

**Comments of Anonymous Referee #2**

**General Suggestions of Reviewer 2**

This manuscript tackles the perplexing behavior of Antarctic sea ice for 2013-2022, especially the remarkable retreat during 2016-2022. Following the slow but steady expansion of sea ice extent since the start of the satellite record in 1979, a period of greatly enhanced variability commenced in 2013. Thus, there is high scientific merit in seeking to understand this unexpected behavior. That being said, I found this manuscript challenging to understand even after reading it twice. The broad range of material tackled contributes to my understanding challenge, likely due to my unfamiliarity with some aspects of sea ice behavior. Also in a very unusual departure, the analysis draws substantially on the supplementary material; the authors should consider moving the most important figures into the main manuscript. Mostly I would classify the specific comments below as a major-minor revision.

We thank the reviewer for her/his helpful comments and constructive remarks. We agree with the reviewer that there is high scientific merit in seeking to understand the recent record-breaking Antarctic sea ice anomalies.

We completely agree with the reviewer that the manuscript covers a “broad range of material”. Certainly, studying the response of the sea ice extent around Antarctica to changes in the polar vortex strength is complex, which can make some parts of the text challenging for certain readers. However, we believe that the reviewers’ remarks and suggestions will allow us to greatly improve the flow and phrasing our manuscript making the reading experience informative and rewarding.

We also agree with the reviewer on the significance of some of the information currently shown as “Supplementary Material”. We are happy to incorporate all his/her suggestions in this regard.

**Specific Suggestions of Reviewer 2**

Page 4: Why did you use ERA5 for some variables and MERRA2 for others?

Line 122: 10 year (2001-2010) reference period for ozone hole area?

Line 166: ”associated with” rather than “the cause of”?

Line 263: How can “cold air to dip northward” lead to “sea ice retreat” in spring 2017? Similarly, the explanation for the sea ice advance in spring 2022 is unconvincing. These comments refer to the Ross Sea and Amundsen Sea region.

The “shapeshifting vortex’s effects” (Section 3.4) rely on the stratospheric anomalies to infer the surface temperature advection. You should show the actual surface circulation anomalies from ERA5 to back up your argument relating low-level air temperatures to sea ice anomalies.

Lines 270-272: I don’t see this association.

Lines 327-330: You are left with unknown cause(s) of the “early spring strengthening of the polar vortex since the mid 2010s” that you have linked with the retreat of the sea ice cover 2016-2022.

Figure 2b: Are these anomalies statistically significant?

According to the suggestions of the reviewer, we will revise our manuscript in the following ways:

- Line 87: Explain why we used both ERA5 and MERRA2.
- Line 122: Correct the typo in Line 122.
- Line 166: Rephrase line 166 according to the suggestion of the reviewer.
- Line 263: Rephrase the text in order to clarify that the comments refer to the Ross Sea and Amundsen Sea region. As shown in Fig. 4, anomalies in this region allowed cold air to dip

northward in Sep 2022, likely contributing to the sea ice advance in the Amundsen region in spring 2022.

- Add a new figure (based on reanalysis data) relating low-level air temperatures and circulation anomalies. We expect that this new figure will allow us to further analyze the effects of the shapeshifting vortex on the air surface temperature and in turn on the sea ice cover.
- Lines 270-272: Rephrase the unclear association described in text Lines 270-272.
- Lines 327-330: Expand upon the limitation of our work and the need for further research on the influence of other competing drivers.
- Figure 2b: Provide additional statistical information for assessing the significance of the relationships shown in Fig. 2b.

We thank the reviewer once again for her/his helpful suggestions and constructive remarks that we believe will greatly improve the clarity of our manuscript. As explained above, the revised version of our manuscript will be modified to address all the points that have been raised.

Best regards,

The authors.