SURFACE DRIFTER MEASUREMENTS IN THE MEDITERRANEAN AND BLACK SEAS

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1. ABSTRACT

Starting in 1986 and 1999, respectively, the surface currents of the Mediterranean and Black Seas have been measured by means of Lagrangian drifters. In 2006 the Mediterranean Surface Velocity Program (MedSVP) has been created to coordinate the deployments in these seas and to make drifter data available for several applications. Some results of two recent studies in the eastern basin of the Mediterranean Sea and in the Marmara Sea are presented.

2. INTRODUCTION

Surface currents in marginal seas, such as the Mediterranean and Black Seas, can be measured efficiently from the drifts of Lagrangian instruments tracked by, and transmitting data to, satellite systems (Argos, Iridium). These surface drifting buoys (called drifters) are low-cost, expandable systems that measure sea surface temperature (SST) and currents through their displacements between satellite fixes. Drifters are actually quasi-Lagrangian since they do not perfectly follow the surface water because of the effects of the winds and waves acting on them. However, over the past two decades, drifters, such as the CODE and SVP designs, have been developed to reduce these effects (Sybrandy and Niiler, 1991; Davis, 1985).

In the Mediterranean and Black Seas, satellite-tracked drifters have been operated starting in 1986 and 1999, respectively, as part of national and international scientific projects and in support of military operations. They have been deployed from research vessels and from ships of opportunity (ferries, small boats, etc.). The data of most drifters operated in the Mediterranean and Black Seas between 1986 and 2009 were assembled in a common database in which all the data have been processed and quality controlled uniformly. This database and corresponding graphical products are available online whereas partial databases have also been released on CD-ROMs (Poulain et al., 2004). The data of more than 1000 drifters (mostly corresponding to CODE and SVP designs) have been included in the database.

Among all the studies in which drifter data can be utilized, it is important to mention their use in concert with satellite maps of SST or surface chlorophyll concentration. The combination of Lagrangian data and satellite maps provides a remarkable description of the often complex spatio-temporal variability, at sub-basin and meso-scales, of the surface circulation and its connection with the SST and chlorophyll fields. From a more statistical point of view, drifter data are also used to compute pseudo-Eulerian maps of mean circulation and sub-grid/temporal (also called eddy) variability. Kinetic energy levels of the surface currents can also be mapped. In addition, using the Lagrangian nature of the drifters, Lagrangian statistics (time-lagged auto-covariance, diffusivity, etc.) can be calculated to investigate the absolution and relative dispersion of water parcels.

3. MEDSVP

International collaboration is crucial to obtain a useful drifter dataset even at the scales of the Mediterranean and Black Seas. The combination of data from drifters with similar properties (same depth of drogue, same effects of wind and waves) in a marginal sea is needed to provide a better description of the complex spatial and temporal variations of the surface currents. Colleagues from the USA, Spain, France, Italy, Tunisia, Ukraine and Russia have contributed to the Mediterranean and Black Sea drifter database between 1986 and 2009. Starting in late 2006, the Mediterranean Surface Velocity Program (MedSVP) has been formed to coordinate the use of surface drifters in the Mediterranean and Black Seas and to make their data available in near-real time (daily) for several end-user applications, including their assimilation into operational numerical forecasting models. Hence, through MedSVP, drifter data are now readily available and represent a component of the Mediterranean Operational Oceanography Network (MOON).

Recently, the eastern basin of the Mediterranean Sea and the Marmara Sea were intensively monitored using drifters within the framework of the international programs EGITTO/EGYPT and TSS, respectively.

4. EGITTO/EGYPT PROGRAM

The main aim of the EGITTO/EGYPT program was to study the surface circulation of the Eastern Mediterranean with particular focus on the Sicily Channel and the southern part of the Levantine.

Oceanographic observations in this latter area were scarce and the drifter data are the first of that kind there (Gerin et al., 2009).

