Review of: egusphere-2025-4480

Observational data of Arctic Sea Ice Melt Ponds: a Systematic Review of Acquisition and Processing Approaches

By Aparício et al.

Summary

The authors provide a review of earth observation (EO) methods used in the study of sea ice melt pond properties. Systematic melt pond property observations using EO are challenging and there are no high quality observations (e.g., ECV or CDR type datasets) despite importance for observing sea ice evolution, making proxy estimates such as albedo or light transmittance, and for predicting sea ice conditions. The paper requires some improvements, as per the major and minor comments provided here, and by others, before consideration for publication in *The Cryosphere*.

Major Comments

1. Given that the paper is a synthesis, the abstract should contain some statements relating to the outcomes of the synthesis. As it is, there only a statement about EO data gaps, along with an outline of the paper's intentions and some motivation statements.

2. It would be advantageous for terminology relating to EO to be tightened up. The authors are focused on what they refer to as the "main" EO methods, which appear to be airborne and satellite-based remote sensing. But in section 3, EO is also used to describe some in situ methods to, which is fine since buoys, weather stations, etc. are EO tools too. The term EO is dropped for remote sensing in the main text – is that distinction intended?

3. The paragraphs on Lines 59-74 needs improvement since some passages are hard the follow. More specific information is needed. How are melt ponds related to a shift in this Arctic sea ice spring predictability barrier? What *is* the barrier exactly? It can be stated better than "melt ponds …predict …September minimum" since melt ponds can't make predictions. More detail should be given on how melt ponds are parameterized in GCMs, especially given the sensitivity, and the overall theme of the paper. What is the link between GCM parameterizations and the Spring predictability barrier, as suggested on Lines 66-67? Overall, seasonal prediction and climate model projections, as they pertain to melt pond properties should be much better described. Otherwise, the motivation statements on Line 87 and Line 100 are not well backed-up.

4. The seasonal evolution of melt pond properties in Section 2, including Figure 3, needs to better differentiate between first-year ice and multiyear ice. There is mention of the influence of ice types in the context of topography, which is good, but there still needs to be seasonal stages in terms of melt pond formation and evolution, and expected melt pond albedo or fraction, defined by ice type. E.g., Stage 4 (freeze-up) rarely occurs for first-year sea ice since the ice melts away / disintegrates during summer.

5. It is generally hard to follow what satellite missions are current or past. Information about data products availability comes later in Table 2, but prior to that there are many missions discussed without enough detail regarding status.

6. Optical (laser) altimetry is addressed but radar altimetry is not. Radar altimetry should be included.

7. In Section 3.2, more emphasis needs to be placed on the salient findings from these campaigns, in the context of melt pond property information retrieval from EO data, where possible. In some cases there are just descriptions of data collected and some observations made (e.g., ICE212). In other cases the descriptions aren't clear (e.g., MOSAiC contributions to spatiotemporal studies – what was learned?).

Minor Comments

L20: "… sensor type."

L48-50: Recommended text: "(Right) True colour composite image of Arctic sea ice melt ponds from the Copernicus Sentinel-2 satellite (illustrating the large variability of melt pond, lead and open ocean reflectance). Acquired on 17th June 2024 off the Northeastern coast of Greenland.".

L75: Add mention that SHEBA and MOSAiC are summarized later on.

L78: Change "struggle to" to "do not".

L93: "…melt pond studies…"

L96: Refer to "… passive microwave" since radar used microwaves too.

L103: Add a description of the basic outline of the sections of the paper.

L114-118: Bare ice is referred to as both stable and changing (as melt progresses). Clarify.

L121: "radiometric" doesn't fit here.

L127: "ice surface features" should be changes to "ice properties" since ice surface and volume properties are important (as is described).

L134-135: Are the timings (by month) always appropriate when Arctic sea ice extends across about 40° latitude?

L136: Here and in Figure 3 the melt onset should be "pond onset" since melt onset precedes the formation of ponds through meltwater accumulation. See, e.g.: https://doi.org/10.1038/s41597-023-02760-5

L142: See major comment 4. The seasonal peak in pond fraction for first-year ice can be at the initial flooding stage, before drainage pathways open up. The Polashenski et al., 2012 paper shows this too.

L159: Delete Earth Observation since "(EO)" was defined earlier.

L160: Be consistent with "in situ" being italicized or not, here and elsewhere.

L162: "….considerations of associated …"

L164: "addresses" (change the tense)

L168: In the Section 3.1 heading "ponds" should be "pond"

L174: Describe how the main applications were determined. In figure 4, "measured parameters" is used; are these the same thing?

