Field Measurements of Wave Breaking Statistics Using Video Camera for Offshore Wind Application

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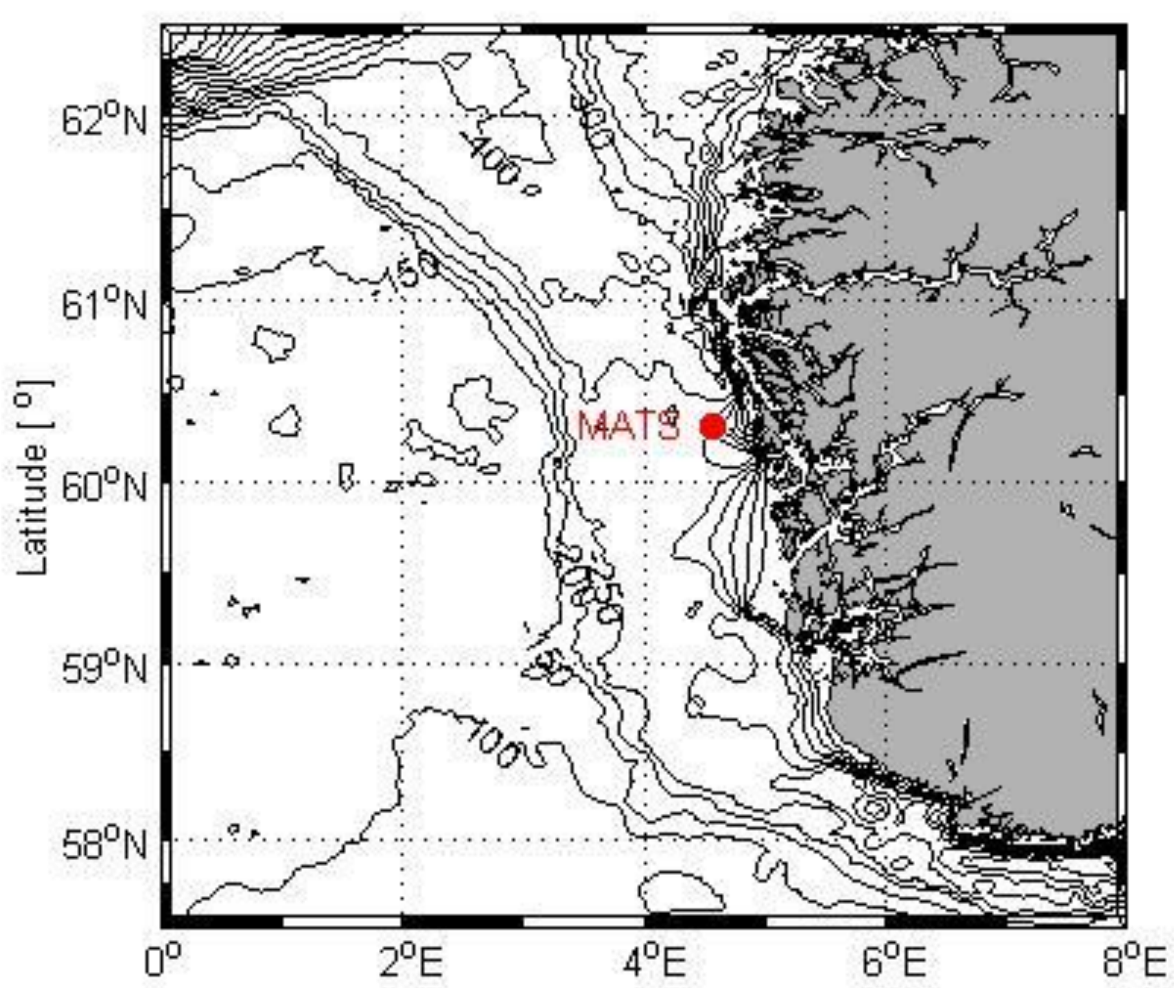
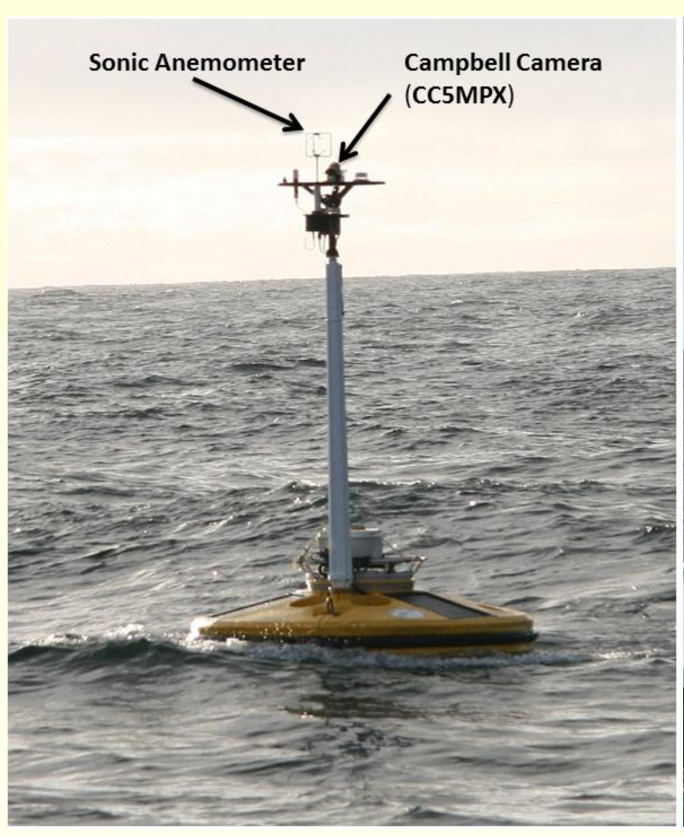
Introduction

