Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

'Avanzamento Delle Energie Rinnovabili Marine: Strategia Europea, Attività In Corso In Italia, e Aggiornamento Del Piano D'azione Nazionale Del Cluster-Big'

Blue Italian Growth Technology Cluster

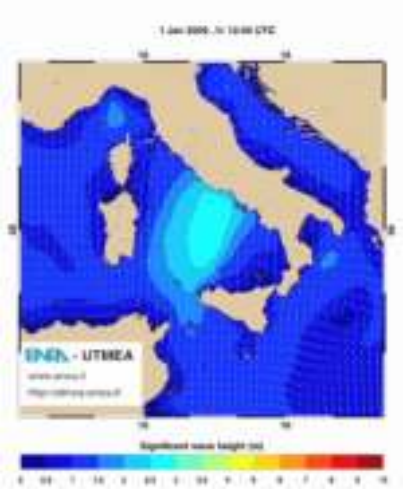
Ocean modelling @ ENEA in the Blue Growth context

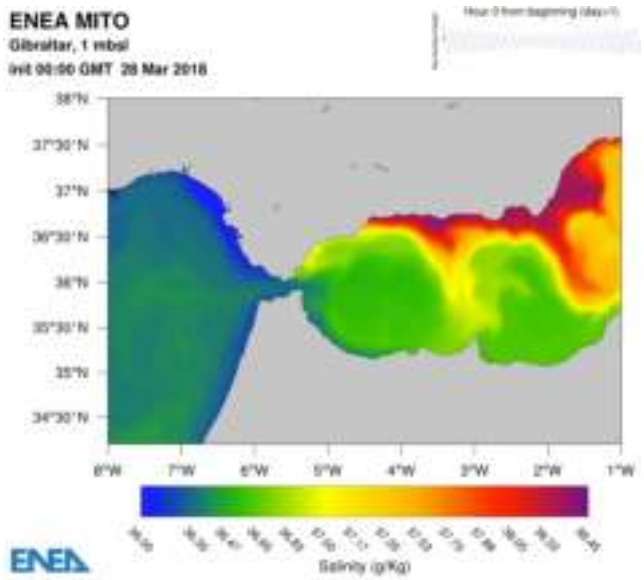
BLUE ITALIAN GROWTH TECHNOLOGY CLUSTER

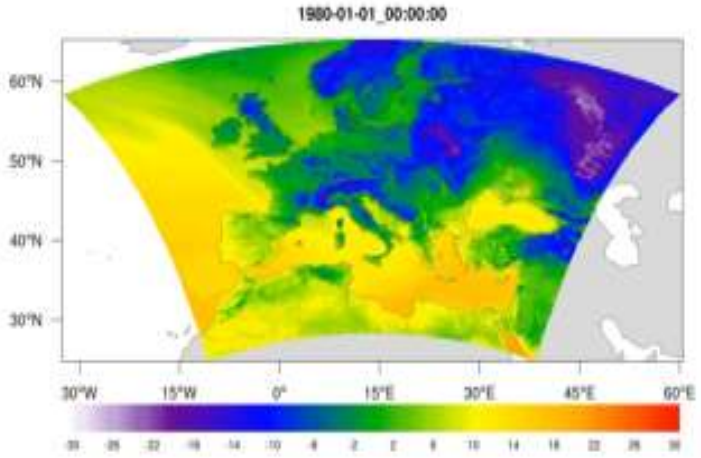
Rome 24-25 February 2022

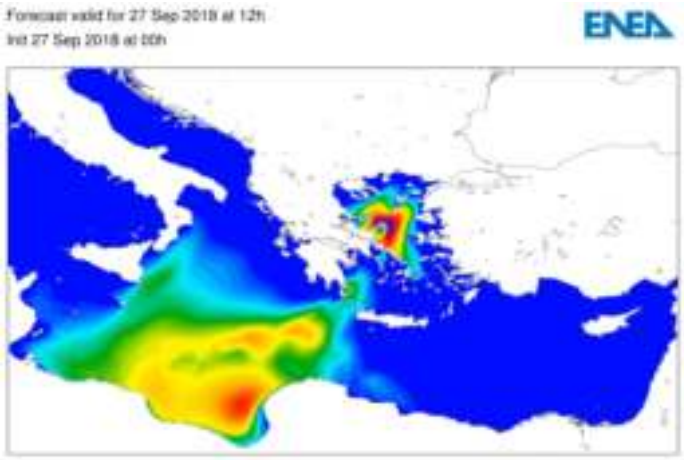
G. Sannino, A. Carillo, I. Cionni, R. Iacono, E. Napolitano, M. Palma

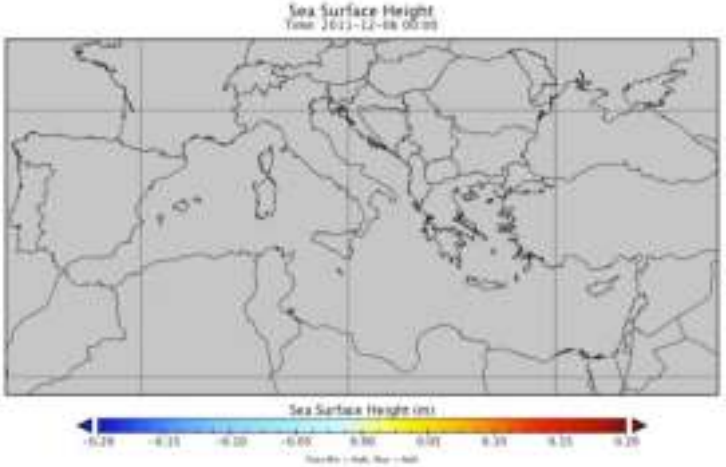
Ocean modelling @ ENEA

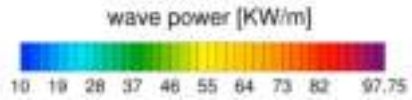












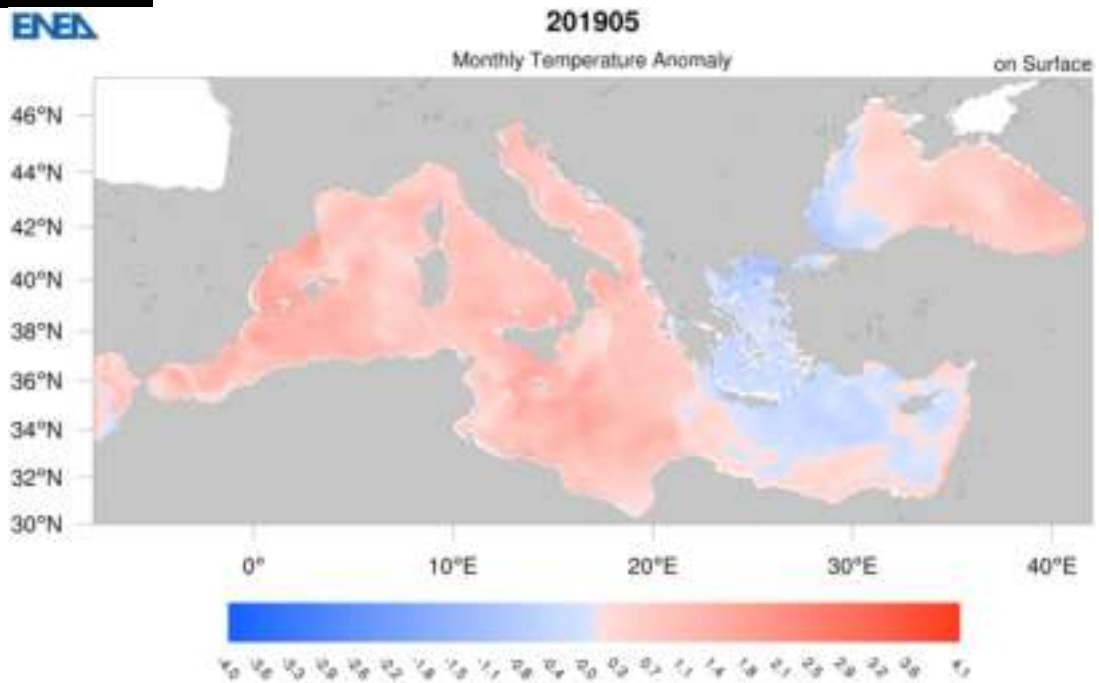
Ocean modelling @ ENEA

Simulations of the ocean circulation and of the sea state, on time scales ranging from few days (*operational forecast systems*), to climatic scales (*from seasonal to multidecadal*) provide scientific knowledge about the marine environment that is essential for a correct management of numerous human activities insisting on coastal areas. These include the extraction of renewable energy, which has been growing in recent years, and will play a key role in the context of future Blue Growth.

