Near-Surface Dispersion and Circulation in the Marmara Sea (MARMARA)

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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 objective of the MARMARA project was to study the near-surface dispersion and circulation in the Marmara Sea, a small (70 x 250 km) basin connecting the Mediterranean Sea (through the Dardanelles Strait) to the Black Sea (via the Bosphorus Strait). It was planned to study the surface circulation dynamics of the Marmara Sea at scales from inertial/tidal to seasonal using drifter observations and ancillary satellite data (SST and ocean color) over about a year (from summer 2008 to spring 2009), in conjunction with other observational programs and numerical simulation exercises conducted by colleagues in the Turkish Straits System.

APPROACH

Surface drifters were deployed in two main episodes (in late summer 2008 and winter 2009) at key locations to maximize the geographical coverage in the Marmara Sea and to construct maps of mean circulation and eddy variability, in terms of seasons and major wind regimes (Eulerian statistics). The deployments were mostly in small (1 nm) clusters of three drifters in order to assess the horizontal dispersion of the surface waters (Lagrangian dispersion statistics). The drifter data were also used in concert with satellite images (sea surface temperature and ocean color) to describe qualitatively the surface dynamics.

WORK COMPLETED

In total, 14 CODE drifters were deployed in the Marmara Sea in August/September 2008 as part of the TSS08 trial of the NATO Undersea Research Centre (NURC). They were deployed in triplets in which drifters are separated by about 1 nm. Two triplets were deployed on 30 August 2008 in the central

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open sea near longitude 28°E (see Figure 1). On 31 August 2008, two other triplets were released south of the Bosphorus in the northeastern Marmara Sea. Finally, three recovered instruments were deployed south of the Bosphorus on 27 September 2008. In November 2009, an expedition was organized to recover some drifters that had stranded (mainly on the southern shore of the Marmara Sea). Seven units were recovered in good working condition. On 20/21 February 2009, 14 CODE drifters were released in the Marmara Sea as part of the NURC TSS09 trial from R/V Alliance. The deployment locations were essentially identical to those in 2008 (Figure 1). Temporarily the drifters sampled the Marmara Sea in September-October 2008 and February-March-April 2009 (Figure 2). The maximum data density occurred during the deployment episodes (10 drifters in late August 2008 and 13 units in February 2009).

The data of all these drifters, as well as additional units deployed in the Aegean and Black seas during the same period, have been processed in near-real time and graphics with trajectories and status tables have been posted on the web (http://nettuno.ogs.trieste.it/sire/drifter/tss/). A web-based database has been assembled to include 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/tss/database/).