Wave breaking as a widespread phenomenon all over the world oceans that interacts in a nonlinear complicated way to marine structures and provides a mechanism for exchange of momentum, heat, gas, energy, and moisture across the air-sea interface. In spite of difficulty to measure this phenomenon in the field, wave breaking in deep and shallow waters have been subjected to several theoretical, laboratory, observational, and numerical studies during the last four decades. Recent research, e.g. Sullivan et al 2009 and Nielsson 2012, has shown that waves have the ability to influence the turbulence structure in the lower marine atmospheric boundary layer and thus to increase loads and fatigue on turbine rotor blades. In addition, wave breakings will doubtless increase loads exerted on the turbine foundations and monopile structure. Investigation of wave breaking processes is therefore highly required for the development of offshore wind farms in deep water. In this study, we use a video camera mounted on a discus buoy during a 10-day deployment at the end of November 2013. The buoy will presumable be moored in the Norwegian Havsul area which is approved for offshore wind farms. This gives us first hand ability to reconstruct the sea surface waves and orbital velocities. Furthermore, we detect breakers with an image processing algorithm and track them on the observed surface. These techniques enable us to capture a broad frequency (wavenumber) range of breakers by conventional visible video techniques. The key breaking quantity extracted from the video recording is the length of breaking crest per unit area. We investigate this parameter for different sea states to estimate the amount of energy dissipated from wave field to the underlying ocean mixing. The obtained dissipation is than compared with modelled and parameterized wave energy dissipation.

