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REAL TIME WAVE PARAMETERS MONITORING USING A FIXED COASTAL BUOY

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Abstract: In order to identify the marine energy potential, the marine environment will be studied through EMSO-EUXINUS network part of EMSO ERIC Pan European Research Infrastructure operated starting with 2013. The most important part of the network is monitoring stations located offshore, including wave coastal buoy in the Black Sea which record also, in real time, wave parameters starting with 2013. The main goal of the wave coastal buoy is to record, in real time, the wave data including wave high and period, direction and speed of the water, water temperature and also meteorological information (wind speed and direction and air temperature). All coastal buoy sensors are managed by a customized low power datalloger, processing and communication system integrated in a stainless-steel cabinet in AISI216L suitable for long life stay in harsh environment and salty atmosphere. The same cabinet host rechargeable battery pack and charge regulat. All the data are recorded and stored on a local data-logger and transmitted to the onshore database, at each 5 minutes via 3G communications.
Key words: wave parameter, monitoring, coastal buoy sensor, real time.

1. INTRODUCTION

The EMSO - EUXINUS is the only observation system enabling real time monitoring of the Black Sea marine environment. It provides real time and a continuous data flow regarding the water quality and dynamics in the Western part of the Black Sea. It is for the first time when the scientific community dealing with the marine environment in the Western part of the Black Sea has such direct and continuous access to information [1].
The main objective of this system is to provide information data for detection, estimation, forecasting and fast notification of the natural marine hazards in conjunction with the other equipment installed offshore in order to protect the two countries (Bulgaria and Romania) against such phenomenon. The second main objective of the network is to provide long time series of physical and bio-chemical data regarding the properties of air and water masses (Figure 1).

2. MATERIALS AND METHODS

The offshore station is composed of a pole, fixed on the sea bed by its foundation, with the sensors installed on-board to monitor meteorological parameters, water quality, wave height and direction, tide and sea current. All the data will be stored on a data-logger and transmitted to the data center onshore [2].
The coastal station, located near the port of Mangalia but also on the Romanian-Bulgarian border, at a water depth of 15 m, is equipped with:
➢Meteorological station, with sensors for pressure, temperature, humidity, wind direction and speed;
➢Multiparameter probe set at 5 m depth;
➢Doppler current sensor;
➢Conductivity sensor;
➢Temperature sensor;
➢Pressure sensor;
➢Oxygen sensor;
➢Turbidity sensor;
➢Chlorophyll sensor;
•Acoustic Doppler Profiler Current for measurement:
➢the statistical directional spectrum that allows the calculation of the main parameters of the waves (The instrument processes the data on waves, every 10-20 minutes):
➢H_{mo} (Significant amplitude)
➢H_{max} (Maximum amplitude)
➢T_m (average period)
➢T_p (peak period)
➢D_m (the average direction of the waves)
➢D_p (top direction)
The transmission of data from the coastal buoy is done in real time using the mobile telephone network

and the coordinates of the coastal buoy are Lat: 43.80217584, Long 28.60248336 [3].

2.1 Coastal buoy architecture

The The main components of the buoy are:

➢ Mounting data pole with foundation for the instrumentation in anti-corrosion, low- maintenance material.

➢ Electrical control cabinet in anti-corrosion and low-maintenance material, ensuring water- proof capabilities following IP68m standards.

➢ Autonomous power supply system composed of solar panels, battery chargers and rechargeable battery pack.

➢ Day and night signaling system for the navigation composed of light and active radar reflector.

➢ Satellite communication segment relied on Iridium technology or VHF/UHF radio communication segment (HF as option) or GSM/UMTS communication segment.

➢ GPS device.

➢ Datalogger able to manage data collection and communication with the wireless communication segments.

➢ Automatic weather station.

➢ Instrumented package at CGS bottom (5m under sea level) composed of Doppler 3D current meter, Oxygen, Temperature, Conductivity, Turbidity, Pressure and Chlorophyll sensors.

➢ Instrumented package at CGS (5m under sea level) composed of Wavemeter and Tide gauge sensor.