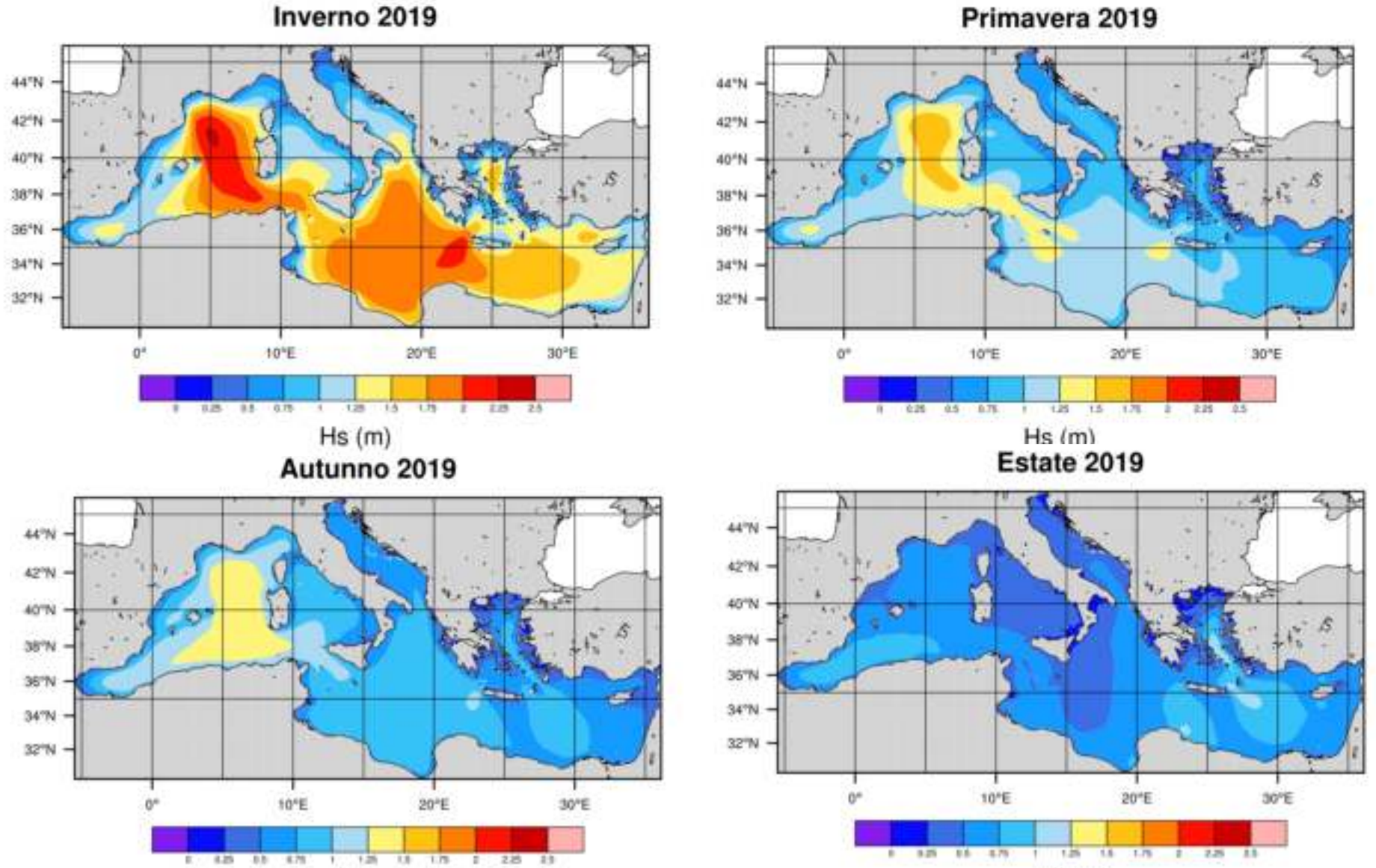
Here we discuss recent developments in three areas:

- *Short-term forecast of Mediterranean circulation and waves.*
- *Seasonal forecast*
- *Simulations of the Mediterranean climate*

Ocean modelling @ ENEA



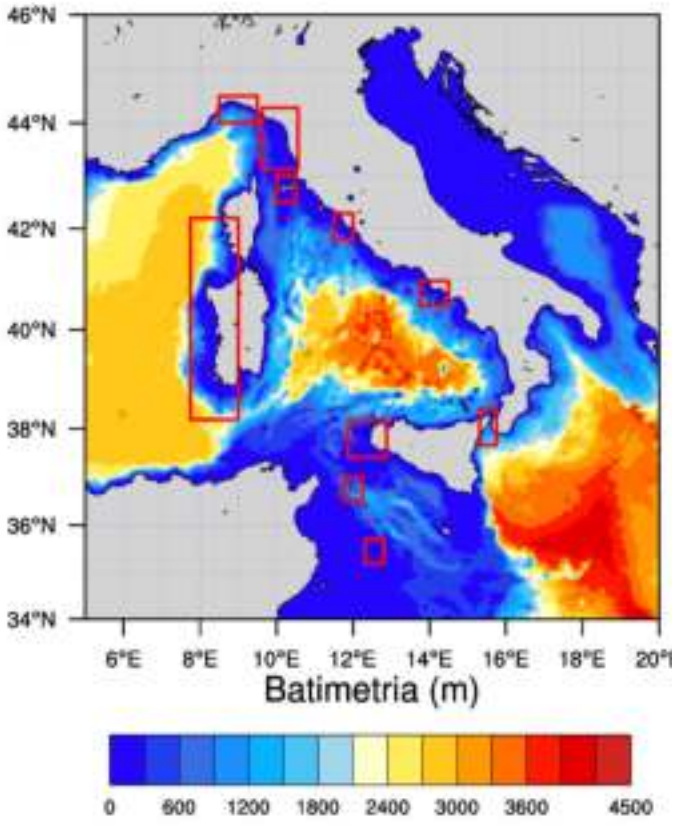
WAVE modelling @ ENEA

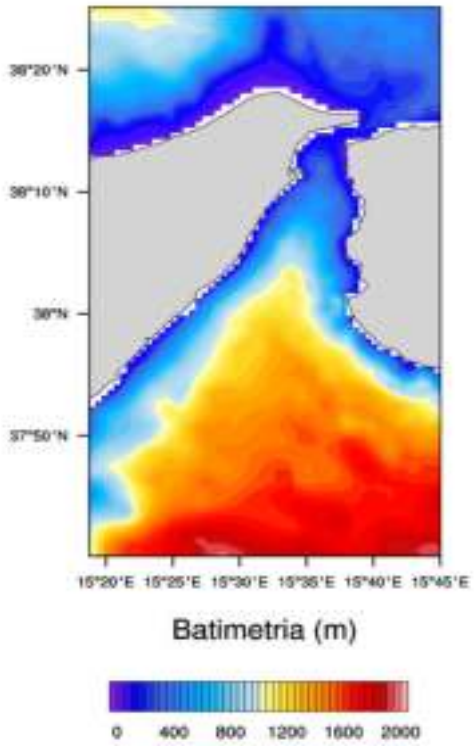


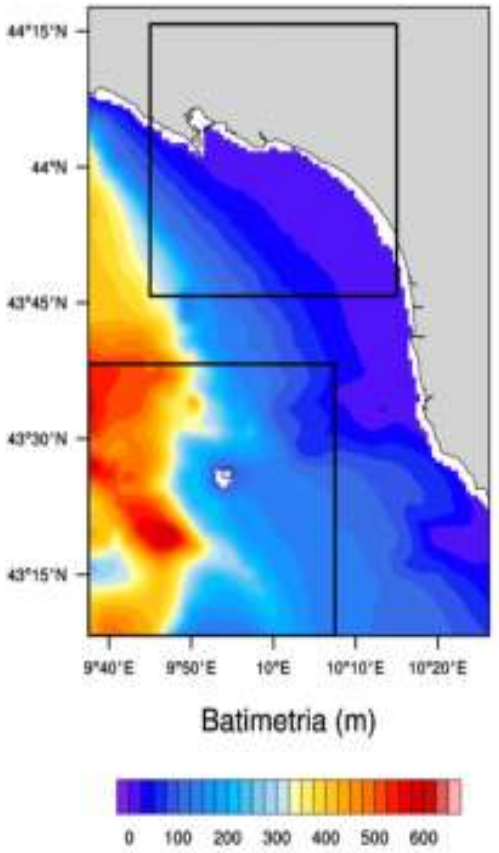
Medie stagionali di Hs per il 2019 calcolata utilizzando il primo giorno di simulazione delle previsioni dell'anno 2019.

WAVE modelling @ ENEA

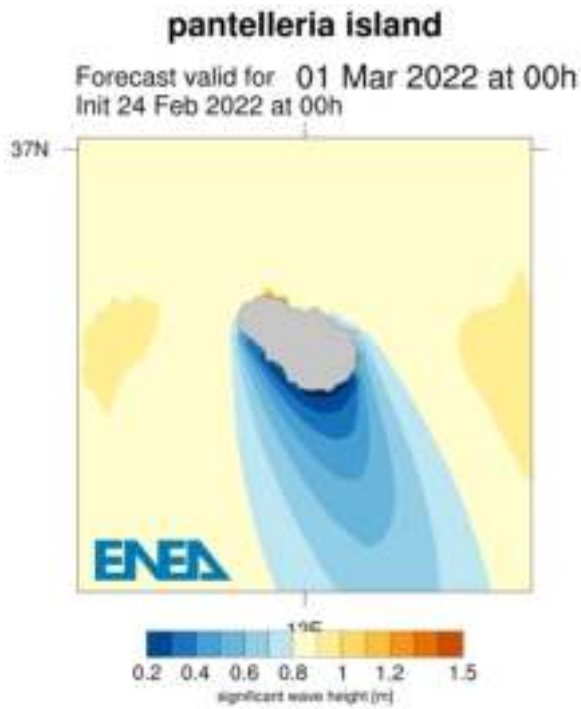
Previsioni operative dello stato del mare per il Mediterraneo e per 10 sotto-bacini italiani

