

# **The POSEIDON System: An operational monitoring, forecasting and information system for marine environmental conditions in the Eastern Mediterranean**

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***What is Operational Oceanography: The delivery of products (data, forecasts) to support the human activities in marine environment***



EuroGOOS

European Global Ocean  
Observing System


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EO

EuroGOOS &gt; About EuroGOOS &gt; What is Operational Oceanography?

## What is Operational Oceanography?

Operational Oceanography can be defined as the activity of systematic and long-term routine measurements of the seas and oceans and atmosphere, and their rapid interpretation and dissemination.

Important products derived from operational oceanography are:

- nowcasts providing the most usefully accurate description of the present state of the sea including living resources
- forecasts providing continuous forecasts of the future condition of the sea for as far ahead as possible
- hindcasts assembling long term data sets which will provide data for description of past states, and time series showing trends and changes

Operational Oceanography usually proceeds by the rapid transmission of observational data to data assimilation centres. There, powerful computers using numerical forecasting models process the data. The outputs from the models are used to generate data products, often through intermediary value-adding organisations. Examples of final products include warnings (of coastal floods, ice and storm damage, harmful algal blooms and contaminants, etc.), electronic charts, optimum routes for ships, prediction of seasonal or annual primary productivity, ocean currents, ocean climate variability etc. The final products and forecasts must be distributed rapidly to industrial users, government agencies, and regulatory authorities.

(Source: EuroGOOS)

# Fundamental terms of Operational Oceanography

- **Monitoring:** Measurements in real time (in-situ or remote sensed), numerical models for nowcasting
- **Forecasting:** Numerical forecasting models, data assimilation techniques
- **Dissemination:** Products available to the end users (governmental agencies, industrial users, regulatory authorities, public) in a comprehensive way.



# Applications of Operational Oceanography



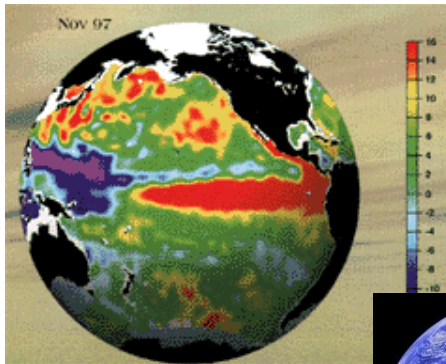
***Safety in the sea***



***Management of marine resources***



***Effective response to pollution accidents***



***Global climate change***



***Efficient planning of marine infrastructure***



# POSEIDON: An operational monitoring, forecasting and information system for marine environmental conditions in the Eastern Mediterranean

## Observations

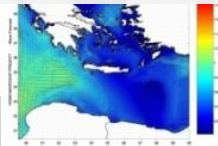
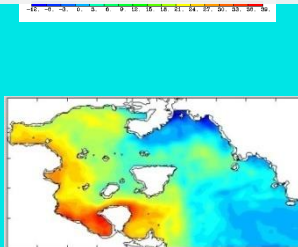


## Processing & Modeling

Significant wave height and direction on 08/07/01 Hour:00:00 UTC

## Information and Decision Support Systems

- ✓ Targeted to end-user needs (incl. public): maritime transport, fisheries, tourism, environment protection, research
- ✓ **Developed through infrastructure funding (EEA & national funds):**  
14.1 M€ in 1997-2000, 9.8 M€ in 2005-2010, 1.2 M€ in 2010-2012
- ✓ Operated by I.O. of HCMR since 2000 – Supported by Greek NMS & Navy
- ✓ Continuously upgraded through collaborative research projects
- ✓ Integrated with / contributing to major European projects and initiatives



End Users

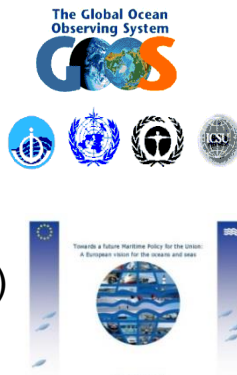
## The Vision / Motivation

“An integrated system able to support science, safety, environment and maritime economy in Greece” e.g.

- **Research** oriented applications (climatic variability, ecosystem functioning)
- Support of **maritime transport** (forecasts, SAR)
- Environment **protection** (ecosystem health, oil pollution)
- Support of **tourism** industry (water quality, yachting, ..)
- **Fisheries** and aquaculture management
- **Coastal** zone management (erosion, etc) & Water framework directive

## Development Strategy

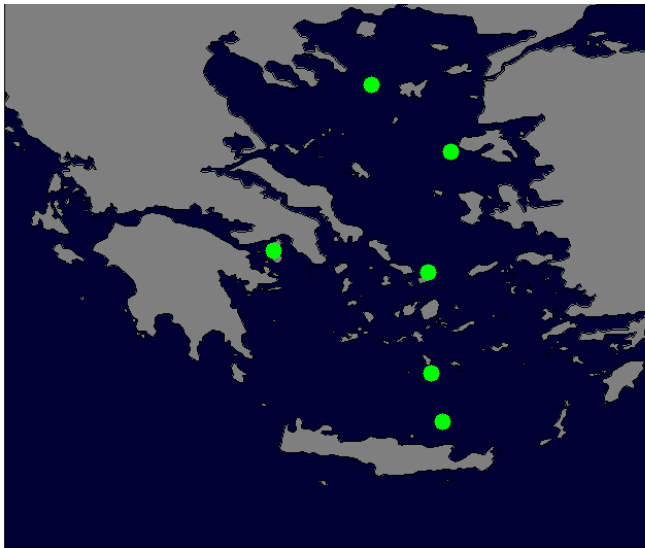
- Embed into appropriate policy frameworks: IOC/GOOS, EuroGOOS, MedGOOS, GEO
- Balance between the operational and research character of the infrastructure
- Integrate national investments with European initiatives: GMES, EMODnet, ESFRI
- Complementarity between national and EU projects: MFSTEP, MERSEA, ECOOP, MARCOAST, MYOCEAN I & II, JERICO, EuroARGO, FixO3 (**25 EU projects since 2000**)
- Integrate coastal - shelf - deep systems & scales: necessary due to specificities of Greek Seas



# Poseidon Monitoring Component: 2000-2006

## Main system development

11 buoys – 6 locations



- *Measurements at the sea surface*
- *Temperature and Salinity recordings down to 50m in selected locations*



### Moorings

Sensors:

#### Atmospheric

- Air temperature
- Atmospheric pressure
- Wind Speed/Direction

#### Oceanographic

- Temperature
- Salinity
- Currents
- Waves

#### Water quality

- Chlorophyll-A
- Oxygen
- Turbidity
- Radioactivity



# Poseidon Monitoring Component: 2007-2012

## Major System Upgrade and Extension

10 locations – 16 buoys

5 new moorings (WaveScan) to support deep sea monitoring including ecosystem variables

### Monitoring network extended to Ionian Sea

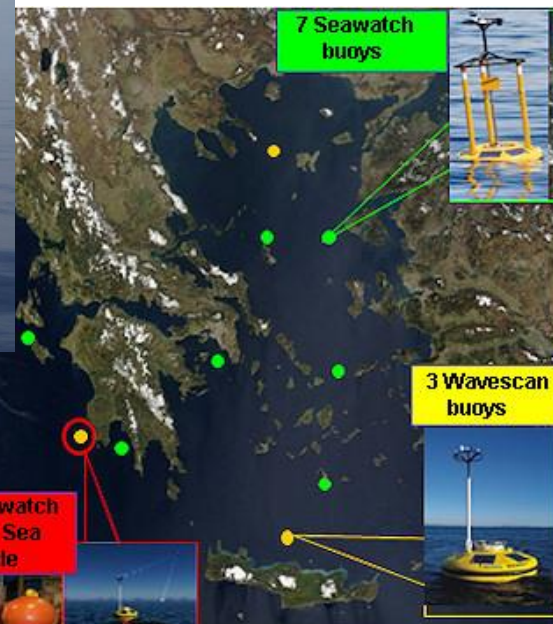
#### ✓Eight met-ocean buoys

- ✓Atmospheric data (wind speed & direction, atmospheric pressure, air temperature)
- ✓Marine data (waves, surface currents, temperature & salinity down to 100m in selected locations)

#### ✓Two reference stations

Cretan Sea  
Pylos-Ionian Sea

#### ✓One seafloor observatory (bottom platform module)





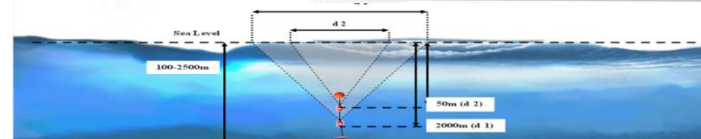
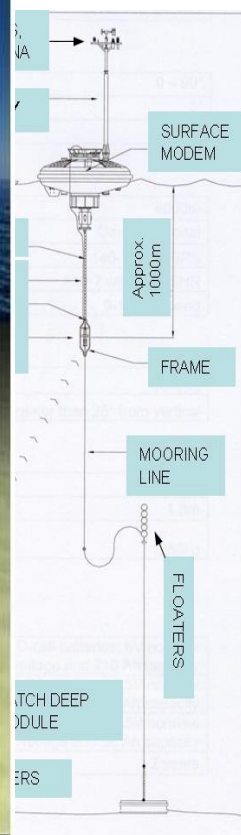
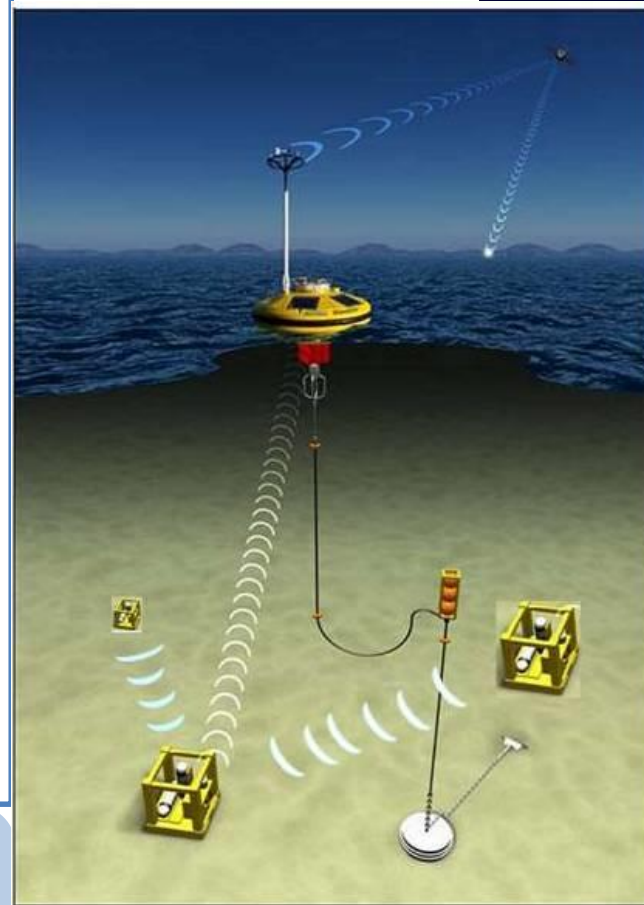
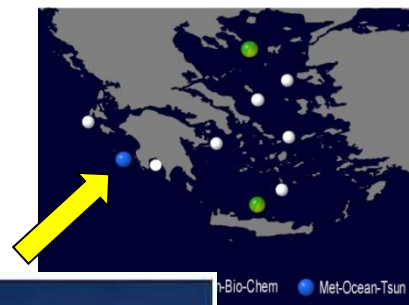


