Long term Underwater localization in extreme conditions, EvoLUL

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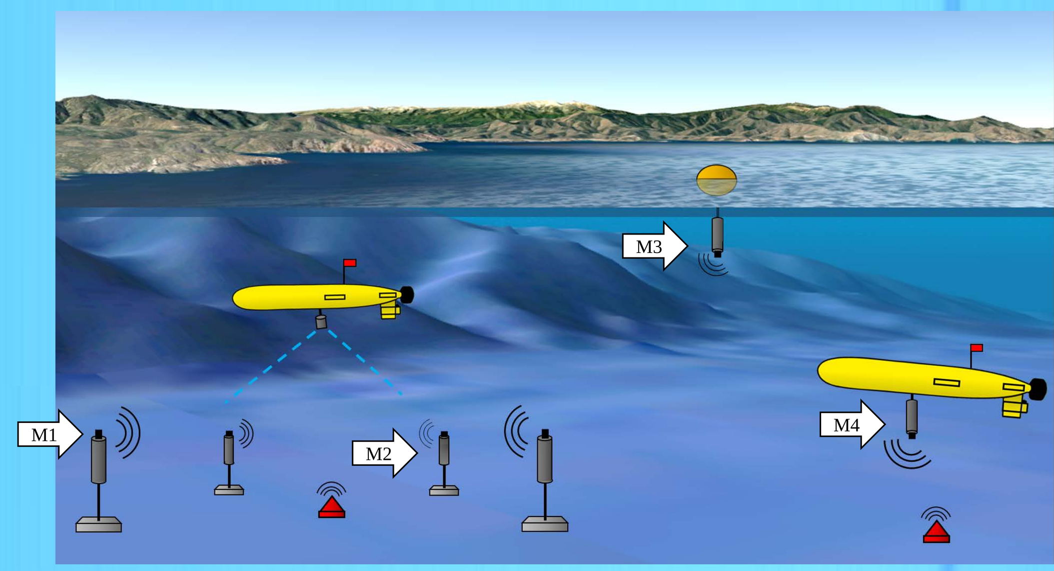

Fig. 1. Acoustic modem deployment scenario

Introduction

The project evaluates different underwater acoustic localization tools deployed in shallow waters. The applications cover both: static and moving targets.

Underwater range measurements are a key factor in underwater acoustic positioning techniques, such as Long Base-Line (LBL) and Ultra Short Base-Line (USBL). These measurements are commonly carried out through acoustic communications between modems and their accuracy can be affected by different factors, such as sea state, weather conditions, and obstacles in the line of sight propagation. This is especially important in shallow waters areas, where other phenomena, such as multi-path, have to be also considered.

A long term deployment experiment was carried out to offer the possibility to ensure robustness of the equipment and quality of the data along time. Variability of the measurements have been studied and correlated with sea conditions since OBSEA underwater observatory platform measures waves, currents and water properties.

Underwater observatory OBSEA

The OBSEA observatory (www.obsea.es) is located at 4 km from the coast of Vilanova i la Geltrú and at 20 m depth. This shallow water deployment area represent a challenging operative scenario to test acoustic communication measurements and their performance in the real-world. The observatory offers six different ports to connect any instrument, avoiding battery issues and allowing real time data communication. On the other hand, different sensors have been installed in this observatory to measure environmental variables, such as a CTD, an Acoustic Doppler Current Profilers (ADCP), and a Buoy with a meteorological station, which can could be used to monitor sea state.

Evologics acoustic modems deployment

Two acoustic modems and one USBL (all from Evologics; www.evologics.de) were installed on December (2017). A representation of this deployment can be observed in Figure 1. The USBL (M1) and one modem (M2) were deployed on the seafloor. These devices were connected to a secondary cylinder, which provides both Ethernet and power supply through the OBSEA observatory. Moreover, an ODROID embedded computer was used as a main controller to perform the tests, which was also allocated inside the cylinder. A second modem (M3) was installed on a buoy, in order to obtain a more challenging operative scenario for the acquisition of the range measurements. Finally, a third modem (M4) was designed to be installed on an Autonomous Underwater Vehicle (AUV) to perform the target tracking tests.

