2)\right]$, $K_0(\cdot)$ being a modified Bessel function of the second kind and $\sigma^2 = \langle\eta^2\rangle$. While the Kirchhoff approximation has known strengths and limitations, the prescribed statistical distribution of the sea surface needs to be reviewed in the light of today's understanding of the surface wave dynamics (M. S. Longuet-Higgins, *Phil. Trans. R. Soc. Lond.*, **249**, 321-387, 1957) and experimental data on scattering (Y. Karasawa and T. Shiokawa, *IEEE Trans. Comm.*, **36**, 1098-1104, 1988).

We reconcile the Miller-Brown model with the surface wave dynamics by using the Kirchhoff approximation with realistic statistics for wave elevation. The nonlinear interaction of the surface waves can lead to smoother troughs and sharper crests, i.e. to asymmetry in the probability distribution of the ocean surface (M. S. Longuet-Higgins, *J. Fluid Mech.*, **17**, 459-480, 1963). Such asymmetry produces a complex-valued scattering coefficient. Both coherent and diffusive scattering can be treated within this approach.

1. (a)
Tihomir Hristov
Department of Earth
and Planetary Sciences
Johns Hopkins University
3400 North Charles Str.
Baltimore, MD
21218 USA
`Tihomir.Hristov@jhu.edu`
   (b) 410-516-8241
   (c) 410-516-7933
2. F - Wave Propagation and Remote Sensing
3. (a)
4. C - Contributed Paper, Program chair: Kenn Anderson
5. No special instructions