Harmonization and Networking for contaminant assessment in the Ionian and Adriatic Seas

Deliverable T3.1.2 - Hydrodynamics

Work Package T3 – Case study of contaminant dispersion

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1. Objective

The aim of activity T3.1.2 is the analysis of both the large-scale circulation (with particular interest for surface velocities) in the Adriatic-Ionian basin, and a more detailed study focused on three selected coastal areas, namely, the Gulf of Trieste, the Bay of Split and the Gulf of Patras.

2. Approach

Numerical Model

The numerical simulations were performed using a customized version of the Massachusetts Institute of Technology general circulation model (MITgcm) [Marshall et al., 1997], which is a three-dimensional, finite volume, general circulation model.

First, we analyzed a basin-scale simulation in order to assess the oil spill risk in the Adriatic-Ionian area (yellow rectangle in Fig. 1). A further run focused on the Adriatic Sea (red rectangle in Fig. 1) was done in order to obtain specific open boundary conditions for the Adriatic coastal areas (Trieste and Split case studies). Overall, we used these large-scale runs (Fig. 2) to obtain the open boundary conditions that we used to force the three high resolution models focused on the Gulf of Trieste (Fig. 3), the Bay of Split (Fig. 4), and the Gulf of Patras (Fig. 5).

The largest domain covers the Adriatic-Ionian region with a horizontal resolution of 1/32° (~3.4 × 2.4 km) and has been described in Querin et al. [2016] (ADIOS simulations). Conversely, the model of the Adriatic Sea has been developed in the framework of the MANTIS project and it is characterized by finer resolution (1/64°: ~1.7 × 1.2 km).

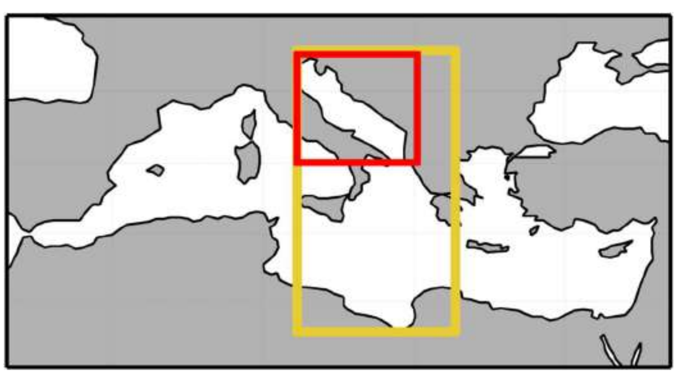

Figure 1. Areas covered by the Adriatic-Ionian model (ADIOS, yellow) and by the Adriatic model (MANTIS project, red). Both simulations cover the period 2006-2012.

