Surface Circulation in the Northeastern Mediterranean (NEMED)

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LONG-TERM GOALS

To investigate the dynamics of semi-enclosed seas dominated by buoyancy input and wind forcing, and influenced by complex topography. To improve the understanding of coastal marine environmental evolution, with particular emphasis on eddy dynamics.

OBJECTIVES

The main goal on the NEMED project was to measure the surface currents in the Eastern Mediterranean Sea with particular focus to the eastern and northern areas of the Levantine sub-basin and to validate (or not) circulation patterns published in the literature based on in-situ observations (CTD and AXBT), remote sensing data (SST and sea surface topography) and models. It was proposed to use low-cost satellite-tracked drifters to measure currents in the near-surface mixed-layer. The monitoring of the circulation in the Northeastern Mediterranean, with main focus on the currents trapped on the topographic slope and on sub-basin and mesoscale eddies, was planned for a full year in order to investigate any seasonal variability. The surface current observations were interpreted in concert with the distribution of tracers (SST and chlorophyll) and the sea dynamic topography (altimeter data) measured from satellites.

APPROACH

The following tasks were performed:

- Literature review of the Levantine Sea oceanography.
- Procurement and deployment of SVP (GDP) drifters with Argos data telemetry and positioning. Seasonal deployments of drifters were carried out in three geographical areas: south of Cyprus, east of Israel and south of the Turkey with the help of local oceanographers.
- Drifter data management in both near-real time (processing and posting on the web) and delayed-mode (creation of a database updated every three months).
- Statistical analyses using the drifter velocity data: mean circulation and eddy variability maps.

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- Downloading of satellite altimeter interpolated products (absolute dynamic topography and surface geostrophic currents) from SSALTO/DUACS distributed by AVISO (www.aviso.oceanobs.com/). Acquisition of AVHRR SST images with Terascan station at OGS.
- Qualitative description of the circulation using drifter and satellite data (creation of images and animations with dynamic topography and SST overlaid with drifter tracks).

Remark: Satellite images of chlorophyll concentration were not used since these research activities were carried by local collaborators, i.e., by the group at IOLR, Haifa, Israel (Gertman et al., 2010).

WORK COMPLETED

Drifter deployments in the Levantine Sea were conducted by our collaborators in Israel (IOLR, Haifa, Dr. Gertman) and Cyprus (Univ. of Cyprus, Nicosia, Dr. Zodiatis), including the following deployment episodes:

- 29 July 2009, 3 drifters off the Israeli coast;
- 3 August 2009, 3 drifters south of Cyprus
- 25 November 2009, 3 drifters off the Israeli coast;
- 3-4 December 2009, 4 drifters south of Cyprus during the sailing boat TARA expedition;
- 2 March 2010, 3 drifters off the Israeli coast;
- 19 May 2010, 4 drifters on transect Limassol (Cyprus) – Haifa (Israel);
- 15 June 2010, 4 drifters on transect Limassol (Cyprus) – Port Said (Egypt);
- 11 August 2010, 3 drifters off the Israeli coast.
- 5 October 2010, 1 drifter south of Cyprus

Unfortunately, the deployments originally planned south of Mersin (Turkey) were not conducted because the drifters were seized by the Turkish Customs authorities in Istanbul.

In total, 28 drifters were deployed in the Levantine Sea. More than 1800 drifter-days worth of data were collected between July 2009 and March 2011. The temporal distribution of the drifter data is depicted in Figure 1.

The NEMED web pages were updated. They provided basic information on the project, near real time (updated on a daily basis) products such as graphs with drifter trajectories and with time series of position (latitude and longitude, speed, sea surface temperature, battery voltage, drogue presence parameter, etc.). A status table was also included to monitor the drifter array. The drifter positions were also implemented in Google Earth (see Figure 2). The URL address of the NEMED main page is: http://nettuno.ogs.trieste.it/sire/drifter/nemed/nemed_main.html

All the drifter data were processed (editing, optimum interpolation, low-pass filtering) and archived in a database. This web-based database includes final descriptions of the observational work, final graphical representations and statistical summaries of the processed data, and data files in MATLAB

binary format (http://nettuno.ogs.trieste.it/sire/drifter/database/NEMED/). Due to the recovery and redeployment of some units (4) and the splitting of the trajectories generated by long data gaps for some drifters (2), the total number of useful processed trajectories is 34.

Drifter tracks were overlaid on satellite images of SST and sea surface dynamic topography to describe qualitatively the spatial structure and temporal evolution of the Levantine Sea dynamics. An example is illustrated in Fig. 3. Pseudo-Eulerian statistics of the near-surface circulation were calculated using bins of 0.5 x 0.5. The mean near-surface circulation derived from the drifter velocities is depicted in Fig. 4.

