Response to Referee 2 Comments

We show referee comments in black text, our response in blue and changes inserted to the manuscript are put in *italics*.

Leads is an important indicator of Antarctic sea ice deformation, and their changes reflect the vulnerability of Antarctic sea ice. However, it is a pity that the relevant research has not attracted enough attention, partly because such a small-scale phenomenon is difficult to detect or simulate. This paper using the latest high-resolution leads detection data push the research in this field to make significant progress, making me exciting. For the first time, it reported regional and seasonal trends in the Antarctic leads. I think it would be important circumstantial evidence that Antarctic sea ice is weakening under the dramatic climate change of the last two decades. I also sincerely commend the authors for their willingness to share leads dataset.

We thank the reviewer for insightful comments on our manuscript. Your comments are valuable and will help improve the quality of the study. We have carefully addressed each of your points.

I believe the conclusion of the article is attractive enough, but a few changes are needed.

1. This paper claims to have developed a new dataset, but the improvement over Reiser's work is very limited: it seems to have only filled in missing values with multi-year means and reduced the resolution to monthly. Therefore, I think it is overstated to emphasize this point in the title and abstract.

   Thank you for your feedback. We disagree, however, on this point. While our dataset is based on the method from Reiser et al. (2020), our main contribution is a detailed analysis of the spatial and inter-annual variability of sea-ice leads. Our study builds on Reiser's work by examining how lead occurrence in Antarctic sea ice changes over the last two decades, across regions, and between seasons and years. Reiser et al. (2020) focused on developing a methodology for detecting leads from thermal infrared satellite imagery and presented a general climatology based on 17 years of data. In contrast, our study uses an extended 21-years gap-corrected dataset and presents a detailed analysis of seasonal patterns, regional differences, and year-to-year variability – topics that were not addressed in earlier study. Therefore, we believe it is appropriate to emphasize the dataset, as it forms the basis for the new analyses and insights presented. The consistently processed monthly dataset enables exploration of spatial and temporal patterns not covered in previous work. We therefore consider the current title and abstract to accurately reflect the study's scope and contributions.

2. Figure 6 shows that there are many misses after 2020, but this period contributes to most of the increasing trend of East Antarctica leads, which weakens the reliability of the trend and would shake the foundation of this article. It is necessary to check the code and recalculate the leads frequency during this time. There are missing AMSR-based sea ice concentrations in 2011-2012, and the authors do not explain how they dealt with this period.

   Thanks for this remark. The identified increase in leads is not a coding artefact, but results from larger data gaps in this period as mentioned in the paper. The increase in missing values after 2020 in the East Antarctic in Figure 6 reflects a decrease in the number of cloud-free days available for reliable lead detection using thermal infrared imagery. This is because the dataset depends on the MODIS cloud mask, and increased cloudiness after 2020 has resulted in larger data gap frequency (dgF). We also do not consider the

observed increase in leads a foundation of this article because we explicitly discuss that this observation cannot be attributed to a significant trend due to the mentioned decrease in data quality.
Regarding the AMSR-based sea-ice concentration data gaps during October 2011 to June 2012, we agree that additional explanation is required. We used AMSR-E/AMSR2 data only to define a mask for the lead analysis by sea-ice extent (sea-ice concentration >=15%). For the months of April to June 2012, the mean sea-ice concentration as derived from the period with available AMSR-E/AMSR2 data was used. This information was missing in the text so far and will be added in the revised version. Thanks again for your comment.

We have added: *For the months of April to June 2012, due to the gap in AMSR-E and AMSR2 data between October 2011 and June 2012, the mean sea-ice concentration as derived from the period with available AMSR data is used.*

Some small comments and presentation issues are also worth noting.

1. Section 3 needs to be better organized, especially Section 3.5 and the following paragraphs. Analysis that is redundant and jumpy with the previous description is confusing. The authors need to find a clear logical thread to rearrange how to present these results.

   We are actually not sure how to comprehend this remark in detail. According to the comments provided by Reviewer 1 we have applied changes in Section 3 in the revised manuscript with respect to the trend analysis and also improved some remarks and associated conclusions to better point out the main findings.

2. Line 80: What's the meaning of "absolute" pIE?

   "Absolute" here means that the pIE has the same unit as LF and is not to be interpreted as a relative error.

3. Line 126: For color blindness, please don't put red and green together. You can replace green with cyan. The same goes for the other figure.

   We appreciate your suggestion. To ensure accessibility for individuals with color blindness, we have replaced green with yellow instead of cyan for the revised version. We believe this will improve the clarity and visibility of the figure for all readers.

4. Line 160: Is the trend significant? It seems that many of the trends in this paper lack p-values.

   In line 160 we only refer to qualitative changes in LF that are visible in the presented time series and do not want to state a presence of trends. That is why this statement is followed by the sentence: "It has to be noted, however, that a large part of this observed increase is attributed to an increase in low-quality data points during the last 3 years of the observed period." We suggest to add the remark: *"which does not allow to infer a trend in LF."*
   In section 3.6 we specifically address trends, associated p-values and limitations for potential conclusions. This section has also been worked over in the revised version of our manuscript to better point out the mentioned issues.

5. Line 211: Please explain "pronounced regional differences" in detail and explain how leads and fast ice are physically related.

   Thank you for your comment. By "pronounced regional differences", we refer to the distinct patterns of LF observed in different regions of the East and West Antarctic. These

differences are particularly evident when comparing the coastal regions with the inner ice pack. The presence of fast ice can locally influence wind and ocean patterns, affecting where leads are likely to form and areas with more frequent flaw-leads generally have less stable fast ice.

We added the following sentence in the revised version: *"The presence of leads can affect the dynamics of fast ice by altering local wind and ocean currents, which can lead to changes in ice thickness and extent and fast ice can also influence the formation of leads by providing a barrier that modifies the stress distribution in the surrounding ice cover, potentially leading to fractures and the opening of leads (Kim et al., 2018, doi: https://doi.org/10.1017/S0954102017000578)."*

6. Line 233: Given the large uncertainties in ocean current simulations, I recommend that you validate your results using multiple analyses/reanalysis.

   Thanks for your recommendation. There is definitely potential to compare spatial lead patterns with different ocean analyses, but we think this would reach beyond the scope of this paper and be misplaced in the presented context. We will consider incorporating additional analysis/reanalysis in future work.

7. Figure 7. This figure does not seem to have any difference from Figure 2a. This one looks a bit prettier, so you can keep just this one.

   We would prefer to stick to both figures as they both provide a different focus on spatial patterns in the lead climatology. While Figure 2a presents, (a) an extension of the climatology presented by Reiser et al. (2020) and (b) it also better points out lead patterns in the inner ice pack and their relation to bathymetry. Figure 7 (now Figure 8 in revised version of the manuscript), in contrast, highlights the spatial lead patterns in coastal areas and how these are connected to fast-ice areas in some regions.