Simulation of the electromagnetic scattering by coastal breaking sea waves in L-band using Adaptive Multiscale Moment Method

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Introduction

We are concerned with the detection and the characterization of the electromagnetic signature induced by the breaking sea waves. We specifically focus upon the scattering in L-band by the coastal breaking waves. To this end, we present the combination of two efficient approaches (an hydrodynamic one and an electromagnetic one) to obtain a global realistic numerical simulation.

Breaking sea wave modeling

Contrary to breaking waves generated by strong wind condition, coastal breaking wave appear under every weather conditions and are mainly due to the variation of the sea depth. From a physical point of view, the dynamic of these coastal waves can be described by nonlinear partial differential equations with rigid (sea bed) and free (sea surface) boundaries.

Various numerical approaches (finite differences, finite elements, standard boundary elements,...) can be exploited to compute the time varying breaking wave sea surface. However, these approaches generally require significant computing resources for realistic simulations. Quite recently, Scolan [1] showed that the Desingularized Technique combined with relevant conformal geometrical transformations of the domain (circumscribed by the physical boundaries) leads to a very efficient method that can be used in the present case.

Considering the sea surface numerically generated by this method, it can be seen that the breaking sea wave profile may have a complex geometrical structure with local high curvatures (wave crests) and large smooth parts.

Electromagnetic scattering

A very standard way to compute the scattering of an electromagnetic wave with wavelength λ by a given shape consists in using linear boundary elements (Method of Moments) with sampling step $\lambda/10$. Unfortunately, high curvatures raise severe convergence difficulties [2] and more sophisticated approaches must be investigated. In [3], we demonstrated that the High-Order Method of Moments (HO-MoM) with a Non Uniform Rational Basis Spline (NURBS) geometry could partially provide a solution to the problem.

In the present study, we show that Adaptive Multiscale Moment Method (AMMM) further improves the performances of the numerical approach. In addition, we highlight the relationship between the fluid surface geometry and this adaptive process. In particular, the influence of the adaptive approach in the vicinity of the breaking wave crest is pointed out.

Finally, we present a time-frequency analysis of the electromagnetic scattered field induced by our time-varying breaking wave simulations.

References

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