Modeling the influence of the Dardanelles outflow on the Aegean Sea dynamics

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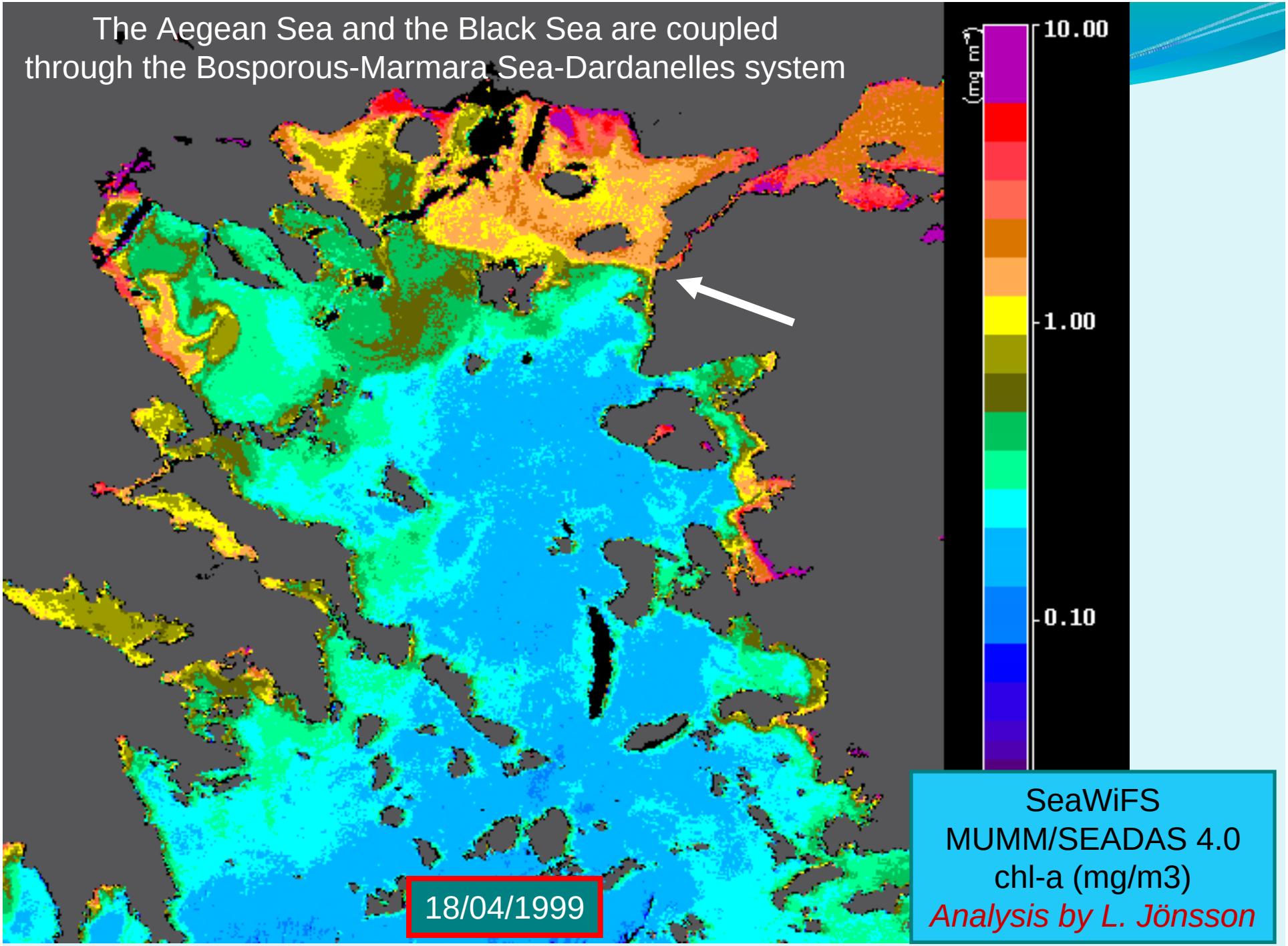
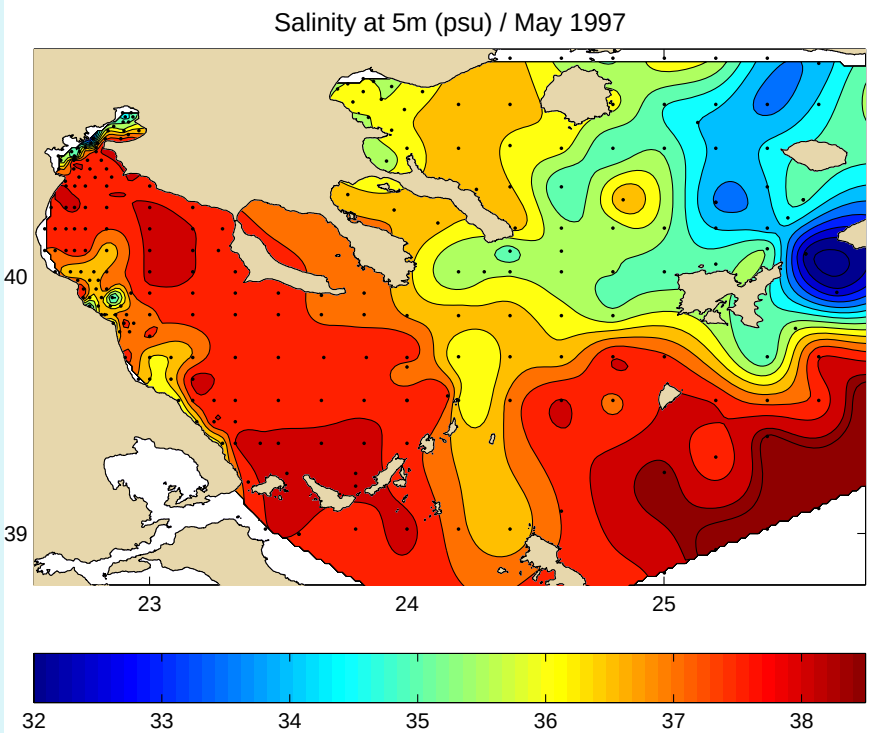
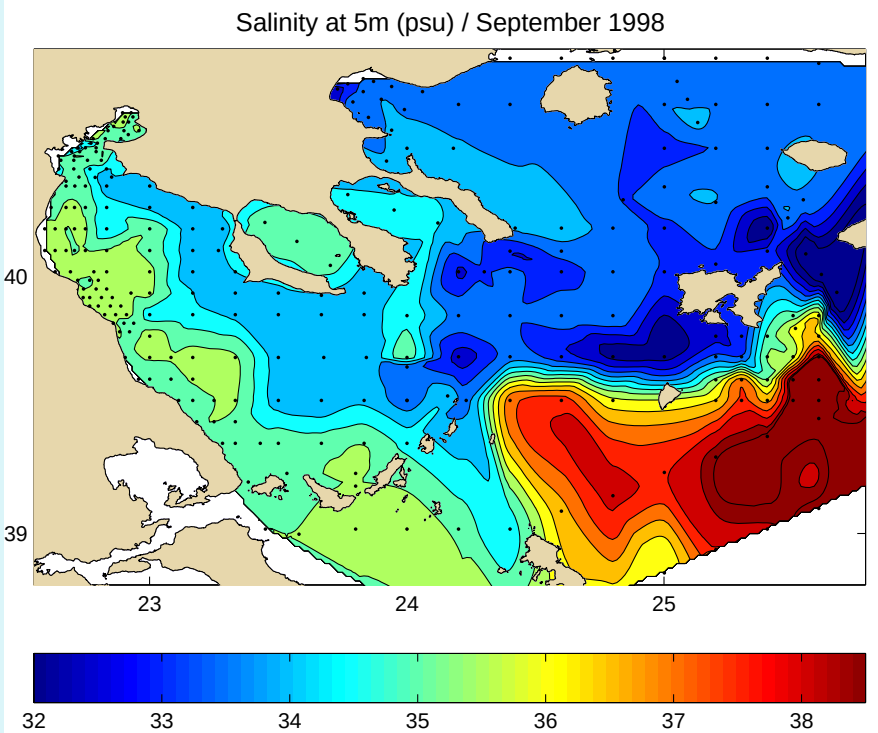
P.M. Poulain (OGS, Italy)
S. Besiktepe (NURC, Italy/international)
EU-SESAME project (HCMR, coordinator)


The Aegean Sea and the Black Sea are coupled
through the Bosporous-Marmara Sea-Dardanelles system
(mg m⁻³)
10.00
1.00
0.10
18/04/1999
SeaWiFS
MUMM/SEADAS 4.0
chl-a (mg/m3)
Analysis by L. Jönsson

Observations: 1997-1998 hydrography



Salinity
(May 1997)



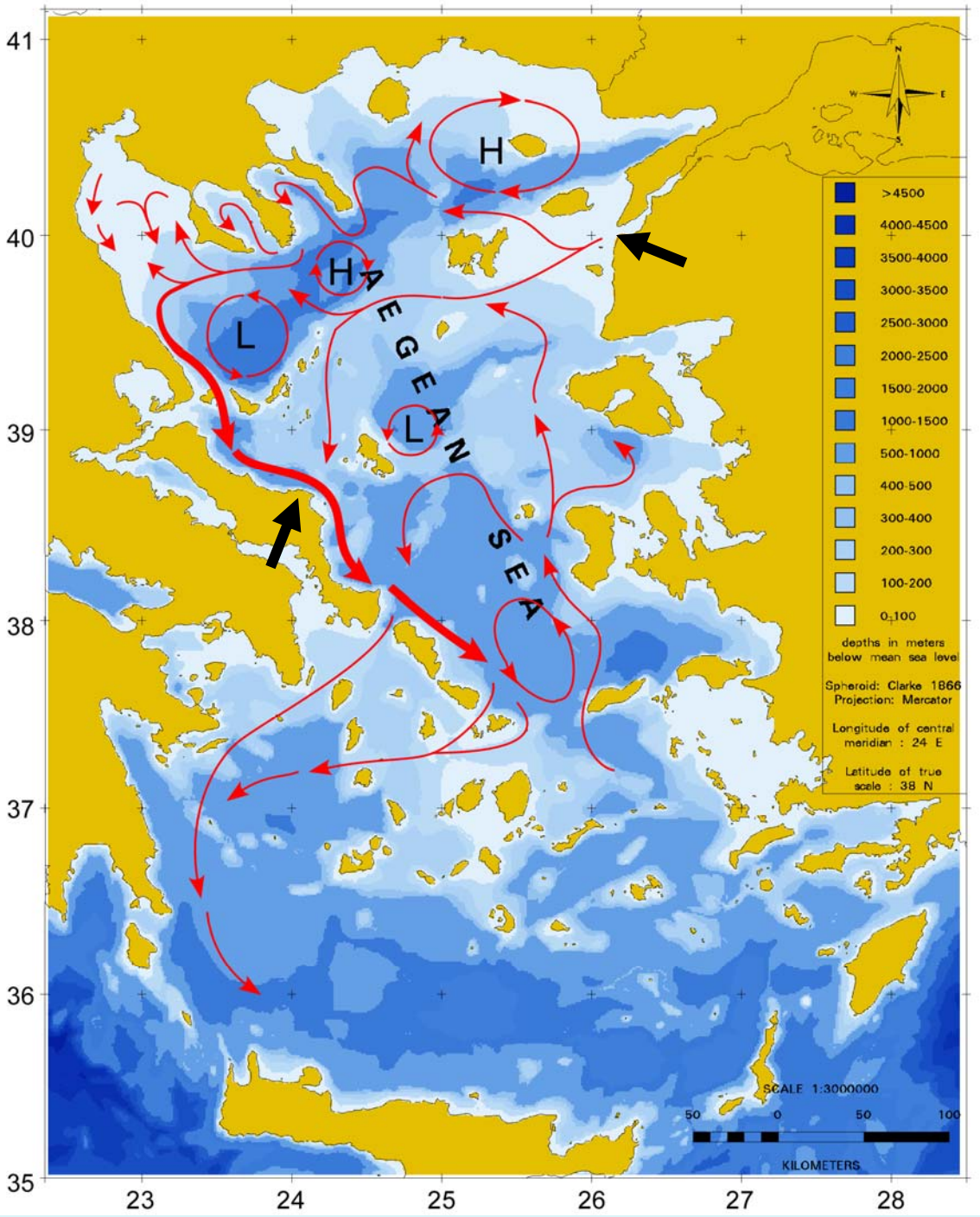
Salinity
(Sept. 1998)

Data provided by:
H. Kontoyiannis (METROMED) and
G. Georgopoulos, V. Zervakis (INTERREG)

