International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop

Operational oceanographic platform in Thermaikos Gulf (Greece): forecasting and emergency alert system for public use

Yannis Androulidakis, Yannis Krestenitis, Katerina Kombiadou, Christos Makris, Vasillis Baltikas
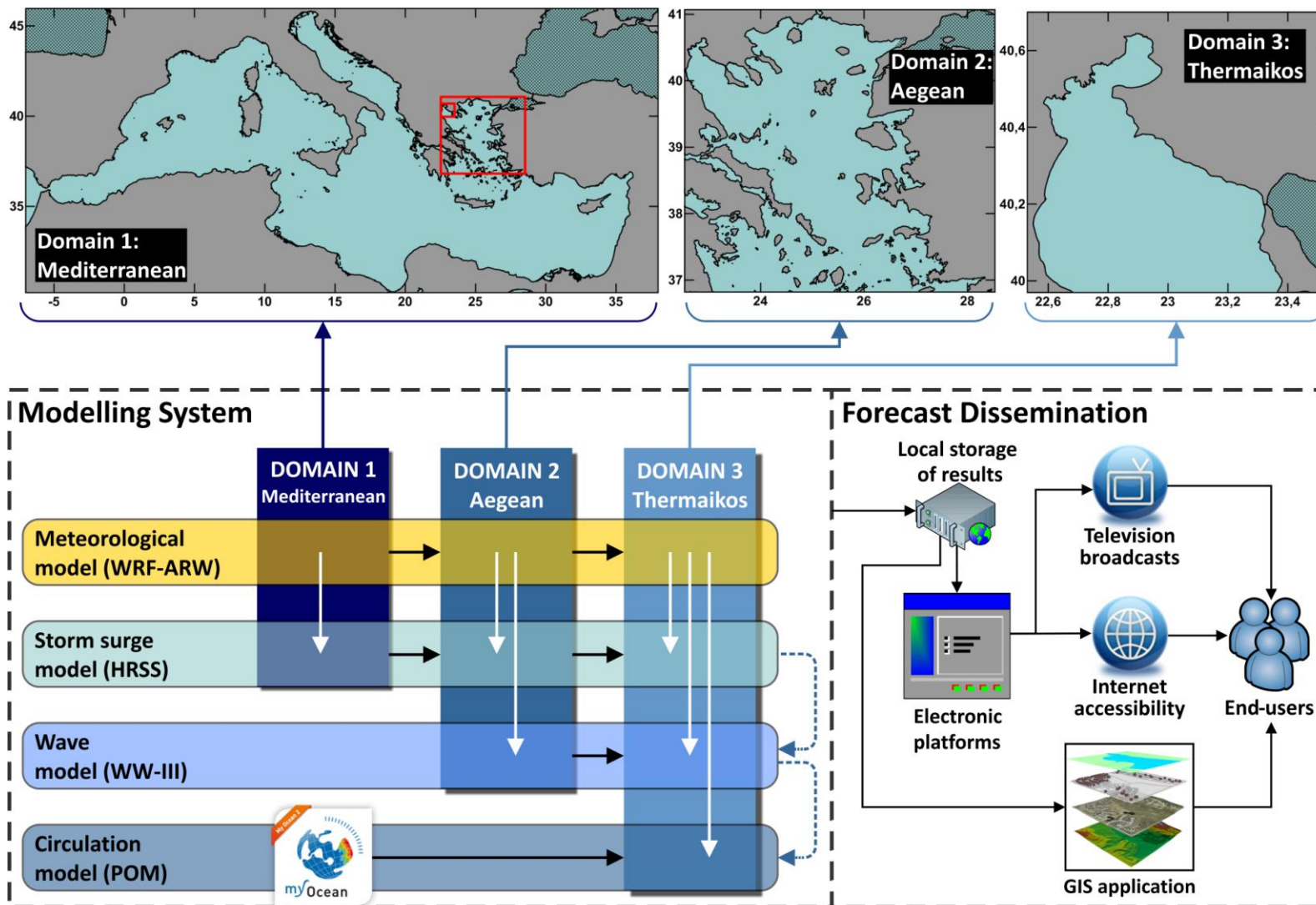
Laboratory of Maritime Engineering and Maritime Works, Civil Engineering Department, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

31 August – 4 September 2015 Instituto Superior Técnico, Lisbon, Portugal

WaveForUs (Wave climate and coastal circulation Forecasts for public Use)
Project aim and objectives

❑ Development of a state-of-the-art forecasting system for wave, circulation and storm surges in the Thermaikos Gulf.

❑ Delivery of 3-day forecasts through television broadcasts and internet and GIS applications.

❑ Dissemination of high-resolution results that are readily exploitable by the users (fisheries, aquacultures, tourism, sea-related recreational and nautathletic activities etc) and other applications, such as environmental modelling and coastal zone management projects.

❑ Delivery of products focused on areas of special interest, like aquacultures and protected areas.

❑ Alerting the public and authorities in cases of extreme events related to sea level rise.

International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop

WaveForUs schematic representation

International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop

WaveForUs (Wave climate and coastal circulation Forecasts for public Use)
# THERMAIKOS GULF

- ❑ 1.5 million population
- ❑ Numerous anthropogenic activities over the coastal zone
- ❑ WaveForUs users:

  - ❑ Professional fishers, aquaculture → *wave and ocean circulation products*
  - ❑ Early warning system of coastal flooding → *storm surge + wave products*
  - ❑ Oil spill accidents → *Circulation products*
  - ❑ Tourism → *Wave and sea temperature products*
  - ❑ Nautathletic activities → *Wave and current products*

