

Fare i conti
con l'ambiente
Rifiuti acqua energia

> Rave
nna
21.22.23
maggio 2014

7^a EDIZIONE
maggio
2014



Aree costiere e fluttuazioni climatiche: potenziali problematiche negli anni a venire

OceanLab, CMCC, Centro EuroMediterraneo sui Cambiamenti Climatici, Lecce
Istituto Nazionale di Geofisica e Vulcanologia, Bologna



G. Coppini, N. Pinardi, A. Guarnieri, I. Federico, P. Oddo, P. Agostini, E. Awad, A. Bonaduce, S.A. Ciliberti, S. Cretí, M.B. Galati, Y. Kumkar, R. Lecci, S. Liubartseva, L. Lusito, G. Mannarini, S. Martinelli, E. Shchekinova, G. Turrisi, G. Verri.

Outline

- Introduction to OceanLab (CMCC) activities: modelling and applications
- Climate change indicators (basin scale, Mediterranean sea)
- Climate change scenarios (local scale, coastal areas)
- Coastal ocean high-resolution forecasting system

Introduction to OceanLab (CMCC) activities

CMCC Mission

To investigate and model Earth climate system and its interactions with society to provide reliable, rigorous, and timely scientific results to stimulate sustainable growth, protect the environment and to develop science-driven adaptation and mitigation policies in a changing climate.

The Euro-Mediterranean Center on Climate Change is a **non-profit research Institution** established in 2005, with the financial support of the Italian Ministry of Education, University and Research.

CMCC manages and promotes scientific and applied activities in the field of **international climate change research**.

The CMCC **network structure** has offices in Lecce, Bologna, Capua, Milan, Sassari, Venice, Viterbo, and Benevento.

6 consortium members, which constitute the following General Meeting of Shareholders:

Istituto Nazionale di Geofisica e Vulcanologia (INGV), Università del Salento, Università degli Studi del Sannio
Centro Italiano di Ricerche Aerospaziali (CIRA S.c.p.a.) Università Ca' Foscari Venezia, Fondazione Eni Enrico Mattei (FEEM)

Introduction to OceanLab (CMCC) activities

The research network is distributed among 6 research divisions that share different knowledge and skills in the field of climate science. The administrative premises are in Lecce.

1. **Simulating the climate system** - Numerical Applications and Scenarios **ANS Division**
2. **Translating climate change in economic values** - Climate Impacts and Policies An Economic Assessment **CIP Division**
3. **Focusing on agriculture and ecosystems** - Impacts on Agriculture, Forest, and Natural Ecosystems **IAFENT Division**
4. **Climate risks for soil and coasts** - Impacts on Soil and Coast **ISC Division**
5. **Supercomputing for climate change research** - Scientific Computing and Operations **SCO Division**
6. **Delivering climate science outputs to stakeholders** - Climate Services **SERC Division**

CMCC has submitted so far more than **180 research proposals** under the EU Framework Program or other public funding agencies. At present, its research projects portfolio is composed by

79 national, European and International funded projects

such as: 2 funded projects in FP6 (6th Research Framework Program of the European Union), 24 funded projects in FP7 and 53 funded projects under other EU and international research grants. **CMCC has coordinated about half of these research projects.**

Introduction to OceanLab (CMCC) activities

OceanLab

- Born in April 2012
- Part of the "Numerical Applications and Scenarios" Division of CMCC

Mission

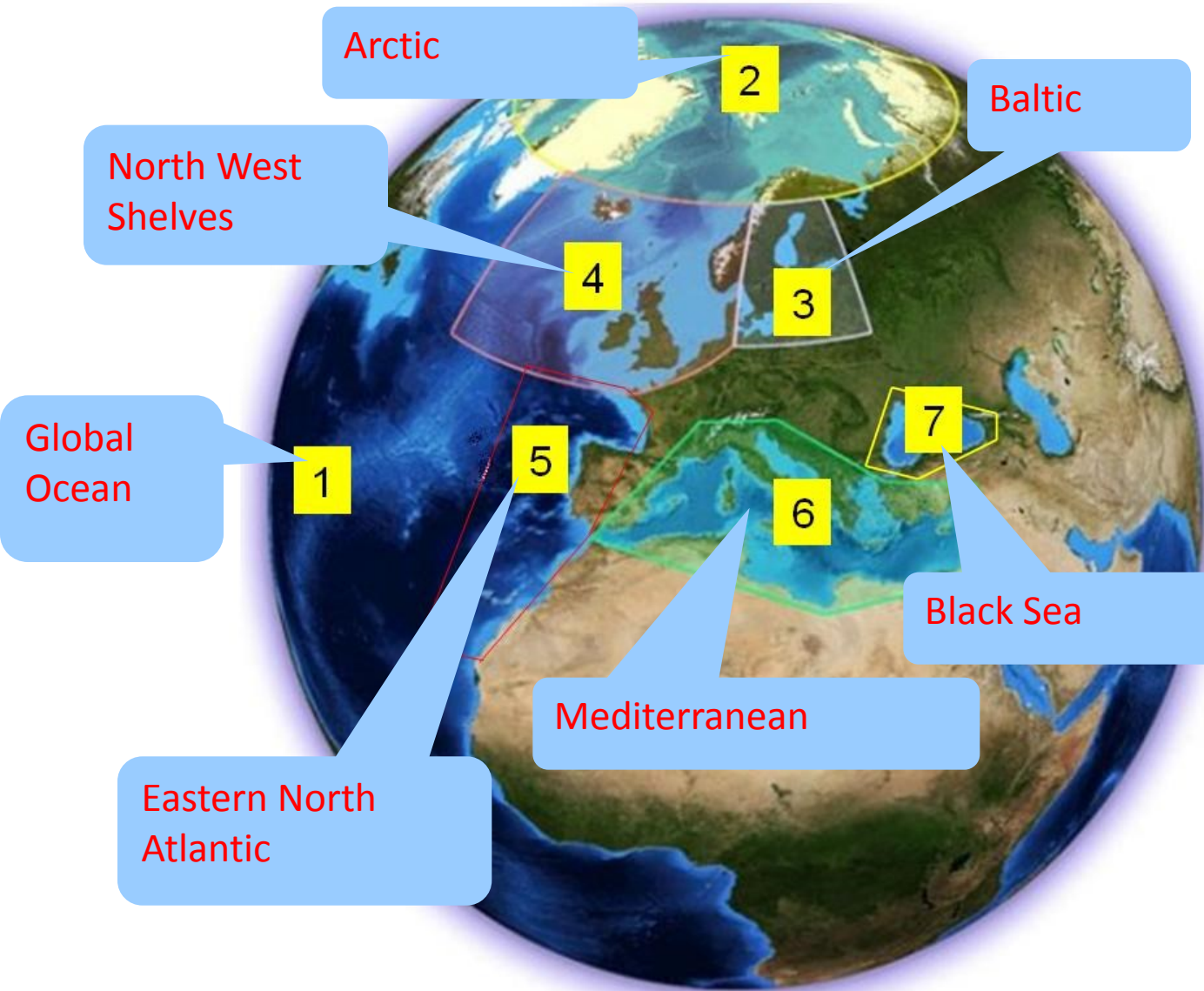
- Development and production of short term ocean forecasts;
- Coastal modeling and forecasting;
- Development of applications and services in the field of maritime safety (i.e. sea situational awareness, search and rescue, ship routing, oil spill modeling);
- Estimate climate impacts assessment in the coastal areas.

OceanLab modelling and applications

- Applied and operational research to develop and operationally maintain short term forecasting system for Italian seas (Adriatic and Ionian seas)
- Applications in maritime safety field (i.e. sea situational awareness, search and rescue, ship routing, oil spill modelling, early warning, etc.), coastal modelling (i.e. sediment transports) and evaluation of climate change impacts in coastal areas.

MyOcean

www.myocean.eu.org



*A Pan-European
network of
existing
infrastructures,
value-added by
the GMES
initiative,
coordinated and
with common
quality
standards*

Modelling and applications

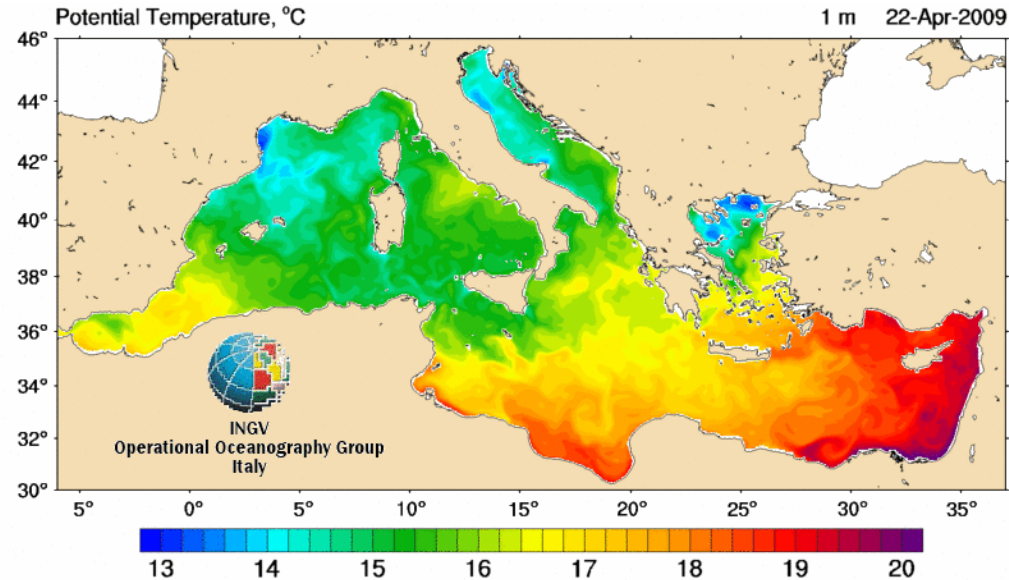
Mediterranean Forecasting System

(MyOcean: large scale numerical forecasts and analyses)

A) Hydrodynamics(INGV)

MyOcean-MED-MFC

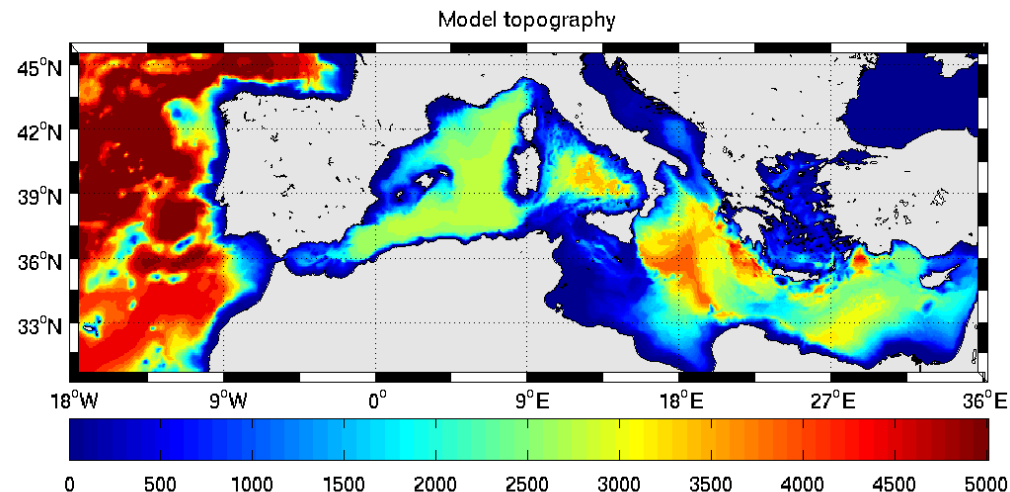
- Horizontal res: $1/16^\circ \times 1/16^\circ \sim 6.5\text{Km}$
- Vert res: 72 unevenly spaced levels
- Lateral open boundary condition in the Atlantic: nesting in Mercator global model
- Coupled wave-current model for wind drag coefficient
- Surface atmospheric pressure: pre-operational implementation



B) Waves (INGV)

CODE: WW3

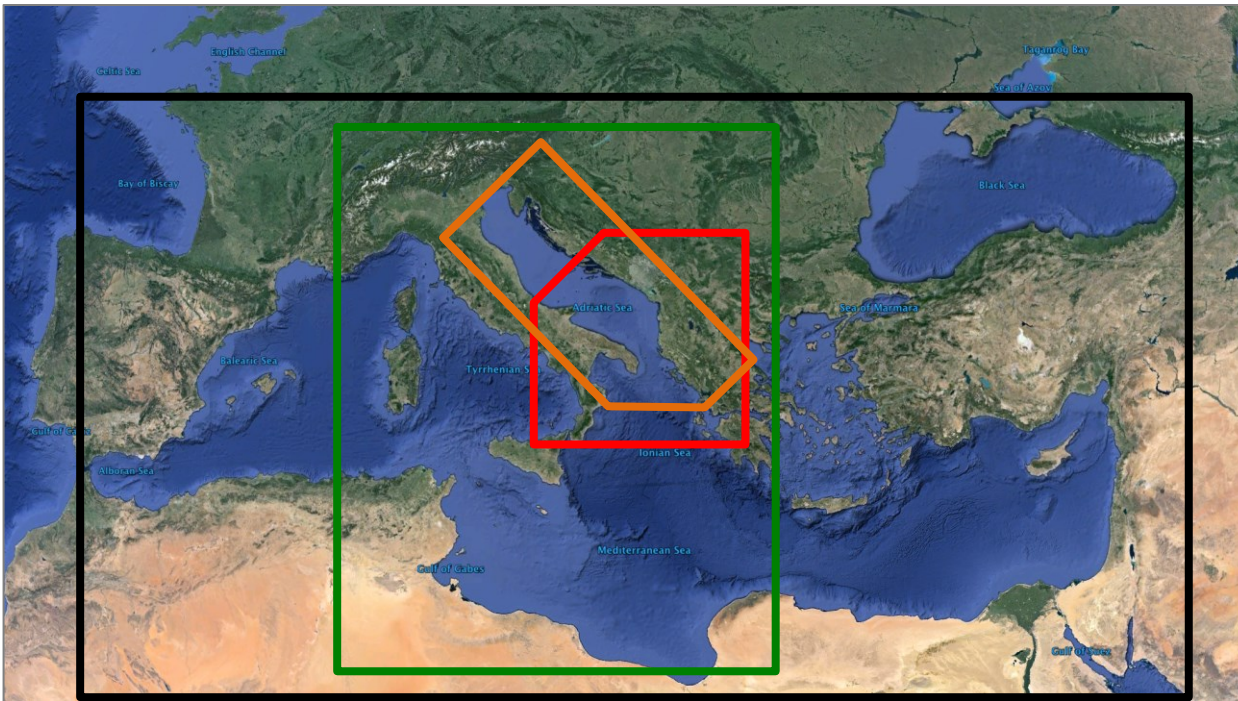
- Horizontal res: $1/16^\circ \times 1/16^\circ \sim 6.5\text{Km}$
- Same bathymetry than hydrodynamics
- 24 directional bins, 30 frequency bins (0.05Hz->0.79316Hz) bins.
- Coupled with MFS currents (hourly for drag, daily for currents)



OceanLab modelling

OceanLab modelling chain

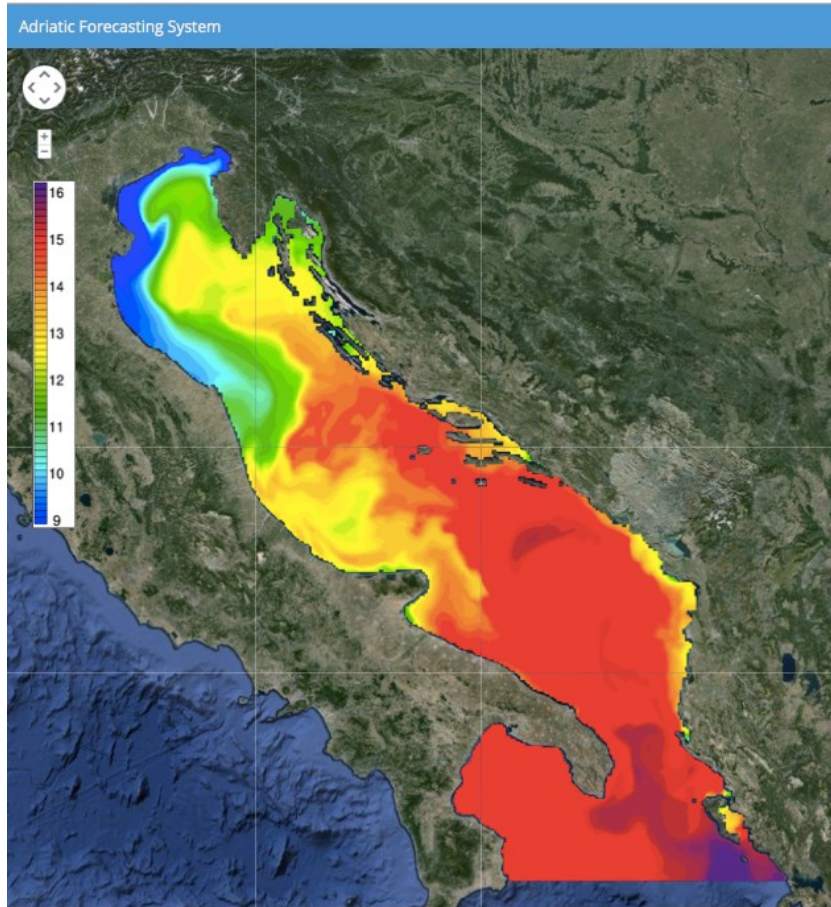
- Mediterranean Forecasting System
- Adriatic Ionian Forecasting System
- Adriatic Forecasting System
- Southern Adriatic Northern Ionian Forecasting System



- Nesting cascade approach – Downscaling approach
- Models ensemble

OceanLab modelling

Adriatic Forecasting System (AFS)



oceanlab.cmcc.it/afs

- Developed by the Italian Group of Operational Oceanography (GNOO, INGV) and maintained operational since April 2003 (Oddo et al. 2005, 2006, Guarnieri et al. 2008).