# Reference station Pylos

**A new Sea-bed observatory developed through POSEIDON –III**

**Deployed in the sea on October 2013**

- ✓ Sensors: Pressure (incl. tsunami mode), T, S, DO, Turbidity, CO<sub>2</sub>, CH<sub>4</sub>, pH
- ✓ Multi-node autonomous platform (acoustic link between nodes)
- ✓ Upgrade of existing platform to form a node of the network
- ✓ Compatibility of hardware (cpu) with rest of the systems
- ✓ Modular – expandable system



Mooring cable also hosts an experimental PAL (passive aquatic listener) sensor

# Calibration Laboratory – Supporting the data quality

Funded through POSEIDON II, turned into operation in 2011



## Oxygen

100lit Tank

Winkler Titration

## Temperature

Dedicated tank 1.5m<sup>3</sup>

2 SBE 35 Standard Thermometers

## Salinity

Salinometer OSIL

## Fluorescence – Chlorophyll A (chl\_a) Turbidity

Phytoplankton lab cultures  
Fluorescence standards

Turbidity solution of known  
concentration

# Data from additional sources

## Ferry Box System



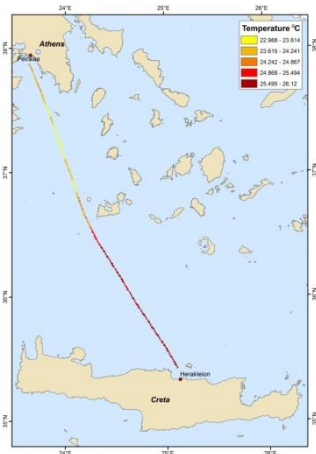
Real time  
continuous  
recording of:

- Temperature
- Salinity
- Chlorophyll-a
- Turbidity
- pH

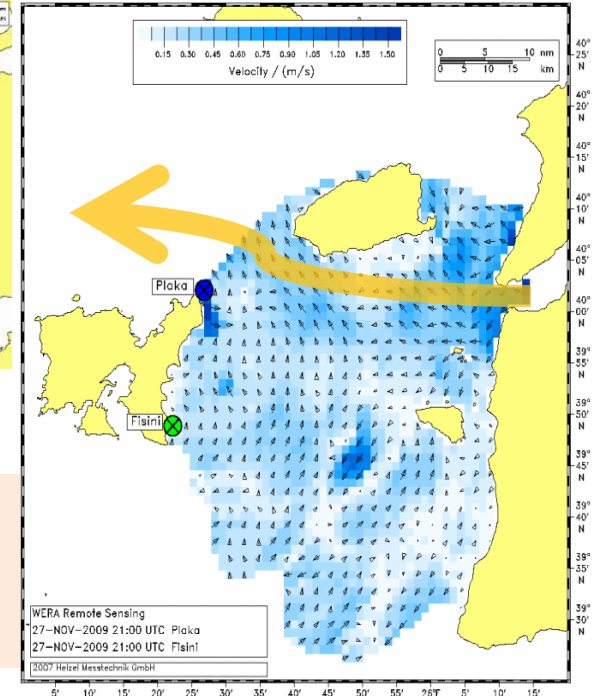
Piraeus-Heraklion

*Olympic  
Champion High  
Speed*

In operation since  
2012



## HF Radar



In operation  
since June  
2009

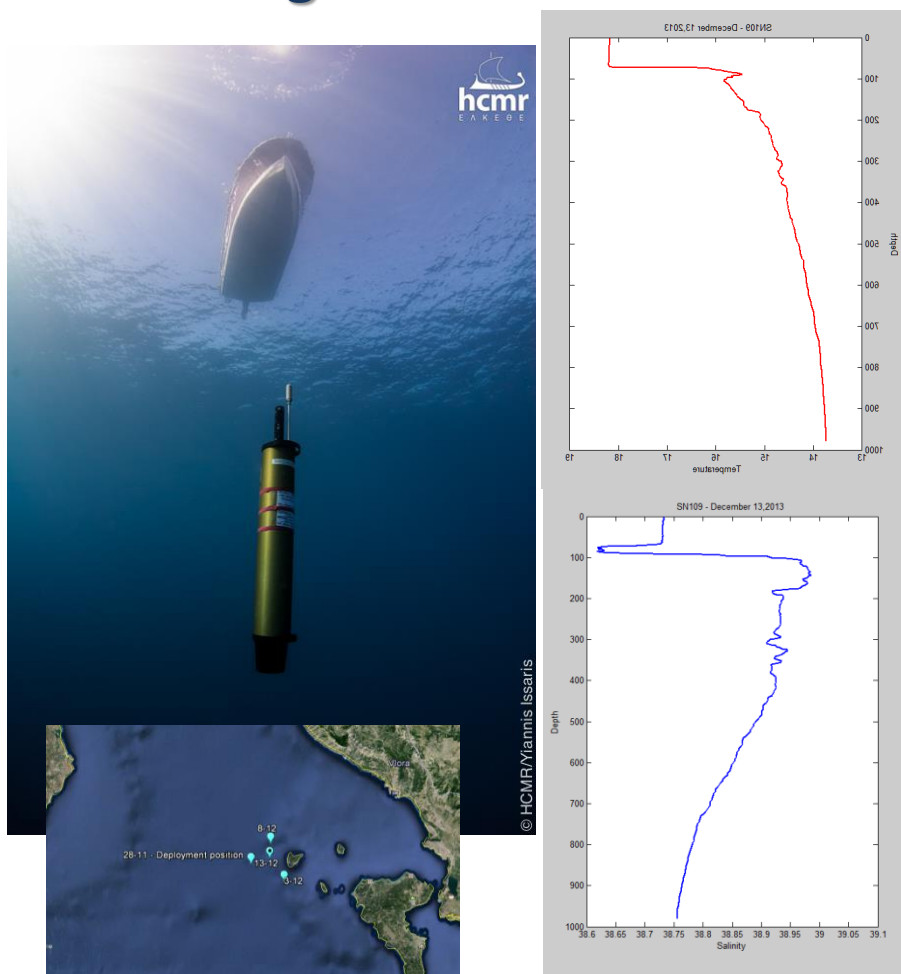
The Black Sea waters outflow through Dardanelles is an important driving mechanism for the Aegean sea hydrology and circulation.

The systematic monitoring of this outflow is a key issue for:

- The validation of the hydrodynamical forecasts
- The improvement on the numerical simulations in the Aegean
- The Search and rescue activities in the area

# Data from additional sources

## Greek Argo infrastructure



Greek contribution to EuroArgo  
Started on 2010

## Ecosystem monitoring at E1-M3A site (Cretan Sea)

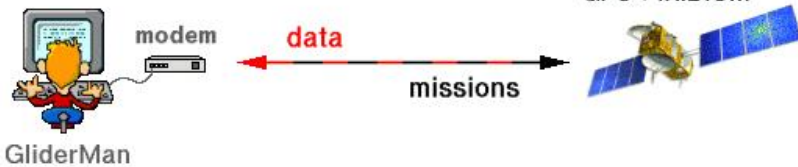


Site is visited in monthly basis  
**Data available since March 2010**

### Parameters:

T, S, nutrients,  $C_T$ - $A_T$ ,  $CO_2$ ,  
Chlorophyll- $a$ , pigments (HPLC),  
planktonic community:  
phytoplankton, coccolithophores,  
bacteria, microzooplankton,  
mesozooplankton





# SeaExplorer Gliders

Added to POSEIDON observation facilities  
on January 2016

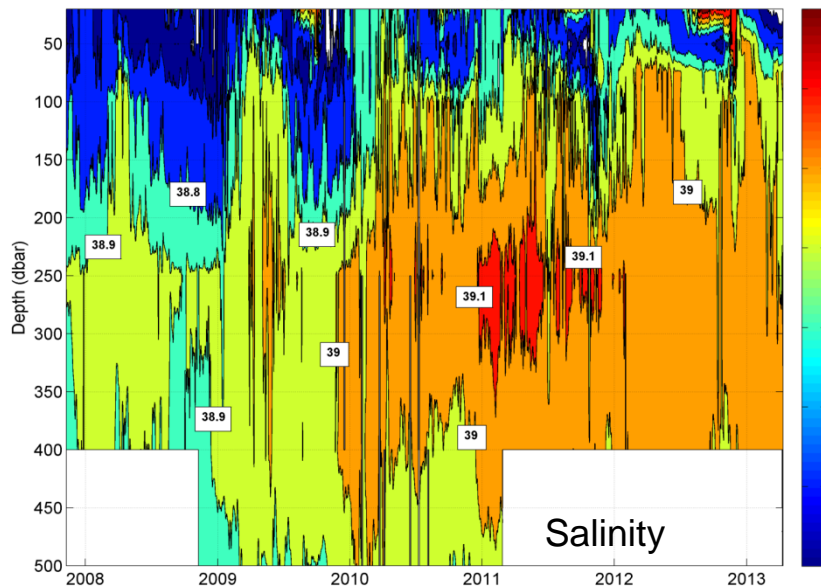


Scientific Payload: CTD, DO  
Typical operational cycle:  
Dive to 700 m  
One descending + One ascending  
profile every 4-5 hours  
6-10 profiles/day  
**180-300 profiles/month**  
**High frequency recording of data**  
**Measuring the Ocean variability**

