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The VENOM network: An ultra-dense tide gauge network based on LoCOS instruments

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***Abstract* – Tide gauges based on LoCOS (Low-Cost Open-Source) technology have been used to deploy the VENOM network. This is an unprecedented ultra-dense low-cost, and yet reliable, tide gauge network around the Balearic Islands that is allowing to understand the very nature of the spatial variability of coastal sea level at different time scales, from sub-hourly processes (e.g., meteotsunamis), to seasonal and interannual variability.**

Keywords *- Tide Gauge, Sea Level, Meteotsunami, Arduino, Mediterranean Sea, Open-Source, Low-Cost.*

I. INTRODUCTION

Characterizing sea level variability in coastal regions is of paramount importance to reduce risks associated with marine storms in present and future climate. Sea level is currently monitored mainly by satellite altimetry and tide gauges, which provide data at different time scales with different spatial resolutions. Satellite altimetry measurements are obtained along tracks which can be separated up to 300 km and with a revisiting time ranging from 7 to 30 days. Also, the validity of altimetry measurements close to the coast is limited and in certain regions may not be representative of the coastal processes. The tide gauge network is better suited for the characterization of coastal sea level, but it is sparse and unevenly distributed, and high frequency data (< 1 hour) is often not available.

In the framework of the VENOM project, we have deployed a new, ultra-dense network of low-cost, and yet reliable, tide gauges. The main goal of this network is to better understand the spatial variability of coastal sea level at different time scales, from sub-hourly processes (e.g., meteotsunamis), to seasonal and interannual variability. Since 2020, the VENOM network has allowed to extend the existing sea level measurement network around the Balearic Islands in the framework of the Western Mediterranean reaching an unprecedent density of high-frequency sea level observations.

II. TIDE GAUGE DEVICES

The LoCOS (Low-Cost Open-Source) tide gauges (Fig. 1) have been developed in the Arduino environment. The main components are a datalogger, a communication module and an acoustic distance sensor, all of them mounted on a dedicaded PCB. Measurements include temperature and atmospheric pressure and the system is powered by a solar panel. Measurements are performed at a slightly more than 1Hz rate, then averaged and locally stored every minute (or at the desired rate), and finally sent to a web database.

A comparison between a LoCOS tide gauge deployed side-by-side with a MIROS based radar station from Puertos del Estado in Palma shows a RMS error of 0.4 cm for hourly data and 0.6 cm for data recorded every minute (see Fig. 1).

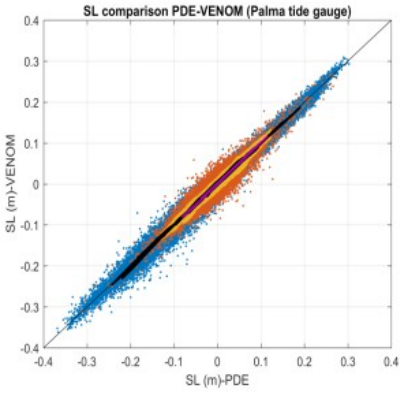

Fig 1. Comparison of sea level observations between the MIROS radar and the VENOM LoCOS Tide Gauge at the Palma harbour. The different

colours indicate different frequency bands (1min-1hour in blue, 1hour-1day in orange, 1day-1month in yellow and over 1 month in purple).

III. THE ULTRA-DENSE TIDE GAUGE NETWORK

Once the tide gauge design was validated, within de frame of the VENOM project, a network of more than 20 tide gauges has been installed to study extreme sea level events in the Balearic Islands 2020 (http://mareografo.ieo.es/). The longest time-series started in 2020 and the network observations has been used for several scientific applications (e.g.: Ramos-Alcántara et al., 2023; Villalonga et al., 2023). An example of the network control panel (https://panell.tremar.cat) is presented in Fig. 2.

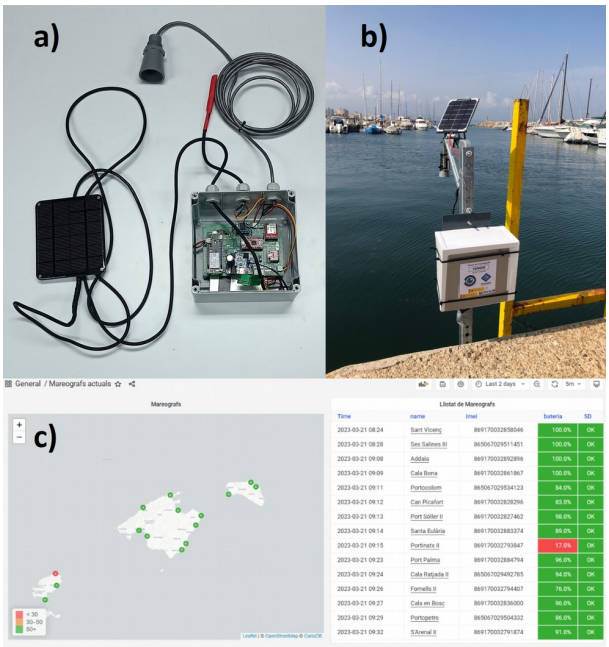

Fig 2. (a) Components of the LoCOS tide gauge (b) Tide gauge installed (c) Web-Based control panel of the VENOM network.

IV. CONCLUSIONS

The LoCOS tide gauges developed in the framework of the VENOM project have successfully used in a new ultra-dense coastal sea level network. The quality of the measurements has been validated against state-of-the-art devices and the measurements obtained have been used in several scientific studies focusing on meteotsunamis and extreme events. This story of success shows that LoCOS technology can be a good solution to complement standard commercial devices.