Anonymous Referee #1

The arcticle of “On the time and length scales of the Arctic sea ice thickness anomalies: a study based on fourteen reanalyses” aims at the Arctic sea ice thickness (SIT) which contains considerable uncertainty in the popular 14 reanalyses. They evaluate the reproduced SITs from the reanalyses, and then investigate the e-folding time and length scales of the SIT anomalies. Clearly, these topic and the consequent findings are helpful to deep understanding the SIT and the concerned variability.

We thank the referee for his time and for the detailed revision of our manuscript. We appreciated very much her/his comments, which were all taken into account in the revised version of the manuscript. Below, we answer point-by-point all specific and technical comments.

It is worthwhile mentioning that in order to better incorporate the referees’ suggestions, the manuscript’s structure has changed. New figures were added, while others were replaced. Thus, all tables, figures, pages and lines referred to in this rebuttal letter are directed to the updated version of the manuscript, unless otherwise stated.

1) Undoubtedly, one conclusion is “reanalyses built with sea ice data assimilation present shorter time and length scales”. However, all the reanalyses were only assimilation of sea ice concentration, and the inferred conclusion is not based on the direct comparison of with and without assimilation in a same system frame. The more proofs based on the sea ice concentration will be helpful to increase the rationality on physics. So the counterpart analysis on sea ice concentration shown in Fig. 2 and Fig. 3 will be robust.

We fully understand the referee’s comment, since we had the same concern during our analyses: **What are the time and length scales of the Arctic Sea Ice Concentration (SIC)?** Nevertheless, after some tests, we realized that it wouldn’t be possible to apply such concepts for this sea ice parameter due to the characteristics of the sea SIC time series. The SIC is not a continuously varying property. For instance, at the region covered by the perennial ice, the SIC is expected to be (nearly) 100% for the all year round. In this case, for instance, the time scale would be “infinity”.

For the BGEP mooring’s location, notice that the SIC can be nearly constant for several months and it suddenly drops during the summer months (Fig. A, top panel). When calculating anomalies (Fig. A, bottom panel), the values remain near to zero for the months marked by nearly constant SIC. We believe the concepts of time and length scales, as they were explored in the paper, are not applicable for the SIC time series.

2) Section 3.2 illustrates the intercomprison of the reanalyses. The current main features shown by Fig. 5 is not meaningful enough: some reanalyses are very close… In this section, more other information about SIT and its anomaly need to be added.

In the second version of the manuscript, we are bringing new elements for discussion. For instance, we have now compared the reanalyses based on several other parameters and specifications (Figs. 12 and 13). In addition, an extended discussion is presented in Sec. 4.

Firstly, the ensemble mean SITs based on with and without assimilation will be useful (P 15 Line 10: “This suggests that higher length scales are associated with thicker ice”). Furthermore, it will be complementary of the previous knowns in Uotila et al. (2018) and Johnson et al. (2012).

Johnson, M., Proshutinsky A., Aksenov Y., Nguyen A. T., Lindsay R., Haas C., Zhang J., Diansky N., Kwok R., et al.: Evaluation of Arctic sea ice thickness simulated by Arctic Ocean Model

Intercomparison Project models. J. Geophys. Res., 117(C8), C00D31, doi:10.1029/2011JC007257, 2012.

Secondly, the standard deviations of the two ensembled SIT anomalies were not shown before and would be interested to the reader to know the variabilities or the distinguishes about the SIT anomaly in the reanalyses and even considering with and without assimilation.

Fig. B (top row) shows the ensemble mean from all reanalyses (top left), as well as the ensemble mean from all systems with (top center) and without (top left) data assimilation. Overall, there is a good correspondence between the patterns of mean SIT in the three panels, but with slightly thicker ice for the systems with data assimilation, which is mainly distinguished off the northern Greenland coast and around the Canadian islands. Fig. B (bottom row) displays the averaged standard deviation from the three groups of reanalyses (Ensemble, DA and NA). As for the mean fields, there is not a big difference between the three panels. Since these fields don't add much in order to distinguish systems with and without sea ice data assimilation, we preferred to leave this figure here in the discussion.