Site: South of Bergen, 20-29 November 2013



Instrumentaqtions

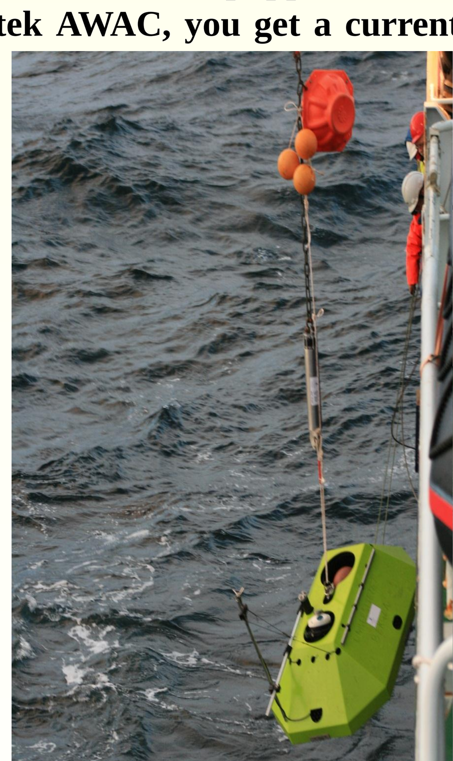


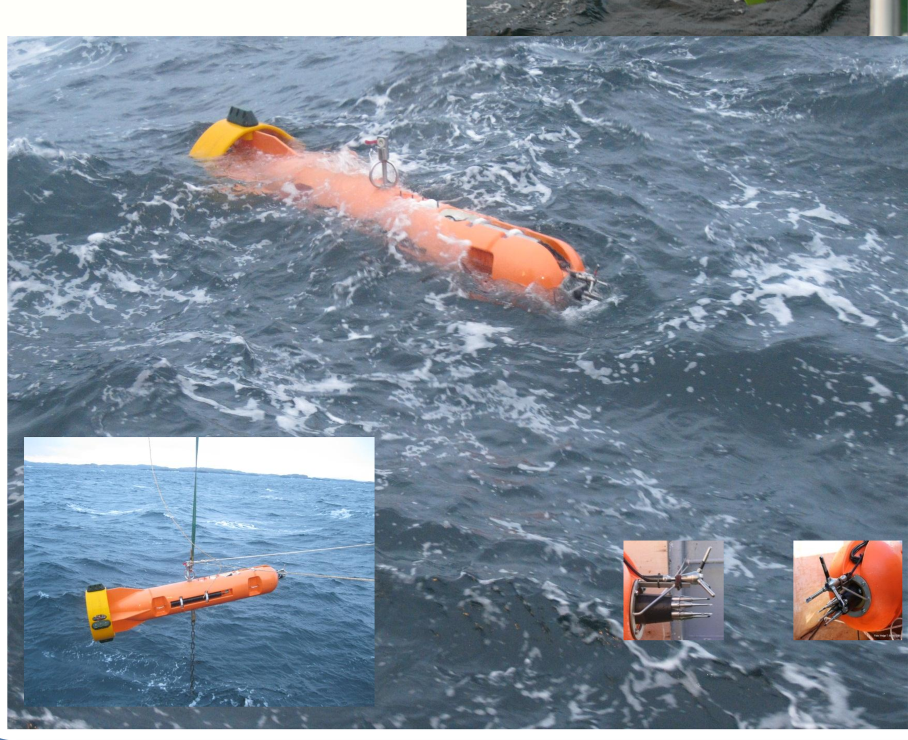
Atmospheric measurements

Two sonic anemometers: mounted on moving buoy abd ship,.

The bottom mounted platform was equipped with different oceanographic sensors including : Acoustic Doppler Velocitimeter (ADV), Nortek AWAC, you get a current profiler and a wave directional system in one unit, and an up-looking Aquadopp to give Burst of current.

Bottom fixed frame



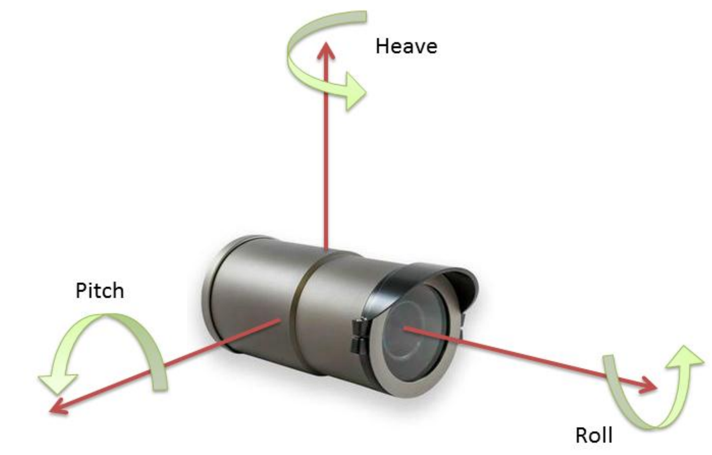


Microstructure Autonomous Turbulence System

Taking image at frequency 1 Hz, mounted on moving moord buoy. The camera installed in such a way pointing out towards surface with small angle below the horizontal plane. For the height of 4.5 m, It was set about 4 degree below the horizontal plane.

Here the difficulties of extracting wave breaking and sea surface wave characteristics from camera are examined. However, accurate analysis require more elaborations.

To date, Gemmrich et al. (2008) used images facquired from a video camera mounted on a floating platform to measure whitecaps passing through the field of view.



Langmuir Cells !?