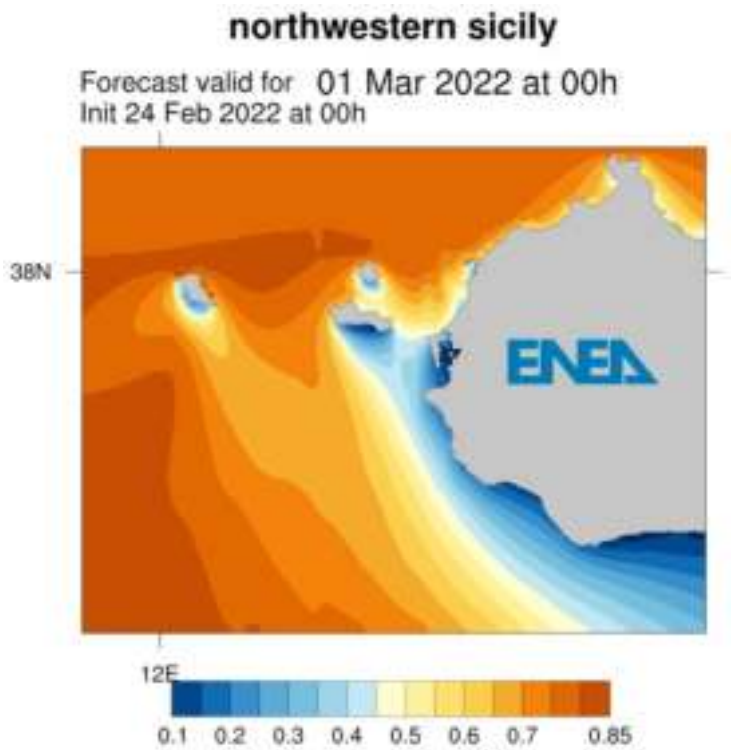


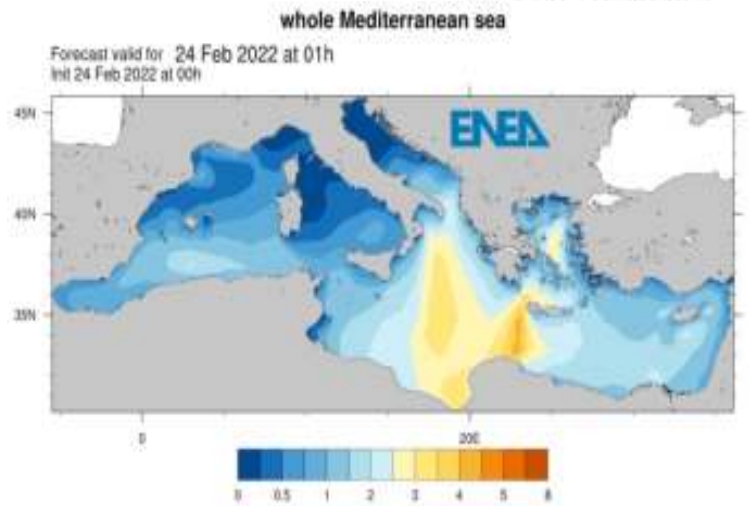


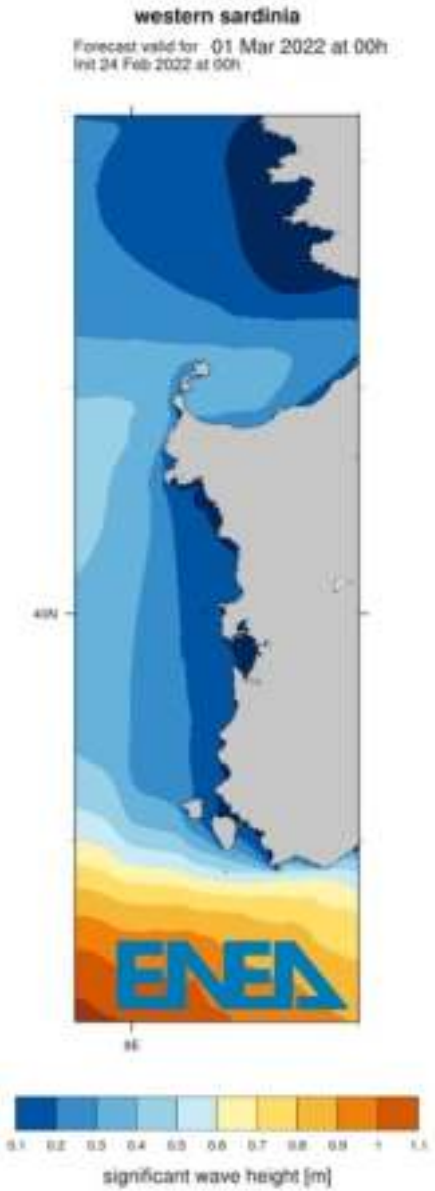


WAVE modelling @ ENEA

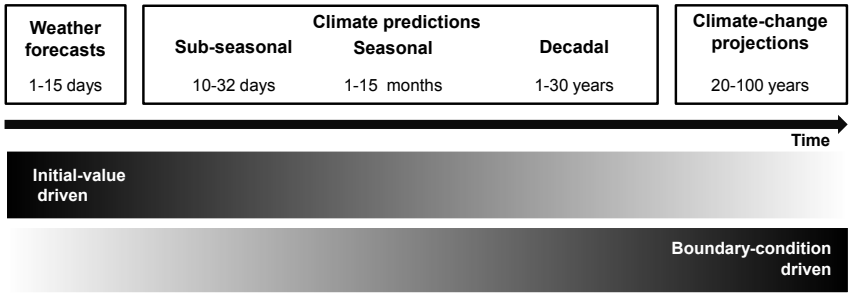








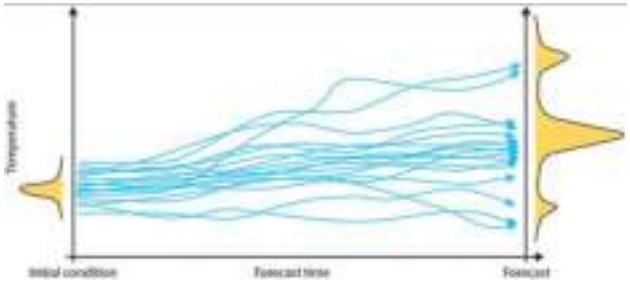
Seasonal predictions



Adapted from: Meehl et al. (2009)

How can we predict seasonal climate?
The feasibility of seasonal prediction relies on the existence of predictable signals at seasonal timescale arising from the ocean, soil moisture, snow cover or sea-ice anomalies/processes that affect the atmosphere.

Seasonal prediction are based on an ensemble of simulations.
The ensemble members are initialised at the same time with slightly different initial conditions



Climate services for the Energy Sector

PAR 2019-2021

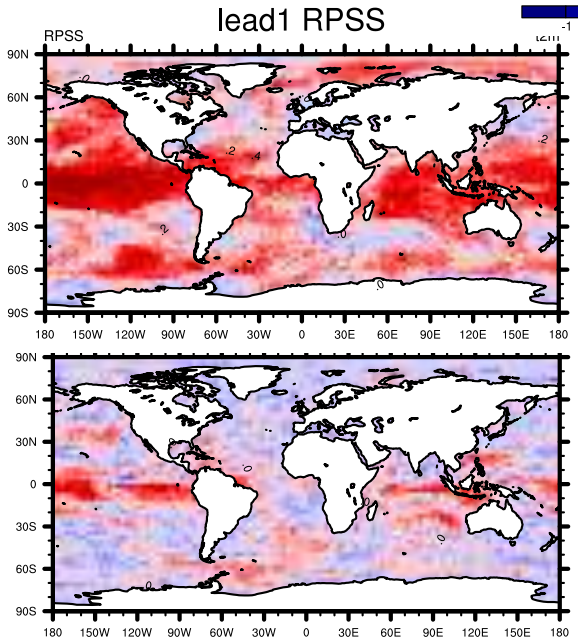
Accurate and reliable information from climate predictions at seasonal time scales can have an essential role to anticipate climate variability affecting the supply of renewable energy and stabilizing and securing the energy network as a whole.

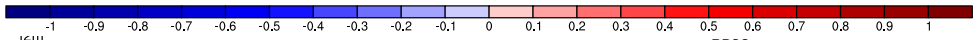
ENEA contributed as a partner to innovative climate services developed in two H2020 projects:

SECLI-FIRM (http://www.secli-firm.eu/)

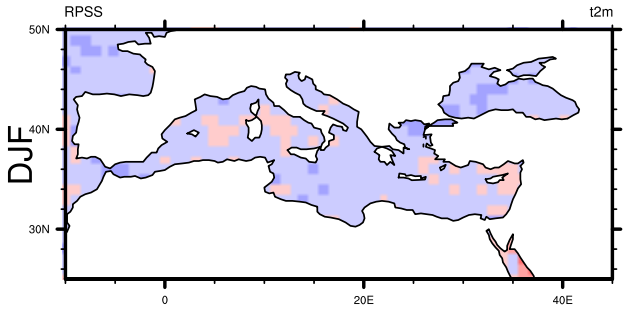
S2S4E (https://s2s4e.eu/)

Predictability at seasonal timescale in the Mediterranean Basin

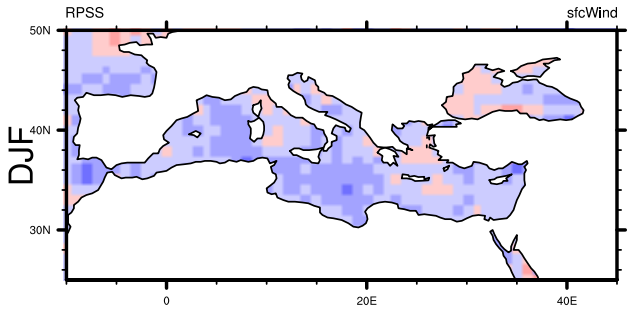




Temperatures



Surface Wind



Seasonal forecasts have significant predictability for tropical climate but only low forecast skill in the extra-tropics (Palmer et al. 2004 e Doblas–Reyes 2013).

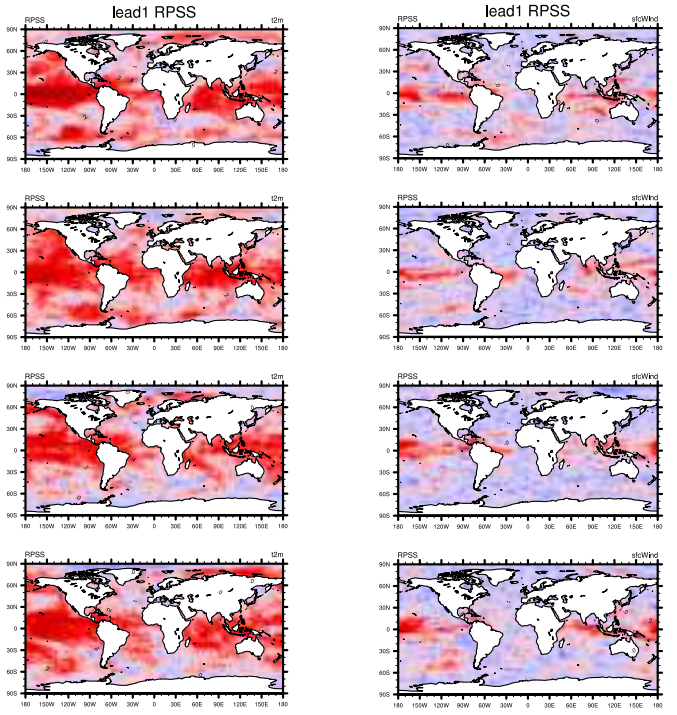
Seasonal forecasts over the Mediterranean area show poor skill…

..BUT an extensive analysis suggests the existence of «windows of opportunity» to the application of seasonal predictions with respect to the application of climatological data.