Nested into MFS – MyOcean (Pinardi et al, 2003, Tonani et al, 2008)

Model code

- Based on Princeton Ocean Model (POM), implemented in the Adriatic sea (called AREG, Adriatic REGIONal model).

Spatial resolution:

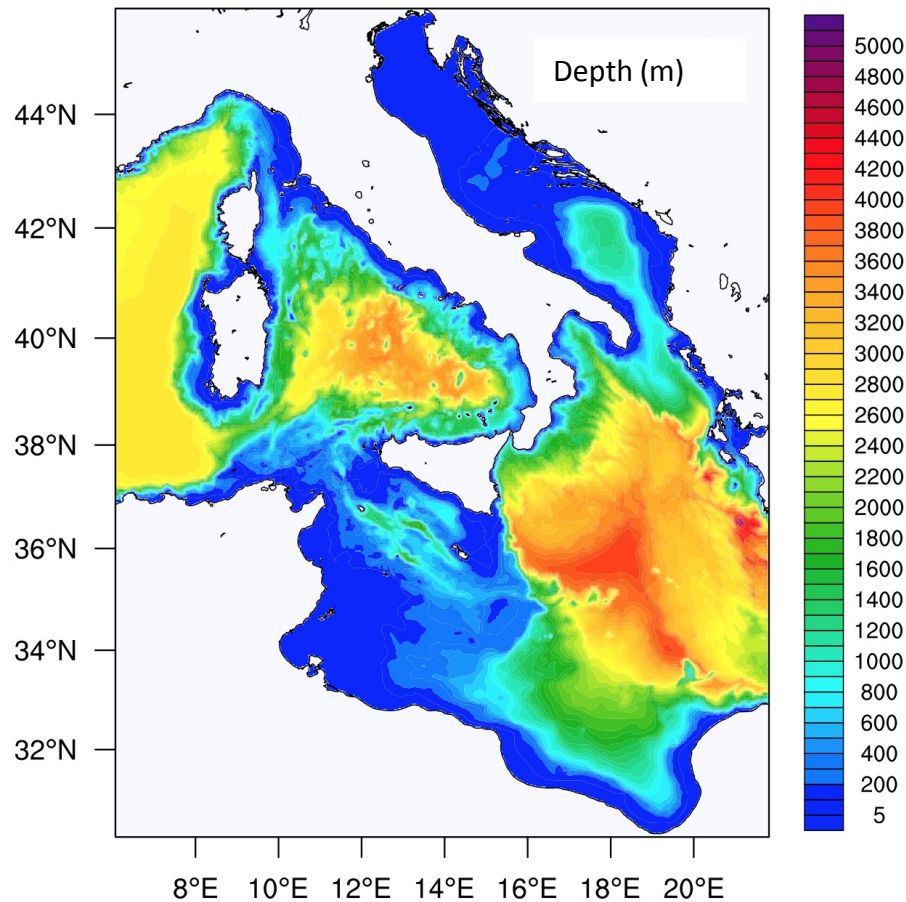
- $1/45^\circ$ (2.2 km) horizontal grid resolution
- 31 σ -levels along vertical direction
- Bottom topography: U.S. Navy $1/60^\circ$ bathymetric database

Simulation and Forecast of main physical fields of the sea:

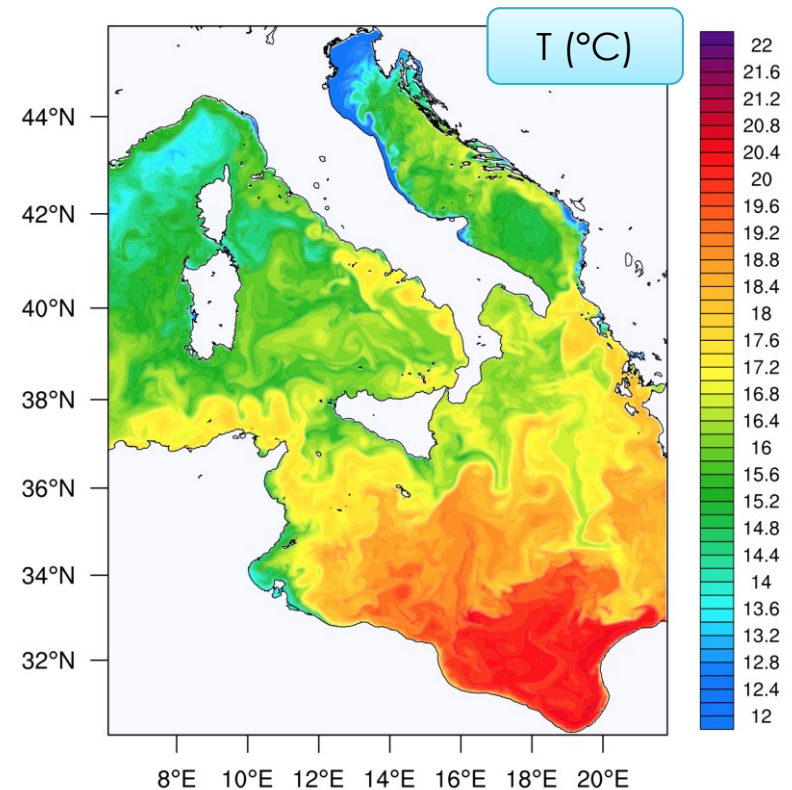
- Temperature, salinity, currents, air-sea fluxes, sea surface elevation, wind stress

OceanLab modelling

Adriatic Ionian Forecasting System (AIFS)

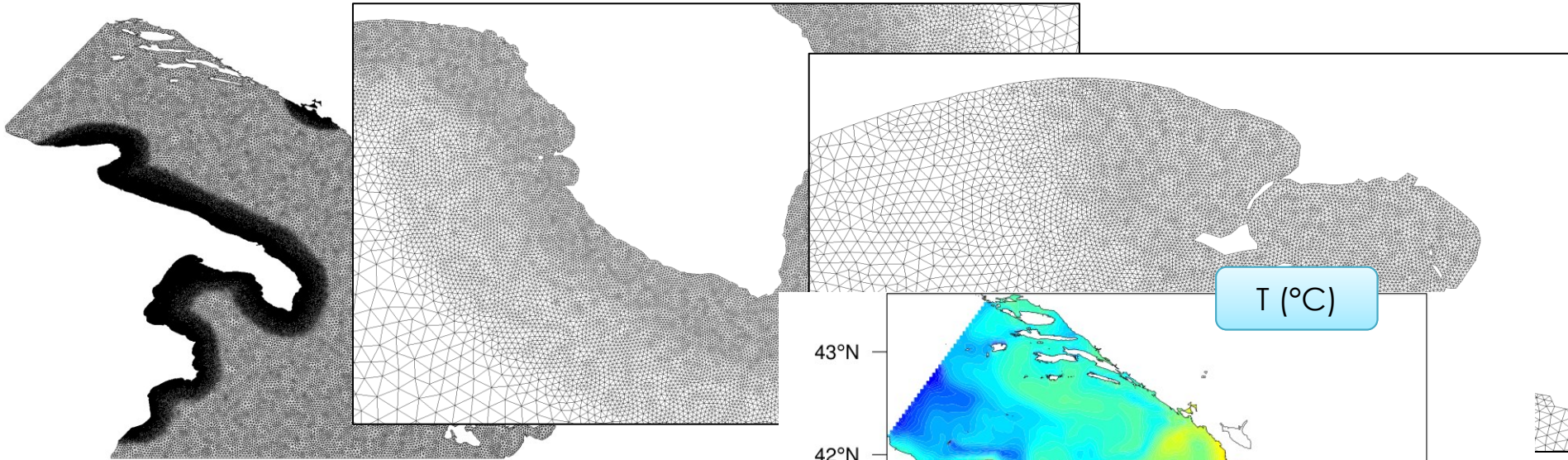


- **Numerical Model:** NEMO v3.4
- **Spatial Domain:** 6° 4'20"E to 21° 48'00"E and from 30° 11'60"N to 45° 47'60"N
- **Spatial Discretization:** 709x703 grid points along zonal and meridional direction, 121 z-levels with partial steps
- **Horizontal Resolution:** 1/45° ($\approx 2\text{km}$)

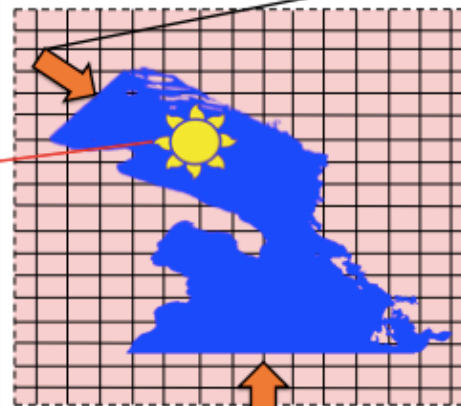
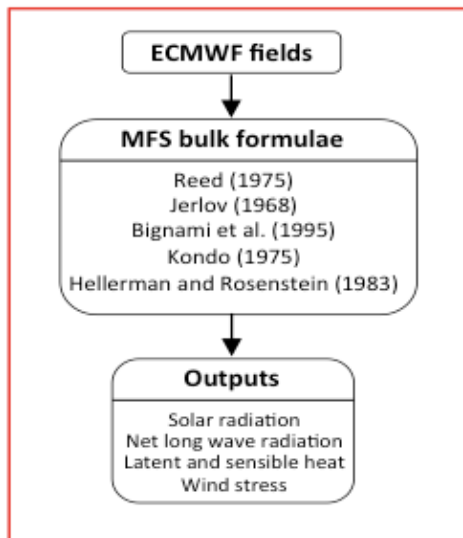


OceanLab modelling

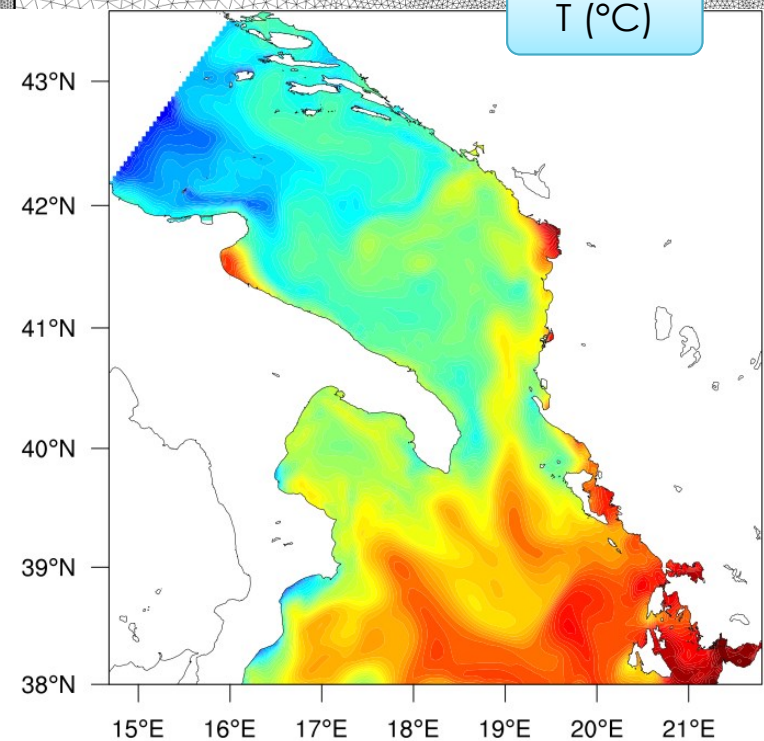
Southern Adriatic Northern Ionian Forecasting System (SANIFS)



