# WEST BLACK SEA LONG TERM MET-OCEANIC OBSERVATIONS THROUGH IOSIN EMSOEUXINUS RESEARCH INFRASTRUCTURE

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**Abstract.** EMSO-EUXINUS research infrastructure, operational starting from 2013 and upgraded during 2024 through an EU project, is continuously monitoring the EOV (Essential Ocean Variables), supplying such datasets (met-oceanic data) for the Black Sea Western region from year 2013 to date. The data records are fundamental for evaluating the amplitude and impact of the climate change at regional scale, as well as for the extreme natural event analysis.

**Key words:** IOSIN EMSO-EUXINUS, EMSO ERIC, Black Sea, Essential Oceanic Variables (EOV), climate change, sea water temperature, wind, currents, real-time monitoring

## 1. INTRODUCTION

IOSIN EMSO-EUXINUS infrastructure come to existence as the result of the cross-border Romanian and Bulgarian project MARINEGEOHAZARD (2011–2013) (Ranguelov *et al.*, 2011, at https://mgu.bg/wp-content/uploads/2025/04/Vol.-54-I-2011-177-182.pdf), having as main objective the building of a marine hazards real-time warning and monitoring system for the Romanian-Bulgarian coastal area of the Black Sea (https://www.euxinus.eu/index_en.html).

From its inception, the real time monitoring and warning (https://geoecomar.ro/en/departments/euxinus-monitoring-alarm-centre/) system IOSIN EMSO EUXINUS has been considered as being the Romanian contribution to the pan-European infrastructure EMSO ERIC (which is dedicated to the sea floor and water column multidisciplinary observation of the Essential Oceanic Variables (EOV)).

In 2016, IOSIN EMSO EUXINUS has been included in the National Interest list of Infrastructures (IOSIN), and from the year 2016 it is also established as EMSO ERIC founding member and infrastructure node for Black Sea. Since 2017, it became a Romanian Landmark Infrastructure, and later, by integrating the GeoPontica GNSS network, was certified as data supplier for EPOS-RO scientific consortium, part of EPOS ERIC (https://www.epos-eu.org/epos-eric).

IOSIN EMSO EUXINUS infrastructure development has been supported through several national and Europeans projects dedicated to marine geo-hazards, eco-systems, and research infrastructures (https://emso.eu/projects/; https://cordis.europa.eu/project/id/211816/reporting).

## 2. MATERIAL AND METHODS

### 2.1. Research infrastructure

IOSIN EMSO-EUXINUS system architecture consists of three offshore observations buoys (EuxRoOB01, EuxRoOB02, EuxRoOB03), located on the Romanian continental plateau, approximately 160 km from the coastline, at depths of maximum 90 m, and three coastal buoy (EuxRoCB01, EuxRoCB02, EuxRoCB03), moored 2 km off the coastlines of Mangalia, Constanța and Sulina, to depths of around 15 m (Fig.1).

All the multiparametric observation systems are attached to the buoy around 6m below sea level, anchored to the seabed, fully automated and connected to the coordination centre ashore via satellite bi-directional communications.

### 2.2. Methodology

IOSIN EMSO EUXINUS observation systems (https://www.euxinus.eu/emso_euxinus_network.html) are coastal and offshore, both types providing a continuous monitoring the weather conditions and the Essential Oceanic Parameters (EOV).

#### *2.2.1. The coastal observation system*

The coastal observation system is anchored on a concrete block at a depth not exceeding 20 m, being provided with a weather station, a multiparameter probe, a hydrophone and an ADCP (Acoustic Doppler Current Profiler). The EOVs measured are temperature, water pressure, conductivity, chlorophyll, turbidity, dissolved oxygen; an oil pollution detector is also included.

#### *2.2.2. The offshore observation system*

The offshore observation system consists of two main components: the floating system (buoy) and the sea-bottom system (deep water module). The buoy is provided with a weather station, a multiparameter water probe and an ADCP. EOVs measured are temperature, water pressure, conductivity, chlorophyll, turbidity, dissolved oxygen, in addition to the hydrodynamic parameters. The sea bottom module supplies temperature, pressure, current, conductivity, dissolved oxygen data, as well as tide and wave parameters, to a maximal depth of 100m.

All the data recorded by EMSO EUXINUS observation systems is sent to the Coordination Centre ashore via a bi-directional satellite link. The data transmission frequency is 1 hour, in case of marine parameters (EOVs) and 15 minutes for the weather station records for coastal buoys. The datasets are digitally recorded and undergo initial conditioning which includes processing and quality control prior being uploaded in the EMSO ERDAPP server and delivered to the interested parties nationally and internationally.

