Reviewer #1

Dear reviewer,

We would like to show our sincere appreciation for your interest and deep analysis of our manuscript, entitled "A new Lagrangian based short term prediction methodology for HF radar currents". We would also like to thank the comments and suggestions you have proposed, they help us realize the paper needed substantial changes to allow more clarity in the presentation of methods and results. The paper has been revised and carefully modified following your advices and comments. They have undoubtedly helped to improve the quality of this manuscript. Our individualized response to your comments can be found below (in blue color).

You can find the new manuscript and the changes that we have done over it, in the final manuscript document that we will upload to the journal (both new and "track changes versions). Line references included in this document, are referred to the "track changes" version and they will be updated if any additional changes are requested by the editor before the final submission of the revised manuscript.

The manuscript describes the application of the method of analogues to the prediction of Lagrangian trajectories computed from HFR.

Lagrangian trajectories are computed from an historical data set providing surface currents from HFR systems. The catalogue of these Lagrangian trajectories is the basis to be compared to any new data set, from a present HFR surface currents. Then the future time evolution of the analogue provides the forecast for the present case.

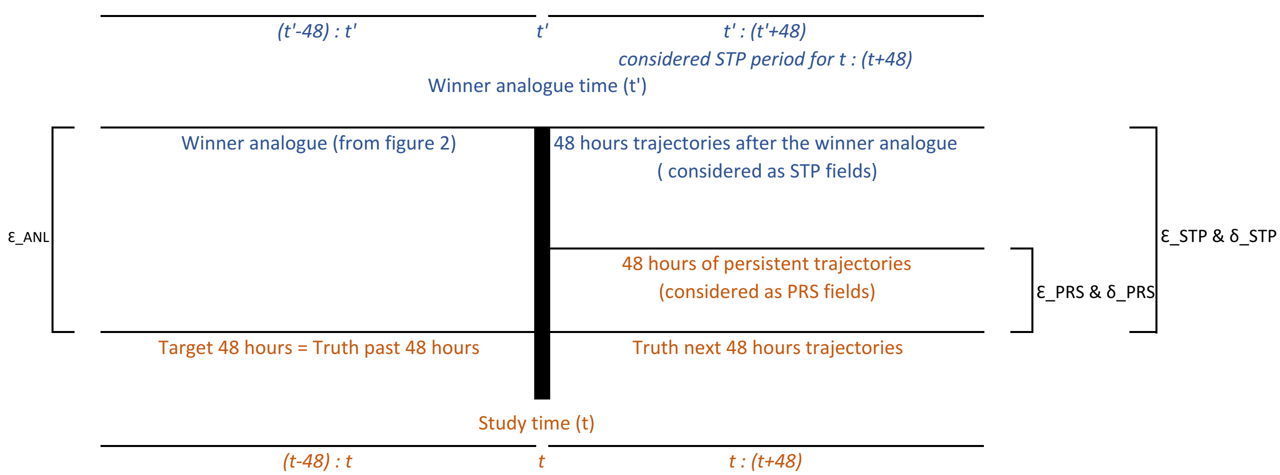
The best analogue is selected in 2 steps. First the difference between the centroid of the 25 trajectories (the 48-h or the end position, is not clear) of each hour of the catalogue is compared with the centroid of the target field. Only the analogues resulting in a difference lower than 10km are selected. Then a Lagrangian error (\epsilon_ANL) is defined as the sum of the mean separation distance between trajectories computed from the catalogue fields and those computed from the target field, at 4 different times (6, 12, 24, 36 hours of advection). This error is in km^2. The field having the lowest error is selected and will provide the analogue forecast.

Why do we need the first step? I suppose that if \delta_cg is bigger than 10km, then the error is high? Is it for computational issues?

This step decreases the computation time. It is short (seconds to few minutes, depending on the historical dataset) but in this way, it is even shorter. It is explained in the manuscript, in the lines 292-299.

To assess the performance of the method, an equivalent Lagrangian error is computed. I'm not sure that the definitions of the errors (\epsilon_STP and \epsilon_PRS) (line 303-304 308-309) are correct. I think that the authors compute the forecast so next 48 hours instead of last 48 hours. Otherwise, I really misunderstood completely the method, which is possible, according to my numerous questions. For example, on Figure 3, I do not understand why the blue dots are the same in a) and c) (or (b) and (d)). The end points of a) shouldn't be the start points of c)? Either (a) is a backward trajectory plot, and (c) a forward plot, or again I'm missing some fundamental explanation.