L179: The Figure 4 caption is incomplete. In the figure, it is unclear if there is a difference between "detection of onset" and "timing of onset". It is odd that melt pond fraction is not mentioned.

L183: Name the spaceborne mission.

L186: It should be “EM spectrum”.

L194: “instruments”

L183-205: Some of these missions are still operational, and others are defunct. Some clarity in this regard is needed. With regards to high-resolution imagery, is WV referenced as an example only? There have been others used; e.g. Webster et al. 2015 used data from the NTM satellites.

L222: State why Landsat is not suitable, and if that is for a specific Landsat mission or all of them.

L223: Sentence “Additionally, for high resolution…” should be re-written for clarity. Are there no data for coastal waters, or limited data?

L226: Remove “Similarly”. The commercial restriction associated with those platforms is not similar to Sentinel-2.

L230-234: This should be made clearer. It is unclear how fresh snow mimicking melting ice leads to misclassification. What is classified/mis-classified? If it is melt pond fraction or pond/ice, aren’t fresh snow or melting ice basically the same class (i.e., *not* melt pond)? It is also unclear why freeze ponds (re-frozen ponds or freezing ponds?) lead to melt pond fraction overestimation.

L240: Sentence on LiDAR should be “LiDAR laser pulses are composed of photons typically emitted at one or both of these wavelengths.”.

L245-248: Mention is made of pond depth and presence, in terms of research. But only pond depth is mentioned in relation to operational products. What about presence?

L249: “…consist of laser penetration…”

L249-252: Add detail on how melt pond presence affects existing ICESat-2 data products for sea ice, and what those products are, if known. Are melt pond areas masked out, or generally unreliable in sea ice data products during spring/summer conditions?

L254: Add a comma after “particles”.

L262-264: The statement about liquid water in snow needs correcting. Snow effects do not create the low signature of melt ponds, since melt ponds are water bodies and their backscatter is dependent on wind/wave roughness.

L272: Clarify what you mean by early melt detections, in the context of X-band suitability over other frequencies.

L274: Correct “melt onset” if necessary. I.e., if this is pond onset.

L275: Change “on” to “for” and make “signatures” to “signature”.

L297: Get rid of the empty space. Also it should be “… poorly distinguishable from smooth sea ice.”.

L301: Provide detail about the swath widths. Smaller than what?

L304-306: The statement about X-band is hard to follow. Optimal performance for deriving what melt pond related information? MYI monitoring of what melt pond related information?

L306-307: Backscatter should not increase due to specular reflection.

L311-313: It is confusing that X-band systems are limited at winds above 5 m/s but optimal retrieval is found at about 6.3 m/s.

L316: “pond onset”

L311-322: It is hard to follow what melt pond properties are being observed/retrieved here. E.g., optimal retrieval of what melt pond information?

L326: The section on scatterometers should be shortened since most of the current focus is on melt onset, which precedes pond onset. Focus should be placed on melt pond properties.

L350: As for scatterometers, the discussion of melt effects in this section should be shortened and more emphasis placed specifically on melt pond related properties.

L376: Low penetration depth also applies to scatterometers and SARs since they operate in the microwave range. It should be noted above too.

L390: Provide some detail on what criteria were used to include these campaigns, and (potentially) exclude others that have studied melt pond properties and detection techniques.

L488: “named”

L506: “that geophysical inversions” doesn’t make sense. Please clarify.

L514: In Figure 8, there is mention of compact polarization but there was no mention of that in the earlier section on SAR approaches.

L515-517: Some of the mentioned studies focus on melt pond fraction prediction, where spring MPF is predicted from winter SAR imagery, e.g., Howell et al., 2020. Others focus on direct estimation of MPF, Tanaka and Scharien, 2022. This should be clarified here, and in the earlier SAR section.

L522: It would be helpful to know if more advanced techniques like ANN represent any increase in efficacy compared to traditional techniques.

L526: “converged”

L530: MPF was defined earlier.

L532: “melt pond” (singular).

L580: Statistically significant “difference”.

L581: Use “MPFs”.

L598: “datasets”

L631: Use “MPF”.

L698: “5. Discussion”

L757: It is unclear why SAR-based methods are specifically identified as lagging in situ methods when, presumably, other satellite-based methods would be similarly lagging. This also comes up on L867.

L765: Use “MPF”

L780: CAA was defined earlier. Use “CAA”.

L821-822: Elaborate what these schemes are, as well as schemes in general as they pertain to melt pond representation in models. This will make this section of the review more accessible to readers focused on in situ and satellite studies.

L850: Elaborate on why specifically pond depths, pond fraction, snow cover and type. Is ice topography and permeability less important?