Surface boundary conditions



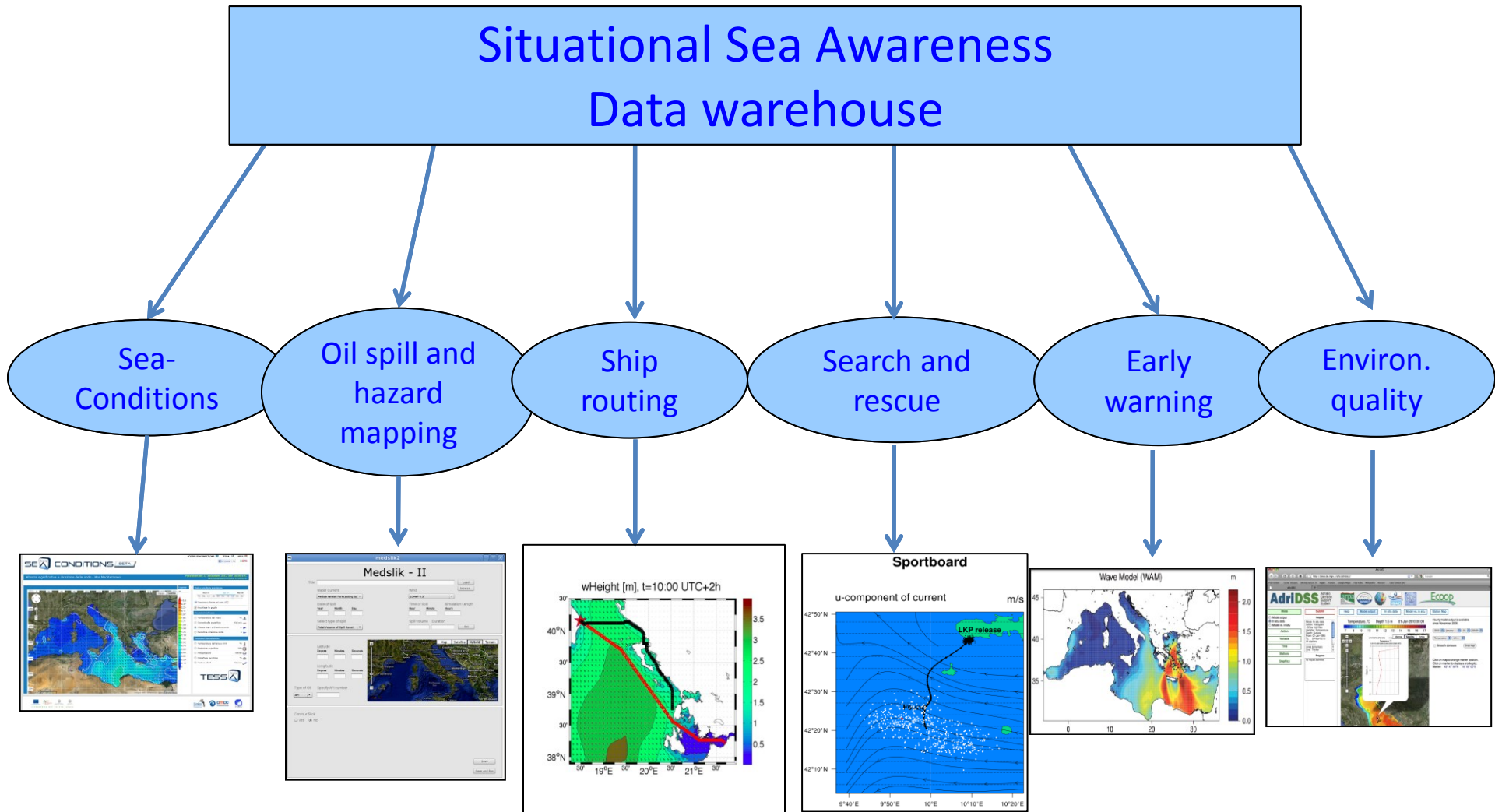
MFS-OTPS



16 16.2 16.4 16.6 16.8 17 17.2 17.4 17.6 17.8 18 18.2 18.4 18.6 18.8 19

OceanLab applications

Research and operational activities: Services



OceanLab applications

Sea-conditions: the web portal

SEA CONDITIONS

SCOPRI SEACONDITIONS

TESSA

CONTATTACI

DISCLAIMER

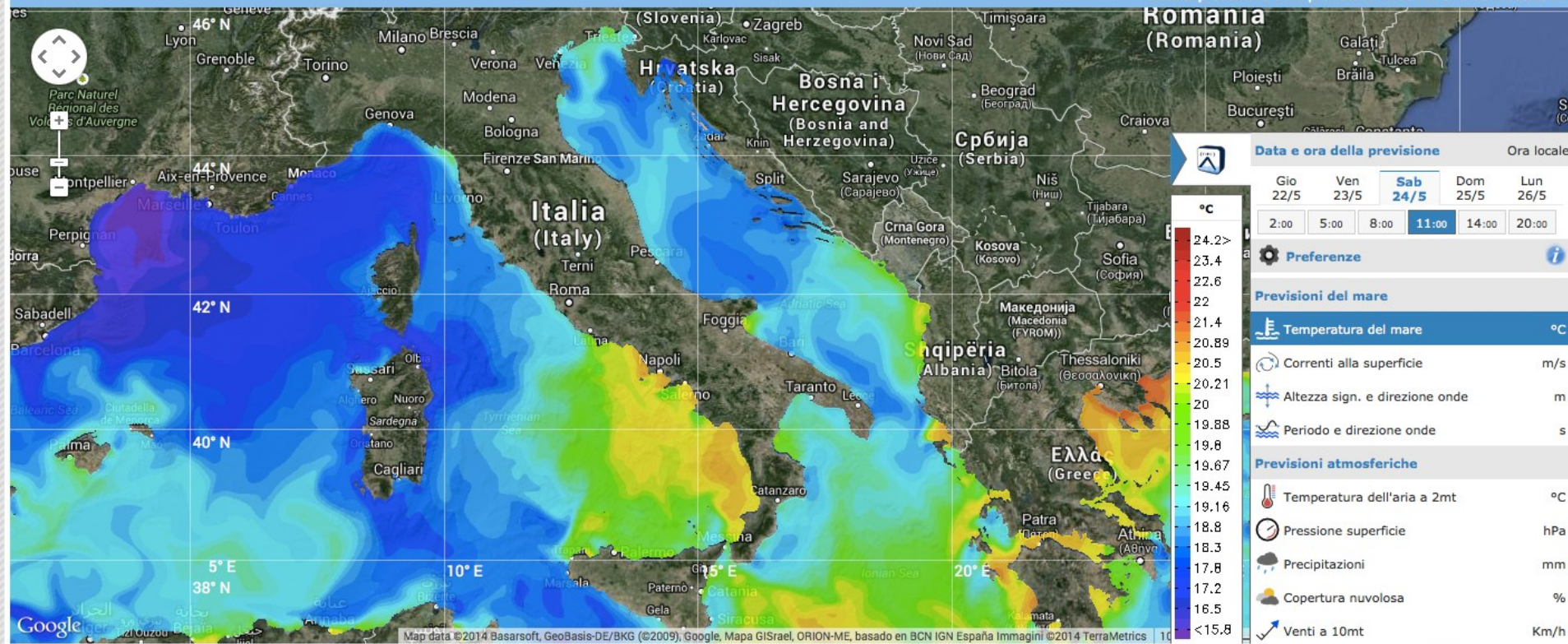
HELP



Temperatura del mare

Previsione del 24 Maggio 2014 alle 11:00

Data di produzione della previsione 12:00 AM UTC del 21/05/2014

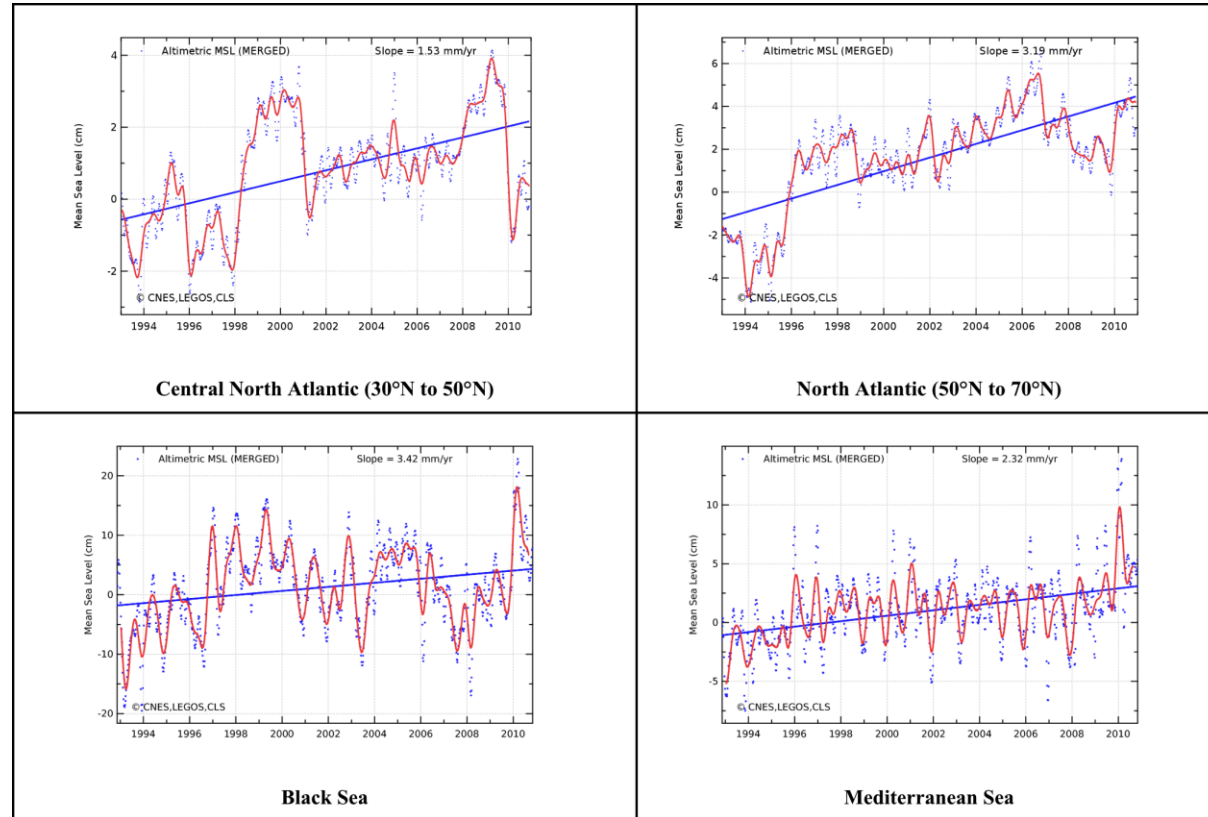


www.sea-conditions.com

Climate change indicators - basin scale

Sea level products

Ocean Indicators and Service to EEA.
MyOcean Specific Core Product



Average sea-level rise in some European seas (satellite observations)
(October 1992–December 2010)

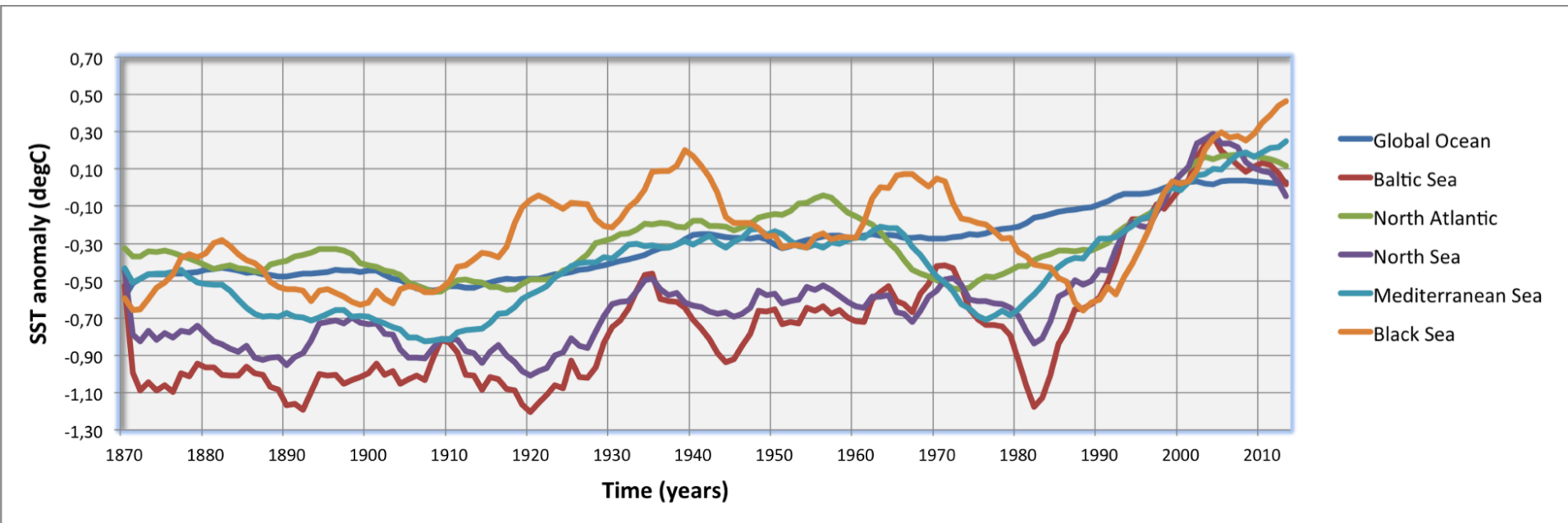
European seas	Sea-level rise (mm/year)
North Atlantic (50° N to 70° N)	3.2 mm/yr
Central North Atlantic (30° N to 50° N)	1.5 mm/yr
Mediterranean Sea	2.3 mm/yr
Black Sea	3.4 mm/yr

Source: Ablain, 2011, produced at
CLS/CNES/LEGOS group, available
through MyOcean.

Climate change indicators - basin scale

SST products

Ocean Indicators and Service to EEA.



SST anomaly ($^{\circ}$ C) from 1870 to 2013 (reference period 1989-2013) in different European seas.

Data sources are: Hadley Centre (HADISST1 (global)), MOON-ENEA (Mediterranean Sea), and BOOS (BSH) (Baltic and North Seas) and MyOcean.

Climate change scenarios - coastal scale

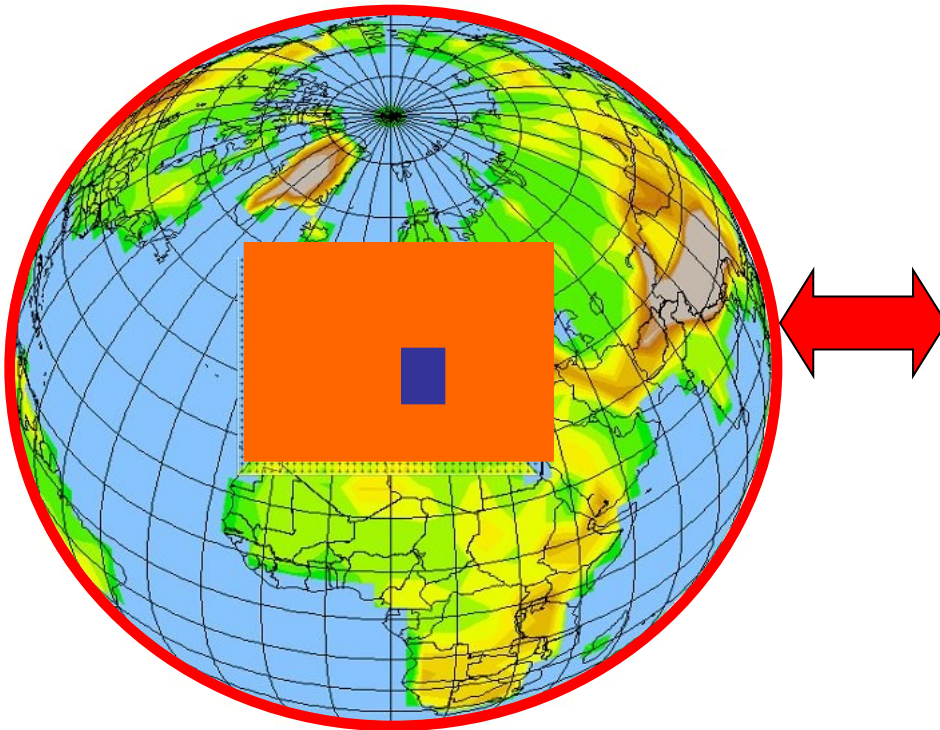


Climate change scenarios - coastal scale

A twofold approach strategy: regionalization and integration:

Models Regionalization (Study case of the Montenegrin area):

recently the scientific community has been facing the issue of bringing the climate change study impact from global to local scale.



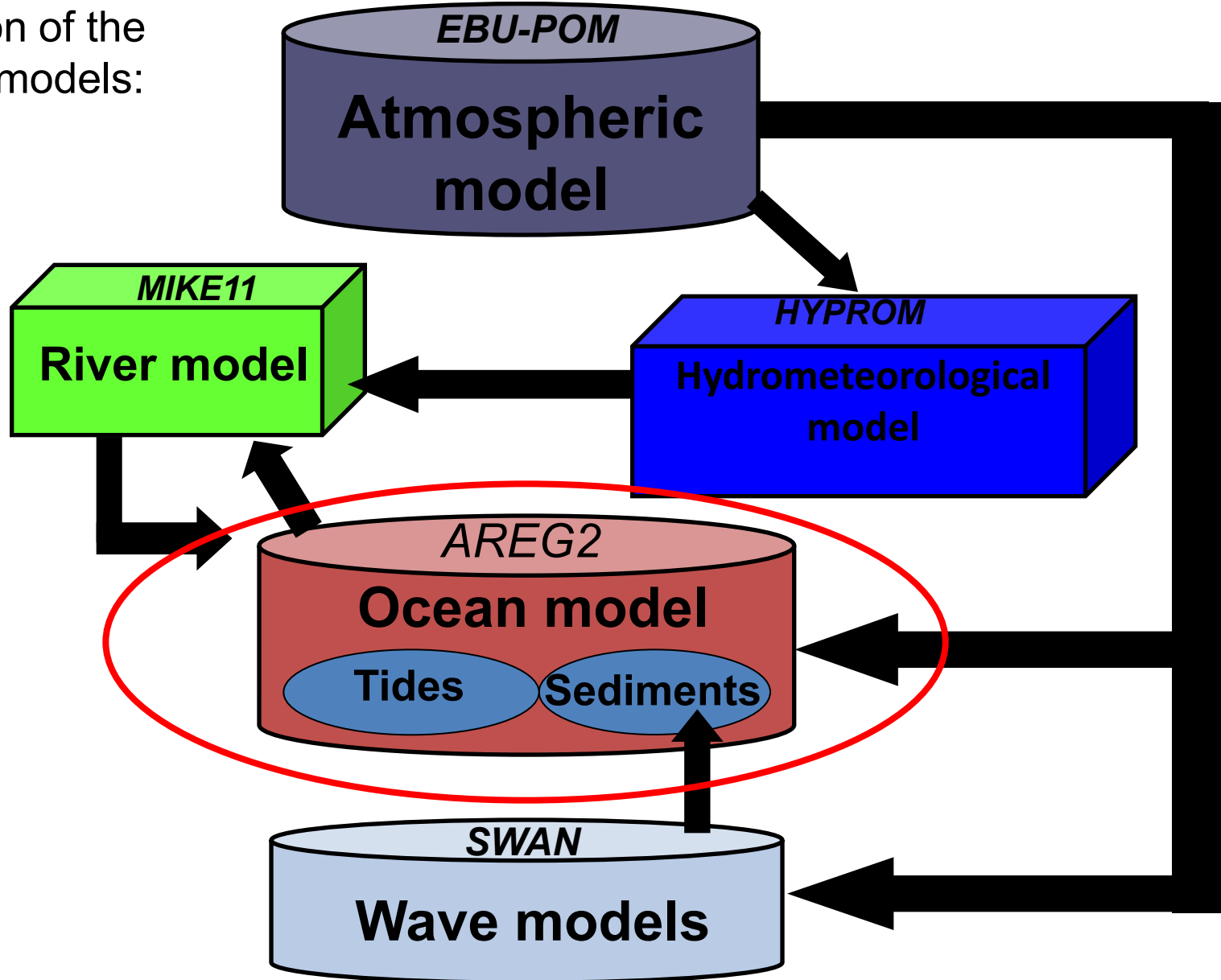
Models Integration:

try to make the forecasting systems more and more accurate and efficient by means of realistic modelling at each level of the water integrated cycle, and also integration with observations



Climate change scenarios - coastal scale

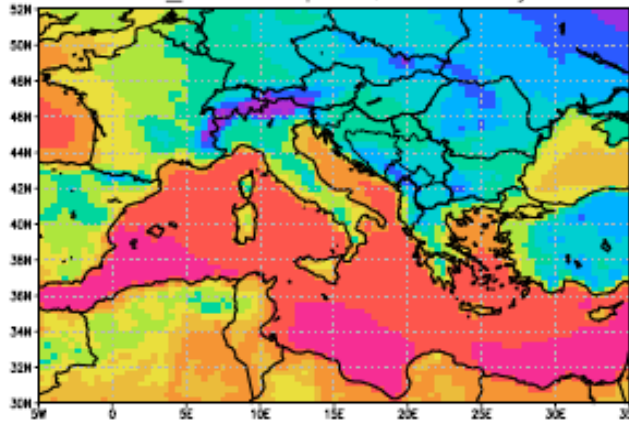
Integration of the involved models:



Climate change scenarios - coastal scale

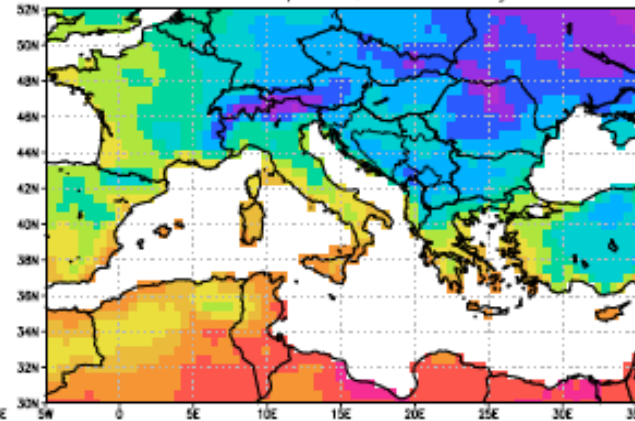
model

EBU_POM: temp 2m; season: djf



observations

CRU: temp 2m; season: djf



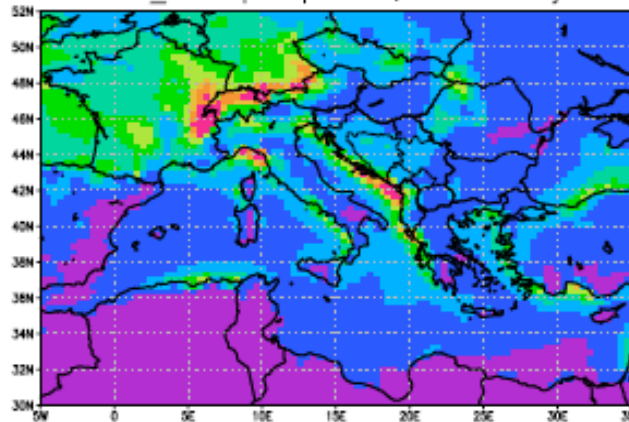
winter mean temperature

Scores for seasonal 2m temperature.
Model vs. CRU data.