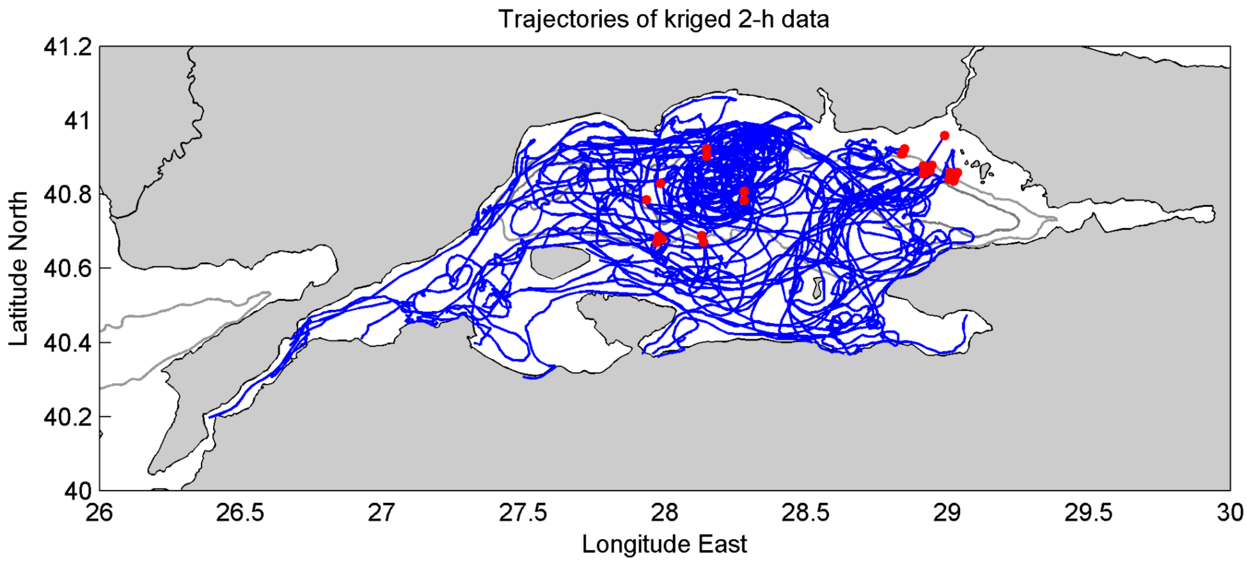

Figure 1. Interpolated (kriged) trajectories of the CODE drifters in the Marmara Sea between 30 August 2008 and 23 April 2009. Red dots indicate the deployment positions.

Eulerian statistics (maps of mean flow and velocity variance) were computed using the whole dataset, the data sorted by experiments (TSS08 and TSS09) and separated by wind regimes (strong northeasterlies and other/low winds). The qualitative description of the surface circulation in the Marmara Sea as derived from the drifter motions and the Eulerian velocity statistics were summarized in a paper submitted to Ocean Dynamics (Gerin et al., 2010). Lagrangian statistics (both absolute and relative dispersion) were also computed but the results turned out to be inconclusive due the short duration of the drifter tracks.

The drifter data were used by our collaborators from NURC (Chiaggiato et al., 2009, 2010) to validate the numerical simulations of the Marmara circulation (using ROMS forced by COSMO winds), with particular focus on a strong event of NE winds in February 2009.

In collaboration with NURC, drifter tracks were overlaid on satellite images of sea surface temperature (AVHRR, MODIS) and chlorophyll concentration (MODIS, MERIS) to describe qualitatively the spatial structure and temporal evolution of the Marmara Sea dynamics. This work is still in progress.

RESULTS

In general, the drifters sampled adequately the Marmara Sea (Figure 1), but the southern part was covered by drifters mainly during the first experiment (September deployments) and the northern area mainly during the second one (February deployments). The lifetime of the drifters in the Marmara Sea is rather low due to the recovery by seafarers and stranding, varying from a few days to 50 days. The mean half lifetime is ~13 days. As a result, the temporal distribution of the data is highly variable and spiky (Figure 2).

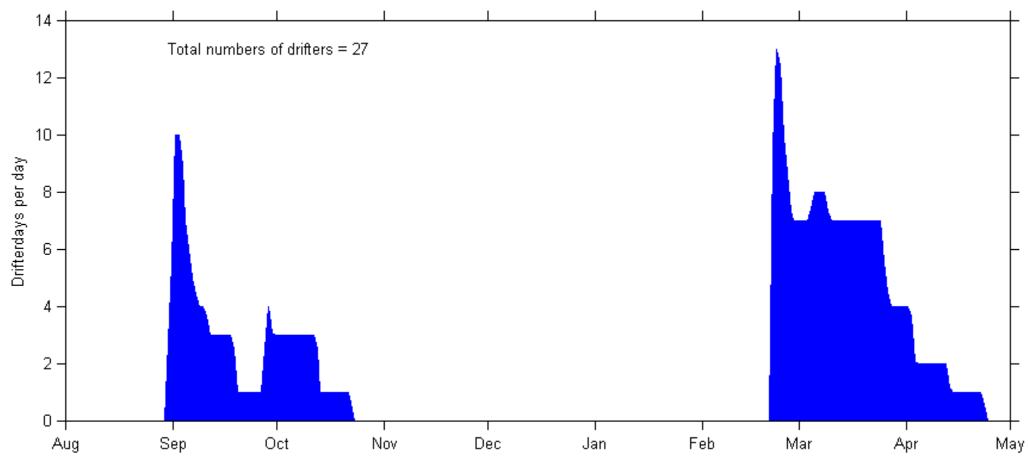

Figure 2. Temporal distribution of the drifter data in the Marmara Sea between August 2008 and 23 April 2009 (number of drifterdays per day).