Nevertheless, we are taking referee's suggestion further in order to better understand the link between Mean State and TS/LS in the new Fig. 13, and its respective discussion in Sec. 4. For this ensemble of reanalyses, where each system considers several different parameters compared to the other systems, it is not clear what is the impact of the variability on the scales, as shown in Fig. D from the rebuttal letter for the second referee.

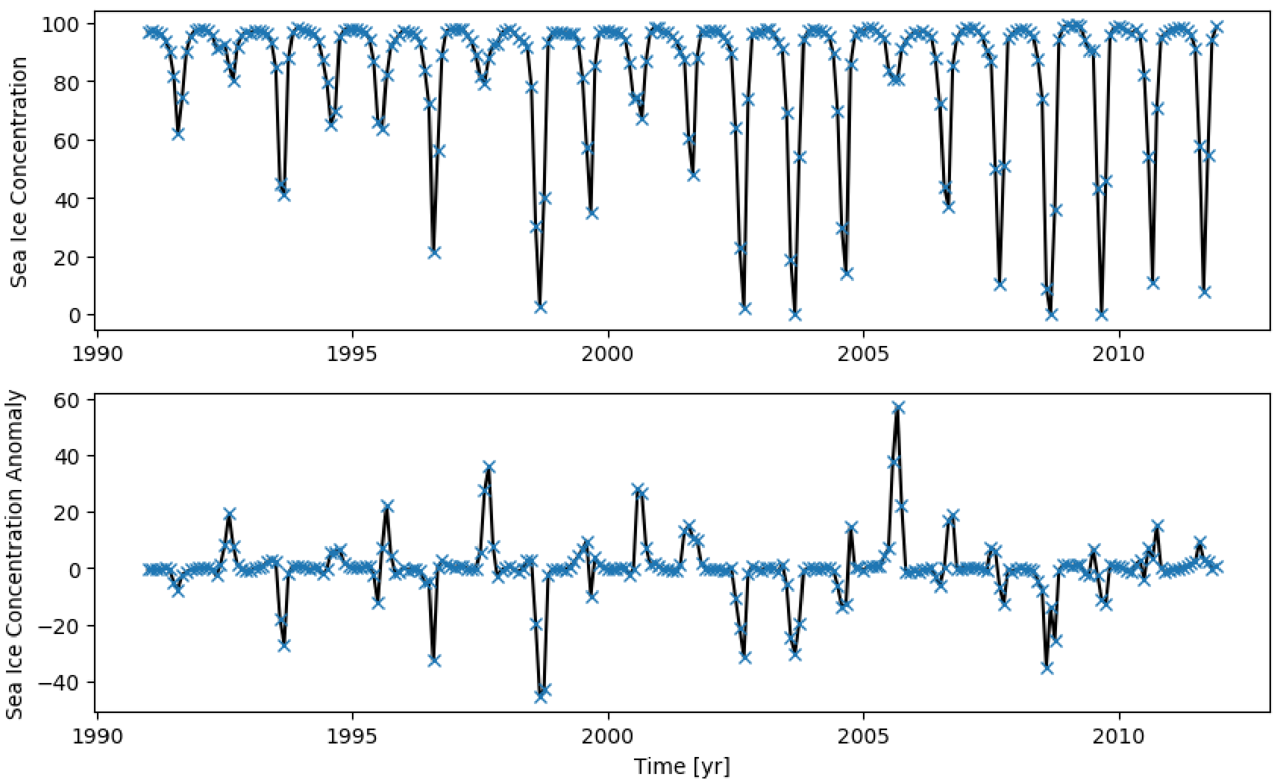

Fig A. (top) Sea Ice Concentration [%] from C-GLORS05 reanalysis at the location of the BGEP oceanographic mooring. (bottom) Same as top panel, but for the Sea Ice Concentration anomaly [%].