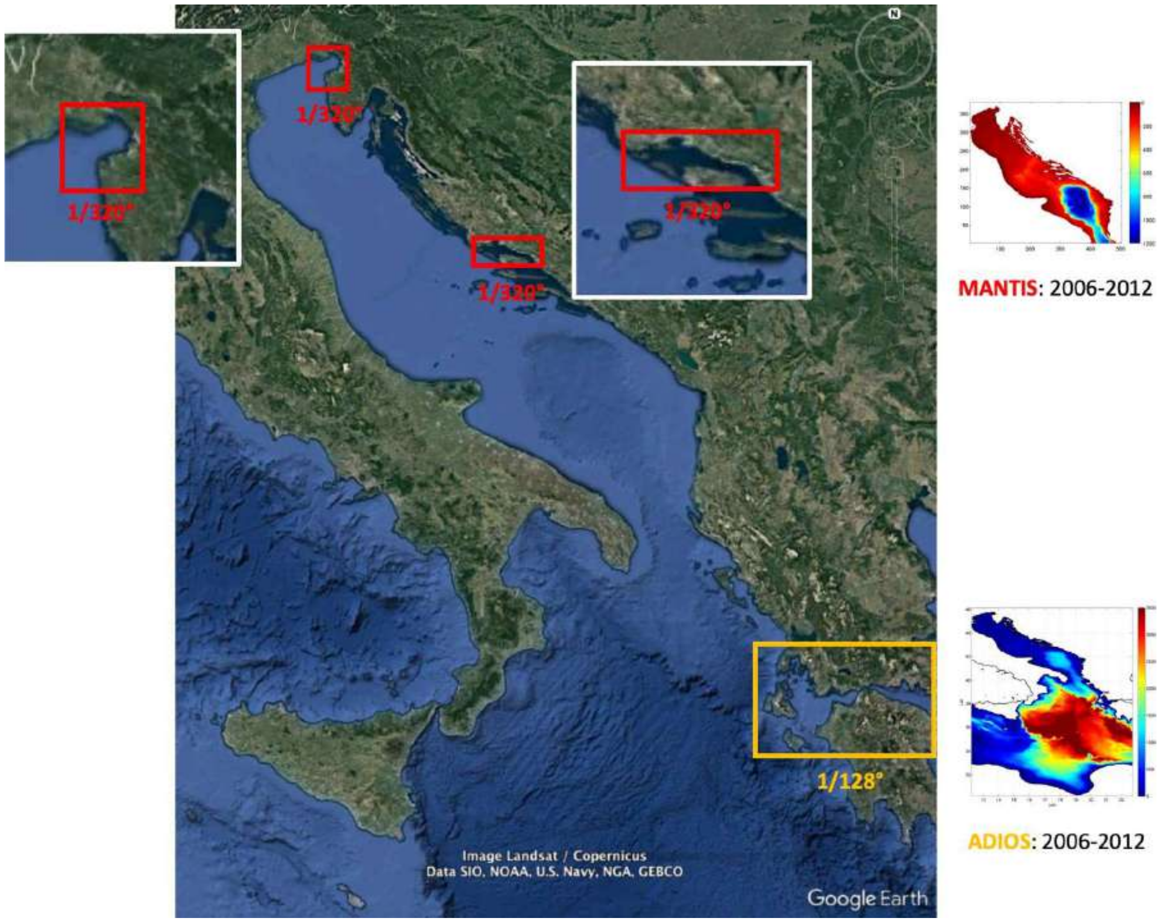

Figure 2. Localization of the 3 high-resolution case studies focused on the Gulf of Trieste and the Bay of Split (nested into the MANTIS simulation, red) and on the Gulf of Patras (nested into the ADIOS simulation, yellow).