The maps of the mean surface flow (Figures 3 and 4) reveals a general surface current to the southwest in the Marmara Sea, connecting the Bosphorus to the Dardanelles. In particular, a jet with mean speeds of about 20 cm/s crosses the central Marmara Sea and joins the two straits with some meandering structure. The time for a surface drifter deployed south of the Bosphorus to reach the entrance of the Dardanelles ranges between 5 and 40 days (mean of 18 days). Besides, the mean circulation map shows two or three eddies located in the northern part of the basin. Another cyclonic eddy is evident in the southeastern area of the Marmara Sea during the period Sep-Oct 2008. If conditional means are calculated for the prevailing wind regimes (strong northeasterlies and other/low winds), it can be seen that the anticyclonic recirculation in the north central basin is strong and extended (Figure 4) under northeasterly winds.

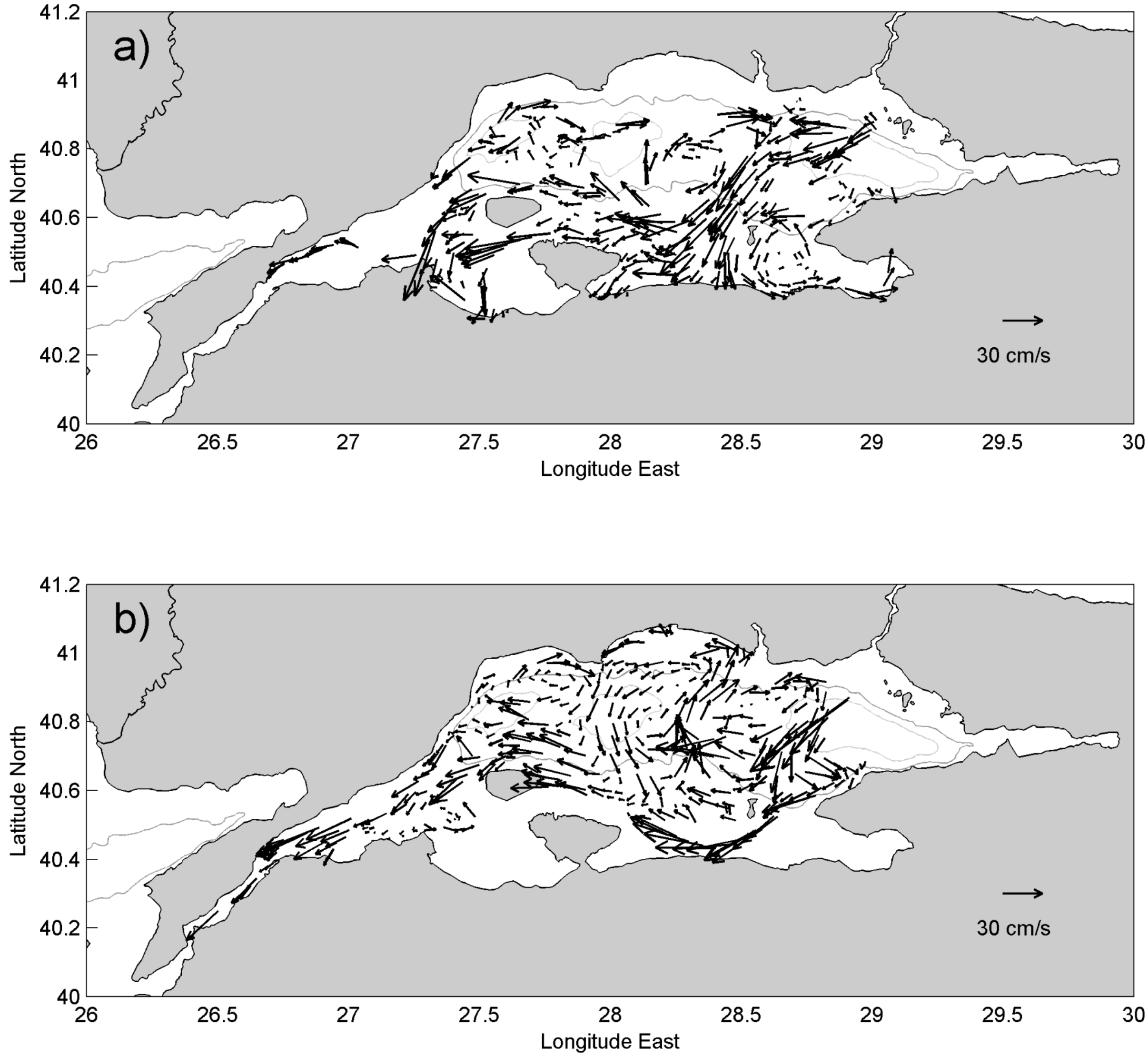

Figure 3. Mean circulation in the Marmara Sea for the periods September-October 2008 (a) and February-March-April 2009 (b) drifter experiments. The mean flow arrows are centred at the centre of mass of the observations in each bin. Data are grouped into 0.1° x 0.1° bins overlapped by 50%. Bins containing less than 5 observations were rejected for the computation of the statistics. The 200 m and 1000 m isobaths are represented with grey curves.