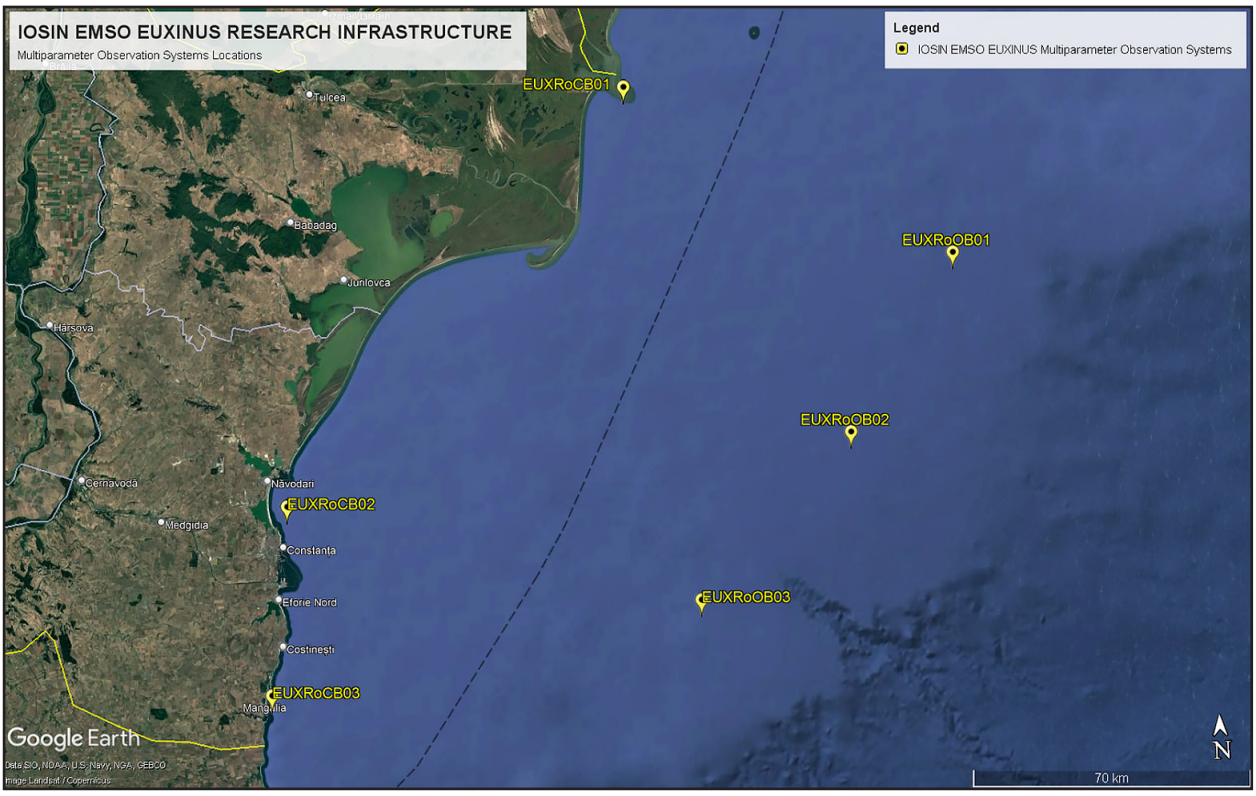


**Fig. 1.** IOSIN EMSO EUXINUS observation systems locations.

## 3. RESULTS

IOSIN EMSO EUXINUS observation datasets support further processing and analysis directed to various scientific purposes. Through long-time data series selection and specific processing, aspects of scientific relevance were demonstrated, such as depicted in the examples below.

### 3.1. Aquatic temperature data

Both measured and conservative (corrected according to TEOS-10 equation) temperatures suggest a visible increase of the season average values of approximately 2–3°C over a measurement span between years 2014–2024, which definitely supports the global warming hypothesis for the Western Black Sea region (cf. chart displayed in figure 2).

The long-term temperature datasets provided by IOSIN EMSO EUXINUS research infrastructure have the potential of validating complex models which reveals clearly trends over determined periods of time and specific areas of interest (i.e. protected marine habitats and third party's sensitive areas and at various depths.

One eloquent example obtained by performing the sea temperature modelling for one significant cross-section (i.e., through EUXRoCB03 Mangalia IOSIN EMSO EUXINUS buoys – as displayed in figure 6) for the Autumn season shows a definite warming trend between years 2015-2023, as displayed in figures 3, 4, and 5. For that particular model, the data supplied by Copernicus (https://dataspace.copernicus.eu/) has been calibrated using the in-situ datasets for the water columns monitored by IOSIN EMSO EUXINUS observation stations EUXRoCB03 and EuxRo03.