About 100 SVP drifters were released between September 2005 and March 2007, on a seasonal basis in the Sicily Channel and in key locations in the Levantine sub-basin. The pseudo-Eulerian statistics (Figure 1) evidence an eastward flow entering the Sicily Channel and crossing the Ionian in its central part. This flow displays a branching behaviour east of Sicily. One branch is northward as far as 39°N and then turns anticyclonically and proceeds to the south depicting an anticyclonic elongated circuit that was observed for about 10 years in the 1990s then vanished from 1998.

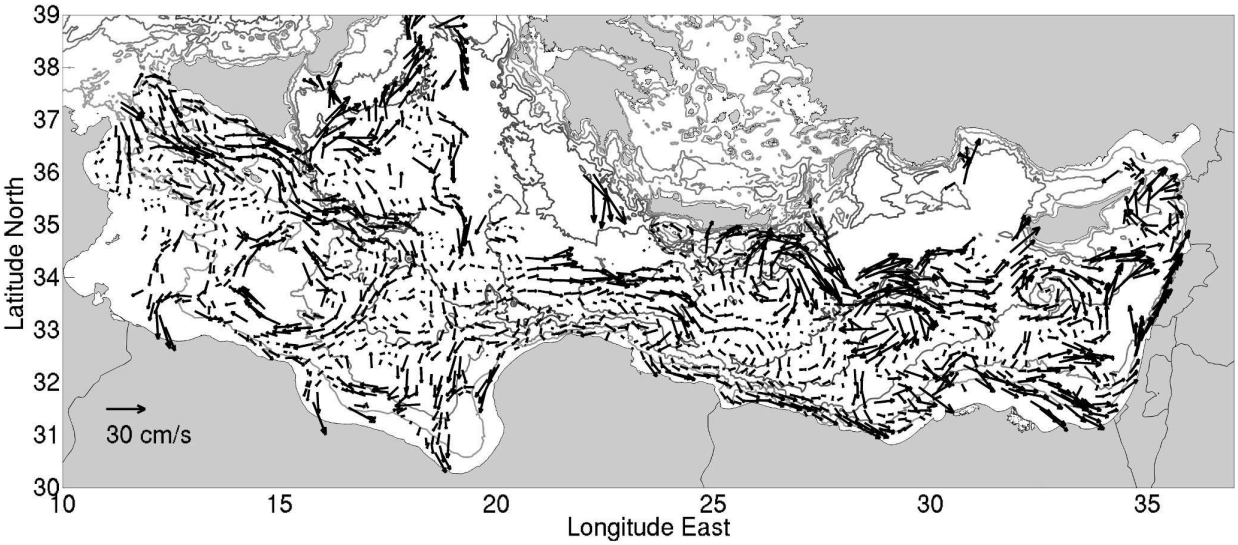

Figure 1. Mean surface flow in the eastern basin of the Mediterranean Sea. The mean flow arrows are centred at the centre of mass of the observations in each bin. Data are grouped into 0.5° x 0.5° bins overlapped by 50% and results for bins with less than 10 observations and 2 different drifters are not plotted. The undrogued observations with a speed ratio (wind-induced slip/drifter speed) larger than 50% were not considered in the computation to exclude erroneous velocity estimates.

The EGITTO/EGYPT drifter data suggest that it re-appeared in 2005-2007. A seasonal variability inducing a reversal of the circulation in the southern part of the Ionian is also striking (westward in summer and eastward in winter).

The main feature in the Levantine, is an eastward flow along the Libyan and Egyptian slopes that continues in a cyclonic circuit along the Middle East and Turkish slopes. This general alongslope circuit can be perturbed locally and temporally by the numerous anticyclonic eddies that co-exist in the Levantine, mainly created by the instability of the slope current in the south, but also by the wind and by the topography. Part of the surface flow can be deflected offshore by these eddies and the effect of a series of contiguous eddies (paddle-wheel effect) can possibly result in an eastward offshore meandering transport. Additionally, when the eddies are close enough to the slope, most of the surface flow is advected seaward and, along the slope, the current is induced by the southern side of the eddies which results in a westward current. Locally and temporally the circulation along the slope can thus be reversed.

