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Interactive comment on "Spaceborne infrared imagery for early detection and cause of Weddell Polynya openings" *by* Céline Heuzé and Adriano Lemos

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We thank the reviewer for their comments. The role of the reviewer has been duly acknowledged with the addition of this sentence in the acknowledgement section:

"We also thank the two anonymous reviewers 1 and 3 and Stephan Kern (reviewer 2) for their comments that greatly improved the clarity and quality of this manuscript"

General comments: 1. The summary of satellite observations for sea ice monitoring needs improvement. A more thorough reading of the relevant references is needed.

» We thank the reviewer for the more specific comments they made further down in

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Discussion paper

their review. All changes to the introduction that were suggested have been made.

2. The method is not clearly described in the manuscript. A flowchart of the "early warning system" could be helpful. For example, how the polynya-prone area is determined and how it varies with years? In Section 3.1, when determining the polynya dates, is the minimum SIC area-wise (the polynya-prone area)? If yes, is the polynya-prone area fixed? How large? How many pixels are we talking about? Such questions pop when we start to read section 3.1, however only find it till the end (in the caption of Figure 3). In section 3.2, why plotting the data on the 15-day minimum and maximum axes? It is not clear that, what are the final criteria for the early detection until I read the manuscript a couple times.

» We agree with the reviewer that the methods were not descriptive enough. We have heavily rewritten the manuscript to add clarity. Furthermore, we have now made our codes freely available on Github, as described in the Code Availability section. We added a flow chart as the reviewer suggested (new Figure 6). We reformulated the description of the polynya-prone region as early as section 2 to answer most of the reviewer's questions: the coordinates are fixed and based on existing literature. We also provide the area and corresponding number of grid cells. Then we added a sentence at the beginning of 3.1 to remind the reader of the main characteristics of this region. Section 3.2 has been clarified and figure 4 has been changed. The final criteria are clearly spelled out in section 3.2, in the conclusions, and indicated on the flow chart.

3. It is a bit difficult to follow the flow of the manuscript, especially for the method. Section 3.1 and 3.2 are part of the method however presented in the "Results and Discussion" section. It could be easier to read if restructuring the "Method" and "Results and Discussion" sections, with "the warning system" (and identifying criteria) in "Method" and "cause of the opening" in "Results and Discussion".

» In response to the other reviewers' comments, we restructured differently from what the reviewer here suggests. The detection method is the main result of this paper; the

cause of opening, an extra result to discuss the usability of infrared data. Hence we dramatically reduced section 3.3 and turned it into section 4: Discussion.

Specific comments: P1L1: “a crucial information” to “crucial”

» Changed.

P2L45-46: “sea ice concentration from passive radiometers or spectrometers (Spreen et al., 2008), mostly in the microwave region...” I don’t recall any spectrometers used for sea ice concentration retrieval. The most commonly used data to derive sea ice concentration is microwave radiometer data, because the sensor (i.e. microwave radiometer) can work independence of light and penetrate clouds. There is no need to mention spectrometers. It can be rewritten to sth like “...sea ice concentration from microwave radiometers (Spreen et al., 2008).”

» That was an unfortunate typo. Thank you for noticing it, the text has been changed as suggested.

P2L46-52: The authors give a list of references to present the low and high resolution applications. It is true that SAR has much higher spatial resolution than microwave radiometer, BUT both are microwave sensors. It is not appropriate to use “microwave products” to refer to the radiometer/scatterometer-based products. On the other hand, it is common to use microwave radiometers for sea ice drift tracking, sea ice classification and thickness retrieval (e.g., SMOS/SMAP). In Korosov et al., 2018, the microwave radiometers were firstly used to derive sea ice drift information, on the basis of which sea ice age was tracked. These sentences should be rephrased. Please also check the use of “microwave” (when referring to microwave radiometer), in the whole manuscript.

» “Microwave” has been constantly changed to ”passive microwave remote sensing” to increase clarity. The reference to Korosov et al. 2018 has been removed and replaced with a more relevant citation. Throughout the manuscript, “microwave” has been removed and replaced with ad-hoc, less ambiguous formulations.

P2L52-53: Microwave radiometers have been used to monitor sea ice since late 1970s,they are not recent sensors compared to infrared sensors.

» This sentence has been rephrased to “Moreover, SAR is a comparatively recent technology for sea ice observation”, i.e. the reference to passive microwave has been removed.

P3L59: “determine the mechanisms” to “understand the mechanisms”

» We disagree with the reviewer’s suggestion here – in this paper, we genuinely solely aim to determine, not build an understanding of the dynamics.

P3L69: “reanalysis”

» This sentence has been rephrased to: “in-situ hydrographic and atmospheric reanalysis data”

P3L72-74: since these two datasets have different resolution, please specify the resolution respectively.

» This part has been changed. All dataset used have their resolution specified.

P6L128-129: “using the traditional criterion sea ice minimum...”, do you mean sea ice concentration minimum? It is not clear here how the “sea ice minimum” is determined? If this is the minimum concentration of the polynya-prone area, a description of how the polynya area is determined and how large is the area is needed.

» This comment is the same as major comment 2. As we explained before, both section 2 and section 3.1 have been rephrased to answer these question.

P7L140: “yield” to “yields”

» Corrected

P7L143: “then a third opens...the largest one splits into two”. It is confusing here, which one is the largest one?

» This paragraph has been removed

P7L147-148: “thirty” to “30”;

» Changed.

P7L166: 3443 days? For how many years? In the next paragraph, the number of days is replaced with the number of events? Why?

» This paragraph has been rephrased for clarity.

P7L160-171: These two paragraphs basically explains that threshold for single band does not work well for early detection but the three bands together do. A summary of the final criteria and the reason is needed.

» This section has been heavily rephrased. A summary has been added as suggested. The final criteria are also mentioned on the flowchart that the reviewer suggested we add (new Figure 6).

P12L220: which three events do you mean? Do you mean the average temperature in the 15 days, or when the opening starts?

» Rephrased to ”three polynya events are colder than or around -10 °C over the entire 15-day period that preceeds the polynya opening”.

In Figure A5, there are more cases with 2 m air temperature of -10 degree by the time of opening.

» This comment from the reviewer is related to the confusing formulation of that sentence, which has now been changed in response to the previous comment.

P13L235: I don’t find temperature and salinity at 480 m depth oscillate with a near 12hour frequency, at least not from -30 days to -13 days. Only smaller oscillations are found during 30-20 days before the event.

» This sentence has been removed in response to reviewer 3.

P13L250: Again, I don't find increase of temperature at depth. It is too small to notice. The brightness temperature increases following the dip of T45 however only for one day.

» This sentence as well has been removed in response to reviewer 3.

P7L257-258: I would suggest delete the two question mark and words in parentheses.

» This paragraph has been rephrased.

P15L265: "rejected"

» Changed.

P17L300: "Sentinel" to "Sentinel-1", the revisit time for the twin Sentinel-1 satellites is 6 days not 4 days

» Changed to Sentinel-1. We agree with the reviewer that the revisit time is 6 days over the same satellite orbit. However, from different orbits the same place can be monitored more often, especially at higher latitudes (as visible on Fig 9).

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