General comments

The authors have conducted a study which is related to a quantitative analysis of sea ice floe characteristics in the Weddell Sea using ICESat-2 high-resolution altimetry data. The study focused on two areas of the Weddell Sea: the western and southern areas, which exhibit different sea ice conditions (as shown in Figure 2). The authors used the MICIT (Multiyear Ice Concentration and Ice Type) dataset to estimate daily concentrations of multiyear ice (MYI), first-year ice(FYI), young ice (YI) and open water, and derieved floe chord distribution (FCD), ice thickness distribution (fITD), lead width distribution(LWD) and vertical floe roundness from ICESat-2 along-track ATL10 data. The main insights the study offered about the seasonal variations in these characteristics were as follows:

1. the seasonality of the FCD is consistent, coinciding with the asymmetric melt/freeze cycle of the pack, while the seasonality of the fITD suggests an anti-phase relationship between the two regions.
2. The LWD is almost identical for the two regions, characterized by a mostly monotonic decrease with size, while the mean lead spacing in the west is up to 2.5 times larger than that in the south.
3. The vertical floe roundness by Compositing floe profiles shows that smaller floes are more vertically round than larger floes, and that the mean roundness of floes increases during the melt season.

This work is justified, as the authors state, knowledge of floe-scale chrematistics is important for understanding the sea ice dynamic. However, I think there are some room for improvements. It should be a good contribution to the TC and sea ice communities, after comments here or from the other reviews are adequately resolved.

Thank you for your review and for recognizing the contributions made by our work.

Specific comments

1. Introduction
Page 1, line 44: “Due to the sparseness of polar imagery, inter-regional comparisons of floe-scale properties are also limited...”
Although there are difficulties in collecting imagery, it would be better to mention the efforts they have made (Koo et al., 2023; Muchow et al., 2021). Studying sea ice in the Weddell using a combination of imagery and altimetry seems feasible.

Agreed. We have added a sentence to that effect on L44-46.

2. Data products
Or Datasets and method?

We have changed to ‘Datasets and methods’
Page 4, line 89: “We use the uncorrected version of the dataset, as the corrected version does not provide FYI and YI concentrations, though the timeseries of multiyear ice (MYI) area in the Weddell Sea compares well between the two products (not shown).”

Why don't you use the version with temperature and drift correction? Although the corrected version does not distinguish between the FYI and YI, but classifies them as non-MYI, it should provide a more reliable distribution of MYI and non-MYI, which is more important. Or it would be better to show the differences between the two versions in the appendix.

We now provide a comparison between the corrected and uncorrected versions of the MYI product in Fig. A1. This figure shows that the two products compare well in the two regions of interest. We keep the uncorrected version in the main paper because the corrected version does not provide data between November and March, and because it does not provide further decomposition into FYI and YI.

Page 4 108: "we define the ice located between two consecutive leads along a track as a single floe, and the extent of that ice segment as the floe chord length (Figure 1)."
How do you deal with the situation often found in ATL07/ATL10 where not all the segments on a lead could be classified as a lead (Figure 8 in Koo et al., 2023)? I think it would increase the number of small floe chords by your current method.

This issue is indeed a limitation that is common to all the studies estimating FSD from altimetry. As shown in Koo et al., 2023, different lead definitions have different sensitivity in capturing leads. In some cases, leads can be misclassified as sea ice, whereas the opposite may occur in other cases. We find here that the absolute value of the FCD slopes changes with the different lead definitions considered (Fig. A2), but the seasonality is robust across them, which is what our study focuses on.

We have made a note about the possibility of sea ice misclassified as leads on lines 125-126 and 364-365.

Page 5 line 120: "We test the sensitivity of our results to the following different lead definitions: (i) Specular + Dark (default)..."
In ATL07, there is actually a third lead definition, ssh_flag, which is the result of the radiometric decision tree and local height filter. Can you at this point add this lead sensitivity test if the "ssh_flag" also exists in ATL10?

We have included this definition in Fig A2 and Fig A3.

3. Results

Page 6 line 135: "the south and west (blue and yellow boxes in Figure 2)."
The southern region should be in the red box. The same typo is also in the description of Figure 2.

Corrected

Page 6 line 138: "The melt/freeze cycle is asymmetric, characterized by rapid melt between November and February, with approximately 15-30 % loss in freeboard thickness (except in 2020-2021)." Is there any explanation for the anomalous increase in sea ice concentration in January? Or a data problem?

