INVESTIGATING THE CIRCULATION IMPACTS OF THE DARDANELLES FLOW EXCHANGE WITH THE NORTH AEGEAN HYBRID COORDINATE OCEAN MODEL

Villy Kourafalou [1]*, Ioannis Androulidakis [2] and Ioannis Krestenitis [2]
[1] University of Miami, Miami, FL, U.S.A. - vkourafalou@rsmas.miami.edu
[2] Arisotle University of Thessaloniki, Thessaloniki, Greece

Abstract

The outflow of low salinity, eutrophic and cool waters of Black Sea origin (BSW) through the Dardanelles Strait is the strongest buoyant input for the North Aegean Sea. This outflow affects significantly the physical and biological characteristics of the basin, with implications for water mass characteristics and the circulation and biotic production around remote coastal ecosystems. This study focuses on the understanding of the processes that influence the initial ballooning of the Dardanelles outflow and the subsequent transport and fate of BSW through the Northern Aegean Sea. The Hybrid Coordinate Ocean Model (HYCOM) is employed in a methodology to parameterize and simulate the coupling of the Aegean and Black Seas through the Dardanelles Strait.

Keywords: Aegean Sea, Black Sea, Circulation Models, Coastal Processes, Coastal Engineering

The Dardanelles outflow contains waters of Black Sea origin (BSW) that are generally cooler and with higher nutrient content than the oligotrophic Aegean Sea [1]. This allows the outflow to be detected in Sea Surface Temperature (SST) and ocean color imagery. The BSW is also fresher and responsible for the overall lower salinities in the northern Aegean, where the frontal areas are related to the spreading of BSW above the saltier modified Levantine Intermediate Water (LIW); [2,3,4]. The evolution of BSW through the North Aegean Sea resembles that of a buoyant plume, under the influence of atmospheric forcing and further modified by the complex topography. This outflow affects significantly the physical and biological characteristics of the basin, with implications for the circulation and biotic production around remote Aegean coastal ecosystems.

Lagrangian observations [5] have revealed the complexity of the BSW pathways and the modification of flows through interaction with narrow passages and straits, around islands, along the rim of shelf/coastal areas and deep sub-basins. It is the complexity of topography that motivated the employment of the Hybrid Coordinate Ocean Model [6] on the North Aegean (NAEG-HYCOM), to allow suitable transitions of the vertical coordinate system from isopycnal in the deep regions to bottom-following (sigma) and cartesian (z-level) in the shelf and coastal areas.

The NAEG-HYCOM has $1/50^{o}$ horizontal resolution and 20 hybrid layers in the vertical. The model has been nested within a basin scale, data assimilative model for the Mediterranean Sea (resolution of $1/25^{o}$). This study is part of 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.

Two types of experiments have been executed in order to elucidate the development and evolution of the Dardanelles buoyant plume, expressed by the initial tendency for ballooning of the outflow and the subsequent formation and variability of the associated rim current. Theory and observations have been employed to evaluate the model results. Several process oriented experiments have isolated and examined each of the distinct physical aspects that affect the North Aegean Sea circulation and mass characteristics. Realistic experiments covering the 2002-2008 period have focused on the interaction of the circulation forcing mechanisms in determining the seasonal and inter-annual variability of the BSW pathways. Sensitivity to the spatial resolution of the atmospheric forcing is revealed through twin experiments with two high-frequency operational atmospheric products, namely the fine scale (1/10 degree) POSEIDON/SKYRON [7] and the coarse scale (1 degree) Navy Operational Global Atmospheric Prediction System (NOGAPS, [8]).

We employ comparisons of the NAEG-HYCOM model and in-situ observations and satellite images to evaluate the river parameterization procedure, the requirements in atmospheric forcing fields and the impact of the parameterization of the coupling between the North Aegean and Black seas through the BSW outflow at Dardanelles. The BSW bulge balooning and several outflow parameters are compared to the findings of [9]. The parameterization of the Dardanelles outflow follows approaches ranging from a river-like buoyant discharge to a two-layer inflow-outflow system, to coupling with an unstructured grid model of the Turkish Straits System (Dardanelles Strait-Sea of Marmara-Bosphorous Strait), suitable to employ updated time series of measured flow properties.

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