Seasonal predictions over the Mediterranean basin

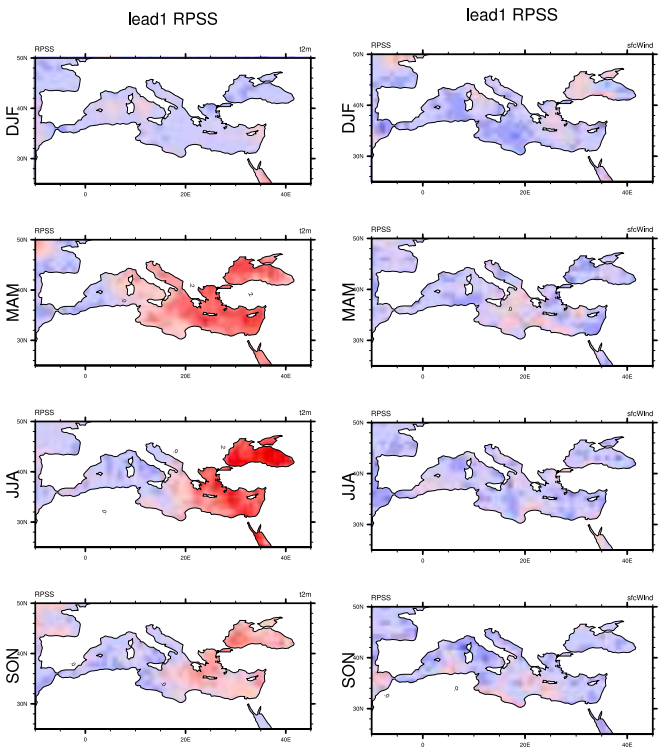
Temperatura

Surface Wind



Temperatura

Surface Wind



«windows of opportunity»

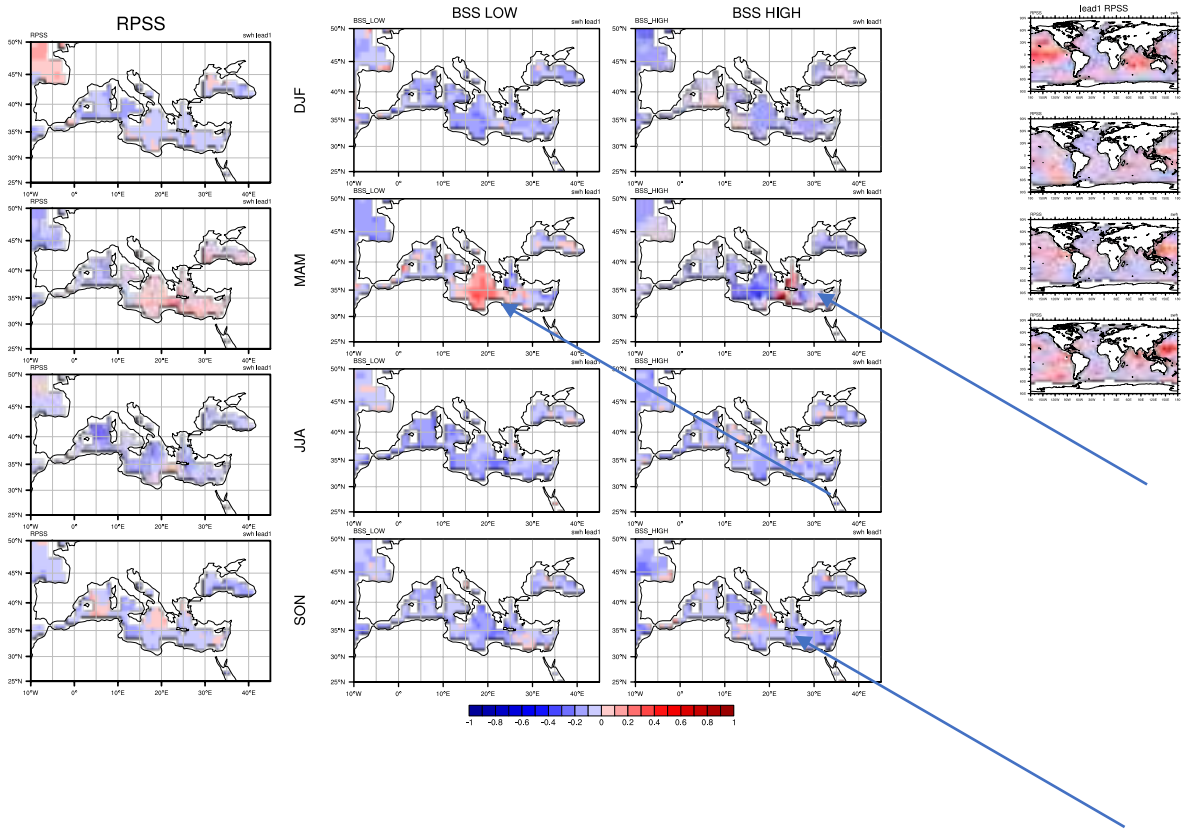
- Seasonal predictions are better in Spring and Summer.
- Skill scores are higher in the East part of the Mediterranean basin.
- Temperature has higher skill than surface wind and mean wave height.

Seasonal predictability of the mean wave height (swh)

Information at seasonal timescale of mean wave height can be valuable for

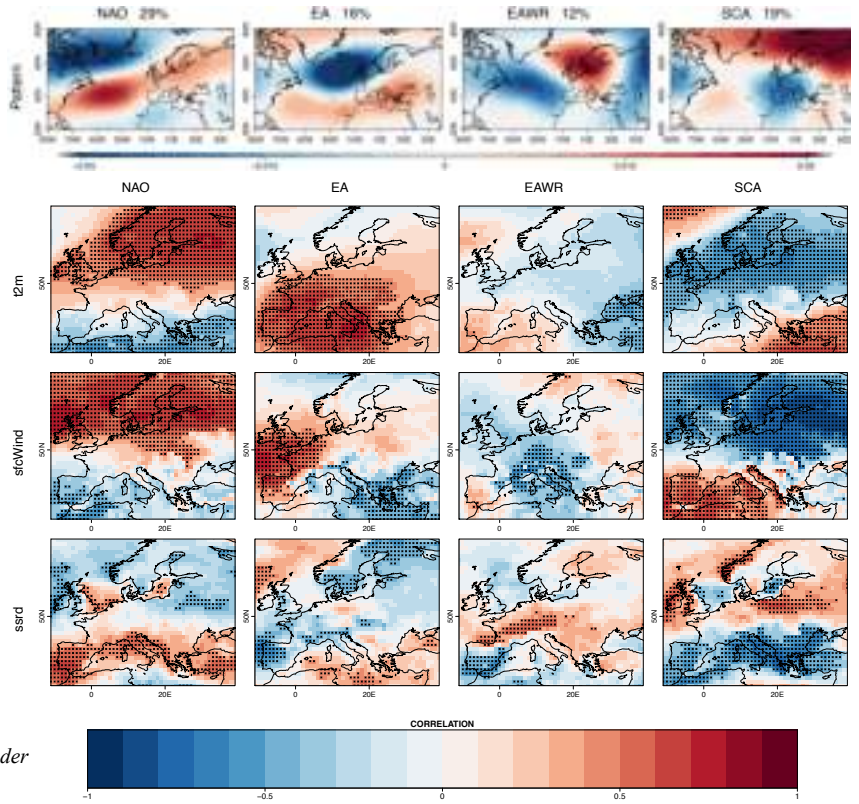
- Extimation of the energy production of the wind farm ;
- Planning of the Operation and Maintanence(O&M).

Extremes events scores as events lower than 10° (BSS LOW) and upper 90°(BSS HIGH) show encouraging results.



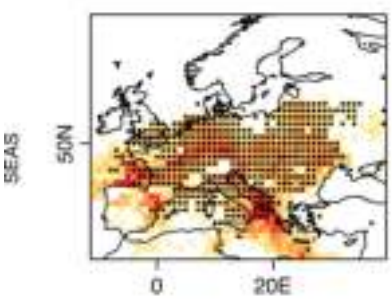
Euro Atlantic Teleconnection and surface variables

We analyzed how the large-scale atmospheric patterns affect the renewable resources over Europe and to what extent an “hybrid model” based on this analysis and seasonal prediction of the large-scale variability might be used to formulate empirical prediction of local climate conditions relevant for the energy sector.



DJF

DJF Temperatura



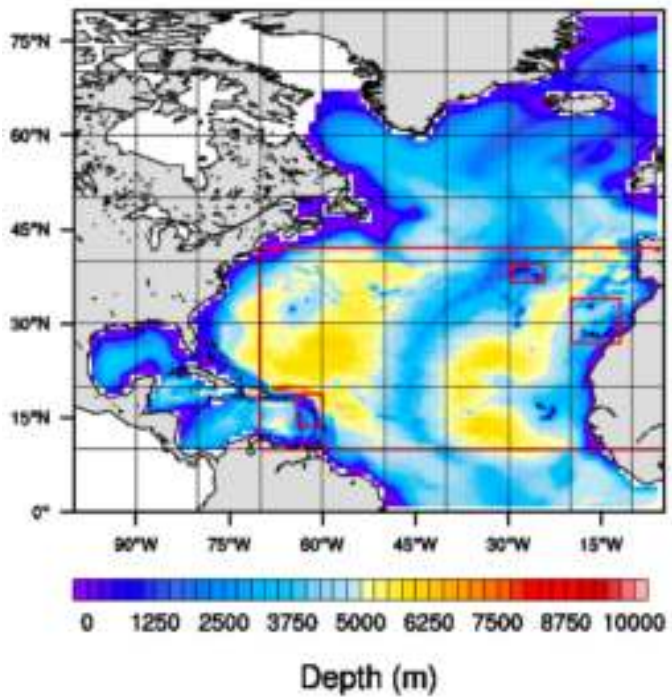
The “hybrid model” shows relevant improvement in the raw seasonal forecast and the climatology.

