

The Cryosphere Discuss., referee comment RC1  
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## **Comment on tc-2022-151**

Anonymous Referee #1

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Referee comment on "Antarctic sea ice regime shift associated with decreasing zonal symmetry in the Southern Annular Mode" by Serena Schroeter et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2022-151-RC1>, 2022

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The manuscript presents an interesting analysis of recent changes in Antarctic sea ice, illustrating well the non-stationary behavior of the sea ice variability patterns and the difference in trends if the 42 years of the satellite period is split in different parts. Many analyzes have been devoted to the satellite records of sea ice concentration but by decomposing the series in different regimes, the authors are able to present an original and useful point of view. They discuss intriguing changes between the first and the second half of the period and they propose a discussion of the possible origin of these changes. They do not answer all the questions raised by their diagnostics but the interpretation is interesting and will certainly stimulate more work on the subject. I thus recommend the publication of this manuscript in The Cryosphere. Some suggestions for a revised version are presented below that, to my point of view, would strengthen the impact of the results presented.

I have first three general points

1/ If I understand well, the main point in the discussion is the modification of the link between SAM and the sea ice concentration (Figure 6), associated with the reinforcement in the recent year of the non-zonal component of SAM (Figure 5). What I am missing at this stage is a clear connection with the total changes in ice extent (Figures 1 and 2 for instance). In other words, the manuscript demonstrates a decreased zonal symmetry in SAM, as mentioned in the title. It suggests qualitatively how this impacts the sea ice concentration as the patterns seems to fit with generally an enhanced north-south flow where sea ice extent decrease/increase. However, the fit is not always good and the authors do not quantify how much of the observed changes in the ice extent can actually be attributed to the shift in SAM and this weakens their conclusion. Additional diagnostics or analysis are thus required for me to quantify the proposed links and the impact of the decreasing zonal symmetry of SAM on Antarctic sea ice.

2/ The origin of the shift in SAM is not discussed. I understand that it is not the subject of the paper. However, the reader would be interested to know if this could be due to multi-decadal variability in the atmospheric circulation, a response to the greenhouse gas forcing, recovery from the ozone hole, or any other mechanism. I would thus suggest to add a paragraph in the final section, at least to present the different hypotheses.

3/ For several diagnostics, I was not totally sure of the diagnostics that is displayed. As this is key for understanding the paper, I would recommend to add more details on the way they are produced. In particular, for figure 2b, that would be useful to explain exactly how regional variability is computed. For figure 4 and 7, regressions of SIA anomalies and SST are mentioned but I am not sure with what SIA or SST is regressed, maybe with time? Can 'regression' here be considered equivalent to 'trend'? If this is the case, I think that it would be useful to specify it. Figure 6 mentions a gradient of 15yr samples of average EOF1 zonal anomaly. I guess it is the zonal gradient and thus the derivative of the plot of Fig. 5d but I am not totally sure.

I have also a few specific points.

1/ In many places, starting in the abstract, the authors mentioned that the long-term trend is skewed towards the earliest years (line 9; line 83, line 211). Maybe 'skewed' can give the feeling that the estimate of the long-term trend is wrong or biased. I would personally preferred 'dominated by the changes in the earliest year' or something equivalent that is more neutral.

2/ Line 113. The eastward shift of the anomalies is interesting for me. The authors interpret the changes in patterns as an increase in the meridional exchanges related to SAM but would it be possible that a part of the signal is due to an eastward shift of the pattern or to the advection of some anomalies by oceanic currents. On this subject, maybe a link with the very recent study of Morioka et al. (2022) would be interesting

Morioka, Y., Iovino, D., Cipollone, A. et al. Decadal Sea Ice Prediction in the West Antarctic Seas with Ocean and Sea Ice Initializations. *Commun Earth Environ* 3, 189 (2022). <https://doi.org/10.1038/s43247-022-00529-z>

3/ Line 244. It is indeed counterintuitive and I do not follow well the argument here. Line 243, it is said that increasing meridional flow over the sea ice zone is driving spatially heterogeneous anomalies. If I understand well the sentence, a higher overall variance of the total sea ice extent would be due to a 'greater agreement across regions of high-magnitude changes'. If this is the case, that would be important to quantify this.

4/ Line 247. Why is it assumed that the changes that are underway are likely to continue? The response of sea ice to wind changes is usually relatively fast. If it is because it is

assumed that the asymmetric flow pattern will continue to intensify, this should be explained in more details here.

5/ Figure 5. The caption does not seem to correspond to the figures. The period 1979-2001 is mentioned in the figures (panel a) but not in the caption. Is the difference (panel d not c) between (a) and (b) or between (b) and (c) ?