International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop
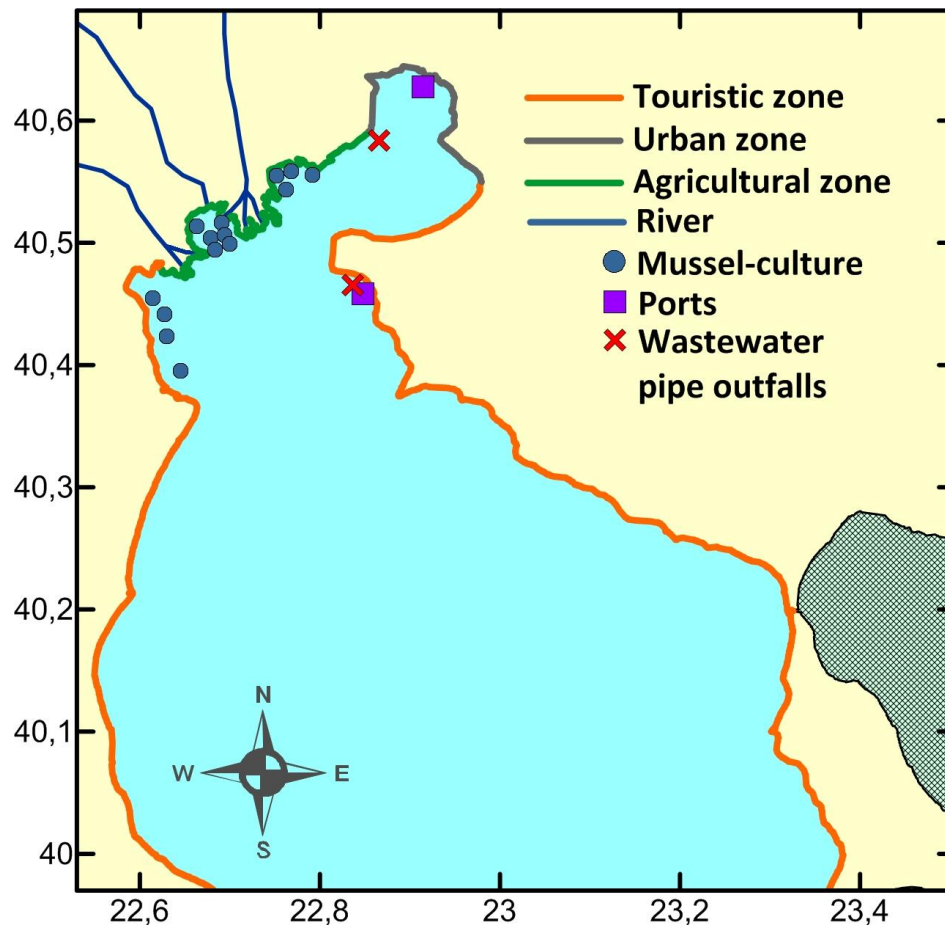
Meteorological model (WRF-ARW)
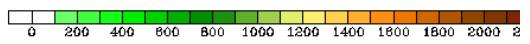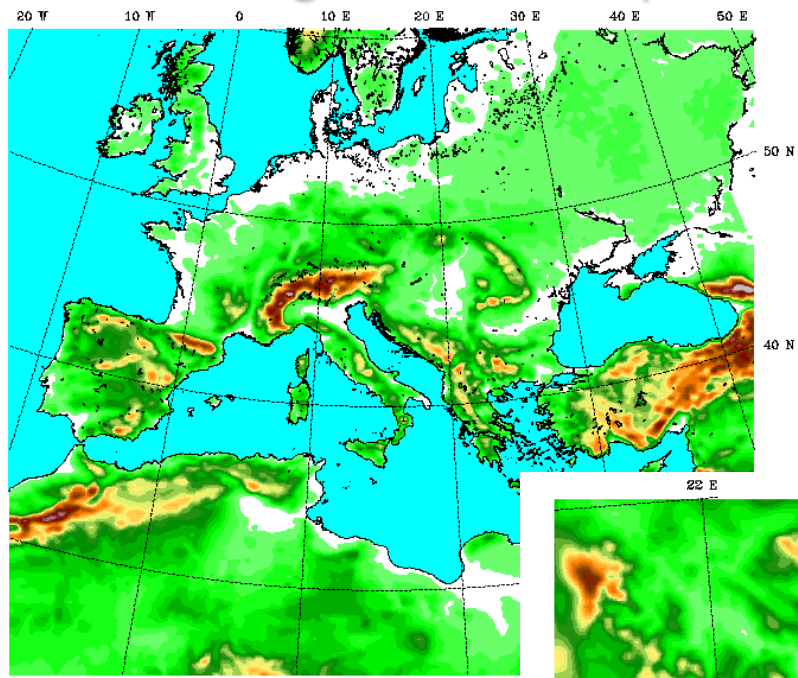
15km x 15km
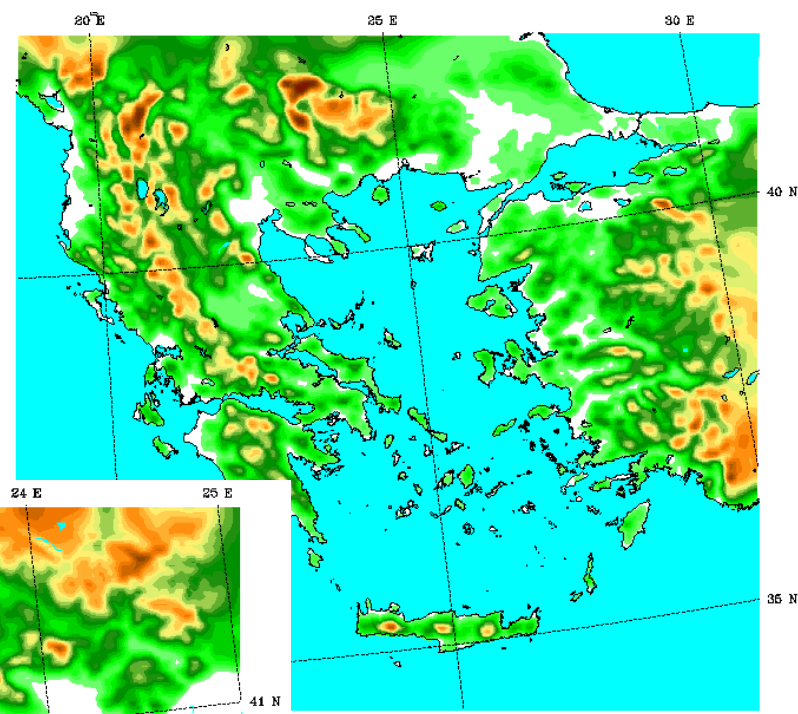
km x 5km
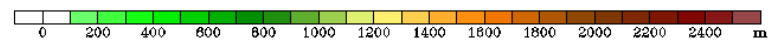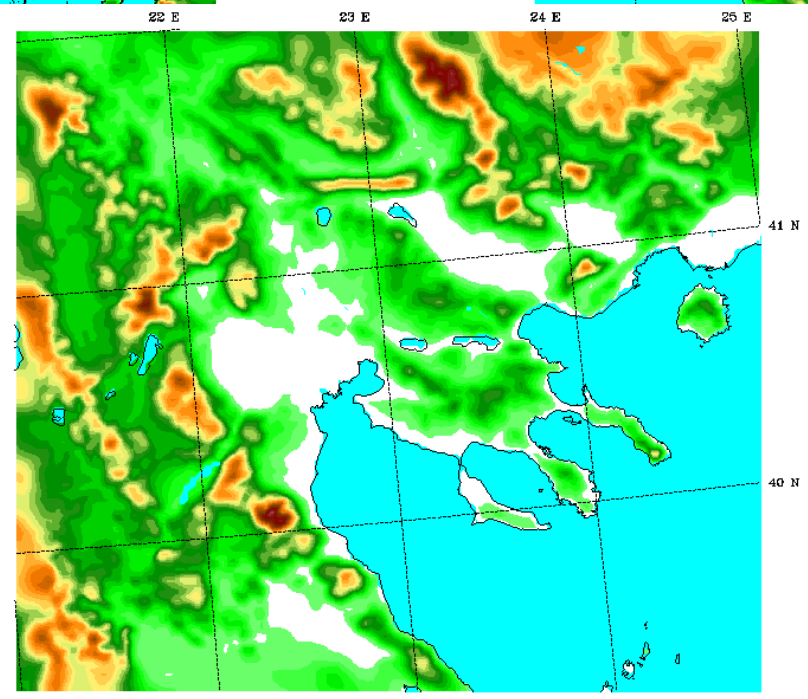
1.7km x 1.7km

Wave model (WaveWatch III: WW-III)

WW-III is a third generation spectral model for the simulation and prognosis of wind-generated wave fields. The governing equations of WW-III include:

- ➤ Wave growth and decay due to the action of wind
- ➤ Refraction
- ➤ Wave breaking
- ➤ Bottom friction
- ➤ Scattering due to wave-bottom interactions
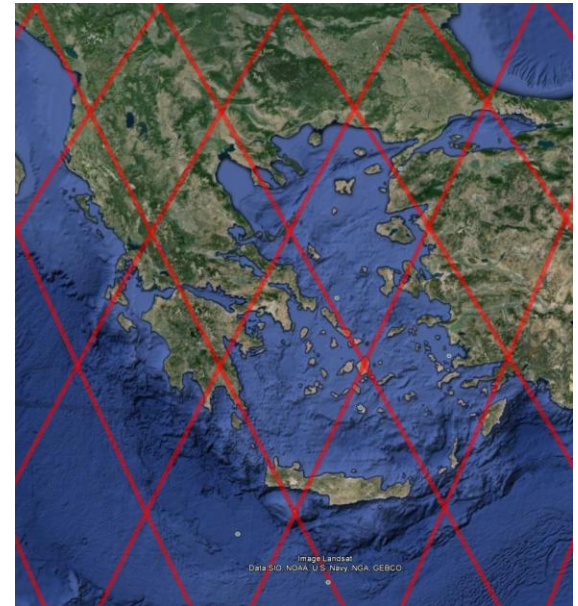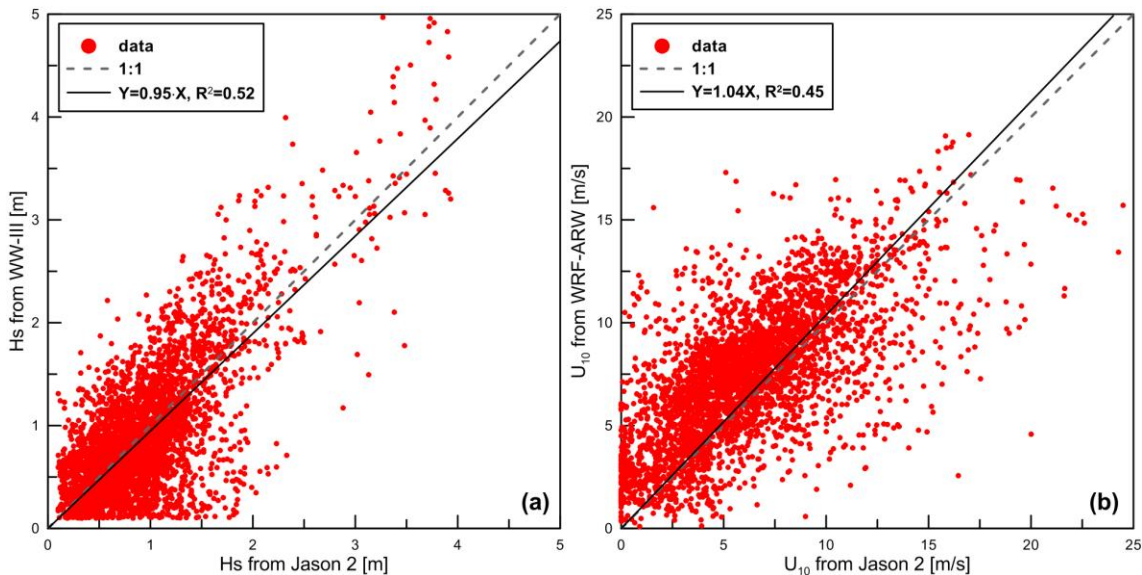
Model results: **Wave height and direction**

