Ocean Science Discussions

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Comment on os-2021-34

Anonymous Referee #2

Referee comment on "Evaluating high-frequency radar data assimilation impact in coastal ocean operational modelling" by Jaime Hernandez-Lasheras et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-34-RC2, 2021

The paper describes the impact of assimilation of HF radar data at the Ibiza Channel (Western Mediterranean Sea). The authors assimilate commonly used data sets (Sea surface temperature, sea level anomaly and Argo profiles) in combination with HF radar data. For the HF radar data two options are considered: either assimilating the total currents (derived from the radial currents) or directly assimilating radial currents. Both assimilation experiments are validated against drifter observations. The authors conclude that the assimilation using total currents fits the Lagrangian observations the best.

Comments:

1. There are some general properties about the Kalman-based assimilation systems with transformed observations that should be mentioned to set the context of the study. If the hypotheses of the Kalman filter are verified (in particular the model is linear, error covariances are perfectly known), then the analysis would provide exactly the results under any invertible linear transformation of the observations (provided the observation operator and the obs. error covariance matrix are transformed accordingly).

The assimilation of any additional observation has the impact to reduce the error of the analysis on average. The consequence of these two properties is that the assimilation of transformed observations (possibly using a non-invertible linear transformation) should not be better than the error using the non-transformed observations. In practice this can be shown by considering the observations associated to a zero singular value of the transformation and the observation with a non-zero singular value separately; the observations with a zero singular value are ignored by the transformation (these correspond to radial HF radar observations for which no matching second HF radar observation exist to derive total currents).

Under these, admittedly restrictive, assumptions, the assimilation of radial currents should work better than the assimilation of total currents. Intuitively, this makes sense because all the information of the total currents is already included in the radial currents and the radial currents have additional information not included in the total currents.

However, for real-world experiments there are some assumptions not verified which can lead to the opposite conclusion. In particular, we know that the model is non-linear, observation error covariances are not perfectly known and arbitrary observation operators cannot be specified by most current assimilation systems. Also it is not completely clear if the mapping from total currents to radial currents is a linear process (can you clarify this point?). I suggest that the authors include this additional information to clarify to the reader the motivation of this study.

2. The observational error covariance is a crucial parameter in the assimilation system which is often not very well known because of the contribution of the representativity error.
Maybe I missed it but I did not see the particular values that were used. It is a bit surprising that the same error covariance values were used for radial currents and total currents. Can you expand this discussion by including the different values of the observational error covariance that were tested in your sensitivity test (line 432)? See also below.

I recommend the publication of this manuscript after revision.

Minor comments:

Line 130: This is a bit confusing. Maybe you can expand this part: "It sometimes happens that there are enough radial observations to compute the total observation for most of the periods but with none of those radial observations satisfying the temporal threshold by itself."

Equation 3: The notation is a bit odd as you have a vector on the left hand side and a scalar on the right hand side.

Line 202: Notice that the nudging is not applied to the velocity fields: quite surprising. Did you also test nudging the velocity field?

Equation 5: ss: should it be upper-case SS?

Table 2, Table 4: can you also include the RMS (without normalization)? Can you also include in this table a validation metric which is sensitive to the direction of the current, not only the speed of the current? (e.g. the RMS error of u and v components individually?)

Line 305: diffusion term: how large is the diffusion coefficient? And how was it determined?

Line 432: "The observation error is considered equal for total and radial currents in this study. ..." This is quite surprising as one would expect the radials a bit noisier and the total currents error variance should depend on the location (among others due to GDOP). Can the paragraph be expanded? Can you also include the value of the observational error covariance?