Figure 6 transect shows a rather crooked shape instead of the expected straight line due to the methodology used in modelling the data. The model is produced using an unstructured network (mesh) of triangles, the variables (i.e. temperature) being processed only in the mesh's nodes, therefore the cross-section cannot possibly follow a straight line, being dependant on the existing data density and the correlation/calibration with the direct data supplied by EUXRoCB03. The network resolution is highest nearby the shore line, becoming weaker as the processing progresses offshore

### 3.2. The hydro-dynamic EOVs monitoring

The monitoring of the hydro-dynamic regime, especially wind and currents vectors is of importance for early warning in case of extreme weather events and for identifying long term trends which can and do affect the coastal area, human activities and natural habitats.

Long term monitoring of the predominant strength and direction for wind and sea currents over an 8 years' time lapse is displayed in figure 6 below as a relevant example. The dynamic display of such diagrams (Fig. 7 and 8) will reveal the changes occurred over a determined period in a certain area of interest, thus supporting the measures of prevention and mitigation in case of need.

The hydro-dynamic datasets provided by IOSIN EMSO EUXINUS are of utility for modelling the EOVs in areas with high risk, given the increased frequency of the extreme weather events affecting the coastal areas of Black Sea. Such models (especially wave and currents ones) are made available to authorities or other entities, in circumstances including vessels and small boats drifting, people lost at sea, marine military hazards (*e.g.*, explosive mines), pollution spots. Using SHYFEM multivariable processing suite (https://www.cmcc.it/models/shyfem), significant waves height or surface currents modelling are produced (examples in figure 9 for wave height significant and figure 10 for near surface currents) thus enabling further actions for the stakeholders.

## 4. DISCUSSION

### 4.1. IOSIN EMSOEUXINUS upgrade and extension linked to met-oceanic monitoring equipment's evolution

The initial IOSIN EMSO EUXINUS configuration included one single coastal buoy and three offshore complex buoys. Later, the observation net has been extended by adding supplementary two coastal buoy. In 2024, all the six-marine met-oceanic observatories have been significantly upgraded to the latest technological level (https://geoecomar.ro/en/projects/upgrading-of-the-emso-euxinus-marine-research-infrastructure/).