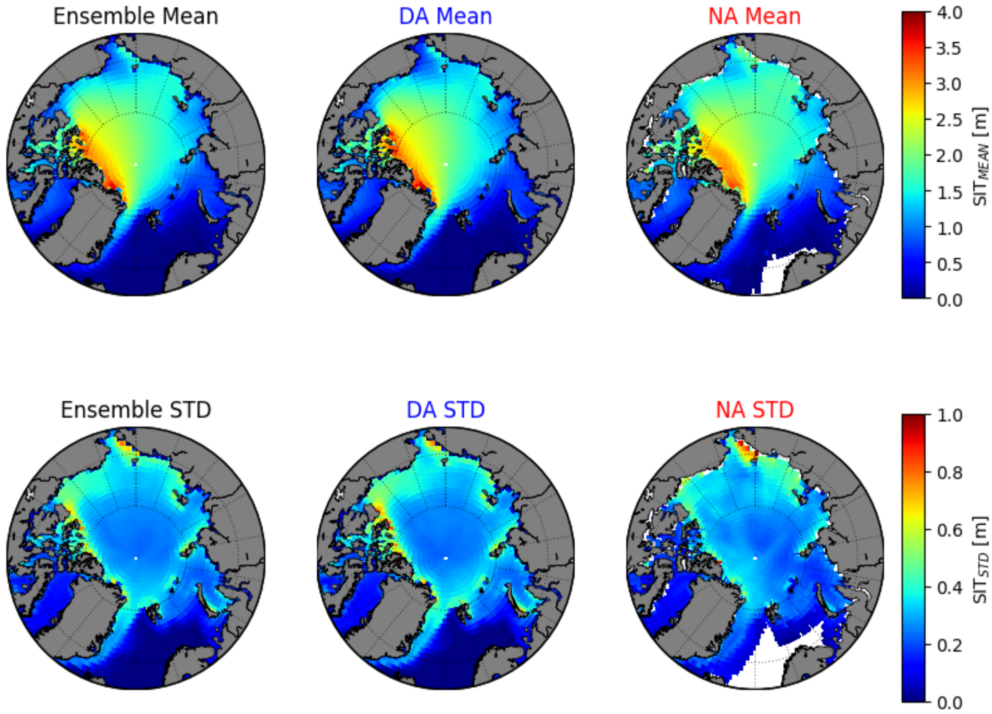

Fig B. (top) Sea ice thickness mean estimated for the (a) entire ensemble, (b) reanalyses with sea ice data assimilation and (c) reanalyses without sea ice data assimilation. (bottom) Same as (top), but for the standard deviation.

3) Figure 2 clearly shows the time scale has been extended from less than 3 months to around 4 months, which is convert with the main finding (P1, Line 9: … data assimilation present shorter time and length scales).

We absolutely agree with referee's comment. In Fig. 2 the reanalyses which do not assimilate data seem to have shorter TS, in contrast with our main finding. Nevertheless, the results that support our main finding is based on the Averaged Weighted Mean (AWM) values, as a representation of all grid cells, while Fig. 2 represents a single grid point.

Fig. 2 should be interpreted with caution. Its main goal is to show that the time scales found for the observations are somehow within the range found for the reanalyses. That's why, Fig. 2 is displayed in Sec. 2.3 ('Methods').

However, we indeed agree that this is an important point and deserves a better clarification in the text (Fig. 11; pg. 20, lines 3-4)

4) The previously compared studies show atmospheric forcing fields essentially drive the results of sea ice simulations (Gerdes and Köberle, 2007; Hunke and Holland, 2007). Can you add some comment or analysis about the impact of the forcing resolutions on the SIT time and length scales?

Gerdes, R., and C. Köberle: Comparison of Arctic sea ice thickness variability in IPCC Climate of the 20th century experiments and in ocean–sea ice hindcasts, J. Geophys. Res., 112, C04S13, doi:10.1029/2006JC003616, 2007.

Hunke, E., and M. Holland: Global atmospheric forcing data for Arctic ice-ocean mod-

eling, J. Geophys. Res., 112, C04S14, doi:10.1029/2006JC003640, 2007.

Even though the atmospheric forcing fields are reported to play a major role in the sea ice simulations, as pointed out by the referee, we could not identify distinguished patterns between the two main sources of atmospheric forcing used by the ensemble of reanalyses: Era-Interim and NCEP/NCAR (Figs. 12c-d). (pg. 20, lines 15-18)

5) The ice draft measurements from submarine have been identified an overall overestimation of +0.29 m (Rothrock and Wensnahan (2007). This dataset also is used in this study. Can you add some comments about these kinds of bias corrections (also to other related observational data) applied here or not.

