

Interactive comment on “Surface circulation in the Eastern Mediterranean using drifters (2005–2007)” by R. Gerin et al.

Anonymous Referee #1

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Review

Title: Surface circulation in the Eastern Mediterranean using drifters (2005–2007)

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Summary

This article summarises the surface circulation in the Eastern Mediterranean as inferred from the deployment of 97 surface drifters over a period of roughly two years. The sampling strategy involved frequent small deployments in, or across, key circulation regions such as channels and persistent eddies. Good coverage by the drifters is available both spatially and temporally, the latter allowing an analysis of seasonal variability. The drifter analysis is thorough, and a number of new and interesting features are discussed, such as the branching behaviour of Atlantic Water (AW) after passing through Sicily Channel and a reversing circulation along the southern edge of the Levantine Basin. Overall, this article makes an important contribution to our understanding of the circulation in the Eastern Mediterranean. However, this article would be improved significantly by further investigation and discussion of the possible mechanisms responsible for the seasonal variability identified. For example, changes in wind forcing are hypothesised as a source of seasonal variability, but not even a qualitative discussion of wind patterns during the time period of this study is provided. It would be nice to see some of these suggestions teased out further. The other major concern is that more information needs to be provided regarding error in the drifter velocity fields.

General comments

1) While the primary readers of this article will most likely be familiar with the region and previous studies conducted here, I feel that the manuscript would benefit from the inclusion of a schematic diagram of the circulation, with the key circulation features (e.g. LE1, MMJ, Mersa Matruh, etc.) labelled. If space provided, it would be particularly nice to have a schematic with multiple panels that showed a historical representation of the circulation and what aspects of the circulation has changed based on these (and other recent) studies.

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2) I have no question that the processing or analysis of the surface drifter data was completed properly—some of the authors have a great deal of experience in this area and the proper references are cited. However, further information needs to be provided about how reliably the drifters are representing the surface flow. At the very least, an error estimate of the velocity measurements needs to be provided. Also, 40% of the observations were collected while the drifter was without a drogue. This is a large percentage of the observations and I would not expect the error in the velocity estimates from drifters without drogues to be the same as those with drogues. You might also consider addressing the following: Are the surface drifters showing largely wind-forced Ekman velocities or geostrophic velocities? Are the surface drifters steered by topography in the different basins?

3) In the discussion a number of seasonal differences in the surface circulation are identified. In most cases only a brief suggestion of the mechanism for the variability is given. The manuscript would be greatly improved by providing the reader with further information about these differences. For example, on Page 539, line 2, "This clockwise elongated circuit seems to be related to the wind forcing that influences the circulation at seasonal time scales as explained by Pinardi and Navarra (1993)." Were there big seasonal differences in the wind velocities during these years? Similarly, further discussion of the reversal in the Levantine Basin between 20°E and 25°E is needed. Are the eddies here (LE1, LE2, EE) permanent features? Is there any evidence that this seasonal reversal is a persistent feature of the surface circulation? What are the implications for the seasonal reversal in the circulation here, is it primarily a transport issue, or will the reversal also lead to changes in the modification processes of AW?

4) A key conclusion of this manuscript is that the Mid-Mediterranean Jet (MMJ) arises from the contributions along the outer edge of the major anticyclonic eddies in the Levantine Basin (what the authors refer to as the paddle-wheel effect). This eastward flow arises in Eulerian maps of the mean flow because of persistent eddies. However, from a Lagrangian standpoint, if all the drifters simply become entrained in the major

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eddies, the MMJ would be an ineffective mechanism for transporting AW eastward. The authors should discuss how frequently drifter trajectories follow the MMJ path into the eastern Mediterranean (it seems to be relatively infrequent from Figures 5 and 6). If trajectories following the MMJ path do exist, then the significance of there being two different paths to the eastern side of the Levantine basin should be discussed. For example, would AW undergo different modification processes along these two different paths?

5) Drifters are drogued at a constant depth, and therefore do not follow individual water masses. Since the surface circulation is uniformly to the east across Sicily Channel, it must be returned at depth. Is there any indication from the drifters (or using other data), where the fluid is sinking to be returned to the western Mediterranean (likely to occur in areas of convergence or divergence). Drifter trajectories will not represent paths of water mass transport in this regions.

Specific comments

The following are minor comments and suggestions to improve the manuscript.

Page 526, line 11, "completes" should be complements. "Several veins are evidenced", not sure what is meant by veins.

Page 527, line 6, "lighter Atlantic water (AW)." Some more details should be given about the signature of AW—is it warmer and fresher or is its reduced density due to a single component. How easy is it to track the flow of AW throughout the eastern Mediterranean?

Page 527 and throughout, it would be preferable if circulation features and eddies were referred to as either cyclonic or anti-cyclonic rather than using clockwise and

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counter-clockwise.

Page 527, first paragraph, Figure 1 and potentially a new figure showing a schematic of the circulation should be referenced here and throughout the introduction to aid the reader in understanding the circulation features discussed.

Page 528, line 2, "displaying a new feature: a clockwise circuit in the northern part of the Ionian." Is this in addition to the counterclockwise circulation mentioned on Page 527, line 17, or is the sense of the circulation in this part of the basin reversed from historical representations? This should be made clear in the text.

Page 528, line 23, "described in the POEM diagram", please add reference.

Page 533, Figure 4, The drifter trajectories in January 2007 are quite different from all the other deployments in this figure. It would be good to add a discussion of what forcing might be responsible for this discrepancy. In particular, it does not appear to be a seasonal issue because trajectories from the February 2006 deployment are very different.

Page 533, line 28, "The curves and sharp bends in trajectories indicate the presence of other eddies . . . and meandering structures." Please be clear that you mean smaller scale eddies, or mesoscale eddies from your definition in the introduction.

Page 535, line 10, "but between 14°E and 16°E where there are more than 100 observations in bins", this is an incomplete sentence.

Page 536, line 22, "It's signature is less intense during winter since drifters were entrained only around [IE]." Is there any other evidence that this feature has seasonal variability. Since it is stationary, is it localised by a topographical feature, or is it related to wind forcing?

Page 537, line 14, "In the Levantine sub-basin, the winter circulation computed is similar to the total average." It would be good to be more quantitative here: what measure of the circulation are you using?

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Page 538, first two paragraphs of Section 4, Most of this is already covered in previous sections and does not need to be repeated.

Page 538, line 26, "It can be compared to the mean circulation already described by Malanotte-Rizzoli et al. (1997)." It would be more useful here to state how this data differs from the circulation picture described in the referenced paper.

Page 539, line 12, "comforted" should be "confirmed".

Page 539, line 23, "This reversal is confirmed by Poulain and Zambianchi (2007) and presumably related to the forcing by the prevailing southeastern winds." Please add some further information about the winds here. Can you give some suggestions for why the flow reverses (see also point 3 above).

Page 545, Reference Figure 1 in the caption of Table 1.

Page 548, Figure 2, It would be nice to use different color trajectories for those that are entrained in the various labelled eddies.

Page 552, Figure 6, This is a nice figure! Filtering like this really pulls out the key structures and their propagation through the basin.

Figures 7-9, It is difficult to make out both the colours showing MKE/EKE with the arrows/ellipses overlaid. You could consider adding more panels to make this clearer. Also, it might be interesting to reduce bin size in interesting regions where you have a large number of observations (such as in LE1 and LE2) to improve the resolution of these eddy features. Also, it is typical to leave titles off the plot panels since the information is given in the caption.

Interactive comment on Ocean Sci. Discuss., 6, 525, 2009.

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