Review of "Data assimilation of SMOS observations into the Mercator Ocean operational system: focus on the Nino 2015 event" by B. Benoit et al. (os-2018-113).

This manuscript describes the scheme of assimilating satellite SSS data in the operational ocean data assimilation system in Mercator Ocean, in particular, the scheme of correcting the bias of the model and satellite SSS. Then, they performed Observing System experiments (OSE), and demonstrate that the misfit between the model and in situ salinity data. They also reported that the equatorial surface zonal currents are affected by the SSS assimilation. The description on the scheme of SSS data assimilation is very comprehensive and valuable for the readers who are developing ocean data assimilation systems or exploit ocean data assimilation results. The OSE results indicate clear benefit of assimilating the satellite SSS data. However, the manuscript has severe problems on its presentation. So, I would like to recommend to perform a substantial revision according to the following comments. Then I expect that I still need to make several comments after the revision. I would like to withhold the judgement whether this manuscript is acceptable or not until it revised well.

General comments

1. The largest problem of this manuscript is English. Although I am not a native speaker, I do not think there are many grammatical mistakes or sentences which are not understandable. I suggest some modifications in the specific comments although I gave up to check the entire manuscript. I recommend authors to ask an English check preferably by native speakers.
2. I found this manuscript is not according to the general rule of writing academic paper in many places. For example, citations are often not according to the general rule. Abbreviations are not defined. They should check the general rule for writing and carefully modify the manuscript.
3. The section titles are often appropriate, and figure captions are often not understandable, and they do not include required information on the figure. They should carefully reconsider those things.
4. The abstract is not appropriate. It describes main result of the OSE results only very briefly and it does not address on the bias correction scheme of SSS. They should revise the abstract.
5. The introduction section also has bad structure. Things which are not directly

related to this paper is written in a substantial length, which should be shortened. The order of descriptions are not reasonable. I made some comments on the structure of the section in the specific comments. I recommend authors to revise the section according to those comments.

Specific Comments

1. P1, L9: I suggest to replace “most often closer to 5 meters deep than the surface” by “mostly closer to 5 meters depth than the surface”

2. P1, l12-14: I think the point addressed in this paragraph is not main pint of this paper and should be omitted. I think the explanation on SMOS-Nino 2015 project can also be omitted. Instead, authors can add the description on the bias correction scheme, and more detailed impacts of SSS data assimilation presented in this paper.

3. Original words for abbreviations should be specified in the main text even if they were specified in the abstract. Therefore, authors should specify the original words of SSS, SMOS, SMAP, etc.

4. P1, L25: What SMOS, Aquarius, and SMAP indicate should be described.

5. P1, L27: Authors should cite some references on the Mercator Ocean system.

6. P1, L27: I suggest to put “evaluated in the SMOS Nino 2015 project ((https://www.godae-25 oceanview.org/projects/smos-Niño15)” after “the Mercator Ocean Operational System”, and remove the html address from P2, L25.

7. P1, L28: I suggest to replace “by the satellite SSS data assimilation, considering all of other ocean observing components” by “by assimilating the satellite SSS in addition to the observation data assimilated regularly in the operation”.

8. P1, L29: I suggest to replace “The focus has been primarily on the 2015- 2016 El Niño event in the Tropical Pacific associated with strong SSS anomalies, seen in in both model and observations” by “The focus has been primarily on the 2015- 2016 El Niño event, in which strong SSS anomalies, are seen in the tropical Pacific in both model simulations and observations.”

9. P2, L3: Authors missed to put tilde on the “n” of “El-Nino”. (There are many mistakes the same as this.)

10. P2, L4: The term of NINO3 or NINO3.4 or NINO4 is generally used for the index indicating strength of ENSO based on SST anomaly instead of “ENSO index”. In addition, definition of indices must be described or references must be cited.

11. P2, L5: Some citations are required for the Multivariate ENSO Index.

12. P2, L6: I do not know what authors means by “its onset in 2014 is visible.” I do not understand what state the “visible” indicates.