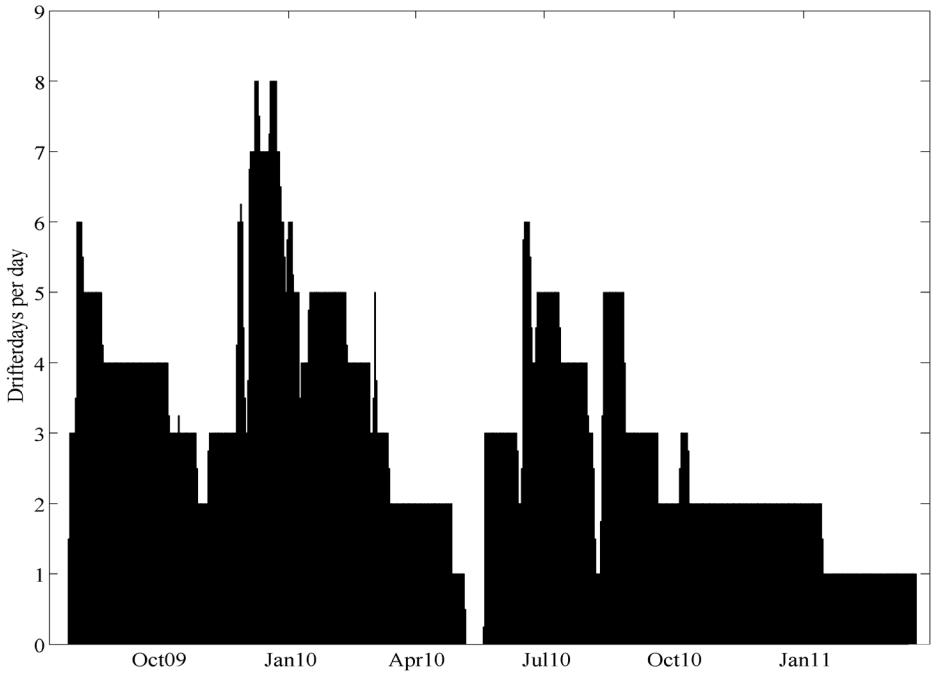

Figure 1. Temporal distribution of the drifter data in the Levantine sub-basin between July 2009 and March 2010: number of active drifters per day versus time.

RESULTS

The drifters put in evidence a strong coastal current flowing northward along the coasts of Israel, Lebanon and Syria. This current can create instability features shown as loops in the drifter trajectories (Figure 2, see also Poulain et al., 2010). In particular, all the drifters deployed off Israel were deviated offshore and got trapped in an anticyclonic eddy northwest of Haifa (also called the Shikmona anticyclone, see Figures 2 and 3). This circulation feature moved subsequently to the northwest and entrapped 2 drifters as long as more than a month. The diameter of this eddy is about 50 km, the period of rotation is about 6 days and typical speeds are 50 cm/s. It is clearly a warm-core eddy well delineated by the satellite images (Figure 3, see also Gertman et al., 2010). In general, there is a remarkable similarity between the patterns seen in the satellite images and the motion of the near-surface drifters.

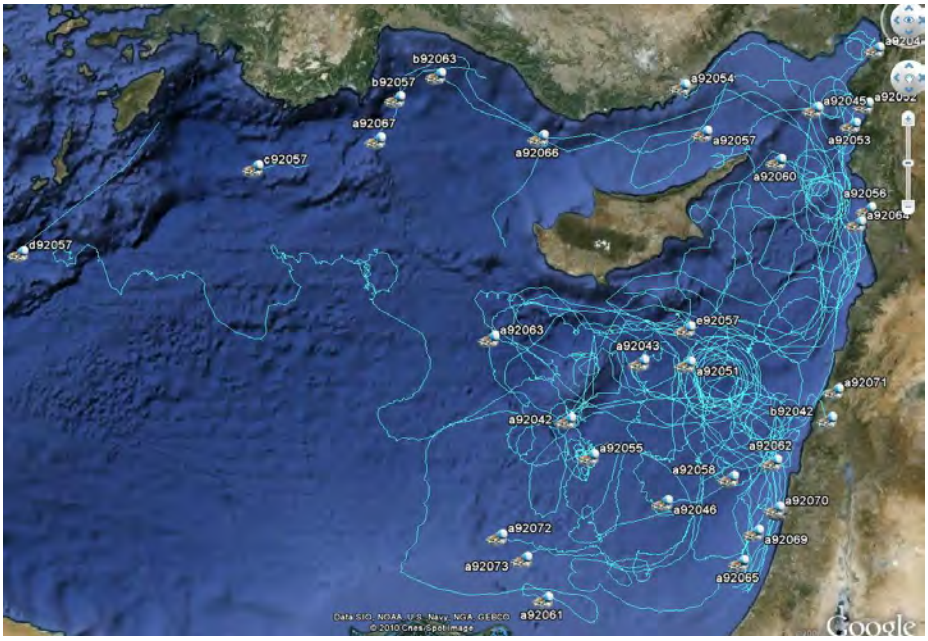

Figure 2. Trajectories of the drifters in the eastern Levantine sub-basin between July 2009 and March 2010 . Drifter identification numbers are posted at the end of the tracks.