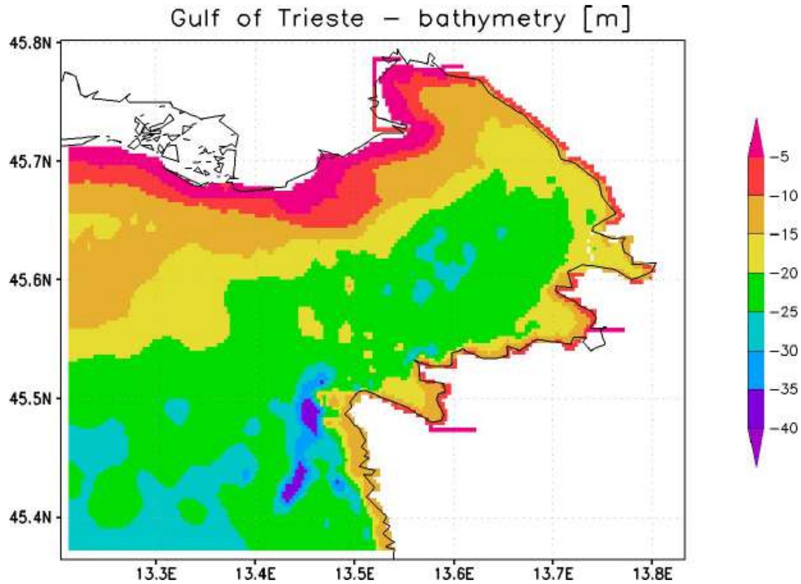

Figure 3. Gulf of Trieste, model domain and bathymetry

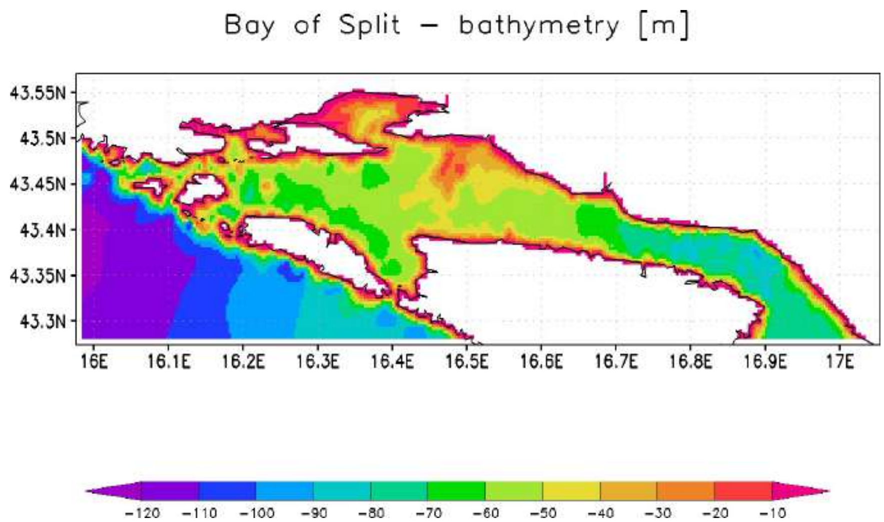

Figure 4. Bay of Split, model domain and bathymetry.

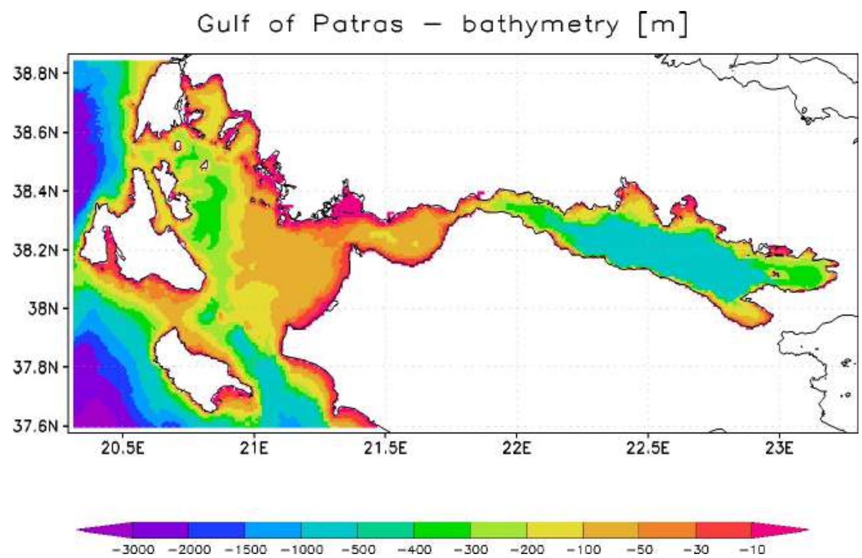

Figure 5. Gulf of Patras, model domain and bathymetry.

Model Configuration

Our MITgcm setup is an upgraded version of the model described in Querin et al. [2013, 2016] and Cossarini et al. [2015], tailored for each particular domain. We used a numerical grid that covered an area spanning from latitude 40°N to 46°N, featured a horizontal resolution ranging from 1/32° to 1/320° (depending on the domain) and was composed of up to 72 unequally spaced vertical levels.

We adopted the second-order moment (SOM) advection scheme described by Prather [1986] and we used the Leith-Smagorinsky and KPP schemes for the horizontal and vertical parameterizations of turbulence, respectively (more details on the MITgcm parameterizations can be found at http://mitgcm.org/public/r2_manual/latest/online_documents/manual.pdf).