The Sea Ice CDR already provides the corrected data. For the US submarine case, notice that the files were produced and made available by Dr. Mark Wensnahan http://psc.apl.uw.edu/sea_ice_cdr/Sources/US%20Submarines.html, one of the researchers who identified and reported (Rothrock and Wensnahan, 2007) the biases (pg. 5, line 7).

Technical issues:

1) As a basic index calculated by the SIT, it still is not clear how to deal with the conflicts of seawater and ice cover at each grid. For example in Fig. 2, when the observed sea ice is lager 0.1m, but the reanalyses are not all covered by sea ice. It is also not clear at P 15 Line 13 when to calculate the correlation between the two points: how to ensure the same lengths of the SIT time series.

In this work the reanalyses provide the mean sea-ice thickness of each grid cell including open water for the reanalyses (i.e. sivol variable in CMIP6). As adopted by Blanchard-Wrigglesworth and Bitz (2014), only grid points wherein the mean ice thickness at the time of summer minimum is greater than 0.1 m are taken into account.

The draft observations used in Fig. 2 represent the location where the oceanographic mooring (BGEP) was deployed (Krishfield et al., 2013), while the reanalyses' data in the same figure come from the nearest grid point to the BGEP oceanographic mooring.

On pg. 15, line 13, we are discussing about the stability of the length scale over time. In order to perform these analyses, we have used only the two long-term reanalyses (GECCO2 and MOVE-CORE), taking into account an overlapping period of 64 years, from 1948 to 2011 so that both time series have the same length.

2) P3, Line 20: "The original horizontal grids range from 0.25 to 1". It is not correct because the reanalysis of TP4 is regional product with the resolution of 12-16km (also see Xie et al. (2017)).

Xie, J., Bertino, L., Counillon, F., Lisæter, K., and Sakov, P.: Quality assessment of the TOPAZ4 reanalysis in the Arctic over the period 1991-2013, Ocean Sci., 13(1), 123-144, doi:10.5194/os-13-123-2017, 2017.

This information has been corrected in the text. It is worthwhile mentioning that the grid resolution of TOPAZ4 and of all the other reanalyses are now displayed in Table 1.

3) P3, Line 27:" … in details by Chevallier et al. (2017) (their Table 1) and Balmaseda et al. (2015)". It is not correct because they did not include the TP4 product as least so recommend of the reference: Xie et al. (2017) or Uotila et al. (2018).

Corrected.

4) P4, Line 27:" the linear relationship between both parameters given by the hydrostatic equation". It is better if clear to state the used equation or give a reference used.

This statement was tempered in the text. The main point here is the fact that we decided not to use the snow cover from the reanalyses for converting sea ice thickness to sea ice draft. This decision was taken in order to avoid adding uncertainties to the SIT fields. So, when comparing SIT from reanalyses against draft from observations, we estimate the linear relationship between both datasets by means of the coefficient of correlation (R) and the Mean Residual Sum of Squares (MRSS). (pg. 5, lines 25-32)

5) Figure 1 adds the grid lines or labels the year on each panel. It is more convenient to march the statement. So P 11, Line 13 "for instance from 2001 to 2004" looks not suitable, and can be replaced by "for instance from 2002 to 2004".

We have added yearly grid lines to Fig. 1. In the new version of the manuscript we are still referring to the period "2001 to 2004", but indeed the grid lines made the comparison between the panels much easier.

6) P 15 Line 10: "This suggests that higher length scales are associated with thicker ice" looks not so precis. It more likes around the North pole.

The relationship between the mean state and the LS is explored further in the new manuscripts' version (Fig. 13a,b; pgs. 21, lines 1-3). But indeed, the previous statement was more related to the region surrounding the North pole and this is what we tried to say with "… near central Arctic." (pg. 15, line 9 – in the first manuscript).

7) P 18 Line3:" .. scales of the sea ice thickness" replaced by "… scales of the sea ice thickness anomaly."

"anomaly" added to the text.

8) Figure 11 adds a panel to show the difference so that details would be more clear.

Fig. 11 shows the difference G2V3-G2V1, both for time (Fig. 11a) and length (Fig. 11b) scales.