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Experimental Research for Metocean Data and Risks in the Vicinity of Platforms in the Black Sea

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ABSTRACT: The knowledge of the metocean data is important for the design and construction of different equipment in offshore area. The paper presents an analysis of environmental factors in different conditions in the location of study, GALATA platform, Bulgaria. The results of the analysis (wind statistics, wind distribution rose, wind speed extreme, monthly mean vertical profile of wind speed) cover the period 2008-2023. To analyse correct design of floating wind turbines must establish wind speed extreme. The data sets obtained were validated using the CFS3D wind database. To study the risks in vicinity of platforms we used tools of NEAT+ software which provides the opportunity to make informed decisions and implement appropriate preventive and corrective measures to protect the environment. The results of the experimental research indicate a favourable general state of the environment in the Black Sea vicinity of platforms area.

1 INTRODUCTION

Metocean data combines meteorological and oceanographic factors, which are then used in the design and optimization of equipment that use renewable energy, both in coastal and offshore areas. These data are monitored for local winds, wind-driven values, peak values, surface currents, and deep water currents dependent on topography and water circulation in the study location basin.

This paper presents wind statistics for metocean analytics on a Galata platform, near Varna, Bulgaria, in offshore area of the Black Sea basin [1].

1.1 *Characteristics of studied location*

The Black Sea is a body of water and marginal sea of the Atlantic Ocean between Eastern Europe, the Caucasus, and Western Asia. It is supplied by a number of major rivers, such as the Danube, Dnieper, Southern Bug, Dniester, Don, and the Rioni, along with the watersheds of neighbouring countries [2].

Some specific characteristics of Black Sea basin must presented [3]: geographical limits, total shoreline (4340 km), water surface (432 000 km^2), river inflow (340.6 km^3), water volume (547 000 km^3), maximal depth (2212 m), salinity (of the surface waters is about 17 ... 18 parts per thousand), average fresh water balance (3.7… 441 km^3), the temperature (in winter from (0.5 ◦C) in the N-E, to about 9 … 10 ◦C in the S-E and to depths of 50 …100 m is about 6.5 … 8 ◦C; in summer, the surface layer is warmed to 23 … 26 ◦C and at depths of 50 … 75 m, a cold layer remains at 7 ◦C), specific organisms, etc. (Figure 1) [3] [4] .

Figure 1. Map of the Black Sea Basin [3]

The topography and environmental factors of the Black Sea basin require the development of new tools for obtaining and processing monitoring data from space [5], [6].

The location of study useful for the installation of an offshore wind turbine is in vicinity of Galata platform (Figure 2): Latitude 28◦11'35"E, Longitude 43◦2'40"N, depth of water-34 m .

Figure 2. Location of the analysis

Obtaining metocean data implies knowing the conditions of the data processing tools [7].

Geographical analysis will furnish valuable information for the study that will be needed before the deployment of the equipment at the final location. The seabed structure is very important in area of Galata platform. Wave parameters and sea currents are evaluated for the deployment and maintenance of the wind farm. Wind resource assessment based on local measurement is key to fully optimise the design of the structures. In addition, it will provide important data for future replications in the area as local measurements are requested by investors and lenders for an accurate assessment of energy production of future commercial wind farms. Furthermore, on the technical side, maximum wind speed will notably be important for dimensioning the mooring system and waves, and surface sea currents measurement are notably used to properly define the operation and maintenance plan. The paper presents the description of the methodology that is the basis of obtaining metocean data.

2 MEASUREMENTS AND METHODOLOGY

2.1 *Wind measurements*

Wind data collected from different sources during period 2008 to 2022 (wind speed and direction) were used for wind statistics in the study location. It was used as Leosphere WindCube Lidar system, which is mobile and was mounted on the Galata platform (Figure 3). For measurements with remote WindCube sensors, the volume of standard measured data assumes the homogeneity of the measurement flow. In the field, this assumption is no longer valid measurements become inaccurate. The specialized literature [7] has developed a method to capture the in homogeneous flow of measurements of the wind characteristics and render them as precise measurements depending on the complex conditions that appear on the flow.