Aegean Sea

Thermaikos Gulf

Boundary conditions
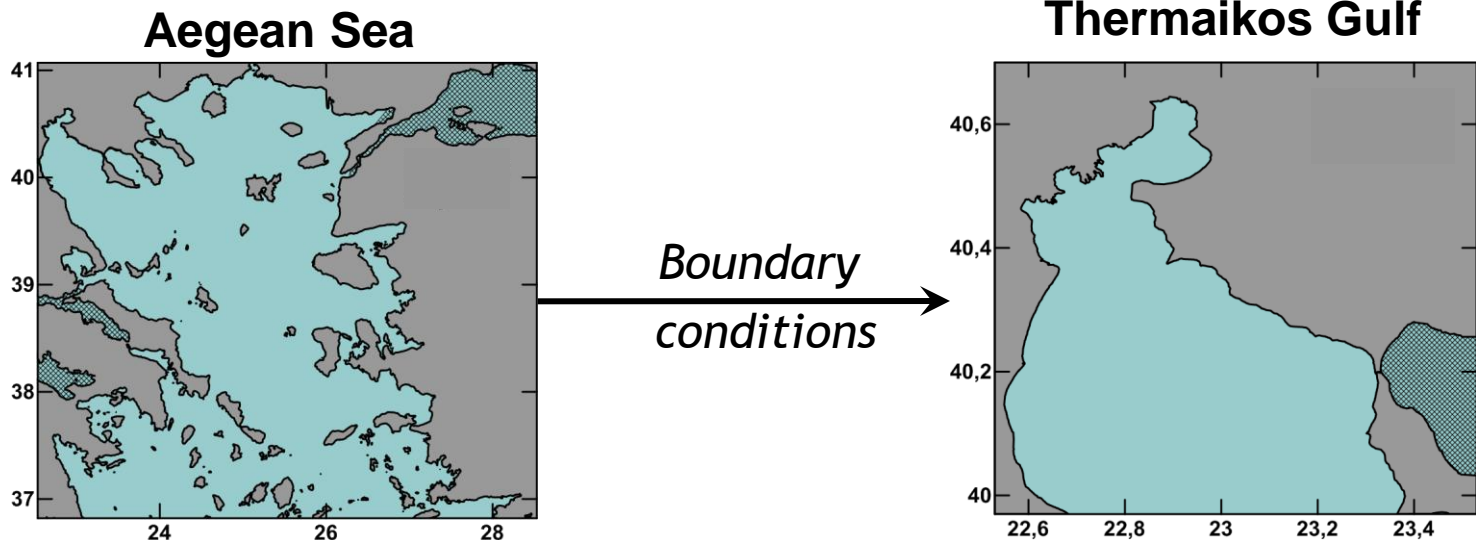
Wave model (WaveWatch III: WW-III)

Model validation using satellite altimetry data

Jason-2 satellite data (after time and space collocation)

Period: 01/03/2013 to 28/02/2014, Domain 2: Aegean Sea

- Linear fit close to a 1:1 relation

- Strongest scattering in relatively low significant wave heights (Hs<1.5m)

- Model predicts energetic wave conditions effectively

- Self-similar scatter pattern for wind velocities

High Resolution Storm Surge (HRSS) model

HRSS is a 2-dimensional hydrodynamic model that simulates the changes to the mean Sea Level Height (SLH) taking into account:

➢ Atmospheric forcing (**wind and pressure fields**)

➢ Geostrophy

➢ Astronomical tides, Schwiderski (1980)

➢ Surface and seabed stresses

➢ Impact of waves

Model results: **SLH & depth averaged currents**

International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop
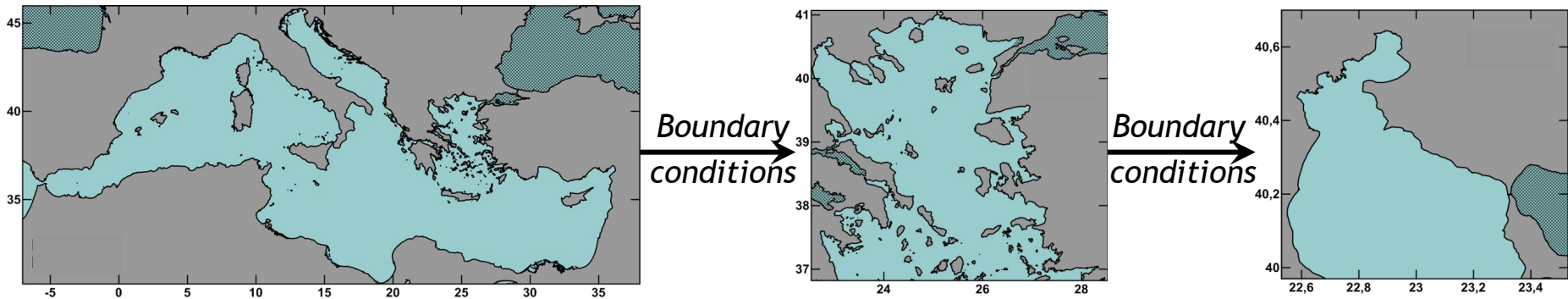
High Resolution Storm Surge (HRSS) model

Storm Surges: Rise of MSL due to combined action of pressure systems and winds
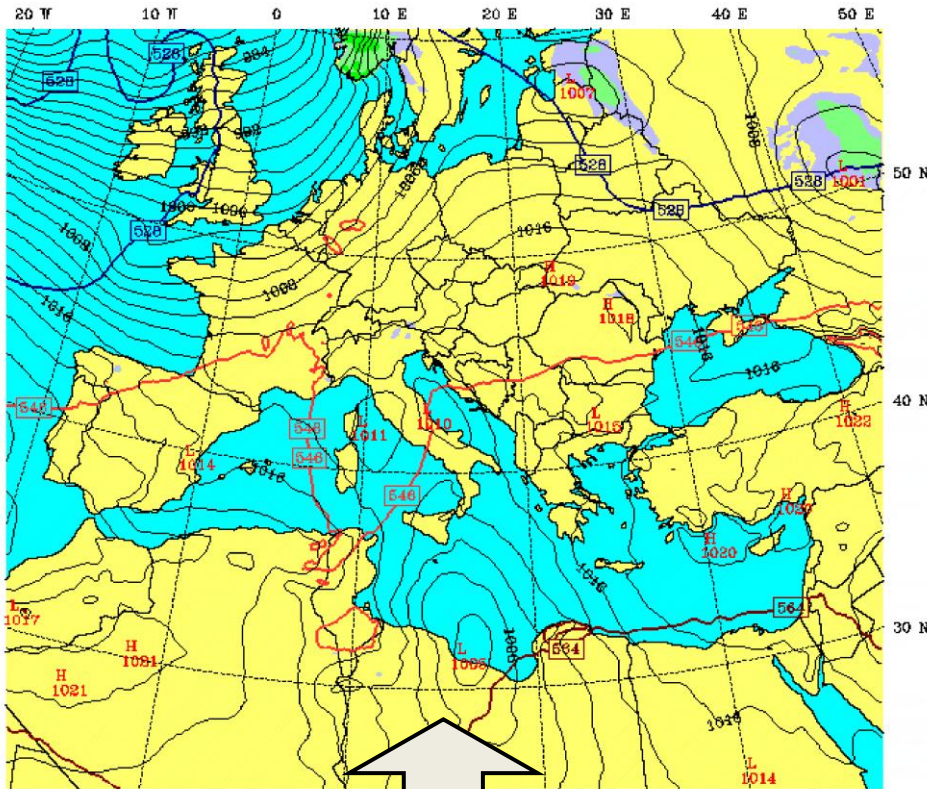
LP → sea level **rise**
HP → sea level **drop**
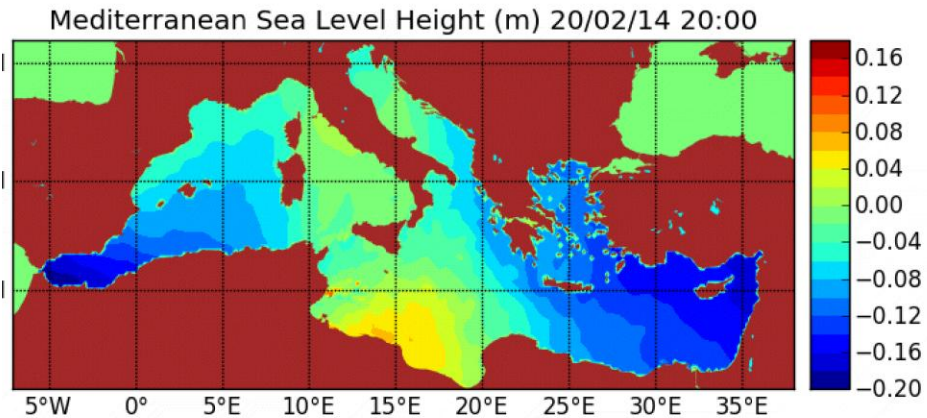
Atmospheric Pressure
WRF-ARW: Mediterranean domain