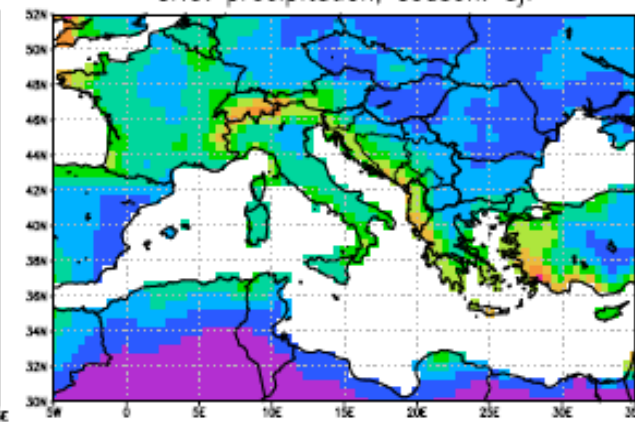
EP/CRU	bias	mae	rmse
DJF	-0.21	1.88	2.15
MAM	1.03	1.59	1.84
JJA	2.63	2.96	3.42
SON	-0.87	1.38	1.83
ANN	0.64	1.63	1.87



EBU_POM: precipitation; season: djf



CRU: precipitation; season: djf



winter mean precipitation (mm/month)

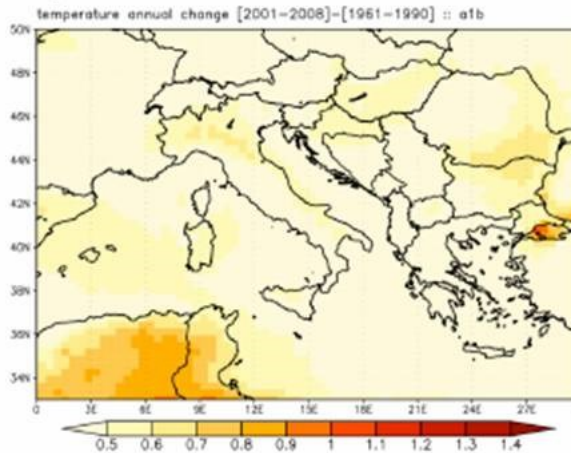


Atmospheric model validation

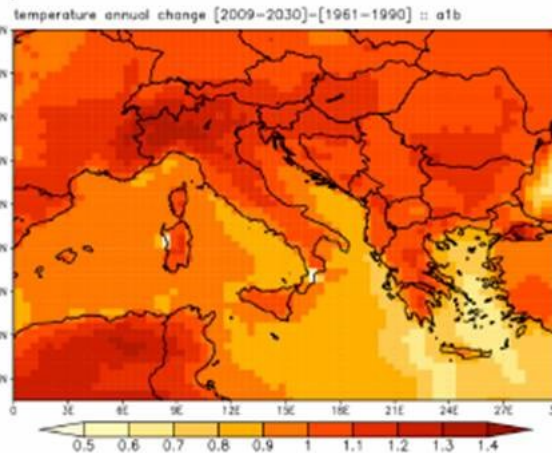
Atmospheric model validation

Annual temperature change compared to 1961-1990

period: 2001-2008

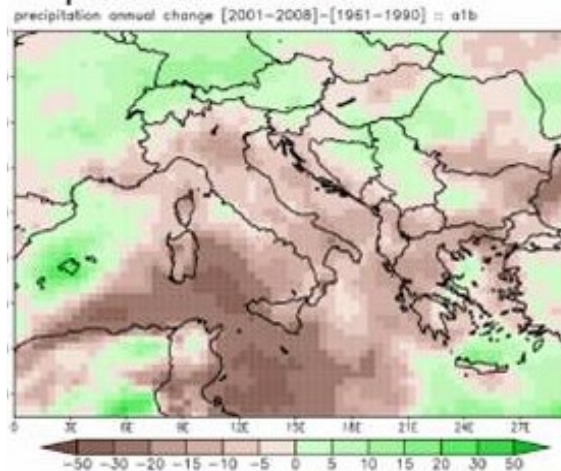


period: 2009-2030

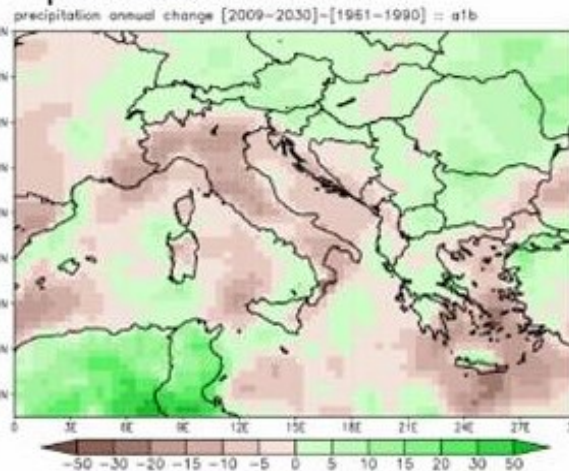


Annual precipitation (%) change compared to 1961-1990

period: 2001-2008



period: 2009-2030

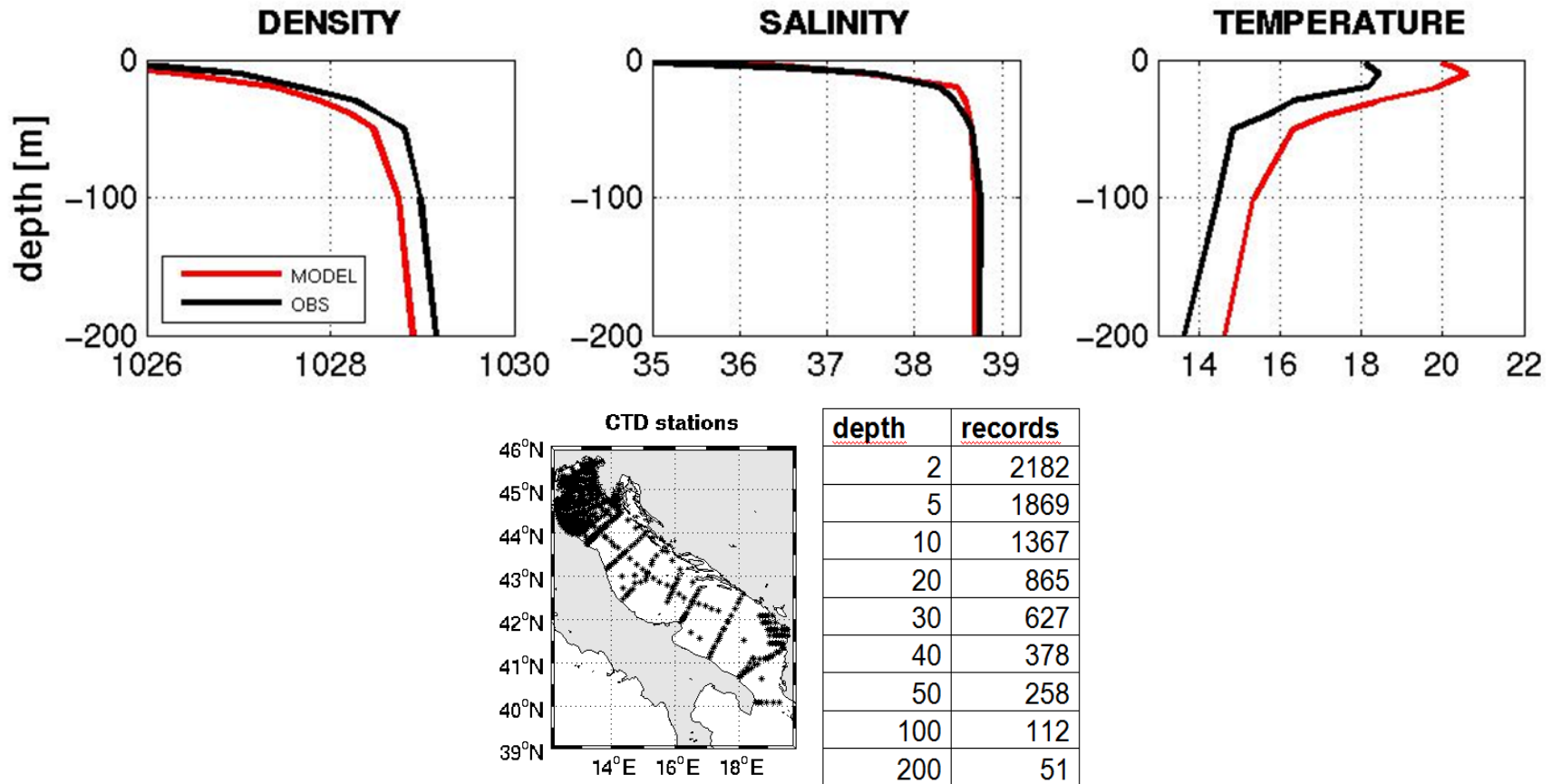


Ocean Model configuration for the study case

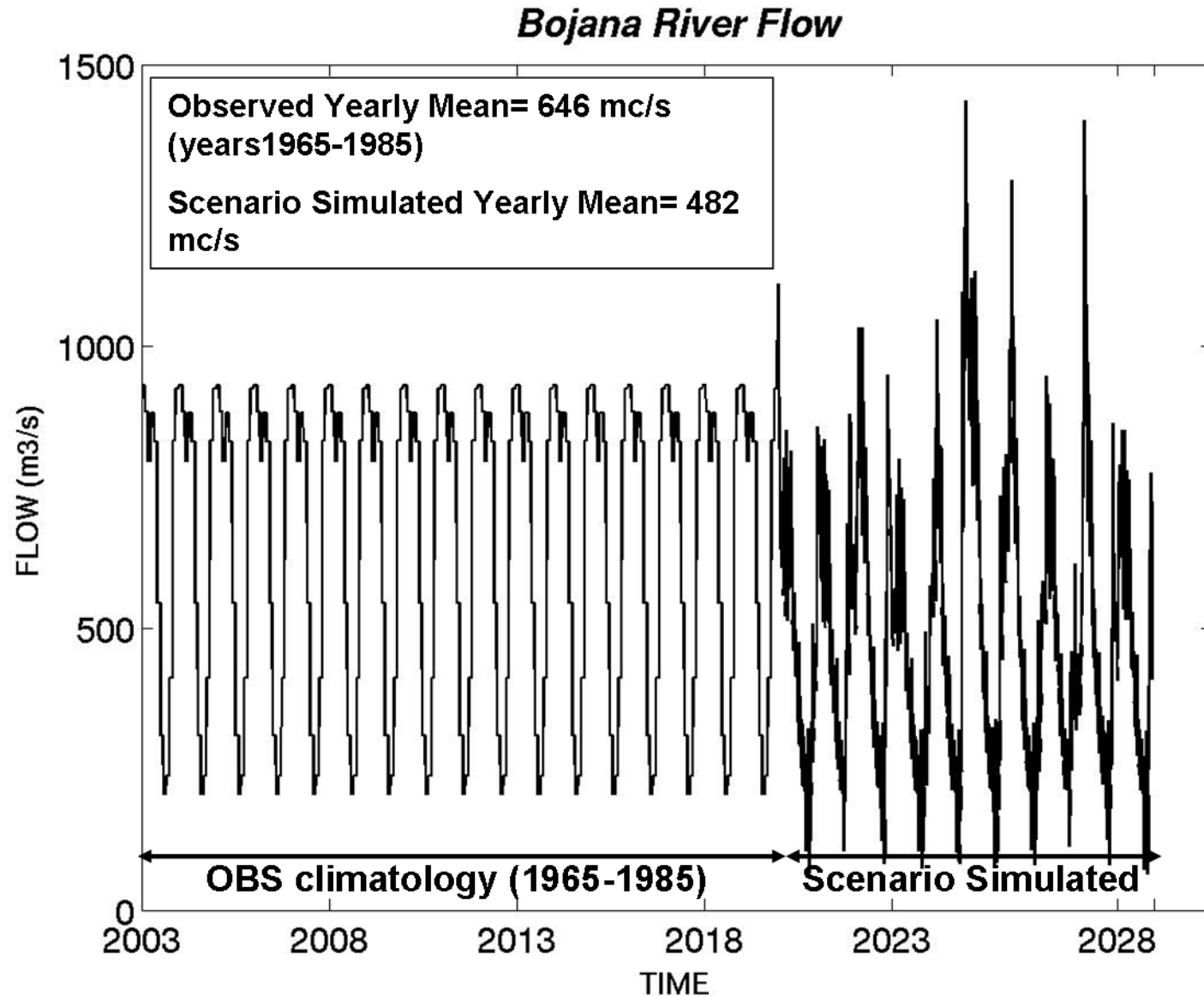
Period of integration of the OGCM	Jan 2001- Dec 2030
Period of integration for sediments	Jan 2020- Dec 2030
Initial conditions for OGCM	Adriatic Forecasting System (AFS)
Initial conditions for sediments	• Concentration 2 gr/m³ • Bottom Sediment 0,5 Kg/m²
Bojana River	• 2001-2019 climatology (Raicich) • 2020-2030 hourly coupling with MIKE11
Other rivers	2001-2030 climatology (Raicich)
Atmospheric forcings	EBU-POM Atm Model (0.25° , 6 hrs)
L.O.B.C	Daily climatology of M.F.S.(1998-2008)

Ocean Model Validation

- To prove the reliability of the climate model, this latter was validated versus observations and compared with the realistic model
- We assume the error in the reproduction of the future climate be the same as the one of the present climate



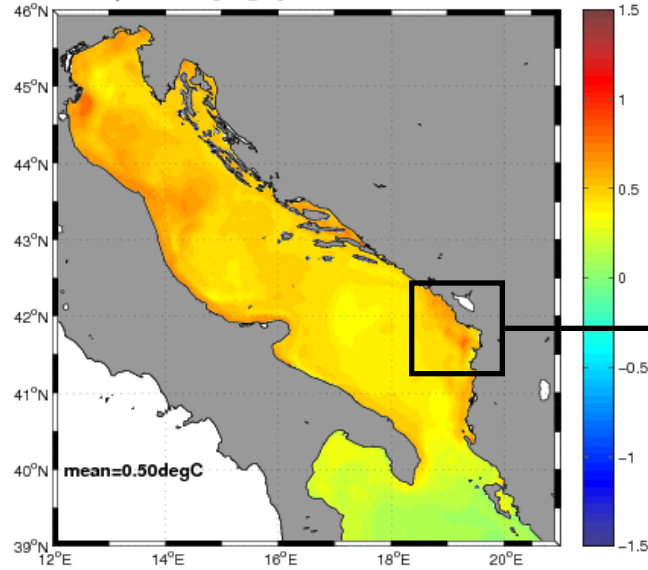
Results: Buna/Bojana flow



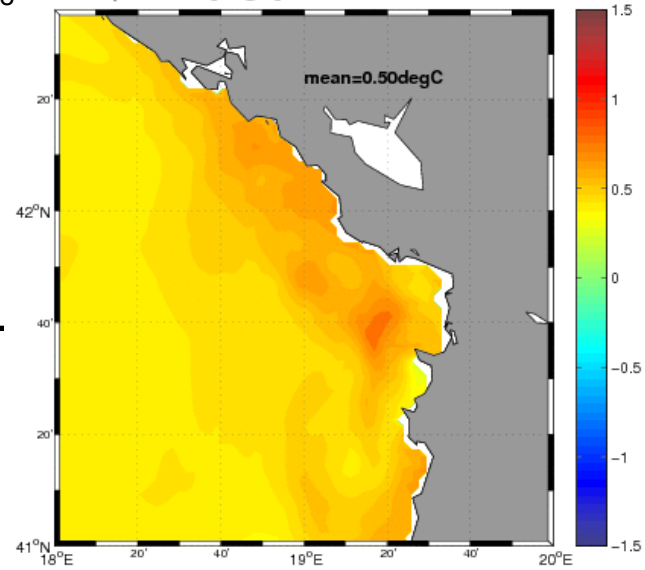
Results: Winter Temperature and Salinity difference

Future = 2025-2030
Present = 2003-2008

Temperature [degC] at -2m: Future-Present

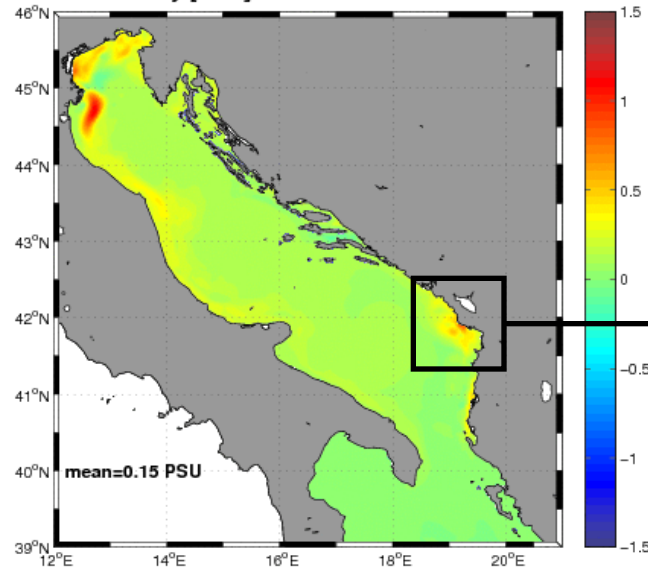


Temperature [degC] at -2m: Future-Present

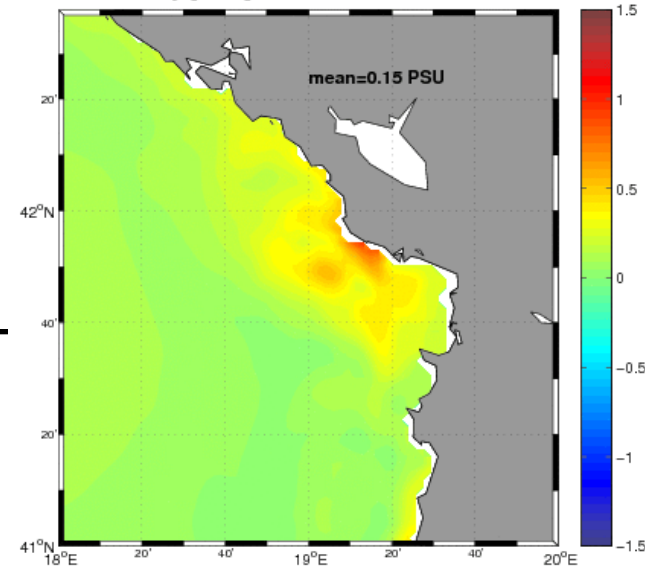


*T Diff
Fut-Pres*

Salinity [PSU] at -2m: Future-Present



Salinity [PSU] at -2m: Future-Present

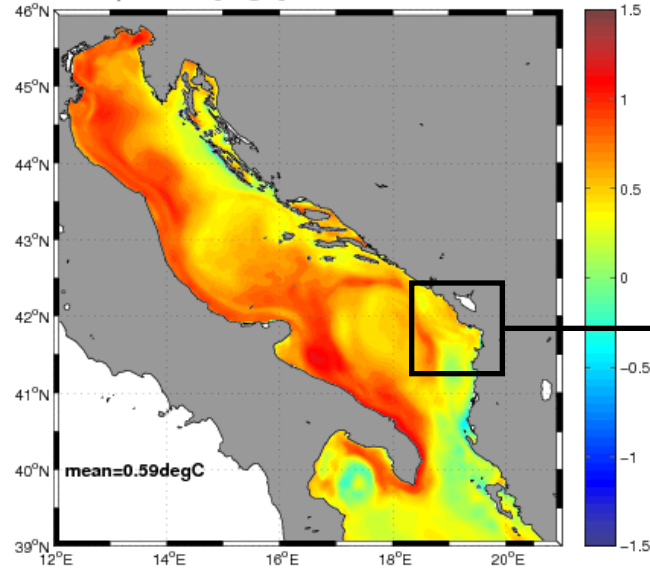


*S Diff
Fut-Pres*

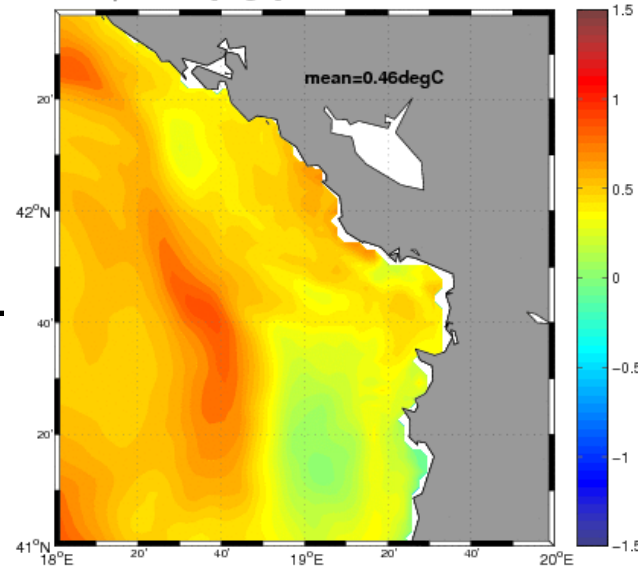
Results: Spring Temperature and Salinity difference