Figure 3. WindCube - assembly at the Galata platform

To obtain the wind speed field, the average value of the horizontal component of the speed is chosen every 10 minutes and the standard deviation for the same time interval.

These quantities are statistical values relative to a point and do not reflect the sequence of velocity values. All the fluctuations that appear in time under 10 minutes represent rapid changes in the wind dynamics, therefore, implicitly in the operation of the wind turbines that we are going to install in that area for the studied flow. To highlight the fluctuations, points are chosen and the corresponding wind statistics are studied.

The following data were used from sources ERA5, Galata platform, EuxRo01, EuxRo03 and CG Meteo sensors: coordinates of point, period, height, spatial resolution, temporal resolution, variables (Table 1)(Figure 4)[8].

Table 1. Data collected from different sources

Sources	ERA5	GALATA	EuxRO01	EuxRO03	CGMETEO
Coordinates	43.2°N 28.2°E	43.04°N 28.19°E	44.7°N 30.779°E	43.98°N 29.936°E	43.802°N 28.605°E
Period	2008-2022	2008	2019-2021	2019-2021	2019-2021
Height [m]	100	300	-	-	-
Spatial resolution [km]	300 km grid	Punctual	Punctual	Punctual	Punctual
Temporal resolution	Hourly	2 minutes	Hourly	Hourly	15 minutes
Variables	Wind speed Wind direction Temp. Pressure	Wind speed Wind direction - -	Wind speed Wind direction Temp. Pressure	Wind speed Wind direction Temp. Pressure	Wind speed Wind direction Temp. Pressure

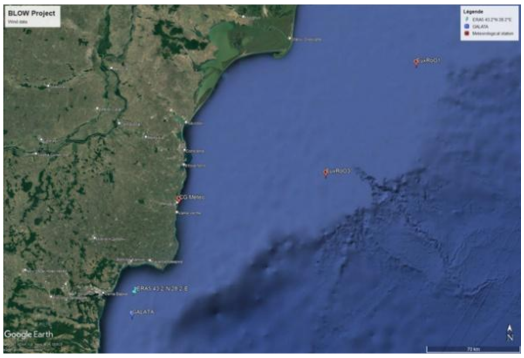

Figure 4 Location of the point with available wind data

2.2 *Methodology for Metocean Analytics*

A preliminary data report is generated for the location of the study point (#25071) based on a statistical analysis provided by several sources for a given period (Table 1). The wind dataset is based on the hourly Global Climate Forecast System (CFS), which is composed of two databases: 1) Climate Forecast System Reanalysis (CFSR) and 2) CFSv2. CFSR includes numerous data assimilations from 1979 to the end of 2010 with a spatial resolution of 38 km (0.3°) and a time step of one hour for the atmospheric model. CFSv2 is a recent climatological database covering the period from 2008 to the end of 2022, with new assimilated data, with a time step of one hour for the atmospheric model and with a spatial resolution of 0.2° [8].

3 RESULTS AND INTERPRETATIONS

3.1 *Data processing and the results obtained*

In order to ensure an efficient design of the floating wind turbine structure, a statistical wind analysis must be done, considering an average of the final results between the reference data provided by the sources and the data provided by the WindCube system.

3.1.1 *Wind rose and wind direction distribution*

This also involves comparing the data with the data from the specialized literature for the study location. First, we take into consideration as the reference data those provided by ERA5 and we check them with the data obtained from point measurements to validate the consistency with the data from ERA5 (e.g. wind data statistics for a month)(Table 2).

After this step followed wind distribution rose and wind direction distribution at point of study (Figure 5, Figure 6)[8].

