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Identifying realistic wave breaking from a measured time history

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Introduction

Wave breaking is an intermittent random process that is very fast in comparison to other wave processes. As it is impossible at this point to make quantitative assessments of the magnitude of velocities and forces involved during the process of wave breaking directly by offshore measurements, this project aims to predict wave breaking from a measured time history by means of an analytical as well as a numerical method.

Methodology

The analytical wave breaking detection method from a measured time history developed by Liu & Babanin (2004) is implemented and tested on a set of laboratory measurements.

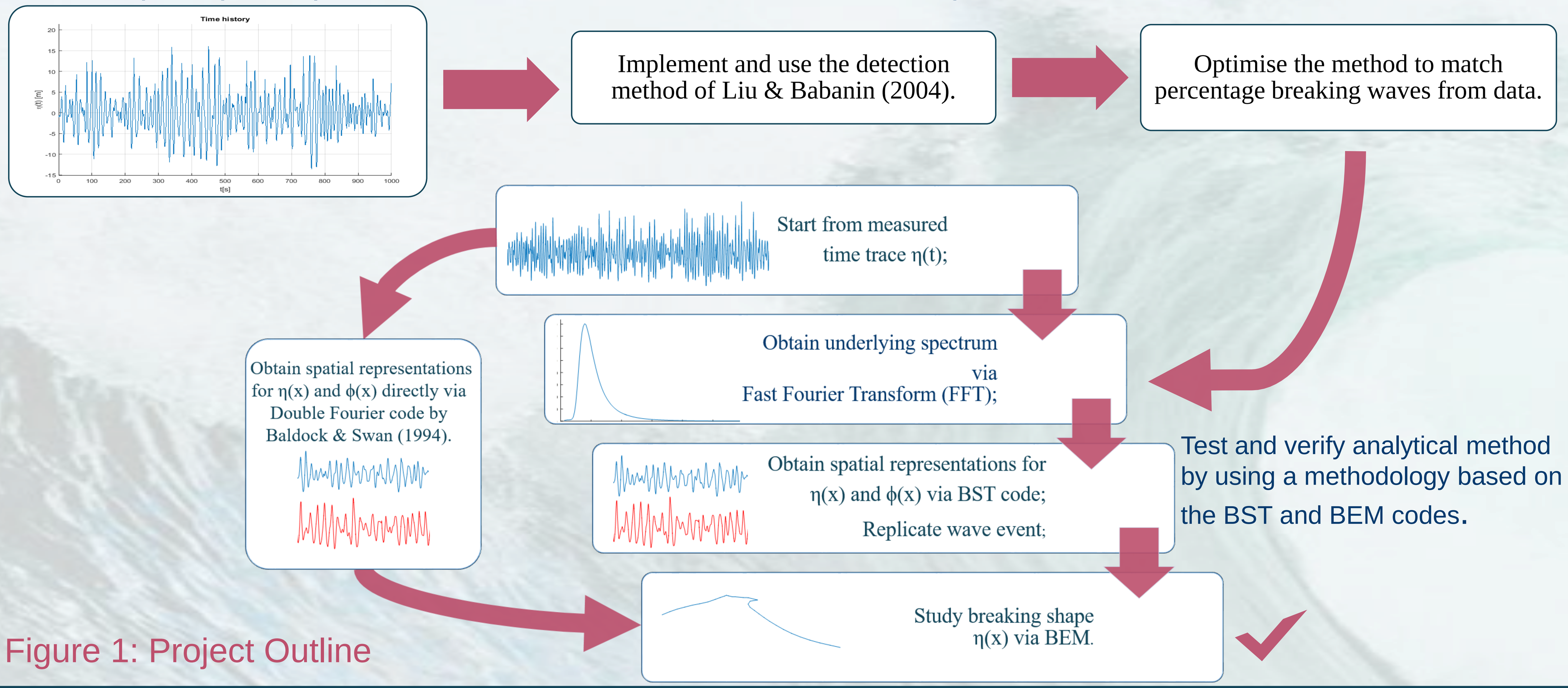


Figure 1: Project Outline

Analytical Method

The method of Liu & Babanin (2004) is based on a wavelet spectrum analysis. Using a complex valued Morlet transform and a Hilbert transform:

1) A localised frequency spectrum for each time step can be computed;

2) A characteristic frequency and amplitude for each time step can be computed;

3) A simple detection threshold for each time step can be deployed $\alpha_{downward} = a\sigma^2 > \gamma g$.