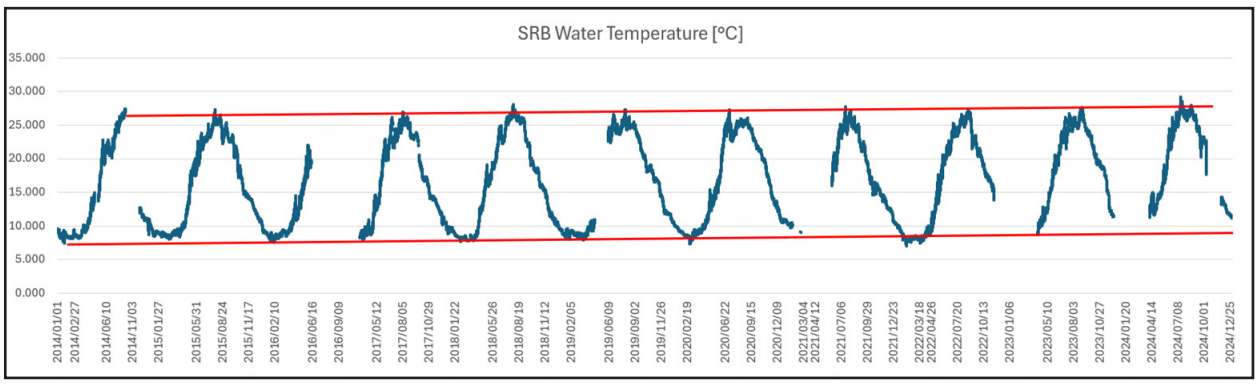


**Fig. 2.** Water temperature evolution between years 2014-2024.

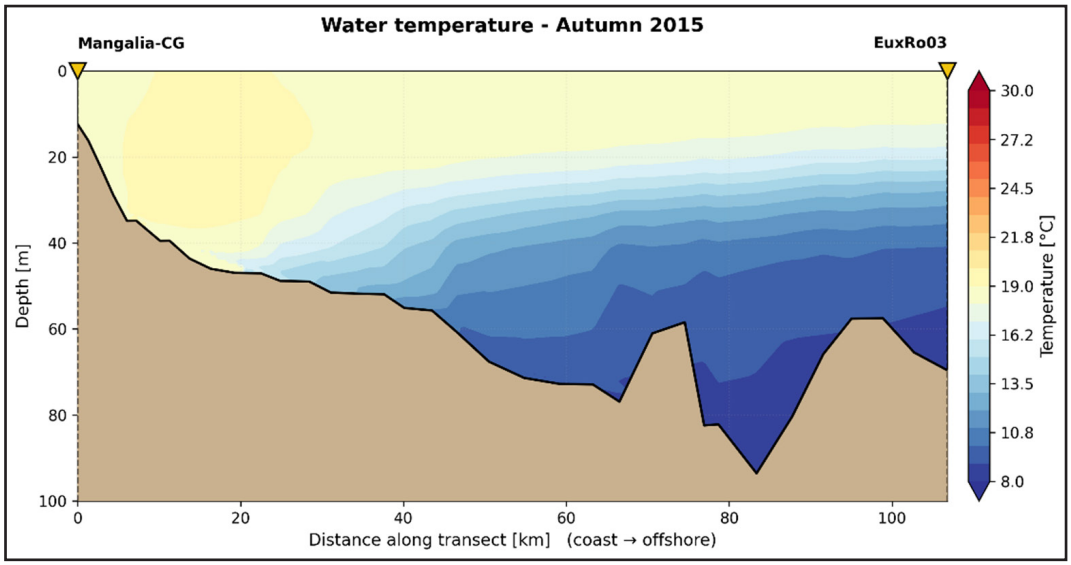


**Fig. 3.** Water temperature – Autumn 2015 – Mangalia transect CC-EuxRo03.

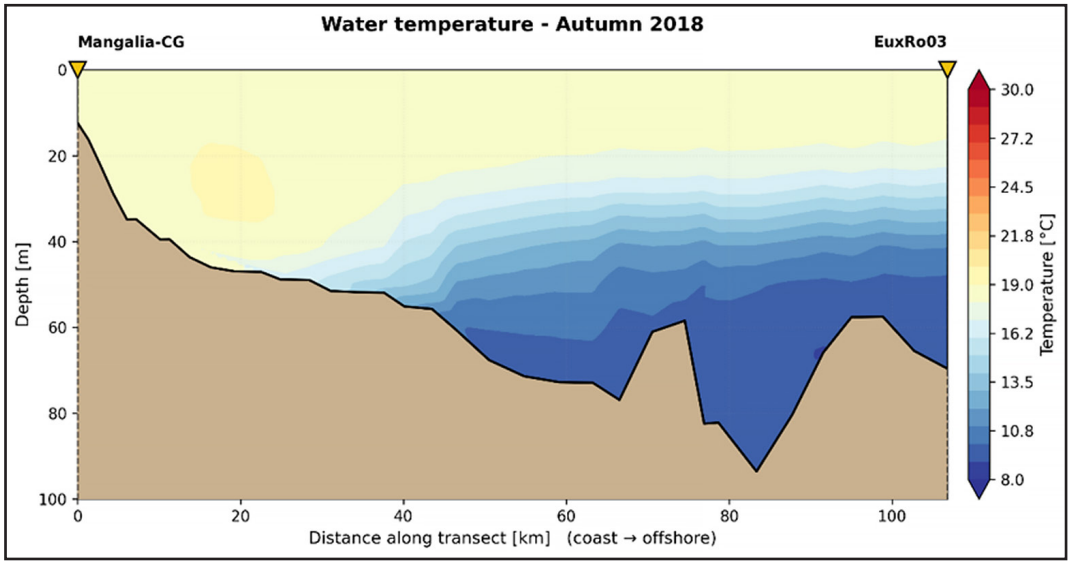


**Fig. 4.** Water temperature – Autumn 2018 – Mangalia transect CC-EuxRo03.

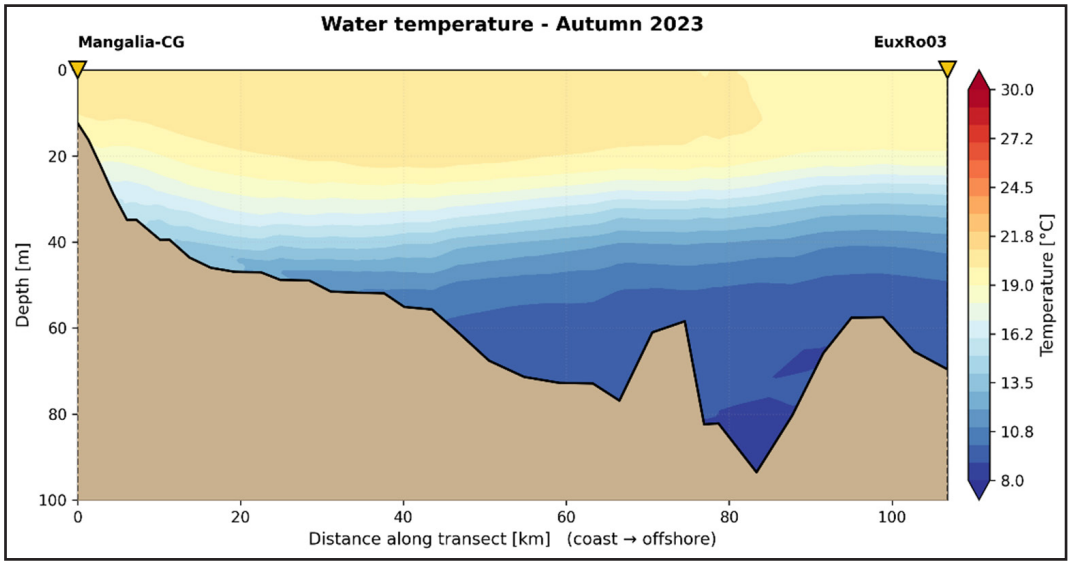


**Fig. 5.** Water temperature – Autumn 2023 – Mangalia transect CC-EuxRo03.

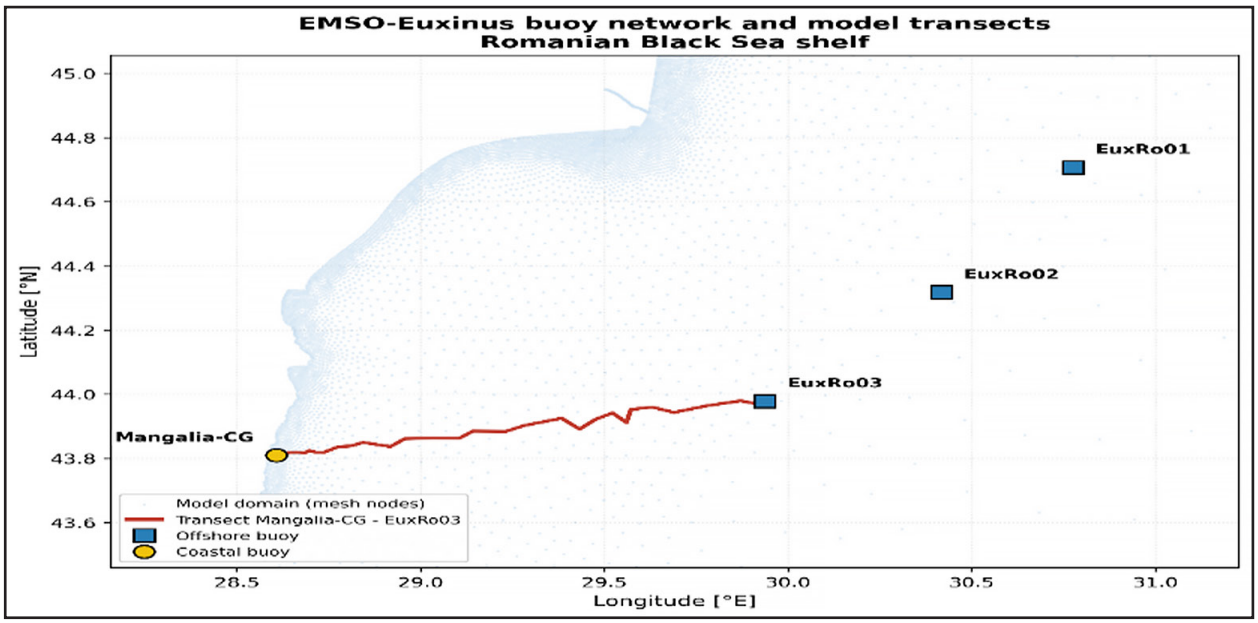


**Fig. 6.** Positioning of the Mangalia transect (modelled through CC-EuxRo03).

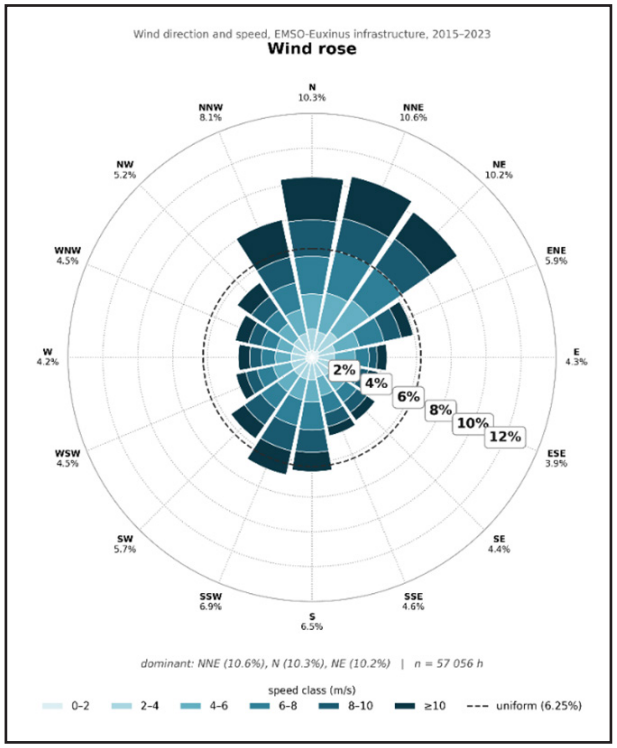


**Fig. 7.** Wind predominant parameters between years 2015-2023.

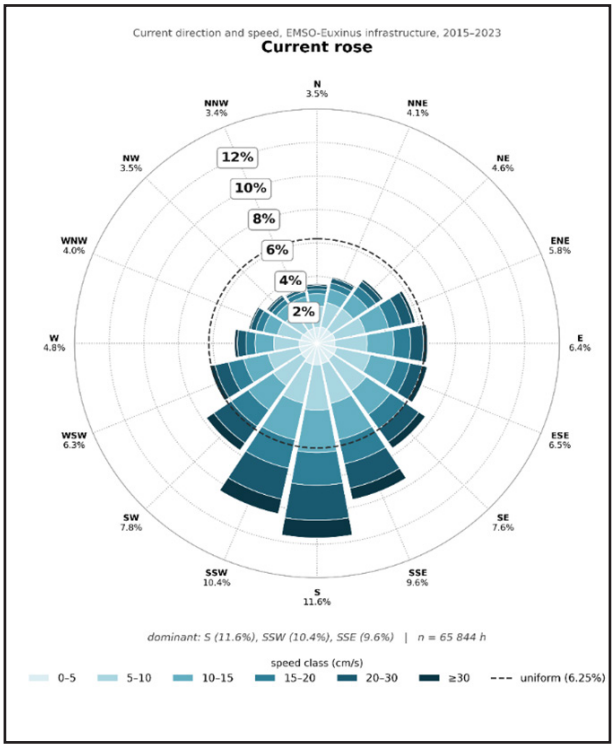


**Fig. 8.** Current predominant parameters between years 2015-2023.

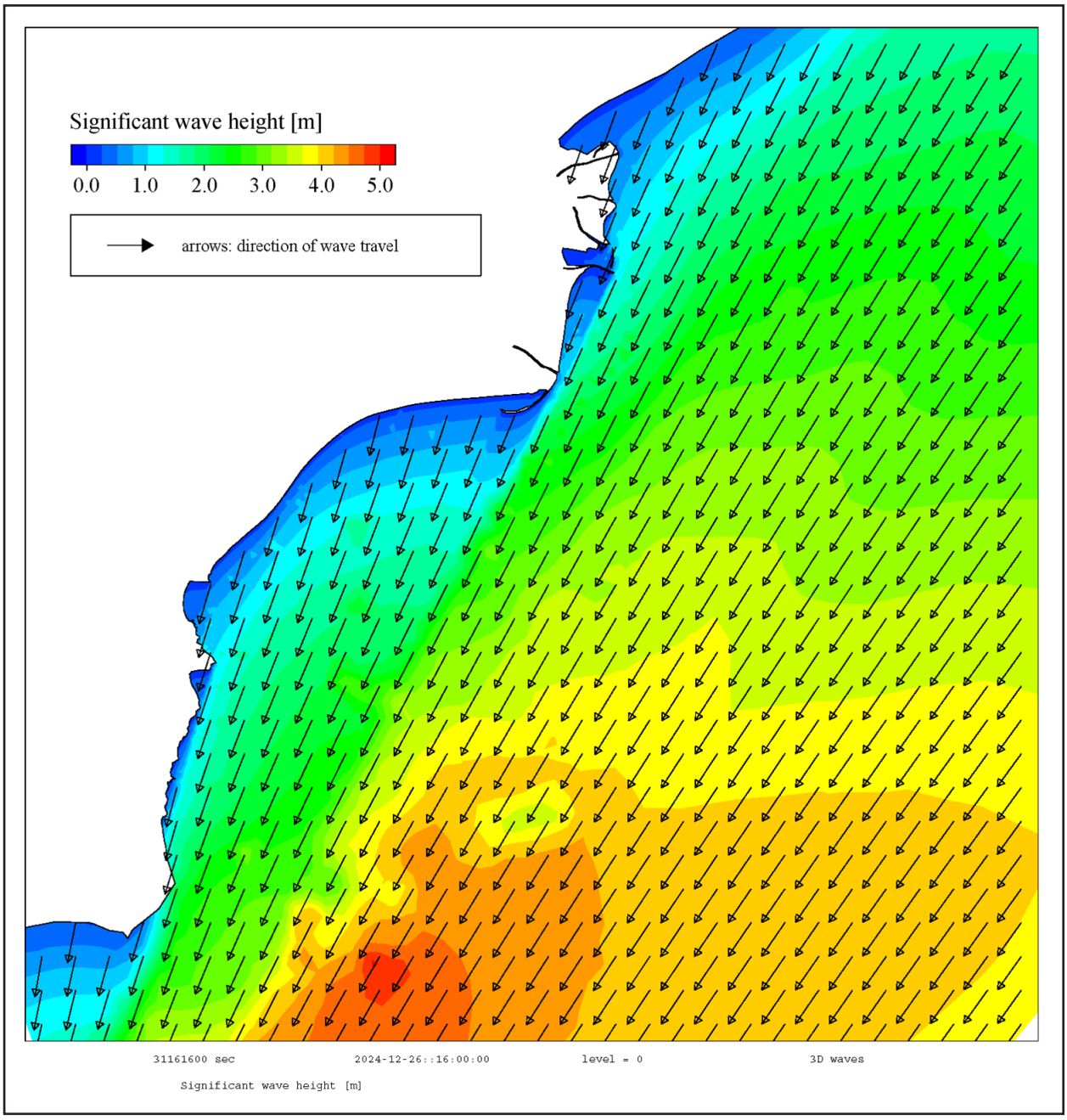


**Fig. 9.** Significant wave height modelling (SHYFEM).

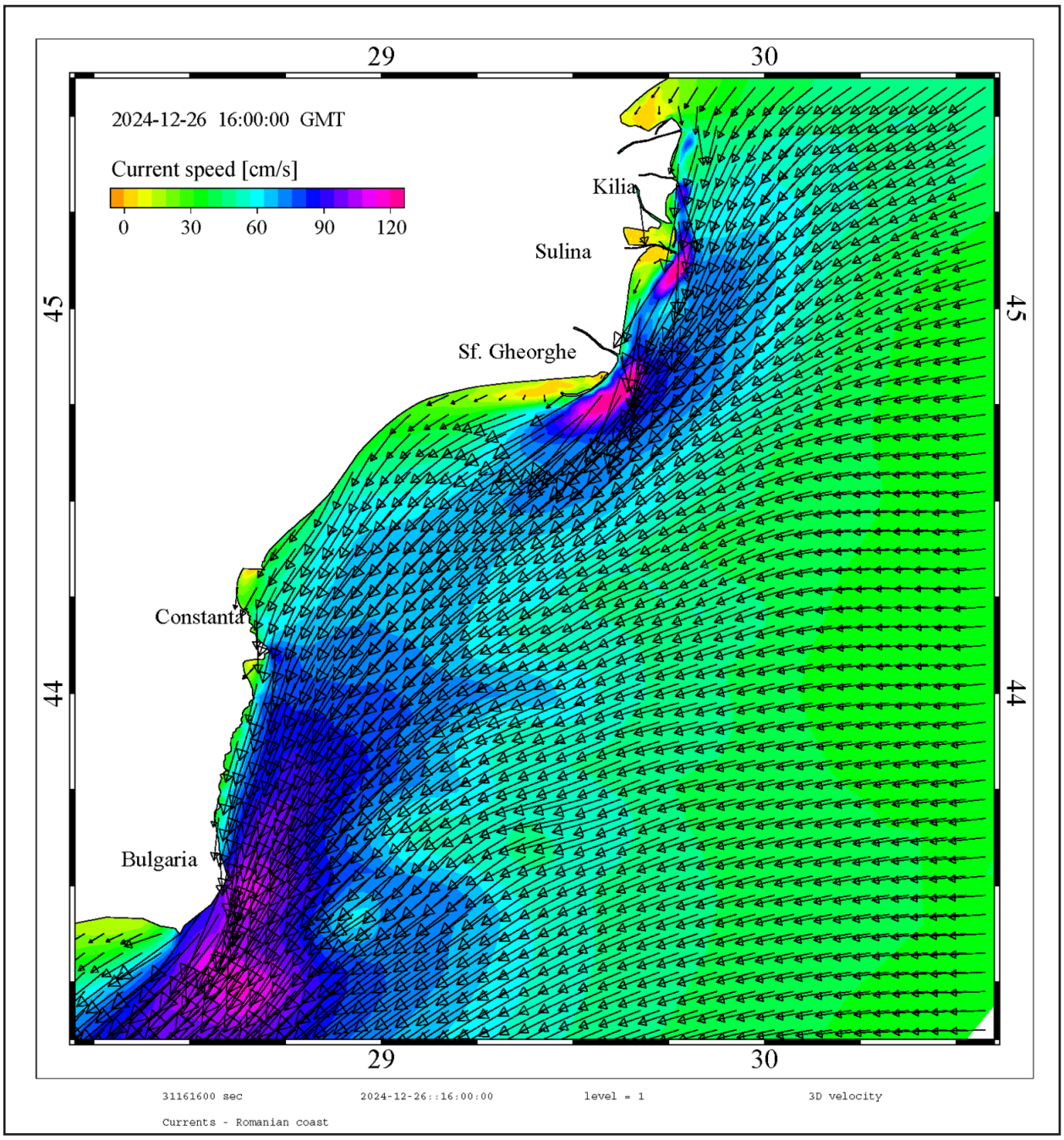