Stainless metal structure that will be fixed close to the bottom or the lower pole necessary to fix the acoustic modem and the package of surface equipment [2].

An architectural diagram of the CGS is illustrated in the following picture (Figure 1) [3]:

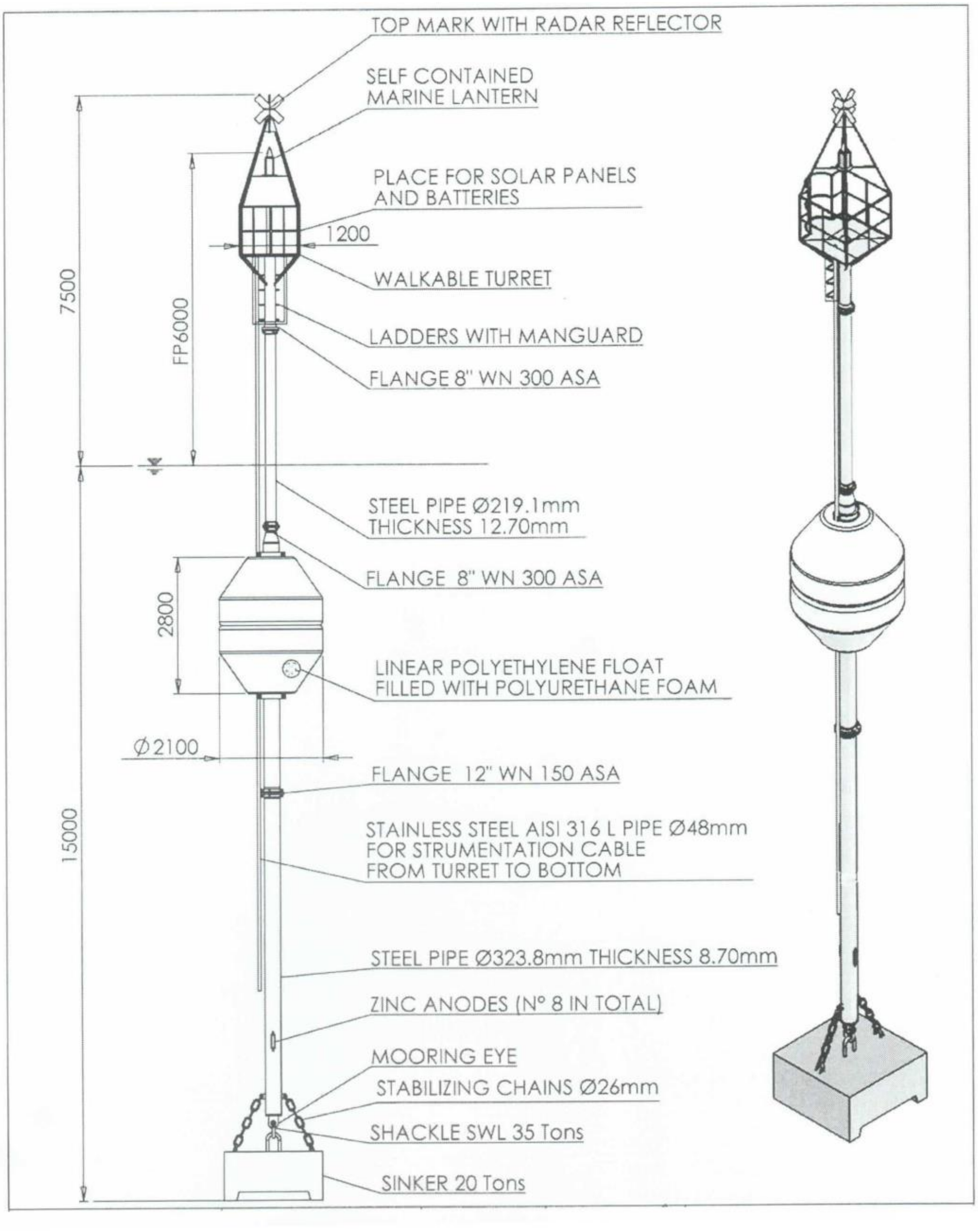

Fig. 1. Coastal gauge architecture. [3]

2.2 Data acquisition

Data acquisition consists in:

2.2.1. Information about data acquisition

➢Obtain and pre-process information from the weather station;
➢Obtain data from the integrated current measuring device;
➢Takes data from acoustic Doppler current profiler for current, wave direction and tidal measurements;
➢Collects data from diagnostic sensors;
➢Stores all data obtained in mass memory.

