TEMPORAL COHERENCE OF THE ELECTROMAGNETIC FIELD SCATTERED BY A MOVING SEA SURFACE IN L-BAND.

Arnaud COATANHAY

Laboratory E3I2, EA 3876, ENSIETA, 29806 Brest Cedex 9, France
Arnaud.Coatanhay@ensieta.fr

1. INTRODUCTION

The analyze of the electromagnetic field emitted by a source of opportunity (GNSS signals for instance) and scattered by the sea surface is a very active research field for the ocean-monitoring activity. For example, the project MOPS- Marine Opportunity Passive Systems [1] was very recently launched to evaluate the performance of different GNSS receivers (L-Band) at dozens meters above the sea surface to measure various oceanographical data.

One of the major limitations for these approaches is the weakness of the signal to noise ratio where the scattered GNSS signal is observed. The most popular way to manage this weakness is to integrate the recorded signal over a very long period of time (from several milliseconds to several minutes). In the same way, to obtain a very accurate measurement of the scattered signal delay, a high sampling rate and a coherent temporal integration are needed. Unfortunately, a coherent integration of the scattered electromagnetic field remains valid only if the experimental conditions are assumed to be static. Obviously, for such period of time, the sea must be considered as a time-varying surface.

The purpose of the present paper is to analyze the temporal coherence of an electromagnetic field scattered by a moving sea surface in L-Band for various weather conditions and various geometrical configurations.

2. SEA SURFACE MODEL

In a very common way, a random ocean-like surface corresponding to a given weather condition (wind speed and wind direction) can be generated using the realistic sea spectrum developed by Elfouhaily et al. [2]. This sea spectrum is in the form:

$$S(K, \phi) = M(K) f(K, \phi) \tag{1}$$

where $M(K)$ represents the isotropic part of the spectrum modulated by the angular function $f(K, \phi)$, and where K and ϕ are respectively the spatial wave number and the wind direction, see figure (1). Using the convolution of this spectrum with a unitary white gaussian random signal, we can generate thousands of one-dimensionnal profiles that represent ocean surfaces for given weather conditions.

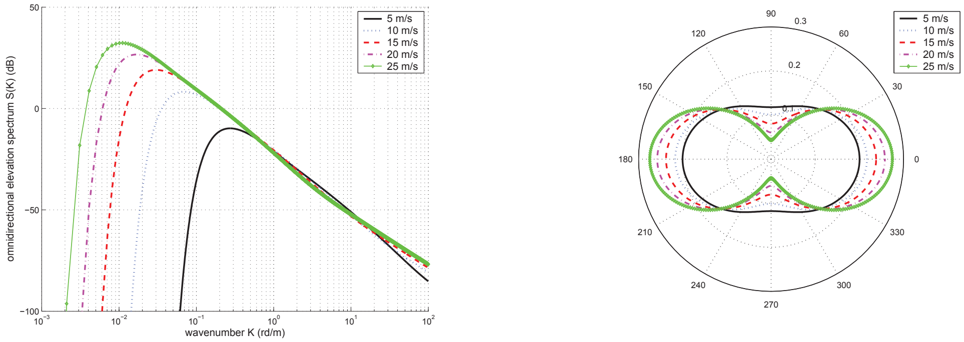
To introduce the movement of the so-generated random profiles, we must take into account the velocity of the sea waves that depends on the wave number [3]. The velocity of the longer wavelength waves is mainly influenced by the gravity, whereas for the shorter wavelength waves the predominant effect in the velocity is the capillary. For non-shallow water, the dispersion relation can be approximated by:

$$\omega(k) \approx k \cdot \sqrt{\frac{g}{k} + \frac{\tau k}{\rho}} \tag{2}$$

where g is the gravitational acceleration, τ is the water surface tension and ρ is the density.

3. ELECTROMAGNETIC SCATTERING MODEL

To compute the electromagnetic field scattered by the ocean-like profiles previously generated, we apply an efficient Method of Moments (MoM) called the Forward-Backward method (FB-MOM) [4, 5]. Then, using the so-computed scattered fields, we



(a) *Omnidirectional elevation spectrum*

(b) *Angular function*

Fig. 1. Elfouhaily sea surface spectra with different wind speeds.

can study the temporal coherence and evaluate the temporal autocorrelation function for any bistatic configuration and for any weather condition.

4. OBTAINED RESULTS

Based on the here presented approach for different polarizations (vv and hh), the numerical results show that the temporal coherence depends on the scattering direction and is significantly influenced by the wind speed.

5. REFERENCES

[1] A. Coatanhay, R. Garello, B. Chapron, and F. Ardhuin, "Project mops - marine opportunity passive systems," in *Passive'08*, 2008.

[2] T. Elfouhaily, B. Chapron, K. Katsaros, and D. Vandemark, "A unified directional spectrum for long and short wind-driven waves," *Journal of Geophysical Research*, vol. 102, no. C7, pp. 15781–15796, 1997.

[3] J. Miranda, A. Camps, J. Gmez, M. Vall-llossera, and R. Villarino, "Time-dependent sea surface numerical generation for remote sensing applications," in *IGARSS'05*, 2005.

[4] D. Holliday, L. L. DeRaad, and G. J.St-Cyr, "Forward-backward: a new method for computing low-grazing angle scattering," *IEEE trans. Antennas Propag.*, vol. 44, no. 5, pp. 722–729, 1996.

[5] A. Iodice, "Forward-backward method for scattering from dielectric rough surfaces," *IEEE trans. Antennas Propag.*, vol. 50, no. 7, pp. 901–911, 2002.