This is indeed an interesting feature. By inspecting maps of sea ice concentration over time, it seems like this increase in sea ice concentration in the South Box might be associated with increased advection of high-concentration ice from the East. However, given the relatively small magnitude of the increase signal, more work would be needed to understand this effect and assess its statistical significance over the years.

Page 6 line 147: “Melsheimer et al. (2023).”
Should be (Melsheimer et al., 2023).

Corrected.

Page 6 line 147: “Between July and December, the total sea ice concentration in the western region tends to drop, driven almost exclusively by a decline in the MYI concentration.”
Why the total sea ice concentration tends to decrease between July and December in both regions, while the freeboard thickness shows different trends in 2020 and 2021.

In the western region, the total sea ice concentration and average freeboard thickness evolve mostly in phase (thinner and less concentrated ice during the melt season), which matches our general expectation.

In the southern region, the total sea ice concentration and average freeboard thickness are not always in phase, indeed. It should be noted that the magnitude of the seasonal cycle in these two quantities is generally weaker in the south than in the west. Therefore, the fluctuations in the south are likely to more strongly reflect longer term variability (e.g. inter-annual). These changes are more difficult to interpret, especially over the 4-year period that we consider.

The slight decline in concentration between January and October in the south happens every year and can be interpreted as net export of sea ice from that region dominating over areal growth. Over most years (except 2019), the freeboard thickness tends to increase between February and October, which reflects thermodynamic growth. In 2019, the freeboard thickness decreases slightly during between January and October, which may be caused by net export of thicker ice. We note however that the relatively sparseness of the freeboard thickness data used to generate the ATL20 product or changes in snowfall could affect some of these inferences.

We have added some more explanations about the seasonal behavior of the total sea ice concentration and mean freeboard thickness on Lines 134-166.

Page 8 line 174: “Very high freeboard values (> 1 m) are also observed over small floe lengths, which may be affected by the presence of icebergs, as discussed in Section 2.3.”
I think it might also be affected by misclassification of real sea ice as lead. For example, if there are several sea ice segments on a thick floe that are classified as lead, they will be calculated as some small floes with high freeboard.

We agree that misclassification of sea ice as leads may occur and have added a statement to that effect on Line 124-127: ‘We also note that the ATL07/10 lead detection product does not always capture leads that are visible from concomitant Sentinel-2 imagery (Koo et al. 2023), and may erroneously classify certain leads as sea ice. Additionally, some sea ice segments may be mistaken for leads, particularly within ICESat-2's `dark lead' classification.'

Nevertheless, we do not have evidence that the misclassification of sea ice as leads occurs more frequently than the opposite, or more frequently within thicker sea ice. Therefore, we do not further highlight that caveat when discussing small and thick floes on Lines 188-189.

Page 10 figure 4c: "αLCF' "
Should be αCLF'.

Corrected.

Page 11 line 212: "Lead width and spacing."
A little confused about the definition of the lead width and the lead spacing. I cannot find a clear answer. Are they the total length of consecutive leads and the distance between two leads, separately? The lead spacing looks like the floe chord. It would be better to clarify them here or in the section 2.3.

- The lead width is the distance between the first and last of segments identified as a single contiguous lead along a track.
- The lead spacing is calculated here between leads that are within the same lead width bin (as defined in Fig 6), so it is different to the floe chord.

We have included these clarifications on Lines 227-228 and Lines 247-248, respectively.

Page 13 figure 6: "while the black 'plus' and 'cross' symbols represent yearly-mean aggregates for the two regions, respectively."
There is no the black 'plus' symbol in the figure.

Corrected.

Koo, Y., Xie, H., Kurtz, N.T., Ackley, S.F., Wang, W., 2023. Sea ice surface type classification of ICESat-2 ATL07 data by using data-driven machine learning model: Ross Sea, Antarctic as an example. Remote Sensing of Environment 296, 113726. https://doi.org/10.1016/j.rse.2023.113726

Muchow, M., Schmitt, A.U., Kaleschke, L., 2021. A lead-width distribution for Antarctic sea ice: a case study for the Weddell Sea with high-resolution Sentinel-2 images. The Cryosphere 15, 4527–4537. https://doi.org/10.5194/tc-15-4527-202