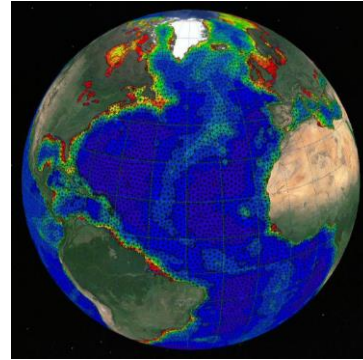
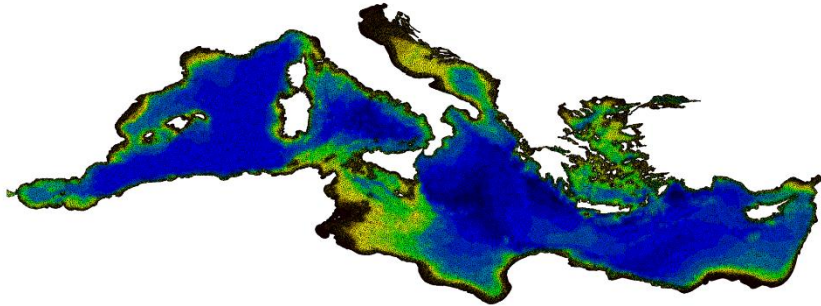


# L'utilizzo dei modelli a diverse scale

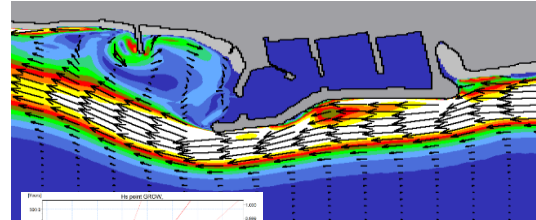
Modelli a scala globale



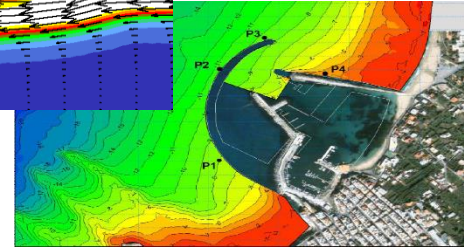
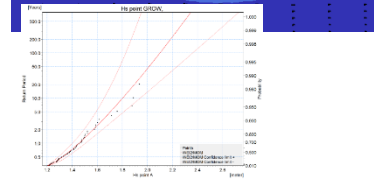
Modelli a scala regionale



Modelli di dettaglio



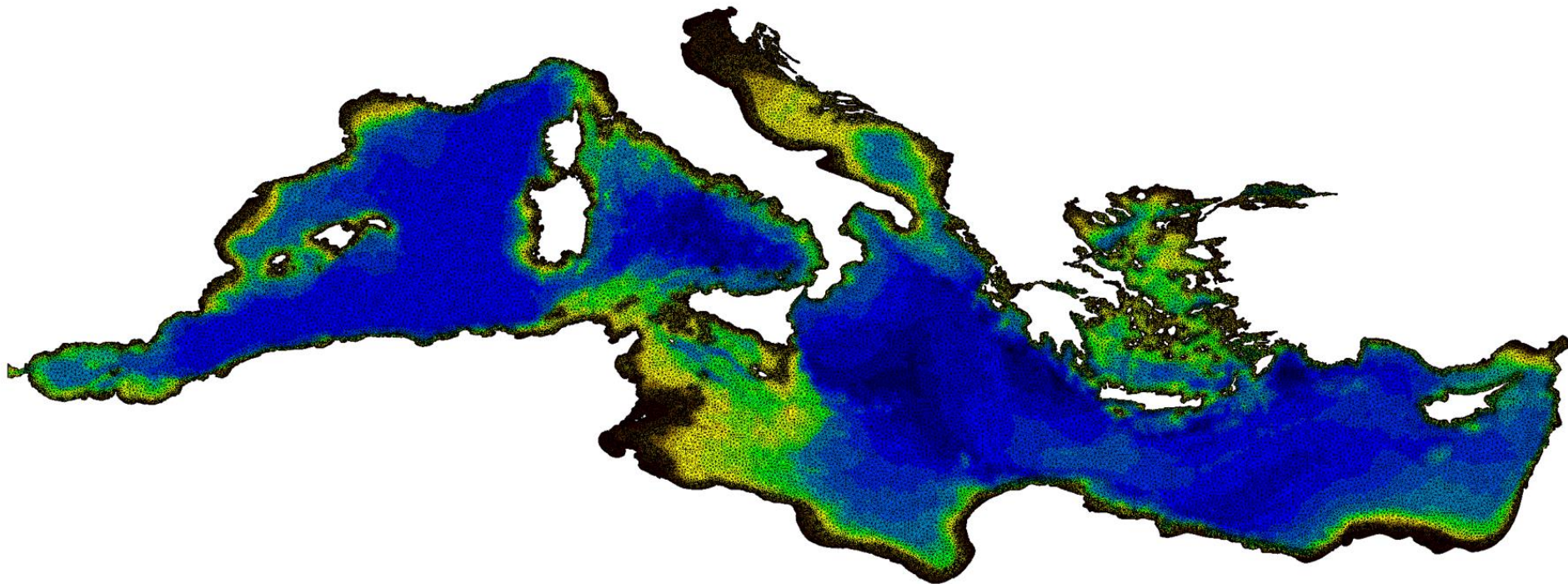
Return Period [years]	Hm0 [m]	SSD Dev. [m]
20	1.89	0.09
50 <sup>1)</sup>	2.01	0.11
100 <sup>1)</sup>	2.10	0.13
200 <sup>1)</sup>	2.18	0.15
500 <sup>1)</sup>	2.29	0.18





# MWM – Mediterranean Wind Wave Model

Un database di vento ed onda nel Mar Mediterraneo



**HyMOLab**  
Hydrodynamics • MetOcean





# Modelling Chain

Global Atmospheric Model (Global)		
CFSR by NCEP	Downloaded Reanalysis	0.5° ( $\approx 50$ km)

Saha, Suranjana, et. al. (2010)  
[The NCEP Climate Forecast System Reanalysis.](#)  
*Bull. Amer. Meteor. Soc.*, Vol. 91, 1015-1057.



IC and BC

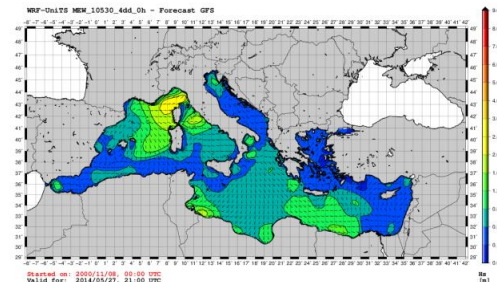
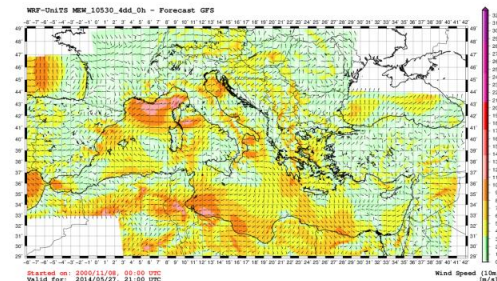
Local Atmospheric Model (Med)		
WRF-ARW	Simulation	0.1° - 0.03°

Michalakes J, et. al., (2005)  
[The WRF Model: Software Architecture and Performance.](#)  
 In Proceedings of the 11<sup>th</sup> ECMWF Workshop on the Use  
 of High Performance Computing in Meteorology. 2005, 56 - 168.



Forcing term

Wave Model (Med)		
MIKE 21	Simulation	0.1° - 0.03°





# Hardware Infrastructure

## InfiniBand Interconnection

Parallel processing

## Virtual Private Network

UniTS datacenter - GARR

## Storage

≈ 82 TB FiberChannel - RAID 6

## 24 compute nodes

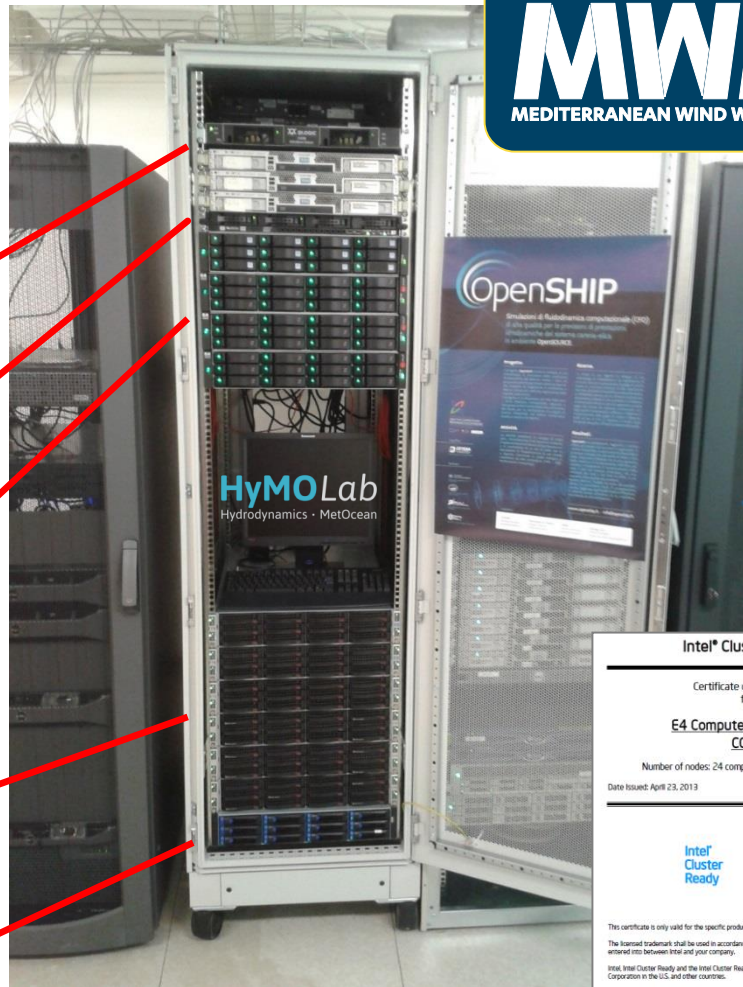
2 x 6 cores/node => 288 cores

700 GB RAM

## Master (head) node

2 x 6 cores/node => 12 cores

96 GB RAM



**MWM**  
MEDITERRANEAN WIND WAVE MODEL

### Intel® Cluster Ready

Certificate of Compliance  
for:

