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Interactive comment on "Seasonal transition dates can reveal biases in Arctic sea ice simulations" *by* Abigail Smith et al.

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We thank the referee very much for their help and constructive comments. Responses to the specific comments are below.

Specific Comments

1. P1 line 13 "the spread between climate model projections of sea ice has been on the order of millions of square kilometers in Coupled Model Intercomparison Project (CMIP)" . Can you specify about which parameter you are talking? Sea ice coverage ?

Yes, this should read "the spread between climate model projections of sea ice AREA has been on the order of millions of square kilometers in Coupled Model Intercomparison Project (CMIP)" and we will correct this in the manuscript.

2. P4 line 92 "(select figures using all available members are provided in the Supplement)." Can you specify which figures ?

Yes, here we are referring to the plots in Figure 9, which are reproduced using all available members in Figure S2. We will clarify this in the text.

3. P9 to P17 : I think it would be beneficial to add maps of the four intra-seasonal periods (melt , freeze , seasonal loss-of-ice and seasonal gain-of-ice periods) and a table of spatial median (and standard deviation) for each model and observation as for table 4. Moreover, you look at the difference between the spatial of the metrics to describe the median of the intra-seasonal periods. But as median(A) - median(B) /= med(A-B), calculating the intra-seasonal period for each pixel before doing the spatial median seems more appropriate.

Thank you for this suggestion. The maps and median tables were initially excluded from the manuscript due to concerns related to the length of the manuscript and the number of figures. Additionally, plots and tables related to the intra-seasonal periods can be difficult to interpret since they show negative values when the dates fall out of order. We will recreate these plots and tables to reassess their utility. We will also calculate the spatial standard deviations and evaluate whether they add to the content of the manuscript.

With respect to the median differences, we are calculating the intra-seasonal period for each pixel before doing the spatial median, so any in-text discussion of the intra-seasonal periods refers to values calculated in this way. We will add text to the manuscript to clarify this process.

4. P11 lines 205-207 "the model spread (May 15- June 3) " : Is it really June 3 or is it June 13 here?

Excluding the CNRM models, the latest satellite-era median melt onset date occurs in the CanESM5 on June 3. We will move the text "(May 15 - Jun 3)" to the end of the

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sentence to make this specification clearer.

5. P14 line 228 : What do you mean by "internal variability of the satellite data" ?

Here we are describing how many of the models fall within 10 days of the satellite data in terms of their satellite-era median freeze onset dates. The value of 10 days is found in Table 3, which shows the spread (latest minus earliest) in medians between the first thirty ensemble members from individual models. Of these models, the largest estimation of internal variability in freeze onset dates is 10 days. We will clarify this assessment in the text.

6. p20 line 302 " (Supplementary Table S3)" : I guess you mean Table S4.

Yes, thank you. We will change the text to read "(Supplementary Table S4)".

7. p22 line 320 "This lack of relationship is a strong indication that the spatial coverage of break-up dates is not sufficient for describing pan-Arctic sea ice feedbacks. " : I wonder if the lack of relationship between March mean ice thickness and break up date can be explained by the inverse relation between ice growth and thickness which explains that the thinner the ice, the more efficient the growth. This relation should temper the delay in break up (see Bitz & Roe, 2004 and Lebrun et al. 2019).

Bitz, C. M., Holland, M. M., Hunke, E. C. and Moritz, R. E.: Maintenance of the Sea-IceEdge, J. Climate, 18(15), 2903?2921, doi:10.1175/JCLI3428.1, 2005.

Lebrun, M., Vancoppenolle, M., Madec, G. and Massonnet, F.: Arctic sea-ice-free season projected to extend into autumn, The Cryosphere, 13(1), 79-96, doi:https://doi.org/10.5194/tc-13-79-2019, 2019.

Thank you for this suggestion. We will evaluate the relationship between March mean ice thickness and break-up in the context of the suggested papers, and we will add related text to this section of the manuscript.

8. p22 line 247 " indicating that the impact of seasonal transition biases can be be

large" you should remove a "be"

We will correct this typo.

9. Figure 2 : This figure seems not describe in detail in the main text. You should move it in supplementary.

We agree and will move Figure 2 to the Supplement.

10. Figures 3 and 6: Can you remind the definition criteria for melt and freeze onset dates in both caption as you did for fig 4,5,7 and 8 ?

Yes, thank you for this suggestion. We will add a short phrase to the captions of Figures 3 and 6 describing how the melt and freeze onset dates are derived.

11. Table 3 : What do you mean by "spread" ?

Here the word "spread" is referring to the difference between the earliest and the latest dates found using the first thirty members of each model. We will define "spread" in the text for clarity.

12. Table 3 - Table 4 : Can you also add a spatial standard deviation for each model and observation?

We will calculate the spatial standard deviations and evaluate whether they add to the content of the manuscript.

13. Table 6 or Table S4 : Caption for both tables are exactly the same. I guess it is a mistake you should fix.

Table 6 shows correlation coefficients between seasonal sea ice transition dates and March sea ice thickness from 1979-2014 while Table S4 shows correlation coefficients between seasonal sea ice transition dates and March sea ice area over the same time period. To clarify what is different for figures and tables with very similar captions, we will add "As in Table 6, Table S4 shows. . .but for..."

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