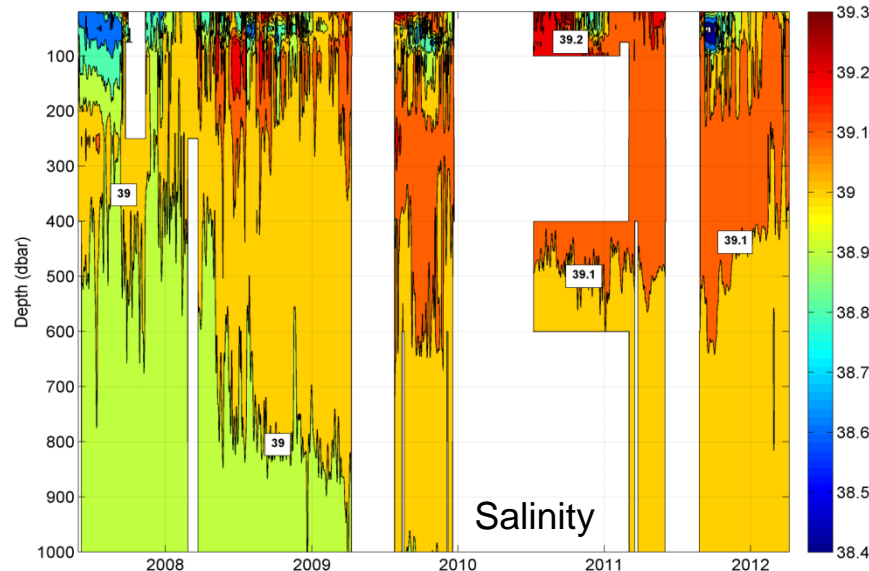


# Long time series data from the reference stations

Southeast Ionian Sea (Pylos)



Cretan Sea E1M3A

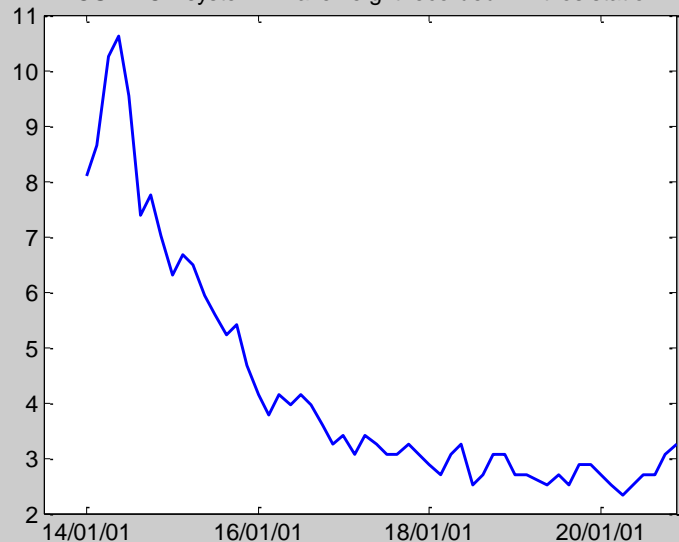


Cretan Sea E1M3A - 1000 dbar



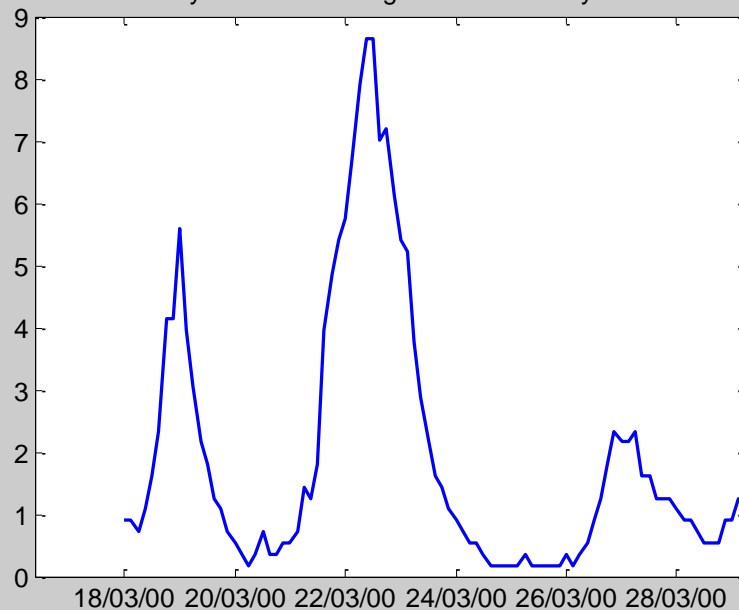
# Extreme wave recordings

POSEIDON system : Wave height recorded in Athos station

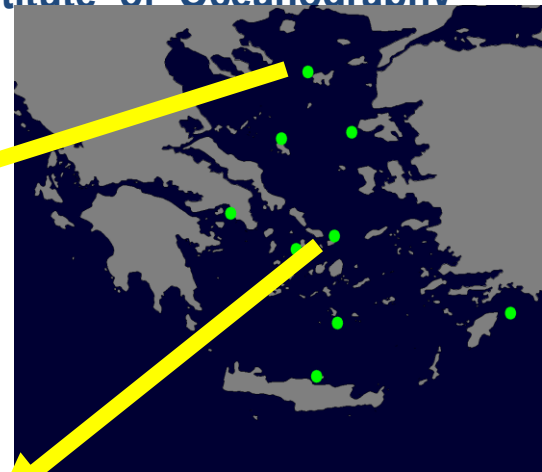


*Athos station : 14 Jan 01,  
wave height:10,8m*

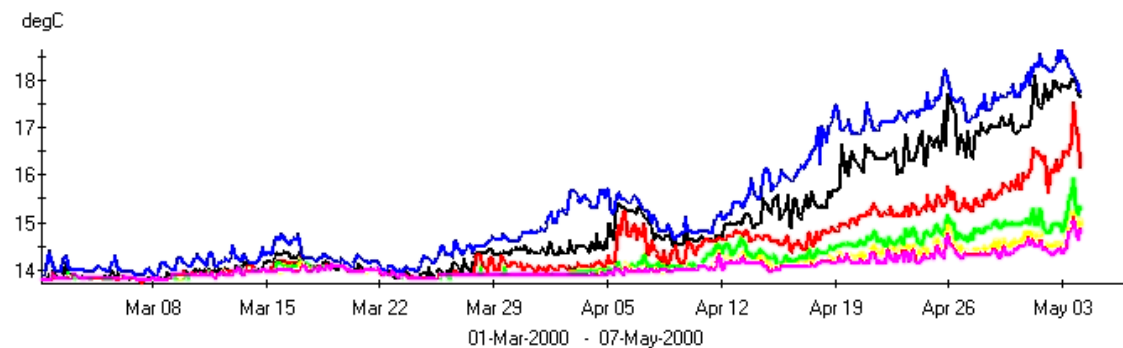
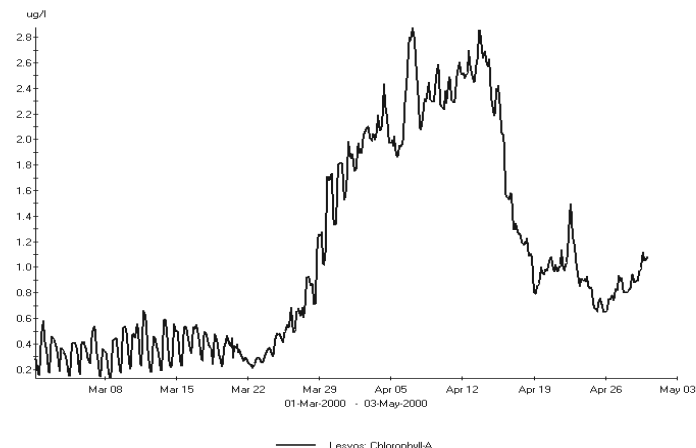
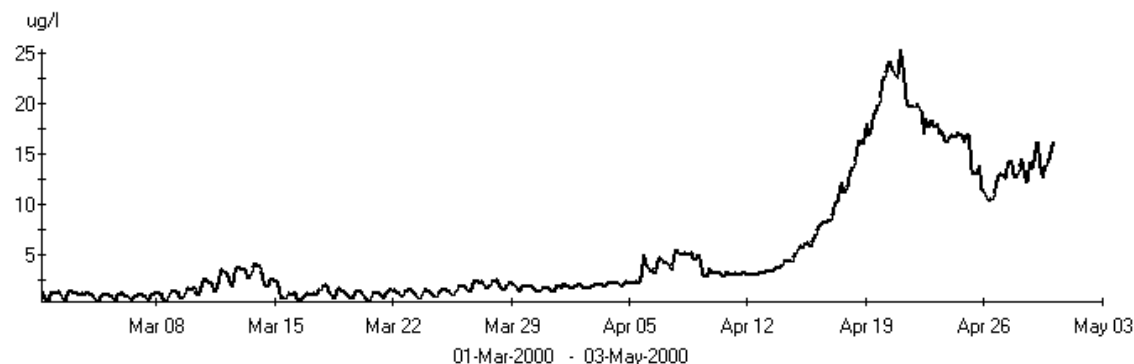
POSEIDON system : Wave height recorded in Mykonos station



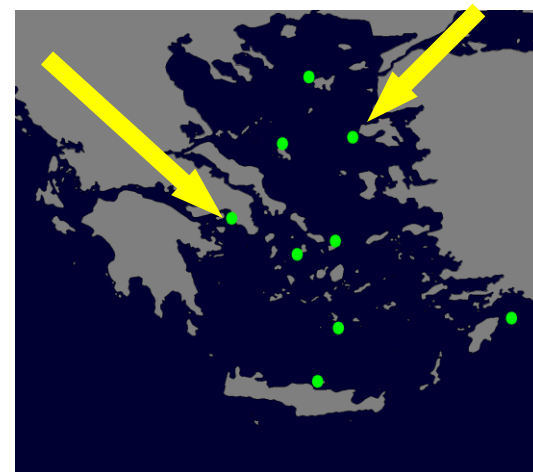
*Mykonos station : 23 Mar 00,  
wave height:8,9m*