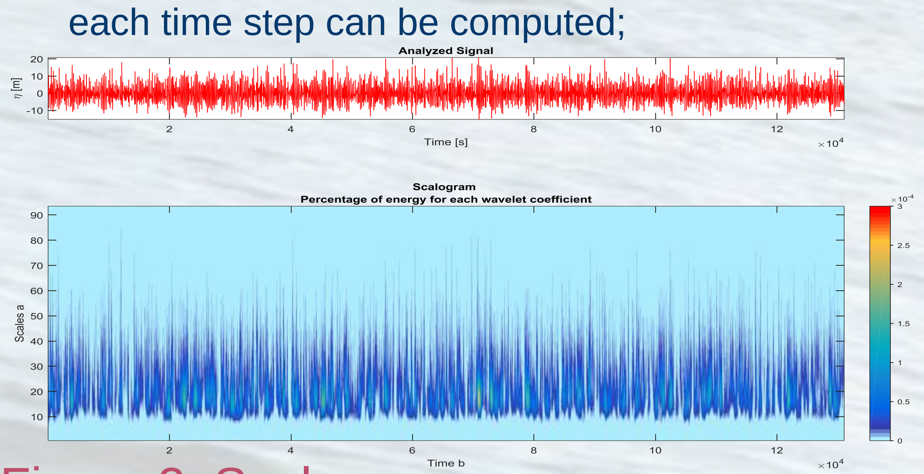


Figure 2: Scalogram

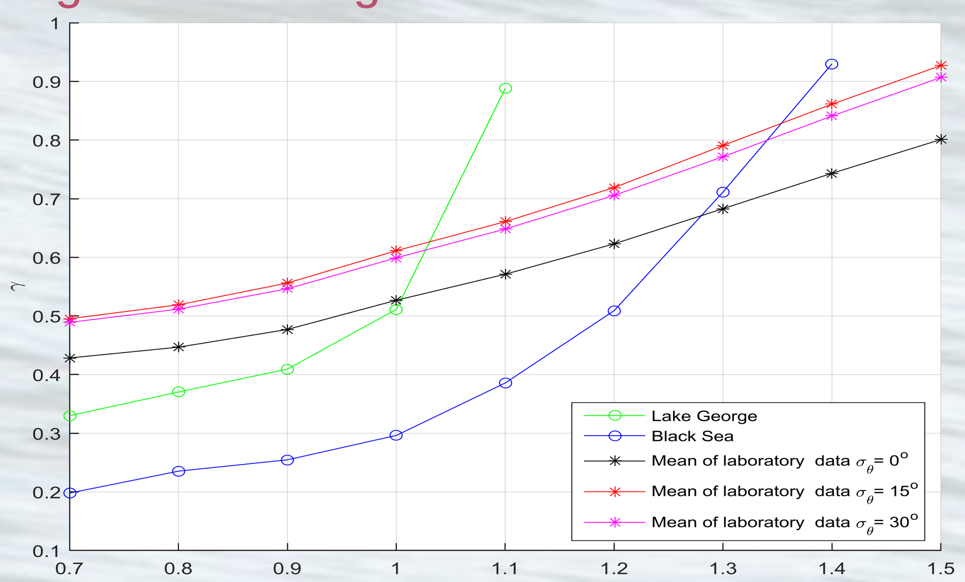


Figure 4: Result Curves

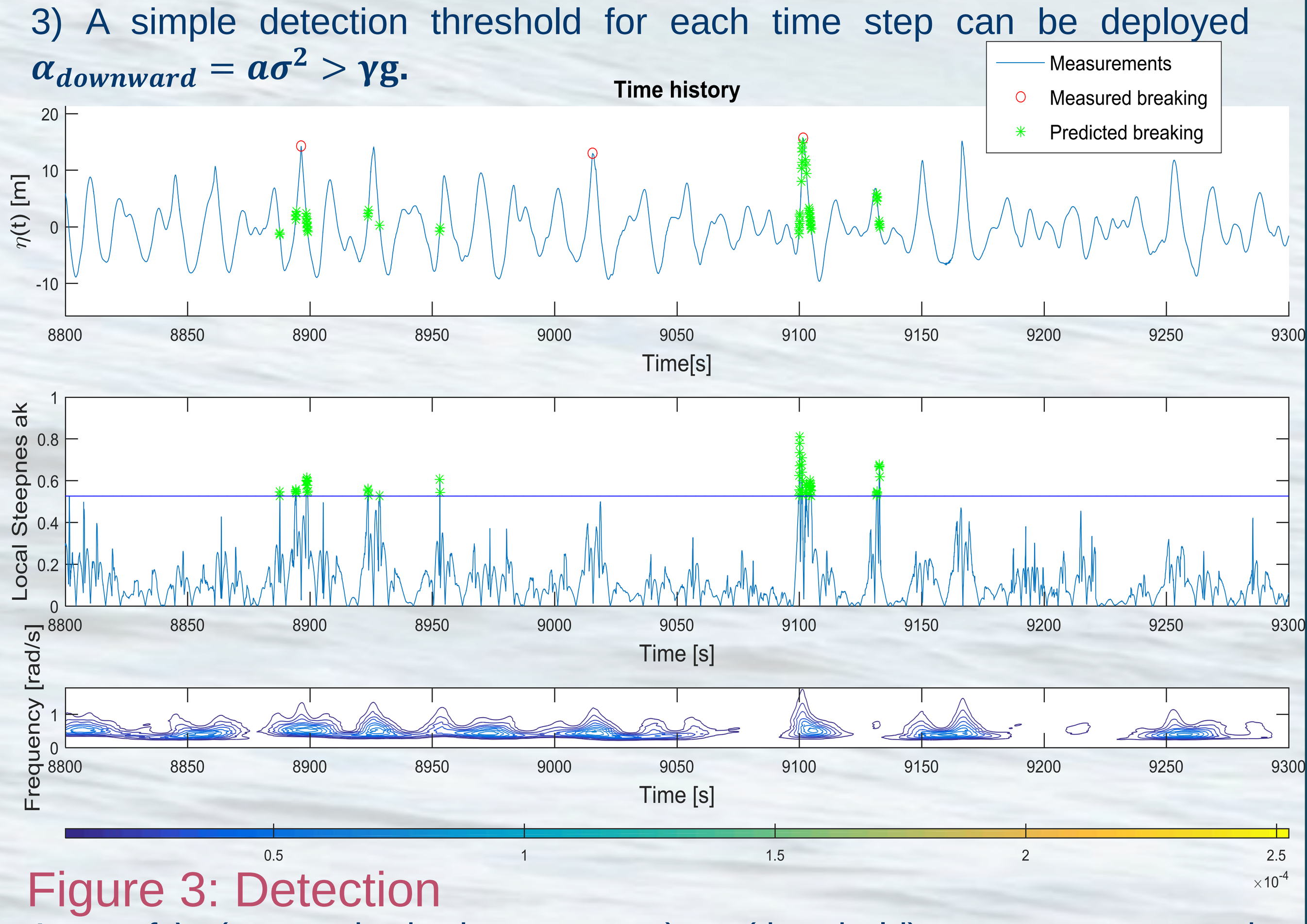


Figure 3: Detection

A set of λ_L (start point in the spectrum)– γ (threshold) parameter curves that ensures the results match the percentage breaking waves present in the data was computed.