Future = 2025-2030
Present = 2003-2008

Temperature [degC] at -2m: Future-Present

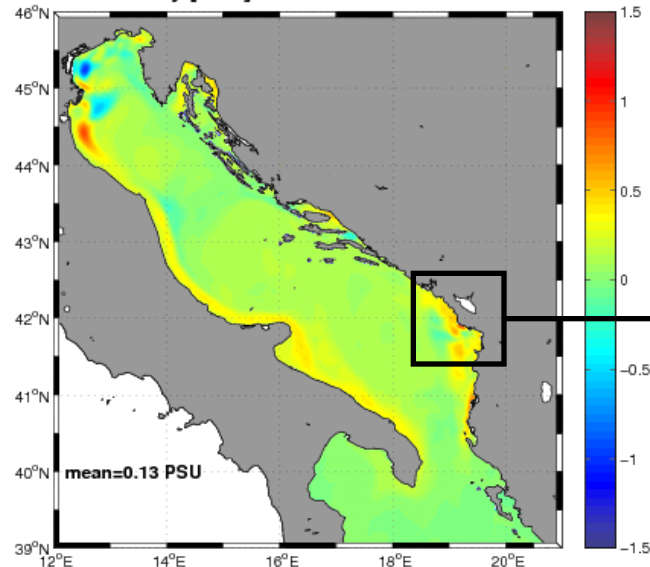


Temperature [degC] at -2m: Future-Present

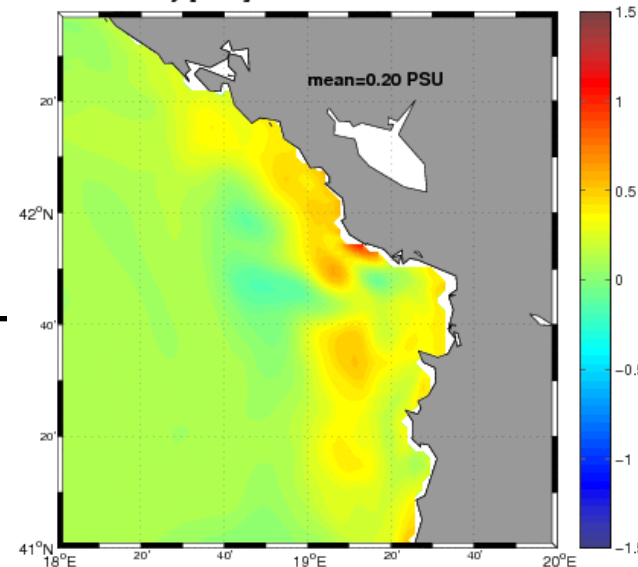


*T Diff
Fut-Pres*

Salinity [PSU] at -2m: Future-Present



Salinity [PSU] at -2m: Future-Present

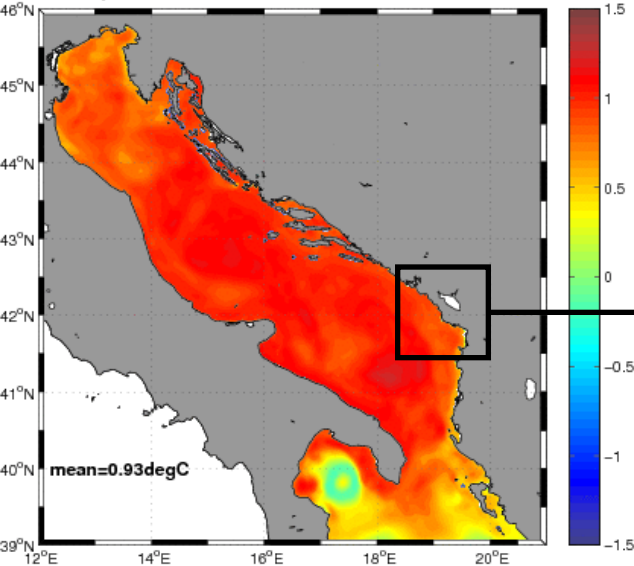


*S Diff
Fut-Pres*

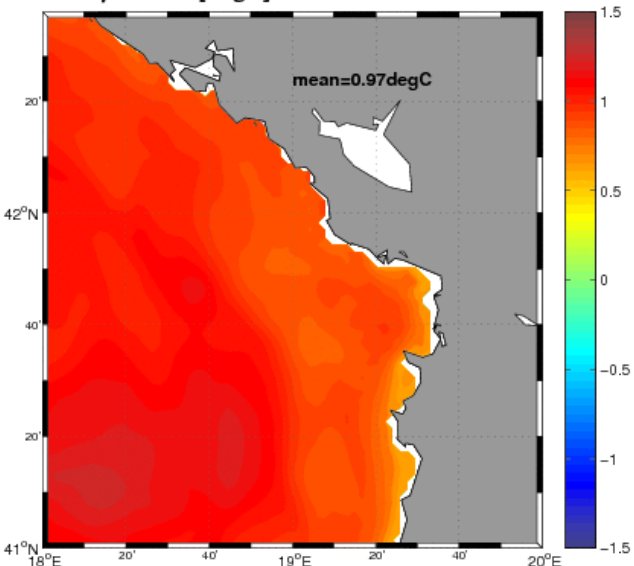
Results: Summer Temperature and Salinity difference

Future = 2025-2030
Present = 2003-2008

Temperature [degC] at -2m: Future-Present

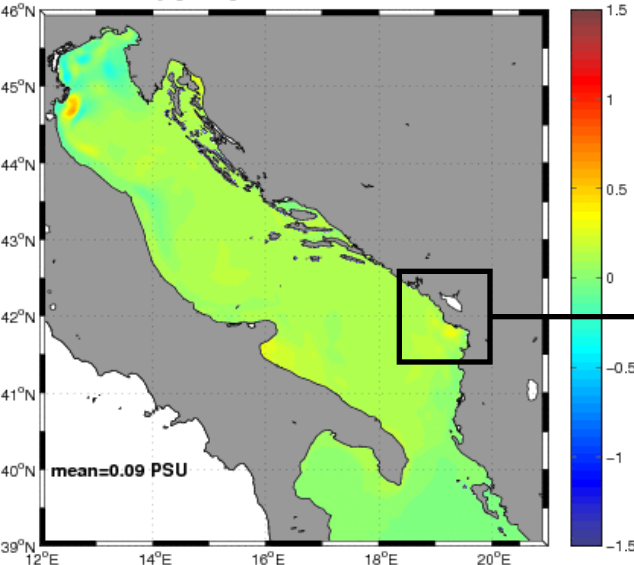


Temperature [degC] at -2m: Future-Present

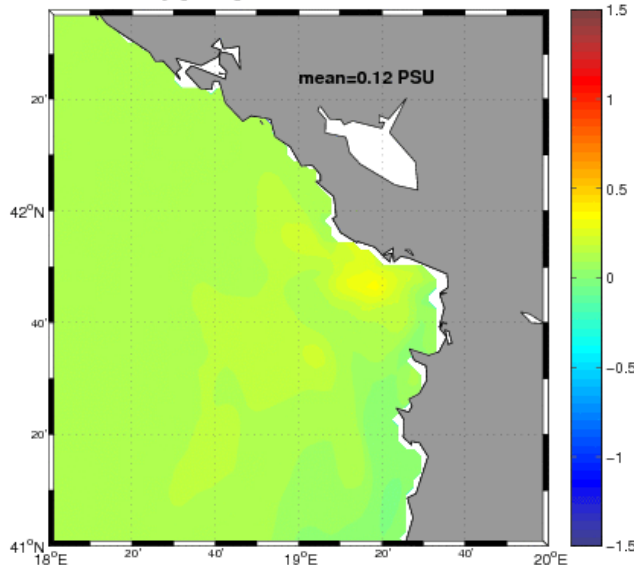


*T Diff
Fut-Pres*

Salinity [PSU] at -2m: Future-Present



Salinity [PSU] at -2m: Future-Present

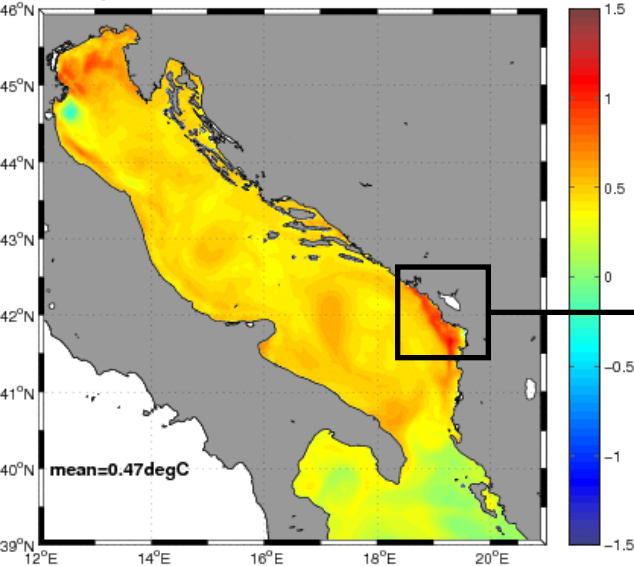


*S Diff
Fut-Pres*

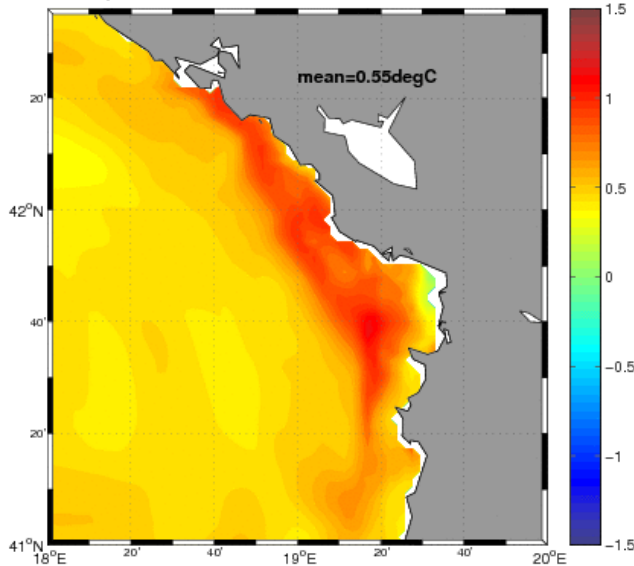
Results: Autumn Temperature and Salinity difference

