Comment on tc-2022-51

Anonymous Referee #1

Referee comment on "Evolution of the dynamics, area, and ice production of the Amundsen Sea Polynya, Antarctica, 2016-2021" by Grant J. Macdonald et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-51-RC1, 2022

I reviewed a previous version of this manuscript that was rejected by TC last year. The resubmitted paper has probably been revised based on the previous comments from the reviewers. However, unfortunately, the changes were minor. They are changes in wording and the deletion/increase of a few figures. At least for me, I felt that those were superficial modifications, and accordingly, I couldn't satisfy with them. Therefore, I recommend rejecting this paper mainly for the following reasons.

The points at issue:

Too qualitative analysis; lack of error analysis and science.

The unclear main focus of this study.

Misinterpretation of inappropriate satellite data.

This manuscript lacks quantitative analysis and also has no error analysis. This leads to a lack of science. Especially in SAR data analysis, this study only shows satellite images (without backscatter scale) and wind condition maps, and then they make stories. Fig. 8 of the previous manuscript was the only statistical analysis. However, the correlation was weak, and this figure has been deleted.

It can be read that the main focus of this study seems to be on the biological production and chemical processes in the summer coastal polynya (complete ice-free ocean) and the accompanying carbon dioxide absorption. However, the biochemical analyses were not conducted in this study. On the other hand, this manuscript estimates sea-ice production in a coastal polynya in winter (A small part may be an open water fraction, but it is mostly covered by frazil ice or thin solid ice). The purpose of estimating production is not clear; what is stated in L. 65 is insufficient. The dense water formed in winter coastal polynyas associated with the prominent ice production is an important source of AABW. This process of bottom water formation is thought to significantly impact the climate system through the transport of heat and substances such as carbon dioxide between the atmosphere and the deep ocean. However, this is not described at all in the manuscript.

The use of SAR data is a challenging point in this study. However, as is clear from video S1, it has many temporal and spatial discontinuities. This suggests that it is not suitable for monitoring a coastal polynya whose variability is large. The authors defined surface conditions in SAR images as follows.

Open ocean: a low backscatter and appears dark

Older icepack: relatively high backscatter and appears bright and more granular

Recently-formed polynya produced ice: an intermediate backscatter

Frazil ice: distinct bands of varying brightness

However, this is very qualitative as it is affected by the SAR's incident angle. For example, in video S1, the open ocean may also appear white (e.g., 21-23 November 2016; 15-17 December 2016; 8-10 January 2017). These examples indicate the difficulty of conducting "quantitative" discussions of sea-ice and open water areas from SAR images. The use of such sparse and unquantifiable data leads to misinterpretation. The authors state that "approximately all of the ice produced between 30 April and 4 November by the main polynya is contained within the red outline on 4 November in Fig. 4" from the SAR images in Video S1 and Fig. 4 (L. 403-405). This is a lack of science to tell this from SAR data alone. It is more natural to assume that the sea ice will grow both thermodynamically and dynamically during this long period of 6-months, resulting in a backscatter similar to that of one-year ice. In any case, this cannot be suggested solely from the SAR images.

The definition of a winter coastal polynya area based on AMSR2 sea-ice concentration (SIC) is questionable. Firstly, this study ignores heat loss and sea-ice production in thin ice areas, the dominant type of sea-ice in winter coastal polynyas. Secondly, an area with SIC <70% was defined as a polynya area, but SIC by the ASI algorithm underestimates SIC in thin ice areas. A similar analysis had to be performed using SIC with other AMSR2

algorithms, and error analysis also had to be performed.

In a previous review, I pointed out the definition of a coastal polynya area. As in the previous manuscript, this manuscript also treats the area where the SIC by AMSR2 is <70% as the polynya (open water) area. The previous manuscript was based on studies of the comparison between a coastal polynya area from the polynya signature simulation method (PSSM) by Markus and Burns (1995) and SIC (Parmiggiani, 2006; Morelli & Parmiggiani, 2013; Preußer et al., 2015). The new manuscript added a comparison with SAR images (Figs. 2b-g). The black low backscatter area (open ocean) in Fig. 2b corresponds to the low SIC area (SIC <70%) in Fig. 2e. Since this is not a SIC map, I do not know the details, but the correspondences between the open ocean and the low SIC (not open ocean) areas seem strange. On the other hand, Figs 2c-d shows a bright band-like feature, which is considered to be covered with frazil ice. Since no dark areas can be seen, it is assumed that this area is mostly covered with sea ice. In other words, the SIC must be close to 100%. However, the AMSR2 map shows a low SIC of <70%. The two areas certainly coincide, but they are not consistent in terms of SIC. Furthermore, even though the area is considered to be covered by ~100% frazil (thin) ice, the authors did not consider the presence of sea ice at all in their estimate of sea-ice production and assumed an ice-free (open) ocean (eq. 1-10). There is an area of intermediate backscatter below (west of) the areas shown as low backscatter area (open ocean, Fig 2b) and the area shown as the band-like feature (frazil ice, Figs. 2c-d). These areas are considered to be "the recently-formed polynya produced ice" as described by the authors. This area is considered to be covered by thin sea ice with ~100% SIC. The sea-ice production in this area is expected to be significant. Sea ice acts as a heat insulator between the atmosphere and the ocean, but its effect decreases rapidly as the ice thickness decreases. The authors had ignored the sea-ice production in thin ice areas.

SIC estimated from brightness temperatures observed by satellite passive microwave radiometer is underestimated in areas covered with new and thin ice areas, such as coastal polynya (Cavalieri et al., 1994). The authors stated an error in the ASI SIC algorithm but ignored the effects of thin ice (L. 204). As described in the previous review comment, a comparison of SIC using the ASI algorithm in the Ross Ice Shelf polynya and the Mertz Glacier polynya in Antarctica with the PSSM polynya map clearly shows that coastal polynyas are covered by thin ice, not open water, in winter (Kern et al. 2007). Moreover, the SIC is underestimated in these regions. The authors should show an error analysis for this. In addition to ASI, NT2 and Bootstrap are other major algorithms for estimating SIC. The analysis had to be done using these SICs as well. Their spatial resolution (about 12 km) is coarser than that by ASI, but it is sufficient to resolve the Amundsen polynya.