Results and discussions

The ranges among all the modems (M1 … M3) are presented in Figure 2 (middle), which where measured from December 6, 2017, to September 19, 2018, with a sample frequency of 5 min. The Received Signal Strength Indicator (RSSI) and Integrity Level of the communication between modems are also presented. These measurements are important for the evaluation of the goodness of the communication, and therefore the range measured. To correlate the measured range variations with the sea state a parameter called total buoy inclination has used. This parameter indicates the absolute buoy inclination respect to the normal vector of the plane x-y, it has been calculated from the combination of the pitch and roll from the buoy and offer an estimation of the sea flatness. Then, the Standard Deviation (STD) of both range measurements and buoy inclination have been computed in groups of 1h to observe the influence of the sea state with the range variations, Figure 2 (bottom). The STD between M1 and M2 is much lower than the STD between M1 (or M2) and M3, as was expected, because of both M1 and M2 were moored on the seafloor whereas M3 was in a buoy. Finally, the range variations can also be compered with the Wave Height and other parameters such as CTD measurements presented in Figure 2 (Top).

The localization experiments using range-only methods were conducted in two scenarios. Firstly, the three modems (M1 … M3) deployed in the OBSEA were localized using a forth modem (M4) installed on a boat (used as an AUV). Two methods were used to estimate the modems' position, a Least Square (LS) and a Particle Filter (PF). The main difference between the LS and PF is observed in M1's positon, where the error introduced by LS is significantly greater(Figure 3). The second scenario was tracking a moving target, in this case a drifting buoy with one modem was tracked for approximately 1h. During this time, the ranges between both target and observer were measured and used with a PF algorithm to track the target's position (Figure 4).

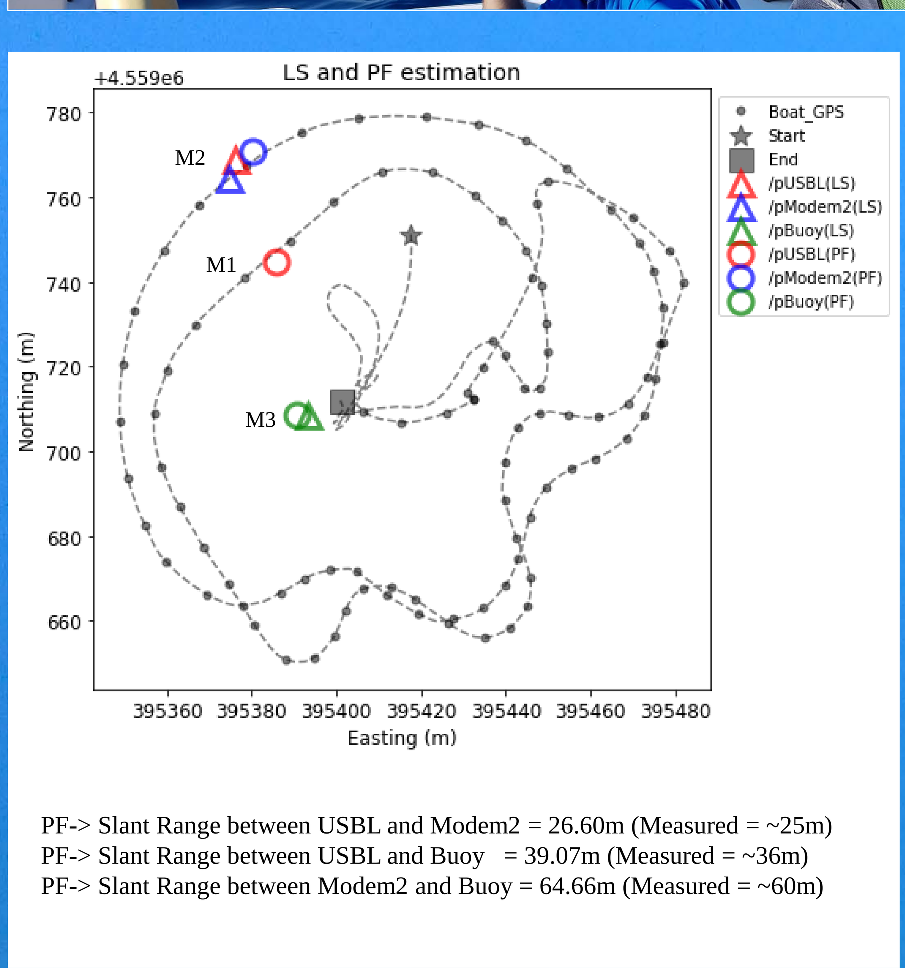

Fig. 3. Static target localization: Test conducted to localize the modems deployed in the OBSEA, using LS (triangles) and PF (circles) algorithms, and their ranges from an observer (grey dots). The slant range obtained using PF and the ones measured with the modems are also represented (bottom).