You are right. ε_{STP} and ε_{PRS} are computed for forecast trajectories to compare them with realized/true trajectories, this was an unfortunate mistake in the captions. Equations' captions have been modified in the text to clarify it and a schema of all the process has also been included in the manuscript (Figure 4) with the same purpose. It is similar to the one that as you can see below, where t is the study time ant t' is the time of the best analogue. We assume that [t : (t+48)] will behave similar to [t' : (t'+48)].



Ɛ is used to select the winner/best analogue

Ɛ_STP , Ɛ_PRS , δ_STP and δ_PRSare used to validate the methodology and estimate final error or separation distandes between real and forecast trajectories

STP fields are the forecast of the L-STP methodology

Figure 3: (now Figure 2). The blue dots are the same in all the subplots; those are the points where we initialize our simulations for 48 hours. They need to have the same starting point to be able to make comparisons between them.

So, let's assume that the authors were mistaken, and that the performance is evaluated by computing the error on the next 48 hours (forecast), by comparing the original field with the analogue forecast. Another forecast is used for comparison, based on a persistent field (constant velocity field for the future). The time series and spatial distribution of the errors have then been analyzed for 2 regions (Bay of Biscay & Black sea).

As pointed in our reply for your previous paragraph, your assumption is right and the performance is evaluated computing the error on the next 48 hours, as this will be the case in real time. And it has been analyzed for 2 regions (Bay of Biscay and Red Sea).

Figure 4 shows the time series of the errors ANL, STP and PRS. The black dots over the timeline shows the times the STP error is higher than PRS according to the caption, the other way around in the text (line 328)! At this point I was thinking to give up the reading, too many errors, to complicate to decrypt the manuscript. But let's go on. . .. PRS method seems better during winter period, since high persistent structures are present. The correlation between ANL-STP is 0.46 and ANL-PRS is 0.05. How significant are both values? Are the authors happy with the 0.46 value? Does it mean something for the methodology?

The black dots over the timeline shows the times when $\varepsilon_{STP} > \varepsilon_{PRS}$, as indicated in the caption. It has been corrected in the text (line 420-421) and it is consistent now.

Regarding the correlation values for ε_{ANL} - ε_{STP} and for ε_{ANL} - $\varepsilon_{PRS,}$ as we are comparing the errors of the past with the errors in the future (from the L-STP), we agree that the 0.46 value is low but significant. We point these values in the description of figure 4 (now converted to figure 5) in the manuscript, just to show that although during persistent periods ε_{STP} is higher that $\varepsilon_{PRS,}$ ε_{PRS} it is not correlated at all with the ε_{ANL} , while ε_{STP} shows bigger correlation, as expected.

Then the analysis is done by plotting errors (STP, PRS) or separation distances versus error_ANL comparisons are shown and discussed. Here my question is how reliable are the results in terms of the dynamics. The error values are enormous, hundreds of km^2, considering the domain size (~$1.5^{\circ}*1.5^{\circ}$ according to Fig1), and the correlation coefficients quite low (maximum of 0.56 according to Table 2). Maybe a visual and qualitative comparison between the eulerian fields (the winner analogue, its forecast vs the target fields) could give an idea of the performance of the method. The values alone are not enough in my sense to validate the methodology.

As explained in our previous paragraph, the fact that the maximum correlation values between past ε_{ANL} and future ε_{STP} or ε_{PRS} is 0.56 does not mean that methodology is not working; this comparison has been done to check the goodness of our forecast compared with the past ε_{ANL} values, and to give an advice to the final user to use Persistence or L-STP as forecast.

Figures 8 and 9 (former 7 and 8) have been generated to assess the performance of the methodology. Those separation distances are similar or even better to previously published and validated results.

Maybe this method is worthwhile to be further investigated, but I would recommend to go through a major review, making the method clearer, making a methodological analysis in parallel to a physical explanation. The methodology should also be more detailed. Results should be better presented to be convincing. The analogue method was developed mainly for meteorological dynamics, which have very different time and spatial scales. Moreover, the application of this method to Lagrangian motion which very often exhibits chaotic behavior, even in regular and simple Eulerian flows, is questionable. A sub region may have analogues in one period, and a distant region another period. The authors may consider to work on sub region, and with a higher number of trajectories.