Table 2. Wind distribution rose for February, 2023 [8]

Occurrence probability [%]					
Wind directions [°]	Wind directions [°]	Wind directions [°]	Wind speed [m/s] [0, 2.5[	Wind speed [m/s] [2.5, 5[	All magnitudes >15
Minim	Centre	Maxim			
348.75	0	11.25	0.39	1.82	15.03
78.75	90	101.25	0.53	1.25	2.99
168.75	180	191.25	0.56	2.13	5.92
258.75	270	281.75	0.55	1.75	4.14
281.25	292.5	303.75	0.50	1.79	5.27
303.75	315	326.25	0.50	1.63	5.28

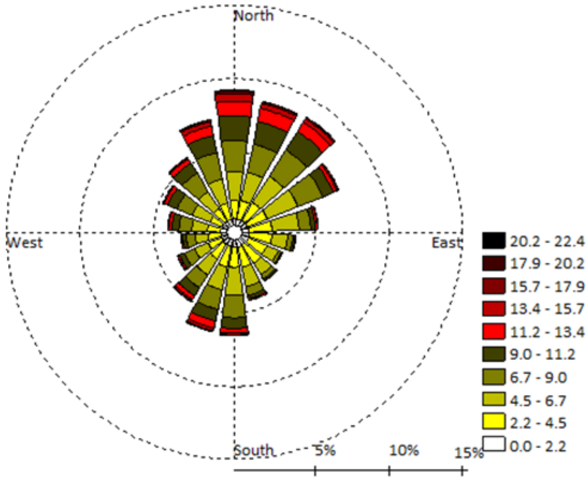

Figure 5. Wind rose over the offshore area of study [8]

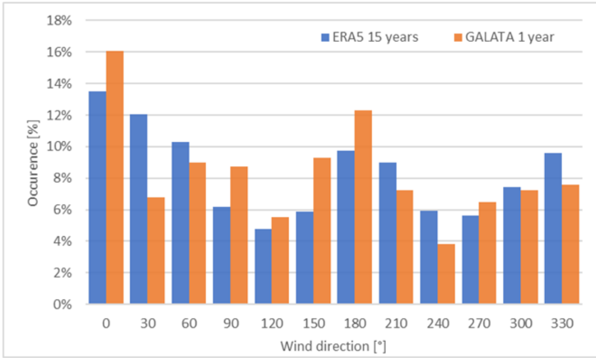

Figure 6. Wind direction distribution

The main wind direction observed are the Northern sector (from 315° to 75°) and from the Southern sector (from 165° to 235°).The highest wind speeds are distributed over all those wind directions [8].

3.1.2 *Wind velocity distribution*

The wind speed measured at GALATA platform is 5.5 m/s at 30m during the year 2008.The wind speed for the period 2008-2022 is evaluated by the measurements made at the GALATA platform and by the data of the ERA5 source at the value of 5.7 m/s at 30 m depth and at 6.5 m/s at 100 m depth. The probabilistic wind distribution at 100m at GALATA platform is presented in Figure 7:

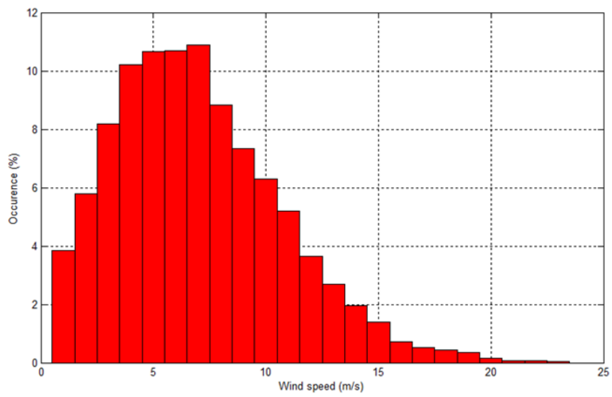

Figure 7. Wind speed distribution at GALATA platform at 100m for the long-term period 2008-2022

3.1.3 *Wind speed extreme*

To analyse correct design of floating wind turbines must establish wind speed extreme (Figure 8).

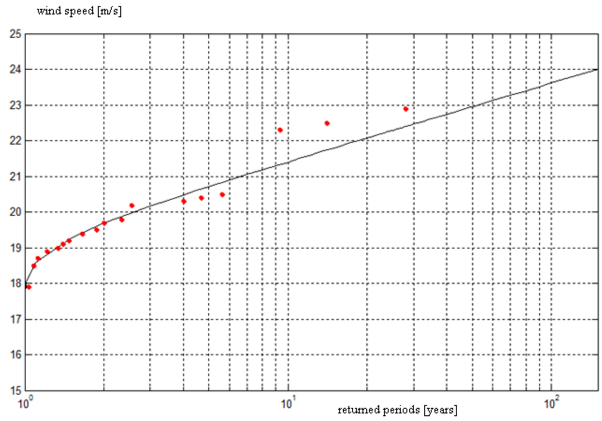

Figure 8. Wind speed extreme

The information of wind speed from ERA5 data from 1996 to 2022 are used, corrected to compute 6.5 m/s over the GALATA area at 100m. Over this 27 years period, the maximum wind speed value in a 1-hour resolution is 23 m/s.