Future = 2025-2030
Present = 2003-2008

Temperature [degC] at -2m: Future-Present

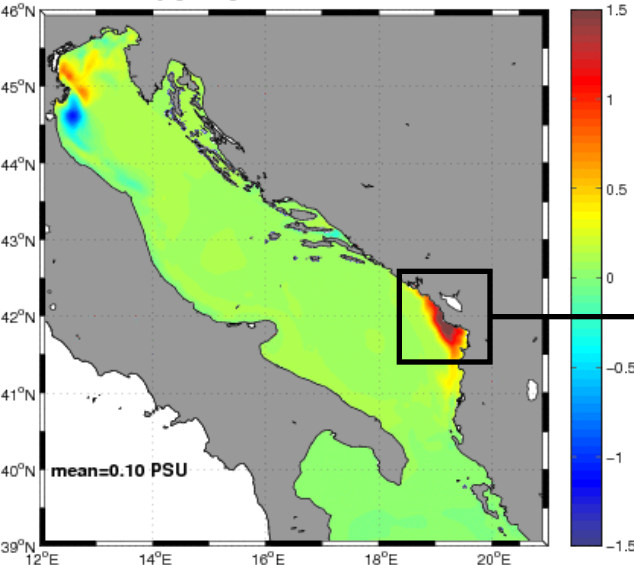


Temperature [degC] at -2m: Future-Present

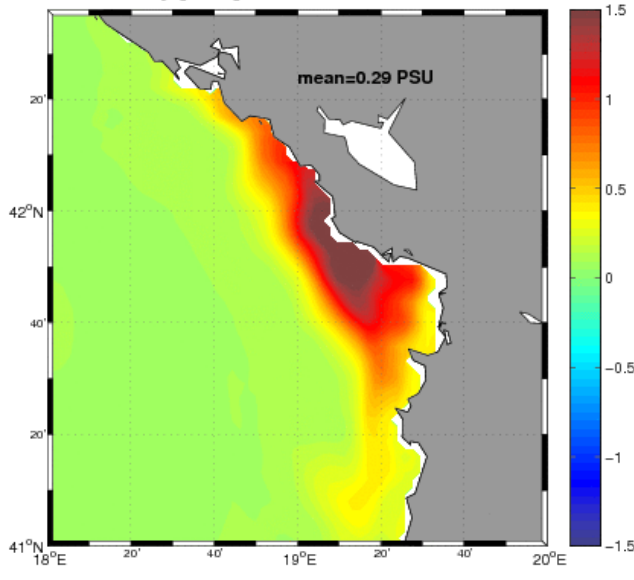


*T Diff
Fut-Pres*

Salinity [PSU] at -2m: Future-Present

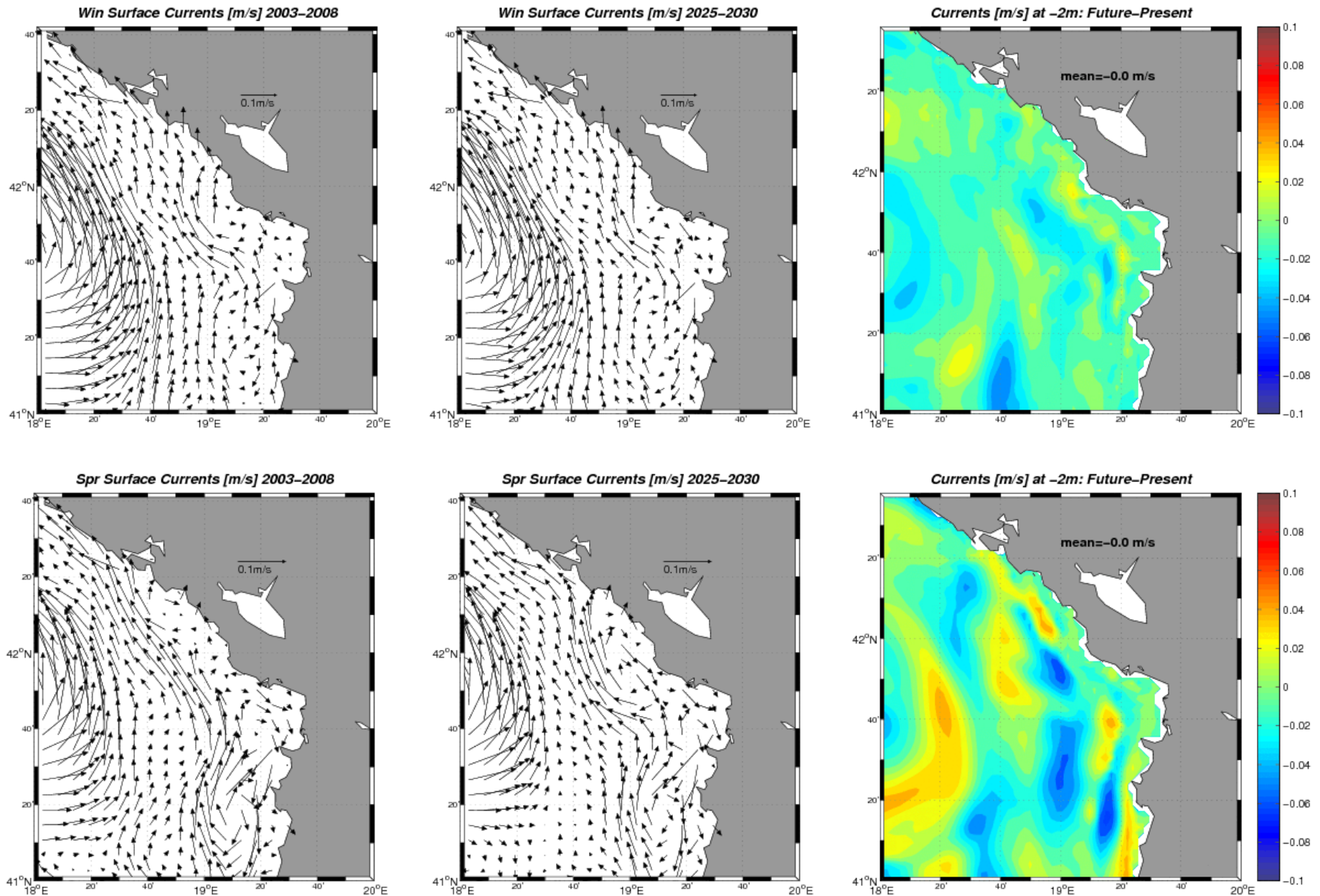


Salinity [PSU] at -2m: Future-Present



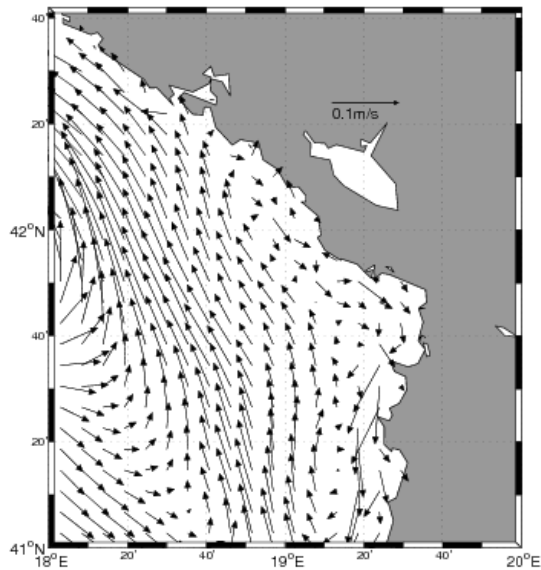
*S Diff
Fut-Pres*

Results: winter and spring surface currents differences

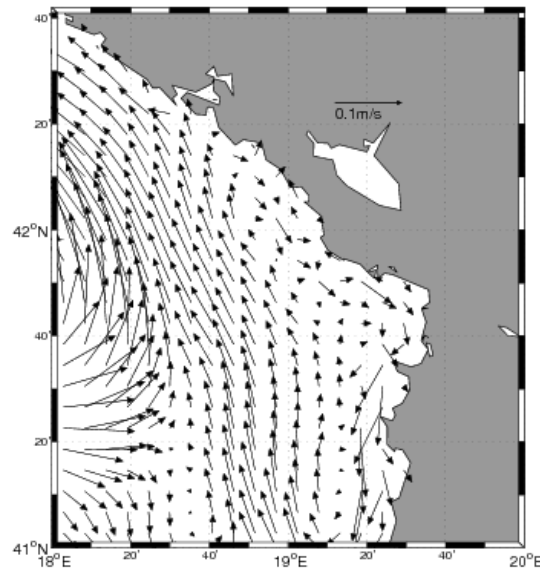


Results: summer and autumn surface currents differences

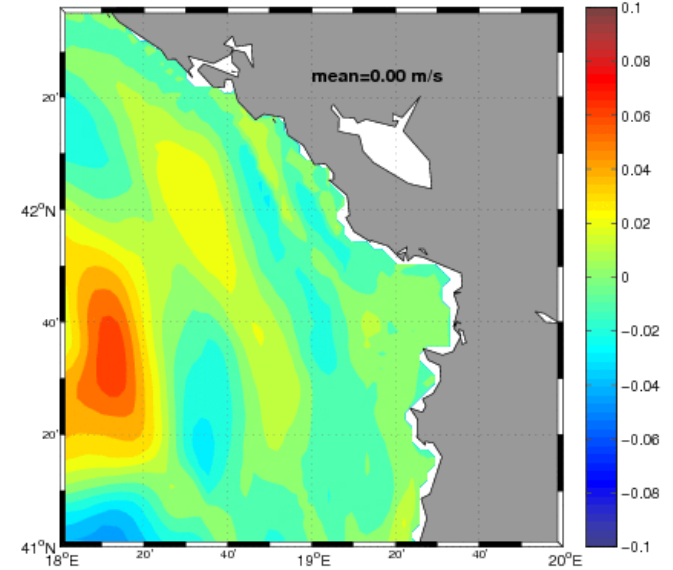
Sum Surface Currents [m/s] 2003–2008



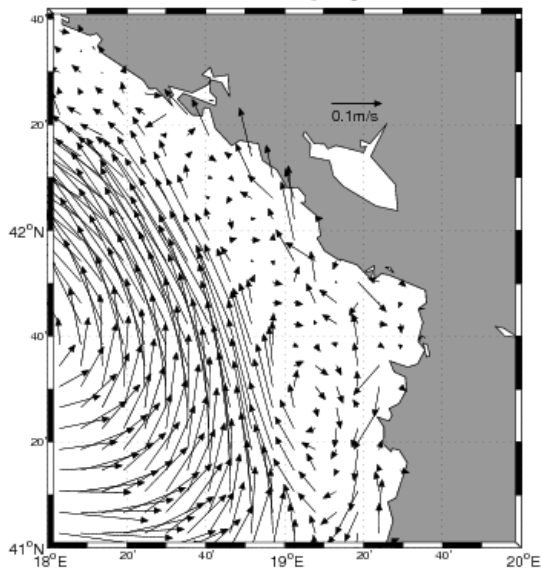
Sum Surface Currents [m/s] 2025–2030



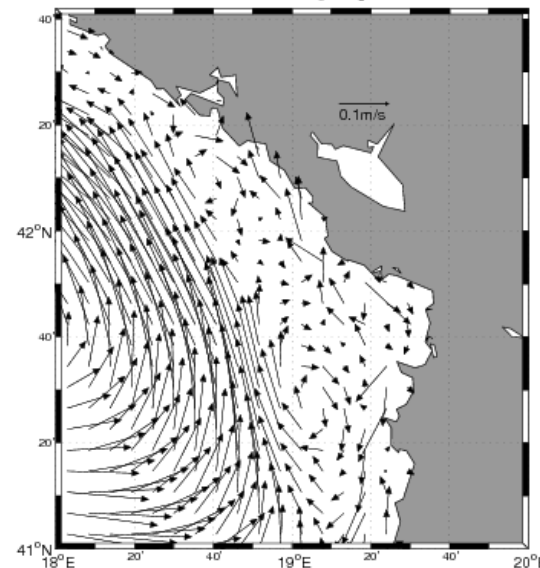
Currents [m/s] at -2m: Future–Present



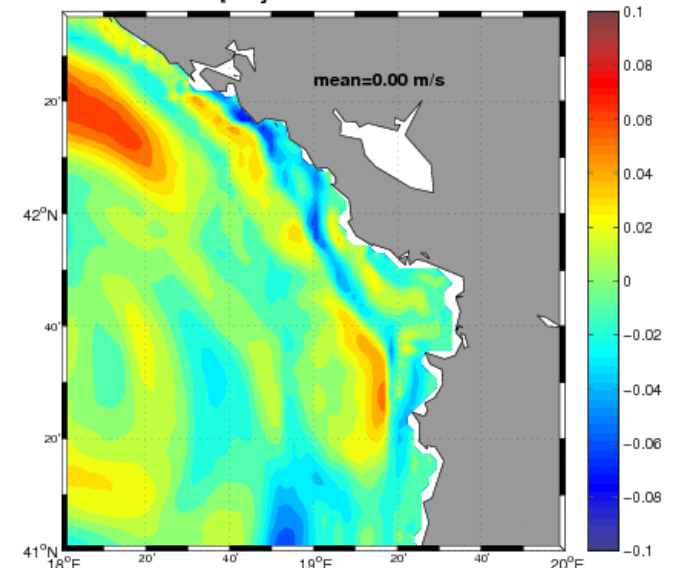
Aut Surface Currents [m/s] 2003–2008



Aut Surface Currents [m/s] 2025–2030

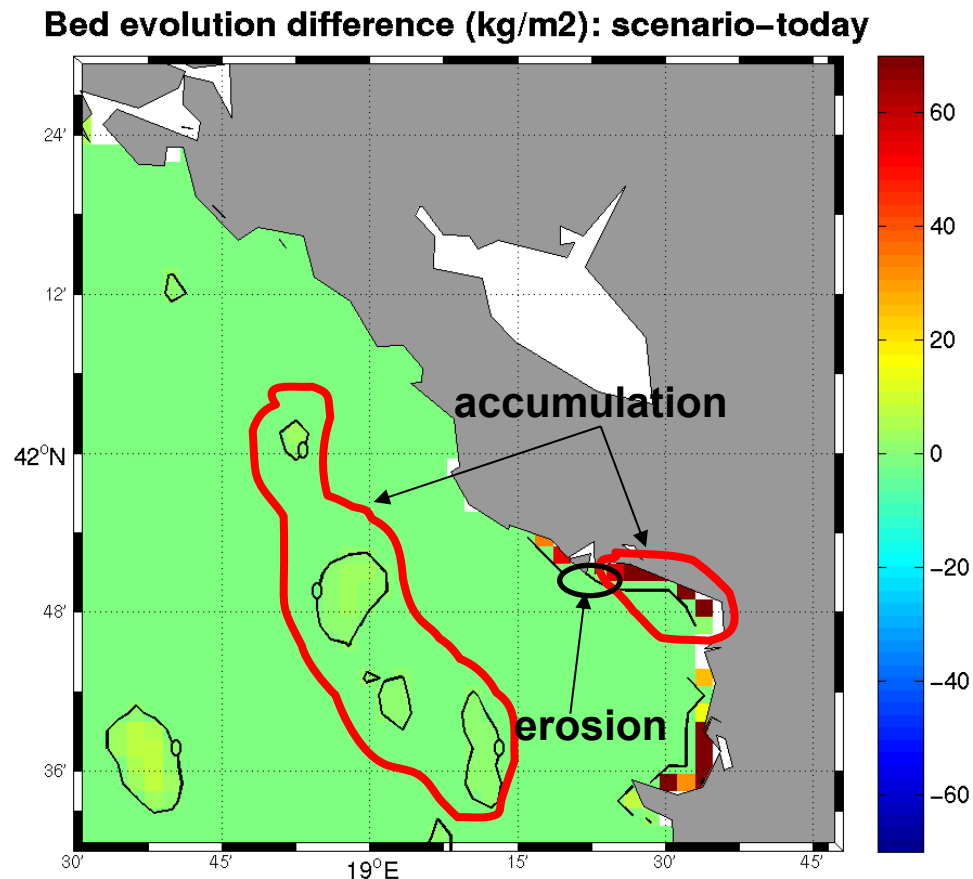
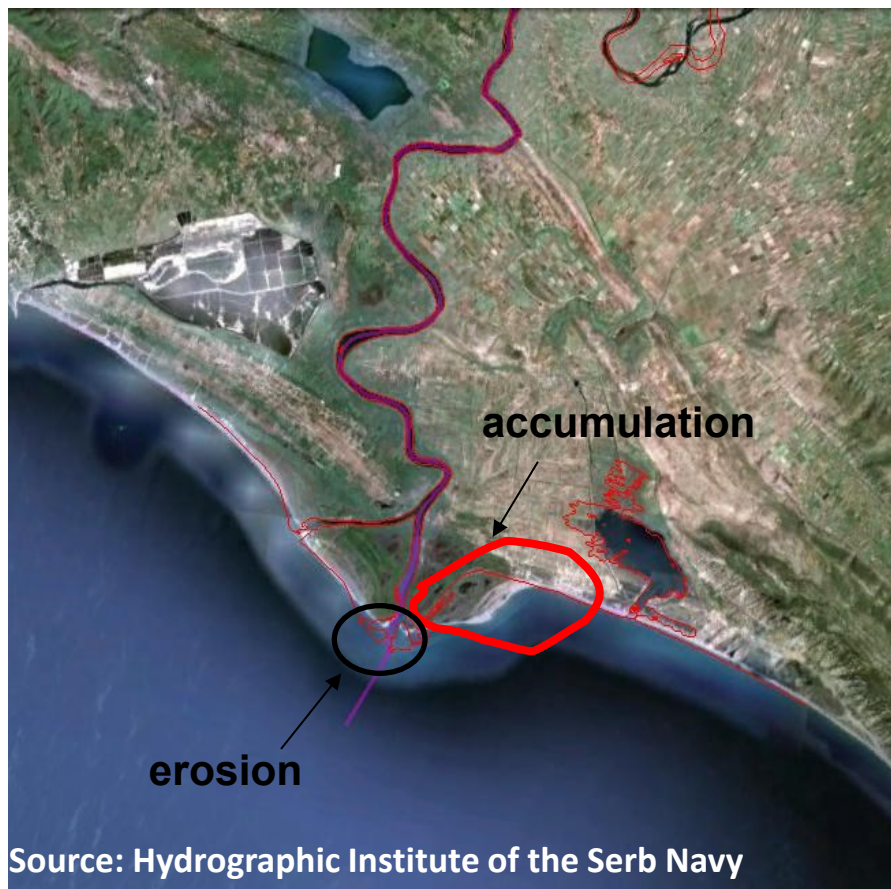


Currents [m/s] at -2m: Future–Present

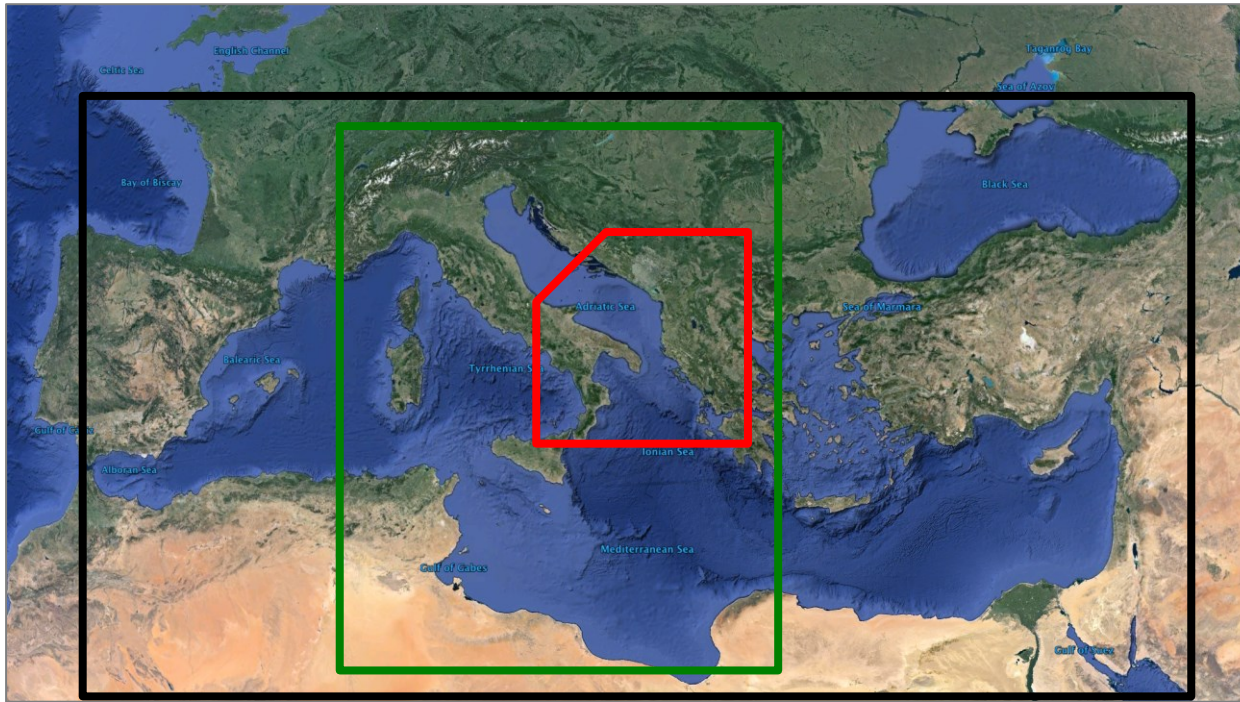


Results: Sediment dynamics 2020-2030

The analysis of the evolution of the coast line since the 60^{ies} up to now shows a strong accumulation area in the area immediately south-east of the Buna/Bojana river. The comparison between the scenario simulation and the present climate seems to confirm the same tendency also for the future years.