**E4 Computer Engineering**  
**COCA**

Number of nodes: 24 compute nodes and 1 head nodes

Date issued: April 23, 2013

Certificate Number: 20130423001



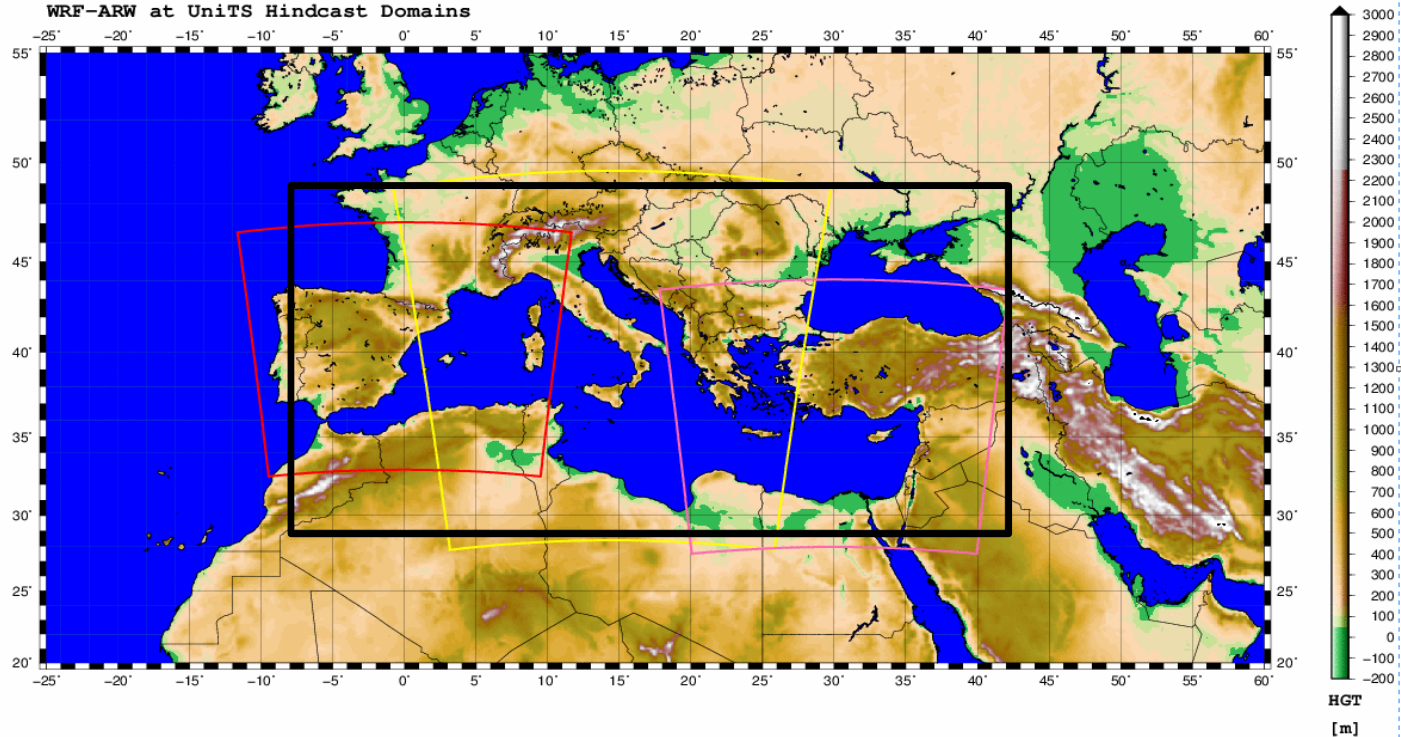
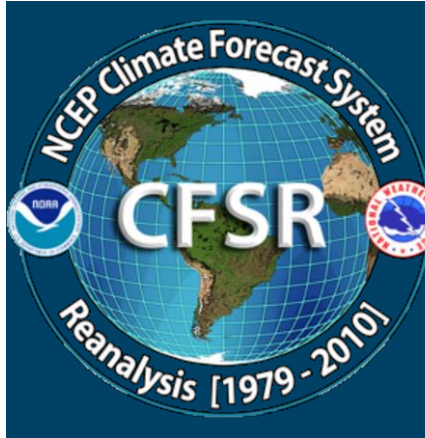
This certificate is only valid for the specific product corresponding to the attached bill of materials.  
The licensed trademark shall be used in accordance with the Intel® Cluster Ready Program Agreement entered into between Intel and your company.  
Intel, Intel Cluster Ready and the Intel Cluster Ready text treatment are trademarks of Intel Corporation in the U.S. and other countries.  
\* Other names and brands may be claimed as the property of others.



# Atmospheric Model

WRF-ARW (NCAR, Boulder) + CFSR (NCAR-NCEP) / GFS

Resolution =  $0.1^\circ$  -  $0.03^\circ$

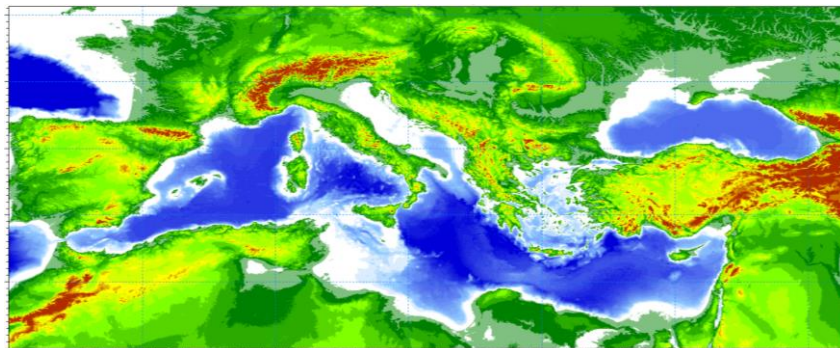




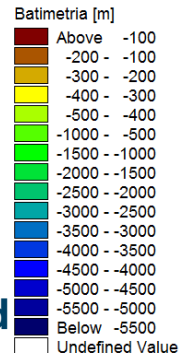
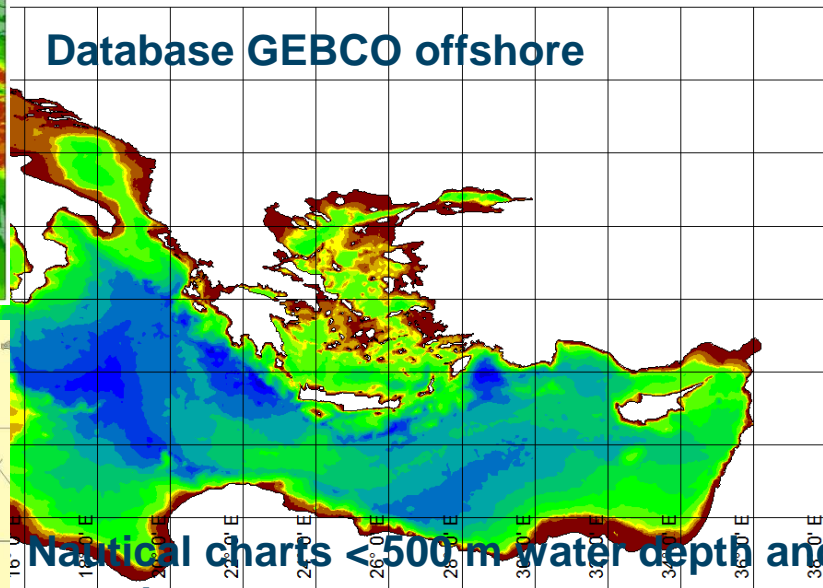
# Wave Model



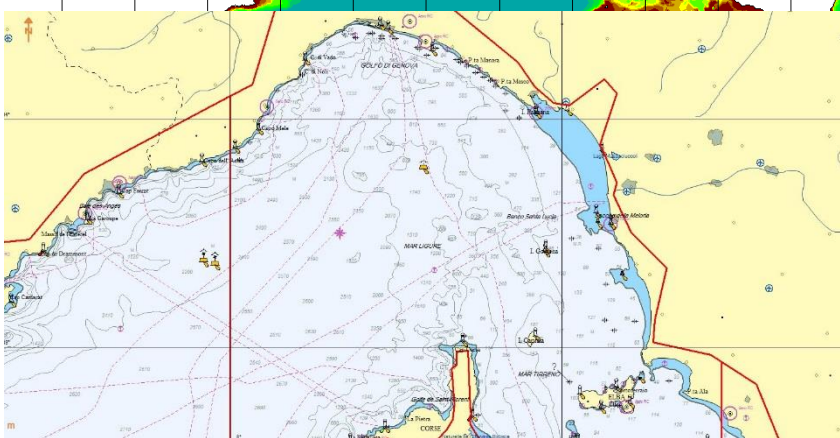
MIKE 21 SW (DHI) - Resolution up to  $0.03^\circ$



