

Review of “Modelling Surface Currents in the Eastern Levantine Mediterranean Using Surface Drifters and Satellite Altimetry”, by L. Issaa et. al.

Overall, I thought that this was a good paper and should be considered for publication after major revision. The concept of being able to assimilate velocities from drifters with velocities inferred from altimetry is very important and relevant to ocean modeling. I felt that the authors did an adequate job explaining their methodology and demonstrating it. I have several major concerns though regarding this manuscript that need to be addressed. My first main concern is in regards to the novelty of the methodology. I don't have an issue with it being a relatively simple method; I agree with the authors in that having a fast system can be beneficial for real-time applications. It appears that the novelty comes in by adding several modifications to Taillandier's system. Other than the moving assimilation window, the author's don't fully demonstrate how these changes impact the system. The authors need to include discussion and possibly results of the impact of constraining the velocity correction to be divergence-free and adding a component to the velocity due to the effect of the wind. The authors mention that the effect of wind is insignificant; I find this a little shocking and would like to see how.

Another concern that I had is that the authors make no mention of the ageostrophic component of velocity, which is typically significant in shallow coastal waters. The drifters are most-likely resolving some of these ageostrophic features whereas the altimetry is not. I suspect that this is one of the primary reasons why these datasets are so different. I suggest that the authors investigate this and discuss it in their paper. I don't think that it's necessary for the author's to rerun any experiments to try and quantify how much of the velocity in this region is ageostrophic, but I do think that it's important to discuss its existence.

I am a little surprised that the authors didn't include any references from the fairly recent CARTHE project (<http://carthe.org>), which was focused around one of the largest drifter deployments (over 300) in the Northeastern Gulf of Mexico. This project included a number of studies looking into using these drifters to improve modeling efforts. One of these studies, in particular, is very similar to this submitted paper. The folks at the Naval Research Lab assimilated CARTHE drifters along with altimeter SSH into their operational ocean model using 4D-Variational Assimilation (Carrier et. al., 2016 and Muscarella et. al., 2015). They too demonstrated the impact that drifters have on resolving small-scale features in the model and how they are a good supplement to altimeter data.

Finally, there were a lot of grammatical errors in the text which sometimes made it difficult to follow and understand the points the authors were conveying. Please carefully go through the text and ensure that the grammar is concise. I also found that many of the figures were difficult to interpret. Please ensure that all of the different lines and markers on each plot are distinguishable.

Minor Corrections:

Abstract: The sentence beginning with ‘The velocity correction is done’ is very confusing. Please rewrite so it is clearer how the velocity data is assimilated.

Line 11: remove the word ‘typically’.

Line 26: Why is Figure 1 on page 5? Typically all of the figures are either at the end of the manuscript, or embedded in the text shortly after they are first referenced.

Figure 1: When printed on paper, it is difficult to distinguish which lines are the drifters and which are the simulated trajectories. I had to magnify the PDF 400% in order to see the ‘x’s for the drifter trajectories and the circles around the starting point. Please modify this figure so there is a clearer distinction between the real and simulated trajectories and also clearly mark the beginning of the trajectories. I.E. Perhaps make the trajectories with a larger thickness than the background AVISO field.

Line 30-32: This sentence alludes that the 3 AVISO trajectories flow away from the coastline. The black and green AVISO tracks appear to properly follow the blue AVISO field. However, the purple AVISO track abruptly turns perpendicular from the blue vectors and runs into the coast. Please explain what is going on here.

Line 34-37: Please edit the last 2 sentences of this paragraph. I am guessing that the authors are trying to make the point that the reason the trajectories from AVISO and the drifters are so different is because they are resolving dynamical features on completely different spatial and temporal scales. Please clarify this point. Also, please elaborate into why these data types are complimentary?

Line 40: do the authors mean “...modifying a dynamical model state...”

Lines 42-47: Please fix this run-on sentence.

Line 51: put ‘a’ in front of the word ‘model’.

Line 53: change ‘drifters’ to ‘drifter’.

Line 63: I don’t understand what is meant by ‘wind and drifters components’. Please clarify.

Line 78: I am unfamiliar with the term ‘model assimilation’. Please include a definition.

Line 87: Should ‘Levantine’ be capitalized?

Lines 86-90: These 2 sentences seem to contradict one another. Please revise.

Line 114: I see you included a footnote for NEMED, but you should also define this acronym in the text. An expansion of this paragraph is needed; what are these 2 projects and what types of data came out of them?

Line 142: change drifters’ to drifter.

Lines 142-148: This paragraph is out of context. This should be moved to section 3.2 with the description of the model.

Line 152: Define the acronym CYCOFOS_CYCOM.

Line 197: Do the authors demonstrate that the effect of wind on the total velocity is negligible? The results in figure 1 lead me to believe that the actual velocity, based on the drifter tracks, is mostly ageostrophic, since they don't follow the geostrophic motion displayed by AVISO.

Line 209: Can the authors please provide more details in how the covariance is constructed? The diffusion filter method is used to model the correlation, but how do you define the model errors? Also, I am not seeing in eq. 9 how observation errors are implemented.

Line 213: How are α_1 and α_2 determined?

Figure 2: The text describing figure 2 is confusing. The text states that 2 of the AltiFloat drifters are simulated and shown in red, but the figure shows a lot more than 2 red lines. What are the other red lines?

Figure 3: Please define the % RMS Error in this figure; what are these errors relative to? Is this the same RMS error defined in equation 10? The markers denoting the different lines are too small and difficult to distinguish; please fix.

Figures 4 - 7: Again, please increase the size of the markers.

Figure 8: I can't see the drifter positions in the right panel. The author's should consider zooming in and just showing the primary region (black box in figure 2) since the remainder of the field appears to be identical.

Lines 372-374: I get the impression that the authors are insinuating that the primary reason for the drifters being able to make such a significant correction to the background is because altimeters are inaccurate near the coast. I agree that altimeters have a low signal to noise ratio near the coast, however I disagree with the assessment that this is the leading cause of the differences. It is well known that currents in coastal regions typically have a significant ageostrophic component, and blended altimetry products, such as AVISO, simply don't have the cross-track resolution to properly resolve these features. Addressing my primary concern above should resolve this issue.

Section 5.1: I appreciate the qualitative results displayed in figures 11-12; they clearly demonstrate that your method is working as designed. For the experiment in fig 12, can you please compute and compare the RMS errors between the non-assimilated drifter and the background/corrected solution.

Lines 397-400: Is the simulated trajectory shown in figure 13? What are the mean and maximum position errors? Is this the difference of the center of the eddy between the background and corrected solutions? Please elaborate.

References:

Carrier, M. J., H. Ngodock, P. Muscarella, and S. Smith, 2016: Impact of assimilating surface velocity observations on the model sea surface height using NCOM-4DVAR. *Mon. Wea. Rev.* (in press), doi: <http://dx.doi.org/10.1175/MWR-D-14-00285.1>

Muscarella, P. A., M. Carrier, H. Ngodock, S. Smith, B. Lipphardt, A. D. Kirwan, H. Huntley (2015). Do assimilated drifter velocities improve Lagrangian predictability in an operational ocean model? *Mon. Wea. Rev.*, *143*(5), 1822–1832.