Coastal ocean high-resolution forecasting system



MFS



AIFS



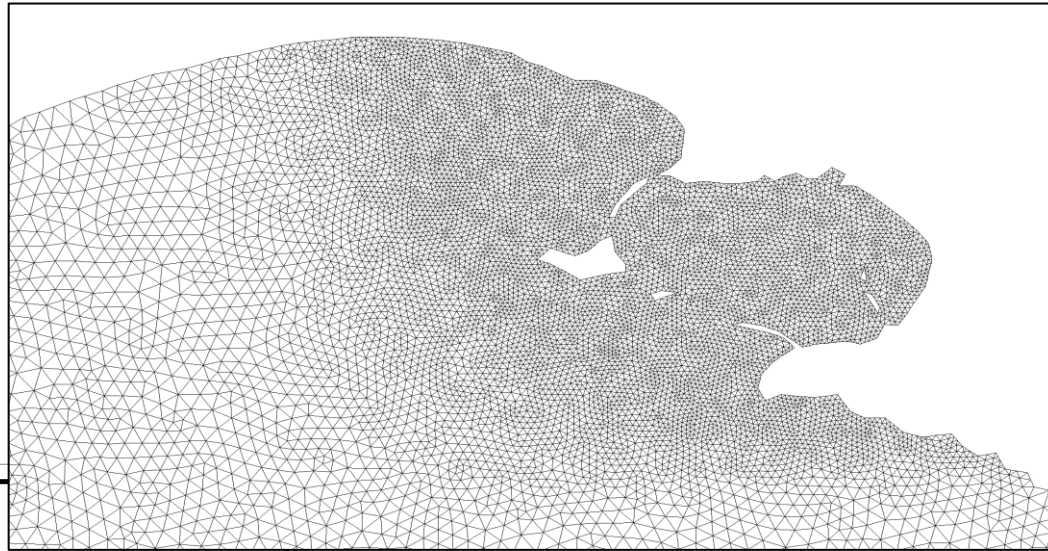
SANIFS

- **Mediterranean** sea and **Southern Adriatic Northern Ionian** seas
- **Operational** chain will be based on a **nesting cascade approach**
- **Validation:**
 - SANIFS model has been validated in different seasons with the MFS operational products in terms of maps and transects.
 - Temperature and salinity results have been compared with observed data (SST satellite observations and ARGO floats).
 - Time-series comparisons between the simulated sea surface height and the observed height at the Italian tide-gauges stations have been performed.
- PreOperational tasks and **short term forecasts**

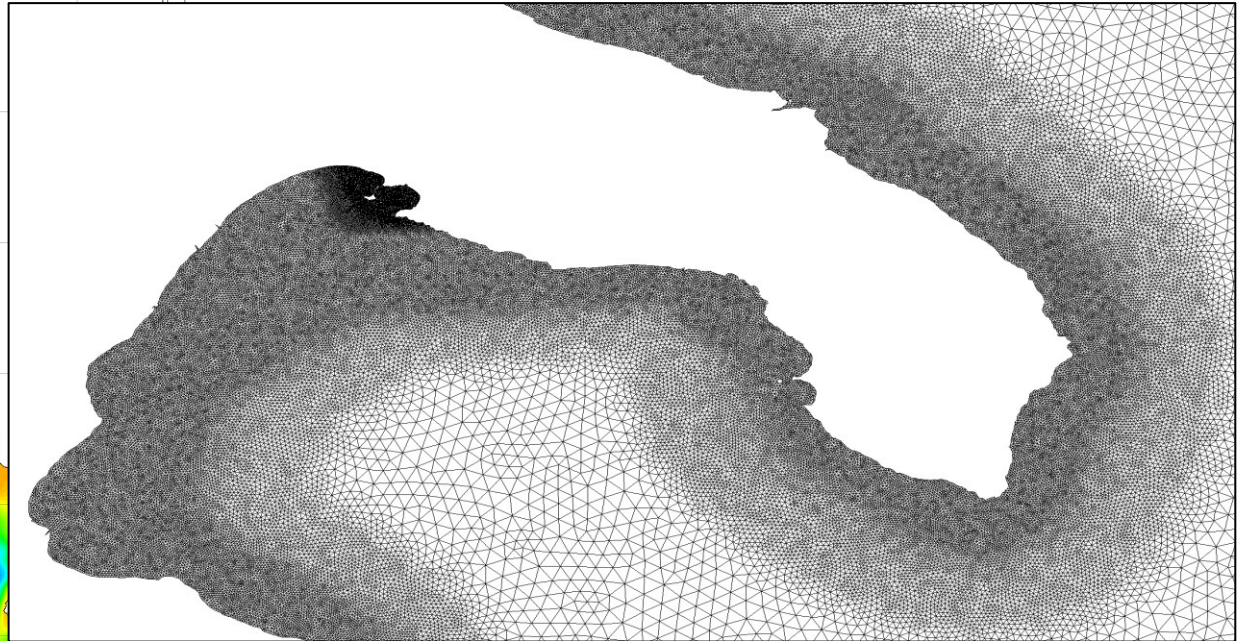
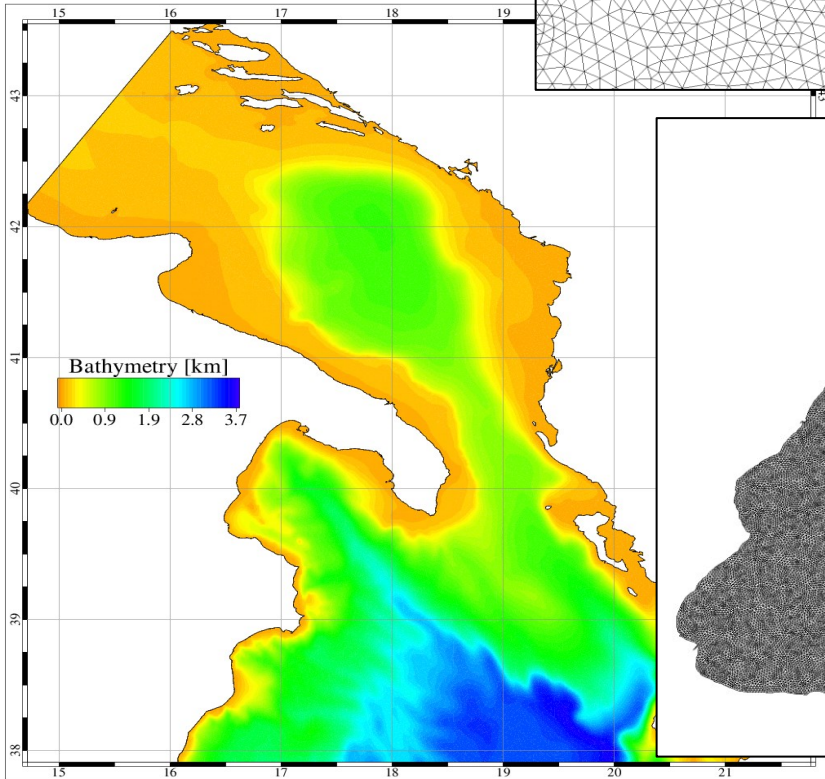
Coastal ocean high-resolution forecasting system

SHYFEM model

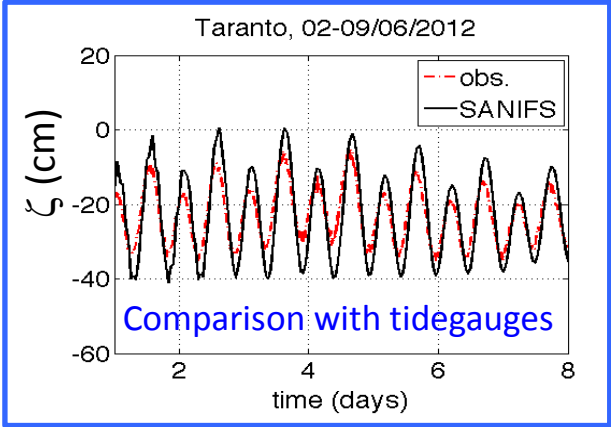
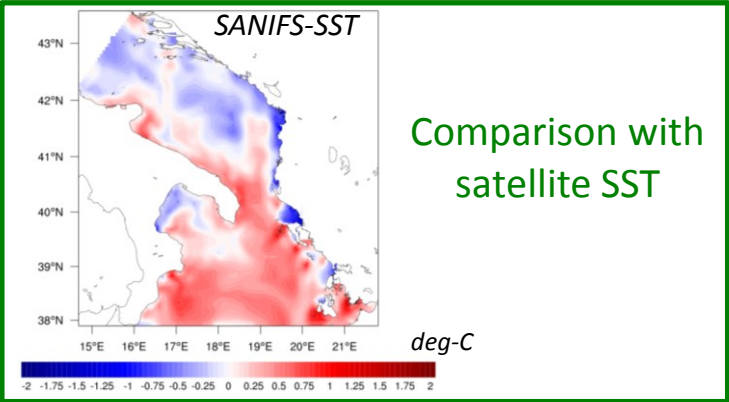
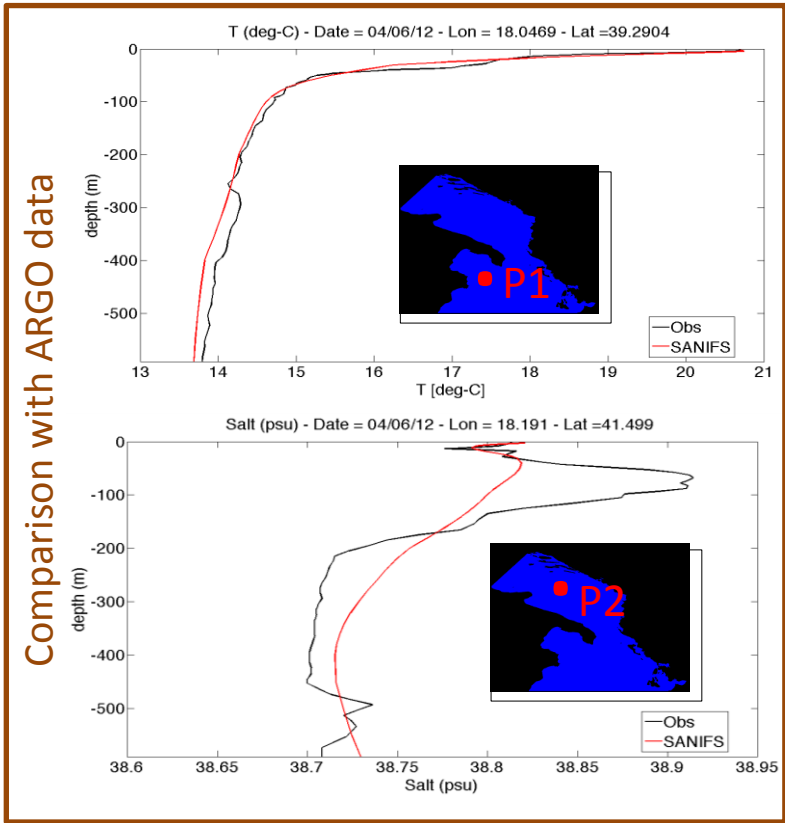
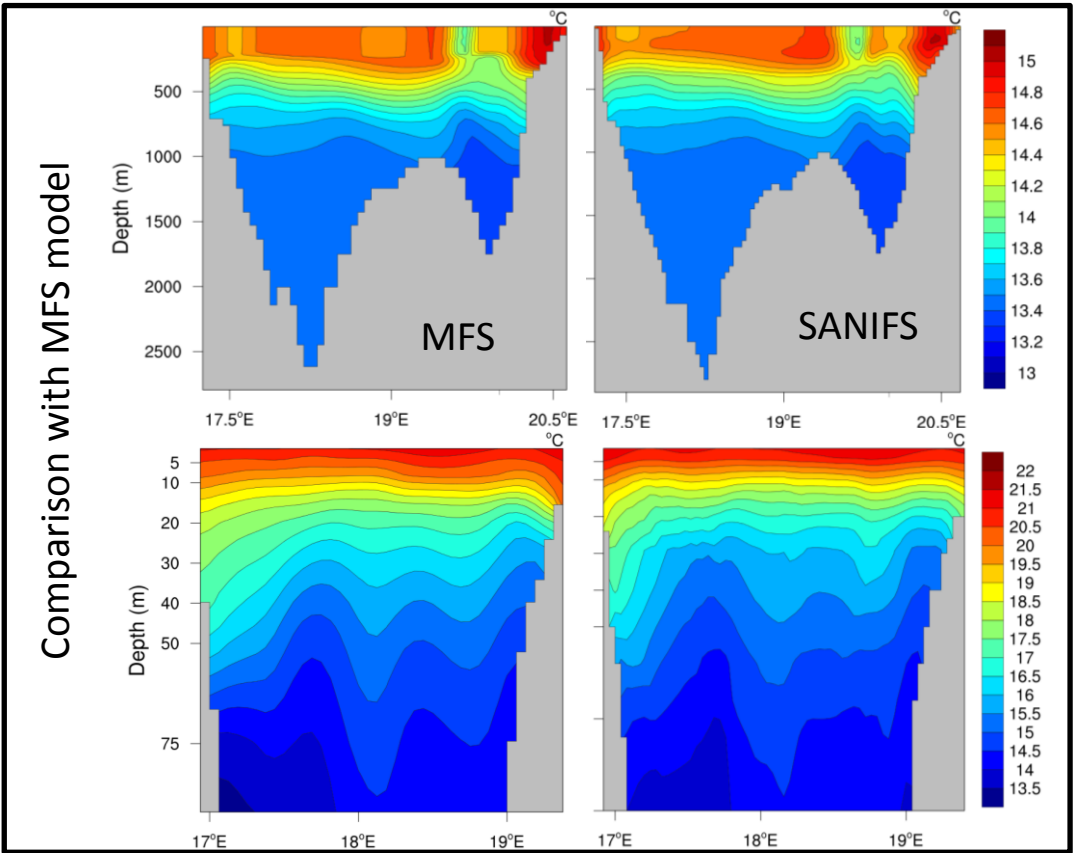
3D unstructured grid
finite element model



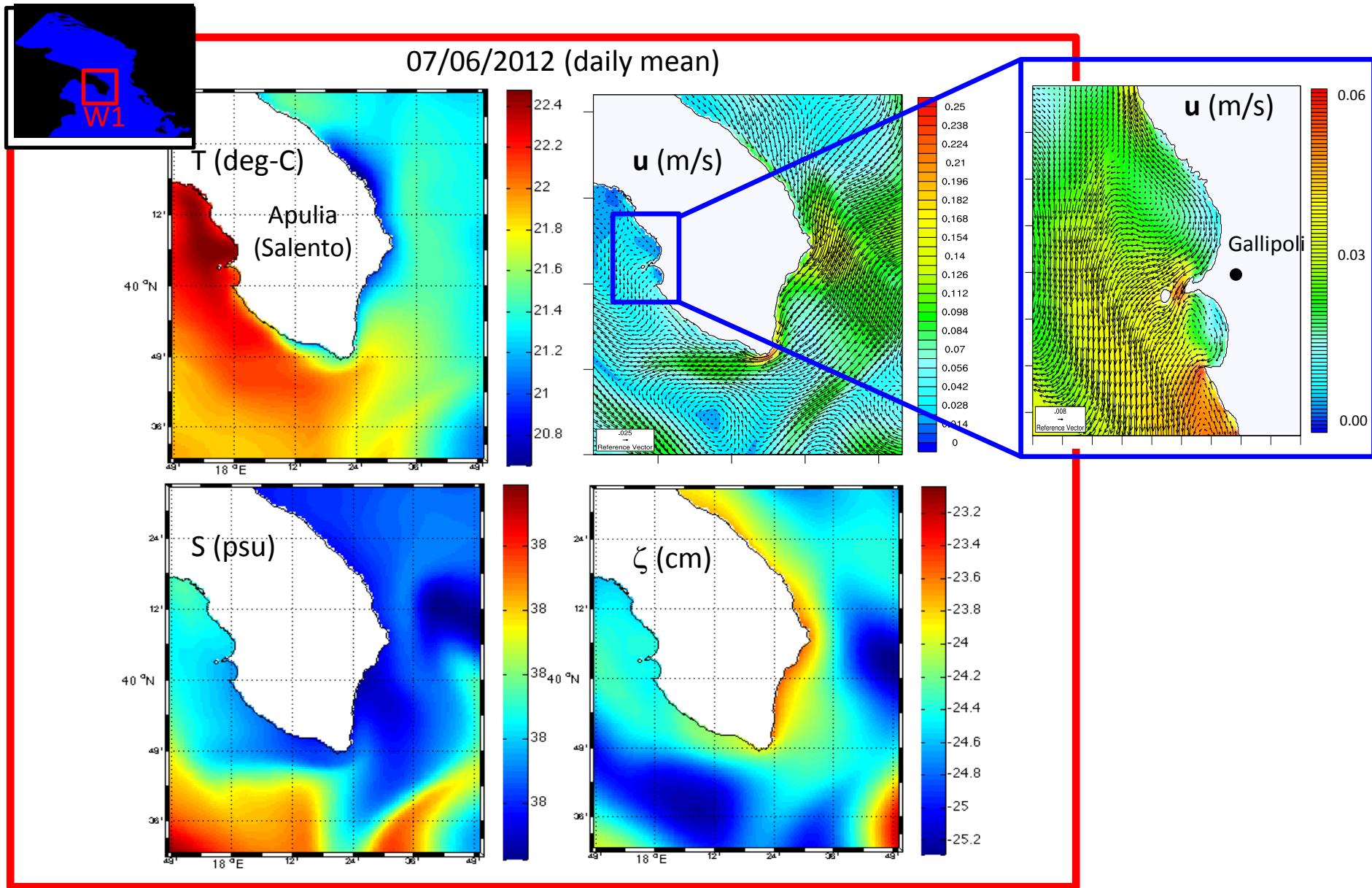
Coastal res: 200-500 m
Open-sea res: 3 km
91 z-levels



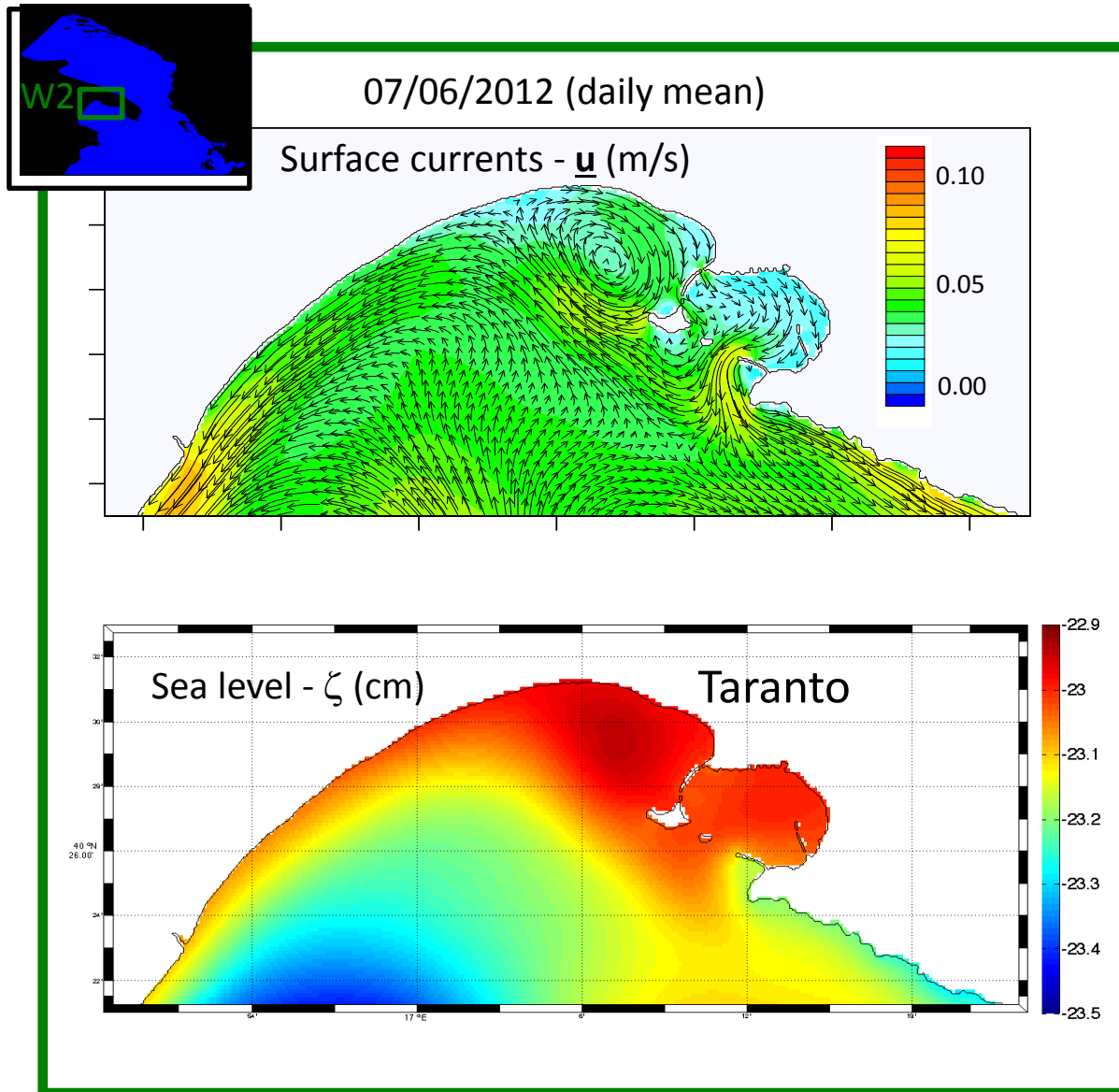
Coastal ocean high-resolution forecasting system - Validation