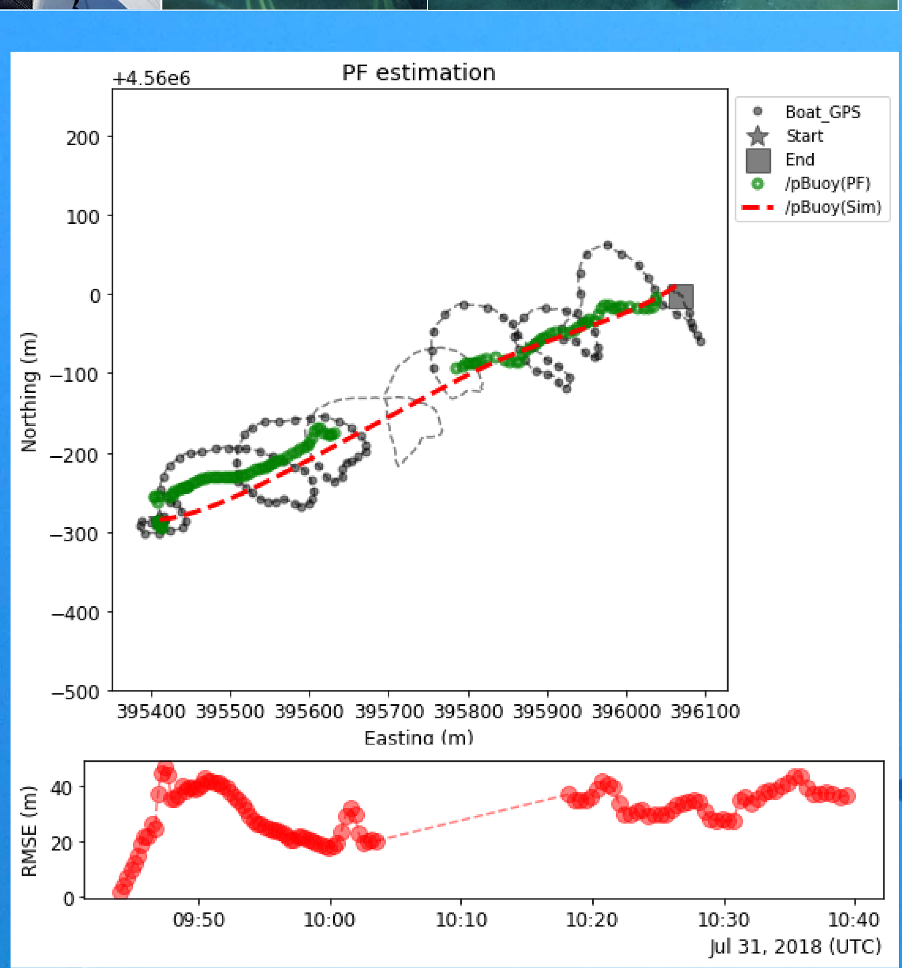

Fig. 4. Moving target tracking: Test carried out to track a drifting buoy equipped with a modem. The x-y position of the observer (grey), the target (red), and the target's estimation (green) are represented on the top figure. The Root Mean Square Error (RMSE) is represented in the bottom figure.