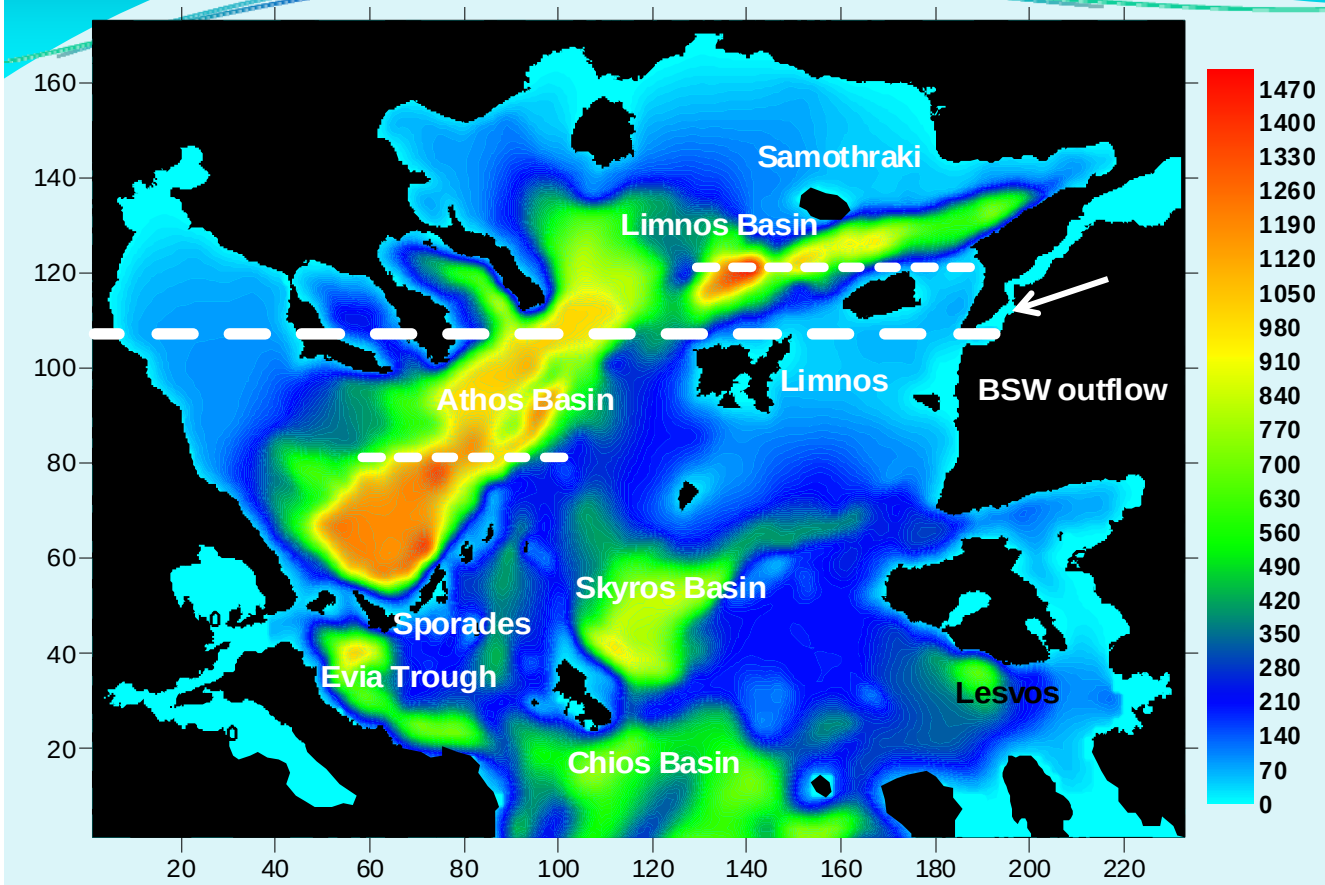
Observations: The 2002-2003 Drifter study

- 4 deployments (March, June, Sept. 2002; Febr. 2003)
- 45 drifters
- ~ 10 m drogue depth
- Generally deployed at depths larger than 200 m

Olson et al., JPO 2007



The North Aegean Hybrid Coordinate Ocean Model (NAEG-HYCOM)



Res.: 1/50^0
Nested in 1/25^{0}MED-HYCOM

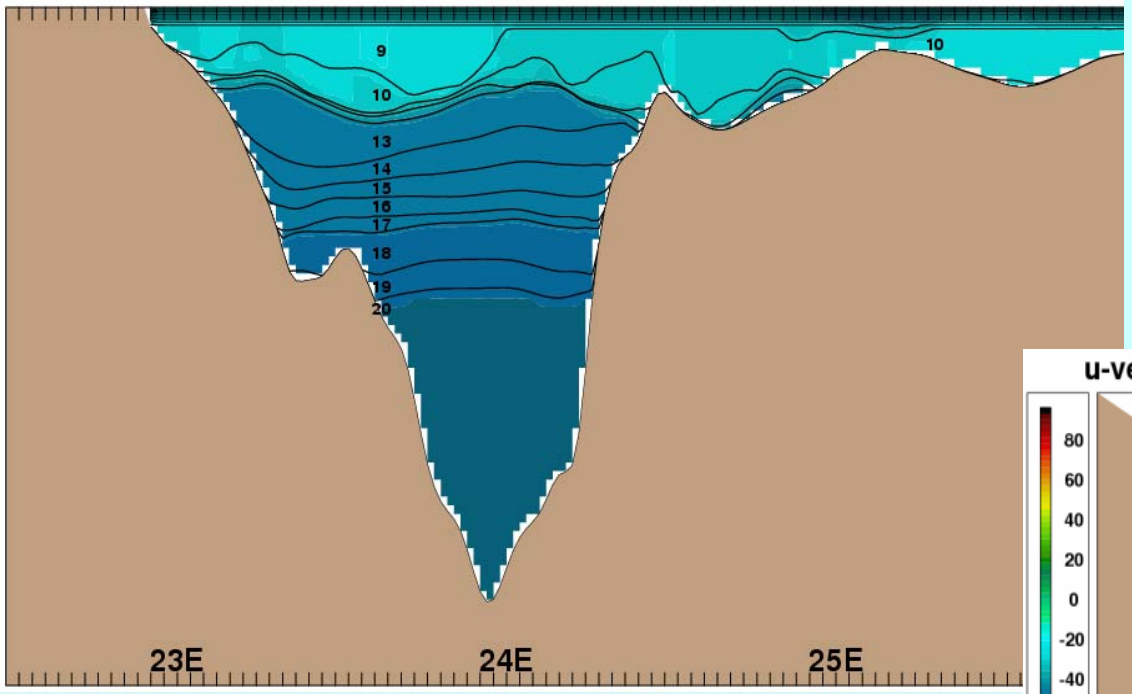
Hmin=2m

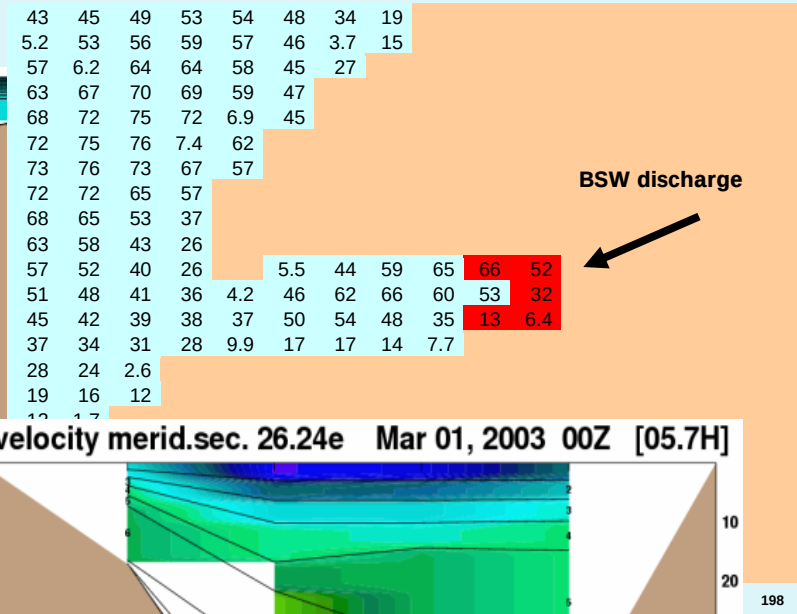
Monthly mean rivers & outflow

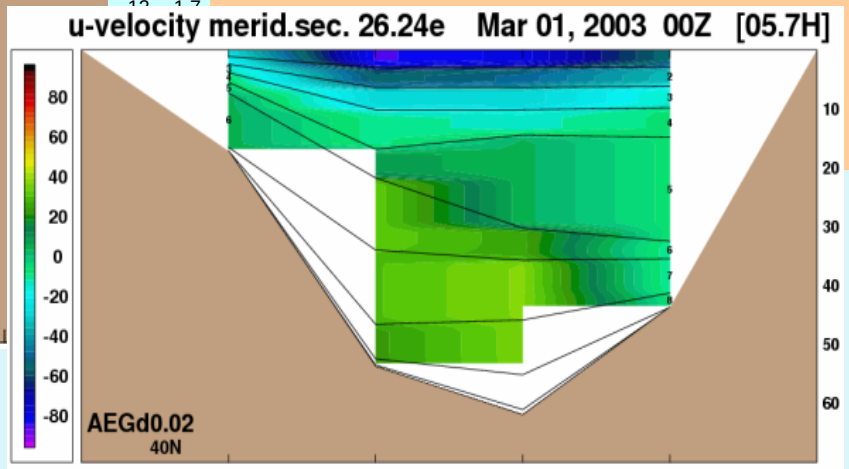
Atm. Forcing:
- NOGAPS 1 deg
- SKIRON/POSEIDON 1/10 deg

- What is the role of outflow properties, strait dynamics and atmospheric forcing in the development of the Dardanelles plume?
- How does the transport and fate of BSW waters vary in seasonal and inter-annual time scales, how is it modified by the complex topography and how does it impact the North Aegean general circulation?
- What is the role of BSW on the North Aegean dense water formation?

Model simulations– Study Period 2002-2009







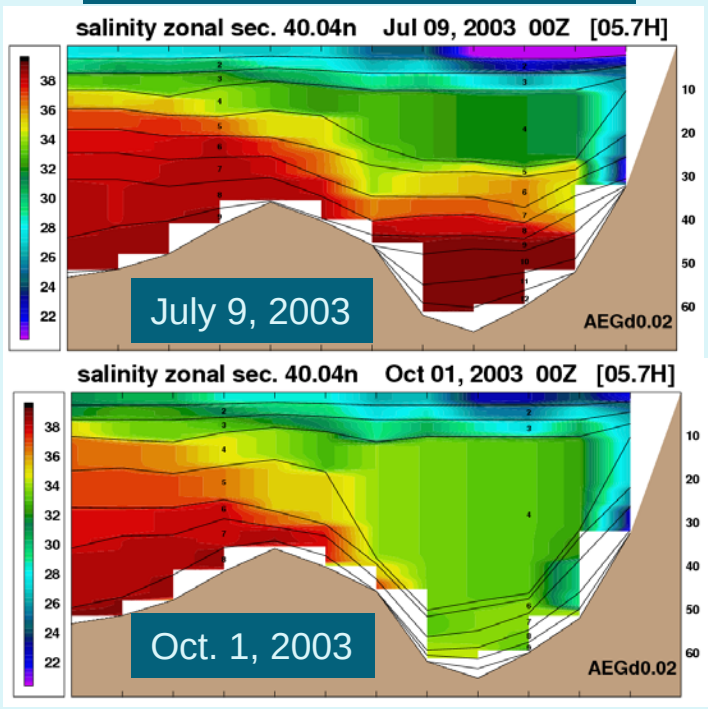
Dardanelles outflow current parameterization: modified river upper layer inflow over top 25 m and spread over 5 cells

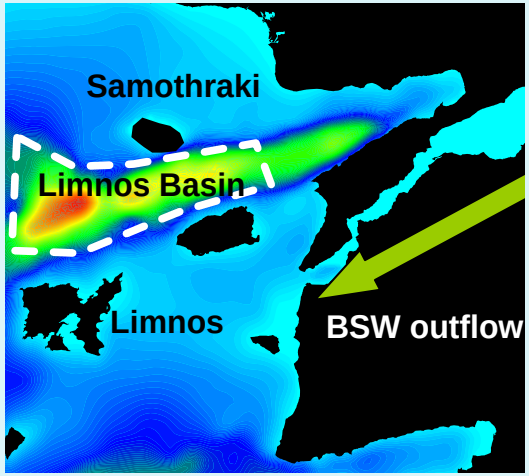
(Schiller and Kourafalou, 2009; Besiktepe, 1994)

