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# A study of the statistics of sea clutter in the northern coast of Taiwan

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## ABSTRACT

Analyses of sea clutter measured at Taipei Harbour were carried out. Statistical models commonly used by researchers for sea clutter were used to fit measured data. These include the Rayleigh, the Weibull, the lognormal, and the so-called (compound) K- distributions. It is shown that the lognormal distribution results in the best fits among all possible candidates. Possible sources for the misfits of the K-distribution suggested by many researchers were also discussed.

KEY WORDS: Sea clutter; statistical distribution; Rayleigh-, lognormal-, Weibull- and K-distributions.

## INTRODUCTION

Sea clutter is the backscattered electromagnetic waves of radar from the sea surface. While they may be considered annoying for the most of time, sea clutters may contain information of the structure of the water surface and are, therefore, considered by oceanographers to be rather useful. It has been shown by many researchers that, valuable information concerning both the wave- and wind-fields can be derived from it (Gommenginger, 1997, see also Gommenginger et al., 2000; Robinson et al., 2000; as well as Lentine, 2006).

Young et al. (1985; Ziemer, 1987; Gangeskar; 2000) have shown that, useful information concerning the wave fields can be extracted from radar image sequences. Using wave heights obtained from the so-called wavenumber-frequency spectrum, Nieto Borge & Guedes Soares (2000; Izquierdo et al., 2004, 2005; Hessner et al., 2006) clearly show that these are in good agreements with on site measurement. Furthermore, it have also been shown that surface current speeds and direction (Senet, 1996), as well as water depth (Outzen, 1998), and information about the wind fields above the water surface (Hatten, 1998; Dankert, 2003) can be inferred from radar images.

Statistical analyses of sea clutter started with the intension of its suppression so that objects other than waves on the sea surface can be detected easily (Ward et al., 1990a, b; Wetzel, 1990). Most commonly used statistical models are, the Rayleigh, Weibull, lognormal, and the so-called K-distributions. Researchers have found that, when the resolution cells are large, and grazing angles are high, the Rayleigh distribution is well situated for describing the sea clutter statistics. However, when the resolution cell is small, and/or the grazing angle low, the clutter statistics gradually develop a "long tail", and this makes them to deviate from the Rayleigh model.

It was often suggested that, the last model, the K-distribution, should be favoured (Ward et al., 1990a; Antipov, 1998). This is because this model can be considered as the product of two distributions, i.e., the Rayleigh and the gamma. The former is considered to represent the effects of small-scale reflectors on the sea surface, such as capillary waves. The latter, on the other hand, is due to the underlying swell, which may have scales larger than the resolution cell. This argument, however, breaks down when it was found that the K-distribution can also be used in modelling both land- and sea-clutters in radar images (Dong, 2004a), or even speckles in the images of ultrasound echoes (Dutt, 1995; Pesavento, 1999).

The sea surface is a collective result of many interacting factors such as surface currents, waves due both to distance storms, or local winds, nonlinear wave-wave interactions, as well as topographic influences. Since sea clutters are the results of multipath reflections of the sea surface, knowledge of their statistics is important, as the information of the sea state may be contained in it (Trizna, 1991).

The Institute of Harbour and River Engineering of the National Taiwan Ocean University started to study radar images a few years ago. Preliminary results were presented in the ISOPE 2006 conference (Yim et al., 2006). In this article, we discuss some results of our recent studies on the statistics of sea clutter.

### The measuring site

The Taipei Port, located in the northern Taiwan, is a new harbour under construction. The Port Authority of Keelung Harbor (PAKH) is responsible for the administrative planning works and procedures. A few years ago, a long-term program to monitor the coastal environments of the Harbour was launched by PAKH. This program has the purpose of gathering all the possible information of the oceanographic processes of the coastal area nearby. The data will then