Database GEBCO offshore

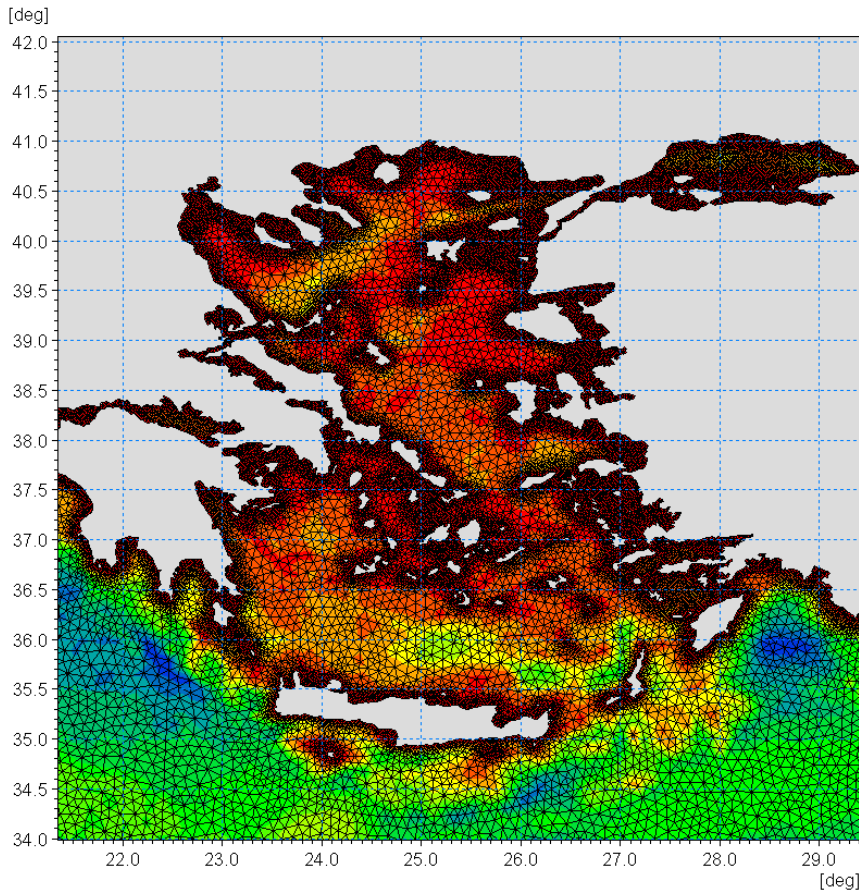


Nautical charts < 500 m water depth and nearshore

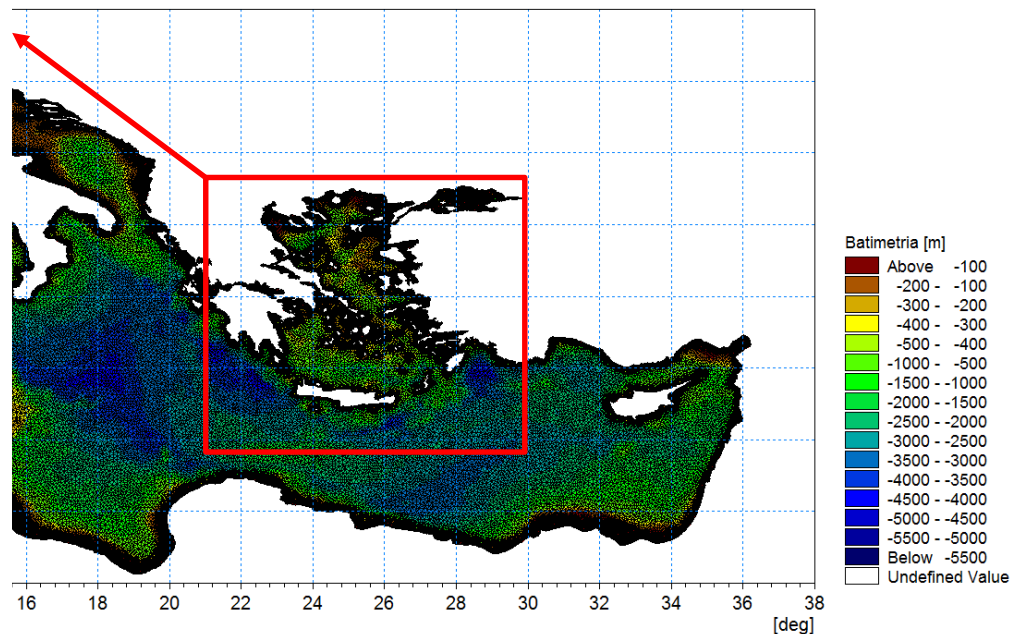




# Wave Model



**MIKE 21 SW (DHI) - Resolution up to  $0.03^\circ$**   
**Bathymetry: GEBCO + Nautical Charts**

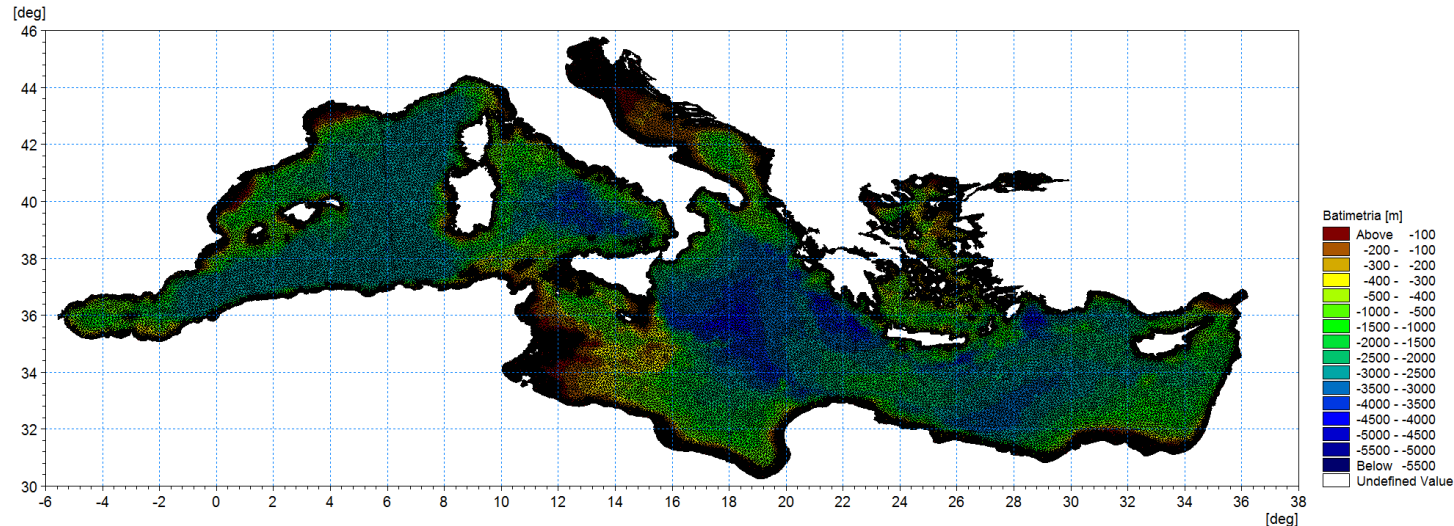




# Wave Model

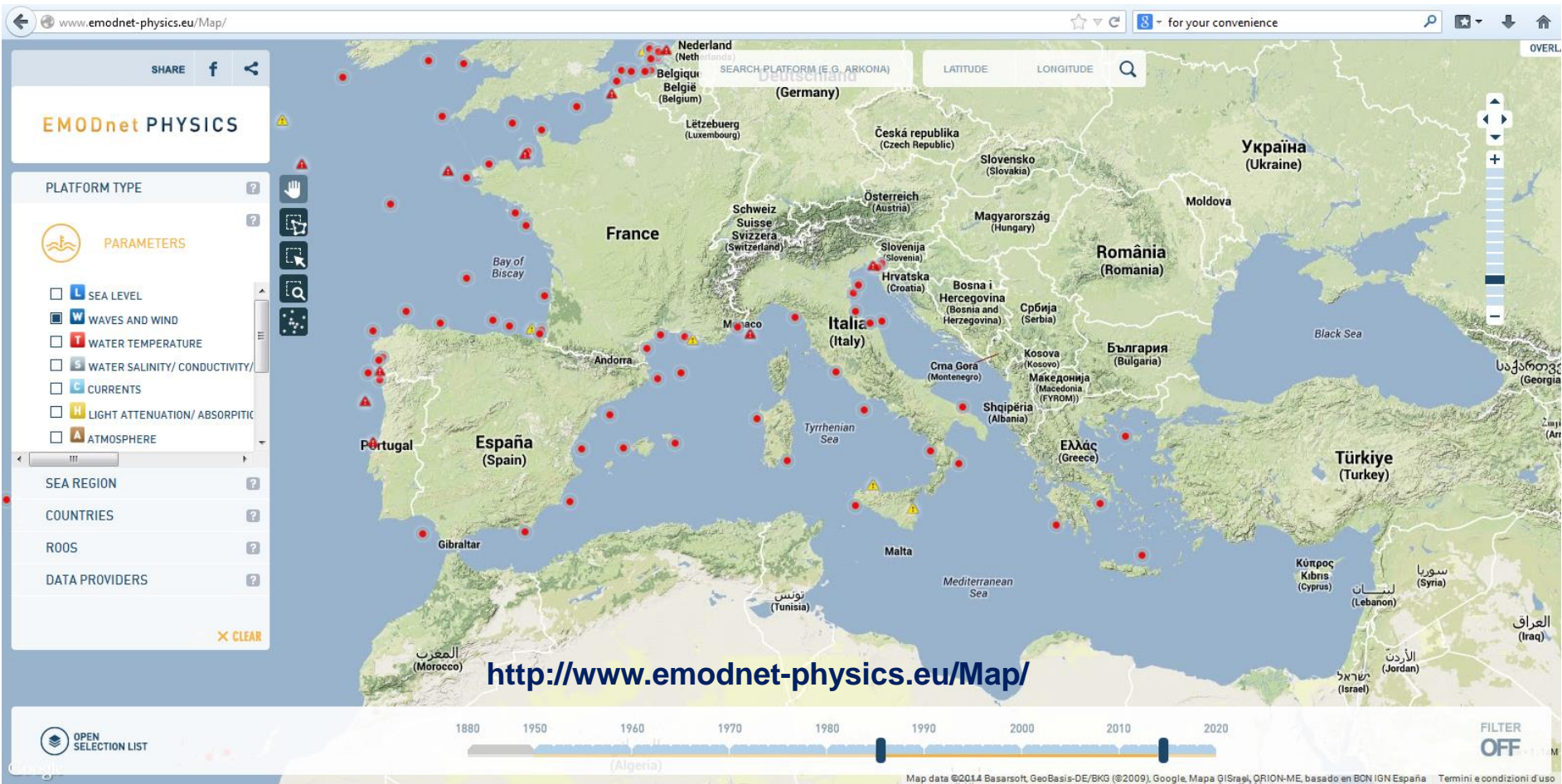


- > 50 configurations tested, accuracy checked against measurements
  - statistical parameters (BIAS, RMS, SI....)
  - time series
- 30 frequencies ( $1.6 < T < 25.0$  s) x 24 directions
- Air-sea interaction: uncoupled formulation
- Main calibration parameters: dissipation due to white capping