Following your advice, we have corrected the definition of the errors that we had in the first submitted version of the manuscript. We have also added a figure to make a more detailed and clearer description of the methodology.

As it is indicated in the lines 255-267 of the "track changes" manuscript, the analogues methodology was firstly applied to the Eulerian velocity fields but results were clearly worse. We later applied the method to Lagrangian trajectories as they are direct measurements of transport of substances at sea. The obtained results are similar to previously developed STP works based on HFR data (table 1) so the methodology is working fine. The main advantage of it, it is that it is simple, easily applicable in real time with previously existing codes and we can add the trajectories catalogue as we get new currents. This aspect is now better detailed in the manuscript.

The number of trajectories was widely discussed by the coauthors during the tests of the methodology. A higher number of trajectories increased computational time while the improvement of the methodology was not appreciable.

Finally, your doubt about the sub regions was also discussed by the coauthors during the tests. We tried to decompose analogue finding, not only for different periods, but also for different regions. But we discarded this option, as one of the main goals of the methodology is to give a real time and simple forecast, with low computational cost but good results. As we were interested on this and you have also suggested it, we have included this point as a future work, as it is really interesting.

Specific comments:

- Once the Error is defined (eq.1) no need to repeat it (eq.2 & 3), since the difference between the errors is not the equation, but the field used to compute the trajectories and the separation distance.

The three errors are different:

Ɛ (equation 1): it is the error of the target 48 hours field and each 48 hour fields of the catalogue. There is no forecast or prediction here. [min Ɛ =$Ɛ_{ANL}$]

$Ɛ\_{STP}$ (equation 2): it is the error between the real 48 hours after the target 48hours, and the next 48 hours of the winner analogue (min Ɛ (=$Ɛ_{ANL}$) from equation 1) [which is considered as our STP forecast].

$Ɛ\_{PRS}$ (equation 3): it is the error between the real 48 hours after the target 48hours, and the 48 hours trajectory fields using the study hour as persistent currents [which is considered as our PRS fields].

As explained in previous paragraphs in this document and following your indications, the definitions have been improved in the text and a new figure (figure 4) has been also included to make the methodology clear.

- Not sure either that the definition of the time interval in line 293 is correct. Maybe the authors wanted to write v(ti)=v(tf), ti=[tf tf+48] ?

The equation is correct but it has been completed in the text to make it clearer (lines 385-391)

- Please find better definitions, and schematize the method. Instead of realized you may use truth, as for the twin experiments in data assimilation?

The definitions have been improved and the method has been schematized in the new figure 4.

"Realized" has been swapped by "truth" through the whole manuscript.

- The authors say that the method has been applied to the eulerian field with unsatis fying results (no improvement compared to other methods). Can the authors suggest some explanations for this?

Hourly HF Radar surface current fields for both study areas have more than 1000 nodes in their respective footprint areas. And each of those nodes have longitudinal and latitudinal velocity values. Moreover, the variability associated to those hourly fields is really high and we usually have to filter the data to make long time analysis of the surface currents.

In the other hand, Lagrangian trajectories measure the transport of the substances and our final goal is to minimize the separation distances between the truth and simulated trajectories. This fact, together with a lower variability associated to the Lagrangian fields, could be the reason of the better behavior of the analogue methodology with the Lagrangian fields.

- How the trajectories are computed is not explained, since the readers may not know the CODAR package. Are they purely advected? Is there any diffusion term?

In the Matlab package used in this paper, particles are advected using the HF radar hourly fields and there is no any diffusion term.

It has been included in the text (line 286)

- What is the physical significance of the error (thousand of kilometers)? - What is the distance between initial points?

The physical significance is the sum of the mean square separation kilometers at 6, 12, 24, 36 and 48 hours. It gives and approximation on how big the separation distance is between the truth and simulated trajectories.

The distance between the initial points is different for both systems:

δ_Lat=0.225 and δ_Lon=0.35 for the BoB

δ_Lat=0.1 and δ_Lon 0.15 for the Red Sea

The initial points and the trajectories to be distributed all around the study area is more important than the separation distance of the initial particles.