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LoCOS-Wave: A Low Cost Open Source pressure gauge for measuring sea waves

Joan Villalonga[1], Joan Puigdefabregas[1,2], Gabriel Jordà[3]

[1] *Departament de Física, Universitat de les Illes Balears, Cra. de Valldemossa, km 7,5. 07122 Palma (Illes Balears), SPAIN https://www.uib.cat/ , joan.villalonga@uib.cat, joan@tremat.cat*
[2] *Departament d'Enginyeria Civil i Ambiental, Universitat Politècnica de Catalunya. C/Jordi Girona 1-3, 08034 Barcelona*
[3] *Centre Oceanogràfic de Balears, Instituto Español de Oceanografía. Moll de Ponent s/n 07015 Palma, SPAIN. http://www.ba.ieo.es. gabriel.jorda@ieo.csic.es*

Abstract – Sea wave observation have been traditionally very expansive, for this reason we have developed a prototype of low-cost do-it-yourself wave gauge. This device measures the bottom sea pressure and retrieve the wave parameters from its Fourier spectrum. The wave parameters estimated with our device are comparable with those obtained from a commercial tide gauge obtain. For this reason, we consider that our device could be useful to perform sea waves measuring experiments obtaining high quality data at a much lower cost.

Keywords – *Wave gauge, low-cost, do-it-yourself, Arduino, wave observations, bottom pressure sensor, water waves.*

I. INTRODUCTION

Sea waves have major consequences in coastal environments and populations. They are the main cause of beach erosion and can represent a hazard for coastal populations and marine infrastructures. Moreover, the impacts associated to wave storms are expected to increase in the near future due to the sea level rise induced by global warming. The study of nearshore waves usually relies on numerical modelling complemented by scarce observational data [1]. The cost of traditional commercial wave gauges often limits the deployment of dense networks of wave gauges either in terms of the number of devices or the temporal coverage [2].

In this work we present a low-cost open-source (LoCOS) wave gauge (Fig. 1) as a prototype of a do-it-yourself device. The main goal is to reduce the cost of sea wave observations, and to foster research by increasing the quantity of available observational data. To do so we take advantage of the open source Arduino environment using a bottom pressure wave gauge and easy-to-find electronic components and hardware.

II. DEVICE TECHNICAL DESCRIPTION

The device (Fig. 1) consists of a ms5803 pressure sensor connected to a datalogger similar to the one described by [3]. In our case, a SAMD21 processor was chosen to allow larger series of data (up to 1024 samples) to be stored and used in computing, and a TPL5110 circuit to switch off the system and reduce power consumption. This timer switch can be adjusted at intervals ranging up to 2 hours. Samples are taken at a configurable rate (4Hz in our experiments) and stored in a data sample series to be processed. Configuration of sample series length, sampling frequency and series interval lead to different duration of the battery. For example, a 2000mAh 1.5V battery would last 8.5 days if 1024 samples were taken at 4 Hz every half an hour. Raw data is stored in a SD card to be post processed if needed.

Fig 1. Image of the low-cost wave gauge. At the left far the electronic components can be seen. The right tube is the waterproof pretection for the electronic components when they are undewater.

The raw data is processed on board of the instrument to produce the wave parameters (Hs, Tp, Tm, etc) from the computed spectrum. Furthermore, since the device measures the pressure from the sea bottom and the wave that we are been measured are not barotropic, an additional correction is applied to transform the measured underwater pressure spectrum at the bottom to the sea surface elevation spectrum [4].

III. VALIDATION EXPERIMENT

To validate the performance of our device, we deployed it next to the Spanish Harbour Authority (Puertos del Estado) tide gauge in Palma Harbour, Mallorca. This tide gauge is a high performing radar that stores sea surface elevation data at 2 Hz. This data is freely available in http://opendap.puertos.es/thredds/catalog/tidegauge_mall/catalog.html. This has allowed to validate the performance of the LoCOS wave gauge by comparing the obtained parameters to those obtained from the radar-based gauge. The results show very good agreement between both devices with a correlation of 0.97 and a RMSE lower than 0.02 m in the significant wave height (Hs) estimation (see figure 2).

IV. CONCLUSIONS

We present a prototype of a low-cost open source gauge that estimates the wave parameters from the Fourier spectrum of the bottom sea pressure. We have then tested it against the wave parameters obtained from a commercial tide gauge obtaining successful results. Further performance tests such as salt water resistance of the sensor and long term stability of measurements are being conducted to assess the use of this prototype in projects aiming the evaluation of the impact of sea waves in the coast, at lower cost than the up to now available commercial devices, thus allowing denser data networks.

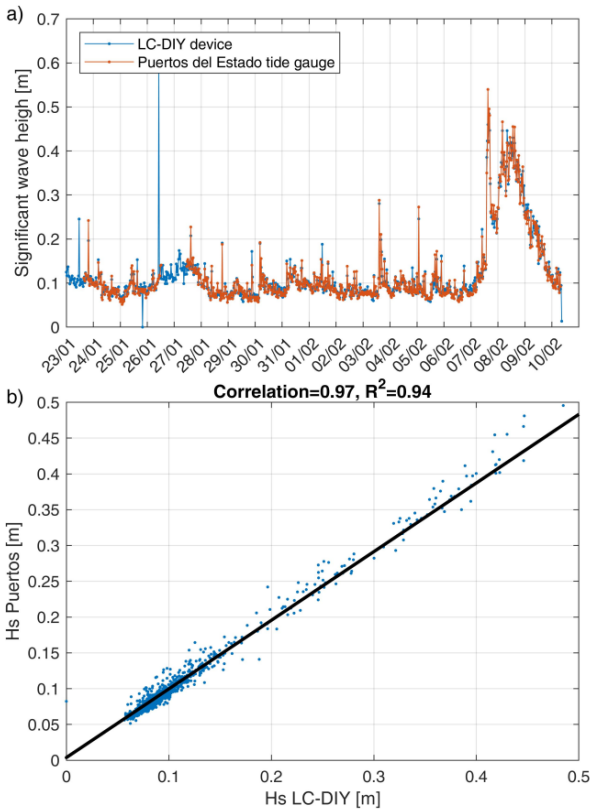

Fig 2. (a) Comparison between the significant wave height (Hs) obtained from the LoCOS wave gauge (LC-DIY, in blue) with the one obtained by the radar based gauge (red). (b) Scatter plot between the two Hs measures, the correlation and R-sqaure values are indicated.

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