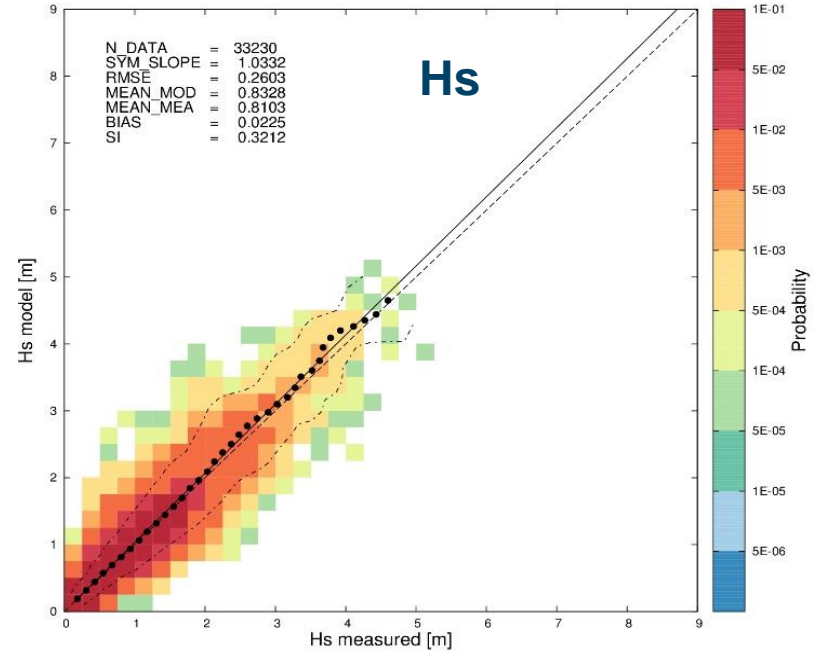
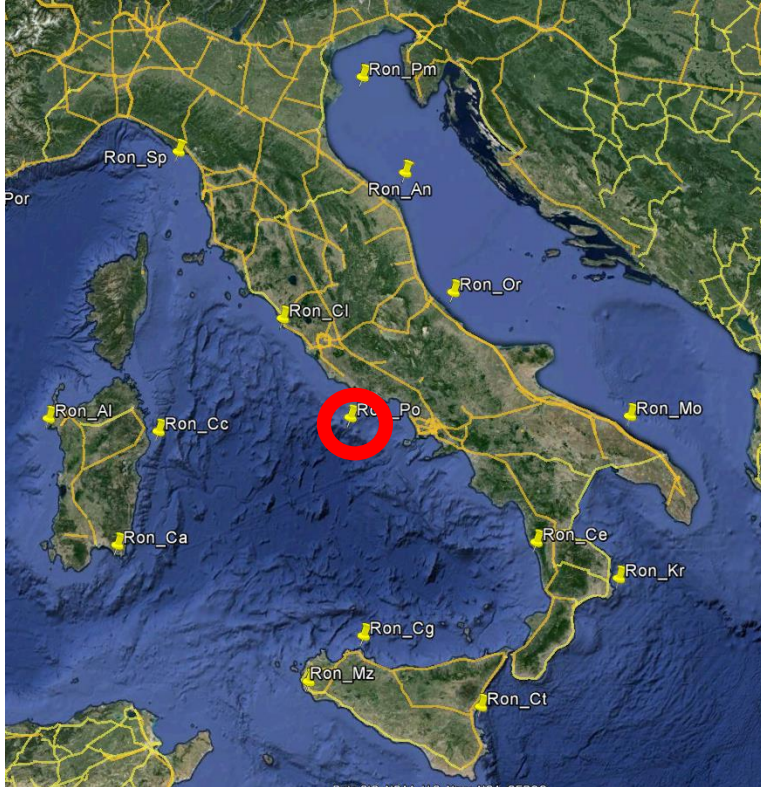
# Extensive validation of model data against measurements....





# Validation against buoys - Tyrrhenian Sea

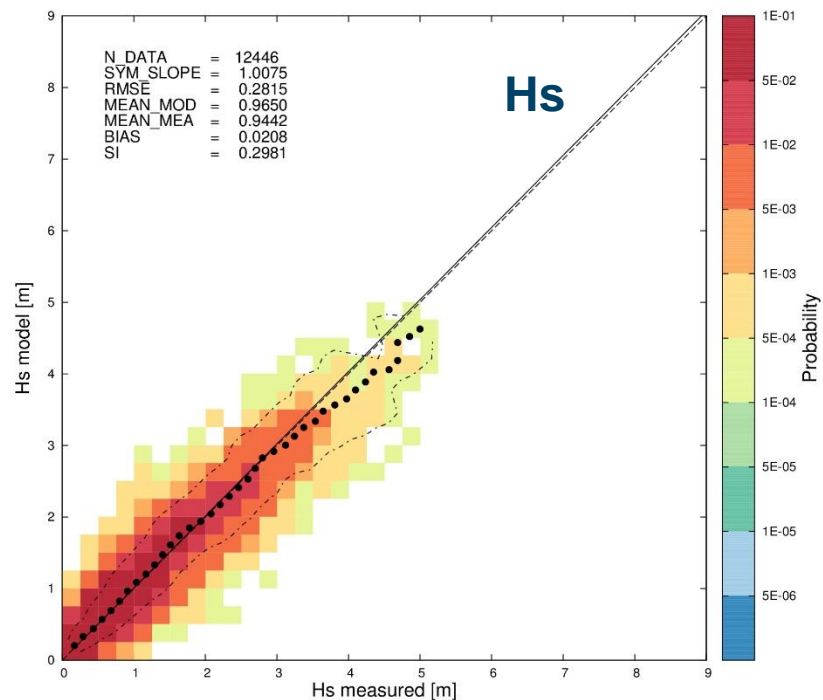
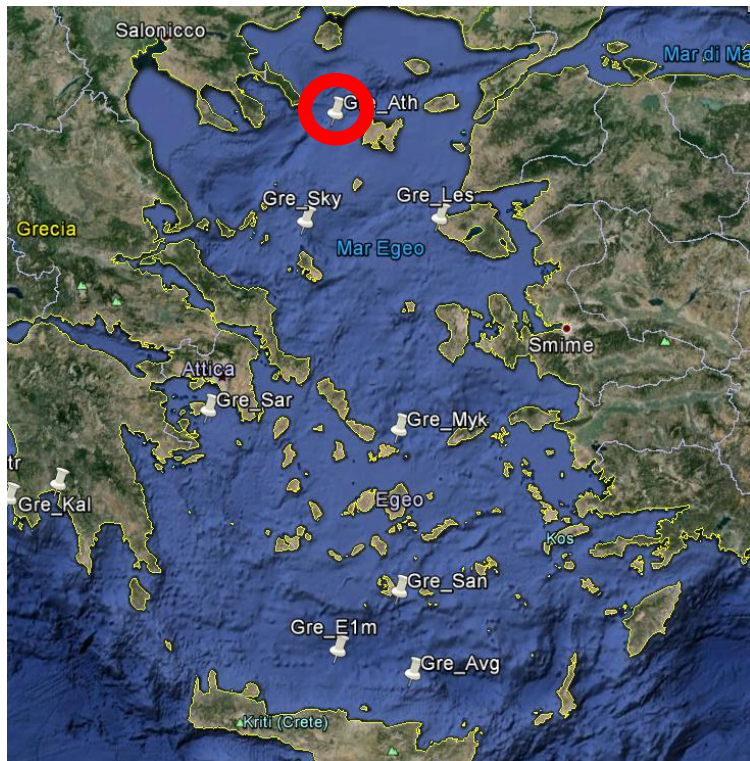
Ponza LON 12.95 LAT 40.87





# Validation against buoys - Aegean Sea

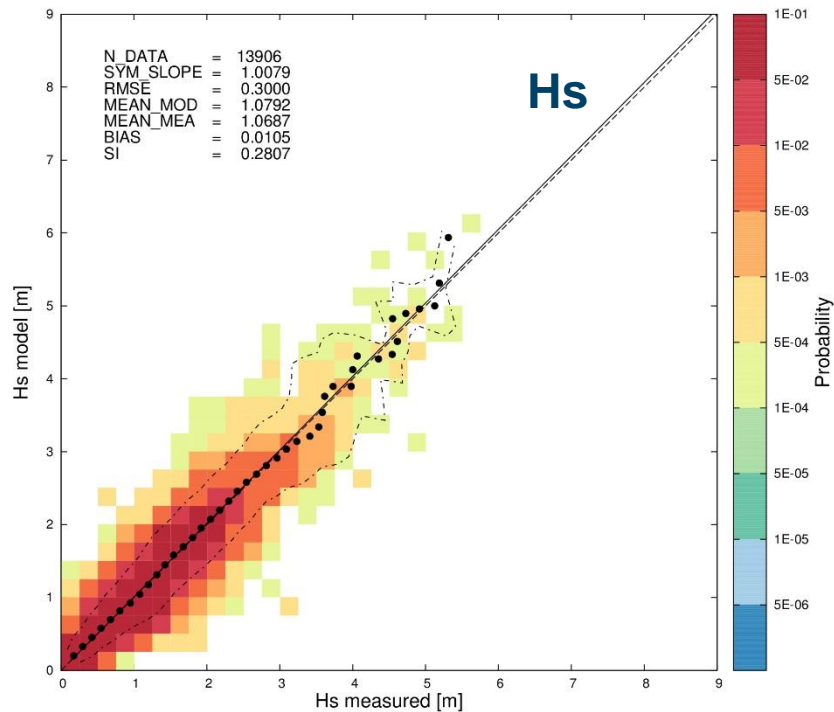
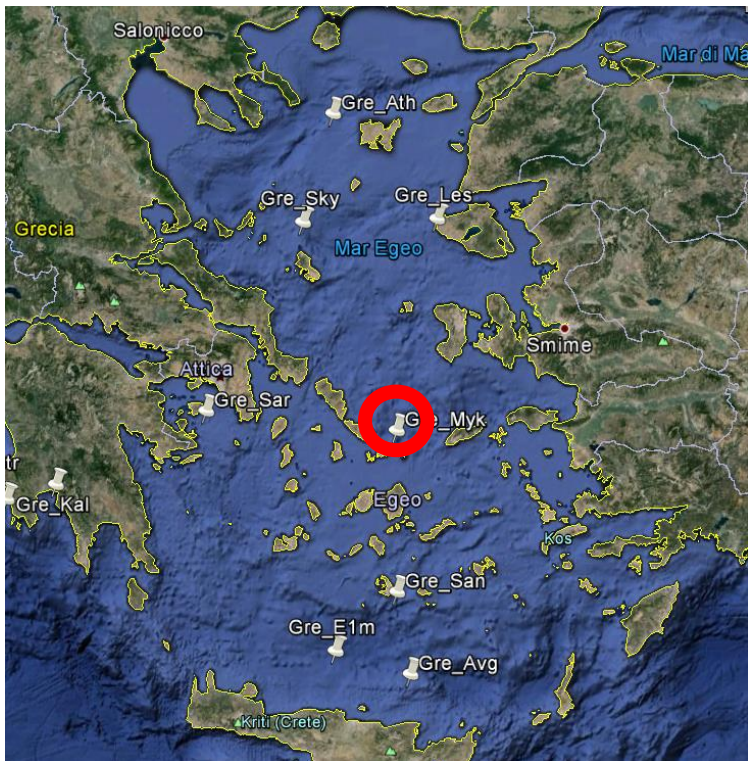
Athos LON 24.72 LAT 39.96





