The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-159-RC2, 2020

The Cryosphere Discussions
Open Access
EGU

Interactive comment on "Improved machine-learning based open-water/sea-ice/cloud discrimination over wintertime Antarctic sea ice using MODIS thermal-infrared imagery" *by* Stephan Paul and Marcus Huntemann

Anonymous Referee #2

Received and published: 6 November 2020

This paper tried to detect a cloud-covered area from a satellite thermal infrared image based on the mechanical-learning. The analysis area is a coastal polynya area close to the Brunt Ice Shelf, Antarctica. A coastal polynya is a low ice concentration or thin ice-covered area formed by divergent ice motion due to wind or ocean current. Heat insulation effect by sea ice is reduced significantly in the case of thin ice or open water fraction. Therefore, large heat loss from the ocean to the atmosphere occurs in a winter coastal polynya, leading to active freezing. The resultant large amount of cold and saline water (brine) rejection leads to the formation of dense water, which is a major

Printer-friendly version

Discussion paper

source of the bottom water. The sinking of the dense water plays a significant role in the global climate system by driving thermohaline circulation and exchanging CO2 between the atmosphere and the deep ocean. Thus, the Antarctic coastal polynyas are vital areas for the global climate system despite their relatively small areal extent (100 km at most).

Satellite data observed by passive microwave (PM) sensor (e.g., SSM/I, SSMIS, AMSR-E/2) are often used for sea-ice monitoring because the sensor can observe the earth surface regardless of darkness and cloud cover. The PM data are also used for coastal polynya studies, and a map of coastal polynyas of the hemispheric scale is revealed (e.g., Tamura et al., 2008; Nihashi and Ohshima, 2015; Nihashi et al., 2018). The disadvantage of PM data is the coarse spatial resolution of 6-12 km. On the other hand, the spatial resolution of a thermal infrared image observed by MODIS used in this manuscript is about 1 km. This higher spatial resolution allows for more detailed monitoring of a coastal polynya. A weak point of the thermal infrared image is that the sensor cannot observe the earth's surface due to darkness and cloud cover, different from the PM sensor. As described in the manuscript, the MODIS data includes cloud information (mask). This cloud mask works well at the normal sea-ice covered area where the ice thickness is not thin. Air temperature over a coastal polynya area is relatively warm due to heat flux from the ocean. This leads to errors in the MODIS cloud mask, and unfortunately, the mask virtually cannot be used over coastal polynya areas. The thin ice thickness algorithm development using PM data is based on comparisons with thermal ice thickness derived from MODIS infrared images (Nihashi and Ohshima, 2015). They found out cloud-free infrared images by manual inspection. I presume that the manuscript's findings can help this algorithm development, and this also would be a useful application. Referring to such a study might raise the value of this manuscript.

In the field of remote sensing, research applying machine learning has been increasing rapidly in recent years. Nevertheless, it is not easy to physically interpret machine learning results in geophysical ones, and many of them are not successful. On the

Printer-friendly version

Discussion paper

other hand, this manuscript's results seem to be an excellent example of applying machine learning to the field of sea-ice remote sensing. The manuscript is well prepared. Perhaps readers interested in this content can predict that they are not very knowledgeable about machine learning, including me, although machine learning experts may not be very interested in this paper. Even for such a beginner, this manuscript explained machine learning clearly and concisely, and I felt it was terrific. Based on my review, I recommend this manuscript for publication in the Cryosphere after minor revision.

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.

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 ...".

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.

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”.

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”.

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 ...”.

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?

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

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

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

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.

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 ...”.

—

References:

Nihashi, S. and K. I. Ohshima (2015), Circumpolar mapping of Antarctic coastal polynyas and landfast sea ice: relationship and variability, J. Clim., 28 3650–3670.

Nihashi, S., K. I. Ohshima, and T. Tamura (2017), Sea-Ice Production in Antarctic Coastal Polynyas Estimated from AMSR2 Data and Its Validation Using AMSR-E and SSM/I-SSMIS Data, IEEE JSTARS, 10(9), 3912–3922.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-159, 2020.

Printer-friendly version

Discussion paper