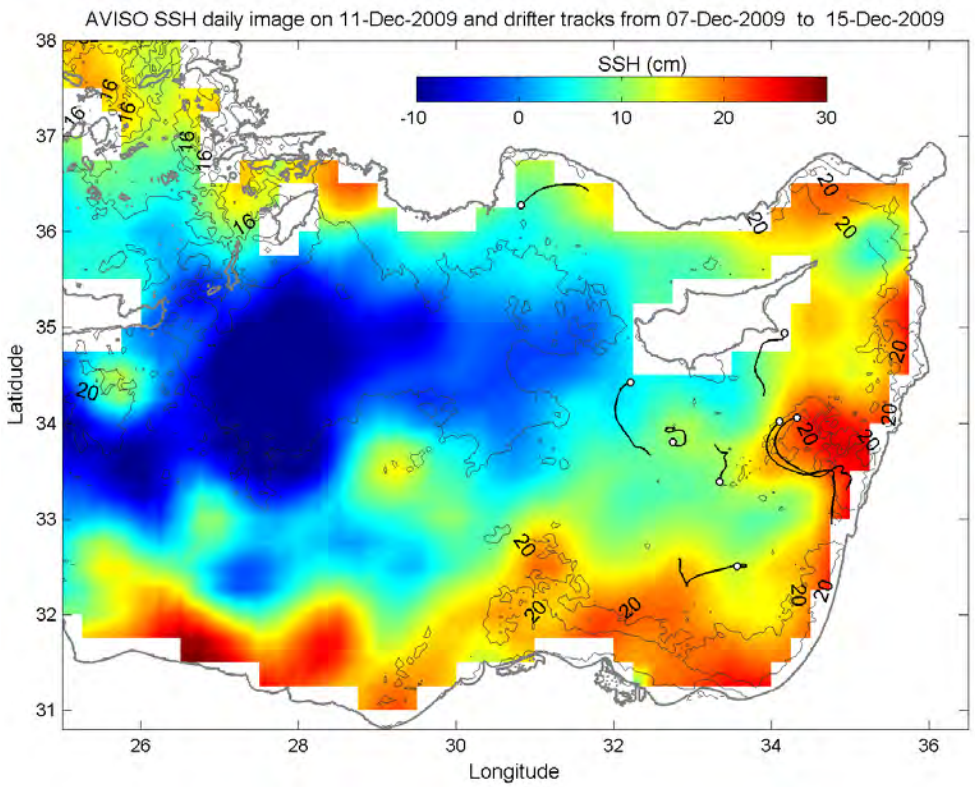

Figure 3. Sea surface height (colors) and sea surface temperature (contour lines with labels in °C) in the Levantine Sea on 11 December 2009. Drifter track segments are overlaid for the period 7-15 December 2009, with the white circle symbols representing the drifter positions at the end of the period.

The mean circulation map constructed with the drifter data (Figure 4) shows a swift coastal current all the way around the Levantine Sea (from the Nile River delta to Crete) with mean velocities reaching 40 cm/s. A westward current prevailing in the central area (more or less connecting Crete to Cyprus) could be the signature of the Mid Mediterranean Jet reported in the literature. Sub-basin scale eddies (south and east of Cyprus, Shikmona) are barely represented in this map due to the smoothing and the scarcity of the data.