Dardanelles Outflow: variability in buoyancy input

- **Maximum: Spring - Summer**
- **Minimum: Autumn - Winter**

2 layer outflow structure

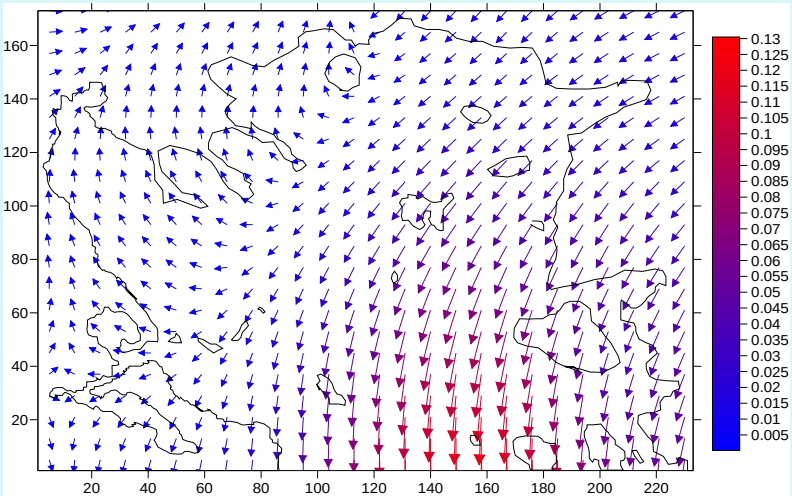




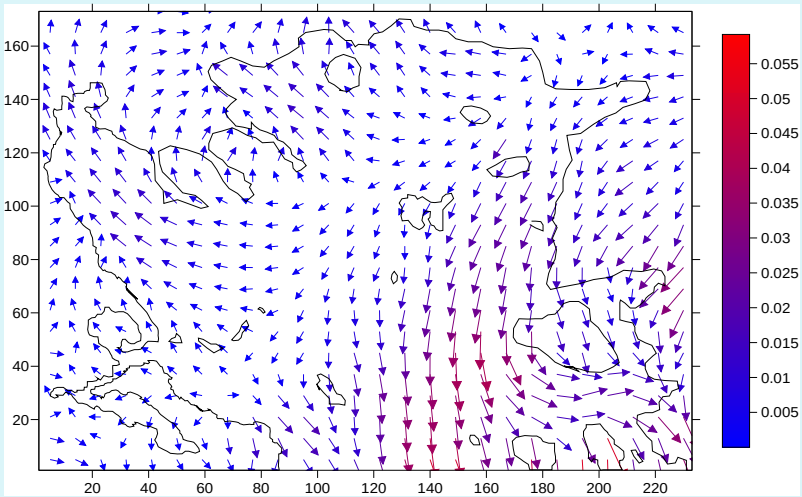
- *BSW outflow is the largest lateral buoyancy input in the Eastern Med.*
- *The BSW pathways exhibit variability in many time scales and are largely influenced by the complex topography*
- *Parameterizations of outflow properties influence basin scale dynamics*
- *Employ new data from ancillary projects (ONR-Poulain, NRL-Jarosz, NURC-Besiktepe, EU-SESAME)*

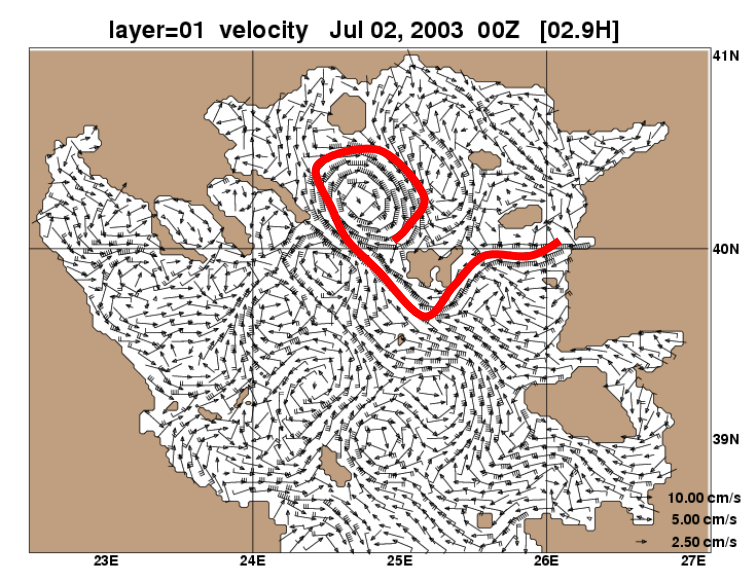
BSW pathways: influence of atmospheric forcing and topographic constrains

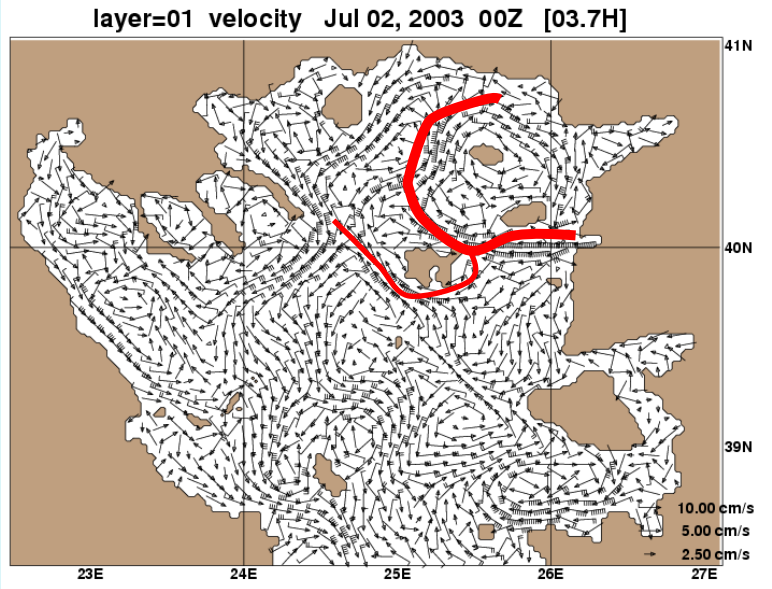
NOGAPS (resolution: 1 degree)



SKIRON (resolution: 1/10 degree)





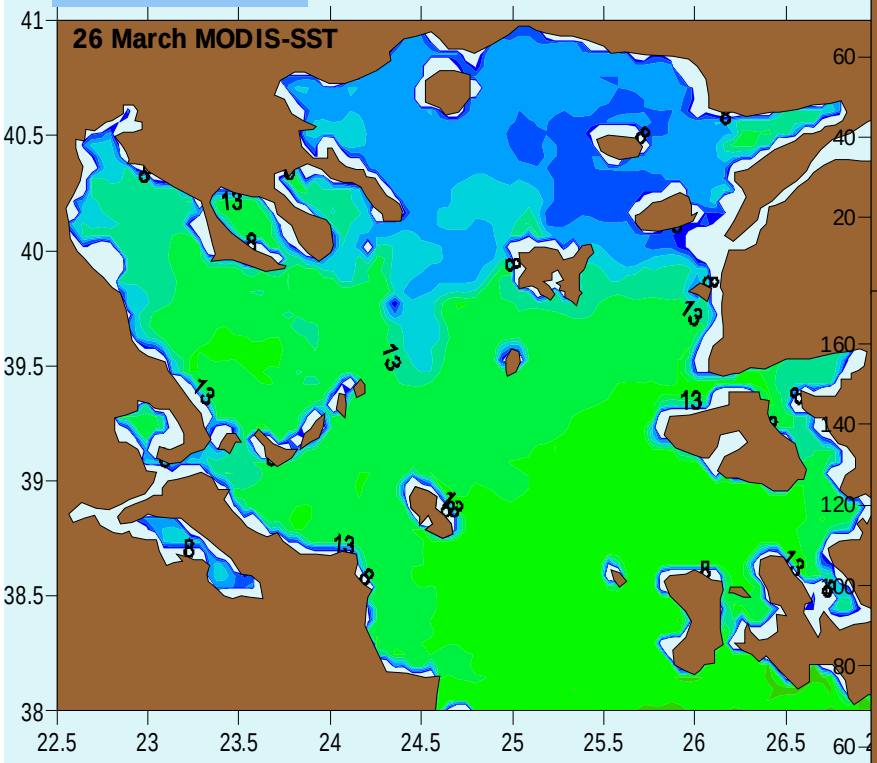


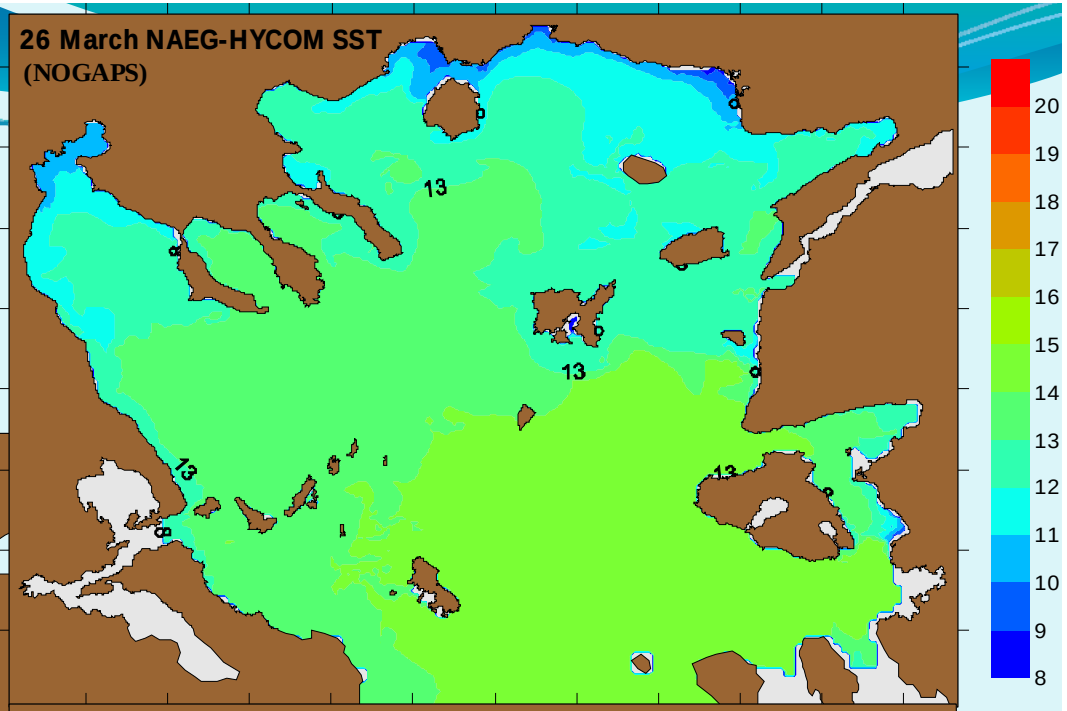
➢Details in high res. wind curl allow the biforcation of the BSW pathways

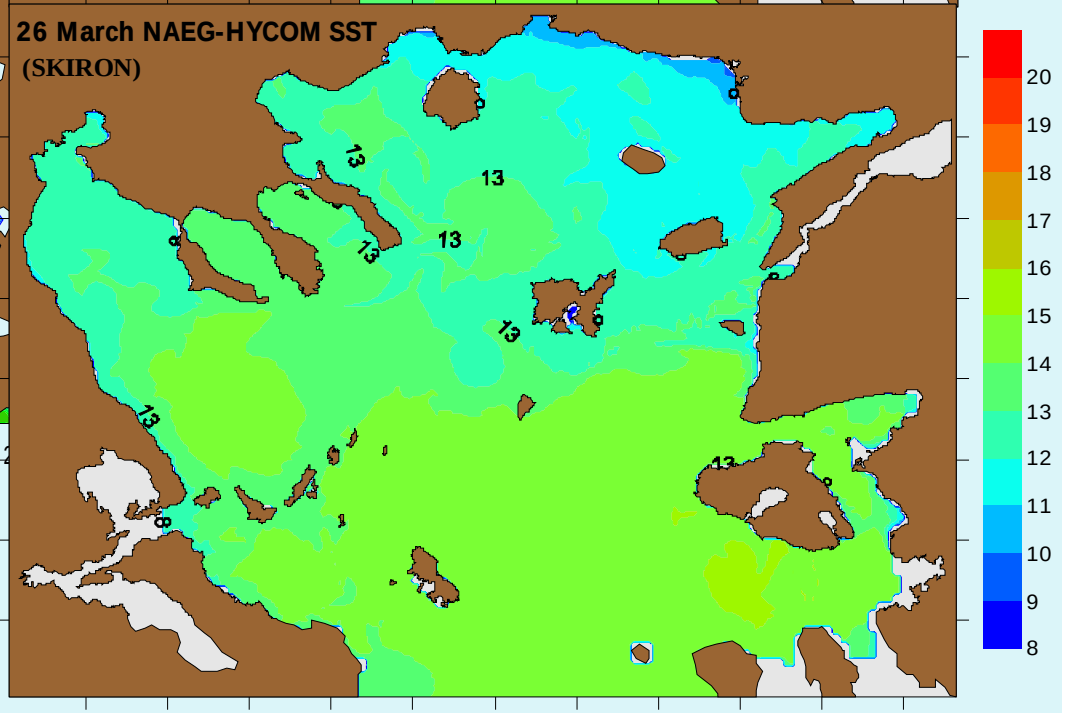
SST evaluation (3/26/03)

