Response to RC2

Thank you for your time and constructive comments on the manuscript "Estimation of duration and its changes in Lagrangian observations relying on ice floes in the Arctic Ocean utilizing sea ice motion product". We will carefully consider all comments and make corresponding changes in our revised manuscript based on these suggestions.

The paper focuses on improving Arctic Lagrangian observations by analyzing long-term sea ice motion data (1979-2020). The study evaluates suitable deployment zones for ice camps and buoys by using sea ice motion products and incorporating atmospheric circulation patterns like the Arctic Oscillation and Arctic Dipole. The authors highlight the declining survival time of ice floes and the increasing challenges for Lagrangian observations due to climate change. This research is highly relevant, given the rapid transformations in Arctic sea ice dynamics and the growing need for precise observational data for climate modeling. By integrating trajectory simulations with EEZ constraints, the study provides actionable insights for future observational campaigns.

I appreciate the exhaustiveness of all sea ice thermodynamic and dynamic throughout the

manuscripts. However, I have several concerns regarding the Area Of Interest (AOI) , the methodology protocol, and some logic explanations. Therefore, I recommend that the paper undergo major revisions before it can be considered for publication.

General Comments:

1. I realized that the aim of the work is to provide the reference for the ideal deployment locations in the central Arctic Ocean (in Line 73), but I don't understand why author choose the starting points region just within the rectangular area instead of within the EEZ boundary since EEZ anyway is divided into BG and IPD? So, I am not sure the motivation, is it just want to find the ideal deployment region within the rectangular only?

Reply: Indeed, the primary objective of our manuscript is to provide insights into the ideal deployment areas in the central Arctic Ocean for the buoys or ice camps to ensure that they drift in the central Arctic Ocean beyond the exclusive economic zones of various coastal countries for a sufficient amount of time.

To save search and recognition time for optimal deployment areas, we have defined a rectangular search area within the open sea in the current manuscript. We have also stated in the text that beyond this rectangular area, the deployments over other peripheral areas cannot meet the requirement of obtaining sufficient survival time of >= 9 months in the open sea area beyond the exclusive economic zones. In order to further confirm the reliability of our identification results, based on the suggestions of the reviewers, we will conduct a global search over the open sea area of the central Arctic Ocean using sea ice motion mean field from 1979 to 2023, which will be extended in the revised version, to further demonstrate the rationality of the defined rectangular area.

2. Data and method part: How do you interpolate the 25 km ice motion when employing Lagrangian methods, linear or inverse distance weighting? Do you apply the Lagrangian method from start to end without any regridding during the period? How do the results compare to a semi-Lagrangian approach?

Reply: (1) We used the bilinear interpolation method to interpolate ice motion speeds; (2) The original grid of sea ice motion products is the Ease-Grid, and the grid of the study area is the Polar Stereographic Grid, so before applying the Lagrangian method, the original sea ice motion is regridded at the study area grid point, and then bilinear interpolation is used to obtain the Lagrangian sea ice motion speed; (3) We will consult the relevant literature and apply the semi-Lagrangian method for further validation in Section 4.1. Additionally, we will include a comparison of reconstruction results of ice trajectories derived from the semi-Lagrangian method with those obtained from the Lagrangian method.

3. The validation of buoy trajectories seems to focus on data after 2014. Are there additional buoy datasets available from earlier periods? If not, are the selected buoys representative and exhaustive for this study?

Reply: Due to the need to use buoy data that has not been assimilated into NSIDC's sea ice motion products, the range of available data is relatively limited. Following the suggestion, we will attempt to collect earlier available buoy data and extend the data time span to the earlier years. Currently, to ensure representativeness, we use 10 buoys for each region of BG and TPD. To further collect data, we will also consider the buoys in both regions to ensure that we have a relatively consistent number of validation samples for both regions.

4. Another interesting point to explore could be backtracking trajectories instead of forward tracking. For trajectories with >9 months survival time (ST), does the backtrack reveal that their starting points are mostly within the rectangular AOI? This may provide valuable insights into uncertainties and trajectory origins.

Reply: Thank you for this suggestion. We plan to integrate these insights into Section 4.1 to explore the uncertainty of sea ice trajectory and assess the effectiveness of recommended deployment areas. Using trajectories with a survival time ST exceeding 9 months, we will obtain the spatial distribution of the endpoints of these forward trajectories during the study years, extending to 1979-2023, and determine the main hotspot areas where the endpoints of the ice trajectories originating from recommended deployment areas are clustered by geographic models such as spatial clustering algorithms. Following this, we plan to reconstruct backward trajectories from the grid points within the hotspot region of endpoints, to investigate whether the terminations of these backward trajectories still can reach the recommended deployment area. Then we can further evaluate the reliability of reconstructed sea ice drift trajectories using the data of sea ice motion field through this closed calibration evaluation method.

