

# Answers to Referee #2

## Font legend of this document:

- Blue original comment of referee
- Black our answer to referee's comment
- Grey suggested changes to the manuscript

The article presents a novel method for characterizing the winter sea ice floe size distribution (FSD) from SAR imagery and linking changes in the FSD to sea ice deformation. The topic is highly relevant for sea ice model development as well as for better understanding the properties of sea ice in winter. The article is very thorough and the visualizations are clear, and thus I recommend publication after minor revisions.

We are very grateful for the positive feedback to our manuscript. We address your raised comments below.

## Minor comments

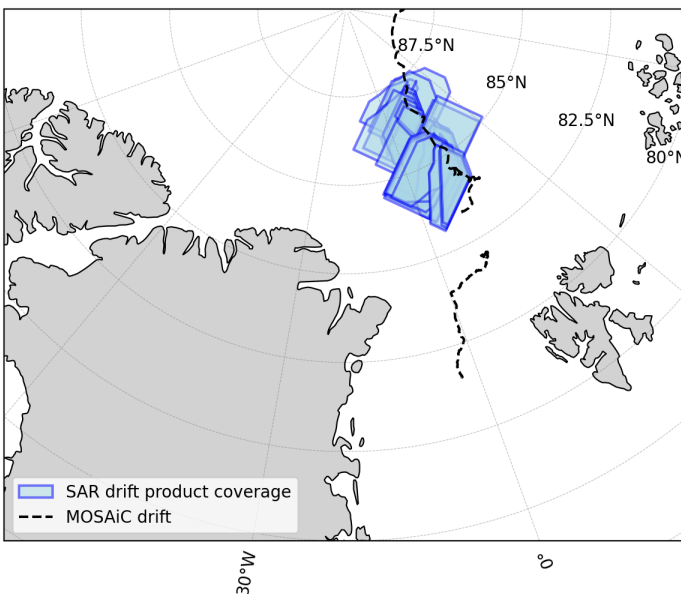
L22: “*deformation of the horizontal ice velocity*” – is it not sea ice deformation inferred from the ice velocity? The phrasing seems odd to me.

Agreed, we rephrase the fracture description to:

“Overall, three groups of processes drive the evolution of the FSD: thermodynamics, interaction with ocean surface waves, and **mechanical fracture from horizontal ice deformation**,”

L75-78: it would help to see where in the Arctic the images come from

We agree that this could be helpful for readers not that familiar with the MOSAiC expedition and produced an overview figure for the appendix:



**Fig A1:** Overview of the spatial location of all SAR scenes analyzed in this study. Sentinel SAR images were cropped to 400 x 400 square kilometer area centered around Polarstern, following the spatial coverage of the SAR drift product (von Albedyl & Hutter, 2023) used in this study. The dashed line shows the passive drift track during MOSAiC. In this study we only use SAR images between March 13 and May 31, 2020.

L82: It would be helpful to provide a brief recap of the derivation of the drift vectors here, so that the reader doesn't need to look up the PANGAEA page to know what method was used.

We extended the description of the drift data with a sentence highlighting the algorithm used: *"The ice drift between consecutive SAR images was previously calculated with a feature tracking method for the MOSAiC campaign (Krumpfen et al., 2021). **The algorithm of Thomas et al. (2008, 2011) and Hollands and Dierking (2011) was applied to HH-polarized Sentinel-1 scenes with a 50-m pixel resolution and a typical temporal spacing of one day, yielding drift fields on a regular 700-m grid from which divergence, convergence, and shear were computed as spatial derivatives.** The complete dataset for SAR-derived ice drift and deformation is available at von Albedyll and Hutter (2023)."*

L95: "binary images of 125 m" The highest MODIS band resolution is 250 m, perhaps 250 m resolution is what is meant here?

Thank you for catching this typo, we corrected it.

L101: Check style guide for vessel names

Done, corrected to ship name in italic: "RV *Polarstern*"

L172: note explicitly what definition you are using for the deformation and shear (either by reference or in the appendix if there is not room in the manuscript).

We added the used definitions into the sentence.

L345: I note that the regime change is happening at about 1/2 the size of the ROI. Have you investigated the sensitivity of the results to the ROI size?

The floe size, at which the change in FSD flips sign, is related to the size of the ROI, since the size of the largest possibly observed floes depend on the ROI size. In an ROI of 50x50km<sup>2</sup> no floes larger than 50km can be observed. Assuming power-law distributed floe sizes, a larger ROI could also include larger floes that could be fractured, potentially shifting the regime transition to larger floe sizes. In Sections 4.3 and 4.4 we discuss that the unchanged floe size  $d_0$  is not a free parameter, but can be derived from the ice area conservation constraints and depends on ROI size, divergence rate and the present FSD. Besides these analysis, we have not studied FSD in different ROI sizes and rather aimed to align our ROI size with the resolution of climate models currently using the prognostic FSD parameterization.

L410: In fitting the power law exponent, how do you choose the minimum and maximum floe sizes?

The power law fit is performed over the full floe size and chord range. We added this information to the caption of Figure 7.

L415: Indeed, you may wish to explicitly mention prior observations of seasonality in the FSD slope.

We agree and added a reference to prior studies on the seasonality of the power-law exponent in the modified test:

*“A seasonal dependence of the FSD slope is well documented, with steeper exponents in fragmented summer conditions and shallower exponents in consolidated winter pack ice (Stern et al., 2018a). Our shallow exponent is therefore consistent with the winter conditions analyzed here, in contrast to the summer conditions studied in most previous studies.”*

## References

- Hollands, T., & Dierking, W. (2011). Performance of a multiscale correlation algorithm for the estimation of sea-ice drift from SAR images: initial results. *Annals of Glaciology*, 52(57), 311–317. <https://doi.org/10.3189/172756411795931462>
- Thomas, M., Geiger, C. A., & Kambhamettu, C. (2008). High resolution (400 m) motion characterization of sea ice using ERS-1 SAR imagery. *Cold Regions Science and Technology*, 52(2), 207–223. <https://doi.org/10.1016/j.coldregions.2007.06.006>
- Thomas, M., Kambhamettu, C., & Geiger, C. A. (2011). Motion Tracking of Discontinuous Sea Ice. *IEEE Transactions on Geoscience and Remote Sensing*, 49(12), 5064–5079. <https://doi.org/10.1109/tgrs.2011.2158005>