# Validation against buoys - Aegean Sea

Mykonos LON 25.46 LAT 37.51





## ...and satellite data



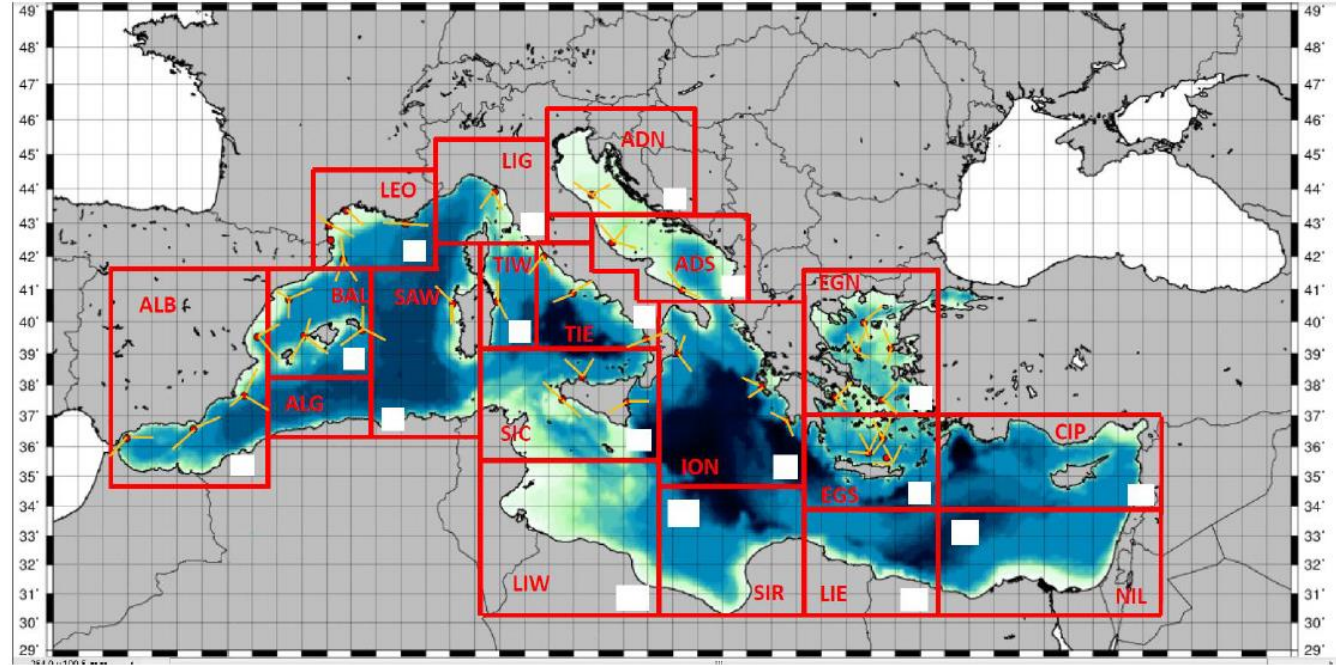
### 7 missions used:

- Envisat
- ERS-2
- Geosat FO
- Jason-1
- Jason-2
- Topex-Poseidon
- CryoSat

Reliable  
estimation of

$W_s$

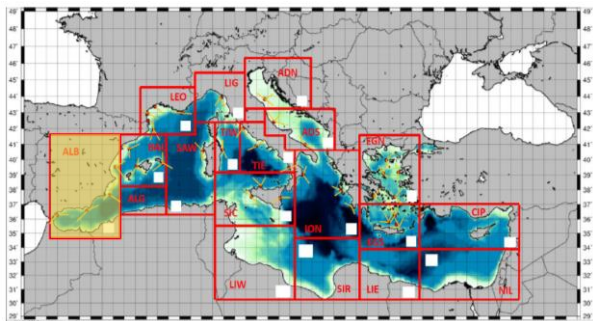
$H_s$



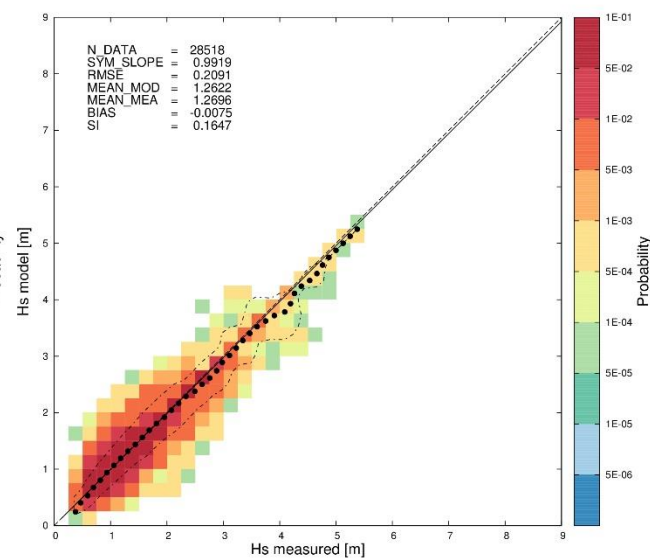
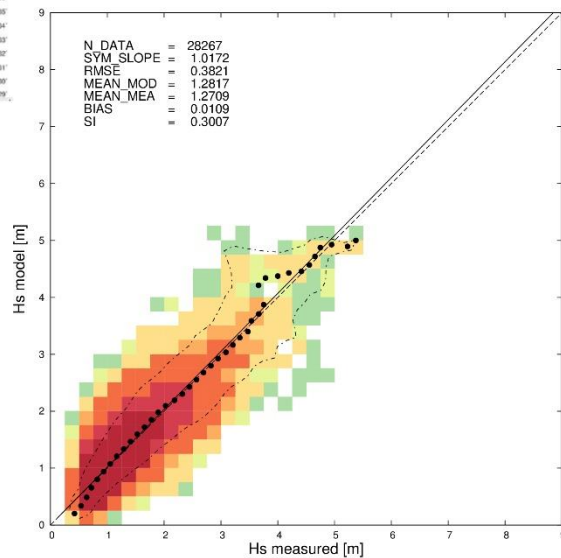
19 sub-domains



# Validation against satellite data - Alboran Sea (2002-2011)



## Envisat, Hs

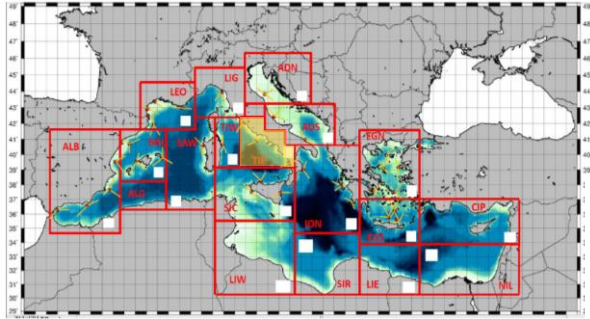


$\Delta\lambda, \Delta\varphi=0^\circ \Delta t=0h$

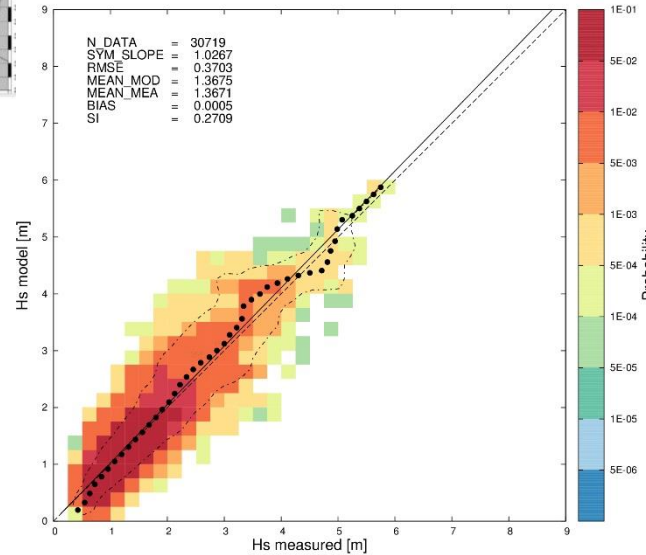
$\Delta\lambda, \Delta\varphi=0.1^\circ \Delta t=3h$



