

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-250

Anonymous Referee #1

Referee comment on "Evolution of the Amundsen Sea Polynya, Antarctica, 2016–2021" by
Grant J. Macdonald et al., The Cryosphere Discuss.,
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This paper investigates the variability of Amundsen Sea polynya over the last five years (2016–20) using backscatter images from the Sentinel-1 SAR and sea-ice concentration (SIC) from the AMSR2 passive microwave radiometer. Unfortunately, this study has a severe problem in the definition of winter coastal polynya and the application of SAR data to polynya studies, as is described later. These shortcomings are fundamental to this study and are not something that would be remedied through the review process. Therefore, I recommend rejecting the paper.

This study defines coastal (latent heat) polynya as an open water area even in winter (L. 38). Specifically, a polynya (open water/low SIC) area is defined as a region where the SIC measured by the AMSR2 is less than 70%. This threshold is the one used by Parmiggiani (2006), Morelli & Parmiggiani, (2013), and Preußer et al. (2015), cited in this paper (L. 192). This threshold is based on a comparison between the SIC and the area of the coastal polynya. The polynya area was detected from brightness temperature observed by a passive microwave radiometer using the polynya signature simulation method (PSSM) by Markus and Burns (1995). They also compared with SIC, and the threshold of 75% was shown.

The question is whether the low SIC area of <70%, which is more extensive than the footprint size (>5 km) of the passive microwave radiometer, can appear in the Antarctic coastal region in winter when the weather conditions are very cold and windy. Under such

conditions, even if an open water fraction does appear, it will soon freeze up and be covered entirely with new frazil (grease) ice, except for very close to shore where divergent ice motion is prominent. In SIC algorithms for passive microwave radiometer data, especially early ones, it is known that the SIC of thin (new) ice is underestimated. This is caused by the polarization ratio (PR) of the brightness temperature used in the algorithm: the PR value of new ice is similar to that of open water compared to that of first-year ice (Cavalieri et al., 1994). In addition, the PR value of landfast ice is similar to that of thin ice (Tamura et al., 2007). Fast ice develops in the ASP region (Fraser et al., 2020; 2021). Therefore, the low SIC region extending offshore during winter in Fig. 10 is speculated to the underestimation due to the influence of fast ice. That is, the SIC of 70 (75)% threshold has no physical meaning. These show that the SIC from passive microwave radiometer is underestimated in thin ice (coastal polynya) and fast ice areas. So what is the point of such an ambiguous parameter-based estimate of the polynya area and the ice production? The estimation of SIC by the newer ASI algorithm used in this study may improve the SIC estimation in thin ice areas to some extent. However, 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. It is reasonable to assume that new (thin) ice with 100% SIC covers the winter coastal polynyas. This is supported by the surface temperature from infrared satellite images, the thermal ice thickness estimated from heat flux calculations using these images (e.g., Tamura et al., 2007), and the SAR images in this study. Based on these facts, the estimation of the winter coastal polynya area using SIC derived from passive microwave radiometer and sea-ice production there does not capture the reality and is meaningless. The heat insulation effect of sea ice decreases rapidly in the case of thin ice. Therefore, the more appropriate approach is to estimate the thermal thin ice thickness from brightness temperature observed by passive microwave radiometer, use it to determine the polynya area, and then estimate ice production from heat flux calculations (e.g., Tamura et al., 2008; Nihashi and Ohshima, 2015; Nihashi et al., 2017). Although these studies' estimates of polynya extent and production are cited (e.g., L. 123-128), the differences in the methods are not discussed at all.

Regarding the SAR data analysis in the first part of this study, the subsection title does indeed say "qualitative analysis" (L. 137; 335), but it is too qualitative. At L. 156-161, the authors describe the relationship between backscatter and ice (ocean) types. This would be generally true, but on what are these based? Quantitatively, which backscatter value corresponds to those surface types? There are no references at all. Furthermore, they did not compare with the SIC used in the second part of this study. At least, a comparison of SAR backscatter with surface temperature and ice thickness from MODIS infrared imagery, as shown in Nakata et al. (2019), will be needed.

In the "qualitative analysis" described in subsection 4.1 starting at L. 335, the SAR images are only shown in Figs. 2 and 3, and the story is developed based mostly on video S1. However, many of the SAR images in this video are missing from the central part of ASP.

This leads to difficulties in following the text. It is also extraordinary to say, "Instead, ice formed by the ASP often remains in the ASP study area for months (Video S1, Fig. 3)" (L. 605) from a discussion which is based solely on SAR images. Why can this be said only from temporally sporadic SAR images? In reality, it is reasonable to think that the area of the thin ice area does not change, and the new ice formed there is either thermodynamically growing or advected and deformed at the edge of the polynya. Therefore, dynamical and thermodynamic analyses with an ice motion are essential to justify the author's claim.

Again, the problems pointed out in this review are fundamental to this research and should not be improved through the review process. Therefore, I recommend rejecting the paper.

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