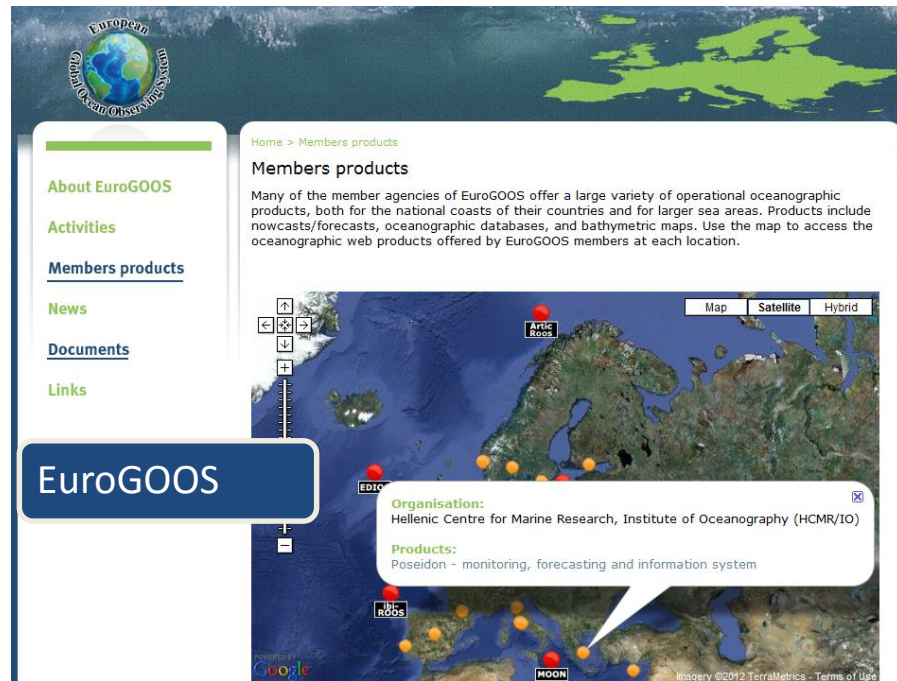
# Biochemical processes



— Egina: WatTemp10m  
 — Egina: WatTemp3m  
 — Egina: WatTemp20m  
 — Egina: WatTemp40m  
 — Egina: WatTemp30m  
 — Egina: WatTemp45m



## POSEIDON participates to the major Operational Oceanography initiatives



**EuroGOOS**

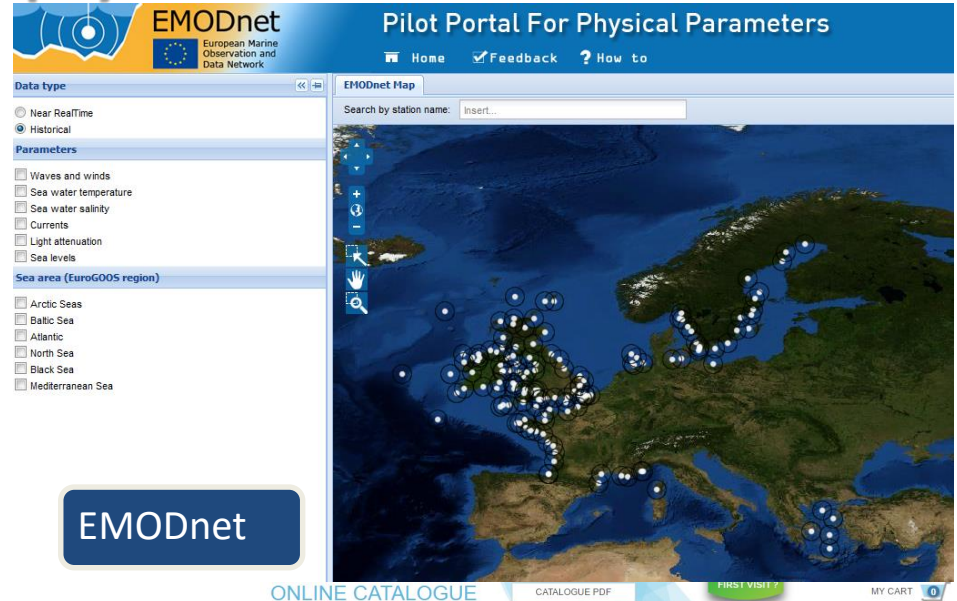
Home > Members products

### Members products

Many of the member agencies of EuroGOOS offer a large variety of operational oceanographic products, both for the national coasts of their countries and for larger sea areas. Products include nowcasts/forecasts, oceanographic databases, and bathymetric maps. Use the map to access the oceanographic web products offered by EuroGOOS members at each location.

**Organisation:**  
Hellenic Centre for Marine Research, Institute of Oceanography (HCMR/IO)

**Products:**  
Poseidon - monitoring, forecasting and information system



**EMODnet**  
European Marine Observation and Data Network

### Pilot Portal For Physical Parameters

Home Feedback How to

Search by station name:

**Data type**

- ☐ Near RealTime
- ☒ Historical

**Parameters**

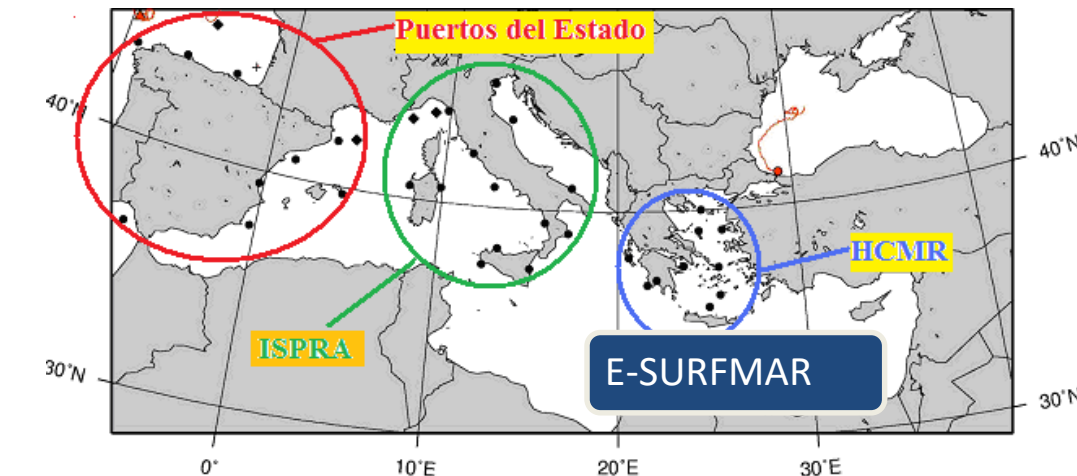
- ☐ Waves and winds
- ☐ Sea water temperature
- ☐ Sea water salinity
- ☐ Currents
- ☐ Light attenuation
- ☐ Sea levels

**Sea area (EuroGOOS region)**

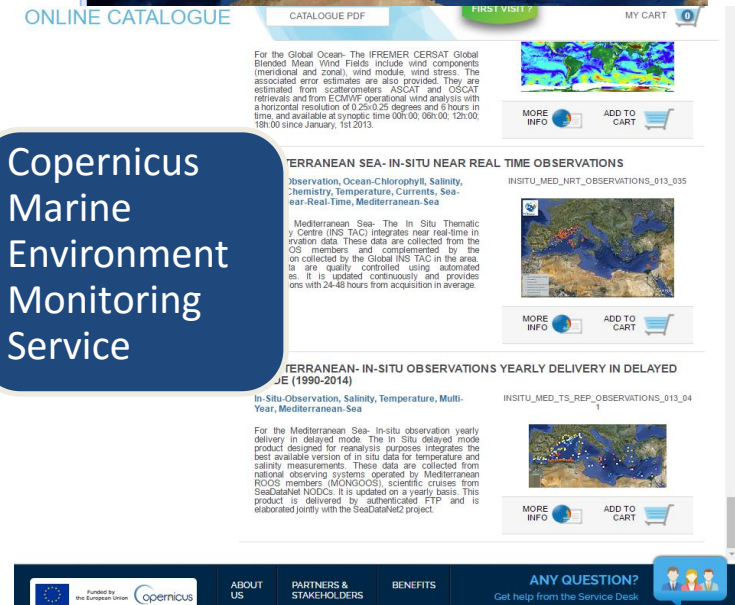
- ☐ Arctic Seas
- ☐ Baltic Sea
- ☐ Atlantic
- ☐ North Sea
- ☐ Black Sea
- ☐ Mediterranean Sea

**EMODnet Map**

ONLINE CATALOGUE



**Copernicus Marine Environment Monitoring Service**



**MEDITERRANEAN SEA- IN-SITU NEAR REAL TIME OBSERVATIONS**

Observation, Ocean-Chlorophyll, Salinity, Chemistry, Temperature, Currents, Sea-ear-Real-Time, Mediterranean-Sea

INSITU\_MED\_NRT\_OBSERVATIONS\_013\_035

**MEDITERRANEAN- IN-SITU OBSERVATIONS YEARLY DELIVERY IN DELAYED MODE (1990-2014)**

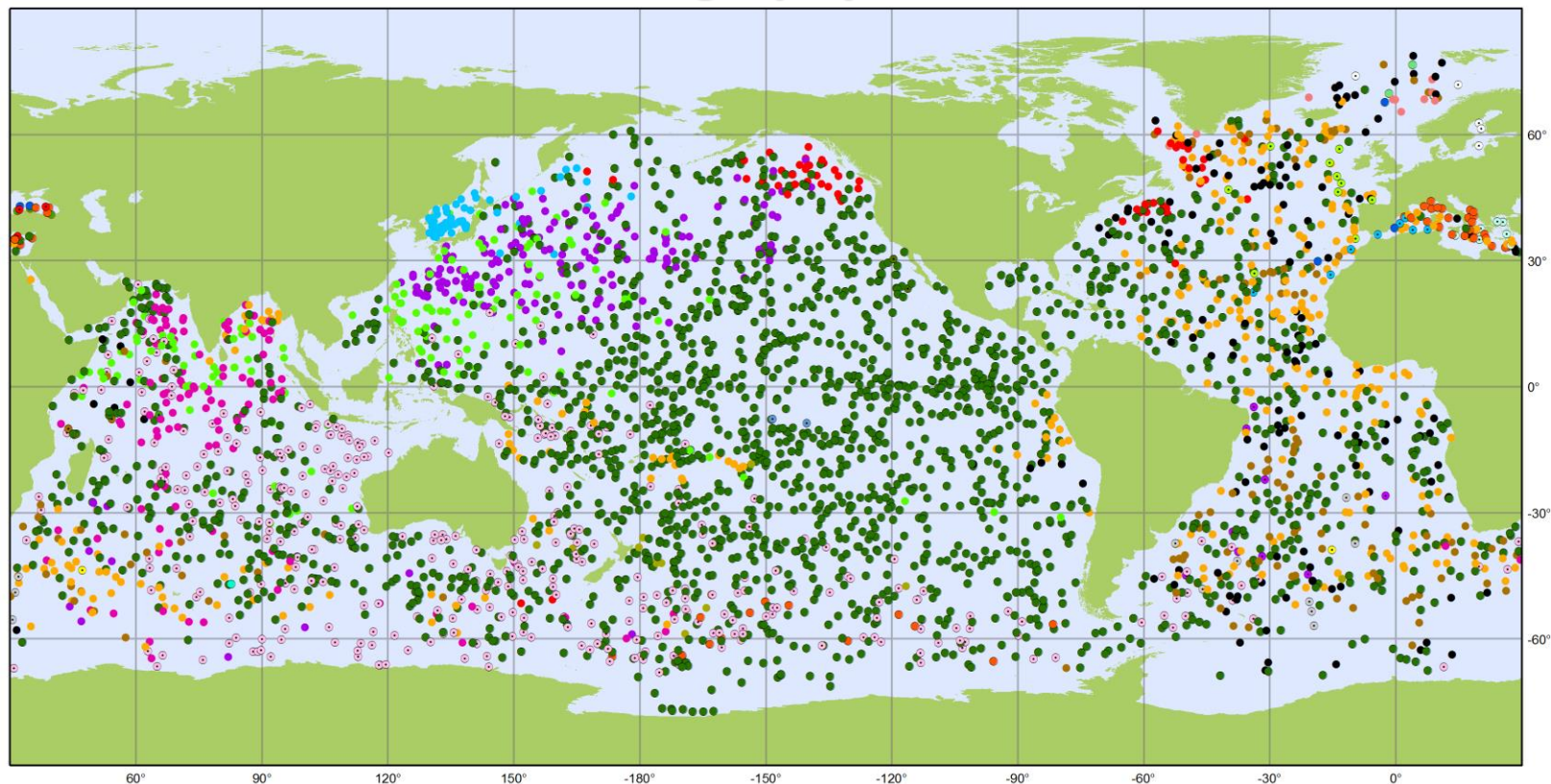
In-Situ-Observation, Salinity, Temperature, Multi-Year, Mediterranean-Sea