**Fig. 10.** Surface currents modelling (SHYFEM).

The previously in-use sensors (produced by Aanderaa, Turner, and LinkQuest) have been replaced with the latest and state of-the-art ones (RBR, Nortek, Seapoint, Lambrecht, Teledyne). Consequently, IOSIN EMSO EUXINUS reached an increased accuracy and precision level, more stability in use and sampling rates increased and optimized, perfectly adequate for continuous monitoring.

Analysing the measuring characteristics for both coastal and offshore buoys observation stations it worth noticing the evolution from single sensor-single parameter technology to the multi-parameter integrated multi-sensor systems and probes, which currently includes supplementary measuring capabilities such as hydrophones, oil polluting sensors, passive and active radar reflectors, status and position-bias sensors. The major upgrade of 2024 considerably augmented measurements' spatial-temporal resolution, allowing the seamless integration of IOSIN EMSO EUXINUS in the European networks EMSO ERIC.

### 4.2. Support for fundamental studies in climate changes monitoring

Integrating in studies additionally monitored EOVs such as: dissolved oxygen content, chlorophyll-a content, and turbidity show consistency with the aforementioned temperature trends, thus offering an essential scientific frame for climate change evaluation over marine ecosystems and subsequent sedimentary and vertical mix processes in the water column.

Hydrodynamic and wind modelling via advanced multivariable processing (*e.g.* SHYFEM developed by CNR-ISMAR of Venice - https://www.ricercamarina.cnr.it/en/ismar.php) enables the gradual transition of the spatial resolution from kilometres offshore to tens of meters in the coastal area. Such modelling has been already successfully applied for the system composed of Mediterranean, Marmara, Black Sea, and Azov Sea.

