ADVANCES IN THE NORTHEASTERN MEDITERRANEAN SEA: COMPLEX PATHWAYS OF THE WATERS OF BLACK SEA ORIGIN THROUGH THE AEGEAN SEA

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Abstract

Recent advances in both observations and modelling have allowed the better understanding of the factors that influence the transport pathways of waters of Black Sea origin and their influence on the Aegean Sea physics and ecosystem over a range of spatial and temporal scales. This study elucidates the related dynamics, focusing on the influence of the biophysical properties of the Dardanelles outflow, atmospheric forcing and the complex topography of the receiving basin on (a) the seasonal and inter-annual variability of observed surface Chlorophyll-a spatial patterns; and (b) long term changes in Sea Surface Temperature and the associated variability in the North Aegean contribution of Eastern Mediterranean dense waters.

Keywords: Continental Shelf, Aegean Sea, Black Sea, Circulation Models, Chlorophyll-a

The outflow of waters of Black Sea origin (BSW) in the Aegean Sea through the Dardanelles Strait is a key mechanism in the coupling of the Mediterranean and Black seas. The low-salinity, nutrient-rich BSW are a key factor in increased biotic productivity for the North Aegean, sustaining one of the most significant fish stocks in the Eastern Mediterranean. They also may influence long term changes in the properties of deep water masses, as they may alter the pre-conditioning for dense water formation.

An international effort has recently focused on the coupling of the two basins, recognizing the key role of the flow exchanges in the Northern Aegean and the Southern Black seas through the Turkish Straits System (TSS: Dardanelles Strait, Sea of Marmara, Bosporous Strait). This effort is a unique collaboration of projects funded by the European Union (SESAME project), the NATO Undersea Research Center (TSS 2008-2009 Sea Trials), the U.S. Naval Research Laboratory (NRL-Stennis Space Center) and the U.S. Office of Naval Research. The coordinated observational and modeling effort is a true breakthrough for the oceanography of this complex region, toward the better understanding of the biophysical dynamics of the coupled Mediterranean and Black Sea system.

This presentation will focus on modeling results, with appropriate examples and references to abstracts that present the analysis of recent observations. Satellite and drifter observations will be employed for model evaluation. In particular, results from two hydrodynamic models (based on the Princeton Ocean Model, POM; and the Hybrid Coordinate Ocean Model, HYCOM) and a coupled hydrodynamic/biogeochemical model (based on POM and the European Regional Seas Ecosystem Model, ERSEM) will be presented. The seasonal variability of BSW pathways will be revealed and the long term (1985-2007) interannual variability of the North Aegean water mass characteristics will be examined and compared against the effects of vertical (atmospheric forcing) and lateral (buoyancy input) fluxes, in an attempt to assess the productivity variability in the N. Aegean over the last decades and identify any possible climatic trends. High frequency/high resolution atmospheric forcing has been used for the 2002-2007 period from the POSEIDON operational atmospheric model [1]. The atmospheric forcing for the 1985-2000 period is based on the ECMWF ERA40 reanalysis [2]. The modelled major events of low Sea Surface Temperature (SST) are in agreement with satellite derived SST and the associated increased dense water formation in the N. Aegean can be connected to the Eastern Mediterranean Transient (EMT, [3,4,5]). This phenomenon of massive dense water formation in the N. Aegean has been attributed to the local atmospheric forcing variability triggering significant buoyancy loss through evaporation, combined to an increased salinity preconditioning induced by a decrease of BSW inflow and/or the increased inflow of Levantine more saline waters [6]. However, the impact of BSW on the preconditioning phase remains unclear.

We also explore and assess the major variables that influence the surface phytoplankton biomass. Temperature, Salinity, Sea Surface Height and Mixed Layer Depth from the two different hydrodynamic models and productivity parameters from the biophysical model have been employed in Generalised Additive Models (GAMs: a flexible regression technique that can model nonlinearities using nonparametric smoothers), to study the contribution of these various physical and ecological factors in the variability of satellite derived Chlorophyll-a, a proxy for BSW influence. The remotely sensed surface Chl-a data were derived from the SeaWiFS sensor, for the period of 2002-2006. Monthly averaged time-series were created from the parameter matrix of both SeaWiFS and the numerical models. The analysis was performed for the whole Northern Aegean Sea and for subdomains in the open sea and over different shelf areas, including regions under the immediate influence of both small (rivers) and large (Dardanelles) buoyant outflows, which provide inputs of high Chl-a content. The GAMs analysis showed that the combined effects of the variables used, explained >80% of the surface Chlorophyll variation. Also it was found that depending on the subarea, the Chl-a was primarily controlled physically rather than chemically (nutrient related) and *vice versa*. As a general rule, higher Chl-a values were associated with lower temperature and salinity values, increasing phosphate and declining nitrate trends. The negative correlation with nitrate indicates that generally the study area is a phosphate limited one. Finally, the influence of cold, nutrient rich, and less saline waters of the Black Sea and/or riverine origin on the observed chl-a patterns, is evident in almost every subarea.

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