

> Editor Decision: Publish subject to technical corrections (06 May 2020) by Ted Maksym

> Comments to the Author:

> Just a few very minor I found, that at most require a few words to clarify:

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> Figure 1 fonts are small.

Increased by a factor of 2.

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> Line 29 – remove comma; remove excess parentheses.

done

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> Line 33 – add “and” before land

done

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> Line 57 – comma before rather

done

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> Line 128 and figure 2. I found this section a bit confusing and had to read a few times. You are comparing the traditional and invariant annual cycles with the actual recorded observations for 2016–2017. Since the traditional and invariant are both versions of the typical annual cycle for the 40-year period, is it not unsurprising that they should not compare well with 2016–2017? The improvement in MSE is surprising, since it is hard to tell the traditional and annual cycles apart from these plots, but I don't understand why we would expect a particular year to match the “mean” annual cycle all that well, or why we might expect the invariant to fit better. Is it not possible that for some years, the invariant might actually fit worse? It is clear that the APAC matches closely, but the reduction in MSE is less than I might have expected compared to the invariant based on Fig 2. Perhaps it is just that the first half of the year matches quite well for all, so the actual MSE is relatively small in all cases. Maybe just some short statement to this effect would help?

We do not expect a particular year to fit well the traditional or invariant. Indeed, 2016 is not even a typical year. We included 2016 to show the scale of deviation of the invariant from the traditional compared to the scale of year-to-year variation. Visually, the invariant does not fit much better and for some years it will be worse. However, taken over the for satellite recorded era the invariant is 28.7% closer to the individual years compared to the traditional. The APAC is a significant improvement over the traditional and invariant in terms of RMSE (0.576, 0.481, 0.272, respectively). In this metric the, APAC is over three times the improvement of the invariant over the traditional.

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> Line 201–204 – isn't the difference in true vs recorded sea ice extent just due to errors in the retrieval (algorithm, weather, etc), and not real variations such as due to sea ice drift? Perhaps you mean that short term variability between the different passes, or timing of passes can create errors due to ice movement (i.e. when the daily extents are averaged from two daily swaths). I suppose real physical variations in ice conditions due to drift or other factors at the ice edge could lead to small changes in the algorithm's

calculated concentration; when this variation occurs when $C \sim 15\%$, then you could get pixels switching between ice and no ice when binarized for ice extent that would contribute to volatility. My only point here is to state why ice drift effects might lead to variations that are not real. Similarly in the conclusion, you conflate the volatility with ephemeral effects, yet there are ephemeral effects that are real day-to-day changes in sea ice extent. I suggest a parenthetical definition of what you mean by ephemeral when this is mentioned in the conclusion.

You make an important point and a subtle one. Statistical, we unambiguously specify the volatility in equation (13). But what are the sources of this variation? Clear sources are the errors in retrieval (algorithm, weather, etc). The definition of SIE, however arbitrary, includes the sea ice drift, so it is a non-source. The more subtle sources are the interaction between the errors in retrieval and weather (that is, how weather effects the quality of the retrieval). Weather can influence both the SIE and the volatility through the interaction between weather and the satellite effects and algorithm artifacts. Another source is timing. We represent the SIE daily, but it temporally continuous so that the timing of the satellite passes, however individually accurate, leads to variation. So these are sources for the volatility also. We have edited the conclusion to help a bit here and have replaced the whimsical "ephemeral" with "transient".

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> Figure 6 – fonts are very small (also, please check font sizes in other figures so they will all be readable when figures are sized for publication).

We edited them all.

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> Line 382 – “writing and editing”

done

In addition, we made minor edits to the "Code and data availability" section (line 375) to indicate the code is (rather than will be) available. The cite will go live on publication.