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

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The Aegean Sea and the Black Sea are coupled through the Bosporous-Marmara Sea-Dardanelles system.
Observations: 1997-1998 hydrography

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°
Nested in 1/25°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)
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)

Maximum: Spring - Summer

Minimum: Autumn - Winter
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 bifurcation of the BSW pathways
Atmospheric fluxes
BSW temperature

MODIS SST
MODEL (w/ NOGAPS)

26 March MODIS-SST

26 March NAEG-HYCOM SST (NOGAPS)

26 March NAEG-HYCOM SST (SKIRON)
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)

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)

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.
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)
Measurements and modeling at the Dardanelles Strait

EU-SESAME project
Provided by E. Ozsoy, METU

Dardanelles Strait ADCP

Nutrients, chlorophyll, plankton continuous measurements station
Moorings and Current Observations in the Dardanelles Strait (Aegean Exit)

Moorings and Current Observations in the Dardanelles Strait (Aegean Exit)
38,589 nodes, 73,433 elements
300 m – 12.4 km resolution

Unstructured Finite Element Mesh

Battlespace Environments

Ancillary project: NRL-SSC
(C.A. Blain)
Ancillary projects: OGS and NURC
(P.M. Poulain and S. Besiktepe)