

The Cryosphere Discuss., author comment AC2
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Reply on RC2

Grant J. Macdonald et al.

Author comment on "Evolution of the Amundsen Sea Polynya, Antarctica, 2016–2021" by
Grant J. Macdonald et al., The Cryosphere Discuss.,
<https://doi.org/10.5194/tc-2021-250-AC2>, 2021

Dear Reviewer 2,

Thank you for your time, comments, and feedback that will undoubtedly improve this manuscript if we are invited to submit a revised version. Here we provide an initial response to your comments. If invited to submit a revised version, we will provide more details regarding changes made related to your comments.

SPECIFIC COMMENTS: MAJOR

(1) Lines 521-522: "Daily mean wind speed at the polynya site and polynya area during the winter period has a weak but significant positive correlation"

Are you sure that these are the two variables (wind speed versus polynya area) you should be comparing together?

*I would have tried to compare the winds against the *change* in polynya area, i.e. $d(\text{area})/dt$.*

A gust of winds would presumably correlate with a change in area ($d(\text{area})/dt$), not the actual area.

*Another related comment is that you are using wind *speed* and ignoring the wind's*

direction.

Wouldn't the wind direction matter, e.g. in distinguishing between an opening (area increases) or a closing (area decreases) of the polynya?

We agree that change in polynya area would be a better variable to compare, we will amend this. We think it is valuable to include a comparison of changes in the polynya with just wind speed, as done in other studies, but agree wind direction is also important, so we will make reference to the daily wind direction shown in Video S3 when discussing changes in polynya area and its relationship with wind.

(2) Lines 529-531: "The mean wind direction throughout the ASP study area is approximately southerly. While this direction corresponds to the direction in which the polynya sometimes forms northward off the Dotson Ice Shelf, it does not correspond to the more typical westward formation off the iceberg chain."

Could you please expand on this in your "response to the reviewers", and demonstrate that the "southerly mean wind direction" isn't a plotting artefact or an error in the postprocessing of ERA5's winds? Although I haven't specifically worked with years 2016-2020, the area just north of the Getz and Dotson ice shelves usually shows mean winds blowing from the southeast or from east-southeast. In contrast, Figure 9 shows winds blowing from the south or from south-southeast.

A few thoughts and suggestions:

---A wind blowing from the south or from the south-southeast would imply that the 'v' wind component is larger (in absolute terms) than the 'u' wind component. Can you go back to the original ERA5 results (meaning before doing any sort of processing) and confirm that this is what you are truly seeing in ERA5's u,v wind components? (We are particularly interested in the region just north of Getz and Dotson ice shelf, i.e. the ASP).

We checked this and it seems to be correct, but we will check more thoroughly before submitting a revision. It would be more precise to say that we calculate the mean wind to come from the SSE in front of the Dotson, and SE to ESE in front of the Getz – we will amend the text to reflect this.

---If you select one single location (latitude = something, longitude = something) where ERA5 winds are defined, please verify that the 'u' value and the 'v' value (in the original ERA5 files) are quantitatively consistent with the arrow's direction shown at that

particular location. If they don't quantitatively match (using the basic trigonometric relations), then there is an error in the plotting or the postprocessing.

As above, it seems to be correct but we will more thoroughly check before submitting a revision.

---Since wind direction is important in Figure 9, shouldn't we add longitudes and latitudes to orient the reader who is not particularly familiar with the Amundsen Sea?

We will do this.

---Please clarify whether the statement about the "southerly" mean wind direction (Line 529) is specific to a time of the year, and if so, what time of the year exactly? This is a confusing thing, considering that Figure 8 is representative of April-October, Figure 9 is representative of November-December, and we just don't know about Line 529."

The reference to 'southerly' on line 529 refers to the year-round mean. We will rephrase for clarity. Figure 9 is representative of the year-round mean, not November-December. Note it is November *2016* to December *2020*. However, we understand how this could confuse and we will adjust the caption to make clear it is the year-round mean over this whole period.

SPECIFIC COMMENTS: MODERATE

(3) Lines 90-91: "...such as Antarctic bottom water formation and global thermohaline circulation..."

The Amundsen Sea doesn't produce Antarctic bottom water. You must be confusing the Amundsen with another location in Antarctica (maybe the Ross Sea?). You have to remove this passage because it simply doesn't apply to the Amundsen Sea.

Thank you, we will remove this.

(4) Lines 301-302: "Additionally, the total SIC for each day was calculated by calculating the sum of all percentage SIC values in the study region. These total SIC values should only be considered useful for analyzing relative changes in SIC"

By defining "total SIC" in this particular way, you are making it unnecessarily difficult to compare your results with past/future studies, because the value obtained will be intimately tied to your grid resolution (the latter being an arbitrary choice).

For example, assume that SIC=100 over a certain geographical area, and that this area is covered by 4 grid points (with the resolution you've chosen). The "total SIC" for this area will be 400. Then, in two years from now, another researcher does a similar analysis and selects a resolution that's twice finer than the one you chose. The same geographical area is now covered by 16 grid points, and the "total SIC" is suddenly 1600.

I'd suggest normalizing the "total SIC" by the total number of grid points within the study region. This way, the number coming out of your analysis isn't so dependent on the arbitrary choice of resolution. Another benefit is that the numbers you'll obtain will be much smaller and less cumbersome. Right now, lines 581-583 are discussing numbers having 7 digits, and that's a bit awkward.

Thank you, we agree that this was a poor choice and will instead normalize as suggested.