The adopted horizontal grid spacing for the Adriatic runs (1/64°: ~1.7 × 1.2 km) allows realistic simulations of the main mesoscale features of the basin (i.e., full eddy resolving simulations), which are characterized by horizontal scales of approximately 5–10 km.

The Adriatic model receives the boundary conditions at the southern open boundary from the MITgcm implementation for the Adriatic-Ionian system, which adopts a lower horizontal resolution (1/32°). This latter model is nested along the Sicily Strait (on the western side) and along the Cretan Passage (on the eastern side) into the 1/16° Mediterranean forecasting system set up in the framework of the Copernicus project (Copernicus Mediterranean Monitoring and Forecasting Centre: Copernicus-Med-MFC, http://marine.copernicus.eu). The vertical discretization adopted for the ADIOS model is the same as that of the Copernicus-Med-MFC model, except

for the surface level, which was further subdivided into two equal layers to obtain a better representation of the surface processes.
The discharge rates of the main rivers flowing into the Adriatic Sea were defined taking into account the new data set presented by Janeković et al. [2014].
Further details on the model setup and numerical implementation are described in Querin et al. [2013, 2016] and Cossarini et al. [2015].

Meteorological Forcing
To drive all the numerical simulations of this study (from the ADIOS run to the local models), we used the meteorological forcing fields produced by the 2016 version of the Regional Climate Modeling system RegCM4, which was developed at the Abdus Salam International Centre for Theoretical Physics (ICTP) and described by Giorgi et al. [2012]. RegCM4 is a hydrostatic and terrain following sigma vertical coordinate model that has multiple physics options. The RegCM modeling system has been used for more than two decades for a wide variety of applications, and the version of this community RCM used in this study is available at the following URL: http://gforge.ictp.it/gf/project/regcm/frs/.
RegCM4 was integrated over the Adriatic-Ionian basin with a horizontal grid spacing of 12 km and 23 vertical levels for the period 2006–2012. The initial and lateral meteorological boundary conditions were provided by a regional climate simulation at 50 km resolution over the Med-CORDEX domain.

3. Synthesis of work done – example of results

We ran 72-month-long simulations of the period from January 2007 to December 2012, after a spin-up run that covered one year (2006).
The three high-resolution studies are focused on the year 2012.
The data uploaded in the Geoportal are in ASCII format.

Adriatic/Ionian Sea
The data cover the period 2007-2012 (6 years) at 1/32° resolution for the Adriatic-Ionian system (setup borrowed from the ADIOS project).
The dataset contains 86 text files:
- grid coordinates [degrees lon, degrees lat];
- bathymetry [m];
- monthly averages of surface velocity from 2007 to 2012 (72 files) [m/s];
- interannual monthly averages of surface velocity (e.g., average of all Januaries in the period 2007-2012 and so on; 12 files) [m/s].

Surface velocities refer to the u (zonal) and v (meridional) components of water current in the top layer of the model (from 0 to 1.5 m depth). All data (model bathymetry and velocities) refer to the points located as specified in the file containing the coordinates of the model grid (grid size ADIOS: 336 x 512 points, with 60 vertical levels).

Gulf of Trieste

The data cover one year (2012) at the resolution of 1/320°. The dataset contains 15 text files:

- grid coordinates [degrees lon, degrees lat];
- bathymetry [m];
- monthly averages of surface velocity (12 files) [m/s];
- yearly average of surface velocity [m/s] (Fig. 6).

Surface velocities refer to the u (zonal) and v (meridional) components of water current in the top layer of the model (from 0 to 0.5 m depth). All data (model bathymetry and velocities) refer to the points located as specified in the file containing the coordinates of the model grid (196 x 135 points, with 40 vertical levels).

