Review of the paper “Contribution of a constellation of two Wide-Swath Altimetry Missions to Global Ocean Analysis and Forecasting” (os-2021-108)

General remarks

The article is generally well written and easy to read. However, in view of the idealized nature of the experimental framework, the authors should be more nuanced in their discussion and conclusions regarding the expected impact of WiSA in operational data assimilation. A major simplification in the experiments is in the representation of WiSA observation errors, which is unrealistically simple compared to expected error sources in wide-swath altimetry, as modeled by the SWOT simulator. Only uncorrelated KaRIn noise is accounted for, with no justification as to why the other significant error sources (roll errors, phase errors...) are neglected. In particular, the roll and phase errors have a highly spatially correlated component, which needs to be adequately accounted for in the data assimilation system in order to be able to assimilate this high-resolution data-set effectively. The authors should at least recognize this important issue in the discussion, especially as this requires non-trivial developments to existing data assimilation systems.

Specific remarks:

1. Section1,line7.“*and has convinced more than thirty thousand expert services and users worldwide.*” Do the authors mean “*attracted*” instead of “*convinced*”?

   Rephrased as “and is now used by more than thirty thousand expert services and users worldwide”

2. Section 1, line 26. “*The main limitation of SWOT is, however, related to its long-time repeat period*.” What about the limitations of existing data assimilation systems to properly assimilate high-resolution SWO observations?

   There are indeed limitations in the data assimilation systems but the main limitation is related to the time sampling. Note that in our SWOT OSSE studies, we made several improvements in the data assimilation system (see Benkiran et al, 2021). Other improvements could be done. In particular, we kept a time window (analysis cycle length) of 7 days to stay as close as possible to our operational system (that assimilates many types of data) while a 10-day cycle (the SWOT sub-cycle) would have been preferrable.

3. Section 3.1, line 18. “*The second model is used to assimilate synthetic observations from the NR in a so-called Free Run (FR)*.” A free run usually refers to a simulation that does not assimilate data, yet here we are told that it does assimilate data. If so, then which data are assimilated. Please clarify.

   The second model called Free-Run (Control Run) is a model without data assimilation. This experiment is called OSSE0 in the following. However, it is with this system that we will do our experiments, we will assimilate the pseudo-data and the experiments will be named OSSE1 and OSSE3 in the following.

4. Section 3.2, p4, lines 33 until end of paragraph. “*The simulator models the most significant errors that are expected to affect the data... In this study, we only use the estimated WiSA KaRIn noise*...”. Related to my main general

remark above about the observation error specification, please provide more justification of this choice and discuss the implications.

The study was indeed a first step. We have added this paragraph in the conclusion that answers the reviewer's concern:

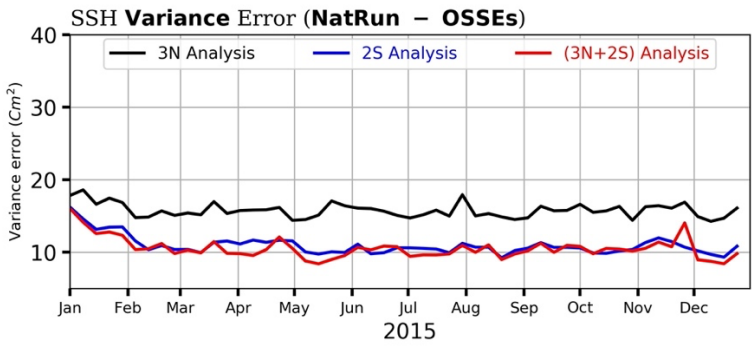
Follow up studies should consider the full error spectrum taking into account, in particular, correlated long wavelength errors inherent to altimeter wide swath techniques (e.g. roll errors). This will require first to better specify these errors given the instrument and platform designs and to assess the impact of techniques that will be used to reduce them. As demonstrated by a series of studies carried out for the preparation of the SWOT mission (Dibarboure et al., 2014), techniques such as swath / swath and swath / nadir cross over minimization will allow reducing a large part of these errors. We thus plan to carry out more advanced OSSEs that take into account the full error spectrum of wide swath altimeters, the reduction of these errors through cross calibration techniques and the assimilation of corrected data and their residual (correlated) errors in advanced data assimilation schemes.

5. Section 3.2. The noise level of WiSA is expected to be larger than that of SWOT (p3, last paragraph). Have the authors adjusted the SWOT simulator parameters to prescribe larger errors indicative of those of WiSA?

Yes the error level of Wisa is higher than SWOT. The simulator includes an error file that depends on the type of data we want to simulate. Here, for the Wisa study, we used specific errors from which the simulation calculates the Karin noise and the errors of the data with the requested data resolution.

6. Section3.4."*OSSE2(not presented here)is similar to OSSE1....*".If the results of OSSE2 are not presented then the authors can remove the reference to this experiment.

Yes, as the main objective is to assimilate both Nadirs and swath data, we have shown that this combination. Ok, we will remove this from the text. For information, we present in the following figure the evolution of the error variance of these three experiments with OSSE2 in blue.