2.2.2. Data communication

➢ It transfers the data collected by the sensors once an hour to the Coordination Center;
➢ Receives configured commands, data request, or test commands from the Coordination Center.

2.2.3. Way of operation

It performs a periodic and unsynchronized task when the command reaches the GPRS-UMTS modem. Periodic tasks are performed once an hour to obtain diagnostic, meteorological, and underwater instrument data (Figure 2) [4].

2.2.4. Primary data processing

The primary data processing is performed with a data export software. An example of the software can be seen below (Figure 3).

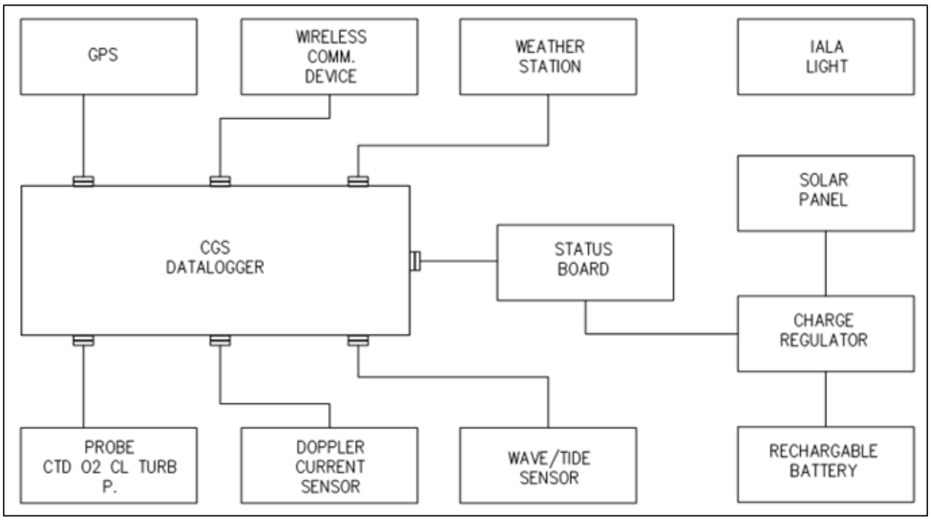

Fig. 2. Coast Station software flow chart