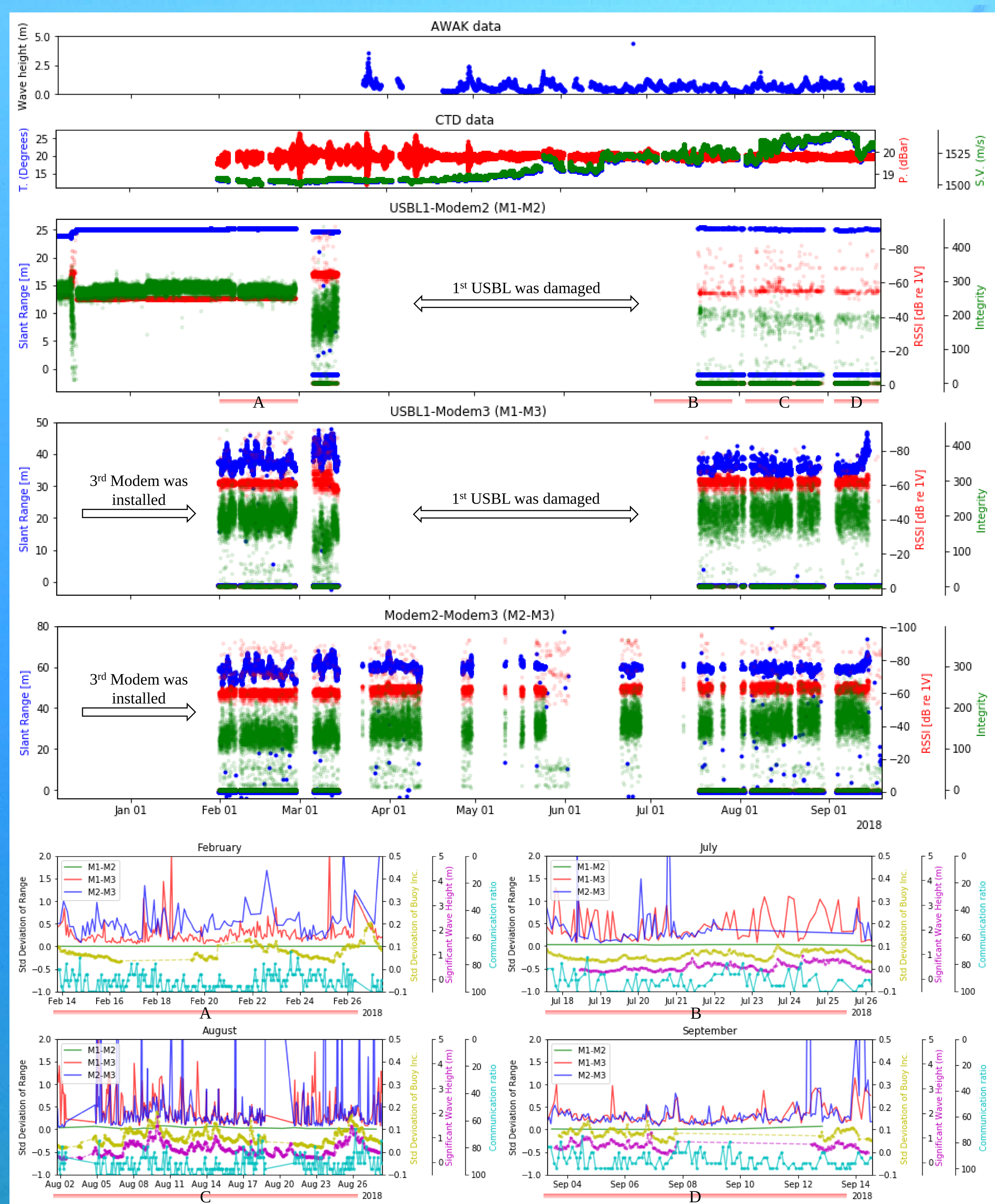

Fig. 2. Long term deployment: Slant Range vs RSSI and Integrity among the modems deployed at OBSEA (top); Range measurement's STD vs Total Buoy Inclination's STD, Wave Height, and Communication ratio, for 4th different time periods (bottom).

Conclusions

A long-term test with slant range measurements (more than 90.000) among different acoustic modems has been carried out under extreme conditions. These measurements could be compared to weather and sea state to find correlations between them. This study helps on the characterization of the range error, and therefore, the knowledge in target positon's estimation. Finally, two tests have been conducted using range-only methods to localize and track different targets under different scenarios. These methods were the LS and PF, where they good capabilities have studied.

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Acknowledgements

JERICO-NEXT has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654410.