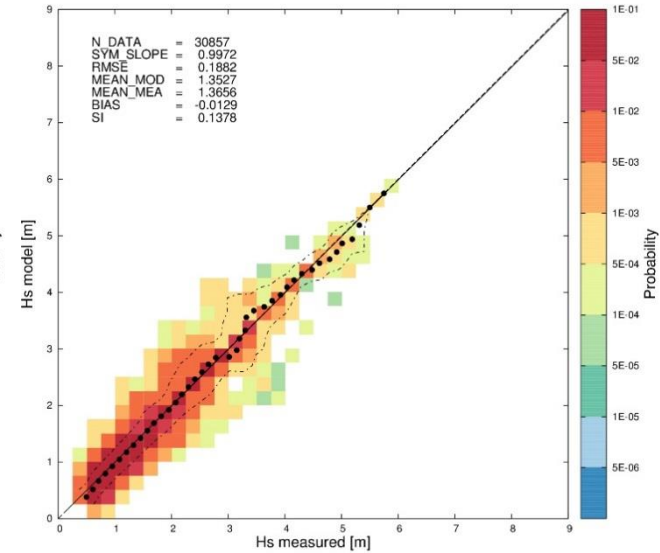
# Validation against satellite data –Thyrrrenian Sea (2002-2011)



## Envisat, Hs



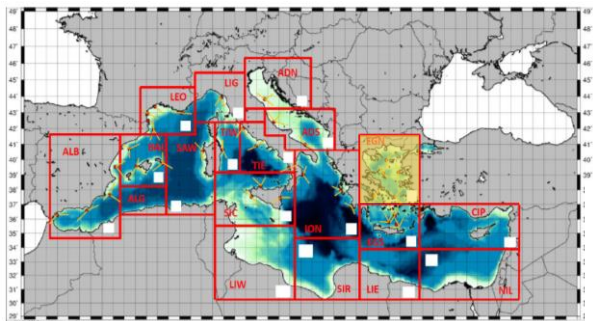
$\Delta\lambda, \Delta\varphi=0^\circ \Delta t=0h$



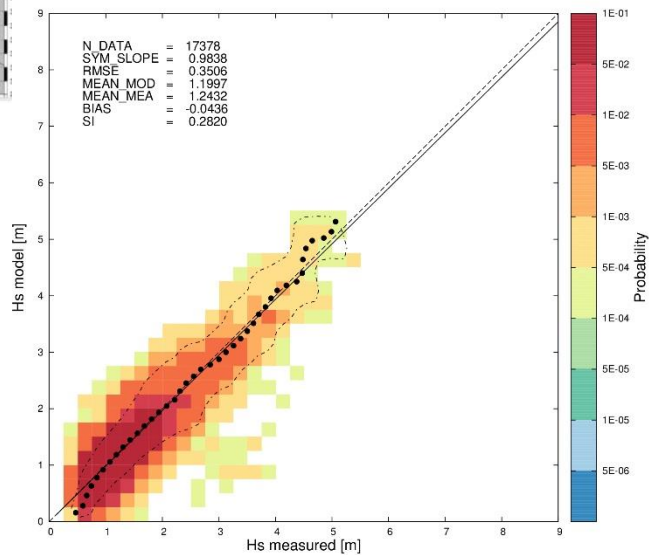
$\Delta\lambda, \Delta\varphi=0.1^\circ \Delta t=3h$



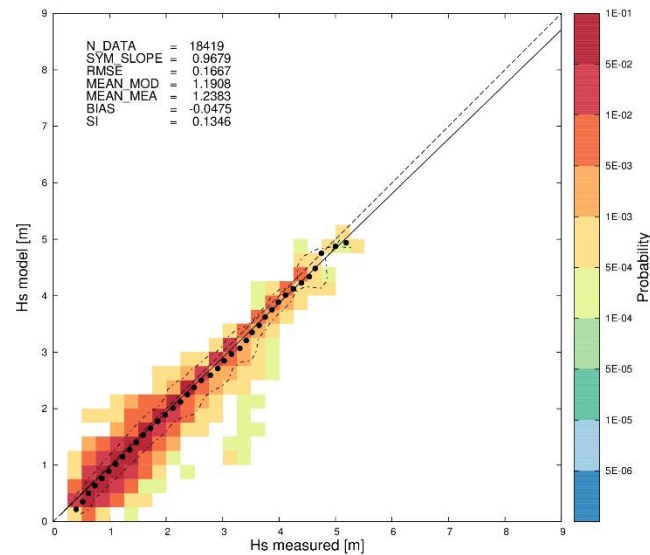
# Validation against satellite data - Aegean Sea (2002-2011)



## Envisat, Hs



$\Delta\lambda, \Delta\varphi=0^\circ \Delta t=0h$



$\Delta\lambda, \Delta\varphi=0.1^\circ \Delta t=3h$



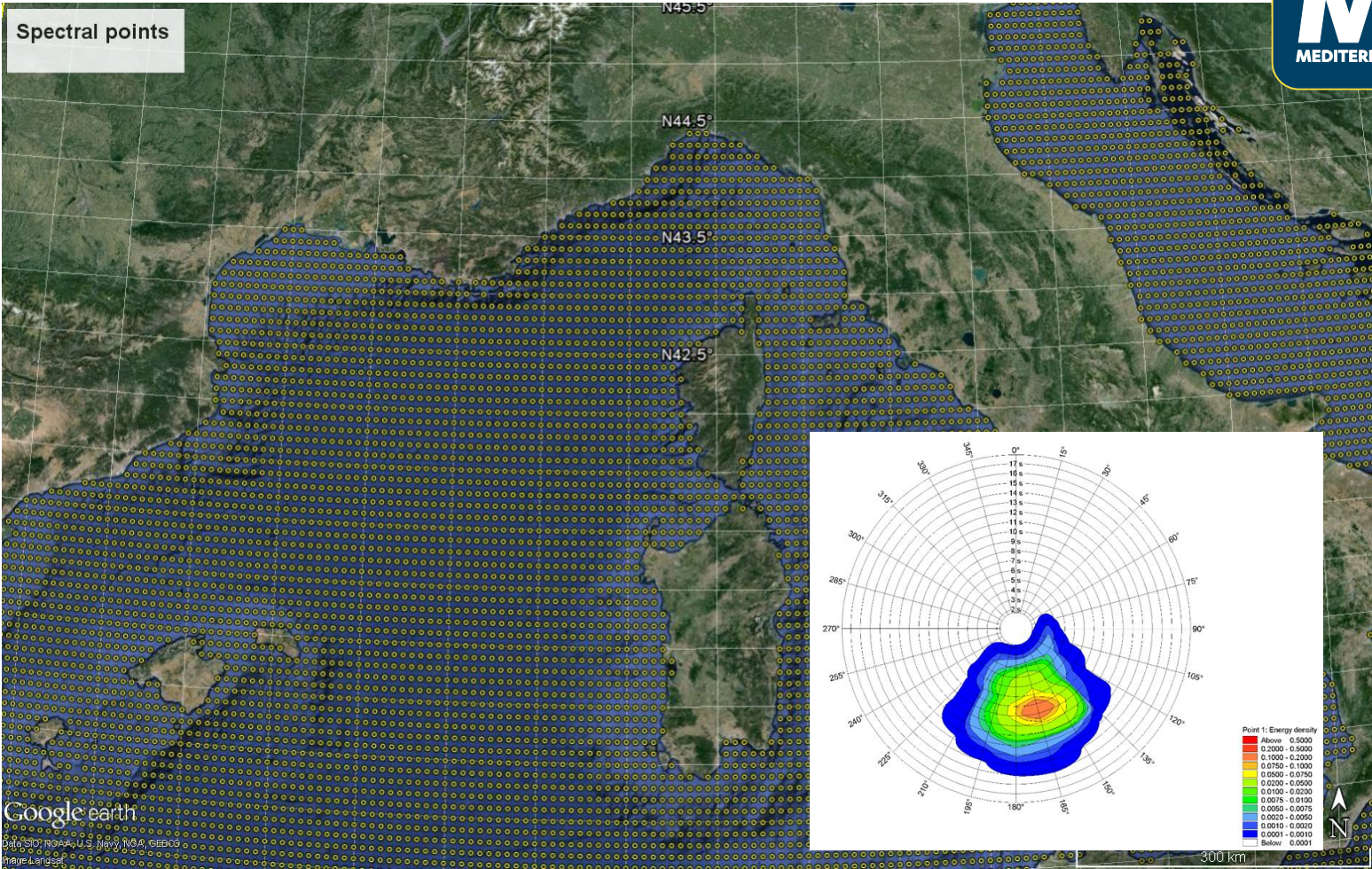
## Available products



- *39 years of hindcast data (1979-2017)*
- *Spatial resolution:  $0.1^{\circ}$  (~10 km) for wind and up to  $0.03^{\circ}$  (~3km) for waves*
  - Wind speed, WS [m/s]
  - Wind direction, WD [deg]
  - Significant Wave height, Hs [m]
  - Mean wave period, Tm [s]
  - Peak wave period, Tp [s]
  - Zero crossing period, Tz [s]
  - Mean wave direction, MWD [deg]
  - Peak wave direction, PWD [deg]
  - Directional standard deviation, DSD [deg]
- **Spectral data available on  $0.1^{\circ} \times 0.1^{\circ}$  grid (10 km x 10 km)**




# Available products





# Downscaling of global / regional models



**COPERNICUS**  
**MARINE ENVIRONMENT MONITORING SERVICE**  
Providing PRODUCTS and SERVICES for all marine applications

Search terms



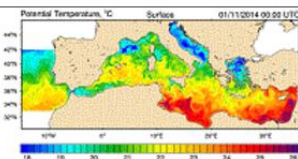
ABOUT US | BENEFITS | NEWS | SCIENCE & MONITORING | TRAINING | SERVICES PORTFOLIO | **SHORT-CUT TO SERVICES**

Home > Services portfolio > Access to products



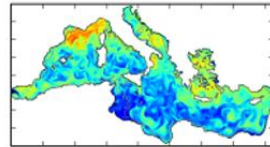
**ONLINE CATALOGUE**   MY CART

**YOUR SEARCH**   
  
**REGIONAL DOMAIN**   
Mediterranean Sea  
**PARAMETERS**   
**TEMPORAL COVERAGE**  
From  To   
☐ If checked, the search results will only show products containing the whole selected time range  
**PRODUCT WITH DEPTH LEVEL** ☐

Found **29 products** matching your criteria.  

