General comments

I found that the topic of this manuscript fits well within the scope of The Cryosphere (TC) Journal. My first impression is that the manuscript in its current form is not suitable for publication as a full research paper. The manuscript is quite brief and lacks sufficient details. The current presentation is primarily descriptive; the authors process several data sets and describe the trends and statistical metrics obtained from the figures, but a deeper interpretation of the results and a robust discussion of the underlying mechanisms are not presented.

Although the title claims to address the "Drivers of Spatially Heterogeneous Changes," I found no adequate discussion of these spatial heterogeneity changes within the manuscript at all. Instead, the authors largely focus on the contrasting trends observed between the northern and southern Weddell Sea and the impact of large-scale atmospheric circulation on sea ice. The latter aligns well with existing research methodologies. To fit the manuscript title, the authors need to add a comprehensive discussion on the "spatial heterogeneity changes" of summer sea ice in the Weddell Sea.

We thank the reviewer for these constructive comments. We acknowledge that the original manuscript did not sufficiently develop the physical interpretation of our findings or adequately discuss the mechanisms underlying the contrasting trends in interannual sea-ice variability across the Weddell Sea.

Our study focuses on changes in interannual summer SIC variance, rather than changes in mean SIC or sea-ice extent alone. The central finding is a pronounced dipole pattern over the past four decades, characterized by increasing interannual SIC variance in the northern Weddell Sea and decreasing variance in the southern Weddell Sea. We identify distinct remote atmospheric circulation patterns associated with SIC anomalies in these two regions. In the southern Weddell Sea, SIC anomalies are associated with a Rossby wave train linked to enhanced convection over eastern Australia, whereas in the northern Weddell Sea, they are associated with a separate wave train linked to enhanced convection over the southern Indian Ocean. The associated circulation anomalies influence sea-ice variability through changes in sea-ice transport and convergence, as well as surface energy exchanges and ice–albedo feedbacks.

In response to the reviewer's concerns, we have substantially expanded the Discussion to provide a more in-depth interpretation of these results. Specifically, we discuss the distinct atmospheric teleconnection pathways associated with the two regions, explain how the resulting circulation anomalies may influence sea-ice variability through dynamic and thermodynamic processes, and examine the potential role of changes in the background sea-ice state. We also clarify the relationship between our findings and previous studies, including the potential influence of differences in seasonal definitions and variability diagnostics. Importantly, we have qualified our interpretation where the statistical relationships do not establish causality and identified analyses needed to further assess the relative contributions of the proposed mechanisms.

We have also revised and expanded the Conclusions to synthesize the principal findings, clarify this study's contribution to understanding spatially heterogeneous changes in Weddell Sea sea-ice variability, and discuss the limitations and implications of our results. In particular, we emphasize that increasing and decreasing interannual SIC variance can occur simultaneously within the same basin, and that the observed regional contrasts are consistent with the combined influence of remote atmospheric forcing, sea-ice dynamics, thermodynamic feedbacks, and the background sea-ice state. We further identify the recent decline in SIC variability in the northern Weddell Sea as an important question for future investigation.

To better reflect the central finding and scope of the study, we have revised the title to "Remote Atmospheric Drivers of Opposing Trends in Summer Sea-Ice Variability in the Weddell Sea." We believe that the expanded Discussion and revised Conclusions provide a more comprehensive physical interpretation of the results, address the reviewer's concerns regarding spatial heterogeneity, and clarify the study's contribution to understanding regional changes in Antarctic sea-ice variability.

"using a newly developed variance-trend diagnostic method": What is this method?

We have added detailed description of the method in Section 2.

The results chapter is too simple. It basically explains the figures.

Please see the response above

Several details:

L83-84: "and sea ice dynamic and thermodynamic variables." What are those variables?

We have clarified the text by explicitly identifying the variables as sea ice motion (dynamic) and sea ice thickness (thermodynamic)..

L84-86: "Together, these datasets provide a comprehensive framework for examining atmosphere–ocean–sea ice interactions associated with interannual sea ice variability in the Southern Ocean". How? Please describe how those datasets can capture the spatial heterogeneity changes of summer sea ice in the Weddell Sea. What are the resolutions of those datasets? What is the spatial scale of the "spatial heterogeneity changes"?

We have expanded the Data and Methods section to provide more details about the datasets, their spatial resolutions, and the methodology used to quantify changes in interannual sea-ice variability. The second paragraph describes the datasets and their respective resolutions, while the fourth paragraph explains how we identify trends in interannual sea-ice variability across the Weddell Sea. As shown in Fig. 2a, the trends exhibit a pronounced dipole pattern, with significantly positive trends in the northern Weddell Sea and significantly negative trends in the southern Weddell Sea. The spatial extents of the two regions are comparable. These

contrasting trends characterize the regional-scale heterogeneity in changes in interannual sea-ice variability that is the focus of this study..

L104-106: “In this study, interannual variability is defined as variability with periods 2-9 years.” What does it mean?

Here, interannual variability refers to sea-ice variability on timescales of 2–9 years, which we quantify by integrating the wavelet power over this period range.

“The resulting variance fields are used to evaluate both temporal trends and spatial patterns of sea ice variability across the Weddell Sea.” How can the “variability with periods 2-9 years” be used to evaluate the spatial patterns?

We have revised this paragraph to explain how the 2–9-year band-limited variance is used to characterize spatial patterns in interannual sea-ice variability. Specifically, we calculate the linear trend in band-limited variance at each grid point to identify regions with increasing or decreasing interannual variability. We then examine the temporal variability of sea-ice concentration averaged over the regions exhibiting significantly positive and significantly negative trends, respectively.

Figure 1: It is very difficult for readers who are not familiar with Antarctica to understand where the Weddell Sea is located.

We have revised Fig. 1 to show the study region in the context of the Antarctic continent, making the location of the Weddell Sea clearer to readers unfamiliar with the region.

Figures S1a and S1b: I can find those figures

We have moved Figures S1, S2, and S3 from the Supplementary Material to the main text and renumbered them as Figures 6, 7, and 8, respectively.

L172: (Yu et al., 2026): I can’t find it in the list of references

We thank the reviewer for catching this error. Upon checking, we found that the citation was incorrect and have removed it from the sentence.

L229: Yu et al. (2026b): I can’t find it in the list of references

We thank the reviewer for catching this omission. It should be 2026, not 2026b. The reference to Yu et al. (2026) has now been added to the reference list.

L263: “The code is available on request from the corresponding author.” a) What code? b) I am not sure if this “on request” is acceptable for TC.

We have modified the sentence.