INSITU\_MED\_TS\_REP\_OBSERVATIONS\_013\_041

**ANY QUESTION?**  
Get help from the Service Desk



# POSEIDON participates to the major Operational Oceanography initiatives



Argo

National contributions - 3814 Operational Floats

May 2016

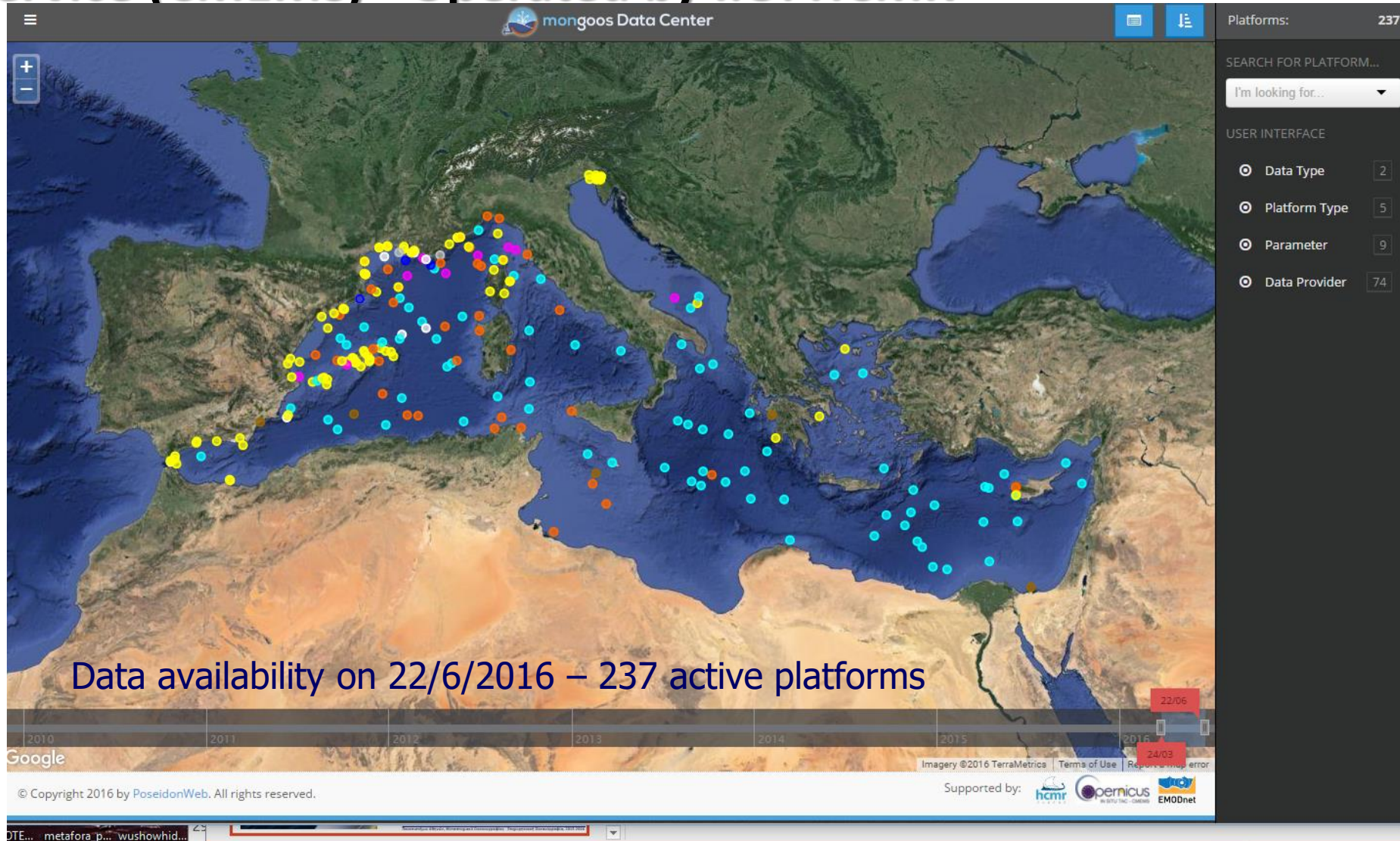
Latest location of operational floats (data distributed within the last 30 days)

● ARGENTINA (2)	● CHINA (147)	● GERMANY (140)	● JAPAN (177)	● NETHERLANDS (11)	● SPAIN (8)
● AUSTRALIA (380)	● ECUADOR (2)	● GREECE (8)	● KENYA (1)	● NEW ZEALAND (11)	● TURKEY (3)
● BRAZIL (10)	● EUROPE (6)	● INDIA (123)	● KOREA, REPUBLIC OF (55)	● NORWAY (10)	● UK (132)
● BULGARIA (3)	● FINLAND (6)	● IRELAND (10)	● MAURITIUS (3)	● POLAND (3)	● USA (2124)
● CANADA (64)	● FRANCE (325)	● ITALY (47)	● MEXICO (2)	● SOUTH AFRICA (1)	





# The Mediterranean Insitu Thematic Assembly Center – Module of the Copernicus Marine Environment Monitoring Service (CMEMS) - Operated by I.O. HCMR

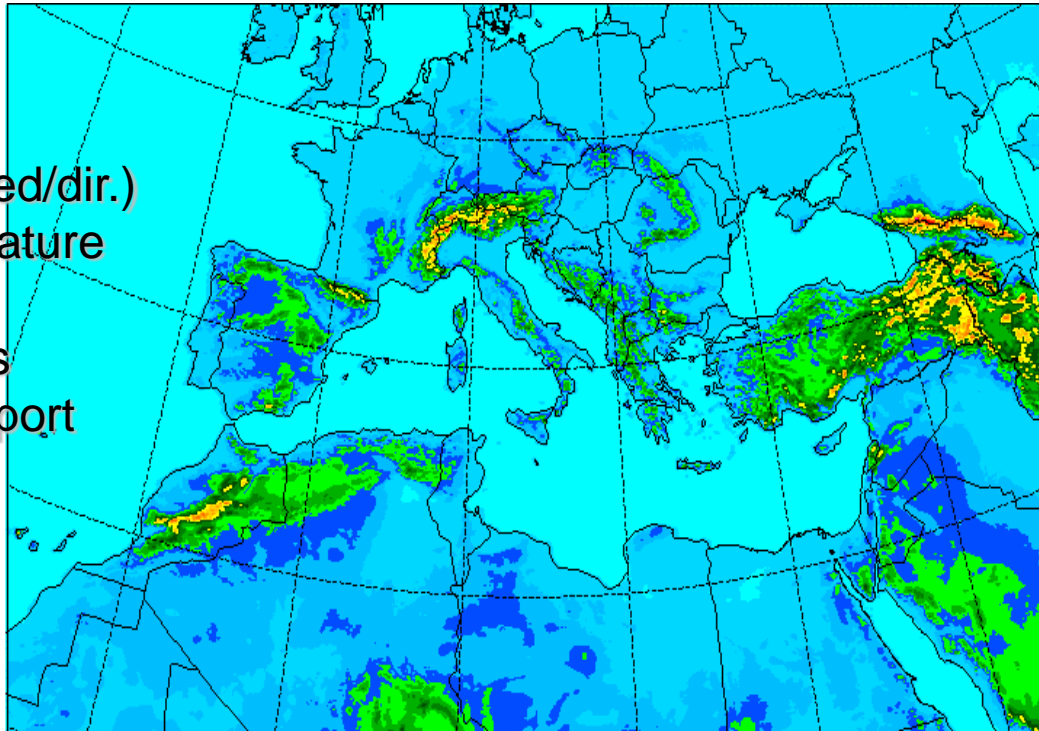


# Forecasting component

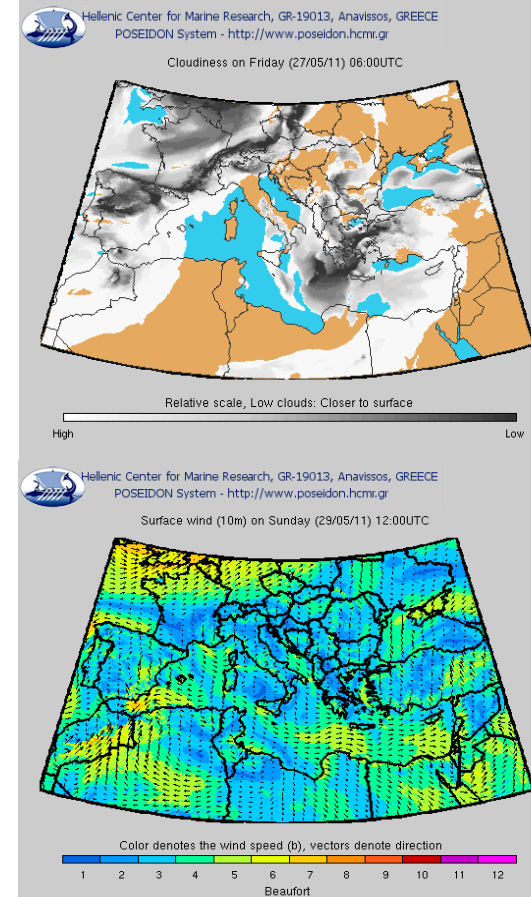
# The POSEIDON weather forecasting system

## Products:

- ✓ Wind (speed/dir.)
- ✓ Air temperature
- ✓ Rainfall
- ✓ Cloudiness
- ✓ Dust transport
- ✓ Fog
- ✓ .....