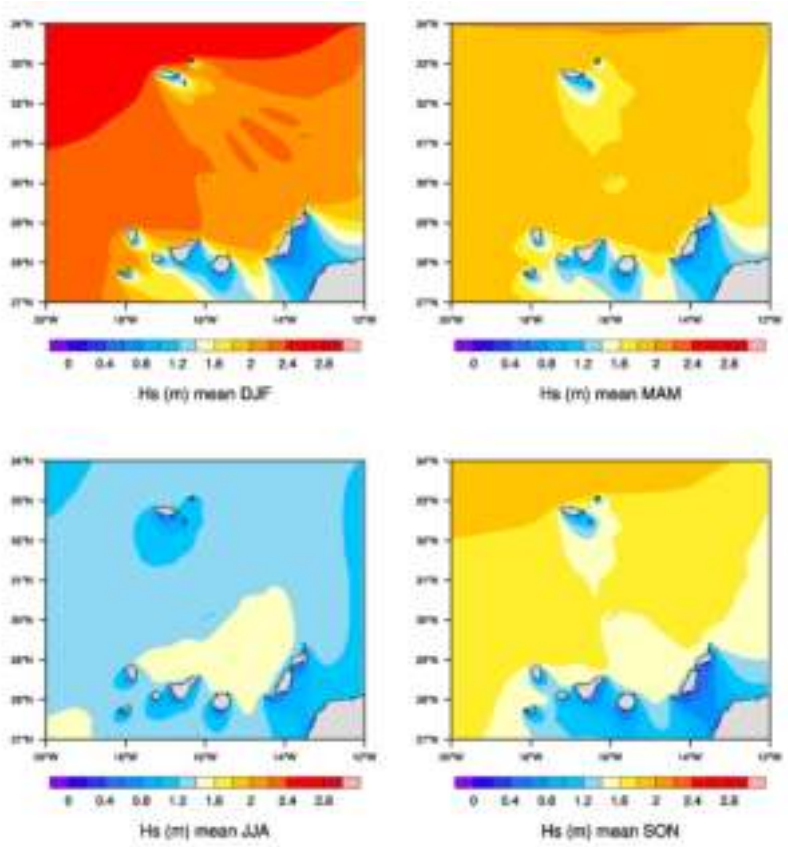
Raw forecasts have been employed as a benchmark. Black full dots indicate grid points where the hybrid predictions are better than the dynamical predictions.

Cionni I. ,Lledo L, Torralba V. and Dell’aquila A.: Seasonal predictions of energy-relevant climate variables through Euro-Atlantic Teleconnections. Submitted to Climate Services (under final review)

WAVE modelling @ ENEA

Figure: extension of the nested domains for the new wave simulations (red boxes delimitate the intermediate and high resolution grids)





New dedicated simulations have been performed by ENEA using the WaveWatchIII model (WW3), for three Atlantic domains including the Antilles, the Canaries, the Azores and Madeira.
In order to reach sufficient resolution, three levels of nesting have been implemented:

- a low-resolution experiment, with a grid covering the entire Atlantic Ocean at the spatial resolution of 1°;
- an intermediate resolution experiment, with a grid extending from 10°N to 42°N at the spatial resolution of 0.25°;
- three high resolution experiments, with smaller grids at the resolution of 0.05°.

ENEA for International Cooperation and Development

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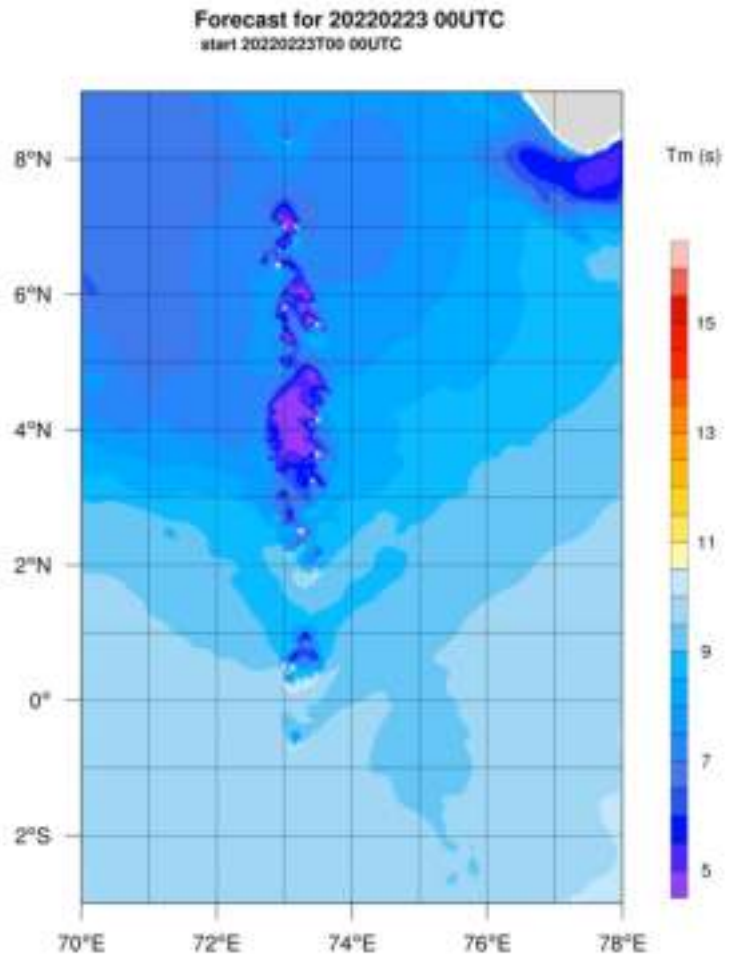
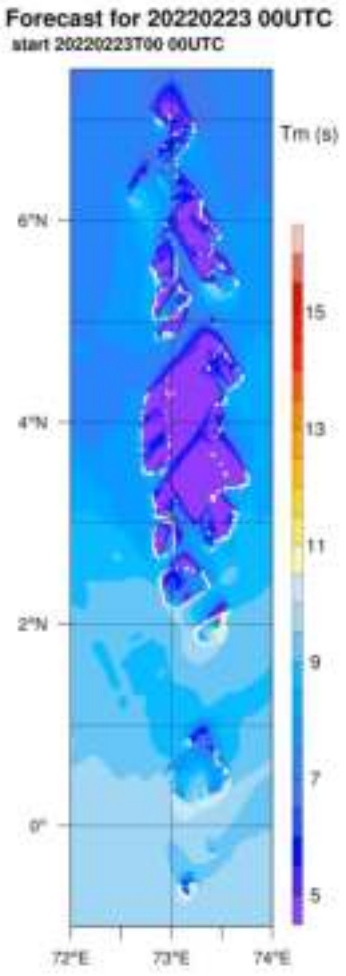