Mean Sea Level (MSL)
HRSS: Mediterranean domain

High Resolution Storm Surge (HRSS) model

Mediterranean Sea Level Height (m) 21/02/14 05:00
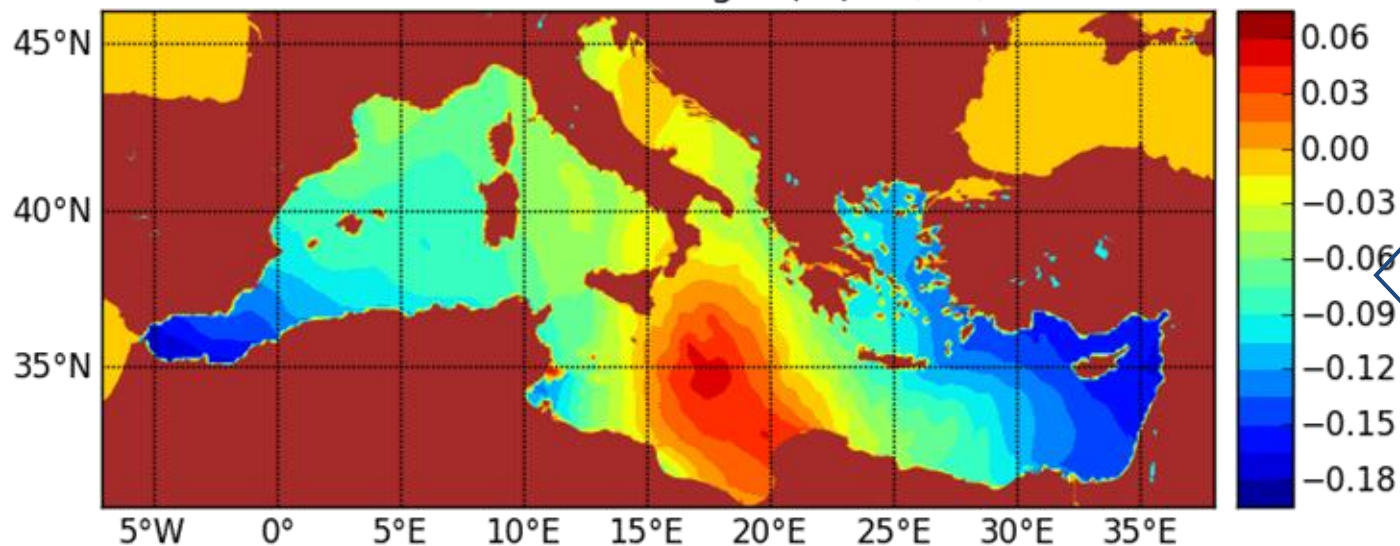
WaveForUs
MSL [m]
21/02/14
03:00UTC
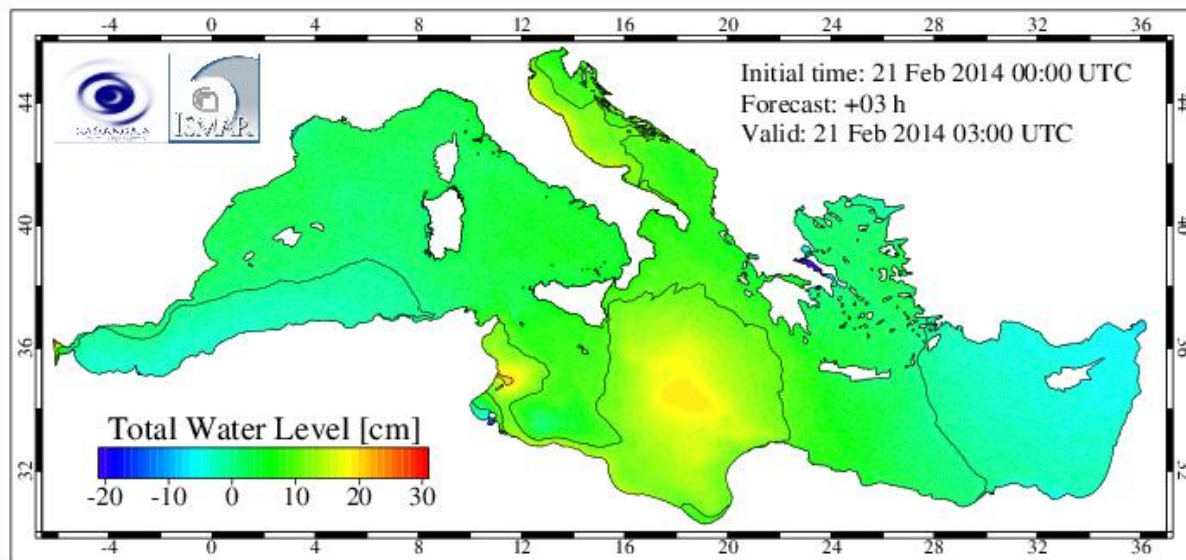
Kassandra
MSL [m]
21/02/14
03:00UTC

http://kassandra.ve.ismar.cnr.it:8080/kassandra

High Resolution Storm Surge (HRSS) model

Mediterranean Sea Level Height (m) 22/02/14 14:00
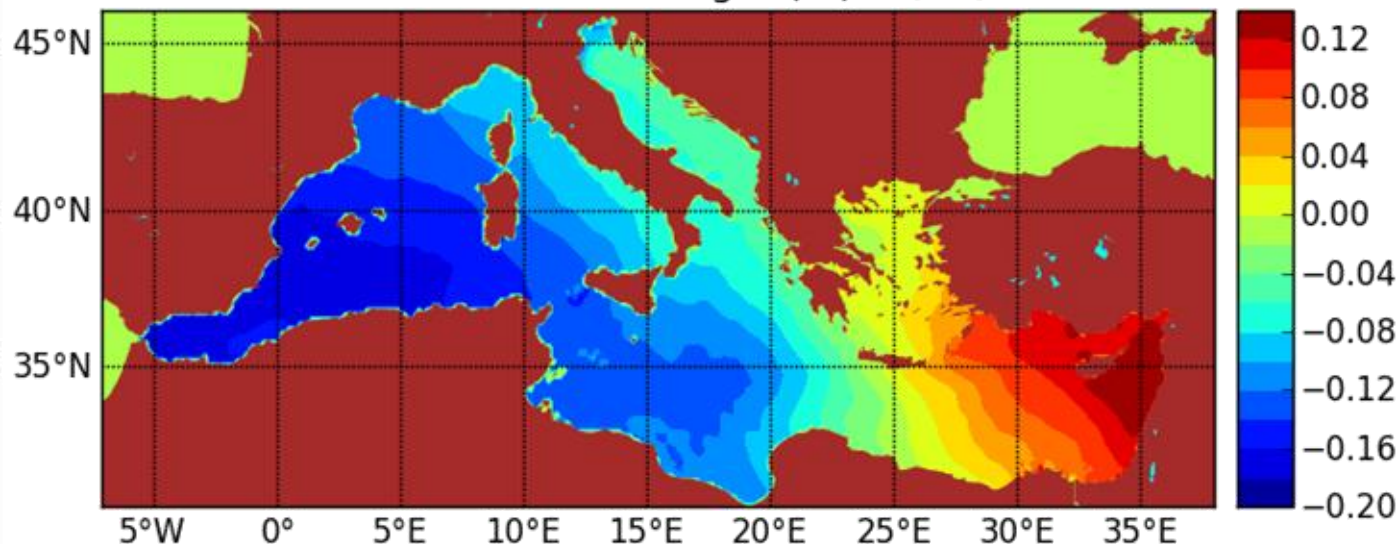
WaveForUs
MSL [m]
22/02/14
12:00UTC