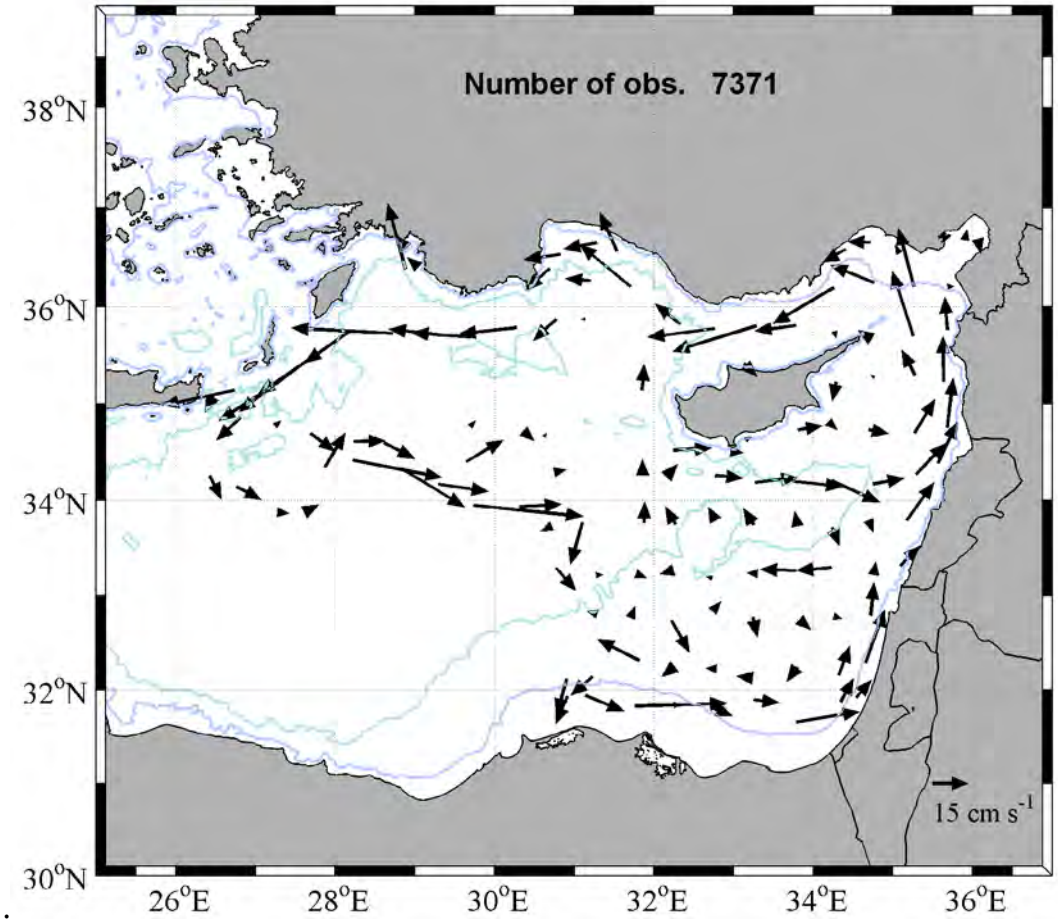

Figure 4. Mean circulation in the Eastern Levantine Sea for the period July 2009 –March 2011. The mean flow arrows are centered at the centre of mass of the observations in each bin. Data are grouped into 0.5° x 0.5° bins. Bins containing less than 5 observations were rejected for the computation of the statistics. The 200 m and 2000 m isobaths are represented with grey curves.

IMPACT/APPLICATION

The scientific impact of this project is to increase our understanding of the Northeastern Mediterranean Sea dynamics and of its major forcing mechanisms. Future application could be the validation of diagnostic numerical models and the assimilation of the drifter data into prognostic numerical models in the framework of operational oceanography projects (e.g., as part of the Mediterranean Operational Oceanography Network – MOON)

RELATED PROJECTS

In addition to national programs conducted by collaborators in Cyprus and Israel, the NEMED project was strongly related to MOON (http://www.moon-oceanforecasting.eu/), both in terms of observational activities, such as the Mediterranean Volunteer Observing Ship program (VOS) and the Mediterranean Argo program (MedArgo; coordinated by the P.I., http://nettuno.ogs.trieste.it/sire/medargo/) and nowcasting and forecasting numerical simulations. In particular, the drifter data were made available in near-real time to MyOcean, an operational oceanography project of the EC 7th Framework Programme (www.myocean.eu). It was also related to the French project to study the entrapped ecosystem related to the Shikmona or Cyprus eddy as part of the TARA Oceans Expedition (http://oceans.taraexpeditions.org/).

PUBLICATIONS

Gertman, I., R. Goldman , Z. Rosentraub , T. Ozer , G. Zodiatis , D. Hayes and P.M. Poulain (2010) Generation of Shikmona anticyclonic eddy from an alongshore current. *Rapp. Comm. int. Mer Médit.*, 39, p. 114.

Poulain, P.M., R. Gerin , M. Menna , I. Taupier-Letage , C. Millot , S. Ben Ismail , C. Sammari , G. Zodiatis and I. Gertman (2010) A Lagrangian view of the Eastern Mediterranean surface circulation over the last two decades. *Rapp. Comm. int. Mer Médit.*, 39, p. 162.

Menna, M, P.-M. Poulain, G. ZOdiatis and I. Gertman (2011) On the surface circulation of the Levantinesub-basin derived from Lagrangian drifters and satellite altimetry data. *Deep Sea Res*., Submitted.