1/32° resolution

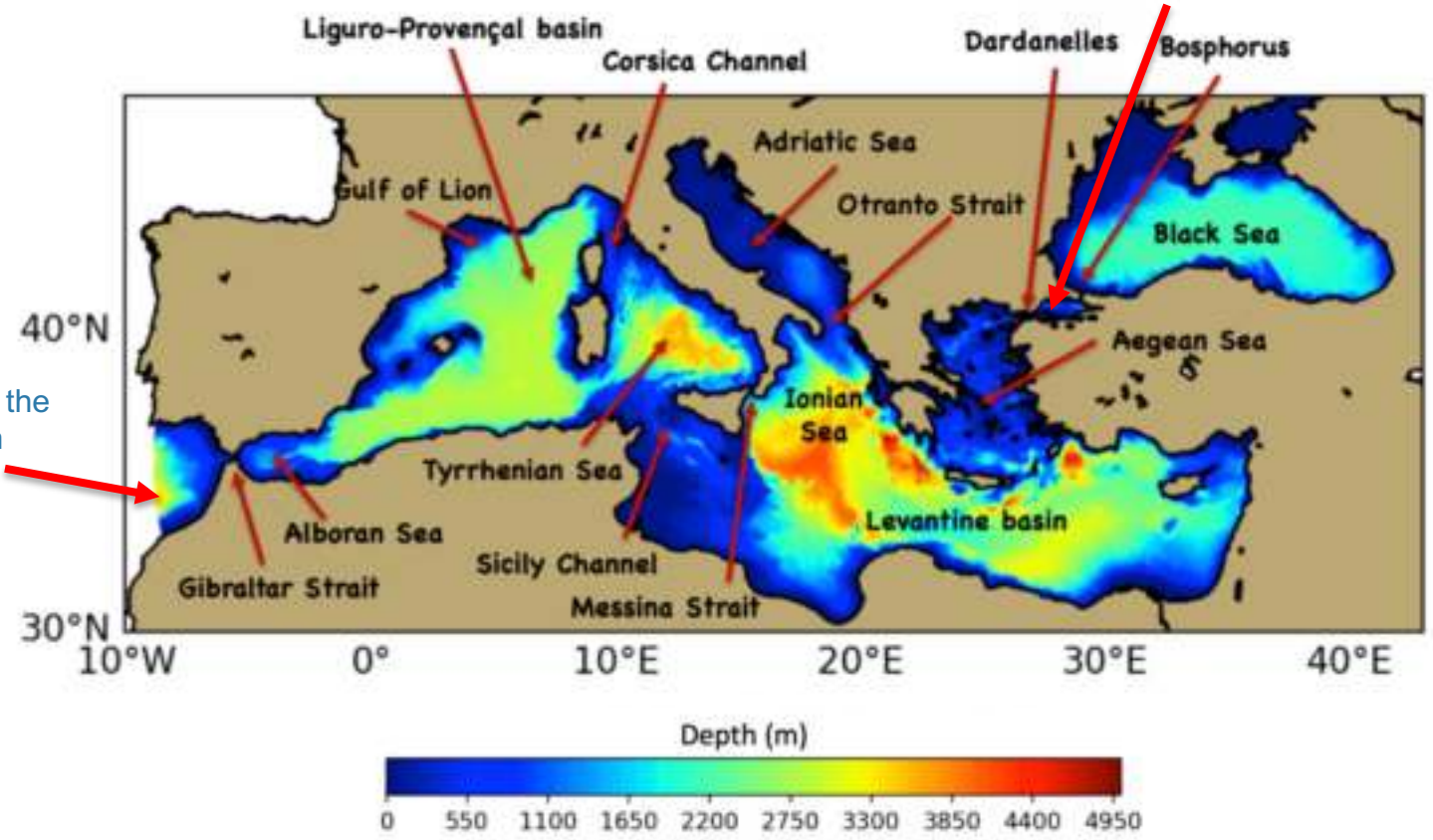


1/128° resolution

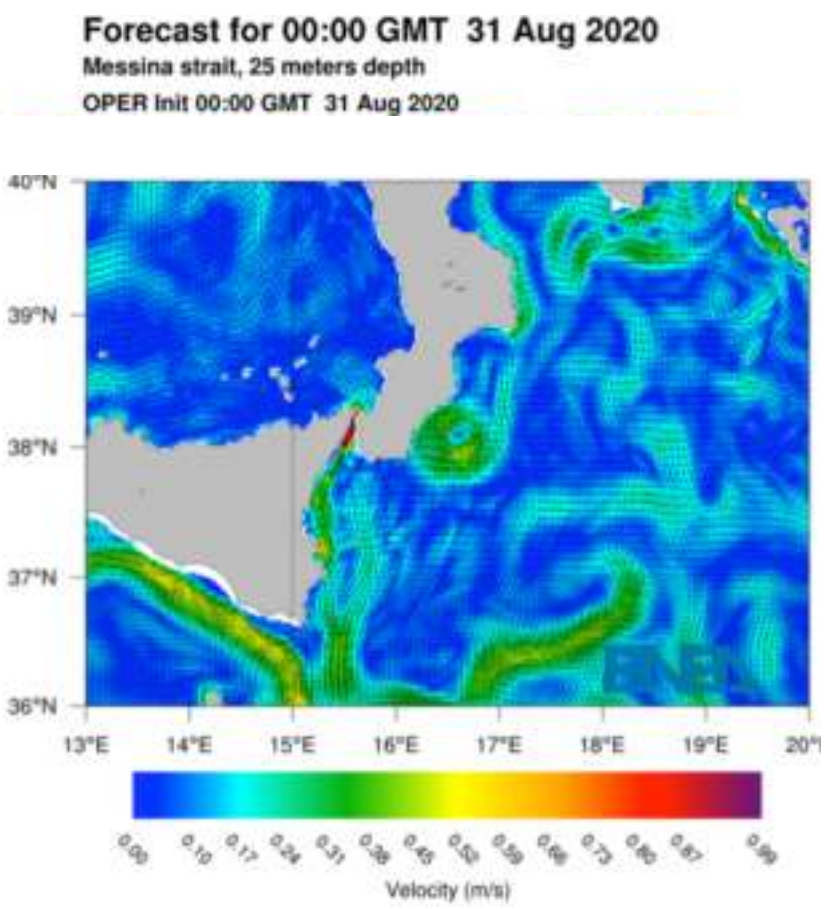
MITO circulation model: computational domain and bathymetry

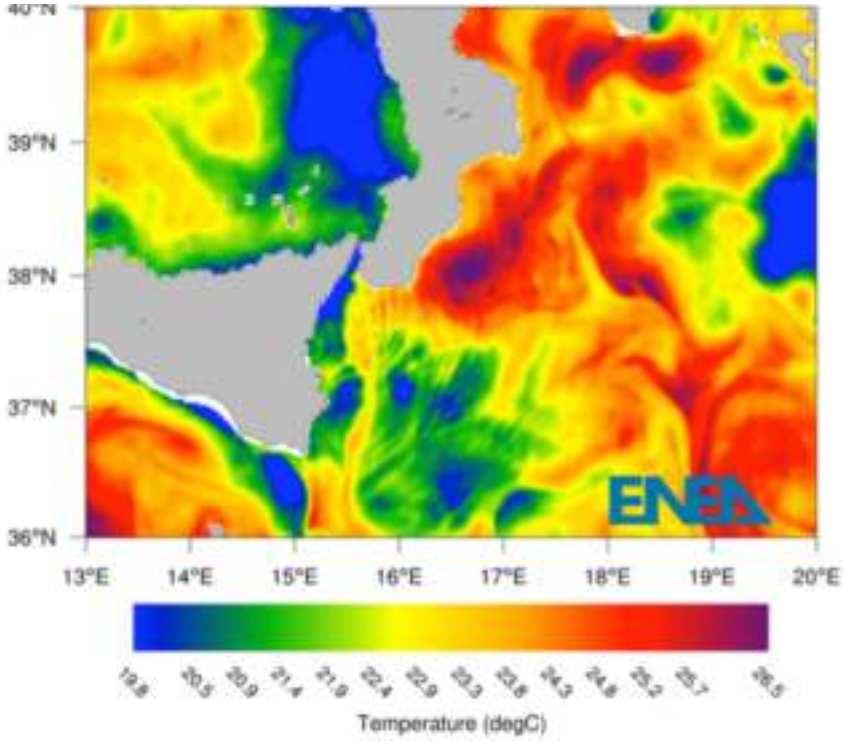
The model includes the Black Sea → Explicit treatment of the exchanges through the Turkish Straits

