Authors’ Response to Editor and Reviewer 1 Comments of Revised Manuscript

September 15, 2021

This document contains the point-by-point reply to the Reviewer 1 and Editor comments for the revised Leonard et al. tc-2020-352 manuscript. Reviewer and Editor comments are indicated in bold. We provide our responses to Reviewer 1 first, followed by our responses to the Editor.

1 Reviewer 1 comments

I consider the manuscript improved overall to be easier to follow than the previous one, thanks to the author’s sincere efforts. However, I have two very minor comments, as described below.

1.1 Minor comments

P. 1, L. 4 (abstract): “We analyse the 2019 sea-ice conditions and relate them to southerly wind events using a Modified Storm Index (MSI).” I guess MSI includes not only wind but air temperature.

Yes, MSI uses air temperature and mean sea-level pressure. We acknowledge the ambiguity identified by the reviewer and have edited the abstract to read:

“We analyse the 2019 sea-ice conditions and relate them to a Modified Storm Index (MSI), a proxy for southerly wind events”.

P. 2, L43: Icebergs C-19 and B-15A are pretty famous. Even so, timing information when these icebergs affect sea ice in the analysis area is helpful for readers.

We have added the approximate timing of when these two icebergs were located in and around the mouth of the sound (refer to lines 43–45 in the revised manuscript). For B-15A, this was from approximately January 2001 to November 2004 (Brunt et al., 2006). For C-19, this was approximately September 2002 to May 2003 (Arrigo and van Dijken, 2003). The second reference was not previously included in our reference list; its citation is:

Arrigo, K. R. and van Dijken, G. L.: Impact of iceberg C-19 on Ross Sea primary production, Geophysical Research Letters, 30, https://doi.org/https://doi.org/10.1029/2003GL017721, 2003

The new text is:

This data set covers March 2000 to February 2018 and includes the time when the sea ice in McMurdo Sound was strongly impacted by the presence of very large, tabular icebergs in the mouth of the sound (e.g., B-15A from approximately January 2001 to November 2004 (Brunt et al., 2006) and C-19 from approximately September 2002 to May 2003 (Arrigo and van Dijken, 2003)).

2 Editor comments

For future reviews, it would be great if you as author(s) would kindly supply a response to the comments of the reviewers and the editor. This would speed up the review of subsequent ms versions, but replying in dot points to each comment raised by reviewers and editor.

We thank the editor for this comment. Although we did go through the editor's comments thoroughly and make changes to the text of the revised manuscript where we identified clarifications were needed, we did not directly address the editor's comments from the first review in our response to reviewer comments because we were aware that these would be posted to The Cryosphere Discussions (TCD). As the editor's comments were not posted to TCD, it was unclear to us if we were meant to provide our responses to the editor's comments in our response to reviewers, therefore, effectively posting the editor's comments to TCD.

We have provided our point-by-point responses to the editor's comments below.

General comments

What are the elevations for the temp and pressure sensors at Scott Base? And over which surface type are deployed? Glacial ice, rock, ... ?

We have added this information to the revised manuscript (refer to lines 108 – 111). We include this information here as well for completeness:

The Scott Base weather station is located immediately adjacent to Scott Base at 77.85° S, 166.76° E, approximately 150 m from the coast and on the order of 30 km east of the centre of the sound. The elevation of the station is 20 m AMSL with the sensors deployed at a height of 6–7 m above the ground. The ground surface is is seasonally snow-free scoria and volcanic rock.

One would expect a clearer katabatic signal if the KWI would be a function of the pressure gradient, and even more if also considering a temperature gradient (normalized relative to freezing temperature).

We thank the editor for raising this point. We had investigated using the temporal temperature and pressure gradients instead of the anomaly; however, this approach results in a very unclear signal due to the noise of the signal as well as the fact that the temperature increase often precedes the pressure decrease.

As KWI is the product of Tair times Pair, how do the authors relate this to a mechanism that leads to the breakup of fast ice in McMurdo Sound? – See below query about TD vs Dyn contribution.

As stated above, we use the KWI (now MSI) as a proxy for southerly wind events, with the wind stress imposed on the sea ice being the primary driver for breakup. We do not propose that either the temperature or the pressure are direct drivers for fast-ice breakup during winter.