5. TSS PROGRAM

One of the main goals of the TSS (Turkish Straits System) program, instead, was to study the surface circulation dynamics of the neighbouring Black, Marmara and Aegean Seas at scales from inertial/tidal to seasonal over about a year (from September 2008 to May 2009). Particular focus was given to the Marmara Sea that was seeded with CODE drifters in two seasonal episodes (September 2008 and February 2009). About 30 drifters were deployed in key locations to maximize the geographical coverage and mainly in small (1 nm) clusters of three drifters.

On the whole, the drifters sampled adequately the Marmara Sea, but the southern part was covered by drifters mainly during the first experiment (September deployments) and the northern part mainly during the second one (February deployments). The lifetime of the drifters in the Marmara Sea is very low due to the

recovery by seafarers and stranding (it span from a few days to 50 days) and the mean half lifetime is only 13 days.

The map of the mean surface flow (Figure 2) shows two eddies located in the northern part of the sea which extend for about 30 km and reach the middle of the Marmara Sea (the western feature is anticyclonic and the eastern one is cyclonic). South of these large features, a flow of about 20 cm/s joins the Bosphorus to the Dardanelles and another cyclonic eddy is evident in the southeastern area of the Marmara Sea.

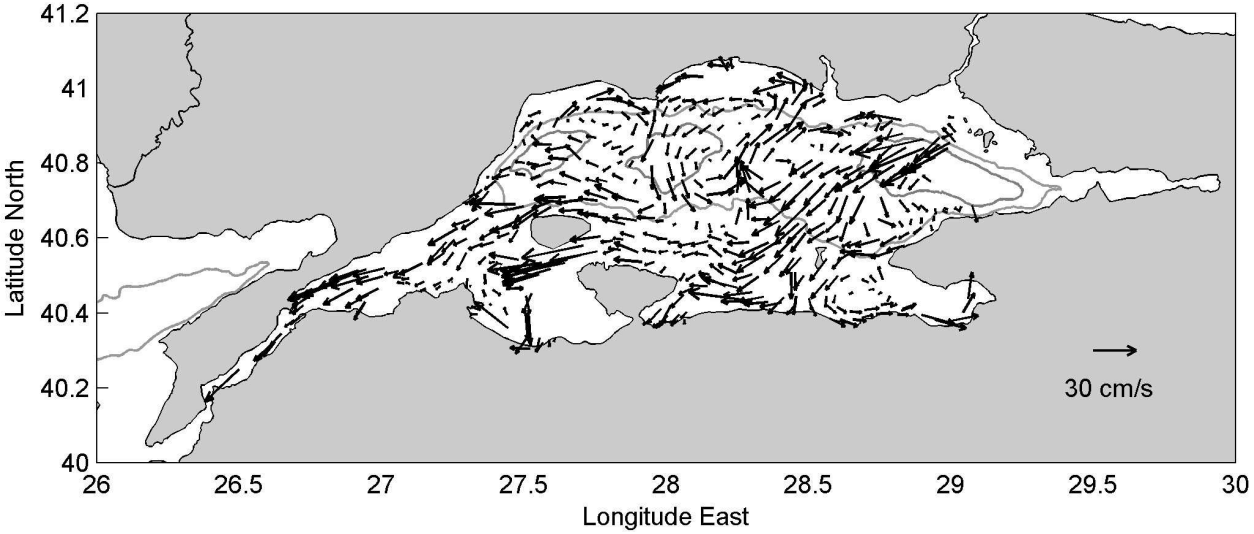

Figure 2. Mean surface circulation in the Marmara Sea. The mean flow arrows are centred at the centre of mass of the observations in each bin. Data are grouped into 0.1° x 0.1° bins overlapped by 50% and results for bins with less than 5 observations are not plotted.

6. REFERENCES

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