Response to Reviewer 2

Dear Reviewer 2

Once again, we would like to extend our thanks to you for the time you have given to provide us with constructive suggestions to improve the quality of our paper after a second round of review. Your efforts are very much appreciated, as we believe the quality of our manuscript has improved thanks to your suggestions.

In this document we have provided an overview of the major changes we have made to our revised manuscript. We have also responded to each of your specific comments in a point-by-point format. Your original comment appears in *italics*, while our response appears in **bold**.

L26: driven by atmospheric

The final sentence of the abstract has been rephrased to emphasize that the observed sea-ice variability is driven by local atmospheric conditions, and the sentence now reads:

"Such information will allow to confirm whether the detected increase in cyclonic vorticity is linked to rapidly changing sea-ice dynamics driven atmospheric changes and establish the measure of rotational sea-ice drift as a potential indicator of weather driven variability in Antarctic sea ice."

Figures 1 and 2: These are fantastic! I am very grateful to the authors for adding these, as I now have a very good feeling for the cyclonic and anticyclonic features they are studying. I had one small thought about the description. In the text the authors understandably focus on the strong local cyclones and anticyclones that they illustrate in the coloured circles. However, there is also a much wider field of vorticity shown in these plots outside those circles, and it is also associated with cyclonic and anticyclonic curvature of the isobars, everywhere as far as I can tell. So perhaps the authors could emphasise that it is not just local storms that are under consideration here, but also the general vorticity field. Relatedly, I see no evidence in either of these figures for any such features as oceanic eddies, boundary jets, coastal currents, etc; the isobars really do seem to explain it all. So maybe the authors could highlight that these figures illustrate their interpretation that the recorded vorticity is dominated by the atmosphere (e.g. on line 395).

We thank the reviewer for the enthusiastic feedback. We agree that we should elaborate more on the atmosphere – ice vorticity link in the entire rectangular region, and not just underneath the specific atmospheric feature described. In the revised Case Study 1 (Sect. 4.1.1), we comment on the vorticity field over the Weddell Sea, an area which is not influenced by the intense polar cyclone, but rather by relatively weak high-pressure ridge. We have added:

"In addition to the area of ice beneath the atmospheric cyclone, the wider vorticity field is also associated with the cyclonic and anticyclonic curvature of the isobars. All four products detect positive vorticity beneath the elongated high-pressure ridge over the Weddell Sea, 7 185 separating two smaller regions of negative vorticity at the ice edge (approximately 62° S and 30° W) and continental coastline (approximately 77° S and 15° W), each of which lie below a pressure trough."

In the revised Case Study 2 (Sect. 4.1.2), we comment on the negative-to-positive vorticity gradient that is seen across the Weddell Sea, and how the overlying parallel isobars lie perpendicular to this vorticity gradient:

"Again, the vorticity fields detected by all four products show a strong correlation with the curvature of the overlying isobars across the entire rectangular region, much like that shown in Case Study 1 (Sect. 4.1.1). This is particularly visible in Fig. 2 along the negative-to-positive vorticity gradient from the western-to-eastern Weddell Sea, where the parallel isobars lie perpendicular to the vorticity gradient, suggesting the atmospheric pressure gradients control the underlying vorticity field. A region of negative vorticity is also detected near the eastern boundary of the rectangular region which mimics the curvature of the overlying low-pressure cell deflecting eastwards."

The vorticity field's strong correlation with the overlying atmosphere and the lack of evidence suggesting an ocean sourced influence both give confidence that the vorticity field is mostly weather driven. We therefore elaborate on this in the revised (i) Abstract and (ii) Discussion by adding:

(i) **"Such information will allow to confirm whether the detected increase in cyclonic vorticity is linked to rapidly changing sea-ice dynamics driven atmospheric changes and establish the measure of rotational sea-ice drift as a potential indicator of weather driven variability in Antarctic sea ice."**

(ii) **"The case studies presented (Sect. 4.1) indicate that the vorticity field of the sea ice is strongly linked to the cyclonic and anticyclonic curvature of daily isobars, both in cases of extreme weather events and mild atmospheric conditions. There is no apparent evidence of oceanic drivers effecting ice rotation in this region at these spatial and temporal scales, suggesting that the detected vorticity field is dominated by weather at daily – or even sub-daily – timescales. This aligns with existing literature that sea-ice variability in the Atlantic Sector of the Southern Ocean is primarily driven by local atmospheric conditions (Kwok et al., 2017; Matear et al., 2015)."**

General: It has only just occurred to me that of course there are more cyclones than anticylones in this area, as it is dominated by a climatological low pressure (the Weddell Sea Low)! If the ice vorticity is dominated by the atmosphere then of course this necessarily means there is more cyclonic ice vorticity than anticylconic. So perhaps the authors could mention this? What this paper shows really nicely is precisely how that difference is manifested – in intensity of cyclones etc.

L459: This explanation seems to miss the most obvious explanation of all: there is more atmospheric cyclonic forcing! It doesn't have to be more effective, or hide the results, there is just more of it! This is a climatological low pressure area, so that implies there will be negative ice vorticity on average.

Following the reviewer's comment, we have added extra text to our revised Discussion to include comments on the overall cyclonic rotation in the atmosphere in our studied region, and that in cases whereby ice motion is primarily weather drive – like such is the case here – the dominance of negative vorticity in the ice is likely influenced by the dominance of negative vorticity in the overlying atmosphere. We have added the following into the revised Discussion (Sect. 5):

"Furthermore, the Weddell Sea is dominated by a climatological low-pressure cell – termed the Weddell Low – which is the result of the frequent passing of cyclones through this region caused by intense cyclogenesis in the Atlantic Sector (Grieger et al., 2018; Simmonds et al., 2003; Wei and Qin, 2016) or low pressure features crossing the Drake Passage to the east (Gonzalez et al., 2018). Since it has been shown that the ice vorticity field is primarily weather driven, this dominance of cyclonic

rotation in the atmosphere likely contributes to the more frequent and intense cyclonic vorticity features detected in the sea-ice."

We therefore included this consideration as a possible reason for dominance of negative vorticity detected in the ice:

"It is thus difficult to discern whether the dominance of cyclonic rotation in the ice – both in frequency of events and their intensity – is due to 1) the dominance of cyclonic rotation in the overlying atmosphere; 2) atmospheric cyclones being more effective at engendering rotational motion in the underlying sea ice than anticyclones; 3) the feature tracking method of drift retrieval being overly sensitive to the conditions under an atmospheric cyclone; 4) any combination of the aforementioned considerations."

References:

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