(5) Line 311: "Daily wind speed and direction at the site of the polynya, ERA5's hourly 'u' and 'v' wind products were processed for a region..."

The sentence makes it sound like these variables are peculiar to ERA5, but they really aren't. Please use the formal terminology to present what u,v are:

"Daily zonal (u) and meridional (v) components of the winds at a height of 10m were obtained from ERA5 and processed for a region..."

We will amend as suggested.

*I also note a confusion between "monthly" (Line 308), "Daily" (Line 311), and "Hourly" (Line 313). This is terribly confusing for the reader. Please state exactly what you've downloaded from ERA5 (monthly? daily? hourly? It has to be *one* of the three), and then correct these sentences as necessary.*

Daily wind speed was calculated from hourly ERA5 data, and we used the ERA5's

monthly product to analyze the overall mean over the study period (i.e. Fig. 9). We see how this is confusing and will rephrase for better clarity, or simply use the same hourly product to calculate the study period mean in order to avoid the unnecessarily confusing explanation.

SPECIFIC COMMENTS: MINOR

(6) Line 50: Why is "Carbon Dioxide" capitalized? This looks unusual.

We will change this.

(7) Lines 107-108: "Westward coastal currents prevail in the area (St-Laurent et al. 2019)..."

"St-Laurent et al." is only a modeling study. I think it would be good to also cite an observational study with actual measurements of the coastal current: Kim et al. 2016, Estuarine, Coastal and Shelf Science, <https://doi.org/10.1016/j.ecss.2016.08.004>

(Same comment for Line 674 of the manuscript.)

Thank you, we will do this.

(8) Line 124: The acronym EOS isn't defined. Please define what EOS stands for, or remove the acronym.

We will do this.

(9) Figure 1a: To give the reader some context, please add to Fig.1a the climatological northward extent of the sea ice cover in Summer and in Winter. Such climatologies are available at, e.g., <https://nsidc.org/data/NSIDC-0192/versions/3>

Having this information will help the reader understand how you chose the extent of the red box. Without this information, the geographical extent of the red box appears arbitrary.

Thank you, we will do this.

(10) Line 224: "Following Cheng et al. (2017) the daily net heat flux, Q (in W/m²), of a pixel was estimated by..."

*Shouldn't it be: "of a *ice-free* pixel"?*

Yes, it should be for an 'open polynya' pixel – we will amend this.

(11) Line 235: $L_o = \epsilon \sigma T_0^4$ (Equation 2)

Why use T_0 (the freezing point of seawater) in Equation 2? Since Equation 2 is the black body radiation of the ocean surface, then Equation 2 should use T_s (the temperature of the water surface), not T_0 .

It's acceptable to assume, later on, that T_s is approximately equal to the freezing temperature, but Equation 2 should nevertheless be written as a function of T_s (not T_0) in order to make physical sense.

Similarly, line 241 should read:

$$T_s \approx T_0 = 273.15 - 0.0137\dots$$

rather than:

$$T_0 = T_s = 273.15 - 0.0137\dots$$

Thank you, we will make these changes.

(12) Lines 256-259: The symbol for pressure is "Pa", not "pa". Please correct throughout the paragraph.

Thank you for spotting this, we will amend it and double check for other similar errors.

(13) Line 274: Acronym GDAL isn't defined. Please define what GDAL stands for, or remove the acronym.

We will define the acronym (Geospatial Data Abstraction Library).

(14) Line 282: The letter "i" in "rho_i" should be a subscript (compare with Line 280 where it is correctly typed).

Thank you for spotting this, we will amend it.

(15) Lines 289-290: "Caution should be used when interpreting the absolute numbers produced by the ice production model, particularly because the input data is modeled climate data..."

Are you referring to ERA5 as "modeled climate data"? ERA5 is an atmospheric reanalysis, which is very different from "modeled climate data". For one thing, an atmospheric reanalysis assimilates historical measurements, while a "climate model" doesn't.

This does refer to ERA5. We will amend this incorrect wording.

(16) Lines 318-319: "wind direction was plotted using the 'matplotlib' function 'quiver'"

The results shouldn't depend on the choice of the graphics software. If this is relevant to the results, then explain in what ways it is relevant. If it's not relevant, then remove the passage.

We will remove the passage.

(17) Figure 4,5,6: Can we make the curves a bit thicker, so that their color is more apparent and makes it easier to distinguish one curve from another? Also, would it be possible to make these figure labels less pixelated, or larger so that the pixelation doesn't show as much?

We will make the lines thicker and the labels larger.

(18) Line 575: "SIC for the broader ASP region on two days in 2017"

Please clarify why you picked these two specific days, and what they represent? Presumably the top figure represents some kind of minimum? And what about the bottom figure?

We will explain in the caption that

- **panel (a) is presented to show an example of when the polynya had no ice boundary to the W/NW due to exceptionally low SIC in the region during the 2016/17 summer**
- **panel (b) is presented to show an example of the low SIC in the region, and narrow icepack bounding the polynya in the subsequent early winter.**

(19) Line 676: "(Koo et al., in review)."

You aren't supposed to cite studies that haven't been accepted for publication. Most journals will systematically remove such references at the copy-editing stage.

We acknowledge this mistake, however the paper in question has now been published so we will retain it in the text.

(20) *There is something wrong in the caption of Figure S1:*

"The figure covers background figure and area is the same as Fig 1b."

Please correct as needed.

Thank you, we will correct this. It should read "The background image and area is the same as in Fig 1b."

Best regards,

Dr Grant Macdonald, on behalf of all authors.