Numerical Method

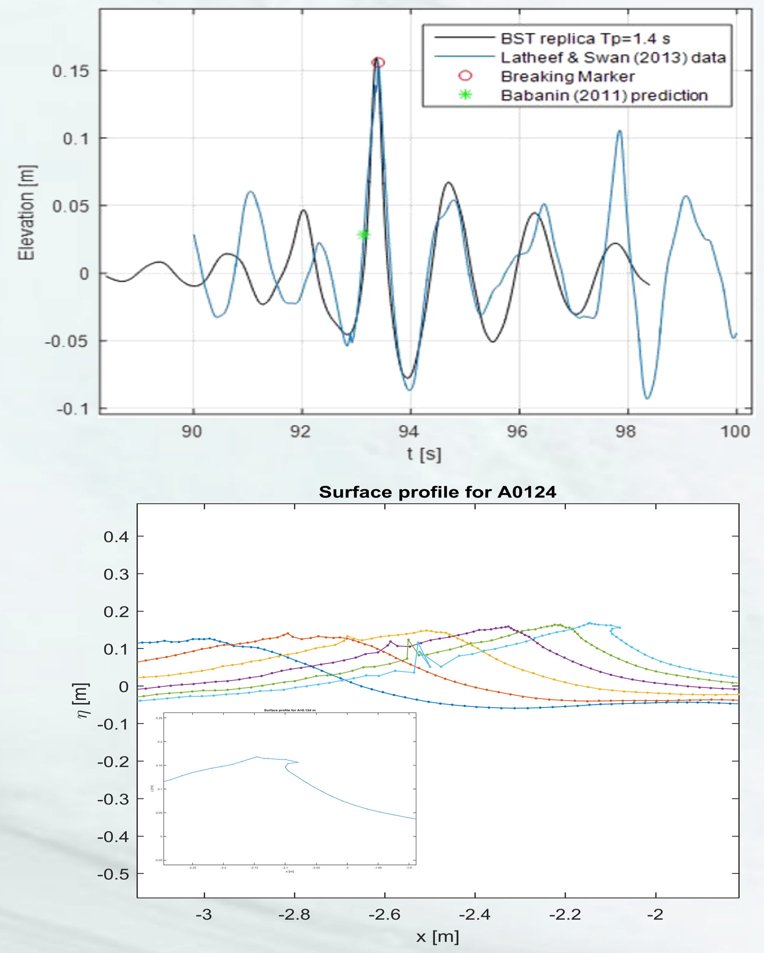
In order to replicate the temporal profile of the selected wave, a fully nonlinear numerical code developed by Bateman et al (2001) was used. The code entitled BST obtained the spatial distribution of the surface profile and velocity potential based on a JONSWAP spectrum.

Table 1: Test Cases

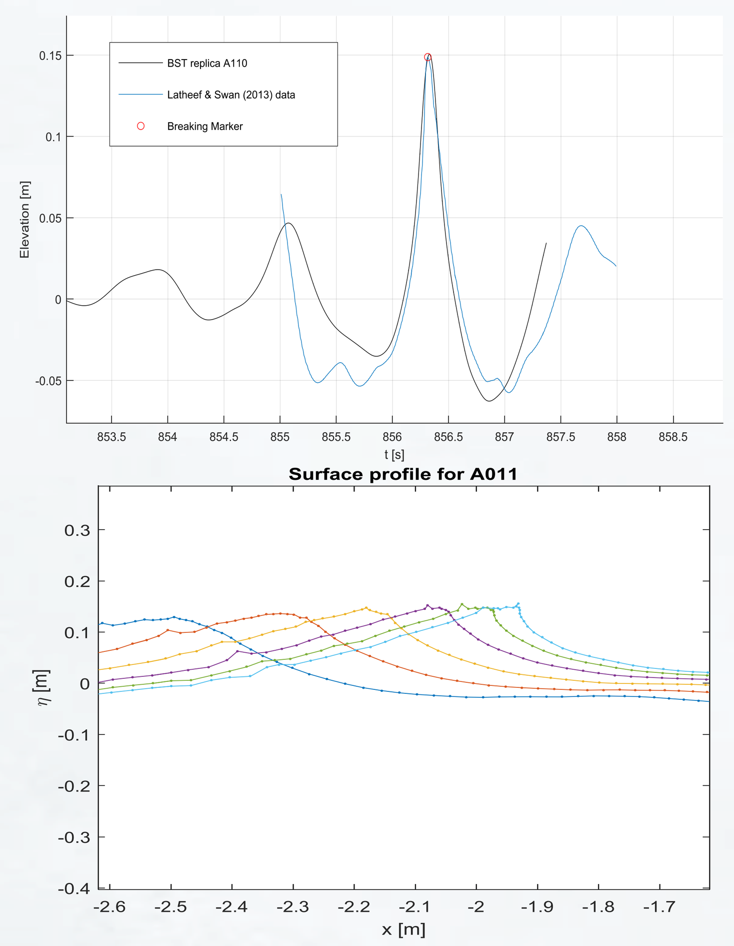
The replicated surface profile at an earlier stage than breaking was an input to the boundary element model (BEM) by Christou (2009). Time marching of each of the replicated events in Table 1 up to the breaking point was done and the shape of the breaking wave was studied.