Also, was any possibly interference with tidal effects considered? If peak tidal elevation would have coincided with the onset of the MSLP gradient, then a plausible mechanism for the fast-ice breakout would have been identified.

We examined the data record from the Cape Roberts tide gauge, located in the northwest of the sound at 77.0° S, 163.2° E, but the temporal resolution of the data (5 minutes) was not sufficient to link break-out events to ocean swell. We also determined that there were no correlations between break-out events and phase of the tidal cycle.

We have amended the following sentence in the manuscript, adding the details of the data that were interrogated (refer to lines 146 – 147):

Kim et al. (2018) did not find a significant relationship between sea-ice temperature and break-out in their

McMurdo Sound study, and we did not find any correlation between tidal state and the 2019 break-out events in this study, based on our analysis of 5-minute sea-level height data from the Land Information New Zealand tide gauge at Cape Roberts (77.0 ° S, 163.2 ° E) in the northwestern sound.

We have also added the data source in the data availability section:

Cape Roberts tide gauge data can be accessed from Land Information New Zealand at `https://www.linz.govt.nz/sea/tides/sea-level-data/sea-level-data-downloads`

Specific comments

We thank the editor for their specific comments, all of which we have implemented. We provide further comment here on a handful of the specific comments that we felt warranted a specific response.

148–150 Pls add how the pack ice found seaward of the fast ice impacts on holding in the fast ice, i.e. compare the seasonal evolution of the pack ice to that of the fast ice.

From our observations, the pack ice immediately to the north of the fast-ice edge does provide protection against swell induced breakup, however, in the southerly wind events that we analysed, the pack ice is advected away from the fast-ice edge before the fast-ice breakup initiates (as evidenced by the opening of the McMurdo Sound Polynya); hence the pack ice does not tend to hold the fast ice in place. As we are investigating individual events, we did not analyse the seasonal evolution of the pack ice as compared to the fast ice. Kim et al. (2018) found a correlation between fast-ice extent and total sea-ice concentration (fast + pack ice) in the sound and also noted that fast ice in McMurdo Sound does not seem to follow pack-ice trends in the Ross Sea, though this is probably heavily influenced by the iceberg effect on the fast ice obscuring other signals. They also noted that strong southerlies pushed the pack ice away from the fast-ice edge (in cases where the fast ice did not break out) which would suggest that pack ice offers little to no protection to the fast-ice cover against southerly winds.

167: Strongly suggest avoid reference to specific sea-ice models such as "CICE" and "LIM". If choosing to retain these, please spell out the model names and add reference.

We have removed reference to specific models.

172: Is the preferred / best access for ESA's S1 SAR data really via the Alaska SAR Facility? Would think to check at Copernicus data server first.

We routinely use the Alaska SAR Facility to search for and acquire SAR imagery as we find its interface intuitive to use. We feel this is appropriate, even when we are accessing ESA datasets, as per the following statement on the Alaska Sar Facility webpage:

"NASA's provision of the complete ESA Sentinel-1 synthetic aperture radar (SAR) data archive through the ASF DAAC is by agreement between the U.S. State Department and the European Commission (EC). As part of the Earth-observation Copernicus program, the Sentinel mission will provide scientists with accurate, timely, and easily accessible information to help shape the future of our planet. Content on ASF's Sentinel web pages is adapted from the ESA Sentinel-1 website."

We appreciate, however, that we have not adequately acknowledged the European Space Agency as the source of the Sentinel-1 SAR imagery. We have now addressed this by adding the following to the data availability section:

Copernicus Sentinel-1 data, retrieved from the Alaska SAR Facility DAAC at `https://search.asf.alaska.edu/` *were processed by the European Space Agency.*

Caption of Fig 2: Add the bin size for the wind roses. For clarification, add info on wind direction being defined as the direction the wind is originating from.

These additions have been made in the figure caption:

The maximum frequency shown is 3 %, with each circle representing an increment of 0.6 %, and the wind direction defined as the bearing from which the wind originated. The bin size of each spoke is 10°.

Finally, in response to a suggestion made by the editor, we have modified some of the text in the Discussion and Conclusions to highlight some of the novel ideas and new information from the study.