Theory and Observations of Ocean Fronts: Lagrangian Studies of Arabian Marginals

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LONG-TERM GOALS

The ultimate goal of his research is to understand the dynamics of the mesoscale eddy field in the coastal oceans and marginal seas as an extension of the earlier work of the investigators on the open ocean eddies and fronts. The physical focus is on the interaction of different regimes; for example, the interactions from the land-side in terms of riverine input and shallow embayment dynamics versus offshore forcing in the creation of the coastal circulation features. Of particular interest is the impact of atmospheric forcing along coastal margins. Similar to the previous work, the objective is to provide an understanding of the role the physics has in producing the biological responses that produce the optical and acoustic properties of the coastal domain. The studies will explicitly consider the role of topography, sediments and benthic communities in coastal dynamics.

OBJECTIVES

The basic objective of the research is to produce large scale mapping of marginal sea environments that resolve scales down to a few kilometers and temporal scales of an hour. These measurements are then used to understand the circulation dynamics in these seas with an emphasis on the structure of flows along boundaries and in proximity to complex topography. The combination of the data sets and their analysis provides a basis for testing and improving model simulations in these marginal basins.

APPROACH

The last two years have been dedicated to procuring and deploying drifter arrays in marginal seas in the Middle East. Through the past grant and an associated DURIP sixty Global Positioning System

(GPS) drifters with one hour positioning and ARGOS system data transmission were constructed. An early deployment in the Arabian (Persian) Gulf started in summer 2001 in collaboration with the Abui Dahbi Wildlife Service who is doing billfish surveys in the southern Gulf. The remainder of the first 30 units was in transit on September 11th and was received by NAVO in Baharain. Due to conditions in the region the authorization to deploy these was reversed and the units were returned to the US. After consultation with the program manager it was decided to launch an exploratory array in the northern Aegean Sea in collaboration with the Greek National Center for Marine Research and the University of Athens. The first deployment occurred in February with a second deployment in June 2002. Sixteen more drifters are scheduled for launch in the Aegean Sea this fall and a final set of 15 units is currently ready to ship to the Gulf if permission is given to deploy an array there. All the data from these units are available in real-time over the WMO/GTS system. Trajectories are updated daily during weekdays on a public U. Miami site (http://www.rsmas.miami.edu/~geoff/gpsdrifters/aegean/aegean.html). Initial work on the data sets is described below in the section on proposed work.

WORK COMPLETED

In addition to the drifter study the results of previously funded efforts led to a number of publications, presentations, and public service during the period. Included in this are two papers on fronts. The first is a comparison of transition zone fronts in the Pacific and Atlantic western boundary layers including a demonstration that the Gulf Stream and Kuroshio involve upwelling rates that match or exceed any of the eastern boundary currents (Olson, 2001a). The second is a chapter in The Sea Vol. 12 on the biophysics of ocean fronts (Olson, 2002). This work, that is the cumulative result of research funded by ONR (PO and BO) over several decades, was also the focus of two short courses funded the Inter-American Institute for Global Change (IAI). The three credit hour graduate level courses trained 40 Latin American students on the biophysics of marine ecosystems and how one might expect them to change. The PI is currently scheduled to teach another short course on the physics of western boundary currents in Sao Paulo in August. Other manuscripts include a section on Lagrangian modeling in the Encyclopedia of Marine Science (Olson et al., 2001), two papers on plankton models (Lima and Olson, 2002; Lima et al., 2002) and two publications on earlier Arabian Sea modeling (Esenkov and Olson, 2002; Esenkov et al., in press). Presentation were made at IUGG in Argentina on western boundary layers, a talk on the Gulf of Oman at a Omani ocean science meeting in January 2001, and participation in two fisheries meetings (Hawaii and La Paz, Mexico). Results of earlier work on western boundary currents were also the basis of a brief presentation at an ONR workshop on a planned acoustic observatory in June 2002. This work is currently being written up in collaboration with Nick Shay , Harry DeFerrari and others. One of the foci of this research has been the development of feature-based models, based on detailed observations of phenomenon in the open ocean/ coastal transition. Work on the Gulf Stream edge as revealed important coherent interactions between the targeted mesoscale field and the internal and acoustic wave fields at the edge of the shelf. Similar issues on coupling between scales in the Middle Eastern Marginal Seas involve initial work with the drifters and QUICKSAT scatterometer winds, which reveal a similar feature-based problem with coastal wind forcing. An important factor is the realization that land-sea breeze phenomenon with diurnal frequency becomes a strong forcing element in most tropical and subtropical environments (Fig 1). Both the Gulf Stream edge and the land breeze involve significant imbalance in the mesoscale features and hence strong coupling across the various classes of motion. In the Gulf case the tidal problem, for example, is strongly influenced by the presence of the wind forcing in the same period bands. A poster on the land-sea breeze forcing was presented at Ocean Sciences in Hawaii (Olson et al., 2002).

The above work and the upcoming analysis of the pilot drifter arrays promise significant opportunities for bridging this research into operational Navy programs and other government programs. One example is working towards transition of the feature-based model of wide straits into the operational models (Olson 2000). The, as yet, incomplete western boundary spin-off eddy description is another potentially important advance for both testing and initializing models. The investigator was also approached by the Department of Justice to assist the FBI in checking testimony of Cuban scientists in relation to an espionage trial. Lagrangian simulations of flow in the Florida Straits were used to discredit the falsified testimony concerning drift of aircraft wreckage in the Straits. The work made use of NOPP funded Caribbean Sea drifters and Lagrangian models developed by the author and A. Griffa with ONR support.