3.2 *Validation of datasets*

The datasets obtained were validated using the CFS3D wind database, which is based on the global hourly Climate Forecast System (CFS). With its help the isobaric surfaces (1000 mb and 850 mb , mb- millibar) and 10m high above ground winds have been interpolated at each time step (keeping the 1h* temporal resolution of the CFS original system) and at each location of the *CFS grids (0.2◦ /0.3◦), to produce a 3D fixed levels (10m, 25m, 50m, 75m, 100m, 125m, 150m, 175m and 200m) dataset.

The results were also compare with the same categories of data from other scientific publications for Black Sea metocean analytics [11], [12], [13],[14].

4 THE RISKS IN VICINITY OF GALATA PLATFORM

Natural resource extraction activities in the Black Sea, such as those in the marine platforms area (GALATA), can lead to a number of ecological and operational hazards, affecting both the marine environment and industrial infrastructure. Among the most significant dangers are: oil or natural gas spills, storms and extreme weather conditions, toxic substances and heavy metals, changes in the current regime, seismic risks and geological instability, etc.

In area of GALATA Platform, scientific research and ecological monitoring are essential for risk assessment and protection of the marine environment. These activities are often regulated by european and national legislation, which imposes strict environmental standards.

In the present study, the risk assessment was carried out with the help of the NEAT+ software (Nexus Environmental Assessment Tool)[15], [16].

For Good Environmental Status (GES) factors such as: water, air, soil quality, biodiversity, the human factor, geological and hydrological risks, climate changes for 1 year and 5 years were evaluated, after which the risk matrix was drawn up (Figure 9,Figure 10, Figure 11).