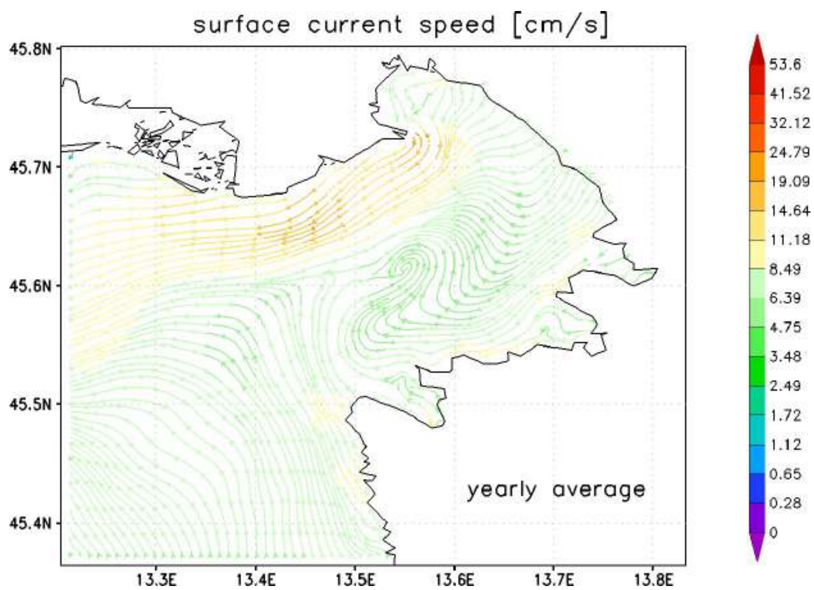

Figure 6. Gulf of Trieste, surface currents in 2012 (yearly average).

Bay of Split

The data cover one year (2012) at the resolution of (1/320°). The dataset contains 15 text files:

- grid coordinates [degrees lon, degrees lat];
- bathymetry [m];
- monthly averages of surface velocity (12 files) [m/s];
- yearly average of surface velocity [m/s] (Fig. 7).

Surface velocities refer to the u (zonal) and v (meridional) components of water current in the top layer of the model (from 0 to 1.5 m depth). All data (model bathymetry and velocities) refer to the points located as specified in the file containing the coordinates of the model grid (340 x 90 points, with 21 vertical levels).

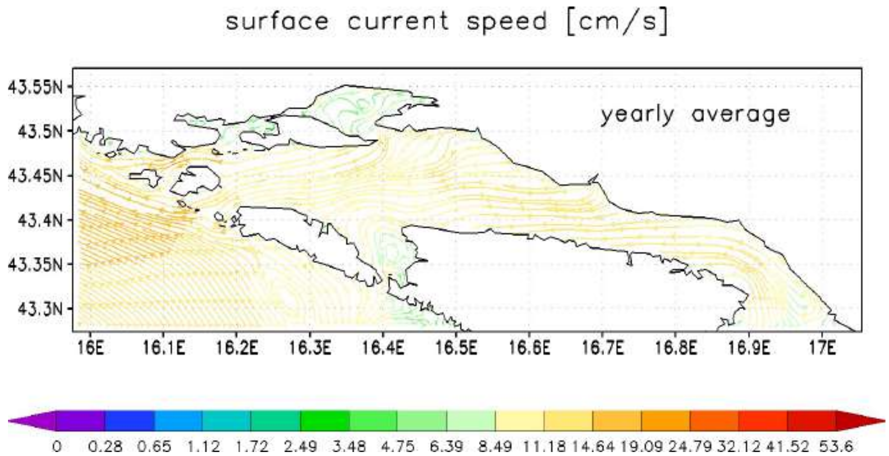

Figure 7. Bay of Split, surface currents in 2012 (yearly average).

Gulf of Patras

The data cover one year (2012) at the resolution of (1/128°). The dataset contains 15 text files:

- grid coordinates [degrees lon, degrees lat];
- bathymetry [m];
- monthly averages of surface velocity (12 files) [m/s];
- yearly average of surface velocity [m/s] (Fig. 8).

Surface velocities refer to the u (zonal) and v (meridional) components of water current in the top layer of the model (from 0 to 1.5 m depth). All data (model bathymetry and velocities) refer to the points located as specified in the file containing the coordinates of the model grid (380 x 160 points, with 67 vertical levels).