<b>MEDSEA_ANALYSIS_FORECAST_PHYS_006_001</b>	
MEDITERRANEAN SEA PHYSICS ANALYSIS AND FORECAST	
MODEL	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
3DUV MLT S SSH T <input type="button" value="i"/>	
0.06 degree x 0.06 degree (72 depth levels)	
From 2013-01-01 to Present	
daily-mean, hourly-mean	
MORE INFO 	ADD TO CART  WMS Sub-setting
	

<b>MEDSEA_ANALYSIS_FORECAST_BIO_006_006</b>	
MEDITERRANEAN SEA BIOGEOCHEMISTRY ANALYSIS AND FORECAST	
MODEL	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
O2 NO3 PO4 CHL phyto <input type="button" value="i"/>	
0.06 degree x 0.06 degree (72 depth levels)	
From 2013-01-01 to Present	
daily-mean	
MORE INFO 	ADD TO CART  WMS Sub-setting
	



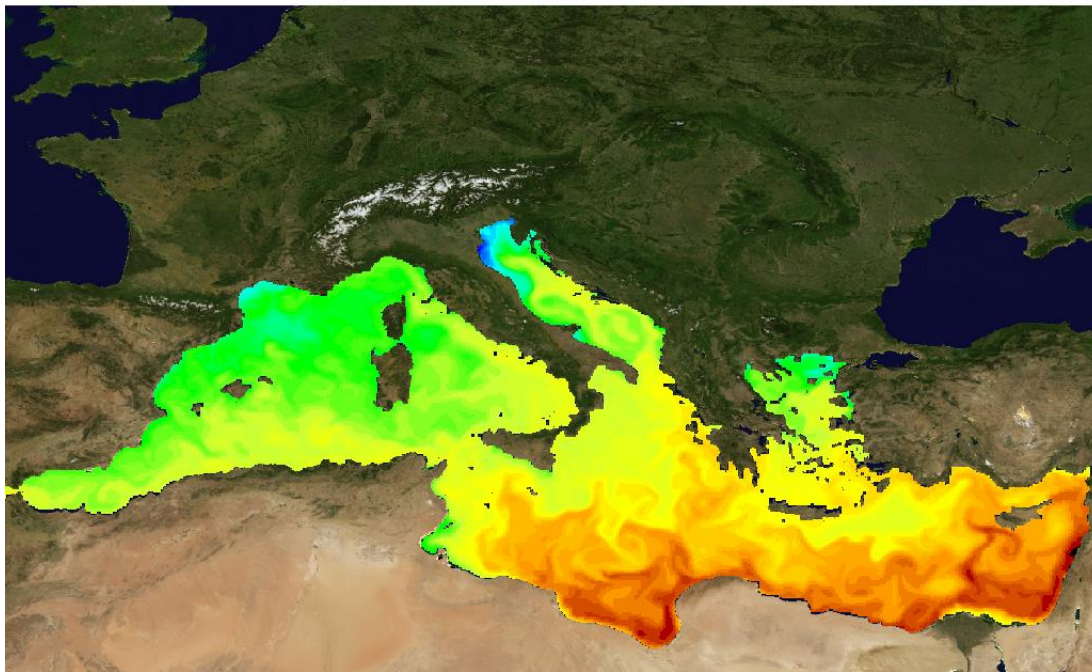


# 3D model of Mediterranean Sea (MFS)

The 3D model of Ligurian Sea is an example of *downscaling* of the Mediterranean model MFS, characterized by spatial resolution  $1/16^\circ \times 1/16^\circ$  ( $\sim 6.5 \times 6.5$  km) available within Copernicus Marine Services



Potential Temperature (3D) - Daily Mean  
sea water potential temperature  
Date: 2013-12-31 00:00 UTC  
Depth: 1.47m



MFS provides forecast and hindcast of:

## surface parameters:

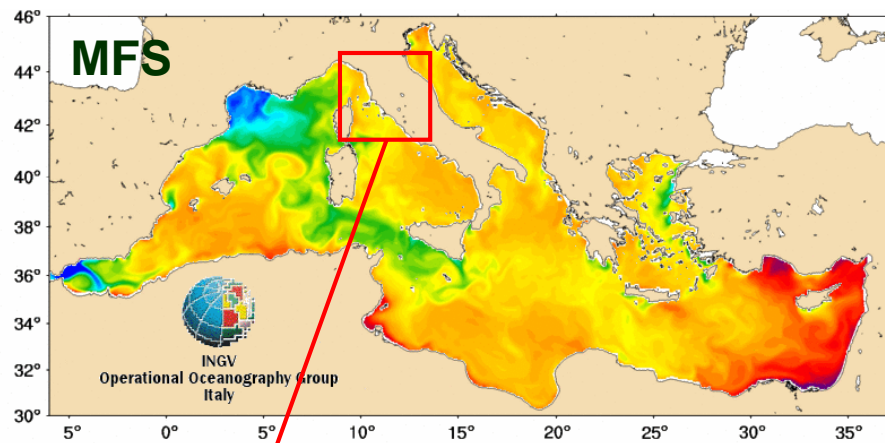
- surface elevation
- total heat flux
- radiative flux

## water column parameters:

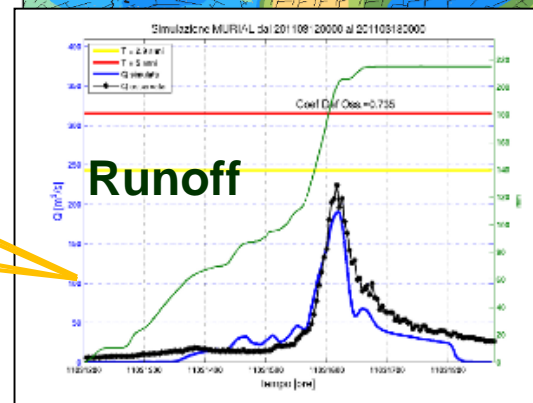
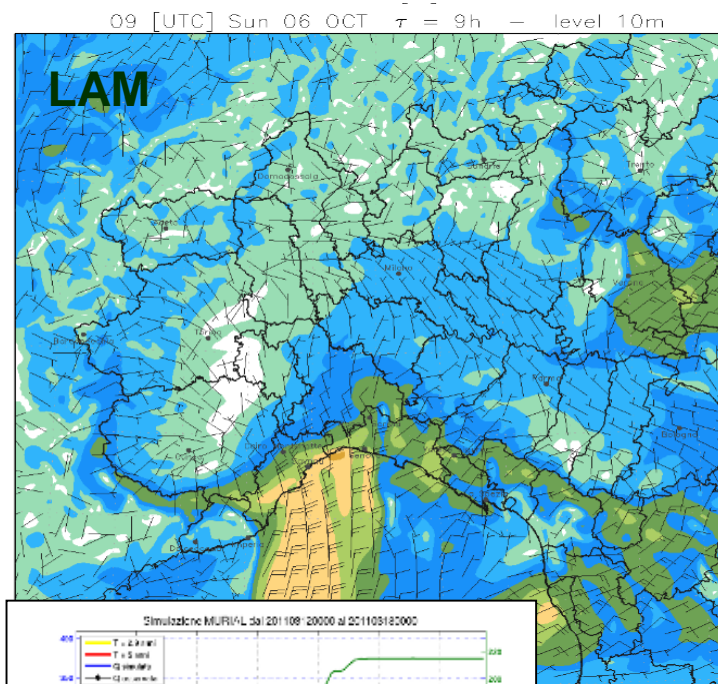
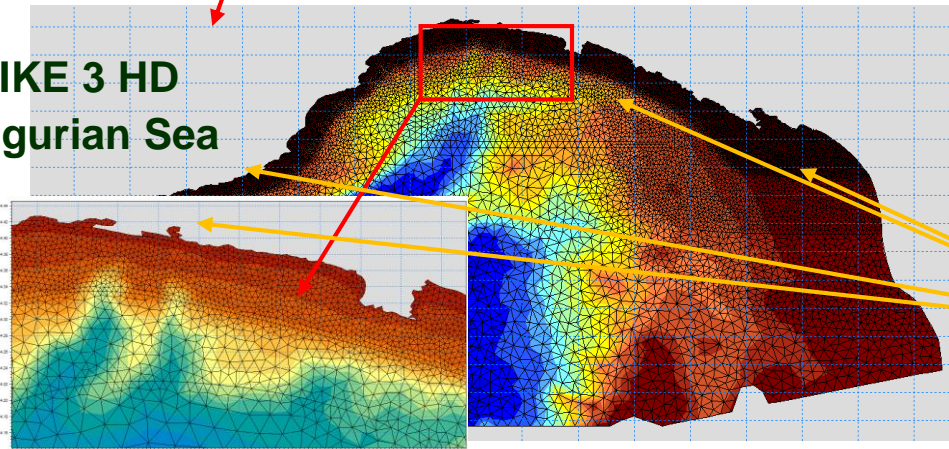
- temperature
- salinity
- zonal component of velocity
- meridional component