5. When using 2m air temperature for calculating Freezing Degree Days (FDD), how was the daily value derived - was it simply a mean of hourly data? Providing clarity on this calculation is crucial for reproducibility. How about the bias in ERA5 temperature.

Reply: We use the daily data obtained by averaging the hourly data of 2-m air temperature when calculating FDD, and we will use the daily data of ERA5 directly for comparison. We will also add some descriptions and previous verification results of the bias of the 2-m air temperature data of ERA5 in the Arctic region.

6. I am more interested in Figure 5, which is more pratically in the future. Shouldn't you further add more recommendation on the deployment for the future based on the 2007-2020 analysis (and also, could you longegate the time span from 1979-2023), and further make some uncertainties or high-recommend and mediate-recommend about the region? Since now for me, the all materials somehow distract me about the whole motivation. Incorporating uncertainty estimates and differentiating regions into high-recommendation and moderate-recommendation zones would greatly enhance the practical utility of the paper. As it stands, the extensive materials somewhat distract from the core motivation of the study.

Reply: According to this suggestion, we will extend the time span to 1979-2023. Based on this, we will subdivide the recommendation degree in all figures containing recommended deployment areas into moderate and high recommendation zones. Among them, the high recommendation area is determined based on the probability distribution of grid points. We will add discussions on uncertainty estimation and provide suggestions for future deployment based on the recommended zones.

7. Section 3.3, I'm not sure how much information related to the motivation can get obtained from here, please considering make them concrete.

Reply: Thanks for this comment. Due to the significant uncertainty in the data on sea ice thickness, the results of the impact of changes in sea ice thickness on future deployment recommendations or the operation of ice camps may not be reliable. Therefore, we will remove the section on sea ice thickness. For Section 3.3, since Section 3.2 discusses the thermodynamic impact of atmospheric forcing on sea ice, we will retain the content related to the ice-wind speed ratio and relocate it to Section 3.2 to discuss the dynamic impact of atmospheric forcing on sea ice. The changes in the response of sea ice to atmospheric forcing are of great significance for considering the near-year-round operation and maintenance of future ice camps, as well as for the interdisciplinary studies on the interactions between sea ice and lower atmosphere or upper ocean.

8. Section 4.1 requires further elaboration. In particular, I recommend adding an uncertainty analysis or sensitivity test to strengthen the robustness of the findings.

Reply: Thanks for this suggestion. To enhance the robustness of the results, we plan to add uncertainty analysis in Section 4.1. Specifically, to improve the representativeness of the verification results, we will try to collect more and earlier buoy data, with approximately consistent quantity of the buoys drifting over the BG and TPD regions. In addition, we will add discussions on methods, comparing the characteristics and applicability of the Lagrangian method and the semi-Lagrangian method and analyzing the uncertainty of the trajectory endpoint using the closed calibration evaluation method based on the further reconstructed backward trajectories.

9. I don't fully capture the Table 1 concerning its physical mechanism, first of all, how to understand the autumn CAI only have the obvious significant correlation with longitude in BH, but more correlated with both IPD and IPD/BH in latitude.

Reply: Table 1 showed the correlation between the atmospheric circulation indices and the longitude or latitude of the sea ice drift trajectory endpoint. Actually, CAI represents the air pressure gradient difference between the east and west of the central Arctic (94°N, 90°W, and 84°N, 90°E), which could characterize the intensity of TPD. In the BG region, sea ice motion is mainly driven by the anticyclonic circulation, so CAI mainly affects the longitude of the sea ice trajectory. In the TPD region, sea ice mainly advects meridionally, so CAI affects the latitude of the ice trajectory more significantly.

Specific Comments:

Line 23: change to "as the sea ice thins"

Reply: Thank you,we will revise it.

Line 117: use "optimal" instead of "most optimal"

Reply: Thanks for the suggestion, we will revise it.

Line 308-309: I am not sure about the statement since we don't know the casuality between
ice motion, wind circulation, near surface ocean current/stress. It is truly that sea ice motion, wind speed, ocean surface stress increase with climate change, but correlation doesn't give us some ideas in who is the trigger and who is the influencer. Could you provide more evidence.

Reply: Thanks, we also recognized this statement is not precise. We will check our result and revise this sentence to avoid doubts.

Line 347: “form” to “from”

Reply: We will revise this typing mistake.

Line 393-395, can you explain why?

Reply: We will consult relevant literature and add sentences to explain why the BH does not reveal more effective interpretability in the BG region.