

The Cryosphere Discuss., referee comment RC1
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Review of "Fate of sea ice in the 'New Arctic': A database of daily Lagrangian Arctic sea ice parcel drift tracks with coincident ice and atmospheric conditions"

Anonymous Referee #1

Referee comment on "Fate of sea ice in the 'New Arctic': A database of daily Lagrangian Arctic sea ice parcel drift tracks with coincident ice and atmospheric conditions" by Sean Horvath et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-297-RC1>, 2021

General comments:

This paper presents a database consisting of a compilation of Lagrangian sea ice tracks combined with established satellite observations, model output, and reanalysis data. This comprehensive database spans from 2002 - 2019 and contains numerous sea ice properties and atmospheric variables. With the Lagrangian framework, i.e., by moving with the ice, the authors provide a useful addition to the more traditional, Eulerian datasets of sea ice and atmospheric properties. For example, the database could be used to study changes in the Arctic energy fluxes. The authors present two use cases for climatological and more process-orientated studies. They provide a detailed outlook of which datasets they plan to incorporate in the future.

The paper provides a detailed description of a Lagrangian database that will be useful to the sea ice community. It is well structured and easy to follow. A very positive aspect of the database is that the authors put a lot of effort into incorporating different datasets and providing a choice to the user. One central aspect I was missing was a detailed discussion of the uncertainties associated with the individual properties due to the spatial/temporal errors in the tracking. In addition, since the paper's focus is on the database, it provides limited new scientific insights about changes in the Arctic. I recommend extending the results section further with a more substantial case study and shortening the outlook.

Specific comments:

Reference to previous Lagrangian studies

The introduction would benefit from a more detailed discussion of previously conducted Lagrangian ice studies in the Arctic. So far, it briefly mentions Eulerian studies (L64-65). You may want to look at the following list (not complete):

- RGPS (RADARSAT Geophysical Processor System, e.g., <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2000JC000469>)
- Lagrangian Ice Tracking System (<http://icemotion.labs.nsidc.org/SITU/>, <https://ui.adsabs.harvard.edu/abs/2019AGUFM.C22D..03P/abstract>)
- IceTrack (<https://www.nature.com/articles/s41598-019-41456-y>, <https://tc.copernicus.org/articles/15/3897/2021/tc-15-3897-2021.html#&gid=1&pid=1>)
- neXtSIM (model): <https://tc.copernicus.org/articles/10/1055/2016/>

Please add a short paragraph that describes the advances of your database compared to the previous work of other Lagrangian studies.

Uncertainties of the Lagrangian drift tracks:

Sections 2.1 and 3.2.1 should be clarified by providing additional details on how you obtained the Lagrangian tracks and how the temporal and spatial uncertainty of the tracks translates into the uncertainty of the atmospheric and sea ice properties. Could you explain why you used the weekly ice motion product and interpolated it linearly to a daily resolution when a daily version of the Polar Pathfinder Sea ice Motion Vectors is available? Since sea ice motion varies substantially on short time scales, I recommend using the highest temporal resolution available if no other reasons speak against it. If this is not possible, please add a sentence why you used the weekly product in the manuscript.

Please estimate (or at least discuss) the uncertainty for the various parameters (ice thickness, air temperature,) introduced by a misplaced trajectory caused by the linear interpolation or errors in the Lagrangian tracking itself. For example, how much does the ice thickness / the air temperature vary if the ice parcel was located 100 km away from the trajectory? Is this spatial uncertainty the same in winter in summer? To evaluate the differences between the interpolated weekly sea ice velocities and the daily (or even sub-daily) velocities, you could use the daily PathFinder product, buoys, or SAR-derived motion field, e.g., https://resources.marine.copernicus.eu/product-detail/SEAICE_GLO_SEAICE_L4_NRT_OBSERVATIONS_011_006/INFORMATION.

Evaluation of snow and ice thickness

The authors state (Section 3.2.2) that the large spatial variability of snow and ice thickness complicates the evaluation with point measurements from ice mass balance buoys. I agree, but this database would gain weight if the authors could present the ice and snow thickness data with a more detailed uncertainty analysis. There are other datasets available that could be used to evaluate the results of your tracks, e.g., satellite-derived ice thickness (CryoSAT/IceSAT) or observations from ULS (e.g., doi: 10.1002/2015JC011102) and electromagnetic induction (<https://doi.org/10.5194/tc-15-2575-2021>). If this is not possible, I recommend including more plausibility checks of the ice thickness and snow results, e.g., by analyzing the ice thickness time series (like in Fig. 9). For example: why is the ice thickness decreasing already as early as April? What causes the little bumps in the ice thickness time series? What role do sea ice dynamics play in the ice thickness increase? The authors should also discuss in the manuscript that the ice mass balance buoys do not consider dynamic thickness changes.

Availability of datasets and uncertainty

Unfortunately, I could not find an example database for testing during the review process. Therefore, I cannot make any comments regarding the actual handling of the database. Please indicate in the revised version where the data will be publicly accessible after the acceptance of the manuscript. I could not check whether the individual data points come with an uncertainty estimate (from the data product and from the spatial missplacement) in the database. Where available, I would highly recommend including this information as it significantly improves the quality of climatological studies. For example, it would be interesting to see the uncertainty estimate in Figure 9, and especially in Figure 10.

Database uses:

The two examples (Section 3.3) are well-chosen to provide "proof of concepts" but contain limited new scientific insights. I recommend extending section 3.3.2 (Case Studies) with an example that provides more detailed insights into an Arctic process.

Future Additions

I found section 3.4 (Future Additions) too detailed for plans. Since changes might occur in the implementation of your plans, I would suggest cutting the subsections down to one section with a few details on the datasets you want to include and especially why you want to use them.