13. P2, L6: I suggest to replace “It was more a Modoki El Nino (Ashok and Yamagata, 2009) than a « classical » one.” to “It was more likely to be a Modoki El Niño (Ashok and Yamagata, 2009) or a central Pacific El Niño (Kao and Yu, 2009) than a classical eastern pacific El Niño.”

14. P2, L9: Please add “ in the year” after “but did not lead to development of an El Nino”

15. P2, L10: “As shown in (Corbett et al., 2017)” must be “As shown in Corbett et al.,(2017)”. Authors do not make citations not in the general way or the general format in many places. They should check the rule of citations in this journal.

16. P2, L8-L24: The details of the process of development of the El Nino and of the difference between westerly wind bursts in 2014 and 2015 are not so related to the following contexts of this manuscript. Thus this paragraph should be shorten substantially.

17. P2, L23: “Note that recently, significant freshening was also observed around 20°N, (Hasson et al., 2018).” is not related to the later context of this manuscript and thus it should be removed.

18. P2 L28: I suggest to replace “(OSE)” by “(OSEs)”.

19. P2, L29: I suggest to replace “The OSE approach consists of comparing two identical assimilation experiments except that one data set, here the satellite SSS, is withheld from

the analysis in one of the experiments." to The OSE approach is conducted by comparing two assimilation experiments which are identical except that the satellite SSS data are withheld in the analysis in one of the experiments.".

20. P2, L32: I suggest to replace "This is a commonly agreed approach to evaluate observation networks within the GODAE OceanView community" to "Similar OSE approaches are generally used to evaluate observation networks in the ocean data assimilation community of GODAE OceanView"

21. P3, L1: I suggest to replace "because of the various and complex biases that affect them, see (Köhl et al, 2014)." by "because of the various complex biases (see, Köhl et al, 2014)"

22. P3, L3: It is not clear what "data and methods" indicates. Does it mean "the observation instruments and data processing methods"?

23. P3, L9: BoB should not be defined if the abbreviation is not used later.

24. P3, L9: I think "still" should be removed.

25. P3, L12: It is better to put citations for "Careful analysis of the SSS data sets shows that a bias correction is needed before their assimilation."

26. P3, L16-28: Discussions in these paragraphs should be moved to the last paragraph of P2.

27. P3, L25: I suggest to replace "OSE experiments" by "OSEs".
28. P3, L25: I do not know which part of Lahoz et al. (2010) states on this point. It is better to cite the related chapter. And I need to know which pages indicates this point for reviewing. In addition, I know that the necessity of comparing with observations that are not assimilated for a fair assessment is pointed out in Fujii et al. (2015) Journal of Operational Oceanography.

29. P4, L2: I suggest to replace "OSE" by "OSEs".

30. P4, L4: I suggest to replace "we will describe in more detail the data assimilation components that were specifically developed or adapted for the SSS data assimilation." by

“we will describe the data assimilation components that were specifically developed or adapted for the SSS data assimilation in detail.”

31. P4, L13, “a satellite-based large-scale correction of precipitation has been performed with climatological estimates from GPCPV2.1 rain-fall”: This sentence is not clear. Does this mean that a bias correction based on satellite-based climatological estimates from GPCPV2.1 rain-fall is applied to the precipitation fields of the ECMWF system?

32. P4, L16: I think “coastal runoff and 100 major rivers” should be “coastal runoff from 100 major rivers”.

33. P4, L18: Citations are required for the Community Land Model Version 3 (CLM3).

34. P4, L18: I suggest to replace “At high latitude” by “At high latitudes”

35. P4, L24: I suggest to replace “Current Network” to “Regular observation data” or “Regularly assimilated observation data”.

36. P4, L27: “L4” should be explained as well as “L2” and “L3”.

37. P5, L28: I do not know what “progressively” means.

38. Caption of Table 1: I suggest to replace “current operational network” to “current operational system”.

39. I recommend to merge Figures 2 and 3.
40. P6, L3: The method how to specify the representativity errors is not described.

41. P6, L9: “minimum” should be “minimizer”.

42. P6, L9: Equation 1 should be put right after “the cost function given by”. And explanation of Equation 1 should be re-structured in a more comprehensive way.