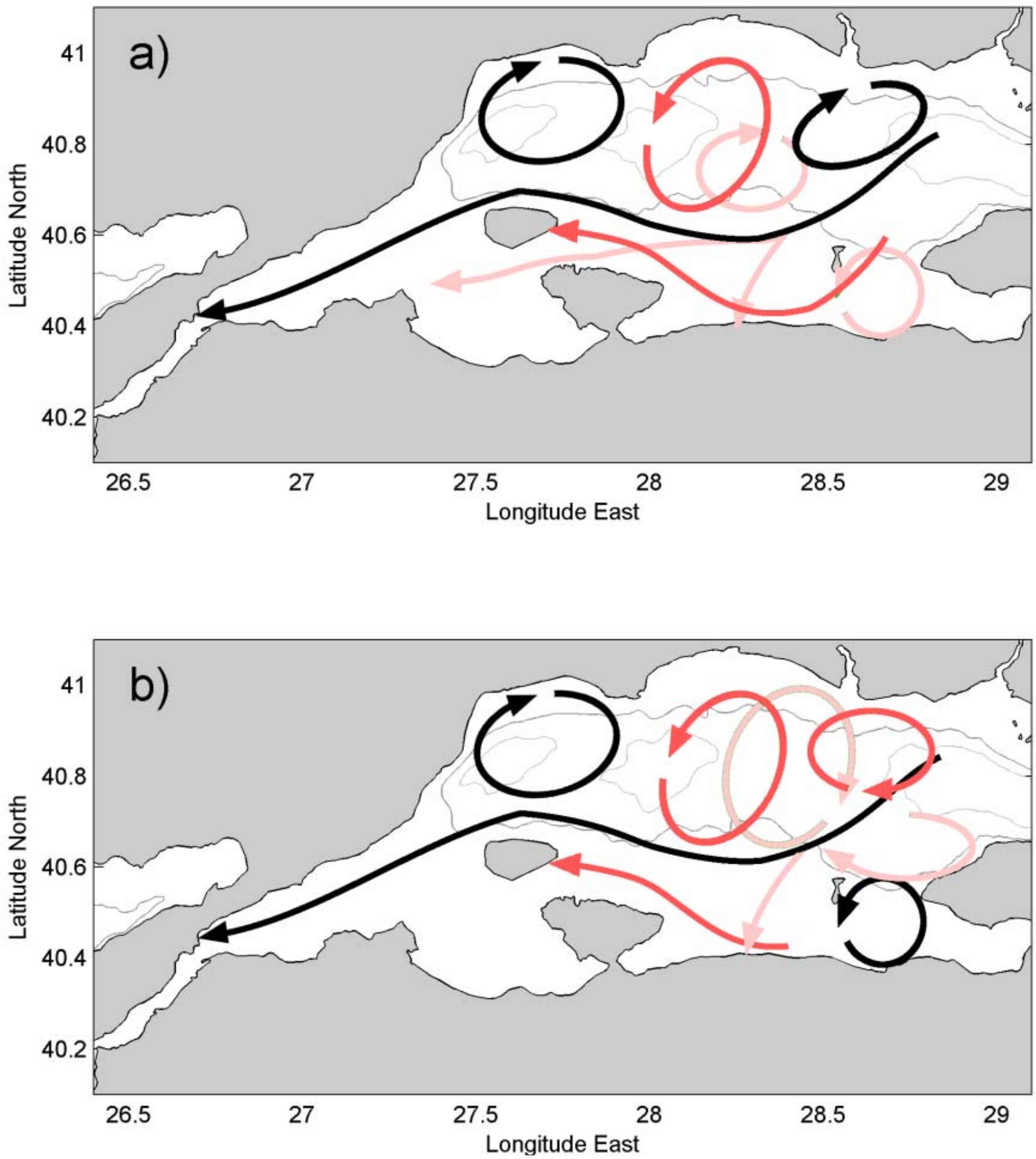

Figure 4. Schemas of the surface circulation in the Marmara Sea for the TSS08 and TSS09 experiments (a) and for different wind regimes (b). Black curves represent features observed during both drifter experiments or during both wind regimes, light (dark) pink curves symbolize the circulation features distinctive of the TSS08 (TSS09) experiment or of the strong northeasterly wind regime (winds from other sectors or low winds). The 200 m and 1000 m isobaths are represented with grey curve.

IMPACT/APPLICATION

The scientific impact of this project is to increase our understanding of the Marmara 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.

RELATED PROJECTS

The MARMARA project was strongly related to, and fully integrated in, projects carried by the Naval Research Laboratory (NRL), NURC and the University of Miami in the Turkish Strait System (Northeastern Aegean, Marmara and Southwestern Black seas).

These programs included:

- The TSS08 project conducted by NURC (P.I.s: Drs. S. Besiktepe and J. Chiggiato)