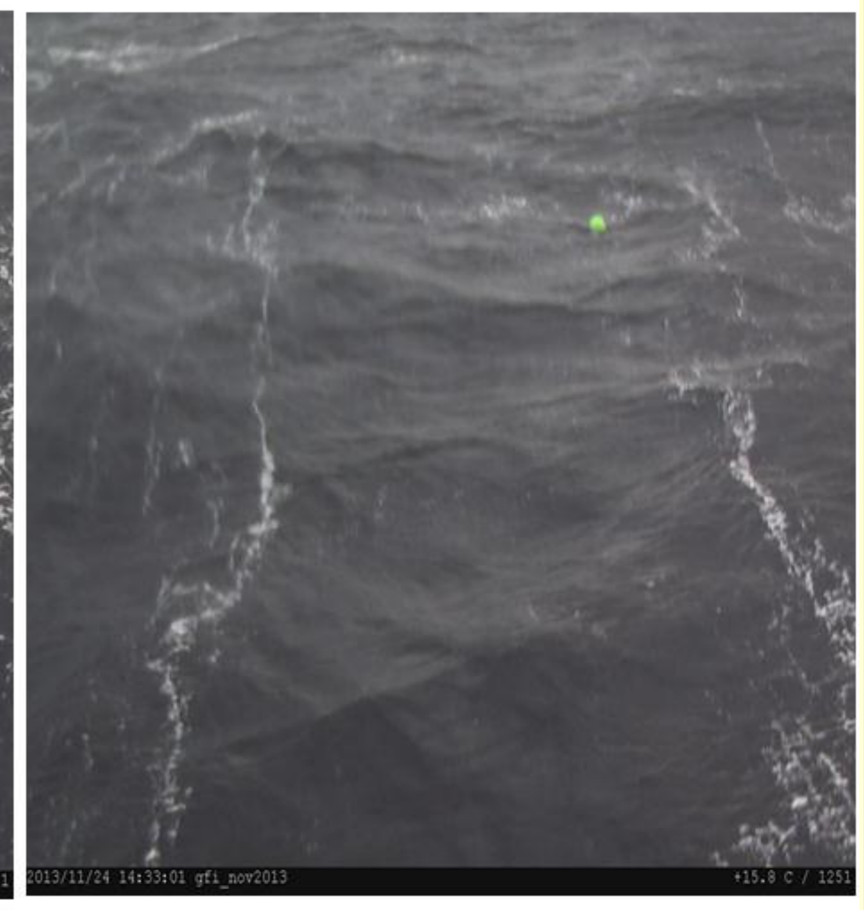


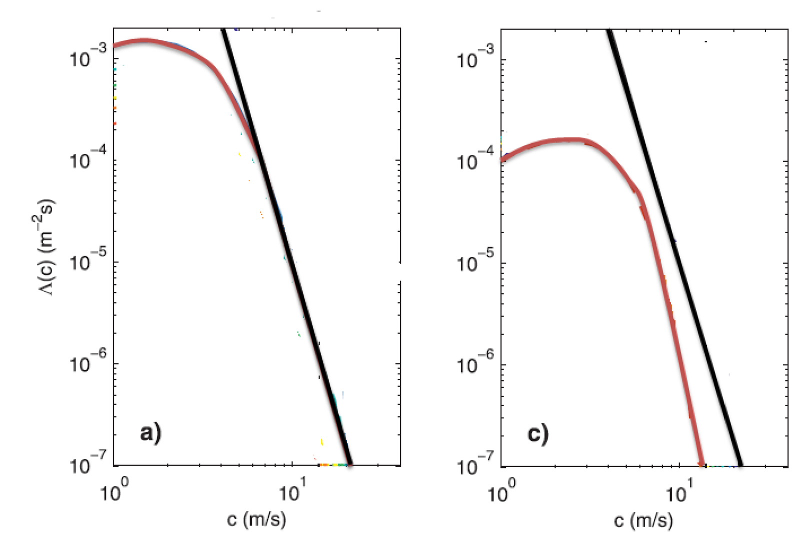
Image Processing

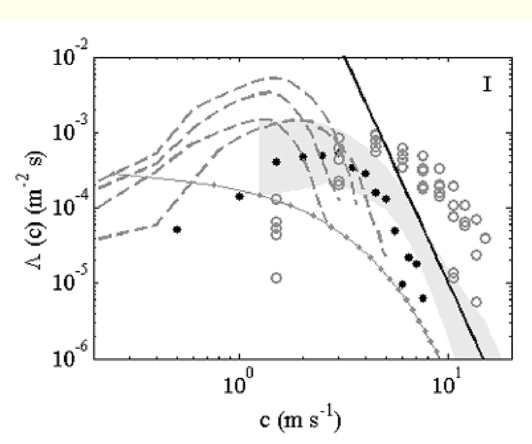
Each sea surface images physical dimensions are calculated using a combination of camera height, camera inclination angle, calibrated lens focal length and size of the camera CCD chip. Furthermore, the effects of lens distortion are removed from . Then, we do transformation over all pixel s to real world coordinates. This allowed us to calculate the whitecaps However, there are different resource of uncertainity in camera motions and lack of tracking whitchaps' patches due to camera wave-induced motion