43. P6, L10: I suggest to replace by “(it is the mean innovation over 1 month on a 1°x1° grid 10 between 0 and 10 meters depth and the mean is symbolized by <>)” by “(it is the mean innovation over 1 month in a 1°x1° box between 0 and 10 meters depth)”. The symbol

of mean should be explained later.

44. Equation (1b): I think this equation is not correct. I think "H$\boldsymbol{\xi}$" in the second term may be replaced by "Hx".

45. P6, L24: "The Fig.4" should be "Figure 5".

46. I recommend to merge Figures 4 and 5.

47. P6, L25: I think it is natural that the SSS bias and the model bias is not similar. I think it would be rather strange if these two bias fields were similar.

48. P6, L26: "SMOSexp" is not defined yet.

49. P7, L7-9: I do not understand the explanation of the iterative boot-strap method.

50. P7, L10: I am not sure whether the increase over the regions with sparse in-situ data is originally included in $\boldsymbol{R}_{\xi^o}$.

51. Fig. 7 is not referred in the text.

52. P7, L20: I suggest to replace "OSEs experiment design" to "OSE design" Since OSE includes "experiment". The same mistake is found at P8, L1.

53. P8, L5: "TOA/TRITN" should be "TAO/TRITON".

54. P8, L8: I suggest to replace "Evaluation of the analysis toward assimilated observations" by "Evaluation of the reduction of the misfit from the assimilated data in the analysis".

55. P8, L10: I suggest to replace "by the SSS data set assimilated" by "by assimilating satellite SSS data".

56. P8, L11: "between" should be replaced by "from".

57. Figure 8: I suggest to modify the figure caption as follows: "RMSE of SSS with respect

to SMOS data (solid lines) and RMSE of salinity at 5 meters depth with respect to in situ salinity data (dashed lines), in the 1-6-day forecast fields in REF (black lines) and SMOSexp (red lines), in the global domain (top), the Tropical Pacific (middle), and in the NINO3.4 region (bottom). RMSEs are evaluated for each weak and the averaged counts of the observations used for the calculation of RMSEs are denoted in the legend." In addition, definitions of "Tropical Pacific" and "NINO3.4 region" must be addressed.

58. Figure 9: I suggest to modify the figure caption as follows: "Mean difference (top) and root-mean-square-difference (bottom) of daily mean SSS with respect to the SMOS data (model minus SMOS) in the analysis fields in REF (left) and SMOSexp (right) on 2015 year."

59. P8, L26: I suggest to replace "Fig. 9 shows the mean and standard deviation of the daily ?? or monthly differences between the (analyzed) SSS for REF and SMOSexp simulations compared to the SMOS SSS observations (non-debiased)" by "Fig. 9 shows the mean and root-mean-square differences of daily mean SSS in the analysis fields in REF and SMOSexp compared to the non-debiased SMOS data."

60. P8, L29: I suggest to shorten this paragraph as follows: "The mean SSS bias in REF exhibits large scale patterns, coinciding with the 2015 SSS anomaly for the open ocean (Fig. 1). Large bias is also found in the Indonesian Archipelago. In contrast, the bias is effectively reduced in SMOSexp as well as the root-mean-square differences."

61. P10, L5: It would be better if what induces the SST rise and why the migration of the warm water pool is accelerated are discussed. The impact on the barrier layer can be presented with the figure on the zonal currents.

62. Figure 15: It is difficult confirm the faster propagation of TIWs by comparing the 2 panels at the right. And the left panel are not discussed and should be omitted.

63. Figure 16: Positions of the TAO/TRITON buoys should be clarified.

64. P11, L12: "West (East) Tropical Pacific" should be "western (eastern) tropical Pacific".

65. P11, L18: I suggest to modify "SSS-OS) (http://www.legos.obs-mip.fr/observations/sss)" to "(SSS-OS; http://www.legos.obs-mip.fr/observations/sss)".

66. Figure 18: The Matisse ship route should be indicated in this figure. And I recommend to merge Figs. 18 and 19.