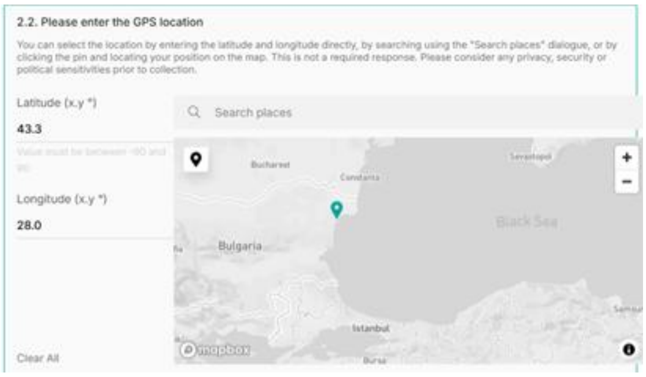

Figure 9. The GPS location of study- GALATA Platform

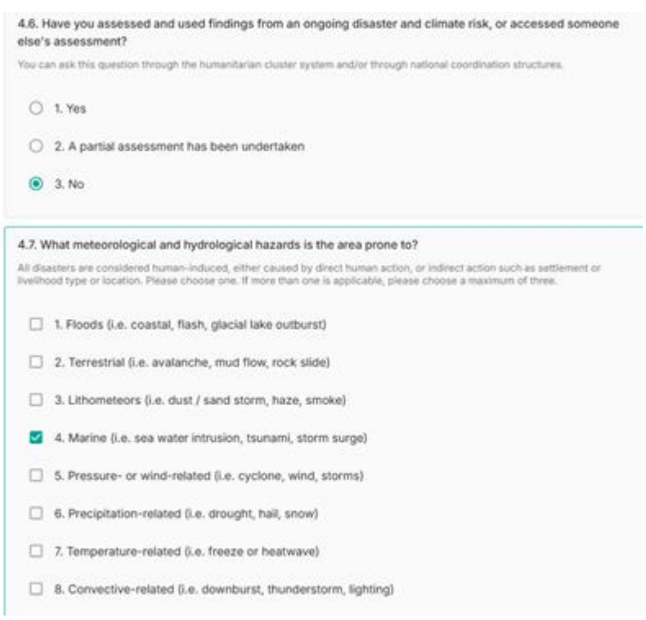

Figure 10. Determination of the GALATA area characteristics

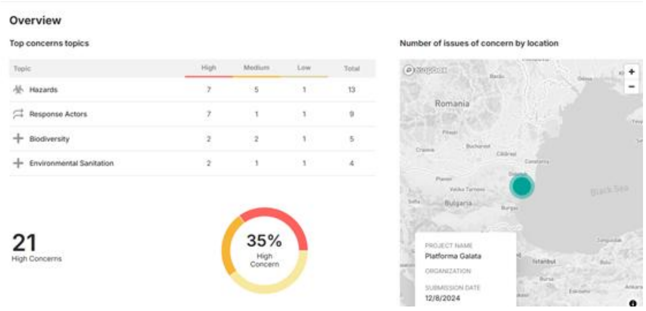

Figure 11. Analysis results based on NEAT+ software

Using results of NEAT+ software, the sensitivity statements severity summary is presented in Figure 12.

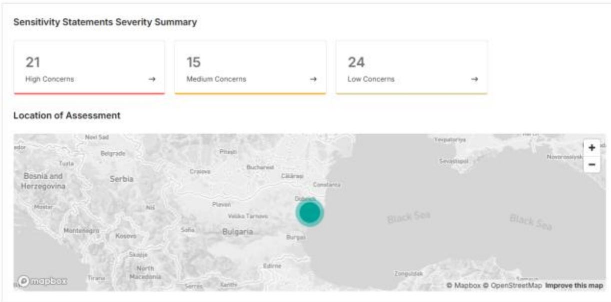

Figure 12. Sensitivity statements severity summary

In the case of the Galata Platform, SEB emphasizes some similar challenges, but also differences related to the specifics of the extraction activities and the ecological regime of the area.

5 CONCLUSIONS

Finally, for wind datasets we can conclude:

– The main wind direction observed are the Northern sector (from 315° to 75°) and from the Southern sector (from 165° to 235°).
– The long-term wind speed over a 15 years period 2008-2022 is evaluated with GALATA in situ data and ERA5 data at 5.7 m/s at 30m a.s.l. and at 6.5 m/s at 100m a.s.l.(wind speed is the rate of the movement of air flow in distance per unit of time).
– The extreme wind speed is evaluated at 21.4 m/s for a 10 years period and 23.6 m/s for a 100 years period.
– In this context, this paper focused on how NEAT contributes to the assessment, monitoring and management of risks in the Black Sea, as well as promoting the sustainable conservation and protection of this wonderful corner of nature. By using this advanced platform, new opportunities are opening up for the conservation of this remarkable ecosystem and its protection from environmental threats so that it can be enjoyed by current and future generations.

In the risk analysis of the Galata Platform area, we can conclude:

1. Water quality: Industrial activities can affect water quality by polluting hydrocarbons and hazardous chemicals. Continuous monitoring and the use of protective technologies are essential to control these risks.
2. Biodiversity and marine habitats: The study points out that the platform affects sensitive marine habitats and biodiversity around it. Projects to restore marine habitats and protect vulnerable species are recommended to counteract negative effects on marine ecosystems.
3. Ecological and physical risks: The risks of coastal erosion and changes in the current regime are more pronounced in this area, which can affect both the marine environment and the infrastructure of the platform.
4. Prevention and management measures: GES proposes a series of measures to reduce risks, including investments in advanced technologies for monitoring and preventing ecological accidents. Greater collaboration between national and international authorities for environmental protection is recommended.

Environmental Impact Assessment (EIA) studies emphasize the importance of implementing pollution prevention measures, continuous monitoring of water quality and biodiversity, and managing ecological and seismic risks. In addition, marine habitat protection and ecological restoration measures are needed to minimize the negative effects of industrial activities on the environment.

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