Initial time: 21 Feb 2014 00:00 UTC
Forecast: +36 h
Valid: 22 Feb 2014 12:00 UTC

Total Water Level [cm]
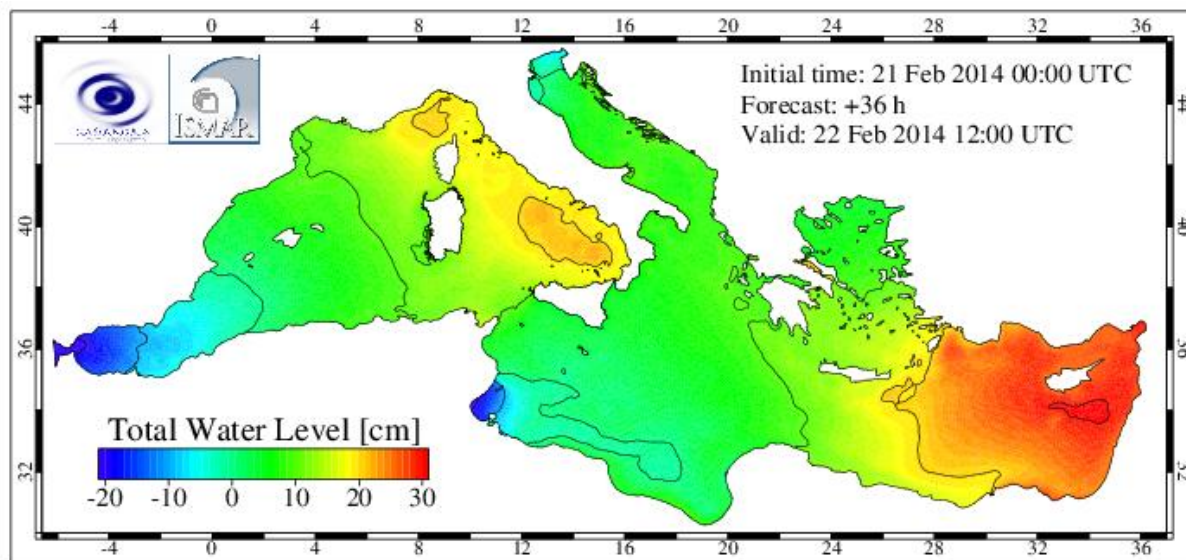
Kassandra
MSL [m]
22/02/14
12:00UTC

http://kassandra.ve.ismar.cnr.it:8080/kassandra

Coastal Circulation model (POM)

Princeton Ocean Model (POM) is a widely applied and validated model for the simulation of various environments, including coastal circulation and mixing processes in rivers, estuaries, shelves and slopes, lakes, semi-enclosed seas, as well as the global ocean. POM is a three-dimensional, free-surface, terrain following model that can deliver prognoses for:

➢ Current speed and direction

➢ Free surface elevation

➢ Seawater thermohaline properties (temperature, salinity, density)

Input atmospheric fields: wind, pressure, temperature, rainfall, humidity and surface thermal and radiation fluxes

Boundary conditions

http://www.myocean.eu/
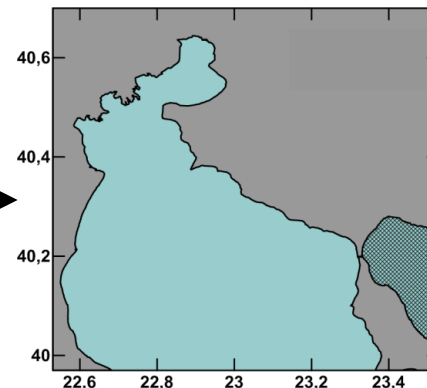
Coastal Circulation model (POM)

Daily assimilation of riverine fluxes
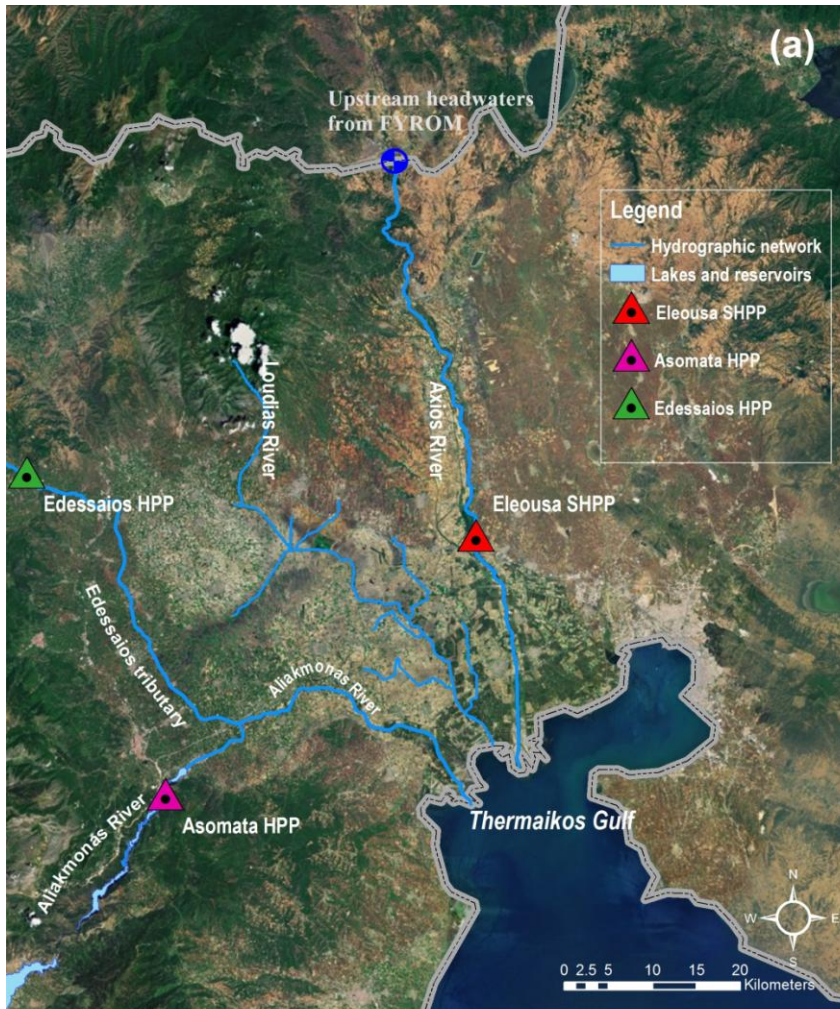
- 3 rivers

- 3 Hydroelectric dams

- Determine the physical characteristics of the enclosed Thermaikos Gulf

- Absence of daily discharge measurements

- Very few historical measurements

- Need for daily outflow rates

Solution
three independent methodologies for the assessment of the river discharges

International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop

Coastal Circulation model (POM)

(a) *Simulated Salinity*

(b) *Satellite Chl-a*

(c)

(d)