MODEL (w/ NOGAPS)

MODIS SST



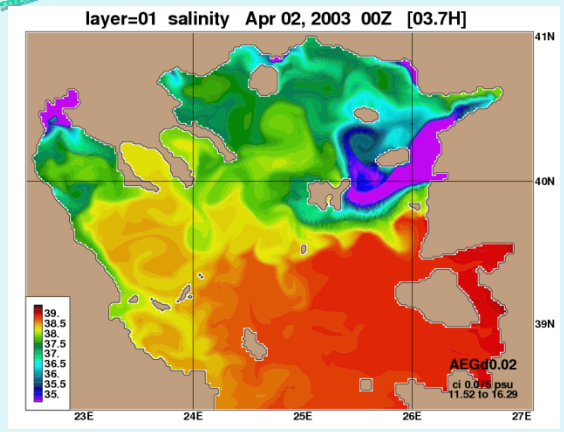


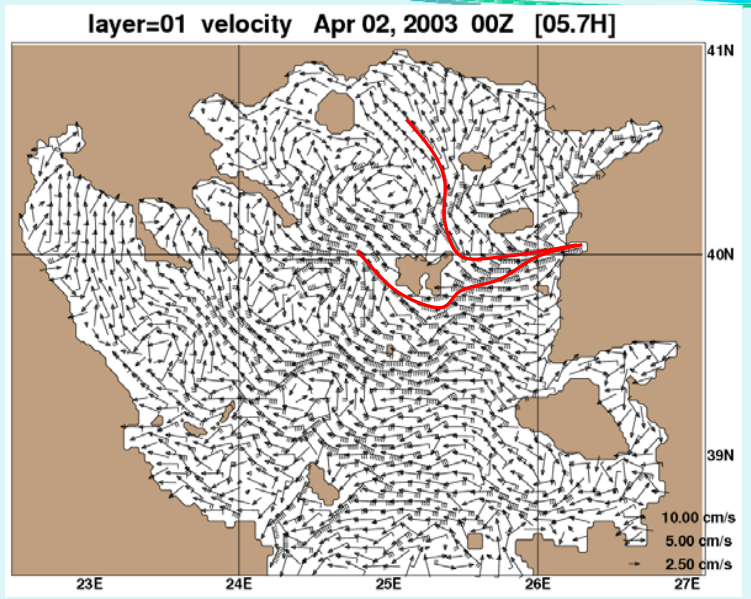


MODEL (w/ SKIRON)

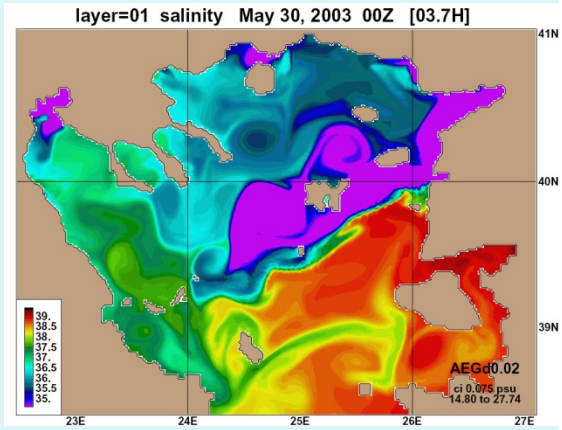
- Atmospheric fluxes
- BSW temperature

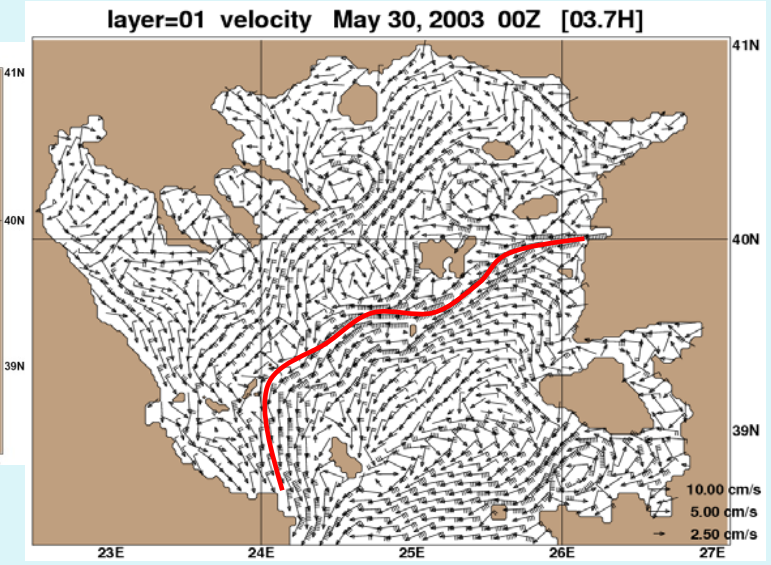
BSW pathways: influence on local and basin-wide dynamics





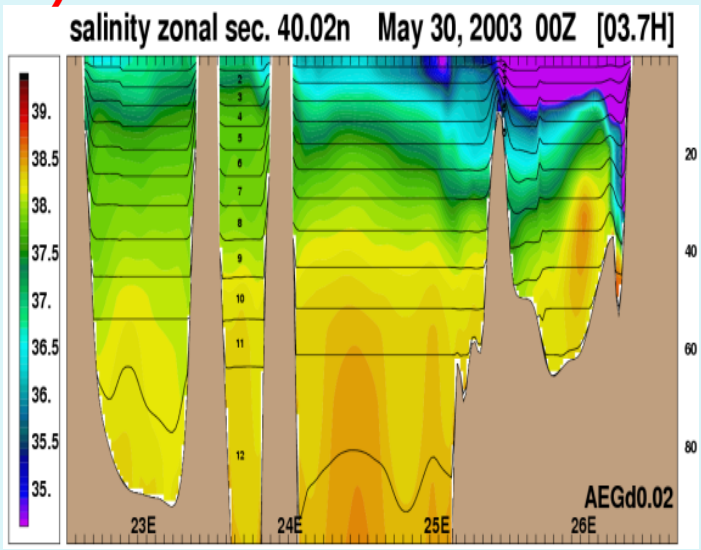
2 April 2003
No cross basin influence

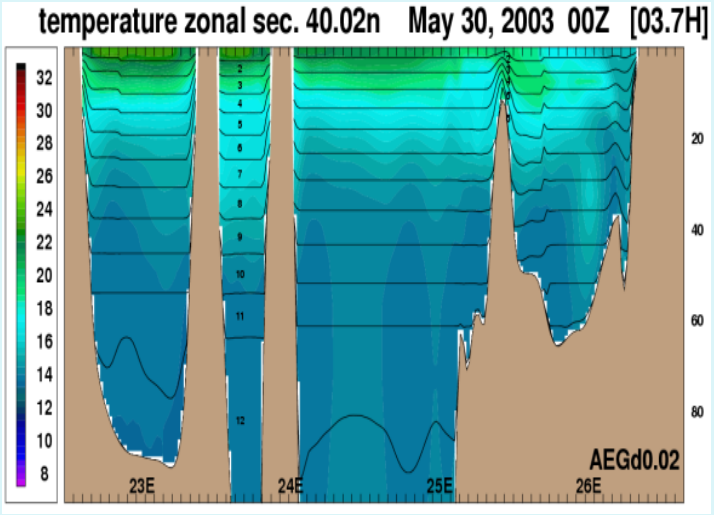


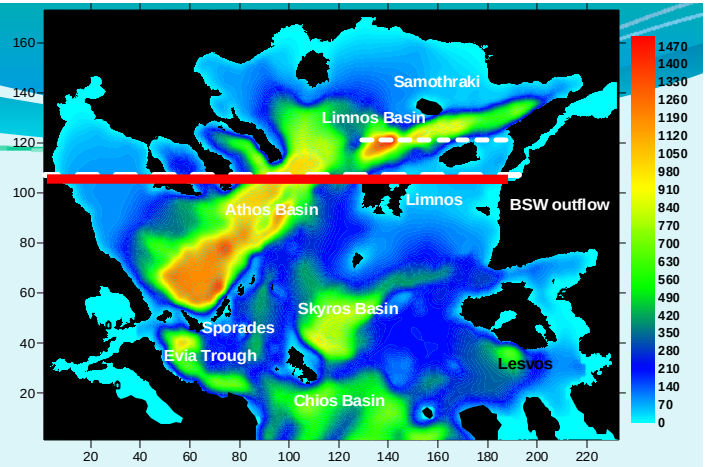


30 May 2003
Strong cross basin influence

BSW pathways: cross-basin structure (upper 100m)