IOSIN EMSO EUXINUS support the scientific research in three important ways: firstly, it contributes to European EOVs databases for the Black Sea region, where the sparsity of the data is notorious, secondly, it enables the calibration of the models by providing in-situ high accuracy data, and last but not least, it enables real-time feedback and adjustments for models and simulations.

## 5. CONCLUSIONS

IOSIN EMSO EUXINUS research infrastructure proves a definite relevance in supporting the global climate change research, the long-term datasets being fundamental for studies and analyses assessing the climate changes influences and impact in the Western Black Sea region. The multi-annual data series provided by IOSIN EMSO EUXINUS confirm at a regional scale the warming trends globally observed and studied. Analyses based on water and air temperature, winds and physical EOVs (hydrodynamics) clearly indicate the increase in intensity and frequency for the occurrences of the favorable conditions which are prone to produce extreme natural events. IOSIN EMSO EUXINUS, through the delivered datasets, supplies critical information for Romanian Authorities and other entities, information representing the essential support for monitoring and early warning for extreme natural events occurrences in the Romanian Black Sea region.

## ACKNOWLEDGEMENTS

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IOSIN EMSO EUXINUS research infrastructure has been fully upgraded and extended in 2024 through "Modernization of the marine research infrastructure EMSO-EUXINUS" project (SMIS CODE: 125943) under "Research Infrastructures for research and development public entities and universities" Low Developed Regions Program with EU non-reimbursable funding.

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