RESULTS

The pilot drifter array in the Arabian Gulf has shown a broad slow flow towards the Straits of Hormuz in the southern edge of the Gulf. The central Gulf is dominated by a combination of flows dominated by tides and dirunal sea breeze wind driven flows. In the Aegean the drifters show a freshwater plume along the western side of the basin. The northern Aegean Sea is dominated by mesoscale eddies in the interior. The flow out of the northern basin involves complex interactions between the mean and mesoscale flow in proximity to straits (Fig. 2). The flow firsts decelerates and then involves small-scale oscillations in the straits. The large strait in the southern Aegean is dominated by a large cyclonic eddy. All of the flow out of the southern Aegean into the sea north of Crete involves flow to the west through the narrow straits in the island arc. The eastern side of the large strait between Mikonos and Ikaria has inflow. To date the drifter arrays has produced data on the flow through 20 different straits. Some of these involve multiple drifters. A compilation of these data into a diagnostic model of strait flows is now underway.

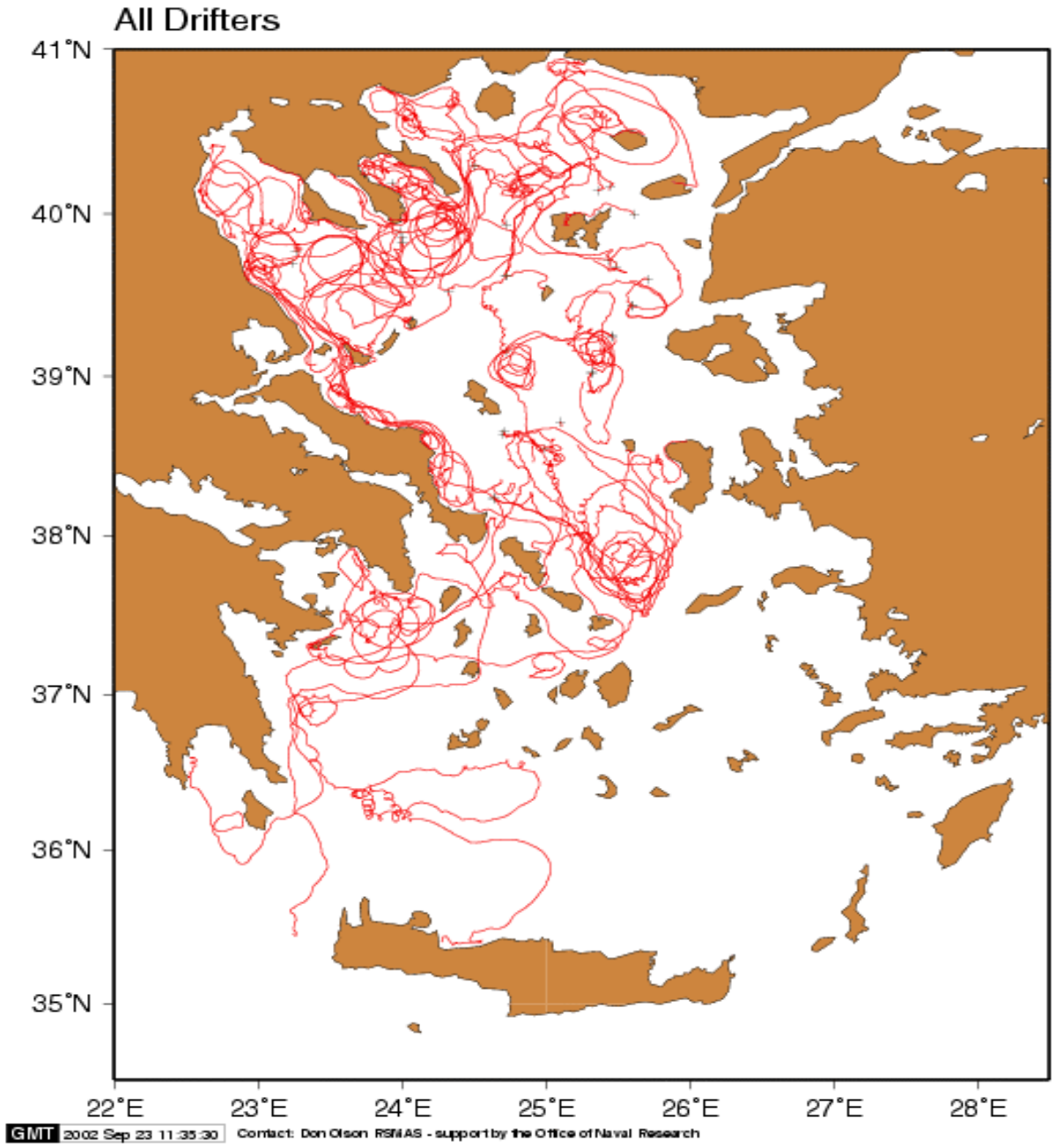

Figure 1: GNC Drifters 2002

IMPACT/APPLICATIONS

The observations in the Arabian Gulf will continue with two more deployments being planned in 2002/2003. The initial array in the Aegean will be one of the central pieces of information used to plan an experiment to understand flows in complex island groups. The P.I.'s are also involved with discussions with NRL and NAVO scientists who are running models of these areas. These

observations are some of the first that can address the degree to which these models can resolve high frequency wind driven events and how good the tidal simulations are. The international collaborations with the Greeks and various groups in the Arabian Gulf are also an important component of this effort.

RELATED PROJECTS

The work on this effort and on earlier ONR funded work in the Straits of Florida and Bahamas has led to two new NSF funded programs to study the connection of the Bahamas to the greater Caribbean and to study large pelagic fish in the Gulf Stream front. The P.I. has also been participating in NAVO hydrographic cruises in the Bahamian straits. Three undergraduates took part in the May 2002 cruise.

PUBLICATIONS

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