# 3D model of Ligurian Sea

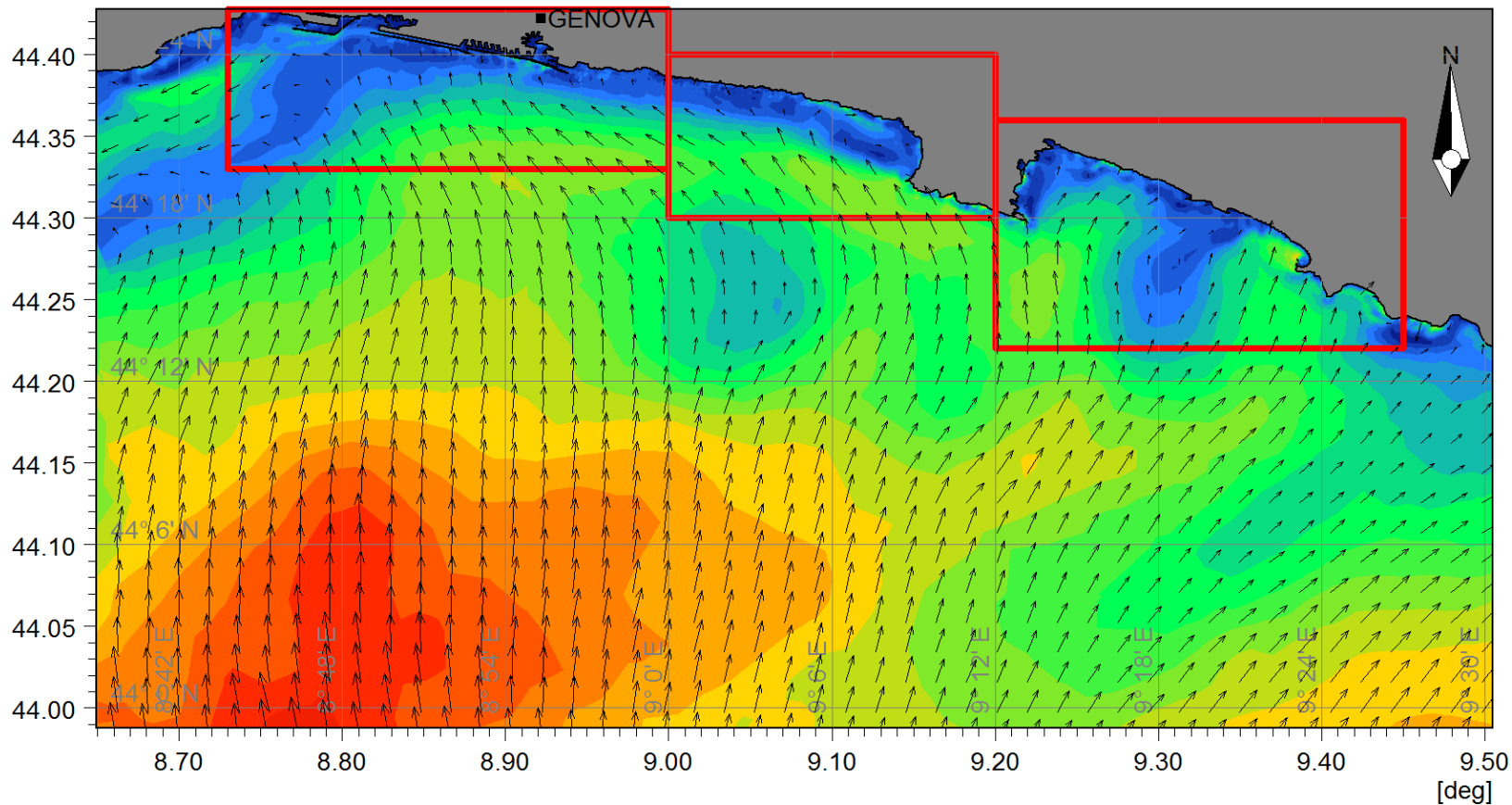


**MIKE 3 HD  
Ligurian Sea**



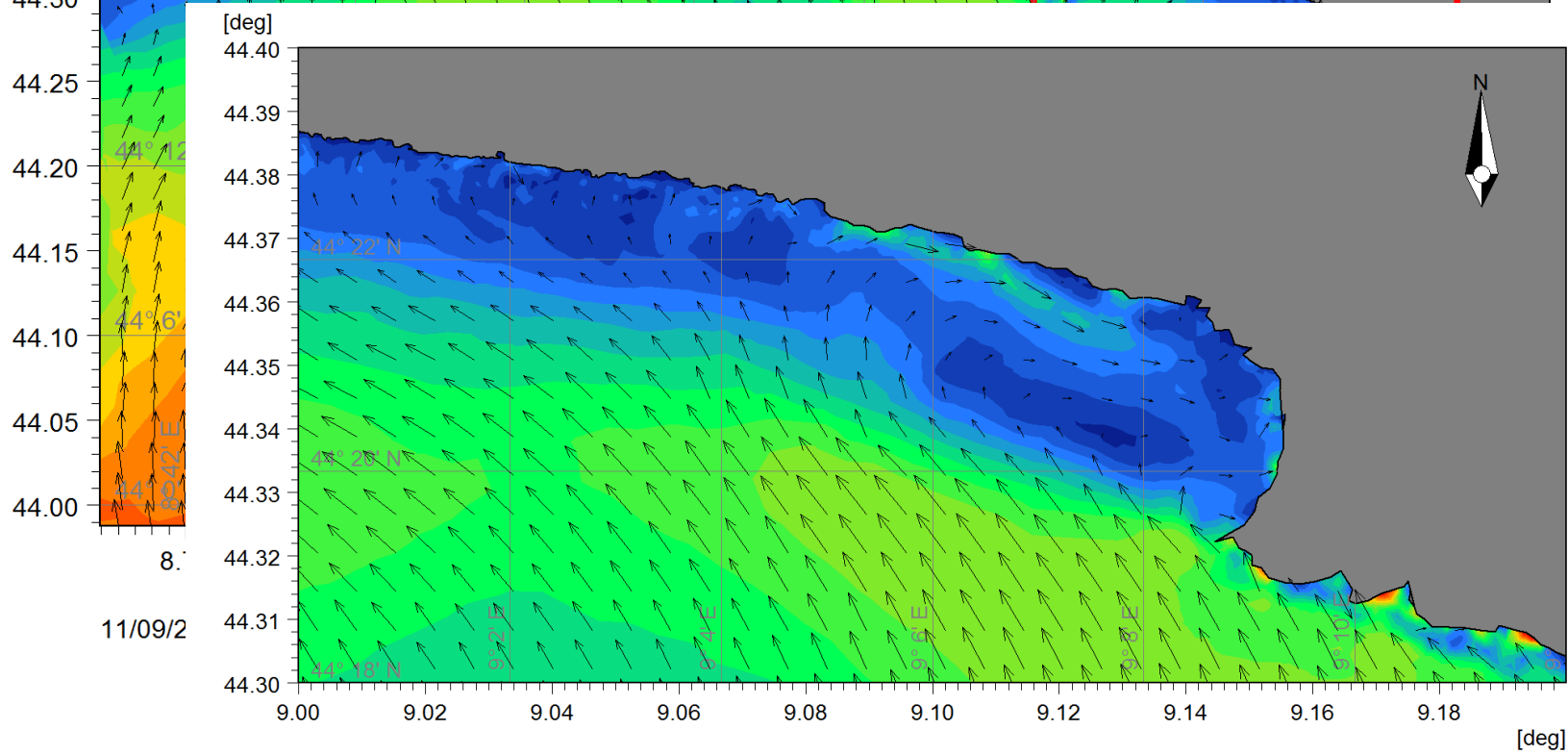
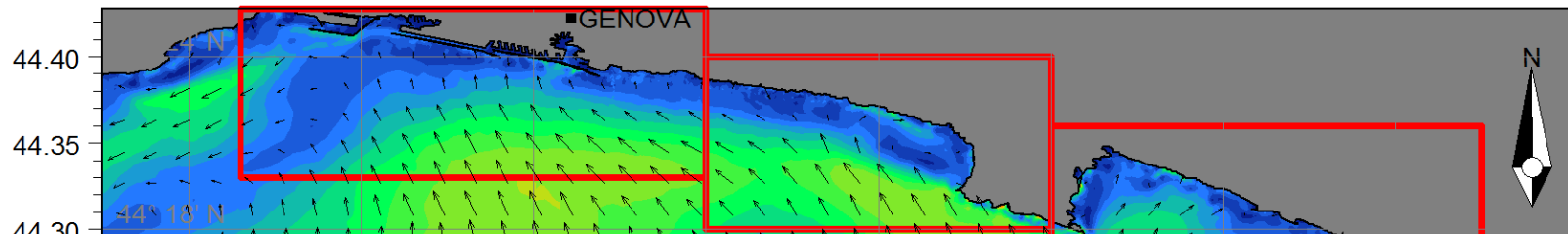


[deg]



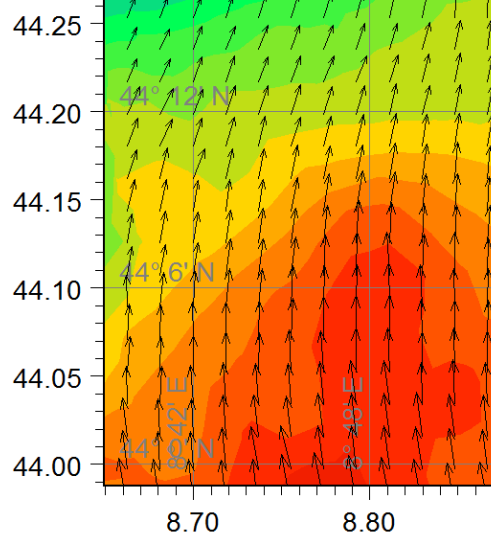
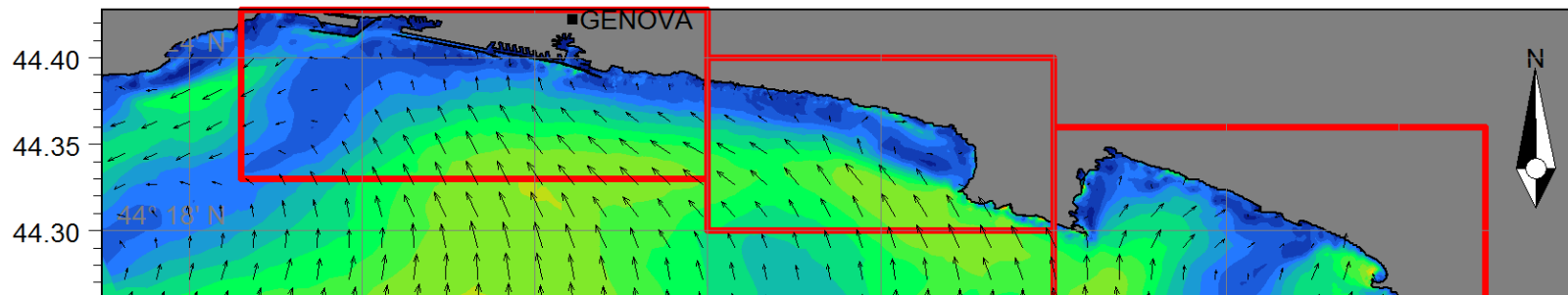


[deg]





[deg]



11/09/2014 12:00:00