Power
produce
converted t

$Q= I/(g$
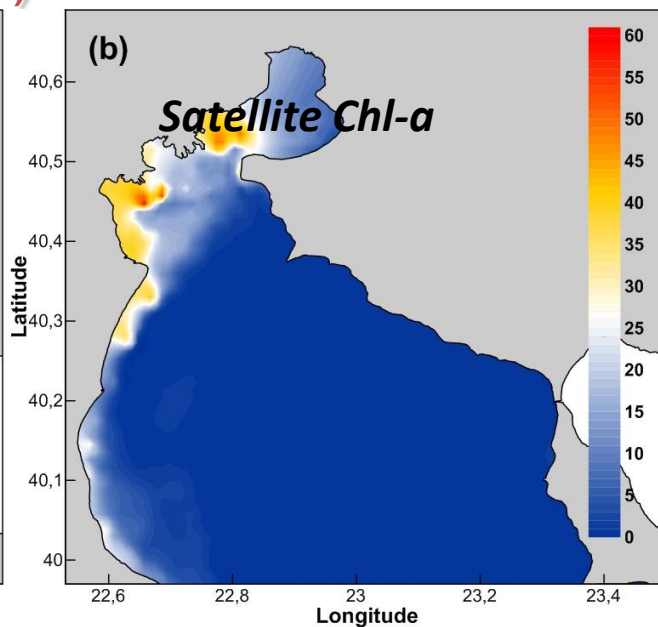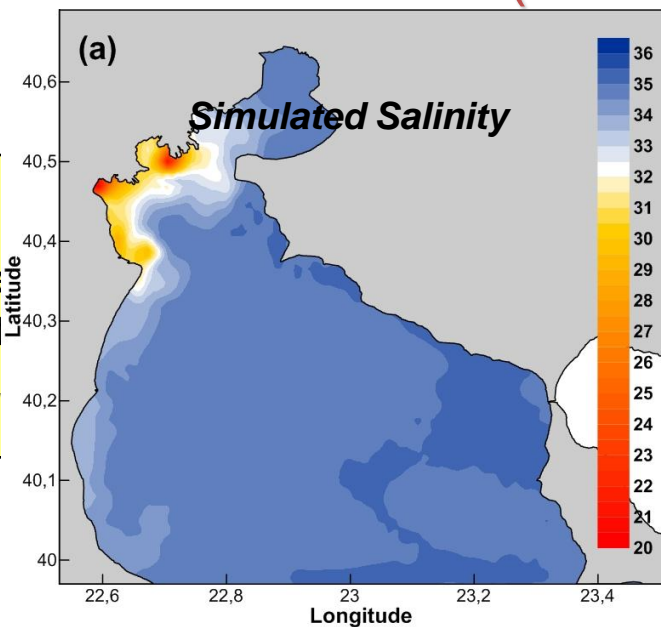
of water
he dam to
charge

$\sqrt{2gH}$

level data
ders of
d Greece,
nrough a
vel sensor

Estimation
from Mar
Plans of
drainag
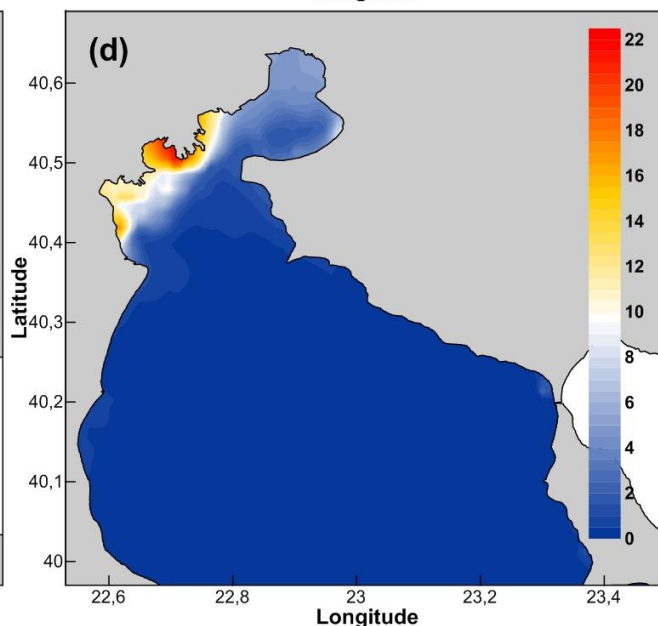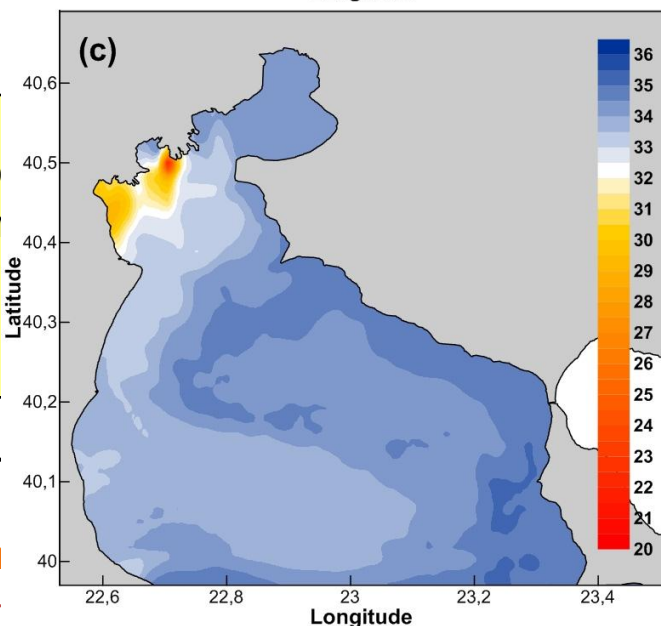
Comparison

No Riveri

With Riverin

se of mean
inity in the
0.2 - 1.2

Coastal Circulation model (POM)