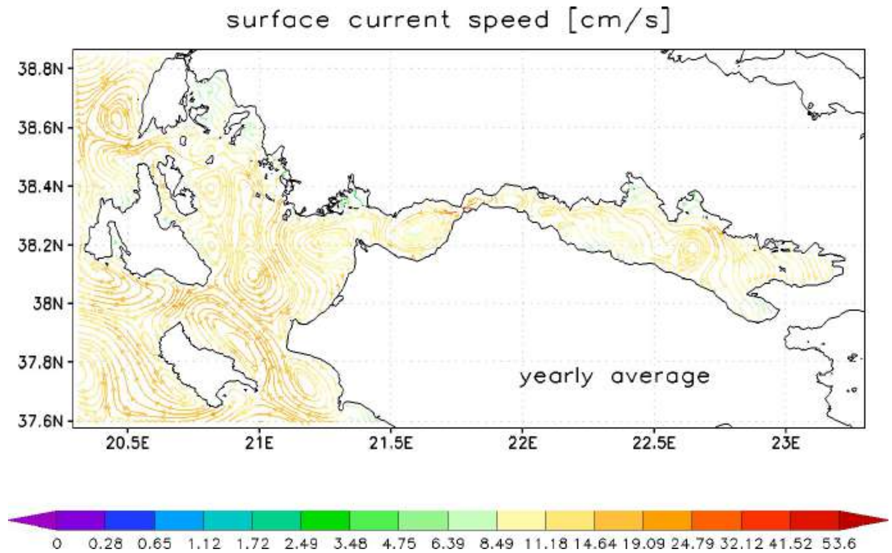

Figure 8. Gulf of Patras, surface currents in 2012 (yearly average).

4. References

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Hydrodynamics and Case Study Selection - Annex to Deliverable T3.1.2

Work Package T3 - Case study of contaminant dispersion

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September 2018

1. Objective

Identification of modelling domain and forcing for the whole year 2012 for the selected high resolution study sites (Gulf of Trieste - IT, Kaštela Bay – HR and Gulf of Patras - GR). This objective has been reached discussing among the WP T.3 partners on data and modelling availability, and based ecological and socio-economical sensitivity of the selected sites.

2. Identification of forcing and boundaries for the three sites

Three model has been implemented in the three selected sites (Gulf of Trieste - IT, Kaštela Bay – HR and Gulf of Patras - GR) according to the best available resolution of model data and simulations set-up.

As shown in figures 1 and 2, boundary conditions have been identified and the modeling set-up table including forcing and boundary conditions for the whole basin and for the 3 sites has been set.