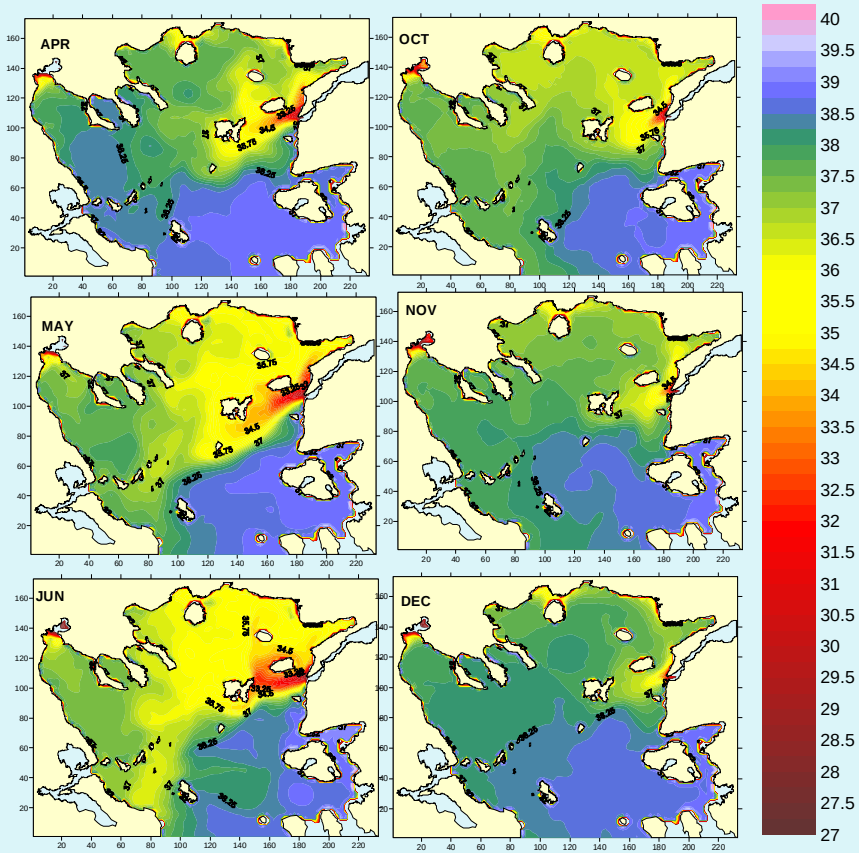


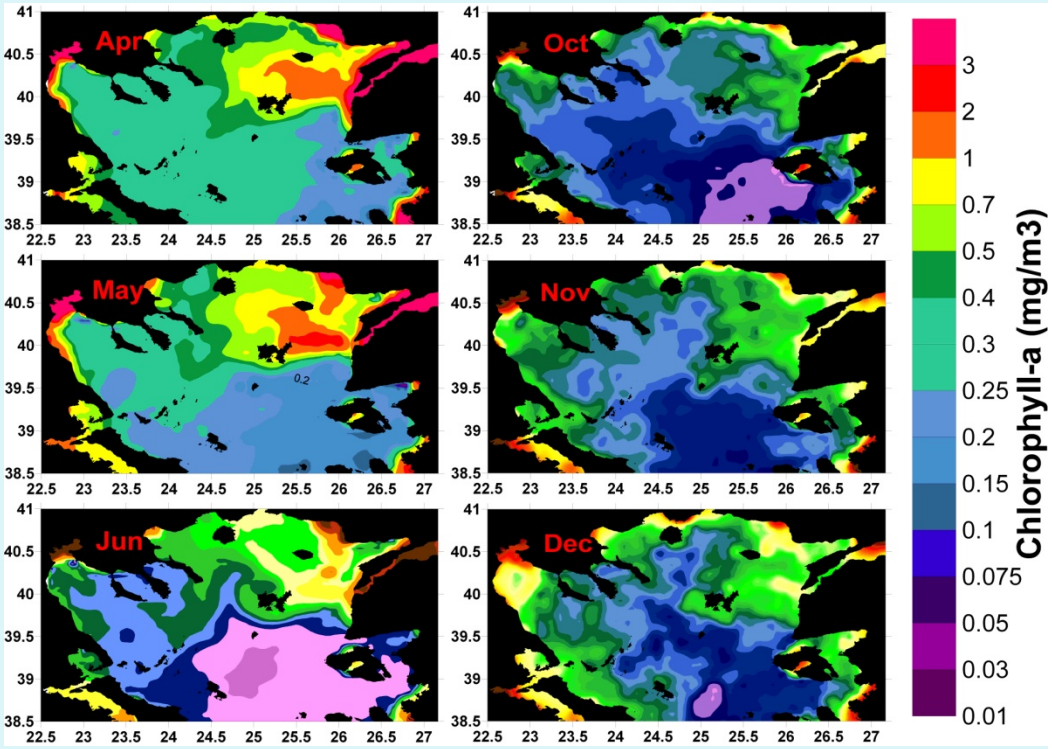
30 May 2003
Strong cross basin influence

BSW pathways: seasonal variability (spring/left panels– fall/right panels)

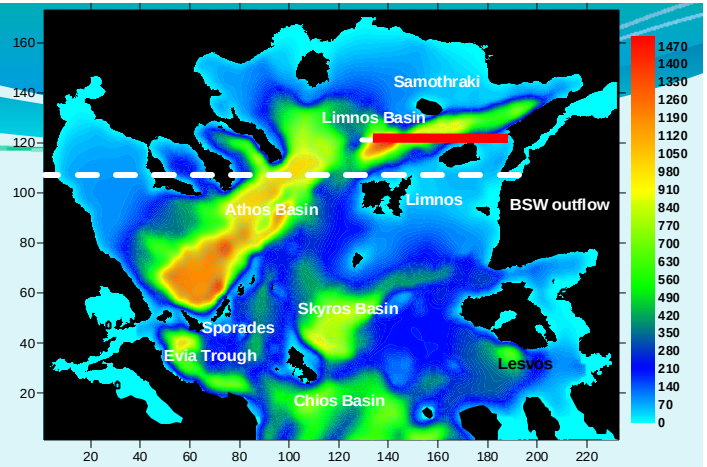
SALINITY (model)

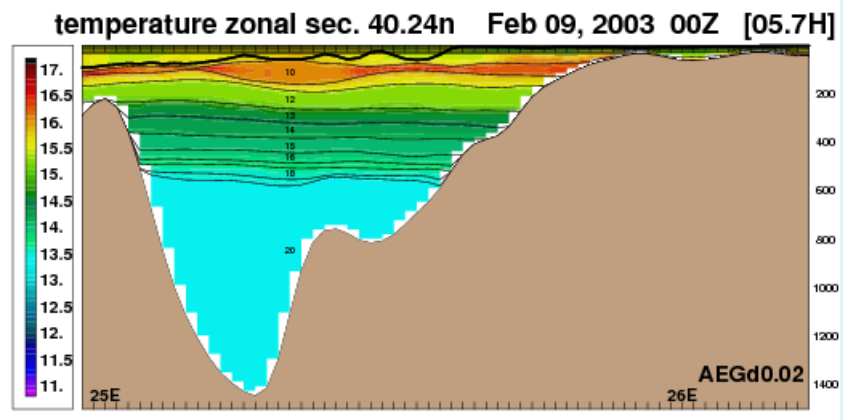
Chl-a (SeaWiFS data)

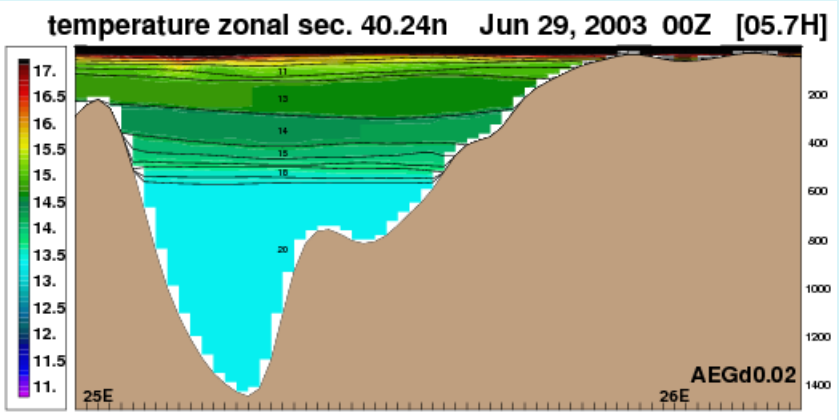


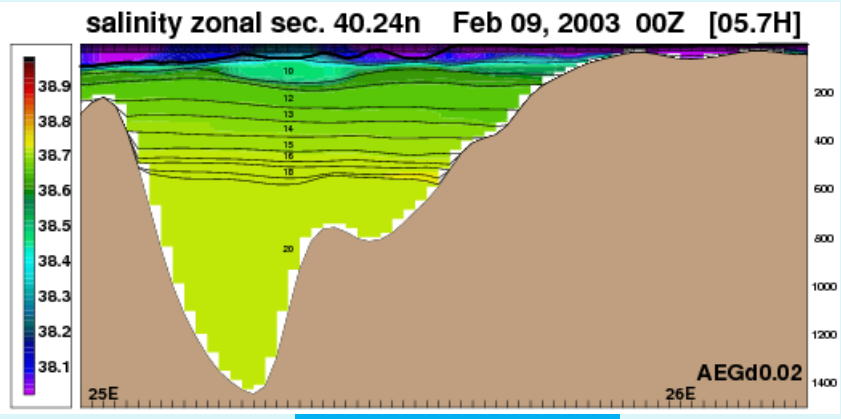


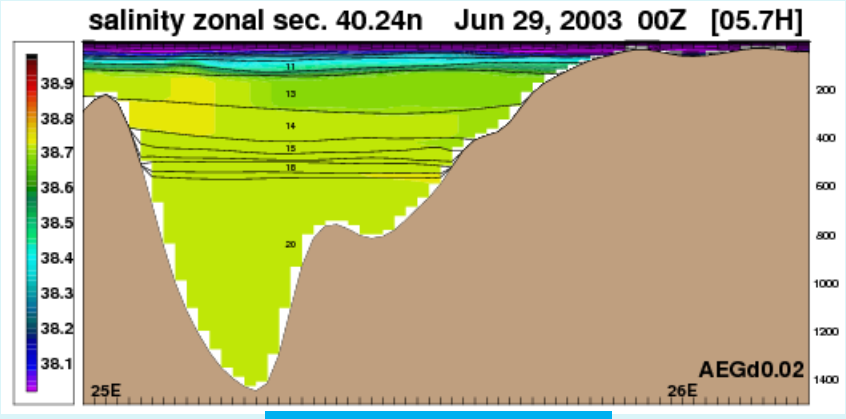
Vertical structure in the Limnos deep basin (1400 m)







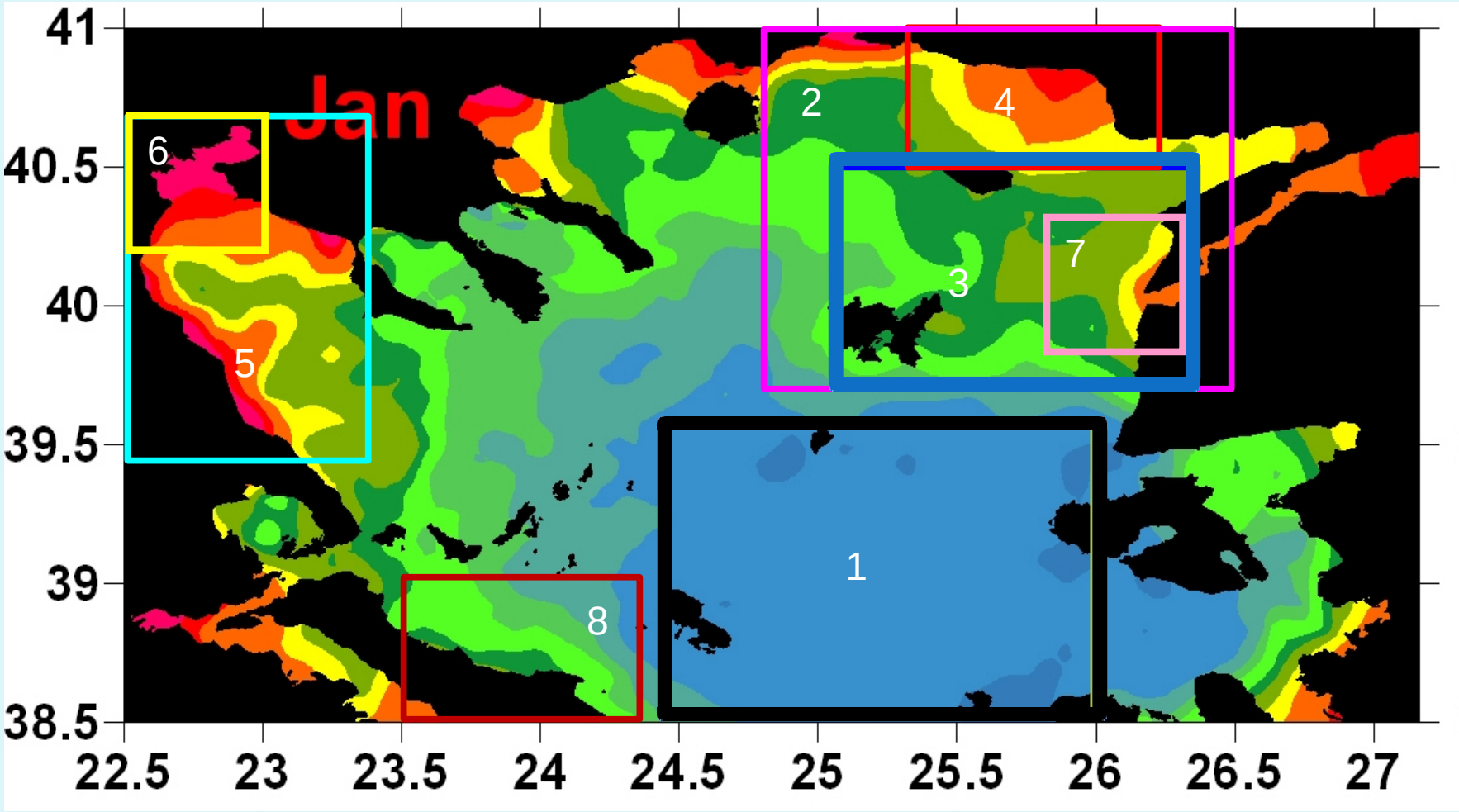




Feb 09, 2003

June 29, 2003

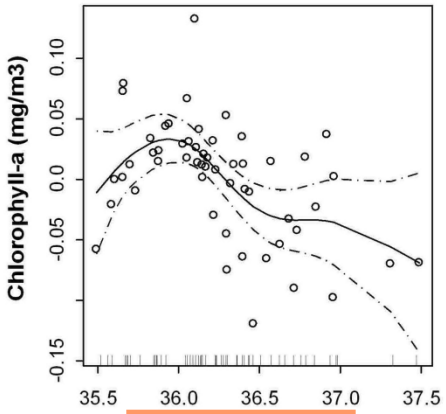
North Aegean subdomains



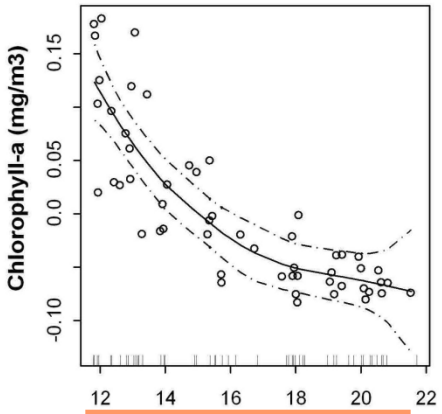
Generalised Additive Models (GAMs) for Area 3 (Broad Dardanelles plume area)