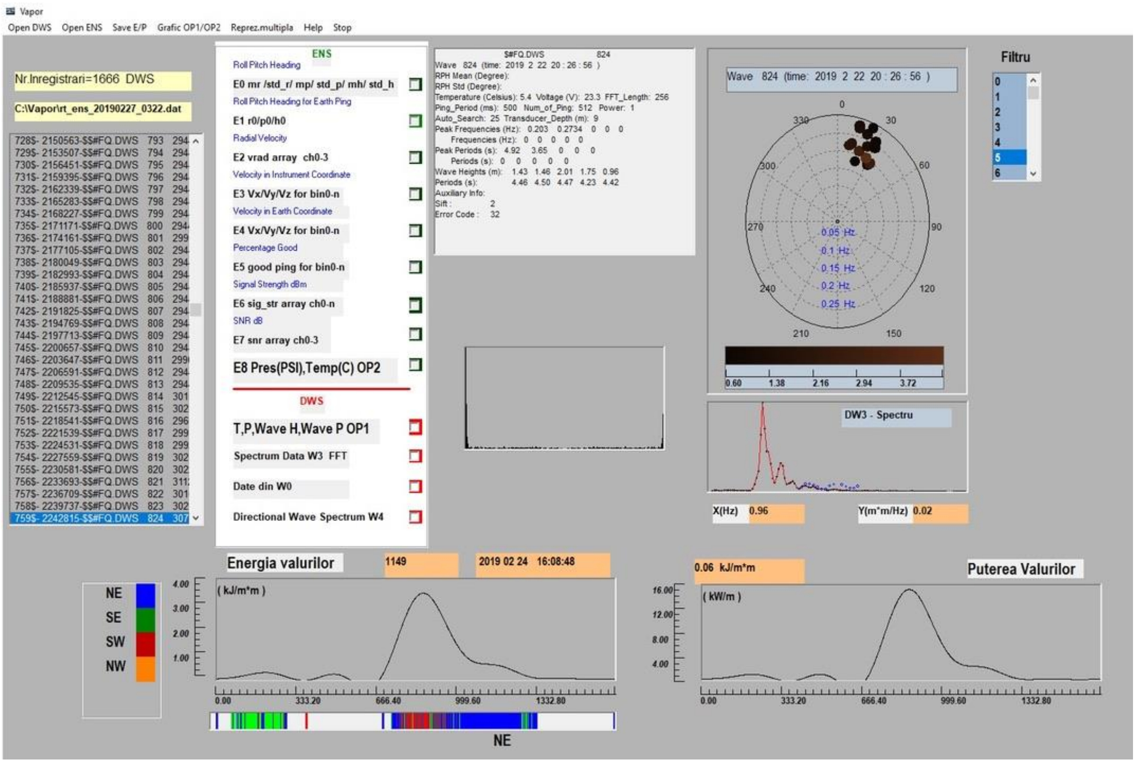

Fig. 3. The primary data processing by software

3. RESULTS AND DISCUSSION

An example of data set obtained results are:

- Spectrum/frequency, [m2 /s/Hz] (Figure 4);
- Waves heights, [m] (Figure 5);
- Period [s]/time, (Figure 6);
- Depths, [m] (Figure 7);
- Velocity spectrum, [m/s] (Figure 8).

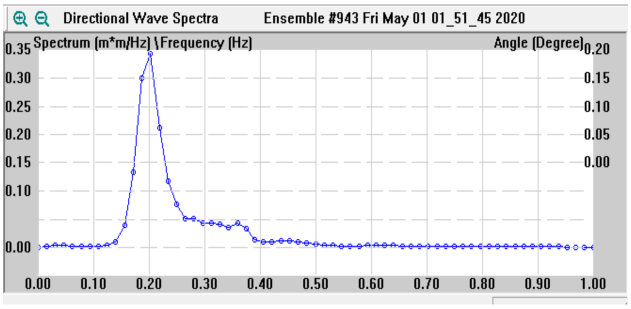

Fig. 4. Directional wave spectrum

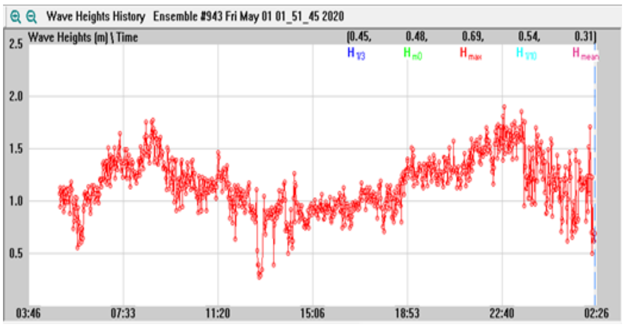

Fig. 5. Waves heights

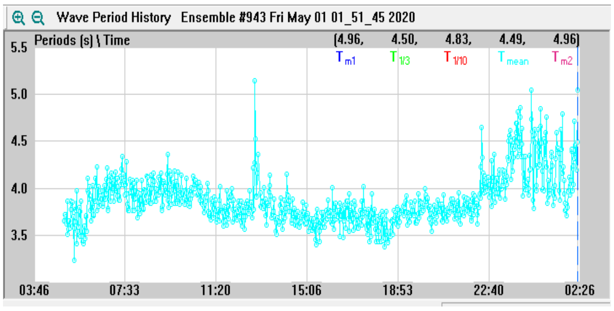

Fig. 6. Periods

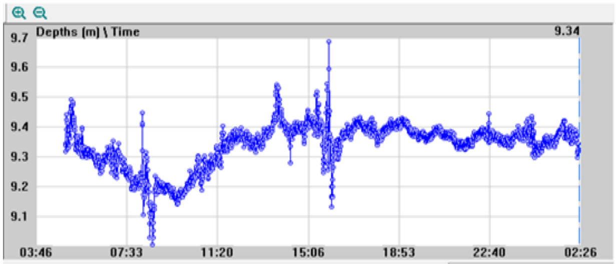

Figure 7. Depths

The final analysis of global results is obtained for different signals and velocities (Table 1, Table 2, Figure 8).