Gibraltar: the only open boundary



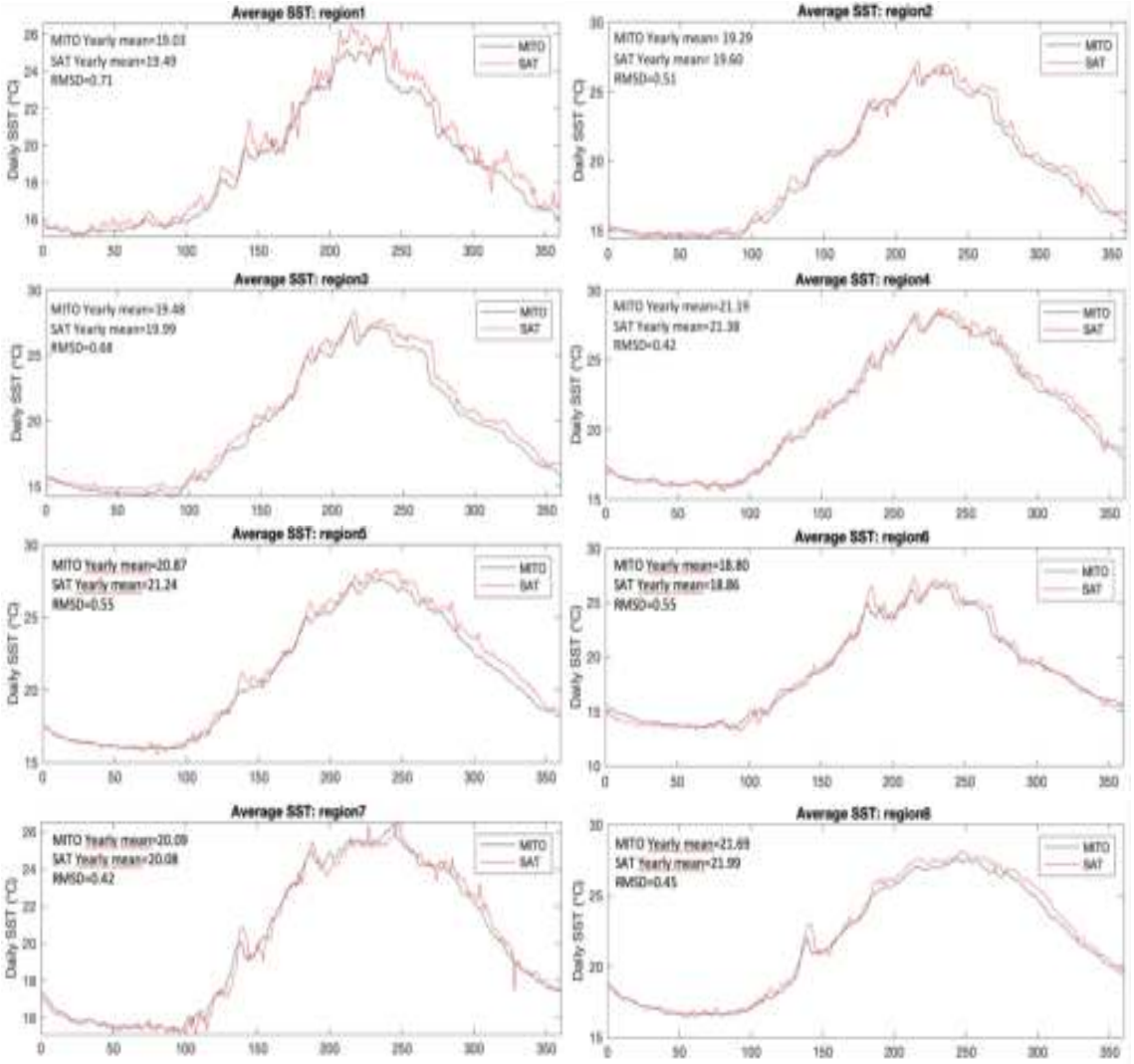
MITO: example of forecast





https://giotto.casaccia.enea.it/forecasts/

MITO: SST

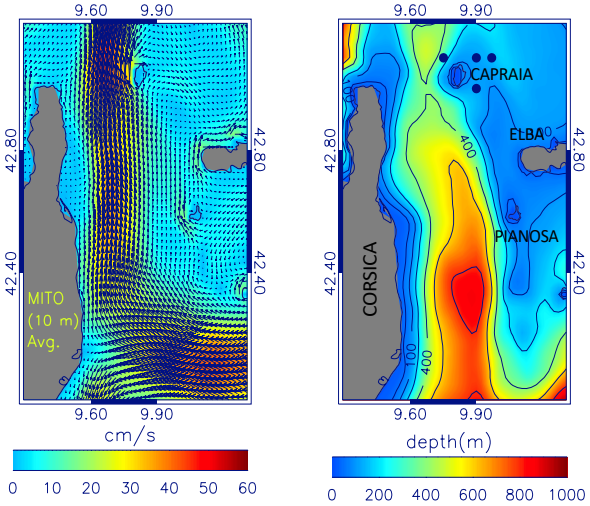


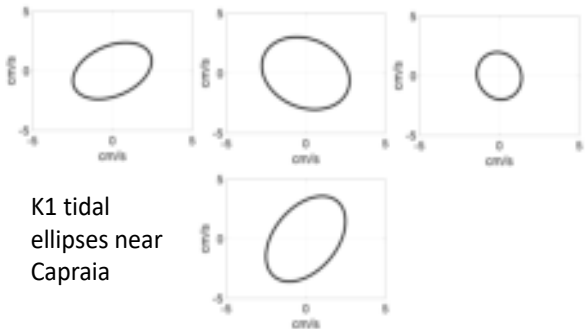
Comparison with satellite SST

SST MITO-SST SAT		
REGION	Mean	RMSD
REGION 1	-0.46	0.71
REGION 2	-0.31	0.51
REGION 3	-0.51	0.68
REGION 4	-0.19	0.42
REGION 5	-0.37	0.55
REGION 6	-0.06	0.55
REGION 7	0.01	0.42
REGION 8	-0.3	0.45

MITO: effects of the tides (3)

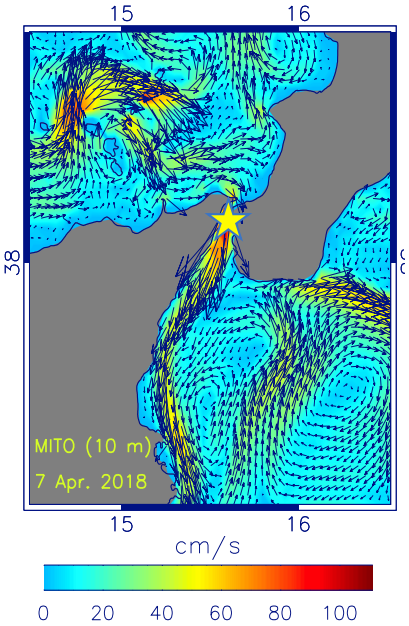
Significant (and unexpected) tide effects in the Straits of Corsica and Otranto

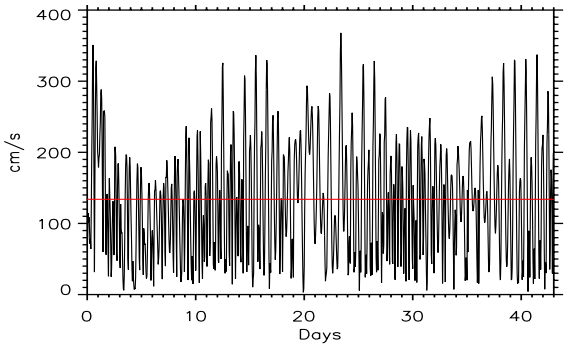


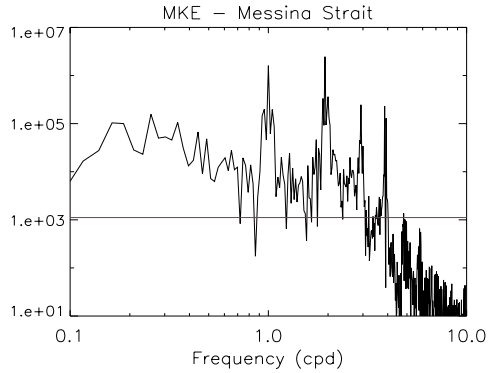


K1 tidal ellipses near Capraia

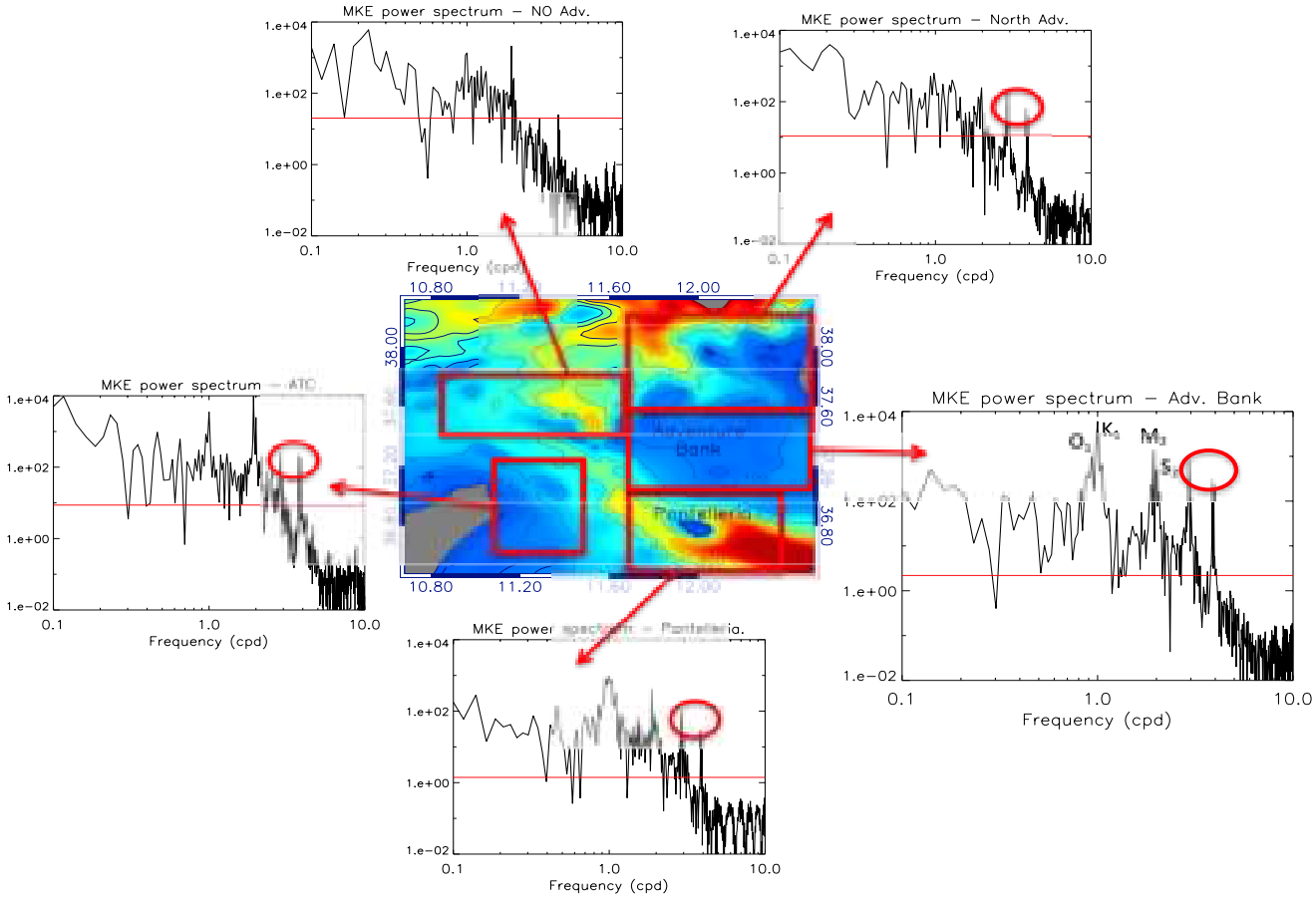
The model captures the main aspects of the dynamics in the Messina Strait







MITO: effects of the tides (1)



Sicily Channel: spectra of kinetic energy (average over the first 100 m) for the five regions in the central panel. The peaks corresponding to the four main tidal components are highlighted in the spectrum corresponding to the Adventure Bank area. Red ovals highlight the components with period of 8 and 6 hous, which are produced by nonlinear interactions.