- flexible regression technique
- ability to model nonlinearities using nonparametric smoothers
- advantage over traditional regression methods (General Linear Models)
- suitable for scenario evaluation

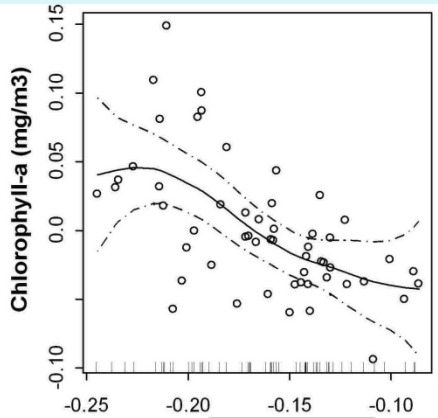
- **Salinity: maximum Chl-a abundance is reached at 35.5-36, whereas after that there is a decline**
- **SST: the colder the waters the highest Chl-a (BSW and upwelling)**
- **SSH: high chl-a with high SSH (BSW input)**
- **Nutrients Chl-a increases as phosphates increase; while Chl-a decreases after a certain amount of nitrates (0.9) (Phosphate limited environment)**



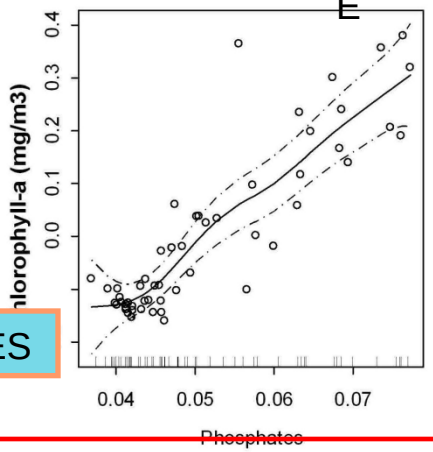
SALINITY



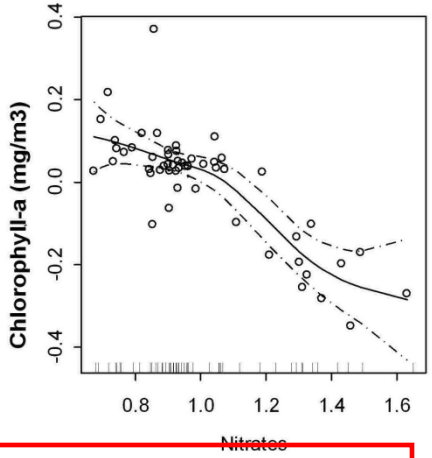
TEMPERATURE



SSH



PHOSPHATES

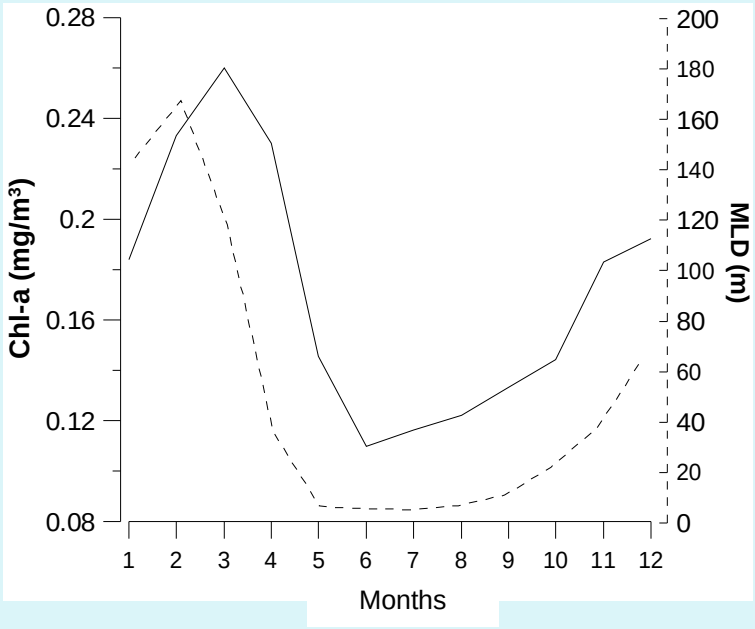


NITRATES

The models stated that the most important factors influencing the Chlorophyll-a in Area 3, are Salinity, SST, SSH, Phosphates and Nitrates (73%) – MLD not important.

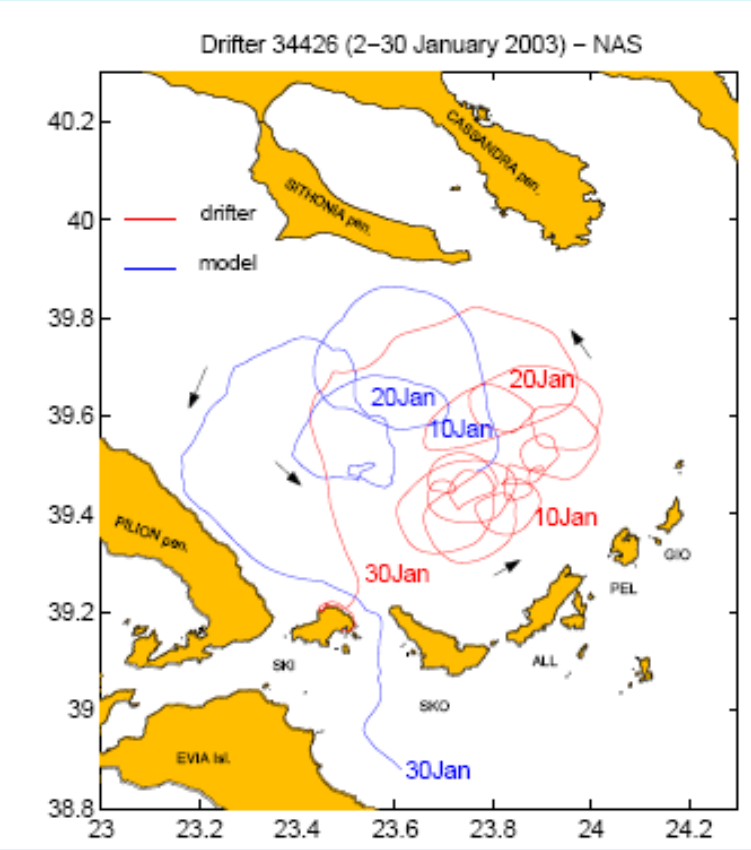
Model Mixed Layer Depth vs. observed chl-a in Area 1 (open sea)

(2003)



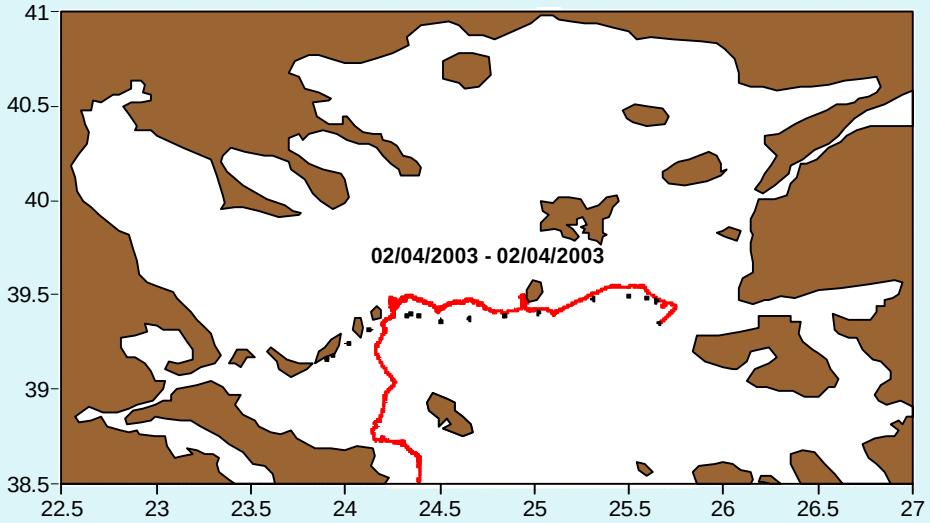
- The NAEG-HYCOM MLD follows the observed Chl-a concentrations in the seasonal cycle
- In summer, the MLD has small values (stratification) preventing the nutrients ascension to the surface layer while in autumn (MLD increase), the nutrient concentration begins to increase resulting in a relative chl-a rise

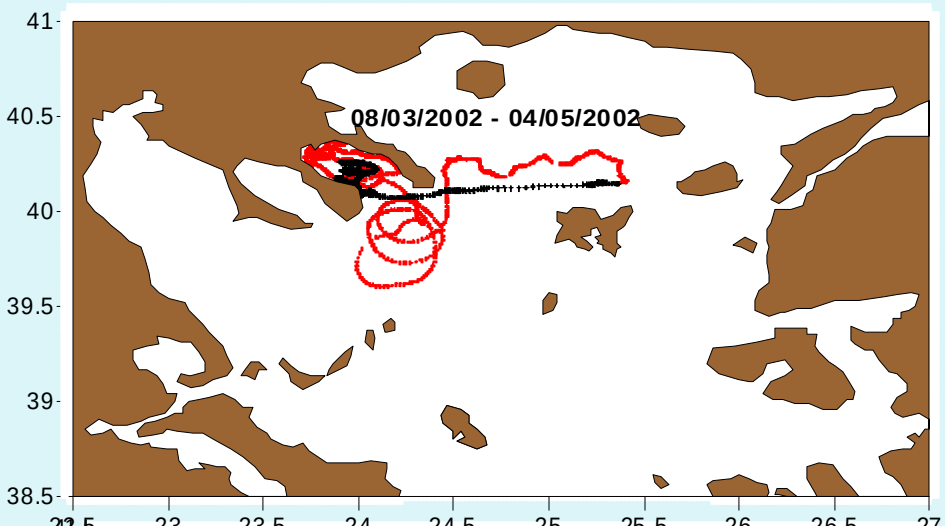
Comparison of model trajectories to drifter data (2002-2003)

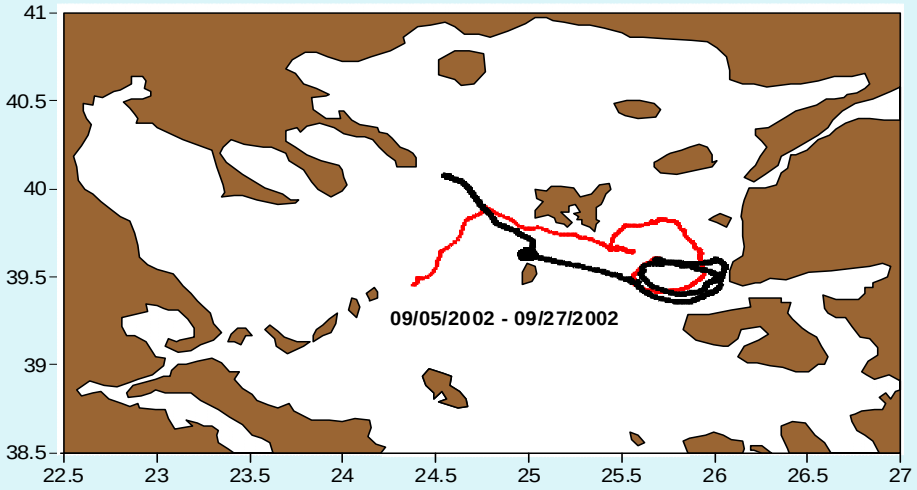


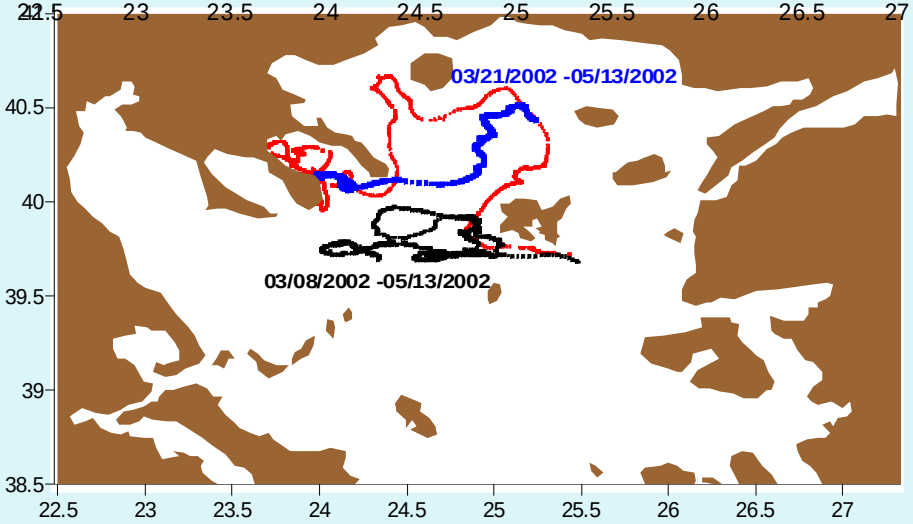
Kourafalou and Tsiaras (2007)

