The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2019-288-AC3, 2020

The Cryosphere
Discussions
Open Access
EGU

Interactive comment on "Observations of Sea Ice Melt from Operation IceBridge Imagery" *by* Nicholas C. Wright et al.

Nicholas C. Wright et al.

ncwright.th@dartmouth.edu

Received and published: 8 May 2020

Author responses are denoted by a > before the paragraph.

Major comments: A number of questions remain about the algorithm performance and the error analysis could be strengthened:

L156. Other than haze, what are the main sources of object misclassifications?

>Haze is the main source of bulk object misclassification. Transitional surfaces (e.g. dark melt ponds, very thin ice) are the second highest source of misclassification. However, because these surfaces are typically transitioning between categories it is difficult to determine their "true" category in the first place. These and other sources are discussed in more detail in the error analysis section of the document describing

Printer-friendly version

Discussion paper

the OSSP methods (Wright and Polashenski, 2018).

L156. How do object misclassifications impact the derived melt pond fraction? On Line 137, you state the shadow detection method is not applied because “typical summer solar zenith angle yields fewer shadows.” The sun angle is still low in the Arctic and ridge shadows do exist in the summer. How are shadows that do exist in the imagery classified if they do not have their own category? Are they classified as melt pond? How does excluding this step impact results? How does aircraft attitude and altitude impact the impact pixels and hence, the classification algorithm and derived melt pond fraction? Have the authors re-quantified the algorithm error, given the modifications to the algorithm (Section starting at Line 107), since Wright and Polashenski, 2018?

>Previous work has determined that in spring imagery ridge shadows make up less than 0.5% of the total ice area (Webster et al., 2015) and are therefore a small source of error even if always misclassified. Their impact would be expected to be even lower in summer, where the sun angles are higher. Misclassified shadows are typically assigned a label of melt pond, and less frequently of dark or thin ice. The total impact of object misclassifications is accounted for in the error analyses described in Wright and Polashenski 2018.

>This dataset is also provided in a reprojected format that does account for aircraft pitch and roll. In this work we are assessing relative fractions and not absolute areas - the difference in calculated surface fraction between images in the corrected vs raw datasets is small. Part of the manual filtering process described in the methods section includes removing those images that were not taken at or near the nominal survey altitude.

>The algorithm adjustments were tested against the same test set as used in Wright and Polashenski, 2018, and were found to not alter the overall performance.

Designation of ice type The authors state on L203 that the flight on July 25th 2017 covers first year sea ice. This does not seem justifiable for two reasons. a) the authors provide their own definition of a FYI flight (Line 197, that 90 % of the images in the flight are FYI). Given this definition, and visual inspection of the DMS imagery from the flight, it is not obvious that the flight is over predominantly FYI. A larger percentage of images with pressure ridges and rubbled ice, indicating a long deformation history, and thus, MYI. Many images resemble the MYI depicted in Figure 11a-c and described as "common examples of ponded multiyear ice floes with characteristically blue ponds that are well consolidated by surface topography" (Line 258). b) the location of the flight line north of Ellesmere Island in the Central Arctic is over sea ice known to be the oldest and thickest ice in the Arctic, and highly unlikely to be predominantly FYI in origin. The 2017 Arctic Report Card found that the ice in this region in March is predominantly MYI (Figure 3c, Perovich et al., 2017). Given that it is well know that the ice in this region is some of the thickest ice in the Arctic (e.g. Figure 2b, Sallila et al. 2019), this area is highly unlikely to be predominantly FYI. For reference: Perovich, D., Meier, W., Tschudi, M., Farrell, S., Hendricks, S., Gerland, S., Haas, C., Krumpen, T., Polashenski, C., Ricker, R., & Webster, M. (2017). Sea Ice [in Arctic Report Card 2017], http://arctic.noaa.gov/Report-Card Sallila, H., Farrell, S. L., McCurry, J., & Rinne, E. (2019). Assessment of contemporary satellite sea ice thickness products for Arctic sea ice. Cryosphere, 13(4).