Table 1. Wave high data

No.crt.	Time	Temp. (°C)	Wave height (m) H_0	Wave height (m) $H_{1/3}$	Wave height (m) H_{max}	Wave height (m) H_{mean}
1.	2020 04 24 12 51 49	10.0328	0.89	0.74	1.00	0.56
2.	2020 04 24 13 01 49	10.09591	0.89	0.74	1.00	0.56
3.	2020 04 24 14 31 49	10.57957	0.88	0.73	0.98	0.55
4.	2020 04 24 15 01 49	10.68502	0.87	0.72	0.98	0.54
5.	2020 04 24 16 01 49	10.79394	0.84	0.69	0.95	0.51
6.	2020 04 24 17 01 49	10.7867	0.81	0.66	0.92	0.49
7.	2020 04 24 18 01 49	10.71413	0.79	0.64	0.89	0.47
8.	2020 04 24 19 01 49	10.63125	0.79	0.65	0.76	0.48
9.	2020 04 24 23 01 49	10.48905	0.96	0.82	1.07	0.62
10.	2020 04 25 00 01 49	10.45119	1.00	0.86	1.14	0.65
11.	2020 04 25 13:41:49	10.04335	1.15	1.06	1.25	0.77

Table 2. Directional wave spectrum

No.crt.	Time	Frequency (Hz)	Direction (grade)	Spectrum	Wave height (m) H_{max}	Wave height (m) H_{mean}
1.1	2020 04 24 12:51:49	0.08	20.08	0.20	1.00	0.56
2.2	2020 04 24 13 01 49	0.18...0.45	139.10....37.40	0.22...0.27	1.00	0.56
3.	2020 04 24 14 31 49	0.00	0.00	0.00	0.98	0.55
4.	2020 04 24 15 01 49	0.00	0.00	0.00	0.98	0.54
5.	2020 04 24 16:21:49	0.05...0.38	281.70...164.20	0.21=const.	0.95	0.51
6.	2020 04 24 20:11:49	0.05...0.20	7.70...187.70	0.20...0.26	0.92	0.49
7.	2020 04 24 23:01:49	0.05...0.25	15.80... 286.50	0.21= const	0.89	0.47
8.	2020 04 24 23:51:49	0.00	0.00	0.00	0.76	0.48
9.9.	2020 04 25 00:01:49	0.14...0.22	328.14... 315.70	0.21...0.25	1.07	0.62
10.	2020 04 25 01:01:49	0.17...0.20	281.70..13.60	0.51...0.46	1.14	0.65
11.	2020 04 25 01:51:49	0.14..0.20	320.50...296.00	0.33...0.31	0.87	0.56
12.	2020 04 25 13:41:49	0.26	144.50... 126.80	0.97...0.40	1.25	0.77

