We would like to thank Reviewer 2 for his comments and appreciate the time and effort he/she put into his/her review of our manuscript. In the following, we would like to go through all comments/suggestions and reply to them or answer them point-by-point. Reviewer comments are put in **bold font**, our replies are colored and changes inserted to the manuscript are put in *italics*.

Major comments:
There are many coastal polynyas around Antarctica. A map of sea-ice production in coastal polynyas derived from the PM data (Nihahshi and Ohshima, 2015; Nihashi et al., 2018) shows that the ice production in a coastal polynya near the Brunt Ice Shelf region is small. This indicates that this small polynya's impact on climate change is not so significant as the other larger polynyas. Why did the authors focus on this minor polynya as a study area? In the title and throughout the manuscript, as stated in "Antarctic sea ice", it gives the impression that this manuscript's results have been achieved as if they represent the entire Antarctic Ocean. I wonder that a result of the cloud mask from a small polynya study can represent the entire Antarctic coastal polynyas or that the result of this manuscript can be applied to other large major coastal polynyas, such as the Ross Ice Shelf Polynya.

This point was brought up by both reviewers. The region was chosen because of earlier experience with the region through the corresponding author (see Paul et al. 2015a,b) as well as several benefits for the setup of the algorithm we would like to explain in the following. While this polynya is not a major player in, e.g., deep-water formation (as correctly pointed out) it is one of the most active regions in the Weddell Sea and similar in ice production to the much larger Ronne Ice Shelf polynya (see Paul et al. 2015b). The high activity as well as the good spatio-temporal coverage through Sentinel-1 led to the decision to start-off with this region. However, the approach is assumed independent of the selected region as it mainly depends on the received satellite TIR signals, i.e., the temperature differences between surface types and clouds. Due to the investigation of a complete freezing period, this is assumed to be comparable to other polynya regions and should also be independent of polynya shape/size. A study applying the proposed procedure to all Antarctic polynyas is currently under preparation.

Regarding the manuscript title, we are sorry that Reviewer 2 was slightly disappointed by not (yet) seeing the algorithm applied to the complete Antarctic. However, we think the title focuses more on the methodology (which is applied in the Antarctic) rather than a particular region and would leave it for now as is.

We will add a clarification to the manuscript: e.g.,

This region was chosen for its combination of high inter-annual polynya activity and high spatio-temporal coverage with Sentinel-1 data. Results are expected to be transferable to other polynya regions in the Antarctic.

Minor comments:
P. 2, L. 22: Please correct "polyanya" to "polynya".
P. 2, L. 23: "both in, the Arctic ...". It would be "both in the Arctic ...".

We will change both. Thanks for pointing those out!

P. 3, Fig. 2: There are no linkages between ted characters of A-H and the manuscript. I felt that elaborating by following these in the manuscript would be helpful for readers.

This is a very helpful suggestion and we will change the manuscript accordingly by adding references to these sub-points in the Data&Methods section.

P. 4, L. 67: “ii) large number”. It would be “ii) a large number”.
P. 5, L. 103: “hyberbolic tangent”. It should be “hyperbolic tangent”.

We will also change those. Thanks for pointing those out!

P. 5, L. 112: Please explain the number: “39-23-10-3-10-23-39” and the meaning of the number shown by the bold character of “39-23-10-3”.

Due to overall changes in the manuscript related to comments by Reviewer 1 and a change in the processing software, this part was also changed. However, numbers remain also in the updated manuscript and refer to the number of hidden layers and associated neurons in the neural network architecture (here the autoencoder). For the above example, this refers to a total of seven layers with an input and output layer consisting of the 39 input variables; two hidden layers with 23 and 10 neurons respectively on each side of the dimensional reduced layer consisting of three neurons. The bold face numbers (on the left) highlight the encoder part of the autoencoder, which is used for the dimensional reduction. The decoder part is only used for the training of the autoencoder and not used afterwards. We added a clarification to the manuscript. For further reading we suggest the standard textbook by Goodfellow et al. (2016); https://www.deeplearningbook.org/.

P. 8, L. 178: Please correct from “, 2003).Generally” to “, 2003). Generally”. Insert a space.
P.9, L. 184: “... data is of ...”. It would be “...data are of ...”.

Another double correction. Thanks!

P. 10, Fig. 3c: Correspondence between cloud, open water/thin ice, and sea ice and color is hard to identify. For example, my suggestion is that clusters 3, 7, 18, and 23 that correspond to the cloud area are shown by similar colors that can clearly distinguish from open water/thin ice and sea ice areas. Also, do each of the 3, 7, 18, and 23 clusters that correspond to clouds reflect the type of cloud? Further, what is the white area that does not belong to any cluster in this figure?

The figure only provides an examples subset of all 35 clusters that we generated for each swath, therefore some area remains white in this example. The different clusters pointed out by reviewer not necessarily correspond to a certain cloud type, but rather represent a mix of temperature and texture. Also, due to the nature of the employed soft clustering (fuzzy c-means) each pixel belongs to all clusters but only with a certain probability. Therefore, it is likely that some of these cloud clusters probably show quite high or similar probabilities to neighboring cloud clusters as the number of 35 total clusters is for certain settings too much.

Our thought for the colors was to show as much clusters as possible with maximum contrast in colors to still be able to distinguish them. However, the suggestion to summarize clusters of the same type with similar colors also has something to it and we might change that in the final manuscript version.

P.11, L. 208: “... a FCM probability ...”. It would be “... an FCM probability ...”.

We will correct this one.

P. 11, L. 212: The authors defined threshold values of temperature. How did you define these values? Is there any physical background?

As stated in the manuscript, the separation was needed to aid the machine learning approach in understanding the image composition, as clouds especially experience a very wide range of temperatures (e.g., in contrast so sea-ice and open-water/thin-ice areas). However, there was no physical background in selecting these thresholds. These were arbitrarily chosen based on the overall temperature distribution in the training data in order to keep a majority in the intermediate class but cover for both extreme ends with sufficient training examples.

P. 13, L. 267: “negliable”. It should be “negligible”.

We will also correct this one.

P. 14, Fig. 4a, e, and i: A polynya area surrounded by red line: the authors described that the area was “manually picked”. How did you define the polynya area?
P. 15, Fig. 5a, e, and i: Same as the above.

We based our decision on the textural differences seen in the SAR image that can be associated with different ice types or open water.

P. 15, bottom: “and MOD/MYD29 estimated”. It would be “and MOD/MYD29 was estimated”.
P. 17, L. 307: “... West of ...”. It would be “... west of ...”.

We will also correct those last typos. Thanks you again!