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Euler characteristics of oceanic sea states

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Abstract

We present an application of a novel Variational Wave Acquisition Stereo System (VWASS) for the estimation of the wave surface height of oceanic sea states. Specifically, we show that VWASS video technology combined with statistical techniques based on Euler Characteristics of random fields provides a new paradigm for the prediction of wave extremes expected over a given area of the ocean.

Keywords: Euler characteristics; Oceanic waves; Image processing; Partial differential equations; Stereo epipolar; Variational methods

1. Introduction

The prediction of large waves is typically based on the statistical analysis of time series of the wave surface displacement retrieved from wave gauges, ultrasonic instruments or buoys at a fixed point P of the ocean. However, in short-crested seas the surface time series gathered at the given location tends to underestimate the true actual wave surface maximum that can occur over a given region of area S around P. Indeed, large waves travel on top of wave groups, and the probability that the group passes at its apex through P is practically null. The large crest height recorded in time at P is simply due to the dynamical effects of a wave group that focuses nearby that location within or outside S forming a larger wave crest. Thus, point measurements can underestimate the global maximum $\eta_{\max}$ of the wave surface height η attained over S. Only in narrow-band sea states, point measurements are exact in predicting such maximum which is expected to be the same at any point in space. However, realistic oceanic conditions are generally short-crested and the expected $\eta_{\max}$ can be underestimated if wave extremes are not modeled both in space and time as maxima of random fields rather than those of random processes of time [1,17,3]. The predictions of such space-time extremes rely on the exceedance probability

$$\Pr\left\{\max_{P\in S}\eta(P) > h\right\} \tag{1}$$

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