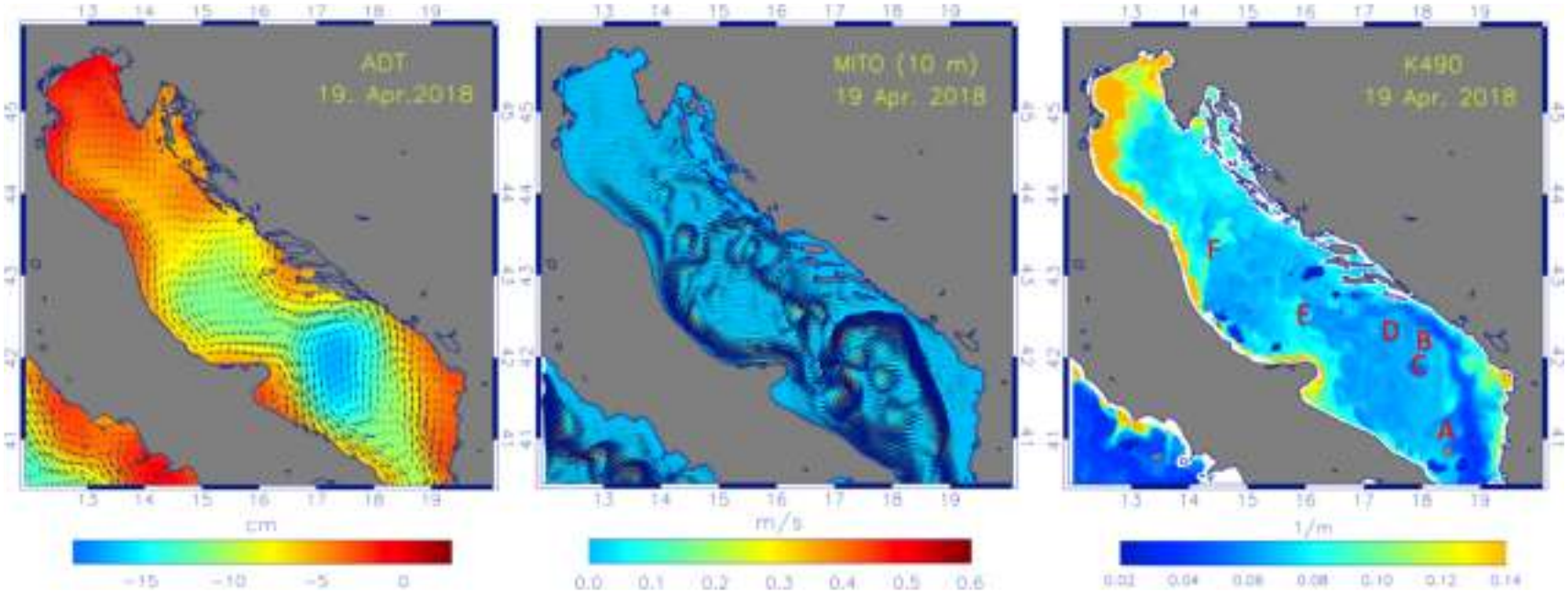
MITO: model validation

The first validation of the model, together with an assessment of the main effects of the tides on the circulation, has been performed through the analysis of a dedicated 40 days simulation (19 March – 30 April 2018) initialized and forced as in the operational implementation.

The results of the analysis are described in:

M. Palma, R. Iacono, G. Sannino, A. Bargagli, A. Carillo, BM. Fekete, E. Lombardi, E. Napolitano, G. Pisacane, MV. Struglia, “Short-term, linear and non-linear local effects of the tides on the surface dynamics in a new, high-resolution model of the Mediterranean Sea circulation.” *Ocean Dyn.,* (2020), https ://doi.org/10.1007/s10236-020-01364-6.

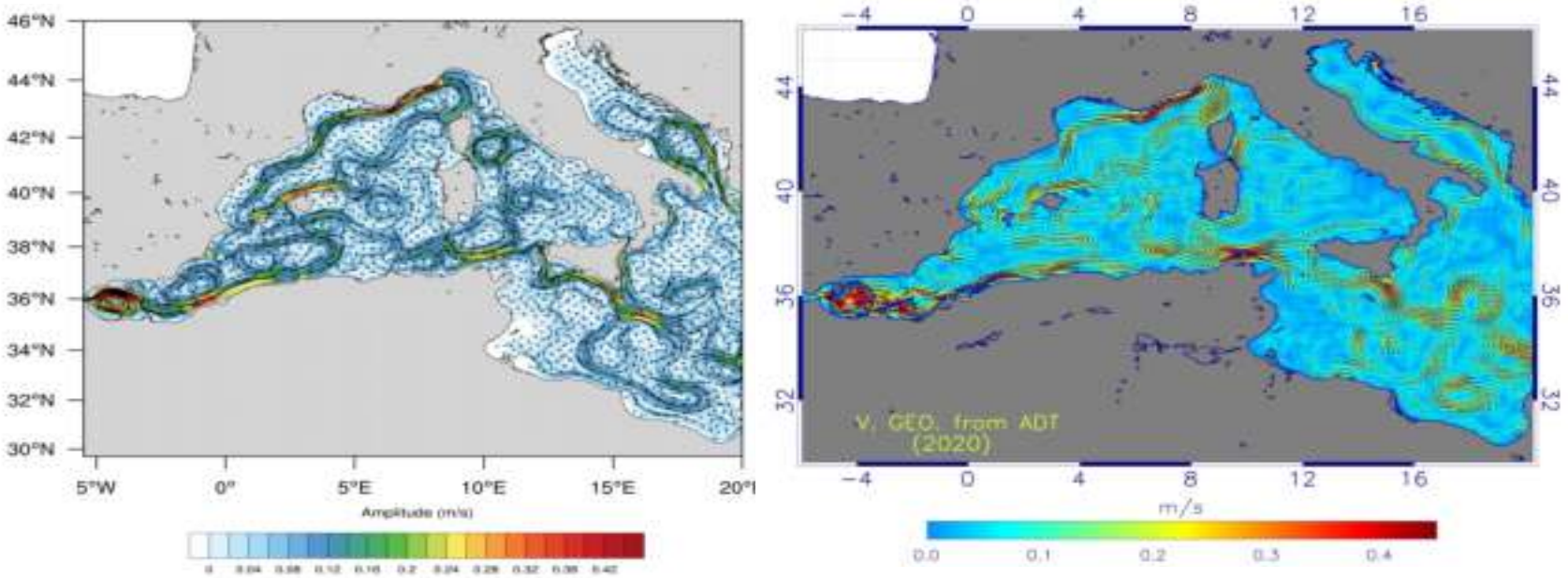
MITO: validation of the circulation (example)



Adriatic Sea: the daily average MITO circulation for April 19 (10 m of depth; central panel) is compared with a satellite high-resolution (1 km) map of K490 (turbidity; right panel), and a map of Absolute Dynamic Topography (ADT; left panel), with a geostrophic reconstruction of the circulation superimposed (dedicated simulation: 19 March -30 April 2018).

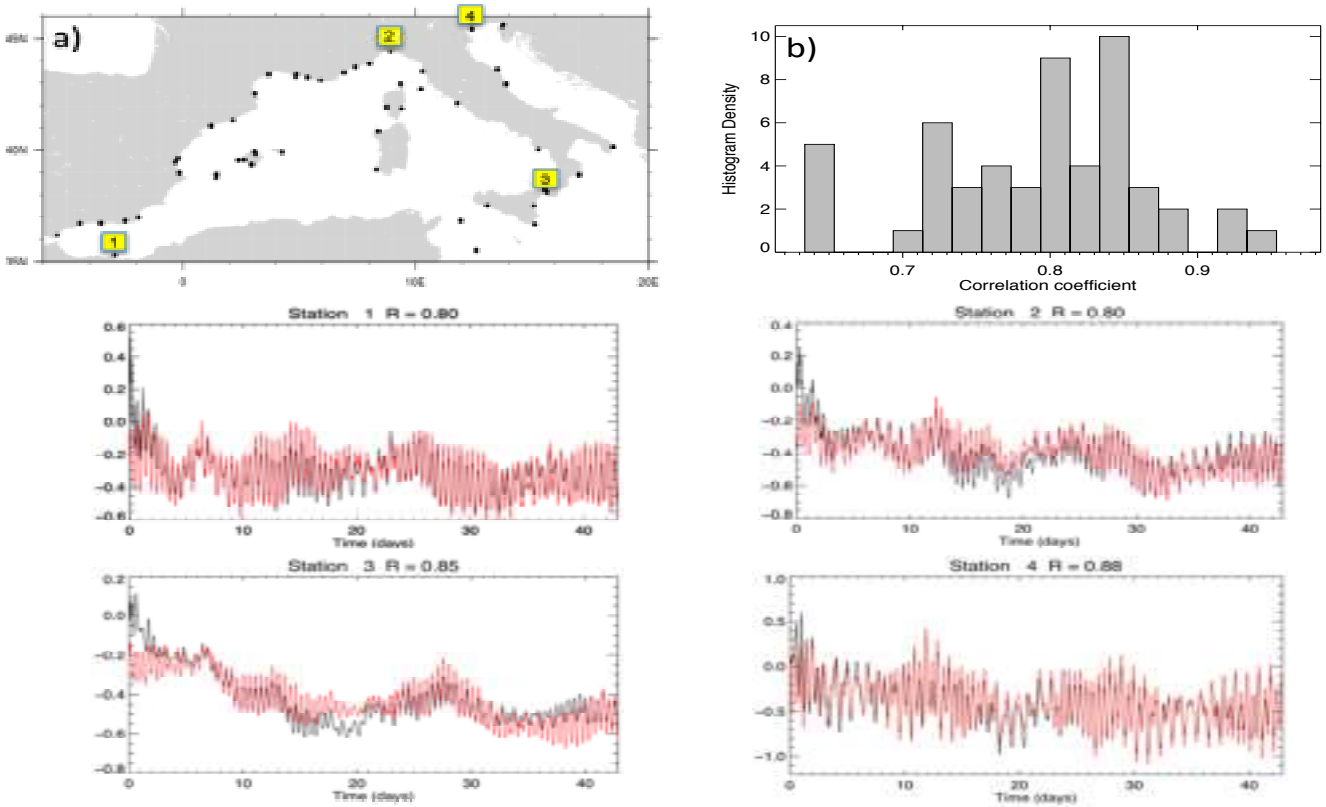
After one month from the beginning of the simulation, the circulation remains very close to the observations.

MITO: surface circulation



MITO 2020 surface circulation vs. a geostrophic reconstruction from satellite data. The comparison is very good for all regions analysed (western Mediterranean in the figure). All the main circulation features, such as the Algerian current, the Liguro-Provencal cyclonic cell, the Bonifacio dipole, the branching of the current in the Sicily Channel are correctly reproduced, as well as many known mesoscale strauctures.

MITO: validation of tide (example)



Validation of tidal dynamics (19 March - 30 April 2018 simulation): comparison with tide-gauge data from the the stations indicated by black dots in the top left panel. Lower panels show hourly time series of the elevation from the model (black) and the observations (red) in stations 1-4, with the corresponding correlation coefficients (R) in the titles. The top right panel is a histogram or R for all stations.

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