Whitecap Foam and breaking waves

One difficult stages in image processing in our application is segmentation of images into regions containing foam, active breaking, and no breaking For this means and to differentiate different regions from each other, a brightness threshold is employed. An important and key parameters here is the Philips breaking crest length per unit area that can be applied to determine wave breaking characteristics. Fig .1 Shows this quantity idealized behavior with respect to breaking crest phase velocity for different thereshholds.

$$b(c)\Lambda(c)c^5 = g^2 S_{ds}(k)\,dk/dc$$





From [2]

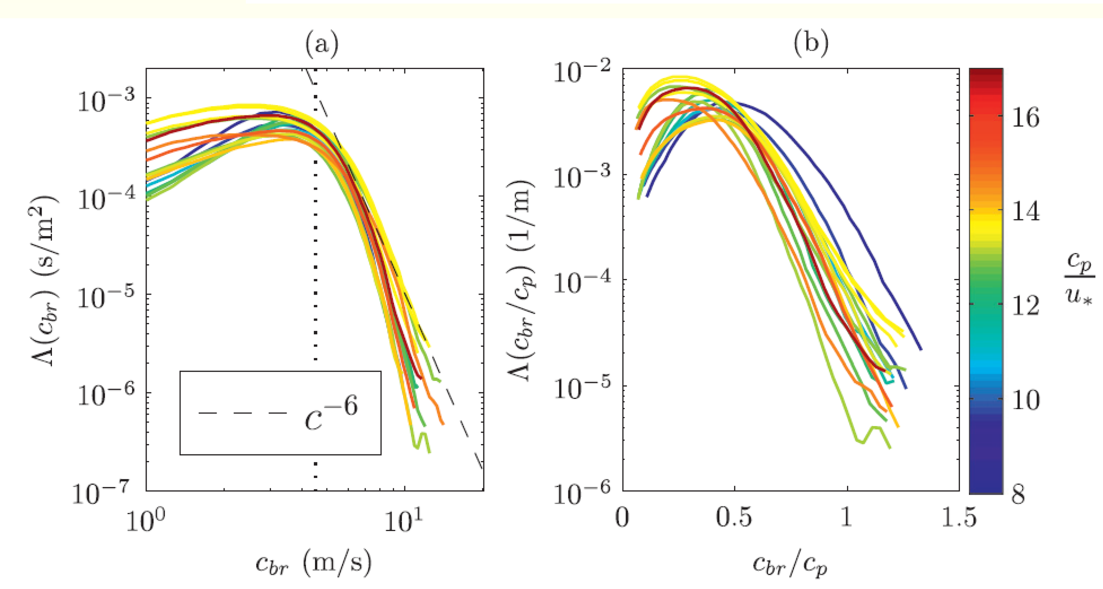


FIG. 9. (a) The $\Lambda(c_{br})$ distributions (Kleiss and Melville 2010) color coded according to the wave age c_p/u_*: the black dashed line is a reference power law of c^{-6} (Phillips 1985) and the vertical dotted line shows $c_o = 4.5\ \mathrm{m\ s^{-1}}$, corresponding to the lower limit of the $\Lambda(c_{br})$ data used in this study. (b) The breaking speed c_{br} is normalized by c_p and is scaled by c_p such that $\Lambda(c_{br}/c_p)d(c_{br}/c_p) = \Lambda(c_{br})dc_{br}$. From [1]

Acknowledgement

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Summary

In this research cruise, different aspects of air-sea interactions were measured using different fixed and moving atmospheric and oceanographic sensors. All platforms were recovered except bottom frame platform. We are analysing both camera data based on image processing and MATS subsurface platform to measure amount of energy and momentum induced to the water column as a result of wave breaking, wave-current, and wave-turbulence interactions. In image proccessing of surface wave images, we calculated physical dimensions of some choosed images using intrinsic properties of camera. Furthermore, we provided required image proccessing algorithms for transformation of images from camera coordinate frame to the world global coordinate system. This can been done with different open source softwares. To approaching goal of this study, we also are runing the state of the art of identifications of whitcap foams and wave breaking using camera images. Important parameter which gives information about breaking crest characteristics is Philips breaking crest length per unit area. The implementations of calculating this parameter together with estimation of dissipation of waves into the water column have been done. However, there are some technical issue in using developed algorithm in our moving camera images mainly to strong platform motion contaminations.

References

[1] L. Romero, W.K. Melville, and J.M. Kleiss, Spectral energy dissipation due to surface wave breaking, J. Phys. Ocean. 2012

[2] A. H. Callaghan, G. Deane, M. Dale Stokes, and B. Ward, Observed variation in the decay time of oceanic whitecape foam, J. Geophy. Res., 2013.