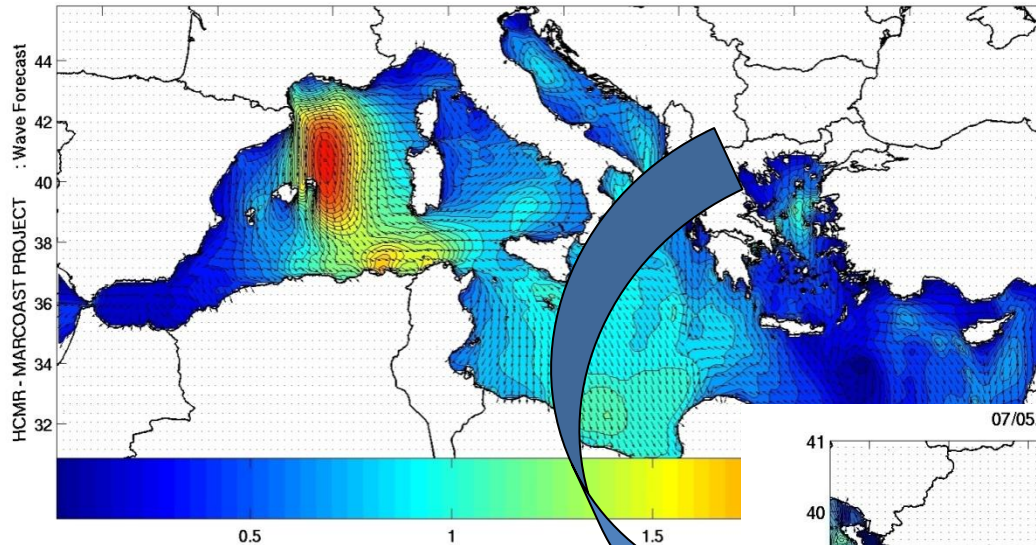
- Non-hydrostatic Eta model
- Horizontal resolution :  $0.05^\circ \times 0.05^\circ$  ( $\sim 5$  km)
- Vertical resolution: 50 levels up to 25 hPa ( $\sim 25$  km)





# Sea state forecasting

07/05/07 12:00 UTC : Significant wave height(m) and direction



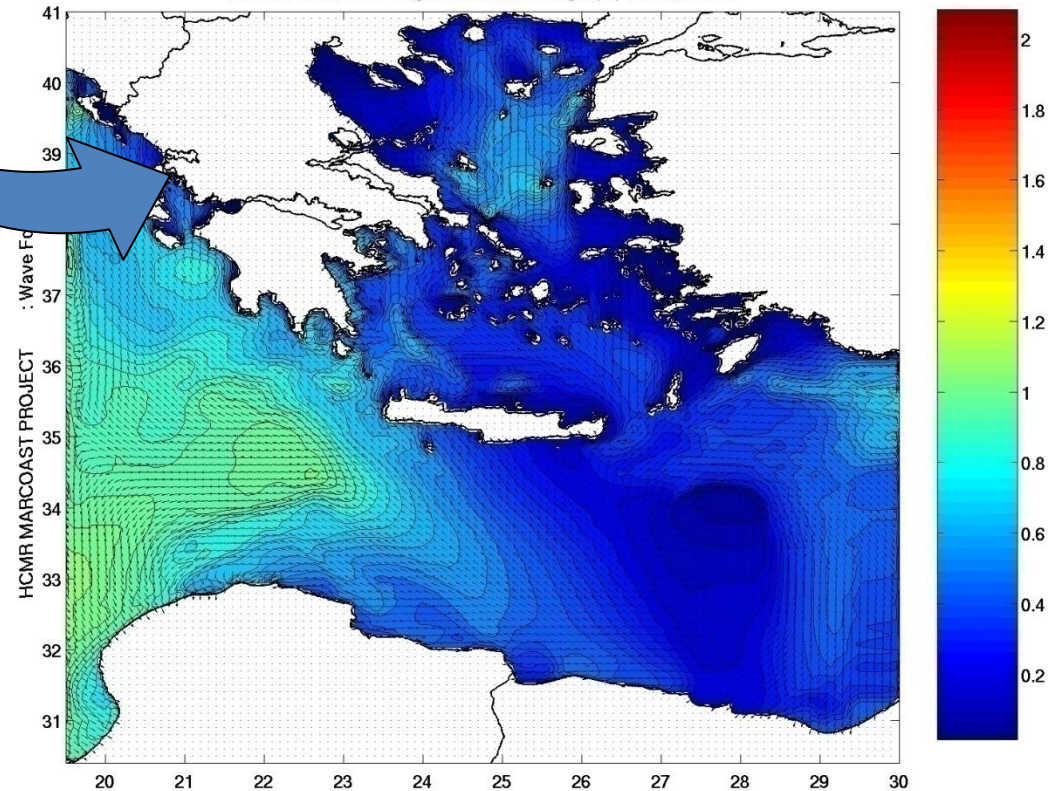
RESOLUTION ~10km

Products:

- ✓ Wave height
- ✓ Direction
- ✓ Period

RESOLUTION ~3km

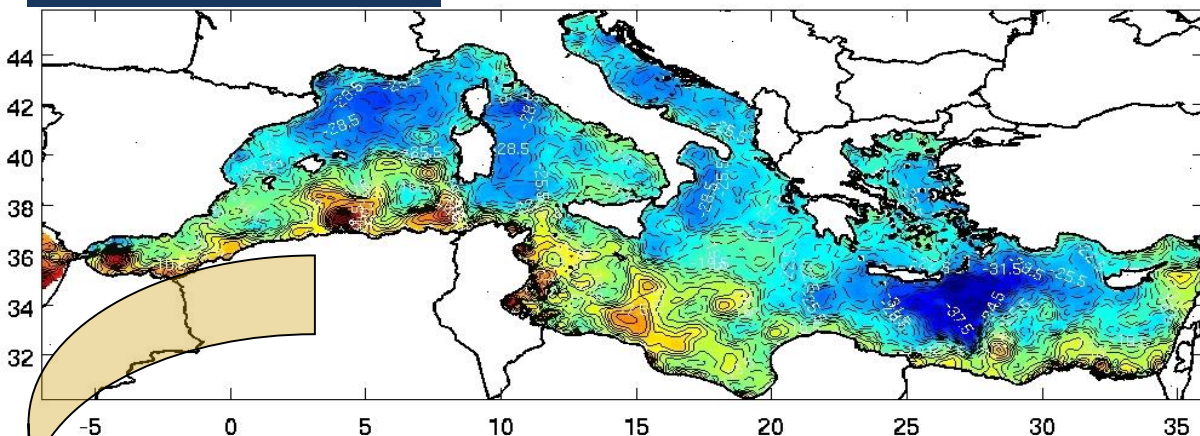
07/05/07 12:00 UTC : Significant wave height(m) and direction



# Forecasting of hydrodynamics

RESOLUTION 10km

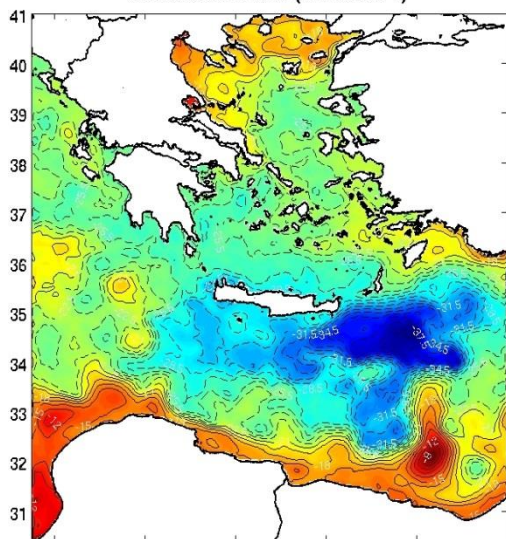
07/05/2008 18 UTC



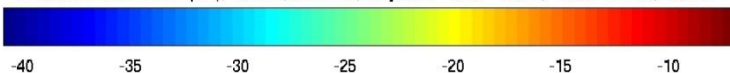
Free surface Elevation (cm), Year=1, Month=5, Day=8.75 Min= -41.0011, Max= 9.5292, CI=1.5

07/05/2008 18 UTC (VERSION 1)

RESOLUTION 3km



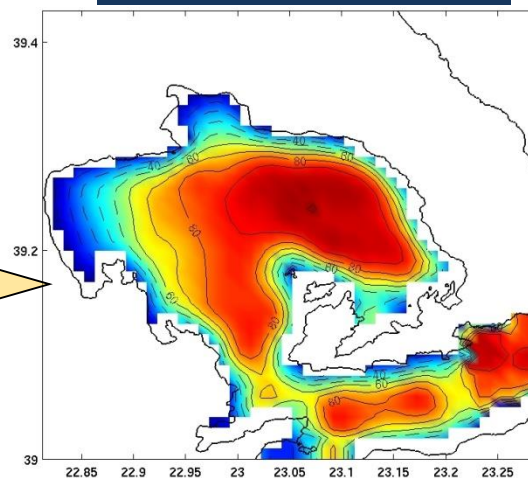
Free surface Elevation (cm), Year=1, Month=5, Day=8.75 Min= -41.017, Max= -7.0698, CI=1.5



Products:

- ✓ Currents
- ✓ Temperature
- ✓ Salinity

RESOLUTION 1km





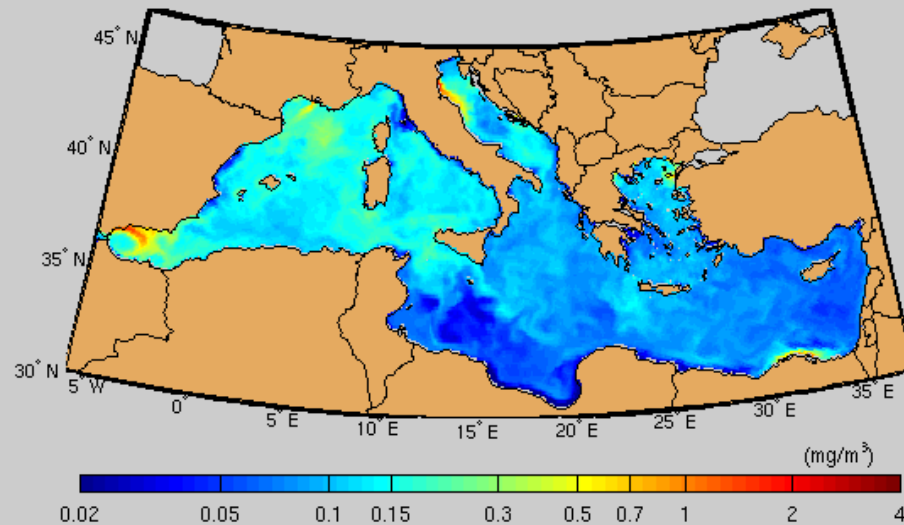
# Ecosystem forecasting



Hellenic Center for Marine Research, GR-19013, Anavissos, GREECE

POSEIDON System - <http://www.poseidon.hcmr.gr>

Chlorophyll-a (0-10m aver.) on Tuesday (10/11/09, daily average)



## Hydrodynamic model

POM (Blumberg and Mellor, 1983)

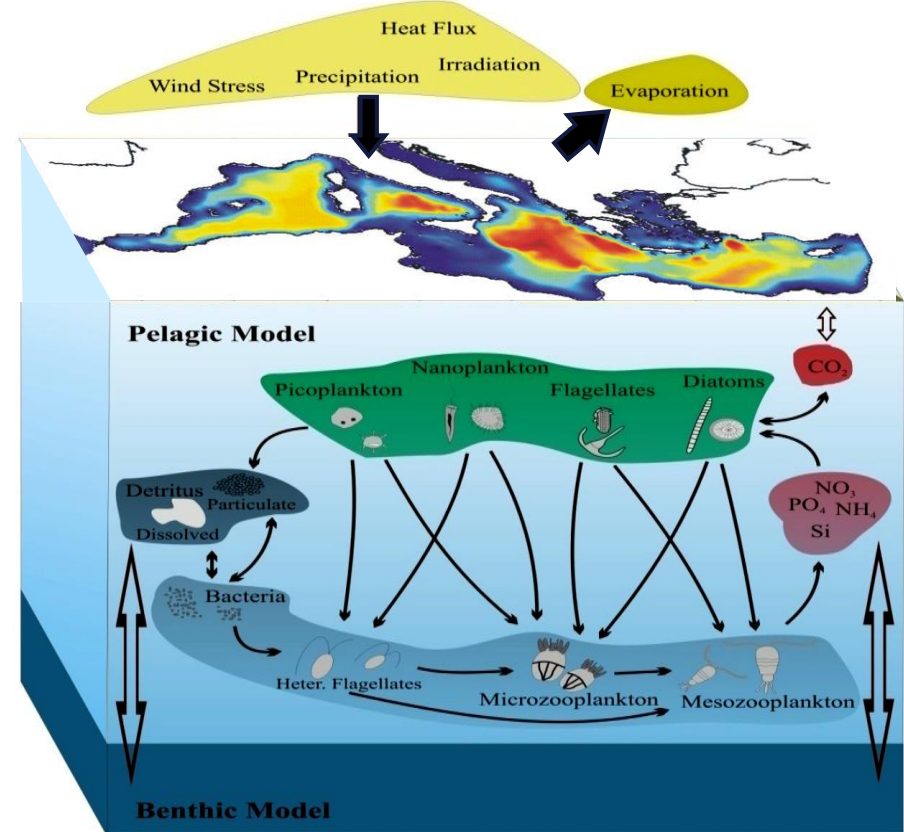
## Ecosystem model

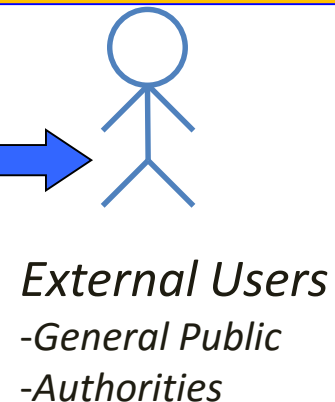
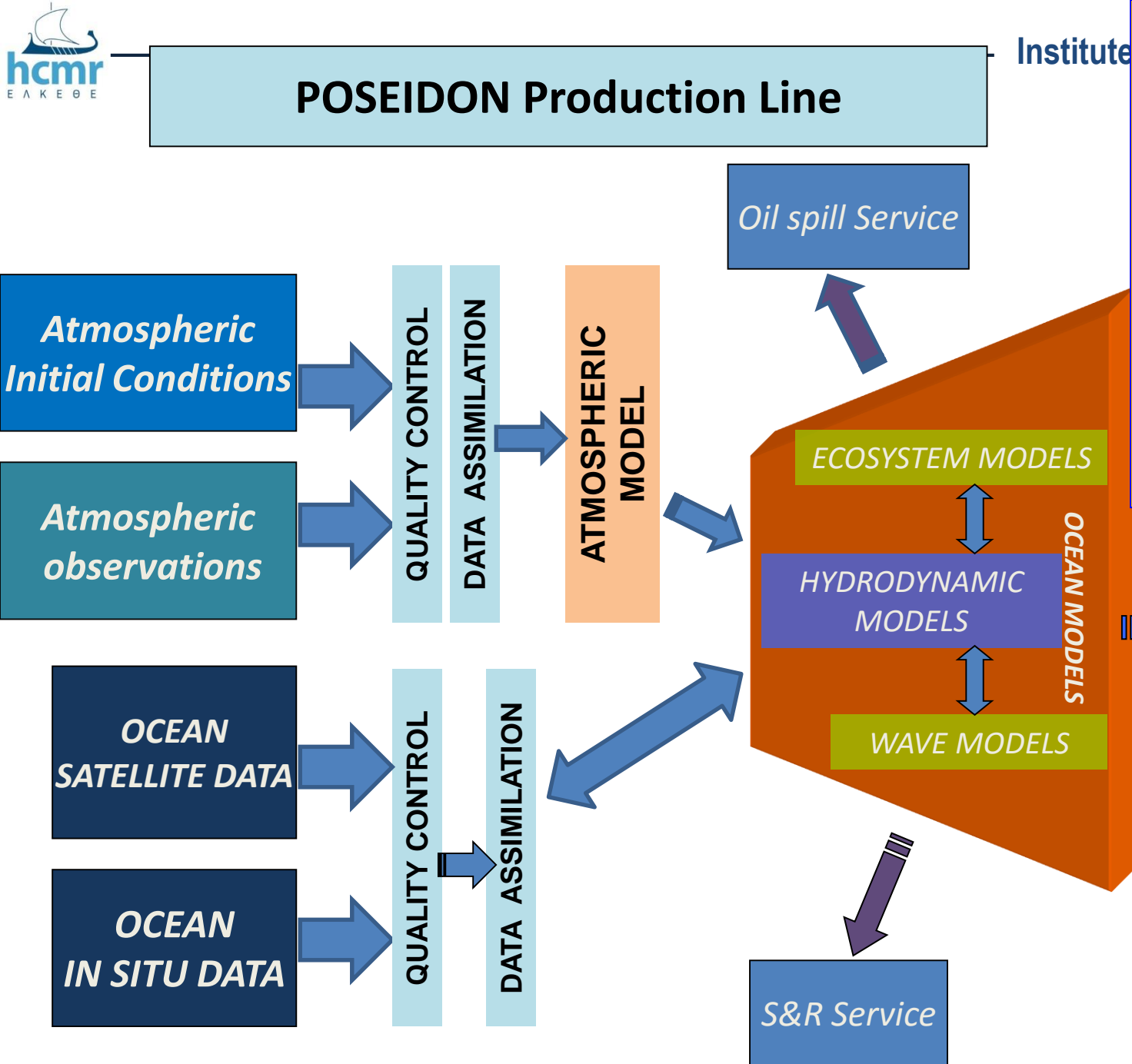
ERSEM (Baretta et al. 1995)

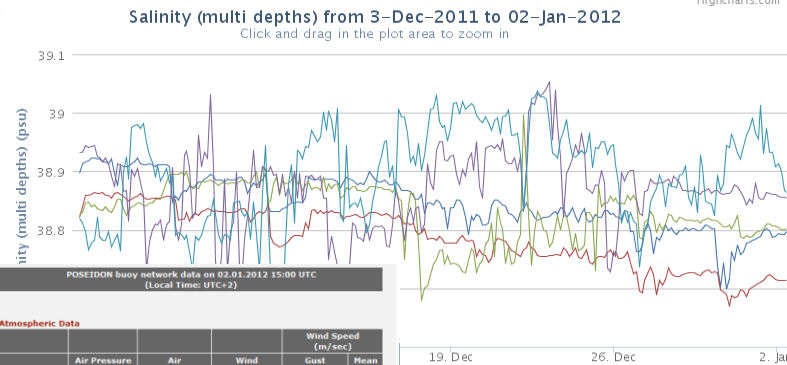
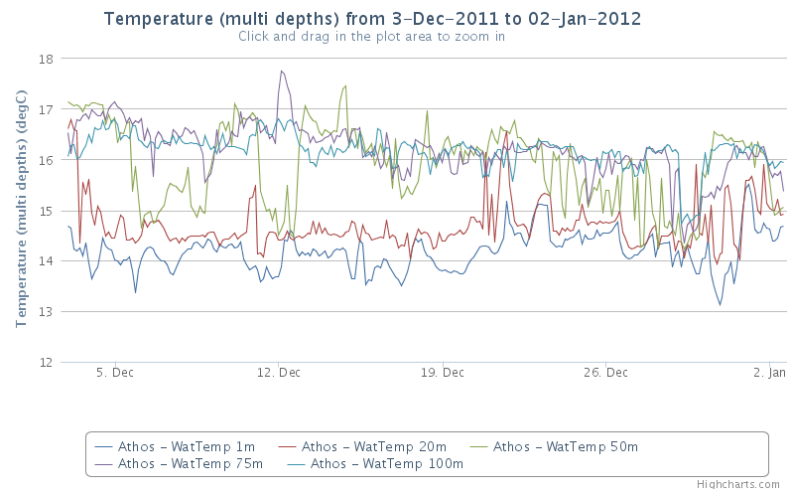
**Horizontal Resolution:  $1/10^\circ$**   
(~10Km)