Comparison of model trajectories to drifter data (2002-2003)









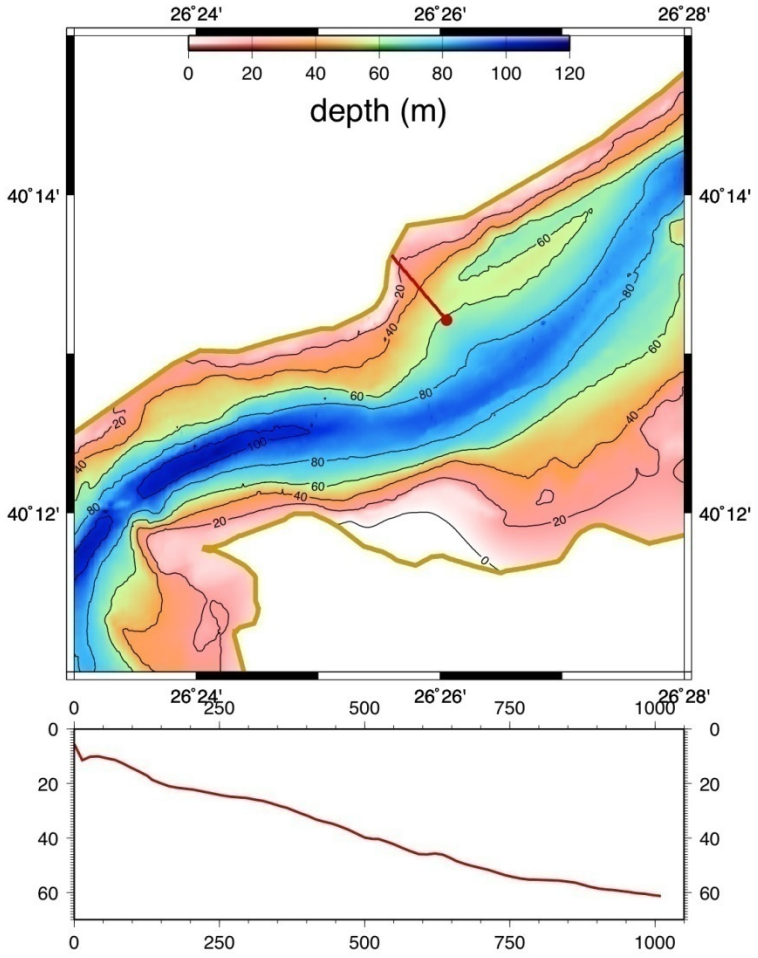
Drifter data

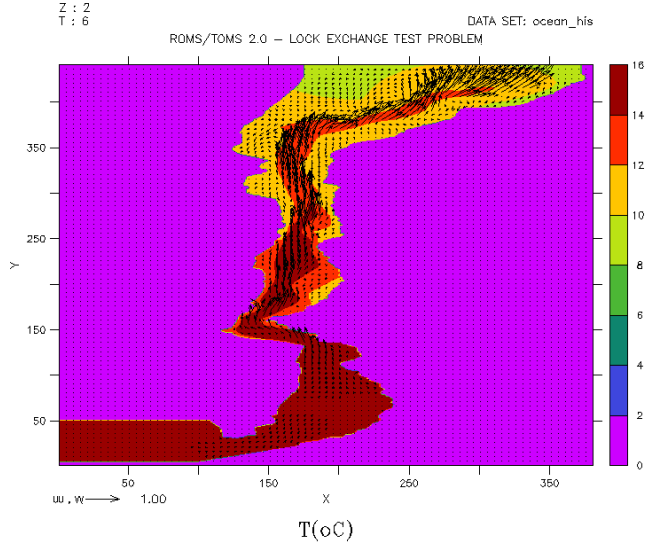
Model trajectory

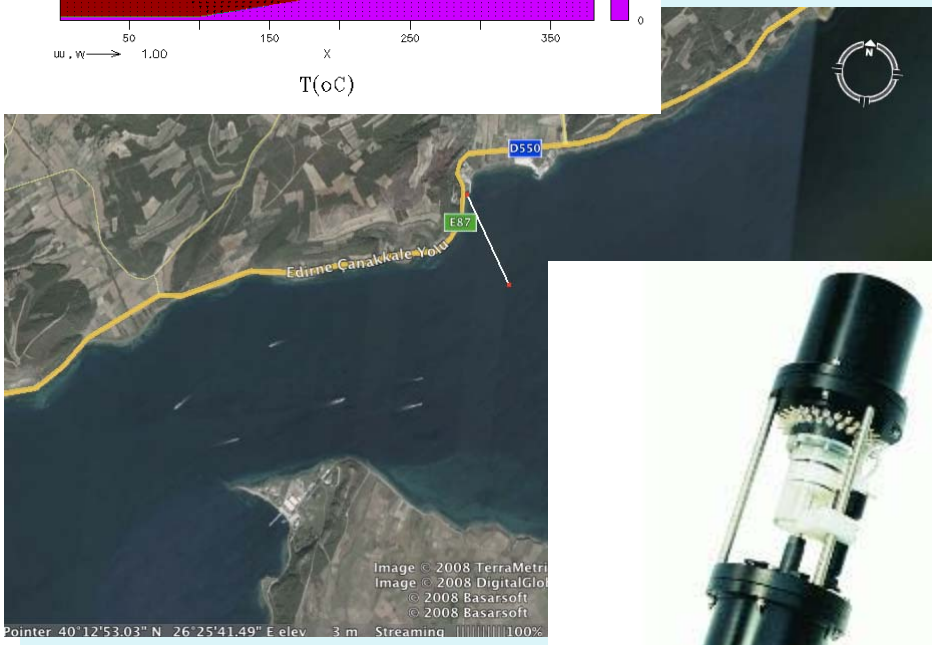
Model trajectory (delayed)

Measurements and modeling at the Dardanelles Strait

EU-SESAME project
Provided by E. Ozsoy, METU



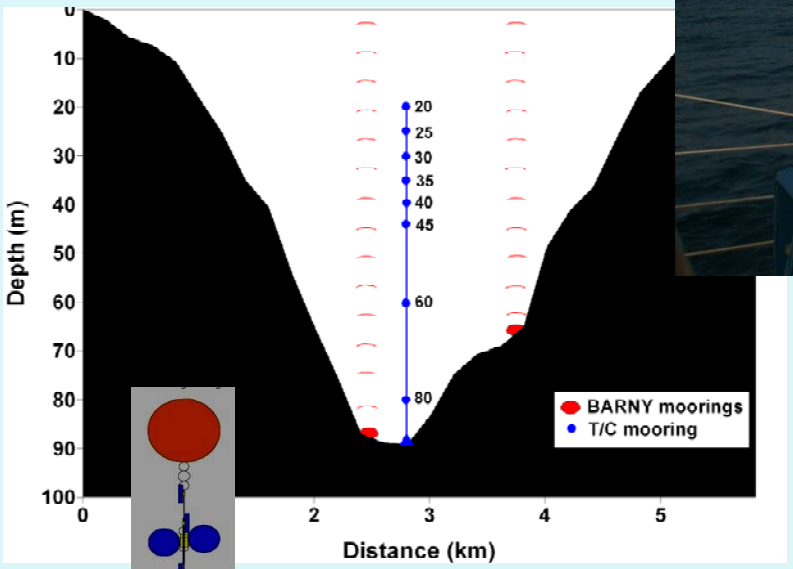


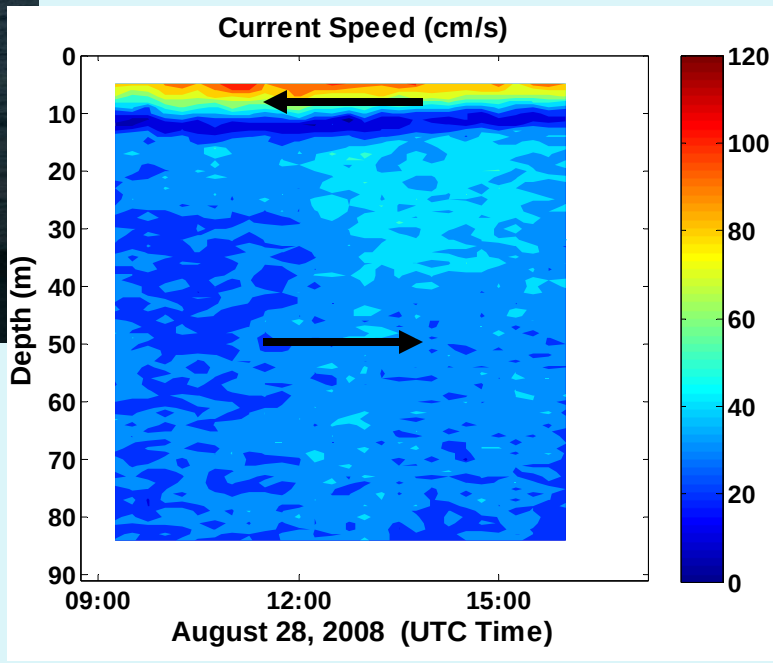


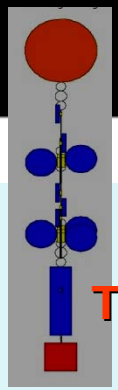
Dardanelles Strait ADCP

Nutrients, chlorophyll, plankton continuous measurements station

Ancillary project: NRL-SSC (E. Jarosz)



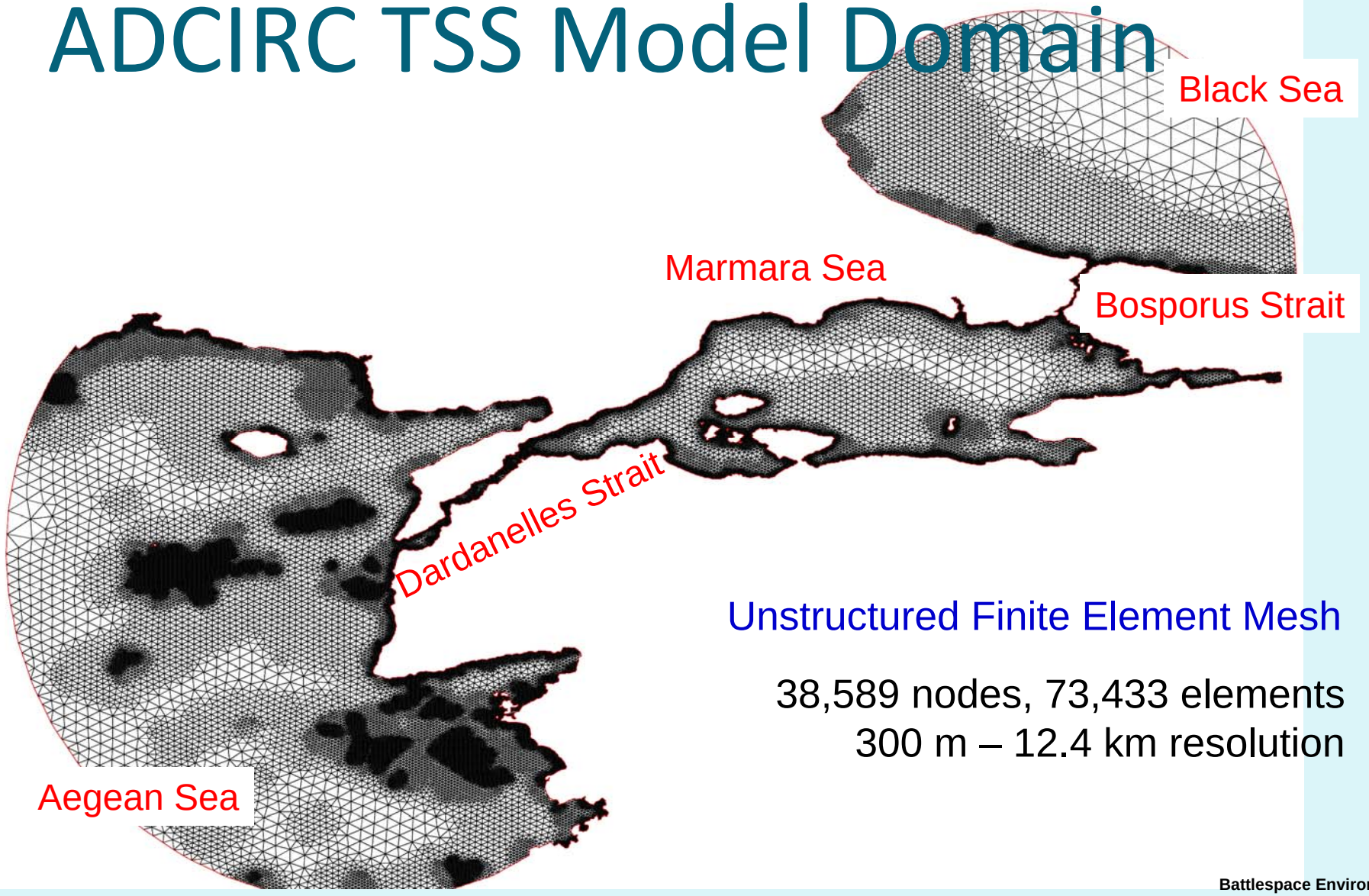




Moorings and Current Observations in the Dardanelles Strait (Aegean Exit)