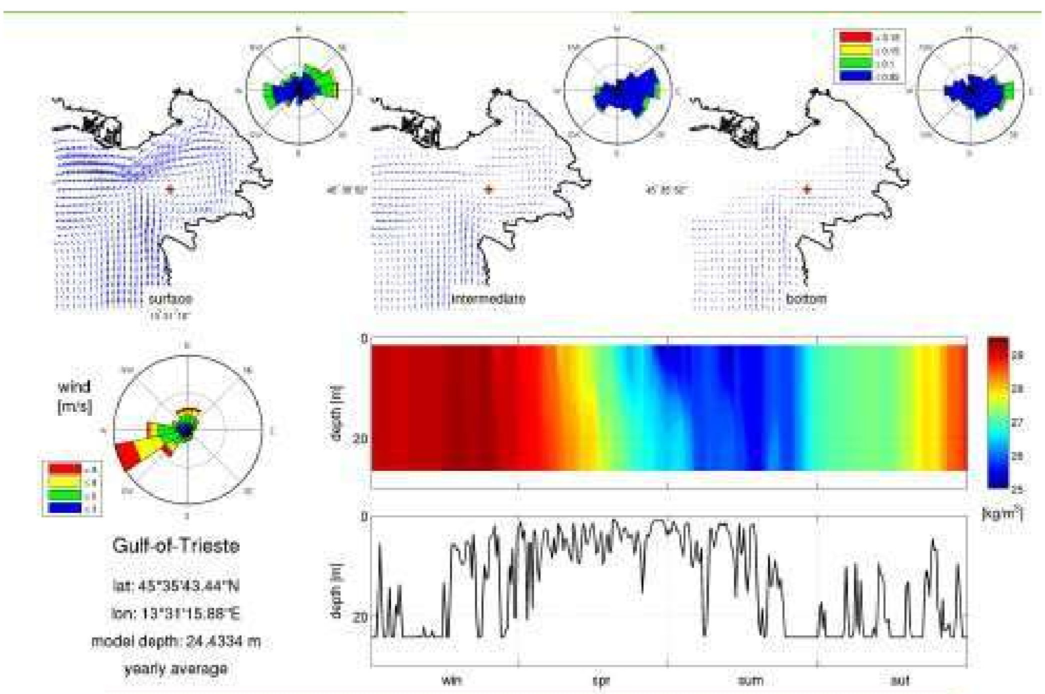

Fig. 1. Meteo-oceanographic characterization of the Gulf of Trieste.

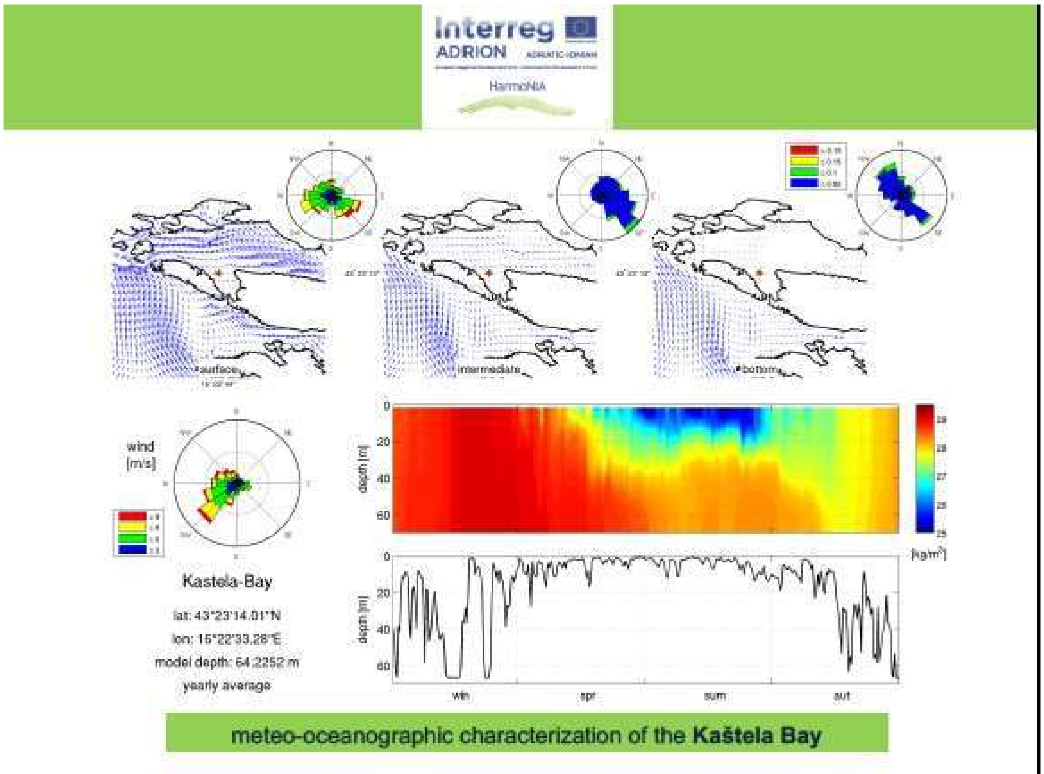

Fig. 2. Meteo-oceanographic characterization of the Kastela Bay.