Name	Scenario	Inputs
A124	Wave that was predicted and observed to be breaking.	A=0.124 m T_p=1.4 s
A110	Wave that was observed to be breaking but not predicted.	A=0.110 m T_p=1.4 s
A005	Wave that was predicted to be breaking but not observed.	A=0.005 m T_p=1 s

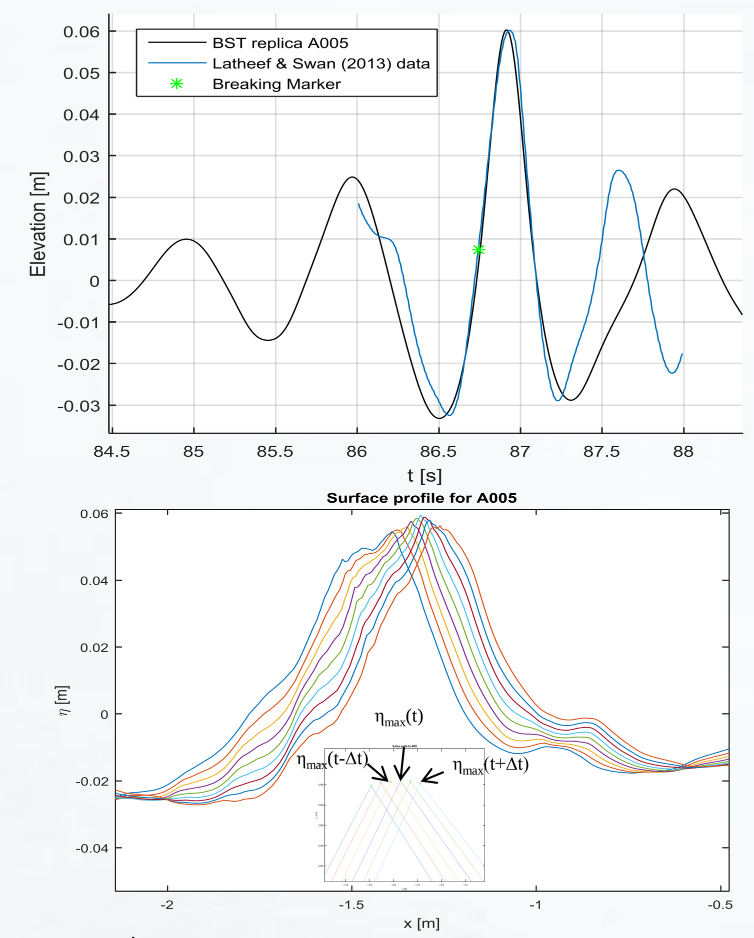
A124 – plunging breaker



A110 – spilling breaker



A005 – limiting steepness



*Fluid particle at crest of wave travels at phase speed

Conclusions and Further Work

While it was found that the biggest waves in the data were detected by the method and the numerical codes have shown that above a certain steepness, plunging breakers form, the less satisfactory detection of intermediate amplitude waves required further analysis. Because of the sensitivity of the Liu & Babanin (2004) method on the selected threshold value for local steepness, 100% matching of data cannot be expected.

The BEM can be used to better calibrate the analytical method by setting a threshold for the filtering of the results when matching percentage breaking. Another improvement is the implementation of the Double Fourier code by Baldock and Swan (1994) (Figure 1).

ACKNOWLEDGMENTS

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