**Vertical Resolution: 25-sigma levels**

**Minimum water column depth : 30m**







POSEIDON buoy network data on 02.01.2012 15:00 UTC  
(Local Time: UTC+2)

#### Atmospheric Data

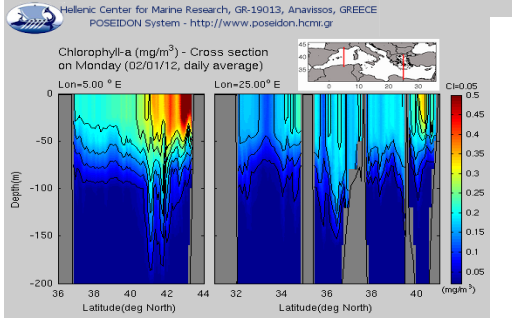
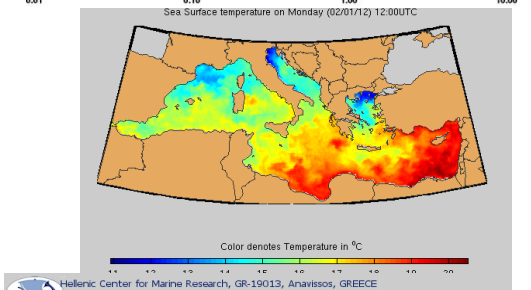
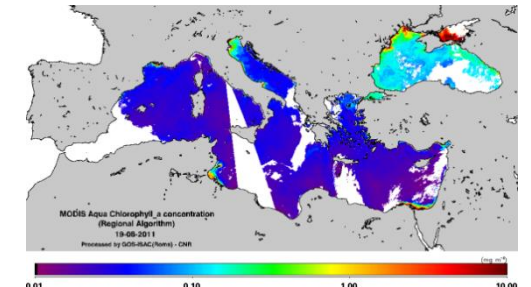
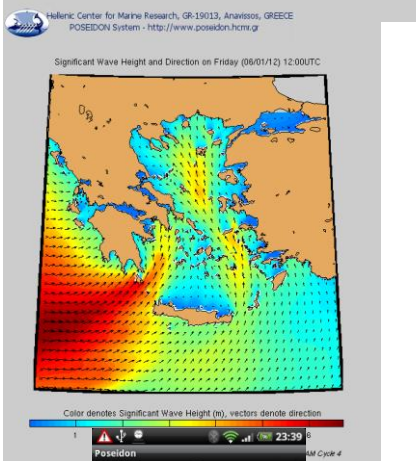
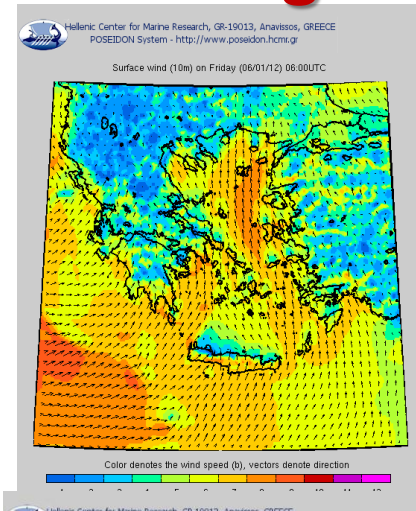
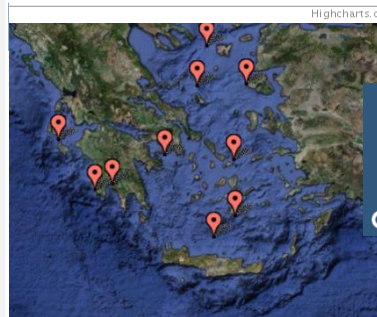
	Air Pressure (mbars)	Air Temperature (°C)	Wind direction (degrees)	Wind Speed (m/sec)	Mean speed
Athos	1025.76	11.11	22.50	1.17	0.23
EIMSA	N/A	N/A	N/A	N/A	N/A
Lesvos	1025.13	9.83	1.41	9.04	6.30
Mykonos	1017.95	11.06	350.42	13.11	9.48
Saronikos	1018.99	11.22	12.04	3.69	2.26
Pylos	N/A	N/A	N/A	N/A	N/A
Santorini	1024.23	33.82	344.53	11.48	8.67
Skýros	N/A	N/A	N/A	N/A	N/A
Zakynthos	1019.94	12.65	99.93	1.60	0.82

#### Marine Data

	Current Data	Waves data	Waves data	Waves data	Waves data	Waves data
	Direction (degrees)	Speed (cm/sec)	Significant height (meters)	Maximum height (meters)	Main direction (degrees)	Surface Temperature (°C)
Athos	156.45	3.22	0.39	0.39	313.59	14.67
EIMSA	N/A	N/A	N/A	N/A	N/A	N/A
Lesvos	78.66	8.64	0.59	0.64	343.92	16.11
Mykonos	97.47	9.16	1.58	2.10	350.24	15.27
Saronikos	145.02	13.40	0.36	0.37	355.99	14.67
Pylos	N/A	N/A	N/A	N/A	N/A	N/A
Santorini	228.52	23.14	1.09	1.56	352.97	14.81
Skýros	N/A	N/A	N/A	N/A	N/A	N/A
Zakynthos	226.14	N/A	0.46	0.68	254.44	17.49

N/A denotes a non-available value

— Pylos - Salinity 50m



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Returning Visitor New Visitor

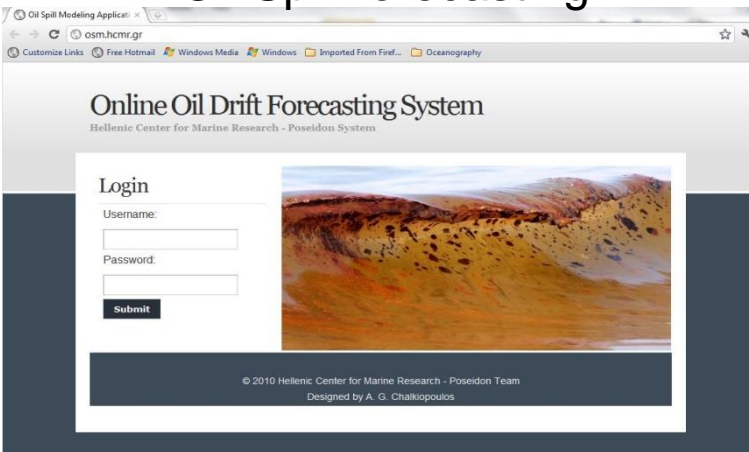


Web: ~1.200.000 user sessions/month



# Products and Services

## Oil Spill forecasting



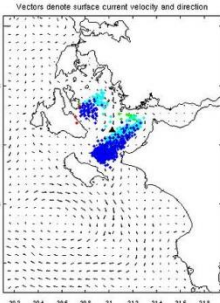
### Results for the Oil Spill Modeling Application

Information about the oil spill event



Date: 10/11/11  
Time (UTC): 00:00  
Initial Position: 21.0278 E 38.1216 N  
Duration of Integration (Hrs): 168 (7 days)  
Evacuation time (Hrs): Instant  
Output graphic every (Hrs): 12

Date: 14/11/11 Hour: 12:00 UTC



Initial volume: 10000  
Evap. volume: 31.4 %  
Emuls. volume: 23.1 %  
0.5% of points on beach

▲ Initial point of accident  
● Sea points, depth=10m  
● Sea points, depth=10m  
● Sedimentation points  
● Land points

14/11/11 Hour: 12:00 UTC Animation

All the graphical outputs with a summary text are available in zip file.

Click here to download the zip file (size: 482.19 KB)

#### About

The POSEIDON Oil Spill fate and trajectory model is based on PARCEL model (Pollani et al. 2001) which is able to simulate not only the drift of the oil but also the chemical transformations under the specific environmental conditions: more...

#### Links

Poseidon System  
Hellenic Center for Marine Research  
Ecoop project  
Roses project  
MarCoast network

## Search and Rescue



**Hellenic National Meteorological Service**

Atmospheric data and weather forecasting models



**University of Aegean Automatic Identification System**

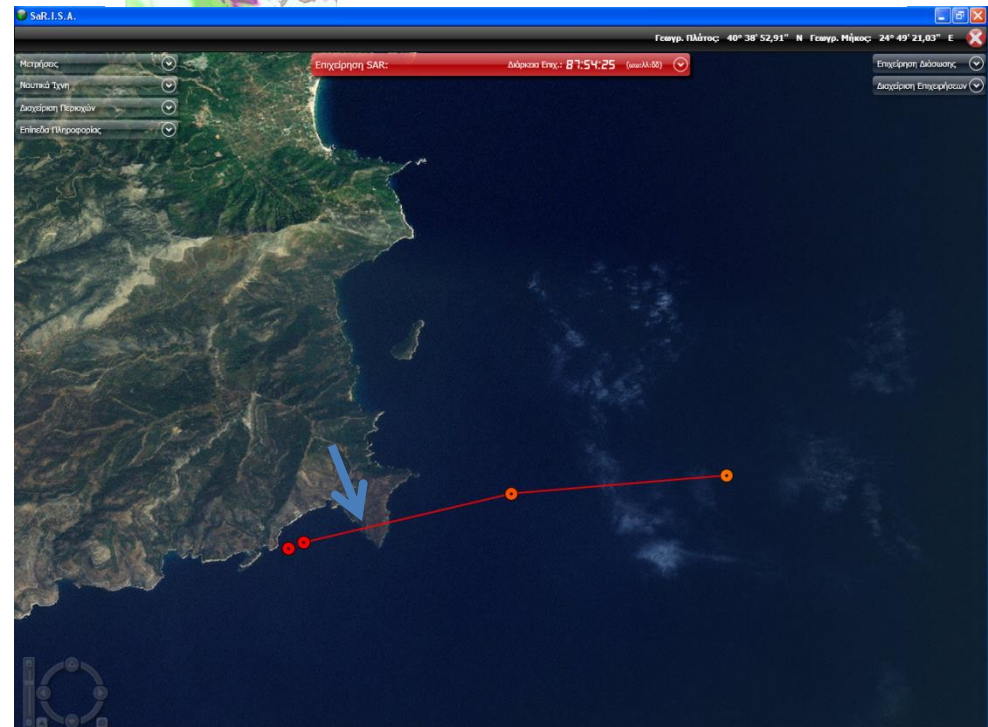


**Hellenic Center for Marine Research**  
Sea currents data and forecasting models



**National Search and Rescue Situation Room**

**SARISA**



# Monitoring the ocean on multiple scales

Introducing a **sea level monitoring component**:  
Integrate the existing network of HHS (National Roadmap), addition of new stations