Performance Indicators	Average	Thessaloniki	Cental Gulf	East Coast	West Coast
MAE±StDev [°C]	0.85±0.96	0.61±1.49	0.71±1.11	0.53±1.23	1.15±1.29
MAE ±StDev [%]	3.60±4.56%	1.67±7.15%	3.21±5.35%	1.47±6.79%	5.42±5.87%
RMSE [°C]	1.28	1.59	1.31	1.33	1.73
R^2	0.97	0.90	0.95	0.95	0.94
Willmott Skill (WS)	0.98	0.97	0.98	0.98	0.97
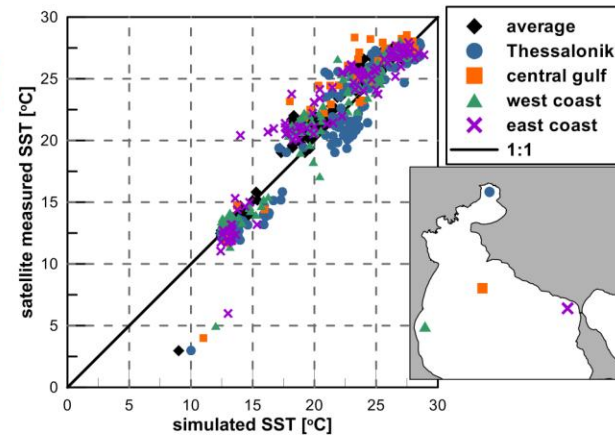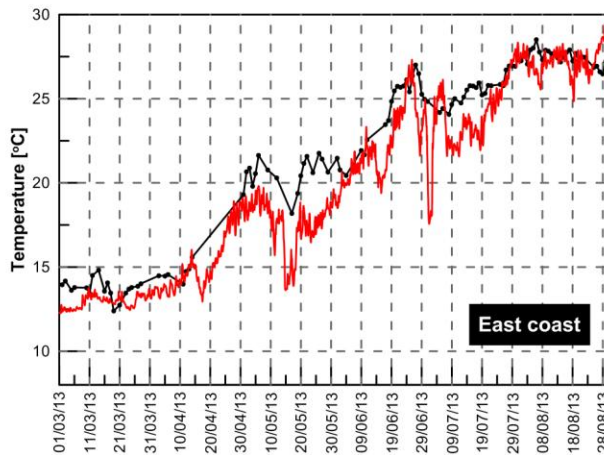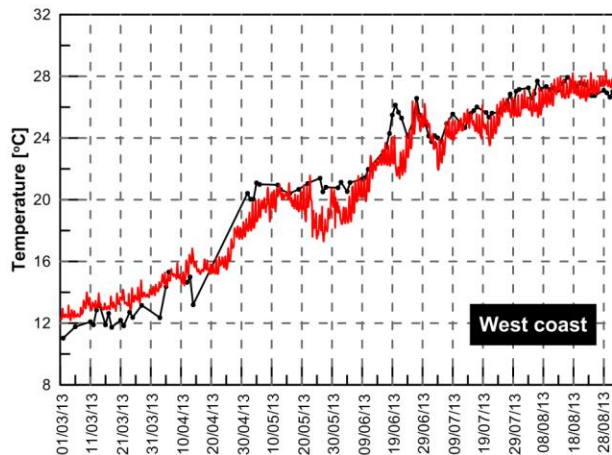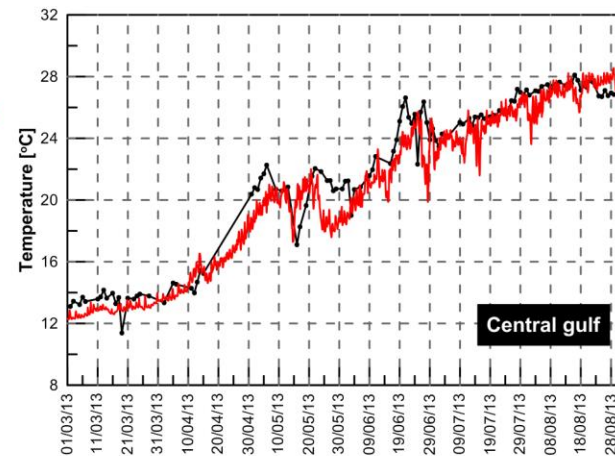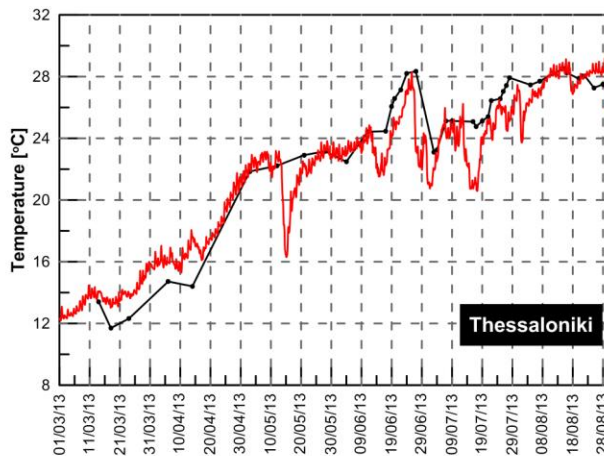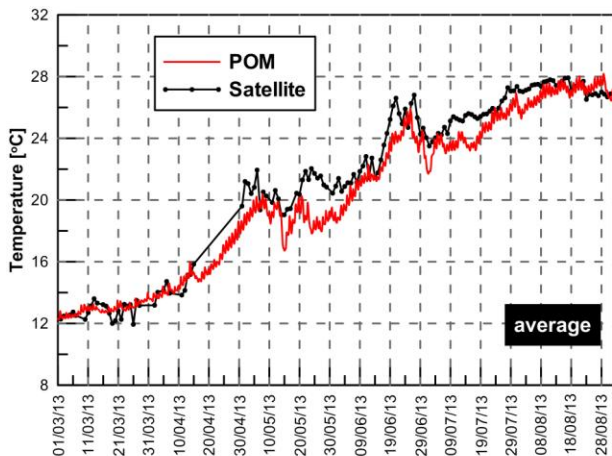
Coastal Circulation model (POM)

Temperature [ºC]
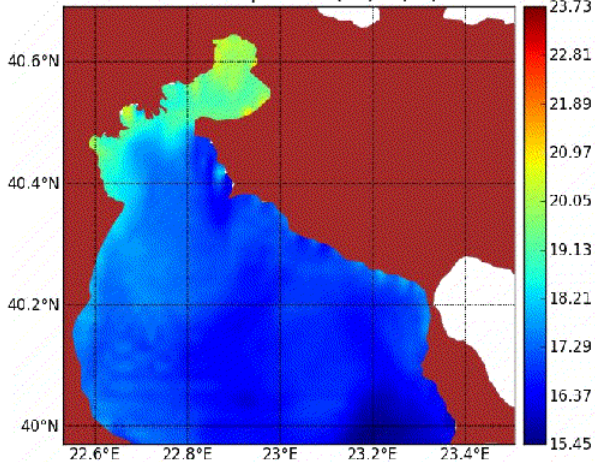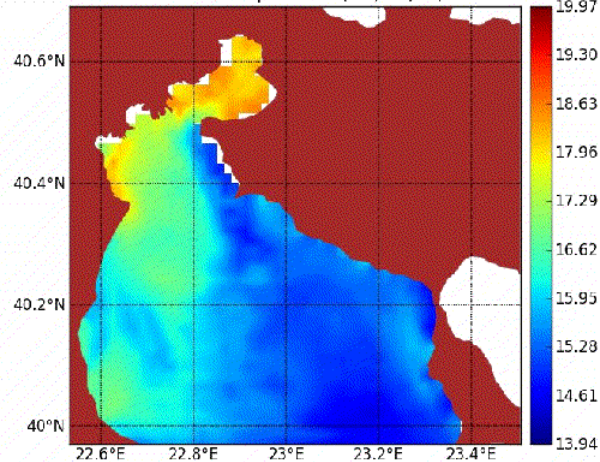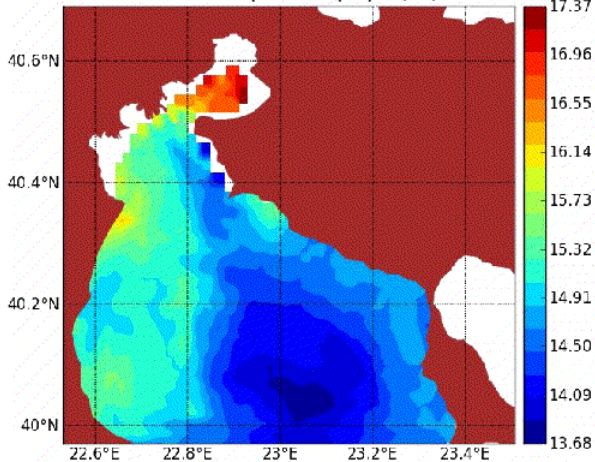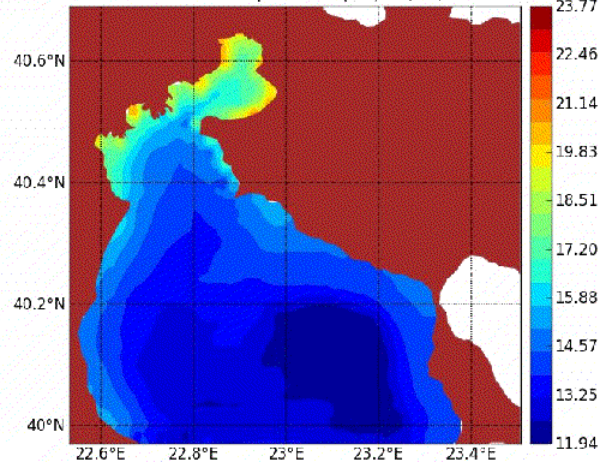
Surface | 10m | 20m | Bottom

Coastal Circulation model (POM)