7. Section4.1,line11."*The temporal evolution of the SSH variance error over the global ocean...*". It is unclear what is meant by "*variance error*". Is this the mean squared error (MSE); i.e., the global average of the squared differences between OSSE and nature run fields (with the mean removed)? A simple formula could help here. This is important as several diagnostics in the paper are based on this quantity. If it is the MSE then why present the squared errors instead of the root mean squared errors (RMSE) (or standard deviation), which is more common and easier to interpret since it has the same physical units as the field itself. It will affect the percentage error reductions reported in the paper;

e.g., the reported reduction of 54% becomes 24% when considering the reduction of RMSE (or standard deviation).

Here we use the error variance (difference between NatRun and OSSEs) as follows:

$$\text{VAR Error}\left(\text{OSSE}_\text{j}\right) = \frac{1}{T}\sum_{t=0}^{T}\left(\Delta SSH(t) - \overline{\Delta SSH(t)}\right)^2$$

$$\Delta SSH = \text{SSH}(OSSE_j) - \text{SSH (NR)}$$

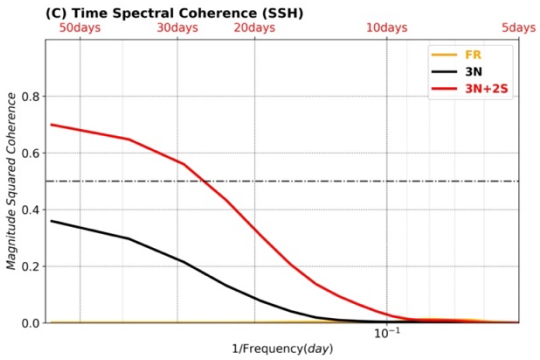
is the temporal variance of SSH error obtained by comparing the NR (NatRun) with a given OSSE at a given location x and y over a period of t 363 days with j 1; 2 referring to the j-th OSSE and nt referring to the maximum time.

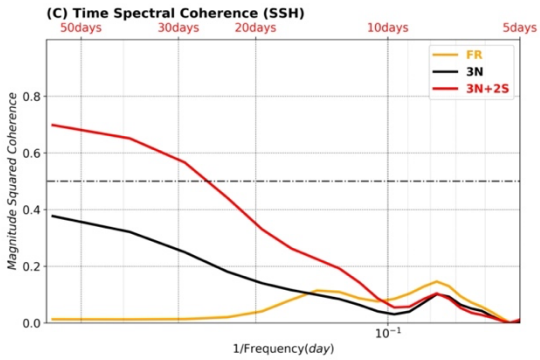
8. Section4.2,lines 37-38."...*errors are characterized for specific time and space scales.*" Please give some detail on how the time and space scales have been separated. Presumably the authors are using a filter of some sort.

for filtering (temporal and spatial) we used python functions (scipy.signal.bessel), we set the cut-off parameters based on spectral slopes.

9. Section 4.2, p8, lines 17-18. "...*was based on filtered SSH fields*...". Please provide some detail on how the fields are filtered.

In a first step we calculated the temporal coherences with the total SSH signal, we obtained (following figure on the right) noisy coherences at small temporal scales (around 10 days). In a second step we did the same operation with the different spatial scale games and we found that this noise comes from the large scale high frequency structures. as it is not our objective here, we decided to filter this large scale high frequency spatial scale to get the following figure on the left.





10. Section 5. "*Results confirm the high potential of such a configuration. Flying a constellation of two wide-swath altimeters will provide a major improvement*...". This is an idealized study so alternative wording should be used to be less definitive; e.g., "*Results suggest the high potential...*" and "*should provide a major improvement*". Proper assimilation of these observations will require

effective data assimilation systems, beyond the current state of the art. More sophisticated treatment of observation errors (correlations and biases), improved background error covariances, and adequate treatment of model bias in data assimilation are important requirements in this respect. Uncertainty in the mean dynamic topography also remains a major issue for the assimilation of all forms of altimeter data (nadir as well as wide-swath).

We agree and modified the text as proposed (suggest the high potential and should provide). See also answer to comment 4

11. Section 5, p9, line 25. "*Surface current forecast errors should be equivalent to today's surface current analysis errors*...". I don't understand this statement. Forecast errors with what lead time?

    7-day . This is precised now. Sentence was also rewritten

12. Many of the figure labels are difficult to read. Please use a larger font.

    All figures were improved with a larger (clearer) label

<u>Minor corrections:</u>

1. P1,line17."point out"(?)insteadof"recall" done
2. P1,line33.Remove"system". Done (P2, line 33)
3. P3, line 36. "What is the relationship between "a feature diameter" and "wavelength" the wavelength is twice the diameter
4. P5,line9."*insitu*". done
5. P5,line14."afreesimulation". done
6. P5,line17."modelcorrections". done
7. P5,line17."velocityfield". done
8. P5,line26."profile". done
9. P6,line6."inFigure3". done
10. P6, line 25. "SST" (use previously defined acronym). done
11. P6, line 31. "nadir" (not "Nadir" to be consistent with rest of article). 12.P6, line 33. "in the global". done
13. P7, line 21. "Bonaduce et al. (2018)". done
14. P8, line 6. "where" and "and" should not be in italics. done
15. P8, line 6. "signals j where j refers to the experiment". done

1.