Technical corrections:

Title:

- The title was a bit misleading because I expected an in-depth analysis of the "fate of the New Arctic" from it. You could change the order of the words, like "A new database to study the fate of sea ice in the New Arctic" or remove the "fate of sea ice in the New Arctic."

Abstract:

- L11: "transitioned": I think this process is still ongoing; consider using the present tense.
- L19: "the database drift track": consider adding "the quality of the database was evaluated..."
- L23: "less accurate": please specify

Introduction:

- Consider adding some more recent literature to your introduction, for example:
 - L30 (e.g. doi:10.1088/1748-9326/aae3ec, doi:10.1088/1748-9326/aade56)
 - L34 (e.g. IPCC 2021)
 - L38 (e.g. doi:10.1088/1748-9326/aae3ec)
- L32: "what happens in the Arctic ...": Consider rephrasing this sentence to express the connection between the Arctic and the lower latitudes.
- L39: "during this time": please specify which time you mean.
- L54-L60: Please consider adding a short note on sea ice dynamics and their role for sea ice thickness and extent.
- L67: See specific comments. What about other studies that used Lagrangian tracking to study changes along the ice?
- L69: specify "characteristics."
- L70: "October 2002 and September 2019".
- L70 "starts in 2002 as this is" : is there a word missing?
- L75: your database is very rich in information and helpful but does not include any ocean information what might be relevant for mass balance studies. Maybe mention this aspect either in the introduction or write a short discussion about it in section 3.4 when you talk about the use for sea ice mass balance studies.

Section 2.1:

- L82: Which version of the PathFinder are you using? Could you please indicate this?
- L82: See specific comments. Would you mind explaining why you interpolate the weekly product?

Section 2.2:

- L112: "used for the Lagrangian tracking method described above": Do you mean that a 15% CDR ice concentration decides when to stop/start the tracking?
- L140: I suggest to remove "J." in the reference of "Stroeve et al. 2020"

Section 2.3:

- L164-166: I suggest moving this paragraph to the beginning of the section, i.e., before 2.3.1. to increase the readability.
- L172: are the errors given with +/-, or is it a bias in one direction? Would you please specify the sign?

Section 2.4:

- L215: You defined N-ICE2015 in L40.

Section 3.2

- L247: What were the criteria for a wrong location?
- L248: Consider including all tracks in Figure 3a and highlight a few to understand better where those buoys were located.
- 253: Consider including an uncertainty estimate for the trajectories based on the region (either from the PathFinder product or from your analysis). If there are such differences between the regions, it would be useful to know this as a data user.

Section 3.3:

- L286: I do not fully understand your conclusion on the increasing number of parcels. Did you remove the number of "surviving" parcels (MYI) from this number? Please specify this in the text. If not, does that mean that now a larger area of the Arctic is covered with sea ice? What else increases this number?

Section 3.4:

- I suggest shortening those subsections to one section (see specific comments) and keeping the details for a second paper when you have implemented your plans. This also applies to the connection with MOSAiC.
- L.389: "from the Multidisciplinary"
- L392: "here. MOSAiC"

Section 4:

- L411: Please specify "less accurate" and state, e.g., the mean error for those buoy subsets.

Figures:

- General comments:
 - Consider adding legends to your figures. I found them hard to read with only the information given in the caption.
 - Make sure that x/y labels are easy to find and close to the plots.
 - Maps 3a, 4, 8 contain little information. Consider combining them into 1 or 2 figures or add more information.

Figure 1:

- I do not understand why the "sea ice parcel" box is 3 times there and what "true location" means. Could you please explain?

Figure 3:

- Would you please indicate in 3a (or any other map) the spatial zones you defined to sort your data into the subregions (Laptev, Central Arctic, ...)?
- Consider adding a histogram with all data.
- Why did you choose 25 km for the red line? In the text, it appeared that 100 km is your "uncertainty estimate".
- Text in b is too small; please enlarge.
- Add the number of buoys for each subregion that you used to calculate the histograms.
- Maybe add a half-sentence about the purpose of the Freedman-Diaconis rule.

Figure 4:

- Please consider combining this figure with Figure 3a or 8.

Figure 5:

- I could not find the units for the parameters. If not done so far, please add them.
- Please consider adding the standard deviation of the distributions to get an idea of the spread.

- Would you please add the number of samples used to calculate the distributions?
- I have trouble reading the plots in panel b due to the different bin widths. Could you consider using regular bins for those plots?

Figure 7:

- Please move the x-label "Day of Year" to one of the plots

Figure 8:

- In the text, you discuss this figure regarding the drift patterns (L320-322). However, I think that showing only one trajectory is not enough to display a full drift pattern. Please consider showing more trajectories or removing this part and combining the figure with one of the other maps.
- In addition, you use Figure 8 to display the track of the time series shown in Fig. 9. Is the track of the time series in Figure 10 also displayed in Figure 8, 3, or 4? If not, please include it in one of them.

Figure 9:

- Is this the time series of one of the green trajectories seen in Figure 2 or the light green in Figure 8? Would you please clarify this in your caption?
- Add "°C" for the skin temperature.
- If possible, please display uncertainties with those variables.
- Indicate the year in the graph or in the caption

Figure 10:

- A legend for a, c, would be very helpful.
- What causes the discrepancy in snow depth for the wintertime (April-June, Nov-Jan)?
- Corresponds the data gap end of September to the restart of your tracking? Consider indicating this and explain the missing time.
- If possible, please display uncertainties with those variables.

Table 1:

- Sea ice drift/Resolution: If you used the weekly product and interpolated it to daily, please indicate this in the table somehow (instead of "daily").