Salinity [‰]
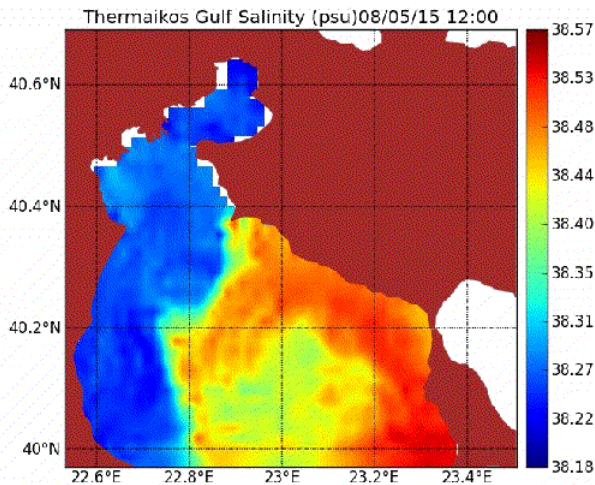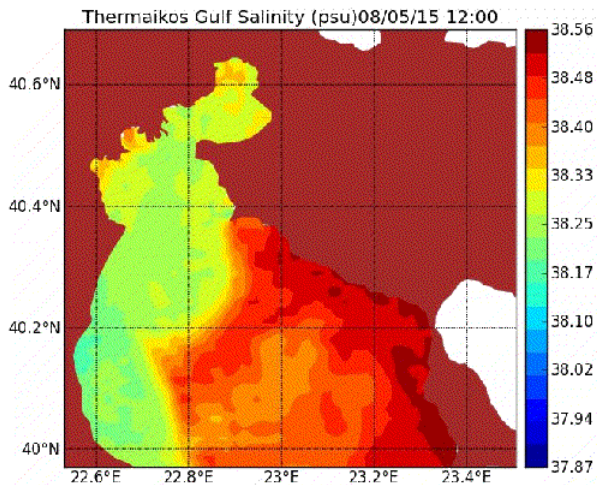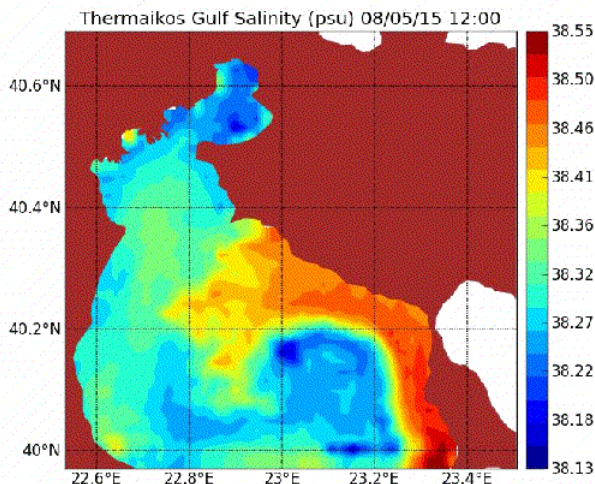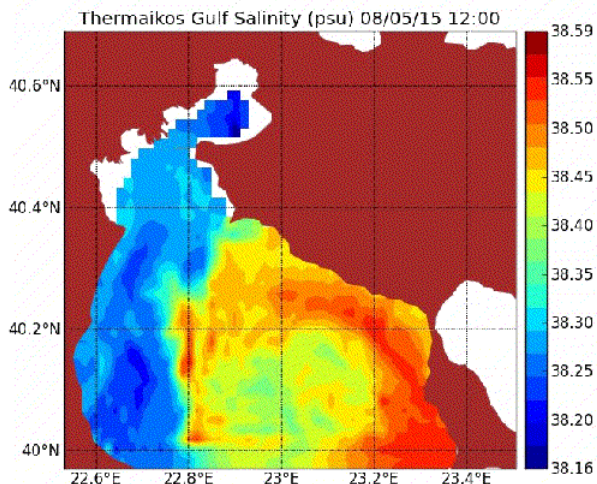
Surface · 10m · 20m · Bottom

Coastal Circulation model (POM)

Currents [m/s]
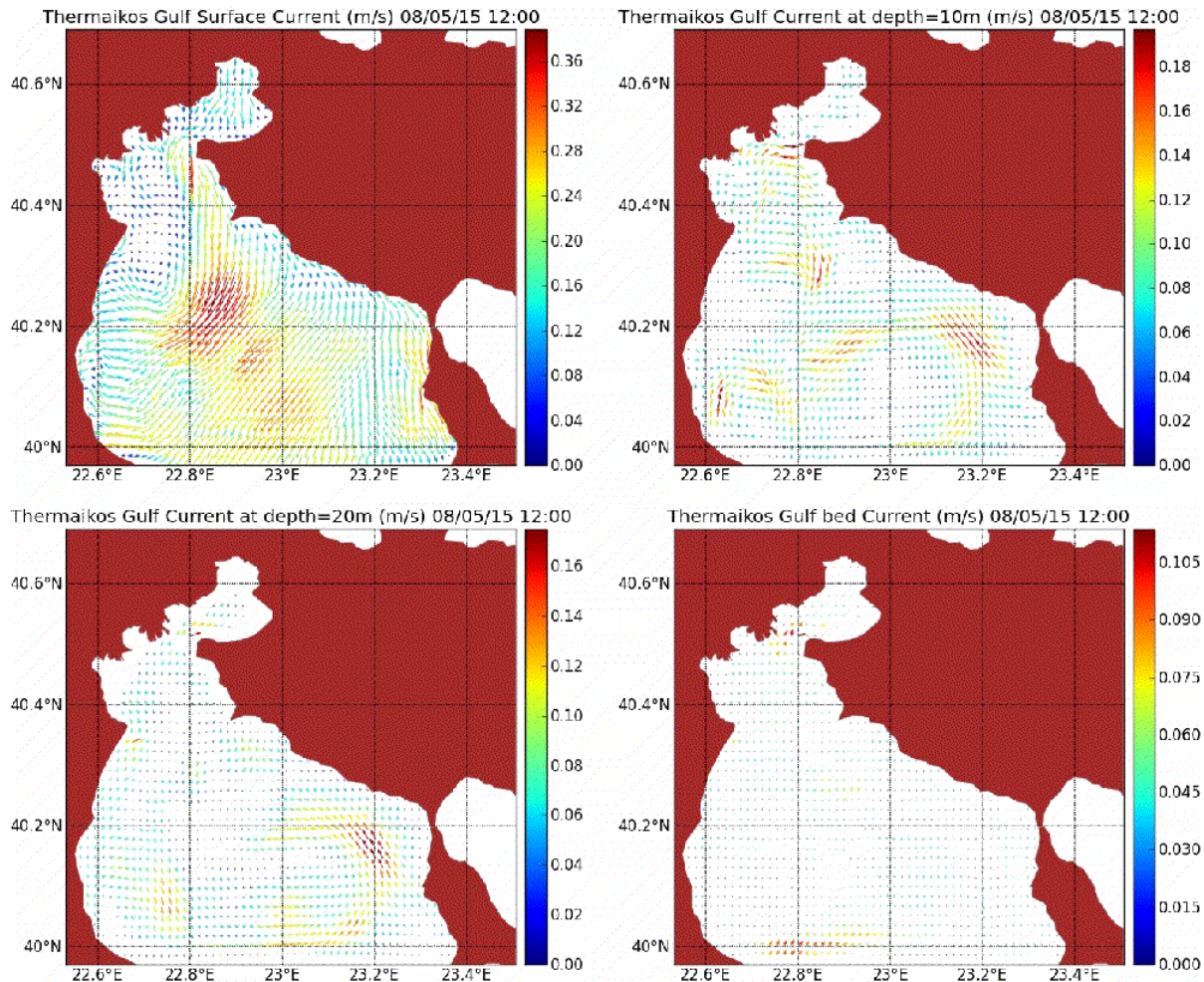
Surface Currents

10m

20m

Bottom

Thermaikos Gulf Surface Current (m/s) 08/05/15 12:00

Thermaikos Gulf Current at depth=10m (m/s) 08/05/15 12:00

Thermaikos Gulf Current at depth=20m (m/s) 08/05/15 12:00

Thermaikos Gulf bed Current (m/s) 08/05/15 12:00

Forecast dissemination

Daily 3-day forecasts at **10:30**

http://wave4us.web.auth.gr/

TV Broadcasts

CW4) of the Coastal and Shelf Seas Task Team
COM Pilot Workshop

Forecast dissemination

Daily 3-day forecasts at **10:30**

http://coastal.web.auth.gr/

Summary

❑ WaveForUs is already providing daily forecast results through the program webpage ([http://wave4us.web.auth.gr/)](http://wave4us.web.auth.gr/), a web-GIS application and 6 daily television broadcasts.

❑ Evaluation of the simulations showed the effectiveness of the sea-state forecasts is quite satisfactory.

❑ The WaveForUs forecasting system may be a useful and reliable tool for users and their sea-based activities.

❑ <u>On-going work</u>

We are conducting a survey with questionnaires in order

- to evaluate the public response to the WaveForUs system

- to produce more friendly-user products to general public and more useful products to professionals

The WaveForUs project is funded by the national action 'COOPERATION 2011:' Partnerships of Production and Research Institutions in Focused Research and Technology Sectors in the framework of the operational programme 'Competitiveness and Entrepreneurship' (NSRF2007-2013)

The WaveForUs system uses MyOcean (http://www.myocean.eu/) products.

Thanks…

International Coordination Workshop (ICW4) of the Coastal and Shelf Seas Task Team (COSS-TT) & ARCOM Pilot Workshop