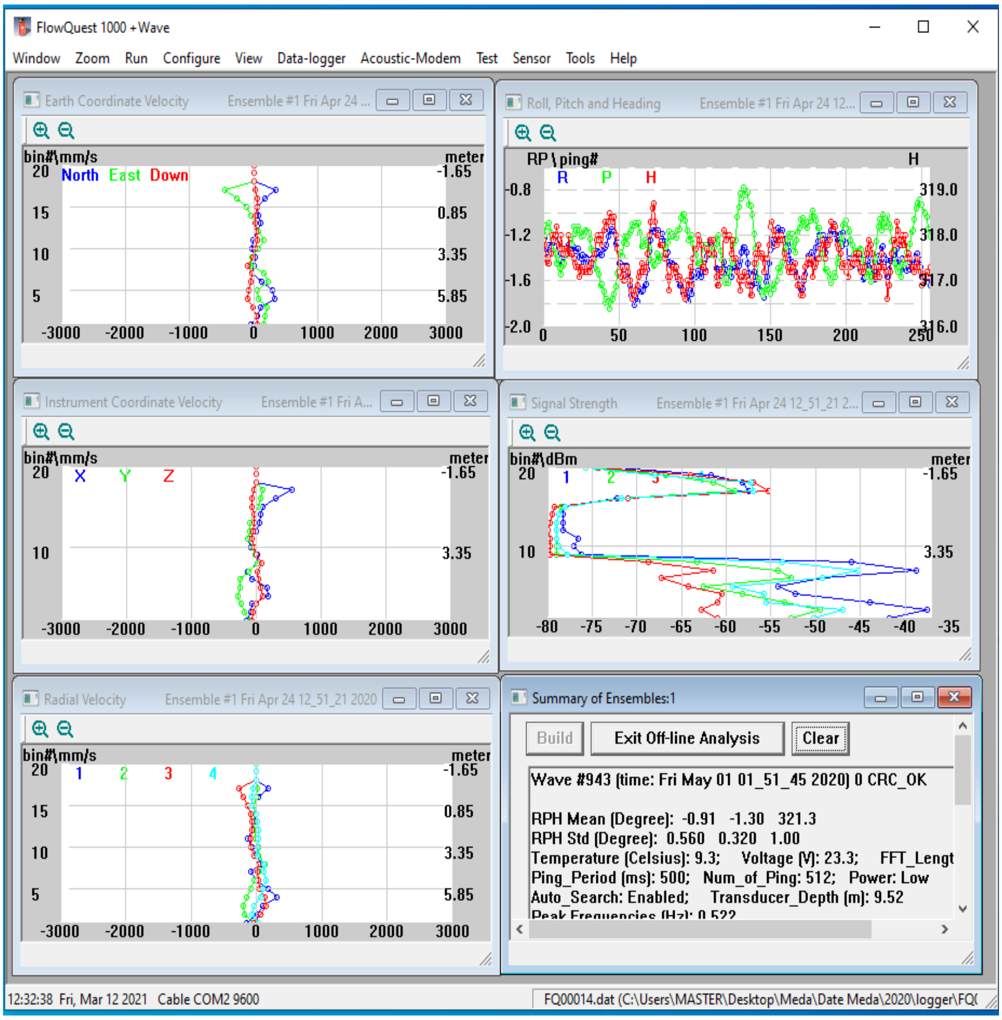

Fig. 8. Results

4. CONCLUSIONS

As can be seen from the data processing we can conclude:

-for initial wave heights between 0.89-1.00m, the main value of the wave heights beteen 0.56-0.65m increase (temperature aprox. 10.4^{0}C);

-at a temperature of 9.9^{0}C and an initial height of 0.89m, the main height remains constant around 0.56m.

-for initial wave heights between 0.89-1.00m, the spectrum varies from 0.2 to 0.51;

-in the same processing period, the frequency of the waves varies from 0.02 Hz to 1 Hz, the spectrum being in the range 0....0.97.

The operator can easily communicate with the system, configure all the parameters, download data from data logger and deployment in real-time. Also, this software provides tolls for off-line analysis, diagnosis and can reset the system, when it is necessary. The data can be exported to other formats (txt, xls).

5. REFERENCES

1. emso ERIC web site, Available from: http://emso.eu/, Accessed on: 16.02.2022.

2. IOSIN EMSO-EUXINUS, Available from: www.euxinus.eu, Accessed on: 23.01.2022.

3. The coordinates of coastal buoy, Available from: https://earth.google.com/web/search/43.80217584,28.60248336/, Accessed on: 16/02/2022.

4. The monitoring and alerting system of natural hazards from the Black Sea, Available from: https://euronaval.ro/2016/08/15/sistemul-de-monitorizare-si-alertare-la-hazarde-naturale-din-marea-neagra/, Accessed on: 03/02/2022.

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