>According to the sea ice age dataset (hosted at NSIDC; citation below) there are pockets of first year ice on/around July 25th 2017 in the location of this flight line. We agree that this area is typically filled by thicker multiyear ice, but that does not exclude the possibility of there being first year ice. Visual inspections of the DMS imagery show characteristics we would expect from younger, thinner ice: darker melt ponds, dark melting ice, and less surface topography.

>Tschudi, M., W. N. Meier, J. S. Stewart, C. Fowler, and J. Maslanik. 2019. EASE-Grid Sea Ice Age, Version 4. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/UTAV7490FEPB.

Forcing conditions affecting sea ice floes in survey area L212. "To investigate melt pond statistics across ice that experienced similar forcing conditions, two flights that contained both FY and MY ice were selected for further analysis" How do the authors know this ice has experienced similar forcing conditions throughout its lifetime? Considering the Beaufort Gyre is known to be an especially dynamic area, the ice observed during the flight surveys may have come from different regions. The ice in this region may, at the time of the survey, be experiencing uniform forcing conditions, but the assumption that all ice covered in a survey has experienced similar forcing conditions throughout its lifetime is invalid.

>By nature, MYI cannot experience the same forcing conditions as FYI over its complete lifetime. Here we are just referring to the current melt season, where the assumption that ice in a similar location on the same date experiences similar atmospheric conditions. We have added more qualifications to this description in the text.

Melt pond fraction calculation clarification: L175. How is melt pond fraction calculated? If the OSSP algorithm classifies melt ponds and submerged ice in the same category, is submerged ice included in the melt pond fraction calculation? How does the inclusion of submerged ice impact the melt pond fraction parameter?

>Melt pond fraction is calculated as: Pond area / (ice are + pond area), and we have added this information to the text. Submerged ice is included in this metric. Including submerged ice as part of melt ponds is discussed in detail in the original OSSP method document. Submerged ice is radiatively similar to melt ponds and is therefore part of the same category, and not considered a misclassification.

L177. Why do the authors choose images with open water area < 70% as a threshold for displaying melt pond fraction results? Do you include images with open water area > 70% in melt pond fraction results (Section 3.2 and 3.3).

>A single IceBridge image typically only covers 600x400m. If 70% of this is ocean, then melt pond fractions calculated from this small area are very easily skewed by large ponds (this area is well below the "aggregate scale"). Note that the images are

still processed, but the pond fraction is not shown in this plot. Even full images have a small enough area for the melt pond fraction to be skewed by large melt ponds, as shown by the orange dots in Figure 5.

Minor questions needing clarification in the text: L80 Are data collected on 15 July 2016 analyzed? This flight survey is plotted in Figure 1, but no results are shown (Figure 4).

>Yes – thank you for pointing this out. That flight was somehow missed when creating Figure 4.

L180. The authors state that data from the 20 July 2016 flight were not processed because “not enough usable images” How do the authors determine what was enough?

>Of the 1587 image frames taken on July 20, less than 30 are completely haze free. We have added these numbers to the text.

L184. Does Figure 5 follow Figure 4, and only show melt pond fraction for images with open water area < 70%?

>No – but if you look at July 24th , 2017 on Figure 4 you will see that few images in this flight were flagged as having >70% open water.

L203: Can you distinguish between the 25July2017 flight A and flight B within the text and/or in Figure 4 (where they are currently shown in the same color)?

>Yes, we have separated these flights to different colors.

L323. How is a melt pond defined in this study? Is a melt pond still a melt pond when it has melted through the sea ice? What about other features: melting snow, thaw holes, algae on ice?

>We use the definition presented in Wright and Polashenski, 2018: “Melt Ponds and Submerged Ice (MPS): applied to surfaces where a liquid water layer completely submerges the ice.”

Printer-friendly version

Discussion paper

>A melt pond is no longer a melt pond when it has melted through the ice. Melting snow falls into the ice/snow category, algae and sediment laden ice are not defined but would likely be assigned to the dark ice category depending on their color and brightness.

Figure 4. Bottom figure. For the 17 July 2017 and 18 July 2017 flights, it looks like there are no images remaining for analysis. Is that correct? Can you provide the total number of images analyzed for each flight, and total discarded? Perhaps this information could be included in a table or added to the figure.

>We have added this information in the methods section.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-288, 2019.