- The NRL Exchange Processes in Ocean Straits (EPOS) project to improve our understanding on the significance of synoptic variability to exchange dynamics in ocean straits (P. I.s: Drs. J. Book and E. Jarosz).
- Development of a multi-scale coupled ocean model system for the Turkish Strait System by NRL (P. I.: Dr. C. A. Blain).
- Coastal and shelf modeling activities carried out at the Rosenstiel School of Marine and Atmospheric Science (University of Miami) (P.I. Dr. V. Kourafalou). (http://coastalmodeling.rsmas.miami.edu/Models/View/AEGEAN_SEA)

PUBLICATIONS

Chiggiato, J., S. Besiktepe, E. Jarosz, J. Book, R. Gerin, P.-M. Poulain and L. Torrisi (2010) Numerical modelling of the surface circulation in the Sea of Marmara during the TSS experiment (September 2008 – March 2009). Geophysical Research Abstracts, Vol. 12, EGU2010-2697.

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Gerin, R., P.-M. Poulain, S. Besiktepe and P. Zanasca (2009) Near-Surface Circulation in the Marmara Sea. LAPCOD Meeting, 7-11 September 2009. La Londe-les-Maures, France. http://www.rsmas.miami.edu/LAPCOD/2009-La_Londe-les-Maures/abstracts/lapcod2009_A104.php

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