Ancillary project: NRL-SSC
(C.A. Blain)

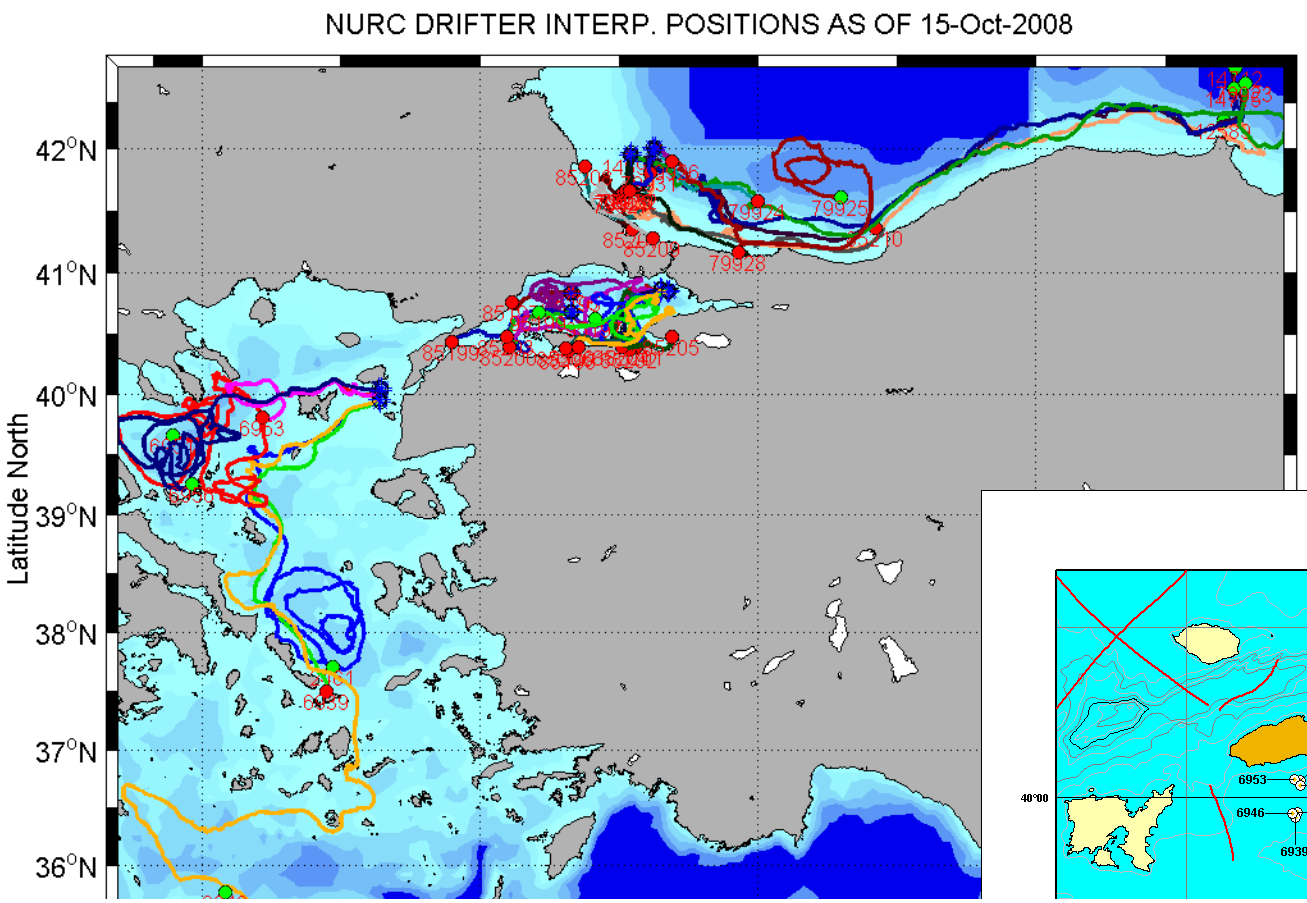
ADCIRC TSS Model Domain

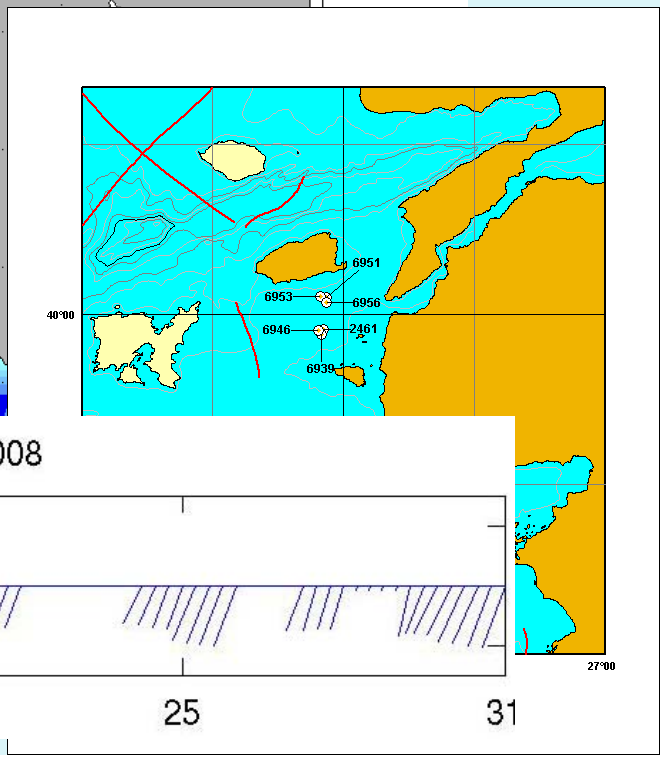


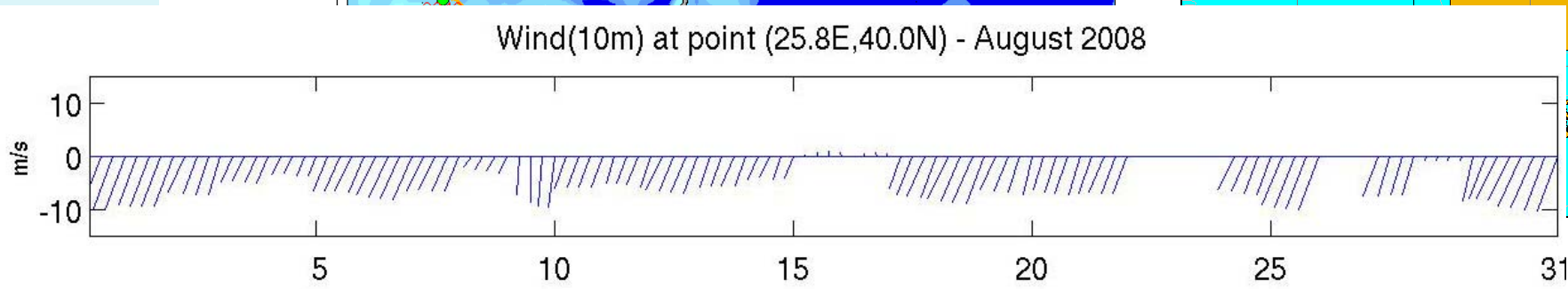
Unstructured Finite Element Mesh

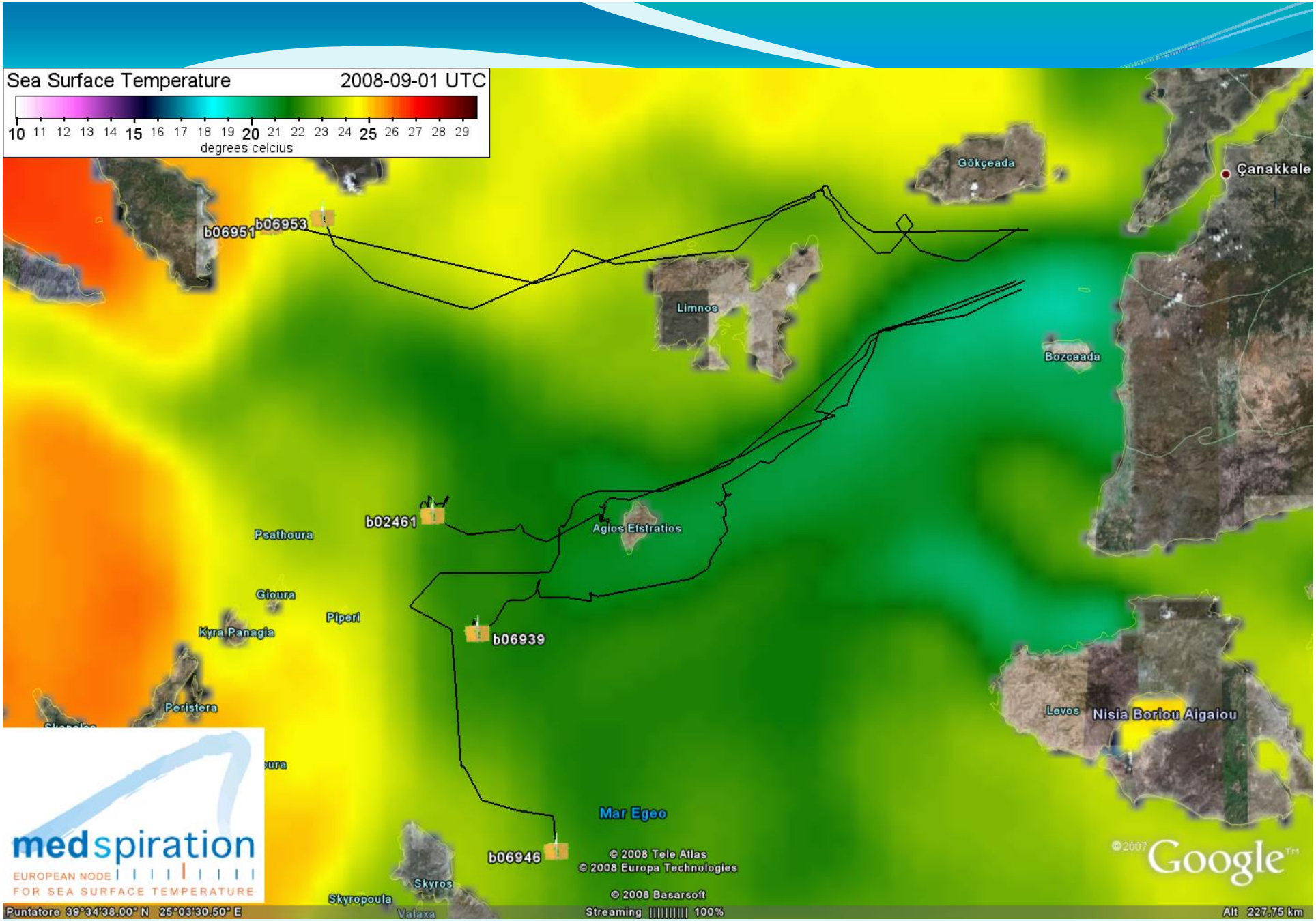
38,589 nodes, 73,433 elements
300 m – 12.4 km resolution

Ancillary projects: OGS and NURC (P.M. Poulain and S. Besiktepe)









Provided by P.M. Poulain, OGS