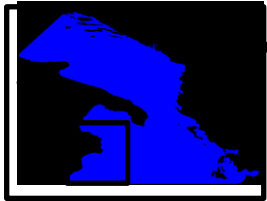
Coastal ocean high-resolution forecasting system – Coastal fields



Coastal ocean high-resolution forecasting system – Coastal fields

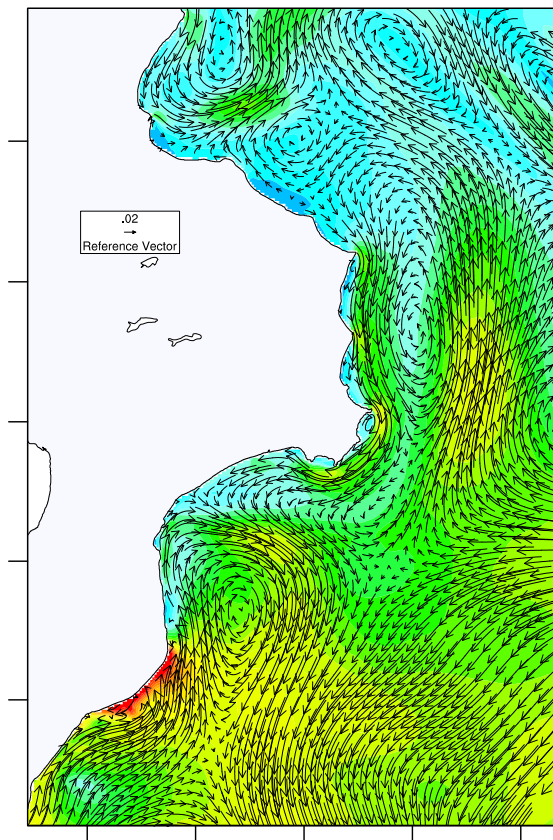


Coastal ocean high-resolution forecasting system – Coastal fields

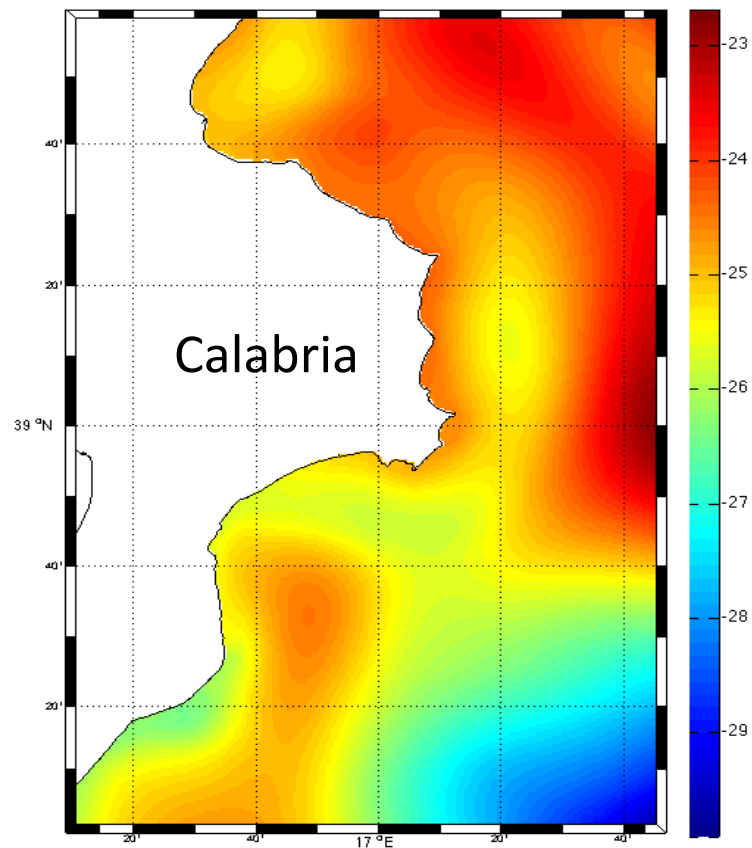


07/06/2012 (daily mean)

Surface currents - $\underline{u}$ (m/s)

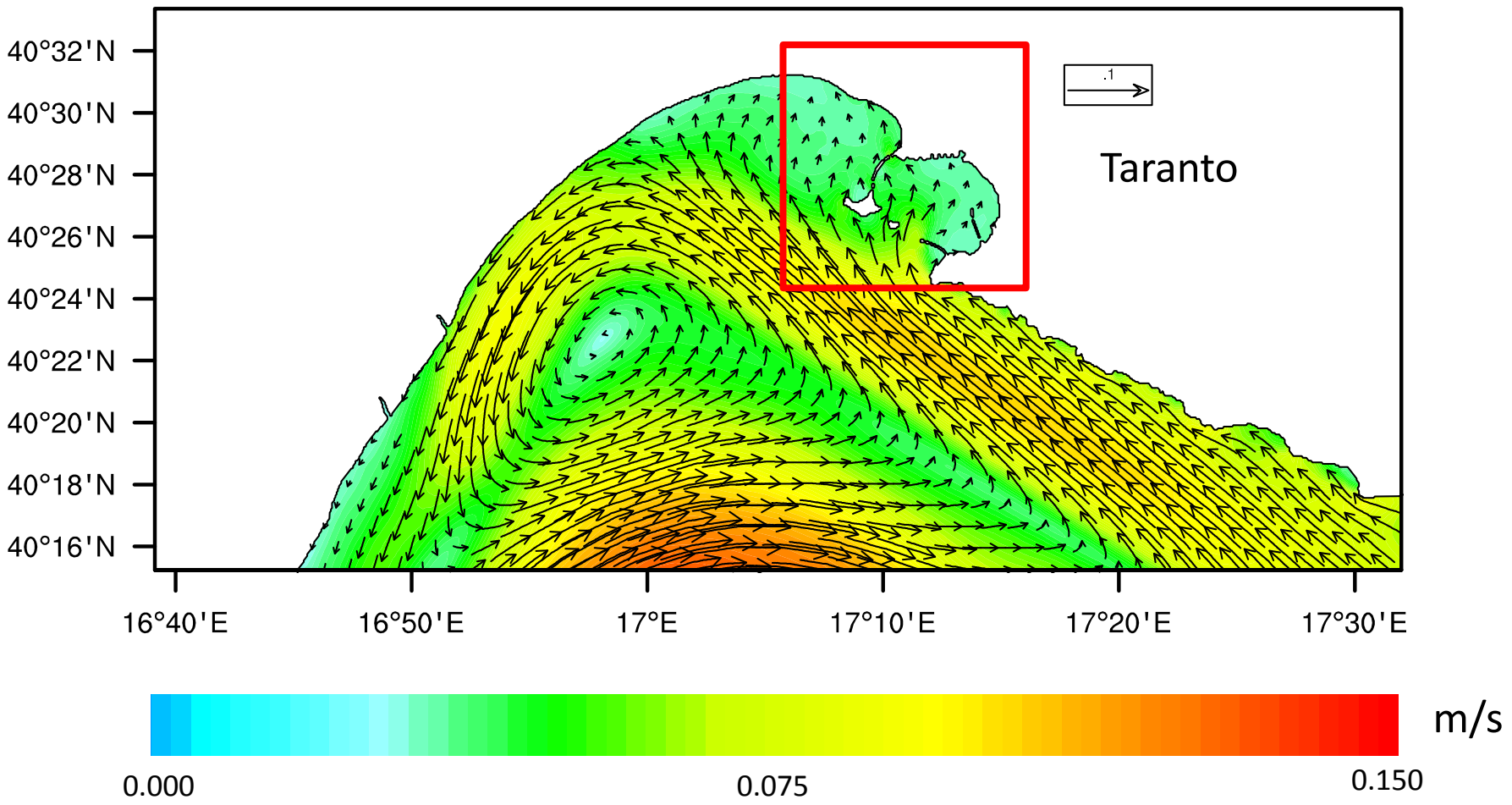


Sea level - ζ (cm)



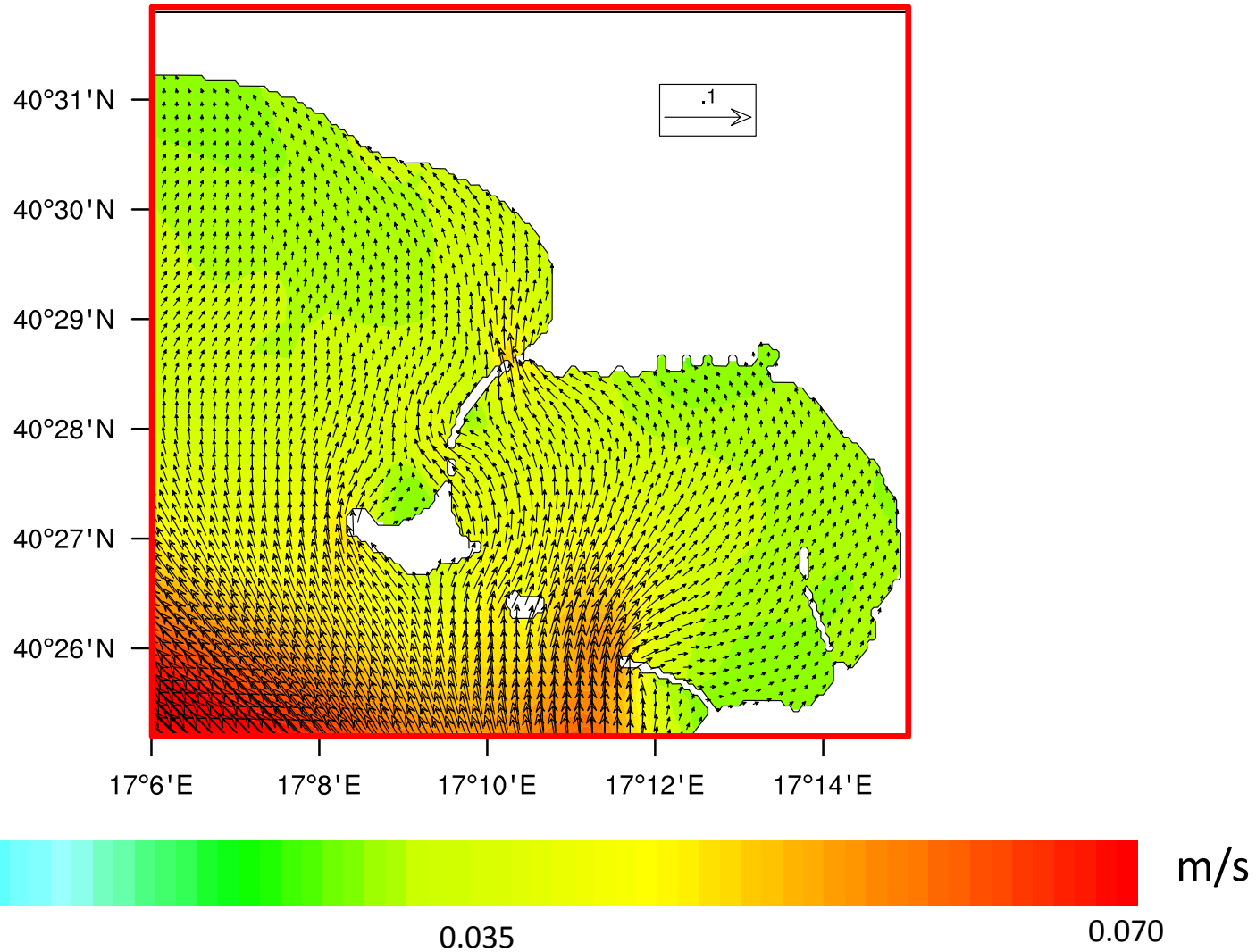
Coastal ocean high-resolution forecasting system – Forecasting

Forecasting: 24 May 2014 - currents



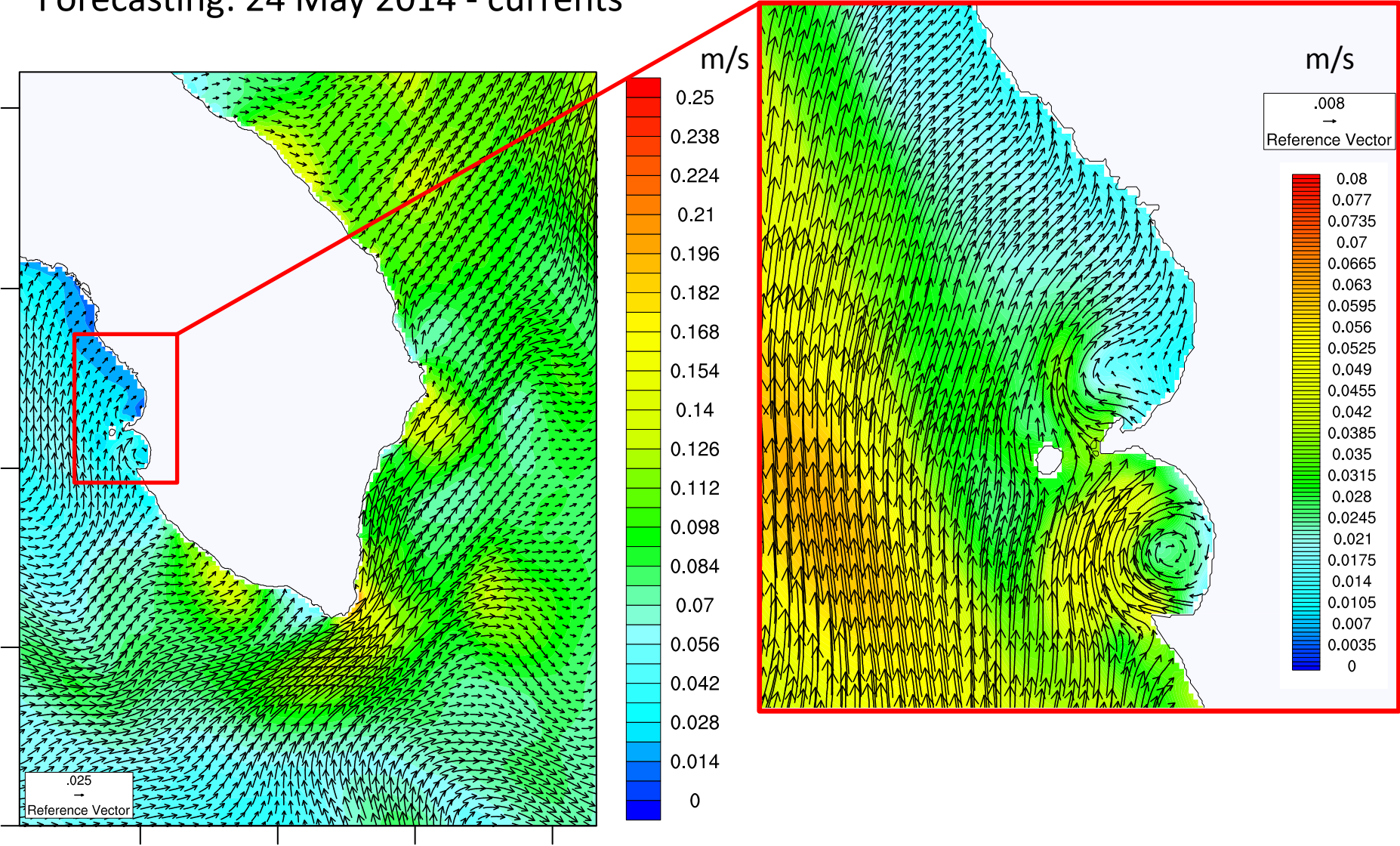
Coastal ocean high-resolution forecasting system – Forecasting

Forecasting: 24 May 2014 - currents



Coastal ocean high-resolution forecasting system – Forecasting

Forecasting: 24 May 2014 - currents



Conclusions

- Climate change indicators on basin scales (Mediterranean sea) in MyOcean
- Climate change scenarios (local scale, coastal areas)
Global climate change scenarios can be used at the coastal scale by use of observations and integrated water cycle modelling, adding complexity and geometry to global scale scenarios
- Coastal ocean high-resolution **forecasting** system
Downscaling approach from open-ocean to coastal areas (SANI region)

è un progetto

labelab

WasteWaterEnergy Engineering

Fare i conti con l'ambiente

Rifiuti acqua energia

>Rave
nna
21.22.23
maggio 2014

7^a EDIZIONE
maggio
2014



Grazie



cmcc

Centro Euro-Mediterraneo
sui Cambiamenti Climatici